

GREEN PLAN

**Webinar on Chile and Green Hydrogen
Potential for Innovation, Sustainability and Development**

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Jointly led by:



Agenda

1. Overview of the Singapore Green Plan
2. Energy Transition: Hydrogen as a Low-Carbon Alternative
3. Potential Areas for Deployment of Low-Carbon Hydrogen in Singapore



GREEN PLAN

Sustainability has always been a part of Singapore's DNA

- Since independence, Singapore has pursued sustainable development by **balancing economic growth with environmental protection and social inclusion**
- Singapore Green Plan 2030 (Green Plan) builds on sustainability efforts of preceding decades to ensure Singapore remains a green and liveable home, with **sustainability as a new engine of growth**



Singapore Green Plan 2030

- A national sustainability movement, with **concrete sectoral plans and targets over the next ten years** that will position Singapore to achieve net zero emissions as soon as viable
- Strengthens our commitment to global sustainable development and climate action efforts, including the UN 2030 Agenda for Sustainable Development and the Paris Agreement



5 Pillars of Singapore Green Plan 2030



City in Nature



Sustainable Living



Energy Reset



Green Economy



Resilient Future

Green Government and Green Citizenry as Key Enablers

As part of Singapore's Energy Reset, we will develop four energy supply sources



Study on Hydrogen Imports and Downstream Applications for Singapore

Key Findings

- Hydrogen has the potential to diversify Singapore's fuel mix towards low-carbon options for electricity generation, heavy transportation, and some industrial processes
- Challenging for Singapore to produce green hydrogen at scale using domestic green electricity, given our limited renewable energy resources
- Singapore will need to explore various supply pathways for price-competitive low-carbon hydrogen
 - Importing hydrogen via shipping (via various carriers)
 - Piping hydrogen from neighbouring countries
 - Domestic production of hydrogen

Key Findings

Prelim Assessment on Potential Use Cases of Low-Carbon Hydrogen

- Maritime
- Power
- Industry
- Aviation
- Mobility Solutions

Steps are being undertaken to further study these applications

Prelim Assessment on Potential Use Cases of Low-Carbon Hydrogen

MARITIME

- Decarbonising the maritime sector will require low- or zero-emission alternative fuels to meet the long-term goals outlined by the International Maritime Organization (IMO)
 - Hydrogen and carriers such as ammonia hold significant promise
- Collaboration among stakeholders will be key
 - The Maritime and Port Authority of Singapore (MPA) is actively encouraging the formation of ecosystems with key stakeholders across the maritime value chain, to come together in joint industry projects to trial and test-bed low-carbon fuels
 - MPA has also announced the establishment of a maritime decarbonisation centre to focus Singapore's efforts in maritime decarbonisation
 - The centre will bring together industry partners to coordinate, drive and catalyse maritime decarbonisation solutions, with a focus on translating technologies into commercially viable solutions for ocean-going vessels

Prelim Assessment on Potential Use Cases of Low-Carbon Hydrogen

POWER

- Hydrogen is one of the low-carbon options in Singapore's Energy Transition
- Hydrogen fuel can be blended with natural gas to fuel the Combined Cycle Gas Turbines (CCGTs) used to generate electricity
- Energy Market Authority of Singapore (EMA) is further studying the infrastructure needed to support the deployment of low-carbon hydrogen technologies, and is working with other agencies to bring down the costs of hydrogen in Singapore

Prelim Assessment on Potential Use Cases of Low-Carbon Hydrogen

INDUSTRY

- Currently, brown hydrogen is produced through steam-methane reforming and partial oxidation on Jurong Island and is a critical feedstock for industry processes (e.g. in the refineries)
- Low-carbon hydrogen can be used to directly replace existing brown hydrogen feedstock with minimal infrastructural impact to end users
- Hydrogen can also be used to replace natural gas for embedded heat and electricity generation
- However, these applications are currently not cost-competitive
 - The Government is keen to partner with industry players to enable new streams of cost-competitive supply or explore possible pilots to couple existing production with CCUS for blue hydrogen

Prelim Assessment on Potential Use Cases of Low-Carbon Hydrogen

AVIATION

- Hydrogen has been identified as a potential solution to reduce the impact on climate change from the aviation sector
- While near-term efforts to move towards carbon-neutral growth in aviation involve the extensive use of hydrogen to produce sustainable aviation fuels (SAF) for aircraft, in the longer term, the plan by the industry is to move towards hydrogen propulsion for future aircraft
- Further research and development (R&D), as well as major infrastructural changes, is needed to ensure the safe and economic use of hydrogen
- The Civil Aviation Authority of Singapore aims to work closely with various stakeholders to study the feasibility of, and conditions for hydrogen deployment within the aviation sector

Prelim Assessment on Potential Use Cases of Low-Carbon Hydrogen

MOBILITY SECTOR

- As hydrogen technology for transport remains nascent, the report does not foresee a global shift towards hydrogen fuel cell electric vehicles (FCEVs) in the near-term
- Battery electric vehicles (BEVs) are projected to remain the more viable cleaner-energy vehicle technology
- A possible exception is the heavy vehicle segment, where FCEVs could be more economically viable than BEVs by 2050
 - Contingent on sufficiently widespread adoption of hydrogen in other areas in Singapore

Further Efforts to Enable Feasible Deployment of Low-carbon Hydrogen in Singapore

- Further studies needed on recommended supply pathways for low-carbon hydrogen
 - Much global uncertainty about trajectory of cost of deploying hydrogen technologies
- Singapore will continue to collaborate closely with industry and academic partners to undertake further technical assessments
 - Technical and economic challenges, as well as need for extensive infrastructural support and new regulations currently limit large scale deployment
- Findings will be used to inform existing Research, Development, and Demonstration efforts, e.g. Low-Carbon Energy Research Funding Initiative, and guide private sector consortia

Partnerships with Industry and Like-minded Countries

- The Singapore Government welcomes partnerships such as private sector consortia on the deployment of low-carbon solutions and development of hydrogen supply chains, and opportunities to pilot new technologies in sectors e.g. maritime, aviation, mobility, industry and power sectors
- Singapore seeks to partner other countries to advance emerging low-carbon technological solutions
 - Joint contributions to international regulations, standards and certification on these emerging technologies
 - Participation in joint RD&D and test-beds
- Chile-Singapore MOU on Low-carbon Hydrogen is a good start for collaborations between Chile and Singapore



Signing of Chile-Singapore MOU on Low-Carbon Hydrogen between Minister Tan and Chile Minister of Energy and Mining Juan Carlos Jobet

Partnerships to Develop and Deploy Low-carbon Hydrogen in Singapore

Keppel, industry partners tie up to explore development of LH2 supply infrastructure

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KEPPEL Corporation, through its data centre unit Keppel Data Centres Holding, has tied up with four other industry partners to jointly explore the development of a supply infrastructure to bring liquefied hydrogen (LH2) into Singapore to power Keppel's data centres.



Collaboration among Keppel Corporation, Kawasaki Heavy Industries, Linde Gas Singapore, Mitsui O.S.K. Line and Vopak LNG Holding to jointly study the technical and commercial viability of LH2 supply chain

Chiyoda and 5 Singapore companies (City Gas, Jurong Port, PSA International, Sembcorp, SLNG, Mitsubishi), will identify and demonstrate use cases using Chiyoda's SPERA Hydrogen, LOHC technology to allow hydrogen to be transported in chemical tankers at normal atmospheric temperature and pressure

CHIYODA AND MITSUBISHI JOIN CONSORTIUM FOR SINGAPORE'S HYDROGEN ECONOMY

By Mary Page Bailey | April 1, 2020



Chiyoda Corp. (Yokohama, Japan; www.chiyodacorp.com) has entered into a memorandum of understanding (MOU) with 5 Singaporean companies, City Gas Ltd., Jurong Port Ltd., PSA International Ltd., Sembcorp Industries Ltd., Singapore LNG Corp., together with Mitsubishi Corp., to collaborate toward a sustainable hydrogen economy in Singapore. In March, a large-scale hydrogen-economy project was announced in Germany as well.

Thank You