MOEJ

Final Report

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

March 2022

Oriental Consultants Co., Ltd.
Sapporo City

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Tables and Figures

List of Abbreviations

Abbreviation	Meaning
BEMS	Building and Energy Management System
CFWH	Coal Fired Water Heater
GHG	Greenhouse Gas
HOB	Heat Only Boiler
JCM	Joint Crediting Mechanism
ZEB	Net Zero Energy Buildings
ZEH-M	Net Zero Energy House Mansion

Chapter 1 Project Overview

1.1 Project Objective

The Paris Agreement came into force in November 2016, and the year 2020 represents the implementation stage of the Paris Agreement. This agreement cites that central governments as well as local governments, cities and non-governmental organizations should accelerate measures against climate change. At the "Online Platform Ministerial Meeting on Recovery from the New Coronavirus and Climate Change/Environmental Measures" held in September 2020, it was confirmed that decarbonization policies are necessary for local governments that engage in activities directly related to communities, and that local community-led development approaches are important. 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 (CO_2) emissions has rapidly increased to over 300.

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 and low carbonization 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 zero/low-carbon societies, will conduct a research project to support the efforts of overseas local governments to form a zero/low-carbon society and the introduction of facilities that contributes to the formation of a zero/low-carbon 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:	September 13, 2021, to March 10, 2022
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. In FY 2016, both cities implemented a city-to-city collaboration project, featuring a survey on the introduction of renewable energy and a waste power generation project. 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. Moreover, Iwatachizaki Inc. and Hokuden Sogo Sekkei Corporation provided technical advice for designing and calculating the energy efficiency of low-carbon buildings/housings while Zeneral Heatpump Industry Co., Ltd. provided support for introducing a geothermal heat pump system. In addition, Hokkaido University shared its survey results during the workshop concerning the combined effects of energy-saving in buildings and housing and measures against potential harm to health in colder areas.

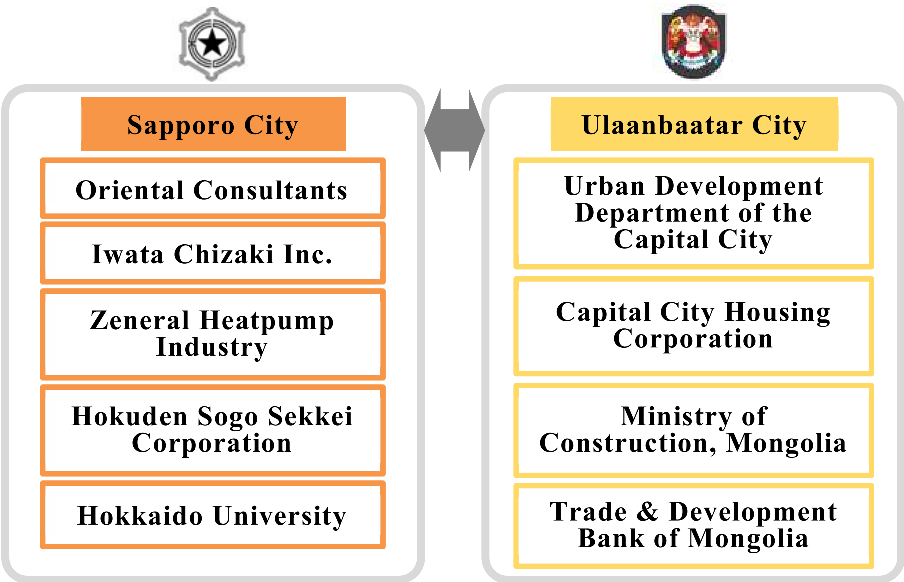


Figure 1-1　Implementation Structure

1.4 Entrusted Project Contents

The project was implemented as the second 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. Mongolia still adopts building standards formulated between the 1960s and 1970s, most of which are unsuitable for present-day circumstances. 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 and tend to use coal and wood-burning stoves. Moreover, heat insulation materials are often not installed. It was confirmed that 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, Ulaanbaatar City plans to develop the Ger area and develop a satellite city. Since housing and infrastructure development is expected to increase, the challenge posed is how best to adopt appropriate standards and technology. As a city similarly located in a cold area, the project introduced technologies and a regional heat supply system adopted in Sapporo City as well as ZEB and ZEH-M; targeting zero energy via various forms of energy-saving/creations.

The first-year survey confirmed that Ulaanbaatar City had a great interest in ZEB and ZEH-M. Accordingly, in the second year, the project considered model building specifications commensurate with the current circumstances in the city. Specifically, four model cases were defined by combining strengthening of the heat supply system using a geothermal heat pump and heat insulation materials which Ulaanbaatar City had already considered adopting and introducing a high-efficiency system. Apartment complexes (Serene Town) and office buildings (new Ulaanbaatar City Hall) were targeted and the scope to reduce energy consumption in each model case was estimated. The project also introduced calculation items and methods for energy-saving performance in Japan as well as actual ZEB and ZEH-M cases.

Table 1-1 Processes for Project Implementation

Project Items	FY2021				FY2022		
	9	10	11	12	1	2	3
1. Meetings	Kick-off ▲			Mid term report ▲		Final report ▲	
2. Capacity Buildingin Ulaanbaatar City							
(1) Examples of ZEB and ZEWH-M Implementation in Japan				←	→	→	
(2) Summary report for energy conservation performance calculation					←	→	
(3) Regularly conducted online workshops to share Sapporo's know-how and introduce cold region technologies and promote the development of JCM projects	the 1st ▲			the 2nd ▲	the 3rd ▲	the 4th ▲	
3. Study of a decarbonized model building in a cold climate suitable for the actual situation in Mongolia							
(1) Preparation of specifications for decarbonized housing models		←	→	→	→	→	
(2) Examining the possibility of developing model homes		←	→	→	→	→	
4. Study regarding green financing					←	→	
5. Monthly report		▲	▲	▲	▲	▲	▲
6. Final report				←	→	→	Submit ▲

Implementation Period: September 13, 2021 to March 10, 2022

Chapter 2 Overview 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 4,704m^2, comprising nine districts. The entire population and average population growth rate in Mongolia is approximately 3.3 million and 3%, respectively. Conversely, the population in Ulaanbaatar City is about 1.54 million and its average population growth rate over five years to 2018 was 5.6%, indicating progressive centralization. It is predicted that, by 2030, the population of Ulaanbaatar City will reach 1.87 million and comprise 55.5% of the national population.

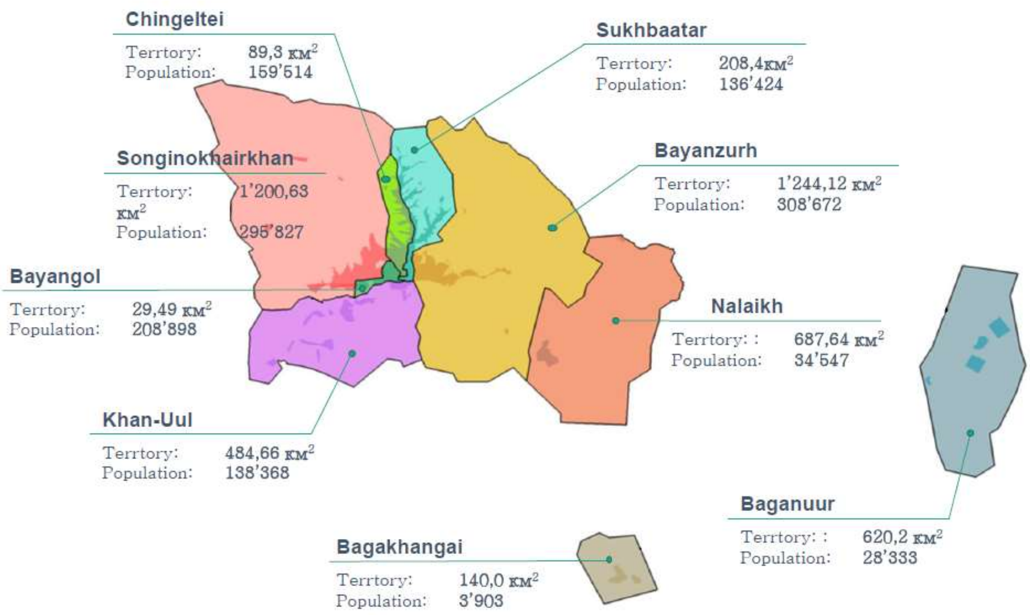


Figure 2-1 Map of Ulaanbaatar City

Settlement status in Ulaanbaatar City is roughly divided into reinforced concrete apartments in downtown areas, Mongolian Gers in Ger areas and wooden houses in suburban areas. The development of infrastructure has not kept pace with the rapid population inflow, while burning coal for power and heating has exacerbated air pollution. In response, the "Vision 2050" was formulated in May 2020 as a long-term development policy; aiming to help Central Mongolia, namely Tov and other provinces surrounding Ulaanbaatar City, become an highly competitive capital region with satellite cities; supported by a proper settlement system based on optimal spatial planning.

2.2 Measures against climate change in Mongolia

In the NDCs (Nationally Determined Contributions) submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in October 2020, the Mongolian Government set a target of reducing GHG emissions from 22.7% by 2030, far higher than the 14% reduction set out as part of the Intended Nationally Determined Contributions (INDCs) in 2016. The emission reductions targets and action plans (Table 2-1) in each sector indicated in the NDCs describe limiting the use of coal, exploiting renewable energy and improving building insulation performance in Ulaanbaatar City.

Table 2-1　Mitigation Actions and Measures of Mongolia's NDC Target

Actions planned	GHG emissions reduction, (Gg CO2-eq.)
1. ENERGY SECTOR	
1.1 Energy sector(production)	
・Use of renewable energy sources ・Reduce electricity and heat transmission and distribution grid losses ・Improved efficiency of energy production	8,340.5
1.2 Energy sector(consumption)	
Transportation ・Switch to Euro-5 standard fuel ・Switch the coal export transportation to rail transport from auto transportation ・Switch the heating of passenger train to electric heating	1,048.8
Construction ・Insulate old precast panel buildings in Ulaanbaatar city ・Limit the use of raw coal in Ulaanbaatar city and switch to the use of improved fuel	830.1
Industry ・Energy saving measures	1,045.2
1. Total GHG emission reduction from the energy sector	11,264.6
2. NON-ENERGY SECTOR	
Agriculture ・Regulate and reduce the livestock number ・Improve the livestock manure management	5,283.3
Industrial Processes and Product Use (IPPU) ・Use waste heat from cement plants ・Use fly ash in cement production ・Use coal bed methane	234.1
Waste ・Reduce the waste volume for landfill through the improved waste treatment and recycling process ・Increase the share of the population with access to improved sanitation and hygiene facilities	106.1
2. Total GHG emission reduction from the non-energy sector	5,623.5
Total GHG emission reduction	16,888.1

Source: MONGOLIA'S NATIONALLY DETERMINED CONTRIBUTION

The nine policy goals set out in Vision 2050 include "low emissions, productive and inclusive green development" aiming to "Contribute to international efforts to mitigate climate change by developing a low-emission, productive and inclusive green economy". Specifically, this goal aims to close the gap between emissions and absorption of greenhouse gas during Stage III (2041-2050). The other policy goal, "Ulaanbaatar and Satellite Cities", seeks to develop a comfortable city with low greenhouse gas emissions and green technologies. According to this Vision, air pollution improved by 50% between 2019 and 2020 against a backdrop of banning the use of raw coal in the capital region in May 2019 and promoting manufacturing and dissemination of improved solid fuel instead. Air pollution is expected to be mitigated up to 80% by running another factory manufacturing cleaner solid fuel.

2.3 Measures against climate change in Ulaanbaatar City

Vision 2050, formulated with the support of the United Nations in 2020, indicates a GHG reduction target by 2030 (Table 2-2). Since 46% of the country population is concentrated in Ulaanbaatar, where a coal-fired power plant 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.

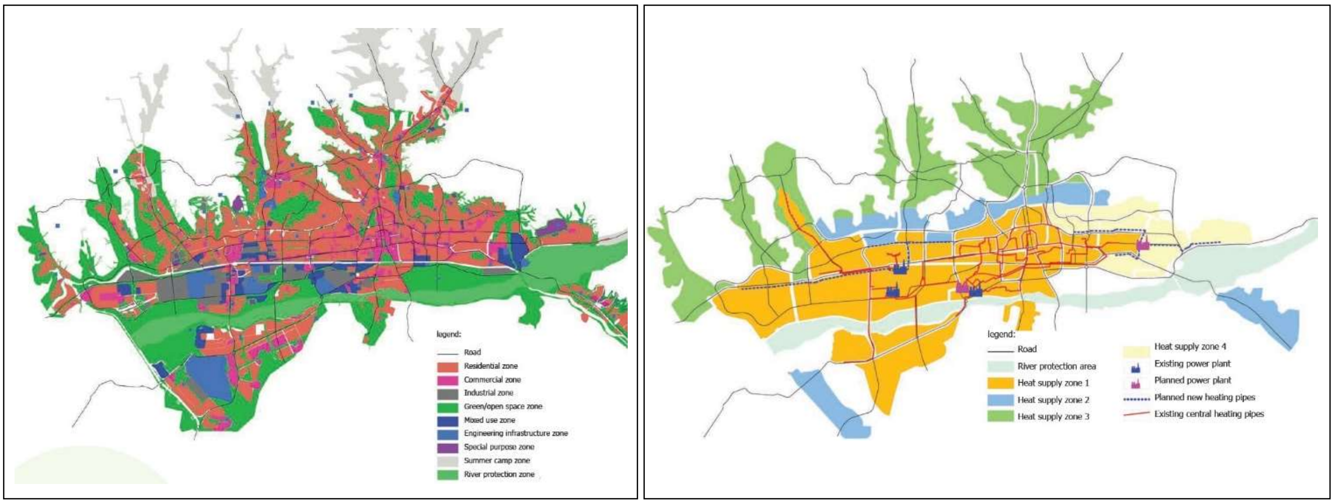
Table 2-2 GHG Reduction Targets of Ulaanbaatar City

Unit: Gg CO2-eq.

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

Source: “Vision 2050”, Ulaanbaatar City, 2020

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.



Source: Ulaanbaatar 2020 Master Plan and Development Approaches for 2030

Figure 2-2 Areas introducing land-use zoning and regional heating supply system

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.

2.4 Energy situation in Ulaanbaatar

2.4.1 Existing energy supply system

Mongolia is a landlocked country and does not frequently import petroleum and natural gas for heating fuels. Mongolia's major energy resource is coal and it also exports crude oil to China.

Table 2-3 Balance of import/export of primary energy

Unit: in 1,000 tons of oil equivalent

	Coal	Petroleum	Oil products	Gas	Electric power	Renewable energy	Hydropower	Total
Domestic production	23,919	1,052				172	5	25,148
Import	19,322	1,037						20,359
Export	1		1,282		135			1,418
Stock/others	1,080	15						1,095
Domestic supply	3,518	0	1,282	0	135	172	5	5,112
Primary energy ratio	69%	0%	25%		3%	3%	0%	100%

Source: IEA Energy Balances of Non-OECD Countries, 2017

As things stand, Mongolia largely depends on coal for heating fuel in winter. As Table 2-4 shows, heating systems in Ulaanbaatar City are classified as central heating by hot water supplied from three thermal power plants, around 200 heat-only boilers (hereinafter, "HOBs") with under 100 kW output, more than 1,000 coal-fired water heaters (hereinafter, "CFWHs") with under 100 kW output and 200,000 to 300,000 million coal stoves in over 130,000 households within Ger areas.

Table 2-4 Heating systems in Ulaanbaatar City

<table>
<tr><th>Installation</th><th colspan="3">Heating method</th></tr>
<tr><td>City-wide</td><td rowspan="3">Central heating system</td><td>Centralized heating</td><td>Centralized heating with hot water from three thermal power stations</td></tr>
<tr><td>Buildings, schools, apartment complexes and small districts</td><td rowspan="2">Distributed heating</td><td>Hot-water heating via HOBs in about 200 locations</td></tr>
<tr><td>Small buildings for office use, etc.</td><td>Hot-water heating via CFWH</td></tr>
<tr><td>Detached houses in Ger areas</td><td colspan="2">Individual heating systems</td><td>Coal-fired stoves</td></tr>
</table>

Source: Project Formulation Survey on Environmentally Friendly Heating System Using Geothermal Heat Pump

In recent years, the use of electric heating in the ger district has tended to increase significantly. Since the capacity of the power system is insufficient, construction work was carried out to improve the transmission system for 40,000 households in order to cope with these loads. Table 2-5 shows the outline of heat sources in Ulaanbaatar. Coal-fired power plants are mainly used in apartments and public facilities, and the amount used is small in ger districts and small houses. Coal stoves are mainly used as the heat source for the ger area and small houses, but the use of propane gas is also on the rise. Conventionally, this propane gas was mainly used in restaurants and general households, but from 2020, it has been used in schools and public facilities based on the government policy.

Table 2-5 Outline of heat sources in Ulaanbaatar

Heat source	Facility	Supply	Apartment/Public facility			Ger/Small house		
			Heating	Cooking	Other	Heating	Cooking	Other
Coal	Power plant	Electricity	○	○	○	△	△	○
		Hot water	○			×		
	HOB	Hot water	○			×		
	Coal stove	Heat	×	×		○	○	
propane gas	Stove	Heat	○	○		△	△	

Legend: ○: Can be used, △: Can be used, but the cost is high and the amount is small, ×: Cannot be used

Source: Information gathering and confirmation survey on environmental infrastructure development in Ulaanbaatar, Mongolia (2021)

Measures to be implemented as part of the National Environmental Pollution Reduction Program approved on March 20, 2017 include "Abolition of hot water boilers in operation in UB city, to consumer central and regional heating supply systems. The connection will be carried out in stages. " As a result, HOB is expected to be phased out. Also, from November 2020, the fuel used by HOB has been converted from raw coal to improved fuel. The characteristics of the improved fuel are as follows. In addition, 80% of the air pollution in Ulaanbaatar is attributed to the coal stove in the ger area and the HOB in Ulaanbaatar.

Table 2-6 Characteristics and manufacturing price of improved fuel

Category	Type	Environmental characteristics	Manufacturing price
Coal	Bituminous coal/lignite	Bad	Inexpensive
Coal briquette	Bituminous coal/lignite base		
	Anthracite base		
	Biocall bricket		
Semi-coke	Semi-coke		
	Semi-coke briquette	Good	Expensive

Source: Ulaanbaatar City, Mongolia Air Pollution Control Capacity Building Project Phase 2 Air pollution countermeasure plan technical examination guidelines (June 2017)

2.4.2 Introducing renewable energy

(1) Possibility of renewable energy in Mongolia

This section organizes the introduction of renewable energy in Mongolia to understand nationwide trends in energy conversion. According to “Renewables Readiness Assessment: Mongolia”, a joint report of the Mongolian Ministry of Energy and IRENA published in 2016, the combined electricity output from solar and wind resources could reach 15 000 terawatt-hours (TWh) per year, which is equivalent to thermal power generation using more than 18 million tons of coal.

In many areas of Mongolia, wind power density of 300 W/m2 or more is expected. Given a power generation capacity of 1.1 TW or higher, at least 2,550TWh/year could be generated by wind power generation.

Table 2-7 Installed generating capacity and total electricity output by wind power density in Mongolia

Wind power density at height of 30m	Wind speed* (m/sec.)	Total area (km2)	Installed generating capacity (MW)	Total electricity output (TWh/year)
300-400	6.4-7.1	130,665	905,500	1,975.5
400-600	7.1-8.1	27,165	188,300	511.0
600-800	8.1-8.9	2,669	18,500	60.2
800-1,000	8.9-9.6	142	1,000	3.4
Total		160,641	1,113,300	2,550.1

* Wind speeds are based on a Weibull k value of 1.8 and an elevation of 1,400 meters.

Source: US National Renewable Energy Laboratory, 2001

Moreover, Mongolia has 270 to 300 sunny days each year and typically an estimated 2,250 to 3,300 hours of daylight per year. This indicates that Mongolia can yield 4,774 TWh of solar electricity per year over a total area of 23,461 km2.

Table 2-8 Solar radiation and solar resources in Mongolia (estimates)

Solar radiation (kWh/m2/day)	Land area (km2)	Total solar resource (TWh/year)
3.4	5,269	654
3.8	3,924	544
4.1	4,210	630
4.5	4,515	742
5.4	5,542	1,092
Total	23,461	4,774

Source: US National Renewable Energy Laboratory, National Renewable Energy Centre of Mongolia

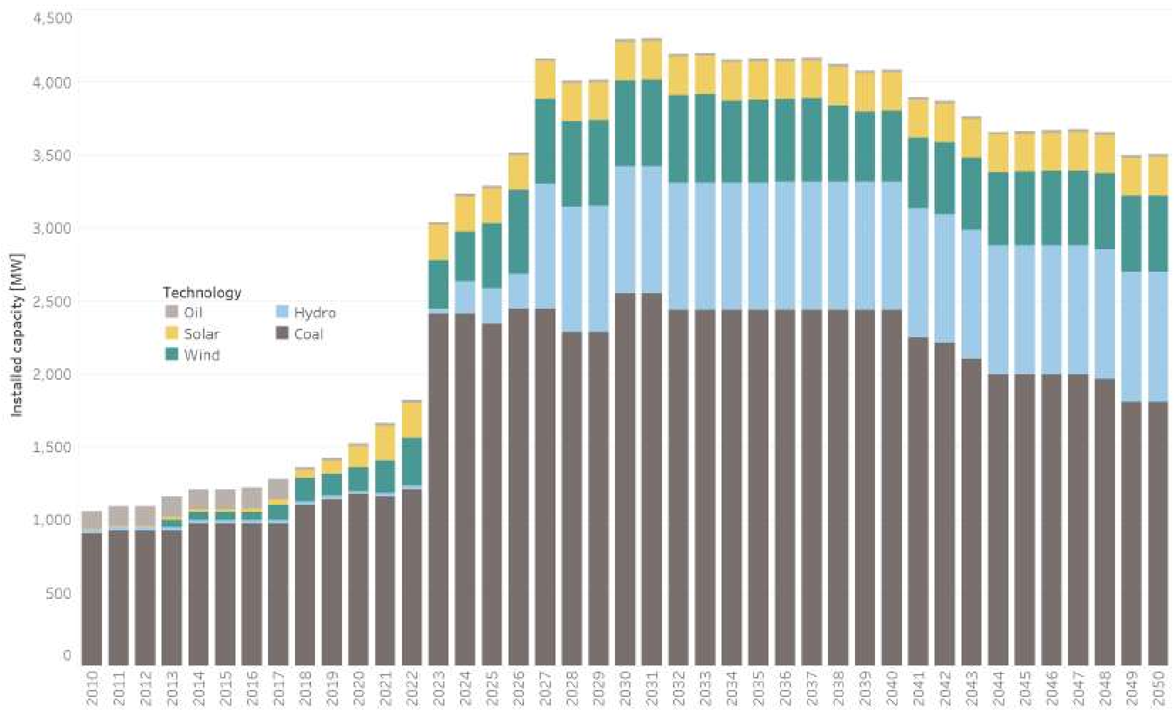
As shown above, although Mongolia is rich in renewable energy resources, approximately 90% of its total power generation capacity currently depends on thermal power generation. Raw coal combustion at the thermal power generation plant, small boiler stations and heating systems in winter as well as declining combustion efficiency in deteriorating thermal power generation plants have increased the volume of air pollutants and GHG emissions. In response, there is a need to promote the use of renewable energy in Mongolia. Accordingly, the Government of Mongolia established the State Policy on Energy 2015-2030 (Energy Act) in 2015, which sets out several numerical goals in two stages: the first between 2015 and 2023 and the second between 2024 and 2030. These goals include boosting the proportion of renewable energy within the power supply composition ratio to 20% by 2023 and 30% by 2030 respectively, from the 7.62%

baseline in 2014. To achieve these targets, Mongolia has promoted efforts to introduce power generation systems using solar, wind and other renewable energies.

Table 2-9 Numerical goals in the Energy Act (renewable energy related)

Indicator	Baseline 2014	1st stage 2015-2023	2nd stage 2024-2030
Profit ratio of the central power transmission system	-16.22%	0%	5%
Internal use of geothermal power generation	14.40%	11.20%	9.14%
Transmission and distribution loss	13.70%	10.80%	7.80%
Percentage of renewable energy in the power supply composition ratio	7.62%	20%	30%
GHG emissions per 1 Gkal of energy production	Equivalent to 0.52 tCO2	Equivalent to 0.49 tCO2	Equivalent to 0.47 tCO2

Source: State policy on energy 2015-2030

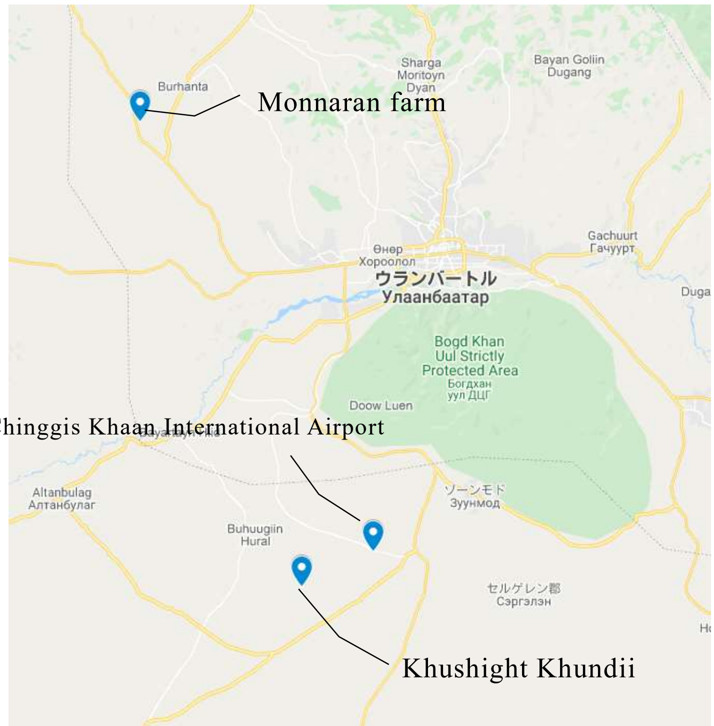


Source: The Mongolian electricity sector in the context of international climate mitigation efforts

Figure 2-3 Actual and planned power generation capacity in Mongolia (2010 to 2050)

(2) Case study on renewable energy introduction in Mongolia utilizing the JCM

In Ulaanbaatar City, solar power generation plants utilizing the JCM model project were installed at two sites: Monnanran farm in the Songino Khairkhan district, located around 37km north of the city center and Khushight Khundii, located around 14km southwest of the Chinggis Khaan International Airport. Their location and the outlines of each JCM project were shown in Figure 2-4 and Table 2-10, respectively.



Source: The Global Environment Center Foundation (GEC) JCM project website

Figure 2-4 Location of solar power generation plants in Ulaanbaatar suburbs

Table 2-10 CM-subsidized Solar power generations in Ulaanbaatar suburb

Name of JCM Project	Location	Generation capacity	Expected GHG emissions reduction
Installation of 2.1MW Solar Power Plant for Power Supply in Ulaanbaatar Suburb	Ulaanbaatar City Songino Khairkhan district (Monnaran farm)	2.1MW	2,424 tCO2/year
Installation of 8.3MW Solar Power Plant in Ulaanbaatar suburb Farm		8.3MW	9,585 tCO2/year
Introduction of 15MW Solar Power System near New Airport	Khushight Khundii, Sergelen district, Tuv province	15MW	18,438 tCO2/year

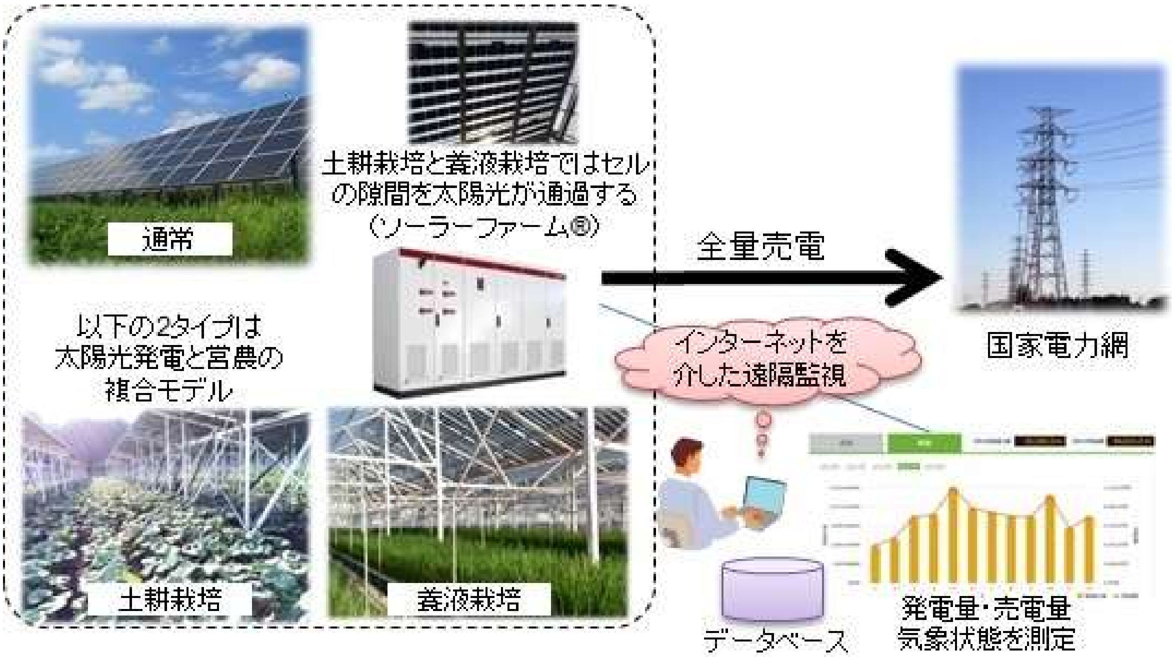
Source: The GEC JCM project website

Ground-based and rooftop solar panels were installed within the premises and agricultural houses of Monnaran farm, located around 39 km north of Ulaanbaatar City. Alternating part of the thermal power generation via solar resources has helped reduce GHG emissions, stabilize the power supply and mitigate air pollution in winter.

In addition, the solar power generation system introduced in the farm has operated as the first hybrid mega-solar power generation plant to be disseminated as a new combined agri-solar power generation model, as shown in Figure 2-5. Since going into operation in 2017, the total solar power generated and electric power sold have amounted to around 40,000 and 38,000 MWh, respectively (as of December 31, 2019). Ultimately, farmers can earn money by selling electric power during winter when farming is suspended; shoring up their income, creating female employment and conducting educational training. Accordingly, the project has helped realize gender equality, which is included in the sustainable development vision of the Mongolian Government.

Source: Embassy of Japan in Mongolia

Figure 2-5　Solar panels within farm premises and agricultural houses



Source: GEC

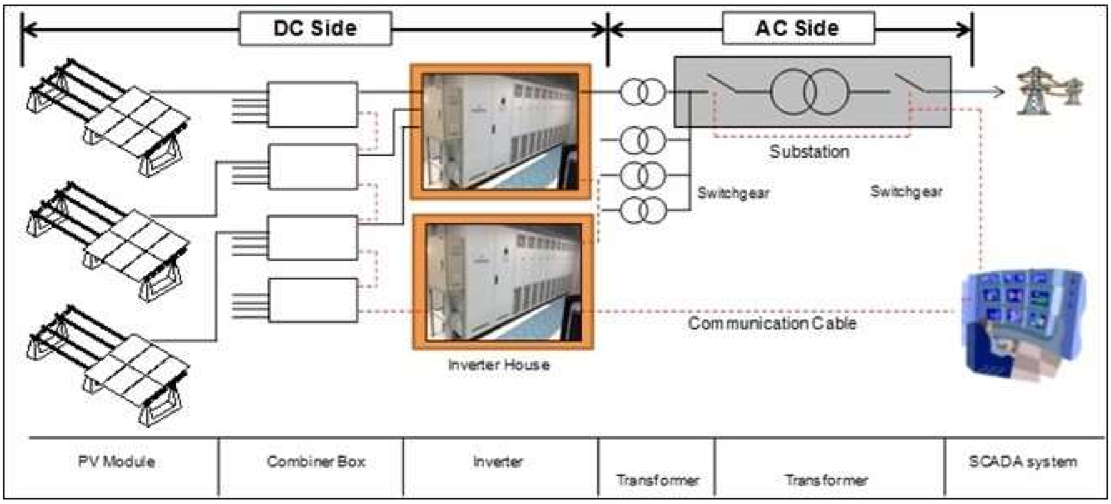
Figure 2-6　Combined solar power generation and farming model at farms in the Songino Khairkhan district

Meanwhile, 51,372 solar panels were installed in an area of 48 ha in Khushight Khundii; located around 14 km southwest of Chinggis Khaan International Airport. The newly installed 110-kV transmission line, with an extension 13.7 km long, supplies power to the central electricity system (CES), which covers the largest area with the greatest electric power demand in Mongolia, including Chinggis Khaan International Airport, for which considerable power consumption is expected.

As a general rule, the greater the distance between power generation plants and facilities accessing electricity, the higher the power loss. For Khushight Khundii, however, its proximity to Chinggis Khaan International Airport and urban areas allows power loss to be limited by making the power supply more efficient and this also helps reduce power loss.

Source: Asian Development Bank

Figure 2-7 Khushight Khundii Solar Power Generation Plant



Source: GEC

Figure 2-8 Khushight Khundii solar power generation system

2.5 Electricity and heat tariffs in Ulaanbaatar City

Table 2-4 in the previous section shows how Ulaanbaatar City adopts a central heating system. Electricity and heat tariffs were surveyed as part of efforts to consider decarbonized building specifications based on the energy situation in the city.

2.5.1 Electricity tariff

Table 2-11 and Table 2-12 show electricity tariffs in Ulaanbaatar City. Since coal is extracted in Mongolia, its energy self-sufficiency is very high. Electricity tariffs are also relatively affordable compared with neighboring countries, but this varies according to the consumer category and consumption duration, both of which include a renewable energy levy.

Table 2-11 Electricity tariff for Central and South regions by consumer (single-rate tariff/VAT excluded)

Unit: MNT/kWh

Consumer category	Fee
Industrial	
Mining, processing industry	167.78
Other industries, business entities and organizations	140.38
Residential	
Monthly consumption below 150kWh	110.28
Monthly consumption above 150kWh	130.08

Excluded the renewable energy levy (11.88 MNT/kWh)

Capacity tariff of other industries: 9,000 MNT/kWh/month

Capacity tariff of mining industry: 25,000 MNT/kWh/month

Source: Energy Regulatory Commission

Table 2-12 Time of use electricity tariffs (VAT excluded)

Unit: MNT/kWh

Consumer category	Fee	
Industrial	Mining industry	Others
Shoulder: from 6 am until 5 pm	167.78	140.38
Peak: from 5 pm until 10 pm	287.88	221.68
Off peak: from 10 pm until 6 am	88.98	88.98
Residential		
Shoulder: from 6 am until 9 pm	116.18	
Off peak: from 9 pm until 6 am	88.98	

Included the renewable energy levy (11.88 MNT/kWh)

Source: Energy Regulatory Commission

2.5.2 Heat tariff

Table 2-13 and Table 2-14 show the heat charges for each application applied to companies / enterprises, households and factories in Ulaanbaatar. Heating of an apartment as a general household in Table 2-14 is 3,421 MNT/GJ (Gigajour), which is about 150 yen/GJ in Japanese yen, and according to the Ministry of the Environment, Japanese general households. Compared to the annual amount of electricity used in Japan and its charge of about 100,000 yen for 15 to 16 GJ, it can be seen that the heat charge for heating an apartment in Ulaanbaatar is cheap.

Table 2-13 Heat charges to companies, businesses and other organizations

No.	Category	Unit	Fee (VAT excluded)
1	Stem for industrial use	MNT/GJ	7,277.00
2	Ventilation	MNT/GJ	3,703.00
3	Hot water for entity consumers	MNT/person	5,955.00
		MNT/m3	2,060.00
4	Hot water (controlled design capabilities of the building)	MNT / GJ	3,703.00

Source: Energy Regulatory Commission

Table 2-14 Heat tariff for residential use

No.	Category			Unit	Fee (VAT excluded)
1	Heating for apartment (applies to heating dormitories, basements, and WS rooms)			MNT/m2	506.00
				MNT/GJ	3,421.00
2	Hot water heating for home use	by number of people	During the heating	MNT/person	1,870.00
			Unheated season	MNT/person	2,806.00
		Depends on water consumption		MNT/m3	1,632.00
		By measurement		MNT/GJ	3,421.00
3	Charges for thermal energy services for household consumers				
3.1	Households with an area of up to 40 square meters			MNT/month	3,300.00
3.2	Households with an area of 41m2 to 80m2			MNT/month	5,500.00
3.3	Households with an area of more than 81 m2			MNT/month	11,000.00

Source: Energy Regulatory Commission

2.6 Carbon dioxide emission factor

Table 2-15 shows the coal consumption, CO2 emission and CO2 emission factor in three thermal power generation plants operating in Ulaanbaatar City as figures to utilize for calculating GHG emissions when considering decarbonized model buildings as discussed later.

Table 2-15 CO2 emissions in thermal power generation plants in Ulaanbaatar City

Item	Unit	Second thermal Power generation plant	Third thermal Power generation plant	Fourth thermal Power generation plant	Entire UB City
Annual coal consumption	i.tons	254	1,305.4	3,495.5	5055.0
Coal consumption for power generation	1,000 t	201.9	676.3	2,315.5	3,193.7
Coal consumption for energy production	1,000 t	52.1	629.1	1,180.0	1,861.2
CO2 emissions from thermal power generation	1,000 t-CO2	236.2	791.2	2,709.2	3,736.6
CO2 emissions from cogeneration	1,000 t-CO2	61.0	736.1	1,380.6	2,177.6
CO2 emissions in thermal power generation plants	1,000 t-CO2	297.2	1,527.3	4,089.7	5,914.2
CO2 emissions per 1kWh (emission factor of electricity)	kg-CO2/kWh	1.49	0.75	0.68	0.75
CO2 emissions per 1GJ of distributed thermal power generation (emission factor of heat supply)	kg-CO2/GJ	98.6	85.7	84.3	87.0

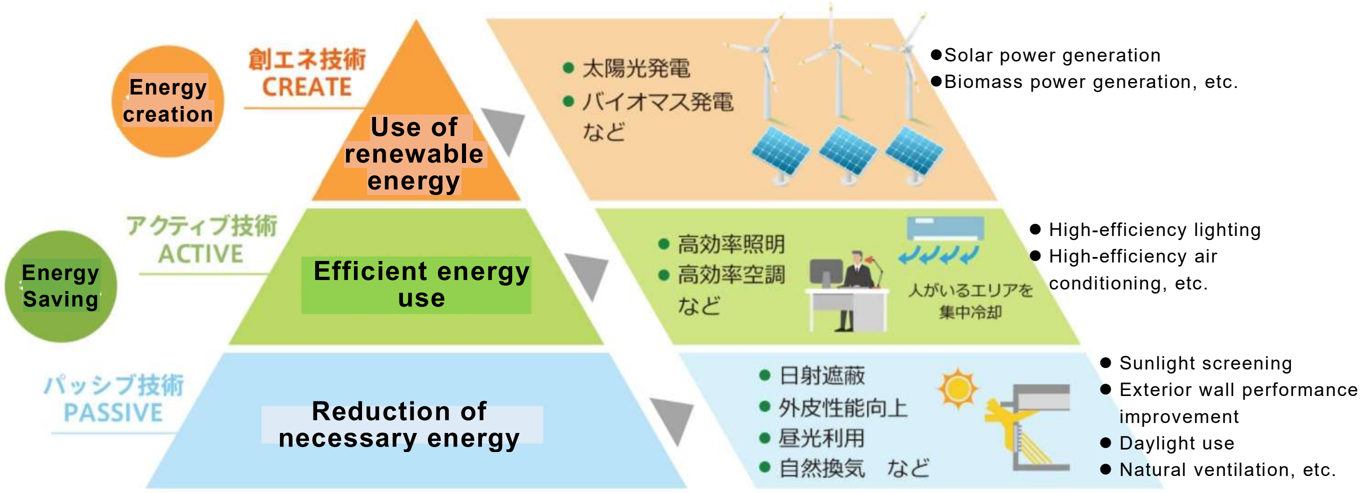
Chapter 3　Capacity Building Assistance for Ulaanbaatar

This chapter provides an overview of the ZEB and ZEH-M in Japan and measures and other efforts in the housing and construction sector in Sapporo City that is a cold area like Ulaanbaatar to share the specific examples with the Mongolian city thereby contributing to the promotion of such measures and capacity building.

3.1 Overview of ZEB and ZEH-M

The ZEB (Net Zero Energy Building) and ZEH-M (Net Zero Energy House Mansion) (The term mansion refers to condominium in Japanese.) in Japan are buildings that aim to consume net zero energy, meaning the total amount of primary energy used by the building on an annual basis is equal to the amount of renewable energy created on the site, improving insulation capacity of the skin and introducing high-efficiency equipment and systems to realize significant energy saving while maintaining a comfortable indoor environment. Of buildings, offices, hospitals, hotels, schools and stores are called the ZEB, residences are called ZEH and condominium buildings are called ZEH-M. The ZEB is categorized into four types in accordance with the achievement level of zero-energy consumption. A building that has achieved 50 percent or more reduction of primary energy consumption through the introduction of energy-saving technology is called ZEB Ready, a building with 75 percent or more reduction with the energy-saving and creation technology and is called Nearly ZEB and a building with 100 percent reduction is called ZEB. Furthermore, large buildings with a total floor area of 10,000m^2 or more that work on the energy saving but it is hard to achieve the ZEB are categorized as ZEB Oriented, when they are used as offices, plants and schools and have achieved 40 percent or more reduction and as hotels, hospitals, department stores and restaurants and have achieved 30 percent or more reduction. Likewise, the ZEH-M is also categorized into four types for all residential units in the building in accordance with the achievement level of zero-energy consumption. A unit that has achieved 20 percent or more primary energy consumption using energy-saving technology is categorized as ZEH-M Oriented, a unit with 50 percent or more reduction with the energy-saving and creation technology is classified as “ZEH-M Ready,” a unit with 75 percent or more reduction being “Nearly ZEH-M,” and 100 percent or more reduction being a “ZEH-M.”

The technology to realize the ZEB and ZEH-M is divided into energy-saving technology to reduce energy consumption and energy creation technology. With the building and energy management system (BEMS), energy consumption can be measured and visualized to control the use of air conditioning and lighting equipment to enable continued energy consumption reduction.



Source: ZEB PORTAL, MOE Japan

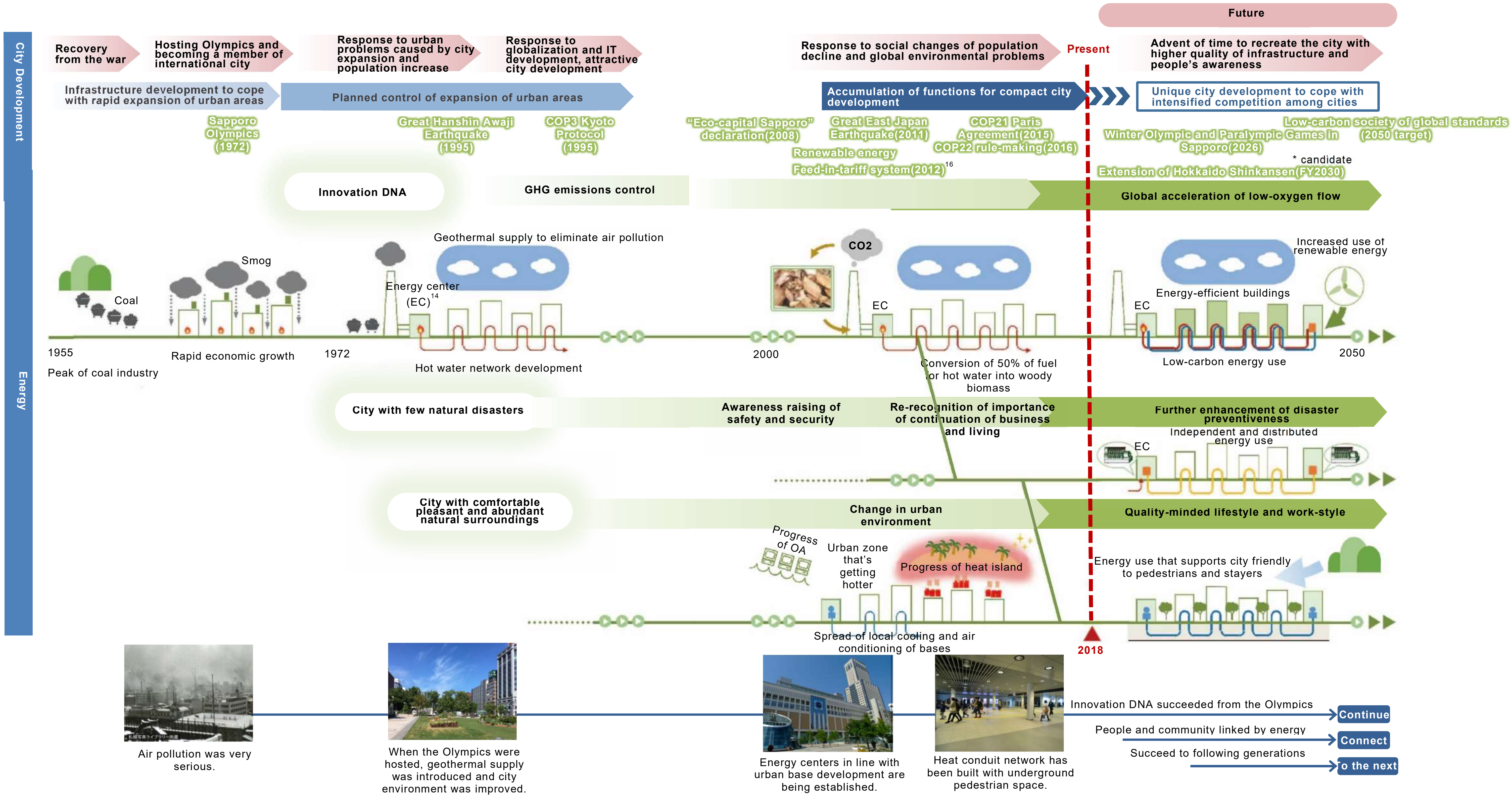
Figure 3-1 Technology to Realize ZEB and ZEH-M

Japan declared to aim at carbon neutrality 2050 (in October 2020) and a reduction of GHG emissions by 46 percent in FY2030 (from FY2013) as nationally determined contribution (NDC) in the Paris Agreement. In response, the sixth energy master plan (cabinet decision in October 2021) aims to secure energy-saving performance of ZEH and ZEB standards for the stock average of existing houses and buildings in 2050 by promoting the renovation for better energy efficiency and the introduction of energy-saving equipment for existing houses and buildings. The plan states the efforts to be taken actively with public buildings and 48 of such buildings were converted into ZEBs between 2016 and 2021 as subsidized projects. On the other hand, only 0.42 percent of all non-residential buildings have achieved the ZEB status and demonstration projects and assistance programs for its increase are planned to be conducted.

3.2 History of Energy Measures in Sapporo City

（1） History of Energy Measures

In Hokkaido where Sapporo City is situated, minable coal is available and coal industry was in its peak in the 1950s. The city also experienced serious air pollution caused by coal in the rapid economic growth period. When it hosted the winter Olympic Games in 1972, it conducted local geothermal supply system development and replaced coal with natural gas. It has also used woody biomass, cold heat from snow and other renewable energies recently. With such a history, Sapporo City has responded to challenges Mongol is facing ahead of other cities.



Source: City Center Energy Master Plan 2018-2050, Sapporo City

Figure 3-2 History of Energy Measures in Sapporo

（2） Current Local Heat Supply System

In central Sapporo, since local heat supply was introduced to control smoke toward hosting the 1972 Winter Olympic Games, the heat supply bases have been established as a theme of the development of an ecological energy-efficient city and, currently, heat is supplied for buildings for various uses in approx. 130 hectares, which is a large-scale heat supply in Japan.

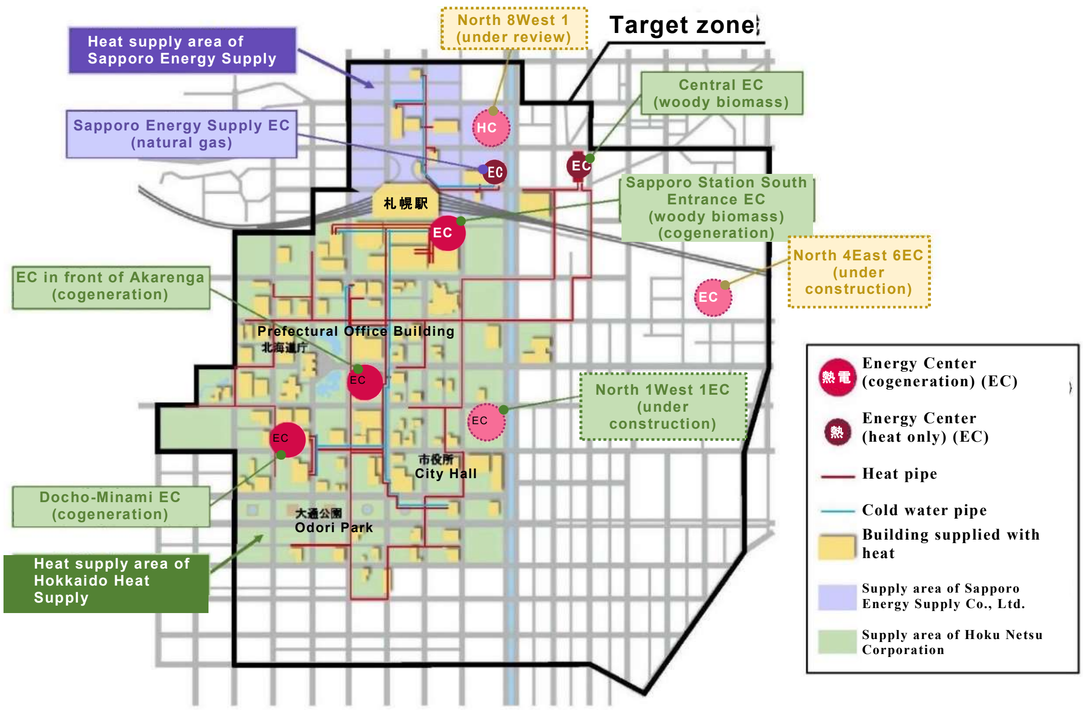
Such renewable energy as woody biomass and cold heat of snow has been utilized actively recently while other efforts to improve efficient and ecological energy consumption, including the introduction of natural gas cogeneration to the energy center at the south exit of Sapporo Station and plant networking.

As of 2018, 22 percent of buildings and 57 percent in terms of the total floor area in the supply area are connected. It has been introduced mainly to relatively large buildings. The connection of more new buildings to the local heat supply that is the energy base in central Sapporo when they are replaced with old buildings is a key to the creation of a low-carbon society.

Table 3-1 Heat Supply Businesses in Central Sapporo
(as of 2018)

Supplier	Sapporo Energy Supply Co., Ltd	Hokkaido Heat Supply Corp.
District	North exit area of Sapporo Station	Central Sapporo
Supply Area	22 ha	106 ha
Supply Cases	10 buildings	86 buildings
Main Heat Sources	Natural gas, electricity, cold heat of snow, free cooling	Natural gas, woody biomass, free cooling

Source: City Center Energy Master Plan 2018-2050, Sapporo City



Utilization of cold heat of snow (area around Sapporo Station North Exit) (snow in a melting tank used as a cold water heat source)

Utilization of woody biomass (Central EC)

Natural gas cogeneration (Sapporo Station South Exit EC)

Source: City Center Energy Master Plan 2018-2050, Sapporo City

Figure 3-3 Overall Image of Current Local Heat Supply Network

3.3 Measures and Efforts in Housing and Construction Sector in Sapporo City

In 2020, Sapporo City declared to be a zero-carbon city to emit net zero GHG by 2050 and formulated the Sapporo Climate Change Action Plan in 2021. It was formulated based on the policies in the Sapporo City Development Strategy Vision (February 2013) that is the highest-level comprehensive plan and the second environmental master plan (March 2018) and it aims to reduce GHG emissions by 55 percent and 5.37 million t-CO2 from 2016 as the target to be achieved in 2030 in view of 2050.

As the indicator to evaluate the results in energy saving in 2030, the energy-saving performance of 80 percent of new housing is equivalent to ZEH or ZEH-M or higher and that of 80 percent of new buildings are equivalent to ZEB or higher. It aims that, as for housing, the energy source of approx. 80 percent of heating device and approx. 70 percent of water heating device is electricity and gas instead of kerosine and heavy oil and LED and high-efficiency lighting is used in 100 percent of housing. The progress of such efforts and GHG emissions are planned to be made public every fiscal year.

Table 3-2 Measures and Target Reduction Amount

Measure	Action	Target reduction amount
[Energy saving] Thorough energy saving measures	(1) Promotion of ZEH	Approx. 1.74 million t-CO2
	(2) Promotion of ZEB	Approx. 1.25 million t-CO2
	Subtotal	Approx. 2.99 million t-CO2
[Renewable energy] Expansion of introduction of renewable energy	(1) Promotion of introduction of renewable energy for buildings, etc.	Approx. 2.18 million t-CO2
	(2) Promotion of introduction of renewable energy in the region	
	Subtotal	Approx. 2.18 million t-CO2
[Transportation] Decarbonization of transportation	(1) Promotion of dissemination of zero emission vehicles	Approx. 1.32 million t-CO2
	(2) Promotion of the use of public transportation	
	(3) Promotion of compact cities	
	Subtotal	Approx. 1.32 million t-CO2
[Resource] Resource circulation and carbon sink measures	(1) Promotion of resource saving and circulation	Approx. 70,000 t-CO2
	(2) Promotion of conservation, creation and utilization of forests, etc.	Approx. 2,000 t-CO2
	Subtotal	Approx. 70,000 t-CO2
[Action] Lifestyle transformation and technological renovation	(1) Lifestyle transformation	-
	(2) Technological renovation	
Total		Approx. 6.56 million t-CO2

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

Sapporo City is promoting conversion of houses and buildings into ZEH and ZEB, which has a long-term impact on CO_2 emissions, from the perspective of building life. With clear goals, it is taking various measures including supporting efforts with its unique scheme and subsidy introduced from the following section, technical seminar for construction companies and dissemination of information to citizens. They are useful for Ulaanbaatar to promote measures in the housing and construction sector.

(1) Sapporo Next-Generation Housing Program

In Sapporo City, the ratio of CO_2 emissions from home is the highest at 37 percent and those caused by energy consumption for heating are higher than other areas in Japan. Although the housing insulation performance is provided in the national energy-saving standards, it is insufficient in the city that is a snowy cold area and thus, since 2012, Sapporo's Next-Generation Housing Program has provided the high insulation performance and super-insulated housing standards higher than the national standards to reduce heating energy consumption and CO_2 emissions from home.

Table 3-3 Standards for Sapporo Next-Generation Houses (for new housing)

Grade	Average thermal transmittance (U_A value) [W/(m2K)]	Primary energy consumption (whole house)	Primary energy consumption (heating+ventilation)	Corresponding gap area (C value) [cm2/m2]
Top runner	0.18 or less	Grade 5	35% or less	0.5 or less
High level	0.22 or less	Grade 5	45% or less	0.5 or less
Standard level	0.28 or less	Grade 5	60% or less	1 or less
Basic level	0.36 or less	Grade 5	75% or less	1 or less
Minimum level	0.46 or less	Grade 4	90% or less	1 or less

Source: Website of Sapporo City

The promotion of Sapporo Next-Generation Housing is one of the core efforts in Sapporo Climate Change Action Plan and there are certification and subsidy programs for it. The certification program is to examine whether the insulation performance, etc., of the house meets Sapporo next-generation housing standards and those that meet them are certified as Sapporo next-generation houses. The houses certified by the city receive a performance label and evaluation sheet that show the housing performance and the label and logo can be used for advertisements with an application. The performance label and logo are to encourage visualization of housing performance and clarification of the quality to be utilized for promoting the next-generation housing. The subsidy program is to provide 500,000 yen to 1.6 million yen as part of the cost for construction and the examination for newly built individual houses in the city that satisfy Sapporo Next-Generation Housing Standards.

(2) Subsidy for ZEB and ZEH-M Design

One of core policies in Sapporo Climate Change Action Plan is to have construction companies motivated to supply ZEB and ZEH, thereby enabling citizens to understand the advantages of such houses and buildings and select them. In line with this policy, Sapporo City provides a subsidy of 600,000 yen to three million yen for those who construct such houses and buildings as the additional design cost necessary for the construction.

Table 3-4 Subsidy for ZEB and ZEH-M Design

ZEB (total floor area: larger than 300m2 and smaller than 2,000m2)	ZEB (total floor area: larger than 2,000m2)	ZEH-M (total floor area: larger than 300m2 and smaller than 2,000m2)	ZEH-M (total floor area: larger than 2,000m2)
1.5 million yen	3 million yen	600,000 yen	1 million yen

Source: Leaflet of ZEB/ZEH-M Design Subsidy

In addition, it also provides subsidies in the table below to introduce renewable and energy-efficient equipment.

Table 3-5 Subsidies for the Introduction of Renewable Energy and Energy-Efficient Equipment

Equipment	Amount of Subsidy and Requirements
Ground source heat pump system	Subsidy amount: 200,000 yen (fixed amount) - It is a system of pumping up heat in the ground to be used as energy for heating (and cooling) and water heating. - The equipment to be used in the system is unused.
Woody biomass heater	Subsidy amount: 50,000 yen (fixed amount) - It is a heater that uses woody pellets as fuel. - It is an independent heater made of inflammable materials and the section where they burn can be airtight. - The smoke can be emitted outdoors with an exhaust fan or chimney. - It cannot use firewood as fuel. (not used combined with wood stove) - It is priced 100,000 or more excluding tax. - It is unused. (Used heaters are not qualified.)
Solar power generator	Subsidy amount: 30,000 yen per kW - To be connected with existing or new power storage facility (stationary storage cell or electric vehicle). * When connecting with a stationary storage cell, it has to meet the requirement for the cell subject to the subsidy. * When connecting with an electric vehicle, V2H charging facility is required. V2H (vehicle to home) charging facility is a system of power supply mutually between the two. - The total solar module output is 1.5kW or more. - Not all generated power is sold but it is consumed personally even in a small volume (surplus wiring). - It is certified by JET (Japan Electric Safety and Environment Technology Laboratories) and can be interconnected with the electric power system of Hokkaido Electric Power Network. - It is unused. (Used heaters are not qualified.)
Stationary storage cell	Subsidy amount: 25,000 yen per kW - To be connected with an existing or new solar power generator. - It uses a lithium-ion battery (including bind battery). (Products consisting solely of lead batteries are not qualified.) - The cell capacity is 2.0kWh or more. - It is certified by JET (Japan Electric Safety and Environment Technology Laboratories) and can be interconnected with the electric power system of Hokkaido Electric Power Network. - It is unused. (Used heaters are not qualified.)
Fuel cell for home use (cogeneration system)	Subsidy amount: 80,000 yen (fixed amount) - It is a fuel cell system consisting of a fuel cell unit and a hot-water storage unit. - Fuel to be used is cold resistant to be stable under the environment at 15 degree below zero. - It is certified by JIA (Japan Gas appliances Inspection Association). - It is unused. (Used heaters are not qualified.)

Source: prepared by the Survey Team based on Efforts to Achieve SDGs in Sapporo provided by Sapporo

(3) Sapporo Built Environment Efficiency Scheme (CASBEE Sapporo)

In the ordinance for ensuring an appropriate living environment, Sapporo City requires those who build or renovate offices, condominiums and other buildings to give considerations to the environment, including energy efficiency, efficient use of resources, greening and snow disposal. Specifically, it requires the submission of CASBEE plan for new or additional construction or renovation with a floor area of 300m2 or more under Sapporo Built Environment Efficiency Scheme (CASBEE Sapporo). The CASBEE Sapporo is based on the evaluation indicators of the national Comprehensive Assessment System for Built Environment Efficiency (CASBEE) and evaluates the environment quality and performance (Q) of the structure and its environmental load (L). In view of the local feature of Sapporo, four items in Table 3-6 are regarded as the core items and environmental efforts regarding 92 items are evaluated comprehensively.

Table 3-6 Core Evaluation Items in CASBEE Sapporo

Core Evaluation Items	Details
Energy efficiency (10 items)	- Use of draft-free windows, etc., to improve insulation performance of entire building - Use of efficient cooling and heating - Use of sunlight and ground heat
Efficient use of resources (20 items)	- Use of recycled materials and local timber - Life extension of wall materials and equipment - Use of rainwater - Emissions control of fluorocarbons, etc.
Greening (4 items)	- Greening of rooftop and exterior wall and around the building - Consideration to the landscape, etc.
Snow disposal (3 items)	- Snow clearing and disposal efforts - Securing snow piling sites, etc.

Source: prepared by study group based on Sapporo Built Environment Efficiency Scheme pamphlet

The evaluation results are classified into five ranks from S to C and can be used for notices in the building and advertising in the form of Sapporo Built Environment Performance Label (environmental performance label). The CASBEE-Sapporo evaluation software and the manual to compile the CASBEE plan are available on the website of Sapporo City. CASBEE Sapporo reporting information and evaluation results are also made public, which contributes to the improvement of environment awareness among citizens and business operators. 1,058 cases were reported by February 2022 from 2007 when the scheme was launched.

3.4 ZEB and ZEM-H Examples in Japan

ZEB and ZEH-M examples in Japan are introduced below. Air conditioning accounts for a large portion of energy consumption in cold areas and because it is used for a long period, for its drastic reduction, it is important to take multiple measures including the introduction of highly efficient air conditioning systems, improvement of skin performance and use of renewable energy as introduced in cases 1 and 2. The hybrid heat supply system of ground and solar heat shown in case 4 of the ground source heat pump is an example that will contribute to Ulaanbaatar that promotes the use of renewable energy for their study. The below examples were translated into Mongolia and distributed to concerned parties of Ulaanbaatar.

1.	ZEB
Name	Ariga Planning Co., Ltd. office building (Sapporo)
It is the first ZEB building in Hokkaido and certified as a BELS 5-star building (highest rank). The ground source heat pump is used for cooling and heating and snow melting technology is used for better energy efficiency. Low-E double-glazed glass is used for windows and lighting of the entire building uses LED and BEMS is also introduced for further energy efficiency improvement. The solar panels on the rooftop and wall are capable of the maximum power output of 50kW.	

Appearance and inside view:

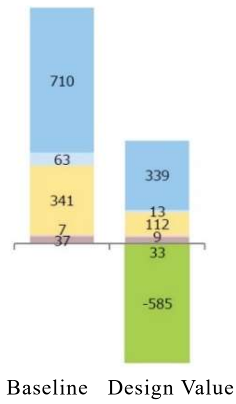
Building overview	Use: office, etc. Structure: steel construction Number of stories: 4 stories above the ground with no basement floor	Total floor area: 644m2 Completion: 2018 New construction

Introduced installations:

Energy-saving (Passive technology)	Exterior wall	125mm spray rigid urethane foam insulation material
	Roof	150mm spray rigid urethane foam insulation material
	Window	Low-E double-glazed glass
Energy-saving (Active technology)	Air conditioning (heat source)	Ground source heat pump
	Air conditioning (system)	Total heat exchanger system, floor heating, fan-coil unit, AC system from floor
	Ventilation (system)	Temperature control
	Lighting (equipment)	LED light fitting
	Lighting (system)	Human detecting sensor control, brightness detection control, time-scheduling control
	Control system	BEMS (building energy management system, load control)
Energy creation	Renewable energy	Solar power generation (50kW), lithium-ion battery

Effects:

Primary energy consumption (MJ/year m2)			BPI/BEI
	Baseline	Design Value	
PAL (skin performance)	480	272	0.57
Air conditioning	710.27	339.05	0.48
Ventilation	62.55	13.04	0.21
Lighting	340.65	111.61	0.33
Water heating	7.12	9.02	1.27
Elevator	37.27	33.13	0.89
Cogeneration	0.00	0.00	-
Energy creation	0.00	-584.50	-
Others	186.95	186.95	-
Total	1,334.81	108.30	0.09
Total creation (energy excluded)	1,334.81	692.80	0.52



Source: Ariga Planning Co., Ltd. Website, ZEB leading owner introduction (Sustainable Open Innovation Initiative)

2.	ZEB Ready
Name	Assisted-living healthcare facility for the elderly, Eau-de-Ekra (Miyagi Prefecture)
The facility is all electric inside. With the use of the ground source heat pump, super-insulating materials and glass are used to improve the skin performance and high-efficiency water heaters and air conditioners as well as an LED lighting control system are introduced.	

Appearance:

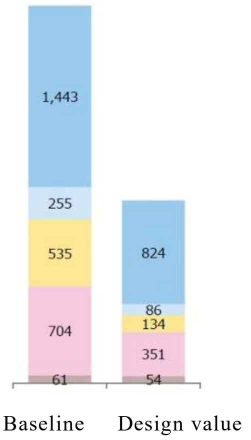
Building overview	Use: hospital, etc. Structure: RC Number of stories: 6 stories above the ground with no basement floor	Total floor area: 8,791m2 Completion: 2018 New construction

Introduced installations:

Energy-saving (Passive technology)	Roof	Urethane foam heat insulating material
	Window	Low-E double-glazed glass
	Shading	Window roof
Energy-saving (Active technology)	Heat source	Ground source heat pump
	Air conditioning (system)	High-efficiency air conditioners, multiple air conditioners for high-efficiency buildings, total heat exchanger system, floor panel air conditioning system, flow changeable control system
	Lighting (equipment)	LED light fitting
	Lighting (system)	Human detecting sensor control, brightness detection control, time-scheduling control
	Water heating (equipment)	Heat pump water heater
	Water heating (heat source)	Ground source heat pump
	Elevator	VVVF control
	Others	Secondary top-runner transformer
	Management system	BEMS (building energy management system, load control)

Effects:

Primary Energy Consumption (MJ/year m2)			BPI/BEI
	Baseline	Design Value	
PAL (skin performance)	744	596	0.81
Air conditioning	1442.65	824.32	0.58
Ventilation	254.65	86.3	0.34
Lighting	534.96	133.64	0.25
Water heating	704.08	351.38	0.50
Elevator	61.20	54.41	0.89
Cogeneration	0.00	0.00	-
Energy creation	0.00	0.00	-
Others	109.00	109.00	-
Total	3,106.54	1,559.05	0.51
Total creation (energy excluded)	3,106.54	1,559.05	0.51



Source: Assisted-living healthcare facility for the elderly, Eau-de-Ekra website, ZEB leading owner introduction (Sustainable Open Innovation Initiative)

3.	Nearly ZEH-M
Name:	Lions Ashiya Grand Fort (Ashiya, Hyogo Prefecture)
It is the first condominium building that achieved Nearly ZEH-M in Japan and certified as a BELS 5-star building (highest rank). The heat insulating performance of the structure and opening is improved and LED lighting and other high-efficiency equipment are introduced for energy saving. Solar panels and fuel cell with high power generation efficiency are introduced per unit for energy creation. With the HEMS (home energy management system), power consumption is visualized to improve users' awareness of energy saving. The solar power generation, fuel cell and storage battery are designed in consideration of securing lifeline in case of disasters.	

Appearance:

Building overview	Use: condominium building Structure: reinforced concrete Number of stories: 5 stories and 1 basement floor, 79 housing units	Total floor area: 4,663m2 Completion: 2019 New construction

Introduced installations:

Energy-saving (Passive technology)	Structure	Enhanced insulation with interior thermal insulation (UA value: 0.6W/m2k or below)
	Opening	Combined sash of aluminum and resin, Argon-gas charged Low-E double-glazed (U value: 1.9W/m2k) 
Energy-saving (Active technology)	Equipment	- LED lighting - Water-saving units (kitchen, bathroom and toilet) - Super-insulated bathtub - Visualization of energy consumption (me-eco)
Energy creation	Renewable energy	- Solar power generation (50kW) - Solar panel: 8 to 12 panels/unit (733 in total) - Supply capacity: 2.34 to 3.51kW - Annual generation capacity per unit:2,508 to 3,773kWh - Next-generation fuel cell (cogeneration system type S) - Storage battery (1kWh)  

Effects: The introduction of high-efficiency installations and equipment led to 32 percent energy saving and 48 percent energy creation with solar power generation to result in the primary energy consumption reduction by an approximate average of 80 percent of all units to achieve Nearly ZEH. It is estimated to reduce the energy bill by 134,000 yen per year per unit.

Source: Lions Ashiya Grand Fort website, presentation session of NET Zero Energy House assistance project survey, 2019 (Ministry of Economy, Industry and Trade and Sustainable Open Innovation Initiative)

4.	Introduction of hybrid ground and solar heat supply system
Name	Rusutsu Children’s Center Pokke (Abuta-gun, Hokkaido)
It was built to replace the old building and it realized the primary energy consumption reduction by approx. 53 percent compared with the conventional system. The ground source heat pump for heating, earth tube to use the ground heat and space conditioner for ventilation, and solar heat water heating system are introduced. For the structure, a large amount of building materials including bricks and timber from Hokkaido are used.	

Appearance and inside view:

Building overview	Use: children’s facility, etc. Structure single-story wooden structure	Total floor area: 1,500m2 Completion: 2015

Introduced installations:

As the facility also serves as an evacuation center in case of disasters, it is an ultra-insulated building (Q value is equivalent to 0.93W/m^{2}K). In ordinary use, at night, the heat pump is operated to store heat in the structure, and during the day, it is heated by releasing the heat there and cool ground heat is used for cooling without using the heat source, which is called free cooling. For water heating, the high-efficiency evacuated glass tube is used for the solar collector to utilize solar heat during the day to enable standardization of electricity load and economic efficiency. For lighting, LED lighting and control system are introduced and the highside and skylight windows are built to let in natural light.

Energy-saving (Passive technology)	Roof	200mm rigid urethane foam board
	Exterior wall	200mm glass wool
	Floor	100mm polystyrene foam board
	Window	Combined sash of wood and aluminum, argon-gas charged low-E double-glazed glass (U value: 1.22W/m2K)
Energy-saving (Active technology)	Air conditioning (heat source)	Ground source heat pump (rating heating output 28kW x 3 units)
	Air conditioning (system)	(Heating)ground source heat exchanger, heat storage electric floor heating (Cooling)fan coil: free cooling of direct use of cold ground source heat
	Ventilation (system)	The earth tube and underground pit are used to preheat and precool air from outside, which goes through the total heat exchange and ventilation unit.
	Humidity control/deodorization (system)	The underground pit is covered with silica shale (26.5t from Wakkanai) and charcoal (2.7t from Shimokawa) to control humidity of and deodorize air from outside.
	Water heating (heat source)	Preheat water with evacuated glass tube solar collectors (3m2 x 2) and heat it further with air-source heat pump for water heating at night.
	Water heating (system)	Heat pump water heater for business use (7.2kWx1), hot-water tank
	Lighting (equipment)	LED light fitting
	Lighting (system)	Wireless control system (human detecting sensor control, brightness detection control, time-scheduling control)

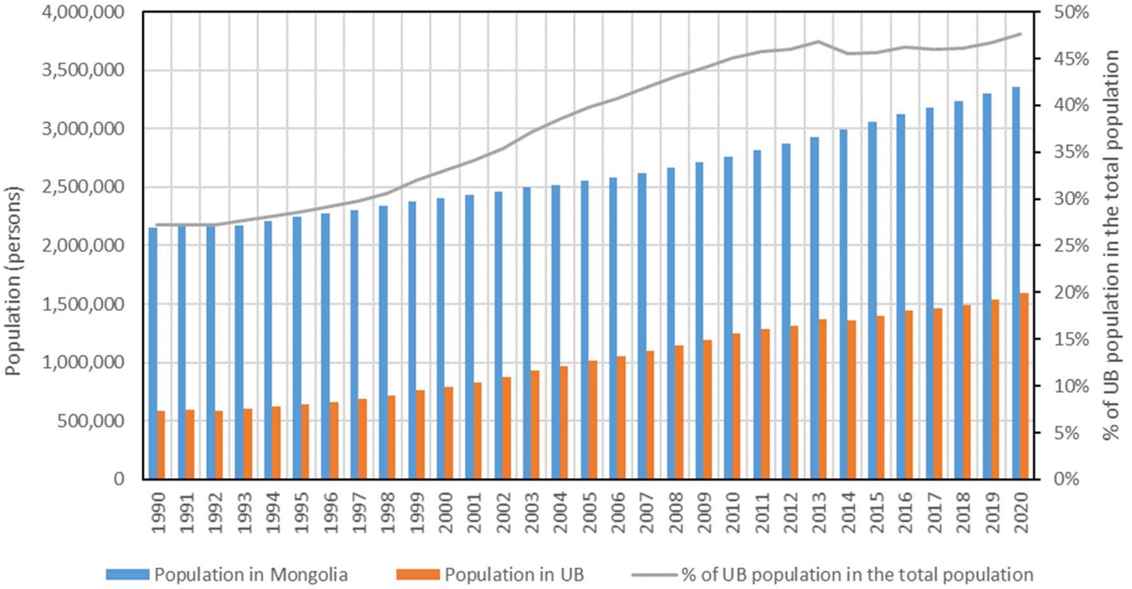
Source: Center Report No.197 (Hokkaido Architecture Advice Center),Outline of Rusutsu Children’s Center Pokke No.3

Chapter 4 Consideration of Decarbonized Model Buildings

4.1 Building specifications and energy consumption in Mongolia

4.1.1 Population change and GHG emission

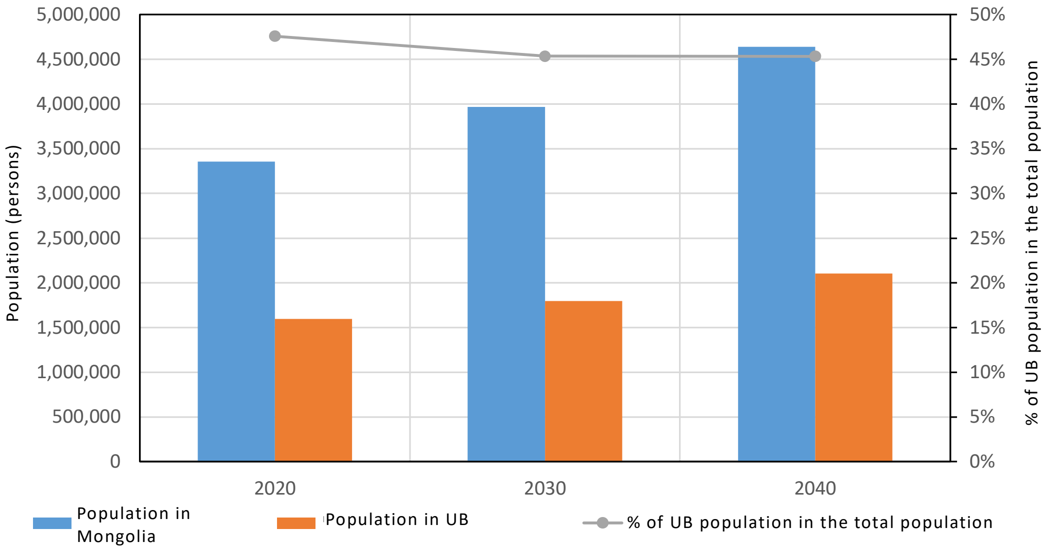
Amid economic development, the population in Mongolia has soared since 2000, growing from around 2.4 million to around 3.35 million in 2020. This inflow has also seen the population in Ulaanbaatar more than double over two decades; from approximately 0.7 million in 2000 to 1.6 million. Ulaanbaatar's population as a percentage of the nation's population has grown from 29% in 2000 to 48% in 2020, indicating a significant concentration of the population.



Source: the Mongolia National Statistic Office database

Figure 4-1 Population trends in Mongolia and Ulaanbaatar City

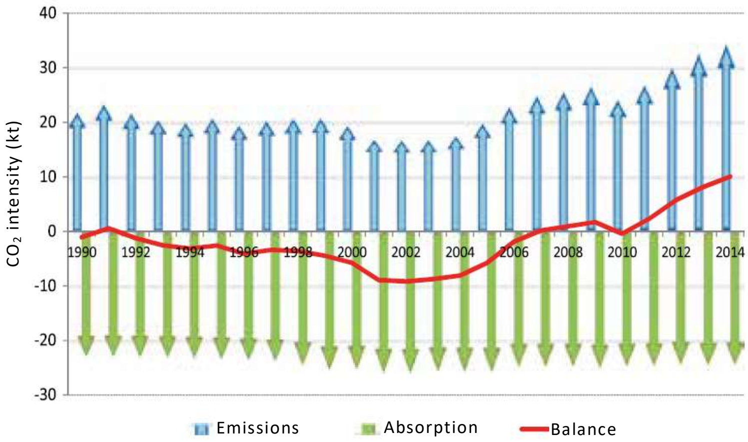
Future projections also indicate that the population of both Mongolia and Ulaanbaatar will continue to grow in the years 2030 and 2040. The population of Ulaanbaatar is projected to exceed 2 million in 2040.



Source: NOSK (estimation)

Figure 4-2 Population trend projection in Mongolia and Ulaanbaatar City

Coal is both affordable and a major fuel in Mongolia, comprising over 90% of the fuel used to generate power, heat and cook. As shown in the table below, GHG emissions have been increasing since 2000. Unless reduction measures are taken, such as striving to save energy and promoting renewable energies, GHG emissions will further increase due to population growth and other factors.

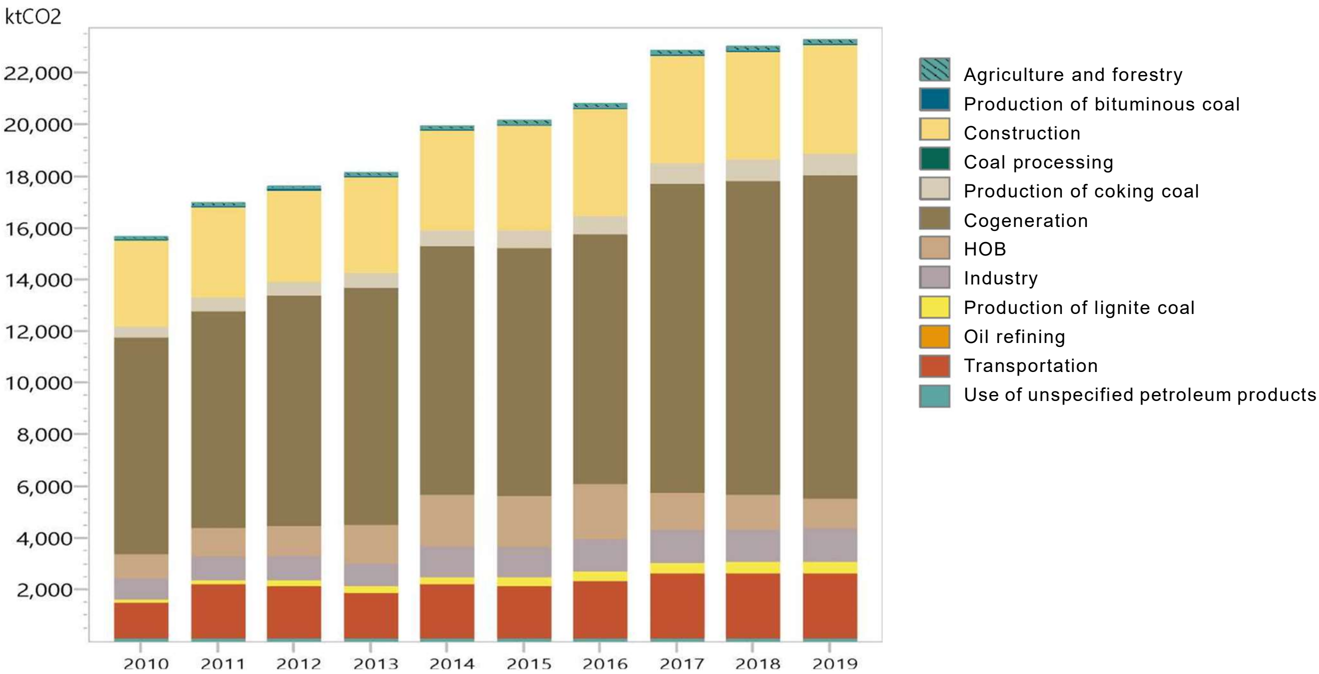


(between 1900 and 2016, Unit: MtCO2e)

Source: MET 2018

Figure 4-3 Changing GHG emissions and absorptions in Mongolia

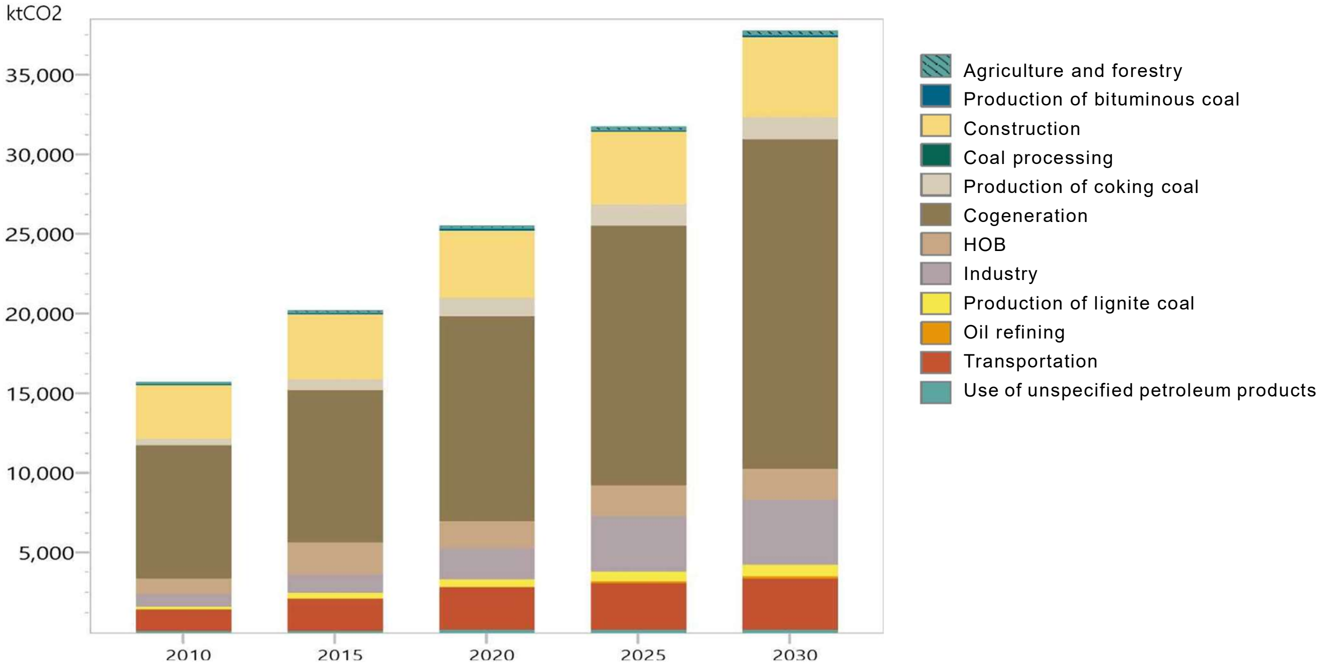
As shown in the figure below, thermal power plants with combined heat and power generation (cogeneration) and heat-supply boilers (HOB) account for a large share of GHG emissions. Therefore, a significant reduction of greenhouse gas emissions in the energy sector can be expected if the introduction of energy conservation and renewable energy in households and business establishments is promoted.



Source: MONGOLIAN LEAP MODEL (Low Emissions Analysis Platform)

Figure 4-4 Composition of Mongolia's greenhouse gas emissions (2010-2019)

In addition, the following is a forecast of future GHG emissions in Mongolia. Emissions from thermal power plants (cogeneration) and industries with combined heat and power generation will continue to increase, and it is necessary to take measures for energy consumption in industries and households.



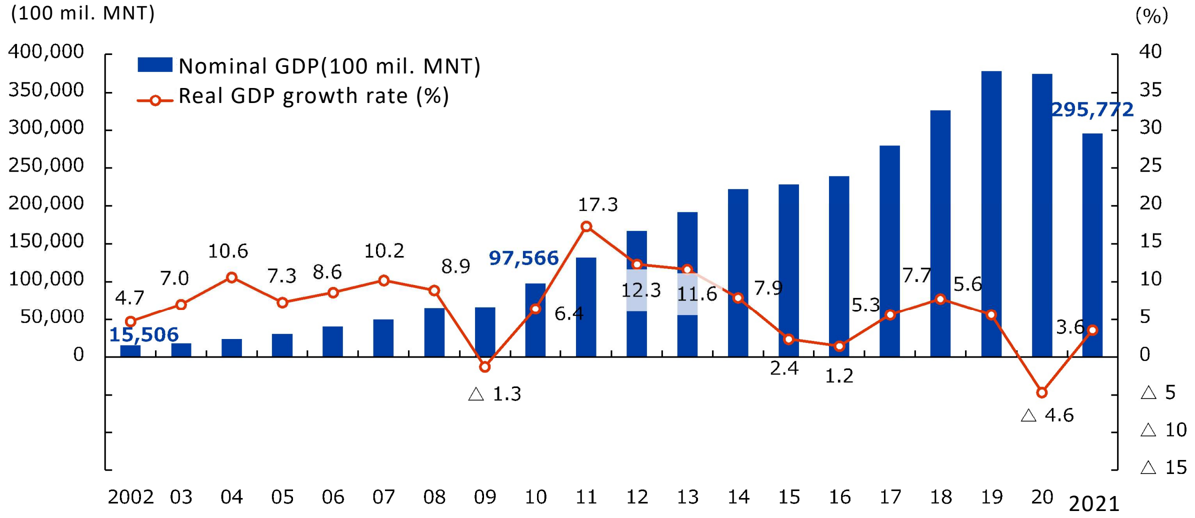
Source: MONGOLIAN LEAP MODEL (Low Emissions Analysis Platform)

Figure 4-5 Future Projections of Mongolian Greenhouse Gas Emissions

4.1.2 Construction market status and building/energy-saving standards in Mongolia

（1） Economic trends in Mongolia

In Mongolia, while the real GDP growth rate exceeded 17% in 2011, it subsequently declined due to a fall in mining resource prices and other factors. The real GDP growth rate in 2015 declined to 2.4% from 7.9% in 2014. The major reasons are failure in direct foreign investment, a decline in resource prices in the mining sector, decreased export due to the Chinese economic recession and other economic decays. Although the real GDP growth rate had shown signs of recovery since 2016, growth turned negative in 2020 due to the COVID-19 crisis. In 2021, however, the rate has recovered slightly.



Source: Survey report on Mongolian Economic Conditions (December 2021), Japan External Trade Organization

Figure 4-6 Changing Nominal GDP and GDP growth rate in Mongolia

（2） Mongolian construction market

The construction investment amount and construction material production increased between 2000 and 2014. In 2015, however, public investment declined due to failure in direct foreign investment, falling resource prices in the mining sector and Chinese economic recession. The construction investment amount in 2015 declined to approximately 16.5 billion yen (447,166 million MNT).

Table 4-1 Trends in construction investment amount and major construction material production in Mongolia

Investment amount, production amount, etc.	Unit	Production volume			
		2012	2013	2014	2015
Domestic construction investment	Mil. MNT	1,307,864	1,102.839	1,146,557	447,166
Housing construction	Mil. MNT	389,418	856,903	1,430,863	N.A.
New apartments	No. of households	11,413	18,012	22,546	N.A.
Housing stock increase	1,000 m2	531	906	1,604	1,263
Cement	1,000 t	349.4	258.8	411.3	410.1
Concrete and mortar	1,000 m3	176.2	317.8	432.6	129.0
Clayish bricks	Mil. Bricks	44.5	66.5	58.9	41.5
Timbers	1,000 m3	14.2	9.8	16.4	15.2
Wooden doors/windows	1,000 m2	7.6	12.4	14.6	7.8
Construction material import amount	Mil. US$	279	336	330	N.A.

Source: Mongolia: Business Environment Guide 2017

Since the Urban Redevelopment Law was approved by Parliament, in 2015, a Ger area development project and a new housing policy for low-income residents have been considered. New apartments constructed during an apartment construction project in Ger areas connect to water and sewage, hot water and heating services for better living conditions. Moreover, an urban policy aiming to realize an efficient and sustainable city with the various functions needed for living, developing infrastructure and constructing housing will be promoted, thereby boosting construction investment. Based on data from the Mongolian National Bureau of Statistics, cement production, a typical construction material, was 410.1 thousand tons in Table 4 1, while in 2020 it will be 1182.2 thousand tons, nearly three times higher, indicating growing construction demand.

(The UB Seventh District in September 2016)

Figure 4-7 New apartment buildings constructed during an apartmentization project in the ger area

4.1.3 Building-related standards in Mongolia

（1） Building and energy-efficiency standards in Mongolia

① Building standards

The framework for legal systems on buildings in Mongolia is prescribed based on the Construction Law 2016, which comprises the following chapters:

Table 4-2 Structure of the Construction Law 2016

Chapter	Title	Article
1	General Provisions	1-8
2	Construction and Construction Categories	9-10
3	Basic Requirements for Construction Activities	11-17
4	Construction Operating Licenses and Construction Work Permit * A construction permit must be granted before constructing new buildings.	18-30
5	Construction Sector Management and Regulation	31-35
6	Participants in Construction Activity	36-46
7	Technical State Control	47
8	Construction Certificate * A construction certificate must be granted before completing the work.	48-49
9	Other Provisions	50

Based on this Construction Law, the Ministry of Construction and Urban Development prepares the Mongolian construction standards which comprise the Construction Codes of Mongolia, Construction 3 Regulations and Other Guidance Documents and Administrative Documents and encompass a total of around 450 documents. The relevant standards are prescribed by 674 Mongolian Standards.

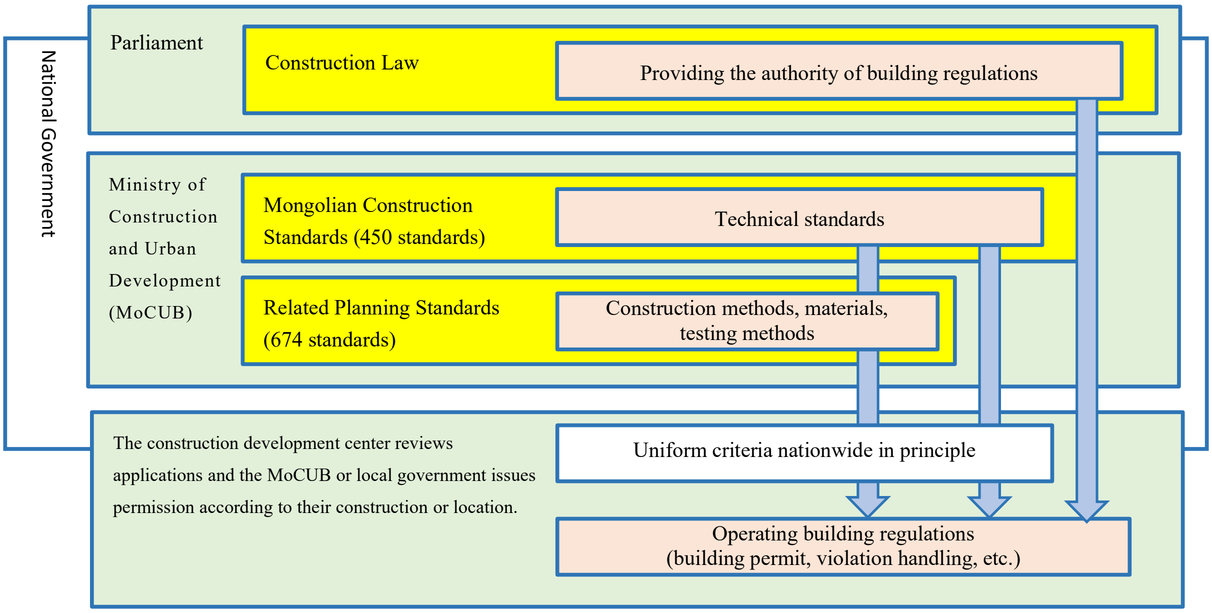


Figure 4-8 Institutional flow in the Mongolian building sector

Current standards in Mongolia remain unchanged from those enacted in the former Soviet Union era between the 1960s and 70s, rendering them incompatible with modern approaches and very complicated. Around one third of the standards were written in Russian and a further third were directly translated from Russian into Mongolian. The remainder were adjusted to Mongolian conditions to some extent and have been published in Mongolian language. The reality is that those standards do not practically function as those aged 30 years or under in Mongolia do not read Russian.

Moreover, although the Construction Law of Mongolia sets out the procedures to be followed in building construction and underlines the need to “meet the requirements and instructions issued by the authorities for the construction phase”, it does not cite technical matters. While technical standards are set forth to complement the Law, they only show construction standards like standard specifications. Accordingly, it is expected that actual insulation performance will differ considerably according to the buildings involved.

In Mongolia, strict paperwork is required; construction permits should be applied with construction drawings and 144 permits should be obtained prior to starting construction work. Despite such strict procedures, however, no mechanism exists to check the execution of works and it is not unusual to see design drawings and specifications of completed buildings diverge. Accordingly, it is deemed impossible to verify whether insulation technology designated by design was actually constructed given the lack of checks and balances. To ensure that construction works are executed as specified in the design drawings, matters to establish and ensure a means of checking construction quality plus improving the legal system are key.

② Heat insulation standards

In Mongolia, standards for thermal technology in building envelope structures are set forth in BCNS23-02-2009 (BCNS) while energy-efficiency requirements are also referenced in those standards, most of which were established during the former Soviet Union era. Comparing the thermal performance standards of Mongolia and the Czech Republic (former Soviet Union) for reference purposes reveals very similar building insulation requirements.

Table 4-3 Comparison of thermal standards between Mongolia and the Czech Republic (the former Soviet Union)

Item	Czech Republic U_N (R_N)[W/(m2K)]	Mongolia U_N(R_N)[W/(m2K)]
Exterior wall	0.30 (3.16)	0.26 (3.70)
Roof	0.24 (4.03)	0.20 (5.00)
Ceiling above non-heating space	0.60 (1.33)	-
Floor	0.45 (2.05)	-
Window	1.50 (0.50)	0.30 (3.16)
Door	1.70 (0.42)	-

Source: BCNS23-02-2009 Building Thermal Performance (Mongolian standards) and CSN730 0540-2 Building Thermal protection (Czech national standards)

③ Energy-efficiency standards

In Mongolia, summers are cool and winters are icy. Regional heating systems are commonplace in urban areas and connecting to the system is mandatory. In 2009, the Building Thermal Performance (CCM 23-02-09) was issued as a set of standards requiring new buildings to be designed to ensure that primary energy is below a certain criterion (Table 3-4), measured after the building comes into operation and checking the results obtained. Classes A, B and C are set according to the design phase of a new or renovated building while Classes D and E are set to check the repair work sequence of those buildings constructed in 2000 or earlier.

Table 4-4 Classification of building energy efficiency in Mongolia

Class	Classification of energy efficiency	Measured value (q^{des}_h) of heat energy consumption rate of building heating system and variable range from the baseline (%)	National governmental measures for the facility
New or freshly renovated building			
A	Very high	Lower than -51	
B	High	Between -10 and -50	
C	Normal	Between +5 and -9	-
Building constructed			
D	Low	Between +6 and +75	Repair of building
E	Very low	Higher than 76	Heat insulation measures must be taken shortly/

It is unclear whether private houses and other common buildings are designed and constructed to conform with these criteria. For insulation and equipment installed with energy efficiency in mind, however, highly efficient Japanese and other foreign products are used in part of the capital city. However, even if quality Japanese materials are applied under current circumstances, they may not be utilized by the construction engineering in Mongolia, given the technical capacity needed to construct buildings sufficiently airtight to allow energy efficiency. To use Japanese materials and products and promote energy efficiency in Mongolia properly in future, efforts to introduce technology and insights in packaged form, over and above products alone, will be effective and can be leveraged to improve infrastructure and operations and promote urban development in Mongolia.

（2） Building specifications and their issues in Mongolia

① Fittings

By around 2010 in Mongolia, many collective buildings with wooden double-glazed windows were not being properly maintained and managed, even in Ulaanbaatar City. Window panes were simply fitted in wooden frames or fixed in place by nails alone in some cases. Given the abundance of distorted glass, the outside air infiltrating the building from such openings severely hampered efforts to secure the indoor environment.

In response, each household fills the glass edges with kneaded flour. However, rainwater still permeates through gaps in the window, resulting in humidity. When the materials later dry, this process generates repeated expansion and contraction, causing the wooden frame to crack and leading to gaps generated by the distorted frame, making it difficult to secure airtightness.

Since around 2005, lower-priced resin sashes have been imported from China. Since frame materials have been imported and sash-processing factories constructed in Mongolia, resin sash materials were chosen to open parts of new buildings, while old buildings were also renovated with resin sash, which is currently the main material used in Ulaanbaatar City. In line with this trend, glass and double-glazing sash are also used, but their performance is insufficient, given the condensation generated inside them in winter. Except for a portion of those sash and glazing products imported or domestically processed, their product qualities are not guaranteed.

Currently, the major type of resin sash method used in Mongolia is the dual-action type, featuring a tilt and turn with a single lever. However, the quality is not guaranteed and the airtightness imperfect; prone to failure or distortion. Accordingly, airtightness is not secured, even when using a resin sash or double-glazing sash.

Since around 2000, with crime prevention in mind, conventional wooden double doors have been replaced with Chinese steel products, which are now commonly used for fittings linked to the outside, such as in entrances. Although gaps between fittings and frames are filled using urethane foam, the construction technique involved largely depends on each craftsman and the insulation performance is not necessarily secured.

② Insulation

By around 2005, insulation had been regulated by the thickness of a brick-built wall. Subsequently, the scope of the specifications was extended to constructing a wall surface with concrete blocks, inserting insulation materials into the central part of the masonry structure and using Styrofoam for external/internal insulation.

In standard construction work specifications in Mongolia, insulation is specified by БНБД31-08-05 (BNBD31-08-05). However, they have not been updated since 2005, rendering them unsuitable for current conditions. Moreover, whether such insulation criteria would be applicable to actual construction works remains in doubt.

The Russian standards saw coal ash insulation materials laid out and asphalt waterproofing applied to schools and other low-rise buildings constructed during the socialist period. Such construction materials deteriorated faster, due to the severe climatic conditions of Mongolia, with leakage from the roof observed in several cases. Accordingly, the insulation performance of coal ash having deteriorated due to moisture is difficult to measure.

③ Airtightness associated with exterior wall deterioration

The annual temperature difference in Mongolia is nearly 70 degree, causing construction materials to deteriorate significantly as they expand and contract in the alternating dry and wet conditions and temperature fluctuations. Steel-frame buildings are rare in Mongolia and the basic structural core of many collective housing blocks is made of reinforced concrete (hereinafter, "RC"), while most exterior walls are constructed with concrete block masonry. Since the opening parts are liable to cracking and damage as building stress is concentrated, finishing materials like mortar are used for such parts. However, work to reinforce opening parts and install contraction joints is often omitted. Although parts around the opening are sealed, a single-component cartridge is often used for sealing without any backup material, which often results in the sealing breaking. Since fittings and the area around them are often left unsealed, the outside air and inflow of rainwater adversely affects the airtightness and building performance.

Moreover, insufficient insulation processing and sash performance around the opening parts leads to indoor condensation. When moisture repeatedly melts and freezes around the window frames, this exacerbates the deterioration of the frame, both externally and internally and hampers efforts to maintain airtightness.

④ Airtightness and ventilation

Mongolia has standard ventilation specifications, which require air-vent installation. Meanwhile, "natural air supply/ventilation" and a "natural air supply and mechanical ventilation system" are commonly applied in Mongolia. In some cases, air vents are closed to prevent outside air from flowing inside the building in winter, where the average temperature is -25 degrees. Energy recovery ventilation systems are seldom used in general collective housing blocks and private housing. In many such buildings, the ventilation system does not work and polluted air is sealed in. Accordingly, securing airtightness and maintaining a comfortable indoor temperature while ensuring ventilation is key.

Many mobile tent houses remain in ger areas, where airtightness is difficult to ensure. Their opening part is located in the ceiling and a chimney should be installed. As well as constructing the entrance only with a wooden door, a padded "futon" type mattress is attached to those parts to secure airtightness but fails to do so sufficiently.

⑤ Heating system

Collective housing blocks and office buildings in Ulaanbaatar City are heated by steam generated from thermal power plants, which is distributed to each building via city-wide plumbing. Each building circulates heat, which is distributed to the top floor and the radiators in each floor via the plumbing, meaning the temperature varies by area and floor, even within the same building. New apartment houses install radiators with a flow regulator, which is expected to solve temperature differences among floors. However, issues like supply stoppages, no supply at the beginning of autumn and unstable indoor temperatures, even when the heat source is supplied normally to buildings, are acknowledged with the heat supply system. In such cases, the boiler must be installed individually

(3) Issue of building construction in Mongolia

In Mongolia, few domestic products are used in sectors like construction and manufacturing, in which steadily accumulated technology, establishing supply chains and introducing ISO and other standards all become important. Accordingly, Mongolian production technology remains behind that of Japan. In the Mongolian construction industry, meanwhile, insufficient construction engineering and a limited choice of materials hampers efforts to regularly supply materials of a certain quality. Construction quality must be improved via ISO and other standards and an administrative monitoring system.

Considering the political instability in Mongolia, the government-led prototype often varies from the initial arrangement and contract due to the regime transition and official financial situation. Accordingly, there is a need to approach the administration side to develop laws and establish ordinances by getting private developers and construction companies to collaborate.

4.2 Study of decarbonized model buildings

4.2.1 Preconditions for studying decarbonized model buildings

As described in Chapter 3. 3.2, Sapporo in Japan experienced serious air pollution caused by excessive use of coal but it gradually realized the conversion from coal fuel to natural gas and other alternative fuel and woody biomass, snow and ice as heat sources and other renewable energy.

As explained in Chapter 2.2.2, the NDC aims to reduce the total GHG emissions by 22.7 percent by 2030 and the reduction goals of each sector and action plan provide coal use control, use of renewable energy and improvement of heat insulation performance. Thus, it will gradually reduce coal-fired power generation and replace the heat supply source with renewable energy. It also needs to reduce CO_2 emissions from coal use by their recovery and fixation and carbon offset. Similarly, energy users will gradually decrease heat demand from coal and increase alternation with electric power and it will also be replaced with renewable energy.

In the future, coal use is forecast to decline gradually. However, in Mongolia where a large volume of inexpensive coal is available, not all coal is replaced with electricity in a short period and the energy will be converted partially and gradually. As described in Chapter 2.2.4, based on the possible gradual energy conversion as shown in the below table in accordance with the heating system in winter in Ulaanbaatar, efforts to achieve NDC goals 2030 will be promoted.

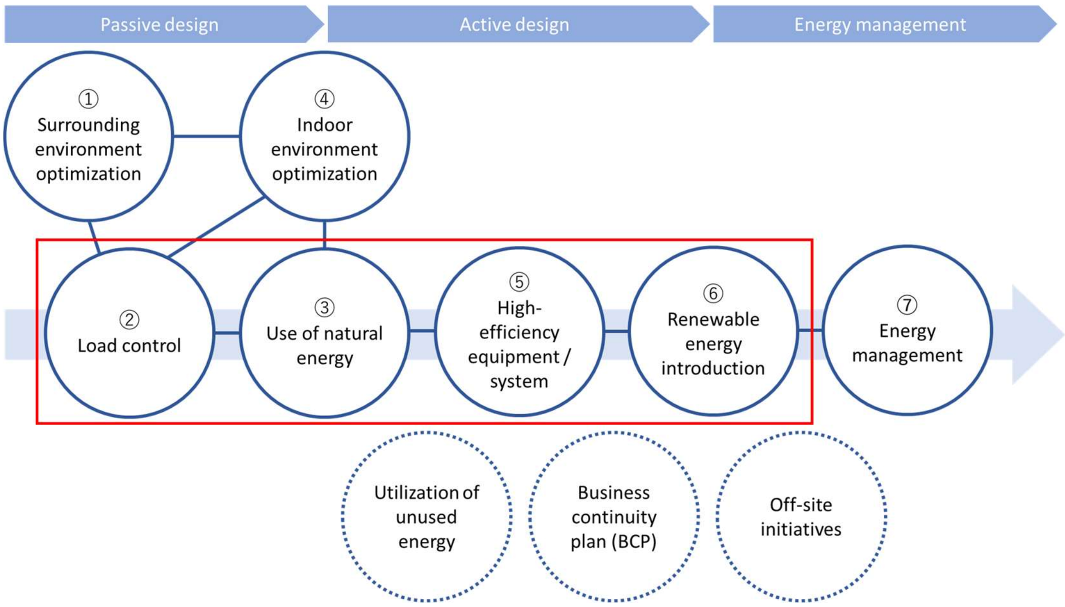
Table 4-5 Example of Possible Gradual Energy Conversion

Stage	Target example [Heating system]	Example of expected energy conversion	2022	2023	2024	2025	2026	2027	2028	2029	2030
Phase 1	・Detached housings in Ger areas [Individual heating system]	・Geothermal heat pump as an alternative to existing coal boilers,introduction of LP gas ・Applying external wall criteria to new buildings, introducing energy-saving, renewable energy equipment ・External wall repair of existing buildings, upgrading energy-saving, renewable energy equipment	■	■	■	■					
Phase 2	・Buidlings, schools, apartments, small districts ・Offices and other small buildings [Central heating system] (Dstributed-type heating system]	・External wall repair of existing buildings ・Upgrading energy-saving, renewable energy equipment		■	■	■	■	■	■	■	
Phase 3	・The whole Ulaanbaatar City ・Aero city development [Central heating system] (Intensive heating system]	・Carbon offset ・Streamlining traffic flow by developing a compact city				■	■	■	■	■	■

Based on the NDC action plan in the NDC, in the Project, the contribution of heat insulation performance improvement mainly of buildings and partial introduction of renewable energy to the realization of decarbonized society is studied. Specifically, the idea of ZEB and application technology already conducted in a cold city of Sapporo in Japan are used to study the decarbonized buildings in line with the Mongolian situation and the buildings are regarded as decarbonized model buildings. The decarbonized model buildings are studied as model cases with a precondition that electricity and heat supply from coal firing is fully replaced with renewable energy.

4.2.2 Study process of decarbonized model buildings

To study decarbonized model buildings with the idea of ZEB, the ZEB design process in ordinary ZEB design guidelines in Japan is summarized as shown in below figure. The study of decarbonized model buildings includes 1) proper surrounding environment development that includes building allocation, construction plan and exterior plan and 7) energy management or BEMS. However, as effects of constructed facility are mainly examined in the study, what’s studied mainly are 2) load control, 3) use of natural energy, 5) increased efficiency of facility and systems and 6) introduction of renewable energy as shown in the below figure.



Source: ZEB Design Guidelines

Figure 4-9 ZEB Design Process

Table 4-6 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

4.2.3 Establishment of cases to study decarbonized model buildings

To examine the effects of decarbonization methods in each study item on energy saving and decarbonization based on the ZEB design process and methods of each item above, multiple study cases as shown in Table 4-7 are set up in consideration of possible partial energy conversion in Mongolia.

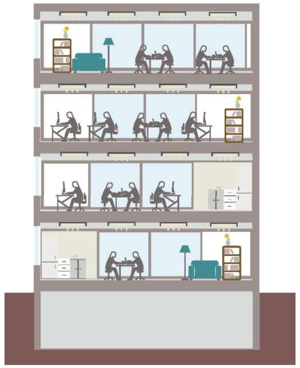
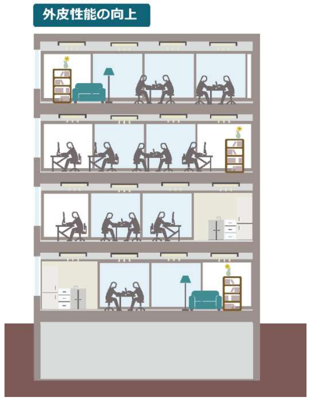
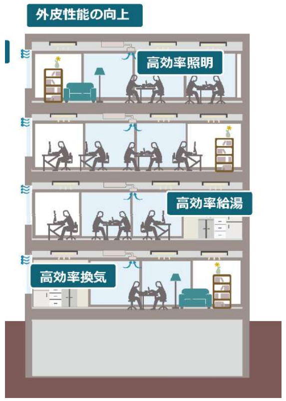
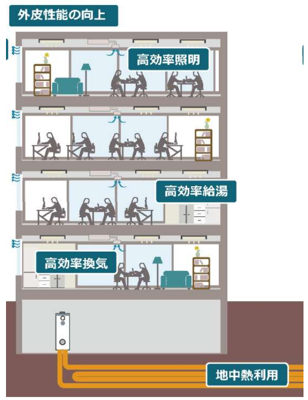
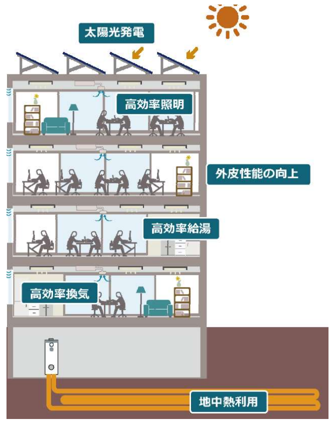
With Case 1 being only the enhanced heat insulation of building skin, efficiency increase of lighting, water heating and ventilation facility and systems is added to it in Case 2.

Case 3 includes the introduction of renewable energy in addition to Case 2. In this case, use of ground source heat pump for the air conditioning system is assumed with solar heat utilization unit as ancillary facility. It is to recover heat in the ground taken by the ground source heat pump with solar heat. When heat is taken continuously with the ground source heat pump, heat in the ground is lost and heat pump efficiency is reduced. It is a complementary unit to prevent it.

In Case 4, in addition to Case 3, solar power generation is introduced fully as renewable energy, thereby making more decarbonized model buildings.

In addition to above cases, Case 0 is set up with no decarbonized model buildings to compare energy effects of Cases 1 to 4. As the study of these cases is to compare their effects on energy saving and decarbonization, the precondition that coal-fired heat supply is replaced with electricity is the same in all cases to compare them accurately.

Table 4-7 Study Cases of Decarbonized Model Buildings

Case	Case 0	Case 1	Case 2	Case 3	Case 4
					
Decarbonization Method	No measure (existing building) *Heat supply system grid power	Skin (enhanced heat insulation)	Skin + lighting, water heating and ventilation	Skin + lighting, water heating and ventilation + renewable energy (ground source heat pump and solar heat) * Solar heat is a complementary system to recover heat in the ground taken by ground source heat pump.	Skin + lighting, water heating and ventilation + renewable energy (ground heat, solar heat and solar power generation)
Concept		Load control	Case 1 + increased efficiency of facility and systems	Case 2 +introduction of renewable energy	Case 3 +introduction of renewable energy (in consideration of solar power generation)
Office building					
GHG reduction	2,091tCO2/year	1,908tCO2/year	1,774tCO2/year	1,387tCO2/year	1,185tCO2/year
% of reduction	—	9%	15%	34%	43%
Housing complex					
GHG reduction	12,018tCO2/year	11,894tCO2/year	9,259tCO2/year	8,807tCO2/year	8,765tCO2/year
% of reduction	—	1%	23%	27%	27%

4.2.4 Study of building specifications in Mongolia

To study decarbonized model buildings in Mongolia, building equipment and fittings of ordinary buildings and those to which ZEB idea is applied need to be compared and sorted out. We interviewed people involved in construction in Mongolia and sorted out specifications by element as shown in Table 4-8. We also compared and sorted out building specifications in Japan to confirm the relevance of the comparison of ordinary and decarbonized model buildings in Mongolia and the result is shown in Table 4-9 as reference.

Table 4-8 Building Specifications of Decarbonized Model Buildings Assumed to be Ordinary Buildings in Mongolia

Common buildings (Mongolia)		
Element	Mongolian specifications	Materials and performance
External wall	Concrete base Insulating Polyethylene foam (EPS) 120mm	Thermal conductivity 0.034 W/m・K 0.12×0.034×1,000 = 4.08
Rooftop	Concrete base + waterproof Insulating polyethylene foam (EPS) 120mm	Thermal conductivity 0.034 W/m・K 0.12×0.034×1,000 = 4.08
Fittings	Aluminum sash (insulation performance: unknown) Insulating glass (assumed)	Thermal transmittance 3.3W/m2・KU
Air-conditioning system (heating)	1. Regional heating (hot water from power generation plant) or 2. Hot water at 70 degree Celsius is supplied via hot water boiler (coal) (use radiator inside building in both cases)	—
Air-conditioning system (cooling)	No cooling	—
Electrical system	Common electrical system Common lighting is assumed (no LED)	—
Others	* Overall construction accuracy (air-tightness)	△
Decarbonized model building (Mongolia)		
Element	Mongolian specifications	Materials and performance
External wall	Concrete base Insulating Polyethylene foam (EPS) 150mm	Thermal conductivity 0.034 W/m・K 0.15×0.034×1,000 = 5.01
Rooftop	Concrete base + waterproof Insulating Polyethylene foam (EPS) 150mm	Thermal conductivity 0.034 W/m・K 0.15×0.034×1,000 = 5.01
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	Water-cooled geothermal heat pump (55 degree Celsius) + recover ground temperature using solar panels (using radiator inside buildings)	—
Electrical system	Energy-efficient electrical system LED lighting	—
Energy creation equipment	Solar panels	
Others	* Overall construction accuracy (air-tightness)	△

Table 4-9 Building Specifications of Ordinary Buildings and Those that Satisfy ZEB Requirements

Common buildings (Mongolia)		
Element	Japanese (Hokkaido) specifications	Materials and performance
External wall	Concrete base or base by secondary concrete base Urethane foam (internal insulation) 50mm	Thermal conductivity 0.036 W/m･K 0.05×0.036×1,000 = 1.08
Rooftop	Concrete base + waterproof Urethane foam (internal insulation) 50mm	Thermal conductivity 0.036 W/m･K 0.05×0.036×1,000 = 1.08
Fittings	Aluminum sash (insulation performance: H-3 or higher) Insulating glass (5+6+5) or double glazing	Thermal transmittance 3.3W/m2･KU
Air-conditioning system (heating)	Various heating equipment (Bunker A, kerosene, gas, electricity, etc.)	—
Air-conditioning system (cooling)	Air conditioner (electricity-type)	—
Electrical system	Common electrical system LED lighting	—
Others	* Overall construction accuracy (air-tightness)	◎
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 creation equipment	Solar panels	
Others	* Overall construction accuracy (air-tightness)	◎

4.3 Selection of target facilities to study decarbonized model buildings

4.3.1 Selection of target facilities

Based on the building specifications summarized in 4.2.4 above, we selected the target facilities suitable as study cases of decarbonized model buildings based on the below policies.

- The target facilities are planned to be constructed and there is a concrete plan with a drawing of expected completion, etc.
- Both public and housing buildings are selected for Ulaanbaatar City to study and cases with the ideas of ZEH-M for housing as well as ZEB for buildings are studied.
- In consideration of future development in the entire city requested by Ulaanbaatar, the housing facility is in the same scale as the residential zone plan of the satellite city (Aerocity) adjacent to the new airport studied in the first year. (Refer to below figure.)

【Outline】 ・Site area: 81,000m2 ・Resident: 2,160 residents in 600 household ・Housing complex building: 27 5-story buildings 6 3-story buildings ・School (approx. 420 students) and kindergarten (360 children) and entertainment facility are also established to be a compact city.	

Source: FY2020 Decarbonized City Development Assistance Project in Ulaanbaatar, Tov Province

Figure 4-10 Overview and Location Map of Aerocity Residential Zone

We continued discussions with Ulaanbaatar Public Housing Corporation (NOSK) in charge of housing development directly managed by the city government based on the above policies.

Ulaanbaatar Public Housing Corporation (NOSK) formulates a legal framework for housing development in the capital city, plans and proposes housing policies and project development, provides funds in accordance with the development plan and housing complex zone plan and constructs housing. To increase the supply of inexpensive housing sustainably in the capital city, it launches financial instruments in the stock markets at home and overseas in cooperation with financial institutions for various financial arrangements to secure capital. It decides conditions to offer housing loans, subsidies and incentives, issues collateralized loan obligations, establishes rental housing funds and manages income from lease. It consists of five sections with 77 fulltime employees.

Furthermore, it introduces new ecological technologies and materials to housing plans and construction, seeks policies for construction cost reduction and investment efficiency improvement and assists private-sector housing construction. It also manages housing security of 1,744 households in the city and operates call centers and monitoring systems with security cameras around the clock.

Type: Buyant-Ukhaa-2 District
Location: Khan Uul District
Target: 972 households

Type: Temporary housing
Location: Sukhbaatar District
Target: 286 households

Type: Housing for sale
Location: Songino Khairkhan District
Target: 70 households

Type: Housing for elderlies
Location: Sukhbaatar District
Target: 300 households

Type: Temporary housing
Location: Songino Khairkhan District, Sukhbaatar District
Target: 100 households

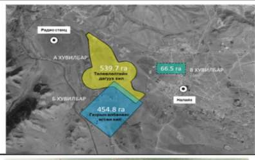
Type: Housing for sale for school staff
Location: Bayanzurkh District
Target: 16 households

Source: Overview of Ulaanbaatar Public Housing Corporation

Figure 4-11 Main Housing Projects Operated and Managed by Ulaanbaatar Public Housing Corporation (NOSK)

With Ulaanbaatar Public Housing Corporation (NOSK), we selected housing projects that can be target facilities as in the below table for concrete discussions.

Table 4-10 Example Housing Projects that Can Be Target Facilities

Foreign investment project				
①	Bayangol Mountain Housing Project	Investor	Export-Import Bank of Korea	
		Target building	Apartment for 2,000 households	
		Investment amount	114.7 million USD	
		Location	Songino Khairkhan District	
②	Wall Material Housing Project	Investor	European Bank for Reconstruction and Development	
		Target building	Apartment for 740 households	
		Investment amount	25 million USD	
		Location	Songino Khairkhan District	
③	Ulaanbaatar Green Affordable Housing and Resilient Urban Renewal Project (AHURP)	Investor	Asian Development Bank	
		Target building	Apartment for 10,000 households	
		Investment amount	570.1 million USD	
		Location	Six locations in Ulaanbaatar City	
Domestic investment project				
④	Affordable Apartment-type Housing Project	Investor	Private company	
		Target building	Apartment for 840 households	
		Investment amount	50 billion MNT	
		Location	Khan Uul District	
⑤	Reconstructed Private Housing Project	Investor	A bank	
		Target building	Apartment for 712 households	
		Investment amount	60 billion MNT	
		Location	Bayanzurkh District	
⑥	Deteriorate Housing Regeneration Planning and Construction Project	Investor	Ulaanbaatar City	
		Target building	Apartment for 126 households	
		Investment amount	60 billion MNT	
		Location	Nalaikh District	
New residential area development project				
⑦	Moring Davaan Housing Project	Target building	Apartment for 5,000 households	
		Investment amount	350 billion MNT	
		Location	Khan Uul District	
⑧	Housing Project in Nalaikh	Target building	Apartment for 5,000 households	
		Investment amount	350 billion MNT	
		Location	Nalaikh District	
⑨	Bio-Songino Apartment Housing Project	Target building	Apartment for 640 households	
		Investment amount	350 billion MNT	
		Location	Khan Uul District	

Source: Overview of Ulaanbaatar Public Housing Corporation

From the above list, we chose 6) Deteriorated Housing Recovery Project funded by Ulaanbaatar with a belief that it would be easy to obtain information on the buildings and we studied it. The construction project consists of two nine-story buildings with one basement floor as a housing complex project in a ger area. Although we obtained the location information and floor plan as shown in the below figure, we were not able to obtain facility drawings necessary for concrete study and thus we gave it up.

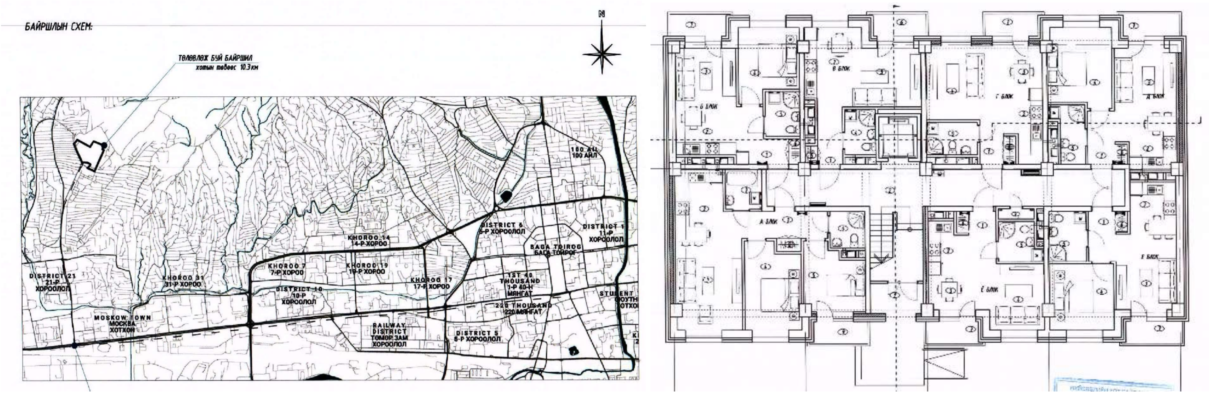


Figure 4-12 Location (left) and Floor Plan (right) of Deteriorated Housing Recovery Project

Meanwhile, we talked with the deputy mayor in charge of construction projects in the city and reconfirmed its needs. He introduced housing complex in a redevelopment project in a ger area and new city hall building that are new construction projects and can also be model cases in future city projects and we studied each as housing complex and public facility (office building) as target facilities. An overview and reason for selecting the two facilities are summarized in the below table.

Table 4-11 Overview and Reasons for Selection of Target Facilities

Target	Housing Complex (e.g., SERENETOWN)	Office Building (e.g., New Ulaanbaatar City Hall)
Photos		
Overview	・Located approx. 5km east of city center ・Plan of all of 15 buildings in progress ・Structure differs by building (average floor area: 72m2 (1 room)) ・Housing complex development project in ger area	・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 is planned to be constructed.
Reason for Selection	As it is a typical mid-sized housing complex in a ger area, it can be studied as decarbonized model buildings.	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.

（1） SERENE TOWN

SERENE TOWN is a housing complex development project in a ger area launched in 2019 to be an efficient and sustainable city with necessary living functions in its vicinity. It is conveniently situated approx. five kilometers east of city center (Figure 4-13) and it has drawn attention as housing with latest facilities. Of 15 blocks, housing units in the fifth block is currently available for sale. As shown in Figure 4-14, there are multiple unit types in each building for families with a floor area of 60m2 to 80m2 and play areas and green paths are built for elderly people and children.

Figure 4-13 Location (SERENE TOWN)

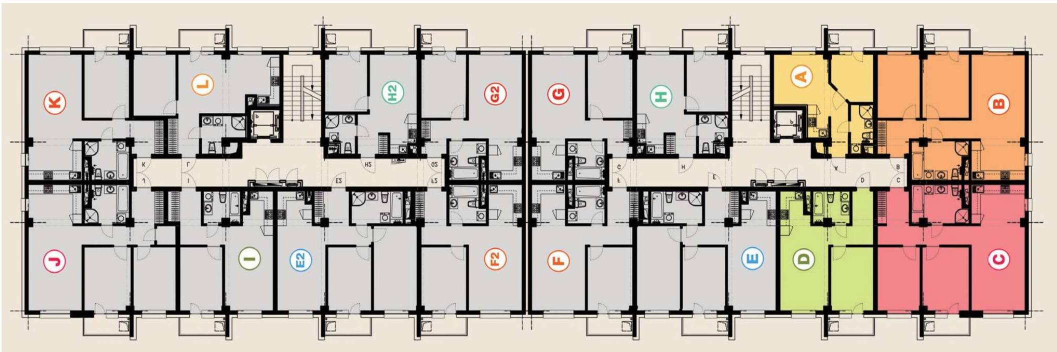


Figure 4-14 Floor Plan with Multiple Types of Units

Figure 4-15 Image of Completed C-Type Housing Unit

To study decarbonized model buildings in the facility, we conducted field survey. (Refer to Figure 4-16.) We also used an infrared thermography camera for simple measurement of the heat loss of the building and confirmed the loss on the balcony and at windows. (Refer to Figure 4-17.)

Figure 4-16　Exterior Features (SERENE TOWN)

Figure 4-17　Confirmation of Heat Loss by Thermographic Measurement

（2）　B block of new Ulaanbaatar city hall

In Ulaanbaatar, a large-scale housing development project is planned in the Yarmag district located between the new airport and city center and the city hall is relocated to form a new city center. Figure 4-18 shows the location of new city hall. Rainwater collection facility construction is also planned and ecological city development is studied. The new city hall is constructed in the district. The city hall consisting of A block building that has been already completed, B block building under construction and C block building has a total floor area of 68,000m2. The construction area of 13-story B block building with one basement floor is 2,500m2 and employees are planned to move there around June 2022.

To study the facility for decarbonized model buildings, we obtained construction drawings (Figure 4-19) of the Block B building, and conducted field survey of the already completed A block and B block under construction (Figure 4-20).

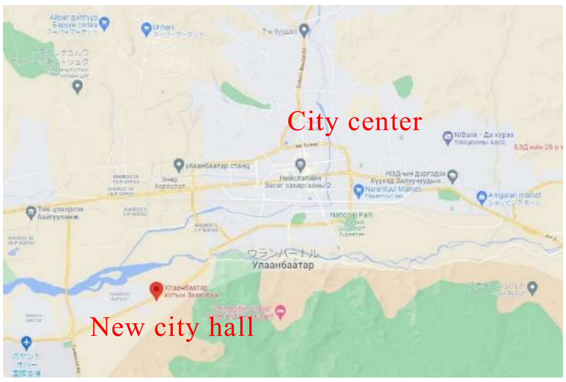


Figure 4-18　Location (B Block of New Ulaanbaatar City Hall)

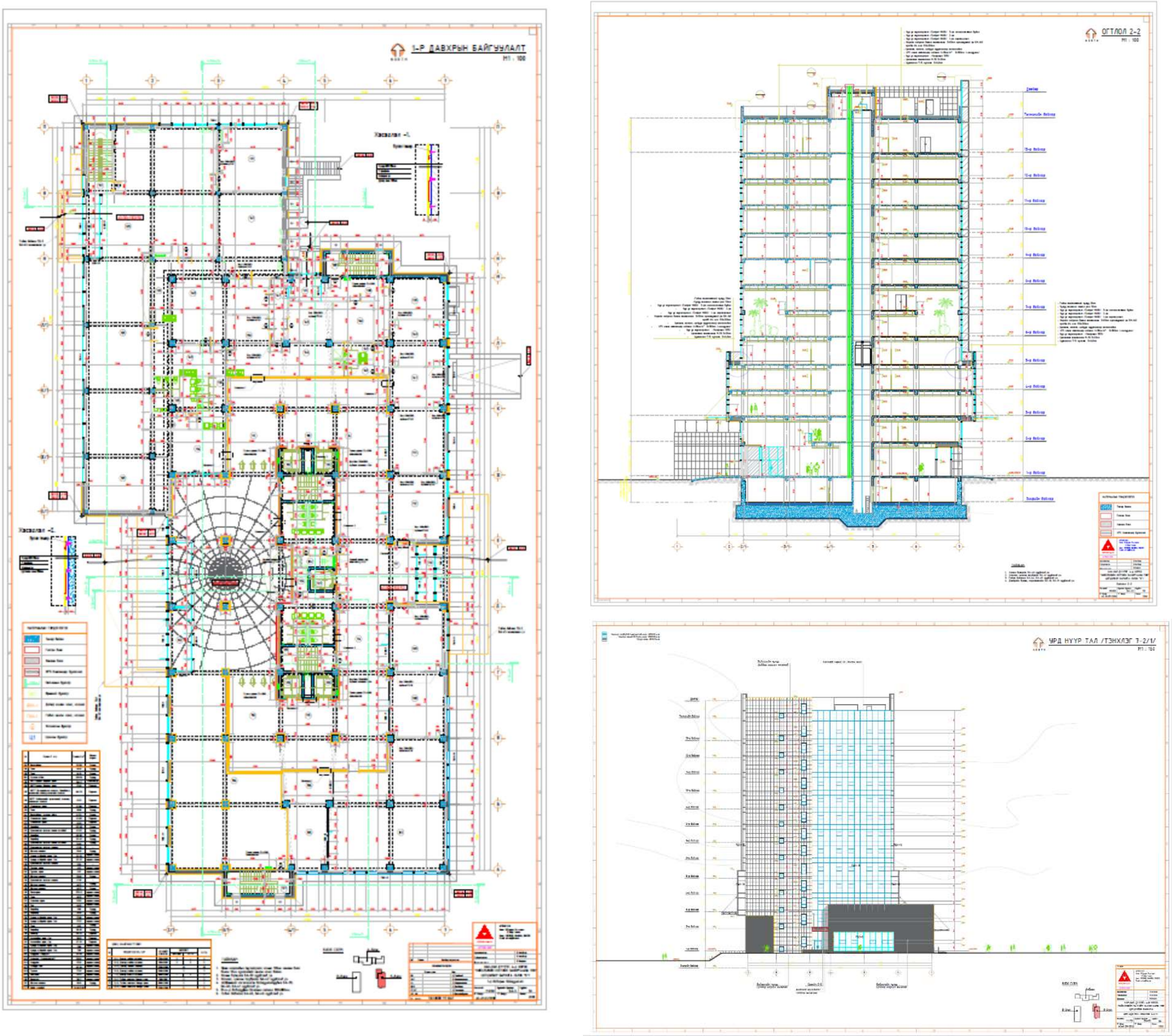


Figure 4-19 Floor Plan and Cross-Section Drawing (B Block of New Ulaanbaatar City Hall)

Figure 4-20 Exterior Features (Completed A Block and B Block under Construction of Ulaanbaatar City Hall)

4.4 Consideration of effects of decarbonized model buildings

4.4.1 Calculation method for decarbonized model buildings

The Energy Consumption Performance Calculation Program (Ver. 3.1.2) developed by the Building Research Institute (known as the "Web program") is applied to calculate figures for decarbonized model buildings.

This Web program is a tool developed for calculating annual primary energy consumption as a set forth in the Act on the Improvement of Energy Consumption Performance of Buildings. The calculation method includes a standard entry method, model building method and small model building method. To obtain ZEB and ZEH certifications in Japan, the standard entry method must be applied for the calculation.

■ Overview of the standard entry and model building methods of the Web program in Japan.

(1) Method under Item 1-(1), Paragraph 1, Article 1 of the standard ministerial ordinance ("standard entry method")

This method confirms that a building conforms to the relevant standards by confirming that the design primary energy consumption, determined using the calculation method provided for by 1-1 of calculation notice, does not exceed the benchmark primary energy consumption determined using the calculation method as set forth in 1-2 of the calculation notice. There is a need to enter floor areas and installed equipment per room in the building.

(2) Method under Item 1-(2), Paragraph 1, Article 1 of the standard ministerial ordinance ("model building method")

This method confirms that a building conforms to the relevant standards by confirming that design primary energy consumption of model building with the same usage as the applied building does not exceed benchmark primary energy consumption of the model building. Unlike the standard entry method entering by room, it is required to enter performance value of major building materials and equipment in the whole building.

Figure 4-21 shows a calculation image using the Web program. Calculation by the Web program determines annual primary energy consumption by accumulating the energy consumption of air-conditioners, ventilators, lightings, etc. in both standard specifications and specifications considered energy-efficient methods (design specification).

Japanese standards apply the Building Energy Index (BEI) as the benchmark for the primary energy consumption of housing blocks and buildings. BEI assesses by dividing design primary energy consumption of a building to be constructed by the benchmark primary energy consumption defined in the region, building usage, room use condition and other factors.

When BEI≦0.50, 0.00<BEI≦0.25 and BEI≦0.00, they are determined as ZEB Ready (50% or more energy is reduced), Neary ZEB (75% or more energy is reduced) and NET ZERO, respectively and judged to be conforming with ZEB (Figure 4-22).

Here, the primary energy consumption refers to unprocessed energy, including petroleum, coal, nuclear power, natural gas, hydropower, geothermal and solar heat while the secondary energy includes electric power and city gas obtained by converging and processing the primary energy.

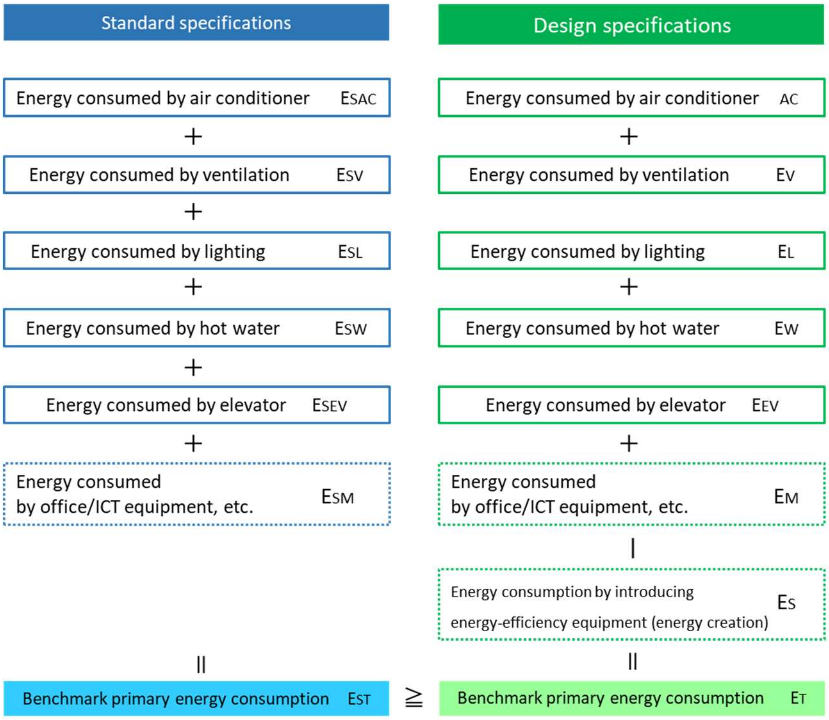
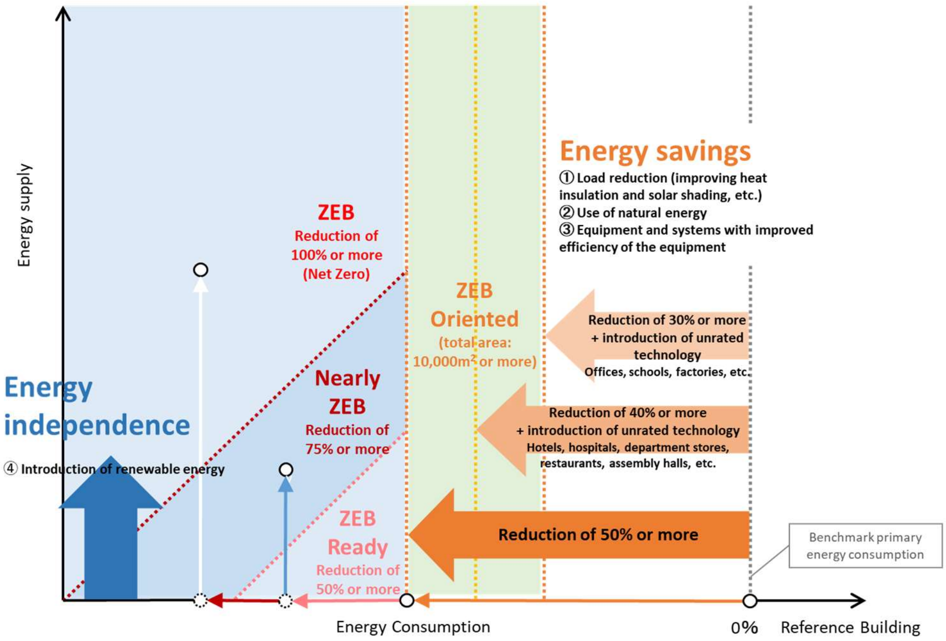


Figure 4-21 Image of calculation using the Web program



Status	Qualitative definition
ZEB	A building with annual primary energy consumption of net zero or lower.
Nearly ZEB	A building with nearly zero annual primary energy consumption by introducing renewable energy, the status of which is exceedingly the same as ZEB and meeting the ZEB Ready requirements.
ZEB Ready	A building with high thermal insulation installed on the building skin and high-efficiency energy-saving equipment as an advanced building aiming to meet ZEB.
ZEB Oriented	A building with high thermal insulation installed on the building skin and high-efficiency energy-saving equipment as an advanced building aiming to meet ZEB as well as measures taken to conduct further energy saving.

Source: ZEB PORTAL, MOE

Figure 4-22 ZEB criteria in Japan

In the Web program, the performance values of the building skin, air-conditioners and lighting are entered in the excel format as follows. The data is imported to the Web program for online calculation.

In Japan, the Web program is applied as a basic calculation method of ZEB and ZEH, which engineers with a general knowledge of architecture can also handle.

①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	
		Enter ③&④ or ⑤								
Building skin name	Direction	Width (W)	Height (H)	Building skin area	Heat insulation specification	Fitting specification title	No. of fittings	Blind installation	Sunscreen effect factor	
		[m]	[m]	[m^2]					Cooling	Heating
(Enter)	(Select)	(Enter)	(Enter)	(Enter)	(Transcript)	(Transcript)	(Enter)	(Select)	(Enter)	(Enter)
West exterior wall	West			840	Heat insulation material 2	Window A	10	Installed		
						Window B	10	Installed		
						Window C	10	Installed		
East exterior wall	East			840	Heat insulation material 2	Window A	10	Installed		
						Window B	10	Installed		
South exterior wall	South			800	Heat insulation material 2	Window A	10	Not installed	0.92	0.96
						Window B	10	Installed	0.92	0.96
						Window C	10	Installed		
North exterior wall	North			800	Heat insulation material 2	Window C	10	Installed		
						Window C	10	Installed		
						Window C	10	Installed		
Rooftop	Rooftop			1000	Heat insulation material 1					

Figure 4-23 Image of entering building system specifications in the Web program

BEI Calculation screen of the Web program

Figure 4-24 BEI Calculation in the Web program

The Web program was outlined to NOSK engineers and their strong interest and significant needs were confirmed. Given the need to calculate the energy consumption performance properly when implementing a JCM model project in future, the Web program was outlined; focusing on Mongolian interests as an alternative document to the JCM Project Promotion Handbook as initially planned. Since the Japanese Web program cannot be directly applied in Mongolia, it summarized the concept of how energy consumption performance is calculated to meet ZEB. The survey team explained the collective outline to Ulaanbaatar City personnel during an online workshop and shared a Mongolian translation with the city (Appendix).

4.4.2 Calculation of energy consumption performance

（1） Energy consumption reduction

1） Apartment housing blocks (SERENE TOWN)

The following table describes the calculation result of primary energy consumption of decarbonized model buildings in apartment housing blocks (SERENE TOWN).

As shown, the primary energy consumption was reduced by applying a Mongolian ZEN technology, where an air-conditioner with a geothermal heat pump has a greater effect. When applying the Mongolian ZEB technology to each case, annual energy consumption can be reduced by around 45% compared with when no measures are taken.

Table 4-12 Primary energy consumption of decarbonized model buildings in apartment housing blocks

Unit: GJ

Case	Case 0	Case 1	Case 2	Case 3	Case 4
Case overview	(without measures taken)	(Case 0 + building skin)	(Case 1 + lighting, hot water supply, ventilation)	(Case 2 + geothermal)	(Case 3 + solar)
Heating system	5,455	4,688	4,013	2,526	2,526
Cooling system	37	39	39	39	39
Ventilation system	228	228	385	385	385
Hot water supplying system	1,752	1,752	1,752	1,618	1,618
Lighting system	231	231	185	185	185
Other systems	1,058	1,058	1,058	1,058	1,058
Power generation system (solar)	--	--	--	--	-846
Total	8,763	7,997	7,433	5,811	4,966
BEI (reference)	1.03	0.94	0.87	0.68	0.58

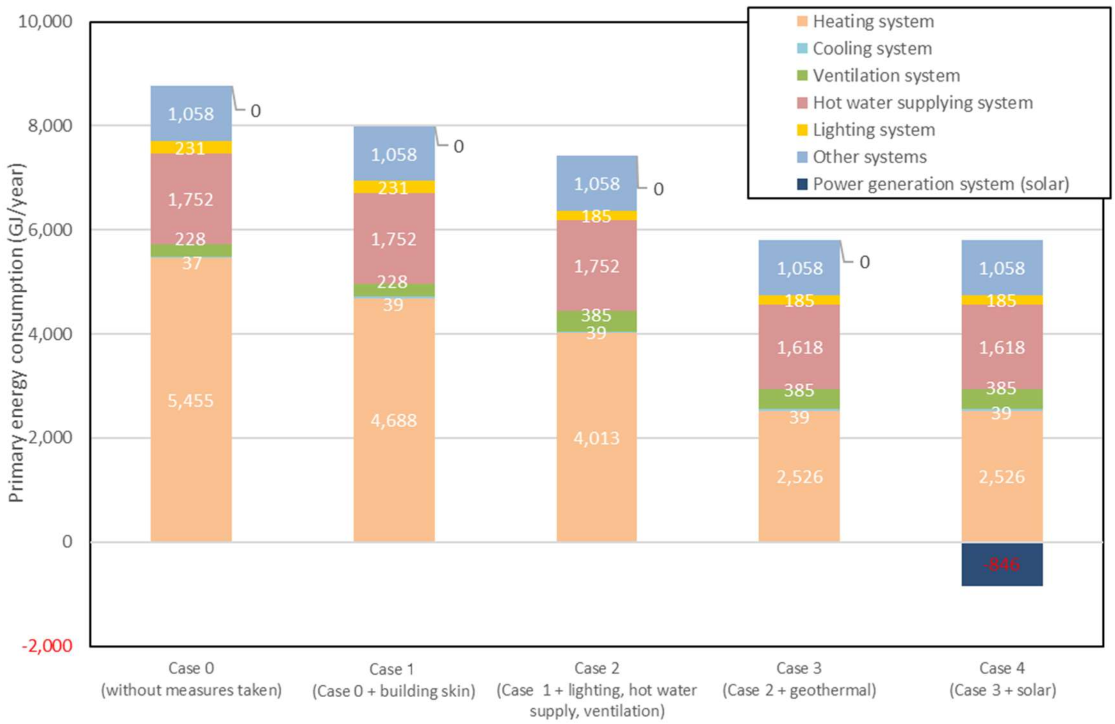


Figure 4-25 Primary energy consumption of decarbonized model buildings in apartment housing blocks

2） Office buildings (new Ulaanbaatar City Hall building)

The following table describes the calculation result of the primary energy consumption of decarbonized model office buildings (new Ulaanbaatar City Hall B Block).

Since it is a relatively new building and expected to have good insulation performance, the decarbonization effect of the building skin (high insulation performance) in Case 1 is minimal. However, high-efficiency equipment in Case 2 shows a considerable effect, thanks to improved lighting and ventilation.

As for the geothermal heat pump in Case 3, no significant effect was confirmed since the energy consumption of the air-conditioning system does not exceed that in apartment housing blocks. Similarly, solar power generation in Case 4 shows no significant effect because the percentage of power generation for overall energy consumption is low.

The insulation performance of target buildings is less than expected for office buildings. Accordingly, targeting those buildings with a larger air-conditioning load will increase the decarbonization effect achieved.

Since geothermal heat pumps require bore halls to collect heat, the larger the air-conditioning load, the more bore holes are needed and the wider the heat exchanger network should be. The new city hall, the project facility, is equivalent to a large-scale office and will require many spaces for bore hole installation. Accordingly, a geothermal heat pump is more likely to be applicable to small- and medium-scale offices with sufficient space for bore hole installation.

Table 4-13 Primary energy consumption of decarbonized model office buildings

Design primary energy consumption Unit: GJ/year

		Case 0	Case 1	Case 2	Case 3	Case 4
		(without measures taken)	(Case 0 + building skin)	(Case 1 + lighting, hot water supply, ventilation)	(Case 2 + geothermal)	(Case 3 + solar)
BEI (reference)	Heating system	17,122	16,598	15,841	13,945	13,945
	Cooling system	0	0	0	0	0
	Ventilation system	20,567	20,567	10,284	10,284	10,284
	Hot water supplying system	956	956	956	956	956
	Elevator	0	0	0	0	0
	Power generation system	0	0	0	0	-175
	Others	11,724	11,724	11,724	11,724	11,724
Total		50,368	49,845	38,804	36,908	36,733
Total (others excluded)		38,645	38,121	27,080	25,184	25,009
BEI (reference)		0.80	0.79	0.56	0.52	0.52

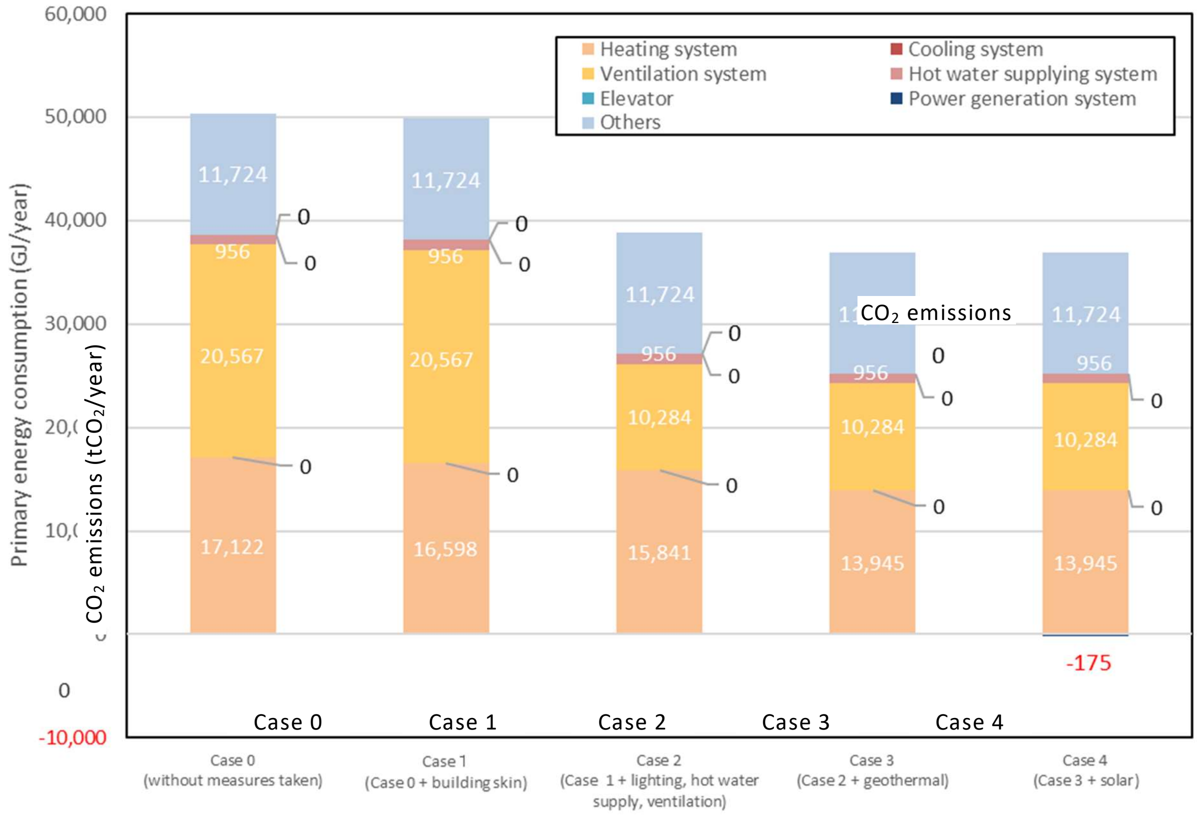


Figure 4-26 Primary energy consumption of decarbonized model office buildings

（2） GHG reduction

1） Calculation of GHG reduction

GHG reduction is calculated by multiplying CO_2 emission factors by energy consumption. Assuming that coal-fired power generation plants will be abolished and renewable energy being introduced across Mongolia, the renewable energy emission factor in Mongolia is applied.

■ Emission factor in Ulaanbaatar City

Emission factor (renewable energy) 0.797 kg－CO2/kWh

0.221 kg－CO2/MJ

Source: Emission factors applied in FY2021 JCT model projects

2） Apartment housing blocks (SERENE TOWN)

CO2 emissions of the decarbonized model building in apartment housing blocks are calculated as follows. As Case 3 shows, CO2 is significantly reduced by introducing a geothermal heat pump. When applying to Case 4, the CO2 reduction rate achieves 46% and a significant reduction effect can be obtained.

Table 4-14 CO2 emissions of decarbonized model buildings in apartment housing blocks

	Energy consumption (GJ/year)	CO2 emissions (tCO2/year)	Reduction rate
Case 0	8,763	1,940	-
Case 1	7,997	1,770	9%
Case 2	7,433	1,646	15%
Case 3	5,811	1,287	34%
Case 4	4,966	1,099	43%

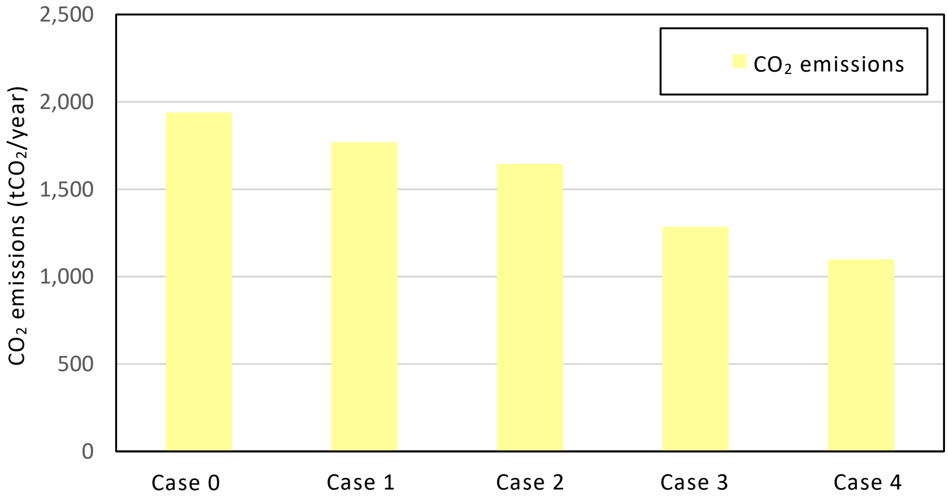


Figure 4-27 CO2 emissions of decarbonized model buildings in apartment housing blocks

3） Office buildings (new Ulaanbaatar City Hall building)

The following table describes the calculation result of CO2 emissions in decarbonized model office buildings. Case 2 shows an example of particularly large CO2 emission reduction by introducing high-efficiency equipment.

When applying to Case 4, the CO2 reduction rate is around 27%, smaller than for apartment housing blocks. The percentage of electricity consumption was originally high in the new Ulaanbaatar City Hall building but energy consumption by air-conditioners is small, leading to the result shown.

As mentioned, introducing high-efficiency equipment (Case 2) certainly reduces energy consumption. Accordingly, it is preferable to target those buildings generating more energy due to the use of air-conditioners and lower insulation performance to achieve higher reduction effects.

Table 4-15 CO2 emissions of decarbonized model office buildings

	Energy consumption (GJ/year)	CO2 emissions (tCO2/year)	Reduction rate
Case 0	50,368	11,151	-
Case 1	49,845	11,035	1%
Case 2	38,804	8,591	23%
Case 3	36,908	8,171	27%
Case 4	36,733	8,132	27%

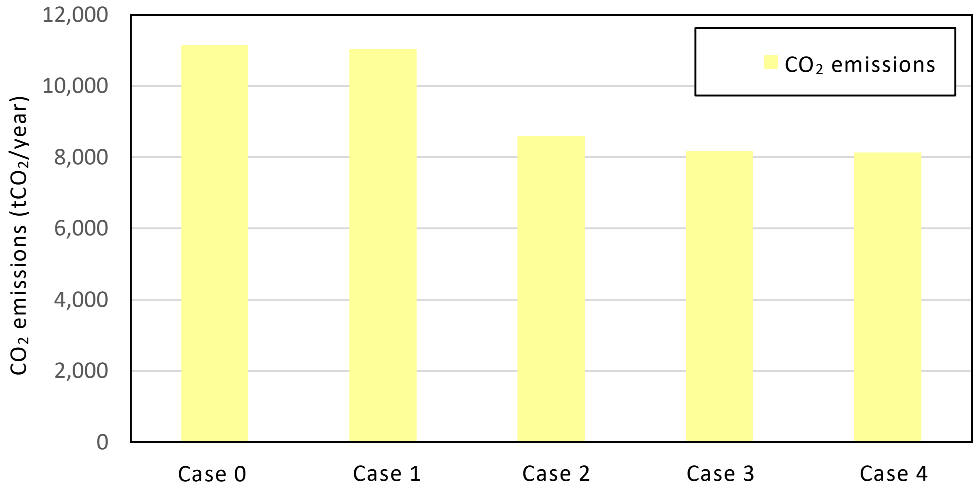


Figure 4-28 CO2 emissions of decarbonized model office buildings

4.4.3 Consideration of cost-effectiveness

The construction cost and cost-effectiveness of applying a decarbonized model building shall be calculated using the following formula After considering the incremental construction costs assumed when changing specifications from a general building to a decarbonized model building, the reduction per ton of CO2 shall be calculated from the assumed GHG emission reductions described above in 4.4.2.

■Cost-effectiveness formula

Cost-effectiveness (yen/t-CO2) = incremental building costs due to decarbonized model buildings /GHG emission reductions from decarbonized model buildings

1） Apartment housing blocks (SERENE TOWN)

In the ZEH Design Guidelines for Apartment Housing Blocks of Japan, a price difference arose between cases of constructing a condominium for sale based on energy-saving standards in 2016 and adopting specifications of ZEH-M Ready. Figures were estimated based on manufacture interviews and a list price as follows. 15% of the rate of cost increase is estimated overall.

Table 4-16 Comparison of costs by specification change

Category	Standard specifications	Increased amount	Estimation including increased amount	increase rate
	(I0,000 JPY)	(I0,000 JPY	(I0,000 JPY)	
Temporary work	9,337	484	9,821	105%
Civil engineering work	4,391	0	4,391	100%
Foundation work	5,836	0	5,836	100%
Frame construction work	32,681	0	32,681	100%
Building skin insulation	41,185	3,343	44,528	108%
Electrical system (lighting/solar)	8,948	3,602	12,550	140%
Plumbing (hot water supply/cogeneration)	11,561	8,698	20,259	175%
Air-conditioning system (cooling, heating,	2,279	1,236	3,515	154%
Elevator	1,167	0	1,167	100%
Miscellaneous expense	14,895	2,653	17,548	118%
Total	132,280	20,016	152,296	115%

Based on the cost increase rate, the cost of constructing an apartment housing blocks (SERENE TOWN) as decarbonized model buildings is calculated. This cost calculation assumes that decarbonization measures are taken in all cases.

If a decarbonized model building is not applied, the ordinary project cost per apartment housing building is assumed as follows, referring to the apartment housing price in Ulaanbaatar City.

■ Estimation of construction costs forSERENE TOWN

Price per m2 of apartment housing in Ul	1,950,000	MNT/m2
(basd on real-estate price information in the east UB)		
Floor area of a SERENE TOWN building	4,800	m2
Project cost for a SERENE TOWN build	9,360,000,000	MNT
	25	MNT/JPY
	374,400,000	JPY

Moreover, as described in Table 4-17, the project cost is calculated by category based on the cost increase rate shown in Table 4-16 while the energy consumption of the air-conditioning system is calculated using the geothermal heat pump costs based on the result of the Feasibility Survey for Environment-Friendly Ground Source Heat Pump System in Mongolia implemented by JICA as follows.

Unit price per kW of geothermal heat pump	330,000 JPY/kW
(based on the JICA project formulation survey result)	
Capacity of geothermal HP system	402 kW
Increased cost by geothermal HP	132,660,000 JPY

Table 4-17 Construction cost of apartment housing blocks (SERENE TOWN) as decarbonized model buildings

Category	increase rate	Estimation (Case 0)	Estimation (Case 4)
		(1,000 JPY)	(1,000 JPY)
Temporary work	105%	24,144	25,396
Civil engineering work	100%	10,795	10,795
Foundation work	100%	14,347	14,347
Frame construction work	100%	80,342	80,342
Building skin insulation	108%	109,466	118,351
Electrical system (lighting/solar)	140%	30,853	43,273
Plumbing (hot water supply/cogeneration)	175%	49,804	87,274
Air-conditioning system (cooling, heating, ventilation)	154%	8,641	132,660
Elevator	100%	2,869	2,869
Miscellaneous expense	118%	43,139	50,823
Total	115%	374,400	566,130

Based on the above cost, the cost-effectiveness is calculated as follows. The expected cost-effectiveness is 4,000 JPY/tCO2 and 4,000 JPY/year or less as defined by JCM model project.

Increased cost by decarbonized model building	179,370,000 JPY
JCM subsidy rate	50%
Actual cost incurred by decarbonized model bu	89,685,000 JPY
CO2 reduction (reduction volume by Cases 0 a	841 tCO2/year
Useful life of building	47 year
Cost effectiveness	2,270 JPY/tCO2

2） Office buildings (new Ulaanbaatar City Hall buildings)

In the ZEH Design Guidelines (for medium-size offices) of Japan, price differences arose between cases where a medium-sized office was constructed based on energy-saving standards in 2016 and the adopted specifications of ZEB Ready were estimated based on manufacturers' interviews and list prices as follows. 12% of the rate of cost increase as a whole is estimated.

Table 4-18 Comparison of cost by specification change

Category	Increased amount (I0,000 JPY)	Estimation including increased amount (I0,000 JPY)	increase rate
Finishing work (high-insulation / solar shading)	120	1,160	112%
Air-conditioning system (air conditioning + ventilation)	160	423	161%
Electrical system (lighting)	56	393	117%
Plumbing (hot water supply)	1	191	100%
Elevator	0	69	100%
Temporary work	24	246	111%
Civil engineering work	0	111	100%
Foundation work	0	144	100%
Frame construction work	0	741	100%
Miscellaneous expense	53	457	113%
Total	414	3,935	112%

Based on the cost increase rate, the cost of constructing office buildings (new Ulaanbaatar City Hall buildings) as decarbonized model buildings is calculated. This cost calculation assumes that decarbonization measures are taken in all cases.

The total project costs for all three blocks in the new Ulaanbaatar City Hall building is 9.5 billion MNT (approx. 3.9 billion JPY). In case the decarbonized model building is not applied, the ordinary project cost of the building in B Block is estimated by its floor area and references the above total costs as follows:

■ Estimation of construction costs for the new City Hall building (Case 0: without measures taken)

All three Blocks in the new Ulaanbaatar	Floor area	68,000	m2
	Total pro	97,000,000,000	MNT
		25	MNT/JPY
		3,880,000,000	JPY
Block B in the new Ulaanbaatar City Ha	Floor area	33,631	m2 (estimation)
	Project cc	1,919,000,000	JPY (estimation)

Moreover, as described in Table 4-19, the project cost is calculated by category based on the cost increase rate shown in Table 4-18 while the energy consumption of the air-conditioning system is calculated using the geothermal heat pump costs based on the result of the Feasibility Survey for Environment-Friendly Ground Source Heat Pump System in Mongolia implemented by JICA as follows.

Unit price per kW of geothermal heat pump	330,000	JPY/kW
(based on the JICA project formulation survey result)		
Capacity of geothermal HP system	2,340	kW
Increased cost by geothermal HP	772,200,000	JPY

Table 4-19 Construction cost of office buildings (new Ulaanbaatar City Hall buildings) as decarbonized model buildings

Category	increase rate	Estimation (Case 0)	Estimation (Case 4)
		(1 mil. JPY)	(1 mil. JPY)
Finishing work (high-insulation/Solar Shading)	112%	566	634
Air-conditioning system (air-conditioning+ventilation)	161%	206	772
Electrical system (lighting)	117%	192	225
Plumbing (hot water supply)	100%	93	93
Elevator	100%	34	34
Temporary work	111%	120	133
Civil engineering work	100%	54	54
Foundation work	100%	70	70
Frame construction work	100%	361	361
Miscellaneous expense	113%	223	252
Total	112%	1,919	2,628

Based on the above cost, the cost-effectiveness is calculated as follows. The expected cost-effectiveness is 4,000 JPY/tCO2 and 4,000 JPY/year or less, as defined by the JCM model project.

Increased cost by decarbonized model buildin;	773,200,000	JPY
JCM subsidy rate	50%	
Actual cost incurred by decarbonized model b	386,600,000	JPY
CO2 reduction (reduction volume by Cases 0 a	3,019	tCO2/year
Useful life of building	47	year
Cost effectiveness	2,725	JPY/tCO2

Therefore, if JCM is to be used in the future, it should be applied to lighting, hot water supply, ventilation, energy conservation (geothermal heat pumps and solar thermal), and energy creation (photovoltaic power generation), excluding the outer skin (enhanced insulation) in Case 4. As an example of the JCM equipment subsidy project, there is an initiative to install high-efficiency chillers, air conditioners with built-in total heat exchangers, heat pump water heaters, and parking lot ventilation systems for smart urban development. The project can be linked to specific proposals for energy improvements.

4.5 Effects of decarbonized model buildings and future consideration

The result of considerations as to whether to apply decarbonized model buildings to apartment housing blocks and office buildings in each case as shown in 4.4 is summarized as follows:

Apartment housing blocks (e.g. SERENE TOWN)

- Primary energy consumption can be reduced by applying decarbonized model building technology on a case-by-case basis (air-conditioners using geothermal heat pumps are particularly effective).
- When applying decarbonized model building technology to all four cases, the energy consumption and CO2 emissions can be reduced by an annual total of around 45% compared to when no technology is approved.

Office buildings (e.g. new Ulaanbaatar City Hall buildings)

- The target buildings are relatively new and expected to achieve good insulation performance. Accordingly, the decarbonization effect of installing a building skin (high insulation) in Case 1 is minimal.
- High-efficiency equipment in Case 2 has a significant decarbonization effect by improving lighting and ventilation systems.
- When applying a decarbonized model building to office buildings, a greater decarbonization effect is expected by targeting those building with a larger air-conditioning load ratio.
- Energy consumption and CO2 emissions can be reduced by approximately 30%.

Above all, it was confirmed that a sufficient decarbonization effect can be expected by applying decarbonized model building to apartment housing an office building. Based on this consideration, the policy for future activity is summarized as follows.

（1） Proposing a case of decarbonized model building application according to target building

Feasible combination between a building skin (reinforcing thermal insulation materials), lighting/hot water supply/ventilation systems and renewable energy (geothermal, solar heat and solar power generation) varies according to the usage, heat supply system and other preconditions of the target building. There is a need to consider a combination that further boosts the effects of decarbonized model buildings in reducing energy consumption and CO2 emissions. Accordingly, proposals should be feasible and on budget by also confirming the insulation performance status, energy consumption rate and other elements of the target building. For example, the method and reference setting for boosting insulation performance by installing a building skin will vary depending on whether constructing new buildings or repairing existing buildings. When installing a geothermal heat pump, target building should have sufficient space and a parking lot near the premises, allowing the installation to be complete, given the need to install bore holes to collect ground heat.

Moreover, this consideration focused on calculating decarbonization effects and the local procurement of construction materials required and their price were not fully confirmed. Accordingly, their confirmation will be needed when considering the project in detail.

（2） Proposing high-efficiency lighting and air-conditioning systems and a proper indoor environment

It was confirmed that a decarbonization effect could certainly be expected by introducing high-efficiency lighting and other systems as assumed in Case 2, regardless of the buildings to be targeted. As described in Section 2.4, central heating systems utilizing affordable coal are the mainstream option in winter in Ulaanbaatar City and completely replacing all such systems for decarbonized model buildings is unrealistic. A feasible option could include partially rolling out decarbonized model buildings on a pilot basis like ZEB Ready in Japan and subsequently disseminating lifestyle details. Proposals for high-efficiency lighting and air-conditioning systems do not involve significant up-front investment and are relatively easy to initiate as well as certainly obtaining a decarbonization effect.

In considering a decarbonized model building, a “proper indoor environment” was excluded from the ZEB design process as described in Table 4-6. However, promoting BEMS (Building Energy Management System) and HEMS (Home Energy Management System) as well as lighting/air-conditioning control will bring it closer to the initiative recommended by ZEB.

Since overheating caused by coal-fired heating systems is problematic in Mongolia, improving temperature control with proper air-conditioning will positively benefit human health. Introducing high-performance filters and an air purifying function is expected to lead measures against smog caused by coal smoke and PM2.5 air pollution which remain protracted issues in Mongolia. Since proper ventilation obtained by improving the air purifying function will also help prevent the spread of COVID-19, this is a new need of considerable interest during the COVID-19 pandemic.

As introduced to Ulaanbaatar City during the second-year activity of the project, a study by Hokkaido University confirmed the energy-saving effects of improving the indoor air environment in buildings in Sapporo City. Accordingly, Sapporo City is continuously expected to share its knowledge and experience in the process of energy conversion from coal.

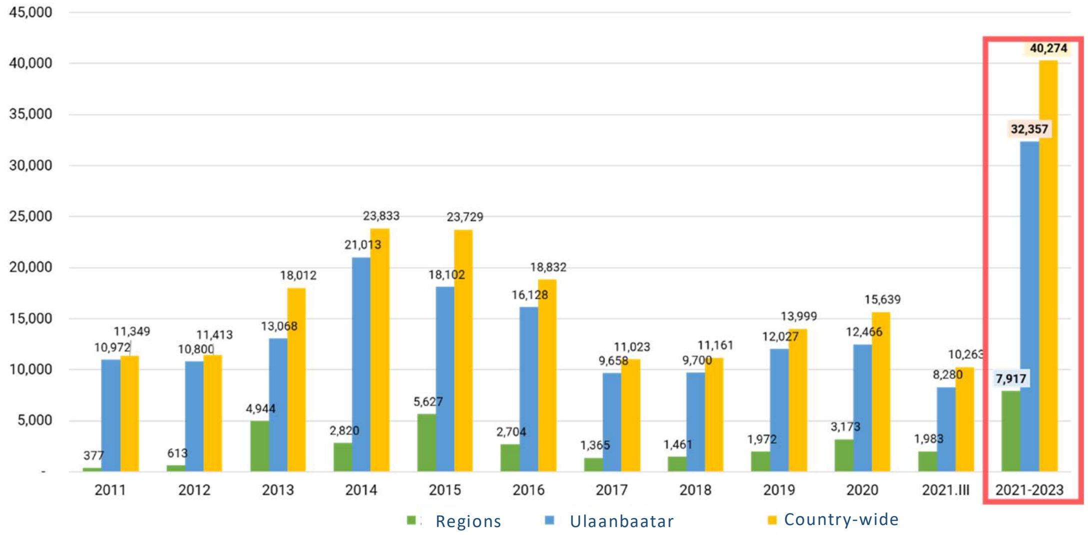
（3） Proposing future urban development and expecting demand for apartment housing blocks

In Mongolia, a future urban development plan has progressed, including the Ulaanbaatar City Master Plan, Ger Area Redevelopment Plan and Aero City Concept planning in accordance with a new airport opening and other plans. To mitigate traffic congestion in Ulaanbaatar City, there are also plans to construct apartment areas, hospitals, schools and various service centers in suburban areas (Tov Province and the Khushigt valley) under a policy for developing an aero city and as part of efforts to expand the decentralized city.

Subcenter formation is considered by a large-scale housing development centering on the new Ulaanbaatar City Hall building which is the target of decarbonized model building while the Ger Area Redevelopment Plan is also progressing by adopting a compact city concept such as SERENE

TOWN.

According to a NOSK survey, a new supply of 40,274 houses nationwide was confirmed nationwide between 2021 and 2023 as shown in Figure 4-29. Demand has rapidly doubled or more and further growth is expected by realizing an aero city in future.



Source: Housing Situations in Ulaanbaatar City

Figure 4-29 Housing (apartment) supply situation

The Ger Area Redevelopment Plan also indicates an NDC target in 2030 as described in Table 4-20, including target values for green buildings, reducing building heat loss and GHG emission reduction in the construction sector. According to NOSK, some survey results indicate that the cost burden of the green facility is the single biggest factor behind soaring housing expenses. Since demands to introduce specifications of decarbonized model building, including the utilization of JCM model projects, it is deemed possible to propose a project prospecting future markets.

Table 4-20 Targets in the Ger Area Land Redevelopment Plan

Criteria	Unit	2018	2021 target	2025 target	2029 target
Mechanization of construction works	%	60.9	61	62	65
Works volume	1 billion MNT	2,944	4,343	8,338	12,330
Green building assessment system	Systems	-	1	2	-
Green accredited building	Buildings	-	5	10	20
Reduction of building heat loss	%	-	20	30	40
GHG reduction in the construction sector	1000 tons CO2	0.3	10.9	30.1	53.7

Source: Housing Situations in Ulaanbaatar City

（4） Proposing by prospecting actual heat supply situation and future energy conversion

Mongolia has rich coal resources and its dependency is extremely high compared to other energy resources. In most cases, coal is used to generate power. Meanwhile, the Mongolian government has set targets which involve boosting the percentage of renewable energy to 20% by 2023 and 30% by 2030 under the national energy policy between 2015 and 2030.

The measures under 4.1.9 implemented as part of the Chapter Four program in the National Program for Reducing Air and Environmental Pollution adopted in 2017 prescribes abolishing hot-water boilers operating in Ulaanbaatar City and commercially connecting central and regional heating supply systems. Following these measures, heat-only boilers (HOBs) have been abolished in 30 to 40 locations every year. As of March 2020, although HOBs remained operational in 406 places, the number will be reduced annually. Accordingly, introducing new hot-water boilers in Ulaanbaatar City is infeasible. Since November 2020, fuels used in existing HOBs have been converted from unprocessed coals to improved fuels.

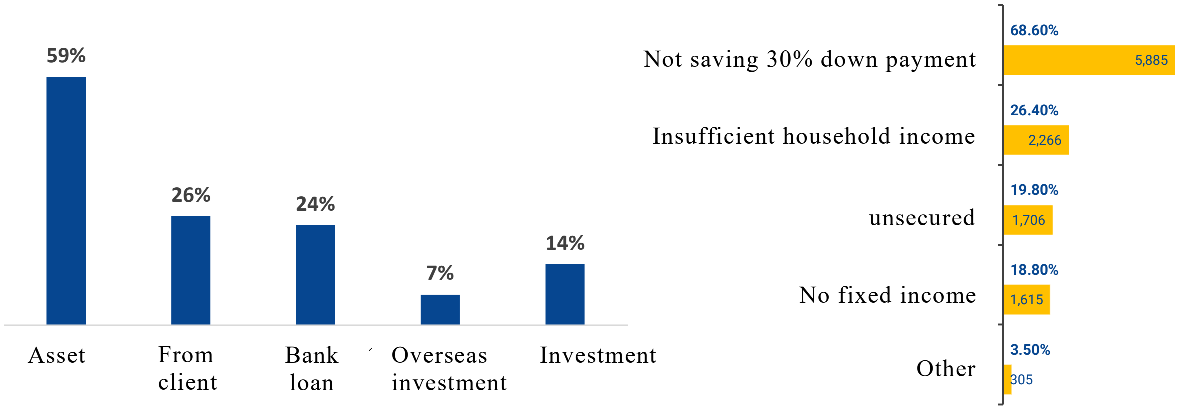
Improved fuels may include gas, oil and electricity generated by coals and renewable energy, but Mongolia currently depends on imports of gas and oil and the construction of an improved fuel manufacturing plant remains in the planning phase. Although wind power, hydropower, solar and geothermal energies can be utilized for renewable energy in Ulaanbaatar and its suburban areas, as described in Section 2.4.2, their supply remains insufficient. Technical development using improved fuels is also considered in the Capacity Development Project for Air Pollution Control in Ulaanbaatar City Phase 3 of JICA.

Cost issues notwithstanding, replacing coal by electrification may be the most practical method in Mongolia since an estimated 95% of households in Ger areas are connected to the power grid. However, as well as the cost challenges, the current network capacity remains insufficient for alternative measures and power supply is restricted during peak load.

As described above, proposals should also encompass the prospect of energy conversion in future while taking the actual heat supply situation in Ulaanbaatar City and Mongolia into account. New energy resources must also be proposed. For example, forests have become increasingly withered and damaged in Mongolia and withered trees covering 0.47 of a 1.2 billion m2 area of timber have remained unlogged, resulting in forest fires and hindering reforestation efforts, according to statistics of the Forest Policy Coordination Bureau of the Ministry of Environment and Tourism of Mongolia. Citing the regional heat supply system in Sapporo City as a reference benchmark, proposing heat supply using biomass resources can also be considered.

Chapter 5 Sharing Knowledge on Green Finance

To promote decarbonized model building, as described in the previous chapter, a financing plan for housing development and an apartment housing project which the Capital City Housing Corporation (NOSK) currently implements will be important. Amid growing demand for housing in Ulaanbaatar City, as shown in Figure 4-28 in Chapter 4, NOSK needs to promote a green finance mechanism as well as securing funds by financial products and diversified financing of domestic and overseas market, working with the Bank of Mongolia and other financial institutions to sustainably supply affordable housing. Figure 5-1 shows the breakdown of NOSK's current financial resources for its construction plan while the financial plan becomes an issue for customers purchasing homes, as shown in Figure 5-2. Accordingly, it is expected that scope to introduce decarbonized model building will increase when the financial support is addressed.



Source: Housing situations in Ulaanbaatar City

Figure 5-1 Financial sources of NOSK's construction projects and customer issues when purchasing homes

In the second year, the project shared knowledge on green finance and green buildings in Ulaanbaatar City with Japanese and overseas cases (Appendix). As part of efforts recommended by the MOE on measures to combat climate change and provide financing in developing countries, the project will also outline the Green Climate Fund (GCF) and the efforts made by the Trade & Development Bank of Mongolia, the GCF accreditation entity, to discuss the potential to utilize the GCF and project formulation. In so doing, the potential to promote the introduction of low-carbon model buildings in future is also considered.

5.1 Overview of Green Bonds

Green Bonds are issued by companies and international organizations to raise funds needed for projects that help resolve global warming and other environmental issues (Green Projects). The proceeds are allocated exclusively to Green Projects and tracked and managed reliably while transparency is ensured by reporting.

As well as the evaluation and selection basis, information on comprehensive and sustainable environmental targets, strategies and policies (mid-term management plan, sustainability strategy, CSR strategy, etc.) and criteria and process (including potential environmental and social risks) of a Green Project are explained to investors. For example, proceeds are applicable for those Green

Projects with a GHG emissions reduction effect, in which “climate change mitigation and adaption” is set as an environmental target. Major types of Green Bonds and specific Green Projects using the proceeds are shown in Table 5-1 and Table 5-2.

Table 5-1 Example of Green Projects specifically using the proceeds

Renewable energy project	Projects including power distribution and transmission and equipment
Project for energy efficiency	Project for the new construction of highly energy-efficient buildings, repair of buildings to improve energy efficiency, energy storage, regional cooling and heating, smart grid, equipment, etc.
Project for pollution prevention and management	Wastewater treatment, GHG emission control, measures against soil contamination, 3Rs of wastes, heat recovery, etc.
Project to manage natural resources sustainably	Sustainable agriculture, fishery, aquaculture, forestry, etc.
Project for biodiversity conservation	Protection of coastal, marine and river basin environment
Projects for clean transportation	Low-emission vehicles including electric vehicles and hydrogen-fueled vehicles, public transportation and railway, automobile, combined transport and other infrastructure development.
Project for sustainable water resource management	Infrastructure for securing drinking water, urban drainage system, flood mitigation measures, etc.
Project for climate change adaption	Climate change observation, early warning system, etc.
Project related to environmentally friendly products and manufacturing technology/process	Development and introduction of eco-friendly products, eco-label and accredited products.

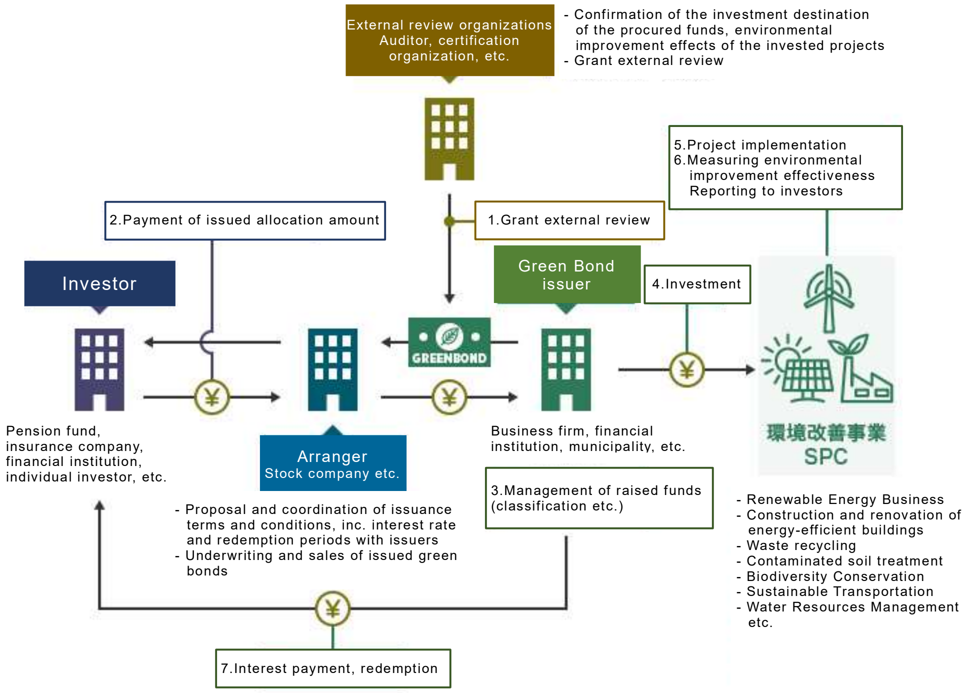
Source: Green Bond Guidelines 2017, Ministry of the Environment of Japan

Table 5-2 Types of Green Bonds

Type	Overview
Standard Green Use of Proceeds Bond	This bond is issued to raise funds for Green Projects. It constitutes recourse-to-the-issuer debt and its redemption does not depend on the cash flows of specific Green Projects.
Green Revenue Bond	This bond is issued to raise funds for Green Projects. It is a non-recourse-to-the-issuer debt and its redemption depends on the cash flows of public Green Projects such as usage fees and special taxes on public facilities linked to Green Projects. For example, bonds for which proceeds are allocated to develop and operate waste treatment sites by extra-governmental organizations and where redemption is only possible via revenue from projects.
Green Project Bond	This bond is issued to raise funds for Green Projects. It is a project bond and its redemption depends on the cash flows of one or multiple Green Projects. For example, the bonds in this category are issued by SPCs that exclusively engage in renewable energy generation projects for which proceeds are allocated to develop and operate facilities and so on and can be redeemed only by the revenue from the projects.
Green Securitized Bond	The bonds in this category usually have multiple assets linked to Green Projects (including loan claims, lease claims and trust beneficiary rights) that are used as collateral and redeemed using cashflows from these assets. For example, ABS (Asset Backed Securities), backed by assets like loan claims linked to solar panels, energy-efficient appliances, equipment, houses and low-emissions vehicles, such as electric vehicles and hydrogen vehicles, belong to this category.

Source: Green Bond Guidelines - Green Loan and Sustainability Linked Loan Guidelines, Ministry of the Environment of Japan

Figure 5-2 shows a general scheme in Green Bond issuance. As well as issuers, investors and arrangers of Green Bond involved, the involvement of external environmental review providers differs from ordinary bonds. Major stakeholders, their roles and examples of businesses and organizations are described in Table 5-3.



Source: The Green Bond Issuance Promotion Platform, the Ministry of the Environment

Figure 5-2 Common Green Bond issuance scheme

Table 5-3 Green bond stakeholders

Stakeholder	Role	Example of businesses/organizations
Issuers	To Issue Green Bonds	- General business operators raising funds for their green projects - Financial institutions raising investment funds and loans for Green Projects - Local governments raising funds for Green Projects
Investors	To Invest to Green Bonds issued	- Institutional investors, such as pension funds and insurance companies, which commit to ESG investment. - Investment managers entrusted with managing ESG investments and individual investors who focus on the use of the proceeds.
Arrangers	Underwrite Green Bonds issued and distribute to investors	- Organizations and entities (mainly security companies) proposing and arranging issuance conditions (interest rate, redemption period, etc.) when Green Bonds are issued
External review providers	Entities objectively assessing appropriate use of the proceeds of Green Bonds and environmental improvement effect by Green Project (auditing company, accreditation body, etc.)	- Auditing company, accreditation body, etc. - Issue an external review for Green Bond issuers (as required)

Source: prepared by the Study Team based on the Green Bond Issuance Promotion Platform, Ministry of the Environment of Japan

For the issuers and investors listed above, the expected benefits of Green Bonds include the following:

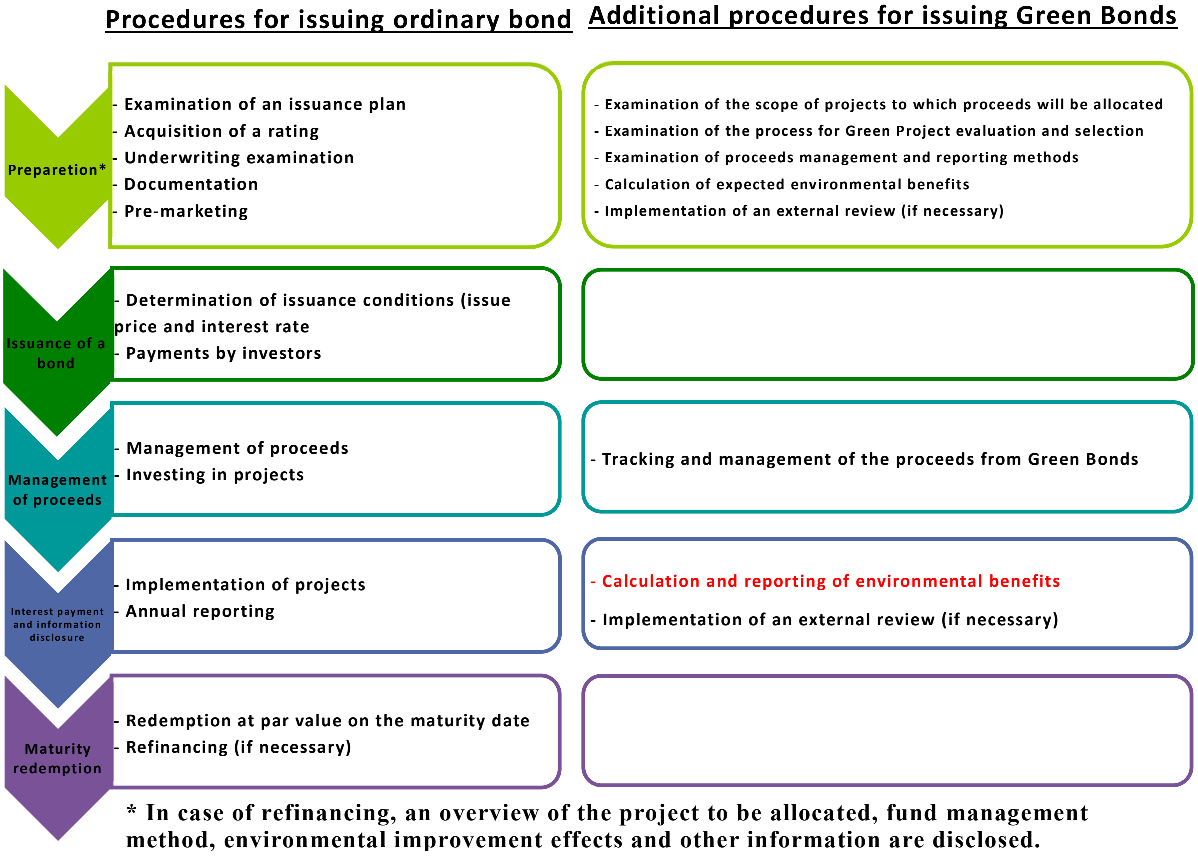
<For issuers>

- Help advance sustainability management.
- Help promote active appeals and social support for Green Project promotion since transparency is ensured.
- Help enhance a funding base by forging relations with new investors who are keenly focused on environmental issues and ecotechnology.
- Potential to raise funds from emerging renewable energy operators, etc.

<Investors>

- As ESG investment considering environment, social and governance elements, to help identify investment goals that could elicit transparent and stable profit.
- Following the adoption of the Paris Agreement, allow direct investment in projects via related Green Bonds with significant investment demand.
- The project evaluation and selection process are fully explained in advance.
- Investment profit and environmental benefits can be balanced.

Investors in Green Bonds, in particular, expect their contributions to be allocated to Green Projects and promote environmental improvement. Accordingly, must also assert and profess that they issued Green Bonds and ensure their transparency. Issuers publicize updated information on how raised funds are used after their issuance in the disclosure stage of the Green Bond issuance flow as shown in Figure 5-3. Fund statement and environmental improvement effects are specified by project item, such as “wind power generation project”, “project related to the introduction of high-energy-efficiency equipment” and “project on constructing and managing waste recycling facilities”. Disclosure of the environmental improvement effect include quantitative indicators, where applicable, as well as calculation methods and preconditions. If inapplicable, transparency is ensured by obtaining LEED, CASBEE and other external accreditations as described in Table 5-4.



Source: Green Building Guidelines, Ministry of the Environment of Japan

Figure 5-3 Common Green Bond issuance scheme

With the promotion of Green Projects by Green Bonds as described above, the following benefits are expected:

- Contribution to global environmental conservation
  Disseminating Green Bonds will help expand private funds to renewable energy, energy-saving and Green Projects, thereby contributing to substantial GHG reduction domestically and overseas in the long term. Moreover, it will also help prevent any decline in of natural assets, which represent the long-term profit basis for businesses.
- Raising awareness of green investment among individuals
  Dissemination of Green Bonds will raise individual awareness on green investment, which motivates institutional investors; entrusting the assets of such individuals to make green investments more actively and raises awareness of individuals on how their funds are used. Accordingly, greening of the economy is also expected.
- Help address socioeconomic issues via Green Project promotion
  Reducing energy costs, strengthening energy security, revitalizing the regional economy, enhancing disaster resilience and other positive outcomes are expected by promoting Green Projects.

5.2 Overview of green building

5.2.1 Definition of green building

There are no specified definitions of green building; the term is commonly used to refer to sustainable buildings, high-performance buildings, green architecture, buildings of nature and other terms. Recently, reference has frequently been made to high-functioning buildings with lower energy consumption than conventional buildings. The green building accreditation system applied worldwide is described in the table below. In Japan, CASBEE is also applied in Sapporo City, a cold region.

Table 5-4 Green building accreditation system in each country

Assessment standards	Country	Rating target	Overview
LEED	United States	- By target type (new and existing buildings, interior design for commercial use, school, retail use, healthcare and housing) - Others (neighborhood development)	- Developed by the U.S. Green Building Council composing representatives of each construction sector in 1996, aiming to provide rating criteria for the design, structure and operation of green buildings. - Rating items are categorized into six areas: landscaping, energy efficiency, resource conservation, environmental quality, water resource conservation and design.
BREEAM	United Kingdom	- By target type (custom-made criteria, courthouse, sustainable housing, existing housing, health and hygiene, industrial facility, international, prison, office, retail store, educational and community facilities)	- Developed by the Building Research Establishment (BRE), a British architectural institute and Energy and Environment (ECD), an energy and environmental consulting company, in 1990. - It aims to empower those who own, live, design and manage buildings, infrastructure or communities to take environmental considerations, encourage optimal design, operation, maintenance and management and make those buildings stand out and earn recognition by setting a broad range of scientifically rigorous requirements that transcend current regulations and practical norms. - BREEAM applies to both new and existing buildings and assesses up to nine areas: management, health and comfort, energy, transportation, water resources, materials, use of premises, regional ecosystems and pollution. - It is the world's first environmental value assessment benchmark and also widely used outside the U.K.
HQE	France	-	- Environmental value assessment criteria for real estates provided by the HQE Association and used from 1996. - This accreditation system was introduced in 2004. - Assessing real estates from four perspectives: environmentally aware building, environmentally aware management, comfort and health.
CASBEE	Japan	- By project stage (planning, new building, existing building, repair) - By target type (construction, housing, urban development, etc.) - Others (heat island)	- Since 2001, a committee within the Institute for Building Environment and Energy Conservation has developed a system to disseminate environmentally aware buildings under the initiative of the Ministry of Land, Infrastructure, Transport and Tourism. It has four basic tools (planning, new and existing buildings and repair) as well as building, housing, urban development and other extension tools for individual purposes. - Three basic concepts: (1) assessing via building life cycles, (2) assessing buildings from both environmental quality (Q) and environmental load (L) and (3) assessing by Building Environmental Efficiency (BEE), an assessment indicator newly developed by introducing the concept of environmental efficiency.

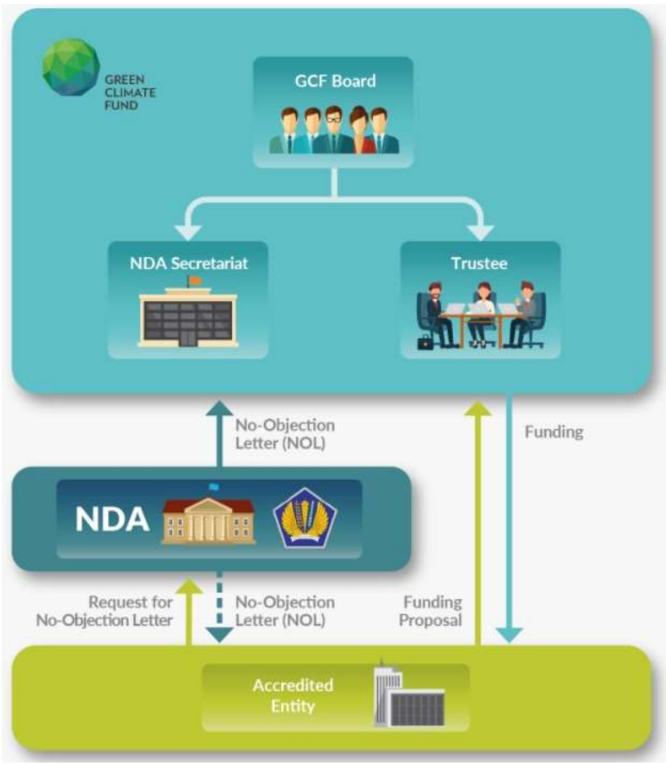
Source: The websites of the Institute for Building Environment and Energy Conservation, USGBC and BREEAM and "Sustainable Buildings in France: Progress Report" (Sustainable Building Conference 08)

5.3 Overview of Green Climate Fund (GCF)

The Green Climate Fund (hereinafter, the "GCF") is an international fund supporting the efforts of developing countries to control, reduce and absorb (mitigate) GHG emissions and address (adapt) the impact of climate change, aiming to promote a "paradigm shift" to ensure developing countries develop with low-carbon and climate-resilient elements. The GCF establishment was decided during the sixteenth session of the Conference of the Parties (COP16) held in 2010. Since 2015, it has started approving applicable projects.

GCF funding is allocated equally to mitigation and adaption measures and half the latter fund is allocated to island countries, least developed countries and Africa. Strategic priorities include "power generation and energy access", "transportation", "forest/land use" and "buildings / cities / industries / appliances" in mitigation measures while "health and well-being, food and water security", "livelihood of people and communities", "ecosystems and ecosystem services" and "infrastructure and the built environment" in adaption measures. Promotion of low-carbon model buildings considered in this project is deemed applicable for "buildings/cities/industries/appliances" in mitigation measures or "infrastructure and the built environment" in adaption measures.

The GCF is to implement and manage projects proposed by developing countries in line with the priority in their development plan and climate change policy, ensuring their project initiative. As specific procedures are described in the table below, applicants must submit funding proposals via accredited entities (AEs) to utilize GCF funds as well as submitting a "No objection letter" issued by the government of the country implementing the project (national designated authorities: NDA). The funding proposal is then examined at the GCF Board, which meets around three times annually. When the Board approves the proposal, GCF funds are provided to projects via AE.



Source: National Designated Authority Green Climate Fund Indonesia

Figure 5-4 Procedures in the GCF

AE is certified by the GCF Board as an entity with functions and roles that include applying funds to the GCF. AE can encompass international, regional and national organizations, private companies and NGOs. In July 2017, JICA and MUFG Bank were certified as the first Japanese AEs.

With the Trade & Development Bank of Mongolia (hereinafter, "TDB") being certified as an AE in 2020, Mongolia has maintained a system of financing national projects and programs to reduce GHG emissions and mitigate the disaster risks caused by climate change. A GCF technical assistance project aiming to expand sustainable green finance is also prepared in Mongolia.

Since 2020, TBD has established a green funding section and started distributing green loan products. Targeting electric heaters, thermal insulation materials, small processing plants, eco-toilets, electric vehicles, scooters and high-energy-efficiency housing and products, 187.9 billion MNT was used to fund 688 small- and medium-sized enterprise customers while approximately 156.6 billion MNT funded to 4,322 people. TDB issued 1,093 Green Loans in areas of air pollution reduction, renewable energy, fuel-efficient vehicles, water and energy efficiency and waste reduction; targeting green loan product development and growth in green loans. Meanwhile, TBD's social investment increased by 15% between 2019 and 2020. Between the third and fourth quarters in 2020, green loans among its asset portfolio increased by around 67% and from 2021 onwards, continuous growth is forecast. Since this project cooperates with TDB based on the expression of interest, TDB's green loans and funding by the GCF can be considered when concretely considering the introduction of low-carbon model buildings in this project.

After the United Kingdom, Japan is the next biggest donor to the GCF (see the table below). Japan has membership of the GCF Board as a board member and alternate board member. To actively contribute to the fund management, the third year of the project will include considering the feasibility of utilizing the fund as a city-to-city collaboration project based on a partnership between Japan and Mongolia.

Table 5-5 Funding to the GCF

Country	Initial contribution	First capital increase
U.K.	1.2 billion $ (0.72 billion £)	1.85 billion $ (1.44 billion £)
France	1 billion $ (0.77 billion €)	1.74 billion $ (1.55 billion €)
Germany	1 billion $ (0.75 billion €)	1.7 billion $ (1.5 billion €)
Sweden	0.58 billion $ (4 billion SEK)	0.85 billion $ (8 billion SEK)
U.S.	3 billion $ (of which, 1 billion $ for initial contribution)	No contribution
Japan	**1.5 billion dollars**	**Up to 1.5 billion $**
Others	2 billion $ in total	2.36 billion $ in total
Total pledges	Approx. 10.3 billion $ (approx. 0.83 billion $ contributed)	Approx. 10 billion $ in total

Source: The website of the Ministry of Foreign Affairs of Japan

In the case of Japan, JICA applied to the GCF for the Project for Building Climate-Resilient and Safer Islands, which was approved by the GCF Board in July 2021. As described in Table 5-6, however, the approval process is expected to be extended for the long term. Accordingly, there is a need to consider long-term efforts in utilizing the GCF.

Table 5-6 Overview and approval process of the Project for Building Climate-Resilient and Safer Islands

Country	Republic of Maldives
Project title	Project for Building Climate-Resilient and Safer Islands
Project period (planned)	April 2022 to September 2028 (78 months)
Amount of the GCF funds applied	25.1 million USD (approx. 2.65 JPY) (Total project amount: approx. 66 million USD (approx. 2.65 JPY)
Executing agency	Ministry of Environment, Climate Change and Technology
Target region	Nationwide
Specific project details	Maldives is located in an area of lower elevation and coastal erosion has become apparent in residential islands. Since this could be further exacerbated by rising sea levels or stronger waves due to climate change, the project aims to increase national land resilience and security by establishing a system to promote coastal conservation and protection measures considering the climate change impact. 1. Establishment of Integrated Coastal Zone Management (ICZM) 2. Implementation of Coastal Conservation/Protection Measures against Disasters 3. Development of Disaster Warning and Information Dissemination 4. Development of Basic Data Collection and Sharing System Related to Climate Change
Background to the approval	July 201 Approached by a Maldivian GCF alternate board member October 2017 Preliminary field survey September 2018 Submit concept note From January Commence a basic data collection/confirmation survey January 2020 Submit the first Funding Proposal January 2020 to April 2021 Coordination with the GCF secretariat May 2021 GCF Board meeting October 2021 Conclude a financing agreement between the GCF and JICA

Source: prepared by the Survey Team based on “introduction of GCF project proposal in Maldives, Nippon Koei Co., Ltd.

Chapter 6 Online Workshops

As part of this project, a total of four workshops were held online. Relevant organizations from Sapporo and Ulaanbaatar shared the policies and initiatives of each city. Companies with experience in the design and construction of low-carbon housing in cold regions and manufacturers of geothermal heat pumps also participated, discussing technical proposals and the potential for introducing geothermal heat pumps in Mongolia. The list of workshops held and the details of each are shown below. The Minutes of the Meeting and the materials used in the presentations are indicated in the Appendix.

Table 6-1 List of Online Workshops

	Date
1st Online Workshop	29 September 2021
2nd Online Workshop	1 December 2021
3rd Online Workshop	25 January 2022
4th Online Workshop	16 February 2022

6.1 1st Online Workshop

(1) Purpose

- To review the three-year project implementation policy, plans, and the results of last year's activities, and to reach an agreement on the details of this year's activities.
- To gain an understanding of the latest information on housing developments in Ulaanbaatar.

(2) Outcome

- The implementation policy and three-year plan for the project were explained, as were the details of activities for this year. Sapporo's expertise in technologies and initiatives in the field of housing and construction were then shared. And it was confirmed that low-carbon model housing specifications suited to the actual conditions in Ulaanbaatar would be considered.
- The housing development project under the jurisdiction of the Ulaanbaatar City Corporation and its progress were confirmed.

(3) Agenda

Time in Mongolia (Time in Japan)	Contents	Presenter
10:00-10:30 (11:00-11:30)	Opening Remarks by Ulaanbaatar City Opening Remarks by Sapporo City Opening Remarks by Iwata Chizaki Corporation	
10:30-11:40 (11:30-12:40)	1.Results of last year and initiatives for this year	Oriental Consultants
	2.Overview of Ulaanbaatar City Public Corporation and housing development projects	Ulaanbaatar City Public Corporation
11:40-11:55 (12:40-12:55)	Question and Answer	
11:55-12:00 (12:55-13:00)	Closing Remarks by Sapporo City	

(4) Minutes of the Meeting, presentation materials (Appendix A1-1 to 7)

6.2 2nd Online Workshop

(1) Purpose

- To understand the policies and future plans for housing developments in Ulaanbaatar.
- To promote an understanding of the JCM equipment subsidy program.
- To introduce ZEB and ZEH-M in Japan, and to promote an understanding of the energy savings and the benefits of low-carbon technologies in the field of housing and construction.

(2) Outcome

- Forecasts on future housing supply and demand in Ulaanbaatar were shared, as was the need for the redevelopment of ger districts and the introduction of area-based heating systems. The need for planned development and initiatives to reduce carbon emissions in the field of housing and construction fields were recognized.
- An outline of the JCM equipment subsidy project and case studies implemented in Mongolia were introduced, and the benefits of utilizing the JCM equipment subsidy project was recognized.
- Japan's ZEB and ZEH-M were introduced as low-carbon initiatives in the field of housing and construction. The need for specifications that introduced technology suitable for cold regions was recognized.

(3) Agenda

Time in Mongolia (Time in Japan)	Contents	Presenter
09:00-09:10 (10:00-10:10)	Opening Remarks by Ulaanbaatar City	Ulaanbaatar City
09:10-09:45 (10:05-10:25)	Planning and progress of the housing development project in Ulaanbaatar	Ulaanbaatar City Capital Public Corporation
09:45-10:00 (10:45-11:00)	Question and Answer	
10:00-10:15 (11:00-11:15)	Introduction of JCM Model Projects	Oriental Consultants
10:15-10:35 (11:15-11:35)	About ZEB Design in Japan	Hokuden Sogo Sekkei Corporation
10:35-10:55 (11:35-11:55)	Question and Answer	
10:55-11:00 (11:55-12:00)	Closing Remarks by Environment Bureau, Sapporo City	Environment Bureau, Sapporo City

(4) Minutes of the Meeting, presentation materials (Appendix A2-1 to 7)

6.3 3rd Online Workshop

(1) Purpose

- To promote an understanding of the importance of proper management of air conditioning systems and health hazards in cold climates.
- To develop an understand the technology used in geothermal heat pump systems and contribute to the consideration of their introduction in Ulaanbaatar.
- To report on the specifications of the low-carbon model housing under consideration and confirm future implementation policies.

(2) Outcome

- The presentation by Hokkaido University shared academic expertise on the management of air conditioning systems and health hazards in cold climates; the importance of appropriately managing air conditioning systems was recognized.
- The presentation by Zeneral HeatPump Industry Co., Ltd. introduced the technology used in geothermal heat pump systems as well as the installation study being conducted in Mongolia. The benefits of using geothermal heat in Ulaanbaatar was recognized.
- A report was made on the progress of proposals for an apartment building (Serene Town) and an office building (Ulaanbaatar New Government Building). The importance of estimating initial equipment costs and running costs as well as calculating energy savings was confirmed.

(3) Agenda

Time in Mongolia (Time in Japan)	Contents	Presenter
11:00-11:10 (12:00-12:10)	Opening Remarks by Ulaanbaatar City	Ulaanbaatar City
11:10-11:30 (12:10-12:30)	Appropriate air conditioning control and health hazard countermeasures for energy saving (PM2.5 Countermeasures)	Hokkaido University
11:30-11:50 (12:30-12:50)	Geothermal Heat Pump and Efforts in Mongolia	Zeneral Heatpump Industry Co., Ltd
11:50-12:05 (12:50-13:05)	Question and Answer	
12:05-12:30 (13:05-13:30)	Progress Report on the Study of Model Specifications for Cold Climate Housing in Mongolia	Iwata Chizaki Corporation
11:30-11:50 (13:30-13:50)	Question and Answer	
12:50-13:00 (13:50-14:00)	Closing Remarks by Sapporo City	Sapporo City

(4) Minutes of the Meeting, presentation materials (Appendix A3-1 to 7)

6.4 4th Online Workshop

(1) Purpose

- To review this year's results and discuss the policies for next year's initiatives.
- To report the results of the study on low-carbon model building specifications and to confirm the implementation policy from next year onward.
- To introduce the implemented case studies of ZEB in Japan and their economic impact, and to contribute to a study on applicability in Ulaanbaatar.

(2) Outcome

- As a result of this year, four model cases for low-carbon model building specifications were established. The calculated energy savings results for an apartment building (Serene Town) and office building (Ulaanbaatar New Government Building) were reported. Next year, the addition of applicable facilities and initiatives on a local basis will be considered. It was confirmed that studies on the availability of materials and equipment in Mongolia, cost effectiveness, and financing are to be conducted.
- An outline of ZEB and ZEH-M in Japan was introduced along with implemented case studies. A proposal was made for next year to promote an understanding of ZEB and ZEH-M, especially among engineers in public corporations.
- The presentation by Ariga Planning introduced specific ZEH initiatives in buildings in cold climates and contributed to an understanding of the effectiveness of installed technologies, including BEMS.

(3) Agenda

Time in Mongolia (Time in Japan)	Contents	Presenter
15:00-15:10 (16:00-16:10)	Opening Remarks by Ulaanbaatar City	Ulaanbaatar City
15:10-15:30 (16:10-16:30)	1.Review of this year's activities and policy for next year's activities	Oriental Consultants
	2.Outline for calculating energy-saving performance and collection of examples of ZEB/ZEH-M implementation	
15:30-15:45 (16:30-16:45)	Results of examine on Model Specifications for Cold Climate Housing in Mongolia	Iwata Chizaki Corporation
15:45-16:00 (16:45-17:00)	Question and Answer	
16:00-16:30 (17:00-17:30)	ZEB initiatives, introduce of office buildings with 100% ZEB	Ariga Planning Corporation
16:30-16:50 (17:30-17:50)	Question and Answer	
16:50-17:00 (17:50-18:00)	Closing Remarks by Environment Bureau, Sapporo City	Environment Bureau, Sapporo City

(4) Minutes of the Meeting, presentation materials (Appendix A4-1 to 7)