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

June 19, 2020

VIA EMAIL and RESS

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 (OEB) File: EB-2019-0294
Low Carbon Energy Project – Interrogatory Responses

Further to the interrogatory responses filed by Enbridge Gas on June 15, 2020, enclosed please find the following outstanding responses.

- Exhibit I.FRPO.4
- Exhibit I.H2GO.4
- Exhibit I.SEC.1
- Exhibit I.SEC.9

The attachment to SEC 9 has been redacted to remove confidential information. The redacted version of the document is filed with this letter. In accordance with the OEB's revised Practice Direction on Confidential Filings effective October 28, 2016, the unredacted version of the attachment to SEC 9 will be sent separately via email (with accompanying cover letter) to the Board.

Please contact the undersigned if you have any questions.

Yours truly,

(Original Signed)

Stephanie Allman
Regulatory Coordinator

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
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
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

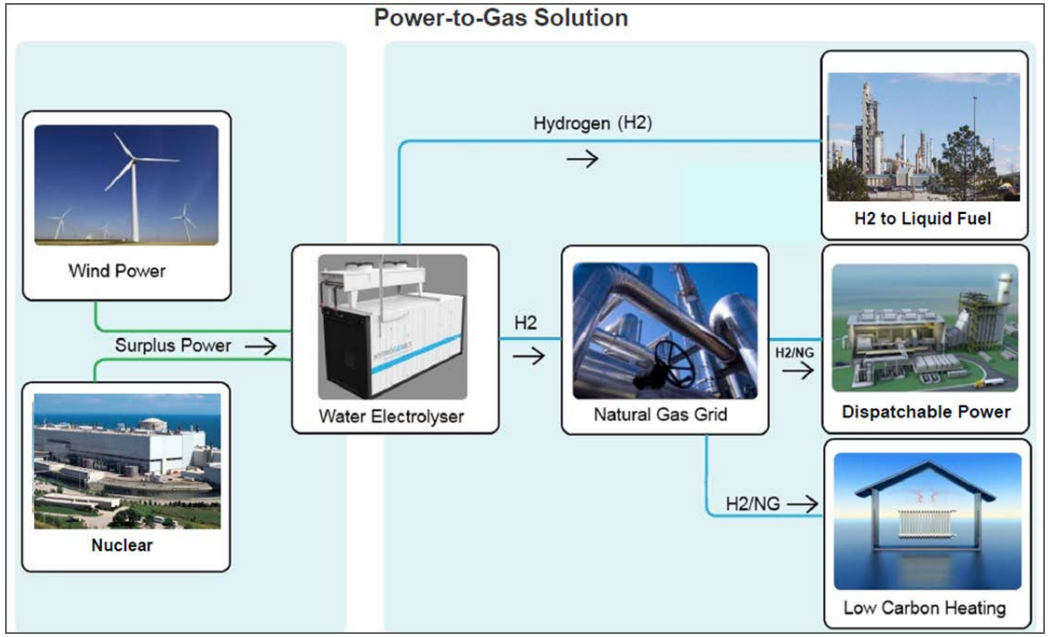
ENBRIDGE

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

- 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

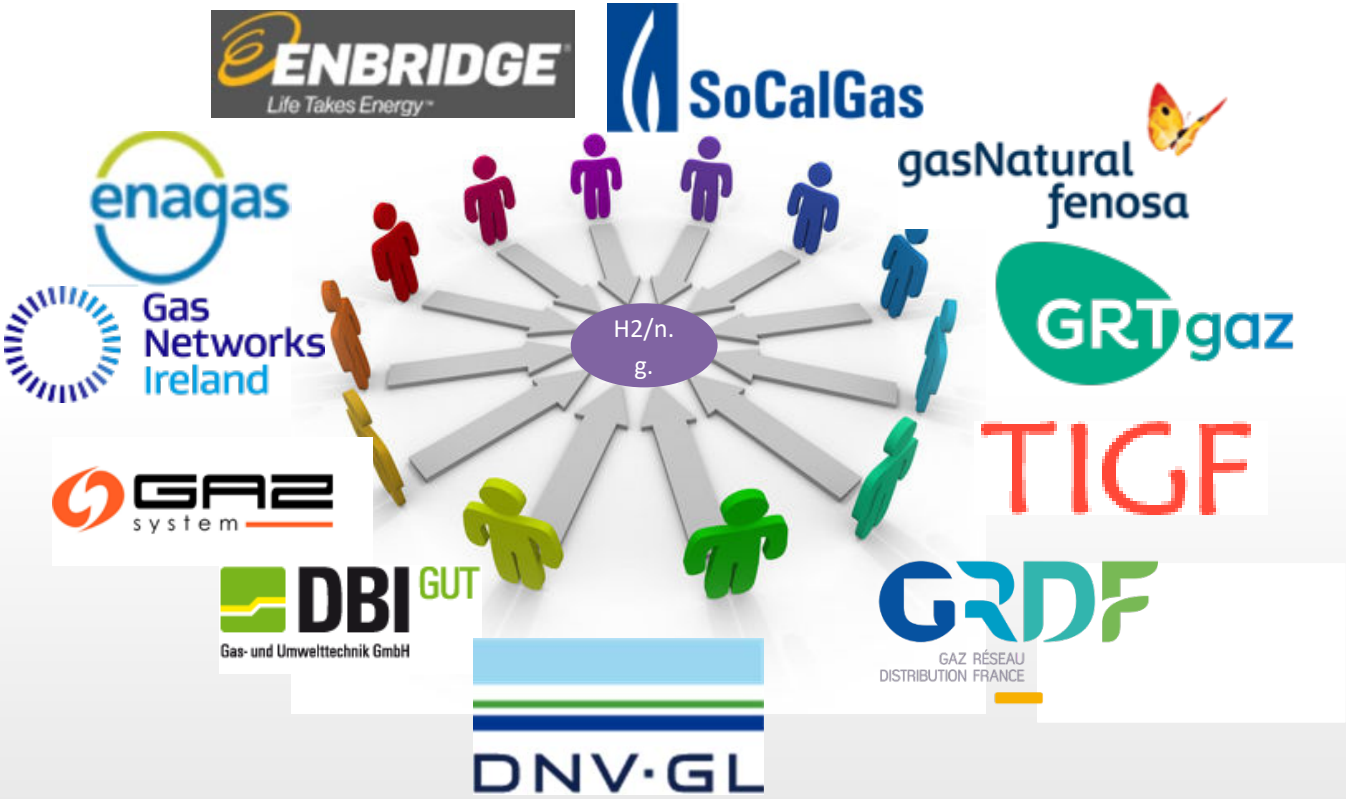
HYREADY Kickoff Meeting Update

- 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



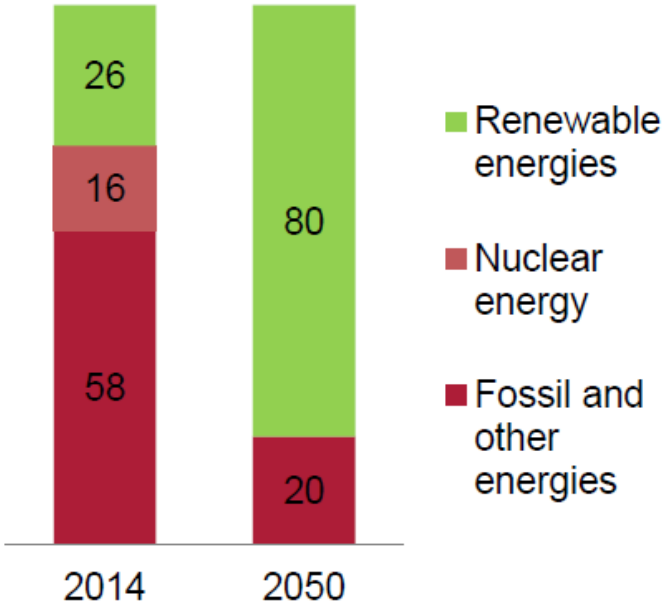
Discussions with several additional parties about their feasible participation in HYREADY are in progress. Nevertheless, new partners remain very welcome!!

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

Source: Deutsche Energie-Agentur GmbH (dena, 09/2015)

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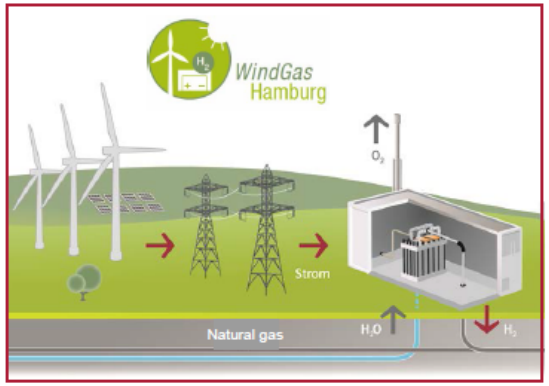
Hanse Werk

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 m^3/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

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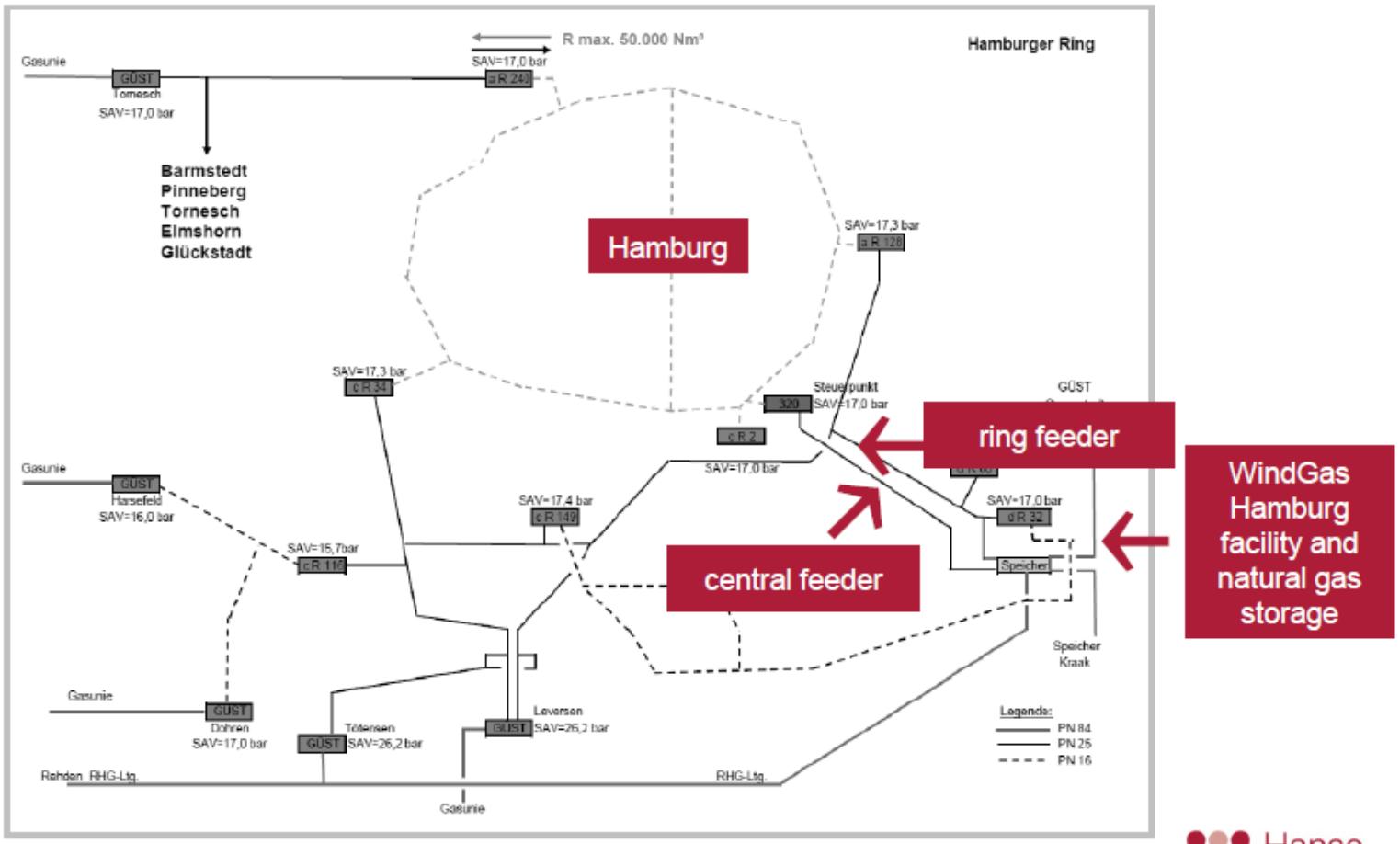
H_2 feeding into the Hamburg Ring



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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

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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

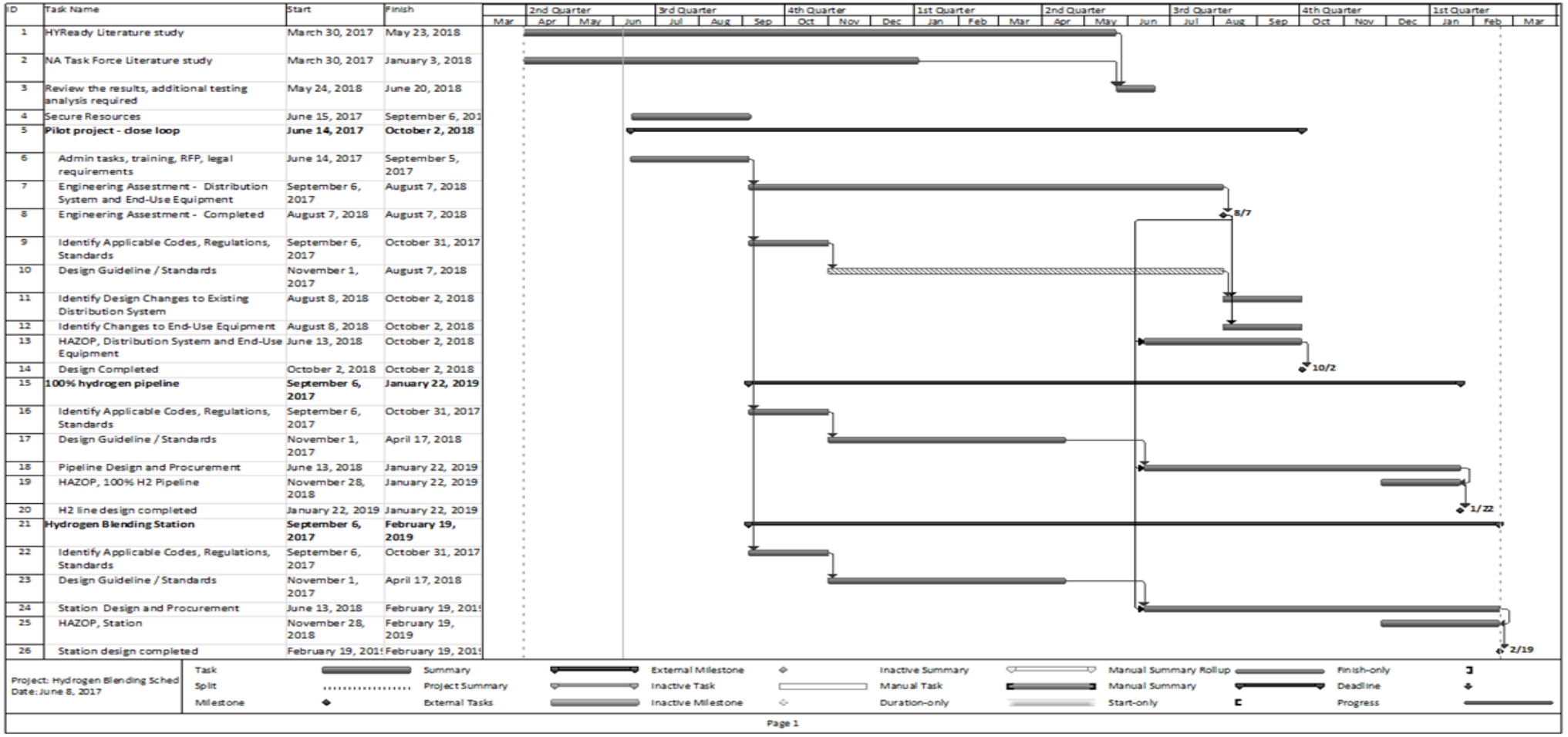
Engineering Project Scope

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

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.

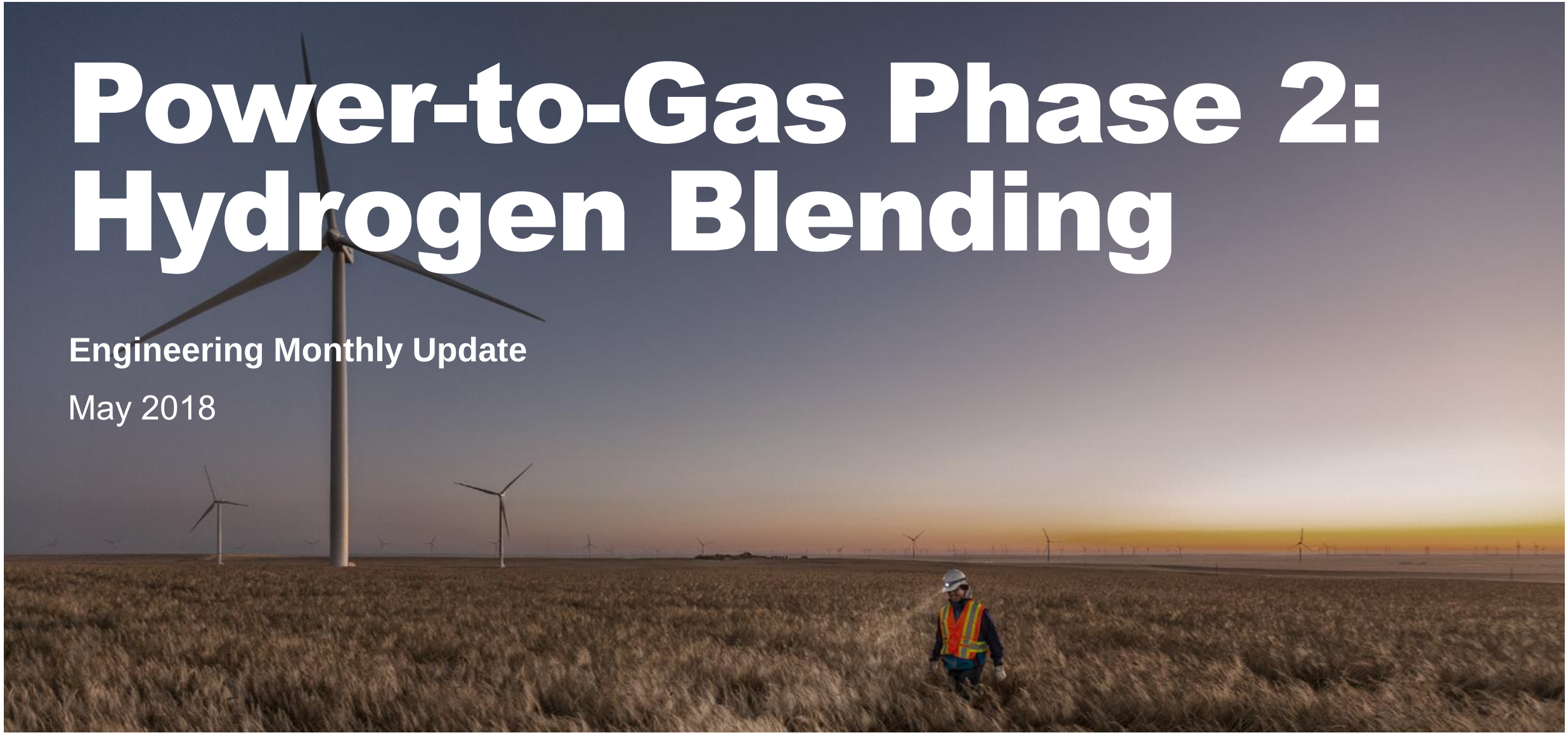
- Work scope segmented into Milestones supported by “Go / No-Go” decision tree, and aligned with funding.
  - Milestone 1 by May 2018 - first segment of H_2 Assessment work ($625k after funding)
  - Milestone 2 by Feb 2019 – completion of H_2 Assessment (additional $425k after funding)
  - In May 2018, 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

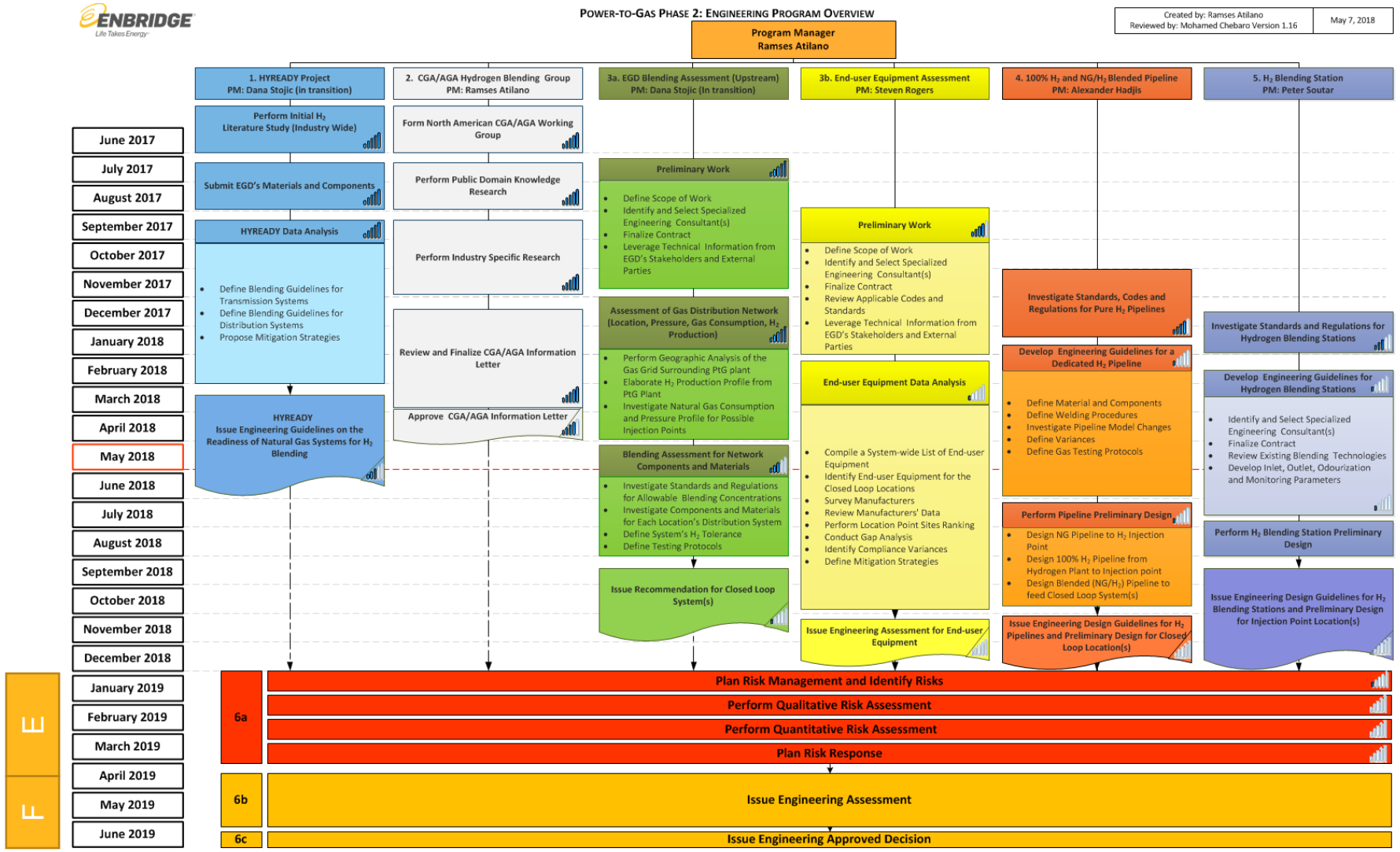
ENBRIDGE

Mohamed Chebaro and Ramses Atilano
Engineering

Power-to-Gas Phase 2

Road Map

A	B	C	D



Power-to-Gas Phase 2

Status Review

On track
Lagging but not on critical path
Lagging and on critical path

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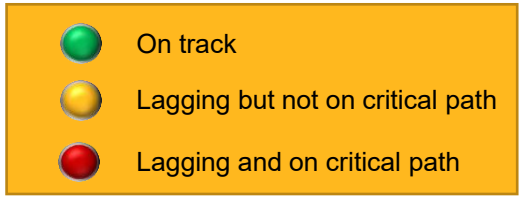
Program Streams	STATUS: Scope	Budget	Timeline
A. Research and Development:			
CGA/AGA Task Force Information Letter			
HYREADY Engineering Guideline Report			
B. Integrity, Engineering and Capacity Assessment			
Closed Loop(s) Identification and Prioritization			
Network Capacity Analysis for Closed 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



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Life Takes Energy™

	STATUS:		
Program Streams	**Scope**	**Budget**	**Timeline**
C. End User Equipment Engineering and Integrity System			
Data collection and analysis for identified closed loops	On track	On track	Lagging but not on critical path
System-wide assessment for end-user equipment	On track	On track	On track
D. Engineering Design and Review			
Pipeline Design (hydrogen pipeline)	On track	On track	On track
Pipeline Design (blended pipeline)	On track	On track	On track
Blending Stations Design (injection station)	On track	On track	Lagging but not on critical path
E. Risk Assessment	Lagging but not on critical path	On track	On track
F. Engineering Assessment	On track	On track	On track

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:			
HYREADY Engineering Guideline Final Report	On track	On track	On track
B. Integrity, Engineering and Capacity Assessment			
Data gathering to continue for Loops S1A and S1B	On track	On track	On track
Preliminary system design for Closed Loop S1	On track	On track	On track
C. End User Equipment Engineering and Integrity System			
Contract execution and commencement of work by DNV-GL	On track	On track	Lagging but not on critical path
Finalize end-user equipment field survey for Closed Loop S1	On track	On track	Lagging but not on critical path
Continue designing the end-user equipment e-survey for Closed Loops S1A and S1B	Lagging but not on critical path	On track	On track

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

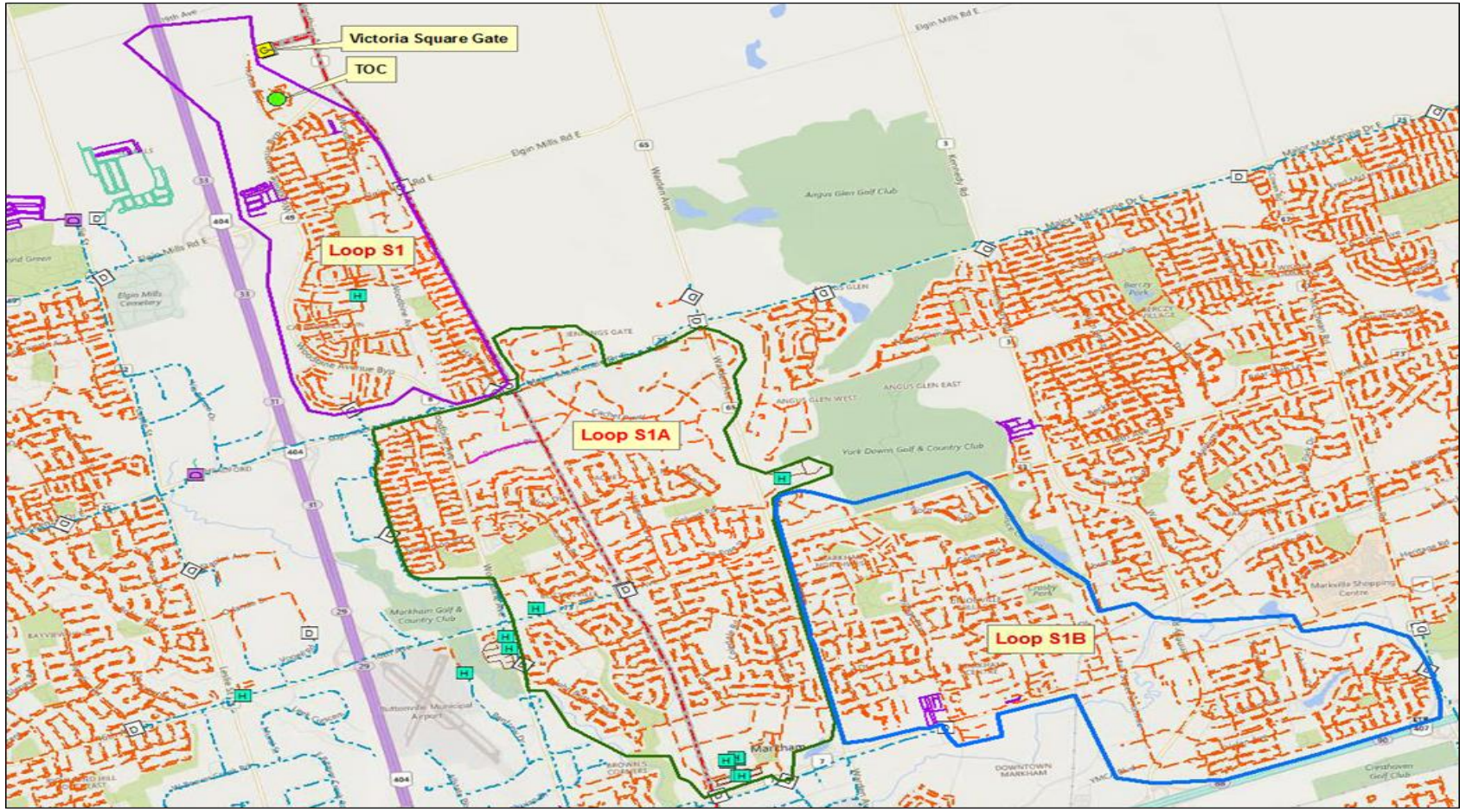
- ✓ Proposals from six consultants have been reviewed and ranked, DNV-GL was selected as the successful bidder
- ✓ Contract is being executed with DNV-GL by the Law Department with support from the Growth team
- ✓ End-user equipment survey for a closed loop was designed and awaits execution by Lakeside 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)

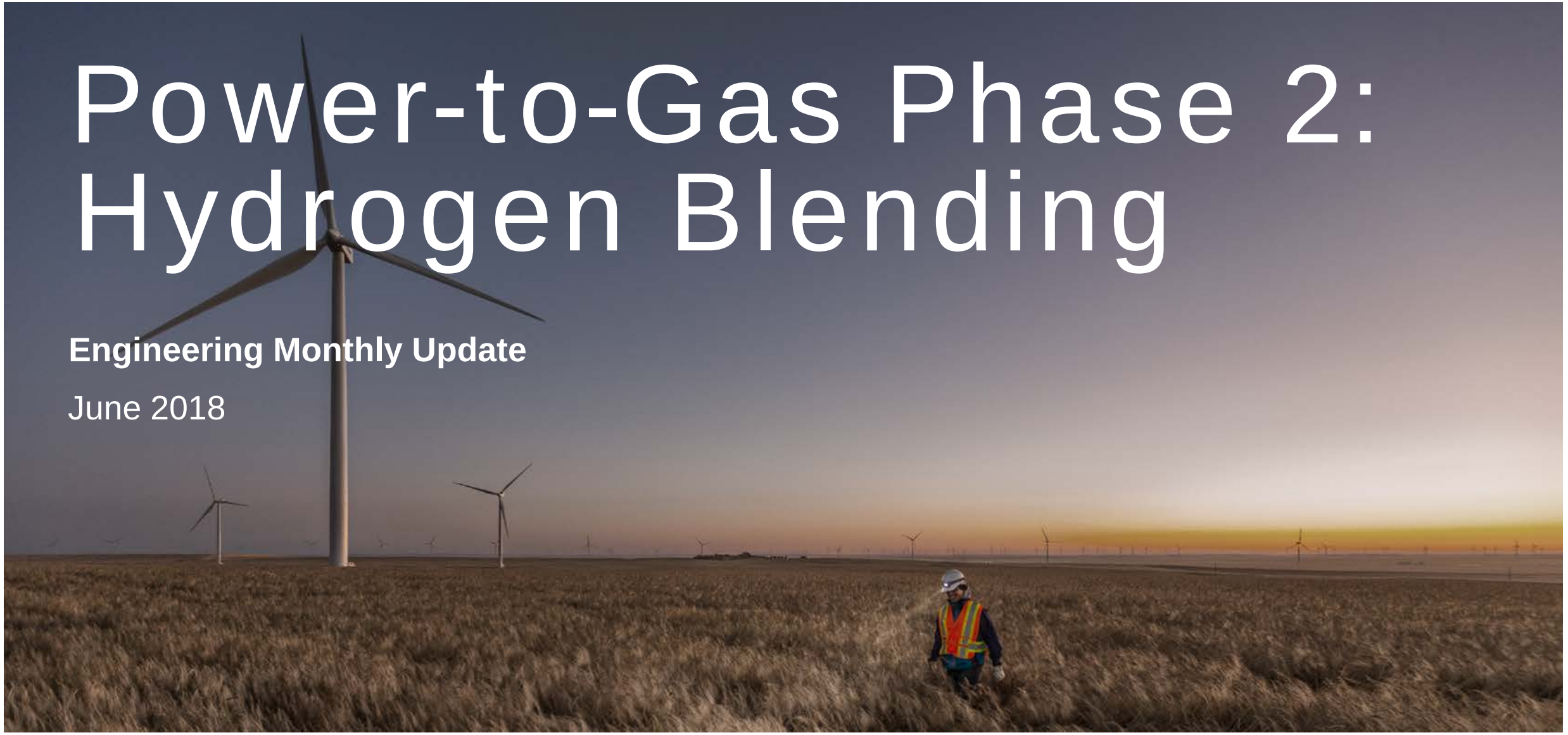
Phase 1
- Loop S1
- ~4,000 customers
- 0-10% Plant Capacity*

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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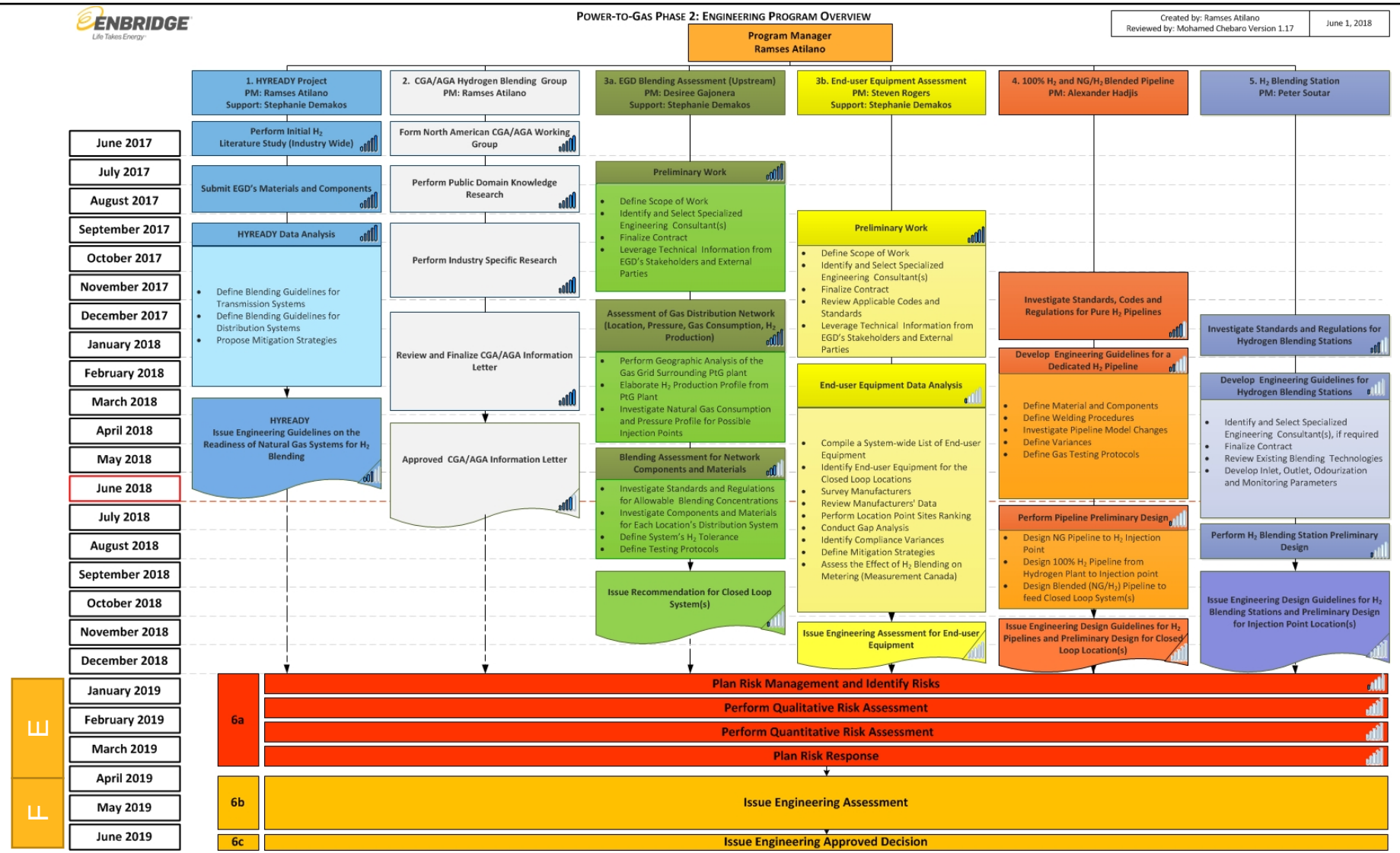
Mohamed Chebaro and Ramses Atilano
Engineering

Power-to-Gas Phase 2

Road Map

A	B	C	D



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**
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 (completed)			
Network Capacity Analysis for Closed Loop Candidates (completed)			
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

ENBRIDGE
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	STATUS:		
Program Streams	**Scope**	**Budget**	**Timeline**
C. End User Equipment Engineering and Integrity System			
Data collection for identified closed loops			
Data analysis for identified closed loops			
System-wide assessment for end-user equipment			
D. Engineering Design and Review			
Pipeline Design (hydrogen pipeline)			
Pipeline Design (natural gas and blended pipelines)			
Blending Stations Design (injection station)			
E. Risk Assessment			
Risk Assessment Report			
Computational Modeling			
F. Engineering Assessment			

Power-to-Gas Phase 2

Upcoming Deliverables

On track
Lagging but not on critical path
Lagging and on critical path

ENBRIDGE
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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

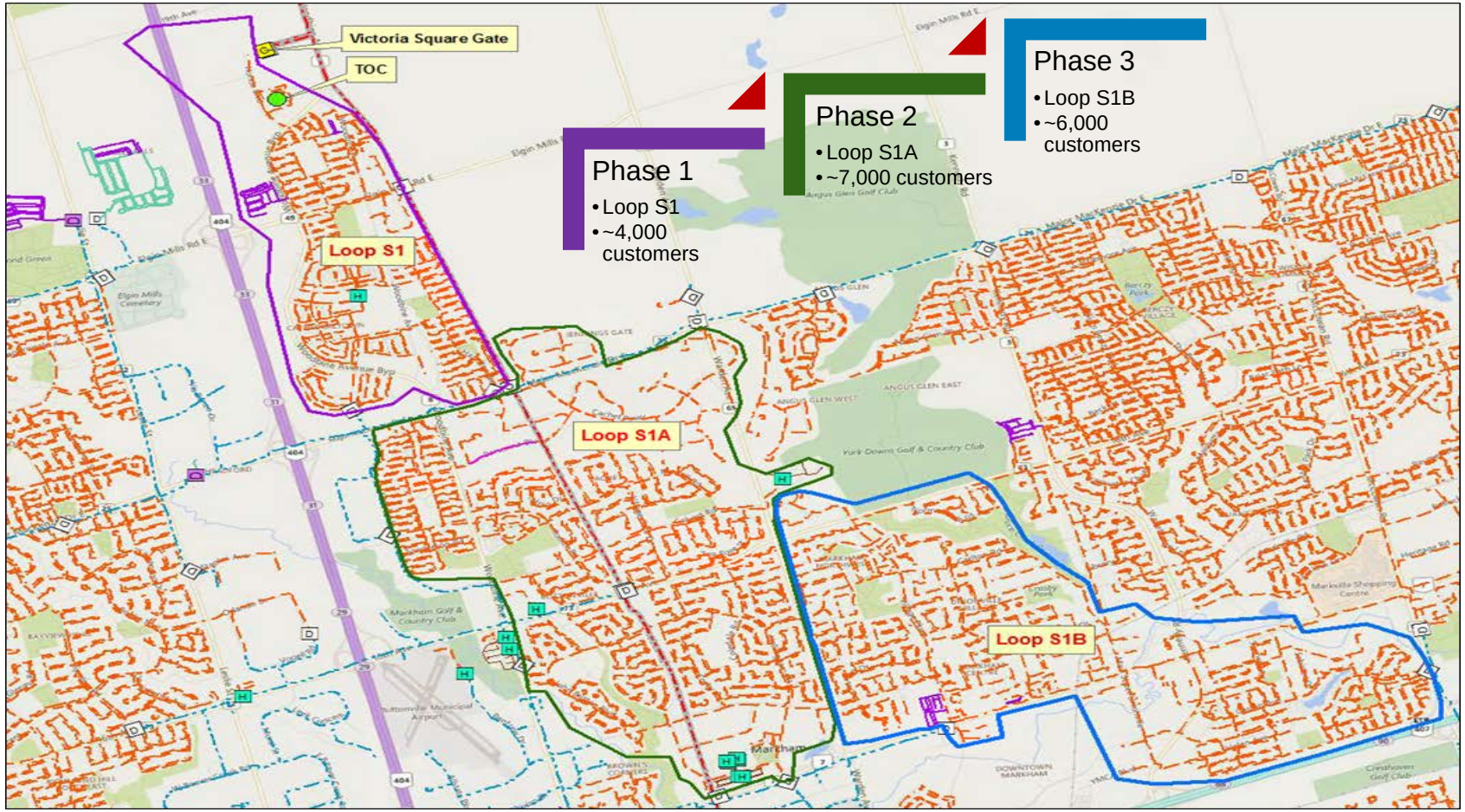
- ✓ Initiated preliminary design for pipelines carrying three different products (100% H_2, 100% NG and blended gas)
- ✓ Initiated preliminary design for the station components (Pressure Regulation and H_2 Injection)
- ✓ Compiled and summarized applicable codes, standards and regulations for H_2 pipelines
- ✓ Initiated discussions with the TSSA

E. Risk Assessment

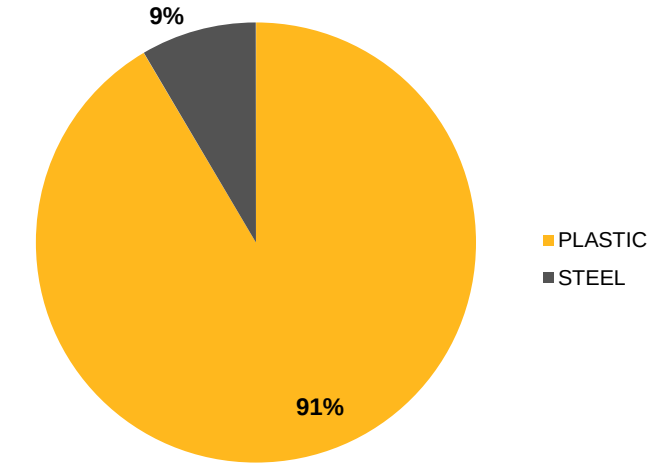
- ✓ Reviewed first draft of the Risk Assessment Work Plan
- ✓ Defined and planned computational dispersion modeling work that will feed into the risk and engineering assessments

Power-to-Gas Phase 2

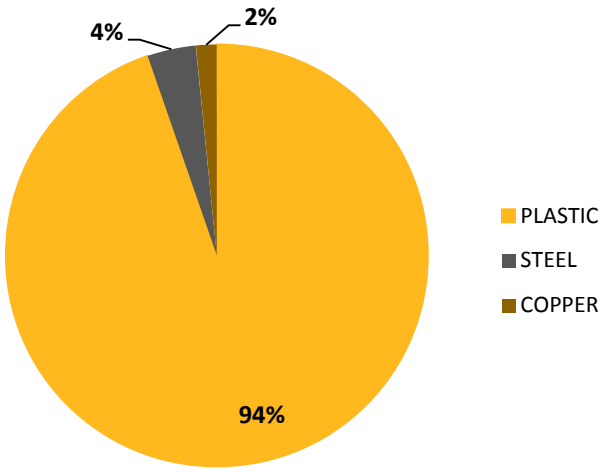
Map of Closed Loop Systems in Markham



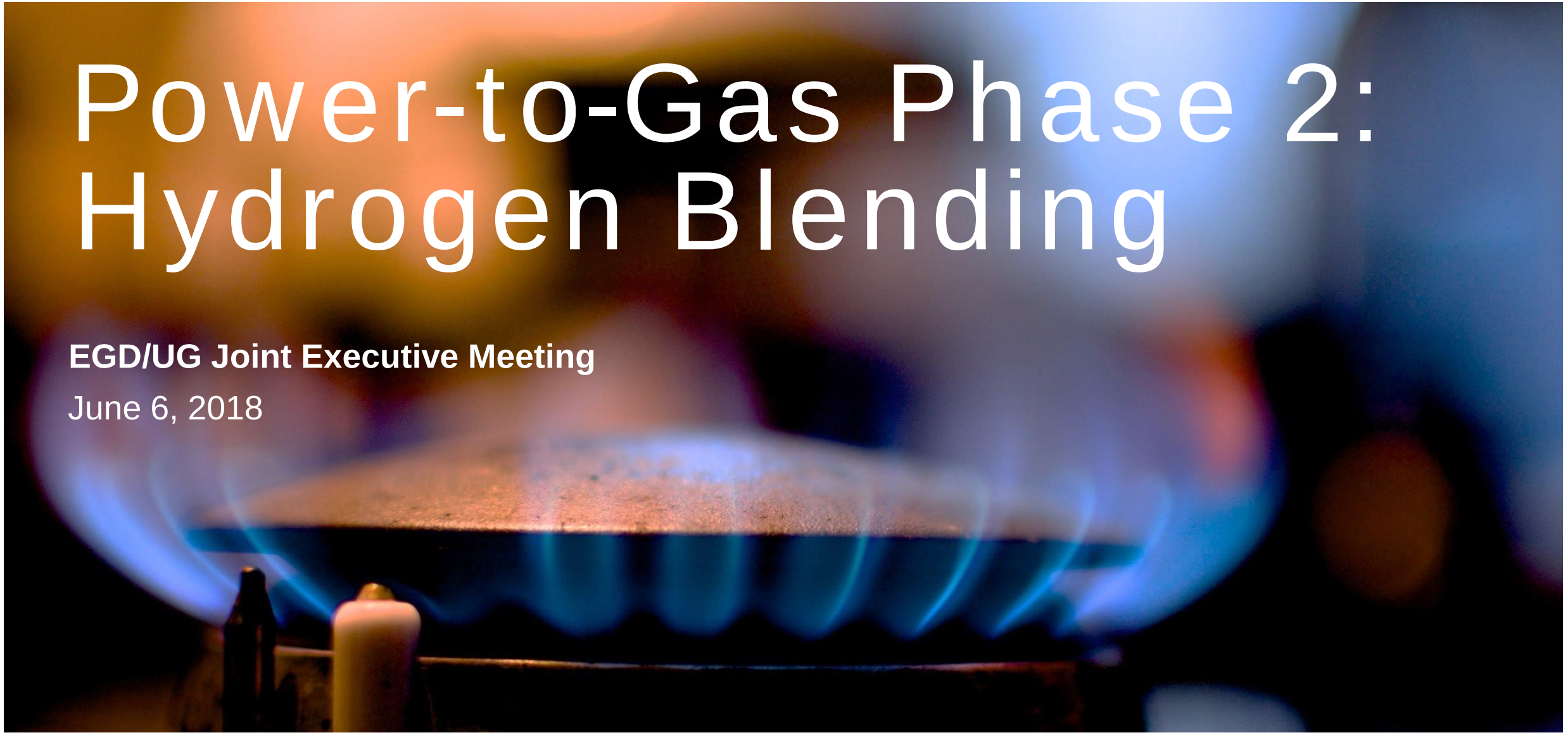
Material- Mains by Length (S1, S1A, S1B)



Material- Services by Number (S1, S1A, S1B)



Power-to-Gas Phase 2: Hydrogen Blending



EGD/UG Joint Executive Meeting

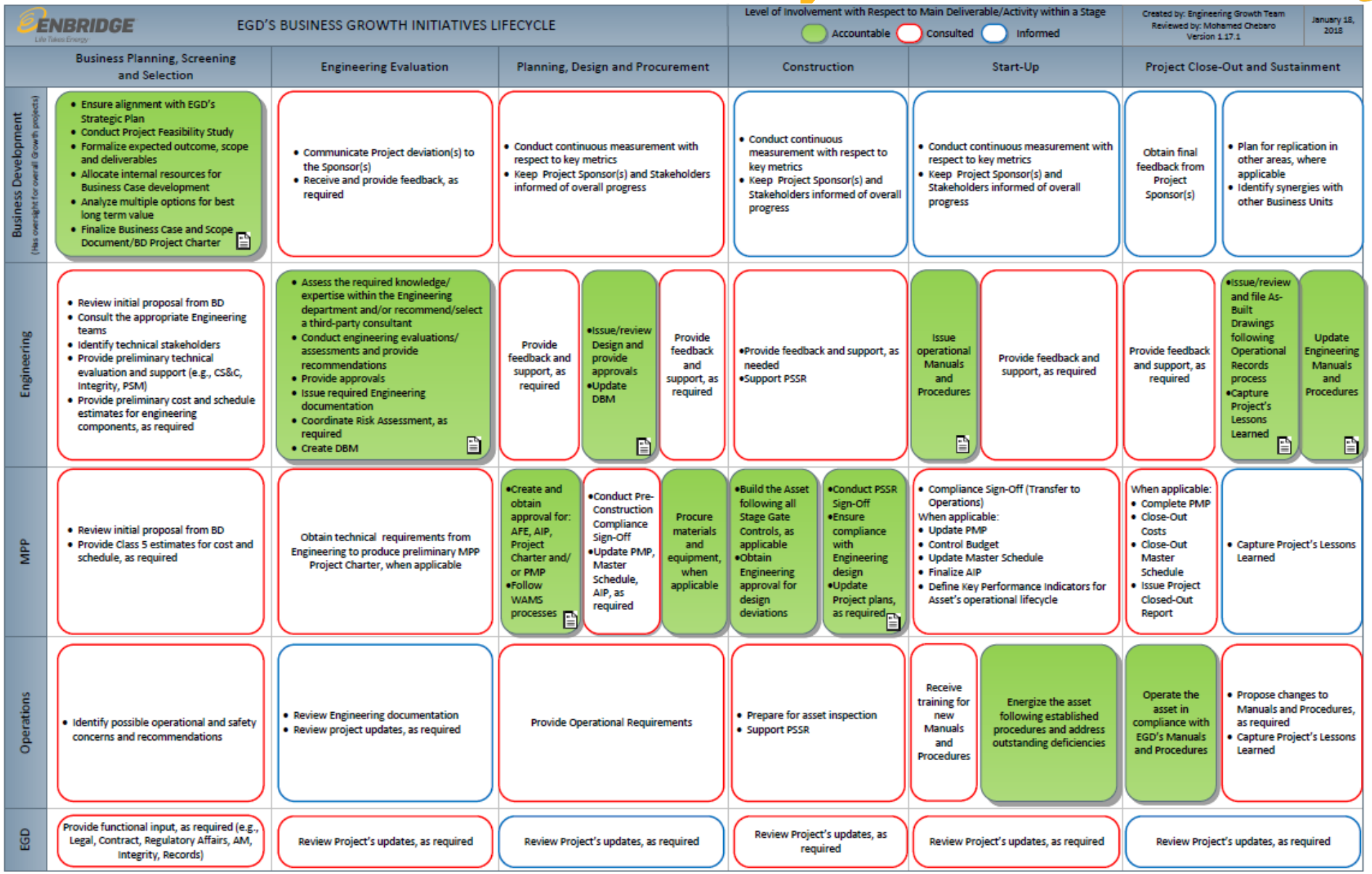
June 6, 2018

ENBRIDGE

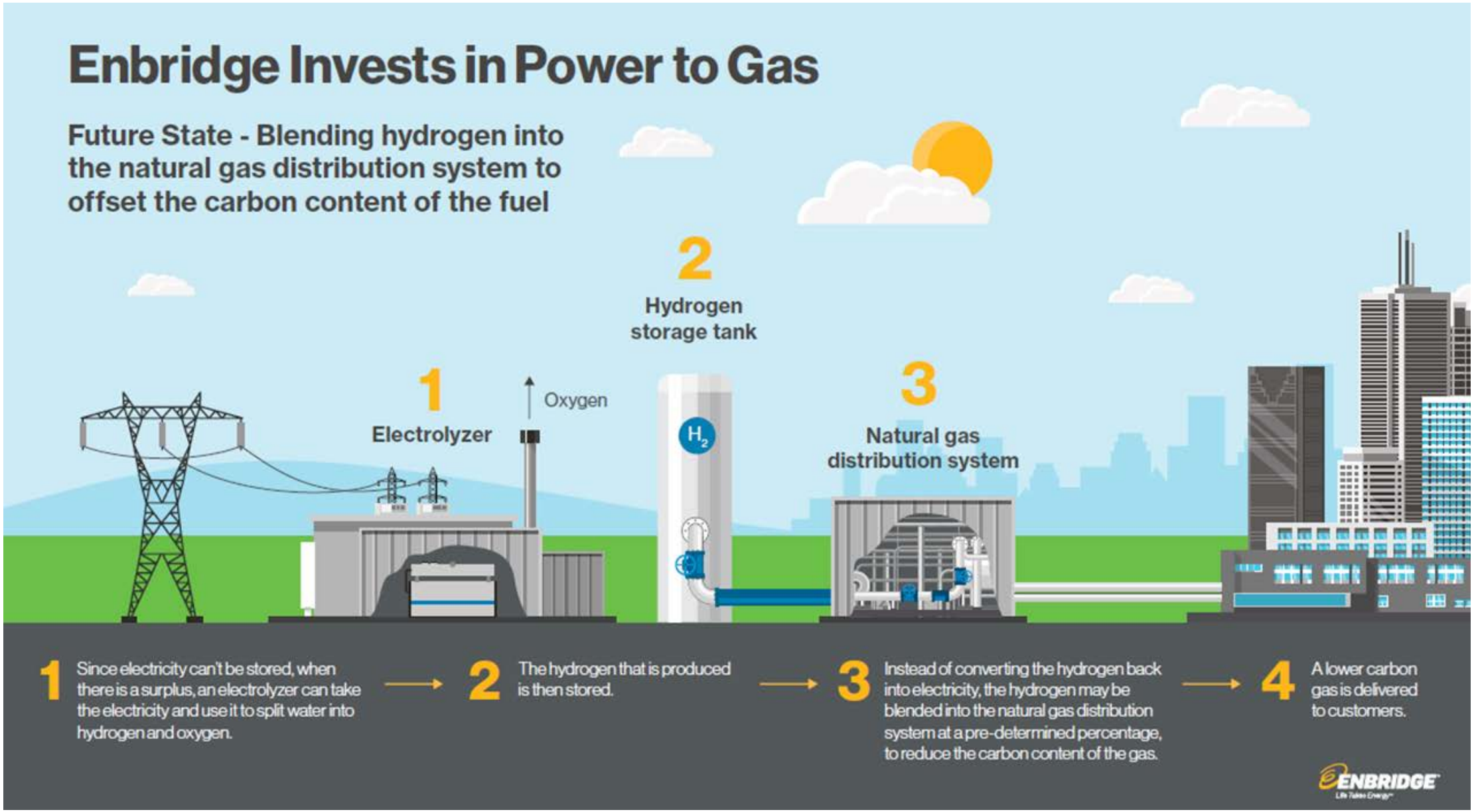
Mohamed Chebaro
Manager, Engineering Customer Safety, Compliance and Growth

Mike Wagle
Chief Engineer

Business Growth Initiatives Lifecycle



Power-to-Gas Technology Overview



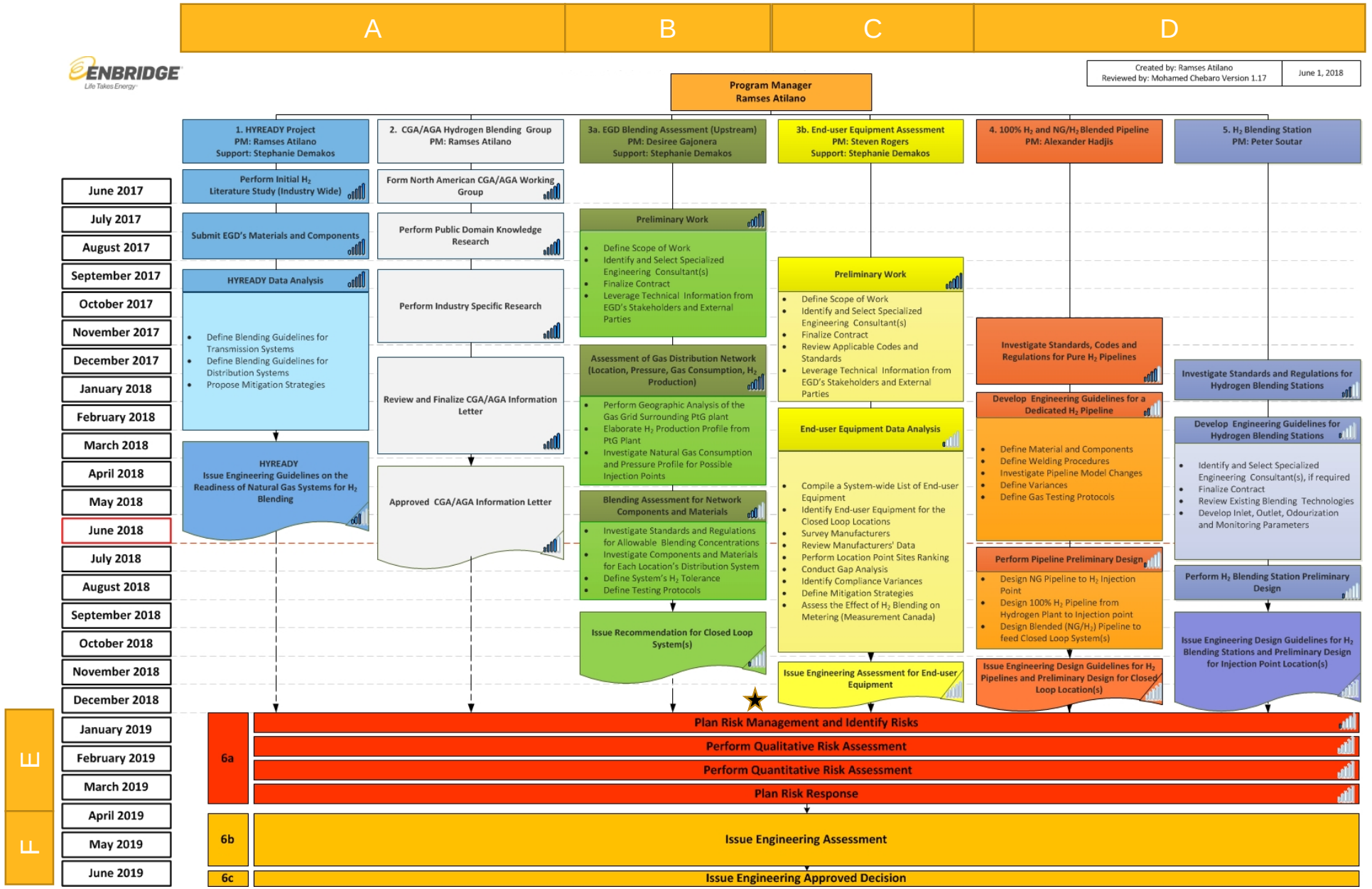
Existing Hydrogen Blending Projects

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



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

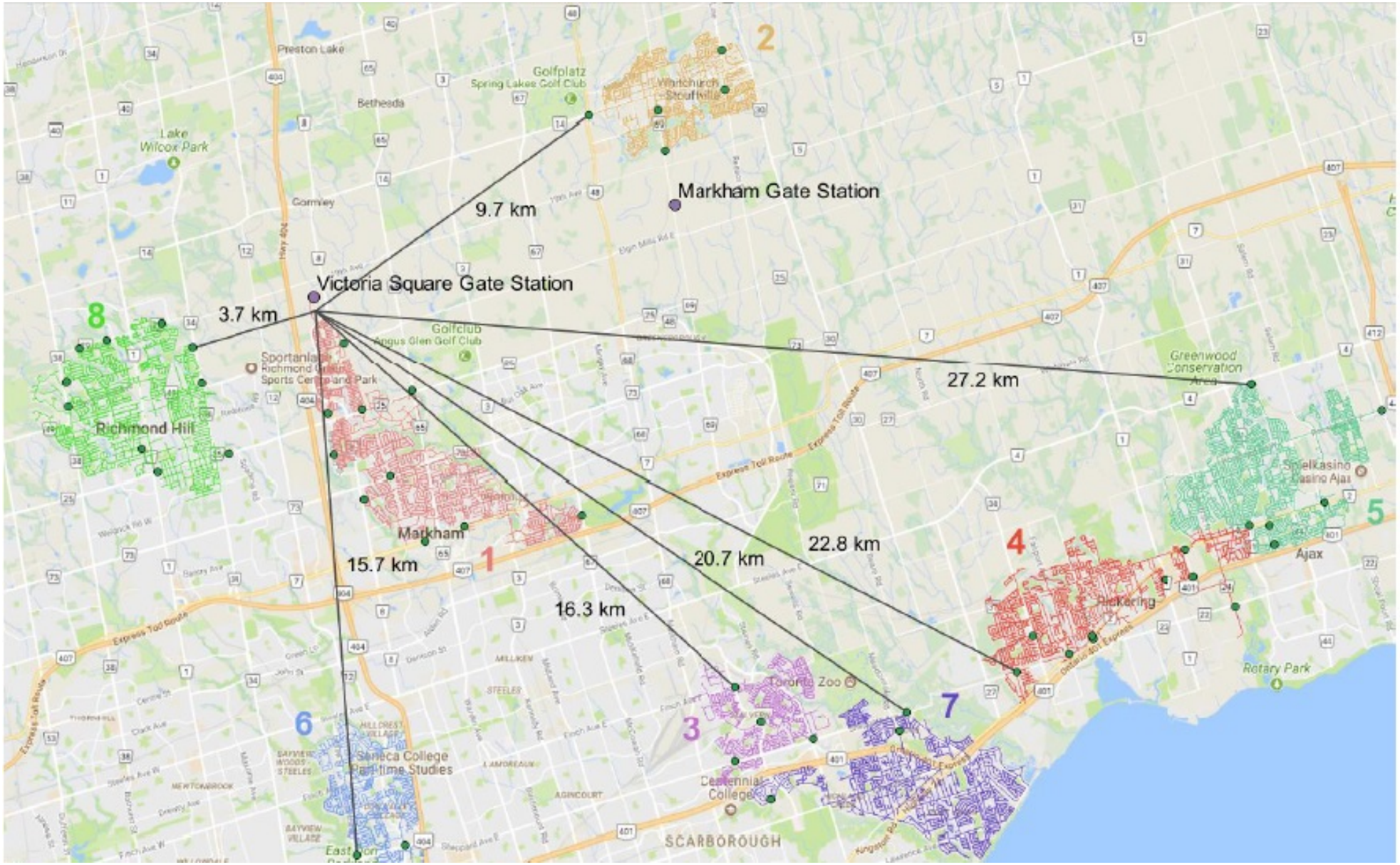
E. Risk Assessment

- Qualitative and quantitative risk assessments for upstream and downstream components
- Uncertainty analysis based on research, testing and consultant recommendations

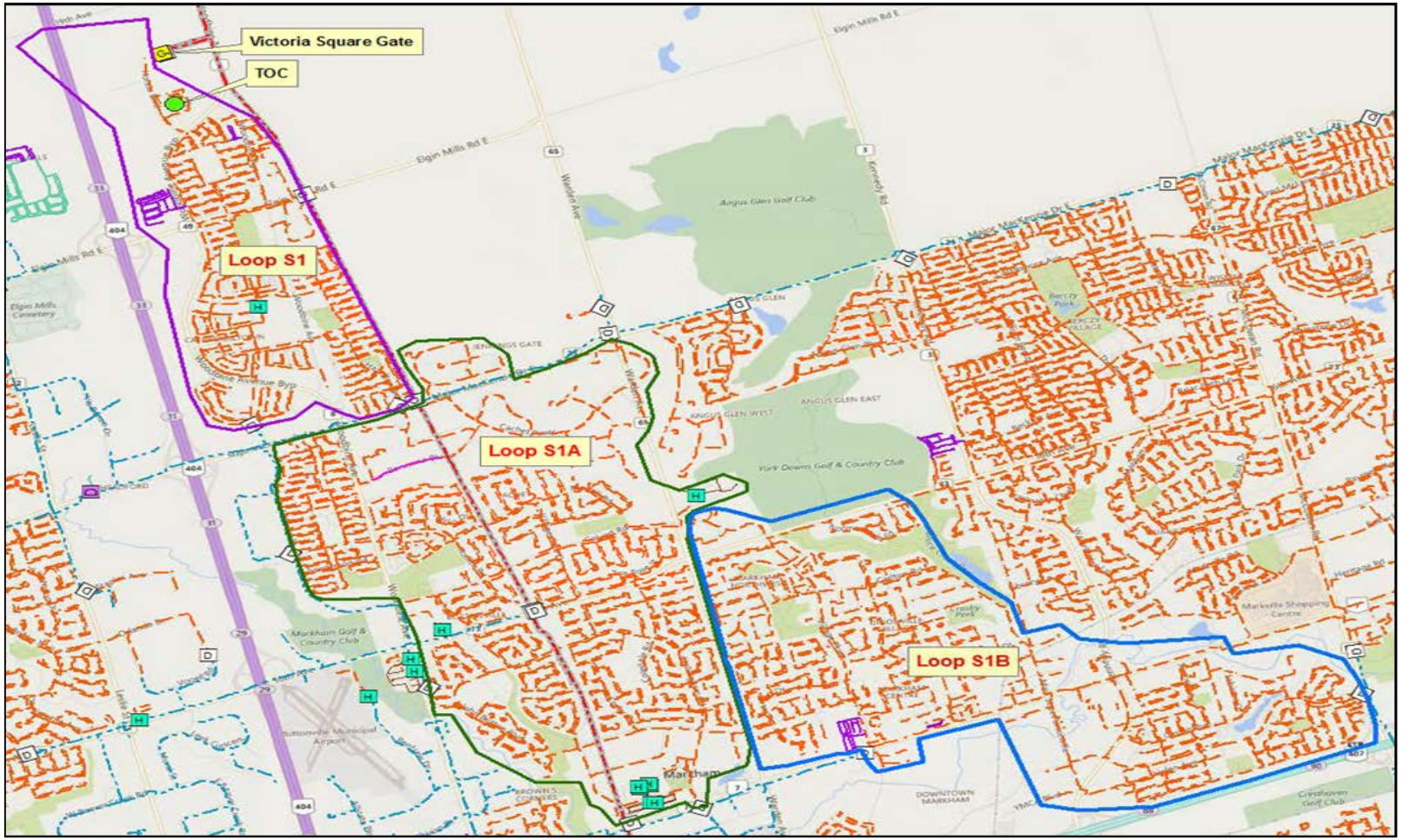
F. Engineering Assessment

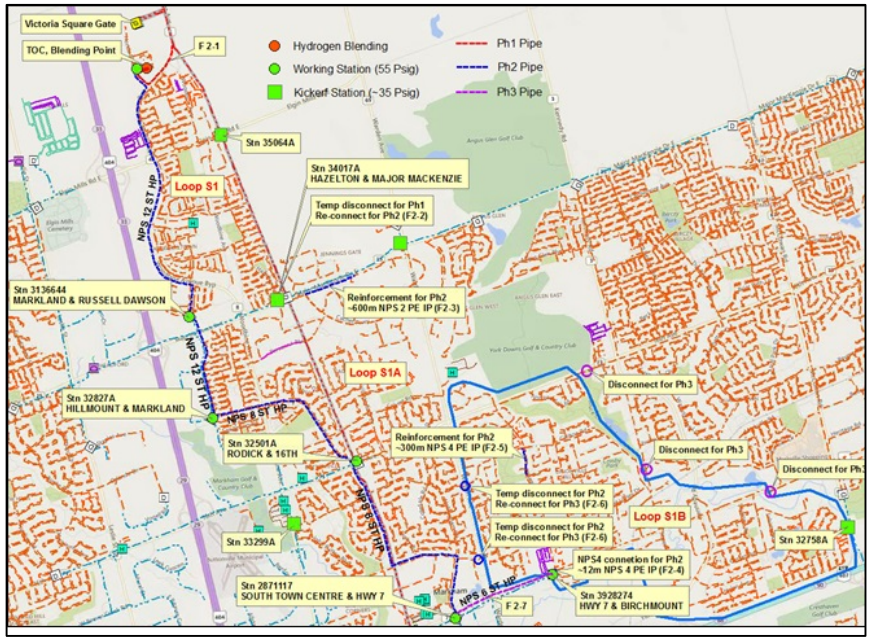
- Final Engineering recommendation and position based on all the above

Overview of Initial Closed Loop Candidates



Probable Closed Loop Candidates





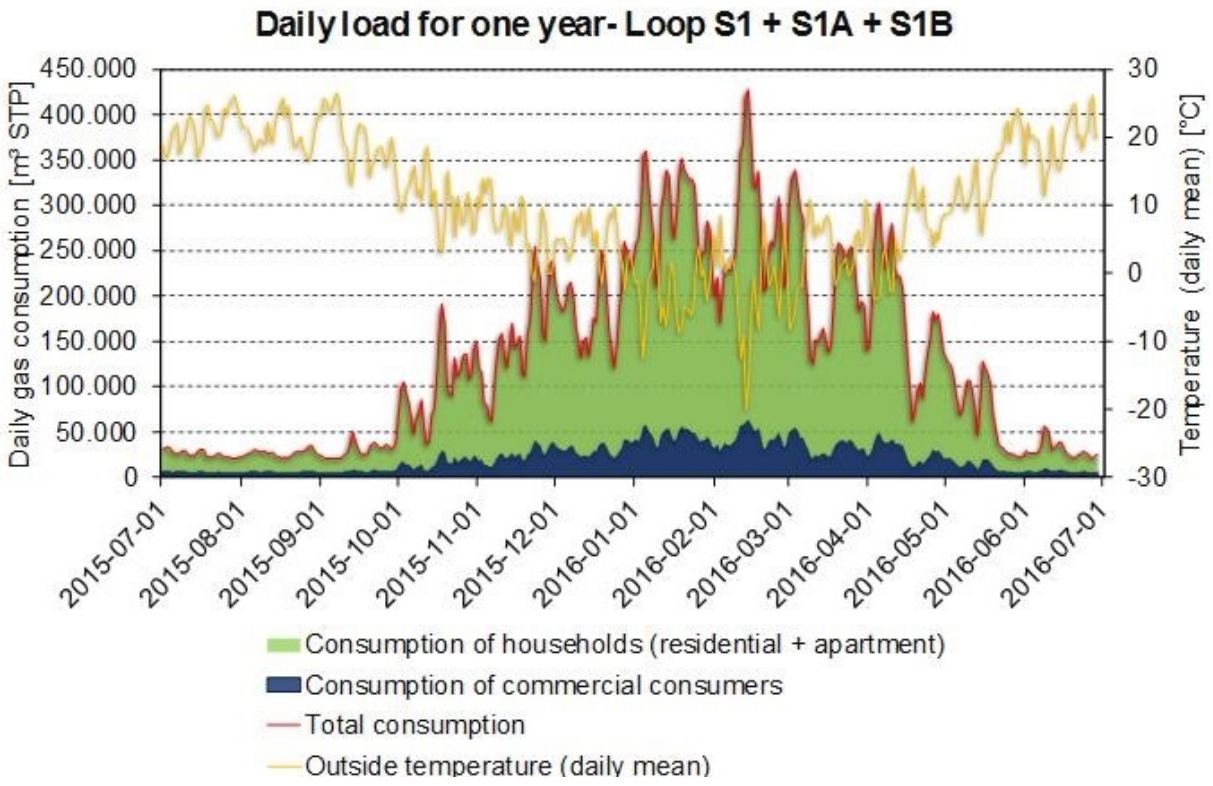
Phase 1
- Loop S1
- ~4,000 customers
- 0-10% Plant Capacity*

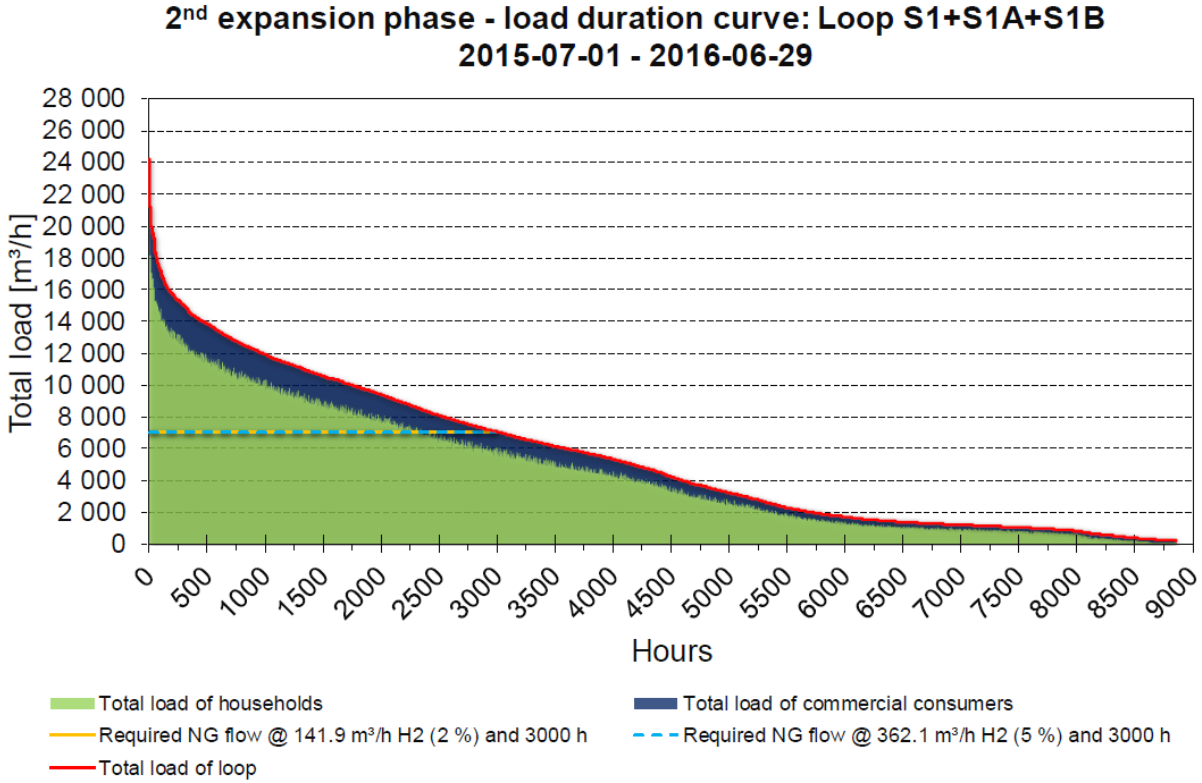
Phase 2
- Loop S1A
- ~7,000 customers
- 10-20% of Plant Capacity*

Phase 3
- Loop S1B
- ~6,000 customers
- 20-30% of Plant Capacity*

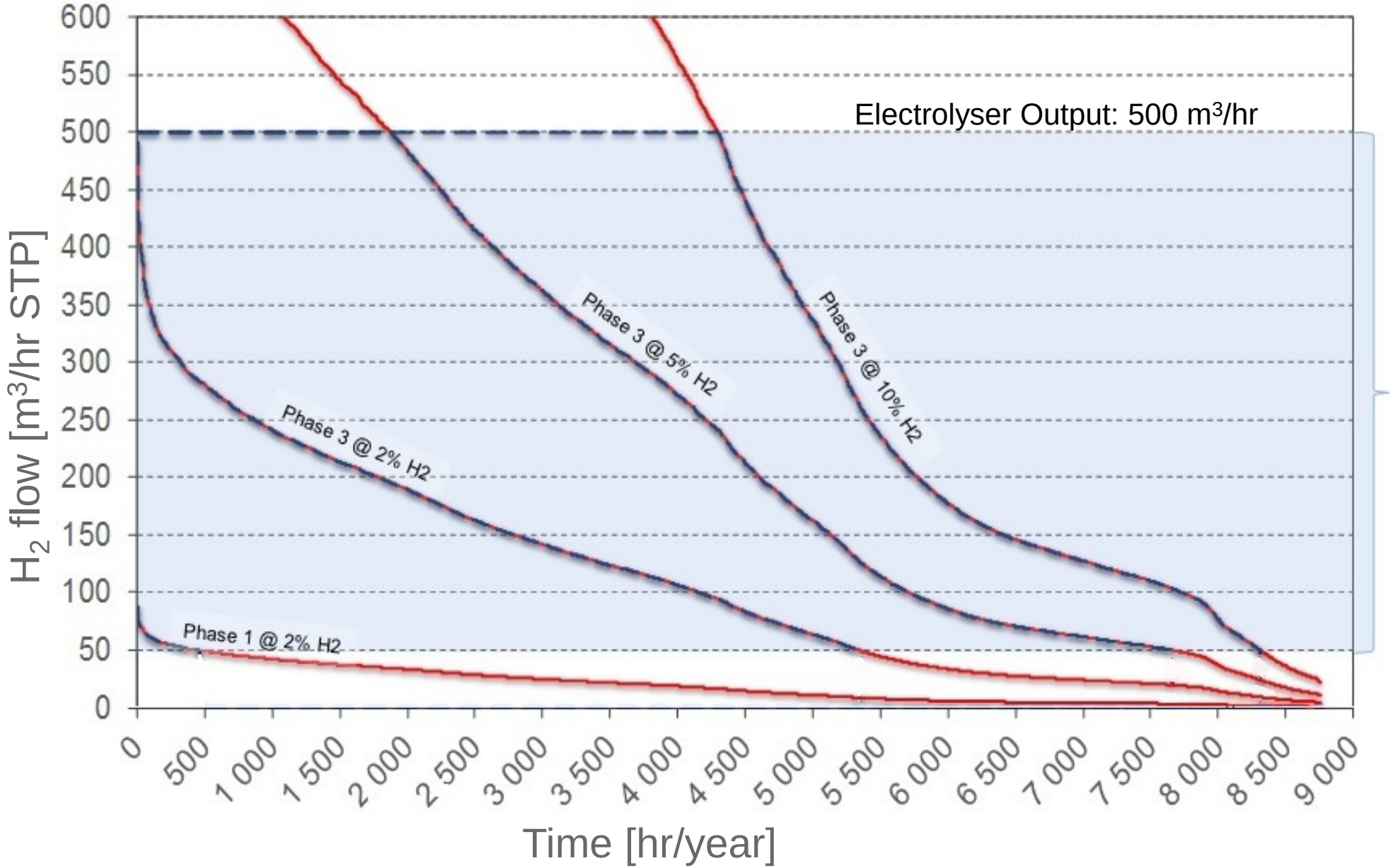
*based on current plant capacity and 3,000 hours of operation per year

Hydrogen Utilization for Closed Loops





Hydrogen Utilization for Closed Loops



Back-up Material

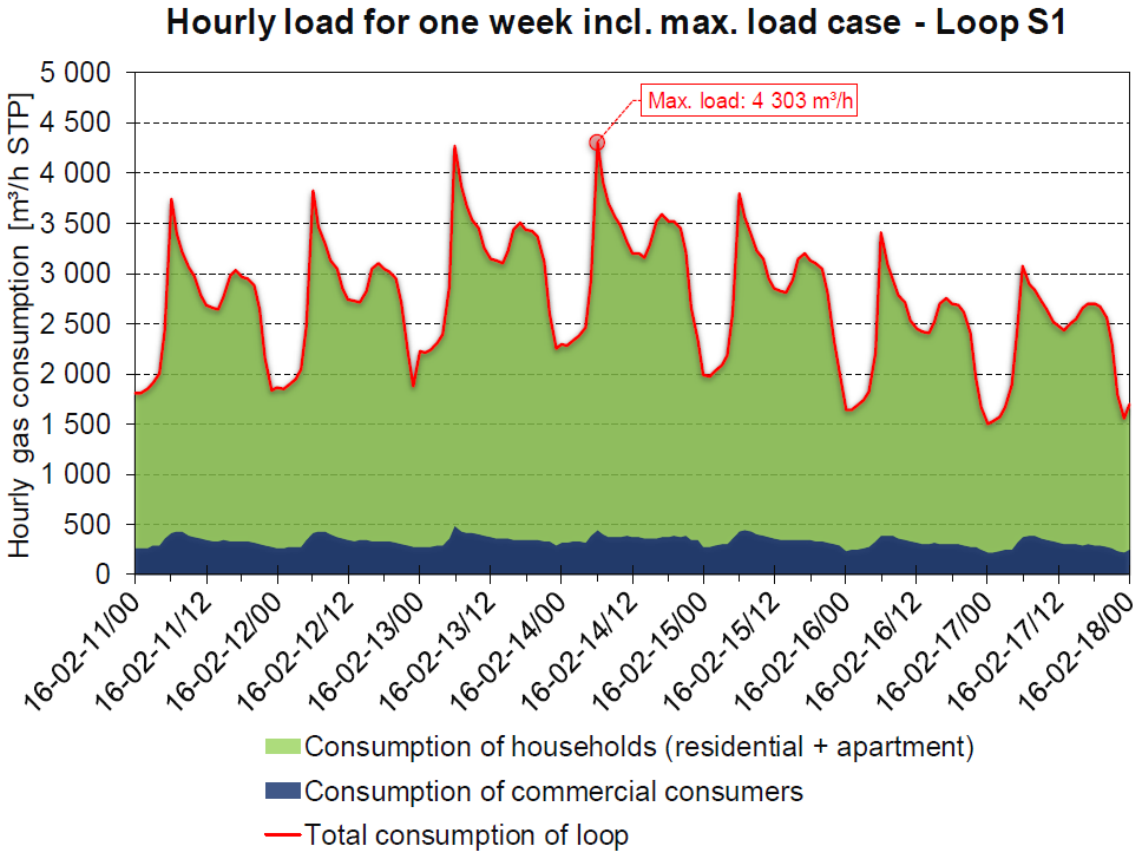
Hydrogen Extraction Technology

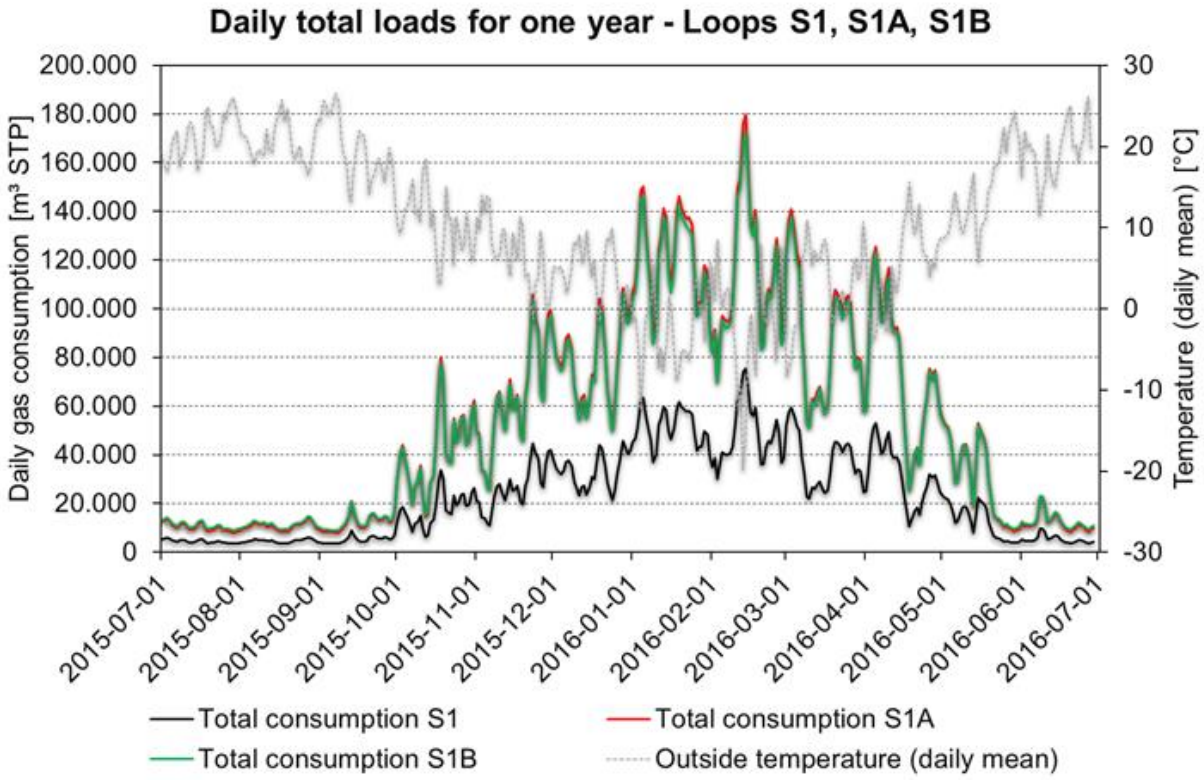
Three Options

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.

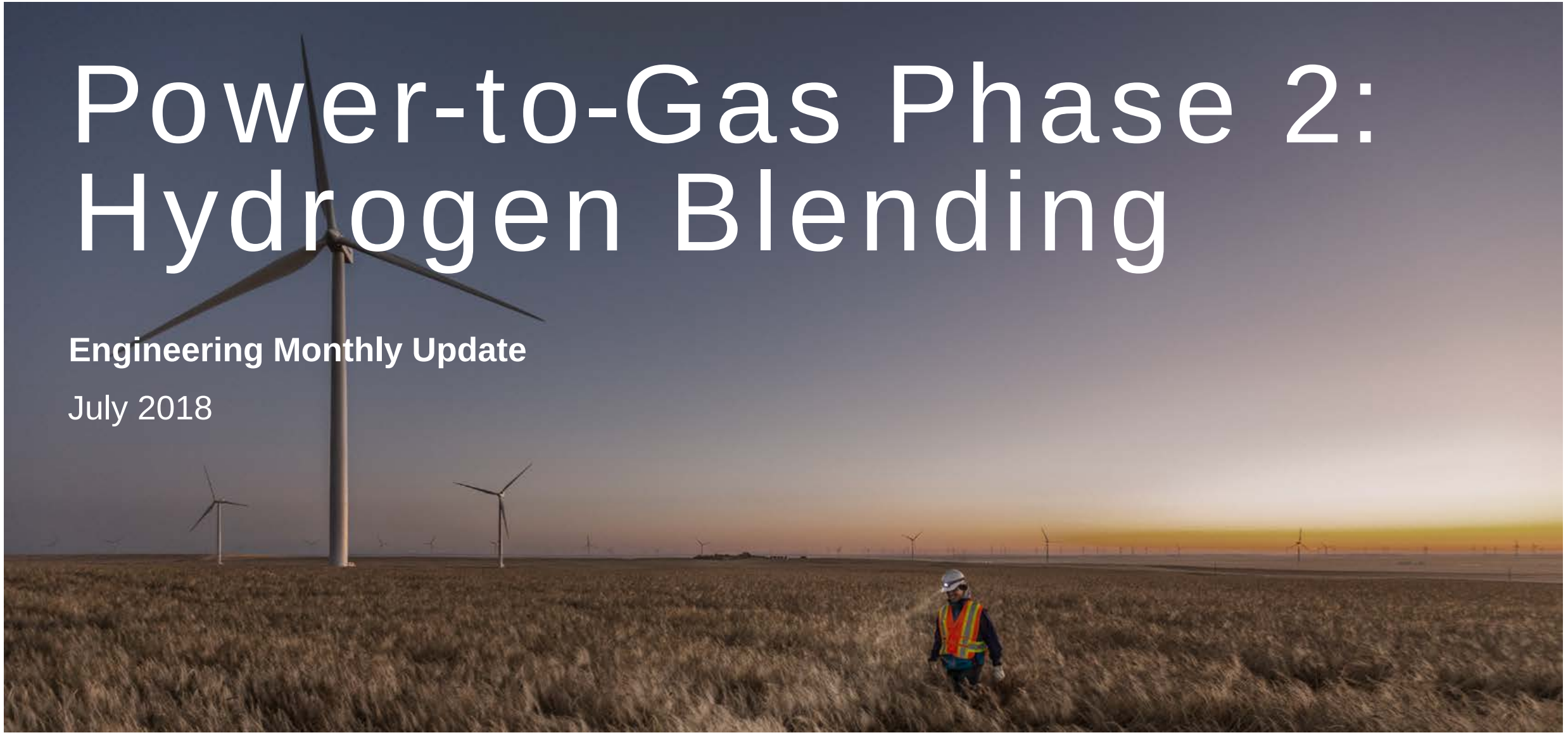
Hydrogen Utilization

Data Derivation





Power-to-Gas Phase 2: Hydrogen Blending



Engineering Monthly Update

July 2018

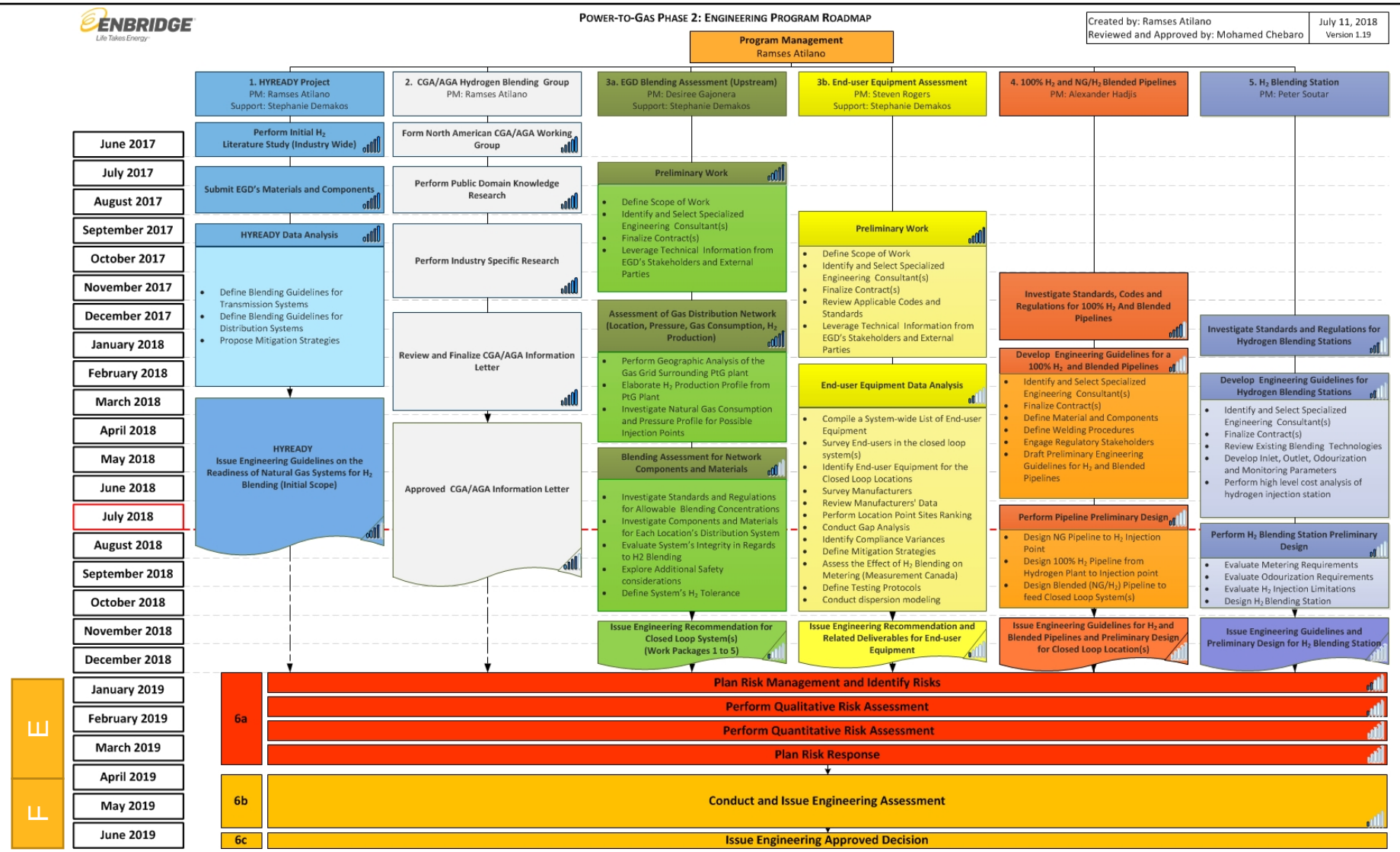
ENBRIDGE

Mohamed Chebaro and Ramses Atilano
Engineering

Power-to-Gas Phase 2

Roadmap

A	B	C	D



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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	STATUS:		
Program Streams	**Scope**	**Budget**	**Timeline**
A. Research and Development:			
CGA/AGA Task Force Information Letter *(in final stages)*			
HYREADY Engineering Guideline Report *(in final stages)*			
B. Integrity, Engineering and Capacity Assessment			
Closed Loop(s) Identification and Prioritization *(completed)*			
Network Capacity Analysis for Closed Loop Candidates *(completed)*			
Material and Component Data Gathering Analysis *(completed)*			
Integrity Assessments for Closed Loop Candidates *(in progress)*			
H_2 Consumption Assessment *(second iteration in progress)*			
Closed Loops Refinement and Design *(second iteration in progress)*			

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**
C. End User Equipment Engineering and Integrity System			
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)*			
D. Engineering Design and Review			
Pipeline Design- Hydrogen pipeline *(in progress)*			
Pipeline Design- Natural gas and blended pipelines *(in progress)*			
Blending Stations Design- Injection station *(in progress)*			
E. Risk Assessment			
Risk Assessment Report *(in progress)*			
Computational Modeling *(in progress)*			
F. Engineering Assessment *(initiated)*			

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

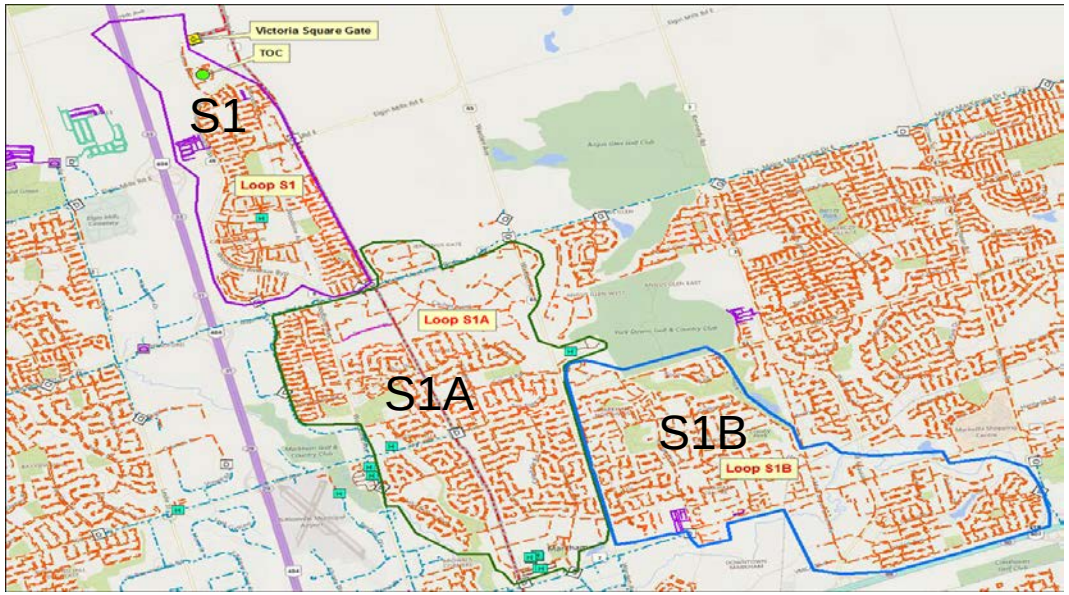
Past Month's Achievements

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

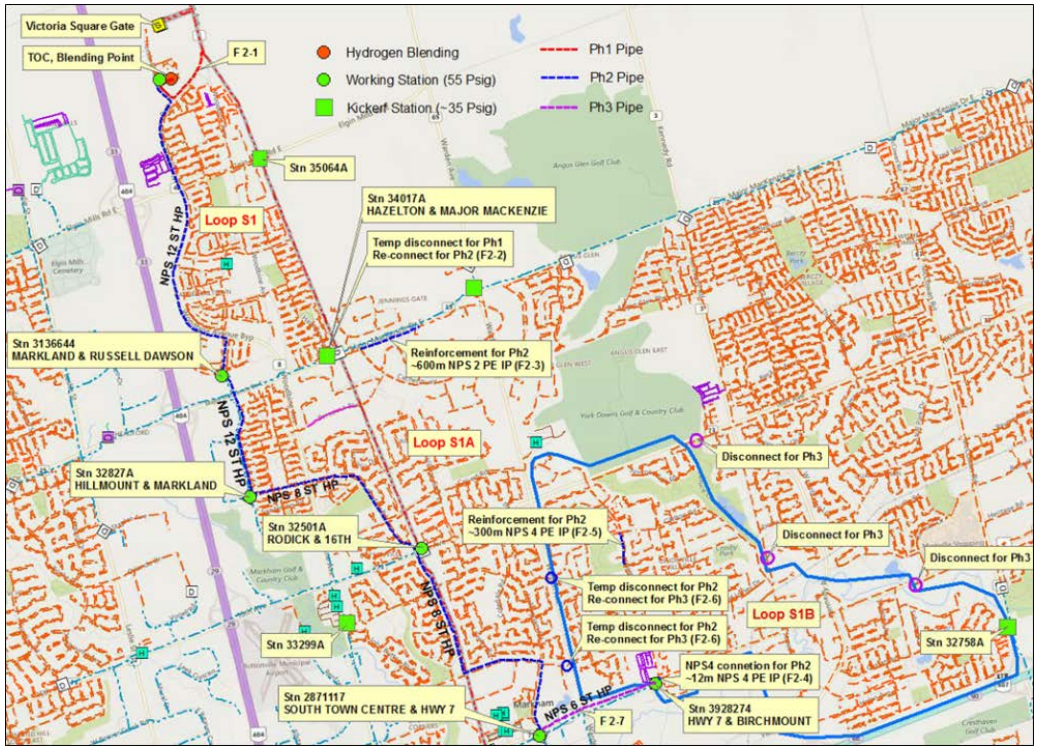
- ✓ Initiated second iteration (design optimization) of preliminary design for pipelines carrying three different products (100% H_2, 100% NG and Blended Gas) to reduce initial construction costs
- ✓ Continued working on preliminary design for the station components (e.g., Pressure Regulation, H_2 Injection)
- ✓ Initiated RFP for specialized consultant to develop Engineering Guidelines for 100% H_2 and blended gas pipelines

E. Risk Assessment

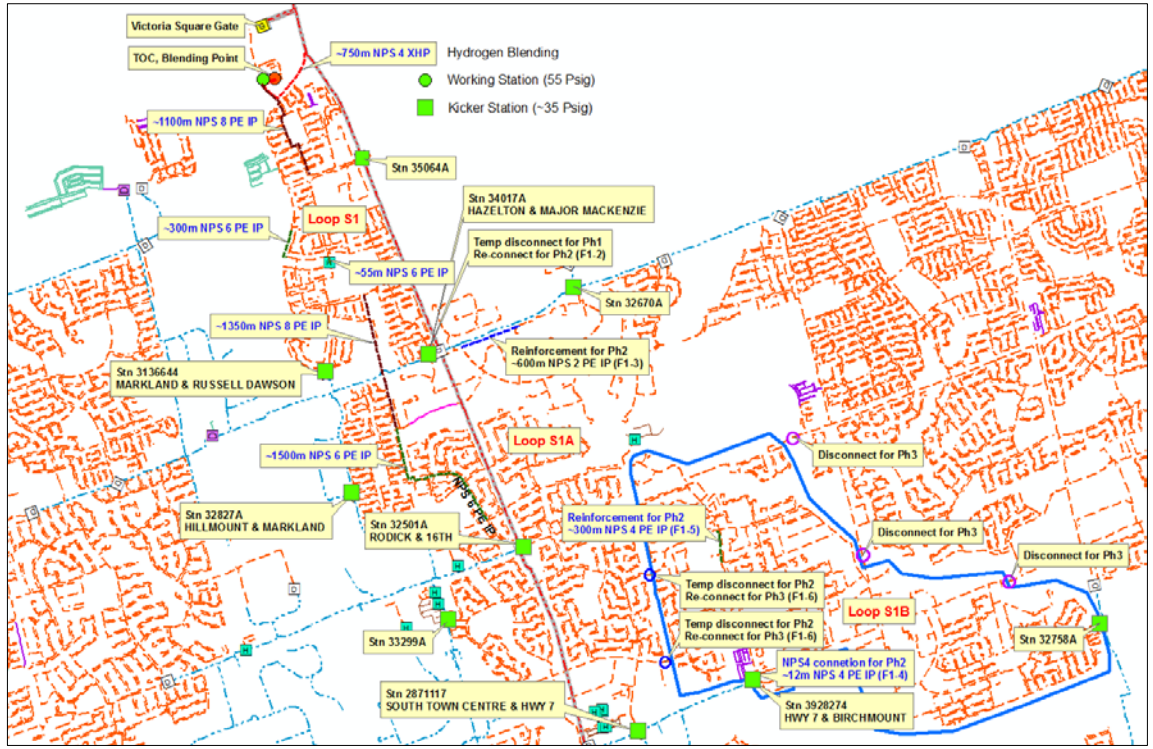
- ✓ Initiated computational work at DBI-GUT (Germany) and C-FER Technologies (Canada) on indoor and external gas dispersion modeling that will become an input to the Quantitative Risk and Engineering Assessments

Power-to-Gas Phase 2

Evolution of Preliminary Close-Loop Pipeline Design



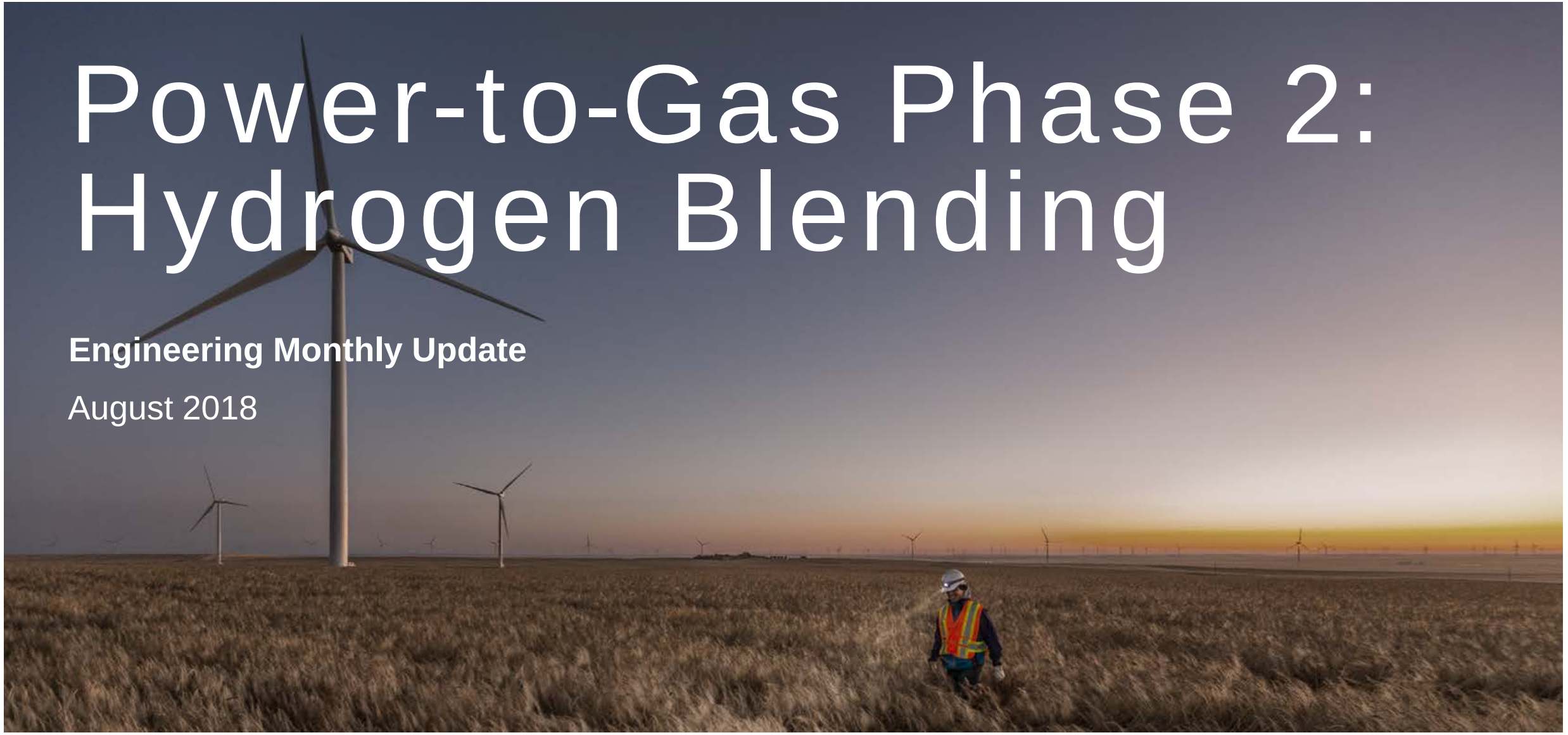
First Preliminary Pipeline Design



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

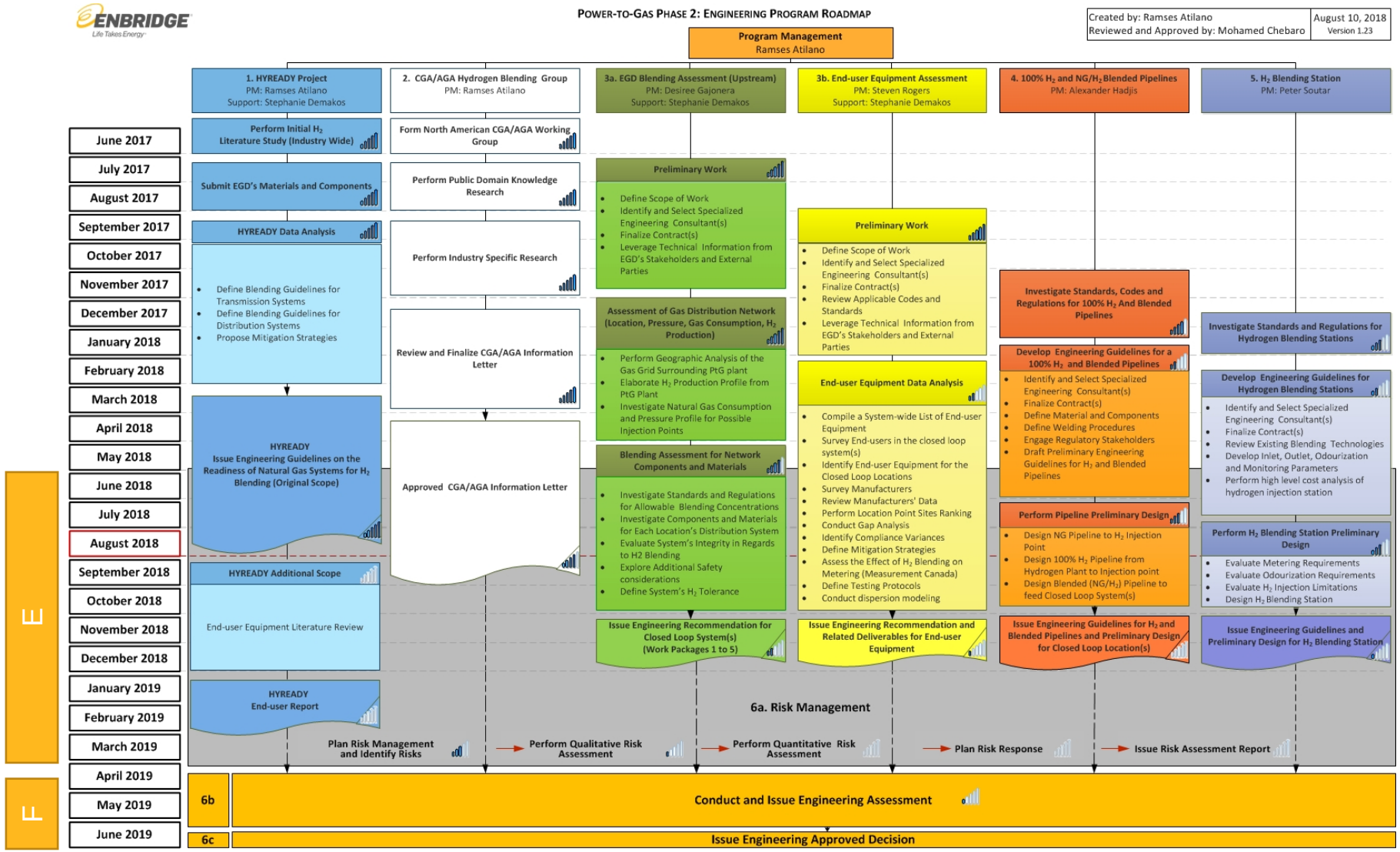
ENBRIDGE

Mohamed Chebaro and Ramses Atilano
Engineering

Power-to-Gas Phase 2

Roadmap

A	B	C	D



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
A. Research and Development:			
CGA/AGA Task Force Information Letter *(in final stages)*			
HYREADY Engineering Guideline Report *(initial scope completed)*			
B. Integrity, Engineering and Capacity Assessment			
Closed Loop(s) Identification and Prioritization *(completed)*			
Network Capacity Analysis for Closed Loop Candidates *(completed)*			
Material and Component Data Gathering Analysis *(completed)*			
Integrity Assessments for Closed Loop Candidates *(in progress)*			
H_2 Consumption Assessment *(third iteration in progress)*			
Closed Loops Refinement and Design *(third iteration 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

Status Review

On track
Lagging but not on critical path
Lagging and on critical path

ENBRIDGE
Life Takes Energy™

Program Streams	Scope	Budget*	Timeline
C. End User Equipment Engineering and Integrity System			
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)*			
D. Engineering Design and Review			
Pipeline Design- Hydrogen pipeline *(in progress)*			
Pipeline Design- Natural gas and blended pipelines *(in progress)*			
Blending Stations Design- Injection station *(in progress)*			
E. Risk Assessment			
Risk Assessment Report *(in progress)*			
Computational Modeling *(in progress)*			
F. Engineering Assessment *(initiated)*			

* 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

ENBRIDGE
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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

ENBRIDGE
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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

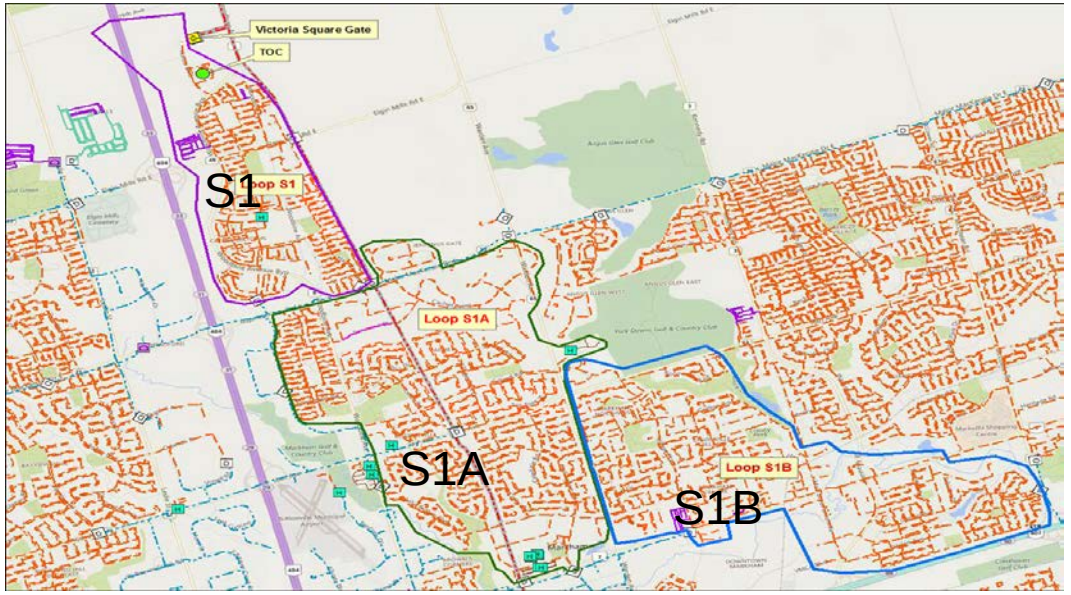
Past Month's Achievements

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

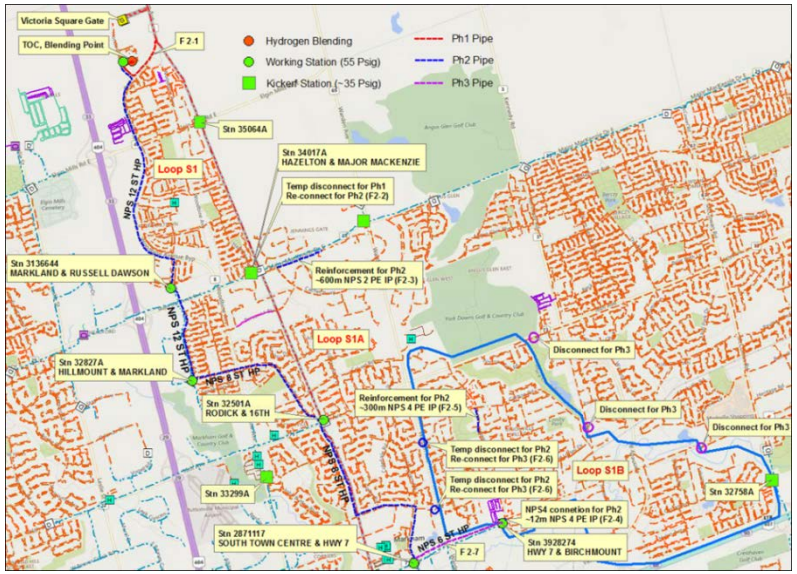
- ✓ Initiated third iteration (design optimization) of preliminary design for pipelines carrying three different products (100% H_2, 100% NG and Blended Gas) to reduce initial construction costs
- ✓ Continued working on preliminary design for the station components (e.g., Pressure Regulation, H_2 Injection)
- ✓ Initiated RFP for specialized consultant to develop Engineering Guidelines for 100% H_2 and blended pipelines

E. Risk Assessment

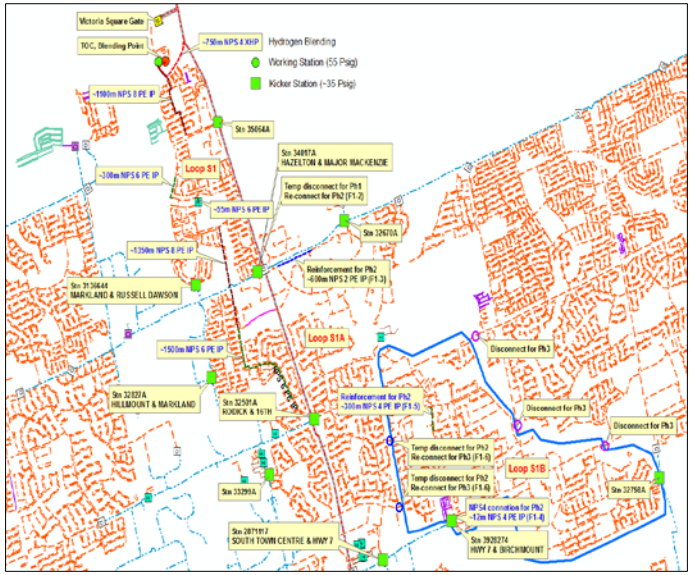
- ✓ Reviewed first iteration of computational work by DBI-GUT (Germany) and C-FER Technologies (Canada) on indoor and external gas dispersion modeling that will become an input to the Quantitative Risk and Engineering Assessments

Power-to-Gas Phase 2

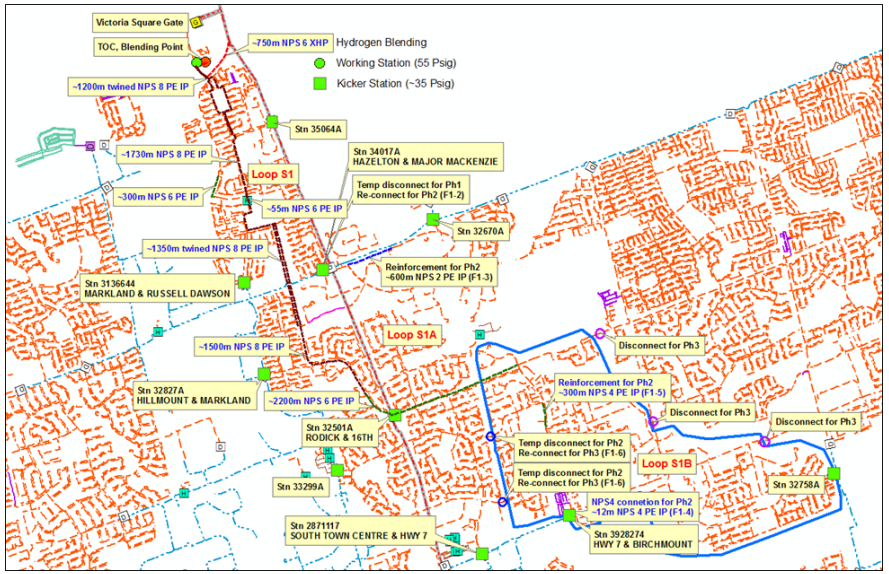
Evolution of Preliminary Closed Loop Pipeline Design



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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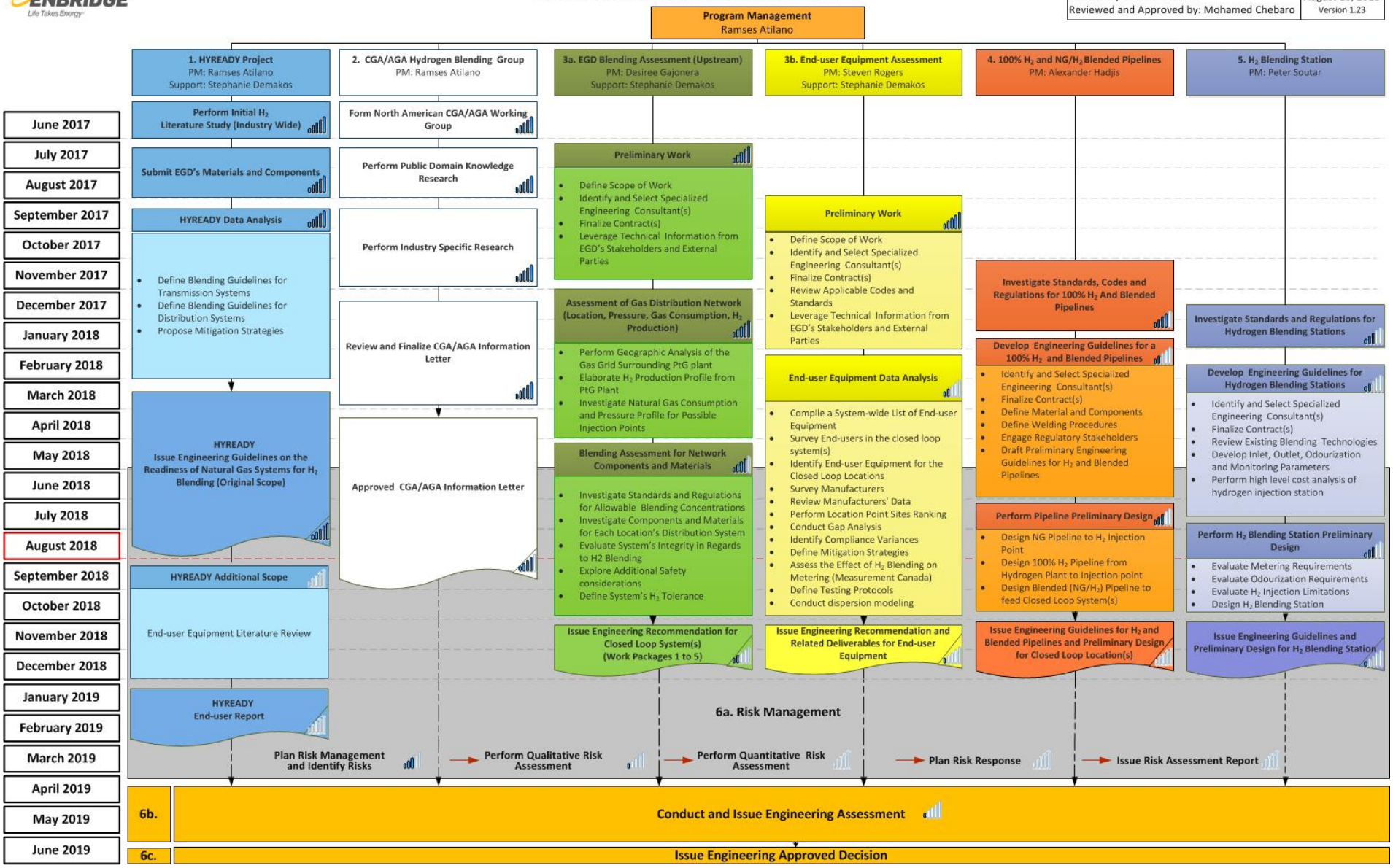
Prepared by: Engineering Growth Team

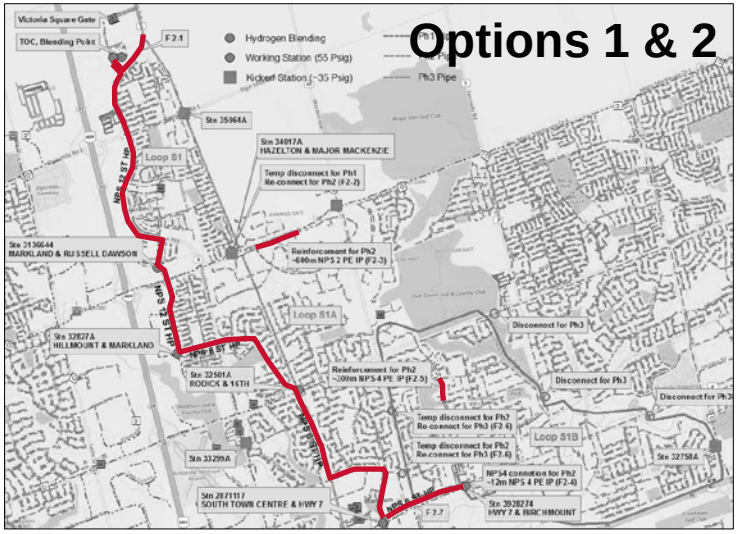
Power-to-Gas Phase 2: Engineering Program Roadmap

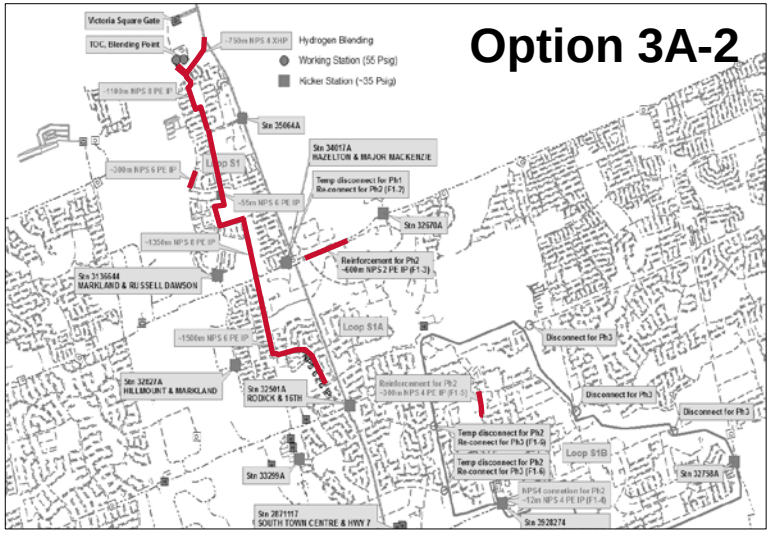
Created by: Ramses Atilano	August 10, 2018
Reviewed and Approved by: Mohamed Chebaro	Version 1.23

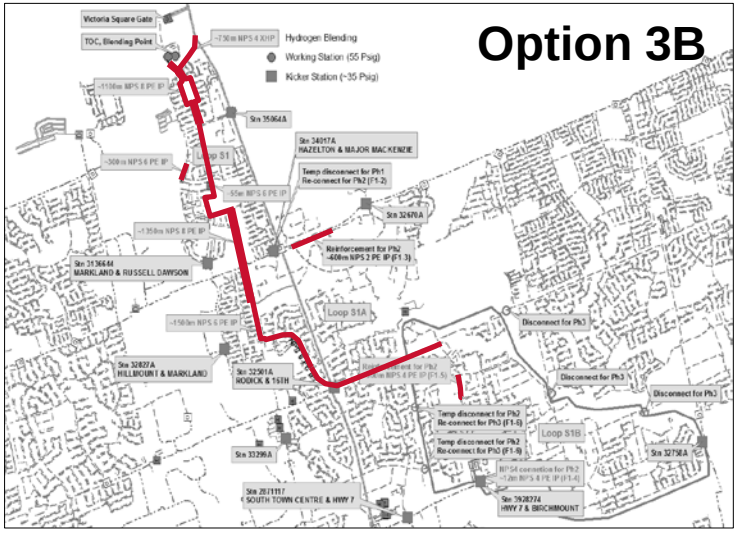


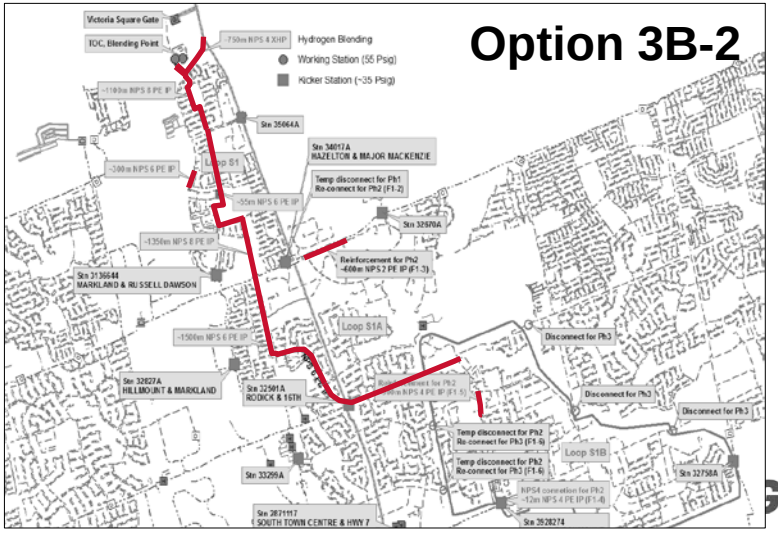
Pilot Construction Phase – Initial Route Options

XHP, HP and IP options included in the cost benefit analysis



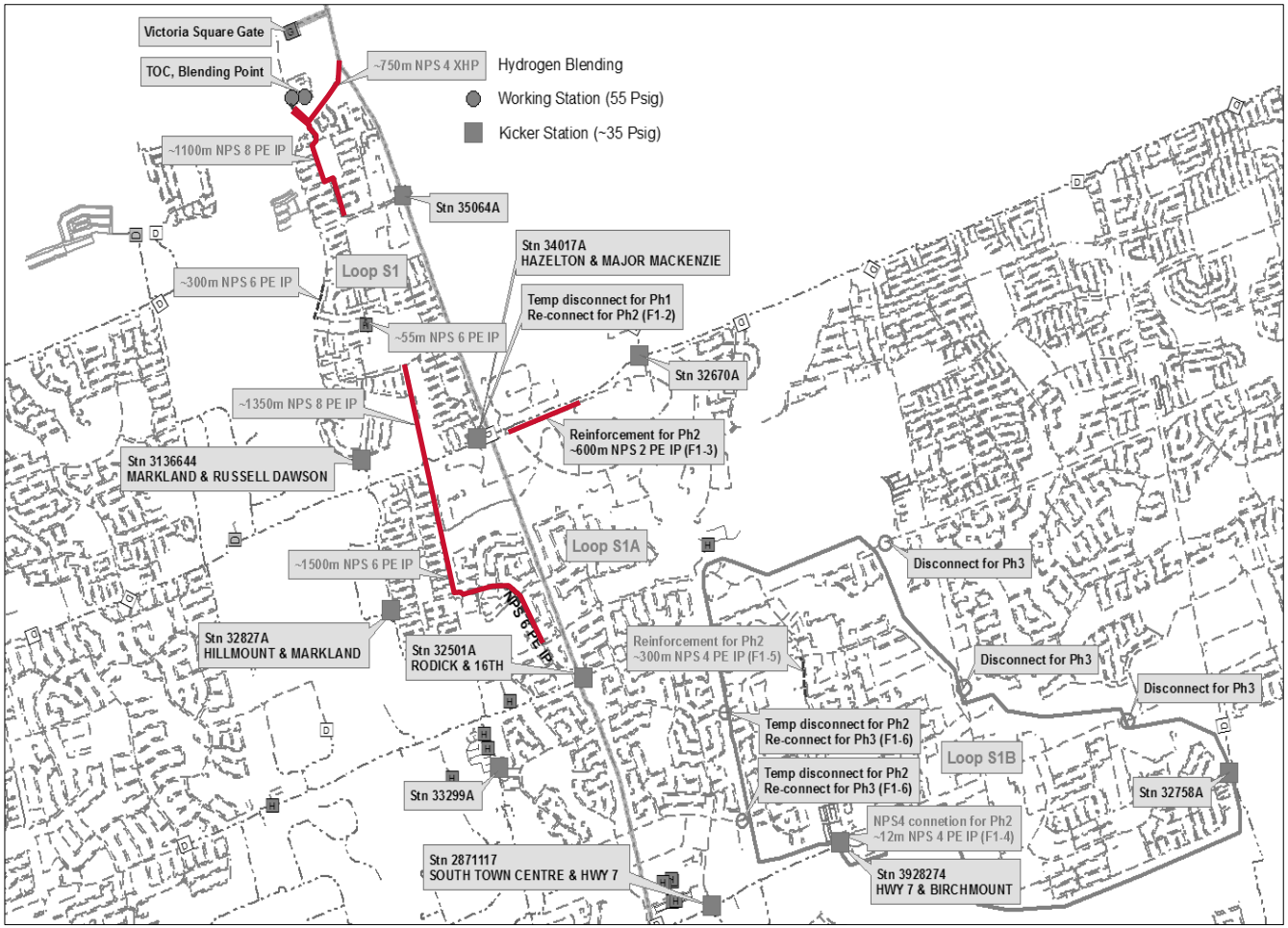






Pilot Construction Phase – Recommended Option: 3A

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

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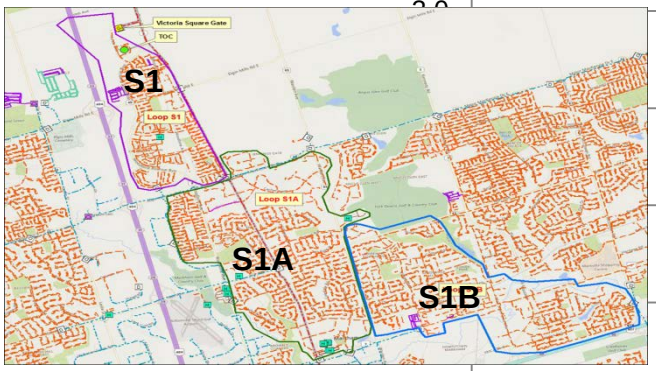
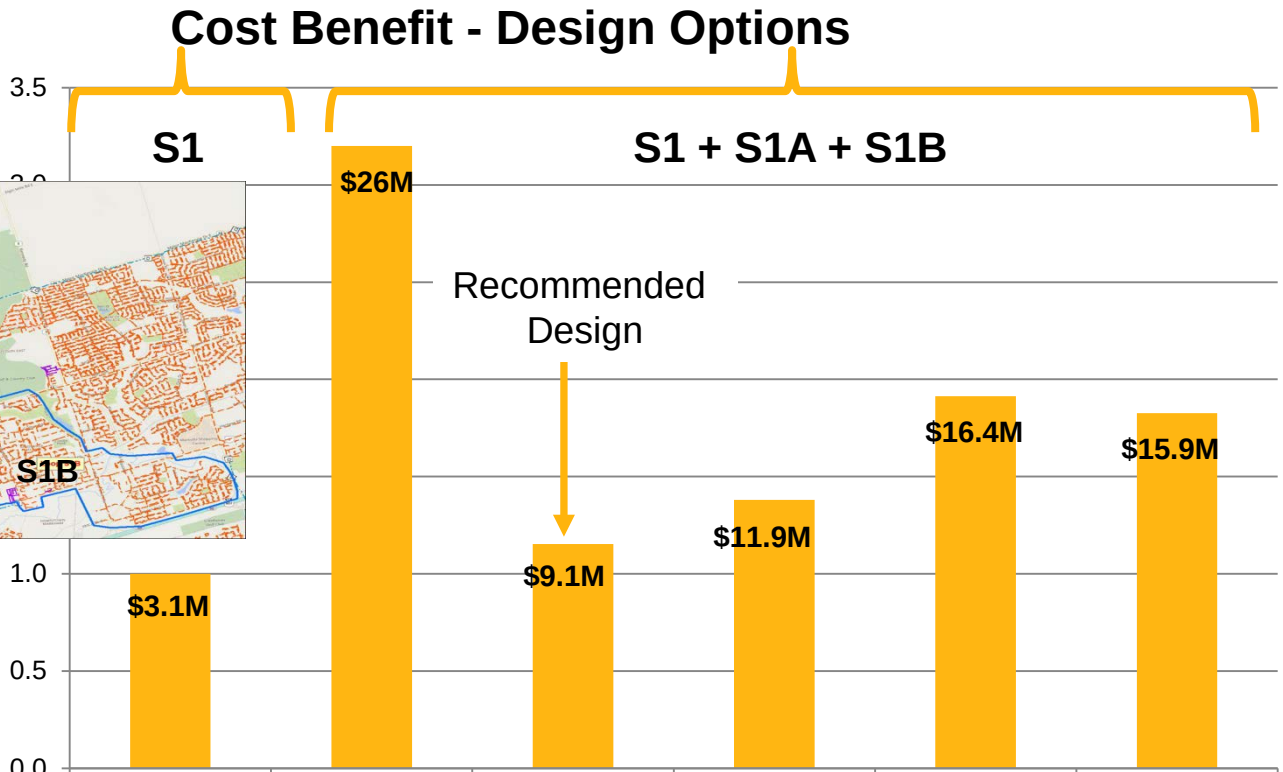
Cost-Benefit Analysis of Design Options – Class 5 Estimates

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

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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	

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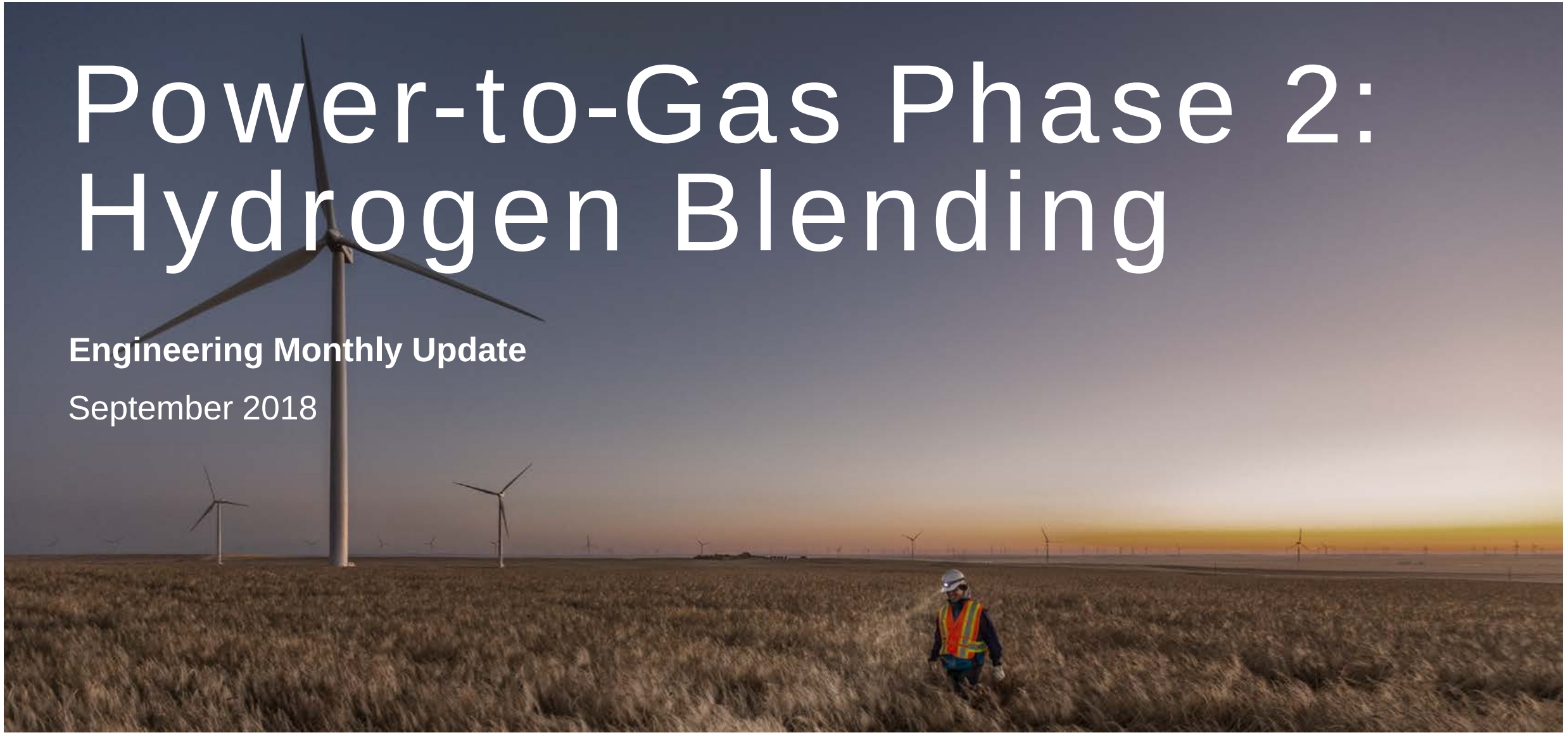
Revised R&D Eng. Budget – August 2018- Class 5 Estimate

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

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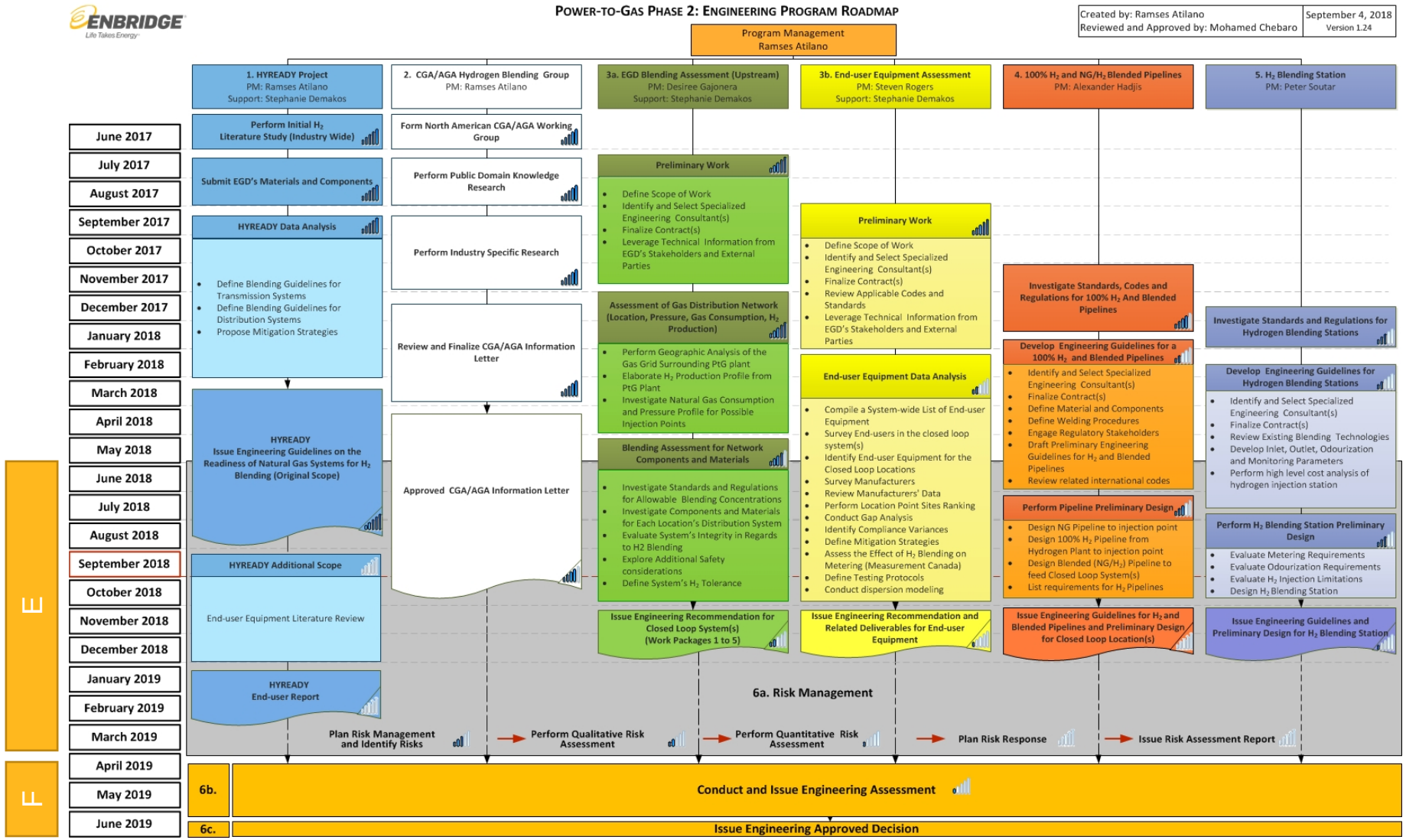
Mohamed Chebaro and Ramses Atilano
Engineering

Power-to-Gas Phase 2

Roadmap

A	B	C	D



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
A. Research and Development:			
CGA/AGA Task Force Information Letter *(in final stages)*			
HYREADY Engineering Guideline Report *(original scope completed)*			
B. Integrity, Engineering and Capacity Assessment			
Closed Loop(s) Identification and Prioritization *(completed)*			
Network Capacity Analysis for Closed Loop Candidates *(completed)*			
Material and Component Data Gathering Analysis *(completed)*			
Integrity Assessments for Closed Loop Candidates *(in progress)*			
H_2 Consumption Assessment *(completed for 3rd design iteration)*			
Closed Loops Design Refinement *(3rd iteration 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

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Program Streams	Scope	Budget*	Timeline
C. End User Equipment Engineering and Integrity System			
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)*			
D. Engineering Design and Review			
Pipeline Design- Hydrogen pipeline *(in progress)*			
Pipeline Design- Natural gas and blended pipelines *(in progress)*			
Blending Stations Design- Injection station *(in progress)*			
E. Risk Assessment			
Risk Assessment Report *(in progress)*			
Computational Modeling *(in progress)*			
F. Engineering Assessment *(initiated)*			

* 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

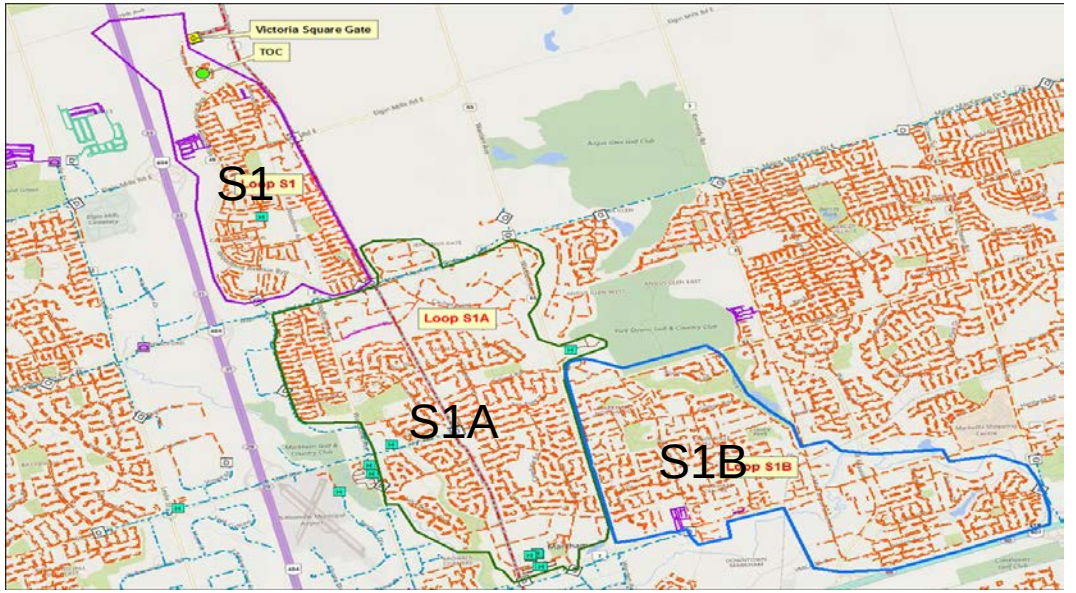
Past Month's Achievements

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

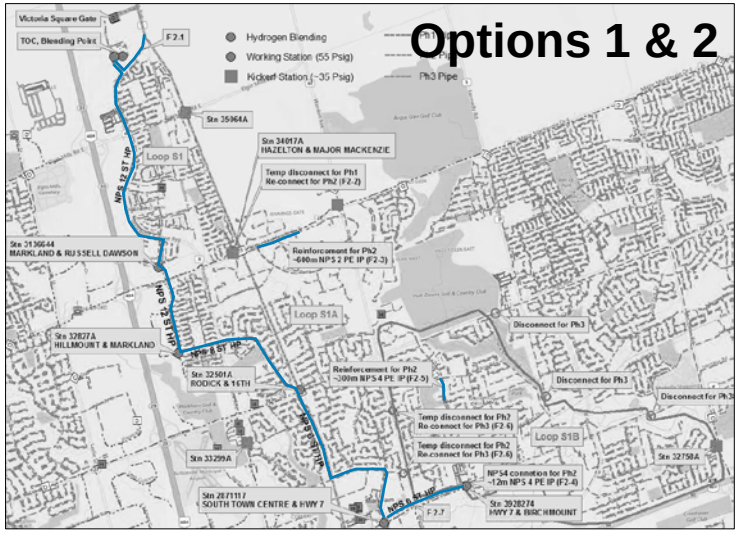
- ✓ Finalized and presented 3rd iteration (design optimization) of preliminary design for pipelines carrying three different products (100% H_2, 100% NG and Blended Gas) to reduce initial construction costs
- ✓ Reduced construction costs from initial design by a factor of 3
- ✓ Continued working on preliminary 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

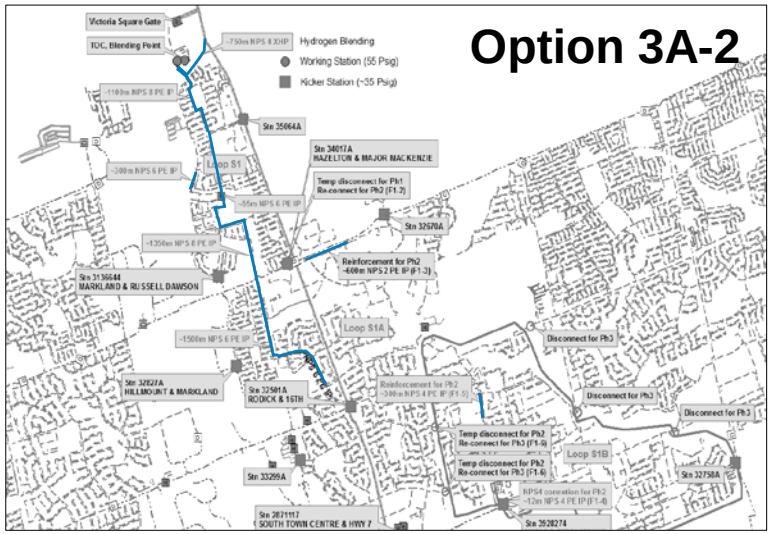
E. Risk Assessment

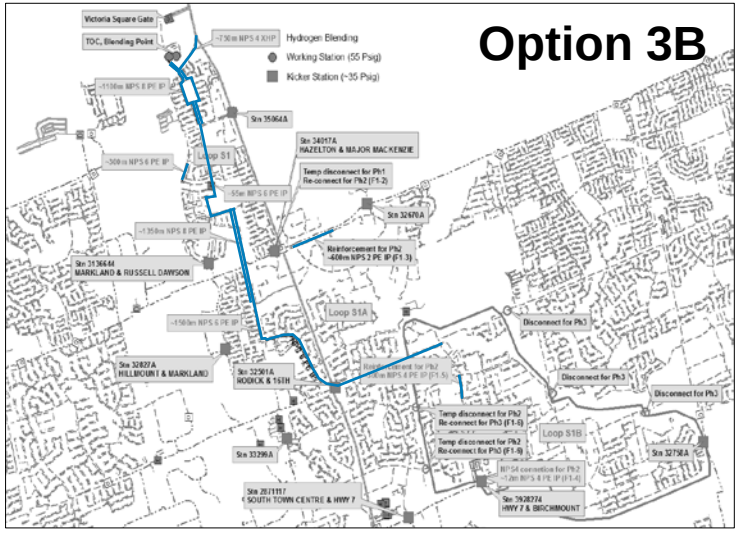
- ✓ Booked HAZID sessions with various SMAs across EGD (Various Ops. and Engineering groups). The outcome of these sessions will feed into the QRA
- ✓ Refined and validated different scenarios for indoor dispersion modeling

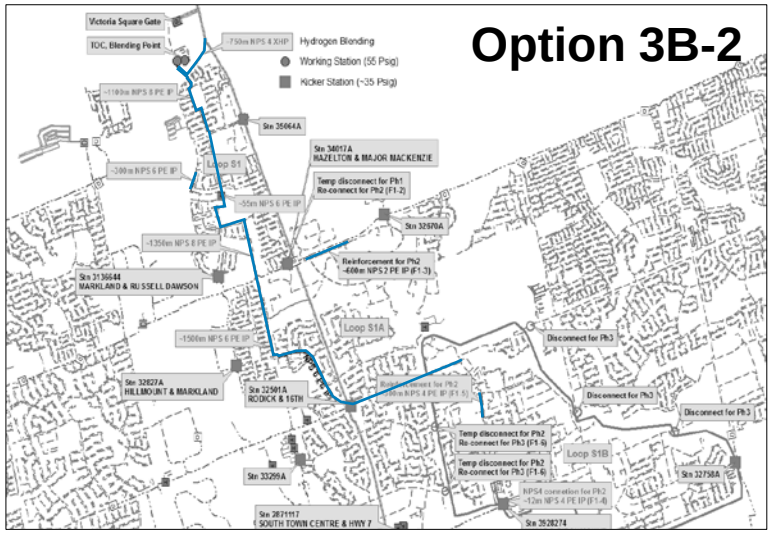
Power-to-Gas Phase 2

Evolution of Closed Loop Pipeline Design

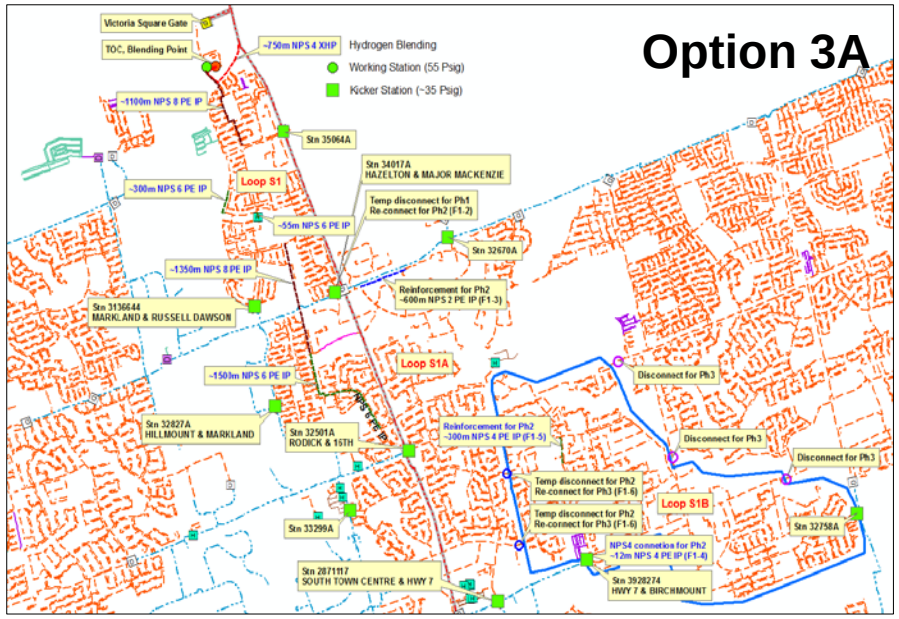








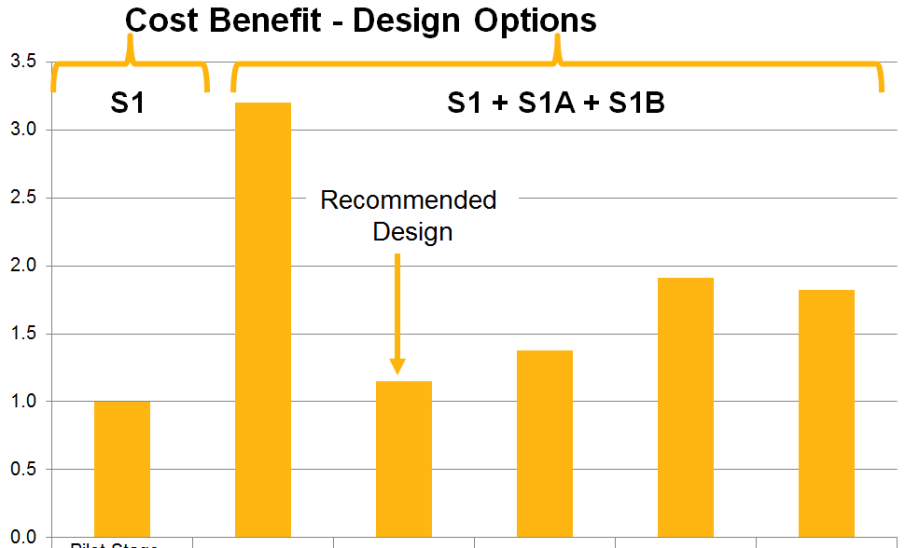
- Conducted Cost/Benefit Analysis
- Assessed H_2 utilization and supply reliability
- Assessed material composition, vintage, among other variables
- Recommended Option 3A for Design of Closed Loops S1, S1A and S1B
- Awaiting Selection Acceptance



Power-to-Gas Phase 2

Evolution of Closed Loop Pipeline Design

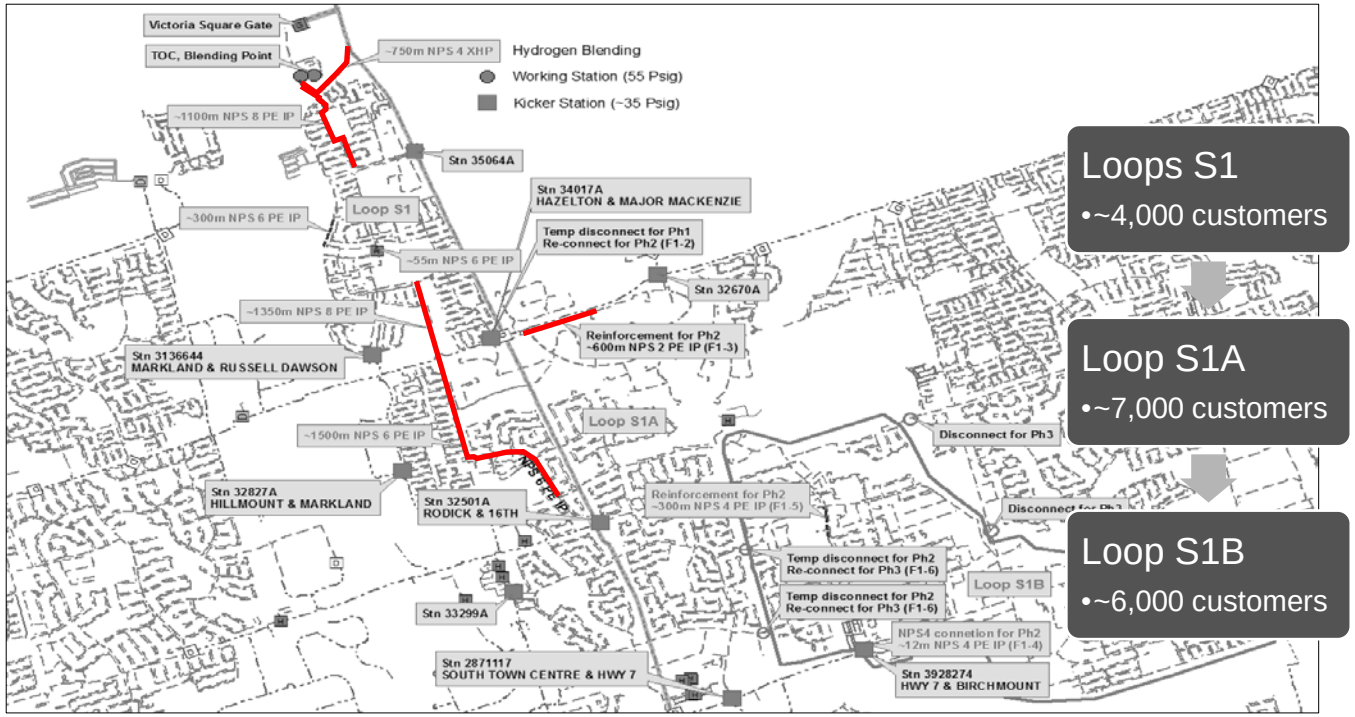
- **Q4 2017- Q1 2018:** Examined 8 macro-loops across the GTA for blending considerations
- **Q1 2018:** Selected the Markham macro-loop for further analysis, divided into 3 loops for phased design
- **Q2 2018:** Produced first pipeline blending design iteration for S1, S1A and S1B
- **Q3 2018:** Initiated design refinements to reduce costs, system pressure and system modifications (completed third iteration in Aug. 2018 for S1, S1A and S1B)



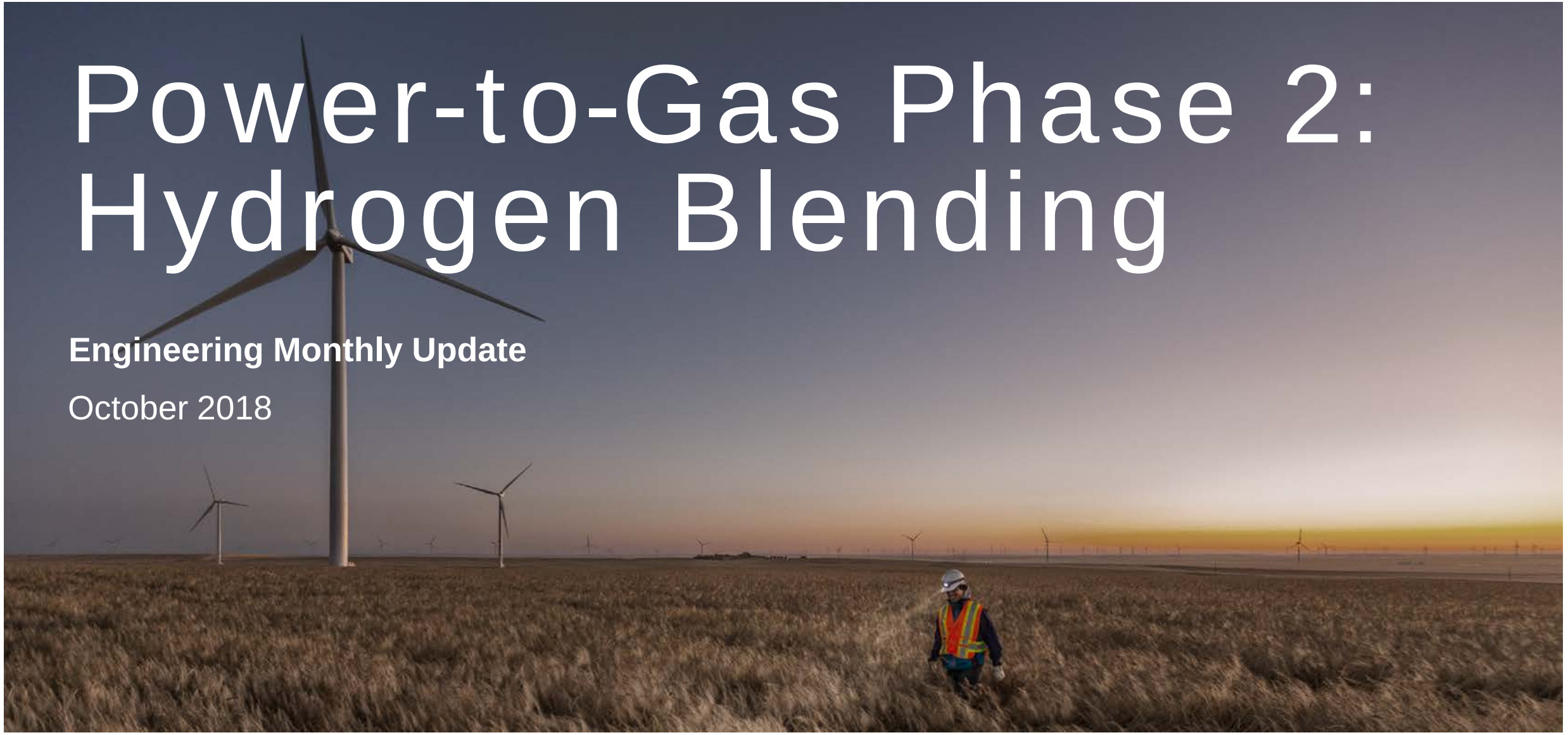
	Pilot Stage – Loop S1	1 and 2	3A	3A-2	3B	3B-2
Function of ($ / utilization x reliability)	1.0	3.2	1.2	1.4	1.9	1.8

Option 3A

Proposed NPS 8 and 6 PE IP for blended gas
Proposed NPS 6 XHP ST for natural gas



Power-to-Gas Phase 2: Hydrogen Blending



Engineering Monthly Update

October 2018

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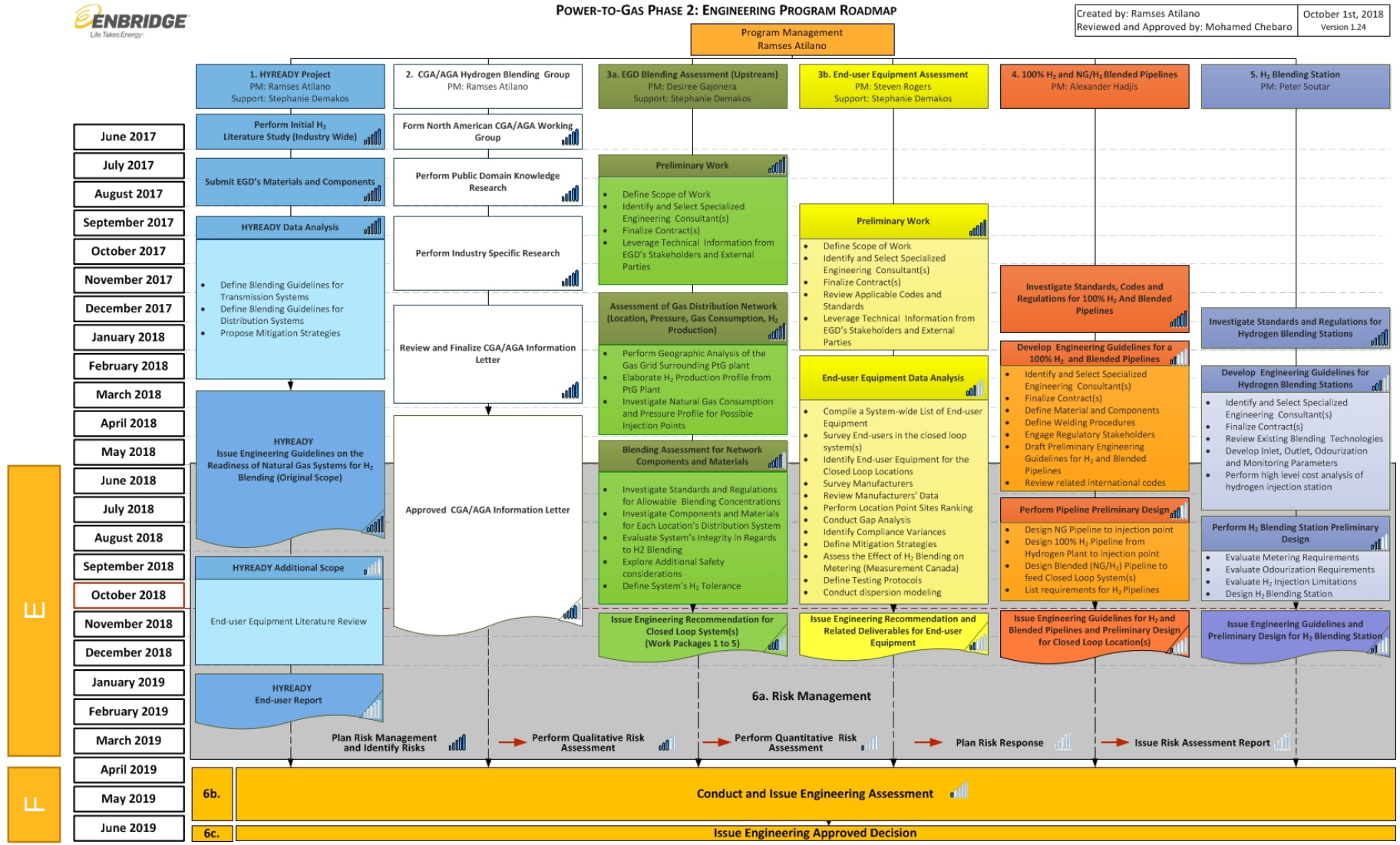
Engineering

Power-to-Gas Phase 2

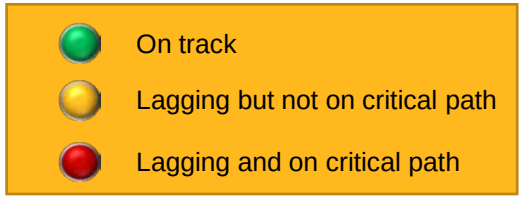
Roadmap

A	B	C	D



Power-to-Gas Phase 2

Status Review



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Program Streams	Scope	Budget*	Timeline
A. Research and Development:			
CGA/AGA Task Force Information Letter *(in final stages)*			
HYREADY Engineering Guideline Report *(original scope completed)*			
HYREADY Added Scope – End user *(initiated)*			
B. Integrity, Engineering and Capacity Assessment			
Closed Loop(s) Identification and Prioritization *(completed)*			
Network Capacity Analysis for Closed Loop Candidates *(completed)*			
Material and Component Data Gathering Analysis *(completed)*			
Integrity Assessments for Closed Loop Candidates *(in final stages)*			
H_2 Consumption Assessment *(completed)*			
Closed Loops Design Refinement *(completed)*			

* 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
C. End User Equipment Engineering and Integrity System			
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)*			
D. Engineering Design and Review			
Pipeline Design- Hydrogen pipeline *(in progress)*			
Pipeline Design- Natural gas and blended pipelines *(in progress)*			
Blending Stations Design- Injection station *(in progress)*			
E. Risk Assessment			
Risk Assessment Report *(in progress, completed HAZID)*			
Computational Modeling *(in progress)*			
F. Engineering Assessment *(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
A. Research and Development:			
Continue building and optimizing the Hydrogen Blending Database			
Manage HYREADY's expanded work scope			
B. Integrity, Engineering and Capacity Assessment			
Compile and analyze operating and integrity data for the three Closed Loops (e.g., corrosion, leaks and damages)			
Complete 100% of H_2 tolerance evaluation for the three Closed Loops			
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

ENBRIDGE
Life Takes Energy™

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

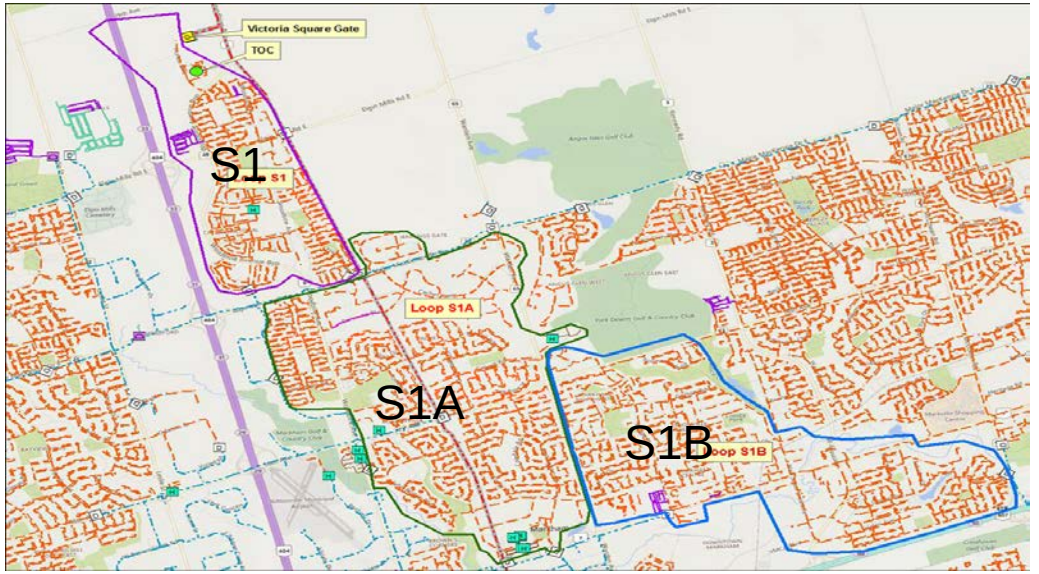
Past Month's Achievements

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

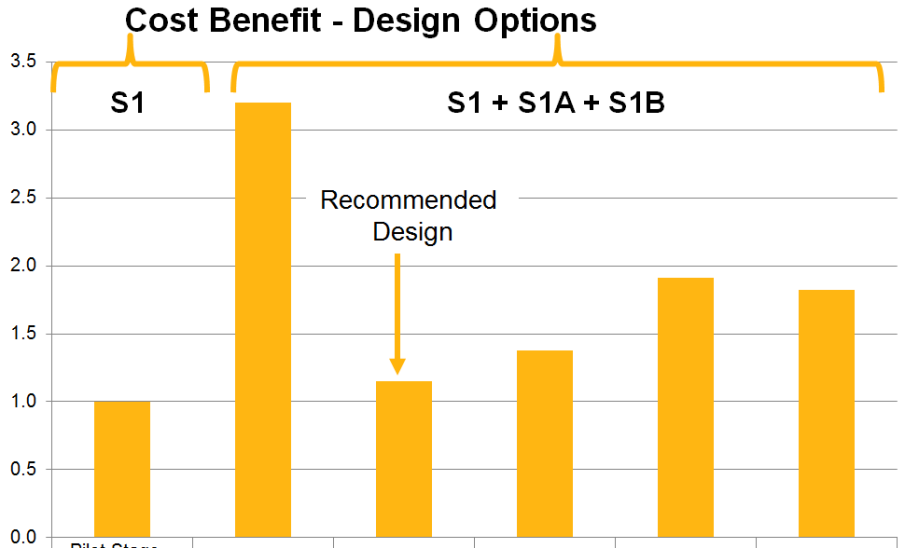
E. Risk Assessment

- ✓ 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

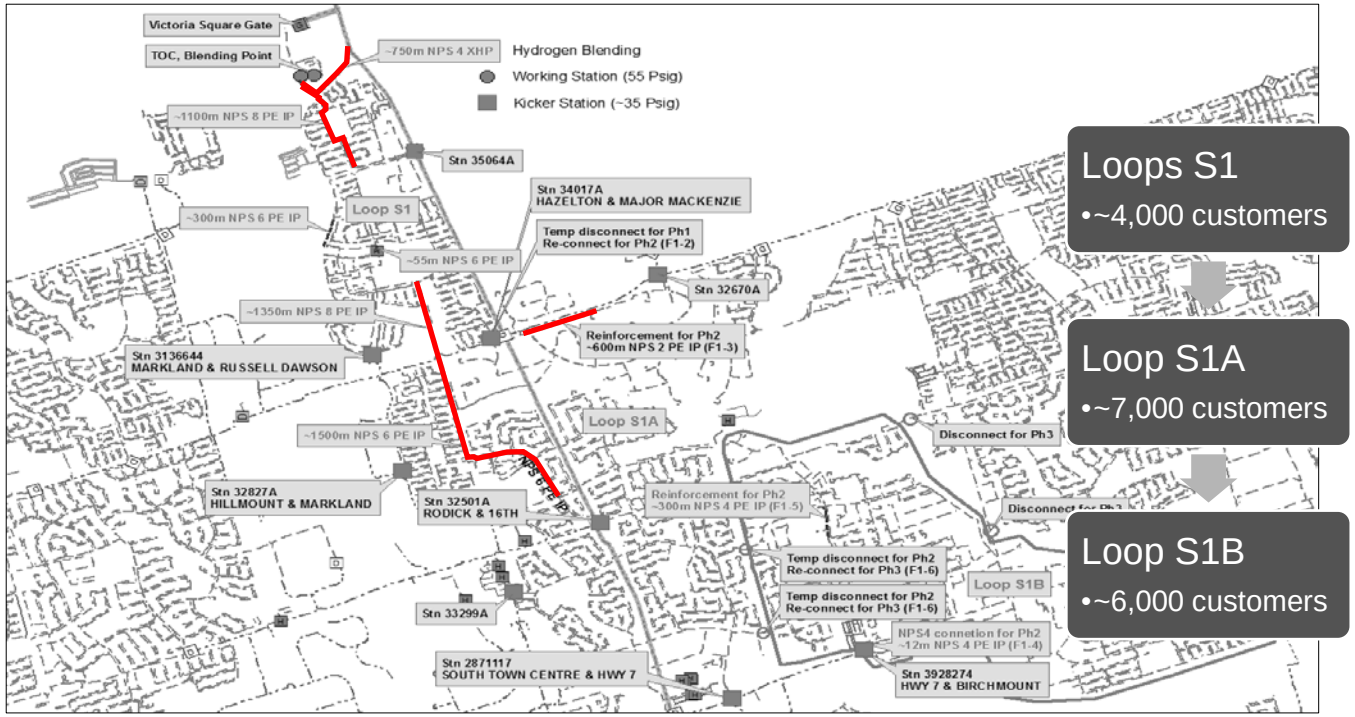
- **Q4 2017- Q1 2018:** Examined 8 macro-loops across the GTA for blending considerations
- **Q1 2018:** Selected the Markham macro-loop for further analysis, divided into 3 loops for phased design
- **Q2 2018:** Produced first pipeline blending design iteration for S1, S1A and S1B
- **Q3 2018:** Issued design refinements to reduce costs, system pressure and system modifications (completed fourth iteration in Sept. 2018 for S1, S1A and S1B)



	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



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).*

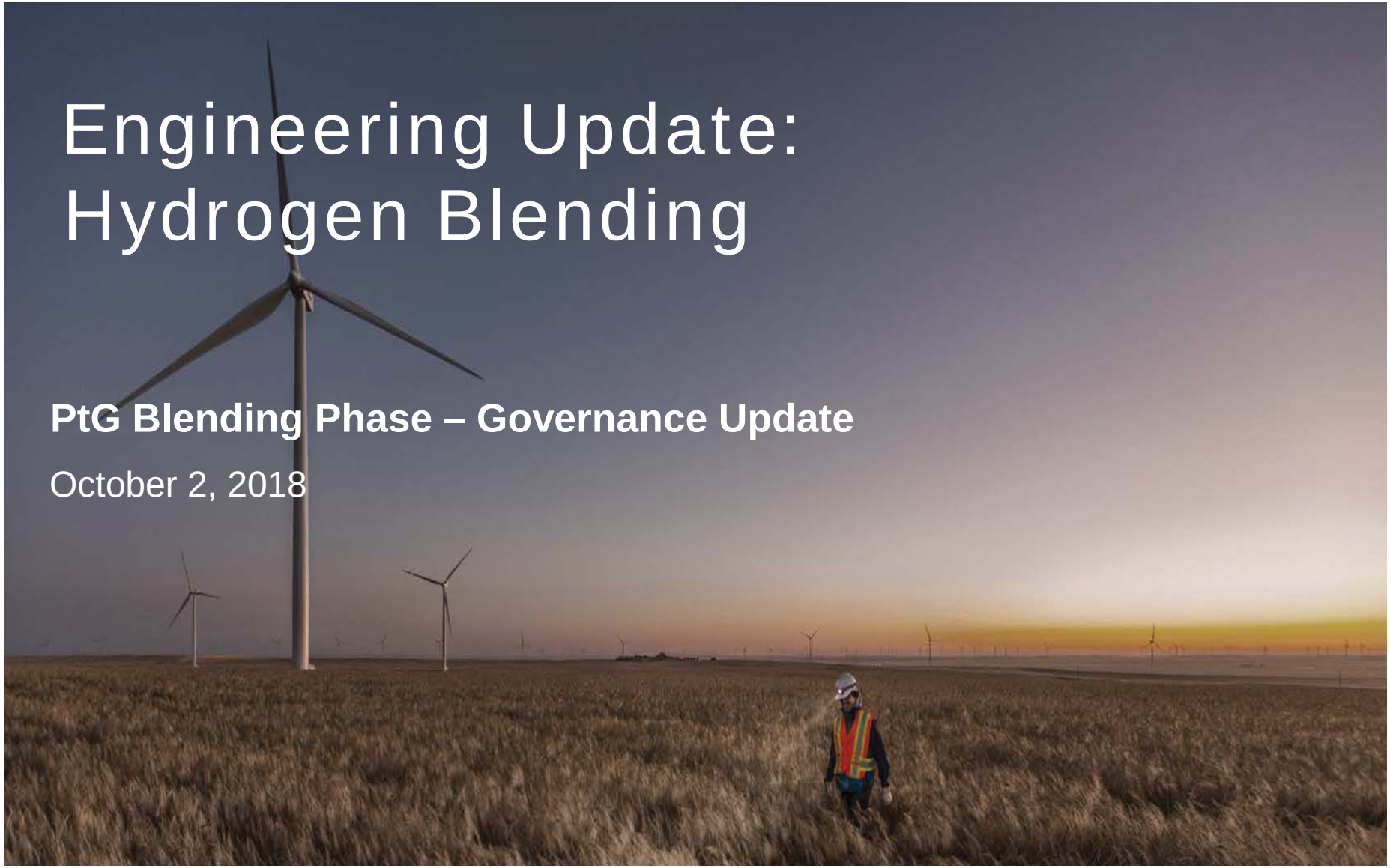
Appliance Type	CO_2	CO	NOx	Flame Temp	Temp Combustion Chamber	Lambda (air to fuel ratio)	Flame Speed
Industrial (retrofit)	↓	↓	↑	↑	=	=	↑
Industrial (no retrofit)*	↓	↓	↓**	↑	↓	↑	↑
Residential (no retrofit)	↓	↓	↓	↑	↓	↑	↑
Turbines (retrofit)	↓	↓	↑	↑	=	=	↑
Engines (no retrofit)	↓	↓	↑	↑	↓	↑	↑

* 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

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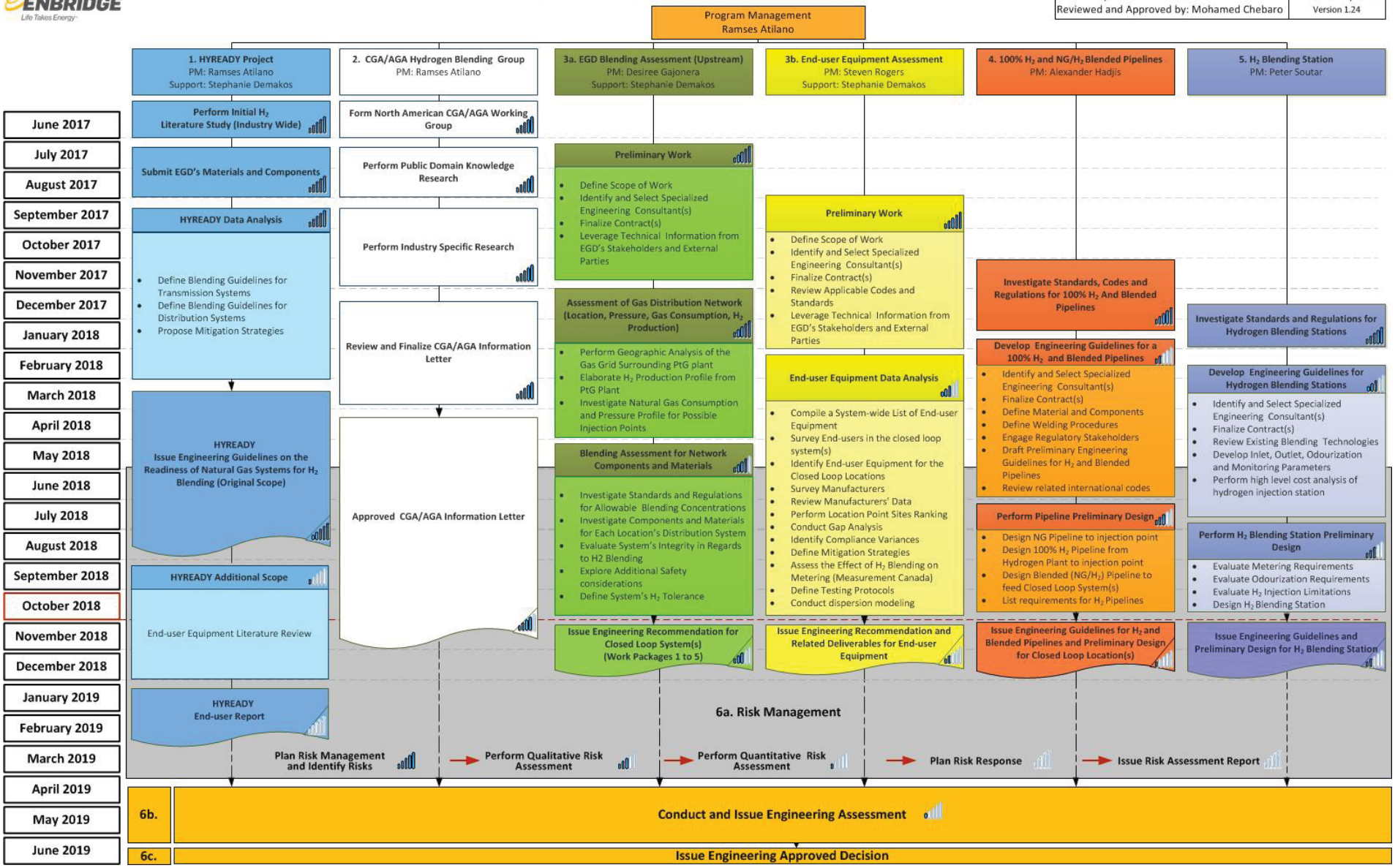
Prepared by: Mohamed Chebaro, Ramses Atilano

Presented by: Mike Wagle

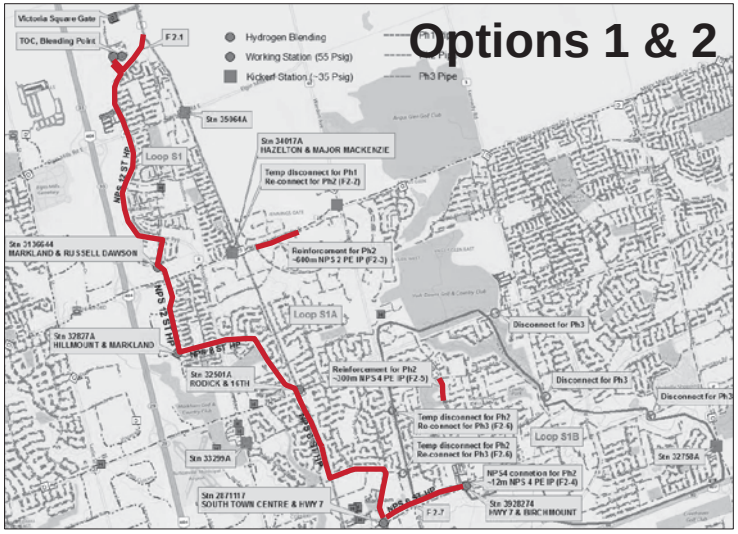
POWER-TO-GAS PHASE 2: ENGINEERING PROGRAM ROADMAP

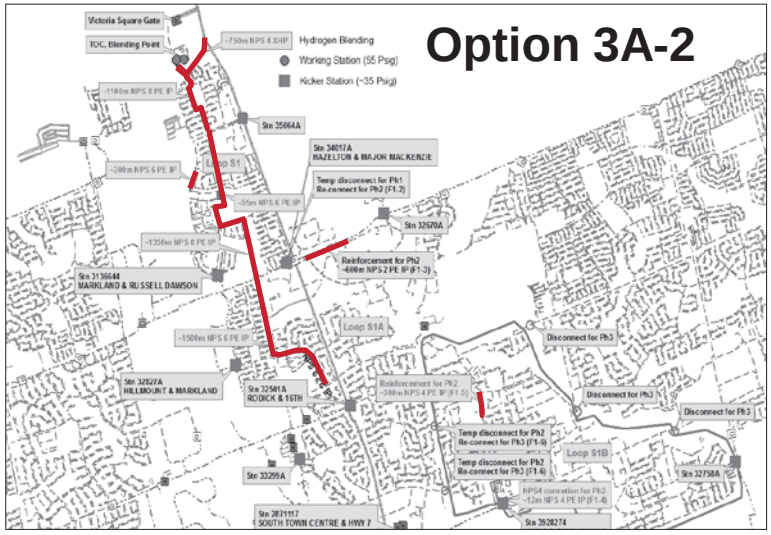
Created by: Ramses Atilano Reviewed and Approved by: Mohamed Chebaro	October 1st, 2018 Version 1.24

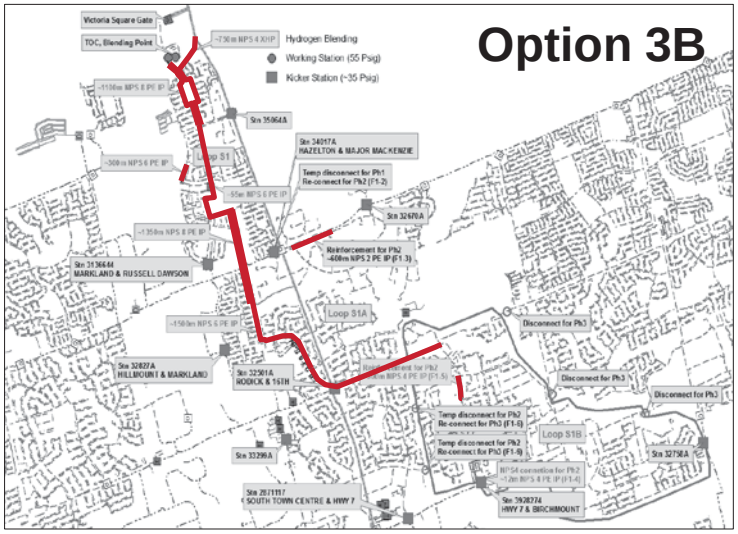


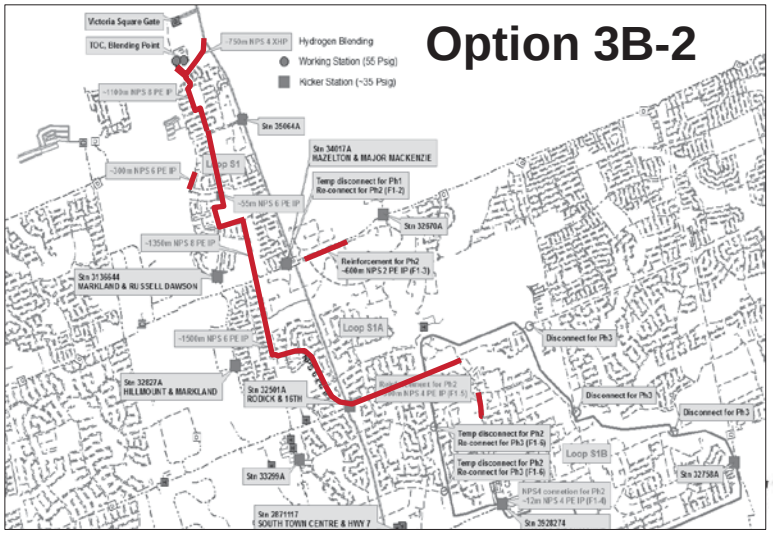
Pilot Construction Phase – Initial Route Options

XHP, HP and IP options included in the cost benefit analysis



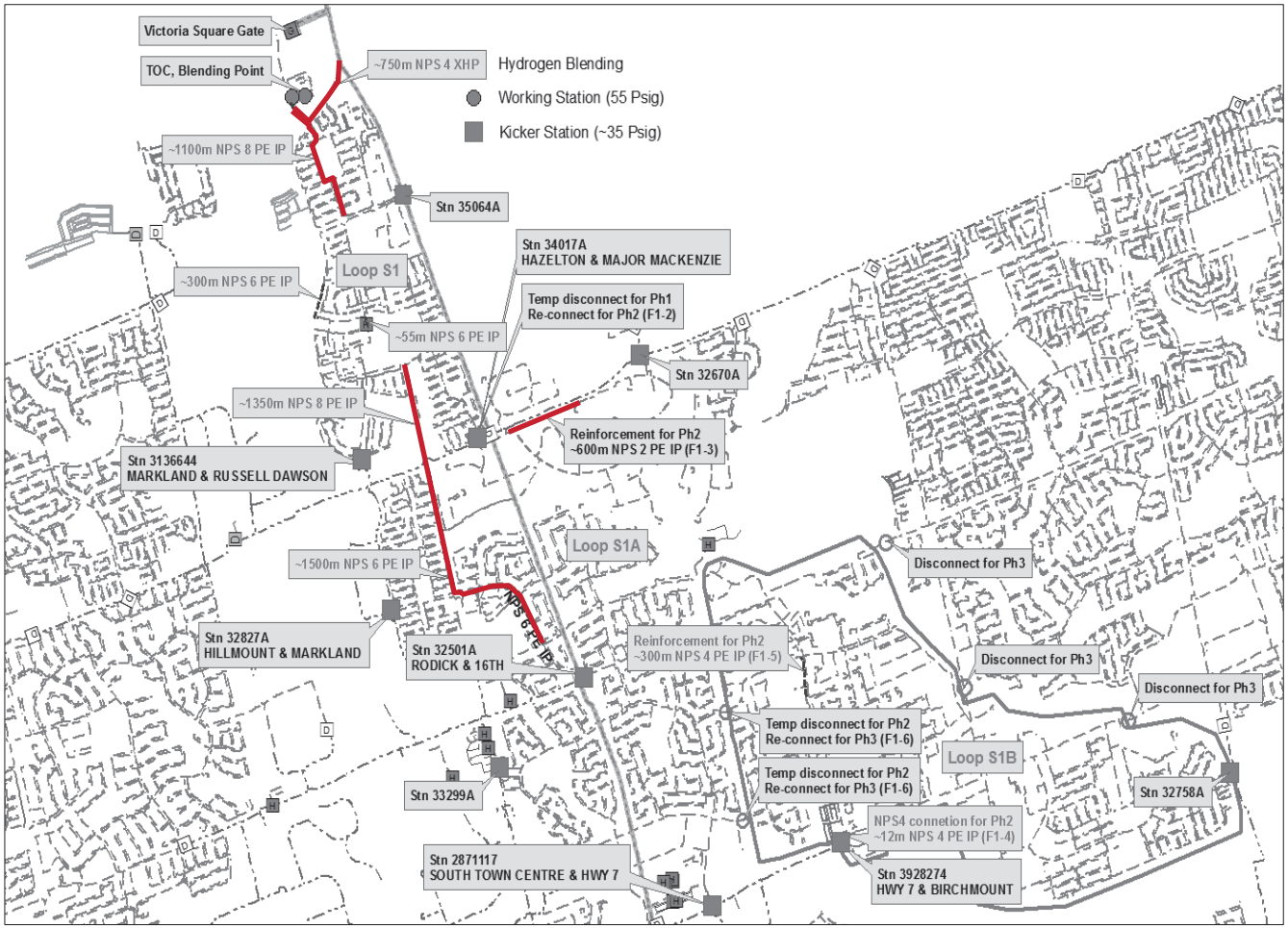






Pilot Construction Phase – Recommended Option: 3A

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

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Option 3A – Feed to Closed Loops

Compressor *
Blended pipeline
Hydrogen pipeline
District Station
Pure NG pipeline
Injection point

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 *

Blended pipeline

Hydrogen pipeline

District Station

Pure NG pipeline

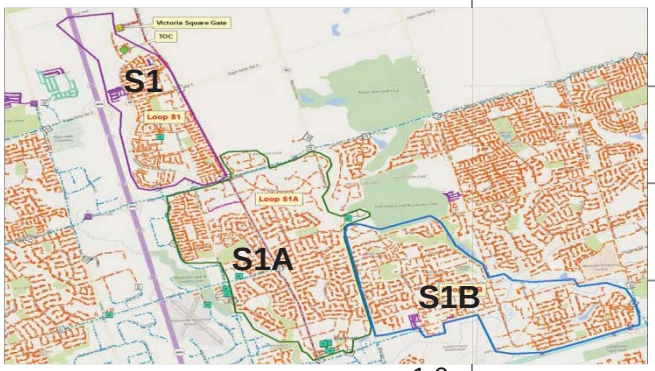
Injection point

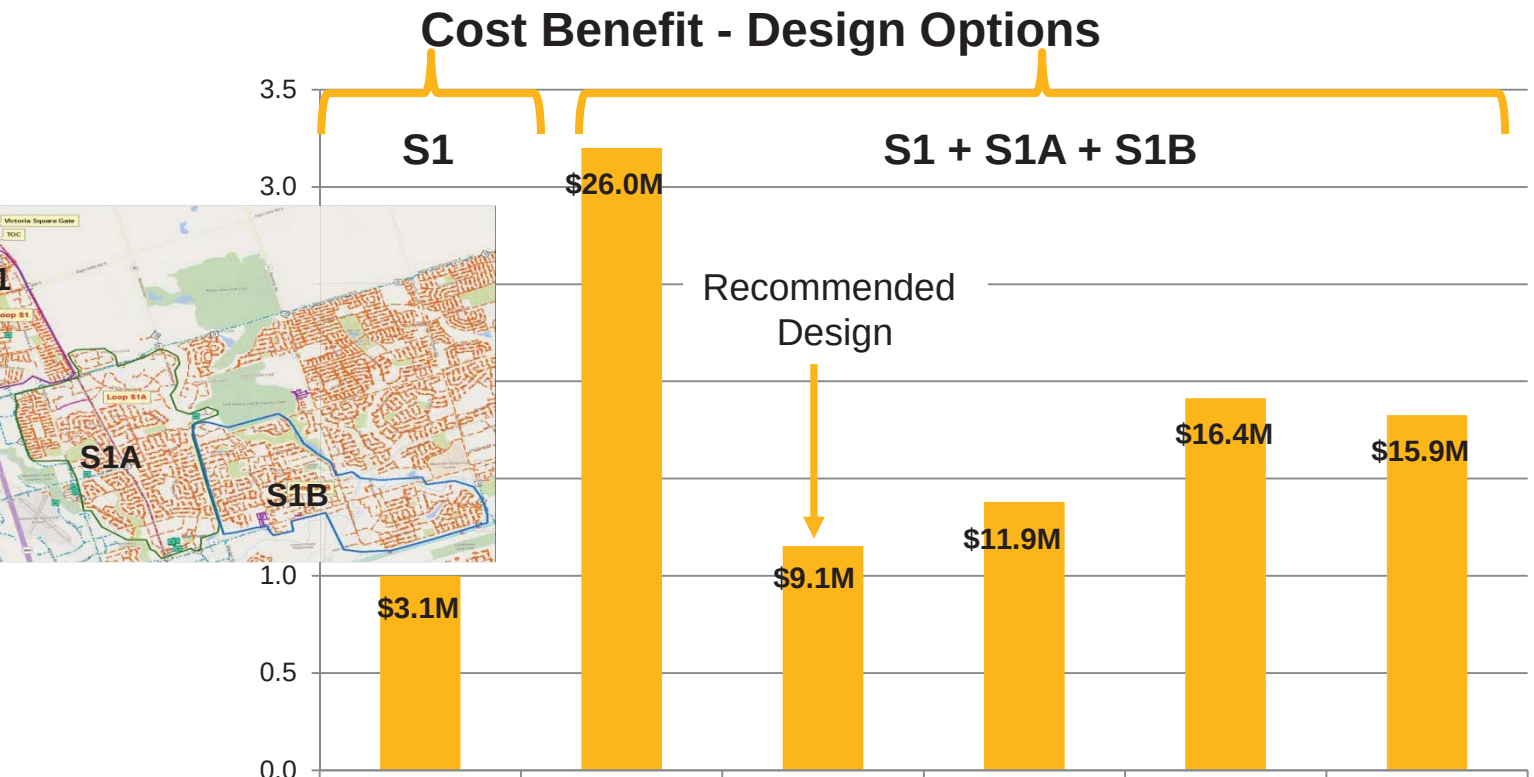
Feed to Vic Square

- 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

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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	

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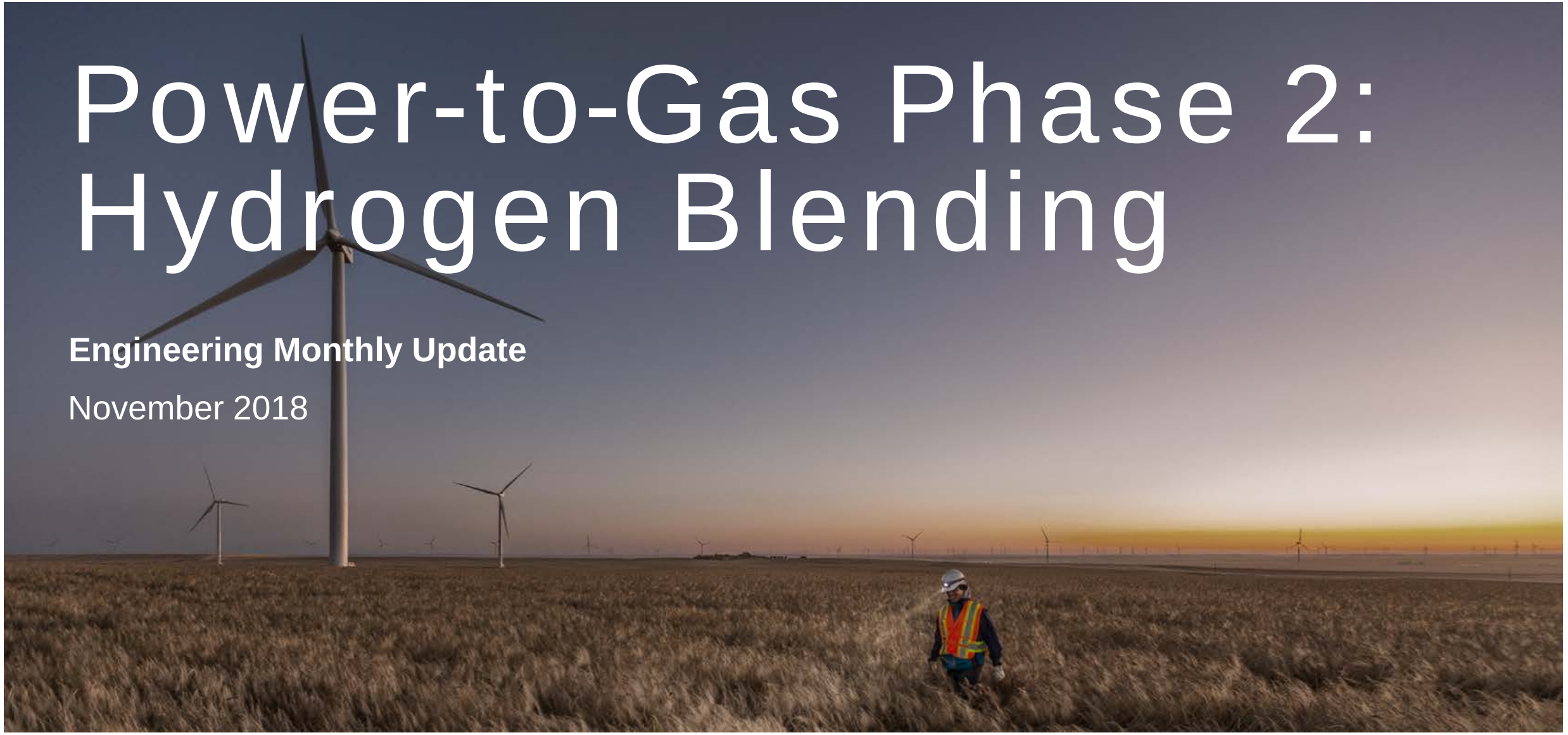
Revised R&D Eng. Budget – Oct. 2018- Class 5 Estimate

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

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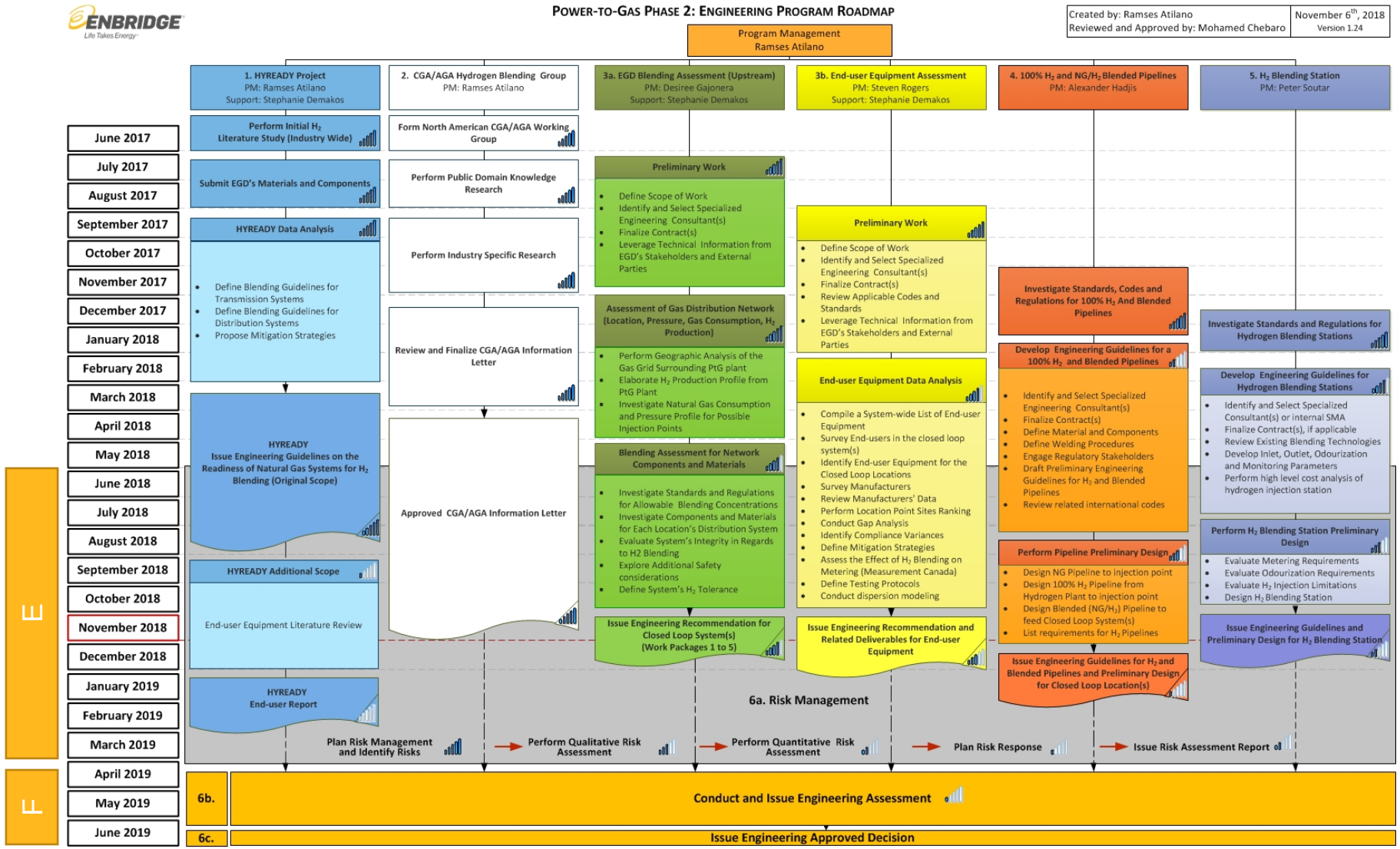
Mohamed Chebaro and Ramses Atilano
Engineering

Power-to-Gas Phase 2

Roadmap

A	B	C	D



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
A. Research and Development:			
CGA/AGA Task Force Information Letter *(completed)*			
HYREADY Engineering Guideline Report *(original scope completed)*			
HYREADY Added Scope – End user *(initiated)*			
B. Integrity, Engineering and Capacity Assessment			
Closed Loop(s) Identification and Prioritization *(completed)*			
Network Capacity Analysis for Closed Loop Candidates *(completed)*			
Material and Component Data Gathering Analysis *(completed)*			
Integrity Assessments for Closed Loop Candidates *(in final stages)*			
H_2 Consumption Assessment *(completed)*			
Closed Loops Design Refinement *(completed)*			

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
C. End User Equipment Engineering and Integrity System			
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)*			
D. Engineering Design and Review			
Pipeline Design- Hydrogen pipeline *(in progress)*			
Pipeline Design- Natural gas and blended pipelines *(in progress)*			
Station Design- Injection station *(in progress, completed DBM draft)*			
E. Risk Assessment			
Risk Assessment Report *(in progress, completed HAZID, QRA initiated)*			
Computational Modeling *(final draft completed and under review)*			
F. Engineering Assessment *(in progress)*			

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			
Finalize analysis for the operating and integrity data for the three Closed Loops (e.g., corrosion, leaks and damages)			
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			
Issue final draft report from DNV-GL for risk			
Compile 100% of field survey targets for Loops S1A/S1B			

Power-to-Gas Phase 2

Upcoming Deliverables

On track
Lagging but not on critical path
Lagging and on critical path

ENBRIDGE
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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

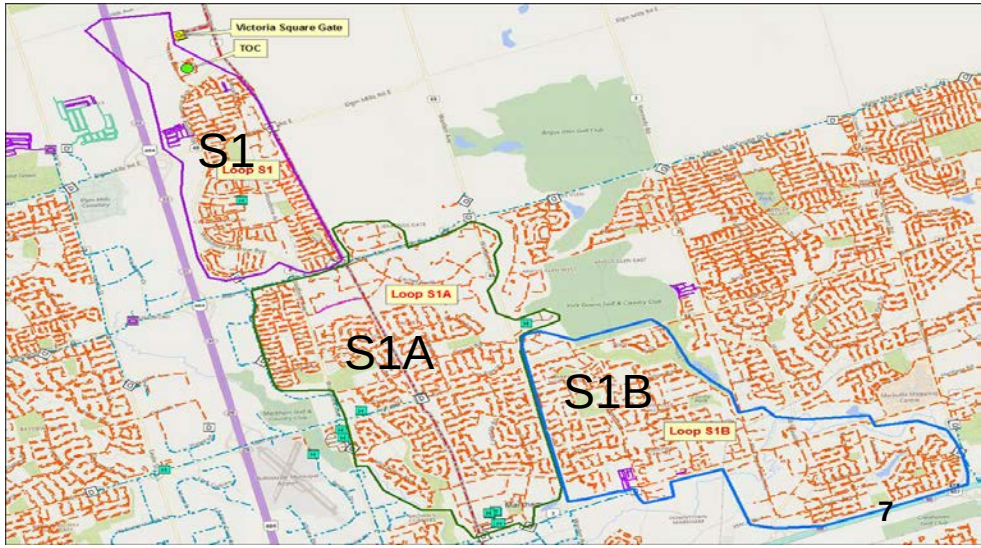
- ✓ Continued building the Hydrogen Knowledge Management Database framework
- ✓ Chaired meetings with CGA/AGA Task Force
- ✓ Received the final version of the information letter approved by both CGA and AGA

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
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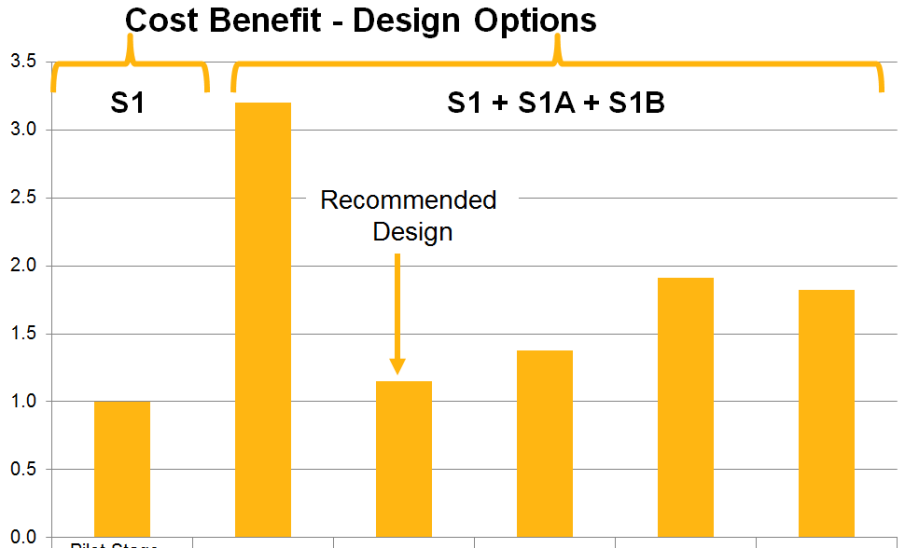

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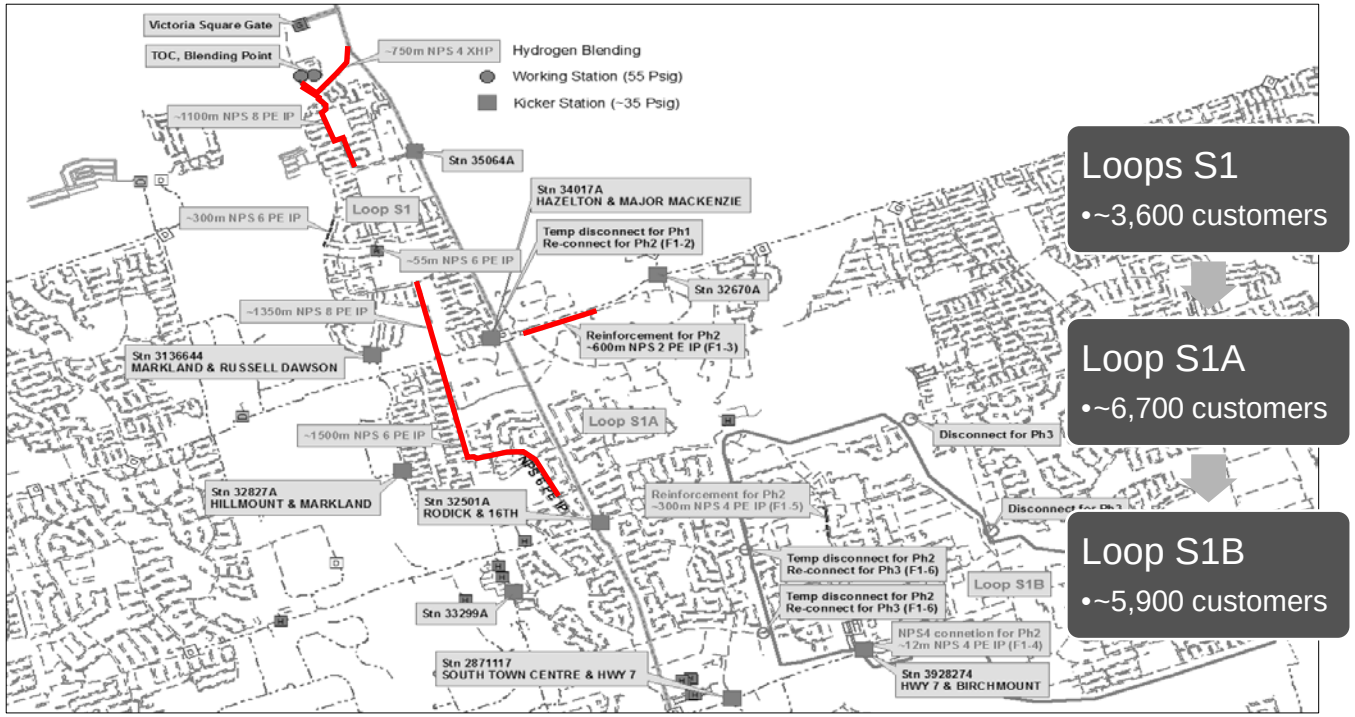
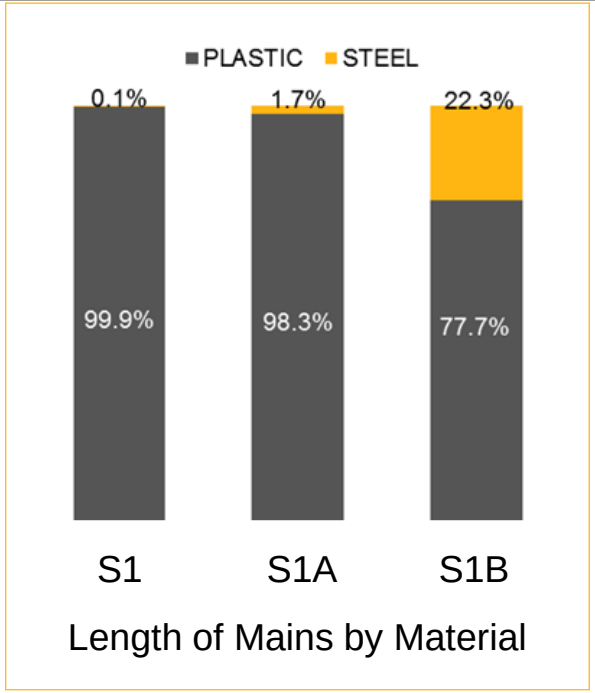
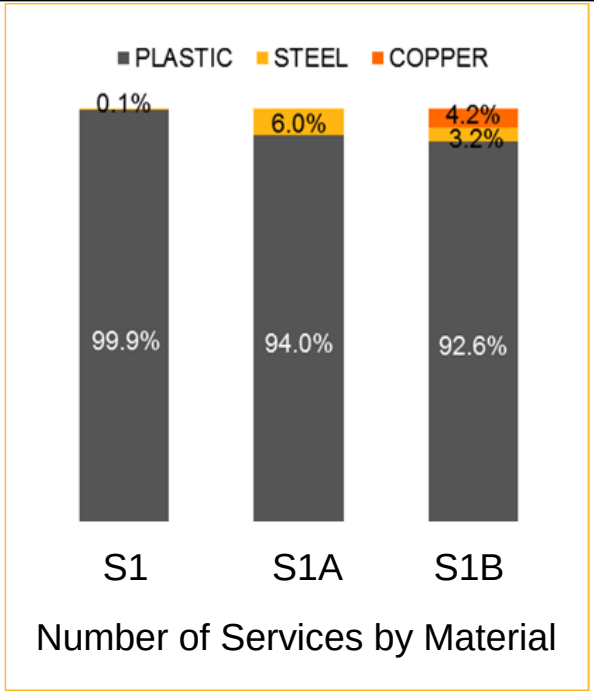


Power-to-Gas Phase 2

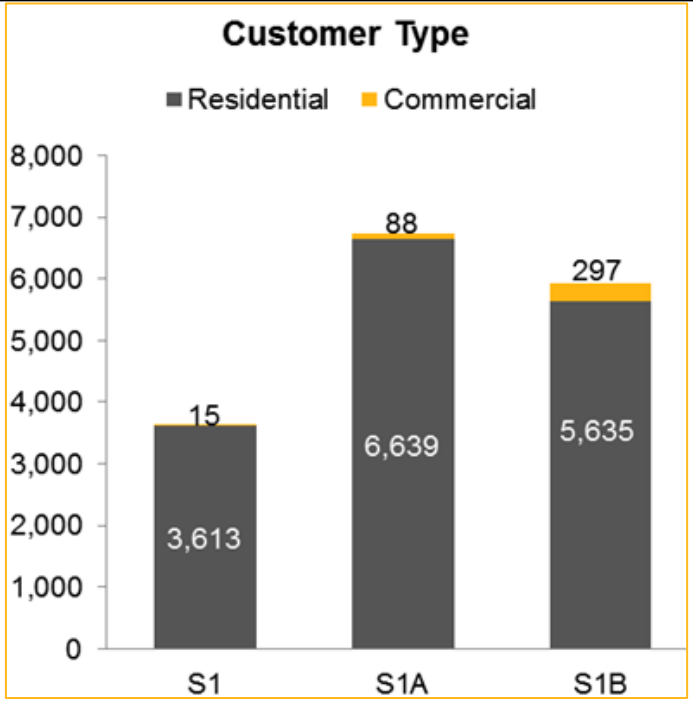
Closed Loop Materials and End-user Survey

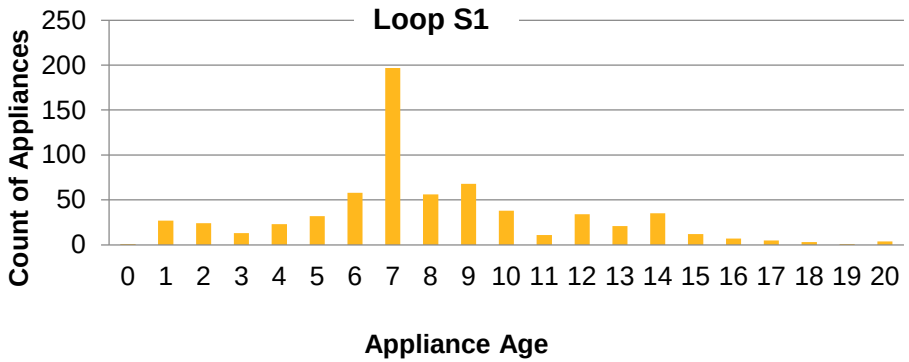


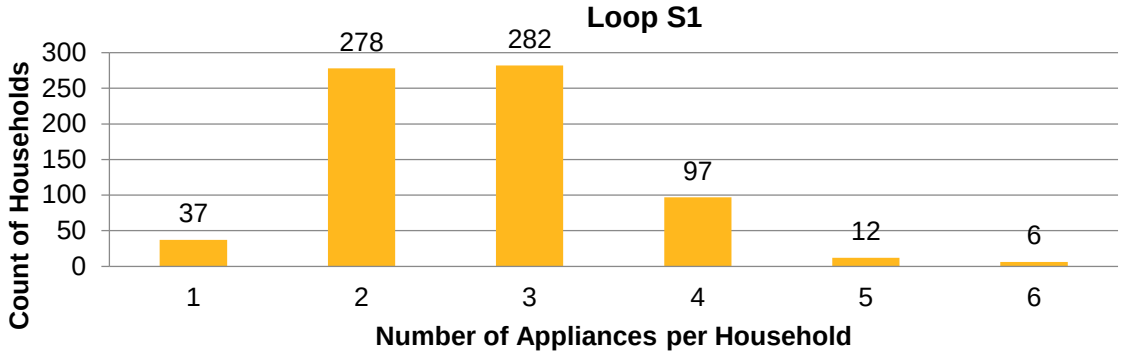
Length of Mains by Material



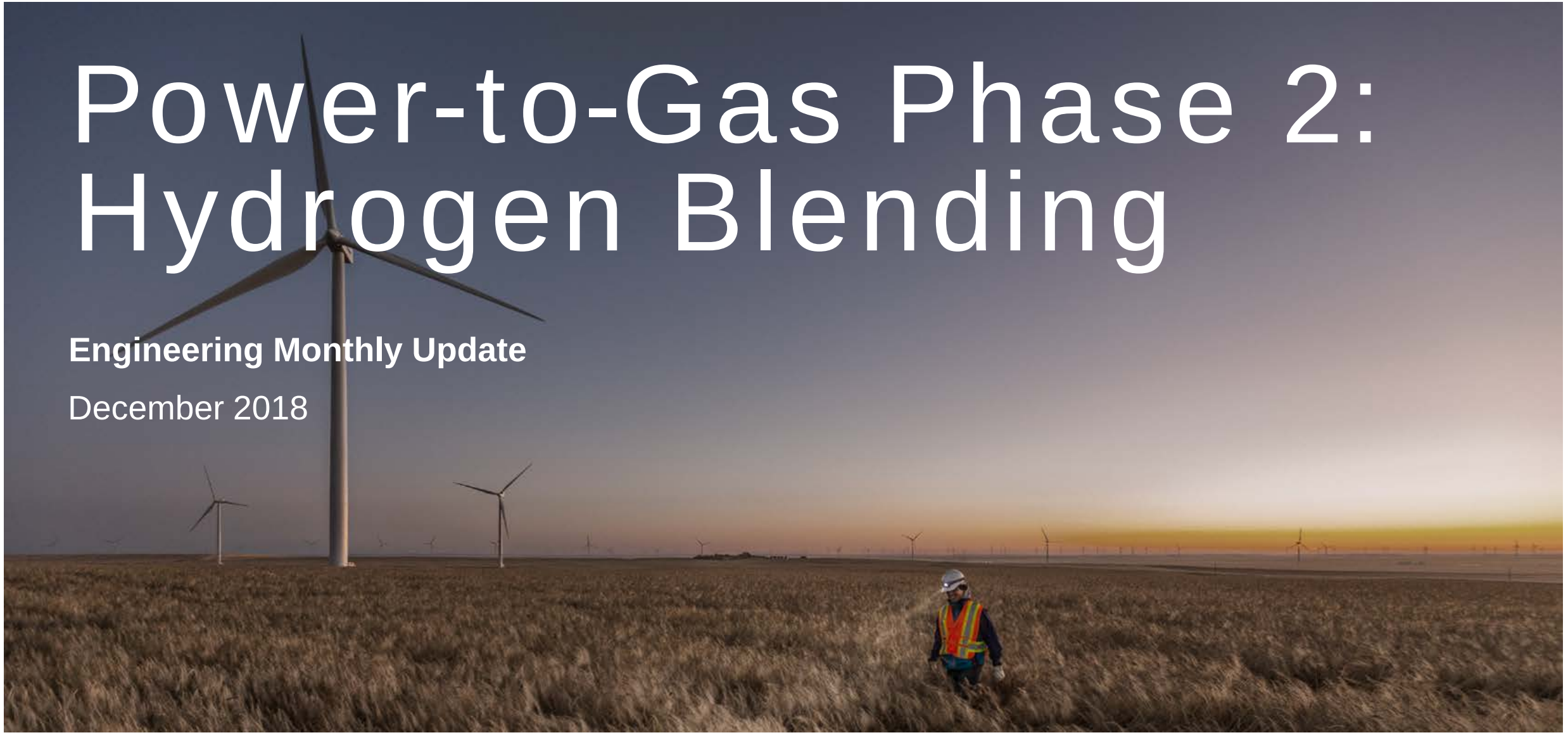
Number of Services by Material







Power-to-Gas Phase 2: Hydrogen Blending



Engineering Monthly Update

December 2018

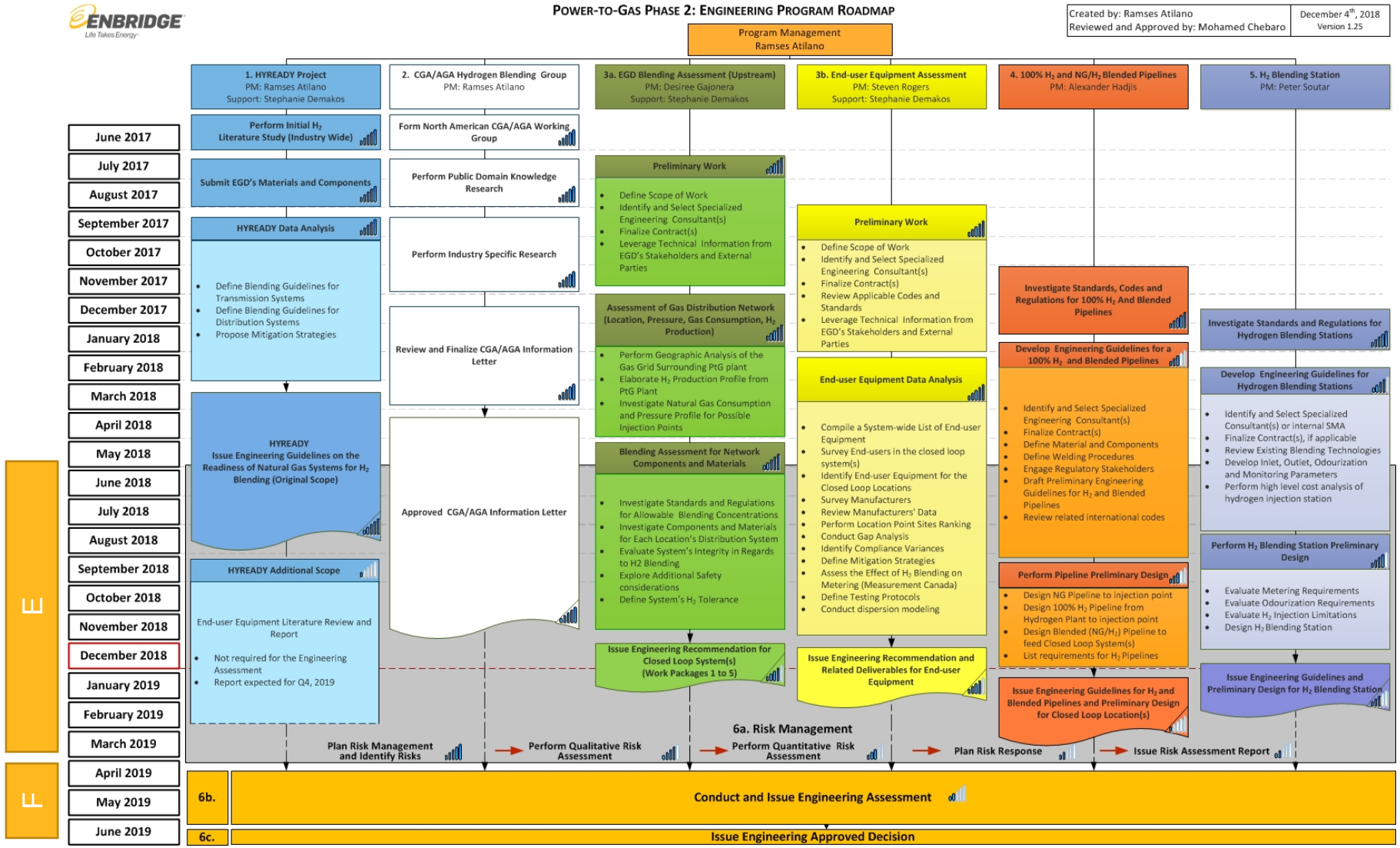
ENBRIDGE

Mohamed Chebaro, Ramses Atilano and Steven Rogers
Engineering

Power-to-Gas Phase 2

Roadmap

A	B	C	D



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
A. Research and Development:			
CGA/AGA Task Force Information Letter *(completed)*			
HYREADY Engineering Guideline Report *(original scope completed)*			
HYREADY Added Scope – End user *(initiated)*			
B. Integrity, Engineering and Capacity Assessment			
Closed Loop(s) Identification and Prioritization *(completed)*			
Network Capacity Analysis for Closed Loop Candidates *(completed)*			
Material and Component Data Gathering Analysis *(completed)*			
Integrity Assessments for Closed Loop Candidates *(in final stages)*			
H_2 Consumption Assessment *(completed)*			
Closed Loops Design Refinement *(completed)*			

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
C. End User Equipment Engineering and Integrity System			
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)*			
D. Engineering Design and Review			
Pipeline Design- Hydrogen pipeline *(in progress)*			
Pipeline Design- Natural gas and blended pipelines *(in progress)*			
Station Design- Injection station *(in final stages, completed DBM draft)*			
E. Risk Assessment			
Risk Assessment Report *(in progress, completed HAZID, QRA in progress)*			
Computational Modeling *(completed)*			
F. Engineering Assessment *(in progress)*			

Power-to-Gas Phase 2

Upcoming Deliverables

On track
Lagging but not on critical path
Lagging and on critical path

ENBRIDGE
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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

ENBRIDGE
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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

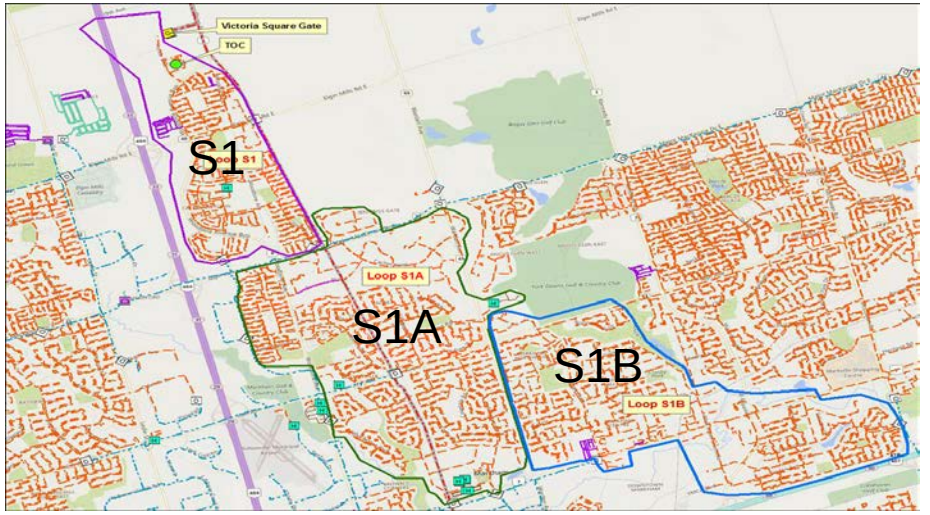
Past Month's Achievements

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

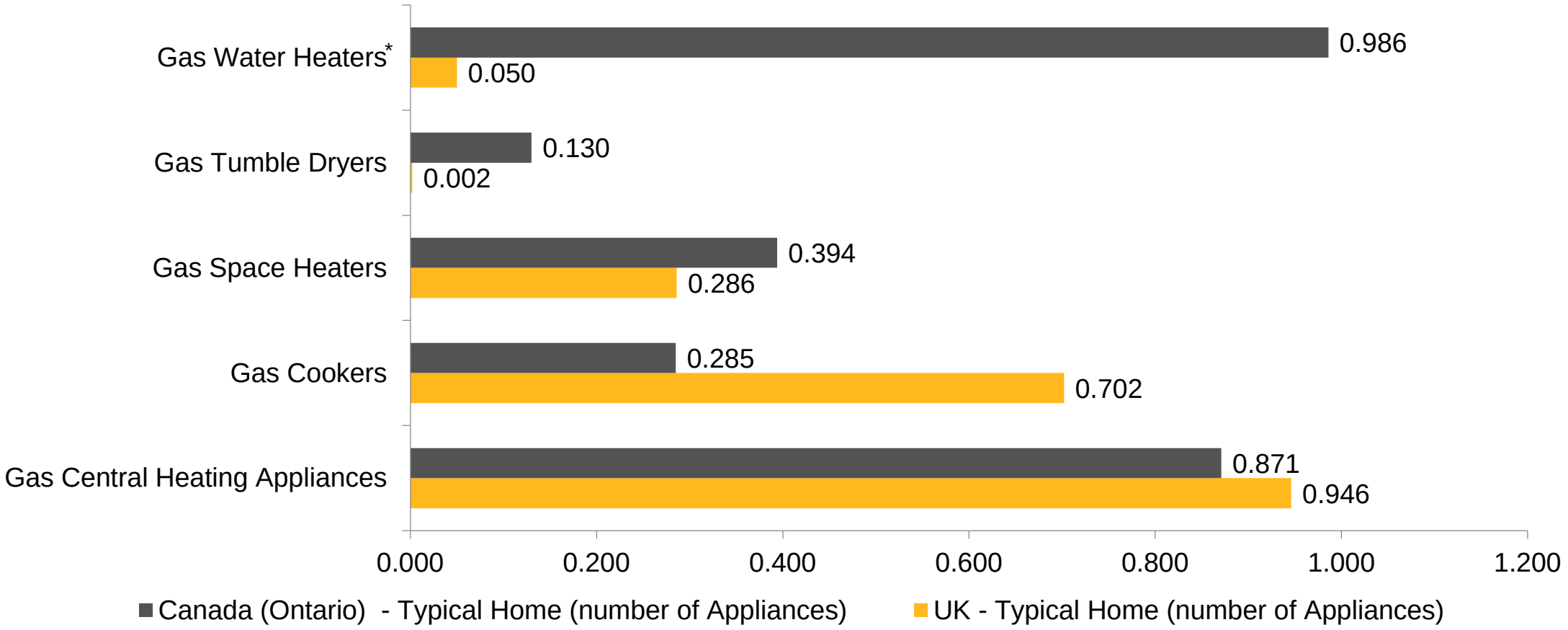
- ✓ Closed out all actions items from the HAZID sessions
- ✓ Finalized Consequence Modeling as part of the Risk Assessment
- ✓ Progressed the Quantitative Risk Assessment
- ✓ Reviewed and accepted the final deliverable for indoor dispersion modeling (C-FER)
- ✓ Reviewed and accepted the final deliverable 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

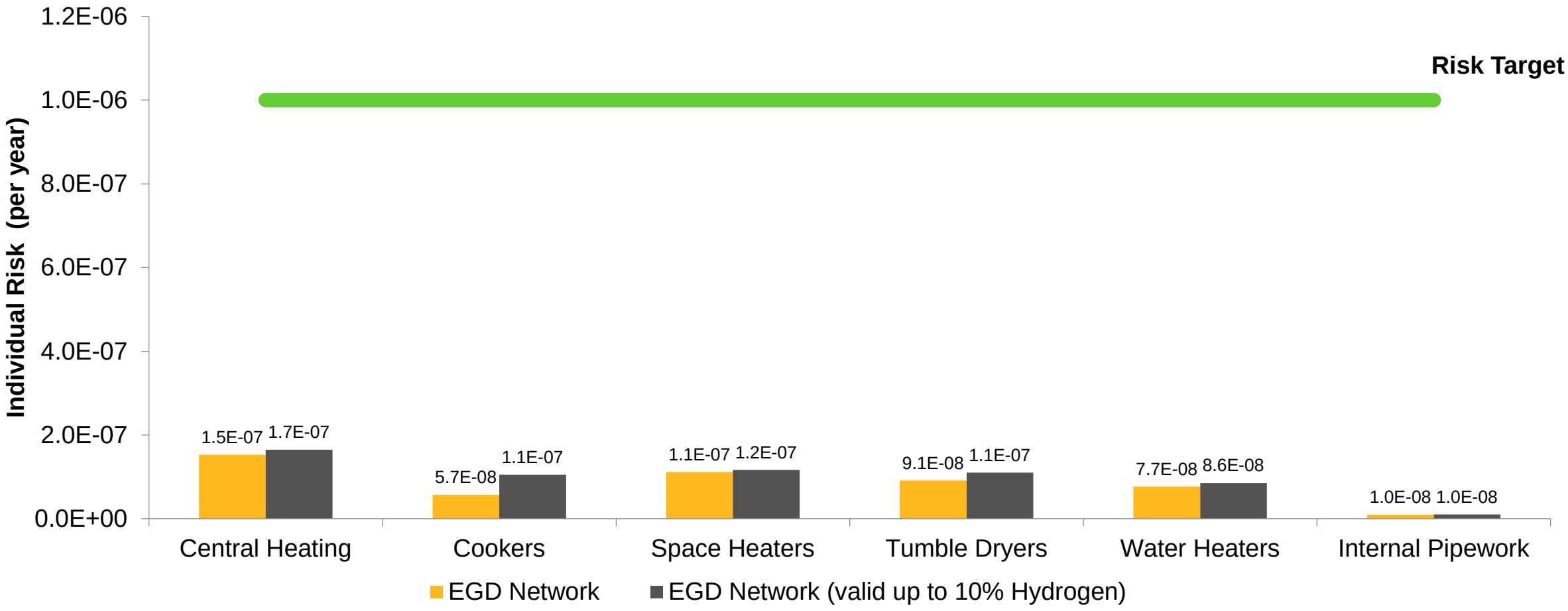
Average Number of NG Appliances per Household (the UK and Ontario)
Source: DNV-GL



* Most central heating in the UK is combo gas/water heaters

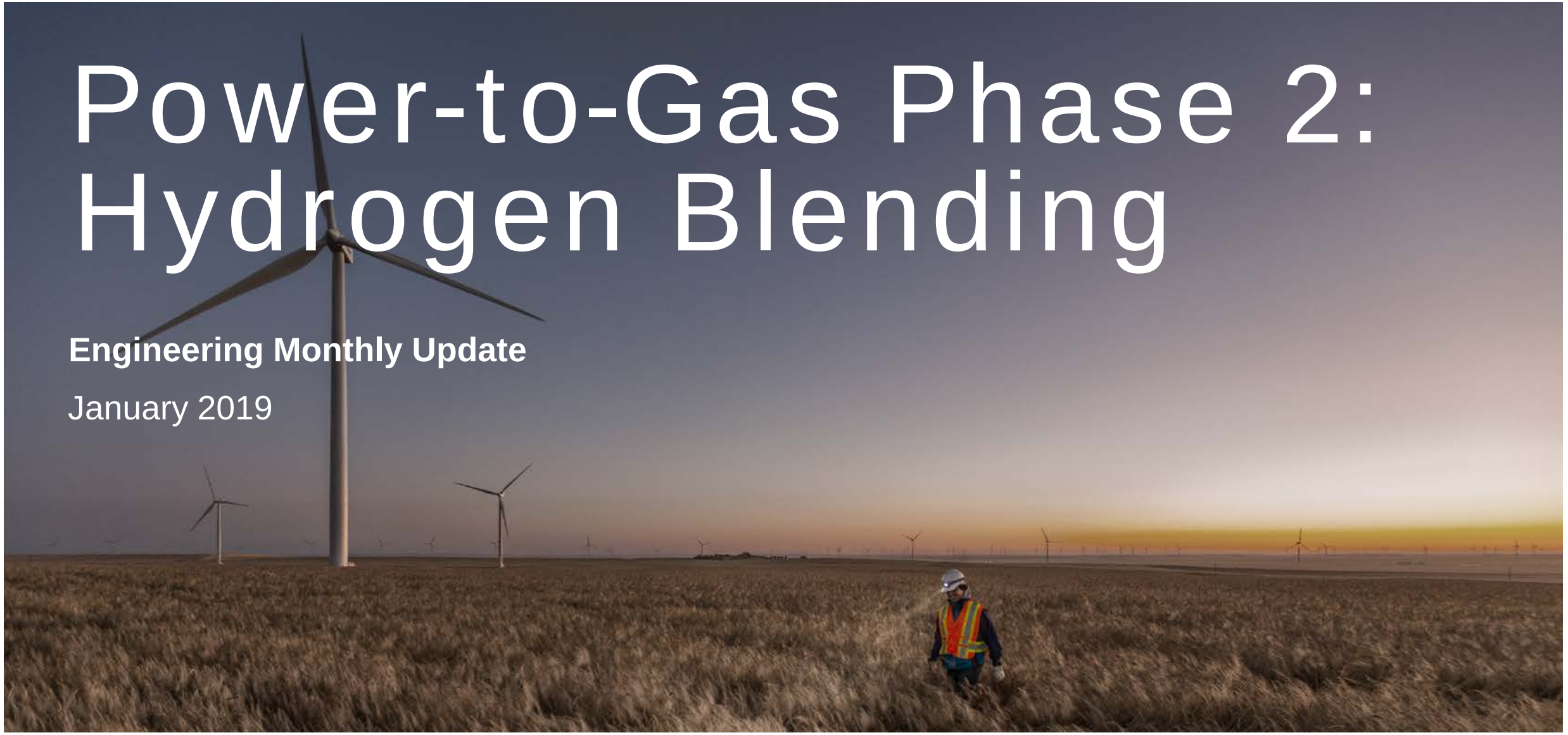
Power-to-Gas Phase 2 – Preliminary Results

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

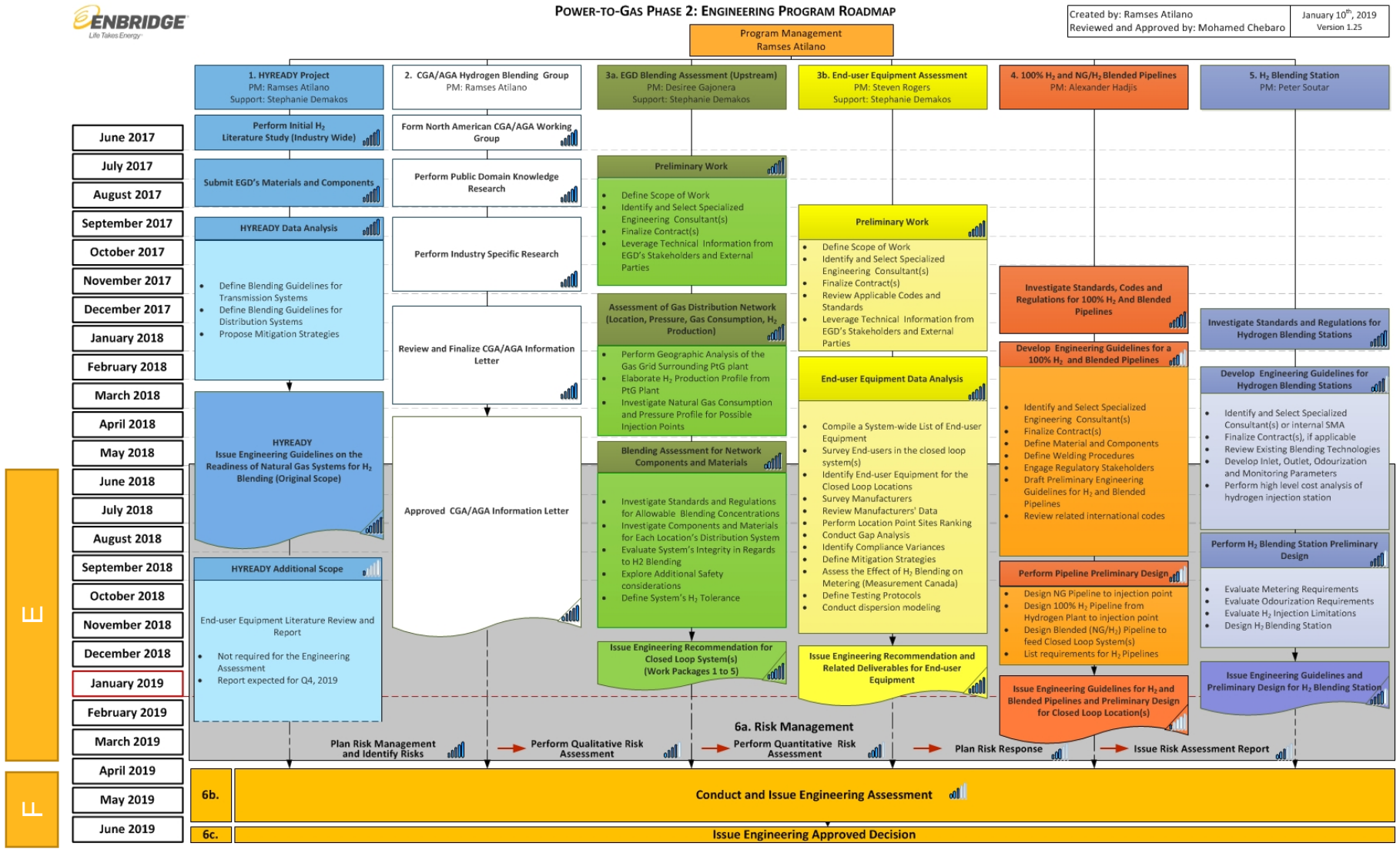
ENBRIDGE

Mohamed Chebaro and Ramses Atilano
Engineering

Power-to-Gas Phase 2

Roadmap

A	B	C	D



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
A. Research and Development:			
CGA/AGA Task Force Information Letter *(completed)*			
HYREADY Engineering Guideline Report *(original scope completed)*			
HYREADY Added Scope – End user *(in progress)*			
B. Integrity, Engineering and Capacity Assessment			
Closed Loop(s) Identification and Prioritization *(completed)*			
Network Capacity Analysis for Closed Loop Candidates *(completed)*			
Material and Component Data Gathering Analysis *(completed)*			
Integrity Assessments for Closed Loop Candidates *(in final stages)*			
H_2 Consumption Assessment *(completed)*			
Closed Loops Design Refinement *(completed)*			

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
C. End User Equipment Engineering and Integrity System			
Data collection for identified closed loops *(completed)*			
Data analysis for identified closed loops *(completed)*			
System-wide assessment for end-user equipment *(completed)*			
D. Engineering Design and Review			
Pipeline Design- Hydrogen pipeline *(in progress)*			
Pipeline Design- Natural gas and blended pipelines *(in progress)*			
Station Design- Injection station *(in final stages, completed DBM draft)*			
E. Risk Assessment			
Risk Assessment Report *(in progress, 50% of Report completed)*			
Computational Modeling *(completed)*			
F. Engineering Assessment *(in progress, 40% of EA completed)*			

Power-to-Gas Phase 2

Upcoming Deliverables

On track
Lagging but not on critical path
Lagging and on critical path

ENBRIDGE
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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

ENBRIDGE
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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

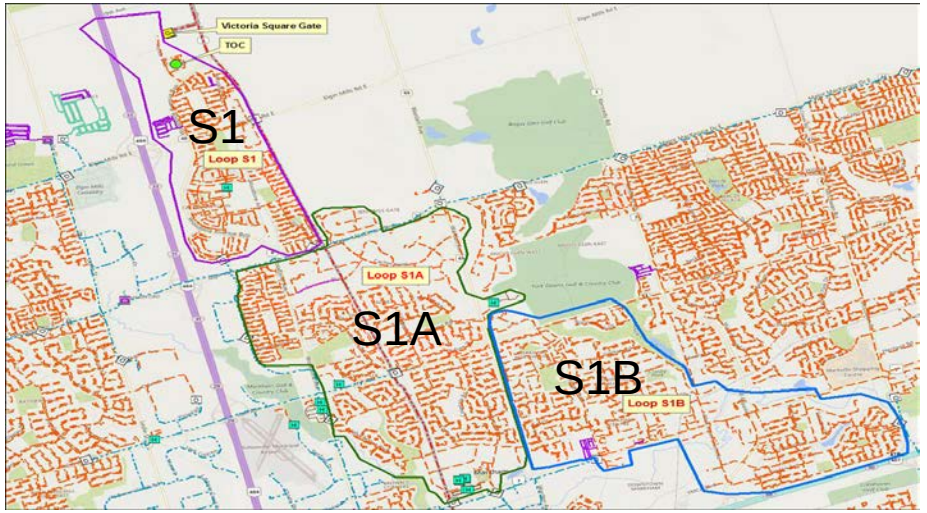
- ✓ Chaired meetings with CGA/AGA Task Force
- ✓ Continued managing HYREADY's expanded work scope (Wiki Platform for Gas Transmission and Distribution Guidelines and End-user Equipment Study)

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

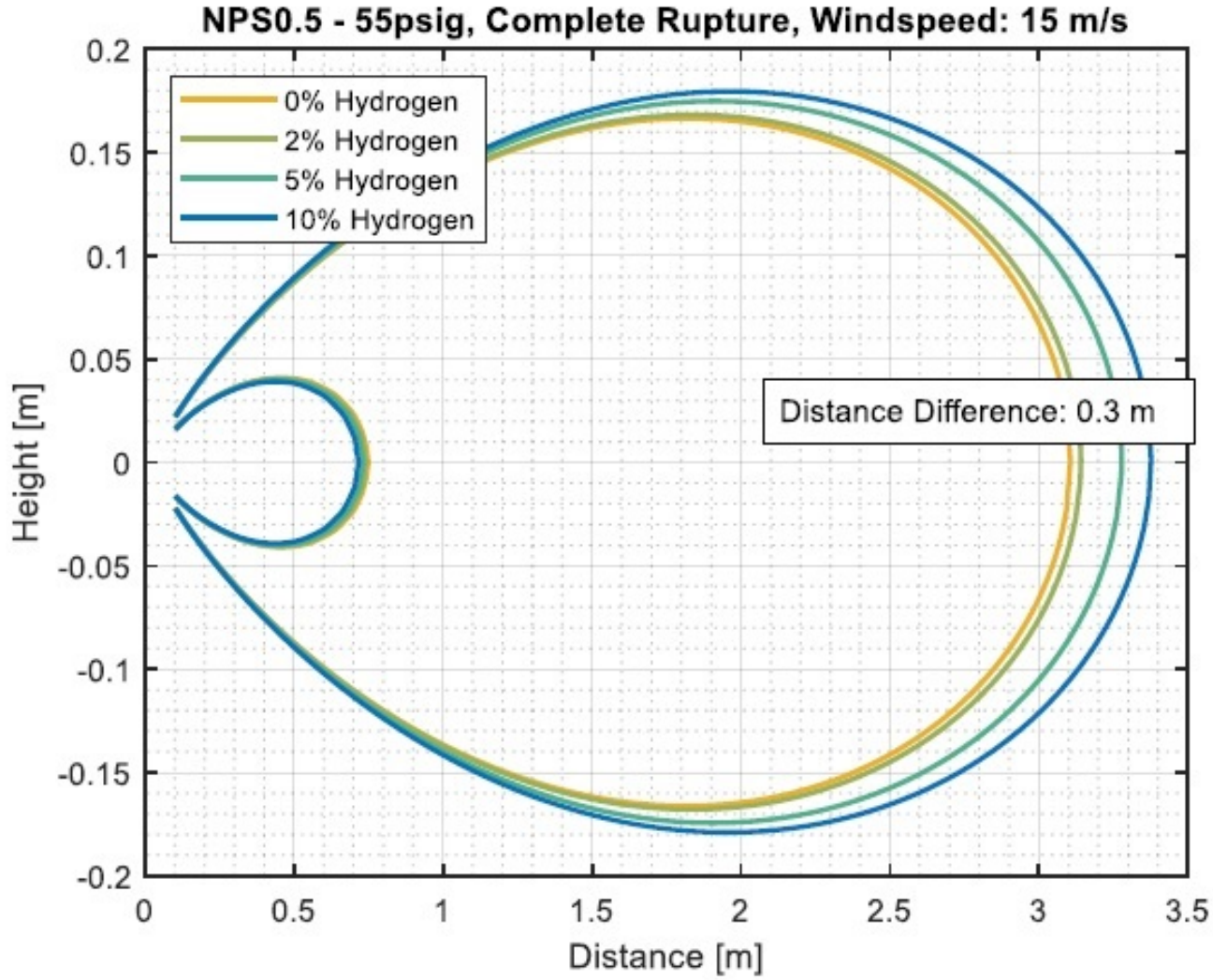
- ✓ Progressed the Quantitative Risk Assessment to 50% completion
- ✓ Received final deliverable for End user equipment risk from DNV-GL
- ✓ Continued working on the Risk Assessment Report in preparation of issuing it in January 2019

F. Engineering Assessment

- ✓ Held strategy sessions within the Engineering Growth Team to design the Engineering Assessment content
- ✓ Completed 40% of Engineering Assessment

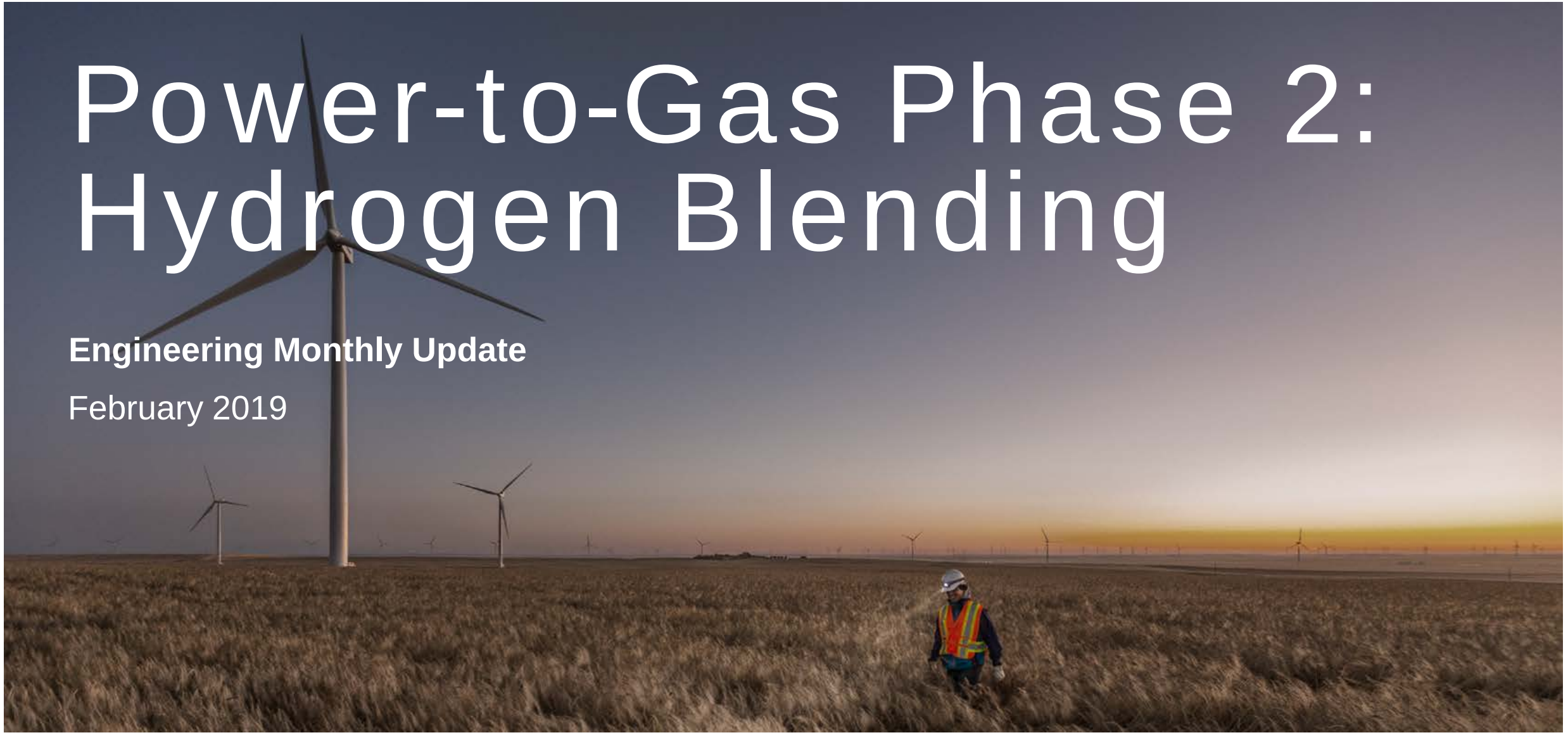
Power-to-Gas Phase 2 – Preliminary Results

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

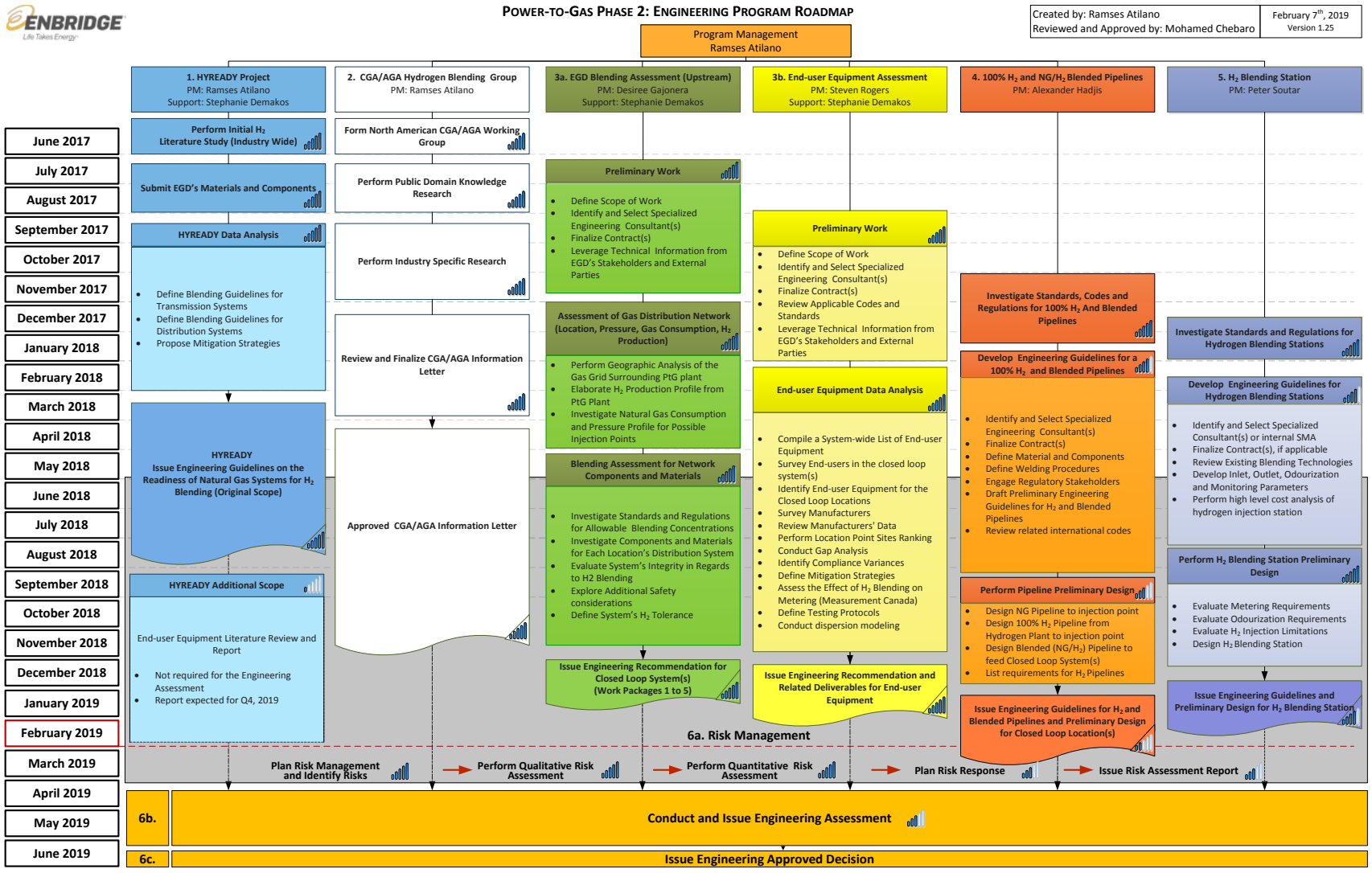
ENBRIDGE

Mohamed Chebaro, Ramses Atilano and Steven Rogers
Engineering

Power-to-Gas Phase 2

Roadmap

A	B	C	D



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
A. Research and Development:			
CGA/AGA Task Force Information Letter *(completed)*			
HYREADY Engineering Guideline Report *(original scope completed)*			
HYREADY Added Scope – End User *(in progress)*			
B. Integrity, Engineering and Capacity Assessment			
Closed Loop(s) Identification and Prioritization *(completed)*			
Network Capacity Analysis for Closed Loop Candidates *(completed)*			
Material and Component Data Gathering Analysis *(completed)*			
Integrity Assessments for Closed Loop Candidates *(under final review)*			
H_2 Consumption Assessment *(completed)*			
Closed Loops Design Refinement *(completed)*			

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
C. End User Equipment Engineering and Integrity System			
Data collection for identified closed loops *(completed)*			
Data analysis for identified closed loops *(completed)*			
System-wide assessment for end-user equipment *(completed)*			
D. Engineering Design and Review			
Pipeline Design- Hydrogen pipeline *(in progress)*			
Pipeline Design- Natural gas and blended pipelines *(in progress)*			
Station Design- Injection station *(in final stages, completed DBM draft)*			
E. Risk Assessment			
Risk Assessment Report *(in progress, first draft received)*			
Computational Modeling *(completed)*			
F. Engineering Assessment *(in progress, 60% of EA 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 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

ENBRIDGE
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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 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

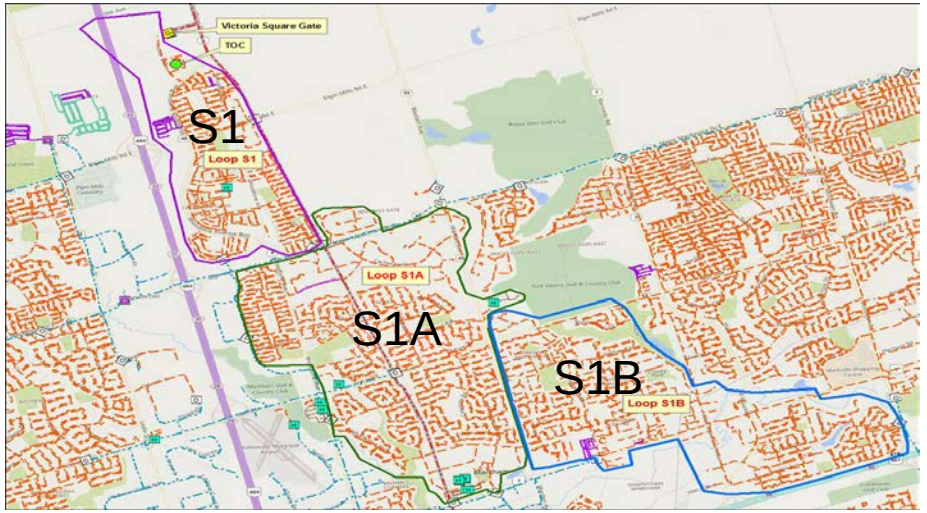
- ✓ Continued managing HYREADY's expanded work scope (Platform for Gas Transmission and Distribution Guidelines and End-user Equipment Study)

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

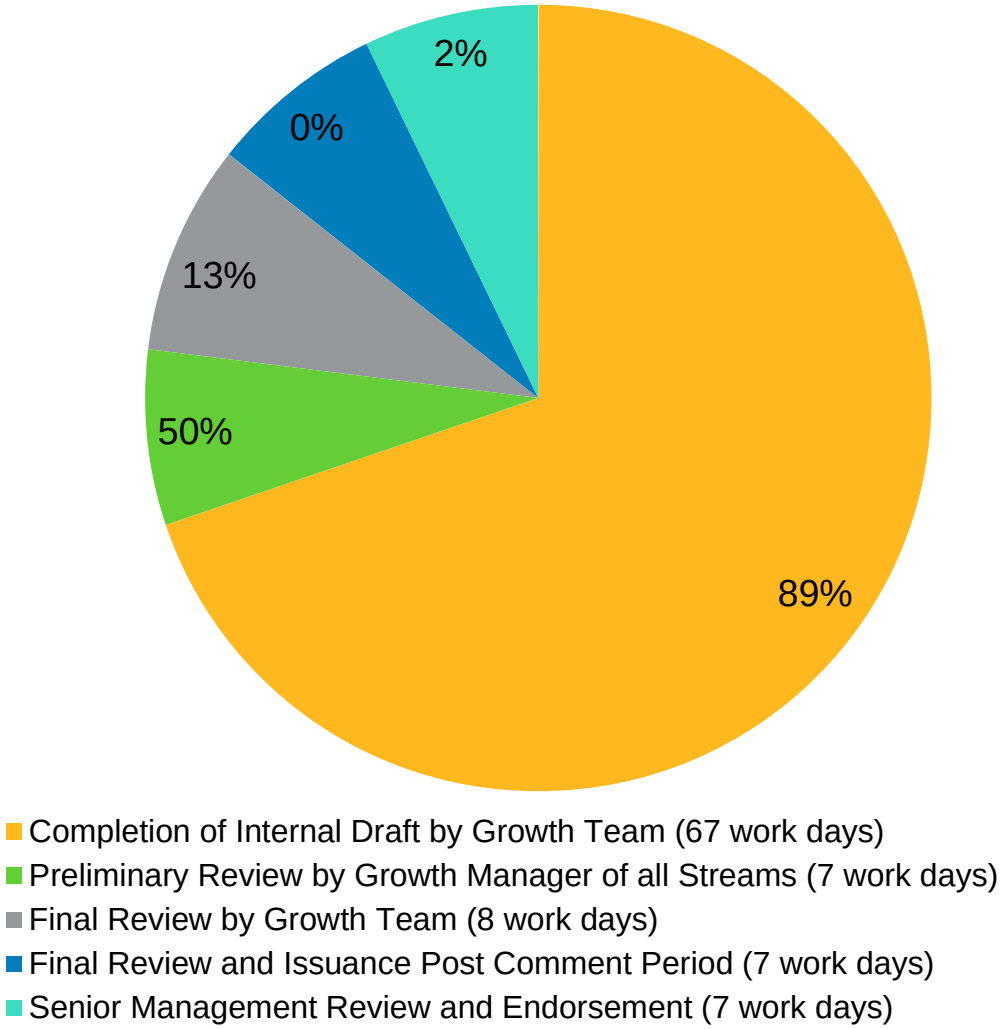
- ✓ Received first draft of the Risk Assessment Report and provided feedback to the Risk Team

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

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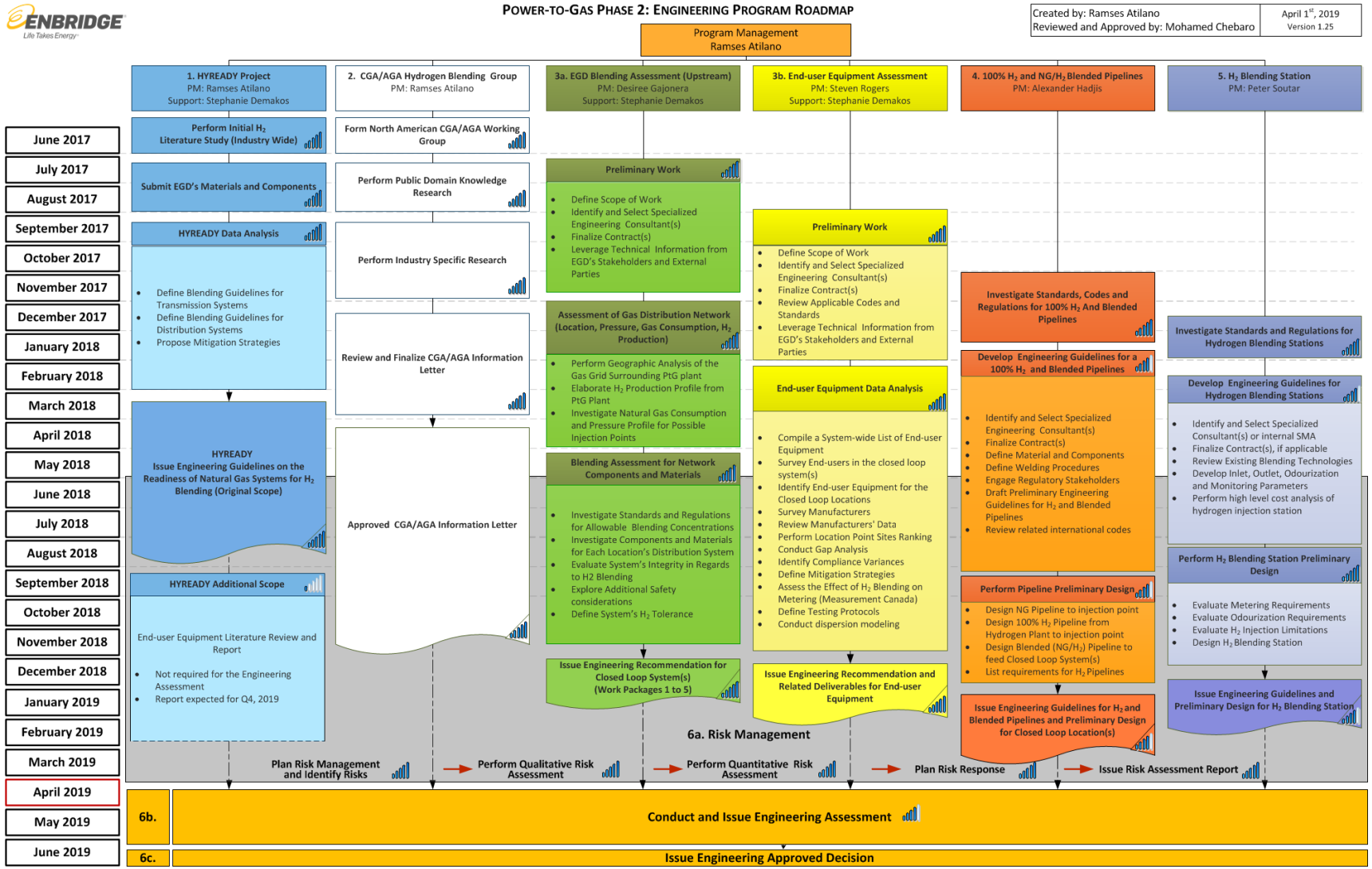
Agenda

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



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

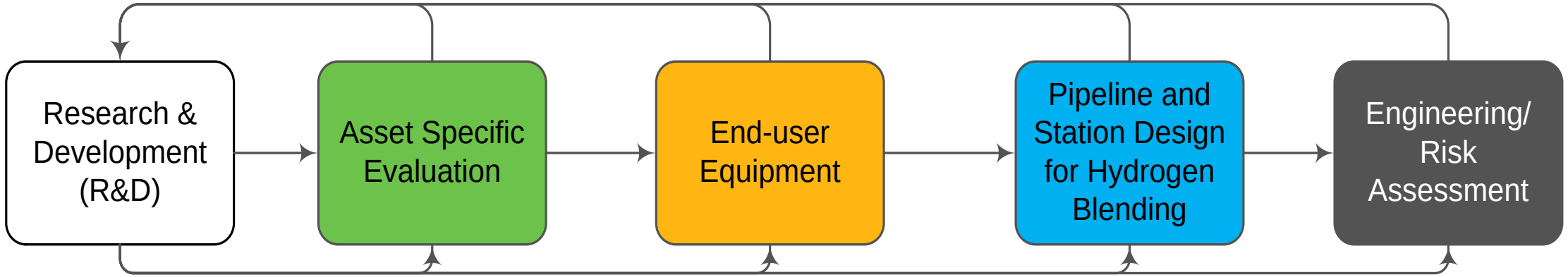
3b. End-user Equipment Assessment
PM: Steven Rogers
Support: Stephanie Demakos

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



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

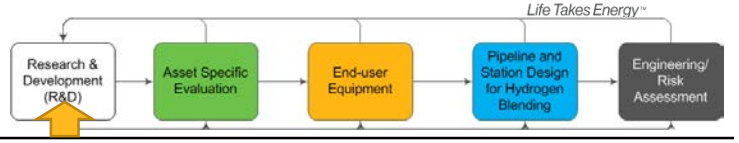
Confirm material suitability through a field survey.
Complete fuel interchangeability analysis.
Modelling of indoor releases

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

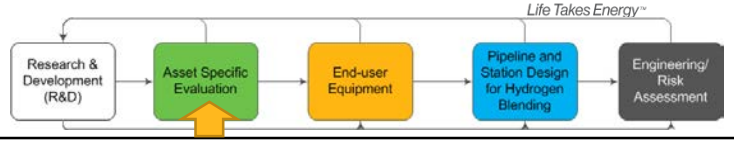
Key Findings



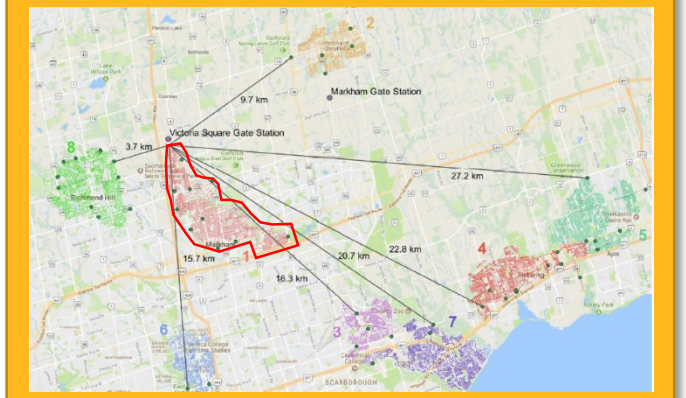
CGA/AGA Task Force	HYREADY Project
• 13 organizations from US and Canada • Component by component review • The gas distribution grid may tolerate blending up to 5% H_2 by vol. with noted exceptions • Recommends site-specific assessment for each blending network	• Global consortium of organizations from 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

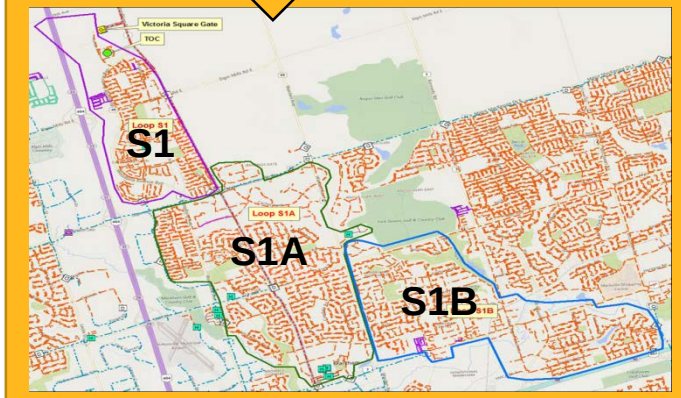


Q4 2017- Q1 2018



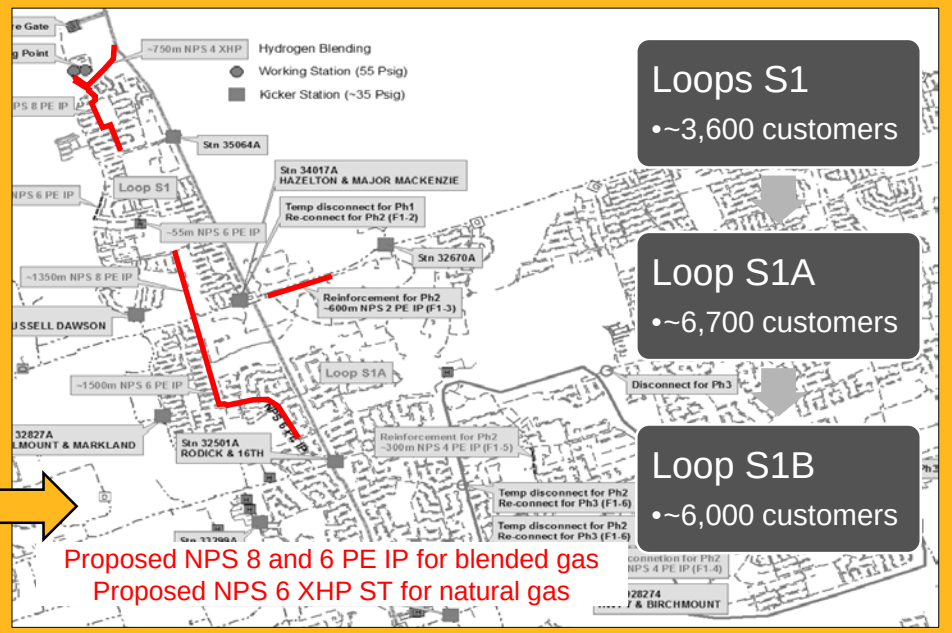
Examined 8 macro-loops (GTA)

Q1 2018



Divided Markham loop into 3

Q2 2018



Loops S1
- ~3,600 customers

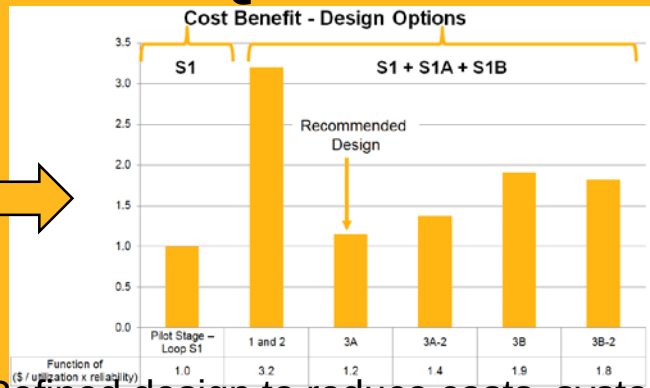
Loop S1A
- ~6,700 customers

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



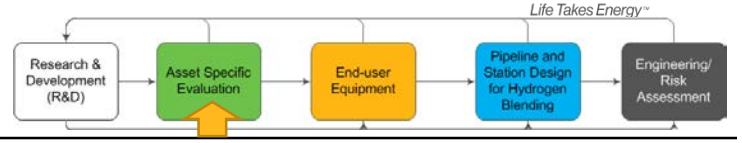
Refined design to reduce costs, system pressure and required modification

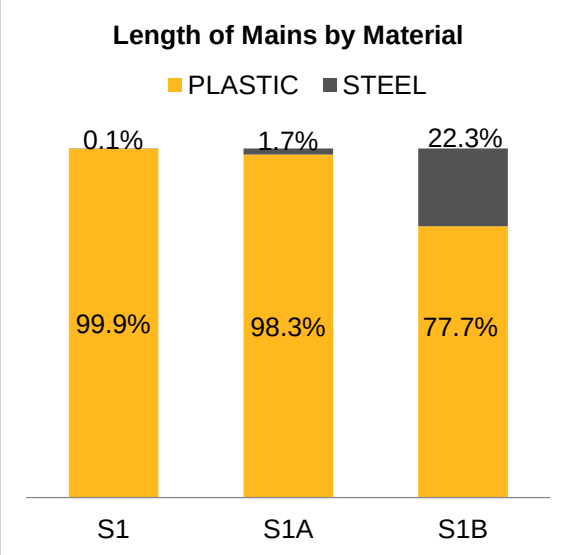
Q1 2019

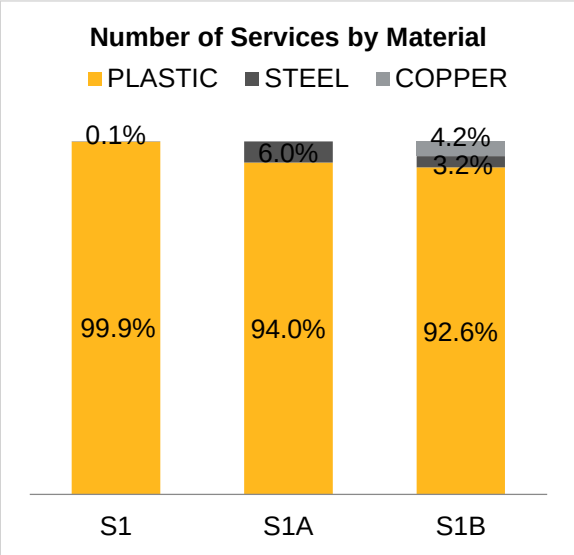
Proposed additional routes to meet regulatory and environmental requirements

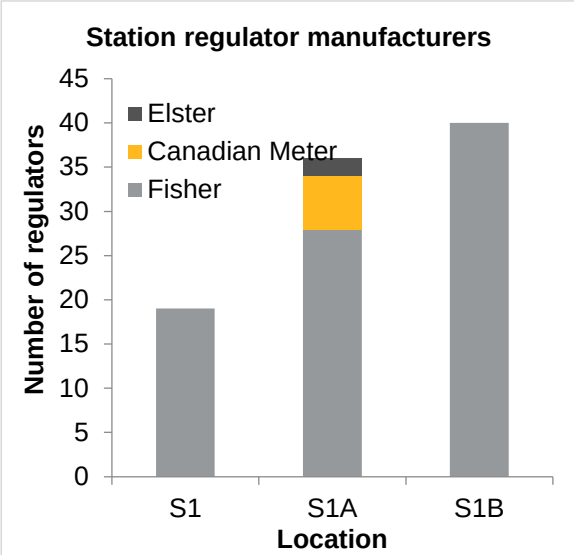
II. B. Network Hydrogen Tolerance

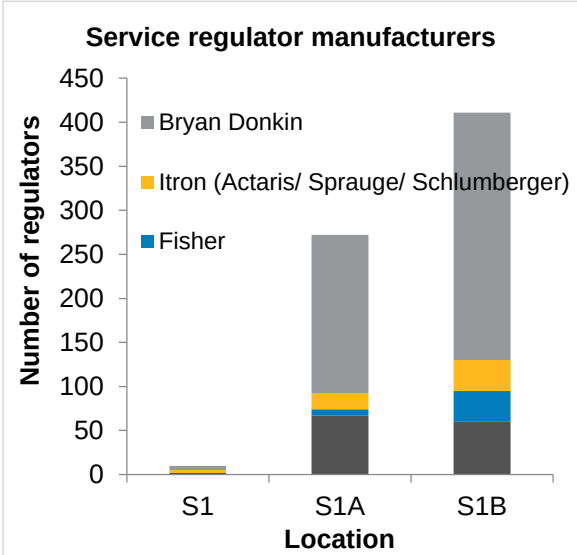
Distribution System Assessment





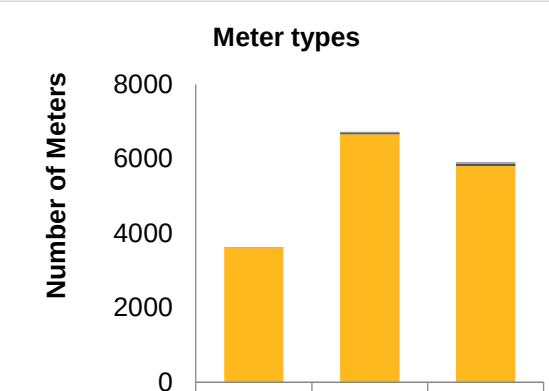






Existing pipe and tubing are compatible with up to 10% by volume hydrogen; the limits for each material type are:

- 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



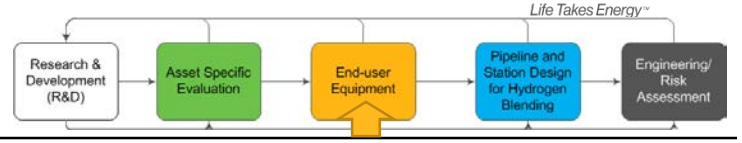
	S1	S1A	S1B
Ultrasonic	0	31	43
Rotary	9	37	55
Diaphragm	3619	6655	5810

Existing regulators are compatible with up to 5% by volume hydrogen

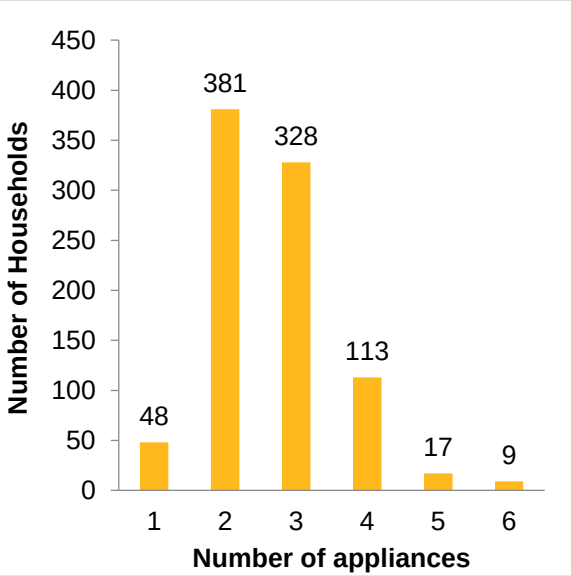
Existing meters are compatible with up to 5% by volume hydrogen

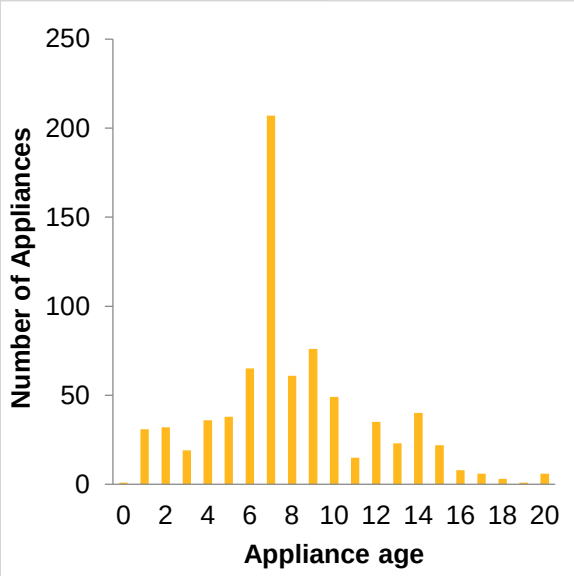
II. C. End-user Equipment Assessment

Two Approaches



1. FIELD SURVEY + ANALYSIS

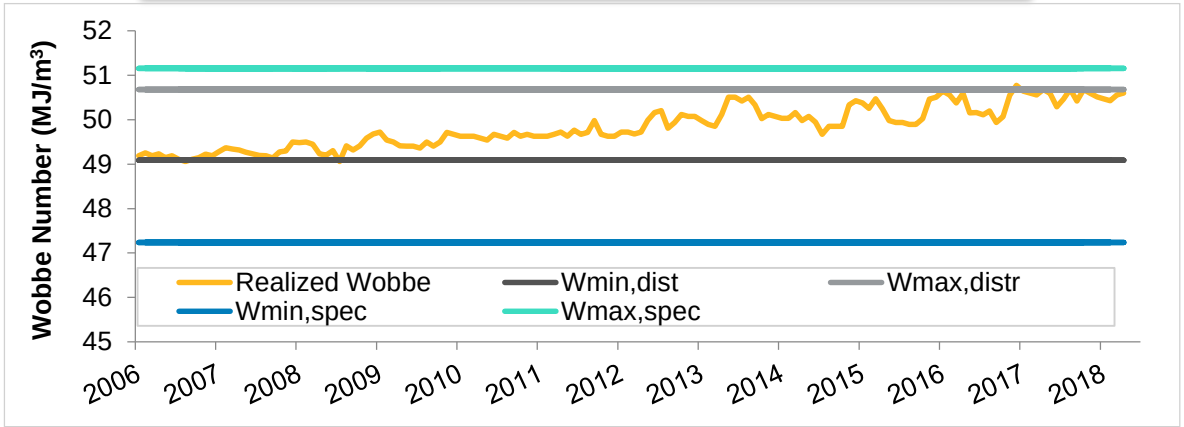




Maximum 5% by volume hydrogen based on an appliance-by-appliance check (limited by fireplaces)

Maximum 2% by volume hydrogen based on interchangeability analysis – the limiting factor is the risk of burner overheating in partially premixed domestic appliances, which is exacerbated at high levels of hydrogen.

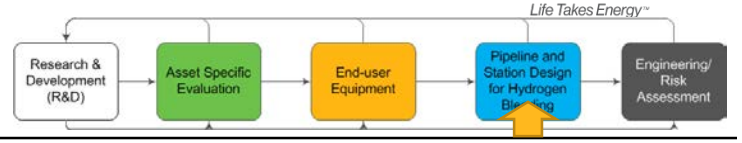
2. INTERCHANGEABILITY ANALYSIS



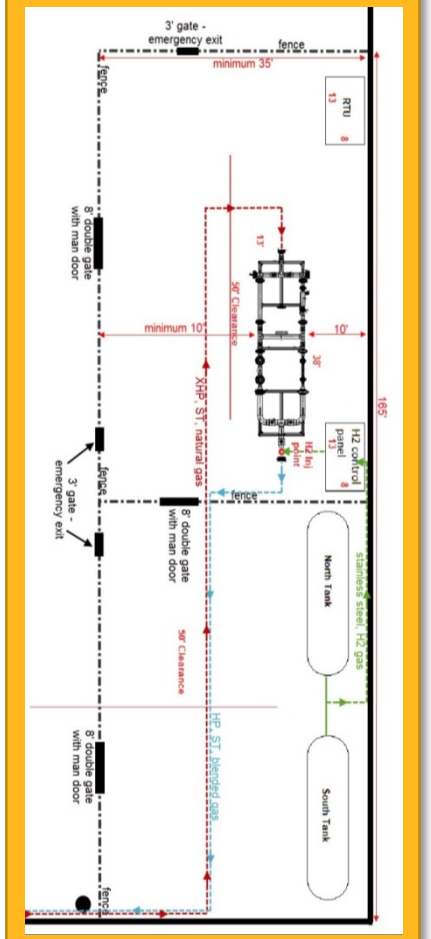
Appliance type	CO_2	CO	NOx	Flame temp	Temp combustion chamber	Lambda (air to fuel ratio)	Flame speed
Residential (no retrofit)	↓	↓	↓	↑	↓	↑	↑
Engines (no retrofit)	↓	↓	↑	↑	↓	↑	↑
Industrial (retrofit)	↓	↓	↑	↑	=	=	↑
Industrial (not retrofitted)*	↓	↓	↓**	↑	↓	↑	↑
Turbines (retrofit)	↓	↓	↑	↑	=	=	↑

II. D. Pipeline and Station Design

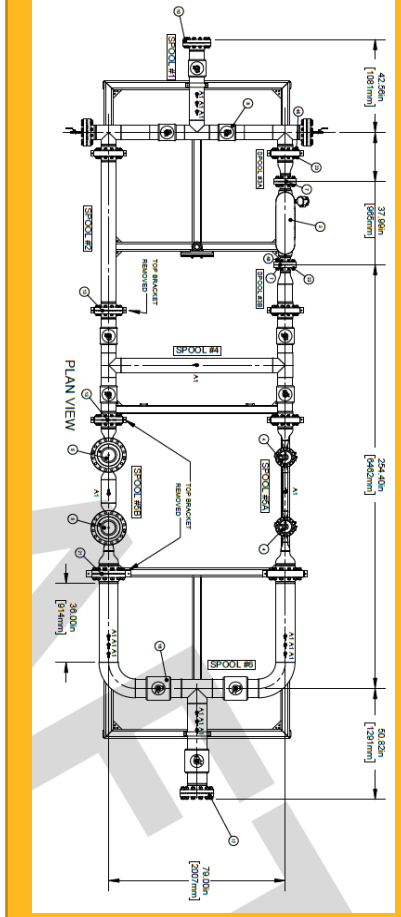
Preliminary Design for Blending



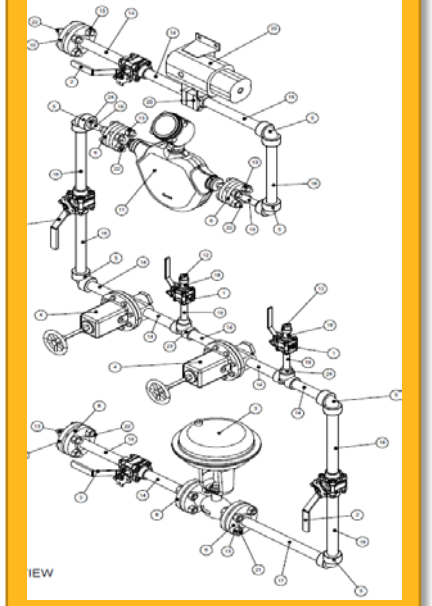
Hydrogen Blending Compound at TOC



Site Plan



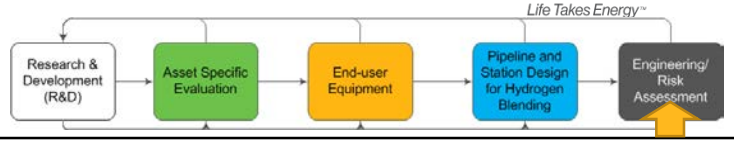
NG Station



H_2 Injection

II. E. Risk Assessment

Methodology and Modelling



Methodology

Hazard Identification Sessions:
- H_2/NG Mixtures
- Customer Assets
- Station Assets
- Pipeline Assets

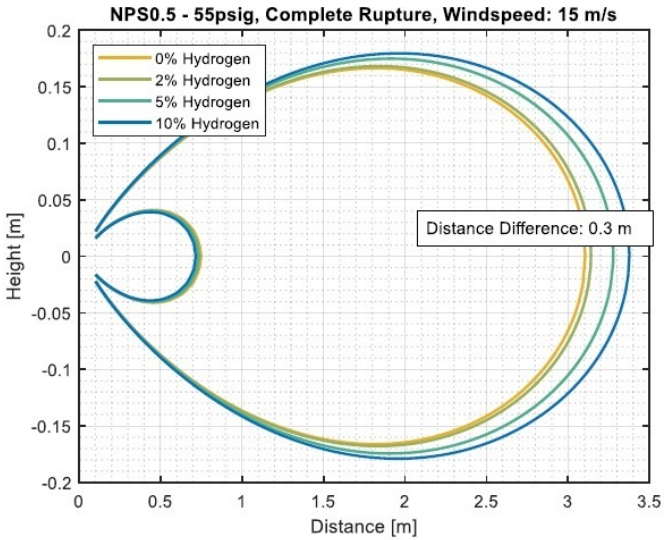
- Consequence Modelling
- Computational Fluid Dynamics (indoor)
- Dispersion modelling (outdoor)

Quantitative Risk Analysis (QRA)

Engineering Assessment (EA)

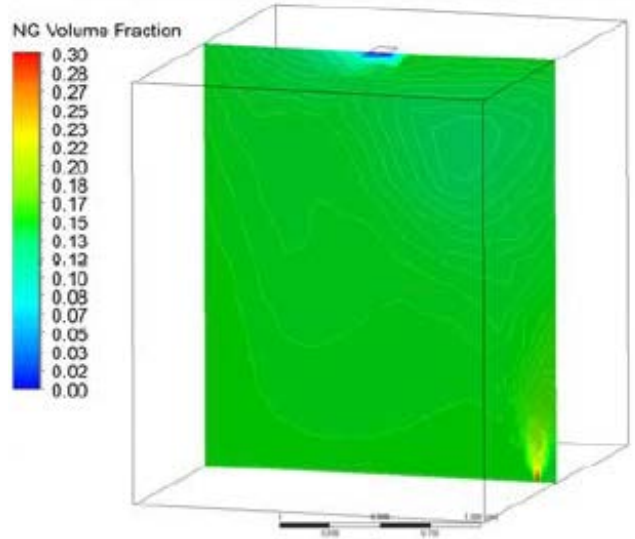
In general, risk will **remain similar or in the same region of risk tolerance**, although it will increase with the addition of hydrogen depending on the type of risk and its inputs.

Outdoor Dispersion Modelling



In the event of an outdoor release, the increase in the distance to LEL changes marginally at 2% by volume hydrogen.

Indoor Release Modelling



Varied parameters: H_2 Concentration (0%, 2%, 5%, 10%), leak size, source pressure, forced ventilation vs. natural ventilation, room size

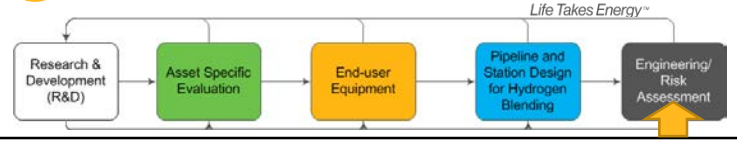
In the event of an indoor release, parameters other than hydrogen concentration (i.e., leak size, pressure, etc.) have a larger effect on the time to reach LEL.

For end-users, the risk increases with the addition of hydrogen, and the best estimate for the increases are (Phillips, 2019):

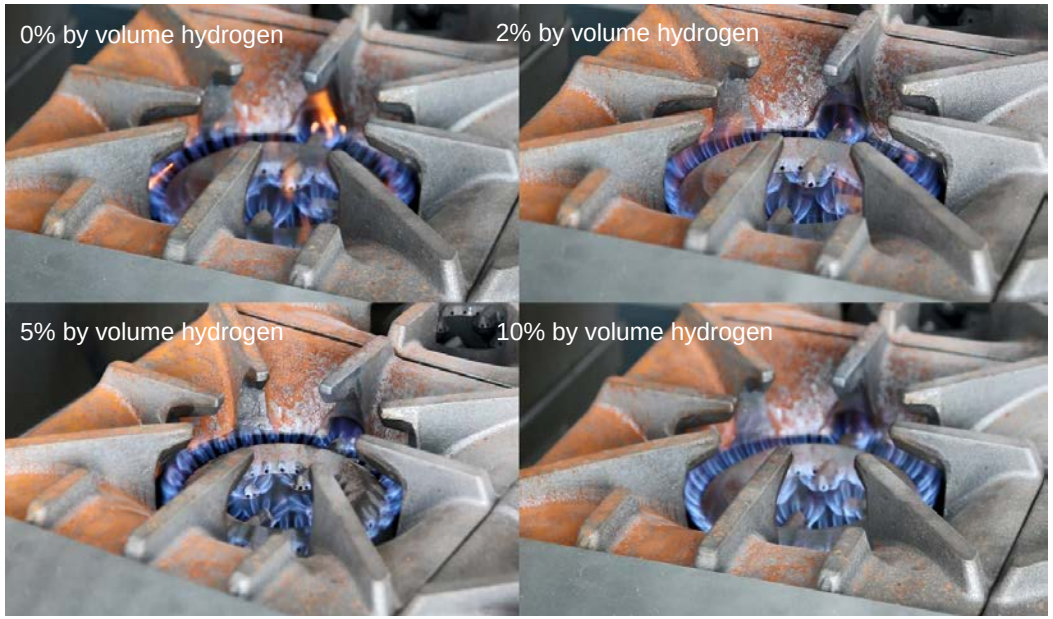
Individual risk increases by 18.9% Societal risk increases by 13.2%

II. F. Leak Detection and Appliance Testing

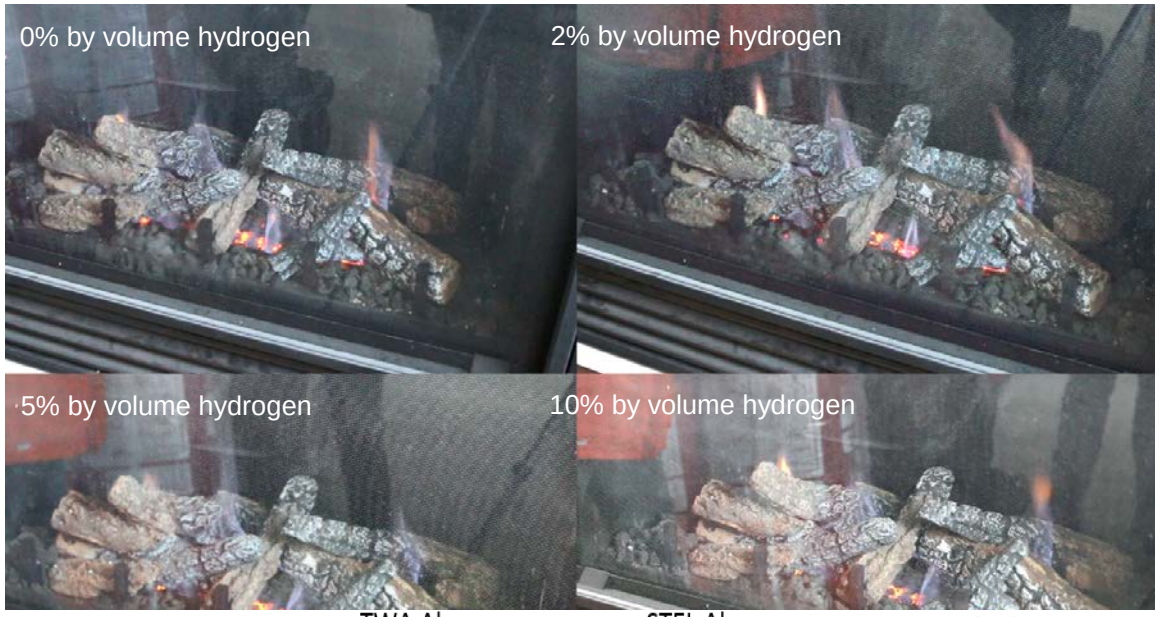
General Observations

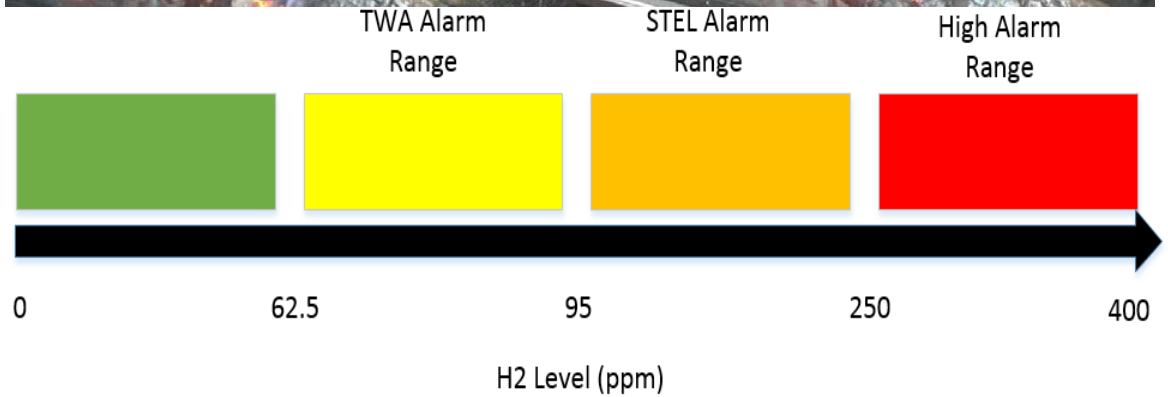


Gas Range Test Results



Fireplace Test Results

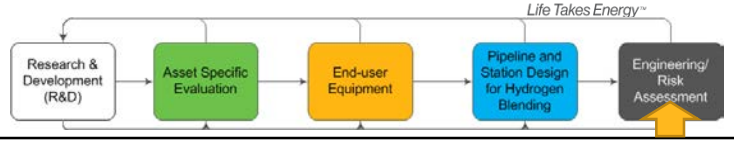




Leak detection equipment using electrochemical sensors can have a cross sensitivity for hydrogen; this needs to be validated against operational procedures, also addressed through training

Conclusions

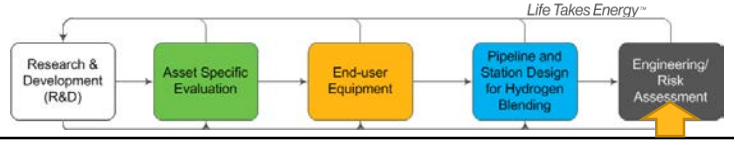
Safety, Integrity and Operations



- 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

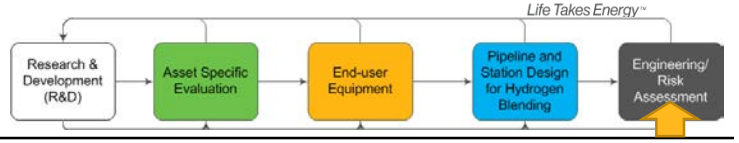
Safety, Integrity and Operations



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

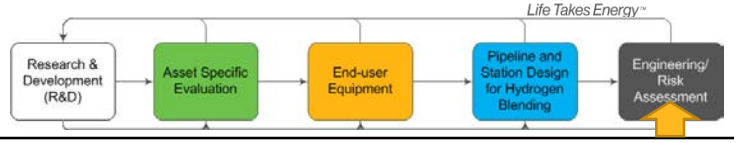
Safety, Integrity and Operations



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:

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

[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 -