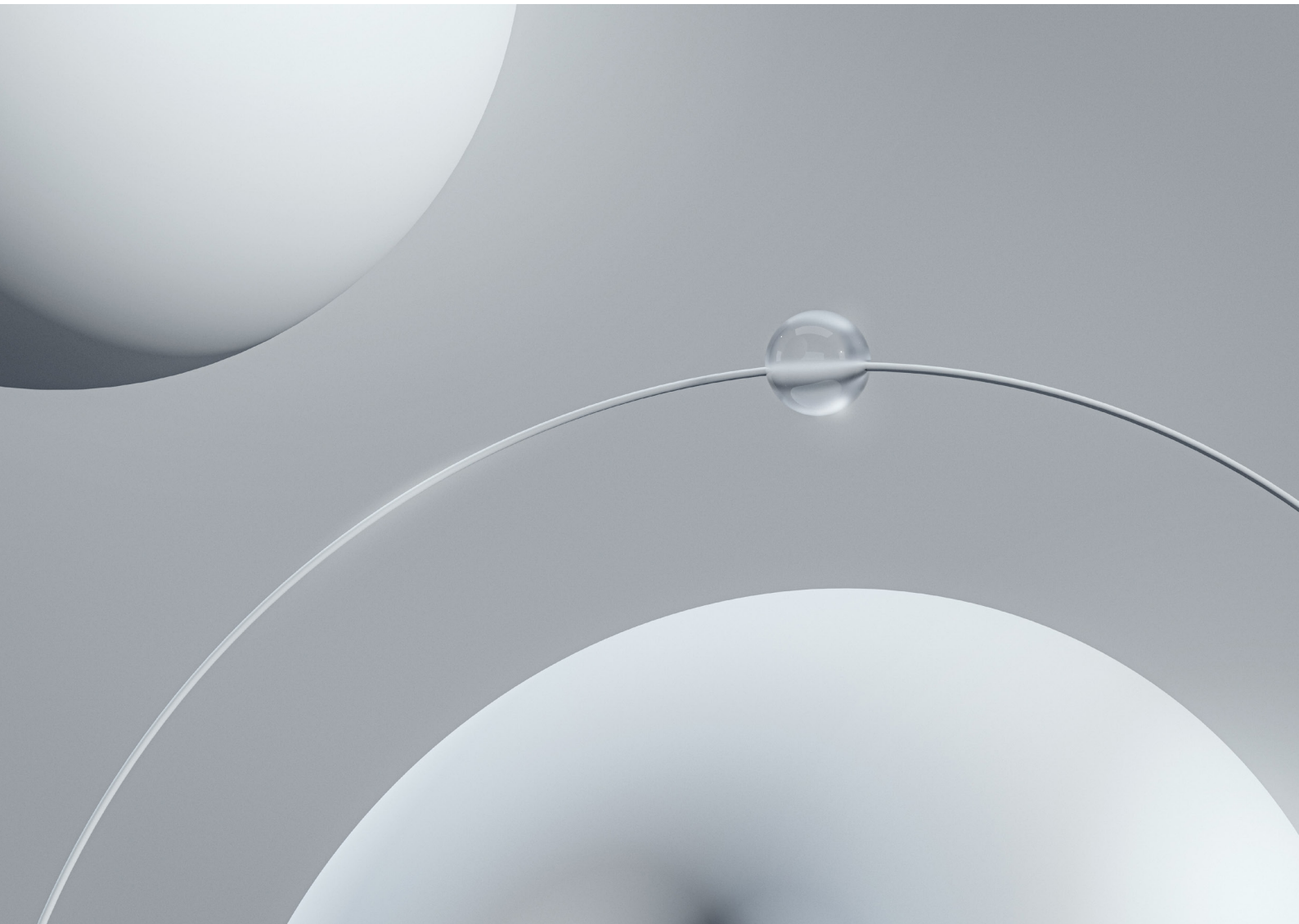
Netherlands Enterprise Agency

Hydrogen developments in Taiwan

By the Netherlands Innovation Network at the Netherlands Office Taipei
Wouter Janssen - February 2022



Taiwan's energy mix: state of play

On Earth Day in April 2021, President Tsai Ing-wen publicly expressed her ambition to get Taiwan on track for carbon neutrality by 2050. Even though this hasn't been ratified as official policy, the Taiwanese government did unveil energy transition targets with clear pathways to a greener electricity supply in 2025. With 98% of the energy imported and around 80% of the electricity generated by fossil fuels, Taiwan will face the challenge of establishing carbon reductions, especially considering the power-intensive manufacturing industry, which makes up a large part of Taiwan's economy and accounts for roughly 31% of the total energy consumption.

Presently, Taiwan is undergoing a transition in electricity generation, decreasing the share of electricity generated from coal and simultaneously focusing on phasing out nuclear energy. The current ruling Democratic Progressive Party (DPP) has been long advocating the denuclearization of the island and remains committed to a "nuclear-free homeland", in which all nuclear power will be fully phased out by 2025 (see Figure 1). Out of the three reactors, two are already being decommissioned and the operating license of the third operational reactor will not be extended past its current expiry date. In addition, the ruling party received support for their agenda when the people voted 'no' on restarting the construction of the mothballed fourth nuclear plant in a four-question referendum in December 2021.

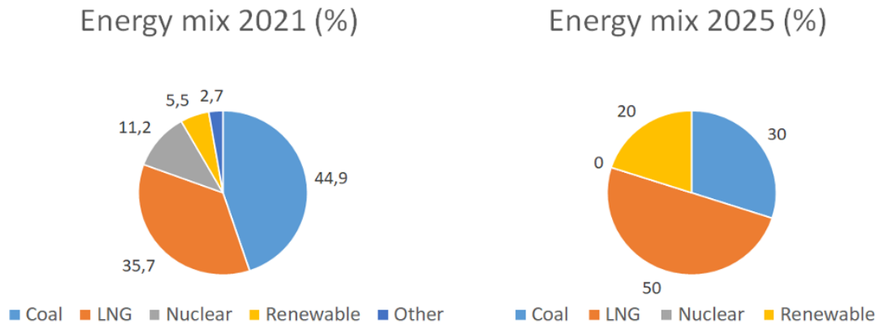


Figure 1: The present day energy mix for electricity generation (left) and the 2025 target (right)

Due to Taiwan's isolated energy grid and complex geopolitical relations in the region, assuring energy security throughout this energy transition poses another significant challenge to the Taiwanese government. Maintaining a stable power supply has already proved to be a potentially problematic when multiple hour-long blackouts occurred across the island in May 2021. Recently, the Ministry of Economic Affairs announced that the anticipated annual increase in domestic power usage is larger than expected (2.5% as opposed to 1.8% annual growth; excluding increased power usage that may result from extreme weather). Several international companies have expressed concern over stable power supply and grid stability in the future. The expected increase in power demand is due to Taiwan's overall growing economy and the increase in demand from industrial users, in particular the semiconductor industry, which has boomed as a result of the rapidly increasing demand for chips. As Taiwan is moving away from both coal and nuclear power, the import of LNG as well as the production of renewable energy are the designated tools to keep up with the growing power demand and fill the gap as left by the shutdown of the nuclear power plants.

In terms of renewable energy, the Taiwanese government aims to increase the supply of electricity from a renewable source to 20% by 2025 (see Figure 1). So far, the production of solar and wind energy has been the primary focus, with targets such as 5.7GW of offshore wind power by 2025 (with an additional expansion of 1GW per year until 2035) and 20GW of solar energy (photovoltaics) by 2025. For 2025, the government has set a target for a total fuel cell capacity of 60MW. However, due to the aforementioned increasing energy demand combined with delays in the installment of renewable energy capacity, the planned renewable power capacity will be likely to amount to 15.2% of the total electricity supply in 2025, as opposed to the set target of 20%.

As illustrated in Figure 1, Taiwan will rely heavily on increased import of LNG in the near future, in order to meet the target of a 50% share of the total energy supply. This means that over the coming years, a significant upgrade is needed in Taiwan's LNG infrastructure in order to facilitate receiving and storing the increased quantity of LNG. In addition to the two existing terminals, the state-owned CPC Corporation is investing heavily in the construction of three new terminals as well as the expansion of the Taichung Port Terminal. In response to occasional interruptions or temporary delays of LNG import, the Taiwanese government has also set a target to increase the security stockpile to 17 days in 2027, meaning that the total storage capacity will have to be expanded to 24 days in total.

Construction plans for the Third Terminal passed the environmental impact assessment in October 2018 after Taiwan's Environmental Protection Agency initially rejected it in July 2018. The construction project received backlash after the assessment estimated damages to the coastal algal reef to be significant. This issue was also addressed in the aforementioned referendum, where a small majority voted 'no' to relocating the terminal.

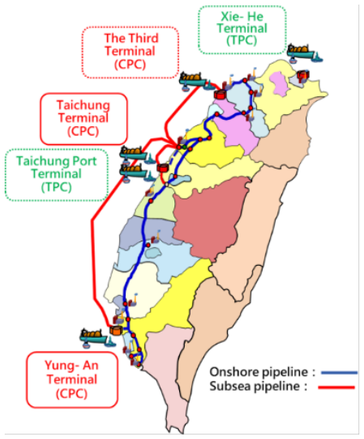


Figure 2: Currently operational LNG receiving terminals (green) and planned/ongoing construction (red).
Source: Bureau of Energy, MoEA

Nonetheless, this serves as an illustration of the shortage of suitable building sites and a delicate balance between nature conservation and (coastal) development in Taiwan; in the long run potentially complicating and slowing the transition to larger volumes of LNG import, and eventually hydrogen import in the long-term.

The Taiwanese government is currently balancing the goal of carbon reduction, phasing out nuclear power and the increasing power demand from industry. All things considered, it is clear that, at least in near future, the Taiwanese government prioritizes LNG import over the development of an extensive hydrogen ecosystem. Until recently, little attention was paid to hydrogen. The government is now starting to formulate a long term strategy on hydrogen, however it will not likely be a government priority until either domestic energy surpluses become available or the international hydrogen market matures and hydrogen import becomes (more) feasible.

Looking forward

Taiwan has not yet announced a comprehensive policy or strategy for the energy transition beyond 2025, making it unclear what the role for hydrogen as an energy carrier will be in the future, at least for the time being. However, the government does recognize hydrogen as a long term energy option and is currently seeking international cooperation for experience sharing in order to potentially join the global hydrogen energy supply chains.

In 2021, the Taiwanese government established a high-level "net zero taskforce" which includes four working groups and an inter-ministerial coordination group. The topic of hydrogen is subdivided under the "Decarbonized Energy Working Group" and has thus far formulated a rudimentary and provisional strategy for hydrogen development. The Taiwanese government will focus on the import of blue and green hydrogen in the short to mid-term, after which the production of green hydrogen from (surplus) local renewable energy will gradually be increased (in the long-term). Moreover, in the short term, the feasibility of developing hydrogen facilities and hydrogen demonstration sites will be assessed, followed by the construction of hydrogen infrastructures based on its application and supply (in the mid to long-term).

Taiwan's hydrogen strategy contains two main fields of application in the short term: power generation and applications in industrial settings. Taiwan's high-tech industry needs stable power supply and hydrogen energy can be a buffer to fall back on when needed. This power generation will be in the form of hydrogen co-firing in gas turbines. The integration of hydrogen into the heavy industry will be initiated in the processes of blast furnace ironmaking and the co-production of steel and chemistry. Hydrogen will only be introduced to other domains in the mid to long-term.

State-owned heavy industry in Taiwan is starting to realize they can't sit idle and are starting to make preparations for carbon neutrality. To illustrate, China Steel Corporation (CSC) has launched a research and development team on hydrogen-powered steelmaking which includes experts from Taiwan's Industrial Technology Research Institute (ITRI), National Cheng Kung University, and National Sun Yat-sen University. CSC plans to build a continuous production line demonstration (50kg/hr of steel production) in 2024 to demonstrate and evaluate the techniques required for carbon neutral commercial operation through a technique called DRI. Fully decarbonizing CSC's steelmaking facilities, however, would require an estimated 1 million tons of hydrogen annually (the equivalent of 14GW of renewable energy, which is more than the current output of all Taiwanese offshore wind parks combined).

One of the current industries already utilizing hydrogen is the semiconductor manufacturing industry, albeit not for the purpose of power generation. Ultra-high purity hydrogen is utilized during a process called Extreme Ultraviolet Lithography (EUV). Recently, the French-Taiwanese joint venture Air Liquide Far Eastern announced a 200 million Euro investment in facilities in the Science Parks of Hsinchu and Tainan in order to produce industrial gases for the semiconductor industry. The ultra-high purity hydrogen will be partially produced from renewable sources. The current facilities in Tainan and the planned facilities in Hsinchu will amount to 25MW of electrolysis and a total of 5000 Nm3 hydrogen per hour.

In addition to the inter-ministerial coordination, the Ministry of Economic Affairs has put together a "Hydrogen Energy Promotion Alliance" which includes the Bureau of Energy (BoE), Department of Industrial Technology (DoIT), Industrial Development Bureau (IDB), and state-owned companies Taipower, CSC Steel and CPC. The near-term goal is to conduct feasibility studies by 2025 and then to work out the "National Hydrogen Development Strategy and Applications" towards low-carbon economic and industrial developments. It's worth noting that those involved have expressed concerns about the current lack of strategy, regulation and certification schemes.

The formulated hydrogen strategy includes the import of blue and green hydrogen in the short and mid-term. An obstacle that will need to be addressed is the current LNG infrastructure in Taiwan, which is unsuitable for the transport of hydrogen or hydrogen carriers. Also, the current international market for hydrogen remains underdeveloped. So far hydrogen is not yet traded as a commodity in significant quantities because of its current unfavorable cost-effectiveness. In the long-term it is largely unclear, besides the aforementioned industrial applications, whom the end-users are going to be of imported hydrogen in Taiwan. At the moment, there is very little demand being created for hydrogen-based solutions in Taiwan. Due to Taiwan's subtropical climate, there is no demand for hydrogen for urban heating and there are currently no signals of hydrogen-use in the mobility sector.

Emphasis on fuel cell technology

Hydrogen plays a modest role in Taiwan's economy and many aspects are still in an infantile stage. So far, Taiwan mainly targeted the development of fuel cells through national R&D subsidy schemes. The government began providing R&D subsidy for fuel cell development as early as 1993 with the 'National Green Energy Development Program'. To further stimulate market driven R&D activities and explore business opportunities, the "Taiwan Fuel Cell Partnership" was established in 2001. The Partnership was assigned to continue the mission of the Executive Yuan's Fuel Cell Research and Development Society, to promote and develop the Taiwan's fuel cell industry.

The year 2009 proved to be a significant milestone for the fuel cell industry in Taiwan, when several policies related to fuel cells were announced:

- Executive Yuan's Energy Conference: "manufacturing & storage of hydrogen, hydrogen transportation strategy, fuel cell and hydrogen internal combustion engine" was assigned under new energy technology development
- A fuel cell demonstration promotion program was initiated in order to stimulate integration of the fuel cell value chain through demonstration projects and a product verification scheme.
- 'The National Green Energy Development Strategy' stated the ambition for Taiwan to become the global fuel cell system assembly center.

Currently, there are a number of fuel cell back-up power applications operational in Taiwan. These are mostly stationary projects and amount to a total of 274kW over 18 sites. Disaster-resistant backup power supply from fuel cells is currently being used to power railway signals and remote and offshore micro-grids. For 2025, the government aims to have a total fuel cell capacity of 60MW installed.

Furthermore, Taiwan had 37 ongoing fuel cell demonstration projects in 2019. These are also mostly backup stationary electricity supply (usually between 15 and 25kW) which have been deployed in telecommunication base stations, factories, exhibitions, universities and remote areas. One example is on the Penghu Islands, where charging stations using methanol-based fuel cells in combination with solar power have been installed to charge scooters for the tourism industry. Non-stationary demonstration projects include fuel cell drones, boats and go-carts. In 2020, AVIX performed a successful demonstration flight with a drone carrying 5kg of fuel cells technology aboard, developed by Industrial Technology Research Institute (ITRI). ITRI plays a key role in the hydrogen R&D landscape. By 2022, ITRI will work on the preliminary evaluation and technical demonstration of green hydrogen production, power generation, industrial energy application, and large-scale transportation.

After years of government support, Taiwan has established a complete and mature fuel cell supply chain. The total output of the Taiwanese fuel cell industry was approximately 4 billion NTD (≈140 million USD) in 2021. Despite the developments in the fuel cell industry in Taiwan, there is a very limited domestic market for fuel cells; most of the market lies outside Taiwan itself. Taiwanese fuel cell technology is exported worldwide. A rapidly developing market for export is China, where hydrogen has been included in the latest Five-Year Plan and the government is incentivizing hydrogen fuel cells, especially for the heavy transportation market.

The Taiwanese supply chain includes, amongst others, fuel supply systems, back-up power generating systems, charging stations, and scooters. The Taiwanese fuel cell supply chain also provides international manufacturers with affordable high quality fuel cell products and related key components, such as raw materials (bipolar plates), battery components (battery packs), system applications (stationary systems and systems for transportation) and peripheral products (such as hydrogen storage tanks, system peripheral components and crude hydrogen). Taiwanese companies are the suppliers of key components of some of the world's largest manufacturers of fuel cells. An example is the American leading fuel cell manufacturer Bloom Energy, which receives components for solid-oxide fuel cell from the Taiwanese Kaori Heat Treatment Co. Another example is CHEM Energy Technology, which has exported fuel cell products to over 30 countries, has a subsidiary in South Africa, and has partnership agreements with leading fuel cell manufacturers Siemens and Ballard Power Systems