NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

Technical background and major issues: Engineering, operations, alternative fuels

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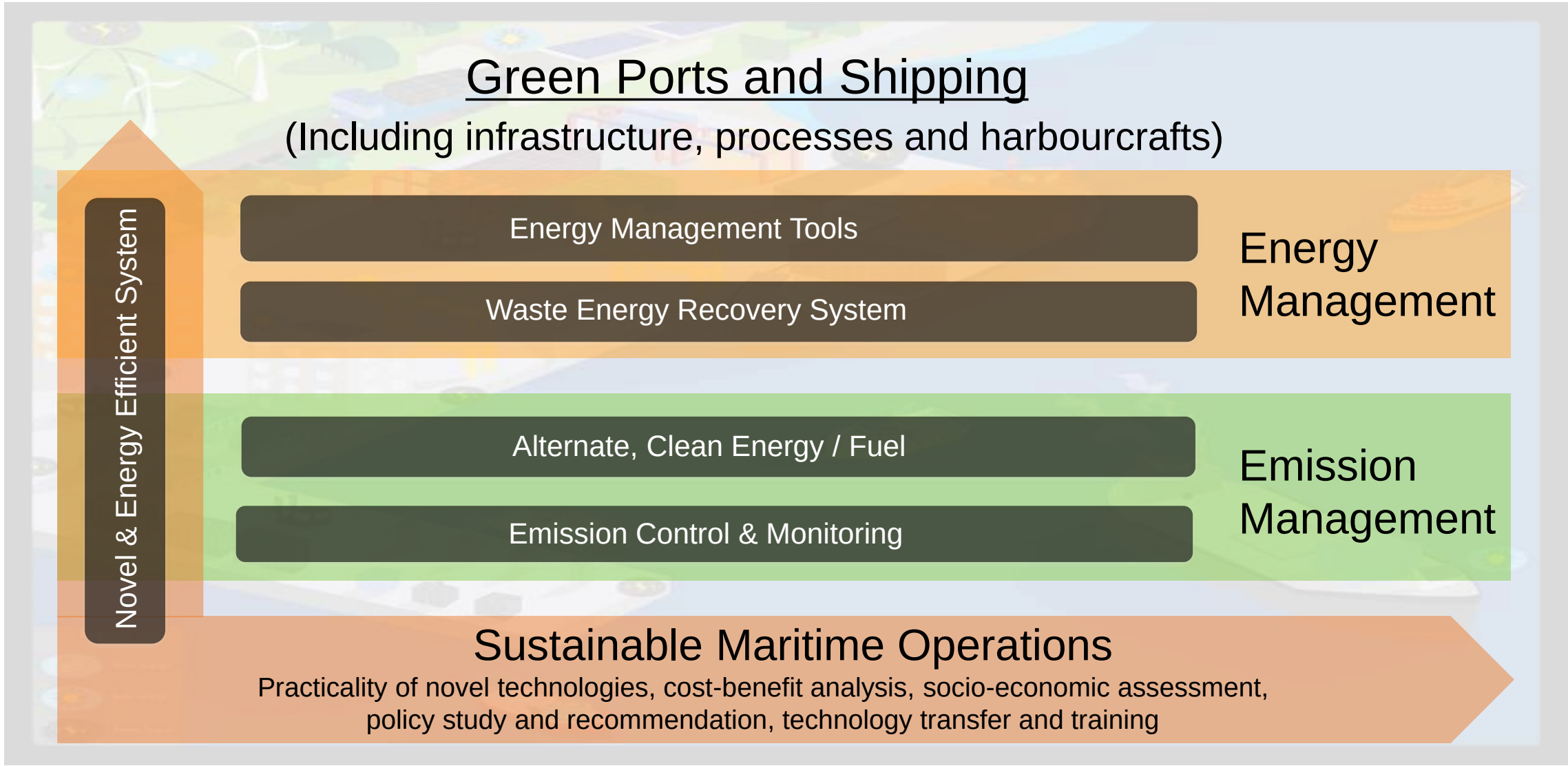
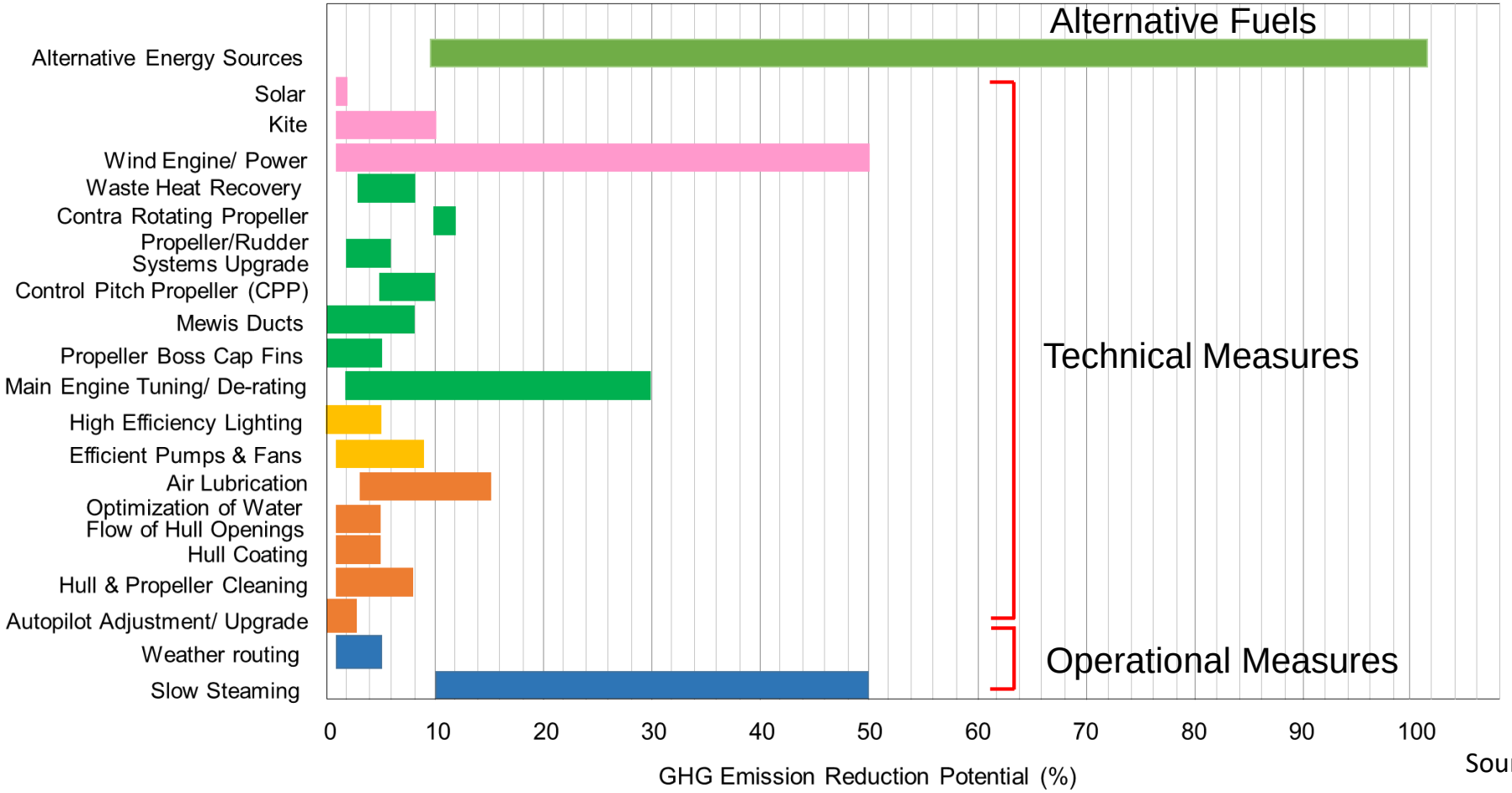
Vision: A leading global translational research centre in maritime energy and sustainable development



Technical & Operational Measures

Measures for GHG Emission Reduction

Technical & Operational Measures and Alt Fuels



T&O measures (19)

The following are the refined T&O measures from this project outcomes

Alternative fuel measures (7)

1. Fossil-based fuels: LNG, methanol and hydrogen
2. Non fossil-based fuels: Biofuels (bio-LNG, biodiesel and bio-methanol) and renewable hydrogen

Source: NTU, NUS

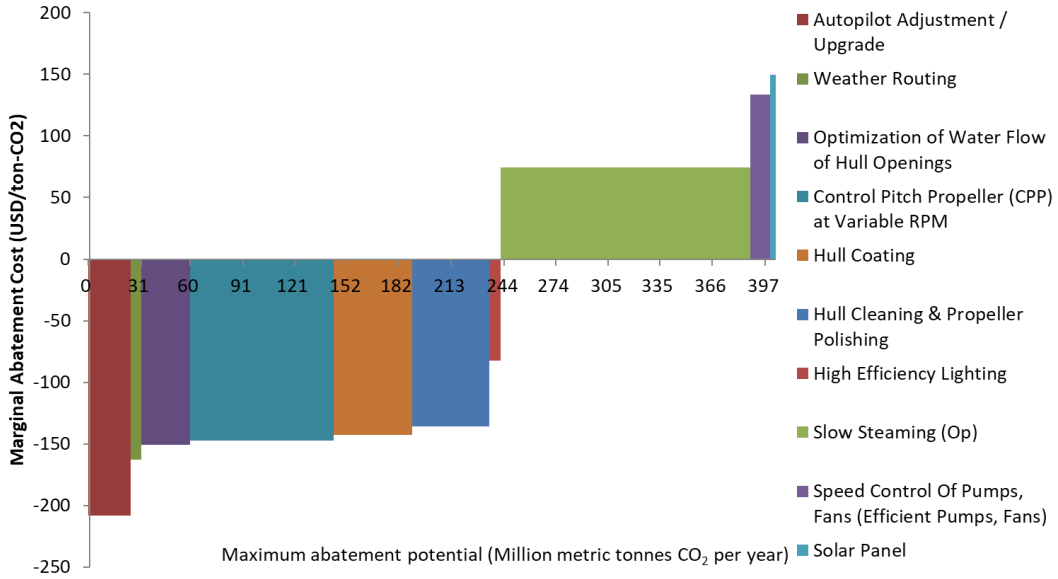
Note: 1. The GHG emission reduction potential shown is for single voyage. Accumulative effect is uncertain.
2. GHG emission reduction by Alt fuels is calculated based on GHG emission due to combustion of HFO.

Technical & Operational Measures Adoption

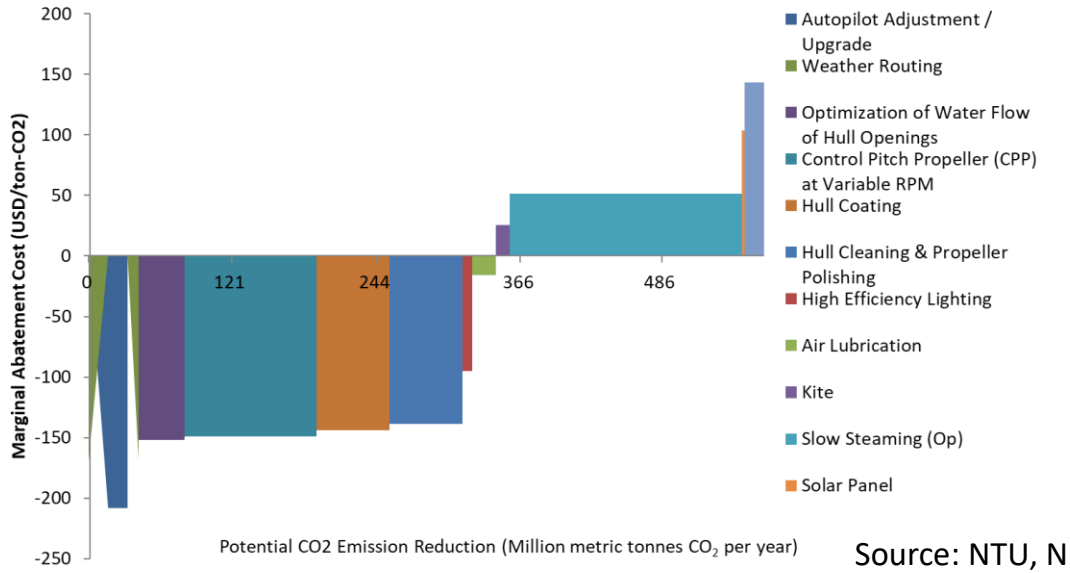
Assumptions:
- T&O measures that are **TRL 7 and above**
- Adoption of **Technical measures** only applies to vessel **below age of 20**

Assumptions:
- T&O measures that are **ALL TRL**
- Adoption of **Technical measures** only applies to vessel **below age of 20**

T&O Measures with High TRL and All MAC - 2030



T&O Measures with All TRL and All MAC - 2050

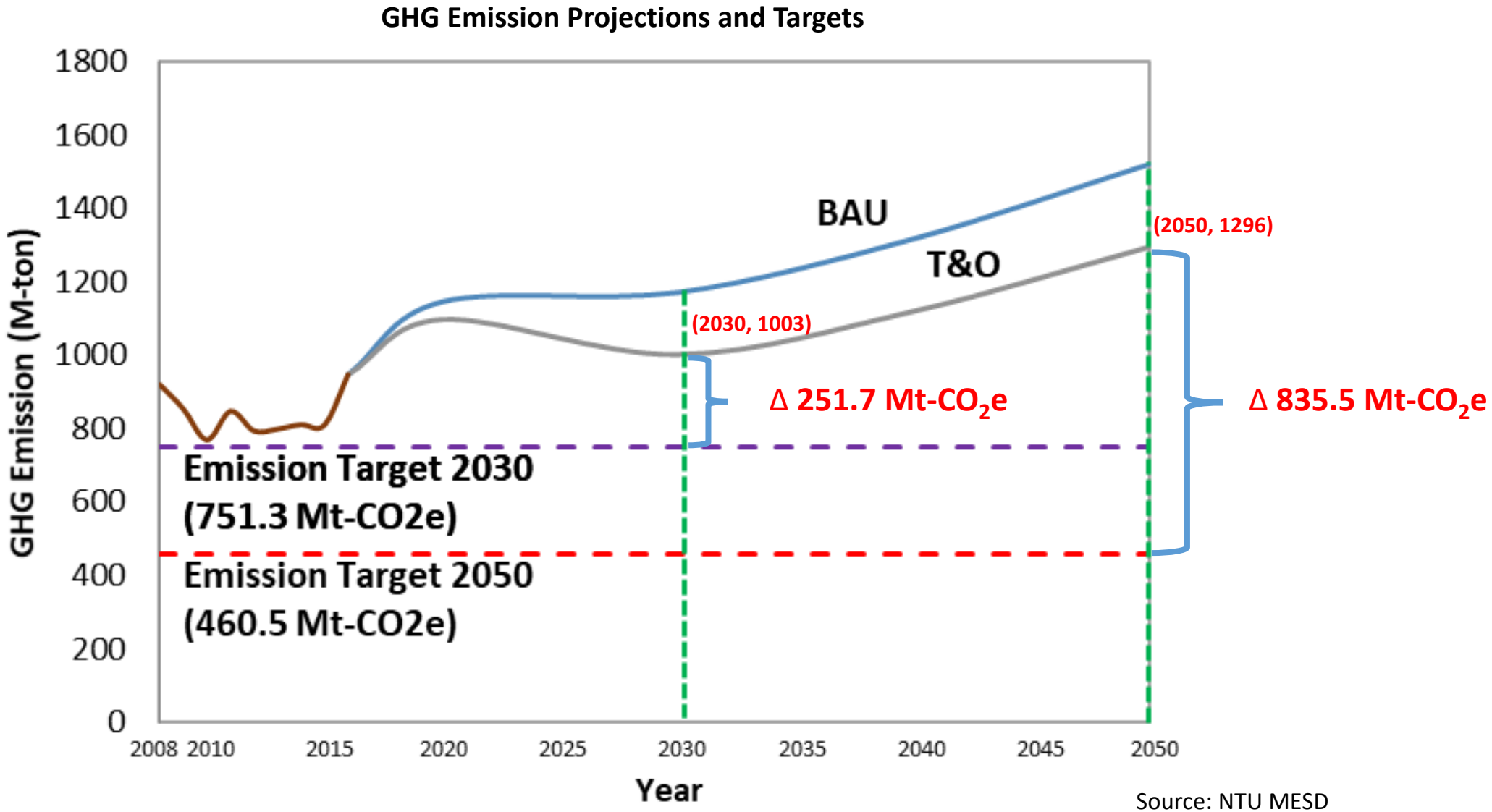


Source: NTU, NUS

Findings:
For the assumed 60% adoption of T&O measures with high TRL-MAC<0, potential GHG emission reduction range between **114 - 224 Mt-CO2e** (Expected Mean: **169 Mt-CO2e**), depending on the range of HFO fuel price, abatement potential, CapEx & OpEx estimate of each measure

Findings:
Assuming the 60% adoption of T&O measures with all TRL-MAC<0, potential GHG emission l range between **162-288 Mt-CO2e** (Expected Mean: **225 Mt-CO2e**), depending on the range of HFO fuel price, abatement potential, CapEx & OpEx estimate of each measure

T&O measures are not sufficient to meet the IMO targets



Source: NTU MESD

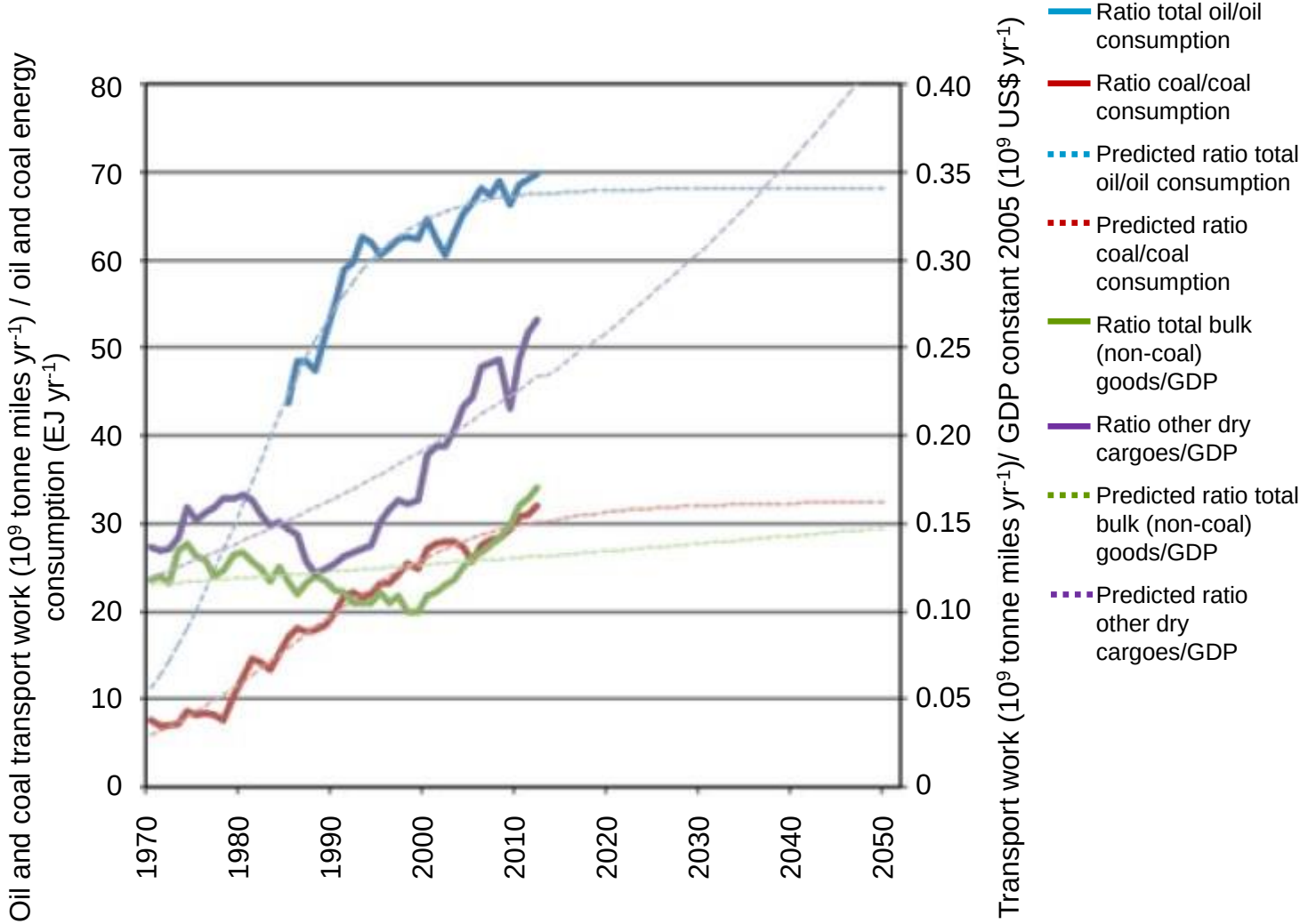
BAU 2008 – 2016 historical data
2016 – 2050 projections based on the data from IHSF and IMO 3rd GHG study

Alternative Fuels

Future energy demand for ships will increase

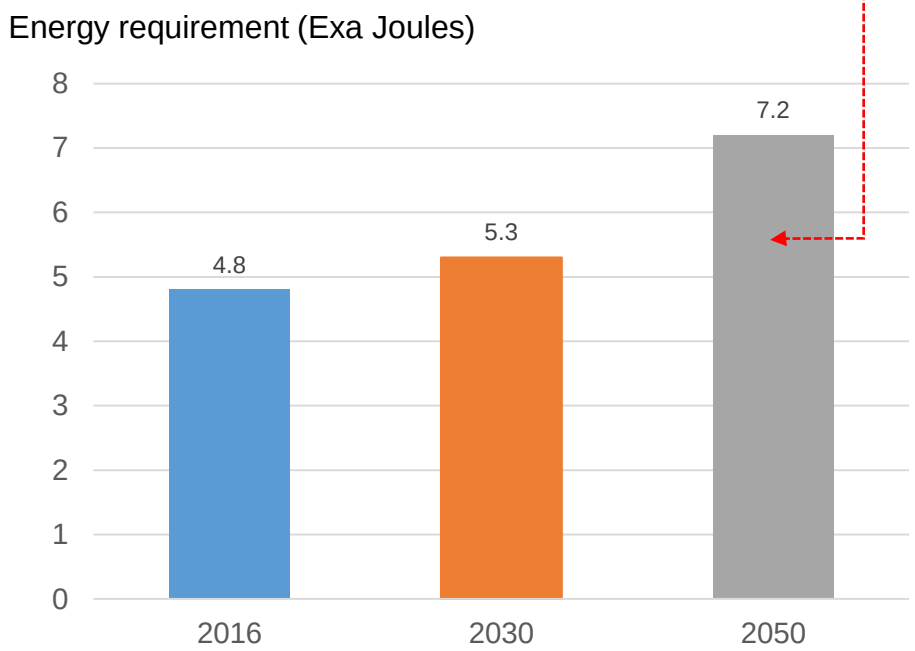
~2.5 x of combined energy outputs of all the 99 US nuclear power plants in 2016 (~2.9 EJ)

Historical and modelled growth curves to 2050



Source: IMO 3rd GHG Study, 2014

Energy Requirement (Ship Engine Output)



Excluding energy loss due to efficiency of energy converter

Source: Projections based on the data from IHSF and IMO 3rd GHG study

Alternative Energy Study

Other Energy Sources for Maritime Application


GENERATION
of alternative fuels/ energy

- Feedstock (current & potential):
  Type, availability, and usage
- Production technologies
- Capacity (current & planned):
  plants worldwide
- Cost and other concerns:
  fluctuation, factors affecting the cost

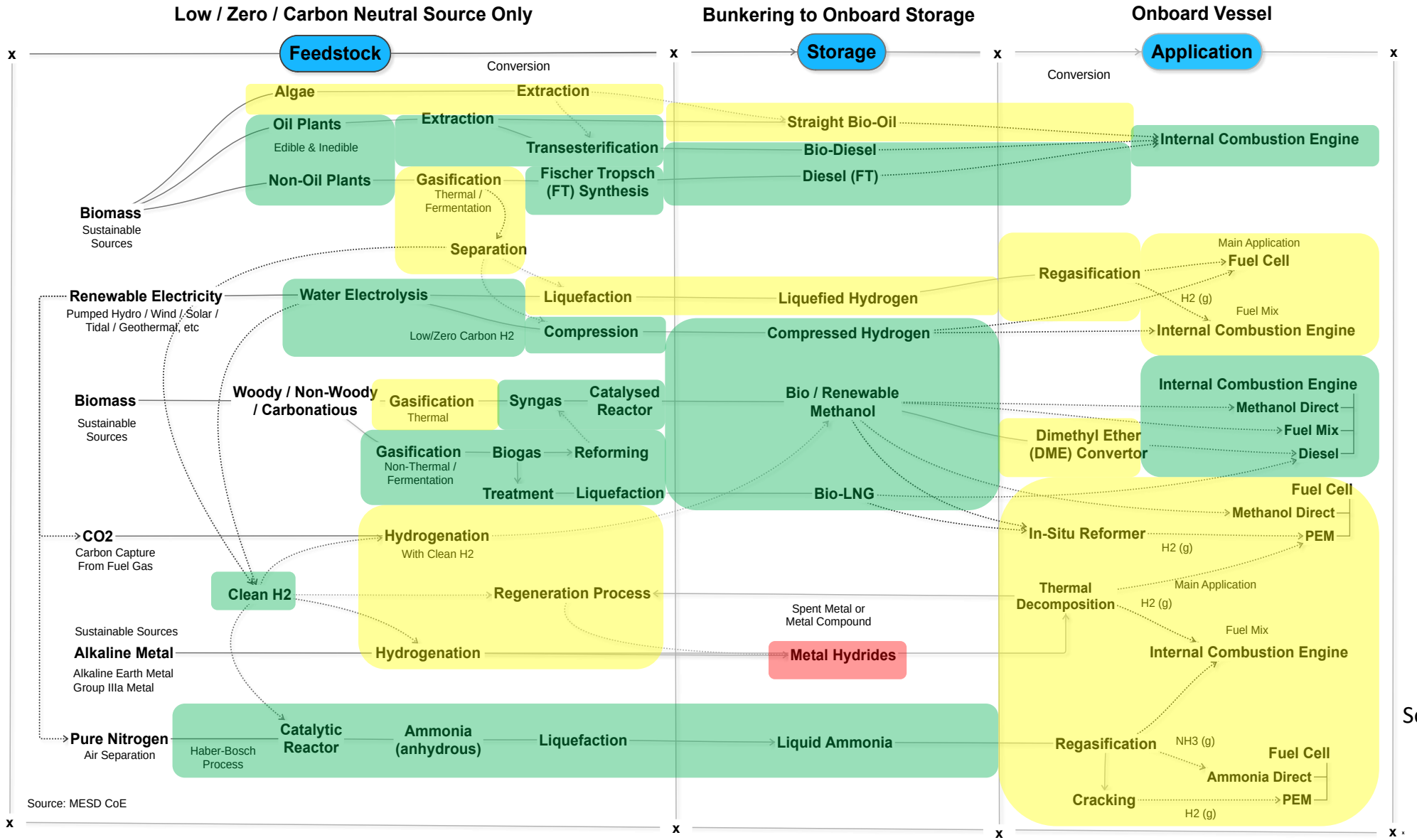
TRANSPORT

- Storage requirement
- Logistics
- Safety & regulations

APPLICATION

- Applicability
- Operation, safety & environment
- Emission reduction:
  GHG emission reduction (on board/ LCA)

Maturity of alternative fuels and their well-to-propeller routes



TRL*

< 6

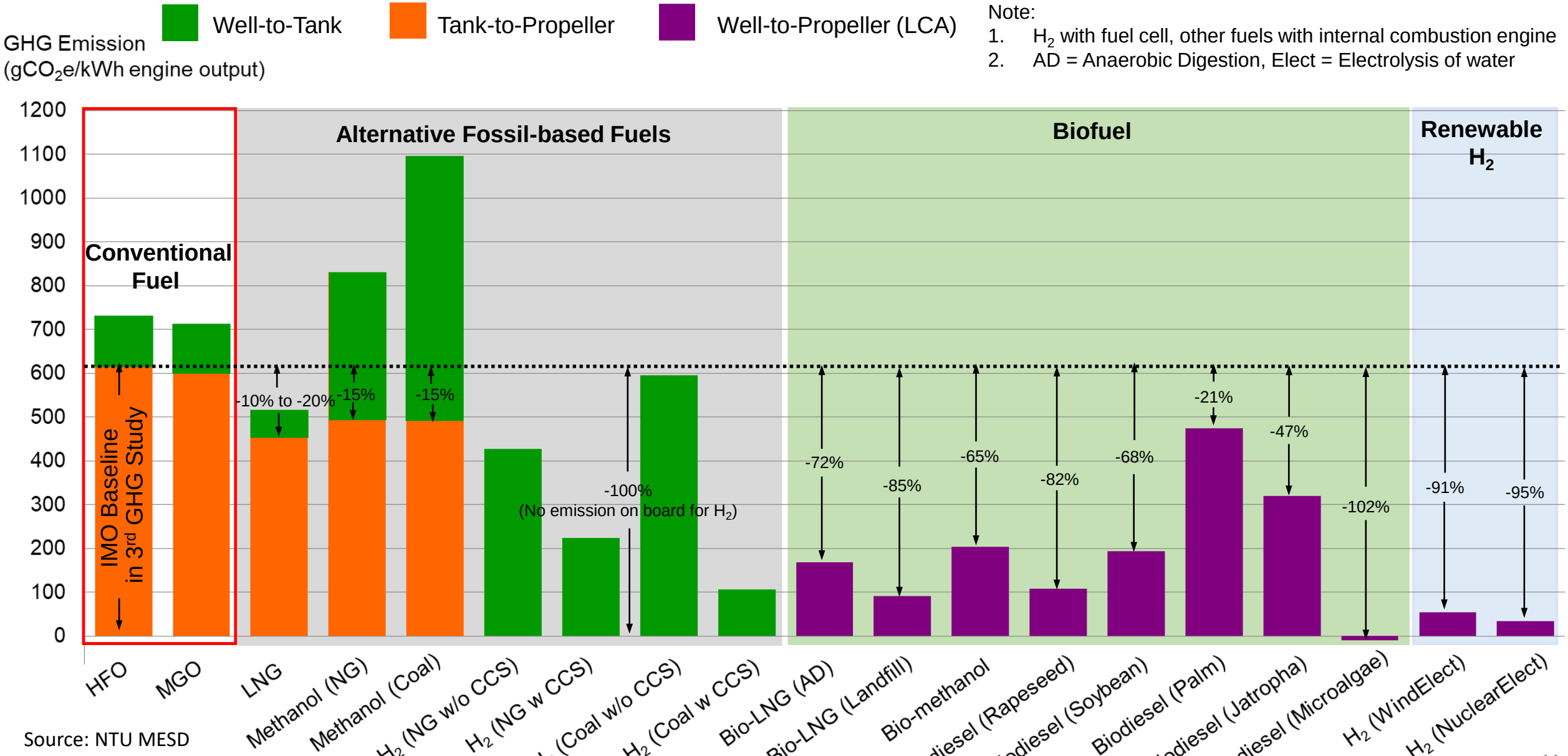
6 - 8

9

*** European Commission Horizon 2020**

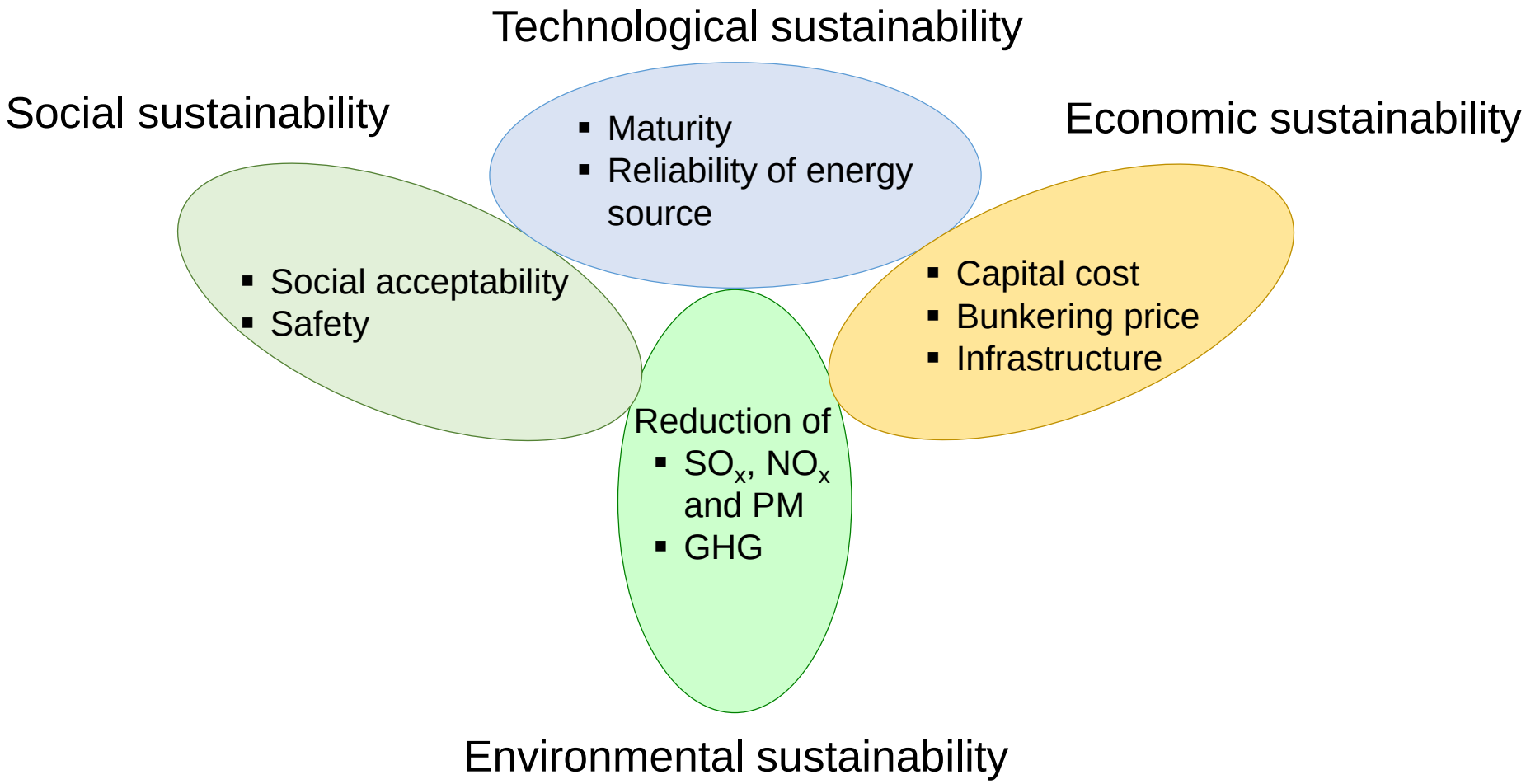
Source: NTU MESD

GHG Emission Reduction Potential Various alternative fuels



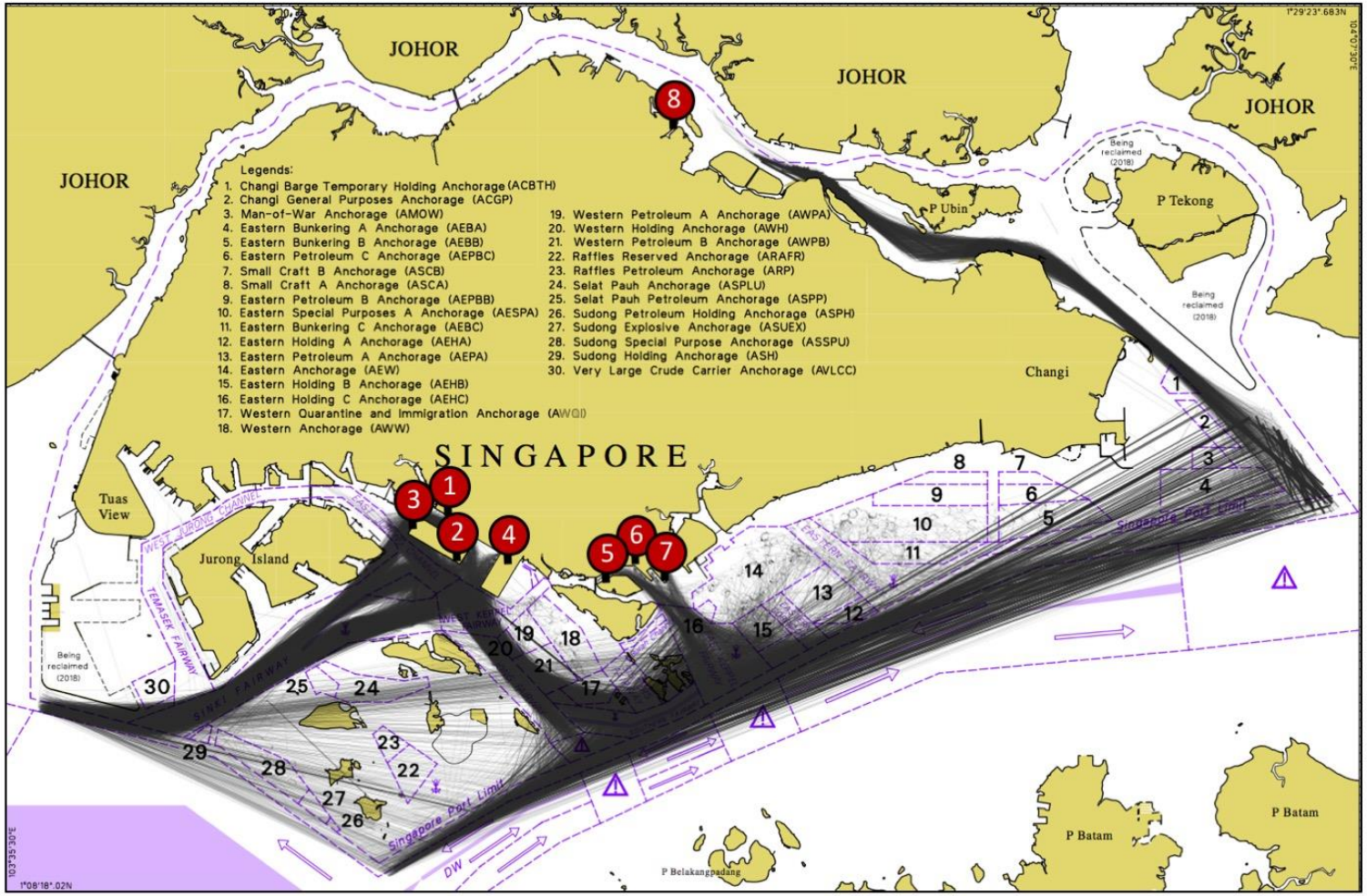
Source: NTU MESD

CRITERIA FOR SELECTION TOWARDS SUSTAINABILITIY



Carbon Emission Accounting

Container Ship Trajectories within Singapore Territorial Water



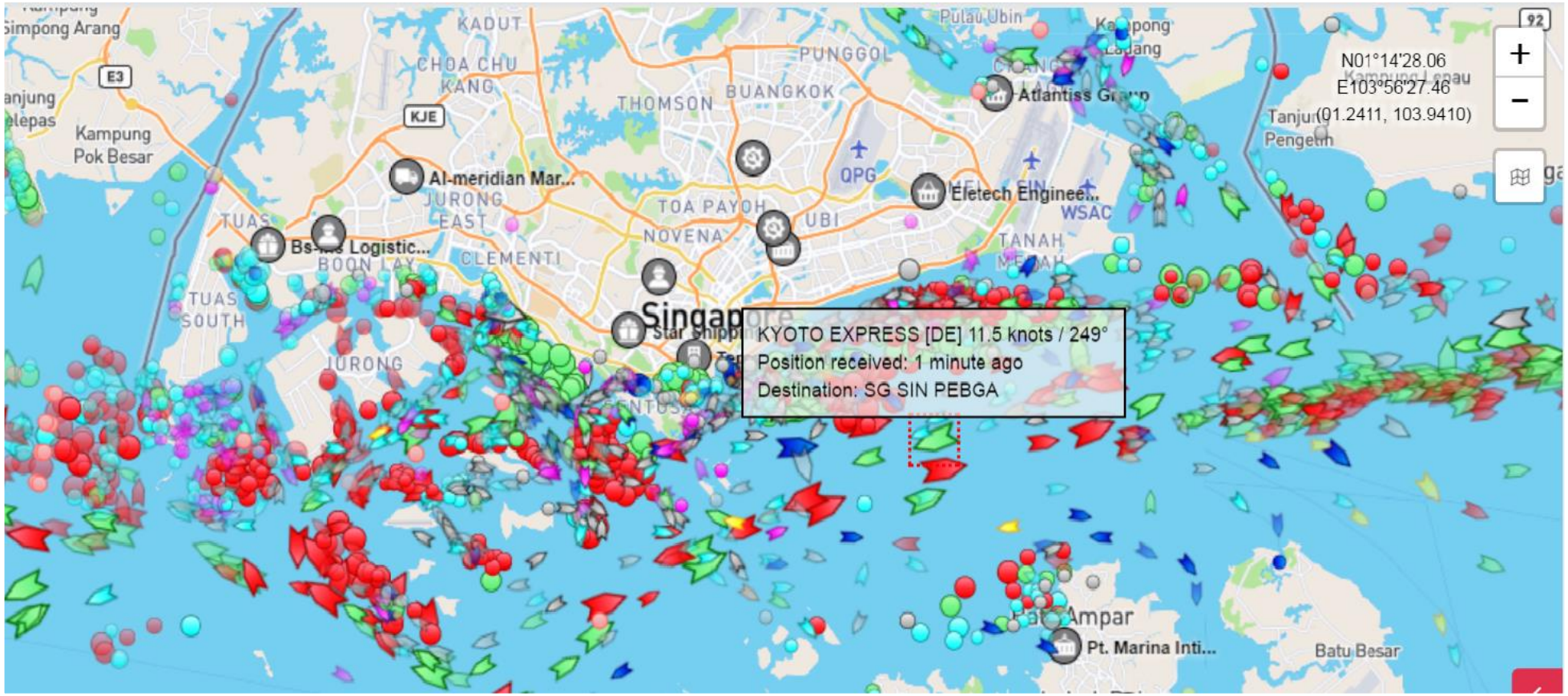
Major Shipping Routes Within Singapore Territory
(Route Plot by Emission Density)

1. Pasir Panjang Terminal 1
2. Pasir Panjang Terminal 2
3. Pasir Panjang Automobile Terminal
4. Pasir Panjang Terminal 3 & 4
5. Brani Terminal
6. Keppel Terminal
7. Tanjong Pagar Terminal
8. Sembawang Shipyard

Source: Lam

Ship emission analysis

- Estimate emissions from ships
- Develop **simulation models** of ship emissions



Source: Lam

Way forward……

- Technical & Operational Measures
- Alternative fuels from renewable sources
- Holistic analysis for sustainability
- Carbon emission accounting

Thank you

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