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November 5, 2020

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California Air Resources Board (**CARB**)
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RE: Low Carbon Fuel Standards – Comments to Regulation Revision

I am writing on behalf of Methanex Corporation (**Methanex**) in response to the request for feedback over the Low Carbon Fuel Standard (**LCFS**) proposed regulatory approach. Methanex is the world's largest producer and supplier of methanol to markets in North America, Asia Pacific, Europe and South America. Our methanol production facilities are located in the United States (Geismar, Louisiana), Canada, New Zealand, Egypt, Trinidad and Chile. Our global 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 is also a shareholder of *Carbon Recycling International (**CRI**)* that operates a renewable methanol plant in Iceland, converting CO_2 to methanol.

Methanol is the simplest alcohol (CH_3OH); it is a clear, colourless liquid that is water soluble and readily 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 is increasingly being produced with lower greenhouse gas (**GHG**) emissions from a wide range of renewable, non-conventional sources, including captured CO_2. Methanol is used in consumer products, industrial products and clean-burning alternative fuel for road, marine and other energy applications. Low carbon intensity (**CI**) methanol can also be used to produce biodiesel, hydrogen, DME and be used in methanol fuel cells. Approximately 50% of global methanol demand comes from energy applications.

There are many uses for methanol that align with the LCFS objectives, and this regulatory revision is an opportunity to incentivize those end uses. We recommend the following inclusions to the LCFS framework as beneficial, as better described in the next section:

- Bio-methanol from renewable natural gas, supported by 'Book and Claim', Mass Balancing
- Low-Carbon Methanol produced through carbon capture, storage, use (**CCSU**)
- Methanol fuel cells as transportation solution

Recommendations to the LCFS

Building upon the perspectives further developed in this document, we recommend the following considerations for the LCFS:

Bio-methanol from Renewable Natural Gas, Supported by 'Book and Claim', Mass Balancing

We recommend that the CARB recognizes the production of bio-methanol from renewable natural gas (**RNG**) as low-carbon fuel. *Bio-MCN* in the Netherlands already uses RNG as a feedstock for methanol, recognized as biofuel by the European Renewable Energy Directive 2 (**RED 2**). Methanex is planning to produce bio-methanol from RNG in its Geismar-LA facility, which could be utilized to further reduce the biodiesel CI. Particularly, we request that LCFS recognizes the 'Book and Claim' and mass balance systems for accounting for the RNG, used as feedstock to produce low-carbon fuel under the LCFS, that does not have a physical pipeline transportation flow from the RNG production site into a low carbon methanol production facility. CARB already allows mass balancing for biodiesel producers who run multiple feedstocks, creating a precedent for methanol production. RED has demonstrated that these systems can lead to increased efficiencies and increased volume of low-carbon fuels produced.

*Low-Carbon Methanol (**LCMeOH**) Produced Through Carbon Capture, Storage, Use (**CCSU**)*

We recommend that CARB expands the concept of CCSU, by recognizing the conversion of carbon oxide (**CO_2**) into chemicals (not used as fuel) as an acceptable pathway to securely capture carbon similarly to underground sequestration, and therefore gaining carbon credits. Recent revisions to the federal 45-Q tax credit program have demonstrated that chemical conversion is an equally valid approach as underground sequestration to securely store CO_2. Methanol is the most efficient and cost-effective fuel produced through captured CO_2 and explicit recognition of utilization of this CO_2 into methanol can increase investment in these technologies.

Methanol Fuel Cells as Transportation Solution

We recommend that the CARB explicitly recognizes methanol fuel cells, as a transportation solution. For example, *Palcan,* a Chinese fuel cell producer, has developed a mobile technology where methanol and water are pushed through an evaporator and reformer to charge high temperature fuel stacks to generate a DC charge, similarly to *Blue World*, a Danish company dedicated to developing methanol fuel cells for transportation. The technology has been deployed to charge shipping vehicles, buses and cold-chain logistic vehicles. A key benefit of this technology is that methanol can reduce logistics costs compared to hydrogen.

We believe these recommendations would create additional opportunities for CARB achieving its GHG reductions targets. In the next pages, we provide the supporting facts and reasoning for these recommendations.

Benefits for California in Supporting Methanol

Methanol is a clean-burning fuel that is used around the world in multiple jurisdictions and energy applications. It can be blended with gasoline in low-quantities and used in existing road vehicles, or in high-proportions (e.g., M85 with 85% methanol and 15% gasoline blend) in flex-fuel vehicles or in 100 per cent dedicated methanol-fueled vehicles (**M100**) and as a diesel substitute. Methanol is also a recognized fuel for marine vessels and power generation. Methanol derivative fuels, such as biodiesel and DME, can also make important and growing contributions to meeting CARB's emission reduction targets, as showed by *Oberon Fuels'* bio-DME plant in Brawley, CA for propane substitution.

As technology matures and becomes commercially viable, methanol will be able to provide significant GHG emission reductions through Green Methanol produced from alternative feedstocks and/or the use of alternative energy systems, such as fuel cells. Methanol can also be a pillar for the Hydrogen Economy, as the best energy carrier for hydrogen and possessing higher energy density than compressed hydrogen, due to its low mass ratio of carbon relative to hydrogen and its liquid state at atmospheric temperature and pressure which lowers logistic costs and infrastructure conversion. The expansion of the Hydrogen Economy would be synergistic with the methanol industry.

Leveraging Green Methanol GHG Emissions Reduction Potential

Methanol produced through renewable or alternative sources (i.e., bio-methanol, renewable methanol and low carbon methanol or "**LCMeOH",** collectively referred as **Green Methanol**) results in significant reductions in GHG emissions, as shown in *Exhibit 1* below. Green Methanol also does not utilize any material land resources and locally produced Green Methanol would provide environmental and energy security.

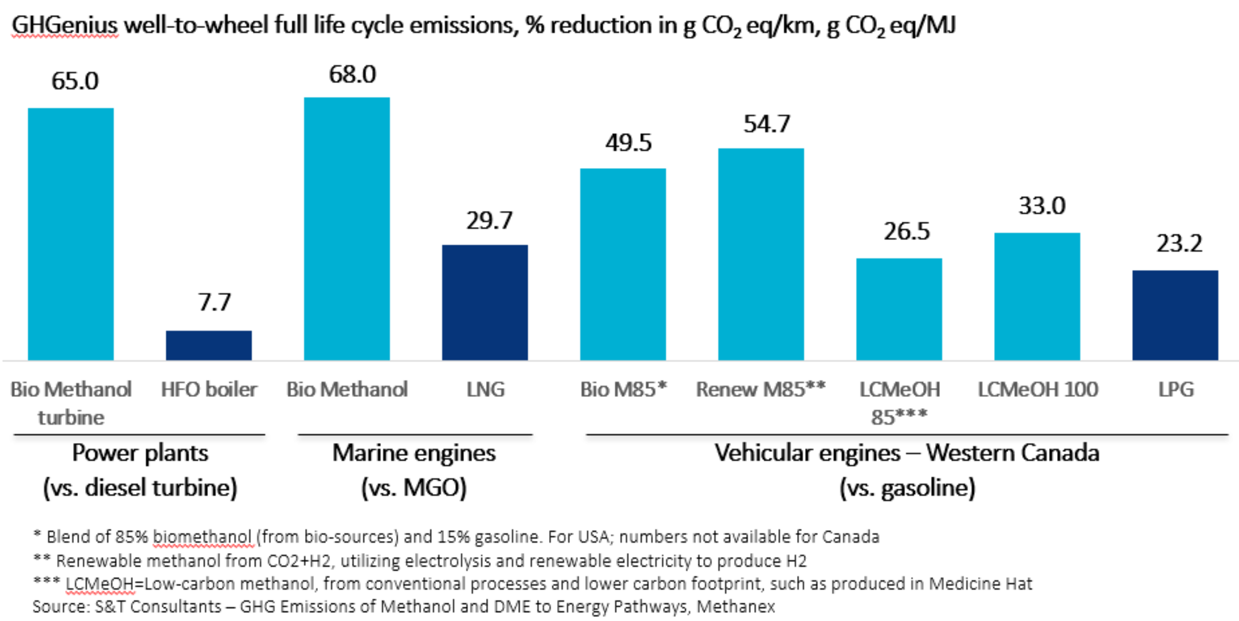

***Exhibit 1:* Life-cycle emissions reduction from Green Methanol**

Symbiotic Relationship Between Methanol and Hydrogen

Global support to the Hydrogen Economy is expanding quickly. The *Hydrogen Council* (www.hydrogencouncil.com), a global industry consortium from an array of sectors, has pointed that 18 countries, accounting for approximately 70% of the global GDP, have issued or are developing strategies for hydrogen. In addition to California's efforts to expand the Hydrogen Economy, Japan and Germany have been heavily investing in creating a network of hydrogen fueling stations, providing clear motivations to the development of hydrogen technologies and businesses. There is also support from OEMs to invest in hydrogen fuel cell electric vehicles (**FCEV**) and *Toyota* is expanding its product line to supply fuel cells and components beyond vehicles into other applications. *Honda* offers a FCEV, *Toyota* is launching the second generation of its FCEV, Mirai, and *Hyundai* is planning to expand its FCEV offering toward trucks. Long-haul, heavy duty trucks are also being developed by *Nikola Corporation*, who has made its initial public offering (**IPO**) and is negotiating a partnership with *General Motors*.

The *Hydrogen Council* considers the transportation sector an attractive application for hydrogen, and methanol can play an important role as the best energy carrier for hydrogen due to its low mass ratio of carbon relative to hydrogen and the potential to leverage the existing liquid infrastructure. Terrestrial, heavy-duty transportation is believed to be a "sweet-spot" for hydrogen, where the FCEV can be more effective than batteries (**BEV**), because it is more user friendly (system weight, mileage, re-fueling). However, the FCEV needs a reduction of hydrogen delivered costs (compression, logistics) and capital costs (electrolysis, fueling station, on-board storage) to be competitive.

A recent study by *VoltaChem*, *TNO, SmartPort* and market parties into the most promising e-fuels for heavy transport applications *(https://files.constantcontact.com/9117ab81401/80e9b03f-3356-42a6-ba4f-4cd320f69408.pdf)* surmises that green hydrogen applicability as a fuel in heavy transport is limited and could be better used to produce e-fuels. "The transport sector is responsible for 23% of global CO_2 emissions, with almost three-quarters of this from road transport. To meet the climate goals, these emissions will have to be reduced by 95% by 2050. Shipping, aviation and heavy road transport are currently lagging far behind when it comes to contributing to sustainable mobility. They must therefore become drastically greener and e-fuels offer a way out as long as stakeholders from the entire value chain will take the necessary steps and increase production and investments in the related infrastructure," says Richard Smokers of *TNO*, one of the authors of the whitepaper. The whitepaper shows that for truck transport, green hydrogen can only be used for shorter and medium distances. For long-distance truck transport e-fuels, such as renewable methanol, are the most attractive options because of their high energy density requiring smaller, cheaper tanks. Hydrogen is also likely to be more expensive to use than renewable methanol due to the high costs of refueling infrastructure and vehicles.

As described above, the hydrogen logistics to support transportation applications pose challenges to the delivered costs. Methanol provides an opportunity for a simplified hydrogen supply chain, because it is easy to store and transport as a liquid, has four times the energy density of compressed hydrogen and can leverage the existing liquid fuels distribution infrastructure. *Element 1*, an Oregon-based company, developed a small stationary production unit for hydrogen fueling station deployment using methanol as feedstock. *Element 1's* methanol-based charging system produces hydrogen at a fraction of the current hydrogen delivered price and it is also structurally more competitive than small-scale electrolysis. Preliminary studies show that a ~US$4.0/kg delivered hydrogen cost at a pump station would be competitive for trucking applications in the short term, but the steam methane reformer (**SMR**)/CCSU solution does not deliver that due to the high hydrogen logistics. *Element 1*'s micro-methanol reformer (currently up to 170 kg H_2/day) might be able to achieve such delivered costs using methanol as a feedstock (the Hydrogen Enabled by Methanol "**HEM"** fuel station solution) as proven by recent investments in *Element 1*'s technology by established hydrogen suppliers, such as *RIX Industries* (https://www.businesswire.com/news/home/20201007005961/en/Element-1-Corp-and-RIX-Industries-Partner-to-Deploy-Hydrogen-Generators-for-Fuel-Cell-Propulsion-Systems), aiming to reduce delivered costs.

There is also the potential to create a zero-emission business model for heavy-haul trucks with green methanol producing hydrogen at a HEM fuel station, capturing CO_2 emitted by the micro-methanol reformer and recycling the CO_2 either to a methanol SMR or injected into permanent CCSU storage. The CO_2 transportation can leverage the back-haul freight from the methanol delivered to a HEM fueling station.

Methanol as Marine and Vehicular Fuel

The same logistics systems that are used for gasoline and ethanol can be used for methanol, limiting the capital requirements for infrastructure development, unlike other alternative fuels. Methanol is one of the top five commodities shipped globally 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. Risks related to methanol are similar to those related to gasoline and diesel fuel, therefore infrastructure transition can be relatively simple.

Methanol is a proven marine fuel, displacing diesel to meet the shipping industry's increasingly stringent emissions regulations defined by the IMO. The dual-fuel engines used on *Stena Germanica*, a ferry running between Germany and Sweden, and *Waterfront Shipping*'s chemical bulk carriers have surpassed 80,000 operating hours of successful commercial operation running on methanol. In fact, *Waterfront Shipping*, a wholly owned subsidiary of Methanex, and *Marinvest* has eleven two-stroke vessels with MAN B&W ME-LGUM in compliance with IMO 2020 emissions regulations and IMO Tier III emission standards through water emulsion (i.e., no need for exhaust gas after treatment). Furthermore, from an environmental perspective, when mixed with water, methanol quickly biodegrades to harmless products, with none of the severe, long-term soil and water contamination issues associated with petroleum spills. Overall, methanol is a well-proven, simple-to-adopt solution that fully complies with IMO 2020 regulations and provides a pathway to meeting IMO 2030 and 2050 CO_2 emission targets.

Conclusion

The LCFS can support the development of many different fuel technologies, including Green Methanol and methanol fuel cells, providing consumers with the best options to reduce GHG emissions. We kindly request the CARB to review regulations in a way that will be technology neutral, fuel neutral and mode neutral in achieving GHG emissions reductions goals. The LCFS already has some attractive technology enablers, such as carbon credits and carbon off-sets and we believe that the additional explicit references described above would further enable environmentally friendly methanol market development in California.

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We welcome the opportunity to discuss this submission. If you have questions, please, feel free to contact.

Sincerely,

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