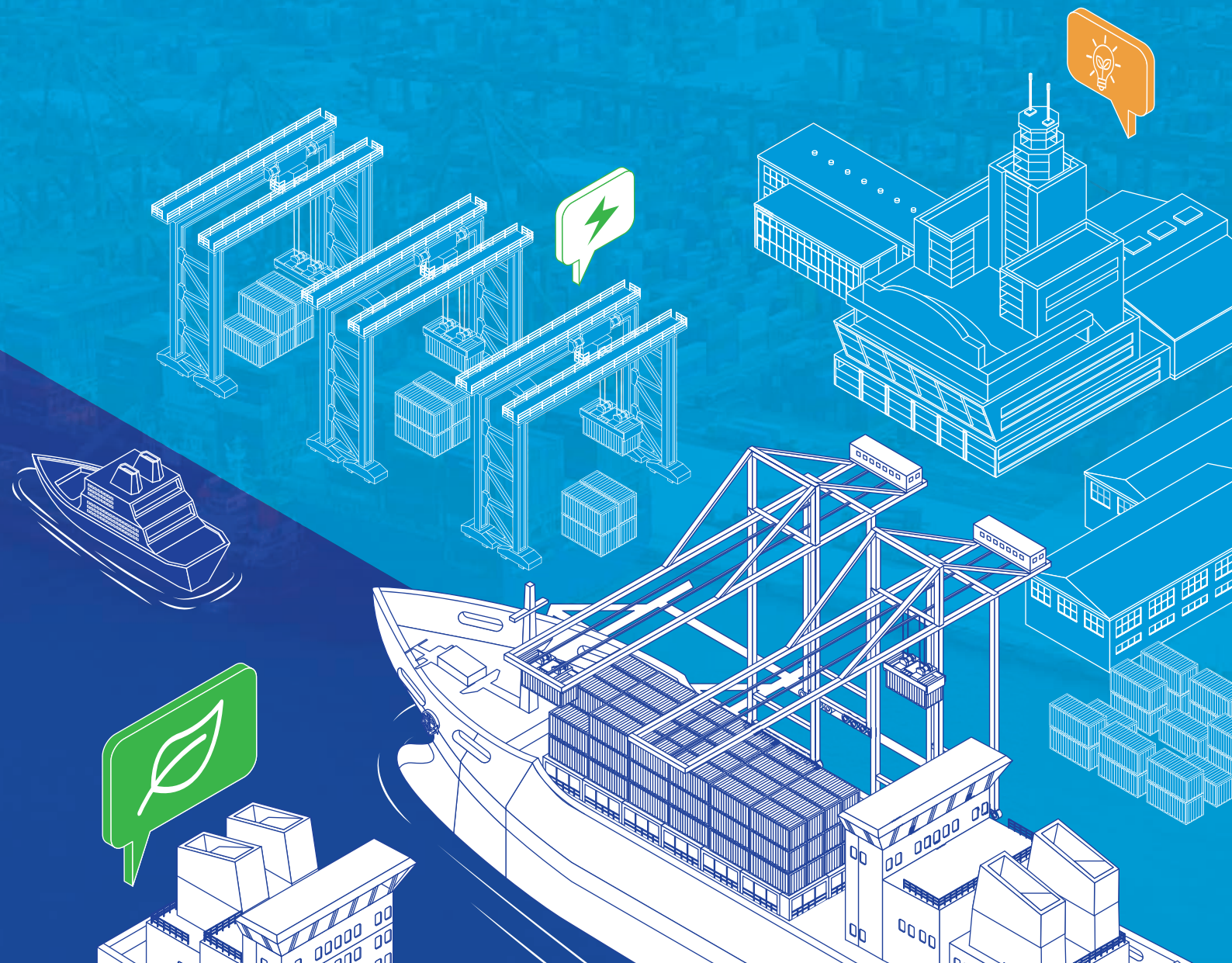


MARITIME SINGAPORE

DECARBONISATION BLUEPRINT

WORKING TOWARDS 2050



Maritime Singapore Decarbonisation Blueprint: Working Towards 2050



The **Maritime Singapore Decarbonisation Blueprint: Working Towards 2050** charts ambitious and concrete long-term strategies to build a sustainable Maritime Singapore. Developed by the Maritime and Port Authority of Singapore in consultation with industry partners, the Blueprint will contribute to Singapore's commitments under the UN's 2030 Sustainable Development Agenda, Paris Agreement and the Initial IMO Strategy, and strengthen our value proposition as a leading global hub port and International Maritime Centre.



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Maritime Singapore Decarbonisation Blueprint: Working Towards 2050



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This Blueprint takes on board the recommendations made by the International Advisory Panel on Maritime Decarbonisation¹ in April 2021, and the consolidated inputs during a two-month long public consultation (April – June 2021) and sector-specific consultations².

Singapore's Commitment to Maritime Decarbonisation

Climate change is a complex global challenge that calls for concerted global action. All stakeholders must work together to address this existential threat. While Singapore contributes only 0.11% of global emissions and is alternative energy-disadvantaged, we have and will continue to do our part. In 2020, Singapore submitted to the United Nations Framework Convention on Climate Change an enhanced 2030 Nationally Determined Contribution to peak emissions at 65MtCO₂e around 2030, and a Long-Term Low Emissions Development Strategy to halve emissions from its peak to 33MtCO₂e by 2050, with a view to achieving net zero emissions as soon as viable in the second half of the century.

As announced by Minister for Finance Mr Lawrence

Wong at Budget 2022, Singapore will raise our climate ambition to achieve net zero emissions by or around mid-century.

A whole-of-nation movement to advance Singapore's national agenda on sustainable development and climate action - The Singapore Green Plan 2030 - was launched in February 2021. The domestic transport sector including domestic maritime transport, will actively contribute to mitigating Singapore's national emissions.

Singapore is a major international maritime transport hub. The Port of Singapore is currently the world's second busiest port in terms of container throughput, with ship arrival tonnage exceeding 2.8 billion gross tonnes in 2021. Singapore is also one of the world's leading bunkering hubs, supplying over 50 million tonnes of marine bunker fuel to vessels that ply international shipping routes in 2021.

The maritime decarbonisation agenda will bring about new areas of green growth for Singapore, for example in the developments of alternative fuels and green technologies. As a global hub port and quality ship registry, Singapore will play an important role in catalysing the greening of international shipping.

To date, Singapore has been a frontrunner in encouraging sustainability practices within the port and shipping sectors. Our port operators continually strive to offer superior connectivity and efficiency. This minimises vessels' idle time in port, and correspondingly reduces emissions from international shipping. To promote clean and green shipping in Singapore, a \$100 million MSGI was launched by MPA in 2011. The MSGI comprises voluntary programmes to

¹Established by the SMF with the support of MPA.

²Consultations were undertaken with the SSA and ASMI.

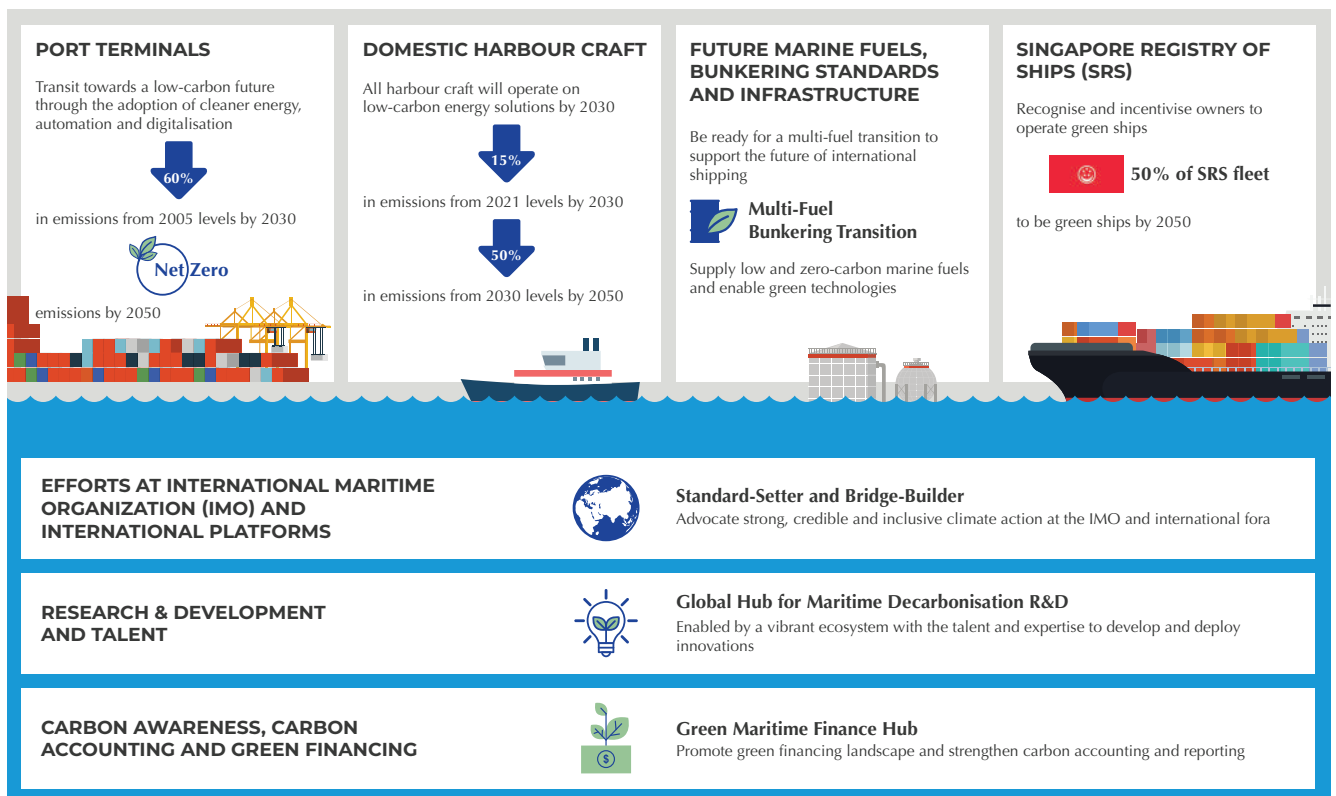
recognise and provide incentives to companies that adopt clean and green shipping practices over and above the minimum required by IMO obligations.

Emissions from international shipping are addressed at the IMO on a global basis. The IMO has adopted Initial IMO Strategy in 2018, with the goals of reducing GHG emissions from international shipping by at least 50% by 2050 compared to 2008, while pursuing efforts to phase them out. Singapore plays an active role at the IMO in the formulation of strategies and measures to reduce such emissions.

Overview of Focus Areas

The Blueprint outlines seven focus areas, which MPA will focus on to support the decarbonisation of the maritime industry:

- i. **Port terminals;**
- ii. **Domestic harbour craft;**
- iii. **Future marine fuels, bunkering standards and infrastructure;**
- iv. **Singapore Registry of Ships;**
- v. **Efforts at IMO and other international platforms;**
- vi. **Research & Development and Talent;**
- vii. **Carbon awareness, carbon accounting and green financing.**



To move more decisively on maritime decarbonisation, **MPA will commit additional funds of at least \$300 million beyond existing commitments to support initiatives outlined in the Blueprint.**

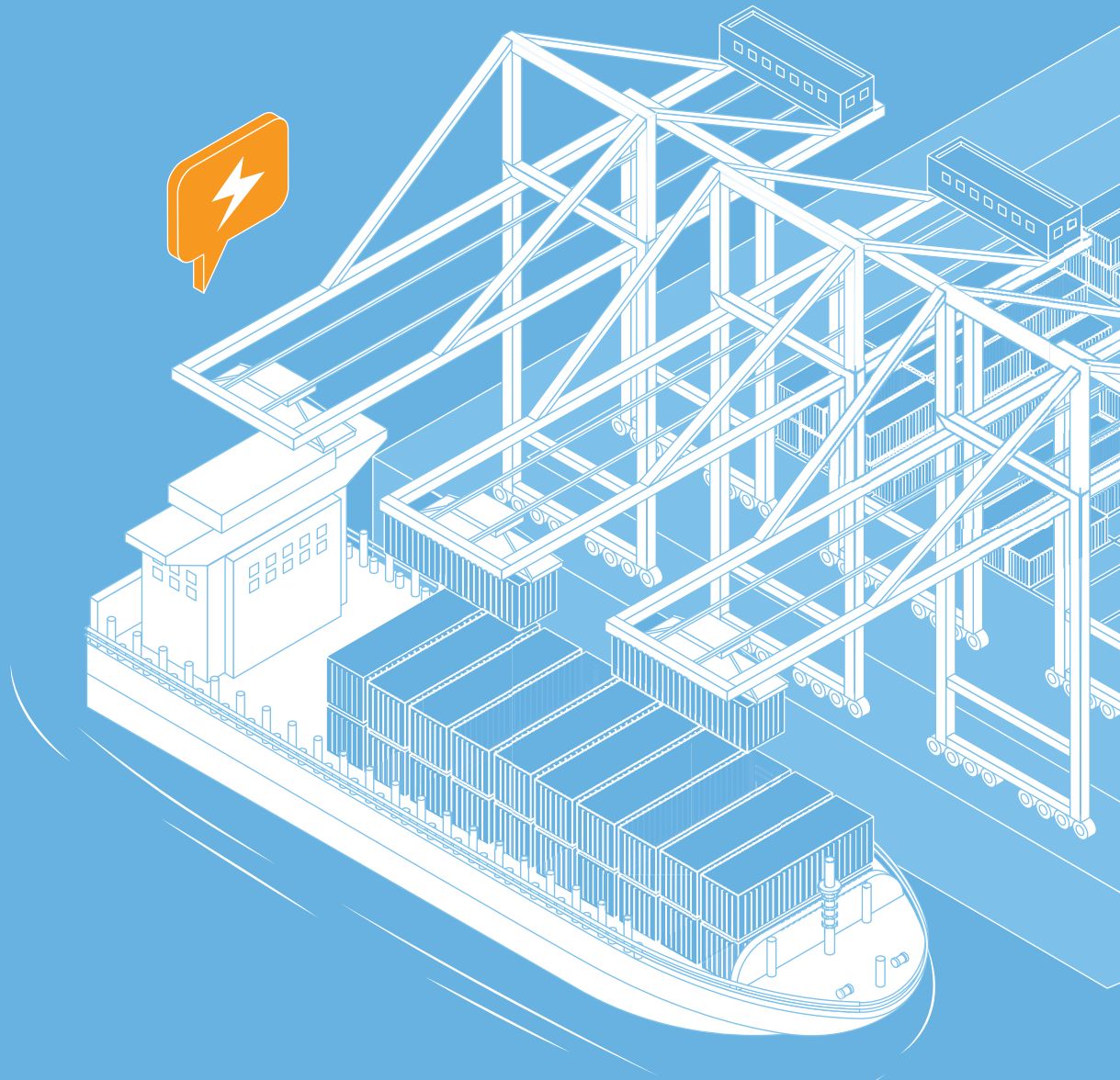
FOCUS AREA 1

PORT TERMINALS

Singapore's port terminals will transit towards a low-carbon future, through the adoption of cleaner energy, automation and digitalisation.

By 2030, our port terminals will reduce absolute emissions by at least 60% from 2005 levels, amidst projected growth in volumes.

By 2050, our port terminals aim to achieve net zero emissions.



Port Terminals



To support Singapore's national emissions target, MPA seeks to reduce emissions from port terminals and transit to a low-carbon future while keeping our port competitive.

Port terminal operators – PSAC and JPPL – are committed to environmental sustainability and have developed concrete strategies aimed at achieving net zero emissions by 2050. These strategies include the greening of port handling equipment, port vehicles, and terminal buildings, as well as improving energy efficiency and adopting cleaner energy alternatives.

PSAC and JPPL have deployed smart systems and solutions to enhance operational efficiency. These help to reduce idle or waiting time by vessels and vehicles at the port terminals. In addition, both port terminal operators have also embarked on projects aimed at improving energy management and utilisation within the terminals, thereby reducing the amount of carbon emissions associated with port operations.

MPA and the relevant public agencies are working with both port terminal operators to develop port-centric industrial ecosystems around the terminals in the medium to long-term. The siting of synergistic industries and activities close to port terminals will yield carbon footprint savings by shortening supply chains, sharing facilities, and optimising resources.



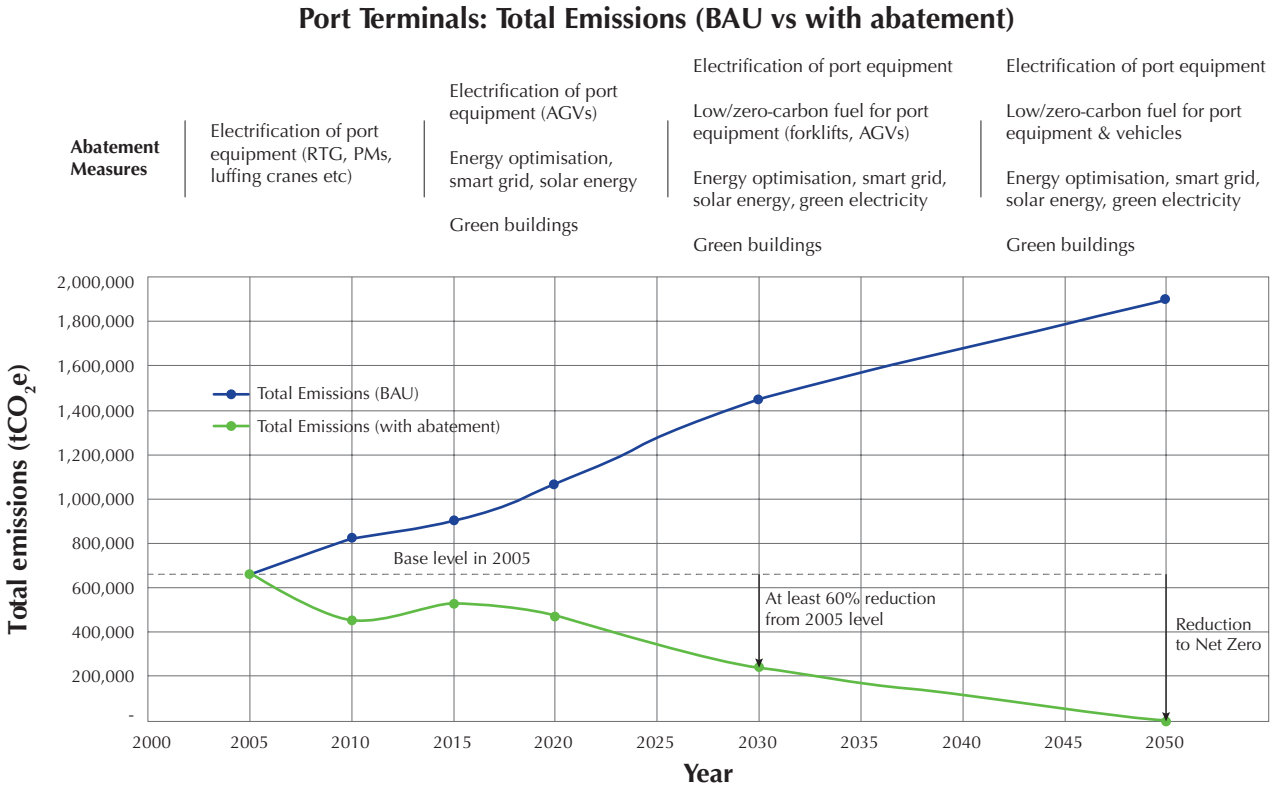
◀ The Port of Singapore is the busiest container transshipment hub in the world. PPT is among one of the four container terminals operated by PSAC.



◀ Jurong Port has been the main gateway for general and bulk cargo into Singapore for more than 50 years. It is moving towards being a next generation multipurpose port by harnessing digitalisation and sustainability models that support the port's growth.

Targets

Both port terminal operators aim to collectively achieve at least 60% reduction of total emissions from port operations by 2030 as compared to 2005 levels, and net zero emissions by 2050. The targets are illustrated in the figures below.



▲ Figure 1: BAU versus targeted emissions of port terminals from 2005 to 2050 (Source: PSA and JPPL).

Greening Port Equipment and Vehicles

PSAC aims to progressively electrify all diesel-based container handling equipment and vehicles at its container terminals. By phasing out combustion engines from container handling equipment and vehicles and switching to cleaner energy from the national power grid, PSAC will significantly reduce its direct emissions.

At PPT, PSAC has deployed electric-automated RMG cranes at its newer terminals since 2015. PSAC has also begun replacing its diesel RTG cranes at the older terminals (i.e. Terminals 1 to 3) with electric-automated ones, since 2019. Currently, diesel RTG cranes account for about one-fifth of PSAC’s overall emissions, and the transition from diesel to electricity will reduce this figure by more than 30%.

At present, prime movers account for around 40% of PSAC’s emissions. PSAC will progressively replace its

fleet of older, diesel-operated prime movers at PPT with movers that are powered by cleaner fuels, such as LNG. In mid-2021, PSAC embarked on a pilot project for 160 LNG-powered prime movers at PPT, representing about 10% of the fleet. PSAC is also exploring the adoption of electric prime movers from 2023.

PSAC is developing the future Tuas Port with sustainability as a key focus. The first phase of this multi-decade project involves deploying port infrastructure with full electric-automated rail mounted gantry cranes and electric AGVs to support automated terminal operations from 2021. Smart fast-charging stations will be built and centrally monitored by PSAC’s fleet management systems. By 2050, PSAC would have fully transitioned away from diesel fuel. Its container handling operations will be powered by electricity, supplemented by low or zero-carbon energy sources such as hydrogen.



▲ Electric-automated RTG cranes at PPT. PSAC aims to progressively electrify all diesel-based port handling equipment and vehicles at its container terminals.



▲ Full electric-automated rail mounted gantry cranes at Tuas Port Phase 1.



▲ A pilot project for LNG-powered prime movers at PPT.

Timeline of PSAC’s efforts to achieving full electrification of port equipment

- 2015** Adoption of new electric automated RMG cranes at the newer phase of PPT (Terminals 4 – 6).
- 2019 - 2027** Replacement of diesel RTG cranes with electric RTG cranes at the older phase of PPT (Terminals 1 – 3).
- 2021** Adoption of new electric automated RMG cranes at Tuas Port Phase 1.
- 2021** Adoption of LNG fuelled prime movers to replace diesel fuelled PMs at PPT (Terminals 4 – 6).
- 2021** Adoption of battery AGVs at Tuas Port Phase 1.
- 2023** Adoption of electric prime movers at PPT.
- 2023** Adoption of Smart Grid at PPT and Tuas Port.
- 2025** Utilisation of imported green electricity.
- 2027** Adoption of hydrogen prime movers at PPT.

JPPL seeks to implement greener solutions for its new businesses and operating models. For instance, when aggregates handling is moved to Jurong Port by 2022, JPPL intends to use electric balance cranes and conveyor belt systems to unload and transfer aggregates from vessels to storage stockpiles.



▲ An artist impression of electric balance cranes that will be used for aggregates handling at Jurong Port by 2022.

JPPL also has plans to establish a centralised inventory yard for steel storage by 2028, which will utilise electric overhead gantry cranes in place of diesel-powered forklifts, for the handling of steel cargo. Such innovations will enable JPPL to reap greater economies of scale and improve energy efficiency in cargo handling.



▲ An artist impression of Jurong Port's centralised inventory yard for steel storage which will utilise electric overhead gantry cranes in place of diesel-powered forklifts for the handling of steel cargo.

JPPL will work with the larger port community to 'green' operations, beyond JPPL's existing direct and indirect emissions. At present, there are around 300 diesel forklifts being used within Jurong Port for cargo handling operations that are owned by individual stevedoring companies. JPPL has started to consolidate and centrally manage this fleet of forklifts, which is expected to reduce the fleet size by approximately 30% through resource optimisation.

JPPL will also introduce cleaner alternative fuels in phases by 2026, such as biodiesel, to power its forklift fleet. This switch to cleaner energy sources is estimated to achieve approximately 15-20% reduction in emissions as compared to traditional diesel.

Reducing emissions from grid electricity

As part of Singapore's energy transition plan, the power sector will harness the four Switches – natural gas, renewable energy, electricity imports and low-carbon alternatives (such as hydrogen and CCSU) to decarbonise the grid. This will enable port operators to reduce their indirect emissions from electric-powered port handling equipment and vehicles.

To this end, PSAC and JPPL are actively collaborating with industry partners and power generation companies to improve their grid emission factor and source green electricity imported from regional grid. From 2025 onwards, PSAC will progressively source for green electricity, subject to economic considerations and availability.

JPPL will also use green electricity when commercially viable. In line with the Singapore government's long-term plan to import 30% of electricity from low-carbon sources, JPPL may tap on existing green electricity within the grid, either generated locally or overseas.

To achieve their net zero emission goals, both port terminal operators intend to use zero-carbon fuels and green electricity, instead of relying on carbon offsets and credits, to directly abate their emissions.

Developing use cases for hydrogen in port operations (Importation of Hydrogen for National Requirements)

PSAC and JPPL are collaborating with agencies, IHLs and industry partners, to develop a hydrogen-based ecosystem for the adoption of hydrogen fuel to be commercially viable.

Through a MOU, Chiyoda, Mitsubishi Corporation and five Singaporean companies (PSAC, JPPL, City Gas Pte Ltd, Sembcorp Industries Ltd and Singapore LNG Corporation) plan to set up a de-hydrogenation plant capable of extracting hydrogen from Liquid Organic Hydrogen Carrier by 2023. The project will pilot the commercial viability of tapping hydrogen in the power generation industry. The project has the potential to offer significant national carbon abatements, which would bring about a cleaner national power grid.



▲ PSAC, JPPL, City Gas Pte Ltd, Sembcorp Industries Ltd, and Singapore LNG Corporation signed a joint Memorandum of Understanding with Chiyoda Corporation and Mitsubishi Corporation to develop ways to utilise hydrogen as a green energy source.

When the de-hydrogenation plant is completed in 2023, PSAC will develop the first proof-of-concept hydrogen use case for prime movers in Singapore. When commercially viable, PSAC further plans to deploy hydrogen-fuelled prime movers for the transportation of containers within PPT, as well as for inter-terminal haulage between PPT and Tuas Port from 2027. PSAC also aims to explore the deployment of hydrogen-powered AGVs for the second phase of Tuas Port’s development.

Green Buildings and Solar Power

Green buildings

PSAC has been developing green buildings at its terminals to lower its energy consumption. For example, building envelopes were designed to reduce heat gain and cooling energy needs, and LED lightings have been installed to improve lighting energy consumption. Air-conditioning and mechanical ventilation systems have also been engineered with smart devices to improve efficient usage of energy and water consumption for cooling, ventilation, and water fixtures.

In 2020, PSAC’s Liveable City project – the development of a 20-storey office tower with an adjacent 4-storey block with recreational amenities at PPT – was awarded a Building and Construction Authority Green Mark Platinum award. Its 6-storey administration building project at Tuas Maintenance Base was also awarded the Building and Construction Authority Green Mark Platinum (Super Low Energy) award in 2021.

Between 2017 and 2018, JPPL conducted trials for a LED conversion programme for its warehouses, with the results showing significant energy savings of over 30%. Looking ahead, JPPL plans to scale up and extend its LED lighting conversion efforts to all its warehouses and facilities, an effort which is expected to generate savings of 1.5GWh or approximately 600 tCO₂e annually from 2025.

Generation of Solar Energy

Aligned with Singapore's national ambitions to quadruple solar energy deployment by 2025, both port terminal operators have made significant investments to tap on solar power as an alternative renewable energy source, to reduce their indirect emissions.

Currently, JPPL has a 76,000 m² solar facility utilising the roofs of its warehouses. At the size of eleven football fields, the facility generates around 9.56 megawatts at peak capacity. This has helped to meet over 10% of the port's electricity needs. Moving forward, JPPL plans to install additional solar PV systems at its premises, such as at its new ready-mix concrete building and steel-handling facilities.



▲ Jurong Port's solar power generation facility offsets more than 10% of the port's electricity needs.

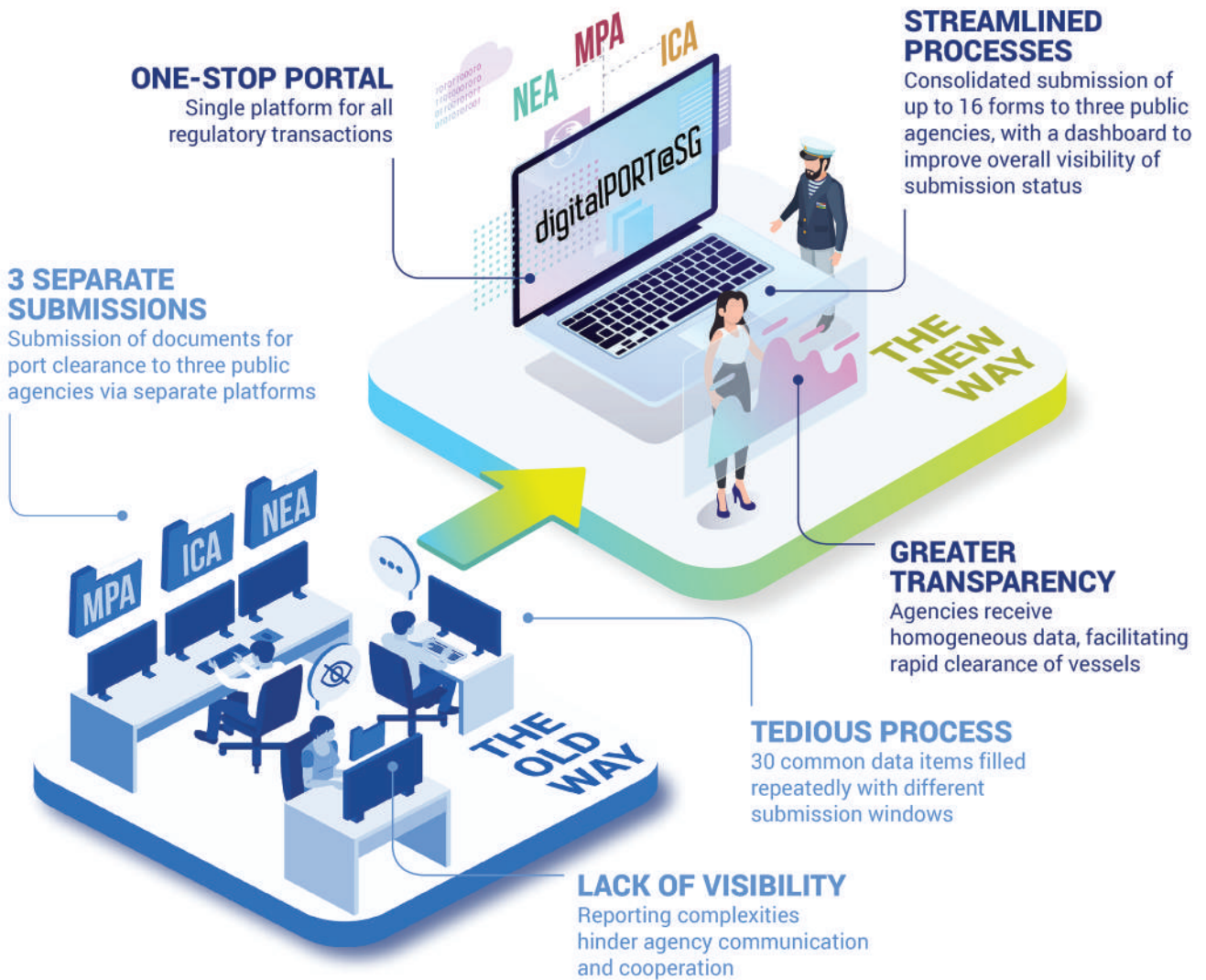
Similarly, PSAC has existing solar photovoltaics systems and roof-top solar panels, installed on its existing buildings across five locations in PPT. In totality, the systems are capable of generating 4.56 GWh of solar energy each year.

PSAC intends to increase its solar PV installations and double its solar energy generation from 4.56 GWh today to 9 GWh a year by 2030. This will be achieved through harnessing solar energy through its buildings.

For instance, the administration building in Tuas Port Maintenance Base will include a roof-mounted PV system with PV modules applied in place of regular claddings, to maximise the available space for harnessing solar energy. This is expected to generate 3 GWh of solar energy each year to support the energy consumption of Tuas Port Maintenance Base. With the solar energy harnessed from the building and adjacent workshops, Tuas Port Maintenance Base will be a net zero energy facility.

digitalPORT@SG™

MPA's digitalPORT@SG™, launched on 30th October 2019, enhances the efficiency, user-friendliness, and transparency of document submissions, providing one-stop clearance for vessel related transactions. This initiative is estimated to save 100,000 man hours per year in productivity.



*Portal for One-stop Regulatory Transactions

Decarbonising supply chains through efficiency gains from transshipment and digitalPORT@SG™

Today, Singapore already contributes to emissions abatement of international shipping through efficient transshipment and digital transformation. Singapore handles around one-seventh of the world's transshipment cargo. It currently connects to some 600 ports via 300 service routes, linking up about 28,000 port pairs.

Transshipment is and remains the most efficient mode of shipping at scale – both economically and environmentally. It lowers the average shipping emissions per container moved, by reducing the number of service routes and port calls required as compared to direct shipping, and allowing for cargo consolidation and the use of larger vessels.

Singapore offers efficient port operations and superior connectivity, reducing idle time of visiting ships and facilitating more efficient transshipment of goods. This translates to shorter port stays and lower emissions by ships that call in Singapore. It also allows Singapore to serve as a “catch up port”, so that ships avoid consuming additional fuel by speeding up to meet their schedules. As an illustration, a typical 15,000 TEU Suez-bound vessel speeding up to compensate for a 1-day delay requires more than 20 tonnes of additional bunker fuel consumption, which is equivalent to about 45 tCO₂e.

Together with the port terminal operators, MPA is committed to enhance the efficiency of port operations, including transshipment operations. A key enabler is the use of technology to reduce or eliminate kinks in the supply chains. For example, common digital platforms that facilitate systems integration and data exchange allow port terminals to be better connected to other key nodes in the maritime supply chain. A more efficient supply chain with reduced vessel and vehicle idle times, translates to reduced emissions at the port and within its associated logistics ecosystem.

Singapore's maritime single window, digitalPORT@SG™ provides real-time information for port stakeholders to better coordinate, plan and allocate port resources. Embedded within this digital platform is a JIT planning and coordination system that allows for more efficient scheduling of port calls and the seamless delivery of marine services such as cargo handling, bunkering, ship re-supply, and repair and maintenance. This allows ships calling at Singapore to better optimise their sailing speeds, routes, or timing of arrivals to achieve berth-on-arrival. This also minimises the idling or waiting time of ships, correspondingly reducing emission from ships that are calling at, or engaging in works in, our port terminals and waters. When fully operationalised, the JIT system is expected to benefit more than 2,000 maritime companies.

Energy Efficiency Gains through Digitalisation

Aside from the adoption of cleaner energy solutions and alternatives, Singapore's port terminals are also leveraging technology and digitalisation to support their decarbonisation efforts.

Smart Prime Movers

PSAC has developed smart prime movers that tap on sensors and telematics, supported by on-board diagnostics. Such digital tools help drivers to “eco-drive” by avoiding hard braking and excessive bursts of acceleration, thereby reducing fuel consumption.

PSAC is also trialling autonomous prime movers with AI-optimised routing, speed and acceleration, to raise the energy efficiency of its prime mover fleet. Having started with two autonomous prime movers in 2020, PSAC plans to further expand such testing efforts to 40 autonomous prime movers from 2023, to cover yard and wharf operations. The adoption of autonomous technology, combined with electrification, is envisaged to yield 50% reduction in emissions per container move, as compared to diesel PMs.

Smart grid management and smart multi-energy systems have enabled our port terminals to manage their overall energy consumption, through effective monitoring of energy efficiencies across port handling equipment, terminal buildings as well as other port facilities. Energy efficiency gains derived from the deployment of such systems could reduce emissions, energy usage as well as costs of port operations.

PSAC and EMA have jointly awarded a \$8 million grant to a consortium, comprising Envision, Durapower, NUS, SUTD, and Anacle, to develop capabilities in energy management and modelling, as well as energy procurement. The consortium will look at smart grid, battery energy storage system, virtual power plant, AI-driven energy procurement, test-bedding of vehicle-to-grid, digital-twin enabled port power infrastructure simulation, and machine learning-based cybersecurity. The implementation of these systems is currently in progress with an expected completion by end-2023. PSAC estimates a reduction of 3% to 5% in electricity consumption, when the systems are deployed at PPT and Tuas Port.

Similarly, JPPL, NTU and SP are developing an AI software for managing and optimising energy generation in a power network. As part of the \$27 million partnership, NTU and SP have designed an AI-powered smart multi-energy system. This system can manage an array of energy sources in a network and pick the most optimal energy mix for specific power demands under different situations. Through analytics, it is also able to utilise weather data to select suitable alternative energy sources to supplement power generation.

Developing Port-Centric Eco-systems

Beyond emissions arising from the direct confines of the port terminals, both port operators and MPA are committed to reduce emissions arising from port operations. From the present till the 2040s, PSAC will be consolidating all its container terminal operations at a single location in Tuas. This will eliminate inter-terminal haulage (via trucking and barging) as well as its associated emissions between the existing City Terminal, PPT as well as Tuas Port. When port operations are fully consolidated at Tuas Port in the

2040s, a national abatement of up to 76,000 tCO₂e annually will be achieved from a peak in 2030, with the elimination of around 2.1 million inter-terminal trips annually.

As part of the Next Generation Port 2030 initiative, MPA is also working with public sector agencies and PSAC to cluster synergistic businesses in the adjacent Tuas Port ecosystem. This will enable Singapore to achieve more efficient cargo flows between the port and industry.

Over at Jurong Port, JPPL has worked with industry players in the RMC ecosystem to co-locate concrete batching plants currently located near various construction sites island-wide to Jurong Port by end-2022. By physically clustering aggregate and cement storages and the concrete batching plant together, the integrated RMC ecosystem streamlines the supply chain and reduces the number of truck movements. JPPL estimates that RMC port-centric ecosystem would generate savings of more than 600,000 truck trips annually, resulting in an estimated national abatement of about 20,000 tCO₂ annually.

Beyond 2030, Jurong Port's future Steel Port-Centric Ecosystem will bring about the physical clustering of steel storage and fabrication nearer to Jurong Port. This will remove existing truck trips between the separate plants, resulting in an estimated national abatement of about 2,000 tCO₂ annually.



▲ An artist impression of Tuas Port, an automated, intelligent and sustainable port. When fully completed in the 2040s, it will consolidate all container port operations at a single location and be capable of handling up to 65 million TEUs per annum.

Reclaiming Tuas Port Sustainably

Sustainability is integral to the design and master planning of the next generation port.

During the development of the port, excavated earth obtained from other land construction projects was reused as reclamation fill materials for the project. Reusing such materials, which would otherwise be disposed of, reduces the quantity of sand fill required for reclamation. This has resulted in fill material cost savings of some \$2 billion for Tuas Port Phases 1 and 2, while alleviating the road congestion and emissions otherwise caused by the movement of such materials. Over 50% of the total reclamation fill in Tuas Port Phases 1 and 2 were sourced from recycled excavated materials from construction projects.



▲ Sustainability is integral to the construction of Tuas Port. More than 50% of the fill materials for Tuas Port Phase 1 reclamation were either dredged from the creation of port's fairways or excavated from other construction projects on land.



▲ S Iswaran, Minister for Transport and Minister-in-charge of Trade Relations (centre), was joined by Chee Hong Tat, Senior Minister of State for Transport (second from left), Niam Chiang Meng, Chairman, MPA (left), Loh Ngai Seng, Permanent Secretary, Ministry of Transport (second from right), and Quah Ley Hoon, Chief Executive, MPA (right) at Tuas Port for the completion of reclamation works for Phase 1.

To make way for reclamation works while ensuring the preservation of Singapore's marine environment, MPA relocated corals at Sultan Shoal, south of Tuas, where the new port is sited. In 2013, a \$6 million conservation programme was established to relocate corals and undertake R&D for setting up of coral nurseries using coral fragments from Sultan Shoal. Some 2,300 hard coral colonies around Sultan Shoal were moved to Sisters' Islands and St John's Island with the help of volunteers and non-governmental nature organisations.

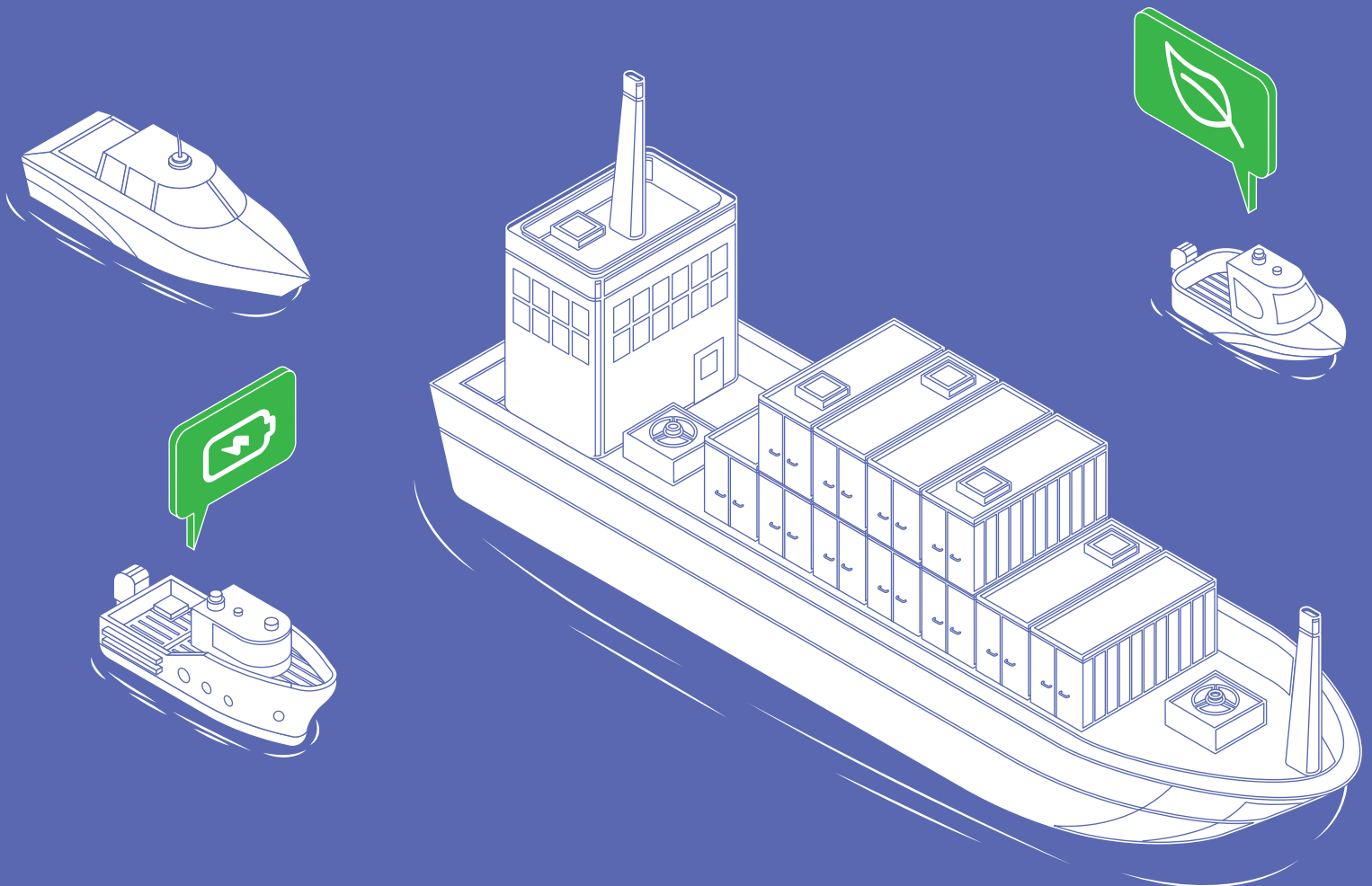


FOCUS AREA 2

DOMESTIC HARBOUR CRAFT

By 2030, MPA aims to reduce absolute emissions from the domestic harbour craft fleet by 15% from 2021 levels, through the adoption of lower-carbon energy solutions such as blended biofuel, LNG, diesel-electric hybrid propulsion, and full-electric propulsion.

By 2050, MPA aims for the harbour craft fleet to halve 2030-level emissions by transitioning to full-electric propulsion and net zero fuels.



Domestic Harbour Craft



▲ MPA is committed to reducing emissions from the domestic harbour craft operating in Port of Singapore.



▲ PSA Aspen, PSA Marine's first dual fuel LNG harbour tug.



▲ GP05, pilot launch operated by PSA Marine.

Domestic harbour craft perform a range of essential marine services within the Port of Singapore, including the delivery of ship supplies and bunker as well as towage and launch services. As part of the efforts to mitigate national emissions, MPA is committed to reducing emissions from domestic marine transportation with a progressive and phased approach.

By 2030, MPA aims to reduce absolute emissions from the domestic harbour craft fleet by 15% from 2021 levels, through the adoption of lower-carbon energy solutions such as blended biofuel, LNG, diesel-electric hybrid propulsion, and full-electric propulsion. By 2050, MPA aims for the harbour craft fleet to halve 2030-level emissions by transitioning to full-electric propulsion and net zero fuels.

The Future Energy Mix of the Domestic Harbour Craft Fleet

In collaboration with MESD CoE¹, MPA conducted a study of potential energy options for Singapore's harbour craft industry over a thirty-year horizon². The study evaluated and ranked ten energy types, taking into consideration their existing levels of adoption as well as future potential for deployment in the local harbour craft fleet.

Findings from the study indicate that biofuels (fatty acid methyl esters and hydrotreated vegetable oil) were the most feasible interim transition fuel, while LNG could be suitable for some larger types of harbour craft. Other future fuels and energy solutions (including fuel cells, full electric battery systems, ammonia, hydrogen, and methanol) could gain maturity and commercial viability in the long-term to achieve 2050 targets.

¹Launched in October 2017, MESD CoE is jointly funded by SMI and NTU. MESD aims to develop innovative and sustainable solutions for port and shipping applications by working closely with all the key stakeholders within the maritime industry.

²Liu M. et al., A Study on the Future Energy Options of Singapore Harbour Craft, NTU MESD CoE Report, November 2020.

Based on the study's findings and taking into consideration the diverse range of harbour craft types in Singapore's domestic fleet, the 1,350 smaller-sized harbour craft – comprising launches, lighters, passenger ferries, tugboats – are expected to transit to fuel cells or full electric battery systems. The 250 larger-sized harbour craft – mainly bunker tankers – are expected to run on net zero fuels such as ammonia, hydrogen, or methanol.

Pilot Use of Biofuel Blends and Electrification

MPA's intent in the immediate term is to pilot the use of biofuel blends amongst existing harbour craft. The main advantage of biofuel is its compatibility with existing shipboard equipment of harbour craft as well as bunkering infrastructure, with minimal or no modifications of existing assets.

To support this transition, MPA will work with industry partners to ensure the availability of various biofuel blends in Singapore. MPA will also look at developing standards for the use of biofuels as bunkers in the domestic harbour craft fleet. This complements the broader interest and adoption of biofuel blends from international shipping lines for ocean-going vessels, which will help drive demand and scale economies in the production of biofuel blends for Singapore's fleet of domestic harbour craft.



Biofuel Compatibility Study for Singapore Harbour Craft

MESD, in collaboration with MPA, has undertaken a 'Biofuel Compatibility Study for Singapore Harbour Craft', as part of the second phase of MESD's core project – 'Study of Potential Alternative Sources of Energy for Singapore's Harbour Craft Industry'.

Through feasibility trials at sea, the study will assess compatible biofuel blends and the life-cycle assessment of carbon reduction as compared to conventional distillate marine fuel. It is expected to be completed in the second quarter of 2022.

◀ *Instruments deployed during the biofuel sea trials to measure energy and emissions performance*

In addition, MPA will support trials for technology to ensure that the overall transition to low and zero-emission solutions is commercially viable for the domestic harbour craft sector. For instance, MPA has co-funded path-finder research in the electrification of harbour craft, to identify more cost-effective solutions. MPA will continue to support industry consortium-led initiatives to develop, deploy, and commercialise technologies and solutions that contribute to the reduction of harbour craft emissions. To power the energy demands of electric harbour craft, MPA will support progressive installation of interoperable charging and battery infrastructure within the port from 2025.

Harbour Craft Electrification

In September 2020, after a series of workshops with the industry, MPA and SMI had launched a joint call for proposals on the electrification of harbour craft with a total co-funding of \$9 million from MPA's Maritime GreenFuture Fund.

The call for proposals drew strong interest from the maritime community, with 73 maritime companies and 10 institutes of higher learning and research institutes submitting a total of 16 proposals. These proposals were evaluated based on their potential technical, operational and commercial viability, as well as strength of local capability development.

To date, MPA and SMI have awarded funding to three consortiums led by Keppel FELS Limited, SeaTech Solutions and Sembcorp Marine (comprising a total of 31 enterprises and research institutions) to research, design, build and operate a fully electric harbour craft in the Port of Singapore by 2025.

These electrification pilot projects will demonstrate both the commercial and technical viability of specific use cases for full electric harbour craft. They will study, testbed and deploy various technologies and charging infrastructures across different types of harbour craft and operating profiles. Current use cases involve two passenger ferries of different capacities and a lighter craft.

Together with industry partners, MPA will further study the following focus areas:

- (i) The development of national standards for shore-charging infrastructure for full-electric harbour craft;
- (ii) The existing gaps in the current grid infrastructure for shore-charging;
- (iii) The technology cost of full-electric harbour craft and shipboard systems.



◀ Artist impression of a full-electric ferry with floating charging station from the industry consortium led by Keppel Offshore & Marine through its wholly owned subsidiary, Keppel FELS Limited, together with DNV, Energy Research Institute @ NTU (ERI@N), Eng Hup Shipping, Envision Digital, Surbana Jurong, and the Technology Centre for Offshore and Marine, Singapore.

Green Financing for Harbour Craft

MPA will encourage harbour craft owners and operators to tap on Singapore's growing maritime financing ecosystem for renewal of their assets. This includes working with various stakeholders including MAS and financial institutions to raise awareness of green financing solutions and tools.

To support the transition of the domestic harbour craft fleet, MPA will look at developing schemes that aid first movers to defray the cost of investment into new green harbour craft. MPA will also work with financial institutions to widen the suite of financing options in Singapore. This includes work to facilitate risk management and catalyse lending by financial institutions to harbour craft owners and operators.

Regulatory Framework for Transition of Domestic Harbour Craft Fleet

MPA plans to require all licensed harbour craft to operate on lower-carbon energy solutions, such as blended biofuel, LNG, diesel-electric hybrid propulsion or full-electric propulsion by 2030. This will help to decisively reduce emissions of the domestic harbour craft fleet. With this, MPA aims to reduce absolute emissions of the fleet by 15% from 2021 levels by 2030.

MPA will progressively introduce new "green" licensing conditions or requirements, such as the use of LNG, biofuel blends and eventually zero-carbon fuels, when harbour craft licences are issued or renewed. With the decommissioning of older harbour craft over time, this will prompt the gradual phase-in of new, greener harbour craft.

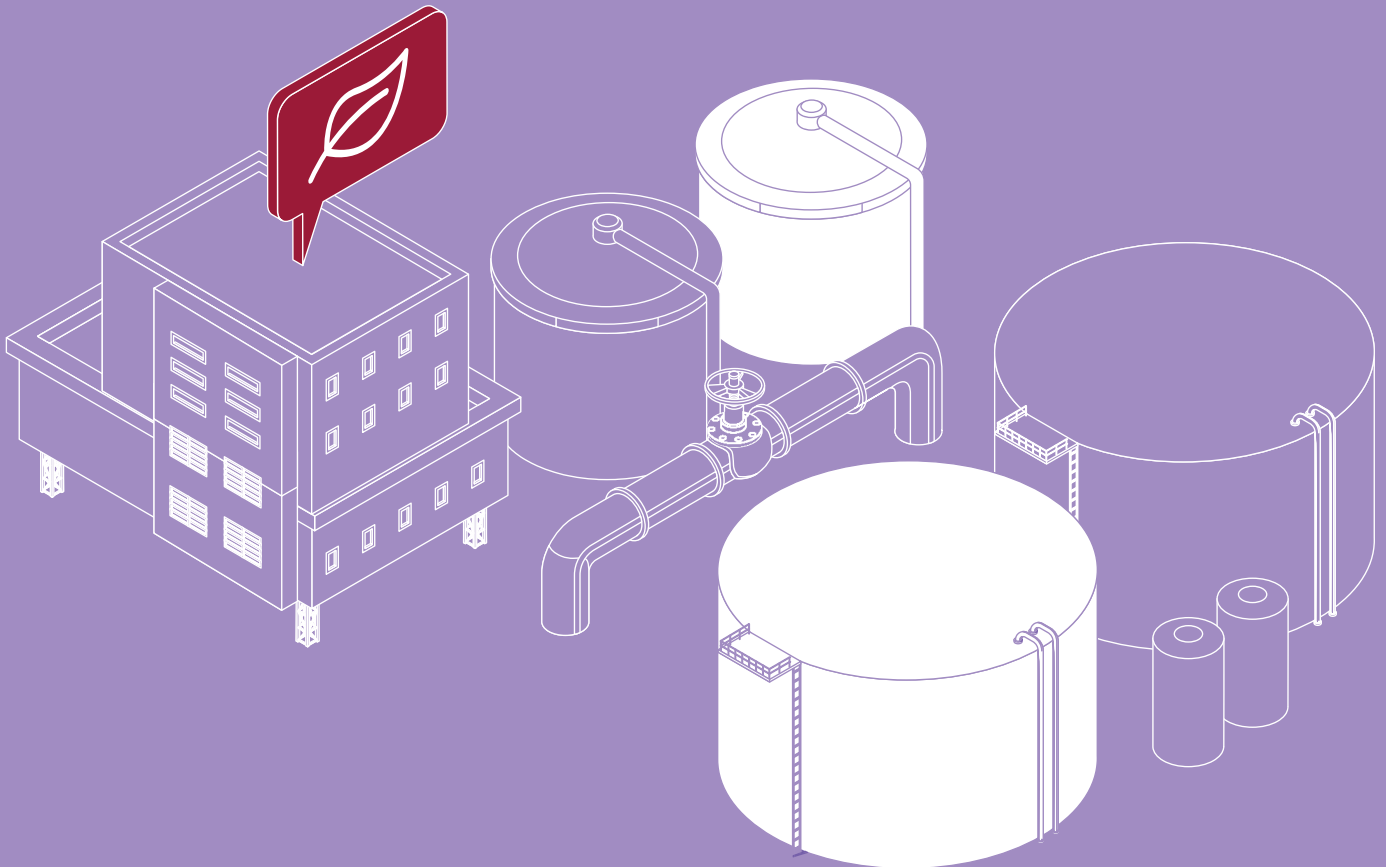
From 2050, MPA envisages that all licensed harbour craft will operate on full-electric propulsion or net zero fuels. By encouraging the uptake of alternative green fuels and energy solutions, while providing sufficient runway and resources for the industry to plan for vessel renewal, MPA seeks to facilitate the orderly and necessary transition of the domestic harbour craft fleet towards a greener future. MPA will work towards the goal to halve 2030-level absolute emissions by 2050.



FOCUS AREA 3

FUTURE MARINE FUELS, BUNKERING STANDARDS AND INFRASTRUCTURE

As a world-class bunkering hub, Singapore will be ready for a multi-fuel bunkering transition to support the future of international shipping, by supplying low and zero-carbon marine fuels including biofuels, methanol, ammonia and potentially hydrogen, while enabling green technologies such as carbon capture, storage and utilisation.



Future Marine Fuels, Bunkering Standards and Infrastructure



Singapore is the world's largest bunkering port, with a total of 50 million tonnes of bunkers supplied in 2021. As a world-class bunkering hub, Singapore remains committed to provide low and zero-carbon fuel solutions to meet the future energy needs of the global shipping industry.



▲ *As the world's largest bunkering port, Singapore will support the decarbonisation of international shipping through a multi-fuel transition*

FUTURE MARITIME ENERGY MIX

Given the current levels of technology, there remains considerable uncertainty over which low or zero-carbon marine fuel the global shipping industry will eventually adopt. Nevertheless, there are clear signs that it will undergo a multi-fuel transition, to hedge risks and cater to different vessel-operating profiles.

Based on current industry pilots and feasibility studies, biofuels and LNG are the likely interim or transitional fuels in the near term. There is a growing order book for LNG-fuelled vessels. There is also growing interest from industry players to carry out biofuel trials¹, given the relative technological maturity and compatibility of biofuels with existing infrastructure and vessels. In the mid to long-term, hydrogen and its carriers (e.g. ammonia, e-methanol) as well as bio-LNG, may also become viable low or zero-carbon marine fuels.

Biofuels and electrification have been identified as most viable energy options for harbour craft operating within Singapore. Biofuels, in particular scored well from the perspective of readiness of supply, infrastructure and maturity of technology. On the other hand, the technologies required for widespread use of liquefied hydrogen and on-board CCSU remain nascent.

	Supply		Technology		Market Demand & Policies	Regulation / Standards
	Availability	Infrastructure	Fuel Cell	Engine		
 Biofuels	✓	✓	✓	✓	✓	✓
 Electrification	✓	✓	✓	✓	✓	✓
 e-Methanol	✓	✓	✓	✓	✓	✓
 Ammonia	✓	✓	✓	✓	✓	✓
 Hydrogen	✓	✗	✓	✗	✗	✗
 Onboard CCSU	✗	✗	✓	✗	✗	✗

Interim fuel choice for **domestic harbour craft** (Biofuels, Electrification)

Long-term fuel choice for **domestic harbour craft** (Electrification)

Frontrunner fuels for **international shipping** (e-Methanol, Ammonia)

Potential long-term fuel choices for **international shipping** (e-Methanol, Ammonia, Hydrogen)

▲ Figure 2: Overview of present assessment of low/zero-carbon fuels.

While not favouring any particular fuel type, MPA expects hydrogen and its carriers (including ammonia, e-methanol) as well as bio-LNG to potentially play important roles in the decarbonisation of international shipping in the mid to long term. Hydrogen can serve as an energy carrier to store and transport renewable energy. At present, there are several JDPs exploring the potential use of ammonia as an alternative marine fuel for ocean-going vessels. One example is The Castor Initiative, which aims to develop the world’s first ammonia-fuelled tanker by 2025.

¹In April 2021, BHP, Oldendorff and GoodFuels conducted the first marine biofuel trial involving an ocean-going vessel bunkered in Singapore. Since then, more vessels have followed suit.

The Castor Initiative

The Castor Initiative is a multinational coalition that aims to design, build, and commission the world's first ammonia-fuelled tanker by 2026. The Initiative currently comprises seven partners: MISC Berhad, Lloyd's Register, Samsung Heavy Industries, MAN Energy Solutions, Yara International ASA, MPA and JPPL.

Named after the Gemini constellation, The Castor Initiative was motivated by the partners' shared belief that the maritime industry needs leadership and greater collaboration to fulfil the level of ambition in the Initial IMO Strategy.

MPA joined The Castor Initiative in February 2021 to contribute its expertise, as a bunkering hub and port authority, on regulatory requirements for ammonia propulsion and bunkering operations for ocean-going vessels.

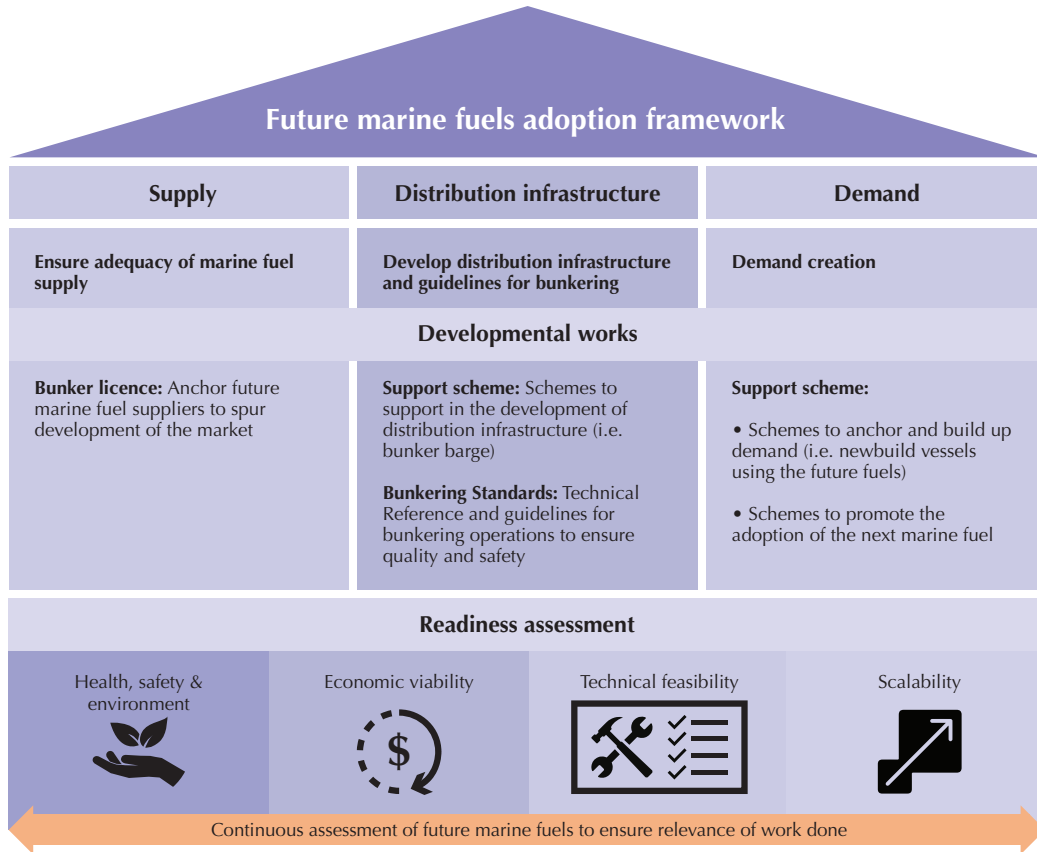
To date, The Castor Initiative has achieved several milestones. In September 2020, Lloyd's Register granted AiP to Samsung Heavy Industries for its ammonia-fuelled tanker design. In September 2021, Samsung Heavy Industries received AiP for its ammonia fuel supply and fuel storage system.



▲ The Castor Initiative's technical meeting in July 2021.

SINGAPORE'S LOW AND ZERO-CARBON MARINE FUELS STRATEGY

Against the global context of possible future marine fuels, **MPA is committed to work with the maritime industry to enable a multi-fuel transition.** The adoption of future marine fuels by Singapore will be guided by the following framework.



▲ Figure 3: Future marine fuels adoption framework.

KEY ANCHORS IN THE TRANSITION TO LOW AND ZERO-CARBON FUELS

MPA will focus on seven anchors to facilitate the transition towards low and zero-carbon fuels, namely: (i) technology trials and R&D, (ii) supply, (iii) regulations and standards development, (iv) demand, (v) financing, (vi) talent and skill development, and (vii) international collaboration and partnerships.

Anchor I: Technology Trials and R&D

First, MPA is actively collaborating with like-minded industry partners to conduct feasibility studies and pilot trials. The aim is to catalyse innovation and R&D needed for the deployment of future fuels and enable the industry to assess the operational and commercial viabilities of the various low and zero-emission fuel solutions. Some ongoing collaborations across various fuel types are as follows:

Category	Partners	Details
Ammonia	MPA, MISC Berhad, Lloyd's Register, Samsung Heavy Industries, MAN Energy Solutions, Yara International ASA	Joint development project to develop Ammonia as a marine fuel (The Castor Initiative)
	ExxonMobil, Hoegh LNG, MAN Energy Solutions, JPPL, PSAC, Itochu Group	Study on "Ammonia as a Marine Fuel in Singapore – Supply Chain, Bunker Safety and Potential Issues"
	Itochu Group, Pavilion Energy, Vopak Terminal, MOL, TotalEnergies, ITOCHU, Enex, MPA	Itochu MOU for Accelerating the Joint Development on Ammonia Fuel Supply Chain in Singapore
	A.P. Moller - Maersk A/S, Fleet Management Limited, MMMDC, Keppel Offshore & Marine, The Maersk Mc-Kinney Moller Center for Zero-Carbon Shipping, Sumitomo Corporation, American Bureau of Shipping and K-Line	SABRE (Singapore Ammonia Bunkering Feasibility Study)
	Awarded consortium: DNV, Surbana Jurong and Singapore Maritime Academy Partners: GCMD, JPPL, PSAC, Vopak Terminals, Oiltanking, Pavilion Energy, Ocean Network Express, Pacific International Lines, Hong Lam, Fratelli Cosulich, Kenoil, Eastern Pacific Shipping, Mitsui O.S.K. Lines, Nippon Yusen Kabushiki Kaisha, Asiatic Lloyd, Sembcorp Marine, Keppel, National Metrology Centre, ViswaLab, Veritas Petroleum Services	IFP – 'Defining safety and operational envelopes to enable ammonia bunkering pilot'
Methanol	NTU, China Waterborne Transport Research Institute	Joint study of the technical and operational feasibility of methanol-fuelled vessels in China and Singapore
	Billion Miles	MPA-supported project examining the development of methanol engine
Renewable marine fuels (e.g. biofuels, bio-LNG)	SMI, MESD CoE	Compatibility study to examine the environmental, technical, operational, and economic viability of biofuels for Singapore harbour craft
Electrification	MPA, SMI	\$9 million fund to co-fund three harbour craft electrification projects
Hydrogen	Shell, Sembcorp Marine, LMG Marin	Shell and Sembcorp to collaborate on pilot trial to develop and install fuel cell on a RO-RO vessel that carries cargo on lorries

Category	Partners	Details
CCSU	MPA, MESD CoE, Kuok Singapore, PaxOcean, Pacific Carriers Limited, PACC Offshore Services Holdings	Proof-of-Concept and Prototype testing to develop a CCSU for shipboard application

▲ Figure 4: Ongoing Future Fuel Studies and Trials.

In addition to participating in trials and joint development projects, MPA will establish regulatory sandboxes to allow industry first-movers to test-bed alternative low and zero-carbon fuel solutions. The qualification requirements and evaluation criteria for regulatory sandboxed projects are:

Category	Requirements	Evaluation Criteria
LCA and its associated CO₂ reduction	Demonstrate that the alternate fuel can contribute significantly to climate-friendly shipping. The alternate fuel should achieve at least 50% reduction from a LCA perspective as compared to marine diesel oil.	The proposed solution should achieve 50% or more CO ₂ reduction from a LCA perspective as compared to marine diesel oil.
Collaborative effort	Applicant must work in collaboration with Singapore-based companies.	The applicant must work in collaboration with one or more Singapore-based companies with clear definition of their role and involvement for the proposed solution.
Action plan	Applicant to include realistic action plans to achieve the intended scenarios and outcome, within a defined timeframe envisioned by the applicant.	The action plan must have a clearly defined scope of work and action items to achieve the milestones set out in MPA's initial assessment framework based on an agreed schedule.
Bankability	Applicant to demonstrate that the project is economically viable.	The quality and financial strength of the involved parties to support the development of the proposed solution.
Value-add to Singapore's maritime industry	Applicant to demonstrate that the project can value add to the industry through new knowledge generation or job creation.	The applicant must demonstrate the innovativeness, feasibility, and also the intention and ability to deploy the proposed solution to be scaled up beyond the regulatory sandbox.
Transition strategy	Applicant to provide a defined transition strategy beyond the regulatory sandbox to move towards broader scale.	The transition strategy must be in line with Singapore's approach towards maritime decarbonisation.

▲ Figure 5: Qualification Requirements for Future Fuels Regulatory Sandbox.

II: Supply – Bunkering, Storage and Distribution

Second, MPA will work with stakeholders across the value chain to ensure that Singapore is able to offer various low and zero-carbon fuel solutions to support the bunkering needs of the global shipping industry. These stakeholders include shipping lines, energy companies, logistics players, storage providers and bunker suppliers. MPA envisages that some existing infrastructure will be retrofitted, whilst investments into new infrastructure will allow the scaling up of fuel supply in line with future demand.

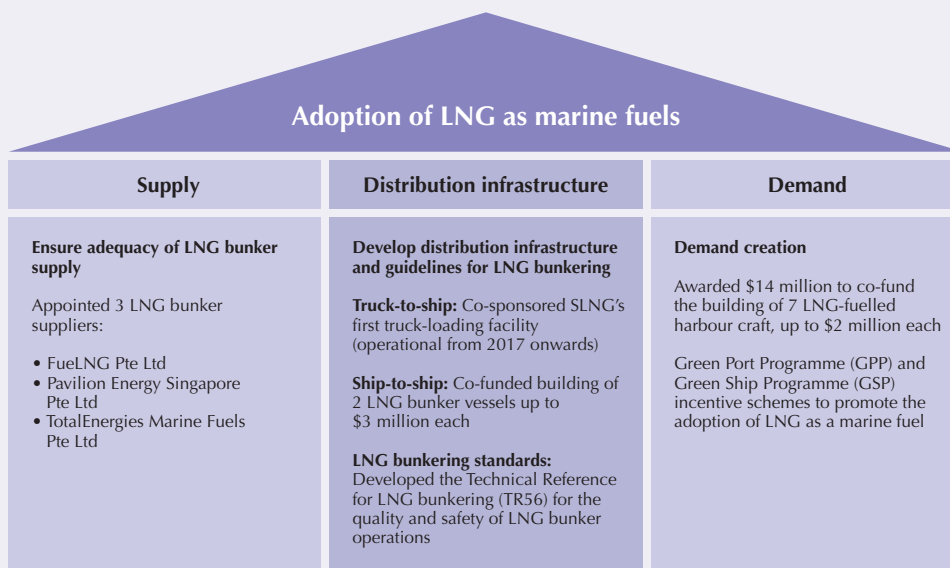
To support first movers, MPA is prepared to explore co-funding supply assets for low and zero-carbon fuel solutions. In 2017, MPA launched the LNG Bunkering Pilot Programme for a period of three years, to test operational protocols, gain operational experience, and strengthen Singapore's LNG bunkering capabilities.

Building the LNG Bunker Supply Chain in Singapore

With near-zero SOx emissions, LNG is an established solution to meet the IMO 2020 regulation to cut SOx emissions from global shipping to 0.5% or less by mass. LNG is also widely recognised for its lower levels of carbon emissions as compared to conventional marine fuels. MPA supports LNG as a transitional fuel. MPA has stepped up our efforts to develop Singapore’s LNG bunkering ecosystem and infrastructure.

LNG Bunkering Pilot Programme (LBPP)

The LBPP was launched in 2017, for a period of three years, to test operational protocols, gain operational experience and strengthen Singapore’s LNG bunkering capabilities. Together with the MSGI, the LBPP aimed to develop the three main pillars of the bunker supply chain, (i) supply; (ii) distribution infrastructure; and (iii) demand.



▲ Figure 6: MPA’s Efforts to develop the LNG Bunker Supply chain.



▲ Naming ceremony of LNG-fuelled bunker tanker, Marine Vicky, in Nantong, China, 2019.



▲ Asia’s first ship-to-containership LNG bunkering undertaken by CMA CGM and FuelNG in Singapore on 24 March 2021.

Following the delivery of the first LNG bunker vessel co-funded under the LBPP, Asia’s first ship-to-containership LNG bunkering operation was carried out by FuelNG and CMA CGM in Singapore on 24 March 2021. A total of 24 ship-to-ship LNG bunkering operations were completed in Singapore in 2021.

LNG Bunkering Infrastructure in the Port of Singapore

To support the berthing of LNG-fuelled ships at Jurong Port, JPPL has established the requisite LNG bunkering infrastructure for truck-to-ship LNG bunkering services. Since April 2018, more than 400 truck-to-ship LNG bunkering operations have been conducted to fuel LNG-fuelled harbour craft. Following the completion of its LNG break-bulking facility, JPPL will have the ability to provide direct ship-shore-ship LNG bunkering for more efficient bunkering operations.

Building on its experience with LNG bunkering, MPA plans to develop the ammonia bunkering ecosystem in Singapore through a pilot programme. The Programme will comprise of pilot trials, testing bunkering procedures, development of bunkering infrastructure, and honing of operational experiences and capabilities in ammonia bunkering.

III: Regulations and Standards Development

MPA is also committed to working with like-minded parties in industry and government to develop bunkering guidelines for future fuels in ports, such as through the Future Fuels Port Network. These guidelines would enable the safe transport and bunkering of low and zero-emission fuels.

For ammonia, GCMD has awarded its first invitation for proposals to define the safety and operation envelopes to enable ammonia bunkering pilots and demonstrations in Singapore. The study is aimed at addressing existing gaps in the safe transportation and handling of ammonia as a marine fuel, which will pave the way for its deployment when available at scale. GCMD will also set up an Industry Consultation and Alignment Panel to solicit inputs in response to the findings and recommendations from the study.

In the longer term, if and when the bunkering of ammonia has been operationalised, MPA also plans to work with stakeholders to develop a set of Technical Reference guidelines on the safe bunkering of ammonia and will partner international partners to achieve harmonised global standards.

IV: Demand – Market Structure and Policy

Another key strategy to developing potential pathways for future fuels is through demand aggregation across such multiple sector applications in Singapore, including transport, power generation, and other domestic applications. This serves to facilitate the creation of a cost-efficient future fuel ecosystem that would reap economies of scale.

An example of this is JPPL's proof-of-concept project to generate green electricity and support the bunkering of low and zero-carbon fuels. JPPL's Holistic Energy Sea Terminal Strategy allows for the repurposing and utilisation of existing storage and terminal infrastructure (e.g. berths, storage tanks, waterfront jetties), to support the handling of low and zero-carbon fuels for power generation as well as maritime applications, including bunkering.

Given the potential future adoption of hydrogen and its carriers in the maritime industry, MPA is working with various government agencies to assess the land-take, infrastructure and resource needs to build the ecosystem needed to trial the import, storage, distribution, and transportation of hydrogen. MPA will also partner the agencies to study the demand projections, regulatory incentives, and safety standards for future fuels across different sectors in Singapore.



▲ Launch of the invitation for proposals on the safety and operations of ammonia bunkering by Prof Lynn Loo, Chief Executive Officer, GCMD, on 8 October 2021.

V: Financing

MPA is working with MAS and industry partners to develop Singapore as a green maritime financing hub and expand the suite of green financing options. This will increase accessibility to sustainability-linked financing for the development of low and zero-carbon fuel solutions. More details can be found in Focus Area 7 on carbon awareness, carbon accounting and green financing.

VI: Talent and Skill Development

As the demand for low and zero-carbon fuels grows, so will demand for knowledge and skillsets pertaining to maritime decarbonisation. These include the operational expertise for the bunkering of low and zero-carbon fuels as well as knowledge of battery technologies and shipboard carbon capture systems. Employers should proactively identify the decarbonisation-related skills that are relevant for their workforce, and encourage and support their staff to upskill.

MPA will work with industry partners to identify and map out these emerging job roles and skills needs, and support enterprises to equip our maritime workforce with the necessary skills and knowledge to support the development of a low and zero-carbon bunkering hub in Singapore. More details can be found in Focus Area 6 on R&D and Talent.



▲ Launch of the FFPN at the Singapore International Bunkering Conference and Exhibition (SIBCON) 2020.

VII: International Partnerships

Finally, given the global nature of international shipping, it is crucial that bunkering standards for future fuels are harmonised and consistently adopted worldwide to ensure safe and seamless operations. Together with the Port of Rotterdam and the Ministry of Land, Infrastructure, Transport and Tourism, Japan, MPA signed a Memorandum of Cooperation in October 2020 to form the FFPN. The FFPN has developed a roadmap to explore the harmonisation of standards for the future marine fuels and pool the knowledge and network of various members to spur the development of future fuels, including the coordination of possible joint bunkering pilot runs with identified shipping lines between ports.

Another international partnership is with Australia. In June 2021, Singapore and Australia announced the formation of a “Low-Emissions Maritime and Shipping Initiative”, building on the Singapore-Australia MOU on Low Emissions Solutions. As part of the initiative, Australia and Singapore have each committed \$10 million to support demonstrations and commercial-scale projects, through delivery partners for low emission fuels and technologies for international maritime and port operations.

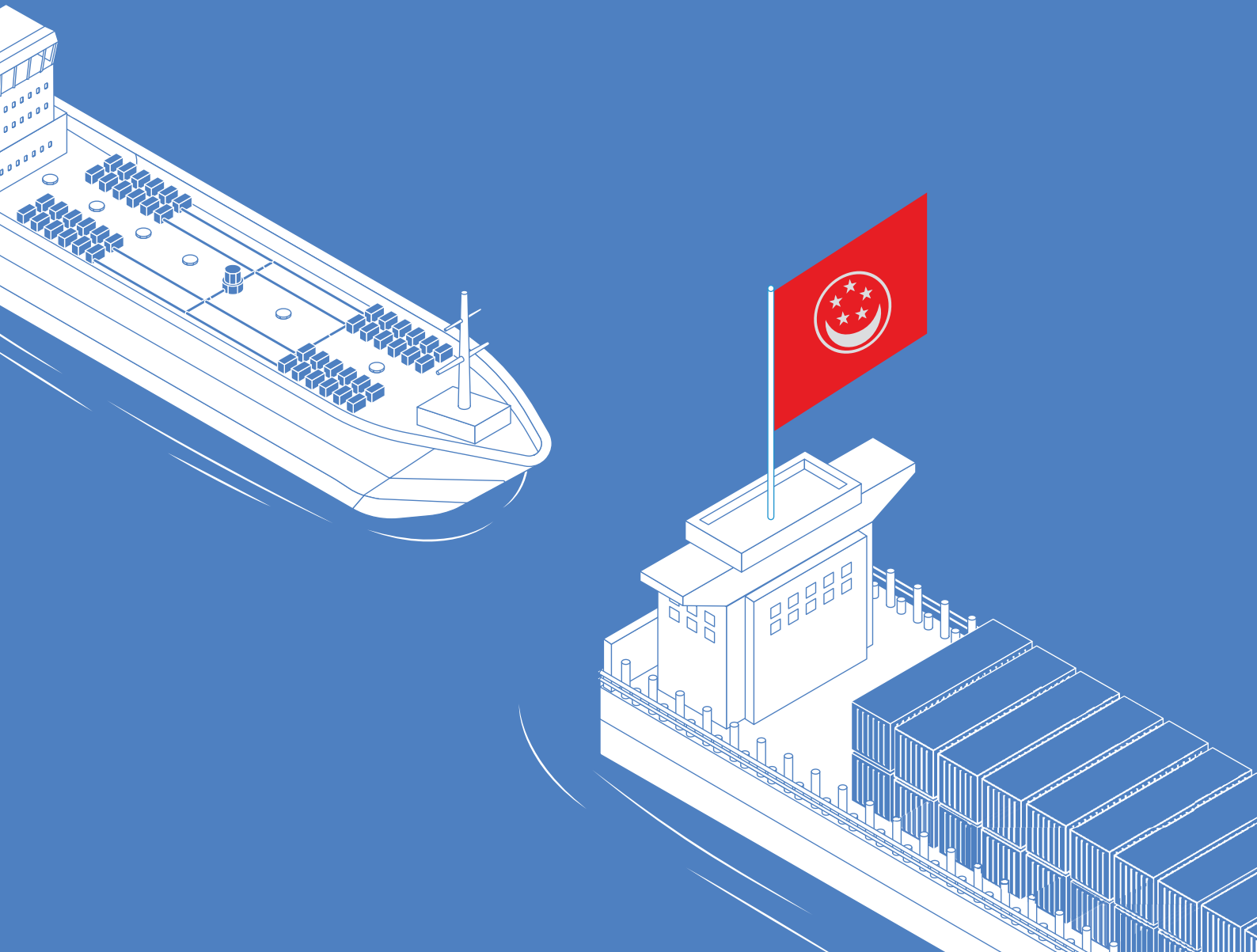


▲ Signing of the MOU between Singapore and Australia for cooperation on low-emissions solutions in October 2021.

FOCUS AREA 4

SINGAPORE REGISTRY OF SHIPS

As the leading flag of choice, the SRS is committed to work with ship owners and operators to achieve their green aspirations – including meeting IMO GHG targets and adopting low- and zero-emission solutions – through the provision of recognition, incentives and technical guidance.





Singapore Registry of Ships



The SRS is consistently ranked amongst the top five ship registries in the world, with its fleet size crossing a significant milestone of 96 million gross tonnage in 2020. As a reputable quality flag, the SRS is committed to tackling GHG emissions arising from international voyages made by Singapore-registered ships.

In 2011, MPA became the world's first maritime administration to launch a comprehensive sustainability initiative, the MSGI. MPA pledged \$100 million towards the establishment of the MSGI. The GSP, one of four components under the MSGI, incentivises Singapore-registered ships to reduce carbon dioxide and sulphur oxides emissions. In 2019, GSP was extended and enhanced, with new carbon emissions-related incentives replacing previous sulphur-emissions related ones. As at 31 December 2021, the number of ships enrolled under GSP totals 645, accounting for 11% of Singapore-registered ships.



▲ To promote and support clean and green shipping, MPA organised the inaugural Maritime Singapore Green Pledge signing ceremony during the Singapore International Maritime Awards in April 2011. At the event, MPA also launched the Maritime Singapore Green Initiative.



▲ Chee Hong Tat, Senior Minister of State for Transport, announced the launch of SRS Notation initiative to recognise ship owners and operators who voluntarily incorporate solutions to drive digital transformation, strengthen cyber security, enhance well-being of seafarers and pursue sustainable shipping.



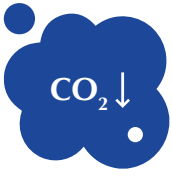
▲ The Red Ensign on a Singapore-registered ship.

Looking ahead, MPA will continue to build on our existing efforts to position the SRS for a low-carbon future. MPA intends to work with shipowners to have a larger fleet of Singapore-registered ships adopting energy efficient technologies and propelled by low or zero-carbon fuels in the long term. MPA will recognise, incentivise and guide shipowners to meet the targets under the IMO Initial Strategy and achieve their sustainability ambitions.

Recognising Green Aspirations – SRS Green Notation

Launched on 1 November 2021, the SRS Green Notation for Singapore-registered ships is awarded to Singapore-registered ships that reduce their carbon intensity to a level that exceeds the IMO EEDI Phase 3 requirements by at least 10% through the adoption of energy efficient technologies and/or adopt the use of alternative fuels. Ships awarded the Notation are issued with a Certificate of Recognition, which serves to enhance the vessel's attractiveness to charterers. Qualifying Singapore-registered ships will receive additional benefits such as reduction in their IRF and rebates on their ATT. Over the next 5 years, MPA expects a total of about 150 ships to be awarded the SRS Green Notation.

Qualifying Criteria for SRS Green Notation



1. SRS Green Carbon Reduction (CR)

SRS Green (CR) will be awarded to Singapore ships that have reduced their carbon intensity to a level that exceeds IMO’s EEDI phase 3 requirements by at least 10%.



2. SRS Green Low Carbon (LC)

SRS Green (LC) will be awarded to Singapore ships that use low carbon fuel with CF (conversion factor between fuel consumption and CO₂ emission) equal to or lower than LNG as primary fuel for their main engine and/or auxiliary engine(s).



3. SRS Zero-Carbon (ZC)

SRS Green (ZC) will be awarded to Singapore ships that use zero-carbon fuel as primary fuel for their main engine and/or auxiliary engine(s).

Supporting Shipowners in the Transition to Future Fuels

To encourage the adoption of low- and zero-carbon fuels as a means to meet the targets of the Initial IMO Strategy, **MPA will revise and enhance the existing GSP¹**. In particular, MPA will look at granting zero-carbon fuelled vessels maximum rebates or reductions on its IRF and ATT. **Over the longer term, MPA aims to have at least 50% of the SRS fleet to be GSP ships by 2050.**

MPA will continue to offer technical guidance and support to industry partners and shipowners. This will enable them to develop and undertake pilot trials for alternative future marine fuels, such as ammonia and hydrogen. For instance, along with relevant experts, MPA will assess whether future marine fuels are able to comply with relevant IMO requirements. In the exceptional case and where necessary, MPA will work with the shipowner to assess if exemptions should be granted, whilst ensuring that mitigating measures are put in place.

MPA will also continue to organise various expert-led industry engagement sessions, such as the annual SRS Forum, on topics such as the green transition in international shipping, to facilitate the exchange of information and best practices and build capacity amongst SRS shipowners.



▲ A new SRS logo, that encapsulates a future-ready and trusted registry, was launched at the SRS 55th Anniversary Forum on 8 October 2021.

¹The existing GSP will expire on 31 December 2024. Currently, incentives under the GSP are awarded to Singapore-registered ships that: i) exceed IMO’s EEDI requirements, ii) adopt engines capable of using LNG, and/or iii) adopt engines capable of using alternative fuel with carbon conversion factor equivalent to or lower than LNG.

FOCUS AREA 5

EFFORTS AT THE IMO AND INTERNATIONAL PLATFORMS

As a leading global hub port, bunkering hub and shipping registry, Singapore will advance strong, credible and inclusive climate action at the IMO and international fora.



Efforts at the IMO and International Platforms



The regulation of emissions from international shipping requires a global approach at IMO, to ensure a level playing field that does not discriminate against any flag or port state. In 2018, the IMO adopted the Initial IMO Strategy, which laid out the following targets:

- To reduce CO₂ emissions per transport work, as an average across international shipping, by at least 40% by 2030 pursuing efforts towards 70% by 2050, compared to 2008; and
- To peak GHG emissions from international shipping as soon as possible and to reduce the total annual GHG emissions by at least 50% by 2050 compared to 2008, whilst pursuing efforts towards phasing them out.

Singapore fully supports the targets that the Initial IMO Strategy sets out. As a leading global hub port, bunkering hub and shipping registry, Singapore had contributed actively to the development of the Initial IMO Strategy. Singapore is committed to strong, credible and inclusive climate action overall and at IMO. Singapore seeks to play three key roles internationally on the decarbonisation agenda – (i) standards-setter, (ii) bridge-builder and (iii) advocate of inclusive climate action.



▲ The Initial IMO Strategy was adopted by the IMO's MEPC during its 72nd session at the IMO Headquarters in London, United Kingdom.

Standards-Setter

Both at IMO and other international fora, Singapore contributes significantly to the development of global standards in areas related to the maritime decarbonisation agenda.

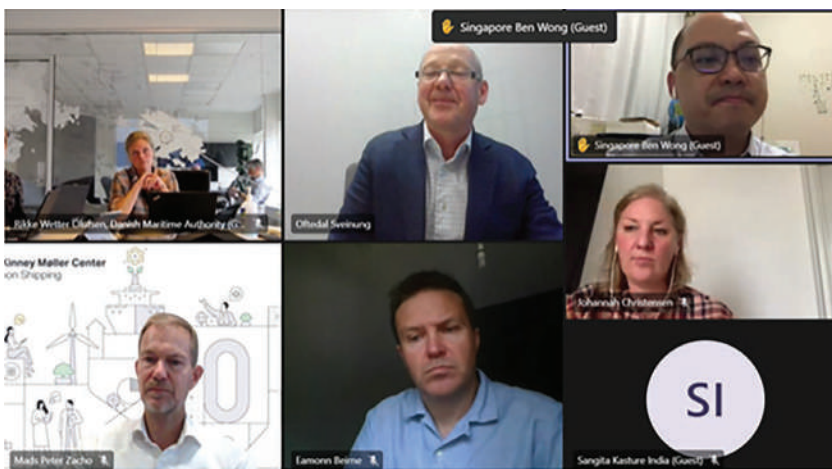
To support the effective uptake of alternative low-carbon and zero-carbon fuels, IMO plans to develop robust lifecycle GHG and carbon intensity guidelines for all alternative fuel types and prepare an implementation programme that will guide Member States to attain the 2030 and 2050 targets of the Initial IMO Strategy. This would include developing a methodology and standards to assess and verify GHG lifecycle emissions. MPA will contribute actively to these discussions at IMO, drawing on our existing efforts with GCNS and SSA in the area of carbon accounting.

As a global hub port, Singapore places great emphasis on ensuring safe international shipping. The adoption of low and zero-carbon fuels will require new, harmonised safety standards and regulations. Singapore seeks to partner fellow port authorities, maritime administrations and industry to develop harmonised standards and regulations for ships and ports to safely bunker alternative fuels, and work with fellow IMO Member States and observer organisations to draft and adopt such global standards at IMO.

In this regard, Singapore can offer its expertise from developing harmonised standards and procedures for LNG bunkering, and its work at the LNG Port Focus Group¹. For example, Singapore and Japan recently co-sponsored a joint submission to the 104th meeting of the IMO's MSC in October 2021, proposing a new work output to develop non-mandatory guidelines for ships using ammonia as fuel.

MPA has established the FFPN together with fellow port authorities, the Port of Rotterdam and Japan's Ministry of Land, Infrastructure and Transport, to develop a roadmap to explore the harmonisation of standards for clean marine fuels.

Singapore also participates alongside Denmark, Ghana, France, India, Morocco, Norway, the Republic of Korea, the United Kingdom, and the United States as a "Core Member" in the Zero-Emission Shipping Mission². Leveraging Singapore's experience as a bunkering hub and port authority, MPA will work closely with fellow Mission members and industry partners to develop the port infrastructure and regulatory standards for future fuels such as hydrogen, ammonia and biofuels.



◀ MPA participated in the Zero-Emission Shipping Mission 'Kick-Off Workshops' in October 2021.

Bridge-Builder

The IMO, through the work of the MEPC, is developing short, medium, and long-term measures to reduce GHG emissions from international shipping. Singapore played a key facilitative role in securing consensus to a package of short-term measures that included the development of the EEXI and CII guidelines with an associated rating system.

When taken together with existing IMO technical measures, the EEXI and CII guidelines will ensure that international shipping achieves the target of reducing carbon intensity by 40% compared to 2008 levels, by 2030. These are tangible first steps towards the reduction targets set out in the Initial IMO Strategy. Singapore will continue to work closely with the industry, Member States and non-governmental organisations with consultative status at IMO, to implement the guidelines for EEXI and CII.

In the short-term, alongside several other IMO Member States, Singapore has also supported the shipping industry's proposal to establish an International Maritime Research and Development Board, to be financed by the international shipping industry through mandatory contributions of US\$2 per tonne of marine fuel consumed.

¹The LNG Bunkering Port Focus Group was first formed in 2014 by MPA, Antwerp Port Authority, Port of Rotterdam and Port of Zeebrugge. The Group subsequently expanded to include the Ministry of Land, Infrastructure, Transport and Tourism, Japan; Ulsan Port Authority, Republic of Korea; the Port of Ningbo-Zhoushan, the Port of Marseille-Fos and the Port of Vancouver. The Focus Group built up a network of LNG bunker-ready ports across the East and West and Trans-pacific trade and developed a set of harmonised LNG bunkering standards and procedures for ocean-going vessels for LNG bunkering.

²The Zero-Emission Shipping Mission is a coalition of countries led by Denmark that aims to engage in activities to develop, test and commercialise maritime and energy technologies and make the market ready for zero emission vessels.

Singapore is supportive of the proposal as it is a global measure that would create urgently needed funds to make low and zero-carbon solutions commercially viable and widely available, while also enabling capacity-building that would support developing countries' climate action.

To facilitate informed and evidence-based decision-making at the IMO, Singapore actively contributes expertise both from MPA and from Singapore-based academic institutions³ to discussions and research on GHG matters. MPA was a member of the Fourth IMO GHG Study Steering Committee and contributed to an expert panel to review the outcomes of the Study. MPA and NUS also contributed expertise to the comprehensive impact assessment of short-term measures to reduce GHG emissions from ships.

Building Consensus on Mid- and Long-Term Measures

The Initial IMO Strategy considers “candidate mid- and long-term measures” to further incentivise the reduction of GHG emissions from ships. Of these, MBMs have been identified as possible candidate mid-term measures. As defined by IMO, MBMs place a price on GHG emissions and serve the purpose of providing an economic incentive for the maritime industry to reduce its fuel consumption by investing in more fuel-efficient ships and technologies and to operate ships in a more energy-efficient manner. To date, MBMs that have been discussed at the IMO include carbon levies and emission trading schemes (cap-and-trade).

Singapore recognises the fundamental importance of supporting mid- to long-term MBMs that achieve three key objectives: firstly, further reducing the sector's GHG emissions in line with the goals of the Initial IMO Strategy; secondly, incentivising the transition to low and zero-carbon emission solutions; and thirdly, assisting climate action in developing countries, particularly SIDS and LDCs.

To this end, **Singapore supports a global carbon levy on international shipping in the medium to long-term.** A global carbon levy can help provide the right price signals to encourage the uptake of low and zero-carbon solutions. It can also potentially strengthen the

architecture for an international R&D fund to develop viable and scalable low and zero-carbon solutions, in the like of the International Maritime Research and Development Board and Fund. As a non-discriminatory and market-based policy measure, a global carbon levy offers greater certainty for international shipping companies and sends the right price signals to encourage the uptake of low and zero-carbon solutions.

Most importantly, a unified, global approach for international shipping is key to achieve the targets set out in the Initial IMO Strategy. The alternative in the form of a patchwork of unilateral regulations will increase the compliance cost and regulatory complexity for international shipping.

Going forward, MPA will continue to actively contribute to global discussions on mid- and long-term measures at IMO, with the view to develop a carbon price mechanism that will move international shipping towards the goals of the Initial IMO Strategy. As discussions at the IMO on what type of measure will best serve the maritime industry are still evolving, Singapore remains open to exploring alternative proposals that are global in nature and is committed to engaging constructively with fellow Member States. To ensure that no country is left behind in its decarbonisation journey, Singapore will continue to advocate that a portion of the funds received from a global MBM should be allocated to support developing countries' climate action.

In addition, to support the implementation of the Initial IMO Strategy in an inclusive and consensus-driven manner, Singapore has pledged a sum of US\$100,000 to the IMO GHG Technical Co-operation – Trust Fund. Through this contribution, Singapore seeks to deepen understanding of relevant technical issues pertaining to GHG emissions reduction and support Member States in their maritime decarbonisation efforts.

In Singapore, MPA will also support first-mover maritime companies who desire to do more, for example, by facilitating the voluntary purchase of carbon credits or by supporting feasibility studies for carbon credits exchange and establishing methodologies for carbon accounting.

³These include the SMI, NUS, MESD CoE, NTU, and GCMD.

Advocate of Inclusive Climate Action

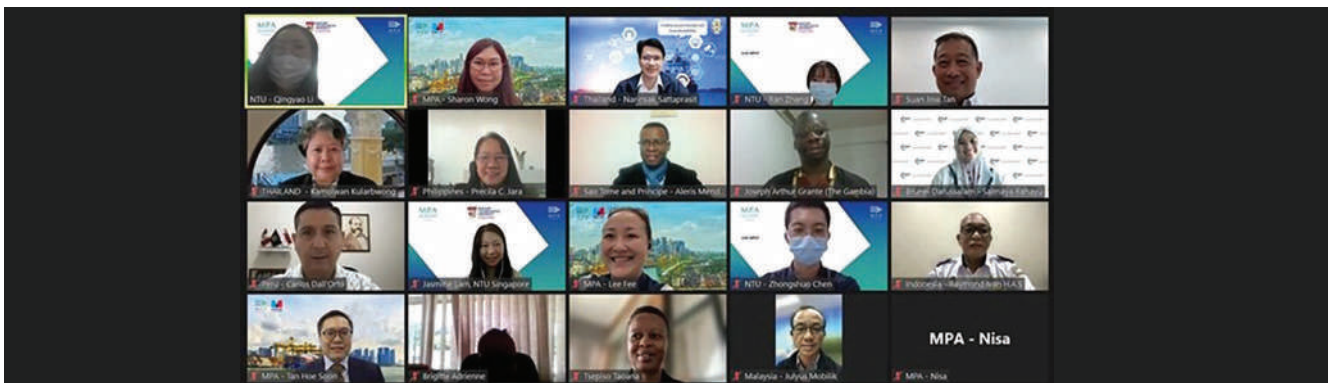
To facilitate information-sharing on decarbonisation initiatives across the maritime industry, Singapore has worked with the IMO to develop the NextGEN - Green and Efficient Navigation - initiative. NextGEN aims to develop a collaborative global ecosystem of maritime transport decarbonisation initiatives to build capacity, share best practices and ensure a level playing field for all countries in their decarbonisation journey.

In addition to NextGEN, Singapore remains committed to offer targeted capacity-building and technical assistance to support SIDS and LDCs in their efforts to meet the goals of the Initial IMO Strategy.

Singapore also actively provides global maritime leadership training for overseas port and maritime

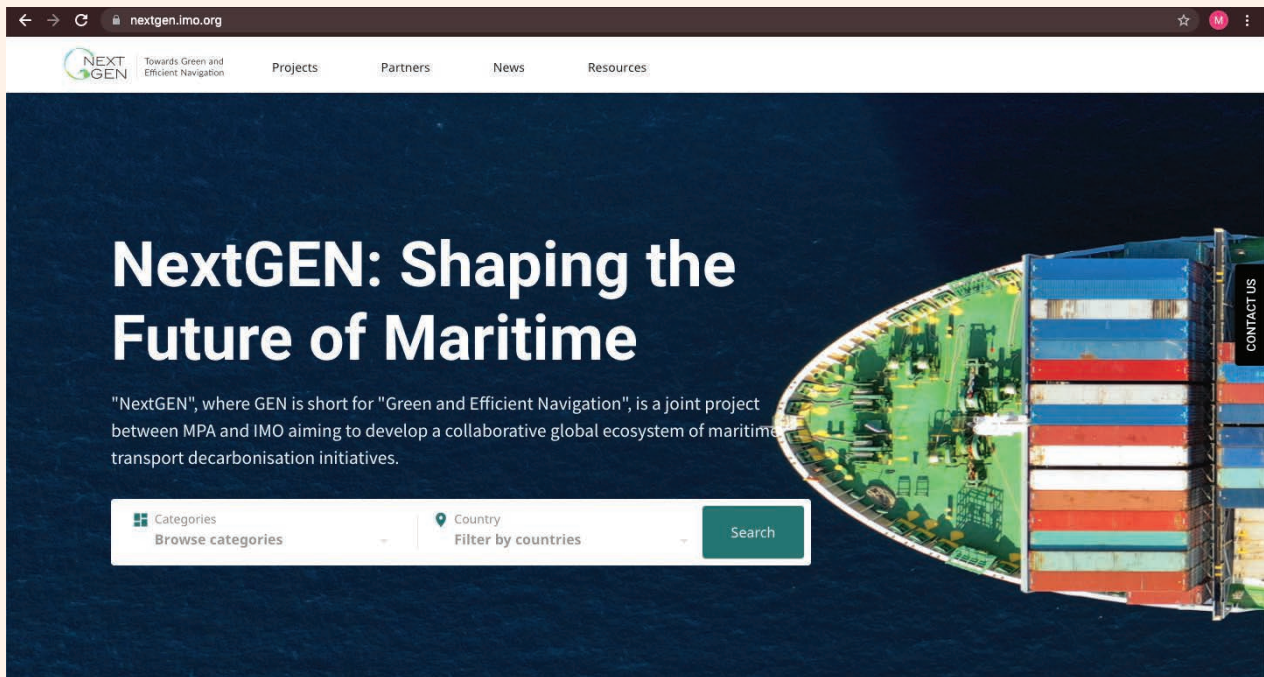
officials, including supporting the training needs of the IMO, through the MPAA's various flagship programmes. These programmes cover a wide range of topics, including leadership, policymaking, crisis communications, port planning and management, shipping economics, maritime law and sustainability.

With the emergence of new challenges and complexities brought about by decarbonisation, the MPAA will expand its existing sustainability module to feature more elements of maritime decarbonisation, such as carbon accounting and carbon reduction measures. Over the next few years, the **MPAA will also be looking to introduce a new flagship programme on maritime sustainability and decarbonisation**, which will leverage on the expertise and ecosystem of the recently established GCMD in Singapore.



▲ Maritime Leaders at at MPAA's 11th Maritime Public Leaders' Programme in November 2021.

Supporting Global Climate Action through the NextGEN Initiative



▲ NextGEN website.

The IMO-Singapore NextGEN initiative (where “GEN” stands for “Green and Efficient Navigation”) aims to catalyse stakeholder collaboration and idea-sharing to facilitate inclusive maritime decarbonisation.

Singapore co-organised the NextGEN Inaugural Meeting with the IMO on 23 April 2021, as part of the Future of Shipping Conference during Singapore Maritime Week 2021. At the Meeting, over 70 participants from governments, industry, international organisations, and academia all over the world came together to discuss some of the challenges countries are facing in their decarbonisation journeys, and brainstorm possible solutions and avenues for cooperation.



▲ The NextGEN inaugural meeting was held on 23 April 2021.

The Inaugural Meeting was followed by the official launch of the NextGEN virtual ecosystem at the IMO-United Nations Environment Programme Zero and Low Emission Innovation Forum on 27 September 2021. To date, the NextGEN virtual database encompasses over 150 maritime decarbonisation projects spanning over 500 partners and 13 fuel types. It has been a useful reference tool for IMO Member States and the industry.



▲ Launch of the NextGEN virtual ecosystem at the IMO-UNEP Zero and Low Emission Innovation Forum on 27 September 2021.

NextGEN is also an important platform to identify opportunities and gaps for decarbonisation in the global shipping community, so that all countries, especially SIDS and LDCs, can take concrete action towards the IMO's goals. The NUS Centre for Maritime Studies has developed "A view on global decarbonisation initiatives through the NextGEN lens", a report that leverages on the NextGEN database to identify technology, infrastructure and resource gaps in the existing maritime decarbonisation landscape.

Going forward, Singapore will be working with the IMO and stakeholders to launch the next phase of NextGEN. "NextGEN Connect" will present scenario-based problem statements derived from NextGEN stakeholders and data collected from the NextGEN database. Through launching a "Call for Proposals" that will be open to industry, academia, and global research centres, NextGEN Connect will bring different stakeholders together to identify inclusive and concrete solutions and seed collaborations to bring all Member States towards the levels of ambition in the Initial IMO Strategy.



FOCUS AREA 6

RESEARCH & DEVELOPMENT AND TALENT

Singapore will be a global hub for maritime decarbonisation R&D solutions, enabled by a vibrant ecosystem, with the talent and expertise to develop, trial, deploy and commercialise innovations.



Research & Development and Talent



Research, innovation, and enterprise underpin Singapore's maritime decarbonisation capability development effort, and talent is the 'glue' that binds the different players together. Singapore is home to a vibrant landscape of start-ups, technology companies and research institutes focusing on green technologies. There is also a broad suite of enablers – such as research infrastructure, regulatory sandboxes, funds for R&D and trials, and incubators and accelerators – to support innovations in green technology products and solutions.

Catalysing R&D and Innovation

Developing and entrenching a maritime decarbonisation ecosystem in Singapore not only increases the likelihood of success of Singapore's domestic mitigation and international efforts, it will also create new opportunities and jobs for people in Singapore. MPA has committed \$80 million worth of funding for maritime decarbonisation R&D. This includes funds allocated to support the establishment of MESD CoE, the Maritime GreenFuture Fund¹, and GCMD, in addition to funding for other programmes and projects with maritime enterprises and research performers. These are expected to catalyse about 20 technology projects, and train over 100 researchers, scientists and engineers in the next five years.

Global Centre for Maritime Decarbonisation (GCMD)

In 2021, MPA and six industry partners launched the GCMD. The objective of the GCMD is to help the maritime industry eliminate GHG emissions by shaping standards, deploying solutions, financing projects, and fostering collaboration across sectors.

As a centre focusing on high TRL development (between TRL 7 to 9), the GCMD will also seek to tap on resources in IHLs to develop knowledge and solutions.

The GCMD will catalyse collaborative projects with a multitude of stakeholders, including shipping companies, energy suppliers, terminal and tank operators, research centres, shipyards, and engineering companies, to advance the deployment

of zero/low-carbon solutions in the maritime industry. Areas of interest include biofuels (e.g. fatty acid methyl esters, hydrotreated vegetable oil, bio-methane and bio-methanol), e-ammonia, and e-liquid hydrogen.



▲ Launch of GCMD in September 2021 with Billy Chiu, Executive Vice President, BW Maritime Pte Ltd (left), Lynn Loo, Chief Executive Officer, GCMD (second from left), Cyril Ducau, Chief Executive Officer, Eastern Pacific Shipping (centre), Quah Ley Hoon, Chief Executive, MPA (second from right), Rashpal Singh, Vice President, Maritime & Supply Chain Excellence, BHP (right).

¹In partnership with SMI, NRF and venture capital partners – Rainmaking and NTU EcoLabs Centre of Innovation for Energy.

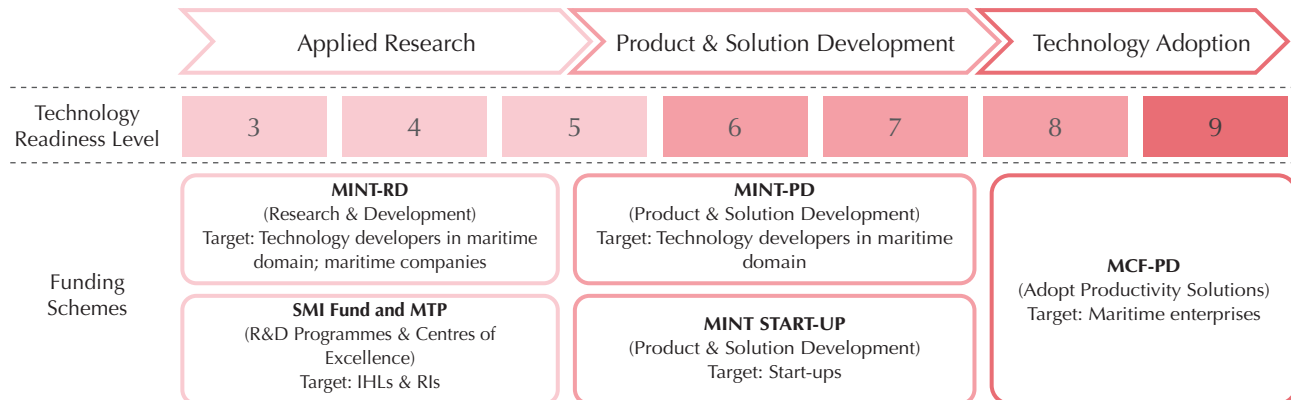
An Enabling Environment for Collaboration & Innovation

MPA collaborates with like-minded partners across value chains. Under the Maritime R&D Roadmap 2030, MPA, SMI and industry stakeholders have jointly outlined green technology capability development areas for the maritime sector in the upcoming decade, as illustrated in the table below.

Green Tech Capability Development Areas

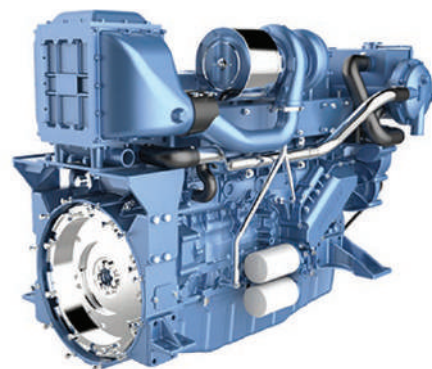
Focus Area	Present to 5 years	In 10 years
Electrification	<p>Harbour craft Pilot: Commence electric harbour craft pilot adoption with charging infrastructure based on a commercially viable approach</p> <p>Infrastructure: Utilise new tools for planning charging infrastructure, optimising electric harbour craft design and integration</p> <p>Terminals Deployment: Electrification of horizontal transport and cargo handling equipment in terminals</p>	<p>Ocean-going vessels Deployment: Long endurance electric vessels</p> <p>Infrastructure: Trials on rapid charging infrastructure</p>
Sustainable Fuels	<p>Harbour craft and ocean-going vessels Pilot: Commence biofuel pilot adoption with a framework for cleaner fuel adoption</p> <p>Measurements: Deploy tools for traceability and accounting of emissions reduction based on LCA</p> <p>Certification/Accreditation: Establish methodologies for emissions, fuel quality and quantity verification</p> <p>Terminals Deployment: LNG for horizontal transport in terminals</p>	<p>Harbour craft and ocean-going vessels Trials: Trials on 3rd and 4th generation biofuels (produced from algae and bacteria respectively, using non-arable land)</p>
Abatement Measures	<p>Harbour craft and ocean-going vessels Study: Validate pathways for shipboard carbon capture, conversion and downstream utilisation</p> <p>Trials: Commence prototype trials for CCSU Terminals</p> <p>Deployment: Circular economy with integrated water-waste-energy within port life cycle</p>	<p>Harbour craft and ocean-going vessels Trials: Sea trials for full scale CCSU</p> <p>Optimisation of capture and conversion technologies</p>
Future Marine Fuels	<p>Harbour craft and ocean-going vessels Studies: Investigate viability of different hydrogen (and hydrogen carriers) as potential zero-carbon fuel</p> <p>Studies: Identify key areas of research necessary for deployment of hydrogen-based fuel</p> <p>Terminals Trials: Hydrogen fuel cell for horizontal transport</p>	<p>Harbour craft and ocean-going vessels Trials: Sea trials for prototype hydrogen-fuelled vessel</p> <p>Trials: Development of high efficiency energy conversion technologies</p> <p>Infrastructure: Future bunkering process and infrastructure</p>

Given the high costs of technology investment, financing mechanisms and funding are crucial to support first movers in their R&D efforts and pilot trials. MPA has and will continue to co-fund worthy decarbonisation projects at the various stages of R&D, pilot trials, translation and deployment, through a range of funds, programmes and platforms. These include the Maritime Transformation Programme², SMI, and MPA’s MINT Fund, in collaboration with GCMD.



▲ Figure 7: Funding schemes for maritime R&D projects.

One such funding scheme is the Maritime GreenFuture Fund launched by MPA in 2020 to support the development of new technologies and pilot the use of alternative marine fuels such as methanol and biofuels, as well as electric vessels. Another example of support is MPA’s MINT Fund support to a local SME, Billion Miles, to develop a novel bi-fuel methanol direct injection system³ under the MINT Fund. Billion Miles’ class-approved novel design allows for a single injection for both fuel types, hence reducing the complexities of engine design and subsequent expected maintenance costs.



▲ Billion Miles’ Bi-fuel Methanol Direct Injection System (BMDi™).

Building Global Talent in Maritime Decarbonisation

As more start-ups, research centres and industry consortiums pursue R&D relating to maritime decarbonisation, the demand for researchers and specialists across a wide range of disciplines – such as chemical engineering, marine engineering and software programming – will grow. An increasing number of maritime companies are also employing sustainability strategists, carbon accountants and business development managers, to chart their businesses’ longer-term decarbonisation pathways and tap on new opportunities that maritime decarbonisation has to offer.

The impact of maritime decarbonisation on jobs and skills would not be limited to niche, sustainability-dedicated job roles. Even while maritime decarbonisation solutions and norms are still being developed today, maritime companies are already sourcing for candidates with decarbonisation-related knowledge to fill existing job roles. Some examples include business development managers with understanding of LNG shipping markets, or strategy analysts with knowledge of maritime decarbonisation trends.

²A funding initiative that leverages NRF’s RIE funds to grow maritime R&D capabilities and transform the sea transport sector.

³The project consists of 2 phases, (1) to design and develop a storage and mixing system for use with an auxiliary marine engine and evaluate the methanol fuel blend with the system on land and (2) to design and develop a storage and mixing system for use with a main marine engine and evaluate the methanol fuel blend with the system onboard a vessel. Billion Miles has successfully completed Phase 1 and Phase 2 is underway.



▲ Chief Digital Innovators and Chief HR Officers from maritime companies discuss future job roles and skills in January 2019.

MPA is prepared to help companies defray manpower costs incurred in Singapore that are associated with qualifying maritime decarbonisation activities, including R&D, pilot trials, translation and deployment, and business growth projects. As the industry transitions to alternative fuels, MPA anticipates that seafarers and superintendents would need to be re-trained and upskilled to handle and operate future vessels types. Employers should proactively identify or consider decarbonisation-related skills that are relevant for their workforce and encourage and support the upskilling of their staff.

Singapore's efforts in maritime decarbonisation are projected to create and upskill a total of 1,200 sustainability-related jobs over the next ten years.

This includes dedicated new green jobs and existing maritime jobs with expanded scopes in sustainability-related fields. This figure is expected to increase over time, as more green innovative technologies mature and the industry transits to meet IMO targets in 2030 and 2050.

MPA will work closely with our industry partners and IHLs to better understand these emerging decarbonisation-related jobs and skills needs and ensure the adequacy of pre-employment and mid-career training opportunities. MPA will also be providing co-funding support to employers and employees to ensure that our maritime workforce has the necessary relevant skills and knowledge in the domain of maritime decarbonisation.



▲ A Maritime Decarbonisation Symposium was held in September 2021, organised by SMF and the Centre for Maritime Studies at the NUS.

Understanding Singapore's Maritime Innovation Landscape

Start-Ups

Start-ups are an important part of the maritime innovation ecosystem in Singapore. From start-up accelerators and incubators to venture capital funds, there is a growing network which supports start-ups in developing commercial capabilities and technology solutions that focus on decarbonisation and sustainable shipping.

This includes MPA's start-up ecosystem building programme, PIER71™, and their partners such as Rainmaking Innovation, KSL Maritime Ventures, ShipsFocus-Quest Ventures and NTU Ecolabs. These business ventures and platforms call upon global tech start-ups and scale-ups to put forth new proposals and solutions for maritime customers. Aside from funding, they provide access to industry mentorship,

maritime tech talent, co-working spaces and active industry engagement and publicity opportunities.

Research Institutes

Singapore is also home to several public and private research centres and IHLs that enrich the maritime innovation ecosystem by driving cutting-edge R&D.

The MESD CoE at NTU was established in 2017, as a leading global translational research centre in sustainable maritime energy. It has worked closely with industry partners on various projects to support their transition towards a low carbon industry. Key projects include studies and trials to support potential alternative energy sources for international shipping and the harbour craft industry.



▲ Publications by the MESD CoE

Knowledge Centres

Various classification societies have set up their knowledge centres in Singapore. Such centres provide technical expertise, platforms and collaborative opportunities for maritime companies. American Bureau of Shipping launched its Global Sustainability Centre in Singapore in April 2019, with the mission to help maritime decarbonise and transition to a sustainable, lower emissions industry.

DNV also established a regional Centre of Excellence for Southeast Asia in Singapore in February 2021, to drive decarbonisation and autonomy in shipping. The centre focuses on establishing new maritime processes, standards and frameworks, and will explore novel fuel technologies to accelerate decarbonisation of the maritime industry.

FOCUS AREA 7

CARBON AWARENESS, CARBON ACCOUNTING, AND GREEN FINANCING

To build Singapore as a green maritime finance hub, MPA will continue to strengthen capabilities in carbon accounting and reporting and promote green financing within the maritime industry.



Carbon Awareness, Carbon Accounting, and Green Financing



Globally, there is growing carbon consciousness in financial institutions, investors, regulators, and customers, who increasingly expect companies to measure, mitigate and offset the carbon footprint of their operations.

The maritime industry is no exception to this trend. However, there is currently no standardised method to comprehensively measure emissions across ship- and shore-based operations. Some prevailing carbon accounting measurements used by maritime entities currently include the IMO's EEDI, the EEOI adopted by the Sea Cargo Charter¹, and the AER in the Poseidon Principles². The lack of a harmonised and accessible measurement system based on common emission classifications is inhibiting maritime companies from progress in their carbon inventory and reporting efforts.

The growing decarbonisation agenda creates opportunities for Singapore to position itself as a leading carbon services hub in Asia. Supported by a conducive regulatory environment, and by developing quality standards or guidelines for carbon accounting and offsetting, Singapore aims to attract and anchor ecosystems of carbon services providers, including within the maritime industry. MPA will undertake various strategies to secure Singapore's position as a green maritime finance hub.

Strengthen Capabilities and Develop Guidelines for Carbon Accounting and Reporting in the Maritime Industry

MPA has been a front-runner in promoting sustainability reporting in the maritime industry. Together with SGX and GCNS, MPA launched the first sector-specific Maritime Sustainability Reporting Guide in 2019, under the Green Awareness Programme of the MSGI. The Guide provided listed and non-listed maritime companies with a practical framework, including best practices, to produce high-quality sustainability reports. Additionally, MPA has co-sponsored maritime companies in cultivating their sustainability reporting capabilities and pursuing sustainable business practices. To date, a total of 10 companies have been awarded funding and received training through workshops and forums.



▲ In 2020, MPA, SSA and GCNS organised an introductory webinar to promote greater carbon awareness amongst the maritime industry and companies. Jimmy Koh, PSA Marine (bottom left); Er. Tham Wai Wah, Chief Sustainability Officer, MPA (top right); Dr Ryal Wun, Deputy Executive Director, GCNS (bottom right); Michael Phoon, Executive Director, SSA (top left).

¹The Sea Cargo Charter is a global framework for assessing and disclosing the climate alignment of chartering activities. It is applicable to all charterers and currently includes 29 charterers as signatories.

²The Poseidon Principles is a global framework for assessing and disclosing the climate alignment of financial institutions' shipping portfolios. Currently, 27 financial institutions are signatories to the Poseidon Principles.

Launch of the Maritime Sustainability Reporting Guide

MPA, together with its partners – SGX, GCNS, Institute of Singapore Chartered Accountants, and sustainability consultants from Ernst & Young LLP, KPMG and PwC Singapore, launched the first sector-specific Maritime Sustainability Reporting Guide in 2019.

The Guide provided a practical framework, including best practices for creating a maritime sustainability report, for both listed and non-listed maritime companies. The need for the Guide was spurred by industry feedback on the growing need for sustainability reporting guidelines, given that sustainability development practices bring various benefits to businesses. The Guide also featured MPA's own sustainability reporting journey as a case study, including its internal sustainability initiatives through the years, and attested to MPA's efforts to champion sustainability reporting for the maritime industry.



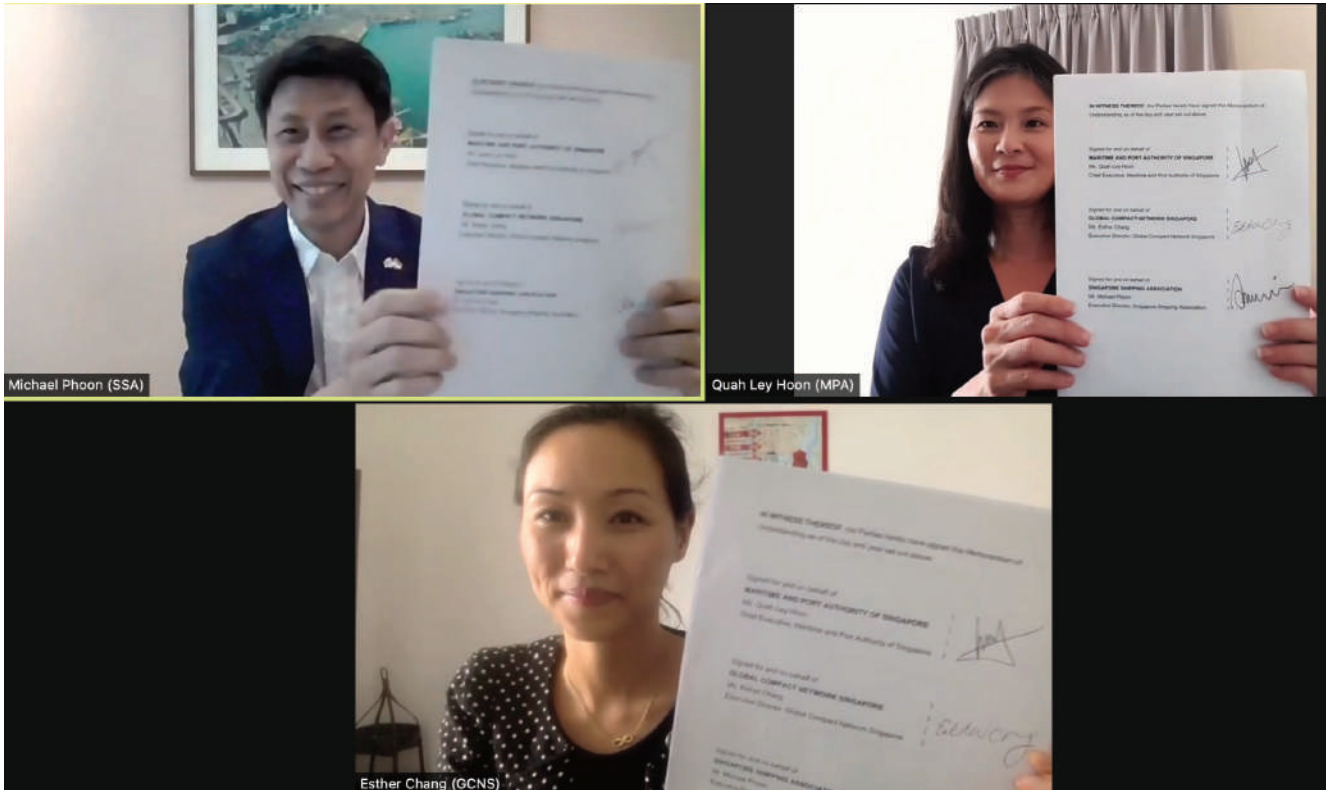
▲ Launch of the first sector-specific Maritime Sustainability Reporting Guide by MPA and its partners in August 2019, to encourage maritime companies to embark on or further invest in sustainability reporting efforts.

In 2021, MPA signed a memorandum of understanding with GCNS and SSA to collaborate on training and sharing of best practices to raise carbon accounting capabilities amongst maritime companies in Singapore. Looking ahead, MPA plans to deepen its partnership with GCNS and SSA, to strengthen awareness and develop similar carbon reporting capabilities for the community of harbour craft operators in Singapore. MPA, GCNS and SSA will conduct industry engagements and training sessions to equip eligible companies with the expertise to track and monitor their emissions data.

Such initiatives will equip maritime companies with a foundation to build up internal capabilities, work towards green certification and adopt internationally

recognised frameworks for sustainability performance reporting such as the Carbon Disclosure Project and Science Based Targets Initiative. This will better position maritime companies to access green financing and conduct green procurement practices.

In the medium term, **MPA aims to develop a maritime sector-specific carbon accounting guide**, which will set out a harmonised and accessible carbon measurement system based on common carbon emissions classifications. With the Guide, MPA intends to offer carbon reporting and accounting training programmes to the wider maritime industry and expand the scope of these programmes to include life-cycle analysis and life-cycle costing associated with carbon accounting methodology guidelines.



▲ MPA, SSA and GCNS signed an MOU at a virtual ceremony in September 2021. Michael Phoon, Executive Director, SSA (top left), Quah Ley Hoon, Chief Executive, MPA (top right), Esther Chang, Executive Director, GCNS (bottom).

Leveraging Whole-of-Government Carbon Accounting Initiatives

LowCarbonSG, a joint initiative between NEA, MSE and MTI, aims to build awareness amongst SMEs about the need to decarbonise, the climate risks and impact to their businesses, as well as the opportunities available. LowCarbonSG also supports local SMEs to kickstart their efforts to measure and track emissions through capability building. To identify opportunities and solutions for emissions reduction, companies under the LowCarbonSG programme are given free access to resources such as workshops and playbooks, guidance on measuring and tracking their resource consumption and emissions, matching with solution providers, and access to government funding.

As sectoral lead for the maritime industry, MPA actively promotes LowCarbonSG to maritime companies. Maritime companies who have participated and completed the MSGI Green Awareness Programme with MPA will also be eligible to participate in the LowCarbonSG programme.

Exploring Opportunities for Voluntary Carbon Trading in the Maritime Sector

MPA is exploring the potential of carbon offsets and services for the maritime industry, by supporting maritime companies in Singapore that wish to study the voluntary use of carbon credits to achieve their decarbonisation objectives. The intention is raise the industry's understanding of voluntary carbon trading and build up capabilities in the field of carbon accounting and offsetting.

Climate Impact X

CIX is a carbon exchange and a global marketplace that provides corporate buyers with effective solutions to tackle climate change through high-quality carbon credits.

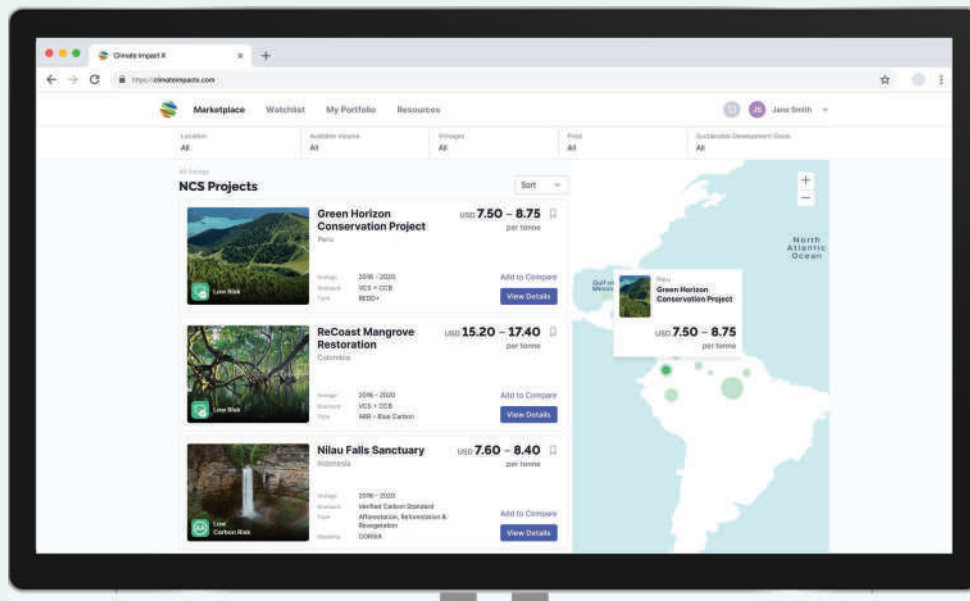
Jointly established by DBS, Singapore Exchange, Standard Chartered and Temasek, CIX delivers high-quality carbon credits in the voluntary carbon market, while providing deep liquidity to serve the growing needs of this market. It harnesses tech-based solutions, such as satellite monitoring and machine learning to deliver transparent data and comprehensive risk ratings to its buyers.

CIX is focused on supporting NCS through its platforms, which involve protection and restoration of natural ecosystems such as forests, wetlands and mangroves. NCS can be cost effective and provide significant additional benefits by supporting biodiversity and generating income for rural communities. CIX features carbon credits from various high-quality NCS projects around the globe on its platforms.

CIX is developing three distinct platforms to serve corporate buyers (e.g. MNCs and institutional investors), along with carbon credit traders:

- a) **The Project Marketplace** – A digital platform for buying high-quality carbon credits from specific projects. The Marketplace is ideal for custom purchases, with each project supported by transparent impact, risk and pricing data.
- b) **Auction** – Brings groups of qualified buyers to bid for select carbon credit projects, and portfolios of projects. The interactive process helps buyers with discovery of fair market value and is well suited to larger-scale transactions of carbon credits.
- c) **The Exchange** – Caters to faster-moving buying, selling and trading of more standardised carbon products. The platform will offer standardized contracts backed by high-quality carbon projects. CIX will also provide access to real-time data that will guide users when taking positions and managing price risks in the market.

Together, these platforms will flexibly serve different buyer needs; providing the liquidity of high-quality standardised credits, alongside premium, project-specific credits with attributes that align directly with a buyer's mission and sustainability priorities.

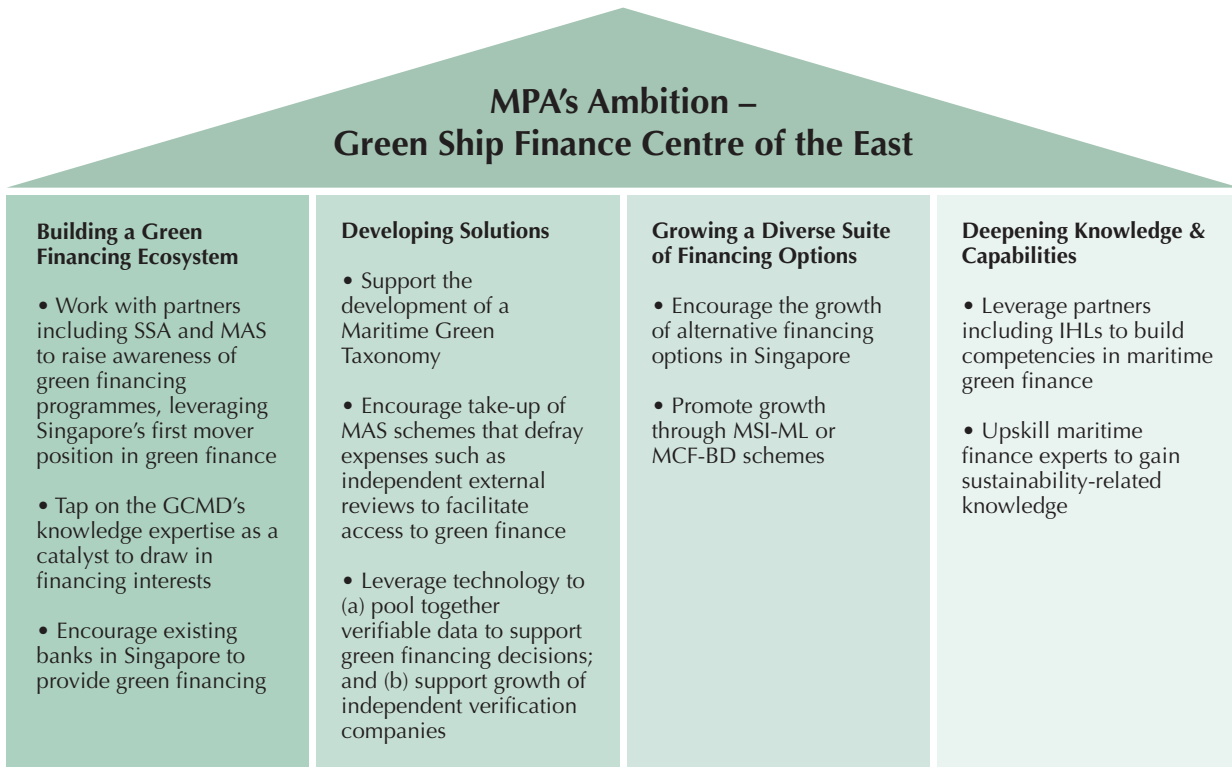


▲ A visual representation of CIX's auction platform.

Developing the Green Financing Landscape in Singapore

Singapore is home to some 20 international banks with ship finance portfolios. This network is complemented by a diverse suite of alternative financing options for the shipping industry, including maritime leasing and listing opportunities on the Singapore Exchange.

MPA aims to establish Singapore as a green maritime finance hub, which complement ongoing efforts by the MAS in cultivating Singapore as a leading centre for green finance in Asia and globally. Working with key stakeholders and partners, our strategies include building a green financing ecosystem, developing a wide range of solutions, building a suite of financing options and deepening knowledge and capabilities.



Building an Ecosystem

MPA's vision is to build an ecosystem comprising diverse players offering both traditional and alternative sources of financing, as well as intermediaries that can connect shipping interests to such sources of financing. By working with industry partners, such as the SSA and financiers, MPA has been actively cultivating platforms to facilitate capital mobilisation – where shipping companies and investors are brought together either digitally or physically. The end goal is to stimulate investors' interest in a wide pool of financing projects and solutions, thereby elevating Singapore's profile as a choice location for maritime companies to source for institutional financing.

MPA will actively encourage maritime companies to tap on schemes such as MAS' GSLS. The GSLS defrays expenses associated with engaging independent

sustainability advisory and assessment service providers for validating the green credentials of a loan, thereby allowing companies to improve their corporate governance and access to green financing.

Developing Solutions

To establish clearer linkages between climate improvement action and capital investment, **MPA will work with MAS, GCMD and relevant partners to develop a standard taxonomy for sustainable assets and activities in the maritime sector.** This will provide corporates, investors, and policymakers across different industries with clearer and more consistent definitions on economic activities that are deemed environmentally sustainable.



Riding the wave of digitalisation, MPA is also engaging local technology companies on possible solutions that can help integrate the assessment of ship operation and emissions data into the lending decision processes of ship financiers. Our goal is a green shipping data ecosystem capable of consolidating relevant, verified ship-centric data from across multiple stakeholders. From here, digital solutions or analytic tools may be developed to help financiers measure or track carbon abatement capabilities and asset performance. Successful deployment of such solutions or tools will enable easier benchmarking, target setting and impact measurement of assets which in turn accelerates maritime green financing.

Building a Diverse Suite of Financing Options

MPA seeks to attract green-focused shipping funds to operate out of Singapore. MPA will use its schemes – MSI-ML and MCF-BD – to facilitate the setting up of such funds and their subsequent expansion in Singapore.

To grow the pool of green financing options, MPA is working with financial intermediaries to ensure that shipping companies based in Singapore continue to have access to varied sources of financing. MPA is engaging various stakeholders to explore the development of new financial products – such as green and sustainability-linked loans and bonds-to deepen the financing landscape for the maritime industry in Singapore.

Driving Industry Growth through Green Financing

In March 2021, Hafnia Limited, a member of Singapore-based BW Group, signed a seven-year US\$374 million (about \$500 million) sustainability-linked term loan and revolving credit facility with a 10-bank syndicate. The facility has an annual sustainability margin adjustment mechanism that tracks the company's continuous improvement in emissions-related key performance indicators, such as decarbonisation targets linked to the Initial IMO Strategy. The loan was the first-of-its kind from the maritime industry to tap on the MAS' GSLS, a grant scheme which helped to defray the expenses of engaging an independent sustainability advisory and assessment service provider to validate the loan credentials.

PSAM, a Singapore-based towage operator, was the first entity in Singapore's maritime industry to be granted a sustainability-linked loan from local bank DBS in November 2021. The three-year loan, valued at over €30 million (about \$46 million), features an interest rate adjustment which is linked to an ESG target – requiring a fleet of PSAM's crew transfer vessels to be substantially deployed to support offshore wind energy-related activities.

In March 2021, Sembcorp Marine secured a \$500 million sustainability-linked financing facility, which references the SORA, from DBS. The facility is believed to be the first SORA-based sustainability-linked loan for the maritime industry. The loan facility features interest rate discounts that are linked to pre-determined ESG targets, aligned to Sembcorp Marine's performance targets set out in its sustainability report.

Deepening Green Financing Skillsets & Capabilities

To develop sustainability-related skillsets and upskill the existing workforce in nascent areas of green finance and related sectors, MPA will work alongside government agencies, tripartite partners and IHLs to formulate curricula for courses and programmes within relevant centres of excellence and institutes. MPA will continue to work with IHLs to develop maritime-relevant courses that have bespoke competencies (e.g. climate risk modelling, impact investing, climate-related financial disclosure) applicable to green financing.

Glossary



AER – Annual Efficiency Ratio	MEPC – Marine Environment Protection Committee (IMO)
AiP – Approval in Principle	MESD CoE – Maritime Energy and Sustainable Development Centre of Excellence
ASMI – Association of Singapore Marine Industries	MNC – Multinational Corporation
AGV – Automated Guided Vehicle	MOU – Memorandum of Understanding
AI – Artificial Intelligence	MPA – Maritime and Port Authority of Singapore
ATT – Annual Tonnage Tax	MPAA – Maritime and Port Authority of Singapore Academy
BAU – Business-as-Usual	MSC – Maritime Safety Committee (IMO)
CCSU – Carbon Capture, Storage and Utilisation	MSE – Ministry of Sustainability and the Environment
CO ₂ – Carbon dioxide	MSGI – Maritime Singapore Green Initiative
CII – Carbon Intensity Indicator	MSI-ML – Maritime Sector Incentive – Maritime Leasing
CIX – Climate Impact X	MTI – Ministry of Trade and Industry
EEDI – Energy Efficiency Design Index	NCS – Natural Climate Solutions
EEOI – Energy Efficiency Operational Index	NEA – National Environment Agency
EMA – Energy Market Authority	NRF – National Research Foundation
ESG – Environmental, Social and Governance	NTU – Nanyang Technological University
EEXI – Energy Efficiency Index for Existing Ships	NUS – National University of Singapore
FFPN – Future Fuels Port Network	PIER71 – Port Innovation Ecosystem Reimagined @ BLOCK71
FOSC – Future of Shipping Conference	PPT – Pasir Panjang Terminal
GCNS – Global Compact Network Singapore	PSAC – PSA Corporation Ltd
GCMD – Global Centre for Maritime Decarbonisation	PSAM – PSA Marine Pte Ltd
GHG – Greenhouse Gas	PV – Photovoltaic
GSLS – Green and Sustainability-Linked Loan and Grant Scheme	RIE – Research, Innovation and Enterprise
GSP – Green Ship Programme	RO-RO – Roll-On, Roll-Off
GWh – Gigawatt Hours	RMC – Ready-Mix Concrete
IFP – Invite for Proposal	RMG – Rail Mounted Gantry
IHL – Institute of Higher Learning	RTG – Rubber Tyre Gantry
Initial IMO Strategy – Initial IMO Strategy on Reduction of Greenhouse Gas Emissions from Ships	R&D – Research and Development
IRF – Initial Registration Fees	SGX – Singapore Exchange Limited
JDP – Joint Development Project	SIDS – Small Island Developing States
JIT – Just-In-Time	SME – Small and Medium Enterprise
JPPL – Jurong Port Pte Ltd	SMF – Singapore Maritime Foundation
LCA – Life Cycle Analysis	SMI – Singapore Maritime Institute
LDCs – Least Developed Countries	SORA – Singapore Overnight Rate Average
LED – Light Emitting Diode	SO _x – Sulphur oxide
LNG – Liquefied Natural Gas	SP – Singapore Power Group
LBPP – LNG Bunkering Pilot Programme	SRS – Singapore Registry of Ships
IMO – International Maritime Organization	SSA – Singapore Shipping Association
MAS – Monetary Authority of Singapore	SUTD – Singapore University of Technology and Design
MBM – Market-Based Measures	tCO ₂ e – Tonnes of Carbon Dioxide Equivalent
MCF-BD – Maritime Cluster Fund – Business Development	TEU – Twenty-foot Equivalent Unit
MCF-PD – Maritime Cluster Fund - Productivity Development	TRL – Technology Readiness Level
MINT Fund – Maritime Innovation and Technology Fund	UNFCCC – United Nations Framework Convention on Climate Change



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