SUMMETH 2015-2017
Methanol as an alternative fuel for smaller marine vessels

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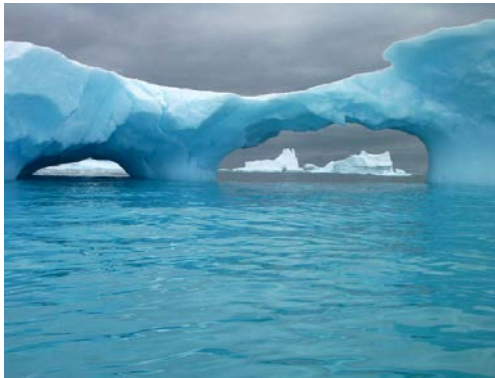
Motivation

- **Emission regulations are tightening**
  - Fuel sulphur max. 0.1% or scrubbers in SO_x emission control areas (SECAs) (2015) and 0.5% globally 2020 (IMO MEPC, 2016)
  - NO_x Tier III regulations (2016) for NECA new vessels
  - Particulate Matter, Black Carbon emissions considered at the IMO
- **Global warming burden of shipping needs to be reduced**
  - GHG strategy of the **IMO target to cut shipping sector's CO_2 emissions by 50% by 2050** (strategy 2018, revision in 2023).
  - The EU's CO_2 emissions from maritime transport to be cut by at least 40% from 2005 levels by 2050 (EC's White Paper on transport, 2011).

A switch to climate-neutral, clean and sustainable fuels for shipping is needed



Photos: VTT

SUMMETH PROJECT: The sustainable marine methanol

To reduce **emissions** (improve air quality) and **carbon footprint** of smaller vessels by developing clean methanol solutions.

- Market study of smaller vessels in NW Europe
- **Development work for smaller methanol marine engines**
- Case study design for methanol conversion of a road ferry
- Renewable methanol supply chain investigation


Photo: Kasper Dudzik

PROJECT PARTNERS

CO-FUNDED BY

SUMMETH reports

- Website: www.marinemethanol.com

For more information contact

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VTT: earlier work on methanol fuel

IEA-AMF Annex V (90's)

- Engine and car testing: M0…M85 at -20…+22 ºC. Cold starting difficult. Emissions generally low, although depending on car and temperature.

Wärtsilä's gas-diesel concept

- **Stena line** methanol ship with Wärtsilä's retrofit. HFO/MDO can be used as a back-up fuel.
- **At VTT testing with Wärtsilä Vasa 4R32 LN/GD engine** (1.6 MW, CR 13.8:1): NO_x 3-5 g/kWh (Low Tier II), low PM (FSN~0,1 HFO as pilot), low formaldehyde emission. Efficiency comparable to running on diesel*.

IEA-AMF Annex 44 (China, Israel, Finland)

- M15, E10, M30, E20, E85, E100: low effect of methanol on carbonyl emissions, but unburnt fuel observed. Low PM and aromatic emissions.

*) Haraldson, Lennart. Methanol as marine fuel, 19 March 2015, Helsinki.

IEA-AMF reports at http://www.iea-amf.org.

Photos: VTT

SUMMETH: MD95 concept testing at VTT

- Marine applications typically use diesel cycle engines.
- Methanol blends with ignition improver candidates (MD95) were tested a) at small-scale b) in a Scania alcohol engine designed for additised ethanol (ED95).

Solubility of different components to methanol were studied with nine blends.

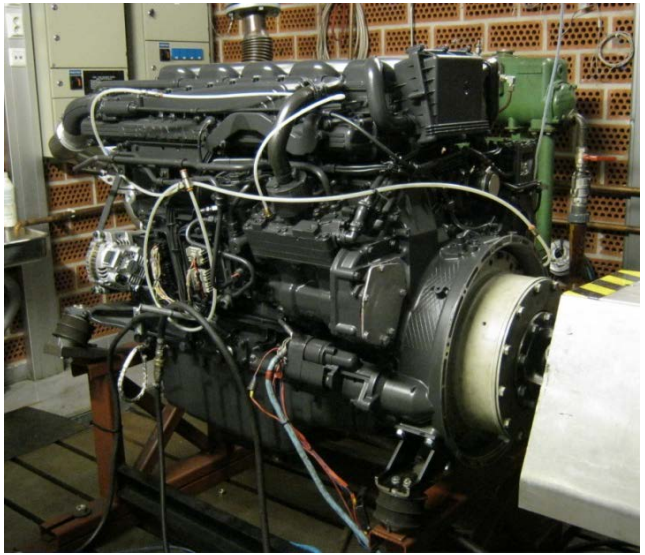
Results and photo from SUMMETH project partner VTT Technical Reeearch Centre of Finland, P. Aakko-Saksa

MD95 fuels:

- Methanol, dry (80-85 wt%)
- Water (5.5 wt%)
- Ignition improvers
- Lubricity improver and oxygenate options case-specifically
- Stability additive

SUMMETH: VTT work with MD95 / Scania engine

- Scania DC9 E02 270 EEV (commercial)
  - Model year 2011, 5 cylinders, 8.9 dm^3
  - Compression ratio 28:1,
  - 198 kW@1900 rpm, 1200 Nm@1100-1400 rpm
  - Emission level Euro 5/EEV
- 13-mode ESC test cycle. CO, THC, NO_x, PM, CO_2, methanol, formaldehyde, sPN(<23nm), particle number size distributions (ELPI)
- Cylinder pressure analysis and intake manifold injection testing (to enhance the start of combustion).
- Preliminary MD95 trial within IEA-AMF Annex 46.*)

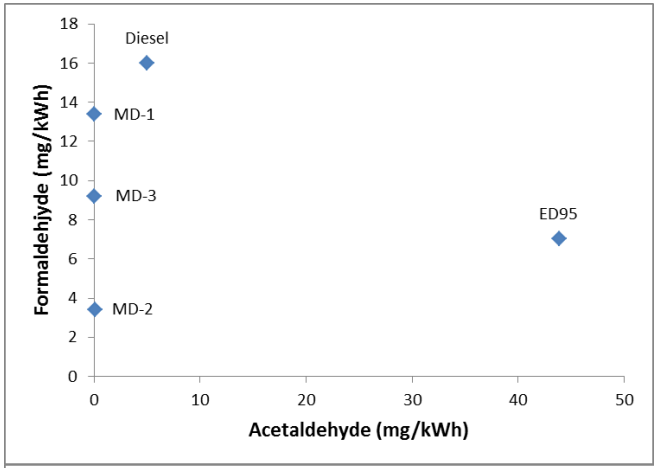


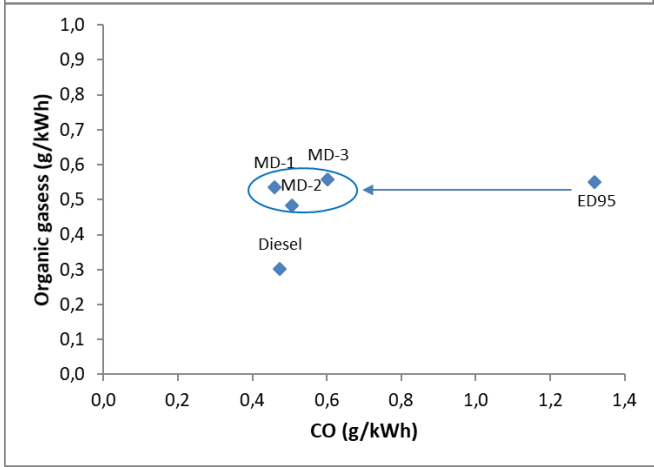
*) Murtonen, T., Nylund, N-O., Westerholm, M., Results with Scania ethanol engine using different fuels. Copenhagen 26.2.2015. (IEA-AMF Annex 46: Alcohol Application in CI Engines, http://www.iea-amf.org/).

Nylund N-O., Murtonen T., Westerholm M., Söderström C., Huhtisaari T., Singh G, Testing of various fuel and additive options in a compression-ignited heavy-duty alcohol engine, 21st ISAF Symposium, 2015.

MD95 concept - results

- Several MD95 methanol blends were **clean burning** in the Scania EEV Ethanol DC9 engine
- Aldehyde emissions were generally low. Particle emissions “liquid”-type material (e.g. additives) that probably removed by oxidation catalyst (belongs to the commercial Scania alcohol engine).
- Cylinder pressure analysis showed similar performance for MD95 and ED95 fuels. Fuel injection in the intake manifold could allow running with low additive dosing.
- **The MD95 concept potential solution to introduce environmentally friendly renewable methanol fuel for smaller vessels.**

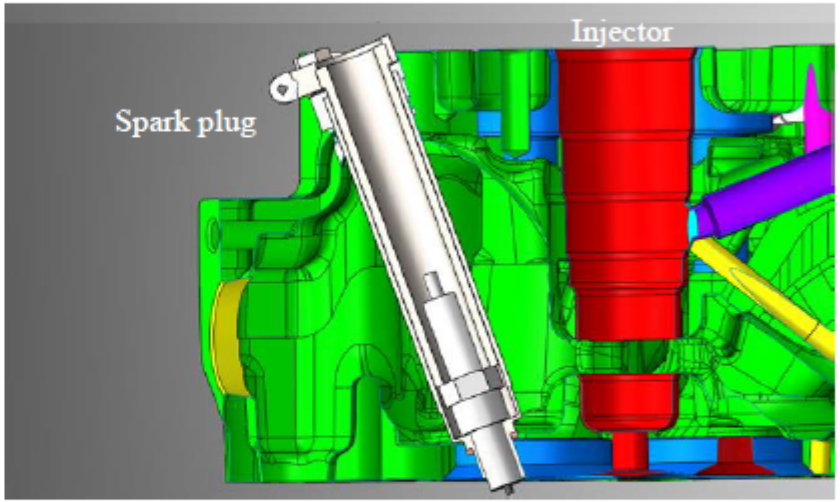




Engine Testing: Direct Injection Spark Ignition

- tests of direct injection spark ignition combustion of methanol were carried out in early 2017
- effects of spark timing, start of ignition, common rail pressure, and exhaust gas recirculation assessed
- indicated gross efficiencies of 54% were found to be possible with methanol
- further testing will focus on port ignition with a glow plug concept

Modified cylinder head



Lee Björnestrand, Lund

Results and figure from SUMMETH project partner Lund Technical University

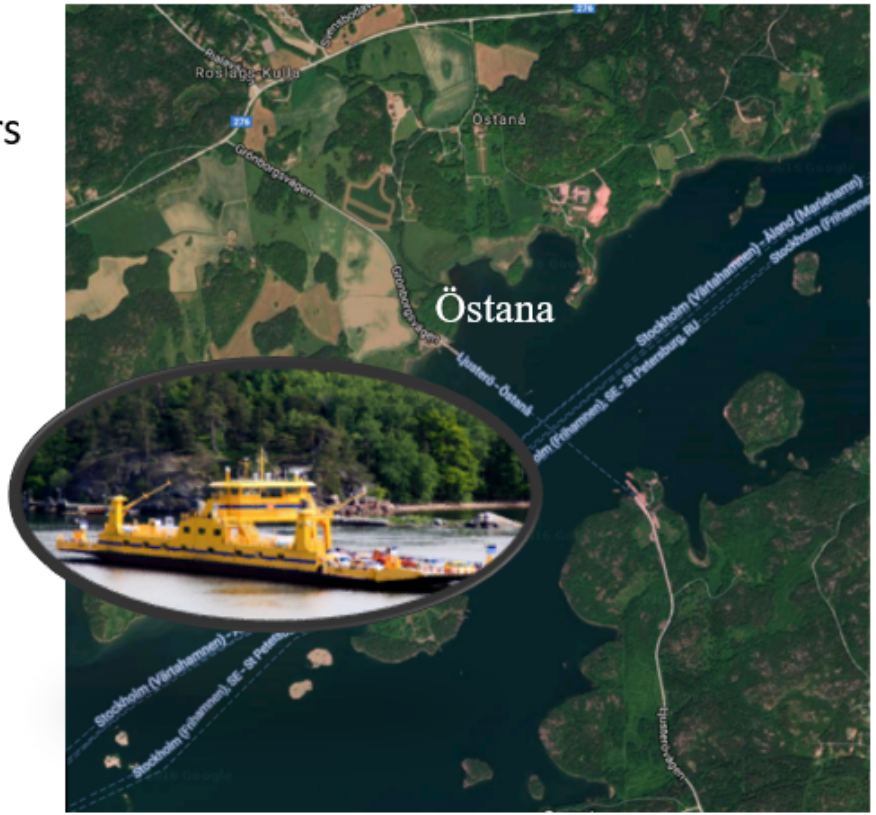
SUMMETH project market analysis

- Focus on vessels using main propulsion engines in the size range of
  a) 250-800 kW (automotive equivalent)
  b) 800-1200 kW (larger marine engines)

- Market analysis used AIS (Automatic Identification System) records to determine the number of ships using engines in the size ranges, together with modelling data. from AIS data was used to estimate **total fuel use and vessel types using the most fuel within the range**.

Case study: Conversion of a Swedish Road Ferry to methanol operation

- M/S Jupiter road ferry – 86 metre length, capacity for 397 passengers and 60 cars
- Currently running on diesel fuel, bunkered by truck
- Developed a methanol conversion design with recommendations for fuel storage and supply, safety systems, and bunkering
- Emissions reduction potential compared to operation on diesel fuel



Conversion design developed by project partner ScandiNAOS

GreenPilot

- Conversion of a Swedish pilot boat to run on methanol
- Two engines tested on board with methanol – using spark-ignited port fuel technology
- Fossil-free methanol produced from pulp mill black liquor was used in the tests
- On board emissions measurements verified very low particulate emissions and low NOx

Co-financed by

SWEDISH MARITIME ADMINISTRATION

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SWEDISH TRANSPORT ADMINISTRATION

METHANOL INSTITUTE

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Summary

- Good results for using methanol with different engine concepts
- **Resonable costs** for conversion of smaller vessels to methanol
- Commercial **smaller marine engine certified for methanol needed**
- **Renewable methanol offers potential to reduce climate burden of smaller vessels**

Thank you

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