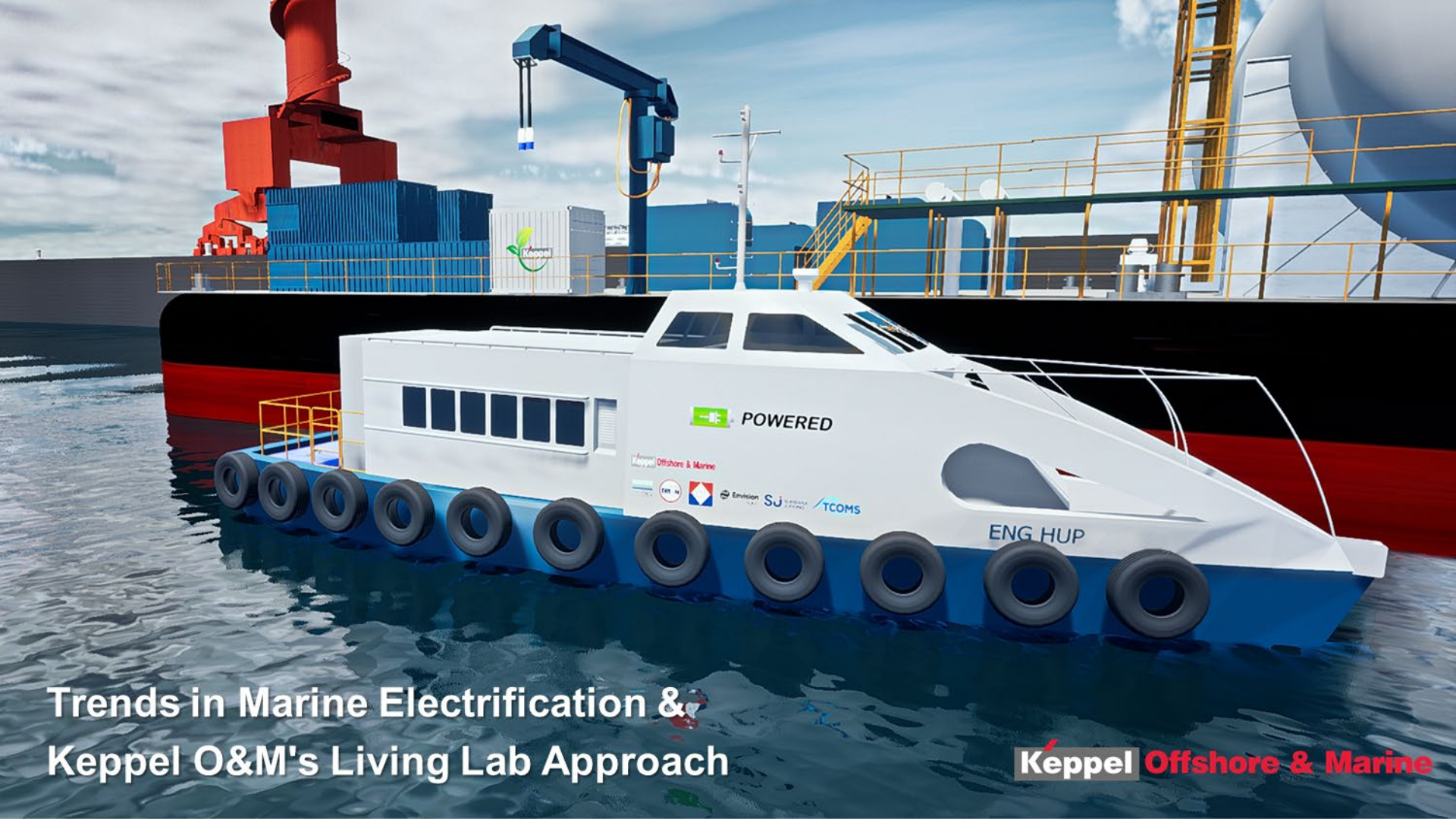


Trends in Marine Electrification & Keppel O&M's Living Lab Approach

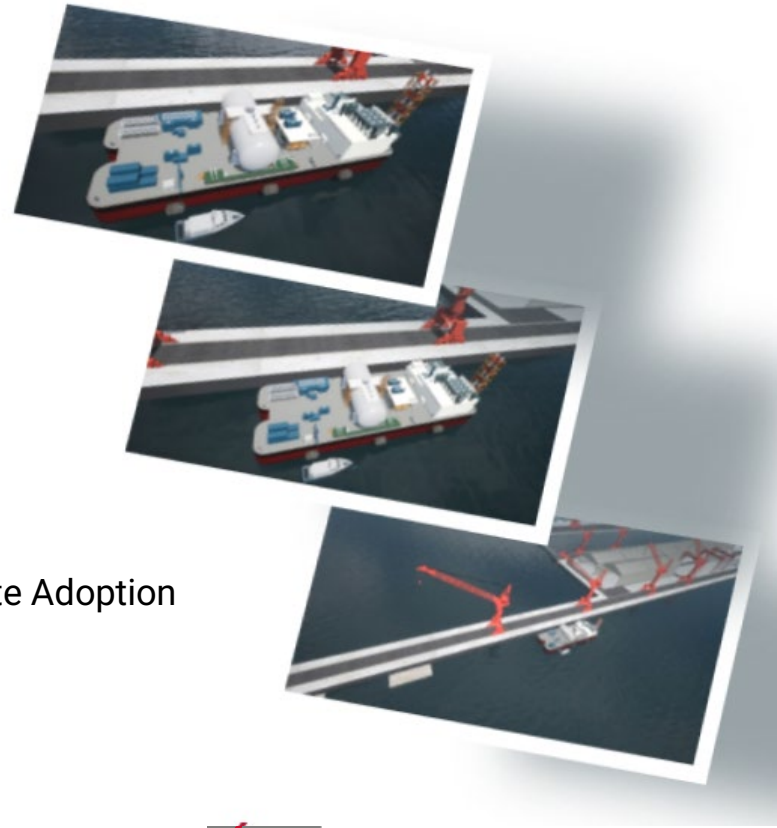
Keppel Offshore & Marine

Agenda

1. Trends in Energy Efficiency and Sustainability

2. Keppel O&M's Focus on Sustainability

3. Marine Electrification
   - Trends in Electrification
   - Keppel O&M's Case Studies
   - Leveraging Keppel O&M's Floating Living Lab to Accelerate Adoption



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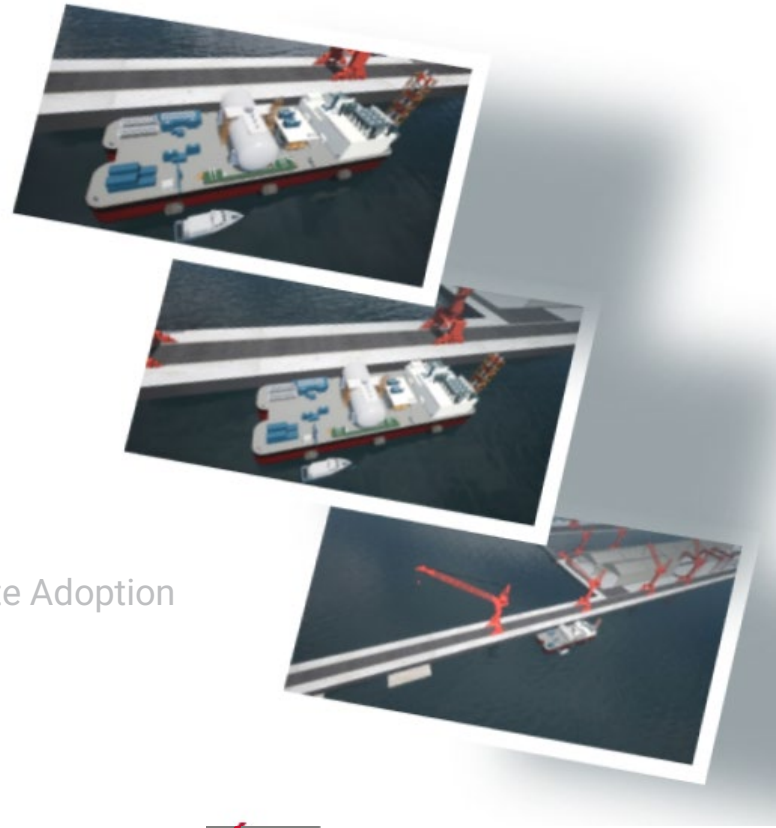
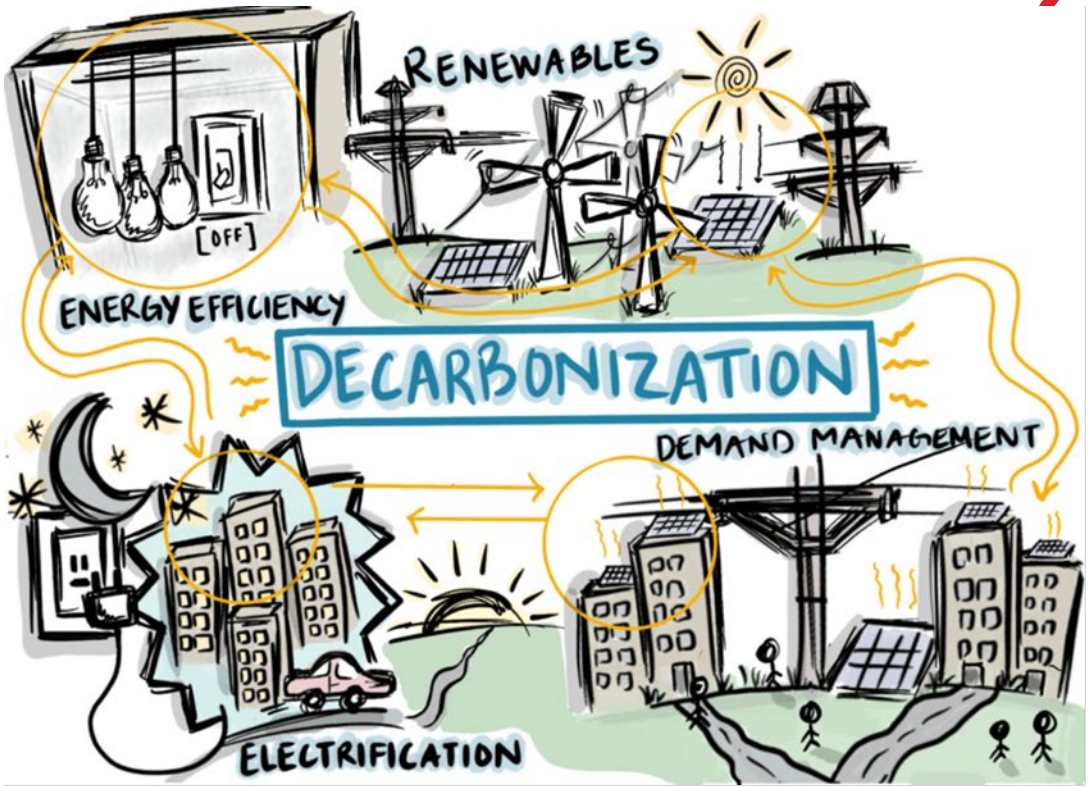


Sustainability – Energy Efficiency



Source: Rita Perez

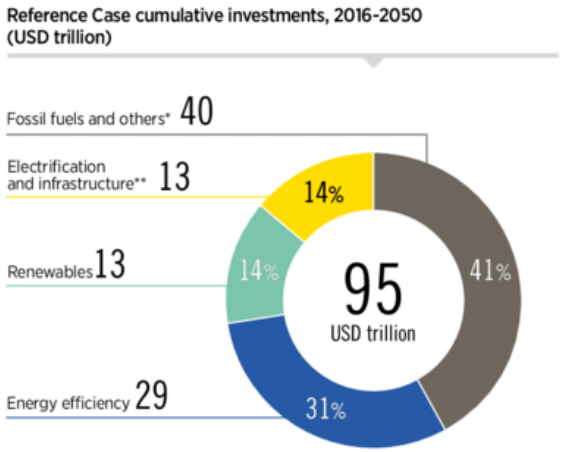
- Supply-> From 100% readily available renewable energy (intermittency challenge may be resolved by ESS)

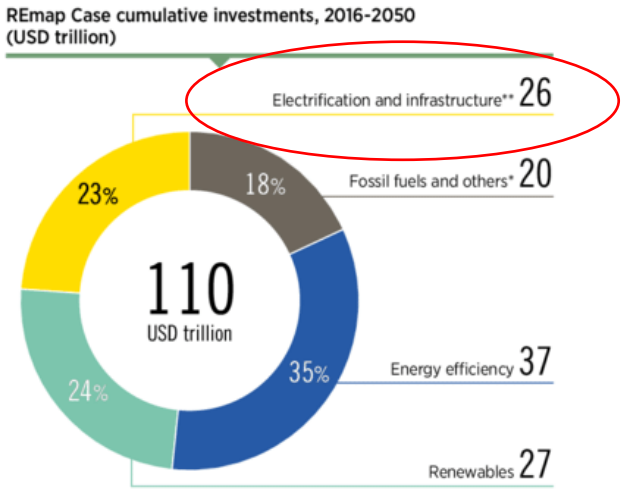
- Demand -> To smart, all-electric buildings, vehicles, ships

Global Investment & GHG Abatement

- Projected shift of investments for Remap case

Source: IRENA





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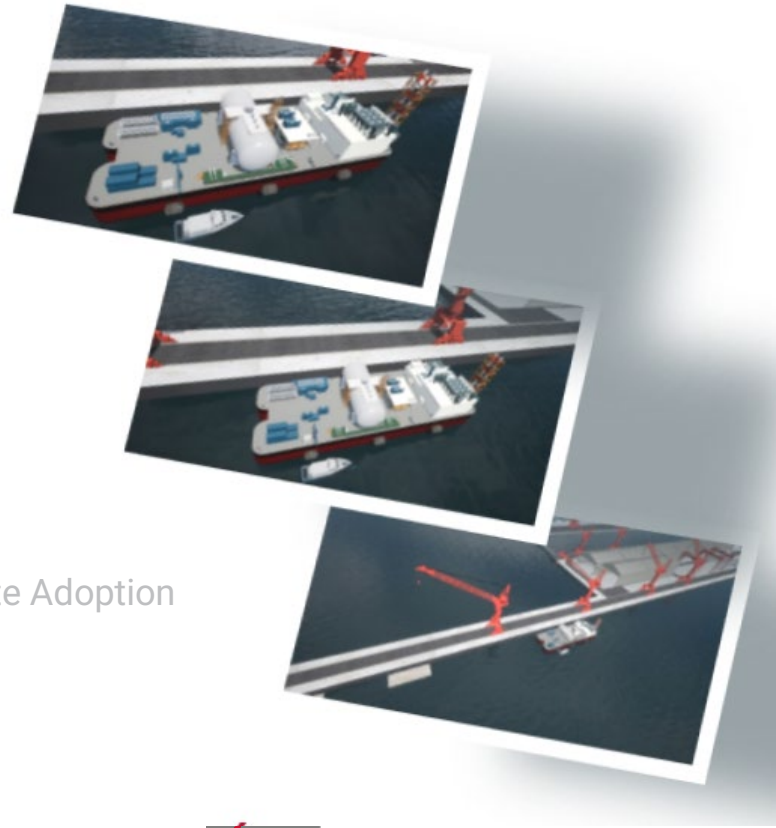


Keppel O&M's Focus on Sustainability

WTIVs

Vessels for full range of installation operations of wind turbines, foundations, jackets, tripods, monopiles, transition pieces for varying water depths

HVDC

Offshore HVDC Converter Stations

Offshore Wind Farm Substations

Alternate Current (AC) Offshore Wind Farm Substation

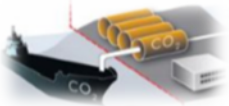
Small Scale Development

Marine Utility, Infrastructure

- Cable Laying Vessels
- DF Dredger
- DF, Hybrid Tugs

Electrification

CCUS



Keppel O&M's Focus on Sustainability

Harvest
Photovoltaics & Diesel Displacement
2017 - 2018

Harnessing PV Energy

Static Frequency Converter for Diesel Displacement

Digitalize
Energy Analytic
2019 - 2020

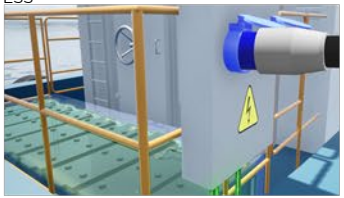
Smart Energy Analytic

Consumption Demography

Electrify
Energy Storage & Charging
2021 & beyond

Plant Based Stacked ESS

DER/Smart Micro Grid Marinised ESS



e-Vessel Charging Infrastructure

8,000+ MWh
Clean Energy Generated Annually

6,000+ t CO_2
Carbon Reduction Achieved Annually
*Since 2018

12%
Savings In Electricity Costs

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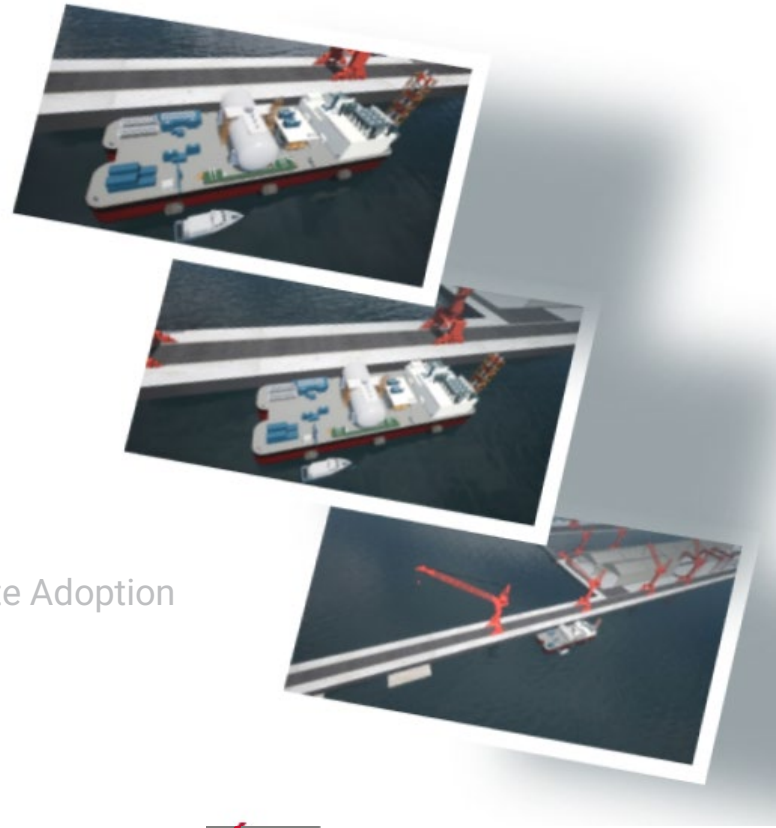
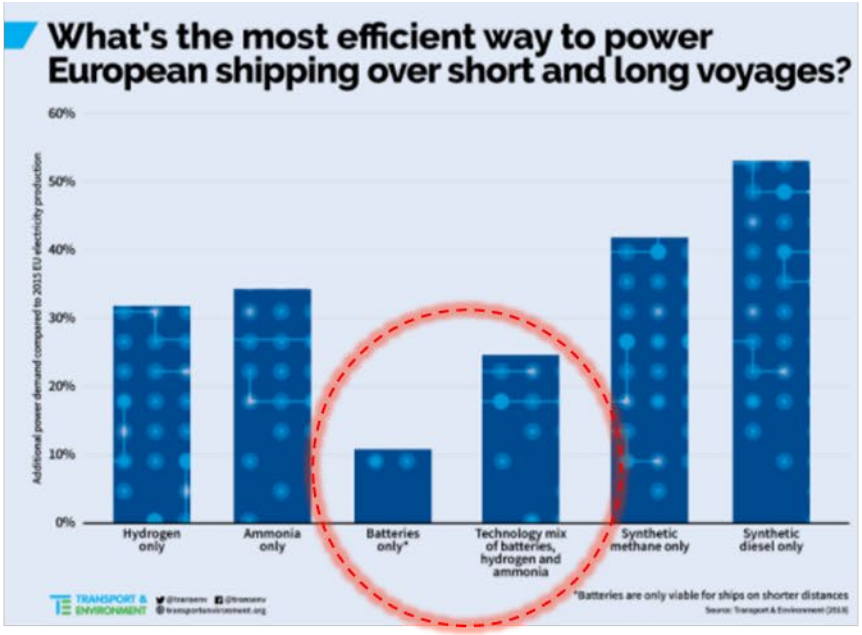
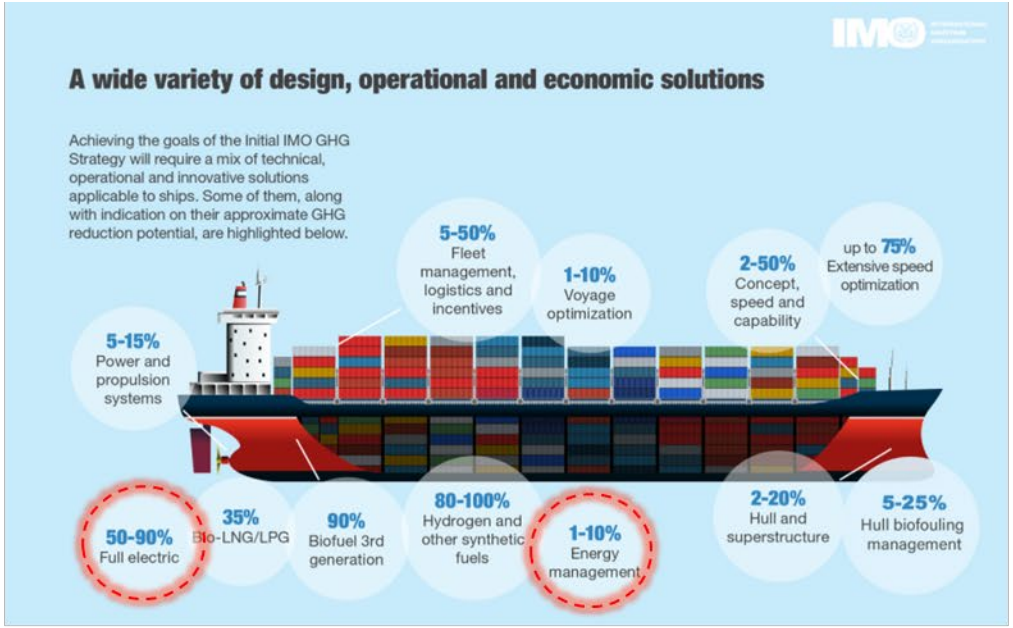


Trends in Electrification



Source: Transportenvironment.org



Source: https://www.imo.org/en/MediaCentre/HotTopics/Pages/Cutting-GHG-emissions.aspx

- Higher energy efficiency factor of electrification (less additional power demand) vs other means

- Full Electric & Energy management as part of the GHG reduction strategy

Trends in Electrification

Potential of GHG Emissions Reductions VS Commercialisation of Energy Storage System

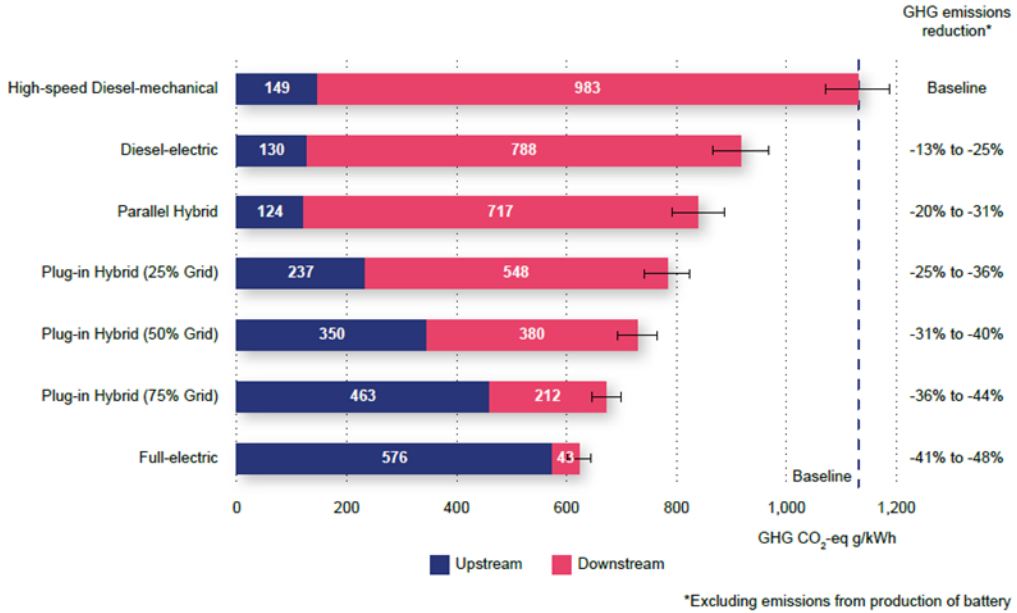
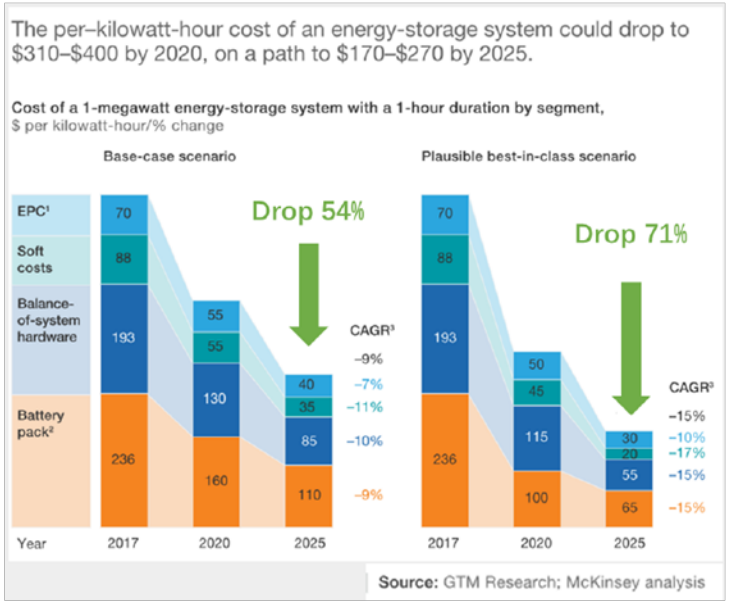


Figure 1.2 GHG emissions reduction potentials for different power configurations with a high-speed diesel-mechanical configuration as the baseline

Source: MESD Report-Electrification of Singapore Harbour Craft-Shore and Vessel Power System Considerations (Page 10)



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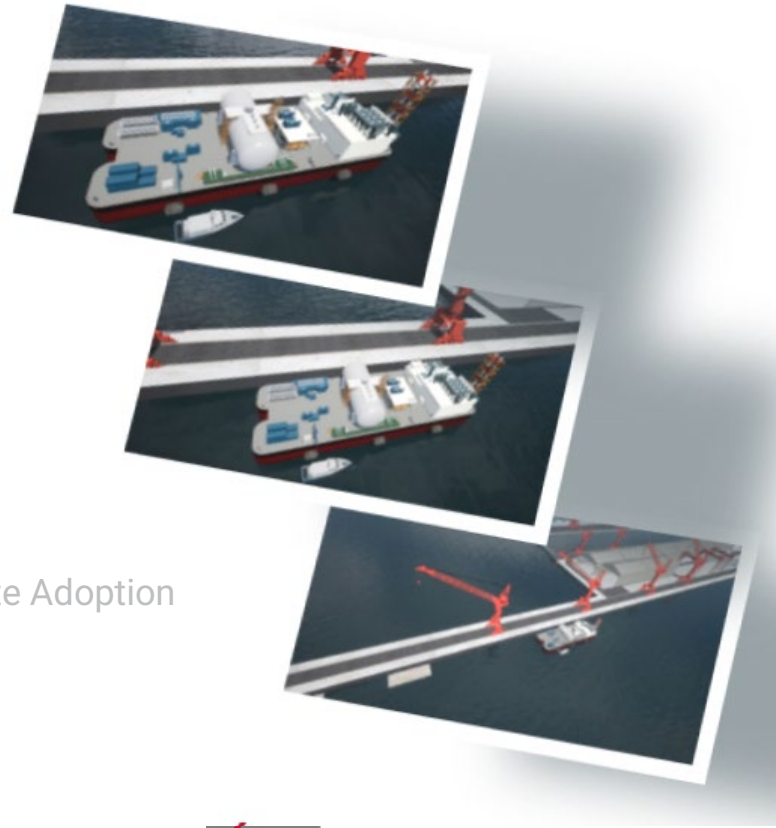
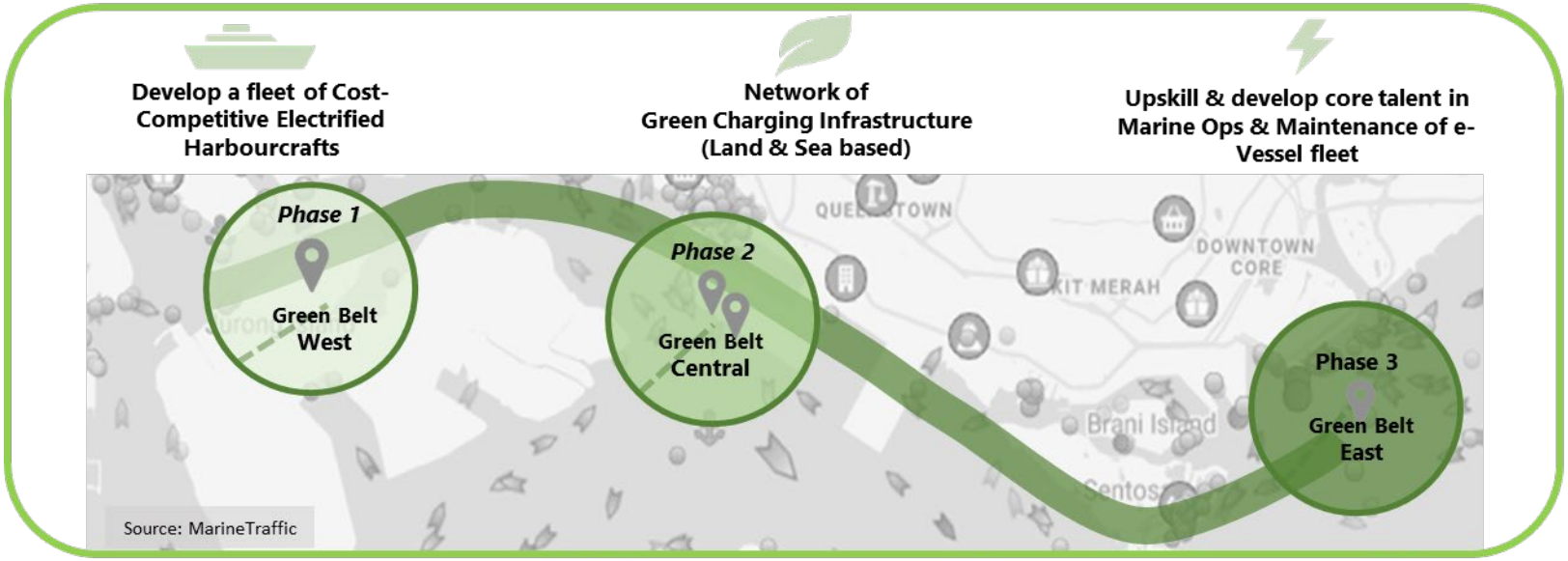


Case Study #1: Developing SG Based Comprehensive e-Vessel Supply Chain

SG-centric consortium aspiration & vision to drive e-vessel adoption



Case Study #1: Collaboration – Leading a Coalition with Wide Range of Expertise

Consortium Lead

Keppel Offshore & Marine

A world leader in providing total solutions to the offshore, marine and energy industries

RI/IHL

NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE | Energy Research Institute @ NTU

- Industrial centric energy research institute

TCOMS

- Co-create innovative concepts and solutions to address to real world challenges (Naval architectural expertise)

Industry Partners

DNV·GL

- Leading marine class society involved in a range of fully electric or hybrid vessel projects

ENG HUP SHIPPING

- Singapore-based leading harbour craft operator with fleet size of 70

Envision

- World leading tier 1 battery manufacturer

SJ SURBANA JURONG

- Leading land centric infrastructure & civil consulting expertise

Case Study #1: Key Highlights

Compact Scalable Shore Charging

- Low footprint, ease of scaling up & enhanced performance
- Certified marine & land based deployment
- Charging Infrastructure Standardisation

Electric Craft Shipboard Kit

- Fit for purpose modularise marinised ESS
- Smart IOT based Support feature operation & maintenance
- Marinised Energy Management System (MEMS)

Interoperability

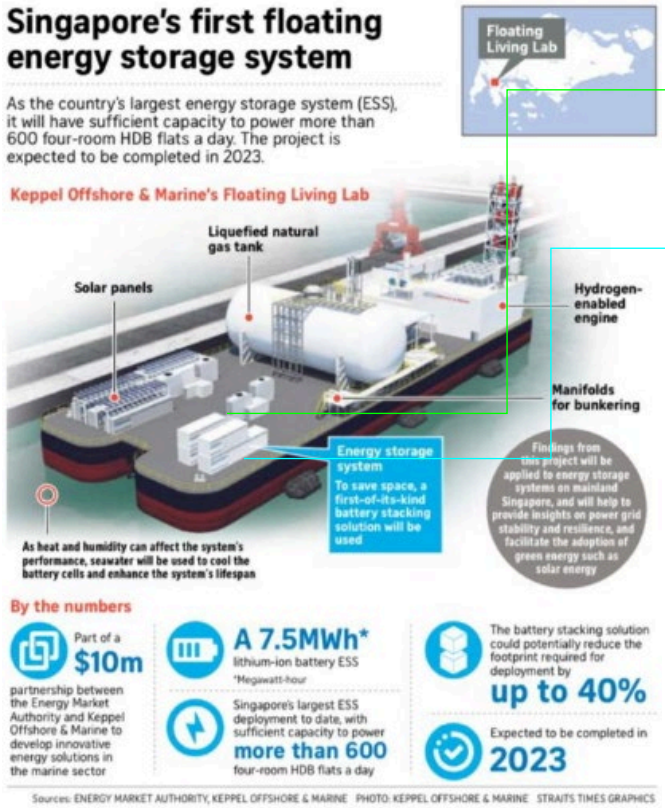
- Develop standards for unification of connection

Business Case Scale Up

- Seek business case that would enable replicability and scale-up of the end-to-end of EV value chain

Case Study #2: Pilot Development for Marinized Energy Storage

A Joint Grant Call between Energy Market Authority & Keppel Offshore & Marine



Developing

MARINIZED ENERGY STORAGE SYSTEMS (ESS) solutions with compact footprints, high capacity & charge cycle operations coupled with

IIOT PLATFORM capable of machine learning for efficient & sustainable lifecycle management

Low footprint

Enhanced lifecycle & density

Stackable containerize

Edged Enabled Smart EMS

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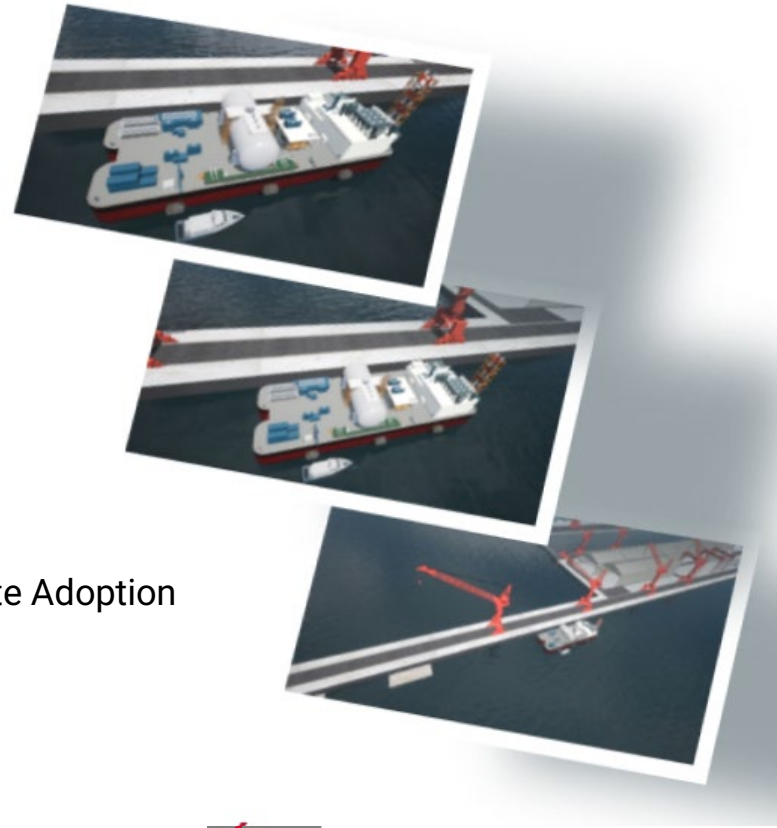


Living Lab Approach to Accelerate Adoptions

Floating Living Lab
Infrastructure

Specific problem-solving
Mission

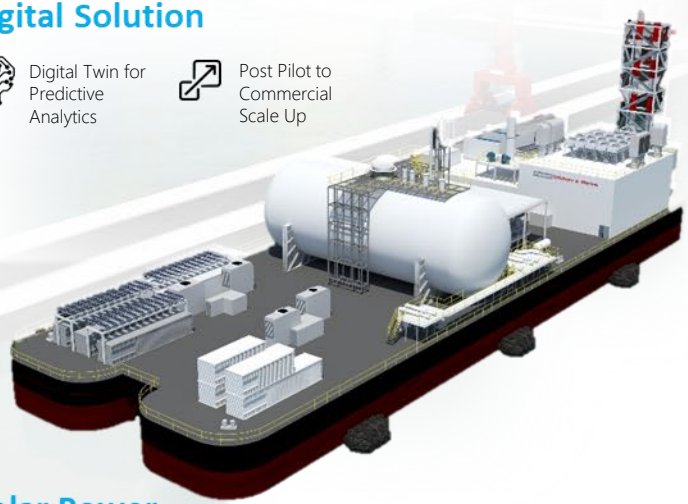
Wide based expertise
Collaborator

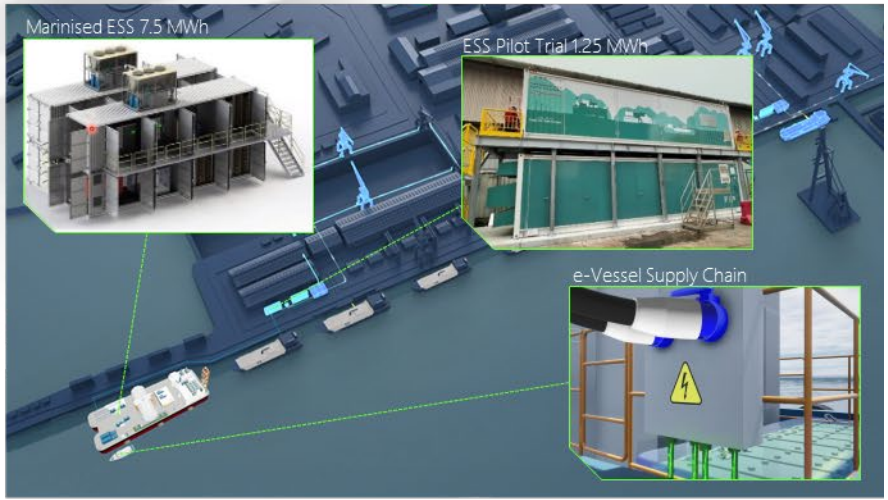
Scalable pilot project
Pilot

Digital Solution

Digital Twin for Predictive Analytics

Post Pilot to Commercial Scale Up





Solar Power

8.8 MWp with 21,000 Solar Panels

3,200 REC Received Since Inception

Electrification

ESS Pilot Trial 1.25 MWh (ACCESS Program)

Marinised ESS 7.5 MWh Dev (Joint Grant Call)

Envision

Extension to Harbour Craft Electrification

Thank You