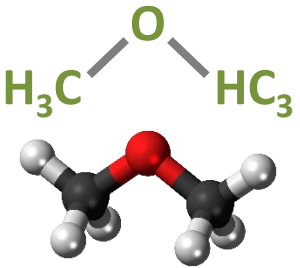
ecomotive solutions

TECHNOLOGIES
TO SUPPORT ECOLOGY

ECOMONDO
THE GREEN TECHNOLOGY EXPO

DME

Renewable Dimethyl Ether



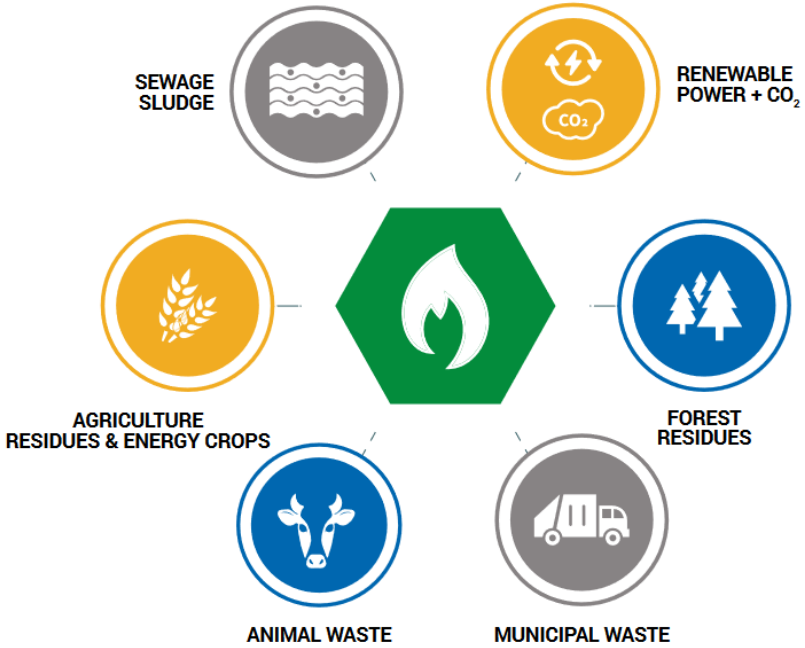
CIB
CONSORZIO ITALIANO BIOGAS

Green Vehicles Alternative Fuel

DME in SI & CI engines

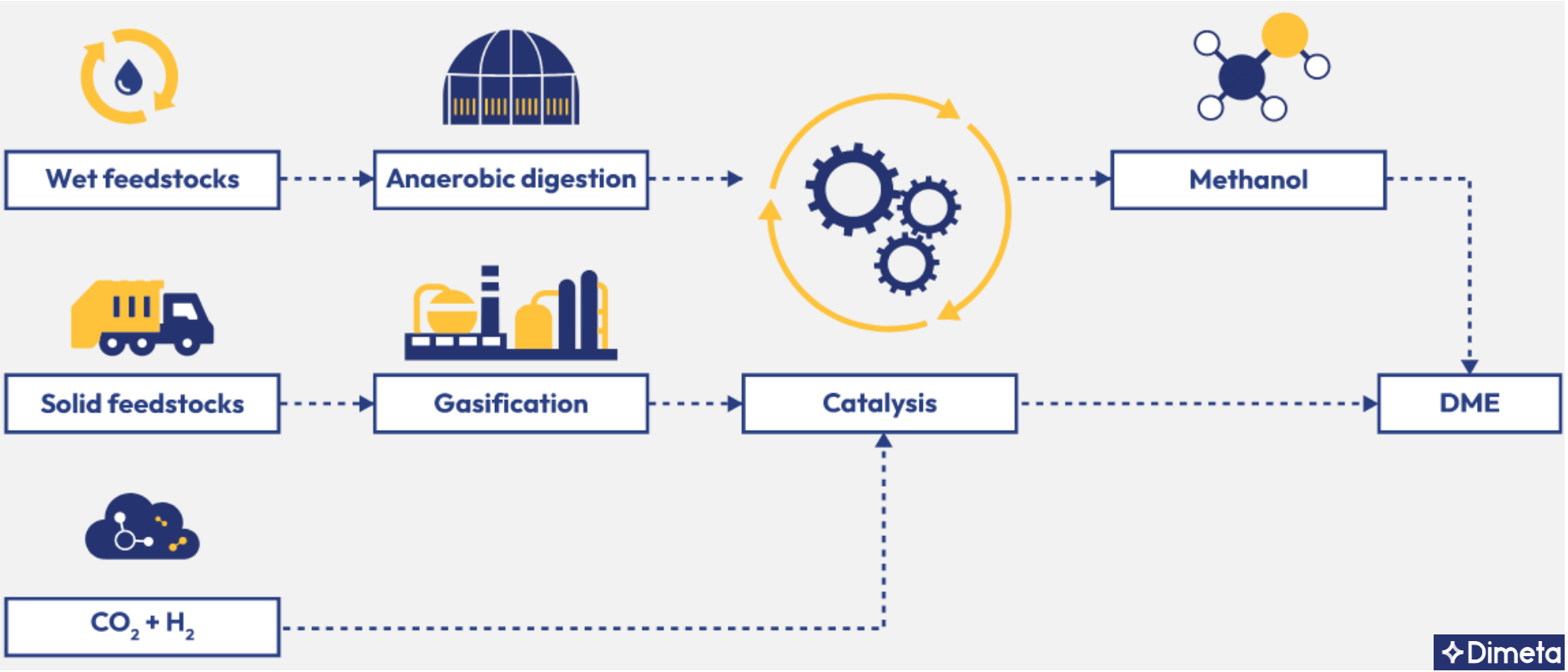
speaker: Roberto Roasio

Renewable DME can be produced from a wide range of sustainable feedstocks



Dimeta

DME as Vehicle Fuel

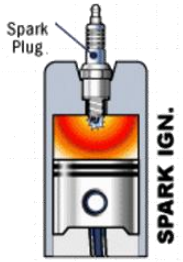


Parameter	Methane	Methanol	LPG	Dimethylo Ether (DME)	Petrol	Diesel
Fo						$C_{14}H_{30}$
Molec (g						198.4
D (g						0.856
Boiling						140–380
Octar						
Cetar						40–55
Lower c (M						41.66
Stoichiomet (k						14.6
SelfIgnitic						150–250
Burni (						
Sulfur (ppm)	7–25	0	10	0	~200	~250

Properties	DME	Diesel fuel
Chemical formula	$CH_3–O–CH_3$	-
Molar mass [g/mol]	46	170
Oxygencontent [% w/w]	34.8	0
Carbon-to-hydrogen ratio	0.337	0.516
Cetanenumber	55–66	40–50
Low calorific number [MJ/kg]	27.600	42.5
Viscosity [cP]	0.15	2
Density [kg/m^3]	660	831
Auto-ignitiontemperature [K]	508	523
Boiling point [K]	248.1	450–643
Stoichiometric air-fuel mass ratio	8.9	14.6

DME for SI & CI Engine

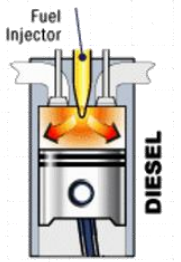
Spark Ignition
Otto Cycle



LPG + 20% DME

Blending rDME with LPG Gives Several Environment Advantages: CO2 emission as HC emission are significantly reduced. The LPG blend Up to 20% DME, don't affect physically the standard LPG vehicle system, so all the components could be those proven with standard LPG fuel.

Compression Ignition
Diesel Cycle

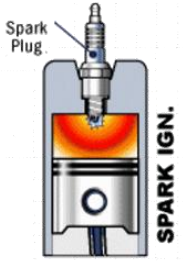


100% DME

rDME tested in a Diesel engine demonstrated that could properly works instead of standard Diesel fuel. The high cetane-number of DME with its chemical characteristics gives several environment advantages, PM is strongly reduced, CO_2 emission can be decreased up to 80% and the other pollutant could keep below the emission standards.

DME + 20% DME for SI Engines

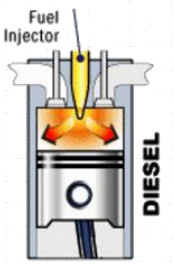
Spark Ignition
Otto Cycle



Ecomotive Solutions is involved in a test on LPG/DEM blending aimed to deeply evaluate the effects on emissions & performance of vehicles, usually running on gasoline and LPG in bi-fuel or monofuel mode.
20% DME and 80% LPG is by now defined as the ideal solution in the balance between emissions and vehicles performances.
The blend could be used on standard vehicles already equipped with any LPG injection system, without changings.

DME as a Fuel for Diesel Engines

Compression Ignition
Diesel Cycle



100% DME

Ecomotive solutions was involved in design and handling the conversion operation from Diesel to DME of a vehicle, supporting emissions measurements in a project with Technion Research Foundation of Haifa university and the EU commission JRC in Ispra Italy, for supporting emissions measurements. The project was funded by the Israeli ministry of energy.

Research Program DME on Diesel

Technion Research & Development Foundation

Exhaust emissions of Diesel engines fueled with DME (Dimethyl Ether)

This research program was focused on emissions measurements of DME compression ignition engine. Since there is no availability of commercial DME engine, during the research a few conversion strategies for conversion of diesel engine to DME fueled engine were developed. Finally, a used Euro 3 truck equipped with common rail diesel engine was converted from diesel to DME. The truck was tested on road and proved to operate satisfactory under various driving conditions. The conversion process was composed from newly designed fuel system, newly designed injection nozzle and remapping of the engine using substitute ECU. The truck was tested on chassis dynamometer under constant load conditions with a few loads. Although spray geometry was not designed according to the combustion chamber, PM emissions were very low, might be below the regulated threshold as described in Euro 6. NOx and HC emissions were similar to diesel mode. Carbon monoxide emissions for DME were very high compared to diesel, probably due to non-optimal spray geometry and engine mapping. **Overall, the results demonstrate the potential of DME as a low emissions fuel. DME can offer lower exhaust emissions using the current diesel after treatment technology.**

We would like to thank:

- *Ecomotive solutions for handling the conversion operation from diesel to DME and supporting emissions measurements.*
- *JRC for supporting emissions measurements.*

A project funded by the Israeli ministry of energy

Test 100% DME - Using DME as the only fuel in Diesel cycle

An Iveco light truck equipped with diesel engine (Tector E3, 4 cylinder – Figure 4) was chosen for conversion to DME, before the conversion the truck was tested for power, torque and emissions, the tests were done at Ecomotive Solutions premises using a chassis dyno and PEMS (portable emission measurement system).

Figure 4 – Iveco Tector 100% DME

Test 100% DME - Using DME as the only fuel in Diesel cycle

The core of the new injection system was a special pump (Figure 5-6). This pump is suitable for DME since it can pump low viscosity liquids (DME viscosity is 30 time less compared to diesel). A special redesign of the original Diesel injectors was made to compensate the DME lower energy content. An Ecomotive Solutions Diesel open ECU was used in this specific test in order to shorten the calibration process.

Figure 5 - Tector DME fuel system

On the output fuel high pressure, we installed a precision pressure regulator in order to regulate more finely the pressure of the fuel. The output pressure can be adjusted operating first on pressure regulator on air circuit and after on precision pressure regulator on the output high pressure

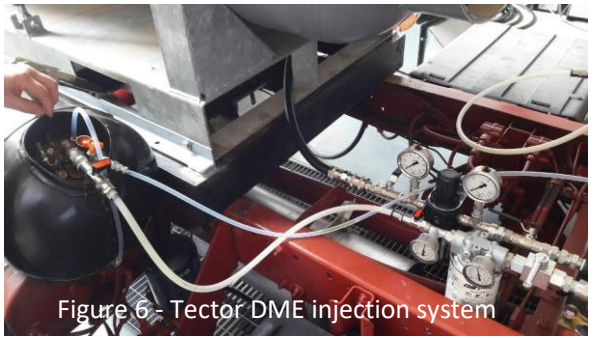


Figure 6 - Tector DME injection system

Test 100% DME - Performance

Following the engine modifications, engine performance was comparable to the original diesel engine. As a matter of fact, due to the modified engine map, engine performance with DME are better compared to the original diesel Figure 6.

The truck was tested on road at various scenarios (urban, extra urban and highway) and showed the conversion from diesel to DME is working properly.

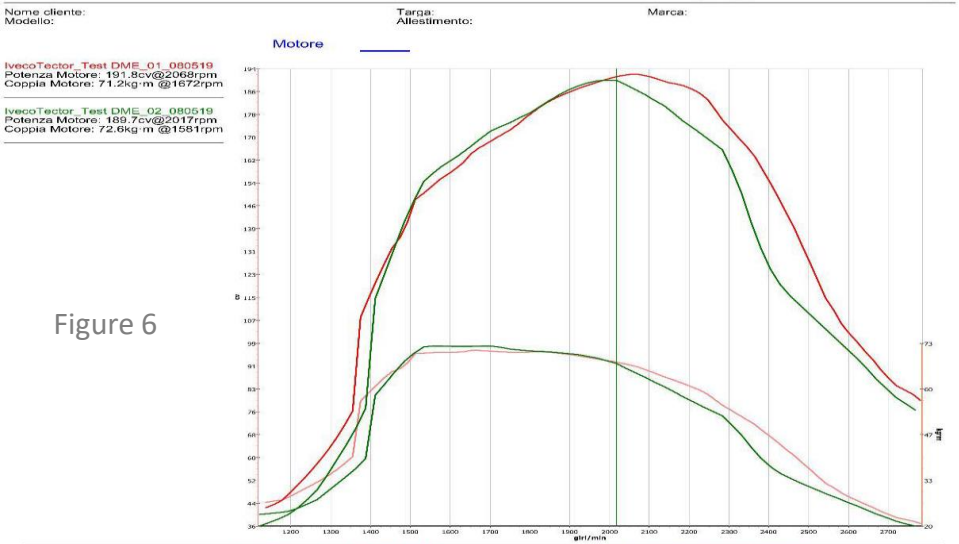
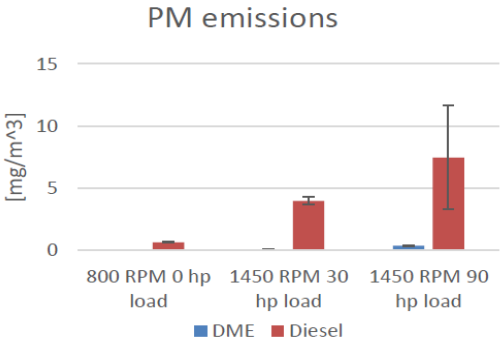
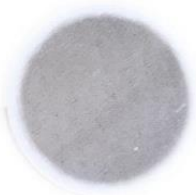


Figure 6

NOME DEL TEST:	IvecoTector_Test DME_01_080519	IvecoTector_Test DME_02_080519
DATI VEICOLO		
CX-SUP FRONTALE	0.80 Cx - 2.5m²	0.80 Cx - 2.5m²
RAPPORTO-MARCIA	2.20 - 4	2.20 - 4
RPM MIN-MAX	1100 - 2800	1100 - 2800
DATI AMBIENTALI		
TEMPERATURA ATMOSFERICA:	14.8°C - 58.6°F	14.9°C - 58.8°F
PRESS. ATM - TEMP. OLIO	1012mBar - 47.4°C	1012mBar - 47.6°C
FATTORE DI CORREZIONE:	(DIN 70020) 0.992	(DIN 70020) 0.992
TEMPO DI ACCELERAZIONE:	10.90s	10.78s
DATI MOTORE		
POTENZA MOTORE	191.8cv@2068rpm	189.7cv@2017rpm
COPPIA MOTORE	71.2kg·m @1672rpm	72.6kg·m @1581rpm
MASSIMI VELOCITÀ - RPM	0km/h - 2798rpm	0km/h - 2798rpm

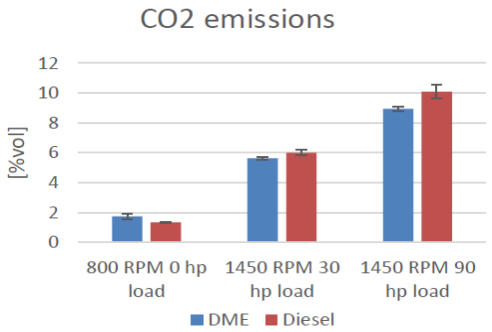
Test 100% DME - Emissions





DME Euro 3

Diesel Euro 3



Qualitative comparison between standard PM filter, of PEMS measurements, all the measurements were done roughly for the same time period and distance, but not on the same vehicle.

Conclusions

The current research program demonstrated the benefits of using DME as fuel for diesel engines.
The targets of the research program was: Convert a diesel engine truck to DME, demonstrate this truck on the road and measure its emissions under DME mode and under diesel mode.

The most outstanding benefit of DME as fuel for diesel engines is the fact that it emits **very low** particle matter and therefore engine calibration can be done with a target to optimize NOx emissions without facing the normal trade-off on PM and NOx emissions.

DME has a very low viscosity and average energy density therefore normal Diesel fuel system and injection equipment might have to be modified in order to inject DME into the engine.

DME has a low critical temperature (relative to diesel), and therefore can create supercritical spray which has better attributes compared to normal spray (increase spray volume).