What are the challenges and opportunities for enhanced energy efficiency, adoption of clean fuels (e.g., RNG, Hydrogen) and emission reduction methods (e.g., carbon capture and storage) to lower emissions in the natural gas system?

One option often discussed is the possibility of **hydrogen blending into legacy natural gas distribution systems**, which has several challenges to overcome. For hydrogen blending to be successful, public safety and infrastructure reliability are paramount. In addition, it is important to understand the cost increases that Ontario consumers will be expected to bear relative to the limited environmental benefits derived from hydrogen blending. Air Products has raised these concerns and issues in similar discussions in other jurisdictions, including in Alberta and California.

Safety & Reliability Concerns:

A "go slow" approach is prudent. Considerable testing and pilot work is required to assess safe levels of hydrogen blending into existing natural gas systems. The current thinking is that 15-20% hydrogen by volume is likely the upper limit for blending safely into local natural gas distribution systems. Blends above 20% are likely to require substantial upgrades to both the natural gas distribution system, and consumer equipment/appliances used in homes and businesses.

Hydrogen can cause degradation in certain piping systems, such as embrittlement or cracking in the welds of transmission pipelines, which can lead to leaks. As such, some piping systems will require wholesale replacement or significant upgrades beyond what is required for natural gas. Hydrogen can also accelerate pipeline fatigue 30-fold and reduce fracture resistance by greater than 50%[1]. Gas-fired furnaces/fireplaces, appliances and commercial equipment are all built for natural gas, and burning hydrogen may change the combustion characteristics of these appliances – potentially voiding warranties.

Also, because hydrogen has a lower heating value than conventional natural gas, it requires more blended gas to be consumed for the same heat requirement. This may require upgrades to piping and compression systems to transmit the gas reliably, and will require the consumer to burn more gas for the desired amount of energy.

From the perspective of safety and consumer confidence, issues associated with utilizing more hydrogen-rich blends in consumer appliances and equipment must be fully tested to build public support for hydrogen in residential applications. Otherwise, any adverse incidents from a rush to higher hydrogen blending percentages and premature changes to residential appliances could lead to an irreversible loss of trust in hydrogen as an energy source, including loss of warranty coverage for appliances due to non-Canadian Standards Association (non-CSA) compliance.

While there is some diversity of thought, there are several credible studies and reviews that urge caution about introducing hydrogen into existing natural gas distribution systems, including:

- The Alberta Utilities Commission (AUC) released its Hydrogen Inquiry Report in June 2022, in response to the Alberta government's directive to inquire and report on matters related to hydrogen blending into natural gas distribution systems. The AUC urged a cautious approach "until the implications of hydrogen blending are better understood". Among the AUC's findings was that

[1] Hydrogen Effects on Pipeline Steels and Blending into Natural Gas (osti.gov)

"safety and engineering assessments should be conducted before hydrogen is blended into distribution systems" to ensure the sustained durability of the pipeline system at proposed hydrogen blend levels. Based on current knowledge, the percentage of hydrogen that may be blended without requiring significant upgrades to the distribution system, including piping metallurgy, meters, connectors, gaskets, compressors, and end-use customer equipment (and the associated costs), may differ for each individual distribution utility system. Hydrogen Inquiry - Final report

- In 2022, an independent evidence assessment, which surveyed 32 studies focused on the safety, viability, and desirability of using blended hydrogen for commercial and heating, also poses significant uncertainties over the viability of converting the gas networks to hydrogen. Is heating homes with hydrogen all but a pipe dream? An evidence review: Joule

- Hydrogen is known to cause embrittlement or cracking in the welds of transmission pipelines. In fact, the referenced report - Review of Release Behavior of Hydrogen & Natural Gas Blends from Pipelines by Sandia National Laboratory concludes that there is no threshold below which these hydrogen effects can be ignored. SAND2021-9802_Release_Behavior_Review_H2NG_Blends_Pipelines_web.pdf

- The California Public Utility Commission (CPUC) Biomethane Proceeding (13-02-008) commissioned a comprehensive study by the University of California Riverside. This study suggests that as blends approach 5%, issues can arise with piping integrity in legacy systems and recommended 3-year pilot studies before setting any kind of procurement targets or minimum/maximum blend levels. CPUC agreed with this path forward. UC Riverside Report to CPUC.PDF

- Proponents often cite hydrogen trials in the UK as they have been advancing projects more quickly than other jurisdictions. These studies were even cited in Ontario's Hydrogen Strategy. However, there has been a substantive level of public concern with these trials, which underpins the need for good consumer outreach to prevent the public from turning against hydrogen. UK scraps hydrogen home-heating trial in Redcar

- The European Parliament passed amended regulations in 2023 that state that "blending of hydrogen into the natural gas system should be a last resort solution, as it is less efficient compared to the use of using hydrogen in its pure form". Instead, "hydrogen should be prioritised for feedstock, raw material or energy purposes in hard-to-decarbonise industries such as steel or chemicals and hard-to-decarbonise maritime and aviation applications." EUHydrogenRegulation.pdf

- Additional recent reports identify issues with blending hydrogen into natural gas systems: Hard to Handle - Hydrogen's Unique Properties Make Using Natural Gas Infrastructure a Difficult Task | RBN Energy and A review of challenges with using the natural gas system for hydrogen - Martin - 2024 - Energy Science & Engineering - Wiley Online Library

Economic Concerns:

Large hydrogen markets (industrial, power, transportation) have the potential to allow producers to achieve economies of scale and lower costs and prices over time. They should be the priority, and nothing should be allowed to impact their development adversely. Utilizing hydrogen for the residential

and commercial heating market is ill-advised as it is the least promising of the hydrogen markets, due to its seasonality and relatively small demand potential.

While the cost of low carbon hydrogen is expected to decrease over time, it is more expensive than natural gas. The risk of using a higher cost fuel as a replacement for natural gas is magnified because hydrogen has a lower heat content than natural gas which then requires a volume of gas to satisfy consumer energy demand. As mentioned above, the higher volume of gas required may necessitate piping and compressor upgrades in legacy systems which will add costs to the incumbent gas distributor's rate base – which is then passed on to Ontario consumers. Thus, the cost implications for hydrogen blending will be reflected in higher commodity costs as well as utility distribution costs.

Even if blending as much as 15-20% hydrogen into the existing natural gas distribution stream proves safe and practical, doing so at scale would be costly. Once blending percentages beyond this threshold are considered, the costs to retrofit infrastructure and appliances will be enormous. Promoting end-use markets aimed at achieving production at scale while also delivering decarbonization benefits is key.

Environmental Concerns:

The greenhouse gas (GHG) mitigation value of hydrogen can only be realized at very large blend percentages, which are not practical in the short or medium term due to the safety and technical challenges yet to be fully understood (as noted above). Hydrogen combusted for energy produces no CO2 and is considered zero-emission from a greenhouse gas standpoint[2]. However, because hydrogen has a lower heating content, a 20% volumetric blend of hydrogen with natural gas only displaces about 7% of the energy demand with a zero-emission fuel – diminishing its effectiveness relative to sources in other sectors. For example, the use of hydrogen in a heavy-duty fuel vehicle to replace a diesel truck is a much more effective use of hydrogen. Not only does the fuel-cell truck tailpipe produce zero emissions (avoiding the significant emissions from diesel trucks), but hydrogen fuel cell trucks are also more efficient than diesel trucks, adding to the environmental benefits.

In addition, use of hydrogen for residential and commercial heat is only a seasonal opportunity. As the limited supply of low carbon hydrogen increases, it will be important to use it in applications where it yields the most environmental benefit.

[2] Hydrogen blends used in combustion equipment may alter the combustion characteristics (due to different combustion air requirements index and a low ignition energy) and can lead to higher local flame temperatures in burners. This can increase NOx emissions in existing equipment.