



Establishment of Maritime Energy Test Bed and Collaboration with ClassNK

presented by

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OVERVIEW OF NANYANG TECHNOLOGICAL UNIVERSITY

INNOVATE
EDUCATE
NURTURE



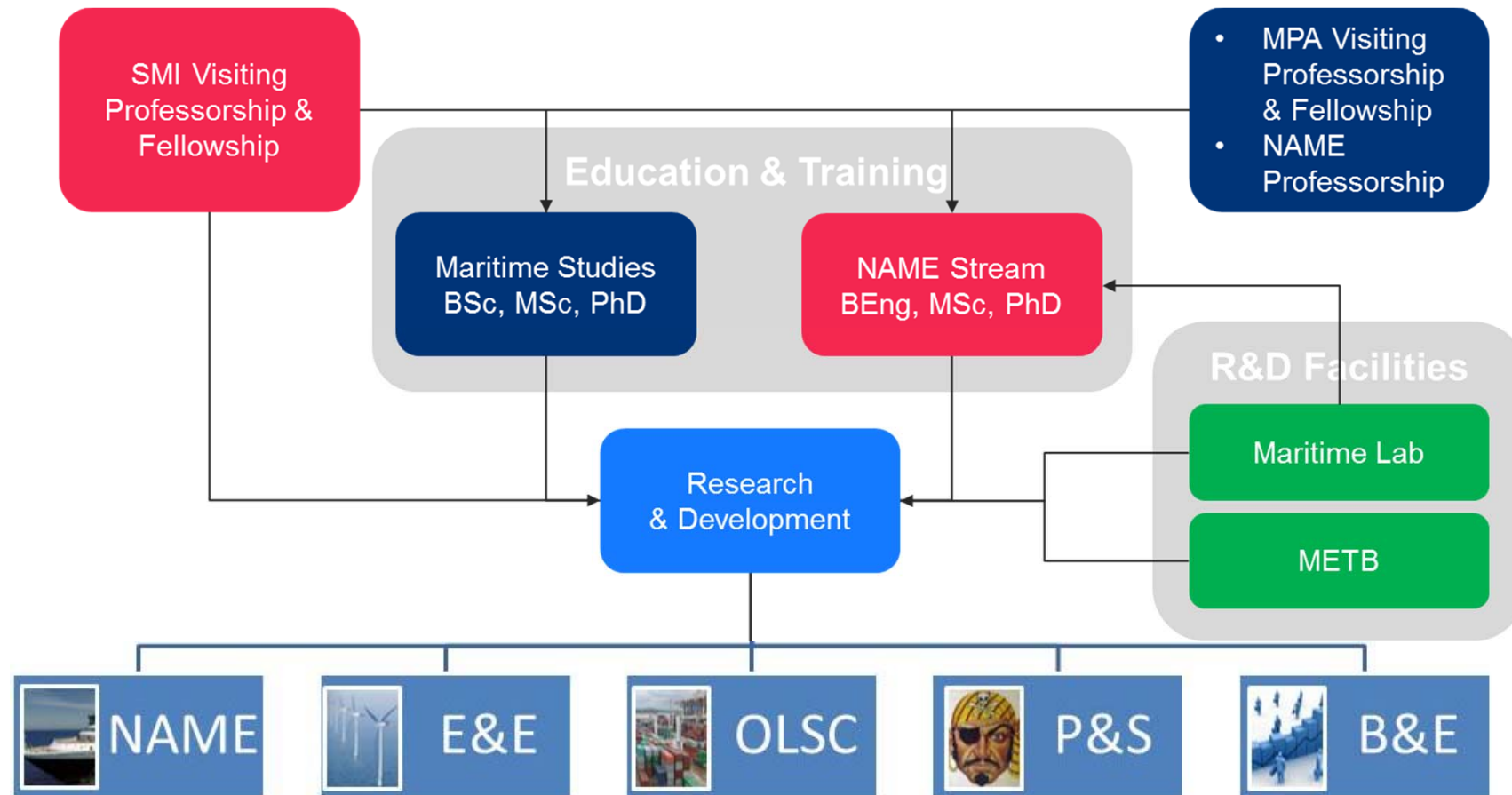
College of Engineering
College of Science
College of Humanities, Arts, and
Social Sciences
Nanyang Business School
National Institute of Education
S Rajaratnam School of
International Studies
Earth Observatory of Singapore
Singapore Centre on
Environmental Life Science
Engineering
Lee Kong Chian School of
Medicine

- Established in 1991
- Strengths in engineering, science, business, humanities, arts, social sciences, education, international studies and medicine
- Fastest-rising Asian university in the world's top 50,
- Ranked 13th in the world and 4th in Asia*
- Research-intensive (S\$502.5million in competitive research grants)
- About 23,500 undergraduates and 9,500 graduate students from 83 countries
- More than 179,800 alumni in 127 countries
- Top 15 most beautiful university in the world

*The latest Quacquarelli Symonds (QS) World University Rankings in 2015



MI@NTU RESEARCH & EDUCATION



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

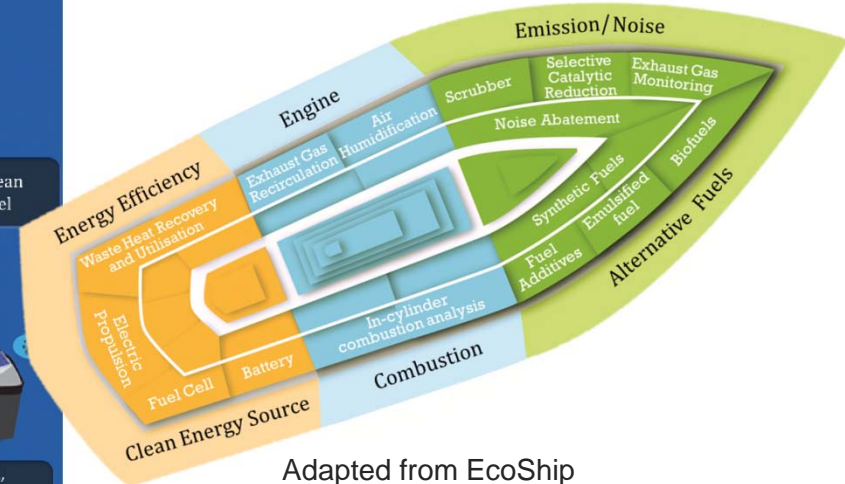
E&E: Maritime Energy and Environment
 P&S: Maritime Policy and Security

MARITIME CLEAN ENERGY RESEARCH PROGRAMME

Maritime **C**lean **E**nergy **R**esearch **P**rogramme: Research platforms to promote *green, carbon-neutral, energy management solutions*



- ❑ Leverage activities within ERI@N and focus on system level solutions in green shipping and green port domain



Adapted from EcoShip
Courtesy: Maritime Research Center, NTU

- ❑ Current portfolio of *25 projects* with industrial collaborators in maritime industry
- ❑ A mixture of TRL 2-5

ESTABLISHMENT OF MARITIME ENERGY TEST BED

Supported by Singapore Maritime Institute (SMI), **M**aritime **E**nergy **T**est **B**ed is jointly initiated by the Maritime Institute at NTU (MI@NTU) and Energy Research Institute at NTU (ERI@N).



A key supporter and user of METB through ClassNK Joint R&D for Industry Program

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



OVERVIEW OF METB

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.

Testing berth



Safety scrubber



Engine room



Engine accessories



Fuel storage



Entrance



Office

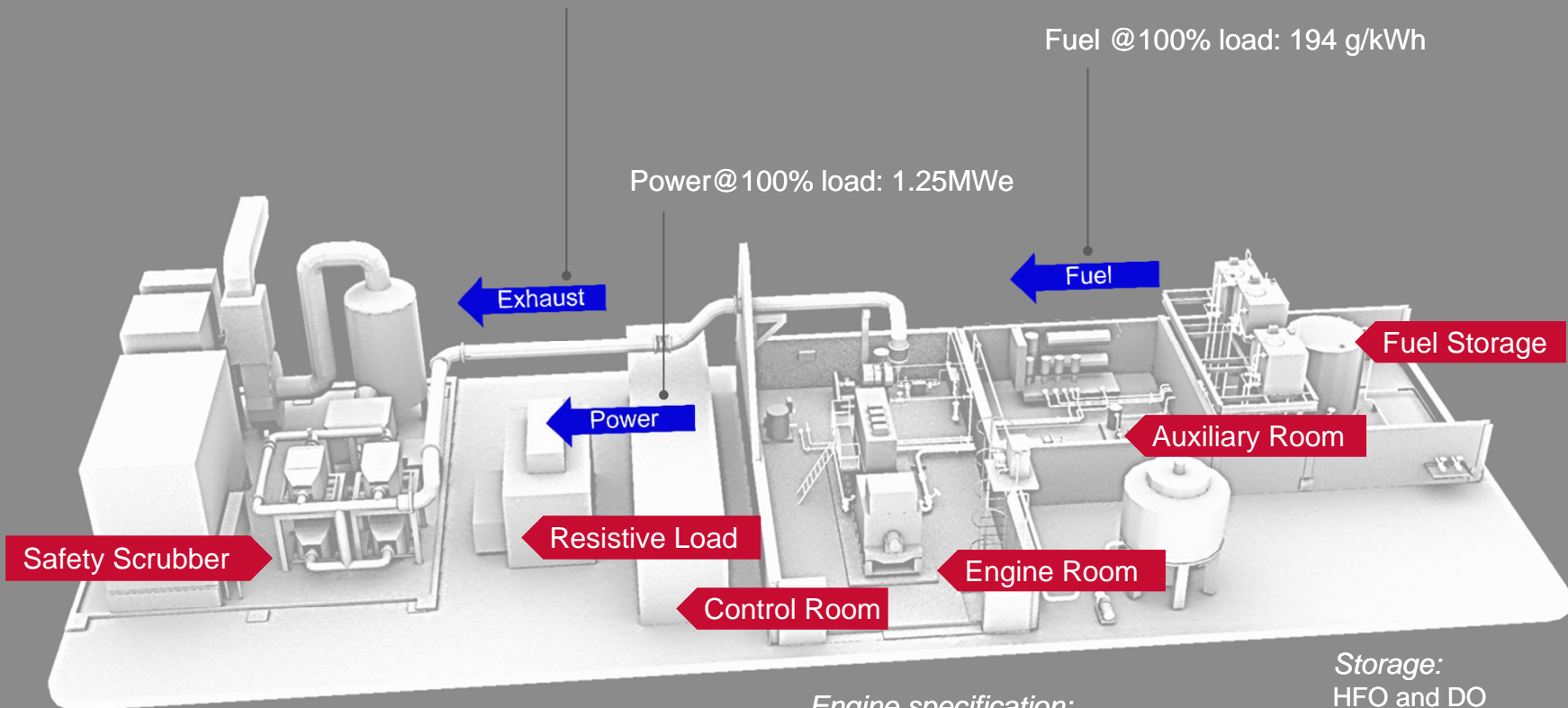


MAJOR COMPONENTS OF METB

Exhaust gas @100% load: 10,300Nm³/hr@380°C

Fuel @100% load: 194 g/kWh

Power@100% load: 1.25MWe



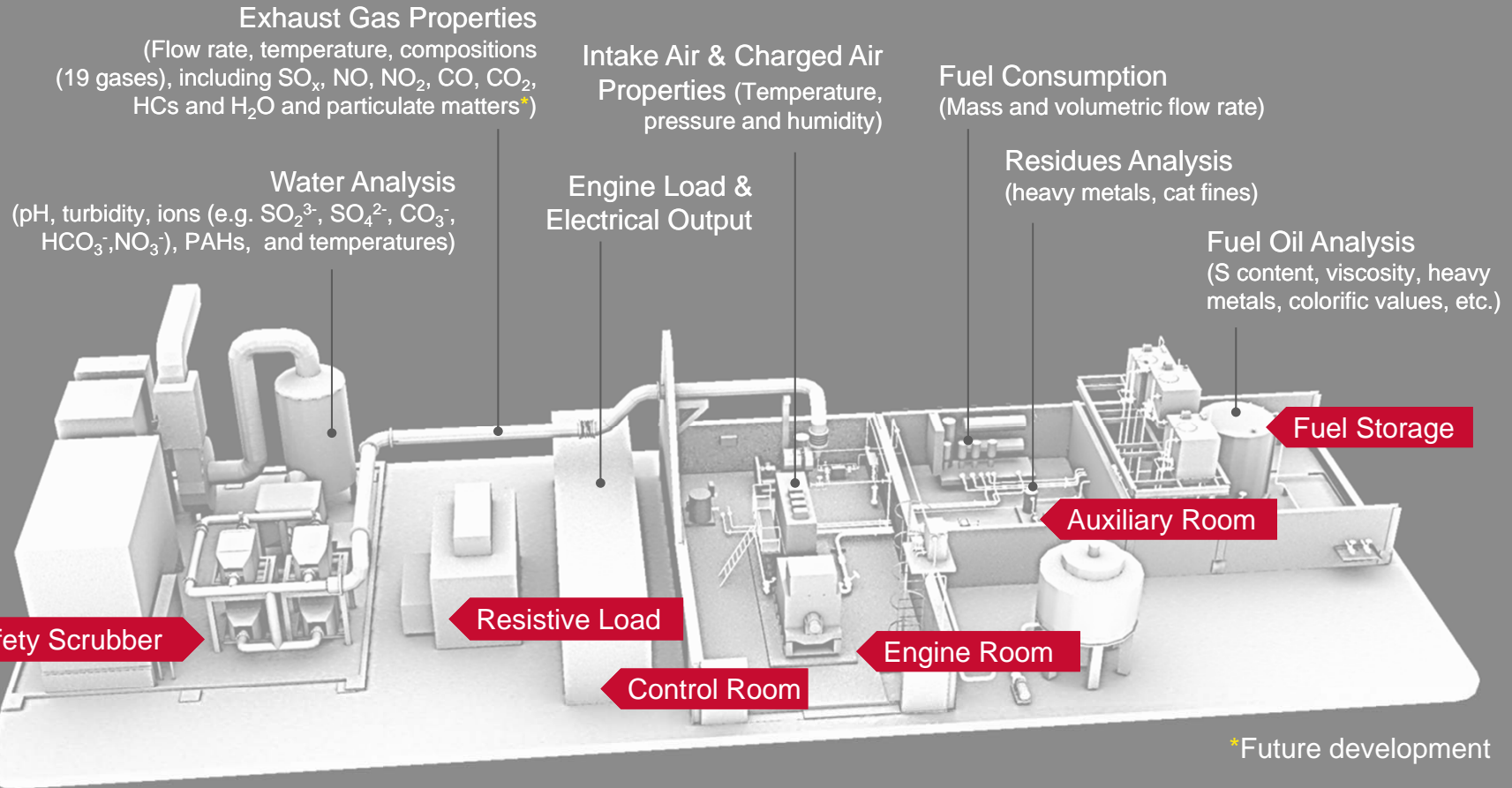
Safety scrubber specification:
 Capacity: 10,300Nm³/hr
 Selective catalytic reduction for NO_x removal
 Wet scrubber for SO_x removal
 Monitoring system

Resistive Load:
 1.5MWe,
 Stepwise adjustable

Engine specification:
 1.5MW Daihatsu Engine
 4 strokes, Tier I, 6 cylinders, 720rpm
 Fuel: HFO, Diesel, Biodiesel
 Alternator: AC 450, 3-phase, 60Hz

Storage:
 HFO and DO

DATA TO BE OBTAINED FROM METB



Sensors, meters and analytical instrument:

- *Fuel Oil*: Coriolis mass flow meter, CHNS analyser, ICP, viscosity meter, bomb calorimeter
- *Air*: Thermometer, barometer and hygrometer
- *Exhaust gas*: Flow meter, thermometer, FTIR, NDIR, transmittance measurement*, data processing for NO_x in g/kWh
- *Water*: pH & temperature meter, colorimeter, ion chromatography, HPLC, Laser sizer & zeta sizer

R&D FOCUS AREAS

Fuels

- Alternative and/or clean fuels (e.g. biofuel, emulsified fuel and synthetic diesel from biomass)



Marine Engine

- In-cylinder combustion analysis (heat release, injection delay, ignition delay, combustion duration and their relationship with specific fuel consumption and engine failure)*
- Establishment of new methodology for time resolved fuel consumption measurement based on emission data
- Exhaust gas recirculation, humidified air, etc.

Exhaust Gas

- Emission control technologies (Wet processes and catalyst)
- Real-time monitoring
- Process modelling

Electricity*

- Grid scale redox flow batteries
- Fuel cells

Fuel Additives

- Fuel additives for improved combustion efficiency and cleanliness on engine parts

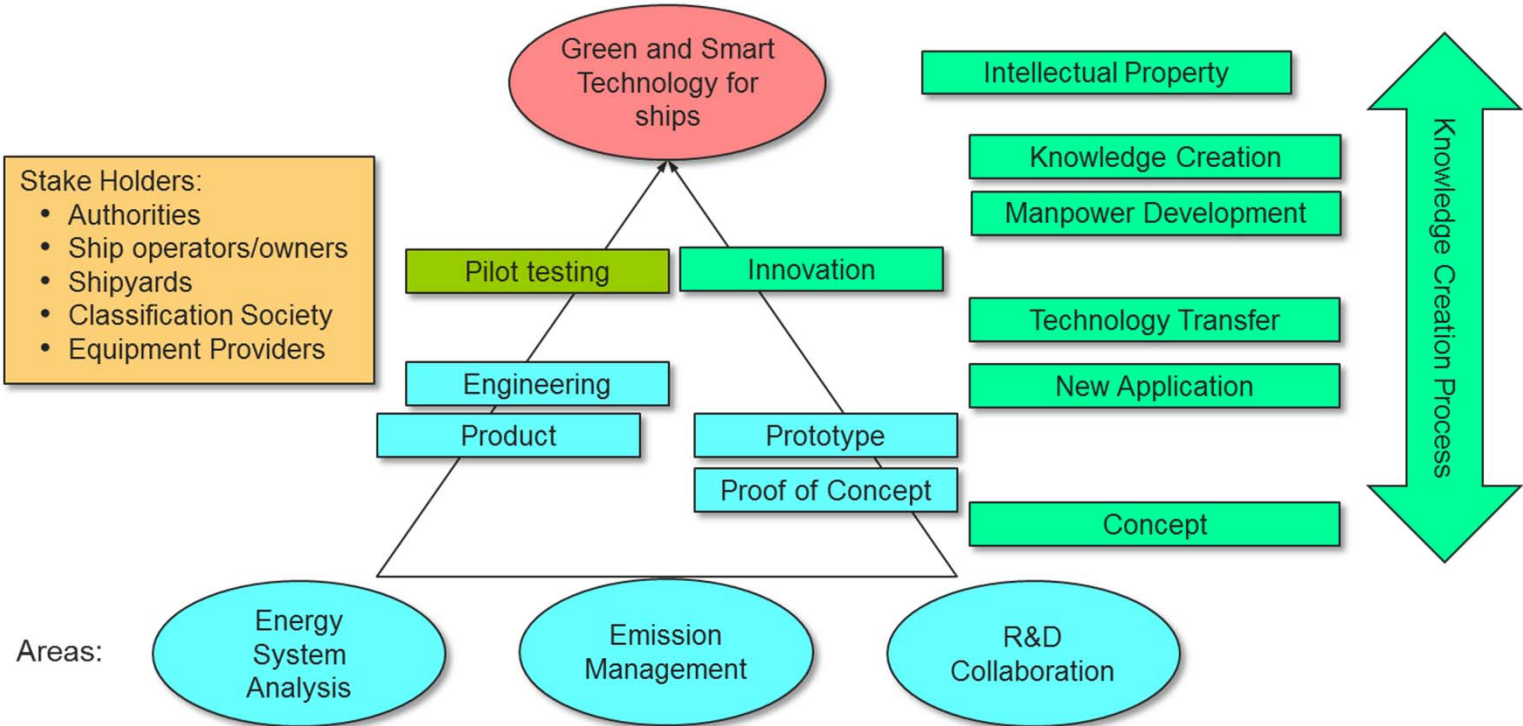
Heat

- Waste heat recovery, waste heat utilisation and energy conservation (e.g. heat to cooling, heat to electricity)

*Future development

METB CAPACILITIES AND POTENTIAL ACTIVITIES

Maritime **E**nergy **T**est **B**ed: provides appropriate testing conditions to overcome issues prior to onboard ship trials



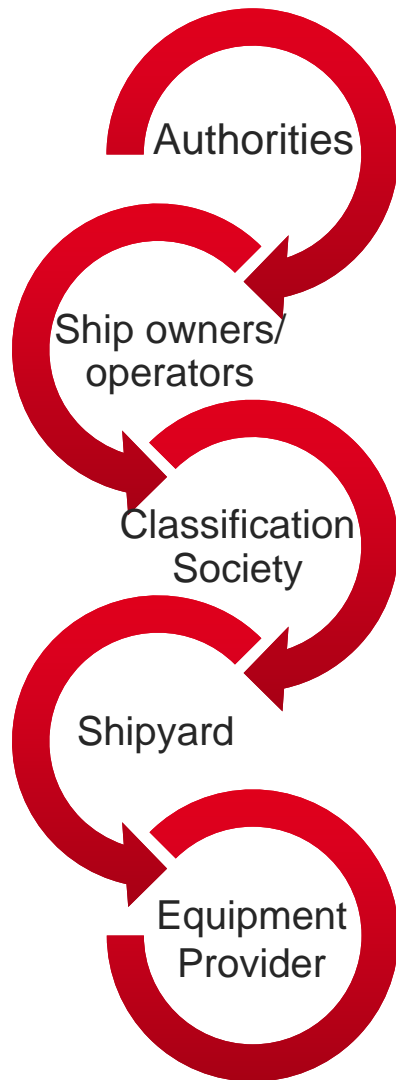
- Alternative fuel evaluation (Bio-fuel, synthetic fuel, etc.)
- Fuel oil additives evaluation
- Equipment evaluation
- Waste heat recovery
- Economic evaluation

- Scrubber validation
- Sensors, monitoring and data acquisition
- Assessment of compliance
- Chemical and sludge handling and storage
- Scaling, corrosion & bio-film and
- Gases evolution
- Motion sensitivity Evaluation*

- 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*

*Future development

BENEFITS TO VALUE CHAIN



- *Technical data* to support decision making, preparedness and readiness of infrastructure, manpower and technologies
- *Potential end-users of green & smart 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 & smart technologies* 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*

MANPOWER DEVELOPMENT

Maritime **E**nergy **T**est **B**ed: Manpower training with world-class R&D facility and projects

Manpower training and development in the following aspects:

- Testing and handling of green technology developed, including emission control system and equipment energy efficiency technology
- Understanding of concept, Ability to design & retrofit the technology developed onboard ships.

Knowledge and technology transfer:

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



Training of marine cadets training at METB

THANK YOU