Moving Towards Commercialization as the 1st Carbon-Negative, Compression-Ignition Fuel

October 12, 2017

Dairy and Livestock Subgroup #2:
Fostering Markets for Digester Projects

Rebecca Boudreaux, Ph.D.
Chair, International DME Association
President, Oberon Fuels

International DME Association

methanex
the power of agility

Ford

VOLVO

oberon
FUELS

MASSY

ISUZU

THE NATIONAL GAS COMPANY
OF TRINIDAD AND TOBAGO LIMITED

ADME Fuels

Parafour
Innovations, LLC

AYGAZ

DME
PT. DUTA MAKSIMA ENERGI

KOGAS
KOREA GAS CORPORATION

SCC
SOUTHERN CHEMICAL
CORPORATION

aum
energy

Blossman
Propane Gas & Appliance

DME
ISRAEL
FUEL OF THE FUTURE

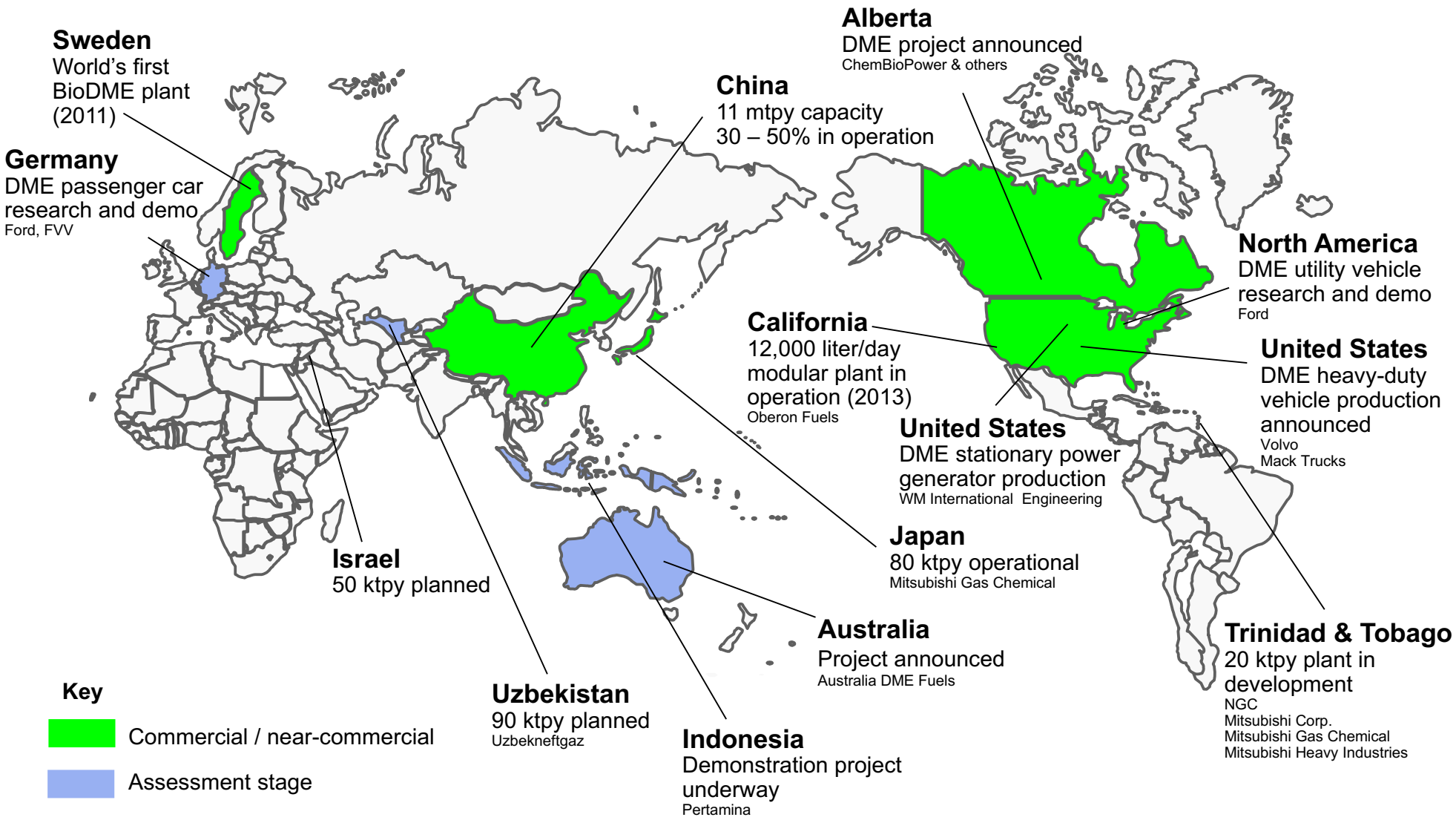
unitel
technologies

AkzoNobel

HALDOR TOPSOE
CATALYSING YOUR BUSINESS

DME Around the World

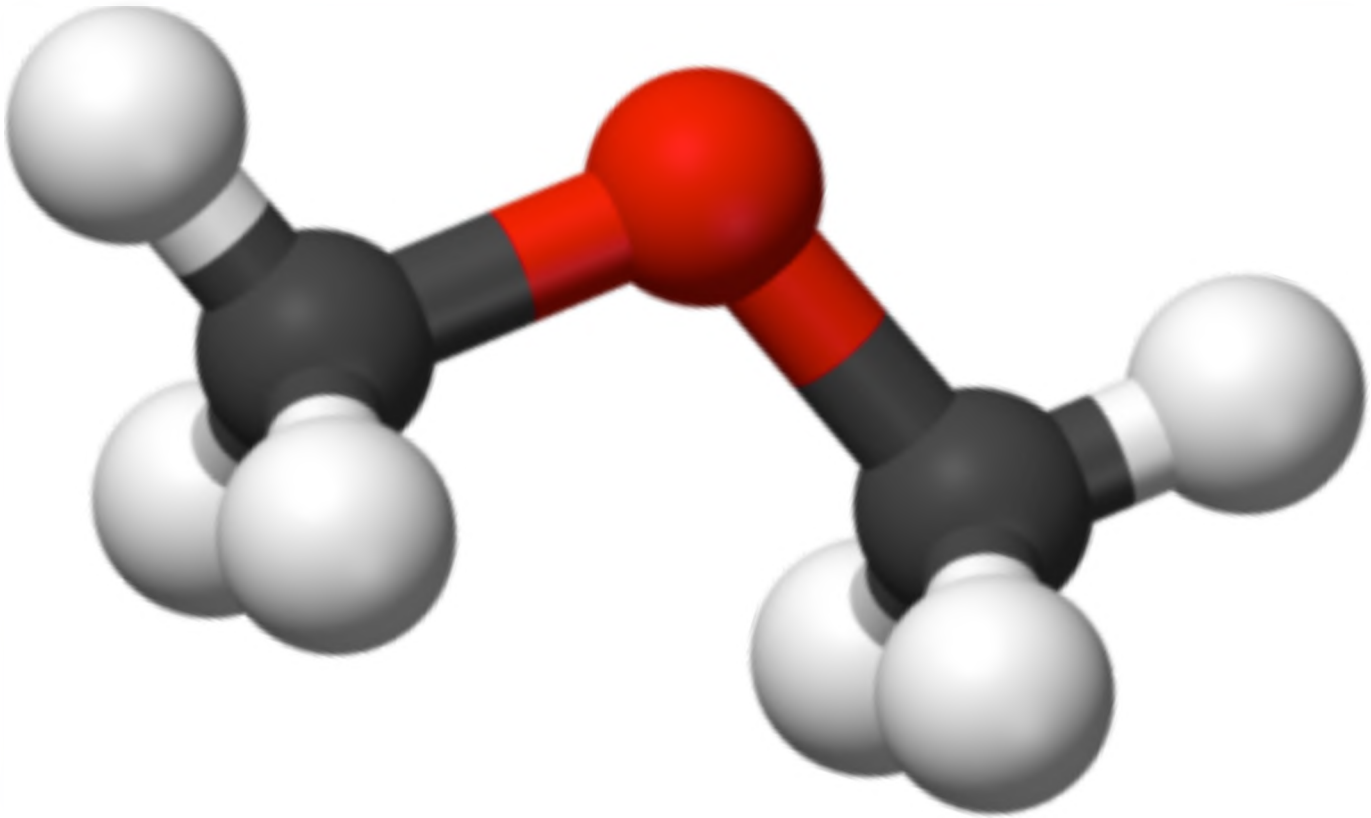
International DME Association




"…significantly expand the number of livestock digester projects in California…"
"…identify both commercial ready and emerging technologies and approaches…"
"…identification of potential impacts, benefits, and barrier to scaling up projects…"

DME is a Renewable Gas

International DME Association



Dimethyl Ether (DME)

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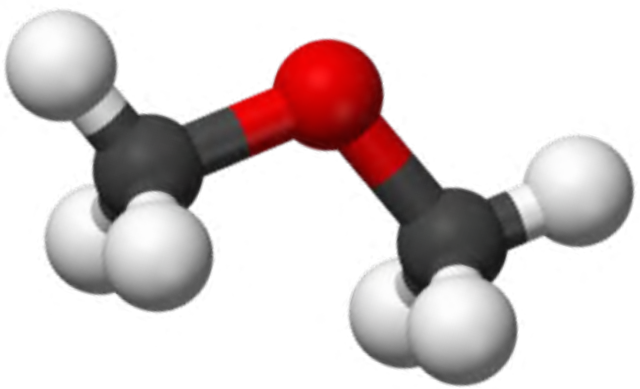
- **Simple Fuel**
  - Clean burning, no soot generated
  - Made from various methane sources

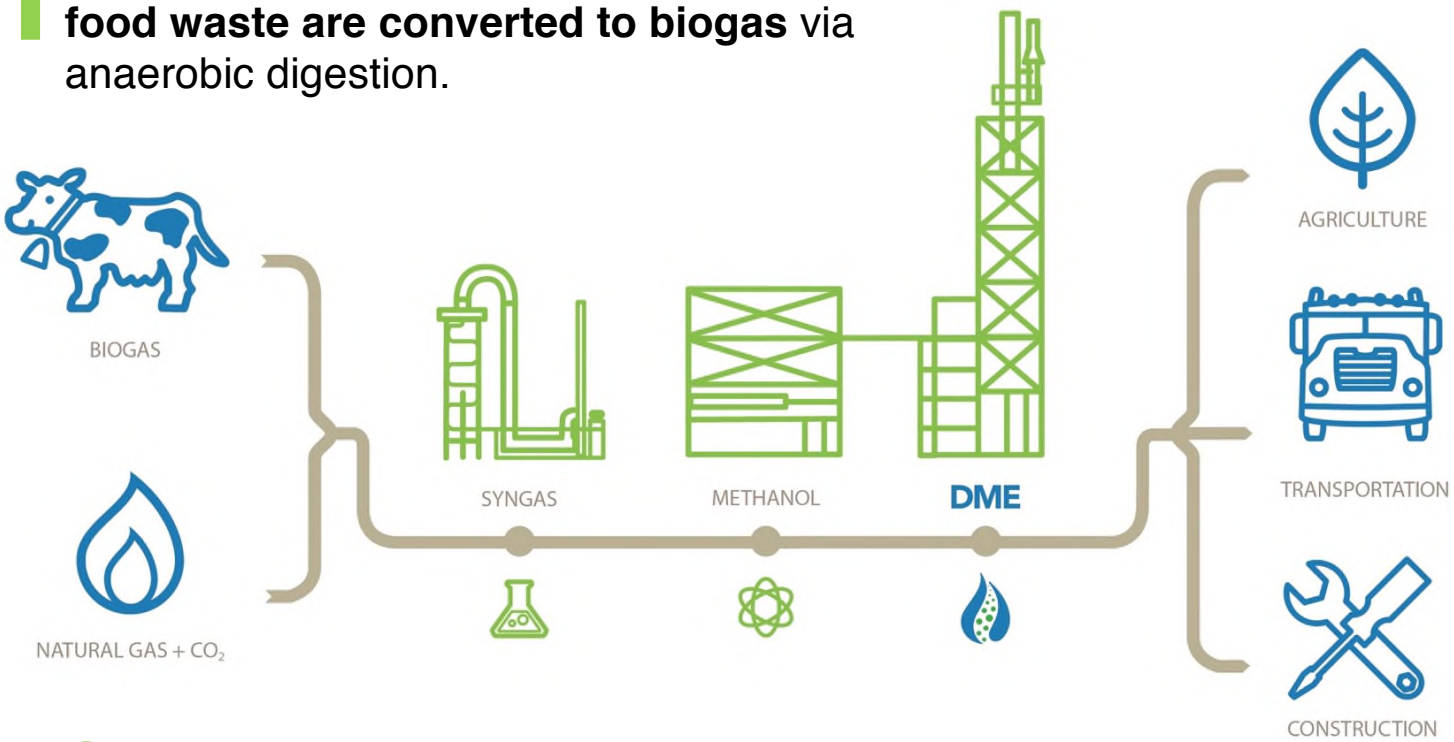


- **Simple Infrastructure**
  - LPG-like Handling (cylinders/tank, only change seal)
- **Simple Engine**
  - Diesel-like performance, less after treatment
  - Efficiency & torque of diesel engine with no soot produced

DME is a Renewable Gas

International DME Association

1 **Dairy manure, agricultural waste, and food waste are converted to biogas** via anaerobic digestion.



2 **Biogas is converted to DME** via the Oberon 3-step process, resulting in a fuel with an estimated carbon intensity of -237. Both the CH_4 and CO_2 in biogas is converted to DME. No CO_2 scrubbing.

3 **DME based on renewable feedstocks** offers a 68-101% GHG reduction, combusts with NO soot/PM, and is an excellent, clean-burning, diesel replacement. Initial Applications: Heavy-duty trucking

DME Environmental Benefits

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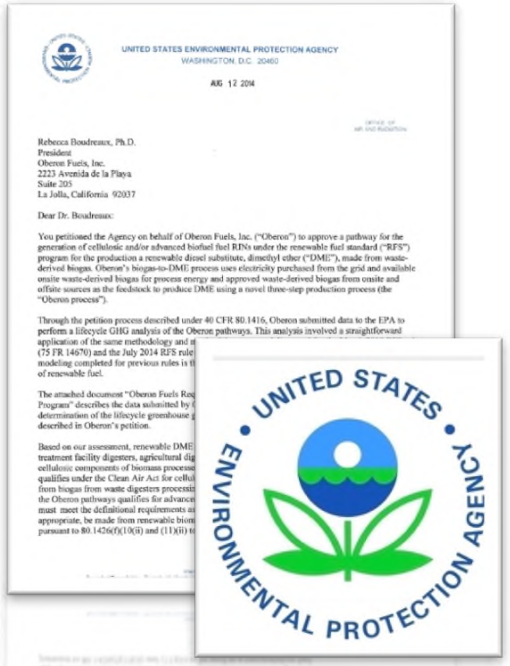
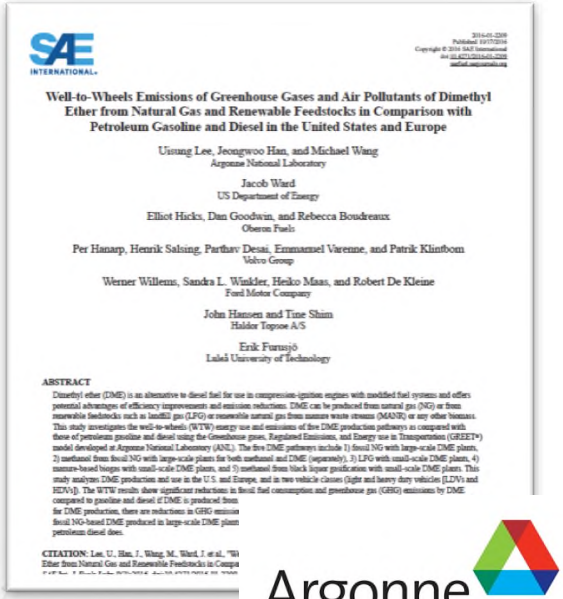
- Biogas-based, Oberon DME qualifies for EPA D-3 & D-5 RINs
- 68% GHG reduction





- In 2016, Argonne updated DME GREET Model
- DME = 85-101% GHG reduction
  (waste biomass, landfill gas, animal & organic waste)

Argonne NATIONAL LABORATORY

Why Bother Converting to DME?

Compression Ignites, No Spark Plugs

Why Convert to DME?

Power & Torque of a Diesel Engine

Why Convert to DME?

Photo Credit: Ron Jautz © 2017

Breaks Open the HD Trucking Market

Why Convert to DME?

Diesel-like Performance, Propane-like Handling

DME Engine Development

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Diesel-like Performance, LPG-like Handling

DME fuel pump at ENN service station (Shanghai)

BioDME Project

Partners include TOTAL, Preem, Delphi, ETC, Chemrec, & Haldor Topsoe

SAIC MOTOR

NAVISTAR®

ISUZU

Ford

Moving Towards Commercialization

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2013

2015

Ford building world's first DME-powered passenger car for on-road testing.

2017

2017

Ford developing world's first DME engine for full-size pickup trucks. Development of the 6.7 liter engine, for use in the popular F-250, F-350, and F-450, is underway.

NYC Department of Sanitation (DSNY) first Mack customer in the world to test a DME-powered Mack truck. (Photo Ron Jautz © 2017)

Moving Towards Commercialization

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- Aftermarket conversions moving forward
- Enable the conversion of 100% diesel vehicles to run on both DME and diesel
- Initial studies indicate 30-60% diesel displacement
- Advanced testing phase of conversion technologies used in the European market, adapted for DME use

What is next for DME?

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DME100

100 DME vehicles on the road in 2018-2019

- **DME** known to be a clean-burning, low-carbon diesel replacement 20+ years. *Technical hurdles are no longer an issue.*
- **Remaining questions are:**
  - How do we scale the DME supply chain economically?
  - Do DME's economics and favorable properties lead to customer demand for the fuel?

Where do we go from here?

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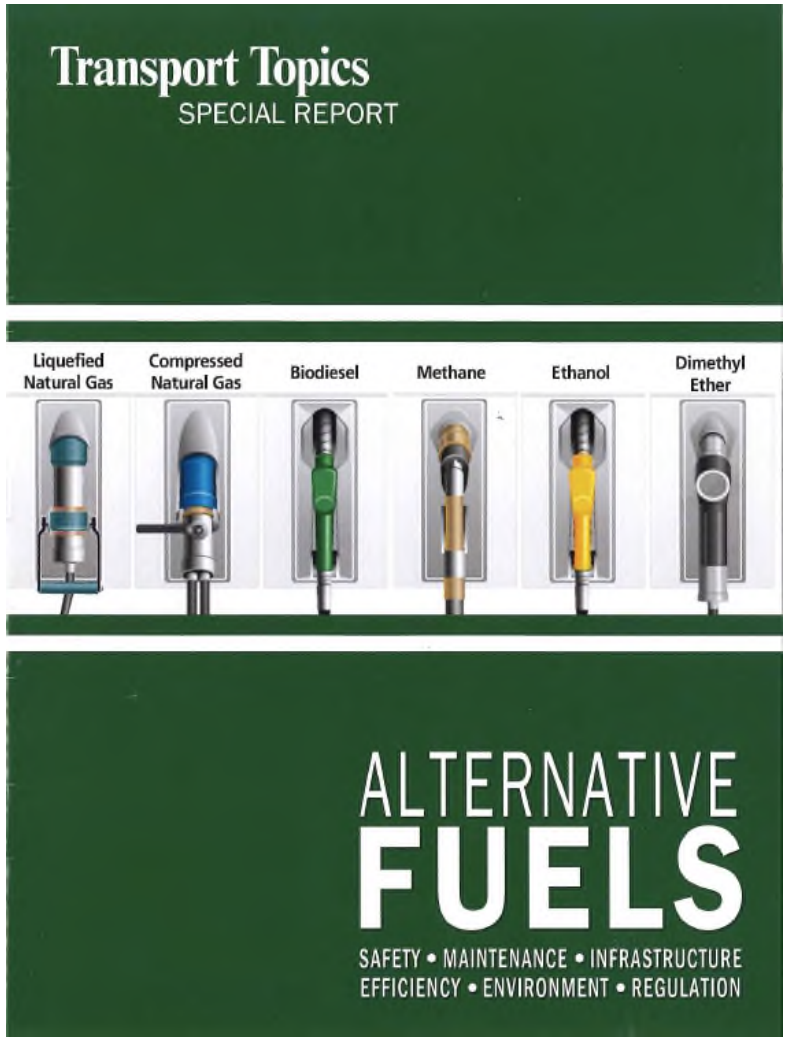
- **Collaborative Projects** for biogas-based fuel production
  - Better understand the economics and applicability of each fuel-type to the CA dairy industry in particular
  - Shared fueling infrastructure
  - Shared alternative-fuel maintenance facilities
  - Determine additional synergies among technology solutions



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International DME Association

DME: 21st Century Energy

DME Regulations

International DME Association

ASTM Intl. Specification

Published 2014
ASTM D7901-14b
DME as a fuel

ISO Standard

Published 2015 as
ISO 16861:2015
DME as a fuel

Legal Fuel in CA

CDFA modified CA Code of Regulations to allow the legal sale of DME as a fuel effective January 1, 2015.

RINS Eligible

Renewable Fuel Standard (RFS) Pathway Approved

Tier 1 Report

As part of Multimedia Assessment process, CARB published DME Tier 1 report February 2015. Evaluated DME effects on air, soil, and water.