Sustainable Low-Carbon Hydrogen/Ammonia Energy

- A Sustainable Low-Carbon Industrial Ecosystem
- Domestic Hydrogen/Ammonia Energy Systems

Background

To achieve net-zero emissions by 2050, Taiwan's energy system must address four major challenges: (1) Intensifying competition for land use due to increased demand for green energy; (2) A higher proportion of green energy increasing the unreliability of the power system; (3)Immature international markets and technology for green hydrogen/ammonia that have high infrastructure investment costs; and (4) Stricter international carbon management regulations driving a substantial increase in domestic demand for low-carbon resources. Thus, hydrogen energy will play a key role in Taiwan's efforts to achieve 2050 net-zero targets.

By diversifying the methods for producing low-carbon hydrogen domestically, it is possible to ensure an adequate supply of low-carbon energy while balancing sustainable development and the lifespan of existing energy infrastructure. This will help mitigate the competition for land use due to renewable energy development and contribute to the decarbonization of the energy system.

To this end, T-STONE has two major strategic goals: (1) Establishing stable and reliable low-carbon energy to accelerate net-zero transition through domestic hydrogen/ammonia energy systems; and (2) Creating a sustainable low-carbon hydrogen/ammonia industrial ecosystem while entering international supply chains by integrating technology and systems.

Global Outlook and Domestic Progress

Global hydrogen applications are steadily increasing, with the focus still primarily on traditional refining and chemical industries, where hydrogen is produced from fossil fuels. To achieve climate goals, it is necessary to transition the use of hydrogen in existing applications to low-carbon hydrogen and expand its use to new areas such as heavy industry or long-distance transportation. In 2022, the National Development Council released Taiwan's Pathway to Net-Zero Emissions in 2050 [1].

To achieve net-zero by 2050, Taiwan plans to build a hydrogen supply and demand system to achieve its long-term goals of net-zero development and transition. This net-zero power system will be made up of 9-12% hydrogen energy, 60-70% renewable energy, and 20-27% gas-fired power plants equipped with Carbon Capture, Utilization, and Storage (CCUS) technology. Additionally, the Ministry of Economic Affairs Hydrogen Promotion Taskforce has been established to formulate promotion strategies for Taiwan's short, medium, and long-term hydrogen supply, as well as to create comprehensive strategies on hydrogen sources and infrastructure planning.

Strategic Planning Frameworks

In 2023, T-STONE formulated seven major strategies (see Figure 1) to implement the three core values of "Innovative Technology Research and Development," "Sustainable Industrial Development," and "Symbiotic Environment Creation". In 2023, the first T-STONE meeting initiated inter-agency joint planning for promotion strategy on sustainable low-carbon hydrogen/ammonia energy. This strategy will first focus on reaching a consensus on infrastructure followed by formulating comprehensive strategies on promoting key technologies.

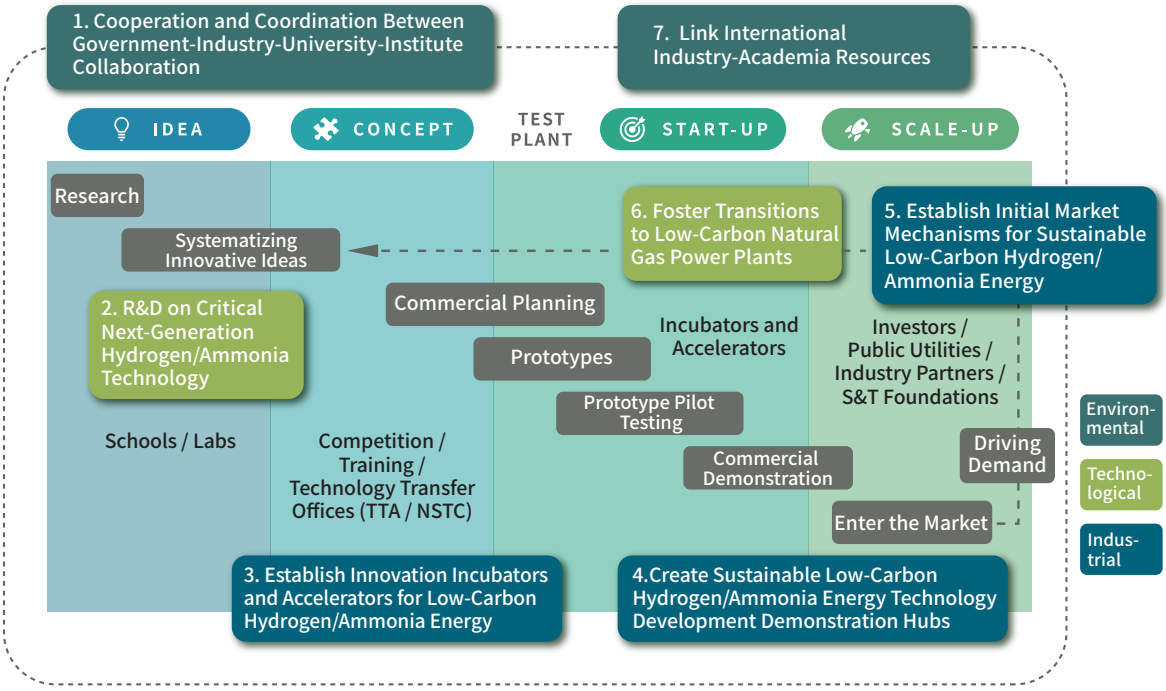

Figure 1 Comprehensive Promotion Strategies for Sustainable Low-Carbon Hydrogen/Ammonia Energy
Source:Taiwan Science and Technology Office for Net-zero Emission (T-STONE) (2023) ; DOE (2019)[2]

Strategy 1: Cooperation and Coordination Between Government-Industry-University-Institute Collaboration

Comprehensive strategies for sustainable low-carbon hydrogen/ammonia energy technology aim to foster opportunities for future economic development by having Taiwan create industries through the hydrogen technology supply chain. However, there are still many challenges in areas such as conducting R&D on foresight technologies, scaling up production technologies, and creating demand while ensuring the procurement and use of sustainable low-carbon hydrogen/ammonia. To overcome these challenges government, industry, university, institute must partner to establish a complex value chain. It is recommended that the Executive Yuan take the lead by regularly convening inter-agency coordination meetings to establish an information exchange and communication platform by promoting coordination and support among relevant agencies.

Strategy 2: R&D on Critical Next-Generation Hydrogen/Ammonia Technology

This strategic plan emphasizes investing in R&D on critical foresight hydrogen/ammonia technologies with significant carbon reduction benefits and low Technology Readiness Levels (TRL) that have the potential to increase the supply of zero-carbon electricity. However, the main focus of this plan will be on the R&D of sustainable low-carbon hydrogen/ammonia production technologies. The technology development projects

of this plan are as follows: (1) Hydrogen Production: Includes next-generation seawater electrolysis, methane pyrolysis hydrogen production, and green ammonia cracking for hydrogen production. (2) Hydrogen Applications: Includes mixed/pure hydrogen combustion turbine generators, high-performance fuel cells, and green natural gas (CO_2 capture + international green hydrogen). (3) Hydrogen Infrastructure: Includes hydrogen safety storage and transport as well as standards, testing, and certification for green hydrogen.

Strategy 3: Establish Innovation Incubators and Accelerators for Low-Carbon Hydrogen/Ammonia Energy

Drive the development of Taiwan's emerging industries by guiding startups to become models of emerging technologies while accelerating their entry into international markets. Create a conducive environment for the development of low-carbon hydrogen/ammonia startups by encouraging relevant incubation policies. Continuously stimulate the emergence of local startups, enhance export competitiveness, and promote domestic industrial growth.

Strategy 4: Create Sustainable Low-Carbon Hydrogen/Ammonia Energy Technology Development Demonstration Hubs

Conduct real-world validation of key next-generation hydrogen/ammonia technologies. Utilize the results to refine foresight technology research. Plan the use of solar photovoltaics (Shalun) and offshore wind power (Taichung Port) as sources of electricity for hydrogen production at the Shalun Green Energy Science City in Tainan and at Taichung Port and Taichung Power Plant. These foresight hydrogen production technologies will promote the formation of an industrial ecosystem by complementing the seven strategic comprehensive strategies to establish two types of low-carbon hydrogen/ammonia energy supply and demand hubs.

To implement this strategy, T-STONE has planned a foresight low-carbon energy park for 2024. The initial concept for this park was to shape Taiwan's low-carbon energy industrial ecosystem by integrating low-carbon energy industry resources in the Taichung area, establishing a track record for domestic industries, and providing research and development resources to industry, academia, and research institutions. As shown in Figure 2, the overall layout of the park will be divided into two major sections: a low-carbon Energy Demonstration Hub and a low-carbon Energy Technology R&D and Testing Center.

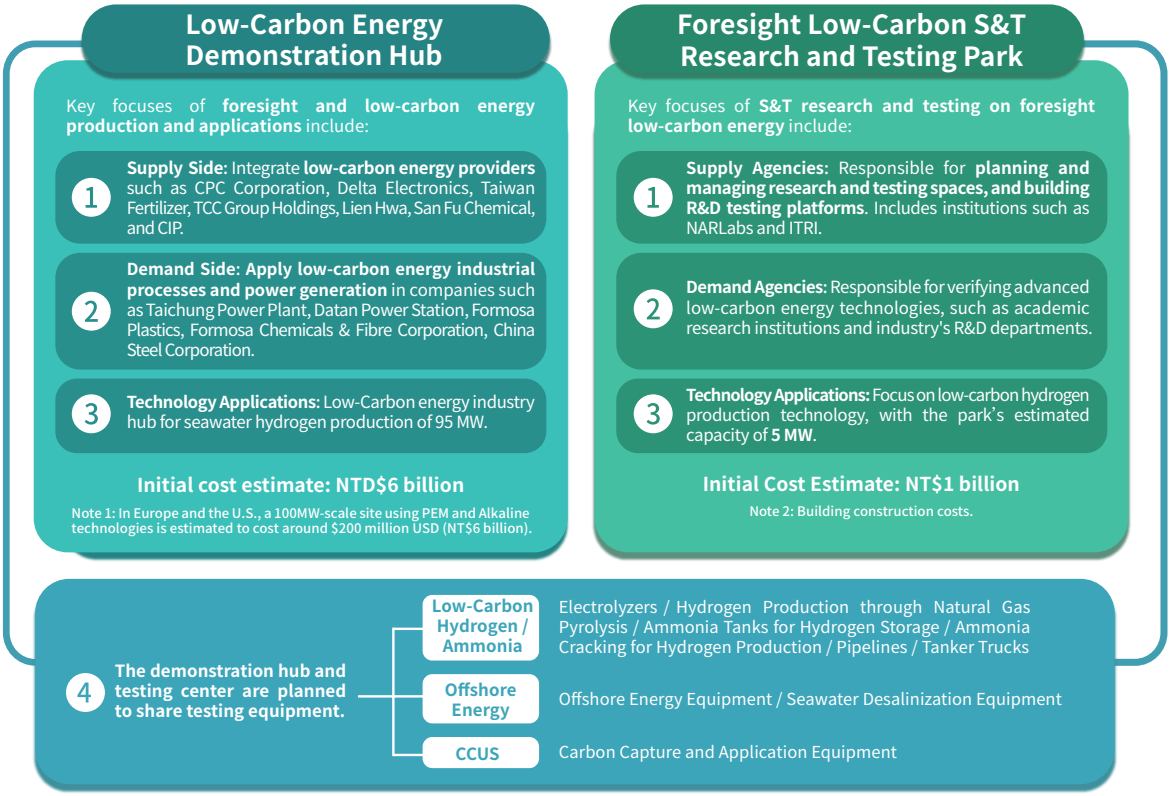

Figure 2 Plans for a Foresight Low-Carbon Energy Park

Source:Taiwan Science and Technology Office for Net-zero Emission (T-STONE) (2024).

Strategy 5: Establish Initial Market Mechanisms for Sustainable Low-Carbon Hydrogen/Ammonia Energy

The complexity of the hydrogen/ammonia energy supply chain comes from areas such as production, midstream distribution and storage, and end-use applications. Thus, it is essential to overcome existing limitations to promote market development. Currently, hydrogen/ammonia energy technology and value chains are still being developed. Thus, many relevant regulations are still narrow in scope. Therefore, the government must support the establishment of mechanisms in the early stages of implementation. In addition, the government must facilitate the creation of an industrial ecosystem that accounts for technology, industry, and the market by designing and implementing a technology sandbox mechanism while establishing standards for low-carbon hydrogen/ammonia certification and safety regulations for hydrogen/ammonia equipment.

Strategy 6: Foster Transitions to Low-Carbon Natural Gas Power Plants

The transition to low-carbon natural gas power plants can effectively reduce Taiwan's power emissions. Promote the development of the following two major technologies while establishing mechanisms for sustainable circular low-carbon hydrogen by coordinating efforts among government, industry, university, and institute collaboration to facilitate the transition to low-carbon natural gas power plants: (1) Use co-fired "Methane Pyrolysis Hydrogen Production" with carbon capture technology to handle carbon emissions from co-firing power generation while providing zero-carbon electricity. (2) Reduce emissions from power generation by capturing and transporting carbon dioxide to green hydrogen-producing countries, where it can be used for the artificial synthesis of "green natural gas," which can be imported and used in Taiwan.

Strategy 7: Link International Industry-Academia Resources

Countries leading in hydrogen energy development, such as Canada, Germany, and the US, have already invested substantial resources in research and development. Therefore, Taiwan can accelerate the development of its own sustainable low-carbon hydrogen/ammonia technology by connecting with international academic and industrial resources to draw on the experiences of these countries that lead technology R&D and industrial development. This approach can be implemented in two phases: (1) Collaborate on research in foresight academic technologies as a foundation. (2) Expand industry participation while jointly promoting commercial-scale demonstration by utilizing bilateral research platforms for foresight hydrogen energy technology.

T-STONE held an exchange meeting in 2023 with the Taipei Economic and Cultural Office in Australia to promote international cooperation in net-zero technologies with leading countries in this field. Discussion focused on future comprehensive strategies for Taiwan-Australia cooperation in sustainable low-carbon hydrogen/ammonia technology. Subsequent communication with the Taipei Economic and Cultural Office in Australia will continue to understand and support Taiwan-Australia hydrogen technology development and resources. In 2024, Taiwan will further establish practical cooperation with international entities by holding discussions with Germany, France, and Chile.

Potential Benefits

Comprehensive strategies for sustainable low-carbon hydrogen/ammonia energy aim to create stable sources for power generation while balancing resilience with decarbonization of the power system by increasing the proportion of domestically produced hydrogen. This is crucial for achieving net-zero emissions by 2050 and fostering emerging industries while promoting future economic development. Through inter-agency cooperation and the integration of different energy sources (such as low-carbon hydrogen/ammonia, wind power, and solar energy), these strategies will jointly promote foresight low-carbon energy demonstration parks to validate feasible technologies and business models. This will promote a low-carbon hydrogen/ammonia energy industry ecosystem that aligns with the "Hydrogen Energy" strategic action plan and targets for net-zero by 2050.

References

[1] National Development Council (March 30, 2022). Taiwan's Pathway to Net-Zero Emissions in 2050.

[2] DOE(2019). Pathways To Success: Clean Energy Innovation Ecosystems

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