Mongolia
Ministry of Energy (MOE)
Energy Regulatory Commission (ERC)
National Dispatching Center (NDC)
National Power Transmission Grid State Own Stock Company (NPTG)
Ulaanbaatar Electricity Distribution Network Company (UBEDN)

Data Collection Survey for Low Carbonization/De-carbonization and Stabilization of Power System in Mongolia

Final Report

February 2022

Japan International Cooperation Agency (JICA)

Tokyo Electric Power Services Co., Ltd. (TEPSCO)
Tokyo Electric Power Company Holdings, Inc. (TEPCO)

IM
JR
22-026

Data Collection Survey for Low Carbonization/De-carbonization and Stabilization of Power System in Mongolia

Final Report

February 2022

Japan International Cooperation Agency (JICA)

Tokyo Electric Power Services Co., Ltd.　(TEPSCO)

Tokyo Electric Power Company Holdings, Inc. (TEPCO)

TABLE OF CONTENTS

Abbreviations

ADB	Asian Development Bank
ARCS	Auto Reclosing Functional System
AUES	Altay Uliastay Energy System
BAU	Business As Usual
BESS	Battery Energy Storage System
CAIDI	Consumer Average Interruption Duration Index
CB	Circuit Breaker
CES	Central Energy System
GHG	Green House Gas
CHP	Combined Heat and Power
CHP 4	Combined Heat and Power 4 (Ulaanbaatar No. 4 Thermal Power Plant)
COP	Coefficient of Performance
DAS	Distribution Automation System
DGR	Direction Ground Fault Relay
DMS	Distribution Management System
DSEDN	Darkhan Selenge Electricity Distribution Network Company
DR	Demand Response
DSM	Demand Side Management
DX	Digital Transformation
EBRD	European Bank for Reconstruction and Development
EEF	Extended Fund Facility
EES	Eastern Energy System
EI	Entity & Industry
ERC	Energy Regulatory Commission
EV	Electric Vehicle
FACTS	Flexible AC Transmission System
FIT	Feed-in Tariff
FS	Feasibility Study
GDP	Gross Domestic Products
GHG	Greenhouse Gas
GIS	Gas Insulated Switchgear
GIT	Gas Insulated Transformer
GOST	Gosudarstvenny Standart

HOB	Heat Only Boiler
IEC	International Electrotechnical Commission
IGCC	Integrated coal Gasification Combined Cycle
IMF	International Monetary Fund
IPP	Independent Power Producer
ISO	International Organization for Standardization
JICA	Japan International Cooperation Agency
LRT	Load Ratio Control Transformer
MCUD	Ministry of Construction and Urban Development
MNT	Mongolian Togrog
MOE	Ministry of Energy
NDC	National Dispatch Center
NDC	Nationally Determined Contribution
NEDO	New Energy and Industrial Technology Development Organization
NPTG	National Power Transmission Grid State Own Stock Company
OCR	Over Current Relay
ODA	Official Development Assistance
PCS	Power Conditioning System
PDM	Project Design Matrix
PST	Phase Shifting Transformer
PV	Photovoltaic
RE	Renewable Energy
RTDS	Real Time Digital Simulator
SAIDI	System Average Interruption Duration Index: SAIDI
SAIFI	System Average Interruption Frequency Index: SAIFI
SCADA	Supervisory Control and Data Acquisition
SM	Smart Meter
S/S	Substation
STATCOM	Static Synchronous Compensator
SVC	Static Var Compensator
SVR	Step Voltage Regulator
TA	Technical Assistance
TEPCO	Tokyo Electric Power Company
TEPSCO	Tokyo Electric Power Services Company
T/L	Transmission Line

TOU	Time of Use
TPP	Thermal Power Plant
UB	Ulaanbaatar
UBDH	Ulaanbaatar District Heating Company
UBEDN	Ulaanbaatar Electricity Distribution Network Company
VRE	Variable Renewable Energy
WAMS	Wide Area Monitoring System
WB	World Bank
WFB	World Bank Factbook
WS	Workshop

Exchange Rates (2021/10/8)

1 JPY = 25.40 MNT (1 MNT = 0.0394 JPY)

1 US$ = 2,850.69 MNT

Chapter 1 Introduction

1.1 Background to the Survey

In 2015, Mongolia's Government adopted a national energy policy that set medium- and long-term energy sector goals for 2030. It set objectives to increase the ratio of renewable energy (hereinafter, RE) to 20 % by 2023, and 30 % by 2030, on a facility power generation capacity basis. The policy aims to introduce RE and establish legal regulations in the first period (2015–2023). For the second period (2024–2030), it aims to interconnect regions with large-capacity transmission lines and establish a system incorporating an interactive Energy Management System (hereinafter, EMS).

In the power distribution division, aging and capacity shortages of facilities, electric power losses, and other issues have become problems. A smooth shift to the next generation smart grid is anticipated by clarifying the RE connection rules, utilizing Demand Side Management System (hereinafter, DSM), and so on, to establish a smart city in the future. As for the power sector, the government aims to create a more competitive market by listing public power producers and privatizing distribution services. From now on, Mongolia's government will promote the liberalization of electricity retailing based on this energy policy.

In line with these measures, the introduction of variable RE sources such as photovoltaic power generation (hereinafter, VRE) is progressing. A high level of system operation capability will be required for a stable supply of electricity in the future, such as addressing the duck curve, which arises from power fluctuations during the day and night and due to climatic conditions, and the shifting of demand peaks. The improvement of technical operation capacity and system adjustment capacity at power generation facilities are also required. Comprehensive system planning and operation and system stabilization measures (including capital investment), such as output simulation, communication facilities, and phase adjustment facilities, are also required.

Mongolia’s power source composition is mainly coal-fired power generation. The country has insufficient adjustable power sources for coping with rapid load fluctuation due to demand changes and VRE output fluctuation. Mongolia depends on Russia for most of the supply-demand adjustment functions through the international interconnection line. In the future, it will need to strengthen measures to combat load fluctuation caused by the increase of RE. To this end, Mongolia's government must consider the use of power storage systems and pumped storage power generation systems and the use of international interconnection lines. It is also necessary to construct an optimal supply-demand adjustment system for Mongolia.

1.2 Objectives and Survey Scope

1.2.1 Objectives

This survey (hereinafter, the Survey) analyses the effects of, and other donors' activities for, tackling the issues mentioned in the Background, identifies priority issues to be addressed and considers a mid-long term cooperation program (hereinafter, the Cooperation Program), a cooperation scheme, and a project plan.

It also covers topics on power loss reduction, the introduction and expansion of distributed generation, and a next generation "Distribution System" with EMS functions.

In other words, this is a survey in which basic data collection and analysis are conducted to identify the direction of future cooperation and project plans in the power sector.

1.2.2 Survey Area

The target area for the Survey is the whole of Mongolia.

1.2.3 Counterparts for Discussion

The main counterparts for the discussion are shown below.

- Ministry of Energy: MOE
- Energy Regulatory Commission: ERC
- National Dispatch Center: NDC
- National Power Transmission Grid State Own Stock Company: NPTG
- Ulaanbaatar Electricity Distribution Network Joint Stock Company: UBEDN

1.2.4 Outline of the Survey

The Survey consists of the following.

(1) Ascertaining Current Situation and Creation of Inception Report

- ✓ Collection and Analysis of Basic Information on Mongolian Power Sector
  - ✧ Ascertaining Overview of the Power Sector in Mongolia
  - ✧ Current Situation Survey
- ✓ Creation of Inception Report
- ✓ Explanation of Inception Report
- ✓ Preparation of Interim Report

(2) Creation of Interim Report 1

- ✓ Survey for Strengthening Power System Operational Skills

    - ✧ Review of Generation and Heat Supply Development Plan, Transmission Development Plan and Current Transmission Operations
    - ✧ Identification of Mid- and Long-Term Issues based on Demand Forecasts for Power and Heat
    - ✧ Recommendations on Improvement of Transmission System Planning and Operation, such as Dispatching and Connecting
    - ✧ Consideration of Introduction of Weather Forecasting and RE Generation Forecasting Systems
- ✓ Survey on Effects on Transmission System due to RE and Grid Stabilization Methods
    - ✧ Review of Past Surveys (EBRD, WB, etc.) and Identification of Technical Issues in System Stabilization
    - ✧ Evaluation of Countermeasures for Grid Stabilization (Pumped Storage Hydro Systems, Battery Energy Storage Systems, DSM, Interconnections, etc.)
    - ✧ Consideration of Preferable Countermeasures for Grid Stability in terms of Effectiveness and Costs/Benefits
    - ✧ Survey on Transmission System Planning and Operation Rules, Development of related Technologies and Investment Plan for Facility Installation for Introduction of Grid Stabilization Methods
- ✓ Proposal of Possibility of using Middle and Low Voltage Distribution Technology, DSM System, etc. for Smart City Development
    - ✧ Analysis of Gaps between Current Situation and Future Plans regarding Smart Grids and Smart Cities
    - ✧ Analysis of Current Situation and Issues regarding Middle and Low Voltage Distribution Lines
    - ✧ Consideration of Improvement of Power Losses, Distribution and Meter Automation, RE connection, DSM, etc.
    - ✧ Analysis of Current Situation regarding Heat Supply Systems and Structure
    - ✧ Consideration of Countermeasures for Improvement of Power and Heat Losses and Low Carbonization
- ✓ Confirmation of Other Donors’ Assistance
- ✓ Consideration of Future JICA Assistance
- ✓ Preparation of New Technical Assistance
- ✓ Creation of Interim Report 1
- ✓ Explanation of Interim Report 1
- ✓ Preparation of Draft Final Report

(3) Creation of Draft Final Report

- ✓ Creation of Draft Final Report
- ✓ Explanation of Draft Final Report
- ✓ Preparation of Final Report

(4) Creation of Final Report

✓ Creation of Final Report

1.3 Implementation Structure and Schedule

1.3.1 Implementation Structure

The team for the Survey (hereinafter the Survey Team) is drawn from Tokyo Electric Power Services Company (TEPSCO) and Tokyo Electric Power Company Holdings (TEPCO), and shown in the following table.

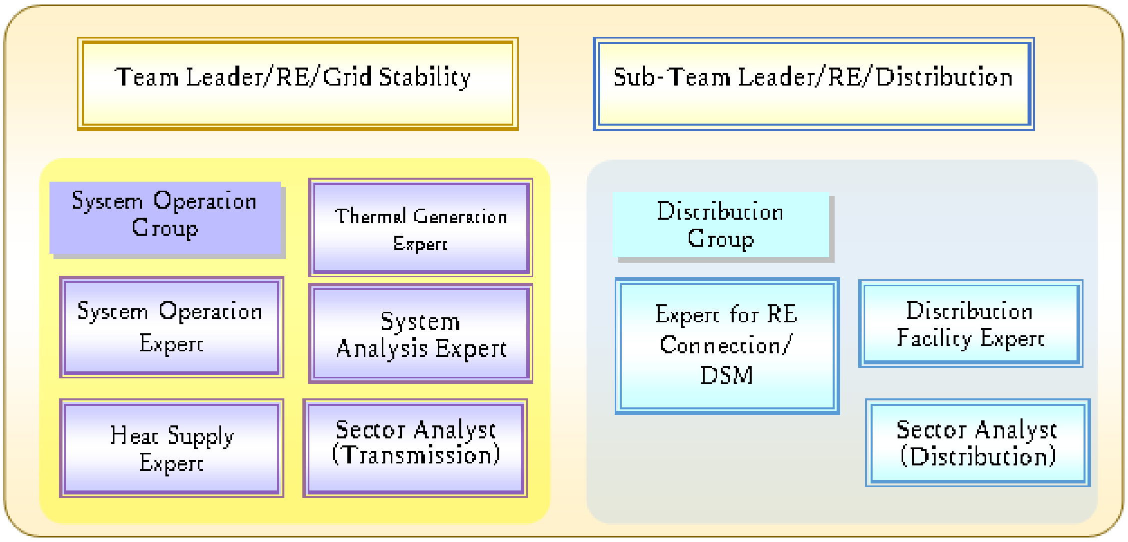


Figure 1-1 Survey Member List

1.3.2 Work Schedule

Because a visit to Mongolia was not realized due to COVID 19 problem, data and information collection was made by remote meetings and interview by local members.

The final work schedule is indicated below.

Table 1-1 Tasks and Work Schedule

Tasks	2020			2021												2022					
	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6
Work in Japan		■	■	■					■	■	■		■			■	■				
Work in Mongolia (Local Member)		■	■	■					■	■	■		■	■	■	■					
(1) Grasping Current Situation and Creation of Inception Report																					
① Collection and Analysis of Basic Information on Mongol Power Sector																					
Grasping Overview of the Power Sector of Mongolia									■	■											
Current Situation Survey			■	■					■												
② Creation of Inception Report		■		■					■												
③ Explanation of Inception Report										■											
④ Preparation of Interim Report 1												■									
(2) Creation of Interim Report 1																					
① Survey for Strengthning System Operation Skill in the Power System																					
Review of Generation and Heat Supply Development Plan, Transmission Development Plan and Current Transmission Operation									■	■	■	■									
Identification of Middle and Long Term Issues based on Demand Forecasts of Power and Heat									■	■	■	■									
Recommendation on Improvement of Transmission System Planning and Operation such as Dispatching and Connecting													■	■	■						
Consideration of Possibility of Introduction of Weather Forecast and RE Generation Forecast System													■	■	■						
② Survey on Effects on Transmission System by RE and Grid Stabilization Methods																					
Review of Past Surveys (EBRD, WB, etc.) and Identification of Technical Issues in System Stabilization									■	■	■	■									
Evaluation of Countermeasures for Grid Stabilization (Pumped Hydro Storage System, Battery Energy Storage System, DSM, Interconnection, etc.)									■	■	■	■			■						
Consideration of Preferable Countermeasures for Grid Stability in terms of Effectiveness and Cost/Benefit									■	■	■	■	■	■	■						
Survey on Transmission System Planning and Operation Rules, Development of related Technologies and Investment Plan for Facility Installation, for Introducing Grid Stabilization Methods									■	■	■	■	■	■	■						
③ Proposal of Possibility of Middle and Low Voltage Distribution Technology, DSM System, etc. for Smart City Development																					
Analysis of Gap between Current Situation and Future Plan in Smart Grid and Smart City											■	■			■						
Analysis on Current Situation and Issues in Middle and Low Voltage															■						
Consideration of Improvement of Power Loss, Distribution and Meter Automation, RE Connection, DSM, etc.											■				■						
Analysis of Current Situation of Hear Supply System and Structure											■				■						
Consideration of Countermeasures for Improvement of Power and Heat Loss and Low Carbonization											■		■	■	■						
④ Confirmation of Other Donor's Assistance											■		■	■	■						
⑤ Consideration of Future JICA's Assistance									■	■	■	■									
⑥ Preparation of New Technical Assistance in 2021									■	■	■	■									
⑦ Creation of Interim Report 1														■	■						
⑧ Explanation of Interim Report 1														■	■						
⑨ Preparation of Draft Final Report																■					
(3) Creation of Draft Final Report																					
① Creation of Draft Final Report																■					
② Explanation of Draft Final Report																■	■				
③ Preparation of Final Report																	■				
(4) Creation of Final Report																					
① Creation of Final Report																	■				
Submission of Reports									△ Inception Report						△ Interim Report 1	△ Draft Final Report	△Final Report				

Chapter 2 General Information on the Power Sector

2.1 Basic Information on the Country

2.1.1 General Information

(1) General Information

General information is shown below.

Table 2-1 General Information

Area	1,564,100 km2
Population	3,357,542 (2020, National Statistical Committee)
Capital	Ulaanbaatar (Population: 1,597,290) (2020, NSC)
Ethnicity	Mongolian (95 %), Kazakhs and others
Language	Mongolian (National official language), Kazakh
Religion	Tibetan Buddhism, Traditional Belief and Others (In February 1992, the new constitution guarantees religious freedom)
Regime	Republic (Combination of presidential system and parliamentary cabinet system)
Head of State	President (Term of office : 6 years, Last election 2021) President Ukhnaa KHURELSUKH (Inaugurated June 25, 2021)
Administrative Division	21 prefectures
Currency	Tugrik

(Source: Ministry of Foreign Affairs of Japan)

(2) Geography

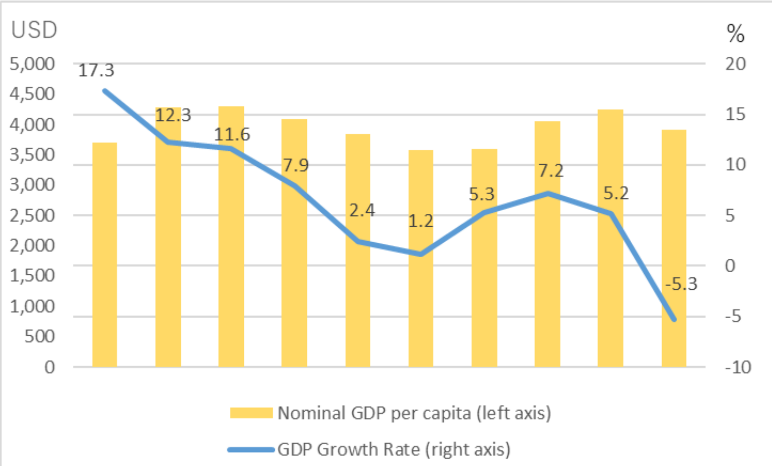
Mongolia is a continental state located on the Mongolian plateau in Northeast Asia, bordering Russia on the north and China on the east, west and south.

The area is 1,564,100 km2, which is almost four times as large as Japan. The land is divided into four zones: the western Altai Mountains, which have many high mountains covered with icecaps, the central Hangayn Hentyn Mountains, which are blessed with rivers, the eastern Dornod Plain, which has a series of plains, and the southern Gobi, which has gravel-like land. Natural conditions are diverse. The average altitude is 1,580 m above sea level, and the capital city Ulaanbaatar (UB) is located on a plateau at a height of 1,351 m.

Figure 2-1 Country of Mongolia

(3) Economic Situation

The figure below shows the changes in nominal GDP and GDP per capita since 2011. Due to the economic slowdown in China and the global depreciation of resources in the mid-2010s, the mining industry, which is the main industry, slowed down significantly. Thus, the Mongolian government began to accept EEF (Extended Fund Facility) from IMF (International Monetary Fund), which led to the rise in the prices of mineral resources such as coal, and economic growth has continued steadily since 2017. However, in recent years, GDP has been negatively growing due to the effects of border blockages to prevent the spread of COVID-19.



(Source: IMF)

Figure 2-2 Changes in Nominal GDP and GDP per Capita (Growth Rate)

The main industries of Mongolia is mining, livestock farming, distribution, and light industry. The ratio of GDP by industry and sector is 50.7 % for services, 36.1 % for mining and construction, and 13.2 % for agriculture (WFB, 2017). Among them, the mining industry accounts for 30 % of GDP, 70 % of mining and industrial production, and 80 % of exports, and the domestic economy is easily affected by mineral resource prices.

(4) Climate

(a) Climate Classification

The entire country of Mongolia belongs to almost the same climate classification, is typical continental, and has a steppe climate in the arid zone in the Köppen climate classification. The average annual rainfall is less than 1/4 of that of Tokyo, and is dry.

(b) Annual Temperature and Precipitation in Ulaanbaatar

The climate (temperature, precipitation) of UB is shown in the table below. Due to the high altitude, the average annual temperature is -0.14 ℃, which is extremely low, and the average temperature in January is -21.7 ℃, which is the lowest among the world's capitals. Thus, it is said to be the coldest capital in the world. On the other hand, the average summer temperature is relatively high and is on par with Western Europe. In this way, the climate has a large annual range. Annual rainfall is only 281.7 mm, most of which is concentrated in summer.

Table 2-2 Climate in Ulaanbaatar

Climate in Ulaanbaatar													
Month	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Year**
Average Maximum Temperature °C	−15.6	−11.4	−2	8.3	16.8	21.6	22.7	21.5	15.6	6.8	−4.4	−13.7	5.52
Daily Average Temperature °C	−21.7	−16.1	−7.0	1.8	10.0	16.0	18.5	16.0	9.5	0.9	−10.6	−19.0	−0.14
Average Minimum Temperature °C	−26.5	−24.1	−15.4	−5.8	2.7	8.3	11.2	9.3	2.2	−6	−16.2	−23.8	−7.01
Precipitation Amount mm	1.1	1.7	2.7	8.3	13.4	41.7	57.6	51.6	26.2	6.4	3.2	2.5	216.4
Average Monthly Sunshine hours	176.7	206.2	266.6	264	300.7	270.0	248.0	257.3	246.0	226.3	177.0	155.0	2,793.80

(Source: Hong Kong Observatory)

2.1.2 National Development Policy

(1) Energy Policy

"State Policy on Energy 2015-2030", which was approved by the diet in 2015, is the energy policy currently approved. The policy is currently being analyzed, but the contents are summarized below.

- Mongolia is rich in primary energy such as coal, oil, uranium, renewable energy, shale and natural gas.
- Electricity comes from five networks: Western, Central, Eastern, Southern and Altai Uliasutai.
- 85 % of the installed capacity of power generation nationwide is a coal-fired cogeneration plant. 5 % is wind power, 7 % is diesel power generation, 2 % is hydropower, and 0.62 % is small-scale renewable energy power generation. 80 % of the electricity supply is covered within the country, but approximately 20 % depends on imports from Russia through the contract (upper limit: 245 MW (the limit was raised up to 345 MW in the end of 2021)) .
- Due to the lack of timely implementation of large-capacity power generation projects for several years, the installed capacity of the whole country is not at a sufficient level. In particular, domestic sources for supplying power for peak loads and enabling operation for stabilizing the system are limited.
- The selling price of electricity and heat is set lower than the actual cost, which makes it difficult for energy companies to make capital investment, overhaul, and innovate at an appropriate level.
- Low energy prices have a negative impact on raising funds for the participation of new large-scale businesses and private businesses.
- The existing thermal power plants and power transmission and distribution networks in

Ulaanbaatar, Darkhan, Erdenet and Domod were built in the 1960s and 1980s, and the proportion of aging equipment is increasing.

- At the national level, the loss of the power transmission and distribution network is 13.7 %, which is relatively higher than that of developing countries in general.

(2) Target Value in Energy Policy

In the above energy policy, the following target values are set.

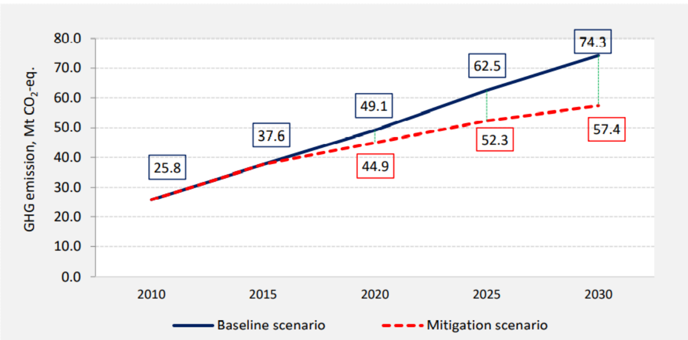
Table 2-3 Energy Policy Targets

	2014 (Base)	2023 (Target Value)	2030 (Target Value)
Power Generation Capacity Reserve	- 10 %	+ 10 % or more	+ 20 % or more
Heat Supply Capacity Reserve of Big Cities	3 %	+10 % or more	+ 15 % or more
Profit in Electricity Price Structure (Central Part)	-16.22 %	0 %	5 %
Internal Use of Electricity in Thermal Power Plant	14.4 %	11.2 %	9.14 %
Power Transmission and Distribution Loss	13.7 %	10.8 %	7.8 %
Renewable Energy Introduction Rate to the Power Generation Capacity	7.62 %	20 %	30 %
Carbon Dioxide Emissions (for 1 Gcal of Energy Output)	0.52 t-CO2	0.49 t-CO2	0.47 t-CO2
Amount of Heat Loss Reduction in Buildings	0 %	20 %	40 %
Applied Technology in Energy Production	High Pressure Technology (Thermal Power)	Subcritical Technology (Thermal Power) Use of Natural Gas High Capacity Storage System Hydroelectric Power Plant	Critical and Supercritical Technology (Thermal Power) Hydrogen Utilization Solar Heat Utilization

(3) Nationally Determined Contribution (NDC)

(a) Overview of NDC

The Mongolian Government announced the GHG emission reduction target by 2030, based on the Government Decree No.407 of November 2019.



(Source: MONGOLIA'S NATIONALLY DETERMINED CONTRIBUTION TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE)

Figure 2-3 GHG Emission Reduction Target of Mongolia

The NDC mentioned that the target is to reduce GHG emissions in BAU in 2030 from 74.3 Mt CO2-eq. to 57.4 Mt CO2-eq. or 22.7 % (of 2030 BAU).

Table 2-4 Overview of Mongolia's NDC

<table>
<tr><th colspan="2">Item</th><th>Number</th></tr>
<tr><td colspan="2">Base Year</td><td>2010</td></tr>
<tr><td colspan="2">Base Year Emission (MT CO2-eq.)</td><td>25.8</td></tr>
<tr><td colspan="2">Target Year</td><td>2030</td></tr>
<tr><td colspan="2">Emission Target by 2030 (Mt CO2-eq)</td><td>57.4</td></tr>
<tr><td colspan="2">BAU Emission in 2030 (Mt CO2-eq.)</td><td>74.3</td></tr>
<tr><td rowspan="2">Emission Reduction Target</td><td>GHG Emission Reduction Target (Mt CO2-eq.)</td><td>16.9</td></tr>
<tr><td>GHG Emission Reduction Target (%)</td><td>22.7</td></tr>
<tr><td colspan="2">Sectors</td><td>Energy Sector
- Energy Production
- Energy Consumption
Non-Energy Sector
- Agriculture
- Industry
- Waste</td></tr>
</table>

(Source: MONGOLIA'S NATIONALLY DETERMINED CONTRIBUTION TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE)

(b) President's Speech in COP 26

President Frelsuf of Mongolia participated in COP 26 held in Glasgow and made the following statement.

- The Mongolian government plans to reduce the amount of GHG emissions, which are a major cause of climate change to 22.7 % of BAU by 2030.
- The Government of Mongolia will support the Asia Super Grid Initiative to increase RE sources in Northeast Asia and further improve energy supply. A large-scale energy complex construction plan using the abundant solar and wind resources of the Gobi Desert will be steadily implemented.
- The Mongolian government is implementing a 1 billion tree planting campaign by 2030. As part of the campaign, up to 1 % of GDP will be spent on climate change support every year.
- A strong will was shown to a framework that applies to all countries and the importance of financial contributions. Now is the time to reach an agreement on a new framework.

(3) Smart City Development Policy

(a) Long-term Development Policy

The long-term development policy of the Mongolian government, “Long-term Vision 2050 (Draft, tentative translation)”, sets the following goal and presents the following development policies.

(Goal)

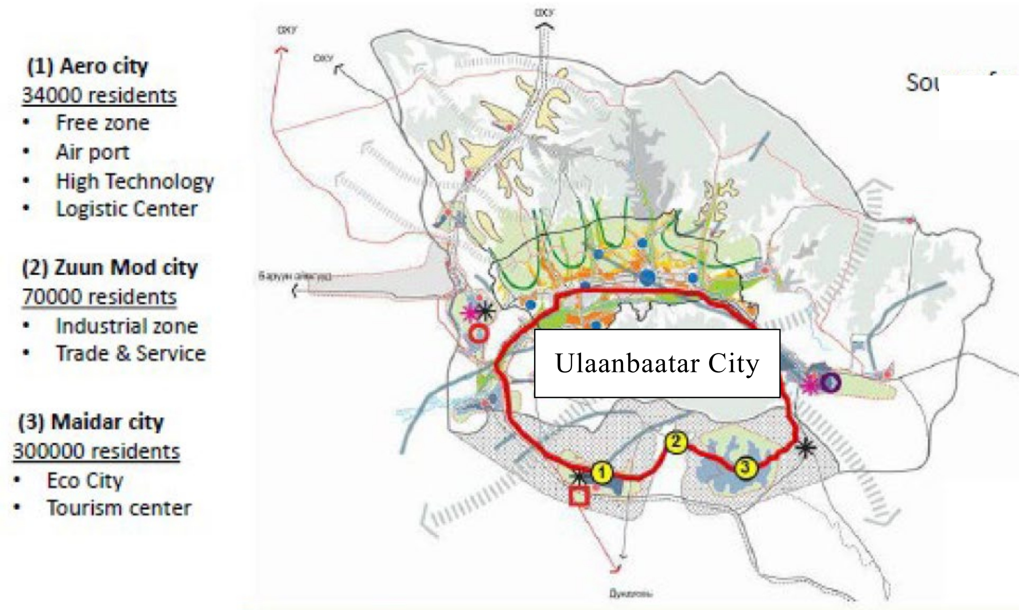
“Develop a comfortable, environmentally friendly, people-centered and smart city”

(Development Policies)

- Become a city of healthy, creative and intelligent citizens with a high labor value, providing opportunities for development of its citizens.
- Establish unified city standards and create a safe and secure environment for citizens to receive education, work, live and move.
- Reduce air, soil and environmental pollution and pollutants by introducing environmentally friendly and advanced know-how and technologies.
- Formulate and implement a plan with correct budget and investment calculations that reflects modern policies and solutions based on scientific evidence, since the implementation of a city plan that properly designs the future of the city will become the basis of the city's development.
- Decentralize Ulaanbaatar by diversifying and developing each satellite town and village in trade, services, culture, education, agriculture, food, light industry, transportation logistics and tourism, and increasing jobs.
- Build a wide variety of smart public transport systems and build highways connecting Ulaanbaatar and satellite cities to eliminate traffic congestion.
- Carry out the decentralization within Ulaanbaatar by developing new city centers, sub-centers, specialized centers and community centers with cultural, educational, trade and services, housing and social infrastructures, in order to establish a multipolar structure within the city.

(b) Urban Development Projects around Ulaanbaatar

According to the Ministry of Construction and Urban Development (MCUD) of Mongolia, the following urban development projects are planned in the southern part of UB.



(Source: MCUD)

Figure 2-4 Smart City Plan around Ulaanbaatar City

2.2 Power Sector Structure, Related Laws and Regulations

2.2.1 Power Sector Enforcement Structure

(1) Overview of Main Power Sector Organizations

The following organizations plan and operate the power sector of Mongolia.

- **Ministry of Energy: MOE**

  MOE decides basic energy policies and formulate plans for the energy sector, as well as conducts procurement management and decides priorities for individual projects.

- **Energy Regulatory Commission: ERC**

  ERC issues the operational licenses and approves the tariffs for the generation, transmission, distribution, dispatching and supply of energy.

- **National Dispatching Center: NDC**

  NDC is the organization that performs the power interconnection and power generation commands. NDC is responsible for the provision of operation development standards. NDC provides advices on system planning to MOE.

- **National Power Transmission Grid State Own Stock Company: NPTG**

  NPTG supplies electricity to 21 states, including Mongolia's capital, UB city and its neighboring areas, which account for 66 % of Mongolia's land. NPTG, which consists of its headquarters and five branch offices, conducts a transmission operation service, imports/exports of electricity, development and maintenance of transmission power systems from 35 kV up to 220 kV, inspections and meter calibrations, etc. NPTG provides advices on system planning to MOE.

- **Ulaanbaatar Electricity Distribution Network Joint Stock Company: UBEDN**

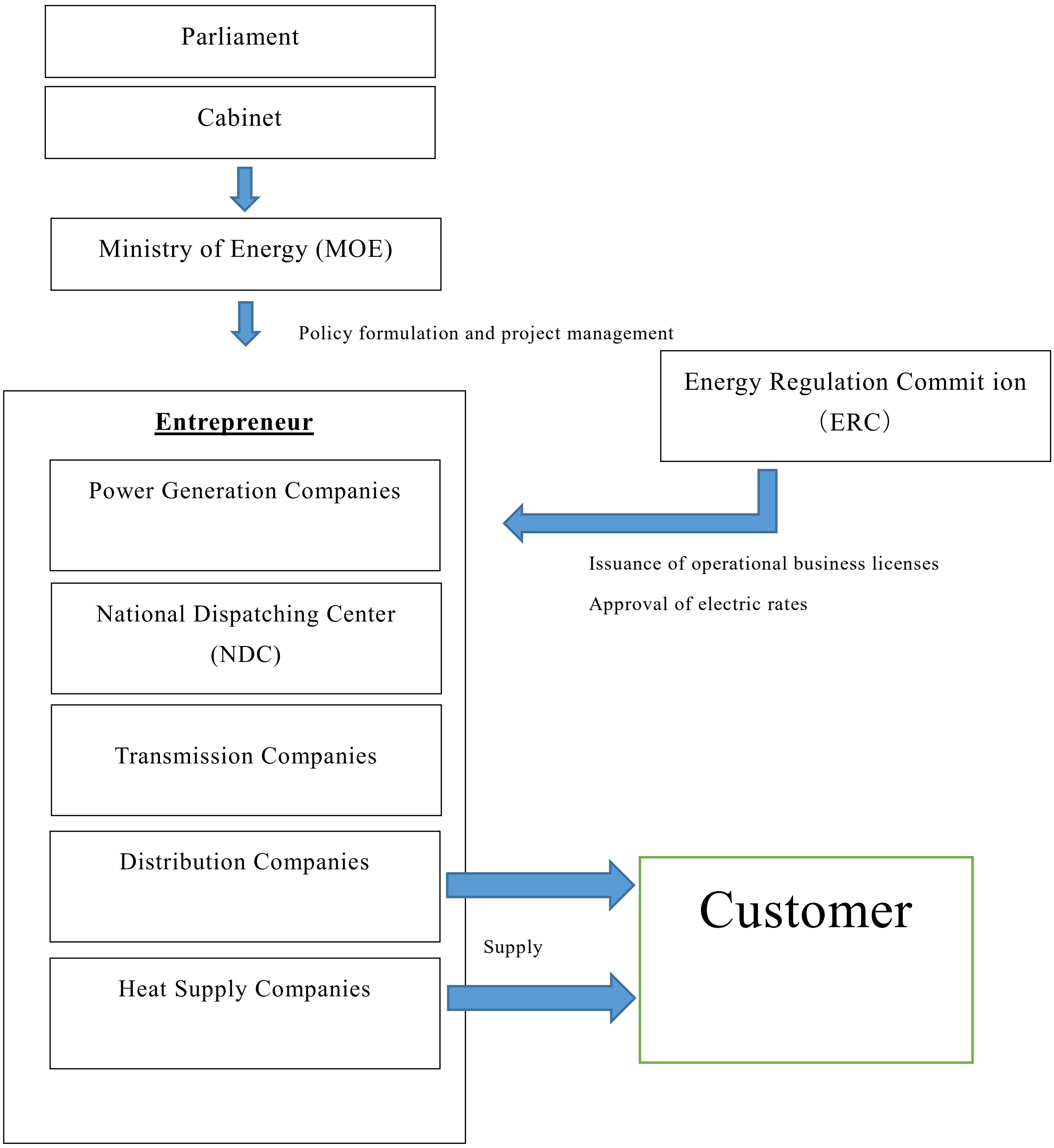
UBEDN conducts planning, construction, maintenance, and management of distribution and transformation facilities under 35 kV in UB city and its surrounding areas.

- **Other Transmission and Distribution Companies**

  In addition, there are 2 major transmission companies (Western Region Power System、Altai-Uliastai Power System) and many distribution companies.

(2) Implementation Structure

The following flow chart shows the implementation structure of the power business.

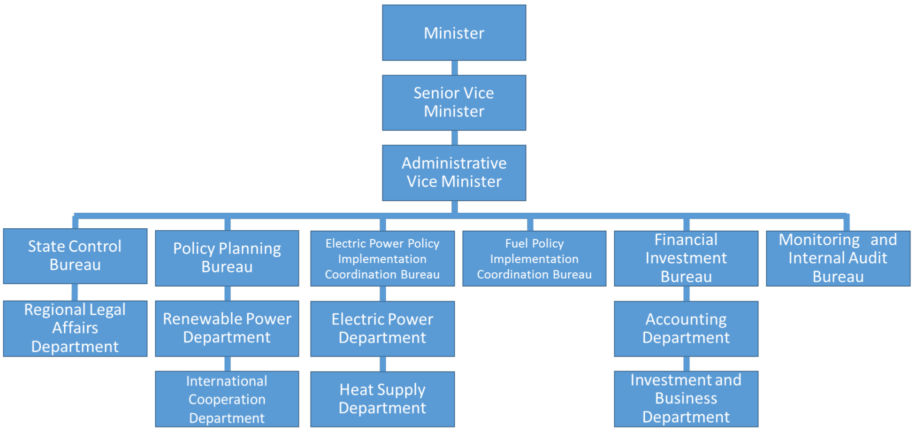


(Source: The Survey Team)

Figure 2-5 Power Business Structure in Mongolia

(3) Ministry of Energy (MOE)

MOE which consists of six divisions is responsible for determining basic energy policies including electricity, developing master plans for the energy sector, and managing procurement to prioritize individual projects. Important policy decision and national budget allocations require parliament and cabinet approval.



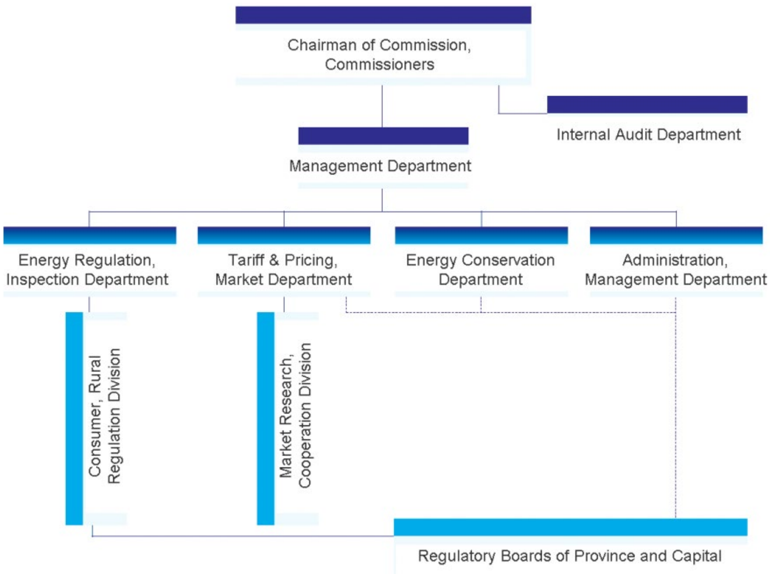
(Source: MOE)

Figure 2-6 MOE Organization Chart

(4) Energy Regulatory Commission (ERC)

Established under the Energy Act of 2001, ERC regulates generation, transmission, distribution and the dispatch and supply of energy business.

ERC issues the operational licenses and review/approves the tariffs for the generation, transmission, distribution, dispatching and supply of energy. It also plays a part in protecting fair rights of both customers and businesses, and establishing conditions for appropriate competition among businesses. The ERC organization chart is shown below.



(Source: ERC)

Figure 2-7 ERC Organization Chart

2.2.2 Overview of Laws and Rules on Electricity Business

(1) Outline

Based on the Law on Energy, the basic law for the electricity business, related laws are enacted, including the Law on Business Licensing, Law on Renewable Energy, Law on Concession, Law on Energy Savings, and other concerned rules such as the Rules for Integrated Power Network, Rules for Electricity Connection Procedure (Transmission and Distribution), Rules for Renewable Energy for Distribution, Rules for Heat Connection, Rules for Heat Transmission and Distribution, and so on. The overviews of these laws and rules are as follows.

(2) Law on Energy

The Law on Energy was enacted in February 2001, and its latest amendment was in January 2017. It stipulates that the State Great Hural determines the state policy on energy and the government implements it. It also stipulates the roles of government administrations, local governments, Energy Regulatory Commission, National Dispatching Center, licenses and issuance, tariff setting, energy supply contract, rights and obligations of energy suppliers and customers, protection strip from the network, and so on.

The Law on Energy and some related rules are planned to be amended (as of December 2021).

(3) Law on Business Licensing

The Law on Business Licensing was enacted in February 2001, and its latest amendment was in August 2020. It stipulates matters on application, approval, terms and cancellation of business license, and scopes of licensing by the national government and local governments. Licensing procedures and related matters concerning energy business are stipulated in the Law on Energy.

(4) Law on Renewable Energy

The Law on Renewable Energy was enacted in January 2007, and its latest amendment was in June 2019. The scope of this law is for supplying electricity/heat energy produced from solar, wind, hydro and biomass, other than self-consumption. It stipulates that the State Great Hural determines the state policy on renewable energy and the government implements it. It also stipulates the roles of government administrations, local governments, Energy Regulatory Commission, business licenses, tariff setting, and so on.

For applying the business license, following documents are required in addition to the requirements stipulated in the Law on Energy.

- ✧ Land possession certificate for renewable energy source
- ✧ Plan for recycling and disposal of expired batteries
- ✧ Research of soil, vegetation, geological and hydrological conditions, geographical location, surface, climate, etc.
- ✧ Certificate to meet international and national standards, for the machinery, equipment and facilities to generate renewable energy

Given the amendment in June 2019, tariffs were set as follows.

✧ Wind Power:	Up to 0.085 US$/kWh
✧ Hydropower up to 5,000 kW:	0.045 - 0.06 US$/kWh
✧ Solar power:	Up to 0.12 US$/kWh

It stipulates that the exceeding generation costs from the tariffs will be compensated, ERC and local governments must consider the economic and social circumstances of the located area for RE power sources interconnected to the distribution network, ERC will examine and determine the tariffs of RE power sources other than those stated above such as geothermal and biomass, and so on.

(5) Law on Concession

The Law on Concession was enacted in January 2010, and its latest amendment was in April 2017. It stipulates types of concession, roles of government administrations and local governments, listing concession items by government administrations and local governments, approval of concession items list by the government and local council, tender, selection, direct contract without tender, concession by project proposal, items in the concession agreement document, rights and obligations of concessionaire, and so on.

(6) Law on Energy Conservation

The Law on Energy Conservation was enacted in November 2015, and its latest amendment was in May 2017. It stipulates that the State Great Hural determines the state policy on energy saving and the government implements it. It also stipulates the roles of government, government administrations, local governments, and the Energy Saving Council as the implementation organization of the policy, rights and obligations of customers regarding energy saving, audit by the energy auditing organization, and so on.

(7) Rules for Integrated Power Network (Integrated Grid Code)

Rules for Integrated Power Network was enacted in May 2010, to stipulate operation and management of the power transmission and distribution network. It stipulates the scope of the main regions network, ranges of frequency and voltage, role of the National Dispatching Center, interconnection to the network, monitoring and control of the network, measures in case of national network shutdown, load limitation, demand supply planning, operation of interconnection between Russia, network operation, emergency measures, classification of network fault, and so on. The contents of this rule are outlined in the later section. This rule is under revision, including additional regulations on RE power sources.

(8) Rules for Electricity Connection Procedure (Transmission and Distribution)

Procedures for the licensees to connect their facilities to the transmission and distribution network, required documents for application such as specification, and related matters are stipulated. It is stipulated that the technical requirements of the facilities that are to be connected are determined by the transmission and distribution licensees, in which they must consider the capacity of the facility, conditions of the load of transmission/distribution facilities and power demand in the area, for the normal operation of the transmission system.

(9) Rules for Renewable Energy for Distribution

Requirements for interconnecting small scale renewable power sources to the distribution network to supply excess power to the network are stipulated, including the rights and obligations of the government, distribution network licensee, and personnel / legal entity of interconnecting equipment, and matters to be stated in the contract. The scope of small scale renewable power sources under this rule is as follows.

- ✧ Personnel: Up to 20 kW, Legal entity: Not more than 50 % of the specified interconnection capacity
- ✧ Voltage of interconnection: 0.4 kV

Technical requirements for interconnection are presented from distribution network licensee. Requirements stipulated in this rule are as follows.

- ✧ Prevent from incurring voltage from interconnected side in the case of no voltage at the distribution side
- ✧ Meet the requirements of IEC61730-1 and IEC61730-2 for solar power sources, and IEEE1547/ IEC61000-3-15/ IEC62116 for inverters
- ✧ Meet the requirements of national standard MNS1778:2007 for the distribution network

(10) Rules for Heat Transmission and Distribution

These are the rules for connecting buildings or facilities of individuals or legal entities to the heat supply/ distribution network, stipulating the application procedure, approval conditions, period of the connection, and so on.

2.2.3 Energy Business

(1) Licenses on Energy Business

Following licenses on energy business are stipulated in Article 12 of the Law on Energy (as of June 2021).

1. Electricity generation
2. Heat production
3. Electricity transmission
4. Heat transfer
5. Electricity/heat dispatch
6. Electricity distribution
7. Heat distribution
8. Regulated energy supply
9. Unregulated energy supply
10. Electricity import and export
11. Energy facility construction
12. Gas supply

Licenses for the construction of lines crossing the state border, energy facilities with capacity of more than 5 MW and for operation of lines crossing the state border, integrated network, central heating supply and gas supply are issued by the national government. Other licenses are issued by the local government. Scopes of each energy business are stipulated in the Law on Energy as follows.

(2) Scope of Each Energy Business

(a) Electricity and Heat Generation

License holders for electricity and heat generation have the rights to generate electricity and heat, and supply them under the approved price and terms, through the electricity and heat transmission and distribution network, except in the following cases:

- ✧ To generate electricity and heat only for its own use
- ✧ To generate electricity without being connected to the grid
- ✧ To sell electricity and heat at the contract price

(b) Electricity and Heat Transmission

License holders for electricity and heat transmission operate the electricity and heat network, and have the following obligations:

- ✧ Transmission license holders operate, maintain and expand the transmission network to ensure the normal operation of the license holders of electricity and heat generation, distribution and supply, and to ensure the reliable electricity and heat consumption of consumers.
- ✧ Transmission license holders develop, approve and follow the connection procedure specified in the Law on Energy.
- ✧ Transmission license holders create conditions for customers to connect to their transmission networks with equal rights.
- ✧ Transmission license holders cannot conduct activities related to electricity and heat generation.

(c) Electricity and Heat Dispatch

As a license holder for electricity and heat dispatch, the National Dispatching Center controls electricity and heat supply with the following rights and obligations.

- ✧ Ensure a low-cost and reliable supply of electricity and heat based on its standards
- ✧ Cut off, limit and restore electricity and heat supply in case of natural disasters and emergencies
- ✧ Conclude electricity and heat supply contracts in accordance with the stipulated procedures
- ✧ Manage the capacity of generation and heat supply and plan for electricity and heat generation to allow an integrated operation of the power system and heat supply system
- ✧ Operate a protection, communication, and management system for an integrated operation of the power system

- ✧ Conduct forecasts on electricity and heat consumption every year
- ✧ Formulate and implement system operation rules
- ✧ Plan and implement electricity transmission services for the purpose of import and export
- ✧ A license holder for electricity and heat dispatch cannot conduct heat generation and energy supply activities

Other license holders shall oblige to the decisions made by the electricity and heat dispatching licensees within the framework of the power system operation and heat supply rules.

(d) Electricity and Heat Distribution

License holders for electricity or heat distribution are obliged to connect all consumers to the distribution network in the territory specified in the license, and have the following obligations.

- ✧ To connect consumer lines and equipment that meet the requirements, to the electricity and heat distribution lines and equipment in the territory
- ✧ To develop, approve and follow the connection procedure
- ✧ To install certified electricity and heat meters at the connection point
- ✧ To provide equal opportunities to regulated or unregulated suppliers through electricity and heat distribution networks
- ✧ To ensure that the consumers can definitely receive electricity and heat by enabling the normal operation of the electricity and heat generation licensees, transmission and heat supply licensees, and regulated or unregulated energy supply licensees
- ✧ To operate, maintain and expand the distribution network
- ✧ To connect users other than the customer's line on the basis of prior agreement with a consumer who meets the requirements of the connection procedure stipulated in the Law on Energy
- ✧ To purchase electricity and heat on the basis of advance payment in accordance with the agreement concluded with the producer or transmitter
- ✧ License holders for electricity and heat distribution may hold a license for regulated supply of energy and may hold a license for unregulated supply of energy

(e) Regulated Energy Supply

License holders for regulated energy supply have the right to purchase electricity, heat, import electricity and sell electricity and heat from holders for generation, transmission and distribution of electricity and heat, and have the following obligations.

- ✧ To provide electricity and heat to consumers in the territory specified in the license
- ✧ To reach an agreement with license holders for generation, transmission, distribution and dispatching of electricity and heat on obtaining a sufficient amount of electricity and heat supply
- ✧ To pay for electricity and heat transmission, distribution and dispatching services
- ✧ To formulate and oblige to the rules of business implementation

- ✧ License holders for regulated energy supply may sell electricity and heat to consumers in the territory specified in the license on the basis of an agreement concluded with an individual or legal entity. The sale price and the fee to be paid to the contracted seller shall be agreed between the parties and sold to the consumer at the price set by the ERC.

(f) Unregulated Energy Supply

License holders for unregulated energy supply have the right to purchase electricity and heat from license holders for generation of electricity and heat, and to sell and export electricity to consumers as determined by the Coordination Committee, under the following obligations.

- ✧ To agree with license holders for generation, transmission, distribution and dispatching of electricity and heat on obtaining and transmitting a sufficient amount of electricity and heat supply
- ✧ To formulate and oblige to the rules of business implementation
- ✧ To supply methane gas to consumers in accordance with the contract

(g) Electricity Import and Export

License holders for electricity import and export have the right to export electricity with unregulated supply and to import electricity with regulated supply. Licenses to import and export electricity through the regional electricity transmission network shall be issued to the license holder of the transmission network. The amount of energy to be imported and exported by a license holder for electricity import and export shall be determined by the government administrative in charge of energy. License holders for electricity import and export shall agree on the terms and technical conditions of dispatching.

(h) Energy Facility Construction

License holders for energy facility construction have the rights to design and construct an energy facility. The licenses shall be issued on the basis of environmental impact assessment in accordance with relevant legislation.

(3) Application for License

An applicant for a license shall submit an application with the following documents, based on the type of energy business.

- ✧ Feasibility study
- ✧ Study of energy resources to be used for energy production
- ✧ Type, quantity and quality of energy to be produced, transmitted, distributed and supplied
- ✧ Basic parameters of equipment to be used
- ✧ Scope of operation, ownership boundary, balance of energy production, supply and consumption
- ✧ Environmental impact assessment
- ✧ Environmental protection action plan

- ✧ Financial, capital resources and economic capacity of the legal entity
- ✧ Date of commencement of operations, amount of investment and source of financing
- ✧ Practices and experiences of professional staffs

A decision of license issuance shall be made within 60 days after receiving the application. The licensing authority may appoint an independent expert to issue an opinion on the application and attached documents if necessary. If several interested legal entities have applied for a license to conduct one activity, it shall be issued through a tender.

(4) Term of License

The term of a license for generation and transmission of energy is 5-25 years, the term of a license for construction of energy facilities is up to 5 years, and the term of other licenses is up to 10 years. The license holder shall extend the term of the license for up to 25 years if the license holder meets the requirements.

2.2.4 Energy Business Licensee

License holders for energy business are shown in the ERC Web Page. The lists of license holders for generation, electricity transmission and import/export are shown as follows (as of June 2021).

(1) Electricity/Heat Generation

Table 2-5 Electricity/Heat Generation

No	Special Licensees (SL) Name	Type of license
Traditional Source		
1	"Thermal Power Plant 4" State-Owned Joint Stock Company (SOJSC)	Power generation
2	"Thermal Power Plant 3" SOJSC	Power generation
3	"Thermal Power Plant 2" SOJSC	Power generation
4	"Darkhan Thermal Power Plant" SOJSC	Power generation
5	"Erdenet Thermal Power Plant" SOJSC	Power generation
6	"Energy system of Dornod region" SOJSC	Power generation
7	"Dalanzadgad Thermal Power Plant" SOJSC	Power generation
8	"MCS International" LLC	Power generation
9	"Altai-Uliastai" power system	Power generation
10	"Mon Cement Building Materials" LLC	Power generation
11	"Erdenet Mining Corporation" LLC	Power generation
Renewable Source		
12	"Tosontsengel HPP" LLC	Power generation
13	"Taishir Guulin HPP" LLC	Power generation
14	"Bogd river HPP" LLC	Power generation
15	"Clean Energy" LLC	Power generation
16	"Durgun HPP" LLC	Power generation
17	"Solarpower International" LLC	Power generation
18	"Clean Energy Asia" LLC	Power generation
19	"Everyday Farm" LLC	Power generation
20	"Naranteeg" LLC	Power generation
21	"Sainshand Wind Park" LLC	Power generation
22	"ESB Solar Energy" LLC	Power generation
Heat Generation		
1	"Thermal Power Plant 4" SOJSC	Heat generation
2	"Thermal Power Plant 3" SOJSC	Heat generation
3	"Thermal Power Plant 2" SOJSC	Heat generation
4	"Darkhan Thermal Power Plant" SOJSC	Heat generation
5	"Erdenet Thermal Power Plant" SOJSC	Heat generation
6	"Energy system of Dornod region" SOJSC	Heat generation
7	"Dalanzadgad Thermal Power Plant" SOJSC	Heat generation
8	"Baganuur Thermal Power Plant" SOJSC	Heat generation
9	"Nalaikh Thermal Power Plant" SOJSC	Heat generation
10	"Amgalan Thermal Power Plant" LLC	Heat generation
11	"Erdenet Mining Corporation" LLC	Heat generation
12	"Dulaan Sharyn Gol" SOJSC	Heat generation
13	"Selenge-Energo" (LSFE)	Heat generation
14	"Durvulj" (LSFE)	Heat generation
15	"Mandal Golomt" LLC	Heat generation
16	"Tuvchandmani DEHG" (LSFE)	Heat generation
17	"Ekh Golomtyn Ilch" LLC	Heat generation
18	"Khutul Energy Heat" LLC	Heat generation
19	"Khentii-Us" LLC	Heat generation

(2) Electricity Transmission, Import/Export

Table 2-6 Electricity Transmission, Import/Export

No	Special Licensees (SL) Name	Type of License
1	"National Power Transmission Network" State-Owned Joint Stock Company (SOJSC)	Power transmission
2	"Western Region Power System" SOJSC	Power transmission
3	"Altai-Uliastai Power System" SOJSC	Power transmission
1	"National Power Transmission Network" SOJSC	Power import and export
2	"Western Region Power System" SOJSC	Power import and export
3	"Dornod Region Power System" SOJSC	Power import and export
4	"Khuvsgul-Energy" Limited Liability Company (LLC)	Power import and export
5	"Ulaanbaatar Railway" Mongolian-Russian Joint Stock Company (JSC)	Power import and export
6	"Tsinghua MAK Nariin Sukhait" LLC	Power import and export
7	Gashuunsukhait Customs Office, under the Mongolian Customs	Power import and export
8	Customs Office in Bichigt, Sukhbaatar aimag, under the Mongolian Customs	Power import and export
9	"National Dispatch Center" LLC	Power import and export

2.2.5 Overview of Energy Tariff

(1) Electricity Tariffs

Electricity tariffs differ in each of the four areas: CES&SES, WES, EES, AUES, and consist of two types including one for industrial use and another for residential use. TOU (Time of Use) rate, which varies depending on the time of use, is available only for customers who purchased a TOU meter. For the others, Single Rate with fixed pay-for-use rate is applied.

All tariffs in those regions except EES include RE levies, with 23.79 MNT/kWh in CES & SES region and 11.88 MNT/kWh in WES and AUES regions.

In addition to the pay-for-use rate, Capacity Tariff is also charged on industrial tariffs, with 25,000 MNT/kW/month for the mining industry and 9,000 MNT/kW/month for others. 2,000 MT/month is added to tariffs for residential use as a basic charge.

(2) Example of Electricity Tariffs in CES Region

As an example, the following table shows the tariff in CES region.

Table 2-7 Electricity Tariff in CES Region

Single rate tariff /VAT excluded/

MNT/kWh

CONSUMER CATEGORY	TARIFFS
INDUSTRIAL	
Mining, processing industry	179.69
Other industries, business entities and organizations	164.38
RESIDENTIAL	
Monthly consumption below 150 kWh	134.28
Monthly consumption above 150 kWh	154.08

Included the renewable energy levy (23.79 MNT/kWh)
Capacity tariff of other industries 9,000 MNT/kW/month
Capacity tariff for mining industry 25,000 MNT/kW/month
Basic fee for residential consumer 2,000 MNT/month

Time of use electricity tariffs /VAT excluded/

MNT/kWh

CONSUMER CATEGORY	TARIFFS	
INDUSTRIAL	Mining industry	Others
Shoulder from 6 am until 5 pm	179.69	164.38
Peak from 5 pm until 10 pm	299.79	245.68
Off peak from 10 pm until 6 am	100.89	112.98
RESIDENTIAL		
Shoulder from 6 am until 9 pm	140.18	
Off peak from 9pm until 6 am	112.98	

Included the renewable energy levy (23.79 MNT/kWh)

(Source: ERC)

(3) Heat Supply Tariff

The heat supply tariffs which differ based on regions are charged in proportion to the residential floor space of a house. However, if a meter is equipped, tariffs are charged based on usage. The word "EI", is an abbreviation for Entity & Industry.

Table 2-8 Heat Supply Tariff in Each Region

/VAT excluded/

Area	Residential (MNT/m²)	EI (MNT/m³)	Tap hot water (MNT person/month)	By meter (MNT/GJ)	
				Residential	EI
Ulaanbaatar	506	472	1,870/2,806*	3,421	7,277
Darkhan	506	470	1,870/2,806*	3,421	6,419
Erdenet	506	504	1,870/2,806*	3,421	7,854
Dornod	506	769	1,870/2,806*	3,421	6,698
Dalanzadgad	506	961	1,870/2,806*	-	20,843
Nalaikh	600	860-1,290	2,875/4,025*	-	25,813
Baganuur	660	1,145-1,239	3,163/4,428*	8,711	18,310-19,795

NOTE: *- Non heating season

(Source: ERC)

2.2.6 Promotion Measure of Renewable Energy

(1) Feed in Tariff System for RE Operators

The "Law of Mongolia on Renewable Energy" in 2012 stipulate the rights and obligations of renewable energy business as follows:

- ✓ To deliver its electricity to the nearest connection point of a transmission licensee,
- ✓ To be responsible for the transmission cost until the connection point, and
- ✓ To implement dispatching regulations requested by the dispatching licensee.

On the other hand, the rights and obligations of transmission and distribution companies to accept renewable energy are defined as described below:

- ✓ To purchase electricity sold by a generator at a price approved by the Energy Regulatory Authority specified in Article 11 of the law
- ✓ To connect a generator to the distribution board of a transmission network complying with technical requirements, to finance cost of required capacity expansion

Article 11 of the law indicated the price range of the feed-in tariff for RE. The range has been changed in the revision in July 2019.

Table 2-9 Price Range of Feed-in Tariff for RE Operators

		Price in 2012 (US$/kWh)	Revision Price in 2019 (US$/kWh)
Solar Power	Connection to Grid	0.150～0.180	～0.120
	Isolation	0.200～0.300	Individually determined by ERC or local government
Wind Power	Connection to Grid	0.080～0.095	～0.085
	Isolation	0.100～0.150	Individually determined by ERC or local government
Hydro Power	Connection to Grid (Up to 5, 000 kW)	0.045～0.060	0.045～0.060
	Isolation (Up to 500 kW)	0.080～0.100	Individually determined by ERC or local government
	Isolation (From 501 to 2, 000 kW)	0.050～0.060	Individually determined by ERC or local government
	Isolation (From 2, 001 to 5, 000 kW)	0.045～0.050	Individually determined by ERC or local government

(Source: Law of Mongolia on Renewable Energy (2012), Amendment of Law of Mongolia on Renewable Energy (2019))

(2) Feed-in Tariff Prices in Distribution Network

ERC announced the Feed-in Tariff price taken by the distribution network in July 2021, as shown in the following table, that is the same value with electricity tariff from 6 AM to 21 PM used by the TOU of the residential customers in CES. Therefore, the residential customers who sell RE to network companies will have the electricity charges deducted according to the sale amount. The spread of smart meters is expected to streamline these trading process.

Table 2-10 Price of Feed-in Tariff in Distribution Network

	Class	Unit	Price
	During a day / from 06:00 to 17:00/	MNT/kWh	140.18
	During peak hours or in the evening / from 17:00 to 22:00 /	MNT/kWh	221.89

(Source: ERC)

2.3 Supply and Demand Balance

2.3.1 Record of Supply and Demand

(1) Track Record of Generation

The table below shows the annual generation amount including imported electricity. Electricity import from Russia is mainly for CES, and the amount of power generation is also prominent in Mongolia. The yearly increase rate from 2011 to 2020 is recorded at 7.0 %.

Table 2-11 Annual Generation Record by Region (Unit: GWh)

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
CES	4,347	4,565	4,809	5,134	5,378	5,494	5,763	6,300	6,561	6,721
EES	113	119	123	178	185	214	231	232	242	210
WES	95	109	119	127	143	146	155	163	172	183
AUES	38	39	45	53	63	69	70	76	81	84
Net import	307	434	1,181	1,397	1,394	1,419	1,523	1,684	1,716	1,706
Total	4,900	5,266	6,277	6,888	7,163	7,342	7,741	8,455	8,773	8,903
Increase (%/year)		7%	19%	10%	4%	2%	5%	9%	4%	1%

(Source: MOE)

(2) Maximum Demand

Despite occasional declines, demand in Mongolia as a whole has been steadily increasing year by year, hitting an average record rate of 7.2 % from 2011 to 2022. The following is annual maximum demand including imported power.

Table 2-12 Annual Maximum Demand Record by Region (Unit: MW)

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
CES	782	863	910	969	965	975	1,016	1,117	1,153	1,303
EES	21	26	26	27	27	31	34	32	39	42
WES	23	27	30	32	28	29	31	39	34	41
AUES	12	14	15	15	15	14	17	18	19	20
Net import CES	120	108	157	144	92	52	45	178	184	228
Import Oyu Tolgoi	0	0	100	125	125	127	140	158	160	160
Total	958	1,038	1,238	1,312	1,252	1,229	1,282	1,542	1,588	1,795
Increase (%/year)		8%	19%	6%	-5%	-2%	4%	20%	3%	13%

(Source: MOE)

(3) Power Supply Capacity

(a) Generation Facilities

As of 2020, the amount of RE introduced has reached 18 % of total capacity, lower than the target value of 20 % for 2023 (as mentioned in “State Policy on Energy 2015-2030”). As other power generation capacity has increased, it makes the ratio of RE introduction seem to be relatively small. The table below lists the generation facilities and facility operation rate.

Table 2-13 Main Generation Capacity and RE Introduction Rate in Mongolia

№	Power Station		2018	2019	2020	2021
1	Combined heat and power	CHP-2	24	24	24	24
2		CHP-3	186	186	186	198
3		CHP-4	703	726	749	772
4		Darkhan CHP	48	59	83	83
5		Erdenet CHP	28.8	28.8	28.8	71
6		ErdenetMC CHP	53	53	53	53
7		Ukhaakhudag CHP	18	18	18	18
8		Dalanzadgad CHP	9	9	9	9
9	Wind PS	Salkhit Wind farm	50	50	50	50
10		Tsetsii Wind farm	50	50	50	50
11		Sainshand Wind farm	55	55	55	55
12	Solar PS	Darkhan nar solar farm	10	10	10	10
13		Monnaran solar farm	10	10	10	10
14		Gegeen solar farm	15	15	15	15
15		Bukhug solar farm	0	15	15	15
16		Sumber solar farm	0	10	10	10
17		DSP solar farm			30	30
		Total (MW)	1,260	1,319	1,396	1,473
		RE Installed Capacity (MW)	190	215	245	245
		RE Rate	15%	16%	18%	17%

(Source: MOE)

Table 2-14 Capacity Factor of Main Generation in Mongolia

№	Power station		2018	2019	2020	2021 /January-September/
1	Combined heat and power	CHP-2	77%	76%	74%	76%
2		CHP-3	67%	65%	64%	63%
3		CHP-4	62%	62%	63%	65%
4		Darkhan CHP	63%	60%	48%	44%
5		Erdenet CHP	65%	65%	63%	41%
6		ErdenetMC CHP	68%	69%	65%	69%
7		Ukhaakhudag CHP	22%	16%	18%	23%
8		Dalanzadgad CHP	10%	16%	41%	39%
9	Wind PS	Salkhit Wind farm	36%	33%	32%	40%
10		Tsetsii Wind farm	34%	37%	35%	43%
11		Sainshand Wind farm	6%	32%	34%	39%
12	Solar PS	Darkhan nar solar farm	19%	20%	18%	17%
13		Monnaran solar farm	21%	22%	18%	20%
14		Gegeen solar farm	11%	20%	19%	19%
15		Bukhug solar farm		21%	19%	20%
16		Sumber solar farm		21%	20%	20%
17		DSP solar farm			4%	19%
18		Total (MWh)	56%	57%	55%	57%

(Source: MOE)

(b) Power Interconnection with Russia

The power interconnection agreement with Russia consists of three factors: transmission capacity of up to 245 MW (* In December 2021, the capacity was raised to 345 MW), transmission power amount, and planned accommodation capacity.

Interconnected power with Russia gives Mongolia flexibility in power supply and demand adjustment. However, when there is an unexpected surplus of RE generation, although the reverse flow to Russia is possible for a moment, a constant reverse flow is not expected in the interconnection. Thus, NDC manages the system operation so that it will not be in such a situation.

The following shows the record of power interconnection with Russia and average import power unit prices.

Table 2-15 Record of Power Interconnection with Russia

Indicators	2016	2017	2018	2019	2020
Imported electricity (GWh)	201.4	270.6	304.1	250.8	186.99
Exported electricity (GWh)	33.9	34.1	26.9	26.5	39.85
Guaranteed capacity (MW)	-	-	-	-	-
Average price of import (thou.USD)	0.08	0.08	0.08	0.10	0.09
Payment (thou.USD)	16,441.7	21,352.2	22,695.8	21,541.9	**16,741.07**

(Source: Statistics on Energy Performance, 2020)

(4) Breakdown of Power Supply Cost

The electricity tariff by equipment costs in CES in the table below shows that power generation is the most expensive, accounting for over 60 % of total supply costs. In addition, the total power supply cost exceeds the income, electricity charges on customers, indicating that deficits are incurred.

Table 2-16 Detail Power Supply Cost of CES, as of 2020

MNT/kWh

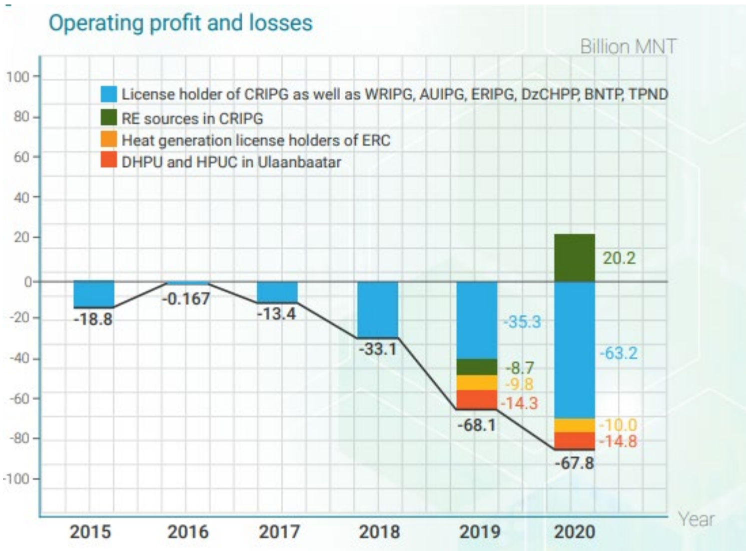
	Generation expenses		Import expenses		Transmission losses		Transmission expenses		Distribution losses		Distribution expenses		Unit cost	Average price for consumer
MNT/kWh	113.10	+	8.24	+	3.45	+	10.22	+	14.00	+	34.64	=	183.65	176.91
Percentage	61.6%	+	4.5%	+	1.9%	+	5.6%	+	7.6%	+	18.9%	=	100.0%	95.9%

(Source: Statistics on Energy Performance, 2020)

(5) Financial Structure of Electric Power Industry

The table below shows the operating profit and loss trend of general power companies in Mongolia (license holders of CER, WES, AUES and WES as illustrated in the following figure).

In 2020, while RE business investors in CES went into black, losses incurred in general power companies were escalated.



(Source: Statistics on Energy Performance, 2020)

Figure 2-8 Profit and Loss Trend of Power Companies and RE Investors

Subsidies are provided by the government to cover those losses, and mainly Transmission Company of WES received it.

Table 2-17 Distribution of Subsidies from Government

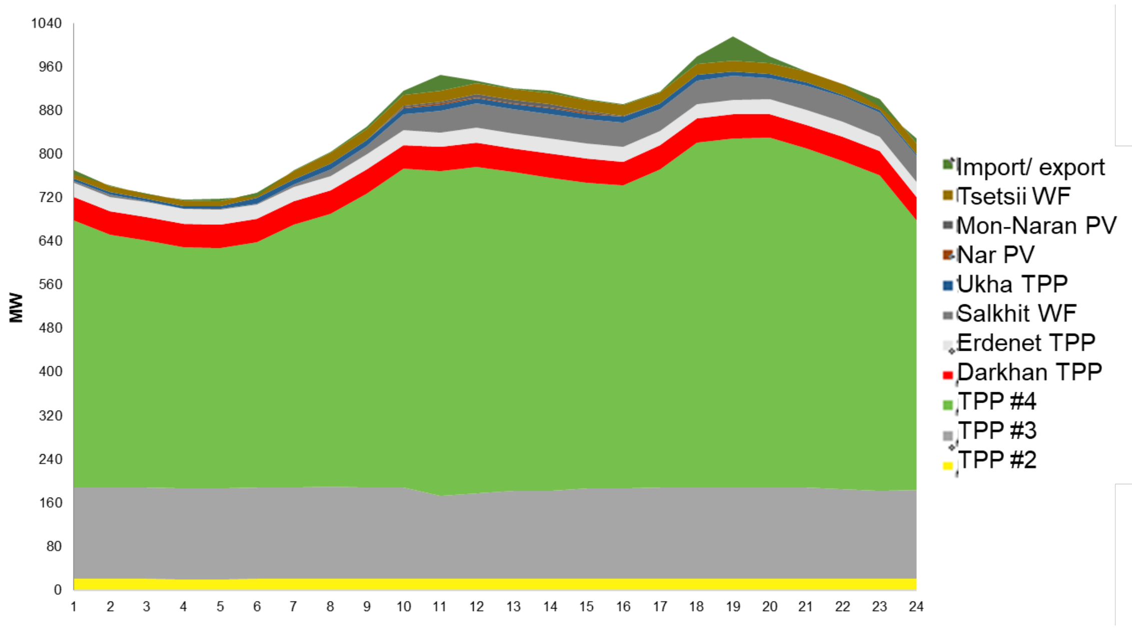
Mln.MNT

Name of LHs	2015	2016	2017	2018	2019	2020
"WRES" SOJSC	8,600.0	8,600.0	8,600.0	8,600.0	8,600.0	16,700.0
"ERIPG" SOJSC	2,200.0	-	-	-	-	-
"DzCHPP" SOJSC	1,600.0	1,600.0	1,600.0	1,600.0	1,600.0	1,447.1
"AUIPG" SOJSC	4,150.0	3,150.0	3,150.0	3,150.0	3,150.0	3,150.0
"BNTP" SOJSC	1,100.0	1,100.0	1,100.0	1,100.0	1,100.0	1,010.0
"TPND" SOJSC	1,400.0	1,400.0	1,400.0	1,400.0	1,400.0	1,238.0
"DSHG" SOJSC	500.0	500.0	500.0	500.0	500.0	482.0
"Selenge Energo" ME	500.0	500.0	500.0	500.0	500.0	428.0
"Khentii-US" Ltd	-	-	300.0	300.0	300.0	269.6
TOTAL	20,050.0	16,850.0	7,150.0	17,150.0	17,150.0	24,724.7

(Source: Statistics on Energy Performance, 2020)

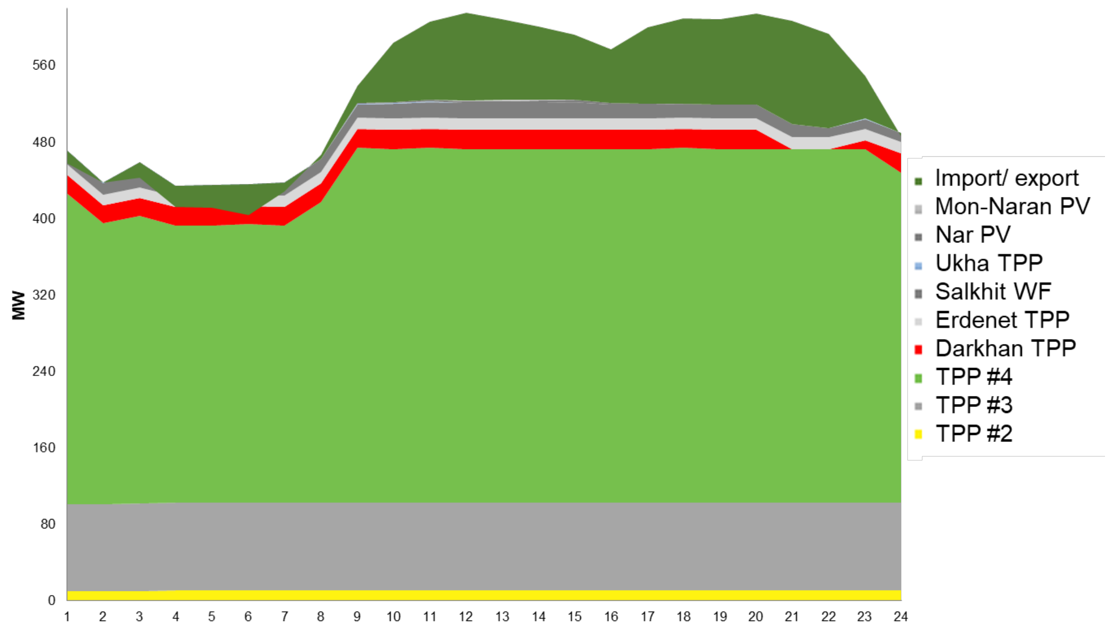
(6) Daily Load Curve

The daily load curves in winter and summer are shown below. In the summer season, because of power demand decreases, some units of thermal power plants stop due to their periodic maintenance. As a result, adjustment capacity (mainly Ulaanbaatar No. 4 Thermal Power Plant (CHP 4), which is indicated as TPP 4 in the following figure) decreases, and import from Russia increases.



(Source: NDC)

Figure 2-9 Sample of Daily Load Curve and Generation Schedule in Winter in CES (2020)

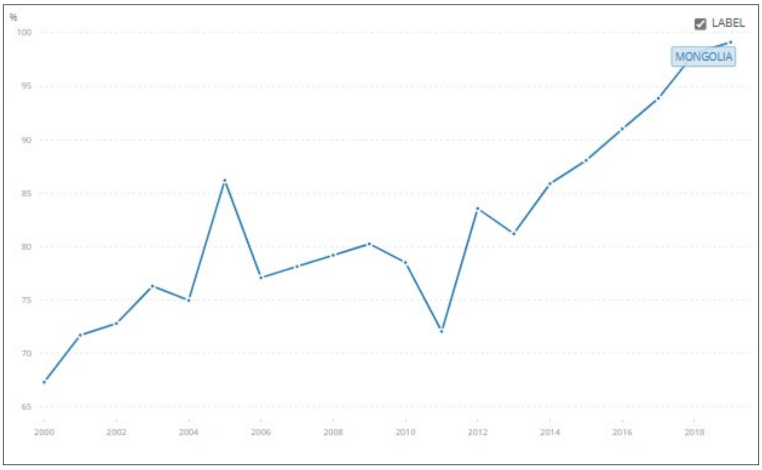


(Source: NDC)

Figure 2-10 Sample of Daily Load Curve and Generation Schedule in Summer in CES (2020)

(7) Electrification Ratio

The table below shows the trend of electrification rate per person in Mongolia, which has reached 99.125 % in 2019.



(Source: WB Global Electrification Database)

Figure 2-11 Transition of Electrification Rate in Mongolia

(8) Transmission and Distribution Loss

Transmission and distribution losses by region are shown in the following table. As of 2020, the target value, 10.8 % in 2023 mentioned in the "State Policy on Energy 2015-2030", has not been achieved in the CES.

Table 2-18 Transmission and Distribution Losses by Region

	AUES	EES	WES	CES
2015	23.51	7.4	25.35	15.07
2016	23.52	4.97	26.73	15.02
2017	23.4	4.1	25.94	14.73
2018	22.53	4.2	24.77	13.97
2019	21.47	3.85	24.27	13.75
2020	19.9	4.4	23.37	13.60

(Source: Statistics on Energy Performance, 2020)

The losses by companies in the table below indicates that UBEDN still struggles with a high loss rate despite the fact that some progress can be seen. According to UBEDN, non-technical loss is calculated as 6 %, out of the total company's distribution loss.

Table 2-19 Losses by Electric Companies

Percentage

Grid Companies	2015	2016	2017	2018	2019	2020
"NPTG" SOJSC	3.15	3.32	3.35	3.15	3.17	3.45
"UBEDN" SOJSC	16.08	15.91	15.79	15.11	14.9	14.72
"DSEDN" Ltd	13.41	14.20	13.65	13.11	10.1	9.09
"EBEDN" SOJSC	3.64	3.43	3.16	2.93	3.35	3.56
"BSEREDN" SOJSC	9.48	9.93	8.15	6.84	7.78	5.10
"Khuvsgul-Energy" Ltd	18.58	18.83	17.97	17.26	16.7	18.71
"Bayankhongor-Energy distribution" Ltd	13.68	13.17	15.77	12.95	13.1	13.35
"SRPDG" SOJSC	17.04	14.77	12.77	11.89	9.74	6.99
Total losses	**15.07**	**15.02**	**14.73**	**13.97**	**13.75**	**13.6**

(Source: Statistics on Energy Performance, 2020)

(9) SAIDI, SAIFI and CAIDI

SAIDI (System Average Interruption Duration Index), SAIFI (System Average Interruption Frequency Index and CAIDI (Consumer Average Interruption Duration Index) are defined as power outage index to measure the quality of power supply in Mongolia. Although SAIDI is gradually improving, the restoration process takes a long time, since the outage period per one blackout lasts for a few hours.

Table 2-20 Outage Index Values

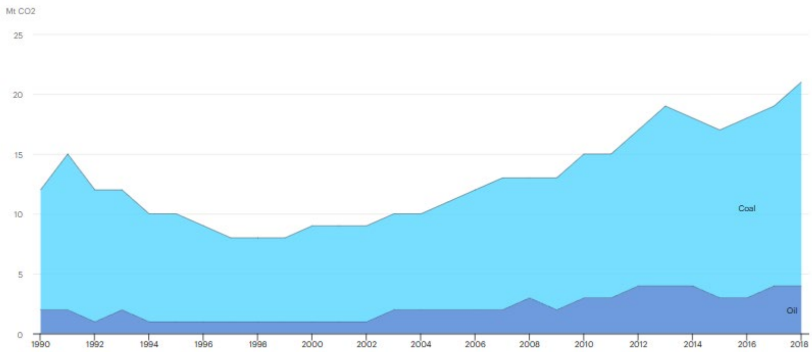
Unit: SAIDI (Hour), SAIFI (Times), CAIDI (Hour)

Region	2017 OH			2018 OH			2019 OH			2020		
	SAIDI	SAIFI	CAIDI	SAIDI	SAIFI	CAIDI	SAIDI	SAIFI	CAIDI	SAIDI	SAIFI	CAIDI
Central region	81	10	8	61	16	4	54	9	6	39	7	6
Western region	11	5	2	126	15	9	103	12	8	119	30	4
AUIPG	54	5	10	26	7	4	22	3	9	19	5	4
Eastern region	4	1	5	3	1	5	10	2	6	11	3	4
Total	73	8	9	62	15	4	54	9	6	42	8	5

(Source: Statistics on Energy Performance, 2020)

(10) Greenhouse Gases Emission Record

The figure below shows the trend of CO_2 emission in Mongolia from 1990 to 2018. Amount of emission is increasing due to the use of coal as primary resource.



(Source: IEA Database)

Figure 2-12 CO_2 Emission by Primary Source in Mongolia

2.3.2 Transmission System

(1) National Power Grid

The transmission system in Mongolia consists of 220 kV, 110 kV and 35 kV. The 220 kV transmission line is the route from the Russian interconnection line through the central part of Mongolia to the south, and the interconnection line from the southern part of Mongolia to China, and the other lines are almost 110 kV transmission lines.

It is divided into 5 regions: Central system (CES), Altai Uliasutai system (AUES), Western system (WES), Southern system (SES), and Eastern system (EES), of which CES and SES send 220 kV. In the electric wire, CES, EES, and AUES are connected by a 110 kV transmission line, and WES is separated.

There are three international interconnections: CES-Russia (220 kV), SES-China (220 kV), and WES-Russia (110 kV). Of these, the interconnection line from China is supplied to some areas of SES and is separated from the line from CES. The table below shows the line length of transmission and distribution lines and the total number of substations nationwide.

Table 2-21 Line Length of Transmission and Distribution Lines Nationwide (Unit: km)

Voltage level		Central region	Western region	AUIPG	Eastern region	South region	Total
1	220 kV	1,956.9	-	-	-	-	1,956.9
2	110 kV	3,675.9	797.4	393.3	1,475.5	-	6,342.1
3	35 kV	6,284.8	1,013.8	919.2	1,817.7	450.0	10,485.6
4	15-20 kV	2,002.0	923.7	1,016.0	922.3	173.4	5,037.4
5	6-10kV	12,953.5	1,468.8	344.0	907.1	427.1	16,100.5
6	0.22-0.4kV	8,677.0	1,490.8	273.0	567.6	9,295.1	20,303.5
TOTAL		**29,931.3**	**3,883.3**	**2,945.3**	**5,690.2**	**10,345.6**	**52,795.6**

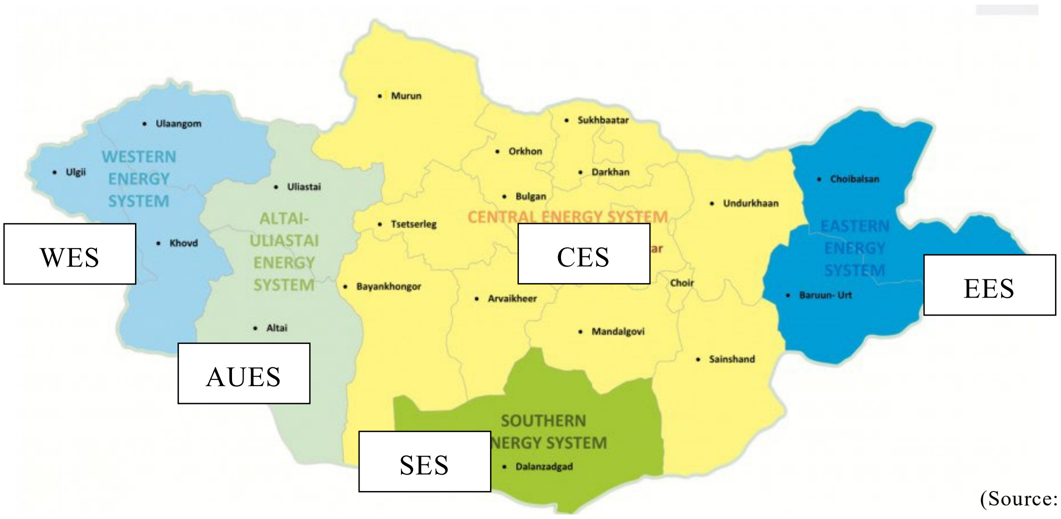
(Source: Statistics on Energy Performance, 2020)

Table 2-22 Total Number of Substations Nationwide

	Voltage level	Central region	Western region	AUIPG	Eastern region	South region	Total
1	220 kV	10	-	-	-	-	10
2	110 kV	72	9	4	10	-	95
3	35 kV	418	22	18	20	35	513
4	15-20 kV	124	74	43	78	28	347
5	6-10kV	9,928	710	187	369	240	11,434
	TOTAL	10,552	784	252	477	303	12,368

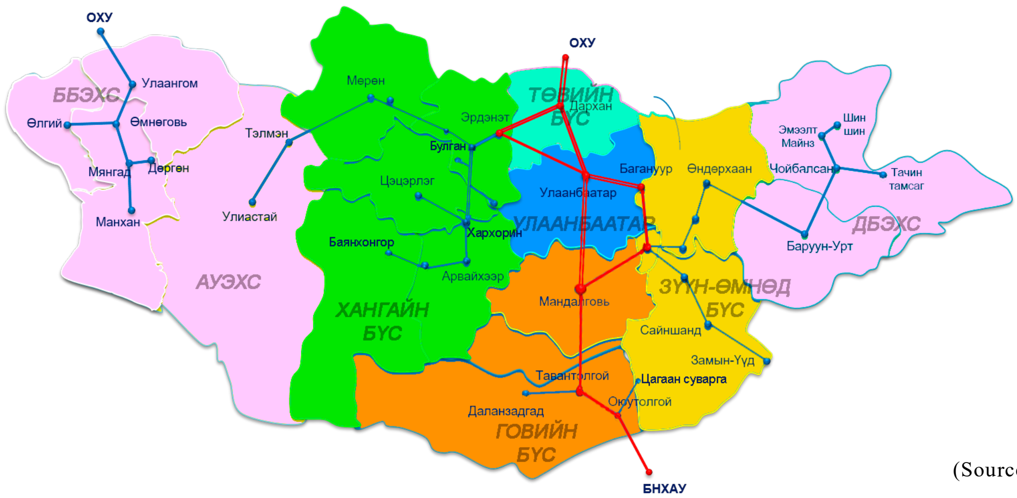
(Source: Statistics on Energy Performance, 2020)

The system classification diagram and transmission system diagram of Mongolia are shown below (Business area of NPTG covers CES and SES in the following table). The red line represents 220 kV and the blue line represents 110 kV.



(Source: ERC)

Figure 2-13 System Classification Map in Mongolia



(Source: ERC)

Figure 2-14 Transmission System diagram in Mongolia

2.4 Energy Development Plan

2.4.1 Power

(1) The Energy Sector Master Plan by WB

(a) Scenario Assumption

The latest energy demand and facility planning, which is still implemented by WB as the interim results (Consultation for ENERGY SECTOR MASTER PLAN February, 2020, PowerPoint version), are observed and described with the Survey Team's comments.

The WB's "Energy Sector Master Plan, February 2020" (hereinafter referred to as the Energy Master Plan), conducts demand forecasts and facility planning for the future under the 6 scenarios as follows.

Scenario 1 (Business As Usual): Coal power plants, which may have economic and technical feasibility, are mainly constructed. Firm capacity (coal power plants) covers the maximum demand even though VRE is expected to reduce the generation of coal power plants.
Scenario 2 (Mid-Term Plan): Firm capacity (coal power plants) is constructed with enough margin compared to the forecasted maximum demand.
Scenario 3 (Balance, VRE, Hydro & Coal): Hydro and VRE are developed in parallel.
Scenario 4 (Balance, VRE, Hydro, Coal & Gas): Coal power plants are drastically replaced by gas power plants.
Scenario 5 (Power Trading): Interconnections from Russia, as well as China, increase.
Scenario 6 (Ambitious VRE & BESS): BESS is installed to make VRE and wind power firm capacity.

(b) Recommended Scenario

The WB conducted an evaluation on the above 6 scenarios by using 6 evaluation axis ranging from A to G. As a result, it recommends Scenario 5, and positions Scenario 3 as the back-up plan for Scenario 5.

Objective	1. BAU	2. MTP	3. BALANCE	4. GAS	5. TRADE	6. HIGH VRE
A. Cost Effective Energy Supply (lifetime Costs compared to BAU)		G	G	B	E	M
B: Reliable and Resilient Supply of Heat and Electricity	M	M	E	E	E	M
C: Energy Self-Sufficiency	M	G	G	M	G	G
D: Connection of Extractive Industries	B	G	E	E	E	M
E: Scaling Up of Renewable Energy	B	B	G	G	E	E
F. NAPSI Compatibility	B	B	B	B	E	B
G: Emission Intensity	B	B	G	E	E	E

E = Excellent; G = Good; M = Medium; B = Bad

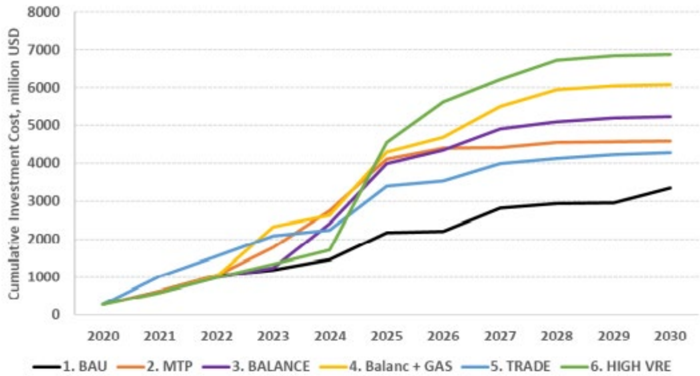
(Source：Energy Sector Master Plan, February, 2020, WB)

Figure 2-15 Results of the Scenario Evaluation by WB

The main contents of Scenario 5 is as follows.

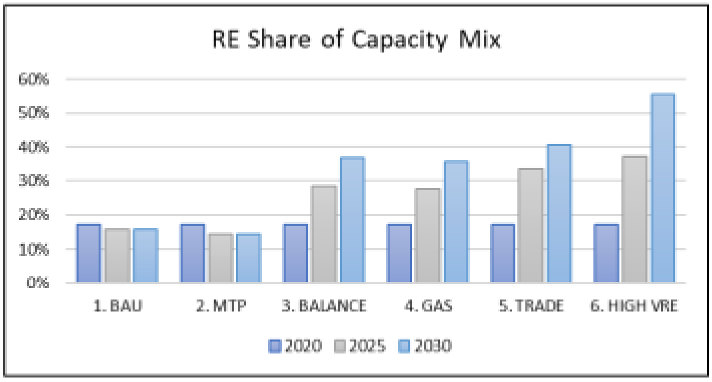
- Back to Back is used to augment power supplies to the CES to allow Oyu Tolgoi mines to be connected to the national grid from 2026.
- 250 MW solar + 250 MW wind connect near Oyu Tolgoi within 2023.
- Oyu Tolgoi mining load is operated in Island mode with help of these VREs and supply from China until Back to Back connecting to CES in 2026.
- National RE targets are satisfied.
- Tavan Tolgoi PP is not developed.

Scenario 5 achieves the RE introduction target as of 2030 (30% of capacity), and the cumulative investment cost up to 2030 will be the second smallest after Scenario 1.



(Source: Energy Sector Master Plan, February, 2020, WB)

Figure 2-16 Cumulative Investment Cost of each Scenario



(Source: Energy Sector Master Plan, February, 2020, WB)

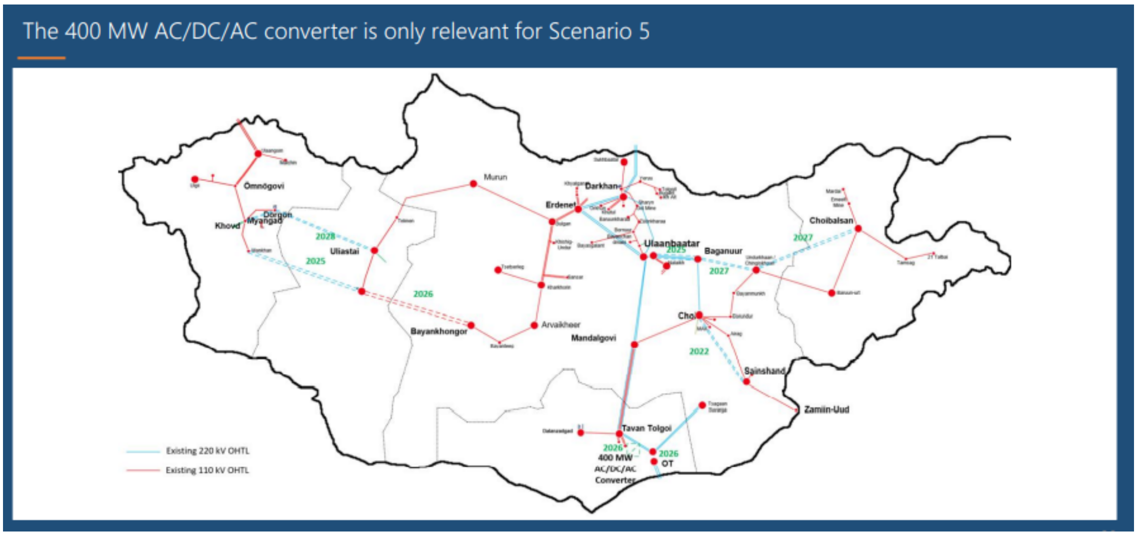
Figure 2-17 Achievement of RE Introduction Rate in each Scenario (Share of Capacity)

The contents of Scenario 3, suggested as the next best plan when a Back to Back (AC/DC converter) equivalent to 400 MW to strengthen the interconnection with China cannot be constructed is as follows.

- Meets national RE target by optimized VRE and complements VRE with hydro mix.

- Oyu Toolgoi assumed to be connected to CES and Tavan Tolgoi PP constructed.
- 1 x 100 MW large hydro (with storage) + smaller hydro plants allowed to enter to provide flexible generation complementing inflexible CHP / coal plant & VRE generation.
- Baganuur entry occurs later and with a reduced capacity (2 x 100 MW).

The transmission system plan when Scenario 5 or Scenario 3 is selected, is as of below. 220 kV system augmentation from Ulaanbatar to Choibalsan in the East, 220 kV system augmentation from Choir to Sainshand, and 220 kV connection between WES and AUES, etc. are commonly proposed as facility augmentation, but the power interconnection through China's Back to Back is only taken into account in Scenario 5. Back to Back is estimated to serve as a self-converter in order to avoid the risk of a large-scale blackout due to accidents in Mongolia spreading its influence to China.



(Source：Energy Sector Master Plan, February, 2020, WB)

Figure 2-18 Design of the Transmission System Plan for Scenario 5 and Scenario 3

(2) Power Demand

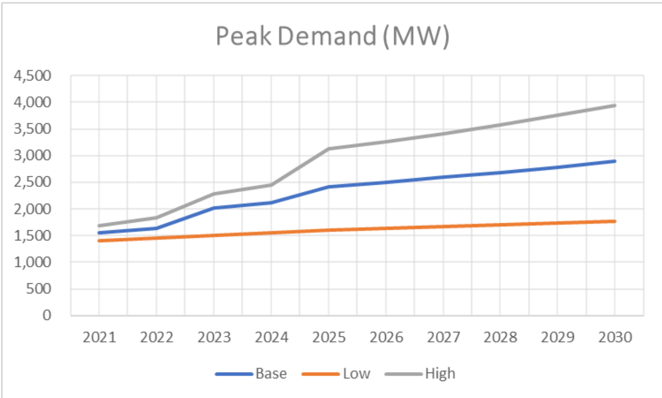
The power demand forecast (total value of Mongolia) obtained from MOE is shown in the table below. As of below, the forecast assumes 3 scenarios: Base Case, Low Case, and High Case, but it can be said that the main feature is the fact that the demand forecast differs greatly depending on whether the demand of large mining centers in South Gobi is included or not.

According to NDC, the draft demand forecast is created by NDC and NDC submits to MOE. MOE coordinates and finalize it. In the NDC drafting, the increase in the electrification rate due to specific technologies, such as the spread of heat pumps in the demand side is not considered.

Table 2-23 Power Demand Forecast in Mongolia (Unit: MW)

	Base	Low	High
2021	1,548	1,408	1,686
2022	1,642	1,455	1,834
2023	2,016	1,504	2,287
2024	2,118	1,551	2,452
2025	2,410	1,598	3,123
2026	2,498	1,633	3,264
2027	2,590	1,668	3,416
2028	2,686	1,703	3,580
2029	2,788	1,738	3,756
2030	2,895	1,773	3,947

(Source: MOE)



(Source: MOE)

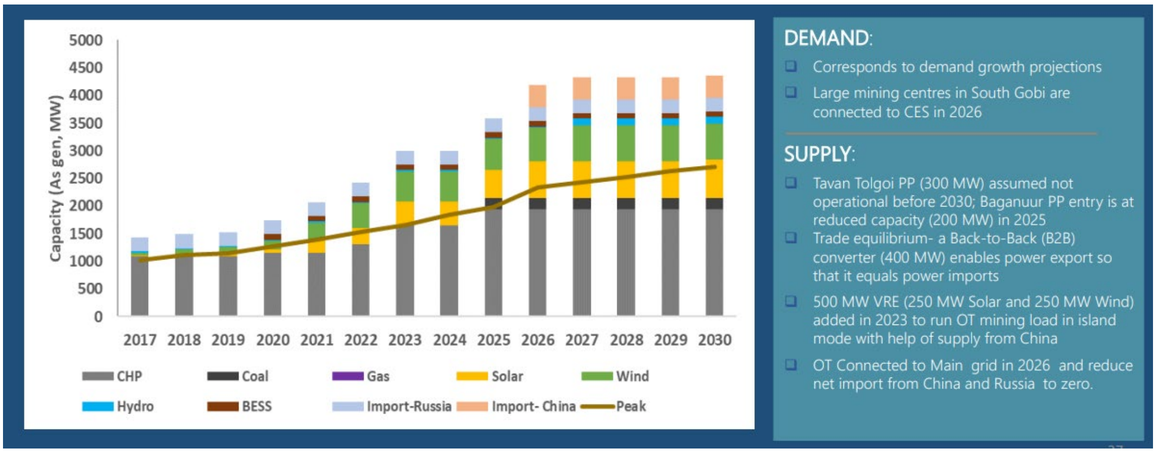
Figure 2-19 Power Demand Forecast in Mongolia (Graph)

(3) Power Development Plan

(a) Power Development Plan of Scenario 5

The power development plan of the recommended scenario (Scenario 5) in the Energy Sector Master Plan by WB is shown in the figure below. The main feature is the fact that power interconnection from China will be extended while introducing VRE such as wind and solar. Overall, the Plan is designed to strengthen connection, along with the expansion of demand in mining centers in South Gobi.

Even for 2030 in cross-section, Farm Capacity (CHP, coal, and import from Russia and China) is enough to cover the maximum power demand.

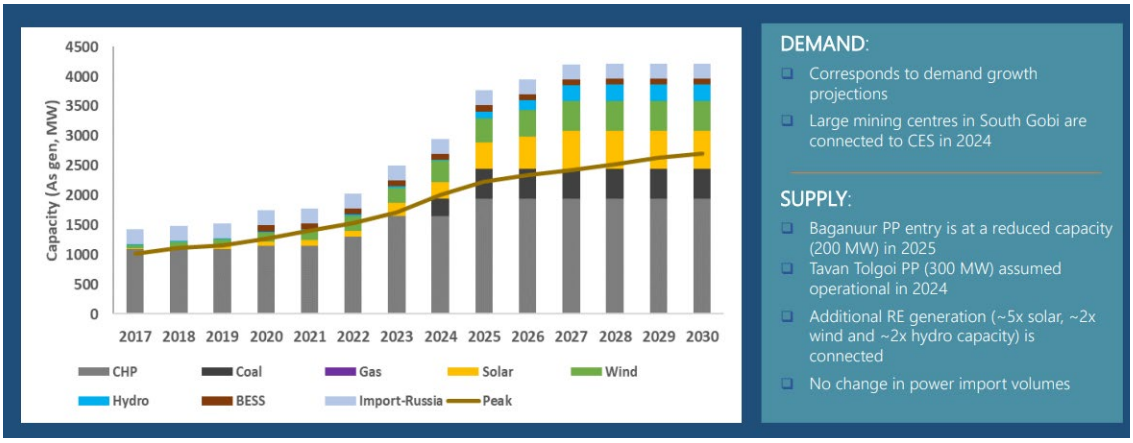


(Source: Energy Sector Master Plan, February, 2020, WB)

Figure 2-20 Power Development Plan of Scenario 5

(b) Power Development Plan of Scenario 3

The power development plan of Scenario 3, which is also proposed as the next best plan in the Energy Sector Master Plan is shown in the figure below. Although it does not include import from China, it can similarly cover the maximum power demand in 2030 cross-section, with farm capacity (CHP, coal, and import from Russia) like Scenario 5.



(Source: Energy Sector Master Plan, February, 2020, WB)

Figure 2-21 Power Development Plan of Scenario 3

(c) Individual Power Investment Plans

The power investment plan common to all of the scenarios is as of below. In addition to the investment plan common to all of the scenarios, Scenario 3 and Scenario 5 have individual plans. Scenario 3 aims for system stabilization through investment in hydropower, whereas Scenario 5 aims for system stabilization through interconnection from China (enabled by Back to Back).

Table 2-24 Power Investment Plan Common to All Scenarios

Year & Type	Project Name	Cost (US$ million)	Size (MW)	Region
[2019] CHP	Darkhan CHP Expansion	25	35	CES
[2020] CHP	CHP4 Expansion	87	89	CES
[2021] CHP	Erdenet CHP Expansion	47	35	CES
[2021] CHP	Dornod CHP Expansion	59	50	EES
[2022] CHP	CHP3 Expansion	86	75	CES
[2025] CHP	CHP3 Expansion	380	250	CES
[2025] CHP	CHP2 Expansion	270	300	CES

US$954 million

(Source: Energy Sector Master Plan, February, 2020, WB)

Table 2-25 Individual Power Investment Plans of Scenario 3 and Scenario 5 (Thermal power and hydropower, storage batteries, etc., excluding VRE)

Scenario 3 - Thermal Plant (including CHPs) + Hydro Plant + BESS

Year & Type	Name of Project and Location	Cost (US$ million)	Size (MW)	Region
[2020] BESS	UB BESS	110	100 MW/ 250 MWh	CES
[2022] CHP	Uliastai PP	60	50	AUES
[2022] CHP	Amgalan 2 (CHP)	45	50	CES
[2023] Coal	Tavan Tolgoi PP	937	300	SES
[2025] Coal	Baganuur PP-1	236	200	CES
[2025] Hydro	Orkhon HPP	297	100	CES
[2026] Hydro	Orkhon govi HPP	53	18	CES
[2026] Hydro	Khashaat HPP	53	18	CES
[2027] Hydro	Erdeneburen HPP	262	97	WES

US$2,114 million

Scenario 5 - Thermal Plant (including CHPs) + Hydro Plant+ BESS

Year & Type	Name of Project and Location	Cost (US$ million)	Size (MW)	Region
[2020] BESS	UB BESS	110	100 MW/ 250 MWh	CES
[2022] CHP	Uliastai PP	60	50	AUES
[2022] CHP	Amgalan 2 (CHP)	45	50	CES
[2025] Coal	Baganuur PP-1	236	200	CES
[2027] Hydro	Erdeneburen HPP	262	97	WES

US$713 million

Scenario 3 leverages hydro to system flexibility, whereas is in Scenario 5 flexibility is provided by the B2B connection with China

(Source: Energy Sector Master Plan, February, 2020, WB)

Table 2-26 Individual Power Investment Plan for Scenario 3 (VRE: Solar power and wind power)

Year & Type	Name of Project and Location	Cost (Million USD)	Size (MW)	Region
[2023] Solar	AUES Solar 1	12	10	AUES
[2025] Solar	AUES Solar 2	34	30	AUES
[2021] Solar	CES Solar 1	39	30	CES
[2022] Wind	CES Wind 1	76	50	CES
[2022] Wind	CES Wind 2	76	50	CES
[2023] Solar	CES Solar 2	61	50	CES
[2023] Solar	CES Solar 3	36	30	CES
[2024] Solar	CES Solar 4	58	50	CES
[2024] Wind	CES Wind 3	72	50	CES
[2025] Solar	CES Solar 5	56	50	CES
[2025] Solar	CES Solar 6	34	30	CES
[2026] Solar	CES Solar 7	54	50	CES
[2026] Wind	CES Wind 4	68	50	CES
[2027] Solar	CES Solar 8	51	50	CES
[2027] Wind	CES Wind 5	66	50	CES
[2026] Solar	EES Solar 1	54	50	EES
[2023] Solar	SES Solar 1	61	50	SES
[2024] Wind	SES Wind 1	72	50	SES
[2025] Solar	SES Solar 2	56	50	SES
[2025] Wind	SES Wind 2	70	50	SES
[2027] Solar	SES Solar 3	51	50	SES

A total of 930 MW VRE with 580 MW Solar + 350 MW Wind installed

US$1,157 million

(Source: Energy Sector Master Plan, February, 2020, WB)

Table 2-27 Individual Power Investment Plan for Scenario 5 (VRE: Solar power and wind power)

Year & Type	Name of Project and Location	Cost (Million USD)	Size (MW)	Region
[2023] Solar	AUES Solar 1	12	10	AUES
[2025] Solar	AUES Solar 2	34	30	AUES
[2021] Solar	CES Solar 1	39	30	CES
[2022] Wind	CES Wind 1	152	100	CES
[2023] Wind	CES Wind 2	74	50	CES
[2023] Solar	CES Solar 2	61	50	CES
[2023] Solar	CES Solar 3	36	30	CES
[2025] Solar	CES Solar 4	56	50	CES
[2026] Solar	CES Solar 5	54	50	CES
[2027] Wind	CES Wind 3	66	50	CES
[2030] Solar	CES Solar 6	26	30	CES
[2026] Solar	EES Solar 1	54	50	EES
[2021] Wind	OT Wind 1	78	50	SES
[2021] Wind	OT Wind 2	78	50	SES
[2021] Wind	OT Wind 3	78	50	SES
[2021] Solar	OT Solar 1	66	50	SES
[2021] Solar	OT Solar 2	66	50	SES
[2021] Solar	OT Solar 3	66	50	SES
[2022] Wind	OT Wind 4	76	50	SES
[2022] Solar	OT Solar 4	63	50	SES
[2023] Wind	OT Wind 5	74	50	SES
[2023] Solar	OT Solar 5	61	50	SES
[2026] Wind	SES Wind 1	68	50	SES
[2026] Solar	SES Solar 1	54	50	SES

A total of 1,130 MW VRE with 630 MW Solar + 500 MW Wind installed

US$1,490 million

(Source: Energy Sector Master Plan, February, 2020, WB)

(4) Individual System Augmentation Plans

The individual system augmentation plans for Scenario 3 and Scenario 5 are as of below.

Table 2-28 Individual System Augmentation Plans for Scenario 3 and Scenario 5

Scenario 3 – Transmission

Year & Type	Name of Project and Location	Cost (US$ million)
[2022] Transmission	220 kV Choir - Sainshand	48
[2024] Transmission	220 kV Oyu Tolgoi – Oyu Tolgoi New	6
[2025] Transmission	220 kV Baganuur - Songino	57
[2025] Transmission	110/220 kV Taishir - Mankhan	43
[2026] Transmission	110 kV Taishir - Bayanhongor	36
[2027] Transmission	220kV OHL Baganuur – Choibalsan	114
[2029] Transmission	220kV OHL Uliastai – Dorgon – Myangad	89

US$393 million

Scenario 5 – Transmission

Year & Type	Name of Project and Location	Cost (US$ million)
[2022] Transmission	220 kV Choir - Sainshand	48
[2025] Transmission	220 kV Baganuur - Songino	57
[2025] Transmission	110/220 kV Tashir - Mankhan	43
[2026] Transmission	400 MW AC/DC/AC converter station*	200
[2026] Transmission	110 kV Tashir – Bayanhongor	36
[2026] Transmission	220 kV Oyu Tolgoi – Oyu Tolgoi New	6
[2027] Transmission	220 kV OHL Baganuur – Choibalsan	114
[2028] Transmission	220 kV OHL Uliastai – Dorgon – Myangad	89

US$593 million

* US$150 million for converter station + US$50 million in supporting upgrades

(Source: Energy Sector Master Plan, February, 2020, WB)

(5) Estimation of the Required RE Introduction Amount to Achieve the 30 % RE Introduction Rate in 2030

The result of calculating the RE introduction rate of 30 % in capacity with respect to the maximum power demand in 2030 from the MOE Base Case scenario is as follows.

Target Value of RE Introduction for 2030: 2,895 MW x 30 % = **868 MW**

2.4.2 Heat Supply

(1) Current Heat Supply Facilities

The current heat supply facilities (main facilities) are as of below. CHP is a combined heat and power facility, but accounts for approximately 60 % of the total amount of heat supply from Ulaanbaatar No. 2, No. 3, and No. 4 thermal plants.

Table 2-29 Current Heat Supply Facilities

Plant	Area	Sourse	Heat Supply Capacity (GJ/h)			Annual Heat Generation (000 GJ)		
			2018	2019	2020	2018	2019	2020
UB №2	CES	CHP	272	272	272	883	1,019	1,026
UB №3	CES	CHP	2,449	2,449	2,449	9,337	9,430	10,074
UB №4	CES	CHP	6,820	6,820	6,820	15,544	16,353	16,871
UB Amgalan HOB	CES	heat Only	1,256	1,256	1,256	2,682	3,054	3,190
Darkhan	CES	CHP	1,675	1,675	1,675	2,258	2,333	2,440
Erdenet	CES	CHP	816	816	816	2,479	2,531	2,597
Erdenet mining Plant	CES	CHP	0	435	435	0	1,933	1,902
Nalaikh HOB	CES	heat Only	335	335	335	453	403	397
Baganuur HOB	CES	heat Only	712	712	712	686	648	688
Dulaan Shariin Gol	CES	heat Only	70	70	70	158	160	149
Selenge Energo	CES	heat Only	209	209	209	382	386	342
Khutul Energy Dulaan	CES	heat Only	251	251	251	286	312	164
Tuv Chandmani	CES	heat Only	131	131	131	384	403	376
Chandmani Ilch	CES	heat Only	219	219	219	224	233	233
Dalanzadgad	CES	CHP	158	158	158	163	213	291
Ekh Golomtiin ILCH	CES	heat Only	164	164	164	265	270	280
Khuvsgul Thermal Plant	CES	heat Only	126	126	126	307	310	333
Hentii Us	CES	heat Only	36	36	36	206	219	215
Energy Plus	CES	heat Only	0	100	100	0	67	118
Gan Ilch	CES	heat Only	62	62	62	284	293	306
Choibalsan	EES	CHP	384	384	384	1,297	1,393	1,460
Durvulj	EES	heat Only	98	98	98	288	288	289
Mandal golomt	AUES	heat Only	156	156	156	256	280	282
US DU	WES	heat Only	65	65	65	46	46	143
Erchimbayan Ulgii	WES	heat Only	188	188	188	252	229	260
Ulaangom Thermal Plant-2	WES	heat Only	126	126	126	157	173	188
Hovd Thermal Plant	WES	heat Only	146	146	146	184	189	206
Total						39,461	43,170	44,820

(Source: MOE)

(2) Development Plan of Heat Supply Facilities

(a) Development Plan

In the Energy Master Plan which has been being developed by WB, there is also a section on the plan for heat supply facilities. The development plan for HOB (Heat Only Boiler) that takes into account Scenario 3 and Scenario 5 regarding power is as follows.

Table 2-30 HOB Development Plan based on Scenario 3 and Scenario 5

Scenario 3 & 5 - Other Heat Sector Investments

Year & Type	Name of Project and Location	Cost (US$ million)
[2020] Heat Network	Heat Network Investments	18.9
[2021] Heat Network	Heat Network Investments	17.8
[2022] Heat Network	Heat Network Investments	17.8
[2023] Heat Network	Heat Network Investments	17.8
[2024] Heat Network	Heat Network Investments	17.8
[2025] Heat Network	Heat Network Investments	16.8
[2026] Heat Network	Heat Network Investments	16.8
[2027] Heat Network	Heat Network Investments	16.8
[2028] Heat Network	Heat Network Investments	16.8
[2029] Heat Network	Heat Network Investments	16.8
[2030] Heat Network	Heat Network Investments	15.7

US$190 million

Scenario 3 & 5 - HOB

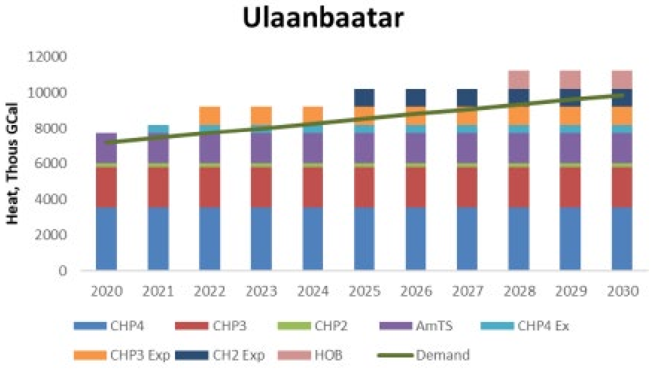
Year & Type	Name of Project and Location	Cost (US$ million)	Size (Gcal/hr)	Region
[2021] HOB	HOB (9 Aimag Centres)*	130		
[2028] HOB	Ulaanbaatar HOB	100	200	CES

US$230 million

(Source: Energy Sector Master Plan, February, 2020, WB)

(b) Heat Supply Development Plan in Ulaanbaatar

The outlook for the heat supply development plan in Ulaanbaatar is as of below. It is assumed that the heat supply of Ulaanbaatar No. 3 and No. 4 thermal power plants will be augmented in the near future.



(Source: Energy Sector Master Plan, February, 2020, WB)

Figure 2-22 Heat Supply Development Plan under Scenario 3 and Scenario 5

2.5 Assistance Trends in the Energy Sector of Other Donors

The trends of other donors such as ADB, WB and EBRD are checked. The latest assistance trends for each donor (as far as it is open to the public) are as follows. In particular, ADB is actively supporting the introduction of RE, as it has approved technical assistance (TA) for NDC on December 2, 2019, and support for the introduction of storage batteries (Grant & Loan) on April 22, 2020.

Table 2-31 Assistance Trend in the Energy Sector of Other Donors

Donor	Project Name	Approval Date
Asian Development Bank (ADB)	Fostering Expanded Regional Electricity and Gas Interconnection and Trade under the CAREC Energy Strategy 2030 (TA, Regional)	2020.7.22
	First Utility-Scale Energy Storage Project (Grant & Loan)	2020.4.22
	Supporting Renewable Energy Development (TA)	2020.1.16
	Smart Energy System for Mongolia (TA)	2019.12.2
	Upscaling Renewable Energy Sector Project (Grant & Loan)	2018.9.20
World Bank (WB)	Ulaanbaatar Heating Sector Improvement Project (Loan)	2020.4.24
	Second Energy Sector Project (Loan)	2017.6.15
European Bank for Reconstruction and Development (EBRD)	Choir - Sainshand Transmission Line (Loan)	2021.6.29
	Ulaanbaatar District Heating Project (Loan)	2019.9.10
	Sainshand Wind Project (Loan, Private)	2017.6.20
	Support for the Implementation of Renewable Energy Auctions in Mongolia (TA)	N.A.

(Source: Homepage of Each Donor)

Chapter 3 Overview of the Main Organizations in the Power Sector

3.1 National Dispatch Center (NDC)

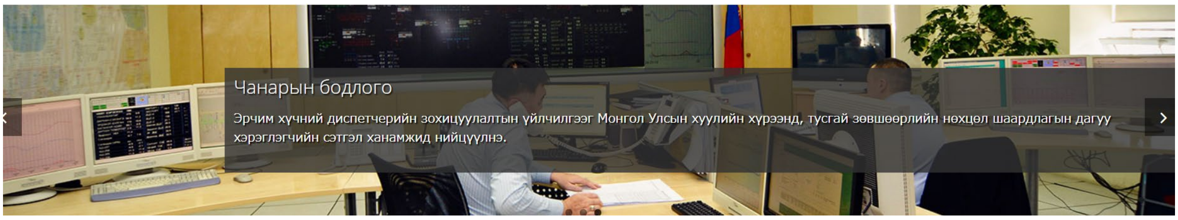
3.1.1 Organization

NDC controls and supervises power and heat supply throughout Mongolia, puts power generation plants and transmission networks under its surveillance, and carries out system planning, supply and demand adjustment, and transmission network operation for power supply. Founded in 1964 and nationalized in 2001, NDC has been run by 124 staff in 10 divisions as of 2021. The Energy Act stipulates the following roles of NDC:

- ✓ Power and heart supply, convey and deliver control
- ✓ Control power import and export
- ✓ Supervise the transmission networks
- ✓ System interconnection management for power producers and heat suppliers
- ✓ Limitation and restoration of power and heat supply in the event of disasters and emergencies
- ✓ Transmission system analysis, protection rely operation, management of related telecommunication
- ✓ Setting and implanting rules for transmission system management

3.1.2 Facility and Equipment

NDC occupies two floors of the government building, and operates central power dispatch facilities owned by themselves, including WAMS (Wide Area Monitoring System) which collects power station and substation information, SCADA (Supervisory Control And Data Acquisition) which supervise the transmission network, and a server.



(Source: NDC)

Figure 3-1 Central Power Dispatch Center (Image)

3.1.3 Tasks of NDC

(1) Supply and Demand Adjustment

NDC relies on international connections to coordinate supply and demand due to the lack of frequency control capability by the AGC (Automatic Generation Control) function, and insufficient domestic supply capacity during demand peak. The CES, which is the largest connected system, balances supply and demand balance with adjustment capacity provided by the Russian system at the northern interconnection point, and WES maintains its balance with the Russian system at the northeastern interconnection point. On the other hand, southern part of the SES is separated from the CES and is connected to the network of China.

NDC ordinary plans for operation and control to import power from Russia during demand peak from daytime to evening. From RE power producers, such as PV and wind power producers, generation forecasts are sent annually, monthly and daily. Hourly generation forecasts of a day, for 24 hours, are sent by 11 AM on the preceding day, and the supply plan is formed so as to utilize the RE. In the cases that the outputs of these RE generations differ from forecasts or supply from IPP is lower than planned, unplanned power trade increases. In the case of excess supply, when it occurs in the nighttime, curtailment or shutdown of wind turbine is ordered, and the excess power is exported to the Russian system. That extra transaction, including import power from Russia during supply shortage and purchase of RE during off-peak hours, drives NDC into an unexpected financial burden, and leads it to restrict the acceptance of RE generated power from IPP.

Power trade with Russia is planned by kW and kWh, and only the import is assumed. Power is exported in the case of excess supply, but since there is the capacity limit and the exported power is almost of no charge, export may not be done for a long time. Also, since the difference between plan and actual record reflects the payment of the power trade, RE outputs are curtailed when the output exceeds the forecast even during the import time, so as to match with the forecast.

Total amount of RE introduction into Mongolia grid was set up to 245 MW in line with the international connection capacity of 245 MW with Russia. Reserving more adjustment capacity is critical as recent increase in power demand ranges from seven to eight percent, while the supply rate has only risen from six to seven percent. Adoption of national energy policy to expand RE introduction, targeting a RE ratio of 20 % in 2023 and 30 % in 2030 on a capacity basis, also make it important to secure additional adjustment capacity.

Currently, CHP 4 (753 MW) is the main controllable power source of Mongolia, and has the capability of 150 MW to 300 MW output control, and +/- 10 % of short time output adjustment by the governor control. Also, increase of interconnection capacity with Russia up to 345 MW has been agreed with Russia in December 2021. In addition, NDC is considering to secure additional supply and demand adjustments domestically, such as rehabilitation of thermal power plants and introduction of hydropower plants, pumped storage hydropower plants, and batteries.

(2) System Operation

There are 110 kV and 220 kV transmission lines in the vast territory of Mongolia. The 220 kV transmission lines stretch out from north to south, linking to Russia and China grid via the CES and the SES systems, as shown in the preceding chapter. The 110 kV transmission network consist of two, one extending from the CES to the SES, EES, and AUES and the other in the WES. EES is operated separately from CES, and is connected to the Russian system. WES is also separated from AUES and is connected to the Russian system. SES is divided into the system connected with CES, including 18 MW and 16 MW of CHPs, and the system connected to the network of China, including approximate 240 MW of the mine development demand. Power demand is concentrated in the Ulaanbaatar area. Relatively large scale thermal power plants are incorporated into the CES system while RE operators are concentrated in the southern region.

It is often pointed out that Mongolia's transmission systems have difficulty in maintaining proper voltage range with such an unbalanced system configuration, and have insufficient capacity to break short-circuit current. Voltage is controlled by controlling generators, transformer taps, switching capacitors, and unenergizing transmission lines. However, it is coming to light that it becomes difficult to keep proper voltage level at the RE connection points in local transmission systems.

The existing SCADA system of NDC collects online data from 38 sites, including 18 power stations and 20 substations (out of them, 1 in AUES, 3 in WES, and 1 in EES), to monitor the transmission network. There were some blackouts which affected the vast areas of Mongolia recently due to issues above, so countermeasures are under consideration and some were implemented, such as updating the SCADA system and utilization of WAMS function, reinforcing system analysis by combining WAMS function and RTDS (Real Time Digital Simulator) introduction, and improvement of the voltage control by "FACTS (Flexible AC Transmission System)" facility introduction including SVC (Static Var Compensator) / STATCOM (Static Synchronous Compensator).

3.1.4 Network Operation Standard

(1) Overview

Integrated Grid Code is the standard for network operation. Contents are outlined in the following subsections. As stated in the previous chapter, this document is under revision. In the following statement, revision document (as of December 2020, in the process of approval at the time of this report) is partly referred to (marked "*").

(2) Component of Regional Networks

(a) Central Energy System (CES)

CES is responsible for electrical and thermal energy production, transmission and distribution in the central region covering Ulaanbaatar, Tuv, Darkhan-Uul, Orkhon, Selenge, Bulgan, Khuvsgul, Arkhangai, Uvurkhangai, Bayankhongor, Dundgobi, Dornogovi, Govisumber, Khentii, Zavkhan, Sukhbaatar, Umnugobi and Gobi-Altai provinces. Energy business Licensees in CES are as follows (*).

Table 3-1 Energy Business Licensees in CES

Abbreviation	Company
TPP-2 Co.	Thermal Power Plant II, Shareholding Company
TPP-3 Co.	Thermal Power Plant III, Shareholding Company
TPP-4 Co.	Thermal Power Plant IV, Shareholding Company
Darkhan TPP Co.	Darkhan Thermal Power Plant, Shareholding Company
Erdenet TPP Co.	Erdenet Thermal Power Plant, Shareholding Company
CRET Co.	Central Region Electricity Transmission Company
UBHDN Co.	Ulaanbaatar Heat Distribution Network Co.
UBEDN Co.	Ulaanbaatar Electricity Distribution Network, Shareholding Company
DSEDN Co.	Darkhan Selenge Electricity Distribution Network, Shareholding Company
EBEDN Co.	Erdenet Bulgan Electricity Distribution Network, Shareholding Company
BSEREDN Co.	Baganuur South Eastern Region Electricity
SEWF	Clean Energy LLC
DSPP	Solar Power International LLC
MNEWF	Everyday Farm LLC
NTPP Co.	Nalaikh Thermal Power Plant, Shareholding Company
ATPP Co.	Amgalan Thermal Power Plant, Shareholding Company

(b) Western Energy System (WES)

WES produces electricity transmission and distribution in the western region, including Uvs, Bayan-Ulgii and Khovd provinces. Energy business Licensees in WES are as follows (*).

Table 3-2 Energy Business Licensees in WES

Abbreviation	Company
WRPS Co.	Western Region Power System Shareholding Co.
Bayan-Ulgii ETLC Co.	Bayan-Ulgii Electric Transmission Line Center Province-owned Co.
Uvs-EDN LLC	UVS Electricity Distrubution Network LLC
Khov-EDN LLC	Khovd Electricity Distrubution Network LLC
Durgun-HPP LLC	Durgun Hydro Power plant LLC

(c) Eastern Energy System (EES)

EES operates electricity distribution and transmission network in the eastern region, including Dornod, Sukhbaatar and Khentii aimags. Energy business Licensees in EES are following (*).

Table 3-3 Energy Business Licensees in EES

Abbreviation	Company
ERPS	Eastern Region Power System Shareholding Co.
Sukhbaatar Province Branch of ERPS	Eastern Region Power Systems Sukhbaatar Province Branch

(d) Altai-Uliastai Energy System (AUES)

AUES produces electricity transmission and distribution in Altai-Uliastai region covering Govi-Altai and Zavkhan provinces. Energy business Licensees in AUES are as follows (*).

Table 3-4 Energy Business Licensees in AUES

Abbreviation	Company
Altai-Uliastai PS Co.	Altai Uliastai Power System Shareholding Co.
Uliastai Erchim	Uliastai Erchim LLC
Esunbulag Energy	Esunbulag Energy LLC
Taishir Guulin HPP LLC	Taishir Guulin Hydro Power Plant LLC
Tosontsengel HPP LLC	Tosontsengel Hydro Power Plant LLC
Galuutai-Khungui HPP LLC	Galuutai-Khungui Hydro Power Plant LLC
Bogd Gol HPP LLC	Bogd Gol Hydro Power Plant LLC

(e) Southern Energy System (SES)

SES produces, transmits and distributes electricity in the Gobi region covering South Gobi and Dornogovi provinces. Energy business Licensees in SES are as follows (*).

Table 3-5 Energy Business Licensees in SES

Abbreviation	Company
Tsetsii EWF	Clean Energy Asia LLC
Ukhaa Khudag PP	Ukhaa Khudag Power Plant
Dalanzadgad TPP	Dalanzadgad Thermal Power Plant
South Region PTDN	South Region Power Transmission and Distribution Network

(3) Quality Standard

(a) Frequency

- Normal frequency is maintained 50 +/- 0.1 Hz. (*)
- Deviation 50 +/- 0.2 Hz is limited within 10 minutes.
- Temporary deviation is allowed up to 50 +/- 0.4 Hz.

(b) Voltage

- According to the National Standard MNS (IEC)38:2001, maximum voltage of each voltage level is as follows.

Table 3-6 Maximum Voltage in Each Voltage Level

Normal Voltage (kV)	Acceptable Maximum Voltage (kV)
6	7.2
10	12
15	17.5
20 or 22	24 or 25
35	40.5
110	123 or 126
220	245 or 252

- Voltage at each voltage control point is maintained within the following.

Table 3-7 Voltage Levels at Voltage Control Points

Minimum Voltage (kV)	Average Voltage (kV)	Maximum Voltage (kV)
5.8	6.3	6.6
9.5	10.5	11
33.3	37	38.5
104.5	115	123
209	230	245

- Voltage control points are as follows. (*)

Table 3-8 Voltage Control Point

CES	35/110 kV of Power Plant-3 110/220 kV of Power Plant-4 110 kV of Darkhan Power Plant 110/220 kV of Darkhan, Erdenet, Baganuur and Ulaanbaatar Substations 110 kV of Tuul Substation 110kV of Dornod 2 Substation 220/110kV of Songino, Choir, Oyutolgoi, Mandalgobi, Tavantolgoi Substations 110/35/10 kV of Zaisan, Bayanchandmani, Zest, Nalaikh, Bulgan, Moron, Undurkhaan Substations
WES	110/35/10 kV of Ulaangom Substation 110/35/10 kV of Umnugovi Substation 110/35/10 kV of Malchin Substation 110/35/6 kV of Myangad Substation 110/35/10 kV of Bayan-Ulgii Substation 110/35/10 kV of Mankhan Substation 110 kV of Durgun Hydropower Plant HV/MV/LV of the Ulaangom Substation and Durgun Hydropower Plants
EES	110 kV of Choibalsan Thermal Power Plant 110/35/6 kV of Choibalsan Substation 110/35/10 kV of Baruun-Urt Substation 110/6 kV of Tumurtei Substation 110/35/6 kV of Undurkhaan Substation 110/35/10 kV of Emeelt Substation 110/35/10 kV of Ulaan Deposit Substation
AUES	110/35/6 kV Taishir Hydropower Plant 110/35/6 kV of Uliastai Substation 110/35/10 kV of Telmen Substation 110/35/6 kV of Mogoin Gol Thermal Power Plant

- In the normal operation situation in the transmission and distribution network, supply voltage is maintained to equal or less than +10 % (* within +/- 10 %) of the nominal voltage.

(c) Planned Supply Interruption

- Supplier notify the customer at least 3 days (* 24 hours) prior to the planned interruption of power supply.

(4) Supply and Demand Plan

(a) Supply and Demand Plan

- To make a long term supply demand plan, each licensed entity shall submit required information to NDC by November 1. NDC shall make plans of long term import/export and capacity of newly installed power plants.
- NDC shall create next year's supply and demand prediction by October 10, create next year's supply and demand plan by November 10, and get approval from related parties.
- Each licensed entity shall submit information required for next year's demand forecast to NDC by September 1, and submit its revision by October 20.

(b) Reserve Capacity Plan

- NDC shall keep reserve energy capacity necessary for the integrated operation of the power network and central heating supply. Each licensed legal entities shall submit the next month's reserve capacity by the 20th of each month to NDC.

(c) Power Energy Balance

- NDC shall make power energy balance plans for the terms of annual, quarter, month, day and hour. Each licensed entity shall report the result to NDC every month.

(d) Power Import and Export

- NDC shall make and implement power import and export plan for the terms of annual, quarter, month, day and hour, based on the national power supply demand plan.

(e) Licensee's Operation Plan

- Each licensed entity shall submit operation plans for the terms of annual, quarter, and month, with the related information including technical conditions to NDC. NDC shall get approval of ERC, after necessary amendment. Each licensed entity shall operate in accordance with the approved plan.

(f) Securing Stability of Network

- CES and WES shall agree and comply technical conditions on the interconnection points with Russia, for the stable operation of the interconnected system.
- For securing network stability, automatic control device shall be equipped and be operated properly.

(5) Grid Connection Requirement

(a) Connection of New Equipment

- Connection of new customer equipment to power source, transmission of electricity and heat network shall meet the “Electricity Usage Rules” and the “Thermal Energy Usage Rules” approved by the government and the “Connection Guidelines” approved by ERC.
- Owner of new equipment to be connected shall submit design documents including following to NDC at least 15 days prior to the connection.
  - Switching procedure, Temporary and final diagram of the connection
  - Proposal switching date
  - Setting changes of protection and control devices due to the new equipment connection
- NDC shall check the contents, and prepare for switching operation in the related substations as needed.
- After the agreement of the conditions and procedures between NDC and transmission/distribution licensed legal entity, the transmission/distribution licensed legal entity shall order switching prior to at least 3 days.

(b) Operating Conditions and Stability (*)

- Licensed legal entities shall conduct survey in accordance with the requirement for installing or upgrading equipment required by NDC at the preliminary stage and the agreement stage.
- Data, conditions, simulation models and related information for the survey shall be submitted to NDC.
- For power/heat generation facility with more than 10 MW and substation/transmission facility with more than 35 kV, survey shall be conducted for both winter peak load time and summer low load time to compare with the situation before connection.
- For the connection of thermal power plant, survey shall include normal operation power flow, voltage control, short circuit current, static stability, dynamic stability, overvoltage, neutral point operating conditions, and shall be approved by NDC.
- For the connection of renewable energy power plant, survey shall include normal operation power flow, loss and voltage drop, short circuit current, static stability, dynamic stability, harmonics, voltage fluctuation, output fluctuation, overvoltage, neutral point operating conditions, and shall be approved by NDC.
- For the connection of substation and transmission facility with more than 35 kV, survey shall include normal operation power flow, loss and voltage drop, short circuit current, static stability, dynamic stability, overvoltage, neutral point operating conditions, and shall be approved by NDC.
- For the connection of load with more than 5 MW, survey shall include normal operation power flow, loss and voltage drop, static stability, dynamic stability, and shall be reviewed by NDC.
- For the stability analysis, setting and operating conditions are checked by NDC.

- For the connection of large scale power source, stability analysis covering the overall network shall be conducted, measures for maintaining stability shall be prepared if needed, and shall be approved by NDC.

(6) Monitoring System

(a) Securing Monitoring and Communication Devices for Dispatching

- Each licensed entity, in cooperation with NDC, shall secure highly reliable operating conditions of monitoring and communication systems such as SCADA system, required for dispatching.

(b) Integrated Metering System (*)

- Integrated metering system shall be managed by NDC, to which the data transmitted from trade meters and control meters in the substations installed by the transmission/distribution licensees are sent to.

(c) Protection and Control Equipment

- NDC shall monitor the overall network condition and take emergency measures when necessary. In order to do this, proper operation of protection and control equipment shall be maintained.
- NDC shall set following devices; automatic load limiter (ACR), generator, 110 – 220 kV transmission line, transformer, 6 – 220 kV sectional automatic facility DZA, APV, BZA, ABR, asynchronous automatic shutdown (APAH), automatic separator (DA), automatic generation control (ARV), emergency recorder (AURA), 110 – 220 kV transmission protection, busbar protection, generator/transformer protection.
- Power generation licensee shall set following devices, NDC shall check the setting; automatic reserve switch (AVR), 0.4 – 6 kV inhouse voltage controller, 10 /6 kV inhouse transformer protection, 6 – 0.4 kV inhouse network protection.
- Transmission licensee shall set following device; substation inhouse equipment protection.
- Distribution licensee shall set following devices, NDC shall check and approve if the device is used in the equipment of other licensee; automatic recloser (APV), automatic switch (AVR), automatic voltage regulator for 35/6 – 10 kVtransformer, voltage controller for 6 kV customer, protection for 6 – 35 kV feeder line.

(d) Overvoltage/ Lightening Protection

- Generation, transmission/substation and distribution facilities shall equip with the device to protect overvoltage caused by lightening. Effect of the device shall be checked before the season of lightening. Each licensee is responsible for overvoltage/ lightening protection of its owned facilities.

(7) Operation in Emergency

(a) Voltage and Reactive Power Control

- NDC shall set the emergency minimum voltage level at each voltage control point. If there is no setting of the emergency minimum voltage, it will be set at 90 % of the nominal voltage of busbar.
- When voltage goes lower than the limit, reactive power consumption of reactors shall be reduced or disconnected without the instruction from NDC.
- When a generator is disconneted due to under voltage, it shall be reconnected immediately and be operated at maximum load and maximum reactive power output within the rated value.
- When the busbar voltage of a voltage control point goes over the upper limit, the station shall control the reactive power adjustment devices in the power station, and NDC shall take measures such as disconnection of light load feeders.
- When the voltage goes beyond the limits in other than the voltage control points, substation shall control the voltage.
- NDC shall monitor the voltages at the voltage control points, and take appropriate measures to maintain voltage, such as tap change of transformers.

(b) Load Limitation

- Customers' load shall be limited under system wide emergency cases as follows. Distribution licensees shall prepare the targets of limitations and its procedures for winter and summer, and report to NDC.
    - Supply power energy (kWh) shortage due to fuel or water short
    - Supply capability (MW) shortage, including overload
    - Supply shortage due to generation trip
    - Activation of ACR protection due to frequency drop
    - Supply and demand unbalance due to network separation
- Distribution licensee may limit the power supply to the unpaid customer, contrary to the supply agreement, after the notice prior to at least 48 hours. NDC may restore from or postpone the limitation if it is necessary for the stable operation of the network.

(8) Network Loss

- NDC develops the criteria of technical loss, and ERC develops the criteria for non-technical loss.
- Transmission and distribution licensee shall calculate annual and monthly network loss and report them to NDC.

(9) Daily Supply Demand Operation

(a) Daily Supply Demand Planning

- NDC shall develop daily load forecast and generation plan, determine daily demand supply plan.

- NDC shall monitor the situation of power supply and demand, and issue preliminary instructions to generation licensee or customer depending on the situation.

(b) Procedure of Daily Supply and Demand Planning

- In coordination with heat supply/consumption forecast from the regional heat supply system, NDC determines the following day's supply and demand plan by 14:00 of each day, and send it to generation, transmission and distribution licensees.
- Each licensee shall send following information to NDC two times a month, for the conditions of developing supply and demand plan and implementing operations.

  Generation licensee: Generation energy (MWh), Number of operation unit, Capable output (MW), Minimum output at night time (MW)

  Transmission and distribution licensee: Transmission energy (MWh), Maximum and night time transmission power (MW), transmission/distribution loss (%, MWh)

(10) Interconnection with Neighboring Countries' Network

(a) Interconnection between CES and Russian Power System

- Synchronized interconnection operation between CES and Russian Power System is conducted to maintain frequency and to compensate power shortage in CES. Technical and trade conditions which are not stated in this Code shall be referred to the agreements by both parties determined separately.
- International interconnection lines are 2 circuits from Selendum to Darkhan 220 kV transmission line, and NDC and Buriat RDU of Russia shall cooperatively operate them.
- Planned outages due to equipment inspection related to the interconnection or other reasons shall be agreed by both parties.
- NDC shall plan trade power and energy. Daily maximum power is sent from Selendum substation to NDC every day, and trade energy is measured on a monthly basis.

(b) Interconnection between WES and Russian Power System

- Based on the agreement, WES and Russian Power System are interconnected and operated synchronously.
- International interconnection line is 110 kV transmission line from WES to Chadan of Russia, and related equipment are operated based on the agreement by both parties.
- Trade power and energy shall be reported monthly, in the form of NDC. (*)

(c) Cooperation with Chinese Power System (*)

- Legal entities importing large amount of power shall report the import amount to NDC weekly.
- In the case of connecting large capacity generation for export, domestic supply shall be included, and the supply shall be conducted by NDC in accordance with this Code.

(11) Network Operation

(a) Equipment Energize/Unenergize Operation

- In energizing and unenergizing operations, each power station and substation shall develop equipment operation procedure, and keep it.
- Based on the energized situations of the equipment, following conditions are defined.
  In operation: Switch for power source is closed and equipment of the customer is energized.
  Under maintenance: All connected switches are opened and equipment is ready for maintenance under the safety work rule.
  Stand-by: The equipment is unenergized or all connected switches are opened, and the switch is ready to close.
  Automatic stand-by: All or part of switches are opened by automatic operation, and can be closed automatically.

(b) Rules in Operation

- Peak time zones are from 1 hour before the morning peak to 1 hour after it, and from 2 hours before the evening peak to 1 hour after it, and the operations by NDC during peak time zone may not be interrupted.
- Operations shall be avoided as much as possible when outside temperature is under -25 degrees Celsius, since switchgear malfunction or operation congestion is more likely when outside temperature is under -30 degrees Celsius.
- Approval of technical responsible personnel shall be obtained when switchgear operation under -30 degrees Celsius or isolator operation under -40 degrees Celsius is conducted.

(c) Equipment Maintenance

- Maintenance is classified as planned maintenance and emergency maintenance.
- Each license holder shall submit maintenance plan to the government administrative by 15th of the preceding month. The government administrative shall examine and determine the date, and notify to the license holder.
- In planning outage of a part of the main network, the plan shall be submitted to NDC 6 months prior. NDC shall examine the situation of supply and demand, and determine the schedule.
- When emergency maintenance is required, emergency maintenance request shall be submitted. NDC shall issue emergency maintenance instruction when normal operation is hindered.
- Even in the case of emergency, outage operation shall be conducted after the emergency maintenance instruction, as much as possible. If the equipment requires emergency outage or went outage, it shall be reported after the outage.

(12) Roles of Concerned Organizations

(a) Roles of Government Administration

- Develop the Energy Policy, Examine for implementation of the Energy Policy
- Research and develop national budget, domestic and foreign loan and grant, projects by national development funds and other activities concerning energy sector, Implement feasibility studies
- Propose power network development components to be conducted by national budget
- Develop power development plan, feasibility study for newly installed power plant
- Approve transmission loss target and loss reduction implementation developed by NDC
- Develop and approve the standards for safety, maintenance and services in renewable power generation operation, Supervise and evaluate their implementations
- Develop the standards for safety and technical matters in operating power network facilities, Supervise their implementations
- Survey fault cause of network faults, Resolve disputes, Develop measures to prevent
- Examine for licensees' productivity improvement, Support their implementation
- Support local government, related organizations and licensees for securing reliability of energy sector and energy policy implementation, in technical matters
- Allocate personnel or equipment from other licensees to the necessary parts, in order for stable operation of power network and problem solving for licensees
- Develop human resources in energy sector

(b) Roles of NDC

- Develop and implement the plan to supply electricity and heat energy in accordance with technical standards and with minimum cost, by electricity/ heat generation licensees, transmission/ distribution licensees, heat transfer/ supply licensees, including regulated and unregulated.
- Adjust generation, transmission and distribution promptly, to make supply and demand of electricity balanced at all times.
- Eliminate network faults
- Set and monitor frequency, voltage, water pressure and water temperature of the main network, Supervise and maintain static and dynamic stability
- Monitor telecommunication and protection system, Recover from the equipment failures, Set limit values, Coordinate between licensees in newly establishment or upgrade of equipment
- Develop and implement non-discriminatory load limiting plan in the case of emergency
- Coordinate for importing supply from other licensee or abroad for integrated operation of central heat supply
- Examine and implement emergency measures as necessary
- Plan and implement electricity import and export
- Make contracts properly with each licensee and customer to make balance of power supply and

demand, Report them to ERC

- Secure confidentiality of other licensees' information, data, contracts concerning supply demand balancing, based on the approval by the related organization
- Implement emergency training at least 2 times a year, including corresponding staffs in the related organizations
- Store operation instructions and operation records
- Develop guidelines for interconnection with foreign network, Keep guidelines by technical management personnels in the related sections
- Cooperate with other licensees in fault investigations
- Scope of responsibility of NDC is facility, protection, control and communication equipment, measuring meters in the main network. Operation shall be conducted by generation, transmission/ distribution licensees.
- Determine neutral point operations in 110 - 220 kV network, Notify them to transmission/ distribution licensees (*)
- Power trade in the main network (*)

(c) Roles of other Licensed Legal Entities in the Integrated Grid

- Each licensee operates facilities for power generation, heat generation, transmission, distribution, heat transfer and heat supply, to secure stable supply of electricity and heat.
- Each licensee develop and implement operation procedures of facilities with most economical, least loss and maintaining network stability, under the approval of NDC.
- Each licensee follows rules, procedures, instructions/orders and decisions by NDC.
- Arbitration shall be asked for ERC in case of conflicts between licensees.
- Each licensee shall make contract with other licensees appropriately.
- Each generation licensee shall operate based on the operation curve and the conditions approved by NDC, and check deviations for every 8 hours. (*)
- Each transmission licensee shall estimate deviations between customer power consumptions and forecasts. (*)
- Each regulated heat producer shall develop heat supply plan and operation conditions, submit them to NDC, and operate based on the supply contract with NDC. (*)
- Each licensee shall suppress deviation between planned and actual values within +/- 2 %. (*)

(13) Classification and Record of Network Fault

(a) Emergency

- Outage of power plant or heat plant of 35 kW and above, for 25 days or more
- Outage of boiler, turbine, generator, or transformer of 315 kW and above, and no possible and reasonable maintenance
- Load limit of 100 MW and above, except for automatic shedding or disengagement

- Frequency drop to 49.0 Hz and below for more than 1 hour continuously or for 3 hours total in a day, due to generation outage
- Outage of power station with more than one generator
- Load limit of 40 % or more customers, due to network separation
- Shedding of 20 % or more distribution network, due to transmission network fault in 6 kV and above
- Outage of heat source or heat supply facility for 5 hours or more, during the heating season
- Outage of urban 1st or 2nd grade customer for 12 hours or more, due to facility damage or violation of related regulation
- Outage of 3rd grade customer for following conditions; for 12 hours or more within 20 km from supply point, for 16 hours or more in 20 – 40 km from supply point, for 22 hours or more in 40 – 80 km from supply point, for 28 hours or more in 80 – 150 km from supply point, for 44 hours or more in 150 – 250 km from supply point, for 56 hours or more at more than 250 km from supply point
- Occurrence of environmental pollution due to outage of ash process system

(b) 1st Grade Fault

- Outage of power system facility or heat plant of 35 kW and above, for 3 - 25 days
- Frequency drop to 49.5 Hz and below, due to generation outage
- Decrease of power plant output for 50 % or more
- Occurrence of load limit due to network separation
- Shedding of 20 % or less distribution network, due to transmission network fault in 6 kV and above
- Outage of heat source or heat supply facility for 2 - 5 hours, during the heating season
- Outage of urban 1st or 2nd grade customer for 4 - 12 hours, due to facility damage or violation of related regulation
- Outage of 3rd grade customer for following conditions; for 4 - 12 hours within 20 km from supply point, for 8 - 16 hours in 20 – 40 km from supply point, for 14 - 22 hours in 40 – 80 km from supply point, for 20 - 28 hours in 80 – 150 km from supply point, for 36 - 44 hours in 150 – 250 km from supply point, for 48 - 56 hours at more than 250 km from supply point
- Occurrence of environmental adverse effects due to emission of liquid/gas hazardous material

(c) 2nd Grade Fault

- Temporary power outage of customer except for the operation of protection or automatic control device
- Temporary or erroneous separation of power /heat source or network facility
- Outage of heat source or heat supply facility for up to 2 hours, during the heating season
- Outage of urban 1st or 2nd grade customer for up to 4 hours, due to facility damage or violation

of related regulation

- Outage of 3rd grade customer for following conditions; for up to 4 hours within 20 km from supply point, for up to 8 hours in 20 – 40 km from supply point, for up to 14 hours in 40 – 80 km from supply point, for up to 20 hours in 80 – 150 km from supply point, for up to 36 hours in 150 – 250 km from supply point, for up to 48 hours at more than 250 km from supply point
- Power outage of customer except for the operation of protection or automatic control device

(d) Fault Reporting

- In the occurrence of emergency and 1st grade fault, licensee shall immediately report to the government administration and NDC.
- Fault report shall include the following: time, outline, contents, damages, customer outages, measures taken, and situation of investigation committee.

(14) Renewable Energy Power Source (*)

(a) Objective

- Requirements and operating conditions for renewable energy power sources to connect to power network are incorporated.
- Renewable energy source include hydropower plant, solar power plant, wind power plant, biomass power plant, and geothermal power plant.

(b) Synchronous Operation with Power Network

- Operation of renewable energy power source shall be followed by the instruction from NDC, issued in accordance with network conditions.
- Load change rate of renewable energy power source shall not be less than 5 MW/ minutes.
- In the case of change in the designated operation condition, it shall be reported to NDC immediately.
- Operating frequency range shall be kept at 50 +/- 0.1 Hz, and emergency operating range shall be 47 – 52 Hz.
- Operating voltage shall be in the following ranges.

Table 3-9 Operation Voltage of Renewable Energy Power Source

Standard Voltage (kV)	Minimum Voltage (kV)	Maximum Voltage (kV)
6	5.8	6.6
10	9.5	11
35	33.3	38.5
110	104.5	123
220	209	245

(c) Monitoring and Control Item

- Following data shall be taken and transmitted by the supervisory and control system (SCADA), and be monitored and controlled by NDC.
  Wind power: Output, Wind speed, Generator (synchronized/ disconnected), Wind direction, Voltage, Outside temperature, Pressure, Air density, Capable output, Curtailed output
  Solar power: PV/ inverter output, Voltage at connection point, Generator/ inverter status, Surface radiation, Outside temperature, Diffuse reflection, Direct reflection, Sunset time, Cloud, Precipitation, Humidity, Generation factor

(d) Requirements for Renewable Energy Power Source

- Solar power plant of 5 MW or more, and wind power plant with battery of 20 % of total plant capacity shall be able to operate for at least 3 hours at maximum output.
- Interconnection shall be conducted by the synchronization device, and in the conditions of voltage difference within +/- 5 %, frequency difference within +/- 0.2 Hz, and angular difference within 10 degrees.
- Independent operation shall be capable at 10 % and above output of the capacity.

(e) Operation Plan

- Each licensee of renewable energy power plant shall submit hourly generation forecast for 7 days from the following day to NDC, by 12 pm.
- Output in the operation plan, annually formed and submitted to NDC, may not exceed the output in the approved feasibility study.

(f) Minimum Output and Requirement for Curtailment

- During the normal operation, minimum output of wind power generation shall be up to 20 % of the capacity for wind speed 12 m/s and above, up to 14 % for 7 to 12 m/s, and up to 4 % for less than 7 m/s.
- Wind power generation may limit the output in case of emergency, regardless of wind speed.
- Other renewable energy power generations may limit the output in normal and emergency situations, regardless of weather conditions.
- Each renewable energy power plant shall operate at normal operation within 5 minutes after the limit.

(g) Frequency and Voltage Control

- In response to the frequency fluctuation, following measures shall be taken.
  - When the frequency goes down below 49.5 Hz, reserve capacity shall be operated and unnecessary in-house load shall be disconnected.
  - When the frequency drops rapidly, automatic load separation shall be activated to be set

after the activation of thermal power's load separation device.

- When the frequency rises, measures such as output decrease shall be taken.

- In response to the voltage fluctuation, following measures shall be taken.
  - When the voltage drops, measures such as reactors disconnection, reactive power output increase shall be taken.
  - In the emergency case of a rapid voltage drop, overload operation shall be allowed within capable range. The range shall be determined by the test or reasonable rule.
  - When the voltage rises, measures such as reactive power output decrease, reactors connection shall be taken.

(h) Allowable Frequency and Voltage Ranges

- In normal operation, allowable voltage ranges are set as follows, based on the generator type (A, B, C) and standard voltage

Type A (220 kV, 110 kV):	0.92 pu - 1.098 pu
Type A (35 kV, 10 kV, 6.3 kV):	0.92 pu - 1.08 pu
Type B (220 kV, 110 kV):	0.92 pu - 1.095 pu
Type B (35 kV, 10 kV, 6.3 kV):	0.92 pu - 1.08 pu
Type C (220 kV, 110 kV):	0.92 pu - 1.09 pu
Type C (35 kV, 10 kV, 6.3 kV):	0.92 pu - 1.078 pu

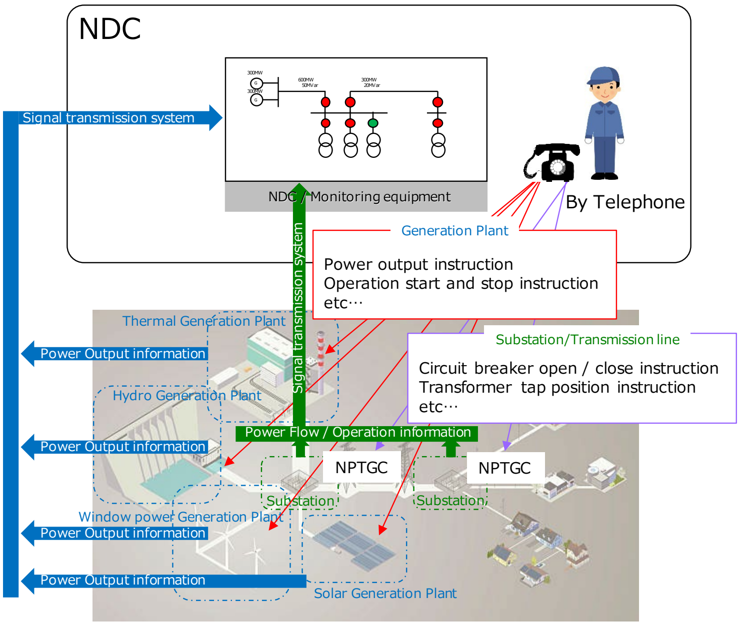
- Standard operation frequency is 50 Hz. Disconnection is allowed in the cases of 51.5 Hz or more for 4 seconds and above and 47.0 Hz or less for 0.2 seconds and above.

3.1.5 Operation of the Integrated Network

NDC is responsible for dispatching power plants and managing overall network (including 24 substations in the main grid). On the other hand, NPTG's central dispatchers operate other equipment except for NDC's controlling equipment and lower voltage transmission system. NPTG operates substation and transmission facilities based on the instruction from NDC. The concrete task allocation is described below.

- NDC monitors the main transmission network situations and issues instructions of output changes of power plants and operations in substations, in response to the conditions of the network. Power stations and substations are controlled in accordance with the instructions.
- 24 substations of NPTG are monitored by NDC and operated by the instruction from NDC.
- NPTG usually manages and operates substation facility, other than the main network facility operated by NDC. In the cases such as network faults, however, NDC may give instructions to operate other substation facilities under the control of NPTG, in order to keep network stability.
- Each of the 5 branches of NPTG reports the operation records of substations under control to the NPTG central dispatcher.

- NPTG central dispatcher reports the 5 branches' operation records of substations to NDC. Planned works and network switches of a day are also reported to NDC, and the operations need to be conducted after the approval from NDC.



(Source: Survey Team)

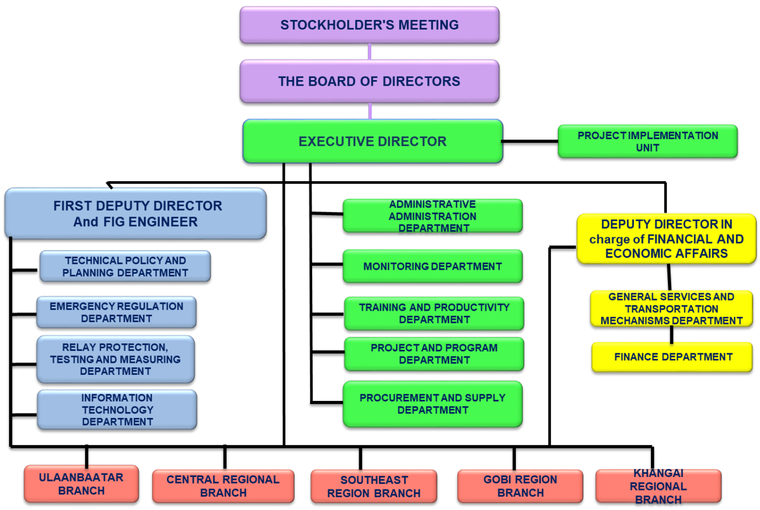
Figure 3-2 Coordination between NDC and NPTG (Schematic)

3.2 National Power Transmission Grid State Own Stock Company (NPTG)

3.2.1 Overview of Organization

(1) Overview of Organization

NPTG operates 220 kV 1,956.9 km, 110 kV 3,608.8 km, 35 kV 18.5 km overhead transmission lines, covering 16 prefectures (Aimag) and more than 300 villages (Sum) throughout the country of Mongolia. The organization chart is shown right.



(Source: NPTG)

Figure 3-3 Organization Chart of NPTG

There are a total of 1,292 employees, consisting of 150 management staff in the Headquarters, 409 staff at Ulaanbaatar branch, 190 staff at Hangai regional branch, 210 staff at Central regional branch, 212 staff at Southeast regional branch, and 121 staff at Gobi regional branch (as of September 2021).

(2) Overview of Facilities

The amount of major facilities owned by NPTG is as follows.

Table 3-10 Overview of Transmission and Transformation Equipment

Voltage	Length of Fictitious Transmission Lines	Number of Substations
220kV	1,956.9 km	10
110kV	3,608.8 km	69
35kV	18.5 km	1
Total	5,584.1 km	80

(Source: NPTG)

Table 3-11 Breakdown of Facilities by Branch Office

Branch Office	220 kV Transmission Line	110 kV Transmission Line	35 kV Transmission Line	Number of Substations
Ulaanbaatar Branch	285.8 km	473.5 km	7.5 km	29
Hangai Regional Branch	208.6 km	1,308.3 km	0 km	12
Central Regional Branch	310.5 km	677.4 km	0 km	18
Southeast Regional Branch	229.7 km	802.2 km	0 km	11
Gobi Regional Branch	0 km	564.3 km	0 km	4

(Source: NPTG)

(3) System Operation Staff

NPTG owns 80 substations. The operation management of NPTG adopts a direct control method, and NPTG's central command office gives instructions to each branch office. A coordinating division is placed in the central command office of NPTG to manage the entire system operation work within the company. The coordination division instructs the operation managers of each branch office to manage operations 24 hours a day, and operates 80 substations and transmission lines throughout NPTG.

At each branch office, power supply commanders works in four shifts, and there are two people in one group. In addition to the power supply commander, each shift is composed of two or three equipment operators who operate the substations.

The power supply commander of the central command office and the power supply commander of the branch office use a communication line connected by a special line. An operation manual is set for this communication, which include directions on emergency response, daily work, relationship between the power supply commander of the central office and the commander of the branch office, and etc., such as the equipment to be operated.

According to this operational manual, power supply commands from the central command office are given to 220/110 kV transmission lines, major substation facilities, and their protection relay equipment. However, the 35/10/6 kV line is under the operational control of the power supply commands of the branch office.

Table 3-12 Breakdown of System Operation Staff at NPTG

No.	Department	Staff Total	Number of Staff at the Rapid Coordination Division			
			Power Supply Commander (Senior Engineer)	Shift Work (Senior Engineer)	Shift Work (Engineer)	Shift Work (Technician)
1	Headquarters (including Boroa Camp)	150	10			
2	Ulaanbaatar Branch	409	9	109	28	131
3	Hangai Regional Branch	190	5	10	30	40
4	Central Regional Branch	210	5	20	29	60
5	Southeast Regional Branch	212	5	10	48	39
6	Gobi Regional Branch	121	5	20	11	24
Total		1,292	39	169	146	294
			648 / 50 % of total number of staff			

(Source: NPTG)

3.2.2 Overview of Transmission Facilities

(1) General Situation of Transmission Facilities

In the "Preparatory Survey for Ulaanbaatar Transmission and Distribution Project (hereinafter referred to as the Preparatory Survey for Transmission and Distribution)" conducted by JICA in 2014, the following is stated on the past structures of transmission facilities.

- NPTG's transmission lines consist of towers and concrete poles.
- The type of the existing conductors are conventional ACSR (Aluminum Conductor Steel Reinforced) and the sizes of the conductors are mainly 240~400 mm^2 for 220 kV system and 70~150 mm^2 for 110 kV system.
- Regarding the insulators, Russian and Chinese glass insulators are used, but contamination by coal smoke is noticeable and is causing insulation degradation problems.

Figure 3-4 Overhead Transmission Lines near CHP 4

Figure 3-5 Glass Insulators (left: Russian-made, right: Chinese-made)

(2) Facility Standards

According to the Preparatory Survey for Transmission and Distribution, most of the existing transmission and transformation facilities in Mongolia are designed in line with Russian standards. Those that do not conform to Russian standards are designed according to standards set out by the IEC (International Electrotechnical Commission) and ISO (International Organization for Standardization).

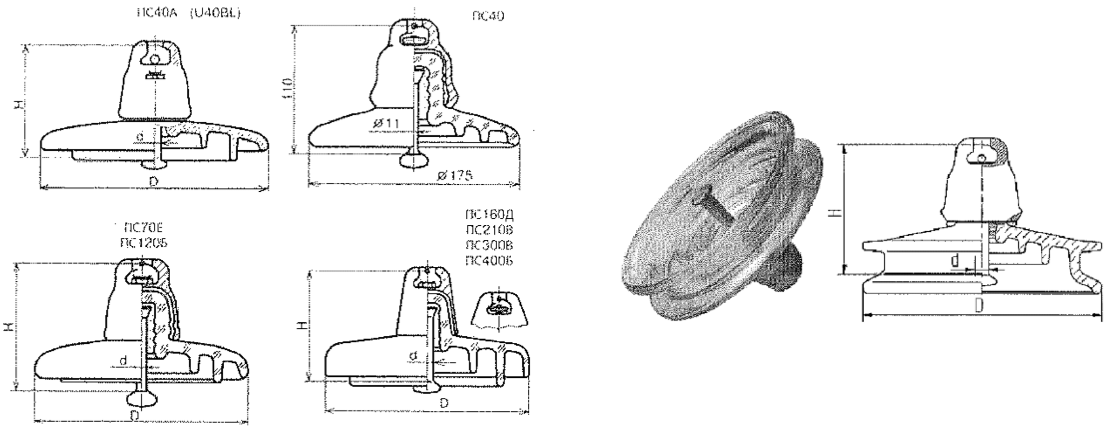
The specifications of existing conductors and insulators are as follows.

Table 3-13 Technical Specifications of the Existing Conductors

Type	Construction [mm]		Cross sectional area [mm^2]			Nominal Diameter [mm]	DC Resistance [ohm/km]	Ampacity [A]	Nominal weight [kg/km]
	AL	Core	AL	Core	Total				
ACSR70	6/3.8	1/3.8	68.0	11.3	79.3	11.4	0.46	265	175
ACSR120	28/2.3	7/2.0	115.0	22.0	137.0	15.2	0.27	380	492
ACSR150	28/2.6	7/2.2	148.0	26.6	174.6	17.0	0.21	445	617
ACSR240	28/3.0	7/2.8	238.0	43.1	281.1	21.6	0.132	610	997
ACSR300	28/3.7	7/3.2	295.0	56.3	315.3	24.2	0.107	690	1257
ACSR400	28/4.2	19/2.2	395.0	72.2	467.2	28.0	0.080	835	1660

Table 3-14 Technical Specifications & Figures of the Existing Insulators

Type	Electromechanical Failing Load	Nominal Creepage Distance	D [mm]	H [mm]	d [mm]	Net weight [kg]
ПС40	40 kN	185 mm	175	100	11	1.7
ПС40А	40 kN	190 mm	175	110	11	1.7
ПС70Е	70 kN	303 mm	255	127; 146	16	3.4
ПС120Б	120 kN	320 mm	255	127; 146; 170	16	4.9
ПС160д	160 kN	370 mm	280	146; 170	20	6.0
ПС210В	210 kN	370 mm	300	170; 195	20	7.1



3.2.3 Overview of Substations

(1) General Situation of Substations

According to the Preparatory Survey for Transmission and Distribution, the following is stated on substation facilities owned by NPTG.

- There are 14 substations in UB city all of which are connected to either a 220 kV or 110 kV Transmission network to deliver electricity to 35 kV or 10kV distribution networks. There are cases in which the loading rates of 110 kV/35 kV or 10 kV substations reach almost 100% during the wintertime.

- The substation facilities have deteriorated due to age, and in particular, mechanical protection relays are still operated with no replacement parts supply.
- Substation operation is basically direct operation by on-site shift, and although there are plans for the introduction of substation SCADA in the future, it is limited to Ummnat substations, etc. The replacement of aged mechanical relays to the IED (Intelligent Electronic Device) type (mainly made by SEL and ABB) has also just started.
- Most substations are equipped with future bays for system expansion and refurbishment, but no reactive power sources have been considered.

Transformer and Busbar of Existing Substation

Cubicle of Russian Manufacturer

Relay Panels and Mechanical Relays

Specification for Machine's Ambient Operational Temperature

Figure 3-6 Situation of Substation Facilities

(2) Facility Standards

The primary voltage of the substation facilities managed and operated by NPTG are 220 kV, 110 kV, and 35 kV, and it is supplied to the distribution company through 35 kV or 10 kV distribution lines. According to the Preparatory Survey for Transmission and Distribution, although it was not possible to obtain a written standard for the capacity standard of transformers, etc. within the system plan, the following contents were confirmed by interviews.

- NPTG wishes to add a 110 kV/10 kV transformer with the capacity of 60 MVA, in addition to the current two standards of 40 MVA and 25 MVA.
- The short-circuit cutoff capacity is basically 40 kA for a 110 kV system, but it was recognized that changes in the short-circuit capacity due to changes in the system configuration needs to be confirmed based on the system future plan.
- Regarding the capacity of the 220 kV substation, the Baganuur substation had a 63 MVA x 2 bank configuration.

Furthermore, regarding the specifications of substation facilities, NPTG is currently aiming to procure the equipment through international competitive bidding based on the international standard set out by IEC, However, the difference from other countries in terms of equipment specifications is that it is assumed to be used in extremely low temperature conditions and high altitude.

In Mongolia, high-voltage substation facilities with outdoor specifications are generally required to be able to operate within the temperature range of -55 ° C to + 40 ° C, and indoor or those near distribution facilities are required to operate in a range of -40 ° C to + 40 ° C. Since the operating altitude is also assumed to exceed 1,000 m, care must be taken when selecting equipment such as checking the insulation performance of gas insulating equipment at extremely low temperatures.

(3) Issues in Protection Relay Setting

According to NPTG, there is a guideline for the setting of protection relays. NPTG estimates that 7 % of the total relays may fail. Although NPTG is updating micro processor relays step by step, they recognize the need for training on methods for setting protection relays properly for products made by different manufacturers.

3.2.4 Financial Status

Profit and loss table of NPTG is shown below. In 2019, the actual income slightly exceeded the costs. In the plan, income and cost is balanced to be equal. In 2020, the actual revenue was almost equal to the costs.

Table 3-15 Profit and Loss Table of NPTG

			Unit	2019 actual	2020		compared to planned		compared to the previous year	
					plan	actual	number	%	number	%
1	**Transmitted electricity**		**mln kWh**	**5951.1**	**5,915.5**	**6,027.9**	**112**	**102**	**77**	**101.3**
2	**Transmission losses**	**%**	**%**	**3.20**	**3.43**	**3.45**	**0**	**101**	**0**	**107.8**
		amount	**mln kWh**	**188.6**	**202.8**	**207.8**	**5**	**102**	**19**	**110.2**
3	**Transmitted electricity**		**mln kWh**	**5,762.6**	**5,712.7**	**5,820.1**	**107**	**102**	**58**	**101.0**
4	**Total income**		**mln MNT**	**379,166.0**	**426,016.1**	**411,918.8**	**-14,097**	**97**	**32,753**	**108.6**
	Operation income		mln MNT	53,811.3	52,749.3	52,749.3	0	100	-1,062	98.0
	Income from Oyutolgoi PPA		mln MNT	319,042.2	358,267.1	349,016.1	-9,251	97	29,974	109.4
	Other income		mln MNT	6,301.5	14,399.8	10,053.4	-4,346	70	3,752	159.5
5	**Total cost**		**mln MNT**	**373,712.0**	**425,916.1**	**411,790.7**	**-14,125**	**97**	**38,079**	**110.2**
	Administration cost		mln MNT	345.3	349.0	341.1	-8	98	-4	98.8
	Cost for Oyutolgoi PPA		mln MNT	319,042.2	358,267.1	349,016.1	-9,251	97	29,974	109.4
6	**Income before tax**		**mln MNT**	**5,443.0**	**0**	**28**	**28**	**0**	**-5,415**	**0.5**
	Tax costs		mln MNT	429.7	0	207.1	207	0	-223	48.2
	Net profit		mln MNT	5,013.3	0	-179.1	-179	0	-5,192	(3.6)
8	**Total recievabels**		**mln MNT**	**5,532.3**	**11,297.7**	**3,928.0**	**-7,370**	**35**	**-1,604**	**71.0**
	Short term recievables		mln MNT	4,411.7	10,433.7	3,090.2	-7,344	30	-1,322	70.0
	Long term recievebles		mln MNT	1,120.8	864.3	837.8	-27	97	-283	74.8
9	**Total loan**		**mln MNT**	**113,264.7**	**193,960.5**	**194,242.4**	**282**	**100**	**80,978**	**171.5**
	Short term loan		mln MNT	3,711.6	1,593.9	4,808.6	3,215	302	1,097	129.6
	Long term loan		mln MNT	109,573.0	192,366.6	189,433.8	-2,933	98	79,861	172.9
10	**Mentenance, investment**		**mln MNT**	**19,342.7**	**11,514.6**	**17,575.4**	**6,061**	**153**	**-1,767**	**90.9**
11	**Employer number**		**people**	**1,223**	**1,258**	**1,257**	**-1**	**100**	**34**	**102.8**

(Source: NPTG Annual Report 2020)

3.3 Ulaanbaatar Electricity Distribution Network Company (UBEDN)

3.3.1 Organization

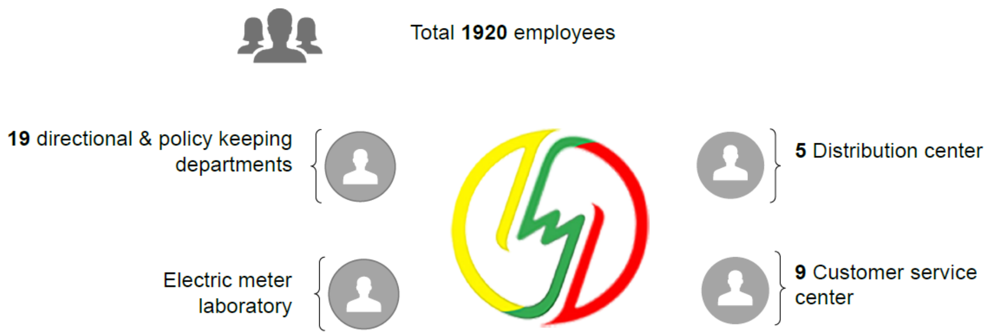
(1) Overview of Business

UBDEN plans operations, constructs, maintenances, and manages distribution and substation facilities 35 kV or less in Ulaanbaatar. It purchases power from NPTG substation and sell to customers. It covers eight districts in Ulaanbaatar and Tov province, approximately 230 km east-west and 163 km north-south.

(Source: UBEDN)

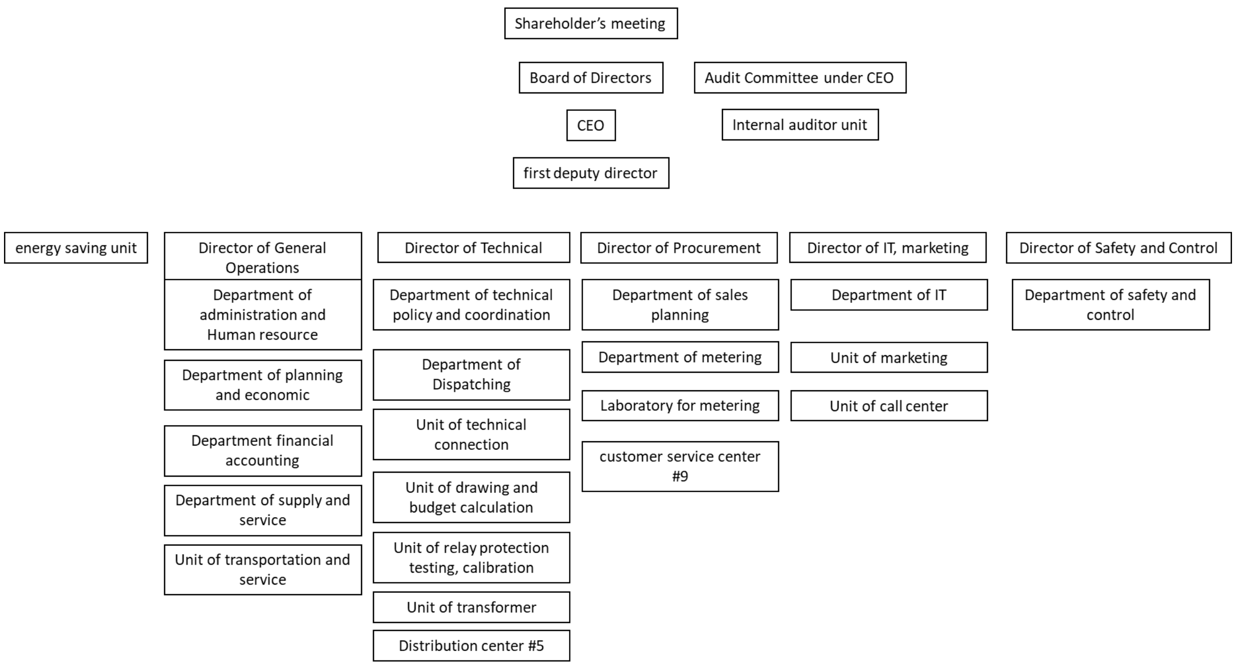
Figure 3-7 UBEDN Business Area

UBDEN consists of 19 departments, and has 1,920 employee as of 2021, five distribution control centers, nine customer service centers, and an electric meter laboratory



(Source: UBEDN)

Figure 3-8 UBDEN Organization



(Source: Report on Activities for 2020, UBDEN)

Figure 3-9 Organization Chart of UBEDN

(2) Voltage Class

Voltage classes of MV in UBEDN are 6 kV, 10 kV and 35 kV, and the MV system is no-grounded. LV are 220 V and 380 V. An UG (Underground) system occupies almost the entire in the city area of UB, and an OH (Overhead) system, on the other hand, is in the suburbs including Ger areas. While main distribution lines in UG are connected for power interchange in the case of a failure, those at end or OH lines are not necessarily linked.

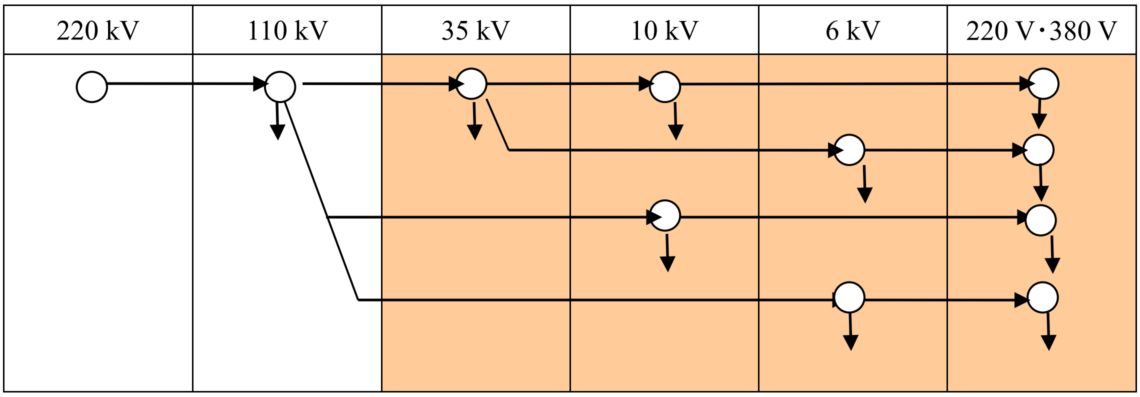
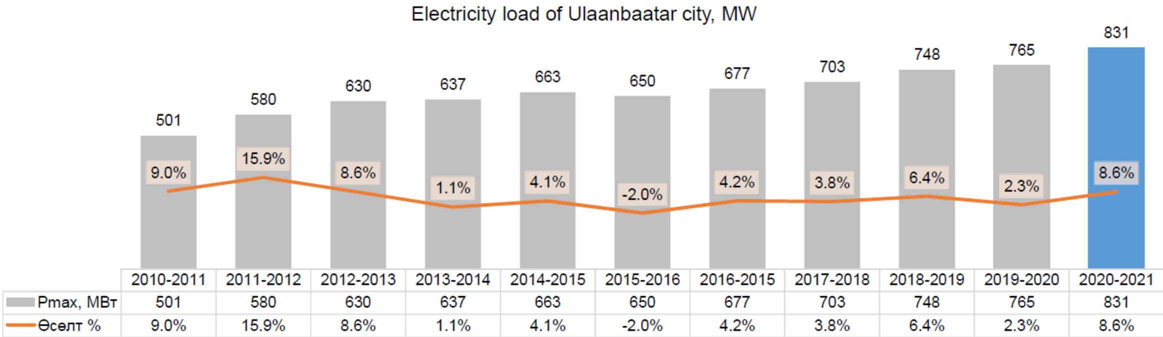


Figure 3-10 Voltage Classes of UBEDN's Facilities

(3) Power Demand

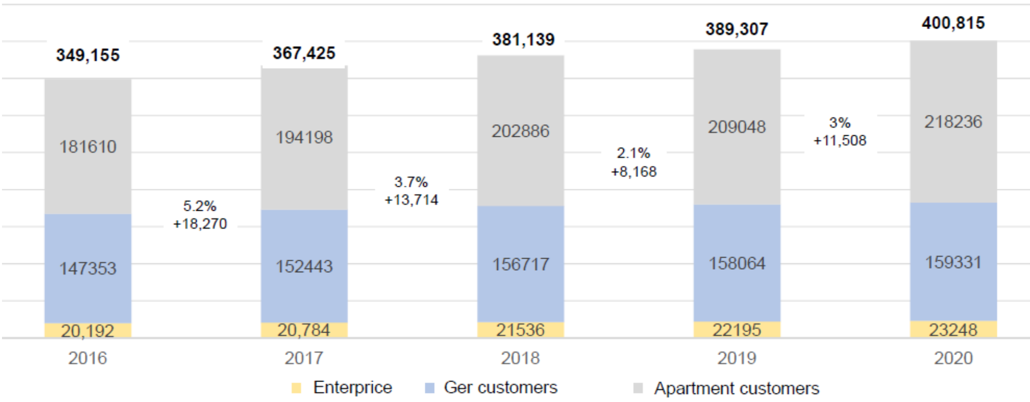
Maximum power demand in 2020 was 831 MW, and the figure below indicates that the demand will keep increasing in the future.



(Source: UBEDN)

Figure 3-11 Power Demand Trend in UBEDN

The transition of the number of customers is shown below. The number is rising steadily at an annual average growth rate of 3.5 %, and exceeded 400,000 customers in 2020.

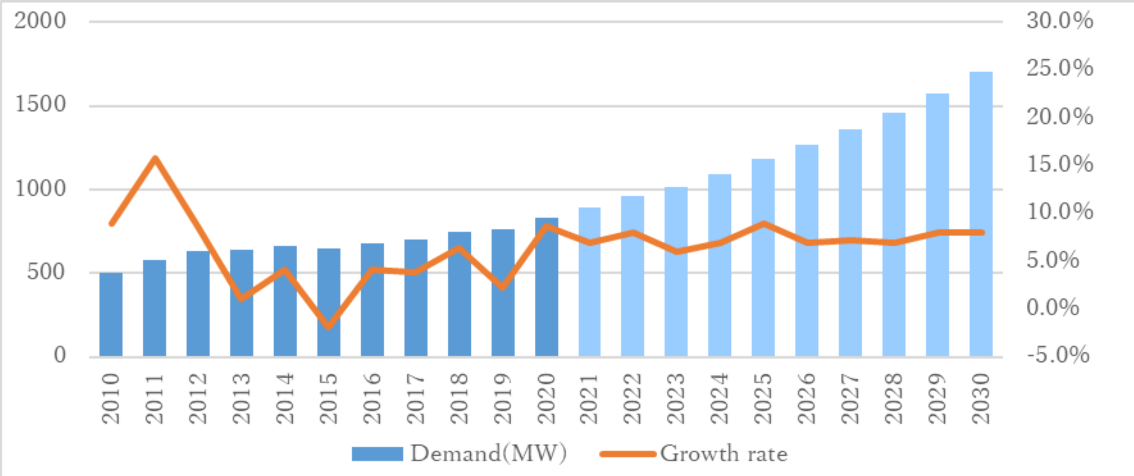


(Source: UBEDN)

Figure 3-12 Transition of Number of Customers in UBEDN

(4) Demand Forecast

The maximum power in 2020 is 831 MW, and high power demand of around 7 % is expected to continue, and exceed 1,600 MW in 2030.

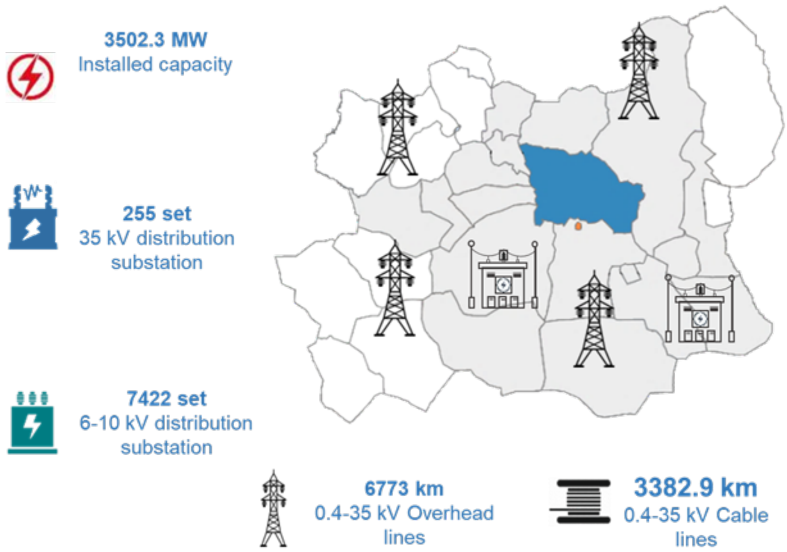


(Source: UBDEN)

Figure 3-13 Demand Forecast in UBEDN

(5) Facilities

The following overview and transition of facilities in UBDEN shows that the replacement of aging facilities are tardy, as approximately 30 % of total facilities are 30 years old and 50 % are 10 years old. Given the above mentioned increase in demand, there is a high possibility that the available capacity of these facilities are limited.



(Source: UBEDN)

Figure 3-14 Overview of Facilities in UBEDN (2020)

3.3.2 Facility Planning Standard

(1) Distribution System Configuration

An underground system (UG) occupies almost the entire in the city area of Ulaanbaatar, and an overhead system (OH), on the other hand, is in the suburbs including Ger areas. While main distribution lines in UG are connected for power interchange in the case of a failure, those at an end or OH network are not necessarily linked to each other.

(2) Supply Power Reliabilities

The climate in the winter season is extremely cold, therefore if customers lose heat during an outage, their lives may sometimes be in danger. From this viewpoint, customers are categorized into 3 types based on the priority to restore electricity.

Category 1. Most significant customers, such as hospitals.

Category 2. Customers which use electricity for heating.

Category 3. Customers which use firewood for heating.

Customers categorized as 1 and 2 are obliged to receive electricity from two different systems (A system and B system) so that they can quickly recover electricity when a fault happens. Customers categorized as 3, on the other hand, are not covered by this rule. They can only receive from one system.

Theoretically, the maximum system utilization factor is 50 % in the case that customers have such duplicate services, but actually, some of the distribution system is operated at more than 50%. Therefore it is difficult to operate the distribution system especially in the winter season.

The following shows the typical power supply structures. Between the A & B system, there are bypass lines like ladders, which is typical for an underground distribution system.

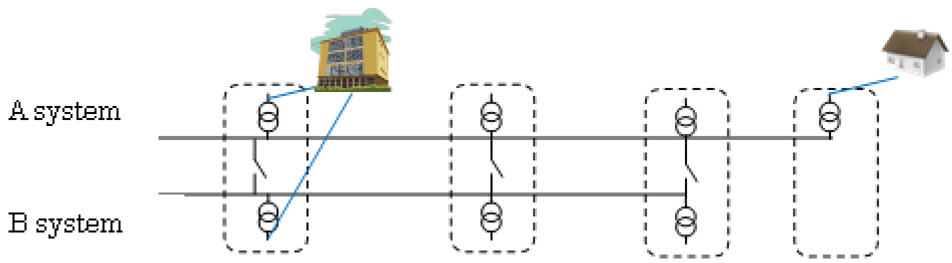


Figure 3-15 Customer's Power Receiving System in Underground Distribution Line

(3) Technical Standard

In the past, technical standard has been based on the Russian national standard, GOST (Gosudarstvennyy Standart) but now, it is based on the IEC.

UB city is located 1,300 m above sea level, and the temperature falls below -40 ℃ in winter. If a power fault happens, the temperature inside substations, switch stations and distribution transformers sometimes reaches the same level as the outside temperature. The devices used for power facilities must work under such low temperatures.

3.3.3 Distribution Facilities

(1) Distribution Substation

The following is a picture of a 110 kV distribution substation, namely, Umard S/S. Most of the facilities in this substation belong to NPTG, and only the distribution cables belong to UBEDN, although CB (Circuit Breaker) and cables of feeders are under the control of UBEDN. However, in the current situation, because the CB's are installed in substations of NPTG, the facility management is also made by NPTG. In addition, NPTG staff implements the operation through requests of UBEDN.


Figure 3-16 110/10/6 kV Substation

(2) Switching Station

A switchyard is a facility that branches a distribution cable from a substation into a plurality of distribution lines (feeders). A circuit breaker is installed at the beginning of each feeder. It is set that automatic re-input is possible for overhead distribution lines and automatic re-input is not possible for underground distribution lines.

Exterior of Switching Station

Switches in Switching Station

Figure 3-17 Switching Station

(3) Distribution Tower (DT)

The distribution tower consists of the following three spaces.

- High-voltage part: disconnector or load switch, high-voltage fuse
- Transformer part: 10 kV (or 6 kV) / 380 V transformer
- Low voltage part: Low voltage switchboard, meter

The fuse in the high voltage section is installed to protect the transformer. The transformer capacities used in UBEDN are 400 kVA, 630 kVA, 800 kVA, and 1 MVA, and 630 kVA is common. Most of the distribution towers are owned by consumers, not distribution companies, and there are problems with equipment management such as difficulty in updating.

Exterior of DT　　　　　　DBs in DT

Figure 3-18 Distribution Tower

Since around 2011, UBEDN has applied the ring main unit to the switchgear as a demonstration test when renewing a distribution tower that has deteriorated significantly. The ring main unit is an underground switchgear that is widely used in Europe and the United States, and is generally composed of switches, circuit breakers, transformer protection fuses, and grounding devices. The equipment is packaged in circuit units, and the structure is such that equipment can be added as the number of circuits increases.

Figure 3-19 Ring Main Units

(4) Distribution Line

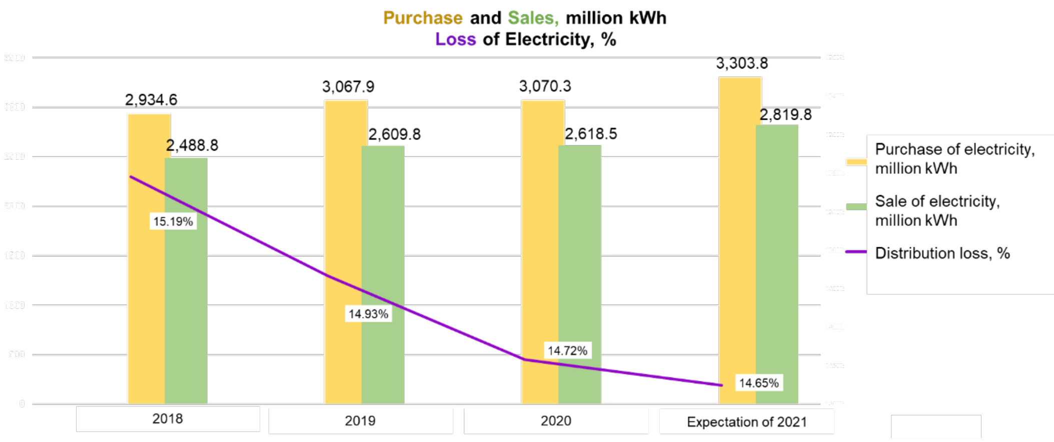
The old overhead power distribution equipment uses wooden poles, but concrete poles are applied at the time of new construction (left in the figure below). Medium-pressure underground cables are laid in pipelines as shown on the right in the figure below at road crossings, but direct burial methods are common at other locations. Cross-linked polyethylene insulated cables (CV cables) are recommended for new cables, but oil-filled cables (OF cables) are often used in old equipment.

Figure 3-20 Distribution Lines (Overhead and Underground Lines)

3.3.4 Index for Distribution System

(1) Distribution Loss

Although the distribution loss rate is decreasing, it is at a high level of over 14 % as of 2021. As a cause of such high loss rate, appropriate load management has not been implemented against surge loads in UB city and distribution lines are too extended to address scattered customers in the suburbs. Also, according to UBDEN, it is estimated that non-Technical loss is near 6 %.

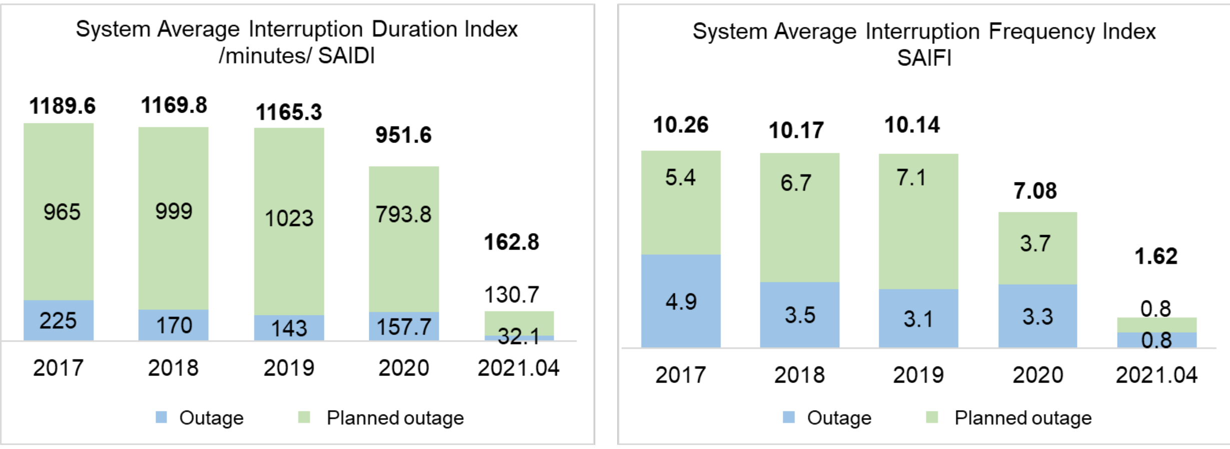


(Source: UBEDN)

Figure 3-21 Transition of Distribution Loss

(2) Supply Power Reliability

SAIFI is 0.7 and SAIDI is 952 minutes in 2020, and those numbers contain planned power outages that occurs owing to construction. Due to the lack of data in 2021, SAIDI seems to have rapidly improved. But according to UBDEN, it will be the average number at the end of the year.



(Source: UBEDN)

Figure 3-22 Transition of Power Supply Reliability

3.3.5 Financial Status

The table below shows financial statements of UBEDN for the period of 2019-2020. Both a 2019 result and a 2020 plan are set to maintain equilibrium between income and expenditure. As for the results in 2020, though electricity sale and profit increased slightly, the final net profit went negative due to growth cost.

Table 3-16 Profit and Loss Table of UBEDN

№	Specifications	Units	2019	2020(Plan)	2020 performance	Change / physical, personal / Plan to complete by 2020	
						difference	percent
1	Purchased electricity	GWh	3,067.90	3,033.10	3,070.30	37.3	101.20%
2	Electricity for sale	GWh	2,609.80	2,606.90	2,618.50	11.6	100.40%
3	**Total income**	**million**	**478,583.20**	**497,791.60**	**502,953.10**	5,161.50	101.00%
	Of which: Sales revenue	million	401,988.30	423,387.00	422,765.30	-621.7	99.90%
	Distribution service fee	million	64,016.70	66,499.50	66,499.50	0	100.00%
	Non-operating income	million	12,578.20	7,905.10	13,688.30	5,783.30	173.20%
4	**Total cost**	**million**	**478,561.40**	**497,091.80**	**513,765.90**	16,674.10	103.40%
	Of which: cost	million	394,070.70	416,075.10	422,090.20	6,015.10	101.40%
	Operating expenses	million	74,570.90	73,888.40	77,934.10	4,045.70	105.50%
	Non-operating expenses	million	9,919.80	7,128.30	13,741.60	6,613.30	192.80%
	Of which: Management costs	million	319.90	472.00	460.50	-11.5	97.60%
5	Profit before tax / loss /	million	21.80	699.80	(10,812.80)	-11,512.60	-1545.10%
	Income tax expense	million	641.10	699.80	528.90	-170.9	75.60%
	Net profit / loss /	**million**	**(619.30)**	-	**(11,341.70)**	-11,341.70	
6	**Total receivables**	**million**	**35,904.50**	**41,281.80**	**59,717.90**	18,436.10	144.70%
	Of which: Electricity receivables	million	30,855.30	28,160.00	38,089.40	9,929.40	135.30%
7	**Total liabilities**	**million**	**87,461.60**	**92,610.30**	**118,672.60**	26,062.30	128.10%
	Of which: Short-term payables	million	33,909.40	30,000.00	58,383.00	28,383.00	194.60%
	Long-term liabilities	million	53,552.10	62,610.30	60,289.50	-2,320.80	96.30%
8	Investment, overhaul, etc.	million	10,933.60	11,163.10	8,921.60	-2,241.50	79.90%
9	Total number of employees	people	1,920.00	1,920.00	1,920.00	0	100.00%

(Source: Report on Activities for 2020, UBDEN)

3.4 Ulaanbaatar No. 4 Thermal Power Plant (CHP 4)

3.4.1 Organization

Ulaanbaatar No. 4 Thermal Power Plant (CHP 4) started operation in 1983. The plant 4 is the biggest capacity power CHP in Mongolia. Installed capacity of power plant is 753 MW.　　.

(Source: JICA Website)

Figure 3-23 Site Overview of the Plant

CHP 4 has eight boilers, seven steam turbines and generators. The outline of each facility is as follows: the steam flows of one boiler is 420 t/h, the steam pressure is 140 kgf/cm2, and the steam temperature is 560 ℃.

In addition, the power generation per steam turbine consists of 80 MW, 100 MW, and 123 MW, with steam pressure of 130 kgf/cm2 and a steam temperature of 535 ℃. The power generation by the generator consists of 80 MW and 100 MW.

CHP 4 added the boiler in 2020 to increase power and heat generation capacity. The steam generated from the eight boilers is combined with the seven steam turbines and generators via a common main pipe.

Table 3-17 Historical Generation Results of CHP 4

Specifications	units	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Boiler	number	7	7	7	7	7	7	7	7	7	8	8
Turbine	number	6	6	6	6	6	7	7	7	7	7	7
Electrical maximum load	MW	582	568	580	588	600	670	640	640	670	640	753
Boiler load	tn / h	393	382	410	414	405	441	440	440	440	400	445
Thermal load	Gcal / h	518	662	593	679	580	573	623	650	694	727	790

(Source: Energy Production, CHP 4 Presentation)

(Source: The Survey Team)

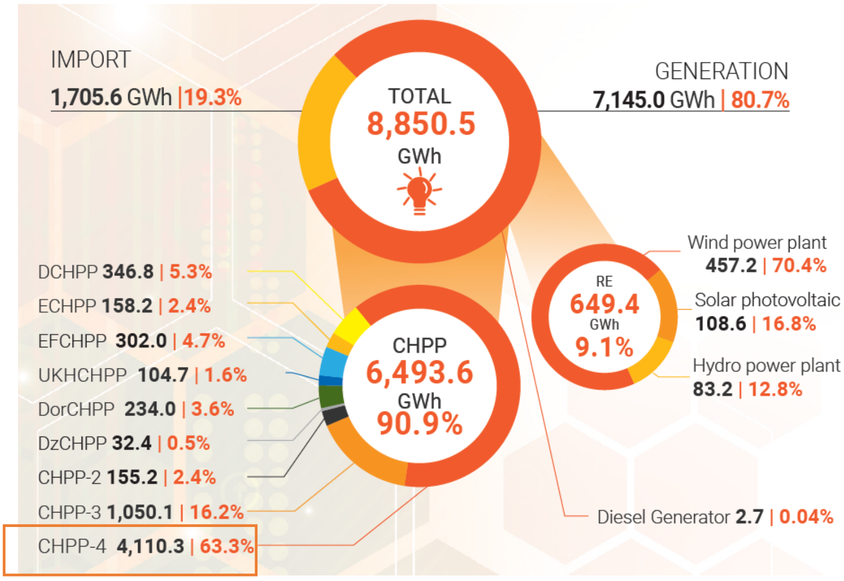
Figure 3-24 Commissioning of the Capacity Expansion Project (December 14, 2021)

3.4.2 Operation Results

(1) Generation

CHP 4 is the biggest power plant and supplies 63.3 % of electricity in the whole country of Mongolia in 2020.

CHP 4 -->



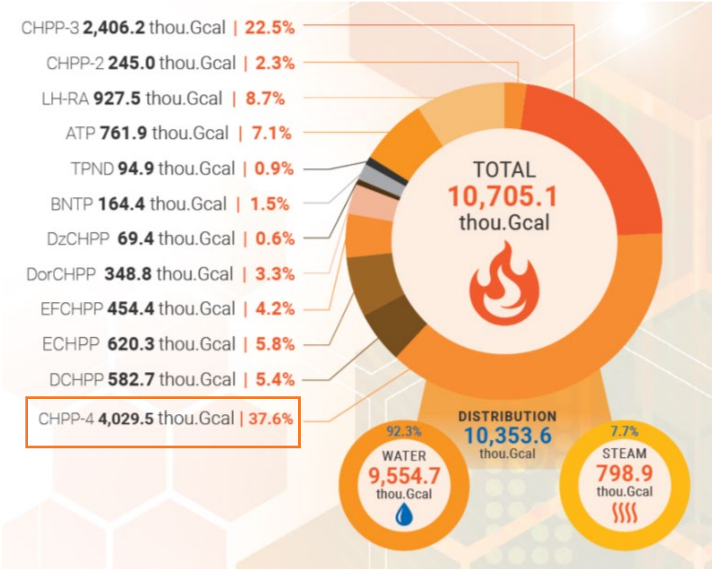
(Source: Statistics on Energy Performance, 2020)

Figure 3-25 Generation Results in Mongolia (2020)

(2) Heat Supply

CHP 4 supplies 37.6 % of the total domestic heat supply demand (10.705.1 thousand Gcal).

CHP 4 -->

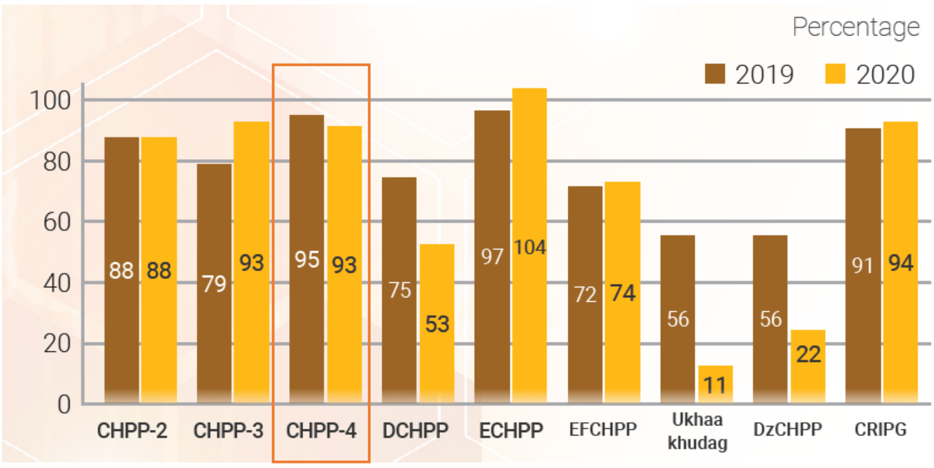


(Source: Statistics on Energy Performance, 2020)

Figure 3-26 Heat Supply Results in 2020

(3) Annual Utilization

Annual utilization of main CHPs in 2019 and 2022 is shown below. CHP 4 operates continuously throughout the year, as it was utilized at 95 % in 2019 and 93 % in 2020.



(Source: Statistics on Energy Performance, 2020)

Figure 3-27 Annual Utilization of Main CHPs in 2019 and 2020

3.4.3 Improvement of Facilities

(1) Assistance through ODA Loan

Regarding CHP 4, Japan has supported the improvement of facilities through ODA loan contracts signed in 1995 and 2001. Automatic control system, direct combustion system, improvement of facilities, combustion efficiency improvement and suit blower, etc. were introduced and added. These projects aimed to reduce environmental impacts by reducing emissions of air pollutants.

Control Room   Pulverizers   Pipes and Boiler

(Source: JICA Evaluation Report 2010)

Figure 3-28 Pictures of ODA Loan Project

(2) Latest ODA Loan Project

The "Ulaanbaatar Thermal Power Plant No.4 Optimization Project", which is an ODA loan project signed into contract in 2013, has been completed in June 2020 (the Project results have not been published yet). The project supported the 1) update of turbine governor/control system, 2) installation of soot blower, and 3) update of coal mill roller, etc.

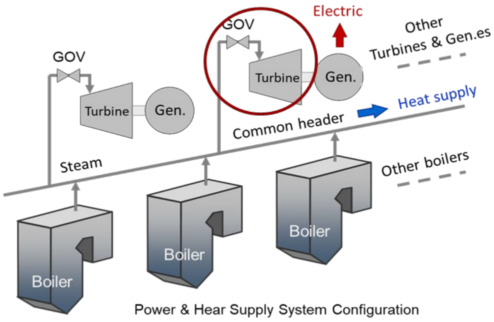
(Source: The Survey Team)

Figure 3-29 Upgrade Boiler 1 to 8 Control System

(3) Other Upgrading and Rehabilitation Projects

According to CHP 4, the following upgrading and rehabilitation projects have been implemented.

- ✧ 123 MW new installation project of turbine Unit No. 7 in 2016
- ✧ Turbine upgrading for No. 1 and No. 4 in 2019
- ✧ Renovation of turbine No. 2 and No. 3 in 2020



(Source: The Survey Team)

Figure 3-30 Rehabilitation of Turbine (Image)

3.5 Heat Supply

3.5.1 General

(1) Overview of Heat Supply System

The heat supply system in Mongolia is divided into the following three systems.

- Wide-area central heating systems, which receive heat from power plants and supply heat to a wide area
- HOB (Heat Only Boiler) heat supply systems, which supply heat from HOB to relatively small areas, housing complexes, schools, etc.
- Individual houses heat supply systems for detached houses

(2) Wide-area Central Heating System

The wide-area central heating system has been adopted in UB city and other areas such as Darkhan and Erdenet where thermal power plants are located. This system generally consists of a power plant, heat exchange stations, and consumers and supplies heat in the following manner.

- The part between the power plant and the heat exchange station is called the primary system. In the primary system, hot water is generated at the power plant and supplied to several heat exchange stations installed in the city. The hot water loses heat in the heat exchangers before returning to the power plant.

- The part from the heat exchange stations to consumers consists of two main components: the secondary system for heating and secondary system for the supply of hot water.
- In the secondary system for heating, hot water for heating is generated at heat exchange stations and then supplied to consumers before returning after losing heat in the heat exchangers.
- The secondary system for hot water supply generates hot water at heat exchange stations and supplies it to consumers.
- Since most of the hot water supplied is consumed for cooking, baths, and showers, the system is connected to the water supply piping to replenish water.

(3) HOB Heat Supply System

HOB heat supply system is often used in urban areas not covered by the city's wide-area central heating systems or in rural areas without thermal power plants. HOB heat supply system is a small-scale version of the wide-area central heating system. It produces hot water in buildings containing a boiler and pump and sends the water to surrounding housing complexes, schools, etc. The main fuel is coal.

Although coal is used, the use of raw coal will be restricted in principle from May 2019 onwards according to the Parliament Second Resolution on Measures Related to Air Pollution Reductions under Article 16.1.5 of the 2018 Air Law. In the future, it is assumed briquetting and gasification of coal will be promoted as replacements.

(4) Individual Heat Supply System for Detached Houses

The individual heat supply system has been adopted in peripheries not covered by the city's wide-area central heating systems or HOB heat supply systems and in rural areas without power plants. It is provided mainly for residential use by fuel-burning stove heaters and electric heaters.

In housing complexes, small HOBs are used to produce hot water and supply it to the entire building.

3.5.2 Implementation of Heat Supply in UB City

(1) Basic Concept of Heat Supply System Formation

In UB city heat is generated and supplied in each region as follows:

- Wide-area central heating is the main heat supplier in areas within reach of pipelines from the No. 2, No. 3, and No. 4 thermal power plants and the Amgalang heat supply facility, both of which generate heat on a large scale. In the entire city of Ulaanbaatar, more than 60 % of the total heat is provided by the No.4 thermal power plant, making it a very important heat source.
- Areas with high density of heat demand such as the city center and residential areas with apartment buildings cannot be supplied by wide-area central heating. They are supplied by the HOB heat supply system, which supplies heat on an area by area basis.
- Small HOBs and stoves provide heating in ger (traditional tent communities) areas distant from the

city center.

Large heat suppliers have been established as public companies for the following roles: heat generation, heat transfer, and heat distribution. The following is an explanation of the structure of the wide-area central heating system.

(2) Power Generation and Heat Generation Companies

In UB city, there are four major CHP plants, etc. (CHP 2, 3, 4 and Amgalang) These are companies who manage, and operate hot water generation facilities by recovering waste heat within their site boundaries.

The Amgalang heat supply facility became operational in September 2015 and is located in the Bayanzurkh district of Ulaanbaatar. It supplies hot water only.

The hot water, which is pumped outside and heat-exchanged at a heat exchange station, is reheated by a heat exchanger and pumped to the city again.

(3) Ulaanbaatar District Heating Company (UBDH)

Hot water for the wide-area central heating system in UB city is supplied to the city from four power plants, etc. through the heat transfer network. The heat transfer pipes consist of heat-insulated overhead pipes and buried pipes.

UBDH is the only heat transfer network company in UB city. This company owns, manages, and operates the pipes outside the power plant site boundaries that connect to heat exchange stations. In some cases the equipment in a heat exchange plant is owned by UBDH, while in others it is sold to a company that purchases it in bulk and is managed by UBDH. In the case of residential use, UBDH usually supplies hot water to the end user, including heat exchange stations.

(4) Bulk Purchasing Companies

There are service companies that supply heat to housing complexes and multi-tenant buildings. In some cases, they own the piping from UBDH's heat exchange stations to the building entrance of the final consumers. The management and operation of the facilities are outsourced to an affiliated company which supplies hot water to the consumers.

(5) Heat Supply to Consumers

A heat exchange station on the heat transfer network supplies the heat-exchanged secondary-system hot water to buildings. During the seasonal transition from autumn to winter or from winter to spring, hot water from the power plants is supplied directly to consumers without being passed through a heat exchanger in a heat exchange station, thereby reducing the energy consumption of the pumps in the secondary system.

The hot water in the secondary system is supplied to each dwelling unit in a building through a branch pipe and then a flow regulator located in the basement of the building. Recently, a system has been introduced to encourage energy conservation by charging according to the amount of energy consumed using meters installed at these locations. A consumer who chooses billing by meter bears the cost of installing the meter.

3.5.3 Example of HOB Heat Supply System

(1) Overview of HOBs

In Ulaanbaatar, about 200 medium-sized HOBs (about 500 kW) and 1,000 small HOBs have been installed. In ger areas, household boilers and individual house heat supply systems are used.

(2) Site of HOBs

The Survey Team visited the HOB heat supply site located in UB city. The boiler on this site supplies heat to School No. 65 and Nursery School No. 81 (total area: 29,000 m2). The site was once the target of a JICA supported project in the past.

The following answers were obtained in interviews during the visit:

- There is a meter to measure the amount of heat flowing from the boiler, but no daily record is kept.
- After installation of equipment from a Japanese company, coal consumption was reduced to 3.2 tons per day in peak season compared with 5.6 tons per day before the improvements.
- In the winter, the boiler runs all day regardless of demand, because once it is shut down the pipes freeze and the boiler can no longer run.

Heat Supply Facilities

Coal Yard

Flow Meter

Boiler

(Source: The Survey Team)

Figure 3-31 Site Status

3.5.4 Reduction of Heat Supply Losses

(1) Insulation Reinforcement of Pipes

When hot water is supplied to a city through pipes for district heating, as it is in Mongolia, a certain amount of "heat transfer loss" is inevitable. Especially in winter, when the temperature drops to about -30 ℃, a large temperature difference between the hot water in the pipes and the outside temperature also increases heat transfer losses. In addition, heat stress tends to shorten the service life of hot water pipes.

The overhead pipes used in the heat transfer network are wrapped with heat insulating material, which has peeled off in many places due to aging. The exposed parts of the pipes are the cause of losses. The buried pipes are also wrapped with heat insulators. However, in the inspection manholes, the pipes in several places are missing heat insulators. The exposed parts of the underground pipes are also the cause of losses, and the pipes are deteriorating with age. Reinforcing the insulation of the piping will reduce heat supply losses.

Hot Water Pipes with Deteriorated Insulation

Overhead Pipes Undergoing Insulation Repairs

(Source: The Survey Team)

Figure 3-32 Status of Thermal Insulation in Heat Transfer System

(2) Meter Billing for Consumers

The rates for the payment of heat tariffs by utilities are specified by the ERC as mentioned above. The tariff structure varies between major cities and provides three options for consumers. These are charges for residential use (MNT/m2) and industrial use (MNT/m3), charges based on the area or space used and the number of people living in the house each month, and meters (for residential or industrial use).

Expanding billing by meters can contribute to energy efficiency, because if meters are not installed, people are charged at a fixed rate based on space and may not be conscious of energy efficiency.

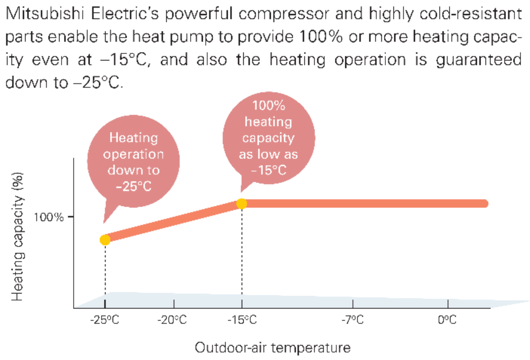
3.6 Heat Supply Facilities Using Heat Pump

3.6.1 Heat Pump

(1) General

Heat pump has been developed and used for a long time, mainly for generating hot and cold heat. However, the efficiency of heat pumps for heating or hot water generation decreases as the outdoor temperature drops because the heat exchange efficiency of the outdoor unit decreases.

The efficiency of heat pump sold by Japanese manufacturers in other countries starts to decrease at -15 ℃ as shown on the right, and can be assured up to -25 ℃.



(Source: Mitsubishi Electric)

Figure 3-33 Decrease of Heating Capacity in Cold Circumstance

In Japan, Hokkaido is the coldest region, but the manufacturers of air conditioners and water heaters generally indicate their usage range is from only -20 to -25 ℃. In general, such equipment should have internal electric heaters for preheating so that they can be used in cold regions. Even if it is possible to develop heat pumps that can be used at temperatures below -25 ℃, few manufacturers will produce and sell them unless their sales potential is large.

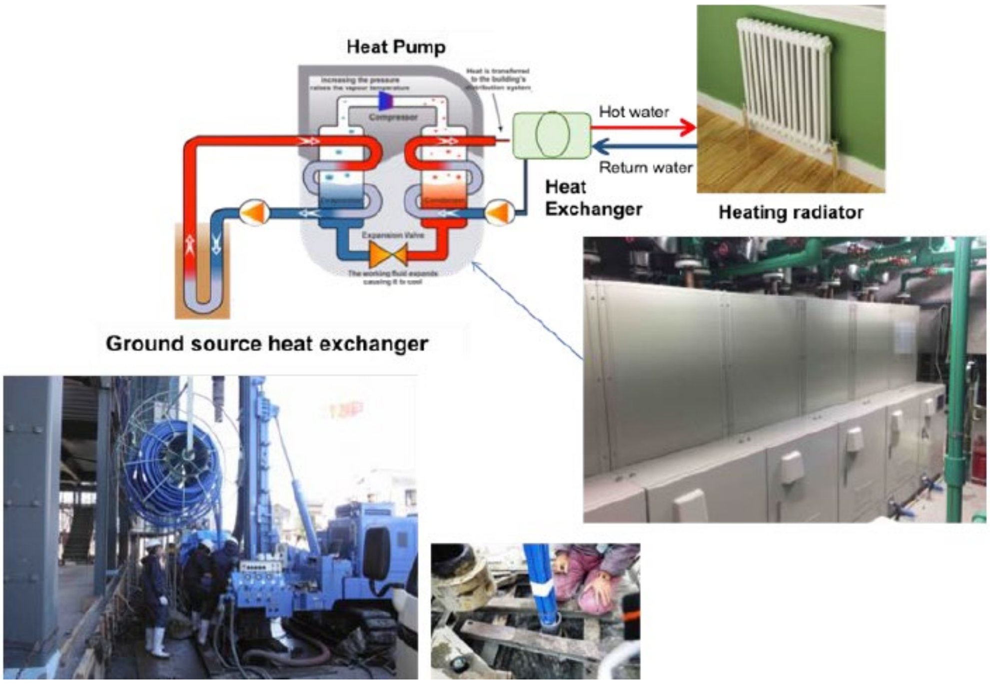
(2) Use of Heat Pump in Mongolia

In some offices, heat pump air conditioning system is installed mainly for cooling, but they cannot be used for heating in extremely cold weather. Therefore, they end up using a system supplying hot water from outside.

In Mongolia, there is an example of applying a geothermal heat pump system that can be used all year round. The geothermal heat pump system relies on geothermal heat rather than outside air for the heat exchange of the refrigerant. In this system, a geothermal heat exchanger is installed in the ground in place of an outdoor unit. Many geothermal heat pumps have been installed in China, the United States, Sweden, Germany, Switzerland, Finland, and other countries.

(3) Basic Configuration of Geothermal Heat Pump System

The system consists of three parts: the primary system (geothermal source side), heat source equipment (heat pump and peripheral equipment), and the secondary system (building heating and cooling, etc.).



(Source: JICA Mongolia Geothermal Heat Pump Installation Study Report, 2018)

Figure 3-34 Geothermal Heat Pump System

○ Primary System (Geothermal Heat Exchanger)

There are two types of systems: the borehole system and the energy pipe (pile foundations) system. In the borehole system, a coaxial pipe or U-shaped tube is inserted into a borehole with a diameter of 125-137 mm and a depth of tens to hundreds of meters to form a heat exchanger. The energy pipe system uses the foundation itself as a geothermal heat exchanger by the installation of tubes during the construction of the foundations of the building.

○ Heat Source Equipment

The heat source equipment in the primary and secondary systems each consists of a circulation pump and an expansion tank. The circulation pump circulates the water (antifreeze) that fills the heat exchanger to the heat pump. The expansion tank eliminates the impact of pressure on the piping from the circulating water (antifreeze) when it becomes hot and expands.

○ The secondary system

To pursue high efficiency for the entire system, it is necessary to improve the basic thermal performance of the building and thus reduce the heat load. Generally, radiator units are used for heating.

(4) Advantages and Disadvantages of Geothermal Heat Pump System

The advantages and disadvantages of geothermal heat pumps are shown below. Although the system is highly reliable, the cost is high because civil engineering work including underground piping is required.

Table 3-18 Advantages of Geothermal Heat Pump System

	Item	Explanation
(1)	Flexibility in selection of construction site	Basically, it can be used on any ground. In principle, however, it should be used below the groundwater level (or in bedrock). In addition, spacing the bore holes at least four meters apart is desirable.
(2)	Higher efficiency	This system is expected to achieve higher efficiency than the air system due to the use of a heat source in the ground that remains at a constant temperature throughout the year. A lattice-pattern buried borehole system with a large heat capacity is expected to increase the efficiency due to the effect of heat storage between seasons. The waste heat from cooling in summer can be used for heating in winter, and the cold heat from heating can be used in summer. In addition, groundwater flow, if available, is expected to supply a larger amount of heat to be collected and radiated as a heat source.
(3)	Compactness	The water heat source heat pump is suitable if compactness and high performance are required. The operation noise is also low. No defrosting operations are needed, unlike with air sources.
(4)	Environment friendly	No noise is audible outside. Cooling exhaust heat is not discharged into the air but is radiated into the ground, contributing to the mitigation of the heat island effect. This system has a long service life because, unlike the outdoor unit of an air source system, no part of it is exposed to wind and rain.
(5)	A long life with high reliability	The geothermal heat exchanger has a service life of more than 60 years due to the use of high-density polyethylene for the U-shaped tubes in the water circulation system. It is also resistant to earthquakes as there are no mechanical joints. The heat pump being a closed cycle generally has a much longer service life and fewer failures than combustion equipment.

Table 3-19 Disadvantages of Geothermal Heat Pump System

	Item	Explanation
(1)	High installation cost and construction of geothermal heat exchanger	In general, small-scale buildings in cold regions require approx. 100 m length of a geothermal heat exchanger for heating, so borehole installation costs are likely to be high. In the case of horizontal type, a land area equivalent to the total floor area of the building needs to be secured.
(2)	Limitation of heat pump models	Since small manufacturers supply heat pump units, proper maintenance can be received only from a limited number of manufacturers.
(3)	Proper utilization of anti-freezing materials	The use of propylene glycol antifreeze is desirable as an antifreeze with high safety. However, propylene glycol has a problem of becoming highly viscous at low temperatures, decreasing circulation volumes and lowering thermal conductivities and consequently decreasing the efficiency of heat pumps. In Sweden, ethanol solution is mainly used as antifreeze. As for piping, it is desirable to use resin pipes that are highly reliable against corrosion and to connect buried parts by fusion splicing.
(4)	Requirement of higher skills on planning and design	Although natural underground temperatures are constant, underground heat transfer is mainly by heat conduction, so underground temperatures around the heat exchanger decreases and increases according to the amount of heat collected and dissipated, and the temperature on the heat source side of the heat pump accordingly changes significantly. Therefore, a high level of technology and knowledge is required to predict these temperature changes and to plan and design a cost-balanced and highly efficient system.

3.6.2 Sample of Geothermal Heat Pump System

(1) Outline of Facilities

Some smaller nursery schools and primary schools in areas without connections to district heating networks have adopted geothermal heat pump systems by introducing technology from Europe. The Survey

Team visited the following site where a geothermal heat pump system has been installed:

(Outline of Facilities)

Nursery school　Total floor space 149 m2

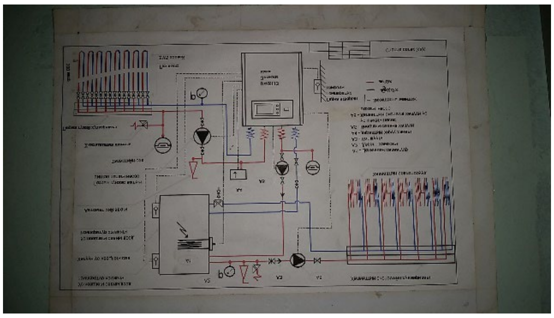
Geothermal heat pump system

Closed-loop header system　100 m borehole　Eight U-shaped tubes

Heat Pump System　17.5 kW

Produced by VIESMANN (Germany), installed in 2009

Branch of Nursery School No. 81



Configuration of Geothermal Heat Pump System

(Source: The Survey Team)

Figure 3-35 Site and Configuration of Geothermal Heat Pump System

(2) Operating Conditions

The staff of the Branch of Nursery School No. 81 answered questions in an interview about the outline of operations as follows.

- The nursery school is heated only by the heat pump. Stoves are not used.
- The heat pump was installed in 2009, and this is the 12th year. It was produced by VIESMANN, a German company.
- The air discharged from the heat exchanger installed indoors is about 40 ℃.
- The tank temperature is set to about 60 ℃. The capacity is 750 liters.
- The temperature is adjusted automatically, and the heat pump runs when the temperature of the room drops. Therefore, it stops more when the weather gets warmer.
- The heat pump has never stopped due to a malfunction so far.
- This is a heat pump water heater that utilizes geothermal heat and has eight pipes installed up to 100 meters underground to absorb geothermal heat. The heat supply output is equivalent to 17 kW. The efficiency is about three times higher.

3.6.3 Prospects for Future Diffusions

Fewer geothermal heat pump systems have been installed in Mongolia than in Europe, the United States, and China due to a delay in the development of a geotechnical information database. Therefore, data needs to be accumulated.

In addition to these technical problems, the use of geothermal heat is not widespread in Mongolia because central heating systems are already used in urban areas, so there is no need to use geothermal heat.

A geothermal heat pump system, even with COP = 3, cannot contribute much to CO2 reduction if the power comes from coal generation. Since hot water can be stored in tanks, it will be possible to reduce the use of coal-derived heat if the system is programmed to generate hot water at night, when there is a surplus of power generated by RE sources. However, a system that can work under the severe condition like Mongolia has to be developed. Thus, considering the cost of such a system, it is not likely to be widespread in the near future.

The first recommended step to take is to develop a system that can make the most of RE suitable for Mongolia.

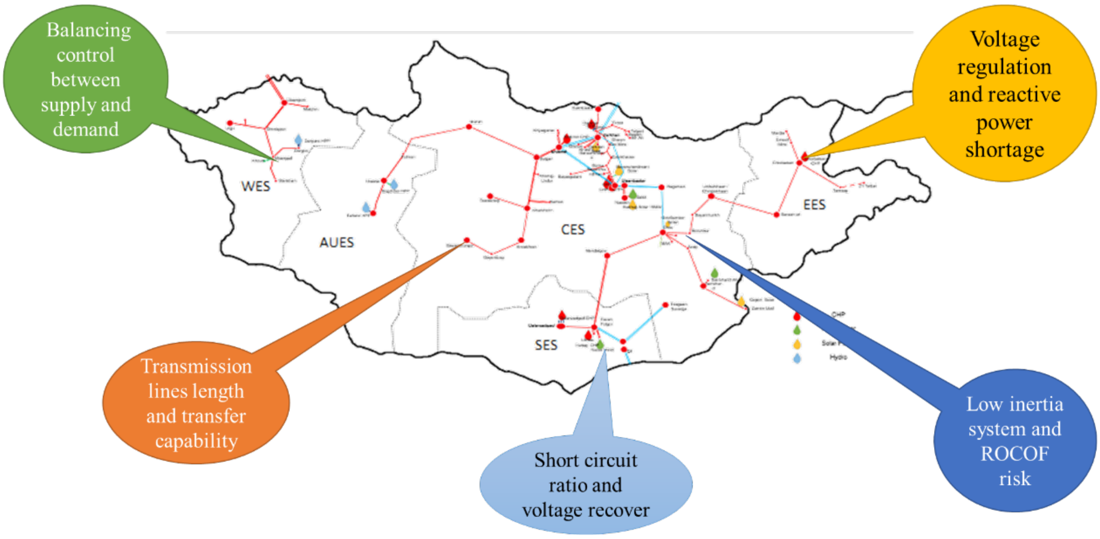
Chapter 4 Review of Issues on Introduction of Renewable Energy

4.1 Issues in Renewable Energy Introduction to the Network

4.1.1 Issues in Transmission Network

(1) Issues from the Viewpoint of NDC

NDC considers that there are 5 major issues in Mongolia's transmission network to introduce renewable energy power sources, that is, low inertia, difficulty in voltage regulation, transmission capacity limit, small short circuit ratio, and difficulty in supply demand balancing. Since solar power sources are concentrated in the southern region, at the end of a long 220 kV transmission line, it is difficult to control the network.

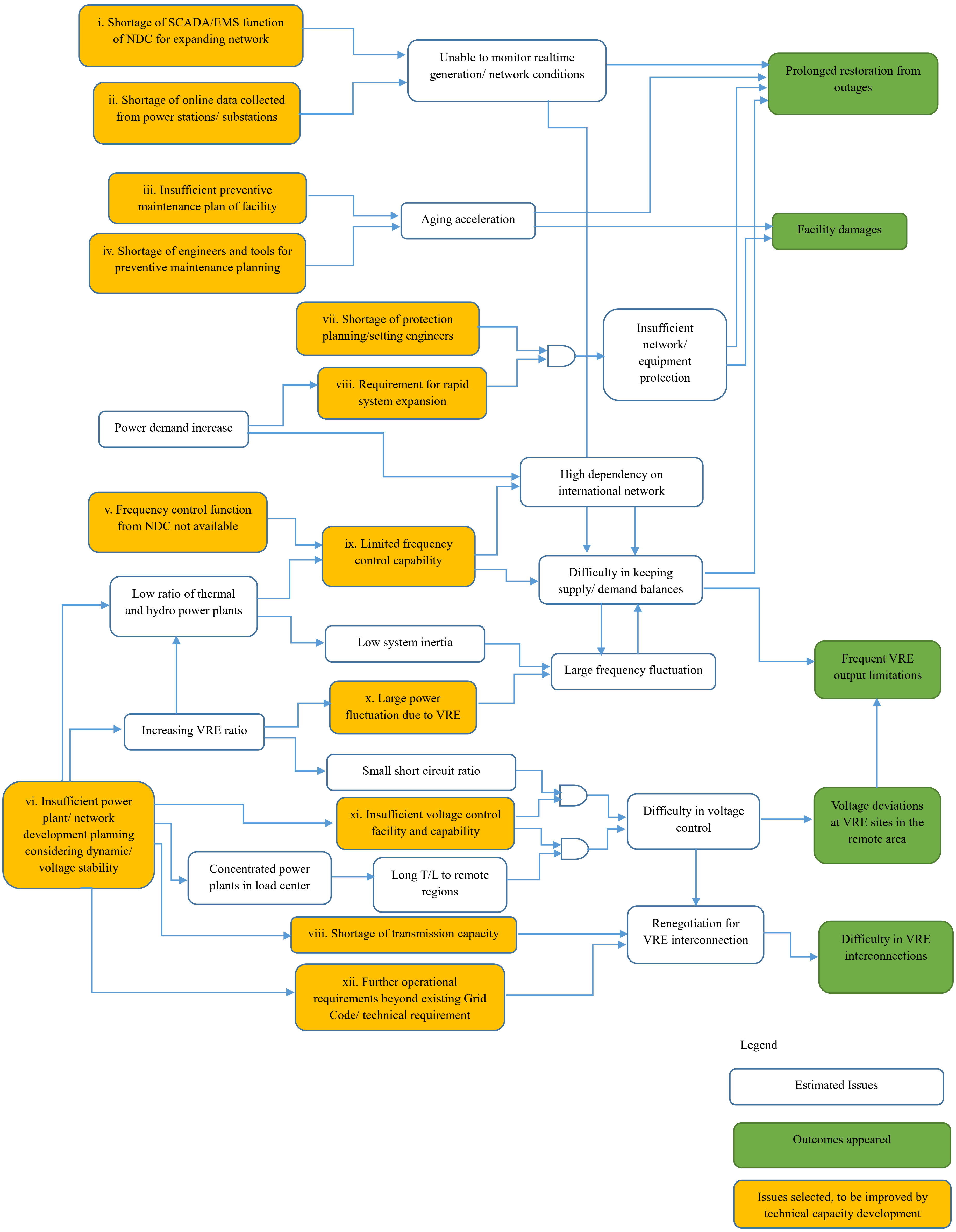


(Source: NDC)

Figure 4-1 Mongolia's National Transmission Network and Issues for RE Introduction

(2) Issues Recognized by the Survey Team

Based on the issues recognized by NDC and the results of discussions on them, the Survey Team formulated the chart of linking issues and outcomes as follows, for the planned technical cooperation.



(Source: The Survey Team)

Figure 4-2 Linkage of Estimated Issues and Outcomes in Transmission Network in Mongolia caused by Renewable Energy Power Introductions

Table 4-1 Measures for Issues in Introducing Renewable Energy Power and Current Situation (Transmission Network)

Issue	Organization	Measure	Situation	Technical Cooperation
i. Shortage of SCADA/EMS function of NDC for expanding network	NDC	Upgrade or enhance SCADA/EMS in NDC	NDC have a plan of constructing new NDC, which requires support. Study on upgrading SCADA / EMS is ongoing under the technical assistance of ADB.	Support New NDC plan, based on the result of ADB technical assistance (ADB's survey has not been completed)
ii. Shortage of online data collected from power stations/ substations	NDC, NPTG, Power Plants	Install WAMS terminals at required sites, other than the existing sites	Study on expanding WAMS system, including extending optical fiber infrastructure, is ongoing under the technical assistance of ADB. Expansion will be conducted based on the study result.	Support New NDC plan, based on the result of ADB technical assistance (ADB's survey has not been completed.
iii. Insufficient preventive maintenance plan of facility	NPTG	Improve preventive maintenance planning capacity	Innovative preventive maintenance planning methods, eg. indices based, are expected.	Support for capacity improvement for developing and implementing innovative preventive maintenance planning, by such as indices based
iv. Shortage of engineers and tools for preventive maintenance planning	NPTG	Support required items for preventive maintenance	Installation of transformer analysis device and appropriate diagnosis tool are planned.	Support for capacity improvement for evaluation, research and diagnosis of required tools for preventive maintenance
v. Frequency control function from NDC not available	NDC, Power Plants	Equip SCADA/ EMS of NDC with LFC function, and equip main power plants with functions to control from NDC	NDC considers to develop procedures for frequency control.	Capacity improvement for dispatching, including investigating requirement for procedures for frequency control
vi. Insufficient power plant/ network development planning considering dynamic/ voltage stability	NDC, NPTG	Improve capacity for NDC to conduct network planning using analysis tools	RTDS has various simulation functions including control and protection, which can foresee and reduce the risk of system instability caused by renewable energy power.	Purchase of RTDS equipment to simulate transmission network of Mongolia, and trainings to conduct simulation
vii. Shortage of protection planning/setting engineers	NPTG	Improve capacity for setting protection relay appropriately in accordance with facilities' renewal	Concerning protection relays, fine tuning, calculations, data processing, network security are under study.	Support for capacity improvement for fine tuning, calculations, data processing, network security, of protection relay
viii. Requirement for rapid system expansion, Shortage of transmission capacity	NDC, NPTG	Increase transmission capacity including international interconnection, Develop long T/, et al	Study is ongoing for upgrading SCADA and expanding optic fiber network, to deal with increasing VRE with securing high reliability of network operation.	Capacity improvement for long and middle term network planning using system planning tool, and for simulation for system operation using RTDS
ix. Limited frequency control capability	NDC, Power Plants	Equip hydro power and major thermal power plants with frequency control capability	Erdenebren Hydropower (90MW) development project is ongoing, to improve frequency control capability and supply capacity. Interconnection capacity with Russia is also planned to increase.	Evaluate the effect of renewable energy power in the case that frequency control capability improved, using the system planning assist tool
x. Large power fluctuation due to VRE	NDC	Develop the function of VRE output forecast and effects	Study is planned to develop model for forecasting voltage fluctuation by RTDS, and take measures for system stability improvement.	Capacity improvement for forecasting voltage fluctuation and investigating measures, using RTDS
xi. Insufficient voltage control facility and capability	NDC, NPTG	Install voltage control equipment in accordance with appropriate plan	Installation of SVC/ STATCOM at the end of long distance T/L is ongoing, and further installation is	Capacity improvement for evaluating the installation effects using

			under study.	system planning assistance tool
xii. Further operational requirements beyond existing Grid Code/ technical requirement	NDC	Develop appropriate interconnection operation rule and technical requirement to meet the situation, Improve network operation capacity	When VRE outputs increase rapidly, output suppress of VRE have to be asked, since it exceeds UB No.4 thermal's capability. Otherwise, excess power will send to Russia for free.	Support for precise forecast of renewable energy power output, securing the control capability of thermal power plant (Reduction of minimum load of unit, improvement of adjusting speed of unit, etc.)

(3) Requirement for Upgrading NDC to New National Dispatching Center

NDC has a plan to upgrade to New National Dispatching Center, as the center to deal with increasing renewable energy power introduction.

Transmission network of Mongolia keeps developing in accordance with the power demand increase, while the current SCADA system of NDC, made by Siemens in 2005, has capability of monitoring only 38 power stations/ substations, and has no capability of generation control by AGC. To deal with this, introduction of SCADA/EMS (Energy Management System), with controlling capability, is planned. Existing NDC has little space for installing the upgraded system to deal with online data in accordance with the expansion of network, which may cause difficulties in managing and controlling increasing RE power plants in the near future. Also, it is pointed out by the building diagnosis consultant that the building is aging and may get damages in the case of disasters such as earthquakes.

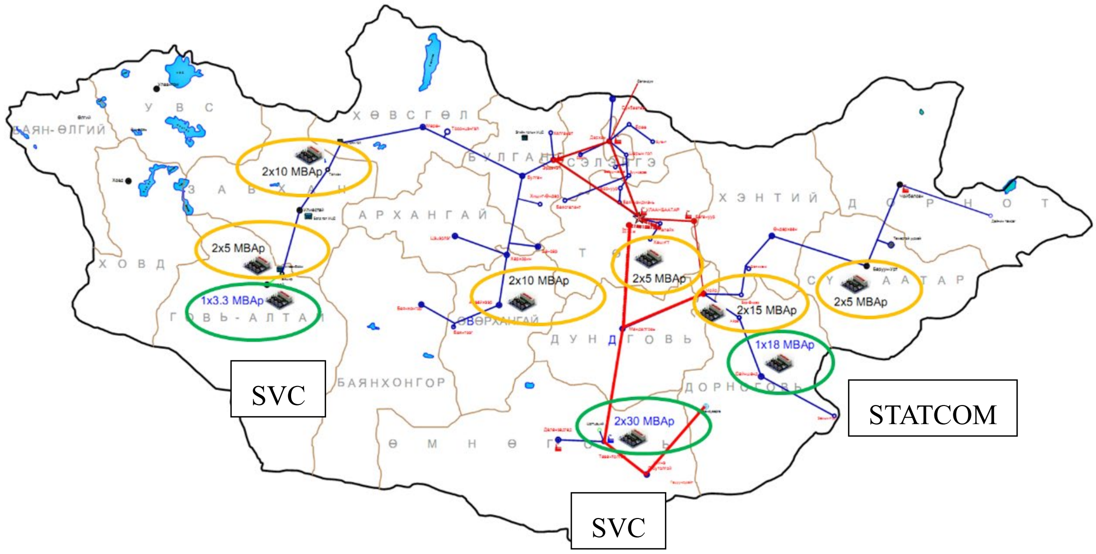
(4) Requirement for System Stabilization Technologies

NDC started to increase installing FACTS (Flexible AC Transmission System, devices to control power flow, increase transmission capability and stabilize AC transmission network using power electronics technology) and Phase adjustment equipment, Synchronous condensers, to prepare for expanding renewable energy power sources introduction.

FACTS devices NDC assumes include the following.

- SVC
- STATCOM
- Series Compensator
- Power flow Controller
- Thyristor Controlled Series Compensation
- Short Circuit Current Limiter

2 SVCs and 1 STATCOM have been already installed (green circle in following figure), and 6 STATCOMs are planned (yellow circle).

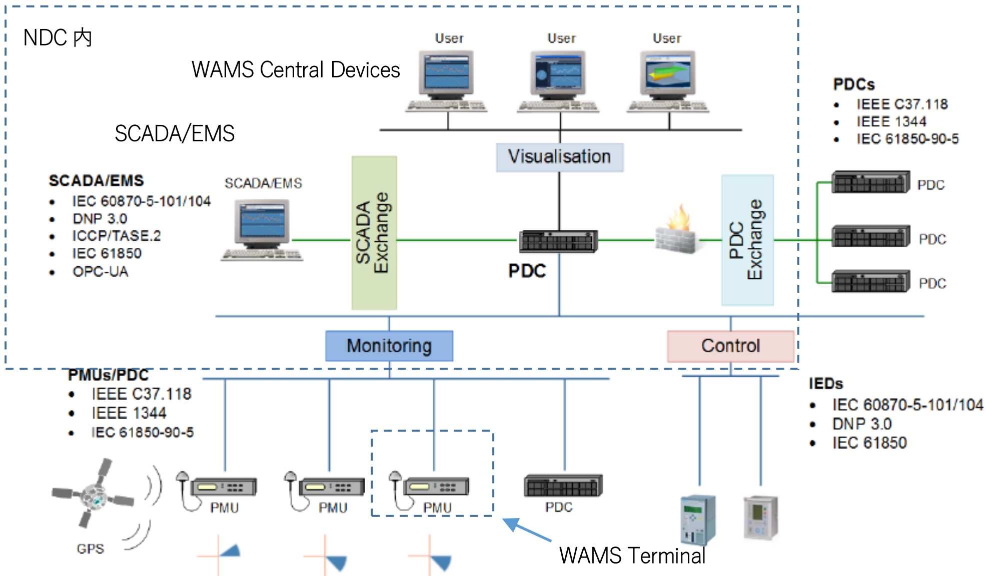


(Source: NDC)

Figure 4-3 System Stabilizing Facilities, Existing and Planned

NDC currently consigns a foreign country to conduct network analysis and event investigation by RTDS (Real Time Digital Simulator) and data collection and analysis by WAMS (Wide Area Monitoring System), in order to plan FACTS introductions. WAMS was introduced in 2019, and has been utilized for analyzing network phenomena since it collects more detail data than SCADA system. It is planned that WAMS is deployed further, including to install in RE sites. Expansion plan of WAMS is now being considered through a survey by ADB (as of October 2021).

WAMS: WAMS can collect the synchronized online data of 1 micro-second cycle from wide area using PMU (Phase Measurement Unit) with time synchronization, while the conventional SCADA data are 1 second cycle or more. It enables to monitor and analyze transient phenomena and transient stability of the network.



(Source: The Survey Team)

Figure 4-4 Components of WAMS

Table 4-2 WAMS Deployment Plan

Year	WAMS terminal (total)
2019	24
2020	24
2021	41
2022 (plan)	68
2023 (plan)	68
2024 (plan)	68
2025 (plan)	137

(Source: NDC)

(5) Power Transmission Equipment

NPTG is in charge of the operation and maintenance of the power transmission equipment in the CES. Similar to NDC, the company issues power supply commands for 220 kV and 110 kV systems. In addition, there is a need to renew transmission and transformation equipment, and in the technology that will be newly introduced in the future, standardization is being promoted with the aim of digitizing technology suitable for the introduction of renewable energy and smarter substations.

Since NPTG is a system equipment owner, basically the same events as NDC are issues, but while NDC aims to improve the adjustment capacity in a range closer to system operation, NPTG is also responsible for medium- to long-term facility upgrades and maintenance facilities such as securing transmission capacity, limiting the range of influence in the event of a system abnormality (appropriate relay setting), and appropriate maintenance of transmission equipment and substation equipment.

4.1.2 Issues in Distribution Network

UBEDN, which distributes power to UB city and the surrounding areas, aims to expand the introduction of renewable energy on a consumer scale because the grid connection standards for roof-mounted photovoltaic power generation facilities have been approved by the government (Rules for supplying power generated by the renewable energy power supply system to the distribution system (2020)).

However, UBEDN is at the stage of formulating a procedure for studying grid connection. Therefore there was a request to standardize Mongolian procedure while learning how to study grid connection in Japan.

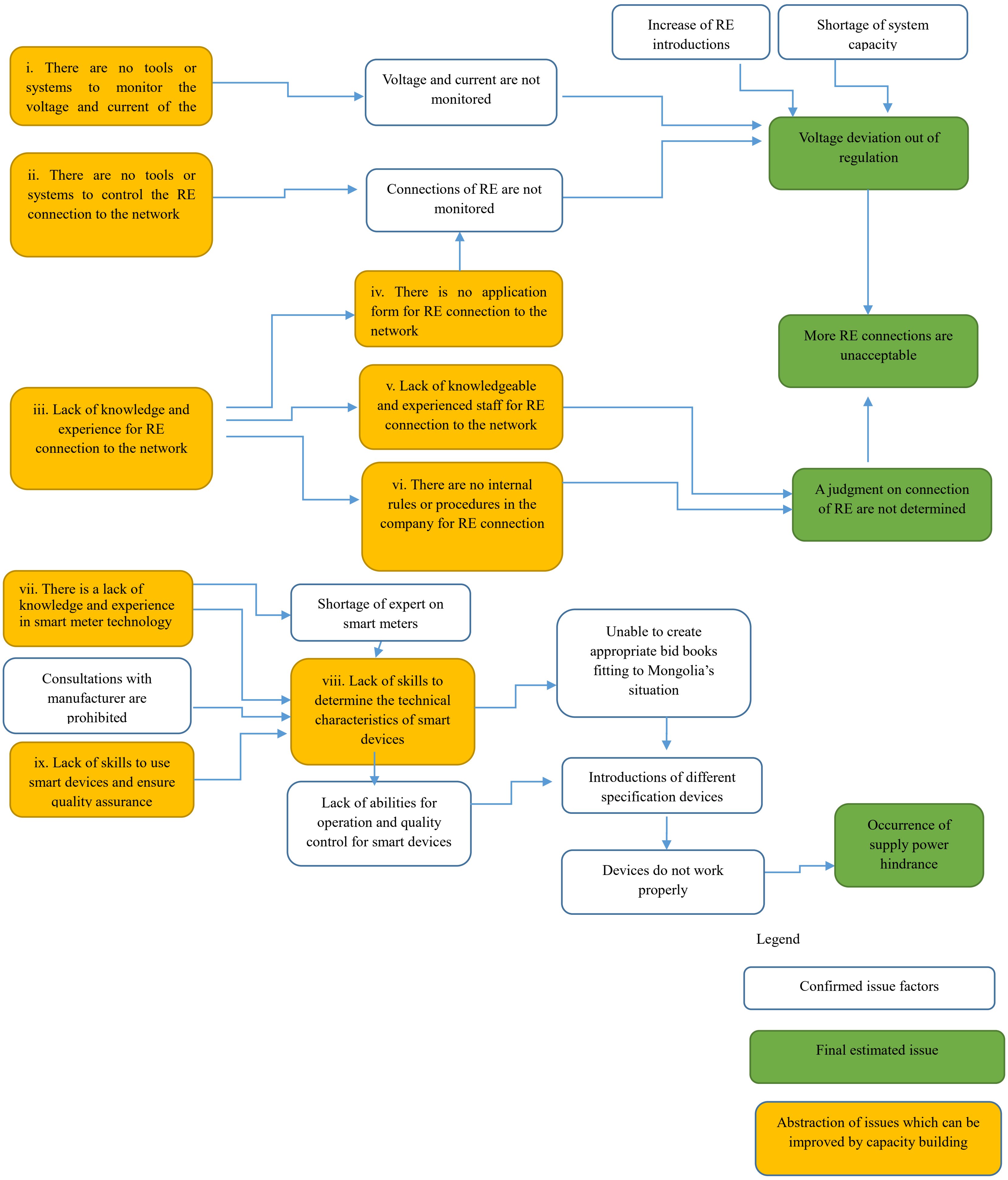
In addition, UBEDN has been piloting the introduction of smart meters in order to improve the efficiency of electricity bill collection. However, as a result of introducing products of other countries' standards in a mixed manner, it was concluded that these smart meters are not operating properly, and it is necessary to set the optimum standard for Mongolia and supervise work to comply with that standard. To that end, UBEDN requested that it was important to improve the technical capabilities of staff.

UBEDN also expects smart meters to function as measures against electricity theft and excess current. On the other hand, the renewable energy purchase system introduced by ERC in 2021 is based on the premise of net metering, and smart meters that can easily measure the amount of electricity traded between customers and UBEDN will contribute to promoting the introduction of renewable energy.

UBEDN has carried out a pilot project for power distribution automation as well as smart meters, but has learned the lesson that it did not match the standards for Mongolia well, and wants to improve the technical capabilities of staff regarding power distribution automation.

Distribution automation system is a device developed for the purpose of expediting the search for accident points and shortening the recovery time by early isolation in the event of a distribution accident. But currently, it has a function to monitor the operating status (voltage, current, etc.) of each distribution line feeder. So, it is increasingly packaged under the name of DMS (Distribution Management System) in a comprehensive sense. When the number of renewable energy connections on the demand side increases, problems such as a voltage rise in the terminal distribution line may occur. As a result, there are cases where it is necessary to introduce equipment for voltage adjustment (SVR (Step Voltage Regulator), STATCOM, etc.) in Japan. In the future, with the spread of roof-mounted photovoltaic power generation in Mongolia, it is of great significance to consider DMS standards that have the function of monitoring voltage and current, not limited to distribution automation.

The following is a summary of the assumed issues and countermeasures for the introduction of renewable energy in UBEDN. Some are assumed by the Survey Team.



(Source: The Survey Team)

Figure 4-5 Linkage of Estimated Issues and Outcome in Distribution Network in Mongolia caused by RE Introductions

Table 4-3 Countermeasure and Current Situation against RE Introductions (Distribution)

Issue	Executing Agency	Supposed Measures	Current Situation	Countermeasure
i. There are no tools or systems to monitor the voltage and current of the distribution network	UBDEN	Improvement of basic skills in voltage and current management tools / systems	There are no tools or systems to monitor the voltage and current of the distribution network.	Learning basic skills on distribution management system including DAS, monitoring system
ii. There are no tools or systems to control the RE connection to the network	UBDEN	Improvement of basic skills in system to control the VRE connection	There are no tools or systems to control the connection of the VRE generator to the network	Learning basic skills on distribution management system including DAS, monitoring system
iii. Lack of knowledge and experience for RE connection to the network	UBDEN	Organization for technological training on knowledge and experience in RE connection	There is a lack of knowledge and experience for RE connecting to the network	Organize technological training on knowledge and experience in RE connection
iv. There is no application form for RE connection to the network	UBDEN	Support to create the necessary template form	No application form has been developed for RE connection to the network	Assistance for creation of application form for VRE connection
v. Lack of knowledgeable and experienced staff for RE connection to the network	UBDEN	Provision of technology training to improve knowledge and skills on RE connection	There is a shortage of knowledgeable and experienced staff for RE connection.	Creation/Revise useful guidance for RE connection
vi. There are no internal rules or procedures in the company for RE connection	UBDEN	Support to provide useful guidance and advice	There are no internal rules or procedures in the company for RE connection	Creation/Revise useful guidance for RE connection
vii. There is a lack of knowledge and experience in smart meter technology	UBDEN	Improvement of basic knowledge and skills such as smart meters, DAS, DMS	It is difficult to process, report, partially and fully analyze the collected data due to collected in particular formats obtained from different systems.	Leaning basic skill about smart meters, DMS, telecommunication way.
viii. Lack of skills to determine the technical characteristics of smart devices	UBDEN	Organization of a workshop to determine the technical specifications of smart devices	The ability to determine the technical characteristics of smart devices needs to be improved.	Organize a workshop related to smart device.
ix. Lack of skills to use smart devices and ensure quality assurance	UBDEN	Organization of training seminars on the use of smart devices and quality assurance	No training seminars on the use of smart devices and quality assurance have been organized	Organize a workshop related to smart device.

Chapter 5 Review of Applicability of Grid Stability Technologies for Renewable Energy

Issues and countermeasures on mass RE introduction are introduced, including cases of Japan, as follows. Applicability to the Mongolian system is also reviewed in this chapter. In Japan, the following issues are assumed for the expansion of RE introduction.

Table 5-1 Assumed Issues for Expansion of RE Introduction (Japan)

	Items	Assumed Issues
Demand and Supply Balance	Long term balance	Fluctuation of frequency by lack of power supply Fluctuation of frequency by surplus power supply
	Short term balance	Fluctuation of frequency by lack of load adjustment capacity Fluctuation of momentary frequency by lack of inertia
Regional Issues in Transmission System	Transmission and distribution capacity	Decline of RE connection by lack of transmission capacity
	Voltage fluctuation	Fluctuation of voltage by RE generation fluctuation

5.1 Issues and Countermeasures on Mass Renewable Energy in the Balance of Supply and Demand

5.1.1 Assumed Issues

In general, to respond to sudden fluctuations due to RE supply, it is necessary that load adjustment capability is secured in large-scale thermal power plants. Thus, such power plants have to have a marginal capacity to absorb the fluctuations of RE.

In a low demand season, if VRE is added to the base load generation (minimum operation of thermal power plants), the supply capacity exceeds the demand due to an occurrence of surplus power. If no response is enacted, the balance between demand and supply may collapse.

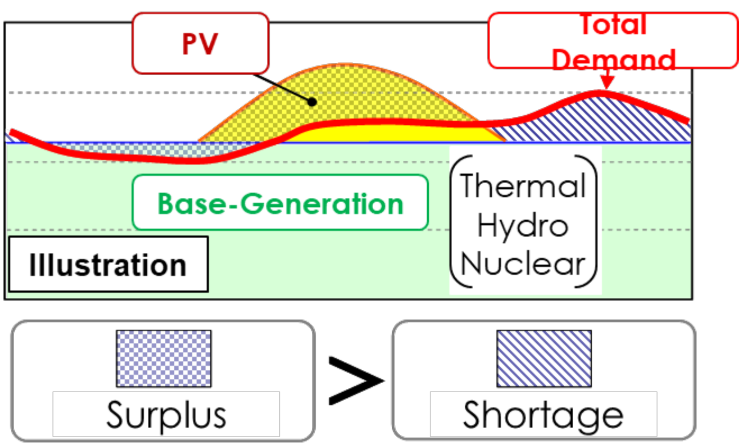


Figure 5-1 Surplus in Supply Generation due to Addition of VRE (Illustration)

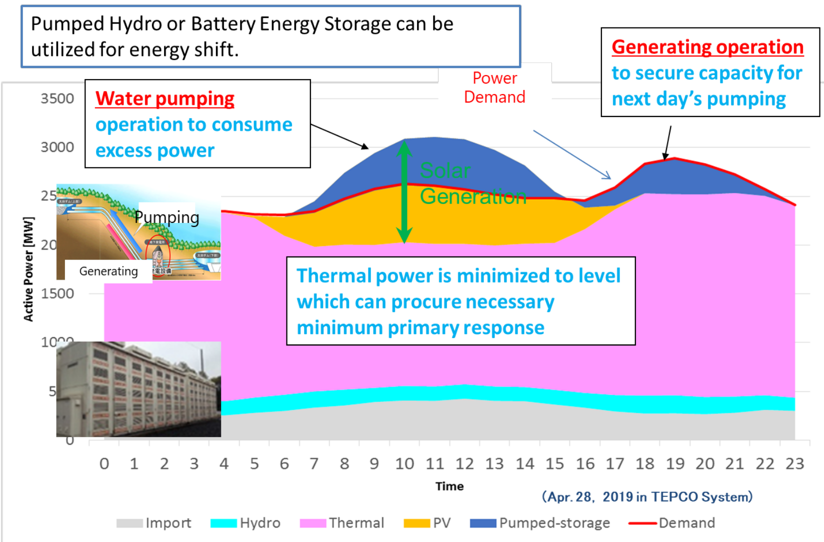
5.1.2 Samples on Countermeasures for Issues regarding Imbalances in Supply and Demand

(1) Pumped Storage Hydro System or Long-Term Battery Energy Storage System

There are technologies which can shift energy usage times by absorbing surplus power during the daytime and releasing storage power during the night-time. That is, pumped storage hydro storage systems or long-term BESS (Battery Energy Storage System).

These energy shifting technologies can be expected to create a reduction in the overall system operation costs borne by power utilities, by releasing storage power generated at affordable costs for tight power supply situations.

Pumped storage hydro storage systems require a long period for construction. On the other hand, a long-term BESS has an advantage in construction time but higher construction unit costs.



(Source: TEPCO)

Figure 5-2 Samples of Use of Pumped Storage Hydro System (or Long-Term BESS) during the Spring Season (Low Demand Season)

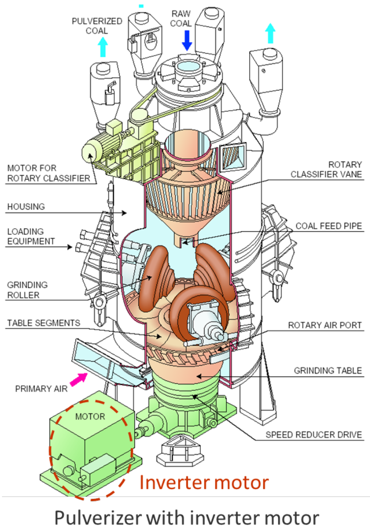
(2) Generation Facilities with Load Flexibility

(a) Samples of Facilities which have Load Flexibility

Hydro power with a regulation pond or pumped hydro power have a higher load flexibility compared to conventional thermal power plants. Load flexibility can be improved by adding inverters to the pulverizer in a conventional thermal power plant in order to reduce the amount of power fluctuations associated with the mass introduction of VREs. These improvements can also be effective for lowering minimum load.

(Source: TEPCO)

Figure 5-3 Hydro Power with Regulation Pond



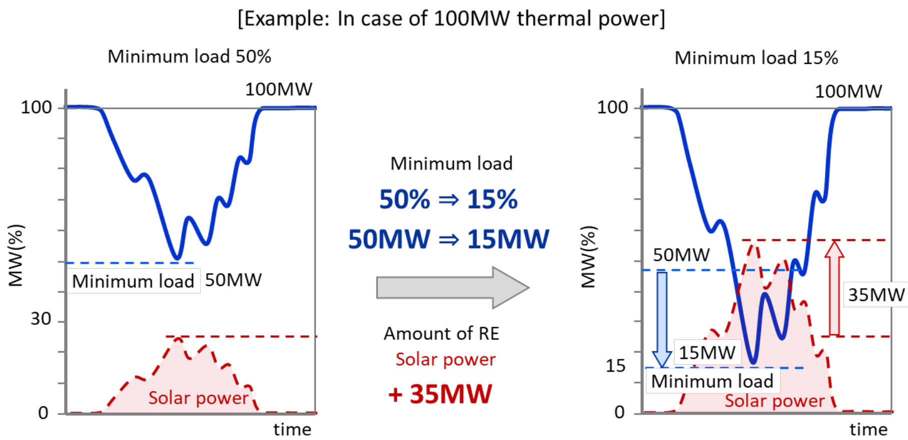
(Source: Joban Joint Power)

Figure 5-4 Pulverizer with Inverter

(b) Sample of Improving the Load Flexibility of Conventional Thermal Power Plant

In order to reduce the power fluctuation caused by the installation of a large amount of VRE, it is effective to reduce the minimum load of conventional thermal power plants. The minimum load of coal-fired thermal power plants can be reduced by expanding the operation range of pulverizers.

The following figure shows the minimum load of coal-fired power and the amount of solar power. The figure shows the daily load change of 100 MW of coal-fired thermal power generation. By reducing the minimum load of conventional coal-fired thermal power from 50 MW to 15 MW, solar power can be increased by 35 MW (= 50 MW - 15 MW).

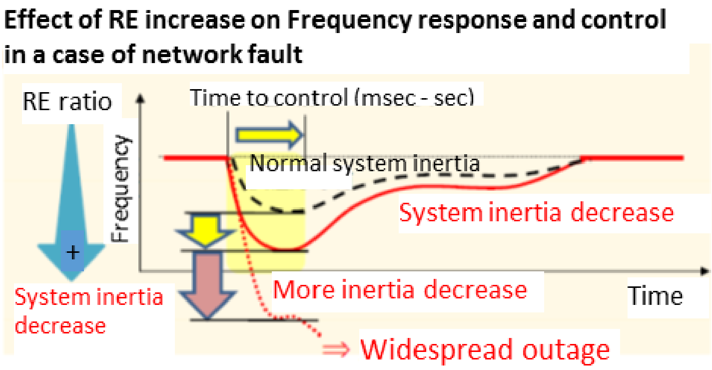


(Source: The Survey Team)

Figure 5-5 Minimum Load of Coal-fired Thermal Power (in case of 100 MW Unit) and Amount of Solar Power Generation

(3) Proper Frequency Control

Proper frequency control is another issue. When fluctuations in RE generation output are large due to the widespread introduction of RE, including VREs, network stability can be jeopardized by disturbances such as transmission network faults. System inertia, the capability of recovering system frequency, also decreases due to VRE.

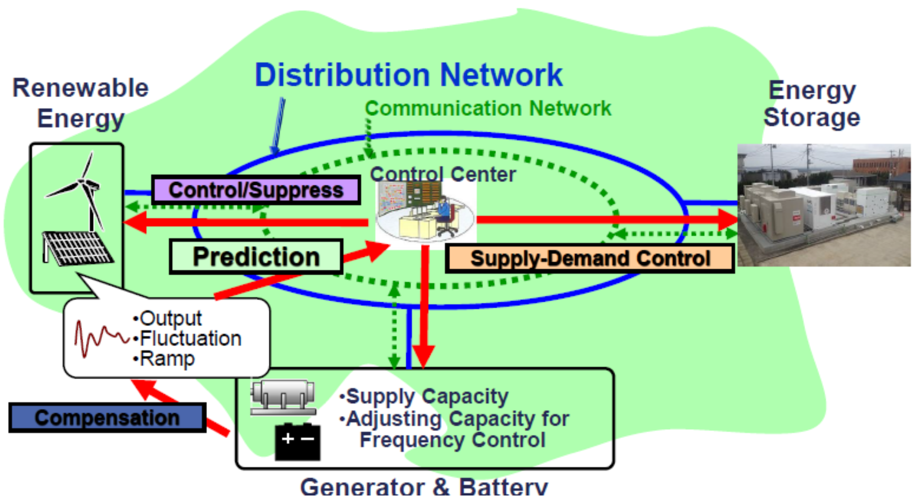


(Source: NEDO)

Figure 5-6 Frequency Response in a Fault with RE Increase

(4) Combination of Renewable Energy and Short-Term BESS for Fluctuation Control

A short-term BESS is jointly equipped in order to respond to the short-term fluctuations caused by RE. An EMS is also included to control RE and the BESS.



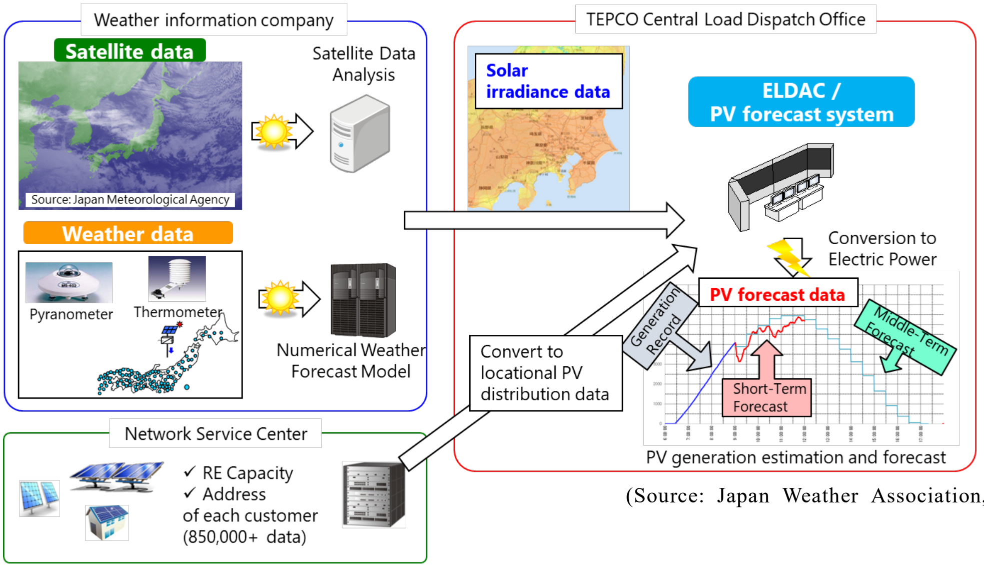
(Source: TEPCO)

Figure 5-7 Outline of RE-Battery Combined Interconnection (Illustration)

(5) Operation using RE Generation Forecasting System

This system forecasts RE generation a few hours or a day ahead based on satellite weather data or measured data. In Japan, such RE generation forecasts are utilized for system operation purposes at the power utility, TEPCO. However, operators are required to possess the skills to reflect the generation forecasts in the system operation planning.

If RE generation forecasting can become more accurate, restrictions in generation at IPP plants may be mitigated.



(Source: Japan Weather Association, TEPCO)

Figure 5-8 RE Generation Forecasting System using Satellite Data (Illustration)

(6) Suppression of RE Generation

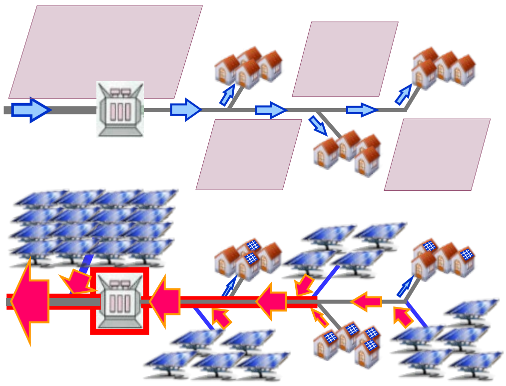
Even though pumped storage hydropower or BESS are built to have a high load adjustment capability, these measures may have a limitation due to issues in installation costs and system operation. For these reasons, it is sometimes necessary to reduce the amount of RE generation. In Japan, the introduction of RE has grown after the implementation of the FIT system, which led to a phenomenon where on some days, the adjustment capacity cannot be secured in large-scale thermal power plants due to the minimum output limit. Thus, the FIT has been amended so that power transmission system operators can curb the output of solar power and wind power for 360 hours and 720 hours a year without compensation. In addition, the revision of the FIT obliges power generation companies to introduce real-time control indicators and power conditioners (PCS) with control functions so that power transmission system operators can suppress output.

5.2 Issues and Countermeasures on Mass Renewable Energy in Transmission System

5.2.1 Assumed Issues

(1) Insufficient Transmission Capacity

Conventionally, power utilities form their transmission networks to transmit power from large-scale power stations through transmission and distribution lines to customers, in line with demand. In this configuration, there is a possibility of transmission/distribution capacity shortages when unexpected power flow increases temporarily due to middle-scale RE generation in the transmission line or VRE on the customer side.

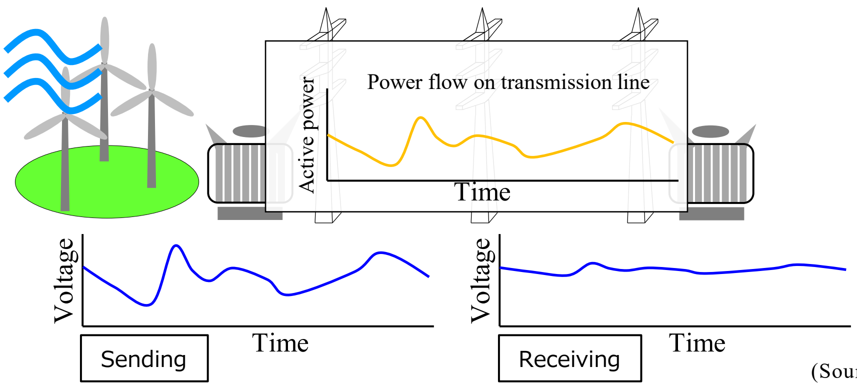


(Source: TEPCO)

Figure 5-9 Transmission/Distribution Capacity Shortage due to RE

(2) Proper Voltage Control

When a disturbed current, which is caused by fluctuation of grid connected RE generation, passes a transmission line, reactive power consumes. Due to this phenomenon, the voltage also changes in accordance with the fluctuation of RE generation. It may cause a deviation of proper voltage. Especially in long-distance transmission lines, the effect becomes apparent.



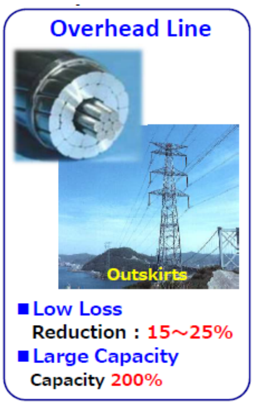
(Source: The Survey Team)

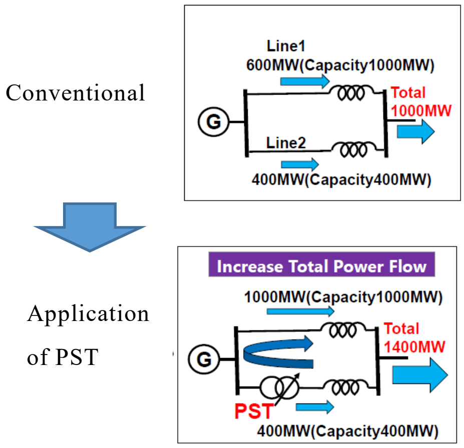
Figure 5-10 Voltage Fluctuation by RE Generation Fluctuation (Illustration)

5.2.2 Samples on Countermeasures for Issues regarding Transmission System

(1) Increase of Transmission/Distribution Capacity

In general, capacity upgrades would be required in transmission/distribution facilities when transmission power increases. The following are examples of transmission capacity increase measures, which can be introduced at a relatively low cost.





(Source: Sumitomo Electric Industries))

(Source: Toshiba)

Low Loss/Large Capacity Line
(Increasing transmission capacity with low losses, via utilization of large surface area

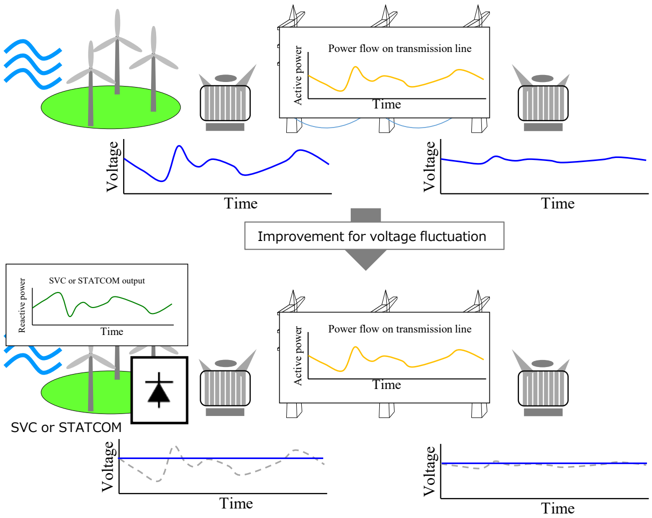
Phase Shifting Transformer (PST)
(By installing a phase shifting transformer in double circuit transmission, power flow of the network can be controlled.)

Figure 5-11 Measures for Increasing Transmission Capacity

(2) Countermeasure for Voltage Drop

The main cause of voltage fluctuation in the transmission line system is that the reactive power is consumed, and the voltage fluctuates due to the consumption of the reactive power by the inductance of the transmission line. Therefore, as one method of improving the voltage fluctuation, supplying the reactive power to the power system by SVC or STATCOM balances the consumption and supply of the reactive power, which leads to the suppression of the voltage fluctuation. Specifically, as shown in the next figure, reactive power is supplied to the power system in symmetry with output fluctuations.

In addition to SVC and STATOCOM , devices that supply reactive power include synchronous condenser (rotary capacitors) and capacitors. Synchronous phase adjusters generally have slower control speeds and larger active power losses than SVC and STATCOM , and capacitors can only be controlled in steps and cannot be appropriately controlled.

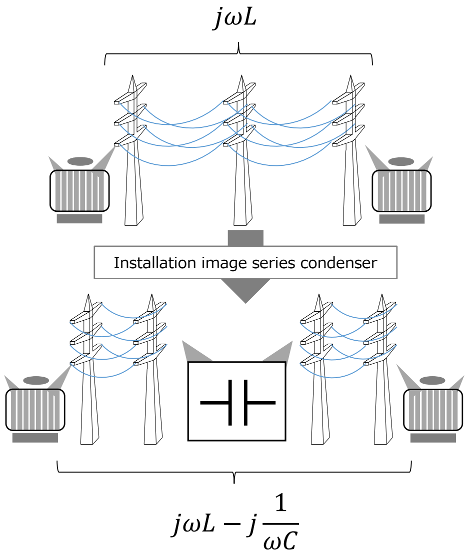


(Source: The Survey Team)

Figure 5-12 Improvement of Voltage Fluctuation by SVC or STATCOM (Illustration)

In addition to SVC and STATCOM , the following series capacitors and synchronous condenser can be used as countermeasures against voltage drops.

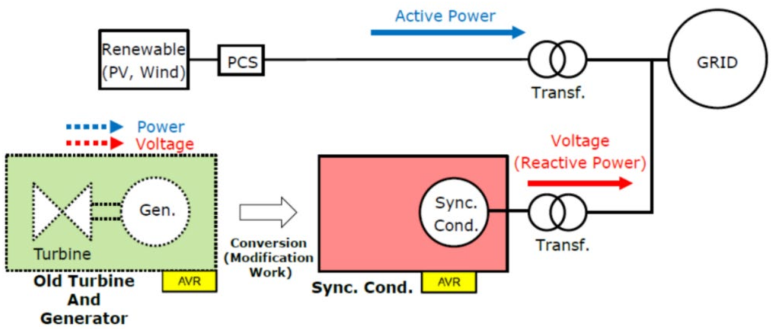
Series capacitor can be installed in series with the transmission line to make the impedance of the transmission line electrically smaller than before installation. Therefore, by installing a series capacitor, the distance of the transmission line can be shortened electrically, although it is physically a long-distance transmission line. However, since the installation of a series capacitor may cause an overvoltage due to a resonance phenomenon or a phenomenon in which the rotating shaft of the generator is twisted, sufficient consideration is required for the installation.



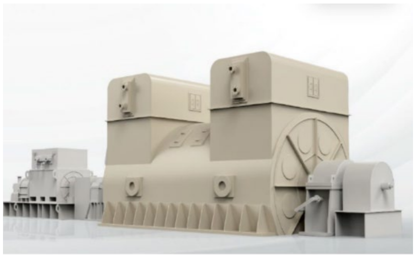
(Source: The Survey Team)

Figure 5-13 Installation of Series Capacitor (Illustration)

Synchronous condenser can be operated by modifying the power plant as shown in the following figure, and is capable of utilizing equipment that stopped generating power due to the deterioration of the boiler. The equipment converted from the generator turbine to the flywheel can supply or consume active power to power system for a short period of time, and can mitigate frequency fluctuations in the power system. The synchronous condenser installed by renovating the existing thermal power plant can make use of the substation equipment that the exiting thermal power plant was connected to in the power system. Therefore, the installation cost of the synchronous condenser may be lower than the installation cost of STATCOM.

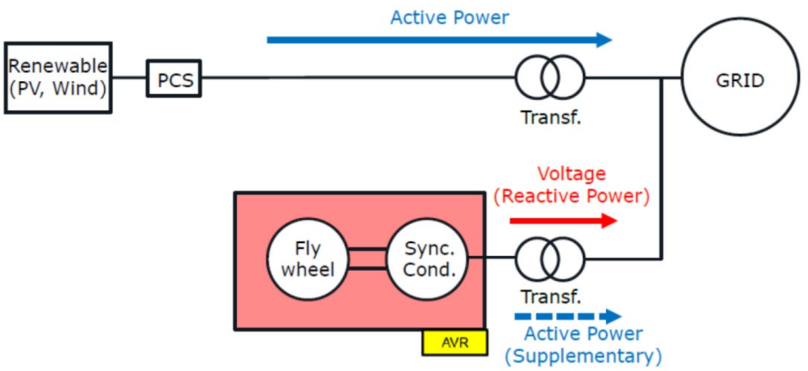


Replace way to Synchronous Condenser from old turbine & Generator



Synchronous Condenser

a) Renovating Power Generation Equipment of Existing Thermal Power Plant to Synchronous Condenser



Fly wheel & Synchronous Condenser

b) Renovating Power Generation Equipment of Existing Thermal Power Plant to Synchronous Condenser and Flywheel

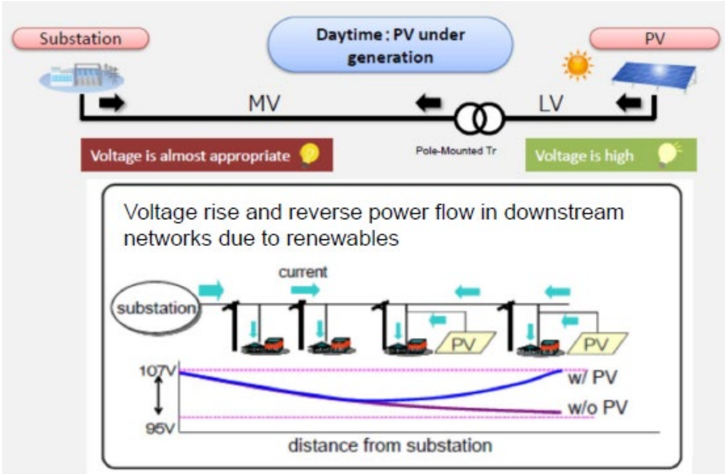
(Source: Mitsubishi Heavy Industries)

Figure 5-14 Synchronous Condenser Installation by Renovating Power Generation Equipment of Thermal Power Plant

5.3 Issues and Countermeasures in Introducing Renewable Energy in Distribution System

5.3.1 Assumed Issues

At distribution lines closer to consumers, the more connected the distributed VREs are, the greater the influence of voltage fluctuations at the end of the distribution line becomes, and there arises a problem wherein it becomes difficult to supply power in a predetermined voltage range.



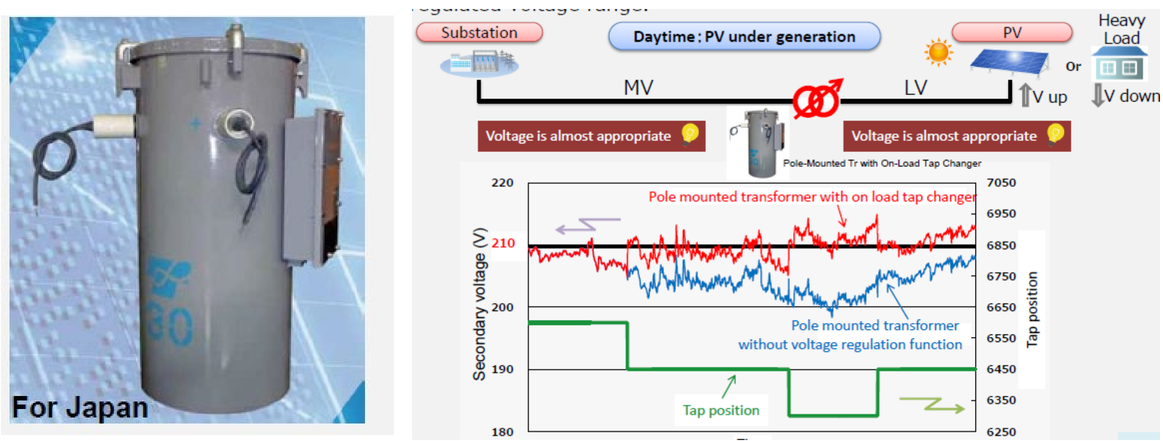
(Source: Takaoka Toko)

Figure 5-15 Voltage Fluctuation at the End of Distribution Lines due to Reverse Power Flow from Distributed VRE (Illustration)

5.3.2 Samples on Countermeasures for Issues regarding Distribution Level

(1) Reverse Power Flow-Compatible Voltage Regulator

Distribution system voltage can be adjusted via reverse power flow-compatible tap changers installed at distribution substations and the reverse power flow-compatible voltage regulators installed in the middle of a distribution line.



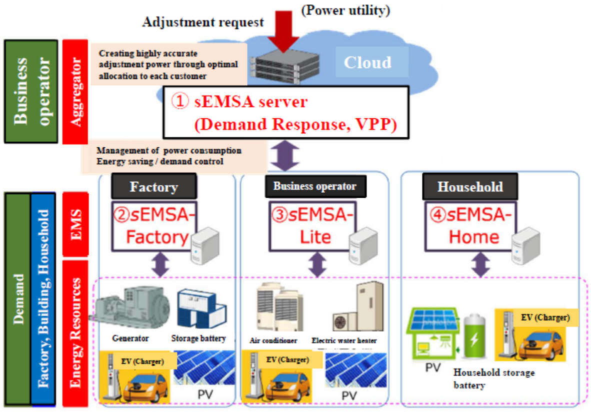
(Source: Takaoka Toko)

Figure 5-16 Reverse Power Flow-Compatible Transformer with Tap Changer under Load and its Effect

(2) Power Output Adjustment via Load Management on the Consumer Side

An EMS that controls the supply capacity and demand of aggregators and consumers, as shown below, has been demonstrated in Japan. This is a system in which an aggregator adjusts the power output of load equipment on multiple consumers by using the EMS. It was originally developed as a demand response system for cases where the power supply is insufficient.

Aggregation can control reverse power flow from RE, which can be a countermeasure for voltage fluctuations. It is also possible to use this system to connect multiple consumers and sell surplus electricity to the capacity market, but in order for each consumer to have surplus electricity, heavy load cutoff equipment and power generation facilities such as VRE and storage batteries (including electric vehicles) are necessary. Therefore, there are still many issues that must be overcome in order for this to be successful as a business.



(Source: Sumitomo Electric Industries)

Figure 5-17 Example of EMS on the Consumer Side

(3) Support for Introduction of Solar Power Generation using Smart Meters

When installing a VRE facility on the roof of a house and selling electricity through distribution lines, it was necessary to install another meter for selling electricity in addition to the meter for purchasing electricity, before the introduction of smart meters. Since the introduction of smart meters, one smart meter can measure the amount of electricity purchased and sold, and the two-way communication equipment enables automatic meter reading for both purchase and sale.

In addition to this, smart meters have various uses such as omitting the meter reading work that was conventionally performed manually and monitoring power demand for the above-mentioned EMS.

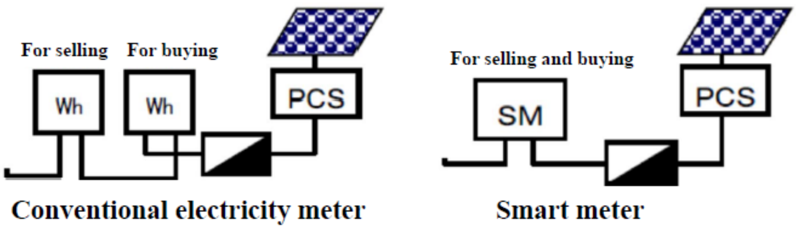
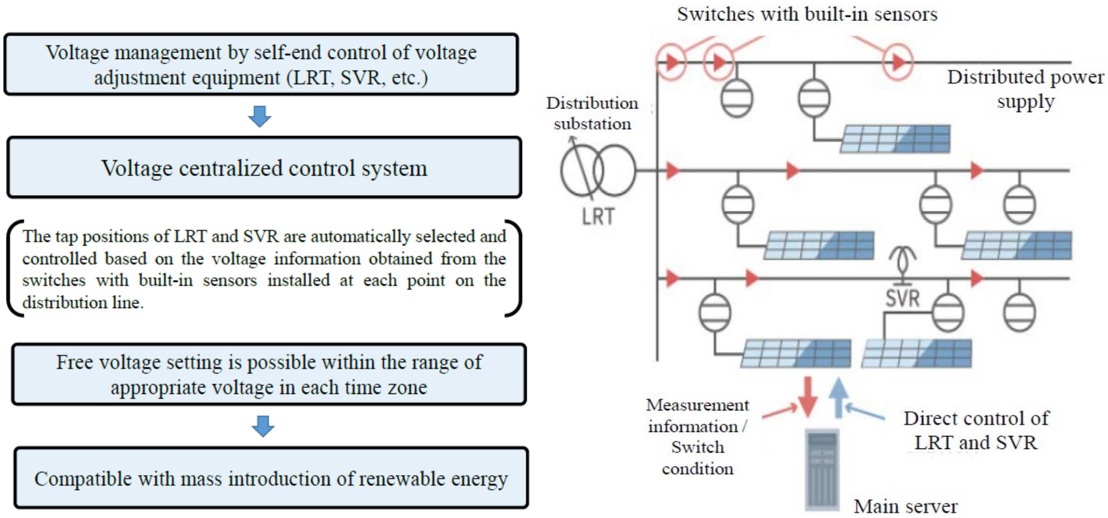


Figure 5-18 Example of VRE Introduction using Smart Meters

(4) Centralized Voltage Control System for Voltage Fluctuation Countermeasure

Until now, the voltage control of the distribution system has been carried out based on the latest measurement information of the voltage regulator (LRT, SVR, etc.) installed in the distribution line. On the other hand, a centralized voltage control system can grasp the system voltage of the entire distribution line in real time from the voltage / current information obtained by the automatic switch with built-in sensor installed at each point in the distribution line. Thus, it is possible to control the voltage regulator so that the entire distribution system has the optimum voltage distribution. Further, when a smart meter system is introduced, by incorporating such information, more accurate voltage control becomes possible.

This voltage centralized control system is one of the voltage measures against solar power generation whose power generation fluctuates depending on the season and weather. It is expected to be an effective measure for expanding the introduction of RE in the future.



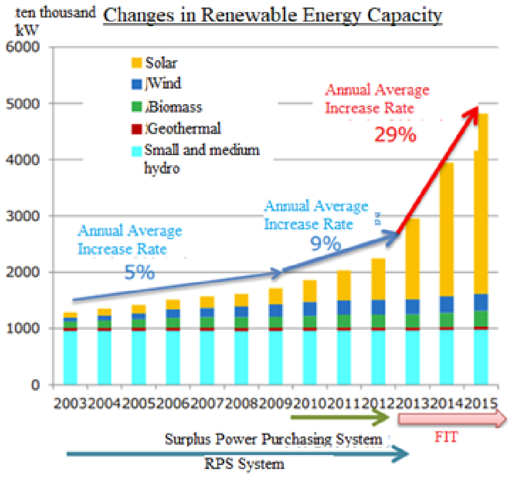
(Source: TEPCO)

Figure 5-19 Centralized Voltage Control System for Voltage Fluctuation Countermeasure

(5) DSM (Demand Side Management)

In Japan, the time of use (TOU) rate system of electricity companies usually aim at power leveling through encouraging the use of electricity at night by setting a low price on electricity use during night time. Setting patterns and prices vary depending on each company. For example, electricity price from 10 PM to 8 AM is set at 65 % of the price during the daytime to mitigate peak demand.

The feed-in tariff, or FIT, was enacted in 2012 as an incentive to promote the introduction of RE. The FIT is a system in which the government obliges utilities to purchase electricity generated by generators at a fix price for a certain period. Part of the cost for purchasing electricity is borne by the customers paying electricity bills. The FIT has led to the rapid increase in RE generation capacity in Japan.



(Source: Agency for Natural Resources and Energy)

Figure 5-20 Changes in Renewable Energy Capacity

Since trading conditions including the price and period of FIT changes every year, its incentive also varies accordingly. This system also allows electricity companies to request generators to reduce output within up to 360 hours for solar power and 720 hours for wind power per year without compensation, for the purpose of balancing supply and demand in the power system and in consideration of the maximum transmission line capacity.

On the other hand, BESS is known as a promising technology for effective use of RE. There are various types of BESS such as lithium-ion battery, redox flow battery, lead storage battery, and sodium-sulfur battery. Lithium-ion battery is widely used in smartphone and electric vehicle (EV) because it has high volumetric energy density, can be miniaturized, and has excellent characteristics such as high charge / discharge characteristics and no memory effect. Although the installation cost of lithium-ion battery for stationary applications such as RE is higher than those used in EVs, continuous improvement of the technology is expected in the future.

Redox flow battery has a lower energy density than lithium-ion battery, but it does not contain ignitable materials and can be operated at room temperature, so it is highly safe and has characteristics suitable for power system storage batteries.

Lead-acid battery is low-cost, but its energy density is low. In recent years, bipolar lead-acid battery has been developed as next-generation storage batteries.

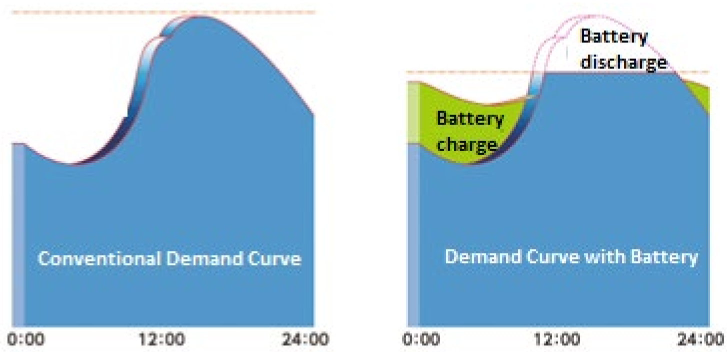
Table 5-2 Features of Each Battery

Energy storage technology		Energy / power density		Typical rated power (MW)	Characteristics
		Wh/kg	W/kg		
Electrochemical	Lead-acid battery	30 – 50	75 - 300	<100	Low cost, Easy maintenance, Recyclable
	Lithium-ion battery	75 – 250	150 – 315	<100	High energy density, High discharge rate, Long battery life
	Vanadium redox flow battery	40 – 130	50 – 140	<100	Long battery life, High safety, Unlimited number of charge / discharge times
	Sodium-sulfur battery	150 – 240	90 – 230	0.1 – 100	High energy density, Long battery life, No self-discharge

(Source: The Survey Team)

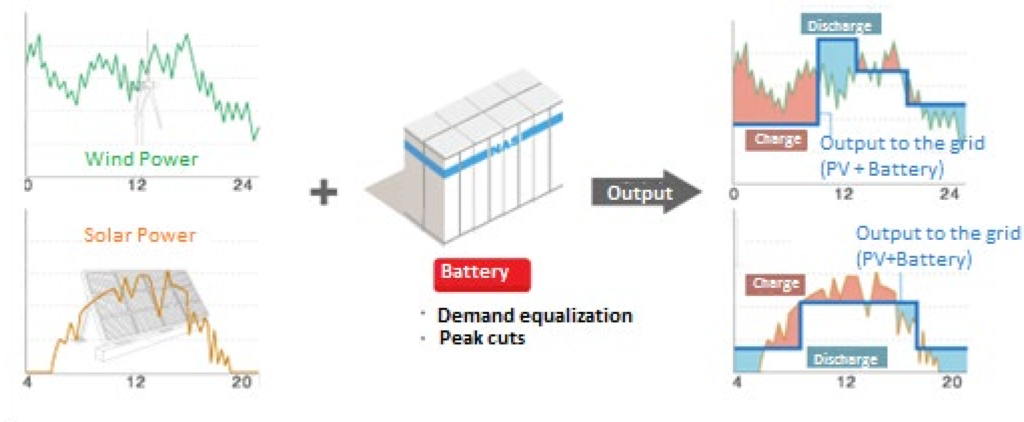
Sodium-sulfur battery has a higher energy density than redox flow battery and lead-acid battery, but has a lower density than lithium-ion battery. Sodium-sulfur battery developed in Japan can store megawatt class power, and has the features of large capacity, high energy density and long life. It is also nearly one-third the size of lead batteries, but capable of supplying the same amount of electricity, and useful for peak cut by leveling the power load and stabilizing renewable energy. It is expected to contribute to low carbonization and decarbonization because it leads to measures for long-period and short-period fluctuations, power saving, and energy cost reduction.

The following shows examples of utilization using sodium-sulfur battery.



(Source: NGK Website)

Figure 5-21 Peak Demand Cut by Sodium-Sulfur Battery



(Source: NGK Website)

Figure 5-22 Stabilization of Renewable Energy Source with Sodium-Sulfur Battery

5.4 Applicability of Grid Stability Countermeasures in Mongolia

For the grid stability issues described in Chapter 4, applicable technologies, which have been used in Japan, are considered as follows.

5.4.1 Adjustment of Supply and Demand Balance

(1) Issues on Supply and Demand Balance

(a) Output Curtailment

Output curtailment is mainly implemented to avoid the generation of surplus supply. According to the interview with NDC, since the demand forecast of RE generation is not so accurate, if there is a possibility that the adjustment capacity range, which depends on CHP 4 will exceed during the night time when the demand is low, the output curtailment may be requested.

The following methods can be mentioned as means for balancing supply and demand to avoid output curtailment

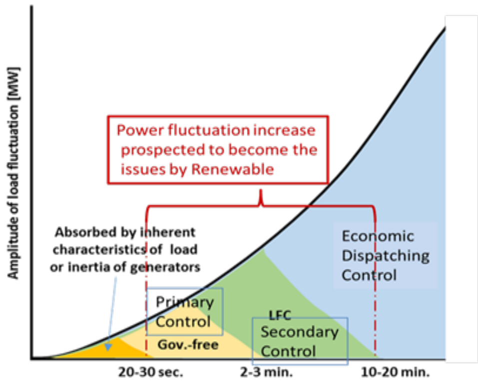
- Introduction of equipment with adjustment power such as reservoir type hydropower, pumped storage hydropower, and BESS.
- Introduction of load flexibility (pulverizer with inverter) to CHP 4.
- Expansion of power flow capacity to Russia.

(b) Supply Capacity

At the end of 2020, the generation capacity of the CES was 1,396 MW including RE. In terms of the capacity of RE, it has been introduced to the interconnection limit to Russia, which is 245 MW. On the other hand, the maximum demand of the CES recorded at 1,309 MW on December 14, 2020. At the time, the reserve margin of generation capacity was about 7 %. In 2021, because the capacity of CHP 4 was added and the maximum limit of the interconnection was also increased, the generation capacity is secured in the short term. However, from a middle to long-term point of view, a proper reserve margin (according to the “State Policy on Energy 2015-2030”, 10 % is the target in 2023) has to be secured along with the demand growth of electricity by increasing the supply capacity.

(2) Comparison of Each Measure in Adjustment Ability

Balance of supply and demand highly affects the frequency of the transmission system. Types of adjustment ability of frequency for change of the supply and demand balance is categorized into 3 functions, namely, primary control (for several tens seconds – 3 minutes), secondary control (for 2 minutes – 30 minutes) and economic dispatching control (for over several minutes). Adjustment ability faster than the primary control expects contribution of inertia of rotated generator for stability.



(Source: The Survey Team)

Figure 5-23 Concept of Frequency Adjustment

The following table shows the comparison of features of four technologies, pumped storage hydropower, reservoir type hydropower, BESS and load flexibility of thermal generation (pulverizer with inverter). Assumed values set by the Survey Team is used for the comparison.

Table 5-3 Comparison of Adjustment Ability in Each Technologies

	Pumped Hydro Storage		Reservoir Hydro		BESS		Pulverizer with Inverter	
Maximum Capacity (Assumption)	200	MW	200	MW	200	MW	0	MW
Effective Duration of Maximum Output (Assumption)	6	hrs	4	hrs	3	hrs	24	hrs
Energy Output	1,200	MWh/day	800	MWh/day	600	MWh/day	0	MWh/day
Unit Construction Cost	High		Mdeium-High		Extra High		Low	
Net Power Production	Negative		292	GWh/year	Negative		Nuetral	
Adjustment Capacity	±200	MW	±100	MW	±200	MW	±10 %	Ratio to Unit Capacity
Response Speed	Inretia, Primary-Secondary		Inretia, Primary-Secondary		Primary-Secondary		Secondary	
Envionmrntal and Social Impact	Large		Large		Small		Small	
Construction Period	Long		Long		Medium		Short	
Net Generation Production	×		◎		×		△	
Adjustment Capacity	◎		◎		○		△	

◎: Very Good, ○: Good, △: Fair, ×: No Good

(Source: The Survey Team)

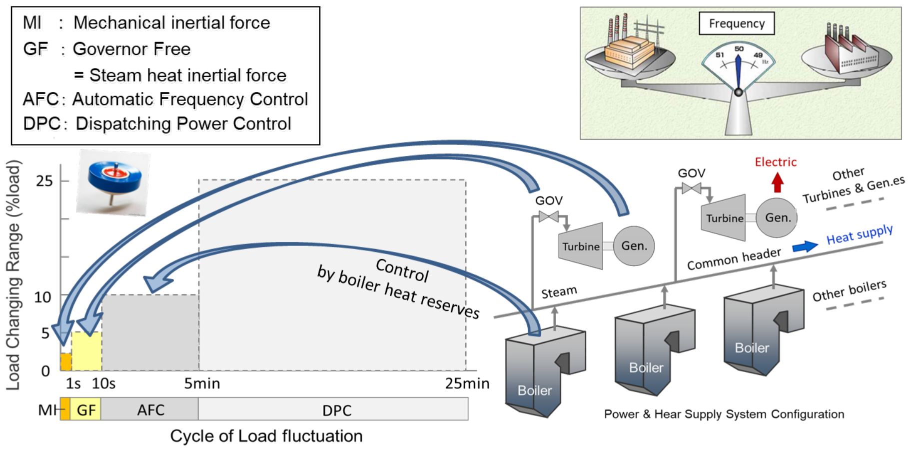
Pumped storage hydropower and BESS have a high capacity for the absorption of RE fluctuation by their load adjustment capabilities according to their scale. However, these require electricity for input, and losses occur between pumping (or recharging) and power generation, so recharging (pumping) using RE sources is necessary to contribute to CO2 reduction and should be considered in combination with these RE generation.

On the other hand, reservoir type hydropower has the capacity to generate electricity as a RE source. In addition, it has an adjustment ability for fluctuation of RE depending on the operation manner. In this context, total operation costs of reservoir type hydropower together with RE may be lower than the combination of pumped storage hydropower and RE. Construction costs of both pumped storage hydropower and reservoir type hydropower are highly dependent on site conditions, so it is not possible to say which is superior than the other as individual projects. However, in general, pumped storage hydropower has the potential to have a smaller impact on the environment and society than reservoir type hydropower because it minimizes the need to take water from rivers.

With regard to the load flexibility of thermal generation, the application in CHP 4 is expected to provide flexibility in generation operation, but there may be seasonal constraints on the operational range of thermal power plants that simultaneously supply heat. In order to ensure flexibility in power generation, it is considered necessary to take a comprehensive approach in combination with other dedicated heat supply facilities.

(3) Maintaining Inertia

Rotated generators represented by thermal generation contribute to the maintenance of inertia that avoid a moment fluctuation of frequency. The following figure shows the relationship between boiler heat and inertia.



(Source: The Survey Team)

Figure 5-24 Contribution to Stability of Frequency by Each Part of Thermal Generation

In general, thermal power plants are controlled to absorb the load fluctuation in accordance with the cycle of load fluctuation.

- The generator, which is a high speed rotating element, has mechanical inertia (MI) and absorbs short cycle fluctuations of one second cycles.
- The turbine governor valve (GOV), which controls the amount of steam supplied to the steam turbine, absorbs fluctuations at the 10-second level.

- The steam held by the boiler absorbs 5-minute level fluctuations. Large fluctuations at the 25-minute level are controlled by controlling the amount of feed water, fuel, and air supplied to the boiler.

On the other hand, power generation from RE sources such as solar power and wind power is a non-continuous power source and has no inertia.

Therefore, the control by the mechanical inertia of the generator, the 10-second level control of the turbine governor valve (GOV), and the 5-minute level control by the boiler steam will play an important role in maintaining the stability of the power system in the RE expansion era.

Generators of hydropower (including pumped storage hydropower) also have the same function of adjustment ability as a rotated generator. These generators are inevitable for a stable operation of the transmission system.

(3) Status of Planned Project

MOE reported on "Energy Sector Development Policy, Future" at a public seminar held on November 17, 2021 in Mongolia. The report included a list of projects for the period 2020-2024 that are currently implemented and under consideration for financing (including power generation heat supply and transmission projects).

Table 5-4 On-Going Projects

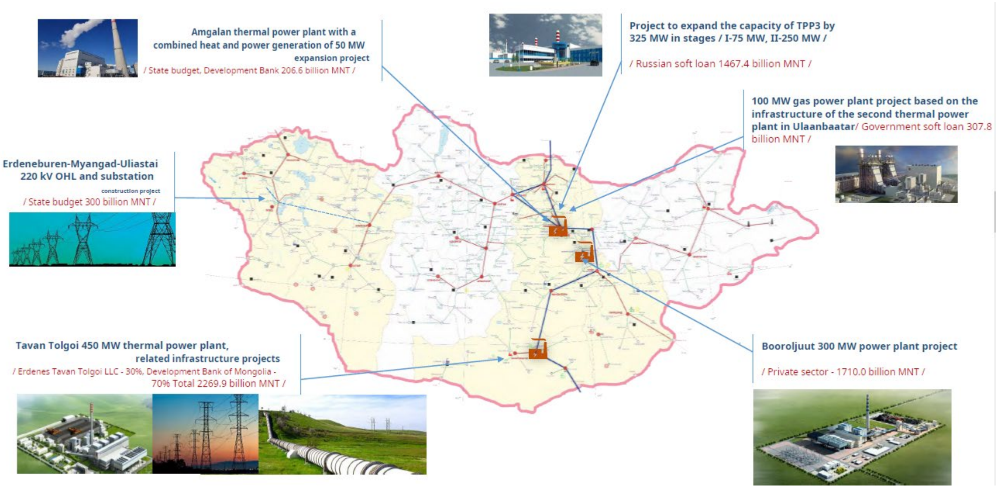
	Project Name	Main Financial Source	Budget (Billion MNT)
1	Ulaanbaatar Heating Sector Improvement Project	Concessional Loan from the World Bank	116.8
2	Ulaanbaatar District Heating Project	EBRD Soft Loan	47.3
3	First Utility-Scale Energy Storage Project	ADB Soft Loan	327.6
4	Choir-Sainshand 220 kV Transmission Line Project	EBRD Soft Loan	180.0
5	Erdeneburen 90 MW Hydropower Project	Concessional loan from China 95%, State Budget of Mongolia 5%	818.0

(Source: Energy Sector Development Policy, Future, MOE, 2021)

Table 5-5 Projects Considered for Finance

	Project Name	Main Financial Source	Budget (Billion MNT)
1	Tavan Tolgoi 450 MW TPP and Related Infrastructure Development project	Erdenes Tavan Tolgoi LLC - 30%, Development Bank of Mongolia - 70%	2,296.9
2	Amgalan TPP Expansion Project with 50 MW of Combined Heat and Power Generation	Development Bank Loan / State Budget	206.6
3	Erdeneburen-Myangad-Uliastai 220 kV OHTL and Substation Construction Project	State Budget	300.0
4	Project to Expand and Renovate the Third TPP in Stages by 325 MW	Russian Soft Loan	1,467.4
5	Infrastructure of the Second TPP in Ulaanbaatar Project to Build a 100 MW Gas Power Plant	Foreign Soft Loan	307.8
6	Baganuur Power Plant Construction Project	Concession Loan	1,808.0
7	Raspberry Power Plant Construction Project	Private Sector	1,710.0

(Source: Energy Sector Development Policy, Future, MOE, 2021)



(Source: Energy Sector Development Policy, Future, MOE, 2021)

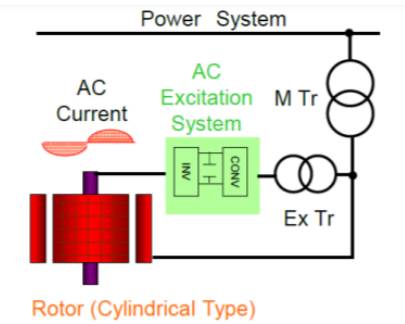
Figure 5-25 Main Projects (Generation and Transmission Line) (2020-2024)

(4) Applicability to the Mongolian System

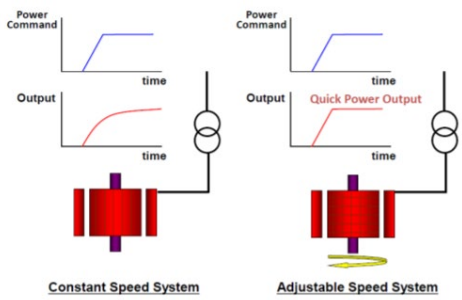
(a) Pumped Storage Hydropower

Applicability highly depends on generation costs which vary by site location and conditions. In general, the following conditions are desirable:

- A situation in which the number of necessary new dams are as few as possible (where the upper or lower reservoirs are available) is desirable from both a cost and environmental point of view.
- Considering the characteristics of absorbing surpluses of RE generation and generating electricity when there is a shortage of supply, it is desirable to have sites close to the areas where REs are connected and the demand areas, in order to reduce transmission losses.
- It is desirable to connect in areas where there is sufficient transmission capacity.
- In Mongolia, since surpluses from RE generation may not be fully absorbed, there is a possibility that adjustable speed pumped storage hydropower is advantageous in terms of adjustment capability during pumping (the system is shown below). This system controls the speed of rotor by adjusting the current supplied to the rotor, so that the input power during pumping can be adjusted variably. In addition, this system has abilities to adjust the power at a higher speed than a conventional pumped storage hydropower in both generating and pumping operation.



System Configuration of Adjustable Speed System



Comparison of Constant Speed and Adjustable Speed System

Figure 5-26 Overview of Adjustable Speed Pumped Storage Hydropower

Generation facilities that contribute to grid stability are basically operated by government entities due to its public purpose. According to NDC, the effectiveness of pumped storage hydropower and BESS were mentioned as follows.

- There is a gap of about 300 MW between day and night demand, so it would be good to have technology to fill this gap.
- The cost of pumped storage hydropower generation may increase due to the need to build dams, but depending on the site this may be reduced. Based on actual results, pumped storage hydropower seems to be cheaper than BESS in generation costs..
- BESS can only be expected to last about 10 years, after which they must be disposed of.

NDC was not aware of any specific pumped storage hydropower project plans, but ADB's TA (Supporting Renewable Energy Development), which started in 2020, includes a study for a pumped storage hydropower pilot project, the Kherlen - Choi (50 MW). In addition, an internet search revealed the following project.

Table 5-6 Pumped Storage Hydropower Project Searched on Internet

Project Name	Facilities	Source
Orkhon Pumped Hydro Power Plant (Located in 320 km West from UB)	Output: 100 MW (25 MW x 4 Units) Annual Generation: 219 GWh Estimated Cost: 400 million US$	News Source: Power Technology, Market Data (2021.12.21) https://www.power-technology.com/market data/orkhon-hydro-power-plant-mongolia/

(b) Battery Energy Storage System (BESS)

With the support from ADB, 80 MW of BESS is being installed (under procurement as of January 2022). The project's original capacity of 125 MW / 160 MWh has been changed to 80 MW / 200 MWh (January 2021).

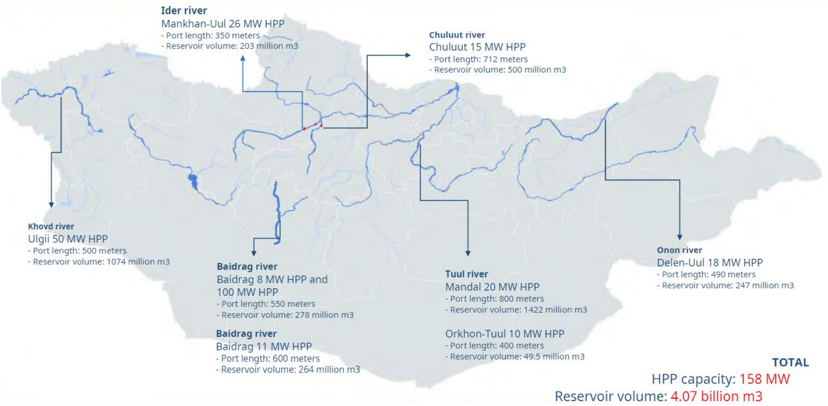
If uncertainty over the supply and demand balance increases due to the expansion of RE installations in the future, the addition of BESS could be a countermeasure, along with pumped storage hydropower. But depending on the requirements for the introduction of RE IPPs in the future, it is also possible that such companies will install BESS in order to equalize the supply of their own power sources.

The advantage of BESS is that, unlike pumped storage hydropower, there are fewer restrictions on site conditions and the capacity for storage and discharge can be planned more freely.

(c) Reservoir Type Hydropower

Plans for reservoir type hydropower projects are presented in the “Energy Sector Development Policy, Future”, mentioned above. There are four projects on the Selenge river system that can be connected to the CES: Mankhan Uul (26 MW), Chunluut (15 MW), Mandal (20 MW) and Orkhon-Tuul (10 MW).

Since reservoir type hydropower involves damming up river water, it has significant environmental and social impacts on downstream communities and countries, and is often difficult to implement.



(Source: Energy Sector Development Policy, Future, MOE, 2021)

Figure 5-27 Location Map of Reservoir Type Hydropower (Plan)

(d) Forecasts of RE Generation

As a main reason for NDC's request for output curtailment, inaccuracy of power generation forecasts submitted from RE business operators (especially wind power) is raised.

In Japan, there is a wind power forecasting system, which uses a meteorological model. This meteorological model can be fine-tuned by a comparison of actual measurements of wind speed and power output at a site.

This forecast method is also affected by topography and may require site-specific corrections, but sites with similar topography will be able to predict with similar accuracy.

This service can be piloted in cooperation with a private wind power site in Mongolia in the next cooperation program of JICA. If the results are deemed to be good, the pilot implementation may be rolled out to other sites.

Step 1: Formulation of Model for Generation Forecast

- Collection of data and analysis
- Formulation of generation forecasting model
- Setting results distribution system

Step 2: Trial Operation of the Forecasting Model

- Trial operation of the model (Duration: 12 months, Forecast Range: 72 hours ahead, Forecast Data: Every 1 hour, Distribution Frequency: 2 times / day)
- Confirmation of accuracy and information-sharing with NDC
- Consideration of possibility to avoid output curtailment

Step 3: Validation of Effects and Possibility of Expansion

- Validation of forecasting results and improvement, if possible
- Consideration of expansion to other RE plants
- Estimation of effects

(e) Load Flexibility of Thermal Generation

Rotated generators such as thermal power, which have flexible adjustment power, have the advantage of being able to absorb the fluctuations of RE generation, which are discontinuous power sources, in the era of their increased introduction.

In Japan, thermal power output is reduced during daytime hours when large amounts of electricity are generated by solar power, and the system is operated with the ability to adjust to fluctuations in RE (wind and solar power) to make use of as much RE as possible. There is also pumped storage hydropower as a backup.

However, as mentioned previously, thermal power generation in Mongolia is often combined heat and power, which may limit the flexibility of operation depending on the season.

5.4.2 Grid Stability in the Transmission System

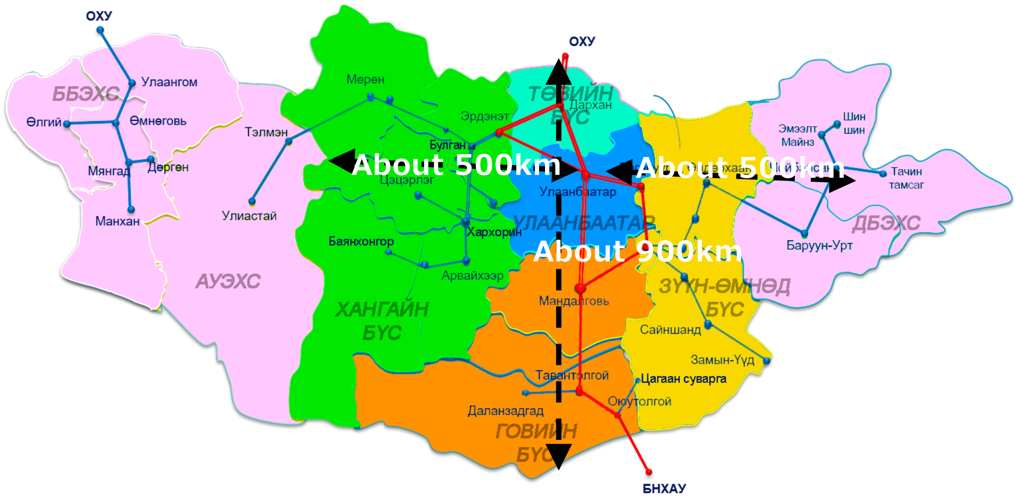
(1) Issues in the Transmission System

(a) Long-distance Transport of Electricity

The CES, including the capital city of Mongolia, consists of 220 kV and 110 kV transmission lines covering a supply area of about 900 km in the north-south direction and about 1,000 km around UB city, as shown in the following figure.

The 220 kV transmission lines are double conductor line of type AC-300, according to a report published by another donor (Source: ADB Technical Assistance Consultant's Report/Mongolia: Strategy for Northeast Asia Power System, February 2020). The current carrying capacity of this transmission line described in this report is approximately 750 A, and the transmission line capacity calculated from this current is 286 MVA. The international interconnection transmission line with Russia is a 220 kV transmission line, which is connected to Darkhan substation. In addition, Darkhan substation and Erdenet substation are connected by two 220 kV transmission lines, and Darkhan substation and Ulaanbaatar substation are connected by a single 220 kV transmission line. These transmission lines transport electricity from Russia to UB city.

The 110 kV transmission lines are single conductor line of type AC-240, according a report by another donor (Source: NEDO Demonstration of low loss conductor by energy-saving power transmission system in Mongolia, February 2019). Although the current carrying capacity of this transmission line is not described in the report, it is assumed to be 300 A (assuming that it is a single conductor based on information from local photographs), and the transmission line capacity calculated from this current is 57 MVA.



(Source : The Survey Team)

Figure 5-28 Power System Network in Mongolia

Transmission lines generally manage power follow with current carrying capacity determined by the heat-resistant temperature of concocter. In addition, there is a transmission line transportation limit determined by the inductance of the transmission line. Transmission line capacity based on current carrying capacity will be larger than the transportation limit determined by the inductance of the transmission line, if the long distance transmission line is several hundred km.

However, the transmission lines in Mongolia may reach the transportation limit of the transmission lines due to long distance transmission lines from power supply substations to receiving substations. The power flow in the transmission line can be calculated by the following equation. The transport limit is the power at the receiving end when delta in this equation is 90 degrees.

$$P_r = \frac{V_s V_r \sin\delta}{X}$$

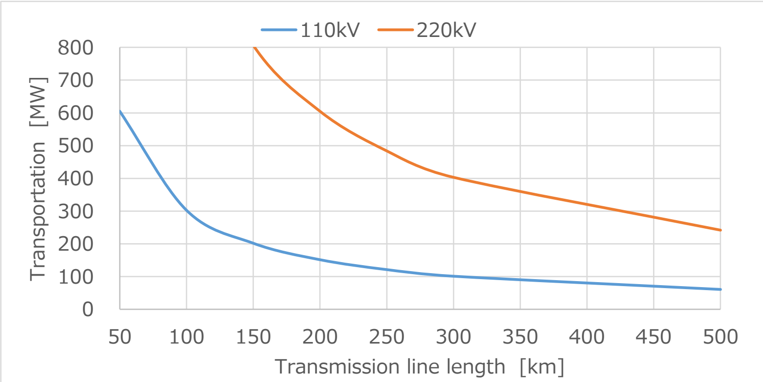
Pr : Receiving power　　Vs : Sending voltage　Vr : Receiving voltage

X : Inductance of transmission line

δ : Phase angle difference between sending voltage angle and receiving voltage angle

As shown in the following figure, the transmission line length and transportation limit of 220 kV transmission line and 110 kV transmission line were calculated using this equation. In the Survey, the inductance of transmission line was set to 0.4 ohm/km (1.3mH/50Hz, NEDO Demonstration of low loss conductor by energy-saving power transmission system in Mongolia, February 2019).

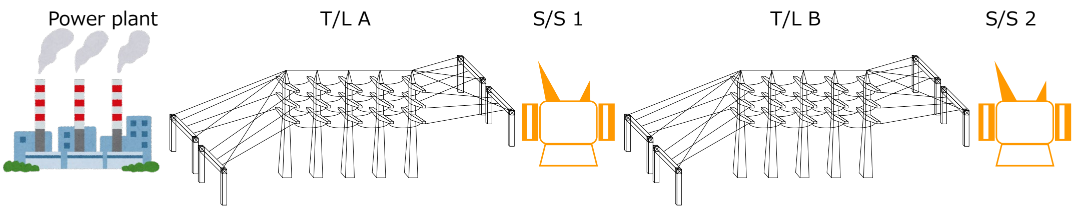
The current carrying capacity of the 220 kV transmission line is 286 MVA, and the transportation limit that can transmit power of 286 MVA is about 400 km. Furthermore, the transportation limit of 76 MVA on the 110 kV transmission line is about 500 km. When the land is vast and the power plant and the demand area are far apart as in Mongolia, the transportation may become a bottleneck instead of the current carrying capacity of the transmission line.



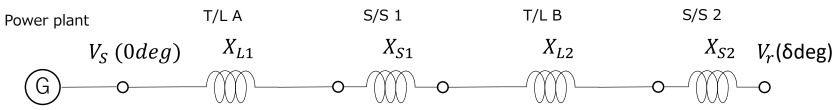
(Source: The Survey Team)

Figure 5-29 Transportation Limit in Case of 0.4 ohm/km (1.3mH/50Hz) as Transmission Line Inductance

The transportation limit is determined by the inductance of the transmission line. However, when looking at the whole power system, as shown in figure a) below, there are transmission lines and substations from the power plant to the demand area, and the inductance of the transmission line and inductance of the transformer in figure b) below are connected in series. The transportation limit from the power plant to the demand area is determined by the total value of inductance as shown in the equation in figure c) below. It is necessary to pay attention to the inductance of the transmission path, when the power plant and the demand area are far apart.



a) Image of power system network



b) Image of electric circuit

$$P_r = \frac{V_s V_r \sin\delta}{X_{L1} + X_{S1} + X_{L2} + X_{S2}}$$

c) Simple equation of transportation limit

(Source: The Survey team)

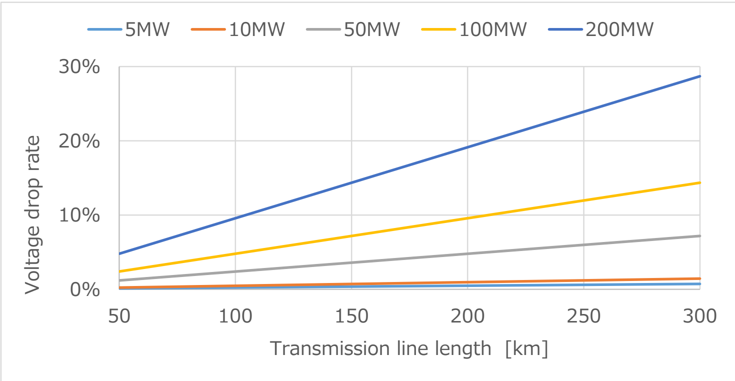
Figure 5-30 Transportation Limit from Power Plant to Demand Area

(b)Voltage Fluctuation

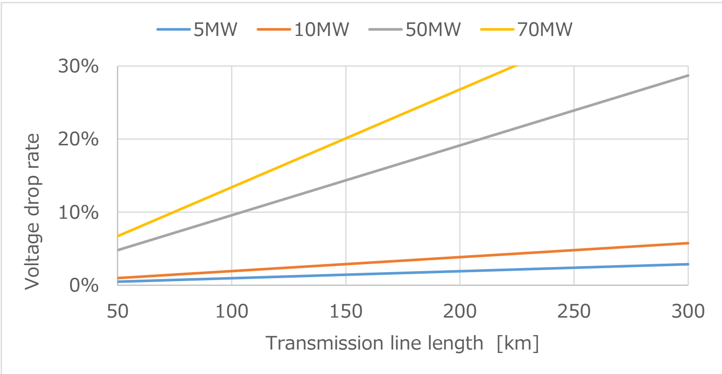
Long distance transmission lines cause large voltage fluctuations. The voltage fluctuation of the transmission line can be calculated by the following equation. The voltage drop rate based on the transmission line length and the effective power of the transmission line is calculated and summarized as follows. The impedance and inductance of the transmission line were assumed to be 0.1 ohm/km and 0.4 ohm/km (1.3mH/50Hz NEDO Demonstration of low loss conductor by energy-saving power transmission system in Mongolia, February 1991). As a result of the trial calculation, the voltage drop rate increases as the power flow increases and the transmission line length increases. When the output of generators such as a wind power generator changes, the voltage fluctuation becomes large. Thus, it is necessary to be careful when developing wind power generators in areas where the transmission line becomes long.

$$\Delta V \fallingdotseq \frac{\mathrm{P} \cdot R + Q \cdot X}{X}$$

ΔV : Voltage change　V : Power system voltage　P : Active power　Q : Reactive power
R : Impedance of transmission line　X : Inductance of transmission line



a)　Transmission line length and voltage drop rate of 220kV transmission lines



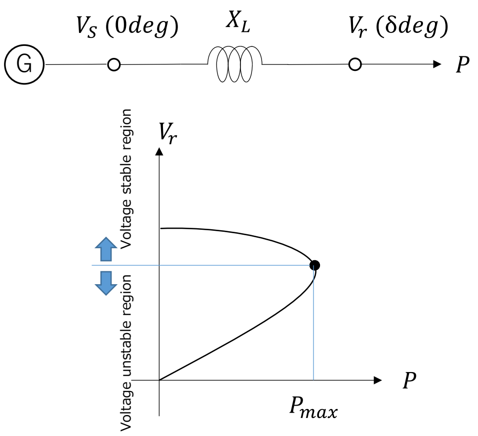
b)　Transmission line length and voltage drop rate of 110kV transmission lines

(Source: The Survey Team)

Figure 5-31 Active Power Flow (Power Factor 0.98) and Voltage Drop Rate of Transmission Lines

The major factor of voltage fluctuation is the process in which the reactive power flows in the transmission line and is consumed by the inductance of the transmission line, as shown in the equation. Therefore, the voltage fluctuation can be suppressed, if reactive power can be supplied to the transmission line to compensate for the reactive power consumed in the transmission line.

The relationship between the active power carried by the transmission line and the voltage is known as the P-V curve, as shown below. The voltage is stable, when the voltage is greater than the voltage of the maximum power, and voltage can be recovered by reducing the active power passing through the transmission line. On the other hand, the voltage is unstable and cannot be recovered by reducing the active power passing through the transmission line, when the voltage is less than the maximum power voltage. The voltage at the maximum power is about 70 % of the rated voltage.



(Source: The Survey Team)

Figure 5-32 P-V Curve of One Transmission Line One Load Model

(c) Overloaded Transmission Lines

The transmission line current carrying capacity in Mongolia is assumed to be 286 MVA for 220 kV lines and 57MVA for 110kV lines, as mentioned in the above section. The contracted power from Russia via the international interconnection line has been expanded from 245 MVA to 345 MVA. The power imported from Russia is transported to Ulaanbaatar, a major consumer of electricity, using 220 kV transmission lines. The contracted power of 245 MVA from Russia was less than the allowable current of the 220 kV transmission line of 286 MVA, but if the new contracted power of 345MVA is used up to the maximum limit, it may exceed the allowable current of the 220 kV transmission line.

It is not expected that all of the power form the international interconnection line will be supplied to Ulaanbaatar city in the normal power system operation. But single equipment failure (N-1 failure) in the power system may cause some transmission lines to be overloaded.

(2) Countermeasures

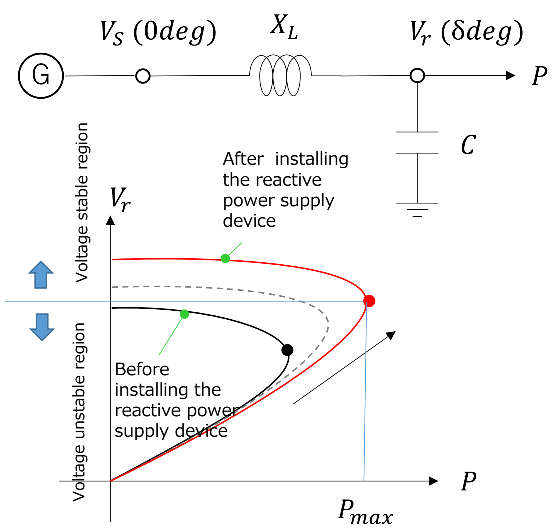
(a) Long-distance Transport of Electricity

Methods to improve the current carrying capacity of long-distance transport of power flow requires lowering the inductance of transmission lines and power transport routes, so measures such as constructing new transmission line routes and adding transformers will be necessary. It is also conceivable to develop a new power source in a place where the power source and the demand area are relatively close. A detailed power facility expansion plan is required through a study of the transmission system master plan, in order to fundamentally solve these issues.

(b) Voltage Fluctuation

Voltage fluctuation is caused by the consumption of reactive power by transmission lines, so one of the measures to prevent voltage fluctuation is to install equipment to supply reactive power. As equipment to supply reactive power, generators of thermal power plants and hydroelectric power plants can be one of the sources, but devices such as STATCOM and synchronous condensers are candidates to supply reactive power at substations that are far from the generators.

It will be possible to extend the maximum power as shown in the P-V curve below, and the voltage of maximum power will also increase, if a reactive power supply device is installed as a countermeasure against voltage fluctuation. The voltage of the maximum power rises by applying the static reactive power supply device. However, the voltage will drop sharply, if the voltage shifts to the unstable region, so care must be taken in power system operation. For reference, a way to increase the maximum power while keeping the P-V curve similar is to increase the number of transmission lines.



(Source: The Survey Team)

Figure 5-33 P-V curve of One Transmission Line and One Load Model with Reactive Power Supply Device Installation

(c) Overloaded Transmission Line

The countermeasures against overloaded transmission lines include increasing the allowable current of transmission lines and constructing new transmission lines. Specific methods of increasing the current carrying capacity of transmission lines include increasing the size of the transmission line conductor or using heat-resistant conductor that can withstand large currents.

The method of increasing the wire size of the transmission line may require reinforcing or rebuilding the existing transmission towers so the weight of the transmission line will be heavier.

Other possible countermeasures for overloaded transmission lines include increasing the number of transmission routes, upgrading the transmission system voltage, and constructing new substations in order to distribute the demand. The implementation of these countermeasures will require a detailed power facility expansion plan through a transmission system master plan.

(3) Examination on Applicability of Japanese Technology to Mongolia

The following is a summary of the issues related to the transmission system in Mongolia, divided into software support and hardware support. The potential applications of Japanese technologies are expected to be low-loss conductor, transmission line conductor with increased current carrying capacity, expansion of substations in narrow spaces (using GIT and GIS), and BESS, etc.

Table 5-7 Applicability of Japanese Technology to Mongolia

Power System Issues	Software Support	Hardware Support
Long-distance transport of electricity (including decrease of short-circuit current capacity)	· Transmission system master plan	· New transmission line · Application of low-loss transmission line conductor and increased-capacity transmission line when constructing new transmission lines · Substation construction · Transformer expansion · Increase capacity of transformer · Synchronous condenser installation
Voltage fluctuation	· Transmission system operation	· STATCOM installation · Synchronous capacitor installation · Storage battery installation
Over load transmission line	· Transmission system master plan · Reinforcement of technology for transmission tower · Transmission tower rebuilding technology	· Application of increased capacity transmission line conductor

5.4.3 Consideration on the Effectiveness of Grid Stability Measures

(1) Grid Stability Measures to Alleviate the Imbalance between Supply and Demand

The need to take grid stabilization measures to ensure power quality has become apparent, as Mongolia promotes the introduction of RE. The development points of REs are often far from the demand areas, requiring long-distance transmission and causing problems with voltage fluctuations. In addition, since RE generators are interconnected to the power system via PCS devices, if a large number of RE generators are interconnected to the power system, the inertia of the power system will be reduced, which may interfere with the operation of existing hydroelectric and thermal power plants.

One of the causes of voltage fluctuation is the output fluctuation of RE generation. Measures to mitigate this output fluctuation include the installation of storage batteries, the construction of pumped storage power plants, and the use of the governor-free function of hydroelectric or thermal power plants.

BESS and pumped storage hydropower are capable of recharging and discharging electricity, and BESSs are effective in dealing with output fluctuations during short periods of time for RE. Pumped storage hydropower cannot switch between charging and discharging as quickly as storage batteries, but they can use their governor-free function during power generation to mitigate fluctuations in RE and improve voltage fluctuations. BESS may also be introduced by the RE IPP side, and the sharing of the installation of BESS with public institutions (transmission side) is another area to be considered.

(2) Measures to Mitigate Instability Caused by Long-Distance Transmission Lines

Another cause of voltage fluctuations is caused by the inductance of transmission lines. As power flows through the transmission line, the inductance of the line consumes reactive power, causing voltage fluctuations. Therefore, the voltage fluctuation could be improved by supplying the reactive power consumed by the transmission line from outside. The devices that supply reactive power include shunt capacitors, SVC, STATCOM, and synchronous capacitor as shown below.

The responsiveness of reactive power control is high for STATCOM. Synchronous condensers are less responsive to control than STATCOM, but they can have inertia that contributes to the transient stability of the power system. As a countermeasure when the inertia is reduced when the RE generator is connected to the power system, the application of synchronous condenser can contribute to the improvement of voltage fluctuation and inertia.

Table 5-8 Reactive Power Supply Equipment, Control Speed and Function

Function	Sh.Cap	SVC	STATCOM	SC
System control function				
Absorption of reactive power	N/A	Medium	High	Medium
Supply of reactive power	Medium	Medium	High	Medium
Voltage control	Medium	Medium	High	Medium
Voltage quality improvement				
Voltage stability improvement	Medium	Medium	High	Medium
Voltage fluctuation improvement	N/A	Medium	High	Medium
Impact on power system				
Fault current supply	N/A	N/A	N/A	Applicable
Inertial force	N/A	N/A	N/A	Applicable

Sh.Cap: Shunt Capacitor
SVC: Static VAR Compensator
STATCOM: Static Synchronous Condenser
SC: Synchronous Condenser

5.4.4 Suggestions for Network Planning and Operation

(1) Transmission Network Planning

With regard to the transmission system planning, the power plants and network facilities of 5 MW and more are planned by NDC or each licensee, examined and evaluated by NDC, and determined by MOE. NPTG owns and manages transmission network facilities as the transmission licensee, as well as conducts related system planning and facility planning. Facility of small capacity with single licensee concerned is developed by the licensee. Overall transmission network planning is conducted by NDC and transmission and substation planning including facility planning is conducted by NPTG. It is important that the situation of the network, including stability and voltage, is analyzed by appropriate tools in the network planning.

(2) Power System Operation

Regarding the power system operation, range of frequency and voltage, and its control methods are stipulated in the grid code. Securing reserve capacity is necessary to deal with short time demand change, to keep demand and supply and to maintain frequency, which currently depends on the Russian network. Increasing controllable power supply capacity will be necessary in planning further deployment of RE.

Although the import capacity from Russia has increased in December 2021, export to Russia is not assumed. It is desirable to create a more flexible scheme to export power as needed, under certain conditions and with considering ancillary service charge.

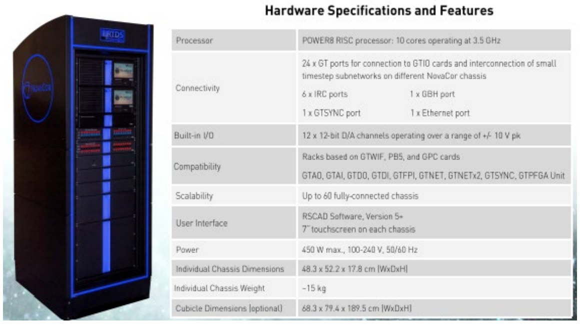
Only CHP 4 is utilized as a controllable power source, but it cannot conduct online automatic control (AGC) from NDC. ADB plans to replace SCADA/EMS of NDC, install Battery System, and provide AGC function to utilize them. If this function can be equipped in most of the relatively large-scale power plants, it will contribute to securing reserves within the country.

As for the voltage, deviations from the rated values have become the issue, due to the long distance transmission lines and dispersed RE in rural areas. Voltage measures should be taken into account in the network planning stage, so as to plan transmission lines, transformers, capacitors, reactors, and FACTS facility appropriately. Currently, SVC and STATCOM are being promoted, and ADB also plans to provide support in this area. The voltage situation would be improved when these facilities are installed in proper sites and controlled automatically. Voltage control operation is currently conducted by controlling generators, transformer taps, switching capacitors, and unenergizing transmission lines according to the rule. Automation of some of these voltage control operation would contribute to the improvement of voltage situation.

(3) Utilization of Real Time Digital Simulator (RTDS)

Since the transmission system of Mongolia is characterized by long distance and the demand area is far from the power plants, it is important to accurately grasp the system status, quickly identify the problems, and consider countermeasures. Currently, in the operation of Mongolia’s power system, the generation status of all REs is not known in real time, and the online information gathering function is not fully equipped. Thus, it is difficult to sufficiently grasp the system events. In order to adopt an optimum operation plan, it is necessary to carry out a large number of simulation cases with the power generation status of REs using various parameters and analyze the status of the entire system. Considering the current situation of Mongolia's transmission system, it is effective to utilize RTDS.

In addition, since RTDS can express the systematic event in a calculation time of several tens of seconds, it may be utilized in the immediate system operation through cause analysis and response.



Hardware Specifications and Features

Processor	POWER8 RISC processor: 10 cores operating at 3.5 GHz
Connectivity	24 x GT ports for connection to GTIO cards and interconnection of small timestep subnetworks on different NovaCor chassis 6 x IRC ports 1 x GBH port 1 x GTSYNC port 1 x Ethernet port
Built-in I/O	12 x 12-bit D/A channels operating over a range of +/- 10 V pk
Compatibility	Racks based on GTWIF, PB5, and GPC cards GTAO, GTAI, GTDO, GTDI, GTFPI, GTNET, GTNETx2, GTSYNC, GTPFGA Unit
Scalability	Up to 60 fully-connected chassis
User Interface	RSCAD Software, Version 5+ 7" touchscreen on each chassis
Power	450 W max., 100-240 V, 50/60 Hz
Individual Chassis Dimensions	48.3 x 52.2 x 17.8 cm (WxDxH)
Individual Chassis Weight	~15 kg
Cubicle Dimensions (optional)	68.3 x 79.4 x 189.5 cm (WxDxH)

(Source: RTDS)

Figure 5-34 Hardware of RTDS (Sample)

5.4.5 Issues on Distribution Network

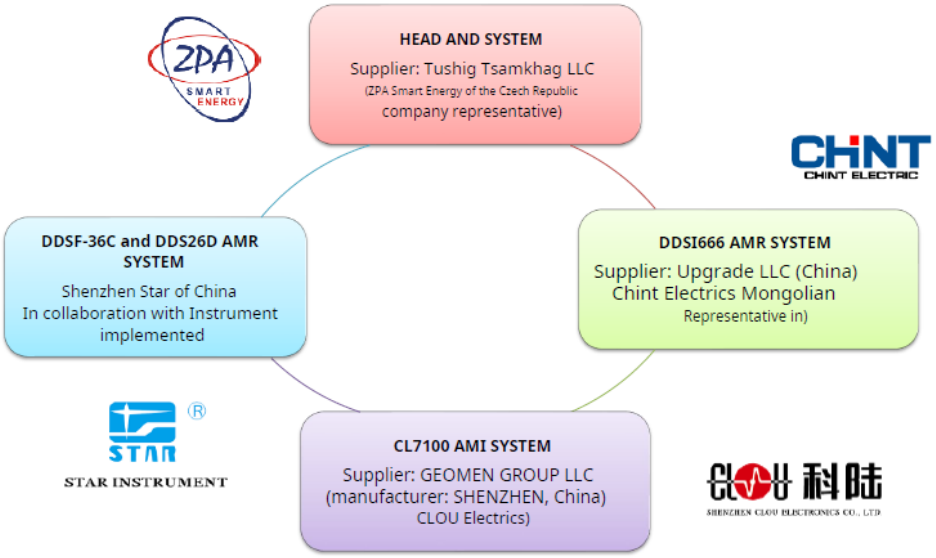
(1) Issues on Distribution Network Level

(a) Outline

The problem in the middle-low voltage network is aging equipment. Almost 40% of the pole transformer are more than 30 years old and there are many pole transformers made in Russia which are low in its efficiency. In addition, a growing number of low efficiency and inexpensive Chinese-made equipment has recently been introduced. The key factor behind this is the current bidding system, which drives the introduction of low-efficiency equipment since it aims to purchase equipment at a lower cost. Therefore, the government is making an attempt to reform its procurement bidding system to apply new specifications taking into account not only cost but also the efficiency rate.

One of the issues with UBEDN is that the load on the distribution system is not managed accurately. Since exemption of charge for customers under 250 kWh per month continues from December 2020 until May 2022 as the COVID-19 economy countermeasure, the surge in demand causes overloading of pole transformers and distribution lines. While government intends to raise electricity prices to squeeze out costs for network maintenance or repair, it is considered that the operators need technology which enable the monitoring/control of basic information including voltage and load. Thus, technology such as SCADA, DAS and smart meters are perceived to be the solutions. However, since the current standards and specifications of those technology being introduced in Mongolia are not unified and are not specified for Mongolia, trouble caused by inconsistencies in interface and specifications occur.

For example, there are four different systems that monitor and control data collected from smart meters as a result of trial introduction from various manufacturers, which make it difficult to interconnect each other between systems.



(Source: UBEDN)

Figure 5-35 Four Smart Meter Systems in UBEDN

(b) Issues with RE Connections

According to UBEDN, the actual number of RE connections to the distribution grid which has been constructed and in operation is only 5, as of December 2021. The problems caused by RE connections to the grid including voltage fluctuations, frequency alternations, and higher harmonic have not been identified. Roof-top solar power is not common in Mongolia. Therefore, necessity of power quality improvement devices such as SVR which are used in Japan has not yet become apparent.

On the other hand, UBDEN assumes that there will be many cases where solar power generation is applied for connection at the distribution level. There are needs for the standardization of internal procedures for RE connections.

(2) Project/Program for Expanding RE at Distribution Network

(a) Smart Meters

There are smart meters that contribute to expand RE connections. The Law on Renewable Energy has been amended to allow detached houses and enterprises which output renewable energy to connect to the grid.

According to UBDEN, the aim of the introduction of smart maters is to streamline electricity billing operations, prevent theft of electricity, and avoid overuse, ERC made a comment that it is desirable to widely use smart meters to facilitate electricity trading.

(b) Roof-top Solar Power

While UBEDN has approved five new RE connections which consists primarily of solar power, a growing number of new connections are expected as FIT has already been enacted. Roof-top solar power, which is a principle example of RE in the distribution network, is not so common in Mongolia yet.

Ger area accounts for 60 to 80 % in UB city. Since 30 % of the mountainous region is not electrified, RE connections to the grid is difficult. Therefore, houses in the rural area often equip off-the-grid facilities with solar power and battery. Depending on the electricity demand of these consumers, such system may be cost advantageous because they do not require additional construction of distribution lines for new grid for connections.

(c) DSM (Demand Side Management)

Although there are EVs and household batteries which are instrumental to promote DSM and DR, currently, there are no clear plans to introduce such contents in Mongolia. TOU is the only conspicuous approach to DSM in Mongolia. But given the pressing supply situation, it is considered that prompting RE introduction and utilization of DSM as the development of generation can contribute to reducing total energy consumption and advancing to a low carbon society.

In particular, since smart meters are useful tools which contribute to the visualization of power consumption as well as those used for short term DR, it can be utilized for peak cuts in combination with demand side power consumption equipment.

Chapter 6 Technologies in Middle and Low Voltage Distribution Line for Smart City

6.1 Gaps between Smart City Plan and Current Status

6.1.1 Outline

Mongolia has just launched initiatives to realize smart cities. While distribution automation system and smart meters are planned to be included as project components, other measures such as Energy Management System (EMS), mini-grid, and demand control center which adjusts supply and demand balance are not taken into consideration in UBEDN, as of January 2022.

6.1.2 Progress of Smart City Plan

Ministry of Construction and Urban Development (MCUD) has led urban city construction plans, and also create an overall layout plan for power lines and communication networks before allocating the work to each ministry. If the plan includes those that are applicable to UB city as a whole, Ulaanbaatar Planning Agency may participate in the planning.

In the Mongolia city planning, introduction of advanced communication technology such as 5G is taken into account while giving priority to securing water resource and thermal power supply due to dry and cold environment. Although there are some uncertainties, the development area is getting attention on whether its water resource is abundant, or if the water can be recycled to utilize it as much as possible.

A rough overview of smart cities by 2021 and 2040 has been released by government. However, they have no concrete plans yet and are still in the conceptual stage, and have not been published in detail. The concept of the plan up to 2030 aims to realize a comfortable life through effective land utilization, and although a detailed outline has not yet been given, there are plans on the construction of RE and gas power plants, and substations, etc.

In the Ger area surrounding UB city, the development of water and power infrastructure is lagging due to environmental contamination, especially air pollution. Until 2020, the area was divided into areas that can be developed and areas that cannot be developed, but by 2040, the plan is to expand and develop the area to include the Ger area. Since the population is concentrated in in UB city, the Mongolian government aims to establish a smart city that can utilize RE and other clean energy. The plan is to develop public offices, public facilities, and transportation systems in each city to realize the smart city plan.

6.1.3 City Planning around the New Ulaanbaatar Airport

There is a city named “New Zuunmod City”, formerly referred to as “Aero City”, located around the new Ulaanbaatar airport supported by JICA for development. This is one of the government policies of top priority aimed at developing a distribution center in line with the Bogd Khanate Railway Development project. This project consists of four phases and aims to improve the urban functions by 2050. As the first phase of the project, the northern part of the new airport is planned to be developed as a commercial, tourism, and residential area as well as an air cargo center will be built in the southern part. In the second phase, there is a plan to develop an industrial complex centered on agricultural-related industrial facilities, including distribution centers. Due to the high need to build distribution centers which can serve as receivers for new demand, there are a lot of development plans and ideas for distribution centers in Mongolia.

New Zuunmod City is expected to provide quality residential environment including schools and hospitals that meet the international standard, commercial facilities, transportation, and smart infrastructure for access to electric power, water and waste disposal. It is planned to become a developed city with a combination of residential, commercial, and industrial complexes in close proximity to work and reside in. As a result of the amendment of the law on the capital status in 2021, satellite cities are allowed to be incorporated in Ulaanbaatar City, and special zones are allowed to be set up in satellite cities. New Zuunmod City is positioned as a satellite city in the master plan for Ulaanbaatar City targeting the year 2040.

Zuunmod City has created “The City Master Plan for the New International Airport” in 2019, but since the construction of high-rise buildings did not meet the height restriction around the airport, it is currently being revised. The local consulting company MONENERGY is also participating in the revision process.

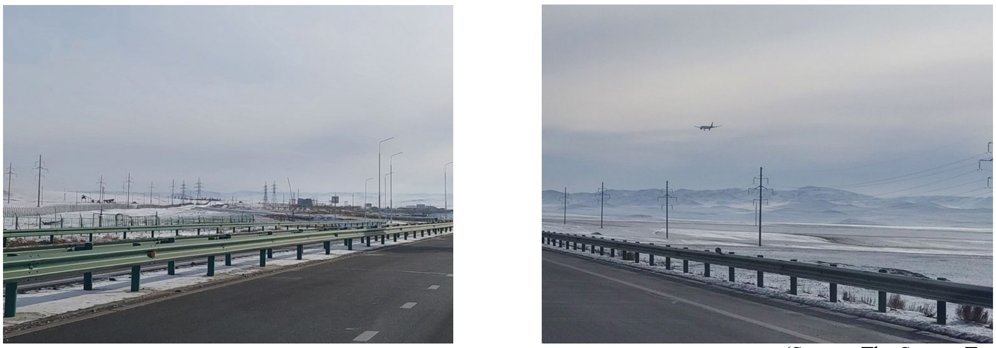
In regards to the smart city in Japan, high reliability is required for electric power, which is the basic infrastructure, but at this stage, UBEDN does not have a special participation or response policy as a distribution company, and said that the only information currently available was on electricity demand.

Although a rough supply plan is envisioned, such as a plan to supply 220 kV transmission lines to the cities around the new airport and a substation of 125 MVA is required as a supply facility, there was no further information on power according to the interview with NPTG and UBEDN.

The image of New Zuunmod City and the current status are shown below. The city is proceeding with city planning to make it a logistics base for the new airport, but at present there are only a few buildings other than airport buildings.

(Source: Narita Airport News Release)

Figure 6-1 Location and Image of New Zuunmod City



(Source: The Survey Team)

Figure 6-2 Current Status around New Zuunmod City

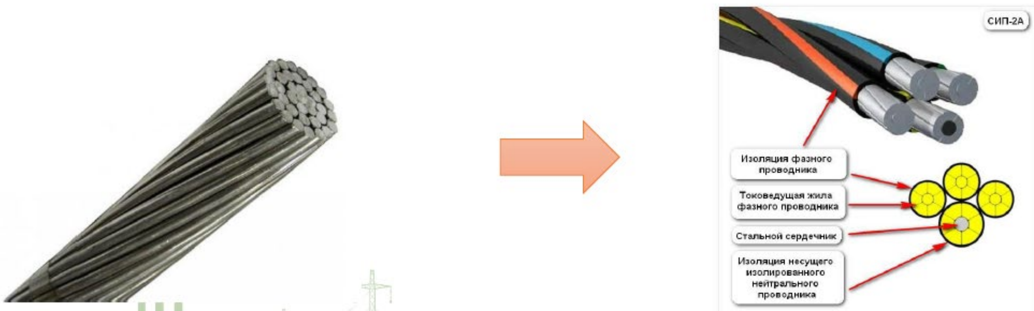
6.2 Smarter Distribution at Medium and Low Voltage

6.2.1 Loss Reduction

(1) Current Status

As mentioned previously, UBEDN's efforts to reduce power loss are gradually progressing. As a measure to reduce technical loss, a low-loss transformer such as an amorphous transformer is effective, but it has not been introduced yet. Currently, although the aged transformers have been replaced gradually, they only contribute slightly to the reduction of power loss. In addition, the Law on Energy Conservation enacted in 2015 requires distribution companies and transmission companies to report loss results once every two years, which is compared with the target. This motivates companies to conduct measures to reduce power loss. However, as mentioned above, the distribution loss rate of UBEDN still exceeds 14 % as of 2021, so it can be said that further measures need to be promoted to reduce the loss that contributes to low carbonization.

On the other hand, as an application example of UBEDN's low-loss equipment, the existing bare wire is being replaced with an insulated wire. Replacing bare wires with insulated wires reduces the number of short-circuit accidents and makes it difficult for electricity to be stolen due to insulation coating, so it is expected to have the effect of reducing non-technical losses (bare wires can be easily used by people).

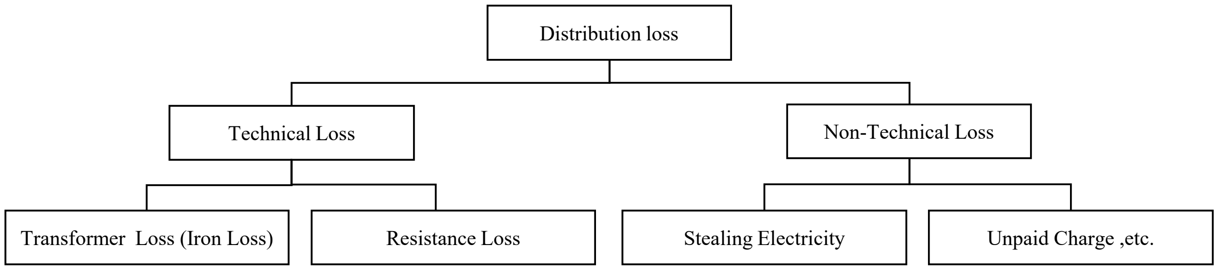


(Source: DSEDN)

Figure 6-3 Covering Bare Wires (Replacement with Insulated Wires)

(2) Improvement Measures for Low Carbonization (Such as Loss Reduction)

The types of distribution losses are classified as shown in the figure below.

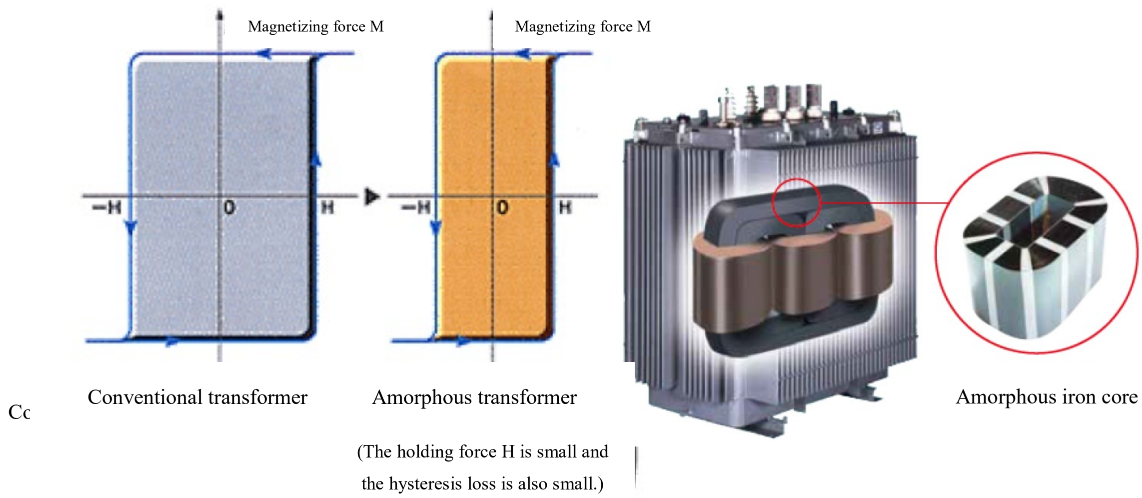


(Source: The Survey Team)

Figure 6-4 Classification of Distribution Loss

Out of the technical losses, resistance loss is the loss caused by the electrical resistance of the wire and is proportional to the square of the current. Generally, in developing countries, it is not possible to reinforce transmission and distribution lines even if power demand increases, and it is unavoidable to supply power under high operation or overload conditions, or to temporarily extend distribution lines without considering the suppression of distribution loss. It is assumed that a lot of resistance loss occurs as a result of these response procedures.

In addition, iron loss in a transformer is a loss that occurs in the iron core of the transformer, and it continues to occur for 24 hours when the transformer is charged regardless of the magnitude of the load. Compared to the previous products, the iron loss of recent silicon steel plate transformers has decreased considerably, but transformers using amorphous metal for the iron core can be expected to further reduce iron loss. Amorphous alloys have a structure with a random atomic arrangement, whereas ordinary metals have a crystal structure in which atoms are regularly arranged. When this is used for the iron core of a transformer, hysteresis loss and eddy current loss are extremely reduced, and power loss can be reduced.

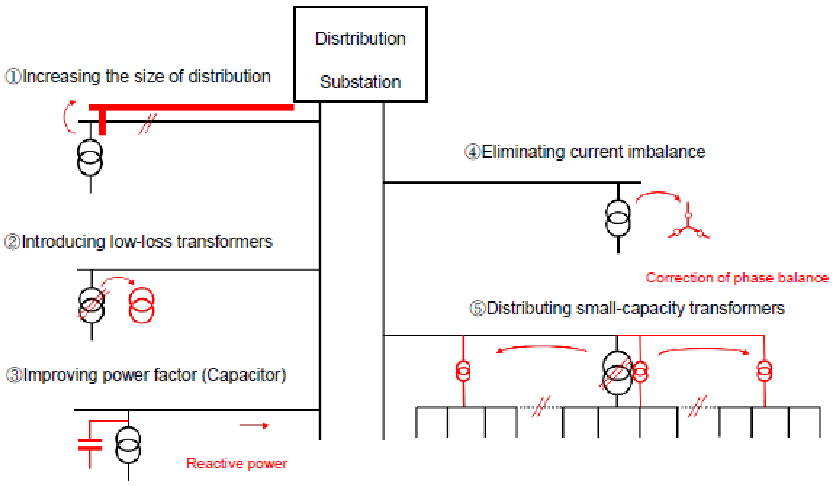


(Source: Hitachi Industrial Equipment Systems HP)

Figure 6-5 Characteristics and Appearance of Amorphous Transformer

On the other hand, non-technical loss is mainly due to electricity theft, unpaid charges, and forgiveness of charges. Electricity theft is an illegal use of electricity by a consumer without going through a meter, and does not appear in the amount of electricity sold measured by the meter. In addition, the unpaid charges include those in which the electric power company cannot collect the charges for the power used measured by the meter (unpaid charges) and those caused by erroneous measurement due to a defective meter.

If a large reduction effect is expected for technical loss among distribution losses, it is necessary to implement reduction measures such as boosting voltage in the entire area. In addition, thickening of distribution lines, introduction of low-loss transformers such as amorphous transformers, improvement of power factor by installing capacitors, elimination of current imbalance, distributed arrangement of small-capacity transformers (multi-transformer method), etc. can be considered. As of 2021, no concrete measures have been taken to improve the power factor in the UBEDN system, and customers are not required to improve the power factor.



(Source: The Survey Team)

Figure 6-6 Example of Technical Loss Reduction Measures

6.2.2 Distribution Automation System

(1) Current Status

Currently, UBEDN has DAS and recloser system in a part of the jurisdiction. Since 2020, DAS using RM6 (Ring Main Unit manufactured by Schneider) has been introduced to seven 6 kV distribution substations (distribution line has an underground loop configuration) and are being used on a trial basis.

(Source: UBEDN)

Figure 6-7 UBEDN Local Equipment for Distribution Automation (Schneider's Ring Main Unit)

Load break switches in Ring Main Unit can be operated remotely from UBEDN's office, and voltage and current can be monitored. Also, the system has the function of fully automatically isolating the accident section by a program in the event of a power outage. A modem-type mobile phone communication line system is used for communication. With the introduction of DAS, UBEDN has obtained simulation results that the average power outage recovery time up to now, 90 minutes, can be reduced to 6 minutes after the introduction of DAS, and it is planned to be expanded to 10 kV distribution systems in the future.

On the other hand, the recloser system is applied to overhead distribution lines. The accident point is automatically separated, but the return operation of the local equipment is performed manually, so to speak, it is a semi-automatic system. As of 2021, about 80 reclosers have been introduced, 60 for 10 kV, 4 for 6 kV, and 15 for 35 kV.

(Source: UBEDN)

Figure 6-8 Example of a Recloser Installed in the Overhead Distribution System of UBEDN

(2) Introduction of DAS

Since UBEDN does not use a unified system like Japanese electric power companies, there are problems such as being unable to connect newly introduced equipment to the existing distribution systems. For example, UBEDN's equipment in distribution, in general, is made in Russia, China, the United States, Germany, and so on. Therefore, it is necessary to clarify the technical policy and unify the specifications. These measures are considered to lead to the DAS with low cost and easy maintenance.

In the Survey, the Survey team found that the specific business plan for DAS was not clear. When deploying various systems such as DAS in Mongolia in the future, it is essential that differences in interfaces and introduction of too many different systems are avoided, and a common platform is created, which is low cost and easy to maintain.

In UBEDN, the large number of aged equipment is a major factor in distribution loss. Also, the inability to properly manage the load is a factor in the inability to operate distribution systems effectively. Efficiently managing loads and voltages by utilizing smart meters and DAS that are being introduced, building distribution equipment databases and working on asset management will contribute to the reduction of power loss and efficient equipment operation.

Chapter 7 Recommendation for JICA's Cooperation Programs

7.1 Mapping of Donor's Assistance

The support status of other donors is mapped in the table below. Projects that were confirmed to be under implementation or financed in donors' documents are listed.

Table 7-1 Projects Under Implementation or Planned by Donors

	ADB	WB	EBRD	Chinese Donors
Power Development	F/S on a pilot project for pumped storage (TA) *1	Master plan on power development and heat supply (TA) *6		Construction of hydropower facility in Erdeneburen (Loan)
RE	Distributed power supply for rural areas using RE (Grant & Loan) *2		Support for RE Auctions (TA) *9 Construction support for private wind power generation facilities (Loan) *10 Related transmission projects (Loan in preparation) *11	
System Operation	Support for considering the introduction of grid condition monitoring systems such as SCADA and WAMS (TA) *3			
Transmission	Connection between Altai-Uliastai and the Western System (TA) *1			
System Stabilization	Support for introducing storage battery (Grant & Loan) *4			
Distribution		Support for strengthening and repairing facilities of local distribution companies (Loan)*7		
Heat Supply	F/S on heat pump usage (TA) *1	Project for improving heat supply in Ulaanbaatar (Loan) *8	Ulaanbaatar Central Heating Supply Project (Loan) *12	
Regional Cooperation	Support for creating strategies on regional electricity and gas interchange (TA) *5			

ADB

- Supporting Renewable Energy Development (TA) *1
- Upscaling Renewable Energy Sector Project (Grant & Loan) *2
- Smart Energy System for Mongolia (TA) *3
- First Utility-Scale Energy Storage Project (Grant & Loan) *4
- Fostering Expanded Regional Electricity and Gas Interconnection and Trade under the CAREC Energy Strategy 2030 (TA, Regional) *5
-

WB

- Energy Master Plan (TA) *6
- Second Energy Sector Project (Loan) *7
- Ulaanbaatar Heating Sector Improvement Project (Loan) *8

EBRD

- Support for the Implementation of Renewable Energy Auctions in Mongolia (TA) *9
- Sainshand Wind Project (Loan, Private) *10

- Choir-Sainshand 220 kV Transmission Line and Substation Construction Project (Loan) *11
- Ulaanbaatar Central Heating Supply Project（Loan） *12

In general, ADB has been the most active in providing support, focusing on grid stabilization represented by SCADA/WAMS and storage battery. In regards to power development policies, WB has taken the initiative in implementing the master plan for power supply policy. As for power supply policy, the WB is taking the initiative in supporting the Energy Master Plan.

EBRD is supporting individual projects related to RE, and plans to provide support for related transmission line projects. In addition, to make RE projects attractive in terms of private sector participation, EBRD has supported the creation of a RE auction scheme.

7.2 Proposal of JICA Technical Cooperation Project

7.2.1 Technical Cooperation Project

(1) Expected Outputs

Table 4-1 and Table 4-3 in Chapter 4 summarize the issues in expanding the introduction of RE. The following is a summary of the expected outputs of the technical cooperation project to deal with these issues.

The issues i and ii in Table 4-1 are not included in the scope of the Technical Cooperation Project, because the possibility of these two aspects to overlap with projects supported by ADB could not be denied, within the period of the Survey.

Table 7-2 Technical Cooperation Project Proposal (Expected Outputs)

	Goal	Category	Issue Number
Output 1	To deepen the understanding on system events caused by greater integration of renewable energy	T/N	vi, viii, x, xi
Output 2	To improve skills to adjust supply and demand and refine the system operation rules to cope with the power system expansion and increased integration of renewable energy	T/N	v, xii
Output 3	To improve the ability to carry out appropriate medium- and long-term system planning with a view to expanding renewable energy installation	T/N	viii, ix, xi
Output 4	To develop the ability to make appropriate relay arrangements in response to the expansion of transmission and substation facilities	T/N	vii
Output 5	To enhance the ability to diagnose and carry out appropriate preventive maintenance for transmission and substation facilities	T/N	iii, iv
Output 6	To standardize the practical procedures for applications for renewable energy connection to the distribution network	D/N	iii, iv, v, vi
Output 7	To gain a deeper understanding for introducing appropriate smart technologies to facilitate the expansion of renewable energy connection at the distribution level	D/N	i, ii, iiv, iiiv, ix

T/N: Transmission Network
D/N: Distribution Network

(2) Proposed Contents of Cooperation

The overview of the technical cooperation project is as follows.

Counterparts: MOE, ERC, NDC, NPTG, UBEDN

Primary Targets of Assistance: NDC, NPTG, UBEDN

Period: 3 years

Implementing Area: Mainly in Mongolia, with trainings in Japan

7.2.2 Ideas for Infrastructure Projects

(1) Grant Aid

(a) Selection Criteria

Out of the projects for which needs were identified through the Survey, those that meet the following criteria are proposed.

- Project scale of approximately 1 billion yen (about 9.1 million US$)
- Project that contributes to low-carbonization and environmental improvement through the expansion of RE introduction
- Project with low revenue-generating business potential or a high demonstration component
- Project that can utilize Japanese technology
- Project that has a showcase purpose
- Project that includes digital transformation (DX)

(b) Suggestions for Project Candidates

The following projects are suggested as possible candidates. The construction of a New National Dispatching Center is highly prioritized in Mongolia, but there is a possibility that it may overlap with assistance from other donors.

Table 7-3 Candidates for Grant Aid Projects

Project Name (Temporary)	Main Components	Reason for Proposal and Expected Output	Points to Note	Priority
Semi-off-grid EMS Project	・Solar generation ・Storage battery ・Connection to distribution lines ・Energy Management System (EMS)	・Local production and local consumption of electricity from RE sources ・Reduction of coal use ・Reduction of transmission loss	・It is necessary to differentiate the objectives when installing storage batteries and EMS to avoid the overlap of support from other donors.	High
Smart Technology Demonstration Project	・Smart meter, communication facilities ・Roof-mounted solar power generation ・EV chargers and EVs that utilize RE	・Promotion of the use of smart meters and rooftop solar panels with a view to applying them to smart cities ・Promotion of the efficiency of transportation with energy sources deriving from RE ・Reduction of coal use ・Improve billing activities, and reduction of power theft ・Promote EV	・As this is a demonstration project to develop cold-weather specifications suitable for Mongolia, it is necessary to reduce the scope of responsibility of manufacturers who can provide such technologies.	High
Project for Construction of New National Dispatching Center	・EMS, SCADA, Server, etc. ・Earthquake-resistant building	・Improvement of efficiency of control for the introduction of RE by expanding the capacity of the existing dispatching center ・Stable and efficient system operation ・Expansion of RE introduction	・It is necessary to confirm whether there is no overlap with the EMS and SCADA for NDC supported by ADB.	Middle

For the semi-off-grid EMS, sites will be selected in the suburbs of cities for demonstration purposes, or in rural grids far from power plants. For the smart technology demonstration project, a site near the new airport is desirable, as it is intended to be used in a smart city. If EVs are to be introduced, it is recommended that they are used as commercial vehicles in urban areas where their range of movement can be limited for safety reasons.

(c) Contribution to Digitalization

Components of DX, which the Government of Japan is promoting, is included in the above project candidates as shown below.

Table 7-4 DX Components and Possible Value Addition

	DX Component	Possible Value Addition
Semi-off-grid EMS Project	Utilization of digital data in EMS for optimum control of solar generation and BESS	Contribution to combination of mobility and RE if EV is also included in the project
Smart Technology Demonstration Project	Utilization of smart meter for efficient billing and contribution to protection of power theft and improvement of energy saving awareness	Sharing infrastructure of smart meter to hot water supply metering and utilization of smart meter data to other business (Caring business, etc.)
Project for Construction of New National Dispatching Center	Utilization of digital data in EMS and SCADA	Contribution to strengthening information security

(2) ODA Loan

(a) Selection Criteria

Out of the projects for which needs were identified through the Survey, those that meet the following criteria are proposed.

- Project scale of more than several billion yen (several tens million US$)
- Project that makes a significant contribution to the stable supply of electricity and energy efficiency
- Project that makes a significant contribution to the expansion of RE introduction
- Project that can utilize Japanese technology

(b) Project Ideas

The following ideas are proposed as possible candidates. In order to enhance RE introduction, grid stability equipment for the nationwide transmission system, which have problems caused by long-distance transmission lines, are recommended from the middle and long term viewpoints. BESS is also one of the top priorities in the short term, to absorb the fluctuation of RE. Since they are both supported by other donors, the details of these projects should be reviewed for their validity as part of the training on system planning in the next JICA Technical Cooperation Project.

A large scale BESS and adjustable speed pumped storage hydropower are expected to be installed in CES which many RE projects are assumed to be developed. However, it should be noted that a reservoir site for a pumped storage hydropower requires a location which is closed to a river.

Table 7-5 Ideas for ODA Loan Projects

Project Name (Temporary)	Main Components	Reason for Proposal and Expected Output	Points to Note	Priority
Project for the Stabilization of the Nationwide Power Transmission Grid System	・Voltage regulation equipment such as STATCOM, SVC, and Synchronous Condensers ・Augmentation of transmission lines ・Replacement by increased-capacity conductors	・Avoidance of voltage instability due to RE expansion ・Avoidance of the lack of transmission capacity due to RE expansion ・Mitigation of voltage fluctuation ・Security of transmission capacity	・It is necessary to confirm whether there is no overlap with the EMS and SCADA for NDC supported by ADB.	High
Large-scale BESS	・Long-term BESS ・AC/DC converter	・Avoidance of reverse power flow to Russia, which is a major factor in RE output control ・Consideration of a firm capacity for RE's unstable capacity ・Expansion of RE introduction ・Reduction of output curtailment ・Adjustment of power output for a moment	・It is necessary to clarify how to recover the cost of BESS. ・It is necessary to avoid overlapping with other donors.	High
Adjustable Speed Pumped Storage Hydropower	・Dams and reservoirs ・Adjustable speed Generator ・Relating substation and transmission line	・Adjustable functions in both generation and pumping ・Consideration of a firm capacity for RE's unstable capacity ・Expansion of RE introduction ・Reduction of output curtailment	・It is necessary to avoid overlapping with other donors.	Middle

(3) Possibility for Private Sector Partnership Projects

Out of the proposed ideas in Grant Aid and ODA Loan Projects, projects which may collaborate between the private sector and the public sector are picked up as follows. Those projects require support schemes to realize a business.

Table 7-6 Private Sector Partnership Projects (Example)

Project Name (Temporary)	Private Sector Part	Public Sector Part	Necessary Scheme
Large-scale BESS through Private Investment	・Installation and operation of BESS	・Provision of land and transmission lines	・Establishment of a pricing system in order to create a storage battery business
EV Using RE	・Utilization of EV	・Provision of infrastructure for chargers	・Introduction of incentive scheme such as subsidiary for high EV costs
Big Data Utilization Using Smart Meter	・Energy saving business by visualization of electricity use ・Business utilization of smart meter big data	・Data sharing of smart meters	・Establishment of rules for security and privacy protection