



JOINT NEWS RELEASE

Singapore, 25 June 2024

NTU Singapore, PSA Singapore and Chiyoda Japan begin dehydrogenation demonstration for green heavy vehicles

Nanyang Technological University, Singapore (NTU Singapore), PSA Singapore (PSA) and Japan's Chiyoda Corporation (Chiyoda) have begun testing how hydrogen can be transported and stored as methylcyclohexane (MCH)¹, a liquid form at ambient temperature and pressure, before gaseous hydrogen is extracted from MCH to be used as a clean fuel for horizontal transportation in the port.

As part of this collaboration and trial, PSA has built and operationalised the first hydrogen refuelling station and provided a hydrogen fuel cell electric prime mover at Pasir Panjang Terminal in Singapore.

The testbed follows successful laboratory proof-of-concept (PoC) experiments led by NTU to enable the efficient and economical transport of hydrogen, which can in turn contribute to the expansion of global hydrogen supply chains.

Hydrogen fuel cells, a promising technology for green energy, produce electricity by a reaction of hydrogen and oxygen that leaves behind only water and heat as by-products. As Singapore has no natural resources, it is reliant on importing hydrogen that can be transported in liquid form through liquid organic hydrogen carriers (LOHC), which can be used for long-term storage and long-distance transportation of hydrogen under ambient condition.

The trial at PSA's Pasir Panjang Terminal is scheduled to run until mid-2025. It aims to validate how transported LOHC can be stored at an industrial setting, and subsequently dehydrogenated. The extracted hydrogen can be used as a fuel for refuelling stations on-site.

In this PoC project, PSA provided a hydrogen refueling station and a prime mover and shares the demonstration site and utilities with industry partners. PSA is responsible

¹ Methylcyclohexane: A chemically stable liquid produced from toluene and hydrogen that can be handled in a liquid state at ambient temperature and pressure. It is widely used as pharmaceutical agent, solvent for agricultural production, admixture for jet-fuel, solvent for correction liquid, etc.

for the construction, commissioning, operation, and maintenance of the hydrogen refueling facility.

This pioneering endeavour places hydrogen at the forefront as a potential sustainable green energy source and plays a pivotal role in expanding the use of hydrogen fuel within PSA and in Singapore. This collective effort demonstrates that hydrogen remains a viable decarbonisation pathway through demand aggregation and innovation.

Professor Lam Khin Yong, NTU Vice President (Industry) said: “NTU researchers have been working closely with partners to develop better catalysts and efficient reactors for extracting hydrogen, and the promising success of laboratory trials have led to real-world tests. Liquid organic hydrogen carrier technology is a promising solution to safely transport hydrogen, enabling green and sustainable technologies. The pilot-scale trials at Pasir Panjang Terminal with our key partners are a vital next step in this industry collaboration, in which we envision a future with alternative sources of energy that are reliable and economical. NTU supports Singapore’s vision of becoming a sustainable nation, and is committed to environmental sustainability through impactful, real-world innovations.”

Mr Nelson Quek, Regional CEO Southeast Asia, PSA International, said: “In collaboration with like-minded industry partners, we are excited to commission the first hydrogen refuelling facility in the port, a significant step forward in our efforts to develop a hydrogen refuelling ecosystem in Singapore. PSA will continue to seek potential technologies and actively test-bed low-carbon, innovative sustainability solutions that can be deployed beyond the industry, as we strive to collectively decarbonise and drive greener outcomes across the entire value chain.”

Chiyoda, headquartered in Japan, provides technical expertise through SPERA Hydrogen™, their proprietary technology that uses dehydrogenation catalysts to extract hydrogen from MCH as LOCH for storage and transportation as a liquid form under ambient conditions.

As an advanced technology provider and key project partner, Chiyoda is collaborating with NTU by applying their engineering expertise and experience to develop and implement the technology on a national scale, and providing their dehydrogenation skids to extract hydrogen from MCH.

Mr Koji Ota, President & CEO, Chiyoda, said: “We are delighted to commence this demonstration using hydrogen for an industrial application which will lead to long-term CO2 emission reductions in Singapore, and contribute to global decarbonisation through SPERA Hydrogen. Chiyoda will further accelerate the expansion of its hydrogen value chain business towards a sustainable future by maximizing the unique advantages of our SPERA Hydrogen system, including its stability under ambient

temperature and pressure, its safe and easy-to-handle characteristics and its cost competitiveness, intensified by using existing petrochemical infrastructure and regulations and standards, as demonstrated by this project which operates under existing laws. This project is of great significance to Singapore and is a major step forward toward the future diffusion of hydrogen on a global scale.”

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About Nanyang Technological University, Singapore

A research-intensive public university, Nanyang Technological University, Singapore (NTU Singapore) has 33,000 undergraduate and postgraduate students in the Engineering, Business, Science, Humanities, Arts, & Social Sciences, and Graduate colleges. It also has a medical school, the Lee Kong Chian School of Medicine, established jointly with Imperial College London.

NTU is also home to world-renowned autonomous institutes – the National Institute of Education, S Rajaratnam School of International Studies, Earth Observatory of

Singapore, and Singapore Centre for Environmental Life Sciences Engineering – and various leading research centres such as the Nanyang Environment & Water Research Institute (NEWRI) and Energy Research Institute @ NTU (ERI@N).

Ranked amongst the world's top universities by QS, NTU has also been named the world's top young university for the last seven years. The University's main campus is frequently listed among the Top 15 most beautiful university campuses in the world, and it has 57 Green Mark-certified (equivalent to LEED-certified) building projects, of which 95% are certified Green Mark Platinum. Apart from its main campus, NTU also has a campus in Singapore's healthcare district.

Under the NTU Smart Campus vision, the University harnesses the power of digital technology and tech-enabled solutions to support better learning and living experiences, the discovery of new knowledge, and the sustainability of resources.

For more information, visit www.ntu.edu.sg

About PSA Singapore

PSA Singapore (PSA) operates the world's largest container transshipment hub in Singapore, handling 38.8 million TEUs of containers in 2023. With connections to 600 ports globally, shippers have access to daily sailings to every major port in the world, operating 24/7 all year round. Beyond port operations, PSA also offers port adjacency services, our unique differentiator in mid-mile logistics, to meet our customers' dynamic needs. This value adding service, supported by our bespoke port adjacency digital solutions, will provide shared visibility of the end-to-end supply chain. As the partner of choice in the port and supply chain operations, PSA is "The World's Port of Call". Visit us at www.singaporepsa.com or follow us on LinkedIn and Facebook (@singaporepsa).

About Chiyoda Corporation

Chiyoda Corporation is a world leading fully integrated engineering company established in 1948, with wide-ranging business interests, including consulting, planning, engineering, procurement, construction, commissioning and maintenance for facilities related to gas, electricity, petroleum, petrochemical, chemical, pharmaceutical, antipollution, environment, preservation, and others. Chiyoda also finances and invests in the exploration of oil, gas and other mineral resources.

For more information, visit <https://www.chiyodacorp.com/en/>

Annex: Project Background

The collaboration is funded by the **Low-Carbon Energy Research Funding Initiative (LCER FI)**, which was started by the Singapore Government to support research, development, and demonstration projects on low carbon energy technology solutions.

It follows the signing of a Memorandum of Understanding in March 2020 between a consortium of industry collaborators from Singapore and Japan.

Under the LCER FI, NTU is leading Research & Development (R&D) of the next-generation dehydrogenation catalyst that improves upon application of Chiyoda's proprietary dehydrogenation catalyst technology. NTU also developed a new reactor that extracts hydrogen from LOHCs in an industry-academia collaboration with Chiyoda.

Since the partnership and R&D started in 2022, the researchers have successfully achieved performance improvement of the next-generation dehydrogenation catalyst and have progressed from laboratory tests to this full-scale plant demonstration.

The trial at PSA's Pasir Panjang Terminal uses imported methylcyclohexane at the terminal's decentralised dehydrogenation skids, which is installed with the next-generation catalyst to verify the results of the R&D in laboratory tests.