Methanol as a Marine Fuel

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Delivered by Greg Dolan and Karin Andersson.
Presentation by Carlos Márquez.

About the Methanol Institute

- First formed in 1989, the Methanol Institute (MI) serves as the trade association for the global methanol industry.
- The use of methanol as a marine fuel is viewed as an historic opportunity
- MI represents the world's leading methanol producers, distributors and technology companies from offices in:

Washington | Brussels | Singapore | Beijing

MI 2016 Members

Methanol as a Marine Fuel

- Part I. Regulations

Part II. Technology

Part III. Main findings

Methanol as a Marine Fuel

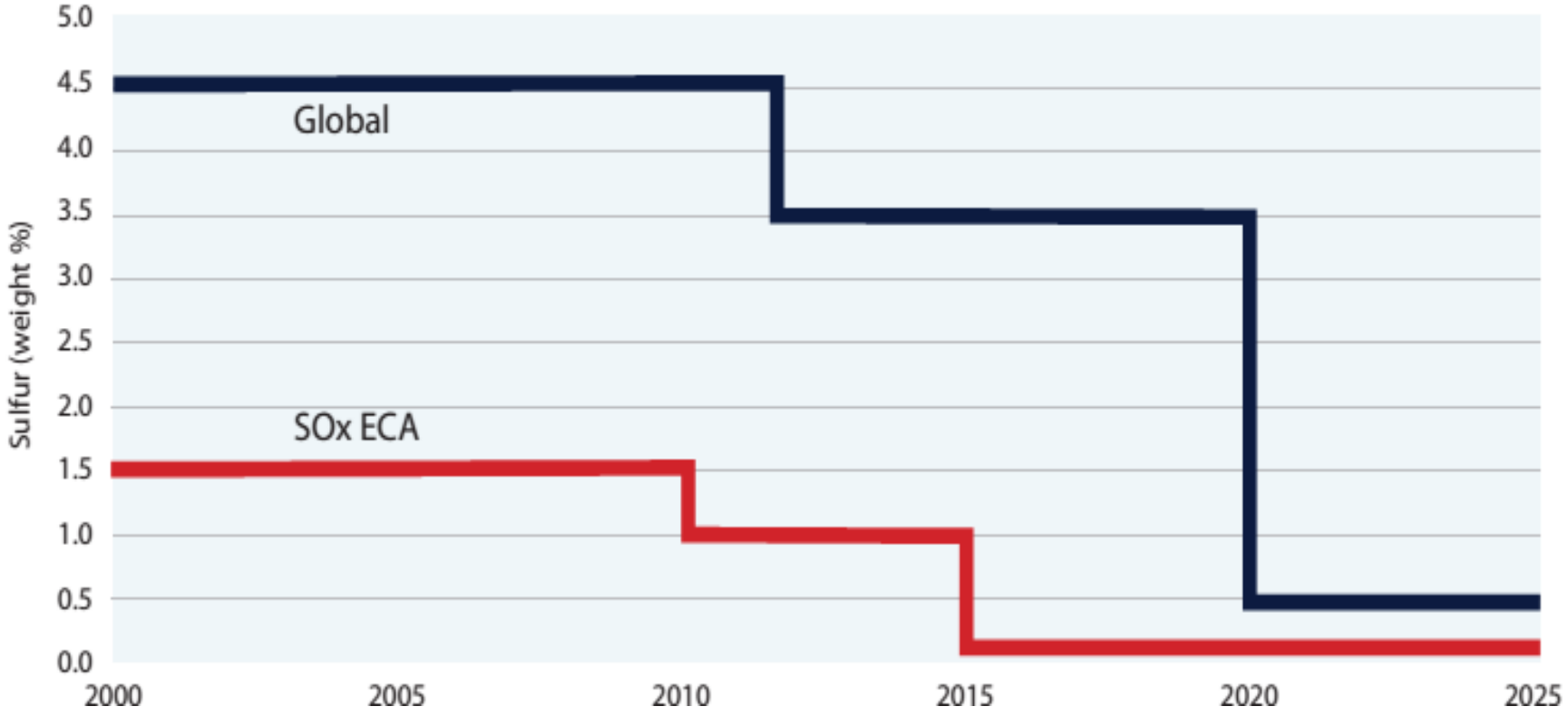
Part I. Regulations

- Emission control areas (ECAs)
  - ✓ SOx
  - ✓ NOx
- California: Ocean-going vessels fuel regulation
- EU Monitoring, Reporting and Verification Rules (MRV)
- Regulatory trends

Methanol as a Marine Fuel

Emission control areas (ECAs)

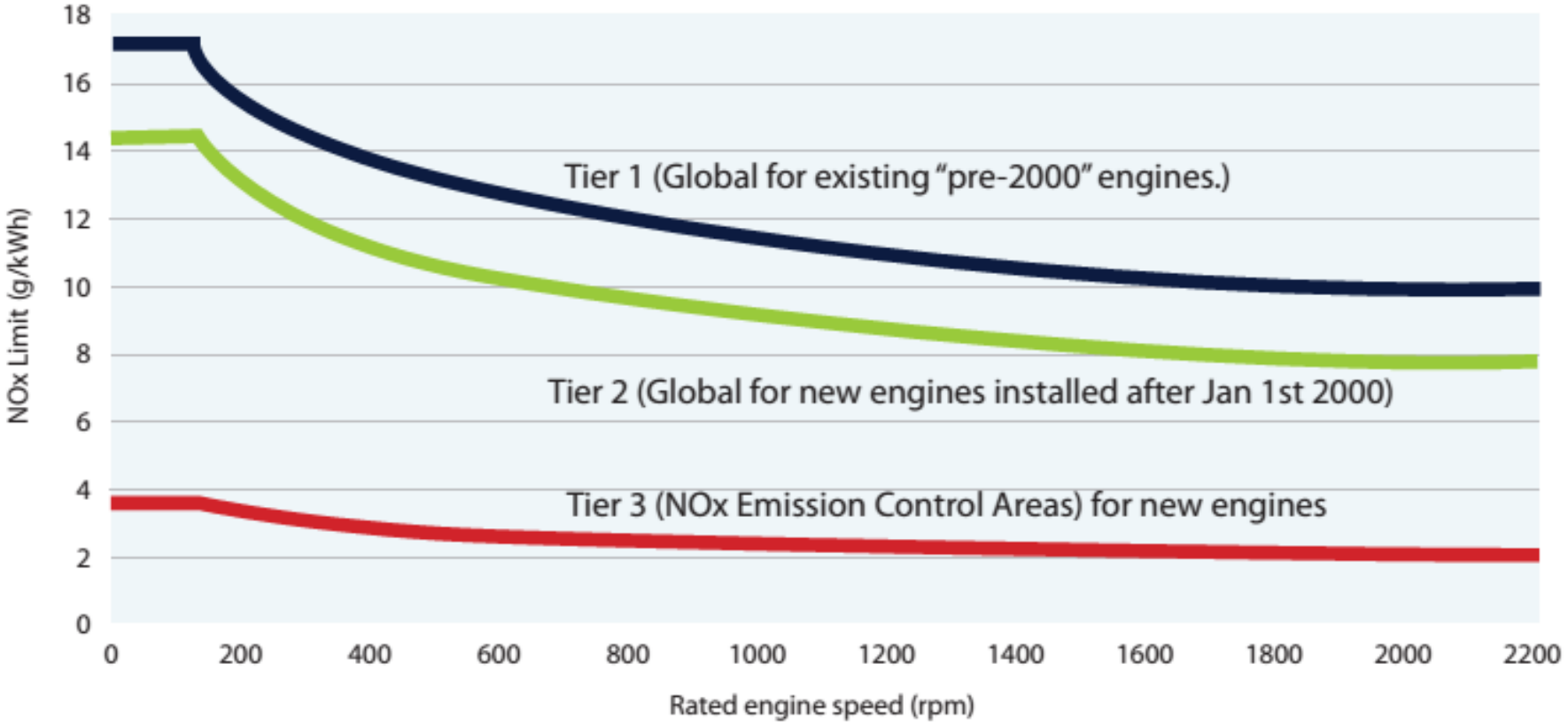
Limits on SOx content in fuel



Methanol as a Marine Fuel

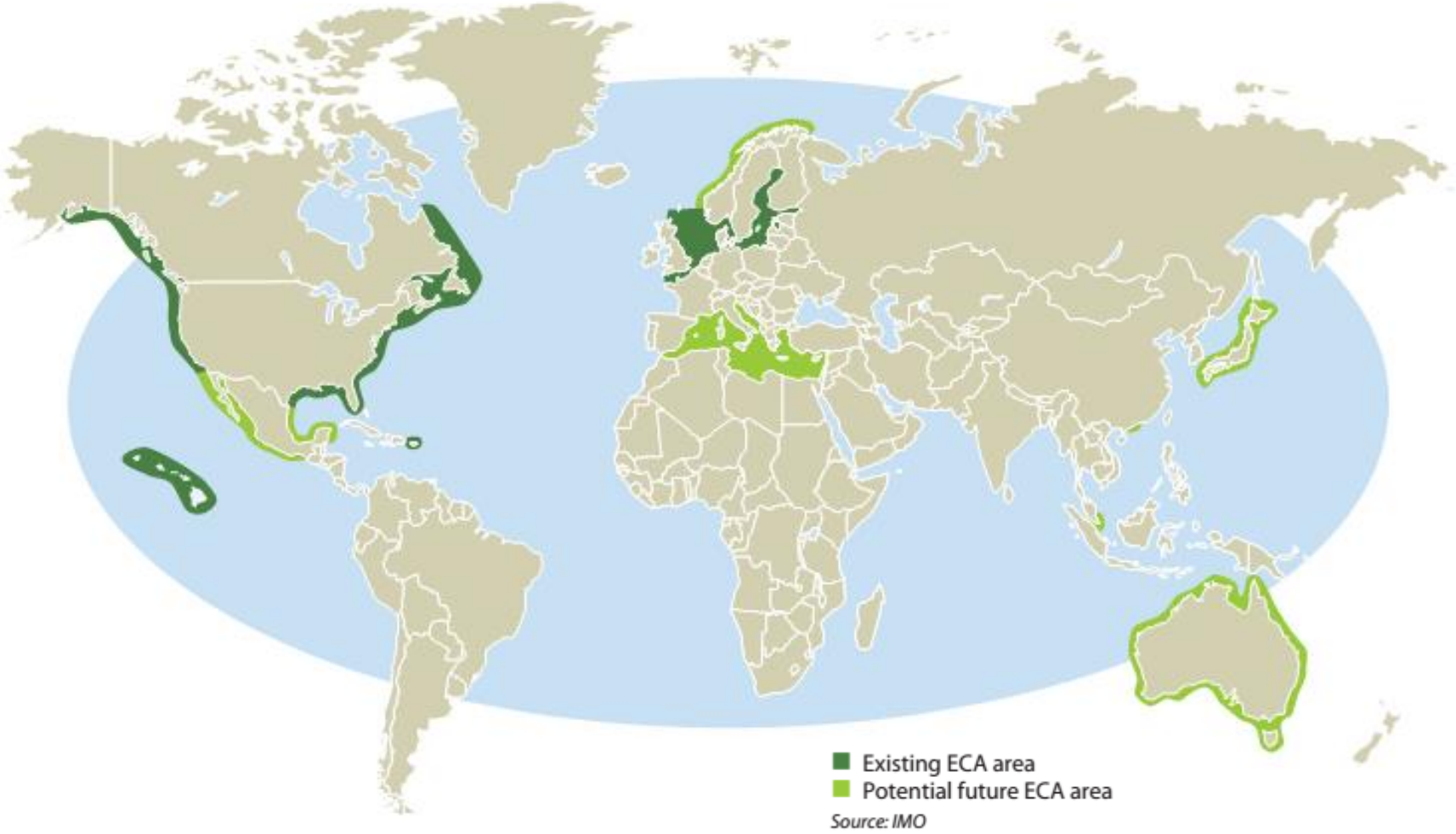
Emission control areas (ECAs)

Limits on NOx emissions for new-build ships



Methanol as a Marine Fuel

Emission control areas (ECAs)



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California: Ocean-going vessels regulation

"Fuel Sulfur and Other Operation Requirements for Ocean-going Vessels within California Waters and 24 Nautical Miles off the California Baseline". (CalEPA)

- Adopted on July the 24th 2008
- Covers SOx, NOx and particulates
- Using scrubbers to mitigate emissions instead of low-sulfur fuel is not allowed
- Fuel must be distillate grade

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EU Monitoring, Reporting and Verification Rules (MRV)

Under the EU Monitoring, Reporting and Verification (MRV) rules, passed by the European Parliament in April 2015, ship-owners will have to monitor CO2 emissions for each ship on a per voyage and an annual basis. (EC)

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Regulatory trends

- Regulation has progressively become more stringent (e.g. IMO proposed a global sulfur cap of 0.5% by 2020)
- Upcoming regulations are likely to target CO2 fuel emissions as well as SOx, NOx and particulates
- Life-cycle emissions and environmental impact of likely to be an important factor in regulation marine fuels

Methanol as a Marine Fuel

- Part I. Regulations
- Part II. Technology

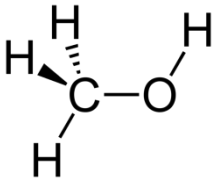
Part III. Main findings

Methanol as a Marine Fuel

Part II. Technology

- Methanol facts
- Environmental performance
- Marine methanol projects
- Conversion and Infrastructure costs

Methanol as a Marine Fuel



Methanol Facts

- Most methanol is today produced from natural gas but it could be produced from many feedstocks (incl. renewable sources, waste etc.)
- Around 70 million metric tons of methanol are produced every year
- Methanol contains no sulfur or other impurities

Methanol as a Marine Fuel

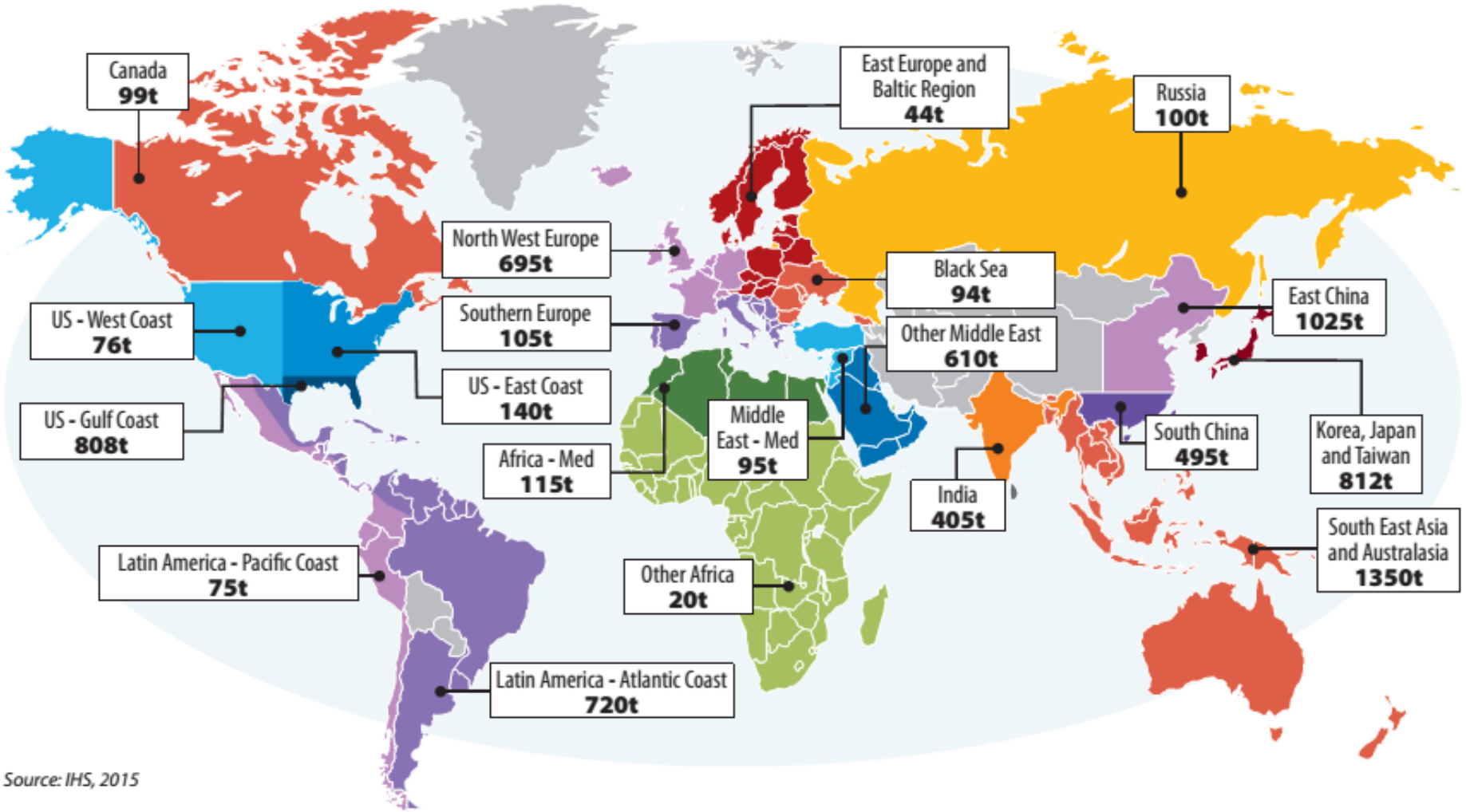
Methanol Facts

- Methanol is a liquid, making its bunkering and transportation easier than gaseous fuels
- Methanol is a low flashpoint fuel (like LNG)
- Methanol is available globally

Methanol as a Marine Fuel

Methanol Facts

Methanol storage capacity estimates (thousand tons)



Source: IHS, 2015

Methanol as a Marine Fuel

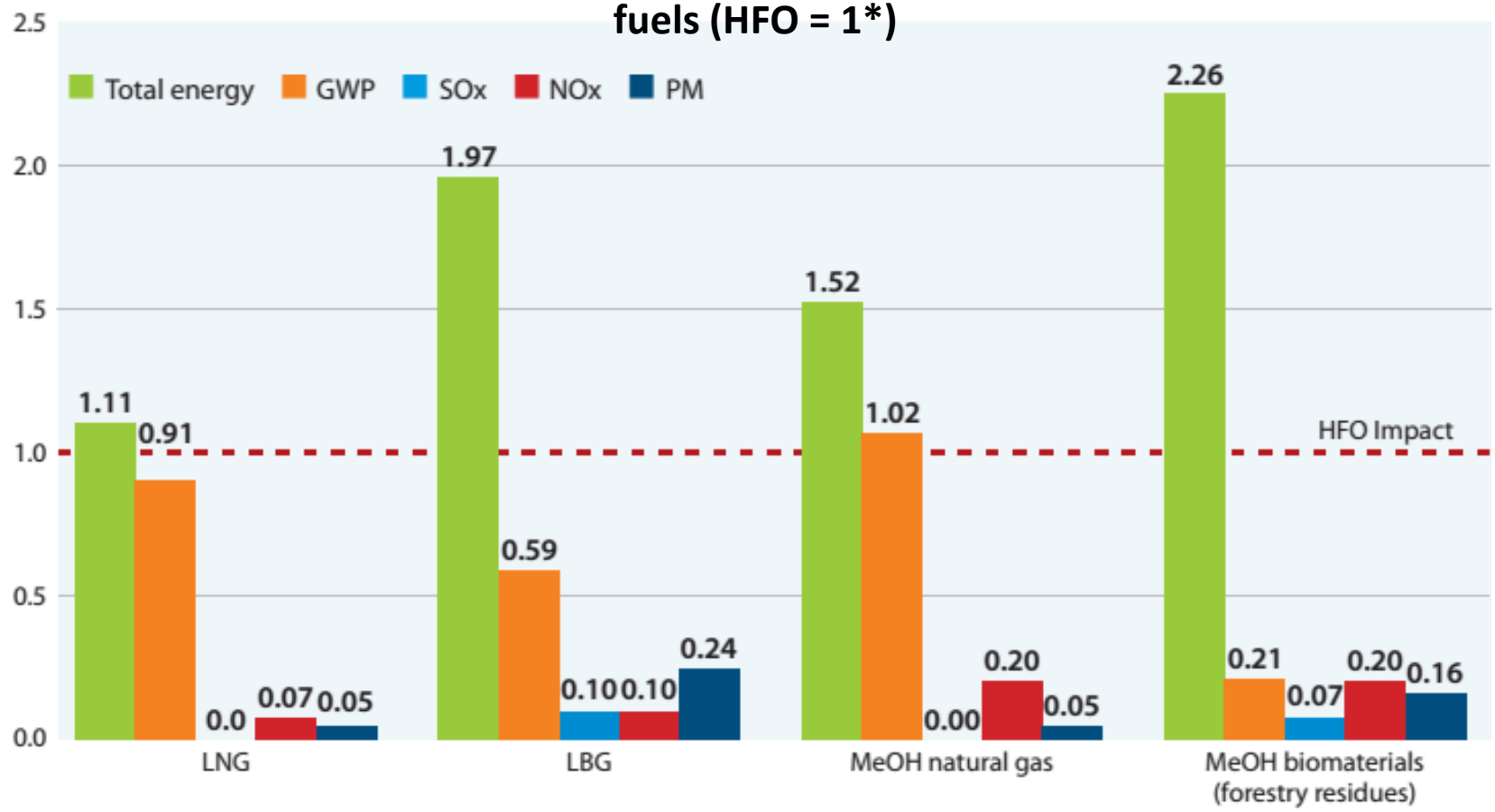
Environmental performance

- Methanol is completely soluble in water
- Most microorganisms can oxidize methanol, making it biodegradable
- As a result, the impact from a large spill would be much lower than from an equivalent oil spill

Methanol as a Marine Fuel

Environmental performance

Lifecycle emissions and energy use of methanol compared to HFO and methane fuels (HFO = 1*)



*Energy input and impacts are considered from a well to propeller perspective and apply to the fuel used for transporting one ton for one km with a RoRo ship. LNG figures assume 4% methane slip, as reported by the manufacturer.

Source: Brynolf et al, 2014

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Marine methanol projects

- **Stena Germanica:** Launched in March 2015, Stena *Germanica* features Wärtsilä methanol-fueled marine engine in EU-sponsored effort.
- **Methanex's Waterfront Shipping** 2016 delivery of seven new vessels with MAN dual-fuel methanol/diesel engines.
- **MethaShip project** led by Lloyd's Register designing cruise ship and ropax ferry over next three years.
- **2016 Pilot Boat** conversion by ScandiNAOS with support from MI, and Swedish Maritime Administration.

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Conversion and Infrastructure costs

Costs provided below are those of the retrofit of the Stena Germanica, a 24 MW RoPax ferry operating in the Baltic sea

- Total Project Cost (incl. storage tank and bunker barge adaptation): €22 million
- Conversion Specific Costs: €13 million
- Time at yard to modify engine: 2 weeks
- This is a first of its kind. Future conversions costs are estimated to be 30 - 40% lower

ESTIMATED CONVERSION COST:

€350/kW

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Conversion and Infrastructure costs

Costs of a new build methanol ship with two 10 MW MAN engines

- Engine costs: €825,000
- Work on engine: €300,000
- Fuel supply system: €600,000
- Fuel tanks: €500,000
- Piping, etc: €500,000

TOTAL COST: €270/kW

Methanol as a Marine Fuel

Conversion and Infrastructure costs

- Conversion or new-build of marine diesel engines to methanol fuel is
  - Technically feasible
  - Leads to lower emissions and ECA compliance
  - Is a pathway to renewable fuel

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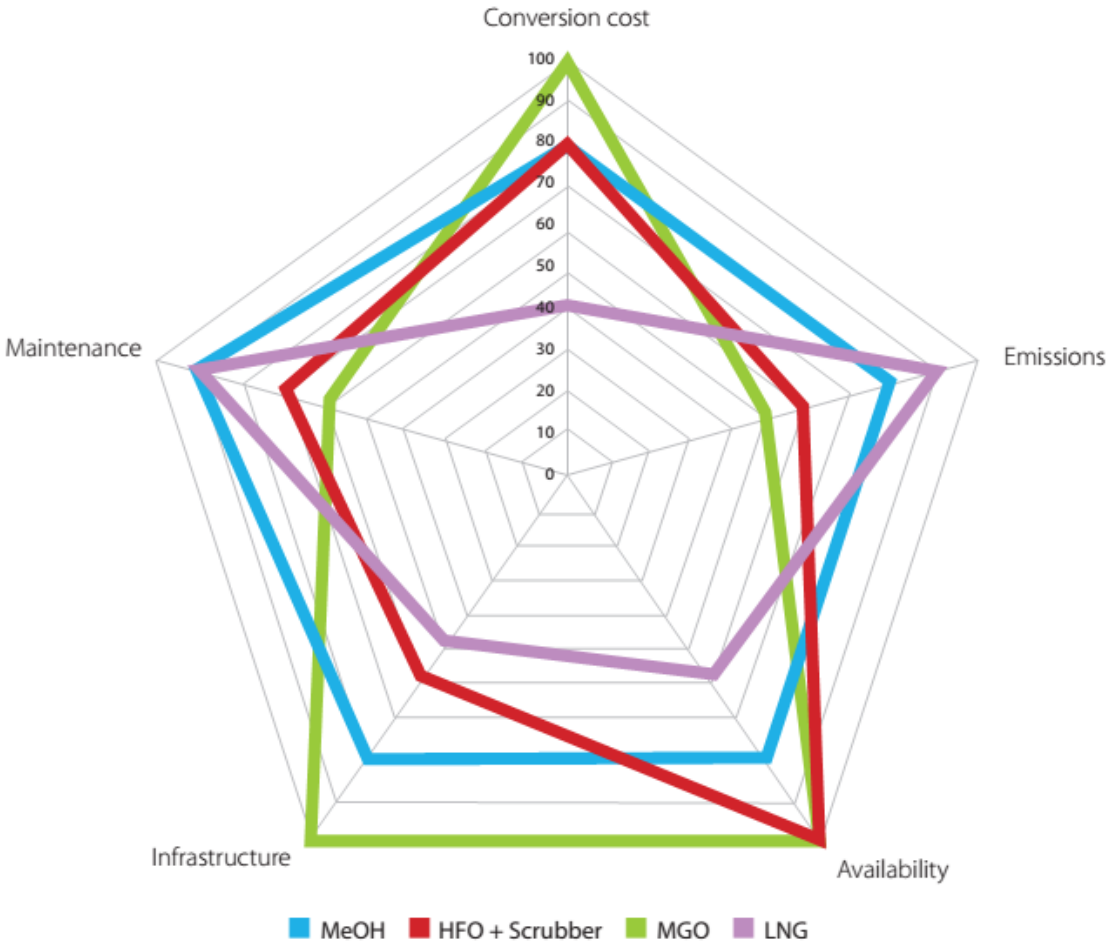
Conversion and Infrastructure costs

Methanol (MeOH) versus other marine fuels



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Methanol as a Marine Fuel

Main findings

- Methanol is plentiful, available globally and could be 100% renewable.
- Methanol is compliant with increasingly stringent emission reduction regulations.
- Current bunkering infrastructure needs only minor modifications to handle methanol.
- Infrastructure costs are relatively modest compared to potential alternative solutions.

Methanol as a Marine Fuel

Main findings

- Methanol prices show regional variation.
- Conversion costs to drop dramatically as experience mounts.
- Current engines have performed well and upcoming technologies will improve on this performance.
- Shipping and chemical industries have a long history and ample experience in handling methanol safely.
- Methanol is biodegradable.