METHANOL INSTITUTE

METHANOL AS AN ALTERNATIVE FUEL

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ASIAN SULPHUR CAP 2020

24 – 25 OCTOBER 2018

SINGAPORE

Contents

01 ABOUT MI

HISTORY

- The Methanol Institute (MI) formed in 1989
- 40+ members internationally

MEMBERS

Tier 1

MHTL
methanex the power of agility
سابك sabic

Tier 2

BP
Qatar Fuel Additives Company Limited
G2XENERGY
MITSUBISHI GAS CHEMICAL AMERICA, INC.
PETRONAS
OCI
Oman Methanol Company L.L.C.

Tier 3

Eni Ecofuel
Sipchem EXCELLENCE everywhere
G2XENERGY
METAFRAX
Mitsubishi International Corporation
Salalah Methanol Company L.L.C. (SFZ)
JM Johnson Matthey Inspiring science, enhancing life

Tier 4

CARBON RECYCLING INTERNATIONAL
FiTech
Muntajat
azelis
HELM AG GERMANY
MOL Mitsui O.S.K. Lines
LEBZI HALAL
SCC Southern Chemical Corporation
TRICON ENERGY
Double Green Bridge
NW INNOVATION WORKS
FUELFREEDOM CHEAPER. CLEANER. AMERICAN-MADE.
IMTT INTERNATIONAL-MATEX TANK TERMINALS
NAKHODKA FERTILIZER PLANT
HALDOR TOPSØE
IGPMethanol
Billionmiles
CLARIANT
Enerkem
CoogeeChemicals
VITUSA PRODUCTS™ INCORPORATED
solvadis we do chemistry

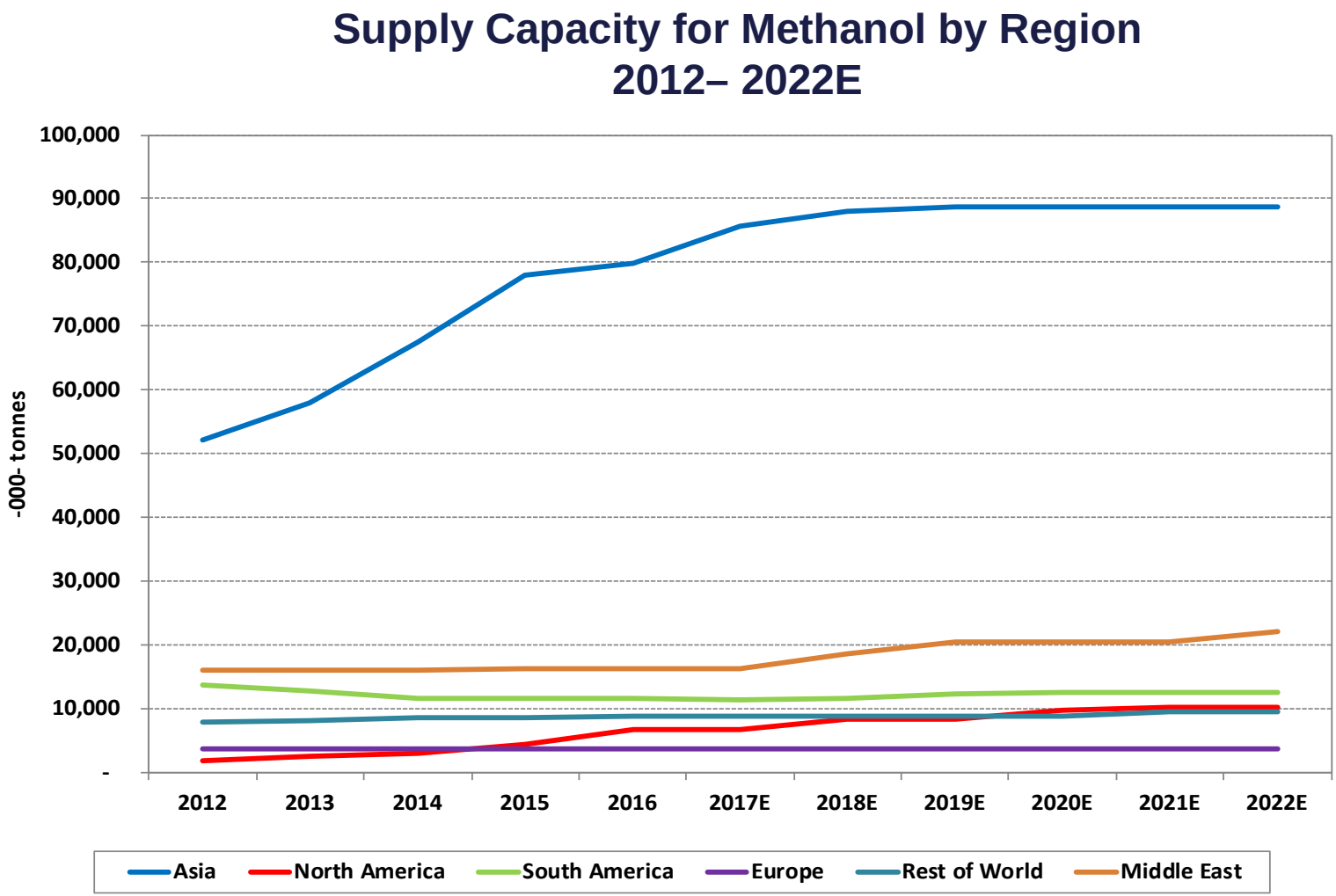
MI STRATEGIC PARTNERS

- China Nitrogen Fertilizer Industry Association
- Asian Clean Fuels Association
- Chinese Association of Alcohol & Clean Ether Fuels & Automobiles (CAAEFA)
- Gulf Petrochemicals and Chemicals Association (GPCA)
- International DME Association (IDA)
- International Methanol Producers & Consumers Association (IMPCA)
- Peking University Center for New Global Energy Strategy Studies
- Lloyd's Register
- International Bunker Industry Association
- Dangerous Goods Advisory Council
- China Classification Society

02 DEVELOPING TRENDS FOR NEW CAPACITY

SUPPLY CAPACITY BY REGION

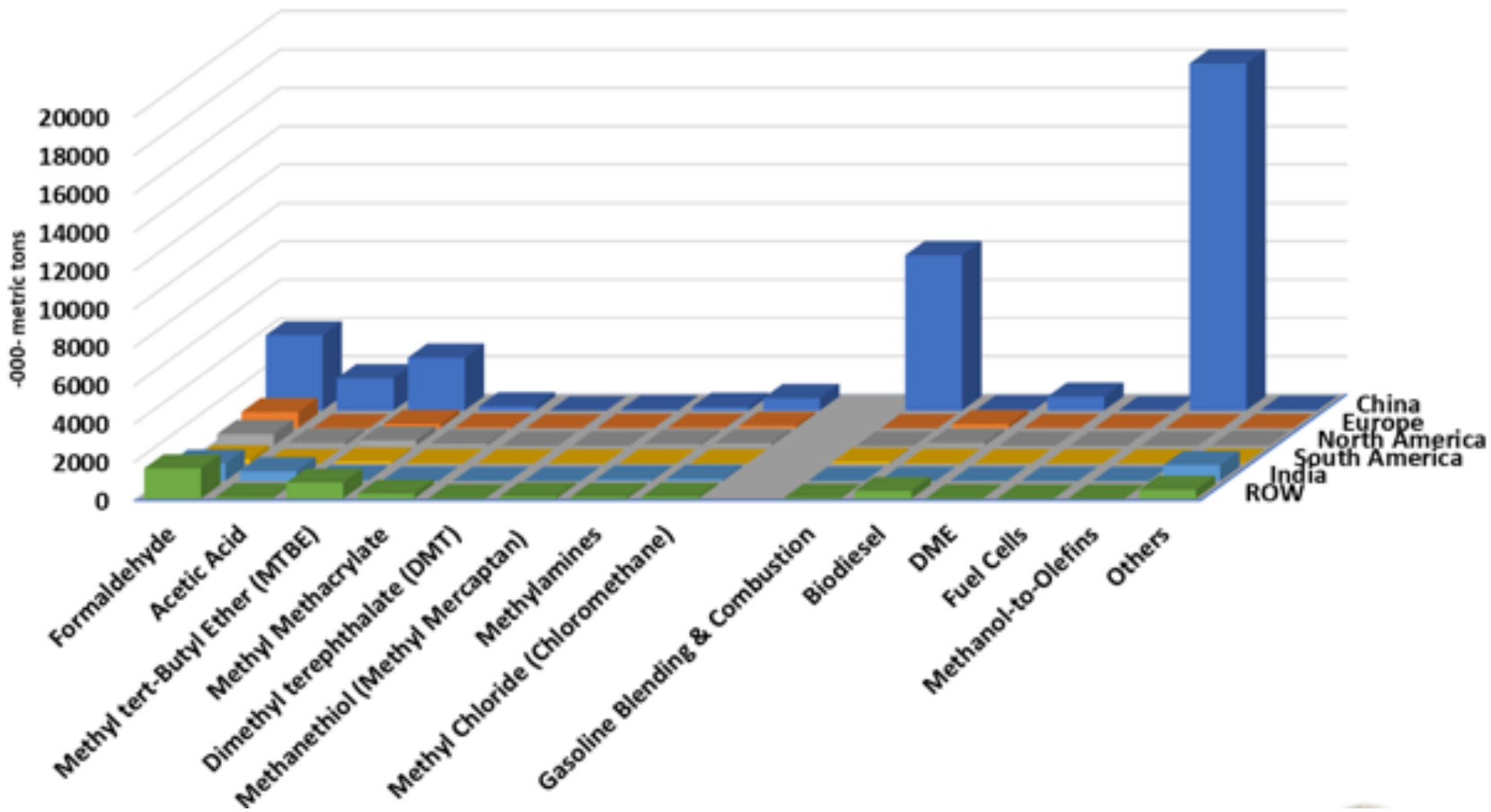
- Merchant projects are focused in USGC
- China future capacity additions may slow, with a focus on integrated facilities



Source: MMSA

CHINA METHANOL DEMAND DRIVES WORLD MARKETS

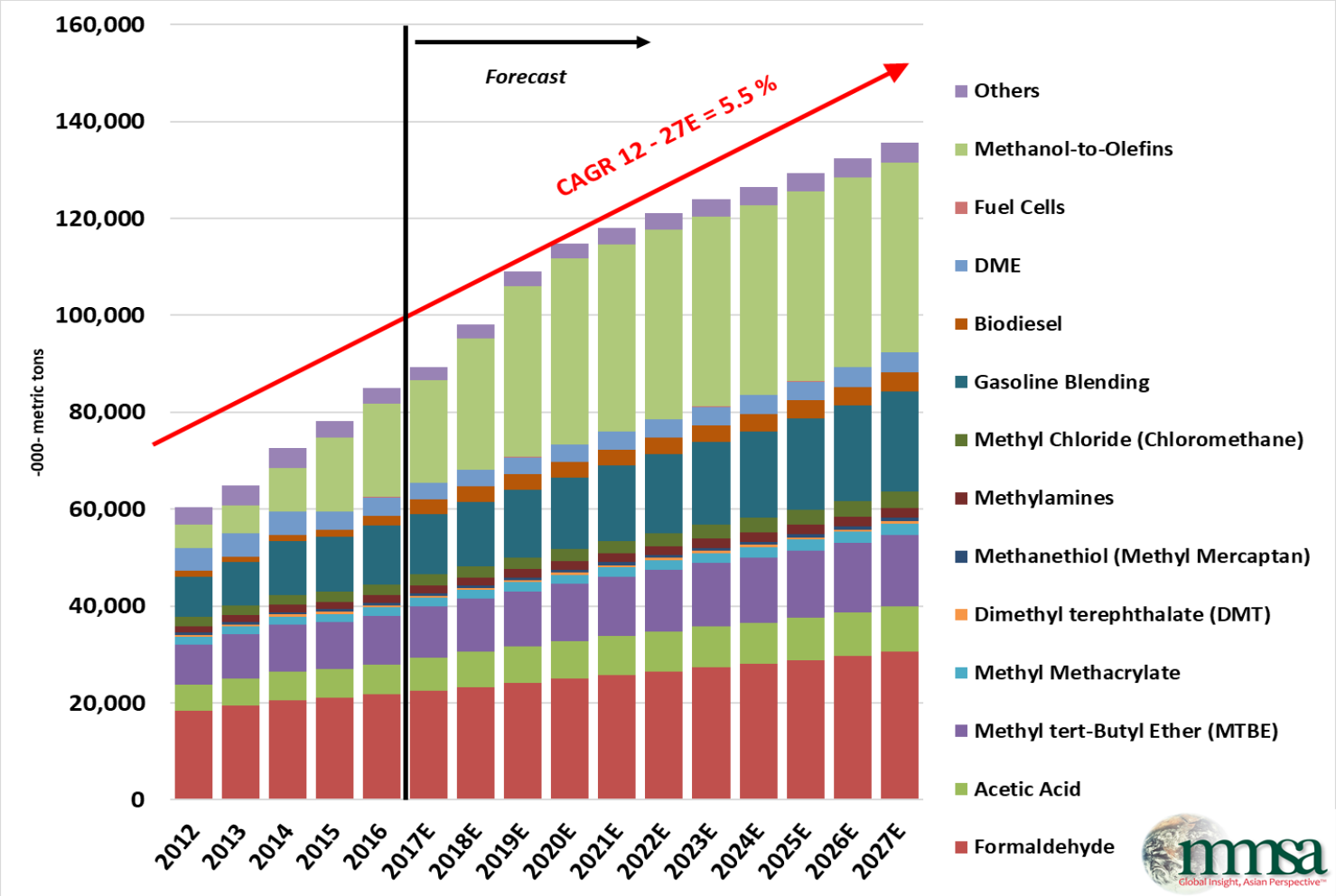
Projected Methanol Demand Growth, by Product & Region
2017– 2027E



Source: MMSA

MTO DRIVING GLOBAL METHANOL DEMAND

Estimated Global Methanol Demand by Derivative
(1Q 2018 MMSA Update – MTO includes integrated facilities)

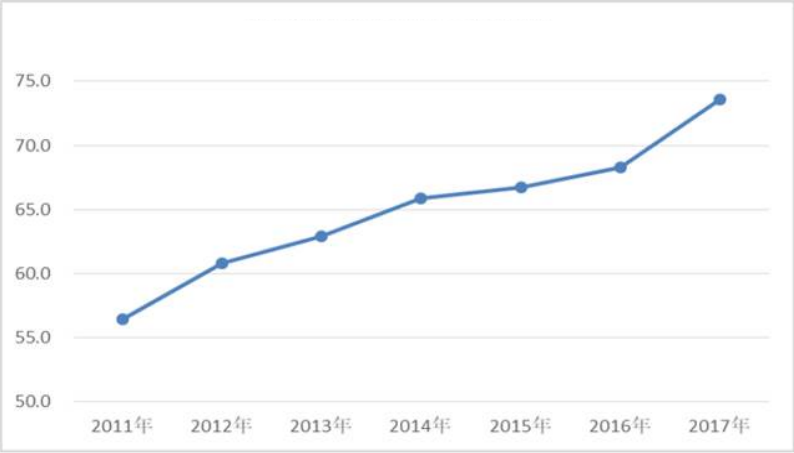


Source: MMSA

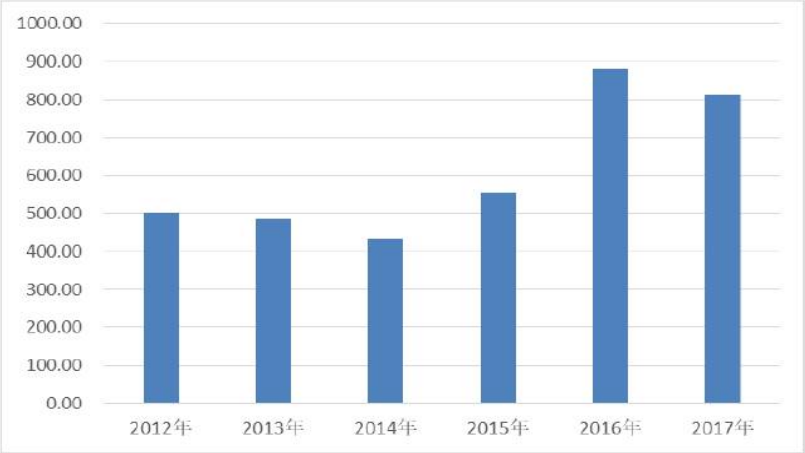
CHINA

- 2017 total capacity 83.51MMT, 8% increase
  - 7MMT of new capacity expected in 2018, reaching 90MMT by 2019
- Total operational rate 73.6%, another 5.4% increase since 2011
- Shut-in capacity 11.02 MMT [9.26 MMTs (84%) has been idle for 2 years]
- China consumption 69.5 MMT, 12.9% increase
  - Olefin (44%), Formaldehyde (20%), Fuel (13%), DME (6%)
- China imports 8.14 MMT, 7.5% decrease
  - Iran 2.52MMT, New Zealand 1.81MMT and Saudi Arabia 0.8MMT

Operating Rates by year

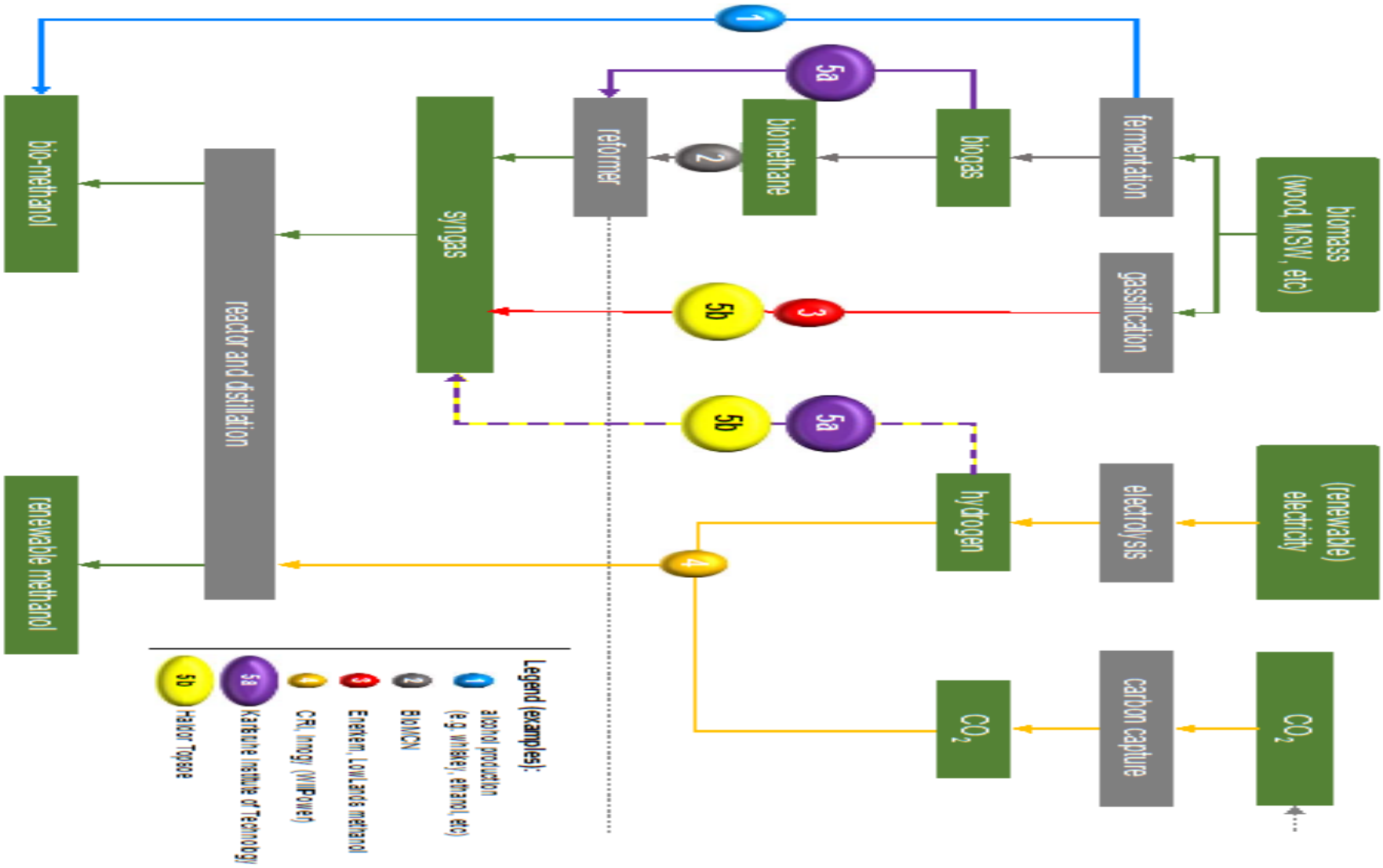


Methanol Imports by year

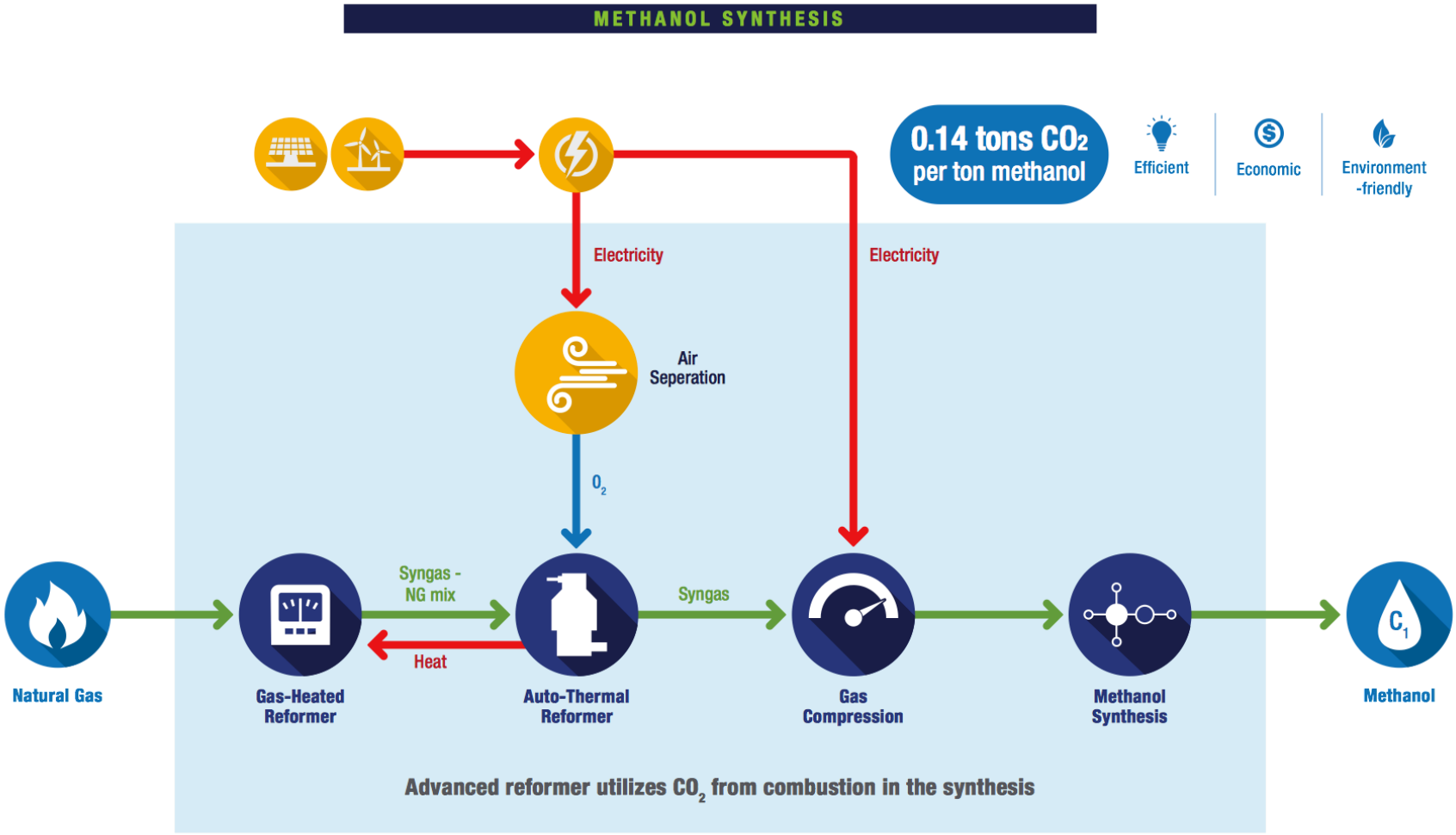


Source: CNFIA, CGNESS

RENEWABLE PATHWAYS

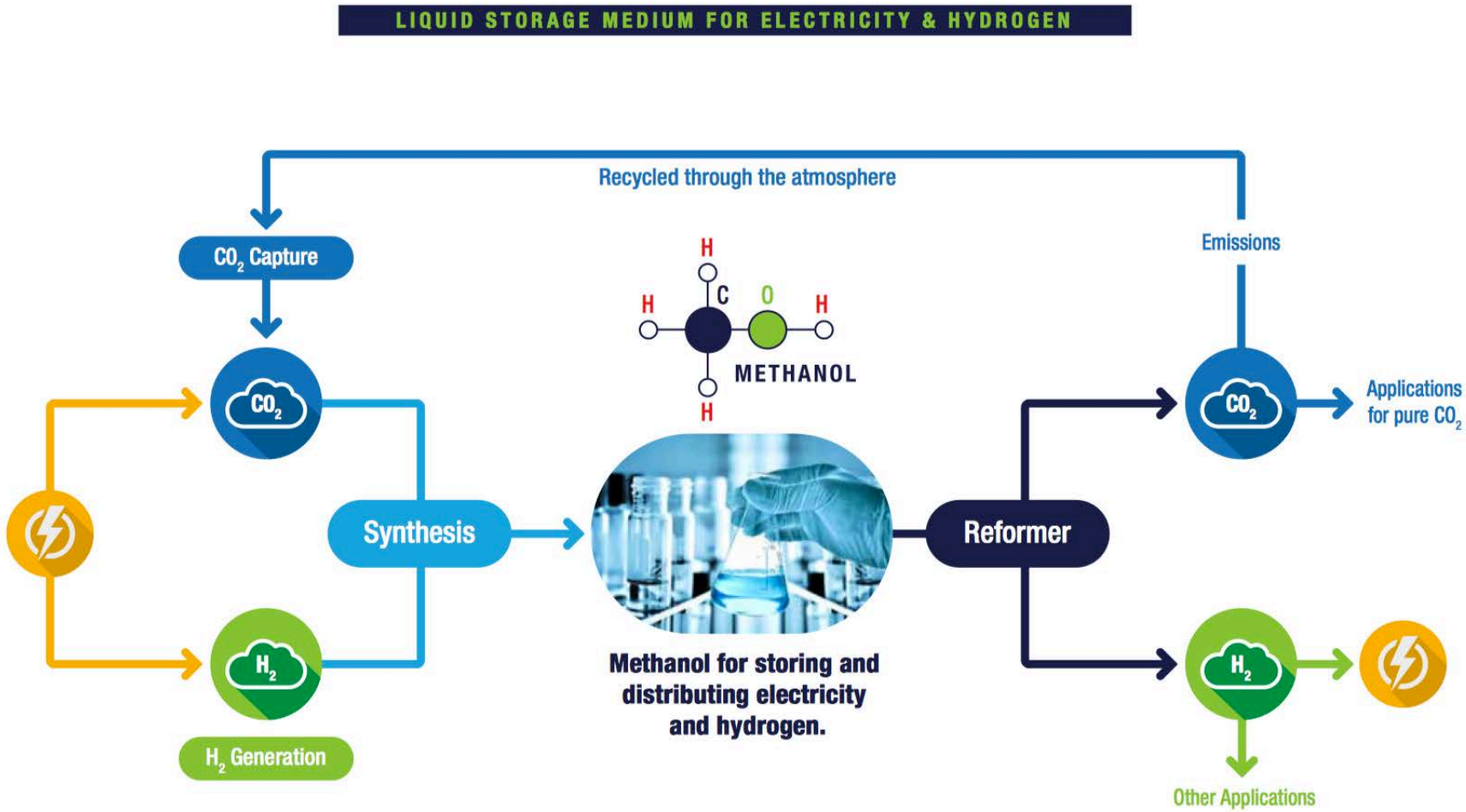


REDUCED CARBON INITIATIVES



*Comparable CO_2 emissions for 1G-Coal and 2G-Gas are 3.33 and 0.56 tons respectively

AN EFFICIENT ENERGY CARRIER



Methanol CH_3OH has, on a volume basis, 40% more H_2 than liquid hydrogen at -253°C, and 140% more H_2 than compressed hydrogen at 700 bars.

SMALL-SCALE PRODUCTION: HALDOR TOPSOE

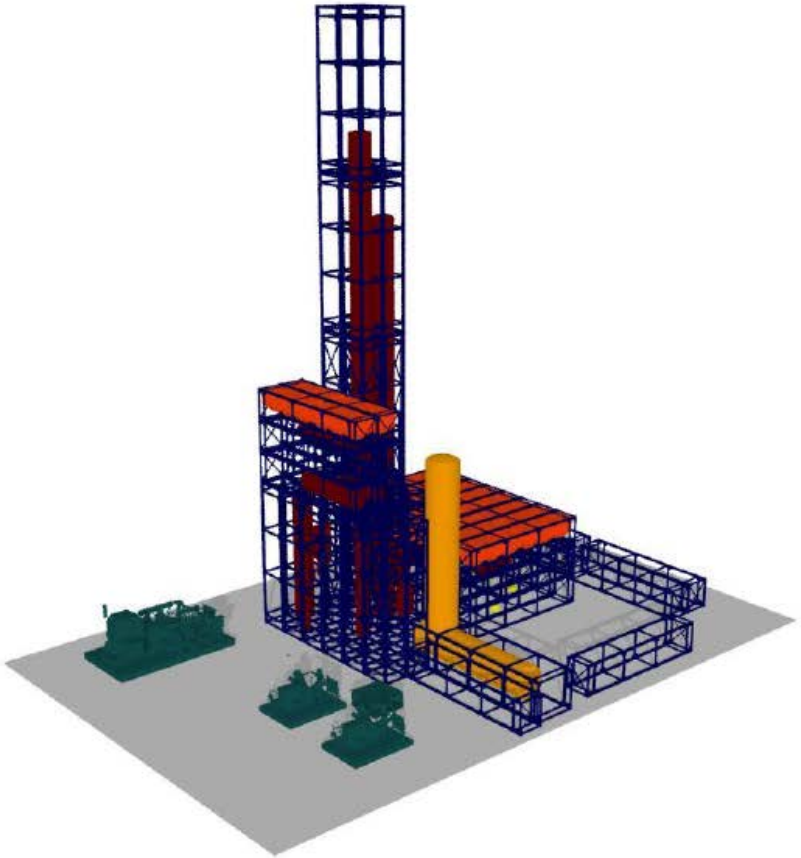
MeOH-To-Go™
Small-scale methanol production

Traditional focus

- Economy of scale
- Focus on energy consumption

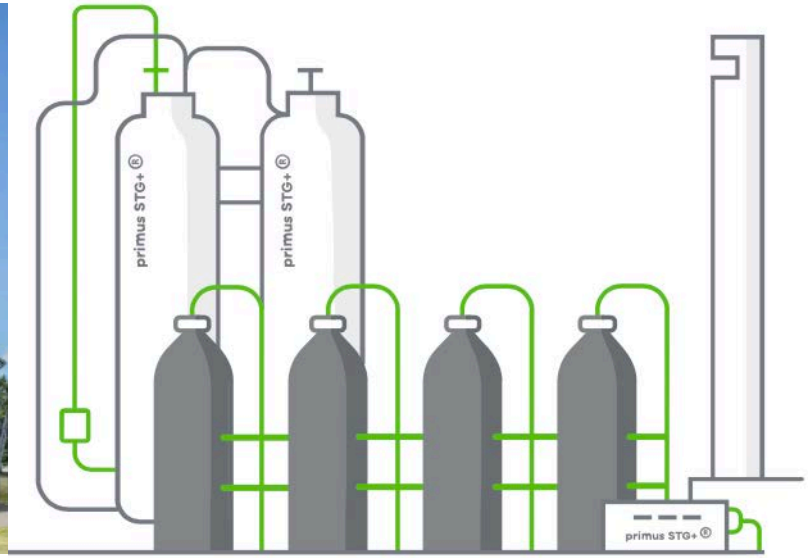
Small scale focus

- Reliable, proven, ease-to-operate
- 215 MTPD Methanol, Grade AA and IMPCA specs
- Competitive CAPEX
- Fast on-site construction
- Ease of transportation



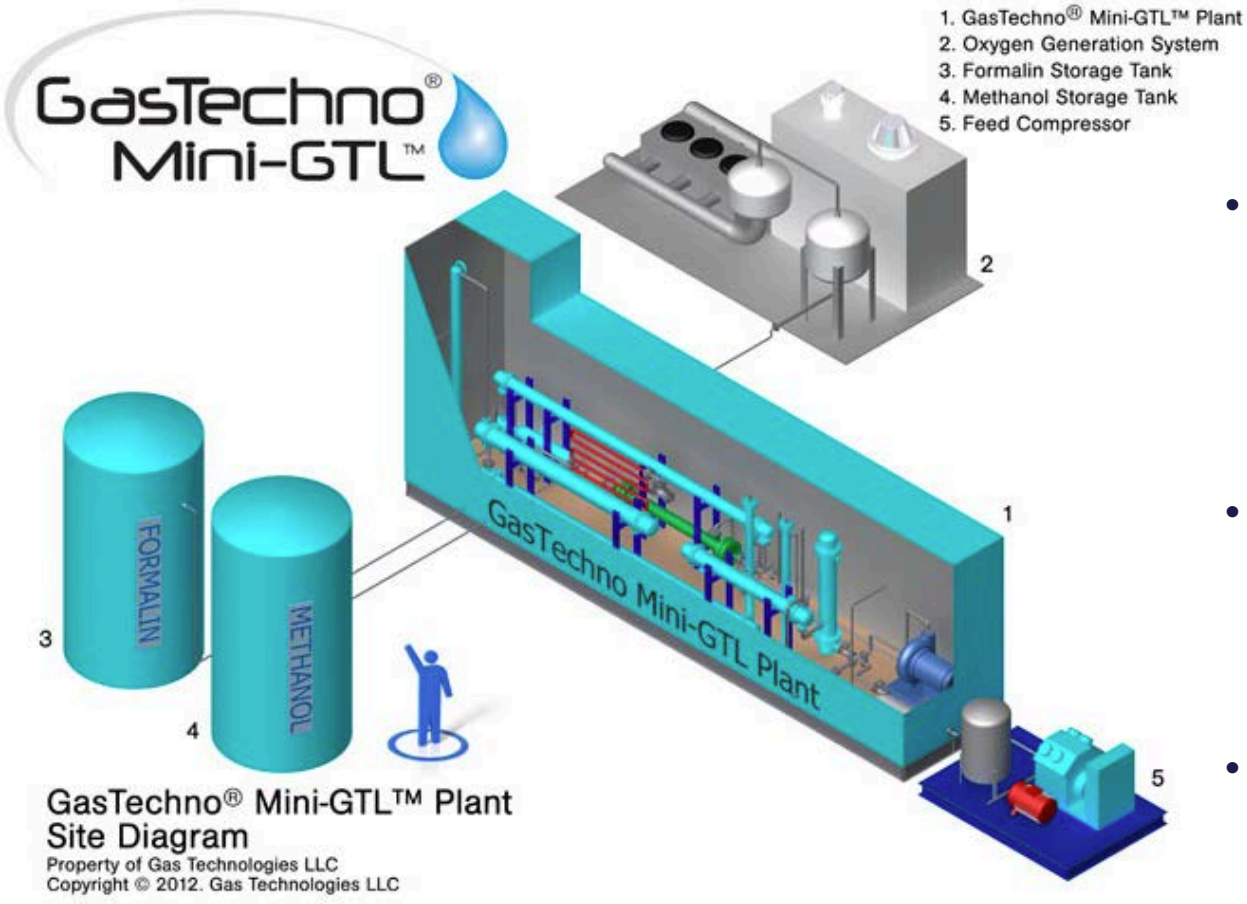
HALDOR TOPSØE

SMALL-SCALE PRODUCTION: PRIMUS



- The systems are simple and economical at scales as low as 500 MMBtu/day (83boe/day)
- Feedstocks: flare gas; stranded ethane; pipeline natural gas; excess syngas from underutilized reformers
- Primus has developed a range of flexible gas-to-liquids systems that can produce methanol, DME or gasoline

SMALL SCALE PRODUCTION: GASTECHNO



- The GasTechno process is a non-catalytic gas-to-liquids technology that converts methane to methanol in one step
- The "Methanol in a Box" system is housed in a 40-foot shipping container
- Designed to monetize flare gas from 50,000 cubic feet per day to 30 million cubic feet per day (9bpd to 5,100bpd)

RENEWABLE PRODUCTION: ENERKEM

The global renewable chemicals market should reach approximately USD 102.76 billion by 2022.*

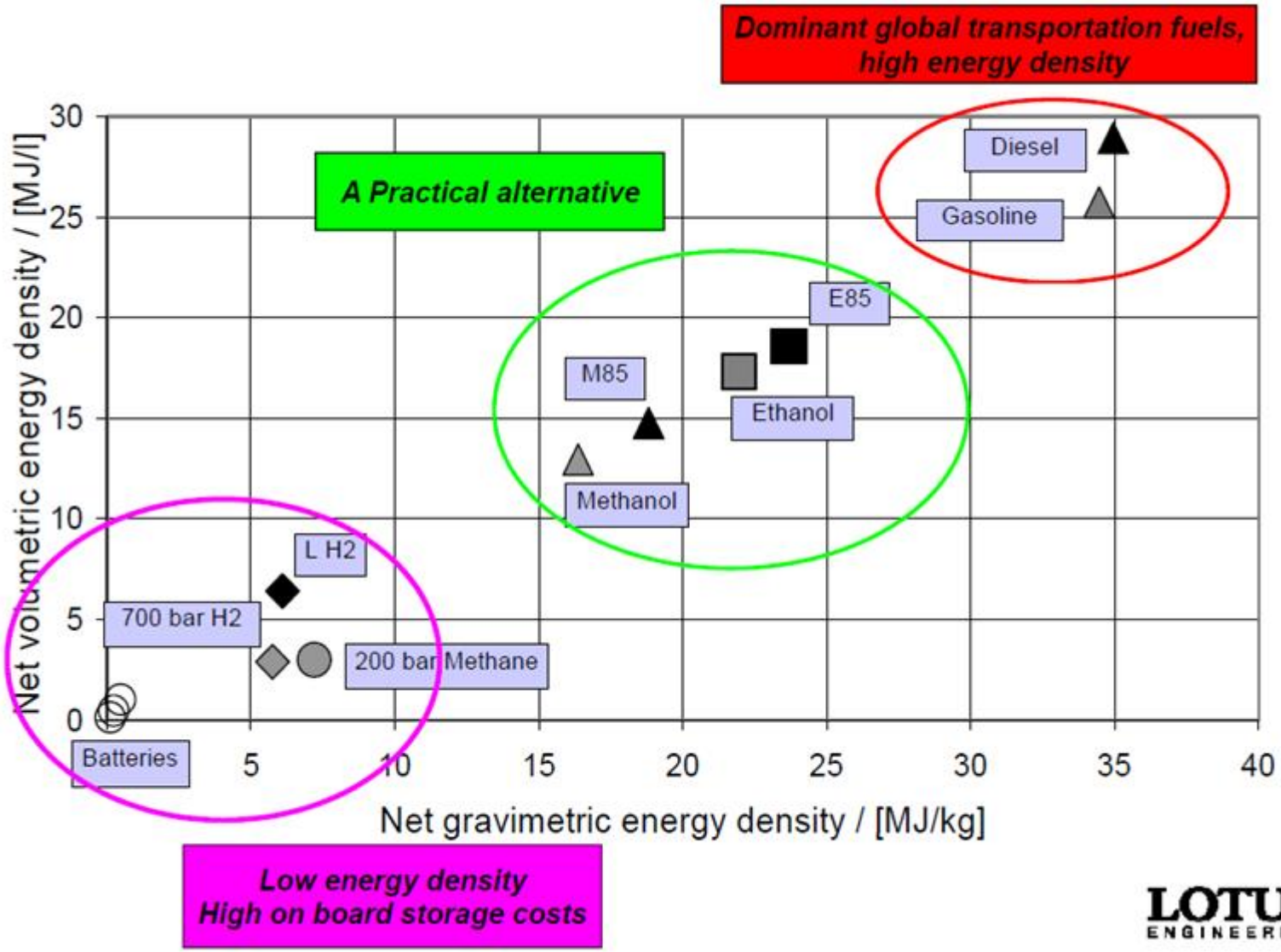
- Retail consumers are becoming increasingly aware of health and environmental concerns, which translates into a growing demand for greener components or a “cradle to cradle” solution in consumer products
- Global consumer goods manufacturers are listening to their customers as they demand greener everyday products
- Global chemical groups, in turn, are looking to add renewable alternative chemicals to their hydrocarbon-based product lines to meet the demand of their own customers

* Source: Zion Market Research

03

GLOBAL METHANOL FUEL BLENDING

PRACTICAL LIQUID FUEL



LOTUS ENGINEERING

Global Transportation Fuel Progress

Israel

- Cooperation with Italy Fiat to promote M15 Fiat 500 Car (Euro 6)
- Testing M70-85 in Flex fuel vehicles
- 2016 First M15 National Standard Released

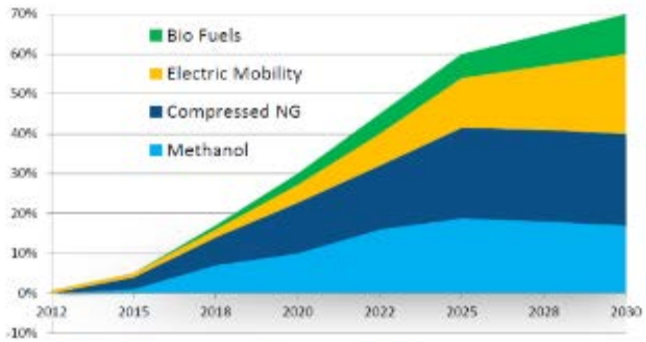
Italy

- ENI and FCA cooperation to promote A20 fuel (M15+E5)
- Fiat 500 cars for car sharing service in 2018
- Compliance with Euro 6 standard and 3% tailpipe emission reduction

Denmark

- Methanol Fuel Cell for EV range extension
- Europe's first methanol filling station in Aalborg, Denmark (Aug. 2015)

Israeli Government Decision:
Reduce the use of oil by 60% by 2025



Expected Penetration Rate for Alternative Fuels in Israel

India: Roadmap to Methanol Economy

- September 2015, NITI Aayog formed the Methanol Economy Expert Group
- Methanol production from coal and biomass, and utilize methanol and DME as transportation fuels
- September 2016, MI jointly organized a Methanol Economy International Seminar held in Delhi
- Launching Projects:
  - M15 fuel blending
  - methanol/DME buses and trucks
  - railway engines
  - inland waterways
  - cook stoves
  - industrial boilers

Union & Road Transport Minister Nitin Gadkari

04 NEW MARKETS

METHANOL BOILERS

- Widely used for heating and industrial steam, new-builds and replacing coal and HFO-fired units
- Capacity range from 1 - 20 t/h
- Standards being developed together with MI and Methanex support
- Blends starting as low as 60% (M60)
- ***Estimated more than 1,000 units currently, consuming over 2M mtpa of methanol***

Vertical Tank

Fuel Metering & Blending

Underground Storage

Boiler Unit

Source: Methanol New Energy Applications in China: Boilers and Cook Stoves

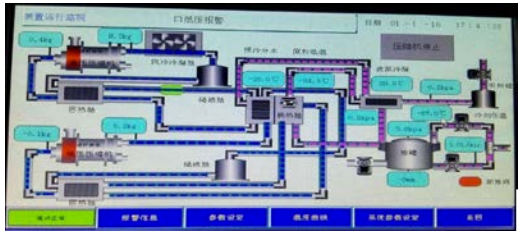
METHANOL COOK STOVES

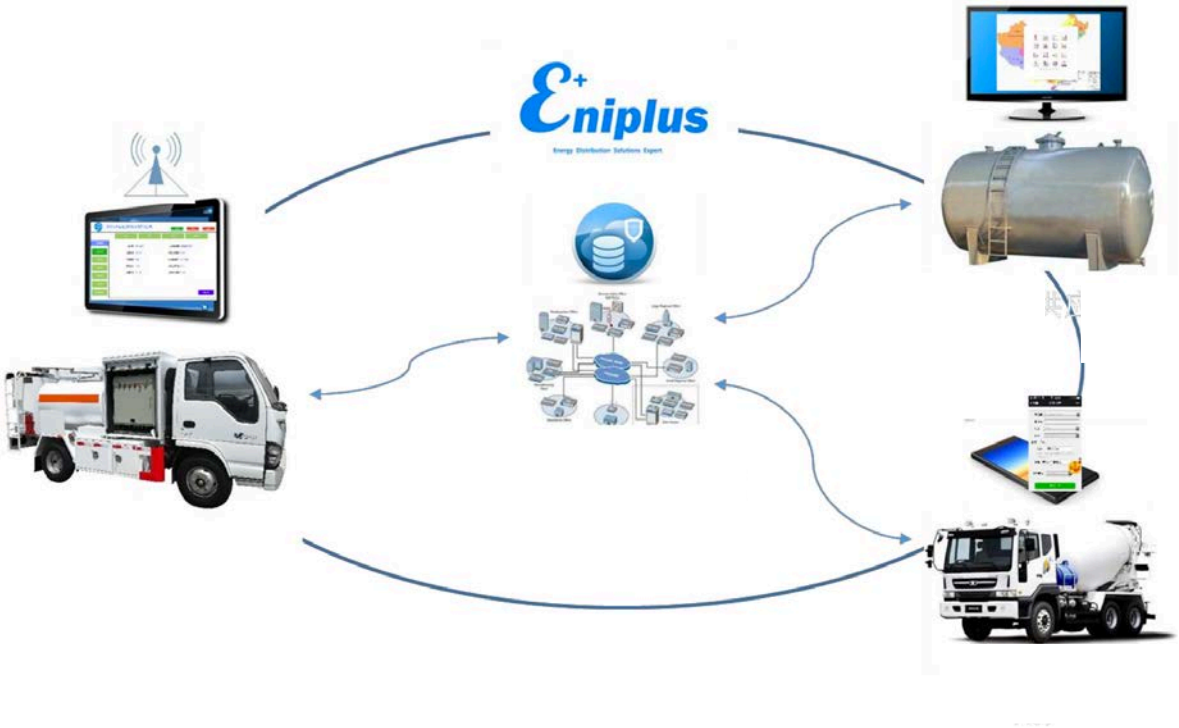
- **Different types of methanol cook stoves:**
  - Single burner heating
  - Stir frying
  - Steaming
- Widely used in restaurants, central kitchens: **mainly cost driven**
- Simple storage and transportation, filling the deficit of NG pipeline capacity
- Fuel:
  - 100% methanol (M100)
  - 80% and higher blends (emulsified with water)

- ***Consuming over 3M mtpa of methanol***

METHANOL SMART SUPPLIERS

METHANOL SMART SUPPLIERS





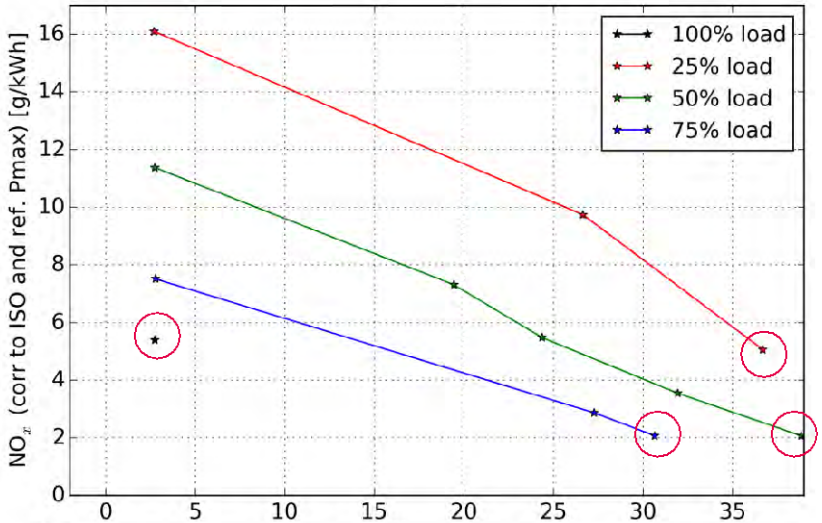
05

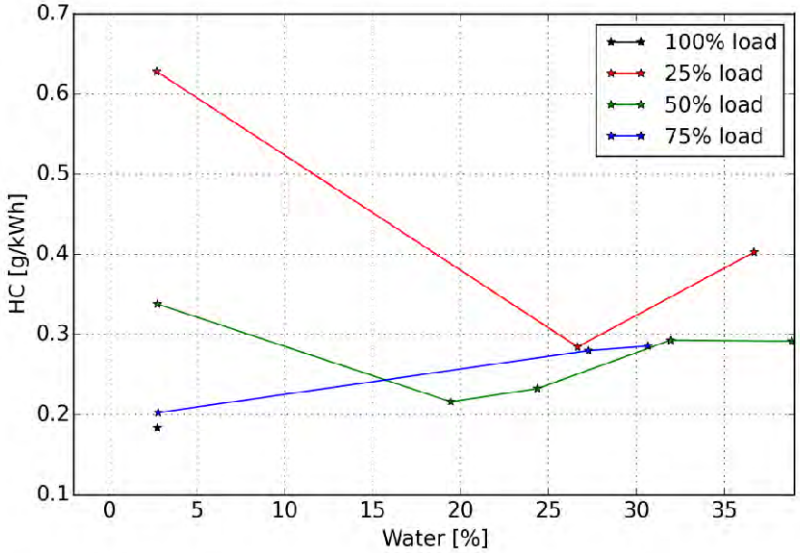
METHANOL AS MARINE FUEL

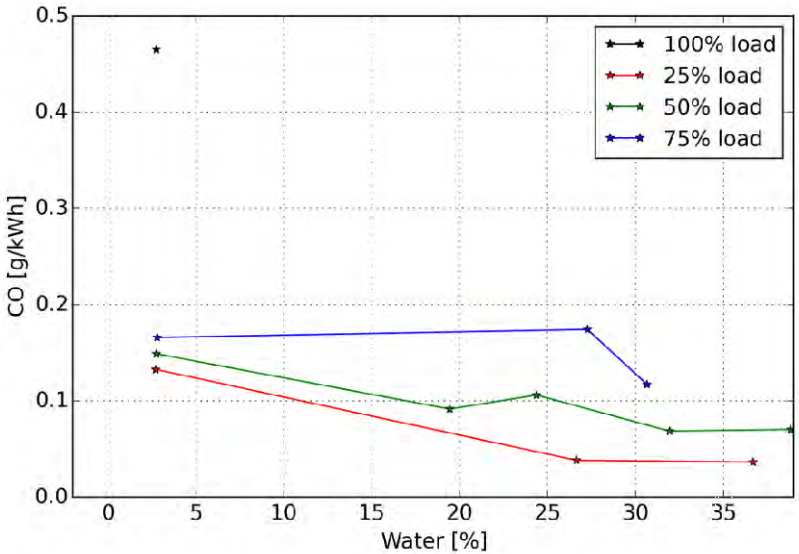
EMISSIONS SCORECARD

- Methanol (MeOH) achieves low emissions & acts as a bridge in lowering CO_2 in the future (renewable/bio methanol)

METHANOL / WATER BLENDING (EMULSIFICATION)





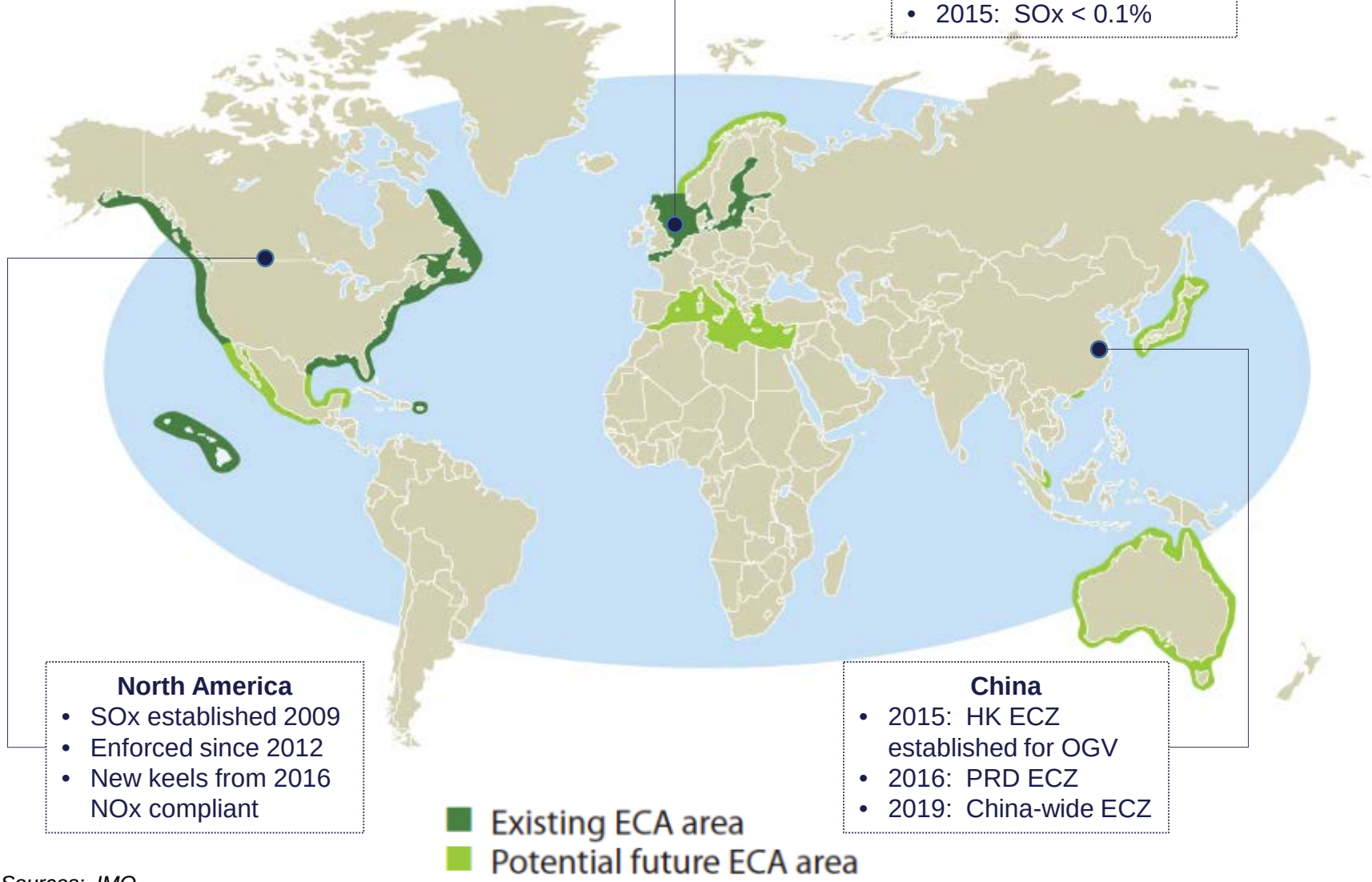


- NOx decreases almost linearly with water content
- NOx emissions are close to 2 g/kWh at 50 and 75% load
- NOx emissions at 25% load is at the "not to exceed limit" for Tier-III, but can be lowered further
- 100% load with high water content not possible due to system limitations

Source: MAN

EMISSION CONTROL AREAS (ECAs)

Europe
- SOx established 2005
- Enforced since 2006
- 2015: SOx < 0.1%

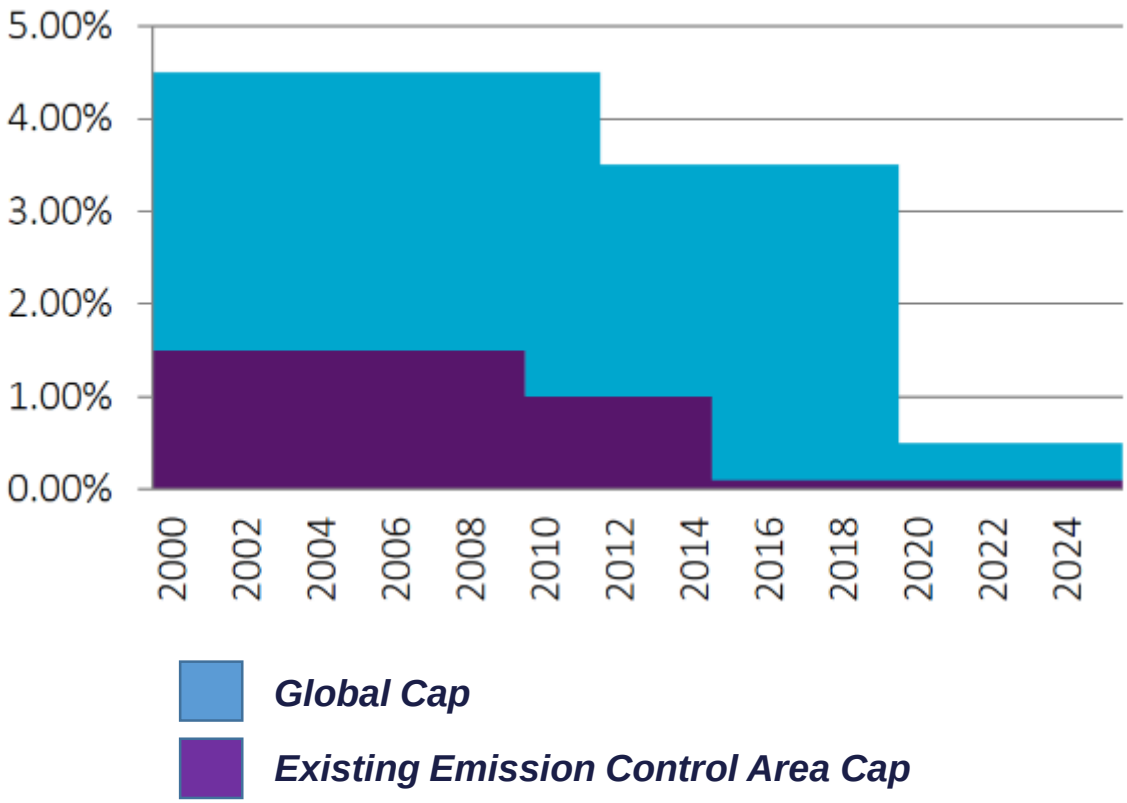


North America
- SOx established 2009
- Enforced since 2012
- New keels from 2016 NOx compliant

China
- 2015: HK ECZ established for OGV
- 2016: PRD ECZ
- 2019: China-wide ECZ

Sources: IMO

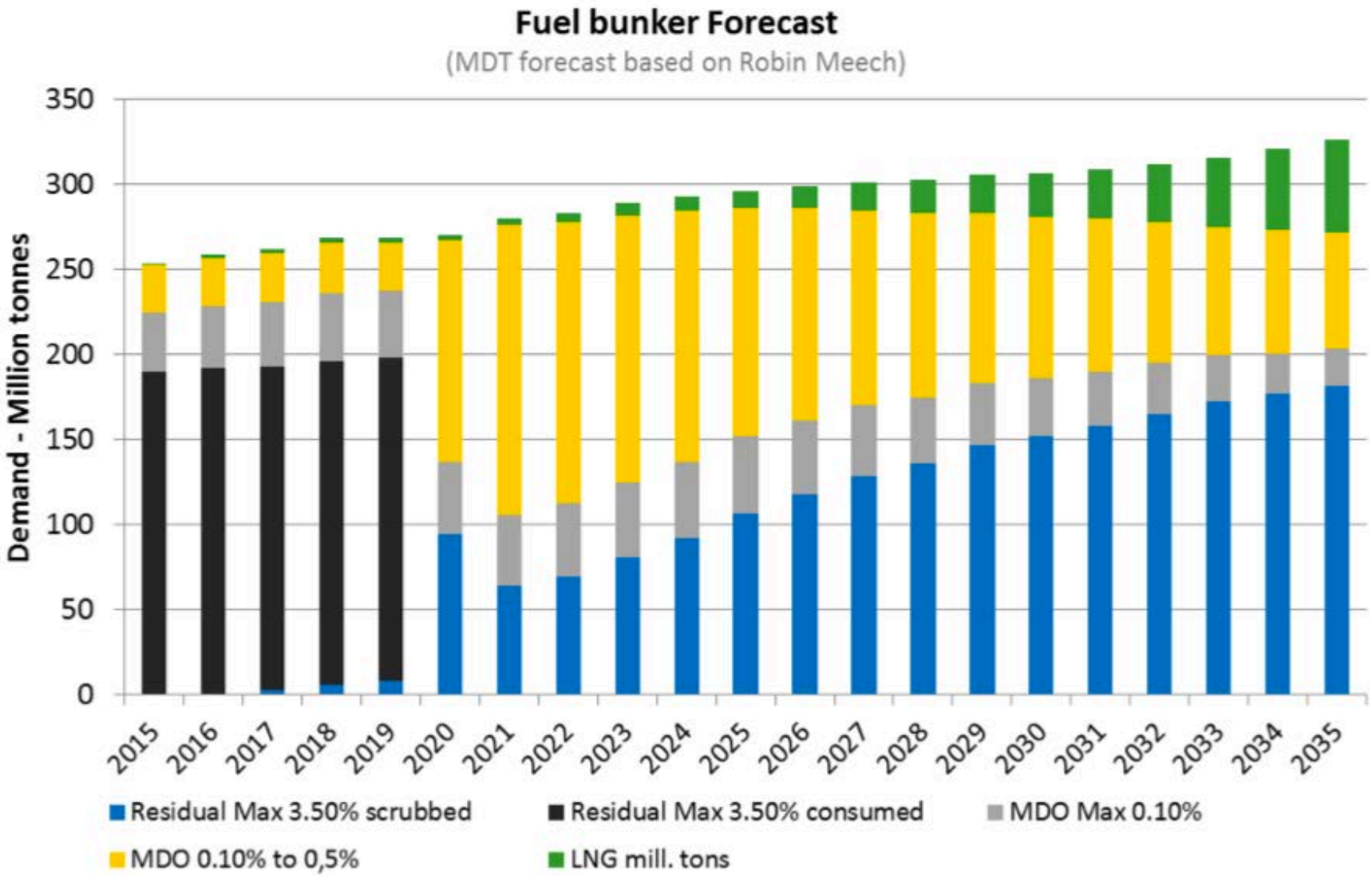
IMO CURRENT & FUTURE SULPHUR LIMITS



- IMO:
  - 0.1% in 2015 in existing ECAs in NA & EU
  - 0.5% in 2020 globally
- Predominant shipping fuel is HFO which does not meet limits – methanol is sulphur free
- China phasing in regulations to reduce sulphur, NOx and PM from marine fuels over next few years
- Marine fuels global market size: 650M mtpa methanol equivalent

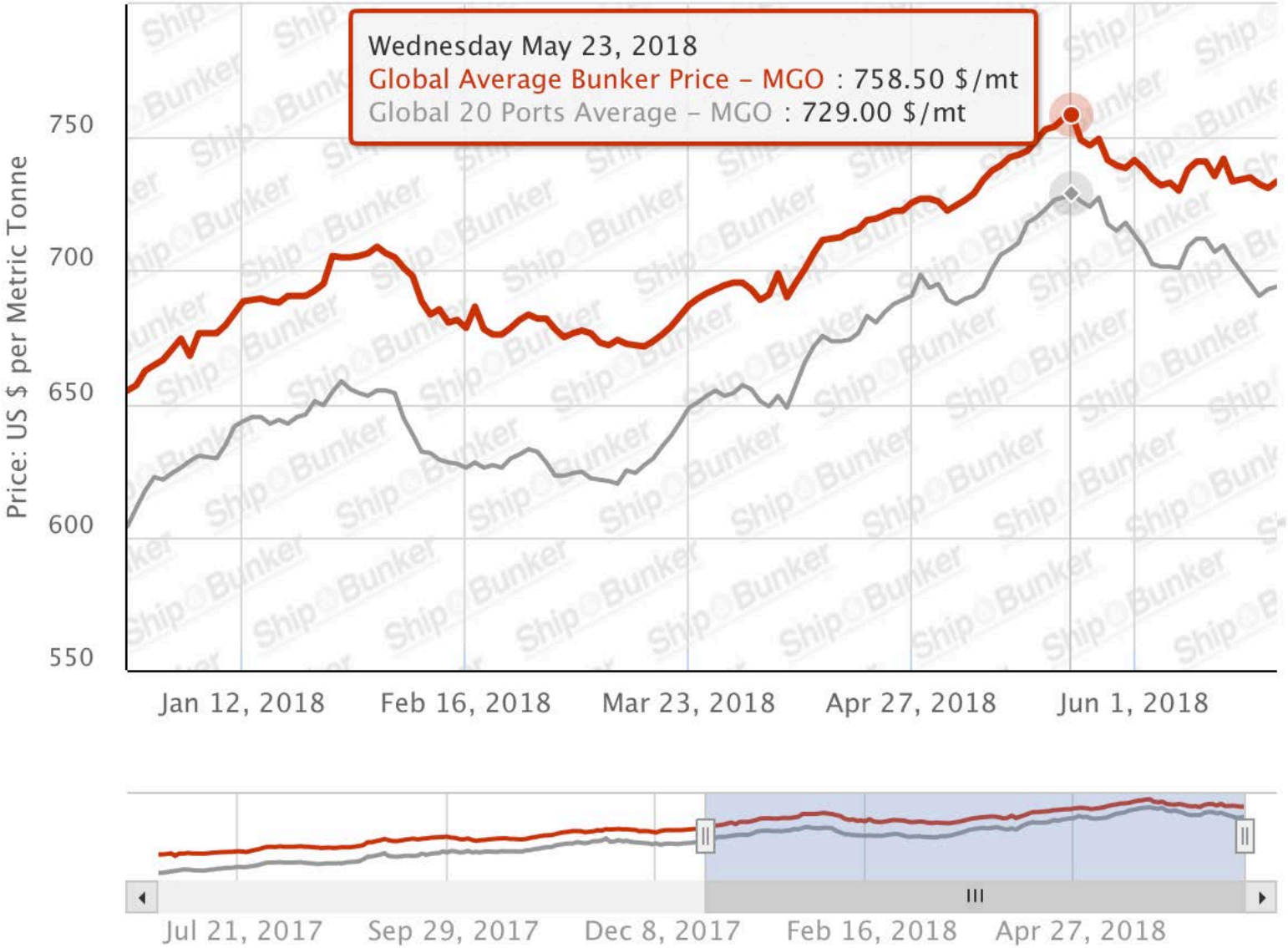
Source: IMO

FUTURE FUEL MIX



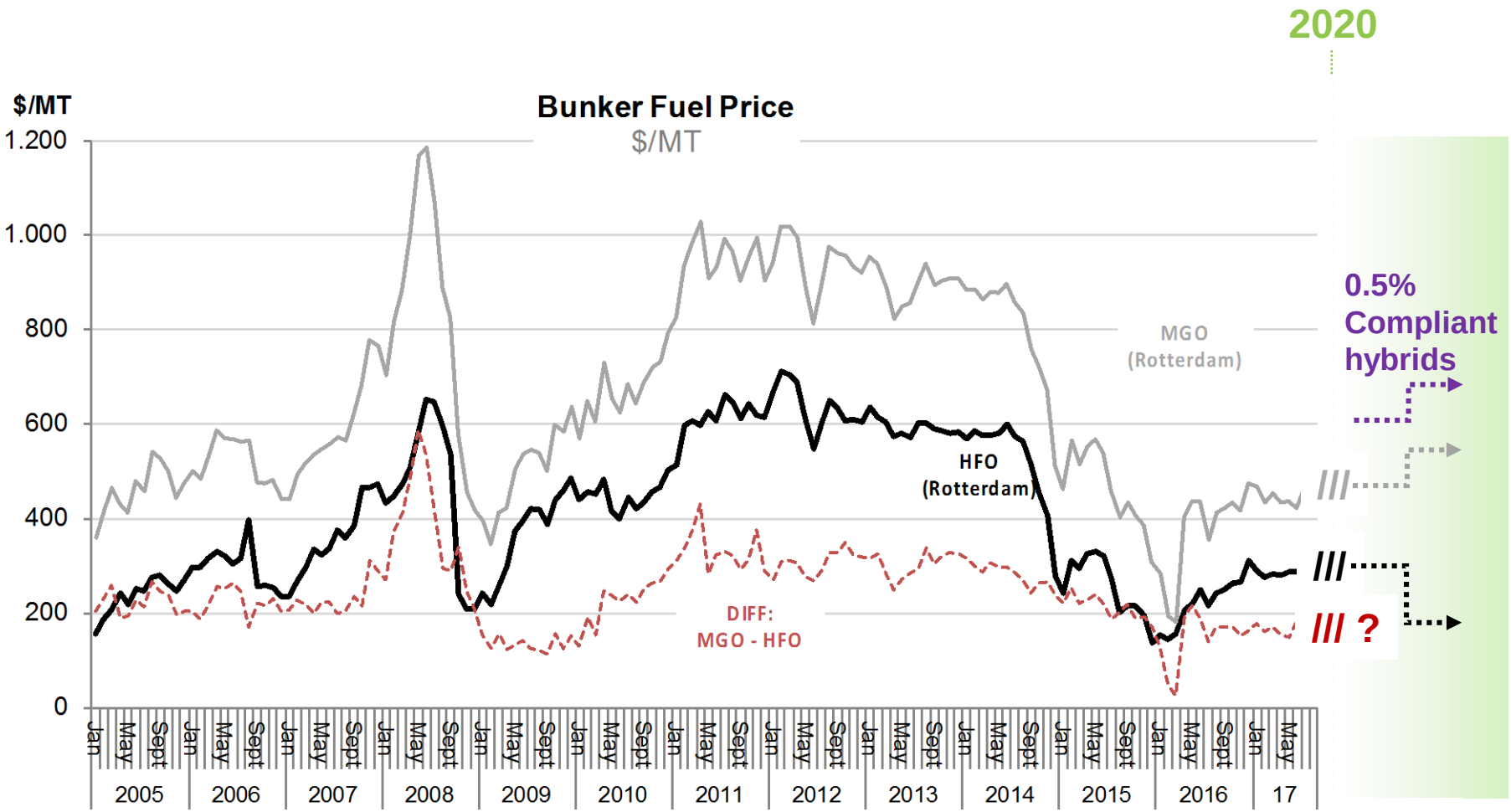
Source: Robin Meech

MGO PRICING



Source: Ship & Bunker

FUTURE FUEL PRICING



Source: Bunkerindex

FUEL COMPARISON MODEL & ONLINE EVALUATOR

Lloyd's Register

User Guide

Fuel Choice Calculator

Vessel Type	Capacity	Design Speed	Average loaded DWT	Annual Distance Travelled
Bulk Carrier	176506 DWT	11.7 Kts	141204.8 tonnes	56712 Nm

Select open or closed loop option for EGCS

- Open
- Closed

Methane Slip	Time spent inside ECA	Asset expected life	Annual fuel consumption conventional fuel
3 %	50 %	25 years	5756.213 mt/y

Calculate

All | Fuel consumption & Costs | NPV & Total Cost

FUEL COMPARISON MODEL & ONLINE EVALUATOR

Total Fuel CAPEX

Total CAPEX LNG	49.766	M USD
Total CAPEX HFO scrubbers	44.167	M USD
Total CAPEX Compliant fuel	42.3	M USD
Total CAPEX Methanol	44.913	M USD

Price Differentials (USD/MT)

	Low	Medium	High
LNG	2(	260.0	31
HFO 3.5	1(	185.0	22
Methanol	1!	199.0	23

Calorific Value

Calorific Value LNG	49	kJ/kg
Calorific Value HFO 3.5	41	kJ/kg
Calorific Value Compliant fuel	43	kJ/kg
Calorific Value Methanol	20	kJ/kg

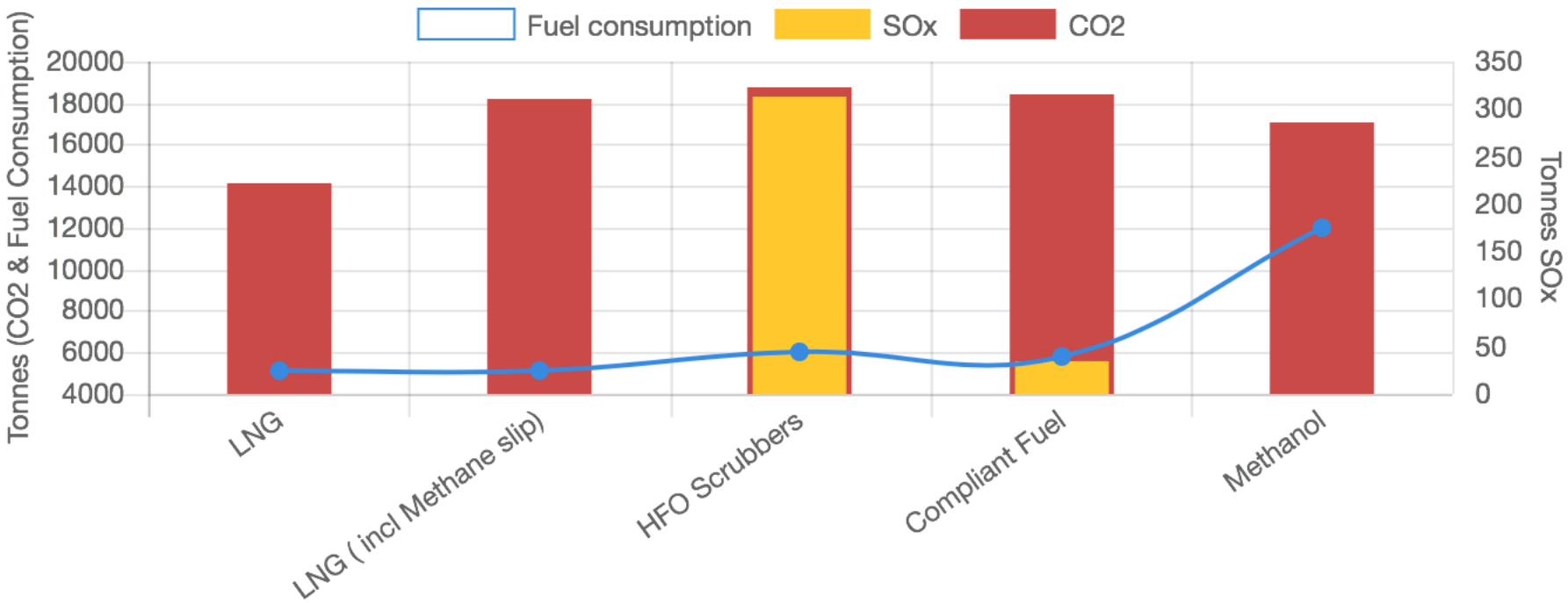
Fuel Costs

Check Fuel Prices

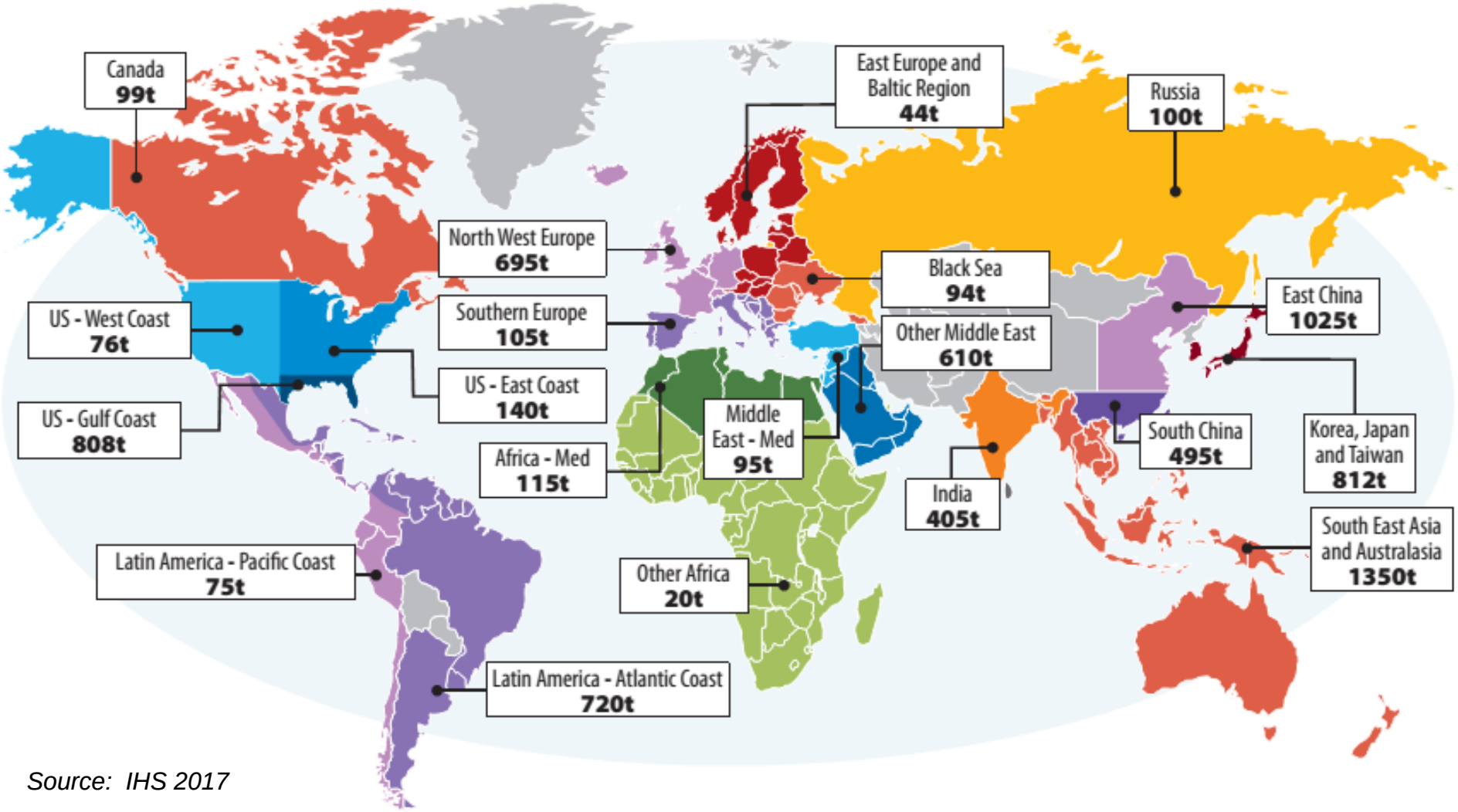
LNG price	315	USD/mt
HFO 3.5 price	390	USD/mt
HFO 0.50 price	550	USD/mt
MGO 0.10 price	600	USD/mt
Methanol price	376	USD/mt

FUEL COMPARISON MODEL & ONLINE EVALUATOR

ANNUAL FUEL CONSUMPTION & EMISSIONS



GLOBAL PORT TERMINAL AVAILABILITY



Source: IHS 2017

MARINE EXPERIENCE

- March 2015: Stena Germanica – Wärtsilä methanol-fueled marine engine

- Apr 2016: Methanex's Waterfront Shipping – dual-fuel MAN methanol/diesel engines

- Lloyd's Register MethaShip project

- LeanShips dual-fuel demo

- Oct 2015: Billion Miles Singapore develops small-marine applications

- Jun 2016: ScandiNAOS Green Pilot Boat conversion

FLAMMABILITY & TOXICITY

TABLE 6-1 HAZARD SUMMARY[a]		
	M100	Gasoline
Flammability		
Ease of Occurrence		
Open & Restricted Areas	4	9
Enclosed Spaces	8 (2-4) [b]	2
Relative Hazard if Fire		
Fire Severity	3	10
Ease of Extinguishing	7	10
Flame Visibility	8	1
Toxicity		
Inhalation-Low Conc.		
Toxicity	3	10
Ease of Occurrence	10	10
Inhalation - High Conc.		
Toxicity	10	10
Ease of Occurrence	3	4
Skin Contact.		
Toxicity	9	8
Ease of Occurrence	3	3
Ingestion		
Toxicity	10	10
Ease of Occurrence	8(2) [c]	3

Table adapted from Machiele, 1998; [a] 1-No concern. 2 to 3 = Low Level concern. 4 to 6 = moderate concern. 7 to 8 = high-level concern. 9 to 10 = extreme hazard. [b] Numbers in parenthesis reflect hazard reductions resulting from design changes. [c] Number in parenthesis incorporates the lowered likelihood of ingestion due to the presence of additives.

Economic Impact - HFO vs Methanol:

	Maritime accident	Maritime accident	Simulation
Ship	Erika	Tanio	-
Fuel	Heavy Fuel Oil	Heavy Fuel Oil	Methanol
Released amount	19 000 t	13 500 t	10 000 t
Affected coastline	400 km	200 km	0 km
Total damage:	$914M	-	-
Cleaning	$100M	$50M	$0
Fishing industry	$98,3M	-	-
Tourist industry	$400-500M	-	-
Claim for damages	$120M	$17M	-
Killed birds	≈ 60,000	≈ 40, 000	-> 0

Takeaways:

- Not more toxic than gasoline or diesel
- Methanol poisoning is treated simply and is not carcinogenic
- No GHG potential (methane slip)
- Miscible in water – a large concentration spill will rapidly decrease with only short term effects
- Far less hazardous to the environment

Sources: Economic, Social & Environmental Effects of the "Prestige" Oil Spill, Meyer-Werft

SAFER FOR THE ENVIRONMENT

LC50, LC = LETHAL CONCENTRATION

Concentration in water, at which half the population died within specified test duration

Better than Diesel by a factor of 240 times

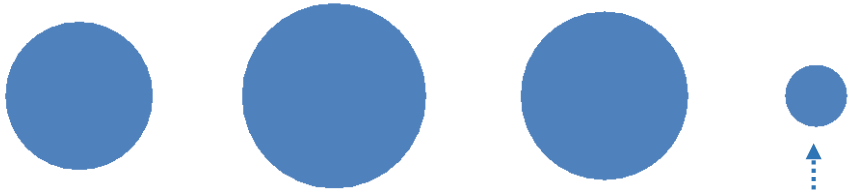
Methanol[1]
15400 (mg/l)

Methane[5]
49,9 (mg/l)

Heavy Fuel Oil[3]
79 (mg/l)

Diesel[4]
65 (mg/l)

Gasoline[2]
8,2 (mg/l)



Better than Gasoline by a factor of 1900 times

[1] ECHA, European Chemicals Agency, registration dossier Methanol
[2] Petrobras/Statoil ASA, Safety Data Sheet, ECHA registration dossier Gasoline
[3] GKG/ A/S Dansk Shell, Safety Data Sheet
[4] ECHA, European Chemicals Agency, registration dossier Diesel
[5] ECHA, European Chemicals Agency, registration dossier Methane

Additional Source: Meyer-Werft

IMO CONFIRMATION OF ETHYL/METHYL ALCOHOLS

2014

CCC 1
- Establish CG to develop measures for:
  - Ethyl/methyl alcohol
  - Fuel cells
  - Low-flashpoint diesel

2015

CCC 2
- Consider establishing WG to develop measures for:
  - Ethyl/methyl alcohol
  - Fuel cells
  - Low-flashpoint diesel
- Consider re-establishing CG
- Consider the need for other sub-committees to examine drafts or parts of them and, if so, make the necessary request to the relevant sub-committee(s)

2016

CCC 3
- Consider establishing WG to finalize measures for:
  - Ethyl/methyl alcohol
  - Fuel cells
  - Low-flashpoint diesel

MSC 97
- Approval
- Not Approved

2017

CCC 4
- Approval
- Consider establishing WG to finalize measures for:
  - Ethyl/methyl alcohol
  - Fuel cells
  - Low-flashpoint diesel
- Not Approved

MSC 98
- Adoption, if required
- Not Adopted

2018

CCC 5
- Approval
- Consider establishing WG to finalize measures for:
  - Ethyl/methyl alcohol
  - Fuel cells
  - Low-flashpoint diesel

MSC 99
- Approval
- Adoption, if required

2019

MSC 100
- Approval
- Adoption, if required

❖ After Approval, IGF Codes may be implemented at flag state level with the understanding that additional amendments may be added, requiring compliance, before IGF Codes come into Force

SUMMARY

- ***Capital costs for ship conversions much less than LNG and after treatment technologies with respect to marine applications***
- ***New Build dual fuel tankers are only marginally more than for traditional fueled vessels and meet Tier III (NOx) requirements***
- ***Methanol is already widely available and alleviates many infrastructure limitations for use as boiler fuel***
- ***Methanol is one of the top 5 seaborne chemical commodities and has been safely handled for over 50 years***
- ***Cost effective and "future proof" fuel which can be produced from a variety of feedstocks – to include renewables***

THANK YOU