



Net-Zero Transition for Infrastructure and Built Environment

Establishing a Positive Cycle Between Infrastructure and Net-Zero Technology

Background

In 2022, the National Development Council (NDC) of Taiwan published “Taiwan’s Pathway to Net-Zero Emissions in 2050,” which outlined the overall strategy for emissions reduction across various agencies. The Pathway aims to achieve Taiwan’s overall carbon reduction targets by having agencies across the board implement concrete emission reduction measures. In addition, the NDC also introduced twelve key strategies to formulate implementation plans and approaches for different sectors. Although Taiwan has set emission reduction targets that correspond to various categories, sectors such as residential, commercial, and transportation must include behavioral transformations at the individual level. These changes require a comprehensive overhaul of infrastructure, new systems, and spatial transformation. However, due to the limited investment in carbon reduction in past public construction budgets and the lack of an established procurement system, it is evident that Taiwan's awareness of net-zero transition for infrastructure and built environment remains insufficient. Therefore, it is absolutely essential that Taiwan drafts strategies for the net-zero transformation of infrastructure and built environment.

For the above reasons, Taiwan must further explore the feasibility of net-zero transformation strategies for infrastructure and the built environment. Crucial preliminary tasks for subsequent implementation must include collecting feedback from public and private sectors on related issues and understanding current developments of key industry value chains. In addition, to ensure the effective development of net-zero transformation for infrastructure, it is necessary to create simulations and design mechanisms of social implementation. Such efforts will establish an implementation model where the planning and execution of Taiwan's net-zero technology initiatives proceed in tandem. Therefore, this strategy aims to have agencies across the board foster a positive cycle where infrastructure drives investment in net-zero technologies. This approach will generate compounding benefits by ensuring that national investments in urban infrastructure and innovation in net-zero technology continuously reinforce each other. In addition, substantial contributions will be made toward achieving overall net-zero goals by developing strategic simulations and real-life demonstration venues.

Global Outlook and Domestic Progress

Infrastructure covers a wide range of areas. Given the maturity of urban areas, the net-zero transformation of infrastructure and built environment must require a comprehensive approach for overall spatial transformation. For example, Japan’s Ministry of Land, Infrastructure, Transport and Tourism is promoting

carbon reduction and energy network transformation at the Akita Coastal Processing Center. This project considers the characteristics of the site and incorporates renewable energy integration models for infrastructure. In addition, the project is implementing measures to localize and optimize energy usage through the creation

of energy hubs. This builds a circular mechanism for regional energy that facilitates the overall net-zero transformation of the space.

In response to Taiwan's 2050 net-zero transition goals, major cities across the country have already introduced local net-zero regulations while setting emission reduction pathways and targets. These transformation strategies primarily focus on sectors such as transportation and construction. In terms of transportation, cities are generally promoting the adoption of electric vehicles and encouraging the use of public transportation. As for construction, certifications for green buildings and energy efficiency are commonly employed as key measures for achieving net-zero targets.

However, upon reviewing current emission reduction

strategies formulated by most cities, it is evident that they generally do not consider implementation strategies that support approaches for infrastructure transformation. Furthermore, comprehensive strategies have not been proposed for the overall net-zero transformation of urban spaces. As a result, current strategies often focus only on surface-level applications and fail to address the existing emissions from infrastructure and the built environment. Thus, the potential of infrastructure transformation to reduce emissions through green infrastructure is overlooked. In addition, appropriate net-zero pathways and carbon reduction measures have not been designed for data centers and other large-scale electricity-consuming infrastructure. This indicates that Taiwan's net-zero transition strategies significantly lack investment in infrastructure.

Strategic Planning Frameworks

To maximize the integrative benefits of introducing Taiwan's technology projects into urban applications for net-zero transformation, this plan will focus on three major areas: Low-Carbon Transportation, Low-Carbon Construction, and Green Infrastructure. It will also concentrate on improving the integration of these three areas with power infrastructure systems through G2V (Grid-to-Vehicle) and G2H (Grid-to-Home) conversions. This approach aims to achieve the three main goals of urban infrastructure and the built environment: Electrification, Smart Technology Adoption, and Increased Efficiency.

(1) Six Key Strategies for Accelerating the Electrification, Efficiency, and Smart Technology Adoption of Urban Infrastructure:

To address the increased electricity demand resulting from Taiwan's electrification efforts, particularly as end-use sectors (e.g., gasoline vehicles, gas-powered appliances) electrify, it is essential not only to boost green electricity production and storage across various agencies, but also to enhance efficiency and smart technology integration to manage and regulate this demand. The main implementation strategies are depicted below in Figure 1:

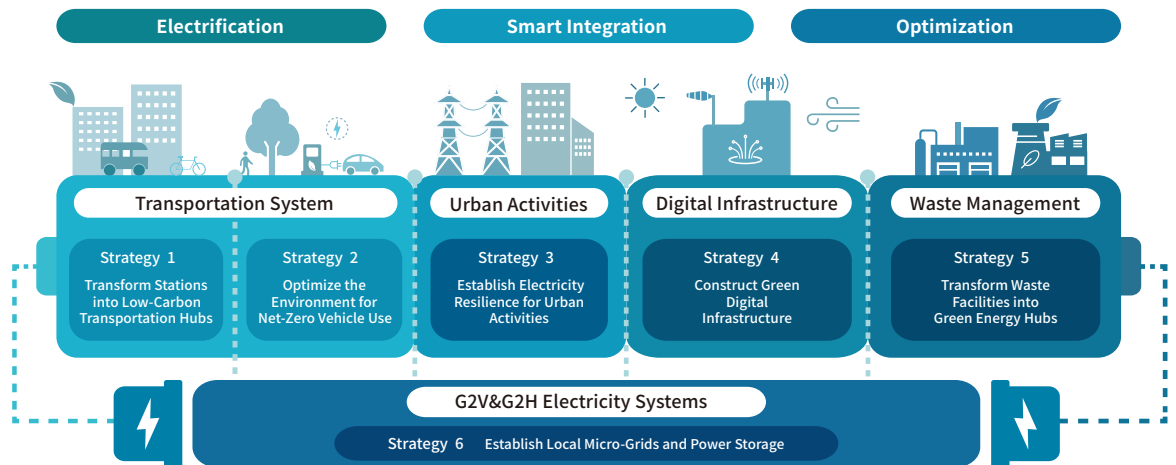


Figure 1 Technology Blueprint for Net-Zero Transition for Infrastructure and Built Environment

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

Strategy 1: Transform Stations into Low-Carbon Transportation Hubs

Effectively reduce the use of private vehicles by introducing alternatives such as electric public vehicles and shared transportation options that meet last-mile demands. Develop low-carbon transportation zones that focus on shared vehicle stations. Transform these stations and their surrounding areas into low-carbon transportation districts. Conduct prior planning for charging infrastructure and related innovations in governance. Such planning must include establishing parking spaces for electric vehicles in public parking lots, installing charging stations for roadside parking spaces, and creating dedicated parking areas for shared vehicles. Further facilitate the transition to low-carbon transportation zones by conducting backtracking analysis that monitors the development of low-carbon transportation zones, expanding strategies to increase the use of public transportation, and promoting transformation in spatial design.

Strategy 2: Optimize the Environment for Net-Zero Vehicle Use

Stations and their surrounding areas typically involve the intersection and integration of multiple transportation modes. Select these areas based on their potential to transform into low-carbon transportation zones. Gradually complete various aspects of the transportation system's charging infrastructure by installing relevant components and enhancing related systems. Prioritize the completion of charging infrastructure in urban parking facilities by providing shared electric vehicles and charging stations in public parking lots. In addition, construct dedicated charging areas for commercial vehicles, which include fast-charging stations and power storage facilities for newly formed commercial fleets. This should include the creation of public charging facility systems and integrated business models. Give consideration to improving the deployment of Taiwan's charging infrastructure through the establishment of energy storage facilities designed for disaster prevention and back feeding into the power grid.

In terms of redesigning roads, focus outcomes on serving green transportation and efficiently connecting public transportation stations. Optimize the environment for low-carbon vehicle use by increasing the usage rates of public transportation and shared vehicles. This should include converting lanes and roadside parking spaces into sidewalks, bike lanes, or designated spaces for the charging of private and shared electric vehicles. Enhance the efficiency of roadways connecting to public transportation stations by implementing smart traffic

signals that improve the convenience of transfers.

Strategy 3: Establish Electricity Resilience for Urban Activities

Increase green energy self-sufficiency in various types of functional urban areas by using backtracking analysis to guide the planning of power resilience in urban development. Adapt infrastructure to enhance power resilience through practices such as net-zero building, energy storage, and energy management. In addition, promote demonstration zones for power resilience in large residential communities and public urban facilities that strengthen power resilience for urban activities.

Strategy 4: Construct Green Digital Infrastructure

Proactively establish systems and frameworks for green data centers in response to the growing demand for large-scale data centers that are being driven by future advancements in AI computing. Create and implement consistent nationwide cross-sector carbon reduction targets and power generation/storage obligations for data centers. Implement efficiency monitoring for critical equipment and conduct R&D on IT equipment such as high-power-consuming cooling systems and servers. Encourage operators to promptly replace inefficient equipment. Promote the net-zero transformation of digital urban ICT infrastructure by incorporating energy-saving and high-efficiency transmission technologies in wired and wireless communication infrastructure, server rooms, and data center nodes into the implementation of carbon footprint regulations.

Strategy 5: Transform Waste Facilities into Green Energy Hubs

In the past, large waste treatment facilities such as incineration plants and wastewater treatment plants, have consumed large amounts of energy while generating large amounts of waste. To meet the rapidly growing demand for green energy at data centers in the future, efforts should be made to improve the energy efficiency of incinerators and develop biogas power generation technologies for wastewater treatment plants and landfills. By transforming urban waste treatment facilities into green energy hubs, Taiwan can meet industrial development's growing demands for green electricity.

Strategy 6: Establish Local Micro-Grids and Power Storage

Enhance the establishment of local microgrids in Taiwan by having new areas for large-scale development implement Area Energy Management Systems (AEMS) that automate the control and allocation of power generation, energy storage, and various demands for

electricity. Plan the required scale of local power generation and storage systems. Construct microgrids and energy storage systems that improve the resilience of local grids and increase the feasibility of commercial ventures through Private Finance Initiatives (PFI).

Moreover, in newly developed areas, actively promote the early adoption of certification systems for energy efficiency in buildings and the expanded use of smart meters and Home Energy Management Systems (HEMS) that respond to changes in energy use. Promote the local net-zero transformation of large-scale urban development areas by increasing the installation of renewable energy and storage devices that help form commercial models for HEMS and ensure carbon reduction in the construction industry.

(2) Expand Measures for Spatial System Transformation in Three Major Urban Areas:

Within cities, key venues for net-zero transformation can be broadly categorized into public transportation stations and their surrounding areas, large new (or redevelopment) zones, and large emission-heavy infrastructure. Spatial transformation strategies must be tailored to the characteristics of a specific location. By promoting net-zero transformation in many small local areas, the amount of net-zero area throughout Taiwan will gradually increase. In turn, this model will enable all parts of Taiwan to achieve net-zero goals by serving as a foundation for promoting the transformation of surrounding areas.

Potential Benefits

Pertinent and suitable transformation can reduce emissions in urban areas. More specifically, reducing the use of fuel-powered vehicles is the main goal of carbon reduction at public transportation stations. For new large-scale areas of development, the focus is on achieving greater self-sufficiency in power. As for high emission infrastructure, goals include gradually enacting demands for green energy generation. Moreover, cities can move towards reducing their carbon emissions by using targeted specific urban spaces to initiate net-zero transition. By analyzing the needs of urban spaces through the three key dimensions mentioned above, Taiwan can implement technology plans that addresses each of those needs. This will amplify the impact and effectiveness of relevant initiatives by strengthening the weak points in Taiwan's 12 key strategies for net-zero green lifestyles while accelerating the achievement of national net-zero targets.

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