Ontario Regulation: Increasing Renewable Content In Fuels

Public Comment March 29, 2019

Proposed regulation amendments

The Government of Ontario is proposing the following amendments to O. Reg. 535/05 (Ethanol in Gasoline) under the *Environmental Protection Act*, R.S.O. 1990, c. E.19:

1. require gasoline fuel suppliers to maintain an average of 15% renewable content (e.g. ethanol) in regular grade gasoline, by volume per calendar year as early as 2025
2. require renewable content (e.g. ethanol) used for compliance to emit significantly fewer greenhouse gas emissions than petroleum gasoline, on a lifecycle basis, concurrently
3. other potential updates related to a new lifecycle assessment model, e.g. updating the compliance formula.

Hydrofuel Inc.'s Comments

Adverse Effect on Food

It is a popular notion that ethanol and biodiesel are the ultimate green fuels because they are agricultural products rather than fossil fuels. However, it is impossible to grow enough biofuel feedstock (typically from corn in North America) for this fuel to displace petroleum to any great extent. As crops are grown for fuel rather than food, this diversion of resources places upward pressure on the price of food. Please refer to the 2008 OECD article about rising food prices (OECD, 2008) as well as the OECD report entitled "BIOFUELS: IS THE CURE WORSE THAN THE DISEASE?" (Doornbosch & Steenblik, 2007) found in the Food and Agriculture Organization of the United Nations web site:

> *The OECD has said biofuels may "offer a cure that is worse than the disease they are seeking to heal".*
>
> *"The current push to expand the use of biofuels is creating unsustainable tension that will disrupt world markets without generating significant environmental benefits."*

"When such impacts as soil acidification, fertilizer use, biodiversity loss and toxicity of agricultural pesticides are taken into account, the overall environmental impacts of ethanol and biodiesel can very easily exceed those of petrol and mineral diesel."

A significant amount of fossil fuels (in form of diesel fuel and natural gas) must be consumed to produce ethanol. Diesel fuel is used to operate the farm equipment used to grow biofuels and natural gas is the main feedstock used to manufacture anhydrous ammonia used to fertilize biofuel crops in order to increase their yield.

Automotive Impact

Ethanol contains less energy than conventional gasoline (76,330 vs 116,090 BTU/gal LHV) so E15 contains 110,126 BTU/gal LHV (US DoE, 2010). This means that, on an energy basis, an engine's fuel consumption will increase 5.1% compared to using E0 (gasoline with zero added ethanol). The feedback control system of modern EFI engines will compensate for E15 by automatically enriching the fuel mixture.

While collector vehicles are a small part of Ontario's vehicle population, E15 will cause significant operating problems for them. The lower vapour pressure of the current E10 gasoline causes vapour lock and percolation issues for carbureted vehicles (British Petroleum, 2005). Increasing the ethanol content of gasoline will serve to exacerbate an already bad situation.

With this change in fuel composition, carburetors will need to be re-jetted to deliver the correct fuel-air mixture for this new fuel (unless the carburetor was already too rich). E15's lower energy content and richer fuel mixture requirement will cause unmodified non-computer-controlled engines to consume more fuel and to likely run poorly. The introduction of E15 87 octane fuel will also cause significant financial hardship to older vehicle owners because they will likely have to switch to the much more expensive E0 91 octane fuel to avoid these operational issues.

Better Alternative

Rather than continuing the use of this potent greenhouse gas contributor – both before and after combustion – it would be far better to manufacture anhydrous ammonia (NH3) from fossil fuels (including oils sands bitumen and natural gas) in Canada. NH3 is the 2nd most manufactured commodity in the world and is more hydrogen-dense than even liquefied hydrogen – without the issues of handling a difficult-to-contain cryogenic liquid.

Hydrofuel Inc in partnership with its research partner, *University of Ontario Institute of Technology* (UOIT), and *Kinetic Emergy LLC* has been working on developing technologies to convert petroleum into anhydrous ammonia while capturing the carbon. This carbon can be sequestered or be used as a feedstock in high-value products. UOIT also has processes to convert natural gas into hydrogen gas (H2) and carbon black (C), thereby completely mitigating any impact that methane leakage downstream of the well and combustion have on climate change and ocean acidification. Even with the conventional method of manufacturing NH3 from natural gas, adding urea production reduces the emissions intensity of process.

NH3 may be safely transported by pipeline to the same ports as planned for oil sands bitumen and LNG and there are thousands of km of NH3 pipelines operating world-wide. Although there have been NH3 pipeline ruptures, these have been very infrequent and, since NH3 readily dissipates into the atmosphere (where it breaks down by photo-dissociation), ground and water contamination effects have been minimal.

Ammonia pipeline advantages compared with diluted bitumen pipeline with respect to operation, accidents, and spills:

- Much lower viscosity (like pumping water vs. molasses), less mechanical stress at pumping stations
- Very low susceptibility to low temperature (think of cold molasses), no freezing or coagulation/separation of bitumen from diluent
- Ammonia lighter than air – dissipates quickly, no soil contamination
- Ammonia biodegrades in the environment within hours
- Ammonia has zero GHG potential in atmosphere
- Ammonia has very narrow explosion limits mixing with air, ignition/explosion much less likely than diluent vaporization from diluted bitumen
- Ammonia is "self-alarming" (easy to smell at concentrations far below danger in outside environments) for small leaks
- Ammonia will not collect in dead spaces or cause fouling of pipeline surfaces, much lower risk of performance degradation or undetected internal problems or corrosion.
- Much lower cost and predictable maintenance, no pigging operations required

Ammonia pipeline advantages compared with diluted bitumen pipeline with respect to shipping:

- Ammonia shipping procedures well established over the last 80 years
- Much more flexible options for delivery (many more ports offload ammonia than diluted bitumen – particularly since there are several additional markets for ammonia).
- Ammonia spill from catastrophic shipping accident (running aground, capsize, collision) leaves no environmental trace in water or onshore (albeit obvious other effects associated with any marine disaster of this type.)
- No potential for separation of liquid components (e.g., bitumen, diluent).
- Tank cleaning and maintenance much less expensive
- Potential to utilize ammonia as CO2-free, ultraclean fuel for ammonia tankers (automatically meeting looming International Maritime Organization regulations for much marine fuel emissions of sulfur, particulates and CO2). As an added benefit, this could kick-start ammonia maritime fuel as a much larger market for Canadian ammonia.

The vast majority of oil sands bitumen will ultimately be combusted with a resulting contribution to greenhouse gas emissions. In contrast, the conversion of this bitumen to NH3 allows the capture and sequestration of CO2 in Alberta. Sequestration of CO2 in Canadian oil wells potentially has the added benefit of increasing the productivity of oil wells without the environmentally adverse effects of Enhanced Oil Recovery (EOR) oil well water injection. Ideally, the increased productivity of the oil wells should also go towards NH3 production.

The incremental cost of capturing all CO2 from a Haber Bosch plant are estimated at 15% or less. Probably significantly less with large scale facilities designed and built for purpose. This is likely to be the cheapest way to produce carbon free fuel if combined with CO2 injection or sales to EOR.

- Enabling The Deployment Of Industrial CCS Clusters IEAGHG Technical Report February 2018 - Very Low Incremental Cost Of Carbon Capture For Ammonia (16% Or Less)

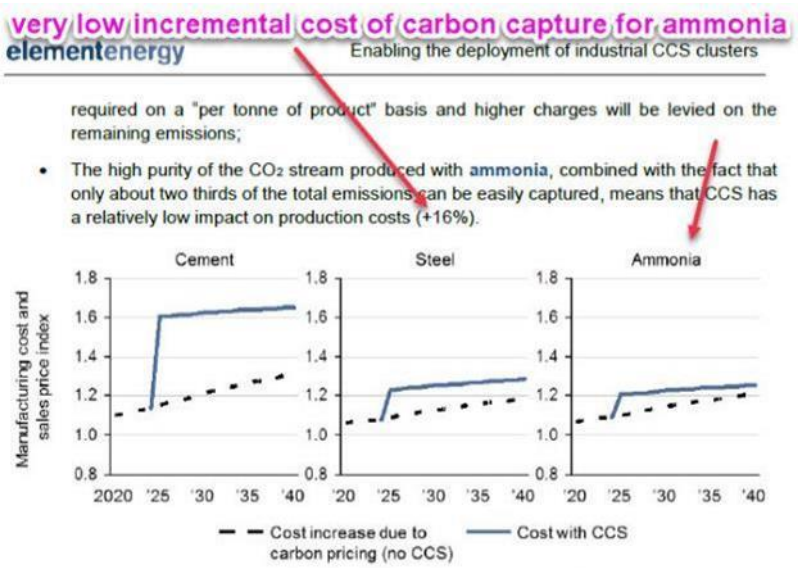

Figure 5: Comparative impact of carbon pricing on three industries.

This is particularly true in Alberta with the Alberta Carbon Trunk Line (ACTL) and the Agrium ammonia plant (largest ammonia plant in North America) as established infrastructure and operations.

- the Alberta Carbon Trunk Line Project Fact Sheet - BY FAR - LARGEST CCS PROJECT IN THE WORLD - AGRIUM NWR ACTL
- ALBERTA HEARTLAND AMMONIA PLANT Agrium Inc. - Redwater - Largest In North America - 1.4 million tonnes of nitrogen based nutrients

New Green Economy

By converting fossil fuels (including oil sands bitumen and natural gas) into anhydrous ammonia, Canada can transform its fossil fuel economy into green energy economy. Building a NH3 facility in Alberta and exporting NH3 rather than fossil fuels means that a pipeline could transport a high-value carbon-free product to tidewater with a resulting significant gain to the Canadian economy. Alberta, BC and other provinces with hydrocarbon resources could use NH3 manufacturing to make five to ten times as much money from petroleum resources than it does now.

In 2007 the *Intergovernmental Panel on Climate Change* (IPCC) recognized the huge opportunity of using NH3 to store renewable energy and to capture and convert CO2 from hydrocarbons into valuable urea in their *Fourth Annual Assessment Report*, and how doing so would be viable compared to all other CCS technologies.

Significant reductions of CO2 emissions, below those achieved by state-of-the-art ammonia plants, could be achieved by using low-carbon or carbon-free hydrogen, which could be obtained through the application of Carbon Capture and Sequestration (CCS) technology, biomass gasification, or electrolysis of water using electricity from nuclear or renewables. About half the ammonia produced for fertilizer is reacted with CO2 to form urea (UNIDO and IFDC, 1998). However, this use of CO2 reduces the potential for applying CCS technology.

In addition, here in Canada, we have vast renewable energy resources that are far from the areas of the continent that need it. The generation of renewable energy does not often match electrical demand in the grid. Very often, those energy-rich areas are within First Nations territories. Green ammonia is manufactured from nitrogen from the atmosphere and hydrogen from water using electricity ultimately from the sun. When it ammonia reacts with oxygen, it once again becomes nitrogen and water. Indigenous communities in these remote locations could then benefit by participating the manufacture of green ammonia from wind and hydroelectric power.

The bulk of Canadian NH3 production is currently from “brown” sources – that is, fossil fuels (like natural gas) are used as the feedstock. However, Canadian NH3 production is among the lowest CO2 emitters in the world due to the recycling of waste CO2 into urea. In fact, all 12 ammonia plants in Canada use about 40% of the sequestered CO2 mostly for producing urea and for the carbon pipeline used for enhanced oil recovery.

We believe that ammonia is the ideal carbon-free fuel because:

- It is the one of the highest-manufactured chemicals in the world.
- It contains more hydrogen than liquefied hydrogen per unit volume.
- It is handled and transported very much like LPG.
- Very small leaks are easily detectable by the human nose without the complexity of added odorants.
- Any land-based spills dissipate into the atmosphere, where photo-dissociation breaks it down without any greenhouse gas effect.
- Any marine spills would dissipate into the ocean without causing a long-term environmental catastrophe.

Concluding Remarks from UOIT's MITACS Study Results about the Decarbonisation of Fossil Fuels, *Chapter 4: FROM HYDROCARBONS TO AMMONIA:*

Utilization of hydrocarbons in an environmentally friendly manner becomes more significant day by day and the dissociation of hydrocarbons such as methane is a promising option. Based on the extensive literature review and assessments, the following concluding remarks are noted.

- Hydrocarbons can be used as a source of hydrogen which is required for ammonia synthesis. There are various alternative pathways for hydrogen production from hydrocarbons such as thermal, non-thermal, plasma routes.
- Methane decomposition reaction is moderately endothermic process. The energy requirement per mole of hydrogen produced is considerably less than that for the steam reforming process.
- Hydrogen via thermo-catalytic dissociation of hydrocarbons represents an alternative solution. It is accompanied by the formation of carbon deposits. Methane can be thermally or thermocatalytically decomposed into carbon and hydrogen without CO or CO2 production.
- It can be estimated that the electric energy supply needed for the cracking operation varies between 4 and 7 kWh per kg of carbon produced or between 1 and 1.9 kWh per normal cubic meter of hydrogen produced.
- Gliding arc discharge reactor is one of the highest efficient route for methane conversion which was experimentally tested by many researchers.
- H2 production cost that can be expected from industrial methane cracking could be of the order of 1.5 $/kg and NH3 in the range of 0.3-0.5 $/kg.
- The microwave energy can be of sufficient power and duration to cause microwave depolymerization of the high molecular weight materials such as bitumen.
- For oil sands or extremely high viscosity reservoirs, where the temperature effect on viscosity is significant, electromagnetic heating could be used as a preheating purposes. Because lower frequency waves carry less energy, heating times are considerably longer compared to the higher energy microwaves.
- Optimized ammonia synthesis using the excess heat in Haber-Bosch ammonia plant for oil sand bitumen extraction which is used for hydrogen production via microwave dissociation process is possible.
- The current ammonia retail prices continue to decrease by low natural gas prices. Current retail price is about 550 US$/ton. However, ammonia price is strictly dependent on natural gas price which can be eliminated if oil sand bitumen is utilized.
- Although hydrocarbon dissociation route is a fossil fuel based process, the technology is clean and environmentally friendly close to renewable resources in some environmental impact categories.

Summary

The production of ethanol for the fuel industry has driven up the general price of food by using corn crops for non-food production. In addition, the life-cycle environmental benefits of ethanol motor fuel from the farmers' field to the tailpipe of a vehicle are negligible at best and adverse at worst. Overall environmental effects must be considered and not just tailpipe emissions.

For the reasons stated above and supported by Dr Ibrahim Dincer's group at UOIT (MITACS reports found in *Other References*), Hydrofuel Inc. believes that it is far better to use renewable hydrogen fuel in the form of anhydrous ammonia rather biofuel fuels to combat climate change.

We recommend that the Government of Ontario contact the *University of Ontario Institute of Technology's Clean Fuel Research Laboratory*, located in Oshawa, Ontario for advice about the best course of action to combat climate change. UOIT is a global leader in clean fuel technology.

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