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Renewable DME as a Cost-effective Carrier for Hydrogen

Please see the attached document

Additional submitted attachment is included below.

oberon FUELS

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October 31, 2018

California Energy Commission
Docket Unit, MS-4
1516 Ninth Street
Sacramento, CA 95814-5512

RE: Docket No. 18-HYD-03: Renewable DME as a Cost-effective Carrier for Renewable Hydrogen

To Whom It May Concern:

Thank you for the opportunity to provide information as part of Docket No. 18-HYD-03. Oberon Fuels (Oberon) wishes to share information on what we believe is a timely opportunity for the State of California to convert its methane waste streams into renewable hydrogen using renewable dimethyl ether (DME) as a carrier of hydrogen molecules.

Using DME as a transportation fuel can significantly reduce heavy duty (HD) diesel vehicle emissions and pollution right now and in the near-term, in addition to fueling hydrogen vehicles in the near future. DME is a transportation fuel alternative to petroleum diesel that is clean, powerful, and easy to produce from local renewable feedstocks and can also serve as a more cost-effective alternative to expensive natural gas pipelines while playing an important contributory role in the state's ambitious target of having five million zero-emission hydrogen vehicles on California's roads by 2030.

As such, Oberon is working with a global coalition to bring DME to our roads and highways. While we recognize that DME is not a household name, it is however well-known among stakeholders in the HD vehicle world because it is the best, near-term option to replace fossil diesel fuel and fossil-based natural gas amid rising demand for a lower-carbon, more sustainable transportation infrastructure. For example:

- DME burns cleanly and quietly and can reduce greenhouse gas (GHG) emissions by 68 – 101 percent, depending on which renewable feedstock is used to produced it. Calculations from the California Air Resources Board (CARB) estimate dairy manure converted to DME to have a carbon intensity (CI) of -278 when using Renewable Natural Gas with a CI of -150 (versus petroleum diesel, which has a CI of 95).
- DME is a single molecule fuel with no impurities. It is sulfur-free and burns with no particulate matter, making it easier to control nitrogen oxide (NOx) emissions.
- DME is also one of the few petroleum diesel replacement fuels that can truly be produced at scale locally. Urban waste streams, dairy manure, and other organic wastes can be repurposed to make DME fuel for fleets of trucks and other vehicles.
- DME also meets tough performance requirements, which is a must for trucking and other heavy-duty applications that need the power and torque of compression-ignition engines.
- DME vehicles are less expensive to operate over their lifetime than vehicles equipped with natural gas engines, given operational and maintenance costs; and DME fueling infrastructure is easy and relatively inexpensive to build, maintain, and expand.

Oberon envisions a future where locally-produced, renewable transportation fuel is moving goods and people, providing jobs, cleaning the air, and making good use of wastes that otherwise would contribute to climate change, water pollution and other environmental problems.

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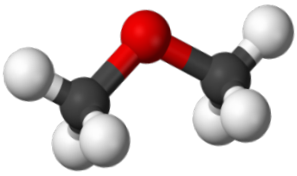
Over the past eight years, Oberon has partnered with Volvo Trucks, Mack Trucks, Ford, and a host of other manufacturers to build DME engines, test demonstration vehicles, get standards approved, and design fueling infrastructure that can make DME a crucial component of global transport networks. The first wave of demonstration vehicles using DME-powered internal combustion engines has passed their rigorous testing with great success and learnings, and large-scale fleet rollouts are on the horizon.

And yet this vision does not tap the full potential of DME. In fact, this molecule may have an invaluable second act as a booster to the emerging hydrogen fuel infrastructure.

DME is an ideal carrier for hydrogen fuel



DME is dense in hydrogen. A single DME molecule has six hydrogen atoms. DME's lack of carbon-to-carbon bonds makes reforming DME into pure hydrogen a simple, inexpensive process compared to natural gas to hydrogen conversion. DME's propensity to liquify at low temperatures also helps hydrogen fuel overcome one of its most intractable problems: *transport*. To compress hydrogen takes pressures of up to 10,000 pounds per square inch (psi), a level that requires expensive equipment. DME, on the other hand, can be transported in modified propane tanker trucks and liquefies at pressures around 73 psi.

These qualities give DME a unique, dual-use potential with the rollout of DME trucks serving as an ideal way to also encourage more hydrogen fueling infrastructure with DME being used to make hydrogen at fueling stations. The bottom line is that DME investments complement and enhance California's battery- and fuel-cell electric initiatives by offering opportunities for the State to leverage those investments and provide a cost-effective pathway to fuel-cell electric vehicles.

The pathway to safe, affordable hydrogen fuel infrastructure

Infrastructure for both DME and hydrogen can be expanded without unwieldy market disruptions or unexpected capital costs. Moreover, DME and hydrogen fuel infrastructure can work in harmony together as their use expands in California. In fact, they may work together so well that implementing actions required to rolling them out commercially could very well occur concurrently.

The first step to building hydrogen fueling infrastructure alongside DME would be to offer truck fleets 100 percent DME vehicles. Both new OEM vehicles and conversion systems that convert diesel trucks to run on 100 percent DME continue to be tested. Additional vehicle deployment is anticipated in 2019. Dedicated DME vehicles have already been demonstrated, and multiple engine manufacturers have programs underway to refine the technology further. In parallel to the development of new OEM vehicles, companies are also developing conversion kits that could modify existing fleets to switch entirely to DME as local fuel supplies come online.

A second pathway involves DME getting a boost from the growth in hybrid-electric vehicles. Range extension using DME is ideal, since the fuel is efficient, lightweight and clean. Diesel-electric hybrids can easily become DME-electric hybrids.

Another parallel pathway is where DME begins to play its double-duty role as a carrier for hydrogen fuel where DME is converted to hydrogen at the fueling station.

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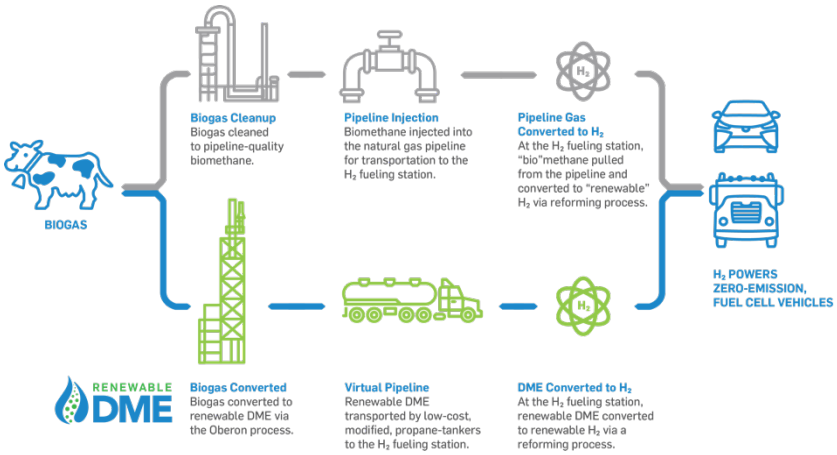
Converting DME to hydrogen at the station



Hauling DME to a hydrogen fueling station would be the simplest approach to using DME as a hydrogen carrier. Non-toxic and easy-to-handle, DME could be trucked to fueling stations for conversion into hydrogen fuel using simple reforming equipment. Existing hydrogen dispensers, storage tanks, and fuel cell vehicles would all still be used.

Moreover, no natural gas pipelines would be required, which would reduce costs and methane pipeline leaks during transit, and expedite project development, thereby resulting in locally-produced, truly green, renewable hydrogen fuel. Renewable methane molecules from local waste streams would be converted first into DME and then into hydrogen. This physical conversion process contrasts with the current "accounting game" that is employed of injecting scrubbed biogas (biomethane) into a pipeline and subsequently pulling out "bio"methane at a different location to make "renewable" hydrogen.

Building on previous clean transportation investments

The most powerful argument for developing DME and hydrogen fuels concurrently is that both fuels can leverage and build upon previous public and private investments made to facilitate clean transportation systems here in California and throughout the world.

For example, engine manufactures are currently busy designing and building heavy trucks that run on DME, and a coalition of international companies across the DME supply chain has formed to design the regulatory frameworks in Europe to enable DME-powered trucks to operate on their roads and highways. Here in the United States, DME is legal to use as a fuel. Oberon's biogas-based DME qualifies for the US EPA's Renewable Identification Number (RIN) credits and has undergone evaluation by CARB under its Low Carbon Fuel Standard (LCFS).

Additionally, international standards have established DME as a legitimate vehicle fuel, including, ASTM International, which in 2014 developed technical specifications for fuel-grade DME that provide guidance for fuel producers, engine suppliers, and infrastructure developers. In 2015, the International Organization for Standardization (ISO) specified DME characteristics for use as fuel.

In California, significant public and private investments have been made to promote a new generation of alternative fuels and vehicles, including fuel cell vehicles. This year, the State of California doubled – from 100 to 200 -- its target for constructing hydrogen fueling stations, and established a target of five million zero emission vehicles (including hydrogen-powered fuel cell electric vehicles), for California's roads by 2030. Yet, even the most ardent supporters for this transportation transformation know that, with all the expense and overcoming of hurdles required to construct an entirely new transportation fueling infrastructure, there is more that can – and needs -- to be done to support truly renewable hydrogen.

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That is why Oberon strongly believes that if DME fuel was rolled at the same time hydrogen fueling infrastructure is being deployed, the combination of DME and hydrogen as concurrently available transportation fuels for California's consumers would help facilitate the utilization and extension of this new fueling infrastructure faster and to a greater degree than anyone previously imagined.

In conclusion, Oberon strongly believes that there exists a mutually beneficial relationship between these two renewable fuels that together can play significant roles in California's ambitious low-carbon and zero-emission fuel objectives, an investment made in a DME fueling station or production facility would also be an investment in renewable hydrogen. DME production on a dairy farm could mitigate methane emissions *and* fuel heavy-duty trucks alongside fuel-cell vehicles. The continued penetration of fuel cell vehicles into California's market would also expand the DME fuel network, thereby giving truck fleets the necessary diesel replacement fuel today they will need to be able to haul the heaviest loads on our highways. Similarly, technology improvements made for DME-powered vehicles will produce tangible benefits for hydrogen-powered vehicles as well.

However, taking advantage of these synergies for the benefit of tomorrow require the alignment of strategies today between the state's policy makers and vehicle developers. Otherwise this timely opportunity could be lost to the detriment of California's important near- and long-term environmental, transportation, and economic goals. With the near-term opportunity for DME fueling infrastructure construction to be aligned with the existing pathways for zero-emission vehicles, now is the time for our visionary state agencies tasked with helping to transform California's 21st century transportation system to foster strategic DME-hydrogen partnerships, which, in turn, can provide the State with practical, cost-effective pathways towards a truly transformational transportation sector that utilizes and thrives upon clean-powered vehicles, recycled waste streams, and locally produced renewable fuels.

Sincerely,

Rebecca Boudreaux

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