



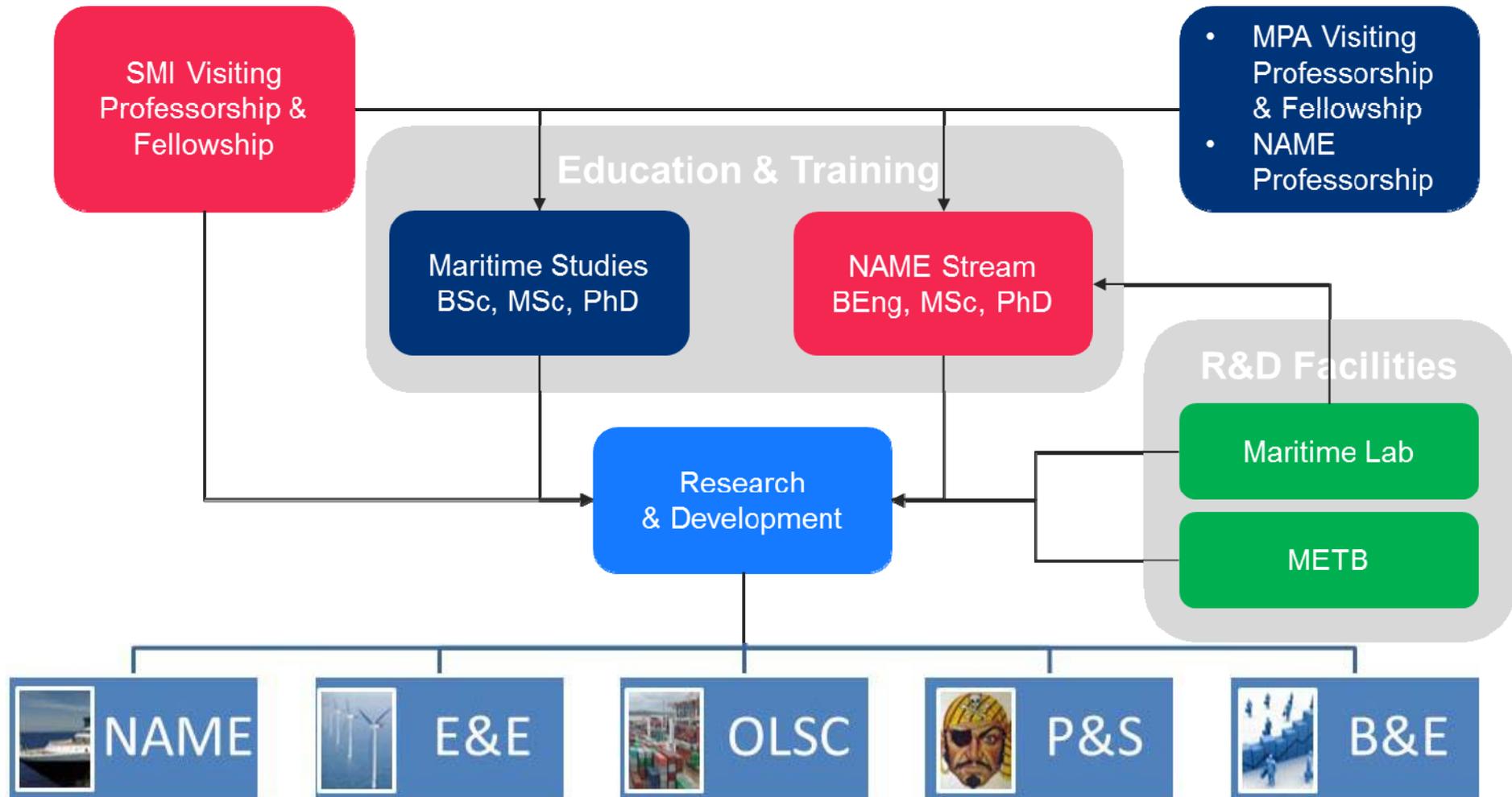
Establishment of Maritime Energy Test Bed (METB) and Future Developments

presented by

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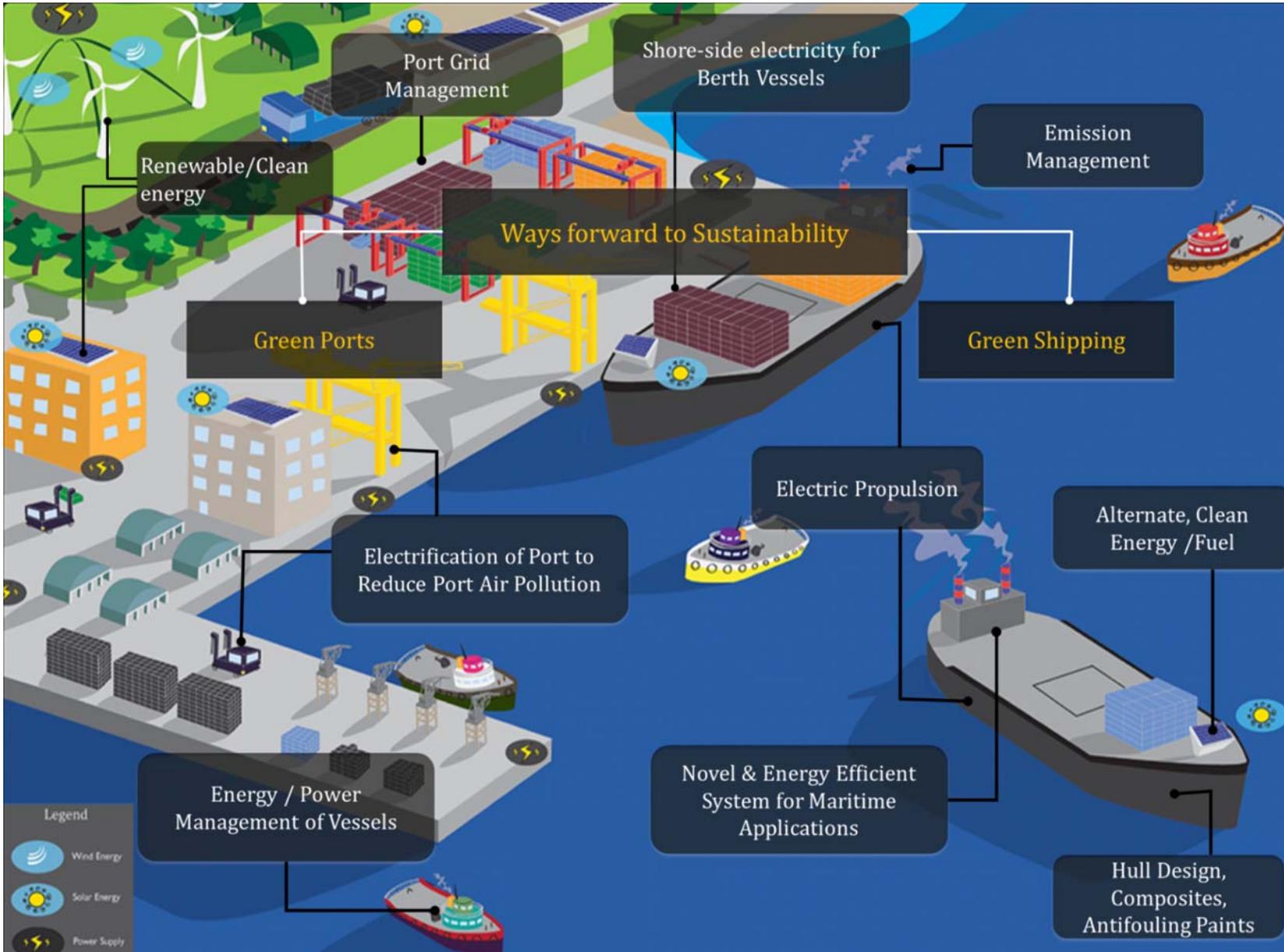
MI@NTU Research and Education



NAME: Naval Architecture and Marine Engineering
 OLSC: Maritime Operations, Logistics and Supply Chain
 B&E: Maritime Business and Economics

E&E: Maritime Energy and Environment
 P&S: Maritime Policy and Security

Maritime Energy | Study Areas



Driving Force and Significance of Innovation

Shipping Pollution

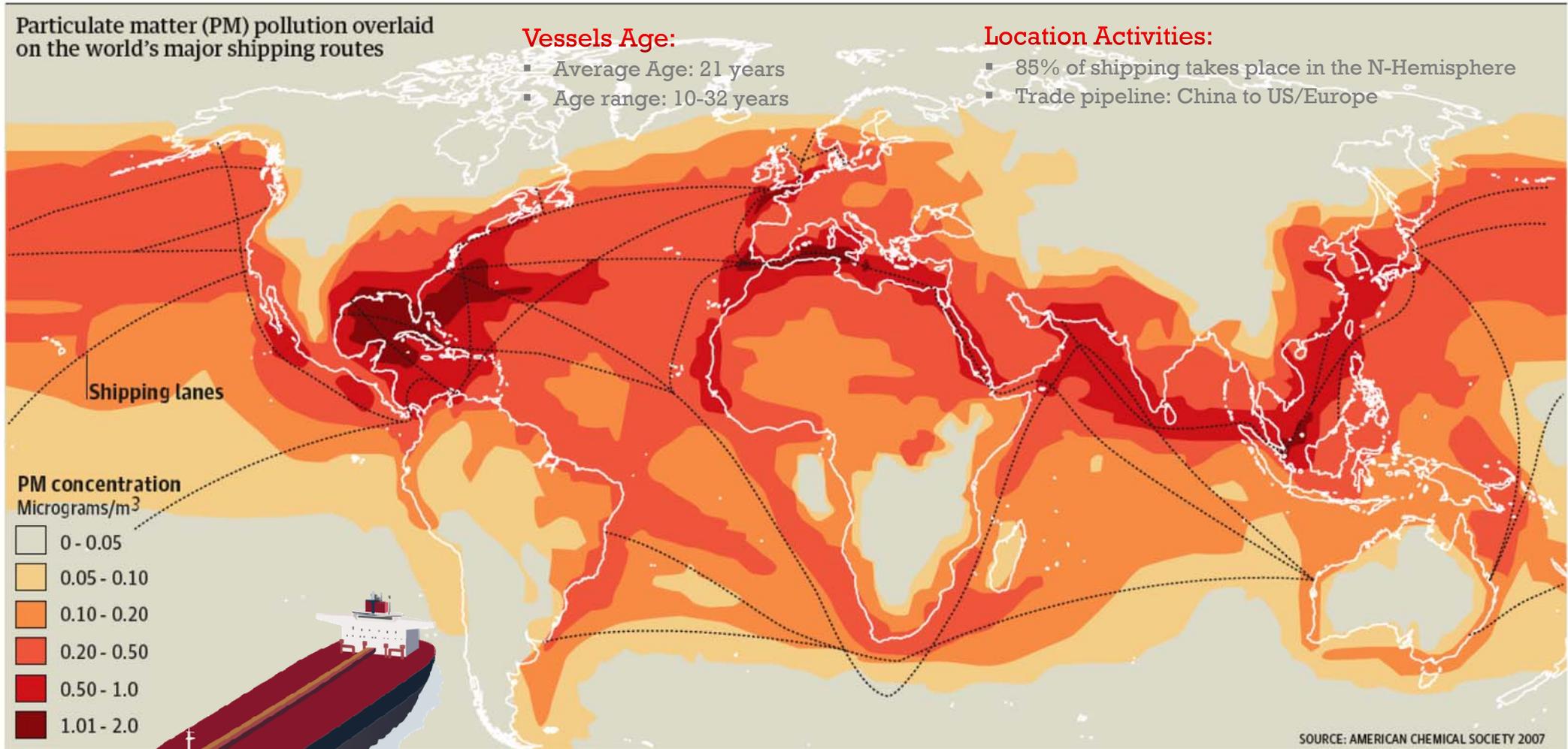
Particulate matter (PM) pollution overlaid on the world's major shipping routes

Vessels Age:

- Average Age: 21 years
- Age range: 10-32 years

Location Activities:

- 85% of shipping takes place in the N-Hemisphere
- Trade pipeline: China to US/Europe



Number of Ships:

- Total: ~ 50,000 (2010)
- Increase rate: ~ 4-5% per year

Marine shipping carries 80% of global merchandise by volume or 90% by weight

“Sustainability” – New Era for Maritime Industry

Energy security:

&

Environmental compliance:

EEDI & EEOI
CO₂ Emission

SO_x Emission
Global Cap

NO_x Emission Tier III
ECAs

Ballast Water
Management

Black Carbon Emission

Fuel Cost Fluctuation

Depletion of Liquid Fuel

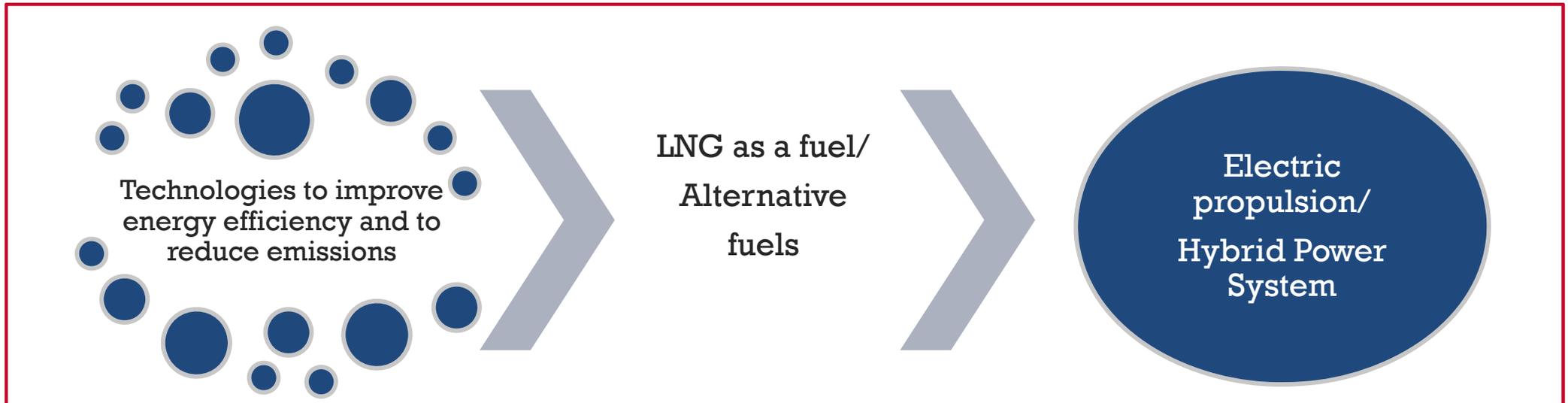
Viable Source of Energy



Source: <http://altinvesthq.com/news/is-the-shipping-container-industry-lucrative-for-private-investors/>

Transition of Technology for Ships

Green Technology for Ships



Cleaner and saver at source:

- **Exhaust Emission Control:**
Emission Control/monitoring and regulatory compliance (SOX, NOX, Particulate Matters, etc.) using novel exhaust gas cleaning systems
- **Technologies for Energy Efficiency for Marine Vessels:**
Materials and approaches for friction reduction, waste heat recovery and utilisation

Truly cleaner:

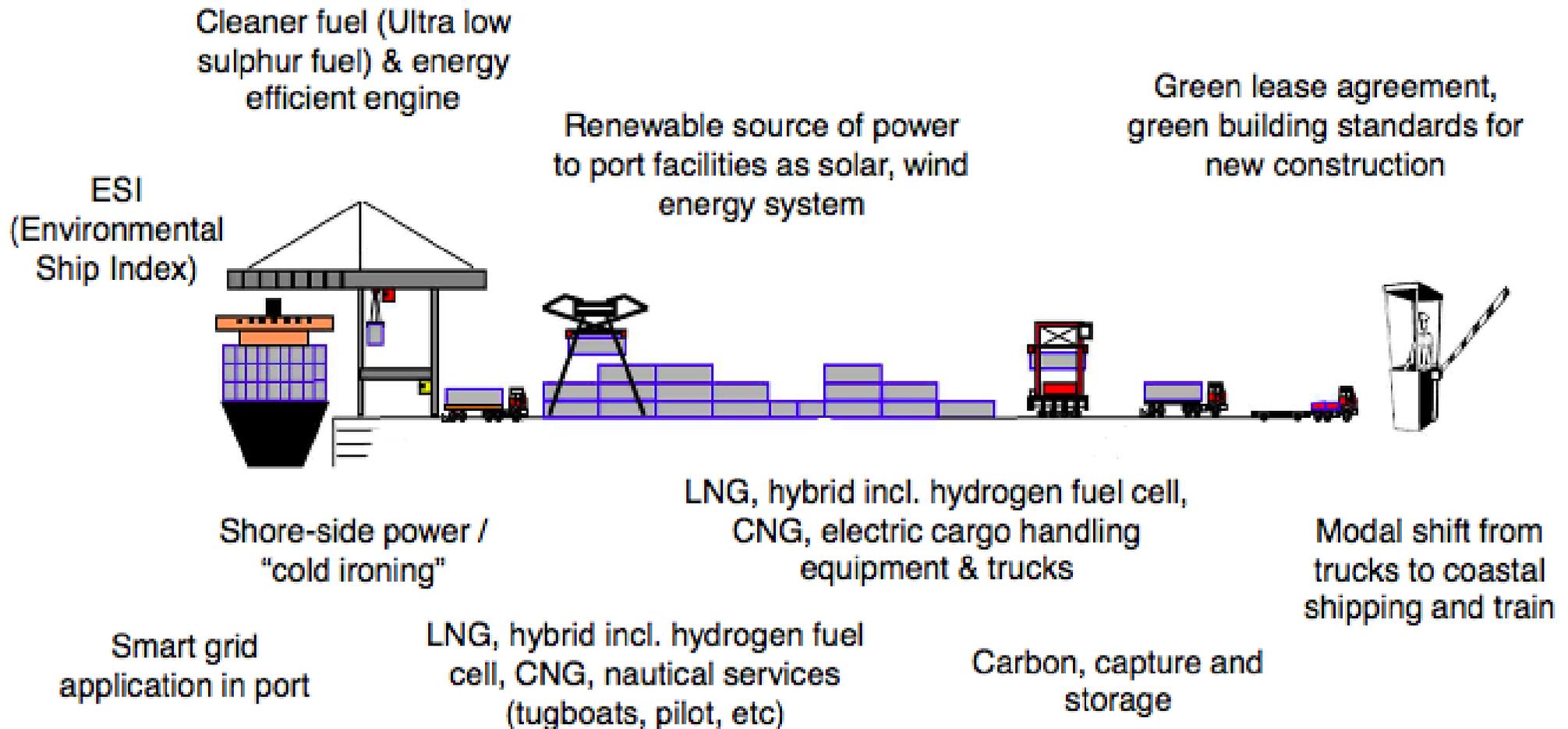
- **LNG Conversion Kit:**
For existing ships to be able to operate using LNG
- **Cold Energy Harvesting and Utilisation:**
Materials and approaches to utilise cold energy from LNG
- **Biofuel:**
Sources, production and compatibility with the current operation

Zero emission:

- **Smart Power Management for Hybrid & Full Electric Systems:**
Intelligent power management and hardware for both hybrid and full electric power generators in marine vessels
- **Energy Storage:**
Light weight and safe operation fuel cell and batteries

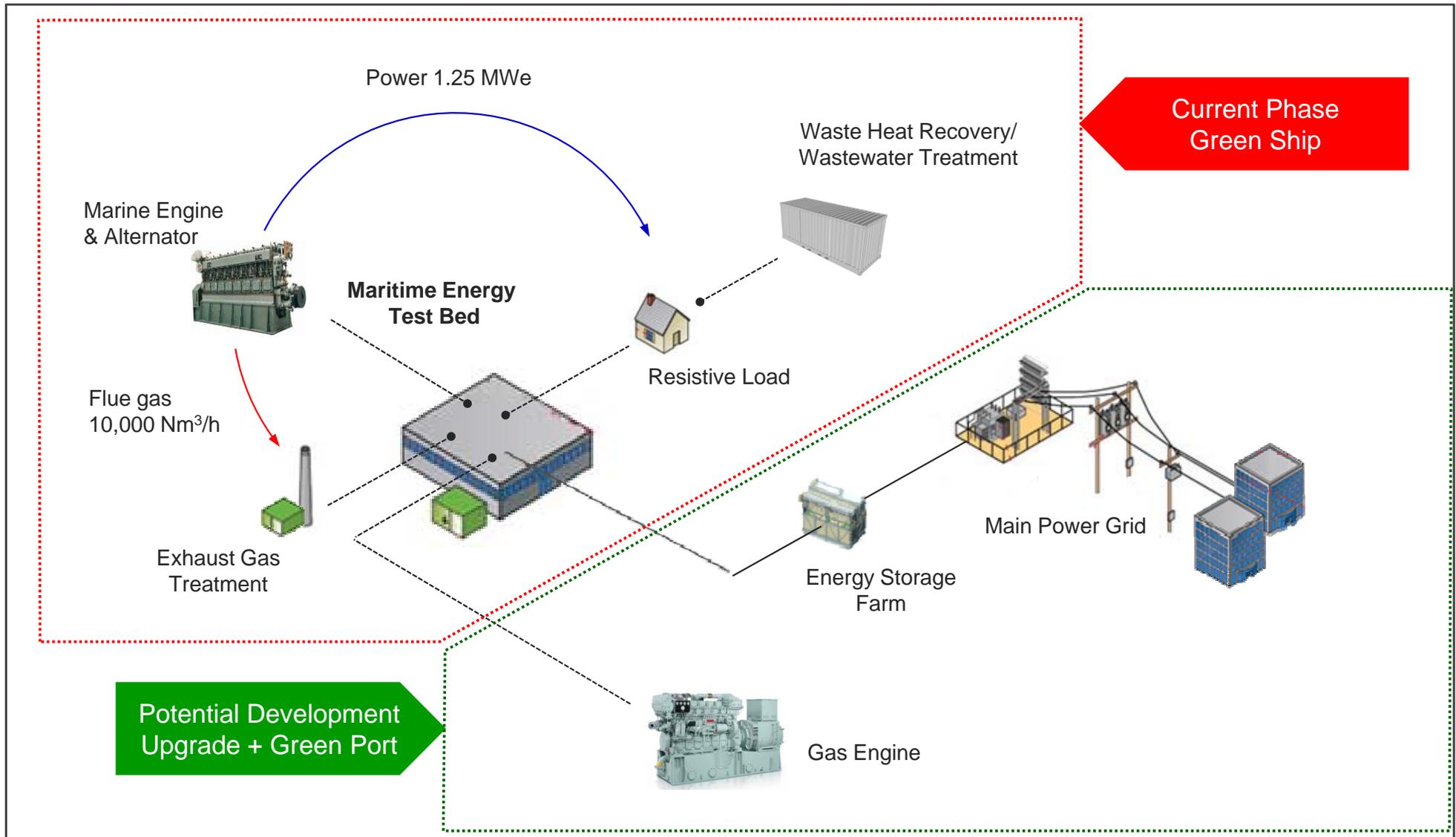
Transition of Technology for Ports

Green Initiatives at ports around the globe



Maritime Energy Test Bed | Current and Future Development

Supported by Singapore Maritime Institute (SMI) & key industry partners, METB is jointly initiated by the Maritime Institute at NTU (MI@NTU) and Energy Research Institute at NTU (ERI@N)



Why Maritime Energy Test Bed ?

Maritime **E**nergy **T**est **B**ed: provides a platform for research institutes and companies to test various green technologies that promote innovation solutions for maritime industry with translation from lab-scale to real-application scale.

Engine Specification

1.5 MW Daihatsu Engine - 4 Stroke, Tier 1, 6 cylinders , 720rpm

Fuel – HFO & Diesel

Alternator – AC 450V, 3-phase, 60Hz

Exhaust Gas – 10,300Nm³/hr

Time and Cost for Equipment Installation

Loading/ unloading &
Installation/ removal of
Equipment with Cost
Involved

Interruption to Ship Operation

Due to unforeseen
problems when testing
under real conditions

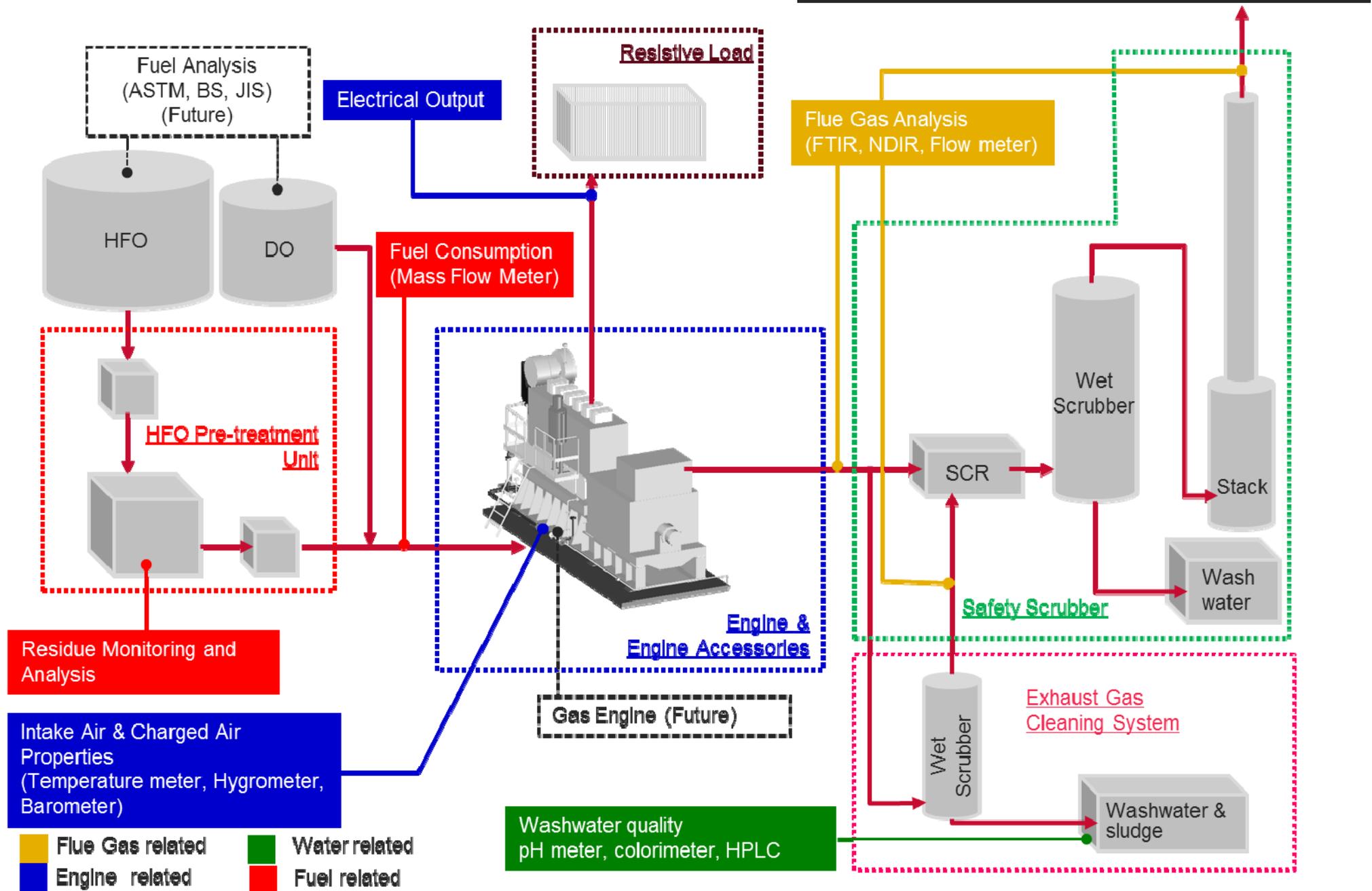
Availability of Instrumentation for Measurement and Control

Flow meter (mass and
volumetric), Gas
analyses, etc.

Accuracy & Precision of Testing and Obtained Results

Due to uncertainty from
external factors such as
weather, loads, etc. for each
tests and from tests to tests

Maritime Energy Test Bed Components (Current Phase)



Maritime Energy Test Bed Layout (Current Phase)

Testing berth



Safety scrubber



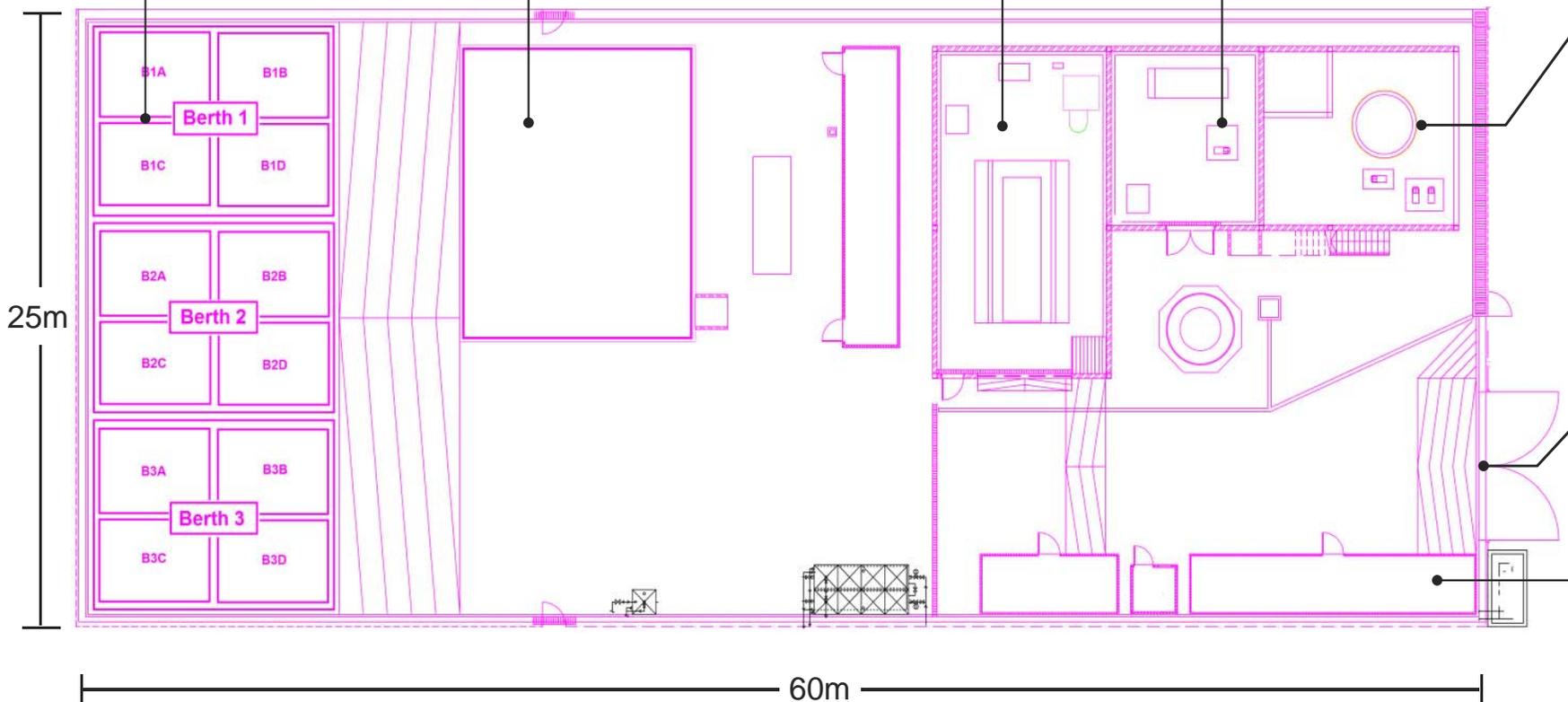
Engine room



Engine accessories



Fuel storage
(HFO and DO)



Entrance



Office

Maritime Energy Test Bed Services (Current Phase)

Providing appropriate testing conditions to overcome issues prior to onboard ship trials

Energy System Analysis

- Alt. Fuel Evaluation (Bio-Fuel)
- Fuel Oil Additive Evaluation
- Equipment Evaluation
- Waste Heat Recovery
- Assessment of Compliance
- Economic Evaluation

Emission Management and Analysis

- Scrubber Validation
- Data Acquisition
- Assessment of Compliance
- Maritime Chemical to Sludge Handling and Storage
- Scaling, Corrosion and Bio-film
- Gases Evolution
- Equipment and Instrument Motion Sensitivity Evaluation

R&D Collaboration

- Proof of Concept Study
- Detrimental Effects on Engines
- Waste Heat Recovery
- Selective Catalytic Reduction
- Maritime Electricity Storage*
- Noise Abatement*
- In-Cylinder Combustion Analysis*
- Electric Propulsion*

Knowledge Development

- SMI Fellowship
- Green Shipping Concept and Design
- Operation of Maritime Scrubber

*Future Service

Future Fuels – Gas engine for emerging fuels



R&D Area:

- Emerging fuels such as CNG/LNG+H₂
- Consistency of the fuel quality and effect to the engine and operations
- Safe storage and bunkering operation of future fuels



Bomb Calorimeter



Gas Chromatography

Manpower training with dedicated R&D facilities and industry projects

Meeting the following objectives in Manpower training and development:

- Testing and handling of green technology developed, including emission control system, equipment energy efficiency technologies & control and data analysis
- Strengthen core competencies in research around the marine engines
- Facilitate appropriate testing conditions and training for pre-installation of emission control equipment prior to onboard ship trial

Knowledge and technology transfer:

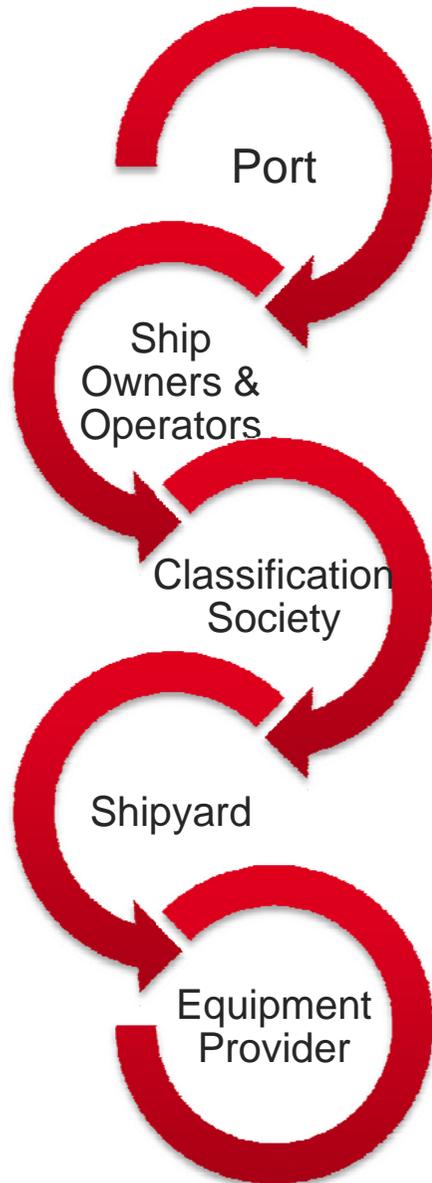
- SMI Fellowship
- Collaborative projects (Industry and Institutes of Higher Learning)

Examples:

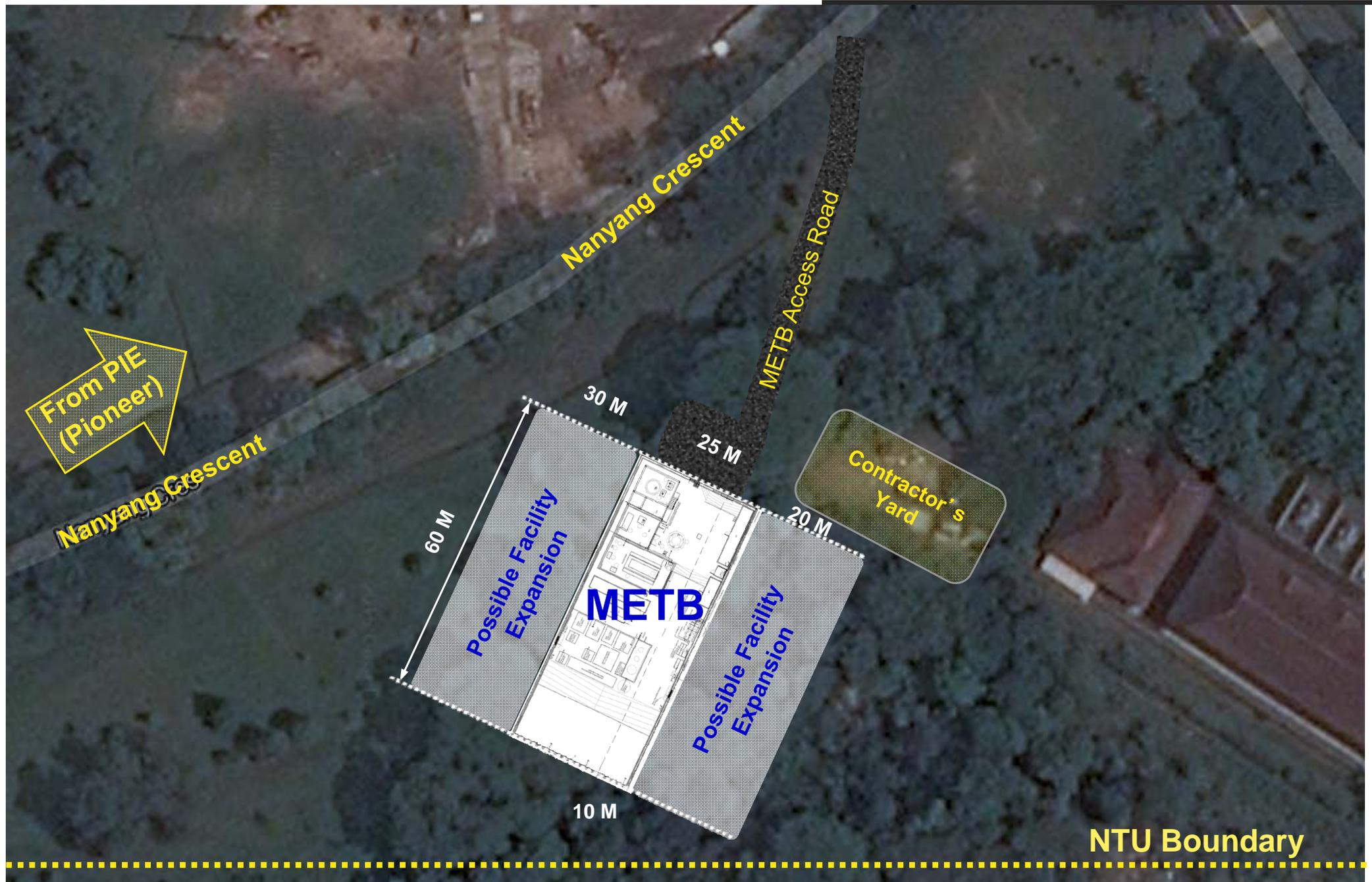
- Internship opportunities for polytechnics and undergraduate students
- Research opportunities for Masters & PhD students
- Short course, seminar or workshop by visiting experts



Manpower training with dedicated R&D facilities and JIP projects



- *Potential end-users of green technologies/ products* to be developed and/or tested (emission, heat recovery and alternative fuel) and/or potential users of the test bed
- *Keeping abreast in green technologies for ships and ports* and help technology developers to overcome foreseen issues in terms of regulations, safety and environmental protection.
- Besides being a global leader in rigs and ships retrofitting, *shipyard will be able to expand its capabilities and services to be more competitive* in attracting customers to retrofit and install systems developed, consequently benefiting our *local suppliers* of shipyards.
- *Potential parties for technology Commercialisation*



Availability and Contact Detail

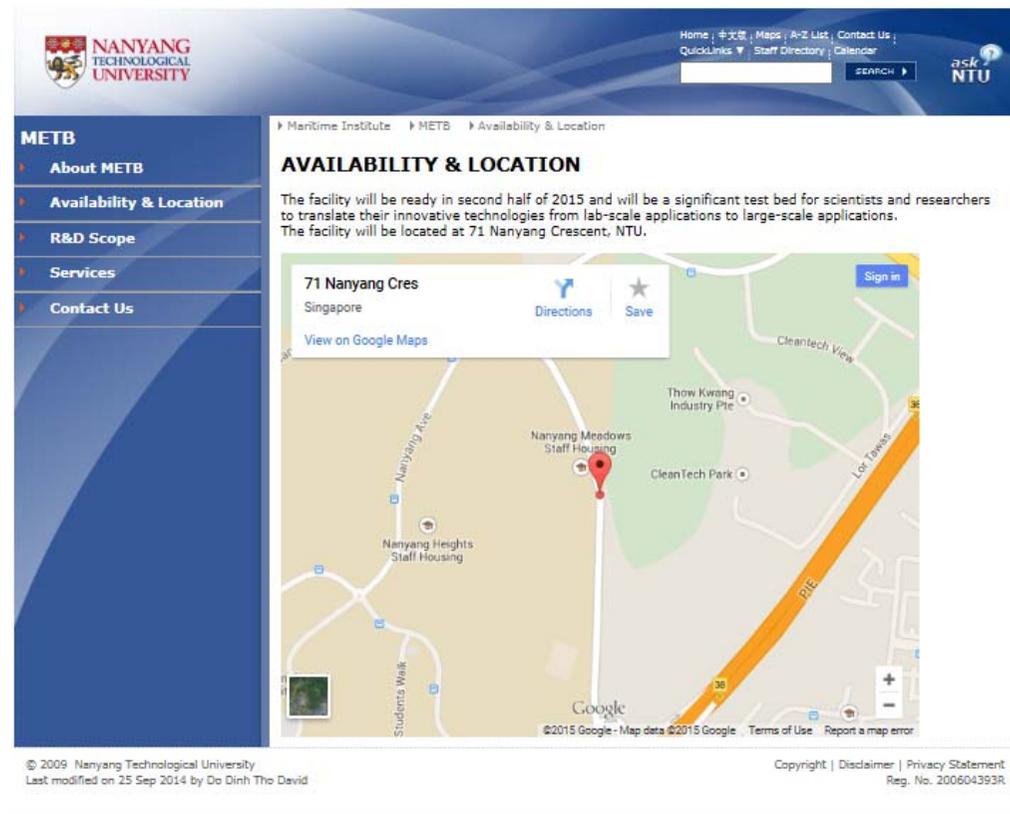
Phase 1- Ready to used

Open to all scientists and engineers from academia and industry for R&D in green & smart shipping technologies.

Website: <http://mi.ntu.edu.sg>

Email: metb@ntu.edu.sg

THANK YOU



The screenshot shows the 'AVAILABILITY & LOCATION' page for the Maritime Institute (MI) at Nanyang Technological University (NTU). The page features a navigation menu on the left with options: About METB, Availability & Location (selected), R&D Scope, Services, and Contact Us. The main content area includes a breadcrumb trail: Maritime Institute > METB > Availability & Location. Below this, the title 'AVAILABILITY & LOCATION' is followed by a text block stating: 'The facility will be ready in second half of 2015 and will be a significant test bed for scientists and researchers to translate their innovative technologies from lab-scale applications to large-scale applications. The facility will be located at 71 Nanyang Crescent, NTU.' A Google Maps embed shows the location at 71 Nanyang Cres, Singapore, with a red pin and a search box. The map includes labels for 'Nanyang Meadows Staff Housing', 'Nanyang Heights Staff Housing', 'CleanTech Park', 'Thow Kwang Industry Pte', and 'CleanTech View'. The page footer contains copyright information: '© 2009 Nanyang Technological University. Last modified on 25 Sep 2014 by Do Dinh Tho David' and 'Copyright | Disclaimer | Privacy Statement. Reg. No. 200604393R'.

Acknowledgements

Singapore Maritime Institute

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R & D PROJECT

A key supporter and collaborator of METB