TITLE: SEOUL’S NOWON ENERGY ZERO HOUSING COMPLEX – REDUCING BUILDING EMISSIONS

ISSUE AREAS

☒ **ICT and SMART technology** ☐ Sustainable mobility ☐ Land use and nature-based solutions
☐ Clean energy ☐ Sustainable solid waste management ☒ **Building energy efficiency**
☐ Innovative urban governance ☐ Behavioral change

OVERVIEW

Initiated as a research and development (R&D) demonstration project for zero-energy building managed by the Ministry of Land, Infrastructure and Transportation (MoLIT), the first energy zero housing complex was built in Nowon-district (gu), Seoul (Ministry of Land, Infrastructure and Transportation, 2019). The consortium consisting of Seoul city, Nowon district, Myongji University, KCC E&C, and Seoul Housing and Communities Corporation Research implemented the project from 2013 and 2017. A budget of about 18 million USD was spent on developing the housing, with a complex model designed to use passive and active strategies to minimize energy consumption from buildings. Since early 2018, energy supply and consumption of the complex has been monitored for four years; the monitoring result has been shared between the Ministry, Korean District Heating Corporation, Seoul City, Nowon-district, and Nowon Environment Foundation on a regular basis. After the first round of monitoring ends by 2021, the complex will continue to be monitored in connection with other energy buildings in the district.

Photo 1. Nowon Energy Zero Housing Complex (Source: Nowon Energy Zero Center)

THE CHALLENGE - WHY HAS THE CITY TAKEN ACTION

2050 carbon neutrality target set by the national and local governments

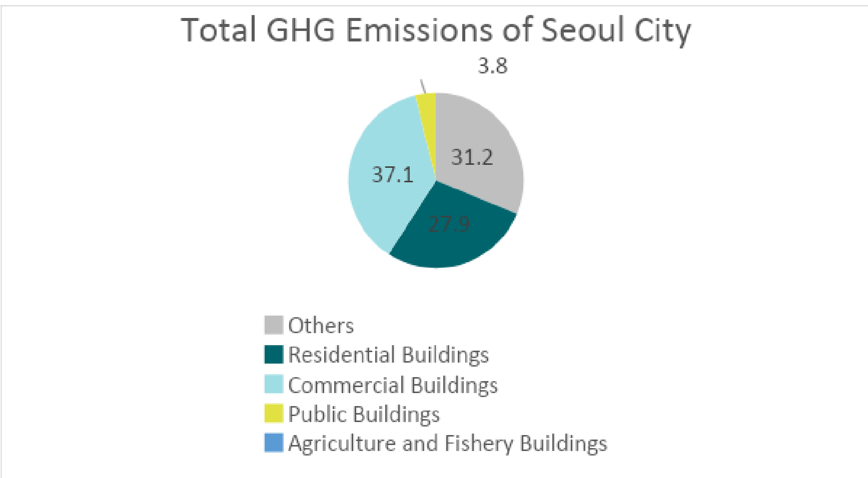
With the Paris Agreement entering into force, the national and local governments of the Republic of Korea set a carbon neutrality target by 2050. The national government sets a greenhouse gas (GHG) emissions reduction target of 40% from the level of 2018 by 2030 which was presented at 2021 United Nations Climate Change Conference (COP26) (Government of Republic of Korea, 2021). Seoul Metropolitan Government (SMG) sets a GHG emissions reduction target of 40% and 70% from the level of 2005 by 2030 and 2040 (Climate and Environment Headquarters, 2021a).

Implementation of Zero Energy Building initiative in phases at the national and city levels

Under the leadership of MoLIT, Zero Energy Building (ZEB) initiative is suggested as a technological solution in reducing GHG emissions from buildings, especially the newly-built buildings. The national mandatory roadmap for the ZEB initiative identified goals and strategies to be implemented in three stages: laying the foundation, promoting the popularisation, and initiating enforcement (Zero Energy Building Certificate System, n.d.). Aligning with the national approach, Seoul city develops ZEB initiative. Although the timeline for enforcement varies according to building types in terms of ownership and GFA, the city moves up the enforcement of ZEB initiative earlier than the national government (Climate and Environment Headquarters, 2021b). Given this, it is arising that the need for assessing technology development and identifying the direction for making synergy effects from collaboration between technology and policy-based initiatives.

The Building sector is the largest GHG emitter of Seoul city

In 2018, buildings were the largest emitter in the energy sector. GHG emissions from the building sector accounted for 68.8% of total GHG emissions of the city. To be specific, there were residential buildings with a portion of 27.9%, commercial buildings with a portion of 37.1%, public buildings with a portion of 3.8%, and agriculture and fishery buildings with a portion of 0% (Climate and Environment Headquarters, 2021c). The city needs effective measures to cap GHG emissions from buildings considering the increase of the Gross Floor Area (GFA) (Climate and Environment Headquarters, 2021b).



GOALS AND OBJECTIVES

- To lower GHG emissions from buildings through optimizing energy equilibrium
- To facilitate expansion of ZEB as a solution to development of low carbon cities
- To contribute to achieving 2050 carbon neutrality target at national and local level

HOW DID STI PROVIDE A LOW CARBON AND CLIMATE RESILIENT SOLUTION?

(STI as a means of implementation)
☒ **Improved decision making** ☐ Offering a low-cost solution ☒ **Inclusive decision making**
☒ **Improved governance** ☒ **Behavioural change**

(STI as a direct technical solution)
☒ **Cleaner/more eco-friendly infrastructure** ☒ **Cleaner/more eco-friendly equipment**
☐ Faster/better/larger data availability/processing

- How was it innovative? (What enabling policies were employed? What were the local/national government's policy targets, goals and strategies? Were new S&T approaches developed or existing S&T approaches enhanced? Was the cities geography/culture capitalised upon?)

Enabling policies

The national government and SMG adopt laws and regulations to control GHG emissions from buildings by presenting the ZEB initiative. For instance, the national government has enforced relevant laws such as *Green Building Construction Support Act* and *Energy Use Rationalization Act.* SMG also develops legal and regulatory frameworks for promoting the ZEB initiative by adopting *Ordinance on the Support for Construction of Green Building, Energy Saving Design Standard Building, and Green Building Construction Plan of Seoul city*.

Targets set by the local and national governments

According to the national government, the ZEB regulation is to be imposed on public buildings with GFA at 1,000m^2 or larger from year 2020 and those with GFA at 500m^2 or larger from year 2023; and private building with GFA at GFA at 1,000m^2 or larger from 2025 and 30 private housing complexes or more from 2025 (Zero Energy Building Certificate System, n.d.). According to SMG, the ZEB regulation is to be imposed on public buildings with GFA at 1,000m^2 or larger from 2020 and those with GFA at 500m^2 or larger from 2021; and private buildings with GFA at 100,000m^2 or larger from 2023 and those with GFA at 10,000m^2 or larger from 2024 (Climate and Environment Headquarters, 2021b).

- What science and technologies were used? (What does it do? How does it work? How does it address the challenge?)

to manage and reduce energy consumption to zero. The maximum insulation performance was designed to minimize energy demand, while renewable energy sources were designed to satisfy energy demand.

Passive technology: High energy efficient materials equipped to four sides of housing - including walls, roofs, floors, ceilings, windows, and doors - all minimized energy loss. For instance, technology was applied in the following manner (Hong, S., 2020):

- To reduce a temperature gap between the interior and exterior of the housing and prevent moulding by applying insulation and calcium carbonate composite to the internal and external walls;
- To enhance insulation by making windows from three layers of glasses;
- To reduce heat loss especially during winter using anchors, rubber pads, and German *Isokorb*;
- To block wind by using tape made of seaweed and electrical outlet cap for preventing heat loss;
- To ventilate the inside of the house even if the window is closed, by installing a heat-recovery ventilator connected with an internet of thing (IoT) equipment in every room;
- To ventilate the inside of housing in rainy days by installing tilt and turn windows;
- To reduce heat loss and noise from outside by installing a thick door with a rubber packing;
- To control sun lights and enhance insulation by using external blinds which automatically stop operating when the wind speed reaches 12 meter per second.

Active technology:

1284 solar panels were installed on external walls and 130 geothermal heat pumps were installed underground all generated clean and renewable energy that can be used for heating and cooling. Heat from people and electronic devices also was used for heating and cooling (Cho, K., 2018).

KEY AREAS OF CONSTRAINT/SUPPORT

- o INFRASTRUCTURE REQUIREMENT

Energy Zero housing complex employing the passive and active technology.

- o POLICIES AND REGULATIONS

As mentioned above, the national and local governments have adopted laws to promote enforcement of the ZEB initiative for public and private buildings in accordance with the size of GFA. The legal and regulatory frameworks create a favourable environment to construct ZEB and proliferate the model. Moreover, Seoul city uses financial instruments such as incentives to encourage housing developers to invest in ZEB. SMG provides financial support to ZEB certification and local tax exemption benefits along with lowering construction standards (Korea Energy Agency, 2017).

- o THE SCALE OF THE PROGRAMME/PROJECT

Nowon-district (gu) in Seoul city

- o TECHNOLOGY CAPACITY

Engagement of architects in the project enabled both passive and active technology to be used for energy management of the housing complex. Passive technologies were applied to maximize the insulation performance, while active technologies were applied to satisfy inevitable energy demand with renewable energy sources.

- o COST AND FINANCING /BUSINESS MODEL

About 49 million USD (46.92 million USD for construction and 0.21 million USD for R&D) was invested in the project.

- o HUMAN RESOURCE CAPACITY

Multi-stakeholders were engaged in the project. Local governments at city and district levels, a university and a research centre, the private companies provided support to the successful implementation and monitoring of the project. Public, private, and academia partnerships contributed to laying the regulative, financial, technological frameworks for the project.

- o POLITICAL COMMITMENT

- o INSTITUTIONAL SET-UP

- o KEY BENEFICIARIES

Residents, manufacturers, SMG, the national government

TIMELINE

2013 – 2017

IMPACTS

- o CARBON REDUCTIONS

No specific data is available. However, the assumption is that energy saving through the ZEB model leads to reduced energy consumption and leads to carbon reduction.

- o RESILIENCE

- o CO-BENEFITS (e.g. JOB CREATION, AIR POLLUTION REDUCTION ETC.)

Energy Saving

One characteristic of energy zero housing is to maintain a constant indoor temperature regardless of outside temperature change. In 2018, the average indoor temperature was 22℃, even the temperature rose to 26℃ in summer (Cho, K., 2018).

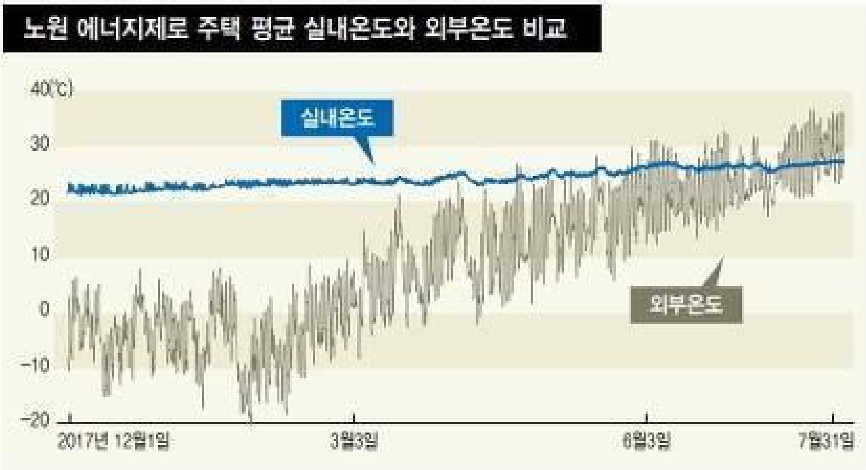


Figure 1. Indoor temperature of Nowon Energy Zero Housing Complex
(Source: Nowon Energy Zero Center
http://www.ezcenter.or.kr/bbs/board.php?bo_table=sub4_1&wr_id=7&page=3\)

The constant indoor temperature reduced energy use for heating and cooling. Monitoring results of energy supply and consumption of the experimental house at the complex is illustrated as follows. During cold waves, energy consumption from November 2016 to February 2017 (221 kWh) was 96.9% lower than that of an ordinary house (7242.9 kWh). Given the experimental house used a pellet boiler, housings using geothermal heat at the complex would consume much less energy for heating. During strong heat waves in 2016, energy consumption for using the air conditioner all day at the experimental house (574 kWh) was also 15% lower than energy consumption for using the air conditioner for four hours per day at ordinary house (675 kWh) (Korea Energy Agency, 2017).

Cost-Saving

Another key characteristic of energy zero housing is to save electricity bills. Energy generated from solar panels and geothermal heat pumps is used to satisfy energy demand from the complex. The rest of the renewable energy is sold to Korea Electronic Power Corporation (KEPCO). Energy offset process helps residents pay less electric fees. Between December 2017 and March 2020, the complex generated renewable energy of 976,104 kWh while consuming 770,130 kWh of energy. Due to the ratio of energy generated to energy consumed is 122%, each household paid a monthly electricity fee of about 41 USD equivalent to about one USD per day (Yeo, I., 2020).

Improvement of Indoor Air Quality

Mechanical ventilation of energy zero housing contributes to improve Indoor Air Quality (IAQ). According to the comparison study on IAQ between Nowon Energy Zero Housing Complex and a conventional housing complex in close proximity, the level of indoor PM_{10}, $PM_{2.5}$, CO_2, and Volatile Organic Compounds (VOCs) was lower in the energy zero housing complex than that in the conventional housing complex. As a result, residents in the energy zero housing complex are exposed to less health risks linked to air pollution such as eye fatigue, allergic rhinitis, and atopic dermatitis. For example, the risk level of children's atopic dermatitis and allergic rhinitis was significantly lower in the energy zero housing complex than in the conventional housing complex (Lim et al., 2021).

FACTORS FOR SUCCESS

A consortium of multi-stakeholders

This project was implemented based on cooperation between the national government (MoLIT), the local governments (Seoul Metropolitan Government, and Nowon-gu District Office), a private construction company (KCC E&C), a university (Myongji University), and a research centre (SH urban institute). The multi-layered perspective created a synergistic effect and encouraged the successful implementation of the project and promotion of its application to buildings. Governments provide regulatory, administrative, and financial support. A private company provides professional knowledge and skills to construct the buildings as it was planned. A university and a research centre also provided professional knowledge and skills to design the building and analyse effectiveness of the project.

LESSONS LEARNED

- OPPORTUNITIES, CHALLENGES, AND SCALING UP
  (LOW HANGING FRUITS:)
  QUICK THINGS THE CITY CAN BE WORKING ON
  SHORT-MEDIUM-LONG TERM STEPS

Challenge 1: Expensive cost for construction of the building model is a major challenge. No matter how effective the model is in terms of energy saving and efficiency, cost is a practical barrier to the promotion of the building model, especially the mass uptake from the private sector. According to MoLIT, in 2019, public buildings accounted for 2.8% of the total number of buildings in Korea. However, only 8 out of 357 ZEBs are owned by the private sector. Given this, active engagement of the private sector seems to be essential to decarbonise the building sector fast. However, the high level of construction cost hampers private engagement (Park, S., 2020). For instance, the construction cost for Nowon Energy Zero Housing Complex might be 24.5% higher than that for a general rental housing complex. In this regard, the incentives provided by the city government seem to be too small to cover the expensive construction cost (Park, S., 2020).

- SUSTAINABILITY

- TRANSFERABILITY

Considering the engagement of the national and local governments, this zero energy housing model expects to be easily applied to buildings at nation- and city-wide scale. Governments' efforts to implement the ZEB roadmap in phases is expected to enable scaling of the model. For instance, small social rental housing buildings constructed by private companies for public interest in Seoul are especially recommended for the project, given that small residential buildings with GFA at 500m^2 or smaller account for 74.4% of the total number of buildings in the city (Park, S., 2020).

- o EFFICIENCY/EFFECTIVENESS

Both passive and active technology used for the housing complex was effective in controlling energy demand and supply from buildings. The passive technology maximized insulation performance, and accordingly minimized energy demand and loss. The active technology maximized energy generation from solar power and geothermal heat, and accordingly reduced dependence on external energy sources for heating and cooling. Although the effectiveness of technology was witnessed from energy savings leading to carbon reduction, lowering the construction cost for ZEB still remains as the major challenge in terms of cost-effectiveness.

- o INSTITUTIONAL CONSTRAINTS/SUPPORTS

FURTHER INFORMATION / CONTACT

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The mandatory roadmap for Zero Energy Building initiative:
https://zeb.energy.or.kr/BC/BC02/BC02_01_001.do

Nowon energy zero housing complex: http://www.ezcenter.or.kr/

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