GreenPilot

Environmental performance of Smaller Ships Using Methanol

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Swedish Maritime Administration

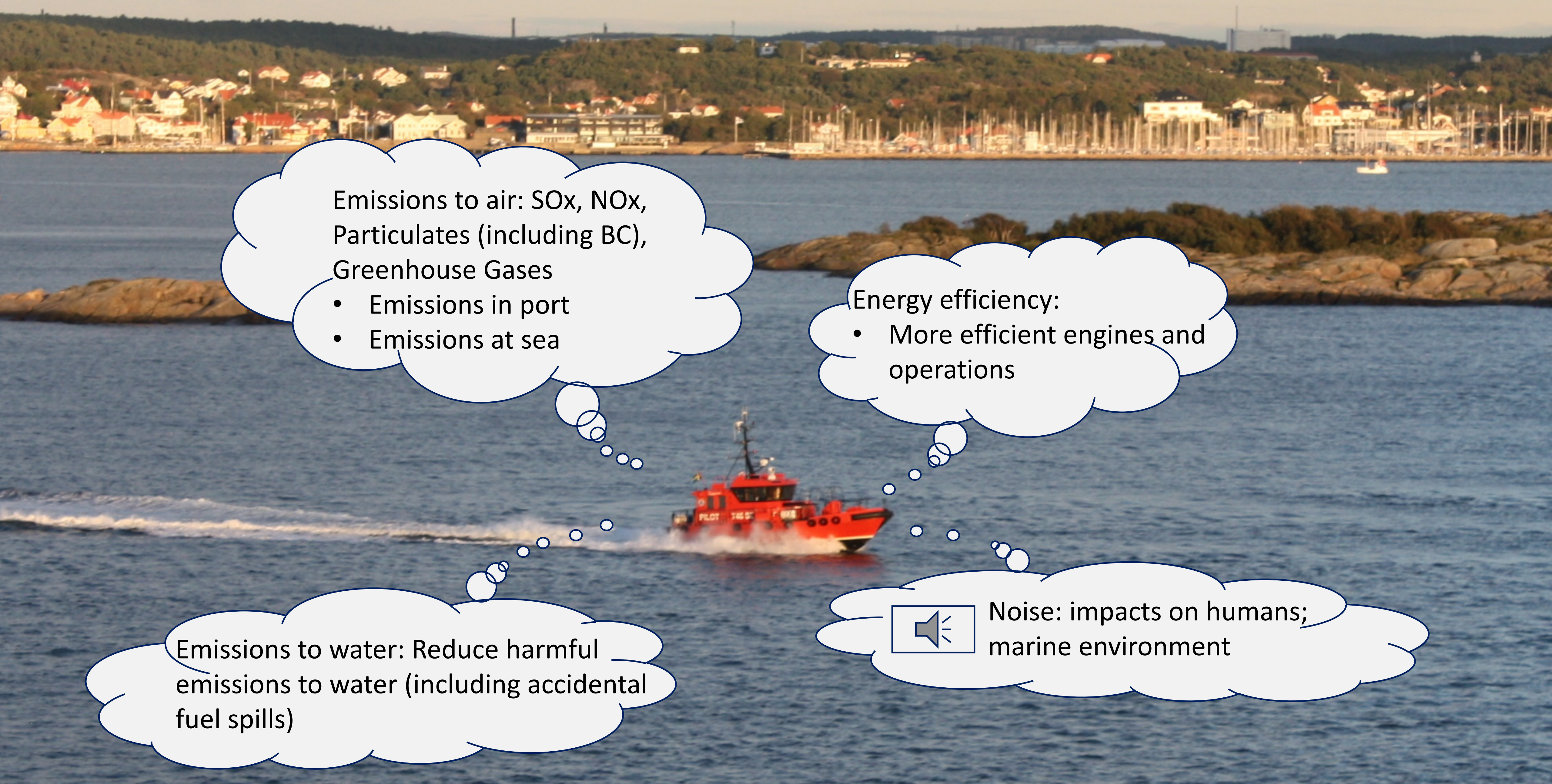
Trafikverket
Swedish Transport Administration

Methanol Institute

OUTLINE

- Environmental performance: categories and drivers
- Environmental assessment for the GreenPilot project
- Green methanol: feasibility of supply for the small vessel market in Sweden
- Summary

ASSESSING ENVIRONMENTAL PERFORMANCE



DRIVERS FOR EMISSIONS REDUCTIONS IN SHIPPING

- SOx emissions regulations:
  - 0.1% in sulphur emission control areas (2015 for the Baltic Sea)
  - 0.5% globally by 2020 (IMO MEPC, October 2016)
- NOx Tier III regulations (2016) for emission control areas – new vessels. The North Sea and Baltic Sea NECA applies to vessels built after 2021
- Particulate Matter
  - Linked to health impacts, premature deaths for long term exposure
  - Black Carbon (a component of particulate matter that strongly absorbs visible light) is a contributor to climate change

GHG EMISSION REDUCTION TARGETS

International: IMO adopted a climate change strategy in April 2018 calling for at least a **50% reduction of GHGs** by 2050 (compared to 2008 levels).

European: EU's CO_2 emissions from maritime transport should be cut by **at least 40%** from 2005 levels by 2050 (EC's 2011 White Paper on transport)

National Examples:

- Sweden: In February, 2018, the Swedish Government directed the Swedish Transport Administration to carry out an analysis of how operation of state-owned vessels, including road ferries and pilot boats, could be fossil-free.
- Norway: Norwegian National Transport Plan 2018-2029: new ferries connected to the national public road system use zero or low emission technology

Corporate Examples:

- Carnival Corporation goal to “reduce the carbon intensity of its operations by 25% by 2020”
- Royal Caribbean Cruises Ltd. set a goal to reduce greenhouse gas emissions by 35% by 2020

New fuels from renewable feedstocks, such as bio-methanol or methanol from CO_2, are required to meet these goals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MEPC 72: IMO GHG Deal Spells End of the Oil-Based Bunker Industry From the 2030's, Says Expert

Monday April 16, 2018

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Last Friday's historic agreement at MEPC 72 to reduce Shipping emissions will spell the end of today's traditional oil-based bunker industry from the 2030's, according to **Dr Tristan Smith** from the **UCL Energy Institute**.

The deal envisions a reduction in the total annual GHG emissions from Shipping of at least **50%** by 2050 compared to 2008, while at the same time pursuing efforts towards phasing them out entirely.

Time could be running out for the traditional bunker industry. File Image / Pixabay.

"From the 2030s, it is highly unlikely that new ocean-going vessels will be dependent on fossil fuels. Rather we will be looking at zero carbon renewable fuels to power the world's fleet," says Smith.

"If you are building a ship or planning to build a ship in the 2020s, it will likely need to be able to switch to non-fossil fuels later in its life, a factor insurers and shipping financiers will need to consider in their business plans through the next decade."

The prospect of such a future has other near-term implications too, such as for those considering - or touting - fossil fuel-dependant solutions for the upcoming "IMO2020" global **0.50%** sulfur cap on marine fuel.

we could see a diverse shipping fleet powered by hydrogen, ammonia

CONSIDERATIONS FOR SPILLS TO THE AQUATIC ENVIRONMENT

- Hydrocarbon fuels (HFO, MGO) do not dissipate readily and are persistent in the marine environment
- Methanol:
  - is fully miscible with water and dissolves readily
  - Biodegradable and does not bioaccumulate
  - Methanol is not rated as toxic to aquatic organisms using the GESAMP rating system (Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection)

IMPACT CATEGORIES - AIR

Assessment categories for fuel life cycle comparison of methanol with conventional MGO:

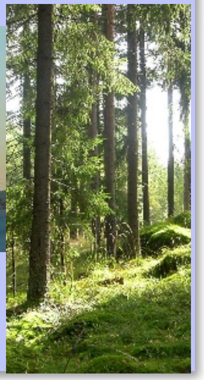
- Greenhouse gases (GHGs) (CO_2, N_2O, CH_4)
- SO_x
- NO_x
- Particulate Matter (PM)

Corresponding to impacts:

- Climate change
- Eutrophication
- Acidification
- Health effects

FUEL LIFE CYCLE ASSESSMENT MAIN STEPS

Extraction, cultivation, capture, etc. of primary energy source

Fuel Production: e.g. refining for oils, gasification for biomass

Transport, Storage, and Distribution of fuel

Fuel Use
Emissions from combustion on board

Well to Tank Chain

Tank to propeller or ”tank to wake”

COMPARISON OF EMISSIONS PER MJ FUEL PRODUCED (WTT)

Fuels	CO_2 g/MJ	CH_4 g/MJ	N_2O g/MJ	GHGs g CO_2e/MJ	NOx g/MJ	SOx g/MJ	PM10 g/MJ
MGO, 0.1% S[1]	7,1	0,078	0,00017	9,3	0,023	0,041	0,00110
Methanol from natural gas[1]	20,5	0,011	0,00031	20,9	0,051	0,003	0,00063
Methanol black liquor[2]	3,1	0,011	0,00835	5,7	-	-	-
*Methanol, from biogenic CO_2, wind energy**	*7,4*	*0,012*	*0,01420*	*11,5*	*0,029*	*0,017*	*0,00239*

Pilot Boat 729 used both methanol from LTU Green Fuels (black liquor and pyrolysis oil gasification) and methanol produced from natural gas

1 Data for production from Brynolf (2014) Environmental assessment of present and future marine fuels. Doctoral Dissertation. Chalmers University of Technology, transport emissions estimated for this study for supply to smaller vessels; 2 Production data from Edwards, R., Larivé, J.-F., Rickeard, D., and W. Weindorf. 2014. Well-to-wheels analysis of future automotive fuels and powertrains in the European Context, Well-To-Tank (WTT) report, Version 4a, transport emissions estimated for supply to smaller vessels; * Estimate based on production of methanol from renewable hydrogen and carbon dioxide from method as described in Matzen and Demeril (2016), with estimated emissions for fuel transport to supply smaller vessels.

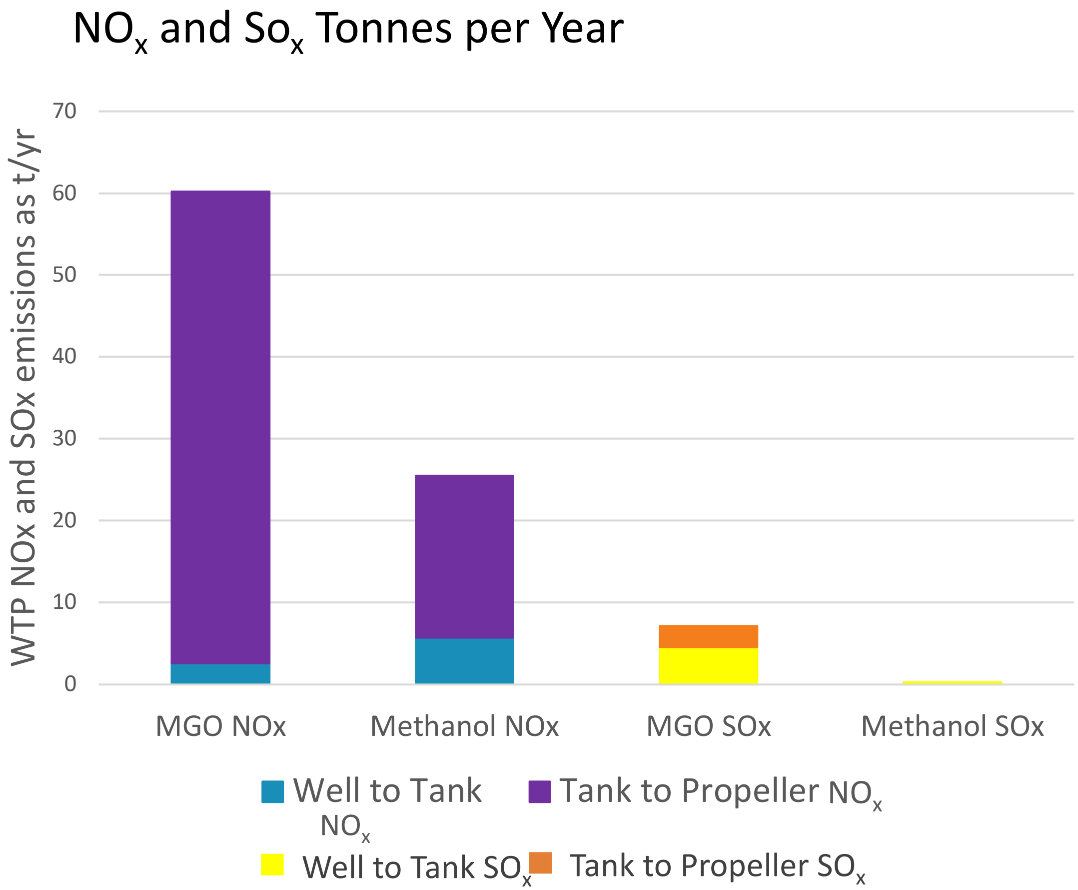
COMPARISON OF EMISSIONS PER MJ FUEL COMBUSTED

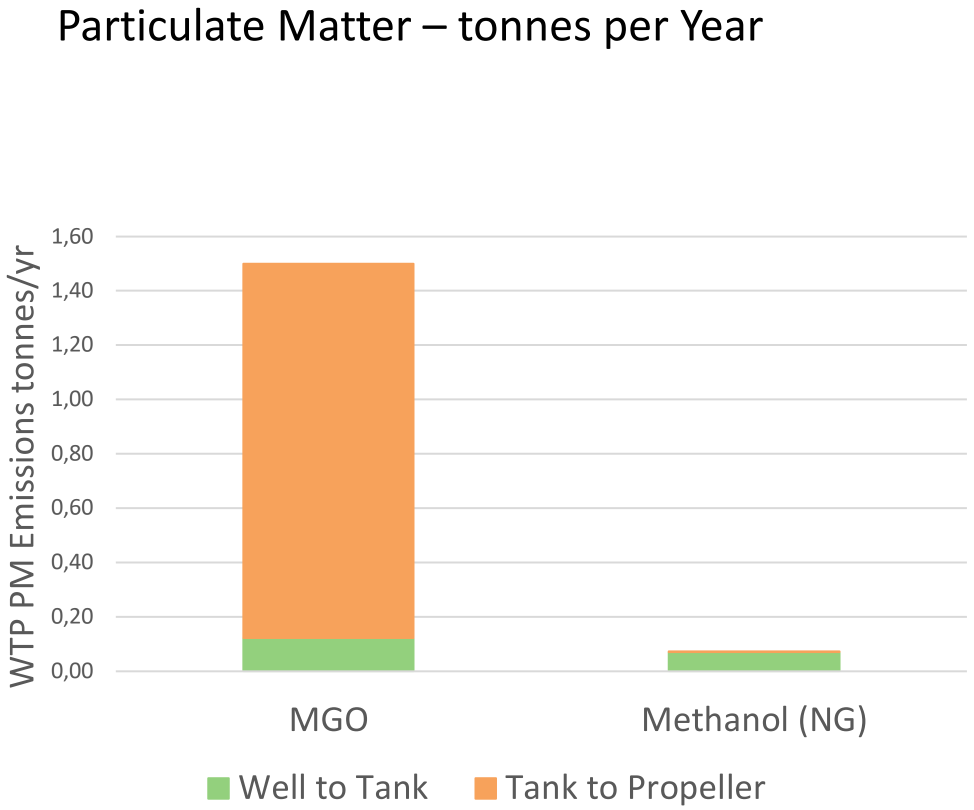
Fuel and Engine	CO_2 g/MJ	NOx g/MJ	SOx g/MJ	PM g/MJ
GreenPilot Engines				
MGO, 0.05% S, High Speed Marine Diesel Engine (Cummins)[1]	74,7	0,518	0,023	0,01240
Methanol, Spark ignited, port fuel injection engine (Weichai)[2]	68,5	0,178	0,000	2,8E-06
Swedish Road Ferry Göta	CO_2 g/MJ	NOx g/MJ	SOx g/MJ	PM10 g/MJ
MK 1 (0.001% S Diesel), no particle filter, HS marine diesel engine (Scania)[3]	72,3	0,820	0,00005	0,00947
MK 1 (0.001% S Diesel), with particle filter, HS marine diesel engine (Scania)[3]	71,5	0,781	0,00005	4,8E-04

[1]from Cummins Inc., 2010 (ISO 8178 E3 Cycle); [2] Molander, 2017 (ISO 8178 Cycle E3); [3] Winnes and Peterson, 2012.

NO_X, SO_X AND PARTICULATE MATTER EMISSIONS - PILOT BOAT FLEET

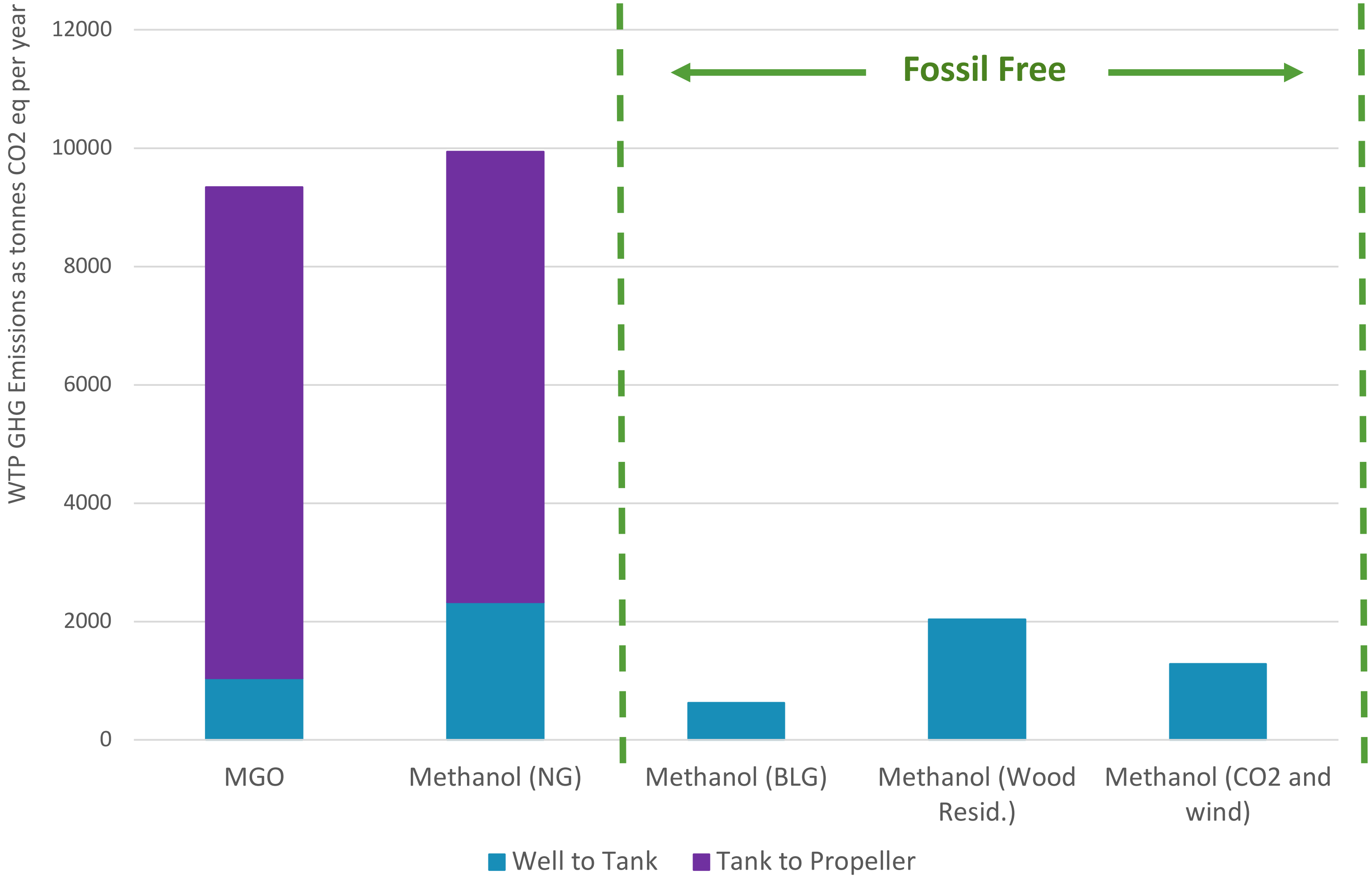
- NOx – majority of emissions occur during the ”tank to propeller” phase; methanol combustion results in significantly lower NOx emissions
- SOx – no sulphur in methanol so no emissions during operations (”tank to propeller”)
- Particulate Matter - significant reductions with methanol
- Pilot boat fleet in 2017: 72 vessels, annual fuel consumption of 3100 m^3





COMPARISON OF GHG EMISSIONS WELL TO PROPELLER, GREENPILOT

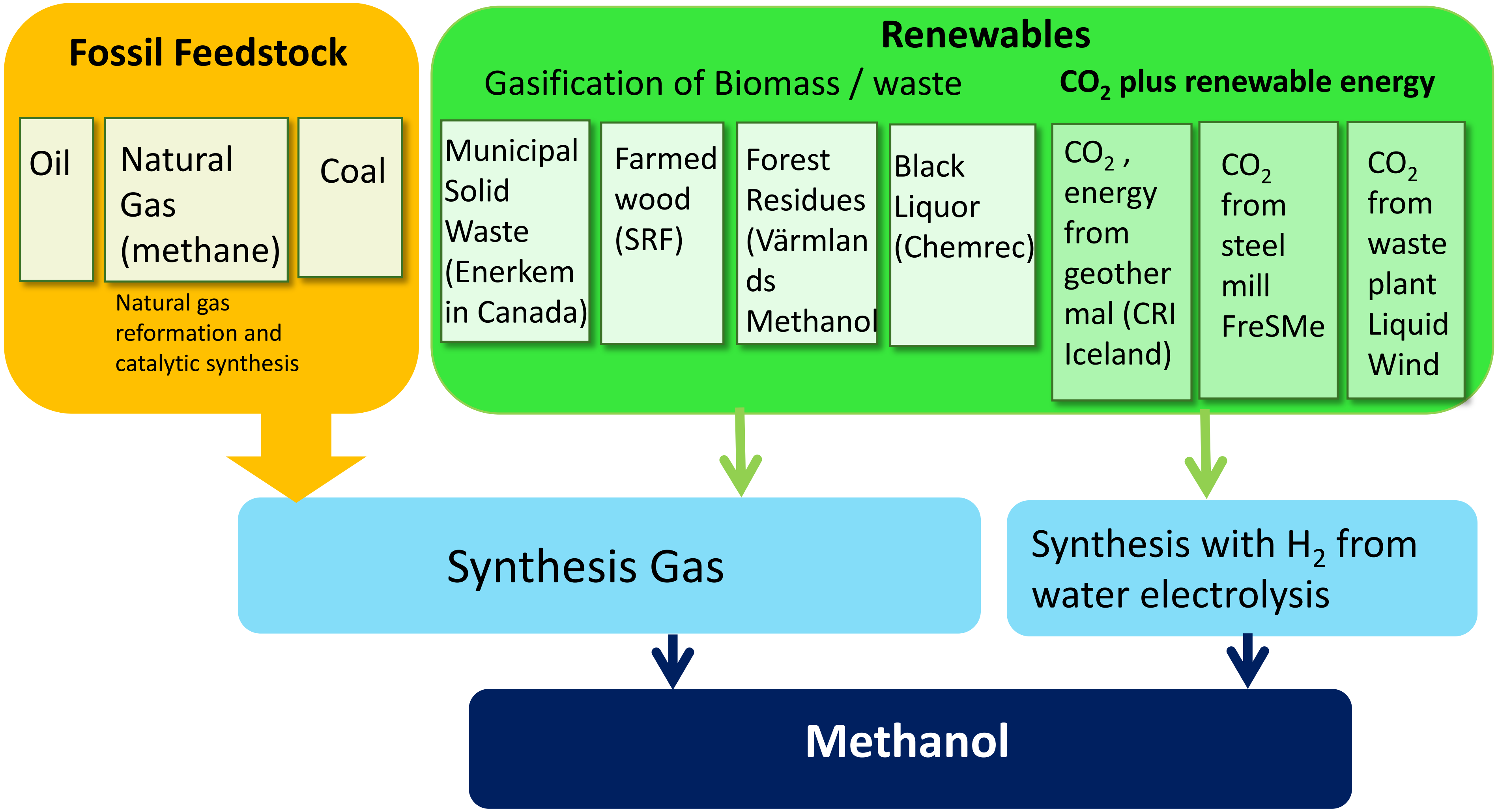
Well to Propeller GHG Emission Estimates for Swedish Pilot Boat Fleet, based on the total annual fuel consumption of 3100 m^3 (2588 tonnes) (2017 usage)



GHG REDUCTIONS OF OTHER METHANOL PRODUCTION PATHWAYS (EXAMPLES OF PLANTS IN CURRENT PRODUCTION)

- **CO_2 and Geothermal Energy**: Carbon Recycling International, Iceland: certified by the International Sustainability and Carbon Certification system (ISCC) as an ultra-low carbon advanced renewable transport fuel. Stated that the methanol has **75% lower GHG emissions** than standard fuel.
- Municipal Waste: Enerkem facility in Alberta, Canada, converts waste to methanol and then further to ethanol. Received the **lowest carbon intensity value ever issued by the British Columbia government under the renewable and low carbon fuel regulation**. (Estimated using the GHGenius model, received a value of -54.8 g CO2e/MJ).

METHANOL FUEL FEEDSTOCK – OVERVIEW AND EXAMPLES OF RENEWABLES



METHANOL SUPPLY IN SWEDEN – POTENTIAL PLANTS, PILOT TESTING, OTHER DEVELOPMENT

Methanol (from fossil feedstock) imported by ship to depots in Malmö and Södertälje

Renewable methanol:

Methanol from electricity and CO_2:

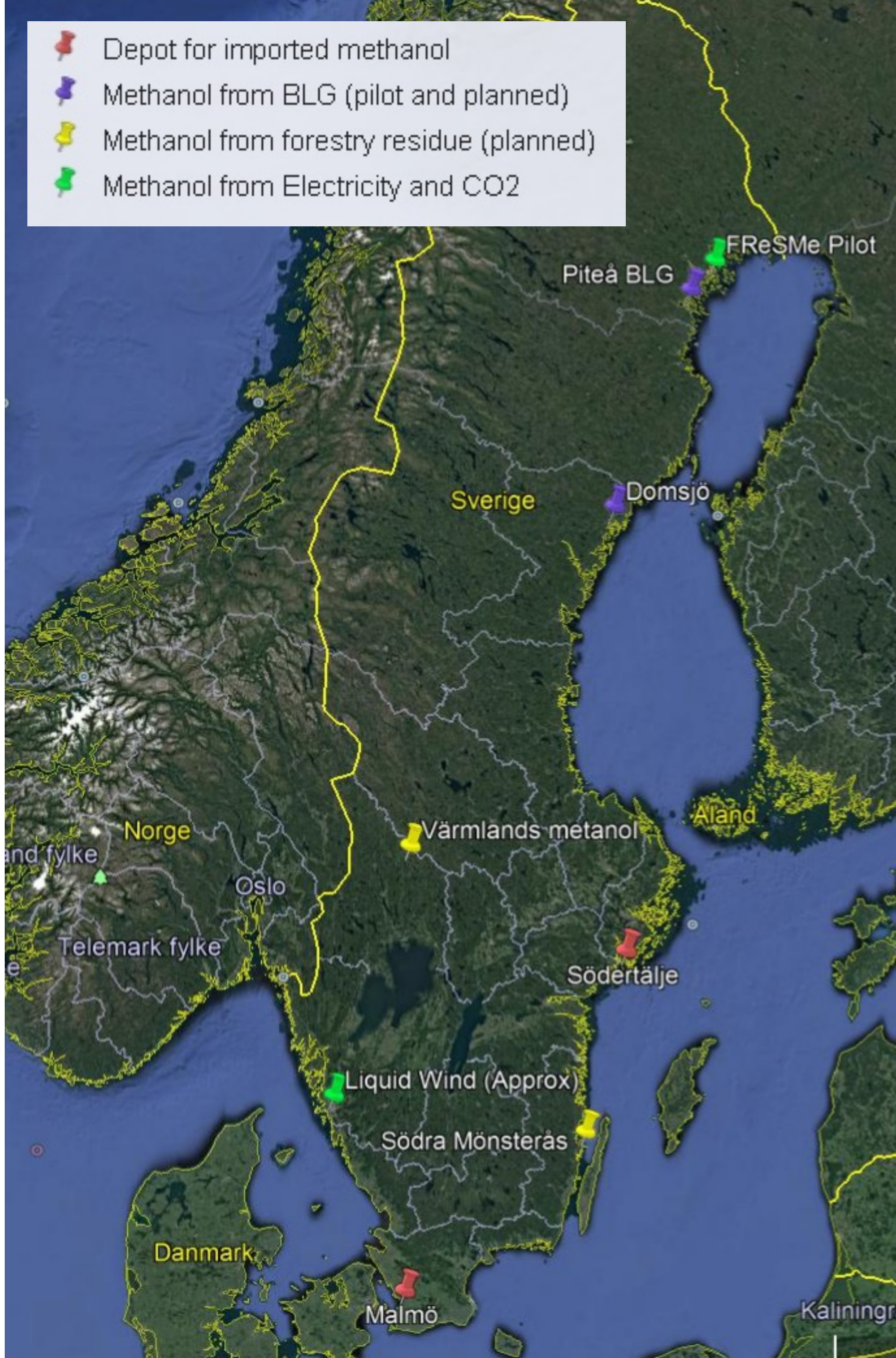
- FReSMe – pilot plant, H2020 Project underway
- Liquid Wind: Feasibility study completed May 2017, work is continuing

Methanol from Forestry Residue:

- Värmlands Methanol: pre-study 2010; additional studies in 2014; on hold
- Södra Mönsterås: started 2017, est. completion 2019, production 5000 tonnes annually

Methanol from black liquor gasification:

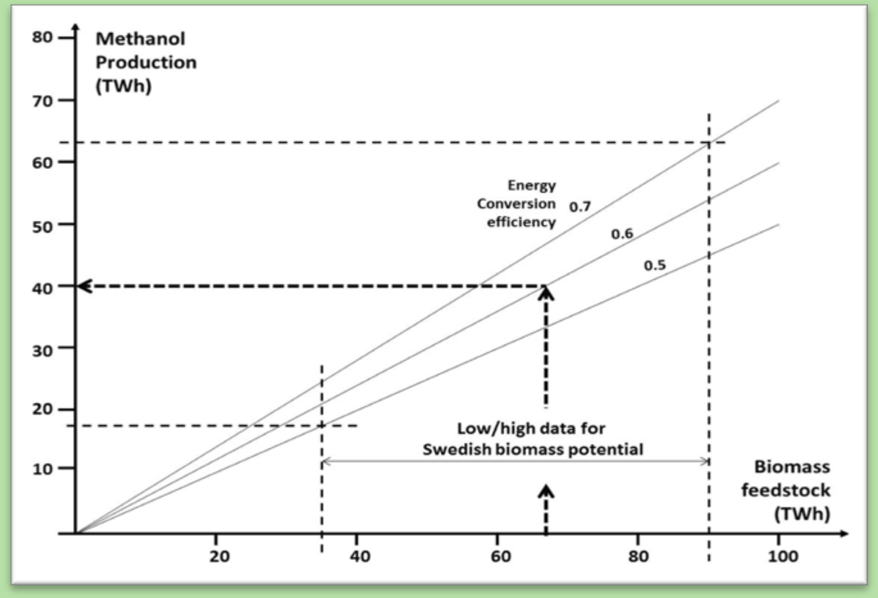
- Piteå (Chemrec) – pilot plant operated more than 25,000 hours
- Domsjö (Chemrec): industrial scale, extensive planning, not built



POTENTIAL PRODUCTION OF RENEWABLE METHANOL IN SWEDEN

Methanol Production Potential

- Domsjö (Chemrec) design capacity: 140 000 t/yr
- Black Liquor Gasification: Approx. 12 TWh of methanol = 2.2 million tonnes methanol from 10 kraft pulp mills in Sweden*
- Biomass: 40 TWh of methanol: 7.2 million t/yr



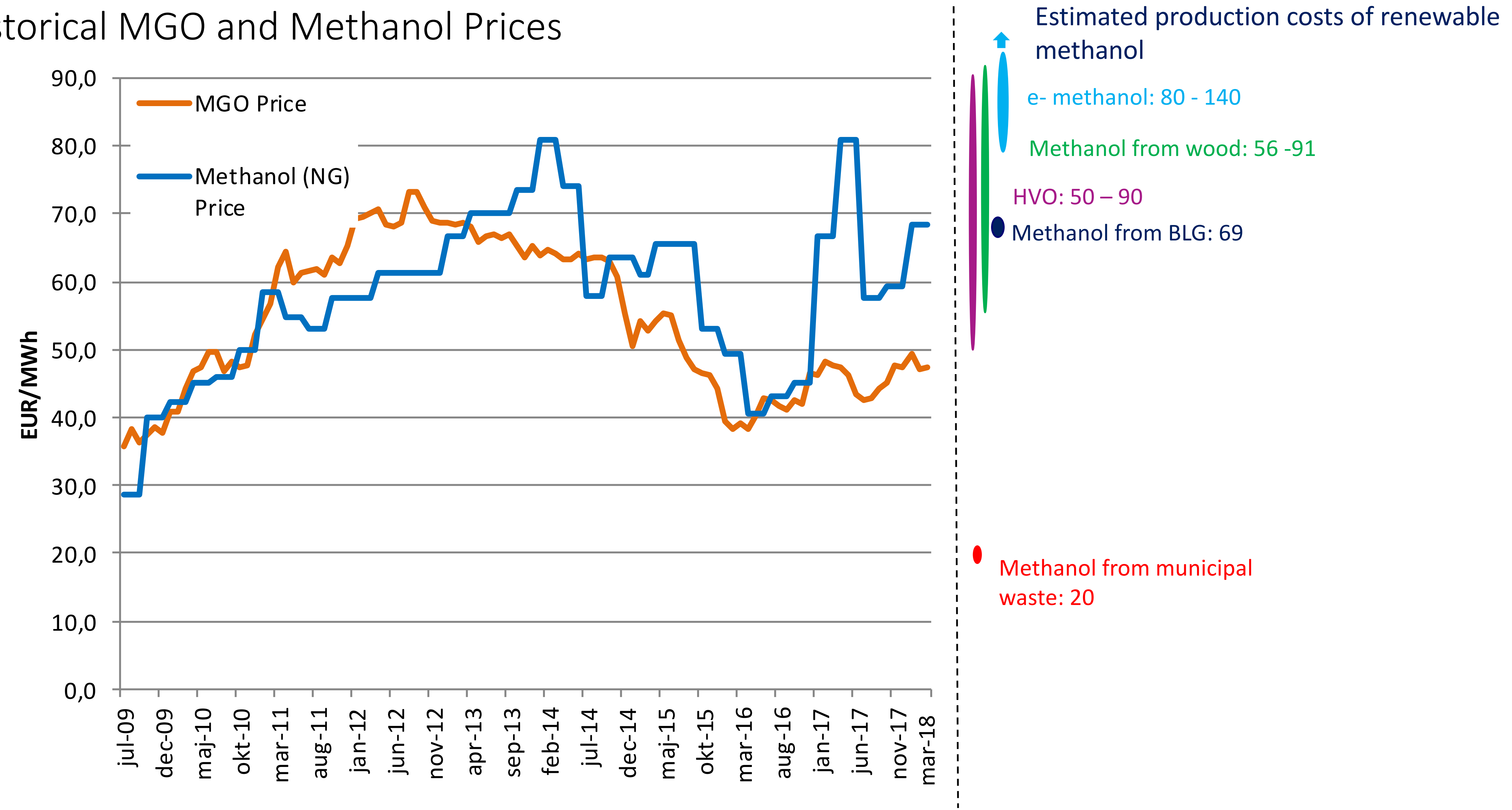
Methanol production as a function of biomass potential for different conversion efficiencies: from Landälv, I. 2017. Methanol as a renewable fuel – a knowledge synthesis. Report No. f3 2015:08. The Swedish Knowledge Centre for Renewable Transportation Fuels (f3)

*Source: Andersson, J. et al. 2016. Co-gasification of black liquor and pryolysis oil: Evaluation of blend ratios andmethanol production capacities. Energy Conversion and Management 110:240-248.

Marine Fuel Use Examples (as methanol equivalent on an energy basis)

Pilot Boat Fleet (2017):	5565 t/yr
Swedish Maritime Administration Total Marine Fuel Use (2017): (Icebreakers, pilot boats, work boats)	21 000 t/yr
Jupiter Road Ferry:	1505 t /yr
Swedish Road Ferries (all):	22 000 t/yr

Historical MGO and Methanol Prices



Data sources: Bunker Index for MGO, Methanex for Methanol NG (European contract price); Landälv (2017) methanol BLG; Landälv and Waldheim (2017) HVO and methanol from wood; Ianquaniello et al. (2017) for methanol from municipal waste; Taljegård et al. 2015 for e-methanol

BUNKERING POSSIBILITIES

For conventional fuels:

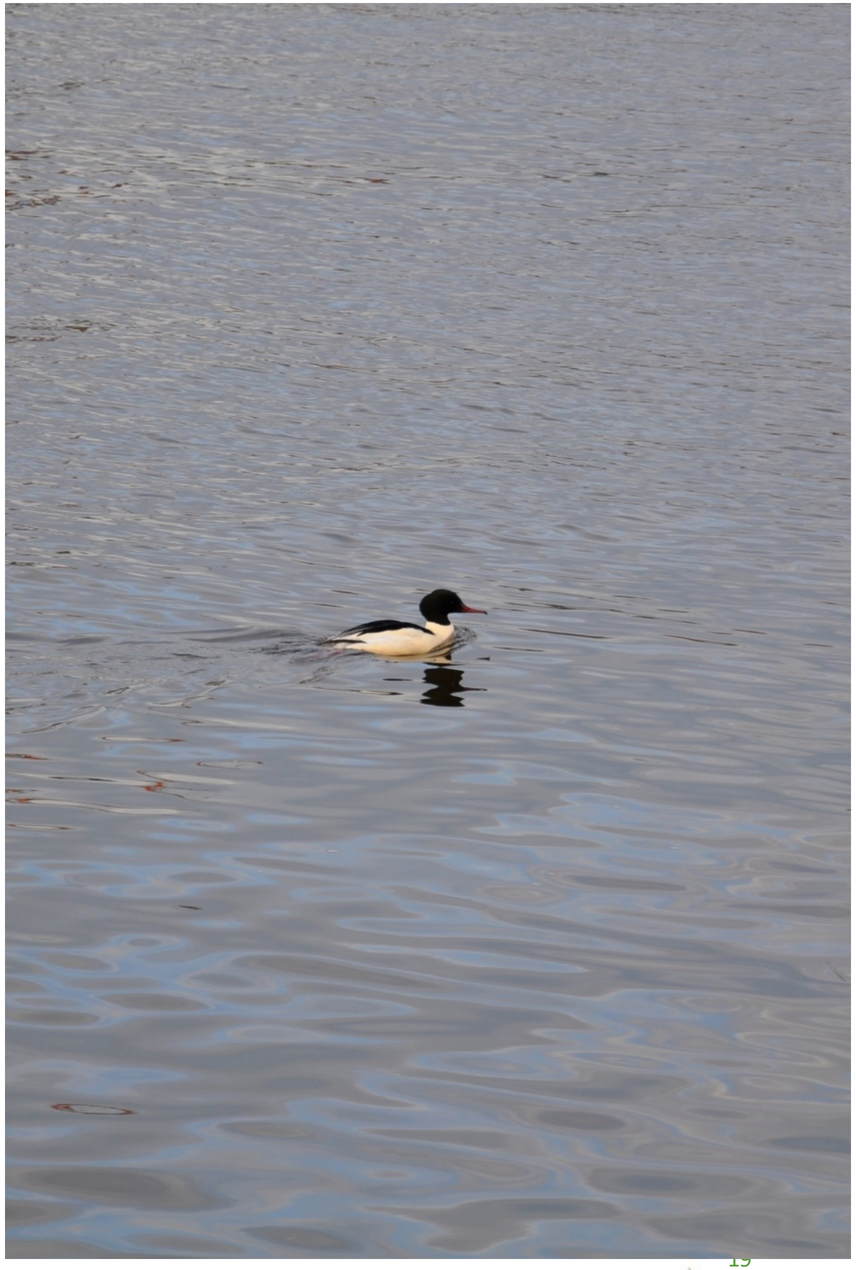
- Ship to ship
  - only available on the West coast of Sweden and for larger vessels
- Truck to ship
  - Almost all bunkering on Sweden's east coast is truck to ship
  - Swedish road ferries, commuter ferries bunker this way
- Land to ship
  - the Swedish Icebreaker fleet bunkers from tank storage in Piteå (Preem)
  - Storage tanks similar to ”gas stations” for smaller recreational vessels, fishing vessels

Methanol:

- GreenPilot: Portable container on a trailer
- Truck bunkering carried out for Stena Scanrail testing and for Stena Germanica
- Methanol delivered by truck routinely for other (non-marine) customers

SUMMARY OF ENVIRONMENTAL PERFORMANCE POTENTIAL – METHANOL FOR SMALLER VESSELS

- Reductions of emissions of SO_x, NO_x, and Particulate Matter with methanol fuel (irrespective of feedstock)
- Significant reduction of GHGs with methanol produced from renewable feedstock
- Many local feedstocks and production opportunities – but development needed
- Distribution system essentially in place, no challenges technically
- Reduced impact of accidental spills
- Lower noise emissions for engine type tested in the GreenPilot project



Thank you

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