

The Net Zero Transformation of Green Building and the Building Energy-Efficiency Rating System in Chinese Taipei

WANG Rong-Jin¹

LO Shih-Chi²

CHEN Chi-Ren³

Architecture and Building Research Institute, Ministry of the Interior, Chinese Taipei

ABSTRACT

In response to the problems of climate change and global warming, many countries around the world have declared net zero emissions targets. Chinese Taipei has built a staunch foundation in building energy conservation through the promotion of green building policies emphasizing ecological, energy saving, waste reduction and health benefits. Under Chinese Taipei's 2050 Net Zero Emission Path and Strategies, the Ministry of the Interior (MOI) is tasked with planning and promoting a path toward net zero building. New international trends in building energy strategies and the local context and subtropical climate with high humidity and temperature are referenced in establishing an energy rating system to assess building energy efficiency. The strategy is for the public to lead the private sector, with priority placed first on energy-intensive buildings. Rolling out the plan in stages, voluntary labeling of building energy rating will first be encouraged then legislated. New buildings will then be required to improve energy efficiency year by year, starting with at least 20% in energy saving and incrementally elevated to 50% or nearly zero carbon building (nZCB). A pilot building energy-efficiency rating system started in 2022, and several applications have been received. This paper provides an analysis of two demonstrative projects recently certified as nZCB, both of which achieved over 50% in energy saving. The aim is to encourage more applications in the future on the path toward the vision of net zero building by 2050.

Keywords: Net Zero Building, Green Building Label, Building Energy-Efficiency Label, Nearly Zero Carbon Building, Net Zero Transformation

¹ Director General

² Director

³ Associate Research Fellow (e-mail address: chiren@abri.gov.tw)

I. Foreword

In response to the problems of climate change and global warming, there are presently over 130 countries around the world which have declared net-zero emissions targets, while the EU, USA, and Japan are advocating for carbon neutral or net-zero emissions by 2050. Countries worldwide have established different levels of policy measures and strategies across the sectors, including transportation, industrial, energy, agriculture, and building. According to “Net Zero by 2050--A Roadmap for the Global Energy Sector” published by the International Energy Agency (IEA), there will be two key tasks to achieving net zero emissions by 2050. First, countries around the world must continue to push for better energy efficiency in various sectors. Second, the energy sector must adopt emission-cutting measures and technologies while actively pursuing renewable energy and novel fuels and the relevant technologies. For the building sector, the main tasks would be to adopt energy-saving technologies that utilize renewable energy and carbon-neutral concepts and propose solutions that effectively reduce total building energy consumption.

Chinese Taipei has also put forth its 2050 net zero goals. On Mar. 30, 2022, the National Development Council published “Chinese Taipei’s 2050 Net-Zero Emission Path and Strategies” [1], outlining key milestones in Chinese Taipei’s net zero transformation pathway in the transportation, industrial, energy, agricultural, and building sectors (Fig. 1). The Ministry of the Interior (MOI) is tasked with planning and implementing the path to “net zero building” (NZB). To this end, it must facilitate net zero transformation by referencing international trends and building on the foundation of its existing Green Building Label system, which is highly effective with a strong track record. The 2050 NZB vision will be achieved gradually by establishing a building energy rating system and developing nearly zero carbon building (nZCB) technologies. The first step is to cut building energy consumption by 50% and then achieve carbon-neutral, and then net zero via renewable energy. The target for each stage for the building sector is as follows:

- (1) Building energy-efficiency Level 1 or nearly zero carbon building in new public buildings by 2030.
- (2) Upgrade to building energy-efficiency Level 1 or nearly zero carbon building in 50% of existing buildings by 2040.
- (3) Nearly zero carbon building in 100% of new buildings and over 85% of existing buildings by 2050.

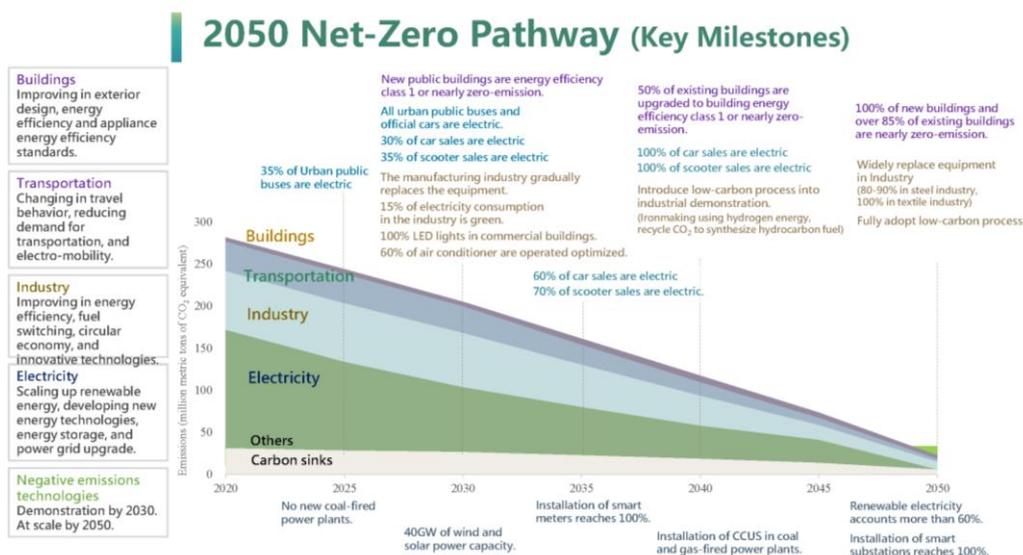


Fig. 1. Key milestones in Chinese Taipei’s net zero transformation pathway (Source: “Chinese Taipei’s 2050 Net-Zero Emission Path and Strategies”, National Development Council)

II. Energy Efficiency Achieved in Chinese Taipei’s Promotion of Green Building

2-1 A green building evaluation system for Chinese Taipei’s subtropical climate

Chinese Taipei’s own green building evaluation system was established in 1989 by the Architecture and Building Research Institute (ABRI), Ministry of the Interior together with the local building industry. It is a scientific and quantifiable green building evaluation system tailored to subtropical climates and fully adapted to demands in Ecology, Energy saving, Waste reduction and Health (hence the acronym EEWH) in Chinese Taipei’s building environment.

2-2 At least 20% in energy saving of Green Building Label

The Green Building Label is a voluntary system in Chinese Taipei, where the public sector takes the lead to help shape a natural market mechanism for the green building industry. Starting in 2001, all new public buildings with a construction budget of \$50M or more must obtain the Green Building Label. Private buildings were also encouraged to do so with incentives on floor area ratio under the “Urban Renewal Act” and the "Statute for Expediting Reconstruction of Urban Unsafe and Old Buildings”. Buildings with the Label achieve at least 20% in energy saving compared to the average in the 2000 building market. Credited to the government’s green building policies and the support of architects and the construction market, there was a clear upsurge in approved cases. As of end-October 2022, there are already a total of 11,141 cases certified with the Green Building Label (Fig. 2). Not only are the cases increasing and breaking records year by year, but participating projects in the private sector have also risen in proportion. The outcome of a saving of 2.482 TWh in electricity, 122.4M tons in water, and 1.394M tons in CO₂ emissions as of end-October 2022 demonstrates excellent performance in Chinese Taipei’s promotion of the Green Building Label.

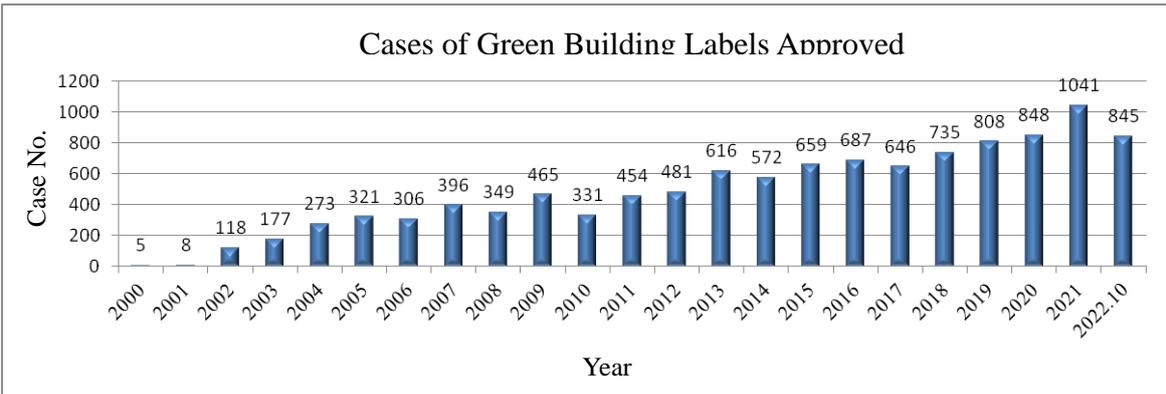


Fig. 2. Cases of Green Building Labels Approved in Chinese Taipei (including candidate certificates)

III. Net Zero Transformation in Green Building and Net Zero Building Pathway

3-1 Net zero transformation in green building

With a view to align with international trends, the MOI added the Building Energy-Efficiency Rating System to the Green Building Labeling system after referencing IEA’s “Net Zero by 2050--A Roadmap for the Global Energy Sector” [3] and concepts from the EU [4-6], USA [7-10], and Japan [11-12]. The energy efficiency of a building is rated based on indicators assessing the building envelop, air conditioning systems and indoor lighting systems. This core policy tool for building energy assessment sets an important foundation for the pathway toward net zero building by 2050.

3-2 The net zero building pathway and promotional strategies

The MOI’s pathway to the net zero building is founded on energy-efficient design with at least 20% in energy saving, which is then improved to 50% to accomplish nZCB. Of course, it is impossible for a building to not use any electricity, but NZB by 2050 is achievable if the remaining electricity may be neutralized by using renewable energy to reach carbon-neutral zero emissions. Therefore, Chinese Taipei’s pathway to net zero building combines the nZCB pathway at 50% energy saving (implemented by the MOI) and the 50% renewable energy pathway (implemented by the Ministry of Economic Affairs) toward the ultimate goal of the carbon-neutral net zero building by 2050 (Fig. 3).

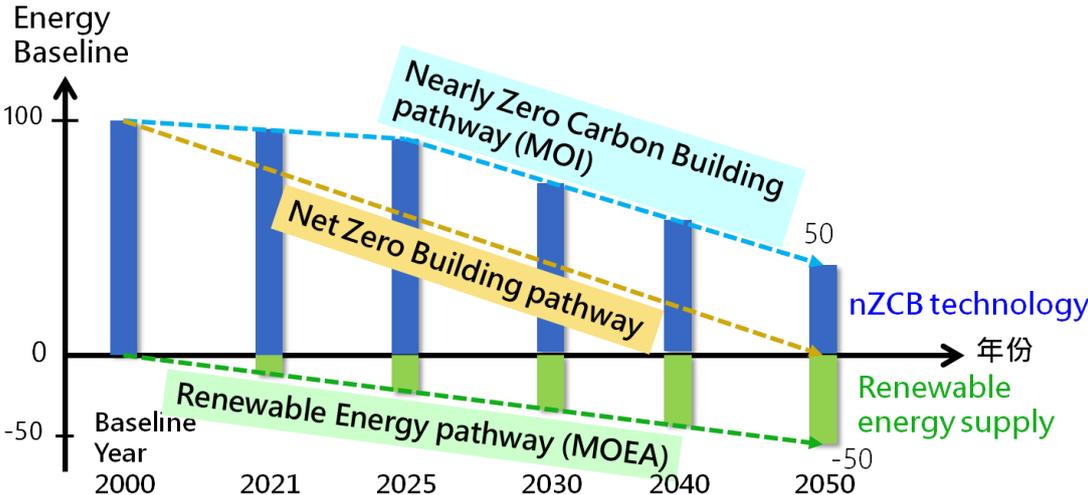


Fig. 3. Chinese Taipei’s net zero building pathway

As for the promotional strategies for net zero building, they will be deployed in stages year by year, with the related central and local government bodies leveraging public buildings to spearhead the way for the private sector. Priority will be placed first on energy-intensive buildings and then broadened to other buildings. For new buildings, incentives will be offered first before mandatory measures are legislated. As for existing buildings, the case amount involved is extensive and public rights are involved, so private ones will primarily be incentivized with bonuses and subsidies, while public ones will be subjected to mandatory requirements. At the same time, energy efficiency in home electronics is to be enhanced and efforts are devoted to research and develop (R&D) and applications in energy and emission reduction technologies and renewable energy. The goal is to pursue energy and emission efficiency and sustainability on all fronts toward the ultimate vision of the net zero building.

3-3 Priorities in net zero building

The four priorities and measures for net zero building are outlined as follows:

- (1) Enhance the energy efficiency of new buildings:** Establish a building energy efficiency rating system, bolster the building energy code, and introduce tiered building energy efficiency controls.
- (2) Improve the energy efficiency of existing buildings:** Gradually impose assessment and improvement of the energy efficiency of existing public buildings and encourage the same in private ones with bonuses and subsidies.
- (3) Raise the energy efficiency of home electronics:** Raise the energy efficiency standards for home electronics in stages, assess the continuation of goods tax discounts, and amend the “Condominium Administration Act Building Administration Division” to require parking spaces for electric vehicles.
- (4) Research and develop new technologies in carbon and energy reduction and promote related applications:** Plan for the R&D and promotion of technologies in carbon and energy reduction suitable to Chinese Taipei’s climatic and energy use characteristics, such as a smart building energy management platform, building energy management database, wood and bamboo structures, circular building economy, building life extension, and pre-fabrication.

IV. Establishing a System for Building Energy-Efficiency Rating and Labeling

(1) Publish the Building Energy-Efficiency Rating System Evaluation Manual

With an eye to promote building energy efficiency assessment and labeling, the ABRI commissioned Pf. Hsien-Te Lin to compile the Building Energy-Efficiency Rating System Evaluation Manual, which was published in December 2021 (Fig. 4). The Manual provides a rating system for energy efficiency complete with calculations and a scoring and labeling system under the existing Green Building Label system.

(2) Establish a building energy-efficiency rating system

The MOI established the Building Energy-Efficiency Rating System (BERS) in Chinese Taipei, which gives a rating of 1 to 7, with 1 being the highest rating. Level-1 buildings belonging the top 50% on the energy efficiency scale are certified as nZCB and labeled as “1⁺”. In the future, buildings certified as nZCB will represent 50% in energy saving, and the remaining electricity use may be neutralized by using renewable energy to achieve “net zero building”.

(3) Integrating building energy efficiency assessment and voluntary labeling into the Green Building Label

The MOI promulgated the amended the “Administrative Directions of Applying for Approval of Green Building Label” on Dec. 2, 2021. Requirements on building energy efficiency assessment and labeling are now integrated into the Green Building Label and come into force on Jan. 1, 2022. Applicants for the Label may voluntarily apply at the same time for building energy rating. The hope is to leverage the effectiveness of the Green Building Label in advancing voluntary energy rating labeling and thus elevating the caliber of energy design in green building. Furthermore, applicants can have a plaque made according to the MOI template (Fig. 5) indicating the energy rating and display it at their building.

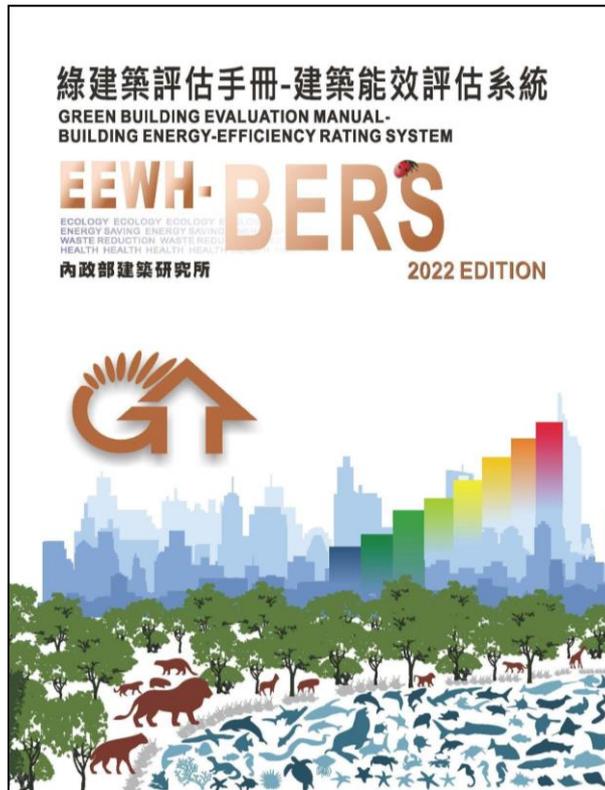


Fig. 4. Building Energy-Efficiency Rating System (assessment criteria) published by the ABRI

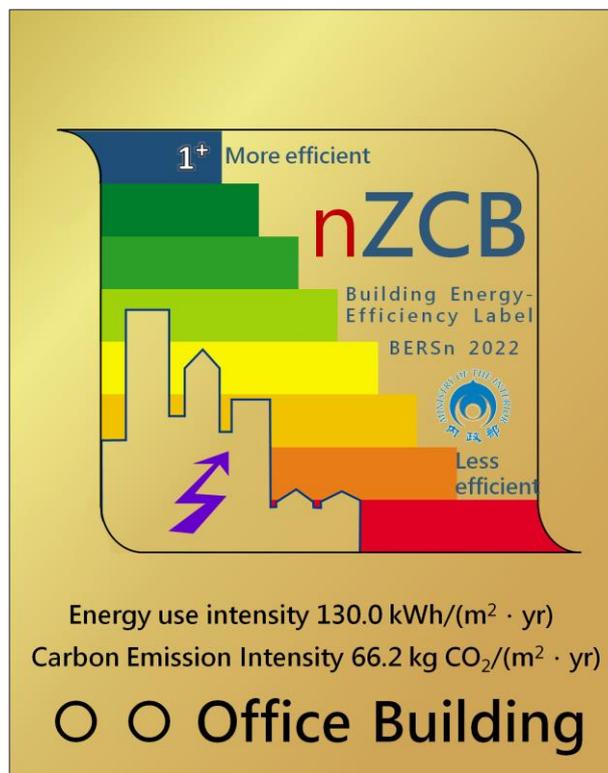


Fig. 5. Plaque indicating the Building Energy-Efficiency Label

V. Case Studies on Building Energy Efficiency Assessment

Inquiries and applications from the public and private sectors have been received upon the implementation of the building energy efficiency assessment and labeling system. The pilot began in 2022, and there are already six approved cases now certified with building energy efficiency labeling. The following is an analysis of two different types of buildings as examples of nZCB.

5-1 Nearly zero carbon building in the office and large space category:

(1) Basic data

Table 1. Example in the office and large space category

Item	Description
Building Name	Y.S. Sun Green Building Research Center (Also known as the “NCKU Magic School of Green Technologies in Chinese Taipei”)
Address	Tainan City
Brief Description	1 level below-grade, 4 levels above-grade; reinforced concrete structure with air-conditioning (zoning: office/cultural/educational)
Assessed Floor Area	2,933.31 m ²
Green Building Rating	Diamond
Building Energy Efficiency Rating	1 ⁺ (nZCB)
Building Energy Saving	68.4%

(2) Energy-saving design of green building

This project (Y.S. Sun Green Building Research Center, Fig. 6 & Fig. 7) incorporates several green building design techniques starting right from the design stage; it received Diamond-level Green Building Label in March 2011 and the Outstanding Green Building Design Award in the same year, both from the MOI. Simulation shows it represents approximately 65% in energy saving compared with buildings of the same type and demonstrates exceptional sustainability and energy and emission efficiency.



Fig. 6. Building designs with deep shading, green roof, and rooftop solar and wind power generation systems

(Source: Green Building in Chinese Taipei: Catalogue of Winners of 6th Outstanding Green Building Award, ABRI, MOI)



(a) No air conditioner required in the lobby with open ventilation design



(b) No glare in the conference hall with indirect light design

Fig. 7. Building designs with natural ventilation and indirect lighting

(Source: Green Building in Chinese Taipei: Catalogue of Winners of 6th Outstanding Green Building Award, ABRI, MOI)

(3) Building energy efficiency assessment

An application for energy efficiency rating in the existing building category was submitted for this public building project in 2022, which became one of the first applications. Based on actual utility bills and electricity consumption data, the annual energy use intensity (EUI) was assessed to be 22.24 kWh/(m² · yr), representing 68.4%

in energy saving compared with buildings in the same category. The project proved it achieved the energy efficiency proposed in the original design, and became the first MOI-certified nZCB in the office and large space category (rated Level 1⁺). Its Building Energy-Efficiency Label is as shown in Fig. 8.

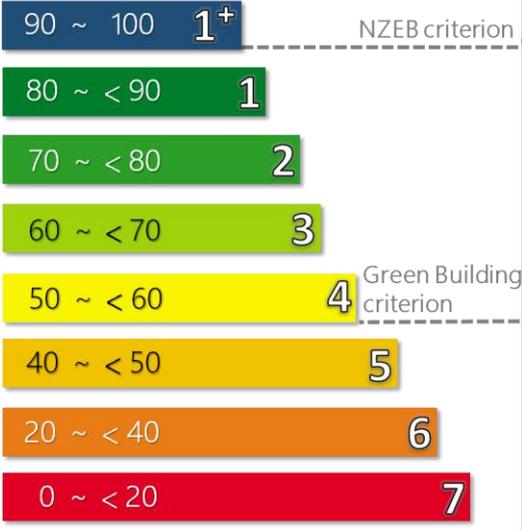
Building Name	Y.S. Sun Green Building Research Center	
Address	Tainan City	
Assessed Floor Area (Afe)	2933.31 [m ²]	
Energy Rating No.	GB-EB-EE-01-00006	
EUI kWh/(m ² .yr)	Score100	EUI Indicator EUI*
≤ 53.9	90 ~ 100 1⁺ NZEB criterion	
≤ 54.9	80 ~ < 90 1	
≤ 56.0	70 ~ < 80 2	
≤ 57.0	60 ~ < 70 3	
≤ 58.0	50 ~ < 60 4 Green Building criterion	
≤ 69.5	40 ~ < 50 5	
≤ 92.3	20 ~ < 40 6	
> 92.3	0 ~ < 20 7	
Energy use intensity indicator EUI* [kWh/(m ² .yr)]		22.24
Carbon Emission Intensity indicator CEI* [kgCO ₂ /(m ² .yr)]		11.32

Fig. 8. Building Energy-Efficiency Label for an nZCB in the office and large space category

(4) Energy-saving measures

Key energy-saving designs in this project include:

A. Building structure:

- a. Shading: Deep overhangs and balconies on the south facade create cool shaded areas and prevent direct thermal exposure in the indoor spaces. Horizontal or lattice shading is provided in the other directions as required. Even the semi-outdoor staircase was designed with horizontal lattice shading to allow breezes to pass through, achieving solar shading and good ventilation at the same time.
- b. Ventilation: Three vent stacks were designed to quickly suck out air from the bottom and achieve ventilation and heat removal utilizing fluid mechanics theories.

B. Energy-saving designs in equipments:

- a. Air conditioning: An inverter-controlled centrifugal chiller with the highest efficiency level (coefficient of performance (COP)=8.0), inverter compressor, and variable refrigerant volume (VRV) system (COP=4.1) were used, together with a variable air volume (VAV) system, variable water volume (VWV) chiller pump system, fresh air volume system with controlled CO₂ concentration, full heat exchange system, and a building energy management system (BEMS), which records, analyzes, and monitors energy use at all times. The project is an excellent example of smart energy management.
- b. Lighting design: Metal halide lamps are provided at the 2m-high walls flanking the International Conference Hall (Chonghua Hall). Light is projected onto white ceilings and then deflected multiple times and evenly distributed over the auditorium, achieving indirect light at approximately 300 lux and significantly cutting lighting fixtures and circuitry in the ceiling; there is no glare, and a comfortable visual environment is provided. Natural light is also introduced with a light well at basement level-1 parking, contributing to dramatic saving in energy use by artificial lighting and exhaust fans.

C. Renewable energy applications:

The abundant sun and wind in southern Chinese Taipei are leveraged by installing photovoltaic panels and a wind turbine on the roof to partially supply the building’s energy use. In addition, the National Cheng Kung University (NCKU) devoted 4.7 ha of campus space to create an extensive subtropical rainforest to help achieve the zero-carbon target. CO₂ emissions from the building were captured through the photosynthesis of the woodland to realize the zero-carbon target of the Magic School of Green Technologies.

(4) International honors

The project was selected by the Intergovernmental Panel on Climate Change (IPCC) of United Nations (UN) in 2022 as one of seven zero carbon buildings worldwide and serves as an international role model in emission reduction.

5-2 Nearly zero carbon building in the convenience store category:

(1) Basic data

Table 2. Example in the convenience store category

Item	Description
Building Name	Antong Store, President Chain Store Corporation
Address	Tainan City
Brief Description	2 levels below-grade, 13 levels above-grade; reinforced concrete structure; streetside convenience store
Assessed Floor Area	412.81 m ²
Green Building Rating	Diamond
Building Energy Efficiency Rating	1 ⁺ (nZCB)
Building Energy Saving	57.7%

(2) Energy-saving design in the convenience store

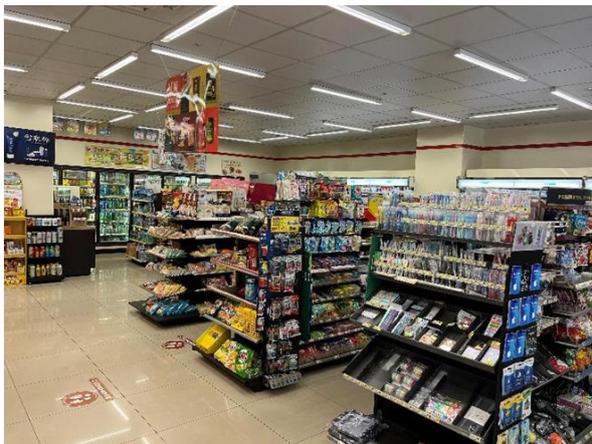
The annual energy use intensity for this project (Antong Store, President Chain Store Corporation, Fig. 9) is assessed to be 466.4 kWh/(m² · yr), representing an energy saving of 57.7% compared to convenience stores (CVSs) of the same type. There is a dense network of CVSs in Chinese Taipei, and they are semi-public spaces affording the most frequent contact for most residents. This project demonstrates superb energy saving and carbon reduction and serves as a great precedent for CVSs and chain supermarkets.



(a) Recessed vestibule to reduce cold air leak



(b) Added air circulation fans to enhance air conditioner efficiency



(c) Modified lighting layout and light-emitting diode (LED) lamp replacement



(d) Centralized customer seating

Fig.9 A nZCB in the convenience store category

(Source: Presentation on Antong Store, President Chain Store Corporation)

(3) Building energy efficiency assessment

As businesses attach increasingly greater importance to environment, social, and governance (ESG), the private sector is actively responding to the government's green building and building energy policies. This project proactively undertook energy assessment and improvement and implemented green operations, becoming the first MOI-certified nZCB (Level 1⁺) in the convenience store category in the country. Its Building Energy-Efficiency Label is as shown in Fig. 10.

(4) Energy-saving measures

Key energy-saving designs in this project include:

- A. Energy-saving vestibule: A buffer space with an inner set of doors is added to the automatic doors at the lobby to prevent cold air from leaking out, enhancing the efficiency of the air conditioner (AC).
- B. Inverter AC system plus air circulation fans: The former AC system is replaced with a higher-performance inverter system, and air circulation fans are installed in the ceiling. As a result, the AC efficiency is improved.
- C. Modified lighting layout and light-emitting diode (LED) light bulb replacement: Lighting fixtures are lined along the corridors to help consumers more easily identify merchandise and thus reduce the total number of fixtures and power consumption required.
- D. Centralized customer seating: The seating is grouped and located next to large external glazing. Natural lighting during daytime reduces the artificial lighting required, and timed and zoned AC and lighting controls depending on the number of customers further lowers energy use.
- E. Inverter fridges and freezers: New inverter fridges and freezers are introduced for improved energy efficiency.
- F. Optimized fridge energy efficiency and defrosting: Fridge defrosting with smart controls improves the 24h energy efficiency, and sensors are added to fridge doors to cut cold air leak.
- G. Reduced lighting on outdoor signage: Instead of lining traditional lightbox signs along the entire storefront, text-style signage is spotlighted to save electricity.

Building Name		Antong Store, President Chain Store Corporation	
Address		Tainan City	
Assessed Floor Area (Afe)		412.8 [m ²]	
Energy Rating No.		GB-EB-EE-01-00003	
EUI kWh/(m ² .yr)	Score 100		EUI Indicator EUI*
≤ 629.7	90 ~ 100 1⁺	NZEB criterion	466.4 kWh/(m ² .yr)
≤ 727.0	80 ~ < 90 1		237.4 kgCO ₂ /(m ² .yr)
≤ 824.4	70 ~ < 80 2		
≤ 921.7	60 ~ < 70 3		
≤ 1046.2	50 ~ < 60 4	Green Building criterion	
≤ 1246.1	40 ~ < 50 5		
≤ 1700.2	20 ~ < 40 6		
> 1700.2	0 ~ < 20 7		
Energy use intensity indicator EUI*		[kWh/(m ² .yr)]	466.4
Carbon Emission Intensity indicator CEI*		[kgCO ₂ /(m ² .yr)]	237.4

Fig. 10. Building Energy-Efficiency Label for an nZCB in the convenience store category

VI. Conclusion and Future Perspective

With a view to facilitate the net zero transformation of green building in Chinese Taipei, the MOI established the Building Energy-Efficiency Rating System (BERS) on the existing foundation of the Green Building Label emphasizing ecological, energy saving, waste reduction and health (EEWH) benefits. The plan is to start with public buildings spearheading the way for the private sector. For new buildings, incentives will be offered first before mandatory measures are legislated. As for existing buildings, the case amount involved is extensive and public rights are involved, so private ones will primarily be incentivized with bonuses and subsidies, while public ones will be subjected to stepwise mandatory requirements. The hope is to leverage the effectiveness of the Green Building Label in advancing voluntary Building Energy-Efficiency Label and thus enhancing building energy efficiency in Chinese Taipei. Another aim is to have exemplary projects serve as a benchmark and encourage new applications, thereby boosting public awareness and raising Chinese Taipei's visibility in the international community. Chinese Taipei is committed to its vision of becoming a hub for green building and environmental education for all subtropical countries and working together toward the vision of 2050 net zero building.

Reference

1. National Development Council, *Chinese Taipei's 2050 Net-Zero Emission Path and Strategies*, Mar. 30, 2022.
2. ABRI, *Disclosure Report on Smart Green Building Promotion*, Aug. 2022.
3. *Net Zero by 2050 - A Roadmap for the Global Energy Sector*, IEA (2021).
4. DENA energieausweis website.
(<https://www.zukunft-haus.info/beratung-planung/energieausweis>)
5. The Energy Performance of Buildings Directive (EPBD), EU (2010).
6. *Buildings Performance Institute Europe (BPIE) 2015 Report: Nearly Zero Energy Buildings Definitions Across Europe*.
7. Energy Independence and Security Act of 2007, EISA 2007.
8. <https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/us-e-portfolio-manager>, website of Energy Star Portfolio Manager
9. <https://www.energy.gov/eere/buildings/building-energy-asset-score>, website of Building Energy Asset Score
10. <https://www.hersindex.com/hers-index/what-is-the-hers-index/>, website of Home Energy Rating System (HERS)
11. <http://www.kankyoallsystem.co.jp/publics/index/39/>, website of Kankyo All System Co., Ltd.
12. *Future Investment Strategies for Transformation toward 2017-society5.0* (Jun. 9, 2017)
(http://www.kantei.go.jp/jp/singi/keizaisaisei/pdf/miraitousi2017_t.pdf)
13. LIN Hsien-Te, KUO Po-Yen, YAN Chia-Ju, *Energy Efficiency Calculation Criteria and Labeling of Non-residential Green Buildings*, 2020.
14. MOI, Presentation on “Preliminary Pathway for the Net-zero Building Pathway”, Oct. 18, 2021.
15. ABRI, *Green Building Evaluation Manual-Building Energy Efficiency Rating System*, Dec. 2022.
16. MOI, template for building energy rating, Jun. 2022
17. ABRI, *Green Building in Chinese Taipei: Catalogue of Winners of 6th Outstanding Green Building Award*, Dec. 2011.
18. <http://www.msgt.org.tw/>, website of The NCKU Magic School of Green Technologies
19. Presentation on Antong Store, President Chain Store Corporation, June. 2022
20. President Chain Store Corporation, President Chain Store Corporation Sustainability Report, 2021.