We would like to thank the Ontario government for inviting comments in support of their low-carbon hydrogen strategy. We strongly support the overall direction that the government is pursuing and commend the government's efforts to better understand the opportunity and determine how they can best support it.

Our response starts with a summary followed by itemized responses to the specific questions the government has raised. As a private company, which has a cost-effective commercially available technology to produce Hydrogen from biogas, we are more than happy to engage with the government on any questions or follow-up and how we can further help support their initiatives.

Our key point is that the strategy document does not include much commentary about the production of hydrogen from organic waste/biomass/biogas ("organics-to-hydrogen") which we see as a critical pathway for cost-competitive low to negative carbon hydrogen in Ontario. This process is one of the most significant pathways to produce low cost, low (even negative[1]) carbon intensity hydrogen in Ontario. This pathway primarily sources biogas from Municipal Solid Waste (MSW), Wastewater treatment facilities (WWTP), and/or Anaerobic Digesters (AD) from agricultural sites and food processing facilities. As well, our technology ReCarbon, is already being deployed internationally.

This organics-to-hydrogen pathway requires less energy, less water and is significantly cheaper than almost all other hydrogen production pathways. Ontario is also naturally blessed with significant organic resources to be able to produce well over 100 tonnes/day of hydrogen from this pathway alone. Moreover, these sites are distributed across Ontario – many close to major transportation networks reducing the need to transport hydrogen long distances and lowering the cost and footprint of getting hydrogen to market.

We believe that there is an excellent opportunity for Ontario to create the backbone of the hydrogen ecosystem. This can be achieved by developing production of hydrogen from organic waste along the 401 corridor. Government support for building hydrogen refueling stations for hydrogen mobility makes for a very compelling case.

The organics-to-hydrogen pathway converts methane (a global warming potential value of 28 times CO_2) from MSW/WWTP/AD facilities that would otherwise be emitted directly into the atmosphere, flared or combusted. This pathway converts methane into syngas or hydrogen as the final product depending on use-case. As a result, this pathway not only reduces the GHG emissions from avoiding the emissions in production of hydrogen but also emissions avoided by using hydrogen as a fuel instead of Diesel/Gasoline/Natural Gas. Complementary, this pathway requires relatively low demands on electricity (no additional burdens to the grid) and low amounts of water.

[1] Project configuration dependent

As a result, you have a very low greenhouse gas (GHG)/low water impact hydrogen production pathway.

The organics-to-hydrogen pathway aligns with Ontario's goals: competitively priced hydrogen, low GHG emissions (in fact the process is a GHG sink[2]), low water and electricity consumption, and stimulates the local economy with manufacturing and local job creation. This production pathway dovetails with Resource Recovery and Circular Economy Act, which directs municipalities and businesses to meet targets of up to 70% reduction and diversion of food and organic waste from landfills by 2025. Furthermore, the technology enables distributed hydrogen production across Ontario which is complementary to hydrogen production from electrolysis. We believe that multiple different sources of hydrogen are important to balance out supply side of the Ontario market and help diversify risk for the province.

ReCarbon technology uses a plasma technology to convert a waste stream (waste CH_4) problem to hydrogen economically, sustainably while significantly reducing GHGs. Our early estimates are that biogas from Ontario Wastewater Plants and Landfill Plants could produce well over 100 tonnes/day of hydrogen in Ontario.

This technology is being deployed at a Municipal Solid Waste facility in the United States, a thermal power station in Korea and will be demonstrated at a municipal wastewater facility in Cornwall, Ontario. This project has been delayed as a result of COVID-19 or it would already be operating. ReCarbon technology is ready to be deployed in Ontario at landfills, wastewater plants and any anaerobic digester facilities to generate low carbon hydrogen. A distinct advantage of the ReCarbon process is that both CO_2 and CH_4 in biogas are utilized, removing the costly separating and upgrading of methane. As well the technology is capable of converting traditional sources of CH_4 into hydrogen and we are looking at industrial applications where our we take the CO_2 and combine it with natural gas to feed our process.

ReCarbon is active internationally and has meaningfully engaged at the highest levels of industry/government stakeholder networks. In alignment with the Australian National Hydrogen Roadmap (CSIRO), Climate Solutions Fund, and the State of Queensland's Hydrogen Initiatives, ReCarbon has established the first Biohydrogen Technology Cluster in Bundaberg, Queensland, and the formation of the first Biohydrogen Working Group. This working group consists of the State Development Queensland, Bundaberg Regional Council, agricultural and commercial biomass generators, hydrogen demand proponents, and hydrogen industry stakeholders such as Ballard, Xebec, Haskel and HYZON Motors. A public hydrogen refueling station is the centerpiece of the project. ReCarbon is also part of a similar initiative in New Zealand which is establishing a national network of 24 hydrogen refueling stations matched with renewable hydrogen production, with commercial and Federal government support.

[2] Depending on project configuration

Due to the nature of biogas produced from waste there is a requirement both pre- and post-gas treatment systems. Gas conditioning is already a requirement for co-generation currently used for energy from waste systems in a number of Ontario landfill and wastewater treatment plants. The scaling up of innovative equipment and production capacity would provide a great opportunity to leverage the existing high-quality manufacturing and design sectors in Ontario to help build out the necessary components. This would further promote local jobs within the manufacturing sector in Ontario. This could include hydrogen/diesel dual fuel, and hydrogen fuel-cell vehicle homologation, particularly for heavy trucks and buses.

To be clear we believe it is important that Ontario should include both electrolysis and organics-to-hydrogen in their strategy. Having multiple different sources provides for a more robust marketplace in the long term. Different production technologies are able to solve different market problems and are able ensure a diversity of supply of hydrogen. This diversity of supply will have a downward price pressure on hydrogen which would, in turn, drive up Hydrogen adoption across different opportunities.

In closing, we thank the government in pursuing this initiative and we look forward to seeing how we can help the Ontario government navigate its role in the hydrogen future. We hope Ontario will emerge as one of the dominate global forces. Our specific answers to questions begin on the following page.

Specific Feedback Questions

Vision

1. Do you support Ontario's efforts to create a hydrogen strategy?

Yes we strongly support the government's initiative to determine how best to engage and support the fast growing low carbon hydrogen markets. We support the development, government collaboration and implementation of Ontario's low carbon hydrogen policy to promote the establishment of Ontario as a leader in hydrogen production and use as a critical zero emissions fuel. Ontario's private and municipal sectors with the support of provincial agencies (regulatory, policy) have an opportunity to significantly increase economic activity, local investment, employment and establish Ontario as a leader.

2. How would you refine the vision statement?

No comment.

3 & 4 What should be the key outcomes of Ontario's hydrogen strategy? How should the hydrogen strategy define and measure success?

Ontario should incentivize the private sector to produce low carbon hydrogen production. We believe the government should support both the demand and supply side in the early stages while the infrastructure and markets are being established. Alongside industry (such as this very step of getting commentary on their strategy) the government should help identify priority areas for Ontario.

We believe a basket of metrics should help guide the success of the government's strategy. Concrete measurables such as the net zero or net reduction of GHG emissions as a result of utilizing hydrogen, jobs created, private investment deployed, volume of hydrogen produced/consumed, the cost of hydrogen relative to global markets, the number of companies/projects developed and broadly monitor the ripple effects established (such as hydrogen adjacent industries).

Another key outcome should be the reduction of air pollutants from transportation emissions. The Ontario government should set a baseline and measure against that baseline as adoption of hydrogen technologies enter the mobility sector.

Reducing greenhouse gas emissions

5. What are Ontario's key technology, regulatory and business opportunities in developing low-carbon hydrogen?

Two pathways should be considered (1) electrolysis and (2) biomass/biogas from landfills, wastewater plants and agricultural anaerobic digesters. The organics-to-hydrogen pathway is not only low-carbon it is potentially negative-carbon but also highly economical and sustainable. Ontario has 600 plus landfills and wastewater plants across the province which could help build Ontario into a leader in distributed hydrogen production/consumption.

Two pathways are important as they will provide multiple methods to produce hydrogen in a sustainable manner. As the H_2 market matures two pathways will create a more competitive and healthier functioning market. Further, the inputs for the processes are different diversifying the supply chain of hydrogen production.

ReCarbon technology is a modular technology allowing for projects both small and very large. Our technology enables production of hydrogen in communities where the waste is generated and where the hydrogen is consumed. Producing the hydrogen locally from local waste offers many benefits such as local jobs. In cases where MSW or WWTP facilities are close to the off-takers, converting waste to hydrogen on-site significantly minimizes transportation costs and emissions associated with getting product to market.

Business opportunity:

Hydrogen Highway

Ontario has a large part of its population located along the 401, along with many MSW sites and WWTPs sources of biogas. Establishing the 401 as a Hydrogen Highway beginning with Long Haul Trucking could not only reduce emissions associated with diesel combustion and but also convert the biogas of the MSW/WWTPs site from emissions to net zero or better helping resolve that problem.

Furthermore, together with the federal incentives for building hydrogen fueling stations, the province could help locate specific locations and leverage funding from the federal government.

Resource Recovery and Circular Economy Act

Another challenge for Ontario is regulatory: 70% reduction and diversion of food and organic waste from landfills by 2025. This provides a unique opportunity to co-digestate organics at existing municipal wastewater digesters for hydrogen production with ReCarbon technology.

6. What is the potential for hydrogen to contribute to Ontario's 2030 greenhouse gas emission reduction target?

Significant and cost effective if we fully develop the organics-to-hydrogen pathway. Our process not only reduces methane (CH_4 which has a global warming potential of 28 times greater than carbon dioxide) emissions associated with municipal solid waste, wastewater treatment facilities but also reduces the end-use emissions associated (i.e. diesel emission from trucks, emissions for internal combustion engines, industrial process emissions etc.). The process requires electricity (significantly less than electrolysis) but in the case where renewable electricity or alternatively the low carbon intensity of the Ontario grid is used it is either a GHG sink or a net zero process.

We can provide more detailed estimates if the government requests a range of outcomes.

7. What additional environmental benefits should be considered in the development of the strategy (for example during hydrogen production)?

Reduction of emissions associated with municipal solid waste facilities, waste water treatment facilities, pollutants associated with internal combustion engines within the mobility sector (i.e. improving the city air we breath and long term health impacts as a result), emissions associated with industrial facilities in which hydrogen can make a significant impact towards reducing emissions, emissions associated with the on-site or upstream electricity production/transmission.

As previously noted the province will be implementing a ban on the landfilling of organic wastes. It would be prudent to measure those impacts and the amount of the problem that the biogas to hydrogen pathway can help resolve, especially around GHG emissions.

Generating economic development and jobs

8. What role can hydrogen play in various regions and sectors?

Hydrogen can play many different roles in a large swath of markets/sectors. From a sector perspective mobility, power, trucking, industrial markets seem the to be the immediate fit.

ReCarbon technology is a distributed H2 production technology that enables production of hydrogen at landfills and wastewater facilities across Ontario.

9. What actions can Ontario take to help Ontario companies get ready to meet expected international demand (for example research and development, innovation, procurement)?

We believe that there is a bit of a cold start challenge currently in the hydrogen industry. For robust development of the markets there need to be dedicated off-takers of hydrogen so that private organizations can invest capital with confidence that supply will remain in place. This will spur greater demand and set up a self reinforcing cycle.

We believe the Ontario government can help provide a base level of support through either supporting local governments or pursuing hydrogen vehicles for public operations. Ontario could, for example, guarantee to purchase a certain number of hydrogen buses for 10 years through Metrolinx in partnership with municipalities. We believe that if the government alongside other private groups were to co-invest this would generate further follow-on investment and build out the infrastructure and help de-risk capital investments. Another possibility is that Ontario could invest in fuel stations in partnership with the private sector and the federal government.

Any policies that can help with R&D, innovation and procurement to help lower the costs of hydrogen equipment use-cases and hydrogen infrastructure should be prioritized. These initiatives should initially target opportunities that are in the short to near term to help build out demand. Once demand hits a tipping point there will likely be significant private investment; there is a considerable amount of private investment waiting to be deployed in hydrogen.

10. What are the training needs for the workforce to support the economy across Ontario?

We anticipate significant quality job opportunities for Ontario workers. As the province has noted – talented employees are a crucial component of building a new large marketplace. Without exceptional talent, and quite frankly, lots of it – hydrogen will have a challenging time rising to the moment.

Training support will be incredibly important. Having talent being able to operate hydrogen fueling stations, engineering and on-site operations would enable a rapid adoption.

Promoting energy resilience

11. How can hydrogen support a reliable and affordable energy system, including energy storage?

Low carbon intensity hydrogen produced from organics via the ReCarbon process is close to the most cost-effective hydrogen in the marketplace. Furthermore it generates

significant environmental benefits. This hydrogen pathway has a relatively low electrical footprint and hydrogen production would not be a significant strain to the electrical grid even at very high rates of adoptions

As for using this pathway for energy storage – there are mechanisms but one of the hurdles is how to appropriately compensate the asset. We understand some of the current challenges with Global Adjustment; ReCarbon could deliver high volumes of hydrogen without adversely impacting electricity prices by not contributing significantly to Global Adjustment.

Hydrogen/long duration storage could provide benefits. A challenge is to put in place the appropriate financial incentives. This will require a closer examination of the costs to produce hydrogen for commercial consumption and to build hydrogen energy storage/grid assets.

12. What are the barriers and opportunities for hydrogen in the energy system? Reducing barriers and enabling action

The challenge is that there are significant capital costs to introduce hydrogen into the energy market. This is further complicated as there is uncertainty as to the future structure of the markets and in particular Global Adjustment. Global Adjustment features in the likely rate structure for sites which we would be using our technology.

From a project development perspective, the uncertainty around Class A and variable costs of electricity make long term production costs more challenging to model. If the government were to provide a consistent pricing mechanism for low or negative GHG hydrogen, this would take out some of the risk in developing these projects. As well, if there was some mechanism to access surplus electricity that is exported at a low cost that would be helpful for our project economics.

Providing some book ends around the electricity price risk over the next decade would be helpful for determining if these kind of capital outlays are indeed worth pursuing.

13. How can the provincial government best support partnerships with the private sector, academia and other government / levels of government?

Off take agreements are critical to financing and to building hydrogen production in these early stages of establishing hydrogen as a core energy source. We believe there are many different pathways that the government can help support the adoption and development of these commercially ready technologies.

If the Ontario government is interested putting funds into the market there are successful models in California for both solar (California Solar Initiative) and energy storage (Self Generating Incentive Protocol) that had higher incentives available at the

front end of the adoption curve and fast step downs. Though it may be out of the purview of Ontario, it might be worth exploring if investor tax credits (similar to how the US incentivized wind and solar) might be another mechanism to promote low-carbon hydrogen economy.

Where hydrogen technology is in the late-stage development phase, the most challenging phase for commercializing technology, Ontario could help the process by providing pricing supports for low carbon hydrogen by developing pilots, public-private fuelling stations, and providing long-term electricity contracts.

The modular nature of ReCarbon technology unlocks our ability to tailor projects both at the very large end of the production scale and at low production volume sites. The challenge, with smaller sites, is that the biogas clean-up and post gas separation are designed for large volume operations. Miniaturizing these operations is key to competitiveness at small volume operations. Ontario universities and colleges may be able to help as well as the manufacturing base. If there were initiatives to help either lower the cost of development or production of the manufacturing components this would be beneficial to reducing the cost of production and allow the development of the long tail of the hydrogen supply curve.

Ontario can support project development by streamlining the current regulatory approvals (Environmental Compliance Approvals) process. It is suggested that the MECP establish a working group including industry and consulting groups to develop a streamlined approvals process that sets out technical and performance expectations for hydrogen production facilities. Industry can assist MECP with education and knowledge of technologies, their potential environmental impacts and the methods of eliminating or minimizing adverse impacts

14. Are you aware of regulatory barriers that need to be addressed or regulatory enabling mechanisms that need to be put in place? Please explain.

As a reference point, in the US, the low carbon fuel standard (LCFS); most developed in the State of California, the renewable identification numbers (RINS) framework for the production of biofuels, and in Australia, the Australian Carbon Credit Units (ACCU) regime established within the Climate Solutions Fund, that can be derived from the utilization of waste methane emissions, are all enablers for the production of hydrogen from organics sources. Enabling mechanisms which are currently afforded to RNG in Ontario for example, could be applied to the production of hydrogen from the same sources.

Ensuring that organics-to-hydrogen pathway gets similar treatment to other technologies that provide similar levels of GHG emission reduction and hydrogen production is crucial to keep the playing field fair. This is important as the draft Clean Fuel Standard that the federal government is currently in its 75-day comment period.

15. What are the best opportunities to cost-effectively support hydrogen across Ontario while respecting tax-payers?

Investing in low carbon hydrogen generation would produce a competitive sustainable energy source and reduce long term health care costs. In the case of ReCarbon – it is a low to negative GHG emission, low cost hydrogen production pathway which solves an emissions problem from WWTP, MSW facilities. We believe it is an excellent pathway to produce hydrogen, support local investment and jobs, while very much respecting tax-payers and bringing more revenue for the province.

16. What potential feedstocks and stages of the hydrogen supply chain (production, storage and distribution, and end-use) do you think Ontario is best-positioned to develop and lead in and which uses have the greatest potential for cost reduction?

Low carbon hydrogen generation from biogas would produce a competitive sustainable energy source. Ontario has an excellent opportunity from an organics feedstock perspective (greater than 100 tonnes per day of H_2), a potential dedicated hydrogen highway and an excellent manufacturing base to become a major player in hydrogen.

17. What are the main risks of hydrogen use in Ontario and are there opportunities for the government to decrease these risks?

The implementation of the strategy and supports should be quick. It is important to signal to industry, investors and municipalities that hydrogen is seen as a priority replacement fuel for the province of Ontario. Failure to act and/or cautious hesitancy could leave Ontario as a small player of the fast-emerging hydrogen future.

Not including organics-to-hydrogen as a key pathway for production on par with electrolysis would also be a large risk. This is because this pathway lowers Ontario's GHG profile, dovetails with legislation for organics-diversion, requires low amounts of water and electricity, and is able to be distributively produced.

18. Considering that low-carbon hydrogen is expected to be more competitive over time, what should be the timeframe for Ontario's hydrogen strategy?

The implementation of the strategy and supports should be quick. It is important to signal to industry, investors and municipalities that hydrogen is seen as a priority replacement fuel for the province of Ontario. Failure to act and/or cautious hesitancy could leave Ontario as a small player of the fast-emerging hydrogen future.