Filed: 2020-06-08
EB-2019-0294
Exhibit I.CCC.1
Page 1 of 1
Plus Attachment

ENBRIDGE GAS INC.
Answer to Interrogatory from
Consumers Council of Canada (CCC)

INTERROGATORY

Question**:**

On March 31, 2020, EGI filed an update to its Application and evidence. Please set out, in a detailed list, what has changed since EGI filed its initial evidence on December 20, 2019.

Response:

As explained in the cover letter dated March 31, 2020, Enbridge Gas updated its evidence to reflect changes to the routing for the Project. The cover letter is filed as Attachment 1 to this response.

The routing change was made because after the initial evidence was filed Enbridge Gas acquired lands contiguous to the current Technology and Operations Centre (TOC). This allowed Enbridge Gas to select the Alternative Route identified in the Environmental Report (ER) for the pipeline. The changed route is shorter and will lower project costs and decrease disruption to stakeholders impacted by the Project. Details are provided at Exhibit C, Tab 1, Schedule 1, para. 17.

The change in Project route resulted in updates to several exhibits. The specific Exhibits that were updated are listed in the March 31, 2020 cover letter.

ENBRIDGE®

Stephanie Allman
Regulatory Coordinator

tel 416-495-5499
EGIRegulatoryProceedings@enbridge.com

Enbridge Gas Inc.
500 Consumers Road
North York, Ontario M2J 1P8
Canada

March 31, 2020

VIA EMAIL and COURIER

Ms. Christine Long
Board Secretary
Ontario Energy Board
2300 Yonge Street, 27th Floor
Toronto, ON M4P 1E4

Dear Ms. Long:

Re: Enbridge Gas Inc. ("Enbridge Gas")
Ontario Energy Board File: EB-2019-0294
Low Carbon Energy Project – Application and Evidence - Redacted

Enclosed please find an updated redacted application and evidence for the Low Carbon Energy Project (Project). This updated application and evidence reflects changes to routing for the Project. The names of Individuals have been removed from the following Exhibits:

- Exhibit C, Tab 1, Schedule 1, Attachment 2 – Updated Consultation Log
- Exhibit C, Tab 1, Schedule 1, Attachment 4 – Stakeholder and Public Consultation Update
- Exhibit C, Tab 1, Schedule 1, Attachment 7 – EA Report Amendment
- Exhibit F, Tab 1, Schedule 1, Attachment 6 - Indigenous Consultation & Attachments

The confidential unredacted exhibits will be provided to the Ontario Energy Board under separate cover.

Please contact the undersigned if you have any questions.

Yours truly,

(Original Signed)

Stephanie Allman
Regulatory Coordinator

ENBRIDGE GAS INC.
Answer to Interrogatory from
Consumers Council of Canada (CCC)

INTERROGATORY

Reference:

Ex. A/T2/S1/p. 2

Question**:**

Please explain what EGI's Technology and Operations Centre is and what functions are undertaken there. Is this facility part of EGI's unregulated business and used to serve both businesses? Who owns the property and any associated buildings? If it is used to serve both regulated and unregulated activities please provide the service level agreements related to the facility.

Response:

The Enbridge Gas Technology and Operations Centre (TOC) houses the Company's utility operations functions that serve the Greater Toronto Area. The TOC also serves as a technical training centre for safety and operations related functions. The property the TOC is situated on and associated buildings are owned by Enbridge Gas Inc., apart from the hydrogen Power to Gas facility.

There is an intercorporate services agreement between Enbridge Gas Inc. and 2562961 Ontario Limited which includes leasing the portion of the TOC property upon which the Power to Gas facility resides to 2562961 Ontario Limited and the provision of Emergency Services by Enbridge Gas Inc.. A copy of the intercorporate services agreement and 4 related schedules are included as Attachment #1.

INTERCORPORATE SERVICES AGREEMENT

THIS AGREEMENT made effective as of the 1st day of January 2017.

BETWEEN:

ENBRIDGE GAS DISTRIBUTION INC., a corporation incorporated under the laws of Canada

(the “Services Provider”)

- and -

2562961 ONTARIO LTD., a corporation incorporated under the laws of Canada

(the “Services Recipient”)

WHEREAS the above-named parties wish to reduce to writing the agreement pursuant to which the Services Provider will provide services to the Services Recipient (this “Agreement”);

NOW THEREFORE THIS AGREEMENT WITNESSES that in consideration of the premises and mutual covenants hereinafter contained, the parties agree that:

Services

1. Services to be provided to the Services Recipient by the Services Provider shall be identified and defined in one or more schedules (the "Services Schedules") which upon execution by the Services Recipient and the Services Provider shall be incorporated into and form part of this Agreement.

2. The parties acknowledge that this Agreement shall be subject to any rule applicable to the Services Provider made by the Ontario Energy Board pursuant to the *Ontario Energy Board Act*, S.O. 1998, c. 15, Sched. B., s. 44, including without limitation, the *Affiliate Relationships Code for Gas Utilities* (the "Code"), as amended from time to time. Specifically, without limiting the generality of the foregoing, the Services Recipient agrees to comply promptly with all requests either made or authorized by the Ontario Energy Board for information with respect to the services provided pursuant to this Agreement. This Agreement shall also be subject to any valid, applicable federal, provincial or other governmental regulatory body or authority having jurisdiction over a party or the subject matter of this Agreement.

3. The services shall be performed in a manner that is satisfactory to the Services Recipient, and according to the performance measures set out in the applicable Services Schedules. The employees of the Services Provider who are performing the services shall possess such skills and qualifications as are

necessary or desirable for the performance of the services in accordance with the applicable professional standards and qualifications governing such employees. If the Services Recipient disputes the quality or level of services provided by the Services Provider hereunder, the parties will endeavour to resolve the dispute forthwith in accordance with the procedures set out in the applicable Services Schedule(s) or if no such procedures are set out in accordance with Section 13 below.

Pricing

4. The fees for services provided by the Services Provider shall be as set forth in the applicable Services Schedule. The Services Provider shall be entitled to adjust the fees as of January 1 in each year in accordance with the terms set out in the applicable Services Schedule.

5. The Services Recipient will be required to reimburse the Services Provider for reasonable out of pocket expenses incurred by the Services Provider that are directly related to the provision of services under any Services Schedule, including (but not limited to) the following:

   - travel charges such as mileage, parking, airfare, out-of-town accommodation and meal expenses;

   - overnight courier charges; and

   - court or government filing and administration fees.

   The Services Provider shall maintain appropriate records to substantiate the provision of services to the Services Recipient and such records shall be made available for review by the Services Recipient upon request.

Payment Notices and Procedures

6. The following sets forth the procedure applicable to invoicing and payments related to services delivered hereunder:

   a) The Services Provider will prepare and send Payment Notices, by means of entries into the electronic inter-company financial systems, or a written invoice as may be agreed upon by the parties (in each case a "Payment Notice"), in accordance with the applicable Services Schedule. Payments shall be due within thirty (30) days of receipt of a Payment Notice or within such other time period as may be agreed upon by the parties from time to time.

   b) Immediately upon request, the Services Provider shall provide the Services Recipient with any supporting information for a Payment Notice reasonably requested within thirty (30) days from the date of a Payment Notice. If the Services Recipient disputes the amount of a Payment Notice within thirty (30) days of receipt of a Payment Notice, the parties shall endeavour to resolve the dispute forthwith, failing which the procedures set out in Section 13 shall be invoked. If no issue is raised relating to a Payment Notice within thirty (30) days from the date of receipt of such Payment Notice, the Payment Notice shall be deemed accepted.

c) Any amount to be remitted by the Services Recipient to the Services Provider and not remitted on or before the date on which it is due shall thereafter bear interest at an annual rate equal to the prime rate of interest of the Toronto Dominion Bank (or its successor) (Toronto, Main Branch) on the due date plus one percent (1%) per annum, compounded monthly.

d) Payment Notices delivered pursuant to this section may include amounts related to the expenditures incurred by the Services Provider to obtain goods or services from third parties for the benefit of the Services Recipient.

e) In the event that the Canada Revenue Agency or any other competent authority at any time proposes to issue or does issue any assessment or assessments that impose or would impose any liability for tax of any nature or kind whatsoever on the Services Provider or the Services Recipient on the basis that the fair market value of the services is different than the amount charged by the Services Provider for the corresponding services (the "Services Charge"), and in the event that the parties hereto agree that the fair market value of the services is different than the Services Charge, then upon such agreement the Services Charge that the Services Recipient is obligated to pay for the said services shall be varied by increasing or decreasing the amount of the Services Charge as the Services Recipient and the Services Provider may agree.

f) All amounts payable under this Agreement are expressed, and shall be paid, in Canadian dollars unless otherwise stated in a Services Schedule.

Reporting Requirements

7. Various management and operating reports as reasonably requested by the Services Recipient shall be provided by the Services Provider, the nature and timing of which shall be described in the respective Services Schedules.

Amendments

8. This Agreement and any related Schedule (including Services Schedules) may be amended from time to time upon the approval in writing of both parties. Version control and archival storage of all amendments shall be the responsibility of the Services Provider.

9. All amendments to this Agreement will be effected in accordance with the service adjustment procedures described in Section 11 below.

Term, Termination and Renewal

10. The following provisions apply to term, termination, and renewal under this Agreement:

a) This Agreement shall be effective January 1, 2017 and for each service shall continue until the expiry date set forth in the applicable Services Schedule, provided that in no event shall this Agreement extend beyond December 31, 2019.

b) The Services Provider must advise the Services Recipient signatory on the Services Schedule (or his or her successor) in writing of the expiry date of any Services Schedule not less than sixty (60) days prior to such expiry date.

c) The Services Recipient shall notify the Services Provider in writing of its intention to renew or not to renew a service, (30) days prior to the end of the term of any Services Schedule. In the absence of such notice, the Services Schedule will automatically be renewed for an additional twelve (12) month period under the existing terms and conditions set forth in such Services Schedule, subject to any service fees adjustments set forth in such Services Schedule.

d) Either party shall have the right to terminate this Agreement immediately in the event that either party ceases to be a direct or indirect wholly owned subsidiary of Enbridge Inc., and in any event, upon giving one hundred twenty (120) days written notice to the other party.

e) The provisions of Sections 13, 14, 15, 16, 17, and 19 shall survive the termination of this Agreement.

Service Adjustments

11. The following provisions apply to service adjustments and amendments under this Agreement:

a) During the term of this Agreement, the parties may identify the need to modify elements of individual Services Schedules, add new services or discontinue existing services. Either the Services Provider or Services Recipient may initiate a request for change. All requested changes must be identified in writing with an appropriate notice period within which the party receiving such notice may respond, such period not to be less than thirty (30) days unless otherwise agreed to by both parties.

b) Either party may propose changes to an existing Services Schedule at any time during the term of such Schedule. No amendment shall be effective unless both parties agree to the requested modifications and the effective date for implementation. The procedures set forth in subsection 13.b) below shall be followed if agreement regarding a change to the Services Schedule or fees cannot be reached by the parties within a reasonable time.

c) If either party expresses a desire to discontinue a service described in an executed Services Schedule, the parties shall endeavour in good faith to determine an appropriate wind-down period and a reasonable allocation of the costs of decommissioning, if any.

Performance Reviews

12. Upon thirty (30) days prior written request, either party may initiate a performance review, the terms and conditions of which shall be negotiated between the parties. All services will be reviewed with reference to the performance measures set out in the Agreement and applicable Services Schedules.

Dispute Resolution

13. In the event that an issue related to the performance of a service described in a Services Schedule, the fees payable under a Services Schedule, or the interpretation of the Agreement cannot be resolved by the Services Provider and Services Recipient, the Services Provider or Services Recipient may refer the matter (the "Dispute") for resolution using the procedures described in this Section 13:

a) The Services Recipient's designated representative and the Services Provider's designated representative must meet within seven (7) business days after either the Services Provider or Services Recipient notifies the other in writing of an unresolved issue. The purpose of the meeting will be to develop an action plan that can be presented to the Services Provider and Services Recipient within seventeen (17) business days after the delivery of the notice described in the preceding sentence. A copy of the action plan for resolution shall be sent to the President of the Services Provider and the President of the Services Recipient. If the action plan fails to bring a resolution to the conflict within twenty-one (21) business days after the delivery of the original notice described above, the issue shall be escalated further.

b) On the twenty-second (22nd) business day after the delivery of the original notice described above, the issue shall be escalated to the President of the Services Provider and Services Recipient if no resolution has been reached by such time.

c) If the problem cannot be resolved by the officers of the parties identified in 13.b) within seven (7) business days after the time it was referred to them, then it shall be escalated further as described below.

d) In the event none of the processes described above result in a resolution of the Dispute, it is the joint responsibility of the officers of the parties identified in 13.b) to escalate the issue and its corresponding documentation to senior management of Enbridge Inc. for final deliberation and resolution, subject to the arbitration provisions below.

e) Any costs associated with the resolution by Enbridge Inc. will be shared equally by the Services Provider and Services Recipient.

f) In the event that the processes described in (d) above do not result in a resolution of the Dispute acceptable to all parties to the Dispute within ninety (90) days after the date on which the Dispute first became known to the parties, the Dispute may be submitted by either party to arbitration pursuant to Exhibit A. Subject to this Section 13.f) and Exhibit A, the Dispute will not be made the subject matter of any action in any court by any party. After completion of the arbitration, an action may be initiated by the parties only for the purpose of enforcing the decision of the arbitrator and recovery of the costs incidental to the action. The decision of the arbitrator will be conclusively deemed to determine the interpretation of this Agreement and the rights and liabilities of the parties in respect of the matter arbitrated.

g) Pending the resolution of any Dispute, all Payment Notices for services specifically related to the Dispute will be held by the Services Provider. If the resolution is in the favour of the Services Provider, then the Services Provider may apply any late charges associated with the payment of services that were postponed due to the invocation of the dispute resolution process.

Liability of the Services Provider

14.1 Notwithstanding anything contained in this Agreement, the Services Provider, the Services Provider's affiliates and its and their respective directors, officers, employees, agents and contractors (collectively, the "**Services Provider representatives**"), shall not, either directly or indirectly, be liable, answerable or accountable to the Services Recipient, the Services Recipient's affiliates and its and their respective directors, officers, employees, agents and contractors (collectively, the "**Services Recipient representatives**") under this Agreement or otherwise at law or in equity, for:

a) any loss resulting from, incidental to or relating to a breach by the Services Provider representatives of any of the terms of this Agreement, the performance or non-performance of services under this Agreement by any of the Services Provider representatives (irrespective of whether such services have been provided before the effective date of this Agreement (the "**Effective Date**")), including any exercise or refusal to exercise a discretion, any mistake or error of judgement or any act or omission believed by the Services Provider representatives to be within the scope of authority conferred thereon by this Agreement, unless the proximate cause of such loss resulted from the fraud or gross negligence of any senior supervisory personnel of Services Provider in performing the services, in which case the benefit of this subsection a) shall not apply to the Services Provider representatives.

b) any loss resulting from, incidental to or relating to a breach by the Services Provider representatives of any of the terms of this Agreement, the performance or non-performance of services under this Agreement by any of the Services Provider representatives (irrespective of whether such services have been provided before the Effective Date), where the proximate cause of such loss is attributable to: (i) acting in accordance with the instructions of the Services Recipient; (ii) any action or omission that occurred with the Services Recipient's advance consent; or (iii) if applicable, the Services Recipient's failure to approve an item in any budget that was proposed by the Services Provider where the omission of the service, activity or operation proposed was the cause of the claim asserted against or loss suffered by the Services Recipient; or

c) any loss resulting from, incidental to, or relating to any act or omission by any of the Services Provider representatives (irrespective of whether such act or omission occurred prior to the Effective Date), provided that such act or omission is based upon the Services Provider representative's reliance on (i) statements of fact of other persons (excluding persons with whom the Services Provider is affiliated) who are considered by the Services Provider to be knowledgeable of such facts; or (ii) the opinion or advice of or information obtained from any expert.

Each of the parties acknowledges and agrees that the limits of liability provided for in this section shall not only be enforceable by the Services Provider and the Services Provider's affiliates but shall also be enforceable directly by each of the other Services Provider representatives.

14.2 **No Liability for Certain Losses**

Notwithstanding anything to the contrary in this Agreement, in no event shall the Services Provider (or the Services Provider representatives) or the Services Recipient (or the Services Recipient representatives) be liable to the other, or to the other's representatives for any exemplary, punitive, remote, speculative, consequential, indirect, special or incidental damages or loss of profits; provided that, if any of the Services Recipient representatives or the Services Provider representatives is held liable to a third party for any such damages and the indemnifying party is obligated to indemnify such Services Recipient representatives or Services Provider representatives for the matter that gave rise to such damages, the indemnifying party shall be liable for, and obligated to reimburse such representatives for, such damages.

14.3 **Exclusive Remedy**

As between the Services Provider representatives and the Services Recipient representatives pursuant to this Agreement the indemnification provisions set forth in Article 15 and the termination provisions set forth in Article 10 will be the sole and exclusive remedies of the parties. Neither party nor any of its respective successors or assigns shall have any rights against the other party or its affiliates with respect to the subject matter of this Agreement other than as expressly contemplated. The remedies contained in Article 10 and Article 15 are given and accepted in lieu of (a) any express or implied warranties by the Services Provider, including warranties of merchantability, fitness for a particular purpose, or good and workmanlike performance, and (b) any obligation, liability, right, claim or remedy at law or in equity arising out of any defect in the services whether such claim arises under contract, negligence, intentional misconduct, other tort, breach of warranty, deceptive trade practice, other statutory cause of action, strict liability, product liability, or other theory of liability. Except as expressly set forth in this Agreement, the Services Provider makes no representations or warranties (expressed, implied, oral or otherwise) regarding any aspect of its performance of (or failure to perform) the services including warranties of merchantability, fitness for a particular purpose, or good and workmanlike performance or its other duties and obligations under this Agreement.

14.4 **Survival**

The provisions of this Article 14 shall survive any termination of this Agreement.

Indemnification

15.1 Indemnification by the Services Recipient

Subject to section 14.2, the Services Recipient shall be liable to and, as a separate covenant, shall indemnify, protect, defend, release and hold harmless each of the Services Provider representatives from and against any claims asserted by or on behalf of any person, and for any losses, incurred by, borne by or asserted against any of the Services Provider representatives and which in any way arise from or relate in any manner to the Agreement or the performance or non-performance of services thereunder (irrespective of whether such services have been provided before the effective date), except to the extent the proximate cause of such claim or loss resulted from the fraud or gross negligence of any senior supervisory personnel of Services Provider in performing the services.

15.2 Indemnification by the Services Provider

Subject to the limits and restrictions on liability of the Services Provider set forth in sections 14.1 and 14.2, the Services Provider shall be liable to and, as a separate covenant, shall indemnify, protect, defend, release and hold harmless each of the Services Recipient representatives from and against any claims asserted by or on behalf of any person, and for any losses, incurred by, borne by or asserted against any of the Services Recipient representatives to the extent the proximate cause of such claim or loss resulted from the fraud or gross negligence of any senior supervisory personnel of Services Provider in performing the services.

15.3 Method of Asserting Claims

a) If a party entitled to indemnification (the "**indemnified party**") intends to seek indemnification under this Article 15 from the other party (the "**indemnifying party**") for any claim by a third party (including a governmental authority) (a "**third party claim**"), the indemnified party shall give the indemnifying party notice of such third party claim for indemnification promptly following the receipt or determination by the indemnified party of actual knowledge or information as to the factual and legal basis of any third party claim which is subject to indemnification and, promptly following receipt of notice of such third party claim. The failure of or delay by an indemnified party to so notify the indemnifying party (as set forth above) shall not relieve the indemnifying party of its indemnification obligations under the Agreement to the indemnified party, however the liability which the indemnifying party has to the indemnified party pursuant to the terms of this Article 15 (and for which the indemnifying party will be obligated to indemnify the indemnified party in respect of) shall be reduced to the extent that any such delay in or failure to give notice as required in this Agreement prejudices the defence of any such third party claim, or otherwise results in any increase in the liability which the indemnifying party has under its indemnity provided for therein.

b) The indemnifying party, at its sole cost and expense, shall have the right to assume the defense of any third party claim brought against the indemnified party with counsel designated by the indemnifying party and reasonably satisfactory to the indemnified party; provided that the indemnifying party will not, without the indemnified party's prior written consent (such consent not to be unreasonably withheld, conditioned, or delayed), settle, compromise, consent to the entry of any judgement in or otherwise seek to terminate any third party claim in respect of which indemnification may be sought, unless such settlement, compromise, consent or termination includes a release of the indemnified party from all liabilities arising out of such third party claim. The indemnified party will give to the indemnifying party and its counsel reasonable access to all business records and other documents relevant to such defence or settlement, and shall permit them to consult with the employees and counsel (if any) of the indemnified party.

c) Notwithstanding the foregoing:

   i) If the defendants in any third party claim include both the indemnified party and the indemnifying party, and the indemnified party is advised by counsel that there are legal defences available to the indemnified party that are additional to those available to the indemnifying party and that in such circumstances representation by the same counsel would be inappropriate; or

   ii) If the indemnified party shall have reasonably concluded that the indemnifying party is not taking or has not taken, all necessary steps to diligently defend such third party claim, the indemnified party has provided written notice of same to the indemnifying party, and the indemnifying party has not rectified the situation within a reasonable time;

then the indemnified party shall have the right to retain separate counsel, the reasonable costs of which shall be at the indemnifying party's expense, to represent the indemnified party and to otherwise participate in the defense of such claim on behalf of such indemnified party. For further certainty, only one legal firm for all indemnified parties may be engaged at the expense of the indemnifying party.

d) Notwithstanding anything contained in this Agreement, an indemnified party shall have the right, at its sole cost and expense, to retain counsel to separately represent it in connection with the negotiation, settlement or defence of any third party claim provided, for further certainty, that such counsel shall not, unless agreed by the indemnifying party, assume control of the negotiation, settlement or defence on behalf of the indemnifying party.

e) Except to the extent expressly provided in this Agreement, no indemnified party shall settle any third party claim with respect to which it has sought or intends to seek indemnification pursuant to this Article 15 without the prior written consent of the indemnifying party, which consent shall not be unreasonably withheld, conditioned, or delayed.

f) If the indemnifying party does not assume the defence of any third party claim brought against the indemnified party, then the indemnified party shall have the right to do so on its own behalf and all such expense in so doing shall be added to the amount of the claim for indemnification by such indemnified party as against the indemnifying party.

15.4 Net Amount

If an indemnifying party is obligated to indemnify and hold any indemnified party harmless under this Article 15, the amount owing to the indemnified party shall be the amount of such indemnified party's out-of-pocket losses (whether paid or payable), net of any such out-of-pocket losses recovered by the indemnified party from any other person; provided that the foregoing shall not be construed so as to obligate an indemnified party to pursue or seek recovery of any of its out-of-pocket losses from any other person whomsoever, including insurers.

15.5 Third Party Beneficiaries

Each of the parties acknowledges and agrees that the rights of indemnification provided for in this Article 15 shall not only be enforceable by the parties but shall be enforceable directly by each of the Services Provider representatives and the Services Recipient representatives, and in this respect:

a) the Services Recipient appoints the Services Provider to act as agent and trustee for the Services Provider representatives as regards the covenants of indemnification by the Services Recipient given in favour of the Services Provider representatives pursuant to section 15.1, and the Services Provider accepts such appointment; and

b) the Services Provider appoints the Services Recipient to act as agent and trustee for the Services Recipient representatives as regards the covenants of indemnification by the Services Provider given in favour of the Services Recipient representatives pursuant to section 15.2, and the Services Recipient accepts such appointment.

15.6 Subrogation Rights

If an indemnified party has a right against a person (other than as against one of the other parties to be indemnified by the indemnifying party) with respect to any damages or other amounts paid by the indemnifying party, then the indemnifying party shall, to the extent of such payment and to the extent permitted by applicable law, be subrogated to the rights of such indemnified party as against such person. Notwithstanding the foregoing, no indemnifying party shall be subrogated to any insurance rights of any indemnified party.

15.7 Survival

The provisions of this Article 15 shall survive any termination of this Agreement, but only to the extent pertaining to any claims or losses that relate to or arise out of events, conditions or circumstances which occurred or are attributable to the period prior to such termination.

Confidential Information and Personal Information

16. Each of the parties hereto agrees to keep all information provided by the other party (the "disclosing party") to it (the "receiving party") that the disclosing party designates as confidential or which ought to be considered as confidential from

its nature or from the circumstances surrounding its disclosure ("Confidential Information") confidential, and a receiving party shall not, without the prior consent of an authorized senior officer of the disclosing party, disclose any part of such Confidential Information which is not available in the public domain from public or published information or sources except:

a) to those of its employees who require access to the Confidential Information in connection with performance of services hereunder;

b) as in the receiving party's judgement may be appropriate to be disclosed in connection with the provision by the receiving party of services hereunder;

c) as the receiving party may be required to disclose in connection with the preparation by the receiving party or any of its direct or indirect holding companies, affiliates or subsidiaries of reporting documents including, but not limited to, annual financial statements, annual reports and any filings or disclosure required by statute, regulation or order of a regulatory authority; and

d) to such legal and accounting advisors, valuers, and other experts as in the receiving party's judgement may be appropriate or necessary in order to permit the receiving party to rely on the services of such persons in carrying out the receiving party's duties under this Agreement.

The covenants and agreements of the parties relating to Confidential Information shall not apply to any information:

i) which is lawfully in the receiving party's possession or the possession of its professional advisors or its personnel, as the case may be, at the time of disclosure and which was not acquired directly or indirectly from the disclosing party;

ii) which is at the time of disclosure in, or after disclosure falls into, the public domain through no fault of the receiving party or its personnel;

iii) which, subsequent to disclosure by the disclosing party, is received by the receiving party from a third party who, insofar as is known to the receiving party, is lawfully in possession of such information and not in breach of any contractual, legal or fiduciary obligation to the disclosing party and who has not required the receiving party to refrain from disclosing such information to others; or

iv) disclosure of which the receiving party reasonably deems necessary to comply with any legal or regulatory obligation which the receiving party believes in good faith it has.

17. If in the course of performing services, the receiving party obtains or accesses personal information about an individual, including without limitation, a customer, potential customer or employee or contractor of the disclosing party ("Personal Information") the receiving party agrees to treat such Personal Information in compliance with all applicable federal or provincial privacy or protection of personal information laws and to use such Personal Information only for

purposes of providing the services. Furthermore, the receiving party acknowledges and agrees that it will:

a) not otherwise copy, retain, use, modify, manipulate, disclose or make available any Personal Information, except as permitted by applicable law;

b) establish or maintain in place appropriate policies and procedures to protect Personal Information from unauthorized collection, use or disclosure; and

c) implement such policies and procedures thoroughly and effectively.

18. The Services Recipient shall be entitled periodically to conduct reviews of the procedures implemented by the Services Provider in relation to the obligations described in Sections 16 and 17. The conduct of any such reviews relating to Confidential Information shall be guided by the recommendations expressed in the Canadian Institute of Chartered Accountants' Handbook.

19. Upon the termination of the provision of the services pursuant to any Services Schedules each party shall immediately return to the other party all Confidential Information and Personal Information provided by the disclosing party to the receiving party, and all copies thereof in its possession or control (other than such Confidential Information or Personal Information which continues to be used or relevant to the provision of services pursuant to any other Services Schedule), or destroy such information and copies and certify to the disclosing party that such destruction has been carried out.

Force Majeure

20. If either party is rendered unable by force majeure to carry out its obligations under the Agreement, other than a party's obligation to make payments to the other party, that party shall give the other party prompt written notice of the event giving rise to force majeure with reasonably full particulars concerning it. Thereupon, the obligations of the party giving the notice, so far as they are affected by the force majeure, shall be suspended during, but no longer than the continuance of, the force majeure. The affected party shall use all reasonable diligence to remove or remedy the force majeure situation as quickly as practicable.

General

21. The Services Recipient shall be responsible for and shall pay all applicable federal, provincial, municipal goods and services taxes arising from the provision of services hereunder, including provincial sales tax if applicable.

22. A party shall, from time to time, and at all times, do such further acts and execute and deliver all such further deeds and documents as shall be reasonably requested by the other party in order to fully perform and carry out the terms of this Agreement.

23. Any notice, request, demand, direction or other communication required or permitted to be given or made under this Agreement to a party shall be in writing

and shall be given by facsimile or other means of electronic transmission or by hand or courier delivery to the party to whom it is addressed at its address noted below or at such other address of which notice may have been given by such party in accordance with the provisions of this Section.

Services Provider:	Enbridge Gas Distribution Inc.
Address:	500 Consumers Road, North York, ON M2J 1P8 Attention: Law Department
Facsimile:	(416) 495-5994
Services Recipient:	2562961 Ontario Ltd.
Address:	500 Consumers Road, North York, ON M2J 1P8 Attention: President, 2562961 Ontario Ltd.
Facsimile:	(416) 495-5994

Notice delivered or transmitted as provided above shall be deemed to have been given and received on the day it is delivered or transmitted, provided that it is delivered or transmitted on a business day prior to 5:00 p.m. local time in the place of delivery or receipt. However, if a notice is delivered or transmitted after 5:00 p.m. local time or such day is not a business day, then such notice shall be deemed to have been given and received on the next business day.

24. This Agreement may be executed in counterparts, no one of which needs to be executed by both of the parties. Each counterpart, including a facsimile transmission of this Agreement, shall be deemed to be an original and shall have the same force and effect as an original. All counterparts together shall constitute one and the same instrument.

25. This Agreement will enure to the benefit of and be binding upon the parties thereto and their respective successors. This Agreement may not be assigned by either of the parties thereto without the prior written consent of the other. For the purposes of this agreement "assignment" shall mean and include any transaction, event or circumstance which results in either the Services Provider or the Services Recipient ceasing to be a direct or indirect wholly owned subsidiary of Enbridge Inc.

26. The division of this Agreement into Articles and Sections and the insertion of headings are for convenience of reference only and shall not affect the construction or interpretation of this Agreement. The terms "this Agreement", "hereof", "hereunder", and similar expressions refer to this Agreement and not to any particular Section or other portion hereof. Unless something in the subject matter or context is inconsistent therewith, references herein to Articles and Sections are to Articles and Sections of this Agreement.

27. Words importing the singular number shall include the plural and vice versa, words importing the masculine gender shall include the feminine and neuter genders and vice versa, and words importing persons shall include individuals, partnerships, associations, trusts, unincorporated organizations and corporations and vice versa.

28. In the event that one or more of the provisions contained in this Agreement shall be invalid, illegal or unenforceable in any respect under any applicable law, the validity, legality or enforceability of the remaining provisions hereof shall not be affected or impaired thereby. Each of the provisions of this Agreement is hereby declared to be separate and distinct.

29. This Agreement may not be modified or amended except by an instrument in writing signed by both of the parties to an Agreement or by their respective successors.

30. This Agreement constitutes the whole and entire agreement between the parties respecting the subject matter of the Agreement and supersedes any prior agreement, undertaking, declarations, commitments, representations, verbal or oral, in respect thereof. Without limiting the generality of the foregoing, the Prior Agreement between the parties is hereby terminated and no longer of any force or effect.

31. In the event that any provision contained in this Agreement conflicts with a provision contained in a schedule hereto, this Agreement shall prevail to the extent of any such inconsistency.

(The next page is the signature page.)

IN WITNESS WHEREOF, and intending to be legally bound, the parties have executed this Agreement by the undersigned duly authorized representatives as of the date first stated above.

ENBRIDGE GAS DISTRIBUTION INC.

Per: ______________________

Malini Giridhar
Vice President
Market Development and Public Affairs

Per: ______________________

James Lord
Vice President, Law

2562961 ONTARIO LTD.

Per: ______________________ July 12, 2017

Scott Dodd President

APPROVED AS TO FORM
LEGAL

Per: ______________________ July 12, 2017

ROBERT MOTZ, VICEPRESIDENT

EXHIBIT A

ARBITRATION PROCEDURES

1. The place of the arbitration will be Toronto, Ontario, or such other location as the parties may agree.

2. The parties will agree on the appointment of an arbitrator.

3. If the parties are unable to agree upon an arbitrator, any of the parties may apply to the Ontario Superior Court for the appointment of an arbitrator.

4. The agreed or appointed arbitrator (in either case, the "Arbitrator") will, in its absolute discretion, establish reasonable rules to govern all aspects of the arbitration and to ensure that the arbitration is conducted expeditiously.

5. The parties, if in agreement, may request that the Arbitrator decide between final and complete proposals submitted by each of the parties.

6. The decision or award of the Arbitrator with respect to the dispute must be rendered in writing, and must contain a brief recital of the facts and principles upon which the decision was made and the reasons therefor.

7. The decision or award of the Arbitrator made pursuant to this Exhibit A is final and binding upon each of the parties and there is no appeal therefrom. Thereafter, any action may only be for the purpose of enforcing the decision or award and the recovery of costs incidental to the action.

8. The decision or award of the Arbitrator will be conclusively deemed to determine the interpretation of this Agreement and the rights and liabilities as between the parties in respect of the matter in dispute.

9. Except as may be otherwise agreed by the parties, or as may be ordered by the Arbitrator, the Arbitrator will be entitled to its or their usual charges for services rendered to be paid equally by the parties.

10. Subject to this paragraph 10, no dispute that is or may be the subject of a submission to arbitration in accordance with this Exhibit A will give rise to a cause of action between or will be made the subject matter of an action in any court of law or equity by either of the parties unless and until the dispute has been submitted to arbitration and finally determined in the accordance with this Exhibit A and any action commenced thereafter with respect to the dispute may only be for judgment in accordance with the decision of the Arbitrator and the costs incidental to the action. In any action of this sort, the decision of the Arbitrator will be conclusively deemed to determine the rights and liabilities between the parties in respect of the dispute.

11. Notwithstanding the foregoing, if the actions or inactions of a party are, in the view of the other party, acting reasonably, producing or likely to produce irreparable harm that cannot be adequately compensated for by damages or that will result in damages that are difficult to estimate, the aggrieved party may apply to a court for

injunctive or mandatory injunctive relief to remedy the situation pending the conduct of arbitration. The court before which the proceeding is brought may, if it determines the arbitration would not, in the circumstances, be beneficial to a continuing relationship between the parties, grant the aggrieved party the right to proceed with an action notwithstanding the otherwise general application of arbitration as the chosen mode of dispute resolution.

12. The parties desire that any dispute that is to be determined in accordance with the dispute resolution provisions should be conducted in strict confidence and that there will be no disclosure to any person of the fact of the dispute or any aspect of the dispute except as necessary for the resolution of the dispute. Any hearing will be attended only by those persons whose presence, in the opinion of the Arbitrator, is reasonably necessary for the determination of the dispute. All matters relating to, all evidence presented to, all submissions made in the course of, and all documents produced in accordance with the dispute resolution procedure or an order of the Arbitrator or created in the course of or for the purposes of the arbitration, including any award or interim award by the Arbitrator, will be kept confidential and will not be disclosed to any person without the prior written consent of all parties to the arbitration except as required to enforce the award or as required by law or as permitted by an order of the Arbitrator made pursuant to a motion or application on notice to all parties to the arbitration.

SERVICES SCHEDULE TO THE INTERCORPORATE SERVICES AGREEMENT BETWEEN ENBRIDGE GAS DISTRIBUTION INC. AND 2562961 ONTARIO LTD. DATED JANUARY 1, 2017 (the "Agreement").

1.0 PREFACE

This Schedule is intended to identify *Accounts Payable Services* to be provided to 2562961 Ontario Ltd. (the "Services Recipient"), by Enbridge Gas Distribution Inc. (the "Services Provider").

The Services defined in this Schedule are to be provided to the Services Recipient for a period of two years (2), commencing January 1, 2017 and ending December 31, 2018. The term of this Schedule may be renewed in accordance with Section 10 of the Agreement. Notwithstanding the provisions of Section 25 of the Agreement, the Services Provider may assign its rights and obligations under this Schedule to an affiliate of the Services Provider upon the delivery of written notice thereof to the Services Recipient.

2.0 DEFINITION OF SERVICES

The Services Provider agrees to provide the Services Recipient with the following services:

- Accounts payable processing including payment of invoices; excluding customer service.

3.0 ROLES AND RESPONSIBILITIES

The Services Provider is responsible for the following:

- Process and pay invoices/cheque requisitions/other pre-approved payments;
- Provide Accounts Payable month-end functions on a monthly basis;
- Comply with and perform Accounts Payable related controls and functions; and
- Including the following functions:
  - Invoice Scanning
  - Invoice Entry
  - Invoice Review / Quality Assurance
  - Invoice Payment including wires, quick cheques, Canadian cheques/payments and EFTs
  - Exception Handling related to Accounts Payable: example - invoice coding corrections, invoice header information corrections
  - Markview Approver Access Requests: review and approval of such requests, maintaining documentation and policy compliance.

The Services Recipient will:

- Provide feedback as required to the Services Provider on the need for any changes or enhancements to any of the financial information provided above.

4.0 PERFORMANCE MEASURES

The Services Provider will:

- Ensure that, in paying bills on behalf of the Services Recipient, all such accounts payable are completed at least weekly, if any;
- Scan invoices/cheque requisitions/other pre-approved payments for the Services Recipient within three (3) days of receipt;
- Enter invoices/cheque requisitions/other pre-approved payments for the Services Recipient within three (3) days of scanning;
- Perform Review / Quality Assurance of invoices/cheque requisitions/other pre-approved payments within three (3) days of invoice approval; and
- Prepare quick cheques within twenty-four (24) hours of the request.

If these performance measures are unable to be met, the parties will discuss the matter to find a remedy in a mutually agreeable manner and timeframe.

5.0 PROBLEM RESOLUTION PROCEDURES

Any concerns with respect to the performance of the Accounts Payable and Employee Expense Services, including failure to meet performance measures, should be brought to the attention of the Controller of the Services Provider if they cannot be resolved with the staff directly involved. Failing resolution, the Problem / Conflict Resolution procedures identified in the Agreement will be followed.

6.0 PRICING AND CONDITIONS

These services will be charged on an hourly basis at the fully allocated cost rate of the Services Provider personnel performing the services to be updated annually by the Services Provider upon written notice to the Services Recipient as soon as practicable after such rate is determined through the annual budgeting process.

[Remainder of page left intentionally blank]

The costs of goods or services from third parties obtained to address special technical requirements or fulfill a special request of the Services Recipient will be borne separately by and agreed upon in advance in advance with the Services Recipient. Non-labour related costs such as materials and supplies, transportation, and travel will be billed (if applicable) to the Services Recipient. Services provided hereunder shall be charged, and payment notices sent, as services are rendered. Payments for services rendered are due in accordance with the schedule set out in the Agreement.

Dated this day of

ENBRIDGE GAS DISTRIBUTION INC.

Per:________________________
Malini Giridhar
Vice President
Market Development and Public Affairs

Per:________________________
James Lord
Vice President, Law

2562961 ONTARIO LTD.

APPROVED AS TO FORM
LEGAL
GP.

Per:________________________ July 22, 2017
Scott Dodd, President

Per:________________________ July 18, 2017
ROBERT MOTZ, VICE PRESIDENT

SERVICES SCHEDULE TO THE INTERCORPORATE SERVICES AGREEMENT BETWEEN ENBRIDGE GAS DISTRIBUTION INC. AND 2562961 ONTARIO LTD. DATED JANUARY 1, 2017 (the "Agreement").

1.0 PREFACE

This Schedule is intended to identify *Financial Services* to be provided to 2562961 Ontario Ltd. (the "Services Recipient"), by Enbridge Gas Distribution Inc. (the "Services Provider").

The services defined in this Schedule are to be provided to the Services Recipient for a period of two years (2), commencing January 1, 2017 and ending December 31, 2018. The term of this Schedule may be renewed in accordance with Section 10 of the Agreement. Notwithstanding the provisions of Section 25 of the Agreement, the Services Provider may assign its rights and obligations under this Schedule to an affiliate of the Services Provider upon the delivery of written notice thereof to the Services Recipient.

2.0 DEFINITION OF SERVICES

The Services Provider agrees to provide the Services Recipient with the following services:

- Provide all processing activities for statutory financial and corporate reporting, based on all business transactions of the Services Recipient, prior to the financial processing cut-off dates as established by the Services Provider in its monthly accounting calendar;

- Prepare actual and budgeted financial statements and corporate reports to specifications for the Services Recipient. Such materials are to be in compliance with government legislated requirements and generally accepted accounting principles ("GAAP"), as well as additional information upon requested by the Management Committee of the Services Recipient;

- Provide financial statements and corporate reports to the management of the Services Recipient;

- Respond to financial inquiries and requests for consulting on accounting issues and policies;

- Accounting research and policy advisory for financial statement preparation; and

- Accounting general ledger advisory.

3.0 ROLES AND RESPONSIBILITIES

The Services Provider is responsible for the following:

- Ensure completeness and accuracy of the journal entries processed for the Services Recipient;

- Post all material journal entries in accordance with the timetable as prescribed in the monthly accounting calendar;

- Manage affiliate transactions, including invoicing to affiliates;

- Reconcile all material general ledger accounts, as well as the sub-ledger control accounts, to the financial statements and corporate reports;
- Maintain month-end rollover based on the accounting calendar;
- Incorporate both Actual and Budget data into corporate reports for the Services Recipient;
- Prepare monthly financial statement package based upon Services Recipient specifications;
- Complete financial statements and corporate reports in accordance with the accounting calendar;
- Consolidate reporting for Enbridge Inc., and ensure affiliate entries are processed accurately;
- Distribute financial statements and corporate reports on behalf of the Services Recipient;
- Respond to Services Recipient requests within two days, identifying a time frame for providing a complete response if additional research or investigation is required;
- Prepare the required budget information and input budget details into the financial statements and corporate reports to the management of the Services Recipient;
- Obtain approval for budget data;
- Prepare management reports as required, which are in addition to the monthly or regularly scheduled financial statements and corporate reports; and
- Deliver all services within agreed timeframes and provide the quality and completeness specified by the Services Recipient.

The Services Recipient will:

- Be responsible for designating the nature of the services to be performed by the Services Provider and for verifying that the results achieved by the Services Provider are satisfactory;
- Provide direction and communicate desired timeframes and budgets;
- Communicate, in a timely manner, changes to scope and timing;
- Involve the representative from Finance in the Management Committee and its regular Committee Meetings and the decision-making process impacting the business of the Services Recipient; and
- Engage the representative from Finance to present financial results to the Board of Director.

4.0 PERFORMANCE MEASURES

The Services Provider will meet all agreed timeframes and meet deliverable quality measures set forth by the Services Recipient.

5.0 PROBLEM RESOLUTION PROCEDURES

Any concerns with respect to the performance of Financial Services should be brought to the attention of the Services Provider's Vice President of Finance if they cannot be resolved with the staff directly involved. Failing resolution, the Problem / Conflict Resolution procedures identified in the Agreement will be followed.

6.0 PRICING AND CONDITIONS

Financial Services will be charged on an hourly basis at the fully allocated cost rate of the Services Provider personnel performing the services to be updated annually by the Services Provider upon written notice to the Services Recipient as soon as practicable after such rate is determined through the annual budgeting process.

This amount excludes any reasonable out of pocket expenses, which will be charged at cost. The costs of goods or services from third parties obtained to address special technical requirements or fulfill a special request of the Services Recipient will be borne separately by and agreed upon in advance with the Services Recipient. Non-labour related costs such as materials and supplies, transportation and travel will be billed to the Service Recipient.

Services provided hereunder shall be charged, and payment notices sent, as services are rendered. Payments for services rendered are due in accordance with the schedule set out in the Agreement.

Dated this day of

ENBRIDGE GAS DISTRIBUTION INC.

Per:________________________

Malini Giridhar
Vice President
Market Development and Public Affairs

Per:________________________

James Lord
Vice President, Law

APPROVED
AS TO FORM
LEGAL GP

2562961 ONTARIO LTD.

Per:________________________

Scott Dodd, President July 12, 2017

Per:________________________

ROBERT MOTZ, VICE PRESIDENT JULY 18, 2017

SERVICES SCHEDULE TO THE INTERCORPORATE SERVICES AGREEMENT BETWEEN ENBRIDGE GAS DISTRIBUTION INC. AND 2562961 ONTARIO LTD. DATED JANUARY 1, 2017 (the "Agreement")

1.0 PREFACE

This Schedule is intended to identify *Legal, Corporate Secretarial, and Executive Services* ("Services") to be provided to 2562961 Ontario Ltd. (the "Services Recipient") by Enbridge Gas Distribution Inc. (the "Services Provider").

The Services defined in this schedule are to be provided to the Services Recipient for a period of two (2) years, commencing January 1, 2017 and ending December 31, 2018. The term of this Schedule may be renewed in accordance with Section 10 of the Agreement. Notwithstanding the provisions of section 25 of the Agreement, the Services Provider may assign its rights and obligations under this Schedule to an affiliate of the Services Provider upon the delivery of written notice thereof to the Services Recipient.

2.0 DEFINITION OF SERVICES

Corporate Secretarial Services: The basic principles of corporate secretarial practice are related to managing contingencies under which board of directors decision-making occurs, compliance with statutes and regulations under which a company must operate and the promotion of good corporate governance procedures. The Services Provider will maintain current knowledge with respect to the legislation, regulations and applicable constating documents which govern the Services Recipient and its subsidiaries. The Services Provider will ensure that all affairs of the applicable Boards of Directors and Board Committees (including organization of Partnership, Board and Committee meetings) are administered in accordance with the principles of good corporate secretarial practice.

Legal Services: The Services Provider will provide legal services to the Services Recipient and its identified business units and subsidiaries on an as required basis. Services will be provided directly through the use of internal resources and, with the approval of the Services Recipient, external legal counsel as required. The Services Provider will be responsible to supervise the quality and cost of outside legal services in such instance.

Executive Services: Certain executives of the Services Provider, as appointed, will act as directors, officers, and/or advisors to the Services Recipient from time to time. These services will be provided in compliance with all applicable laws and regulations governing the duties of directors and officers to business corporations.

3.0 ROLES AND RESPONSIBILITIES

Corporate Secretarial Services

The Services Provider will, as required:

- ensure a proper information flow to the applicable Boards and Committees;
- provide legal and procedural advice to the Chairs, Boards and Committees as required;

- organize and prepare shareholders' and board meetings, including the settlement of meeting dates and agendas and preparation and approval of all Board minutes;
- ensure compliance with applicable corporate and securities legislation/regulations, including statutory reporting and filings;
- maintain corporate records and documents on behalf of the Services Recipient;
- act as agent for the purposes of receipt of all legal and official documentation and notices served on the Services Recipient; and
- address share, shareholder and shareholder register issues as required.

Legal Services

The Services Provider will, as requested:

- identify laws and statutes which impact upon the Services Recipient's daily and routine business decisions and acquainting management in a general manner with these laws;
- identify risks and, to the extent possible, suggest alternative courses of action;
- identify risks in a positive manner so that management can make informed decisions;
- promote compliance with laws applicable to the Services Recipient and its employees;
- provide policy advice and develop forms of standard documentation (e.g. standardized services agreements) in appropriate circumstances;
- provide legal advice/opinions and related business advice to the Services Recipient, its managers, employees and subsidiaries;
- prepare, review and revise commercial agreements;
- manage external legal services; and
- interpret key statutory or regulatory provisions affecting the Services Recipient and its businesses.

Executive Services

Appointed executives of the Services Provider will, as required:

- attend and conduct Board of Director and Committee meetings;
- oversee the business affairs of the Services Recipient; and
- advise on other miscellaneous business and governance matters.

The Services Recipient will:

- pay for the Services as rendered within the time periods set out in the Agreement; and
- ensure that all instructions and information relevant to the Services Provider's assignments are provided to the Services Provider on a timely basis.

4.0 PROBLEM RESOLUTION PROCEDURES

Any concerns with respect to the performance of the Services should be brought to the attention of the Service Providers' Vice President, Law if they cannot be resolved with the staff directly involved. Failing resolution, the Problem / Conflict Resolution procedures set forth in the Agreement will be followed.

5.0 PRICING AND CONDITIONS

These services will be charged on an hourly basis at the fully allocated cost rate of the Services Provider personnel performing the services to be updated annually by the Services Provider upon written notice to the Services Recipient as soon as practicable after such rate is determined through the annual budgeting process.

The Services Provider will ensure that all Services (either through the Services Provider's own resources or by external counsel) are provided in accordance with the terms of this Schedule. The Services Recipient acknowledges that some consultation with external legal advisors (law firms) will be necessary in connection with the routine delivery of the legal services. However, the Services Provider will ensure that the Services Recipient's approval is obtained prior to the retention of external legal advisors for significant files.

The Services Recipient will be charged for actual time spent by the Services Provider, as determined by time dockets, for providing the Services. Except for services provided by external counsel, payment notices for Services will be sent to the Services Recipient at the end of each calendar quarter and payments are due in accordance with the schedule set out in the Agreement. All amounts charged to the Services Recipient by external legal counsel (including both fees and disbursements) shall be paid in full by the Services Recipient on a timely basis.

The Services Recipient will be required to reimburse the Services Provider for reasonable out of pocket expenses incurred by the Services Provider in accordance with the Agreement.

Dated this day of

ENBRIDGE GAS DISTRIBUTION INC.

Per:____________________

Malini Giridhar
Vice President
Market Development and Public Affairs

APPROVED
AS TO FORM
ap

Per:____________________

James Lord
Vice President, [illegible]

2562961 ONTARIO LTD.

Per:____________________ July 12, 2017
Scott Dodd, President

Per:____________________
ROBERT MUTZ, VICE PRESIDENT JULY 18, 2017

SERVICES SCHEDULE TO THE INTERCORPORATE SERVICES AGREEMENT BETWEEN ENBRIDGE GAS DISTRIBUTION INC. AND 2562961 ONTARIO LTD. DATED JANUARY 1, 2017 (the "Agreement")

1.0 PREFACE

This Schedule is intended to identify *Taxation Services* to be provided to 2562961 Ontario Ltd. (the "Services Recipient") by Enbridge Gas Distribution Inc. (the "Services Provider").

The Services defined in this schedule are to be provided to the Services Recipient for a period of two years (2), commencing January 1, 2017 and ending December 31, 2018. The term of this Schedule may be renewed in accordance with Section 10 of the Agreement. Notwithstanding the provisions of Section 25 of the Agreement, the Services Provider may assign its rights and obligations under this Schedule to an affiliate of the Services Provider upon the delivery of written notice thereof to the Services Recipient.

2.0 DEFINITION OF SERVICES

The Services Provider agrees to provide the Services Recipient with:

- Preparation and filing of annual federal and provincial corporate income tax returns for the Services Recipient from the accounting systems of the Services Recipient and information provided by the Services Recipient;
- Computation and payment of monthly federal and provincial corporate income tax installments for the Services Recipient;
- Provide advice and assistance related to the calculation of the monthly income tax accounting provisions for the Services Recipient's financial statements;
- Provide advice and assistance related to the preparation of income tax notes required for the annual financial statements of the Services Recipient;
- Provide advice and assistance related to the preparation of annual income tax provisions for the Services Recipient's budgets;
- Review of regulatory income tax calculations;
- Provide general income tax assistance related to any regulatory issues;
- Preparation, payment and filing of monthly GST and any required provincial sales tax returns;
- Preparation and filing of GST and provincial sales tax refund claims of the Services Recipient;
- Provide Property Tax advisory services;
- Provide general tax advice to the Services Recipient including responses to general income and commodity tax questions from the Services Recipient but excluding advice on proposed Services Recipient acquisitions, new businesses and divestitures; and
- Manage federal and provincial income and commodity tax audits of the Services Recipient and negotiate issues arising in the course of such audits.

3.0 ROLES AND RESPONSIBILITIES

The Services Provider is responsible for the following:

- Recommend to and obtain approval of the Services Recipient of filing position on potential contentious tax issues within the time frame agreed upon at the time the issue is identified;
- Assist and advise on accounting policy development as it relates to income taxes;
- Review the draft income tax returns, elections and other forms prepared by the Trustee under the LMCI (NEB) Trust agreements;
- Provide the Services Recipient with completed tax returns for the company at least two weeks prior to the filing date for each return;
- File all annual income tax returns and monthly GST and provincial sales tax returns by their due dates;
- Provide the Services Recipient with installment schedules one week prior to first required payment date;
- Prepare or Review monthly tax provisions and analysis for financial statement and budget tax provisions by dates identified by the Services Recipient;
- Provide timely and accurate responses to general tax questions within the time frame agreed upon when question is asked; and
- Review proposed and issued tax assessments and recommend to Services Recipient, at least 1 month before deadline for filing a notice of objection, either acceptance and payment or commencement of litigation.

The Services Recipient is responsible for the following:

- Provide Taxation with unconsolidated financial statements and schedules and information required for accurate preparation of tax returns at least 2 months prior to the filing date for the returns;
- Provide Taxation access to all systems necessary to enable Taxation to provide the above services to the Services Recipient;
- Provide the Services Provider with all information required to calculate budget tax provisions at least 2 weeks prior to the required completion date;
- Disclose to Taxation all potential tax issues as they arise and new transactions, projects and revenue streams before they arise (to the extent this is controllable by the Services Recipient);
- Provide the Services Recipient with drafts of all income tax returns, elections and other forms prepared by the Trustee under the LMCI (NEB) Trust agreements;
- Identify all dates to the Services Provider for monthly and annual reporting requirements at least 2 weeks in advance of any scheduled date;
- Review and approve income tax returns;
- Review monthly provision; and
- Review the annual note disclosures.

4.0 PERFORMANCE MEASURES

- Preparation of tax returns by filing due dates 100% of the time.
- All other service levels will be met by timing as agreed upon by both parties.

The Services Provider will meet semi annually, or as requested by the Services Recipient, to review the performance of the Services Provider from the last such meeting including assessment of the value added, risk areas, responsiveness to Services Recipient concerns, etc. Action steps and follow up will be identified where possible.

5.0 PROBLEM RESOLUTION PROCEDURES

Any concerns with respect to the performance of the Taxation Services should be brought to the attention of the Services Provider's Technical Manager Tax Reporting, if they cannot be resolved with the staff directly involved. Failing resolution, the Problem / Conflict Resolution procedures set forth in the Agreement will be followed.

6.0 PRICING AND CONDITIONS

These services will be charged on an hourly basis at the fully allocated cost rate of the Services Provider personnel performing the services to be updated annually by the Services Provider upon written notice to the Services Recipient as soon as practicable after such rate is determined through the annual budgeting process.

This amount excludes any reasonable out of pocket expenses, which will be charged at cost. The costs of goods or services from third parties obtained to address special technical requirements or fulfill a special request of the Services Recipient will be borne separately by and agreed upon in advance with the Services Recipient

Services provided hereunder shall be charged, and payment notices sent, as services are rendered. Payments for services rendered are due in accordance with the schedule set out in the Agreement.

Dated this day of

Enbridge Gas Distribution Inc.

Per:________________________

Malini Giridhar
Vice President
Market Development and Public Affairs

Per:________________________

James Lord
Vice President, Law

APPROVED AS TO FORM

2562961 ONTARIO LTD.

Per:________________________ July 12, 2017
Scott Dodd, President

Per:________________________
ROBERT NOTZ, VICE-PRESIDENT JULY 18, 2017

ENBRIDGE GAS INC.
Answer to Interrogatory from
Consumers Council of Canada (CCC)

INTERROGATORY

Reference:

Ex. A/S2

Question**:**

Please set out a list of all potential risks associated with the Project, indicate who is expected to bear those risks and how EGI intends to mitigate those risks.

Response:

In the table below, Enbridge Gas sets out risks that it has identified as being relevant to the Project and indicates who bears the risks and how they may be mitigated. Please note that there could be other risks associated with the Project, but the ones listed are the key items known to the Company at this time.

Risk Category	**Description of Risk**	**Risk Bourne by Whom?**	**Potential Mitigants**
Safety	Construction of a hydrogen blending facility and interconnection of that facility to the gas distribution system.	Enbridge Gas	• Application of appropriate technical standards. • Ongoing consultation with TSSA regarding the Project. • Use of Management of Change processes to establish design and operational standards. • Leverage safety credibility and culture. • Develop and employ hydrogen industry expertise. • Leverage Enbridge Gas's experience in developing and maintaining a safe and reliable distribution system. • Use qualified construction and trade personnel. • Natural gas pipeline systems and hydrogen blending facilities are designed to the appropriate codes and standards including the Z662 code and other specific codes and standards as indicated at Exhibit B, Tab 1 Schedule 1, Attachment 1, page 19.
	Lack of public and other stakeholder awareness	Enbridge Gas	• Host open houses and community outreach initiatives. • Engagement with first responders, On

			Call personnel, operational personnel. • Continue to build knowledge internally and externally via awareness training. • Update GIS systems. • Update company manuals to recognize the BGA, where appropriate.
	System malfunction resulting in hydrogen and/or blended gas loss.	Enbridge Gas	• Portions of the system that is 100% hydrogen will be operated and maintained by trained ticketed/certified hydrogen personnel. • Portions of the system conveying blended gas will have all applicable Enbridge Gas operational and safety processes applied. • Continuous dialogue between 2562961 Ontario Ltd. and Enbridge Gas. • Mock safety exercises with all stakeholders • Emergency Operations Center inclusion • Existing district stations to remain operational, further increasing the flexibility in the area.
	Leaks	Enbridge Gas	• Perform leak detection proactively and increase leak survey frequency in first 5 years of blending

			• Establishing and continuing to evolve the leak detection and integrity management systems based on the above to establish the most appropriate and effective means of leak detection longer term • Undertake all leading safety indicator activities as would with natural gas assets • Amend leak detection procedures to identify the potential cross-sensitivity of certain detectors with hydrogen. Some currently employee leak detectors may be cross sensitive to hydrogen, meaning that they will indicate a leak at much lower levels of blended gas than the equivalent natural gas without the addition of hydrogen.
	Unintentionally supply blended gas to Non BGA customers	Enbridge Gas	• Introduce processes to ensure that events in the network are assessed in the context of hydrogen blending. • Introduce processes for customer additions, relocations, and reinforcements in the area to ensure that sensitive customers are not unintentionally supplied blended gas. • Educate all contractors working on the gas distribution system internally and

			externally.
	Customer Equipment	Enbridge Gas	• BGA has been thoroughly examined and surveyed for types of appliances and customer types. • BGA does not include industrial customers. • Distribution assets are appropriate for hydrogen blending • Interchangeability analysis indicates that hydrogen concentration will not impact appliance performance.
Supply	Over supply of hydrogen for blending	Enbridge Gas	• The Project has been assessed based on a variable amount of hydrogen supply and not a fixed amount. Supply can range from 0% hydrogen by volume to a maximum of 2% hydrogen by volume. • Oversupply of hydrogen (i.e. supply of greater than 2%) has been mitigated by safety controls at the blended gas station including shut-off of hydrogen based on: o Metering of Hydrogen and Natural Gas o Gas Quality Monitoring o High Pressure Hydrogen Injection Outlet o 24/7 Monitoring o Manual Shutoff

			o H2 Leak Detection o Power Loss at site
Financial	Cost impact to ratepayers beyond the BGA and on immediate BGA rate payers	Enbridge Gas	• All rate payers including those in the BGA, will be kept whole as Enbridge Gas will pay to the hydrogen supplier (2562961 Ontario Ltd.) the same cost it pays for a unit of natural gas • Customers will use a small incremental amount of natural gas due to the difference in energy content and will be compensated for this additional volume via a rate rider.
	LCEP Budget	Enbridge Gas and Ratepayers	• Route review undertaken and resulted in capital cost reductions. • Materials procured via pre-qualified vendors. • Long lead items kept to a minimum to ensure they can be procured in a timely and cost effective manner.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Consumers Council of Canada (CCC)

INTERROGATORY

Reference:

Ex. A/T2/D1/p. 4

Question**:**

The evidence states that EGI expects to commence construction of the LCEP in the second quarter 2021. In addition, EGI has indicated that in order to meet the Project timelines approval is required as soon as possible and not later than November 2020. Has the COVID-19 pandemic had any impact on these dates? If, so please explain what those impacts are and what is the newly expected timeline. What are the implications for the Project if approval is delayed beyond November 2020?

Response:

The COVID-19 pandemic has not had any impact on the Project timeline.

Station Material procurement is the longest lead item with 22 weeks lead time. If Project approval is received by November 2020, station material is planned to be ordered by December 1, 2020 which would result in the station material delivery to site by May 4, 2021 in line with the construction timeline of April 1, 2021 to August 31, 2021.

A delay in Project approval would result in a delay in the material procurement and ultimately the proposed in-service date.

A delay in Project approval beyond January 15, 2021 could result in increased Project cost and longer Project timeline due to the following:

- Pipeline tie in and station commissioning may be delayed to beyond October 15, 2021 when the weather is cooler and gas demand is higher.
- Performing these activities in cooler weather will require additional risk mitigation action including installation of a temporary bypass to ensure that there will be no customer loss and that Enbridge Gas maintains its delivery commitments to its customers.
- These additional requirements are not currently included in the Project cost estimate.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Consumers Council of Canada (CCC)

INTERROGATORY

Reference:

Ex. A/T2

Question**:**

Has EGI had any discussions with representatives of the Ontario Government regarding this Project? If so, please describe the nature of those discussions and provide copies of any related correspondence. Has EGI had any discussions with OEB Staff regarding this Project? If so, please describe the nature of those discussions and provide copies of any related correspondence.

Response:

Enbridge Gas met with Board Staff in March of 2019 to discuss the Project and to explore if there was potential for the Project to be completed within the Board's Innovation Sandbox. A copy of the presentation provided at that meeting is included as Attachment 1 to this response.

Additionally, Enbridge Gas has discussed the Project with OEB Staff in the context of regular update meetings where the Company provides information about upcoming applications. Any information provided was consistent with what is set out in the prefiled evidence.

In December of 2019 Enbridge Gas notified the Ministry of Energy, Northern Development and Mines (Ministry) that a leave to construct application would be filed for the Project. Prior to filing the leave to construct application Enbridge Gas provided the Ministry with some details related to the Project. A copy of the email provided to the Ministry is set out at Attachment 2 to this response.

Note that the GHG reductions provided in Attachment 2 are incorrect. The correct value is 108 tCO2e per year for the entire BGA assuming each customer consumes 2,400 m^3 per year. Please see the response to Exhibit I.STAFF.1 for detailed calculations.

Low-Carbon Energy Project

Candidate Project for the Ontario Energy Board Innovation Sandbox

ENBRIDGE®

March 5, 2019

Agenda

ENBRIDGE
Life Takes Energy™

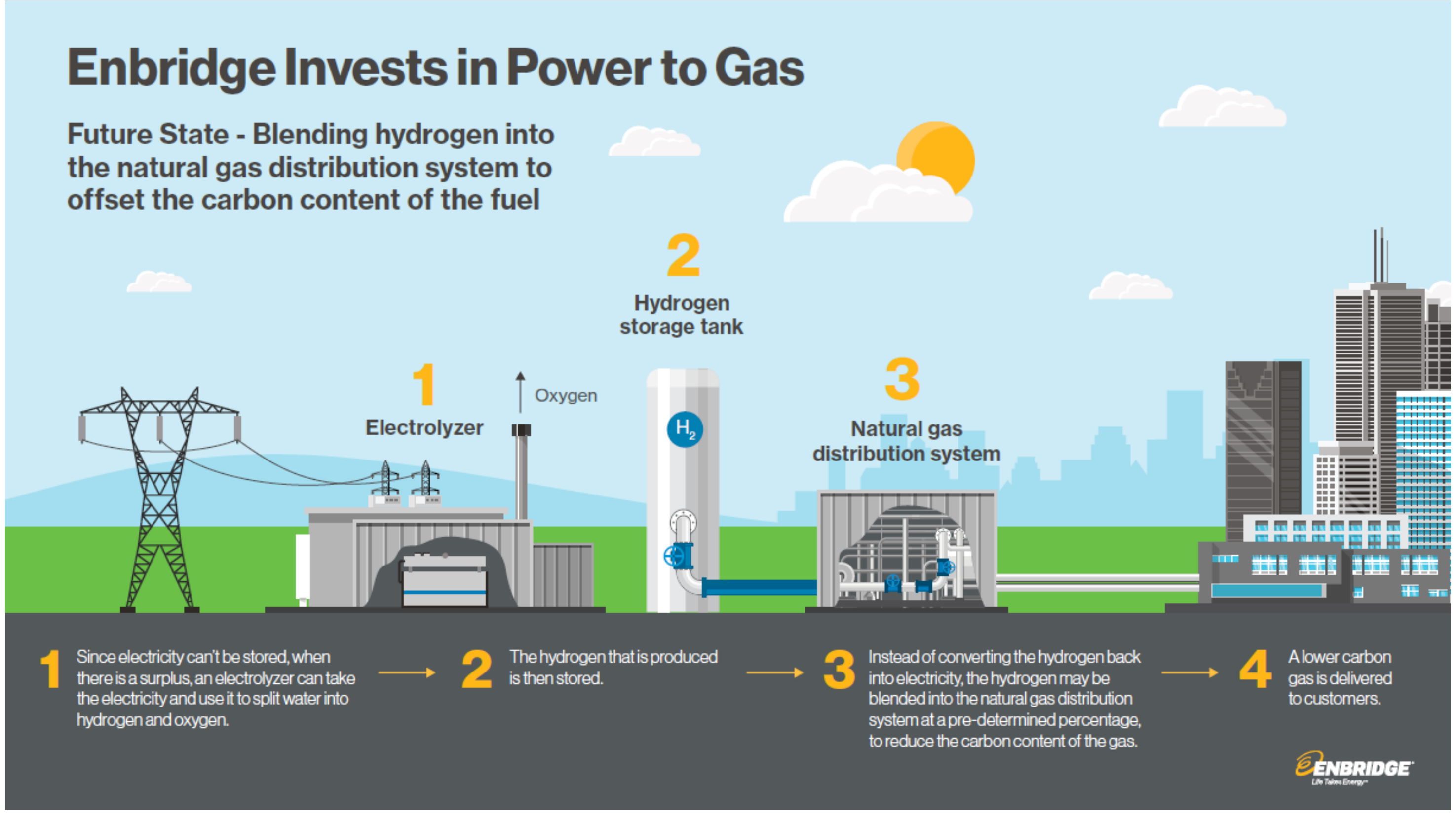
- The Low-Carbon Energy Project (LCEP) is a pilot project that will test the use of natural gas blended with hydrogen
- Enbridge is seeking relief from Leave to Construct requirements
- Introduce Board Staff to the LCEP
- Determine if the LCEP is a good candidate for the Board’s Innovation Sandbox
    - Project description
    - Project benefits
    - Regulatory hurdles

Introduction to Low-Carbon Energy Project

- What is the Low-Carbon Energy Project?
  - Improves flexibility of pipelines to diversify low-carbon gas supply options
  - Demonstrating how electricity and natural gas networks can be interconnected for improved operating results and lower energy consumer costs
  - Establishes new industry standards for the injection of new gas supply compositions
    - E.g. hydrogen as identified in federal and provincial emission compliance plans
- Project Benefits
  - Gas supply diversity can lower energy costs – particularly over medium and long-term
  - Project results can better inform planning processes like Integrated Resource Planning
  - Example of energy innovation – may highlight new opportunities in regulatory process
  - Leveraging existing, resilient energy infrastructure
- Low-carbon Energy Project is a candidate for the OEB’s Innovation Sandbox
  - Project has high potential to provide benefits to natural gas and electricity stakeholders
  - Existing regulatory framework may have limits in assessing future operating flexibilities

Building Blocks of the Low-Carbon Energy Project

Validate the expected performance of the natural gas distribution system, and end-use appliances, when hydrogen is a component of the gas supply



Enbridge Invests in Power to Gas

Future State - Blending hydrogen into the natural gas distribution system to offset the carbon content of the fuel

1 Since electricity can't be stored, when there is a surplus, an electrolyzer can take the electricity and use it to split water into hydrogen and oxygen. →

2 The hydrogen that is produced is then stored. →

3 Instead of converting the hydrogen back into electricity, the hydrogen may be blended into the natural gas distribution system at a pre-determined percentage, to reduce the carbon content of the gas. →

4 A lower carbon gas is delivered to customers.

Background on P2G Hydrogen Supply for Project

Markham Energy Storage Project is currently providing power grid stability services (Frequency Control) to IESO

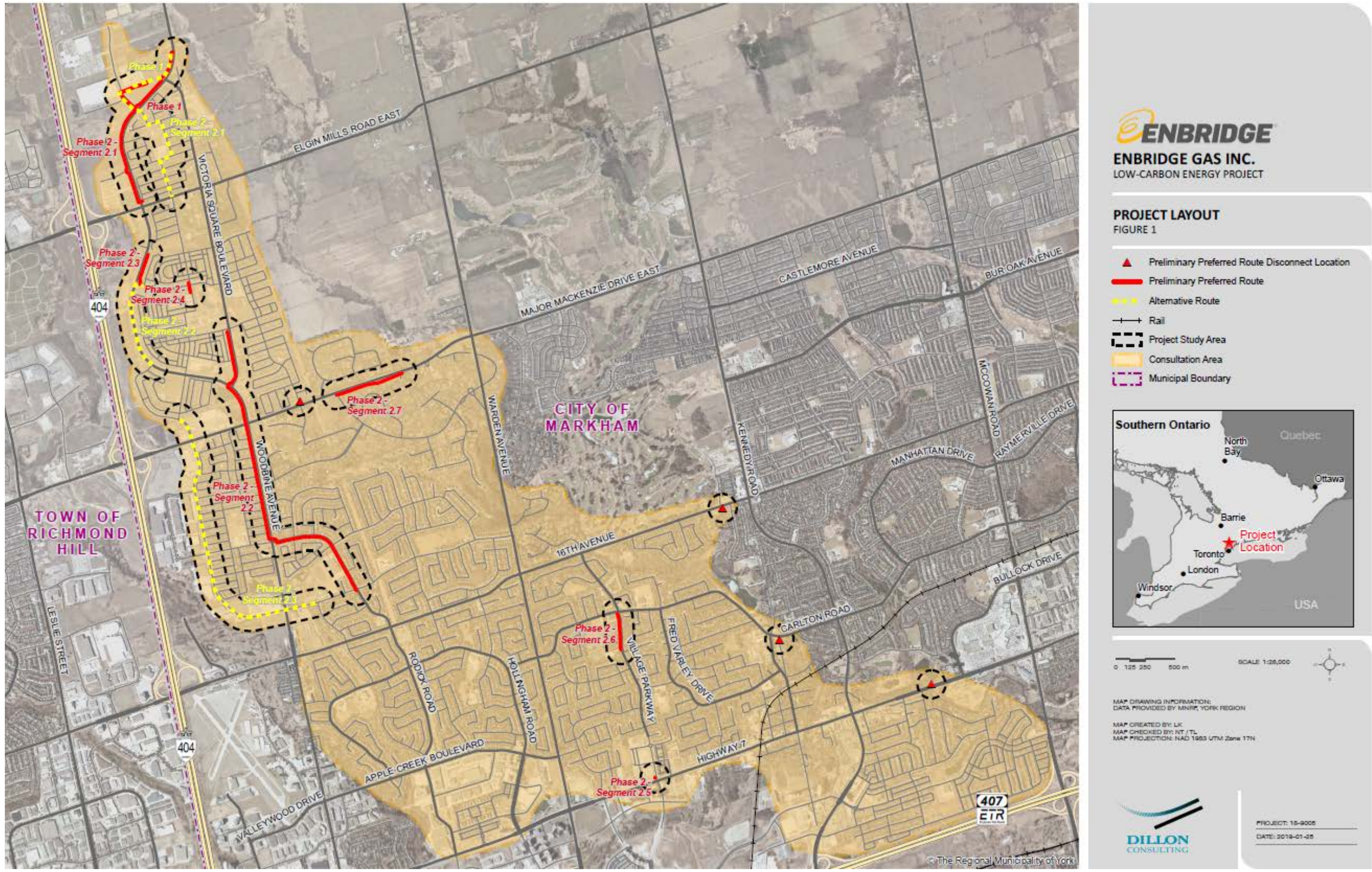
Source Image: Two Hydrogenics 1.25 MW electrolyser stacks installed at Markham Energy Storage Facility

- Demonstrating a more accurate, and faster, Regulation Service
- Accuracy/speed may allow IESO to require less of this in future
- Can produce up to 1,000 kg/day of low-carbon hydrogen

- Existing low-carbon supply for controlled injection area
- Expands LCEP Learning; creates new intertie between power and pipeline grids

Proposed Controlled Hydrogen Injection Area

A controlled injection area is required to manage hydrogen concentrations in LCEP to compare against engineering forecasts



Project Benefits to Consumers and Environment

- Greenhouse gas emission reductions (inclusion of hydrogen in natural gas)
  - Federal and Provincial emission reduction plans are evaluating hydrogen as one type of renewable energy content in natural gas pipelines
  - Future renewable natural gas (RNG) production technologies are expected to co-produce hydrogen with renewable methane
  - Demonstrating a new operating intertie between IESO controlled power grid and the wholesale natural gas network may lead to new solutions for surplus base load generation (SBG) and reduced curtailment of large hydro / wind generation
    - Use Ontario’s wealth of low-carbon power for its competitive advantage rather than export to competing markets

- Further diversification of gas supply locally produced
  - Hydrogen blending has the potential to expand the viable supplies of renewable content for pipelines, and it is can be locally produced / sourced
  - Carbon compliance costs could be mitigated in the anticipated Clean Fuel Standard with more renewable content supply being available in the market

Innovation Sandbox

- Not clear how existing regulatory framework assesses capital investments to improve flexibility for pipeline operations and evolving gas supply compatibility
- Existing regulatory process tends to assess electricity and natural gas infrastructure separately
    - The ability for the LCEP to leverage an existing hydrogen energy storage project as a supply source offers expanded learning for the gas utility, the OEB and the IESO
    - Aligns well with the Integrated Regional Planning goals which are evolving
- Enbridge believes the Low-Carbon Energy Project is a candidate for Innovation Sandbox Stream 1 treatment
    - Partial isolation of Markham distribution system would require a Leave to Construct application
        - Cost is approximately $7 million
    - Project does not fit neatly into any Board policy
        - EBO 188 applies to system expansion projects
        - EBO 134 applies to transmission pipelines

Innovation Sandbox

Low-Carbon Energy Project Candidacy for Innovation Sandbox

Innovation Sandbox Criteria	Fit With Sandbox Criteria
1. **Consumer Benefit and Protection:** Sandbox projects must demonstrate a reasonable prospect of providing clear benefits to consumers, whether through long-term economic efficiencies, improvements in cost performance, enhancements to service or other forms. Projects must also demonstrate that there are sufficient safeguards in place to provide consumers with a reasonable degree of protection during the trial.	Benefits include greening the gas grid and lower GHG emission costs (blended gas is locally produced and renewable), further diversification of gas supplies, load balancing for the electricity grid .
2. **Relevance:** The project must relate to natural gas or electricity services in Ontario.	The project is related to the natural gas distribution system and the electricity grid in Ontario. Highlights the potential for mutually beneficial connections between both energy systems.
3. **Innovation:** The project must involve testing a new product, service or business model that is not widely in use in Ontario and is conducive to scaling, replication or serving as a potential model for others to adopt or deploy.	Hydrogen blending is a new process not currently being used in Ontario for the purpose of displacing traditional gas supplies. Although it is used in Germany as a product blended with natural gas it is not currently offered in Ontario. Enbridge believes that the project is scalable and expandable to appropriate parts of the Ontario gas distribution grid once proven out in this sandbox initiative.
4. **Readiness:** Upon submission of a proposal, the proponent must demonstrate their preparation and readiness for testing their innovation in a live environment. Testing plans must be well developed and have clear objectives and measures. The tools and resources required to enable Sandbox testing must be in place.	Enbridge is prepared to go live with the project once it is enabled to do so. This will also assist by proving out, and expediting, future processes with all stakeholders on hydrogen blending by having transparent and verified information.
5. **True Regulatory Barrier (Stream 1):** For projects seeking relief from a specific regulatory requirement, proponents must articulate the regulatory requirement(s) that may be at issue for the project moving forward.	Current Regulatory framework requires leave to construct under E.B.O. 134 or E.B.O. 188

From: [redacted]
To: [redacted] [redacted] (MNDM); '[redacted] [redacted] (ENDM)"
Cc: [redacted] [redacted]
Subject: LTC for Power-to-Gas pilot project
Date: Wednesday, December 18, 2019 4:15:00 PM

[redacted],

Enbridge is preparing to file Leave to Construct application tomorrow for the next phase on our Power to Gas facility in Markham.

Below is an overview and some key points on the proposed project.

Let me know if you have any questions.
[redacted]

Overview

- Enbridge Gas has an operational Power-to-Gas ("P2G") plant in Markham at our Training and Operations Centre ("TOC") which provides grid balancing services to the IESO. It is also creating renewable hydrogen, which can be injected into the natural gas pipeline to blend with traditional natural gas.
- Enbridge Gas is proposing to inject up to 2% by volume of hydrogen into a designated closed loop portion of the natural gas system adjacent to the facility in Markham. Roughly 3,600 homes are within the proposed project area and would receive natural gas blended with hydrogen. Results from customer engagements (e.g. community open houses, surveys) indicate customer support and the City of Markham is also supportive.
- In order to proceed with hydrogen blending, a small portion of pipe is required to connect the P2G facility with the distribution pipeline for that closed loop system. This triggers a Leave to Construct ("LTC"), which will be filed with the OEB this week.

Key Information

1) **It's safe.** Hydrogen has been blended into the pipe in other jurisdictions over the last decade with successful outcomes. In addition, Enbridge Gas has completed a thorough analysis of the safety of hydrogen blended into our system. There would be no changes in the reliability of the service in the blended gas areas.
2) **It's clean.** The hydrogen produced has zero GHG emissions and by blending it into the natural gas stream, reduces the overall carbon intensity of the supply. The average home that uses 2,400m^3s per year would reduce their annual GHG emissions by 109 tCO_2e.
3) **The cost is the same.** The cost of the hydrogen would be charged at the standard cost of natural gas. Given the density of hydrogen, customers may require a small incremental volume versus a natural gas only supply. This small incremental amount will be spread out over the Enbridge Gas franchise area and therefore would equate to approximately 12 pennies per year.

4) **There are benefits for the electricity system.** In addition to the critical grid balancing services already being provided, the P2G blending project would demonstrate the ability to re-purpose non-dispatchable electricity (converted into hydrogen) by storing and blending it into the existing natural gas grid. This would also help in offsetting the need to build new capital infrastructure for energy storage, as the energy could be stored in the existing natural gas grid.

5) **Ontario will be a leader in North America.** The interest in hydrogen blending is picking up significantly, with several jurisdictions looking at building hydrogen P2G plants. Given our P2G facility is already up and running, when this application moves ahead, it would be the first facility at this scale in North America to blend hydrogen into the natural gas stream.

[redacted]
Government Affairs Strategist
Public Affairs, Communications & Sustainability
—
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Safety. Integrity. Respect.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Consumers Council of Canada (CCC)

INTERROGATORY

Reference:

Ex. B/T1/S1p. 1 and Ex. B/T1/S1/p. 16

Question**:**

The LCEP is a pilot project that will allow EGI to "green" a portion of the natural gas grid in Ontario. Has EGI sought nay funding from the Provincial or Federal Government for this Project beyond that expected from Sustainable Development Technology Canada? If so, please describe the nature of the funding. If not, please explain why not.

Response:

Please see Exhibit I.SEC.4.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Consumers Council of Canada (CCC)

INTERROGATORY

Reference:

Ex. B/T1/S1/p. 2

Question**:**

The evidence states that EGI has consulted with the TSSA to introduce and provide information on the Project. The TSSA has indicated that it will act as a technical reviewer on behalf of the OEB for the LTC if requested. Please explain what is meant by the term “technical reviewer”. Please indicate what the roles and responsibilities would be if the TSSA becomes the technical reviewer.

Response:

The TSSA is responsible for enforcement activity related to the fuel safety code under which EGI operates (CSA Z662), therefore the design and installation of blended gas pipelines would be overseen by the TSSA.

The TSSA’s authority is mandated as the technical authority through Ontario Regulation (O. Reg) 210/01 Oil and Gas Pipeline Systems and the FS 238-18 Oil and Gas Pipeline systems code adoption document which adopts the CSA Z662. The scope section of the CSA Z662 Oil and Gas Pipeline Systems states that it is applicable for pipeline systems that convey gas, such as Manufactured Gas (MG) and Synthetic Natural Gas (SNG), which have high hydrogen contents. These gases contain a mixture of hydrogen and carbon monoxide, with potential presence of methane and carbon dioxide. SNG/MG transportation in pipelines represents a harsher service condition when compared to traditional natural gas.

SNG/MG covers a wide range of compositions that generally fall within the following limits:

- 10 to 90% by volume hydrogen
- 200 ppm to 90% by volume carbon monoxide
- Balance – inert gasses, carbon dioxide, methane

Although the CSA Z662 definition of “gas” does not explicitly cover blended gas, the design requirements for a SNG pipeline (which is covered by CSA Z662) would need to be more stringent than those for the blended gas service. Enbridge Gas has taken the requirements for a SNG pipeline requirements into account (where applicable) for the new facilities required in this application.

Initial consultation with the TSSA provided clarification that when there is a fuel installation outside of the current code, which also represents new technology, a Field Development Project may be required. This is a project-specific review by the TSSA for projects not specifically covered by existing Codes. Further engagement is expected with the TSSA on the exact mechanism required for the LCEP, given the Project's unique nature. Enbridge Gas will ensure that all necessary approvals are obtained from the TSSA before the Project is put into operation.

Details about recent communications between Enbridge Gas and the TSSA are set out at Exhibit I.STAFF.10.

Enbridge Gas understands that where an application is before the OEB, then the OEB can request that the TSSA act as a "technical reviewer". Enbridge Gas understands this to be a role where, on request, the TSSA can provide advice to the OEB in relation to whether applicable Code and similar requirements are being met in a project or project proposal. The TSSA would determine the level and form of its involvement after the request is made. Enbridge Gas understands that the OEB has now asked the TSSA to provide a letter of comment on the Project.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Consumers Council of Canada (CCC)

INTERROGATORY

Reference:

Ex. B/T1/S1/p. 2

Question**:**

The evidence states that the Project will require isolation of a small portion of the distribution system, the BGA. EGI will distribute blended natural gas to customers located in the BGA. THE BGA is required to ensure that blended gas is not distributed broadly across EGI's distribution network to an area not suitable for hydrogen blending. Please describe what constitutes and area "not suitable for hydrogen blending".

Response:

Table 2 of Exhibit B, Tab 1, Schedule 1, Attachment 1, page 11, sets out the criteria used in the initial selection of the suitable closed loop system for the Project. Any customers, geographical locations or pipeline parameters outside of the criteria would be deemed not suitable for hydrogen blending for the initial stage of this project.

In its review of suitable locations for the pilot LCEP, Enbridge Gas only assessed existing assets and approved materials for new construction in the proposed blended gas areas to confirm they are suitable for hydrogen blending. Areas "not suitable for hydrogen blending" refers to other networks that were out of scope for the completed study. Although other parts of the Enbridge Gas distribution system may be suitable for hydrogen blending, the Company will not determine that they are suitable until a network-specific study is completed to confirm this is the case.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Consumers Council of Canada (CCC)

INTERROGATORY

Reference:

Ex. B/T1/S1/p. 2

Question**:**

Please explain why this type of project has not been done in other North American jurisdictions.

Response:

Enbridge Gas does not comment on the motivations and considerations that other North American jurisdictions might take into account when evaluating hydrogen blending with natural gas for distribution purposes. As set out at Table 1 of Exhibit B, Tab 1, Schedule 1, there a number of hydrogen blending projects that have been initiated in Europe, and one utility-sponsored project has proceeded in California.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Consumers Council of Canada (CCC)

INTERROGATORY

Reference:

Ex. B/T1/S1/p. 4

Question**:**

What is the commodity cost differential between the hydrogen gas technology proposed and traditional natural gas?

Response:

There is no cost differential between the renewable hydrogen that will be supplied to Enbridge Gas for the Project and traditional natural gas. As explained at Exhibit B, Tab 1, Schedule 1, pages 4 and 18, Enbridge Gas will procure hydrogen from 2562961 Ontario Ltd. in a manner that keeps ratepayers cost-neutral.

Please see the response to Exhibit I.STAFF.2 (d) and Exhibit I.STAFF.2 (f) for further detail.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Consumers Council of Canada (CCC)

INTERROGATORY

Reference:

Ex. B/T1/S1/p. 5

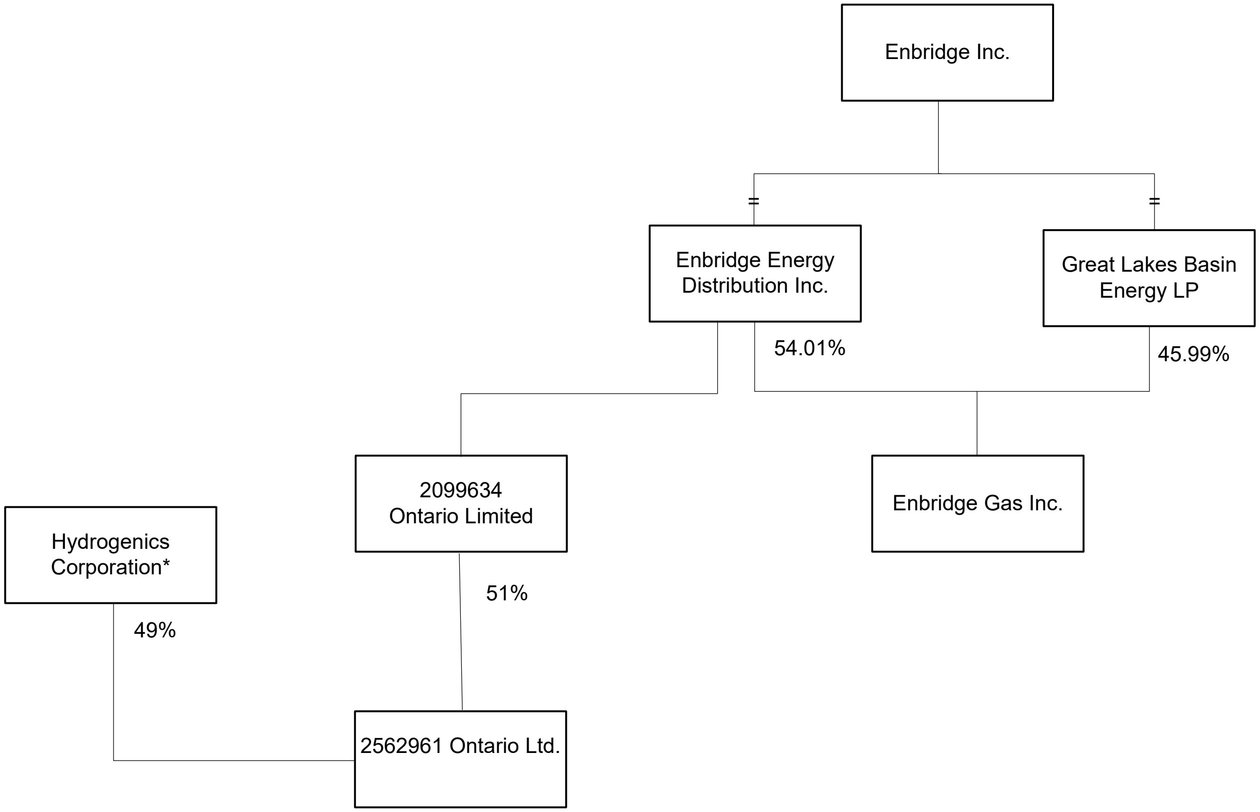
Question**:**

Please provide an organizational chart setting out the relationships between Enbridge Gas Inc., Enbridge Inc., 2562961 Ontario Ltd., and Hydrogenics Corporation. What Enbridge Inc.'s role in the Project?

Response:

The 2562961 Ontario Ltd. organizational chart can be found at Attachment 1 to this response. Enbridge Inc. has an ownership interest in 2562961 Ontario Ltd., but does not have any direct management role in the Project.

2562961 Ontario Ltd. Organizational Chart



*Enbridge Inc. and affliates have no interest in Hydrogenics Corporation

Ownership is 100% unless otherwise noted

ENBRIDGE GAS INC.
Answer to Interrogatory from
Consumers Council of Canada (CCC)

INTERROGATORY

Reference:

Ex. B/T1/S1/p. 14

Question**:**

EGI undertook a consultation and market research program in order to gauge customer attitudes and acceptance of blending hydrogen with natural gas. What was the overall cost of the consultation and the market research? How was it funded?

Response:

The overall cost of the consultation and the market research was $34,139.75 (without HST). The costs were funded through existing revenues and expensed to operating costs.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Consumers Council of Canada (CCC)

INTERROGATORY

Reference:

Ex. B/T1/S1/Attachment 1, p. 2

Question**:**

The evidence states that EGI has concluded that a closed loop within its distribution network is suitable for hydrogen blending. The analyses leading to these conclusions were based on literature reviews, analytical modeling, risk assessments, field surveys, industry consultation, integrity consideration and engineering judgment. Please provide copies of the literature reviews and risk assessments.

Response:

Please refer to Exhibit I.H2GO.1.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Consumers Council of Canada (CCC)

INTERROGATORY

Question**:**

Given this is a pilot project, please explain how EGI intends to use the results of the pilot. Will the results ben made publicly available? If not, will they not?

Response:

Enbridge Gas intends to use the results of the pilot project to inform future decisions with respect to the potential for blending hydrogen with natural gas in other parts of its gas distribution system.

The Company will disclose this information where required in order to attain any required approvals for expansion of hydrogen blending to other parts of its system. Enbridge Gas notes that some or all of the information about the pilot project may be commercially sensitive and valuable to other players interested in commercializing hydrogen. In order to ensure that Enbridge Gas can retain the value of information and data collected through the pilot project, it may be necessary to seek confidential treatment of some or all of the information.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Consumers Council of Canada (CCC)

INTERROGATORY

Question:

Is EGI in the process of developing further LCEPs in its franchise area? If so, please describe the work that is being undertaken.

Response:

As explained in Exhibit B, Tab 1, Schedule 1, pages 10-13, there is potential to expand the Project to include adjacent loops to the south and east of the “Loop S1” blended gas area (BGA) for the current Project.

Enbridge Gas is not currently developing further LCEPs in its franchise area. However, the Company will look to the potential for further LCEPs in the event that the pilot Project is successful and future conditions are favourable to the expanded use of hydrogen blending.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Consumers Council of Canada (CCC)

INTERROGATORY

Reference:

EX. D/T1/S1 – Table 8
EGI has set out in Table 8 the Estimated Project Costs:

Question**:**

a) Please set out in detail how these cost estimates were developed;
b) For each of the items listed please provide a detailed budget;
c) Please explain how EGI determined the level of Indirect Overheads allocated to this project and indicate if that allocation methodology differs from other projects;
d) Does EGI typically include a 25% contingency for all direct capital costs? Does EGI typically apply a 40% contingency for station material costs?
e) What relief is EGI seeking from the OEB with respect to the Project Costs at this time?

Response:

a) The Project cost estimate is developed using a bottom up approach in alignment with internal Enbridge Gas best practices and used the standard approach/methodology for capital project Cost Estimating. Specifically, the Project team used semi-detailed rates, Preliminary Field Estimates, Contractor Courtesy Quotations, and High Level/Budgetary Estimates from Vendors along with subject matter experts' input, and experience on past projects on the preliminary drawings of the selected pipeline route and station location for this Project.

   Contingency is added as a percentage to the total project and is reflective of the project risk associated with the development stage of the project. The contingency allowance is the amount of funds set aside to account for unquantified project costs, to cover known risks to the project (known-unknowns). To determine the amount of contingency assigned to the Project, a risk scorecard was used to evaluate this Project against typical project types at Enbridge Gas in terms of the risks to safely and consistently deliver projects on time and on budget, while attaining highest standards for safety, quality, customer satisfaction, environment and regulatory compliance.

At the time of application, this Project has a preliminary project definition and scope which include pipe size, materials, selected route of the proposed pipeline and station location. The Project was at the stage where topographical survey and environmental reports were available and general permit requirement is known. A preliminary schedule were developed based on Stakeholder Timelines (pipeline tie in and station commissioning tie in window, need for blended gas, etc.) and Third Party Restrictions (e.g. municipal requirements).

Based on the project development stage and following the Company's typical approach in determining the amount of contingency to capital project as described above, the Project team determined that 25% overall contingency is suitable for this Project.

A 40% contingency is chosen for the station materials for the proposed Hydrogen Blending Station and Hydrogen Station only. The proposed hydrogen blending station is still in the planning and design stage with a preliminary scope and only some regulatory and permitting requirements known. Enbridge Gas's expertise is in the design and operations requirements for natural gas facilities. The proposed hydrogen blending station and hydrogen station will be the first facility of its kind for Enbridge Gas. The Company is leveraging the knowledge and experience of external parties to complete the design. As Enbridge Gas progressesthrough the design process, the need for more specialized regulation, measurement, electrical, and controls equipment (beyond the typical equipment used for natural gas facilities) may be identified which will lead to additional costs that cannot be foreseen until the detailed design is complete. The Project team thus felt that it is prudent to include additional contingency to account for these known unknowns.

b) The Project estimate is broken down to five categories as follows:

- Construction: This includes the contractor costs for the installation of pipeline and stations and is based on the courtesy estimates of the preliminary drawings of the selected pipeline route and station location.
- Materials: Pipeline materials includes costs of pipe, valves, fittings, and custom fittings. Station materials includes the costs of the design build contract for the Hydrogen Blending station compound and other stations required to support the blending activities.
- Internal labour: This include costs of internal Enbridge Gas labour that is working directly on the project.
- Outside Services: This includes all consultant costs for design and engineering services, pipeline testing, environmental assessment, legal, costs associated with OEB filing, etc.
- Land and Permits: This component includes all cost associated with obtaining required permits for both pipeline and station installation.

The table below further separates the costs for the pipeline components and the station components and its respective contingency amount:

Item No.		**Description**			**Cost**	**% Contingency**	**Contingency**	**Cost + Contingency**
1		**Material Costs (Pipeline & Station)**			**$941,000***	25%	$235,250	$1,176,250
			Description	Cost + Contingency				
	1a	Pipeline material	25 % contingency applied	$ 166,250				
	1b	Other stns material	25 % contingency applied	$ 143,750				
	1c	Hydrogen Blending stn and Hydrogen Stn design build	40 % contingency applied only to the station materials for Hydrogen Blending Stn and Hydrogen Station of this vendor's quote	$ 866,250				
				$ 1,176,250				
2		Labour Costs (Pipeline & Station)			**$1,284,000**	25%	$321,000	$1,605,000
			Description	Cost + Contingency				
	2a	Pipeline labour cost	25 % contingency applied	$ 1,183,750				
	2b	Stations labour cost	25 % contingency applied	$ 421,250				
				$ 1,605,000				
3		External Permitting, Land, Environmental & Regulatory Costs			**$20,000**	25%	$5,000	$25,000
			Description	Cost + Contingency				
	3a	Overall External Permitting, Land, Environmental & Regulatory Costs	25 % contingency applied	$ 25,000				
4		Outside Services			**$761,000**	25%	$190,250	$951,250
			Description	Cost + Contingency				
	4a	Outside services related to the design and installation of the pipeline	25 % contingency applied	$ 895,000				
	4b	Outside services related to the design of the station	25 % contingency applied	$ 56,250				
				$ 951,250				
5		Direct Overheads			**$105,000**	25%	$26,250	$131,250
			Description	Cost + Contingency				
	5a	Overall Direct Overheads	25 % contingency applied	$ 131,250				
		SUBTOTAL			$2,170,000		$777,750	$3,888,750
6		Contingency Costs (rounded up to nearest $1000)			**$778,000**			
7		Project Cost (including contingency)			**$3,889,000**			
8		Indirect Overheads			**$1,260,395**			
9		Interest During Construction			**$82,870**			
10		Total Project Costs			**$5,232,265**			
				Legend	material cost breakdown			
					amount reported in EX. D/T1/S1 – Table 8			

c) Indirect Overheads is calculated as a percentage based on the yearly spend of the Project. The annual percentage applied to the Project is provided by the Capital Financial Planning & Analysis group and based on the result of capitalization study. This allocation methodology is consistent with the other capital projects during the deferred rebasing term, including ICM projects.

d) No. Please refer to part a), above.

e) Enbridge Gas is seeking leave to construct approval, which typically includes a determination that the forecast costs are reasonable. Enbridge Gas is not seeking any specific other approval related to the project costs at this time. There will be no rate impact from the Project during the deferred rebasing term, because Enbridge Gas is not seeking ICM treatment. The actual project costs, as reflected in updated rate base, will be included in the next rebasing application for 2024 rates and will be reflected in ESM calculations during the deferred rebasing term.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Environmental Defence (ED)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1

Question**:**

(a) Please elaborate on the purpose and need for this project, and hydrogen injection more generally, as it relates to mitigating the financial risks to fossil fuel consumers associated with climate change and the related shifts in energy use patterns.
(b) Please provide a copy of all studies that Enbridge has commissioned or possesses that analyze the risk to natural gas consumers and natural gas markets associated with climate change, including the potential shifts in energy use patterns from market forces and/or government policy.
(c) Please itemize and describe the financial risks to gas customers related to the potential changes in energy use patterns arising from climate change.
(d) What percent of Ontario's GHG emissions (CO2e) arise from natural gas? Please provide a response for the latest year available and as a five-year average.
(e) What are the total annual GHG emissions (CO2e) arising from the consumption of natural gas in Ontario? Please provide a response for the latest year available and as a five-year average.
(f) How much natural gas is consumed in Ontario in a year (m3 and GJ)? Please provide a response for the same periods as in (d).
(g) Please estimate the total annual GHG emissions (CO2e) arising from the fugitive natural gas in Ontario? Please provide the answer on a best efforts basis with the information available to Enbridge. For example, if Enbridge can only speak to the fugitive emissions arising in its own facilities, please still provide this information. In this question, fugitive natural gas refers to any natural gas that is lost to the environment before reaching the customer's equipment.
(h) What are Canada's GHG emission reduction targets? Please express the targets as total annual emissions (CO2e) for each year there is a target.
(i) Please provide Ontario's portion of Canada's GHG emission reduction targets (CO2e). For the purpose of this answer, please assume that Ontario's GHG emissions remain the same proportion of Canada's GHG emissions as they are today.
(j) Please complete the following table and provide a copy in Excel format:

GHG Reduction Targets and Associated Declines in GHGs from Natural Gas				
	2019 (historic levels)[1]	2020	…	2050
Canada's GHG Reduction Targets (CO2e)[2]				
Ontario's Portion of Canada's GHG Reduction Targets (CO2e)[3]				
Ontario GHGs From Natural Gas (business as usual)				
Ontario GHGs From Natural Gas (GHG target reduction scenario)[4]				

(k) Please provide a line chart illustrating the above table.

Response:

(a) The purpose of the project, as stated in the "*Purpose & Need*" section of the evidence is to provide valuable insight into the use of hydrogen as a method for decarbonizing the natural gas grid and provide a means through which the company

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[1] If 2019 historic figure are not yet know, please start at 2018.

[2] For 2019 please use the actual historic figure. For each year for which there is a targeted level, please bold the figure. For years between figures, please calculate the trajectory of the targets on a straight-line basis.

[3] For 2019 please use the actual historic figure. For each year for which there is a targeted level, please bold the figure. For years between figures, please calculate the trajectory of the targets on a straight-line basis. Please assume that Ontario's GHG emissions remain the same proportion of Canada's GHG emissions as they are today.

[4] For the purpose of this answer, please assume that the GHG emissions from natural gas remain the same proportion of Ontario's total GHG emissions as is the case today.

can begin to prepare for the requirements of the Clean Fuel Standard (CFS). At paragraph 24 of Exhibit B, Tab 1, Schedule 1, Enbridge Gas describes additional benefits from blending hydrogen into the natural gas grid.

(b) In 2015, Enbridge Gas engaged ICF to undertake an analysis on the proposed Cap and Trade program and the potential of several GHG abatement opportunities. The final report was submitted to the Ontario Energy Board on April 22, 2016 in the EB-2016-0004 community expansion proceeding. Additional reports produced as part of this engagement were filed on March 17, 2017 in EB-2016-0300 Cap-and-Trade proceeding.

(c) Enbridge Gas recognizes that there may be some financial risk to customers related to potential changes in energy use patterns arising from climate change and related policies. For example, customers may incur a financial impact through switching to other forms of energy such as electricity, both in the form of a cost to replace their existing equipment and potentially increased energy costs. As mentioned in the response to a) above, the Company is pursuing projects such as the LCEP in order to allow customers to continue using natural gas and its related existing infrastructure in their homes, while lowering emissions and transitioning into a lower carbon future.

(d) to (f) Please see Attachment 1 to this response.

g) In 2018, fugitive emissions from natural gas as reported in the 2020 National Inventory Report for Ontario were 960 kt CO2e.

h) Canada's GHG reduction targets are:

- 2020: 17% reduction in emissions from 2005 levels, which results in a target GHG level of 607 Mt CO_2e;
- 2030: 30% reduction in emissions from 2005 levels, which results in a target GHG level of 511 Mt CO_2e; and
- 2050: net-zero emissions[5].

i) The federal government has not published province specific targets to meet their GHG reduction target, however the Ontario government has set a GHG reduction target for 2030, which is a 30% reduction in emissions from 2005 levels, which results in a target GHG level of 143 Mt CO_2e.

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[5] The government of Canada has announced intentions to develop a plan to achieve net-zero emissions by 2050, including setting 5-year emission reduction milestones, however to date, Enbridge Gas is not aware that this plan, or a 2050 emissions target level, have been published.

j) and (k) Please see the requested table below.

A line chart has not been provided as Enbridge Gas considered there to be insufficient data points.

GHG Reduction Targets and Associated Declines in GHGs from Natural Gas				
	2018 (historic levels)	2020 Target	2030 Target	2050 Target[6]
Canada's GHG Emissions (CO2e)	716 Mt CO_2e	607 Mt CO_2e	511 Mt CO_2e[7]	
Ontario's GHG Emissions (CO2e)	159 Mt CO_2e		143 Mt CO_2e[8]	
Ontario GHGs From Natural Gas (business as usual)	50.4 Mt CO_2e			
Ontario GHGs From Natural Gas (GHG target reduction scenario)			42.9 Mt CO_2e[9]	

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[6] The government of Canada has announced intentions to develop a plan to achieve net-zero emissions by 2050, including setting 5-year emission reduction milestones, however to date, Enbridge Gas is not aware that this plan, or a 2050 emissions target level, have been published.

[7] 2020, Environment and Climate Change Canada, PROGRESS TOWARDS CANADA'S GREENHOUSE GAS EMISSIONS REDUCTION TARGET

[8] 2018, Ministry of Environment, Conservation and Parks, A Made-in-Ontario Environment Plan

[9] No GHG reduction target has been specified for natural gas. The value provided assumes natural gas contributes approximately 30% of Ontario's total GHG emissions and was calculated as 30% of the 143 Mt CO2e target.

Attachment 1, ED 1 e) d) f)

Year	2015	2016	2017	2018	2019	Average
Natural Gas Consumed (m3/yr)[1]		24,183,965,000	23,772,594,000	26,881,340,000	30,722,126,000	26,390,006,250
Natural Gas Consumed (GJ/yr)[1]		922,198,700	907,602,700	1,027,615,600	1,175,638,400	1,008,263,850
Emissions from Natural Gas Combustion (kt CO2e/yr)[2]		45,321	44,550	50,376	57,573	49,455
Ontario GHG Emissions (kt CO2e/yr)[3]	163,000	160,000	155,000	165,000		160,750
Percent of Emissions from Natural Gas (%)		28%	29%	31%		29%

Notes:

1) Consumption data aggregated from Statistics Canada, Canadian Monthly Natural Gas Distribution, Table 25-10-0059-01, downloaded on June 10,2020.

2) Based on a natural gas emission factor of (tCO2e/m3): 0.001874

3) Environment and Climate Change Canada, 2020 National Inventory Report. GHG Emission Summary for Ontario, Table A11-12.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Environmental Defence (ED)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, Page 3

Preamble:

Enbridge states that: “Enbridge Gas estimates that, for the BGA, GHG emission reductions can range from approximately 98 tons carbon dioxide equivalent (tCO2e) to 117 tCO2e per year.”

Question**:**

(a) Why does Enbridge estimate a *range* of forecast GHG emission reductions?
(b) Does Enbridge assume that the GHG emissions associated with the hydrogen to be used in this project are zero? If yes, please explain.
(c) Please provide a table showing the hours during which the power-to-gas facility operated in 2019. For each of those hours, please indicate the percent of Ontario’s power generation provide by gas-fired generation. Please provide this information in a table.
(d) Please calculate the carbon intensity of the power consumed in 2562961 Ontario Ltd.’s power-to-gas facility in 2019 and provide a forecast for 2021 to 2025. Please also provide the total GHG emissions associated with that power for each year.

Please answer the questions on a best-efforts basis and with any caveats as necessary. If a portion of the historic data or forecast is impossible to provide, please explain why and answer the question over as long a time period as possible. If certain parts of the answer cannot be estimated, please explain why and provide as much of the table as possible. Please make assumptions as necessary and state all assumptions.

Response:

a) Please see Exhibit I.Staff.1.

b) Enbridge assumes that hydrogen when combusted by natural gas customers produces zero GHG emissions as it is a zero carbon fuel.

c) Please see the table below.

Month	Hours of Operation	Percent of Gas-fired generation[1]
Jan	702.8	7%
Feb	572.6	10%
March	644.3	10%
April	323.6	4%
May	353.21	3%
June	400.6	2%
July	547	11%
August	587.9	7%
September	450.45	4%
October	419.14	3%
November	423.7	7%
December	431	6%

d) Enbridge Gas has not calculated the carbon intensity of power consumed at the Power to Gas facility for the requested time periods, nor the GHG emissions associated with that power, as a methodology to calculate the lifecycle carbon intensity of hydrogen or project specific power supplies under the Clean Fuel Standard has yet to be released. The Power to Gas facility has been contracted by the IESO to provide frequency regulation to support Ontario's electricity system, and as such Enbridge Gas is not able to say definitively that the Power to Gas plant represents an incremental load where the average electrical grid carbon intensity may be assumed.

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[1] IESO, 2020, Generator Output by Fuel Type Monthly Report

ENBRIDGE GAS INC.
Answer to Interrogatory from
Environmental Defence (ED)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, p. 1

Preamble**:**

Enbridge states as follows: “When combusted, hydrogen is a zero carbon emission fuel source.”

Question:

(a) What is the carbon intensity of electricity generation in Ontario (CO2e/kWh)? Please provide a forecast of this for each year from now until 2040 (the period covered by the IESO’ annual planning outlook).
(b) Please provide a forecast of the carbon intensity of hydrogen created in Ontario through power-to-gas from now until 2040 based on the forecast carbon intensity of electricity and the amount of electricity required to produce hydrogen. Please make assumptions as necessary and please state all assumptions. Please provide the response separately per GJ and m3 of hydrogen. Please also include a row stating the carbon intensity of hydrogen as a % of the carbon intensity of natural gas of the same heating value.
(c) How much electricity (kWh) is required to produce (i) a m3 of hydrogen and (ii) a GJ of hydrogen. If they differ, please provide the figures for Enbridge’s power-to-gas plant and for the industry average.
(d) Please provide the following conversion rates and figures: (i) m3 of natural gas to m3 of hydrogen of the same hearing value, (ii) m3 of natural gas to GJ of natural gas, (iii) m3 of hydrogen to GJ of hydrogen, (iv) CO2e per m3 of natural gas, (v) CO2e per GJ of natural gas, and (iv) kg of hydrogen to GJ of hydrogen.

Response:

(a) The carbon intensity of electricity generation in Ontario was 30 g CO_2e/kWh in 2018, which is the most recent year for which data is available in the federal National

Inventory Report.[1] The forecast carbon intensity for Ontario, based on IESO's Annual Planning Outlook for 2020 to 2040 is shown in Attachment 1.

(b) Enbridge Gas cannot provide the information requested. Please refer to Exhibit I.ED.2(d).

(c) An average of 4.4 kWh is required to produce 1 m^3 of hydrogen, and an average of 346 kwh is required to produce 1 GJ of hydrogen.

(d) The requested conversion rates are shown below.

i. m^3 of natural gas to m^3 of hydrogen: multiple of the ratio of the density of NG to H_2, i.e.: ~ 7.85:1
ii. m^3 of natural gas to GJ of natural gas: ~ 0.0385 GJ per m^3 natural gas
iii. m^3 of hydrogen to GJ of hydrogen: ~ 0.0127 GJ per m^3 hydrogen
iv. CO2e per m^3 of natural gas: 0.001874 tCO_2e per m^3 natural gas
v. kg of hydrogen to GJ of hydrogen. ~0.1335 GJ hydrogen per kg of hydrogen

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[1] National Inventory Report 1990 – 2018: Greenhouse Gas Sources and Sinks in Canada, Part 3, Table A13-7

Forecast Carbon Intensity for Electricity Generation in Ontario based on IESO Annual Planning Outlook January 2020

Scenario	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Carbon intensity - reference case (g CO_2e/kWh)	35.02	31.31	36.01	56.96	55.08	73.64	70.71	66.36	71.43	66.58	70.15	76.49	70.68	68.78	70.57	68.01	69.97	76.52	76.26	82.00	79.69
Carbon intensity - energy efficiency case (g CO_2e/kWh)	35.02	30.72	34.13	54.05	50.40	69.23	65.16	60.77	64.30	59.59	62.09	69.21	63.52	61.64	63.50	60.46	63.17	70.41	70.22	75.93	73.31

Notes:

1. Carbon intensity in gCO_2e/kWh is calculated as the GHG emissions (MT CO_2e) divided by production (TWh). Production numbers include exports, but does not include imports.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Environmental Defence (ED)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, p. 1

Preamble**:**

Enbridge states as follows: “When combusted, hydrogen is a zero carbon emission fuel source.”

Question:

(a) What is the carbon intensity of hydrogen created through natural gas reforming? Please make assumptions as necessary and please state all assumptions. Please provide the response separately per GJ and m3 of hydrogen. Please also include a row stating the carbon intensity of hydrogen (from natural gas reforming) as a % of the carbon intensity of natural gas of the same heating value.
(b) How much natural gas is required to produce (i) a m3 of hydrogen and (ii) a GJ of hydrogen through natural gas reforming.
(c) Approximately what percent of the hydrogen produced in Canada is created via natural gas reforming?
(d) Approximately what percent of the hydrogen produced in the United States is created via natural gas reforming?
(e) Is there an overall GHG reduction benefit associated with injecting hydrogen into the natural gas stream if that hydrogen was created with natural gas reforming? Please explain and quantify the answer.
(f) Is there an overall GHG reduction benefit associated with injecting hydrogen into the natural gas stream if that hydrogen was created with any method other than power to gas from a low-carbon electricity source? Please explain and quantify the answer.
(g) If Enbridge were to expand hydrogen injection beyond this pilot project would it consider including hydrogen created via natural gas reforming?

Response:

The LCEP as proposed by Enbridge Gas in this application does not contemplate the use of hydrogen produced by natural gas reforming. The LCEP will be supplied with hydrogen created through electrolysis only. Enbridge Gas has no plans to introduce hydrogen made through natural gas reforming. As such, the information requested in this interrogatory is not relevant to the Company's LCEP application and will not be provided.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Environmental Defence (ED)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1

Question:

(a) Please explain how Enbridge anticipates the Clean Fuel Standard will apply to its natural gas operations in Ontario and natural gas consumers in Ontario.
(b) Will the Clean Fuel Standard create a financial incentive to reduce the carbon intensity of natural gas? If yes, will that incentive accrue to consumers, supplies, both, or other? How much is this incentive expected to be worth per m3 of hydrogen or per avoided carbon emissions (CO2e)?
(c) Does Enbridge anticipate that the Canada's Clean Fuel Standard will require Enbridge to reduce the carbon intensity of the fuel in its system?
(d) Please itemize and describe the other measures that Enbridge is considering as a response to the Clean Fuel Standards.

Response:

(a) to (c) Please refer to Exhibit I.STAFF.2(h) and Exhibit I.H2Go.2(e). Enbridge Gas cannot estimate the dollar value (as an incentive or compliance cost) associated with CFS credits generated from hydrogen production and distribution as the CFS credit market does not yet exist.

(d) Enbridge Gas has not developed a plan for CFS compliance, however the Company anticipates that hydrogen blending, along with renewable natural gas and compressed natural gas vehicles will be utilized as means to address the requirements of the CFS in the near term.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Environmental Defence (ED)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, p. 15-18

Preamble:

Enbridge states at page 17 of the reference:

> “To support this pilot project, Enbridge Gas has arranged to procure hydrogen from 2562961 Ontario Ltd. in a manner that keeps ratepayers cost-neutral. This treatment would apply to the hydrogen supply for the BGA until rebasing or until such earlier time that a different treatment is appropriate based on future developments; for example, the implementation of a CFS.”

Question:

(a) Please estimate the cost per m3 and GJ of hydrogen produced by 2562961 Ontario Ltd.
(b) Please explain the relationships between 2562961 Ontario Ltd, Hydgrogenics Corporation, the IESO, and Enbridge. Please provide all contracts between any of those parties relating to this pilot project or the power-to-gas plant.
(c) How much does 2562961 Ontario Ltd pay for electricity and how much is it forecast to pay for electricity over the next 10 years?
(d) Will the provision of hydrogen at the rates proposed by Enbridge result in losses or profits for any of the entities described in (b)? Please explain and estimate the quantum of any losses or profits.
(e) Please provide a table showing Ontario’s annual surplus electricity (kWh), historic and forecast, from 2010 to 2040.
(f) Hydrogen is less expensive if generated with surplus power. What is the hydrogen generation potential from surplus power between now and 2040 (m3 and GJ)?
(g) Please provide a best estimate of the cost at which hydrogen can currently be produced in Ontario (per m3 and GJ) via power-to-gas. Please include and separately itemize the cost of electricity and the cost of converting electricity to hydrogen. Please make all assumptions as necessary and state all assumptions.
(h) If technological advancements are expected, please provide a best estimate of the cost at which hydrogen could be produced in Ontario in 2030 (per m3 and GJ) via power to gas. Please include and separately itemize the cost of electricity and the

cost of converting electricity to hydrogen. Please discuss and provide a qualitative answer if a quantitative one is not possible.

(i) What is the going market rate for hydrogen in Ontario (per m3 and GJ)? If a single rate cannot be provided, please provide a range and some examples.

(j) What is the going market rate for hydrogen in Ontario (per m3 and GJ) *created from power-to-gas*? If a single rate cannot be provided, please provide a range and some examples.

(k) What is the going market rate for hydrogen in California (CAD per m3 and GJ)? If a single rate cannot be provided, please provide a range and some examples.

(l) What is the going market rate for hydrogen in California (CAD per m3 and GJ) *created from power to gas*? If a single rate cannot be provided, please provide a range and some examples.

(m)What is Shell Canada charging for hydrogen in its hydrogen refuelling stations in Quebec? An average, approximate, or point-in-time answer is sufficient. Would this hydrogen be mostly from natural gas reforming or power to gas?

(n) What is the percentage difference between the current cost for hydrogen and natural gas in Ontario of the same heating value (for hydrogen created via power to gas)? Please provide the forecast difference between now and 2040, both annual and average over that period? Please provide the underlying calculations.

Response:

(a) Please see Exhibit I.STAFF.2(d) for a description of the price to be paid by Enbridge Gas to purchase hydrogen from 2562961 Ontario Ltd. and a copy of the associated term sheet. Enbridge Gas is not prepared to disclose 2562961 Ontario Ltd.'s costs to produce hydrogen as that information is commercially sensitive. Enbridge Gas does confirm, however, that 2562961 Ontario Ltd.'s costs to produce hydrogen are higher than the price to be paid by Enbridge Gas to purchase hydrogen. That is consistent with the information provided below in the response to (g) regarding a hypothetical hydrogen plant.

(b) Please see Exhibit I.CCC.11 for a description of the relationship between Enbridge Gas, Enbridge Inc., 2562961 Ontario Ltd and Hydrogenics Corporation. Please see Exhibit I.CCC.2 for a copy of the intercorporate services agreement between Enbridge Gas and 2562961 Ontario Ltd. Please see Exhibit I. STAFF.2(d) for a description of the price to be paid by Enbridge Gas to purchase hydrogen from 2562961 Ontario Ltd. and a copy of the associated term sheet.

As explained at Exhibit B, Tab 1, Schedule 1, page 5, there is a contract with the IESO for the provision of regulation service from the Power to Gas plant (which is owned by 2562961 Ontario Ltd.). Please see Exhibit I.SEC.9.

(c) Enbridge Gas does not believe that this question is relevant.

(d) As noted above, the price paid by Enbridge Gas to 2562961 Ontario Ltd. is lower than cost. As a result, there will be a loss to 2562961 Ontario Ltd. Enbridge Gas does not believe that the quantum is relevant.

(e) Enbridge Gas is not in possession of the requested information and has been unable to find the information through review of the IESO website.

(f) Enbridge Gas is not in possession of the requested information and has been unable to find the information through review of the IESO website.

(g) There are a number of factors which will determine the cost of hydrogen production by electrolysers in Ontario including the scale of the plant and time of day that the plant runs. Using a scenario of running a new 20MW Power-to-Gas plant during off-peak hours at an average delivered price of electricity in the range of \$0.038/kWh to \$0.044/kWh, the estimated cost for producing hydrogen over the life of the plant would be as follows:

- \$44 to \$55 per GJ
- \$0.56 to \$0.70 per m^3

Note that this is the cost of producing hydrogen only and it does not include any costs associated with the storage and distribution of hydrogen. The amount of electricity to run the electrolysis equipment is about 4.7 kWh/m^3.

(h) Technological advances in electrolysers are expected in several areas. Larger scale plants will permit scale economies in the balance of plant equipment. Demand for renewable hydrogen increases globally is expected to drive production volumes significantly over the next decade driving the industry down the learning cost curve as the supply chain matures. Current research in membrane technology will increase the efficiency of electrolysers. Capex is certainly one of the most important drivers of the cost of hydrogen production, but as suggested in the question, the price of electricity is most important. There are many studies that have examined this question in depth; one example is the IRENA study on Hydrogen from Renewable Power.[1] It shows a projected future hydrogen production cost in Denmark under different capacity factors. In Ontario, it is expected that the generation mix will continue to have a very low carbon footprint, but a key question will be the price of electricity. Enbridge Gas agrees with published reports forecasting a significant reduction in the cost of building Power-to-Gas plants in the

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[1] https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Sep/IRENA_Hydrogen_from_renewable_power_2018.pdf (pg.26)

next decade and expect that the resulting reduction in the cost of producing hydrogen in Ontario will more than offset the increase in cost from higher delivered electricity prices. The Company expects that costs to produce hydrogen could see a net reduction on the order of 20%-30%.

(i) Phone calls to three separate Companies in Ontario or companies selling to Ontario provided the following prices for traditionally made hydrogen:

   i. ~\$58/GJ or \$0.74/m^3
   ii. ~\$62.5/GJ or \$0.79/m^3
   iii. ~\$59.49/GJ or \$0.76/m^3

   Note that this price covers hydrogen production, storage and delivery. The source of this hydrogen is typically Steam Methane Reforming of natural gas.

(j) Enbridge Gas is not aware of any Power to Gas facility in Ontario selling hydrogen to the market.

(k) According to the California Fuel Cell Partnership[2] and NREL[3] the going rate for Hydrogen converted to CDN dollars using ForEX:US\$1 = CDN\$1.31 is:

   i. ~CDN\$(1.51 to 1.88)/m^3 or CDN\$(112.84 to 148.80)/GJ [
   ii. ~Most common price is US\$1.65/m^3 or CDN\$137.27/GJ

   Note that these prices are for delivered hydrogen dispensed at pressure at a hydrogen fueling station. The Company is not aware of a going rate for hydrogen in California for injection into the natural gas grid.

(l) Enbridge Gas has not been able to find the requested information.

(m) Enbridge Gas's information is that Shell does not have any H2 stations in Quebec. Enbridge Gas understands that the only retail hydrogen station in Quebec is from HARNOIS and is located at an ESSO station in Quebec City. It is not a full Power to Gas facility like the one owned by 2562961 Ontario Ltd. The retail price observed at the pump in February 2020 was \$18.40/kg.

(n) Currently in Ontario, hydrogen produced by Power-to-Gas using electrolysis at scale is only done by 2562961 Ontario Limited. There is no market price for this hydrogen, and it is being provided to Enbridge Gas at the same price as conventional natural gas.

   Using the information set out above in part (i) about the current price for traditionally

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[2] https://cafcp.org/content/cost-refill#:~:text=Long%20Answer%3A,cost%20of%20%240.21%20per%20mile.

[3] https://ww2.energy.ca.gov/2015publications/CEC-600-2015-016/CEC-600-2015-016.pdf

made hydrogen[4], one can determine the approximate percentage difference between the cost of hydrogen and natural gas. The approximate percentage difference based on natural gas at approximately $0.12/m^3 based on July 1, 2019 natural gas rates is:

$$\boldsymbol{abs}\ \frac{\left[\$\mathbf{0.}\frac{\mathbf{12}}{\boldsymbol{m3}} - \$\mathbf{0.}\frac{\mathbf{.72}}{\boldsymbol{m3}}\right]}{\$\mathbf{0.12}} * \mathbf{100}\% = \mathbf{500}\%$$

The requested “forecast difference between now and 2040, both annual and average over that period” has not been done and is therefore not available.

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[4] The calculations are based on the hydrogen cost estimates in part (i), which are related to hydrogen produced by Steam Methane Reformation (SMR): Using an average of the three results in costs of delivered (non renewable) hydrogen of approximately: ($60.00/GJ or $0.72/m3).

ENBRIDGE GAS INC.
Answer to Interrogatory from
Environmental Defence (ED)

INTERROGATORY

Reference:

Exhibit A, Tab 2, Schedule 1, p. 1; Exhibit B, Tab 1, Schedule 1, Attachment 1

Preamble:

Preamble: Enbridge states at Exhibit A, Tab 2, Schedule 1, p. 1 that:

> “The LCEP is a pilot project that will allow the Company to green a portion of the natural gas grid in Ontario. The experience gained through the implementation of the LCEP will position Enbridge Gas to then expand hydrogen injection into other parts of its gas distribution system, further enhancing reductions to GHG emissions across the province.”

Question:

(a) Enbridge is currently planning to inject hydrogen at the rate of 2%. If hydrogen injection is expanded, what is the likelihood that this percentage could be increased? Please discuss.
(b) Page 19 of attachment 1 (Ex B-1-1) seems to suggest that the 2% limit for this pilot project is based primarily on the end-user equipment. Is that true? Please discuss.
(c) Are the concerns associated with consumer end-user equipment (e.g. flashback and overheating) mostly associated with stoves, furnaces, or water heaters?
(d) Are other jurisdictions exploring or implementing mandatory equipment standards (e.g. for new furnaces) that would allow greater percentages of hydrogen injection? Is Enbridge considering advocating for changes in this direction in Canada?
(e) What is the highest percentage of hydrogen injection in a pilot project known to Enbridge?
(f) What is the approximate highest percentage of hydrogen injection that Enbridge believes could be technically feasible?

Response:

(a) Enbridge Gas plans to inject up to 2% by volume of hydrogen into a small carefully selected portion of its natural gas distribution system. There is no current plan to increase the concentration beyond the 2% maximum amount by volume. Any likelihood of an increase at this time is speculative as it would depend on a thorough review on a case by case basis based on prudent engineering principles plus the careful consideration of important factors that could affect the resiliency of the distribution system, its integrity, its reliability and its cost effectiveness. Please also see Exhibit I.STAFF.8.

(b) Yes. The studies conducted by Enbridge Gas for the BGA focused on determining an appropriate amount of hydrogen blending concentration such that there would be no material change to the safety, operability or reliability of customer gas appliances within the BGA.

(c) The type of appliance is not a direct risk factor. Concerns related to, for example, flashback and overheating, are related to the method of combustion (for example partially pre-mixed, fully pre-mixed or diffusion style) used by an appliance. Enbridge Gas's research focused on ensuring that hydrogen blending would not change the operating parameters of combustion methods in the BGA. See response to (b) above.

(d) The Deutscher Verein des Gas- und Wasserfaches (DVGW) is a German association for gas and water standards similar to the CSA in Canada, and allows for up to 10% by volume hydrogen in natural gas in Germany. Enbridge Gas is not currently advocating for Canadian standards that would allow higher concentrations of hydrogen in natural gas distribution or appliances. Instead, the Company is focused on implementing and learning from the LCEP pilot. In the future, Enbridge Gas might advocate for such a directive if this was seen to benefit the transition to renewable hydrogen as part of the economy.

(e) At the current time, the HyDeploy demonstration project in the UK has the potential to blend up to 20% by volume into Keele University via the existing gas network. A demonstration of blended gas is taking place on part of the Keele gas network and will finish in August 2020.

(f) At this time, Enbridge Gas has only assessed existing assets and approved materials for new construction in the proposed blended gas areas to confirm they are suitable for up to 2% by volume hydrogen blending. The Company does not have a position as to the highest possible hydrogen blending percentage that would be safe and technically feasible. For discussion about how Enbridge Gas would consider a higher concentration of hydrogen blending, please see Exhibit I.STAFF.8.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Environmental Defence (ED)

INTERROGATORY

Reference:

Exhibit A, Tab 2, Schedule 1, p. 1

Preamble:

Enbridge states that:

> “The LCEP is a pilot project that will allow the Company to green a portion of the natural gas grid in Ontario. The experience gained through the implementation of the LCEP will position Enbridge Gas to then expand hydrogen injection into other parts of its gas distribution system, further enhancing reductions to GHG emissions across the province.”

Question:

(a) What was Ontario’s natural gas consumption (m3 and GJ) (i) in 2019 and (ii) on average over the past 5 years?
(b) Please estimate the incremental annual commodity cost ($) of replacing 2% of Ontario’s natural gas consumption with hydrogen created via power-to-gas.
(c) Please estimate the incremental annual commodity cost ($) of replacing 20% of Ontario’s natural gas consumption with hydrogen created via power-to-gas.
(d) Please provide any studies or documentation Enbridge has prepared on the possibility of expanding hydrogen injection in its distribution system. Please include any estimates of the feasibility, physical requirements, and costs.
(e) How much natural gas was exported from Ontario in the most recent year for which data is available (m3 and GJ)?
(f) If Enbridge were to expand hydrogen injection what steps would be needed in relation to exports to other jurisdictions? Would Enbridge also inject hydrogen into gas that would be exported? Would Enbridge need to isolate and separate the gas for Ontarians versus the gas to be exported? Would that be physically and financially feasible?
(g) If Enbridge were to expand hydrogen injection throughout the province, would this require a parallel hydrogen pipeline system throughout the province? Could the hydrogen be injected in only a few locations near where it was produced?

Please provide a rough range or order of magnitude of the cost to build the necessary pipeline facilities to inject hydrogen throughout Ontario's natural gas system

Response:

a) Please see Exhibit I.ED.1.

b) Enbridge Gas has not considered the indicated scenario, and as a result is not able to provide this information

c) Enbridge Gas has not considered the indicated scenario, and as a result is not able to provide this information

d) Enbridge Gas has not yet considered and studied other possible locations for hydrogen injection beyond the blended gas area (BGA) proposed in this application and adjacent loops to the south and east of the BGA. The Company will look to the potential for further LCEPs in the event that the pilot LCEP is successful and future conditions are favourable to the expanded use of hydrogen blending.

e) According to OPIS PointLogic, in 2019 1.38 PJ/d (37 $10^6 m^3$/d) of natural gas was exported from Ontario to Quebec and New York.

f) Enbridge Gas's current plans for hydrogen blending are to introduce blended gas into isolated BGAs. This approach would not see hydrogen introduced in gas streams that might be exported.

g) At this stage in the LCEP pilot, it is too early to speculate if a dedicated hydrogen infrastructure would be required to expand hydrogen supply throughout the province.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Environmental Defence (ED)

INTERROGATORY

Reference:

Exhibit A, Tab 2, Schedule 1, p. 1

Question:

(a) Would the expansion of hydrogen injection require changes to the OEB's regulatory guidelines or tests?
(b) Please file a copy of the relevant documentation detailing Enbridge's allowed business activities.

Response:

(a) Enbridge Gas does not believe that the introduction of hydrogen injection at a 2% concentration requires changes to the OEB's regulatory guidelines or tests.

(b) Legacy Enbridge Gas Distribution's permitted business activities are as set out in its Undertakings to the Lieutenant Governor. There was some expansion in the permitted business activities included in Minister's Directives issued to EGD in 2006 and 2009. These documents are included at Attachment 1.

Ministry of Energy, Science and Technology

Office of the Minister

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Ministère de l'Énergie, des Sciences et de la Technologie

Bureau du ministre

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Ontario

DEC 15 1998

Mr. Floyd Laughren
Chair, Ontario Energy Board
2300 Yonge Street
Suite 2601
P.O. Box 2319
Toronto, Ontario
M4P 1E4

Dear Mr. Laughren:

The Government has approved undertakings of Union Gas and Enbridge Consumers Gas to eliminate overlap with the new legislation and to allow Ontario gas utilities to participate in business opportunities with a similar degree of flexibility as is available to electricity utilities. I enclose a copy of the Order in Council and the new undertakings.

Please accept my best wishes

Sincerely,

Jim Wilson

Jim Wilson
Minister

Attachment

cc: Robert Reid, President and CEO of Union Gas
Rudi Reidl, President of Enbridge Consumers Gas

Ontario
Executive Council
Conseil des ministres

Order in Council
Décret

On the recommendation of the undersigned, the Lieutenant Governor, by and with the advice and concurrence of the Executive Council, orders that:

Sur la recommandation du soussigné, le lieutenant-gouverneur, sur l'avis et avec le consentement du Conseil des ministres, décrète ce qui suit :

WHEREAS Westcoast Energy Inc., 1001142 Ontario Inc., Union Energy Inc., Union Gas Limited, and Union Shield Resources Ltd. provided Undertakings dated the 27th day of November, 1992 to the Lieutenant Governor in Council and these Undertakings were referred to in Order in Council No. 3639/92;

AND WHEREAS Enbridge Inc. (previously IPL Energy Inc.) and The Consumers' Gas Company Ltd. provided Undertakings dated the 21st day of June, 1994 to the Lieutenant Governor in Council and these Undertakings were referred to in Order in Council No. 1606/94;

AND WHEREAS, with the receipt of Royal Assent for the *Energy Competition Act, 1998* on the 30th day of October, 1998, it is considered expedient to approve new Undertakings provided by Union Gas Limited, Centra Gas Utilities Inc., Centra Gas Holdings Inc., Westcoast Gas Inc., Westcoast Gas Holdings Inc. and Westcoast Energy Inc. and by The Consumers' Gas Company Ltd., Enbridge Consumers Energy Inc., 311594 Alberta Ltd., Enbridge Pipelines (NW) Inc. and Enbridge Inc.(the "New Undertakings");

NOW THEREFORE the New Undertakings, attached hereto, are accepted and approved.

Recommended Jim Wilson
Minister of Energy, Science & Technology

Concurred R. W. Runciman
Chair of Cabinet

Approved & Ordered DEC 9 - 1998
Date

Hilary M. Weston
Lieutenant Governor

O.C./Décret 2865/98

UNDERTAKINGS OF THE CONSUMERS' GAS COMPANY LTD., ENBRIDGE CONSUMERS ENERGY INC., 311594 ALBERTA LTD., ENBRIDGE PIPELINES (NW) INC. AND ENBRIDGE INC.

TO: Her Honour The Lieutenant Governor in Council for the Province of Ontario

WHEREAS Enbridge Consumers Energy Inc. holds all of the issued and outstanding common shares of The Consumers' Gas Company Ltd. ("Consumers");

AND WHEREAS 311594 Alberta Ltd. holds all of the issued and outstanding common shares of Enbridge Consumers Energy Inc.;

AND WHEREAS Enbridge Pipelines (NW) Inc. holds all of the issued and outstanding common shares of 311594 Alberta Ltd.;

AND WHEREAS Enbridge Inc. ("Enbridge") holds all of the issued and outstanding common shares of Enbridge Pipelines (NW) Inc.;

the above named corporations do hereby agree to the following undertakings:

1.0 Definitions

In these undertakings,

1.1 "Act" means the *Ontario Energy Board Act, 1998*;

1.2 "**affiliate**" has the same meaning as it does in the *Business Corporations Act*;

1.3 "**Board**" means the Ontario Energy Board;

1.4 "**business activity**" has the same meaning as it does under the Act or a regulation made under the Act; and

1.5 "**electronic hearing**", "**oral hearing**" and "**written hearing**" have the same meaning as they do under the *Statutory Powers Procedure Act*.

2.0 **Restriction on Business Activities**

2.1 Consumers shall not, except through an affiliate or affiliates, carry on any business activity other than the transmission, distribution or storage of gas, without the prior approval of the Board.

3.0 **Maintenance of common equity**

3.1 Where the level of equity in Consumers falls below the level which the Board has determined to be appropriate in a proceeding under the Act or a predecessor Act, Consumers shall raise or Enbridge and its affiliates shall provide within 90 days, or such longer period as the Board may specify, sufficient additional equity capital to restore the level of equity in Consumers to the appropriate level.

3.2 Any additional equity capital provided to Consumers by Enbridge or its affiliates shall be provided on terms no less favourable to Consumers than Consumers could obtain directly in the capital markets.

4.0 Head Office

4.1 The head office of Consumers shall remain within the franchise area of Consumers.

5.0 Prior Undertakings

5.1 Subject to Article 5.2, these undertakings supersede, replace and are in subsitution for all prior undertakings of Consumers, Enbridge and their affiliates.

5.2 The undertakings of British Gas PLC and Consumers dated June 16th, 1994 and approved by the Lieutenant Governor in Council on June 23rd, 1994, remain in full force and effect.

6.0 Dispensation

6.1 The Board may dispense, in whole or in part, with future compliance by any of the signatories hereto with any obligation contained in an undertaking.

7.0 Hearing

7.1 In determining whether to grant an approval under these undertakings or a dispensation under Article 6.1, the Board may proceed without a hearing or by way of an oral, written or electronic hearing.

8.0 Monitoring

8.1 At the request of the Board, Consumers, Enbridge and their affiliates will provide to the Board any information the Board may require related to compliance with these undertakings.

9.0 Enforcement

9.1 The parties hereto acknowledge that there has been consideration exchanged for the receipt and giving of the undertakings and agree to be bound by these undertakings.

9.2 Any proceeding or proceedings to enforce these undertakings may be brought and enforced in the courts of the Province of Ontario and Enbridge, Consumers and their affiliates hereby submit to the jurisdiction of the courts of the Province of Ontario in respect of any such proceeding.

9.3 For the purpose of service of any document commencing a proceeding in accordance with Article 9.2, it is agreed that Consumers is the agent of Enbridge and its affiliates and that personal service of documents on Consumers will be sufficient to constitute personal service on Enbridge and its affiliates.

10.0 Release from undertakings

10.1 Enbridge, Consumers and their affiliates are released from these undertakings on the day that Enbridge no longer holds, either directly or through its affiliates, more than 50 per cent of the voting securities of Consumers or on the day that Consumers sells its gas transmission and gas distribution systems.

11.0 Effective Date

11.1 These undertakings become effective on March 31, 1999.

DATED this 7th day of December, 1998.

THE CONSUMERS' GAS COMPANY LIMITED

by ______________________

____

ENBRIDGE CONSUMERS ENERGY INC.

by ______________________

____

311594 ALBERTA LTD.

by ______________________

____

ENBRIDGE PIPELINES (NW) INC.

by ______________________

____

ENBRIDGE INC.

by ______________________

____

Ontario
Executive Council
Conseil des ministres

Order in Council
Décret

On the recommendation of the undersigned, the Lieutenant Governor, by and with the advice and concurrence of the Executive Council, orders that:

Sur la recommandation du soussigné, le lieutenant-gouverneur, sur l'avis et avec le con- sentement du Conseil des ministres, décrète ce qui suit:

WHEREAS Enbridge Distribution Inc. and related parties gave undertakings to the Lieutenant Governor in Council that were approved by Order in Council on December 9, 1998 and that took effect on March 31, 1999; and Union Gas Limited and related parties gave undertakings to the Lieutenant Governor in Council that were approved by Order in Council on December 9, 1998, and that took effect on March 31, 1999;

AND WHEREAS opportunities exist for Enbridge Distribution Inc. and Union Gas Limited to carry on business activities that could assist the Government of Ontario in achieving its goals in energy conservation;

AND WHEREAS the Minister of Energy may issue, and the Ontario Energy Board shall implement, directives that have been approved by the Lieutenant Governor in Council that require the Board to take steps specified in the directives to promote energy conservation, energy efficiency, load management or the use of cleaner energy sources, including alternative and renewable energy sources;

NOW THEREFORE the attached Directive is approved.

Recommended: ____________________
Minister of Energy

Concurred: ____________________
Chair of Cabinet

Approved and Ordered: AUG 10 2006
Date

____
Administrator of the Government

O.C./Décret 1537/2006

Minister of Energy

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Ontario

MINISTER'S DIRECTIVE

Re: Gas Utility Undertakings

Enbridge Gas Distribution Inc. and related parties gave undertakings to the Lieutenant Governor in Council that were approved by Order in Council on December 9, 1998 and that took effect on March 31, 1999 ("the Enbridge Undertakings"); and Union Gas Limited and related parties gave undertakings to the Lieutenant Governor in Council that were approved by Order in Council on December 9, 1998 and that took effect on March 31, 1999 ("the Union Undertakings").

Pursuant to section 27.1 of the *Ontario Energy Board Act, 1998*, I hereby direct the Ontario Energy Board to dispense,

- under section 6.1 of the Enbridge Undertakings, with future compliance by Enbridge Gas Distribution Inc. with section 2.1 ("Restriction on Business Activities") of the Enbridge Undertakings, and
- under section 6.1 of the Union Undertakings, with future compliance by Union Gas Limited with section 2.1 ("Restriction on Business Activities") of the Union Undertakings,

in respect of the provision of services by Enbridge Gas Distribution Inc. and Union Gas Limited that would assist the Government of Ontario in achieving its goals in energy conservation, including services related to:

(a) the promotion of electricity conservation, natural gas conservation and the efficient use of electricity;

(b) electricity load management; and

(c) the promotion of cleaner energy sources, including alternative energy sources and renewable energy sources.

.../cont'd

In addition, pursuant to section 27.1 of the *Ontario Energy Board Act, 1998*, I hereby direct the Board to dispense, under section 6.1 of the Enbridge Undertakings, with future compliance with section 2.1 of the Enbridge Undertakings in respect of research, review, preliminary investigation, project development and the provision of services related to the following business activities:

(a) the local distribution of steam, hot and cold water in a Markham District Energy initiative; and

(b) the generation of electricity by means of large stationary fuel cells integrated with energy recovery from natural gas transmission and distribution pipelines.

Further, pursuant to section 27.1 of the *Ontario Energy Board Act, 1998*, I hereby direct the Board to dispense, under section 6.1 of the Union Undertakings, with future compliance with section 2.1 of the Union Undertakings in respect of research, review, preliminary investigation, project development and the provision of services related to the following business activities:

(a) the generation of electricity by means of large stationary fuel cells integrated with energy recovery from natural gas transmission and distribution pipelines.

To the extent that any activities undertaken by Enbridge Gas Distribution Limited or Union Gas Limited in reliance on this Directive are forecast to impact upon their regulated rates, such activities are subject to the review of the Ontario Energy Board under the *Ontario Energy Board Act, 1998*.

In this directive, "alternative energy source" and "renewable energy source" have the same meanings as in the *Electricity Act, 1998*.

Dwight Duncan
Minister

Order in Council
Décret

Ontario
Executive Council
Conseil des ministres

On the recommendation of the undersigned, the Lieutenant Governor, by and with the advice and concurrence of the Executive Council, orders that:

Sur la recommandation du soussigné, le lieutenant-gouverneur, sur l'avis et avec le consentement du Conseil des ministres, décrète ce qui suit:

WHEREAS Enbridge Gas Distribution Inc. and related parties ("Enbridge") gave undertakings to the Lieutenant Governor in Council that were approved by Order in Council on December 9, 1998 and that took effect on March 31, 1999 ("the Enbridge Undertakings"), and Union Gas Limited and related parties ("Union") gave undertakings to the Lieutenant Governor in Council that were approved by Order in Council on December 9, 1998 and that took effect on March 31, 1999 ("the Union Undertakings");

AND WHEREAS the Minister of Energy and Infrastructure has the authority under section 27.1 of the *Ontario Energy Board Act, 1998* to issue directives, approved by the Lieutenant Governor in Council, that require the Ontario Energy Board to take steps specified in the directives to promote energy conservation, energy efficiency, load management and the use of cleaner energy sources including alternative and renewable energy sources;

AND WHEREAS The Government of Ontario has, with the passage of the *Green Energy and Green Economy Act, 2009,* embarked upon a historic series of initiatives related to promoting the use of renewable energy sources and enhancing conservation throughout Ontario;

AND WHEREAS certain amendments to the *Ontario Energy Board Act, 1998* provided for by the above-noted statute authorize electricity distribution companies to directly own and operate renewable energy electricity generation facilities with a capacity of ten (10) megawatts or less, facilities that generate heat and electricity from a single source, or facilities that store energy, subject to criteria to be prescribed by regulation;

AND WHEREAS it is desirable that both Enbridge and Union are accorded authority similar to those of electricity distributors to own and operate the kinds of generation and storage facilities referenced above, while clarifying that the latter two activities, namely the ownership and operation of facilities that generate heat and electricity from a single source, or facilities that store energy, are to be interpreted to include stationary fuel-cell facilities each of which does not exceed 10 Megawatts in capacity, as well as to allow Enbridge and Union the authority to own and operate assets required in respect of the provision of services by Enbridge and Union that would assist the Government of Ontario in achieving its goals in energy conservation including where such assets relate to solar-thermal water and ground-source heat pumps;

AND WHEREAS the Minister of Energy has previously issued a directive pursuant to section 27.1 in respect of the Enbridge Undertakings and the Union Undertakings, under Order-in-Council No. 1537/2006, dated August 10, 2006.

NOW THEREFORE the directive attached hereto is approved and is effective as of the date hereof.

Recommended: ____________________
Minister of Energy and Infrastructure

Concurred: ____________________
Chair of Cabinet

Approved and Ordered: SEP 0 8 2009
Date

____
Lieutenant Governor

O.C./Décret 1540/2009

MINISTER'S DIRECTIVE

Re: Gas Utility Undertakings Relating to the Ownership and Operation of Renewable Energy Electricity Generation Facilities, Facilities Which Generate Both Heat and Electricity From a Single Source and Energy Storage Facilities and the Ownership and Operation of Assets Required to Provide Conservation Services.

Enbridge Gas Distribution Inc. and related parties gave undertakings to the Lieutenant Governor in Council that were approved by Order in Council on December 9, 1998 and that took effect on March 31, 1999 ("the Enbridge Undertakings"); and Union Gas Limited and related parties gave undertakings to the Lieutenant Governor in Council that were approved by Order in Council on December 9, 1998 and that took effect on March 31, 1999 ("the Union Undertakings").

The Government of Ontario has, with the passage of the *Green Energy and Green Economy Act, 2009,* embarked upon a historic series of initiatives related to promoting the use of renewable energy sources and enhancing conservation throughout Ontario.

One of those initiatives is to allow electric distribution companies to directly own and operate renewable energy electricity generation facilities of a capacity of not more than 10 megawatts or such other capacity as is prescribed by regulation, facilities which generate both heat and electricity from a single source and facilities for the storage of energy, subject to such further criteria as may be prescribed by regulation.

The Government also wants to encourage initiatives that will reduce the use of natural gas and electricity.

Pursuant to section 27.1 of the *Ontario Energy Board Act, 1998*, and in addition to a previous directive issued thereunder on August 10, 2006 by Order in Council No. 1537/2006, in respect of the Enbridge Undertakings and the Union Undertakings, I hereby direct the Ontario Energy Board to dispense,

- under section 6.1 of the Enbridge Undertakings, with future compliance by Enbridge Gas Distribution Inc. with section 2.1 ("Restriction on Business Activities") of the Enbridge Undertakings, and
- under section 6.1 of the Union Undertakings, with future compliance by Union Gas Limited with section 2.1 ("Restriction on Business Activities") of the Union Undertakings,

in respect of the ownership and operation by Enbridge Gas Distribution, Inc. and Union Gas Limited, of:

(a) renewable energy electricity generation facilities each of which does not exceed 10 megawatts or such other capacity as may be prescribed, from time to time, by regulation made under clause 71(3)(a) of the *Ontario Energy Board Act, 1998* and which meet the criteria prescribed by such regulation;

(b) generation facilities that use technology that produces power and thermal energy from a single source which meet the criteria prescribed, from time to time, by regulation made under clause 71(3)(b) of the *Ontario Energy Board Act, 1998*;

(c) energy storage facilities which meet the criteria prescribed, from time to time, by regulation made under clause 71(3)(c) of the *Ontario Energy Board Act, 1998*; or

(d) assets required in respect of the provision of services by Enbridge Gas Distribution Inc. and Union Gas Limited that would assist the Government of Ontario in achieving its goals in energy conservation and includes assets related to solar-thermal water and ground-source heat pumps;

(e) for greater certainty, the use of the word "facilities" in paragraphs (b) and (c) above shall be interpreted to include stationary fuel-cell facilities each of which does not exceed 10 Megawatts in capacity.

This directive is not in any way intended to direct the manner in which the Ontario Energy Board determines, under the *Ontario Energy Board Act, 1998,* rates for the sale, transmission, distribution and storage of natural gas by Enbridge Gas Distribution Inc. and Union Gas Limited.

George Smitherman

George Smitherman
Deputy Premier, Minister of Energy and Infrastructure

ENBRIDGE GAS INC.
Answer to Interrogatory from
Environmental Defence (ED)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1 Page 1

Question:

(a) In support of this application, Enbridge notes that it is “consistent with the environmental goals of public policy provincially and federally.” Please list these and include copies of the relevant policy documents.
(b) Please elaborate on how public policy consistency is relevant for the criteria for approval under the sections of the OEB Act at issue (s. 90 and 36) and the associated OEB rules and guidelines. Please specifically identify the pertinent criteria, its source, and how public policy factors in.

Response:

a) The policy documents are listed below along with links to each document.

Provincial

Ontario:

1. Under the previous Liberal government in Ontario:
   a. *The Ontario Climate Change Action Plan 2016-2020.*
   b. (Ref: http://www.applications.ene.gov.on.ca/ccap/products/CCAP_ENGLISH.pdf)

2. Under the current Conservative Government in Ontario:
   a. *A Made-in-Ontario Environmental Plan.*
   b. (Ref: https://www.ontario.ca/page/made-in-ontario-environment-plan)

Federal

1. Clean Fuel Standard – which is still in its development stage
   - (Ref: https://www.canada.ca/content/dam/eccc/documents/pdf/climate-change/pricing-pollution/Clean-fuel-standard-proposed-regulatory-approach.pdf)

2. NSERC Hydrogen Canada Strategic Research Network (2008-2013)
   - Ref: (https://www.nserc-crsng.gc.ca/Business-Entreprise/How-Comment/Networks-Reseaux/H2CAN-H2CAN_eng.asp)

3. 2019 Hydrogen Pathways – Enabling a Clean Growth Future for Canadians
   - (Ref: https://www.nrcan.gc.ca/energy-efficiency/energy-efficiency-transportation/resource-library/2019-hydrogen-pathways-enabling-clean-growth-future-canadians/21961)

4. Canada's Energy Transition
   - (Ref: https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/CoucilReport_june27_English_Web.pdf)

b) In making decisions under the *Ontario Energy Board Act*, including under sections 36 and 90, the Board is guided by the objectives set out in section 2 ("Board Objectives, gas").

One of these objectives speaks directly to consistency with the Government's energy conservation policies. Section 2(5) indicates that one of the objectives is "To promote energy conservation and energy efficiency in accordance with the policies of the Government of Ontario, including having regard to the consumer's economic circumstances." The LCEP will lower GHG emissions for all Ontarians and will do so in a manner that will ensure customers are not paying any more for natural gas than they otherwise would absent the Project.

Additionally, the EB-2017-0129 Report of the Board: Framework for the Assessment of Gas Distributor Gas Supply Plans, dated October 25, 2018 states the Board's expectation that the utility's gas supply plan will be developed to ensure that it supports and is aligned with public policy where appropriate (section 3.1, page 8). Hydrogen procurement and the production of blended gas supports and is aligned with public policy related to GHG emission reductions.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Environmental Defence (ED)

INTERROGATORY

Reference:

Exhibit A, Tab 2, Schedule 1, p. 1

Preamble:

Enbridge states that:

> “The LCEP is a pilot project that will allow the Company to green a portion of the natural gas grid in Ontario. The experience gained through the implementation of the LCEP will position Enbridge Gas to then expand hydrogen injection into other parts of its gas distribution system, further enhancing reductions to GHG emissions across the province.”
>
> It also states that this project is “consistent with the environmental goals of public policy provincially and federally.”

Question:

(a) Please calculate the cost of GHG emissions reductions ($/CO2e) from hydrogen injection including only the incremental commodity costs of replacing natural gas with hydrogen created via power-to-gas. Please use Enbridge’s estimate of the cost to produce hydrogen by power-to-gas in Ontario. Please provide a table showing the underlying calculations.

(b) Please calculate the cost of GHG emissions reductions ($/CO2e) from hydrogen injection including both the incremental commodity costs (replacing natural gas with hydrogen created via power-to-gas) and the incremental capital costs (upgrades to gas distribution and transmission). For the incremental commodity costs, please use Enbridge’s estimate of the cost to produce hydrogen by power-to-gas in Ontario. For the incremental capital costs, please use Enbridge’s best estimate of the capital cost per m3 of injecting hydrogen into the gas system. Please provide a table showing the underlying calculations.

(c) Please recalculate the cost of GHG reductions in (b) but for the incremental capital costs, please use the cost per m3 of hydrogen for this pilot project. Please provide a table showing the underlying calculations.

(d) Please provide the annual forecast throughput of hydrogen for the proposed pilot project.
(e) For comparative purposes, please provide the cost of GHG emissions reductions (\$/CO2e) from natural gas energy efficiency programs. Please provide an explanation if Enbridge's figures are inconsistent or out of line with those in the OEB's Marginal Abatement Cost Curve Final Report, EB-2016-0359, July 20, 2017 (which indicates a significant negative cost per CO2e for energy efficiency).
(f) For comparative purposes, please provide the cost of GHG emissions reductions (\$/CO2e) from renewable natural gas. Please provide an explanation if Enbridge's figures are inconsistent or out of line with those in the OEB's Marginal Abatement Cost Curve Final Report, EB-2016-0359, July 20, 2017.
(g) For comparative purposes, please provide the cost of GHG emissions reductions (\$/CO2e) from converting to geothermal instead of natural gas including only the difference in annual operating costs (i.e. commodity costs). Please base the answer on the evidence prepared by Dr. Stanley Reitsma, P. Eng. in EB-2016-0004 dated March 21, 2016 (p. 35-37) or explain why different figures are used.
(h) For comparative purposes, please provide the cost of GHG emissions reductions (\$/CO2e) from converting to geothermal instead of natural gas including the difference in annual operating costs (lifetime) and incremental capital costs (including the capital costs to expand gas service to the new community). Please base the answer on the evidence prepared by Dr. Stanley Reitsma, P. Eng. in EB-2016-0004 dated March 21, 2016 (p. 35-37) or explain why different figures are used.

For each of the above, please answer the question on a best-efforts basis and with any caveats as necessary. If a portion of the historic data or forecast is impossible to provide, please explain why and answer the question over as long a time period as possible. If certain parts of the answer cannot be estimated, please explain why and provide as much of the table as possible. Please make assumptions as necessary and state all assumptions.

<u>Response:</u>

a) Because hydrogen will be sold to Enbridge Gas at the same price as conventional natural gas (see Exhibit I.STAFF.2(d)), there is no incremental commodity cost to replace natural gas with hydrogen for the LCEP pilot. As there is no incremental cost, there is no cost of GHG emission reduction per tonne CO_2e. If one was to assume a price of \$0.55 to \$0.70 per m^3 for hydrogen as indicated at Exhibit I.ED.6 (d) and assuming annual blending of up to approximately 200,000 cubic meters of hydrogen results in a reduction of 120 tCO_2e per year, the cost of GHG emission reductions from the assumed cost of hydrogen is estimated as between \$925 and

$1,151 /tCO$_2$e. See Attachment 1 for calculations and assumptions.

b) The cost of GHG emission reductions from incremental hydrogen commodity costs is set out in the response to part (a) above.

Enbridge has estimated the annual maximum revenue requirement for capital recovery of system upgrades as $487,000. Assuming an annual blending of up to 200,000 cubic meters of hydrogen results in a reduction of approximately 120 tCO$_2$e per year, the cost of GHG emission reductions from the incremental capital cost is estimated as $4,058/tCO$_2$e. The capital cost of system upgrades expressed on a dollar per cubic meter hydrogen basis was estimated at $2.44 per cubic meter of hydrogen. This impact will be reduced if Enbridge Gas expands the LCEP to include loops S1a and S1b. Note that there is no impact from the capital additions until rebasing in 2024.

c) Refer to part (b) above.

d) The maximum estimated forecasted annual throughput of hydrogen for the proposed pilot project is ~200,000 m^3/y or ~2,400 GJ/year.

e) Please see Exhibit I.Staff.8 (d).

f) Enbridge Gas's estimation of the marginal abatement carbon cost for RNG are consistent with the MACC where the average RNG abatement cost ranged from $133 to $1,867/t CO2e. Enbridge Gas notes that the RNG abatement costs as provided in the OEB's MACC Final Report are not based on a lifecycle approach and are limited to emission reductions from the displacement of natural gas. RNG may provide further GHG reductions from the capture of methane that may have otherwise been released to the atmosphere. GHG reductions from the avoided release of methane can be quantified in various carbon offset protocols.

g) Please see Exhibit I.Staff.8 (d).

h) Please see Exhibit I.Staff.8 (d).

	(a)	(b) = (a) x (p)	(c) = (b) / (s)	(d) = (c) * (r)
Scenario	Average Customer Usage (m^3)	Average Customer Energy Input (MJ)	Blended Gas Volumetric Consumption (m^3)	Volume of Hydrogen in Blended Gas (m^3)
Average	2,400	92,472	2,433	49
Maximum	2,671	102,914	2,707	54
Minimum	2,153	82,955	2,182	44

Assumptions:

(p)	Higher Heating Value of Natural Gas (MJ/m^3)	38.5
(q)	Higher Heating Value of Hydrogen Gas (MJ/m^3)	12.7
(r)	Amount of Hydrogen (% by volume)	2
(s)	= (q)*(r) + (1-(r))*(p) Higher Heating Value of the Blended G	38.01
(t)	Emission Factor (tCO_2e/m^3)	0.001874
(u)	Number of Customers	3,600
(v)	Commodity Cost of Natural Gas ($/m3)	0.0812
(w)	Carbon Charge at $30/t ($/m3)	0.0587
(x)	Commodity Cost of Low Range Hydrogen ($/m3)	0.56
(y)	Commodity Cost of High Range Hydrogen ($/m3)	0.70

(e) = (c) - (d)	(f) = (a) * (t)	(g) = (e) * (t)	(h) = (f) - (g)	(i) = (h) * (u)	(j) = (c) * (u)
Volume of Methane in Blended Gas (m^3)	GHG From Traditional Natural Gas (tCO_2e)	GHG From Blended Gas (tCO_2e)	GHG Reductions per customer (tCO_2e)	Total GHG Reductions (tCO_2e)	Annual Volume of Hydrogen Blended (m3)
2,384	4.50	4.47	0.03	108	175,148
2,653	5.01	4.97	0.03	120	194,926
2,139	4.03	4.01	0.03	97	157,123

(k) = (a) * ((v) + (w))	(l) = ((d) * (x)) + ((e) * (v)) + ((c) * (w))	(m) = ((d) * (y)) + ((e) * (v)) + ((c) * (w))	(n) = ((l) - (k)) / (h)	(o) = ((m) - (k)) / (h)
Cost of Traditional Natural Gas ($/yr)	Cost of Blended Gas at Lower Price Hydrogen ($/yr)	Cost of Blended Gas at Higher Price Hydrogen ($/yr)	Cost of GHG Reduction for Lower Cost Blended Gas ($/tCO2e)	Cost of GHG Reduction for Higher Cost Blended Gas ($/tCO2e)
336	364	370	925	1,151
374	405	412	925	1,151
301	326	332	925	1,151

ENBRIDGE GAS INC.
Answer to Interrogatory from
Federation of Rental-housing Providers of Ontario (FRPO)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, Page 3

Preamble:

EGI evidence states: “The heating value of hydrogen is approximately 1/3 that of natural gas.”

We appreciate that EGI is striving to compensate for the impact to heat value. We would like to understand how EGI is compensating for other aspects of the hydrogen stream.

Question**:**

What is the maximum pressure that flows through a customer meter in the service territory?

a) Please describe how EGI has compensated for the difference in hydrogen’s characteristics of supercompressibility.

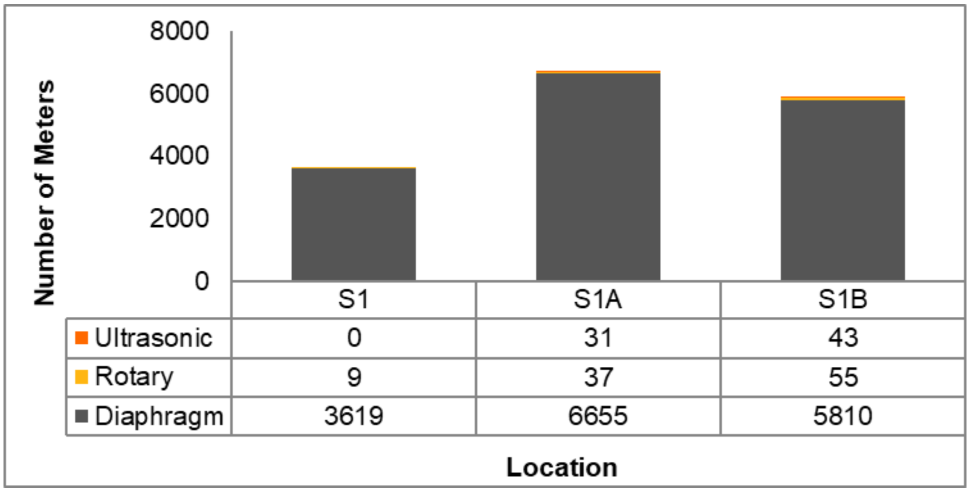
Response:

The maximum pressure which flows through a customer meter would be 55 psig, where measurement occurs upstream of the regulator.

a) Prior to blending hydrogen in natural gas the correction factors used in the blended gas area will be evaluated and corrected accordingly. The supercompressibility of the fuel is factored into the correction factors modules for rotary meters which correct for temperature and pressure. Updates to rotary meters can be completed onsite via computer. Diaphragm meters do not have supercompressibility factors because they to not contain an electronic corrector module.

   Diaphragm and rotary meters are positive-displacement meters that operate on the principle of using a fixed volumetric space that fills and empties as the meter turns. As this volume is fixed, the volume of the blended gas will be measured in the same way as traditional natural gas. As shown in the Figure below, positive-displacement meters consist of 99.5% of the meter population with diaphragm meters at 98.9% and rotary meters at 0.6%.

An ultrasonic meter measures the velocity of the gas using ultrasound to calculate the volumetric flow. The gas composition impacts the acoustic properties of the gas, which can change the measurement accuracy. The addition of hydrogen can affect the measurement accuracy if it changes the density or viscosity of the blended gas compared to natural gas. The ultrasonic meters installed in these networks are smaller scale models. Sonix (the manufacturer) confirmed the suitability of their ultrasonic meters with up to 5% by volume hydrogen.



	S1	S1A	S1B
■ Ultrasonic	0	31	43
■ Rotary	9	37	55
■ Diaphragm	3619	6655	5810

There are other types of meters approved for use in Legacy EGD’s distribution system; however, they are not installed in the selected networks.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Federation of Rental-housing Providers of Ontario (FRPO)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, Page 4

Preamble:

EGI evidence states: "Commodity Impact – This is the gas cost impact associated with procuring hydrogen rather than traditional natural gas for customers in the BGA. Enbridge Gas is proposing to acquire hydrogen in a manner that keeps ratepayers cost-neutral."

We would like to understand better the expected cost of hydrogen.

Question**:**

From the research done by EGI, what was the cost of hydrogen.

a) What agreement does EGI have in place with its affiliate to pay for hydrogen?
b) Please provide the mechanism, formula or other construct that EGI has entered into to pay for hydrogen.

Response:

a) & b) Please see Exhibit I.CCC.10 and Exhibit I.STAFF.2(d).

ENBRIDGE

Enbridge
500 Consumers Road
North York, ON, M2J 1P8

HYDROGENICS
SHIFT POWER | ENERGIZE YOUR WORLD

Hydrogenics
220 Admiral Blvd,
Mississauga, ON L5T 2N6

December 18, 2019

2562961 Ontario Ltd.

Non-Binding Term Sheet for: Sale of Renewable Hydrogen from 2562961 Ontario Ltd. To Enbridge Gas Inc. For Hydrogen Blending Pilot Project

This *Term Sheet* **(the "Term Sheet")** sets out without limitations, the basic terms to be included in a future Agreement between *Enbridge Gas Inc. ("EGI")* and *2562961 Ontario Ltd.*, a joint venture between 2099364 Ontario Limited and Hydrogenics Inc., for the procurement of renewable hydrogen. The proposed transaction is subject to finalization and acceptance of an agreement negotiated between both parties. This term sheet does not constitute a binding contract between the parties.

Subject to the *Ontario Energy Board's* **("OEB")** approval of EGI's, *Leave to Construct* **("LTC")** Application, for its *Low Carbon Energy Project* **("LCEP")** to blend hydrogen into a portion of its gas distribution system, 2562961 Ontario Ltd., agrees to sell up to 200,000 m^3 annually (approximately 16,700kg or 2,400GJ) of electrolyzed hydrogen to EGI, to support EGI's blending of renewable hydrogen into a portion of its natural gas distribution system pilot project.

Price

Unless otherwise directed by the Ontario Energy Board, the price paid for the hydrogen procured by EGI will not result in any impact to EGI customer bills in the applicable EGI rate zone.

Term of Service

The term of this agreement will be effective from the in-service date for the LCEP project currently scheduled to be Q4-2020 and shall survive for as long as EGI's pilot project for blending hydrogen into its natural gas distribution system continues. The need to supply renewable hydrogen will cease when EGI discontinues its hydrogen blending project, or the project has come to the end of its service life.

Terms Subject to Change

The supply of renewable hydrogen by 2562961 Ontario Limited is subject to the following conditions which may alter the production and subsequent sale of hydrogen by 2562961 Ontario Ltd to EGI:

1. Survival and renewal of the contract between the 2562961 Ontario Ltd. and the Independent Electric System Operator (the "IESO Contract") at the end of its current three (3) year term.
2. Changes in IESO Contract pertaining to 2562961 Ontario Limited's cost of electricity under that agreement.
3. Introduction of new government regulations such as the Clean Fuel Standards **("CFS")**
4. The hydrogen produced will be produced by electrolysis at 2562961 Ontario Limited's facility located in Markham Ontario.

Terms shall be subject to an update when the federal government CFS comes into force on January 1 2023 for gaseous and solid fuels regulations.

2562961 ON Ltd.

By:
Name: Scott Dodd
Title: President

By:
Name:
Title:

Enbridge Gas Inc.

By:
Name: Jamie LeBlanc
Title: Director Gas Supply

By:
Name: **Malini Giridhar**
Title: **Vice President,**
Business Development & Regulatory

ENBRIDGE GAS INC.
Answer to Interrogatory from
Federation of Rental-housing Providers of Ontario (FRPO)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, Page 5

Preamble:

EGI evidence states: “An affiliate of Enbridge Gas, 2562961 Ontario Ltd., has developed and built North America’s first utility scale PtG facility in Markham, Ontario.”

We would like to understand how EGI is managing the potential for conflict of interest in this relationship.

Question**:**

Please provide the percentage ownership that Enbridge Inc. has in the named Ontario company.

a) Please describe how EGI plans to manage any potential conflicts of interest in this emerging market.

Response:

For information concerning the ownership structure of 2562961 Ontario Limited please see Exhibit I.CCC.11.

a) Any potential conflicts of interest between Enbridge Gas and 2562961 Ontario Limited have been and will continue to be addressed through Enbridge Gas’ adherence to the requirements of the Ontario Energy Board’s Affiliate Relationships Code for Gas Utilities.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Federation of Rental-housing Providers of Ontario (FRPO)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, Page 6

Preamble:

EGI evidence states: “The hydrogen produced by the plant will be captured, stored and injected into the portion of the Company’s gas distribution system serving the BGA, thereby lowering the GHG emissions associated with the consumption of natural gas in this area and greening the gas distribution grid.”

We would like to understand better how equipped EGI is to maintain a constant 2% blend during this pilot.

Question**:**

Based upon an average winter day consumption, how many days can the hydrogen storage provide a 2% hydrogen injection into the system?

Response:

The power to gas plant at the TOC operates when dispatched by the IESO. The power to gas plant was commissioned in 2018. In 2019 and year to date 2020, average day hydrogen production from the power to gas plant was in excess of 3,000 m^3 per day. Other than times when the power gas plant has not operated because of downtime required for maintenance, the plant has been dispatched virtually every day.

Enbridge Gas forecasts that it may require up to 200,000 m^3 per year of hydrogen to supply blended gas (at a 2% by volume concentration) to customers in the BGA. The hydrogen production from the power to gas plant is more than sufficient for this blending requirement.

In 2018 average winter day demand for residential customers in the BGA was 41,380 m^3 per day. 2% of this volume is 828 m^3. The hydrogen storage tank onsite at the TOC has a capacity of 2,000 m^3. Operationally the storage tank can deliver approximately 1,000 m3 per day. This equates to 1.2 days of storage on an average winter day. The storage tank be cycled unless the power to gas plant is not operational.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Federation of Rental-housing Providers of Ontario (FRPO)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, Page 12

Preamble:

EGI evidence states: “The hydrogen blending station will control the amount of blended gas being injected into the natural gas distribution system.”

We would like to understand better the risks and mitigation strategies that EGI has contemplated.

Question**:**

Please describe the potential failure modalities of the blending station.

a) For each, please provide the fail safe mechanism that is applied.

Response:

Please refer to Exhibit I.CCC.3.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Federation of Rental-housing Providers of Ontario (FRPO)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, Page 16

Preamble:

EGI evidence states: “Given that the Proposed Facilities are required to enable the Company to reduce the GHG footprint of its utility gas distribution system, these facilities should be fully attributed to system reinforcement and general distribution growth and managed within the rolling project portfolio in accordance with Enbridge Gas’s normal business practice.

We would like to understand the basis upon which EGI is proposing this classification and what options were or should have been considered.

Question**:**

Please describe how this investment contributes to reinforcement of the system and growth of the distribution system.

a) Please describe what other categories considered (e.g., separate account to track capital, analysis, maintenance costs)
b) Please provide the company’s view on why this investment is not an investment in long-term recovery of asset return more akin to business development.

Response:

With respect to the Company’s Rolling Project Portfolio, the OEB’s EBO 188 final report states;

> The Board is of the view that all distribution system expansion projects should be
> included in a utility's portfolio. This includes projects being developed for security of supply and system reinforcement reasons. The Board will be prepared on an exception basis to consider a utility's submissions as to why a proposed project should not be included in the portfolio but treated separately.
>
> (EBO 188, Final Report of The Board, para 2.1.2, page 7)

Enbridge Gas is of the view that the proposed facilities that are the subject of this application meet the above requirement.

a) Enbridge Gas has not considered any other treatment of the costs associated with this project. (e.g., separate account to track capital, analysis, maintenance costs).

b) In the Company's view that the facilities which are the subject of this application are long term gas distribution system assets and their costs should be treated in the same manner as any other gas distribution system asset.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Federation of Rental-housing Providers of Ontario (FRPO)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, Page 18

Preamble:

EGI evidence states: “There will be no impact to customer bills as the cost of hydrogen will be the same as the cost of traditional natural gas.”

We would like to understand better the equivalency suggested in this statement.

Question**:**

Please clarify on what basis is the price of hydrogen and natural gas equivalent?

a) On that basis of equivalency, please provide the market price of hydrogen from a referenced source.

Response:

a) Please refer to Exhibit I.CCC.10 and Exhibit I.Staff.2.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Federation of Rental-housing Providers of Ontario (FRPO)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, Attachment 1, Page 2

Preamble:

EGI evidence states: "Any recommendations resulting from this work were based on validation against existing operational and design practices to identify and track potential gaps and/or incompatibilities in order to facilitate the effective implementation into Enbridge Gas's Operations."

We would like to understand better this validation process and what "existing operational and design practices" were used for this novel application.

Question**:**

Please provide the source technical documents relied upon for the impact of hydrogen on pipeline components and appliances.

a) Please provide the report containing the recommendations.
b) What is the company's opinion on who would be at risk for any costs incurred as a result of failure of components or appliances as a result of the hydrogen blend.

Response:

a) Please see Exhibit I.H2GO.1.

b) Enbridge Gas's research concludes that the maximum 2% hydrogen blend by volume does not cause a material change to the combustion parameters of the gas that has been distributed within the BGA. Enbridge Gas research indicates that the risk associated with hydrogen blending in the BGA is acceptable. Any instance of appliance failure or failure of appliance components would more likely be attributable to wear and tear or lack of maintenance. In the unlikely event that it is determined that the hydrogen content of the blended gas delivered in the BGA caused the failure of components or appliances the Company would compensate the affected customer. Enbridge Gas research indicates that the risk associated with hydrogen blending in the BGA is acceptable.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Federation of Rental-housing Providers of Ontario (FRPO)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, Attachment 1, Page 10

Preamble:

EGI evidence states: “This information was gathered in order to inform subsequent work streams on which levels of hydrogen blending should be considered and served as information to orient the further investigation required. Among other things it served to provide a baseline range of hydrogen blending values that may be technically feasible. It also identified the key issues and challenges that must be addressed at a network specific level.

We would like to understand better how this assessment was performed (individually, combined, etc.).

Question**:**

Please provide a summary of the information collected.

a) Were the different aspects of pipeline components and appliances researched separately?
b) Were the ranges of acceptable hydrogen blend the same? Please clarify the ranges defined.

Response:

a) Enbridge Gas has conducted a holistic engineering assessment that separately considered all of the pipeline components and customer appliances in the blended gas area. Enbridge Gas considered all aspects equally in order to derive the conclusions presented in the evidence.

Enbridge Gas’s engineering assessment concluded that 2% hydrogen blending is the acceptable limit for the selected injection area. At the studied levels of hydrogen blending in this area, no direct (safety) issues (flashback, burner overheating, etc.) related to end use equipment is anticipated. The levels were selected as to have no potential “material change”. The definition of “material change” is either a noticeable impact from operation or combustion parameter from the historically delivered fuel.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Federation of Rental-housing Providers of Ontario (FRPO)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, Attachment 1, Page 14

Preamble:

EGI evidence states: "In heating and cooking appliances, the major concerns are flashback and burner overheating. Flashback occurs when the flame retreats back into the tip of the combustion nozzle. Burner overheating can result in failure in extreme cases, but over time can cause issues with the integrity of burners that were not designed for higher temperatures or built with substandard materials."

We would like to understand better this concept of overheating when considered in conjunction with other evidence provided.

Question**:**

If the heat value of hydrogen is less than natural gas, please explain how the blended gas stream would cause the potential for overheating?

Response:

By limiting the hydrogen content of the blended gas stream in the area of study flame temperatures will be equivalent to those historically seen in the area. As referenced in Exhibit B, Tab 1, Schedule 1, page 8, an interchangeability analysis supports this conclusion.

The heating value of hydrogen is lower because the density of hydrogen is approximately 1/8th that of natural gas. However, a pure hydrogen flame burns hotter than a natural gas flame which will in some cases raise the flame temperature of the blended gas. This is dependent on the appliance type, the state of the appliance, operating pressure, hydrogen content and combustion type.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Federation of Rental-housing Providers of Ontario (FRPO)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, Attachment 1, Page 15-16

Preamble:

EGI evidence states: "Enbridge Gas consulted with the Technical Standards and Safety Authority (TSSA) to introduce and provide information on the Project. The TSSA indicated that they will act as a technical reviewer on behalf of the Ontario Energy Board for the LTC application if requested."

We would like to understand better how the TSSA intends to perform the role of technical reviewer.

Question**:**

Please provide a reference to the standards that the TSSA has applied to technical reviews of other hydrogen-natural gas blend projects?

- a) Would these standards be applied to the review of this project?
- b) If not, what standards will be applied?

Response:

a) and b) Please refer to Exhibit I.CCC.7.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Federation of Rental-housing Providers of Ontario (FRPO)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, Attachment 1, Page 16

Preamble:

EGI evidence states: “SNG/MG covers a wide range of compositions that generally fall within the following limits:

- 10 to 90% by volume hydrogen
- 200 ppm to 90% by volume carbon monoxide
- Balance – inert gasses, carbon dioxide, methane

Question:

Please provide the referenced source for the ranges of composition.

Response:

This evidence is based on multiple sources and is included in the evidence for illustrative purposes. The composition of SNG/MG varies widely depending on the specific production method and location. The range is given to demonstrate how broad the definition is. The range put forward was based on information from consultants and some specific production methods that produced the SNG/MG for use in additional processes as a feedstock. Because feedstock process were used the ranges were quite wide.

Depending on the source of production, the SNG/MG utilized in a gas distribution system, would typically be comprised of:

- 10% to 60% by volume hydrogen (much higher than Enbridge Gas is proposing)
- 200 ppm to 50% by volume carbon monoxide
- Balance – inert gasses, carbon dioxide, methane

For example, the historical composition of the fuel in East(ern) Germany is seen below in Figure 1. In this case, town gas can be equated to SNG/MG.

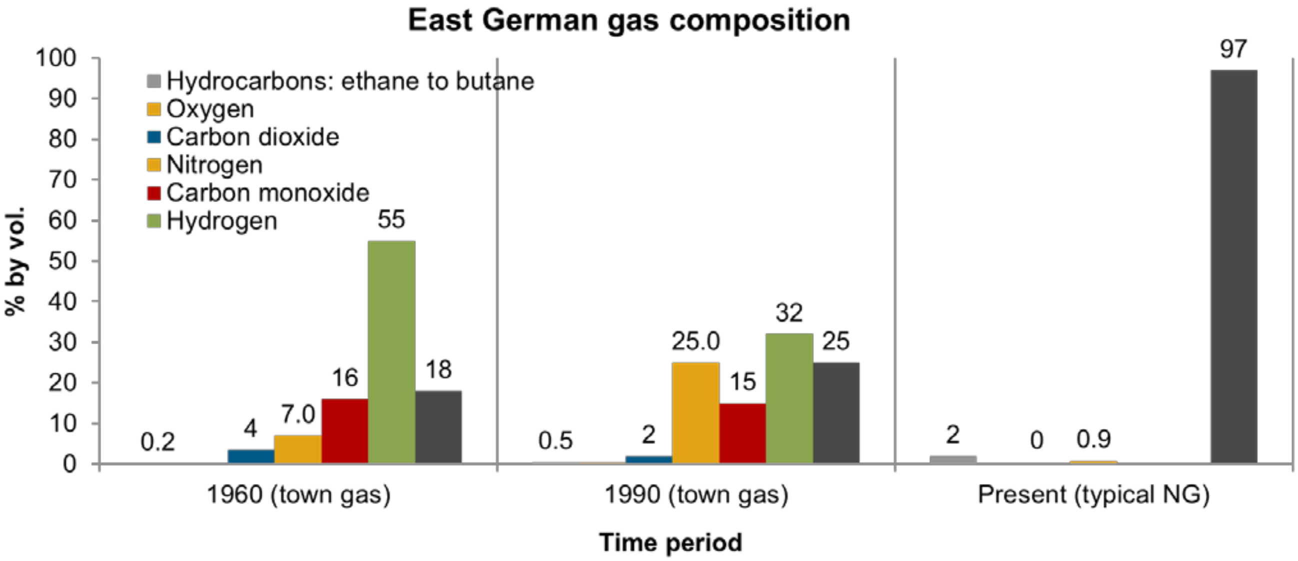


Figure 1: Composition of East(ern) German Gas over Time

Several sources which discuss the composition of SNG/MG are provided below.

Sources:
https://www.nrel.gov/docs/fy13osti/51995.pdf
http://www.heritageresearch.com/documents/More%20About%20Manufactured%20Gas.pdf
https://semspub.epa.gov/work/01/458914.pdf

ENBRIDGE GAS INC.
Answer to Interrogatory from
Federation of Rental-housing Providers of Ontario (FRPO)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, Attachment 1, Page 16

Preamble:

EGI evidence states: "*End-user Equipment*: In the specific area of study, based on the local gas composition, heating equipment and appliances, the upper limit for hydrogen was found to be 2% by volume."

We would like to understand better the constraints on the chosen level of blend.

Question**:**

Please provide the interaction that produced the limitation.

a) What other alternatives to hydrogen limit threshold were considered?

Response:

The interchangeability analysis, where the maximum concentration by volume hydrogen added to the average local gas composition, while remaining within historical performance boundaries, was 2%.

Enbridge Gas' assessment concluded that 2% hydrogen blending is the acceptable limit for the selected injection area. At the studied levels of hydrogen blending in this area, no direct (safety) issues (flashback, burner overheating, etc.) related to end use equipment is anticipated. The levels were selected as to have no potential "material change". The definition of "material change" is either a noticeable impact from operation or combustion parameter from the historically delivered fuel.

In the interchangeability analysis at approximately 2% by volume hydrogen added to natural gas, the burner temperature was calculated to begin to be hotter than the historical range. Since the temperature would be hotter than that of the historically delivered fuel, the possibility of burner overheating would be increased. This increase is difficult or impossible to quantify without further study. Many other factors were calculated but this was the specific factor in the interchangeability analysis that limited the overall conclusion.

a) While a survey of homes and appliances was completed, it was impractical to check every single appliance in the BGA for several reasons (for example, not being able to access, cost, replacement and sustainment of appliances in the area, etc.). It was for this reason that the interchangeability analysis formed the basis of the conclusions for the end-user equipment. This type of analysis is used frequently when assessing the potential to supply LNG from different sources, as well as when converting from manufactured gas to natural gas.

   In the interchangeability analysis the range of acceptable gas composition could have also been based on the tariff limits, however since the actual gas composition in the area has been within a much more narrow band this approach was not followed.

   Mitigation measures have been proposed for end use equipment that include adjustment or replacement of appliances at higher percentage of hydrogen, however, these levels were not investigated due to the holistic review, as noted in the evidence.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Federation of Rental-housing Providers of Ontario (FRPO)

INTERROGATORY

Reference:

Exhibit D, Tab 1, Schedule 1

Preamble:

The referenced exhibit identifies test pressures for leak tests. We would like to understand better the testing that EGI has contemplated to test continued integrity of the system after a long duration of exposure (e.g. years) to the hydrogen blend.

Question**:**

Are the pipelines in the loop amenable to any imaging or other inspections which would inspect their integrity after lengthy exposure?

a) Please explain in detail how EGI will ensure that there are no compromises to the integrity of the system prior to expanding the application of the hydrogen blend to other areas.

Response:

Enbridge Gas's Integrity Management Program will track any potential future concerns within the closed loops, such as premature failures. The frequency of leak surveys for the first 5 years following the introduction of blended gas will follow Enbridge Gas's leak survey process and will be increased to identify and track any increases in leak rates. This will allow comparison for leak occurrences within the closed loops with the overall system incidence.

The operation of the Integrity Management Program facilitates proper tracking and mitigation if required. In addition to the activities typically carried out through the Integrity Management Program, Enbridge Gas plans to undertake the following activities additional activities for the BGA:

i. Monitor the leak frequency of the blended gas networks and compare to the expected leak rates
ii. Opportunistic testing of abandoned assets
iii. Evaluation of material and customer issues in the BGA subject to hydrogen

blending.

The table below sets out the type of pipelines in the BGA and the inspection methods for existing pipelines applicable to the BGA.

Type of Pipe	Inspection Method(s)
Plastic • Operating at 55 psig • NTS ½ to NPS 6	• Leak survey
Steel • Operating at 55 psig • NTS ½ to NPS 8	• Leak survey • The steel pipe in the BGA is non-piggable and it is impractical to pig the network with current technology due to a variety of factors.

a) In order to develop the Project, Enbridge Gas has conducted an extensive assessment of the natural gas pipeline infrastructure in the BGA to ensure that it is appropriate for hydrogen blending. Once approved, the Project will become live and Enbridge Gas will monitor the BGA using the methods outlined above to ensure integrity of the BGA.

   Any expansion of hydrogen blending to other areas of the distribution system would require a similar suitability assessment to determine suitability for hydrogen blending in that area. The assessment of suitability would incorporate the application of the assessment methodology applied to the BGA for the immediate Project and the results of this pilot project which will be informed by the inspection methods identified above.

ENBRIDGE GAS INC.
Answer to Interrogatory from
H2GO Canada (H2GO)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, Attachment 1, paras 1, 10-13, 18, 20-21
Exhibit B, Tab 1, Schedule 1, para 4

Preamble:

EGI states that it has conducted a detailed review of the feasibility and recommendations for blending hydrogen into natural gas supply for distribution using existing infrastructure (para 1).

EGI further states that it engaged several consultants in order to complete the analysis and investigation work for hydrogen blending, including a consultant experienced with town-gas applications and a global consulting firm specializing in risk management (para 18).

EGI has concluded that blending hydrogen in a concentration of up to 2% hydrogen is safe and reliable for the LCEP. To define the appropriate hydrogen blending concentration (2%), EGI followed an assessment methodology that included a research and development (R&D) work stream (i.e., literature review) to leverage existing industry knowledge and recommendations from the Canadian Gas Association (**CGA**) / American Gas Association (**AGA**) Task Force on Hydrogen Blending, the HYREADY Consortium, the multi-year European-led NATURALHY technical study and other technical literature (paras 20-21).

EGI's assessment methodology also included a work stream focused on gas distribution network hydrogen tolerance. EGI's investigation into the Blended Gas Closed Loops concluded that 5% hydrogen by volume can be injected (para 24).

Question**:**

Please file copies of any reports, working papers, presentations, datasets, or other materials related to the work performed by the consultant experienced with town-gas applications.

Please file copies of any reports, working papers, presentations, datasets, or other materials related to the work performed by the global consulting firm specializing in risk management.

Please file copies of any reports, working papers, presentations, datasets, or other materials that EGI reviewed in connection with its literature review, including any such materials related to the CGA/AGA Task Force on Hydrogen Blending, the HYREADY Consortium, and the multi-year European-led NATURALHY technical study.

Given that EGI's investigation concluded that up to 5% hydrogen by volume can be injected (para 24), please provide an outline of the reasons why EGI limited both the study and the LCEP to injection of 2% hydrogen by volume. Please file copies of all related reports, working papers, presentations, datasets, or other materials.

Please file a copy of the 2-year engineering assessment recommending 2% hydrogen by volume (Exhibit F, Tab 1, Schedule 1, Attachment 5, p. 3).

Please provide (preferably in table format) EGI's assessments of the potential greenhouse gas (**GHG**) emissions reductions, additional power and gas efficiencies, and costs that may result under each of the following scenarios:

(i) 4% hydrogen by volume and:
  a. 15% enhanced used of natural gas blend as a transportation fuel; and
  b. status quo usage of natural gas and 15% enhanced use of electricity as a transportation fuel.

(ii) 2% hydrogen by volume and:
  a. 15% enhanced used of natural gas blend as a transportation fuel; and
  b. status quo usage of natural gas and 15% enhanced use of electricity as a transportation fuel.

<u>Response:</u>

a) to c) Attachment 1 to this response sets out a literature review report developed by the CGA/AGA. The report contains a summary of findings of a literature review conducted by the CGA/AGA related to hydrogen blending. The CGA has confirmed that this document can be publicly produced.

Enbridge Gas has summarized the findings of its technical review and reports from consultants in Exhibit B, Tab 1, Schedule 1, Attachment 1.

Enbridge Gas has responded to other interrogatories seeking specific additional information about technical aspects of the Project.

Enbridge Gas believes that there is sufficient information on the record related to the safety and technical aspects of the Project.

Other than the CGA/AGA study, Enbridge Gas is not prepared to provide copies of the requested documents (engineering assessment, consultant report, working papers and datasets) for several reasons, including the following.

- The detailed review undertaken by Enbridge Gas (including work by consultants) includes technical information that will be valuable to third parties, including other parties seeking to commercialize hydrogen and/or use hydrogen in gas distribution systems. It is not in the interests of Enbridge Gas and its ratepayers to file such material so that it will be available to these other parties at no cost. That deprives Enbridge Gas and its ratepayers of potential future financial benefit of this material.

- Some of the material requested comes from third party consultants and organizations who have provided the material to Enbridge Gas on a paid basis, and on the understanding that it will not be shared publicly. Those third parties will suffer harm if their work product is provided to the public at no charge.

- The information requested is technical in nature and some of it relates specifically to the portions of the Enbridge Gas distribution system being considered for the Project. The Company is concerned that other parties who access the detailed technical information being requested could mis-interpret of mis-use the information, causing potential safety concerns and potential future exposure to Enbridge Gas.

d) Enbridge Gas's engineering assessment concluded that 2% hydrogen blending is the acceptable limit for the selected injection area. The 5% by volume limit referred to in the question was based on review of the different components in the subject distribution network – when other parts of the review were also taken into account, the conclusion was that 2% blending was the appropriate limit (see

Exhibit B, Tab 1, Schedule 1, Attachment 1, para. 33).

e) Refer to H2GO 1 a) to c).

f) i) to ii)
Set out below are the GHG emission impacts of using hydrogen blending of 2%. Enbridge Gas is not requesting a 4% blending approach. As explained at Exhibit I.STAFF.2, Enbridge Gas has arranged to receive hydrogen for 2% blending at no additional cost versus conventional natural gas. There is no such agreement for the volume of hydrogen required for 4% blending. Enbridge Gas estimates the emission reduction from its LCEP pilot to be in the range of 97 to 120 tCO2e/yr.

No responses are provided for the request to consider the implications of the enhanced use of natural gas and electricity as a transportation fuel, since these are outside the scope of this application.

Blending of Hydrogen into Natural Gas Delivery Systems

American Gas Association

CANADIAN GAS ASSOCIATION
ASSOCIATION CANADIENNE DU GAZ

Information Summary Report

May 2019

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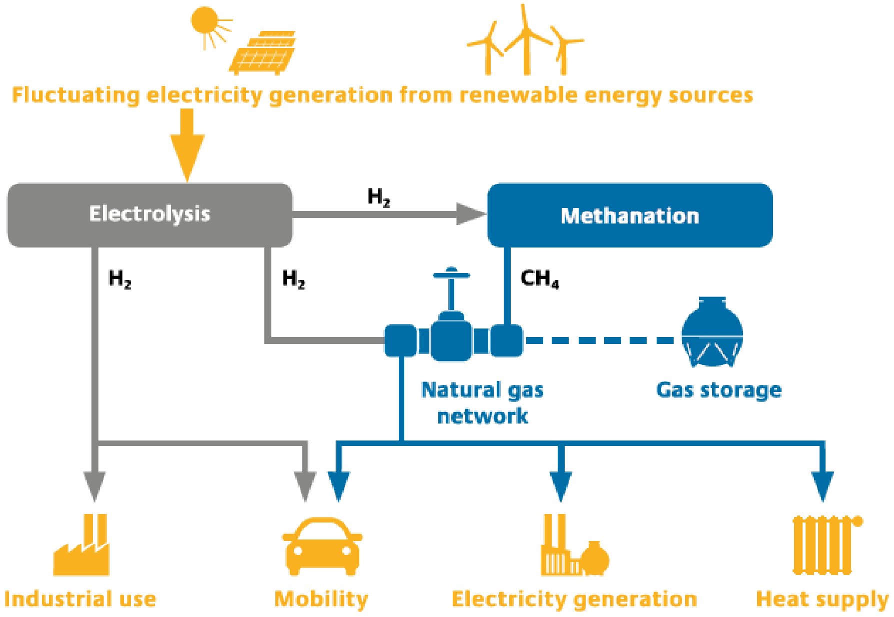
SUMMARY

A successful transition towards a cleaner and more sustainable energy system in the next decades will require large scale implementation of sustainable and renewable energy sources. Renewable power sources, like wind and solar energy, can mainly be distinguished from conventional fossil-based power sources by their low life cycle carbon emissions and their intermittent character. By introducing intermittent energy sources, the need for overall flexibility in our energy system increases strongly. Multiple solutions exist for providing the required flexibility; one of them is Power-to-Gas (PtG).

Power-to-Gas is the common description of the conversion of electrical energy into chemical energy in the form of hydrogen or methane. The process typically uses water electrolysis, powered from renewable energy sources, to 'split' water molecules (H_2O) to produce hydrogen (H_2) and oxygen (O). Hydrogen can be directly fed into the existing natural gas infrastructure and blended with natural gas. To convert and feed in a greater volume of renewable electricity, methane (synthetic natural gas, SNG) can be produced in a second step using this hydrogen with the addition of carbon dioxide.

This alternative energy concept is currently being piloted in Europe and has the potential to deliver a number of overall societal benefits to North America (Appendix A). These include development of an additional renewable energy supply and reduction in the greenhouse gas emissions profile of natural gas, development of a mechanism to help balance the power system using surplus electricity in off-peak periods and provision of a storage vessel for surplus electricity. Existing gas infrastructure may be leveraged (pipes and gas-powered electricity generating plants) to reduce the need for building additional electrical generation or transmission facilities. It could also help enable the growth of the use of hydrogen powered vehicles.



As part of the United States and Canada's commitment to increase the use of renewable and alternate energy in North America, the AGA's Operations Section Managing Committee and the CGA's Standing Committee on Operations and Safety formed a Task Group to conduct an open-source literature search around the introduction of hydrogen into existing natural gas delivery systems.

General Note

In reading this **Blending of Hydrogen into Natural Gas Delivery Systems, Information Summary Report**, it must be understood that the agree-to scope for the Task Group's work was for 0% to 5% blending of hydrogen into natural gas.

This specific scope limitation was in no way meant to imply that blending rates greater than (>) 5% are not possible or feasible. The CGA & AGA believe that hydrogen blending at >5% is an important consideration for a number of reasons, that will require further, separate study that both organizations will take forward as a possible next step in their combined work around understanding potential sustainable and renewable energy sources.

Summary of Findings from the Literature Search

The body of information found via the literature search was substantial. A key finding was that, due to the complexity of natural gas delivery systems, and the wide variety of the components, materials and equipment, it is not possible to specify a limiting hydrogen value which would be valid for all parts of North American natural gas delivery infrastructure.

And as with every ongoing research subject and initiative, there are gaps in the knowledge, and studies do not always come to the same conclusions. Nonetheless, the information summarized from the literature search suggests that the natural gas delivery system may be able to accommodate blending of hydrogen from 0% to 5% with little effect on the systems being utilized for delivery or the end user.

However, it must be understood that a system-specific analysis will be required for each location where the introduction of hydrogen is being considered, to determine specific hydrogen concentrations that do not pose an unacceptable level of risk to the affected areas of the natural gas system or end-users. In particular, the non-typical end-use equipment within any given natural gas delivery system must be identified and considered individually through a detailed engineering assessment, e.g., dispensing to CNG vehicles, natural gas use as a feedstock, etc.

Each system, code and regulatory framework is different and proposed solutions must be customized accordingly even if an engineering assessment is carried out.

Recommendations

Based on the results of this literature search, the acceptability of hydrogen blending into natural gas streams from 0% to 5% will depend on critical pipeline system components, end-user equipment tolerances and operating considerations. These items, among others, would need to be addressed and documented in an engineering assessment that would examine the safety, integrity and reliability of company-owned and customer-owned assets. The corresponding company would also need to ensure that the blended gas meets its tariff requirements. However, it is in no way a general value, and each organization must consider a number of factors which must be applied on a system-by-system basis, i.e., each specific system must be looked at in the context of the materials it is made up of and the end-users that it serves. It should be noted that there is no one international standard for the percentage blending rate of hydrogen into natural gas delivery systems. Upgrading of components can be considered by the distribution company where it is feasible and practical to do so.

General Considerations

Natural gas infrastructure is rather complex: from the production sites to storage, transmission and distribution pipelines to a wide variety of end-users, there are many types of materials, components and appliances to consider. Blending hydrogen into natural gas requires attention to safety, integrity, reliability and interchangeability, as hydrogen has different properties than methane.

Each organization considering blending hydrogen into natural gas streams should review and understand their own system details. The information gathered may assist each organization in their decision-making processes within their own tolerance parameters concerning hydrogen blending into natural gas streams.

Comparison of Hydrogen & Methane Properties

The basic properties of hydrogen (H_2) are different than those of methane (CH_4), the primary component of natural gas (92% - 96%), as shown in the table below.

Hydrogen is a colourless, odourless[1], tasteless, non-toxic, and non-poisonous gas. It's also non-corrosive, but it can lead to embrittlement in some metals, especially steel alloys. Compared to methane, hydrogen is a very small and light molecule with low viscosity, and thus prone to leakage through porous materials, fittings, and seals. Hydrogen has the lowest density of all gases: it is 8 times less dense than methane.

Due to its low density, hydrogen has a volumetric energy content 3 times lower than methane at standard conditions for temperature and pressure. This means more hydrogen is needed to provide the same energy as methane (by volume). Since hydrogen does not have the same density and volumetric energy content as methane, its Wobbe Number is different. Being that it is an indicator of the interchangeability of fuel gases, it means that a burner rated for natural gas may not function correctly with the addition of hydrogen.

Hydrogen has a broader flammability range than methane, and under the optimal combustion conditions (e.g., stoichiometric conditions: a 29% hydrogen-to-air or a 9% methane-to-air volume ratio), the energy required to initiate hydrogen combustion is much lower (e.g., a small spark will ignite it). The flame speed of hydrogen is also far greater than that of methane (8 times), meaning the flame propagation in a hydrogen-air mixture is much quicker. For these reasons, hydrogen is a much more flammable gas than methane. However, it should be noted that the auto-ignition temperatures[3] of hydrogen and methane are very similar.

[1] Methane is also odourless, but industry adds a sulfur-containing odorant to natural gas for safety reasons, so that people can detect it by smell.

Comparison between the properties of hydrogen and methane as the principal constituent of natural gas

Item	Methane	Hydrogen
Chemical Formula	CH_4	H_2
Molecular Size[1]	416 pm (isotropic molecule)	340 pm / 304 pm (anisotropic molecule)
Molar Mass[2]	16.043 g/mol	2.016 g/mol
Specific Gravity[2]	0.5548	0.0695
Density[2]	0.6787 kg/m³ 0.0424 lb/ft³	0.0851 kg/m³ 0.0053 lb/ft³
Higher Calorific Value (HHV)[2]	37.7 MJ/m³ 1,013 BTU/ft³	12.1 MJ/m³ 325 BTU/ft³
Wobbe Number (WN)[2]	50.6 MJ/m³ 1,359 BTU/ft³	45.9 MJ/m³ 1,231 BTU/ft³
Lower Explosive Limit (LEL)	5 %	4 %
Upper Explosive Limit (UEL)	15 %	75 %
Minimum Ignition Energy (MIE) at Stoichiometric Ratio	0.300 mJ 0.284 µBTU	0.017 mJ 0.002 µBTU
Auto-ignition Temperature	600 °C 1,112 °F	560 °C 1,040 °F
Flame Speed	0.43 m/s 1.41 ft/s	3.46 m/s 11.35 ft/s
Boiling Point	-161.5 °C -258.7 °F	-252.8 °C -423.2 °F
Products of Combustion	Carbon Dioxide (CO_2) Water Vapour (H_2O)	Water Vapour (H_2O)

All properties given at standard conditions for temperature and pressure (15.6°C and 101.4 kPa or 60°F and 14.7 psia)

[1] Molecular size based on the Van der Walls radius of the molecule.

[2] Value of properties calculated in accordance to standard ISO 6976 with NGTC's Interchangeability Calculator.

General Energy Delivery System Considerations

- Safety & Integrity;
- Load-balancing;
- Transmission & Distribution;
- End-Users:
    - Interchangeability;
    - Residential & Commercial;
    - Industrial (equipment and feedstock);
    - Transportation.

Higher Heating Value (HHV) & Wobbe Number

The HHV seems the most obvious property to consider when looking at the interchangeability of gases, however, it only provides a crude indication; the Wobbe Number was defined to give more accurate information. The definition of the Wobbe Number is based on the HVV and specific gravity of a gas and it is related to the thermal input to a burner (BTU per hour). The usefulness of the Wobbe Number is that for any given orifice, all gas mixtures that have the same Wobbe Number will deliver the same amount of heat.

Given that hydrogen's HVV and Wobbe Number are lower than methane's, the addition of hydrogen to natural gas produces a blend with a reduced HHV and Wobbe Number; in other terms, the energy content decreases with higher percentages of hydrogen. However, the decrease is much more significant for the HHV than the Wobbe Number, which suggests that this property would become limiting first (see table below).

Impact of blending hydrogen into methane on the Higher Heating Value and the Wobbe Number

Blend	Higher Heating Value (HHV)		Wobbe Number	
100 % Methane	37.7 MJ/m^3 1,013 BTU/ft^3	-	50.6 MJ/m^3 1,359 BTU/ft^3	-
99 % Methane / 1 % Hydrogen	37.5 MJ/m^3 1,006 BTU/ft^3	- 0.7 %	50.5 MJ/m^3 1,356 BTU/ft^3	- 0.2 %
98 % Methane / 2 % Hydrogen	37.2 MJ/m^3 999 BTU/ft^3	- 1.4 %	50.4 MJ/m^3 1,353 BTU/ft^3	- 0.4 %
95 % Methane / 5 % Hydrogen	36.4 MJ/m^3 978 BTU/ft^3	- 3.5 %	50.0 MJ/m^3 1,343 BTU/ft^3	- 1.2 %

All properties given at standard conditions for temperature and pressure (15.6°C and 101.4 kPa or 60°F and 14.7 psia).
Value of properties calculated in accordance to standard ISO 6976 with NGTC's Interchangeability Calculator

It should be noted that while Wobbe is an effective, easy to use screening tool for interchangeability, the industry historically recognizes that the Wobbe Number alone is also not sufficient to completely predict gas interchangeability because it does not adequately predict all combustion phenomena. The same thing can be said about the HHV.

Specific Blending Rate Admissibility Considerations

The specific blending rates and the accompanying information in this Information Summary Report are intended for use by each organization in their decision-making processes within their own risk tolerance parameters concerning hydrogen introduction into natural gas streams. Given the complexity of natural gas delivery systems, this Information Summary Report is an overview focusing on larger issues and is not intended to be an exhaustive investigation.

There are any number of suggestions about what percentage of hydrogen in natural gas streams should be considered. The GERG study states that it is not currently possible to specify a limiting hydrogen value which would generally be valid for all parts of the European gas infrastructure, and a case-by-case analysis is therefore recommended.

For this Information Summary Report, the PtG TG did decide to limit the consideration of blending hydrogen into natural gas streams to 0% to 5 %. This was chosen for three reasons:

- There is a greater body of research and analysis work, primarily European, for blending rates of under 5% leaving less uncertainty and fewer potential operating concerns.
- Under 5% hydrogen, the literature reviewed seems to indicate there is little impact on the Wobbe Number, thereby having little impact on end-use.
- Typical natural gas tariff specifications on the higher heating value support a hydrogen content of 5%.

The specific percentage blending information obtained from the literature search has been summarized into specific groupings in the tables below:

- General Knowledge Points;
- Areas where no H_2 Blending into NG streams have been addressed;
- H_2 Blending into NG streams at less than or equal to (≤) 1%;
- H_2 Blending into NG streams at less than or equal to (≤) 2%;
- H_2 Blending into NG streams at less than or equal to (≤) 5%.

Each percentage level of hydrogen blending into natural gas streams identifies potential risks/areas of concern and what actions could be considered.

Blending of H_2 in NG, General Knowledge

Specifics	Areas of Focus	Potential Impacts	Comments
Blending of H_2 in NG **General Knowledge Points**	Safety – Fire and Explosion Risks	Hydrogen has a broader range of conditions under which it will ignite.	Results indicate that mixtures of 0% to 5% hydrogen in natural gas unlikely to present a significantly greater issue in practical situations.
	Integrity – Hydrogen Embrittlement and Durability of Metal Pipes	The durability of high-strength metal pipes can degrade when exposed to hydrogen over long periods, particularly with hydrogen in high concentrations and at high pressures.	Existing studies have concluded that concentrations of hydrogen at 0% to 5% do no cause any issues for metal pipes.
	Integrity – Permeability of Hydrogen Through Metal and Plastic Pipes	The hydrogen permeation coefficient in plastic piping is 4-7 times higher than that of methane.	Leakage rates from permeation are insignificant from a safety point of view. Existing studies have concluded that concentrations of hydrogen at 0% to 5% do not cause any issues.
	Integrity – Leakage	Leakage rates through joints in steel pipes for hydrogen are about three times higher than that for natural gas.	At o% to 5% of hydrogen, leakage is negligible in gas distribution pipework systems.
	Gas Meters	Volumetric gas meters will record quantities of either methane or methane/hydrogen mixtures with almost equal accuracy. Mass flow meters are not affected.	Calibration and approval from Federal Authorities (e.g. Measurement Canada) may be needed.
	Pressure Reduction Stations	Pressure reduction stations are not affected by the addition of hydrogen, as it pertains to temperature effects.	Temperature increases with hydrogen as it expands and this increase will depend upon percentage of hydrogen.

Blending of H_2 in NG, General Knowledge

Specifics	Areas of Focus	Potential Impacts	Comments
Blending of H_2 in NG **General Knowledge Points**	Odorization	There seems to be no chemical incompatibility issues of notes between hydrogen and the odorizing compounds commonly used in natural gas. However, the literature reviewed does not state clearly why odorants are non-reactive with hydrogen.	Most odorants contain sulphur, and hydrogen is often used in chemical processes which would be adversely affected by the presence of sulphur compounds. If the natural gas-hydrogen blend is to be used as a hydrogen feedstock, sulphur-containing odorants will need to be removed prior to use.
	Interchangeability: Impacts on Higher Heating Value and Wobbe Number	A mixture of hydrogen with natural gas will decrease the higher heating value and the Wobbe Number.	Based on sample tariffs, 5% hydrogen could be added while still respecting the specifications for the HHV, and Wobbe Number.
	Interchangeability: Other Impacts	The addition of hydrogen also increases flashback and lifting, reduces yellow tipping and creates a more complete combustion.	
	Impact on End-use Systems	Effects of hydrogen addition on end-use systems are variable due to the wide range of existing equipment. Some might tolerate high hydrogen blends while for others, no hydrogen blends would be acceptable. How well the equipment is adjusted will also have an impact on the hydrogen content it could tolerate.	A case-by-case approach is preferable.

Blending of H_2 in NG, Points Not Addressed

Specifics	Areas of Focus	Potential Impacts	Comments
Blending of H_2 in NG **Points not addressed**	Underground Gas Storage (UGS)	Hydrogen addition could have an impact on the tightness of the cap rock, both for porous reservoirs and salt caverns. In porous reservoirs, there is also the potential for bacterial growth. Hydrogen is a good substrate for sulfate-reducing and sulphur reducing bacteria. The associated issues are principally loss of gas volume and disappearance of injected hydrogen, as well as potential damage to the cavity itself, and production of H_2S (poisonous, corrosive, and flammable).	The geology, operating pressure and temperature will differ according to reservoir and therefore the degree to which hydrogen addition may be problematic will also differ. The suitability of UGS should be carefully assessed on an individual basis. It is worth noting that hydrogen storage within caverns or porous reservoirs is exercised in specific locations within Europe and the US, but there is a lack of information on the subject.
	Natural Gas Liquefaction Plants	Hydrogen is a non-condensable gas and will therefore pass through an LNG liquefaction system, adding a non-productive load on the compressors and ultimately degassing in the LNG tanks.	No publicly available information concerning the impact of hydrogen addition on LNG facilities was found in the literature review. Further research is needed.
	Gas Metering	The addition of hydrogen changes the properties of the gas. Thus, it has an effect on volume measurement, gas composition analysis, metering and measurement of calorific value.	Federal Government approval might be required.
	Compressor Stations – Equipment Other Than Compressors	In addition to compressors, compressor stations include other equipment such as gas cooling systems.	No information was found about potential issues with the addition of hydrogen for this equipment.

Blending of H_2 in NG at ≤ 1%

Specifics	Areas of Focus	Potential Impacts	Comments
Blending of H_2 in NG at ≤ 1%	Gas Chromatographs	Chromatographs are unable to detect hydrogen.	Only low levels of hydrogen are acceptable for now, but chromatographs could be retrofitted to measure hydrogen.
	End-users – Industrial Combustion Equipment	The consequences of mixing hydrogen with natural gas for industrial combustion applications should be considered case by case. Compared to domestic or commercial equipment, industrial equipment usually has stricter fuel specifications, and therefore narrower tolerances for fuel composition variations.	
	End-users – Gas Turbines	Most of the currently installed gas turbines are specified for a 1 % blend of hydrogen in natural gas. Even very low fractions of hydrogen to natural gas could cause issues due to low tolerances to gas composition variation, including increasing NOx emissions.	Up to 5% may be attainable with tuning or modification measures. Current fuel specifications for many gas turbines place a limit on the hydrogen content in natural gas below 5 %.
	End-users – Feedstock	Effects of hydrogen addition are dependent on the process involved.	Action is needed in order to identify sensitive processes and mitigation measures.

Blending of H_2 in NG at ≤ 2%

Specifics	Areas of Focus	Potential Impacts	Comments
Blending of H_2 in NG at ≤ 2%	End-users – Stationary Reciprocating Gas Engines	Addition of hydrogen reduces the Methane Number of the fuel and increases knocking in engines. It can also increase NOx emissions.	Existing studies have concluded that 2-5 % hydrogen addition could be acceptable for engines. Pending further study, caution suggests setting the limit at the lower end of the study's results, i.e., 2 %.
	Transportation – Steel Tanks in CNG Vehicles	A maximum limit of 2 % hydrogen in CNG as a fuel is set for tank cylinders that are manufactured from steel with an ultimate tensile strength exceeding 950 MPa (137,800 psi), which is usually the case of type 1 and 2 tanks.	Type 3 or 4 tanks for on-board storage are technologically mature and used in fuel cell hydrogen electric vehicles, as well as in some models of CNG vehicles.

Blending of H_2 in NG at ≤ 5%

Specifics	Areas of Focus	Potential Impacts	Comments
Blending of H_2 in NG at ≤ 5%	Safety – Leak Detection	FID & DIAL devices are not sensitive to hydrogen and will give an inaccurate response due to the diluting effect of addition of H_2.	In terms of accuracy, use of FID and DIAL devices could be acceptable in situations with hydrogen blends up to 5 %, but it needs further investigation.
	Compressors	Centrifugal compressors are affected by hydrogen's higher volumetric flow rate: either the rotational velocity would have to be increased or a higher number of compression stages would be required.	At 0% to 5% of hydrogen, the effects are expected to be minor, but further investigations should be performed.
	End-users – Residential & Commercial	Available studies show that the current appliances can handle the addition of 5 % to 28 % hydrogen if they are properly serviced and adjusted.	Due to the wide range of hydrogen limits recommended in the studies, and the wide variety of existing appliances, caution suggests setting the limit, pending further study, at the lower end of the studies' results, i.e., 0% to 5%.
	Transportation – Engines in CNG Vehicles	The impact of hydrogen mixture for natural gas vehicle engines is similar to stationary engines, but vehicle engines do not suffer the same knock problems since they are not tuned to optimum efficiency and can therefore tolerate higher hydrogen blends. However, due to hydrogen's lower energy content, the vehicle range will be reduced.	Since the literature on the subject is limited, caution suggests setting the limit lower, ≤5%.
	Transportation – Refuelling Stations	CNG dispensers rely on mass-based flow meters for proper fill level (temperature compensation) and retail sale.	Need for "smart" dispenser controls and/or communications.

APPENDIX A. POTENTIAL BENEFITS OF BLENDING H_2 IN NATURAL GAS STREAMS

The Rational for Power-to-Gas

- Grid-scale storage is needed to support rapidly expanding intermittent renewable power sources such as solar and wind energy, i.e., balancing of the electric grid and making use of excess power in off-peak periods.
- Existing natural gas grid infrastructure can be leveraged to support renewable power development and to stabilize the power grid, by using natural gas piping systems as energy storage vessels for (renewable) electricity both short-term and seasonal.

General Societal Benefits

- Expanded use of natural gas piping systems as delivery vessels for renewable energy, e.g., biomethane, hydrogen, syngas, solar fuels, etc.
- Decarbonizing heat/reducing greenhouse gas (GHG) emissions.
- Enabling the growth of hydrogen powered transportation adoptions.
- Production of gas or chemicals from renewable sources as feedstock for industry and mobility.
- Paving the way for methanation, the production of synthetic methane from hydrogen and carbon dioxide.

Benefits for the Gas Industry

- Ongoing knowledge development for the future optimization of the gas network.
- Regulatory Compliance, e.g., potential regulation around renewable energy content and emissions.
- Environmental stewardship; assisting the natural gas delivery industry in pursuit of its aspirational goals for renewable energy content within natural gas streams.

ENBRIDGE GAS INC.
Answer to Interrogatory from
H2GO Canada (H2GO)

INTERROGATORY

Reference:

Exhibit A, Tab 2, Schedule 1, paras 6, 13
Exhibit B, Tab 1, Schedule 1, paras 6-7, 26-27

Preamble:

With leave of the Board, EGI expects to commence construction of the LCEP in the second quarter of 2021. EGI says this timing is required in order to gain experience with the blending of hydrogen into the natural gas distribution system in advance of pending carbon abatement regulations (including the Clean Fuel Standard (**CFS**)).

EGI states that the CFS will seek to reduce the carbon footprint of carbonaceous fuels by setting “lifecycle carbon intensity requirements for liquid, gaseous and solid fuels used in transportation, industry and buildings” and will become more stringent over time.

EGI indicates that hydrogen is expected to be a means of compliance and a pathway for the generation of CFS credits and that the LCEP will prepare the natural gas grid for implementation of the CFS.

EGI also believes that successful implementation of this pilot project will support it in pursuing additional and larger scale hydrogen blending activities in other parts of its distribution system.

Question**:**

A. Please provide an outline of the steps EGI proposes to take in order to gain the necessary experience with the blending of hydrogen into the natural gas distribution system over the period prior to the second quarter of 2021.

B. Please provide an outline of how EGI proposes to learn from the LCEP in order to prepare the natural gas grid for implementation of the CFS.

C. Does EGI anticipate that it will retain ownership of any environmental attributes generated through the LCEP? If so, please explain how it will account for such environmental attributes. If not, please explain why not.

D. Please provide an explanation of how EGI envisions that pathway for the generation of CFS credits under projects similar to the LCEP.

E. Please file any and all analysis EGI has performed in connection with the use of hydrogen in the natural gas grid as a means of compliance with the CFS.

F. Please outline EGI's plans to pursue "additional and larger scale hydrogen blending activities in other parts of its distribution system."

G. The CFS for gaseous and solid fuel regulations will come into force January 1, 2023. Please complete the following chart:

Year	**Estimated Volume of Hydrogen Blending by EGI (m^3)**	**Estimated GHG Emissions Reductions from Hydrogen Blending by EGI (tCO2e)**	**Anticipated Number of CFS Credits Generated by EGI through Hydrogen Blending Activities**
2023			
2024			
2025			
2026			
2027			
2028			
2029			
2030			
2031			
2032			
2033			

H. Please provide any and all assumptions that EGI has made regarding the design and implementation of the CFS system in Canada, its inter-operability with the US, the fungibility of the CFS, and US and California LCFS related credits/units.

I. Please comment on how hydrogen blending may currently and over the next five years impact:

   (i) gas storage;
   (ii) security of natural gas supply; and
   (iii) natural gas commodity and transportation pricing.

<u>Response:</u>

A. The intent of the referenced evidence is to indicate that Enbridge Gas seeks to have the LCEP pilot approved and in operation by the time that the CFS is implemented, so that the Company can have practical experience to evaluate whether additional similar projects are appropriate as ways to address obligations under the CFS.

B. The Clean Fuel Standard (“CFS”) is designed to lower the carbon intensity of distributed fuels. The blending of low carbon fuels, such as renewable natural gas (“RNG”) and hydrogen, is anticipated to be the most readily available method of meeting the CFS compliance obligation for Enbridge Gas. The amount of low carbon fuels required to meet the compliance obligation is anticipated to increase over time. It is important to gain experience in the injection and distribution of hydrogen in the natural gas system, so as to make the receipt of hydrogen in other areas of the natural gas system a viable compliance option in the future.

C. Enbridge Gas expects the production of hydrogen to generate CFS credits or other environmental attributes that will be initially owned by 2562961 Ontario Ltd. Where custody of the hydrogen fuel is transferred between parties, Enbridge Gas anticipates the ownership of any environmental attributes will be specified between parties under hydrogen fuel purchase agreements. Enbridge Gas will determine its interest in acquiring environmental attributes with the hydrogen fuel where it sees value in doing so.

D. Please refer to Exhibit I.Staff. 2(h).

E. To date, Enbridge Gas has not performed an analysis of hydrogen as a means of compliance with the CFS as two principal gaseous fuels CFS design components have yet to be released. Firstly, the lifecycle assessment (“LCA”) model that Enbridge Gas would be required to use to calculate the carbon intensity of hydrogen produced from the Power to Gas facility has not yet been released. Secondly, the gaseous carbon intensity reduction requirements have yet to be released so that the potential credit value of the hydrogen produced from the Power to Gas facility cannot be estimated.

F. Enbridge Gas’s approach will be disciplined. The first step following approval by the Board of this application is for the Company to safely and effectively blend a small, carefully determined amount of renewable hydrogen into a small but carefully selected portion of its natural gas distribution system.

Upon implementation, the Company will monitor and validate the effects of its intended hydrogen blend into the system, and make recommendations on where, when and how any plans for larger scale blending should be implemented.

Finally, any proposals for additional blended gas areas within the Enbridge Gas distribution system would be evaluated on a case by case basis for discrete areas and would not be done system wide.

G. The anticipated number of CFS credits generated from hydrogen produced from the Power to Gas facility cannot currently be estimated, as per the explanation provided in E above. The estimated volume of hydrogen produced and estimated GHG reductions are provided in the table below.

Year	**Estimated Volume of Hydrogen Blending by EGI (m^3)**	**Estimated GHG Emissions Reductions from Hydrogen Blending by EGI (tCO2e)**	**Anticipated Number of CFS Credits Generated by EGI through Hydrogen Blending Activities**
2023-2040	200,000 m3/yr	97 to 120 tCO2e/yr	Not available

H. Enbridge Gas assumes there will be no fungibility of CFS credits with the US Renewable Fuel Standard (“RFS”) or the California Low Carbon Fuel Standards (“LCFS”), or acceptance of credits generated from the RFS or LCFS within the Canadian CFS.

I.

(i) At this time, Enbridge Gas has no plans to store hydrogen within the Company’s gas storage facilities.

(ii) Enbridge Gas does not foresee any impact to the security of natural gas supply resulting from the proposed hydrogen blending pilot. Hydrogen will only make up a very small portion of the gas supply provided to customers in the BGA and will not reduce the upstream gas supply assets in place for planned peak day and seasonal gas delivery requirements. In the unlikely event of equipment failure causing an interruption to hydrogen supplies into the BGA, Enbridge Gas’ distribution system and gas supply portfolio includes ample flexibility to replace the small amount of lost hydrogen supply with traditional natural gas.

(iii) Enbridge Gas expects no impact to natural gas commodity or transportation pricing as a result of the proposed LCEP pilot. As discussed in Exhibit B, Tab 1, Schedule 1, page 17, “Enbridge Gas has arranged to procure hydrogen from 2562961 Ontario Ltd. in a manner that keeps ratepayers cost-neutral.”

ENBRIDGE GAS INC.
Answer to Interrogatory from
H2GO Canada (H2GO)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, paras 7, 16
Exhibit F, Tab 1, Schedule 1, Attachment 5, p. 2

Preamble:

EGI estimates that, for the blended gas area (**BGA**) of the LCEP, GHG emissions reductions can range from approximately 97 tons carbon dioxide equivalent (tCO2e) to 120 tCO2e per year (para 7).

EGI states that hydrogen has a positive effect on GHG emissions when blended into the natural gas distribution system by serving to reduce the overall carbon content of natural gas. The result is a reduction in GHG emissions associated with the combustion of natural gas (para 16).

In a response to a question asked by Mississaugas of the Credit First Nation, EGI stated that, for blend of 2% by volume hydrogen, 0.663% of emissions due to natural gas are reduced. EGI further indicated that it anticipates approximately 625 tCO2e could be offset annually (based on 2018 natural gas volumes used in the area), equal to the amount of GHG emissions of approximately 139 homes in a year (based on average yearly gas usage).

Question:

a) Please provide a detailed explanation of the formula EGI used to calculate the estimate of emissions reductions of 97 to 120 tCO2e per year for the BGA.

b) Please explain what factors are likely to contribute to variability within the range of estimated GHG emissions reductions in the BGA.

c) Please file copies of any reports, working papers, presentations, datasets, or other materials related to EGI's determination that blending

2% hydrogen by volume results in a 0.663% reduction of emissions due to natural gas.

d) Has EGI performed any analysis of how the LCEP — and hydrogen blending generally — will affect the imposition of federal carbon charges on customers in the BGA. If so, please provide the analysis. If not, please explain why no such analysis has been performed.

e) Please confirm that the estimate of emissions reductions of 97 to 120 tCO2e per year for the BGA is specific to Phase 1 of the LCEP. Please provide details of EGI's forecast, if any, of the GHG emissions reductions in Phase 2 of the LCEP.

Response:

a) and b) Please refer to Exhibit I.STAFF.1.

c) Please refer to the table provided in Exhibit I.STAFF.1. The percent reduction can be calculated as the emission reductions from blended gas usage (column (h)) divided by emissions from unblended gas usage (column (f)), which results in a value of 0.668%.[1]

d) Enbridge Gas has reviewed the Greenhouse Gas Pollution Pricing Act and has spoken with the federal government on the imposition of the Federal Carbon Charge on the hydrogen portion of blended gas. Currently, the Company is unaware of any mechanism for hydrogen blended into the natural gas distribution system to be exempted from the Federal Carbon Charge. Enbridge Gas has continued to pursue conversations with the federal government on a mechanism to exempt hydrogen blended into natural gas. The Company is hopeful this exemption can be put in place, given that hydrogen injection into the natural gas distribution system is accepted as a GHG reduction in the federal Clean Fuel Standard ("CFS"), which is currently under development.

e) Confirmed. An updated forecast for Phase 2 has not been completed.

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[1] Calculation based on values shown Exhibit I.STAFF.1 is 0.03 tCO_2e ÷ 4.50 tCO_2e x 100% = 0.668%.

ENBRIDGE GAS INC.
Answer to Interrogatory from
H2GO Canada (H2GO)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, paras 14-15

Preamble:

EGI states that a Power to Gas (**PtG**) plant owned by an affiliate will provide electricity regulation service under contract with the Independent Electricity System Operator (**IESO**).

EGI further states that, in the future, blending of hydrogen into the natural gas stream will provide a solution to the challenge of storing the province's surplus electrical energy. In doing so, hydrogen blending can establish an intertie between the electrical grid and the natural gas distribution system, and improve energy utilization, by using existing pipeline infrastructure to effectively store electrical energy.

Enbridge also states that, in addition to storing electrical energy as hydrogen, the PtG process provides a valuable dispatchable ancillary service to the province's IESO, delivering benefits not only to natural gas rate payers, but also to the province's electrical ratepayers. The ability to more effectively balance the electricity system is important in order to balance the electricity production of the province's renewable generation fleet. It will become more important if the renewable generation fleet in the province expands.

Question:

Please complete the following chart:

PtG Plant Electricity Consumption (annual average) (kWh)	PtG Plant Hydrogen Production (annual average) (m^3)	Quantity of Hydrogen Blended into BGA (m3)

Does EGI expect that 100% of the hydrogen produced by the PtG plant will be used for hydrogen blending in the BGA? If so, please explain how EGI will ensure that hydrogen is not over-produced. If not, please explain what other applications EGI anticipates for the hydrogen produced by the PtG plant.

Please explain how EGI proposes to store hydrogen produced by the PtG plant. Please further explain whether EGI anticipates using its existing pipeline infrastructure to store hydrogen and provide details.

Response:

Please refer to the table below.

PtG Plant Electricity Consumption (annual average) (kWh)	PtG Plant Hydrogen Production (annual average) (m^3)	Quantity of Hydrogen Blended into BGA (m3)
See Exhibit I.ED.3 for an estimate of the electricity required to produce hydrogen on a per m^3 basis.	See Exhibit I.FRPO.4.	~200,000 m^3/y

Enbridge Gas does not expect all the hydrogen produced at the PtG plant to be used for hydrogen blending in the BGA. The owner of the facility (2562961 Ontario Ltd.) will determine appropriate options for “surplus” hydrogen produced.

Please see Exhibit I.FRPO.4. Some of the hydrogen (approximately 2,000m^3 [~170kg]) produced by the Power to Gas facility is stored on site in compressed tanks. Enbridge Gas does not own the hydrogen storage tanks. These are part of the Power to Gas facility, which is owned by 2562961 Ontario Ltd.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Pollution Probe (PP)

INTERROGATORY

Question**:**

Please confirm that the evidence Enbridge filed March 31, 2020 entitled " EGI_APPL_REDACTED_v2_LTC_Markham_LCE_20200331" replaces the evidence filed December 20, 2019 entitled " EGI_APPL_REDACTED_LTC_Markham_Low Carbon Energy_20191220".

Response:

Confirmed.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Pollution Probe (PP)

INTERROGATORY

Reference:

[Ex .A, T2, S1]

Question**:**

Please explain why Enbridge selected the proposed boundaries for the blended gas area (BGA) and how they relate to the other potential “loops”.

Response:

Alternative Response: Exhibit B, Tab 1, Schedule 1, Attachment 1, pages 10 to 13 describes the methodology and criteria used by Enbridge Gas to determine the boundaries of the closed loop system to be provided with blended natural gas. The entire closed loop system was then divided in to loops S1 (i.e. the BGA), S1a and S1b based on based on the number of modifications to the existing networks that would needed in order to isolate these loops.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Pollution Probe (PP)

INTERROGATORY

Reference:

[Ex. A, T2, S1]

Question**:**

a) Please provide an explanation of the (chemical) combustion process that results in hydrogen enriched natural gas having a low heating value.

b) Please explain why a slight volumetric increase is required for customers in the BGA and the incremental volume calculation assuming a 2% hydrogen level.

Response:

a) and b) Please see Exhibit B, Tab 1, Schedule 1, page 17 under the heading “Consumption Impact” for an explanation of the reasons for why blended natural gas has a lower energy content than traditional natural gas. The referenced Exhibit also explains the implications of this as it relates to the Project.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Pollution Probe (PP)

INTERROGATORY

Reference:

[Ex. B, T1, S1]

Question**:**

a) Please provide and explain the maximum percent of hydrogen that could be safely added to the natural gas distribution system (e.g. BGA).

b) Please provide the calculation showing that GHG emission reductions can range from approximately 97 tons carbon dioxide equivalent (tCO2e) to 120 tCO2e per year due to this project.

c) Please confirm that any additional grants or incentives (incremental to the potential SDTC grant) would go toward reducing the net capital cost of the project.

Response:

a) Please see Exhibit I.STAFF.8 (a), Exhibit I.STAFF.8 (b) and Exhibit I.ED.7 (a).

b) Please see Exhibit I.STAFF.1.

c) Please see Exhibit I.SEC.4. In the event that any additional grants or incentives are made available for the Project such funds will be applied to the Project's cost in compliance with the terms and conditions of such funding.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Pollution Probe (PP)

INTERROGATORY

Reference:

[Ex. B, T1, S1]

Question**:**

a) Please confirm that this project is contributing to the most cost-effective path for the City of Markham (and consumers) to meet the municipal energy plan net zero by 2050 targets.

b) Do the facilities proposed in this project provide any additional capacity, operational flexibility or other benefits?

Response:

a) The Company is unable to confirm that this project will contribute the most cost-effective means by which the City of Markham might meet its municipal energy plan targets. However, the Company can confirm that the City of Markham supports the Project (see Exhibit B, Tab 1, Schedule 1, Attachment 2).

b) The LCEP facilities will provide an additional feed into the distribution network located in Markham.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Pollution Probe (PP)

INTERROGATORY

Reference:

[Ex. C, T1, S1, Attachment 1]

Question**:**

The link provided does not appear to work. Please file a copy of the Environmental Report for this project.

Response:

The ER is too large to send via email.

The link provided in Exhibit C, Tab 1, Schedule 1, Attachment 1 does work (https://www.enbridgegas.com/About-Us?utm_source=donriver30&utm_medium=redirect&utm_campaign=FriendlyURLs#Projects). The link is to the Enbridge Gas Projects page. On that page, please scroll down to the Low Carbon Energy Project, and expand the menu to access the Environmental Report (ER).

ENBRIDGE GAS INC.
Answer to Interrogatory from
Pollution Probe (PP)

INTERROGATORY

Reference:

[Ex. D, T1, S1]

Question**:**

a) Table 8 indicates Indirect Overheads related to this project of $1,260,395 and it is Pollution Probe's understanding that Capital Overheads are capped for the current IR period. Is Enbridge planning to exceed it capital overheads in the current IR period by $1,260,395 due to this project or manage within its allowed capital envelop?

b) Please provide any updates to the project schedule in Table 7 due to COVID-19 or any other factors.

Response:

a) No. Enbridge Gas is not planning to exceed its expected capital overhead provision in the current IR period due to this Project. The capital spend for this project, both direct and overheads, will be managed within the ICM Threshold.

b) Please see Exhibit I.CCC.4. At this point in time the Project schedule is not expected to be impacted by COVID-19 or any other factors.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Pollution Probe (PP)

INTERROGATORY

Reference:

[Ex. D, T1, S1]

Question**:**

Reference: 25% contingency applied to all direct capital costs except for the station material costs which have a 40% contingency.

a) Please provide a table of contingency percentages (OEB approved and actuals) related to direct capital cost for the past 5 competed projects where Leave to Construct was granted by the OEB.

b) Please provide a table of forecasted and actual contingency percentages related to station material costs for the past 5 competed projects of a similar nature.

c) Please confirm that the total project costs of $5,232,265 are the maximum capital costs and that Enbridge will only seek to recover actual costs.

Response:

a) The table below sets out contingency percentages for 5 completed projects for which leave to construct was granted by the OEB. The actual project costs for these projects are not available and will be filed with the Board according to the conditions of approval for each of the projects.

Docket Number	**Project name**	**Status**	**% Contingency applied**
EB-2018-0306	Stratford Reinforcement Project	Project in-service as of September 14, 2019; completed as of September 27, 2019	15%*
EB-2018-0226	Georgian Sands Project	Construction was to commence October 7, 2019; project intended to be in-service by May 30, 2020	20%
EB-2018-0097	Bathurst Reinforcement Project	Project in-service as of December 11, 2019	30%
EB-2018-0096	Liberty Village project	Project in-service as of March 28, 2019	25%
EB-2018-0108	Don River Valley 30inch Replacement Project	Project in-service as of April 21, 2020	30%

*This project is a Legacy Union project and was filed with the OEB prior to the amalgamation of the two legacy companies. The cost estimate for this project was developed using Legacy Union cost estimating standards which is a different approach than the one used in this application.

b) Contingency percentages for station materials are typically included as part of the overall project contingency. See the response to (a) above for past contingency percentages used. Please refer to Exhibit I.CCC.17(a) regarding the decision to use 40% contingency for station material cost in this project.

c) Not confirmed. The total project cost of $5,232,265 is what Enbridge Gas expects based on the filed estimate. The actual project cost can be over or under the estimate provided. Enbridge Gas will seek to recover actual costs for the Project at the next rebasing application for 2024.

ENBRIDGE GAS INC.
Answer to Interrogatory from
School Energy Coalition (SEC)

INTERROGATORY

Reference:

General

Question**:**

Please provide all presentations, memoranda, and similar materials provided to the Board or Directors or the Executive Management of the Applicant dealing in whole or in part with this Application, the Low Carbon Energy Project, or 2562961 Ontario Ltd.

Response:

Attached to this response are presentations made to Enbridge Gas executive management related to the hydrogen blending proposal made in this application (the LCEP). Portions of the presentations related to the Power to Gas plant have not been produced, as they are not relevant to the application. There were no presentations to the Enbridge Gas Board of Directors.

HYDROGEN BLENDING PRESENTATIONS

HYDROGEN BLENDING
and
POWER-to-GAS (PtG)

January 13, 2017

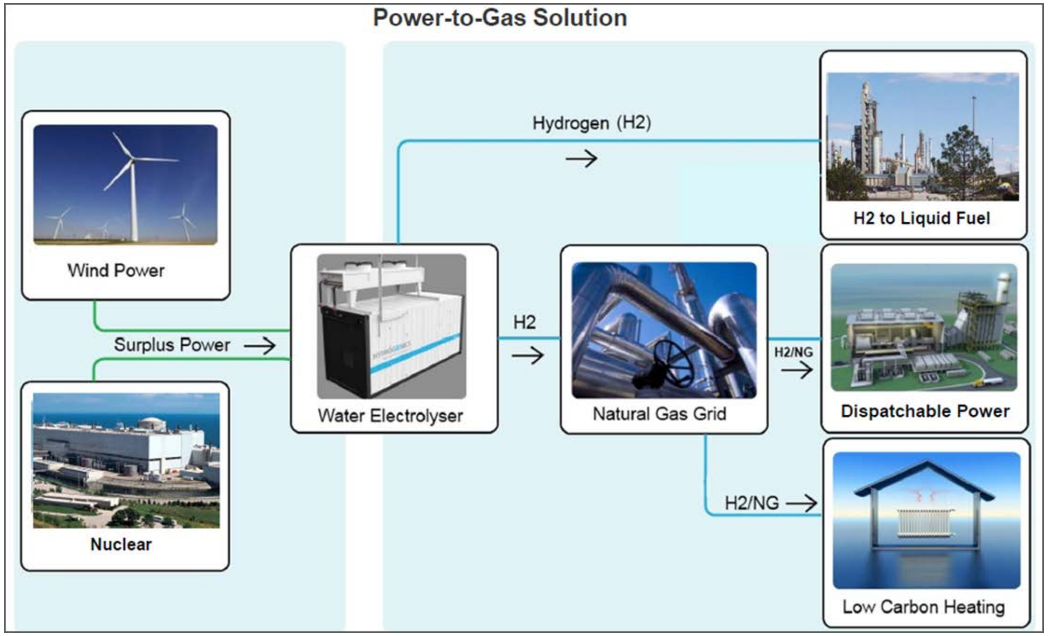
ENBRIDGE®

AGENDA

- Business Objective
- Problem Statement
- Scope of Required Work
- Progress to Date
- Recommendation on Next Steps
- Discussion

BUSINESS OBJECTIVE

- Blend 4% of hydrogen by volume within the natural gas distribution system
- Provide energy storage for excess electricity within the natural gas network across the province
- Green the natural gas as a source of energy through addition of hydrogen resulting in lower GHG emissions



Problem Statement

Impact to operating risk resulting from the introduction of hydrogen through blending of up to 4% by volume into the natural gas distribution system is unknown.

ENGINEERING WORK REQUIRED

Assess the effects of hydrogen on the integrity of:

- Transmission steel pipeline
- Distribution steel and plastic pipeline
- Pressure regulating equipment including rubber goods
- Measurement equipment
- End-use equipment downstream of the meter – industrial, commercial, residential
- NGV systems and vehicles

Quantify the effect on Operational Risk.

FINDINGS TO DATE

- GTI study – non-metallic materials
  - Laboratory tests performed on Aldyl-A and Styrene Butadiene Rubber
  - Hydrogen introduction of 5% by volume may reduce the life expectancy of Aldyl-A
  - No significant increase in leakage rate observed
- GTI study – metallic materials
  - Literature search performed
  - Hydrogen has negative effects on mechanical properties at various pressures(RA @ 1,000 psig, fracture toughness @ 290 psig, crack propagation resistance@ 950-1,000 psig, fatigue crack growth rates @ 2.9 psig)
  - Recommendation to perform lab testing specific to material grades and operating pressures

FINDINGS TO DATE

- Uniper Energy Storage – Germany
  - Two injection sites in operation
  - DVWG allows up to 10% H2 injection
  - Sites operate at 2% H2 – limited by CNG/NGV
  - Carbon steel pipe at the injection site running 100% H2 at 800 psig – no pressure fluctuation is the key
  - Research into using existing natural gas storage assets for storage of H2 ongoing

FINDINGS TO DATE

- DNV GL – Netherlands
  - Working on hydrogen blending since 2004
  - Project NATURALHY – 2004-2009
  - Experiments on: burning velocity, vented explosions, vapour cloud explosions and resulting overpressures
  - Conclusion – addition of up to 30% hydrogen possible without significantly increasing risk to general public
  - Next project – HYREADY – 2017-2019
  - Scope – Guidelines on hydrogen blending encompassing hydrogen injection, transmission and distribution networks, and end use

FINDINGS TO DATE

- Hydrogen blending attracts a lot of attention across North America

- North American Power to Gas Working Group formed

- Mandate – Under the AGA’s Operations Section Managing Committee & the CGA’s Standing Committee on Operations, represent the best interests of the American & Canadian natural gas delivery industry & its customers related to the introduction of H_2 into natural gas delivery systems.

- Participants – CGA, AGA, GTI, NGTC, 8 NG utilities

Options to Proceed

Option	Pros	Cons
Join Industry Efforts	Covers most risk	Longer timelines
Team up with SoCal	Faster to the finish line	More costly, less risk covered
Proceed on our own	Full control over project scope, specific to EGD	Most costly, foregoing input from the industry, least risk covered

Recommendations & Next Steps

- Join industry efforts
- Influence to leverage efforts between North America and Europe
- Chair North American P2G Group – Dana Stojic
- Continue defining EGD requirements.

Power to Gas – Project Execution

Sponsor Update January 19, 2017

Engineering – Boris Visnjevac, Dana Stojic
Business Development – David Teichroeb, Tim Short, Parag Datta

New BD & Engineering Developments

- Establishing a work plan for 2017:
  a) Material integrity due-diligence for hydrogen
  b) Establishing gas quality standards for allowable hydrogen concentrations
  c) Initial hydrogen pipeline estimates and design for TOC to Vic Square
- In final stages of negotiating funding for above work via SDTC Natural Gas Fund
- Seeking “Sponsor” approval to join European HYReady project for $40k Euro
  – Initial funding via BD O&M with plan to capitalize

Power to Gas – Project Execution

Sponsor Update February 16, 2017

Engineering – Michael Wagle, Dana Stojic
Business Development – David Teichroeb, Tim Short, Parag Datta

HYREADY Kickoff Meeting Update

- Project Background:
  - PtG - chemical energy at demand and at low cost.
  - Multiple projects that study impact of the hydrogen addition on elements of gas distribution and transmission system
  - Convert the knowledge gained into concrete engineering guidelines.
- Project Objective:
  - To prepare clear engineering guidelines for TSOs and DSOs to support them with the preparation of their existing natural gas transmission & distribution networks and operations for H2/natural gas mixtures with acceptable consequences.
- Project Timeline: 16 months

HYREADY Kickoff Meeting Update Cont.

- Project Methodology:
  - Consequence of 2, 5, 10, 20 and 30 % H2 and feasible countermeasures to be considered at three levels:
    - System (grid capacity, safety issues, odorization, measurement, detection),
    - Component (leakage, permeation, integrity, accuracy, lifetime) and
    - Location level (installation requirements, safety zoning).
- Project Scope:
  - Transmission (16-100 bar) and distribution (<16 bar) - including pipeline, stations, measurement and regulations components, valves, pig traps, odorization equipment, seals, filters, actuators, etc.
- HYREADY Next Steps:
  - EGD to provide overview of the components, materials, MOP, standards, manufacturers to be considered.

The Current HYREADY Consortium

ENBRIDGE Life Takes Energy

SoCalGas

gasNatural fenosa

enagas

Gas Networks Ireland

GRTgaz

TIGF

GAZ system

DBI GUT Gas- und Umwelttechnik GmbH

GRDF GAZ RÉSEAU DISTRIBUTION FRANCE

DNV·GL

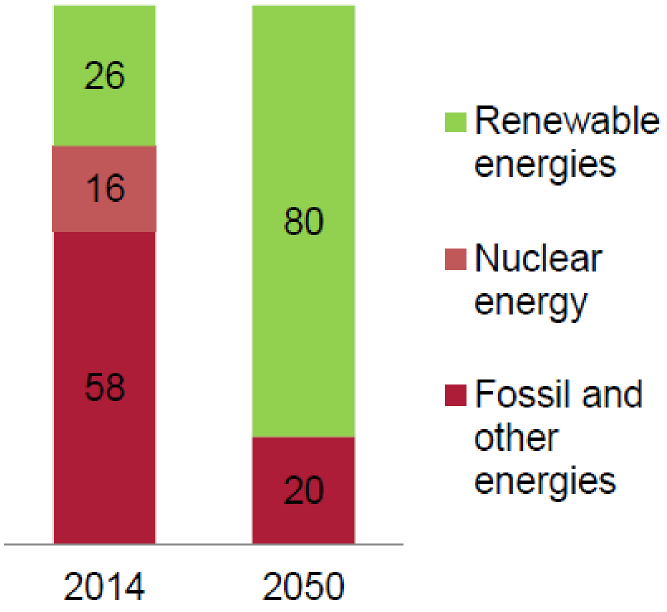
Discussions with several additional parties about their feasible participation in HYREADY are in progress. Nevertheless, new partners remain very welcome!!

Energy Transition in Hamburg and Germany

Energy concept for Hamburg

- Doubling the renewable energies until 2030
- Investments into storaging and converting renewable energies
- Reduction of CO_2-emissions throughout a new heat concept
- „Smart“ energy solutions
- Extension of the e-mobility

Energy concept by the german government

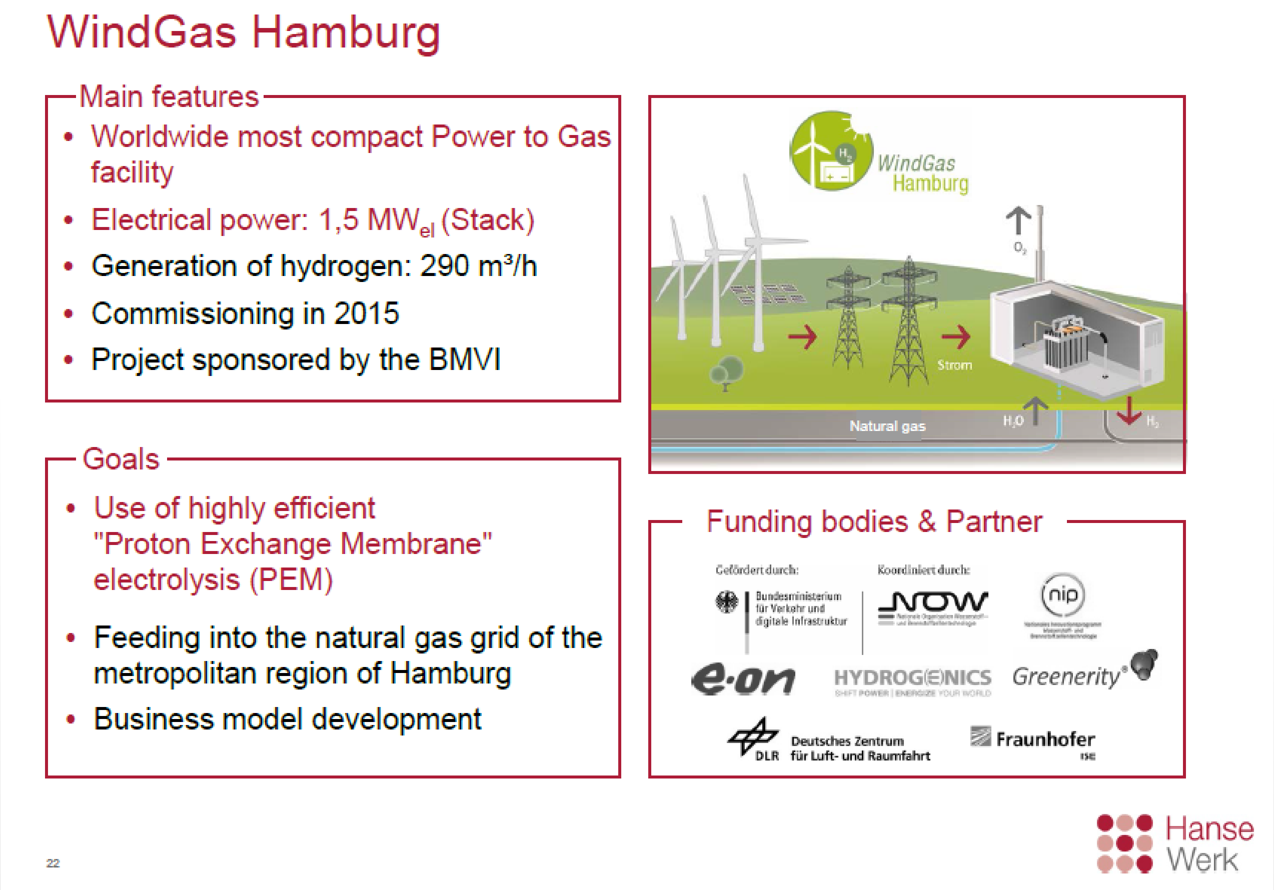


Power to Gas projects in Germany

- ● In use
- ● under construction
- ● In planning

Source: Deutsche Energie-Agentur GmbH (dena, 09/2015)

PtG in Germany - Hamburg



WindGas Hamburg

Main features

- Worldwide most compact Power to Gas facility
- Electrical power: 1,5 MW_{el} (Stack)
- Generation of hydrogen: 290 m³/h
- Commissioning in 2015
- Project sponsored by the BMVI

Goals

- Use of highly efficient "Proton Exchange Membrane" electrolysis (PEM)
- Feeding into the natural gas grid of the metropolitan region of Hamburg
- Business model development

Funding bodies & Partner

Gefördert durch:
Bundesministerium für Verkehr und digitale Infrastruktur

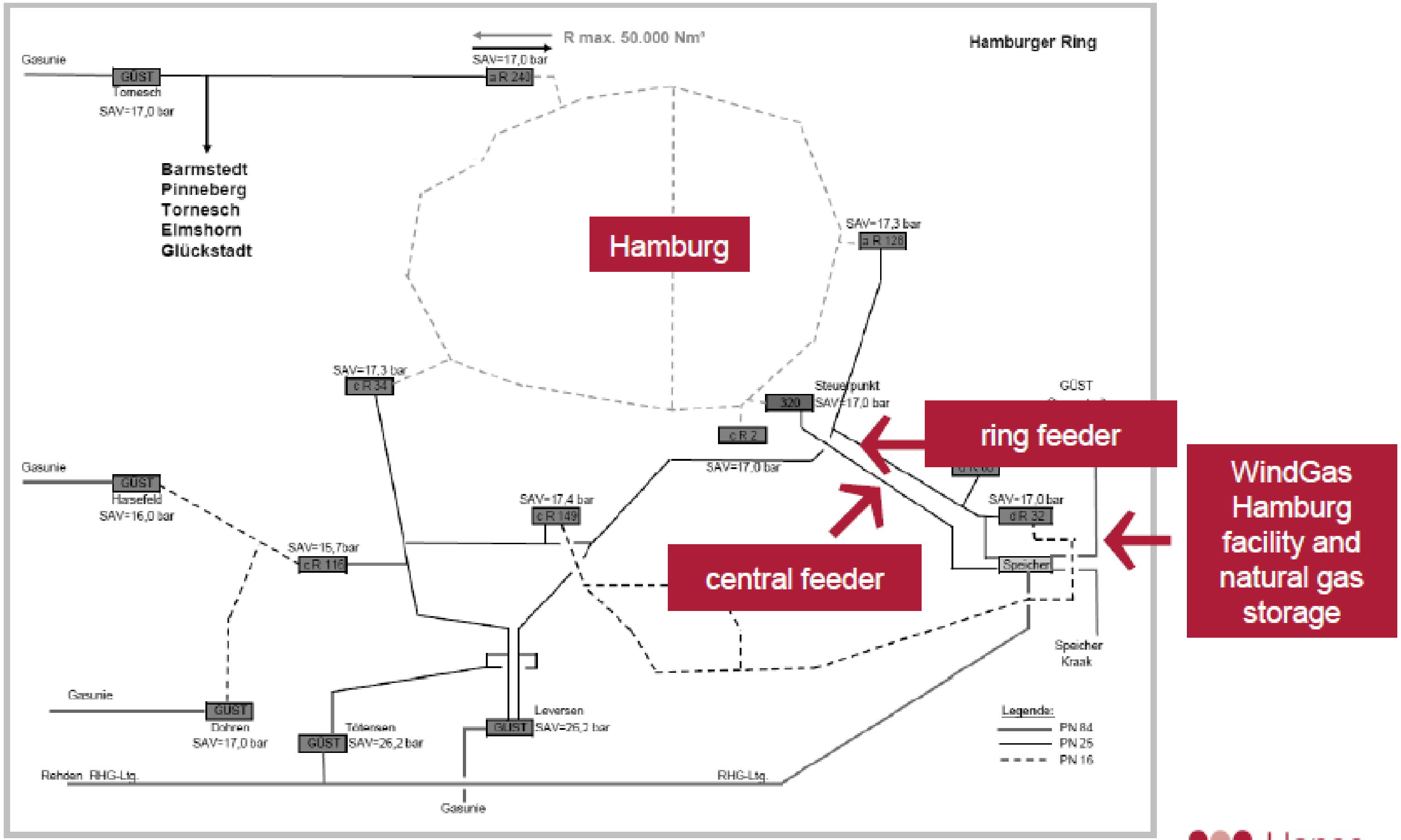
Koordiniert durch:
NOW

nip

e·on
HYDROGENICS
Greenerity
DLR Deutsches Zentrum für Luft- und Raumfahrt
Fraunhofer ISE

HanseWerk

H_2 feeding into the Hamburg Ring



ring feeder

central feeder

WindGas Hamburg facility and natural gas storage

30

Hanse Werk

Power to Gas – Project Execution

Sponsor Update March16, 2017

Engineering – Michael Wagle, Dana Stojic
Business Development – David Teichroeb, Tim Short, Parag Datta

New Business – Hydrogen Activities

- Hydrogen pipeline development from TOC to Victoria Square
  - Primary purpose - Support future blending of hydrogen as EGD compliance options to meet MoECC requirement for renewable content under cap-and-trade and enhance power-to-gas economics
  - Secondary – short lateral could support delivery of hydrogen to Honda Canada for fuel cell vehicle refueling (refueling station has NRCan funding support)
- Negotiating agreements for government funding to support pipeline and blending developments (Ontario Centres of Excellence and the SDTC – Natural Gas Fund via CGA) – April Target for agreements
- Establishing business considerations amongst Enbridge, Hydrogenics, Honda and gov't funders that will include:
  - Target for in-service on pipeline / blending supported by series of Go/NoGo milestones to be established
  - Blending due diligence team under Dana Stojic gap analysis to understand what engineering and integrity needs are by internal / external parties)
  - Pipeline development team under Sam McDermott (budget development to support gov't funding agreements and initial technical design and work scope development)

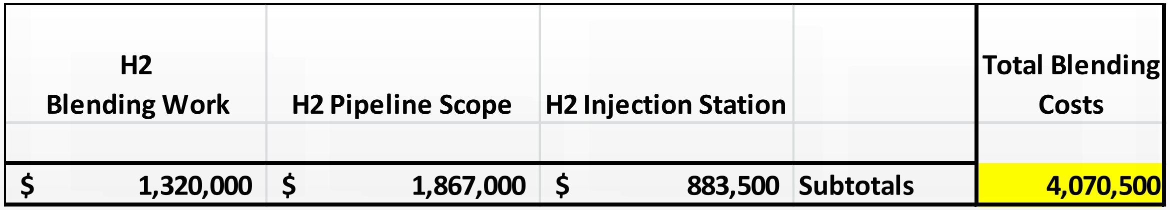
Power to Gas – Project Execution

Sponsor Update May 25, 2017

Engineering – Michael Wagle, Dana Stojic
Business Development – David Teichroeb, Sam McDermott

New Business Priorities for PtG

- Hydrogen (H_2) Blending Stds., H_2 Pipeline Construction and H_2 Blending Station
- Cost Estimates – Class 5 for purposes of locking down government funding
  - Achieves some level of blending; but system-wide capability is expected to require additional work after pilot project is in-service



H2 Blending Work	H2 Pipeline Scope	H2 Injection Station		Total Blending Costs
$ 1,320,000	$ 1,867,000	$ 883,500	Subtotals	4,070,500

- Gov’t Funds cover 50% of project costs
  - $2 million for blending project developments
  - $1.5 million for future expansion of PtG to 5 MW

Next Steps for Government Funding Support

- Business case to document purpose, need and timing for:
  - H_2 pipeline and blending capability to support TOC project contributions to renewable content
  - $ 2 million investment by Industry
  - Matched by $2 million investment by SDTC/OCE
- Hydrogenics – Enbridge to complete consortium agreement early June
- Balance of SDTC/OCE funding supports the expanding TOC plant to 5 MW
- Enbridge BD and Engineering working on Blending Milestone Dates *:
  - Define criteria for optimal blending location – targeted completion Q3 2017
  - Define blending area – primary areas considered: Victoria Square city gate station a) north, or b) segment of North – secondary areas considered – c) closed area away from Vic Square, tertiary areas considered - Victoria Square city gate station d) south – targeted completion Q3 2017
  - Define optimal H2 percentage for chosen area – targeted completion Q1 2018
  - Gap analysis for the defined close loop blending area (primary or secondary) – targeted completion Q1 2018
  - Gap analysis for tertiary area – targeted completion Q4 2018
  - Standards/regulatory requirements for closed loop system – targeted completion Q2 2018
  - the targeted pipeline/station design and construction commencement will be established after blending area is confirmed and initial gap analysis indicate no major road blocks

* the projected completion targets estimated based on project commencement in Q2 2017

Engineering Assessment Project Brief

- Draft Project Brief already issued for stakeholder comments;
- Draft is considering the following subtasks:
  - Participation in HYREADY literature study
  - Participation in CGA/AGA literature study
  - Engineering Assessment that shall include
    - Gap Analysis
    - Optimal blending percentage
    - Issues list with specific blending area/locations
    - Decision tree definition, etc.
- Expected to be finalized first half of June.

Power to Gas – Project Execution

Sponsor Update   August 23, 2017

Engineering – Michael Wagle / Mohamed Chebaro / Dana Stojic
Business Development – Scott Dodd / David Teichroeb

PtG
Hydrogen Blending

PtG Hydrogen Blending

Recap of Engineering Project Scope

- June 14th, Engineering approval of the technical work scope and timelines
  - "Hydrogen Blending Engineering Assessment" (H_2 Assessment)
  - Engineering Class 5 Estimate is approximately $2 million

- Business Development & Hydrogenics working to secure government funding
  - 50% of costs share for H_2 Assessment and H_2 pipeline and blending system
  - Funding via Sustainable Development Technology Canada (SDTC) in final contracting negotiations with Hydrogenics – end of August 2017
  - Ontario Centre of Excellence (OCE) agreements also targeting August 2017

PtG Hydrogen Blending

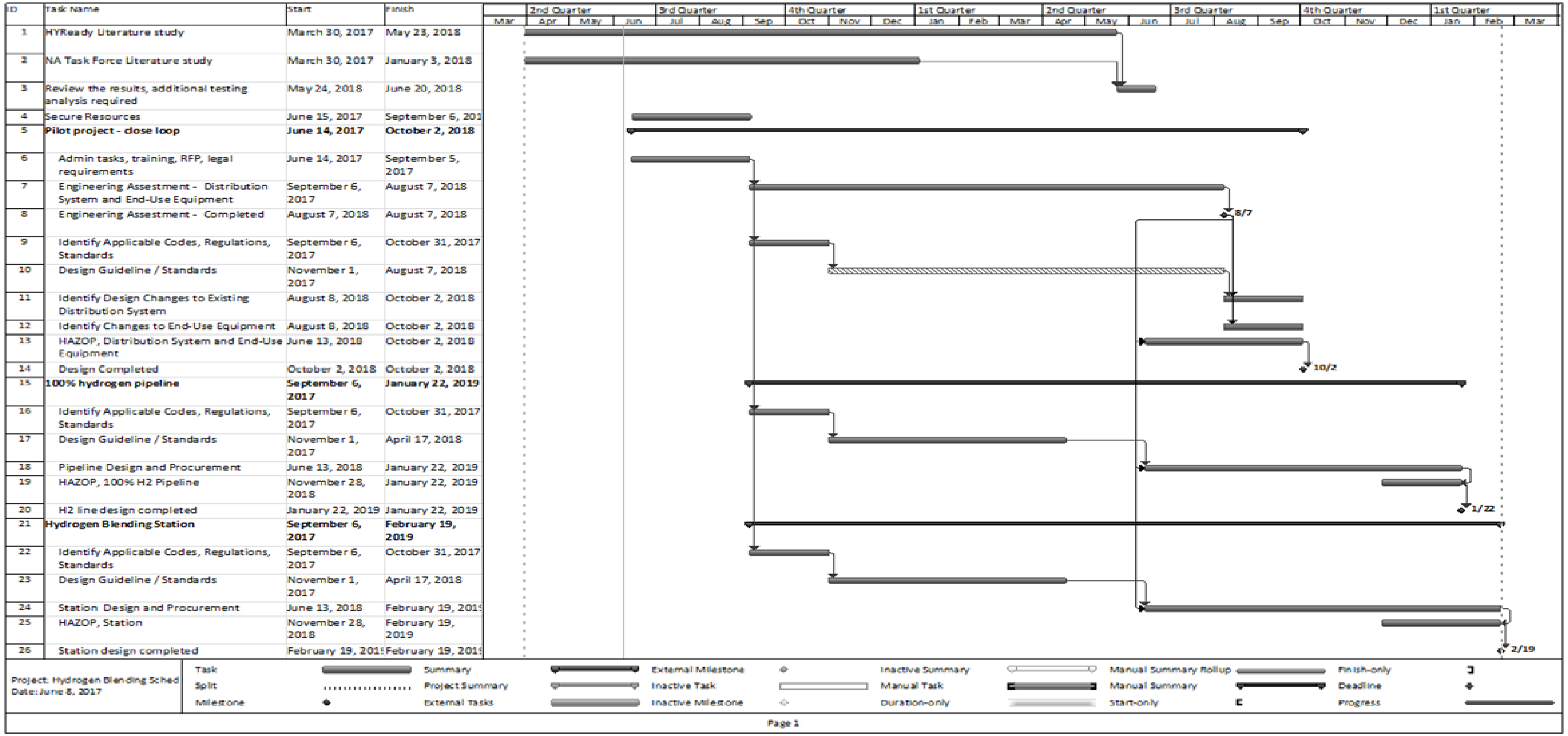
Engineering Project Scope

Timelines for Engineering Assessment Project Scope as signed:

1	HYReady Literature study	Q1 2017	Q2 2018
	• The progress update issued by DNV GL		
2	NA Task Force Literature study	Q2 2017	Q4 2017
	• The draft issued for comments		
3	Pilot Project - Closed Loop Design	Q2 2017	Q3 2018
	• DBI-GUT proposal reviewed by engineering, request for additional information issued		
4	100% Hydrogen Pipeline Design	Q3 2017	Q1 2019
	• Not started yet		
5	Hydrogen Blending Station Design	Q3 2017	Q1 2019
	• Not started yet		
Overall Engineering Support		Q2 2017	Q1 2019

PtG Hydrogen Blending

Engineering Project Scope



ID	Task Name	Start	Finish
1	HYReady Literature study	March 30, 2017	May 23, 2018
2	NA Task Force Literature study	March 30, 2017	January 3, 2018
3	Review the results, additional testing analysis required	May 24, 2018	June 20, 2018
4	Secure Resources	June 15, 2017	September 6, 201
5	**Pilot project - close loop**	**June 14, 2017**	**October 2, 2018**
6	Admin tasks, training, RFP, legal requirements	June 14, 2017	September 5, 2017
7	Engineering Assestment - Distribution System and End-Use Equipment	September 6, 2017	August 7, 2018
8	Engineering Assestment - Completed	August 7, 2018	August 7, 2018
9	Identify Applicable Codes, Regulations, Standards	September 6, 2017	October 31, 2017
10	Design Guideline / Standards	November 1, 2017	August 7, 2018
11	Identify Design Changes to Existing Distribution System	August 8, 2018	October 2, 2018
12	Identify Changes to End-Use Equipment	August 8, 2018	October 2, 2018
13	HAZOP, Distribution System and End-Use Equipment	June 13, 2018	October 2, 2018
14	Design Completed	October 2, 2018	October 2, 2018
15	**100% hydrogen pipeline**	**September 6, 2017**	**January 22, 2019**
16	Identify Applicable Codes, Regulations, Standards	September 6, 2017	October 31, 2017
17	Design Guideline / Standards	November 1, 2017	April 17, 2018
18	Pipeline Design and Procurement	June 13, 2018	January 22, 2019
19	HAZOP, 100% H2 Pipeline	November 28, 2018	January 22, 2019
20	H2 line design completed	January 22, 2019	January 22, 2019
21	**Hydrogen Blending Station**	**September 6, 2017**	**February 19, 2019**
22	Identify Applicable Codes, Regulations, Standards	September 6, 2017	October 31, 2017
23	Design Guideline / Standards	November 1, 2017	April 17, 2018
24	Station Design and Procurement	June 13, 2018	February 19, 201
25	HAZOP, Station	November 28, 2018	February 19, 2019
26	Station design completed	February 19, 201	February 19, 201

Project: Hydrogen Blending Sched
Date: June 8, 2017

PtG Hydrogen Blending

Business Case

- Business development approved business case for Milestone 1 of the H_2 Assessment work scope:
  - Finance is making final determination on the source of funds which could be from the Carbon Compliance Plan or from core capital
  - Final decision from Finance expected prior to end of August.

- Work scope segmented into Milestones supported by “Go / No-Go” decision tree, and aligned with funding.
  - Milestone 1 by May 2018 - first segment of H_2 Assessment work ($625k after funding)
  - Milestone 2 by Feb 2019 – completion of H_2 Assessment (additional $425k after funding)
  - In May 2018, separate business cases will be prepared for the construction of a hydrogen pipeline and blending station (Milestone 1 improves accuracy of work scope and budget)

PtG Hydrogen Blending

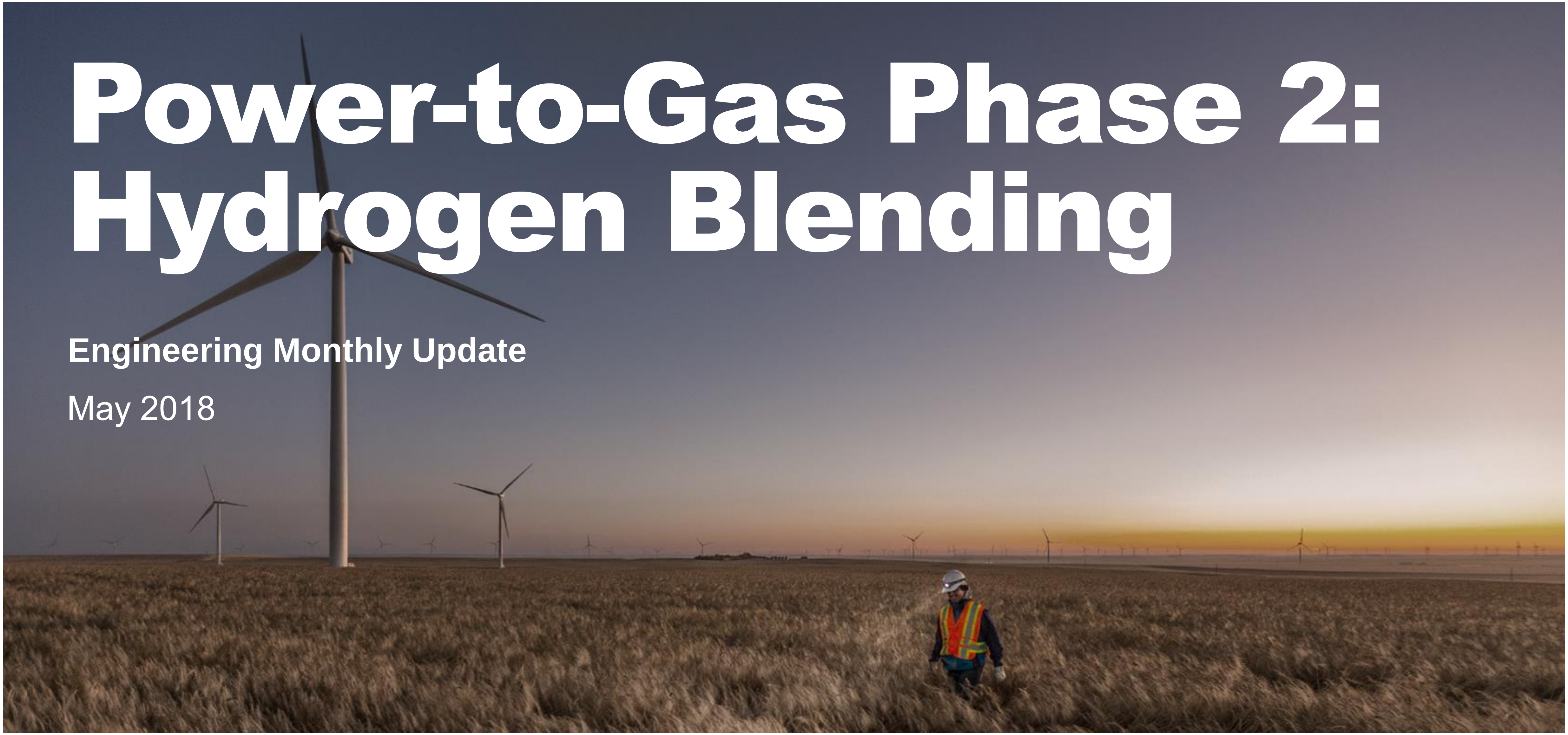
Recap Business Drivers and Timeline Risks for Hydrogen Blending

- Objective of H_2 Assessment is to achieve a staged progression of EGD’s ability to accommodate system-wide hydrogen (H_2) blending
- Ability to accept hydrogen in distribution network supports the growth of renewable content via power to gas and next-generation RNG supplies like biomass gasification
- In addition to the TOC power to gas plant, the market is signaling an interest / need for hydrogen injections (early inquiries are being received from stakeholders like Emerald Energy and Canadian Tire in Peel/Brampton)
- EGD’s long-range investment plan is forecasting growth in power to gas, but until we demonstrate viable hydrogen blending pathways the investment opportunities are limited
- The H_2 Assessment work scope by Engineering (Milestone 1 & 2) is scheduled for completion by Q1 2019 – Questions for consideration include:
    1. Can pipeline and blending station engineering and construction take place on a concurrent timeline (e.g. during Milestone 2) so as to implement hydrogen blending by Q2 2019?
    2. What additional resources could help expedite hydrogen blending capabilities?
    3. Other activities that support engineering, integrity and business growth objectives?

Power-to-Gas Phase 2: Hydrogen Blending

Engineering Monthly Update

May 2018



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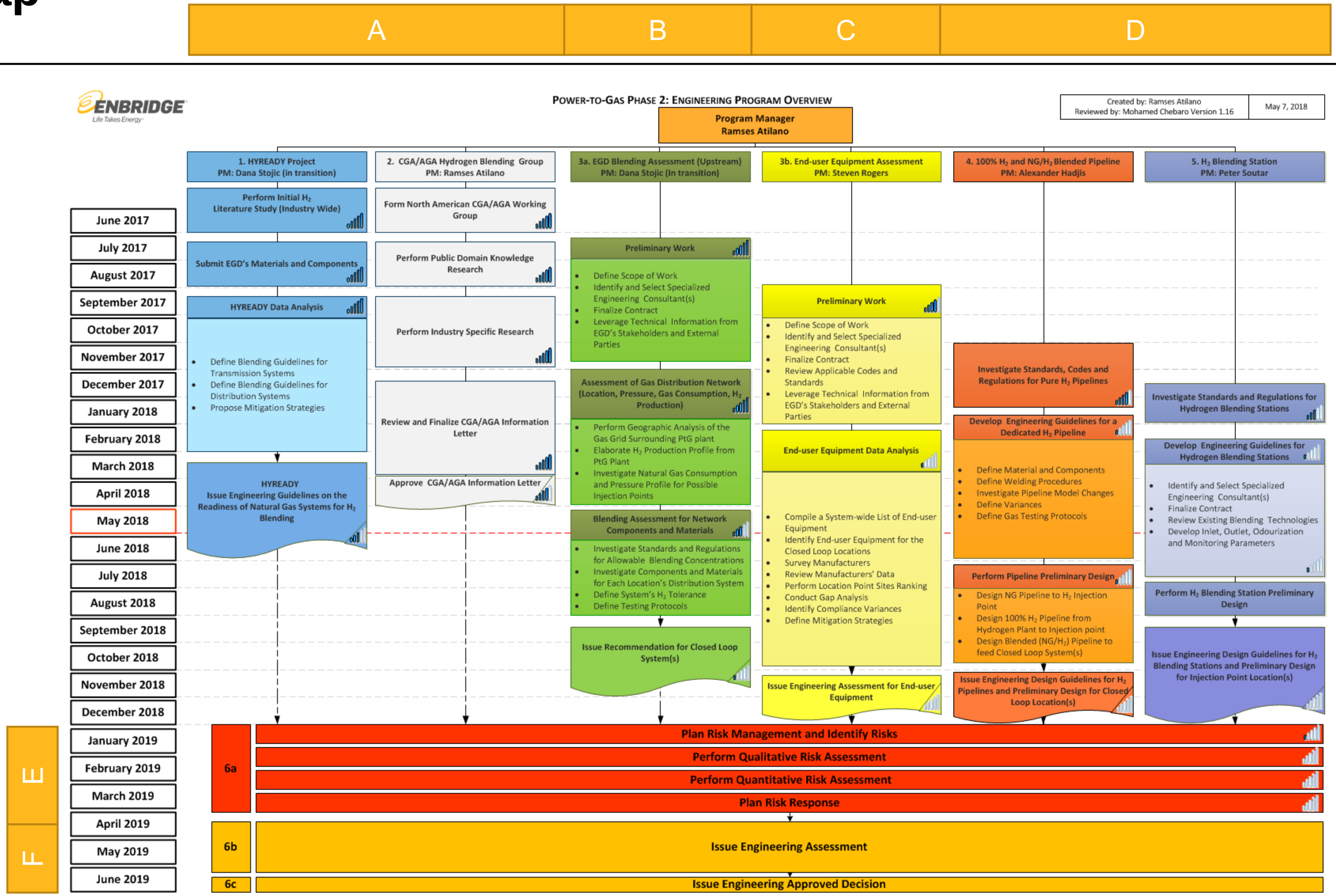
Mohamed Chebaro and Ramses Atilano
Engineering

Power-to-Gas Phase 2

Road Map



POWER-TO-GAS PHASE 2: ENGINEERING PROGRAM OVERVIEW

Created by: Ramses Atilano
Reviewed by: Mohamed Chebaro Version 1.16

May 7, 2018

Program Manager
Ramses Atilano

June 2017
July 2017
August 2017
September 2017
October 2017
November 2017
December 2017
January 2018
February 2018
March 2018
April 2018
May 2018
June 2018
July 2018
August 2018
September 2018
October 2018
November 2018
December 2018
January 2019
February 2019
March 2019
April 2019
May 2019
June 2019

1. HYREADY Project
PM: Dana Stojic (in transition)

- Perform Initial H_2 Literature Study (Industry Wide)
- Submit EGD's Materials and Components
- HYREADY Data Analysis
  - Define Blending Guidelines for Transmission Systems
  - Define Blending Guidelines for Distribution Systems
  - Propose Mitigation Strategies
- HYREADY Issue Engineering Guidelines on the Readiness of Natural Gas Systems for H_2 Blending

2. CGA/AGA Hydrogen Blending Group
PM: Ramses Atilano

- Form North American CGA/AGA Working Group
- Perform Public Domain Knowledge Research
- Perform Industry Specific Research
- Review and Finalize CGA/AGA Information Letter
- Approve CGA/AGA Information Letter

3a. EGD Blending Assessment (Upstream)
PM: Dana Stojic (In transition)

- Preliminary Work
  - Define Scope of Work
  - Identify and Select Specialized Engineering Consultant(s)
  - Finalize Contract
  - Leverage Technical Information from EGD's Stakeholders and External Parties
- Assessment of Gas Distribution Network (Location, Pressure, Gas Consumption, H_2 Production)
  - Perform Geographic Analysis of the Gas Grid Surrounding PtG plant
  - Elaborate H_2 Production Profile from PtG Plant
  - Investigate Natural Gas Consumption and Pressure Profile for Possible Injection Points
- Blending Assessment for Network Components and Materials
  - Investigate Standards and Regulations for Allowable Blending Concentrations
  - Investigate Components and Materials for Each Location's Distribution System
  - Define System's H_2 Tolerance
  - Define Testing Protocols
- Issue Recommendation for Closed Loop System(s)

3b. End-user Equipment Assessment
PM: Steven Rogers

- Preliminary Work
  - Define Scope of Work
  - Identify and Select Specialized Engineering Consultant(s)
  - Finalize Contract
  - Review Applicable Codes and Standards
  - Leverage Technical Information from EGD's Stakeholders and External Parties
- End-user Equipment Data Analysis
  - Compile a System-wide List of End-user Equipment
  - Identify End-user Equipment for the Closed Loop Locations
  - Survey Manufacturers
  - Review Manufacturers' Data
  - Perform Location Point Sites Ranking
  - Conduct Gap Analysis
  - Identify Compliance Variances
  - Define Mitigation Strategies
- Issue Engineering Assessment for End-user Equipment

4. 100% H_2 and NG/H_2 Blended Pipeline
PM: Alexander Hadjis

- Investigate Standards, Codes and Regulations for Pure H_2 Pipelines
- Develop Engineering Guidelines for a Dedicated H_2 Pipeline
  - Define Material and Components
  - Define Welding Procedures
  - Investigate Pipeline Model Changes
  - Define Variances
  - Define Gas Testing Protocols
- Perform Pipeline Preliminary Design
  - Design NG Pipeline to H_2 Injection Point
  - Design 100% H_2 Pipeline from Hydrogen Plant to Injection point
  - Design Blended (NG/H_2) Pipeline to feed Closed Loop System(s)
- Issue Engineering Design Guidelines for H_2 Pipelines and Preliminary Design for Closed Loop Location(s)

5. H_2 Blending Station
PM: Peter Soutar

- Investigate Standards and Regulations for Hydrogen Blending Stations
- Develop Engineering Guidelines for Hydrogen Blending Stations
  - Identify and Select Specialized Engineering Consultant(s)
  - Finalize Contract
  - Review Existing Blending Technologies
  - Develop Inlet, Outlet, Odourization and Monitoring Parameters
- Perform H_2 Blending Station Preliminary Design
- Issue Engineering Design Guidelines for H_2 Blending Stations and Preliminary Design for Injection Point Location(s)

6a
- Plan Risk Management and Identify Risks
- Perform Qualitative Risk Assessment
- Perform Quantitative Risk Assessment
- Plan Risk Response

6b
- Issue Engineering Assessment

6c
- Issue Engineering Approved Decision

Power-to-Gas Phase 2

Status Review

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

	STATUS:		
Program Streams	**Scope**	**Budget**	**Timeline**
A. Research and Development:			
CGA/AGA Task Force Information Letter			
HYREADY Engineering Guideline Report			
B. Integrity, Engineering and Capacity Assessment			
Closed Loop(s) Identification and Prioritization			
Network Capacity Analysis for Closed Loop Candidates			
Material and Component Data Gathering Analysis			
Integrity Assessments for Closed Loop Candidates			
H_2 Consumption Assessment			
Closed Loops Refinement and Design			

Power-to-Gas Phase 2

Status Review

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

	STATUS:		
Program Streams	**Scope**	**Budget**	**Timeline**
C. End User Equipment Engineering and Integrity System			
Data collection and analysis for identified closed loops			
System-wide assessment for end-user equipment			
D. Engineering Design and Review			
Pipeline Design (hydrogen pipeline)			
Pipeline Design (blended pipeline)			
Blending Stations Design (injection station)			
E. Risk Assessment	🟡		
F. Engineering Assessment	🟢		

Power-to-Gas Phase 2

Upcoming Deliverables

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

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	STATUS:		
Next Month's Deliverables	**Scope**	**Budget**	**Timeline**
A. Research and Development:			
HYREADY Engineering Guideline Final Report			
B. Integrity, Engineering and Capacity Assessment			
Data gathering to continue for Loops S1A and S1B			
Preliminary system design for Closed Loop S1			
C. End User Equipment Engineering and Integrity System			
Contract execution and commencement of work by DNV-GL			
Finalize end-user equipment field survey for Closed Loop S1			
Continue designing the end-user equipment e-survey for Closed Loops S1A and S1B			

Power-to-Gas Phase 2

Past Month's Achievements

A. Research and Development:

- ✓ CGA/AGA Task Force Information Letter final version received by EGD
- ✓ HYREADY Draft Report Reviewed by Engineering

B. Integrity, Engineering and Capacity Assessment

- ✓ Draft Report issued by DBI-GUT for Work Package 1, which assesses the H_2 capacity of the gas grid for three high likelihood closed loop systems. The report has been reviewed and validated by EGD's Growth and Network Analysis teams
- ✓ Bill of Materials for one Closed Loop system (S1) has been finalized
- ✓ Work on the bill of materials for two additional Closed Loops (S1A and S1B) has been initiated

C. End User Equipment Engineering and Integrity System

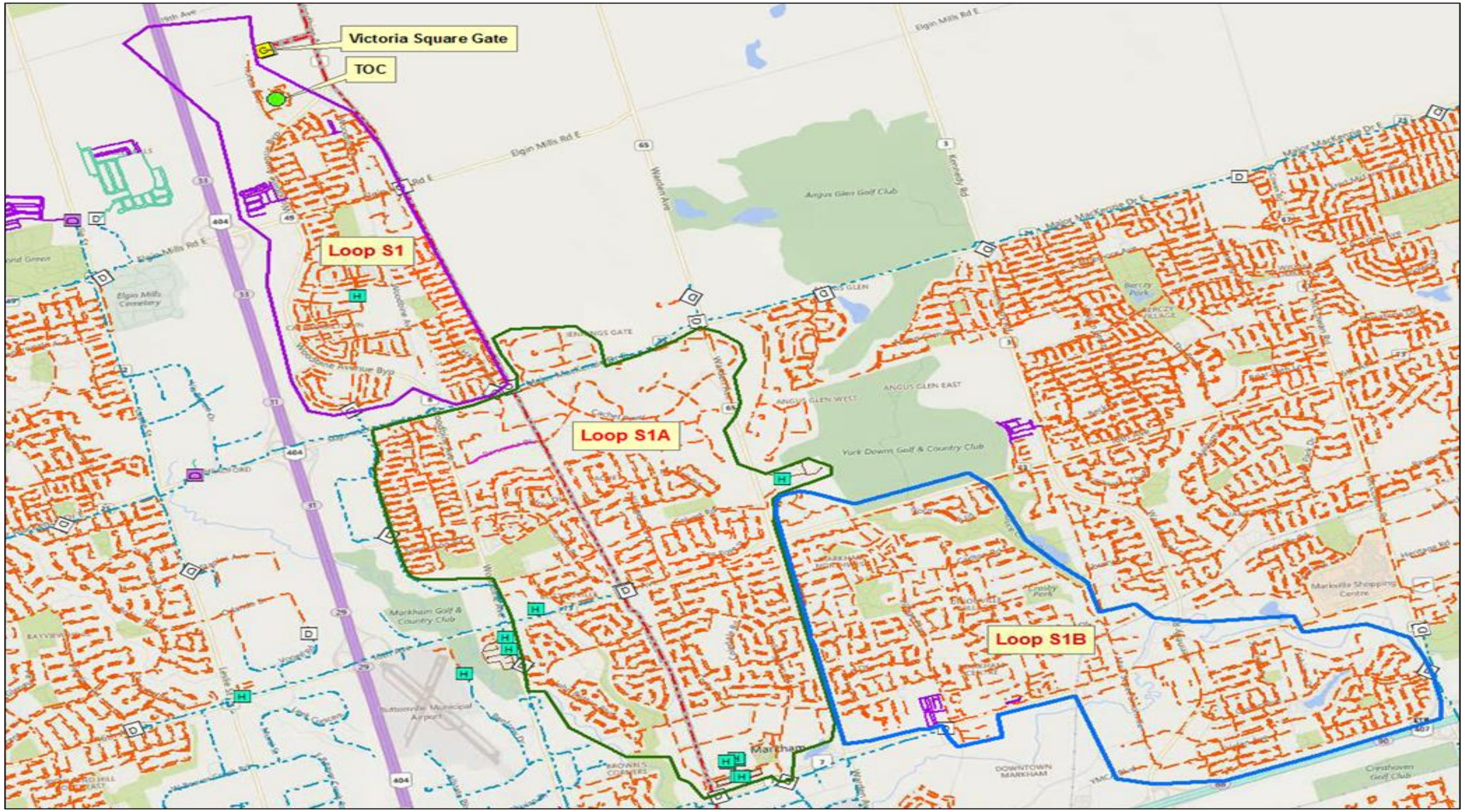
- ✓ Proposals from six consultants have been reviewed and ranked, DNV-GL was selected as the successful bidder
- ✓ Contract is being executed with DNV-GL by the Law Department with support from the Growth team
- ✓ End-user equipment survey for a closed loop was designed and awaits execution by Lakeside Gas

D. Engineering Design and Review

- ✓ All applicable codes, standards and regulations for H_2 pipelines have been compiled and summarized

Power-to-Gas Phase 2

Map of Likely Candidates for Closed Loop Systems



- Phased approach to increase H_2 consumption capacity
- Connect loops with blended pipelines
- Isolate areas of concern (e.g., CNG stations)

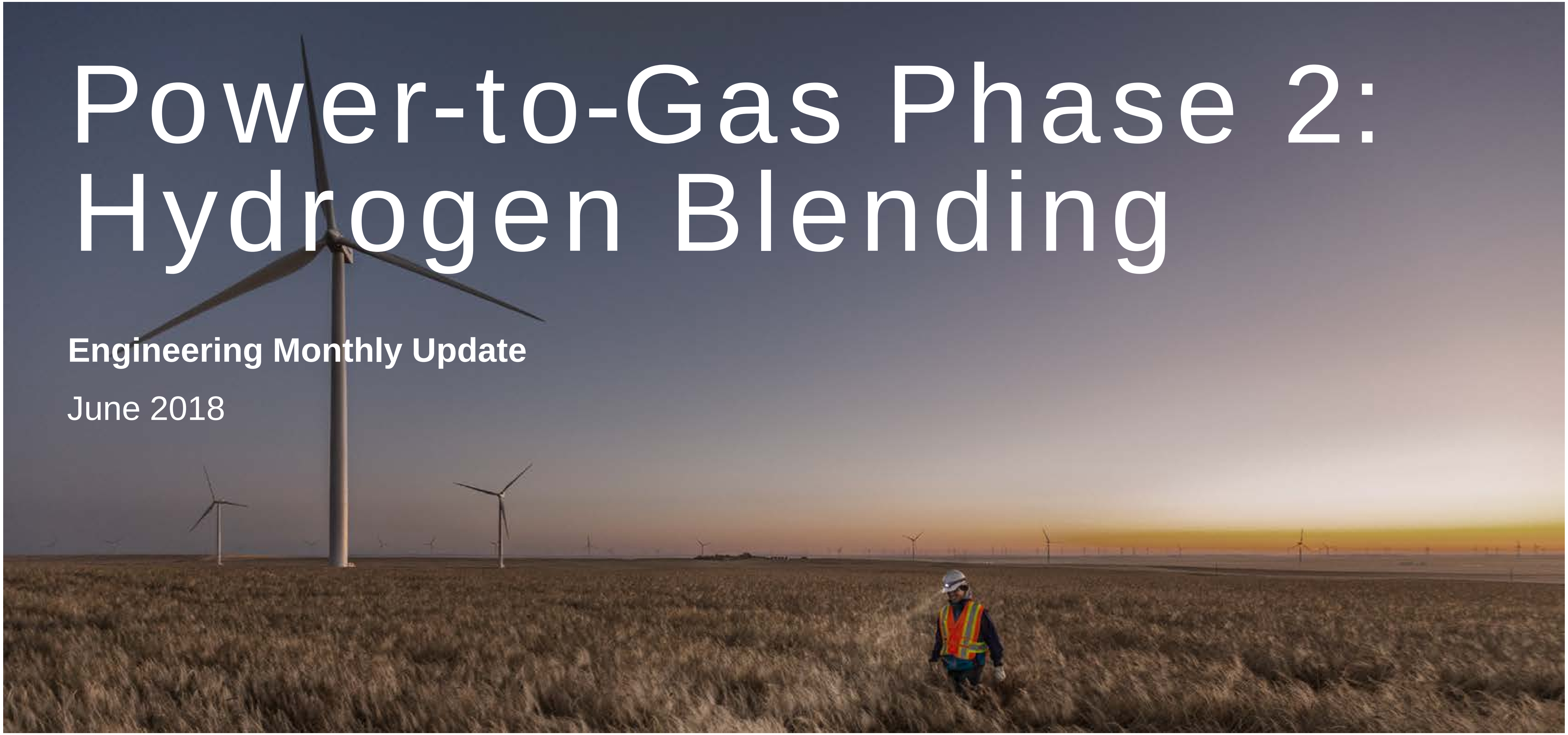
Phase 1
- Loop S1
- ~4,000 customers
- 0-10% Plant Capacity*

Phase 2
- Loop S1A
- ~7,000 customers
- 10-20% of Plant Capacity*

Phase 3
- Loop S1B
- ~6,000 customers
- 20-30% of Plant Capacity*

*based on current plant capacity and 3,000 hours of operation per year

Power-to-Gas Phase 2: Hydrogen Blending



Engineering Monthly Update

June 2018

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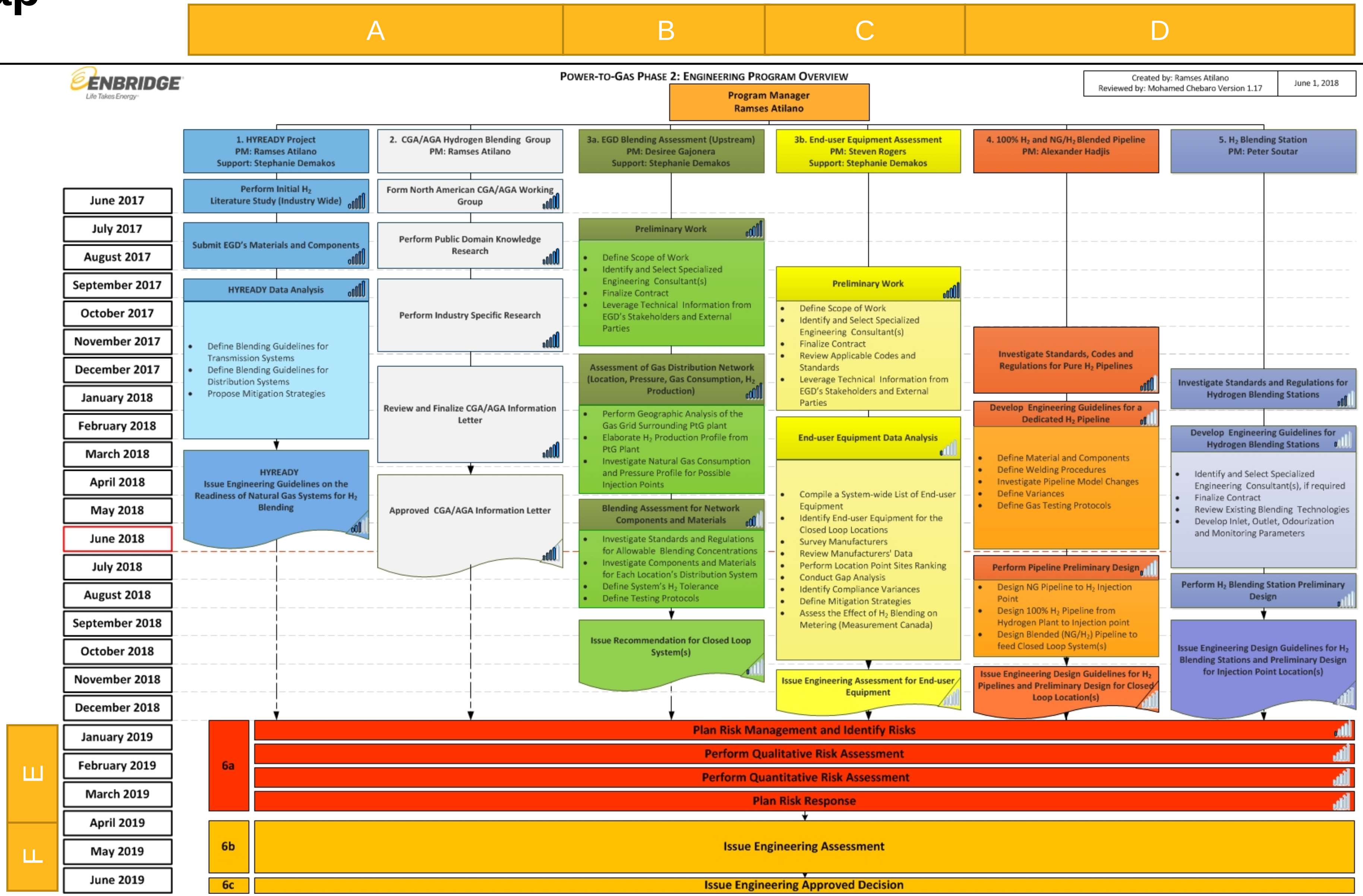
Engineering

Power-to-Gas Phase 2

Road Map



POWER-TO-GAS PHASE 2: ENGINEERING PROGRAM OVERVIEW

Created by: Ramses Atilano
Reviewed by: Mohamed Chebaro Version 1.17

June 1, 2018

Program Manager
Ramses Atilano

June 2017
July 2017
August 2017
September 2017
October 2017
November 2017
December 2017
January 2018
February 2018
March 2018
April 2018
May 2018
June 2018
July 2018
August 2018
September 2018
October 2018
November 2018
December 2018
January 2019
February 2019
March 2019
April 2019
May 2019
June 2019

1. HYREADY Project
PM: Ramses Atilano
Support: Stephanie Demakos

- **Perform Initial H_2 Literature Study (Industry Wide)**
- **Submit EGD's Materials and Components**
- **HYREADY Data Analysis**
  - Define Blending Guidelines for Transmission Systems
  - Define Blending Guidelines for Distribution Systems
  - Propose Mitigation Strategies
- **HYREADY Issue Engineering Guidelines on the Readiness of Natural Gas Systems for H_2 Blending**

2. CGA/AGA Hydrogen Blending Group
PM: Ramses Atilano

- **Form North American CGA/AGA Working Group**
- **Perform Public Domain Knowledge Research**
- **Perform Industry Specific Research**
- **Review and Finalize CGA/AGA Information Letter**
- **Approved CGA/AGA Information Letter**

3a. EGD Blending Assessment (Upstream)
PM: Desiree Gajonera
Support: Stephanie Demakos

- **Preliminary Work**
  - Define Scope of Work
  - Identify and Select Specialized Engineering Consultant(s)
  - Finalize Contract
  - Leverage Technical Information from EGD's Stakeholders and External Parties
- **Assessment of Gas Distribution Network (Location, Pressure, Gas Consumption, H_2 Production)**
  - Perform Geographic Analysis of the Gas Grid Surrounding PtG plant
  - Elaborate H_2 Production Profile from PtG Plant
  - Investigate Natural Gas Consumption and Pressure Profile for Possible Injection Points
- **Blending Assessment for Network Components and Materials**
  - Investigate Standards and Regulations for Allowable Blending Concentrations
  - Investigate Components and Materials for Each Location's Distribution System
  - Define System's H_2 Tolerance
  - Define Testing Protocols
- **Issue Recommendation for Closed Loop System(s)**

3b. End-user Equipment Assessment
PM: Steven Rogers
Support: Stephanie Demakos

- **Preliminary Work**
  - Define Scope of Work
  - Identify and Select Specialized Engineering Consultant(s)
  - Finalize Contract
  - Review Applicable Codes and Standards
  - Leverage Technical Information from EGD's Stakeholders and External Parties
- **End-user Equipment Data Analysis**
  - Compile a System-wide List of End-user Equipment
  - Identify End-user Equipment for the Closed Loop Locations
  - Survey Manufacturers
  - Review Manufacturers' Data
  - Perform Location Point Sites Ranking
  - Conduct Gap Analysis
  - Identify Compliance Variances
  - Define Mitigation Strategies
  - Assess the Effect of H_2 Blending on Metering (Measurement Canada)
- **Issue Engineering Assessment for End-user Equipment**

4. 100% H_2 and NG/H_2 Blended Pipeline
PM: Alexander Hadjis

- **Investigate Standards, Codes and Regulations for Pure H_2 Pipelines**
- **Develop Engineering Guidelines for a Dedicated H_2 Pipeline**
  - Define Material and Components
  - Define Welding Procedures
  - Investigate Pipeline Model Changes
  - Define Variances
  - Define Gas Testing Protocols
- **Perform Pipeline Preliminary Design**
  - Design NG Pipeline to H_2 Injection Point
  - Design 100% H_2 Pipeline from Hydrogen Plant to Injection point
  - Design Blended (NG/H_2) Pipeline to feed Closed Loop System(s)
- **Issue Engineering Design Guidelines for H_2 Pipelines and Preliminary Design for Closed Loop Location(s)**

5. H_2 Blending Station
PM: Peter Soutar

- **Investigate Standards and Regulations for Hydrogen Blending Stations**
- **Develop Engineering Guidelines for Hydrogen Blending Stations**
  - Identify and Select Specialized Engineering Consultant(s), if required
  - Finalize Contract
  - Review Existing Blending Technologies
  - Develop Inlet, Outlet, Odourization and Monitoring Parameters
- **Perform H_2 Blending Station Preliminary Design**
- **Issue Engineering Design Guidelines for H_2 Blending Stations and Preliminary Design for Injection Point Location(s)**

6a
- **Plan Risk Management and Identify Risks**
- **Perform Qualitative Risk Assessment**
- **Perform Quantitative Risk Assessment**
- **Plan Risk Response**

6b
- **Issue Engineering Assessment**

6c
- **Issue Engineering Approved Decision**

Power-to-Gas Phase 2

Status Review

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

	STATUS:		
Program Streams	**Scope**	**Budget**	**Timeline**
CGA/AGA Task Force Information Letter	🟩	🟩	🟩
HYREADY Engineering Guideline Report	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟨
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩

Power-to-Gas Phase 2

Status Review

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

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	STATUS:		
Program Streams	**Scope**	**Budget**	**Timeline**
Data collection for identified closed loops	🟩	🟩	🟨
Data analysis for identified closed loops	🟩	🟩	🟨
System-wide assessment for end-user equipment	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
Risk Assessment Report	🟩	🟩	🟨
Computational Modeling	🟩	🟩	🟩
	🟩	🟩	🟩

Power-to-Gas Phase 2

Upcoming Deliverables

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

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	STATUS:		
Next Month's Deliverables	**Scope**	**Budget**	**Timeline**
A. Research and Development:			
Receive HYREADY Engineering Guideline Final Report	🟩	🟩	🟩
B. Integrity, Engineering and Capacity Assessment			
Compile Bill of Materials for Loops S1A and S1B	🟩	🟩	🟨
Complete 40% of H_2 tolerance evaluation for the three Closed Loops	🟩	🟩	🟨
C. End User Equipment Engineering and Integrity System			
Host technical sessions with DNV-GL regarding Gas Interchangeability	🟩	🟩	🟩
Compile 50% of required field survey information for Loop S1	🟩	🟩	🟨
Plan field survey evaluation for Loops S1A and S1B	🟩	🟩	🟩

Power-to-Gas Phase 2

Past Month’s Achievements

Program Management

- ✓ As of July 2, 2018, the Engineering Growth team will be fully resourced

A. Research and Development

- ✓ Received CGA/AGA Task Force Information Letter with comments from AGA
- ✓ Designed Hydrogen Knowledge Management Database framework. The team will continue to update on a daily/weekly basis (e.g., industry-wide available reports, papers, standards)

B. Integrity, Engineering and Capacity Assessment

- ✓ Reviewed multiple iterations of the DBI report for the H_2 capacity assessment of the gas grid for the three Closed Loops systems
- ✓ Finalized the Bill of Materials list for the two additional Closed Loops (S1A and S1B) for Pipelines and Valves
- ✓ Worked on the bill of materials for Closed Loops S1A and S1B for fittings and above ground assets
- ✓ Completed 20% of the H_2 tolerance evaluation for the three selected Closed Loops has been completed
- ✓ Completed first iteration of preliminary design for Closed Loop S1

Power-to-Gas Phase 2

Past Month’s Achievements

C. End User Equipment Engineering and Integrity System

- ✓ Contract with DNV-GL has been fully executed
- ✓ Defined Work Plan for DNV-GL, including technical exchanges on Gas Interchangeability with several involved stakeholders from EGD
- ✓ Finalized planning for the end-user equipment survey for Loop S1
- ✓ Initiated the end-user equipment survey for Loop S1 by Lakeside Gas
- ✓ Advanced the design work on the end-user equipment survey options for Closed Loops S1A and S1B

D. Engineering Design and Review

- ✓ Initiated preliminary design for pipelines carrying three different products (100% H_2, 100% NG and blended gas)
- ✓ Initiated preliminary design for the station components (Pressure Regulation and H_2 Injection)
- ✓ Compiled and summarized applicable codes, standards and regulations for H_2 pipelines
- ✓ Initiated discussions with the TSSA

E. Risk Assessment

- ✓ Reviewed first draft of the Risk Assessment Work Plan
- ✓ Defined and planned computational dispersion modeling work that will feed into the risk and engineering assessments

Power-to-Gas Phase 2

Map of Closed Loop Systems in Markham

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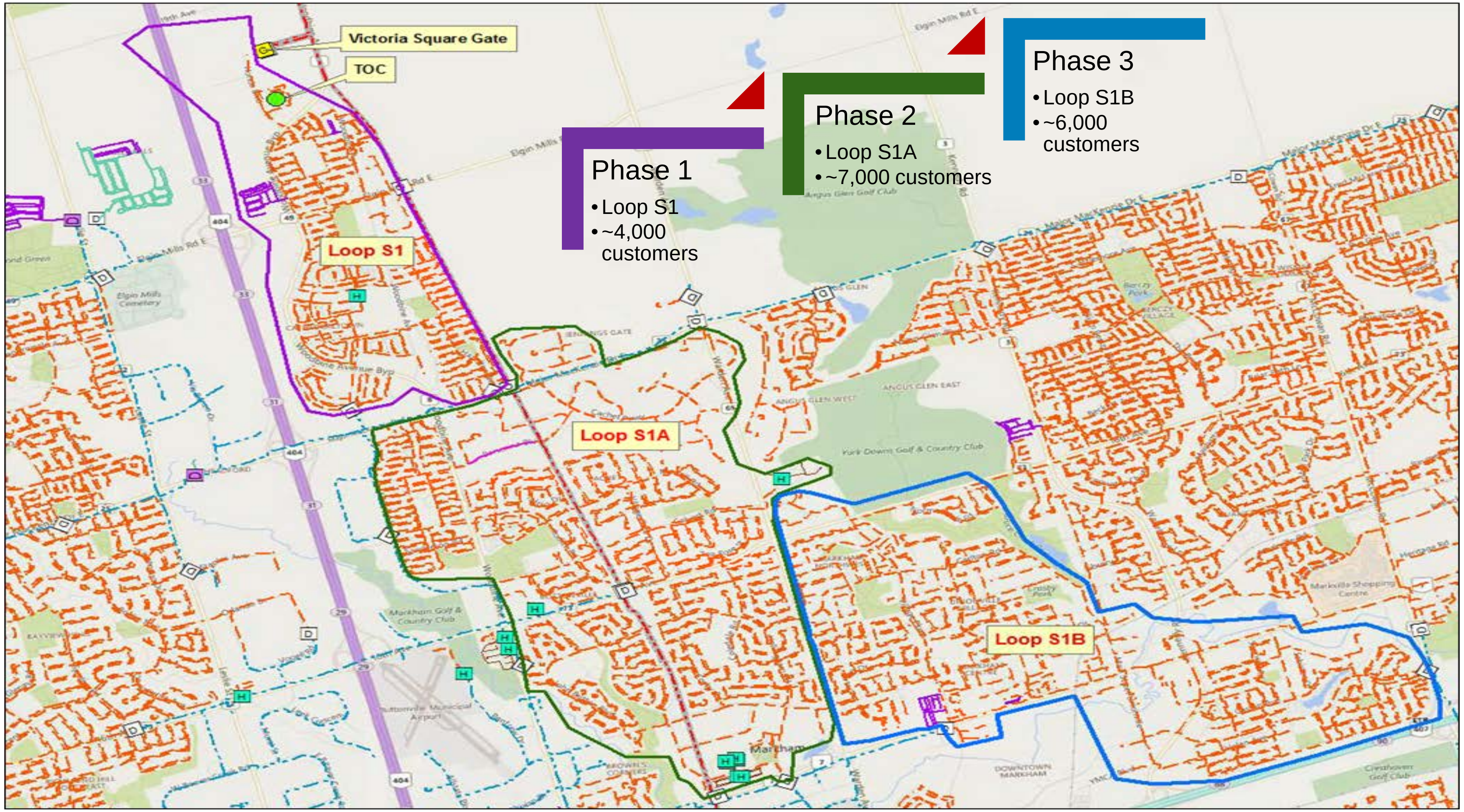
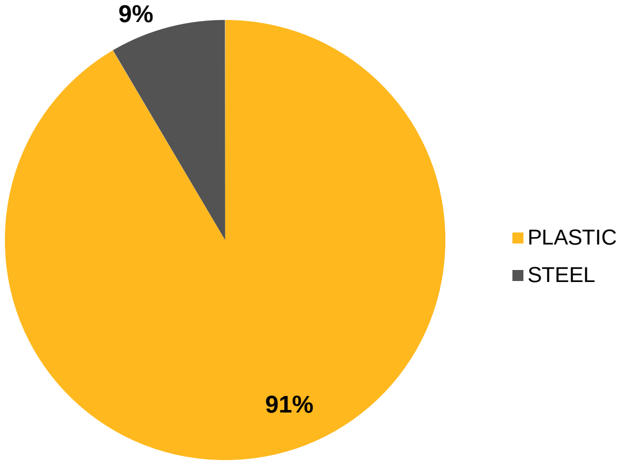


Phase 1
- Loop S1
- ~4,000 customers

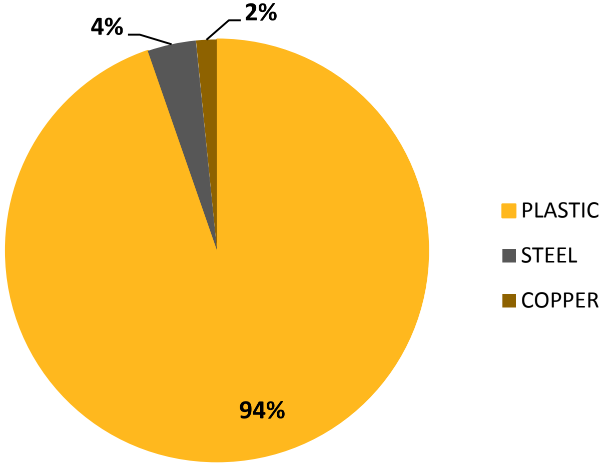
Phase 2
- Loop S1A
- ~7,000 customers

Phase 3
- Loop S1B
- ~6,000 customers

Material- Mains by Length (S1, S1A, S1B)



Material- Services by Number (S1, S1A, S1B)



Power-to-Gas Phase 2: Hydrogen Blending

EGD/UG Joint Executive Meeting

June 6, 2018

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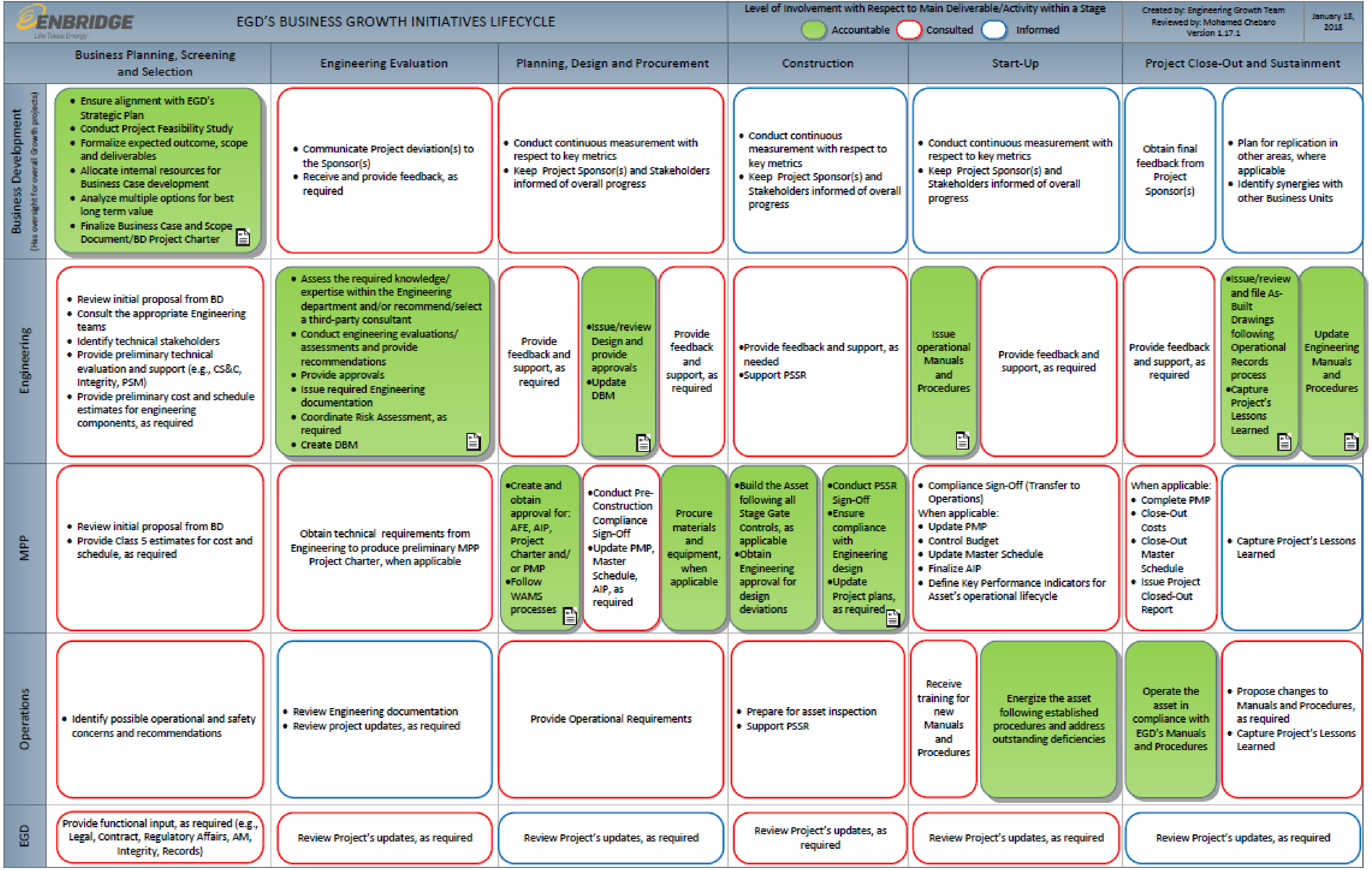
Mohamed Chebaro
Manager, Engineering Customer Safety, Compliance and Growth

Mike Wagle
Chief Engineer

Business Growth Initiatives Lifecycle



EGD'S BUSINESS GROWTH INITIATIVES LIFECYCLE

Level of Involvement with Respect to Main Deliverable/Activity within a Stage

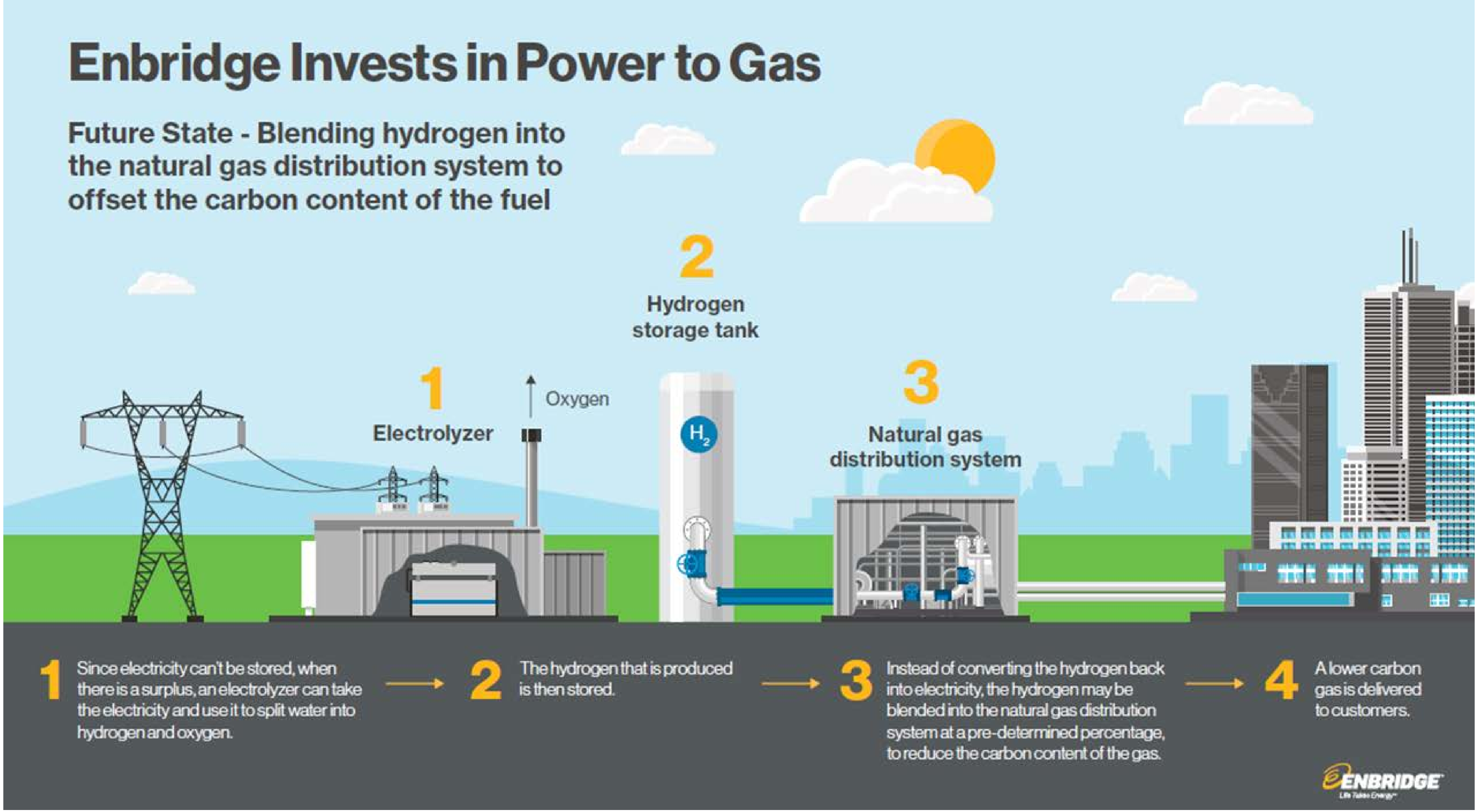
🟩 Accountable 🟥 Consulted 🟦 Informed

Created by: Engineering Growth Team
Reviewed by: Mohamed Chebaro
Version 1.17.1

January 18, 2018

	Business Planning, Screening and Selection	Engineering Evaluation	Planning, Design and Procurement	Construction	Start-Up	Project Close-Out and Sustainment
Business Development (Has oversight for overall Growth projects)	🟩 • Ensure alignment with EGD's Strategic Plan • Conduct Project Feasibility Study • Formalize expected outcome, scope and deliverables • Allocate internal resources for Business Case development • Analyze multiple options for best long term value • Finalize Business Case and Scope Document/BD Project Charter	🟥 • Communicate Project deviation(s) to the Sponsor(s) • Receive and provide feedback, as required	🟥 • Conduct continuous measurement with respect to key metrics • Keep Project Sponsor(s) and Stakeholders informed of overall progress	🟦 • Conduct continuous measurement with respect to key metrics • Keep Project Sponsor(s) and Stakeholders informed of overall progress	🟦 • Conduct continuous measurement with respect to key metrics • Keep Project Sponsor(s) and Stakeholders informed of overall progress	🟦 Obtain final feedback from Project Sponsor(s) 🟦 • Plan for replication in other areas, where applicable • Identify synergies with other Business Units
Engineering	🟥 • Review initial proposal from BD • Consult the appropriate Engineering teams • Identify technical stakeholders • Provide preliminary technical evaluation and support (e.g., CS&C, Integrity, PSM) • Provide preliminary cost and schedule estimates for engineering components, as required	🟩 • Assess the required knowledge/ expertise within the Engineering department and/or recommend/select a third-party consultant • Conduct engineering evaluations/ assessments and provide recommendations • Provide approvals • Issue required Engineering documentation • Coordinate Risk Assessment, as required • Create DBM	🟥 Provide feedback and support, as required 🟩 •Issue/review Design and provide approvals •Update DBM 🟥 Provide feedback and support, as required	🟥 •Provide feedback and support, as needed •Support PSSR	🟩 Issue operational Manuals and Procedures 🟥 Provide feedback and support, as required	🟥 Provide feedback and support, as required 🟩 •Issue/review and file As-Built Drawings following Operational Records process •Capture Project's Lessons Learned 🟩 Update Engineering Manuals and Procedures
MPP	🟥 • Review initial proposal from BD • Provide Class 5 estimates for cost and schedule, as required	🟥 Obtain technical requirements from Engineering to produce preliminary MPP Project Charter, when applicable	🟩 •Create and obtain approval for: AFE, AIP, Project Charter and/ or PMP •Follow WAMS processes 🟥 •Conduct Pre-Construction Compliance Sign-Off •Update PMP, Master Schedule, AIP, as required 🟩 Procure materials and equipment, when applicable	🟩 •Build the Asset following all Stage Gate Controls, as applicable •Obtain Engineering approval for design deviations 🟩 •Conduct PSSR Sign-Off •Ensure compliance with Engineering design •Update Project plans, as required	🟥 • Compliance Sign-Off (Transfer to Operations) When applicable: • Update PMP • Control Budget • Update Master Schedule • Finalize AIP • Define Key Performance Indicators for Asset's operational lifecycle	🟥 When applicable: • Complete PMP • Close-Out Costs • Close-Out Master Schedule • Issue Project Closed-Out Report 🟦 • Capture Project's Lessons Learned
Operations	🟥 • Identify possible operational and safety concerns and recommendations	🟦 • Review Engineering documentation • Review project updates, as required	🟥 Provide Operational Requirements	🟥 • Prepare for asset inspection • Support PSSR	🟥 Receive training for new Manuals and Procedures 🟩 Energize the asset following established procedures and address outstanding deficiencies	🟩 Operate the asset in compliance with EGD's Manuals and Procedures 🟥 • Propose changes to Manuals and Procedures, as required • Capture Project's Lessons Learned
EGD	🟥 Provide functional input, as required (e.g., Legal, Contract, Regulatory Affairs, AM, Integrity, Records)	🟥 Review Project's updates, as required	🟦 Review Project's updates, as required	🟥 Review Project's updates, as required	🟥 Review Project's updates, as required	🟦 Review Project's updates, as required

Power-to-Gas Technology Overview



Enbridge Invests in Power to Gas

Future State - Blending hydrogen into the natural gas distribution system to offset the carbon content of the fuel

1 Since electricity can't be stored, when there is a surplus, an electrolyzer can take the electricity and use it to split water into hydrogen and oxygen. →

2 The hydrogen that is produced is then stored. →

3 Instead of converting the hydrogen back into electricity, the hydrogen may be blended into the natural gas distribution system at a pre-determined percentage, to reduce the carbon content of the gas. →

4 A lower carbon gas is delivered to customers.

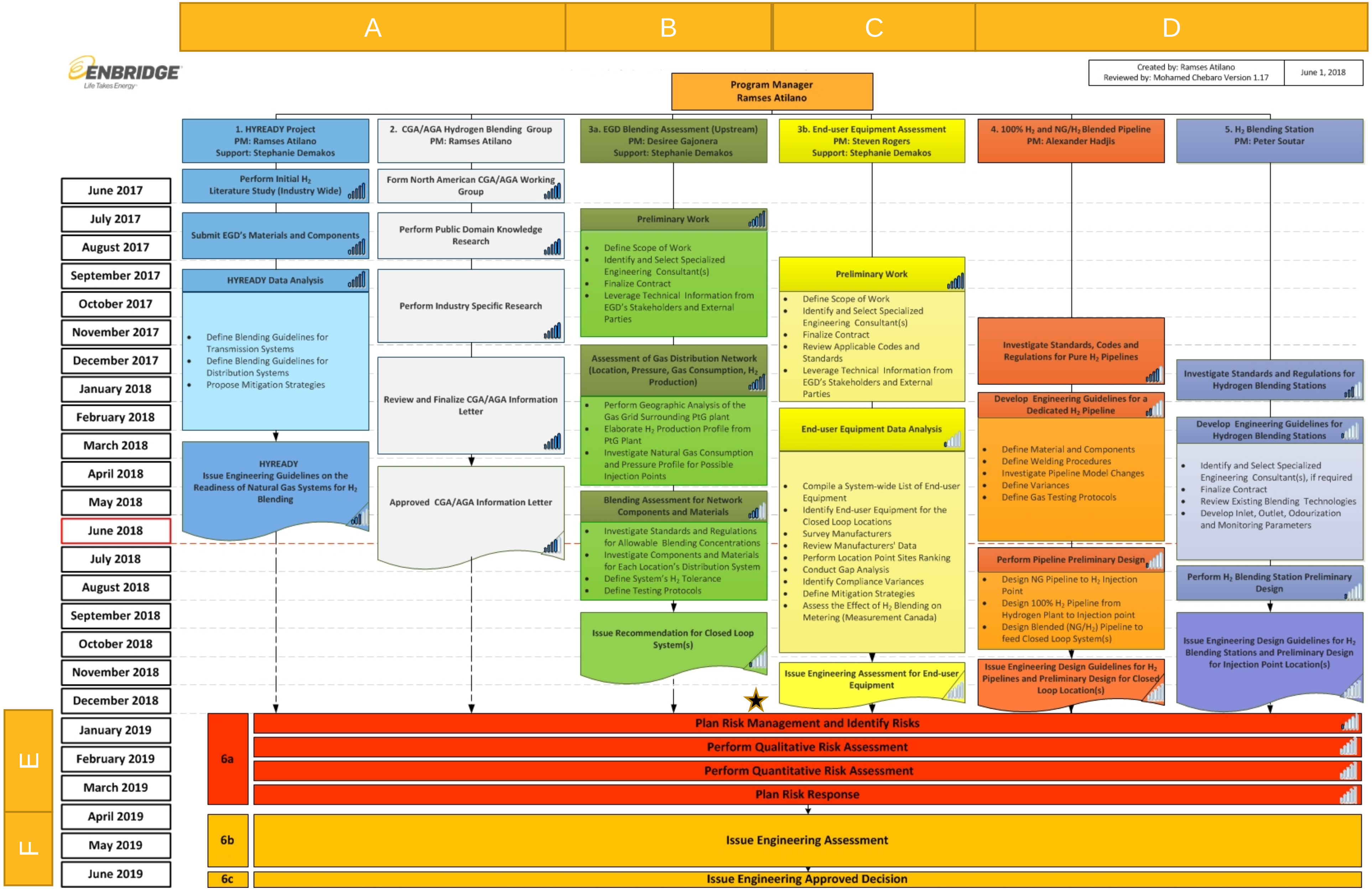
Existing Hydrogen Blending Projects

France, Germany, UK and USA

- Dunkirk (France) – Started in 2013, 2 years preliminary study + 5 years execution/monitoring
  - NGV Bus Fueling Station, 50 buses to run with a CH_4/H_2 mixture, starting at 6% H_2
  - New residential neighborhood of around 200 homes (pre-designed system), 6% H_2
- Mainz (Germany) – Operational since 2016
  - DVGW standards allow up to 10% H_2 in natural gas networks in Germany
  - Around 2,000 customers, up to 10% H_2, distribution network loop was built in the 1980s, ~1,000 appliances were inspected/investigated beforehand, gas quality and odourization levels have been constantly monitored for 2.5 years
- HyDeploy (UK) – In progress, not operational yet

  Keele University trial, up to 20% H_2 injected on campus (130 customers), safety verification will be conducted on every appliance, pre-designed for H_2
- University of California Irvine (US) – Operational since October 2016
  - Customer piping, privately-owned, sponsored by SoCal, work started in 2014
  - Research purposes, 1.0% H_2 currently, to be expanded (started at 0.25%)

Power-to-Gas Phase 2 Road Map



A | B | C | D

Created by: Ramses Atilano
Reviewed by: Mohamed Chebaro Version 1.17
June 1, 2018

Program Manager
Ramses Atilano

1. HYREADY Project
PM: Ramses Atilano
Support: Stephanie Demakos

Perform Initial H_2 Literature Study (Industry Wide)

Submit EGD's Materials and Components

HYREADY Data Analysis

- Define Blending Guidelines for Transmission Systems
- Define Blending Guidelines for Distribution Systems
- Propose Mitigation Strategies

HYREADY
Issue Engineering Guidelines on the Readiness of Natural Gas Systems for H_2 Blending

2. CGA/AGA Hydrogen Blending Group
PM: Ramses Atilano

Form North American CGA/AGA Working Group

Perform Public Domain Knowledge Research

Perform Industry Specific Research

Review and Finalize CGA/AGA Information Letter

Approved CGA/AGA Information Letter

3a. EGD Blending Assessment (Upstream)
PM: Desiree Gajonera
Support: Stephanie Demakos

Preliminary Work

- Define Scope of Work
- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract
- Leverage Technical Information from EGD's Stakeholders and External Parties

Assessment of Gas Distribution Network (Location, Pressure, Gas Consumption, H_2 Production)

- Perform Geographic Analysis of the Gas Grid Surrounding PtG plant
- Elaborate H_2 Production Profile from PtG Plant
- Investigate Natural Gas Consumption and Pressure Profile for Possible Injection Points

Blending Assessment for Network Components and Materials

- Investigate Standards and Regulations for Allowable Blending Concentrations
- Investigate Components and Materials for Each Location's Distribution System
- Define System's H_2 Tolerance
- Define Testing Protocols

Issue Recommendation for Closed Loop System(s)

3b. End-user Equipment Assessment
PM: Steven Rogers
Support: Stephanie Demakos

Preliminary Work

- Define Scope of Work
- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract
- Review Applicable Codes and Standards
- Leverage Technical Information from EGD's Stakeholders and External Parties

End-user Equipment Data Analysis

- Compile a System-wide List of End-user Equipment
- Identify End-user Equipment for the Closed Loop Locations
- Survey Manufacturers
- Review Manufacturers' Data
- Perform Location Point Sites Ranking
- Conduct Gap Analysis
- Identify Compliance Variances
- Define Mitigation Strategies
- Assess the Effect of H_2 Blending on Metering (Measurement Canada)

Issue Engineering Assessment for End-user Equipment

4. 100% H_2 and NG/H_2 Blended Pipeline
PM: Alexander Hadjis

Investigate Standards, Codes and Regulations for Pure H_2 Pipelines

Develop Engineering Guidelines for a Dedicated H_2 Pipeline

- Define Material and Components
- Define Welding Procedures
- Investigate Pipeline Model Changes
- Define Variances
- Define Gas Testing Protocols

Perform Pipeline Preliminary Design

- Design NG Pipeline to H_2 Injection Point
- Design 100% H_2 Pipeline from Hydrogen Plant to Injection point
- Design Blended (NG/H_2) Pipeline to feed Closed Loop System(s)

Issue Engineering Design Guidelines for H_2 Pipelines and Preliminary Design for Closed Loop Location(s)

5. H_2 Blending Station
PM: Peter Soutar

Investigate Standards and Regulations for Hydrogen Blending Stations

Develop Engineering Guidelines for Hydrogen Blending Stations

- Identify and Select Specialized Engineering Consultant(s), if required
- Finalize Contract
- Review Existing Blending Technologies
- Develop Inlet, Outlet, Odourization and Monitoring Parameters

Perform H_2 Blending Station Preliminary Design

Issue Engineering Design Guidelines for H_2 Blending Stations and Preliminary Design for Injection Point Location(s)

June 2017
July 2017
August 2017
September 2017
October 2017
November 2017
December 2017
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June 2019

E

F

6a
Plan Risk Management and Identify Risks
Perform Qualitative Risk Assessment
Perform Quantitative Risk Assessment
Plan Risk Response

6b
Issue Engineering Assessment

6c
Issue Engineering Approved Decision

Program Overview

Six Work Streams

A. Research and Development:

- CGA/AGA Task Force Information Letter
- HYREADY Engineering Guideline Report

B. Integrity, Engineering and Capacity Assessment

- Closed Loop(s) Identification and Prioritization
- Network Capacity Analysis and Injection for Closed Loop Candidates
- Material and Component Data Gathering Analysis
- Integrity Assessments for Closed Loop Candidates
- H_2 Consumption Assessment
- Closed Loops Refinement and Design
- Safety and Operational Considerations

Program Overview

Six Work Streams

C. End User Equipment Engineering and Integrity System

- Data collection and analysis for identified closed loops
  - Field surveys (commercial/residential)
  - Potential electronic surveys
  - Potential appliance and leak testing; manufacturer qualification
  - Utilization of prior European appliance testing and research
  - Comparison of Canadian/European standards
- System-wide assessment for end-user equipment

D. Engineering Design and Review

- Pipeline Design (hydrogen, blended, natural gas)
  - Discussions underway with the TSSA regarding regulatory piece of H_2 blending
- Blending Stations Design
  - Injection station
  - Safety design considerations
  - Potential odorization

Program Overview

Six Work Streams

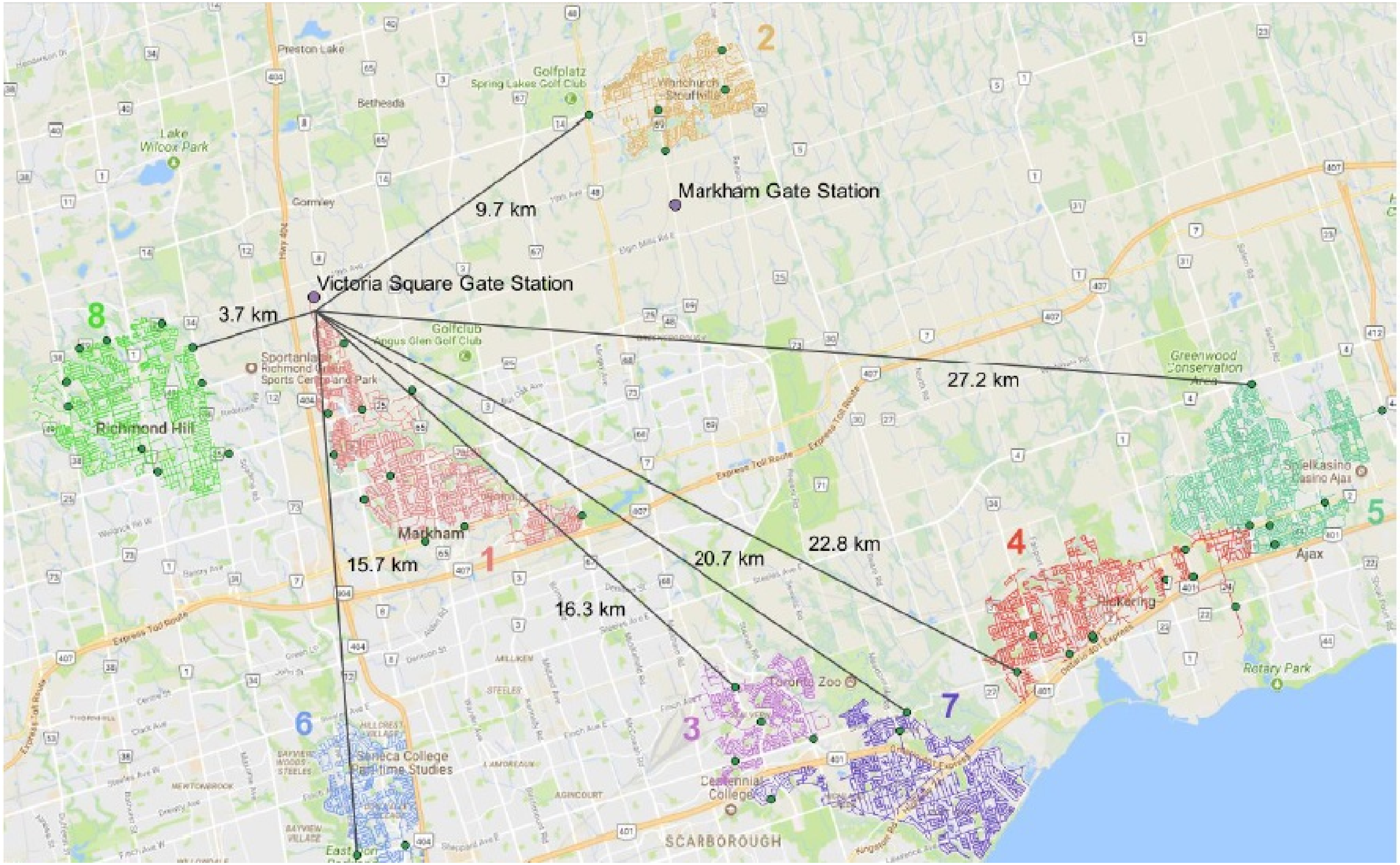
E. Risk Assessment

- Qualitative and quantitative risk assessments for upstream and downstream components
- Uncertainty analysis based on research, testing and consultant recommendations

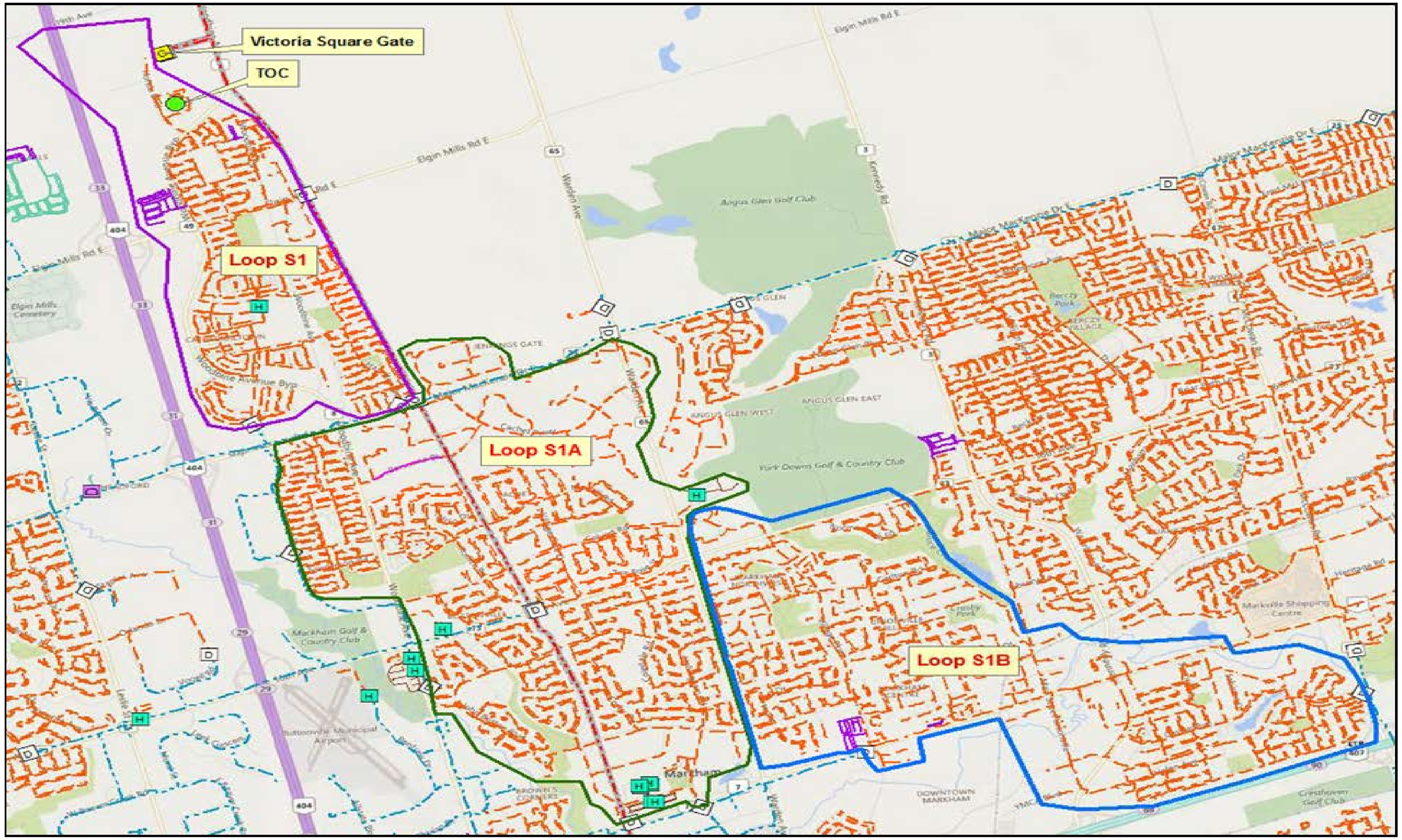
F. Engineering Assessment

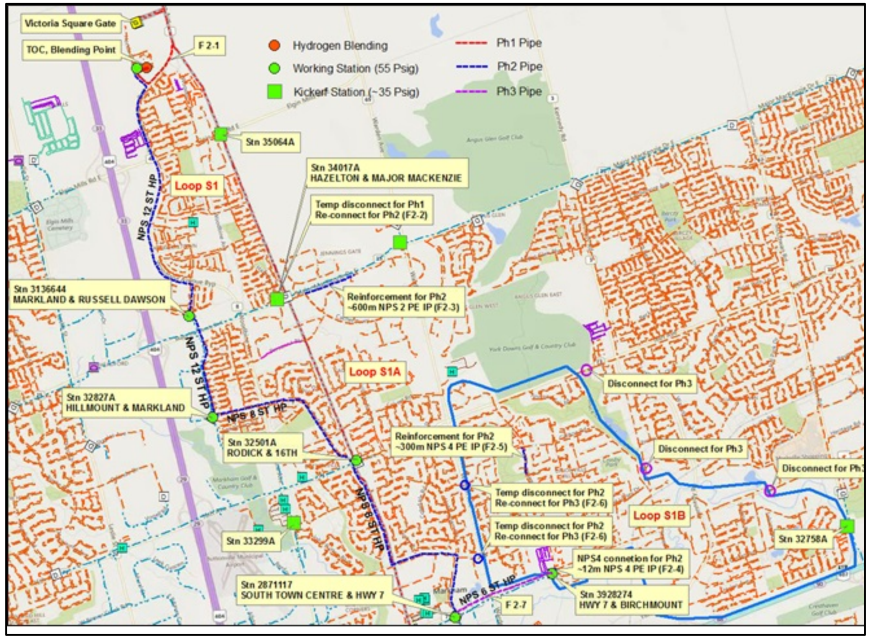
- Final Engineering recommendation and position based on all the above

Overview of Initial Closed Loop Candidates



Probable Closed Loop Candidates





Phase 1

- Loop S1
- ~4,000 customers
- 0-10% Plant Capacity*

Phase 2

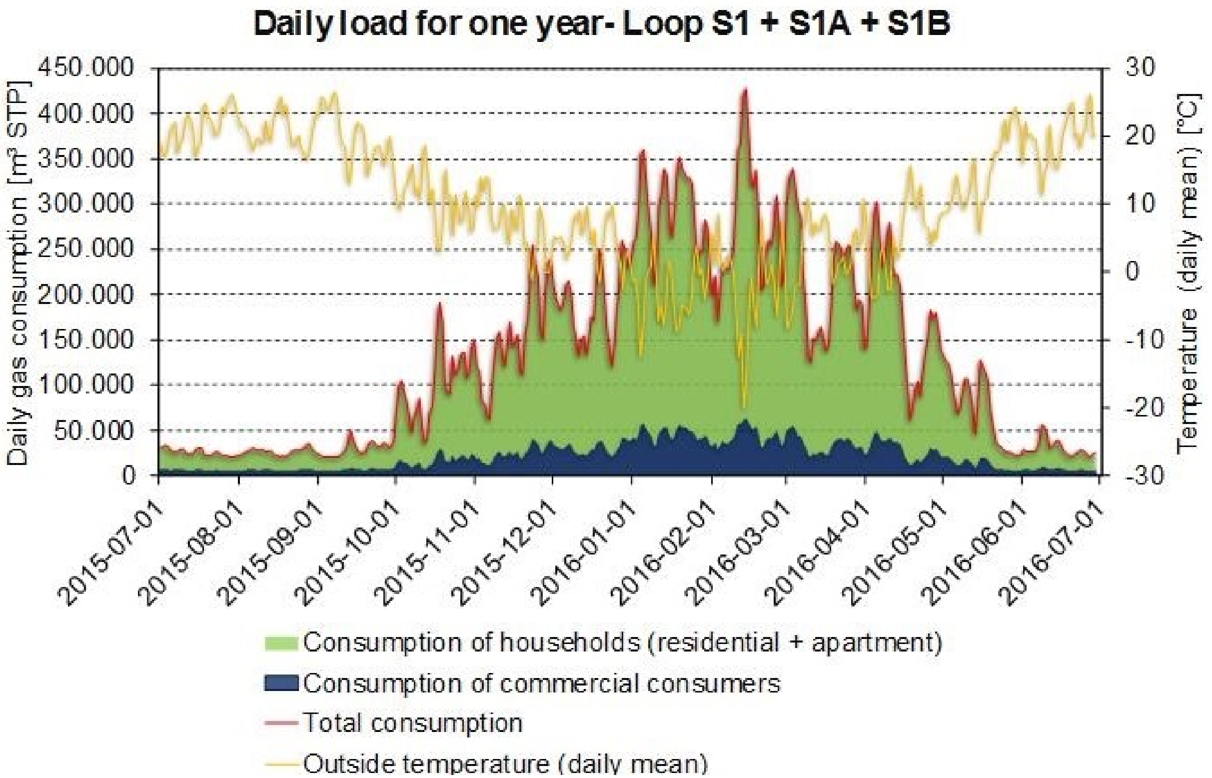
- Loop S1A
- ~7,000 customers
- 10-20% of Plant Capacity*

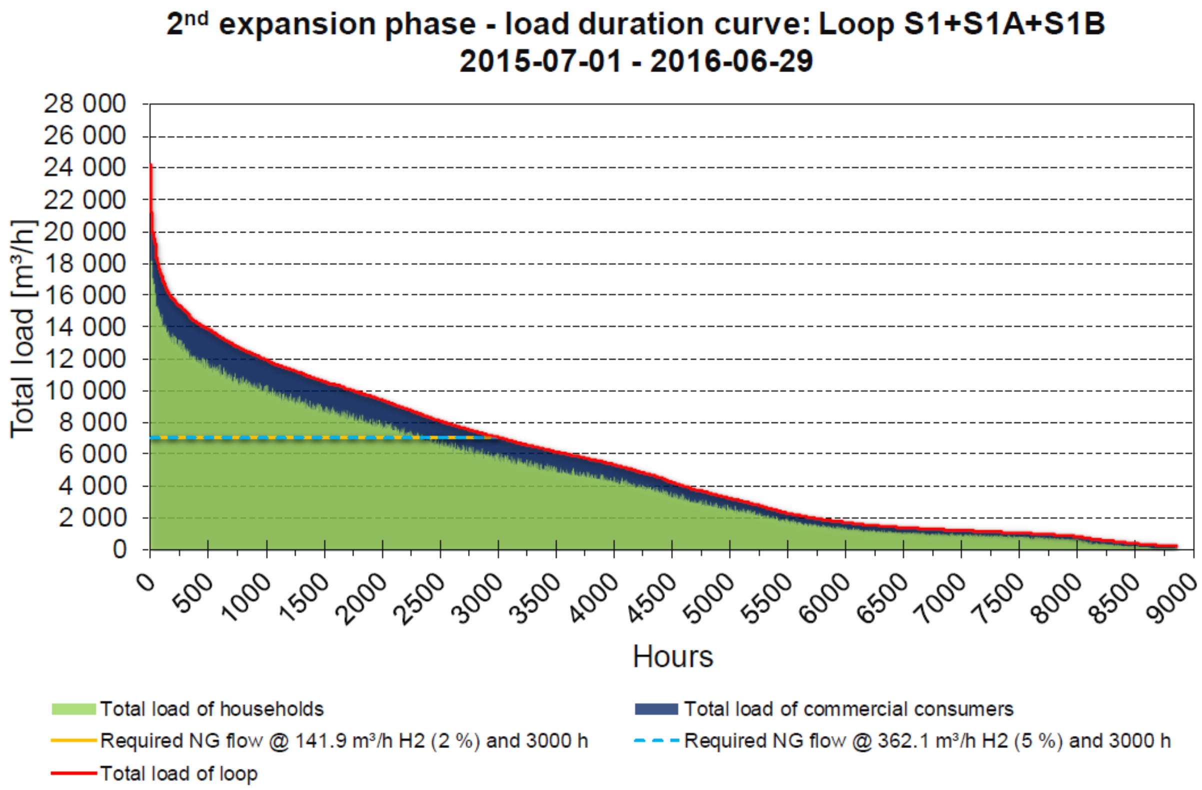
Phase 3

- Loop S1B
- ~6,000 customers
- 20-30% of Plant Capacity*

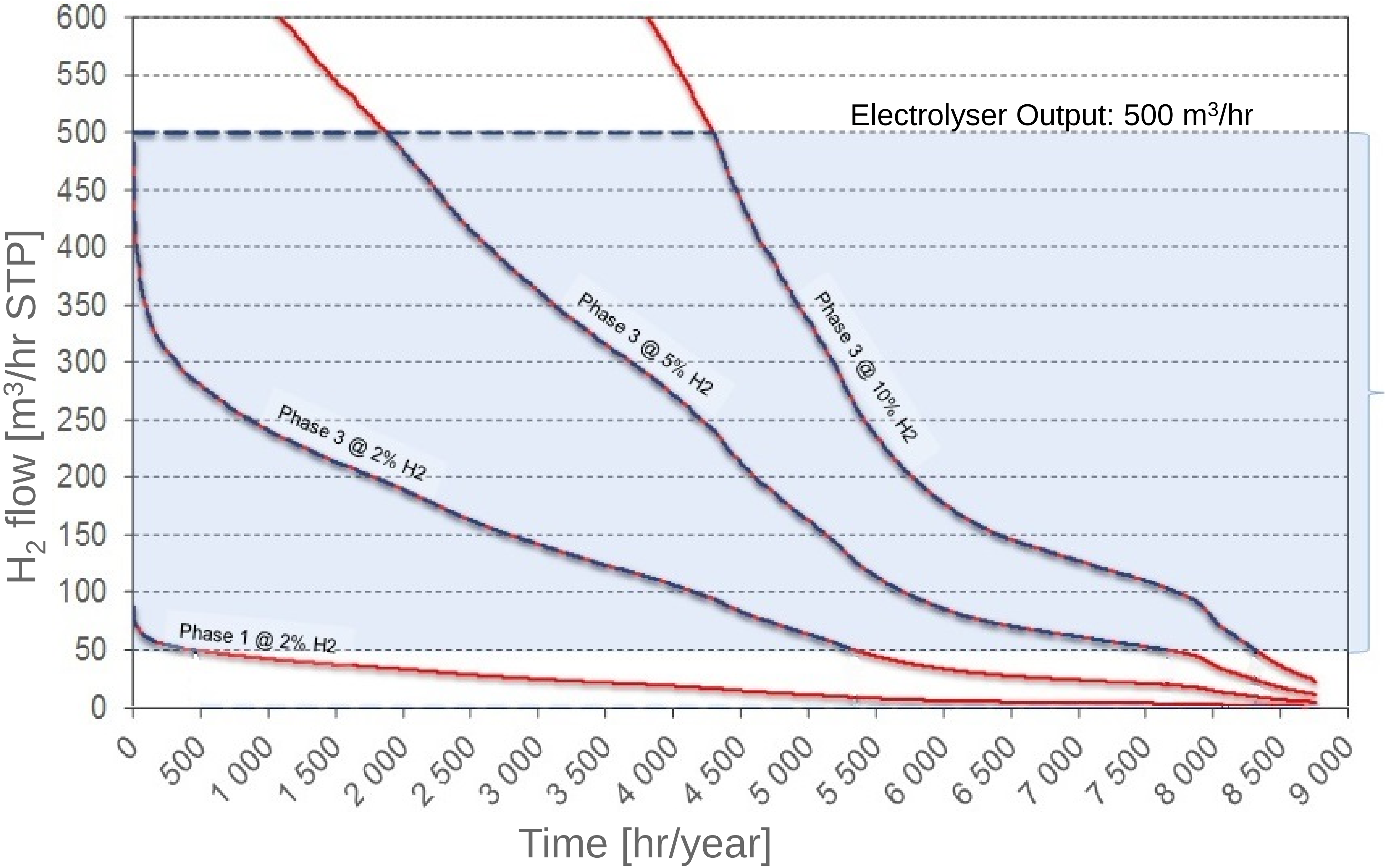
*based on current plant capacity and 3,000 hours of operation per year

Hydrogen Utilization for Closed Loops





Hydrogen Utilization for Closed Loops



Back-up Material

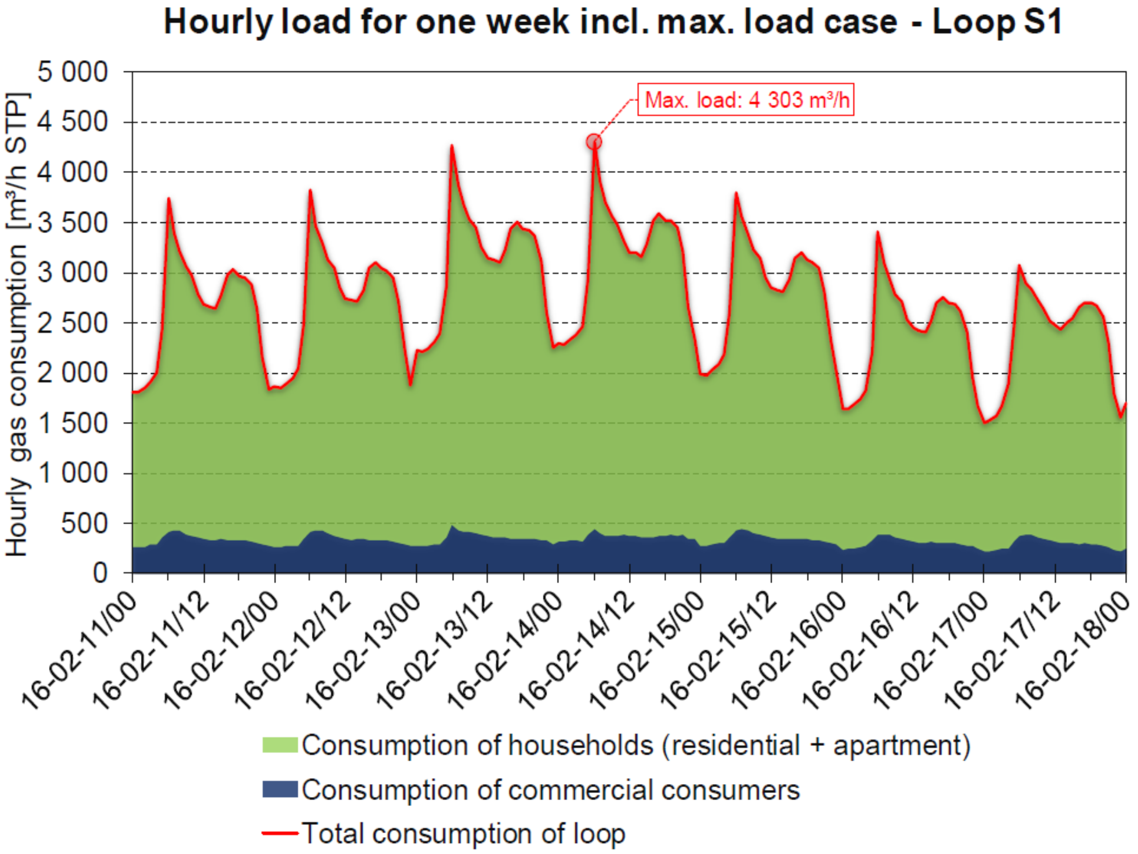
Hydrogen Extraction Technology

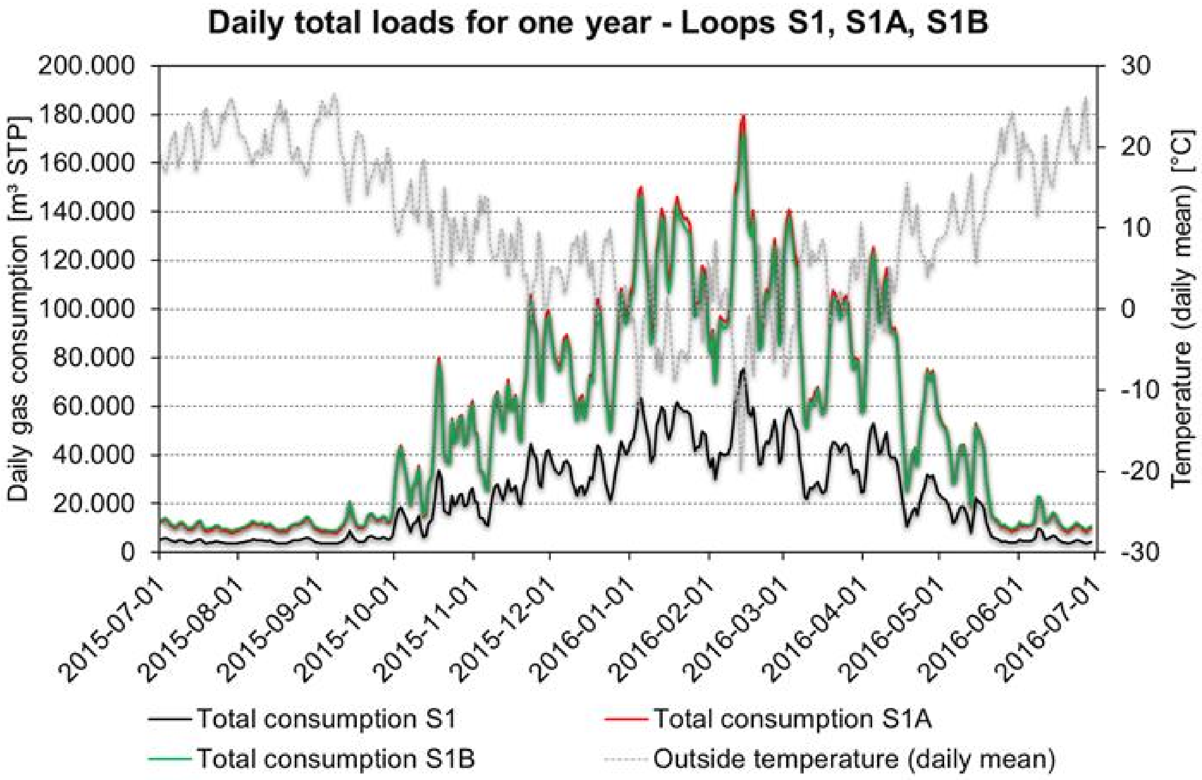
Three Options

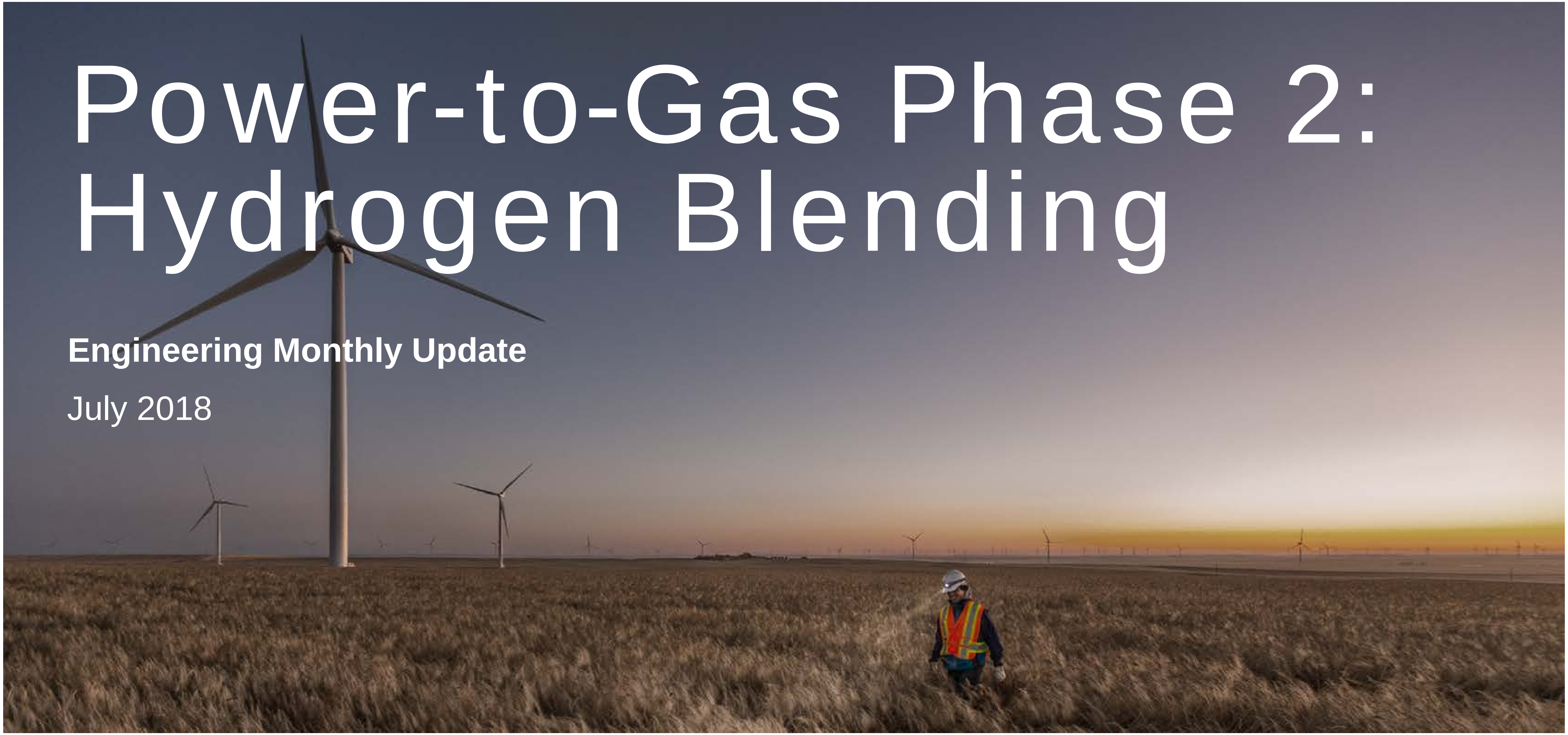
Pressure Swing Adsorption (PSA)	• Gas species separated from a mixture of gases under pressure according to the species' affinity for an adsorbent material
Membrane Separation	• Drives to equilibrium across permeable membrane and partial pressures on each side used to separate out the H_2 molecule
Electrochemical Hydrogen Separation (Hydrogen Pumping)	• Process gas passes across fuel stacks • Current applied across the stack to atomically dissociate hydrogen from process gas and re-associate it in hydrogen on the product side.

Hydrogen Utilization

Data Derivation







Power-to-Gas Phase 2: Hydrogen Blending

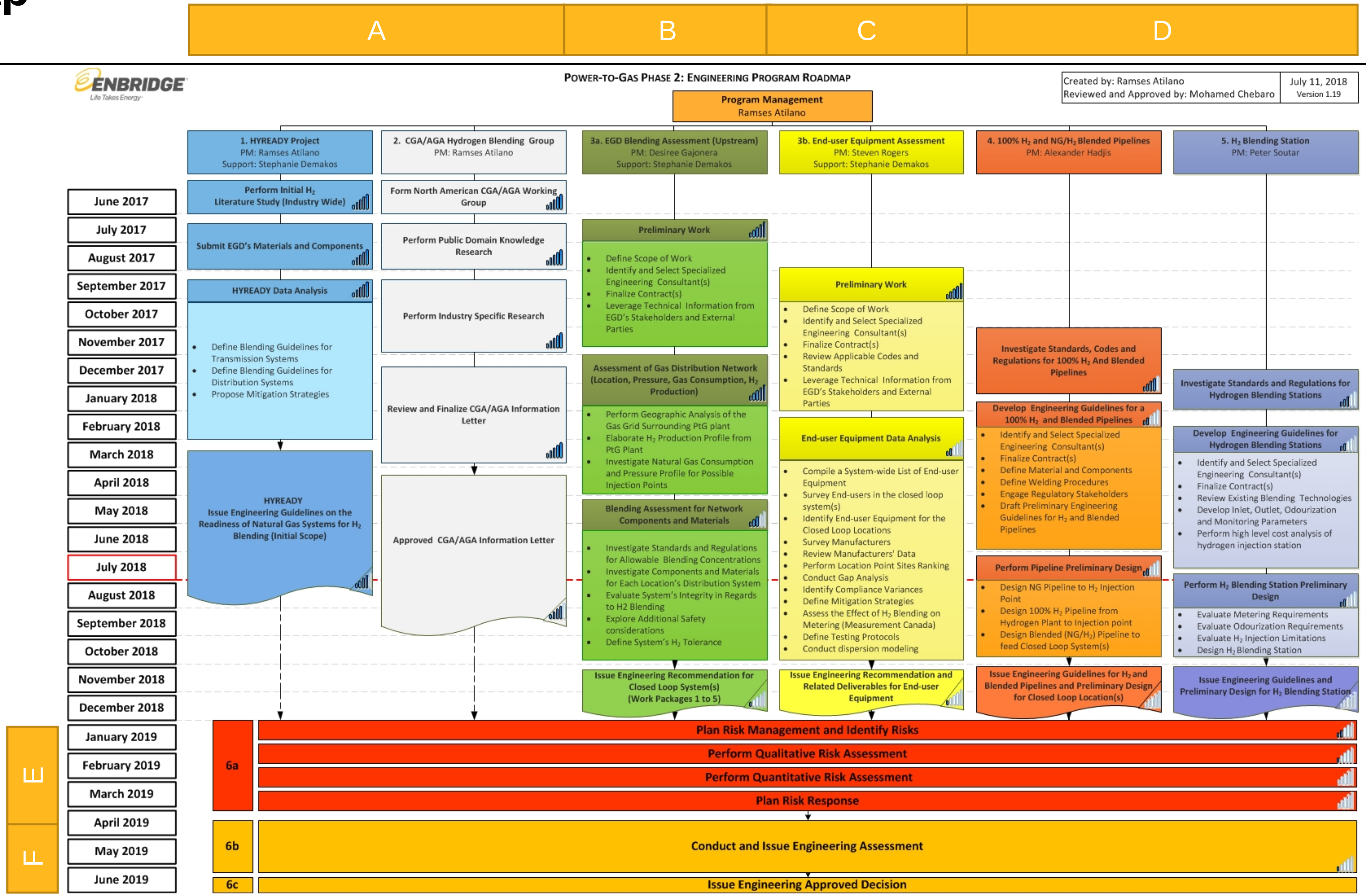
Engineering Monthly Update

July 2018

Mohamed Chebaro and Ramses Atilano
Engineering

Power-to-Gas Phase 2

Roadmap



POWER-TO-GAS PHASE 2: ENGINEERING PROGRAM ROADMAP

Created by: Ramses Atilano
Reviewed and Approved by: Mohamed Chebaro
July 11, 2018
Version 1.19

Program Management
Ramses Atilano

June 2017
July 2017
August 2017
September 2017
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March 2019
April 2019
May 2019
June 2019

1. HYREADY Project
PM: Ramses Atilano
Support: Stephanie Demakos

Perform Initial H_2 Literature Study (Industry Wide)

Submit EGD's Materials and Components

HYREADY Data Analysis
- Define Blending Guidelines for Transmission Systems
- Define Blending Guidelines for Distribution Systems
- Propose Mitigation Strategies

HYREADY
Issue Engineering Guidelines on the Readiness of Natural Gas Systems for H_2 Blending (Initial Scope)

2. CGA/AGA Hydrogen Blending Group
PM: Ramses Atilano

Form North American CGA/AGA Working Group

Perform Public Domain Knowledge Research

Perform Industry Specific Research

Review and Finalize CGA/AGA Information Letter

Approved CGA/AGA Information Letter

3a. EGD Blending Assessment (Upstream)
PM: Desiree Gajonera
Support: Stephanie Demakos

Preliminary Work
- Define Scope of Work
- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Leverage Technical Information from EGD's Stakeholders and External Parties

Assessment of Gas Distribution Network (Location, Pressure, Gas Consumption, H_2 Production)
- Perform Geographic Analysis of the Gas Grid Surrounding PtG plant
- Elaborate H_2 Production Profile from PtG Plant
- Investigate Natural Gas Consumption and Pressure Profile for Possible Injection Points

Blending Assessment for Network Components and Materials
- Investigate Standards and Regulations for Allowable Blending Concentrations
- Investigate Components and Materials for Each Location's Distribution System
- Evaluate System's Integrity in Regards to H2 Blending
- Explore Additional Safety considerations
- Define System's H_2 Tolerance

Issue Engineering Recommendation for Closed Loop System(s) (Work Packages 1 to 5)

3b. End-user Equipment Assessment
PM: Steven Rogers
Support: Stephanie Demakos

Preliminary Work
- Define Scope of Work
- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Review Applicable Codes and Standards
- Leverage Technical Information from EGD's Stakeholders and External Parties

End-user Equipment Data Analysis
- Compile a System-wide List of End-user Equipment
- Survey End-users in the closed loop system(s)
- Identify End-user Equipment for the Closed Loop Locations
- Survey Manufacturers
- Review Manufacturers' Data
- Perform Location Point Sites Ranking
- Conduct Gap Analysis
- Identify Compliance Variances
- Define Mitigation Strategies
- Assess the Effect of H_2 Blending on Metering (Measurement Canada)
- Define Testing Protocols
- Conduct dispersion modeling

Issue Engineering Recommendation and Related Deliverables for End-user Equipment

4. 100% H_2 and NG/H_2 Blended Pipelines
PM: Alexander Hadjis

Investigate Standards, Codes and Regulations for 100% H_2 And Blended Pipelines

Develop Engineering Guidelines for a 100% H_2 and Blended Pipelines
- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Define Material and Components
- Define Welding Procedures
- Engage Regulatory Stakeholders
- Draft Preliminary Engineering Guidelines for H_2 and Blended Pipelines

Perform Pipeline Preliminary Design
- Design NG Pipeline to H_2 Injection Point
- Design 100% H_2 Pipeline from Hydrogen Plant to Injection point
- Design Blended (NG/H_2) Pipeline to feed Closed Loop System(s)

Issue Engineering Guidelines for H_2 and Blended Pipelines and Preliminary Design for Closed Loop Location(s)

5. H_2 Blending Station
PM: Peter Soutar

Investigate Standards and Regulations for Hydrogen Blending Stations

Develop Engineering Guidelines for Hydrogen Blending Stations
- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Review Existing Blending Technologies
- Develop Inlet, Outlet, Odourization and Monitoring Parameters
- Perform high level cost analysis of hydrogen injection station

Perform H_2 Blending Station Preliminary Design
- Evaluate Metering Requirements
- Evaluate Odourization Requirements
- Evaluate H_2 Injection Limitations
- Design H_2 Blending Station

Issue Engineering Guidelines and Preliminary Design for H_2 Blending Station

6a
Plan Risk Management and Identify Risks
Perform Qualitative Risk Assessment
Perform Quantitative Risk Assessment
Plan Risk Response

6b
Conduct and Issue Engineering Assessment

6c
Issue Engineering Approved Decision

Power-to-Gas Phase 2

Status Review

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

ENBRIDGE
Life Takes Energy™

	STATUS:		
Program Streams	**Scope**	**Budget**	**Timeline**
CGA/AGA Task Force Information Letter *(in final stages)*	🟩	🟩	🟩
HYREADY Engineering Guideline Report *(in final stages)*	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩

Power-to-Gas Phase 2

Status Review

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

ENBRIDGE
Life Takes Energy™

	STATUS:		
Program Streams	**Scope**	**Budget**	**Timeline**
Data collection for identified closed loops *(surveys in progress)*	🟩	🟩	🟨
Data analysis for identified closed loops *(in progress)*	🟩	🟩	🟨
System-wide assessment for end-user equipment *(in progress)*	🟩	🟩	🟩
	🟨	🟩	🟩
	🟨	🟩	🟩
	🟩	🟩	🟩
Risk Assessment Report *(in progress)*	🟩	🟩	🟨
Computational Modeling *(in progress)*	🟩	🟩	🟩
	🟩	🟩	🟩

Power-to-Gas Phase 2

Upcoming Deliverables

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

ENBRIDGE
Life Takes Energy™

	STATUS:		
Next Month's Deliverables	**Scope**	**Budget**	**Timeline**
A. Research and Development:			
Receive HYREADY Engineering Guideline Final Report	🟩	🟩	🟩
B. Integrity, Engineering and Capacity Assessment			
Compile and analyze operating and integrity data for the three Closed Loop systems (e.g., corrosion, leaks and damages)	🟩	🟩	🟩
Complete 50% of H_2 tolerance evaluation for the three Closed Loops	🟩	🟩	🟩
C. End User Equipment Engineering and Integrity System			
Obtain second iteration of DBI report on End-user equipment	🟩	🟩	🟩
Compile 75% of field survey information for Loop S1	🟩	🟩	🟨
Compile 20% of field survey information for Loops S1A and S1B	🟩	🟩	🟨

Power-to-Gas Phase 2

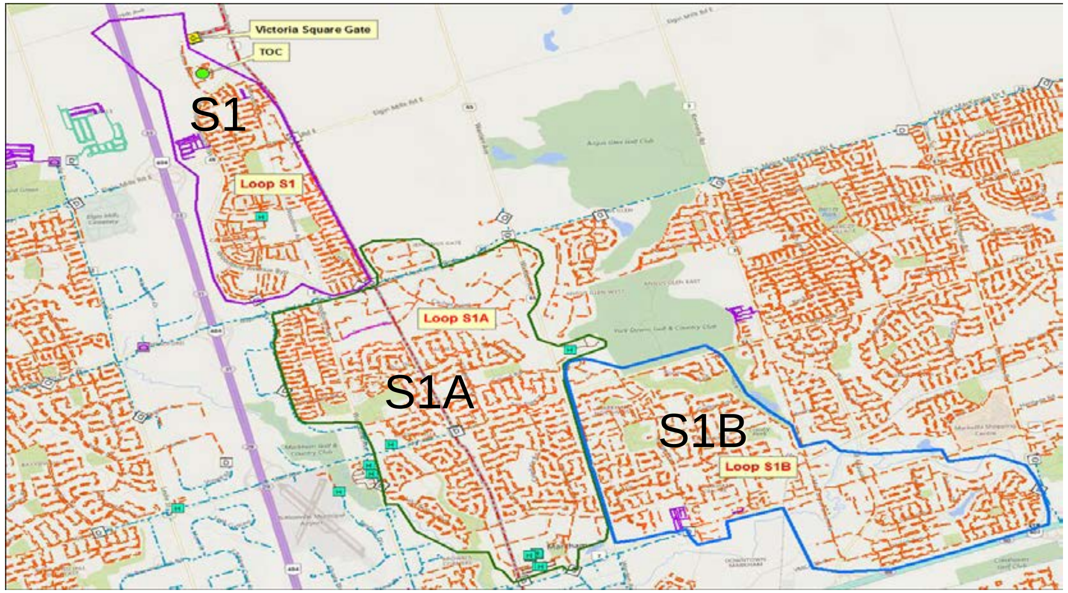
Past Month’s Achievements

A. Research and Development

- ✓ Reviewed and addressed comments from the AGA related to the CGA/AGA Information Letter
- ✓ Continued working on the Hydrogen Knowledge Management Database framework

B. Integrity, Engineering and Capacity Assessment

- ✓ Received the final DBI report on H_2 Capacity Assessment for the three Closed Loops
- ✓ Compiled and validated list of manufacturers for distribution components identified in the three Closed Loops
- ✓ Compiled Bill of Materials for Closed Loops S1A and S1B for fittings and above-ground assets
- ✓ Completed 40% of the H_2 tolerance evaluation for the three selected Closed Loops
- ✓ Initiated second iteration of preliminary design for Closed Loops S1, S1A and S1B
- ✓ Started gathering operating data for the three Closed Loop systems (e.g., corrosion, leaks and damages)



Power-to-Gas Phase 2

Past Month’s Achievements

C. End User Equipment Engineering and Integrity System

- ✓ Hosted engineering exchange with DNV-GL on Gas Interchangeability with several technical stakeholders
- ✓ Started gathering and analyzing results based on the field survey for Loop S1
- ✓ Expanded the end-user equipment survey for Loop S1 to increase statistical sample size
- ✓ Initiated end-user equipment survey for Closed Loops S1A and S1B for future analysis
- ✓ Compiled end-user equipment manufacturer list based on initial survey results

D. Engineering Design and Review

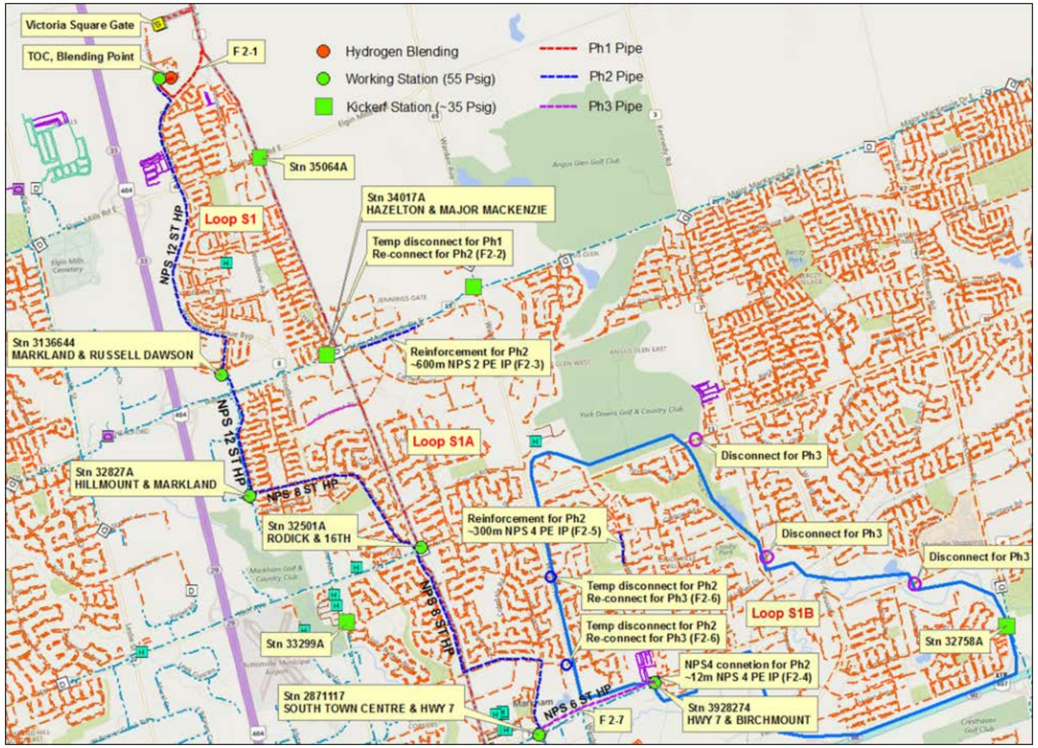
- ✓ Initiated second iteration (design optimization) of preliminary design for pipelines carrying three different products (100% H_2, 100% NG and Blended Gas) to reduce initial construction costs
- ✓ Continued working on preliminary design for the station components (e.g., Pressure Regulation, H_2 Injection)
- ✓ Initiated RFP for specialized consultant to develop Engineering Guidelines for 100% H_2 and blended gas pipelines

E. Risk Assessment

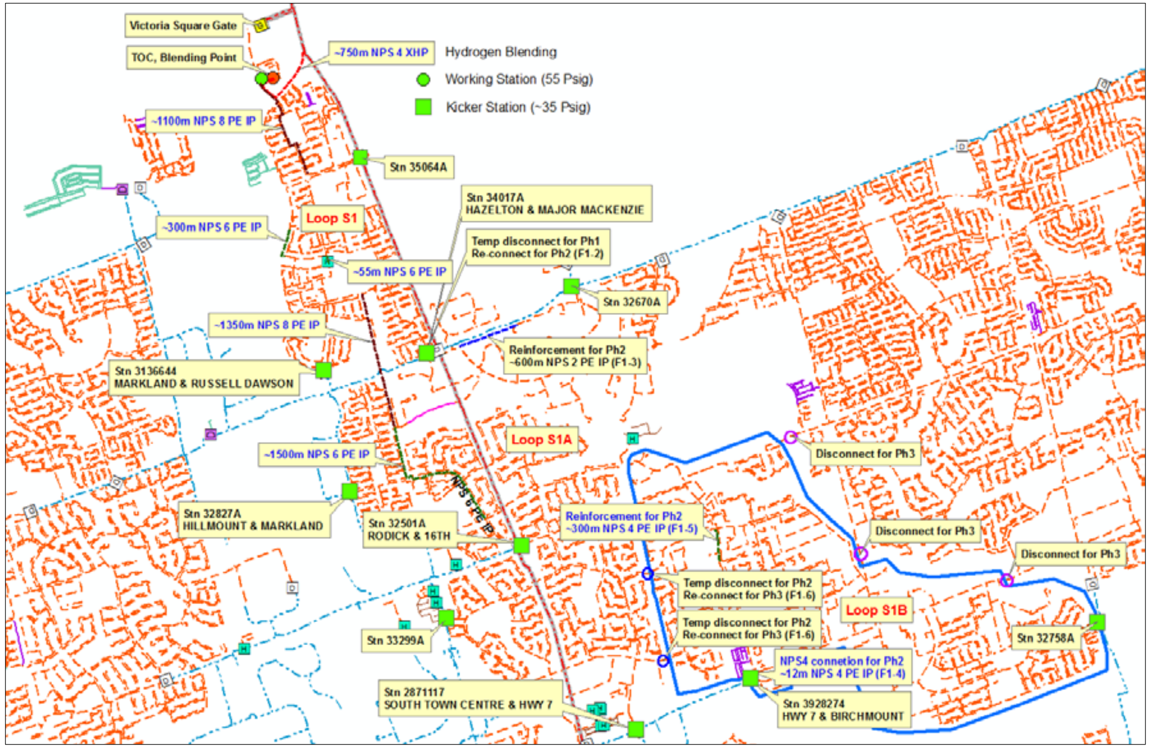
- ✓ Initiated computational work at DBI-GUT (Germany) and C-FER Technologies (Canada) on indoor and external gas dispersion modeling that will become an input to the Quantitative Risk and Engineering Assessments

Power-to-Gas Phase 2

Evolution of Preliminary Close-Loop Pipeline Design

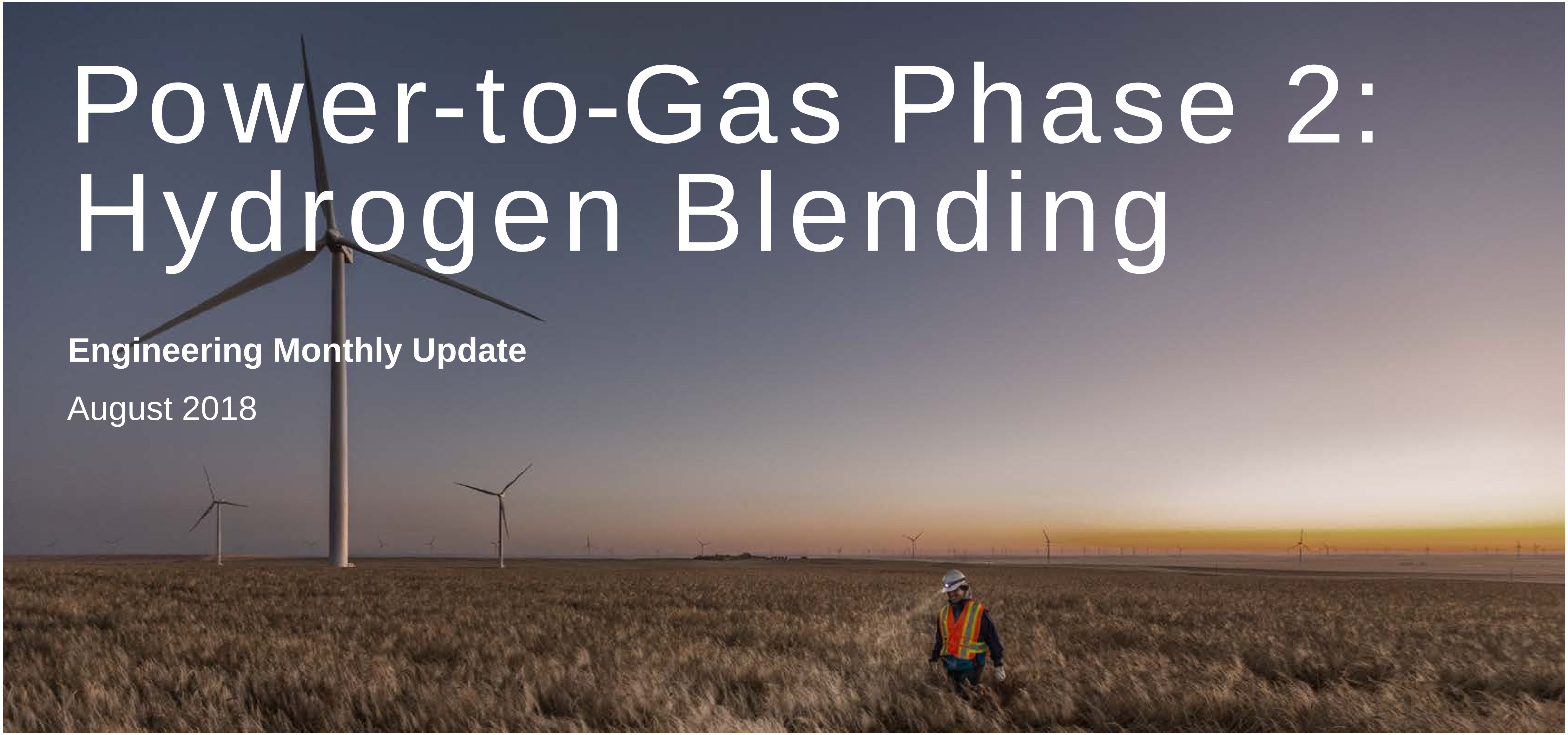


First Preliminary Pipeline Design



Second Preliminary Pipeline Design

- Q4 2017-Q1 2018: Examined 8 macro-loops across the GTA for blending considerations
- Q1 2018: Selected the Markham macro-loop for further analysis, divided into three loops for phased, detailed design
- Q2 2018: Produced first pipeline blending design iteration for Closed Loops S1, S1A and S1B
- Q3 2018: Initiated design refinements to reduce costs, system pressure and required system modifications



Power-to-Gas Phase 2: Hydrogen Blending

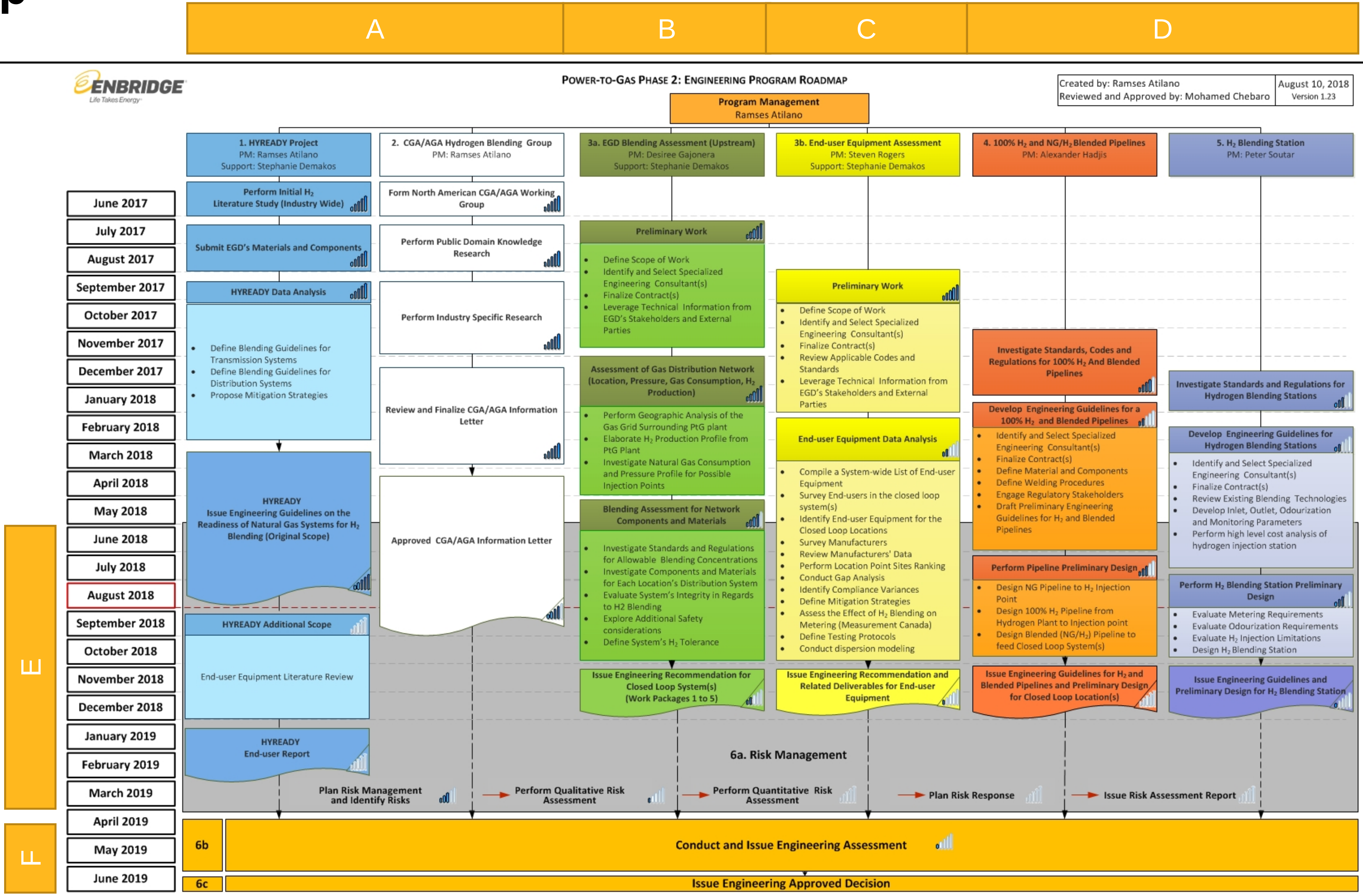
Engineering Monthly Update

August 2018

Mohamed Chebaro and Ramses Atilano
Engineering

Power-to-Gas Phase 2

Roadmap



Power-to-Gas Phase 2: Engineering Program Roadmap

Created by: Ramses Atilano
Reviewed and Approved by: Mohamed Chebaro
August 10, 2018
Version 1.23

Program Management
Ramses Atilano

June 2017
July 2017
August 2017
September 2017
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May 2018
June 2018
July 2018
August 2018
September 2018
October 2018
November 2018
December 2018
January 2019
February 2019
March 2019
April 2019
May 2019
June 2019

1. HYREADY Project
PM: Ramses Atilano
Support: Stephanie Demakos

- Perform Initial H_2 Literature Study (Industry Wide)
- Submit EGD's Materials and Components
- HYREADY Data Analysis
  - Define Blending Guidelines for Transmission Systems
  - Define Blending Guidelines for Distribution Systems
  - Propose Mitigation Strategies
- HYREADY Issue Engineering Guidelines on the Readiness of Natural Gas Systems for H_2 Blending (Original Scope)
- HYREADY Additional Scope
  - End-user Equipment Literature Review
- HYREADY End-user Report

2. CGA/AGA Hydrogen Blending Group
PM: Ramses Atilano

- Form North American CGA/AGA Working Group
- Perform Public Domain Knowledge Research
- Perform Industry Specific Research
- Review and Finalize CGA/AGA Information Letter
- Approved CGA/AGA Information Letter

3a. EGD Blending Assessment (Upstream)
PM: Desiree Gajonera
Support: Stephanie Demakos

- Preliminary Work
  - Define Scope of Work
  - Identify and Select Specialized Engineering Consultant(s)
  - Finalize Contract(s)
  - Leverage Technical Information from EGD's Stakeholders and External Parties
- Assessment of Gas Distribution Network (Location, Pressure, Gas Consumption, H_2 Production)
  - Perform Geographic Analysis of the Gas Grid Surrounding PtG plant
  - Elaborate H_2 Production Profile from PtG Plant
  - Investigate Natural Gas Consumption and Pressure Profile for Possible Injection Points
- Blending Assessment for Network Components and Materials
  - Investigate Standards and Regulations for Allowable Blending Concentrations
  - Investigate Components and Materials for Each Location's Distribution System
  - Evaluate System's Integrity in Regards to H2 Blending
  - Explore Additional Safety considerations
  - Define System's H_2 Tolerance
- Issue Engineering Recommendation for Closed Loop System(s) (Work Packages 1 to 5)

3b. End-user Equipment Assessment
PM: Steven Rogers
Support: Stephanie Demakos

- Preliminary Work
  - Define Scope of Work
  - Identify and Select Specialized Engineering Consultant(s)
  - Finalize Contract(s)
  - Review Applicable Codes and Standards
  - Leverage Technical Information from EGD's Stakeholders and External Parties
- End-user Equipment Data Analysis
  - Compile a System-wide List of End-user Equipment
  - Survey End-users in the closed loop system(s)
  - Identify End-user Equipment for the Closed Loop Locations
  - Survey Manufacturers
  - Review Manufacturers' Data
  - Perform Location Point Sites Ranking
  - Conduct Gap Analysis
  - Identify Compliance Variances
  - Define Mitigation Strategies
  - Assess the Effect of H_2 Blending on Metering (Measurement Canada)
  - Define Testing Protocols
  - Conduct dispersion modeling
- Issue Engineering Recommendation and Related Deliverables for End-user Equipment

4. 100% H_2 and NG/H_2 Blended Pipelines
PM: Alexander Hadjis

- Investigate Standards, Codes and Regulations for 100% H_2 And Blended Pipelines
- Develop Engineering Guidelines for a 100% H_2 and Blended Pipelines
  - Identify and Select Specialized Engineering Consultant(s)
  - Finalize Contract(s)
  - Define Material and Components
  - Define Welding Procedures
  - Engage Regulatory Stakeholders
  - Draft Preliminary Engineering Guidelines for H_2 and Blended Pipelines
- Perform Pipeline Preliminary Design
  - Design NG Pipeline to H_2 Injection Point
  - Design 100% H_2 Pipeline from Hydrogen Plant to Injection point
  - Design Blended (NG/H_2) Pipeline to feed Closed Loop System(s)
- Issue Engineering Guidelines for H_2 and Blended Pipelines and Preliminary Design for Closed Loop Location(s)

5. H_2 Blending Station
PM: Peter Soutar

- Investigate Standards and Regulations for Hydrogen Blending Stations
- Develop Engineering Guidelines for Hydrogen Blending Stations
  - Identify and Select Specialized Engineering Consultant(s)
  - Finalize Contract(s)
  - Review Existing Blending Technologies
  - Develop Inlet, Outlet, Odourization and Monitoring Parameters
  - Perform high level cost analysis of hydrogen injection station
- Perform H_2 Blending Station Preliminary Design
  - Evaluate Metering Requirements
  - Evaluate Odourization Requirements
  - Evaluate H_2 Injection Limitations
  - Design H_2 Blending Station
- Issue Engineering Guidelines and Preliminary Design for H_2 Blending Station

6a. Risk Management

Plan Risk Management and Identify Risks → Perform Qualitative Risk Assessment → Perform Quantitative Risk Assessment → Plan Risk Response → Issue Risk Assessment Report

6b Conduct and Issue Engineering Assessment

6c Issue Engineering Approved Decision

Power-to-Gas Phase 2

Status Review

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

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Program Streams	Scope	Budget*	Timeline
CGA/AGA Task Force Information Letter *(in final stages)*	🟩	🟨	🟩
HYREADY Engineering Guideline Report *(initial scope completed)*	🟩	🟨	🟩
	🟩	🟨	🟩
	🟩	🟨	🟩
	🟩	🟨	🟩
	🟩	🟨	🟩
	🟩	🟨	🟩
	🟩	🟨	🟩

* The funding for the Engineering Program is still in the process of being secured by EGD, as of August 10, 2018.

Power-to-Gas Phase 2

Status Review

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

Program Streams	Scope	Budget*	Timeline
Data collection for identified closed loops *(surveys in progress)*	🟩	🟨	🟨
Data analysis for identified closed loops *(in progress)*	🟩	🟨	🟩
System-wide assessment for end-user equipment *(in progress)*	🟩	🟨	🟩
	🟨	🟨	🟩
	🟨	🟨	🟩
	🟩	🟨	🟩
Risk Assessment Report *(in progress)*	🟩	🟨	🟩
Computational Modeling *(in progress)*	🟩	🟨	🟩
	🟩	🟨	🟩

* The funding for the Engineering Program is still in the process of being secured by EGD, as of August 10, 2018.

Power-to-Gas Phase 2

Upcoming Deliverables

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

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Next Month's Deliverables	Scope	Budget	Timeline
A. Research and Development:			
Continue building and optimizing the Hydrogen Blending Database	🟩	🟩	🟩
B. Integrity, Engineering and Capacity Assessment			
Compile and analyze operating and integrity data for the three Closed Loop systems (e.g., corrosion, leaks and damages)	🟩	🟩	🟩
Complete 60% of H_2 tolerance evaluation for the three Closed Loops	🟩	🟩	🟩
C. End User Equipment Engineering and Integrity System			
Obtain second iteration of DBI report on End-user equipment	🟩	🟩	🟨
Analyze 90% of field survey obtainable information for Loop S1	🟩	🟩	🟩
Compile 25% of field survey obtainable information for Loops S1A/S1B	🟩	🟩	🟨

Power-to-Gas Phase 2

Upcoming Deliverables

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

Next Month’s Deliverables	Scope	Budget	Timeline
D. Engineering Design:			
Initiate the design review for the H_2 Blending Station	🟩	🟩	🟩
Progress Consultant Selection process to develop Engineering Guidelines for 100% H_2 and blended gas pipelines	🟩	🟩	🟩
E. Risk Assessment			
Obtain the second iteration for indoor dispersion modeling (C-FER)	🟩	🟩	🟩
Obtain the second iteration for outdoor dispersion modeling (DBI-GUT)	🟩	🟩	🟩
Hold HAZID sessions with specialized stakeholders for the Risk Study	🟩	🟩	🟩
Initiate the Qualitative Risk Analysis	🟩	🟩	🟩

Power-to-Gas Phase 2

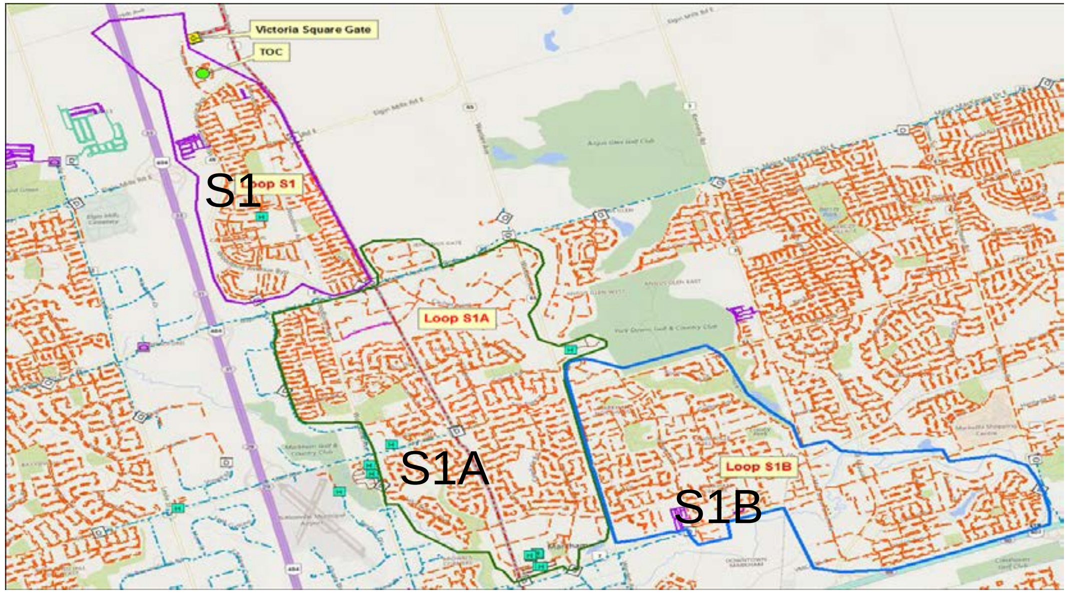
Past Month’s Achievements

A. Research and Development

- ✓ Received final version of HYREADY Guidelines (Initial Scope)
- ✓ Continued working on the Hydrogen Knowledge Management Database framework

B. Integrity, Engineering and Capacity Assessment

- ✓ Started contacting manufacturers for distribution components identified in the three Closed Loops
- ✓ Completed 50% of the H_2 tolerance evaluation for the three selected Closed Loops
- ✓ Initiated third iteration of preliminary design for Closed Loops S1, S1A and S1B
- ✓ Finished gathering operating data for the three Closed Loop systems (e.g., corrosion, leaks and damages)



Power-to-Gas Phase 2

Past Month's Achievements

C. End User Equipment Engineering and Integrity System

- ✓ Continued analyzing results based on the field survey for Loop S1
- ✓ Completed over 90% of the end-user equipment field survey for Loop S1
- ✓ Continued end-user equipment survey for Closed Loops S1A and S1B for future analysis
- ✓ Initiated end-user equipment manufacturer survey

D. Engineering Design and Review

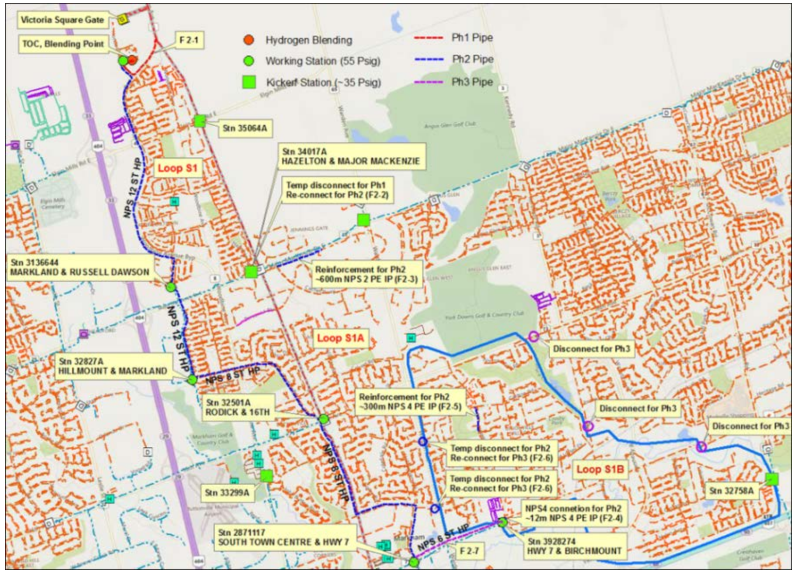
- ✓ Initiated third iteration (design optimization) of preliminary design for pipelines carrying three different products (100% H_2, 100% NG and Blended Gas) to reduce initial construction costs
- ✓ Continued working on preliminary design for the station components (e.g., Pressure Regulation, H_2 Injection)
- ✓ Initiated RFP for specialized consultant to develop Engineering Guidelines for 100% H_2 and blended pipelines

E. Risk Assessment

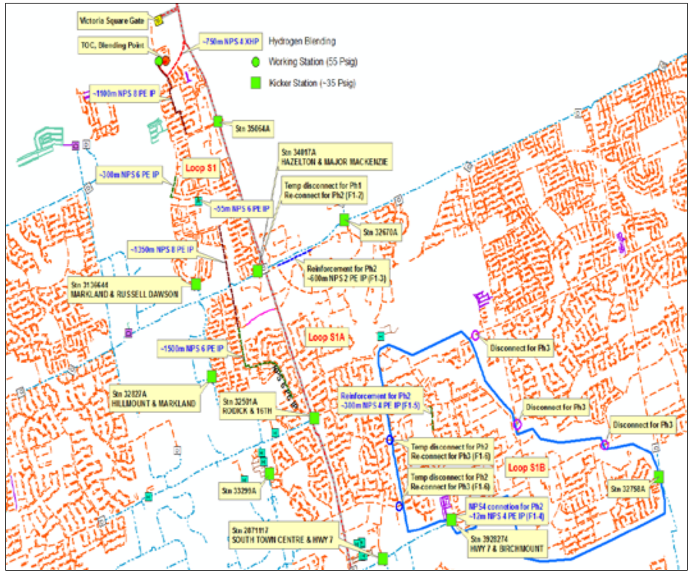
- ✓ Reviewed first iteration of computational work by DBI-GUT (Germany) and C-FER Technologies (Canada) on indoor and external gas dispersion modeling that will become an input to the Quantitative Risk and Engineering Assessments

Power-to-Gas Phase 2

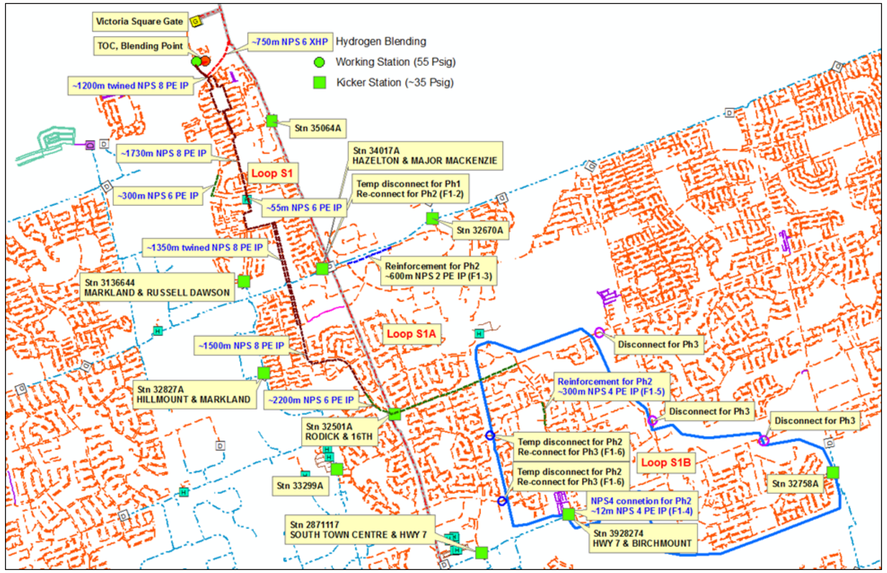
Evolution of Preliminary Closed Loop Pipeline Design



First Preliminary Pipeline Design

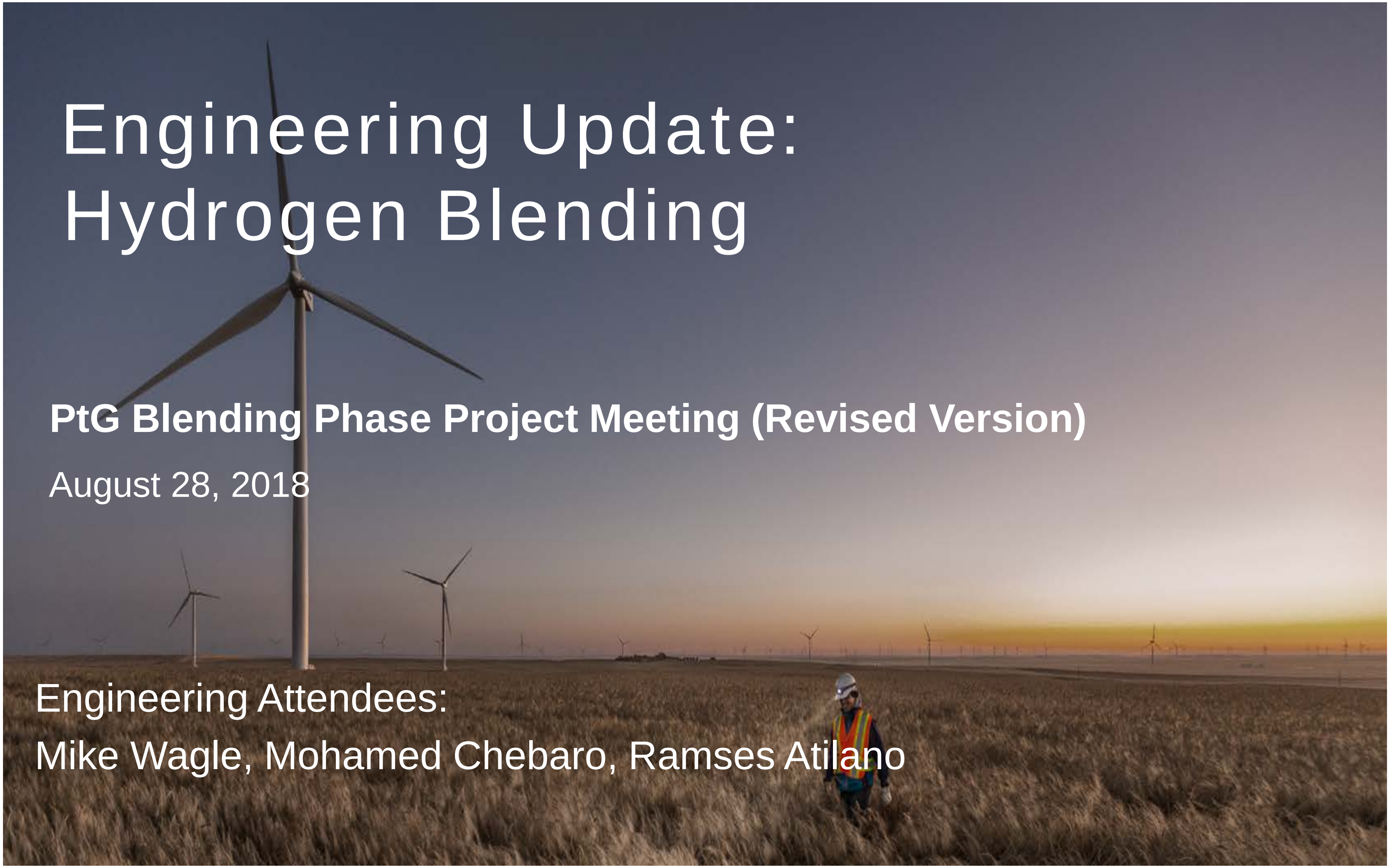


Second Preliminary Pipeline Design



Third Preliminary Pipeline Design

- **Q4 2017- Q1 2018:** Examined 8 macro-loops across the GTA for blending considerations
- **Q1 2018:** Selected the Markham macro-loop for further analysis, divided into three loops for phased, detailed design
- **Q2 2018:** Produced first pipeline blending design iteration for Closed Loops S1, S1A and S1B
- **Q3 2018:** Initiated design refinements to reduce costs, system pressure and required system modifications (currently working on third iteration for loops S1, S1A and S1B)



Engineering Update: Hydrogen Blending

PtG Blending Phase Project Meeting (Revised Version)

August 28, 2018

Engineering Attendees:
Mike Wagle, Mohamed Chebaro, Ramses Atilano

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Prepared by: Engineering Growth Team

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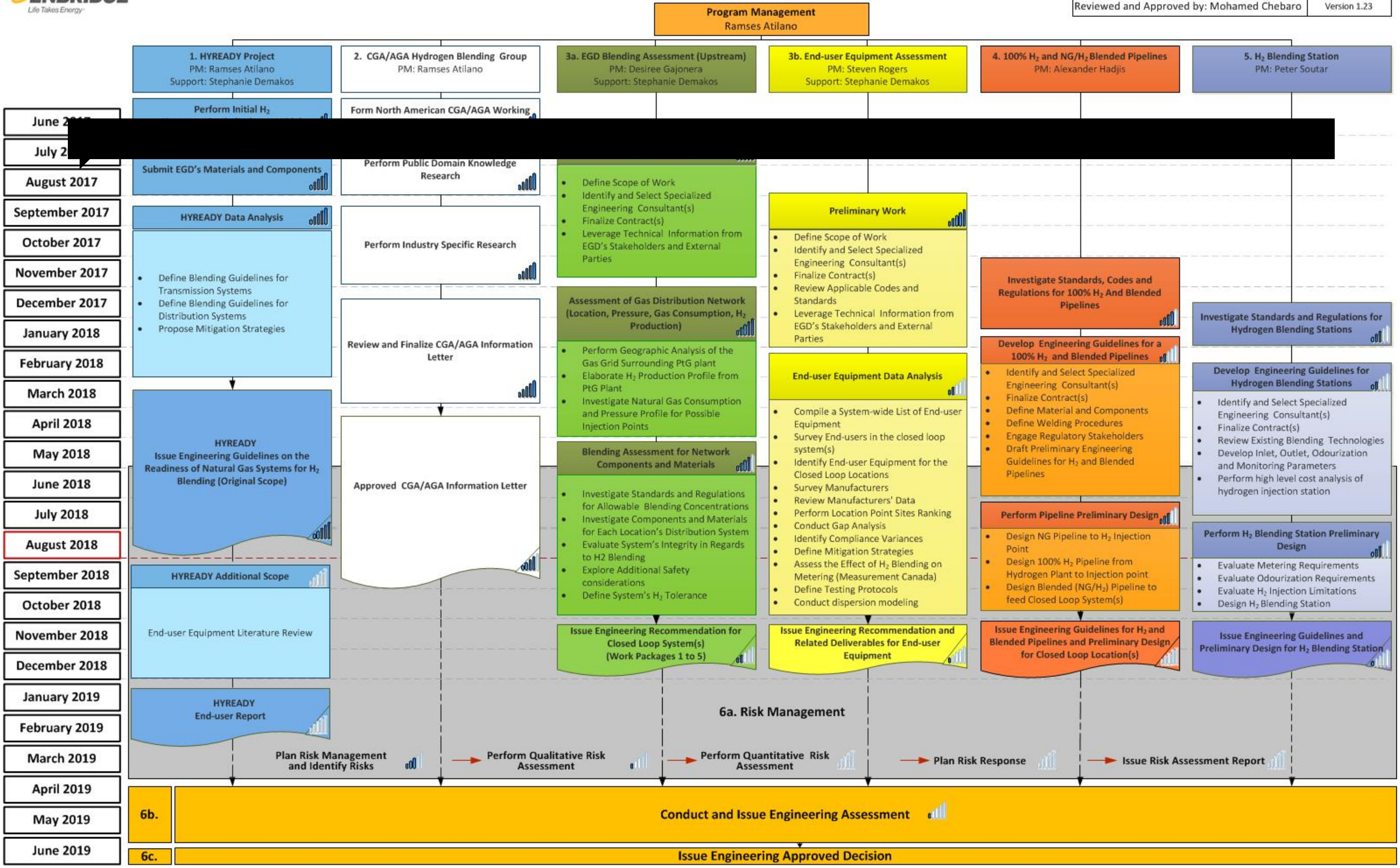
POWER-TO-GAS PHASE 2: ENGINEERING PROGRAM ROADMAP

Created by: Ramses Atilano Reviewed and Approved by: Mohamed Chebaro	August 10, 2018 Version 1.23



Program Management
Ramses Atilano

June 2
July 2
[redacted]
August 2017
September 2017
October 2017
November 2017
December 2017
January 2018
February 2018
March 2018
April 2018
May 2018
June 2018
July 2018
August 2018
September 2018
October 2018
November 2018
December 2018
January 2019
February 2019
March 2019
April 2019
May 2019
June 2019

1. HYREADY Project
PM: Ramses Atilano
Support: Stephanie Demakos

- Perform Initial H_2
- Submit EGD's Materials and Components
- HYREADY Data Analysis
  - Define Blending Guidelines for Transmission Systems
  - Define Blending Guidelines for Distribution Systems
  - Propose Mitigation Strategies
- HYREADY Issue Engineering Guidelines on the Readiness of Natural Gas Systems for H_2 Blending (Original Scope)
- HYREADY Additional Scope
  - End-user Equipment Literature Review
- HYREADY End-user Report

2. CGA/AGA Hydrogen Blending Group
PM: Ramses Atilano

- Form North American CGA/AGA Working
- Perform Public Domain Knowledge Research
- Perform Industry Specific Research
- Review and Finalize CGA/AGA Information Letter
- Approved CGA/AGA Information Letter

3a. EGD Blending Assessment (Upstream)
PM: Desiree Gajonera
Support: Stephanie Demakos

- Define Scope of Work
- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Leverage Technical Information from EGD's Stakeholders and External Parties

Assessment of Gas Distribution Network (Location, Pressure, Gas Consumption, H_2 Production)

- Perform Geographic Analysis of the Gas Grid Surrounding PtG plant
- Elaborate H_2 Production Profile from PtG Plant
- Investigate Natural Gas Consumption and Pressure Profile for Possible Injection Points

Blending Assessment for Network Components and Materials

- Investigate Standards and Regulations for Allowable Blending Concentrations
- Investigate Components and Materials for Each Location's Distribution System
- Evaluate System's Integrity in Regards to H2 Blending
- Explore Additional Safety considerations
- Define System's H_2 Tolerance

Issue Engineering Recommendation for Closed Loop System(s) (Work Packages 1 to 5)

3b. End-user Equipment Assessment
PM: Steven Rogers
Support: Stephanie Demakos

Preliminary Work

- Define Scope of Work
- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Review Applicable Codes and Standards
- Leverage Technical Information from EGD's Stakeholders and External Parties

End-user Equipment Data Analysis

- Compile a System-wide List of End-user Equipment
- Survey End-users in the closed loop system(s)
- Identify End-user Equipment for the Closed Loop Locations
- Survey Manufacturers
- Review Manufacturers' Data
- Perform Location Point Sites Ranking
- Conduct Gap Analysis
- Identify Compliance Variances
- Define Mitigation Strategies
- Assess the Effect of H_2 Blending on Metering (Measurement Canada)
- Define Testing Protocols
- Conduct dispersion modeling

Issue Engineering Recommendation and Related Deliverables for End-user Equipment

4. 100% H_2 and NG/H_2 Blended Pipelines
PM: Alexander Hadjis

Investigate Standards, Codes and Regulations for 100% H_2 And Blended Pipelines

Develop Engineering Guidelines for a 100% H_2 and Blended Pipelines

- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Define Material and Components
- Define Welding Procedures
- Engage Regulatory Stakeholders
- Draft Preliminary Engineering Guidelines for H_2 and Blended Pipelines

Perform Pipeline Preliminary Design

- Design NG Pipeline to H_2 Injection Point
- Design 100% H_2 Pipeline from Hydrogen Plant to Injection point
- Design Blended (NG/H_2) Pipeline to feed Closed Loop System(s)

Issue Engineering Guidelines for H_2 and Blended Pipelines and Preliminary Design for Closed Loop Location(s)

5. H_2 Blending Station
PM: Peter Soutar

Investigate Standards and Regulations for Hydrogen Blending Stations

Develop Engineering Guidelines for Hydrogen Blending Stations

- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Review Existing Blending Technologies
- Develop Inlet, Outlet, Odourization and Monitoring Parameters
- Perform high level cost analysis of hydrogen injection station

Perform H_2 Blending Station Preliminary Design

- Evaluate Metering Requirements
- Evaluate Odourization Requirements
- Evaluate H_2 Injection Limitations
- Design H_2 Blending Station

Issue Engineering Guidelines and Preliminary Design for H_2 Blending Station

6a. Risk Management

Plan Risk Management and Identify Risks → Perform Qualitative Risk Assessment → Perform Quantitative Risk Assessment → Plan Risk Response → Issue Risk Assessment Report

6b. Conduct and Issue Engineering Assessment

6c. Issue Engineering Approved Decision

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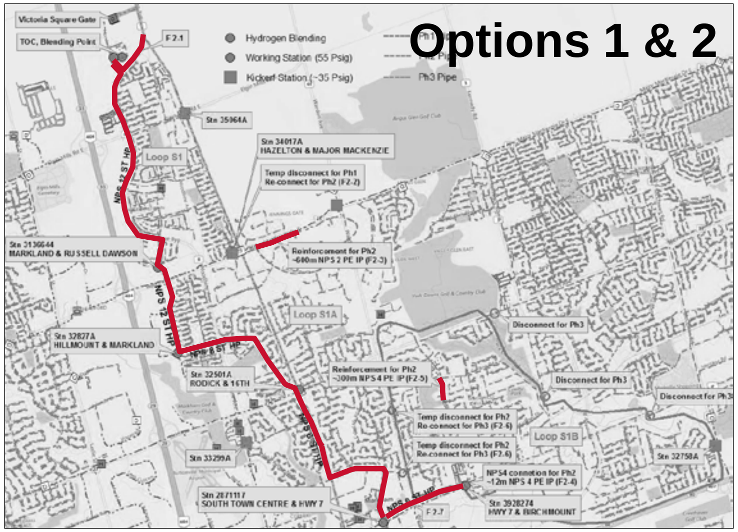
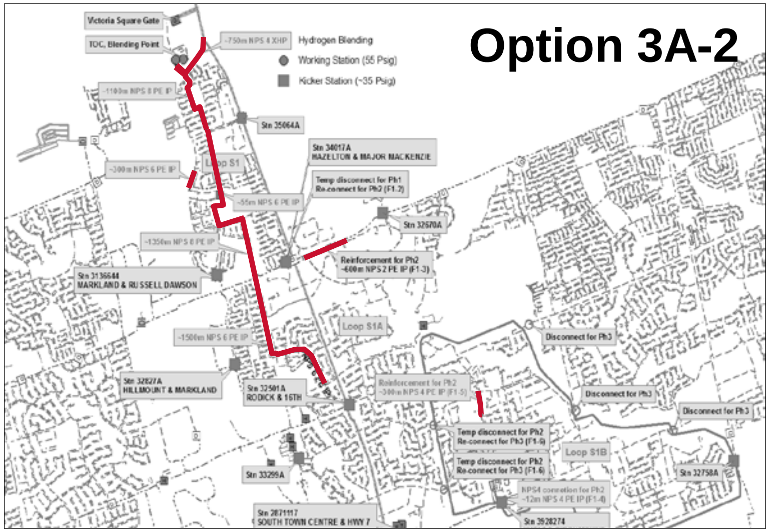
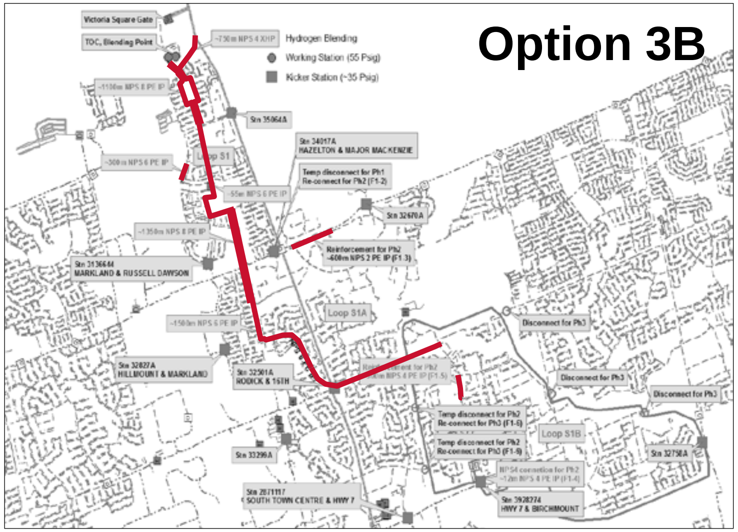
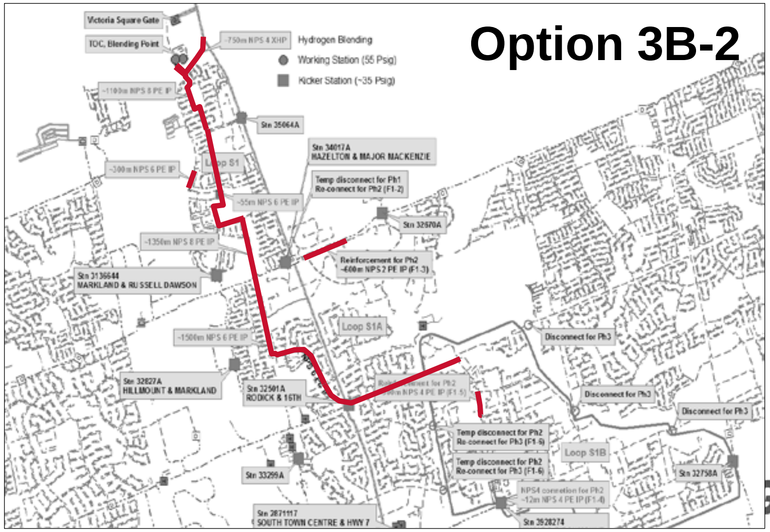
Pilot Construction Phase – Initial Route Options

XHP, HP and IP options included in the cost benefit analysis



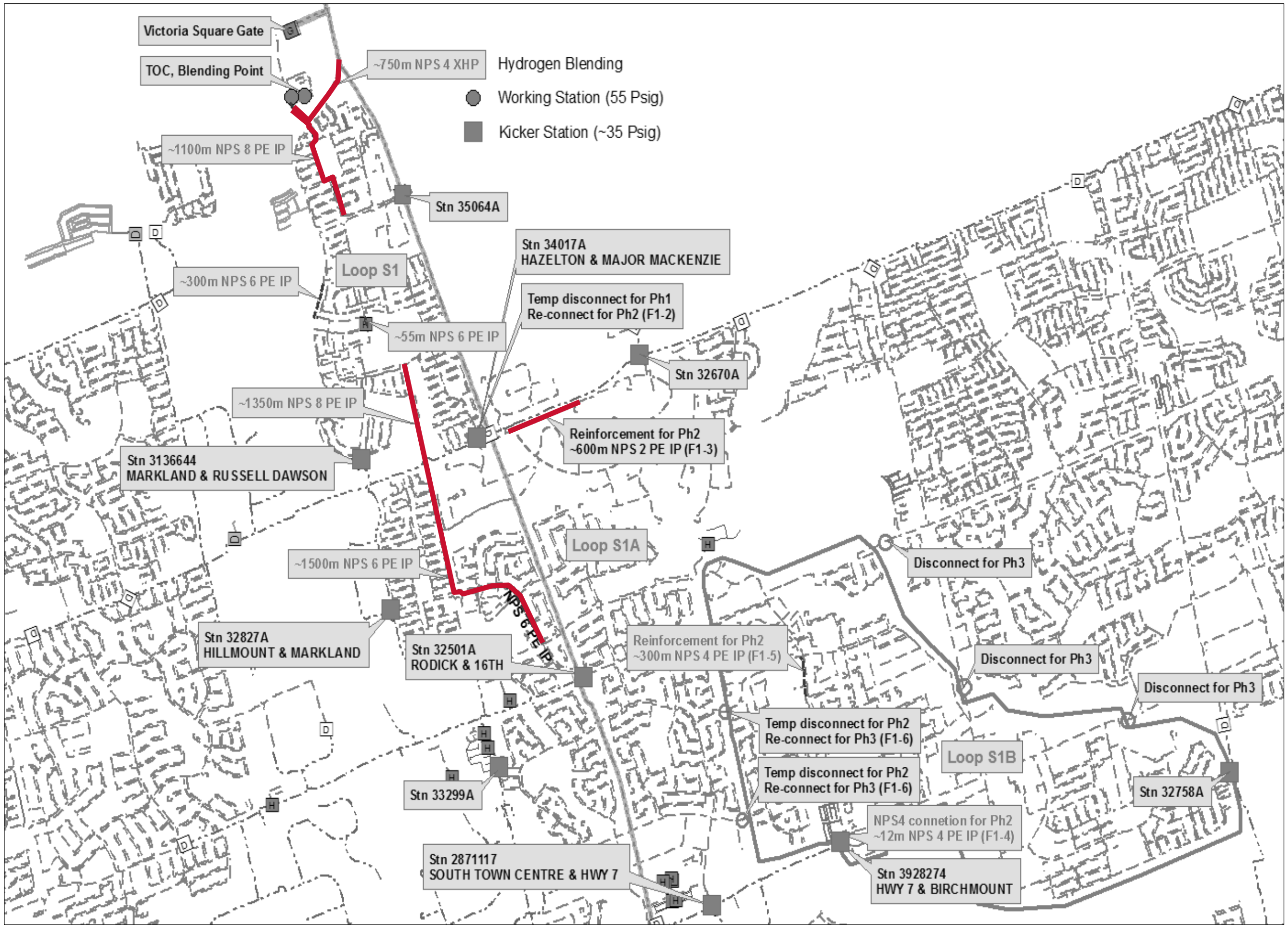






Pilot Construction Phase – Recommended Option: 3A

New NPS 8 and NPS 6 PLASTIC intermediate pressure main and use existing NPS 6 and NPS 4 PE IP mains



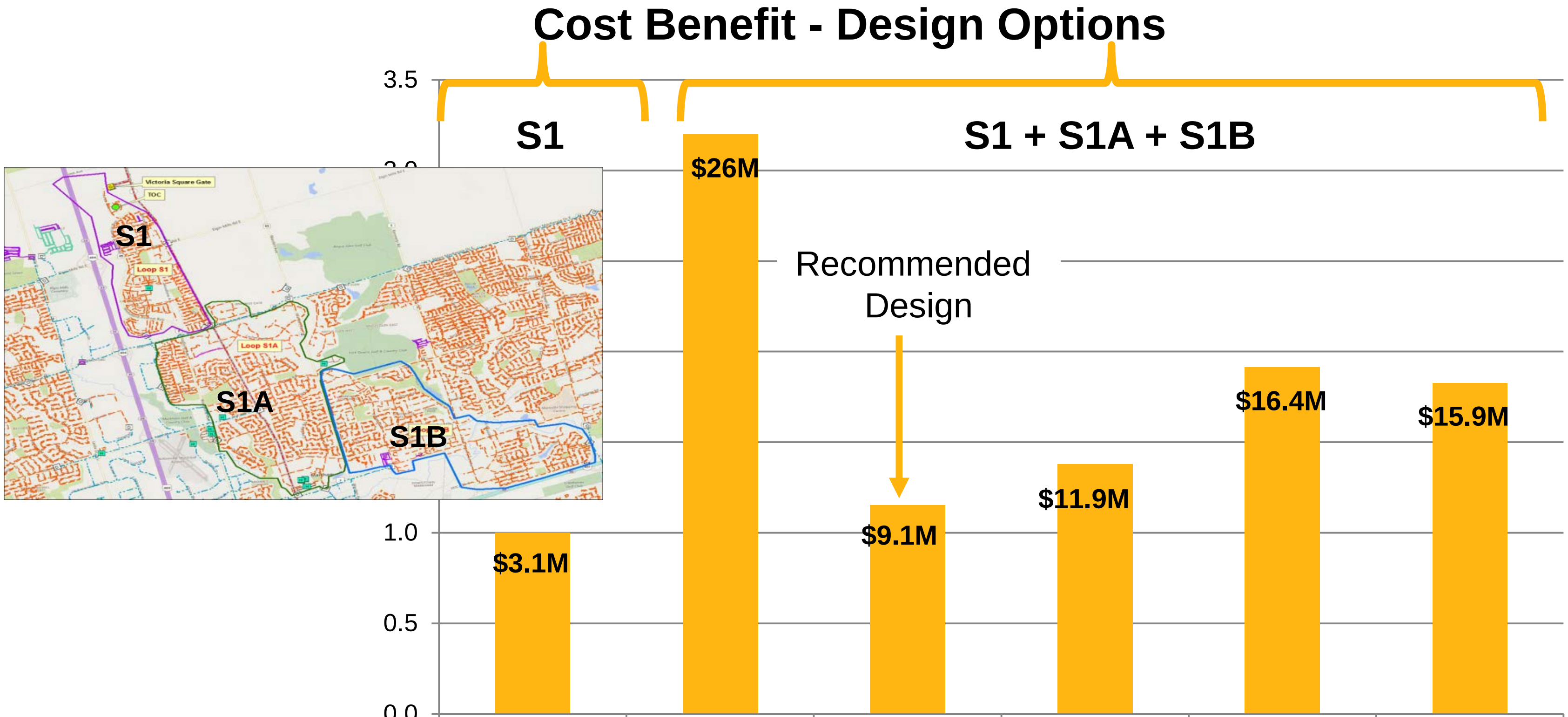
Loops S1
- 4,000 customers

Loop S1A
- 7,000 customers

Loop S1B
- 6,000 customers

Cost-Benefit Analysis of Design Options – Class 5 Estimates

Option 3A presents the most value based on selection criteria


Cost Benefit - Design Options

	Pilot Stage – Loop S1	1 and 2	3A	3A-2	3B	3B-2
Function of ($ / utilization x reliability)	1.0	3.2	1.2	1.4	1.9	1.8

* Budgetary estimate from BD is $9-10M, including research

Justifications for Design Options

Advantages and disadvantages of each option that were considered in the recommendation

Design Iteration	Construction & Operations	Hydrogen Utilization and System Reliability
Pilot Stage (S1)		
1 and 2	XHP is not preferred for blended gas at this point. The construction estimate for the HP main is not feasible.	**BASE CASE** - Utilization 22.9% with 100% predicted constant concentrations.
3A	NPS 6 and 8 PE, IP. In line with existing business practices and procedures.	Utilization 1.9% less than option Options 1 and 2 with 84.5% of the predicted time with constant Hydrogen concentrations.
3A-2	NPS 12 pipe and fittings are not approved for general use by EGD and will require a variance from TSSA to install. Potential operational concerns because of limited experience with NPS 12 PE IP.	Utilization 0.2% less than option Options 1 and 2 with 98.0% of the predicted time without constant concentrations.
3B	Potential operational concerns and Permits for the proposed twinned mains because this area already has existing dual mains.	Utilization 0.3% less than option Options 1 and 2 with 96.5% of the predicted time without constant concentrations.
3B-2	NPS 12 pipe and fittings are not approved for general use by EGD and will require a variance from TSSA to install. Potential operational concerns because of limited experience with NPS 12 PE IP.	Utilization marginally less than option Options 1 and 2 with 99.6% of the predicted time without constant concentrations.

Justification for Adding S1A and S1B

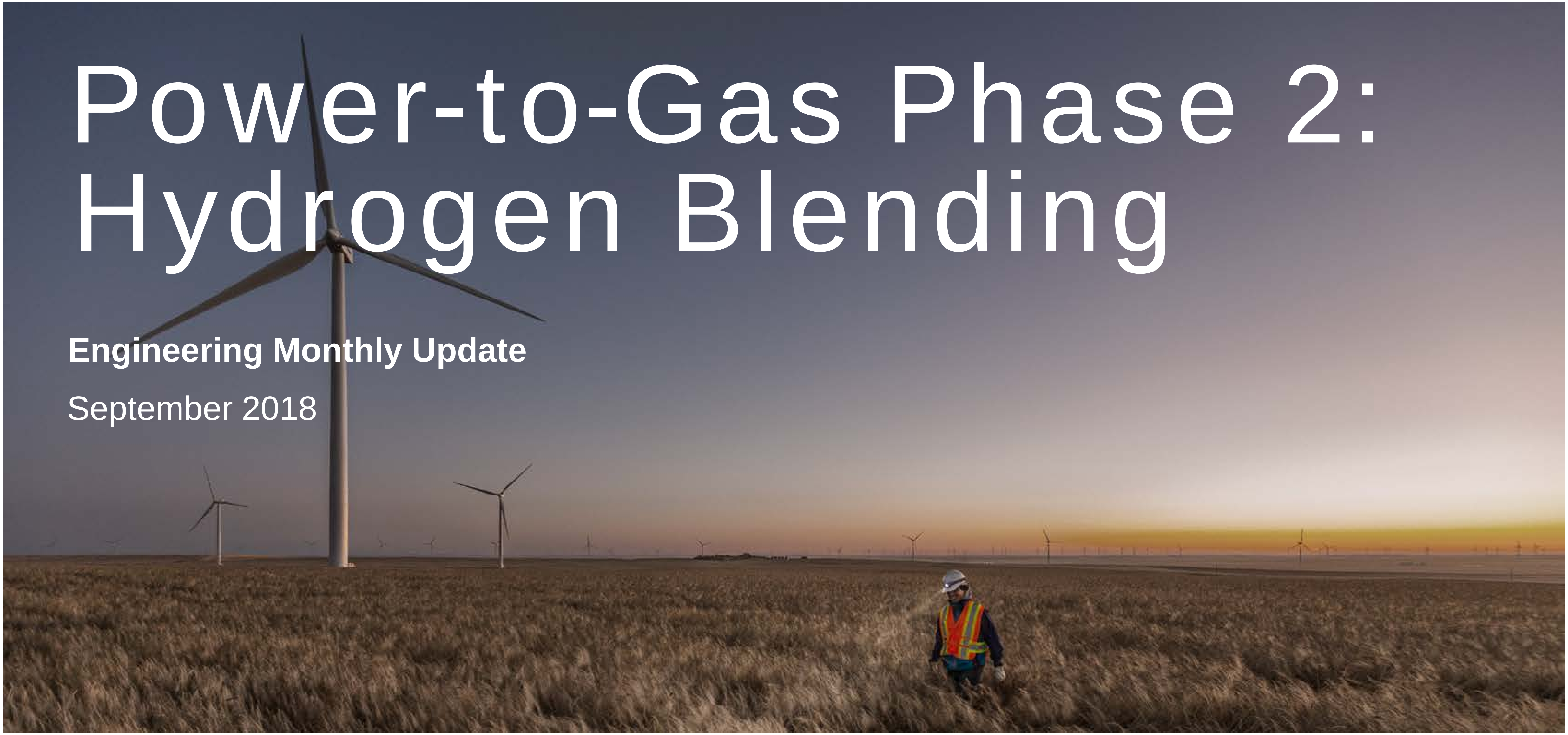
Loop S1 vs S1 + S1A + S1B

Loop	Material Composition	Vintage	Value (Upstream)	Value (End User)	Value (H_2 Utilization)	Effort Required (Research/Records)
S1A	Mains: 98% Plastic 2% Steel Services: 90% Plastic 10% Steel	Almost all pipes were installed between 1980 and 2012. Some PE pipe was installed pre-1980 (Aldyl-A).	This loops offers an acceptable representation of the EGD network as it contains both new and older pipelines.	This survey will provide some visibility into older appliances, so the impacts of H_2 on their performance can be assessed.	6,700 additional customers, 7% more H_2 utilization	Not all records are available. An accurate bill of material could only be obtained by performing a dedicated records investigation that includes miscellaneous (missy) tickets, as-laids, job cards, and pipe daylight. The most conservative approach would be to compile Engineering approved parts and technical announcements (TAs) for those years.
S1B	Mains: 77% Plastic 23% Steel Services: 91% Plastic 9% Steel	Installation dates range from 1958 to 2012.	This could be defined as a true representation of the EGD network due to the variety of assets contained here including very old steel pipes, Aldyl-A, Amp fittings, copper services. It offers an unique opportunity to test the effects of hydrogen in older systems in the event that the company decides to pursue this venture system-wide in the future.		5,900 additional customers, 8% more H_2 utilization	

Revised R&D Eng. Budget – August 2018- Class 5 Estimate

Project cost estimates comparison as of August 2018 (second forecast iteration)

Stream	Original Estimate (May 2017 Project Brief)	2018 Projection (April 2018)	Revised 2018 Projection (August 2018)	Variance (April 2018 to August 2018)	Comments Change in 2018 Estimates
1. HyReady Literature study	$70,000	$70,000	$70,000	$0	No change
1b. Knowledge Acquisition	$30,000	$112,000	$94,000	-$18,000	Project brief underestimated this cost. Savings found in the revised budget.
2. North American Task Group (CGA/AGA)	$30,000	$9,400	$9,400	$0	Project brief cost was overestimated.
3a. EGD Blending Assessment (Closed Loop)	$800,000	$1,075,000	$645,500	-$429,500	Cost reduction of $429k from earlier 2018 estimate by limiting scope of work to 3 closed loops in Markham only.
3b. End-user Equipment Assessment (System Wide)	$50,000	$1,001,000	$700,000	-$301,000	The end-user equipment stream accounts for most of the risk. It was significantly underestimated in 2017. Savings in 2018 were based on limiting experimental work, field surveys, and customer type in closed loops.
4. 100% Hydrogen Pipeline	$0	$204,000	$204,000	$0	Phase was not budgeted in the project brief.
5. Hydrogen Blending Station	$0	$172,000	$172,000	$0	Phase was not budgeted in the project brief.
Risk Assessment	$100,000	$325,000	$231,250	-$93,750	Project brief did not account for several types of modelling required for the risk assessment. Reduced cost in 2018 projection by performing a portion of the work in-house.
Total (No Salaries)	$1,080,000	$2,968,400	$2,126,150	-$842,250	Achieved savings of $842k
Team	$900,000	$969,250	$723,375	-$245,875	Included salaries for only half of 2019 until the Engineering Assessment is issued in June 2019.
Grand Total	**$1,980,000**	**$3,937,650**	**$2,849,525**	**-$1,088,125**	



Power-to-Gas Phase 2: Hydrogen Blending

Engineering Monthly Update

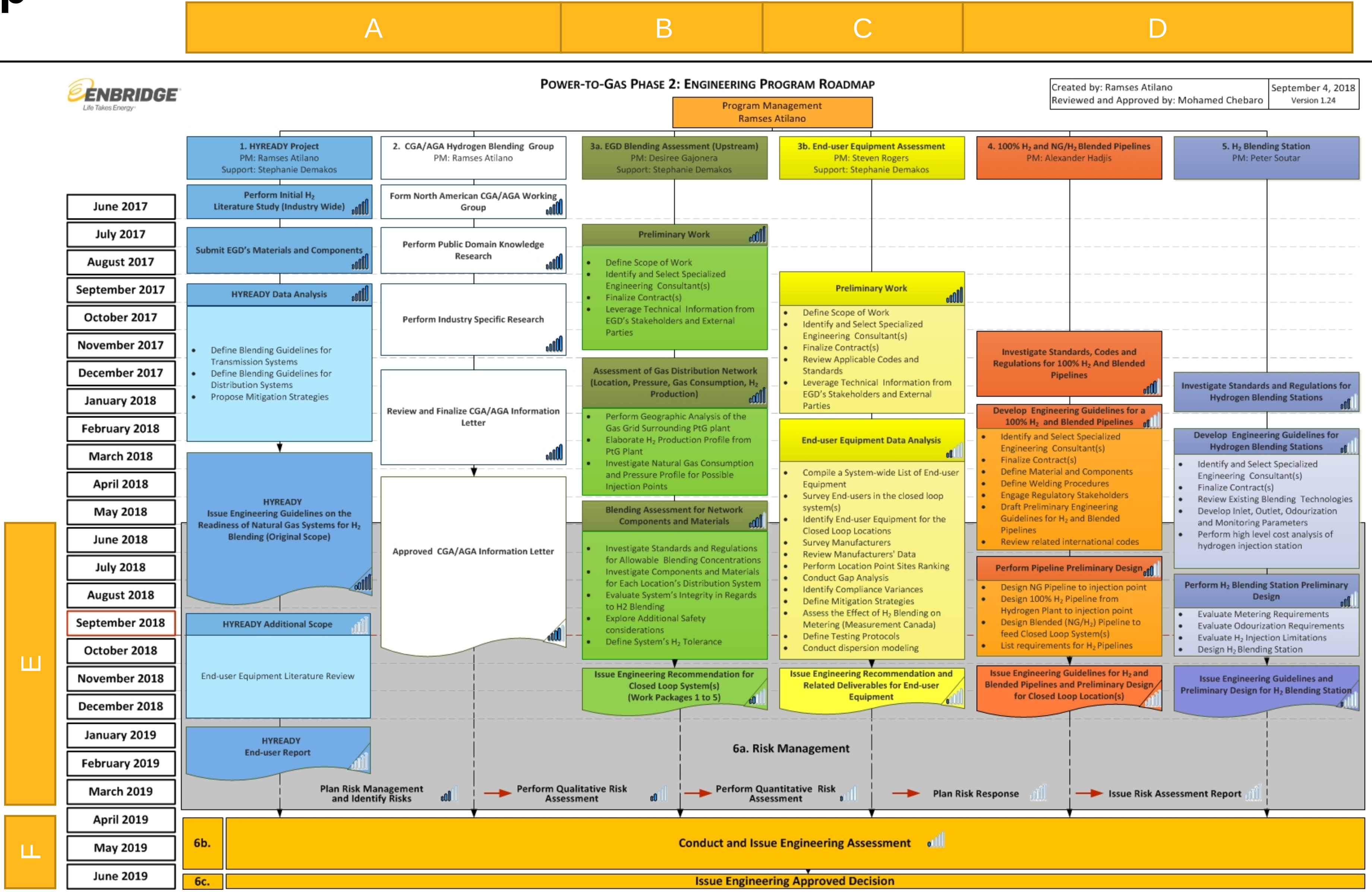
September 2018

ENBRIDGE®

Mohamed Chebaro and Ramses Atilano
Engineering

Power-to-Gas Phase 2

Roadmap



POWER-TO-GAS PHASE 2: ENGINEERING PROGRAM ROADMAP

Created by: Ramses Atilano
Reviewed and Approved by: Mohamed Chebaro
September 4, 2018
Version 1.24

Program Management
Ramses Atilano

June 2017
July 2017
August 2017
September 2017
October 2017
November 2017
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March 2018
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May 2018
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March 2019
April 2019
May 2019
June 2019

1. HYREADY Project
PM: Ramses Atilano
Support: Stephanie Demakos

- Perform Initial H_2 Literature Study (Industry Wide)
- Submit EGD's Materials and Components
- HYREADY Data Analysis
  - Define Blending Guidelines for Transmission Systems
  - Define Blending Guidelines for Distribution Systems
  - Propose Mitigation Strategies
- HYREADY Issue Engineering Guidelines on the Readiness of Natural Gas Systems for H_2 Blending (Original Scope)
- HYREADY Additional Scope
  - End-user Equipment Literature Review
- HYREADY End-user Report

2. CGA/AGA Hydrogen Blending Group
PM: Ramses Atilano

- Form North American CGA/AGA Working Group
- Perform Public Domain Knowledge Research
- Perform Industry Specific Research
- Review and Finalize CGA/AGA Information Letter
- Approved CGA/AGA Information Letter

3a. EGD Blending Assessment (Upstream)
PM: Desiree Gajonera
Support: Stephanie Demakos

- Preliminary Work
  - Define Scope of Work
  - Identify and Select Specialized Engineering Consultant(s)
  - Finalize Contract(s)
  - Leverage Technical Information from EGD's Stakeholders and External Parties
- Assessment of Gas Distribution Network (Location, Pressure, Gas Consumption, H_2 Production)
  - Perform Geographic Analysis of the Gas Grid Surrounding PtG plant
  - Elaborate H_2 Production Profile from PtG Plant
  - Investigate Natural Gas Consumption and Pressure Profile for Possible Injection Points
- Blending Assessment for Network Components and Materials
  - Investigate Standards and Regulations for Allowable Blending Concentrations
  - Investigate Components and Materials for Each Location's Distribution System
  - Evaluate System's Integrity in Regards to H2 Blending
  - Explore Additional Safety considerations
  - Define System's H_2 Tolerance
- Issue Engineering Recommendation for Closed Loop System(s) (Work Packages 1 to 5)

3b. End-user Equipment Assessment
PM: Steven Rogers
Support: Stephanie Demakos

- Preliminary Work
  - Define Scope of Work
  - Identify and Select Specialized Engineering Consultant(s)
  - Finalize Contract(s)
  - Review Applicable Codes and Standards
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- End-user Equipment Data Analysis
  - Compile a System-wide List of End-user Equipment
  - Survey End-users in the closed loop system(s)
  - Identify End-user Equipment for the Closed Loop Locations
  - Survey Manufacturers
  - Review Manufacturers' Data
  - Perform Location Point Sites Ranking
  - Conduct Gap Analysis
  - Identify Compliance Variances
  - Define Mitigation Strategies
  - Assess the Effect of H_2 Blending on Metering (Measurement Canada)
  - Define Testing Protocols
  - Conduct dispersion modeling
- Issue Engineering Recommendation and Related Deliverables for End-user Equipment

4. 100% H_2 and NG/H_2 Blended Pipelines
PM: Alexander Hadjis

- Investigate Standards, Codes and Regulations for 100% H_2 And Blended Pipelines
- Develop Engineering Guidelines for a 100% H_2 and Blended Pipelines
  - Identify and Select Specialized Engineering Consultant(s)
  - Finalize Contract(s)
  - Define Material and Components
  - Define Welding Procedures
  - Engage Regulatory Stakeholders
  - Draft Preliminary Engineering Guidelines for H_2 and Blended Pipelines
  - Review related international codes
- Perform Pipeline Preliminary Design
  - Design NG Pipeline to injection point
  - Design 100% H_2 Pipeline from Hydrogen Plant to injection point
  - Design Blended (NG/H_2) Pipeline to feed Closed Loop System(s)
  - List requirements for H_2 Pipelines
- Issue Engineering Guidelines for H_2 and Blended Pipelines and Preliminary Design for Closed Loop Location(s)

5. H_2 Blending Station
PM: Peter Soutar

- Investigate Standards and Regulations for Hydrogen Blending Stations
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  - Evaluate H_2 Injection Limitations
  - Design H_2 Blending Station
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6a. Risk Management

Plan Risk Management and Identify Risks → Perform Qualitative Risk Assessment → Perform Quantitative Risk Assessment → Plan Risk Response → Issue Risk Assessment Report

6b. Conduct and Issue Engineering Assessment

6c. Issue Engineering Approved Decision

Power-to-Gas Phase 2

Status Review

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

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Program Streams	Scope	Budget*	Timeline
CGA/AGA Task Force Information Letter *(in final stages)*	🟩	🟨	🟩
HYREADY Engineering Guideline Report *(original scope completed)*	🟩	🟨	🟩
	🟩	🟨	🟩
	🟩	🟨	🟩
	🟩	🟨	🟩
	🟩	🟨	🟩
	🟩	🟨	🟩
	🟩	🟨	🟩

* The funding for the Engineering Program is still in the process of being secured by EGD, as of September 5, 2018.

Power-to-Gas Phase 2

Status Review

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

Program Streams	**Scope**	**Budget***	**Timeline**
Data collection for identified closed loops *(survey #2 in progress)*	🟩	🟨	🟨
Data analysis for identified closed loops *(in progress)*	🟩	🟨	🟩
System-wide assessment for end-user equipment *(in progress)*	🟩	🟨	🟩
	🟨	🟨	🟩
	🟩	🟨	🟩
	🟩	🟨	🟩
Risk Assessment Report *(in progress)*	🟩	🟨	🟩
Computational Modeling *(in progress)*	🟩	🟨	🟩
	🟩	🟨	🟩

* The funding for the Engineering Program is still in the process of being secured by EGD, as of September 5, 2018.

Power-to-Gas Phase 2

Upcoming Deliverables

🟢	On track
🟡	Lagging but not on critical path
🔴	Lagging and on critical path

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Next Month's Deliverables	Scope	Budget	Timeline
A. Research and Development:			
Continue building and optimizing the Hydrogen Blending Database	🟩	🟩	🟩
B. Integrity, Engineering and Capacity Assessment			
Compile and analyze operating and integrity data for the three Closed Loop systems (e.g., corrosion, leaks and damages)	🟩	🟩	🟩
Complete 80% of H_2 tolerance evaluation for the three Closed Loops	🟩	🟩	🟩
C. End User Equipment Engineering and Integrity System			
Review second iteration of DBI report on End-user equipment	🟩	🟩	🟨
Obtain first draft report from DNV-GL for emissions	🟩	🟩	🟩
Compile 30% of field survey obtainable information for Loops S1A/S1B	🟩	🟩	🟨

Power-to-Gas Phase 2

Upcoming Deliverables

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

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Next Month's Deliverables	Scope	Budget	Timeline
D. Engineering Design:			
Continue the design review for the H_2 Blending Station	🟩	🟩	🟩
Manage Consultant Selection process to develop Engineering Guidelines for 100% H_2 and blended gas pipelines	🟩	🟩	🟩
E. Risk Assessment			
Obtain the second iteration for indoor dispersion modeling (C-FER)	🟩	🟩	🟩
Obtain the second iteration for outdoor dispersion modeling (DBI-GUT)	🟩	🟩	🟩
Facilitate HAZID sessions with SMAs as part of the Risk Study	🟩	🟩	🟩
Continue progressing the Qualitative Risk Analysis	🟩	🟩	🟩

Power-to-Gas Phase 2

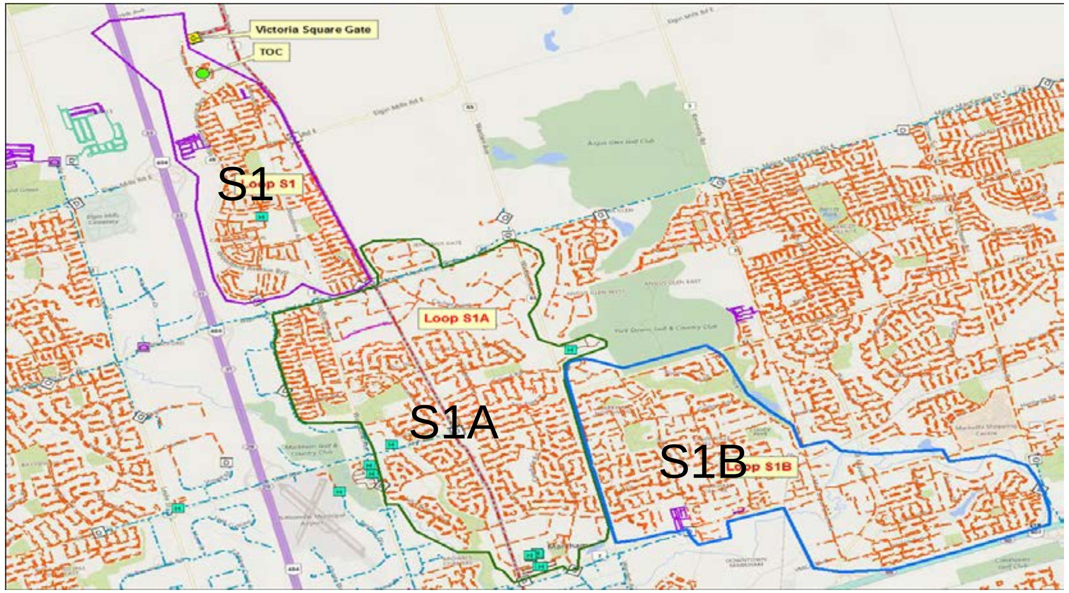
Past Month's Achievements

A. Research and Development

- ✓ Continued building the Hydrogen Knowledge Management Database framework through research review and conversations with worldwide SMEs

B. Integrity, Engineering and Capacity Assessment

- ✓ Continued contacting manufacturers for distribution components identified in the three Closed Loops
- ✓ Completed 60% of the H_2 tolerance evaluation for the three selected Closed Loops
- ✓ Finalized the 3rd design iteration of Closed Loops, including network capacity, optimization analysis, cost benefit analysis
- ✓ Analyzed and summarized operating data for the three Closed Loop systems (e.g., corrosion, leaks and damages)
- ✓ Presented to Engineering, BD, Operations and Critical Infrastructure the all 6 blending designs to date, with a focus on the latest design iteration. Presented an update on timelines, budgetary estimates and cost/benefit analyses



Power-to-Gas Phase 2

Past Month’s Achievements

C. End User Equipment Engineering and Integrity System

- ✓ Completed 99% the end-user equipment field survey for Loop S1
- ✓ Continued surveying end-user equipment for Closed Loops S1A and S1B for future analysis
- ✓ Continued with end-user equipment manufacturer survey
- ✓ Obtained second iteration of DBI report on end-user equipment

D. Engineering Design and Review

- ✓ Finalized and presented 3rd iteration (design optimization) of preliminary design for pipelines carrying three different products (100% H_2, 100% NG and Blended Gas) to reduce initial construction costs
- ✓ Reduced construction costs from initial design by a factor of 3
- ✓ Continued working on preliminary design for the station components (e.g., Pressure Regulation, H_2 Injection)
- ✓ Issued RFP for supporting the development of Engineering Design Guidelines for 100% H_2 and blended pipelines

E. Risk Assessment

- ✓ Booked HAZID sessions with various SMAs across EGD (Various Ops. and Engineering groups). The outcome of these sessions will feed into the QRA
- ✓ Refined and validated different scenarios for indoor dispersion modeling

Power-to-Gas Phase 2

Evolution of Closed Loop Pipeline Design

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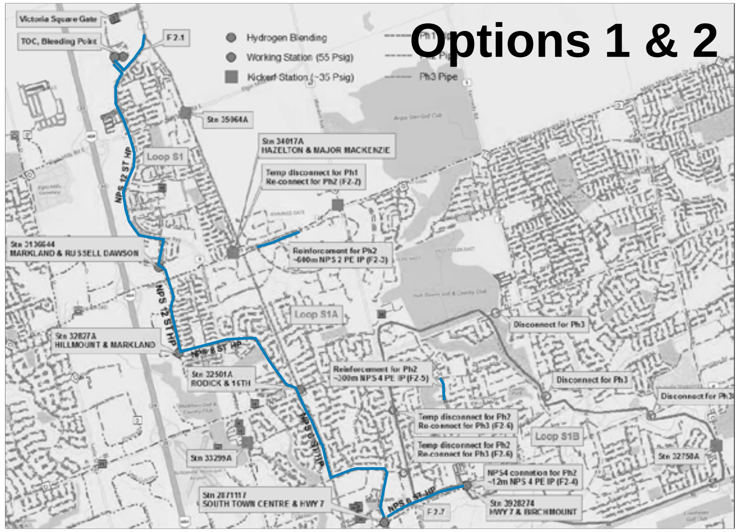
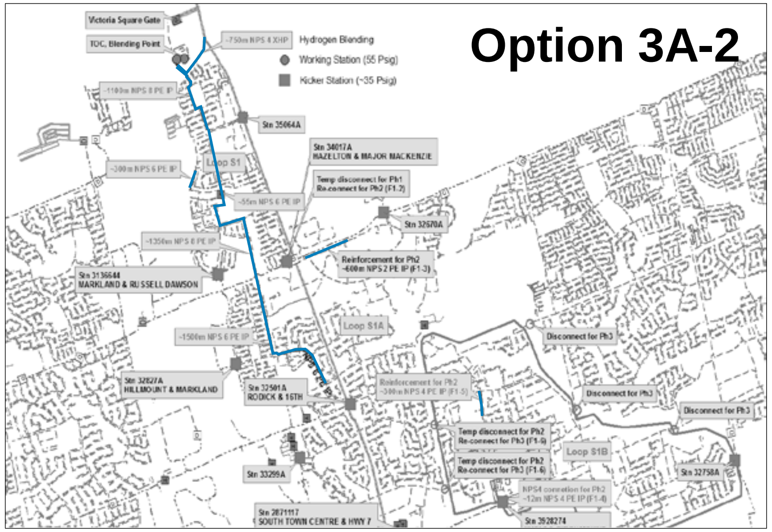
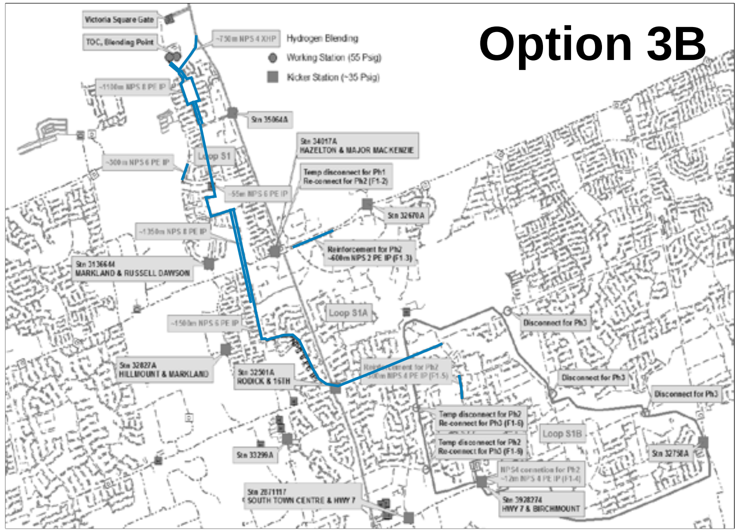


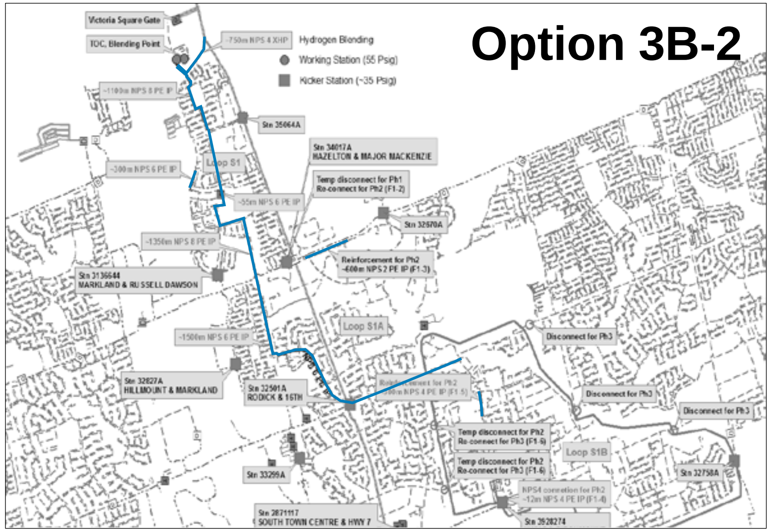
Options 1 & 2



Option 3A-2

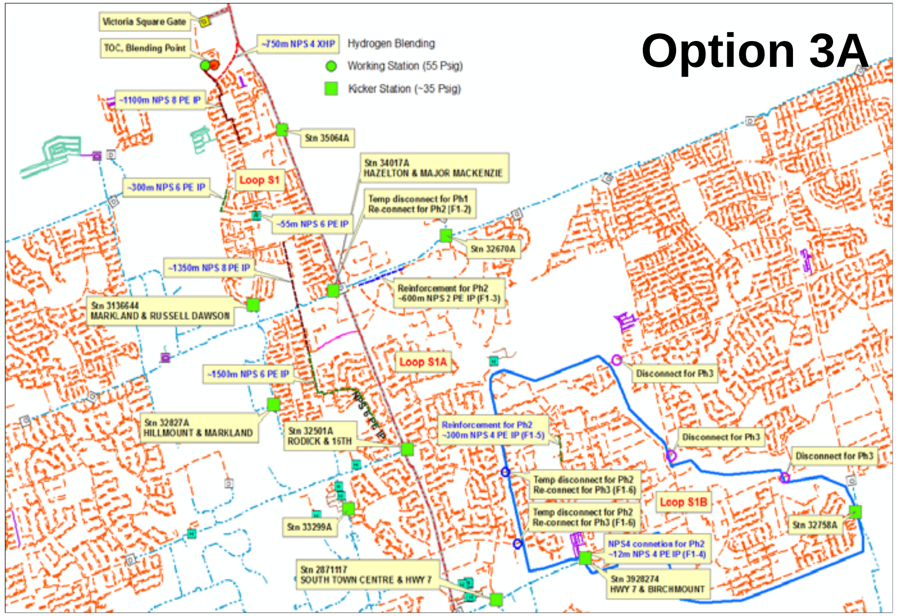


Option 3B



Option 3B-2

- Conducted Cost/Benefit Analysis
- Assessed H_2 utilization and supply reliability
- Assessed material composition, vintage, among other variables
- Recommended Option 3A for Design of Closed Loops S1, S1A and S1B
- Awaiting Selection Acceptance



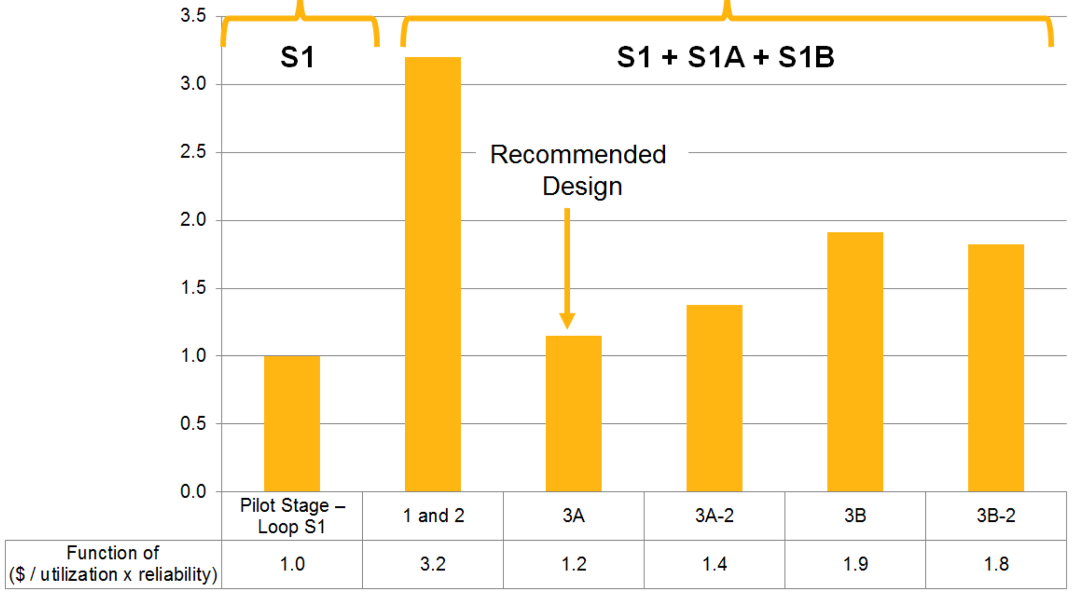
Option 3A

Power-to-Gas Phase 2

Evolution of Closed Loop Pipeline Design

- **Q4 2017- Q1 2018:** Examined 8 macro-loops across the GTA for blending considerations
- **Q1 2018:** Selected the Markham macro-loop for further analysis, divided into 3 loops for phased design
- **Q2 2018:** Produced first pipeline blending design iteration for S1, S1A and S1B
- **Q3 2018:** Initiated design refinements to reduce costs, system pressure and system modifications (completed third iteration in Aug. 2018 for S1, S1A and S1B)

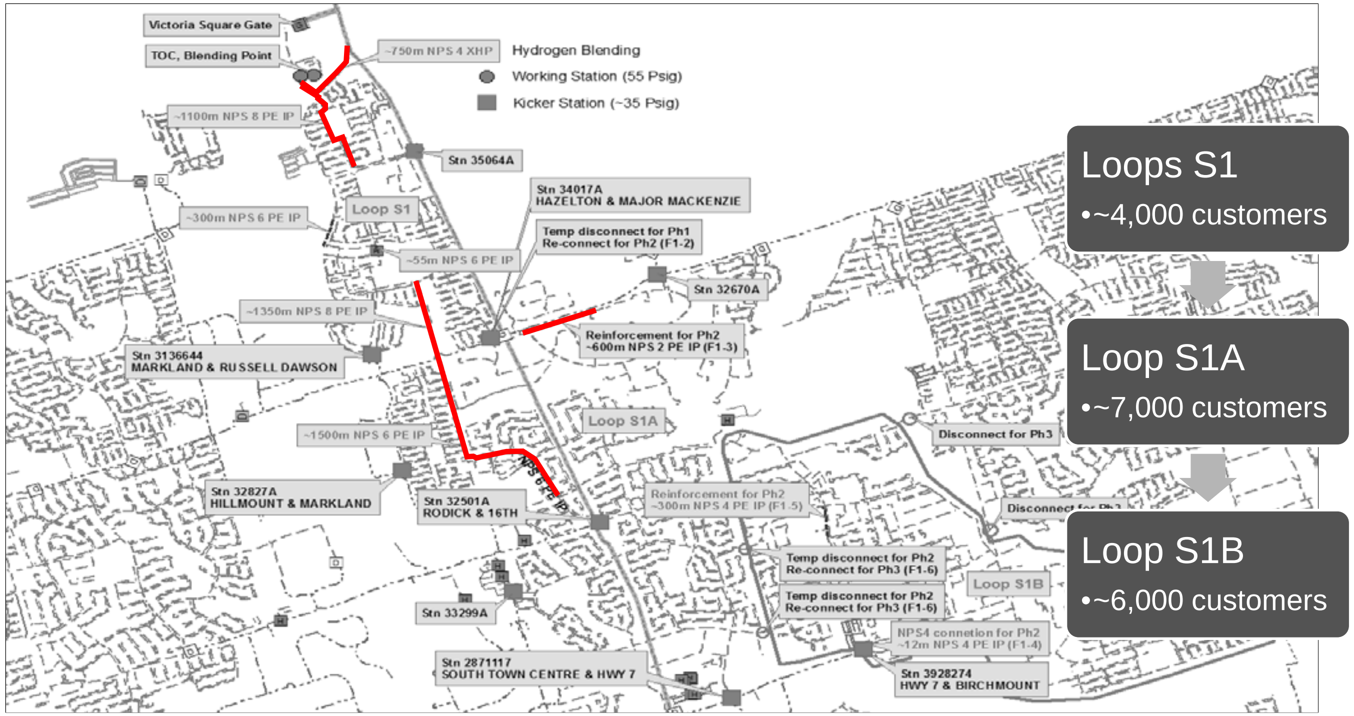
Cost Benefit - Design Options



	Pilot Stage – Loop S1	1 and 2	3A	3A-2	3B	3B-2
Function of ($ / utilization x reliability)	1.0	3.2	1.2	1.4	1.9	1.8

Option 3A

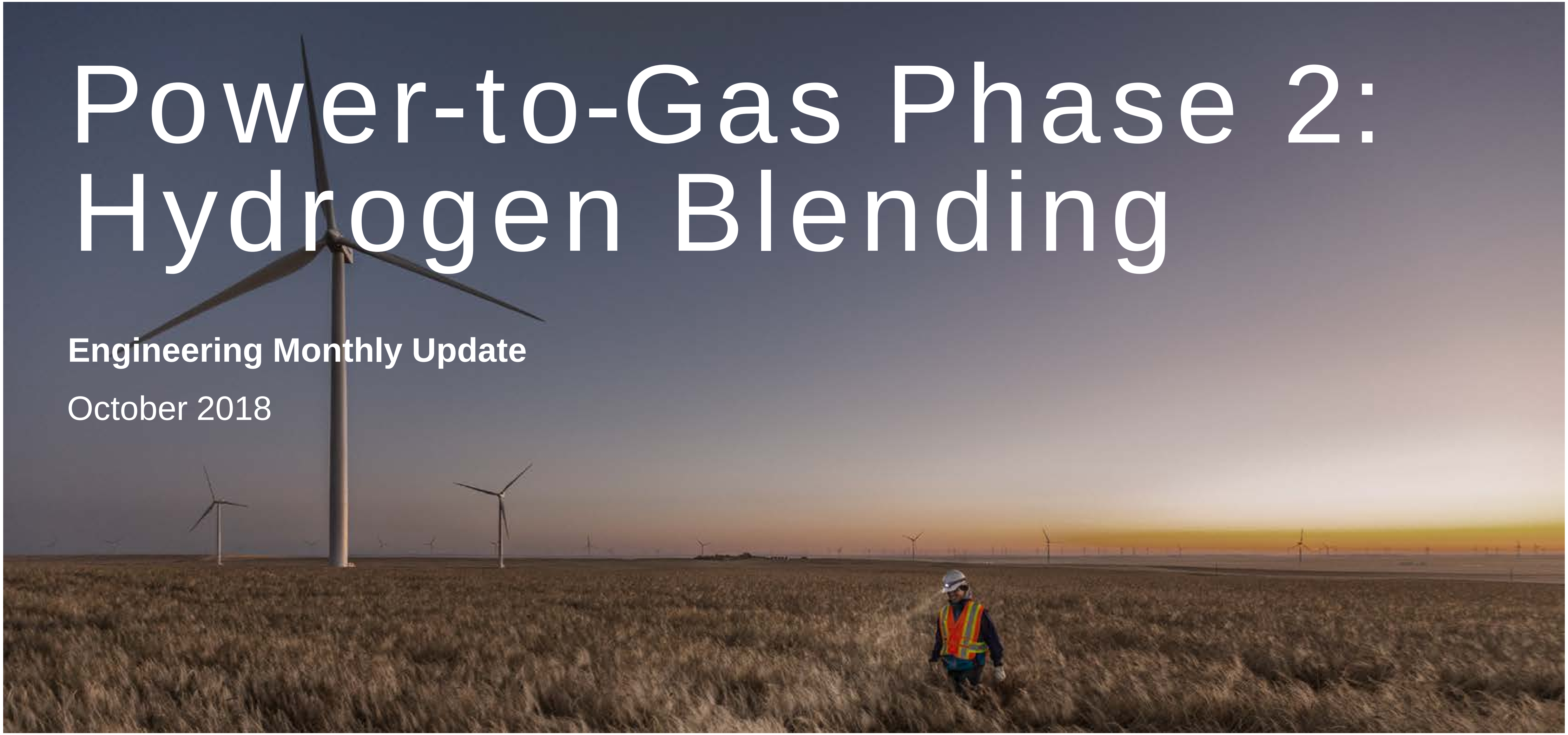
Proposed NPS 8 and 6 PE IP for blended gas
Proposed NPS 6 XHP ST for natural gas



Loops S1
- ~4,000 customers

Loop S1A
- ~7,000 customers

Loop S1B
- ~6,000 customers



Power-to-Gas Phase 2: Hydrogen Blending

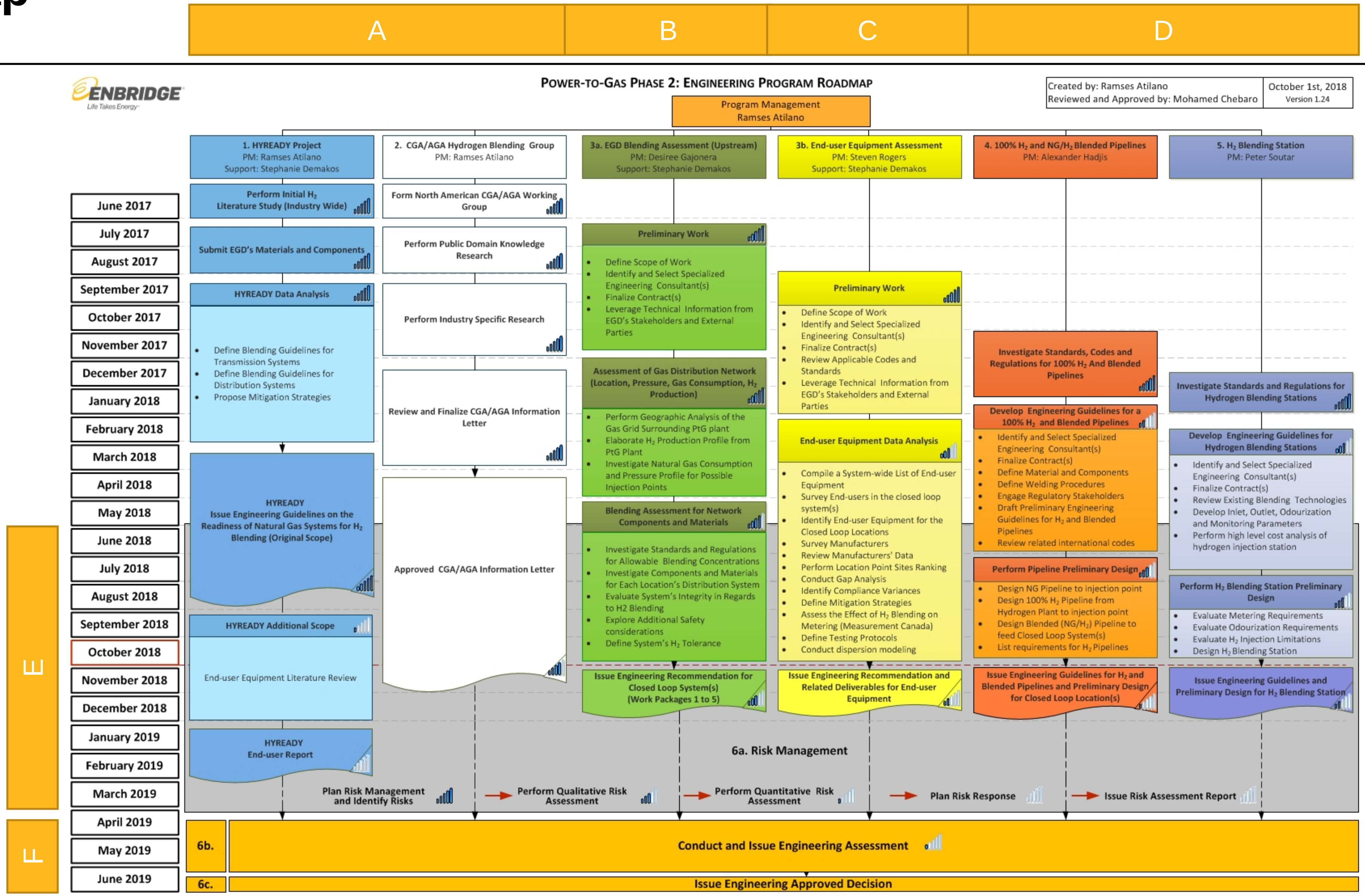
Engineering Monthly Update

October 2018

Mohamed Chebaro and Ramses Atilano
Engineering

Power-to-Gas Phase 2

Roadmap



POWER-TO-GAS PHASE 2: ENGINEERING PROGRAM ROADMAP

Created by: Ramses Atilano
Reviewed and Approved by: Mohamed Chebaro
October 1st, 2018
Version 1.24

Program Management
Ramses Atilano

June 2017
July 2017
August 2017
September 2017
October 2017
November 2017
December 2017
January 2018
February 2018
March 2018
April 2018
May 2018
June 2018
July 2018
August 2018
September 2018
October 2018
November 2018
December 2018
January 2019
February 2019
March 2019
April 2019
May 2019
June 2019

1. HYREADY Project
PM: Ramses Atilano
Support: Stephanie Demakos

Perform Initial H_2 Literature Study (Industry Wide)

Submit EGD's Materials and Components

HYREADY Data Analysis
- Define Blending Guidelines for Transmission Systems
- Define Blending Guidelines for Distribution Systems
- Propose Mitigation Strategies

HYREADY
Issue Engineering Guidelines on the Readiness of Natural Gas Systems for H_2 Blending (Original Scope)

HYREADY Additional Scope
End-user Equipment Literature Review

HYREADY
End-user Report

2. CGA/AGA Hydrogen Blending Group
PM: Ramses Atilano

Form North American CGA/AGA Working Group

Perform Public Domain Knowledge Research

Perform Industry Specific Research

Review and Finalize CGA/AGA Information Letter

Approved CGA/AGA Information Letter

3a. EGD Blending Assessment (Upstream)
PM: Desiree Gajonera
Support: Stephanie Demakos

Preliminary Work
- Define Scope of Work
- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Leverage Technical Information from EGD's Stakeholders and External Parties

Assessment of Gas Distribution Network (Location, Pressure, Gas Consumption, H_2 Production)
- Perform Geographic Analysis of the Gas Grid Surrounding PtG plant
- Elaborate H_2 Production Profile from PtG Plant
- Investigate Natural Gas Consumption and Pressure Profile for Possible Injection Points

Blending Assessment for Network Components and Materials
- Investigate Standards and Regulations for Allowable Blending Concentrations
- Investigate Components and Materials for Each Location's Distribution System
- Evaluate System's Integrity in Regards to H2 Blending
- Explore Additional Safety considerations
- Define System's H_2 Tolerance

Issue Engineering Recommendation for Closed Loop System(s) (Work Packages 1 to 5)

3b. End-user Equipment Assessment
PM: Steven Rogers
Support: Stephanie Demakos

Preliminary Work
- Define Scope of Work
- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Review Applicable Codes and Standards
- Leverage Technical Information from EGD's Stakeholders and External Parties

End-user Equipment Data Analysis
- Compile a System-wide List of End-user Equipment
- Survey End-users in the closed loop system(s)
- Identify End-user Equipment for the Closed Loop Locations
- Survey Manufacturers
- Review Manufacturers' Data
- Perform Location Point Sites Ranking
- Conduct Gap Analysis
- Identify Compliance Variances
- Define Mitigation Strategies
- Assess the Effect of H_2 Blending on Metering (Measurement Canada)
- Define Testing Protocols
- Conduct dispersion modeling

Issue Engineering Recommendation and Related Deliverables for End-user Equipment

4. 100% H_2 and NG/H_2 Blended Pipelines
PM: Alexander Hadjis

Investigate Standards, Codes and Regulations for 100% H_2 And Blended Pipelines

Develop Engineering Guidelines for a 100% H_2 and Blended Pipelines
- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Define Material and Components
- Define Welding Procedures
- Engage Regulatory Stakeholders
- Draft Preliminary Engineering Guidelines for H_2 and Blended Pipelines
- Review related international codes

Perform Pipeline Preliminary Design
- Design NG Pipeline to injection point
- Design 100% H_2 Pipeline from Hydrogen Plant to injection point
- Design Blended (NG/H_2) Pipeline to feed Closed Loop System(s)
- List requirements for H_2 Pipelines

Issue Engineering Guidelines for H_2 and Blended Pipelines and Preliminary Design for Closed Loop Location(s)

5. H_2 Blending Station
PM: Peter Soutar

Investigate Standards and Regulations for Hydrogen Blending Stations

Develop Engineering Guidelines for Hydrogen Blending Stations
- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Review Existing Blending Technologies
- Develop Inlet, Outlet, Odourization and Monitoring Parameters
- Perform high level cost analysis of hydrogen injection station

Perform H_2 Blending Station Preliminary Design
- Evaluate Metering Requirements
- Evaluate Odourization Requirements
- Evaluate H_2 Injection Limitations
- Design H_2 Blending Station

Issue Engineering Guidelines and Preliminary Design for H_2 Blending Station

6a. Risk Management

Plan Risk Management and Identify Risks → **Perform Qualitative Risk Assessment** → **Perform Quantitative Risk Assessment** → **Plan Risk Response** → **Issue Risk Assessment Report**

6b. **Conduct and Issue Engineering Assessment**

6c. **Issue Engineering Approved Decision**

Power-to-Gas Phase 2

Status Review

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

Program Streams	Scope	Budget*	Timeline
CGA/AGA Task Force Information Letter *(in final stages)*	🟩	🟨	🟩
HYREADY Engineering Guideline Report *(original scope completed)*	🟩	🟨	🟩
HYREADY Added Scope – End user *(initiated)*	🟩	🟨	🟩
	🟩	🟨	🟩
	🟩	🟨	🟩
	🟩	🟨	🟩
	🟩	🟨	🟩
	🟩	🟨	🟩
	🟩	🟨	🟩

* The funding for the Engineering Program is still in the process of being secured by EGD, as of October 3, 2018.

Power-to-Gas Phase 2

Status Review

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

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Program Streams	Scope	Budget*	Timeline
Data collection for identified closed loops *(survey #3 in progress)*	🟩	🟨	🟩
Data analysis for identified closed loops *(in progress)*	🟩	🟨	🟩
System-wide assessment for end-user equipment *(in progress)*	🟩	🟨	🟩
	🟩	🟨	🟩
	🟩	🟨	🟩
	🟩	🟨	🟩
Risk Assessment Report *(in progress, completed HAZID)*	🟩	🟨	🟩
Computational Modeling *(in progress)*	🟩	🟨	🟩
	🟩	🟨	🟩

* The funding for the Engineering Program is still in the process of being secured by EGD, as of October 3, 2018.

Power-to-Gas Phase 2

Upcoming Deliverables

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

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Next Month's Deliverables	Scope	Budget	Timeline
Continue building and optimizing the Hydrogen Blending Database	🟩	🟩	🟩
Manage HYREADY's expanded work scope	🟩	🟩	🟩
Compile and analyze operating and integrity data for the three Closed Loops (e.g., corrosion, leaks and damages)	🟩	🟩	🟩
	🟩	🟩	🟩
C. End User Equipment Engineering and Integrity System			
Issue final iteration of DBI report on end-user equipment	🟩	🟩	🟩
Issue final draft reports from DNV-GL for end-user emissions and risk	🟩	🟩	🟩
Compile 75% of field survey obtainable information for Loops S1A/S1B, including 18 field validations for potentially miscategorized equipment	🟩	🟩	🟩

Power-to-Gas Phase 2

Upcoming Deliverables

- 🟢 On track
- 🟡 Lagging but not on critical path
- 🔴 Lagging and on critical path

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Next Month's Deliverables	Scope	Budget	Timeline
D. Engineering Design:			
Continue the design review for the H_2 Blending Station	🟩	🟩	🟩
Select Consultant to develop Engineering Guidelines for 100% H_2 and blended gas pipelines	🟩	🟩	🟩
E. Risk Assessment			
Obtain the final iteration for indoor dispersion modeling (C-FER)	🟩	🟩	🟩
Obtain the final iteration for outdoor dispersion modeling (DBI-GUT)	🟩	🟩	🟩
Analyze the results of all HAZID sessions as part of the Risk Study	🟩	🟩	🟩
Finalize Qualitative Risk Analysis and progress the Quantitative Risk Assessment	🟩	🟩	🟩

Power-to-Gas Phase 2

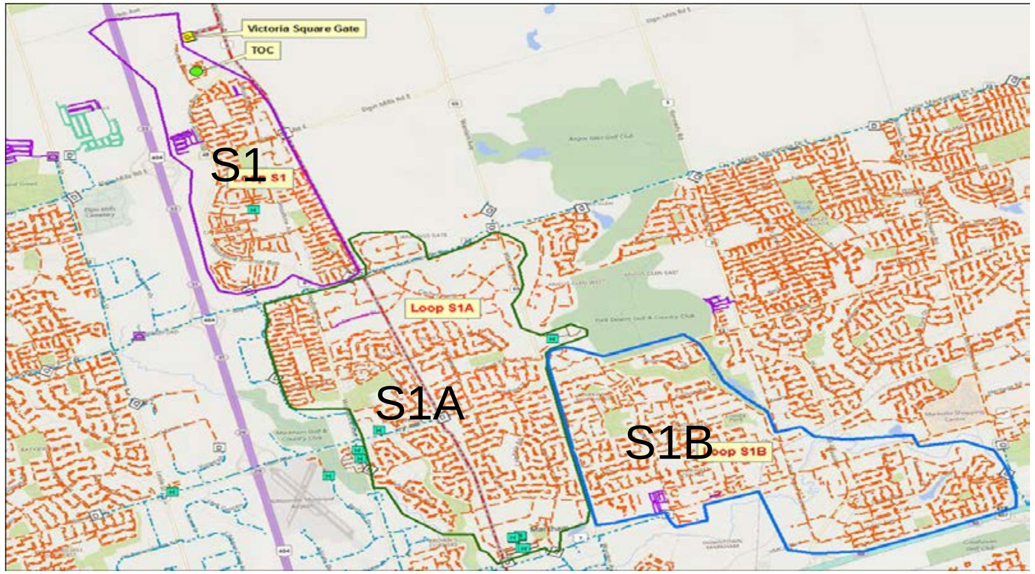
Past Month’s Achievements

A. Research and Development

- ✓ Continued building the Hydrogen Knowledge Management Database framework
- ✓ Worked with the CGA/AGA Task Force in preparation of the CGA report adoption

B. Integrity, Engineering and Capacity Assessment

- ✓ Continued contacting manufacturers for distribution components identified in the three Closed Loops
- ✓ Completed 80% of the H_2 tolerance evaluation for the three selected Closed Loops
- ✓ Finalized the latest design iteration of Closed Loops, including network capacity, optimization analysis, cost benefit analysis
- ✓ Received business support for the selected design
- ✓ Presented an update on timelines, budgetary estimates and cost/benefit analyses to BD, Critical Infrastructure and other stakeholders
- ✓ Developed a testing plan for leak detection equipment on blended hydrogen mixtures at TOC



Power-to-Gas Phase 2

Past Month's Achievements

C. End User Equipment Engineering and Integrity System

- ✓ Completed 100% the end-user equipment field survey for Loop S1 with a 90% confidence level
- ✓ Completed 44% of end-user equipment survey for Closed Loops S1A and S1B for future analysis
- ✓ Continued with end-user equipment manufacturer survey
- ✓ Obtained third and final iteration of DBI report on end-user equipment

D. Engineering Design and Review

- ✓ Finalized design optimization for pipelines carrying three different products (100% H_2, 100% NG and Blended Gas) to reduce initial construction costs, detailed design to follow
- ✓ Continued working on station components design (e.g., Pressure Regulation, H_2 Injection)
- ✓ Received proposals from six companies for the development of Engineering Design Guidelines for 100% H_2 and blended pipelines, evaluations to follow, initiated evaluations

E. Risk Assessment

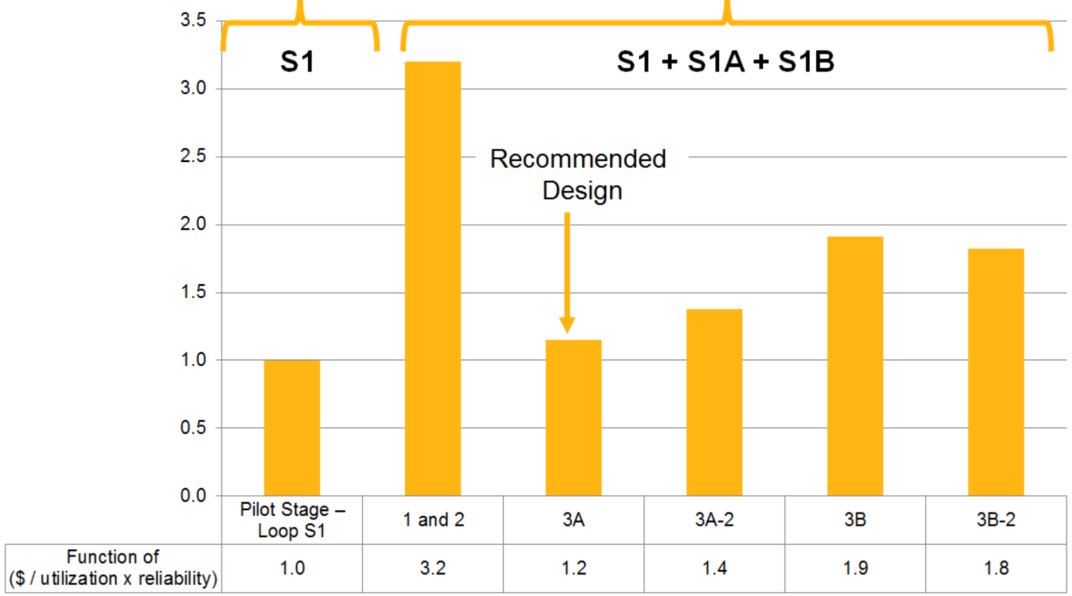
- ✓ Completed four HAZID sessions with various SMAs across EGD (Ops., Integrity, Risk and Engineering groups). The outcome of these sessions will feed into the Quantitative Risk Assessment (QRA)
- ✓ Further refined and validated different scenarios for indoor and outdoor dispersion modeling

Power-to-Gas Phase 2

Evolution of Closed Loop Pipeline Design

- **Q4 2017- Q1 2018:** Examined 8 macro-loops across the GTA for blending considerations
- **Q1 2018:** Selected the Markham macro-loop for further analysis, divided into 3 loops for phased design
- **Q2 2018:** Produced first pipeline blending design iteration for S1, S1A and S1B
- **Q3 2018:** Issued design refinements to reduce costs, system pressure and system modifications (completed fourth iteration in Sept. 2018 for S1, S1A and S1B)

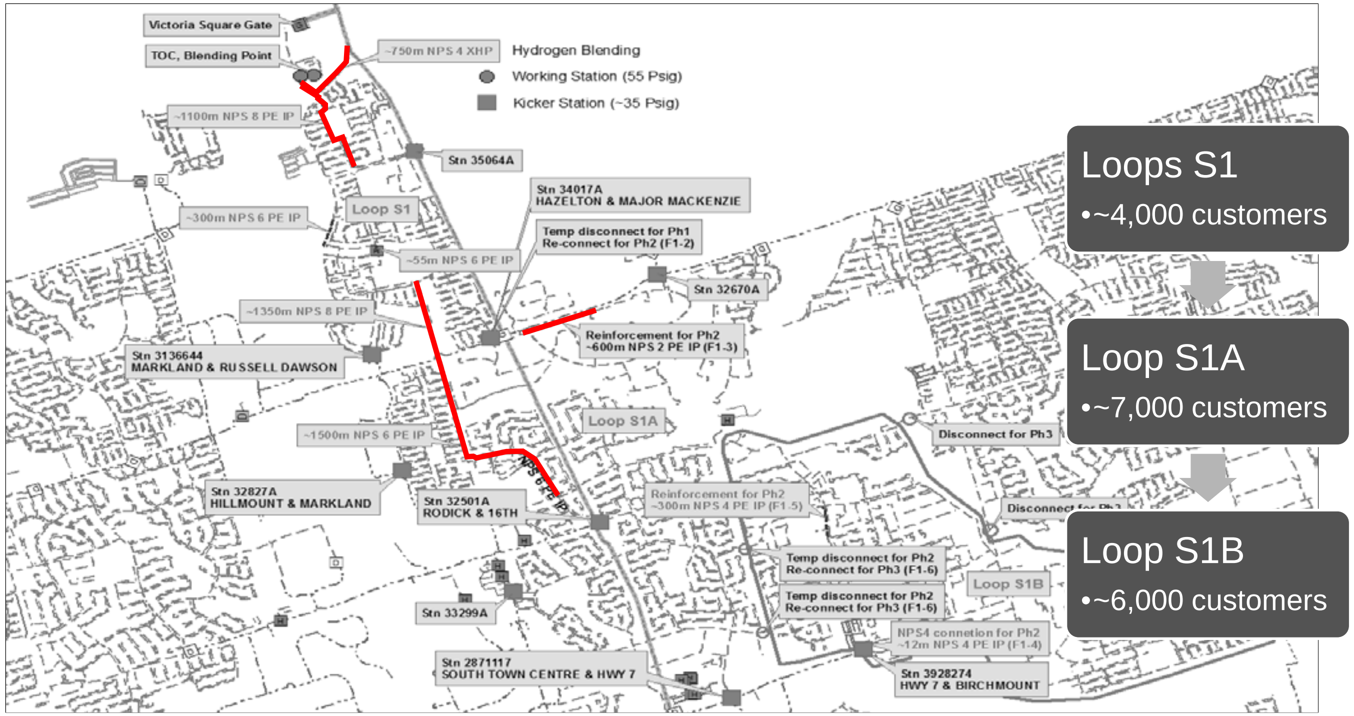
Cost Benefit - Design Options



	Pilot Stage – Loop S1	1 and 2	3A	3A-2	3B	3B-2
Function of ($ / utilization x reliability)	1.0	3.2	1.2	1.4	1.9	1.8

Option 3A

Proposed NPS 8 and 6 PE IP for blended gas
Proposed NPS 6 XHP ST for natural gas



Loops S1
- ~4,000 customers

Loop S1A
- ~7,000 customers

Loop S1B
- ~6,000 customers

Power-to-Gas Phase 2

Preliminary Emission Impact from Hydrogen Blending

Gas Interchangeability Study[1]: *The ability to substitute one gaseous fuel for another in a combustion application without materially changing the operational performance of the application (safety, efficiency or emissions).*

Appliance Type	CO_2	CO	NOx	Flame Temp	Temp Combustion Chamber	Lambda (air to fuel ratio)	Flame Speed
Industrial (retrofit)					=	=	
Industrial (no retrofit)*		↓	↓**	↑	↓	↑	
Residential (no retrofit)		↓	↓	↑	↓	↑	
Turbines (retrofit)		↓	↑	↑	=	=	
Engines (no retrofit)							

* It is not practical not to retrofit equipment for industrial users, as this will be detrimental to their processes.

** The NOx-formation in non-retrofitted plants should theoretically drop; however, in practice, it depends on plant parameters.

---

[1] Guidebook to Gas Interchangeability and Gas Quality. International Gas Union/BP, 2012.

Engineering Update: Hydrogen Blending

PtG Blending Phase – Governance Update

October 2, 2018

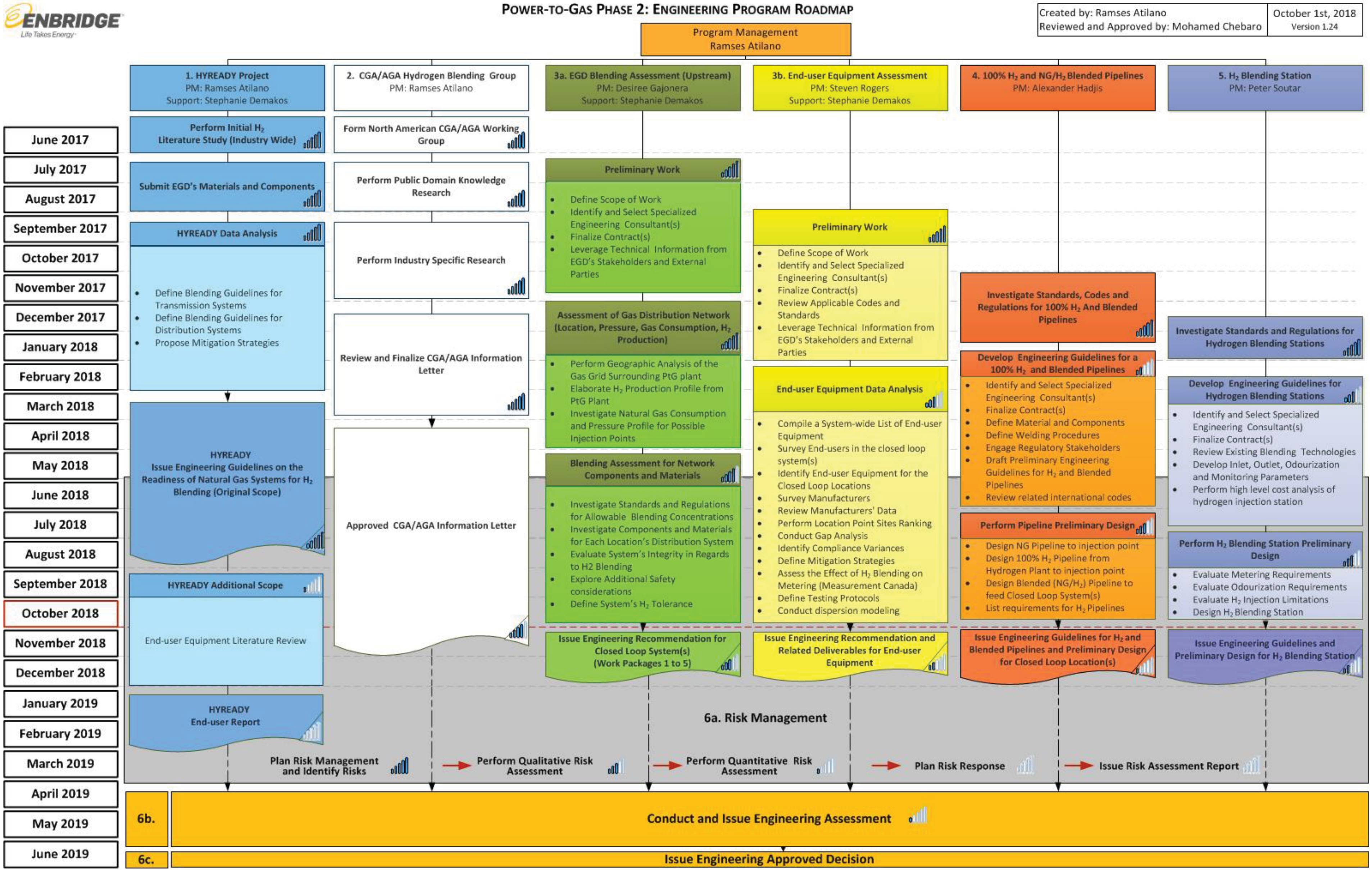
Prepared by: Mohamed Chebaro, Ramses Atilano

Presented by: Mike Wagle

POWER-TO-GAS PHASE 2: ENGINEERING PROGRAM ROADMAP

Created by: Ramses Atilano
Reviewed and Approved by: Mohamed Chebaro

October 1st, 2018
Version 1.24



Program Management
Ramses Atilano

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June 2019

1. HYREADY Project
PM: Ramses Atilano
Support: Stephanie Demakos

Perform Initial H_2 Literature Study (Industry Wide)

Submit EGD's Materials and Components

HYREADY Data Analysis

- Define Blending Guidelines for Transmission Systems
- Define Blending Guidelines for Distribution Systems
- Propose Mitigation Strategies

HYREADY Issue Engineering Guidelines on the Readiness of Natural Gas Systems for H_2 Blending (Original Scope)

HYREADY Additional Scope

End-user Equipment Literature Review

HYREADY End-user Report

2. CGA/AGA Hydrogen Blending Group
PM: Ramses Atilano

Form North American CGA/AGA Working Group

Perform Public Domain Knowledge Research

Perform Industry Specific Research

Review and Finalize CGA/AGA Information Letter

Approved CGA/AGA Information Letter

3a. EGD Blending Assessment (Upstream)
PM: Desiree Gajonera
Support: Stephanie Demakos

Preliminary Work

- Define Scope of Work
- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Leverage Technical Information from EGD's Stakeholders and External Parties

Assessment of Gas Distribution Network (Location, Pressure, Gas Consumption, H_2 Production)

- Perform Geographic Analysis of the Gas Grid Surrounding PtG plant
- Elaborate H_2 Production Profile from PtG Plant
- Investigate Natural Gas Consumption and Pressure Profile for Possible Injection Points

Blending Assessment for Network Components and Materials

- Investigate Standards and Regulations for Allowable Blending Concentrations
- Investigate Components and Materials for Each Location's Distribution System
- Evaluate System's Integrity in Regards to H2 Blending
- Explore Additional Safety considerations
- Define System's H_2 Tolerance

Issue Engineering Recommendation for Closed Loop System(s) (Work Packages 1 to 5)

3b. End-user Equipment Assessment
PM: Steven Rogers
Support: Stephanie Demakos

Preliminary Work

- Define Scope of Work
- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Review Applicable Codes and Standards
- Leverage Technical Information from EGD's Stakeholders and External Parties

End-user Equipment Data Analysis

- Compile a System-wide List of End-user Equipment
- Survey End-users in the closed loop system(s)
- Identify End-user Equipment for the Closed Loop Locations
- Survey Manufacturers
- Review Manufacturers' Data
- Perform Location Point Sites Ranking
- Conduct Gap Analysis
- Identify Compliance Variances
- Define Mitigation Strategies
- Assess the Effect of H_2 Blending on Metering (Measurement Canada)
- Define Testing Protocols
- Conduct dispersion modeling

Issue Engineering Recommendation and Related Deliverables for End-user Equipment

4. 100% H_2 and NG/H_2 Blended Pipelines
PM: Alexander Hadjis

Investigate Standards, Codes and Regulations for 100% H_2 And Blended Pipelines

Develop Engineering Guidelines for a 100% H_2 and Blended Pipelines

- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Define Material and Components
- Define Welding Procedures
- Engage Regulatory Stakeholders
- Draft Preliminary Engineering Guidelines for H_2 and Blended Pipelines
- Review related international codes

Perform Pipeline Preliminary Design

- Design NG Pipeline to injection point
- Design 100% H_2 Pipeline from Hydrogen Plant to injection point
- Design Blended (NG/H_2) Pipeline to feed Closed Loop System(s)
- List requirements for H_2 Pipelines

Issue Engineering Guidelines for H_2 and Blended Pipelines and Preliminary Design for Closed Loop Location(s)

5. H_2 Blending Station
PM: Peter Soutar

Investigate Standards and Regulations for Hydrogen Blending Stations

Develop Engineering Guidelines for Hydrogen Blending Stations

- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Review Existing Blending Technologies
- Develop Inlet, Outlet, Odourization and Monitoring Parameters
- Perform high level cost analysis of hydrogen injection station

Perform H_2 Blending Station Preliminary Design

- Evaluate Metering Requirements
- Evaluate Odourization Requirements
- Evaluate H_2 Injection Limitations
- Design H_2 Blending Station

Issue Engineering Guidelines and Preliminary Design for H_2 Blending Station

6a. Risk Management

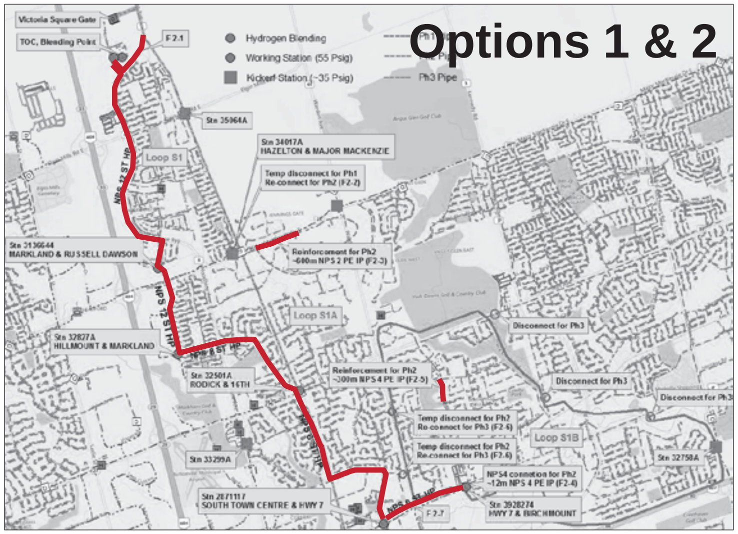
Plan Risk Management and Identify Risks → **Perform Qualitative Risk Assessment** → **Perform Quantitative Risk Assessment** → **Plan Risk Response** → **Issue Risk Assessment Report**

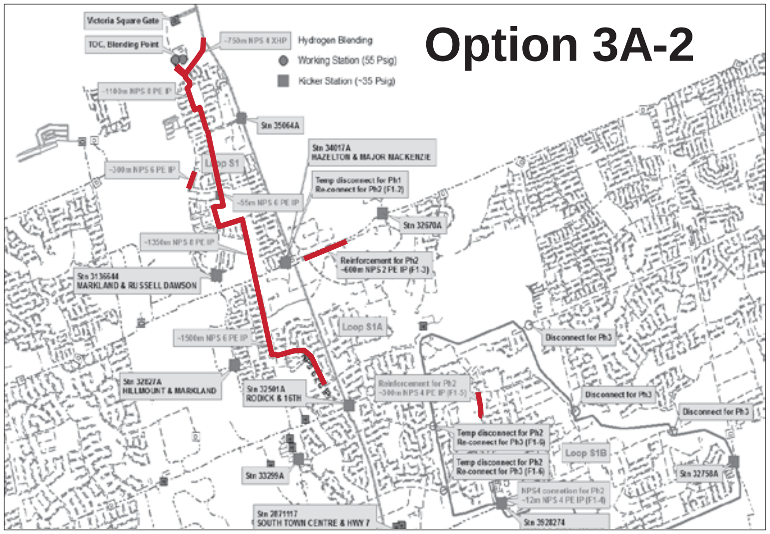
6b. **Conduct and Issue Engineering Assessment**

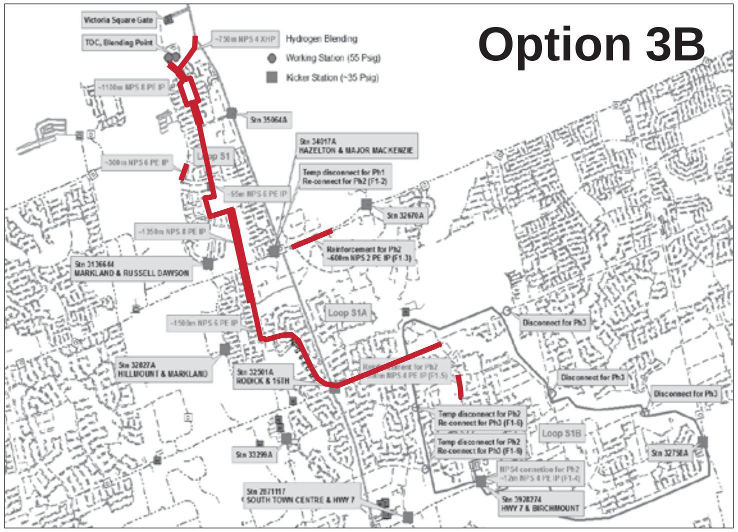
6c. **Issue Engineering Approved Decision**

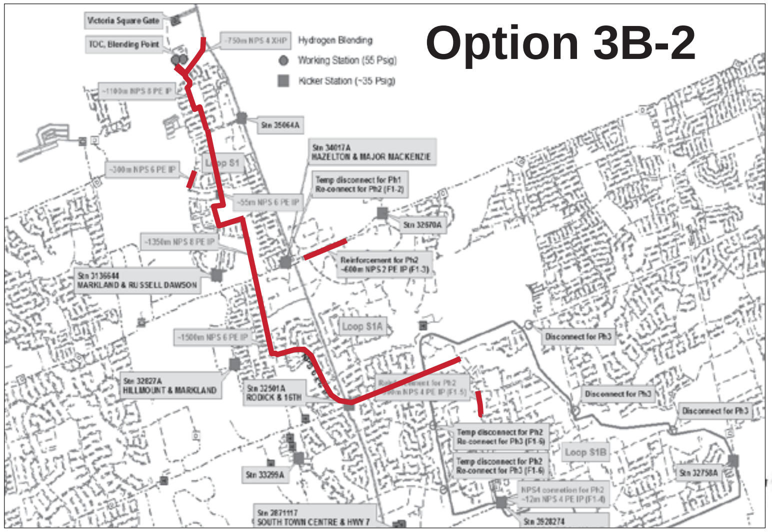
Pilot Construction Phase – Initial Route Options

XHP, HP and IP options included in the cost benefit analysis



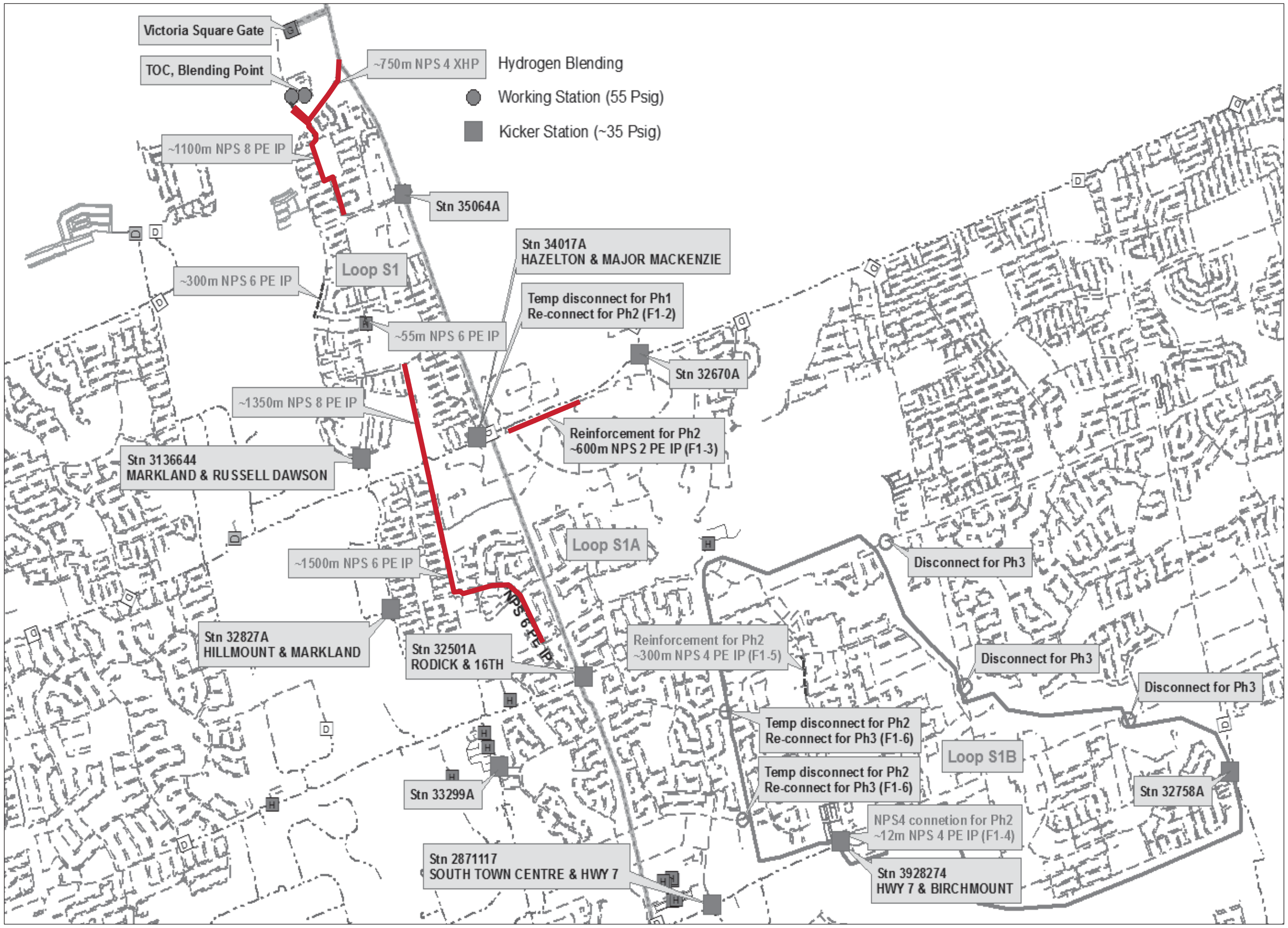






Pilot Construction Phase – Recommended Option: 3A

New NPS 8 and NPS 6 PLASTIC intermediate pressure main and use existing NPS 6 and NPS 4 PE IP mains

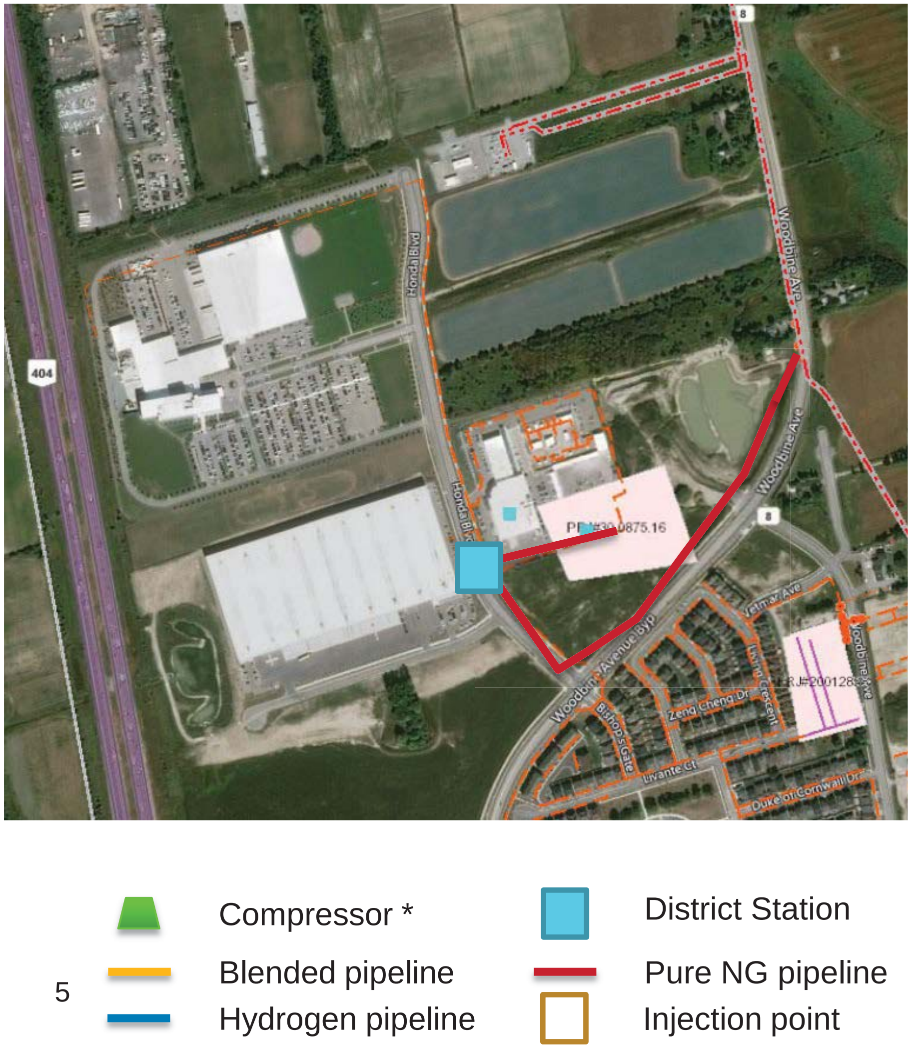


Loops S1
- 4,000 customers

Loop S1A
- 7,000 customers

Loop S1B
- 6,000 customers

Option 3A – Feed to Closed Loops



NG Feed from NPS 30	Why not NG feed from Vic Square?
• Pipeline design in line with current business practices, codes and regulations • Allows gathering pertinent information while minimizing additional risk • Utilizes a relatively new portion of the system in a controlled environment	• Long distance / increased costs • Additional pipeline required to Vic Square in the future anyway to maintain closed loops • Pipeline to Vic Square needed to potentially blend in North Feed would likely have a large H_2 concentration, which is currently under evaluation (codes, standards)

Option 3A – Future Expansion

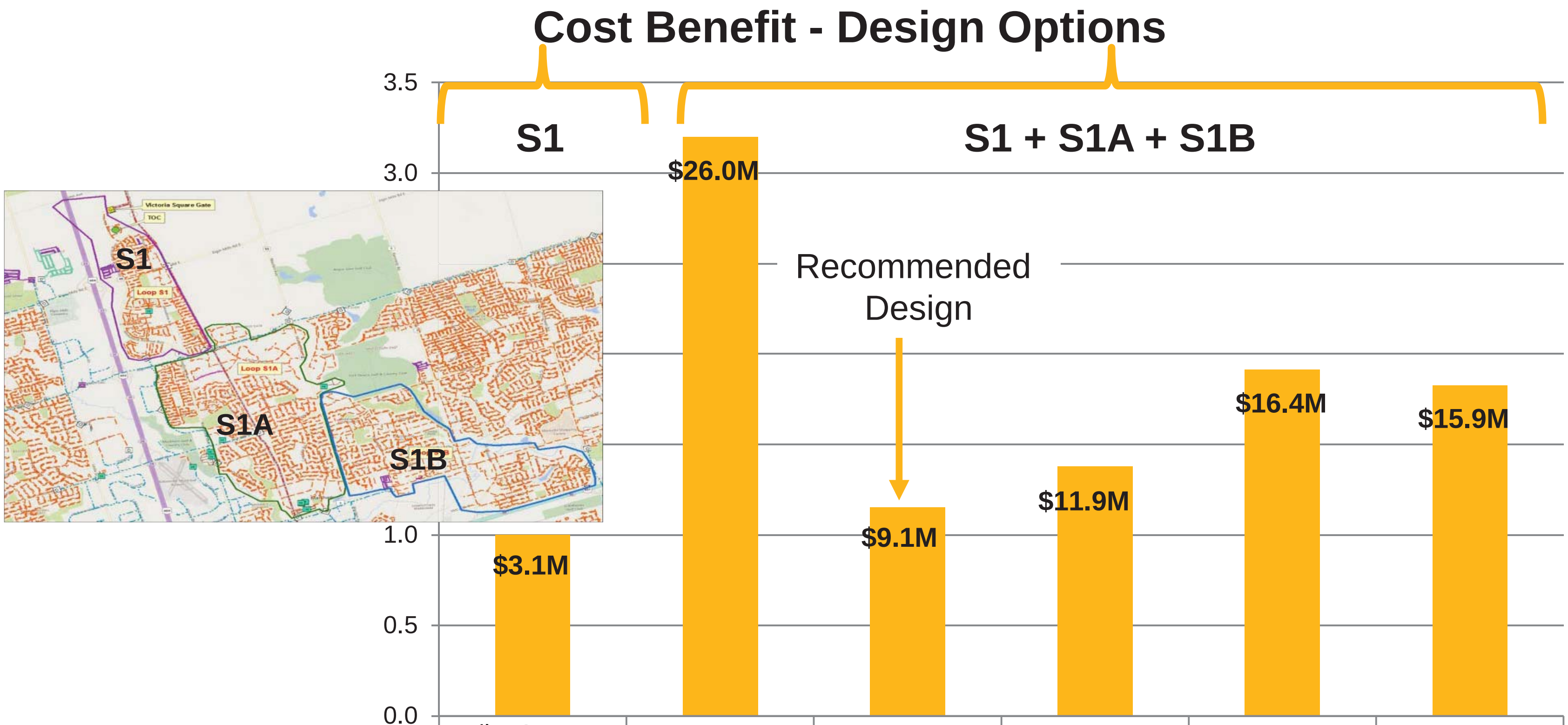
- ▲ Compressor *
- 🟦 District Station
- ▬ Blended pipeline
- ▬ Pure NG pipeline
- ▬ Hydrogen pipeline
- ☐ Injection point

Feed to Vic Square

- As a future phase, post-Engineering Assessment, Engineering will look into potentially blending into the North Feed of Vic Square at low concentrations, while maintaining the closed loop blending active
- This would require a separate pipeline (high concentration of H_2) from TOC to Vic Square
- Conducting such a large scale blending exercise would require additional assessments, which will take place in 2019 and potentially 2020
- Lessons learned from closed loops S1, S1A and S1B will be required for this activity

Cost-Benefit Analysis of Design Options – Class 5 Estimates

Option 3A presents the most value based on selection criteria



	Pilot Stage – Loop S1	1 and 2	3A	3A-2	3B	3B-2
Function of ($ / utilization x reliability)	1.0	3.2	1.2	1.4	1.9	1.8

* Budgetary estimate from BD is $9-10M, including research

Justifications for Design Options

Advantages and disadvantages of each option that were considered in the recommendation

Design Iteration	**Construction & Operations**	**Hydrogen Utilization and System Reliability**
Pilot Stage (S1)		
1 and 2	XHP is not preferred for blended gas at this point. The construction estimate for the HP main is not feasible.	**BASE CASE** - Utilization 22.9% with 100% predicted constant concentrations.
3A	NPS 6 and 8 PE, IP. In line with existing business practices and procedures.	Utilization 1.9% less than option Options 1 and 2 with 84.5% of the predicted time with constant Hydrogen concentrations.
3A-2	NPS 12 pipe and fittings are not approved for general use by EGD and will require a variance from TSSA to install. Potential operational concerns because of limited experience with NPS 12 PE IP.	Utilization 0.2% less than option Options 1 and 2 with 98.0% of the predicted time without constant concentrations.
3B	Potential operational concerns and Permits for the proposed twinned mains because this area already has existing dual mains.	Utilization 0.3% less than option Options 1 and 2 with 96.5% of the predicted time without constant concentrations.
3B-2	NPS 12 pipe and fittings are not approved for general use by EGD and will require a variance from TSSA to install. Potential operational concerns because of limited experience with NPS 12 PE IP.	Utilization marginally less than option Options 1 and 2 with 99.6% of the predicted time without constant concentrations.

Justification for Adding S1A and S1B

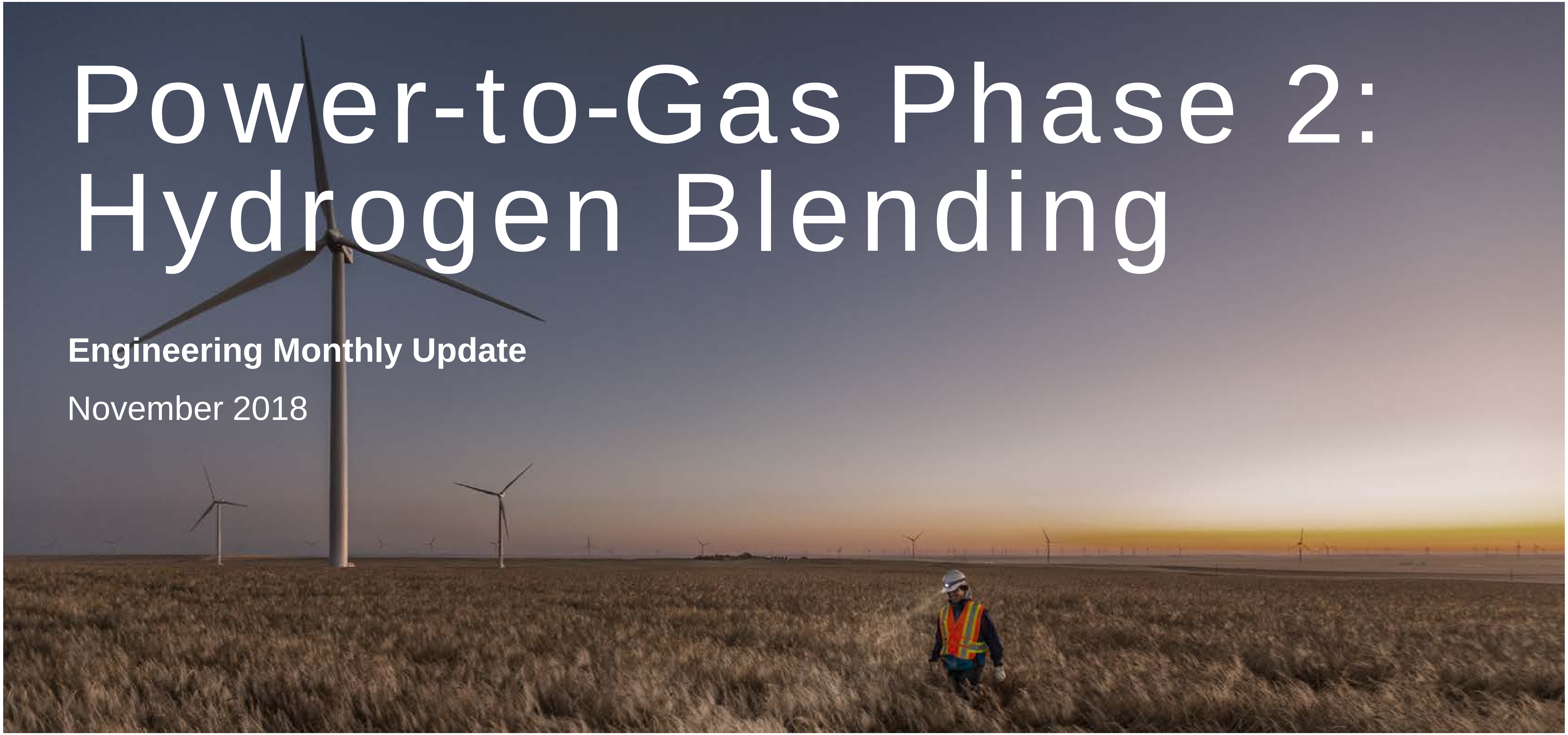
Loop S1 vs S1 + S1A + S1B

Loop	Material Composition	Vintage	Value (Upstream)	Value (End-User)	Value (H_2 Utilization)	Effort Required (Research/Records)
S1A	Mains: 98% Plastic 2% Steel Services: 90% Plastic 10% Steel	Almost all pipes were installed between 1980 and 2012. Some PE pipe was installed pre-1980 (Aldyl-A).	This loops offers an acceptable representation of the EGD network as it contains both new and older pipelines.	This survey will provide some visibility into older appliances, so the impacts of H_2 on their performance can be assessed.	6,700 additional customers, 7% more H_2 utilization	Not all records are available. An accurate bill of material could only be obtained by performing a dedicated records investigation that includes miscellaneous (missy) tickets, as-laids, job cards, and pipe daylight. The most conservative approach would be to compile Engineering approved parts and technical announcements (TAs) for those years.
S1B	Mains: 77% Plastic 23% Steel Services: 91% Plastic 9% Steel	Installation dates range from 1958 to 2012.	This could be defined as a true representation of the EGD network due to the variety of assets contained here including very old steel pipes, Aldyl-A, Amp fittings, copper services. It offers an unique opportunity to test the effects of hydrogen in older systems in the event that the company decides to pursue this venture system-wide in the future.		5,900 additional customers, 8% more H_2 utilization	

Revised R&D Eng. Budget – Oct. 2018- Class 5 Estimate

Project cost estimates comparison as of Sept. 2018 (third forecast iteration)

Stream	**Original Estimate** (May 2017 Project Brief)	**2018 Projection** (April 2018)	**Revised 2018 Projection** (Aug. 2018)	**Revised 2018 Projection** (Sept. 2018)	**Comments Change in 2018 Estimates**
1. HyReady Literature study	$70,000	$70,000	$70,000	$74,184	No change
1b. Knowledge Acquisition	$30,000	$112,000	$94,000	$88,000	Project brief underestimated this cost. Savings found in the revised budget.
2. North American Task Group (CGA/AGA)	$30,000	$9,400	$9,400	$9,400	Project brief cost was overestimated.
3a. EGD Blending Assessment (Closed Loop)	$800,000	$1,075,000	$645,500	$620,500	Cost reduction of $429k from earlier 2018 estimate by limiting scope of work to 3 closed loops in Markham only.
3b. End-user Equipment Assessment (System Wide)	$50,000	$1,001,000	$700,000	$600,000	The end-user equipment stream accounts for most of the risk. It was significantly underestimated in 2017. Savings in 2018 were based on limiting experimental work, field surveys, and customer type in closed loops.
4. 100% Hydrogen Pipeline	$0	$204,000	$204,000	$204,000	Phase was not budgeted in the project brief in early/mid 2017.
5. Hydrogen Blending Station	$0	$172,000	$172,000	$85,000	Phase was not budgeted in the project brief in early/mid 2017.
Risk Assessment	$100,000	$325,000	$231,250	$168,750	Project brief did not account for several types of modelling required for the risk assessment. Reduced cost in 2018 projection by performing a portion of the work in-house.
Total (No Salaries)	$1,080,000	$2,968,400	$2,126,150	$1,849,834	Achieved savings of approx. $1.1M from original April 2018 projection
Team	$900,000	$969,250	$838,375	$838,375	Included salaries for only half of 2019 until the Engineering Assessment is issued in June 2019.
Grand Total	**$1,980,000**	**$3,937,650**	**$2,964,525**	**$2,688,209**	



Power-to-Gas Phase 2: Hydrogen Blending

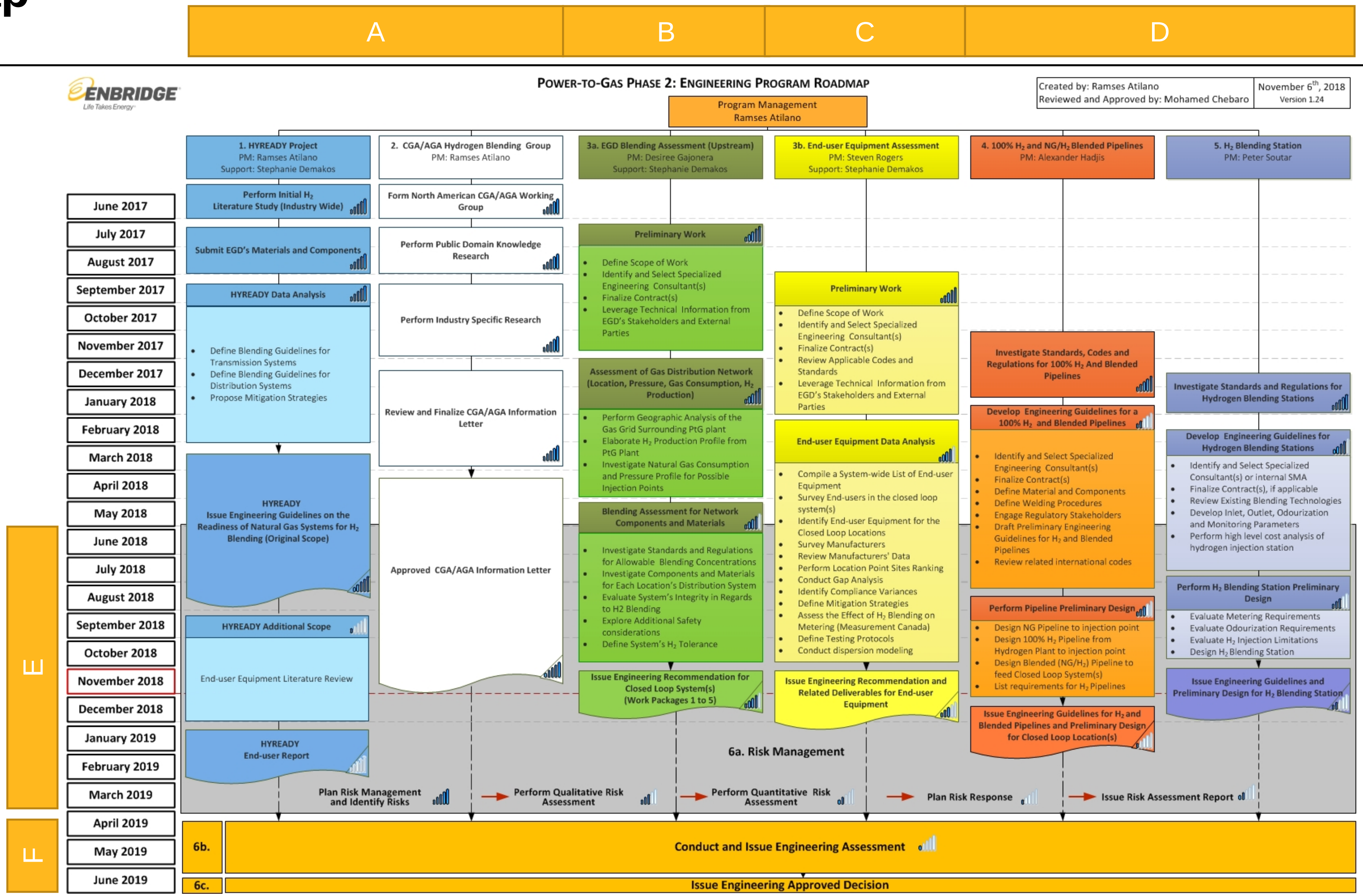
Engineering Monthly Update

November 2018

Mohamed Chebaro and Ramses Atilano
Engineering

Power-to-Gas Phase 2

Roadmap



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POWER-TO-GAS PHASE 2: ENGINEERING PROGRAM ROADMAP

Created by: Ramses Atilano
Reviewed and Approved by: Mohamed Chebaro

November 6th, 2018
Version 1.24

Program Management
Ramses Atilano

June 2017
July 2017
August 2017
September 2017
October 2017
November 2017
December 2017
January 2018
February 2018
March 2018
April 2018
May 2018
June 2018
July 2018
August 2018
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February 2019
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April 2019
May 2019
June 2019

1. HYREADY Project
PM: Ramses Atilano
Support: Stephanie Demakos

Perform Initial H_2 Literature Study (Industry Wide)

Submit EGD's Materials and Components

HYREADY Data Analysis

- Define Blending Guidelines for Transmission Systems
- Define Blending Guidelines for Distribution Systems
- Propose Mitigation Strategies

HYREADY
Issue Engineering Guidelines on the Readiness of Natural Gas Systems for H_2 Blending (Original Scope)

HYREADY Additional Scope

End-user Equipment Literature Review

HYREADY
End-user Report

2. CGA/AGA Hydrogen Blending Group
PM: Ramses Atilano

Form North American CGA/AGA Working Group

Perform Public Domain Knowledge Research

Perform Industry Specific Research

Review and Finalize CGA/AGA Information Letter

Approved CGA/AGA Information Letter

3a. EGD Blending Assessment (Upstream)
PM: Desiree Gajonera
Support: Stephanie Demakos

Preliminary Work

- Define Scope of Work
- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Leverage Technical Information from EGD's Stakeholders and External Parties

Assessment of Gas Distribution Network (Location, Pressure, Gas Consumption, H_2 Production)

- Perform Geographic Analysis of the Gas Grid Surrounding PtG plant
- Elaborate H_2 Production Profile from PtG Plant
- Investigate Natural Gas Consumption and Pressure Profile for Possible Injection Points

Blending Assessment for Network Components and Materials

- Investigate Standards and Regulations for Allowable Blending Concentrations
- Investigate Components and Materials for Each Location's Distribution System
- Evaluate System's Integrity in Regards to H2 Blending
- Explore Additional Safety considerations
- Define System's H_2 Tolerance

Issue Engineering Recommendation for Closed Loop System(s) (Work Packages 1 to 5)

3b. End-user Equipment Assessment
PM: Steven Rogers
Support: Stephanie Demakos

Preliminary Work

- Define Scope of Work
- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Review Applicable Codes and Standards
- Leverage Technical Information from EGD's Stakeholders and External Parties

End-user Equipment Data Analysis

- Compile a System-wide List of End-user Equipment
- Survey End-users in the closed loop system(s)
- Identify End-user Equipment for the Closed Loop Locations
- Survey Manufacturers
- Review Manufacturers' Data
- Perform Location Point Sites Ranking
- Conduct Gap Analysis
- Identify Compliance Variances
- Define Mitigation Strategies
- Assess the Effect of H_2 Blending on Metering (Measurement Canada)
- Define Testing Protocols
- Conduct dispersion modeling

Issue Engineering Recommendation and Related Deliverables for End-user Equipment

4. 100% H_2 and NG/H_2 Blended Pipelines
PM: Alexander Hadjis

Investigate Standards, Codes and Regulations for 100% H_2 And Blended Pipelines

Develop Engineering Guidelines for a 100% H_2 and Blended Pipelines

- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Define Material and Components
- Define Welding Procedures
- Engage Regulatory Stakeholders
- Draft Preliminary Engineering Guidelines for H_2 and Blended Pipelines
- Review related international codes

Perform Pipeline Preliminary Design

- Design NG Pipeline to injection point
- Design 100% H_2 Pipeline from Hydrogen Plant to injection point
- Design Blended (NG/H_2) Pipeline to feed Closed Loop System(s)
- List requirements for H_2 Pipelines

Issue Engineering Guidelines for H_2 and Blended Pipelines and Preliminary Design for Closed Loop Location(s)

5. H_2 Blending Station
PM: Peter Soutar

Investigate Standards and Regulations for Hydrogen Blending Stations

Develop Engineering Guidelines for Hydrogen Blending Stations

- Identify and Select Specialized Consultant(s) or internal SMA
- Finalize Contract(s), if applicable
- Review Existing Blending Technologies
- Develop Inlet, Outlet, Odourization and Monitoring Parameters
- Perform high level cost analysis of hydrogen injection station

Perform H_2 Blending Station Preliminary Design

- Evaluate Metering Requirements
- Evaluate Odourization Requirements
- Evaluate H_2 Injection Limitations
- Design H_2 Blending Station

Issue Engineering Guidelines and Preliminary Design for H_2 Blending Station

6a. Risk Management

Plan Risk Management and Identify Risks → **Perform Qualitative Risk Assessment** → **Perform Quantitative Risk Assessment** → **Plan Risk Response** → **Issue Risk Assessment Report**

6b. **Conduct and Issue Engineering Assessment**

6c. **Issue Engineering Approved Decision**

Power-to-Gas Phase 2

Status Review

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

Program Streams	Scope	Budget*	Timeline
CGA/AGA Task Force Information Letter *(completed)*	🟩	🟩	🟩
HYREADY Engineering Guideline Report *(original scope completed)*	🟩	🟩	🟩
HYREADY Added Scope – End user *(initiated)*	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩

Power-to-Gas Phase 2

Status Review

🟢 On track

🟡 Lagging but not on critical path

🔴 Lagging and on critical path

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Life Takes Energy™

Program Streams	Scope	Budget*	Timeline
Data collection for identified closed loops *(survey #4 in progress)*	🟩	🟩	🟩
Data analysis for identified closed loops *(in progress)*	🟩	🟩	🟩
System-wide assessment for end-user equipment *(in progress)*	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
Risk Assessment Report *(in progress, completed HAZID, QRA initiated)*	🟩	🟩	🟩
Computational Modeling *(final draft completed and under review)*	🟩	🟩	🟩
	🟩	🟩	🟩

Power-to-Gas Phase 2

Upcoming Deliverables

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

Next Month's Deliverables	Scope	Budget	Timeline
Continue building and optimizing the Hydrogen Blending Database	🟩	🟩	🟩
Manage HYREADY's expanded work scope	🟩	🟩	🟩
Finalize analysis for the operating and integrity data for the three Closed Loops (e.g., corrosion, leaks and damages)	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩

Power-to-Gas Phase 2

Upcoming Deliverables

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

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Life Takes Energy™

Next Month’s Deliverables	Scope	Budget	Timeline
D. Engineering Design:			
Continue the design review for the H_2 Blending Station	🟩	🟩	🟩
Secure Contract with Consultant to develop Engineering Guidelines for 100% H_2 and blended gas pipelines	🟩	🟩	🟩
E. Risk Assessment			
Review/accept the final iteration for indoor dispersion modeling (C-FER)	🟩	🟩	🟩
Review/accept the final iteration for outdoor dispersion modeling (DBI)	🟩	🟩	🟩
Closed out all the action items from the HAZID sessions	🟩	🟩	🟩
Progress the Quantitative Risk Assessment based on HAZID outcomes	🟩	🟩	🟩

Power-to-Gas Phase 2

Past Month's Achievements

A. Research and Development

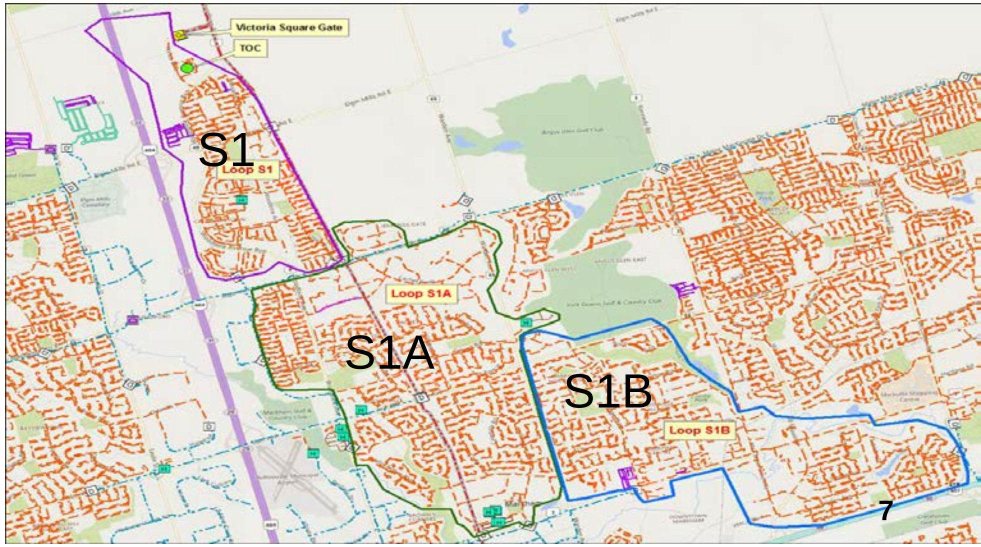
- ✓ Continued building the Hydrogen Knowledge Management Database framework
- ✓ Chaired meetings with CGA/AGA Task Force
- ✓ Received the final version of the information letter approved by both CGA and AGA

B. Integrity, Engineering and Capacity Assessment

- ✓ Completed manufacturers survey for distribution components identified in the three Closed Loops
- ✓ Completed 100% of the H_2 tolerance evaluation for the three selected Closed Loops
- ✓ Procured the required equipment for in-house leak testing on blended H_2 mixtures. Scheduled testing with EMEC and Technical Training

C. End User Equipment Engineering and Integrity System

- ✓ Completed 75% of end-user equipment survey for S1A and S1B
- ✓ Continued with end-user equipment manufacturer survey
- ✓ Continued the commercial customer surveys for Loops S1A/S1B
- ✓ Received final draft report from DNV-GL for end-user emissions
- ✓ Field-validated 18 potential Industrial customers and properly classified them as Commercial
- ✓ Issued final iteration of DBI report on end-user equipment



Power-to-Gas Phase 2

Past Month’s Achievements

D. Engineering Design and Review

- ✓ Finalized design and refined cost estimates for 100% H_2, 100% NG and blended pipelines
- ✓ Continued working on station components design (e.g., Pressure Regulation, H_2 Injection)
- ✓ Performed technical and financial evaluations of six proposals for the development of Engineering Design Guidelines for 100% H_2 and blended pipelines (evaluation is in final stages)

E. Risk Assessment

- ✓ Closed out 15 out of 39 actions items form the HAZID sessions
- ✓ Finalized Qualitative Risk Analysis as part of the Risk Assessment
- ✓ Initiated the Quantitative Risk Assessment (QRA)
- ✓ Received final draft reports for indoor and outdoor dispersion modeling (DBI and C-FER)

F. Engineering Assessment

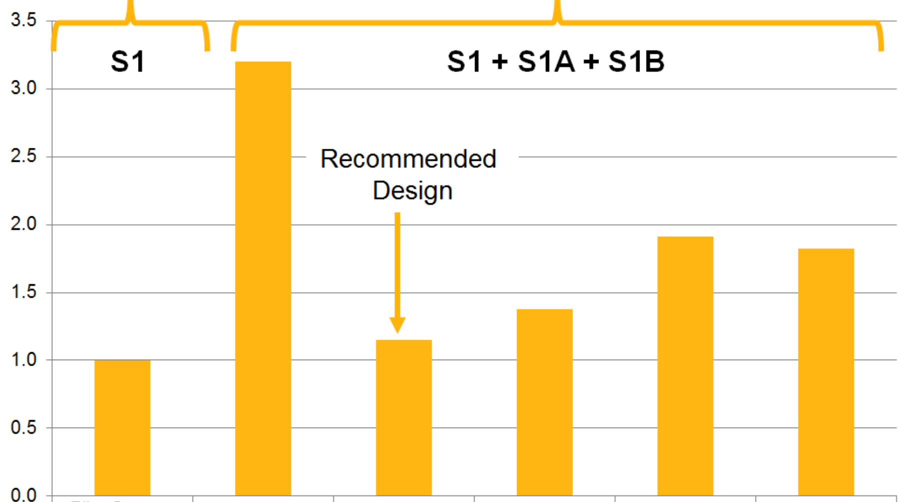
- ✓Conducted strategy sessions among the Growth Team to start shaping the Engineering Assessment
- ✓Met with the TSSA to discuss the topic of Hydrogen Blending, including design approvals, TSSA’s general involvement, research elements, next steps, etc.

Power-to-Gas Phase 2

Evolution of Closed Loop Pipeline Design

- **Q4 2017- Q1 2018:** Examined 8 macro-loops across the GTA for blending considerations
- **Q1 2018:** Selected the Markham macro-loop for further analysis, divided into 3 loops for phased design
- **Q2 2018:** Produced first pipeline blending design iteration for S1, S1A and S1B
- **Q3 2018:** Issued design refinements to reduce costs, system pressure and system modifications (completed fourth iteration in Sept. 2018 for S1, S1A and S1B)

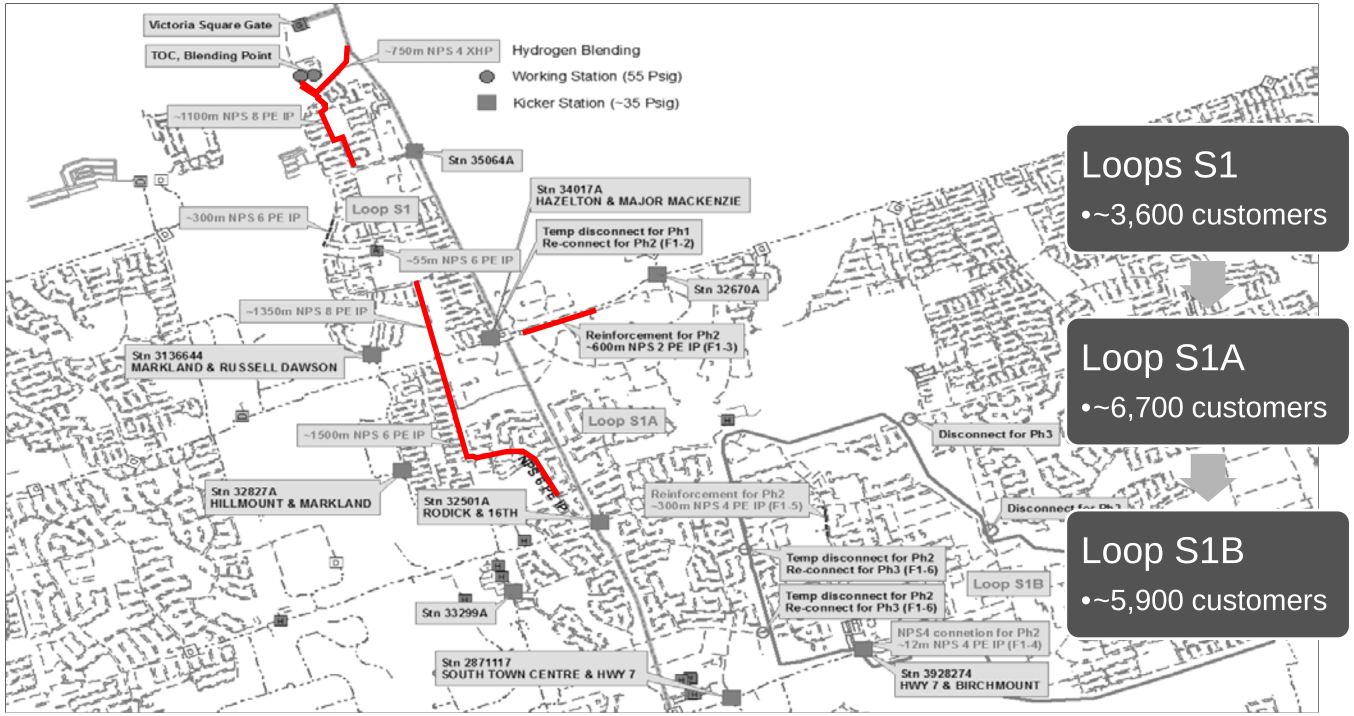
Cost Benefit - Design Options



	Pilot Stage – Loop S1	1 and 2	3A	3A-2	3B	3B-2
Function of ($ / utilization x reliability)	1.0	3.2	1.2	1.4	1.9	1.8

Option 3A

Proposed NPS 8 and 6 PE IP for blended gas
Proposed NPS 6 XHP ST for natural gas



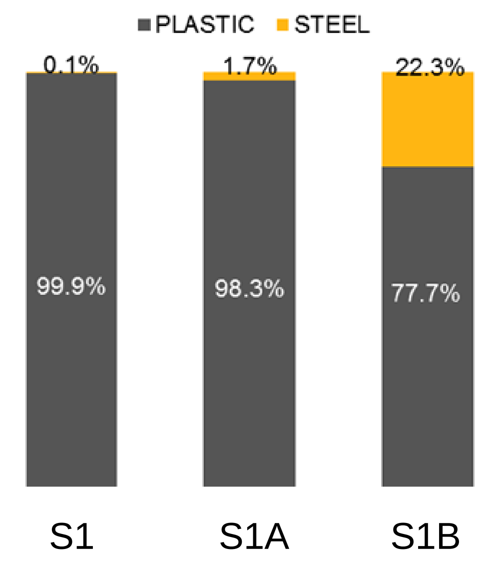
Loops S1
- ~3,600 customers

Loop S1A
- ~6,700 customers

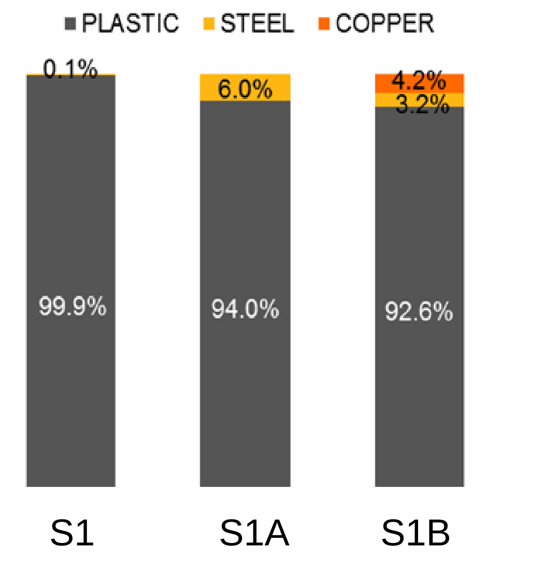
Loop S1B
- ~5,900 customers

Power-to-Gas Phase 2

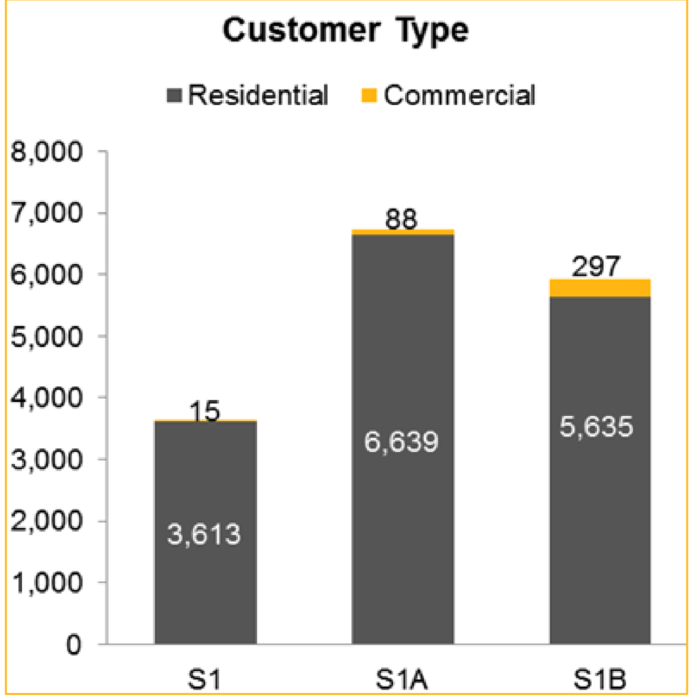
Closed Loop Materials and End-user Survey

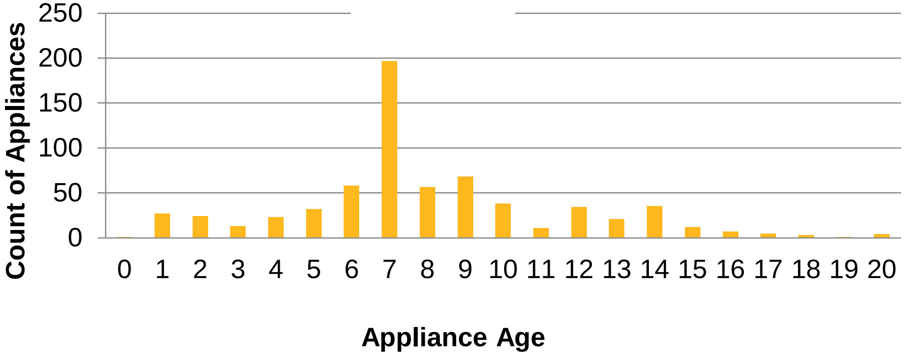


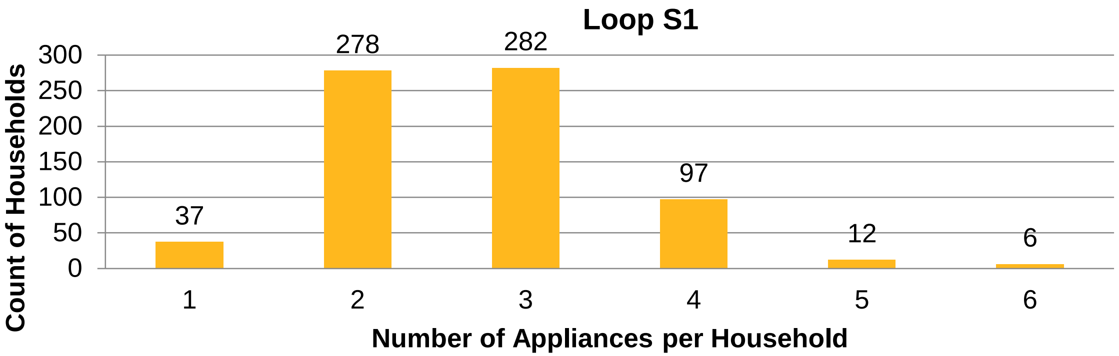
Length of Mains by Material

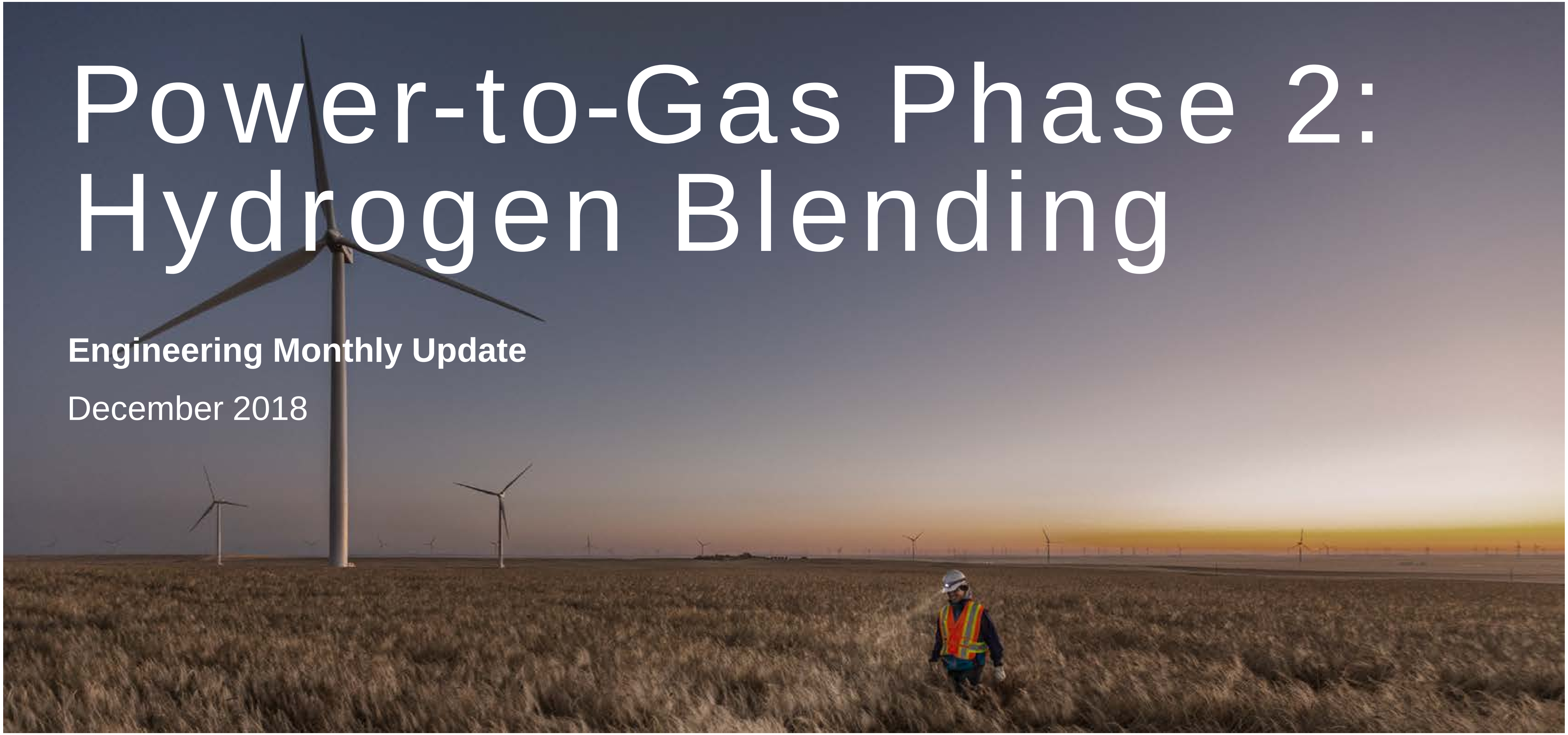


Number of Services by Material









Power-to-Gas Phase 2: Hydrogen Blending

Engineering Monthly Update

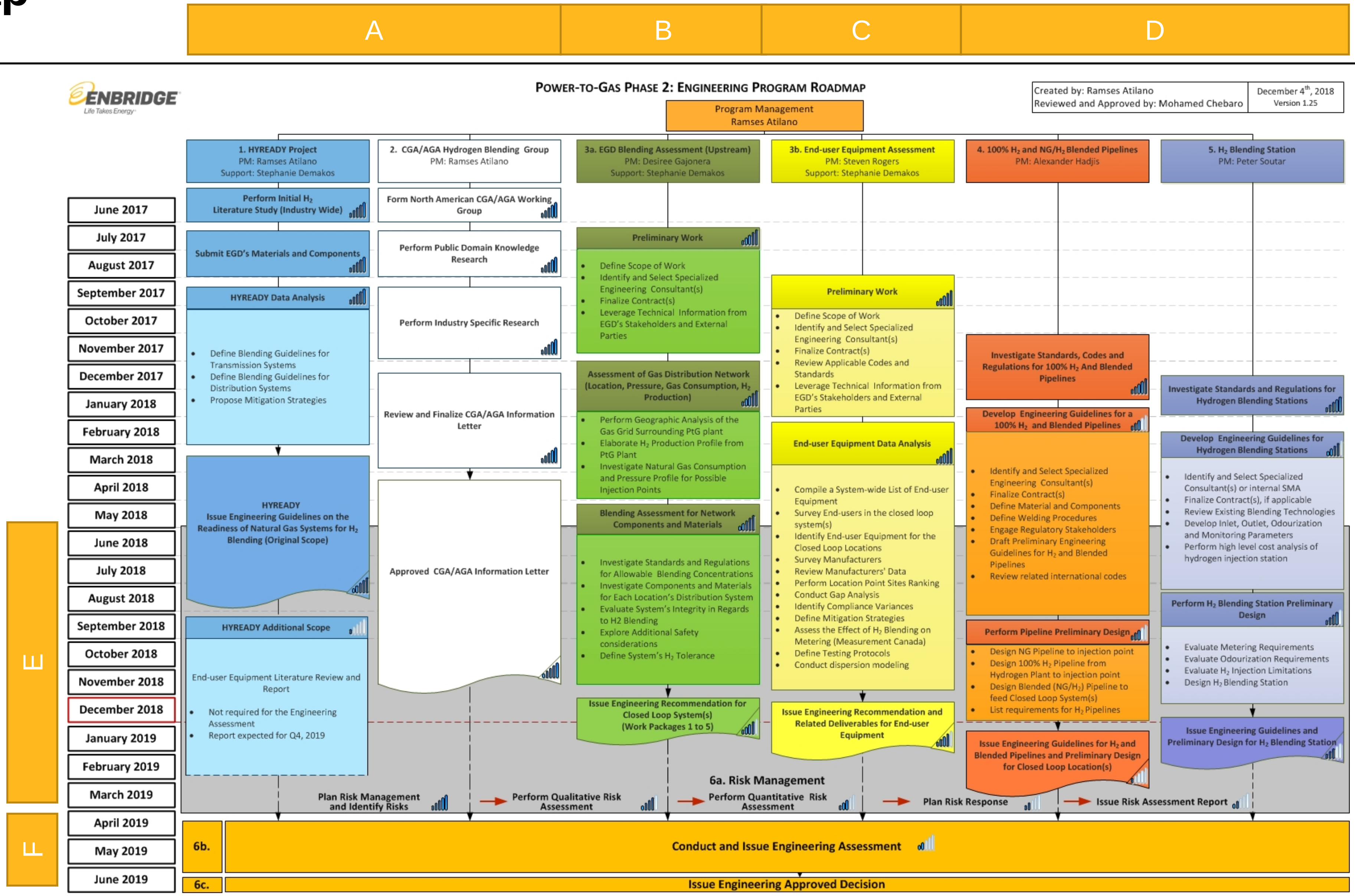
December 2018

ENBRIDGE®

Mohamed Chebaro, Ramses Atilano and Steven Rogers
Engineering

Power-to-Gas Phase 2

Roadmap



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POWER-TO-GAS PHASE 2: ENGINEERING PROGRAM ROADMAP

Created by: Ramses Atilano
Reviewed and Approved by: Mohamed Chebaro

December 4th, 2018
Version 1.25

Program Management
Ramses Atilano

June 2017
July 2017
August 2017
September 2017
October 2017
November 2017
December 2017
January 2018
February 2018
March 2018
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April 2019
May 2019
June 2019

1. HYREADY Project
PM: Ramses Atilano
Support: Stephanie Demakos

Perform Initial H_2 Literature Study (Industry Wide)

Submit EGD's Materials and Components

HYREADY Data Analysis

- Define Blending Guidelines for Transmission Systems
- Define Blending Guidelines for Distribution Systems
- Propose Mitigation Strategies

HYREADY
Issue Engineering Guidelines on the Readiness of Natural Gas Systems for H_2 Blending (Original Scope)

HYREADY Additional Scope

End-user Equipment Literature Review and Report

- Not required for the Engineering Assessment
- Report expected for Q4, 2019

2. CGA/AGA Hydrogen Blending Group
PM: Ramses Atilano

Form North American CGA/AGA Working Group

Perform Public Domain Knowledge Research

Perform Industry Specific Research

Review and Finalize CGA/AGA Information Letter

Approved CGA/AGA Information Letter

3a. EGD Blending Assessment (Upstream)
PM: Desiree Gajonera
Support: Stephanie Demakos

Preliminary Work

- Define Scope of Work
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- Finalize Contract(s)
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Assessment of Gas Distribution Network (Location, Pressure, Gas Consumption, H_2 Production)

- Perform Geographic Analysis of the Gas Grid Surrounding PtG plant
- Elaborate H_2 Production Profile from PtG Plant
- Investigate Natural Gas Consumption and Pressure Profile for Possible Injection Points

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- Investigate Components and Materials for Each Location's Distribution System
- Evaluate System's Integrity in Regards to H2 Blending
- Explore Additional Safety considerations
- Define System's H_2 Tolerance

Issue Engineering Recommendation for Closed Loop System(s) (Work Packages 1 to 5)

3b. End-user Equipment Assessment
PM: Steven Rogers
Support: Stephanie Demakos

Preliminary Work

- Define Scope of Work
- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Review Applicable Codes and Standards
- Leverage Technical Information from EGD's Stakeholders and External Parties

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- Define Mitigation Strategies
- Assess the Effect of H_2 Blending on Metering (Measurement Canada)
- Define Testing Protocols
- Conduct dispersion modeling

Issue Engineering Recommendation and Related Deliverables for End-user Equipment

4. 100% H_2 and NG/H_2 Blended Pipelines
PM: Alexander Hadjis

Investigate Standards, Codes and Regulations for 100% H_2 And Blended Pipelines

Develop Engineering Guidelines for a 100% H_2 and Blended Pipelines

- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Define Material and Components
- Define Welding Procedures
- Engage Regulatory Stakeholders
- Draft Preliminary Engineering Guidelines for H_2 and Blended Pipelines
- Review related international codes

Perform Pipeline Preliminary Design

- Design NG Pipeline to injection point
- Design 100% H_2 Pipeline from Hydrogen Plant to injection point
- Design Blended (NG/H_2) Pipeline to feed Closed Loop System(s)
- List requirements for H_2 Pipelines

Issue Engineering Guidelines for H_2 and Blended Pipelines and Preliminary Design for Closed Loop Location(s)

5. H_2 Blending Station
PM: Peter Soutar

Investigate Standards and Regulations for Hydrogen Blending Stations

Develop Engineering Guidelines for Hydrogen Blending Stations

- Identify and Select Specialized Consultant(s) or internal SMA
- Finalize Contract(s), if applicable
- Review Existing Blending Technologies
- Develop Inlet, Outlet, Odourization and Monitoring Parameters
- Perform high level cost analysis of hydrogen injection station

Perform H_2 Blending Station Preliminary Design

- Evaluate Metering Requirements
- Evaluate Odourization Requirements
- Evaluate H_2 Injection Limitations
- Design H_2 Blending Station

Issue Engineering Guidelines and Preliminary Design for H_2 Blending Station

6a. Risk Management

Plan Risk Management and Identify Risks → **Perform Qualitative Risk Assessment** → **Perform Quantitative Risk Assessment** → **Plan Risk Response** → **Issue Risk Assessment Report**

6b. **Conduct and Issue Engineering Assessment**

6c. **Issue Engineering Approved Decision**

Power-to-Gas Phase 2

Status Review

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

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Program Streams	Scope	Budget*	Timeline
CGA/AGA Task Force Information Letter *(completed)*	🟩	🟩	🟩
HYREADY Engineering Guideline Report *(original scope completed)*	🟩	🟩	🟩
HYREADY Added Scope – End user *(initiated)*	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩

Power-to-Gas Phase 2

Status Review

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

ENBRIDGE
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Program Streams	Scope	Budget*	Timeline
Data collection for identified closed loops *(survey #4 in final stages)*	🟩	🟩	🟩
Data analysis for identified closed loops *(in final stages)*	🟩	🟩	🟩
System-wide assessment for end-user equipment *(completed)*	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
Risk Assessment Report *(in progress, completed HAZID, QRA in progress)*	🟩	🟩	🟩
Computational Modeling *(completed)*	🟩	🟩	🟩
	🟩	🟩	🟩

Power-to-Gas Phase 2

Upcoming Deliverables

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

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Next Month's Deliverables	Scope	Budget	Timeline
A. Research and Development:			
Continue building and optimizing the Hydrogen Blending Database	🟩	🟩	🟩
Manage HYREADY's expanded work scope	🟩	🟩	🟩
B. Integrity, Engineering and Capacity Assessment			
Continue to compile and address action items from the H_2 tolerance evaluation for the three Closed Loops	🟩	🟩	🟩
C. End User Equipment Engineering and Integrity System			
Analyze surveys for commercial customers for Loops S1A/S1B	🟩	🟩	🟩
Finalize report on leak detection and appliance testing for H_2 mixtures	🟩	🟩	🟩

Power-to-Gas Phase 2

Upcoming Deliverables

- 🟢 On track
- 🟡 Lagging but not on critical path
- 🔴 Lagging and on critical path

Next Month’s Deliverables	Scope	Budget	Timeline
D. Engineering Design:			
Continue the design refinement for the H_2 Blending Station	🟩	🟩	🟩
Initiate work with Worley Parsons to develop Engineering Design Guidelines for 100% H_2 and blended pipelines	🟩	🟩	🟩
E. Risk Assessment			
Finalize the Quantitative Risk Assessment based on HAZID outcomes	🟩	🟩	🟩
Issue first Draft of the Risk Assessment Report fro internal review	🟩	🟩	🟩
F. Engineering Assessment			
Progress the first draft of the Engineering Assessment	🟩	🟩	🟩

Power-to-Gas Phase 2

Past Month’s Achievements

A. Research and Development

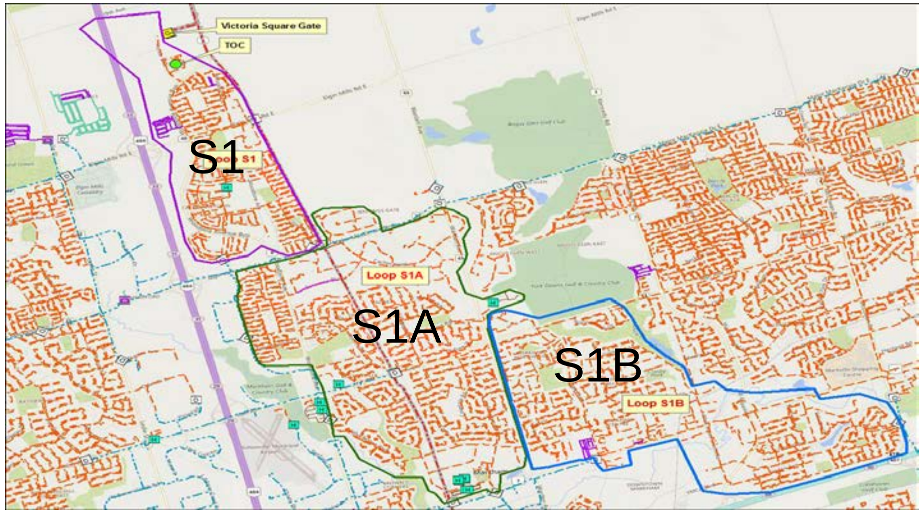
- ✓ Chaired meetings with CGA/AGA Task Force
- ✓ Attended the official kick-off meeting with HYREADY Steering committee for the expanded work scope (Wiki Platform for Gas Transmission and Distribution Guidelines and End-user Equipment Study)

B. Integrity, Engineering and Capacity Assessment

- ✓ Completed and documented in-house leak testing at EMEC on blended H_2 mixtures, using EGD’s gas composition
- ✓ Finalized analysis for the operating and integrity data for the three Closed Loops (e.g., corrosion, leaks and damages)

C. End User Equipment Engineering and Integrity System

- ✓ Completed 100% of end-user equipment survey for S1A and S1B
- ✓ Completed end-user equipment manufacturer survey
- ✓ Completed 51 commercial surveys in Loops S1A/S1B
- ✓ Completed and documented in-house appliance testing on blended H_2 mixtures.



Power-to-Gas Phase 2

Past Month's Achievements

D. Engineering Design and Review

- ✓ Continued working on station component design (e.g., Pressure Regulation, H_2 Injection)
- ✓ Selected Worley Parsons for the development of the Engineering Design Guidelines for 100% H_2 and blended pipelines (contract is now fully executed)

E. Risk Assessment

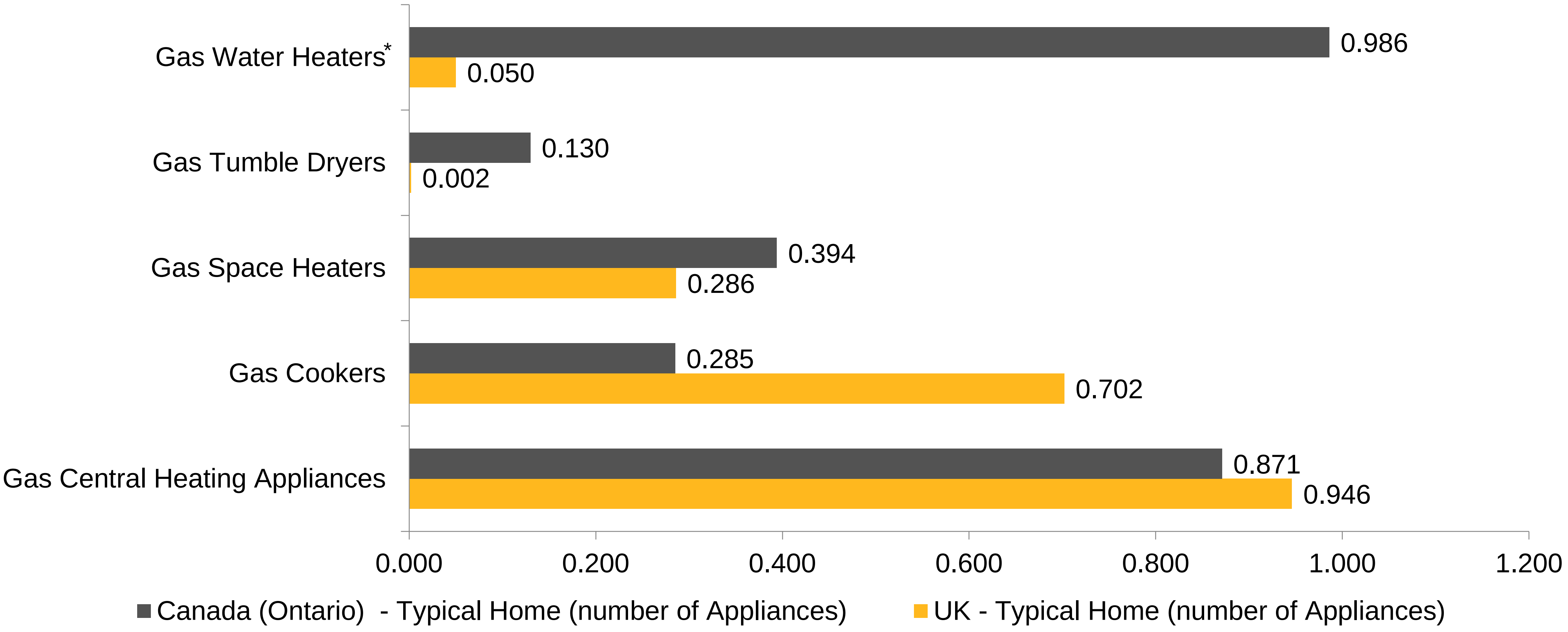
- ✓ Closed out all actions items from the HAZID sessions
- ✓ Finalized Consequence Modeling as part of the Risk Assessment
- ✓ Progressed the Quantitative Risk Assessment
- ✓ Reviewed and accepted the final deliverable for indoor dispersion modeling (C-FER)
- ✓ Reviewed and accepted the final deliverable for outdoor dispersion modeling (DBI)
- ✓ Received and reviewed the final draft deliverable for End user equipment risk (DNV-GL)

F. Engineering Assessment

- ✓ Conducted strategy sessions among the Growth Team to start shaping the Engineering Assessment
- ✓ Continued working on the Engineering Assessment Report (50% complete)

Power-to-Gas Phase 2 – Preliminary Results

Average Number of NG Appliances per Household (the UK and Ontario)
Source: DNV-GL

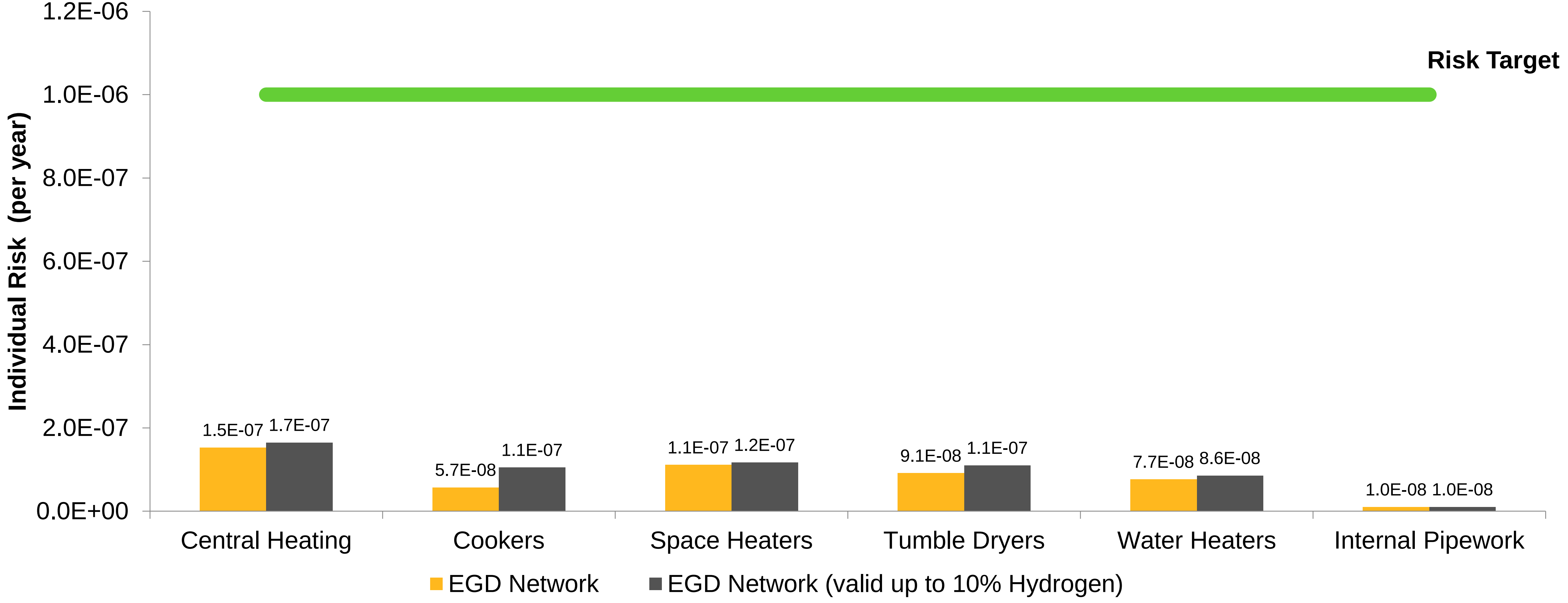


	Canada (Ontario) - Typical Home (number of Appliances)	UK - Typical Home (number of Appliances)
Gas Water Heaters*	0.986	0.050
Gas Tumble Dryers	0.130	0.002
Gas Space Heaters	0.394	0.286
Gas Cookers	0.285	0.702
Gas Central Heating Appliances	0.871	0.946

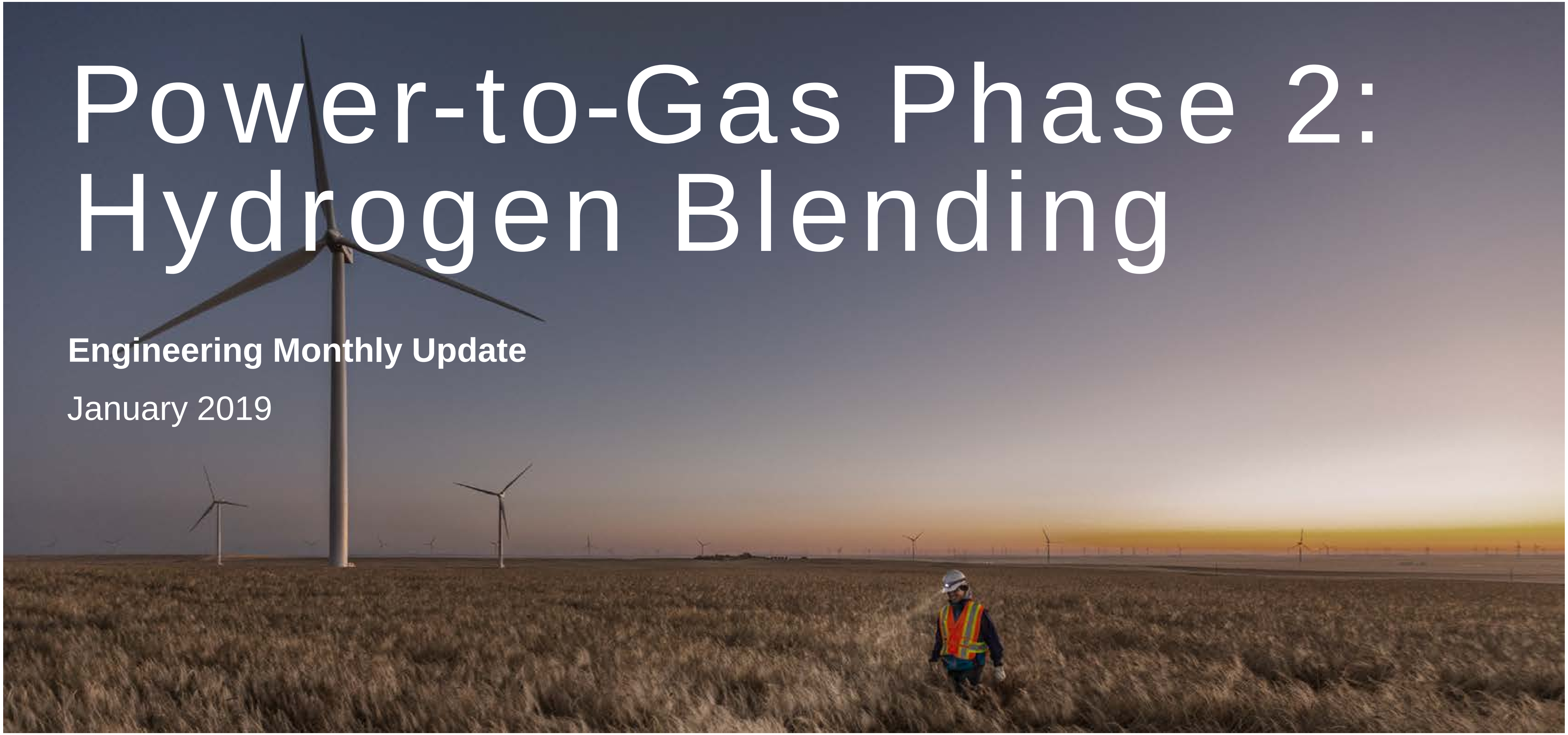
* Most central heating in the UK is combo gas/water heaters

Power-to-Gas Phase 2 – Preliminary Results

Quantitative Risk Assessment – Individual Risk for Customers (per year) by Appliance Type
Source: DNV-GL



Note: The figure above compares the individual risk for customers by appliance type only. Pipeline risk is considered separately and will feed into the overall individual risk. The risk tolerance value is per document “Risk Tolerance For EMT 2017 Q1”.



Power-to-Gas Phase 2: Hydrogen Blending

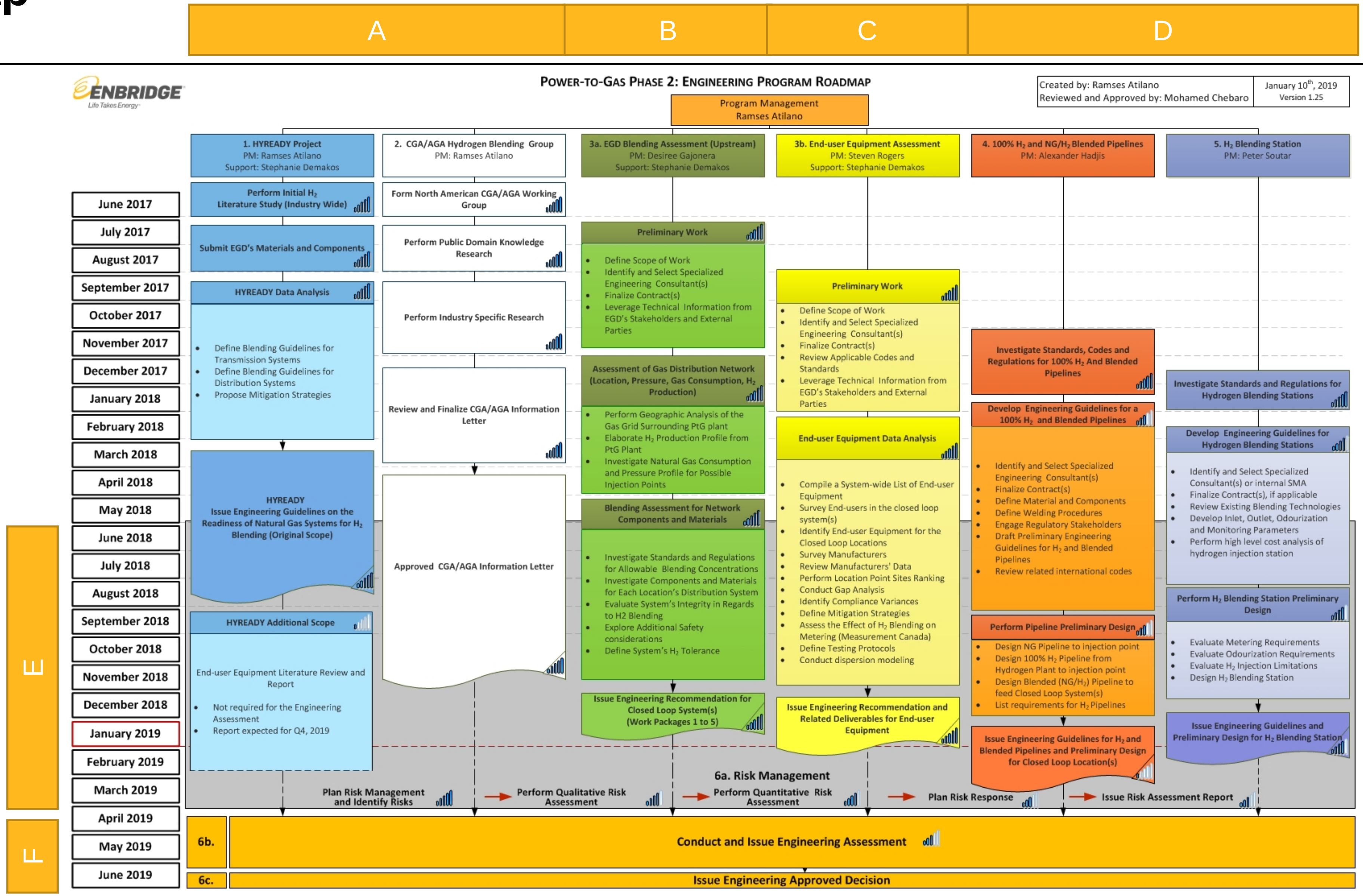
Engineering Monthly Update

January 2019

Mohamed Chebaro and Ramses Atilano
Engineering

Power-to-Gas Phase 2

Roadmap



A

B

C

D

E

F

POWER-TO-GAS PHASE 2: ENGINEERING PROGRAM ROADMAP

Created by: Ramses Atilano
Reviewed and Approved by: Mohamed Chebaro

January 10th, 2019
Version 1.25

Program Management
Ramses Atilano

June 2017
July 2017
August 2017
September 2017
October 2017
November 2017
December 2017
January 2018
February 2018
March 2018
April 2018
May 2018
June 2018
July 2018
August 2018
September 2018
October 2018
November 2018
December 2018
January 2019
February 2019
March 2019
April 2019
May 2019
June 2019

1. HYREADY Project
PM: Ramses Atilano
Support: Stephanie Demakos

Perform Initial H_2 Literature Study (Industry Wide)

Submit EGD's Materials and Components

HYREADY Data Analysis

- Define Blending Guidelines for Transmission Systems
- Define Blending Guidelines for Distribution Systems
- Propose Mitigation Strategies

HYREADY
Issue Engineering Guidelines on the Readiness of Natural Gas Systems for H_2 Blending (Original Scope)

HYREADY Additional Scope

End-user Equipment Literature Review and Report

- Not required for the Engineering Assessment
- Report expected for Q4, 2019

2. CGA/AGA Hydrogen Blending Group
PM: Ramses Atilano

Form North American CGA/AGA Working Group

Perform Public Domain Knowledge Research

Perform Industry Specific Research

Review and Finalize CGA/AGA Information Letter

Approved CGA/AGA Information Letter

3a. EGD Blending Assessment (Upstream)
PM: Desiree Gajonera
Support: Stephanie Demakos

Preliminary Work

- Define Scope of Work
- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Leverage Technical Information from EGD's Stakeholders and External Parties

Assessment of Gas Distribution Network (Location, Pressure, Gas Consumption, H_2 Production)

- Perform Geographic Analysis of the Gas Grid Surrounding PtG plant
- Elaborate H_2 Production Profile from PtG Plant
- Investigate Natural Gas Consumption and Pressure Profile for Possible Injection Points

Blending Assessment for Network Components and Materials

- Investigate Standards and Regulations for Allowable Blending Concentrations
- Investigate Components and Materials for Each Location's Distribution System
- Evaluate System's Integrity in Regards to H2 Blending
- Explore Additional Safety considerations
- Define System's H_2 Tolerance

Issue Engineering Recommendation for Closed Loop System(s) (Work Packages 1 to 5)

3b. End-user Equipment Assessment
PM: Steven Rogers
Support: Stephanie Demakos

Preliminary Work

- Define Scope of Work
- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Review Applicable Codes and Standards
- Leverage Technical Information from EGD's Stakeholders and External Parties

End-user Equipment Data Analysis

- Compile a System-wide List of End-user Equipment
- Survey End-users in the closed loop system(s)
- Identify End-user Equipment for the Closed Loop Locations
- Survey Manufacturers
- Review Manufacturers' Data
- Perform Location Point Sites Ranking
- Conduct Gap Analysis
- Identify Compliance Variances
- Define Mitigation Strategies
- Assess the Effect of H_2 Blending on Metering (Measurement Canada)
- Define Testing Protocols
- Conduct dispersion modeling

Issue Engineering Recommendation and Related Deliverables for End-user Equipment

4. 100% H_2 and NG/H_2 Blended Pipelines
PM: Alexander Hadjis

Investigate Standards, Codes and Regulations for 100% H_2 And Blended Pipelines

Develop Engineering Guidelines for a 100% H_2 and Blended Pipelines

- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Define Material and Components
- Define Welding Procedures
- Engage Regulatory Stakeholders
- Draft Preliminary Engineering Guidelines for H_2 and Blended Pipelines
- Review related international codes

Perform Pipeline Preliminary Design

- Design NG Pipeline to injection point
- Design 100% H_2 Pipeline from Hydrogen Plant to injection point
- Design Blended (NG/H_2) Pipeline to feed Closed Loop System(s)
- List requirements for H_2 Pipelines

Issue Engineering Guidelines for H_2 and Blended Pipelines and Preliminary Design for Closed Loop Location(s)

5. H_2 Blending Station
PM: Peter Soutar

Investigate Standards and Regulations for Hydrogen Blending Stations

Develop Engineering Guidelines for Hydrogen Blending Stations

- Identify and Select Specialized Consultant(s) or internal SMA
- Finalize Contract(s), if applicable
- Review Existing Blending Technologies
- Develop Inlet, Outlet, Odourization and Monitoring Parameters
- Perform high level cost analysis of hydrogen injection station

Perform H_2 Blending Station Preliminary Design

- Evaluate Metering Requirements
- Evaluate Odourization Requirements
- Evaluate H_2 Injection Limitations
- Design H_2 Blending Station

Issue Engineering Guidelines and Preliminary Design for H_2 Blending Station

6a. Risk Management

Plan Risk Management and Identify Risks → **Perform Qualitative Risk Assessment** → **Perform Quantitative Risk Assessment** → **Plan Risk Response** → **Issue Risk Assessment Report**

6b. **Conduct and Issue Engineering Assessment**

6c. **Issue Engineering Approved Decision**

Power-to-Gas Phase 2

Status Review

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

Program Streams	Scope	Budget	Timeline
CGA/AGA Task Force Information Letter *(completed)*	🟩	🟩	🟩
HYREADY Engineering Guideline Report *(original scope completed)*	🟩	🟩	🟩
HYREADY Added Scope – End user *(in progress)*	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩

Power-to-Gas Phase 2

Status Review

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

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Program Streams	Scope	Budget	Timeline
Data collection for identified closed loops *(completed)*	🟩	🟩	🟩
Data analysis for identified closed loops *(completed)*	🟩	🟩	🟩
System-wide assessment for end-user equipment *(completed)*	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
Risk Assessment Report *(in progress, 50% of Report completed)*	🟩	🟩	🟩
Computational Modeling *(completed)*	🟩	🟩	🟩
	🟩	🟩	🟩

Power-to-Gas Phase 2

Upcoming Deliverables

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

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Next Month's Deliverables	Scope	Budget	Timeline
A. Research and Development:			
Continue building and optimizing the Hydrogen Blending Database	🟩	🟩	🟩
Manage HYREADY's expanded work scope	🟩	🟩	🟩
B. Integrity, Engineering and Capacity Assessment			
Continue to compile and address action items from the H_2 tolerance evaluation for the three Closed Loops (e.g., Measurement, Regulation, Materials, Leak Detection, Integrity)	🟩	🟩	🟩
C. End User Equipment Engineering and Integrity System			
Continue to address action items related to End user equipment for the Engineering Assessment	🟩	🟩	🟩

Power-to-Gas Phase 2

Upcoming Deliverables

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

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Next Month’s Deliverables	Scope	Budget	Timeline
D. Engineering Design:			
Progress design refinements for the H_2 Blending Station, per DBM	🟩	🟩	🟩
Receive first draft of the Engineering Guidelines from Worley Parsons that assess impact on Legacy EGD related Engineering Manuals	🟩	🟩	🟩
Continue progressing the design of the blended pipeline (e.g., System Improvement, Drafting, Engineering, Permitting)	🟩	🟩	🟩
E. Risk Assessment			
Issue the first Draft of the Risk Assessment Report for internal review	🟩	🟩	🟩
F. Engineering Assessment			
Progress the first draft of the Engineering Assessment to 60% completion	🟩	🟩	🟩

Power-to-Gas Phase 2

Past Month’s Achievements

A. Research and Development

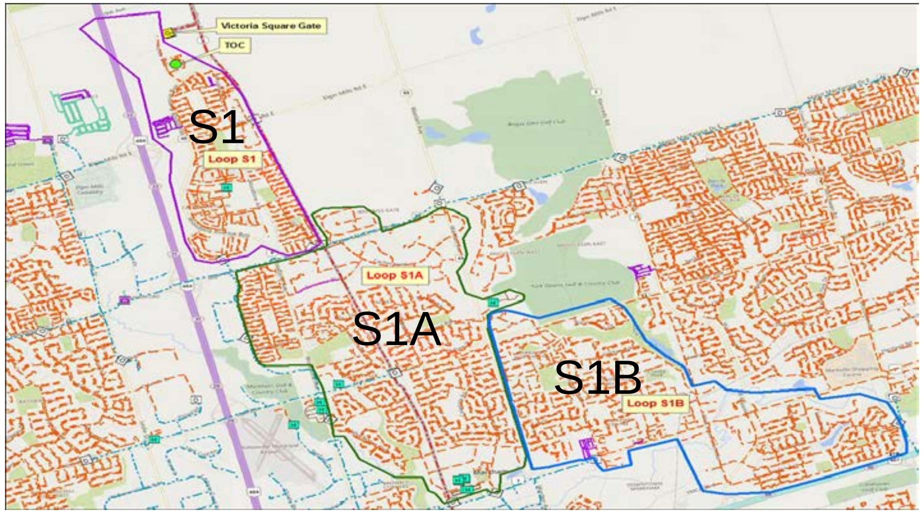
- ✓ Chaired meetings with CGA/AGA Task Force
- ✓ Continued managing HYREADY’s expanded work scope (Wiki Platform for Gas Transmission and Distribution Guidelines and End-user Equipment Study)

B. Integrity, Engineering and Capacity Assessment

- ✓ Continued to address action items from the H_2 tolerance evaluation for the three Closed Loops. This included meetings with internal and external stakeholders related to leak detection implications, measurement, regulation and integrity,

C. End User Equipment Engineering and Integrity System

- ✓ Received first draft of EMEC’s report on leak detection equipment in-house testing, initiated reviews by Engineering
- ✓ Received first draft of statistical analysis for surveys
- ✓ Completed 100% of commercial surveys in Loops S1A/S1B



Power-to-Gas Phase 2

Past Month's Achievements

D. Engineering Design and Review

- ✓ Continued working on station component design (e.g., Pressure Regulation, H_2 Injection)
- ✓ Initiated work with Worley Parsons for the development of the Engineering Design Guidelines for 100% H_2 and blended pipelines
- ✓ Hosted sessions (codes, standards and regulations) with multiple SMEs from Worley Parsons and EGI
- ✓ Received a general outline of the recommended changes to EGI's Engineering Manuals related to Hydrogen Blending and 100% Hydrogen pipelines

E. Risk Assessment

- ✓ Progressed the Quantitative Risk Assessment to 50% completion
- ✓ Received final deliverable for End user equipment risk from DNV-GL
- ✓ Continued working on the Risk Assessment Report in preparation of issuing it in January 2019

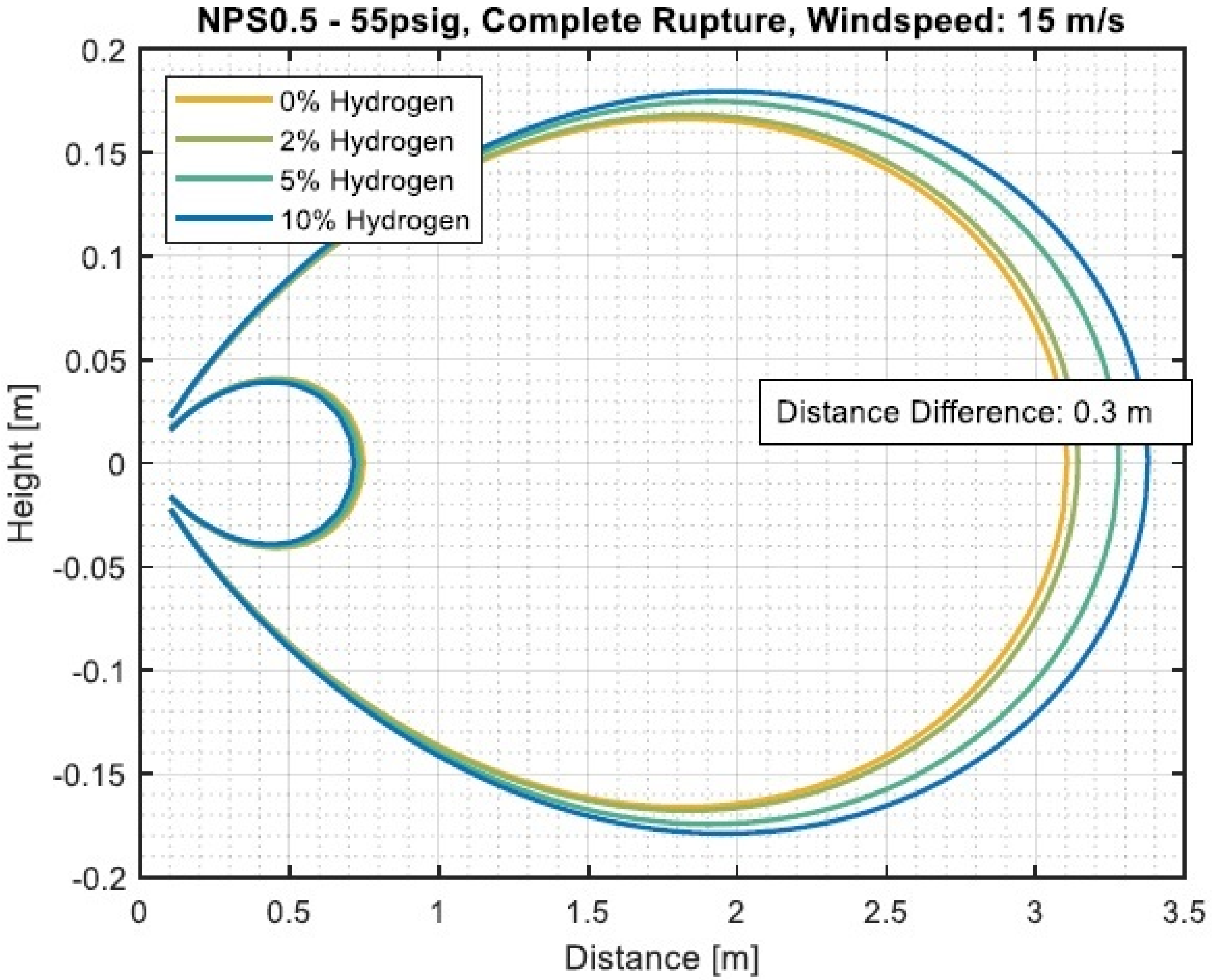
F. Engineering Assessment

- ✓ Held strategy sessions within the Engineering Growth Team to design the Engineering Assessment content
- ✓ Completed 40% of Engineering Assessment

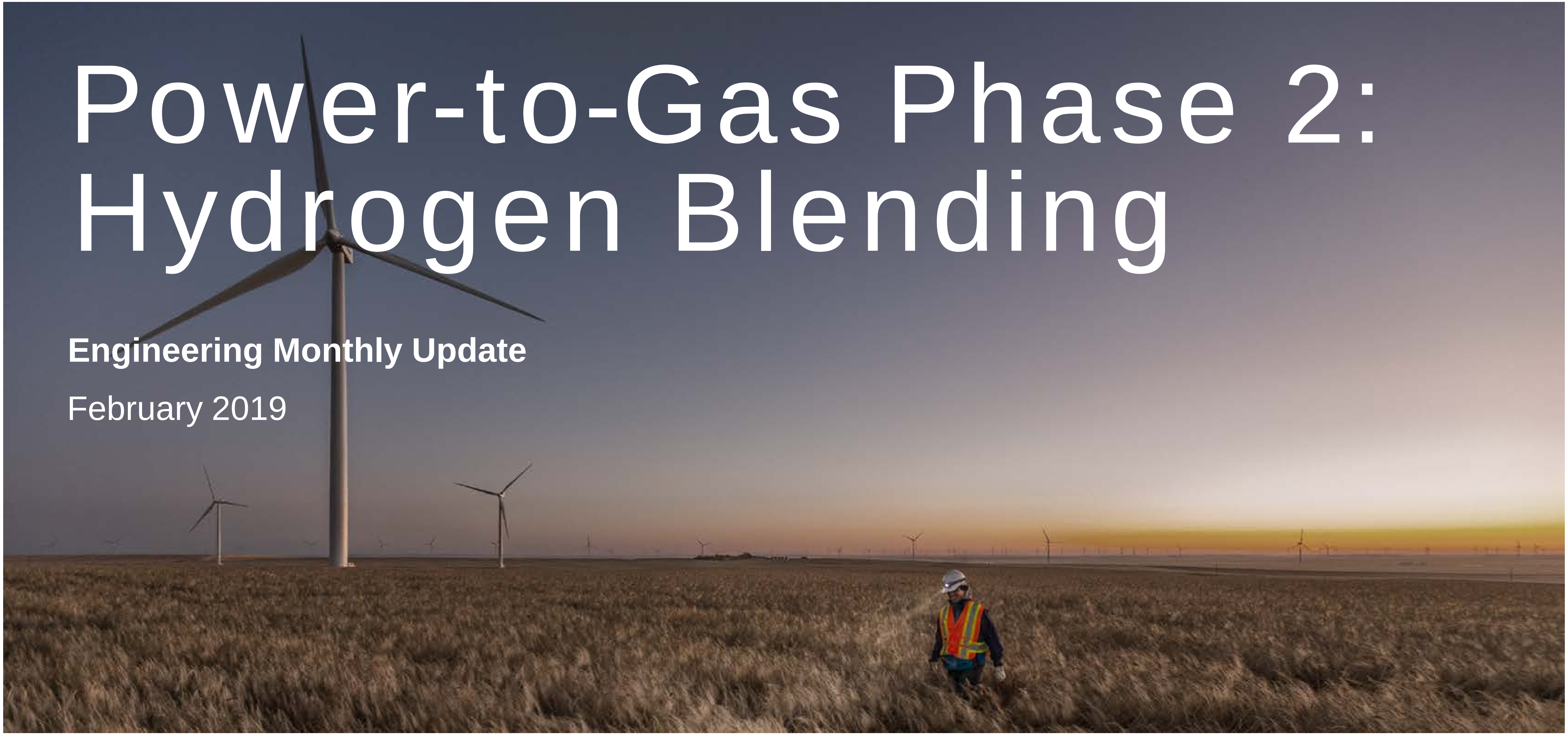
Power-to-Gas Phase 2 – Preliminary Results

Graphical Representation of Outdoor LEL Development with the Addition of H_2

Source: DBI-GUT



Note: For a complete rupture of an IP (55 psig) NPS 0.5 line with 54 km/h wind, the LEL downstream distance would increase by ~1.3% at 2.0% H_2 concentration when compared to a baseline of 100% natural gas.



Power-to-Gas Phase 2: Hydrogen Blending

Engineering Monthly Update

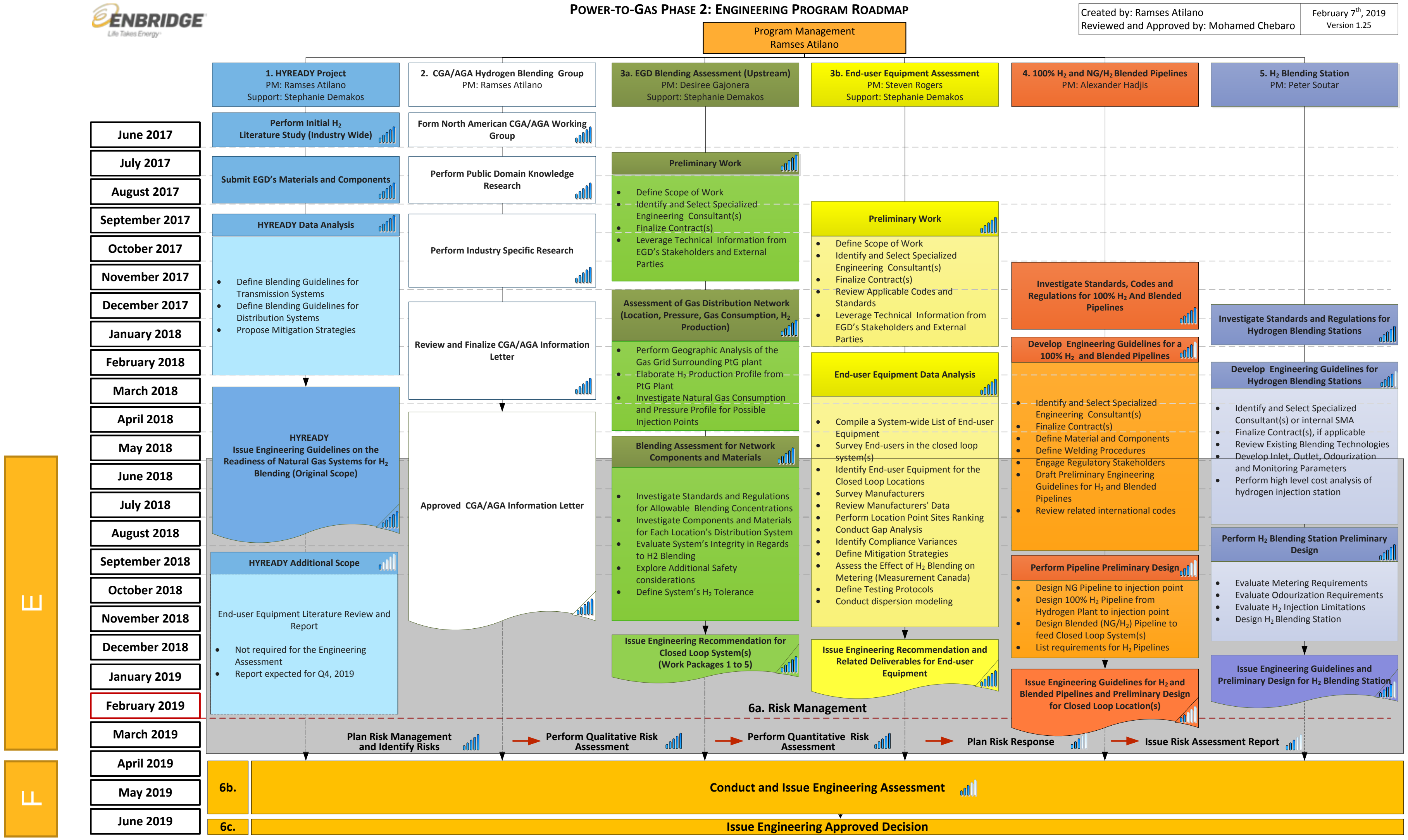
February 2019

Mohamed Chebaro, Ramses Atilano and Steven Rogers
Engineering

Power-to-Gas Phase 2

Roadmap

A | B | C | D



POWER-TO-GAS PHASE 2: ENGINEERING PROGRAM ROADMAP

Created by: Ramses Atilano
Reviewed and Approved by: Mohamed Chebaro

February 7th, 2019
Version 1.25

Program Management
Ramses Atilano

1. HYREADY Project
PM: Ramses Atilano
Support: Stephanie Demakos

- Perform Initial H_2 Literature Study (Industry Wide)
- Submit EGD's Materials and Components
- HYREADY Data Analysis
  - Define Blending Guidelines for Transmission Systems
  - Define Blending Guidelines for Distribution Systems
  - Propose Mitigation Strategies
- HYREADY Issue Engineering Guidelines on the Readiness of Natural Gas Systems for H_2 Blending (Original Scope)
- HYREADY Additional Scope
  - End-user Equipment Literature Review and Report
  - Not required for the Engineering Assessment
  - Report expected for Q4, 2019

2. CGA/AGA Hydrogen Blending Group
PM: Ramses Atilano

- Form North American CGA/AGA Working Group
- Perform Public Domain Knowledge Research
- Perform Industry Specific Research
- Review and Finalize CGA/AGA Information Letter
- Approved CGA/AGA Information Letter

3a. EGD Blending Assessment (Upstream)
PM: Desiree Gajonera
Support: Stephanie Demakos

- Preliminary Work
  - Define Scope of Work
  - Identify and Select Specialized Engineering Consultant(s)
  - Finalize Contract(s)
  - Leverage Technical Information from EGD's Stakeholders and External Parties
- Assessment of Gas Distribution Network (Location, Pressure, Gas Consumption, H_2 Production)
  - Perform Geographic Analysis of the Gas Grid Surrounding PtG plant
  - Elaborate H_2 Production Profile from PtG Plant
  - Investigate Natural Gas Consumption and Pressure Profile for Possible Injection Points
- Blending Assessment for Network Components and Materials
  - Investigate Standards and Regulations for Allowable Blending Concentrations
  - Investigate Components and Materials for Each Location's Distribution System
  - Evaluate System's Integrity in Regards to H2 Blending
  - Explore Additional Safety considerations
  - Define System's H_2 Tolerance
- Issue Engineering Recommendation for Closed Loop System(s) (Work Packages 1 to 5)

3b. End-user Equipment Assessment
PM: Steven Rogers
Support: Stephanie Demakos

- Preliminary Work
  - Define Scope of Work
  - Identify and Select Specialized Engineering Consultant(s)
  - Finalize Contract(s)
  - Review Applicable Codes and Standards
  - Leverage Technical Information from EGD's Stakeholders and External Parties
- End-user Equipment Data Analysis
  - Compile a System-wide List of End-user Equipment
  - Survey End-users in the closed loop system(s)
  - Identify End-user Equipment for the Closed Loop Locations
  - Survey Manufacturers
  - Review Manufacturers' Data
  - Perform Location Point Sites Ranking
  - Conduct Gap Analysis
  - Identify Compliance Variances
  - Define Mitigation Strategies
  - Assess the Effect of H_2 Blending on Metering (Measurement Canada)
  - Define Testing Protocols
  - Conduct dispersion modeling
- Issue Engineering Recommendation and Related Deliverables for End-user Equipment

4. 100% H_2 and NG/H_2 Blended Pipelines
PM: Alexander Hadjis

- Investigate Standards, Codes and Regulations for 100% H_2 And Blended Pipelines
- Develop Engineering Guidelines for a 100% H_2 and Blended Pipelines
  - Identify and Select Specialized Engineering Consultant(s)
  - Finalize Contract(s)
  - Define Material and Components
  - Define Welding Procedures
  - Engage Regulatory Stakeholders
  - Draft Preliminary Engineering Guidelines for H_2 and Blended Pipelines
  - Review related international codes
- Perform Pipeline Preliminary Design
  - Design NG Pipeline to injection point
  - Design 100% H_2 Pipeline from Hydrogen Plant to injection point
  - Design Blended (NG/H_2) Pipeline to feed Closed Loop System(s)
  - List requirements for H_2 Pipelines
- Issue Engineering Guidelines for H_2 and Blended Pipelines and Preliminary Design for Closed Loop Location(s)

5. H_2 Blending Station
PM: Peter Soutar

- Investigate Standards and Regulations for Hydrogen Blending Stations
- Develop Engineering Guidelines for Hydrogen Blending Stations
  - Identify and Select Specialized Consultant(s) or internal SMA
  - Finalize Contract(s), if applicable
  - Review Existing Blending Technologies
  - Develop Inlet, Outlet, Odourization and Monitoring Parameters
  - Perform high level cost analysis of hydrogen injection station
- Perform H_2 Blending Station Preliminary Design
  - Evaluate Metering Requirements
  - Evaluate Odourization Requirements
  - Evaluate H_2 Injection Limitations
  - Design H_2 Blending Station
- Issue Engineering Guidelines and Preliminary Design for H_2 Blending Station

6a. Risk Management

Plan Risk Management and Identify Risks → Perform Qualitative Risk Assessment → Perform Quantitative Risk Assessment → Plan Risk Response → Issue Risk Assessment Report

6b. Conduct and Issue Engineering Assessment

6c. Issue Engineering Approved Decision

Power-to-Gas Phase 2

Status Review

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

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Program Streams	Scope	Budget	Timeline
CGA/AGA Task Force Information Letter *(completed)*	🟩	🟩	🟩
HYREADY Engineering Guideline Report *(original scope completed)*	🟩	🟩	🟩
HYREADY Added Scope – End User *(in progress)*	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩

Power-to-Gas Phase 2

Status Review

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

ENBRIDGE
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Program Streams	Scope	Budget	Timeline
Data collection for identified closed loops *(completed)*	🟩	🟩	🟩
Data analysis for identified closed loops *(completed)*	🟩	🟩	🟩
System-wide assessment for end-user equipment *(completed)*	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
	🟩	🟩	🟩
Risk Assessment Report *(in progress, first draft received)*	🟩	🟩	🟩
Computational Modeling *(completed)*	🟩	🟩	🟩
	🟩	🟩	🟩

Power-to-Gas Phase 2

Upcoming Deliverables

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

ENBRIDGE
Life Takes Energy™

Next Month's Deliverables	Scope	Budget	Timeline
A. Research and Development:			
Continue building and optimizing the Hydrogen Blending Database	🟩	🟩	🟩
Manage HYREADY's expanded work scope	🟩	🟩	🟩
B. Integrity, Engineering and Capacity Assessment			
Continue to address action items from the H_2 tolerance evaluation for the three Closed Loops (e.g., Measurement, Regulation, Materials, Leak Detection, Integrity) and provide recommendations in the EA	🟩	🟩	🟩
C. End User Equipment Engineering and Integrity System			
Continue to address action items related to End User equipment in the Engineering Assessment	🟩	🟩	🟩

Power-to-Gas Phase 2

Upcoming Deliverables

🟢 On track
🟡 Lagging but not on critical path
🔴 Lagging and on critical path

Next Month’s Deliverables	Scope	Budget	Timeline
D. Engineering Design:			
Progress design refinements for the H_2 Blending Station, per DBM	🟩	🟩	🟩
Receive final draft of the Engineering Guidelines from Worley Parsons that assess impact on Legacy EGD related Engineering Manuals	🟩	🟩	🟩
Continue progressing the design of the blended pipeline (e.g., System Improvement, Drafting, Engineering, Permitting)	🟩	🟩	🟩
E. Risk Assessment			
Issue the second draft of the Risk Assessment Report for internal review	🟩	🟩	🟩
F. Engineering Assessment			
Progress the first draft of the Engineering Assessment to 80% completion	🟩	🟩	🟩

Power-to-Gas Phase 2 – Overall Progress

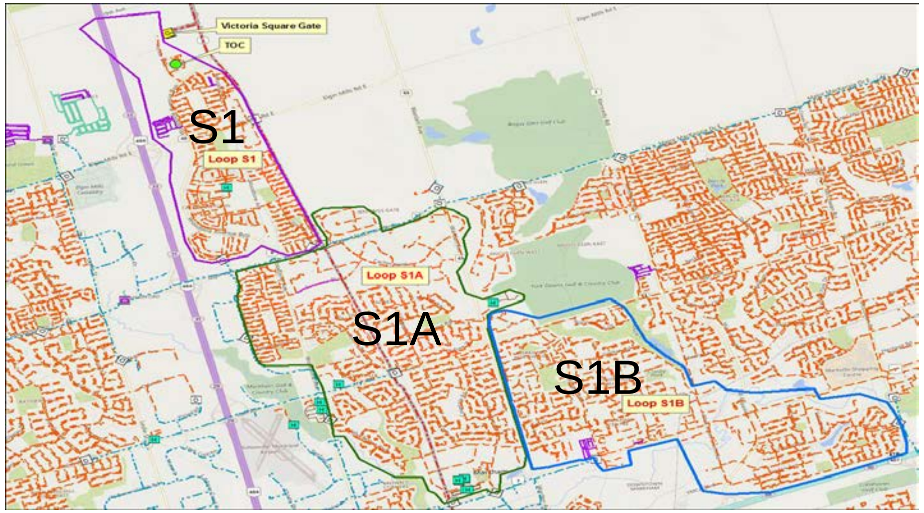
Past Month's Achievements

A. Research and Development

- ✓ Continued managing HYREADY's expanded work scope (Platform for Gas Transmission and Distribution Guidelines and End-user Equipment Study)

B. Integrity, Engineering and Capacity Assessment

- ✓ Continued to address action items from the H_2 tolerance evaluation for the three Closed Loops. This included meetings with internal and external stakeholders related to leak detection implications, measurement, regulation and integrity



C. End User Equipment Engineering and Integrity System

- ✓ Received final version of EMEC's report on leak detection equipment in-house testing, after reviews by Engineering
- ✓ Received second draft of statistical analysis for surveys
- ✓ Presented related outcomes to Operations

Power-to-Gas Phase 2 – Overall Progress

Past Month's Achievements

D. Engineering Design and Review

- ✓ Continued working on station component design (e.g., Pressure Regulation, H_2 Injection)
- ✓ Continued working with Worley Parsons for the development of the Engineering Design Guidelines for 100% H_2 and blended pipelines
- ✓ Hosted review sessions of Legacy EGD Engineering Manuals with multiple SMAs from Worley Parsons and EGI
- ✓ Received first draft of recommended changes to EGI's Engineering Manuals related to Hydrogen Blending and 100% Hydrogen pipelines
- ✓ Continued progressing the design of the blended pipeline (e.g., System Improvement, Drafting, Engineering, Permitting)

E. Risk Assessment

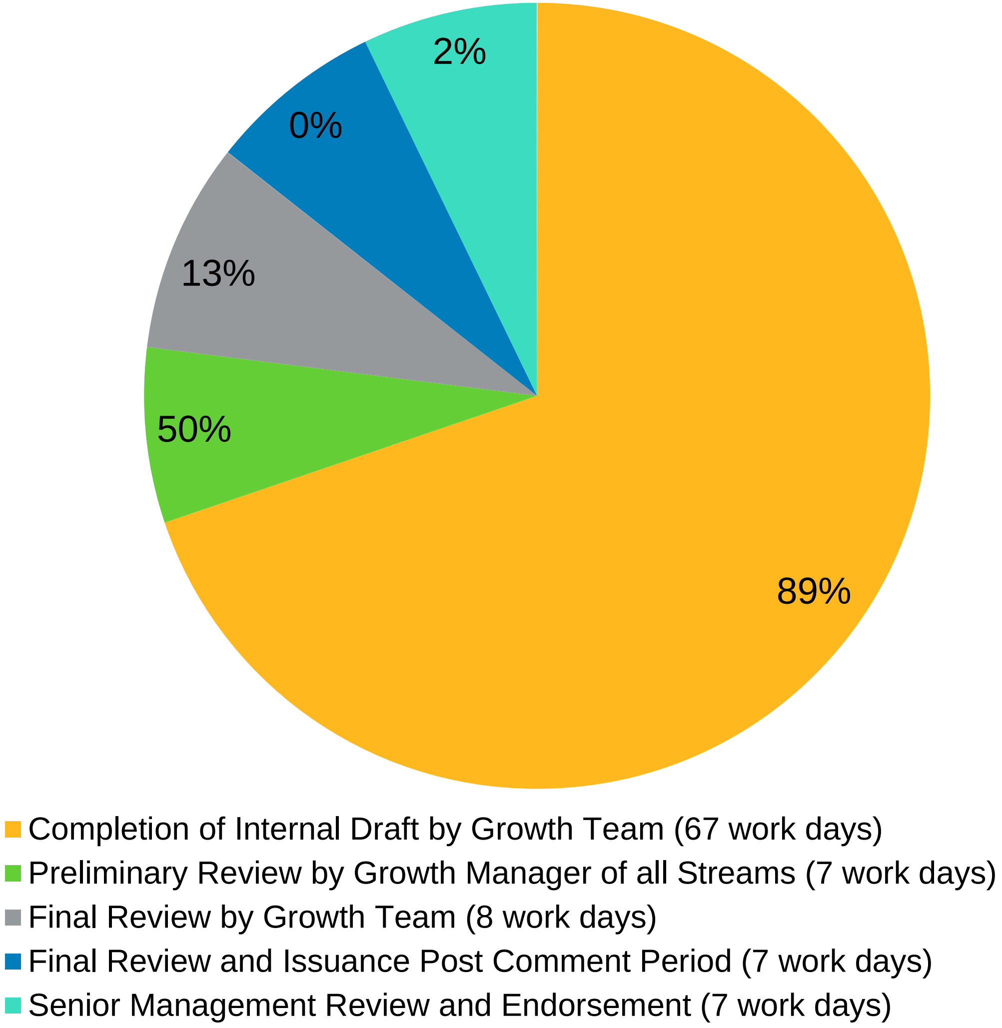
- ✓ Received first draft of the Risk Assessment Report and provided feedback to the Risk Team

F. Engineering Assessment

- ✓ Held strategy sessions within the Engineering Growth Team to design the Engineering Assessment content
- ✓ Completed 60% of Engineering Assessment

Power-to-Gas Phase 2 – EA Progress

Graphical Representation of Progress to Date Based on Major Milestones



Note 1: The EA full cycle represents 96 work days

Note 2: The percentages in the chart represent the completion rate for each of the efforts highlighted in the legend below

The Hydrogen Blending Opportunity

Greening the Natural Gas Grid With Up to 2% Hydrogen

Accomplishments

- Drafting of Leave to Construct (LTC) underway.
- Engineering assessment completed; recommends up to 2% Hydrogen blend by volume into a specific section of the natural gas grid.
- Answers to questions from the Open Houses completed; final review by PAC prior to release.
- Environmental Assessment (EA) completed

Key Dates

- LTC Filing: Late Q2- early Q3, 2019
- OTC: April 2020
- ISD: September 2020

The Hydrogen Blending Opportunity

Greening the Natural Gas Grid With Up to 2% Hydrogen

Key Issues

- Hydrogen has 1/3 the energy content of natural gas.
- Blended hydrogen slightly increases the customer’s natural gas consumption.
- Customer may not be readily accepting of hydrogen in their natural gas.
- Strong opposition to blended hydrogen in gas may impact LTC filing to the OEB
- Regulatory requires the cost the utility will purchase hydrogen from the JV Co. for to be included in the planned LTC filing
- Limited space at the TOC to accommodate blending infrastructure and H2 Sale infrastructure

The Hydrogen Blending Opportunity

Greening the Natural Gas Grid With Up to 2% Hydrogen

Challenges

- Educating customers on the merits of blended hydrogen into the natural gas grid
- Determine most effective means of acknowledging participating customers
- Determination of a fair cost for selling hydrogen to the utility

Next Steps

- Undertake franchise market study to measure public perception and acceptance of hydrogen.
- Continue work with Regulatory to complete the LTC.
- Develop appropriate costing model with Finance, for cost of hydrogen
- Coordinate with Hydrogenics to ensure hydrogen sale and blending station can be accommodated at or near TOC

Power to Gas Project

Hydrogen Blending Engineering Assessment Overview

Mike Wagle, P.Eng.
Chief Engineer

Mohamed Chebaro, P.Eng., PMP
Manager, Electrical, Controls and Energy Systems

Agenda

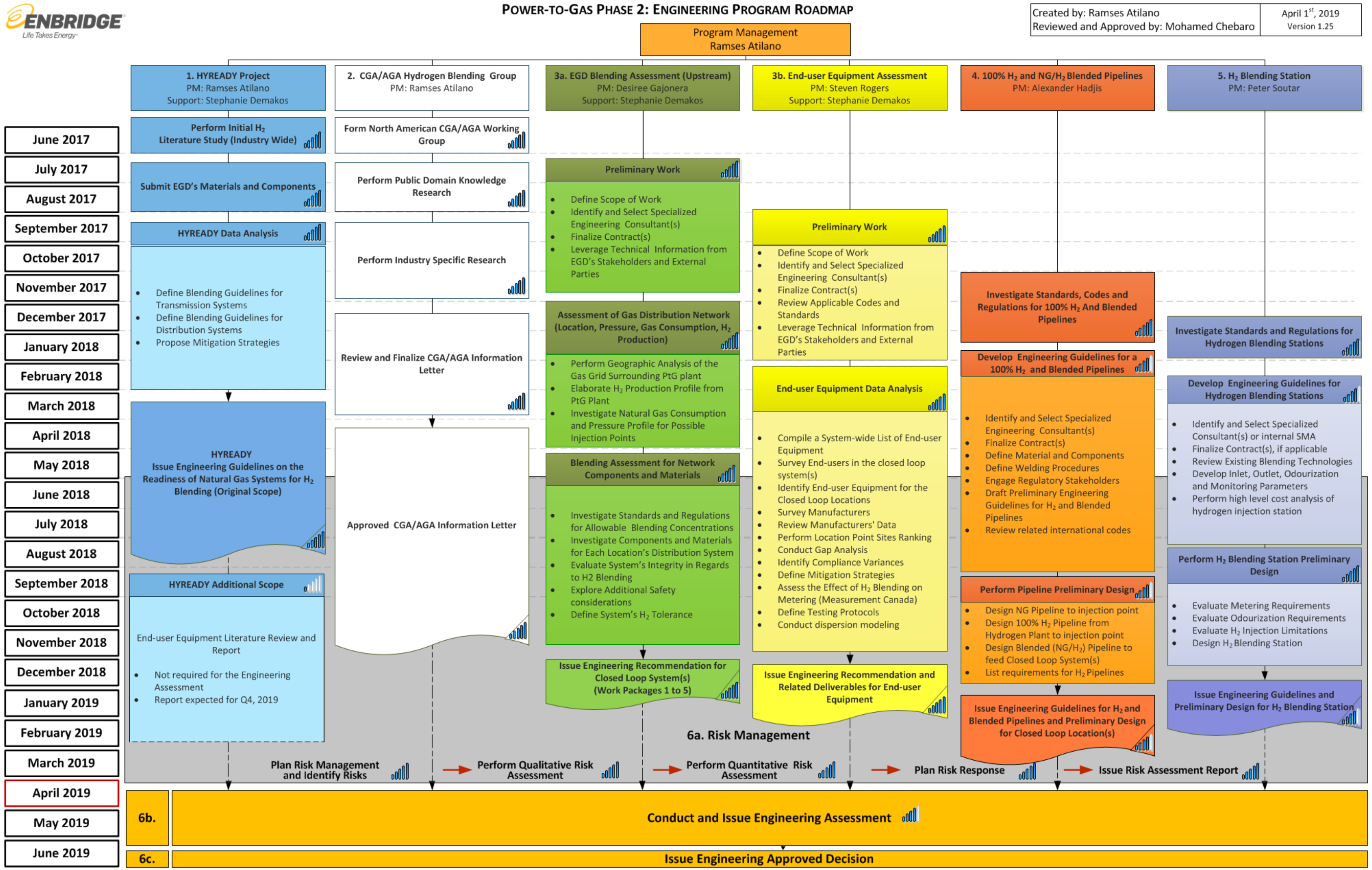
I. Engineering Program Strategy
    A. Methodology and Technical Approach

II. Major Findings and Conclusions
    A. Research & Development
    B. Gas Distribution Network
    C. End-user Equipment
    D. Pipeline and Station Design
    E. Risk Assessment and Modelling
    F. Leak Detection and Appliance Testing

III. Action Items

I. Engineering Program Strategy

Hydrogen Blending Program Roadmap



POWER-TO-GAS PHASE 2: ENGINEERING PROGRAM ROADMAP

Created by: Ramses Atilano
Reviewed and Approved by: Mohamed Chebaro
April 1st, 2019
Version 1.25

Program Management
Ramses Atilano

- June 2017
- July 2017
- August 2017
- September 2017
- October 2017
- November 2017
- December 2017
- January 2018
- February 2018
- March 2018
- April 2018
- May 2018
- June 2018
- July 2018
- August 2018
- September 2018
- October 2018
- November 2018
- December 2018
- January 2019
- February 2019
- March 2019
- April 2019
- May 2019
- June 2019

1. HYREADY Project
PM: Ramses Atilano
Support: Stephanie Demakos

Perform Initial H_2 Literature Study (Industry Wide)

Submit EGD's Materials and Components

HYREADY Data Analysis

- Define Blending Guidelines for Transmission Systems
- Define Blending Guidelines for Distribution Systems
- Propose Mitigation Strategies

HYREADY
Issue Engineering Guidelines on the Readiness of Natural Gas Systems for H_2 Blending (Original Scope)

HYREADY Additional Scope

End-user Equipment Literature Review and Report

- Not required for the Engineering Assessment
- Report expected for Q4, 2019

2. CGA/AGA Hydrogen Blending Group
PM: Ramses Atilano

Form North American CGA/AGA Working Group

Perform Public Domain Knowledge Research

Perform Industry Specific Research

Review and Finalize CGA/AGA Information Letter

Approved CGA/AGA Information Letter

3a. EGD Blending Assessment (Upstream)
PM: Desiree Gajonera
Support: Stephanie Demakos

Preliminary Work

- Define Scope of Work
- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Leverage Technical Information from EGD's Stakeholders and External Parties

Assessment of Gas Distribution Network (Location, Pressure, Gas Consumption, H_2 Production)

- Perform Geographic Analysis of the Gas Grid Surrounding PtG plant
- Elaborate H_2 Production Profile from PtG Plant
- Investigate Natural Gas Consumption and Pressure Profile for Possible Injection Points

Blending Assessment for Network Components and Materials

- Investigate Standards and Regulations for Allowable Blending Concentrations
- Investigate Components and Materials for Each Location's Distribution System
- Evaluate System's Integrity in Regards to H2 Blending
- Explore Additional Safety considerations
- Define System's H_2 Tolerance

Issue Engineering Recommendation for Closed Loop System(s) (Work Packages 1 to 5)

3b. End-user Equipment Assessment
PM: Steven Rogers
Support: Stephanie Demakos

Preliminary Work

- Define Scope of Work
- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Review Applicable Codes and Standards
- Leverage Technical Information from EGD's Stakeholders and External Parties

End-user Equipment Data Analysis

- Compile a System-wide List of End-user Equipment
- Survey End-users in the closed loop system(s)
- Identify End-user Equipment for the Closed Loop Locations
- Survey Manufacturers
- Review Manufacturers' Data
- Perform Location Point Sites Ranking
- Conduct Gap Analysis
- Identify Compliance Variances
- Define Mitigation Strategies
- Assess the Effect of H_2 Blending on Metering (Measurement Canada)
- Define Testing Protocols
- Conduct dispersion modeling

Issue Engineering Recommendation and Related Deliverables for End-user Equipment

4. 100% H_2 and NG/H_2 Blended Pipelines
PM: Alexander Hadjis

Investigate Standards, Codes and Regulations for 100% H_2 And Blended Pipelines

Develop Engineering Guidelines for a 100% H_2 and Blended Pipelines

- Identify and Select Specialized Engineering Consultant(s)
- Finalize Contract(s)
- Define Material and Components
- Define Welding Procedures
- Engage Regulatory Stakeholders
- Draft Preliminary Engineering Guidelines for H_2 and Blended Pipelines
- Review related international codes

Perform Pipeline Preliminary Design

- Design NG Pipeline to injection point
- Design 100% H_2 Pipeline from Hydrogen Plant to injection point
- Design Blended (NG/H_2) Pipeline to feed Closed Loop System(s)
- List requirements for H_2 Pipelines

Issue Engineering Guidelines for H_2 and Blended Pipelines and Preliminary Design for Closed Loop Location(s)

5. H_2 Blending Station
PM: Peter Soutar

Investigate Standards and Regulations for Hydrogen Blending Stations

Develop Engineering Guidelines for Hydrogen Blending Stations

- Identify and Select Specialized Consultant(s) or internal SMA
- Finalize Contract(s), if applicable
- Review Existing Blending Technologies
- Develop Inlet, Outlet, Odourization and Monitoring Parameters
- Perform high level cost analysis of hydrogen injection station

Perform H_2 Blending Station Preliminary Design

- Evaluate Metering Requirements
- Evaluate Odourization Requirements
- Evaluate H_2 Injection Limitations
- Design H_2 Blending Station

Issue Engineering Guidelines and Preliminary Design for H_2 Blending Station

6a. Risk Management

Plan Risk Management and Identify Risks → **Perform Qualitative Risk Assessment** → **Perform Quantitative Risk Assessment** → **Plan Risk Response** → **Issue Risk Assessment Report**

6b. **Conduct and Issue Engineering Assessment**

6c. **Issue Engineering Approved Decision**

1. HYREADY Project
PM: Ramses Atilano
Support: Stephanie Demakos

2. CGA/AGA Hydrogen Blending Group
PM: Ramses Atilano

3a. EGD Blending Assessment (Upstream)
PM: Desiree Gajonera
Support: Stephanie Demakos

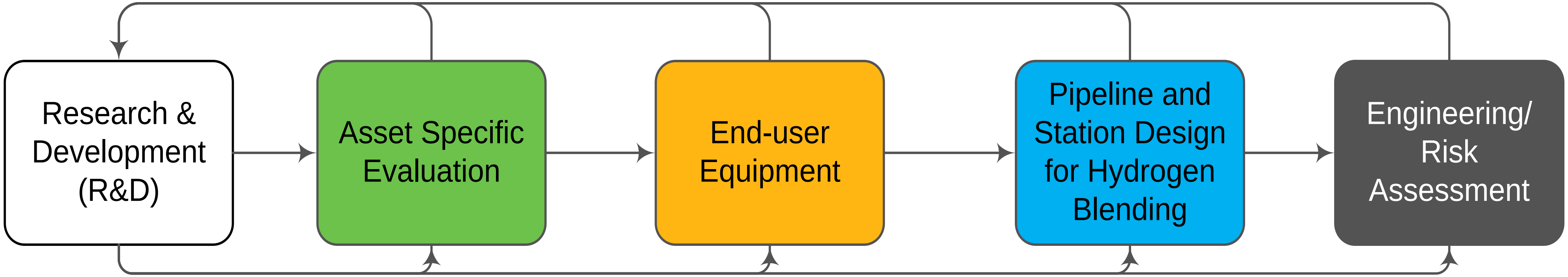
3b. End-user Equipment Assessment
PM: Steven Rogers
Support: Stephanie Demakos

4. 100% H_2 and NG/H_2 Blended Pipelines
PM: Alexander Hadjis

5. H_2 Blending Station
PM: Peter Soutar

I. A. Engineering Assessment

Methodology and Technical Approach



Research & Development (R&D)

Asset Specific Evaluation

End-user Equipment

Pipeline and Station Design for Hydrogen Blending

Engineering/ Risk Assessment

Practical starting point based on the acceptable ranges of H_2 content (percentage by volume) in existing literature

Identify all installed assets and their materials of construction and evaluate their H_2 compatibility

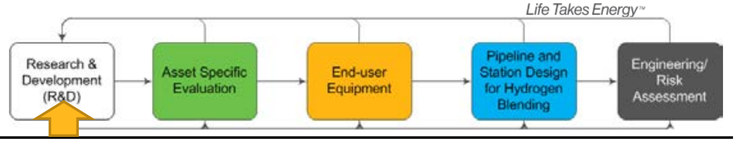
Confirm material suitability through a field survey. Complete fuel interchangeability analysis. Modelling of indoor releases

Define design requirements for the pure hydrogen/ blended gas pipeline, and blending station

Recommend maximum percentage by volume hydrogen and provide list of action items to be completed for the safe and reliable distribution of blended gas

II. A. Research & Development

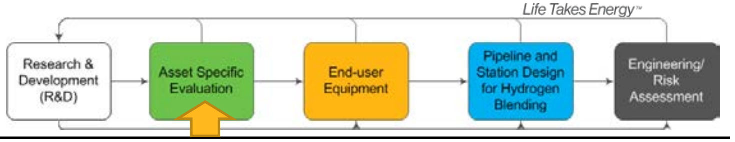
Key Findings



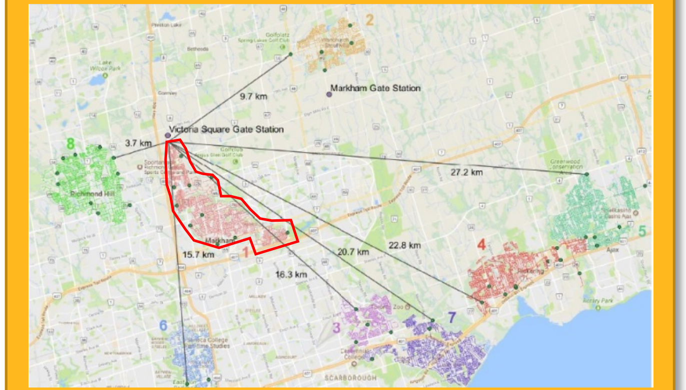
CGA/AGA Task Force	HYREADY Project
• 13 organizations from US and Canada • Component by component review • The gas distribution grid may tolerate blending up to 5% H_2 by vol. with noted exceptions • Recommends site-specific assessment for each blending network	• Global consortium of organizations from Europe and North America • Group general components and assigned maximum % by vol. H_2 for each • High level operational considerations – effects on metering, leak detection, regulation, etc.

II. B. Network Hydrogen Tolerance

Injection Optimization

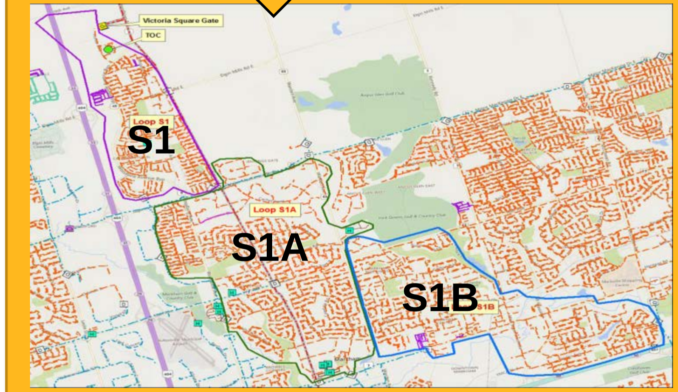

Research & Development (R&D)
Asset Specific Evaluation
End-user Equipment
Pipeline and Station Design for Hydrogen Blending
Engineering/ Risk Assessment

Q4 2017- Q1 2018



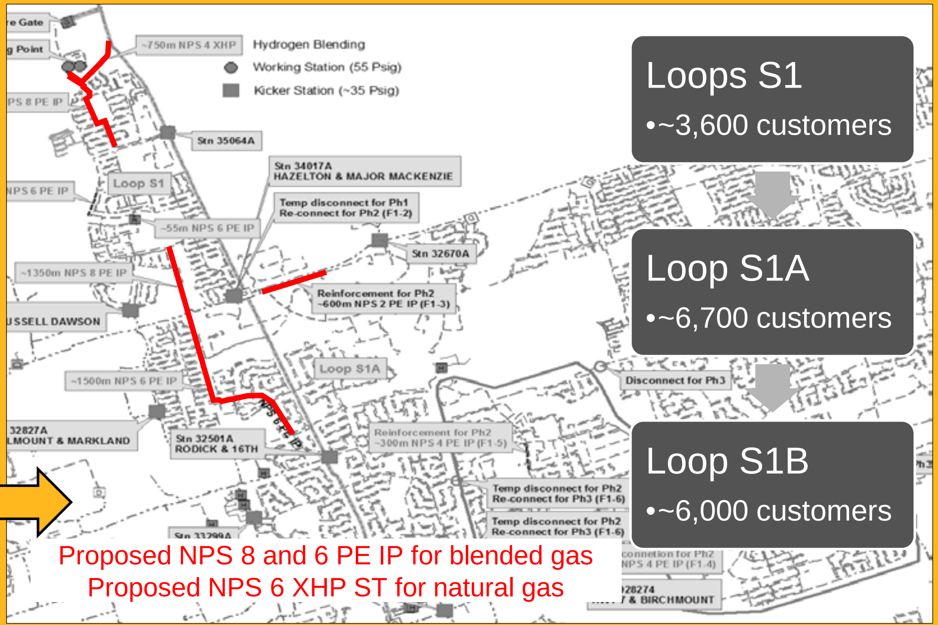
Examined 8 macro-loops (GTA)

Q1 2018



Divided Markham loop into 3

Q2 2018



Loops S1
- ~3,600 customers

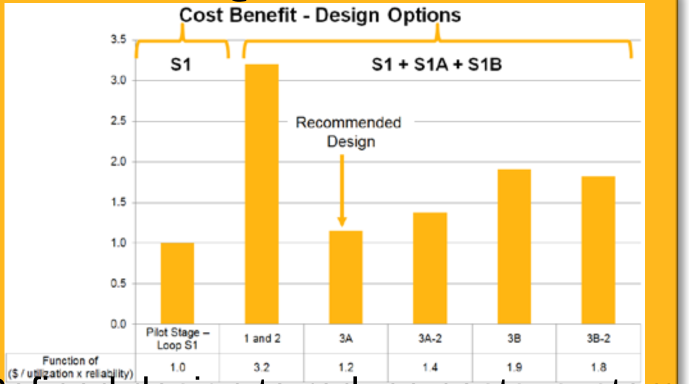
Loop S1A
- ~6,700 customers

Loop S1B
- ~6,000 customers

Proposed NPS 8 and 6 PE IP for blended gas
Proposed NPS 6 XHP ST for natural gas

Produced optimal pipeline blending design

Q3 2018



	Pilot Stage – Loop S1	1 and 2	3A	3A-2	3B	3B-2
Function of ($ / utilization x reliability)	1.0	3.2	1.2	1.4	1.9	1.8

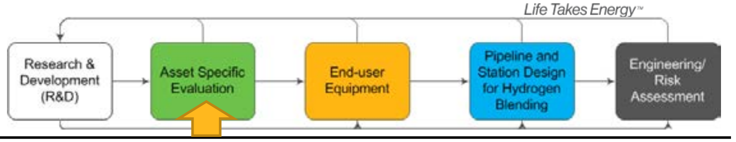
Refined design to reduce costs, system pressure and required modification

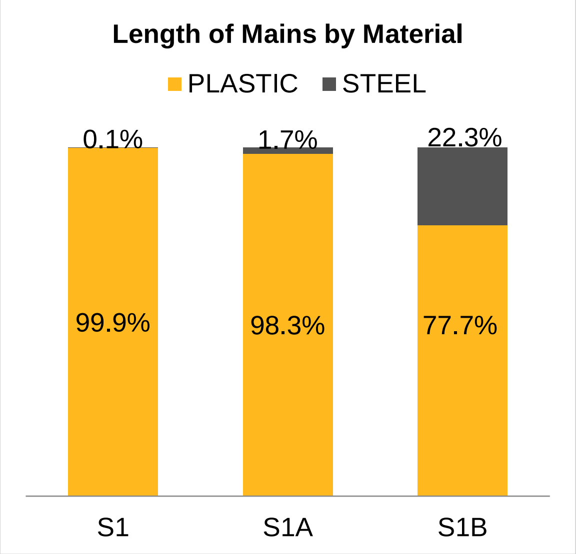
Q1 2019

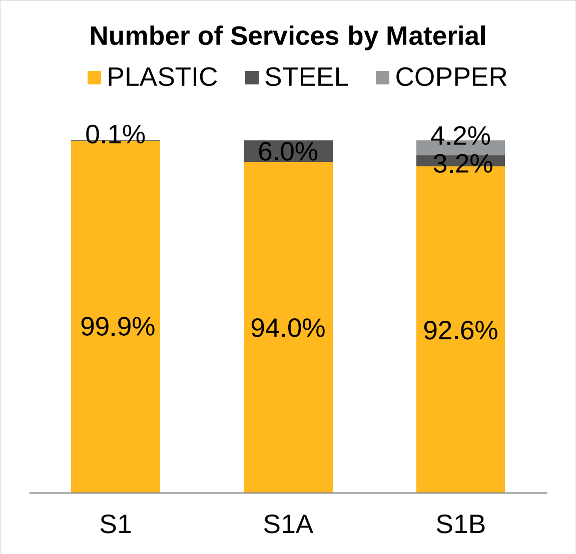
Proposed additional routes to meet regulatory and environmental requirements

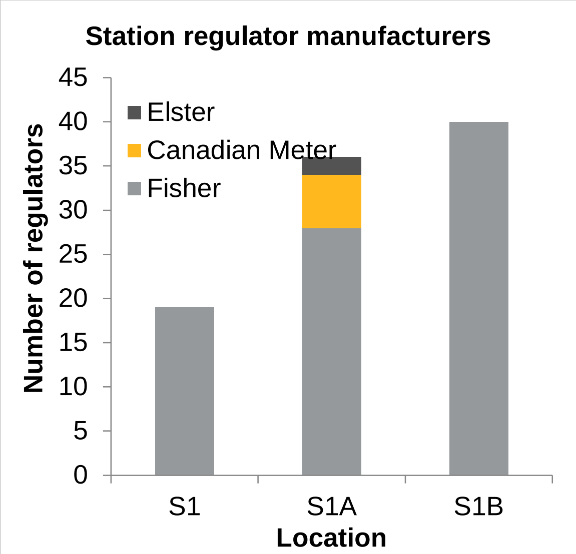
II. B. Network Hydrogen Tolerance

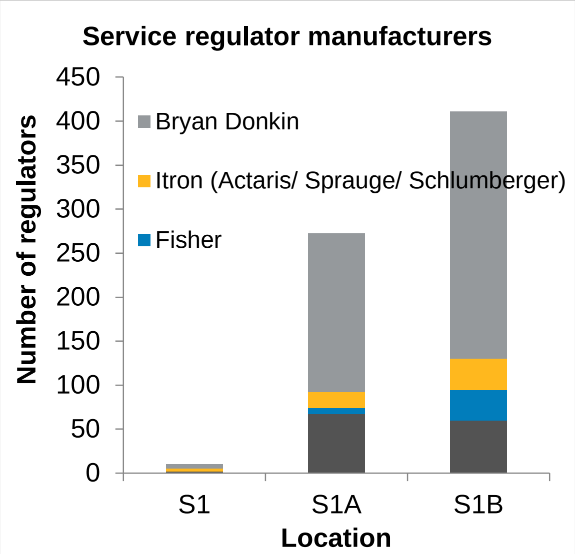
Distribution System Assessment


Research & Development (R&D)
Asset Specific Evaluation
End-user Equipment
Pipeline and Station Design for Hydrogen Blending
Engineering/ Risk Assessment


Length of Mains by Material

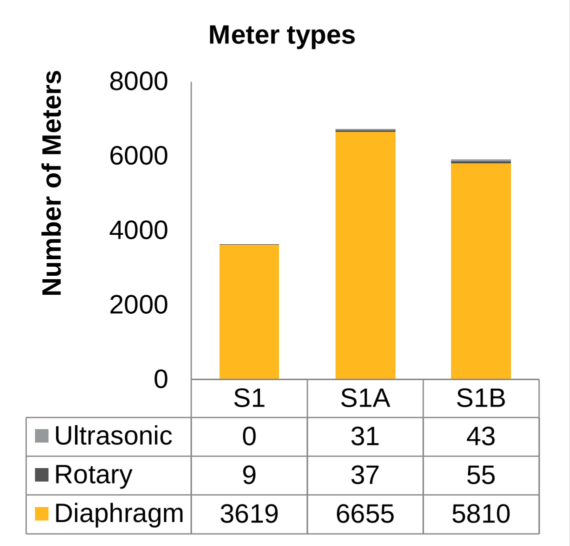

Number of Services by Material


Station regulator manufacturers


Service regulator manufacturers

Existing pipe and tubing are compatible with up to 10% by volume hydrogen; the limits for each material type are:

- 25% by volume hydrogen for steel pipe for mains, services and stations
- 10% by volume hydrogen for steel pipe and nipples in customer meter sets
- 45 by volume hydrogen for plastic mains and services
- 30% by volume hydrogen for copper services and risers


Meter types

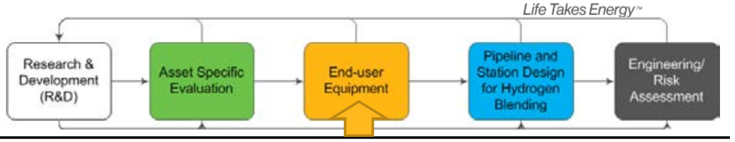
	S1	S1A	S1B
Ultrasonic	0	31	43
Rotary	9	37	55
Diaphragm	3619	6655	5810

Existing regulators are compatible with up to 5% by volume hydrogen

Existing meters are compatible with up to 5% by volume hydrogen

II. C. End-user Equipment Assessment

Two Approaches



Research & Development (R&D)

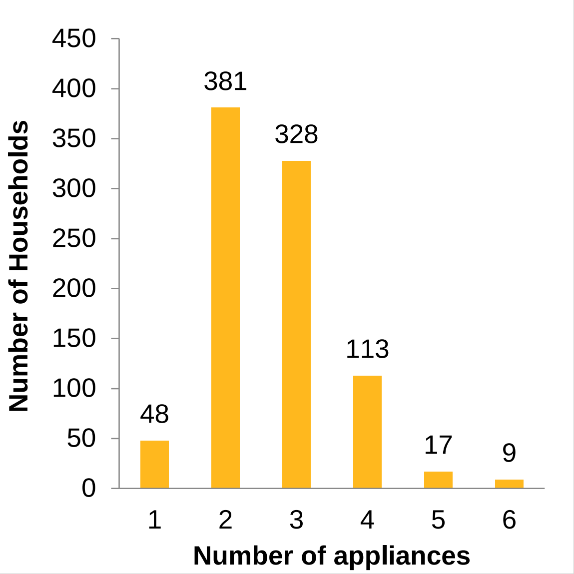
Asset Specific Evaluation

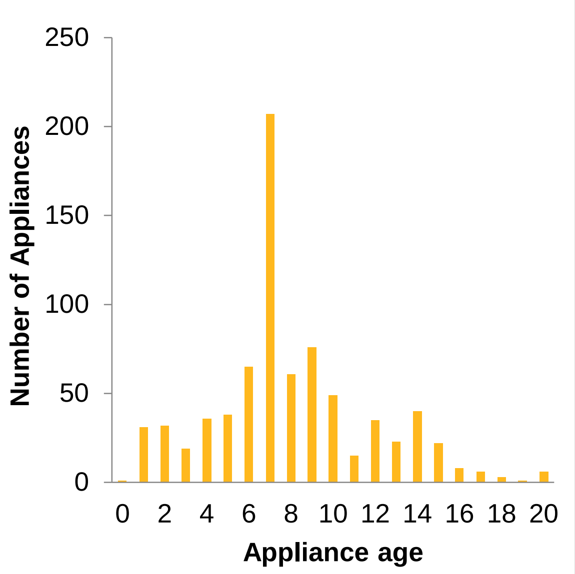
End-user Equipment

Pipeline and Station Design for Hydrogen Blending

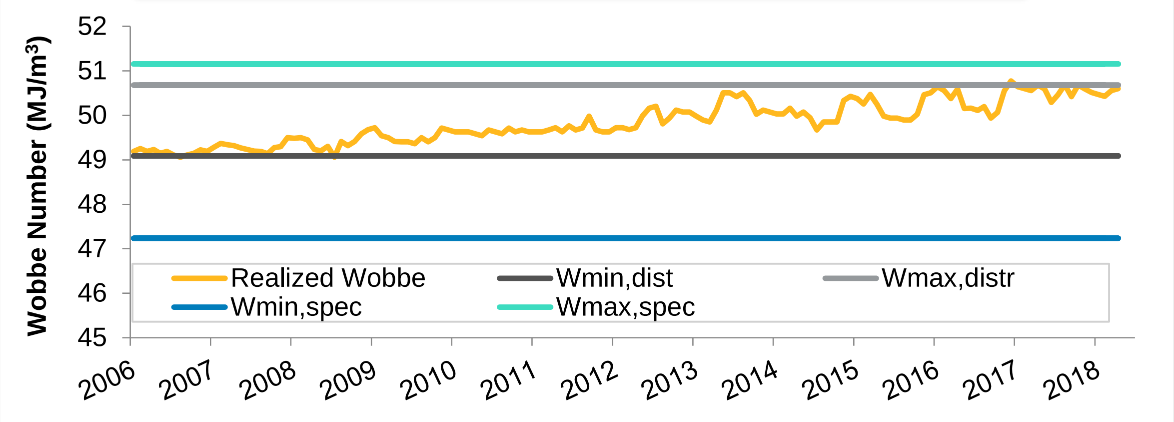
Engineering/ Risk Assessment

1. FIELD SURVEY + ANALYSIS





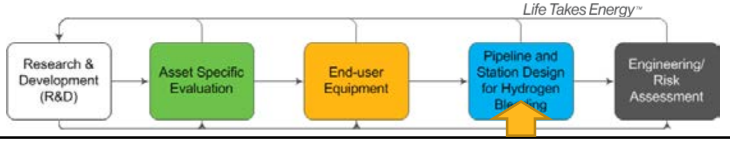
2. INTERCHANGEABILITY ANALYSIS



Appliance type	CO_2	CO	NOx	Flame temp	Temp combustion chamber	Lambda (air to fuel ratio)	Flame speed
Residential (no retrofit)	↓	↓	↓	↑	↓	↑	↑
Engines (no retrofit)	↓	↓	↑	↑	↓	↑	↑
Industrial (retrofit)	↓	↓	↑	↑	=	=	↑
Industrial (not retrofitted)*	↓	↓	↓**	↑	↓	↑	↑
Turbines (retrofit)	↓	↓	↑	↑	=	=	↑

II. D. Pipeline and Station Design

Preliminary Design for Blending



Research & Development (R&D)

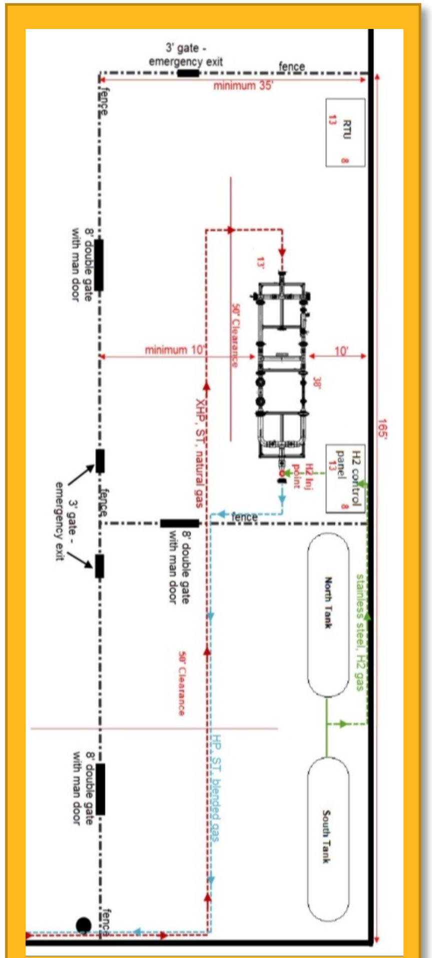
Asset Specific Evaluation

End-user Equipment

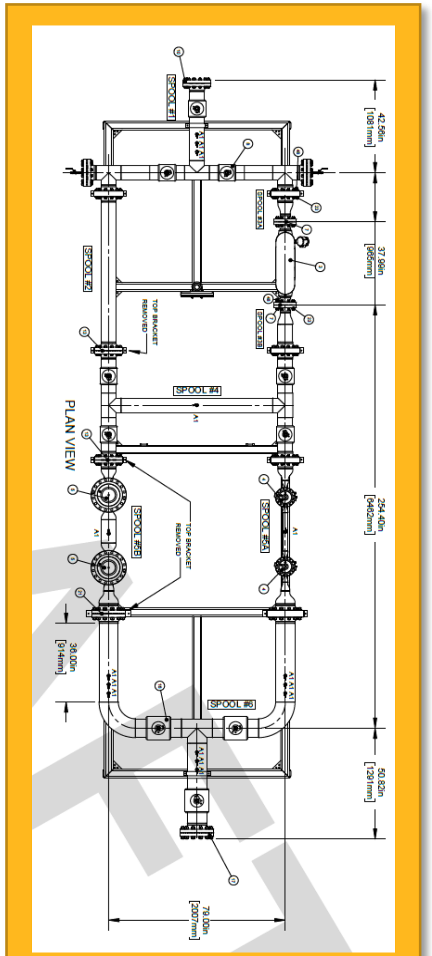
Pipeline and Station Design for Hydrogen Blending

Engineering/ Risk Assessment

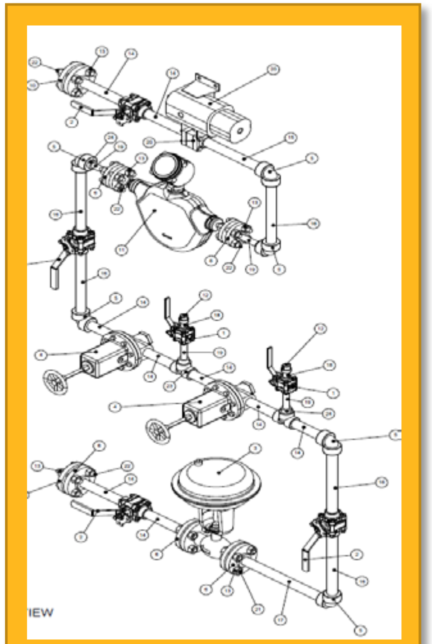
Hydrogen Blending Compound at TOC



Site Plan



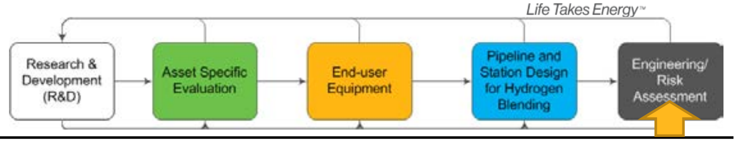
NG Station



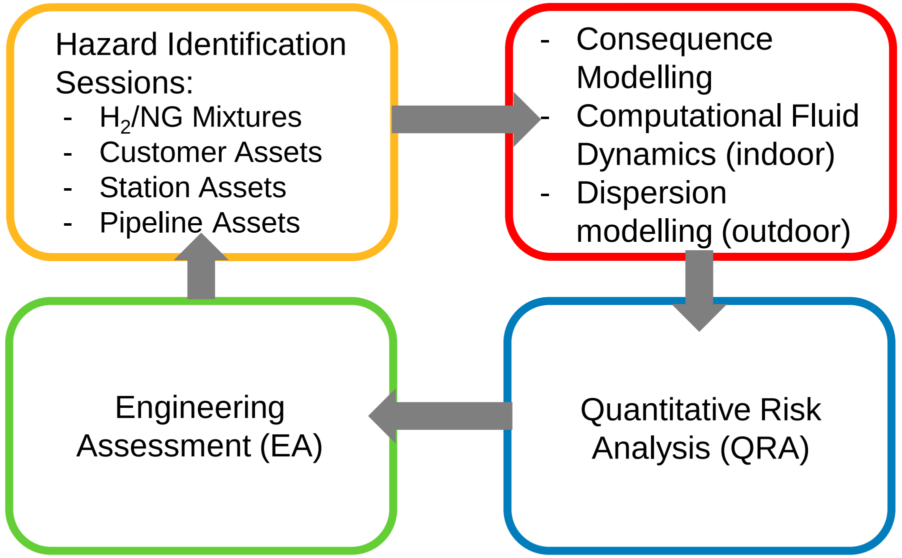
H_2 Injection

II. E. Risk Assessment

Methodology and Modelling



Methodology



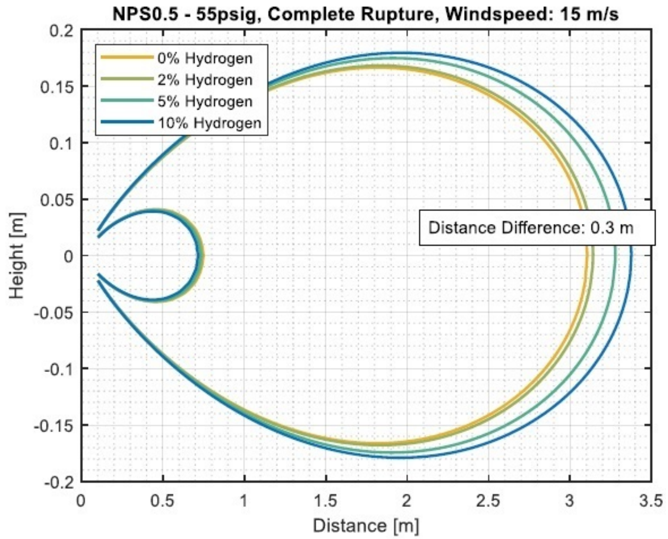
Hazard Identification Sessions:
- H_2/NG Mixtures
- Customer Assets
- Station Assets
- Pipeline Assets

- Consequence Modelling
- Computational Fluid Dynamics (indoor)
- Dispersion modelling (outdoor)

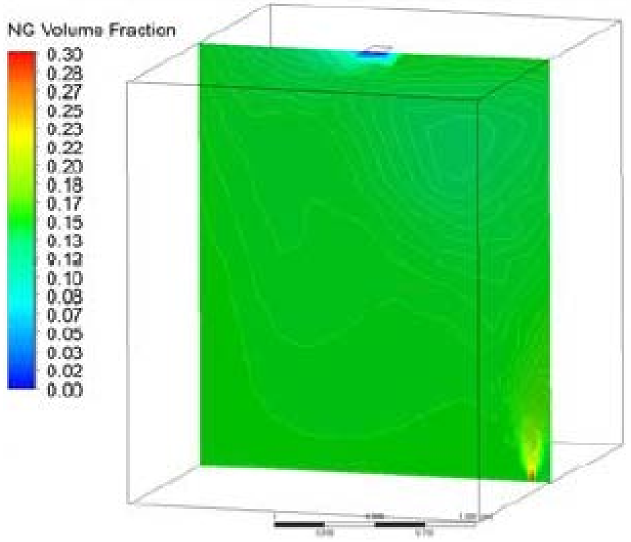
Quantitative Risk Analysis (QRA)

Engineering Assessment (EA)

Outdoor Dispersion Modelling



Indoor Release Modelling

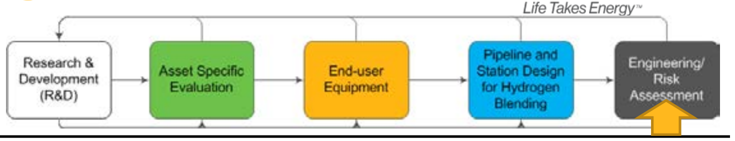


In the event of an outdoor release, the increase in the distance to LEL changes marginally at 2% by volume hydrogen.

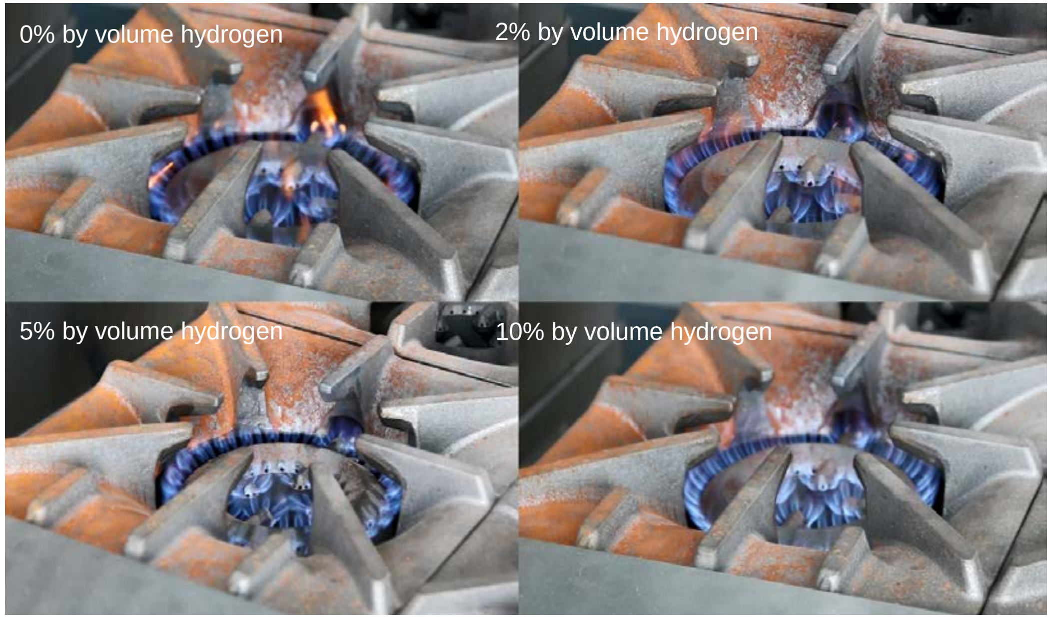
II. F. Leak Detection and Appliance Testing

General Observations

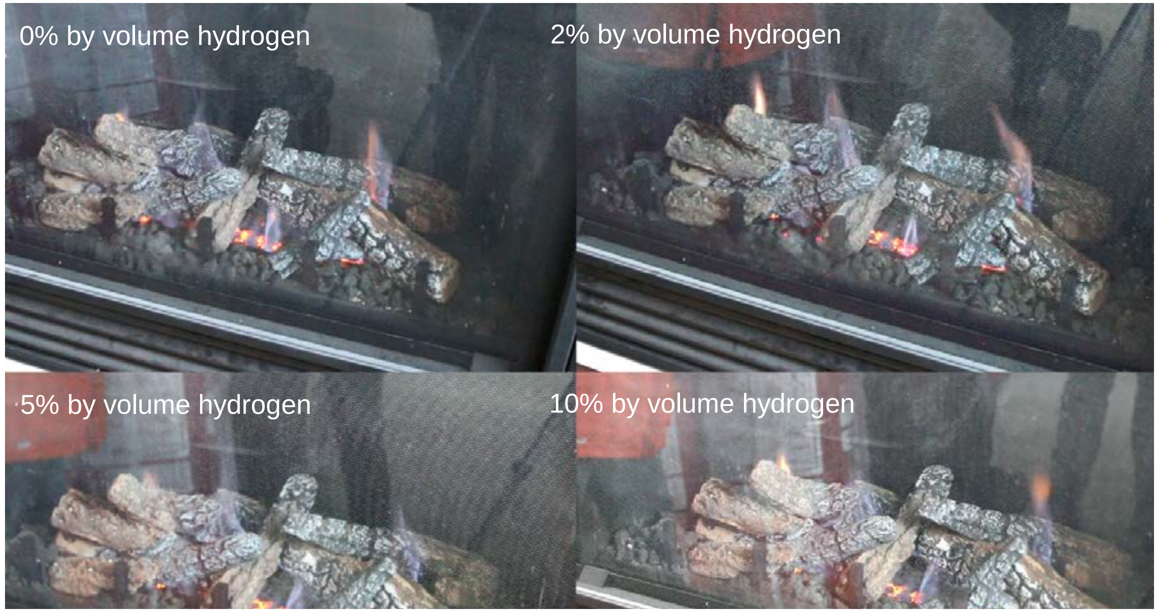
ENBRIDGE
Life Takes Energy™



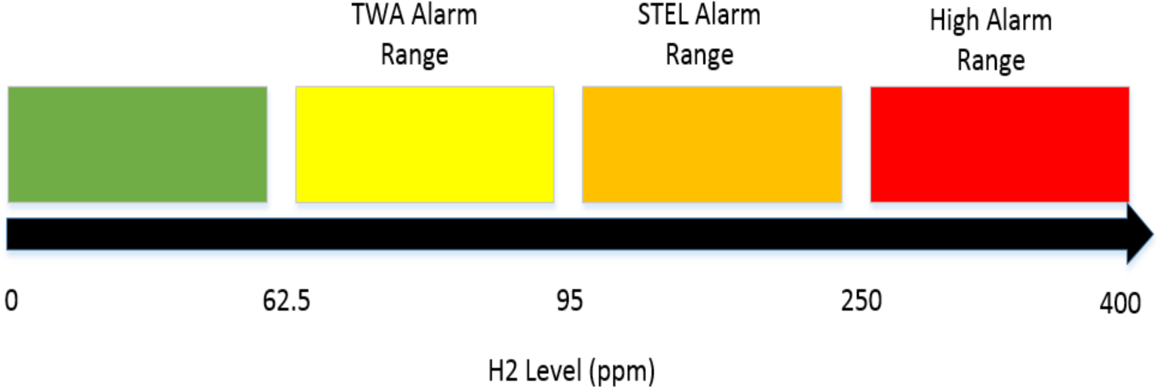
Gas Range Test Results



Fireplace Test Results

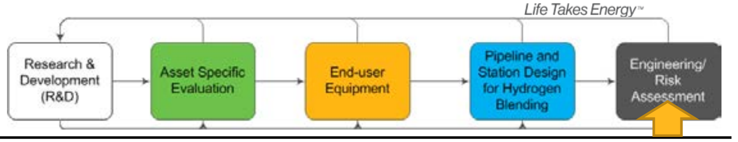


Leak detection equipment using electrochemical sensors can have a cross sensitivity for hydrogen; this needs to be validated against operational procedures, also addressed through training



Conclusions

Safety, Integrity and Operations



Research & Development (R&D)

Asset Specific Evaluation

End-user Equipment

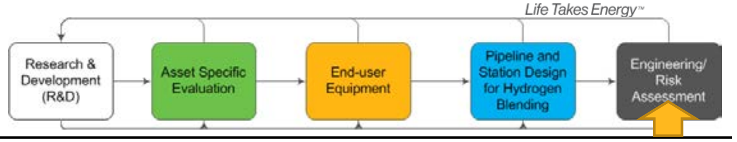
Pipeline and Station Design for Hydrogen Blending

Engineering/ Risk Assessment

- Loop S1 and subsequently Loops S1A and S1B were found to be appropriate networks for blending up to 2.0% by volume hydrogen.
- Completing the entire scope of work is advantageous because Loops S1A and S1B are more representative of the overall Legacy EGD distribution network, considering the vintage and corresponding materials of construction.
- The above conclusion applies, provided that the Engineering action items are successfully implemented prior to blending initiation. Minimal modifications would be required to safely and reliably inject the recommended hydrogen concentration in the selected loops.

III. Action Items – Pre-Blending

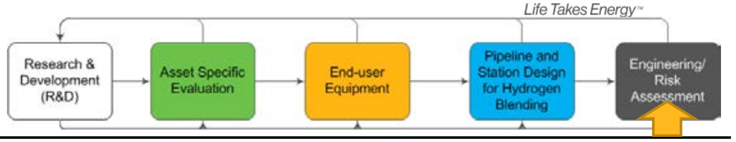
Safety, Integrity and Operations



1. Develop and deliver training packages for blended natural gas for first responders; create new procedures for:
   a. Emergency Procedures Manual
   b. Leak detection cross-sensitivity
   c. Blending Station and Hydrogen Assets –Commissioning, Operation, Maintenance, Gas Control
   d. Energization procedure for the initial introduction of blended gas
2. Perform a FMEA on the Blending Station as part of detailed design
3. Seek formal clarification on the applicability of O. Reg 210/01 and FS 238-18 from the TSSA *(in progress)*
4. Increase the frequency of leak surveys in the first 5 years of blending

III. Action Items – Pre-Blending

Safety, Integrity and Operations



Research & Development (R&D)

Asset Specific Evaluation

End-user Equipment

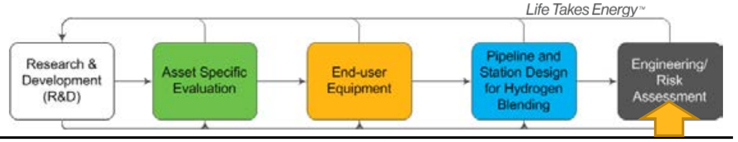
Pipeline and Station Design for Hydrogen Blending

Engineering/ Risk Assessment

5. Create processes to capture:
    a. Addition of sensitive customers to the network
    b. Network modifications resulting in blended gas being fed to areas that were out of scope for this assessment
    c. Addition of CNG stations or Vehicle Refueling Appliances
    d. Assessment of material faults within the closed loop(s) within the context of hydrogen blending
    e. Any impacts on billing due to increased volumetric usage

III. Action Items – Post-blending

Safety, Integrity and Operations



1. Integrity monitoring of the blended network:
    a. Monitor the leak frequency of the blended gas networks and compare to expected leak rates for natural gas networks
    b. Perform and track leak surveys on Amp and Chicago fittings to quantify any operational impact and accelerate replacement if required
2. Track the hydrogen production and consumption profile for future evaluation
3. Seek formal clarification on EGI meter shop's ability to certify meters that are intended for blended gas
4. Conduct additional testing for added conservatism on:
    a. Valve and regulator bypass
    b. Appliance safety devices (thermopiles/thermocouples)
    c. NOx emissions from appliances

Q&A

Engineering Hydrogen Blending Team:

Ramses Atilano, Steven Rogers, Desiree Gajonera, Alexander Hadjis, Peter Soutar, Stephanie Demakos

Many others from across EGI contributed to the success of this Program.

ENBRIDGE GAS INC.
Answer to Interrogatory from
School Energy Coalition (SEC)

INTERROGATORY

Reference:

Exhibit A/Tab 2/Schedule 1, p. 5; Ex. B/1/1, p. 9

Question**:**

Please confirm that, at the end of the pilot Project, all intellectual property arising out of the project will be owned by the Applicant as utility assets, held for the benefit of the customers of the Applicant. If not confirmed, please provide a detailed explanation of the anticipated ownership and future exploitation of intellectual property arising out of the Project.

Response:

Enbridge Gas confirms that intellectual property developed through the LCEP pilot project relating to hydrogen blending for gas distribution systems will be owned by the Applicant as utility assets. Enbridge Gas does not confirm that utility assets are held for the benefit of ratepayers. Enbridge Gas does acknowledge, however, that the Board may find it appropriate for ratepayers to share in future financial proceeds arising from future use of intellectual property developed by Enbridge Gas through the LCEP pilot project relating to hydrogen blending for gas distribution systems.

ENBRIDGE GAS INC.
Answer to Interrogatory from
School Energy Coalition (SEC)

INTERROGATORY

Reference:

Ex. B/1/1, p. 2

Question**:**

Please provide details as to what steps are required, whether by the Board or otherwise, to cause the TSSA to do a technical review of the Project. Please describe what review is proposed or required.

Response:

Please refer to Exhibit I.CCC.7.

ENBRIDGE GAS INC.
Answer to Interrogatory from
School Energy Coalition (SEC)

INTERROGATORY

Reference:

Ex. B/1/1, p. 2

Question**:**

Please provide a detailed list of all grants, loans, or other government assistance, and all tax credits or accelerated tax deductions or other tax benefits, expected to arise as a result of the Project. In each case, please identify what entity will benefit from those amounts, and in the case of the Applicant how it will account for them.

Response:

The only source of additional funding for the Project is the grant funding described at Exhibit B, Tab 1, Schedule 1, Page 16 under the section *"Project Costs".*

Enbridge Gas's standard accounting practices will be applied to the Project and will take into account all applicable tax deductions including accelerated CCA rates in reference to Bill C-97.

ENBRIDGE GAS INC.
Answer to Interrogatory from
School Energy Coalition (SEC)

INTERROGATORY

Reference:

Ex. B/1/1, p. 3, 17, and Attach.1, p. 2

Question**:**

SEC is trying to reconcile the tons of carbon dioxide equivalent and natural gas displaced as set forth in the Application. To assist:

a. Please confirm that the estimate of 2433 m^3 of blended gas per residential customer using 2400 m^3 of natural gas implies that the blended gas for that residential customer will be 50 m^3 hydrogen and 2383 m^3 natural gas, and that 16.67 m^3 of natural gas will be displaced for each such customer annually.

b. Please confirm that the Applicant is assuming 0.512 kg/m^3 of carbon, consistent with EPA standards. If this is not the case, please provide the conversion the Applicant is assuming.

c. Please provide the Applicant's full calculations to get to the figures of 97 tons and 120 tons of CO2 equivalent.

Response:

a) This response assumes that an average customer within the BGA consumes 2,400 m^3 annually. For residential customers in the BGA consuming this amount of traditional natural gas annually, Enbridge Gas estimates that residential customers will consume on average 2,433 m^3 of blended gas. Of the 2,433 m^3 of blended gas consumed on an annual basis, 2,384 m^3 of this gas is natural gas and 49 m^3 is hydrogen gas and 16m^3 of natural gas per customer will be displaced.

b) Not confirmed. Enbridge Gas has used the emission factor of 0.001874 t CO_2e/m^3 (or 1.874 kg CO_2e/m^3) for natural gas. This value is taken from the Ontario Ministry of Environment, Conservation and Parks "Guideline for Quantification, Reporting and Verification of Greenhouse Gas Emissions", April 2019. This value is representative of the emissions from natural gas in Ontario.

c) Please refer to Exhibit I.STAFF.1.

ENBRIDGE GAS INC.
Answer to Interrogatory from
School Energy Coalition (SEC)

INTERROGATORY

Reference:

Ex. B/1/1, p. 3

Question**:**

Please confirm that the Applicant intends that the annual rate rider in the BGA will continue as long as the customers are receiving blended gas, or until the Board orders otherwise. If not confirmed, please explain the circumstances in which the rider would terminate while the additional volumes are still being delivered and billed.

Response:

Confirmed. The annual rate rider applicable to the BGA will continue as long as the customers are receiving blended gas, or until the Board orders otherwise.

ENBRIDGE GAS INC.
Answer to Interrogatory from
School Energy Coalition (SEC)

INTERROGATORY

Reference:

Ex. B/1/1, p. 5

Question**:**

Please provide the following with respect to the Affiliate, 2562961 Ontario Ltd.:

a. Its most recent financial statements.

b. Its most recent business plan and/or financial forecasts.

c. Details of the ownership, governance and voting structure.

d. Any existing shareholders agreement or similar document.

Response:

Please see Exhibit I.CCC.11 for details of the ownership of 2562961 Ontario Ltd.

Please see Exhibits I.CCC.2 and I.CCC.10 for copies of agreements between 2562961 Ontario Ltd. and Enbridge Gas.

The other information requested in this interrogatory is not relevant.

ENBRIDGE GAS INC.
Answer to Interrogatory from
School Energy Coalition (SEC)

INTERROGATORY

Reference:

Ex. B/1/1, p. 5, 18

Question**:**

Please provide any agreements, memoranda of agreement, or letters of intent between the Applicant and the Affiliate with respect to the Project. Without limiting the generality of the foregoing, please provide details of how the Applicant will ensure security of supply of hydrogen given the IESO control of hydrogen production.

Response:

Please see Exhibit I.SEC.7. For the second part of this question please refer to Exhibit I.FRPO.4.

ENBRIDGE GAS INC.
Answer to Interrogatory from
School Energy Coalition (SEC)

INTERROGATORY

Reference:

Ex. B/1/1, p. 6, 8

Question:

Please provide any agreements, memoranda of agreement, or letters of intent between the IESO and the Affiliate with respect to the regulation service and/or the production of hydrogen by the Affiliate.

Response:

Attached is a redacted copy of the agreement governing the provision of service from 2569261 Ontario Ltd. to the IESO. The redactions reflect confidential information that the parties to the agreement are not prepared to have publicly disclosed.

CONFIDENTIAL

AGREEMENT

ieso
Power to Ontario.
On Demand.

IESO – Hydrogenics for Procurement of Regulation Service

Between

Hydrogenics
As The Ancillary Service Provider

and

INDEPENDENT ELECTRICITY SYSTEM OPERATOR

November 1, 2014

THIS AGREEMENT dated this November 1, 2014

BETWEEN:

Hydrogenics Corporation, a federally incorporated company having its registered address at 220 Admiral Boulevard, Mississauga, Ontario, L5T 2N6 (the "**ASP**")

- and -

The Independent Electricity System Operator, a corporation established and continued under the *Electricity Act, 1998,* S.O. 1998, c. 15, Sched. A, having its registered address at Suite 410, 655 Bay St., Toronto, Ontario, M5W 4E5 (the "*IESO*")

WHEREAS:

A. The *market rules* for the Ontario electricity market and the policies established by the *IESO* pursuant thereto set out: the rights, obligations and qualifications of *ancillary service providers* associated with the registration, testing and certification of facilities to provide a*ncillary service;* the rights and obligations of the *IESO* with respect to matters relating to the procurement of *ancillary service;* and the rights and obligations of *ancillary service providers* and the *IESO* with respect to the provision, monitoring and payment for *ancillary service.*

B. The ASP wishes to be registered by the *IESO* as an *ancillary service provider* for the provision of Regulation Service.

C. The ASP shall be participating in the *IESO-administered markets* including *energy* and *operating reserve* markets, as appropriate, and other such markets that may be developed over the term of this Agreement.

CONSIDERATION

NOW therefore, in consideration of the mutual covenants set forth herein and of other good and valuable consideration, the receipt and adequacy of which is hereby acknowledged, the Parties agree as follows:

ARTICLE 1
INTERPRETATION

1.1 **Incorporation of *market rules* Definitions:** All italicized terms shall have the meaning given to them in Chapter 11 of the *market rules* and all capitalized terms shall have the meaning set out in section 1.2.

1.2 **Supplementary Definitions:** In this Agreement, the following expressions shall have the meanings set out below unless the context otherwise requires:

"Affiliate" means, with respect to the ASP: (i) any other person or persons that Control the ASP, or is or are Controlled by the ASP, or is or are Controlled by the same person or persons that Control the ASP; and (ii) if the ASP or any such person mentioned in (i) is a corporation, any other corporation that is an "affiliate" of the first corporation as defined in the Business Corporations Act (Ontario).

"Agreement" means this agreement, including the Schedules to this agreement, and the expressions "hereof", "herein", "hereto", "hereunder", "hereby" and similar expressions refer to this agreement and not to any particular section or other portion of this agreement;

"Applicable Law" means all present and future laws, statutes, regulations, treaties, judgments and decrees applicable to that Party, property, transaction or event and, whether or not having the force of law, all applicable requirements, requests, official directives, rules, consents, approvals, authorizations, guidelines, orders and policies of any Governmental Authority having or purporting to have authority over that Party, property, transaction or event.

"ASP" has the meaning set out in the preamble to this Agreement.

"ASP Intellectual Property" means, any and all Intellectual Property which is conceived, invented, developed, improved or acquired solely by the ASP during the term in or related to the Facility.

"Breakage Costs" means without duplication, amounts reasonably and properly incurred by the ASP as a direct result of the termination of this Agreement before the Service Completion Date, but only to the extent that:

(a) such amounts are incurred in connection with the Project, including without duplication: (i) costs of materials or goods ordered or subcontracts placed that cannot be cancelled without such amounts being incurred; (ii) expenditures reasonably incurred in the anticipation of the performance of the Project in the future; (iii) demobilization costs, including the cost of any relocation of equipment or materials used in connection with the Project; and (iv) termination payments that are required under applicable law or lawful contracts of employment to be made to employees of the ASP provided that such contracts of employment were entered into solely in connection with the Project;

(b) the amounts are incurred under arrangements and/or agreements that are consistent with terms that have been entered into in the ordinary course of business and on reasonable commercial arm's length terms;

(c) the ASP has used all reasonable efforts to mitigate the quantity of such amounts; and

provided that, for certainty, the Breakage Costs shall not in any event include compensation for loss of future profits or business opportunity of the ASP or any subcontractors or any penalty clauses for early termination of contracts and/or agreements between the ASP and any third party.

"Certification" means the Facility has successfully completed the applicable Certification Tests as specified in Schedule 2 and **"Certified"** shall have the same meaning.

"Certification Tests" has the meaning given to it in section 2 of Part 1 of Schedule 2.

"Confidential Information" includes, without amending the definition of *confidential information* in the *market rules*, the information set out in Schedules 4, 5, and 6. The Parties agree that Confidential Information does not constitute "relevant terms and conditions of the contracts" within the meaning of section 9.8.1.4 of Chapter Seven of the *market rules.*

"Contract Price" has the meaning given to it in section 2 of Schedule 6.

"Control" means any of the following:

(a) the power to direct or cause the direction of the management, actions, policies or decisions of that person, whether directly or indirectly through other persons, and whether through the ownership of shares, voting securities, partnership interests, units of ownership or other ownership interests, or by contract, or otherwise;

(b) legal or beneficial ownership or control over equity or ownership interests in that person, whether directly or indirectly through other persons (i) having a subscribed value (taking into account contributions to be made) of more than one half of the subscribed value (taking into account contributions to be made) of all equity or ownership interests in that person; or (ii) carrying more than one half of the voting rights for: (A) the management, actions, policies or decisions of that person; or (B) the election or appointment of directors or managers of that person; or

(c) if the person is a corporation, "control" within the meaning of the Business Corporations Act (Ontario) in effect as at the date of this Agreement.

"Default" means either a Financial Default or a Material Non-Financial Default.

"Defaulting Party" has the meaning given to it in section 6.1.

"Direct Costs" means the direct costs properly and reasonably incurred by the ASP to carry out the Project between the Effective Date and the Termination Date and which are substantiated by the ASP, provided that the Direct Costs shall not in any event include compensation for loss of future profits or business opportunity of the ASP or any subcontractors or any penalty clauses for early termination of contracts and/or agreements between the ASP and any third party.

"Effective Date" means the date of this Agreement.

"Facility" means the *facility* to be constructed by the ASP to provide the Regulation Service as described in Schedule 4 and "Facilities" means, collectively, each Facility, if applicable.

"**Financial Default**" means a failure by a Party to pay any amount under this Agreement to the other Party when due, including any amount payable as compensation or indemnification for any loss or damage suffered by a Party which amount has been agreed by the Parties or, if disputed, has been determined in accordance with the dispute resolution procedures contemplated herein.

"Fixed Monthly Payment" has the meaning given to it in section 1 of Schedule 6.

"Governmental Authority" means any domestic government, including, any federal, provincial, municipal or local government, and any government agency, tribunal, commission or other authority exercising or purporting to exercise executive, legislative, judicial, regulatory or administrative functions of, or pertaining to, government.

"**Government Funding**" means any funding, tax credit, rebate, grant, or similar monetary assistance received or to be received by the ASP or an Affiliate from a Governmental Authority in connection with the provision of the Regulation Service.

"**Grid Energy Storage**" means commercially available technology that is *connected* to the transmission or *distribution system* and is capable of:

(a) absorbing grid energy (charging);

(b) storing grid energy for a period of time; and

(c) injecting grid energy (discharging) minus reasonable losses back into the grid or its equivalent (to reduce consumption by approximately the same amount of energy that was absorbed).

"**Insolvency Event**" means the occurrence of any one or more of the following events:

(d) the Party ceases or threatens to cease to carry on its business or a substantial part of its business as either an *ancillary service provider* or an *independent electricity system operator*;

(e) the Party enters into or takes any action to enter into an arrangement, composition or compromise with, or an assignment for the benefit of, all or any class of its creditors or members or a moratorium involving any of them;

(f) the Party is, or states that it is, unable to pay any or a portion of its debts when they fall due for payment;

(g) a receiver or receiver and manager or person having a similar or analogous function under the laws of any relevant jurisdiction is appointed in respect of any property of the Party which is used in or relevant to the performance by the Party of any of the obligations imposed on the Party as an *ancillary service provider* or *Independent Electricity System Operator* under the *market rules* or with any of the Party's obligations under this Agreement;

(h) an administrator, liquidator, trustee in bankruptcy or person having a similar or analogous function under the laws of any relevant jurisdiction is appointed in respect of the Party, or any action is taken to appoint such person;

(i) an application is made for the winding up or dissolution or a resolution is passed or any steps are taken to pass a resolution for the winding up or dissolution of the Party;

(j) the Party is wound up or dissolved, unless the notice of winding up or dissolution is discharged; or

(k) a court determines that the Party is insolvent or unable to generally pay its debts when they become due.

"Intellectual Property" means all domestic or foreign intellectual property of any kind, whether registered or not, including:

(a) trade-marks, design marks, logos, service marks, certification marks, official marks, trade names, business names, corporate names, trade dress, distinguishing guises, slogans, meta tags, keywords, adwords and other characters, brand elements or other distinguishing features used in association with wares or services, whether or not registered or the subject of an application for registration and whether or not registrable, and associated goodwill ("Trade-marks");

(b) inventions, discoveries, improvements, ideas, concepts, arts, processes, machines, articles of manufacture, compositions of matter, business methods, formulae, developments and improvements, whether or not patented or the subject of an application for patent and whether or not patentable, methods and processes for making any of them, and related documentation (whether in written or electronic form) and know-how ("Inventions");

(c) software in source code or object code form, documentation, literary works, artistic works, pictorial works, graphic works, musical works, dramatic works, audio visual works, performances, sound recordings and signals, including their content, and any compilations of any of them, whether or not registered or the subject of an application for registration, or capable of being registered ("Works");

(d) domain names, whether registered primary domain names or secondary or other higher level domain names ("Domain Names");

(e) industrial designs and all variants of industrial designs, whether or not registered or the subject of an application for registration and whether or not registrable ("Designs");

(f) all know-how and related technical knowledge, trade secrets, Confidential Information and other proprietary know-how, information of a scientific, technical, financial or business nature regardless of its form, and user documentation relating to the foregoing ("Technical Information");

(g) all registrations and applications for registration for any of the foregoing, together with any counterpart, renewal, extension, reissue, division, continuation or continuation-in-part or substitution or modification thereof; and

(h) the benefit of all waivers of moral rights.

"Joint Intellectual Property" means any and all Intellectual Property which is conceived, invented, developed, improved or acquired jointly by ASP and a third party during the Term in the performance of the Project.

"Longstop Date" means the day that is 30 months from the Effective Date.

"**Material Non-Financial Default**" means a breach of a term or condition of this Agreement by a Party, but does not include a Financial Default, having or reasonably expected to have, a material adverse effect on the other Party's ability to obtain and enjoy the primary rights and benefits under this Agreement.

"Monthly Payment" has the meaning given to it in section 3 of Schedule 6.

"Non-Defaulting Party" has the meaning given to it in section 6.1.

"Party" means a party to this Agreement and "Parties" means every Party.

"Project Intellectual Property" means, collectively, the ASP Intellectual Property, the Third Party Intellectual Property, and the Joint Intellectual Property.

"**Project**" has the meaning given to it in section 3.1.

"Proposal Extracts" means the extracts from the ASP's proposal (as defined in the Request for Proposal) as may be amended or supplemented by the ASP's responses to various requests for clarification issued by the *IESO* (pursuant to the terms of the Request for Proposal), all of which extracts, responses and requests for clarification are attached as Schedule 4 Appendix 4A.

"Regulation Capacity" means the amplitude of variation of power output about a base-point which a *facility* is capable of executing when providing Regulation Service. Regulation Capacity is expressed as (± MW).

"Regulation Service" means the contracted *regulation* service to be provided by the ASP to *IESO* pursuant to this Agreement.

"Restricted Person" means any person who, or any member of a group of persons acting together, any one of which:

(a) has, directly or indirectly, its principal or controlling office in a country that is subject to any economic or political sanctions imposed by Canada for reasons other than its trade or economic policies;

(b) has as any part of its business the illegal manufacture, sale, distribution or promotion of narcotics substances or arms, or is or has been involved in the promotion, support or carrying out of terrorism;

(c) in the case of an individual, he or she (or, in the case of a legal entity, any of the members of its board of directors or its senior executive) has been sentenced to imprisonment or otherwise given a custodial sentence, other than a suspended sentence, for any criminal offence, other than minor traffic offences, less than five years prior date at which the consideration of whether such individual is a "Restricted Person" is made hereunder;

(d) has as its primary business the acquisition of distressed assets or investments in companies or organizations which are or are believed to be insolvent or in a financial standstill situation or potentially insolvent;

(e) is subject to a claim of the IESO or any Governmental Authority under any proceedings (including regulatory proceedings) which have been concluded or are pending at the time of any proposed transaction and which (in respect of any such pending claim, if it were to be successful) would, in the view of the IESO, in either case, be reasonably likely to materially affect the performance by the ASP of its obligations under this Agreement;

(f) has been convicted of an offence under the Proceeds of Crime (Money Laundering) and Terrorist Financing Act (Canada), or has been convicted of the commission of a money laundering offence or a terrorist activity financing offence under the *Criminal Code* (Canada); or

(g) whose standing or activities are inconsistent with or may compromise the reputation or integrity of the IESO.

"Service Commencement" means the ASP has satisfied the conditions set out in section 3.8 resulting in the issuance by the *IESO* of a Service Commencement Notice and the ASP has acknowledged receipt of such notice.

"Service Commencement Date" means the day on which Service Commencement occurs.

"Service Commencement Notice" means a new facility notification, or equivalent, that authorizes the ASP to start providing the Regulation Service.

"Service Completion Date" means the date that is 36 months from the Service Commencement Date as may be extended pursuant to section 7.9 of this Agreement.

"Suspension" has the meaning given to it in section 7.8.

"Target Service Commencement Date" means March 1, 2016 or such other date as may be determined by the *IESO*, in its sole discretion.

"Termination Date" has the meaning given to it in section 7.1.

"Third Party Intellectual Property" means, any and all Intellectual Property which is conceived, invented, developed, improved or acquired solely by a third party, during the Term in the performance of the Project.

"Total Fixed Payment" has the meaning given to it in section 1 of Schedule 6.

"**Variable Payment**" means the net wholesale energy related costs and charges incurred by the ASP in providing Regulation Service and if applicable 75% of assessed local distribution demand charges.

1.3 **Interpretation:** In this Agreement, unless the context otherwise requires:

1.3.1 when italicized, other parts of speech and grammatical forms of a word or phrase defined in this Agreement have a corresponding meaning;

1.3.2 a reference to an article, section, provision or schedule is to an article, section, provision or schedule of this Agreement;

1.3.3 a reference to any statute, regulation, proclamation, order in council, ordinance, by-law, resolution, rule, order or directive includes all statutes, regulations, proclamations, orders in council, ordinances, by-laws or resolutions, rules, orders or directives varying, consolidating, re-enacting, extending or replacing it and a reference to a statute includes all regulations, proclamations, orders in council, rules and by-laws of a legislative nature issued under that statute;

1.3.4 a reference to a document or provision of a document, including this Agreement and the *market rules* or a provision of this Agreement or the *market rules*, includes an amendment or supplement to, or replacement or novation of, that document or that provision of that document, as well as any exhibit, schedule, appendix or other annexure thereto;

1.3.5 a reference to a person includes that person's heirs, executors, administrators, successors and permitted assigns;

1.3.6 a reference to sections of this Agreement or of the *market rules* separated by the word "to" (*i.e.*, "sections 1.1 to 1.4") shall be a reference to the sections inclusively;

1.3.7 the expression "including" means including without limitation, the expression "includes" means includes without limitation and the expression "included" means included without limitation; and

1.3.8 a reference in this Agreement to the *market rules* includes a reference to any policies established by the *IESO* pursuant to the *market rules*.

1.4 **Headings:** The division of this Agreement into articles and sections and the insertion of headings are for convenience of reference only and shall not affect the interpretation of this Agreement, nor shall they be construed as indicating that all of the provisions of this Agreement relating to any particular topic are to be found in any particular article, section, subsection, clause, provision, part or schedule.

1.5 **Conflict of Documents:** In the event of any ambiguities, conflicts or inconsistencies between or among the provisions of this Agreement, the Proposal Extracts, or the *market rules*, the following principles shall apply:

1.5.1 the interpretation of this Agreement shall be purposive and liberal so as to avoid to the extent reasonably possible findings of inconsistency between this Agreement and the *market rules;*

1.5.2 in the case of any ambiguity, conflict or inconsistency relating to the requirements or the scope of the Project to be provided by the ASP, the provisions (including any part of the Proposal Extracts) establishing the more stringent requirements or broader scope of the Project shall prevail;

1.5.3 subject to section 1.5.1, in the case of any ambiguity, conflict or inconsistency between or among the Proposal Extracts and any other provision of this Agreement, the provisions of this Agreement or the relevant part or parts thereof shall prevail unless, in its discretion, the *IESO* confirms that the relevant Proposal Extract or the relevant part or parts thereof shall prevail; and

1.5.4 notwithstanding sections 1.5.1, 1.5.2, and 1.5.3, the *market rules* shall prevail.

ARTICLE 2
MARKET RULES

2.1 **Market Rules:** The Parties will comply with the *market rules*.

2.2 **Exemptions:** The ASP shall be responsible for obtaining any *exemption* or amendment to the *market rules* which is necessary to facilitate the Project as set out in this Agreement. The *IESO* agrees to reasonably assist the ASP in any efforts to obtain any such *exemption* or amendment to the *market rules*. The ASP acknowledges that there is no assurance that any such *exemption* or amendment to the *market rules* will be obtained.

ARTICLE 3
RIGHTS AND OBLIGATIONS IN RELATION TO THE ASP

3.1 **The Project**: Subject to and in accordance with the provisions of this Agreement, the ASP shall:

3.1.1 provide, perform and carry out all work required to construct the Facility and provide the Regulation Service in accordance with:

(a) the terms and conditions of this Agreement;

(b) the technical obligations set out in Schedule 1;

(c) the procedure for communicating Regulation Service requirements and provision as set out in Schedule 3;

(d) the description of the Facility set out in Schedule 4;

(e) the Regulation Capacities and ramp rates as set out in Schedule 5;

(f) the Proposal Extracts;

(g) all Applicable Laws; and

3.1.2 perform and observe all of its other obligations under this Agreement;

(collectively, the "**Project**"), all at its own cost and risk and without recourse to the *IESO*, except as expressly provided otherwise in this Agreement.

3.1.3 The Parties agree that the permitting, detailed engineering and pre-construction phase of the project may identify barriers to the ASP constructing the project at the location as outlined in Schedule 4, Table 1. If such barriers are identified, the Parties agree that the ASP has the right to identify an alternate location in Envelope 4 for the Project provided:

(a) the Project description and specifications set out in Schedule 4 shall continue to apply to the Project in such new location;

(b) the revised project location is submitted to the IESO for review and subsequent approval, which shall not be unreasonably withheld;

(c) all cost and risks related to the relocation of the Project, to a new location, are born by the ASP; and

(d) the Longstop Date remains in effect.

3.2 **Regulation Services:** Without limiting anything in section 3.1 of this Agreement, the ASP shall:

3.2.1 deliver the hourly quantities of the Regulation Services requested by the *IESO* as set out in Schedule 3 and reconciled as described in Schedule 6 of this Agreement; and

3.2.2 provide, Regulation Service quantities from the Facility in accordance with:

(a) the requirements set out in Schedule 4;

(b) the estimated acceleration rates, and certified Regulation Capacities and ramp rates as set out in Schedule 5 of this Agreement; and

3.2.3 respond to *dispatch instructions* to enable the *IESO* to assess the Facility's capabilities at both the bulk transmission and distribution levels to provide *ancillary services* and other services including bulk energy services, transmission infrastructure services, distribution infrastructure services and/or customer energy management services; and identify the opportunities that Grid Energy Storage could provide to the future operation of the *IESO-administered markets* (IAMs) and how best to integrate it into the IAMs.

3.3 **Compliance with *market rules***: The ASP hereby agrees to be bound by and to comply with all of the provisions of the *market rules* so far as they are applicable to Regulation Service providers in the same manner as if such provisions formed part of this Agreement.

3.4 **Permits and Licenses:** The ASP shall from the Service Commencement Date, and at all times thereafter and during the term of this Agreement hold and maintain in good standing all permits, licenses and other authorizations that may be necessary to enable it to carry out the Project and carryon the business and perform the functions and obligations of an *ancillary service provider* as described in the *market rules*. For greater certainty, the ASP shall be solely responsible for obtaining all such licenses, permits and other authorizations.

3.5 **Notification Obligations**: The ASP shall, immediately notify the *IESO* upon the occurrence of, or upon becoming aware of any circumstances that may give rise to, any of the following events:

(a) the ASP ceases to satisfy any material qualifications referred to in Chapters 4, 5 and 7 of the *market rules* in relation to the provision of Regulation Service;

(b) the ASP ceases to satisfy any material requirement imposed upon it as a condition of its registration as a *generator* in order to provide an *ancillary service*;

(c) it becomes unlawful for the ASP to comply with any of the obligations imposed on *ancillary service providers* under the *market rules* or with any of the ASP's obligations under this Agreement;

(d) a license, permit or other authorization referred to in section 3.4 is suspended, revoked or otherwise ceases to be in full force and effect;

(e) an Insolvency Event in respect of the ASP; and

(f) any other event in respect of the ASP that is likely to materially affect:

  (i) the performance by the ASP of its obligations under the *market rules* or this Agreement in relation to the provision of Regulation Service; or

  (ii) the performance by the *IESO* of its obligations under the *market rules* or this Agreement in relation to the provision of Regulation Service.

3.6 **Payment Obligations:** The ASP shall make all payments required to be made under this Agreement promptly upon receiving any invoice therefore.

3.7 **Exceptions**: Nothing in this Agreement shall require the ASP to maintain the availability of Regulation Capacity during an *outage*, or where to do so would endanger the safety of any person, damage equipment, harm the environment, or violate any Applicable Law, regulation, operating or good "corporate citizenship" limit.

3.8 **Service Commencement:** In order to achieve Service Commencement the following conditions must be met prior to the Target Service Commencement Date and no later than the Longstop Date:

(a) the ASP must be a registered *market participant*;

(b) the Facility must have achieved Certification; and

(c) the ASP is not in Default.

For greater certainty, the ASP shall be solely responsible for meeting the conditions listed above and the *IESO* shall be under no obligation to deem that such conditions have been met other than as explicity set out in this Agreement (including Schedule 2 of this Agreement with respect to Certification of the Facility).

3.9 **Certification:** The Facility must be Certified at all times it is providing the Regulation Service. If, following a Certification Test pursuant to Schedule 2, the Facility is deemed not to have maintained its Certification, the ASP shall have no further obligation or responsibility whatsoever to comply with the performance standards described in this Agreement in relation to the provision of Regulation Service. However, in accordance with *market rules* Chapter 7 section 9.5.2, when necessary in order to maintain system *reliability* or when the *IESO controlled grid* is in an *emergency operating state*, the *IESO* may direct a *registered facility* to provide Regulation Service even though the *IESO* does not have an *ancillary service contract* with that *registered facility*.

3.10 **Disclosure of Government Funding**: The ASP is obligated to promptly disclose to the *IESO* the amount and source of any and all Government Funding, and represents that it has disclosed to the *IESO* the amount and source of all Government Funding it has received prior to the Effective Date Subject to the confidentiality requirements in this Agreement the ASP shall disclose to any Governmental Authority which has provided Government Funding that the ASP has a contract for Regulation Service with the *IESO*.

3.11 **Additional Revenue:** If, during the term of this Agreement, the Facility: (i) obtains revenue from electricity sector mechanisms existing as of the Service Commencement Date as measured by a registered wholesale meter; or (ii) obtains any new revenue streams that are not captured in this Agreement (collectively the "**Additional Revenue**"); the Additional Revenue will be netted against any net wholesale energy costs that may accrue to the Facility or the ASP. For greater certainty if, during the term of this Agreement, the ASP becomes a *market creditor* the IESO will deduct the Additional Revenues from their Monthly Payments as set out in Schedule 6.

ARTICLE 4
RIGHTS AND OBLIGATIONS IN RELATION TO THE *IESO*

4.1 **Compliance with Market Rules:** The *IESO* hereby agrees to be bound by and to comply with all of the provisions of the *market rules* so far as they are applicable to the *IESO* in the same manner as if such provisions formed part of this Agreement.

4.2 **Information:** The *IESO* shall promptly disclose or provide to the ASP such information as is required to be disclosed or provided to the ASP pursuant to the *market rules* and this Agreement. Information disclosed or provided by the *IESO* shall be, to the best of the *IESO 's* knowledge, acting reasonably, true, correct, and complete at the time at which such disclosure or provision is made. Where the *IESO* discovers that any information previously disclosed or provided by it to the ASP was untrue, incorrect, or incomplete, the *IESO* shall as soon as reasonably practicable in the circumstances rectify the situation and disclose or provide the true, correct, or complete information to the ASP.

4.3 **Audits:** The *IESO,* at its own cost, shall have the right to audit, once every six months during normal business hours and upon reasonable notice, the records and procedures of the ASP in order to verify compliance by the ASP with its obligations under this Agreement.

4.4 **Performance Evaluation:** The *IESO* shall evaluate the ASP performance as it relates to Regulation Service through testing specified in Schedule 2 of this Agreement.

4.5 **Payment:** The *IESO* shall make all payments required to be made to the ASP in accordance with section 7.7 of this Agreement, Schedule 6 and the *IESO Settlement Schedule and Payments Calendar*. The *IESO* will include compensation and *settlement* details for the *contracted ancillary service* contracts in the monthly *settlement statements*, invoices and funds transfer as per the *real-time market settlement process* specified in the *market rules*.

4.6 **Government Funding**: In the event that the ASP or an Affiliates receives any Government Funding, the *IESO* shall have the right to modify either the Fixed Payments or Variable Payments to be made to the ASP in order to offset any amounts received by the ASP pursuant to this Agreement which the *IESO* determines, in its sole discretion, are duplicated by such Government Funding.

4.7 **Notification of Significant Events**: The *IESO* shall, as soon as reasonably practicable in the circumstances, notify the ASP of the occurrence of, or upon becoming aware of any circumstances that may give rise to, any of the following events:

4.7.1 if the *IESO* ceases to satisfy any material qualifications referred to in the *market rules* in relation to the procurement of Regulation Service;

4.7.2 if it becomes unlawful for the *IESO* to comply with any of the obligations imposed on the *IESO* under the *market rules* or with any of the *IESO's* obligations under this Agreement;

4.7.3 if the *IESO* experiences an Insolvency Event; and

4.7.4 any other event that is likely to materially affect the performance by the *IESO* or the ASP of their obligations under the *market rules* or this Agreement in relation to the procurement of Regulation Service including without limiting the generality of the foregoing proposed changes to the *market rules* which are likely to have a material effect on the ASP 's rights and obligations relating to the provision of Regulation Service.

For greater certainty, the ASP acknowledges and agrees that the process for notification of an amendment to the *market rules* which exists thereunder shall satisfy the obligations of the *IESO* under this section 4.7.

ARTICLE 5
REPRESENTATIONS AND WARRANTIES

5.1 **Representations and Warranties of the *IESO*:** The *IESO* hereby represents and warrants that:

5.1.1 the execution, delivery and performance of this Agreement by it has been duly authorized by all necessary corporate and/or governmental action;

5.1.2 this Agreement constitutes a legal and binding obligation on the IESO, enforceable against the IESO in accordance with its terms; and

5.1.3 the IESO has reviewed this Agreement to ensure its consistency with and full compliance with the provisions of the *market rules*, and this Agreement and to the best of the IESO's knowledge is consistent with and in full compliance with the provisions of the *market rules*.

5.2 **Representations and Warranties of the ASP:** The ASP hereby represents and warrants that:

5.2.1 the execution, delivery and performance of this Agreement by it has been duly authorized by all necessary corporate and/or governmental action and that this Agreement constitutes a legal and binding obligation on the ASP, enforceable against the ASP in accordance with its terms;

5.2.2 it holds or will, prior to commencing to act as an *ancillary service provider*, hold all permits, licenses and other authorizations that may be necessary to enable it to carry on the business and perform the functions and obligations of an *ancillary service provider* as described in the *market rules* and in this Agreement;

5.2.3 the information provided in and in support of its application for registration as an *ancillary service provider* is true, accurate and complete in all respects;

5.2.4 the ASP is not a party to or, to its knowledge, threatened with any litigation or claim that, if successful, would materially adversely affect the financial condition of the ASP or its ability to fulfil its obligations under this Agreement; and

5.2.5 the ASP is not a Restricted Person.

ARTICLE 6
DEFAULT OBLIGATIONS

6.1 **Notice by Defaulting Party:** If a Party becomes aware of an event or occurrence which constitutes, or, which it reasonably believes is likely to constitute, or result in, a Default by it, the Party (the "**Defaulting Party**") shall:

(a) provide written notice to the other Party (the "**Non-Defaulting Party**") immediately after becoming aware of such event or occurrence, which notice shall include:
  - (i) a description of the event or occurrence giving rise to the Default;
  - (ii) the Defaulting Party's estimate of the likely duration of the Default; and
  - (iii) the steps the Defaulting Party intends to take to cure or mitigate the Default;

(b) keep the Non-Defaulting Party informed at reasonable intervals or upon the request of the Non-Defaulting Party, as soon as practicable thereafter, of:
  - (i) the cessation of that Default or the Defaulting Party's current estimate of the likely duration of the Default; and
  - (ii) any successful mitigation or minimization of the effects of that Default or any steps not yet taken which the Defaulting Party intends to take to cure or mitigate the Default; and

(c) provide the Non-Defaulting Party with any other information which it may reasonably request in connection with the Default or the matters referred to in paragraphs 6.1(a) and (b).

6.2 **Notice by Non-Defaulting Party:** If a Party becomes aware of an event or occurrence which constitutes or which, it reasonably believes is likely to constitute or result in, a Default by the other Party, then the Non-Defaulting Party may give the Defaulting Party notice of such event or occurrence. Upon receipt of such notice, the Defaulting Party shall keep the Non-Defaulting Party informed in accordance with sections 6.1 (a) and (b).

6.3 **Obligation to Cure:** Upon receiving notice under section 6.2 or otherwise becoming aware of an event or occurrence which constitutes, or is likely to constitute or result in, a Default by it, the Defaulting Party must make take all reasonable efforts to cure the Default or prevent the Default from occurring (as applicable).

6.4 **Acknowledgement:** For greater certainty, the Parties hereby acknowledge and agree that the following events constitute a Default and the Parties shall act in accordance with their obligations under this Article 6 upon their occurrence: (a) in the case of the ASP the events described in section 3.5; and (b) in the case of the *IESO* the events described in sections 4.7.1, 4.7.2 and 4.7.3.

ARTICLE 7
TERM AND TERMINATION

7.1 **Term:** This Agreement shall come into force on the Effective Date and shall remain in full force and effect until the Service Completion Date unless terminated earlier in accordance with Sections 7.2, 7.3, 7.4, 7.5, and 7.6 (the "**Termination Date**") .

7.2 **Termination for Change of Law:** Upon a change in the *market rules* or any Applicable Law of a Governmental Authority which has a material adverse impact on a Party's rights and obligations relating to the Project (a "**Change in Law**"), that Party may terminate this Agreement upon 30 days written notice and, without limiting the foregoing right of termination, the Parties may, by mutual agreement, enter into negotiations to adjust the Contract Price to reflect the effects of the applicable Change in Law on the Project.

7.3 **Termination for Insolvency Event**: If an Insolvency Event occurs in relation to a Party, then the other Party may terminate this Agreement at any time upon written notice to the first Party.

7.4 **Longstop Termination**: If Service Commencement has not occurred by the Longstop Date, then the *IESO* may terminate this Agreement at any time by written notice to the ASP.

7.5 **Termination for Default**: If a defaulting Party does not cure a Material Non-Financial Default within 30 days of providing notice to the Non-Defaulting Party as set out in section 6.1 or receiving notice from the Non-Defaulting Party as set out in section 6.2, then the Non-Defaulting Party may terminate this Agreement upon further written notice to the Defaulting Party. Notwithstanding the foregoing, if the Material Non-Financial Default cannot reasonably be cured within 30 days, the Defaulting Party may submit a plan (the "**Rectification Plan**") for curing the Default to the Non-Defaulting Party, which shall include a proposed timeline for doing so. If the Non-Defaulting Party, in its reasonable discretion, accepts the Rectification Plan, then it shall not terminate this Agreement unless the Default is not cured by the time indicated in the Rectification Plan .

7.6 **Termination for Convenience:** The *IESO* may terminate this Agreement at any time for any reason other than those listed in sections 7.2 to 7.5 upon 30 days written notice to the ASP.

7.7 **Compensation on Termination**

7.7.1 **Compensation for ASP Non-Default Termination:** if this Agreement is terminated: (i) by the *IESO* pursuant to section 7.6; (ii) by the ASP pursuant to section 7.3 or 7.5; or (iii) by either Party pursuant to section 7.2; then the *IESO* shall pay to the ASP an amount, without duplication, equal to:

(a) the Direct Costs; plus

(b) the Breakage Costs;

minus

(c) any amounts paid by the *IESO* to the ASP pursuant to Schedule 6 as of the Termination Date;

but in no event shall such amount exceed the Total Fixed Payment.

7.7.2 **Compensation on ASP Default Termination:** if this Agreement is terminated by the *IESO* pursuant to section 7.3, 7.4, 7.5 or 7.8 then the ASP shall not be entitled to any amount other than payments received by the ASP from the *IESO* pursuant to Schedule 6 as of the Termination Date.

7.8 **IESO Right of Suspension**: Following the Service Commencement, if the ASP fails to maintain Certification, then the IESO may suspend the ASP's performance of the Regulation Service under this Agreement upon written notice to the ASP (the "**Suspension**"). The Suspension shall continue until the Facility has once again achieved Certification and the IESO issues a written notice to the ASP to resume the Regulation Service under this Agreement. Notwithstanding the foregoing, if the IESO reasonably determines, in its sole discretion, that the planned and/or unplanned outage rate of the Facility is excessive such that the Facility is not able to provide the Regulation Service consistently, the IESO may exercise its right of Suspension until such time that the ASP provides sufficient assurance that it can provide the Regulation Service. In addition, the ASP may, with sufficient notice to the *IESO*, elect to suspend the contract for a limited amount of time to allow the ASP to resolved unanticipated issues. The duration of all Suspensions during the term of this Agreement shall not exceed six months, at which time the IESO may terminate this Agreement upon written notice to the ASP.

7.9 **Extension of Service Completion Date:** The Service Completion Date shall be extended by an amount of time equal to the duration of a Suspension under section 7.8 but in no event shall the Service Completion Date be extended by more than six months.

ARTICLE 8
PAYMENT

8.1 **Pricing Criteria:** The *IESO* shall use the pricing structure described in Schedule 6 of this Agreement for calculation of the payments due to the ASP for the provision of Regulation Service pursuant to this Agreement.

ARTICLE 9
MISCELLANEOUS

9.1 **Confidentiality Obligation:** Each Party shall keep confidential any Confidential Information pertaining to the other Party in accordance with the provisions of the *market rules*. Notwithstanding the foregoing, the IESO may, at any time, disclose orally or in writing (including in a press release or associated briefing documents) your selection as a Preferred Respondent, as well as the type of technology, Power Storage Capacity, and envelope location of the Selected Project.

9.2 **Dispute Resolution:** Any dispute that arises under this Agreement shall be dealt with in accordance with the provisions of section 2 of Chapter 3 of the *market rules*.

9.3 **Amendment:** No amendment of this Agreement shall be effective unless made in writing and signed by the Parties.

9.4 **Assignment:** This Agreement may not be assigned, whether absolutely, in whole or in part, by a Party without the prior written consent of the other Party, such consent not to be unreasonably withheld or delayed provided that the proposed assignee agrees to assume all of the rights, responsibilities and obligations of the assigning Party under this Agreement.

9.5 **Successors and Assigns**: This Agreement shall ensure to the benefit of, and be binding on, the Parties and their respective heirs, administrators, executors, successors and permitted assigns.

9.6 **Further Assurances:** Each Party shall promptly execute and deliver or cause to be executed and delivered all further documents in connection with this Agreement that the other Party may reasonably require for the purposes of giving effect to this Agreement.

9.7 **Waiver:** A waiver of any Default, breach or non-compliance under this Agreement is not effective unless in writing and signed by the Party to be bound by the waiver. No waiver will be inferred or implied by any failure to act or by the delay in acting by a Party in respect of any Default, breach or non-observance or by anything done or omitted to be done by the other Party. The waiver by a Party of any Default, breach or non-compliance under this Agreement shall not operate as a waiver of that Party's rights under this Agreement in respect of any continuing or subsequent Default, breach or non-observance (whether of the same or any other nature).

9.8 **Severability**: Any provision of this Agreement that is invalid or unenforceable in any jurisdiction shall, as to that jurisdiction, be ineffective to the extent of that invalidity or unenforceability and shall be deemed severed from the remainder of this Agreement, all without affecting the validity or enforceability of the remaining provisions of this Agreement or affecting the validity or enforceability of such provision in any other jurisdiction.

9.9 **Notices**: Any notice, demand, consent, request or other communication required or permitted to be given or made under this Agreement shall be given or made in the manner set forth in section 8.1 of Chapter 1 of the *market rules*. Either Party may change its address and representative as set forth in Schedule 7 by written notice to the other Party given as aforesaid. Such change shall not constitute an amendment to this Agreement for the purposes of the application of section 9.3.

9.10 **Governing Law:** This Agreement shall be governed by and construed in accordance with the local domestic laws of the Province of Ontario and the laws of Canada applicable therein.

9.11 **Counterparts:** This Agreement may be executed in any number of counterparts, each of which shall be deemed to be an original and all of which taken together shall be deemed to constitute one and the same instrument. Counterparts may be executed either in original or faxed form and the Parties adopt any signatures received by a receiving facsimile machine as original signatures of the Parties; provided, however, that any Party providing its signature in such manner shall promptly forward to the other Party an original signed copy of this Agreement which was so faxed.

9.12 **Third Party – Beneficiaries**: In connection with this Agreement, the Parties shall be acting on their own behalf and shall benefit from the limitations of liability and other provisions of this Agreement. The Parties shall not be acting as agent, fiduciary or trustee for any other person or legal entity, and accordingly it is the Parties' intention that no person or legal entity other than the Parties hereto shall have any rights or remedies under or the ability to enforce this Agreement in any manner, directly or indirectly. The Parties further agree that the foregoing provisions shall not act as a waiver of subrogation by the Parties' insurers.

9.13 **Liability, Indemnification and Force Majeure:** The Parties acknowledge and agree that section 13 of Chapter 1 of the *market rules* applies to this Agreement. Notwithstanding anything to the contrary in section 13 of Chapter 1 of the *market rules*, the aggregate liability of the IESO to the ASP shall not exceed an amount equal to the Total Fixed Payment.

9.14 **Entire Agreement:** This Agreement constitutes the entire agreement between the Parties with respect to the matters contemplated by this Agreement and supersedes all prior agreements, representations, undertakings, warranties, negotiations and discussions, whether oral or written, of the Parties.

9.15 **Collaboration and Assessment:** Both Parties agree to meet no less than twice a year to review the operation of the Facility providing Regulation Service, and to identify opportunities to enhance the Facility's contribution to the reliable operation of the *IESO-Controlled Grid* during the term of this Agreement. Both Parties agree to participate in this collaboration and assessment activity in good faith.

9.16 **Project Intellectual Property:** The Parties acknowledge and agree that the Project Intellectual Property is the sole and exclusive property of ASP and that the *IESO* does not have any proprietary rights therein or any right to compensation therefor. The *IESO* shall reasonably cooperate with the ASP, without additional cost or expense to *IESO*, in the ASP's efforts to obtain such Project Intellectual Property.

9.17 **Currency:** All monetary amounts herein refer to lawful currency of Canada.

9.18 **Survival:** Notwithstanding any other provision of this Agreement, the provisions of sections 2.1, 5.1, 5.2, 7.7, 9.1, 9.2, 9.10, 9.12, 9.13, 9.16, and 9.18 shall survive the expiry of this Agreement. For greater certainty, the termination or expiration of all or part of this Agreement for any reason does not affect any rights of either Party against the other that arose prior to the time at which such termination or expiration occurred or otherwise relate to or may arise at any future time from any breach or non-observance of obligation under this Agreement occurring prior to the termination or expiration.

9.19 **Schedules:** The following Schedules are attached to and form part of this Agreement:

Schedule 1: Technical Obligations of the ASP for the Regulation Service
Schedule 2: Procedures For Testing Regulation Service Capability
Schedule 3: Procedure For Communicating Regulation Service Requirements, Assigning *Facilities* To Provide Regulation Service, And Reconciling Hourly Quantities For Payment
Schedule 4: Description Of Facilities Providing Regulation Service
Schedule 5: Certified Regulation Capacities and Ramp Rates
Schedule 6: Payment
Schedule 7: Nominated Representatives for Notifications

IN WITNESS WHEREOF the Parties have, by their duly appointed representatives, executed this Agreement.

Hydrogenics Corporation

By: ________________________________ c/s

Name: Daryl Wilson
Title: President & CEO, Hydrogenics

Independent Electricity System Operator

By: ________________________________ c/s

Name: Kim Warren
Title: Chief Operating Officer

SCHEDULE 1

TECHNICAL OBLIGATIONS OF THE ASP FOR REGULATION SERVICE[1]

PART 1: *Regulation*

A *market participant* providing *regulation* from a *facility* must meet the following requirements. It is recognized and agreed by the ASP and the *IESO* that deviations from these requirements may occur from time to time, and that the ASP shall advise the *IESO* of any such deviations as soon as reasonably practicable in the circumstances. The following sections of the *market rules* contain requirements concerning *regulation*.

(a) Chapter 2, Appendix 2.2
(b) Chapter 4, Appendices 4.2, 4.8, 4.15, and 4.19
(c) Chapter 5, sections 4.4, 4.9, 4.10, section 12, and Appendix 5.1 section 1.1
(d) Chapter 7, section 9

1. The *facility* shall be capable of complying with the Performance Standards for *Ancillary Services* set out in the *market rules* Chapter 5 Appendix 5.1 section 1.1.

2. The *ancillary service provider* shall provide *regulation* ramp rates from its *facilities* as specified in Schedule 5.

3. The *ancillary service provider* shall provide from its *facilities* hourly *regulation* capacities scheduled day ahead by the *IESO*, and confirmed or changed day at hand.

PART 2: Responding to *Dispatch Instructions*

A *market participant* providing Regulation Services may be required to participate in the *IESO-administered markets* including *energy* and *operating reserve* markets, as appropriate, and other such markets that may be developed over the term of this Agreement. As such, they must meet the following additional requirements. It is recognized and agreed by the ASP and the *IESO* that deviations from these requirements may occur from time to time, and that the ASP shall advise the *IESO* of any such deviations as soon as reasonably practicable in the circumstances.

4. Submit data to the *IESO*, which may be *dispatch data*, in the time-frame and format required, to allow the *IESO* to determine an economic *dispatch* of the *facility*.

5. Respond to *dispatch instructions* in a manner consistent with its Technical Capabilities and in compliance with the *market rules*.

Part 3: General

6. The *facility* shall be a *registered facility* with the *IESO* (satisfying all applicable registration requirements).

7. Communication services approved by the *IESO* shall be in place between the *facility* control interface and the *IESO* Energy Management System (EMS).[2] The *IESO* may agree to the *facility* meeting equivalent standards to those set forth in the PTRM which the *IESO* determines are suitably applicable to the *facility* and which do not impact the reliable operation of the *IESO-controlled grid*.

8. Primary and alternate voice communications services approved by the *IESO* shall be in place to provide voice communication between the *IESO* control center and the operator controlling the *generation facility* or *load facility* as the case may be. If the *control centre* acting as the designated dispatch entity is located outside of Ontario, the

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[1] Throughout this *Agreement* and in the referenced sections of the *market rules* any specific references to *generation facilities* as providers of *regulation* service do not exclude any other *facilities* from providing this service and any technical requirements associated with the provision of Regulation Services from *generation facilities* in these sections shall also be applied to the provision of Regulation Services from *energy* storage devices subject to the terms of this Agreement.

[2] Refer to the *IESO*'s Market Manual 6: Participant Technical Reference Manual (PTRM) for details. This Manual is accessible through the Internet, at www.ieso.ca.

Market Participant shall provide the *IESO* internet access at the proposed *control centre*.

9. The participant *dispatch* messaging system to the *ancillary service provider* shall be in place.
10. When events such as scheduled maintenance, *forced outages*, equipment faults and deratings make a *facility* unable to supply its certified Regulation Capacity or ramp rate or meet its Grid Energy Storage capabilities, the *ancillary service provider* will inform the *IESO* of such restriction on the *facility's* supply of Regulation Service together with the reason.

– End of Section –

SCHEDULE 2
PROCEDURES FOR TESTING REGULATION SERVICE CAPABILITY AND GRID ENERGY STORAGE CAPABILITY

PART 1: GENERAL

1. This Schedule 2 sets out the requirements and procedures for Certification of the Facility. Part 1 of this Schedule 2 sets out definitions and general provisions. Part 2 of this Schedule 2 describes the requirements for Certification prior to Service Commencement. Part 3 of this Schedule 2 describes the requirements for Certification following Service Commencement. Part 4 of this Schedule 2 sets out the procedures for the Facility Certification Tests. Part 5 of this Schedule 2 sets out the procedures for the On-Line Diagnostic Test.

2. In this Schedule 2, the following expressions shall have the meanings set out below unless the context otherwise requires:

   "**Annual Certification Tests**" has the meaning given to it in section 2 of Part 3 of this Schedule 2;

   "**Certification Tests**" means, collectively, the Facility Certification Tests and the On-Line Diagnostic Test;

   "**Certified Capabilities**" means the Facility Capabilities set out in Schedule 5 of this Agreement;

   "**Facility Capabilities**" means the Regulation Capabilities and the Grid Energy Storage Capabilities;

   "**Facility Certification Tests**" means, collectively, the Regulation Capability Test and the Grid Energy Storage Capability Test;

   "**Grid Energy Storage Capabilities**" has the meaning given to it in section 4.5.1 of Part 4 of this Schedule 2;

   "**Grid Energy Storage Capability Test**" has the meaning given to it in section 4.5.1 of Part 4 of this Schedule 2;

   "**On-Line Diagnostic Test**" has the meaning given to it in section 5.1.1 of Part 5 of this Schedule 2;

   "**Proposed Capabilities**" means the Facility Capabilities set out in Schedule 4 of this Agreement;

   "**Reduced Capabilities**" means the Tested Capabilities do not meet the Certified Capabilities;

   "**Regulation Capabilities**" means, collectively, the Regulation Capacity and the Regulation Ramp Rate;

   "**Regulation Capability Test**" has the meaning given to it in section 4.1.1 of Part 4 of this Schedule 2;

   "**Results Notice**" has the meaning given to it in section 1.5 of Part 1 of this Schedule 2;

   "**Results Notice Date**" means the day on which the ASP receives the Results Notice from the IESO; and

   "**Tested Capabilities**" means the Facility Capabilities as measured by the results of a given Certification Test.

3. All Certification Tests shall be conducted in accordance with *market rules* Chapter 5, Section 4.9.2.6 and Appendix 5.1 – Performance Standards for *ancillary services* or as otherwise set forth in this Schedule 2.

4. The tests described in this Schedule 2 assume that any necessary tuning of the *regulation* controllers at the *IESO* and at the Facility, to match the sending characteristics with the receiving characteristics, has previously been carried out, in accordance with the *outage* scheduling process.

5. The *IESO* shall provide the results of any Certification Test in writing to the ASP within 5 days of such test (the "**Results Notice**").

6. The ASP shall be responsible for all costs incurred by it in respect of any Certification Tests.

PART 2: CERTIFICATION REQUIREMENTS PRIOR TO SERVICE COMMENCEMENT

1. The Facility must achieve Certification prior to Service Commencement.

2. Prior to the Target Service Commencement Date (and in no event later than the Longstop Date), the ASP shall inform the *IESO* , by written notice, that it believes the Facility is capable of successfully completing the Certification Tests. The *IESO* and the ASP shall then schedule a date (or dates) to conduct the Certification Tests.

3. If the Tested Capabilities meet or exceed the Proposed Capabilities, then the Facility shall be deemed to have achieved Certification.

4. If, the Tested Capabilities do not meet or exceed the Proposed Capabilities, then the *IESO* may:

   (a) accept the Tested Capabilities in which case the Facility shall be deemed to have achieved Certification and the Tested Capabilities shall become the Certified Capabilities;

   (b) conditionally accept the Tested Capabilities, in which case the Parties shall enter into good-faith negotiations for a period of 30 days from the Results Notice Date to determine a corresponding revision to the Contract Price. If the Parties reach an agreement on a revised Contract Price (the "**Revised Contract Price**"), then the Facility shall be deemed to have achieved Certification, the Facility Capabilities shall become the Certified Capabilities and the Contract Price shall be amended to reflect the Revised Contract Price. If the Parties are unable to reach an agreement on a revised Contract Price then section 4(c) of this Part 2 of Schedule 2 shall apply; or

   (c) reject the Tested Capabilities in which case the Facility shall not have achieved Certification and the ASP may request to have the Facility tested again pursuant to Part 4 of Schedule 2.

PART 3: CERTIFICATION REQUIREMENTS FOLLOWING SERVICE COMMENCEMENT

1. The Facility must be Certified at all times from the Service Commencement Date to the Service Completion Date.

2. The Facility shall undergo the Certification Tests once during each 12-month period following the Service Commencement Date (the "**Annual Certification Tests**") in accordance with the *IESO outage* scheduling process, at a time that is mutually agreeable to the ASP and to the *IESO*.

3. If reasonably required the *IESO* may carry out an on-line diagnostic test (the "**On-Line Diagnostic Test**") to confirm Regulation Service operation from the Facility, to identify a possible failed *regulation* component so that a substitution can be made quickly when a failure has occurred, or to confirm that the Facility is meeting or exceeding the Facility Capabilities. The *IESO* shall cooperate with the ASP to ensure that the test is conducted in a manner causing minimum impact on the operation of the Facility.

4. If, following the Annual Certification Tests or the On-Line Diagnostic Test, as applicable, the Tested Capabilities meet or exceed the Certified Capabilities, then the Facility shall be deemed to have maintained Certification.

5. If the Annual Certification Tests or the On-Line Diagnostic Test, as applicable, result in Reduced Capabilities then the Facility shall be deemed not to have maintained Certification and the *IESO* may:

   (a) permit the ASP 30 days from the Results Notice Date to repair or correct the issue which caused the Reduced Capabilities at which time the Facility shall repeat the Annual Certification Tests or the On-Line Diagnostic Test, as applicable; or

   (b) exercise its right of Suspension pursuant to section 7.8.

6. During a Suspension, the ASP shall inform the *IESO* , by written notice, that it believes the Facility is capable of successfully completing the Annual Certification Tests, or On-Line Diagnostic Test, as applicable. The *IESO* and the ASP shall then schedule a date (or dates) to re-conduct the applicable test.

7. If, following the repeated Annual Certification Test or On-Line Diagnostic Test, pursuant to section 5(a) or 6 of this Part 3 of Schedule 2, the Tested Capabilities meet or exceed the Certified Capabilities, then the Facility shall be deemed to have achieved Certification.

8. If the repeated Annual Certification Tests or the On-Line Diagnostic Test pursuant to section 5(a) or 6 of this Part 3 of Schedule 2, again result in Reduced Capabilities then the *IESO* may:

    (a) accept the Reduced Capabilities in which case the Facility shall be deemed to have achieved Certification and the Certified Capabilities shall be amended to reflect the Reduced Capabilities;

    (b) conditionally accept the Reduced Capabilities, in which case the Parties shall enter into good-faith negotiations for a period of 30 days from the Results Notice Date to determine a corresponding revision to the Contract Price. If the Parties reach an agreement on a revised Contract Price (the "**Revised Contract Price**"), then the Facility shall be deemed to have achieved Certification, the the Certified Capabilities shall be amended to reflect the Reduced Capabilities and the Contract Price shall be amended to reflect the Revised Contract Price. If the Parties are unable to reach an agreement on a revised Contract Price then section 8(c) of this Part 3 of Schedule 2 shall apply; or

    (c) exercise its right of termination pursuant to section 7.5.

PART 4: FACILITY CERTIFICATION TESTS

4.1 Verification of Regulation Service Capabilities

1. The ability of the Facility to provide the Regulation Service shall be tested as set forth below in order to verify that the Regulation Service Capabilities are accurate and reflect the true capabilities of the Facility (the "**Regulation Capability Test**").

2. To validate operation of voice circuits, the *IESO* shall confirm the date and time of the test with the ASP using both the primary and alternate voice circuits.

3. When testing a group of units or single units which may provide somewhat different test results from test to test, the *IESO* or the ASP with the agreement of the other Party may repeat the tests below and reject results or make use of averaged test results as mutually agreed.

4.2 *Regulation* Raise Test

1. The *IESO* control center shall direct the operator at the *facility* to operate its *facility* to be tested, at an output at, or slightly below its maximum output for *regulation* operation as specified by the ASP less its Regulation Capacity as stated in Schedule 5. The *IESO* shall place the *facility* in Test mode and wait for the *facility* to be stable before sending any *regulation* signal to the *facility.* (A *load facility* or aggregated *load facility* providing *regulation* would be directed to operate at its maximum *load*).The *facility* will not be required to remain at its full charge set-point longer than its state of charge allows.

2. The *IESO* shall manually send a raise signal to the *facility* under test at a site. Just before sending the raise signal, the *IESO* will notify the ASP that the raise is about to occur so the ASP can verify the raise test. The *regulation* signal shall direct the *facility* to increase its output as fast as it can, by the amount of the Regulation Capacity, up close to its maximum output while on *regulation* control. The *IESO* shall record a graph of the output of the *facility* against time. (A *load facility* or aggregated *load facility* providing *regulation* would be sent a corresponding signal to reduce its load.) The *facility* will not be required to remain at its full charge set-point longer than its state of charge allows.

3. If the *facility* increases its output by its Regulation Capacity stated in Schedule 5 in less than ten minutes, the *IESO* shall record the ramp rate RUP as the Regulation Capacity (MW) divided by the time (minutes) it took for the *facility* to increase its output by its Regulation Capacity CUP. If the *facility* increases its output by an amount less than or equal to its Regulation Capacity stated in Schedule 5 in more than ten minutes, the *IESO* shall record the Regulation Capacity CUP as the output change (MW) in ten minutes. The *IESO* shall record the ramp rate RUP (MW per

minute) as the output change in ten minutes divided by ten minutes. (For a *load facility* or aggregated *load facility* providing *regulation*, the *IESO* would record the *load* reduction, time to reduce, and calculate the corresponding Rate.)

4.3 *Regulation* Lower Test

1. The *IESO* control center shall direct the operator at the *facility* to operate its *facility* to be tested, at an output at, or slightly above its minimum output for *regulation* operation as specified by the ASP plus its Regulation Capacity as stated in Schedule 5. The *IESO* shall place the *facility* in Test mode and wait for the *facility* to be stable before sending any *regulation* signal to the *facility*. (A *load facility* or aggregated *load facility* providing *regulation* would be directed to operate at its minimum load). The *facility* will not be required to remain at its full charge set-point longer than its state of charge allows.

2. The *IESO* control center shall manually send a "lower" signal to the *facility* under test. Just before sending the lower signal, the *IESO* will notify the ASP that the lower is about to occur so the ASP can verify the lower test. The *regulation* signal shall direct the *facility* to decrease its output as fast as it can, by the amount of its Regulation Capacity, down close to its minimum output while under *regulation* control. The *IESO* shall record a graph of the output of the *facility* against time. (A *load facility* or aggregated *load facility* providing *regulation* would be sent a corresponding signal to increase its load.) The *facility* will not be required to remain at its full charge set-point longer than its state of charge allows.

3. If the *facility* decreases its output by its Regulation Capacity stated in Schedule 5 in less than ten minutes, the *IESO* records the ramp rate RDOWN as the Regulation Capacity (MW) divided by the time (minutes) it took for the *facility* to decrease its output by its Regulation Capacity CDOWN. If the *facility* decreases its output by an amount less than or equal to its Regulation Capacity stated in Schedule 5 in more than ten minutes, the *IESO* records the Regulation Capacity CDOWN as the output change (MW) in ten minutes. The *IESO* records the ramp rate RDOWN (in MW per minute) as the output change in ten minutes divided by ten minutes. (For a *load facility* or aggregated *load facility* providing Regulation Service, the *IESO* would record the load increase, time to increase, and calculate the corresponding Rate.)

4.4 Test Results

1. The *IESO* records the verified *regulation capacity* "C" as the lesser of $\{C_{UP}, C_{DOWN}\}$. The *IESO* records the verified *regulation* ramp rate "R" as the lesser of $\{R_{UP}, R_{DOWN}\}$.

4.5 Verification of Grid Energy Storage Capabilities

1. The ability of the Facility to provide Grid Energy Storage, shall be tested through a protocol mutually upon by the Parties, in order to verify that the Grid Energy Storage Capabilities are accurate and reflect the true capabilities of the Facility (the "**Grid Energy Storage Capability Test**"). The capabilities to be tested and verified are set forth below (the "**Grid Energy Storage Capabilities**").

2. Response Time: The Grid Energy Storage Facility's ability to follow the *IESO's* signals at any time without the need for advance notification or warning (except when safety or environmental concerns are involved, and depending upon their state of charge). The Respondents shall provide the largest time interval required by the technology to switch from injection/store to absorption or absorption/store to injection upon receipt of the *IESO* signal.

3. Ramping Capability: The Grid Energy Storage Facility's ability to consistently ramp up or down, at any charge level, over their entire registered range. The ASP shall provide a single ramp rate (MW/minute) achievable at least 90% of the time, both for increasing and decreasing output while under *IESO* control. Where the ramping capability for absorbing and injecting energy are different, the ASP should provide the average of them. The ASP may use the derived ramping results conducted as set forth in this Schedule 2 to satisfy this ramping capability test.

4. Conversion Losses: The Grid Energy Storage Facility's conversion (charge/discharge) losses. The ASP shall provide these losses as a percentage of the total energy stored assuming that a full charge cycle is immediately followed by a full discharge cycle.

5. Storage Losses: The proposed Facility's storage (hold full charge) losses. The ASP shall provide these losses as a percentage of the total stored energy at full charge over 2, 12, and 16 hours assuming no intermediate re-charging or top-up.

6. Availability: The amount of time, expressed in percentage (%) of time over one calendar year the proposed Facility is available for providing the contracted services. The ASP should provide the percentage (%) of time the Facility is expected to be on-line that excludes the projected time required for regular maintenance, eventual upgrades (including firmware upgrade/re-commissioning) and changes or due to weather impact (assuming normal minimums and/or maximum according to Environment Canada's "climate normals" for the nearest weather station). For greater clarity it is understood that verification of availability is not permissible until the Grid Energy Storage Facility has been providing regulation service for over one calendar year. This test will be a retroactive assessment conducted by the ASP upon the direction of the IESO.

7. Power Storage Capacity of the Grid Energy Storage Facility. This means the maximum rate (in MW) at which the Facility can absorb or inject energy.

8. Energy Storage Capacity of the Grid Energy Storage Facility. This meansthe maximum amount of energy (in MWh) that the Facility holds in storage when fully charged.

9. Minimum and Maximum Full Charge Cycle Duration (hours) The "full charge cycle duration" is the time required by the grid energy storage facility to charge from its minimum loading point to its maximum loading point. "Minimum full charge cycle duration" is the shortest time the grid energy storage facility can achieve ("fast charge"), while "maximum full charge cycle duration" is the longest acceptable time (trying to charge slower than this would most likely result in unacceptable losses or damage the equipment).

10. All test results in this section shall be accurately reflected in Schedule 4.

4.6 Verification of Facility Communication Systems

1. The communication systems of the Facility shall be tested through a protocol mutually agreed upon by the Parties, in order to ensure that the IESO can communicate with the Facility. The communication systems to be tested are set forth below.

2. The *ancillary service provider* shall carry out the following tests under direction of the *IESO*:
   (a) confirmation of control communication path performance,
   (b) confirmation of voice circuits and the *dispatch* messaging system for receipt of *dispatch instructions*, and
   (c) confirmation of control by the *IESO* Energy Management System (EMS) over the range of *regulation* specified in Schedule 4 of this Agreement.

PART 5: ON-LINE DIAGNOSTIC TEST

5.1 General

1. The *IESO* may occasionally, only if reasonably required, carry out an on-line diagnostic test (the "**On-Line Diagnostic Test**") with respect to the provision of Regulation Service. Such tests will be conducted with ten minutes notification, outside the normal *outage* planning process. Such tests will be carried out with the intent of causing minimum impact to the ASP in its operation of the *facility*. At the *IESO*'s discretion, a subset of the tests listed in section 5.2 of this Part 5 of this schedule may be executed.

5.2 Test Procedure

1. The *IESO* shall inform the ASP of the need for an on-line diagnostic test and will inform the ASP of any evidence it has that would help identify why a *facility* is considered deficient. If the *IESO* requires more than one *facility* to be tested, both Parties will agree on the order of testing at each site.

2. To test the ability of the *facility* to provide *regulation*, the following steps are taken:

   a) At the beginning of testing at each *facility*, the *IESO* shall remove the agreed *facility* from *regulation* automatic control, and place it in Regulation Service control in Test mode. The *IESO* shall request the operator at the *facility* to operate the *facility* at its base-point.
   b) The *IESO* shall wait for the *facility* output to be stable before sending any Regulation Service signal to the

facility.

c) The *IESO* shall manually send a raise signal to the *facility* under test at the site. Just before sending the raise signal, the *IESO* will notify the ASP that the raise is about to occur so the ASP can verify the raise test. The Regulation Service test signal shall direct the *facility* to increase its output as fast as it can, by an amount equal to its amount *of* Regulation Capacity as indicated in the daily Regulation Service schedule. The *IESO* will observe the response of the unit(s) under test for ten minutes, and will calculate the Regulation Service ramp rate R_{UP} and capacity response C_{UP} in the manner described in Section 2.2.

d) The *IESO* shall wait up to ten minutes for the *facility* under test to stabilize. The *IESO* shall then manually send a lower signal to the regulation *facility* under test at a site. Just before sending the lower signal, the *IESO* will notify the ASP that the lower is about to occur so the ASP can verify the lower test. The *regulation* test signal shall direct the *regulation facility* to decrease its output, back to its *regulation* base-point. The *IESO* will observe the response of the unit(s) under test for ten minutes, and will calculate the *regulation* ramp rate R_{DOWN} and capacity response C_{DOWN} in the manner described in Section 2.3.

e) The *IESO* shall record the verified Regulation Capacity "C" as the lesser of $\{C_{UP}, C_{DOWN}\}$. The *IESO* shall record the verified *regulation* ramp rate "R" as the lesser of $\{R_{UP}, R_{DOWN}\}$.

f) If the *IESO* requires more than one *facility* to be tested, steps (a) to (e) are repeated until all required *regulation facilities* have been included in tests.

3. The ASP and the *IESO* shall work together to develop a testing protocol to perform an on-line diagnostic test to evaluate the ability of the Facility to meet the certified Grid Energy Storage capabilities as set forth in Schedule 5.

5.3 Restoration of Original Ratings after Poor Test Results

1. After the ASP has completed corrective action to restore Regulation Capacity or Regulation Service ramp rate from a facility, which when tested was found to perform poorly, the ASP may request a re-test through the *outage* scheduling process, or at short notice (within the next 4 hours) in order to demonstrate restored ratings. The test of Part 3 would be used in such cases.

2. If a *facility* has failed an on-line diagnostic test within the previous three months, and has not successfully passed an on-line diagnostic test within one month of the original failure, the *IESO* may schedule testing of the Regulation Service capability, in accordance with the *outage* scheduling process, if the *IESO* still questions the accuracy of the Regulation Service ramp rate or Regulation Capacity data provided by the ASP for the *facility*, which are published in Schedule 5, or doubts the ability of the Facility to meet the certified Grid Energy Storage capabilities listed in Schedule 5. This test is identical to the Regulation Service Certification Test of Part 2. The *IESO* shall inform the ASP of any evidence it has that would help identify why a *facility* is considered deficient.

- End of Section -

SCHEDULE 3

PROCEDURE FOR COMMUNICATING *REGULATION* REQUIREMENTS AND ASSIGNING *FACILITIES* TO PROVIDE *REGULATION* SERVICE

1.0 General

1. The ASP will provide the following information in its Regulation Service schedule returned to the *IESO*:
   (a) *facilities* that will supply *regulation*,
   (b) Regulation Capacity (± MW) to be supplied from each *facility,* including minimum and maximum limits for each source.

2.0 Day Ahead

1. The *IESO* publicly submits its 24 hourly quantities of total Regulation Capacity requirements (± MW) for the following day. The minimum overall ramp rate requirement is 50 MW/minute, sustainable for a minimum of two minutes. The *IESO* submits these Regulation Service Hourly Requirement quantities via the morning System Status Report, sent out at 05:30 EST.

2. The ASP returns a Regulation Service schedule to the *IESO* of its available Regulation Service resources to help meet the total Regulation Service requirements for the following day by 08:00 EST. The *IESO* reviews the ASP resource schedules of all ASP*s* for Regulation Service, selects ASP resources for each hour, and informs each ASP of its Regulation Service schedule by 10:00 EST. Each Regulation Service schedule includes hourly required Regulation Capacity (± MW) and ramp rate.

3. The *IESO* will confirm Regulation Service requirements by issuing a *dispatch* message for activation of the Regulation Service contract for the relevant period. The ASP will accept the *dispatch* message promptly.

4. Notwithstanding the above, upon mutual agreement, the Parties may modify the procedure to assign *facilities* to provide Regulation Service should there be a more appropriate mechanism as a result of the ASP`s specific technology.

3.0 Current Day

1. For a *facility* providing Regulation Service, if the *IESO* has an unexpected immediate need to change the Regulation Service requirement, and if the *IESO* requests the ASP to change the amount of Regulation Service provided, consistent with *good utility practice* the ASP will respond as soon as possible, with a target of 10 minutes to provide the changed amount of Regulation Capacity.

2. If in order to supply the required amount of Regulation Service the ASP has an unexpected immediate need to change or replace a source of Regulation Service due to a *forced outage* or forced de-rating on a *facility* supplying Regulation Service or other such equipment limitations affecting minimum or maximum points~~,~~
   a) The ASP shall promptly inform the *IESO* of the *forced outage* or forced de-rating or equipment limitation in accordance with the *outage* process of Chapter 5, Sections 6.3.4 and 6.3.5 of the *market rules*.

3. Using commercially reasonable measures, both Parties on an ongoing basis will monitor the amount of Regulation Service provided versus Regulation Service scheduled. Should either Party notice a discrepancy it will promptly notify the other Party. Upon notification of under-provision, the Parties will mutually agree upon the quantity and duration of under-provision. In the absence of such agreement regarding the beginning of such under provision the under-provision will be deemed to have begun no earlier than the hour before the Party became aware or ought to have become aware of the discrepancy. In the event that the Parties do not agree, the Parties will conduct an On Line Diagnostic Test in accordance with Schedule 2 Part 3. If there is under- provision, other than requested by the *IESO*, payment will be made in accordance with Schedule 6.

- End of Section -

SCHEDULE 4

DESCRIPTION OF FACILITIES PROVIDING REGULATION SERVICE

Table 1: Specifications for Facilities with Installed Regulation Service Capability

Specifications (units)	**Value**
Location (Ontario) including electrical connection point	[redacted]
Technology	[redacted]
Number of facilities with Regulation Capability	[redacted]
Regulation Capacity to be Offered (± MW)	[redacted]
Maximum output for operation under *regulation* control (MW)	[redacted]
Minimum output for operation under *regulation* control (MW)	[redacted]
Ramp Rate (MW/minute)	[redacted]
Grid Energy Storage capabilities:	
Power Storage Capacity of the Facility (MW)	[redacted]
Energy Storage Capacity of the Facility (MWh)	[redacted]
Response Time for variation of energy input and output (seconds)	[redacted]
Availability (% of time annually)	[redacted]
Conversion losses (% of total energy stored)	[redacted]
Storage losses over 2 hours (% of total energy stored)	[redacted]
Storage losses over 12 hours (% of total energy stored)	[redacted]
Storage losses over 16 hours (% of total energy stored)	[redacted]
Minimum Full Charge Cycle Duration (hours)	[redacted]
Maximum Full Charge Cycle Duration (hours)	[redacted]

Note: All details associated with Facility to be included: Table to be completed upon selection of Preferred Respondent

- End of Section -

APPENDIX 4A

PROPOSAL EXTRACTS

SCHEDULE 5

CERTIFIED REGULATION CAPABILITIES

Item	Value
Certified Regulation Capacity	
Certified Regulation Ramp Rate	
Certified Grid Energy Storage Capabilities:	
Power Storage Capacity of the Facility (MW)	
Energy Storage Capacity of the Facility (MWh)	
Response Time for variation of energy input and output (seconds)	
Availability (% of time annually)	
Conversion losses (% of total energy stored)	
Storage losses over 2 hours (% of total energy stored)	
Storage losses over 12 hours (% of total energy stored)	
Storage losses over 16 hours (% of total energy stored)	
Minimum Full Charge Cycle Duration (hours)	
Maximum Full Charge Cycle Duration (hours)	

- End of Section -

SCHEDULE 6

PAYMENT

1. **Payment Amounts:** The table below sets out the applicable payment amounts under this Agreement:

Payment	Amount
Total Fixed Payment	[redacted]
Fixed Monthly Payment	[redacted]
Variable Payment	As defined in section 1.2.

2. **Contract Price:** The ASP shall perform its obligations under this Agreement including without limitation sections 3.1 and 3.2 of this Agreement, for the Total Fixed Payment plus the total of all Variable Payments paid to the ASP pursuant to section 3 of this Schedule 6 (the "**Contract Price**"). The Contract Price is not subject to change or adjustment except as expressly provided in this Agreement or as may be mutually agreed upon by the Parties. The ASP agrees to accept the Contract Price as full payment and reimbursement under this Agreement for the Project.

3. **Monthly Payments:** Subject to sections 4 and 5 of this Schedule 6, for each month following the Service Commencement Date prior to the Termination Date, the *IESO* shall pay to the ASP an amount equal to the Fixed Monthly Payment plus the Variable Payment for that month (the "**Monthly Payment**") including, for greater certainty, whether or not the Regulation Service is actually taken. The Monthly Payment shall be made in accordance with the *IESO Settlement Schedule and Payments Calendar*.

4. **Adjustment:** Without limiting any other rights and remedies under this Agreement, if the ASP receives any Government Funding pursuant to section 3.10, or Additional Revenue as a *market creditor* pursuant to section 3.11, the *IESO* will have the right to adjust the Monthly Payment to reflect these revenues. If a Party receives a retroactive adjustment to any of the pricing elements then set out in this Schedule 6, in addition to payment of the adjustment amount, that Party shall also receive interest on the adjustment amount based on the prime rate, calculated and accrued daily from the effective date of the adjustment to the pricing elements to the date that the adjustment amount is paid.

5. **Suspension:** If a Suspension is in place pursuant to section 7.8, then the *IESO* shall be under no obligation to make Monthly Payments upon notice to the ASP until such time as the Facility becomes recertified pursuant to section 3.8 or the Suspension ends pursuant to section 7.8.

– End of Section –

SCHEDULE 7

NOMINATED REPRESENTATIVES FOR NOTIFICATIONS

IESO

Name of *IESO* Representative:	[redacted]
Title:	[redacted]
Address:	[redacted]
City/Province/Postal Code	[redacted]
Email address:	[redacted]
Phone:	[redacted]
Fax:	[redacted]
IESO Shift Contact Phone	[redacted]
IESO Shift Contact e-mail	[redacted]

ASP

Name of ASP Representative:	[redacted]
Title:	[redacted]
Address:	[redacted]
City/Province/Postal Code	[redacted]
Email address:	[redacted]
Phone:	[redacted]
Fax:	[redacted]
ASP Shift Contact Phone	[redacted]
ASP Shift Contact e-mail	[redacted]

- End of Section –

- End of Document -

ENBRIDGE GAS INC.
Answer to Interrogatory from
School Energy Coalition (SEC)

INTERROGATORY

Reference:

Ex. B/1/1, p. 16

Question**:**

Please provide a copy of the Applicant's application to SDTC for the grant funding, including all attachments.

Response:

The application for funding to the SDTC related to funding for the Power to Gas project and was submitted by Hydrogenics Inc. Enbridge Gas is not party to the agreement with the SDTC concerning the funding of the Power to Gas project. The SDTC's contribution toward the hydrogen blending portion of the Power to Gas Project is to be conveyed to EGI as per the terms of a letter agreement between Enbridge Gas and 2562961 Ontario Limited, a copy of which is attached to this response.

ENBRIDGE

Enbridge
500 Consumers Road
North York, ON, M2J 1P8

HYDROGENICS
SHIFT POWER | ENERGIZE YOUR WORLD

Hydrogenics
220 Admiral Blvd,
Mississauga, ON L5T 2N6

December 19, 2019

Attention: Malini Giridhar

500 Consumers Road
North York Ontario
M2J 1P8

Re: Funding for Low Carbon Energy Project (the "Project")

The undersigned confirm that pursuant to the terms of the agreement between Sustainable Development Technology Canada (" SDTC") and Hydrogenics Corporation ("Hydrogenics") dated as of the 27th day of March 2018 (the" SDTC Agreement"), upon completion of the second milestone, as set out in Schedule C.3 of the SDTC Agreement, the second milestone payments totaling ***$221,568.49*** (the "Milestone Payments") shall be paid as follows:

1. Upon the completion of the second milestone and approval of SDTC, Hydrogenics agrees that the Milestone Payment shall be forwarded to 2562961 Ontario Ltd. ("256");
2. Upon receipt of the Milestone payment from Hydrogenics, 256 agrees that the Milestone Payment shall be forwarded to Enbridge Gas Inc. ("EGI") as a contribution to the Project.
3. Any portion of the Milestone Payments held back by the SDTC until the completion of the agreement between SDTC and Hydrogenics shall be conveyed to EGI upon receipt by Hydrogenics.

This Milestone has been broken into two components:

Milestone 2a – which comprises the development and filing of the LTC to the OEB and;

Milestone 2b – whose scope include the construction of the related facilities required to blend hydrogen and natural gas in an isolated portion of the Enbridge Gas distribution system.

The SDTC will be obligated to make payments once it is demonstrated that successful completion of the milestones 2a and 2b has been accomplished.

ENBRIDGE

HYDROG(E)NICS
SHIFT POWER | ENERGIZE YOUR WORLD

Enbridge
500 Consumers Road
North York, ON, M2J 1P8

Hydrogenics
220 Admiral Blvd,
Mississauga, ON L5T 2N6

AGREED AND ACKNOWLEDGED

Scott Dodd

President, 2562961 Ontario Ltd.

Rob Harvey (Hydrogenics Corporation)

Title: Director, Energy Infrastructure

Enbridge Gas Inc.

S. McGill

Technical Manager, Business Development

ENBRIDGE GAS INC.
Answer to Interrogatory from
School Energy Coalition (SEC)

INTERROGATORY

Reference:

Ex. B/1/1, p. 17

Question**:**

Please confirm that only residential customers will be served by blended gas. If not confirmed, please advise how the annual rate rider will be adjusted for non-residential customers to reflect their higher volumetric differential due to the blended gas.

Response:

There are a small number of Rate 6 customers in the BGA, 20 as of June 2020. Enbridge Gas will adjust the annual rate rider to accommodate for the higher gas demands of these customers.

Based on January 2020 QRAM rates, a typical Rate 6 customer in the BGA consuming 22,606 m^3 per year of traditional natural gas would have to consume approximately 22,918 m^3 of blended gas. This equates to a typical Rate 6 customer in the BGA paying approximately $76.77 more per year than a non-BGA customer based on the higher volume of blended gas that would be consumed.

Similar to the rate rider treatment for Rate 1 customers, Enbridge Gas is proposing to provide an annual rate rider of $86.00 for Rate 6 customers in the BGA.

ENBRIDGE GAS INC.
Answer to Interrogatory from
School Energy Coalition (SEC)

INTERROGATORY

Reference:

Ex. B/1/1/Attach 1, p. 12; Ex. C/1/1, p. 3

Question**:**

Please confirm that the Applicant is seeking approval for Phase 1 of the Project, comprising Loop S1, and that Phase 2 of the Project, comprising Loops S1A and S1B, is not a subject for this Application. If not confirmed, please explain in more detail the phases and the approvals. In either case, please provide details on the schedule for Phases 1 and 2.

Response:

Confirmed. Enbridge Gas is currently seeking approval via the current filing for Phase 1 of the Project comprised of Loop S1.

Please see Exhibit I.VECC.9 for discussion of conditions that will be required before Phase 2 proceeds.

ENBRIDGE GAS INC.
Answer to Interrogatory from
School Energy Coalition (SEC)

INTERROGATORY

Reference:

Ex. B/1/1/Attach 1, p. 15

Question**:**

Please provide a copy of the “consultant report on gas interchangeability”.

Response:

Please refer to Exhibit I.H2GO.1.

ENBRIDGE GAS INC.
Answer to Interrogatory from
School Energy Coalition (SEC)

INTERROGATORY

Reference:

Ex. D/1/1, p. 12

Question**:**

Please provide details of the scheduling requirements (e.g. order lead times, subsequent approvals, contracting process, etc.) from November 2020 to April 2021 that require the Applicant to have OEB approval by November 2020 in order to start construction in April.

Response:

Please refer to Exhibit I.CCC.4.

ENBRIDGE GAS INC.
Answer to Interrogatory from
School Energy Coalition (SEC)

INTERROGATORY

Reference:

Ex. D/1/1, p. 12

Question**:**

Please confirm that “Completion of Reinstatement” means returning the system to its pre-Project state in December 2021. If confirmed, please confirm that it is not expected that the assets included in the Project will be in rate base at the time of the next rebasing. Please provide a detailed explanation of the rate base impacts expected in each year from 2020 to 2024 for all Project costs, including any planned Phase 2 costs.

Response:

“Completion of Reinstatement” means restoring the land in accordance with the OEB’s Decision and Order in EB-2019-0294.

Please refer to Exhibit I.CCC.17(e) for discussion of the impacts during the deferred rebasing term, and at rebasing.

ENBRIDGE GAS INC.
Answer to Interrogatory from
School Energy Coalition (SEC)

INTERROGATORY

Reference:

Ex. D/1/1, p. 13

Question**:**

Please confirm that all of the listed costs are capital costs, and will be added to rate base in 2021.

Response:

Confirmed. All listed costs are capital costs.

Please refer to Exhibit I.CCC.17(e) regarding impact to rate base.

ENBRIDGE GAS INC.
Answer to Interrogatory from
OEB Staff (STAFF)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, page 3

Preamble:

In Enbridge Gas' initial application[1], the estimated number of customers in the BGA was 3,600 and the estimated GHG reductions was 98-117 tCO2e per year. In Enbridge Gas' revised application (Application)[2], the estimated number of customers in the BGA is 3,600 and the estimated GHG reductions is 97-120 tCO2e per year.

Question**:**

a) Please explain why there is a change in the estimated GHG reductions.

b) What is Enbridge Gas' most current estimate of the GHG reductions?

Response:

a) A range of GHG reductions was provided because the actual amount of GHG reductions will vary in large part on how much gas is consumed by customers within the BGA and the number of customers within the BGA. The range provided is based on the lowest and highest residential average use (i.e. a warm year and a cold year) for customers within the BGA for the period 2010 to 2018. In the initial application, the warm year or lower end of the range was developed based on data for 2016 with an average use of 2,153 m^3 and 3,638 residential customers. The cold year or upper end of the range was developed based on data for 2014 with an average use of 2,671 m^3 and 3,509 residential customers. In the updated application Enbridge Gas assumed a constant customer count of 3,600 residential customers when calculating the range of GHG emission reductions. The effect of using 3,600 customers to normalize the GHG emission reduction calculations was to increase the upper end of the range provided and to lower the lower end of the range provided. The calculations underpinning the GHG emission reduction range of 97-120 tCO_2e are provided in the table below.

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[1] Filed December 20, 2019
[2] Filed March 31, 2020

	(a)	(b) = (a) x (j)	(c) = (b) / (m)	(d) = (c) * (l)	(e) = (c) - (d)	(f) = (a) * (n)	(g) = (e) * (n)	(h) = (f) - (g)	(i) = (h) * (o)
Scenario	Average Customer Usage (m^3)	Average Customer Energy Input (MJ)	Blended Gas Volumetric Consumption (m^3)	Volume of Hydrogen in Blended Gas (m^3)	Volume of Methane in Blended Gas (m^3)	GHG From Traditional Natural Gas (tCO_2e)	GHG From Blended Gas (tCO_2e)	GHG Reductions per customer (tCO_2e)	Total GHG Reductions (tCO_2e)
Average	2,400	92,472	2,433	49	2,384	4.50	4.47	0.03	108
Maximum	2,671	102,914	2,707	54	2,653	5.01	4.97	0.03	120
Minimum	2,153	82,955	2,182	44	2,139	4.03	4.01	0.03	97

Assumptions:

(j) Higher Heating Value of Natural Gas (MJ/m^3)	38.5
(k) Higher Heating Value of Hydrogen Gas (MJ/m^3)	12.7
(l) Amount of Hydrogen (% by volume)	2
(m) = (k)*(l) + (1-(l))*(j)	
Higher Heating Value of the Blended Gas (MJ/m^3)	38.01
(n) Emission Factor (tCO_2e/m^3)	0.001874
(o) Number of Customers	3,600

b) Enbridge Gas’s most current estimate of the range of GHG emission reductions is the range provided in the updated application, that is GHG emission reductions of 97-120 tCO2e per year.

ENBRIDGE GAS INC.
Answer to Interrogatory from
OEB Staff (STAFF)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, pages 3-10 and 18

Preamble:

Enbridge Gas is applying for approval of a rate rider (credit) to compensate customers in the BGA for the additional extra costs associated with the increase in volumetric requirements for blended gas as compared to conventional natural gas (Consumption Impact). Enbridge Gas says that this treatment would apply until rebasing or until such earlier time that a different treatment is appropriate based on future developments; for example, the implementation of a Federal Clean Fuel Standard (CFS). Enbridge Gas' next rebasing is in 2024.

Enbridge Gas says that its affiliate, 2562961 Ontario Ltd., has developed and built North America's first utility scale PtG facility in Markham, Ontario. It is located at Enbridge Gas' Technology and Operations Centre (TOC) in Markham. The PtG facility was developed in partnership with Hydrogenics Corporation. Hydrogenics Corporation is part owner of 2562961 Ontario Ltd.

Enbridge Gas is proposing to acquire hydrogen from 2562961 Ontario Ltd. in a manner that keeps ratepayers cost-neutral. Enbridge Gas is proposing to recover the cost of procuring hydrogen from all customers in the legacy EGDI rate zone until rebasing after which time the cost would be recovered from all customers, or until such earlier time that a different treatment is appropriate based on future developments (e.g., the implementation of the CFS).

Enbridge Gas says the CFS will be a performance-based approach designed to incent the innovation and adoption of clean technologies in the oil and gas sector and the development and use of low-carbon fuels throughout the economy. The gaseous and solid fuel regulations were scheduled to be published in early 2020 and to come into force on January 1, 2023[3]. However, the Government of Canada announced in April 2020 that publication of the regulations will be delayed to the fall of 2020 due to COVID-

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[3] https://www.canada.ca/en/environment-climate-change/services/managing-pollution/energy-production/fuel-regulations/clean-fuel-standard/regulatory-approach.html#toc48

19[4]. Under the CFS, hydrogen is expected to be a means of compliance and a pathway for the generation of CFS credits.

Question**:**

a) Based on the best information available to date, please identify and explain any alternate treatments that may be available to address the Consumption Impact at rebasing and as a result of the CFS.

b) Based on the best information available to date, please identify and explain any alternate treatments that may be available for the procurement of hydrogen at rebasing and as a result of the CFS.

c) Please explain the rationale for why the cost to procure hydrogen should initially be recovered from all rate payers in the EGDI rate zone and then all Enbridge Gas rate payers after rebasing in 2024.

d) Please explain what is meant by “cost neutral”. For example, does it mean that the commodity cost of the hydrogen will be the same as the commodity cost of natural gas? Or, does it mean that the commodity cost of the hydrogen will be that same as the landed cost of natural gas (i.e., inclusive of commodity, transportation and storage costs)?

e) Will the procurement of hydrogen continue to be cost neutral after rebasing? Please explain.

f) OEB staff would like to compare the relative local costs of natural gas and hydrogen. Please provide the following information. Or, if the requested information does not provide for a good comparison, please provide more suitable information.

    i. Please provide the current commodity cost of natural gas for a residential customer in Markham, Ontario, in $/GJ.

    ii. Disregarding the proposed cost-neutrality arrangement mentioned above, please provide the current commodity cost of hydrogen in Markham, Ontario, from 2562961 Ontario Ltd. in $/GJ.

g) Please discuss the implications of the cost-neutral arrangement with respect to the Affiliate Relationship Code.

h) Based on the best information available to date, how does Enbridge Gas believe that the CFS credit system will work? In the response, please include an explanation for how Enbridge Gas would use CFS credits, and how that use may benefit its ratepayers.

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[4] https://www.canada.ca/en/environment-climate-change/services/managing-pollution/energy-production/fuel-regulations/clean-fuel-standard.html

i) Will the delayed publication of proposed regulations for the liquid fuel class of the CFS until fall 2020 impact the timing of the Project?

Response:

a) Enbridge Gas does not have enough information about the CFS compliance requirements to be in a position to indicate whether an alternate treatment of consumption impact might be appropriate in the future. More generally, if the delivery of blended gas including hydrogen to Enbridge Gas customers becomes a more wide-spread activity and numerous Blended Gas Areas become established in the future, Enbridge Gas may consider customer billing of some or all customers on a GJ of heat consumed basis, rather than volumetrically based billings. This might require metering changes. As a further alternative, if delivery of blended gas including hydrogen becomes more widespread, Enbridge Gas could consider discontinuing the consumption impact Rider. Note that none of these alternatives are being proposed in this proceeding, and that Enbridge Gas would seek OEB approval before implementation of any alternative.

b) Enbridge Gas anticipates that the establishment of a CFS and demonstrated success of this pilot Project may encourage development of additional Ontario sources of hydrogen that would be appropriate for hydrogen blending. Enbridge Gas will monitor the marketplace, and consider alternative sources for hydrogen for future Blended Gas Areas.

c) Customers located within the BGA are within Enbridge Gas' EGD rate zone. Enbridge Gas is proposing that the cost of the hydrogen commodity procured for the BGA during the hydrogen blending pilot program should be recovered from the EGD rate zone in the same manner as the cost of traditional natural gas supply procured for the EGD rate zone. Note that the cost of hydrogen procured for the Project is expected to be the same as the cost of conventional natural gas – please see response to part (d) and part (f) below.

   At this time Enbridge Gas has not made a proposal for how the commodity impact of the cost of hydrogen will be recovered after rebasing. Depending on the final design of future carbon pricing programs that may be implemented prior to rebasing in 2024, such as the CFS, it *may* be appropriate to treat the cost of hydrogen differently than the cost of traditional natural gas. For example, if the purchase of hydrogen for injection in Enbridge Gas' distribution system were to provide benefits under a future CFS program to all Enbridge Gas customers, it may be appropriate for all customers to share in the cost of the hydrogen.

d) For the duration of the pilot Program, Enbridge Gas has arranged to procure hydrogen from 2562961 Ontario Ltd. at the same price per GJ as the traditional natural gas commodity that will be displaced. The small amount of hydrogen purchased by Enbridge Gas will displace traditional natural gas supply that would otherwise have been purchased at Dawn and transported to the EGD rate zone. The price paid for hydrogen will not be inclusive of any upstream transportation or storage charges as those services will not be required for this supply.

Therefore, there will be no “Commodity Impact” as defined in Exhibit B, Tab 1, Schedule 1, page 17 since Enbridge Gas is paying the same price for hydrogen as it would for traditional natural gas and ratepayers are therefore “cost-neutral.”

The Term Sheet between Enbridge Gas and 2562961 Ontario Ltd. for hydrogen procurement for the Project is set out at Attachment 1 to this response.

e) Please see response to part (c) and (d) above.

f)

  i. Enbridge Gas does not believe the total gas supply commodity rate for a residential customer in Markham, Ontario is a relevant price to compare to the purchase price of hydrogen for the purposes of the pilot program. This charge is a QRAM regulatory construct meant to recover the actual pass-through costs of natural gas from customers; not a market price paid for commodity at a specific time and location. It incorporates a wide variety of functions including but not limited to a prospective forecast of natural gas prices over a 12 month period, a true-up of actual prices against forecast prices, a true-up of actual volumes against forecast volumes, an adjustment to the cost of gas in storage, and the cost of upstream transportation to bring gas from other markets into Ontario. Rather, Enbridge Gas proposes that the appropriate price to compare the cost of hydrogen to is the market price of the traditional natural gas that will be displaced (i.e. Dawn). The Dawn Monthly Index settlement price for natural gas delivered to Dawn in the month of June 2020 is $2.11 CAD per GJ.

  ii. See Exhibit I.ED.6 (a) and (g).

g) The arrangement to purchase hydrogen from 2562961 Ontario Ltd. at the same price per GJ as the traditional natural gas commodity that will be displaced is compliant with the Affiliate Relationships Code. The Affiliate Relationships Code requires that utilities pay no more than the market price for products purchased from an affiliate and, in situations where a reasonably competitive market for the product does not exist, no more than the affiliate's fully allocated cost to provide the product.[5] For the purposes of the pilot Program, Enbridge Gas is purchasing hydrogen from 2562961 Ontario Ltd. at a price that is significantly below the market price of hydrogen as well as 2562961 Ontario Ltd.'s fully allocated cost to provide the hydrogen.

h) Based on the Clean Fuel Standard Proposed Regulatory Approach[6], Enbridge Gas believes that the CFS credit system will work as follows:

  - The gaseous fuel sector will have a carbon intensity reduction target, expressed in grams of carbon dioxide equivalent ("CO_2e") per megajoule (gCO_2e/MJ) that becomes increasingly stringent (lower) between 2023 to 2030.
  - A gaseous fuel distributor will determine its CFS credit obligation by comparing the carbon intensity of the fuel it distributes to the annual carbon intensity reduction target. Where the carbon intensity of the distributed fuel is greater than the carbon intensity reduction target, the fuel will be in a deficit position. The fuel deficit (gCO_2e/MJ) is then multiplied by the amount of fuel distributed (MJ) to determine the CFS credit obligation, expressed in tonnes CO_2e (tCO_2e).
  - A low carbon fuel will presumably have a carbon intensity lower than the annual carbon intensity reduction target and therefore be in a credit position. The fuel credit is then multiplied by the amount of low carbon fuel produced to determine the amount of CFS credits generated in tCO2e.
  - CFS credits are expected to be generated at the point of fuel production and attached to the low carbon fuel. The CFS credits are expected to remain attached to the fuel and sold under contract to the fuel distributor (note that the Term Sheet for sale of hydrogen from 2562961 Ontario Ltd. to Enbridge Gas does not address the sale or transfer of CFS credits – that is an item to be determined later when there is more information about the CFS framework). Once consumption of the low carbon fuel is confirmed, Enbridge Gas expects the CFS credit may be separated and then remitted to the Federal Government to fulfill the CFS compliance obligation.
  - Environmental and Climate Change Canada has proposed a 10% limit on the amount of CFS credits that can be obtained from other fuel streams to satisfy compliance obligations. Enbridge expects this restriction to limit compliance options and CFS credit availability to predominantly the production and use of low carbon fuels, such as RNG and hydrogen.

Enbridge Gas anticipates that the Company will file an application with the Board to

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[5] Affiliate Relationships Code for Gas Utilities, section 2.3.4 and section 2.3.9.

[6] Environment and Climate Change Canada, "Clean Fuel Standard Proposed Regulatory Approach", June 2019

recover the costs associated with meeting its obligations under CFS, similar to the applications filed previously for Cap and Trade and the Federal Carbon Pricing Program. Enbridge Gas anticipates, pending Board approval, that the costs and any potential benefits associated with the CFS would accrue to the Company’s customers.

i) The delay in the proposed regulations for the liquid fuel class of the CFS will not impact the timing of the LCEP. However, the delay in the publication of the final liquid fuel regulation until fall 2021 may reduce the amount of early action CFS credits the LCEP can produce.

ENBRIDGE

Enbridge
500 Consumers Road
North York, ON, M2J 1P8

HYDROGENICS
SHIFT POWER | ENERGIZE YOUR WORLD

Hydrogenics
220 Admiral Blvd,
Mississauga, ON L5T 2N6

December 18, 2019

2562961 Ontario Ltd.

Non-Binding Term Sheet for:
Sale of Renewable Hydrogen from 2562961 Ontario Ltd. To Enbridge Gas Inc. For Hydrogen Blending Pilot Project

This *Term Sheet* **(the "Term Sheet")** sets out without limitations, the basic terms to be included in a future Agreement between *Enbridge Gas Inc. ("EGI")* and *2562961 Ontario Ltd.*, a joint venture between 2099364 Ontario Limited and Hydrogenics Inc., for the procurement of renewable hydrogen. The proposed transaction is subject to finalization and acceptance of an agreement negotiated between both parties. This term sheet does not constitute a binding contract between the parties.

Subject to the *Ontario Energy Board's* **("OEB")** approval of EGI's, *Leave to Construct* **("LTC")** Application, for its *Low Carbon Energy Project* **("LCEP")** to blend hydrogen into a portion of its gas distribution system, 2562961 Ontario Ltd., agrees to sell up to 200,000 m^3 annually (approximately 16,700kg or 2,400GJ) of electrolyzed hydrogen to EGI, to support EGI's blending of renewable hydrogen into a portion of its natural gas distribution system pilot project.

Price

Unless otherwise directed by the Ontario Energy Board, the price paid for the hydrogen procured by EGI will not result in any impact to EGI customer bills in the applicable EGI rate zone.

Term of Service

The term of this agreement will be effective from the in-service date for the LCEP project currently scheduled to be Q4-2020 and shall survive for as long as EGI's pilot project for blending hydrogen into its natural gas distribution system continues. The need to supply renewable hydrogen will cease when EGI discontinues its hydrogen blending project, or the project has come to the end of its service life.

Terms Subject to Change

The supply of renewable hydrogen by 2562961 Ontario Limited is subject to the following conditions which may alter the production and subsequent sale of hydrogen by 2562961 Ontario Ltd to EGI:

1. Survival and renewal of the contract between the 2562961 Ontario Ltd. and the Independent Electric System Operator (the "IESO Contract") at the end of its current three (3) year term.
2. Changes in IESO Contract pertaining to 2562961 Ontario Limited's cost of electricity under that agreement.
3. Introduction of new government regulations such as the Clean Fuel Standards **("CFS")**
4. The hydrogen produced will be produced by electrolysis at 2562961 Ontario Limited's facility located in Markham Ontario.

Terms shall be subject to an update when the federal government CFS comes into force on January 1 2023 for gaseous and solid fuels regulations.

2562961 ON Ltd.

By: ______________________
Name: Scott Dodd
Title: President

By: ______________________
Name:
Title:

Enbridge Gas Inc.

By: ______________________
Name: Jamie LeBlanc
Title: Director Gas Supply

By: ______________________
Name: **Malini Giridhar**
Title: **Vice President,**
Business Development & Regulatory

ENBRIDGE GAS INC.
Answer to Interrogatory from
OEB Staff (STAFF)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, page 5

Preamble:

An Enbridge Gas affiliate, 2562961 Ontario Limited, is currently under contract with the Independent Electricity System Operator (IESO) for power grid stability and reliability services in the province. An electrolyzer owned by the affiliate uses surplus electricity to split water into hydrogen and oxygen. The hydrogen is stored and when there is a demand for electricity, a fuel cell converts the hydrogen into electricity for the grid.

Question:

a) Is the amount of hydrogen available to Enbridge Gas for hydrogen blending limited as a consequence of the contractual arrangements between 2562961 Ontario Limited and the IESO?

b) Please explain what Enbridge Gas would do if it were unable to procure sufficient quantities of hydrogen to supply the BGA as planned? What impact could this have on such things as the duration of the Project and the amount of the rate rider?

Response:

a) Please see Exhibit I.FRPO.4

b) Please see the response to a) above. In the event that hydrogen is not available for blending, Enbridge Gas will provide customers within the BGA with 100% traditional natural gas. In that circumstance, Enbridge Gas could make a request to the Board to discontinue the rate rider.

ENBRIDGE GAS INC.
Answer to Interrogatory from
OEB Staff (STAFF)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, page 16

Preamble:

Enbridge Gas is proposing to offset the Consumption Impact on customers within the BGA by way of an annual rate rider providing a credit of $9.00 per year. Based on October 2019 Quarterly Rate Adjustment Mechanism rates, a typical residential customer in the BGA consuming approximately 2,433 m^3 per year would pay approximately $8.75 more each year than a non-BGA customer based on the slightly higher volumes consumed.

Question:

a) Please provide a flat file (e.g., Excel printout) that clearly demonstrates step-by-step how the approximate $8.75 rider was calculated. Please include any assumptions, conversions or other information needed to understand the calculation.

b) Does the proposed rider account for Federal Carbon Charges[5]? Please explain.

Response:

a) This interrogatory refers to the bill impact from the previous filing from December 20, 2019. That filing used October 2019 QRAM rates and resulted in a Consumption Impact of $8.75 per year to customers within the BGA. The updated application, filed on March 31, 2020, indicated a Consumption Impact of $8.99 per year to customers within the BGA. January 2020 QRAM rates were used for the derivation of this Consumption Impact. Enbridge Gas would also note that the proposed rate rider is an annual rate rider of $10 per customer within the BGA and not $8.75 as indicated above. What follows describes the derivation of the $8.99 Consumption Impact.

The residential customer volume profiles for a typical customer or non-BGA

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[5] EB-2018-0205, Enbridge Gas Inc., 2019 Federal Carbon Pricing Program Application

customer (2,400 m^3) and for BGA customers (2,433 m^3) as well as the same set of the Board-approved rates from the January 2020 QRAM are used to derive the typical bills. The volume profile for BGA customers is derived by increasing the monthly volume for non-BGA customer by 1.38%, resulting in the annual volume variance of 33 m^3 as shown in the table on the next page. The table below also shows the breakdown of annual bill for BGA customer and non-BGA customer and Column (A) and Column (B) respectively.

The typical residential bills for BGA and non-BGA customers are derived using the same methodology as the typical customer bill calculations for the QRAMs. The monthly charge includes Rider K (Bill 32 and Ontario Regulation 24/19).

The Distribution Charge is the sum of Delivery Charge and Facility Carbon Charge. For delivery charge, the monthly volume is broken down into different delivery blocks and multiplied by the unit rate for that block. The sum of all blocks and months equals the total delivery charge. The Facility Carbon Charge is calculated as the Facility Carbon unit rate multiplied by volume. The derivation of Load Balancing Charge, Gas Supply Charge and Federal Carbon and Facility Carbon Charges is the unit rate multiplied by volume.

The last column in the table shows the variances between Table 2 and Table 3, broken down by component. The total annual bill impact is approximately $8.99.

Annual Residential Bill

(A) BGA Customer vs (B) Non-BGA Customer

		(A)	**(B)**	**CHANGE**
				(A) - (B)
VOLUME	m³	2,433	2,400	0
CUSTOMER CHG.	$	257.75	257.75	0.00
DISTRIBUTION CHG.	$	211.96	209.20	2.76
LOAD BALANCING	§ $	136.19	134.33	1.86
SALES COMMDTY	$	227.45	224.37	3.08
FEDERAL CARBON CHARGE	$	95.13	93.84	1.29
TOTAL SALES	**$**	**928.48**	**919.48**	**8.99**

§ The Load Balancing Charge shown here includes proposed transportation charges.

b) The proposed rider accounts for the Federal Carbon Charges as explained in a).

ENBRIDGE GAS INC.
Answer to Interrogatory from
OEB Staff (STAFF)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, page 8

Preamble:

Enbridge Gas says that in order to complete the analysis and investigation work for hydrogen blending, several consultants were engaged. One was a consultant experienced with town-gas applications, and another was a global consulting firm specializing in risk management.

Question:

a) Please provide the name of the consultant experienced with town-gas applications. Please provide a curriculum vitae for each of the key employees from this consultancy that were accountable for the work performed in respect of the Project.

b) Please provide the name of the global consulting firm. Please provide a curriculum vitae for each of the key employees from this consultancy that were accountable for the work performed in respect of the Project.

Response:

a) The name of the consultant experienced with town-gas applications is DBI-GUT (Liepzig, Germany). Attachment 1 to this response sets out the curriculum vitae requested.

b) The name of the global consulting firm is DNV-GL (Calgary, Canada; Loughborough, UK; and Groningen, Netherlands). Attachment 2 to this response sets out the curriculum vitae requested.

CURRICULUM VITAE – PHILIPP PIETSCH

Primary contact person/ project lead: Philipp Pietsch

Telephone: (+49) 3731-4195 352

Email: philipp.pietsch@dbi-gruppe.de

Qualification: Graduate engineer (Dipl.-Ing.), Technical University Dresden, Germany

Scientific specialization: Power Engineering, Combustion, energy management

Position: Team Leader

Experience: Project lead of several large-scale project

Team Leader since 2017 Previous employer: Siemens AG

Years for proponent: Since 2015

Similar projects: lead or participation in the projects 1, 2, 3, 4, 5, 6, 7 (please see project experience)

STAFF:

Marco Henel:

Qualification: Graduate engineer, HTWK Leipzig, Germany

Position: Team Leader Power-to-Gas

Experience: Large scale Power-to-Gas in Germany and Europe

Werner Vieweg

Qualification: Graduate engineer (Dipl.-Ing.), TU Bergakademie Freiberg, Germany Power Generation, Combustion

Position: project engineer

Experience: Project lead of several large-

	scale project Expert for gas and gas pressure controlling Expert for usage of special gases

Frank Erler

Qualification:	Graduate engineer (Dipl.-Ing.), TU Bergakademie Freiberg, Germany Combustion, Gas appliances
Position	Project engineer
Experience:	Expert on gas appliances
	Head of CHP-demonstration centre Testing and monitoring of gas appliances

Dr.-Ing. Jürgen Koppe:

Qualification:	Graduate engineer, doctoral degree (Dr.-Ing.) TU Bergakademie Freiberg, Germany; Power Engineering, energy management
Position:	Project engineer
Experience:	Energy carrier changes from 1990-1995 (city gas to natural gas) and since 2016 (lower to higher calorific natural gas)
	Energy market studies

Michael Kühn:

Qualification:	Graduate engineer, TU Bergakademie Freiberg, Germany
	Process Engineering
Position:	Project engineer
Experience:	Feed stock plants, gas process engineering

Chris Schaaf:

Qualification:	Graduate engineer, TU Bergakademie Freiberg Mechanical Engineering
Position:	Project engineer
Experience:	Influence of hydrogen on gas engines

Dr.-Ing. Stefan Anger:

Qualification:	Graduate engineer, doctoral degree, TU Bergakademie Freiberg, Germany Process Engineering
Position:	Team Leader hydrogen process engineering
Experience:	Hydrogen reforming, hydrogen process engineering

APPENDIX B: CURRICULA VITAE

The following CVs are included:

Name
Howard Levinsky
Sander Gersen
Martijn van Essen
Berthil Slim
Andrew Phillips
Clive Robinson
Mike Acton
Akvilina Valaityte
Saul Algar
Jake Abes

DNV·GL

CURRICULUM VITAE

Howard Levinsky

Senior Principal Specialist in combustion processes

Personal statistics

Citizenship: American
Date of birth: December 11, 1953

Language capabilities

Language	Speaking	Reading	Writing
English	Native Speaker		
Dutch	Excellent	Excellent	Excellent

Academic

Field of expertise	University/School	Year
Ph.D. Chemistry	New York University	1982
M.Phil. Chemistry	New York University	1979
M.A. Chemistry	New York University	1978
B.A. Chemistry	New York University	1975

Summary of professional experience

Howard Levinsky is an internationally recognized expert in gas quality issues and pollutant formation in gas-fired combustion equipment. His work on the physical and chemical origins of the effects of gas quality on the behaviour of practical combustion equipment (gas interchangeability), initiated in 1986 while he was working at N.V. Nederlandse Gasunie, has given DNV GL unique knowledge of technical issues regarding gas interchangeability. Since 1998, he is also part-time professor of Combustion Science at the University of Groningen, where he chairs the Laboratory for High Temperature Energy Conversion Processes in the Faculty of Science and Engineering. The research performed there on elementary processes in combustion, specifically on the effects of fuel composition, form the growing fundamental basis for the current interchangeability knowledge at DNV GL.

Prof. Levinsky combines his fundamental technical knowledge with insight into the economic and policy aspects of gas quality issues. He has worked on European harmonization of gas quality since 2002, as a member of the Marcogaz working group on gas quality, which developed the basis for the combustion aspects of the EASEE-gas CBP. He was also a gas quality expert in the GASQUAL consortium working on CEN Mandate M400, regarding the harmonization of standards for high calorific value natural gas in the EU. In addition, Prof. Levinsky has been a consultant for various parties, including LNG producers and local distribution companies, regarding end-use aspects of the introduction of LNG into new markets in the US and Europe. He has contributed to the discussion on gas quality standards in the US, regarding both natural and renewable gases. He has co-authored studies for the Dutch government on gas quality, which form the basis for the current policy for the transition to new gas compositions. Most recently, his

group at DNV GL has been working on standarizing combustion aspects of LNG as a transportation fuel and developing control systems for domestic appliances, industrial/commercial burners and gas engines to enable them to accept a wide range of fuel composition, particularly regarding the admixture of renewable fuels to natural gas and pure hydrogen.
He is (co-)author of more than 80 publications and presentations at international conferences.

Relevant work experience (selected projects at DNV GL)

Dates	**Company**
2015 - present	Shell, ENGIE, Wärtsilä and FPT (co-funded by Dutch government) **Project name** Development of a correct "octane number" for LNG **Location and Country** Europe **Position and description** Senior Principal Specialist Supervise and contribute to development of physically based method to quantify engine knock in response to variations in LNG compositions for different engine types used in land-based and marine applications. The method is intended for use as an international standard method to characterize engine knock, and to help engine manufacturers characterize LNG fuels.
Dates	**Company**
2015 -2016	Shell **Project name** Development of a fuel adaptive engine control system **Location and Country** Netherlands **Position and description** Senior Principal Specialist Supervise and contribute to the development of a fuel adaptive engine control system to optimize engine performance for a broad range of LNG compositions. In this project DNV GL demonstrated the value of applying an LNG composition sensor combined with LNG knock characterization for real-time engine performance optimization i.e. improved efficiency and reduced emissions.
Dates	**Company**
2014 - 2015	Dutch Ministry of Economic Affairs **Project name** Requirements for gas quality and gas appliances

Location and Country
Netherlands
Position and description
Senior Principal Specialist
Contributed technical and policy expertise in gas quality in project to assess what the future gas quality standards for domestic consumers should be for a possible Dutch changeover to so-called H gas.

Dates
2013 - 2017

Company
Large engine manufacturer
Project name
Development of knock ranking tool for well-head and pipeline gases
Location and Country
Europe
Position and description
Senior Principal Specialist
Supervise and contribute to development of physically based method to analyze engine knock in response to the wide range of fuel compositions occurring when employing gas engines at well sites. The method will be used to aid the manufacturer in specifying high-performance engines for this purpose, while maintaining power, efficiency and emissions performance.

Dates
2010 – 2015

Company
Gasunie (EDGaR project)
Project name
Effects of sustainable gases on end-use equipment
Location and Country
Netherlands
Position and description
Project Leader and Senior Specialist
This project focussed on the effects of supplying sustainable gases via the current Dutch natural gas infrastructure on the behaviour of the major classes of end-use equipment in the Netherlands: domestic/industrial, large-scale/industrial and for power generation.
Gas interchangeability methodologies for lift, flashback and CO were developed and successfully tested by using practical equipment for a wide range of gases. The behaviour of a number of large-scale industrial burners was analysed. For gas turbines a model was developed to determine the risk of the ocurrance of pre-ignition in the combustion chamber of premixed gas turbines. Results show that no increased risk for pre-ignition occurs when future (sustainable) gases will be introduced into the NG grid.

Dates	**Company**
2010 – 2015	Gasunie (EDGaR project) **Project name** Optimum use of sustainable gases **Location and Country** Netherlands **Position and description** Senior Specialist This project focusses on assessing the advantages/complications when expanding the current Dutch distribution band of natural gases to accommodate sustainable gases, particularly in the sectors of domestic appliances and gas engines. The knowledge acquired in this project gave detailed insight into the specific advantages or requirements that arise through the use of a wider band of natural gases when accommodating sustainable gases and will also be an important factor in deciding on a long-term path to the transition to these gases in the Netherlands.

CURRICULUM VITAE

Sander Gersen

Senior specialist in combustion processes

Personal statistics

Citizenship: Dutch
Date of birth: Oct 02, 1976

Language capabilities

Language	Speaking	Reading	Writing
English	Good	Good	Good
German	Fair	Fair	Fair
Dutch	Excellent	Excellent	Excellent

Academic

Field of expertise	University/School	Year
PhD. Combustion engineering	University of Groningen	2007
MSc. Chemical engineering	University of Groningen	2002

Other training and professional attainment

Year	Institute	Description
2016-2017	Haas School of Business, University of California Berkeley	DNV GL Innovation & Strategy development program at Haas School of Business, University of California Berkeley. The 1 year program focussed on technical innovation, latest state of technologies, renewable energy and strategy
2008 - 2009	OAG School of management	Gasunie management development program at Academy for Management, University of Groningen. The 1 year program focussed on strategy, finance, corporate culture, management, branding, corporate social responsibility and marketing

Dates	**Company**
2014 - 2015	Dutch Ministry of Economic Affairs **Project name** Requirements for gas quality and gas appliances **Location and Country** Netherlands **Position and description** Senior Specialist Contributed technical and policy expertise in gas quality in project to assess what the future gas quality standards for domestic consumers should be for a possible Dutch changeover to so-called H gas.
Dates	**Company**
2015 - 2017	National Grid **Project name** Natural gas grid operators in the UK: Development of specifications for siloxanes in biogas for domestic appliances in the UK **Location and Country** Netherlands **Position and description** Project leader & Technical consultant Studying experimentally and theoretically the effects of silica deposition in domestic appliances present in the UK. The results will form the basis for the development of specifications for siloxanes in natural gas/biomethane.

Dates	**Company**
2015 - 2017	Shell, ENGIE, Wärtsilä and FPT (co-funded by Dutch government) **Project name** Development of a correct "octane number" for LNG **Location and Country** Europe **Position and description** Senior Specialist As senior specialist contributed to development of physically based method to quantify engine knock in response to variations in LNG compositions for different engine types used in land-based and marine applications. The method is intended for use as an international standard method to characterize engine knock, and to help engine manufacturers characterize LNG fuels.

Dates	**Company**
2013 - 2017	Large engine manufacturer **Project name** Development of knock ranking tool for well-head and pipeline gases **Location and Country** Europe **Position and description** Project Leader and Senior Specialist Development of a model to analyze engine knock in response to the wide range of fuel compositions occurring when employing gas engines at well-head sites. The manufacturer uses the model to determine the methane number of gaseous fuels with high accuracy which allows the OEM to specify high-performance engines, while maintaining power, efficiency and emissions performance.

Dates	**Company**
2012 – 2015	Gasunie **Project name** Development of a next-generation knock resistance yardstick **Location and Country** Netherlands **Position and description** Senior Specialist Development a physically based model to analyze engine knock in response to variability in the natural gas composition, specifically for CHP engines. The model can be used to assess the impact of the

introduction of for example hydrogen into the gas grid on the risk of the occurrence of engine knock.

Dates	**Company**
2010 – 2015	Gasunie (EDGaR project) **Project name** Effects of sustainable gases on end-use equipment **Location and Country** Netherlands **Position and description** Project Leader and Senior Specialist This project focussed on the effects of supplying sustainable gases via the current Dutch natural gas infrastructure on the behaviour of the major classes of end-use equipment in the Netherlands: domestic/industrial, large-scale/industrial and for power generation. Gas interchangeability methodologies for lift, flashback and CO were developed and successfully tested by using practical equipment for a wide range of gases. The behaviour of a number of large-scale industrial burners was analysed. For gas turbines a model was developed to determine the risk of the ocurrance of pre-ignition in the combustion chamber of premixed gas turbines. Results show that no increased risk for pre-ignition occurs when future (sustainable) gases will be introduced into the NG grid.

Dates	**Company**
2010 – 2015	Gasunie (EDGaR project) **Project name** Optimum use of sustainable gases **Location and Country** Netherlands **Position and description** Senior Specialist This project focusses on assessing the advantages/complications when expanding the current Dutch distribution band of natural gases to accommodate sustainable gases, particularly in the sectors of domestic appliances and gas engines. The knowledge acquired in this project gave detailed insight into the specific advantages or requirements that arise through the use of a wider band of natural gases when accommodating sustainable gases and will also be an important factor in deciding on a long-term path to the transition to these gases in the Netherlands.

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CURRICULUM VITAE

Berthil slim

Senior specialist in combustion processes

Personal statistics

Citizenship: Dutch
Date of birth: Jul 06, 1958

Language capabilities

Language	Speaking	Reading	Writing
English	Good	Good	Good
German	Good	Good	Good
Dutch	Excellent	Excellent	Excellent

Academic

Field of expertise	University/School	Year
MSc. degree mechanical engineering	University of Twente	1984

Other training and professional attainment

Year	Institute	Description
2007	Nuclear Research Group	Safety & Reliability
2007	Penspen	Pipeline Defect Assessment
2006	CLARION	Major Hazard Awareness Course
2001	NIMA-A	marketing , ISBW (2001)
2006	Hogeschool Utrecht	Corrosion Mechanisms, (2006)
2006	Hogeschool Utrecht	Corrosion Protection
1998	GASTECH	Gas utilisation technology Gas distribution technology

Summary of professional experience

Berthil Slim is a very experienced technical professional in the field of natural gas and energy. Before becoming part of DNV GL – Gas Consultancy and Services he has worked for more than 20 years at N.V. Nederlandse Gasunie, the Dutch gas transmission network operator. Besides a few years of pipeline safety and integrity research and consultancy, he has mainly focussed on gas utilisation, in particular on structural integrity of the material used in end use equipment, energy efficiency, emission reduction and gas quality issues in gas-fired combustion equipment. Within this area of work, he has been the main author of a number of publications.

Berthil Slim has both well-developed theoretical and analytical abilities combined with insight that is more practical and the experience required for experimental and engineering subjects.

A quotation by a former colleague illustrates very well what is meant by this rare combination of skills. He once said: "Berthil is the only person I know who can both design and repair a car".

As an experienced project manager Berthil Slim has always dealt with people having various backgrounds, educational levels, nationalities. Many times Berthil has been successfully "the bridge closing the gap" between the member of the project team, the client and other stake-holders.

Berthil has been a consultant for both combustion equipment manufacturers and users.

Noteworthy is the design of a low-NOx gas-fired burner for large industrial steam and hot-water boilers, a very low-NOx flameless oxidation burner for high-temperature kilns and furnaces and a vastly improved design of a so-called Rapid Compression Machine to compare the knock propensity of different gaseous fuels such as hydrogen in internal combustion engines.

Furthermore, Berthil has a lot of experience in improving energy efficiencies in various high-temperature processes in the ceramic industry and large-scale greenhouse heating boilers and on the effect of the addition of hydrogen to natural gases as a fuel in high temperature combustion processes.

Berthil his focus in the near future will mainly be the effect of gas quality (and its rate of change) on gas-fired combustion equipment, mainly in terms of energy efficiency, emissions of pollutants.

Relevant work experience (selected projects at DNV GL)

Dates	**Company and location**
Jul 2009 - Aug 2013	DNV KEMA Groningen, Netherlands **Position and Description** senior specialist gas quality and combustion Project leader of a project to investigate the effect of gas composition and its rate of change on industrial burners for boilers, kilns and furnaces within the European Easygas framework. This research will incorporate industrial scale experiments and possibly developing or redesigning burner systems.

Dates	**Company and location**
Nov 1998 - Jun 2009	N.V. Nederlandse Gasunie Groningen, Netherlands **Position and Description** Researcher gas transportation and utilisation technology Responsible as a project leader for several projects on: - Gas/Air mixing - Pressure losses in gas pipelines - Filtering of dust and liquids in gases - Improving the controllability of large ball valves - Development of burners for boilers - Optimisation of high temperature gas utilisation - Evaluation and feasibility study of flameless oxidising burners - Optimising domestic cogeneration units - Industrial scale gas turbine cogeneration units - Investigating the consequences of hydrogen addition to natural gas for industrial utilisation systems - Investigating the effect of gas composition on the auto ignition ("engine knock") in industrial scale reciprocating ("piston") engines - developing a quantitative risk assessment methodology for gas transport installations - Updating an External Corrosion Direct Assessment method to assess the threat of corrosion to the integrity of unpiggable pipelines

Dates	**Company and location**
Nov 1985 - Oct	Vredestein Banden B.V.

1988

Enschede, Netherlands

Position and Description

Tyre Performance and construction Engineer
Project leader of a project:
- to develop a new series of passenger car (snow) tyres
- develop a new generation of agricultural implement tyres

Professional experience record

Dates
Jul 2009 -
Dec 2010

Company
KEMA

Project name
Effect of gas composition on industrial burners

Location and Country
Groningen, Netherlands

Position and description
Project leader
Investigating the effect of gas composition and its rate of change on industrial burners for boilers, kilns and furnaces within the European Easygas framework. This research incorporates industrial scale experiments and possibly developing or redesigning burner systems.

Dates
Jan 2008 -
Jun 2009

Company
Gasunie and KEMA

Project name
ECDA Review

Location and Country
Groningen, Netherlands

Position and description
Project leader
Reviewing and optimizsng the External Corrosion direct Assessment (ECDA) process of a gas transmission company in the Netherlands

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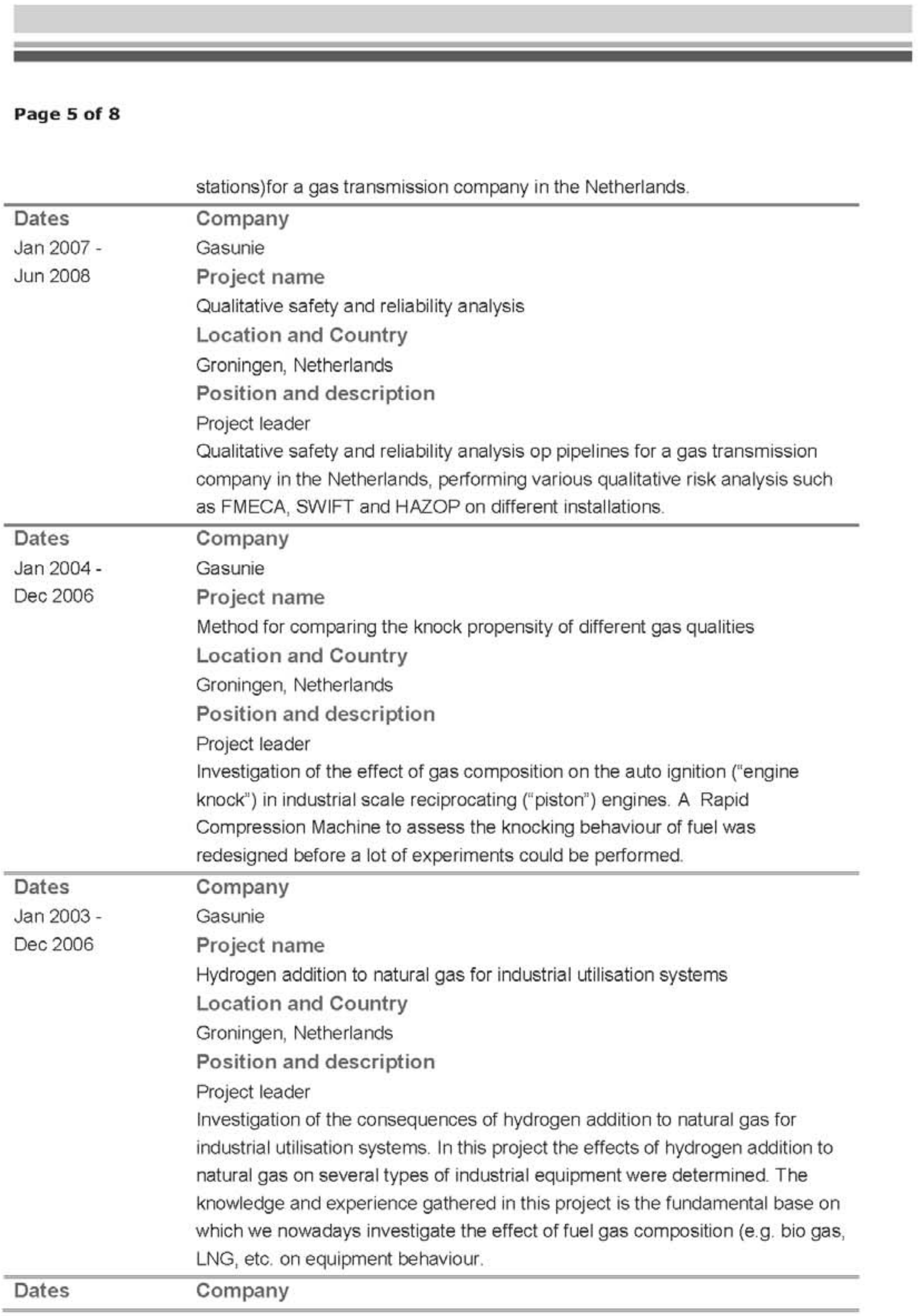
Dates
Jan 2007 -
Aug 2008

Company
Gasunie

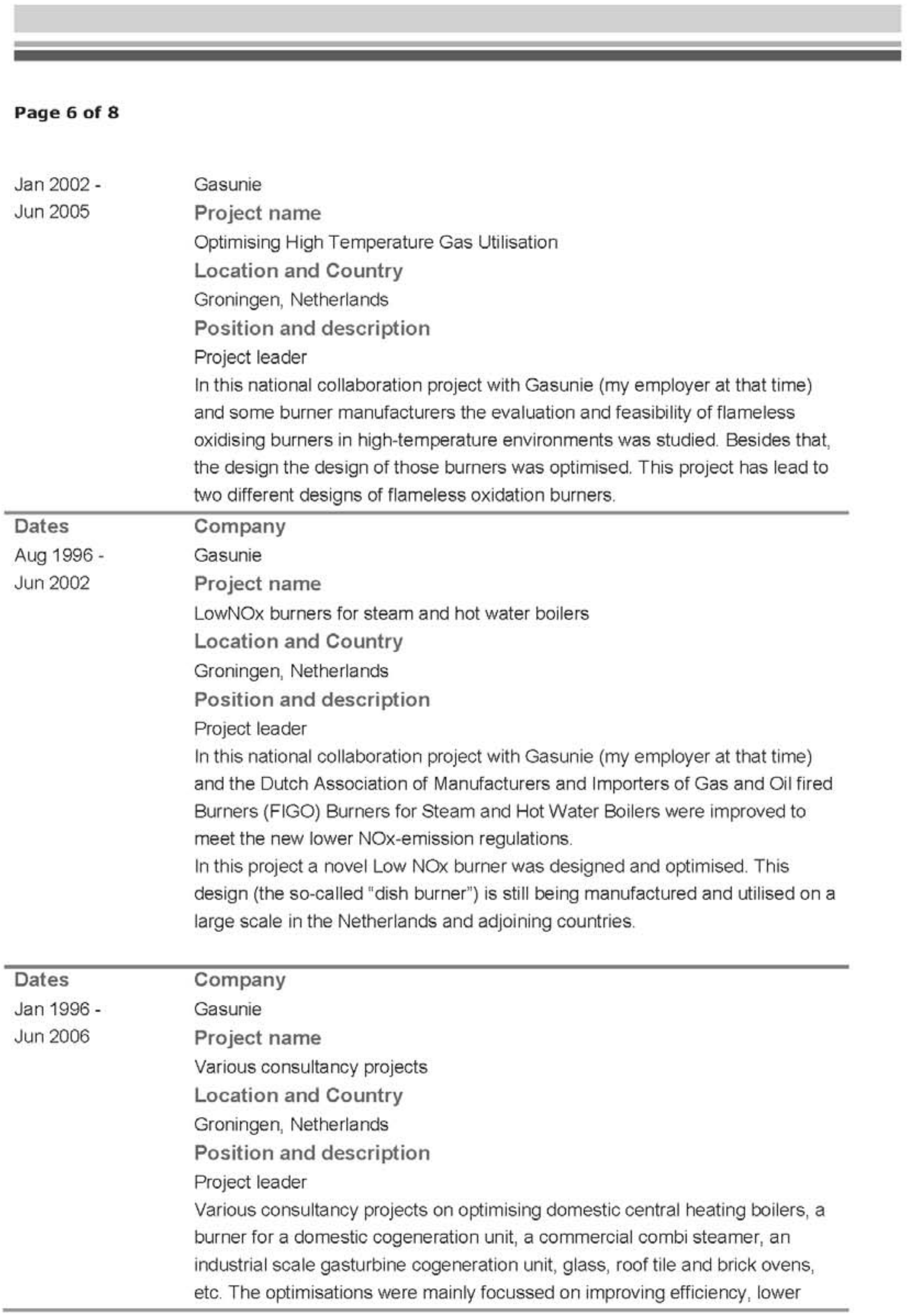
Project name
Quantitative Risk Assessment

Location and Country
Groningen, Netherlands

Position and description
Project leader
Quantitative risk assessment of pipelines and installations (e.g. compressor



	stations)for a gas transmission company in the Netherlands.
Dates	**Company**
Jan 2007 -	Gasunie
Jun 2008	**Project name**
	Qualitative safety and reliability analysis
	Location and Country
	Groningen, Netherlands
	Position and description
	Project leader Qualitative safety and reliability analysis op pipelines for a gas transmission company in the Netherlands, performing various qualitative risk analysis such as FMECA, SWIFT and HAZOP on different installations.
Dates	**Company**
Jan 2004 -	Gasunie
Dec 2006	**Project name**
	Method for comparing the knock propensity of different gas qualities
	Location and Country
	Groningen, Netherlands
	Position and description
	Project leader Investigation of the effect of gas composition on the auto ignition ("engine knock") in industrial scale reciprocating ("piston") engines. A Rapid Compression Machine to assess the knocking behaviour of fuel was redesigned before a lot of experiments could be performed.
Dates	**Company**
Jan 2003 -	Gasunie
Dec 2006	**Project name**
	Hydrogen addition to natural gas for industrial utilisation systems
	Location and Country
	Groningen, Netherlands
	Position and description
	Project leader Investigation of the consequences of hydrogen addition to natural gas for industrial utilisation systems. In this project the effects of hydrogen addition to natural gas on several types of industrial equipment were determined. The knowledge and experience gathered in this project is the fundamental base on which we nowadays investigate the effect of fuel gas composition (e.g. bio gas, LNG, etc. on equipment behaviour.
Dates	**Company**



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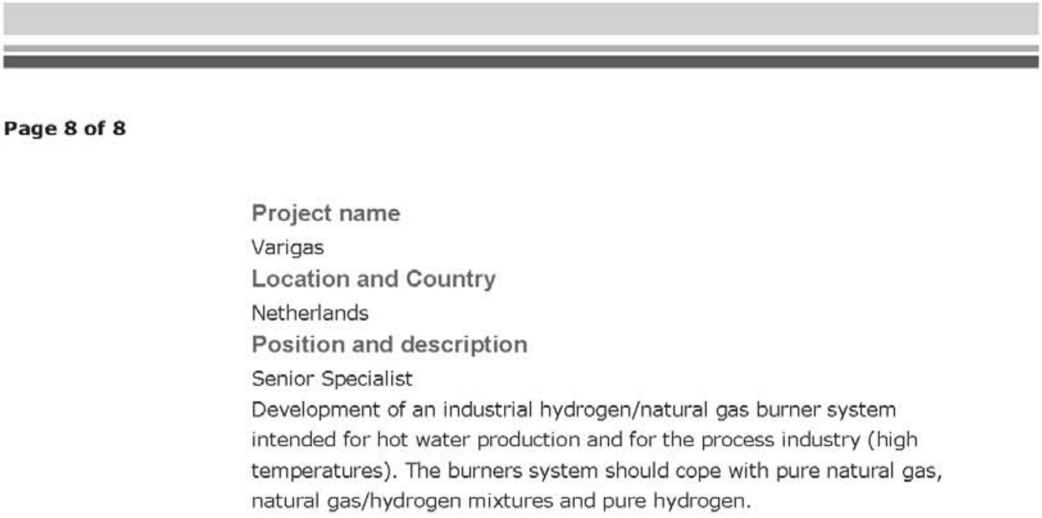
Jan 2002 - Jun 2005	Gasunie **Project name** Optimising High Temperature Gas Utilisation **Location and Country** Groningen, Netherlands **Position and description** Project leader In this national collaboration project with Gasunie (my employer at that time) and some burner manufacturers the evaluation and feasibility of flameless oxidising burners in high-temperature environments was studied. Besides that, the design the design of those burners was optimised. This project has lead to two different designs of flameless oxidation burners.
Dates	**Company**
Aug 1996 - Jun 2002	Gasunie **Project name** LowNOx burners for steam and hot water boilers **Location and Country** Groningen, Netherlands **Position and description** Project leader In this national collaboration project with Gasunie (my employer at that time) and the Dutch Association of Manufacturers and Importers of Gas and Oil fired Burners (FIGO) Burners for Steam and Hot Water Boilers were improved to meet the new lower NOx-emission regulations. In this project a novel Low NOx burner was designed and optimised. This design (the so-called "dish burner") is still being manufactured and utilised on a large scale in the Netherlands and adjoining countries.
Dates	**Company**
Jan 1996 - Jun 2006	Gasunie **Project name** Various consultancy projects **Location and Country** Groningen, Netherlands **Position and description** Project leader Various consultancy projects on optimising domestic central heating boilers, a burner for a domestic cogeneration unit, a commercial combi steamer, an industrial scale gasturbine cogeneration unit, glass, roof tile and brick ovens, etc. The optimisations were mainly focussed on improving efficiency, lower

pollution levels and better quality of the heat-treated product.

Dates Mar 1991 - Jul 1996	**Company** Gasunie **Project name** Various consultancy projects **Location and Country** Groningen, Netherlands **Position and description** Project leader Various consultancy projects on gas transmission subjects, such as measuring and improving pressure losses in gas pipelines, improving the controllability of large ball valves, the mixing process of natural gas and nitrogen at large mixing stations, the filtering of dust and liquids in natural gas installations, etc.
Dates Nov 1988 - Dec 1991	**Company** Gasunie **Project name** Gas/Air mixing research **Location and Country** Groningen, Netherlands **Position and description** Project leader In this project gas/air mixing system and methods for measuring and interpreting pressure losses and inhomogeneities in mixtures of natural gasses and combustion air. The results were used to optimise the design of gas mixing stations and gas combustion systems
Dates 2015 -2017	**Company** Ministry of economic affairs **Project name** Sustainoflame **Location and Country** Netherlands **Position and description** Senior Specialist Development of a fuel adaptive control system for industrial burners that can handle a wide range of (sustainable) gas compositions.
Dates 2017-present	**Company** Ministry of economic affairs



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Project name

Varigas

Location and Country

Netherlands

Position and description

Senior Specialist

Development of an industrial hydrogen/natural gas burner system intended for hot water production and for the process industry (high temperatures). The burners system should cope with pure natural gas, natural gas/hydrogen mixtures and pure hydrogen.

Andrew Phillips

Principal Engineer

DNV·GL

Curriculum Vitae:

Personal Statistics:

(Last revision: 2016-03-21)

Citizenship : United Kingdom
Date of Birth : 1977-08-22

Language Capabilities:

Language	**Level**
English	Native
German	Low

Academic and Professional Attainment:

Chartered Engineer, IGEM, 2011
Doctor of Philosophy, University of Nottingham, Mechanial Engineering, 2003
Bachelor of Science w\Honours, University of Nottingham, Mathematical Physics, 1998

Summary of Professional Experience:

Andrew has worked on a wide range of projects related to risk assessment since joining Risk Advisory in 2001. He acts primarily as the technical lead, subject expert or reviewer for quantitative safety studies. Areas of experience include:

- Quantitative Risk Assessment (QRA) of a wide range of assets including onshore sites and pipelines.
- Development of risk assessment methodology and mathematical models.
- Facility siting studies and onshore occupied building assessments.
- Fire and explosion safety risk assessments.
- Modelling of physical effects and consequences including fires, explosions and toxic releases.
- Design and operation of FPSOs and FLNG facilities.

Present Position:

Andrew is a Principal Engineer in the Risk Advisory team, based in the UK. He specialises in quantitative safety studies such as quantitative risk assessment (QRA), fire risk assessment (FRA), explosion risk assessment (ERA), occupied buildings assessment (OBA), ALARP demonstration and facility siting and layout studies. He works on onshore sites, transmission pipelines and distribution mains. He is also involved in the development of risk assessment methodology, the documentation of guidance and technical training of junior personnel.

Detailed Professional Experience:

DNV GL ***2001, present***

Venture Global LNG Sites **2016-02, 2016-08**

QRAs, OBAs and related consultancy for two FEED stage LNG export sites in Louisiana, USA. The sites consist of multiple parallel small capacity LNG production trains.

Aldbrough Battery Risk Assessment **2016-05, 2016-06**

Investigation into the interactions between the existing salt cavity gas storage site and a potential new battery facility associated with the electrical national grid.

Andrew Phillips

Principal Engineer

Curriculum Vitae:

Atwick Gas Storage Site **2016-02, 2016-03**
Quantification of risk reduction and cost benefit analysis of a number of potential risk mitigation measures.

Concept Stage FLNG Facility **2015-05, 2015-12**
QRAs of three design options for a concept stage FLNG facility, including different liquefaction processes.

Pipeline River Crossings **2015-03, 2015-05**
Involved in the development of methodology for risk assessments of transmission pipelines crossing waterways.

Atwick Gas Storage Site **2014-12, 2015-03**
QRA and OBA for the 2015 COMAH Report update.

Angola LNG Site **2014-10, 2015-12**
QRA of the as-built onshore site, explosion risk study and investigation into fire loading on the slug catcher.

Mozambique LNG Site **2013-05, 2015-03**
A series of FEED stage studies including QRA, fire and explosion risk assessments, occupied buildings assessment, layout studies, escape and evacuation assessment, emergency systems survivability assessment and a number of investigations into design options.

FLNG Facility **2013-05, 2013-10**
Due diligence work for a Floating LNG facility.

Jetty Separation Study **2013-04, 2013-11**
Study to explore the possibility of adding another jetty to an existing site handling hazardous materials. Included a review of existing sites and international guidance and standards, as well as a quantitative assessment of the risks for various options.

Channel Islands LPG Sites **2013-02, 2014-11**
QRAs, OBAs and related safety studies for three island LPG sites including ship import, storage and road export.

Tengiz Future Growth Project **2012-09, 2016-01**
QRAs, OBAs, assessments of fire, explosion and toxic exposure of buildings and structures, and various safety studies for wells, pipelines and two onshore oil and gas processing facilities. Included treatment of modular construction and high concentrations of toxic vapour.

FLNG Facility **2012-07, 2012-09**
Due diligence investigation of a Floating LNG facility, primarily focusing on safety and design aspects, including reviewing previous studies.

In Amenas Gas Processing Site **2012-03, 2012-10**
QRA of the site using the client's in-house methodology.

Andrew Phillips

Principal Engineer

DNV·GL

Curriculum Vitae:

Queensland Curtis LNG	**2011-06, 2013-11**

Systematic Risk Assessment (SRA), QRA, ALARP workshop and EMERA for the onshore LNG export facility.

LPG Storage and Distribution Sites	**2011-04, 2016-02**

QRAs, OBAs and risk mitigation studies for several LPG sites featuring storage, cylinder filling and road truck transfer. Clients include Flogas and SGN.

Plastic Gas Distribution Mains	**2010-09, 2016-01**

Development and application of risk assessment models to plastic pipework within the UK gas distribution network.

Ichthys Feed Gas Pipeline and LNG Export Site	**2010-01, 2014-12**

QRAs, fire and explosions assessments of various stages of the offshore and onshore feed gas pipeline and onshore terminal. A shipping risk study and various supporting studies were also carried out.

Clive Robinson

Senior Principal Consultant, UK Risk Advisory

Qualifications:	BSc (Physics), University of Birmingham
	PhD (Fluid Mechanics), University of Nottingham
	CEng
Professional Memberships:	Member of the Institute of Physics

Profile and Key Skills:

Clive Robinson is a Chartered Engineer with over 20 years experience working on safety aspects of oil and gas projects including Safety Cases, Quantitative Risk Assessments, Safety Engineering (including CFD gas dispersion and explosion modelling) for offshore platforms, FPSOs, gas reception terminals, Liquefied Natural Gas sites, pressure reduction stations and pipelines.

Recent experience:

CFD gas dispersion and explosion modelling – projects include:

CFD dispersion and explosion modeling, using FLACS, for an offshore platform to determine design overpressure and drag loads on equipment and structural items. The study included assessing the benefit of installing a blast wall on an offshore platform in terms of protection to the LQ and utility equipment and specification of the detailed design loads for the blast wall.

Assessment of the adequacy of existing fire and gas detection arrangements on an offshore platform. This was done by surveying the platform and comparing the layouts with legislative requirements, standards and good practice. In addition CFD gas dispersion modeling, using FLACS, was used to assess the gas detector layouts. Fire detector layouts were studied using the position and coverage of the specific fire detectors in use. The findings were used to specify revised fire and gas detector systems that would comply with necessary legislative requirements, standards and good practice and that would detect releases that could lead to major hazards. The layouts were also shown to have sufficient redundancy so that loss of a single detector did not impair the performance of the system.

LNG pool spill modelling, using FLACS, to determine the extent of the LNG pool interface with an FPSO hull for various release sizes, taking into account the effect of the current on the spill. The study also assessed the subsequent temperatures of the hull by using the outputs from the FLACS study as input to a finite element model of the hull.

Sour gas dispersion modelling, using FLACS, to assess gas concentration levels at the ground in the vicinity of a site. The modelling included a detailed representation of the terrain around the site as this fundamentally affected the dispersion of the sour gas.

CFD dispersion and explosion modeling, using FLACS, to derive design loads for a new design of an LNG FPSO. The results were used to validate concept engineering design loads and specify new design loads for structures and equipment as appropriate. The study also investigated a number of risk reduction options including internal and external turret options, plating and grating of decks and module separation.

Helideck study using FLACS CFD dispersion modelling to determine if the turbine exhaust plumes from an FPSO could cause impairment due to temperature rise. A series of simulations were carried out for different operating modes and meteorological conditions to determine the temperature rise above the helideck in the helicopter operating zone. The results were compared with Civil Aviation Authority guidance and recommendations made regarding restrictions to helicopter operations.

Quantitative Risk Assessment (QRA) – projects include:

QRA for a proposed LNG export terminal in Australia. The QRA included an assessment of individual and societal risks followed by a risk reduction workshop with the client and the assessment of the effectiveness of suggested risk reduction measures. Design options including electric drive compressors and GBS storage were assessed. The work also consisted of an initial layout review to determine the most appropriate separation of plant and location of occupied buildings.

QRA of Simultaneous Operations (SIMOPS) risks for a material replacement project for an oil and gas facility in Kazakhstan. The QRA was used to examine different options for carrying out the SIMOPS project, in terms of manning distributions and operation of the facility, across a 3 year timeframe to ensure that individual and group risks were reduced to tolerable levels.

QRA of port expansion project for Ras Laffan port in Qatar. The QRA consisted of the evaluation of the interaction and separation of berths handling different products. The QRA included product pipeline risks, unloading risks and shipping risks using the results of a detailed marine study.

Sour Gas QRA for modifications to a gas terminal in Tunisia. This consisted of an assessment of changes due to the introduction a new sulphuric acid plant and removal of the existing sulphur removal facilities, together with the construction of an adjacent gas processing facility. Risks to personnel during the construction period were also addressed.

QRA for a new offshore platform for the Gulf of Mexico. The QRA included fire and explosion aspects as well as transportation and dropped objects risks. The QRA was used to influence design considerations such as equipment layout and solid or grated floors.

Safety Cases – projects include:

Safety Case for a number of gas facilities in Kazakhstan including wells, pipelines, and production plants. Responsible for carrying out qualitative and quantitative risk assessments for the Safety Case and for writing the Control of Major Hazards and Justification for Continued Safe Operations section of the Safety Case. The Safety Case has been used to assess if any improvements to safety are justified at the different facilities in the field.

Safety Case update for an offshore platform in Tunisia. The existing offshore safety case was updated to comply with new internal company guidelines and to incorporate changes made to the platform since the last revision. The new guidelines required development of bow-tie diagrams and qualitative, pictorial representations of the major hazards.

Safety Case and QRA for an LNG export terminal in Egypt. The safety case was prepared using company specific guidance for the operational phase of the project. As part of the work the existing QRA produced at the design stage was updated to reflect operational data.

Publications:

Robinson, C.G. and Halford, A.R. "Assessing the consequences of accidental releases from sour oil and gas facilities". September 2016, ESREL, Glasgow, UK

Acton, M.R., Acton, O.J. and Robinson, C. 'A Review of Natural Gas Transmission Pipeline Incidents to Derive Ignition Probabilities for Risk Assessment', Paper 23, Hazards 26, 2016.

Coates, T.D, Robinson, C.G. 'The Effect of the Transient Stages of an Accidental Release on Gas Cloud Formation', Paper 44, Hazards 25, 2015.

McBride, M., Pal, P., Robinson, C. 'Gas detection systems: Does your system meet your safety requirements?', Paper 29, Offshore Mediterranean Conference and Exhibition in Ravenna, Italy, March 2009.

McBride, M., Marsh, C., Herbert, I., and Robinson, C. 'Retrospective Hazard Identification of Ageing Plant', Paper 68, Hazards XXI, 2009.

Cleaver, R.P., Halford, A.R., and Robinson, C.G. 'Analysing high consequence, low frequency accidents', The Chemical Engineer, 2002.

Farrel, R. and Robinson, C.G. 'COMAH Emergency Planning and Simulation', ISM, September 2002.

Haynes, D., Robinson, C.G. and Tam, V 'LNG FPSOs: Safe by Design', LNG Journal, July/Aug 2002.

Robinson, C., Haynes, D. and Tam, V. H. Y., 'LNG FPSOs - Safe by Design', AIChE Spring National Meeting, Topical Conference on Natural Gas Utilization, New Orleans, March 2002.

Cleaver, R.P., Humphreys, C.E., Morgan, J.D. and Robinson, C.G. 'Development of a model to predict the effects of explosion in compact congested regions', Journal of Hazardous Materials, (53), 1997, 35-55.

Cleaver, R.P. and Robinson, C.G. 'An analysis of the mechanisms of overpressure generation in vapour cloud explosions', Journal of Hazardous Materials, (45), 1996, 27-44.

Cleaver, R.P., Humphreys, C.E. and Robinson, C.G. 'Accidental generation of gas clouds on offshore process installations', Journal of Loss Prevention in the Process Industries, (7), 1994, 273-280.

Dr Mike Acton
Senior Principal Consultant

Qualifications:	BSc (Hons) Physics, Durham University (1984) DPhil Physics, Oxford University (1989)
Professional Memberships:	CPhys - Chartered Physicist MSaRS - Member of the Safety & Reliability Society
Awards:	Hutchison Medal for 2007 awarded by IChemE

Profile and Key Skills:

Mike has worked for over 25 years at DNV GL (formerly British Gas Research and Technology and subsequently Advantica) on safety and environmental issues in the oil and gas industry. A strong background in physics, including a doctorate for studies of brittle fracture behaviour, provides a firm foundation for understanding hazard and risk analysis techniques and their application to solve practical problems. He joined British Gas shortly after the Piper Alpha disaster in the UK North Sea, and immediately became involved in ground-breaking work to understand the explosion and fire hazards offshore, and to identify methods of mitigating the risks. He has since been responsible for major experimental programmes to study jet fire hazards for high pressure gas and other fuels and involved in many large scale experiments to study the hazards associated with high and low pressure underground pipelines, including full-scale experiments in Canada to study ruptures of gas transmission pipelines and experiments performed at DNV GL's Spadeadam Test Site in the UK to study the hazards from high pressure pipelines transporting hydrogen.

Other projects include:

- The development of quantified risk assessment (QRA) techniques for pipelines and associated installations.
- Application of QRA techniques to influence the design and routing of pipelines and installations and to address issues such as infringements to pipeline design codes,
- Studies to support safe working practices and procedures.

He has been a member of DNV GL's incident investigation team for 25 years and has investigated over 30 gas-related fire and explosion incidents including a terrorist attack on a gas storage site. He also undertook an investigation into a major transmission pipeline incident in Argentina, involving extensive work in-country and presentation of the findings to the Board of the safety regulator.

He is a Chartered Physicist and a member of the Institute of Physics and of the Safety and Reliability Society. He is also a member of the Gas Transmission and Distribution Committee (GTDC) of the Institute of Gas Engineers and Managers (IGEM), and has contributed to the development of Codes of Practice for the gas industry including IGEM/TD/1[1], IGEM/TD/2[2] and IGE/GL/8[3]. He is an invited technical adviser to the Risk Assessment Working Group of UKOPA (the UK Onshore Pipeline Operator's Association).

Recent experience:

Chairman of the PIPESAFE group (continuously since 1996); an international collaboration of gas companies, developing and maintaining the PIPESAFE risk assessment package for gas transmission pipelines. Currently project manager of a number of other international joint industry projects on pipeline safety issues, including quantification of the effectiveness of risk reduction measures and collection of data from pipeline incidents.

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[1] Steel pipelines and associated installations for high pressure gas transmission
[2] Assessing the risks from high pressure Natural Gas pipelines
[3] Reporting and investigation of gas-related incidents

Completed a detailed Independent Safety Review on behalf of the Irish Government of the controversial Corrib gas pipeline, including extensive public consultation. Advisor to the Irish Government (Commission for Energy Regulation) on the development of a new Petroleum Safety Framework including Individual and Societal Risk criteria published in 2013.

Led a study for Centrica concerned with the effectiveness of the current obligations to read and inspect gas and electricity meters in terms of managing risk associated with the existing meter population and the future implications for "Smart" metering, including technical representation to support Centrica in consultations with Ofgem, HSE and gas companies to support a derogation request, subsequently granted by Ofgem.

Advisor on hazard and risk issues as part of feasibility studies and planning applications for new underground gas storage facilities, including legislative compliance requirements, assessment of alternative options and consultation with the UK Health & Safety Executive and Planning Authorities on behalf of a number of different clients.

Led a major feasibility study for a proposed new transmission pipeline system in Asia including consultation with the client's technical and commercial departments and with project partners. The study required co-ordination of a range of technical activities including network modelling of a range of demand scenarios, engineering design and routing of alternative options, consideration of public safety implications and high level risk analysis.

Leads an ongoing R&D project for National Grid to develop and apply risk assessment methodologies for pipelines and Above-Ground Installations (AGIs) and to investigate the effectiveness of means of reducing risk. Provided technical leadership for the development of a software tool to integrate pipeline integrity management systems and pipeline risk assessment methodologies on behalf of National Grid to automate risk calculations, to support risk management decisions and compliance.

He continues to be actively involved in the investigation of gas-related explosion and fire incidents, and is responsible for the provision of the service throughout Great Britain on behalf of National Grid and other network operators.

Publications:

Acton, M.R. and Wilks, J., 1989, "Cone Cracks and the Auerbach Relationship in Diamond", Journal of Materials Science, vol. 24, 4229-4238

Acton, M.R., Sutton, P. and Wickens, M.J., 1990, "An Investigation of the Mitigation of Gas Cloud Explosions by Water Sprays", Piper Alpha: Lessons for Life Cycle Safety Management, IChemE Symposium Series No. 122

Sekulin, A.J. and Acton, M.R., 1995, "Large Scale Experiments to Study Horizontal Jet Fires of Mixtures of Natural Gas and Butane", Final Report to the EC

Acton, M.R., Baldwin, P.J., Baldwin, T.R., and Jager, E.E.R., "The Development of the PIPESAFE Risk Assessment Package for Gas Transmission Pipelines", Proceedings of the 2nd International Pipeline Conference 1998 (Calgary), ASME International

Acton, M.R. and McCollum, D.J., "Risk Assessment of Onshore Gas Transmission Pipelines and the PIPESAFE Package", Risk Based and Limit State Design and Operation of Pipelines Conference, Aberdeen, 1998

Acton, M.R. and Smith, B.J., "The Development and Application of Risk Assessment Techniques for Gas Distribution Pipelines", Rio Oil & Gas Conference, IBP24000, October 2000

Acton, M.R., Hankinson, G., Ashworth, B.P., Sanai, M. and Colton, J.D., "A Full Scale Experimental Study of Fires following the Rupture of Natural Gas Transmission Pipelines", Proceedings of the 3rd International Pipeline Conference 2000 (Calgary), ASME International

Acton, M.R., Gosse, A.J. and McCollum, D., "Pipeline Risk Assessment: New Developments for Natural Gas and Hydrocarbon Pipelines", The Pipeline Pigging, Integrity Assessment and Repair Conference, Houston, Texas, February 2001

Harris, R.J. and Acton, M.R., "Development and Implementation of Risk Assessment Methods for Natural Gas Transmission Pipelines", China Gas 2001, Chongqing, China

Acton, M.R., Baldwin, T.R., and Jager, E.E.R., "Recent Developments in the Design and Application of the PIPESAFE Risk Assessment Package for Gas Transmission Pipelines", Proceedings of the 4th International Pipeline Conference 2002 (Calgary), ASME International

Acton, M.R., Baldwin, T.R., and Cleaver, R.P., "Development and Implementation of Risk Assessment Methods for Onshore Natural Gas Terminals, Storage Sites and Pipelines", Proceedings of the 22nd World Gas Conference Tokyo 2003, International Gas Union

Acton, M.R., Baldwin, P.J., Cleaver, R.P. and McCollum, D.J. "Methods for Assessing Risks at Above Ground Installations", Proceedings of the 5th International Pipeline Conference 2004 (Calgary), ASME International

Acton, M.R., Baldwin P.J. and Cleaver, R.P., "Risk Management – A New Approach across Gas Networks", International Gas Research Conference, IGRC2004, Vancouver

Acton, M.R. and Andrews, R., "Independent Safety Review of the Proposed Corrib Gas Pipeline", January 2006, Dept. of Communications, Marine & Natural Resources, Ireland, www.dcmnr.gov.ie

Cleaver, R.P., Halford, A.R. and Acton, M.R. "Modeling the Effects of Pipeline Fires and the Response of People in Large Buildings", Proceedings of the 6th International Pipeline Conference 2006 (Calgary), ASME International

Lowesmith, B.J., Hankinson, G., Acton, M.R. and Chamberlain, G., "An Overview of the Nature of Hydrocarbon Jet Fire Hazards in the Oil and Gas Industry and a Simplified Approach to Assessing the Hazards", TransIChemE, Part B, Process Safety and Environmental Protection, 2007, 85(B3): 207-220

Acton, M.R., Baldwin, P.J. and Dimitriadis, K., "The Application of Risk Assessment to Routing Issues for Gas Transmission Pipelines", 12th International Symposium on Loss Prevention and Safety Promotion in the Process Industries, 22 – 24 May 2007, Edinburgh

Acton, M.R. and Baldwin, P.J., "Ignition Probability for High Pressure Gas Transmission Pipelines", Proceedings of the 7th International Pipeline Conference 2008 (Calgary), ASME International

De Stefani, V., Wattis, Z and Acton, M., "A Model to Evaluate Pipeline Failure Frequencies based on Design and Operating Conditions", AIChE 5th Global Congress on Process Safety, Tampa, Florida, April 2009

Acton, M.R., Jackson, N.W. and Jager, E.E.R., "Developments of Guidelines for Parallel Pipelines", Proceedings of the 8th International Pipeline Conference 2010 (Calgary), ASME International

Acton, M.R., Allason, D., Creitz, L.W. and Lowesmith, B.J., "Large Scale Experiments to Study Hydrogen Pipeline Fires", Proceedings of the 8th International Pipeline Conference 2010 (Calgary), ASME International

Lana, J.A., Betrán, M., Acton, M.R., Cleaver, R.P. and Dimitriadis, K., "Simulation of Releases of Natural Gas and LNG: Development of ORDER" (Published in Spanish), Ingenieriá Química, No. 493, April 2011

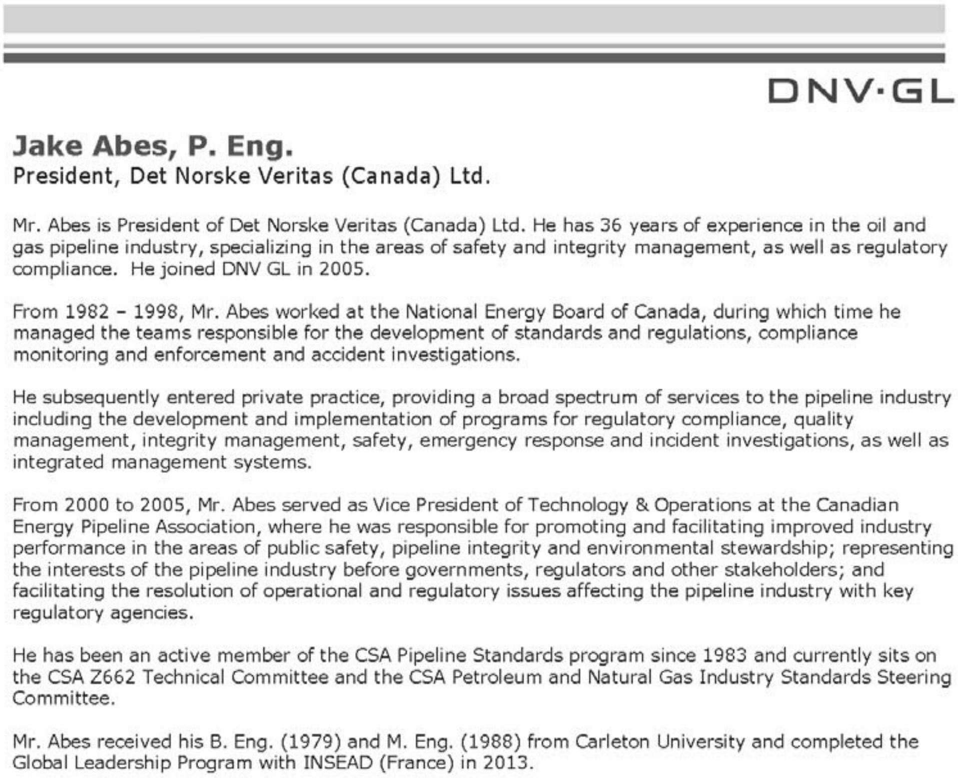
Cleaver, R.P., Maycock, K., Halford, A.R., Potts, S.J., McCollum, D.J., Sadd, A.W.T.S., and Acton, M.R. "Risk Evaluation at Compressor Stations and Above-Ground Installations", Proceedings of the 9th International Pipeline Conference 2012 (Calgary), ASME International

Acton, M.R., Lechi, M., Pognonec, G. and Rogers, M., "Development of a Fault Tree Approach for Quantifying the Effectiveness of Protective Measures for Underground Pipelines", Hazards 25 (Edinburgh), Symposium Series No. 160, IChemE, May 2015

Acton, M.R., Dimitriadis, K., Manns, T., Martin, S., McCollum, D. and Potts, S., "Development of a Risk Based Asset Management Tool for Gas Transmission Pipelines", Hazards 25 (Edinburgh), Symposium Series No. 160, IChemE, May 2015

Roels, R. and Acton, M.R., "Excavating Near Pipelines – The Human Factor", Gas International, August 2015, IGEM

Acton, M.R., Acton, O.J. and Robinson. C., "A Review of Natural Gas Transmission Pipeline Incidents to Derive Ignition Probabilities for Risk Assessment", Hazards 26 (Edinburgh), Symposium Series No. 161, IChemE, May 2016



Jake Abes, P. Eng.

President, Det Norske Veritas (Canada) Ltd.

Mr. Abes is President of Det Norske Veritas (Canada) Ltd. He has 36 years of experience in the oil and gas pipeline industry, specializing in the areas of safety and integrity management, as well as regulatory compliance. He joined DNV GL in 2005.

From 1982 – 1998, Mr. Abes worked at the National Energy Board of Canada, during which time he managed the teams responsible for the development of standards and regulations, compliance monitoring and enforcement and accident investigations.

He subsequently entered private practice, providing a broad spectrum of services to the pipeline industry including the development and implementation of programs for regulatory compliance, quality management, integrity management, safety, emergency response and incident investigations, as well as integrated management systems.

From 2000 to 2005, Mr. Abes served as Vice President of Technology & Operations at the Canadian Energy Pipeline Association, where he was responsible for promoting and facilitating improved industry performance in the areas of public safety, pipeline integrity and environmental stewardship; representing the interests of the pipeline industry before governments, regulators and other stakeholders; and facilitating the resolution of operational and regulatory issues affecting the pipeline industry with key regulatory agencies.

He has been an active member of the CSA Pipeline Standards program since 1983 and currently sits on the CSA Z662 Technical Committee and the CSA Petroleum and Natural Gas Industry Standards Steering Committee.

Mr. Abes received his B. Eng. (1979) and M. Eng. (1988) from Carleton University and completed the Global Leadership Program with INSEAD (France) in 2013.

DNV·GL

CURRICULUM VITAE

Saul Nicholas Algar

Senior Engineer

Current position

Saul is a Senior Engineer in the Risk Advisory team, based in the UK. He is responsible for leading and delivering quantitative safety studies, SHE audits and FLACS CFD studies. He is also the Assistant Manager of the Incident Investigation team and Technical Secretary of the Gas Transporters Incident Review Panel (GTIRP).

Education

Field of expertise	University/School	Year
Masters w\Honours, Chemical Engineering	Loughborough University	Sep 2012

Summary of professional experience

Saul joined DNV GL (formerly GL Noble Denton) in 2012 and has since been involved in a wide range of projects related to hazard, consequence and risk management in the oil and gas industry. He is currently a Senior Engineer within UK Risk Advisory, leading and delivering these types of services to a range of oil & gas clients in the UK and overseas. Specific responsibilities and areas of technical expertise include:

- Quantitative Risk Assessment (QRA) of a range of assets including onshore oil, gas & LNG sites.
- Facility siting studies and onshore occupied building assessments (OBA).
- Fire and explosion risk assessments (FRA and ERA).
- Advanced safety modelling of gas dispersions and explosions using FLACS CFD software
- Assistant Manager of the gas-related fire and explosion Incident Investigation team
- Lead Internal HSE Auditor for gas plant demolition, land remediation and site investigations
- Facilitator and technical secretary of the Gas Transporters Incident Review Panel (GTIRP)

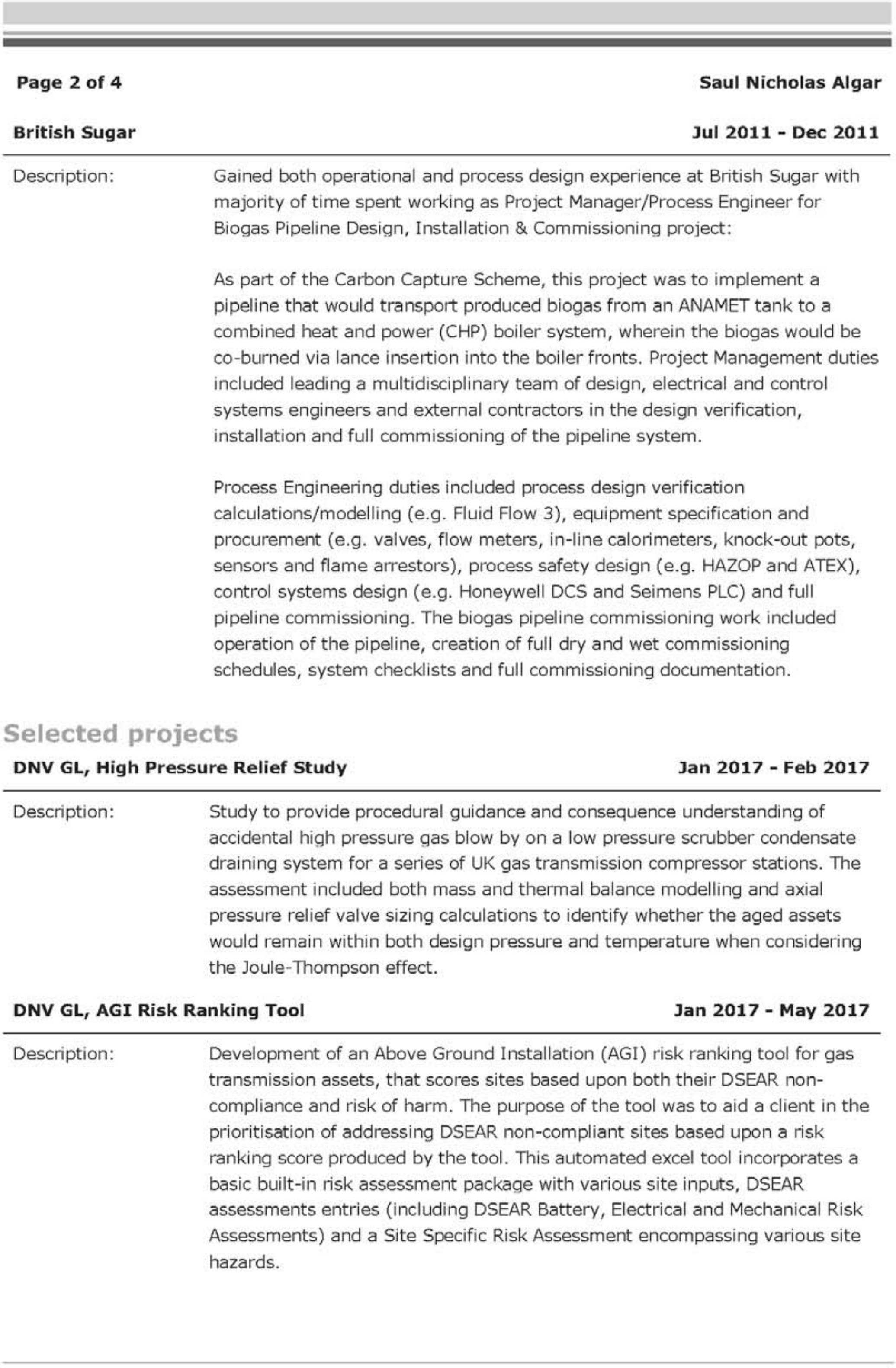
Saul also has a background in operations and process engineering having spent 2.5 years working in industry at Procter & Gamble, AstraZeneca and British Sugar whilst studying at Loughborough University. Furthermore, he is involved with full scale explosion experiments at Spadeadam Test Site as part of his ongoing PhD in gas explosions at Leeds University.

Papers and publications

- "Gas Explosions in Partially Filled, Large Twin Enclosures Connected with an Open Door and Having Variable Vent Sizes on Both Compartments", Tomlin G.B., Phylaktou H.N., Johnson D.M., Andrews G.E. and Algar S.N., Proceedings of the 8th International Seminar on Fire and Explosion Hazards, Apr 01, 2016

Employment

DNV GL	**Aug 2012 - Present**



British Sugar **Jul 2011 - Dec 2011**

Description:

Gained both operational and process design experience at British Sugar with majority of time spent working as Project Manager/Process Engineer for Biogas Pipeline Design, Installation & Commissioning project:

As part of the Carbon Capture Scheme, this project was to implement a pipeline that would transport produced biogas from an ANAMET tank to a combined heat and power (CHP) boiler system, wherein the biogas would be co-burned via lance insertion into the boiler fronts. Project Management duties included leading a multidisciplinary team of design, electrical and control systems engineers and external contractors in the design verification, installation and full commissioning of the pipeline system.

Process Engineering duties included process design verification calculations/modelling (e.g. Fluid Flow 3), equipment specification and procurement (e.g. valves, flow meters, in-line calorimeters, knock-out pots, sensors and flame arrestors), process safety design (e.g. HAZOP and ATEX), control systems design (e.g. Honeywell DCS and Seimens PLC) and full pipeline commissioning. The biogas pipeline commissioning work included operation of the pipeline, creation of full dry and wet commissioning schedules, system checklists and full commissioning documentation.

Selected projects

DNV GL, High Pressure Relief Study **Jan 2017 - Feb 2017**

Description:

Study to provide procedural guidance and consequence understanding of accidental high pressure gas blow by on a low pressure scrubber condensate draining system for a series of UK gas transmission compressor stations. The assessment included both mass and thermal balance modelling and axial pressure relief valve sizing calculations to identify whether the aged assets would remain within both design pressure and temperature when considering the Joule-Thompson effect.

DNV GL, AGI Risk Ranking Tool **Jan 2017 - May 2017**

Description:

Development of an Above Ground Installation (AGI) risk ranking tool for gas transmission assets, that scores sites based upon both their DSEAR non-compliance and risk of harm. The purpose of the tool was to aid a client in the prioritisation of addressing DSEAR non-compliant sites based upon a risk ranking score produced by the tool. This automated excel tool incorporates a basic built-in risk assessment package with various site inputs, DSEAR assessments entries (including DSEAR Battery, Electrical and Mechanical Risk Assessments) and a Site Specific Risk Assessment encompassing various site hazards.

DNV GL, Pressure Reduction Installation Sites	**Aug 2016 - Present**
Description:	Land use planning assessments and QRAs of various gas gate stations (PRIs) including equipment in below ground pits/vaults and above ground assets with nearby off-site populations. The assessments include consequence modelling of gas dispersions, fires and confined explosions, release frequency assessment and production of societal risk exceedance curves for various designs. Production of a Screening Risk Assessment Tool created for PRIs that quickly identifies whether a proposed site design requires either; re-design due to intolerable risk, detailed QRA to prove suitability or no further assessment due to tolerable risk.

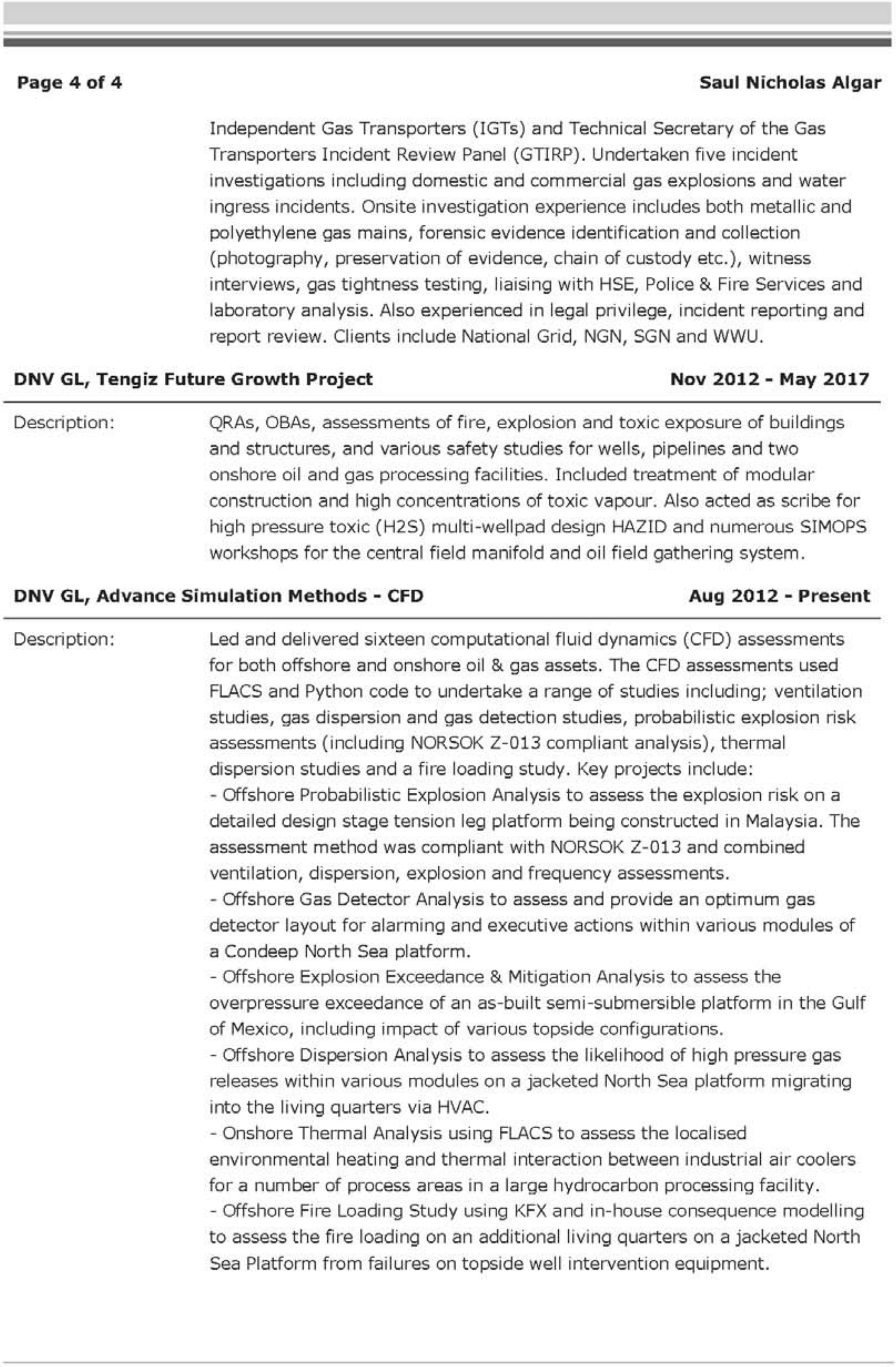
DNV GL, Venture Global LNG Sites	**Feb 2016 - May 2017**
Description:	QRAs, OBAs and related consultancy for two FEED stage LNG production, storage and export sites in Louisiana, USA. The sites consist of multiple parallel small capacity LNG production trains.

DNV GL, COMAH Compliance Suite Update	**Nov 2015 - Jan 2016**
Description:	Updating a suite of COMAH compliance documentation for a UK gas distribution client in order to reflect changes in their assets and bring the supporting documents for their Major Accident Prevention Policy (MAPP) in line with the updated COMAH Regulations 2015.

DNV GL, Nat. Gas, LPG & LNG Storage and Distribution Sites	**Jan 2015 - May 2017**
Description:	QRAs, OBAs, cost-benefit analysis and risk mitigation studies for several Natural Gas, LPG and LNG sites featuring storage (including high pressure vessels/pipe arrays and low pressure gasholders), multi-junction pipelines, vaporising and road truck transfer. Clients include National Grid and SGN.

DNV GL, SHE Audits & Incident Investigation	**May 2014 - Present**
Description:	Lead Auditor for over 75 Internal SHE Audits / SHE Oversight Visits of several types of site including; gasholder demolition, land remediation, site investigation, earthworks and pipeline construction. Lead Incident Investigator for several onsite SHE incidents (near misses, HIPOs, LTIs) including; significant gas release, asset damage, gasholder fire and security incident. Support Incident Investigator for several onsite SHE incidents (near misses, HIPOs, LTIs) including; gasholder fire, dropped object, overturned dumper, manual handling injury and environmental incident.

DNV GL, Fire & Explosion Incident Investigation	**Jun 2013 - Present**
Description:	Assistant Manager of the gas-related fire and explosion Incident Investigation team covering the UK Gas Distribution Networks (GDNs) and most



Independent Gas Transporters (IGTs) and Technical Secretary of the Gas Transporters Incident Review Panel (GTIRP). Undertaken five incident investigations including domestic and commercial gas explosions and water ingress incidents. Onsite investigation experience includes both metallic and polyethylene gas mains, forensic evidence identification and collection (photography, preservation of evidence, chain of custody etc.), witness interviews, gas tightness testing, liaising with HSE, Police & Fire Services and laboratory analysis. Also experienced in legal privilege, incident reporting and report review. Clients include National Grid, NGN, SGN and WWU.

DNV GL, Tengiz Future Growth Project **Nov 2012 - May 2017**

Description: QRAs, OBAs, assessments of fire, explosion and toxic exposure of buildings and structures, and various safety studies for wells, pipelines and two onshore oil and gas processing facilities. Included treatment of modular construction and high concentrations of toxic vapour. Also acted as scribe for high pressure toxic (H2S) multi-wellpad design HAZID and numerous SIMOPS workshops for the central field manifold and oil field gathering system.

DNV GL, Advance Simulation Methods - CFD **Aug 2012 - Present**

Description: Led and delivered sixteen computational fluid dynamics (CFD) assessments for both offshore and onshore oil & gas assets. The CFD assessments used FLACS and Python code to undertake a range of studies including; ventilation studies, gas dispersion and gas detection studies, probabilistic explosion risk assessments (including NORSOK Z-013 compliant analysis), thermal dispersion studies and a fire loading study. Key projects include:

- Offshore Probabilistic Explosion Analysis to assess the explosion risk on a detailed design stage tension leg platform being constructed in Malaysia. The assessment method was compliant with NORSOK Z-013 and combined ventilation, dispersion, explosion and frequency assessments.
- Offshore Gas Detector Analysis to assess and provide an optimum gas detector layout for alarming and executive actions within various modules of a Condeep North Sea platform.
- Offshore Explosion Exceedance & Mitigation Analysis to assess the overpressure exceedance of an as-built semi-submersible platform in the Gulf of Mexico, including impact of various topside configurations.
- Offshore Dispersion Analysis to assess the likelihood of high pressure gas releases within various modules on a jacketed North Sea platform migrating into the living quarters via HVAC.
- Onshore Thermal Analysis using FLACS to assess the localised environmental heating and thermal interaction between industrial air coolers for a number of process areas in a large hydrocarbon processing facility.
- Offshore Fire Loading Study using KFX and in-house consequence modelling to assess the fire loading on an additional living quarters on a jacketed North Sea Platform from failures on topside well intervention equipment.

DNV·GL

CURRICULUM VITAE

Akvilina Valaityte
Senior Engineer

Current position
Akvilina is a senior engineer in the Risk Advisory team, based in the UK. She specialises in quantitative safety studies such as quantitative risk assessment (QRA), fire risk assessment (FRA), explosion risk assessment (ERA), occupied buildings assessment (OBA), facility siting and layout studies. She works on onshore sites, transmission pipelines and distribution mains. She is also involved in the risk assessment documentation of guidance and technical training of junior personnel.
Akvilina also has experience in functional safety, reliability and RAM studies for offshore installations.

Languages

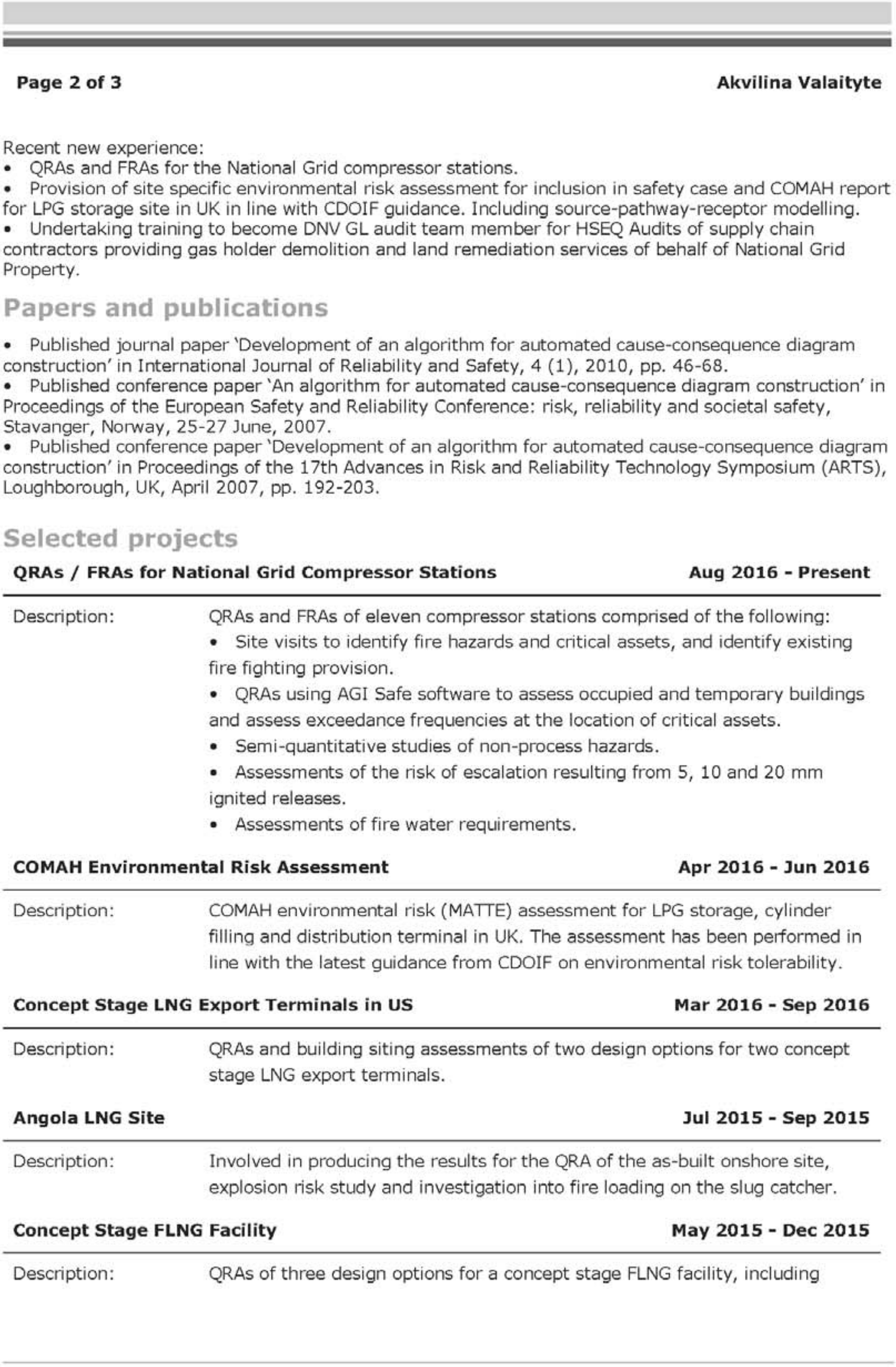
Language	Speaking	Reading	Writing
English	High	High	High
Lithuanian	High	High	High
Russian	Medium	High	Low

Education

Field of expertise	University/School	Year
Master of Science, Applied Mathematics	Kaunas University of Technolog	Jun 2004
Bachelor of Science, Applied Mathematics	Kaunas University of Technolog	Jun 2002

Summary of professional experience
Akvilina has worked on a wide range of projects related to risk and reliability assessments in the oil and gas industry since joining DNV GL Risk Advisory in 2008. Areas of experience include:

- Quantitative Risk Assessments (QRA) of a wide range of assets including onshore sites and pipelines.
- Risk assessments of vapour and liquid transmission pipelines.
- Facility siting studies and onshore occupied building assessments.
- Fire and explosion safety risk assessments.
- Documentation of guidance of risk assessment methodology.
- Experience with commercial computational software packages such as:
  - FROST and AGI Safe for consequence and risk assessments,
  - Fault Tree+ for reliability studies,
  - OPTAGON for reliability, availability and maintainability studies, etc.



Recent new experience:
- QRAs and FRAs for the National Grid compressor stations.
- Provision of site specific environmental risk assessment for inclusion in safety case and COMAH report for LPG storage site in UK in line with CDOIF guidance. Including source-pathway-receptor modelling.
- Undertaking training to become DNV GL audit team member for HSEQ Audits of supply chain contractors providing gas holder demolition and land remediation services of behalf of National Grid Property.

Papers and publications

- Published journal paper 'Development of an algorithm for automated cause-consequence diagram construction' in International Journal of Reliability and Safety, 4 (1), 2010, pp. 46-68.
- Published conference paper 'An algorithm for automated cause-consequence diagram construction' in Proceedings of the European Safety and Reliability Conference: risk, reliability and societal safety, Stavanger, Norway, 25-27 June, 2007.
- Published conference paper 'Development of an algorithm for automated cause-consequence diagram construction' in Proceedings of the 17th Advances in Risk and Reliability Technology Symposium (ARTS), Loughborough, UK, April 2007, pp. 192-203.

Selected projects

QRAs / FRAs for National Grid Compressor Stations **Aug 2016 - Present**

Description: QRAs and FRAs of eleven compressor stations comprised of the following:
- Site visits to identify fire hazards and critical assets, and identify existing fire fighting provision.
- QRAs using AGI Safe software to assess occupied and temporary buildings and assess exceedance frequencies at the location of critical assets.
- Semi-quantitative studies of non-process hazards.
- Assessments of the risk of escalation resulting from 5, 10 and 20 mm ignited releases.
- Assessments of fire water requirements.

COMAH Environmental Risk Assessment **Apr 2016 - Jun 2016**

Description: COMAH environmental risk (MATTE) assessment for LPG storage, cylinder filling and distribution terminal in UK. The assessment has been performed in line with the latest guidance from CDOIF on environmental risk tolerability.

Concept Stage LNG Export Terminals in US **Mar 2016 - Sep 2016**

Description: QRAs and building siting assessments of two design options for two concept stage LNG export terminals.

Angola LNG Site **Jul 2015 - Sep 2015**

Description: Involved in producing the results for the QRA of the as-built onshore site, explosion risk study and investigation into fire loading on the slug catcher.

Concept Stage FLNG Facility **May 2015 - Dec 2015**

Description: QRAs of three design options for a concept stage FLNG facility, including different liquefaction processes.

Channel Islands LPG Sites	**Feb 2013 - Dec 2014**
Description:	QRAs, OBAs and related safety studies for three island LPG sites including ship import, storage and road export.

Tengiz Future Growth Project	**Sep 2012 - Mar 2014**
Description:	QRAs, OBAs, assessments of fire, explosion and toxic exposure of buildings and structures, and various safety studies for two onshore oil and gas processing facilities. Included treatment of modular construction and high concentrations of toxic vapour.

LPG Storage and Distribution Sites	**Apr 2011 - Jul 2016**
Description:	QRAs, OBAs and risk mitigation studies for several LPG sites featuring storage, cylinder filling and road truck transfer. Clients include Flogas and SGN.

Risk Assessment for Small Enclosures	**Jan 2011 - Apr 2011**
Description:	QRA for National Grid UK district governor enclosures.

Carbon Capture and Storage Safety Studies	**Jan 2010 - Dec 2012**
Description:	QRAs of proposed carbon dioxide transmission pipelines. Pipeline routing studies and contribution in development of risk-based routing guidelines for pipelines transporting dense phase carbon dioxide. Investigation of the consequences of carbon dioxide pipeline releases.

Ichthys Feed Gas Pipeline and LNG Export Site	**Jan 2009 - Dec 2014**
Description:	QRAs, fire and explosions assessments of various stages of the offshore and onshore feed gas pipeline and onshore terminal. A shipping risk study and various supporting studies were also carried out.

LNG Process Safety Support	**Jan 2008 - Dec 2009**
Description:	LNG tank failure frequency study. Fault tree analyses of tank overfilling at National Grid UK sites.

Other information

Akvilina is an engineering associate member of IGEM (Institution of Gas Engineers and Managers).

ENBRIDGE GAS INC.
Answer to Interrogatory from
OEB Staff (STAFF)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, Attachment 1, Table 2, page 11

Preamble:

Enbridge Gas provided a table that summarizes the initial criteria for the selection of closed loop systems for use as BGAs. One criteria is pipeline material. Enbridge Gas states that some carbon steel pipes and welds might be affected by the presence of hydrogen, under certain conditions, and that plastic pipelines could exhibit fewer issues with regards to hydrogen. Enbridge Gas also states that it is known that turbines, compressed natural gas (CNG) tanks and some other sensitive equipment are not compatible with low levels of hydrogen.

Question:

a) Please explain what effect(s) hydrogen has on carbon steel pipes and welds? Besides limiting the concentration of hydrogen, are there any other actions that Enbridge Gas can take to mitigate these effects? Please explain.

b) How much more permeable are plastic pipe and fittings to hydrogen that steel? Could any difference in permeability result in a change to the operational effectiveness of steel or plastic pipe and fittings in terms of leaks or other factors? Please explain.

c) In addition to turbines and CNG tanks, what other types of equipment are not well suited to blended gas? Is avoidance the only means of mitigation?

d) How would blended gas affect large volume consumers who use natural gas for process load or as a feedstock? For example, fertilizer manufacturers.

Response:

a) The addition of hydrogen may lead to hydrogen embrittlement, hydrogen-induced cracking, hydrogen-induced stress corrosion cracking and hydrogen-induced cold crack (also known as delayed crack or cold cracking). However, based on the studies analyzed and conducted by Enbridge Gas this is not expected to be a concern when adding up to 2% of Hydrogen by volume in this BGA. More study is required at higher pressures and percentages of hydrogen in order to fully understand the mitigation that might be required to prevent issues in those scenarios.

b) Permeation is very slow through steel, and does not increase due to higher pressure. It increases with temperature (because it enhances the dissociation of the hydrogen molecules), which can lead to high temperature hydrogen attack (HTHA) at temperatures above 200°C, resulting in hydrogen becoming trapped in the material. Distribution lines operate at temperatures significantly lower than 200°C.

Permeation of hydrogen is higher than that of methane though plastic piping, however an increase in permeation at the concentration levels studied was found to be negligible.

c) Other types of equipment that may not be well-suited for blended gas include natural gas engines, commercial and industrial burners and applications that use natural gas as feedstock to produce fertilizer and other products.

For most equipment, mitigation of impacts from blended gas may be possible through machine readjustments. Specific impacts and potential mitigations will depend on the application and need to be assessed on a case-by-case basis, according to manufacturer’s specifications.

d) Please refer to the response for question (c) stated above. In addition,
The impact on a large volume customer who may use blended natural gas will depend on the specific equipment used. There are no large volume customers in the BGA. Enbridge Gas has not conducted a survey of customer equipment for large volume customers across its franchise and cannot comment on specific customer equipment without further investigation.

ENBRIDGE GAS INC.
Answer to Interrogatory from
OEB Staff (STAFF)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, Attachment 1, Figure 3

Preamble:

Figure 3 is a map that illustrates the extents of loops S1, S1A and B1 relative to Enbridge Gas' existing distribution system. Most of the existing pipelines are orange in colour. There are small portions of pipelines that are in purple; some are inside a loop (e.g., northeast corner of Elgin Mills Road East and Highway 404) and some are outside a loop (e.g., northwest corner of 10th Avenue and Kennedy Road).

Question:

What is the significance of the purple pipelines? Are they related to the Project in some way? If so, please explain

Response:

The map provided at Exhibit B, Tab 1, Schedule 1, Attachment 1, Figure 3 is a screenshot of a GIS map of the Enbridge Gas distribution system in and around the TOC. It shows, at a point in time, the status of proposed pipelines, pipelines that are active and in-service, pipelines under construction and pipelines scheduled for decommissioning.

At the time the map was produced the purple lines were proposed pipelines. None of the purple pipelines identified in Figure 3 are directly related to the Project. However, the purple pipelines contained in the area identified as Loop S1 will become part of the BGA and receive blended gas once the Project is in-service. The purple pipelines at the western edge of the BGA have been constructed and energized and will become part of the BGA. The purple pipelines in the north in the BGA are proposed and not yet constructed and in-service, however they will form part of the BGA when they are in-service.

ENBRIDGE GAS INC.
Answer to Interrogatory from
OEB Staff (STAFF)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, Table 1 and pages 1-3 and 13
Exhibit C, Tab 1, Schedule 1, Attachment 4, page 53

Preamble:

Enbridge Gas is seeking approvals for a pilot project that involves injecting a controlled quantity of hydrogen into its natural gas distribution system to create a blended gas comprised predominantly of methane with up to 2% hydrogen by volume.

When combusted, hydrogen is a zero carbon emission fuel source. As a result, the blended gas would produce less GHG emissions relative to combusting regular natural gas. Enbridge Gas estimates that the GHG reductions associated with using blended gas having 2% hydrogen by volume in Loop S1 would be between 97-120 tCO2e per year.

OEB staff notes that, in 2017, Ontario's GHG emissions attributable to petroleum refining and natural gas distribution were 7.9 MtCO2e[6].

Enbridge Gas says the 2% limit was based on literature reviews, analytical modeling, risk assessments, field surveys, industry consultation (e.g., external consultants, internal subject matter experts, manufacturers, etc.), integrity considerations and engineering judgement. This included an assessment of gas interchangeability to confirm that the combustion parameters of the blended gas remain within the range of Enbridge Gas' gas specifications based on historical gas distribution values for the past 12 years. Enbridge Gas also completed a survey of appliances in the BGA to ensure compatibility with hydrogen concentrations of up to 2% by volume.

Enbridge Gas says that its investigation into the various components of loops S1, S1A and B1 yielded the conclusion that up to 5% hydrogen by volume could be injected into the system.

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[6] https://www.cer-rec.gc.ca/nrg/ntgrtd/mrkt/nrgsstmprfls/on-eng.html

A sample of international projects reveals that some had blended gas with concentrations of hydrogen as high as 20% by volume.

Question:

a) Based on its research to date, does Enbridge Gas believe that it is possible for its residential and commercial customers' appliances to consume blended gas with concentrations of hydrogen greater that 2% by volume?

b) Does Enbridge Gas intend to increase the concentration of hydrogen above 2% in loops S1, S1A and B1 in the future?

c) Does Enbridge Gas anticipate that other loops throughout its system may be able to safely accept blended gas with greater than 2% hydrogen?

d) Has Enbridge Gas compared the GHG reduction benefits of hydrogen blending to other existing or potential programs that reduce GHGs (e.g., Demand Side Management) in terms of metrics such as $ spent / tCO2e reduced? If so, please provide a summary table that lists the alternatives and their corresponding metrics. If not, please explain why not.

Response:

a) Determination of whether or not hydrogen blending is possible and at what concentrations requires a network specific study to determine if a specific network is suitable for hydrogen blending, including review of the customer appliances and equipment within that network. Enbridge Gas has selected the 2% by volume percentage as to not cause a material change to the appliances in the Blended Gas Area (BGA). A material change is defined as one where there will be no noticeable change to appliance operation and that the combustion characteristics will be similar or the same to the fuel historically delivered in the area. While it is possible that a concentration of more than 2% hydrogen by volume could be used in the future, this would require further study of the relevant BGA, including the appliances used in that network. At this time, Enbridge Gas is not prepared to recommend any higher concentration without further study and practical experience.

b) Enbridge Gas does not intend to increase the concentration of hydrogen in loops S1, S1a and S1b in the near future. Please see response to a) above.

c) Please see response to question a) above.

d) Enbridge Gas has not undertaken any detailed review of the relative cost/benefit analysis for GHG reductions from hydrogen blending as compared to other activities with similar objectives. The Company does not currently have enough information to meaningfully complete such analysis. For example, there is insufficient information available related to the potential compliance cost implications of the Clean Fuel Standard, and the cost of future hydrogen LCEPs are not known. The main purpose of this pilot Project is to assess the technical feasibility and customer related aspects of blending limited amounts of hydrogen into the Company's gas supply stream. The learnings from this Project will then serve to inform future decisions as to the viability of hydrogen blending as a means of reducing GHG emissions associated with the use of natural gas which will include associated economic considerations.

ENBRIDGE GAS INC.
Answer to Interrogatory from
OEB Staff (STAFF)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, Attachment 1, pages 11-13

Preamble:

Enbridge Gas says that industrial customers are much more sensitive to variations in their fuel, and therefore would not be suitable for the first phase of hydrogen blending.

Question:

Given that demand for natural gas by industrial customers represents a large portion of the total annual demand for natural gas in Ontario – and therefore represents a large portion of potential GHG reductions from the use of blended gas – does Enbridge Gas intend to serve industrial customers with blended gas in future phases? Please explain.

Response:

Enbridge Gas does not intend to serve industrial customers with blended gas at this time. The decision as whether or not to do so will be dependent on future research that includes the assessment of various types of industrial customer equipment and the physical characteristics of the Company's gas distribution system in areas considered for blended gas delivery in the future.

ENBRIDGE GAS INC.
Answer to Interrogatory from
OEB Staff (STAFF)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, Attachment 1, page 16

Preamble:

Fuels safety falls under the purview of the Technical Standards and Safety Authority (TSSA), so hydrogen and blended gas pipelines are under the jurisdiction of the TSSA.

The TSSA requires compliance with the Canadian Standards Association (CSA) Z662 Oil and Gas Pipeline Systems (CSA Z662)[7]. The CSA Z662 definition of “gas” does not explicitly cover blended gas. However, the scope of the CSA Z662 includes pipeline systems that convey Manufactured Gas and Synthetic Natural Gas, which have high hydrogen contents.

Prior to filing the Application, Enbridge Gas consulted with the TSSA and provided information on the Project. The TSSA indicated to Enbridge Gas that it would act as a technical reviewer of the Application on behalf of the OEB if requested.

OEB staff contacted the TSSA to inquire about its support. The TSSA indicated that it would not intervene in this proceeding, but that it would file a letter of comment.

Question:

Has Enbridge Gas had any discussions with the TSSA since it filed the Application? If so, please provide a summary of those discussions.

Response:

In March 2020, Enbridge Gas filed an Application for Review of Pipeline Project with the TSSA, which is a standard requirement for any pipeline project. In April 2020, the TSSA provided a number of technical questions to Enbridge Gas, which the Company is in the process of answering.

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[7] https://www.tssa.org/en/fuels/resources/Documents/Code-Adoption-Document---Oil-Updated-Contact-Numbers.pdf

Enbridge Gas has also had communications with the TSSA (Fuel Safety Branch) since the application was filed, to inform the TSSA of the filing and the pending OEB review process. Through these communications, Enbridge Gas shared the filed application materials, and also provided a public link to the interrogatories on the OEB website. The focus of the brief discussion between Enbridge Gas and the TSSA was on the role that the TSSA might play in this application. For details please see Exhibit I.CCC.7.

ENBRIDGE GAS INC.
Answer to Interrogatory from
OEB Staff (STAFF)

INTERROGATORY

Reference:

Exhibit 1, Tab 1, Schedule 1, Attachment 1, page 19

Preamble:

In summarizing the conclusions from each of the work streams conducted to evaluate the suitability of hydrogen blending both internally for its distribution system and externally for customer-owned piping and equipment, Enbridge Gas states, “Risk Assessment (Hazard Identification and Quantitative Risk Assessment work): Completed and the results were accepted.”

Question:

a) What does “accepted” mean? Does it mean that someone approved the risk mitigation strategies and residual risks?

b) Who accepted the results and what are their qualifications to do so?

Response:

a) and b) “Accepted” means that Enbridge Gas (EGD at the time the assessment was performed) accepted the quantitative risk assessment as an accurate reflection of the risks related to the introduction of hydrogen in the natural gas distribution system. This acceptance affirms that:

- The technical quality of the risk assessment was appropriate
- The risk assessment was adequate to support the decision to move ahead with hydrogen blending and includes the mitigation strategy and the residual risks

The acceptance of the results of the risk assessment is done by Enbridge Gas’s engineering department, through established processes which ensure thorough review. The persons involved in the risk assessment review and approval process are qualified engineers and operational specialists with lengthy experience with gas distribution activities.

ENBRIDGE GAS INC.
Answer to Interrogatory from
OEB Staff (STAFF)

INTERROGATORY

Reference:

Exhibit 1, Tab 1, Schedule 1, page 19

Preamble:

Enbridge Gas states that, “[i]ncreased monitoring of the gas distribution network in Markham will take place in the initial period of the Project in order to confirm the findings of Enbridge Gas.”

Question:

Please confirm that the “initial period” means Phase 1. If not, please explain.

Response:

Confirmed. The initial period means Phase 1. Enbridge Gas intends to increase monitoring of the distribution network in Markham for the first five years after the introduction of blended gas into the BGA – please see Exhibit I.FRPO.14.

ENBRIDGE GAS INC.
Answer to Interrogatory from
OEB Staff (STAFF)

INTERROGATORY

Reference:

Exhibit C, Tab 1, Schedule 1, page 5

Preamble:

Enbridge says that an Environmental Protection Plan (EPP) for the Project will be completed prior to mobilization and construction. The EPP will incorporate recommended mitigation measures contained in the Environmental Report (ER) and those mitigation measures obtained from agency consultation for the environmental issues associated with the proposed works.

Question:

Please provide a status update on agency communications related to the EPP since Enbridge Gas filed the Application.

Response:

The EPP for the Project will be completed prior to mobilization and construction, so that it can be tailored to include agency comments (if received). As the Board has not yet granted leave to construct for the Project, an EPP has not been created. To date, no additional agency communications related to the EPP has been received since Enbridge Gas filed the Application. Once an EPP has been finalized, it will be filed with the Board.

ENBRIDGE GAS INC.
Answer to Interrogatory from
OEB Staff (STAFF)

INTERROGATORY

Reference:

Exhibit C, Tab 1, Schedule 1, Attachment 2, Appendix E, page 5

Preamble:

During public consultations, a resident asked Enbridge Gas for a copy of the engineering assessment. Enbridge Gas responded that the assessment would be available at the time that Enbridge Gas applied to the OEB.

Question:

Please confirm that the resident was provided a copy of the engineering assessment and on what date. Were there any concerns raised by the resident regarding the engineering assessment? If so, please provide the nature of the comments raised and Enbridge's response to these comments. If a copy of the assessment was not provided, please explain why not.

Response:

Enbridge Gas has not provided a copy of the engineering assessment to the resident. Please see Exhibit I.H2GO.1.

ENBRIDGE GAS INC.
Answer to Interrogatory from
OEB Staff (STAFF)

INTERROGATORY

Reference:

Exhibit C, Tab 1, Schedule 1, Attachment 2, pages 6-7
Exhibit C, Tab 1, Schedule 1, Attachment 4, page 4

Preamble:

Enbridge Gas' consultation logs show that a particular resident asked a number of questions including one about the impact of the use of blended gas on home insurance. The log indicates that Enbridge Gas responded to the resident's questions, but does not record the answers that were given.

During the open house that was held as part of completing the ER Addendum, another resident asked about the impact of the use of blended gas on home insurance and property tax.

Question:

Please file a copy of the information that Enbridge Gas provided to these residents in response to their questions about the impact of the use of blended gas on home insurance and property tax?

Response:

The Attachments to this response contain the information and responses provided to the residents referenced above.

Attachments 1 to 3 set out the responses and information provided to the resident referenced at Exhibit C, Tab 1, Schedule 1, Attachment 2, pages 6-7.

Attachment 4 sets out a question provided by a stakeholder to Enbridge Gas on an Information Session Questionnaire related to how the costs of the project will be passed along. A response could not be provided to the stakeholder that asked this question, as no contact information was provided by the stakeholder.

Energy, Low-Carbon <lowcarbonenergyea@dillon.ca>

RE: [External] RE: Low-Carbon Energy Project

[redacted]@enbridge.com> Thu, May 23, 2019 at 3:55 PM
To: [redacted]@rogers.com" [redacted]@rogers.com>
Cc: "Energy, Low-Carbon" <lowcarbonenergyea@dillon.ca>

Hi [redacted]

Below is a response to the questions you provided to us at the open house, that were photocopied by a team member.

1. Reason for this project: environmentally friendly? Costs to Enbridge will be paid by who, us, who else?

    - The purpose of the project is to reduce greenhouse gas emissions. By injecting hydrogen, a carbon free gas, into the natural gas grid Enbridge expects that the project, once fully in service, could reduce carbon emissions by those using the blended gas by 625 metric tons of CO2e annually. This figure was derived from the gas consumed in 2018 for the area that will be receiving blended gas. This is equal to the total amount of greenhouse gas emissions from approximately 139 homes in a year (based on the average consumption of a home in a year).

    - The costs of the Low Carbon Energy project and the hydrogen we would be using would be built into rates for customers across our rate base, pending OEB approval. There could also be some cost savings due to using cleaner blended gas, as Enbridge may be able to pay lower carbon taxes. If these savings are realized, they would be passed on to Enbridge customers as well.

2. Is this project approved by the City of Markham or its at the study level? If approved already why community affected by this project was not involved in the initial stages to get familiar and express our concerns?

    - Enbridge is regulated by the Ontario Energy Board (OEB). The project has not been approved, as the OEB still needs to review the supporting documentation. Currently, Enbridge is undertaking a consultation program as part of the environmental assessment required by the OEB. This is the stage where residents can become familiar with the project and express their concerns. All feedback received from the public (including your submitted questions) are considered and documented in the Environmental Report that will be submitted to the OEB as part of Enbridge's Leave to Construct application.

3. Notification method: was this the proper way to inform everyone affected? A single piece of paper that looks like a worthless flyer? Everyone I called thought it was a flyer and put it in the recycling bin. I receive every month letters from Enbridge asking me to pay for a furnace maintenance. This important notice was not worth to put it in an envelope with the name and address to each house affected?

    - Thank you for your comments. The Notice of Commencement (NOC) was distributed by unaddressed admail through Canada Post. This method has been effectively used on previous projects to reach a large study area (over 33,600 Notices were delivered). In addition, the NOC was published in local newspapers on March 7 and 14 (Markham Economist & Sun) and March 9 and 18 (Ming Pao). As well, some local councilors shared the project and open house information in their e-newsletters, and the notices were also posted in City of Markham-run community centers in the project area.

4. Where - where this mix of gasses has been used - is used - currently. Is it the City of Toronto, the province of Ontario, Canada, North America, anywhere on the planet? If not are we the guinea pigs of the world?

    - Power-to-Gas is not a new technology. Several Power-to-Gas facilities successfully operate in Europe, some for over a decade. Enbridge's engineering department researched, analyzed, and tested the technical feasibility and safety of using hydrogen for this proposed project.

5. Why - why are you mixing a very combustible gas as hydrogen in with propane gas? Have you accumulated some big amount of this gas by some process (by-product) and you would put it in the pipeline with possible great financial gains to your corporation? What is the cost of 1 cubic metre of hydrogen gas versus 1 cubic metre of natural gas? Is this new mix going to be cheaper for the consumer?

    - The purpose of the project is to reduce greenhouse gas emissions. How we use energy and the sources we rely on are changing. Ontario is seeking lower-carbon, sustainable energy solutions, like hydrogen and renewable natural gas made from organic waste. We believe that all forms of energy have a role to play in this shift to a low-carbon economy. This means leveraging all of our company's assets – whether it's pipelines, renewable power or our natural gas infrastructure – to provide an energy system that meets the demand for safe, reliable and affordable energy.

    - Your question included a reference to hydrogen being a very combustible gas. Hydrogen, as with every combustible fuel including natural gas, requires proper safety procedures and handling. Although hydrogen is more readily combustible than natural gas, both are safe if handled properly. The lower explosive limit of hydrogen and natural gas are similar, and there is only a marginal change with natural gas with up to 2% by volume hydrogen versus previously delivered natural gas. We are managing this project carefully to ensure the safety of our employees, our customers, the general public and our system.

    - With respect to the source of the hydrogen gas, the Power-to-Gas facility, located at Enbridge's office at Honda Blvd and Woodbine Ave, uses electricity to produce hydrogen. Once the hydrogen gas has been generated, it is stored in hydrogen storage tanks on site. The hydrogen gas can either be converted back into electricity when needed, or blended with natural gas as a less carbon-intensive energy source, or as a potential fuel for Hydrogen Fuel Cell Electric Vehicles. Through this project, we are using carbon-free hydrogen gas to help move toward a low-carbon economy.

    - If hydrogen blended gas is used in your home, you would see a slight increase in your gas usage compared to traditional natural gas on your bill. The increase is anticipated to be less than $10 per year based on typical gas usage of a residential home. Enbridge is currently looking at ways to acknowledge the slight increase in consumption as a result of the blended gas.

6. Safety - could you please talk to us about the safety of this and how you have tested it and where? Hydrogen is odorless, colourless, and extremely combustible. What will be the impact on our property premiums if our insurance company believes the mix to be of a high risk? Who will pay for the additional expense? (if applicable)

    - Safety is Enbridge's top priority and one of its core values. We have applied rigorous safety standards to the planning, design, development and construction of the blending project. We've taken a number of steps to reduce risks, including several safety studies to identify potential risk scenarios and actions to address them. In addition to this, we consulted with and drew upon the knowledge and experience of specialized consultants involved in previous hydrogen projects around the world. Through this process, which spanned over 2 years, we were able to meet our stringent safety and risk requirements, as well as drive towards our goal to reduce our carbon footprint. Enbridge is focused on ensuring the safety of the public and our employees and reliability of the service we provide. As well, the Ontario Energy Board and Technical Standards and Safety Authority would be involved in granting approvals prior to the introduction of any blended gas to customers. The following paragraphs describe in more detail the work and studies we've undertaken for this project.

- Our studies included research, analysis, and testing into the technical feasibility and safety of this proposed project. This included evaluating the performance of our own infrastructure and collecting information on appliances in the proposed blended gas distribution area (e.g., furnaces, hot water tanks). For instance, we looked at the gas interchangeability with appliances in the area to confirm that the combustion parameters would remain within the range of our gas specifications (based on our historical gas distribution values for the past 12 years). We also looked to ensure compatibility with hydrogen concentrations of 2% by volume, which included engaging manufacturers and distributors to verify the compatibility of their appliances with our project parameters. Based on the results of the information we collected on appliances, they would continue to operate as they have been. Customers should always follow manufacturer recommendations for maintenance.

- We also met with the representatives from Fire and Emergency Services at the City of Markham and advised of them of our proposed project. There were no critical concerns identified at the time and we will continue to engage and work with Fire and Emergency Services should the project be approved. Also, an evaluation was also done by an independent third-party that specializes in risk assessments to make sure building occupants and neighbouring properties will continue to be safe.

- In particular, our Engineering department researched, analyzed, and tested the technical feasibility and safety of using hydrogen for this proposed project. Hydrogen is similar to natural gas in some respects. For example, both fuels are lighter than air and will rise and disperse when released into the atmosphere. Both fuel sources require proper safety procedures and handling for safe use, and are flammable and explosive under certain conditions. Although hydrogen is more readily combustible than natural gas, both are safe if handled properly. The lower explosive limit of hydrogen and natural gas are similar, and there is marginal change with natural gas with up to 2% by volume hydrogen versus previously delivered natural gas. It's important to note that Enbridge is not planning to alter the existing odourant, and the smell of blended gas would maintain the distinct ""rotten egg"" smell like natural gas.

- Enbridge expects blending hydrogen into the natural gas distribution system would not have any discernable impact on insurance premiums.

7. Equipment - what will be the impact on our current equipment? (furnace, gas range, water heater, gas fireplace). Are we going to be forced to [buy] all these appliances new? What if the mix causes all these appliances to break down frequently or become inoperable?

- As outlined above, we have completed a compatibility study on appliances in the blended gas distribution area. Based on the results, your appliances would continue to operate as they have been. Customers should always follow manufacturer recommendations for maintenance.

8. Meetings of affected residents - I suggest that all the residents in the affected area call a meeting(s) to bring awareness and to discuss the impact of this project to our safety and also costs to replace any or all of our appliances. We should invite experts on this subject to provide us their opinion related to this project.

- Comment noted. Please let us know if you require any further information in advance of your meeting. We would be happy to attend and answer questions at the meeting if you would like.

[redacted] I also note that you have requested notification for when the preferred route is selected. The preferred route was selected during the environmental assessment process, and presented in the Environmental Report. The Environmental Report was submitted to the Ontario Pipeline Coordinating Committee for review, and will then be submitted to the Ontario Energy Board as part of the LTC application. The Environmental Report has been uploaded to the project website for public viewing (https://www.enbridgegas.com/About-Us#tab-content – click on "Projects" → Low-Carbon Energy Project →Environmental Report. Once an LTC application is submitted to the Ontario Energy Board for review, members of the public can request updates on a project by visiting www.oeb.ca, selecting the project, and entering an email address in the ""get updates about this application"" section.

We anticipate to submit the LTC application to the Ontario Energy Board in the summer of 2019, with an anticipated decision from the OEB late 2019. We would proceed in construction along the preferred route pending OEB approval. To be notified of the OEB decision, please provide your email address to the OEB website.

I hope this email provides further clarity on our project, however if there is any further information you are looking for, please feel free to let me know and I will do my best to provide you with an answer!

Thanks [redacted]

[redacted] M.Sc., P.Ag.

Sr Environmental Advisor

—

ENBRIDGE GAS INC.
TEL: 416-495-3103 | CELL: 416-371-8790
101 Honda Blvd., Markham, Ontario L6C 0M6

enbridgegas.com
Safety. Integrity. Respect.

From [redacted]
Sent: Wednesday, May 22, 2019 2:49 PM
To: [redacted]@rogers.com
Cc: Energy, Low-Carbon
Subject: RE: [External] RE: Low-Carbon Energy Project

Hello [redacted]

My apologies that it has taken us longer than expected to get back to you! I expect to have a response to your questions this week!

We have not yet filed an application to the OEB.

Thanks for your patience.

[redacted] M.Sc., P.Ag.

Sr Environmental Advisor

—

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From: [redacted]@rogers.com [mailto [redacted]@rogers.com]
Sent: Monday, May 13, 2019 12:48 PM
To: [redacted]
Subject: RE: [External] RE: Low-Carbon Energy Project

Hello,

It's been over a month since the last time I heard from you and I'm still waiting to get your response regarding my questions from the public meetings in March.

I know that you (Enbridge) are going to present to the OEB for approval of your plans in June (I was told about this in the meeting).

If you respond to my concerns/questions to Enbridge after the OEB hearing, I will take it that what I asked for was water under the bridge to you.

I expect to get a response sooner rather than later (if not too late already).

[redacted]

From: [redacted]@enbridge.com]
Sent: April 11, 2019 9:26 AM
To: [redacted]@rogers.com
Cc: lowcarbonenergyea@dillon.ca
Subject: RE: [External] RE: Low-Carbon Energy Project

Good Morning [redacted]

Thanks for reaching out. We have your list of questions and our team is working on sending you a thorough response. It will take us some time to gather the information you requested, as I will be consulting with some of the technical specialists on this project. Due to our recent consultation events, we have a large volume of inquiries we are responding to, and are working towards responding to them.

Thank you for your patience while we pull this together.

[redacted] M.Sc., P.Ag.

Sr Environmental Advisor, Environmental Programs

—

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enbridgegas.com
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From: [redacted]@rogers.com [redacted]@rogers.com]
Sent: Wednesday, April 10, 2019 8:06 PM
To: [redacted]
Subject: [External] RE: Low-Carbon Energy Project

Hello,

In the two presentations which I attended, I asked a number of questions that your reps couldn't-wouldn't answer to me.

I was told that you were going to send me an email with the answers. Someone took a photocopy of the two pages of questions/concerns

Which I brought to the first meeting. Where is your response?

You telling me that you tested this mix somewhere means nothing to me and all my fellow neighbors.

Please give us specific information about where and how you did the testing.

I will proceed to bring our concerns to our elected representatives and ask them to kindly get involved and help us in this effort to understand how this

project will affect our safety/additional charges to our energy bills/property insurance coverages/warranties of appliances.

I'm still waiting to receive answers to my questions which I handed to you (Enbridge) in the two public meetings.

[redacted]

Concerned resident

From: [redacted]@enbridge.com]
Sent: April 9, 2019 3:12 PM
To: [redacted]@rogers.com
Cc: lowcarbonenergyea@dillon.ca
Subject: Low-Carbon Energy Project

Hello!

Thank-you for your inquiry at the public open house for the Low-Carbon Energy Project. We understand you were looking for more information on how to access the technical information and regulatory application that is made to the Ontario Energy Board (OEB). We are in the process of completing our Environmental Report, which will form part of the regulatory application. We plan to submit our regulatory application to the OEB this summer.

Once the application is submitted to the OEB, it will be available on the project website: www.enbridgegas.com/lowcarbonenergyproject. You can keep checking the above website for project updates..

As for your concerns regarding appliances, a sample of customer appliances were thoroughly assessed in this area and the appliances should continue to operate as they have been. This was a common question that came up during the consultation process, and all questions and comments that were received by email and comment forms will be documented as part of the Environmental Report and submitted with the regulatory application to the OEB.

I hope this answers your questions, but if not, feel free to reach out to us.

[redacted] M.Sc., P.Ag.

Sr Environmental Advisor, Environmental Programs

—

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ENBRIDGE LOW-CARBON ENERGY PROJECT
ENBRIDGE/DILLON USE – OPEN HOUSE COMMENT FORM
JULY 9, 2019 (OH3)

Open House Date:	2019-July-9
Name of Note-Taker:	[redacted]
Name of Commenter:	[redacted]
Contact Information of Commenter:	[redacted]@ROGERS.COM EFFECT ON INSURANCE PREMIUM?
Role of Commenter (if applicable, e.g. councillor):	

1. Issues, concerns or follow-up items raised during the open house:

If a customer (such as himself) is to call his home insurance, and report the change in composition, what effect would it have? Higher premium?

[redacted]

From: [redacted]@dillon.ca on behalf of Energy, Low-Carbon <lowcarbonenergyea@dillon.ca>
Sent: Monday, July 22, 2019 8:07 AM
To: [redacted]@rogers.com
Cc: [redacted]
Subject: Re: [External] RE: Low-Carbon Energy Project

Hi [redacted]

At the latest information session for the Low-Carbon Energy Project on July 9, you left a follow-up question with an Enbridge team member ([redacted] asking if the change in gas composition is expected to affect home insurance premiums. Enbridge expects blending hydrogen into the natural gas distribution system would not have any discernible impact on insurance premiums.

Please get in touch if you have any additional questions or comments.

[redacted] [redacted]
Environmental Assessment Project Manager
(519) 571-9833 Ext. 3138
LowCarbonEnergyEA@dillon.ca

On Thu, May 23, 2019 at 3:55 PM Tanya Turk [redacted]@enbridge.com> wrote:

> Hi [redacted]
>
> Below is a response to the questions you provided to us at the open house, that were photocopied by a team member.
>
> 1. Reason for this project: environmentally friendly? Costs to Enbridge will be paid by who, us, who else?
>
>   - The purpose of the project is to reduce greenhouse gas emissions. By injecting hydrogen, a carbon free gas, into the natural gas grid Enbridge expects that the project, once fully in service, could reduce carbon emissions by those using the blended gas by 625 metric tons of CO2e annually. This figure was derived from the gas consumed in 2018 for the area that will be receiving blended gas. This is equal to the total amount of greenhouse gas emissions from approximately 139 homes in a year (based on the average consumption of a home in a year).
>
>   - The costs of the Low Carbon Energy project and the hydrogen we would be using would be built into rates for customers across our rate base, pending OEB approval. There could also be some cost savings due to using cleaner blended gas, as Enbridge may be able to pay lower carbon taxes. If these savings are realized, they would be passed on to Enbridge customers as well.

2. Is this project approved by the City of Markham or its at the study level? If approved already why community affected by this project was not involved in the initial stages to get familiar and express our concerns?

   - Enbridge is regulated by the Ontario Energy Board (OEB). The project has not been approved, as the OEB still needs to review the supporting documentation. Currently, Enbridge is undertaking a consultation program as part of the environmental assessment required by the OEB. This is the stage where residents can become familiar with the project and express their concerns. All feedback received from the public (including your submitted questions) are considered and documented in the Environmental Report that will be submitted to the OEB as part of Enbridge's Leave to Construct application.

3. Notification method: was this the proper way to inform everyone affected? A single piece of paper that looks like a worthless flyer? Everyone I called thought it was a flyer and put it in the recycling bin. I receive every month letters from Enbridge asking me to pay for a furnace maintenance. This important notice was not worth to put it in an envelope with the name and address to each house affected?

   - Thank you for your comments. The Notice of Commencement (NOC) was distributed by unaddressed admail through Canada Post. This method has been effectively used on previous projects to reach a large study area (over 33,600 Notices were delivered). In addition, the NOC was published in local newspapers on March 7 and 14 (Markham Economist & Sun) and March 9 and 18 (Ming Pao). As well, some local councilors shared the project and open house information in their e-newsletters, and the notices were also posted in City of Markham-run community centers in the project area.

4. Where - where this mix of gasses has been used - is used - currently. Is it the City of Toronto, the province of Ontario, Canada, North America, anywhere on the planet? If not are we the guinea pigs of the world?

   - Power-to-Gas is not a new technology. Several Power-to-Gas facilities successfully operate in Europe, some for over a decade. Enbridge's engineering department researched, analyzed, and tested the technical feasibility and safety of using hydrogen for this proposed project.

5. Why - why are you mixing a very combustible gas as hydrogen in with propane gas? Have you accumulated some big amount of this gas by some process (by-product) and you would put it in the pipeline with possible great financial gains to your corporation? What is the cost of 1 cubic metre of hydrogen gas versus 1 cubic metre of natural gas? Is this new mix going to be cheaper for the consumer?

   - The purpose of the project is to reduce greenhouse gas emissions. How we use energy and the sources we rely on are changing. Ontario is seeking lower-carbon, sustainable energy solutions, like hydrogen and renewable natural gas made from organic waste. We believe that all forms of energy have a role to play in this shift to a low-carbon economy. This means leveraging all of our company's assets – whether it's pipelines, renewable power or our natural gas infrastructure – to provide an energy system that meets the demand for safe, reliable and affordable energy.

   - Your question included a reference to hydrogen being a very combustible gas. Hydrogen, as with every combustible fuel including natural gas, requires proper safety procedures and handling. Although hydrogen is more readily combustible than natural gas, both are safe if handled properly. The lower explosive limit of hydrogen and natural gas are similar, and there is only a marginal change with natural gas with up to 2% by volume hydrogen versus previously delivered natural gas. We are managing this project carefully to ensure the safety of our employees, our customers, the general public and our system.

   - With respect to the source of the hydrogen gas, the Power-to-Gas facility, located at Enbridge's office at Honda Blvd and Woodbine Ave, uses electricity to produce hydrogen. Once the hydrogen gas has been generated, it is stored in hydrogen storage tanks on site. The hydrogen gas can either be converted back into electricity when needed, or blended with natural gas as a less carbon-intensive energy source, or as a potential fuel for Hydrogen Fuel Cell Electric Vehicles. Through this project, we are using carbon-free hydrogen gas to help move toward a low-carbon economy.

- If hydrogen blended gas is used in your home, you would see a slight increase in your gas usage compared to traditional natural gas on your bill. The increase is anticipated to be less than $10 per year based on typical gas usage of a residential home. Enbridge is currently looking at ways to acknowledge the slight increase in consumption as a result of the blended gas.

6. Safety - could you please talk to us about the safety of this and how you have tested it and where? Hydrogen is odorless, colourless, and extremely combustible. What will be the impact on our property premiums if our insurance company believes the mix to be of a high risk? Who will pay for the additional expense? (if applicable)

- Safety is Enbridge's top priority and one of its core values. We have applied rigorous safety standards to the planning, design, development and construction of the blending project. We've taken a number of steps to reduce risks, including several safety studies to identify potential risk scenarios and actions to address them. In addition to this, we consulted with and drew upon the knowledge and experience of specialized consultants involved in previous hydrogen projects around the world. Through this process, which spanned over 2 years, we were able to meet our stringent safety and risk requirements, as well as drive towards our goal to reduce our carbon footprint. Enbridge is focused on ensuring the safety of the public and our employees and reliability of the service we provide. As well, the Ontario Energy Board and Technical Standards and Safety Authority would be involved in granting approvals prior to the introduction of any blended gas to customers. The following paragraphs describe in more detail the work and studies we've undertaken for this project.

- Our studies included research, analysis, and testing into the technical feasibility and safety of this proposed project. This included evaluating the performance of our own infrastructure and collecting information on appliances in the proposed blended gas distribution area (e.g., furnaces, hot water tanks). For instance, we looked at the gas interchangeability with appliances in the area to confirm that the combustion parameters would remain within the range of our gas specifications (based on our historical gas distribution values for the past 12 years). We also looked to ensure compatibility with hydrogen concentrations of 2% by volume, which included engaging manufacturers and distributors to verify the compatibility of their appliances with our project parameters. Based on the results of the information we collected on appliances, they would continue to operate as they have been. Customers should always follow manufacturer recommendations for maintenance.

- We also met with the representatives from Fire and Emergency Services at the City of Markham and advised of them of our proposed project. There were no critical concerns identified at the time and we will continue to engage and work with Fire and Emergency Services should the project be approved. Also, an evaluation was also done by an independent third-party that specializes in risk assessments to make sure building occupants and neighbouring properties will continue to be safe.

- In particular, our Engineering department researched, analyzed, and tested the technical feasibility and safety of using hydrogen for this proposed project. Hydrogen is similar to natural gas in some respects. For example, both fuels are lighter than air and will rise and disperse when released into the atmosphere. Both fuel sources require proper safety procedures and handling for safe use, and are flammable and explosive under certain conditions. Although hydrogen is more readily combustible than natural gas, both are safe if handled properly. The lower explosive limit of hydrogen and natural gas are similar, and there is marginal change with natural gas with up to 2% by volume hydrogen versus previously delivered natural gas. It's important to note that Enbridge is not planning to alter the existing odourant, and the smell of blended gas would maintain the distinct ""rotten egg"" smell like natural gas.

- Enbridge expects blending hydrogen into the natural gas distribution system would not have any discernable impact on insurance premiums.

7. Equipment - what will be the impact on our current equipment? (furnace, gas range, water heater, gas fireplace). Are we going to be forced to [buy] all these appliances new? What if the mix causes all these appliances to break down frequently or become inoperable?

- As outlined above, we have completed a compatibility study on appliances in the blended gas distribution area. Based on the results, your appliances would continue to operate as they have been. Customers should always follow manufacturer recommendations for maintenance.

8. Meetings of affected residents - I suggest that all the residents in the affected area call a meeting(s) to bring awareness and to discuss the impact of this project to our safety and also costs to replace any or all of our appliances. We should invite experts on this subject to provide us their opinion related to this project.

- Comment noted. Please let us know if you require any further information in advance of your meeting. We would be happy to attend and answer questions at the meeting if you would like.

[redacted] I also note that you have requested notification for when the preferred route is selected. The preferred route was selected during the environmental assessment process, and presented in the Environmental Report. The Environmental Report was submitted to the Ontario Pipeline Coordinating Committee for review, and will then be submitted to the Ontario Energy Board as part of the LTC application. The Environmental Report has been uploaded to the project website for public viewing (https://www.enbridgegas.com/About-Us#tab-content – click on “Projects” → Low-Carbon Energy Project →Environmental Report. Once an LTC application is submitted to the Ontario Energy Board for review, members of the public can request updates on a project by visiting www.oeb.ca, selecting the project, and entering an email address in the ""get updates about this application"" section.

We anticipate to submit the LTC application to the Ontario Energy Board in the summer of 2019, with an anticipated decision from the OEB late 2019. We would proceed in construction along the preferred route pending OEB approval. To be notified of the OEB decision, please provide your email address to the OEB website.

I hope this email provides further clarity on our project, however if there is any further information you are looking for, please feel free to let me know and I will do my best to provide you with an answer!

Thanks [redacted]

[redacted] [redacted] M.Sc., P.Ag.

Sr Environmental Advisor

—

ENBRIDGE GAS INC.
TEL: 416-495-3103 | CELL: 416-371-8790
101 Honda Blvd., Markham, Ontario L6C 0M6

enbridgegas.com
Safety. Integrity. Respect.

From: [redacted]
Sent: Wednesday, May 22, 2019 2:49 PM
To: [redacted]@rogers.com
Cc: Energy, Low-Carbon
Subject: RE: [External] RE: Low-Carbon Energy Project

Hello [redacted]

My apologies that it has taken us longer than expected to get back to you! I expect to have a response to your questions this week!

We have not yet filed an application to the OEB.

Thanks for your patience.

[redacted] M.Sc., P.Ag.

Sr Environmental Advisor

—

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From: [redacted]@rogers.com [redacted]@rogers.com]
Sent: Monday, May 13, 2019 12:48 PM
To: [redacted]
Subject: RE: [External] RE: Low-Carbon Energy Project

Hello,

It's been over a month since the last time I heard from you and I'm still waiting to get your response regarding my questions from the public meetings in March.

I know that you (Enbridge) are going to present to the OEB for approval of your plans in June (I was told about this in the meeting).

If you respond to my concerns/questions to Enbridge after the OEB hearing, I will take it that what I asked for was water under the bridge to you.

I expect to get a response sooner rather than later (if not too late already).

[redacted]

From: [redacted]@enbridge.com]
Sent: April 11, 2019 9:26 AM
To: [redacted]@rogers.com
Cc: lowcarbonenergyea@dillon.ca
Subject: RE: [External] RE: Low-Carbon Energy Project

Good Morning [redacted]

Thanks for reaching out. We have your list of questions and our team is working on sending you a thorough response. It will take us some time to gather the information you requested, as I will be consulting with some of the technical specialists on this project. Due to our recent consultation events, we have a large volume of inquiries we are responding to, and are working towards responding to them.

Thank you for your patience while we pull this together.

[redacted] M.Sc., P.Ag.

Sr Environmental Advisor, Environmental Programs

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From: [redacted]@rogers.com [redacted]@rogers.com]
Sent: Wednesday, April 10, 2019 8:06 PM
To: [redacted]
Subject: [External] RE: Low-Carbon Energy Project

Hello,

In the two presentations which I attended, I asked a number of questions that your reps couldn't-wouldn't answer to me.

I was told that you were going to send me an email with the answers. Someone took a photocopy of the two pages of questions/concerns

Which I brought to the first meeting. Where is your response?

You telling me that you tested this mix somewhere means nothing to me and all my fellow neighbors.

Please give us specific information about where and how you did the testing.

I will proceed to bring our concerns to our elected representatives and ask them to kindly get involved and help us in this effort to understand how this

project will affect our safety/additional charges to our energy bills/property insurance coverages/warranties of appliances.

I'm still waiting to receive answers to my questions which I handed to you (Enbridge) in the two public meetings.

[redacted]

Concerned resident

From: [redacted]@enbridge.com]
Sent: April 9, 2019 3:12 PM
To: [redacted]@rogers.com
Cc: lowcarbonenergyea@dillon.ca
Subject: Low-Carbon Energy Project

Hello!

Thank-you for your inquiry at the public open house for the Low-Carbon Energy Project. We understand you were looking for more information on how to access the technical information and regulatory application that is made to the Ontario Energy Board (OEB). We are in the process of completing our Environmental Report, which will form part of the regulatory application. We plan to submit our regulatory application to the OEB this summer.

Once the application is submitted to the OEB, it will be available on the project website: www.enbridgegas.com/lowcarbonenergyproject. You can keep checking the above website for project updates..

As for your concerns regarding appliances, a sample of customer appliances were thoroughly assessed in this area and the appliances should continue to operate as they have been. This was a common question that came up during the consultation process, and all questions and comments that were received by email and comment forms will be documented as part of the Environmental Report and submitted with the regulatory application to the OEB.

I hope this answers your questions, but if not, feel free to reach out to us.

[redacted] M.Sc., P.Ag.

Sr Environmental Advisor, Environmental Programs

—

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ENBRIDGE LOW-CARBON ENERGY PROJECT
July 9, 2019 INFORMATION SESSION QUESTIONNAIRE

Name:	
Group/Organization:	
Email Address:	
Mailing Address:	
Telephone:	

1. How did you hear about the Enbridge Low-Carbon Energy Project?

☒ Newspaper
☐ Local media
☐ From a friend or neighbour (word of mouth)
☒ Received information in the mail
☐ Other (please specify) ____________

2. Do you own property or live within the study area?

☒ Yes ☐ No

3. Do you use natural gas in your home? Natural gas can be used as a fuel source for a number of purposes including heating, water heating, cooking, and more.

☒ Yes ☐ No

4. Are there any potential effects to you, your property or business that you feel would need to be addressed prior to construction/operation of the project?

Cost - how it will pass along to property owner & ~~to~~ as a tax payer.

5. How familiar would you say you are with low carbon initiatives, such as blending hydrogen gas with natural gas?

☐ Very familiar
☐ Somewhat familiar
☒ Not very familiar
☐ Not at all familiar
☐ Don't know

6. What is your view of the proposed project?

☒ I am supportive ☐ No opinion at this time ☐ I am not supportive

7. Did you receive an adequate understanding of the hydrogen blending process?

☒ Yes ☐ No

If not, what additional information do you require?

8. Were your questions adequately addressed by a project representative?

☒ Yes ☐ No ☐ Partly

If not, please list your questions below and provide a description on how you think we can best address them.

9. Do you have any additional questions about hydrogen safety that were not addressed?

☐ Yes ☒ No

If so, please list your questions below and provide a description on how you think we can best address them.

10. Do you have any additional comments?

Please drop this Questionnaire off in the designated box before you leave today, or with a team member.
Alternatively, you can mail this form to: Tristan Lefler, Environment Assessment Project Manager, Dillon Consulting Limited, 51 Breithaupt Street, Suite 200, Kitchener, ON, N2H 5G5
OR Email to: LowCarbonEnergyEA@dillon.ca

Under the Freedom of Information and Protection of Privacy Act, all comments and questions submitted regarding this project will be submitted as part of the LTC project that will be a part of the public record and will be made available to individuals or organizations with an interest in this project. Personal information such as name, address, and telephone number will not be included in the environmental assessment report or additional consultation reports but may be released, if requested, to any person as part of the review process.

ENBRIDGE GAS INC.
Answer to Interrogatory from
OEB Staff (STAFF)

INTERROGATORY

Reference:

Exhibit E, Tab 1, Schedule 1, Table 1, pages 2-4
Exhibit F, Tab 1, Schedule 1, Attachment 1, page 5

Preamble:

Table 1 in Exhibit E contains a list of required permits and approvals along with the permitting authority. In Exhibit F, the Project Description Letter to the Ministry of Energy, Northern Development and Mines (MENDM) lists “potential authorizations”. The two lists are the same, with the exception that Exhibit F includes three authorizations not listed in Exhibit E:

a) Ministry of Natural Resources and Forestry
b) Electrical Safety Association
c) Technical Standards and Safety Association

Question:

Please confirm that permits or approvals are required from the three authorities listed above. If so, please update and refile Exhibit E, Table 1.

Response:

Enbridge Gas would note that Exhibit E is related to land matters and permits and approvals related to lands. The Project Description Letter is developed at a very early stage of any project and identifies potential authorizations, including those authorizations related to lands and other authorizations.

No approvals are required from the Ministry of Natural Resources and Forestry for the Project. Certification will be required from the Electrical Safety Association for electrical equipment installed in the hydrogen blending facility and approvals from the TSSA will be required as part of hydrogen station fabrication and commissioning.

For further discussion of the role of the TSSA in relation to the Project, please see the response to Exhibit I.CCC.7.

ENBRIDGE GAS INC.
Answer to Interrogatory from
OEB Staff (STAFF)

INTERROGATORY

Reference:

Exhibit E, Tab 1, Schedule 1, page 1 and Attachment 1

Preamble:

Enbridge Gas states that temporary working areas may be required where the road allowance is too narrow or confined to facilitate construction. These areas will be identified with the assistance of the contractor that will construct the Project. Agreements for temporary working rights will be negotiated where required. Enbridge Gas provided a copy of the proposed form of working area agreement.

Question:

a) Was the proposed form of working area agreement approved for use by the OEB in a previous proceeding? If so, please provide the case number for that proceeding.

b) Have any changes been made to the proposed form of working area agreement since it was last approved for use by the OEB? If so, please list and explain them.

Response:

a) Yes. The form of working area agreement was used in the Georgian Sands Pipeline Project, EB-2018-0226, and approved by the Board in that proceeding.

b) There have not been any changes to the working area agreement since it was approved for use by the Board in EB-2018-0226.

ENBRIDGE GAS INC.
Answer to Interrogatory from
OEB Staff (STAFF)

INTERROGATORY

Reference:

Exhibit F, Tab 1, Schedule 1, page 2

Preamble:

Enbridge Gas provided the Ontario Ministry of Energy, Northern Development and Mines (MENDM) with a project description for the Project on January 4, 2019. On March 1, 2019, Enbridge Gas received a letter from the MENDM indicating that the MENDM had delegated the procedural aspects of consultation to Enbridge Gas for the Project. The Delegation Letter identified six Indigenous communities to be consulted with. A copy of Enbridge Gas's Indigenous Consultation Report (ICR) was provided to the MENDM on March 31, 2020. The MENDM has not yet issued a letter to Enbridge Gas with its opinion on the adequacy of Enbridge Gas' Indigenous consultations to date.

Question:

Please provide an update on any communication with the MENDM in respect of its letter of opinion. If it has not already been received, when does Enbridge Gas anticipate receiving the letter and filing it into evidence?

Response:

Enbridge Gas has not received a letter from MENDM regarding the sufficiency of Indigenous consultation for the Project. Enbridge Gas has contacted MENDM regarding the status of the sufficiency letter. MENDM indicated, on June 3, 2020, that they had received confirmations from Huron Wendat First Nation, Hiawatha First Nation and Alderville First Nation. MENDM also indicated that they were awaiting responses from Curve Lake First Nation, Mississaugas of the Credit First Nation and Mississaugas of Scugog Island First Nation. MENDM has followed up with the aforementioned three first nations and hopes to hear back from these first nations soon. MENDM also indicated that the Mississaugas of the Credit First Nation office is closed until July 6, 2020. Enbridge Gas will file the sufficiency letter when it is received from MENDM.

ENBRIDGE GAS INC.
Answer to Interrogatory from
OEB Staff (STAFF)

INTERROGATORY

Reference:

Exhibit F, Tab 1, Schedule 1, Appendix A

Preamble:

The consultation update summary and logs in Appendix A are watermarked “Draft”.

Question:

Please confirm that the consultation update and summary logs in Appendix A are the final version. If not, please file a copy of the final version.

Response:

Enbridge Gas has assumed that Board Staff is referring to the document entitled “Enbridge Gas Inc. Low-Carbon Energy Project Environmental Report Amendment” which is set out in draft form in the Attachments to Exhibit F, Tab 1, Schedule 1, Attachment 6.

The consultation update and summary logs contained in this document are draft versions and not the final version. As indicated in the notices of project change, for example at Exhibit F, Tab 1, Schedule 1, Attachment 6, Line Item 1.16, Attachment 1.10, Indigenous groups were provided with a draft version of the ER amendment for review.

The final ER amendment, including the final consultation update summary and logs, can be found at Exhibit C, Tab 1, Schedule 1, Attachment 7.

ENBRIDGE GAS INC.
Answer to Interrogatory from
OEB Staff (STAFF)

INTERROGATORY

Reference:

Exhibit A, Tab 2, Schedule 1

Preamble:

The OEB Act permits the OEB, when making an order, to “impose such conditions as it considers proper.”[8]

Question:

OEB staff has prepared the following draft Conditions of Approval. If Enbridge Gas does not agree to any of the draft conditions of approval noted below, please identify the specific conditions that Enbridge Gas disagrees with and explain why. For conditions in respect of which Enbridge Gas would like to recommend changes, please provide the proposed changes and an explanation of the changes.

Enbridge Gas Inc.
Low Carbon Energy Project
OEB Act Sections 36 Rates, 90 Leave to Construct and 97 Land Use

DRAFT CONDITIONS OF APPROVAL

1. Enbridge Gas Inc. (Enbridge Gas) shall construct the facilities and restore the land in accordance with the OEB’s Decision and Order in EB-2019-0294 and these Conditions of Approval.
2. (a) Authorization for leave to construct shall terminate 12 months after the decision is issued, unless construction has commenced prior to that date.

   (b) Enbridge Gas shall give the OEB notice in writing:

      i. of the planned in-service date, at least ten days prior to the date the facilities go into service;

      ii. of the date on which construction was completed, no later than 10 days following the completion of construction; and

---

[8] OEB Act, s. 23

    iii. of the in-service date, no later than 10 days after the facilities go into service.

3. Enbridge Gas shall implement all the recommendations of the Environmental Report filed in the proceeding, and all the recommendations and directives identified by the Ontario Pipeline Coordinating Committee review.
4. Enbridge Gas shall advise the OEB of any proposed change to OEB-approved construction or restoration procedures. Except in an emergency, Enbridge shall not make any such change without prior notice to and written approval of the OEB. In the event of an emergency, the OEB shall be informed immediately after the fact.
5. Enbridge Gas shall file, in the proceeding where the actual capital costs of the project are proposed to be included in rate base, a Post Construction Financial Report, which shall indicate the actual capital costs of the project and shall provide an explanation for any significant variances from the cost estimates filed in this proceeding.
6. Both during and after construction, Enbridge Gas shall monitor the impacts of construction, and shall file with the OEB one paper copy and one electronic (searchable PDF) version of each of the following reports:

   (a) A post construction report, within three months of the in-service date, which shall:

      i. provide a certification, by a senior executive of the company, of Enbridge Gas' adherence to Condition 1;

      ii. describe any impacts and outstanding concerns identified during construction;

      iii. describe the actions taken or planned to be taken to prevent or mitigate any identified impacts of construction;

      iv. include a log of all complaints received by Enbridge Gas, including the date/time the complaint was received, a description of the complaint, any actions taken to address the complaint, the rationale for taking such actions; and

      v. provide a certification, by a senior executive of the company, that the company has obtained all other approvals, permits, licenses, and certificates required to construct, operate and maintain the proposed project.

   (b) A final monitoring report, no later than fifteen months after the in-service date, or, where the deadline falls between December 1 and May 31, the following June 1, which shall:

      i. provide a certification, by a senior executive of the company, of Enbridge Gas' adherence to Condition 3;

ii. describe the condition of any rehabilitated land;

iii. describe the effectiveness of any actions taken to prevent or mitigate any identified impacts of construction;

iv. include the results of analyses and monitoring programs and any recommendations arising therefrom; and

v. include a log of all complaints received by Enbridge Gas, including the date/time the complaint was received; a description of the complaint; any actions taken to address the complaint; and the rationale for taking such actions.

Response:

Enbridge Gas does not object to any of the Draft Conditions of Approval.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Vulnerable Energy Consumers Coalition (VECC)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, page 2

Enbridge notes: "*The TSSA indicated that they will act as a technical reviewer on behalf of the Ontario Energy Board for the LTC application if requested*."

Question**:**

a) Please explain how Enbridge envisions coordination between the TSSA and OEB to advance and monitor this project? For example, is Enbridge seeking a coordinating committee from the two agencies?

b) Please explain what form (frequency and type) of reporting is anticipated for this project. Would all reports be made available publicly or does Enbridge anticipate developing its own intellectual property from this project?

c) What form of consumer or public input will be sought after a trial period and analysis of the results?

Response:

a) Please refer to Exhibit I.CCC 7.

b) Please refer to Exhibit I.CCC.15.

c) Enbridge Gas has not yet determined whether or how consumer or public input may be sought as the LCEP pilot proceeds.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Vulnerable Energy Consumers Coalition (VECC)

INTERROGATORY

Reference:

Reference: Exhibit B, Tab 1, Schedule 1, page 3

Question:

a) How was the 97-120 carbon dioxide equivalent estimate for the project calculated (please include assumptions).

Response:

a) Please see Exhibit I.STAFF.1(a).

ENBRIDGE GAS INC.
Answer to Interrogatory from
Vulnerable Energy Consumers Coalition (VECC)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, pages 4, 18

"*Enbridge Gas is proposing to acquire hydrogen in a manner that keeps ratepayers cost-neutral*." ……"*There will be no impact to customer bills as the cost of hydrogen will be the same as the cost of traditional natural gas*"

Question**:**

a) Please explain the manner in which ratepayers are kept cost neutral when acquiring the hydrogen supply.

b) Given the limited number of suppliers of hydrogen (single sourced in this project) how is the price for hydrogen established?

c) Does Enbridge Gas have a supply contract with 2562961 Ontario for hydrogen and other services? If so please provide the contract or if for reasons of confidentiality this cannot be done outline the terms of the contract.

d) Does 2562961 Ontario Limited have a generator or other regulatory licence issued by the Ontario Energy Board?

Response:

a) Please see Exhibit I.STAFF.2(d).

b) Please see Exhibit I.STAFF.2(d).

c) For a copy of the term sheet for hydrogen supply, please see Exhibit I.STAFF.2(d). For the intercorporate services agreement between Enbridge Gas and 2562961 Ontario Ltd., please see Exhibit I.CCC.2.

d) Yes. 2562961 Ontario Ltd. has an Electricity Storage License.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Vulnerable Energy Consumers Coalition (VECC)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, page 10

Question**:**

a) As the Clean Fuel Standard regulations are at an early stage and not expected to come into force until 2023 why does EGI believe that hydrogen blending will be a means of compliance or credits under a future CFS policy?

b) Should this not happen or the project otherwise is abandoned what financial risk might accrue to ratepayers?

Response:

a) While the Clean Fuel Standard (CFS) compliance obligation for gaseous fuel parties is expected to come into force in 2023, Environment and Climate Change Canada have indicated that Early Action Credits from the production and use of low-carbon fuels, such as hydrogen, may begin upon the publication of the Final Draft Liquid Fuel Regulation expected in the fall of 2021. The CFS Proposed Regulatory Approach published in June 2019, identified hydrogen as a low-carbon fuel that will be eligible to create CFS credits.

b) Please see Exhibit I.CCC.3 for a discussion of the risks of the Project.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Vulnerable Energy Consumers Coalition (VECC)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, page 16

The evidence states: "*Given that the Proposed Facilities are required to enable the Company to reduce the GHG footprint of its utility gas distribution system; these facilities should be fully attributed to system reinforcement and general distribution growth and managed within the rolling project portfolio in accordance with Enbridge Gas's normal business practice*."

Question**:**

a) Given the unusual nature of the project and the fact that it is a pilot project from which presumably the Utility hopes to gain a better understanding of both the technical and financial challenges and benefits, why would it not be preferable to account for this project discretely and outside of the rolling project portfolio?

Response:

a) Please see Exhibit I.FRPO.6(b).

ENBRIDGE GAS INC.
Answer to Interrogatory from
Vulnerable Energy Consumers Coalition (VECC)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, page 4

Question**:**

a) Please provide a copy of the HYREADY guidelines followed for this project.

Response:

a) Please see Exhibit I.H2GO.1.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Vulnerable Energy Consumers Coalition (VECC)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, Attachment 1, page 4

Question**:**

a) Please provide the results of the CGA/AGA literature search aimed at understanding the impacts of adding hydrogen to natural gas.

b) Please provide the studies which Enbridge relied upon to show that hydrogen blending would be safe at the levels contemplated and would not have a detrimental effect on customer of utility equipment.

Response:

a) and b) Please see the response to Exhibit I.H2GO.1.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Vulnerable Energy Consumers Coalition (VECC)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, Attachment 1, page 16

The following Ontario Regulations are applicable to the project:

- *Ontario Regulation (O. Reg) 210/01 Oil and Gas Pipeline Systems*
- *FS 238-18 Oil and Gas Pipeline systems code adoption document, Dated: 15th February 2018*

Question**:**

a) Please provide the Ontario regulations referenced.

Response:

a) Current and past versions of the regulations are available under the Ontario Consolidated e-Laws. Similarly, the TSSA adoption documentations are available on the TSSA website. Links to the regulations are provided below:

https://www.ontario.ca/laws/regulation/010210

https://www.tssa.org/en/fuels/resources/Documents/Oil-and-Gas-Pipelines-CAD-Amendment_FIX.pdf

For ease of reference the regulations are also included in the Attachments to this response.

Filed: 2020-06-15
EB-2029-0294
Exhibit I.VECC.8
Attachment 1
Page 1 of 6

Technical Standards and Safety Act, 2000
Loi de 2000 sur les normes techniques et la sécurité

ONTARIO REGULATION 210/01

OIL AND GAS PIPELINE SYSTEMS

Consolidation Period: From June 27, 2001 to the e-Laws currency date.

No amendments.

This Regulation is made in English only.

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CONTENTS

Interpretation

1. (1) In this Regulation,

"appliance" means a device that consumes or is intended to consume gas and includes all valves, fittings, controls and components attached or to be attached to it;

"approved" means,

(a) with respect to a standard or a laboratory test report, that it is listed in "Titles of Standards and Laboratory Test Reports Authorized in the Province of Ontario under the Act" published by the designated administrative authority from time to time,

(b) with respect to an appliance, equipment, a component or an accessory, that it bears the label or symbol of a designated testing organization or a label or symbol authorized by the director, certifying that it complies with an approved standard or laboratory test report, or

(c) with respect to an installation or work, that it complies with this Regulation or, where the installation or work was installed before this Regulation came into force, that it complies with the predecessor to this Regulation as it existed when the installation or work was carried out;

"certificate" means a certificate issued under Ontario Regulation 215/01 (Fuel Industry Certificates);

"code adoption document" means the "Oil and Gas Pipeline Systems Code Adoption Document" adopted as part of this Regulation under Ontario Regulation 223/01;

"distributor" means a person who conveys or supplies gas to an end user, but does not include a person who supplies gas to a vehicle or cylinder, and "distribute" and "distribution" have corresponding meanings;

"equipment" means a device that is used in venting gas or in the handling of oil and gas;

"facility" means a site where oil or gas is stored or handled other than in portable containers;

"gas" means any gas or mixture of gases suitable for domestic or industrial fuel that is conveyed to the user through a pipeline;

"gas pipeline inspector" means a holder of a certificate as a gas pipeline inspector issued by the director;

"handling" means the storage, transmission, transportation or distribution of oil and gas, but does not include putting compressed natural gas into the fuel tank of a motor vehicle or into a container at a self-serve facility as provided in Ontario Regulation 214/01 (Compressed Natural Gas), and "handle" and "handler" have corresponding meanings;

"hydrocarbon" means a chemical compound of hydrogen and carbon used as a fuel, either liquid or gaseous;

"install" includes placing equipment in position for permanent or temporary use, venting it and connecting piping to it, and "installation" has a corresponding meaning;

"maintenance" means the inspection, servicing or repair of equipment, including replacement with equipment having similar performance specifications to that being replaced where it is not necessary to change the layout perimeters directly associated with the equipment being replaced;

"oil" means crude oil, liquid petroleum products, natural gasoline, natural gas liquids, liquefied petroleum gas and any condensate resulting from the production, processing or refining of hydrocarbons;

"operating company" includes an individual, partnership, corporation, joint venture, consortium, public agency or other entity operating a gas or oil pipeline system;

"pipeline" means a pipe that is used for the transmission or distribution of oil and gas and includes fittings, valves, controls, compressor stations, pressure regulating stations, meter stations and pump stations, but does not include the pipe, fittings, valves or controls of the end user;

"routine maintenance" means scheduled maintenance or maintenance that is generally accepted as good engineering practice;

"transmitter" means a person who supplies oil and gas by pipeline to a distributor, and "transmit", "transmission" and "transmission line" have corresponding meanings;

"work" means a facility used in the handling of oil and gas. O. Reg. 210/01, s. 1 (1).

(2) In the event of a conflict between a provision of this Regulation and the code adoption document, this Regulation prevails. O. Reg. 210/01, s. 1 (2).

Application

2. (1) This Regulation applies to the design, construction, operation and maintenance of oil and gas industry pipeline systems that convey,

(a) liquid hydrocarbons, including crude oil, condensate, liquid petroleum products, natural gas liquids and liquefied petroleum gas; and

(b) gas. O. Reg. 210/01, s. 2 (1).

(2) This Regulation does not apply to,

(a) piping in natural gas liquid extraction plants, gas manufacturing plants, and mines; or

(b) oil refineries, terminals, other than pipeline terminals, and marketing bulk plants. O. Reg. 210/01, s. 2 (2).

General requirement for compliance

3. (1) Every person engaged in an activity, use of equipment, process or procedure to which the Act and this Regulation apply shall comply with the Act and this Regulation. O. Reg. 210/01, s. 3 (1).

(2) For the purposes of subsection (1), the reference to an activity, use of equipment, process or procedure includes, but is not limited, to design, construction, erection, maintenance, alteration, repair, service or disposal. O. Reg. 210/01, s. 3 (2).

Duty of employer

4. (1) Every person who operates, installs, removes, repairs, alters or services equipment or works shall instruct their employees to comply with the Act and this Regulation. O. Reg. 210/01, s. 4 (1).

(2) Every person who employs a person to carry out any activity referred to in subsection (1) shall take every precaution that is reasonable in the circumstances to ensure that the employee complies with the Act and this Regulation. O. Reg. 210/01, s. 4 (2).

Licence required

5. No person shall handle oil and gas unless the person is the holder of a licence. O. Reg. 210/01, s. 5.

Certificate required

6. No person shall install, alter, purge, activate, repair, service or remove any pipeline or equipment or other thing employed or to be employed in the handling or use of oil or gas unless the person is the holder of a certificate for the purpose. O. Reg. 210/01, s. 6.

Initial putting into use

7. (1) Where premises are connected to a supply of gas for the first time, no person shall put into use for the first time an appliance on the premises that is connected to the pipeline until the distributor has examined the installation of the appliance and is satisfied that the installation and use of the appliance are in compliance with this Regulation. O. Reg. 210/01, s. 7 (1).

(2) An examination under subsection (1) shall include the examination of all appliances intended to be installed at the time of occupation of the premises. O. Reg. 210/01, s. 7 (2).

Distributor's right of access

8. A distributor shall have access, at all reasonable times and upon reasonable notice, to all parts of every premises to which the distributor supplies gas by pipeline for the purpose of,

(a) examining any appliance or equipment in or on the premises and disconnecting the appliance or equipment if it, its installation or its use does not conform with this Regulation or its predecessor; and

(b) placing, protecting, setting, shutting off, removing, repairing or altering any meter or regulator owned by the distributor in or on the premises. O. Reg. 210/01, s. 8.

Ascertaining pipeline locations

9. (1) No person shall dig, bore, trench, grade, excavate or break ground with mechanical equipment or explosives without first ascertaining from the licence holder the location of any pipeline that may be interfered with. O. Reg. 210/01, s. 9 (1).

(2) The licence holder shall provide as accurate information as possible on the location of any pipeline within a reasonable time in all the circumstances. O. Reg. 210/01, s. 9 (2).

No interference with pipeline

10. No person shall interfere with or damage any pipeline without authority to do so. O. Reg. 210/01, s. 10.

Approval of appliances and equipment

11. Where this Regulation requires that an appliance or any equipment be approved, no person shall,

(a) offer for sale, sell, lease or rent;

(b) install;

(c) use; or

(d) supply gas to,

any appliance or equipment that is not approved or will not be approved prior to being put into use. O. Reg. 210/01, s. 11.

Off-site testing and approval

12. (1) This section applies only to the testing of an appliance, equipment, a component or an accessory that is carried out at a place other than the place where the appliance, equipment, component or accessory is installed for its intended use. O. Reg. 210/01, s. 12 (1).

(2) A person may apply to a designated testing organization to have an appliance, equipment, a component or an accessory tested under this section. O. Reg. 210/01, s. 12 (2).

(3) Organizations accredited by the Standards Council of Canada are designated organizations to test equipment, components and accessories to applicable approved standards or laboratory test reports for the purposes of this Regulation. O. Reg. 210/01, s. 12 (3).

(4) A designated testing organization that tests an appliance, equipment, a component or an accessory under this section shall place its label or symbol on it if it conforms to the applicable approved standards or laboratory test report. O. Reg. 210/01, s. 12 (4).

On-site testing and approval

13. (1) This section applies only to the testing of an appliance, equipment, a component or an accessory that is carried out at the place where the appliance, equipment, component or accessory is installed for its intended use. O. Reg. 210/01, s. 13 (1).

(2) A person may apply to the director or an inspector designated by the director, to have an appliance, equipment, a component or an accessory tested under this section. O. Reg. 210/01, s. 13 (2).

(3) The director or inspector may refuse to test the appliance, equipment, component or accessory if its design is substantially the same as one that has been tested and approved by a designated testing organization. O. Reg. 210/01, s. 13 (3).

(4) The director or inspector may test the appliance, equipment, component or accessory to applicable approved standards or laboratory test reports for the purposes of this Regulation. O. Reg. 210/01, s. 13 (4).

(5) If an appliance, equipment, component or accessory tested under this section conforms to the applicable approved standards or laboratory test reports, the director or inspector shall place an approved label or symbol on it. O. Reg. 210/01, s. 13 (5).

(6) If an appliance, equipment, component or accessory is tested under this section, the director or inspector shall,

(a) determine whether its fuel features comply with the approved standards and this Regulation; and

(b) affix or cause to be affixed a label or symbol approved by the director to the appliance, equipment, component or accessory, if the director or inspector determines that its fuel features comply with the approved standards and this Regulation. O. Reg. 210/01, s. 13 (6).

(7) The applicant shall provide to the director or inspector all information, and shall conduct or cause to be conducted, all tests required to determine that the appliance, equipment, component or accessory complies with clause (6) (a). O. Reg. 210/01, s. 13 (7).

(8) An applicant who applies to have an appliance, equipment, a component or an accessory tested and approved under this section shall pay the fees set by the designated administrative authority for the time reasonably spent,

(a) in reviewing information about the thing to be tested;

(b) in inspecting its fuel features;

(c) in observing any test of the fuel features to determine if they comply with this Regulation; and

(d) in use of the thing during testing. O. Reg. 210/01, s. 13 (8).

Accidents and occurrences

14. (1) Where it appears that carbon monoxide poisoning, asphyxiation, explosion or fire has occurred, or an accidental release, vent or spill has occurred because of the use, handling or storage of oil or gas, the licensee shall notify forthwith an inspector of the occurrence by telephone, facsimile, or any other form of electronic transmission, and a licence holder shall have in place procedures for such notification. O. Reg. 210/01, s. 14 (1).

(2) No person shall interfere with or disturb any wreckage, an article or thing at the scene of and connected with the occurrence except in the interest of public safety, saving a life, relieving human suffering, continuity of service or preservation of property. O. Reg. 210/01, s. 14 (2).

(3) Where it is permitted to interfere with or disturb any wreckage, an article or a thing under subsection (2), no person shall carry away or destroy any wreckage, article or thing unless an inspector gives permission to do so. O. Reg. 210/01, s. 14 (3).

Activation of pipeline

15. (1) No person shall activate a pipeline unless the pipeline is licensed and a certificate holder for the purpose has ensured that the pipeline meets the requirements of this Regulation. O. Reg. 210/01, s. 15 (1).

(2) A transmitter or distributor shall ensure that a pipeline is not activated unless the requirements of subsection (1) have been met. O. Reg. 210/01, s. 15 (2).

Use of oil and gas pipelines

16. (1) Before using an oil pipeline, an operating company shall, except with respect to routine maintenance, obtain a declaration from a professional engineer declaring that the design, construction, installation, replacement, extension, reclassification and testing of the pipeline have been carried out in accordance with this Regulation. O. Reg. 210/01, s. 16 (1).

(2) An operating company that has a gas pipeline having a diameter in excess of 219.1 millimetres or that is intended to operate at a pressure in excess of 860 kPa, that is constructed, installed, replaced, extended or upgraded, shall obtain a declaration from a professional engineer declaring that the design of and the construction specifications for the pipeline are in accordance with this Regulation. O. Reg. 210/01, s. 16 (2).

(3) Subsection (2) does not apply to a service line, as defined in the code adoption document, with a diameter of less than 88.9 millimetres. O. Reg. 210/01, s. 16 (3).

(4) Before using a gas pipeline, an operating company that has a gas pipeline installed or tested shall obtain a declaration from a person who is certified for that purpose under Ontario Regulation 215/01 (Fuel Industry Certificates) declaring that the installation or testing was carried out in accordance with this Regulation. O. Reg. 210/01, s. 16 (4).

(5) Before activating a pipeline that has been upgraded, an operating company shall obtain a declaration from a professional engineer declaring that the pipeline has been upgraded. O. Reg. 210/01, s. 16 (5).

(6) An operating company shall file the declaration referred to in subsection (5) with the director, where the upgrading results in an operating stress level greater than 30 per cent of the specified minimum yield strength of the pipeline. O. Reg. 210/01, s. 16 (6).

(7) The operating company shall retain the declarations obtained under subsections (1) to (5) for the life of the pipeline and shall make the records readily available upon request of the director. O. Reg. 210/01, s. 16 (7).

(8) In this section,

"professional engineer" means a person licensed under the *Professional Engineers Act*. O. Reg. 210/01, s. 16 (8).

Unsafe condition

17. Where the director has reason to believe that an unsafe condition exists in a pipeline, an operating company shall uncover any part of the pipeline at the written request of the director. O. Reg. 210/01, s. 17.

Application for licence

18. (1) An application for the following licences or their renewal shall be made to the director in the form published by the designated administrative authority and shall be accompanied by the fee set by the authority:

1. A licence to transmit gas.

2. A licence to distribute gas.
3. A licence to transmit oil. O. Reg. 210/01, s. 18 (1).

(2) An operating company need not be licensed if its oil transmission pipeline system is less than 20 kilometres in length. O. Reg. 210/01, s. 18 (2).

(3) A licence or a renewal expires 12 months after it is issued. O. Reg. 210/01, s. 18 (3).

(4) A licence or a renewal shall state the date on which it is issued and the date on which it expires. O. Reg. 210/01, s. 18 (4).

(5) An inspector may inspect a pipeline for the transmission of oil or gas, or a pipeline for the distribution of gas, of an applicant for or the holder of a licence referred to in subsection (1). O. Reg. 210/01, s. 18 (5).

(6) An inspector may inspect the installations and repairs performed by or on behalf of an applicant for or holder of a licence referred to in subsection (1) and the workmanship relating to those installations and repairs, to determine whether they comply with this Regulation. O. Reg. 210/01, s. 18 (6).

(7) No licence or renewal shall be issued until the applicant for or holder of the licence has paid the fee set by the designated administrative authority for an inspection under subsection (5) or (6). O. Reg. 210/01, s. 18 (7).

Lost or destroyed licence, etc.

19. (1) A person who is the holder of a licence referred to in subsection 18 (1), whose licence is lost or destroyed shall apply for a duplicate or, where the name of the licence holder has changed, shall apply for a new licence. O. Reg. 210/01, s. 19 (1).

(2) The director shall issue a duplicate licence or, where the name of the licence holder has changed, a new licence, on receiving an application therefor and upon payment of the fee set by the designated administrative authority. O. Reg. 210/01, s. 19 (2).

(3) The holder of a licence whose address has changed shall notify the director of the new address within 30 days of the change. O. Reg. 210/01, s. 19 (3).

20. OMITTED (PROVIDES FOR COMING INTO FORCE OF PROVISIONS OF THIS REGULATION). O. Reg. 210/01, s. 20.

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Fuels Safety Program	Ref. No.: FS-238-18
Oil and Gas Pipeline Systems Code Adoption Document Amendment	Date: February 15th, 2018

IN THE MATTER OF:

Technical Standards and Safety Act, 2000, R.S.O. 2000, c. 16, Ontario Regulation 223/01 (Codes and Standards Adopted by Reference), and Ontario Regulation 210/01 (Oil and Gas Pipeline Systems)

The Director for the purposes of Ontario Regulation 210/01 (Oil and Gas Pipeline Systems), pursuant to sections 8(1) and 8(2) of Ontario Regulation 223/01 (Codes and Standards Adopted by Reference) and section 36(3)(a) of the Technical Standards and Safety Act 2000, R.S.O. 2000, c. 16, hereby provides notice that the OIL AND GAS PIPELINE SYSTEMS CODE ADOPTION DOCUMENT published by Technical Standards and Safety Authority dated June 1, 2001, as amended, is further amended as follows:

All sections of the Oil and Gas Pipeline Systems Code Adoption Document (including previous amendments thereto) are revoked and replaced with the following:

Background:

This amendment to the Oil and Gas Pipeline Systems Code Adoption Document (CAD) revokes and replaces the previous amendment (FS-220-16, dated July 19, 2016). A delta symbol (Δ) in the left margin indicates a provision that is new or that has changed since the previous CAD amendment.

The following are the most significant changes from the previous CAD amendment:

- Security standard, CSA Z246.1 re-adopted on this version of CAD
- Definition of “ground disturbance” changed to align with the O.Reg.210/01
- Exemption on digester and landfill sites corrected to reflect appropriate code for the pipeline passing through public domain.

Section 1

CODES ADOPTED BY REFERENCE

1. The Director hereby adopts and requires all persons to whom O. Reg. 210/01 (Oil and Gas Pipeline Systems) applies to comply with the standards, procedures and other requirements of the following codes and regulations:

a) **CSA Z662-15 (Oil and Gas Pipeline Systems)**, published by the Canadian Standards Association, as amended by Section 3 of this document.

b) **CSA Z276-15 (Liquefied Natural Gas (LNG) - Production, Storage and Handling),** published by the Canadian Standards Association,

Δ c) **CSA Z246.1-17 Security management for petroleum and natural gas industry systems**, published by the Canadian Standards Association, Background:

This Standard adopted in previous Code Adoption Document (CAD), FS-196-12, which was removed from CAD, is being reintroduced.

d) **CSA Z247-15 Damage Prevention for the Protection of Underground Facilities**, published by the Canadian Standards Association, as amended by section 2 of this document.

Δ

Section 2

AMENDMENTS TO CSA Z247-15 (Damage prevention for the protection of underground infrastructure)

2. The following clauses and/or sections of the CSA-Z247-15 (Damage prevention for the protection of underground infrastructure) are amended as follows:

(1) Ground disturbance definition is amended as follows:

Ground disturbance — means; digging, boring, trenching, grading excavation or breaking ground with mechanical equipment or explosives.

Background:

Definition of Ground disturbance changed for consistency with O. Reg. 210\01

Section 3

AMENDMENTS TO CSA Z662-15 (OIL AND GAS PIPELINE SYSTEMS)

The following clauses and/or sections of the CSA-Z662-15 (Oil and Gas Pipeline Systems) are amended as follows:

(1) Clause **1.2** is deleted and substituted by the following:

1.2

The scope of this Standard, as shown in Figures 1.1 and 1.2, includes

(a) for oil industry fluids, piping and equipment in onshore pipelines, tank farms, pump stations, pressure-regulating stations, and measuring stations;

(b) oil pump stations, pipeline tank farms, and pipeline terminals;

(c) pipe-type storage vessels;

(d) for gas industry fluids, piping and equipment in onshore pipelines, compressor stations, measuring stations, and pressure-regulating stations;

(e) gas compressor stations;

(f) gas storage lines and pipe-type and bottle-type gas storage vessels; and

(g) pipelines that carry gas to and from a well head assembly of a designated storage reservoir.

(2) Clause **1.3** is amended by adding the following items:

(o) gathering systems

Δ (p) digester gas or gas from landfill sites or waste gas within the boundary of the site.

(q) multiphase fluid systems

(r) offshore pipeline systems

(s) oil field water systems

(t) oilfield steam systems

(u) carbon dioxide pipeline systems.

Background:

Originally digester and landfill sites were interpreted to be exempt from Z662 as they were within the jurisdiction of O. Reg 212/01. However, O. Reg 212/01 did not account for the possibility that the gas produced by digester and landfill sites would be exported or conveyed via pipeline through the public domain. This addition limits the exemption for these pipelines within the boundary of the sites. When pipes pass through the public domain, they are considered as pipeline and applicable code is CSA Z662.

(3) Clause 2.2 is amended by adding the following clarification:

For the purpose of this Code Adoption Document, within a gas pipeline system, transmission pipelines are those lines that operate at or above 30% of the pipe's specified minimum yield strength (SMYS) at MOP.

(4) Clause **3.2** is amended by renumbering the existing clause 3.2 to 3.2.1 and adding the following clause:

3.2.2

Natural gas distributors shall incorporate into the procedures for managing the integrity of pipeline systems required in clause 3.2.1 an action plan that includes:

a. a description of the steps taken or that will be taken to mitigate the potential of penetration of sewer lines by a natural gas pipeline during trenchless installation;

b. a program that raises stakeholder awareness of the potential safety issues that could arise when attempting to clear a blocked sewer service line beyond the outside walls of a building; and

c. an assessment of potential risks and a plan to mitigate these risks.

Δ (5) Clause **4.1.7** is deleted and substituted with the following:

4.1.7

Steel oil and gas pipelines may be designed in accordance with the requirements of Annex C, Limit States Design, provided that such designs are suitable for the conditions to which such pipelines are to be subjected, and provided that the design has been reviewed and approved by the Director prior to installation or use.

Background:

An editorial change. Previous version of CAD had mistakenly referred to section 4.1.8. That mistake is corrected in this version.

(6) Clause **4.3.4** is amended by adding the following clauses:

4.3.4.9 High consequence areas

4.3.4.9.1 Definitions

The following definitions apply to the remainder of clause 4.3.4:

Assessment means the use of testing techniques set out in this section to ascertain the condition of a covered pipeline segment.

Covered segment or ***Covered pipeline segment*** means a segment of oil or gas transmission pipeline located in a high consequence area. The terms “oil”, “gas” and “transmission" are defined in O. Reg. 210/01

High consequence area means

(a) for a gas transmission pipeline, an area defined as:

  (i) a Class 3 location under CSA Z662-15, Clause 4.3.3;

  (ii) a Class 4 location under Clause 4.3.3;

  (iii) any area in a Class 1 or Class 2 location where the potential impact radius is greater than 200 metres and the area within the potential impact circle contains 20 or more buildings intended for human occupancy; or

  (iv) any area in a Class 1 or Class 2 location where the potential impact circle contains an identified site; and

(b) for an oil pipeline, an area containing:

  (i) a commercially navigable waterway, which means a waterway where a substantial likelihood of commercial navigation exists;

  (ii) a high population area, which means an urbanized area, as defined and delineated by the latest Statistics Canada Census, that contains 50,000 or more people or has a population density of at least 385 people per square km;

  (iii) any other populated area and/or place, as definedy the latest Statistics Canada Census, that contains a concentrated population, such as an incorporated or unincorporated city, town, village, or other designated residential or commercial area; or

(iv) an unusually sensitive area, as defined in company's pipeline integrity management program.

Identified site means, for Class 1 and Class 2 locations, any of the following areas:

(a) an outside area or open structure that is occupied by twenty (20) or more persons on a minimum of fifty (50) consecutive or non-consecutive days in any twelve-month (12) period. Examples include but are not limited to: beaches, playgrounds, recreational facilities, camping grounds, outdoor theaters, stadiums, recreational areas near a body of water, and areas outside rural building such as a religious facility;

(b) a building that is occupied by twenty (20) or more persons on a minimum of five (5) consecutive or non-consecutive days in any given week for at least ten (10) weeks in any twelve-month (12) period. Examples include, but are not limited to, religious facilities, office buildings, community centers, general stores, 4-H facilities, sporting and entertainment facilities; or

(c) a facility occupied by persons who are confined, are of impaired mobility, or would be difficult to evacuate. Examples include but are not limited to hospitals, prisons, schools, day-care facilities, retirement facilities and assisted-living facilities.

Potential impact circle, for natural gas or HVP pipelines systems, is a circle of radius equal to the potential impact radius (PIR).

Potential impact radius (PIR) means the radius of a circle within which the potential failure of a pipeline could have significant impact on people or property, determined by the following formula:

Δ r = 0.00313 times square root of (pd^2)

where:

r is the radius of the circular area surrounding the point of failure in meters (m) p is the MOP of the pipeline in kPa d is the nominal diameter of the pipeline in mm

NOTE: 0.00313 is the factor for natural gas based on conversion from a formula used in GRI-00/0189. This number will vary for other gases depending upon their heat of combustion. An operator transporting gas other than natural gas shall refer to ASME/ANSI B31.8 S for the formula to calculate the potential impact radius.

<u>Background:</u>

This is an editorial change. The formula had a typographical error in the previous version of the CAD and it is corrected in this version.

4.3.4.9.2 Identification of high consequence areas

(a) *General*. Operating companies shall identify which segments of its oil and gas transmission pipeline system are in high consequence areas. The operator must describe in its integrity management program the method used to establish high consequence areas, including the determination of the potential impact radius.

(b) *Identified sites*. The operator shall identify identified sites by:

- (i) using information the operator has obtained from routine operation and maintenance activities; and
- (ii) obtaining information about locations that are likely to meet the criteria for identified sites from public officials with safety or emergency response or planning responsibilities (such as officials from local emergency planning response agencies or from municipal planning departments).

(c) *Identified sites – where public officials cannot assist*. If the public officials mentioned above are unable to provide information useable to identify potential identified sites, the operator shall review and use the following information, as appropriate, to identify potential identified sites:

- (i) the presence of signs, public notices, flags or other markings that suggest that the area may qualify as an identified site; and
- (ii) the existence of publicly available information, including online and at local land registry offices, that suggests the area may qualify as an identified site.

(d) *Newly identified high consequence areas*. When an operator obtains information suggesting that the area around a pipeline segment not previously identified as a high consequence area could constitute a high consequence area, the operator shall evaluate the area to determine if the area is a high consequence area. If the segment is determined to constitute a high consequence area, it must be incorporated into the operator's baseline assessment plan as a high consequence area within one year from the date the area is identified.

Δ Note: Pipeline operators shall keep records of the above requirements pursuant to section 3.1.2 (f) (v) of CSA Z662-15.

Background:

Note section was added to reiterate the requirements of "record keeping" which is essential part of Integrity Management Program.

4.3.4.10 Operator's responsibility to implement this clause

4.3.4.10.1

An operator of a covered pipeline segment shall develop and follow a written program (as part of the pipeline system integrity management program (IMP)) that contains all the elements described in the IMP and that addresses the risks associated with each covered transmission pipeline segment.

4.3.4.10.2 Implementation standards

An operator may use an equivalent standard or practice as required by clause 4.3.4 only when the operator demonstrates in its Integrity Management Program that the alternative standard or practice provides an equivalent level of safety to the public and property.

4.3.4.11 Risk assessment

The operator shall conduct a risk assessment that follows Annex B Guidelines for risk assessment of pipelines falling within the scope of CSA Z662-15 for each covered segment. The risk assessment shall include the high consequence areas and determine if additional preventive or mitigation measures are needed.

The operator shall prioritize the covered pipeline segments according to risk.

4.3.4.12 Remediation

For each covered segment, the operator shall develop and establish measures to prevent or reduce the probability of an incident and to limit the potential consequences thereof.

These measures shall include conducting a risk analysis of the pipeline segment to identify additional measures to enhance public safety or environmental protection. Such measures may include, but are not limited to:

(a) establishing shorter inspection intervals;
(b) installing emergency flow restricting devices (remote operated valves, check valves and automatic shut off valves, as applicable);
(c) modifying the systems that monitor pressure or detect leaks, as applicable;
(d) providing additional training to personnel on response procedures;
(e) conducting drills with local emergency responders; and
(f) adopting other management controls.

Evacuation procedures shall take into consideration the PIR.

For oil pipeline segments located in high consequence areas, the operating company shall provide the Ontario Ministry of Natural Resources and Forestry (MNRF) and the Ontario Ministry of Environment and Climate Change (MOECC) an opportunity to comment on the company's contingency plan for leaks or spills and shall address any comments provided by MOECC or MNRF.

(7) **Table 4.2** is amended by substituting the requirements for LVP (non-sour services) with the following:

	Class 1 location	**Class 2 location**	**Class 3 location**	**Class 4 location**
Transmission lines (refined products)	1.000	0.900	0.700	0.550
Uncased railway crossings	0.625	0.625	0.625	0.625

This requirement is not retroactive and applies to new pipelines only.

(8) Clause **7.10.3.2** is deleted and substituted with the following:

7.10.3.2

For HVP and for sour service pipeline systems, all butt welds shall be inspected by radiographic or ultrasonic methods, or a combination of such methods, for 100% of their circumferences, in accordance with the requirements of clause 7.10.4.

(9) Clause **10.3.8.1** is deleted and substituted with the following:

10.3.8.1

Prior to a change in service fluid, including from non-sour service to sour service, the operating company shall conduct an engineering assessment to determine whether the pipeline systems would be suitable for the new service fluid. The assessment shall include consideration of the design, material, construction, operating, and maintenance history of the pipeline system and shall be submitted to the Director for approval.

(10) Clause **10.3** is amended by adding the following clause:

10.3.11

For the protection of the pipeline, the public and the environment, the operating company shall develop a pipeline integrity management program for steel pipelines operated at 30% or more of the SMYS of the pipe at MOP that complies with the applicable requirements of clause 3.2 of CSA Z662-15.

(11) Clause **10.5.2** is amended by adding the following clauses:

10.5.2.5 Emergency communication meetings

The operator of a transmission pipeline shall conduct meetings with local authorities, inviting police, firefighting authorities, Ontario Ministry of Transportation (MTO), Ministry of Natural Resources and Forestry (MNRF), Ministry of the Environment and Climate Change (MOECC), local conservation authorities and TSSA, to explain to the authorities the characteristics of the pipeline system the operator operates, the type of fuels being transported and the typical behavior of these fuels in case of uncontrolled escapes or spills and the capabilities and the coordination required to respond to pipeline emergencies.

These meetings shall be conducted at intervals not exceeding five years at locations that ensure the key stakeholders can attend. The meetings shall be prioritized to correspond to the operating company's prioritization of the covered pipeline segments according to the risk.

10.5.2.6

Operating companies shall prepare an emergency response plan and make it available on request, to local firefighting authorities, as well as the authorities referred to in clause 10.5.2.5.

(12) Clause **10.6** is amended by adding the following clause:

10.6.5 Right-of-way encroachment

10.6.5.1

No person shall construct, erect or install any structure or tangible item on or within the pipeline right-of-way, including but not limited to patios, concrete slabs, buildings, pool houses, garden sheds, swimming pools, hot tubs, fish or other man-made ponds, saunas or fences, unless written permission is first obtained from the operating company.

10.6.5.2

No person shall deposit or store any flammable material, solid or liquid spoil, refuse, waste or effluent on or within the pipeline right-of-way.

10.6.5.3

Notwithstanding the above, operating companies may erect structures required for purpose of pipeline system operation on the pipeline right-of-way.

10.6.5.4

No person shall operate a vehicle or mobile equipment except for farm machinery or personal recreation vehicles across or within a pipeline right-of-way unless written permission is first obtained from the operating company or the vehicle or mobile equipment is operated within the travelled portion of a highway or public road already existing in the pipeline right-of-way.

10.6.5.5

Operating companies shall develop written procedures for periodically determining the depth of cover for pipelines operated over 30% of SMYS of the pipe at MOP. Such written procedures shall include a rationale for the frequency selected for such depth determinations. Where the depth of cover is found to be less than 60 cm in lands being used for agriculture, an engineering assessment shall be done in accordance with clause 3.3 and a suitable mitigation plan shall be developed and implemented to ensure the pipeline is adequately protected from hazards.

(13) Clause **10.15.1.2** is amended by adding the following items:

(e) maintain warning signs and markers along the pipeline right-of-way;

(f) maintain existing fences around above ground pipeline facilities; and

(g) empty tanks and purge them of hazardous vapours within 60 days of deactivation.

(14) Clause **12.4.11.1** is renumbered as clause 12.4.11.1.1. Clause **12.4.11** is amended by adding the following clauses:

12.4.11.1.2

All new and replacement natural gas service regulators shall comply with the requirements of CSA 6.18-02 (R2008) (Service Regulators for Natural Gas), published by the Canadian Standards Association, including the Drip and Splash Test contained in Appendix A of the said standard. Where a regulator-meter set installation or supplemental protective devices provides equivalent protection against regulator vent freeze up passes a successful test in accordance with Appendix C of the said standard, the requirements of Appendix A (Drip and Splash Test) and those contained in clause

14.15 (Freezing Rain Test) of the standard are waived. Evidence of tests completed in accordance with Appendix C of the standard shall be retained by the operating company as permanent records.

12.4.11.1.3

Regulator-meter set configurations shall be included in the operating company's operating and maintenance procedures.

(15) Clause 12.4.15.6 is revoked and substituted with the following:

12.4.15.6

Where regulator failure would result in the release of gas, open ends of the vents shall be located where the gas can escape freely into the atmosphere and away from any openings in the buildings. Clearances from building openings shall be commensurate with local conditions and the volume of gas that might be released, but shall not be less than those set out in the following table:

Clearance from service regulator vents discharge (m)

Column:	I	II	III	IV
Building opening	0.3	1	3	1
Appliance vent outlet	0.3	1	1	1
Moisture exhaust duct (dryers)	1	1	1	1
Mechanical air intake	1	3	3	3
Appliance air intake	0.3	1	3	3
Source of ignition	0.3	1	1	3

Column I applies to natural gas regulators certified under CSA 6.18 standard, incorporating an OPCO system and with a limited relief of 1.5 m3/h.

Column II applies to natural gas regulators certified under CSA 6.18 standard (if within the scope of the standard) with a relief capacity up to 55 m3/h.

Column III applies to natural gas regulators with a relief capacity over 55 m3/h.

Column IV applies to propane regulators.

Where regulators may be submerged during floods, either a special anti-flood-type breather vent fitting shall be installed or the vent line shall be extended above the height of the expected flood waters.

(16) Clause 12.4.15 is amended by adding the following item:

12.4.15.10

No person other than an employee or person authorized by the distributor shall interfere with or perform any alterations, repairs, tests, services, removals, changes, installations, connections, or any other type of work on the distributor's system.

(17) Clause 12.10.12 is amended by adding the following items:

(e) For polyethylene piping installed in Class 1 and Class 2 locations, the upgraded maximum operating pressure shall not exceed the design pressure calculated in accordance with the requirements of Clause 12.4.2; and

(f) For polyethylene piping installed in Class 3 and Class 4 locations, the upgraded maximum operating pressure shall not exceed the design pressure calculated in accordance with the requirements of clause 12.4.2 with a combined design factor and temperature derating factor (F x T) of 0.32, unless the operating company conducts an engineering assessment to determine whether it would be suitable for the existing polyethylene piping to be operated at the new pressure. The assessment shall include consideration of the design, material, construction, operating, and maintenance history of the pipeline system and be submitted to the Director for approval.

(18) Clause 12.10 is amended by adding the following clause:

12.10.16

Operating companies shall establish effective procedures for managing the integrity of pipeline systems operated at less than 30% of SMYS of the pipe at MOP (Distribution Systems) so that they are suitable for continued service, in accordance with the applicable requirements of clause 3.2 of CSA Z662-15.

Section 4

POLYETHYLENE PIPE CERTIFICATION

3. Polyethylene piping and fittings that are used in a polyethylene gas pipeline shall be certified by a designated testing organization accredited by the Standards Council of Canada as conforming to CSA-B137.4 (Polyethylene Piping Systems for Gas Services).

Section 5

WELDER QUALIFICATION

4. Welds shall not be made in any steel pipe that forms or is intended to form a part of a steel oil or gas pipeline or a component of a steel pipeline unless the welding procedures have been approved and the welder is qualified to make the weld in accordance with the requirements of CSA-Z662-15 (Oil and Gas Pipeline Systems) and is the holder of the appropriate authorization issued under O. Reg. 220/01 (Boilers and Pressure Vessels) made under the Act.

Section 6
EFFECTIVE DATE; MISCELLANEOUS

5. (1) This Code Adoption Document amendment is in effect on **February 15, 2018**.

(2) Where there is a conflict between this document and a code, standard or publication adopted by this document, this document prevails.

(3) Any reference to “Director” in a code, standard or publication adopted by this document means the Director for the purposes of O. Reg. 210/01 (Oil and Gas Pipeline Systems).

DATED at Toronto, Ontario, this 15th day of February 2018.

ORIGINAL SIGNED BY

John Marshall
Director, O. Reg. 210/01 (Oil and Gas Pipeline Systems)

Any person involved in an activity, process or procedure to which this document applies shall comply with this document.
This document was developed in consultation with the Pipeline Risk Reduction Group

ENBRIDGE GAS INC.
Answer to Interrogatory from
Vulnerable Energy Consumers Coalition (VECC)

INTERROGATORY

Reference:

Exhibit B, Tab 1, Schedule 1, page 10 / Exhibit F, Tab 1, Schedule 1, Attachment 1

Question**:**

a) Enbridge explains that it is proceeding with constructing loop S1 or Phase 1 of the project. The public consultation identifies Phase 2 as approximately 5.5 km of pipeline in the Cachet and Rodick Road-Unionville area. Phase 2 is also discussed in some detail at Exhibit F (letter of January 4, 2019 to Ministry of Energy, Northern Development and Mines). Please explain when Phase 2 is contemplated and under what condition it will proceed.

Response:

Enbridge Gas does not have an immediate plan to undertake Phase 2 of the Project, and no definitive date is under contemplation for the near future. Phase 1 is anticipated to be sufficient to begin the initial investigation and validation into the blending of hydrogen into a portion of the natural gas distribution system.

As work has been done on Phase 2, the conditions under which Phase 2 would proceed would be dependent on several variables which may include positive validation from Phase 1 as well as demand or requirement for further expansion of decarbonization of the distribution system. A leave to construct application would most likely be necessary to undertake Phase 2, because of work required for connection to Phase 1 and isolation from other parts of the Enbridge Gas system.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Vulnerable Energy Consumers Coalition (VECC)

INTERROGATORY

Reference:

Exhibit C, Tab 1, Schedule 1, Attachment 4 /Exhibit E, Tab 1, Schedule 1, page 2

Question**:**

a) Please update of the status of acquisition permits as shown in Table 1 of Exhibit E.

b) Has Enbridge received the required easements from the City of Markham and Hydro One Networks?

Response:

a) All of the permits and authorizations shown in Table 1 of Exhibit E, Tab 1, Schedule 1 will be applied for when leave to construct for the Project is granted by the Board.

b) Enbridge Gas will not require an easement from Hydro One or the City of Markham. The gas main will be installed in the road allowance and will not be installed in any of Hydro One’s registered easements.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Vulnerable Energy Consumers Coalition (VECC)

INTERROGATORY

Reference:

Exhibit C, Tab1, Schedule 1, Attachment 4, page 53

Question**:**

a) Enbridge states that it has completed a study on appliances in the blended gas distribution area. Please provide this study.

b) Has Enbridge undertaken a study or reviewed an existing study on the impact of hydrogen fuel on common household natural gas appliances (i.e. furnaces, stove-ovens, water tanks and clothes dryers)? If yes please provide that study or studies.

Response:

a) and b) Please see the response to Exhibit I.H2GO.1.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Vulnerable Energy Consumers Coalition (VECC)

INTERROGATORY

Reference:

Exhibit B, Tab 2, Schedule 4 / Exhibit D, Tab 1, Schedule 1, page 7

Question**:**

a) Please confirm or correct that hydrogen at certain concentrations is known to have a detrimental impact (embrittlement) on some types of steel pipe.

b) Please explain why this issue is not a concern with respect to natural gas burners and other steel-based customer equipment.

c) Enbridge notes that it will be testing pipeline additions "*in accordance to guidelines from the Canadian Hydrogen Installation Code*." What incremental requirements are incorporated in this Code that would not normally be done if the pipeline was anticipated only to carry unadulterated natural gas?

Response:

a) Confirmed. Please refer to Exhibit I.STAFF.6 (a) for additional details.

b) Natural gas burners are to be made of corrosion resistant steel. The 2% hydrogen by volume mixture in the studied area is not expected to impact this equipment. These materials are not susceptible to the detrimental effects of hydrogen at the blending levels contemplated. The consultant familiar with town gas applications has determined through literature search and field tests that corrosion-resistant steels in burners have no limitations from the addition of hydrogen at the studied levels.

c) The Canadian Hydrogen Installation Code is only applied to pure hydrogen pipelines and facilities. It will be applied to the proposed hydrogen blending station. After hydrogen is blended with natural gas the standard that applies is CSA Z662.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Vulnerable Energy Consumers Coalition (VECC)

INTERROGATORY

Reference:

Exhibit B, Tab 2, Schedule 4 / Exhibit D, Tab 1

Question**:**

a) Please confirm (or correct) that hydrogen has a different permeation coefficient than methane?

b) Given that hydrogen is a much smaller molecule than methane does it have a higher tendency to leak (at seals, meters etc.) than unadulterated (methane) natural gas? If so, please explain what steps are taken to mitigate this effect.

c) Please explain what impact hydrogen may have on the accuracy of existing gas meters.

d) Please explain what steps will be taken during the pilot program to understand the impact of hydrogen blending on distribution pipes, meters and customer equipment.

Response:

a) This is correct. Refer to Exhibit I.STAFF.6 b) for more detail.

b) Although the permeation rate of hydrogen in seals is higher than methane, the leakage rate of hydrogen is extremely low due to the small surface area. Additionally, since the permeation is related to the partial pressure, at the blending levels for this project, this impact is further reduced. Refer to Exhibit I.STAFF.6 b) for more detail.

c) Please refer to Exhibit I.FRPO.1. There are three types of gas measurement equipment used in the area of study: diaphragm, rotary and ultrasonic. Diaphragm and rotary meters are positive-displacement meters that operate on the principle of using a fixed volumetric space that fills and empties as the meter turns. As this volume is fixed, the volume of the blended gas will be measured in the same way with low partial pressures of hydrogen. An ultrasonic meter measures the velocity of the gas using ultrasound to calculate the volumetric flow. The gas composition impacts the acoustic properties of the gas, which can change the measurement accuracy. The addition of hydrogen can affect the measurement accuracy if it changes the density or viscosity of the blended gas compared to natural gas. The ultrasonic meters installed in these networks are smaller scale models. The manufacturer confirmed the suitability of their ultrasonic meters with up to 5% by volume hydrogen.

d) Refer to Exhibit I.FRPO.14 for the response on distribution equipment. Enbridge Gas does not expect any adverse impact on customer appliances (see Exhibit I.FRPO.8(b)) but will consider follow-up and customer surveys if evidence emerges of customer equipment issues.

ENBRIDGE GAS INC.
Answer to Interrogatory from
Vulnerable Energy Consumers Coalition (VECC)

INTERROGATORY

Reference:

Exhibit D, Tab 1, Schedule 1, page 13

Question**:**

a) Please clarify which line items (1-10) in Table 8 attract a 40% contingency and which attract a 25% contingency.

b) Please explain more fully what “specialized” equipment or design requirements are uncertain and therefore the costs less certain.

Response:

a) and b) Please see Exhibit I.CCC.17 d)