January 8, 2018

Michael Rensing, PhD
Director, Low Carbon Fuels
Renewable Energy Development Branch
PO Box 9314, Stn Prov Govt
Victoria, British Columbia
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Dear Mr. Rensing:

Please accept this letter as the submission of Methanex Corporation on the pathway assessment for the British Columbia *Greenhouse Gas Reduction (Renewable and Low Carbon Fuel Requirements) Act* (Act) and the Renewable and Low Carbon Fuel Requirements Regulation (Regulation).

Methanex is headquartered in Vancouver, BC, and is the world's largest producer and supplier of methanol. Methanex currently operates production sites in Canada, Chile, Egypt, New Zealand, Trinidad and Tobago and the United States. Our operations are supported by an extensive global supply chain of terminals, storage facilities and the world's largest dedicated fleet of methanol ocean going vessels.

Methanex adheres to Responsible Care®, a United Nations recognized sustainability initiative, and to the highest principles of health, safety, environmental stewardship, product stewardship and social responsibility. Methanex actively promotes safe-handling information to ensure our product is manufactured, stored, transported and used safely.

Methanol is the simplest alcohol (CH_3OH); it is a clear liquid chemical that is water soluble and biodegradable. Methanol production is regarded as the most efficient means of converting natural gas into a liquid fuel. While methanol is typically produced from natural gas, it can also be produced from a wide range of renewable and non-conventional sources, including captured CO_2. Methanol is used to make a countless array of consumer and industrial products, and is also used around the world as a clean-burning alternative fuel for road, marine and other energy applications. Approximately 45% of global methanol demand now comes from energy applications.

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We recognize that the LCFS is an important program in achieving the planned reductions under the government's climate change plan. We support the utilization of clean fuels, and look forward to working with the government to demonstrate how methanol, dimethyl ether (DME) and biodiesel can help meet your objectives. We are concerned about some of the conclusions and comments in the current pathway assessment and offer the following information regarding methanol, dimethyl ether (DME) and biodiesel fuels for your consideration.

We would welcome the opportunity to discuss the expanded use of these fuels with you at your earliest convenience. We plan to participate in the session planned to be in Victoria the week of January 22, 2018. If you have any questions, please do not hesitate to contact me directly.

Sincerely,

[redacted]

Paul Daoust,
Vice-president North America

CC: lcfrr@gov.bc.ca

Submission on the Low Carbon Fuels Compliance Pathway Assessment

A. Pathway Assessment for METHANOL

Responding to Section 10.2 – Market Outlook, Challenges and Opportunities for Methanol:

Methanol/gasoline blends are permitted in a number of countries and regions, and are under consideration in many others. Methanol is permitted in the European fuel standards and is currently blended into gasoline in some countries in Europe through normal retail outlets. Like ethanol, methanol serves as an octane enhancer and results in lower refining costs for traditional refiners. For example, methanol blends are available at retail outlets in the Netherlands (Argos) and in the United Kingdom (Greenergy). GEM, a fuel blend containing gasoline, methanol and ethanol, is under consideration in Sweden[1].

Supported by national and provincial standards, methanol is also being blended into gasoline extensively in China in ranges from 5% up to 100%, which is discussed further below. Interest in methanol gasoline blending is growing with New Zealand, Israel, Italy, and Australia recently updating regulations or announcing pilot programs to support the introduction of methanol blends with up to 15% methanol (M15). Other countries, including India, are undertaking efforts for the introduction of methanol in the transportation fuels markets. In December 2017, the government of India gave notice of its intent to amend the Central Motor Vehicle Rules to introduce flex-fuel methanol M15 or M100 and methanol MD95 vehicles. Even in the U.S., the *Open Fuel Act of 2017* was introduced in the House to broaden and diversify the U.S. fuel pool to include methanol and other alternative energy sources to gasoline. In 2012, the US Environmental Protection Agency approved a petition from Baker Hughes for the use of an alternative corrosion inhibitor (TOLAD MFA 10A) with the CAA Section 211(f)(4) OCTAMIX waiver blend of up to 5% methanol by volume along with 2.5% co-solvents in gasoline.

In Denmark, fuel retailer "OK" has recently opened Europe's first M100 refueling station supplying electric vehicles fitted with methanol fuel cells as range extenders in a program supported by the Danish government.[2] Following recent discoveries of large-scale natural gas reserves, the Israeli government has sponsored development of M15 and M70 fuel standards under its Fuel Choices Initiative, as an energy security measure. Israel approved its M15 fuel standard in 2017,[3] and has a stated intention of ensuring that methanol makes up 20% of the transport fuel supply by 2025.[4]

Methanol/gasoline blends are widely used without adverse impact on the vehicle fleet or fuel

[1] https://bioenergyinternational.com/biofuels-oils/study-explores-gasoline-ethanol-methanol-gem-fuel-potential-sweden

[2] *The opening of Europe's first methanol filling station,* Press release, Serenergy A/S, 27 August 2015

[3] http://methanolfuels.wpengine.com/wp-content/uploads/2013/05/Israel-M15-Press-Release-8_2016.pdf

[4] *Israel's Fuel Choices Initiative* Dr. Anat Bonshtien, Prime Minister's Office, retrieved October 2015 (www.methanolfuels.org/wp-content/uploads/2013/05/Anat-Bonshtien-Israel-Prime-Ministers-Fuel-Choices-Initiative.pdf)

distribution systems. Methanol has similar characteristics to ethanol when blended into gasoline. Therefore, facilities designed for ethanol blending are likely to be easily adaptable for methanol blending. The 2006 Report on Waivers for Biofuel Blend commissioned by MBIE provides a useful reference in this regard.[5]

Methanol is more commonly produced from natural gas (although it can also be produced from biomass and other renewable sources), a natural resource that is readily available in British Columbia and Western Canada. Methanol is also produced in Alberta with established logistic routes through British Columbia. Supporting methanol as fuel can further create regional manufacturing facilities, generating well-paying jobs and taxes, in addition to increasing the regional energy independency and security.

Methanol has a long history of safe manufacture, distribution and use in Canada. Globally methanol is one of the top five commodities shipped every year. Through an extensive global supply chain and distribution network of terminals and storage facilities, methanol is delivered to customers worldwide by tanker, barge, rail, truck and pipeline. Like gasoline and other fuel components, methanol needs to be stored and handled appropriately to ensure there are no adverse health or environmental impacts. The same logistics systems that are used for gasoline are used for methanol.

Methanol blending in British Columbia could be undertaken using similar processes and infrastructure already used for ethanol/gasoline blending. The successful adoption of ethanol/gasoline blends in British Columbia over the past decade provides the template for introducing low-level methanol blends into the fuel pool, possibly with a GEM composition, to build upon current operations and standards, without disrupting the ethanol blending alternative.

While we recognize that the views of the original equipment providers (OEMs) are important to any discussion on fuel content and quality, we do believe that the global evidence supports methanol's widespread use. In the past, at higher blends, there were some issues associated with components of automotive fuel systems. However, since then the components for fuel systems in cars have advanced to the point where materials now used are tolerant to higher levels of alcohols such as methanol and ethanol. In the early 1990s, automakers developed Society of Automotive Engineers (SAE) guidelines recommending the use of M15 as a reference fuel to qualify materials for general use in automotive fuel systems.[6] This indicates that since at least the early 1990s, fuels systems have been designed to be safe for operation with methanol/gasoline blends containing up to 15% methanol.

There is no better example to illustrate this point than China, the largest user of methanol for automotive fuel. In China, the use of methanol is widespread. It is estimated that methanol makes up more than 6% of China's national petroleum fuel consumption from a passenger vehicle fleet greater than 100 million vehicles. The most common blending level in China is M15 (15% methanol), which is

[5] *Investigation of Fuel Specification Waivers for Biofuel Blends* for Ministry of Economic Development (now MBIE); Hale & Twomey September 2006

[6] (i) *M15 Gasoline Blends, 35 years of research supports its use*, Methanol Institute.
(ii) *A Rational Approach to Qualifying Materials for use in Fuel Systems,* SAE 2000-01-2013

used in standard vehicles supplied by global automakers without modification. China also has national standards for M85 and M100 use in modified vehicles.

China's domestic automakers have not found it necessary to add any cautionary statements on methanol in their vehicle's owner manuals even though the fuel system materials are the same as platforms in other global markets. China's successful experience with commercializing and growing the M15 fuel blend market in the existing vehicle fleet without need for modification has been investigated and summarized by the IAGS (Institute for the Analysis of Global Security).

By way of example only, attached is a report that features the work of Fiat-Chrysler – a member of the Canadian Vehicle Manufacturers Association – which is producing vehicles that have higher methanol blends.[7] [8]

Responding to Section 10.3 – Outlook for Carbon Intensity of Methanol:

We encourage the LCFS to take a comprehensive view of the impact that a fuel has on the environment. Methanol is a clean burning fuel and there are pathways to achieve emissions reductions. We would point out that methanol produced using carbon dioxide injection technology (low carbon), engine improvements, fuel cell based technology, and renewable methanol offer significant opportunities for GHG reductions.

There is a commercial scale municipal solid waste to methanol conversion facility in Edmonton operated by Enerkem capable of converting municipal solid waste into methanol and ethanol. Pathways for other renewable sources of methanol that have been deployed or are under development around the world include: paper pulp (Lundberg), black liquor conversion (Chemrec), black liquor purification (Invicotech, AB), Crude Glycerine (BioMCN), Biogas (both from sugar and municipal waste) (BioMCN), Electrolysis (CRI) and wood gasification (Värmlands Metanol AB).[9]

One particularly promising development internationally has been using carbon dioxide emissions to produce methanol. In 2011, Carbon Recycling International (CRI) opened a methanol plant in Iceland that captures carbon dioxide from geothermal steam and using electricity from renewable sources produces methanol as a carbon neutral fuel (power to methanol). Methanol from this plant is sold to fuel markets in Iceland and Europe, including for use in methanol/gasoline blends in accordance with EU specifications on oxygenates.

The Methanex facility in Medicine Hat, Alberta uses natural gas (methane) both as feedstock and as fuel gas for the methanol production process. A notable part of the process is the incorporation of CO_2 injection to produce a methanol product stream with a lower carbon intensity. In this process, CO_2

[7] https://www.fcagroup.com/en-US/sustainability/fca_news/Pages/FCA_Methanol.aspx
[8] http://www.press.fcaemea.com/press/article/fiat-chrysler-automobiles-presents-jointly-with-dor-chemicals-and-ifci-the-result-of-the-m15-project-the-first-methanol-powered-euro-6-vehicle-the-fiat-500-m15
[9] http://www.methanol.org/wp-content/uploads/2016/07/Bo-Gleerup-presentation.pdf

that has been captured from a neighboring industrial facility is injected into the methanol synthesis loop, which significantly improves carbon efficiency in the process. This low-carbon methanol stream offers life-cycle carbon intensity reductions compared to a variety of traditional fuels. (S&T)[2] undertook an analysis of the GHG emissions of the incremental methanol produced from CO_2 injection at our Medicine Hat plant and the result was that the methanol offers an approximately 30% reduction in GHG emissions compared to gasoline. Furthermore, this process is recognized by the Alberta Carbon Competitiveness Incentive. We believe it should be recognized under the LCFS as well.

Methanex estimates that significant reductions in GHG emissions compared to other fuels are possible in B.C. from using methanol from renewable and non-conventional sources, including carbon injection, and alternative engine technologies as shown in the wells to wheels GHG reduction comparisons in Figure 1.[10] The data shown in this table is from commercially-ready technologies currently utilized or demonstrated in other jurisdictions.

Figure 1

Methanol Fuels - Reductions in GHG Emissions Compared to Gasoline	
Conventional Methanol Produced from Natural Gas	
M85 (Flex-fuel vehicle), W Can	(4.9%)
M100 (Geely / Methanol Tuned ICE), W. Can.	(9.4%)
Serenergy Methanol Fuel Cell Vehicle	(20.0%)
Methanol from Renewable/Non- Conventional Sources	
M100 (CO2 Injection, Medicine Hat, AB)	(30.0%)
M85 (Municipal Solid Waste)	(49.5%)
M85 (Power to methanol - B.C.)	(54.7%)
M85 (wood residue)	(59.2%)

On the vehicle side, there are manufacturers who are realizing reductions in GHG emissions from designing methanol specific engines. Geely, a Chinese automobile manufacturer, has introduced a M100 passenger vehicle that reduces the GHG emissions by 9.4%. They have also introduced several vehicles in the heavy-duty truck and bus category that use M100. It is possible that further optimization of the engine may improve this performance.[11] Serenergy, a Danish fuel cell manufacturer, has used its methanol fuel cells as range extenders in small electric vehicles adding another 800 km to the range of a battery EV. This application can reduce the GHG emissions by 20% to 23% compared to a gasoline or diesel vehicle using conventional methanol produced from natural gas. Improved performance could be achieved with renewable methanol.

Other Environmental and Health Benefits of Methanol as a Transportation Fuel:

Methanol spills to the soil, groundwater, and surface water will quickly biodegrade under both aerobic and anaerobic conditions and, consequently, methanol is not expected to persist in the environment. When compared to other petroleum based fuels, methanol is more environmentally benign, and these are not insignificant variables to consider.

[10] Methanex generated table based on report prepared by (S&T)[2] Consultants using GHGenius
[11] http://methanolfuels.org/cri-unveils-geely-m100-car-in-iceland/

Methanol exhibits a lower toxicity to both humans and indigenous microbes than conventional gasoline. While methanol is often considered to be more toxic than gasoline, the threshold limit value (TLV) for methanol vapour is only slightly lower than that for gasoline; and the U.S. Department of Energy considers gasoline to be 'overall' more hazardous to health than neat methanol (USDOE, 1991). In 1994, the US EPA noted that methanol was a safer fuel than gasoline, harder to ignite, slower to burn, and releases heat at only one-eighth the rate of gasoline fires.

Additional Consideration – Methanol as Marine Fuel:

Leading shipping companies such as Stena, Westfal-Larsen, Waterfront Shipping, Mitsui O.S.K. Lines and Marinvest/Skagerack Invest have selected methanol as a fuel. In 2014, Methanex collaborated with industry partners to complete the SPIRETH ("alcohol (spirits) and ethers as marine fuel") demonstration project. This led to the development of the world's first methanol-powered ferry, the Stena Germanica, which operates exclusively in the Baltic Sea, a SOx ECA. By running on methanol as its main fuel, the ferry reduces emissions of SOx by 99%, NOx by up to 60%, and particulate matter by 95% compared to traditional marine fuel. Methanex currently operates seven new methanol tankers in its global shipping fleet equipped with dual-fuel engines able to operate on either methanol or traditional marine fuels. These ships entered service in 2016.

Engine manufacturers including MAN Diesel and Wärtsilä have developed efficient methanol dual-fuel engines. Other engine manufacturers and stakeholders are also advancing projects to commercialize methanol as a marine fuel. These include the MethaShip project in Germany, which is focused on methanol-powered cruise ships and ferries, as well as several projects focused on the smaller marine engine market including the EU-supported Leanships and the SUMMETH and GreenPilot Projects in Sweden. In China, Methanex is also working with Tianjin University and the Ministry of Agriculture to demonstrate methanol as a marine fuel for a fishing vessel as well as supporting the development of methanol marine fuel guidelines. As well, Singapore-based Billion Miles (S) Pte Ltd. is working to put methanol fueled harbor tugboats in the city-port.

What is not mentioned in the pathway assessment – but is vitally important to understand – are important environmental and human health benefits that arise from switching from heavy fuel oil to methanol for marine transportation. Methanex is actively marketing methanol as a marine fuel due to the significant overall emissions reduction of pollutants compared to other petroleum-based fuels. This is important in the West Coast shipping lanes as vessels are operating within an International Maritime Organization (IMO)-designated environmental control area (ECA) and are subject to stricter emissions regulation.

The entry into force of MARPOL Annex VI in 2005 marked the beginning of what is set to be a sea-change for the sector. Since 2005, we have seen the introduction of ECAs, initially in Europe, followed in 2012 by North America. In 2015, the sulphur content of bunker fuel being burned in these zones was capped at 0.10% by weight. Alongside this, some countries (i.e., China) have introduced at-berth

fuel regulations, limiting fuel to a maximum sulphur content of 0.50%. This means that vessels today need to burn a range of fuels to meet these requirements.

On January 1, 2020, the global sulphur cap on marine fuel lowers to 0.50%. The industry's preferred bunker fuel of today, high sulphur heavy fuel oil (HFO), will only be able to be burned by those who install scrubbers, in order to achieve an equivalent method of compliance to those burning a compliant low sulphur fuel. In 2020, the vast majority of vessels are expected to switch to Marine Gas Oil (MGO) or compliant blended fuels. This is a significant opportunity for methanol. Methanol is a clean-burning fuel that produces fewer smog-causing emissions than conventional fuels. By using methanol as a marine fuel, the emissions of sulphur oxides (SOx) are reduced by approximately 99%t, nitrogen oxides (NOx) by 60% and particulate matter (PM) by 95%. Methanol can help ships meet environmental fuel regulations and improve air quality and related human health issues. Methanol marine fuel complies with the most stringent regulations in ECAs and would comply with even the most stringent future emissions regulations currently being considered.[12]

Methanol quickly dissolves in water and biodegrades rapidly. The environmental effects of a large methanol spill would be much lower than those from an equivalent oil spill. For over 100 years, methanol has been shipped globally, handled and used safely in a variety of energy applications.

Methanol is one of the top five chemical commodities shipped around the world each year. Unlike some alternative fuels, it is readily available through existing global terminal infrastructure and well positioned to reliably supply the global marine industry.

Additional Consideration – Methanol for Power Generation and Industrial Boilers:

The same methanol combustion engines that are being used in the marine sector could also be used to generate power in stationary applications. These engines would reduce NOx, SOx, and particulate matter compared to liquid petroleum fuels. In remote locations that currently 'fly-in' diesel, or during times of high electricity demand, methanol-fueled engines could be used to serve an isolated market or bolster the electric grid's capacity. Methanol has been demonstrated to be a viable replacement to oil as a fuel for these crucial generators, as well as a more environmentally friendly way of improving their performance. Reducing the use of diesel generators in remotes parts of the province will also reduce exposures to black carbon, methane and ozone.

Around the world, several projects are also underway to incorporate methanol into existing, dual-fueled gas turbines and industrial boilers. Methanol's low heating value, low lubricity, and low flash point make it a superior fuel compared to natural gas and distillate, which can translate to lower emissions, improved heat rate, and higher power output. Recent methanol-to-power demonstration projects have shown the viability of this technology, especially for areas not situated near pipelines. In

[12] https://www.methanex.com/sites/default/files/about-methanol/MMF-web-2017.pdf

China, methanol is also being used to replace coal-fired boilers with a significant positive environmental impact.

B. Pathway Assessment for BIODIESEL

Responding to Section 12 – Biodiesel:

As you may know, the use of methanol is an important part of the transesterification process for biodiesel production. Methanol is used to convert the triglycerides present in the feedstock oils into useable fuel. This process reacts to form fatty acid methyl esters and creates the by-product glycerin.[13] Biodiesel production is growing in Canada, and as noted in the LCFS pathway assessment document, this fuel is essential to meeting the GHG intensity reduction requirements for diesel fuel. It has been demonstrated as a fuel in cold temperatures, with the best example being Minnesota.[14]

Methanex fully supports the province's intent to see additional biodiesel included in B.C.'s fuel mix. Additional biodiesel should be made available as an option to consumers and businesses, and it will be a pathway to greater reduction of GHGs in British Columbia.

C. Pathway Assessment for Dimethyl Ether (DME):

Responding to Section 8 – Dimethyl Ether (DME):

Methanol is used in the production of dimethyl ether (DME). DME is widely used as an ultra-clean, ultra-low emission fuel, principally as a substitute for liquefied petroleum gas (LPG) for heating and cooking; it also has significant potential as a diesel substitute for both heavy- and light-duty transport. DME is permitted for use by the US EPA and has recently been approved as a low-carbon transport fuel in California, which has one of the most stringent environmental regulations in the US at state-level.[15] DME is the ideal low-carbon alternative for both light and heavy-duty trucks in Canada.

DME is benign, evaporates after a spill, burns smoke free with no sulfur, and minimizes nitrous oxide. In British Columbia, fuels that provide lower GHG emissions, while eliminating any possible spill remediation to a water and/or soil resource should be viewed as a success and should be preferred as they provide an ancillary benefit to petroleum products that can have generational effects that impact an ecosystem if released accidentally.

There are few barriers to DME usage within Canada. DME follows the same distribution protocols as propane. We believe the pathway assessment should recognize that the technology readiness level for DME in Canada is currently quite advanced.

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[13] http://www.methanol.org/wp-content/uploads/2016/06/Biodiesel-FS.pdf
[14] http://www.mda.state.mn.us/renewable/biodiesel/aboutbiodiesel.aspx
[15] *Specifications for Dimethyl Ether in Compression Ignition Engines"* Division of Measurement Standards, California Department of Food & Agriculture, approval effective January 1 2015

This is supported by using the U.S. Department of Defense definitions, that DME production (10 Mt DME global capacity, 600 kt MeOH Canada), DME logistics (using the propane distribution chain) and DME engine powered equipment (China, Korea, Japan, Sweden, USA, Germany) qualify as an "Actual system proven through successful mission operations".

Currently, a DME-powered Mack Pinnacle 13L truck is completing a training test for the NYC Sanitation Department. Ford has announced its interest in commercializing DME for passenger cars.[16] And in Alberta, a government-sponsored partnership for the expansion of DME is underway. The initial phase of the project, which is funded by Alberta Economic Development and Trade, brings researchers from the Northern Alberta Institute for Technology (NAIT) together with Volvo – which owns Mack Trucks – and California-based Oberon Fuels, a North-American DME producer. Alberta was a key jurisdiction for this project to ensure the efficacy of the technology in extreme cold weather.

Summary:

Canadian produced methanol is immediately available. Methanol is a clean, sustainable transportation fuel that is being used around the world. It can be blended with gasoline in low-quantities and used in existing road vehicles, or in high-proportions in flex-fuel or dedicated methanol-fueled vehicles. Methanol is also a clean-burning fuel for power generation and for marine fuel displacing diesel fuels to meet the shipping industry's increasingly stringent emissions regulations. Methanol derivative fuels, such as biodiesel and DME, can also make important and growing contributions to meeting B.C.'s renewable and low carbon fuel requirements.

Methanol provides an opportunity to produce immediate reductions in GHG emissions in the transport sector, and longer term significant and sustainable benefits. The use of emerging engine technologies using methanol as fuel (such as GEM fuel and methanol fuel cells) and production of methanol from renewable and low carbon resources are potential pathways that should be given serious consideration. The pathway assessment provides only a passing reference to this opportunity.

It is worth noting that very recently the OECD released a report[17] on Canada's current pan-Canadian climate framework. That report was very clear about the role that the transportation sector plays in the increasing GHG footprint in Canada. The report highlights the ability to see reductions through expanding the use of natural gas and biofuels for freight and passenger transport. This is something that is entirely consistent with the expansion of methanol, biodiesel and DME as transportation fuels.

Based on the numerous benefits discussed in this submission, consideration should be given by the government to progress the adoption of methanol fuels, as well as the advancement of biodiesel and DME.

[16] https://www.aboutdme.org/index.asp?bid=564
[17] http://www.oecd.org/environment/oecd-environmental-performance-reviews-canada-2017-9789264279612-en.htm

We thank you for considering our submission. If there are any details that require further clarification, or if you require more general information about Methanex, please do not hesitate to contact us.