MOEJ

Final Report

City to City
Collaboration for
Zero-carbon Society in FY2022

Zero-carbon Society Development by Promoting Architecture and Renewable Energy Suitable for Cold Regions in Ulaanbaatar City

March 2023

Oriental Consultants Co., Ltd.
Sapporo City

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List of Abbreviations

Abbreviation	Meaning
ADB	Asian Development Bank
BAU	Business as Usual
BCP	Business Continuity Plan
CEMS	Community Energy Management System
CGS	Co-Generation System
COP	Conference of the Parties
GEF	Global Environmental Facility
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft fur Internationale Zusammenarbeit
IFC	International Finance Corporation
JCM	Joint Crediting Mechanism
NDC	Nationally Determined Contribution
NOSK	Capital City Housing Corporation
SDC	Swiss Agency for Development and Cooperation
SDGs	Sustainable Development Goals
UNFCCC	The United Nations Framework Convention on Climate Change
VOC	Volatile Organic Compound
VPP	Virtual Power Plant
WHO	World Health Organization
ZEB	Net Zero Energy Buildings
ZEH-M	Net Zero Energy House Mansion

Chapter 1 Project Overview

1.1 Project Background and Objective

With the Glasgow Climate Pact adopted during the 2021 United Nations Climate Change Conference (COP26) held in November 2021, limiting the temperature increase to 1,5 °C above pre-industrial levels was confirmed as a new global goal. To achieve this goal, each country must accelerate their efforts at province, city, district and various other levels. In Japan, it has been declared that the country aims to achieve a decarbonized society with zero greenhouse gas emissions as a whole by 2050, and the number of municipalities declaring virtually zero carbon dioxide (CO2) emissions has rapidly increased to over 800 (as of January 31, 2023). Each municipality has created advanced measures and proceeded with their initiatives extending nationwide under the Regional Decarbonization Roadmap formulated in June 2021.

As described above, the role of cities and local governments is becoming more important in considering and implementing specific regional climate change countermeasures and projects. In order to realize a global decarbonized society, it is necessary to accelerate the movement toward building a sustainable decarbonized society, especially in Asia, where economic growth is remarkable, and it is a place for activities that support socio-economic development. The movement to support the efforts of cities is being strengthened internationally toward the decarbonization of cities.

In addition, in the current situation of the spread of the COVID-19 infection, cities are under pressure to address issues related to the spread of infection and at the same time readjust and consider new measures to achieve sustainable development. It is extremely important to build a new method and a new city through cooperation between cities.

In this project, Japanese research institutes, private companies, universities, etc., together with Japanese cities that have experience and know-how regarding the development of decarbonized societies, will conduct a research project to support the efforts of overseas local governments to form a decarbonized society and the introduction of facilities that contributes to the formation of a decarbonized society.

1.2 Project Overview

Entrusted Project Name:	City to City Collaboration for Zero-carbon Society in FY2021 Zero-carbon Society Development by Promoting Architecture and Renewable Energy Suitable for Cold Regions in Ulaanbaatar City
Implementation Period:	July 8, 2022, to March 10, 2023
Ordering Party:	International Cooperation / Environmental Infrastructure Strategy Section, Global Environment Bureau, Ministry of the Environment
Consignee:	Oriental Consultants Co., Ltd.

1.3 Implementation Structure

The project implementation was initiated by the Environmental Bureau of Sapporo City, the Urban Development Department of Ulaanbaatar City and the Ulaanbaatar City Capital Public

Corporation. The relevant parties discussed via a workshop in cooperation with the Vice-Mayor of Ulaanbaatar City overseeing infrastructure development.

The World Winter Cities Association for Mayors is an international network advocated by Sapporo City; comprising 22 cities in nine countries. Since Ulaanbaatar City became a member in 1998, both cities have exchanged information and technologies. Sapporo City declared its goal of becoming a “Zero-Carbon City” and targeting virtually zero GHG emissions in 2050, with measures promoted around these clear goals. Accordingly, Sapporo City is expected to support efforts and technologies to build a decarbonized society in Ulaanbaatar City, which is also located in a cold and snowy region.

In the third year of the project, knowledge was shared through workshop and green building seminar. Moreover, Hokkaido Gas Co., Ltd. and Hokkaido University presented their knowledge during the workshop.

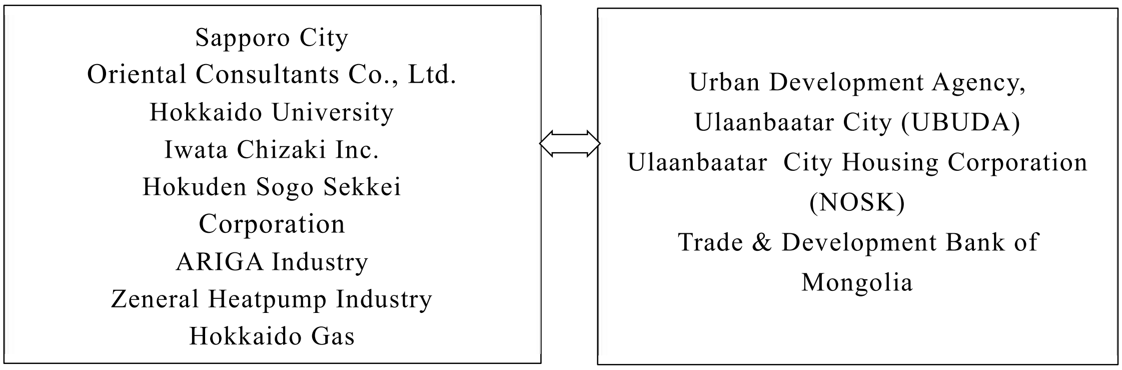


Figure 1-1 Implementation Structure

1.4 Entrusted Project Contents

The project was implemented as the third year of a three-year plan formulated in FY 2020.

A basic survey was conducted in the first year to confirm Mongolian building standards and housing status in Ulaanbaatar City as well as the needs and interests of the city. Housing in Ulaanbaatar City can be roughly divided into apartment complexes built of bricks or precast concrete in downtown areas and simple housing featuring tents or detached houses in the Ger area. Although apartment complexes in the inner area are linked to a regional heating system, there are some cases of interspaces caused by distortion and no heat insulation materials installed. Conversely, simple forms of housing are not linked to any regional heating system, in which heat insulation materials are not installed, and tend to use coal and wood-burning stoves. The building specifications of both forms of housing are insufficient for colder area in airtightness and heat insulation terms, which results in an increase in GHG emissions and exacerbates the issue of air pollution. As part of its master plan formulated in 2014, Ulaanbaatar City plans to redistribute population by redeveloping the Ger area and developing a satellite city, Accordingly, housing and infrastructure development is expected to increase in in the future.

It was confirmed that Ulaanbaatar City had a great interest in green building. Accordingly, in the second year, the project considered model building specifications commensurate with the current circumstances in the city by utilizing ZEB of Japan.

In the third year, based on the second-year result, the project share knowledge with and provide capacity building support to Ulaanbaatar City via introducing the Sapporo City Energy Plan regional and regional energy management system, recommendations of proper energy management based on environmental measurement and analysis by Hokkaido University and other contents. A green building seminar was organized, and project formulation was facilitated incorporating specifications of decarbonized model buildings for cold areas.

Table 1-1 Process for Project Implementation

Project Items	FY 2022									
	6	7	8	9	10	11	12	1	2	3
Meetings and reporting	▲	Kick-off	Progress report	▲			Mid term report	▲	Final report ▲	
(1) Sharing knowledge with and capacity building of Ulaanbaatar City										
1) Knowledge sharing by introducing energy transformation and plan in Sapporo City and precedent cases of regional heat supply system in cold area (smart energy project)										
2) Seminars utilizing energy saving calculation guidelines of ZEB and ZEH-M										
3) Environmental measurement concerning air pollution inside buildings, recommendations of proper energy management										
4) Discussions toward the feasibility of the CN declaration										
(2) Project formulation by low-carbon/decarbonized model buildings in cold areas which are applicable to the actual situation in Mongolia										
1) Development of specifications for decarbonization model building and examination of target facilities and technologies (equipment) to be introduced by phase										
2) Specific extraction of target facilities and technologies (equipment) to be introduced during initial phases										
3) Formulation of a plan for introducing in the target facilities during initial phases										
4) Examination of schemes/systems to be utilized for promoting the introducing plan										
5) Examination toward realizing a "implementation domino" proposed to private developers										
6) Identify target technologies and projects under the JCM scheme via the above activities to formulate a JCM project.										
Field survey (expecting to utilize local consultants and resources and conduct an online survey)										
Workshop organization					▲		▲			
Meetings held by the Ministry of the Environment, policy dialogue (meetings designated by the MOE)										
Monthly report		▲	▲	▲	▲	▲	▲	▲	▲	
Report preparation								Draft report		Submit ▲

Implementation Period: July 8, 2022, to March 10, 2023

Chapter 2 State of Ulaanbaatar City and its Efforts against Climate Change

2.1 Overview of Ulaanbaatar City

Ulaanbaatar City is administratively designated as a "capital city" with the same territorial sovereign function as the province. The city area is 4,704m2, comprising nine districts. The Ulaanbaatar City area occupies only 0.3% of the national land.

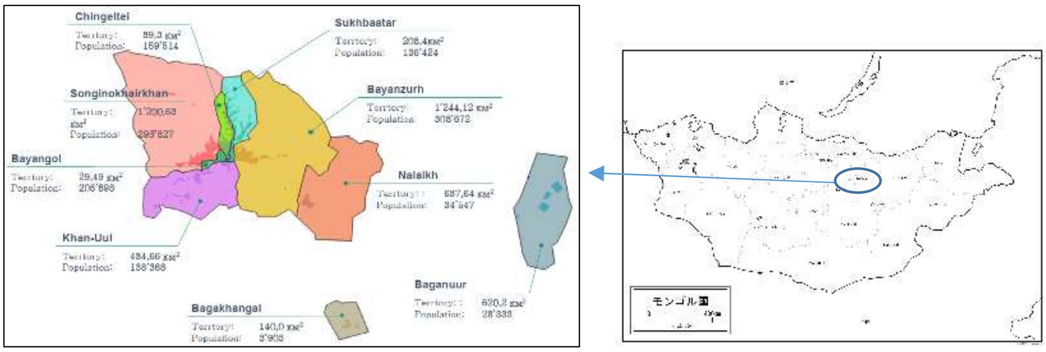


Figure 2-1 Map of Ulaanbaatar City

The population in Ulaanbaatar City was approximately 0.7 million in 2000. Due to the population inflow from other regions since then, the population was rapidly grown to approximately 1.6 million in 2020, making up around 48% of approximately 3.35 million of the entire population in Mongolia. Although the average population growth rate in Mongolia is around 3%, that of in Ulaanbaatar City over five years to 2018 was 5.6%, indicating progressive centralization.

Future population in Ulaanbaatar City is expected to exceed 2 million in 2040.

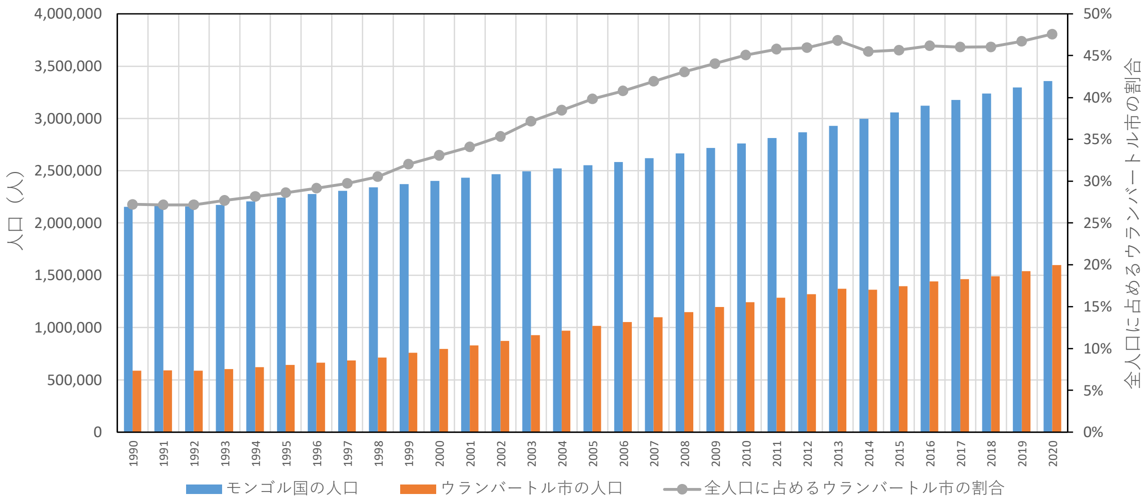


Figure 2-2 Population trends in Mongolia and Ulaanbaatar City (1990 to 2020)

Source: the Mongolia National Statistic Office database

Many of residents removed from other regions has settled in the Ger area where people build ger house in a disorderly manner without administrative approval. Today, the population of Ger areas in Ulaanbaatar City achieves about 0.84 million which is more than a half of the population in the capital.

In Ulaanbaatar City, the development of infrastructure has not kept pace with the rapid population inflow. Settlement status in Ulaanbaatar City is roughly divided into precast concrete apartments and other types of apartments in downtown areas and Mongolian Gers in Ger areas and wooden houses in suburban areas. About 50% of Ger areas are located far from the central city area and difficult to access existing infrastructures.

In winter seasons, the temperature in Mongolia is lower than -20 degrees. Many of precast concrete apartment buildings, in which about 20% of the population in Ulaanbaatar reside, were constructed during the socialist period and older buildings of which have insufficient heat insulation. In Ger areas, basic infrastructures are further underdeveloped while the heat insulation of buildings are more insufficient causing larger heat loss.

Redevelopment projects in Ger areas have recently been activated and housing complexes for 140,000 households are expected to be newly constructed in Ulaanbaatar City between 2020 and 2030.

Mongolia has joined the Paris Agreement, an international framework for reducing greenhouse gas (GHG) emissions and other initiatives after 2020, and committed to reduce GHG emissions. It is a priority of Mongolia’s National Determined Contribution (NDC) to improve energy efficiency in the building sector and reduce CO_2.

2.2 State and issues of GHG emissions and in Mongolia

（1） Current GHG emissions

Mongolia has very rich coal resources and affordable coals become the main fuel in the country. More than 90% of fuel consumptions for power generation, heating and cooking are coals, indicating that its dependency is high in terms of securing fuel energy. Although GHG emissions are low in Mongolia, consuming energy involves high GHG emissions.

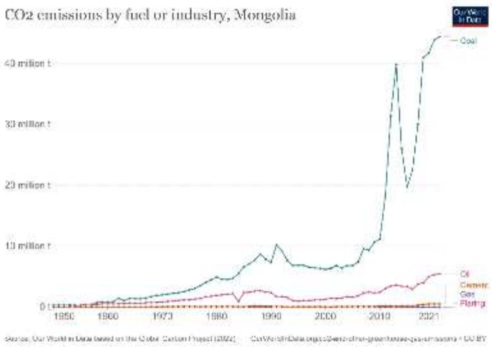


Figure 2-3　　CO_2 emissions by fuel or industry, Mongolia

Source: Our World in Data[1]

[1] https://ourworldindata.org/co2/country/mongolia

Mongolia occupies only 0.1% of the global GHG emissions. Meanwhile, GHG emissions per capita in Mongolia has increase since 2010, exceeding that of Japan and the global average. Accordingly, GHG emissions in Mongolia is expected to further increase with population growth if any reduction measures by saving energy or introducing renewable energy are not promoted.

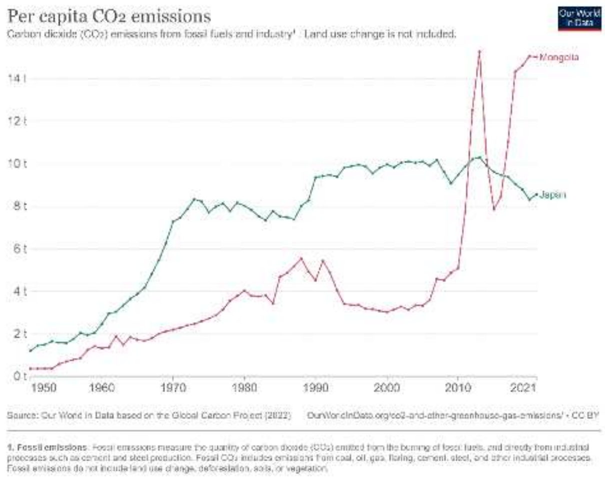


Figure 2-4 Per Capita CO_2 emission

Source: Our World in Data[2]

(2) Current GHG emissions in the building sector

The energy, agriculture and industry sectors are the largest source of GHG emissions in Mongolia. According to the Ministry of Construction and Urban Development of Mongolia, the construction sector consumes 56% of heat energy and 38% of electricity in Mongolia, accounting for about 30% of GHG emissions[3]. Thanks to the recent development in Ulaanbaatar City, about 200 buildings connects central heating supply systems which has increased energy consumption for heating supply by 3 to 8% per annum. According to the Ministry of Construction and Urban Development of Mongolia, energy consumption in the construction sector in 2021 increased by 5% or 10,000 tons of CO_2 compared to the previous year.

Ulaanbaatar City has the largest number of buildings in Mongolia including 1077 precast concrete apartments constructed from 1965 to 2000, of which more than 420 houses were built before 1990 and need to install heat insulation materials[4]. Heat loss of these buildings is large particularly in chilly seasons, consuming energy of 1.1 billion kW/hour for heating with 1.19 million tons of GHG emissions.

It is expected that renovating these precast concrete apartments will increase energy efficiency in the building sector, reduce the need of heating system and thereby reduce 31% of the thermal load per hour[5]. Such reduced heat energy will reduce about 170,000 tons of coals used in thermal power generation plants in Ulaanbaatar City which is expected to lead the reduction of 231,000

[2] https://ourworldindata.org/co2/country/mongolia
[3] https://mcud.gov.mn/a/809
[4] https://mcud.gov.mn/a/809
[5] Global Green Growth Institute, 2018

tons of GHG emissions[6].

Moreover, the reduction of 595,000 tons of GHG emissions are expected by banning the use of raw coals in Ger areas in Ulaanbaatar City and promoting the use of advanced fuels.

Table 2-1 Expected GHG emissions reduction in the building sector (unit: 1,000 tons of CO_2)

	2015	2020	2025	2030
Baseline scenario	4,006.6	4,395.5	4,737.2	5,151.2
Mitigation scenario	4,006.6	3,792.2	4,037.3	4,321.1
Total GHG emission reduction volume		603.3	699.9	830.1
(Using advanced fuels in Ger areas)		(530.1)	(561.0)	(598.9)
(Upgrading heat insulation materials of precast apartments)		(73.2)	(138.9)	(231.2)

Source: GGGI 2021年

2.3 Measures against climate change in Mongolia

2.3.1 Overview of measures against climate change

In the NDC, the Mongolian Government aims to reduce GHG emissions by 22.7% by 2030. Policies of the Mongolian Government concerning sustainable development and green development involving measures against climate change are described as follows:

Table 2-2 Mongolian policies related to climate change

Year	Policy title, etc.
2011	National Action Program on Climate Change
2014	Green Development Policy
2015	INDC submitted
2016	Mongolia Sustainable Development Vision 2030
2016	NDC approved
2020	National Development Policy “Vision 2050”
2020	NDC updated

Source: prepared by the Survey Team

2.3.2 Policy concerning measures against climate change

（1） The National Action Program on Climate Change

The National Action Program on Climate Change was established with the purpose of securing an ecological balance, socio-economic sector development adapting climate change, mitigation of GHG emissions, promotion of economic effectiveness and efficiency and implementation of green development goals.

The first phase from 2011 to 2016 aimed to enhance the mitigation capacity and adaptability as well as establishing legal and management systems while implementing the climate change adaption and starting GHG emission mitigation actions were set as goals for the second phase from 2017 to 2021 to establish the growth developmental foundation of green economy.

6 GGGI, “Greenhouse Gas Mitigation Assessments to Inform Future Nationally Determined Contribution Updates in Mongolia: Technical Guide”, 2021

（2） Green Development Policy

During the United Nations Conference on Sustainable Development in 2012, it was recognized that the significance of green economy was recognized which balances sustainable development goals, environmental conservation and economic growth. Following the outcome, in 2014, the Green Development Policy was formulated in Mongolia, in which to "promote a sustainable consumption and production pattern with efficient use of natural resources, low greenhouse gas emissions, and reduced waste" was set as one of the strategic objectives. As measures for GHG emission mitigation policy by 2030, Mongolia will reduce building heat losses by 20 percent by 2020, and by 40 percent by 2030, compared to 2014. In addition, the target numeric values were presented as "ensuring that the share of renewable energy used in total energy production is at 20 percent by 2020, and at 30 percent by 2030".

（3） Mongolia Sustainable Development Vision 2030

In February 2016, the Mongolia Sustainable Development Vision 2030 was approved by Parliament. It set out ten goals to be achieved by 2030 and one of which is to "preserve ecological balance and to be placed among first 30 countries on the rankings of the countries by the Green economy index in the world". It specifies as strategy for the policy implementation that increasing the share of renewable energy in the energy and infrastructure sector.

（4） Vision 2050

The Vision 2050 is a long-term development policy of the country approved by Parliament in May 2020, setting nine basic goals (human development, good governance, safe and secure society, green development, shared national values, quality of life and middle class, reginal and local development, Ulaanbaatar and satellite cities, and economic development) and 50 medium- and long-term development objectives. It describes actions and objectives in three stages by 2050: green technology and green economy will be established during the period from 2020 to 2030; the foundation of green development will be formulated during the period from 2031 to 2040; and sustainable green development is established during the period from 2041 to 2050.

As part of major initiatives concerning measures for buildings, it prioritizes to increase green areas, set requirements for providing citizens with comfortable housing, introduce energy-efficient green-building technologies and supply affordable housings.

For the period from 2020 to 2030, as part of efforts to reduce GHG emissions in the building sector, it plans to provide businesses with loans to reduce GHG emissions as well as implementing green housing and renewable energy projects in Ulaanbaatar City in collaboration with the Green Climate Fund and with support from overseas donors.

During the last stage from 2041 to 2050, it sets a goal of net-zero GHG emissions by closing the gap between GHG emissions and absorption. Making an environmentally friendly and smart capital city with low GHG emissions is also presented in the goal.

(5) Nationally Determined Contribution (NDC)

In October 2020, the Mongolian Government submitted updated NDC to the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC). Based on the Government Decree No.407 of November 2019, the Mongolian Government set its GHG emission reduction target by 2030, reducing 74.3 Mt CO2-eq of GHG emissions in the business as usual (BAU) scenario in 2030 to 57.4 Mt CO2-eq, decreasing by 22.7% compared to the BAU in 2030.

Restricting the use of coals, utilizing renewable energy and enhancing building heat insulation performance are indicated in reduction targets and action plans for each sector as described in the NDC.

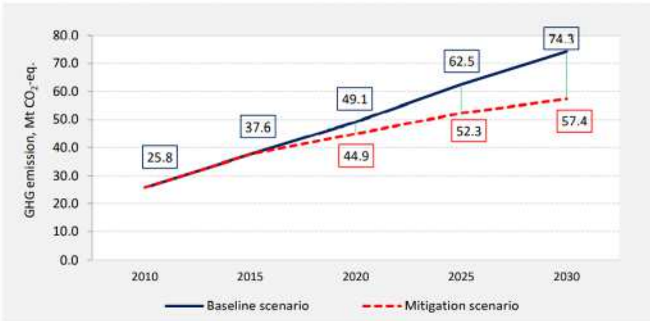


Figure 2-5 GHG emission targets in the NDC

Source: Mongolia's NDC[7]

President of Mongolia Khurelsukh stated during COP27 held in November 2022 that "our country has set an ambitiously raised target to reduce greenhouse gas emissions by 27.2 percent"[8] and also mentioned that Mongolia sets goals to promote GHG emission reduction and absorption and close the gap between emissions and absorption by 2050.

2.3.3 Actions related to measures against climate change

(1) State of the use of renewable energy

In Mongolia, the proportion of renewable energy within the power supply composition ratio in 2020 was approximately 10%. Wind power generation has increased since 2015 while solar and hydroelectric power generations has also increased recently.

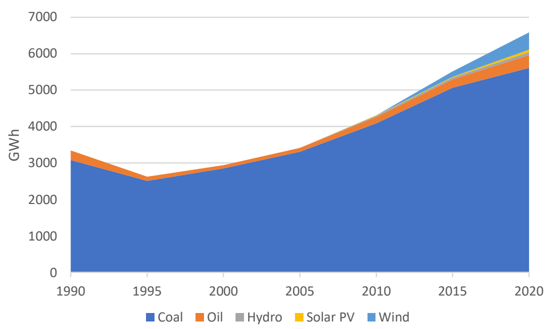


Figure 2-6 Power generation volume in Mongolia by energy source (1990 to 2020)

Source: IEA[9]

7 https://unfccc.int/sites/default/files/NDC/2022-06/First%20Submission%20of%20Mongolia%27s%20NDC.pdf
8 https://montsame.mn/en/read/307646
9 https://www.iea.org/countries/mongolia

(2) "Billion Trees" national movement

Climate change and deforestation has seriously affected nomads' livelihood and water security in Mongolia. As part of its mitigation efforts, President Khurelsukh initiated a national movement of planting billion trees by 2030. The first stage of the movement is headed by 2024 and the subsequent period by 2026 is to improve the activity. Ulaanbaatar City and 21 provinces has committed to plant about 0,7 billion trees while 21 large-scale national corporations have also promised to plant about 0.6 billion trees[10].

Figure 2-7 A report on planting movement in Ulaanbaatar City

Source: Ulaanbaatar City

(3) The Regional Forum on Green Financing

In March 2022, the first forum was held with the participation of President Khurelsukh with the aim to formulate a financial roadmap for sustainable financing to GHG emission reduction and measures against climate change. Participants discussed about matters related to environment and green finance and a goal was set to boost green loans in the bank sector to 10% by 2030

2.4 Efforts against climate change in Ulaanbaatar City

(1) Vision 2050,

Vision 2050, formulated with the support of the United Nations in 2020, indicates a GHG reduction target by 2030. Since around a half of the country population is concentrated in Ulaanbaatar, where a coal-fired power plant (cogeneration) is also located, it is also where most energy is consumed, meaning great scope for GHG reduction. Vision 2050 prioritizes measures against climate change in city policies and plans and aims to establish a mechanism to boost effective planning and management capacity and secure a budget to improve urban infrastructure.

Table 2-3 GHG Reduction Targets of Ulaanbaatar City

Unit: Gg CO2-eq.

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Reduction target	1,524	1,671	1,818	1,966	2,113	2,406	2,700	2,993	3,287	3,580

Source: prepared by the Survey team based on "Vision 2050", Ulaanbaatar City, 2020

[10] https://montsame.mn/en/read/295372

（2） Ulaanbaatar 2020 Master Plan

Moreover, the priority for the Ulaanbaatar 2020 Master Plan and Development Approaches for 2030 formulated in 2014 is that “Ulaanbaatar will be a safe, healthy and green city resilient to climate change”, reflecting the aim of building a smart city with Mongolian features. Specific strategies include the introduction of land-use zoning to prevent unplanned urban expansion, redeveloping Ger areas, introducing new power plants and expanding the introduction of regional heating supply systems.

The direction of the Master Plan 2020 succeeds the Master Plan 2040 which is currently being formulated and defines the integrated development of cities corresponding to climate change and helping save energy/resources and neighboring satellite cities and other policies.

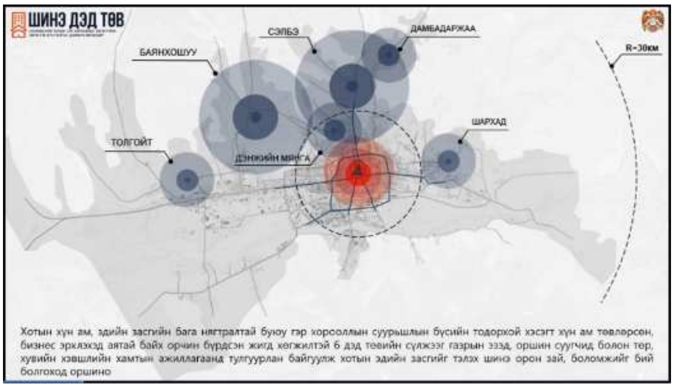


Figure 2-8 Subcenter development plan for six districts in Ulaanbaatar City

Source: Ulaanbaatar City

（3） Ulaanbaatar City Action Plan 2020-2024

Targets of the item of “green development policy” in the Ulaanbaatar City Action Plan 2020-2024 determined in 2020 include reducing heat loss of housings and apartments in the city, enhancing air quality control capacity, expanding forest areas and increasing GHG absorption.[11]

2.5 Green building policy in Mongolia

Global ABC[12], a global platform established during COP21, proposes the GlobalABC Global and Regional Roadmaps for Buildings and Construction. The following figure shows recommended actions by Global ABC to introduce zero-emission and resilient buildings in Asia by 2050.

They propose to develop passive and affordable construction strategy for new buildings, develop and implement building energy codes and standards and monitoring system, develop and implement affordable low-energy decarbonization strategies for existing building retrofits, and promote adoption of low-carbon materials for building construction. Likewise other Asian countries, these policies need to be developed and implemented in Mongolia and are being gradually progressed with international supports.

[11] https://road.ub.gov.mn/?p=7411

[12] Global ABC is established in 2015 and operated by the United Nations Environment Programme (UNEP). It is organized by 256 members including 37 national governments and serves as a platform for governments, private sector, civil society, research institutes and other stakeholders.

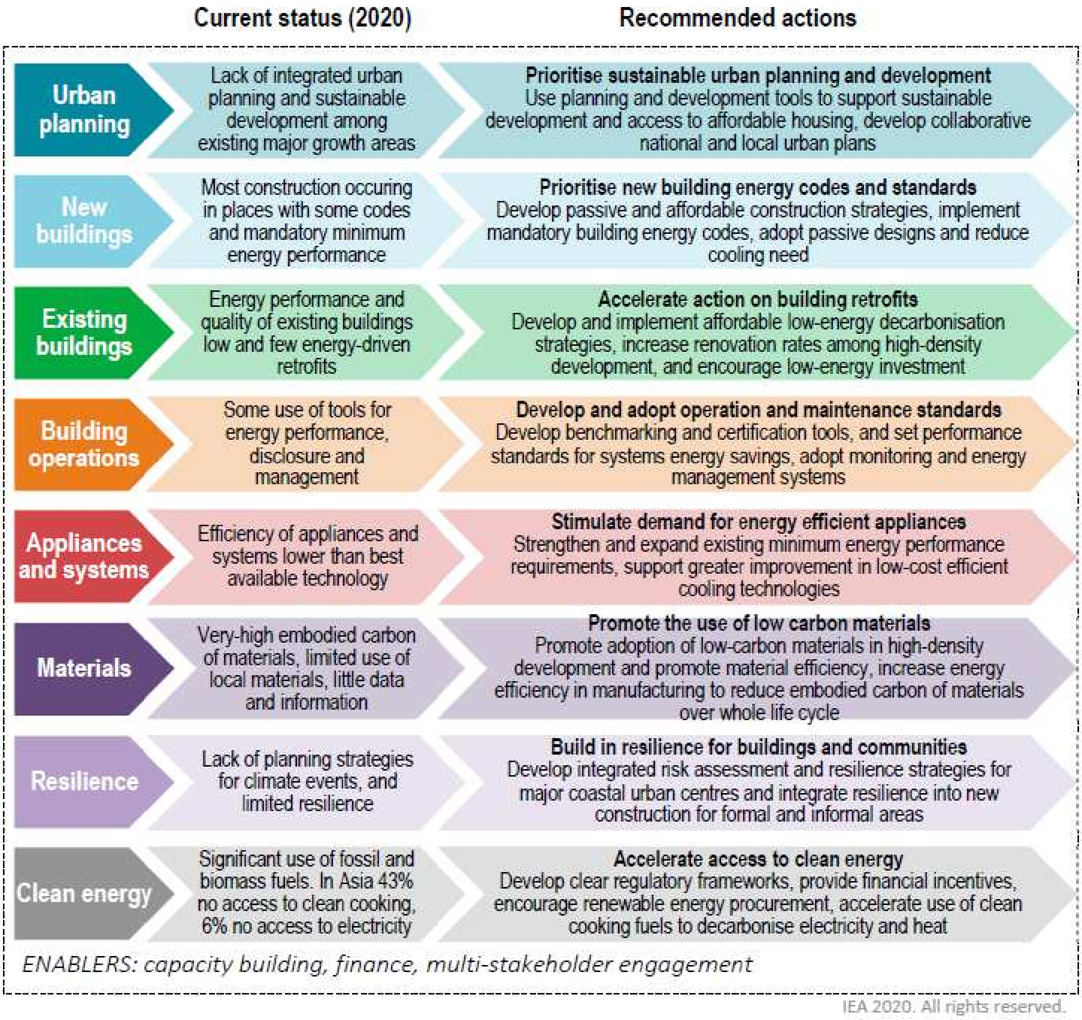


Figure 2-9　GlobalABC Regional Roadmap for Buildings and Construction in Asia

Source: Global ABC[13]

（1） Government policy for the construction industry between 2019 and 2029

Regarding Mongolian development policy documents, a plan and general construction rules and concept of environmentally friendly and high energy- and resource-efficiency buildings were approved by the Green Development Policy in 2014. Subsequently, implementation of green development and activities in the construction and urban development sectors, boosting investment in the private sector and update of relevant construction codes were indicated by the Sustainable Development Vision and Vision 2050.

In 2019, the National Construction Industry Policy was approved[14], which describes action plan for policy implementation by the construction industry from 2019 to 2029, national and local budgets including domestic and overseas loans for financing, and cooperation with the private sector.

[13] 「Regional Roadmap for Buildings and Construction in Asia 2020‒2050」
[14] https://legalinfo.mn/mn/detail?lawId=14164 (accessed the page on January 13, 2023)

(2) GHG Emissions Reduction Plan for the construction and urban development sectors 2021-2030

The plan approved in 2021 is to reduce GHG emissions by developing the construction and urban development sectors according to the Mongolian weather conditions and promoting environmentally friendly and sustainable development. Objectives and action policies by 2030 as indicated in the plan are described below. Based on these objectives and action policies, the plan also defines details of action, responsible organizations and implementation periods.

Table 2-4 Outline of the GHG Emissions Reduction Plan for the construction and urban development sectors 2021-2030

	Objectives	Action policy
1	Adapt laws, norms and normative documents to the requirements of green and sustainable development	1.1: Develop proper legal and financial environments of supporting measures for the GHG Emissions Reduction Plan for the construction and urban development sectors. 1.2: Manage and optimize the construction and urban development sectors. 1.3: Generate innovation and develop technology which help reduce GHG emissions and enhance resilience of the construction and urban development sectors against climate change. 1.4: Human resource development in the construction and urban development sectors.
2	Enhance energy efficiency of the construction and urban development sectors to develop green and sustainable sector.	2.1: Formulate a green city plan. 2.2: Construct buildings with construction materials in line with green and sustainable development so that improving energy efficiency. 2.3: Provide and increase buildings and engineering infrastructures that are high energy-efficiency with low GHG emissions. 2.4: Install heat insulation systems in existing buildings to reduce heat loss.
3	Secure capacity of the construction and urban development sectors to respond to dangerous events caused by natural disaster and climate change to enhance adaptability to climate change	3.1: Formulate a climate-resilient city plan. 3.2: Develop climate-resilient buildings and construction materials. 3.3: Construct and provide more climate-resilient buildings and engineering infrastructures. 3.4: Refurbish buildings to enhance their resilience to climate change.
4	Expand green financing in the construction and urban development sectors	4.1: Establish systems of preferential financing, taxation and incentives for constructing high energy-efficient and environmentally friendly buildings.
5	Establish systems for reporting and verifying GHG emission measurement in the	5.1: Develop systems of measuring, reporting and verifying GHG emissions in the construction and urban development sectors. 5.2: Establish systems of reporting and verifying results of

	construction and urban development sectors	GHG emissions and adaptation measures, flow of funds and interests. 5.3: Improve quality and management of statistics, data and information. 5.4: Strengthen the capacity of measuring GHG emissions and reporting

（3） Update of building heat insulation standards

In 2021, the Ministry of Construction and Urban Development approved new building standards for building heat performance applicable to residential, public, commercial, agricultural and storage buildings to promote energy saving, energy efficiency and GHG emission control.

Under BNbD 25-01-20[15], the building heat insulation standards apply to new or refurbished apartments, and public, industrial and agricultural facilities as well as warehouse buildings with the area over 50 m^2. Their heat insulation standards, energy efficiency of ventilation, required energy and energy consumption of buildings are reviewed. With the update of standards, BNBD23-02-09, heat insulation standards established in 2009 became ineffective.

Table 2-5 New building standards for building heat performance

Laws, etc.	Content
Ministerial Orders A/257 and A/252	Regulations related to the certification for building energy
BNbD 23-105-20 /Order No. 37 of 2020	Calculation method for GHG emission of buildings
BNbD 25-101-20 /Order No. 37 of 2020	Recording and reporting protocol for GHG emissions of buildings
BNbD 25-01-20	Building heat insulation standards

Source: the Survey Teams

(4) Building energy certification system

In December, Regulations related to the Building Energy Certification" in A/257 and A/252 of the Joint Ministerial Order was approved by the Ministry of Construction and Urban Development and the Ministry of Energy[16]. The regulations define the building energy efficiency and set criteria and basic conditions of evaluation system for green buildings and high energy-efficient passive buildings. By implementing this certification protocol, energy consumption of new, expanded and refurbished buildings is classified in accordance with the efficiency indicators, by which the Level C or higher energy efficiency is required.

Figure 2-10 Building energy certification example
Source: Mongolian Housing Corporation (TOSK)[17]

With refurbishment of heat insulation of buildings constructed before 2000 and issuance of energy certification for new buildings, heat energy is expected to be saved. Building energy certification will play an important role in implementing required measures in a comprehensive manner, including incorporating energy saving and cost reduction in building design and reducing building heat loss.

15 https://legalinfo.mn/mn/detail?lawId=211242&showType=1
16 https://mcud.gov.mn/a/809
17 https://tosk.gov.mn/?p=7580

Table 2-6 Energy efficiency classification for housings and public buildings

Class	Definition	Ratio of recommended and normative values of specific heating system and ventilation consumption	Recommendations by the government
A++	Passive	Less than 20%	Economic support
A+	Low energy building	From 40% to 20%	
A	High energy efficient	From 65% to 40 %	
B	Energy-efficient	From 90% to 65%	
C	Normative level	From 90% to 110 %	Need to meet the reference value
D	Non-energy-efficient	From 110% to160%	Consider refurbishment
E	Non-energy efficient	Above 160%	Consider refurbishment/demolition

Source: BNaC 25-01-20 Building heat Insulation Standards

（5） EDGE Certification

With supports from the International Finance Corporation (IFC), a member of the World Bank Group, and Asian Development Bank (ADB), the Mongolian Government prepares to adapt to the Excellence in Design for Greater Efficiencies (EDGE), a green building certification[18]. EDGE developed by the IFC is a green building certification system focusing on boosting building resource efficiency.

EDGE is a software and criteria designed for emerging markets as well as a green building certification system, supporting cost calculation to meet green specifications and the energy and water volumes to be saved. EDGE focuses on three categories related to resource efficiency (energy, water and materials), provides technical support for reducing building material consumption and reduce GHG emissions and building operational costs.

In 2018, minutes of meeting on introducing EDGE certification in Mongolia was concluded between the Ministry of Construction and Urban Development and the IFC and subsequently relevant trainings for human resource development have been conducted and building standards were revised. Moreover, reviewing major documents including building standards 2009 related to building heat performance was intended to adapt Mongolian building standards to EDGE.

It is expected to utilize EDGE to increase the financing possibility by green bonds. Moreover, it aims to reduce long-term demands for heating of new and refurbished buildings and reduce coal combustion by enabling to set high price by certifying commercial buildings as well as generating incentives of private developers to improve their energy efficiency.

EDGE certification comprises of three levels. Levels 1 and 2 do not require to update the status after certification while the level 3 requires the update the certificate in case of using 100% renewable energy or purchasing carbon offset every four and two years, respectively.

[18] https://mcud.gov.mn/a/1062

Table 2-7　EDGE Classification

Level 1	Level 2	Level 3
EDGE Certified	EDGE Advanced	Zero Carbon
20% or more savings in energy, water and embodied energy in materials.	EDGE certified with 40% or more on-site energy savings and 20% or more savings in water and materials.	EDGE Advanced with 100% renewables on-site or off-site, or purchased carbon offsets to top off at 100%.

Source: https://edge.gbci.org/

In September 2021, a private house was certified the first EDGE Advanced in Mongolia. This house adopts the passive house technology and excludes the use of bricks and other energy-intensive building materials. With financial supports from the Mongolian Bankers Association (MBA) and the Mongolian Sustainable Financial Association (ToC), the house was constructed as part of a project supported by Deutsche Gesellschaft fur Internationale Zusammenarbeit (GIZ) and the Swiss Agency for Development and Cooperation (SDC).

Figure 2-11　The first EDGE certified building in Mongolia

（6）Establishment of Mongolia Green Building Council

In May 2022, the Mongolia Green Building Council was established with the aim of reducing GHG emissions in the construction and urban development sectors, implementing green development and collaborating with the World Green Building Council.

The Green Building Council supports sustainable development, promotes understandings of green building and sustainable development of the construction industry and their capacity development and take responsibility for the evaluation and certification of EDGE and LEED which are the green building certification.

2.6 International support for green building in Ulaanbaatar City

Table 2-8 International supports for green building

Organization	Project title	Project period
GIZ / SDC	Energy Efficient Building Refurbishment Project in Mongolia	2019 to 2022
GIZ	Promoting energy-efficient retrofitting of prefabricated concrete residential buildings in Mongolia	2022 to 2027
ADB	Green Affordable Housing and Resilient Urban Renewal Sector Project	2018 to 2026
ADB	Mongolia: Ulaanbaatar Air Quality Improvement Program– Phase 2	2019 to 2021
ADB	Infrastructure Development for Green and Resilient New Satellite City in the Khushig Valley Area	2023 to 2024 (Preparatory period)
GEF	Nationally Appropriate Mitigation Actions in the Construction Sector in Mongolia	2016 to 2020

Source: the Survey Team

(1) GIZ/SDC: Energy Efficient Building Refurbishment Project in Mongolia (2019 to 2022)

The project provided supports for the following four themes:

1. Develop the Local Energy Efficiency Action Plan (LEEAP)
2. Introduce transparent, effective and gender-considered public investment management processes in Ulaanbaatar through the practice of building energy efficiency.
3. Improve the capacity of the private sector for energy efficiency.
4. Introduce the energy efficiency technology in Ger areas.

LEEAP developed by this project includes actions and supports to achieve energy efficiency targets in the building sector. Moreover, a public investment guide was prepared, and the protocol of building and investment data management system was developed.

Refurbishment of 22 schools and kindergarten buildings were implemented as pilot projects, by which energy data before and after the refurbishment was collected and analyzed, skills of private companies involved in the refurbishment were improved and a budgetary management training was conducted for local governments. In addition, as part of this project, loans for high energy-efficient housings were developed and experimentally implemented for low-income households in Ger areas with support from the MBA and ToC.

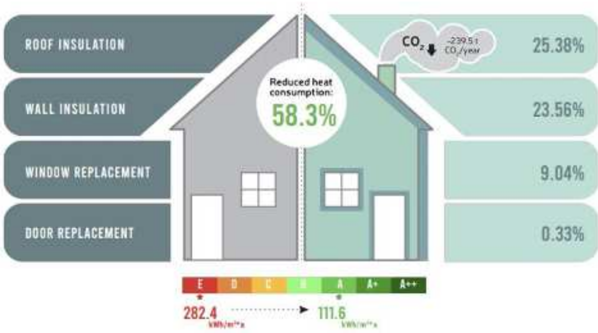


Figure 2-12　Heat loss reduced by refurbishment[19]

Figure 2-13　Schools refurbished with heat insulation

（2） GIZ: Promoting energy-efficient retrofitting of prefabricated concrete residential buildings in Mongolia (2022 to 2027)

This Nationally/Appropriate Mitigation Actions (NAMA) support project with support from the Ulaanbaatar City authority and the Ministry of Construction and Urban Development is to improve heat insulation performance and increase energy efficiency of precast concrete housings in Ulaanbaatar City.

It plans to retrofit about one-third of precast concrete housings in Ulaanbaatar City (about 375 buildings) during the project period. To increase investment in energy efficiency, the project will support legal amendment of the government and help establish energy efficiency system and disseminate technology and expert knowledge[20].

To retrofit residential buildings with high energy efficiency, this project plans to establish a financial support mechanism, such as establishment of funds to secure long-term financing and introduction of fixed price purchasing scheme and other programs to save energy. It aims to directly mitigate 2.4 million tons of CO_2 during the project period at a cost efficiency of 15 EUR/tCO2[21].

Figure 2-14　A GIZ project (before and after retrofitting of apartments)

Source: the GIZ website[22]

19 https://energypedia.info/wiki/EEP_in_Mongolia_Technology_and_Pilots
20 https://www.giz.de/en/worldwide/114152.html
21 https://nama-facility.org/projects/mongolia-energy-performance-building-retrofitting/
22 https://www.giz.de/en/worldwide/114152.html

(3) ADB : Green Affordable Housing and Resilient Urban Renewal Sector Project (2018 to 2026)

ADB will redevelop those Ger areas prone to climate change and with worse living conditions. It plans to construct 10,000 housing units in 100 ha of Ger areas to change them to ecological areas which are low carbon and fair price, adaptable to climate change and convenient. Specifically, housings to be redeveloped are designed as passive house[23], using renewable energy and securing sufficient public space. 11 MW of photovoltaic generation system is installed on the rooftop of residential buildings to generate 156 GWh of renewable energy per annum. By shifting to green buildings, it is expected to reduce the annual heat energy consumption from 395 kWh/m^2 to 150 kWh/m^2. Of 10,000 housing units to be constructed, 55% are housings for low- and medium-income groups, 15% are public housings for low income groups and 30% are housings at market price. The target areas will be Bayankhoshuu, Selbe and Tsaiz.

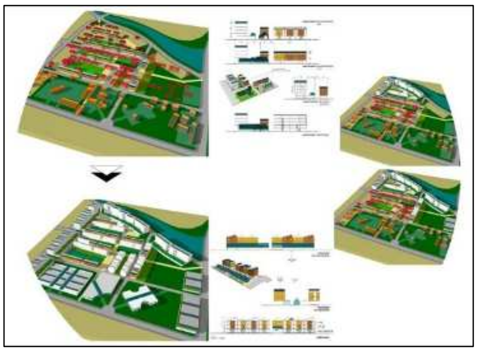


Figure 2-15 An ADB project

Source: the ADB website[24]

(4) ADB : Mongolia: Ulaanbaatar Air Quality Improvement Program – Phase 2 (2019 to 2021)

This project was implemented to strengthen the regulatory framework for air quality management of the Mongolian Government to improve air pollution in Ulaanbaatar. The Phase 1 project provided support for banning raw coal combustion. Activities of the Phase 2 project include the establishment of EDGE which is customized for public and private buildings in accordance with the needs in Mongolia. During the activity, building standards concerning building heat performance was reviewed to adopt EDGE to the Mongolian construction sector. In 2021, the Ministry of Construction and Urban Development conducted EDGE training and awareness-raising campaign[25].

[23] Passive House is energy saving criteria of housings developed in Germany. A house should meet criteria of heat insulation materials, high performance windows, ventilation system with low heat loss and other requirements. Conventional huge use of heating tools become unnecessary by enhancing building performance and obtaining internal heat and other “passive” methods.

[24] https://www.adb.org/results/building-affordable-greenhouses-mongolia-s-ger-districts

[25] https://www.adb.org/sites/default/files/project-documents/51199/51199-001-53028-001-pcr-en.pdf

(5) ADB: Infrastructure Development for Green and Resilient New Satellite City in the Khushig Valley Area (Preparatory survey between 2023 and 2024)

As of January 2023, this project is at the preparatory stage to select consultants. It considers supporting the development of a resilient, environmentally friendly and climate-adaptable satellite city in the Khushig Valley area near the new Ulaanbaatar International Airport. The city is planned by Ulaanbaatar City to resolve Ulaanbaatar centralization.

It aims to establish the Khushig Valley area as an international logistic hub in Northeast Asia with the population size of 150,000 to 200,000. It is expected to construct overall 20,000 housing units.

(6) GEF: Nationally Appropriate Mitigation Actions in the Construction Sector in Mongolia (2016 to 2020)

The Global Environment Facility (GEF), a trust fund established in the World Bank, provides grant aid to those projects concerning global environmental issues. With this project, an electronic GHG calculation system for the Mongolian construction industry was developed in accordance with the Clean Development Mechanism Methodologies adopted by the UNFCCC to help improve energy efficiency in the construction industry and reduce heat loss to mitigate climate change. The system was introduced in 2018. Measurement and reporting systems of the effect of GHG emission reduction projects and other efforts were maintained and trainings for concerning experts were conducted to develop relevant human resources.

Figure 2-16　An electronic GHG calculation system for the construction industry

Source: Ministry of Construction and Urban Development[26]

[26] https://mcud.gov.mn/a/300

Chapter 3 Support for capacity-building in Ulaanbaatar City

This chapter covers specific examples of decarbonization initiatives in Sapporo, a city that shares the same cold climate as Ulaanbaatar City. The aim is to share the case study with Ulaanbaatar City and help promote the city's policies and encourage capacity-building.

3.1 Sapporo's initiatives toward carbon neutrality

3.1.1 Overview of Sapporo City

Sapporo is the political, economic and cultural center of Hokkaido and Japan's northernmost ordinance-designated city, with a population estimated at around 1.97 million in 2023, a cold climate and average annual snowfall of 5 m or so. This is the reason why the residential heating energy consumption is about three times higher than the national average in Japan. Carbon dioxide comprised 98% of the greenhouse gas emissions emitted from Sapporo in 2016 and emissions by sector, households, businesses and transportation comprised 90% or so.

Sapporo City has established a goal of reducing greenhouse gas emissions by 55% relative to 2016 levels by the year 2030. This objective is a significant step toward achieving a zero-carbon city by 2050. To accomplish this target, the city is promoting the adoption of zero-energy buildings (ZEB) and zero-emission buildings (ZEH) as comprehensive energy-saving measures, while introducing renewable energy sources like solar power generation as a way of expanding the incorporation of clean energy. Furthermore, the city is endorsing the installation of renewable energy sources in buildings as a means of expanding the introduction of sustainable energy. In addition, Sapporo City Hall, being one of the largest businesses in the city, contributes approximately 6% of the city's greenhouse gas emissions. To demonstrate its leadership in achieving the city-wide target, the city has set a goal of reducing greenhouse gas emissions by 60% relative to 2016 levels by the year 2030, thereby encouraging thorough energy-saving measures in city-owned facilities and the introduction of renewable energy in buildings. The city is currently executing thorough energy-saving measures in city-owned facilities and expanding the adoption of renewable energy sources to support the reduction of greenhouse gas emissions.

The Hokkaido region, home to Sapporo, witnessed a flourishing coal industry as coal mining became prominent. In 1966, the industry marked a milestone by producing a record 22.95 million tons of coal. During the 1960s, Sapporo's population and economy both soared, leading to a high concentration of people in the city. However, the coal industry also brought with it severe air pollution and various other pollution types unique to colder regions. Fortunately, the city seized the opportunity to develop a district heating system during the 1972 Winter Olympics, paving the way to move from coal to more sustainable energy sources like natural gas and alternative fuels. Recently, the region has started to utilize renewable energy sources such as wood biomass, snow and ice heat. These energy transitions have positioned Sapporo as a trailblazer city in tackling contemporary energy challenges faced by Mongolia.

3.1.2 Zero-carbon city initiatives

（1） Sapporo City Climate Change Action Plan

Sapporo City has set out its aim to become a 'Zero-Carbon City' by slashing greenhouse gas emissions from the city to almost zero by 2050. To achieve this, the city formulated Sapporo City Climate Change Action

Plan in March 2021. By March 2015, Sapporo City had already developed the Sapporo Global Warming Action Plan to promote the reduction of greenhouse gas emissions toward realizing a sustainable low-carbon society and was working on measures to achieve it. However, as the world rapidly transitions from a low-carbon society to a decarbonized society, Sapporo City responded by formulating Sapporo City Climate Change Action Plan to accomplish a sustainable decarbonized society. The plan brings together the 'Sapporo City Global Warming Countermeasures Promotion Plan,' 'Sapporo City Energy Vision,' and 'Sapporo City Hall Energy Reduction Plan' and is positioned as a 'Regional Climate Change Adaptation Plan' based on the Climate Change Adaptation Act. It is also formulated in accordance with the policies established in the 'Sapporo City Development Strategy Vision (2013-2022)' and the 'Second Sapporo City Development Strategy Vision (2022-2031),' which represent the top comprehensive plan for urban development in Sapporo. Furthermore, the 'Second Sapporo City Basic Environment Plan (formulated in March 2018)' was also taken into consideration during the development of this plan. Systematic diagram showing Sapporo City Climate Change Action Plan and other relevant individual projects.

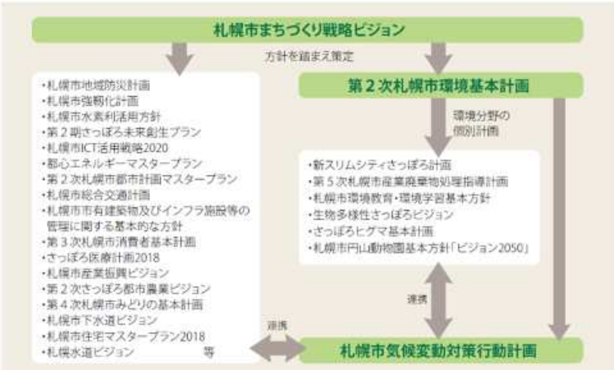


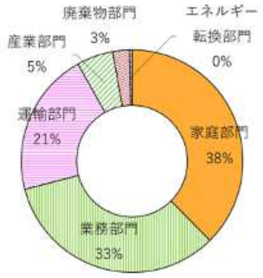
Figure 3-1 Systematic diagram of Sapporo City Climate Change Action Plan and related main plans.

Source: Sapporo City Climate Change Action Plan (2021, Sapporo City)

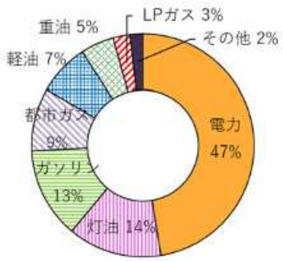
Sapporo City is implementing a comprehensive approach that emphasizes thorough energy-saving measures and expanding renewable energy sources while setting an example to its citizens and businesses by taking the lead in reducing its own emissions to meet the city-wide targets. The multifaceted city-wide efforts, ranging from establishing concrete objectives and supporting via its own systems and subsidies, as described in the subsequent section, to offering technical training to construction companies and disseminating information to citizens, will help Ulaanbaatar's policies in housing and building sectors progress.

(2) Current status and reduction targets for GHG emissions in Sapporo

Across Sapporo City, total greenhouse gas emissions in 2020 amounted to 10.47 million tons of CO_2, which represents a reduction of 12% compared to 2016. Residential and commercial sectors accounted for approximately 71% of the emissions, with household contributing to 38% and commercial to 33%. The transportation sector contributed 21%, while the remaining emissions originated from the industrial and waste sectors. This indicates that almost 70% of CO_2 emissions from Sapporo are produced by buildings, including residential and commercial structures. Additionally, Sapporo's unique climatic conditions, synonymous with cold weather and heavy snowfall, results in a large energy consumption rate during winter, where the heating energy consumption in households is approximately three times the national average, while utility expenses are 1.25 times higher. Accordingly, promoting zero-energy buildings and homes (ZEB and ZEH) in the housing and building sector is a significant and effective measure toward reducing greenhouse gas emissions.



Sectoral breakdown of CO_2 emissions.



Breakdown of CO_2 emissions by energy type.

Figure 3-2　Breakdown of greenhouse gas emissions in Sapporo

Source: "Sapporo City Climate Change Action Plan" Progress reports (preliminary 2020 and final 2018).

Sapporo City aims to reduce greenhouse gas emissions by 55% from 2016 levels (target emissions: 5.37 million t-CO_2) as a target for 2030 with 2050 in mind. Specific performance indicators for 2030 in the field of energy efficiency and conservation include having 80% of newly built houses equivalent to ZEH or ZEH-M or higher and 80% of newly built buildings, etc. equivalent to ZEB or higher. The city is also promoting a shift away from equipment using paraffin and heavy oil as energy sources and aims to achieve an installation rate of around 80% of heating equipment using electricity or gas as the energy source in homes, a 70% installation rate of hot-water supply equipment and a 100% diffusion rate of high-efficiency lighting such as LEDs. With regard to building service life, Sapporo City is systematically promoting the conversion of houses and buildings to ZEB and ZEH, which will affect GHG emissions in the long term going forward.

Figure 3-1 Sapporo City initiatives and targeted reductions by measure

Measure	Action	Target reduction amount
[Energy-saving] Thorough energy-saving measures	(1) Promotion of ZEH	Approx. 1.74 million t-CO_2
	(2) Promotion of ZEB	Approx. 1.25 million t-CO_2
	Subtotal	Approx. 2.99 million t-CO_2
[Renewable energy] Expansion of introduction of renewable energy	(1) Promotion of introduction of renewable energy for buildings, etc.	Approx. 2.18 million t-CO_2
	(2) Promotion of introduction of renewable energy in the region	
	Subtotal	Approx. 2.18 million t-CO_2
[Transportation] Decarbonization of transportation	(1) Promotion of dissemination of zero-emission vehicles	Approx. 1.32 million t-CO_2
	(2) Promotion of the use of public transportation	
	(3) Promotion of compact cities	
	Subtotal	Approx. 1.32 million t-CO_2
[Resource] Resource circulation and carbon sink measures	(1) Promotion of resource-saving and circulation	Approx. 70,000 t-CO_2
	(2) Promotion of conservation, creation and utilization of forests, etc.	Approx. 2,000 t-CO_2
	Subtotal	Approx. 70,000 t-CO_2

[Action] Lifestyle transformation and technological renovation	(1) Lifestyle transformation	-
	(2) Technological renovation	
Total		Approx. 6.56 million t-CO_2

Source: Sapporo City Climate Change Action Plan (2021, Sapporo City)

(3) Current status and reduction targets for GHG emissions at Sapporo City Hall

Sapporo City Hall is one of the city's largest businesses, emitting about 6% of the city's greenhouse gases. As shown in the following figure, 35% is attributable to schools, public facilities and government buildings and 31% to water supply and sewerage, transportation and roads, collectively comprising over 60%.

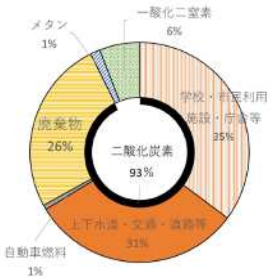


Figure 3-3 Composition of greenhouse gas emissions from municipal offices by use. (2018)

Figure 3-4 Composition of CO_2 emissions in city halls by energy type (2018).

Source: 「Sapporo City Climate Change Action Plan」 Progress reports (preliminary 2020 and final 2018).

Based on the need to show citizens and businesses that it is taking the initiative in reducing emissions to help achieve city-wide targets, Sapporo City Hall has set itself the target to achieve a level of greenhouse gas emissions by 2030, the benchmark year of the plan, of 60% below the 2016 level (target emissions: 292 000 t-CO CO_2) and is working to roll out more energy-saving measures in city-owned facilities and expand the introduction of renewable energy. The initiatives and target reductions at Sapporo City Hall are as follows:

Table 3-2 Sapporo City Hall initiatives and targeted reductions by measure

Measure	Initiative	Target reduction
[Energy conservation] Thorough energy-saving measures	(1) Energy efficiency of municipal facilities and equipment (2) Operating facilities and equipment efficiently to reduce energy losses.	Around 153,000 t-CO_2
	Total	Around 153,000 t-CO_2
[Energy conservation] Expanding the roll-out of renewable energy sources	(1) Installation of renewable energy in municipal facilities by businesses (2) Introduction of renewable energy to urban centers. (3) Use of waste incineration, sewage energy and hydro energy (4) Taking environmentally friendly electricity contracts into consideration (5) Study of the 'RE100-isation model project' for city-owned facilities.	Approx. 210,000 t-CO_2
	Total	Approx. 210,000 t-CO_2
[Shift] Decarbonizing mobility	(1) Moving from official vehicles to next-generation vehicles (2) Using public transportation	Approx. 20,000 t-CO_2
	Total	Approx. 20,000 t-CO_2

[Resources] Resource recycling and sink measures	(1) Environmental management (2) Reduction of plastic waste generation and discharge (3) Food waste reduction (4) Use of Hokkaido timber	Approx. 69,000 t-CO_2
	Total	Approx. 69,000 t-CO_2
[Action] Lifestyle change and technological innovation	(1) Environmental management (2) Promoting work-life balance	—
Total		434,000 t-CO_2

Source: Prepared by the Survey Team based on the Sapporo City Climate Change Action Plan (2021, Sapporo City).

(4) Initiatives as an SDGs future city

The SDGs Future Cities system was established by the Cabinet Office in 2018 to encourage local governments to propose initiatives aimed at achieving the SDGs and select cities nationwide with exceptional initiatives as 'SDGs Future Cities'. Sapporo was designated as an 'SDGs Future City' in the inaugural selection held on June 15 of the same year. As a city selected as an 'SDGs Future City', Sapporo has developed the 'Sapporo SDGs Future City Plan.' The plan consists of two phases: the first phase (2018-2020) and the second phase (2020-2023), with the second phase currently underway. The plan envisions a future image of Sapporo as an 'Environmental Capital SAPP‿RO,' a sustainable city where the next generation can thrive and live joyfully. Sapporo aims to become a sustainable city by executing the following measures.

- By fostering an environment in which citizens continuously improve and refine their lifestyles in cold and snowy regions, Sapporo aims to protect natural resources going forward and establish a culture of prosperous living that embodies the unique charm of the city.
- Sapporo leads the way in addressing environmental issues at national and global levels, such as global warming countermeasures, conservation of biodiversity and sustainable resource circulation, by promoting collaboration among academia, industry, government and citizens. The city strives to disseminate its proactive initiatives and appeal domestically and internationally.
- The city has successfully developed an economically sustainable cycle within Hokkaido, where energy and locally produced products are consumed within the region and environmental-related industries have flourished, by utilizing the abundant natural resources and energy available.

To achieve this envisioned future state, Sapporo City has prioritized challenges in areas including 'environment,' 'economy,' and 'society,' and established SDG goals and targets for each of these areas as follows:

Table 3-3　Main SDG initiatives of Sapporo City

Item	Goal, target number	KPI	
Environment	7.2 7.3 13.1 13.3	Indicator: City-wide greenhouse gas emissions	
		Current (2018): 11.55 million t-CO_2	FY2030: 5.37 million t-CO_2 (55% reduction compared to 2016)
	12.2 12.6 12.8	Indicator: Waste generated within the city	
		Current (2019): 602,000 tons	FY2027: New Slim City Sapporo Plan 523,000 tons (100 g/person/day reduction from 16 years)
Economy	8.3 8.4 8.9	Indicator: Annual visitor total	
		Current (2019): 15.26 million people	FY2022: Sapporo City Urban Development Strategic Vision and Action Plan Target Values: 18 million people
	11.3 11.7 11.a	Indicator: Number of cooperating municipalities in Hokkaido under the theme of the SDGs.	
		Current (2020): 3 municipalities	2030: 10 municipalities
Society	3.4 3.6 11.2 11.7	Indicator: Percentage of those satisfied with the living environment in their area.	
		Current (2019): 76.0%	FY2022: Sapporo City Urban Development Strategic Vision and Action Plan Target Values: 95%

Source: Prepared by the Survey Team based on the Sapporo SDGs Future City Plan (2021-2023).

Embracing this approach, with 2030 in mind, the aim is to encompass the 'economy' and 'society', starting by promoting 'environmental' initiatives and build a global model of an 'environmental city in a cold region' by promoting initiatives that leverage what the region of Hokkaido has to offer.

3.1.3 Development-led low-carbon measures

(1)　Urban Energy Master Plan

In March 2018, Sapporo City created the Central Energy Master Plan, which outlines the fundamental approach to environmental and energy measures to be undertaken alongside the development of the city center. The plan sets targets for achieving low-carbon and sustainable urban development toward 2050 and a roadmap for the associated initiatives. As a continuation of this plan, Sapporo City formulated the Urban Energy Action Plan in December 2019. This medium-term implementation plan, spanning until 2030, is aimed at achieving the goals outlined in the Master Plan with determined actions.

Development guidance is what underpins the 'Urban Energy Master Plan'. To realize the basic 'low-carbon', 'resilience' and 'comfort and health' policies set in the plan, a system has been formulated for building operators responsible for urban development. Specifically, the system includes 'prior consultation' with building developers at the planning stage to discuss the details of the development plan, follow-up with a report on the CO_2 emission status of the building after completion of construction and support for highly rated developers.

The goal of the pre-consultation process is to streamline communication and expedite discussion by providing building operators with proposed initiatives for the Sapporo City center in advance, while requesting the consultation and collaboration to draw up plans. For buildings that are operational after the start of this initiative, an annual performance report is required to confirm compliance with the submitted plan and actual CO_2 emissions. The data from these performance reports will be utilized for project management of the Master Plan and provide feedback when revising and updating the submitted plan. Details of the consultation will also be disclosed on Sapporo City's website, while recognition and active promotion are planned for buildings that meet a particularly high standard. The purpose of this system is to encourage building operators to pursue activities in line with Sapporo's basic policies, rather than engage in activities such as building reconstruction.

(2) Sapporo City center E! Town Development Promotion Scheme

This system was formulated for building operators who are responsible for urban development, based on the Urban Energy Plan formulated by Sapporo City. It aims to achieve the following goals and has been in operation since May 9, 2022.

1. When rebuilding and redeveloping Sapporo's city center, the city engages in prior consultation with business operators to promote initiatives that lead to decarbonization, resilience and enhanced comfort in the city center
2. Public and private sectors collaborate to realize the goals of the City Center Energy Plan through receiving reports on the operational performance of the building after it is put into service.

The system is divided into two parts: one in which the business operators take the lead and the other led by Sapporo City. Business operators head the formulation of the plan, including 'preliminary discussions' on the content during the planning phase, such as building reconstruction and ‘operational performance reports’ during the operational phase of the building. During preliminary discussions, Sapporo City and business operators hold consultations to ensure that development plans are linked to ‘decarbonization,’ ‘resilience,’ and ‘improved comfort’ in the city center. In the operational performance reports, the energy usage and facility operating status of buildings built after preliminary discussions are reported to Sapporo City once a year.

Sapporo City Outline to Promote Sustainable Zero-Carbon Urban Development in the City Centre was also prepared, which stipulates the operation of this system, including commendations by the mayor for building owners, designers and constructors who are recognized as making significant contributions to help promote energy measures in the city center, as well as the necessary support for building activities recognized as contributing to the development of a low-carbon and sustainable city center of Sapporo. It also provides for necessary support for building owners for building activities that are deemed to contribute to the creation of a low-carbon and sustainable town in the heart of Sapporo.

Figure 3-5　Sustainable Zero-Carbon Urban Development Promotion Scheme in the City Centre of Sapporo.

Source: Sapporo City

The target area is around 480 ha (the red-boxed area shown in the diagram below), which is positioned in the Sapporo Municipal Land Adequacy Plan as an 'Urban Function Guiding Area (Urban Center)'. The shaded area is also positioned as a key area to strengthen the urban center.

Figure 3-6　Sapporo City center E! Areas covered by the Town Development Promotion Scheme

The scope includes new constructions, extensions, reconstruction, large-scale repair and redecoration and repurposed buildings. Large- and small-scale projects are eligible provided the total area of the project exceeds 5,000 m^2 in the target area, whereas in the Urban Enhancement Leading Area, there is no scale requirement and all projects are eligible. In addition, plans that do not fall under any of the other target sizes can also be discussed in advance on a voluntary basis.

3.1.4 Local energy management system

（1） New Sapporo Station Area Project

The Shin Sapporo Station Area Project (Shin Sapporo Station Area District G and I Development Project), which will begin construction in 2019 and is currently under construction, is a flagship project of the Sapporo City Development Strategy Vision and Energy Vision. It comprises seven buildings - four hospitals, condominiums, commercial premises and a hotel - and plans to promote energy-saving throughout the city block via the following initiatives.

1． Achieving a low-carbon compact city by constructing a smart, integrated infrastructure energy-center optimized automatic operation using AI, advanced demand response (energy-saving guided and user-participation) and other 'next-generation CEMS' that integrate demand and supply to realize energy-saving and low-carbon city-wide.

2． Contribution to urban functional resilience

A community-wide BCP system has been established to provide a stable supply of electricity and heat as required in the event of a disaster to medical, commercial, accommodation and condominium facilities, consolidating urban functions and strengthening the resilience of the area, including around the city block.

3． By coordinating the demand and supply of energy within and outside the block, the Virtual Power Plant (VPP) is being realized through the North Gas Group's integration of renewable energy sources, including those constructed outside the block, with the demand-adjustment functions of the natural gas cogeneration systems (CGS) and heat storage tanks within the block, thus helping further expand renewable energy adoption in Hokkaido.

The New Sapporo Energy Center manages both demand and supply in an integrated manner with a Community Energy Management System (CEMS) and the entire district strives to save energy.

Address: 1-6 Atsubetsu Chuo 1-jo, Atsubetsu Ward, Sapporo City, Hokkaido
Completion date: New Sapporo Energy Center June 2022; hospital July 2022; condominiums July 2023; hotel September 2023; commercial facilities November 2023.

Figure 3-7 New Sapporo Energy Center Landscape and completion dates of various facilities

Source: Hokkaido Gas Co.

(2) CEMS (Community Energy Management System)

The Community Energy Management System (CEMS) is a system that efficiently manages community-wide energy. In this project, the New Sapporo Energy Center takes the lead in connecting each building that uses energy through communication, promoting energy-saving advice and peak shift measures, conducting surveys using QR codes for residents and advancing an energy model that balances comfort and energy conservation. The system coordinates all information of each building and user in real time with the energy center and achieves energy conservation for the entire community through the automatic optimal control of the CEMS, which is responsible for energy supply.

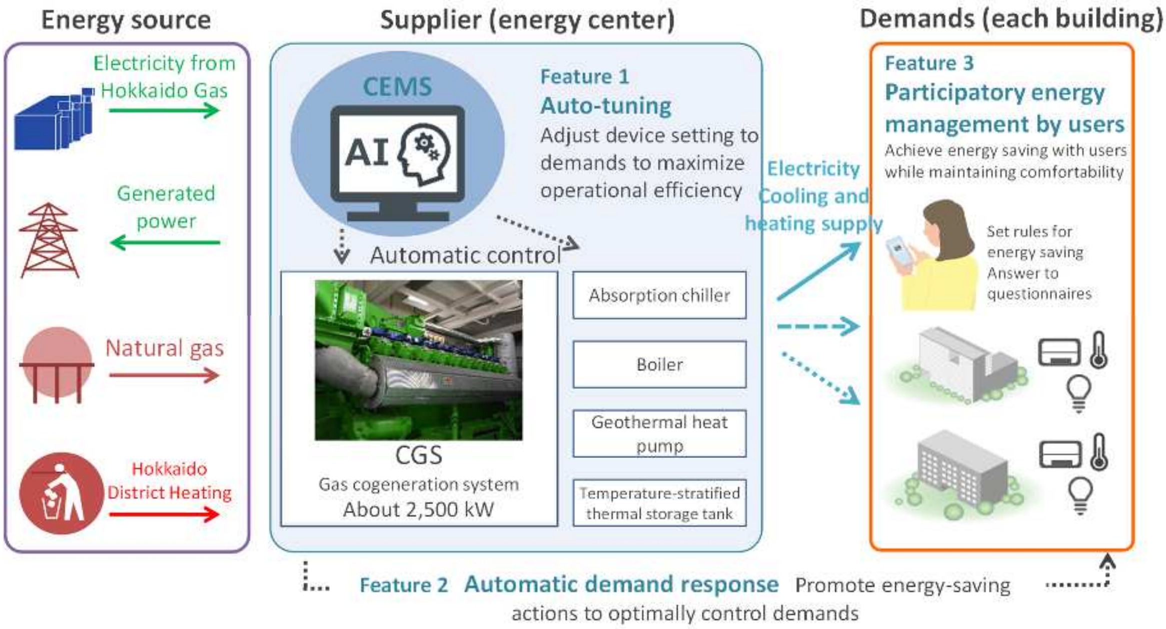


Figure 3-8　CEMS overview

Source: Extracts from Hokkaido Gas presentation material

The CEMS features installed in the project are as follows:

1． Demand forecasting and optimal operation planning by AI
AI predicts electricity and heat consumption based on past energy use, temperature, humidity and other actual data, as well as the day's weather forecast and calendar. Based on these forecasts, target values are set and optimal operation plans for equipment such as gas cogeneration systems (CGS) are drawn up, enabling optimum control.

2． Visualization of electricity and heat consumption forecast results.
Demand forecasting, which underpins CEMS operation, visualizes the impact of the information required for forecasting on the results, such as rankings and enables facility operators to analyze demand forecasts on their own. This makes it easier to increase operations and contributes to improved forecasting accuracy.

3． Energy-saving in energy centers
The CEMS monitors operational efficiency of each facility and system-wide in the New Sapporo Energy Center on an ongoing basis. If any decline in system-wide efficiency is detected, the factors are analyzed and the set values of the equipment are reconfigured to ensure efficient operation at all times. AI also allows a skilled and responsive environment 24 hours a day, 365 days a year.

4． Supports energy savings and comfort for users
The system automatically adjusts the room temperature while ensuring the comfort of each set area in every facility within the user's rules. For instance, during winter, energy is conserved by lowering the heating temperature in areas with less foot traffic (e.g. corridors). Moreover, if reducing energy demand could optimize the operation of the New Sapporo Energy Center

facilities, demand is reduced without sacrificing user comfort. Thus, energy producers and users collaborate to promote energy savings across the city.

3.1.5 Toward the 2023 G7 Sapporo Ministerial Meeting on Climate, Energy and the Environment

In 2023, the G7 Sapporo Climate, Energy and Environment Ministers' Meeting will be held in Sapporo on April 15-16. The meeting is one of the ministerial meetings related to the G7 Summit held in Japan, specifically focusing on climate, energy and the environment. The 'G7 Sapporo Climate, Energy and Environment Ministers' Meeting Executive Committee' of Sapporo City is not only responsible for organizing the meeting, but also aims to generate momentum and accelerate environmental initiatives and SDG-related efforts. The city also plans to engage many citizens and raise awareness of environmental issues and SDGs through various events, including an exhibition and experiential event called 'Environmental Plaza Hokkaido 2023' aimed at promoting environmental businesses. The entire city hall of Sapporo will be involved in various related projects.'

During the 'Environment Square Hokkaido 2023' event to be held in Sapporo in conjunction with the G7 Climate, Energy and Environment Ministers' Meeting, a plan is being developed, with the support of JICA, for Ulaanbaatar City and Mongolian companies to visit and inspect Sapporo and Hokkaido companies. On April 16, a business seminar introducing the businesses of Japanese and Mongolian companies is planned to be held at the 'Environment Square Hokkaido 2023', which is expected to promote business exchanges between Mongolian and Hokkaido companies.

3.2 Leading Decarbonization areas in Sapporo City

3. 2. 1 Selection as a leading decarbonization region

The Japanese government has declared its goal of achieving a carbon-free society by 2050 by reducing greenhouse gas emissions to zero. In addition, the government has announced its intention to reduce greenhouse gas emissions by 46% by 2030 compared to 2013 levels.

To achieve these goals, collaborative efforts between national and local governments are essential and the national government is targeting regional decarbonization, with regions taking the lead. 'Decarbonization advanced regions' are being created, spearheaded by local governments, local companies and financial institutions and implementing pioneering initiatives toward decarbonization based on the unique characteristics of each region. If selected as a decarbonization advanced region, it will be eligible to receive grants for regional decarbonization transition and promotion of renewable energy.

Within this 'priority decarbonization area' the aim will be to achieve practically zero CO_2 emissions associated with the power consumption of households and other non-industrial sectors by 2030, toward carbon neutrality by 2050. Other greenhouse gas emissions reductions, including those from the transportation sector and heat utilization, are also targeted for reduction in alignment with the 2030 targets, according to the characteristics of each region.

Sapporo was selected as a leading decarbonization region in November 2022. Sapporo City's initiatives indicate the following as targets: the Sapporo City Center Private Facility Complex, the Hydrogen Model District, the Northern Campus of Hokkaido University, the Public Facility Complex and the Olympic and Paralympic Facility Complex.

Figure 3-9　Overview of Leading Sapporo Decarbonization Areas.

Source: Sapporo Climate Change Action Guidebook.

Private facilities within the Sapporo City center are promoting the adoption of zero-energy buildings and solar power generation by utilizing a cogeneration system (CGS) and establishing an energy network. They are also promoting the use of renewable energy sources such as woody biomass as a heat source and switching to carbon-neutral gas to achieve decarbonization of electricity and heat.

Within the hydrogen model city zone, stationary hydrogen stations will be installed to demonstrate the operation of fuel cell trucks.

At the Hokkaido University Kita Campus, a carbon-free energy system with BCP (Business Continuity Plan) functions is being built in the 6th building of the Integrated Research Facility.

This refers to expanding the introduction of renewable energy to public facilities through various methods such as ZEB (Zero Energy Building) conversion, monitoring of electricity demand and rolling out private-sector initiatives, to achieve thorough energy-saving measures.

As part of efforts to attract the 2030 Winter Olympics and Paralympics, Sapporo is considering introducing ZEB into the facilities to be used, as well as using zero-emission vehicles for transportation during the games, with the aim of realizing a climate-positive event.

Chapter 4　Surveys Related to Environmental Measurements in Ulaanbaatar City

Air pollution countermeasures were discussed at the 14th Japan-Mongolia Environmental Policy Dialogue held in 2021. The scope of activity by the Acid Deposition Monitoring Network in East Asia (EANET), whose promotion is being led by Japan, has been expanded to include yellow dust, fine particulate matter (PM2.5), volatile organic compounds (VOC), and so on. Based on this expansion, it was confirmed in the Environmental Policy Dialogue that further cooperation will be promoted with regard to Mongolia's air pollution countermeasures.

This chapter is based on knowledge obtained from environmental measurements related to air pollution in buildings in Ulaanbaatar City conducted by Professor Mori of Hokkaido University, who has advanced academic knowledge about energy-saving houses and buildings in cold regions and who presented efforts on ZEB at the World Winter Cities Association for Mayors (WWCAM) held in November 2021.

4.1 State of the Air in Ulaanbaatar City

4.1.1 Issues Related to Air Pollution

In terms of air quality in Ulaanbaatar City, sulfur gas (SO2), nitrogen dioxide (NO2), PM2.5, PM10, carbon monoxide (CO), and ozone are measured by automatic measuring instruments in residential areas, on expressways, and in industrial areas, and this data is reported by the National Agency for Meteorology and Environmental Monitoring of Mongolia (NAMEM).

The standard for PM10 is an annual average of 20 μg/m^3 and 50 μg/m^3 or less averaged over a 24-hour period according to WHO guidelines. The average concentration in Ulaanbaatar City exceeded the standard values during the winter of each year between 2017 and 2022.

The average concentration of PM10 during the 2021-2022 winter period rose when compared to 2019-2020 and 2020-2021, but it was 25% lower than 2017-2018 and 34% lower than 2018-2019.

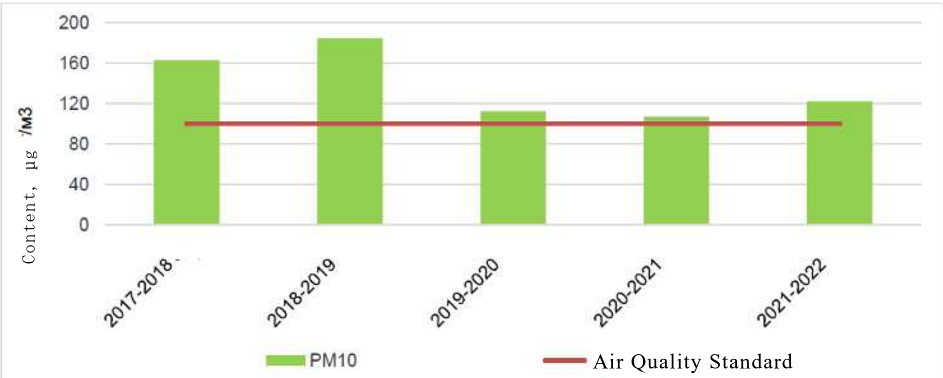


Figure 4-1. Average Concentration of PM10 in Ulaanbaatar City in the Winter Between 2017 and 2022

Source: NAMEM[27]

In the 2010s, the average concentration levels of particulate matter and sulfur dioxide in

[27] http://www.agaar.mn/article-view/1106

Ulaanbaatar City were among the most polluted in the world, but they have now improved slightly. This improvement may be due to improvements in stoves through administrative support in houses in the ger districts of Ulaanbaatar City as well as the complete ban by the Mongolian government on the use of raw coal, which was often used to heat spaces in the ger districts. The economic stagnation due to the COVID-19 pandemic from the beginning of 2020 through 2021 may also have had an impact.

Maximum concentrations of PM10 are often observed in December and January. The average monthly maximum concentration of PM10 in the 2021-2022 winter period was observed in December 2021.

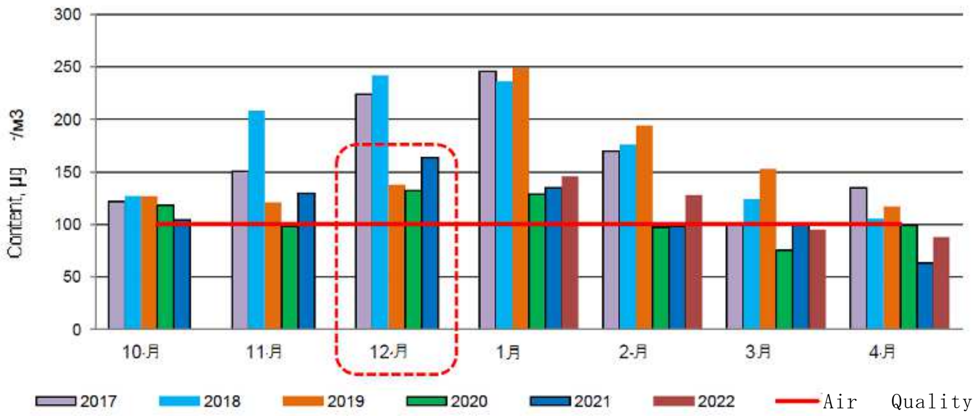


Figure 4-2. Average Monthly Concentration of PM10 in Ulaanbaatar City in the Winter Between 2017 and 2022

Source: NAMEM[28]

While measures have been implemented, such as improving stoves in homes in ger districts and switching from raw coal to charcoal briquettes, no fundamental solution to the air pollution has been reached. Also, as a result of introducing charcoal briquettes, although the PM2.5 and PM10 values have decreased, there are reports that SO2 and ash have increased.

4.2 Overview of Environmental Measurements

4.2.1 Purpose of Measurements

Air pollution is a serious problem in Ulaanbaatar City.[29] Looking at the causes of air pollution, 10% is from automobile exhaust in congested traffic and 10% from coal-fired power plants and local heating supply boilers. A percentage in the single digits is a result of other factors, and the rest comes from houses in the ger districts. Ger districts lack infrastructure, and coal stoves provide heating. Ulaanbaatar is also a highland basin, and because it is a cold environment, air pollutants tend to stay in urban areas because of the inversion over the atmosphere.

[28] http://www.agaar.mn/article-view/1106
[29] Development Bank, 2021

Figure 4-3. Causes of Air Pollution in Ulaanbaatar City

Figure 4-4. Air Pollution in Ulaanbaatar City in the Winter

Needless to say, air pollution is a phenomenon that is hazardous to health. Coal dust also causes many health problems in Japan.[30] Also, there is significant evidence concerning health hazards caused by PM—fine suspended matter—and the effects on children's health have been pointed out in Ulaanbaatar in particular.[31] Up until now, numerous measurements of air pollution have been conducted, with the Environmental Bureau also carrying out measurements in Ulaanbaatar. These values have been disclosed by IQAir and so on.[32] In terms of Japanese institutions, Kanazawa University performs measurements using simple measuring instruments.[33] However, most measurements measure outside air concentrations; cases have not been found where indoor measurements were performed. As most of daily life during the winter is carried out indoors in cold regions in particular, it is impossible to determine the amount of exposure to the human body without measuring indoor concentrations. It is also important to investigate the causes of changes in indoor concentrations. Contaminants from the outside air flow inside by some means. But because there are several factors—ventilation systems, draughts, open windows, and so on—it is necessary to identify the cause(s) and implement countermeasures.

Therefore, with these environmental measurements, indoor environment measuring instruments were installed in several houses in Ulaanbaatar with the cooperation of Associate Professor Amarbayar of the National University of Mongolia. Indoor temperature, relative humidity, carbon dioxide concentration, PM concentration, and VOC were measured. In addition, air purifiers were installed in several houses, and their effectiveness in reducing PM concentration was examined.

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[30] Environmental Policy Division, Eco-City Promotion Department, Environmental Bureau, Sapporo City, 2022
[31] Ariunzaya Davaa, 2016
[32] Air Quality in Mongolia, 2022
[33] Batbold et al., 2022

4.2.2 Methods of Measurement

An indoor environment measuring instrument was installed indoors in one location. This indoor environment measuring instrument is a DIY sensor consisting of a microcomputer board (hereinafter referred to as “microcomputer”) (M5CORE2), a CO_2 sensor (Sensirion SCD30), which measures temperature and humidity at the same time), a PM sensor (Sensirion SPS30), and a VOC sensor (SparkFUN CCS811) connected by I2C. However, the sensors themselves were evaluated in advance and the accuracy data is also available. And because data is transmitted digitally from the sensors to the microcomputer, measurements can be performed with sufficient accuracy. The measurement principle of each sensor is shown below.

CO_2 sensor (Sensirion SCD30)

This CO_2 sensor uses an infrared sensor. Also, a[34] temperature and humidity sensor is mounted on the board using a thermistor. The infrared sensor can also be calibrated. The infrared sensor takes advantage of the fact that infrared rays are easily measured with CO_2. Measurements are performed based on the extent to which infrared rays generated by the infrared lamp reach the probe.

PM sensor (Sensirion SPS30)

This sensor uses scattered laser light. Particles that are not PM are removed through a filter, and PM is led into a chamber by a fan. A laser is turned on in the chamber, and the scattered light is measured to evaluate the concentration and size of the PM.

VOC sensor (SparkFUN Air Quality Breakout - CCS811)

This sensor measures gas concentrations by using the fact that the resistance of MOX heated by a sensor called a metal oxide (MOX) gas sensor changes depending on volatile organic compounds in the air. While the types of gases cannot be distinguished, this sensor is suitable for measuring aggregates of various organic chemicals such as total volatile organic compounds (TVOC).

4.2.3 Measurement Locations

The instruments were installed in several houses and offices in Ulaanbaatar City. A list of the locations is shown below.

No.	Location of installation	District	Type	Type of heating	m^2
1	Khoroolol apartment, 9th floor	18th khoroo, Bayanzurkh district	Apartment	Central heating	76
2	Library of the National University of Mongolia, 6th floor RE lab. room	6th khoroo, Sukhbaatar district	Office	Central heating	59
3	Passive house (Ger district)	Gandan street, Sukhbaatar district	Office/ Apartment	4.3 kW PV system	70
4	Passive house, Institute office room	Tumur zam, 25-2, 8th khoroo, Bayangol district	Office/ Apartment	Central heating	30
5	Detached office in ger district	Uliastai, Bayanzurkh district	Detached house	Stove	56

[34] A temperature sensor that uses changes in resistance when heat is detected

Since measuring instruments at installation locations 3 to 5 were unable to acquire data on a continuous basis for a long period of time, this report mainly describes the results of measuring instruments 1 and 2.

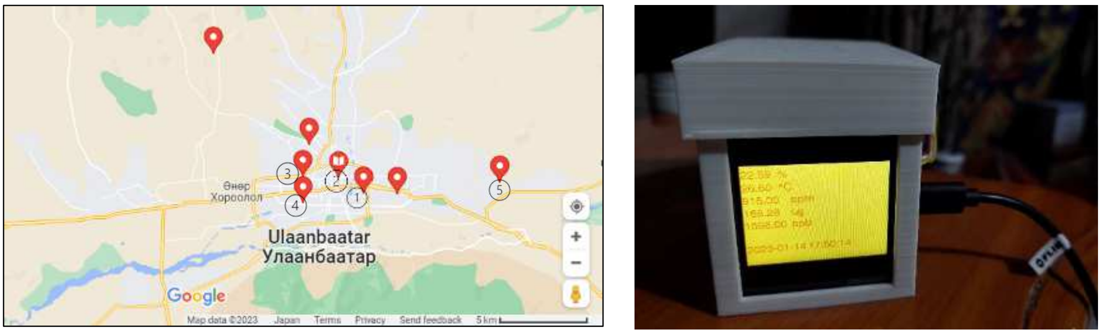


Figure 4-5. Installation Locations and an Observation Instrument

4.2.4 Measurement Period

Measurements began in mid-October 2022. Measurements will continue until the end of the winter heating season in 2023. We plan to measure the fluctuation patterns of PM concentrations due to the intensity of the heating.

4.3 Environmental Measurement Results and Discussion

4.3.1 Measurement Results and Discussion

A: Apartment measurement results (Installation location (1))

The figure below shows the measurement results for the temperature, relative humidity, and CO_2 concentration in an apartment in Ulaanbaatar City. This apartment is kept at constant temperature between 20 and 25 degrees C. Heat is constantly supplied by a local heating supply, making for a comfortable environment. The relative humidity is very dry at around 20%. In cold regions, the outside air is extremely dry, so ventilation causes the inside air to become dry. In Japan, a comfortable humidity is said to be around 50%. But as there are differences in how humidity is perceived, we cannot draw the conclusion that humidification should be performed. Also, care must be taken when humidification is performed, as condensation may occur on window frames and so on. The CO_2 concentration is kept low at around 500 ppm, with ventilation taking place. There are times when the concentration exceeds 1000 ppm about once every few days, but this is thought to be due to cooking.

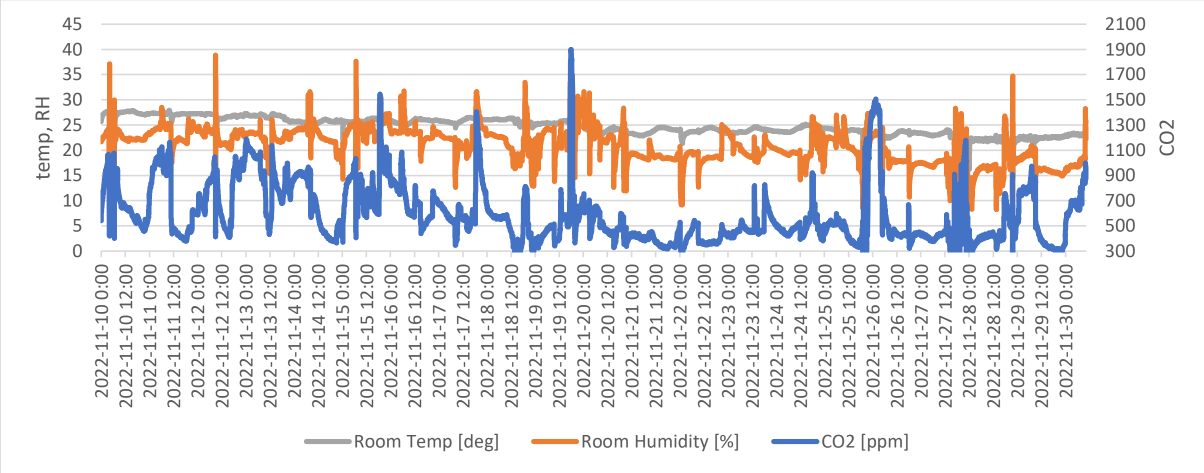


Figure 4-6. Temperature, Relative Humidity, and CO_2 Concentration in a City Apartment

Changes in PM and VOC are shown in the figure below. PM values gradually rose from 11/10 to 11/30. This is thought to be because of an increase in the use of stoves as the outside temperatures dropped. The four lines in the figure indicate WHO guidelines. The upper two are the loosest standards for provisional measures, and they are the annual average standard and the 24-hour average standard, respectively. The measured values are often below these guidelines; it is thought that the standards have been cleared. The bottom two lines indicate WHO final standards. The measured values exceed these standards at many points; it is thought that WHO's Air Quality Guidelines (AQG) have not been met.

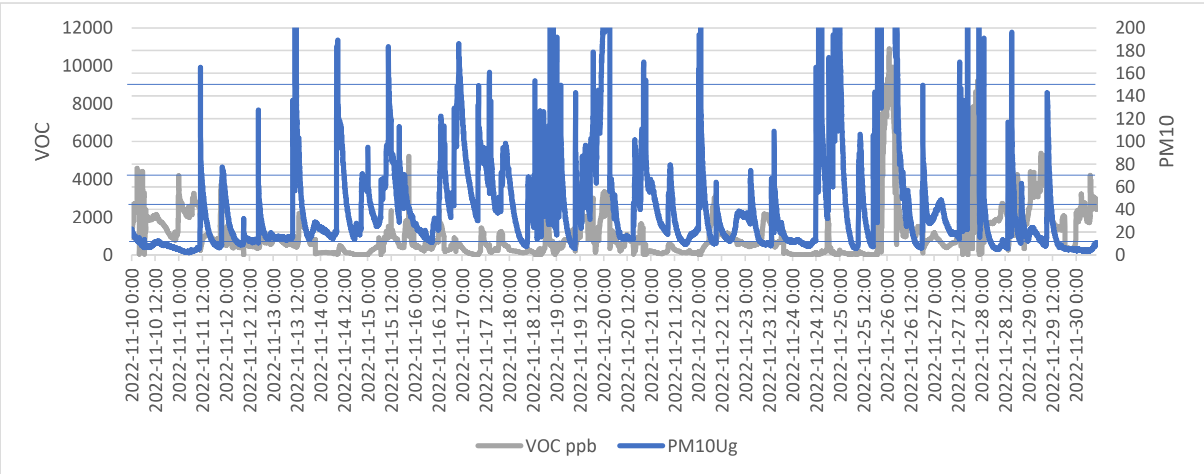


Figure 4-7. Changes in PM10 and VOC in a City Apartment

B: Office (Installation location (2))

The figure below shows changes in the room temperature, relative humidity, and CO_2 level in an office. Unlike the apartment, we can see there is a difference in temperature and CO_2between weekdays and days off. The temperature, humidity, and CO_2 concentration rise during working hours in the office and then they all drop after work. Given that the temperature does not drop significantly, although heat is constantly supplied to the office via a radiator, it is thought that the temperature and relative humidity rise due to human body heat and heat from devices. The CO_2 concentration also rises as human activity occurs in the office after the start of work. The reason for the CO_2 concentration dropping so rapidly after work is due to ventilation via a draught or a ventilation fan. A trend can also be seen with the temperature gradually rising over the weekend and the humidity and the CO_2 concentration gradually decreasing. The temperature in the office is controlled by opening a window, and since the frequency increases as the temperature inside the office rises over the weekend, it is thought that the humidity and CO_2 concentration fall due to this ventilation.

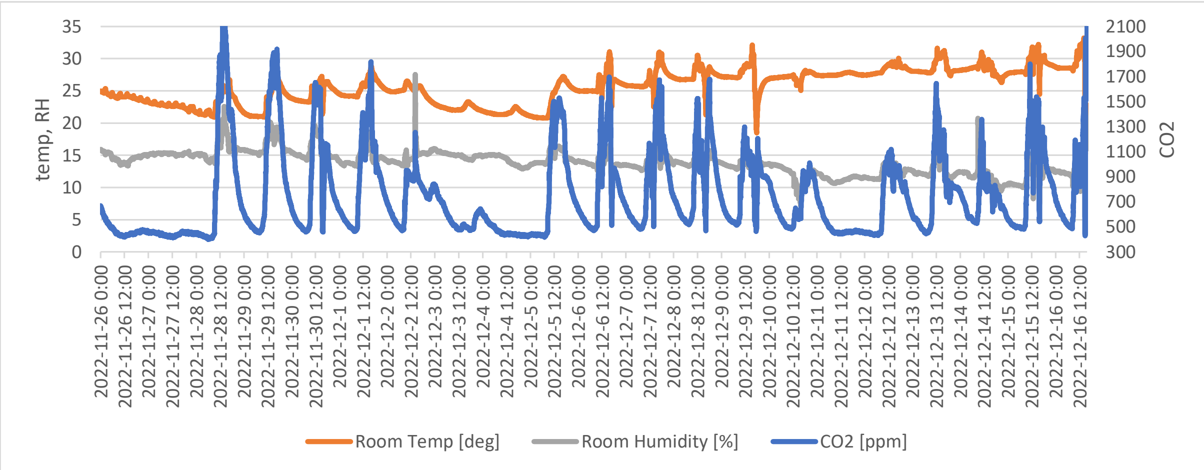


Figure 4-8. Temperature, Relative Humidity, and CO_2 Concentration in a City Office

The figure below shows changes in PM and VOC levels in the office. When compared to the apartment, the fluctuations are small, but pattern-wise similar fluctuations can be seen. The reason for the more subtle fluctuations in the apartment is thought to be due to the fact that the office does not see activities unique to residences, such as cooking. The data for a few days beginning 11/23 show differences between the apartments and the office. Whereas the values in the apartment are low, the values in the office rise. This is thought to be because the office was not used during this period.

The office saw lower levels of VOCs than the apartment. Because VOCs are often generated during cooking, it is thought that the office, which has no cooking take place, has lower values.

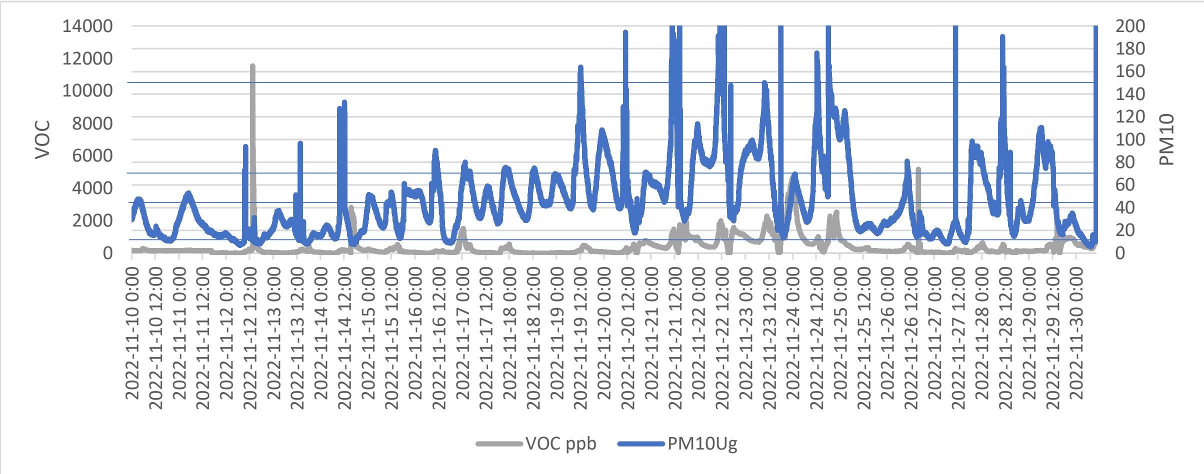


Figure 4-9. Changes in PM10 and VOC Concentrations in City Offices

4.4 Recommendations Based on Environmental Measurements

As a result of performing environmental measurements, it was found that PM concentrations exceeding WHO guidelines were measured indoors over a long period of time. PM may cause health hazards. Continuous high concentrations indoors, where much of life takes place during the winter season, are dangerous. The following recommendations are made as measures to improve this situation.

1. Short-Term Measures

The source for most PM are thought to be the coal stoves used in the ger districts. But quickly switching from these stoves is difficult. Therefore, the following countermeasures are possible.

① Installation of Air Purifiers

Install an air purifier indoors. As PM comes from outside air, the air purifier should be installed near an air supply port or near a window.

② Installation of a Filter to an Air Supply Port

Change the ventilation system to one with a HEPA filter to remove PM from outside air. For example, in the case of offices, air conditioners with energy recovery ventilation functions and HEPA filters to remove viruses from the air are available. The introduction of such units should lower indoor PM concentrations. Also, relatively inexpensive energy recovery ventilation fans with HEPA filters are available for homes. If current ventilation systems are replaced with these, the quality of the air flowing into residences can be improved. There are, however, caveats to keep in mind: a. Consider an installation method that facilitates easy filter maintenance (ventilation fan maintenance is poor even in Japan, so it is necessary to create a system that is easy to maintain); b. If a HEPA filter is installed, the volume of air that can be ventilated may decrease significantly (it is necessary to re-examine the entire system, including fan capacity and duct diameter, rather than replacing just part of the system); and c. Houses in ger districts are thought to have poor airtightness, meaning that a filter installed at an air supply port will be meaningless because outside air will flow in from other places. In this case, the installation of an air purifier is thought to be more effective.

③ Thermal Insulation Improvement of Houses in Ger Districts

In houses in the ger districts, PM from indoor sources is a more serious issue than from outside air. Therefore, it is thought that the indoor environments can be greatly improved by first improving the insulation performance, which would allow heating to be achieved with a smaller heat source and less energy. There are more houses made through DIY methods than detached ger houses in ger districts. Bricks are often used in these houses. The indoor environment will improve dramatically if a moisture barrier is formed on the current bricks using vinyl film, the height of the floor is adjusted with water-resistant EPS, and then a frame for fiber-based insulation is built on top of this to add about 150 mm of insulation. Looking at roofs, while it was not possible to enter houses in a ger district to confirm the current state of the structures, if a ceiling is attached, blowing fiber-based insulation material is thought to be the easiest method of construction.

２． Long-Term Measures

① Improving the Insulation Performance of Buildings in the Ger Districts

Coal stoves installed in houses in the ger districts are thought to be the source of air pollution. Charcoal briquettes are used as fuel, and the quality of this fuel is low. PM is thought to be generated as a result. Therefore, when the performance of houses in the ger districts improves, the amount of coal burned decreases, meaning the amount of generated PM decreases. And when performance is improved, sufficient room temperatures can be maintained even with heating devices with smaller outputs. This means that, for example, heating devices that do not generate pollutants such as electric heaters are sufficient. Apartment complexes are being developed in ger districts. Currently, apartment complexes that have been sold have external insulation of about 150 mm, which is thought to be effective.

② Changes to Heating Systems

Together with the development of apartment complexes, changes in heating systems are also effective. Improving insulation performance allows for heating in most periods using air conditioners with low output. Currently, due to the sprawl seen in Ulaanbaatar, demand for heating supply, not electricity, is increasing, so it makes sense to be able to heat indoor spaces with electricity using air conditioners. There is an issue where the output of air conditioners does not increase when the outside temperature is low. But in recent years, there is a growing number of air conditioners available in Japan for cold regions, and there is the possibility these can be used in Ulaanbaatar. And the output of air conditioners becomes an issue during the four months from November to February when it is the coldest. Air conditioners are effective during other periods, including the following.

③ Development Regulations for Ger Districts

The population in Ulaanbaatar is growing (at a rate of 45,000 people per year), and the uncontrolled expansion of ger districts is progressing. As the development of local heating supply infrastructure has not kept up, houses must be heated with coal stoves prepared by residents, and these stoves are the cause of air pollution. Ger districts, which expand out to the suburbs, are also a cause of traffic congestion, necessitating immediate countermeasures.

④ Redevelopment of Ger Districts

A project is currently underway in Ulaanbaatar to redevelop the ger districts using apartment complexes. The heating load in these districts can be reduced by making the apartment complexes superinsulated. And as electrification is also possible, projects can be implemented even in areas without heating supply infrastructure in place. Currently, most apartment complexes in Ulaanbaatar have flat facades with no balconies. But considering electrification, it is necessary to have spaces to install outdoor units and change ventilation filters. It is also necessary to consider plans with balconies for long-term insulated exterior wall and window maintenance. The introduction of renewable energy also needs to be done at the same time as electrification. Up until now, there have been large-scale solar cell installation projects in and around Ulaanbaatar through city to city collaboration projects and so on. It will also be possible to make use of this experience and expertise.

Chapter 5　Workshops and Courses

As part of this project, two workshops and two courses were held. Relevant organizations from Sapporo City and Ulaanbaatar City shared the policies and initiatives of each city during these workshops. The results of the workshops and courses held are shown below. Attached are the materials, etc. used in the workshop and course presentations.

Table 5-1. Results of Workshops and Courses

Contents	Date
1st Workshop	21 October 2022
2nd Workshop	15 December 2022
1st ZEB/ZEH Course	22 October 2022
2nd Passive House Course	16 December 2022

Also, the Ministry of the Environment held and co-hosted the Zero Carbon City International Forum with the US on March 1, 2023, based on the Global Subnational Zero Carbon Promotion Initiative led by Japan and the US. The purpose of this forum was to discuss cooperation measures and so on between countries and local governments ahead of this year's G7 Ministers' Meeting on Climate, Energy and Environment in Sapporo, which Japan will chair, and to share advanced cases of urban decarbonization transition, resilience, circular economy, nature positive economy, etc. aimed at decarbonizing cities in Japan and overseas, and to accelerate urban climate action globally.

Sapporo Mayor Katsuhiro Akimoto took the stage at the high-level session of this forum, and commitments and lessons learned as city leaders were shared in order to aim for net zero status.

5.1 1st Workshop

（1） Purpose

- To share the objective of the project and activities from 2022
- To share the current state of Ulaanbaatar City

（2） Outcome

- The objective, goals, processes, etc. of this year's project were explained, and the cooperation of Ulaanbaatar City was confirmed.
- Ulaanbaatar City confirmed information and intentions on the city's plan to realize a zero-carbon society, such as public housing complex insulation construction to reduce energy consumption and the promotion of bus use to reduce carbon dioxide emissions.

（3） Overview of Event

Date: 15:00–16:15 (JST 16:00–17:15), Friday, 21 October 2022

Venue: Ulaanbaatar City Hall

Participants: [from Mongolia] Ulaanbaatar City Hall, Urban Development Department of the Capital City, Capital City Housing Corporation, Ministry of Construction and Urban Development

[from Japan] Sapporo City (online), Oriental Consultants

（4） Agenda

Time in Mongolia (Time in Japan)	Contents	Presenter
15:00–15:10 (16:00–16:10)	Opening: Opening Remarks by Ulaanbaatar City Opening Remarks by Sapporo City	Ulaanbaatar City Sapporo City
15:10–16:00 (16:10–17:00)	<Presentation and Discussion> Description of the 2022 Project (Objectives, Goals, Processes, etc.)	Oriental Consultants
	General Development Plan of Ulaanbaatar Until 2040	Ulaanbaatar City
	● Meeting on Project Details ● About the 10/22 seminar on learning from Japan's experience promoting energy-saving housing and construction (ZEH/ZEB) ● Question and Answer	Oriental Consultants Ulaanbaatar City
16:00–16:15 (17:00–17:15)	Closing: Closing Remarks by Ulaanbaatar City Closing Remarks by Sapporo City <Group Photo>	Ulaanbaatar City Sapporo City

（5） Minutes of the Meeting, Presentation Materials (Appendix A)

- Agenda (Mongolian)
- Presentation Materials (Japanese, English)
- Participant List
- Minutes (Japanese, Mongolian)
- Photos

5.2 2nd Workshop

（1） Purpose

- To share Ulaanbaatar City's climate change-related initiatives
- To promote understanding related to energy management based on examples in Sapporo City and environmental measurements carried out in Ulaanbaatar City, and consider its use in Ulaanbaatar's policy initiatives
- To discuss issues regarding low-carbon candidate projects under consideration and discuss future implementation policies

（2） Outcome

- Initiatives aimed at achieving carbon neutrality were shared, such as Sapporo City's energy plan.
- A regional energy management system was introduced by Hokkaido Gas, and the importance of constructing a new energy model that supports a sustainable low and zero-carbon society was confirmed.
- The status of environmental measurements related to indoor air pollution was shared. And

because PM concentrations above WHO guidelines were measured indoors, the need to improve the situation in order to reduce health hazards was recognized.

（3） Overview of Event

Date: 15:00–16:30 (JST 16:00–17:30), Friday, 15 December 2022

Venue: 14F Hall A, Ulaanbaatar City Hall

Participants: [from Mongolia] Ulaanbaatar City Hall, Capital City Housing Corporation, Ministry of Construction and Urban Development, the National Development Agency

[from Japan] Sapporo City, Hokkaido University, Hokkaido Gas (online), Oriental Consultants

（4） Agenda

Time in Mongolia (Time in Japan)	Contents	Presenter
15:00–15:05 (16:00–16:05)	Opening: Opening Remarks by Ulaanbaatar City	Ulaanbaatar City
15:05–15:15 (16:05–16:15)	Participant Introductions <Group Photo>	—
<Presentation and Discussion>		
15:15–15:20 (16:05–16:20)	Action plan and implementation of NDP in construction and urban development	Ministry of Construction and Urban Development
15:20–15:35 (16:20–16:35)	Introduction of the Sapporo City's Energy Plan	Sapporo City
15:35–15:50 (16:35–16:50)	Introduction of regional energy management systems	Hokkaido Gas
15:50–16:05 (16:50–17:05)	The status of environmental measurements related to indoor air pollution and recommendations for appropriate energy management	Hokkaido University
16:05–16:15 (17:05–17:15)	Introduction of feasible projects	Oriental Consultants
16:15–16:25 (17:15–17:25)	Question and Answer	—
16:25–16:30 (17:25–17:30)	Closing: Closing Remarks by Ulaanbaatar City Closing Remarks by Sapporo City	Ulaanbaatar City Sapporo City

（5） Minutes of the Meeting, Presentation Materials (Appendix B)

- Agenda (Mongolian)
- Participant list (Mongolian)
- Presentation Materials (Mongolian, Japanese, English)
- Photos

5.3 1st ZEB/ZEH Course

（1） Background

Ulaanbaatar City is the coldest capital city in the world. Compared to other regions, the daily lives of citizens and economic activities consume large amounts of energy, and CO_2 emissions are also high. Air pollution is also a serious problem in Ulaanbaatar City, adversely affecting the health and lives of citizens. The primary source of air pollution are the stoves used in houses in the ger districts. Switching to superinsulated, high-density housing is one effective means of reducing energy consumption and counteracting air pollution.

（2） Purpose

To go over energy-saving housing (ZEH/ZEB), to introduce policies and initiatives by Japan and Sapporo City that promote energy-saving housing/construction (ZEH/ZEB), and to exchange views on what should be applied in Ulaanbaatar City having learned from the examples and experiences of Sapporo, another cold region city.

（3） Overview of Event

Date: 14:00–16:00 (JST 15:00–17:00), Friday, 22 October 2022

Location: Conference Hall, Mongolia-Japan Center

Participants: Persons in charge and engineers from Ulaanbaatar City Hall, Urban Development Department of the Capital City, Capital City Housing Corporation, Ministry of Construction and Urban Development, as well as citizens interested in energy-saving housing (ZEH/ZEB)

（4） Program

Time in Mongolia (Time in Japan)	Contents	Presenter
14:00–14:10 (15:00–15:10)	Opening Remarks	Oriental Consultants
14:10–15:00 (15:10–16:00)	• About energy-saving houses (ZEH/ZEB) • How to design and calculate ZEH/ZEB • Japan's policies to promote energy-saving housing and construction (ZEH/ZEB) and implementation status • ZEB/ZEH assistance and case studies in Sapporo City, a cold region city	A. Амарбаяр, Associate Professor & Research Fellow, Institute for Sustainable Development, School of Engineering and Applied Sciences, National University of Mongolia
15:00–15:15 (16:00–16:15)	Coffee Break	
15:45–16: 00 (16:45–17:00)	Exchange of views on what should be applied in Ulaanbaatar City based on Japan's advanced examples and policy formulation experience Closing: Closing Remarks by Ulaanbaatar City Closing Remarks by Sapporo City <Group Photo>	A. Амарбаяр, Associate Professor & Research Fellow, Institute for Sustainable Development, School of Engineering and Applied Sciences, National University of Mongolia Oriental Consultants

（5） Summary of Course Content

Explanations were given on Japan's energy consumption, on the relevant trends and context, and on policies to promote energy-saving housing and construction (ZEH/ZEB) and their implementation status. There were also explanations of the history and context for Japan's establishment of a policy framework to encourage the adoption of ZEH/ZEB. Additionally, there were explanations on the introduction of the concept of home fuel efficiency, on the definition and classification of energy-saving housing (ZEH/ZEB), on the BELS building energy saving performance labeling system, and on a registered BELS evaluation organization. ZEH/ZEB design guidelines and an overview of calculation methods were introduced. And at the end, views were exchanged between participants and presenters.

（6） Question and Answer

Question 1: In what ways are citizens of Sapporo, Hokkaido receiving specific assistance for the introduction of ZEB/ZEH?

Answer: Specific options are available depending on the size of the house. For example, there is support of up to 1.6 million yen for Top Runner, 1.4 million yen for High Level, and 1.1 million yen for Standard Level energy-saving houses/buildings. We hope to have personnel and experts from Sapporo City participate in the next course and provide specific explanations and introductions.

Question 2: What are the standard values and conditions for Top Runner houses?

Answer: According to the Sapporo City website, if a newly built house is Top Runner grade, the average thermal transmittance (U_A value) is 0.18 or less, and the corresponding gap area is 0.5 or less [cm^2/m^2]. To put it simply, energy-saving houses that consume about five times less energy than ordinary homes are defined as Top Runner houses. The two-story 70 m^2 model low energy house (LEH)[35] built in the Gandan ger district of Ulaanbaatar City is considered a Top Runner within Mongolia. The average thermal transmittance U value for the walls of this house is 0.085, making this a Top Runner. The weather conditions in Ulaanbaatar City are harsher than those of Sapporo City, so it is unclear if this can be cleared.

Question 3: Are there any comparative studies on weather conditions in an average year between Sapporo City and Ulaanbaatar City, both of which are cold region cities?

Answer: There are no research studies or detailed materials comparing the weather conditions in Sapporo City and Ulaanbaatar City yet. Incidentally, the National University of Mongolia has been researching solar radiation for many years, having sett up a test site in Sainshand, a town in the Gobi Desert located in the south of Mongolia. As Sainshand and Sapporo City share a similar latitude, when comparing solar energy, Sainshand is about 1.7 times higher in average years. If the same solar cell were to be installed in Sainshand and Sapporo City, the cell in the Gobi Desert would generate about 1.7 times more electricity.

[35] Source: Passive House Database, https://passivehouse-database.org/index.php?lang=en#d_6654

（7） Materials for 1st Course (Appendix C)

- Agenda (Mongolian)
- Photos
- Presentation Materials (Mongolian)
- Participant List

5.4 2nd Passive House Course

（1） Background

The Ulaanbaatar City administration needs to learn about advanced examples, policies, and implementation methods regarding energy-saving housing in cold region cities in developed countries. There were also many requests from participants who registered online for the 1st course to learn about energy-saving housing, especially passive houses. The content of the first course focused on Japan's energy conservation policies and their implementation. The second course was on basic knowledge regarding energy-saving housing and energy-saving housing standards (passive houses), which are garnering attention in Mongolia.

（2） Purpose

1) To share the basics and applications of energy-saving housing with the general public and stakeholders as a countermeasure against climate change and air pollution, as well as improve acceptability.
2) To introduce Sapporo City’s energy plan and its implementation status as an advanced example of a cold region city, and to have it be used as a reference for policies in Ulaanbaatar City.
3) To promote understanding related to energy management based on examples in Sapporo City and indoor environmental measurements carried out in Ulaanbaatar City.

（3） Overview of Event

Date and time: 12:40–16:20, Friday, 16 December 2022

Location: Hall 303, Library of the National University of Mongolia

Participants: [from Mongolia] Persons in charge and engineers from Ulaanbaatar City Hall, Urban Development Department of the Capital City, Capital City Housing Corporation, Ministry of Construction and Urban Development, as well as citizens interested in energy-saving housing (ZEH/ZEB)

[from Japan] Sapporo City, Hokkaido University, Oriental Consultants

(4) Program

Time in Mongolia	Contents	Presenter
12:40–13:00	Registration Opens	
13:00–13:10	Opening Remarks	Oriental Consultants
13:10–13:40	Basic course on energy-saving housing and construction as a countermeasure against climate change and air pollution. Covering the ZEB/ZEH popular in Japan, design methods, and case studies	A. Amarbayar, Professor, Renewable Energy Lab, School of Engineering and Applied Sciences, National University of Mongolia
13:40–14:10	Sapporo City’s Environmental Policy: Aiming for a Zero-Carbon City	Teruhiro Satake, Environmental Policy Division, Eco-City Promotion Department, Environmental Bureau, Sapporo City
14:10–14:40	Indoor air quality (IAQ) and its measurement and monitoring in cold region cities Ulaanbaatar City and Sapporo City	Professor Mori, Hokkaido University
14:40–14:50	Break Time	
14:50–15:10	Current status and issues regarding energy-saving housing and buildings in Mongolia: planning and implementation of passive houses	S. Tuvshinkhuu, Director, Mongolia Passive House Research Institute
15:10–15:30	How to design energy-saving passive houses using PHPP tools	E. Otgonzul, Director, Mongolia Passive House Research Institute
15:30–15:50	The airtightness of energy-saving housing passive houses	E. Enkh-Uchral, School of Engineering and Applied Sciences, National University of Mongolia
15:50–16:10	Question and Answer	
16:10–16:20	Closing Remarks <Group Photo>	Ulaanbaatar City, Sapporo City

(5) Summary of Course Content

- Ulaanbaatar City Councilor and Urban Development and Infrastructure Commission Chair B. Sukhbaatar made the opening remarks for the course. A. Amarbayar of the National University of Mongolia gave explanations on Japan’s energy consumption, on the relevant trends and context, and on policies to promote energy-saving housing and construction (ZEH/ZEB) and their implementation status. The basic concepts of ZEB/ZEH, their design methods, and advanced case studies were introduced.
- T. Satake from the Sapporo City Environmental Bureau introduced the environmental policies of Sapporo City, covering the Sapporo Climate Change Action Plan, 2030 goals and initiatives aimed at their achievement in Sapporo City, standards for Sapporo Next-Generation Houses, local heating supply in the city center, the Sapporo City Center E-City Development Promotion System, and examples of incentives that induce highly effective initiatives and their implementation status.
- Professor Mori of Hokkaido University covered the history and recent trends in housing development in cold regions of Japan, as well as the need for IAQ, health-related research,

IAQ measurement and monitoring, open design, retrofitting, the preservation traditional technologies, and issues facing the construction industry.

- Mr. S. Tuvshinkhuu, director of the Mongolia Passive House Research Institute, covered the current status and issues of energy-saving housing and buildings in Mongolia, specifically explaining Mongolian construction standards, insulation standards, heat loss calculation methods, and reductions in CO_2. Mr. E. Otgonzul, director of the Mongolia Passive House Research Institute,[36] used case studies to introduce design methods for energy-saving passive houses using PHPP tools. E. Enkh-Uchral of the School of Engineering and Applied Sciences at the National University of Mongolia covered the airtightness of energy-saving passive houses, its necessity, and gave an example of a Blower Door Test airtightness measurement evaluation.

（6） Question and Answer

Question 1: How do I obtain a passive house calculation tool?

Answer: You can purchase PHPP with a serial number from the International Passive House Association. This serial number is required to take the certified Passive House Designer exam.

Question 2: Has wool ever been used as an insulating material for buildings in Japan? Wool is organic, absorbs moisture well, and dries easily, so it may be a good material to use in humid countries like Japan.

Answer: Unlike Europe, glass wool is often used in Japan. It is a recycled material, making it cheap and frequently used. Organic materials such as cellulose fiber and wood fiber are also available, but because the prices are relatively high, they are not used as often as glass wool. I would like to consider wool, but in order to use it as a building material in Japan, it is necessary to clear the Fire Service Act testing in Japan, which presents a though hurdle. In addition, moisture must not be absorbed into the insulation material. It is important to prevent such moisture. When calculating buildings in warm regions with a passive house calculation tool, there are cases where attention is paid to insulating materials that absorb moisture.

Question 3: I heard that the WHO guidelines say that indoor temperatures should be kept at 18 degrees C, but in Mongolia it is sometimes said that it is better to keep indoor temperatures at 22 degrees C. Can you explain the difference between these?

Answer: Indoor temperatures are set at 18 degrees in places such as Japan where there was no previous thought about raising indoor temperatures. We have researched what indoor temperatures should be set at, and I think 22 degrees C is appropriate.

Question 4: What is the difference in cost and performance between a one-story house with an effective area of 100 square meters and a two-story house?

Answer 1: When considering the price of land, a two-story house is cheaper.

[36]Passive House Planning Package is a software tool that calculates the energy consumption of buildings created by the Passive House Institute.

Answer 2: The smaller the surface area of the outside of a building, the lower the heat loss, meaning spherical or cubic shapes perform better.

(7) Materials for 2nd Course (Appendix D)

- Agenda (Mongolian)
- Presentation Materials
- Participant List

5.5 Considerations from Implementation of the Passive House Course

The National University of Mongolia and the Mongolia Passive House Research Institute are working together to disseminate knowledge about the basic concepts of passive houses, their design methods, their construction, and so on. This has had some impact. In recent years, interest in superinsulated, high-density houses has increased among the public and those in the construction industry in Mongolia.

These two courses introduced the energy-saving housing policies and implementation methods in Sapporo City, a cold region city, to Mongolian administrative staff, policy makers, and politicians. From FY 2015 to FY 2019, the Japanese government examined the policy system for encouraging ZEH/ZEB and developed a form suitable for the situation in Japan. Going forward, the most effective approach in formulating policies in Mongolia will be to explain these circumstances and the background in more detail to Mongolian administration officials, policy makers, politicians, researchers, and so on, and conduct courses that include case studies, proposals, etc. suitable for the current situation in Mongolia.

Also, there was a high level of interest in Japan’s ZEB/ZEH design guidelines and the specific examples of top runners introduced from members of the general public and people in the construction industry who participated in the courses. There were many questions for Professor Mori of Hokkaido University, who participated in the 2nd course, that indicated a desire to learn about Japan’s experiences. The implementation of courses with veteran Japanese experts and university professors will continue to be effective in the future. Furthermore, it is expected that sending university students, graduate students, young experts, and researchers from Mongolia to Hokkaido University to share knowledge and experience on energy-saving housing at a high level through training activities and encouraging close relationships will be effective. The creation of opportunities to train young workers from the Mongolian construction industry at construction sites in Hokkaido is also conceivable.

At the same time, the general public’s idea of energy-saving buildings and lack of knowledge is an obstacle to the adoption of energy-saving housing. Therefore, it will be necessary to conduct multiple courses that use actual examples to carefully teach the concept and basic knowledge regarding energy conservation to the general public. Support for the development of programs related to energy-saving buildings for the general public and the preparation of learning materials is also needed.

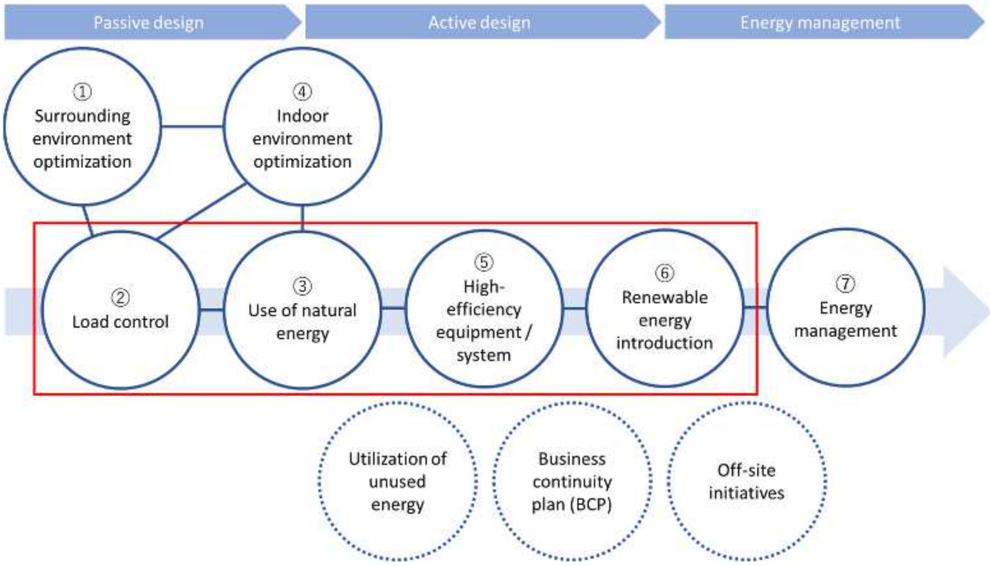
Chapter 6　Study of JCM Project Development

6.1 Sorting of study cases of decarbonized model building

This chapter discusses the development of a JCM project in line with decarbonized model building cases the team assumed in FY 2021.

6.1.1 Study cases of decarbonized model buildings in cold areas

In the ZEB design process in general Japanese ZEB design guidelines, main cases set up in this survey are 2) load control, 3) use of natural energy, 5) high-efficiency equipment/system, and 6) renewable energy introduction as effects of building specifications themselves as show in the below figure.



Source: ZEB Design Guidelines

Figure 6-1　ZEB Design Process

Table 6-1　Study Items in ZEB Design Process and Decarbonization Methods

Study Items	Decarbonization Methods
1) Proper surrounding environment	Building allocation, proper construction and exterior plan
2) Load control	Enhanced heat insulation of building skin, reduction of inside heat evolution
3) Use of natural energy	Use of natural daylighting and ventilation
4) Proper indoor environment	Proper heating, air quality and light environment
5) Efficiency increase of facility and systems	Efficiency increase of air conditioning and ventilation, heat source, lighting and water heating systems
6) Introduction of renewable energy	Solar and wind power generation, etc.
7) Energy management	Use of BEMS, lifecycle energy management, visualization, etc.

Source: ZEB Design Guidelines

Based on the abovementioned ZEB design process and each item and methodology, methodologies for decarbonization in each target study item are used to set up multiple study cases.

Case 1 is only to enhance heat insulation of building skin and Case 2 is to introduce facility efficiency improvement that includes lighting, water heating and ventilation in addition to Case 1.

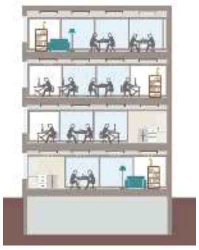
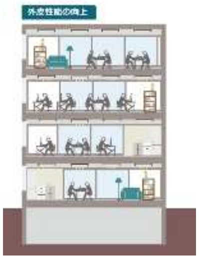
Case 3 is to introduce renewable energy to the air conditioning system in addition to Case 2. In this case, the ground source heat pump system is used for the air-conditioning system. Although the ground source heat pump is considered as renewable energy, it is to use the heat in the ground and provide the heat using the electric power of ground source heat pump system in comparison with the heating of the building using the ordinary air heat pump, and thus it is also considered as energy-efficient facility.

As accompanying facility, it is also equipped with solar power equipment. This is to recover ground source heat taken with the ground source heat pump system with solar heat. Continuously taking the heat with the ground source heat pump lowers the heat pump efficiency as the heat in the soil is taken away and it is complementary facility to prevent it.

In Case 4, in addition to Case 3, solar power generation (energy generation) is used as renewable energy (energy generation), thereby making a more decarbonized model building.

As it is not realistic to introduce all specifications concurrently, in this survey, the feasibility of the introduction with focus on each additional technology.

Table 6-2 Study Cases of Decarbonized Model Buildings in Cold Areas

	Case 0	Case 1	Case 2	Case 3	Case 4
					
Method of decarbonization with reduced energy	No measure (Buildings with existing specifications) * Electric power for heat supply system	Building skin (enhanced insulation)	Building skin (enhanced insulation) + energy-efficient facility (lighting, water heating and ventilation)	Building skin ＋(enhanced insulation) + energy-efficient facility (lighting, water heating and ventilation) ＋ energy-efficient heat supply (ground source heat pump system/solar heat) * Solar heat is a complementary system to recover ground source heat taken with the heat pump)	Building skin ＋(enhanced insulation) + energy-efficient facility (lighting, water heating and ventilation) ＋ energy-efficient heat supply (ground source heat pump system/solar heat) ＋ energy generation (solar power generation)
Studied technology for introduction		Load reduction only by enhanced insulation of exterior wall and fittings	Promotion of energy saving by improved efficiency of facility	Use of renewable energy (ground source heat) for the heat supply system	Solar power generation as renewable energy for part of power consumption to reduce power purchase from the grid

6.2 Study of introduction of energy-efficient facility (streetlights of high-efficiency LED)

Of the above cases, Case 2, introduction of streetlights of high-efficiency LEDs as energy-efficient facility to Serena Town, redevelopment project in a ger area, is examined.

6.2.1 Overview of the premises

Serena Town is a housing complex development project in a ger area launched in 2019 by a Mongolian developer, Batkhereid LLC, with an aim to develop an efficient and sustainable city with various functions necessary for living in its vicinity. It is conveniently situated approx. five kilometers east of city center and the buildings are for family use with multiple rooms and playground and green walking paths for children and elderly people are also built.

Table 6-3　Overview of Serene Town

<table>
<tr><td>Target</td><td>Housing Complex　SERENE TOWN, Ger Area Redevelopment</td></tr>
<tr><td>Photo and Map</td><td>

Location</td></tr>
<tr><td>Overview</td><td>・Located approx. 5km east of city center
・Housing complex development project
・Premises:　6.83ha
・Land use:　building32%, recreational (green zone and park) 51%, parking and roads 17%
・4 buildings with 96 housing units have been completed.
・As of December 2022, 2 housing buildings and one multiple-use facility were under construction.</td></tr>
<tr><td>Reason for Selection</td><td>As it is a typical mid-sized housing complex in a ger area, it can be studied as decarbonized model buildings.</td></tr>
</table>

The below is a summary of the interview with the developer about the target area.

Target interviewees:　Batkhereid LLC:　Sodbileg Erdene-od and two other people

- Currently, a six-storied building with 96 housing units and a nine-storied building shopping center are under construction in Serena Town. The sewage, centralized heating and heat exchanging systems as well as substation have been completed.
- In part of the Serena Town in the ger area, relocation of residents is still underway.
- The concept and standards for green buildings have been introduced to newly constructed buildings recently. However, the standards are not being adopted yet to buildings.
- The design of a kindergarten for approx. 240 children and a primary school for approx. 640

students has been approved by Ulaanbaatar City and they are slated to be constructed. The design uses the conventional design drawings that have been used for such facilities. The construction cost of the school is borne with Serena Town construction cost and it is planned to be sold to the Ulaanbaatar city authority after construction. With the current budget, it is difficult to use specifications of a green building.

- Although such new technologies as green buildings can be introduced up to two percent of the Serena Town construction cost, the amount of the budget is so small and thus what can be done is limited.
- It may be possible to introduce smart lighting with solar energy for the streetlights within the budget. The cost of the street lighting is planned to be borne by the management company of the residents, which means that it is borne by them.
- If the insulation is added to the specifications of the planned residential building, whose drawings will be approved, it requires approval of Ulaanbaatar City on the building specifications as a housing complex.

As a result of the above interview, the survey team found out that it is difficult to introduce the heat insulation technology to the construction of the building in Serena Town (Case 1).

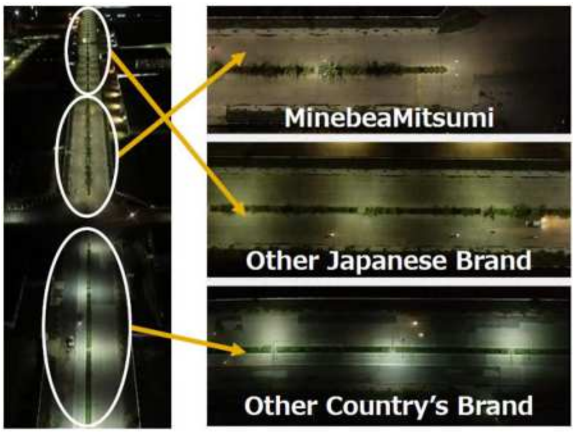
On the other hand, the team also found out that there is demand for efficient energy of the streetlights and because the town premises are vast, a certain scale of its effects can be expected. Thus, it will examine the feasibility of introducing the efficient energy equipment in Case 2.

6.2.2 Technology overview

The high efficiency LED streetlights of Minebea Mitsumi have the following features.

① Use of LED＋high-efficiency optic lens

In comparison with conventionally used mercury lamps and high-pressure sodium vapor lumps for streetlights, high efficiency and long-life LED lights are used and when it is combined with the use of optically designed lens, it is possible to reduce light leakage, limit lighting direction and consider the luminance and brightness



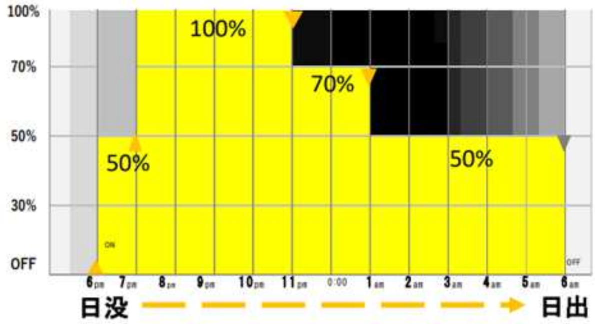
Source: Monebea Mitsumi

Figure 6-2 Comparison of Illuminance Consistency

② Light control

The illuminance can be controlled by different time zones depending on the traffic volume and reduce the power cost.

For example, the power consumption can be reduced by approx. 30 percent by reducing the illuminance by 50 percent during such time zones as after the sunset when it is relatively light and midnight when the traffic volume is small.



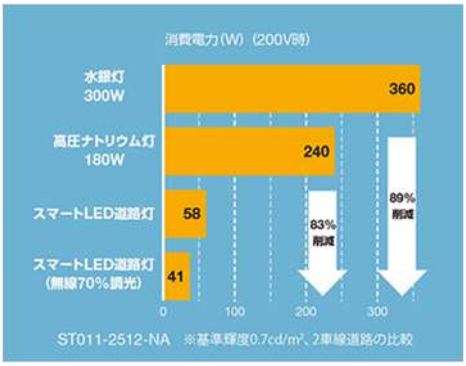
Source: Minebea Mitsumi

Figure 6-3　An Example of Lighting Control Schedule

6.2.3 Study of reduction impacts

The following is the study of reduction impacts of the high-efficiency LED streetlights to be installed in Serena Town.

They can be installed on an area of 3.48ha (51%) for the green zone and parks and 1.16ha (17%) for roads and parking lots of the total premises of 6.83ha. Based on the interview in the field study, the survey team found out that 50 units are planned to be installed.



Source:　Miebea Mitsumi website

Figure 6-4　Energy Saving Impacts of High-Efficiency LED Streetlights

As mentioned above, when compared with mercury lumps that have been generally used as a light source, energy consumption can be expected to be reduced by 89 percent.

The estimated CO_2 emissions are reduced as shown in the below table.

Table 6-4 Calculation of CO_2 Emissions Reduction

a	Lighting time	12	hours/day	
b	Number of lighting units	116	units	
c	Mercury lump power consumption	300	Watt	
d	Power consumption of high-efficiency LED streetlights	33	Watt	
e	Power consumption reduction	160.20	kWh/day	(c-d)×a×b/1000
f	Power consumption reduction	58.47	MWh/year	e×365/1000
g	Emissions coefficient	0.859	tCO_2/MWh	Emissions coefficient of FY2022 JCM facility auxiliary project
h	CO_2 emissions reduction	50.22	tCO_2/year	f×g

6.2.4 Study and future development concerning the applicability to JCM facility auxiliary project

From the above discussions, the team found out that the replacement of the streetlights with high-efficiency LED lights on the premises can be expected to enable reduction of GHG emissions. However, with our knowledge, there is no past example of the introduction of the product to Mongolia and based on the past examples in Japan, the cost is likely to be high.

The below is the challenges toward the introduction and future development.

（1） Improvement of cost efficiency

As a major challenge is to reduce the initial and running cost to improve the cost efficiency, discussed below is possible measures to be taken.

① Combined use with power generation facility that uses natural energy

Use of electricity generated at natural-energy power generation facility necessary for the LED streetlights enables reduction of the amount of power consumption. Also by making it independent from the power grid on the premises, the cable installation cost and maintenance cost are expected to be reduced.

There are products that feed power using solar power and wind power generation and the use of such products can be studied. The below requires particular attention when studying the products.

・Need for system connection

If power can be generated only with natural energy, such cost as the cabling cost can be also reduced. However, if sufficient amount of power cannot be generated due to such a factor as the weather condition, sufficient illuminance cannot be obtained and thus it is necessary to study the location of the lights to be installed to select those where temporary insufficient illuminance does not cause any problem.　temporarily.

・Performance in cold areas

Products that have never been used in Mongolia need to be studied to see whether their designed performance can be achieved under such climate conditions as the daylight time and temperature in Mongolia.

The below shows products available in Japan as reference. Because neither product has been introduced overseas, their usability outside Japan needs to be studied.

Table 6-5　Examples of Domestically Available Solar-Powered Streetlights

Product Name	Solar light	Solar wind light
Photo		
Feature	Equipped with a storage battery and can be lit for up to 14 hours when it is fully charged. When connected with grid power source and when there is not sufficient daylight, it can be lit if power is supplied from the grid.	Wind power generation facility is added to solar power generation, which enables more stable power supply.

Source:　Panasonic website

（2）　High value addition to accommodate local challenges

Values can be added to the proposed product by attaching sensors and measuring instruments to make it smart streetlights. For example, environmental sensors can be installed to obtain air pollution and climate data to provide it to the residents and security cameras can be attached to improve the security level.

It is also possible to improve convenience of residents by expanding the Wi-Fi network as a smart city and thus it can be expected to be used at commercial facilities and value-added residential buildings.

Source:　Minebea Mitsumi website

Figure 6-5　Examples of Functions that can be Added to Make Smart Streetlights

（3）　Future development

The below is the possible schedule for the introduction of the high-efficiency LED streetlights to Serena Town.

Based on the overall construction work of the town, the schedule is studied to be in line with the exterior work and power facility installation work.

Table 6-6　Proposed Schedule of High-Efficiency LED Streetlights Introduction

Month	1	2	3	4	5	6	7	8	9	10	11	12
Field survey	Confirmation of local needs and required specifications											
Design			Plan and basic design					Implementation design				
Legal compliance					Application for approval							
Installation										Installation work		

The high-efficiency streetlights can be introduced also to commercial development sites in addition to the redevelopment site in the ger area in Ulaanbaatar and thus it can be studied for every project.

6.3 Study of introduction of solar-power generation (garage equipped with solar panels)

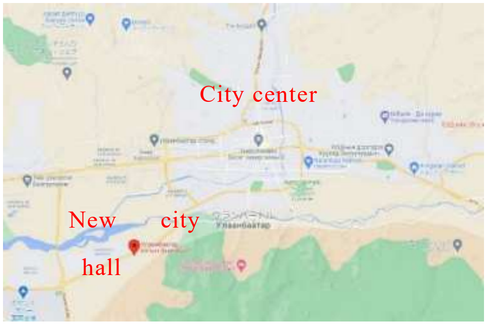
This section examines the introduction of decarbonized model buildings to the new Ulaanbaatar City Hall.

In Ulaanbaatar, a large-scale residential development project is planned in the Yarmag District situated between the new airport and city center and the city hall is planned to be relocated to form a new city center. Rainwater reservoir facility is also planned and studied in the district to create a green city.

6.3.1 Overview of the premises

An overview of the new Ulaanbaatar city hall is provided below.

Table 6-7　Overview of New Ulaanbaatar City Hall

Target	New Ulaanbaatar City Hall
Photo and Map	  Location of new city hall
Overview	・Located 10km southwest of city center ・New Ulaanbaatar city hall (of total floor area of 33,631m2, 2,500m2 of 13-story B block building with one basement floor
Reason for Selection	It is a recently built representative office building serving as public facility. As it consumes a large volume of energy, energy saving effects are expected.

The survey team interviewed the architect about the target area and the interview is summarized as below.

- It is difficult to change the building specifications as it has been already designed.
- Also the team proposed solar power on the garage roof, it may be in the shade as the building C that is to be built is 48 meters tall.
- If solar power is introduced, it is mixed with thermal power. However, if the amount of solar power is measured, coal-fired thermal power can be reduced and the reduced amount of CO_2 emissions can be measured.
- The windows are big and the room conditions on the south and north sides differ.

Because the design of the new Ulaanbaatar city hall has been completed, it is difficult to introduce the technology to the entire building. On the other hand, installation of solar panels on the garage roof is likely to have a significant impact as the garage where employees and visitors park their cars is quite big and thus introduction of solar power generation facility in Case 4 is studied.

6.3.2 Technology overview

There are multiple solar panel products integrated with the garage roof sold in Japan and overseas. The garage with solar panels consists of the following products:

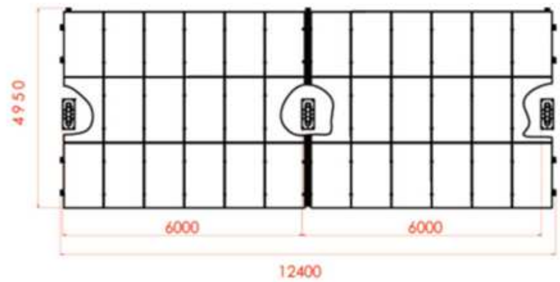
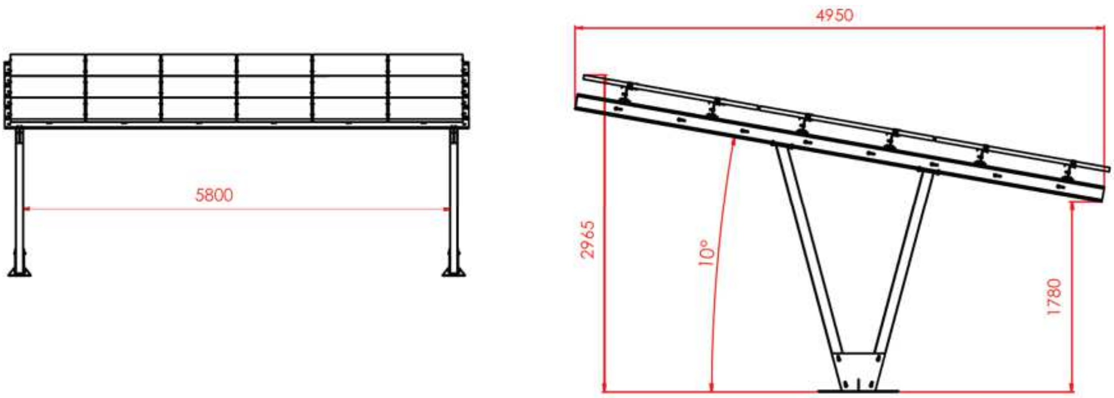
① Solar power generation facility:
  solar panel, inverter

② Garage:
  roof, frame and foundation

③ Power cabling equipment:
  equipment necessary for connection with cables and grid

The below is an overview of the products sold in Mongolia.

Table 6-8 Overview of Garage Roof Equipped with Solar Panels

<table>
<tr><td></td><td>
</td></tr>
<tr><td>Photo</td><td>Roof framing plan</td></tr>
<tr><td colspan="2">
</td></tr>
<tr><td colspan="2">Elevation plan</td></tr>
</table>

The specifications of the garage with solar power generation facility installed by the Mongolian Ministry of Road and Transport Development are provided below.

Table 6-9 Overview of Specifications of Garage Equipped with Solar Panels

Capacity	40kW
Number of parked vehicles	12
Number of panels	90
Estimated price	164,107,350MNT (breakdown) Solar power system: 73,737,000 Power cabling: 8,900,000 Garage roof: 48,031,500 Design: 9,450,000 Construction: 149,188,500 VAT 10%

When generated power is not used there, storage batteries are needed in addition to the above. However, as the city hall consumes a large amount of power during the day, different from housing, and thus it can be used on the premises, which enables cost reduction for the batteries and maintenance.

6.3.3 Study and future development concerning applicability to JCM facility auxiliary project

The below is the possible schedule for the introduction of the solar power generation facility to the new Ulaanbaatar city hall.

As the confirmation of local needs and required specifications, the team will confirm the candidate site of the parking area and examine the feasibility of the installation. Because high-rise building is planned to be constructed, the daylight condition also needs to be confirmed. It will also confirm the requirements and systems to consume power generated on the premises.

Then, in the plan and basic design, specifications will be decided and applications for approval will be sent to relevant authorities before detailed implementation design. Because the new city hall is being used, consideration will be given to the users' convenience and safety when the installation procedures and zones are decided.

Table 6-10 Proposed Schedule of Introduction of Garage equipped with Solar Panels

<table>
<tr><th>Month</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th></tr>
<tr><td>Field survey</td><td colspan="3">Confirmation of local needs and required specifications</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Design</td><td></td><td></td><td colspan="3">Plan and basic design</td><td></td><td></td><td colspan="2">Implementation design</td><td></td><td></td><td></td></tr>
<tr><td>Legal compliance</td><td></td><td></td><td></td><td></td><td colspan="3">Application for approval</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Installation</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">Installation work</td></tr>
</table>

Another possibility is that the new city hall is a high-rise building and there is a large amount of exterior wall and thus solar panels on the exterior wall can be effective. However, it needs to be examined together with the structure and exterior wall.

Against the backdrop of congestion of Ulaanbaatar, structures are becoming higher. Because the area where the solar panels can be installed becomes small in the case of solar power systems that are usually installed on the rooftop floor and the roof, the use of exterior wall is likely to increase.

6.4 Study of introduction of energy-efficient heat supply facility (ground source heat pump system)

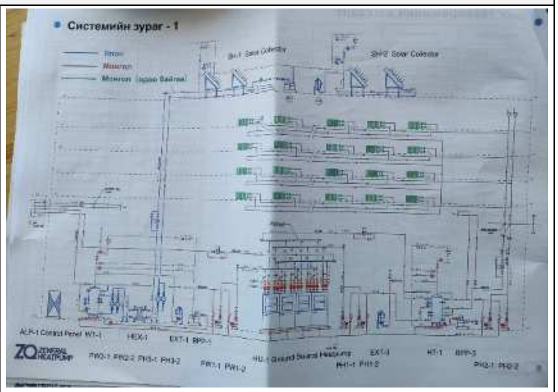
This section discusses Case 3, introduction of heating system that uses ground source heat pump system.

6.4.1 Overview of the premises

School No. 121 in Songinokhairkhan District is a site where General Heatpump Industry Co., Ltd. is conducting renovation work and substantiative experiment of a hybrid ground source heat pump and solar heating system as an alternative of coal firing as a project of low-carbon technology creation and familiarization project for developing countries under co-innovation.

The survey team visited the site and interviewed the project operator about the project. It is summarized as below.

Table 6-11 Outline of School No. 121 in Songinokhairkhan District

Target	School No. 121 in Songinokhairkhan District	
Photos	 Location of School No. 121	 Design drawing

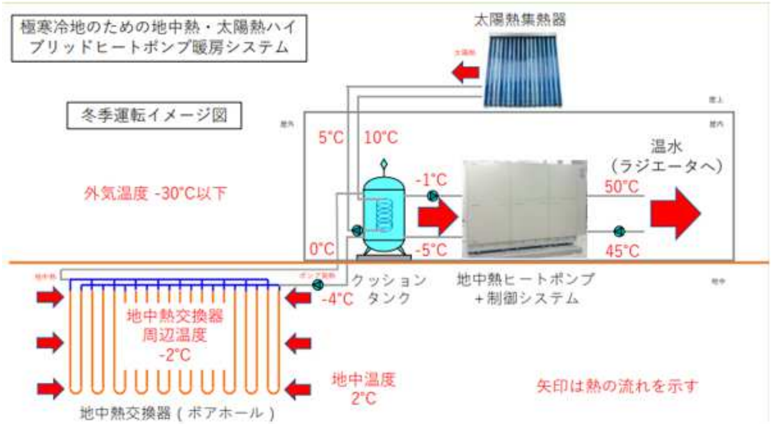
<table>
<tr><td></td><td>
School building and school ground where piling work is to be conducted</td><td>
Current heating facility</td></tr>
<tr><td>Facility Overview</td><td colspan="2">・ Songinokhairkhan District school belongs to No. 21 xopoo (subdivision) with a population of 6,245.
・School No. 121 is a primary and middle school with 640 students from grades 1 to 12.
・Solar panels are installed on the roof of the school building. After spring, heat pump installation work is planned (piling of 64 stakes on the school ground).
・Currently, improved fuel is used for heating.</td></tr>
<tr><td colspan="3">Interview summary</td></tr>
<tr><td colspan="3">■Substantiative experiment
・Originally, work has been behind the schedule. The work was originally planned to be completed on Sep. 15.
・The delay was caused because one-third of the funds to be provided by Mongolia were not provided. They were working to conduct bidding to secure the budget of Ulaanbaatar City.
・As for equipment and machinery, the first cargo (heat pump, control panel, etc.) has been shipped. No more postponement was requested but it is difficult. Almost no work can be conducted in winter because of the cold weather (Public works projects are prohibited.). Realistically, it will be launched after March and completed in September next year.
・The team pans to be dispatched to the site from Japan when the boring survey and construction is conducted.
・The hybrid system with heat pumps requires an HOB manager and the labor cost cannot be reduced. The cost effectiveness cannot be expected unless it is a small-scale project that solely uses ground source heat. It needs to be conducted in a ger area, etc., that is not connected to local heat supply.</td></tr>
</table>

6.4.2 Technology overview

The heat pump is a unit that draws heat from low-temperature medium by circulating antifreeze liquid and other refrigerant and carry the heat to high temperature medium. As it carries heat from low to high places, it is called heat pump. Heat is exchanged by compression and expansion of the refrigerant and the energy consumption efficiency is higher by several times than the electric heater.

In Japan, it is generally used for air-conditioners. However, I Mongolia, the efficiency decreases when the outside temperature is low in very cold areas like Mongolia and heat needs to be obtained from the ground whose temperature is relatively stable throughout a year.

In the ground source heat pump system, coaxial pipes and U-shaped tubes are inserted in a bore hole with a diameter of 125 to 137mm and a depth of several tens of meters to below two hundred meters to use it as a heat exchanger.



Source: General Heat Pump Industry Co., Ltd.

Figure 6-6 Overview of Ground Source Heat Pump System

6.4.3 Study and future development concerning applicability to JCM facility auxiliary project

After the substantiative experiment, General Heatpump plans to demonstrate it at other primary and secondary schools to assess the technical conformity, environmental improvement impacts and financial effectiveness together with relevant government officials. Based on it, it will work in cooperation with the Ministry of Energy and draw up guideline concerning the introduction of the ground source heat pump system and then collaborate with local companies to develop a business implementation scheme. To develop a project using the JCM scheme, it aims to introduce the system to buildings targeting the redevelopment project in the ger area around the city center of Ulaanbaatar using Asia Development Bank (ADB) funds, etc.

The ground source heat pump system can replace the currently used coal-fired heating system and thus can be expected to have a significant GHG emissions reduction. However, it requires a substantial area for piling and its introduction cost tends to be high.

To introduce the system, it needs to be an area that is not connected to local heat supply and where the heat source with the current high heating cost can be replaced and the facility cost needs to be controlled by improving the heating performance and combining it with other energy-saving specifications to maximize the cost efficiency.

Candidate sites of the introduction of the system can be schools and clinics in suburbs that are not connected to local heat supply. As these buildings are not used during the night, the heat load is relatively low the installation cost can be reduced. Low-rise and small buildings require less insulation renovation work, the introduction of the system itself without other energy-saving specifications is effective. Because the replacement of the coal-fired heating system with the ground source heat pump system contributes to emissions reduction of air pollutants, air quality of the users can be expected to improve.

The below is a possible schedule for the introduction of the ground source heat pump system.

Table 6-12 Proposed Schedule of Ground Source Heat Pump System

Year	1	2	3	4	5
Basic survey	Candidate site survey (school, clinic, etc., in suburb)				
Introduction study		Study of introduction plan Study of and application for various scheme			
Design			Implementation deign, work, bidding, etc.		
Construction				Insulation improvement work, ground source heat pump system installation	

As the basic survey, the team will choose sites which include suburban schools and clinics where the system may be introduced and study the scale and use of the facility, heating system condition and needs.

For the candidate sites with high feasibility, necessary facility scale based on the basic survey results will be studied. The knowledge gained from the experience of School No. 121 in Songinokhairkhan District will be used and insulation improvement and energy-saving technology of the facility will be also studied to make a highly efficient facility introduction plan.

Because it can be implemented on multiple sites on the design construction stage, it will become more efficient and consideration will be also given in the survey and study phases.

6.5 Study of decarbonized model building (mid- to long-term phase)

The decarbonized model buildings in Case 1 with good heat insulation combined with the technology introduced in Cases 2 to 4 are efficient and ideal.

The introduction of the decarbonization model to the buildings themselves needs to be studied from the initial stage of the plan, projects with possibility of the introduction are summarized as candidate sites.

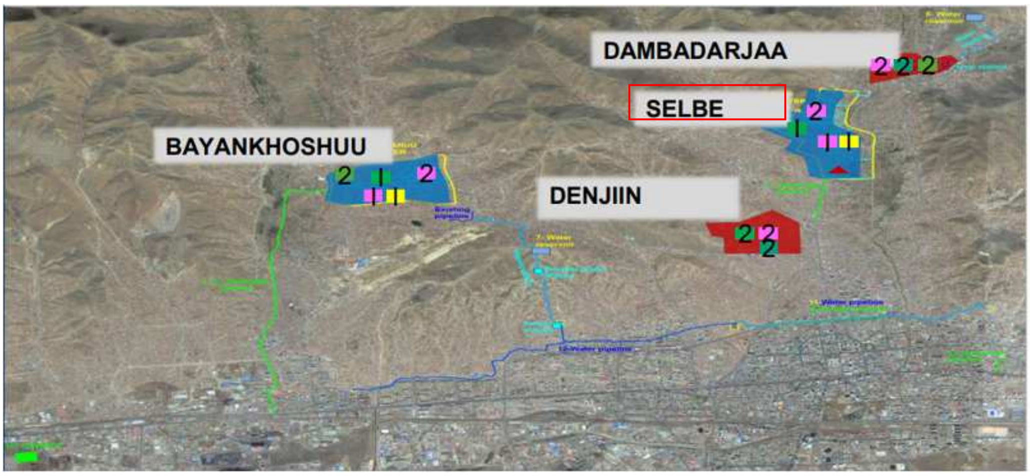
6.5.1 Overview of the candidate sites

（1） ECO DISTRICT AND AFFORDABLE HOUSING

As part of ger area development, a large-scale housing development project called ECO-DISTRICT AND AFFORDABLE HOUSING is underway funded by ADB.

Its overview is provided below.

Table 6-13　Overview of ECO-DISTRICT

<table>
<tr><th>Target</th><th colspan="2">ECO-DISTRICT Project</th></tr>
<tr><td rowspan="2">Materials</td><td colspan="2">

Location of ECO-DISTRICT</td></tr>
<tr><td>

Outline of development plan</td><td>
Development image
Source:　Asian Gateway Corp.</td></tr>
<tr><td>Facility Outline</td><td colspan="2">・Development of an ger area of 6.4ha into a green housing area to provide good housing environment and urban life for a wide range of citizens
・Including 584 low-rise housing complex, etc.
・4,000-square-meter solar panels
・13500-square-meter green zone (park, etc.)</td></tr>
</table>

The survey team interviewed Asian Gateway Corp. based in Japan that has shown interest in participating in the project. The interview is summarized as below.

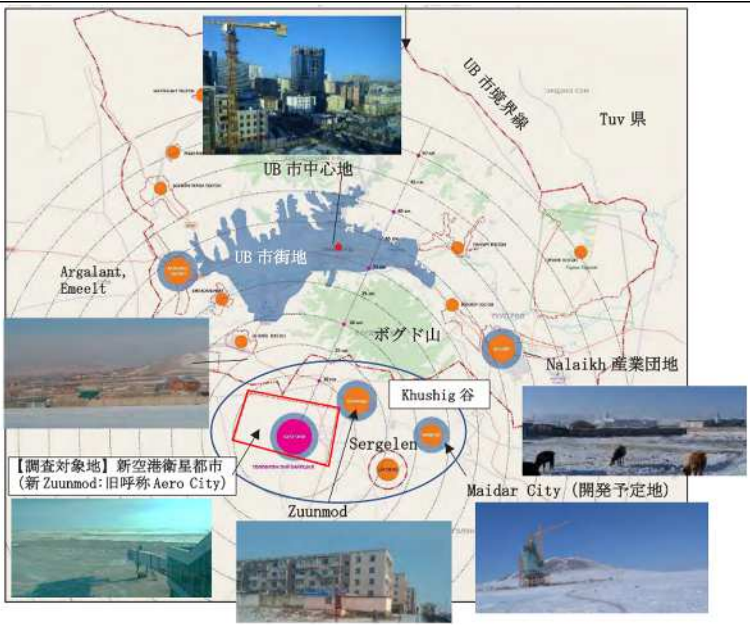
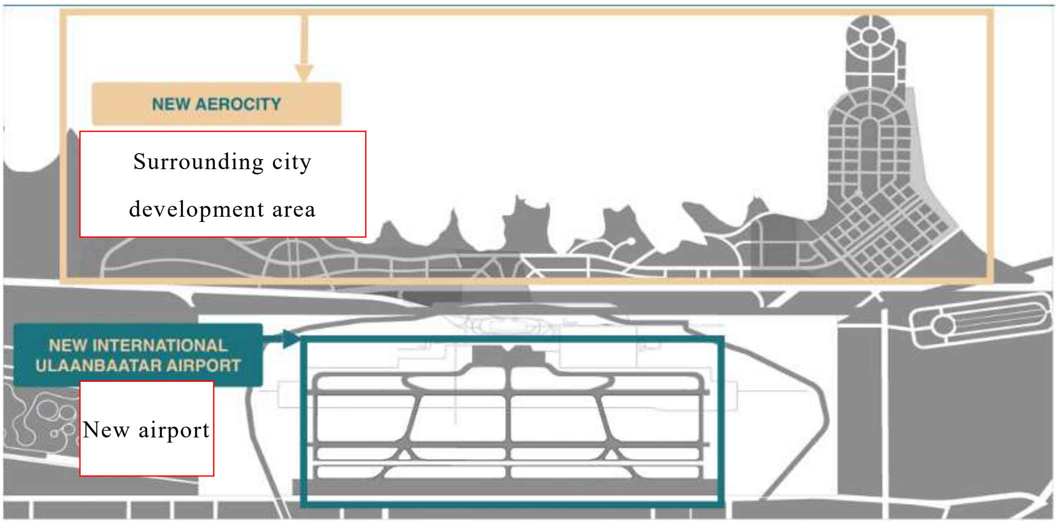
・ There is a plan to introduce renewable energy to the ECO DISTRICT development in cooperation with a Turkish company. ・ Funds are likely to be obtained from a Mongolian bank and its feasibility is very high. ・To apply to a JCM facility auxiliary project, Asian Gateway that is qualified as a representative is involved.

Development around airport

The Mongolian cabinet approved the New Airport Satellite City Master Plan (PM) in 2019 and the government has been since studying it as the comprehensive new city plan in the Khushig Valley area. As part of it, new Zuunmod development is planned as a satellite city of the new airport. The new Zuunmmod used to be called Aero City until 2020. Although the name, Aero City is likely to be used in the future development, details are unknown.

Its overview is provided in the following page.

Table 6-14 Overview of New Zuunmod

Target	New Zuunmod Development Plan
Photos	 Location of New Zuunmod and its surrounding areas Source: Information gathering and confirmation survey concerning new Ulaanbaatar international airport satellite city development (2022, JICA) 

Partly because the new Zuunmod development is regarded as one in the new satellite city master plan to ease congestion in Ulaanbaatar, high quality living environment is expected to be created.

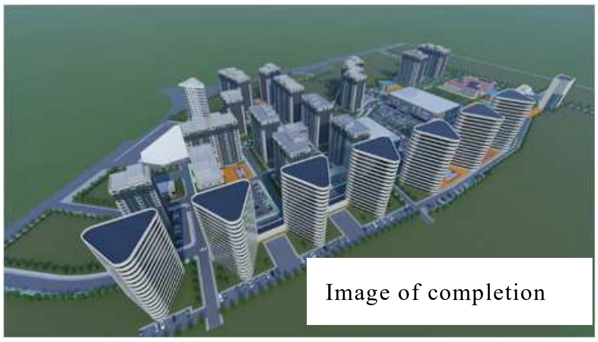
It is effective to study detailed information on the project and consider the introduction of environmental technology in line with the development concept.

（2） Bayanzurkh project

The survey team visited Tsamkhag Construction that is implementing a development project in a ger area and interviewed it about the project situation.

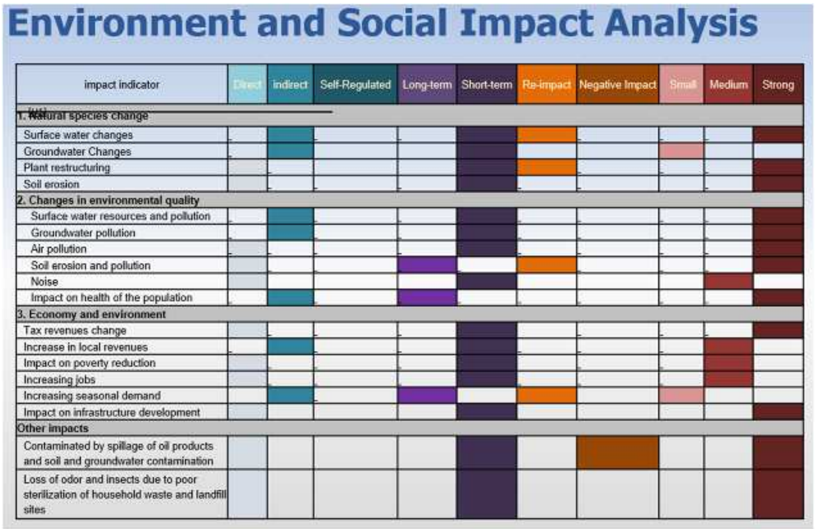
Tsamkhag Construction: ・Tsamkhag Construction built School No. 121. It conduct school construction and ger area development projects. ・It is currently implementing a redevelopment project with 2,850 housing units in a ger area.

Table 6-15 Outline of Bayanzurkh project

Target	（3） Bayanzurkh project	
Photos	 Planned project site	 Master plan
Facility overview	・Bayanzurkh district, Chuluun ovoo area ・Premises: 22.2ha ・Project period: 2020 to 2032 ・Consisting of one- to 16-storied buildings	 Image of completion
	・Housing complex (21 blocks, 2,034 units) ・2 middle school buildings (1,560 students) ・2 kindergartens (640 children) ・Recreation center: 3,018 square meters ・Swimming pool: 760 square meters (water surface) ・Commercial space: 7,616 square meters ・Local service center: 450 square meters ・Consisting of recreation center and green playground for children and elderly people	

	・2 buildings with 330 housing units have been completed and sold. ・2 buildings are under construction. ・Connected to water and sewer systems and local thermal heating

The project purpose is to create a green town where people can live and work safely, comfortably, healthily and lively and the company also has analyzed the social and environmental impacts of the project.



Source: Tsamkhag Construction

Figure 6-7 Environmental and social impact analysis of Bayanzurkh project

Because there is likely to be a big opportunity of the proposal of the introduction of the green decarbonized model building being accepted, it is desired that the introduction be studied based on the understanding of the current specifications and needs.

6.5.2 Technology overview

The technology to be introduced to the decarbonized model buildings is examined below.

(1) Japanese ZEB specifications

Technological specifications introduced to ZEB construction in Japan are summarized below.

Introduction of these specifications enables the realization of decarbonized model buildings. However, because some materials and construction methods are not introduced to Mongolia and it may incur excess cost if they are introduced as they are, they need to be modified to suit the local situation.

Table 6-16　ZEB Specifications in Hokkaido

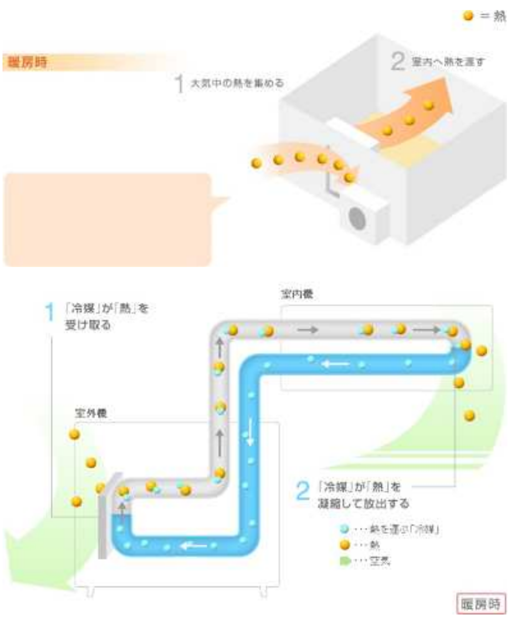
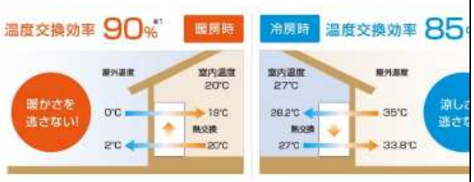
ZEB (Japan and Hokkaido)		
Element	Japanese (Hokkaido) specifications	Materials and performance
External wall	Concrete base or base by secondary concrete base Urethane foam (internal insulation) 100mm Urethane foam (external insulation) 100mm	Thermal conductivity 0.036 W/m・K 0.1×0.036×1,000＝2.16
Rooftop	Concrete base ＋　waterproof Urethane foam (internal insulation) 100mm Urethane foam (external insulation) 100mm	Thermal conductivity 0.036 W/m・K 0.1×0.036×1,000＝2.16
Fittings	Aluminum sash (insulation performance: H-3 or higher) Low-e insulating glass, multi-layered glass	Thermal transmittance 1.6W/m2・KU
Air-conditioning system	Air conditioner (electricity-type) Various heating equipment (geothermal ＋　HP) BEMS management	—
Electrical system	Energy-efficient electrical system LED lighting	—
Energy generation equipment	Solar panels	
Others	* Overall construction accuracy (air-tightness)	◎

The below is a summary of technology that has been introduced in Japan with the potential of being introduced to buildings in Ulaanbaatar to promote carbon neutrality.

Table 6-17　Japanese Technology with Potential of Introduction

<table>
<tr><th>Technology</th><th>Target</th><th>Feature</th><th>Project span</th></tr>
<tr><td>Inner window renovation


Source:　Lixil website</td><td>Building itself</td><td>- Can be attached to existing buildings
- Can be implemented for each housing unit
- It is difficult to fit well if the window closes inwardly which is common in Mongolia</td><td>6 to 12 months</td></tr>
<tr><td>Solar power generation system on exterior wall</td><td>Building itself, Electric power system</td><td>- Exterior wall that accounts for a large area of a high-rise building can be used for power generation.
- If transparent type is used, it can be installed on the glass. When combined with sunlight</td><td>2 years to longer period</td></tr>
</table>

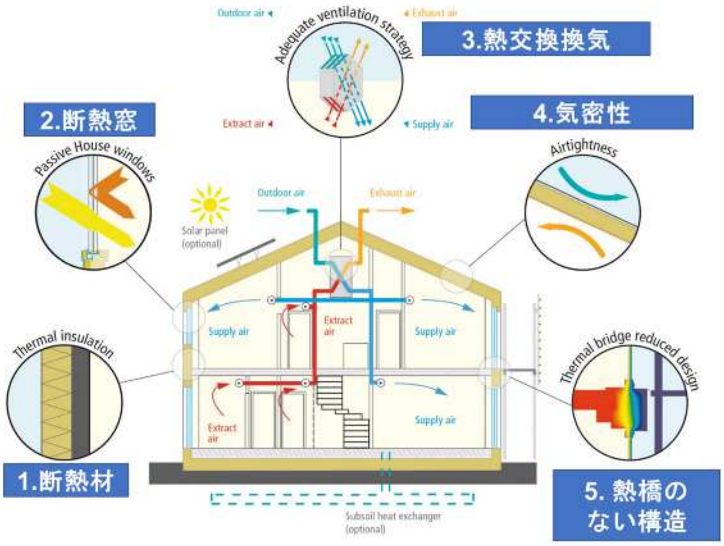
 Source: Taisei Corp.’s announcement, T-Green Multi Solar		control, it can contribute to significant energy saving. - The structure and exterior wall need to be planned together and it requires high technological capacity.	
Heat pump air-conditioning system  Source: Daikin website	Mechanical equipment	- It is desired to be introduced from the planning and design stage. However, it can be introduced to renovation. - Drawbacks are lower heat efficiency in cold areas and maintenance of outdoor unit. - Indoor air quality can be expected to improve.	6 to 24 months
Total heat exchange ventilation system  Source: Daikin website	Mechanical equipment	- Ventilation system that makes the indoor temperature close to outside temperature - It contributes to improvement of indoor air quality as it is ventilated without losing heating efficiency.	6 to 24 months

Solar power water heater  Source: Noritz website	Mechanical equipment	- As solar power is used for water heating, it can be installed independently from the power grid. - It can be introduced to both new construction and renovation. - Cost is relatively low. - Study required for cold areas	6 to 12 months
LED lighting system	Electricity system	- It is desired to be introduced from the planning and design stage, but it can be introduced to renovation.	6 to 12 months

（2） Collaboration with Passive House Institute

Because Passive House Institute in Mongolia that promotes the spread of knowledge about the basic concept, design method and construction of the passive house jointly with the Mongolian National University has much knowledge about the passive house specifications bult in the country, collaboration with the institute concerning the specifications that fit the local condition is beneficial.

The institute summarized the specifications of an actually built passive house as below.



Source:　Passive House Institute

Source: Passive House Institute

Figure 6-8　An example case of passive house in Mongolia

The specifications are as below.

① Heat insulating material:　thickness 40 to 55mm

② Window: well-insulated low-e triple glass window. Because the window’s heat insulating property is lower than the exterior wall, big windows are installed on the south side that absorbs sunlight and small windows are built on other sides.
Low-e coating, triple-layer argon gas filled glass package (heat reflux rate: 0.92W/m2K), big window on south side: 12.3 square meters, small windows on west and east sides: 0.55 square meters, 1.65 square meters

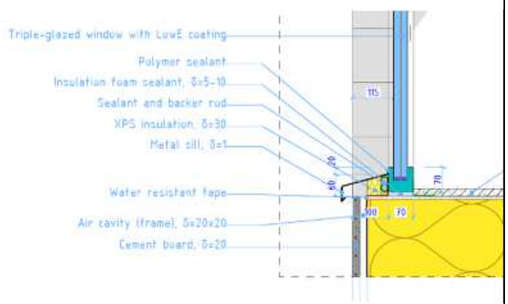
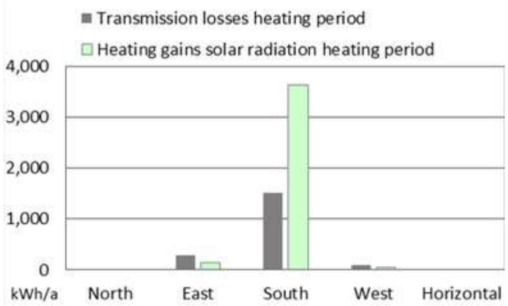
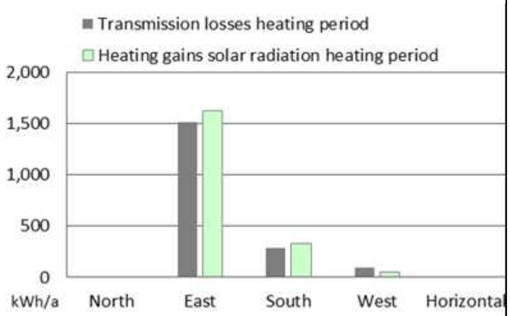
③ Ventilation system: heat exchanger type, external air pipe is installed in the shortest distance.

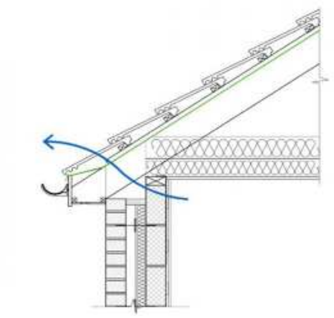
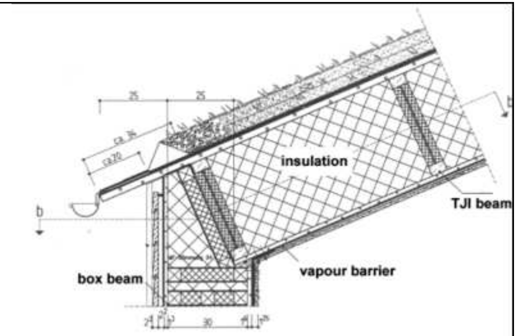
④ Air tightness: High air tightness to restrict heat leakage

⑤ Structure with no heat bridge: heat insulation is enhanced to prevent indoor heat from escaping by making the area that cannot be insulated from outside heat bridge with the parallel material.

The institute organizes technology that meets the above and assists design and construction.

Table 6-18 Specifications of Passive House in Mongolia

<table>
<tr><td rowspan="2">Specifications</td><td></td><td>
</td></tr>
<tr><td>An example of passive house in Mongolia</td><td>Detailed drawing of specifications of standard passive house</td></tr>
<tr><td rowspan="2">Window</td><td>
</td><td>
</td></tr>
<tr><td colspan="2">Comparison of heat loss and obtained solar heat depending on the window direction:
The left-side graph shows a case when the window in the same size is installed on the south side and the right-side graph is a case when the it is installed on the east side. It shows that the window on the south side has bigger heat acquisition (green bar) and less heat loss (gray bar).</td></tr>
</table>

Heat bridge measures		
	Heat bridge occurs.	Detailed drawing of enhanced heat insulation

6.5.3 Future development

(1) Promotion of understanding of decarbonized model building and technological capacity improvement

It is essential to improve the energy efficiency of the building itself in order to maximize the GHG emissions reduction through the introduction of new facility. Introduction of effective specifications requires accurate installation skills to plan and design the wall, heat insulating material, openings and equipment in a well-balanced manner and use the specifications of materials.

Knowledge sharing through lectures and workshop given in the survey and technological capacity improvement through the training on the construction site of decarbonized model buildings should be conducted continuingly.

(2) Selection of candidate sites in consideration of future city development and demand for housing complex

In Mongolia, future urban development plan including the satellite city (Aerocity) plan is in progress in line with Ulaanbaatar City Master Plan, ger area redevelopment plan and opening of the new airport. In the capital city of Ulaanbaatar, there are construction plans of apartment complex zone, hospitals, schools and various service centers in the suburbs (Tov Province and Khushig Valley) with the policy of dispersed city plan. Residential area development is also planned in the surrounding areas of these main projects and it is important to propose the introduction of decarbonized model buildings to these candidate sites.

(3) Proposal in consideration of human resources and indoor environment

In the study of decarbonized model buildings, proper indoor environment in the ZEB design process is excluded. However, it is possible to make it close to the efforts recommended in ZEB by promoting BEMS (Building Energy Management System) and HEMS (Home Energy Management System) together with the lighting, air-conditioning management.

In particular, in Mongolia, they are concerned about the impacts of the improper heat supply of the coal-fired heat supply system on human health. Proper indoor environment includes high-performance filters and air purification technology. If proper ventilation is achieved with the technology, it contributes to prevention of the spread of COVID-19 infection and it will meet the new type of demand.

As a case in which the improvement of indoor air quality in buildings in Sapporo, a cold area, has led to energy saving by controlling the indoor energy has been presented by Hokkaido University, sharing of knowledge of Sapporo City that has realized energy conversion from coal dependence is also expected.