



Systematic and Integrated Resource Planning for Net-Zero Science and Technology



In March 2023, the Executive Yuan of Taiwan approved the Net-Zero Science and Technology Program (NZSTP) (Phase 1 2023-2026), which outlined the developmental framework for five key technological fields: Sustainable and Foresight Energy, Low Carbon and Carbon Reduction, Carbon Negative, Circularity, and Humanities and Social Sciences. By integrating resources to support net-zero R&D, the plan aims to accelerate the progress of Taiwan's net-zero goals. Furthermore, in May 2023, Taiwan Science and Technology Office for Net-zero Emission (hereafter referred to as T-STONE) was established to assist in the implementation of the NZSTP.

T-STONE has invited experts and scholars from relevant fields to form expert groups across the aforementioned five S&T fields. These expert groups have partnered with thinktanks and other stakeholders to jointly propose eight integrated strategies and a sandbox testing program. Each of them is: Sustainable Low-Carbon Hydrogen/Ammonia Energy, Hybrid Offshore Renewable Energy, Promotion Strategy for Geothermal Energy and Green Finance, Net-Zero Smart Grid, Power-Saving Industrial Equipment with Embedded AIoT, Techno-Societal Governance of Carbon Capture and Storage, Sustainable Biomass Energy Conversion, Net-Zero Transition for Infrastructure and Built Environment and Net-Zero Civic Experimentation and Sandbox Innovation Projects.

Based on systematic and integrated R&D strategies, the NZSTP aims to accelerate the achievement of Taiwan's 2050 net-zero transition goals by promoting the foresight implementation and practical application of net-zero technology through cross-ministries and cross-discipline cooperation.



The Importance of Systematic and Integrated Resource Planning

In 2023, Taiwan's Climate Change Response Act incorporated the goal of achieving net-zero emissions by 2050. In the same year, the Executive Yuan demonstrated Taiwan's commitment to reaching net-zero by approving the Net-Zero Science and Technology Program, creating a steering committee, and establishing Taiwan Science and Technology Office for Net-Zero Emission (T-STONE). However, the transition to net-zero requires a systemic endeavor that not only relies on integrating technology programs for local emissions reduction, but also involves multi-faceted issues such as the development of emerging technologies, governance frameworks, and the engagement of the public and private sectors. Achieving a net-zero transition also requires collaborative efforts across ministries,

sectors, and different levels of government. However, technology projects often lack comprehensive planning and integration because they often focus on achieving specific objectives of ministries. This may lead to issues such as redundant resource allocation or failure of achieving the national net-zero goals without cross-ministries collaboration.

Currently, many countries view hybrid energy systems as a key strategy for decarbonizing national energy supply and demand systems. In addition to systematically assessing overall resources and promoting technology development, many countries also place importance on formulating integrated regulations and shaping market mechanisms while strengthening communication and participation with the public. Taiwan should utilize

Integrated Resource Planning (IRP) to comprehensively account for factors such as space limitations of renewable energy installations, the resilience of energy supply, the grid stability of electricity, the capacity for construction and maintenance of energy infrastructure, the commercialization of energy technologies, and environmental vulnerability. Such efforts will help Taiwan achieve a net-zero transition by ensuring a stable energy supply and effectively promoting the decarbonization of the energy supply and demand system while reducing the impact on the environment

and improving the recognition of the public. It has been recommended that the government integrates current net-zero technology research and development projects while utilizing systematic pathways to coordinate between key strategies and technology development projects. T-STONE has identified a total of eight systematic and integrated approaches for net-zero science and technology development. The following is an explanation of these recommendations for the Taiwanese government to follow.

Key Topics and Implementation Mechanisms

The summary of the 2023 Executive Yuan Science and Technology Advisory Board Meeting emphasized that Taiwan should enhance energy self-sufficiency and resilience by developing renewable energy that aligns with the country's unique geographic conditions. Taiwan should also leverage the opportunity to cultivate a local green supply chain while transitioning to net-zero, and plan development pathways for low-carbon hydrogen energy, hybrid marine energy, and deep geothermal energy. President Lai, Ching-Te stated that Taiwan is committed to a new era of the second energy transition, which will focus on developing diversified green energy and smart grids, enhancing the resilience of the power system, and maximizing the use of green energy in Taiwan. Utilizing various net-zero technologies such as carbon capture and storage (CCUS) will create sustainable net-zero lifestyles by accelerating decarbonization while advancing the two-pronged transformation of digital and green industries.

Given the highly interdisciplinary nature of net-zero technologies, it is essential to adopt a cross-sector, hybrid approach for systematic integrated planning that maximizes synergy by strengthening inter-agency collaboration. There are five major technological fields within the Net-Zero Science and Technology Program: Sustainable and Foresight Energy, Low Carbon and Carbon Reduction, Carbon Negative, Circularity, and Humanities and Social Sciences. Through the assessment of Taiwan's technological research and development capacity as well as the current allocation of research funding and existing gaps, T-STONE proposed key comprehensive strategies for hybrid science and technology issues by systematically evaluating technical, economic, social, and environmental feasibility from both supply and demand sides (see Figure 1).

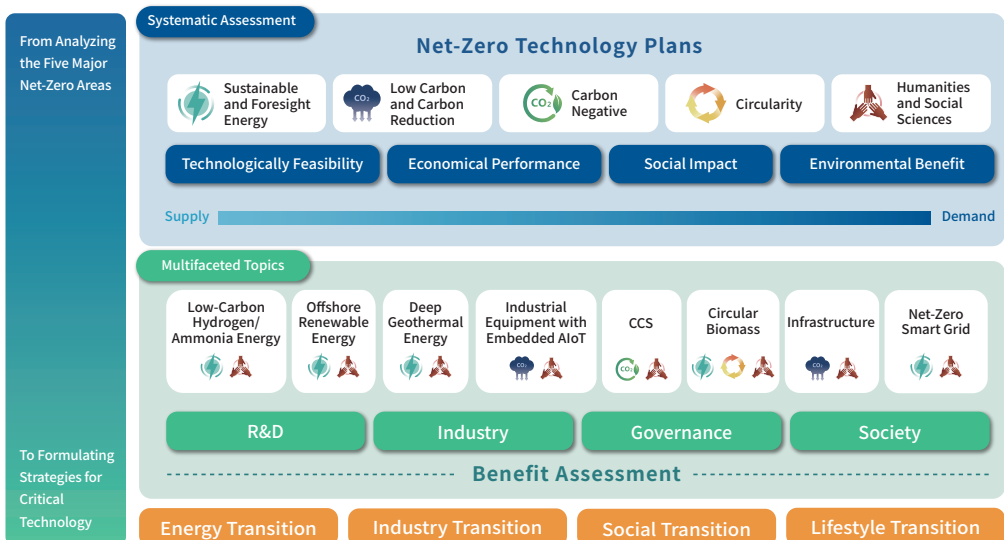


Figure 1 The Taiwan Science and Technology Office for Net-zero Emission's Comprehensive Foresight Net-Zero Strategies

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

In terms of determining hybrid science and technology projects, renewable electricity must reach 60-70% of total electricity in 2050 to meet the net-zero goal. However, the reality of renewable energy development currently faces great challenges such as unstable power output and requiring large amounts of land resources. Renewable energy development must address two major challenges: The Stability and Resilience of Power Output, and The Acquisition of Limited Space. It is necessary to expand the amount of utilized space through hybrid methods to increase green energy output. Leveraging smart technologies, power electronics, and foresight operational mechanisms can strengthen the resilience of the power grid. Advancing innovative geothermal engineering technologies will ensure a stable baseload energy supply. Additionally, effective energy carriers (such as low-carbon hydrogen/ammonia) should be used in renewable energy storage and conversion, which will assist in reducing carbon emissions amongst industrial applications.

Given these considerably large carbon reduction targets, CCUS and biomass recycling must be implemented to accelerate decarbonization. Reducing emissions in the industrial sector will require the introduction of digitization and artificial intelligence technologies to enhance energy-saving performance. In terms of residences and infrastructure, creating sustainable, livable, and intelligent living environments will require integrating circular economy principles, low-carbon smart transportation, and low-carbon construction methods. Throughout this process, it is essential to adopt the IRP approaches while maintaining close communication with various stakeholders.

As such, T-STONE has proposed comprehensive strategies focused on energy transition, including “Sustainable Low-Carbon Hydrogen/Ammonia Energy,” “Hybrid Offshore Renewable Energy,” and “Promotion Strategy for Geothermal Energy and Green Finance.” In terms of promoting industrial decarbonization, T-STONE has proposed initiatives such as the “Power-Saving Industrial Equipment with Embedded AIoT,” “Techno-Societal Governance of Carbon Capture and Storage,” and “Sustainable Biomass Energy Conversion.” In terms of net-zero infrastructure, T-STONE has introduced hybrid issues such as “Net-Zero Smart Grid” and “Net-Zero Transition for Infrastructure and Built Environment.” As for net-zero society, T-STONE has devised the “Net-Zero Civic Experimentation and Sandbox Innovation Projects”. These initiatives aim to

formulate comprehensive strategies for technological projects with the potential of industrial application by 2030 while promoting unique approaches considering Taiwan's specific conditions. Additionally, the sandbox testing program can continuously provide innovative research and practical experiments which also enhance the technological, network, and social capabilities of our civil society. T-STONE's strategies will maximize synergy by planning and promoting hybrid initiatives across agencies and sectors. As shown in Figure 2, the eight integrated strategies involve key technological projects and tasks across five major fields. The rationale behind each hybrid issue, the current status of domestic and international policies, R&D, strategic frameworks, the benefits of this initiative and the process of the sandbox testing program are explained in detail below.

The development of hybrid technology strategies will adopt the IRP approaches, which focus on value facets such as creating verification for innovative technology, promoting the formation of supply chains, and establishing support systems. This will require inter-agency collaboration and cross-domain cooperation among industries, government, academia, and research institutions to maximize synergy. T-STONE will gradually propose comprehensive technology strategies for hybrid net-zero topics by taking stock of the current state of research funding while identifying areas that can be strengthened. Through communication, exchange, and collaboration across agencies and disciplines, T-STONE will gather input from representatives of relevant government agencies, industries, and civic organizations. These stakeholders will work together in co-designing comprehensive technology strategies that integrate expertise from all sectors, and provide recommendations to optimize cross-departmental and multi-level governance strategies and mechanisms. Such efforts will accelerate the maturity and implementation of net-zero technologies, support the decarbonization of the industrial ecosystem, and accelerate Taiwan's net-zero transition.

 Sustainable and Foresight Energy

 Low Carbon and Carbon Reduction

 Carbon Negative

 Circularity

 Humanities and the Social Sciences



Figure 2 Key Science and Technology Projects and Comprehensive Strategies for Each Hybrid Issue

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