Methanol: Clean Market Access for Hydrogen

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By:
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INDEPENDENT. OBJECTIVE. GLOBAL METHANOL ADVISORS

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MMSA – Independent, Objective Market Advisors

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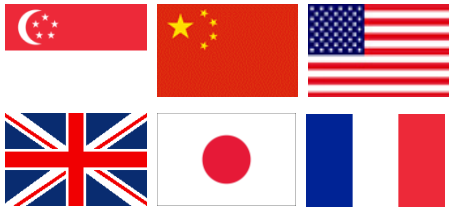
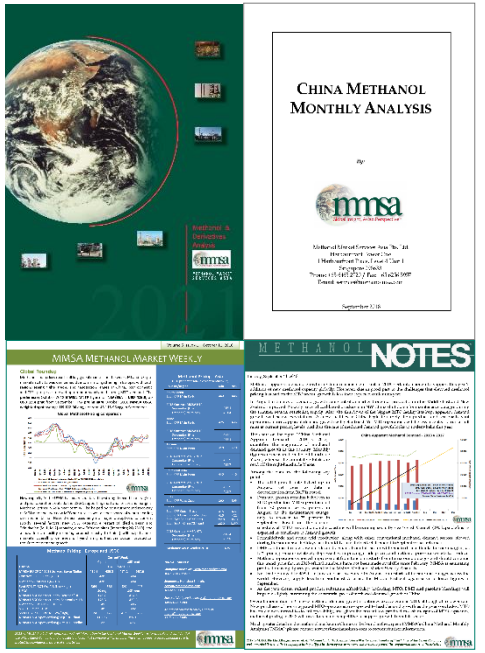


- **20th Year of Operation, based in Singapore**
  - Employee owned, independent advisors
  - Over 192 years of methanol industry experience: Singapore, Shanghai, Tokyo, UK, France, Houston, Seattle
- **Multi-Client Services**
  - **Methanol & Derivative Analysis**
    - Methanol, Formaldehyde, Acetic Acid, MTBE, MMA, Energy Use globally– 700+ pages; updated quarterly
  - **Methanol Notes™**
    - One-page topics of relevance, weekly since 2005
  - **MMSA Weekly Methanol Analysis**
    - Global market analysis and price assessment every Friday Singapore time – limited to 8 pages
  - **China Monthly Methanol Analysis (CMMA)**
    - Quantitative analysis of world's largest methanol market – Feedstocks, Costs, Affordability, MTO, S/D, Pricing
  - **Methanol Vessel Tracking Analysis**
    - Daily monitoring of 670+ methanol carrying vessels (and growing)
  - **MTO Business Analysis**
    - Monthly assessment of profitability of 24+ CTO and MTO facilities in China
- **Project Services**
  - Market and Technical Due Diligence Support, Bankable Project Assessments, Valuation, other custom-made, proprietary efforts
  - Methanol (including "low carbon" meOH), Acetic Acid, Formaldehyde, MMA, MTBE



- **MMSA IMPCA International Methanol Conference: Oct 31 – Nov 2, 2023 – Pan Pacific Singapore**

Today's Topics & Takeaways

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- Methanol can store and create hydrogen
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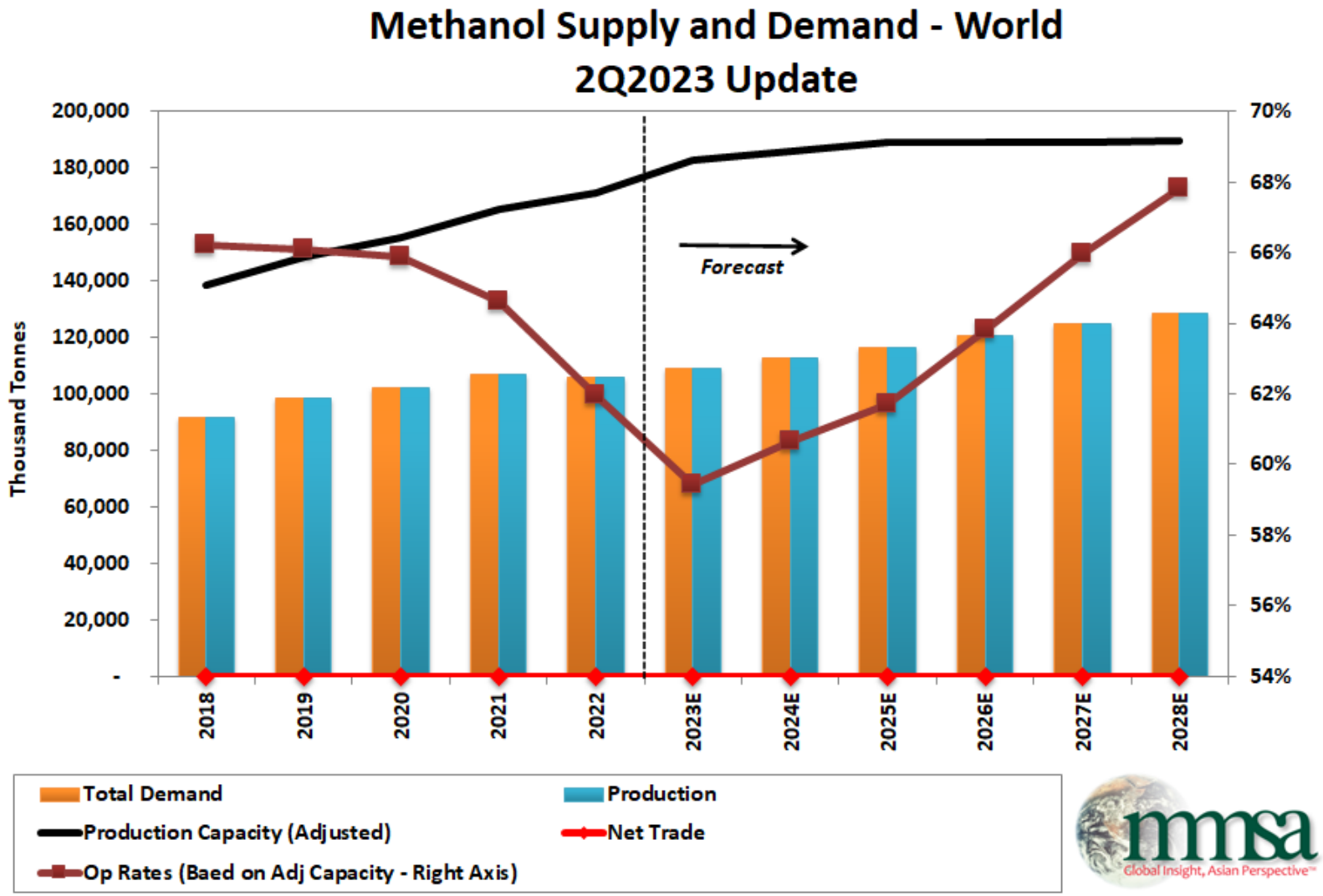
Well supplied with operating rates currently low on recent China expansion, China post-pandemic swoon, slowed global economies



Conventional methanol demand to grow 22.7M mt from ‘22 to ‘28E on additional China, MTO, and formaldehyde needs

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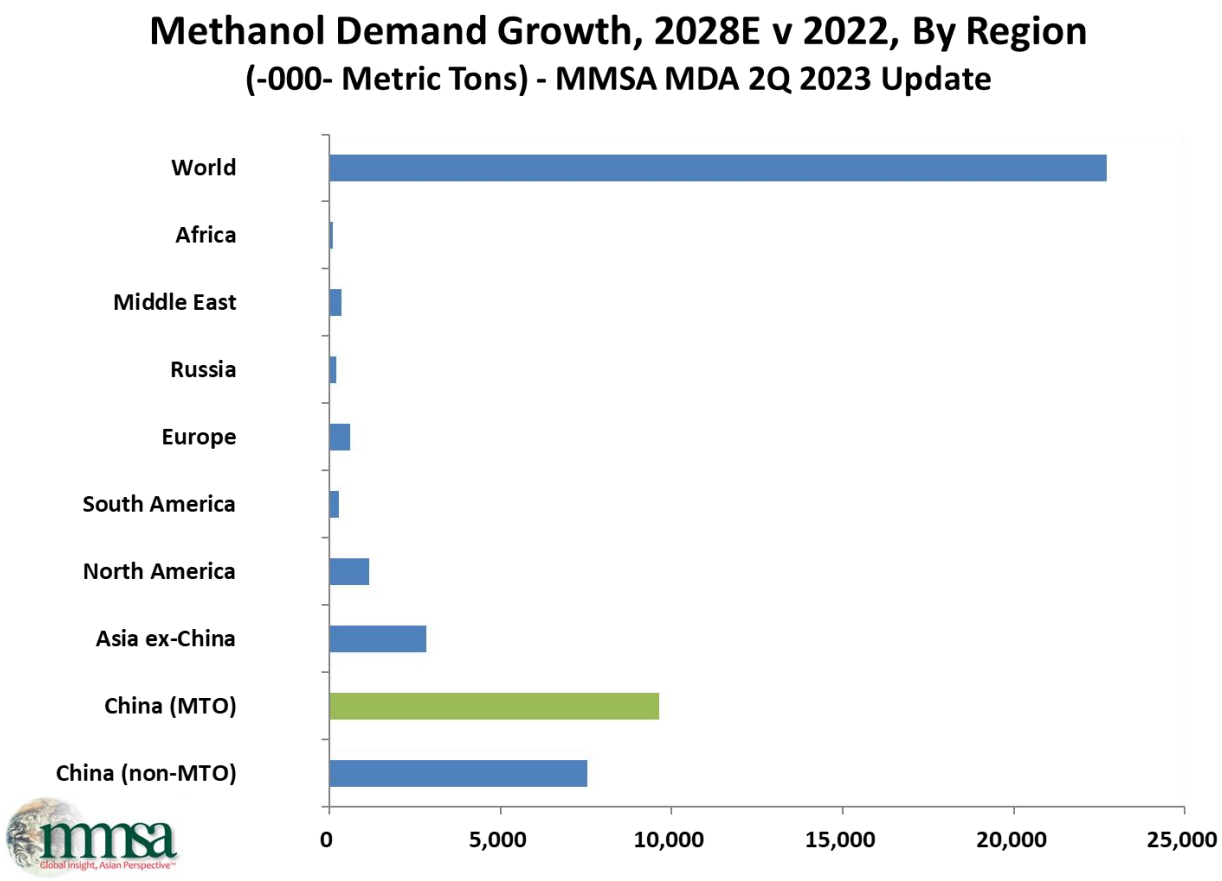
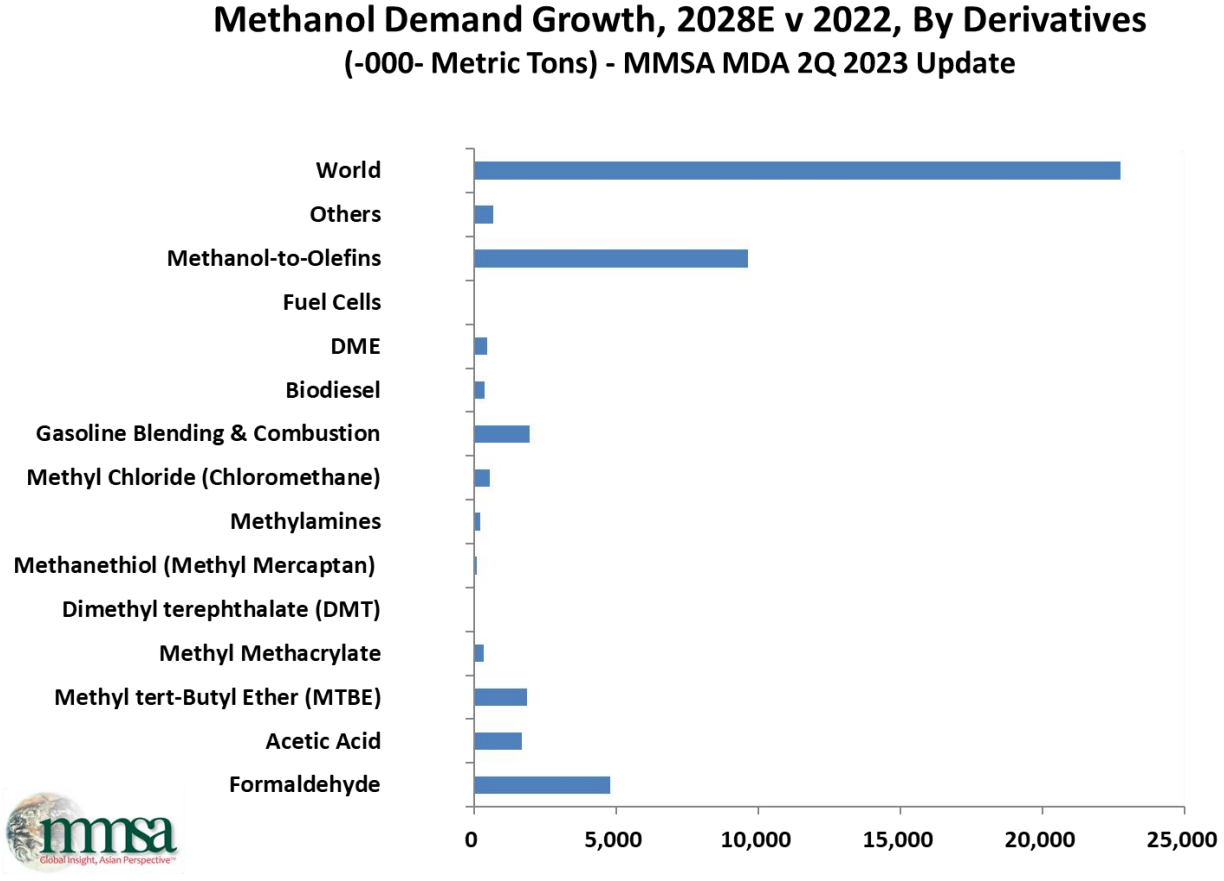
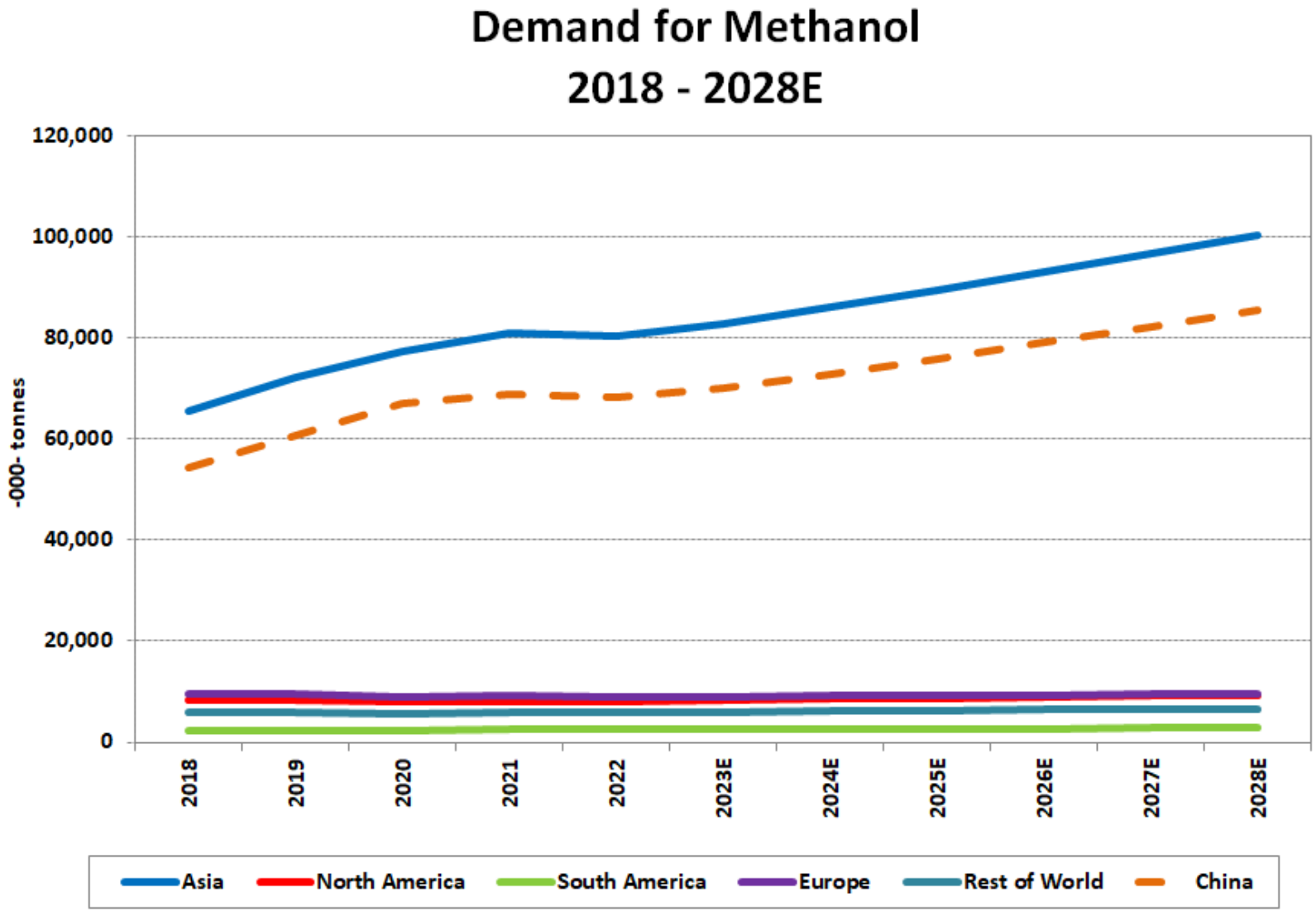


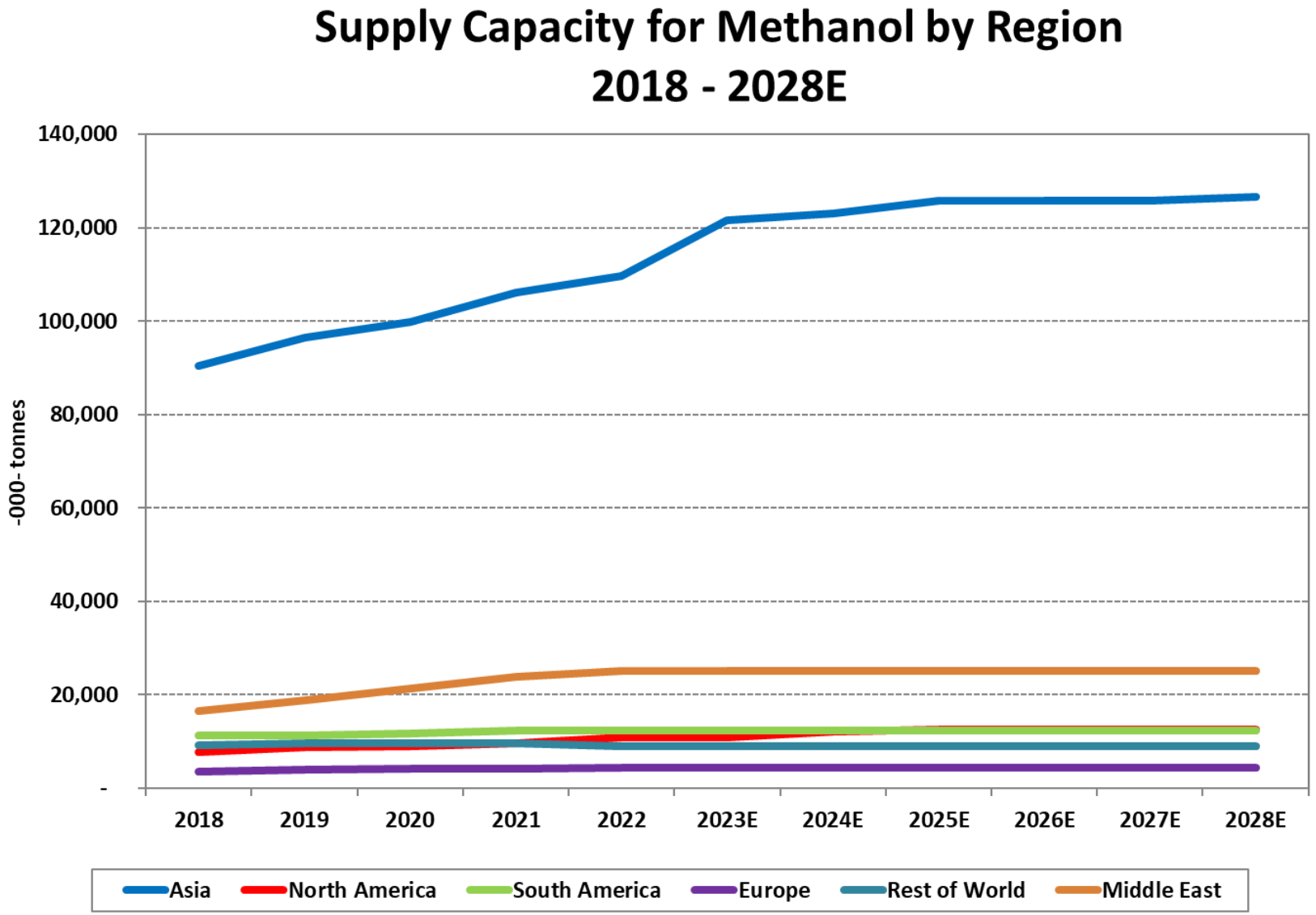


Loss of MTO demand leads to global contraction in 2022, return to slower-yet-GDP multiple growth by 2028



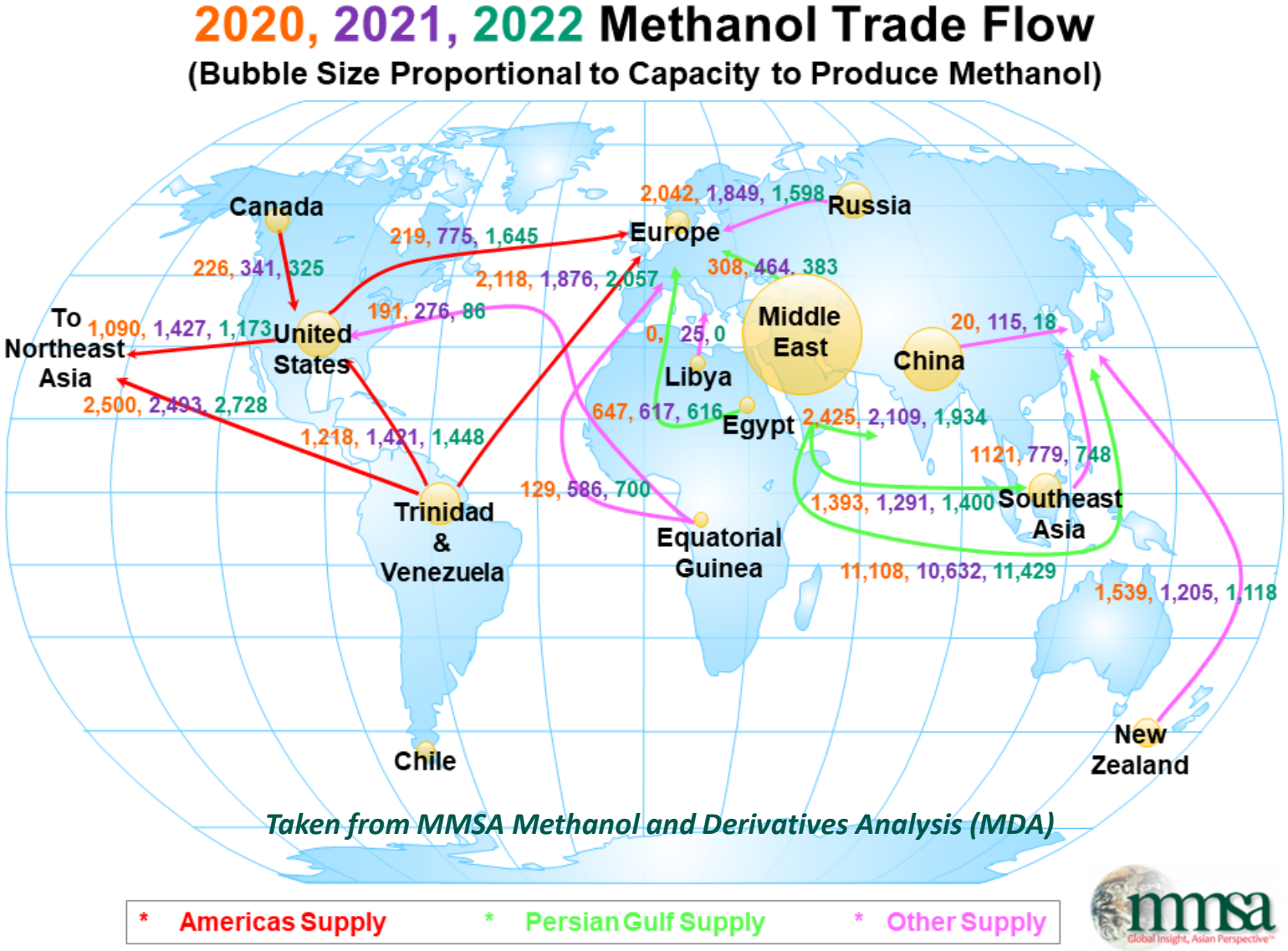
Conventional methanol supply

- Global methanol capacity announcements outside China have slowed
- China investments not clear either
- Must reinvest in conventional methanol to support demand growth long term
- From North America, Middle East, China (coal based unless access to natural gas improves)
- Must reinvest in conventional methanol to support demand growth long term
  - Next plants will be more efficient; current assets will be revamped to lower carbon intensity

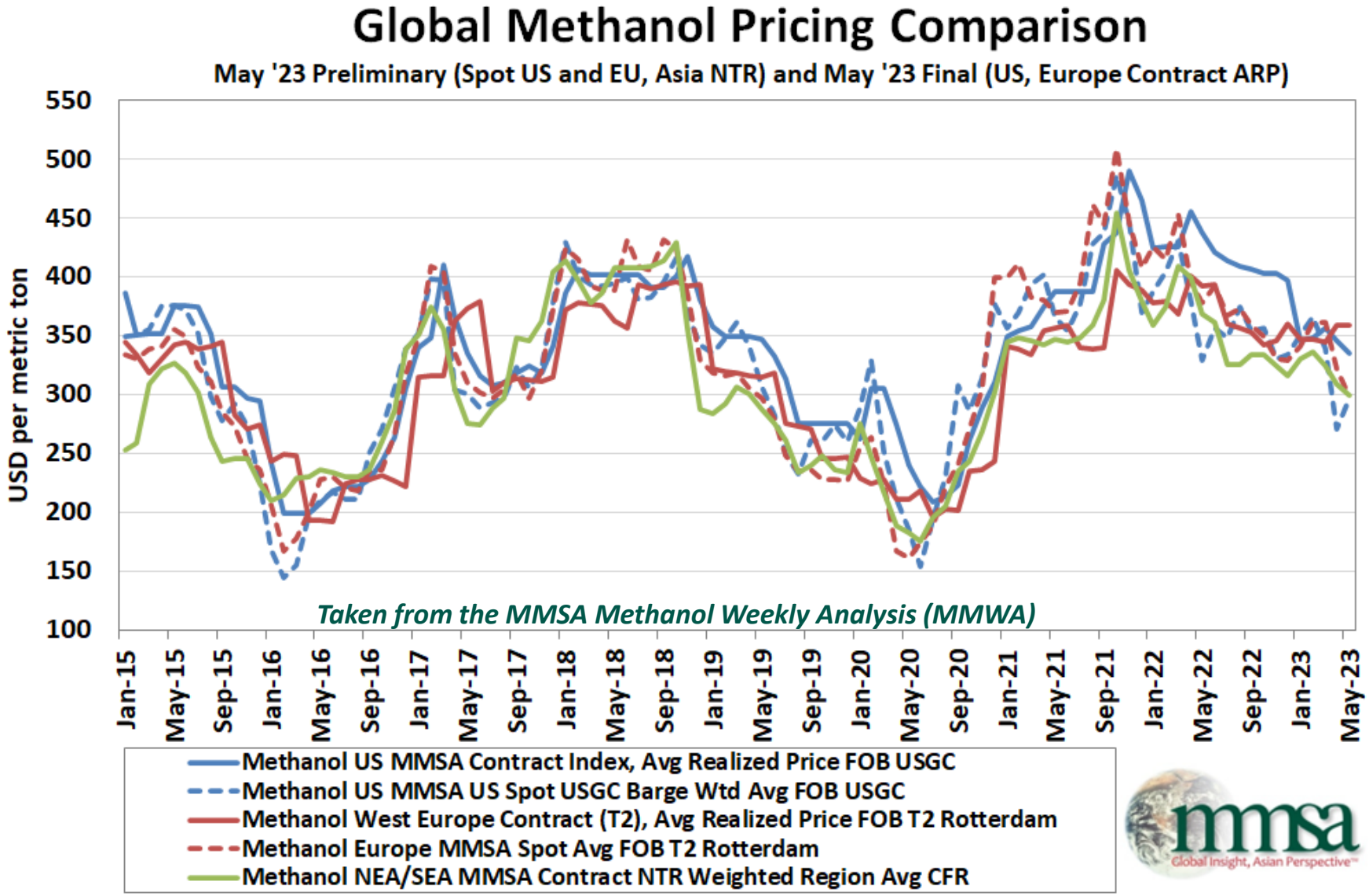


Methanol a fungible commodity, scope for expansion is large

- Middle East historical swing supplier, US Gulf and Caribbean surpluses clear out to Asia
- Europe increasing imports
- US now a net exporter, tilting to Europe
- Trinidad to Asia trade increasing
- Trinidad exports dependent upon access to reasonably priced natural gas
- Russia joins Iran as supplier to China, India, expanding into Turkey
- US exports to expand further



Pricing follows own cycles and is constrained by costs of coal-based manufacturing and affordability into MTO application



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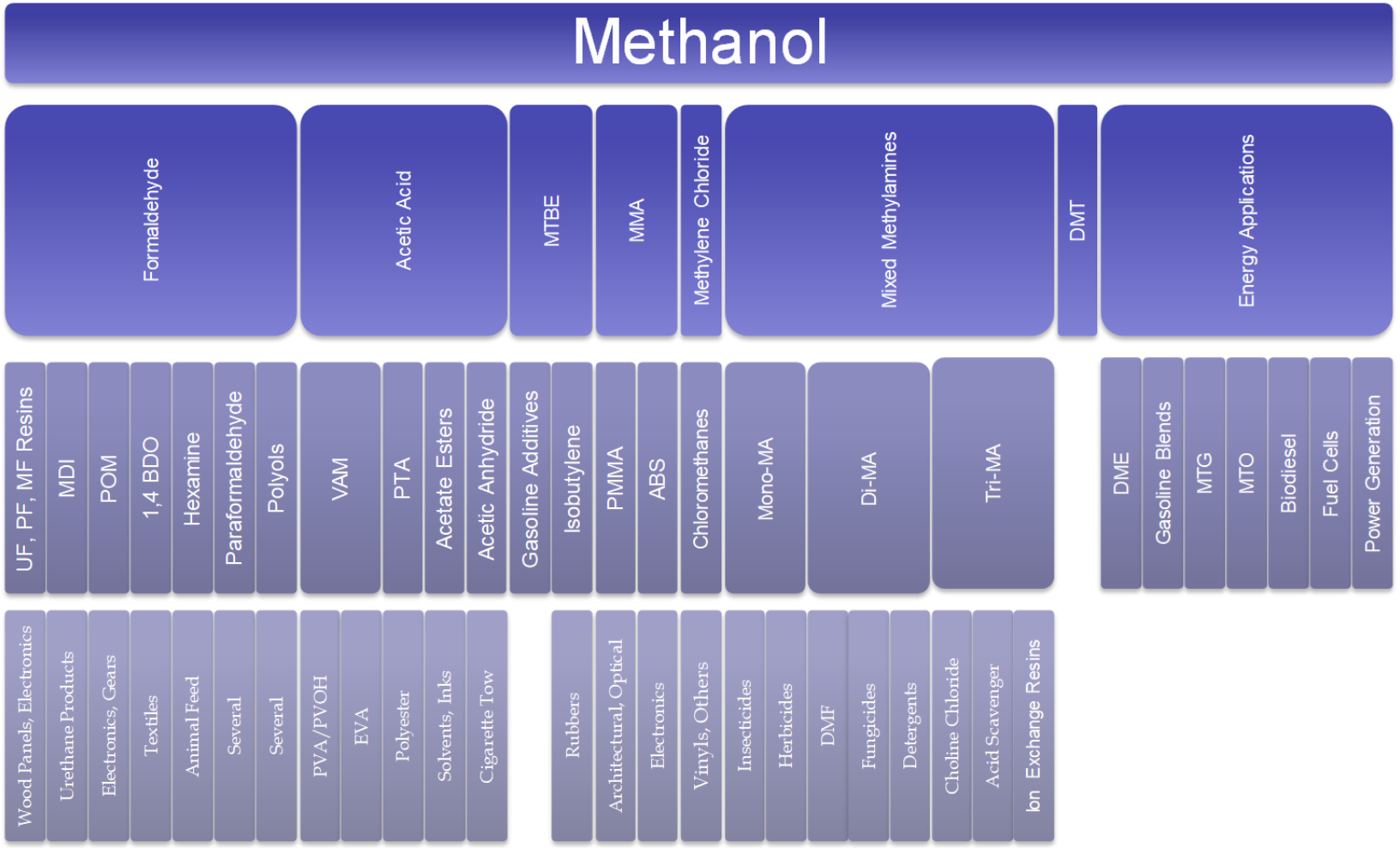
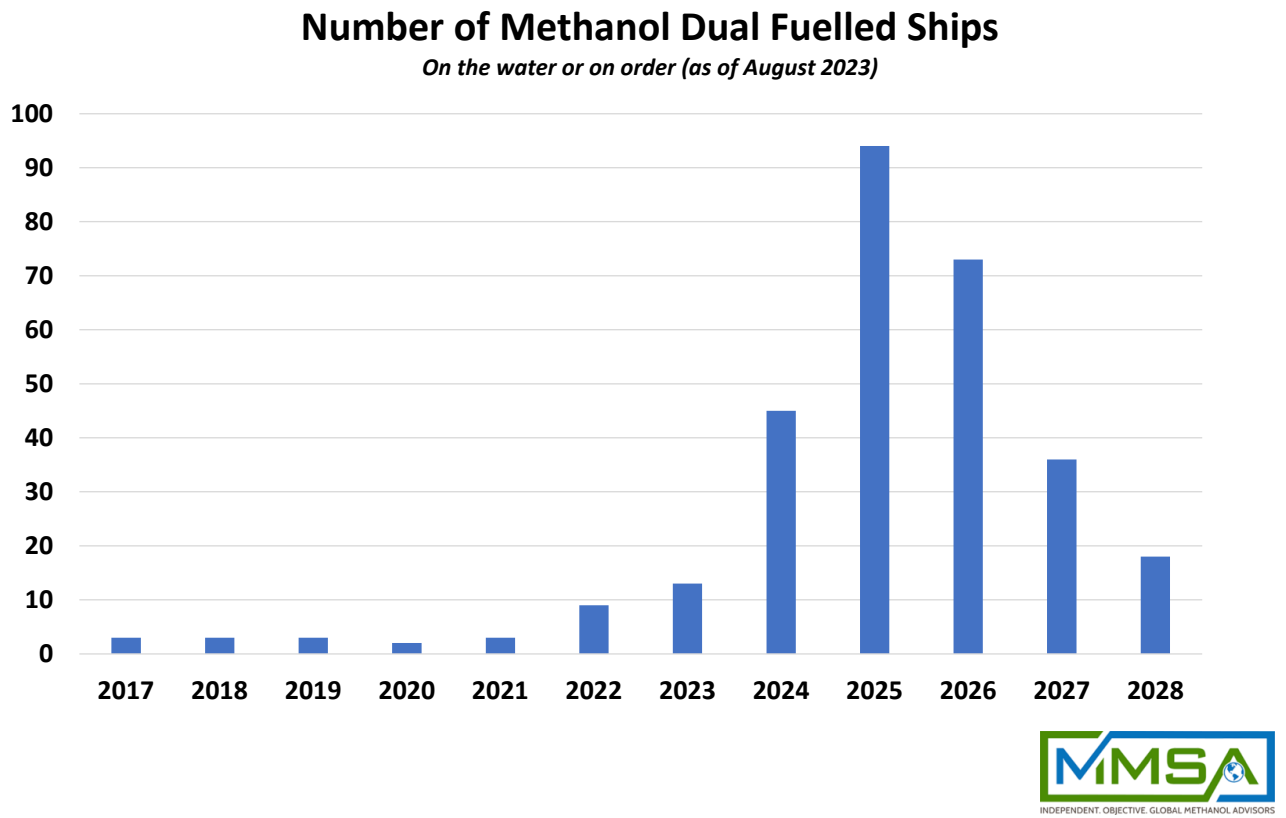
Methanol is an established raw material for multiple chemical value chains



First, second and third level derivatives shown.

Available demand on the rise from methanol-diesel dual fueled ships

- >300 methanol fuelled ships either on the water or on order books at shipyards.
- Approx. 4 million mtpa capacity to consume methanol by 2030
- Further announcements of retrofits not included



Companies with orders (including methanol manufacturers) include the world's largest ship owners: Maersk, CMA CGM, OOCL, COSCO Shipping Lines, Mitsui OSK Lines, Mitsui & Co, Proman Shipping, Proman Stena Bulk, WFS & Marinvest JV, Iino & Mitsui JV, Stena Line, HMM, Disney Cruise Lines, CSL Group, Algoma Central Corp, X-Press Feeders, MPC Container Ships, SAL Heavy Lift, Cecon Contracting, Pelagic Partners, ESVAGT, Stellar Ship Mgmt, Nippon Yusen Kaisha, KSS Line, Meiji Shipping, Marinvest, Osaka Shipping, Meiji Shipping, Westfal-Larsen Mgmt

Low carbon methanol may rekindle previously sought after methanol markets

- Table at right developed in 2005
- At the time, demand for most of these applications was close to zero
- Only MTO has “fulfilled the dream”
- All sectors can lower carbon intensity via low carbon methanol
  - Marine Fuels poised to deliver – requires patience

Developing Global Methanol Markets Summary

Application	Current Methanol Demand (2023E, -000- Tons)	Potential* Methanol Demand (-000- Tons)
Alternative Fuels		
Gasoline Blending & Combustion	11790	50,000 - 60,000
Biodiesel	3463	25,000 - 40,000
Dimethyl Ether (DME)	3266	10,000 - 15,000
Marine Fuels	195	10,000 - 20,000
Power Generation & Others	75	40,000 - 60,000
Fuel Cells	21	3,000 - 8,000
Methanol-to-Olefins	33652**	30,000 - 40,000
Methanol-to-Gasoline	500***	15,000 - 35,000

** Rough estimates of peak demand calculated as replacement percentage of existing global demand as a substitute*
*** 31 commercial-scale MTO plants commissioned in China as of April 2023 (18 integrated with meOH production, 13 merchant MTO buyers).*
**** Turkmengaz MTG plant commissioned in 2019, running sporadially*

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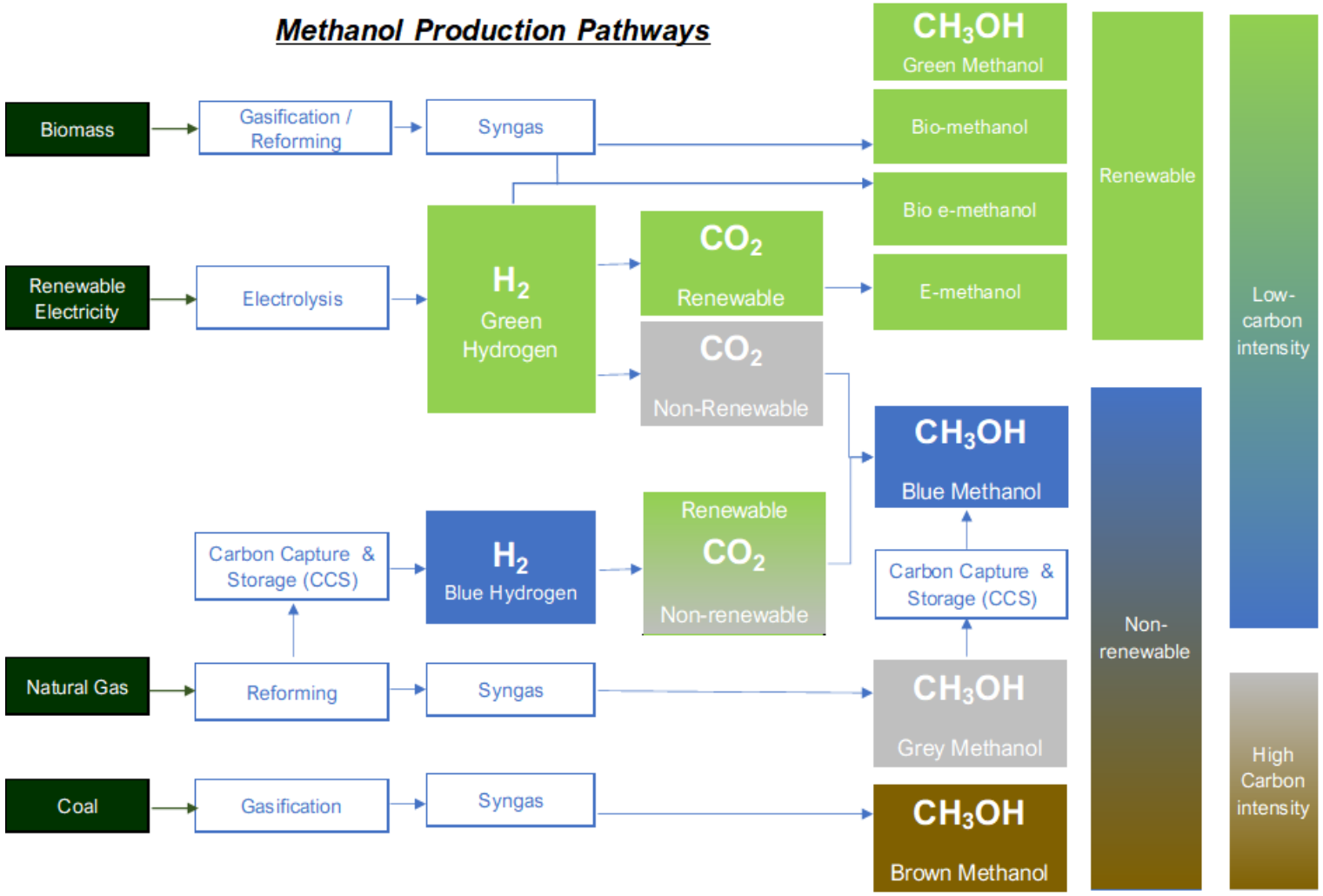
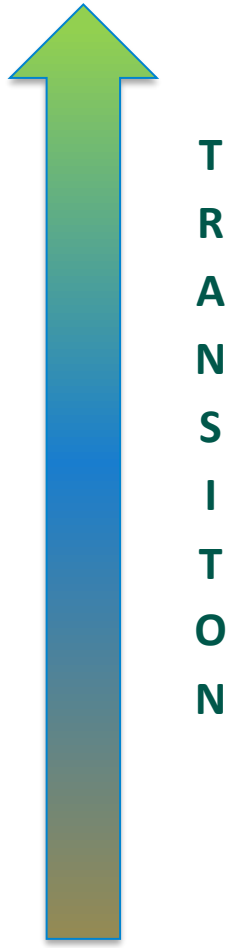
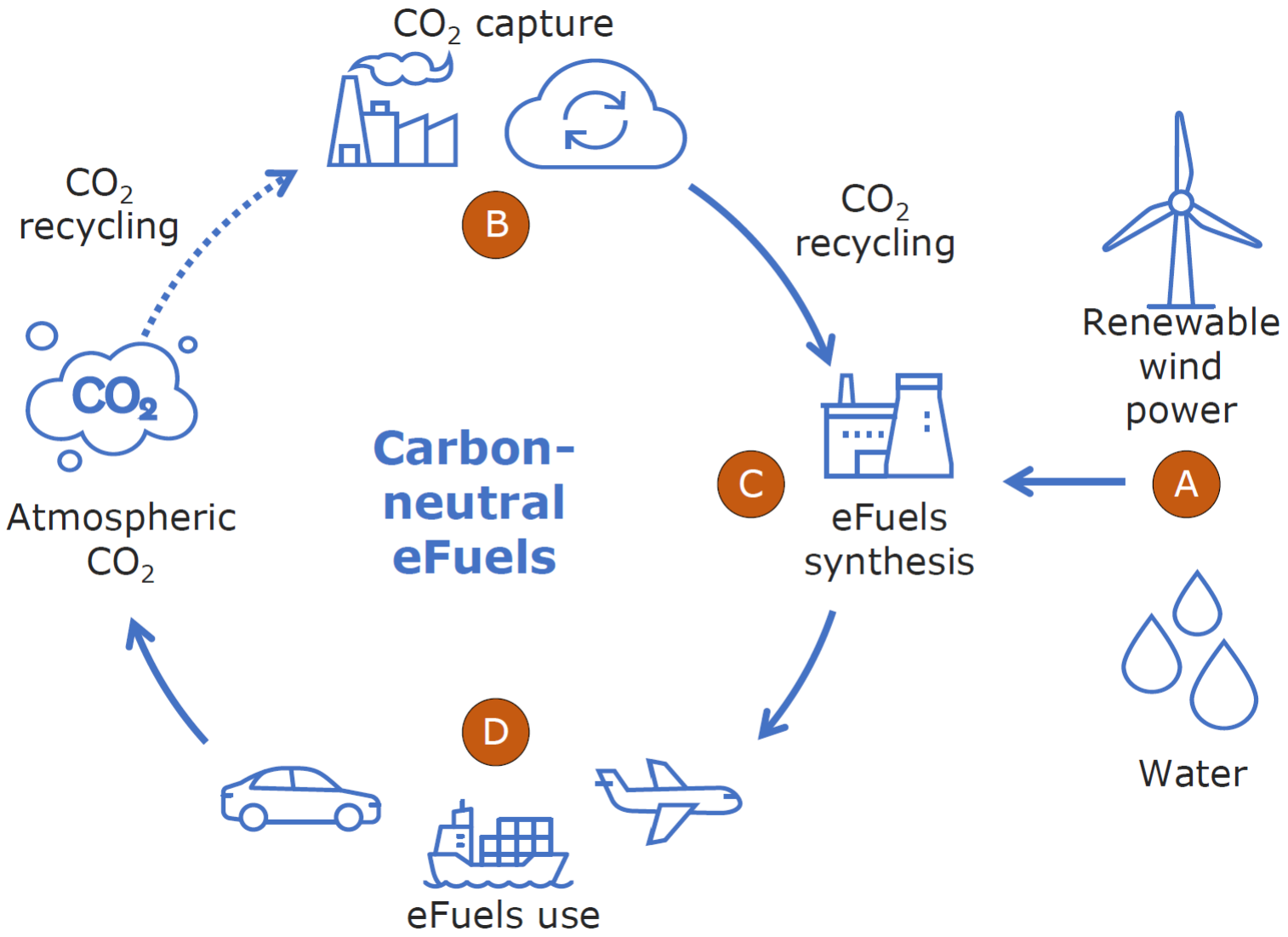
Green methanol technology is developing while the mainstream industry transitions





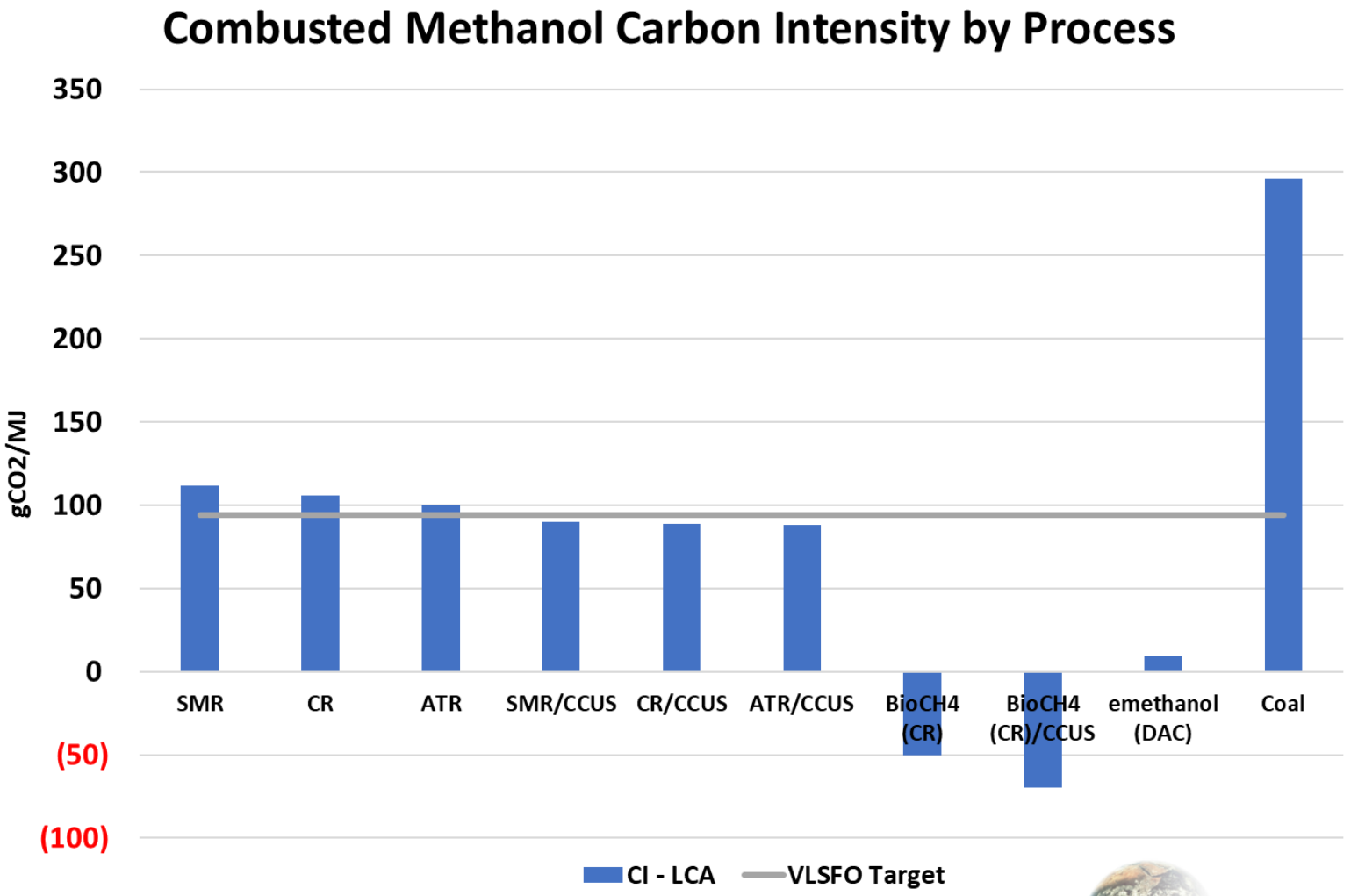
“eMethanol” projects expanding in scale globally

- **A** Use renewable energy to produce green hydrogen through electrolysis
- **B** Carbon dioxide (CO_2) captured from industrial emissions as feedstock, biogenic sources and Direct Air Capture
- **C** Captured CO_2 and green hydrogen are combined to produce emeOH; replace fossil fuels
- **D** Release of CO_2 completes the carbon-neutral life cycle



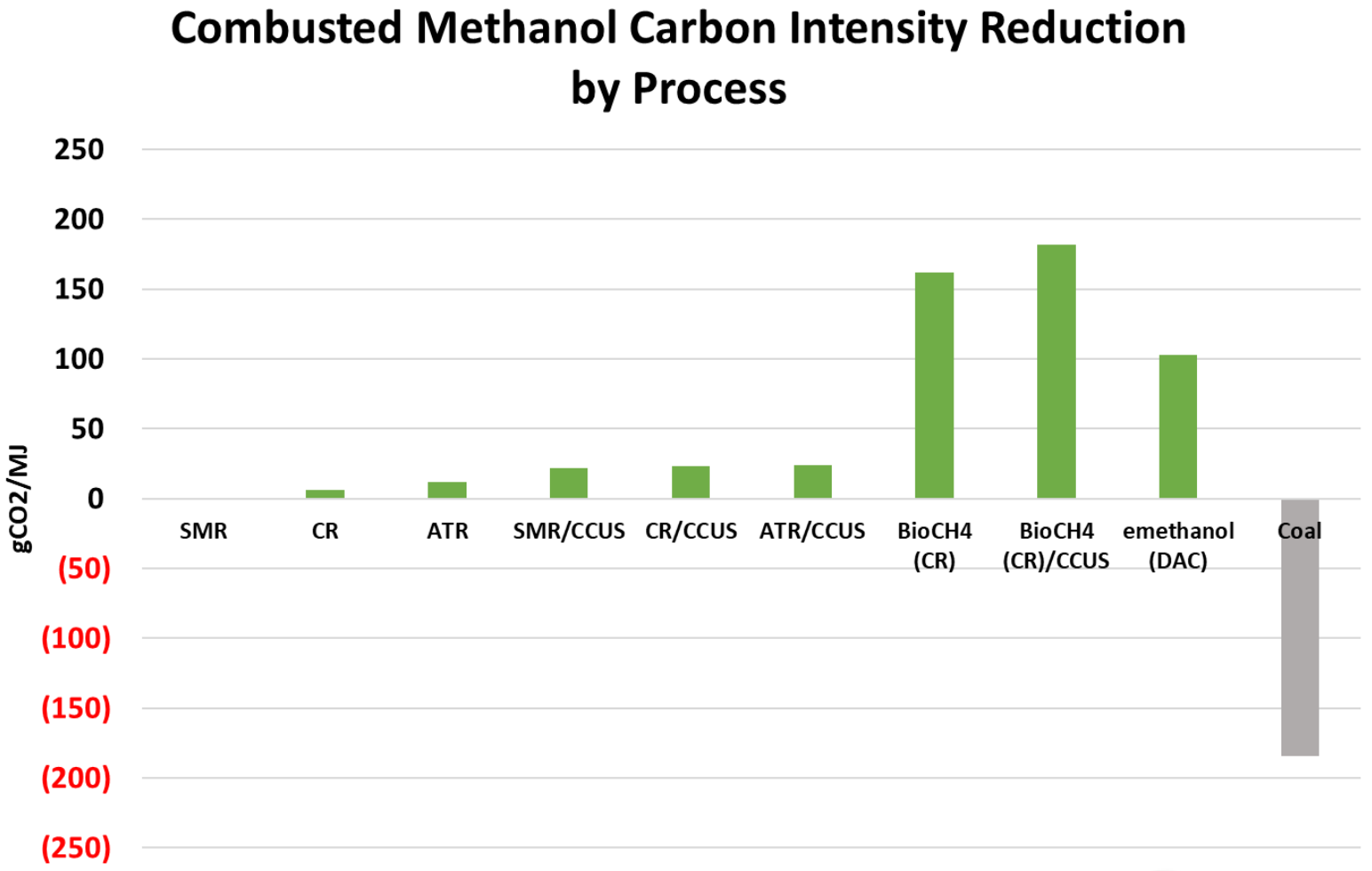
Processes to lower LCA Carbon Intensity (CI) exist…

- Wide range of possibilities
  - Typical SMR – 112 g CO_2 /MJ WTW LCA
- "Tweaks" by improving process efficiency (i.e. CR, ATR) insufficient to allow conventional methanol to help VLSFO users reduce their GHG footprint (although improved NOx, SOx)
- CCUS helps to an extent
- Biomethane "gold standard"
- Coal moves the industry toward elevated GHG wise



…with varying effectiveness

- Figures to the right can be improved
  - Scope 3 feedstock can be reduced by use of “responsibly sourced” natural gas
  - Scope 3 combustion use adds fixed 69 gCO2/MJ
    - Unavoidable unless biomethane, renewable (electrolytic) H2 used as feed
- Chemical uses also benefit
  - CO2 “buried” with long-lasting methanol derivatives
  - CO2 “avoidance” with methanol derivatives replacing (Scope 4)



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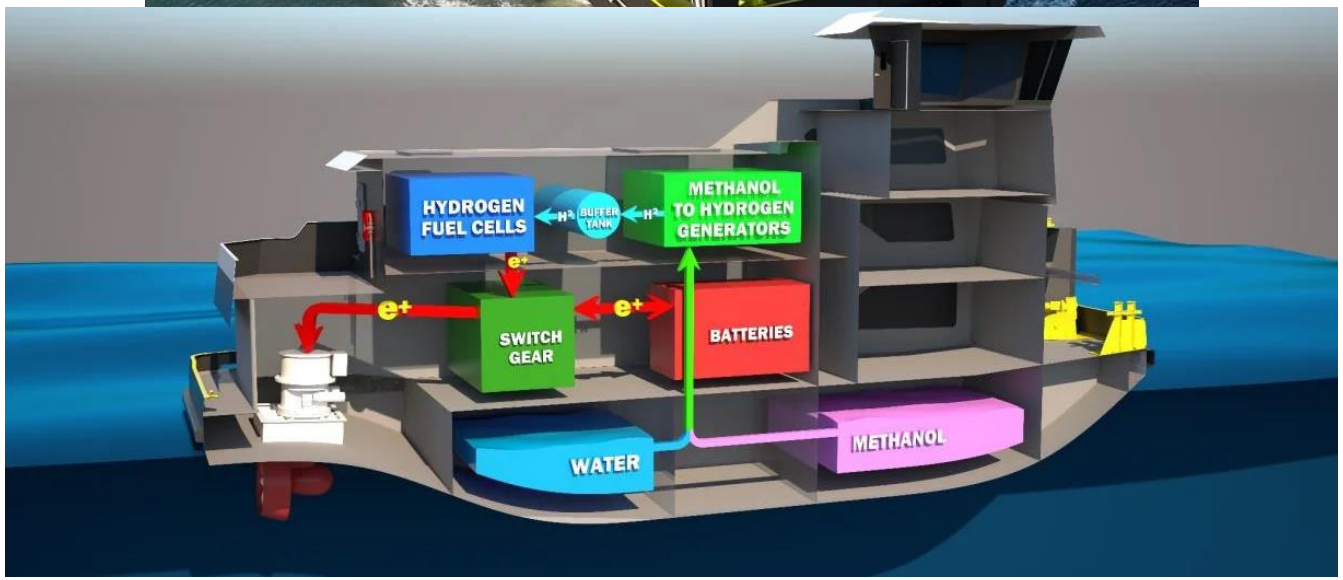
Reversing the Charge – power from methanol – based hydrogen

M/V Hydrogen One – using hydrogen from methanol

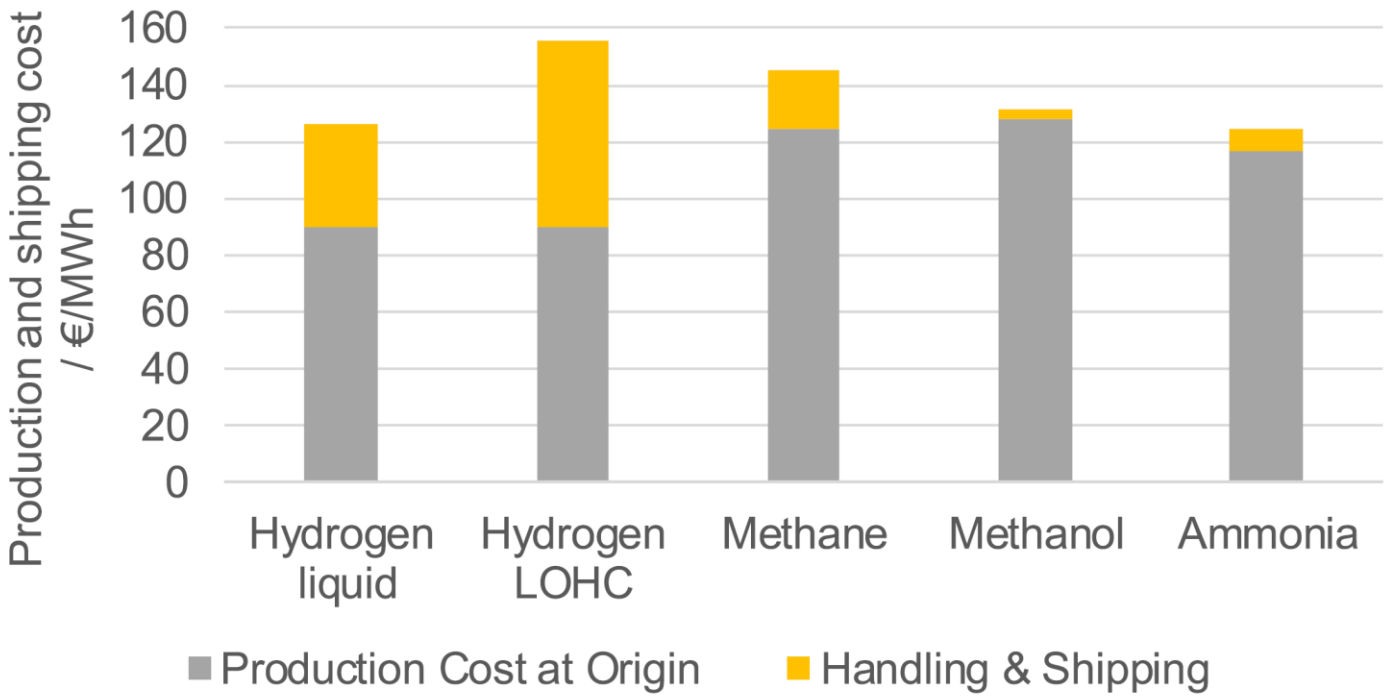
- Methanol reformer hydrogen-powered tow boat
- In operation and testing in the Gulf of Mexico Intracoastal Waterways
- Operating 24 hours a day with a fuel range of up to 4 days
- Twin propulsors of 1,000 hp each
- Onboard hydrogen generators: Ten e1 Marine M18 Hydrogen Generators
- Fuel Cell Power: Ten PowerCell PS185 fuel cell power modules



Cost of shipping safe renewable methanol compares well with hydrogen

Cost assumptions:

- Renewable H_2 ~ USD 3000 pmt
- CO_2 ~ USD 500 pmt



Production, as well as handling and shipping costs for a distance of roughly 3000 km, of various ***renewable*** energy carriers, based on Sternberg, Köppel, Holst, Smolinka, Schaadt, Hebling, Henning. "Energy efficiency and economic assessment of imported energy carriers based on renewable electricity"

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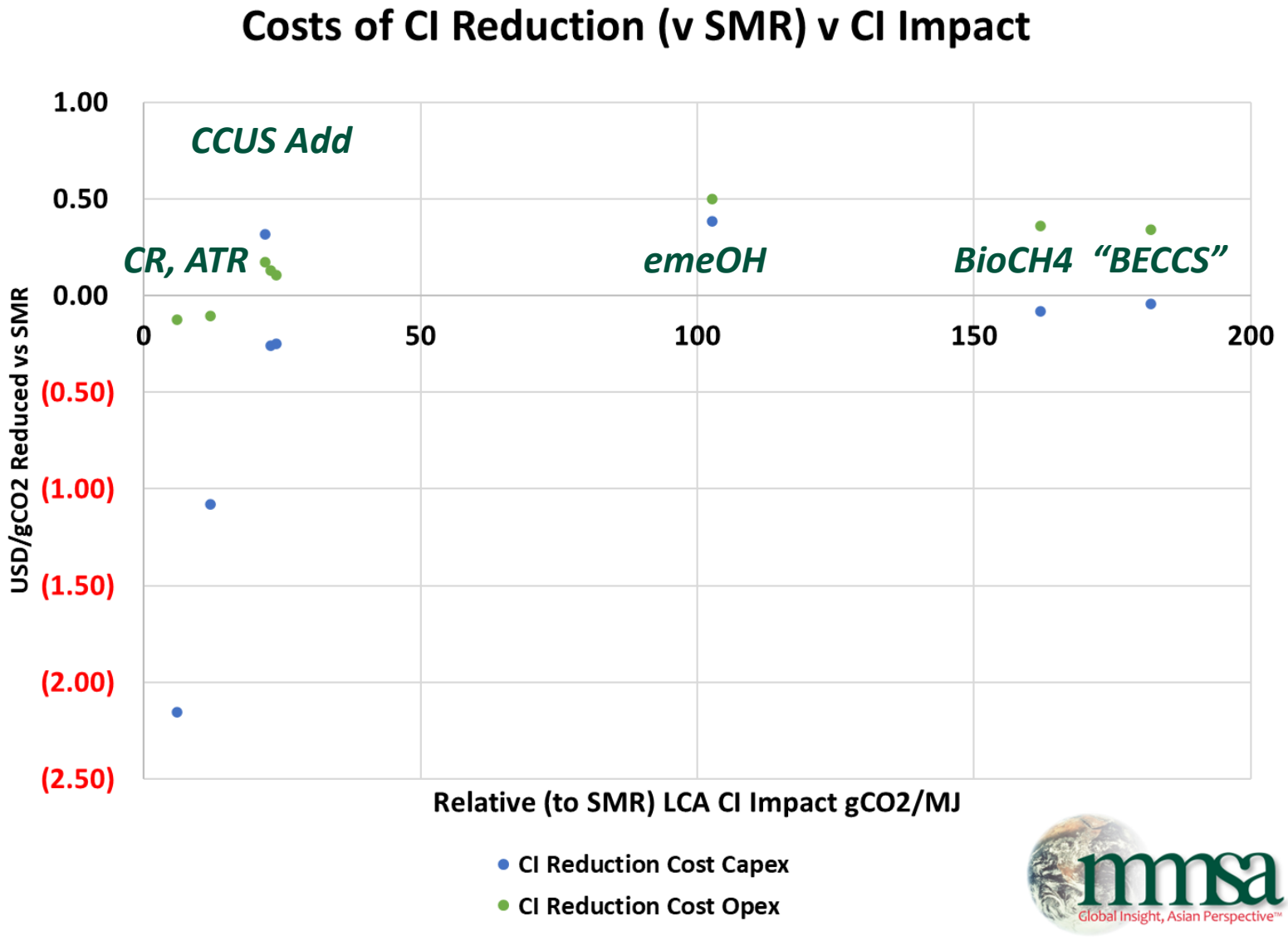
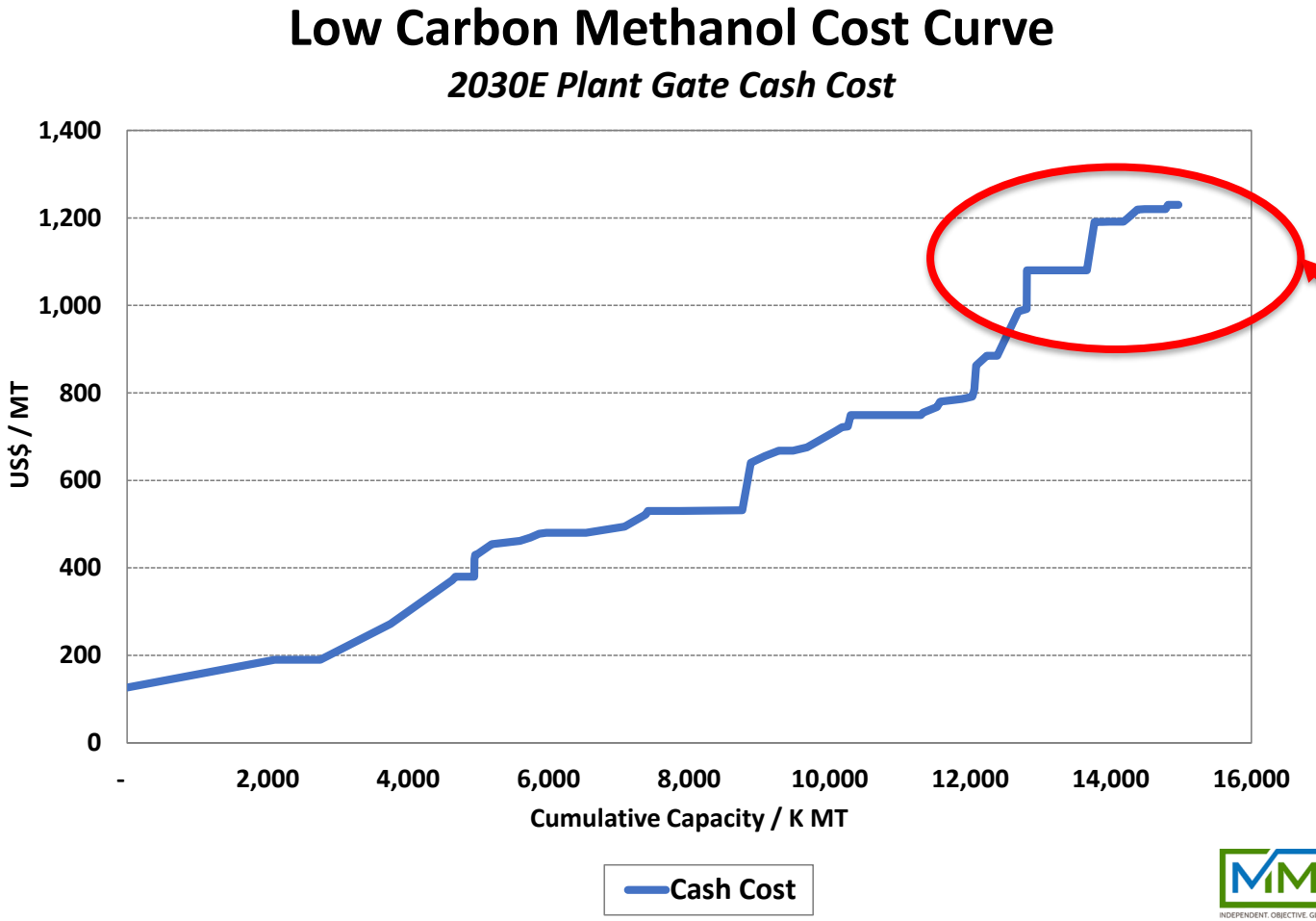
Methanol provides sustainable pathways for the energy transition

- First steps: select more efficient technologies (underway)
- CCUS provides the next steps (in planning)
- Biomethane provides the best in CI reduction when it can be afforded (underway, very limited due to high feedstock demand)
- Limitation in biomethane feedstocks will require investment in electrolytic methanol (underway, slow, small for now)
- How can we afford all of this?



Low carbon methanol cost-curve based on announced low carbon methanol projects



Most emeOH falls in this portion of the curve today. DAC and H2 learning curve improvements are underway, some with significant potential

- Plant gate, cash costs only shown. Includes current methanol plants in the US buying RNG.

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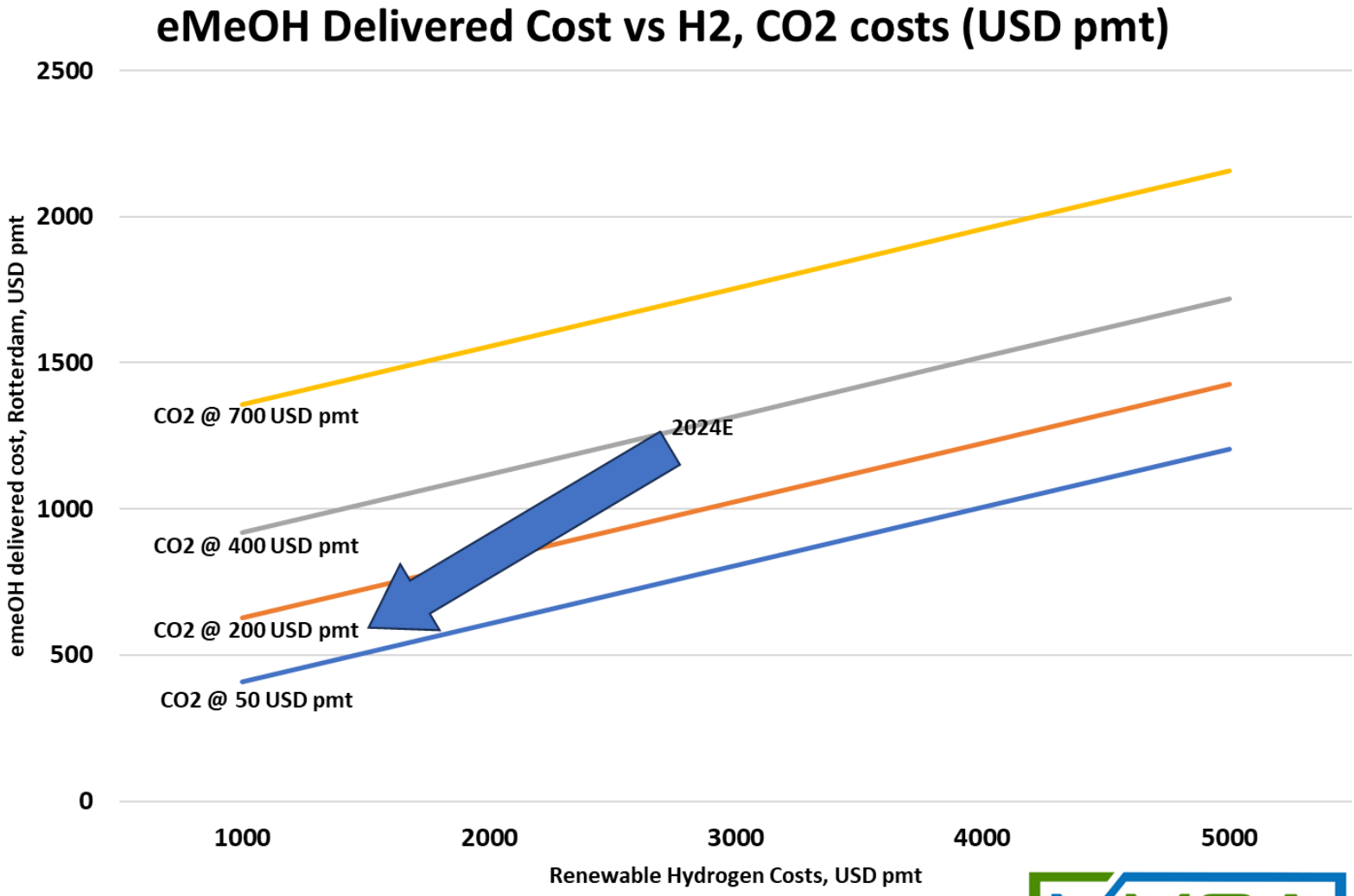
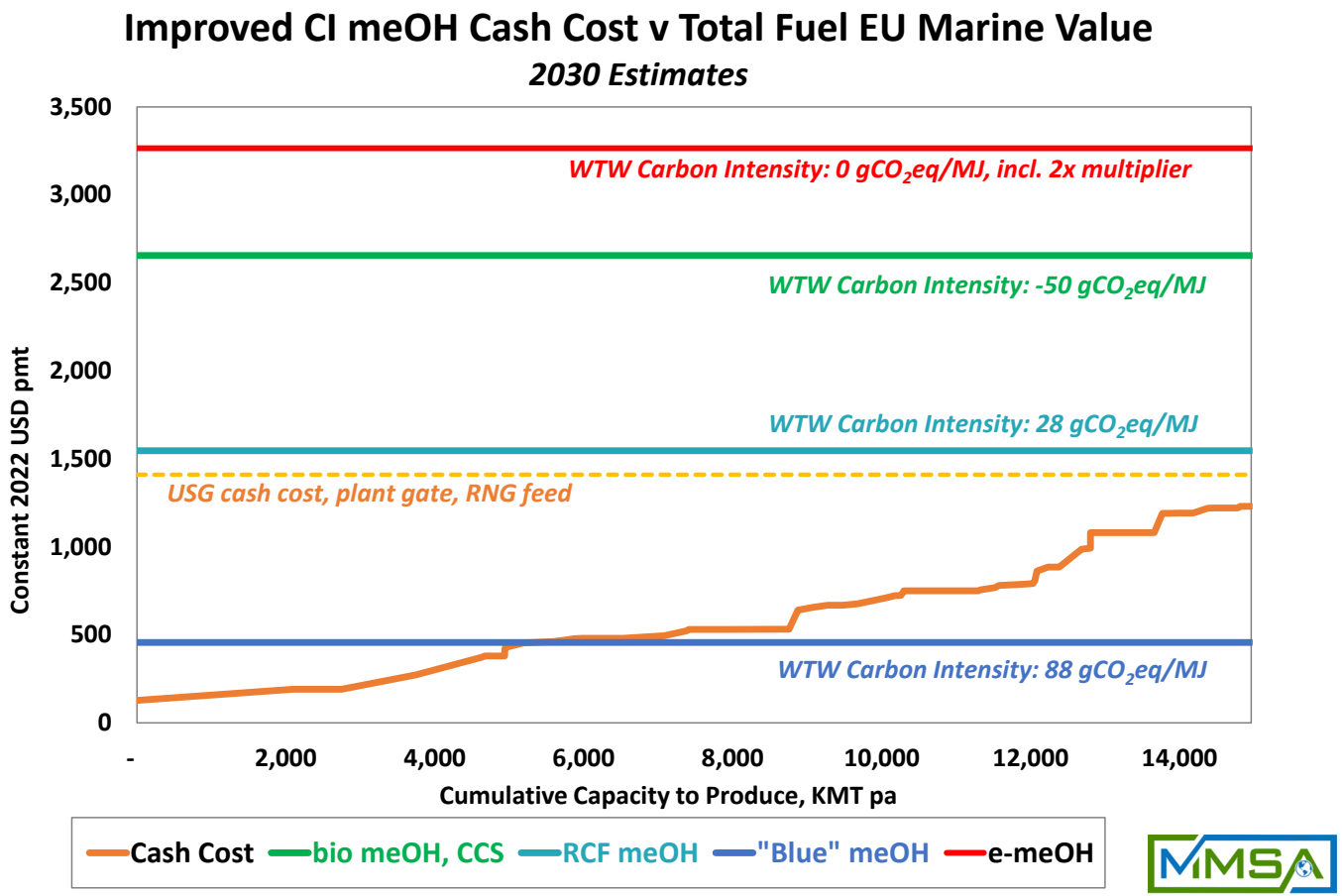
MMSA models for emeOH production – scope for cost reduction exists



Significant spreads available for low carbon methanol in emerging marine markets

- Between 3.5 – 4.5m mtpa capacity to consume low carbon methanol by 2030 on order books
- EU Fuel Maritime sets out formulae for penalization of fleets
  - Begins 2025
  - Chart to the right shows estimates for “max affordability” of methanol (value of avoiding penalties – horizontal lines)
- Lower LCA score yields higher values
  - Values are not prices! They are ceilings
- Costs are floors – proper designs will yield value above cost



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