Case Studies based on
GGGI's Activities

GGGI

Development of Green Energy Systems and Energy Efficiency in Mongolia

May 2020

Global Green Growth Ins tute
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ACKNOWLEDGEMENTS

This case study is intended to serve as an example of policies and practices relevant to pursuing a green growth model of development. It describes activities and programs made possible with the support of the Government of Mongolia and the Energy Regulatory Commission and the Municipality of Ulaanbaatar city.

GGGI would like to express very special thanks to Dr. A.Tleikhan, L.Jambaa, Ts. Atarjargal and P.Khiimorisain of the Energy Regulatory Commission and Mr. O. Bavuudorj of the Ministry of Energy for sharing their time generously to provide continuous support and feedback.

Continuous support from the Ministry of Environment and Tourism has played an important and specific role for GGGI to build track record in Mongolia. The country team would like to acknowledge immense support and genuine advices and directions received from T.Bulgan and Ts.Uranchimeg and their team members. It has been always great to work closely with the Ministry of Environment and Tourism.

The authors also would like to acknowledge GGGI Mongolia team who has contributed to the solid pathways to green growth impact. This gratitude also goes to Ch.Bolormaa, Ts.Bulganmurun, Jon Lyons, A.Oyunchimeg, Romain Brillie and U.Unurtsetseg for their excellent services delivered as Mongolia team. Special thanks to Bulganmurun who initiated the idea of producing this business case and contributing largely to the context.

Assistance on design and layout was provided by Ms. Bayarmaa and Ms. Sujeung Hong.

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Acronyms

ADB	Asian Development Bank
BAU	Business As Usual
CES	Central Energy System
CHP	Combined Heat and Power
CNIS	Chinese National Institute of Standardization
CSO	Civil Society Organizations
DE	Designated Entities
DFI	Development Finance Institution
EMCA	Energy Management Companies Association of China
ERC	Energy Regulatory Commission
FiT	Feed-in Tariff
Gcal	Giga calories
GDP	Gross Domestic Product
GGGI	Global Green Growth Insitute
GHG	Greenhouse Gas
GoM	Government of Mongolia
GTC-K	Green Technology Centre of Korea
GWh	Gigawatt Hours
HOB	Heat only boilers
ICLEI	ICLEI- Local Governments for Sustainability
LEAP	Long-range Energy Alternative Planning System
MCUD	Ministry of Construction and Urban Development
MET	Ministry of Environment and Tourism
MOE	Ministry of Energy
MRIA	Mongolian Renewables Industries Association
NAMA	Nationally Appropriate Mitigation Actions
NECC	National Energy Conservation Centre of China
NDC	Nationally Determined Contribution
PM	Particulate Matter
PPA	Power Purchase Agreement
SEI	Stockholm Environment Institute
SMEs	Small and Medium-sized Enterprises
SDG	Sustainable Development Goal
UNDP	United Nations Development Programme
WHO	World Health Organization

Executive Summary

Mongolia has been perceived to the outside world as a land of horse riders and of pristine nature. Its vast landscape and nomadic lifestyle practiced by herder people throughout centuries is a common image to picture Mongolia. However, the impact of globalization, urbanization and climate change is changing Mongolia's environment and socio-economic life significantly. There has been a dramatic increase in rural migration to the cities mainly due to socio-economic reasons. Many herders lost their animals during natural disasters and cannot find alternative income sources in rural areas. Traditional livestock-based economy has been gradually overtaken by the mining industry given the country's rich mineral resources.

Mongolia has sufficient reserves of coal, 40 percent of which is exported as raw. The energy system in Mongolia is mainly based on coal. The country's heating and power infrastructure was constructed over 60 years ago, and there is huge room for efficiency improvement. Growing heating demand in residential and commercial areas are met with energy generated at the Central Heating Plants (CHPs), Heat only boilers (HOBs) and raw coal burning in sub-urban areas. As of 2018, the heating demand of central Ulaanbaatar city was 3540.3 GCal, with 2020.4 GCal (57%) supplied from CHPs and Amgalan thermal power plant. In addition to that, over 210 thousand households in off-grid areas rely on refined coal briquets for space heating. This contributes to heavy air pollution in urban centers, especially in Ulaanbaatar, where PM levels exceed 7-35 times of the WHO level[1].

Due to a growing population and mining-centered economic growth, total installed capacity of Mongolia's energy system has more than doubled from 538MW in 2001 to 1239.8MW in 2018. Over the past 10 years, energy consumption has increased on average 5 percent per year. Currently, Mongolia imports 20 percent of its energy and requires further need in investment and development of new renewable energy resources and improved energy efficiency.

Heat and power supply over the long and cold winter period is essential for every Mongolian and their socio-economic prosperity. The average annual temperature is 0.2°C and average winter temperature ranges between -10°C and -30°C. The country uses more than 90 percent of generated energy for heating purposes only, and approximately 57 percent of the total heat generated is used for space heating and water heating in residential buildings only.

Government of Mongolia (GoM) has made a strong political commitment towards green development and adoption of renewable energy. In 2012, GoM announced green development as the new economic development strategy and adopted the National Green Development Policy (NGDP) and Sustainable Development Vision-2030 in the following years. Mongolia has ambitious targets of increasing installed capacity of renewable electricity generation from current 18.1 percent to 20 percent by 2023 and to 30 percent by 2030 in its National Determined Contribution (NDC). GoM plans to utilize its abundant resources of renewable energy sources in hydropower, solar and wind.

Since 2013, Global Green Growth Institute (GGGI) has been actively supporting Mongolia's energy sector, particularly in energy efficiency, technical analysis, and development of alternative energy resources, including supporting the adoption of the NGDP, its Action Plan and 38 Mongolian Green Growth Outcome Indicators in 2015-2017. These economic, social, and environmental indicators include specific measurements on energy intensity, share of renewable energy in installed capacity and reduction of building heat loss. To increase absorption of renewable energy, GGGI has also supported the GOM in improving power purchase agreements for battery storage systems.

GGGI collaborated with the GoM and the Stockholm Environment Institute (SEI)-US in formulation of the Strategies for Development of Green Systems in Mongolia, which forecasted and analyzed four different scenarios on Mongolia's energy supply and demand within the industry, transport, buildings, and agriculture sectors. These scenarios helped in developing policy and planning targets in energy and other sectors for the NGDP and its Action Plan.

[1] *Pollution levels in the central Ulaanbaatar and sub-urban districts greatly differ. World Bank study on effects on air pollution on human health indicated PM levels in Ulaanbaatar city centers are 7-15 times greater than the WHO standards, whereas in sub-urban district the PM levels are 17-35 times higher than the WHO standards. National Energy Efficiency Action Programme (2018-2022) Mongolia: Renewable Energy Readiness Assessment, IRENA, March 2016*

GGGI's work in Mongolia also focuses on sustainable heat supply and reducing heat loss to reduce dependency on coal and improve air quality. The heating energy assessment was conducted to i) support implementation of the long-term strategy of Mongolia for greener energy sources with a focus on comprehensive heat planning alternatives; ii) data collection to measure NGDP targets on green energy and energy efficient buildings; and iii) build institutional capacity for effective energy management and planning and assessing the environmental, social and economic impacts of heating systems.

In 2016, GGGI with the Ministry of Environment and Tourism (MET) and the Ministry of Energy (MoE), analyzed the heating systems in Arkhangai, Bulgan and Khovd aimag centers to identify long-term solutions for transforming heating systems and reducing air and environmental pollution in rural settlements. The assessment results were integrated in the Green Development Plans of Arkhangai, Bulgan and Khovd aimags, in which necessary political and financial commitments were undertaken. In addition to supporting GoM's immediate agenda to reduce urban air pollution from raw coal combustion for heating purposes, GGGI developed a business case study to identify Low-Carbon Small Scale Heating solutions for off-grid buildings in peri-urban areas.

Energy Efficiency is another important pathway to the development of low carbon heating systems. GGGI assisted GoM and Energy Regulatory Commission (ERC) in the design and implementation of the National Energy Efficiency Action Programme (NEEAP) 2018-2022, with objectives to improve energy efficiency coordination and management, introduce innovations in energy efficient technologies, and support energy auditing mechanisms.

Moreover, GGGI, with the partnership of GoM and the Mongolian Sustainable Finance Association pioneered the establishment of Mongolia Green Finance Corporation (MGFC) as a National Green Financing Vehicle in September 2017. The MGFC aims to encourage local green financing, build institutional capacity and mobilize private sector investments.

Sectors in Focus	Green Growth, Sustainable Energy
Key Challenges	High-energy intensity, outdated technology, low efficiency in energy produc on and transi on, high-energy loss in buildings, limited knowledge and capacity in energy efficient policy and technology, limited financial resources for green infrastructure development
Impacts	Environmental: 717,347 tCO_2eq reduc on from energy audits conducted at 15 Designated En es, energy savings in mul -family residen al buildings, low carbon space hea ng of public school, and the green kindergarten Social: Improved air quality and health benefits to over 2500 kindergarten and school children in Songinorkhairkhan district of Ulaanbaatar city; improved air quality in Tsetserleg, Khovd and Bulgan ci es, increased thermal comfort in 375 pre-cast residen al building blocks in Ulaanbaatar city Economic: By 2023, reduc on of fuel use per electricity produc on from 312.5g/kWh to 305.5g/kWh, reduc on of fuel use per heat produc on from 175.9kg/Gcal to 170kg/Gcal (NEEAP), reduced housing heat loss by 40 percent
Keywords	sustainable energy, energy efficiency, minimum energy performance standard, green financing
Geographic Coverage	Mongolia 

Country context

In Mongolia, heat and power are generated from coal-fired CHPs that were built over 60 years ago. The energy sector has numerous challenges to meet its continuously growing energy demand and to increase efficiency on both demand and supply side, including high energy losses in the transmission and distribution network and industrial and building sectors. Over the past 10 years, energy demand in the country increased twofold with about an average of 5 percent per year.

The Mongolia energy system is divided into 4 systems that are not interconnected. It includes Central, Eastern, Western and Altai-Uliastai Integrated Systems. Total installed capacity of Mongolian power energy sector is 1,130 MW. Power is supplied from the energy systems through a 41,726 km long power transmission network. There 330 soums in Mongolia and 319 out of these soums are connected to the power supply. One soum has access to renewable energy and another 10 soums are connected to power systems in Russa and China.

Approximately 77 percent of total consumed power energy is generated at the CHPs, and less than 1 percent is generated from diesel-fueled stations and hydro power plants. Approximately, 2 percent is generated from wind parks. The share of energy generation from solar power plants is less than 0.1 percent of total energy generation. In order to meet growing demand and manage peak load in the power sector, the country imports over 20 percent of its total energy needs from two neighboring countries:China and Russia. Power imported from China is mainly used for mining operations.

In cold weather with an annual average temperature of 0.2^{o}C, being warm is essential for Mongolians to survive winter and maintain socio-economical life. There is a local saying that equals warmth to 1,000 gold bars. Majority of urban commercial and residential buildings are heated from district heating system that are connected to the CHPs. Still, some rural and peri-urban areas of larger cities rely on coal-fired HOBs for space heating and hot water. Yet, very few villages have diesel-fueled power. This results in poor air and environment pollution.

Solar and wind resources are widely available across the country, and Mongolia enjoys more than 250 days of sunshine. The country has significant potential for development of different types of renewable energy, including solar, wind, and some hydroelectric resources. In 2013, the first utility-scale Salkhit Wind Park of 50 MW was operationalized.

Rapid growth in the renewable energy sector was triggered by the feed-in tariff of the Renewable Energy Law that was approved in 2007. The Law applied a feed-in-tariff for on-grid solar of *$0.15/kWh-$0.18/kWh* and wind of *$0.08/kWh-$0.095/kWh*. Within a short period of 6 years from 2013 to 2019, 7 individual power producers were connected to the Central Energy system (CES): 3 wind farms of 152MW capacity *and* 4 Solar power plants with 45MW capacity. Total installed capacity of renewable energy reached 18.1 percent. This puts Mongolia on track to reach its intended target of NGDP of 20 percent by 2020, and 30 percent by 2030.

Recent Amendment to the Renewable Energy Law[2] (2019) introduced a competitive procurement mechanism with upper tariff limit for wind and solar resources. According to the Amendment, the tariff for renewable energy plants that will be connected to the CES has been changed to *up to $0.085/kWh* for wind and *$0.12/kWh* for solar energy. It is still considerably high compared to the average production cost of coal-fired power plants, which aresubsidized.

Despite the recent increase in clean energy installed capacity, coal-fired power plants will still be dominant in Mongolia. The country's abundance in raw coal and existing energy co-generation facilities and subsidized energy tariff maintain energy production costs at a lower level than the actual market costs.

[2] *Renewable Energy Law of Mongolia, 2007 (amended in 2015): https://www.legalinfo.mn/law/details/465*

GGGI in Mongolia

Sustainable energy development has been one of the key priorities in GGGI's work based on the belief that energy powers economic growth and social development. GGGI's activities focus on energy transition, energy system planning, and scaling-up investment in clean and energy efficient infrastructure in its member countries. GGGI acknowledges multi-benefits of energy efficiency that has significant impact in reducing GHG emissions and improving air quality, health and well-being of the communities.

In Mongolia, GGGI delivers policy advisory and technical assistance in supporting Mongolia's transition from brown to green and sustainable energy and improving energy efficiency. Within this framework, GGGI pursued a series of approaches: i) policy and planning support to Mongolia's transition to green energy systems (including green financing mechanisms such as PPP and MGFC); ii) technical analysis on alternative energy systems for peri-urban areas of Ulaanbaatar and aimag centers with focus on energy demand side; iii) design and development of energy efficient projects for public education buildings; and iv) development guidelines, methodologies and pipeline projects for planning and designing energy efficiency measures.

Defining Long-term Strategies for Transition to Green Energy Systems

GGGI partnered with GoM and the SEI-US to formulate "*The Strategies for Development of Green Energy Systems in Mongolia*" in 2014. It involved exploring Mongolia's energy potential and reducing GHG emissions through 2035 by employing a bottom-up techno-economic analysis of energy and GHG-reduction scenarios. The study used The Long-range Energy Alternatives Planning system (LEAP), a software tool developed by SEI for energy policy analysis and climate change mitigation assessment. The study presented four broad scenarios of how energy supply and demand could evolve in Mongolia through 2035 by using the same economic and demographic growth forecasts to determine the needs for energy services. particularly steady growth of Mongolia's economy in mining and industrial sectors and related effects like increasing demand for freight and personal transportation.

The Strategies for Development of Green Energy Systems in Mongolia for the period 2016-2035 analyzed four different scenarios on Mongolia's energy supply and demand within the industrial, transport, buildings, and agriculture sectors, and forecasted projections to assist the country in long-term planning and policy development for energy and other sectors.

(1) The reference scenario forecasts a Mongolia that continues to rely on mineral extraction for its primary source of energy, both for export and domestic consumption. This scenario sees total energy demand more than doubling in Mongolia between 2010 and 2035, with demand for electricity and petroleum products growing especially fast. Coal-fired plants continue to be the primary source of energy to meet this demand, with renewable energy contributing less than 5 percent to the production of electricity. In the reference scenario, overall GHG emissions rise to approximately 56 million tons of CO_2 by 2035 from a benchmark of just over 15 million tons in 2010.

(2) The recent plans scenario describes the potential impact to energy supply and demand in Mongolia as a result of the successful implementation of renewable energy and increased energy efficiency plans, such as the retrofitting of residential buildings to reduce energy demand by 6 percent, and the expansion of hydroelectricity and wind power to increase the contribution of renewable energy to total electricity production by 15 percent. The recent plans scenario would see total GHG emissions rise to about 46 million tons of CO_2 by 2035.

(3) In the expanded green energy scenario, Mongolia makes a stronger transition to renewable energy and implements extensive energy efficiency measures across its economy. These initiatives help reduce energy demand by 32 percent when compared to the reference scenario, while the realization of multiple hydro, solar PV and wind power projects increase the contribution of renewable energy to electricity production to more than 40 percent. Reductions in energy demand coupled with increases in renewable energy production provides Mongolia with the option to phase out aging coal-fired power plants and possibly avoid new plants altogether. As a result, GHG emissions would be half, or 28 million tons, of those forecast in the reference scenario.

(4) The shifts in energy export scenario realizes the same reduction in energy demand as the expanded green energy scenario and differs only in that Mongolia has divested itself from mineral-based energy exports in favor of renewable energy exports. Rapidly investing in and developing its solar PV and wind resources would allow Mongolia to install almost 12 GW of renewables by 2031, which could displace a large fraction – perhaps even all – of the value of expected coal exports noted in the reference scenario. The shift scenario would increase Mongolia's "low-carbon competitiveness" within a global market where demand for fossil fuels has declined due to increasing concerns over climate change.

Supporting Energy Efficiency Policy Framework

Mongolia identified Energy Efficiency as one of key measures to achieve sustainable development. Key policy documents, such as NDC, NGDP, State Policy on Energy (2015), and Mid-Term Energy Strategy (2019) has specific outcome indicators to improve energy efficiency by 2030. This includes:

- Reduction of building heat loss by 20 percent by 2020 and by 40 percent by 2030 compared to 2014 levels;
- Increasing renewable electricity capacity from 7.63 percent in 2014 to 20 percent by 2020 and 30 percent by 2030 as a share of total electricity generation capacity;
- Reductin electricity transmission losses from 13.7 percent in 2014 to 10.8 percent by 2020 and 7.8 percent by 2030;
- Reduce own-use energy of Combined Heat and Power Plants from 14.4 percent in 2014 to 11.2 percent by 2020.

The Energy Regulatory Commission (ERC) is the governmental regulatory agency with a mandate to implement the Energy Conservation Law at the national level. In March 2016, the Energy Efficiency and Conservation Division (EECD) was established to enable the energy efficiency regulatory framework related to the implementation of the Energy Conservation Law. In addition to the energy efficiency responsibility, the ERC is responsible for the licensing of enterprises in electricity and district heating markets, setting and supervising the tariffs for electricity and heat, and for formulating the coal pricing methodology and developing a tariff price index.

ERC and GGGI signed Memorandum of Understanding (MoU) of Collaboration in March 2017. As part of the support, GGGI is providing policy advisory and technical assistance on implementation of the Energy Conservation Law and the country's first National Energy Efficiency Action Programme (NEEAP).

The NEEAP for the period of 2018-2023 was adopted in September 2017 with support of GGGI. Objectives of NEEAP are to reduce GHG emissions, mitigate climate change through integrated management of conservation and efficient use of the energy resources, and to introduce and promote use of advanced energy efficient technique and technologies. NEEAP sets out specific measures to carry out at the national and sectoral level, mainly for industrial, transport, public, construction and energy sectors. NEEAP promotes development of energy efficiency standards and norms, classification, monitoring, labeling, construction of energy efficient houses, creation of incentive mechanisms for energy saving users, facilitation for energy efficiency public procurement, establishment of energy efficiency online database, capacity building of energy efficiency auditors, planners, managers and technicians, creation of tax and customs tariff incentives, facilitation of loan mechanisms and support for energy efficient technology uses, approval of the National Energy Balance Accounting methodology, national mechanism of GHG emission monitoring, reporting and verification (MRV), advocacy and dissemination of benefits of energy savings and introduction of educational programs in the school curriculum.

In terms of introducing energy efficiency in public infrastructures, NEEAP mandates the assessment of costs and benefits in public procurement replacement of energy efficient lights on street lighting, promotion of innovation and new technologies in reducing heat and water consumption in energy production facilities, introduction of thermostats and heat regulators in apartment units in major cities, change of users' behavior through energy tariff measures, development of energy calculation and use methodologies for different type of buildings, introduction of green mortgage mechanism and naturalization of MNS ISO 50001:2014 energy management standard.

Achievement on the policy targets and commitment to mitigate GHG emissions related to the energy efficiency largely depends on how existing challenges of the country are addressed, such as lack of financial resources, subsidized heat and power tariff, limited capacity and awareness of stakeholders, including consumers and uncertainty risks in investing energy efficiency projects.

Effective Standards and Labeling (S&L) regulation and enforcement through the Energy Efficiency Incentive Mechanism will offer multiple benefits for Mongolian citizens and for the environment. Restricting the most energy inefficient and polluting appliances from entering the market saves energy, reduces GHG emissions and local pollutants, saves consumers money, and reduces the need to invest in additional energy generation assets.

In support to the implementation of the NEEAP, GGGI carried out technical assessment in 2018. The study revealed that with introduction of Minimum Energy Performance Standards (MEPS) and mandatory energy labelling can save over 1,000 GWh of electricity annually by 2040 and reduce 1,3 million tCO_2 of GHG emissions. The MEPS also activates demand for efficient products and creates a framework to structure eligibility for green financing. Pursuant to the Law on Energy Conservation (Article 12.1) and the NEEAP(Article 4.1) , the country is in process of development of the Energy Efficiency Incentive Mechanism to promote energy conservation practices.

Examining Alternative Heating Systems in Ulaanbaatar and Secondary Cities (Provincial Centers)

Green energy situational analysis in selected aimags

Sustainable solutions for low-carbon heating systems in provincial centers is critical for the country's socio-economic growth. GGGI supported the GOM in undertaking a situation analysis of heating systems in Arkhangai, Bulgan and Khovd aimag centers in 2016. The study identified and prioritized the interventions required for improvement of the heating systems to reduce air pollution.

The situational analysis examined planning and development for alternative heating systems through i) desktop review of heating systems and methodology for measuring policy targets; ii) situation analysis and capacity assessment of heating systems for selected three aimag centers; iii) guidebook development on heating systems planning tools; iv) capacity building on heating systems planning; v) investment analysis and prioritization for heating systems; and iv) multi-stakeholder communications and outreach.

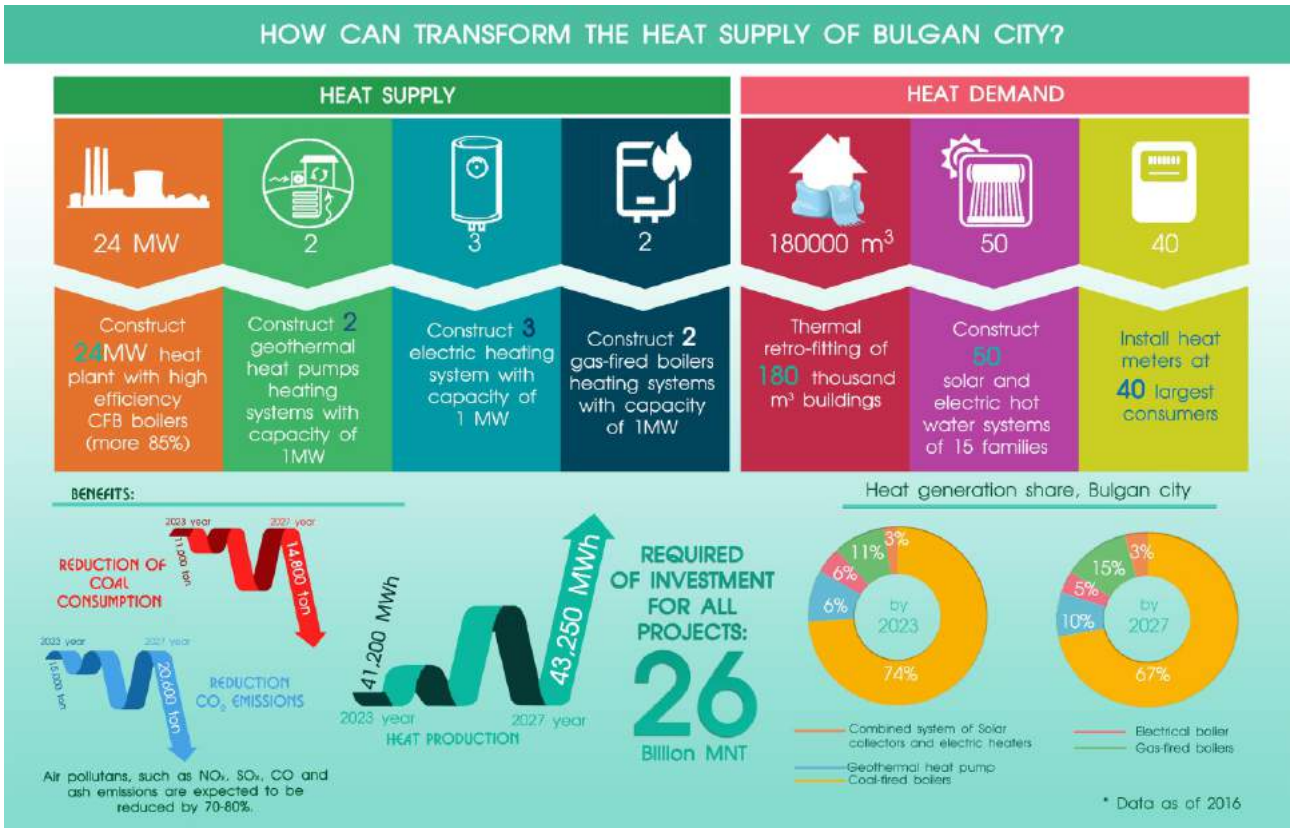
The study investigated baseline performance and main technical aspects of the local context, including climate conditions and socio-economic characteristics[3]. Alternatives recommended to transform current heating systems in three (3) cities is expected to reduce GHG emissions by 49.9tCO_2eq by 2023 and 67.1tCO_2eq by 2027 with total investment of US$45.5mln

Administrative Map of Mongolia

[3] *Market Scoping, Program Design, and Impact Assessment for a Mongolian Standards & Labeling (S&L) Program, IIEC, 2017*

Bulgan city in Bulgan aimag is located in 330 km from Ulaanbaatar city. The city is home for 12,400 people. Annual consumption of coal for district heating system is 10,200 tons, with GHG emission of 14,500 CO_2. Current heating system includes 6 medium-sized HOBs and 130 low-pressure HOBs and privately-owned heating network system. Total existing heat load of Bulgan city was 13.6 MW in 2015. A district heating power plant of 28MW, constructed in 2014, has not been commissioned yet due to absence of thermal substation, and water circuit, in addition to uncertainties around the ownership and management.

Recommended low-carbon heating system for Bulgan city is 24MW heat plant and highly efficient (85 percent) CFB boilers, 2 geothermal heat pumps, 3 electric heating system, 2 gas-fired boilers heating system with capacity of 1MW each. It requires thermal retrofitting of 180 thousand cubic meter buildings, and installing 50 solar and water heating systems and 40 heat meters for largest energy consumers.



These measures will achieve GHG reductions of 15,000 CO2eq by 2023 and 20,600 CO2eq by 2027. Total estimated investment for transformation of the heating system in Bulgan city is MNT26 billion (US$ 13.1mln).

Figure 1: View of Bulgan city

Figure 2: View of Bulgan city

Photos taken by GGGI consultants (2016)

Tsetserleg city in Arkhangai aimag is home for 21,000 people. The heating system is consisted of coal-fired 10 boilers, with very low efficiency of 55-60 percent, 40 low pressure HOBs, and privately owned heating network that provide space heating only. Hot water is supplied from household electric water boilers mainly. Total existing heat load of Tsetserleg city was 10.34 MW in 2015. Its annual coal consumption of the district heating system is 11,500 tons that emits GHG emissions of 16,000 CO_2 eq.

Recommended low-carbon heating system for Tsetserleg city is 25MW heat plant and highly efficient (85 percent) CFB boilers, 3 geothermal heat pumps, 2 electric heating system, 5 gas-fired boilers heating system with capacity of 1MW each. In addition, it requires thermal retrofitting of 203 thousand cubic meter buildings, and installing 50 solar and water heating systems and 40 heat meters for largest energy consumers. These measures will result in reduction of GHG emissions of 16,900 CO_2eq by 2023 and 26,500 CO_2eq by 2027. Total estimated investment for transformation of heating system in Tsetserleg city is MNT 34 billion (US$ 17.2mln).

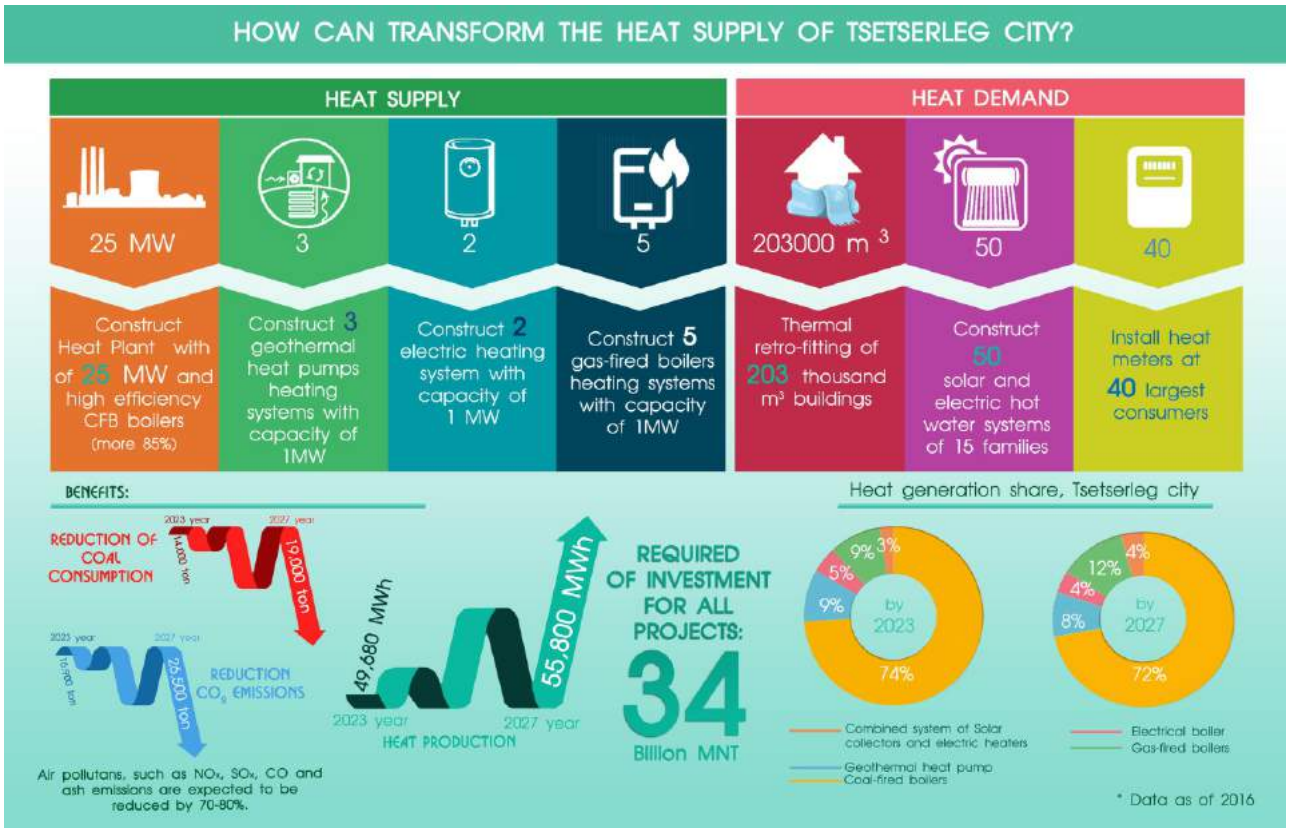


Figure 3: View of Tsetserleg city

Figure 4: View of Tsetserleg city

Photos taken by GGGI consultants (2016)

Khovd city in Khovd aimag is center of the western region in Mongolia, with population of 27,500 people. Two medium capacity power stations generate energy for space heating and hot water the city residents, with interruptions from May to September. Total existing heat load of Khovd city was 24.3 MW in 2016. Its annual coal consumption heating system is 13,680 tons, and for sub-urban residential district is 29,000 tons, with total GHG emission of 59,470 CO_2eq.

The Situational Analysis recommends to replace current coal-fired HOBs with highly efficient (85 percent) CFB boilers, and installation of 5 geothermal heat pumps, 2 electric heating system, 5 gas-fired boilers heating system with capacity of 1MW each. In addition, it requires thermal retrofitting of 270 thousand cubic meter buildings, and installing 50 solar and water heating systems and 50 heat meters for largest energy consumers. These measures will result in reduction of GHG emissions by 18,000 CO_2eq by 2023 and 20,000 CO_2eq by 2027. Total estimated investment for heating system transformation in Khovd city is MNT 30 billion (US$ 15.2mln).

Green Energy Plans were integrated into the Green Development Strategies of the respective Provinces respectfully in 2016. Based on the analysis of potential green heating technologies, the local Governments analyzed the investment costs and prioritized spending on heating systems of their city.

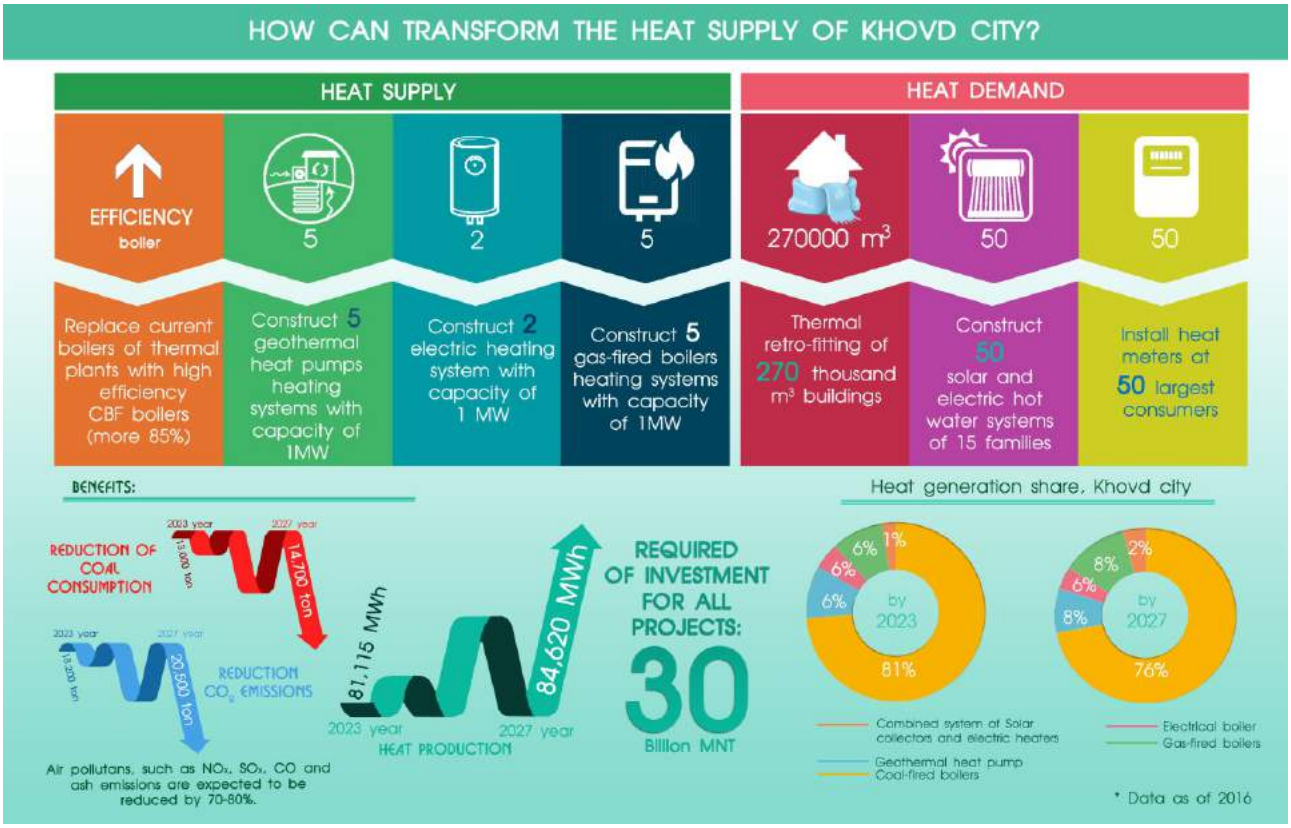


Figure 5: View of Khovd city

Figure 6: View of Khovd city

Photos taken by GGGI consultants (2016)

Low carbon heating solution for Public School in peri-urban area of Ulaanbaatar city

The Action Plan of GoM for 2016-2020 has set solid commitments on comprehensive measures to reduce air pollution with objective "*to reduce air, water and soil pollution and implement appropriate waste management in cities and other urban areas*". According to the National Action Program for Reducing Air and Environmental Pollution (NAPRAEP), household coal stoves (210 thousand) and 3,200 HOBs in ger districts of Ulaanbaatar city account for 80 percent of the urban air pollution. Approximately 400,000 vehicles emit about 10 percent of the urban air pollution and power plants are responsible for other 6 percent. About 4 percent of the urban pollution comes from dust, waste, soild and other sources.

Total coal consumption used for cooking and heating purposes of the country is approximately 2.84 million tons. To mitigate urban air pollution in the immediate future, the NAPRAEP sets out number of specific actions, including demolishing certain number of HOBs through shifting users to centralized heating systems and promoting electric and other alternative space heating at household levels. However, due to weak economic incentives and lack of strong technical knowledge, use of renewable energy in the heating sector is underdeveloped in the country. Continental cold climate of the country is another contributing factor to limited use of renewables in larger scale.

Figure 7: Air pollution in Ulaanbaatar

Figure 8: Air pollution in Ulaanbaatar

There are 65 public kindergartens and schools in Ulaanbaatar city that are not connected to the district heating systems due to the remoteness. For space heating purposes, off-grid public schools and kindergartens have HOBs that are fueled with raw coal. At average, annual heating costs per school range between MNT 55 to 65 million (US$23,300) depending on size of the school and terms and agreements signed with heat supplier.

In 2018, GGGI developed a business case study on low-carbon space heating for public schools with intention to pilot and scale up to other regions. The Mongolian University of Science and Technology (MUST) was selected and carried out the business case study for the 122nd Public School in Takhiltiin am, 22nd khoroo, Songinokhairkhan district of Ulaanbaatar city.

The school was selected with following criteria:

- It has off-grid heating system and there is no plan to connect the school to the district heating system. The building is not connected to the district heating system because of its remote location from the city center. No future plans to do so as well.
- The school building has better thermal performance than other schools in peri-urban areas. It was constructed with the Japan International Cooperation Agency (JICA), Japanese Grant Aid Project "The Project for Improvement of Primary Education Facilities (Phase IV)" in 2013. It is one of five schools (118, 120, 121, 122 and 123) that were constructed with same building design[4].
- Songinokhairkhan district is has the highest number of pro-poor communities in Ulaanbaatar city. Songinokharikhan district is known for heavy air pollution and dense population, mostly migrants from rural areas.

- It has off-grid heating system and there is no plan to connect the school to the district heating system. The building is not connected to the district heating system because of its remote location from the city center. No future plans to do so as well.

Technological assessment recommended a ground source heat pump (GSHP) system as an optimum alternative taking into account its baseline performance, heat generation capacity and simple and reliable operation. Increased thermal comfort and avoidance of handling raw coal and ash emission will be also achieved.

As a result of regular consultation and engagement with the Ministry of Environment and Tourism (MET), the business case study was piloted and commissioned in 2019. Under the framework of NAPRAEP, total allocated state budget for the pilot project was MNT 720 million (US$250 thousand).

Figure 9 and Figure 10 : Installation of Ground Source Heat Pump of 122nd Public School of Ulaanbaatar city, October 5, 2019. Photo credit to Green Solar Energy LLC

Application of GSHP for space heating resulted in reducing GHG emissions by 133 tons CO_2eq and 42 tons of air pollutants. Heating costs of the school was reduced from MNT 65million to MNT 7million after installing the GSHP. The school does not have to buy and combust raw coal anymore. Instead, the school has to pay only for power they use to operate the GSHP and personnel who operate and maintain the new heating system.

[4] *At the request of the GOM, the UN-PAGE program developed a green building design for its extension building and in 2017. The extension building will be constructed with the ADB funding in 2020.*

Accelerating Energy Efficiency in Green Public Infrastructure

Energy Efficiency in precast multi-family residential buildings

This activity has been carried out in support of the 2016-2020 Action Programme, GoM aims to improve energy efficiency and reduce building heat loss by 20 percent by 2020 and 30 percent by 2030. More than 90 percent of heat and power energy co-generated at the CHPs is used for space heating of multi-family residential and office buildings.

The capital city has the largest building stock in the country. There are 1,077 precast residential building blocks in Ulaanbaatar city that were constructed during 1965-2000. In order to reduce GHG emissions from energy consumed in residential buildings, the mayor's office has designed and implemented a number of preparatory sub-programs and projects. These include development of TTR blueprints with the Construction Development Center, pilot investment-grade energy audits to selected 3 pre-cast residential buildings with GGGI and carrying out city-wide earthquake resilience tests.

One of GGGI's work on sustainable energy in Mongolia focuses on reducing heat loss of the building sector. In 2017, GGGI carried out investment -grade energy audits to 3 selected precast residential buildings that demonstrated great potential for monetized energy savings and GHG emissions reductions. In addition to the audits, GGGI installed all three buildings with heat meters. Building up on this work, GGGI has, in partnership of the Ulaanbaatar Municipality Office, and ICLEI East Asia., developed a business model with a Standard Offer Approach to initiate green innovative financing mechanisms for thermal retrofitting of multi-family residential buildings.

GGGI is currently seeking to attract financing for the implementation of Thermo-Technical Retrofitting (TTR) of residential buildings in UB city from Nationally Adapted Mitigation Actions (NAMA) Facility. A concept note for “Mongolia – Energy Performance Contracting for Residential Retrofitting in Ulaanbaatar City” was selected for the phase of detailed project proposal development by NAMA in 2019. The proposal will be completed and submitted to NAMA in 2020. It will be addressing main challenges in country such availability of financial resources, capacity gaps in private sector and stakeholders and increasing public awareness on benefits of TTR. Also, it will be using NAMA funds as a leverage to mobilize additional financial resources, project beneficiaries and private sector to improve market conditions for energy performance contracting and trigger the government to review its heating sector subsidy scheme.

Figure 11.

Figure 12.

Common Multi-Family Apartment Block, 2019 Photo by GGGI Mongolia

The expected benefits of retrofiiting 375 buildings blocks over 5 years is to be at least 70,000 tons direct CO2 emissions annually, with a 10-year cumulative savings of 524,000 tCO2e.

Green building

The introduction of green building principles to educational facilities has multiple benefits. It improves health and well-being of children, reduces operational and maintenance costs relevant to the space heating and domestic hot water and reduces GHG emission reductions. In general, public schools and kindergartens spend the majority of their funds for personnel salary, but 75 percent of the remaining expenditure is spent on space heating only. At a larger scale, costs saved from

improved energy consumption behavior can help the GoM achieve budget savings. Most importantly, it will enable GOM to fulfill its obligation to create an opportunity for every child to access pre-school education and optimize the use of limited public funds and other resources.

In 2015, GoM requested GGGI to design a green kindergarten blueprint. GGGI partnered with the Green Technology Center of Korea (GTC-K) on an initial assessment and designed a blueprint for a green public kindergarten with total enrollment capacity of 125 children for a specific site selected in Songinokhairkhan district of Ulaanbaatar city. Technology solutions for green kindergarten buildings have been further elaborated to include (i) resource efficiency; (ii) technology friendliness from both educations users and environment perspectives; (iii) cost effectiveness and (iv) overall green building principles, including indoor air quality, comfort level, use of renewable energy and (v) social inclusiveness.

The selected site for the Pilot Green Kindergarten, with a capacity of 125 students, is the low-income peri-urban area of Songinokhairkhan district in Ulaanbaatar. According to the Cost-Benefit Analysis (CBA), upfront investment for green kindergarten construction is 26 percent higher than ordinary kindergarten. However, in the long run, operation and maintenance costs are lower by 50 percent in heating, 95 percent in electricity, 16.6 percent in water, and 99.5 percent in wastewater. In addition, the green kindergarten prevents the burning of at least 68-89 tons of coal per year that will result in reductions of 91.8-120.15 tCO2 eq.tons per year.

The kindergarten will be constructed with ADB funding[5] with a total estimated investment of US$766,308 as part of the loan package to finance the growing demand for education buildings, under a five-year project titled *"Sustaining Access to and Quality of Education During Economic Difficulties Project"* signed between GoM and the ADB[6].

Figure 13: Demonstration green kindergarten design

[5] https://www.adb.org/sites/default/files/project-documents/50091/50091-002-pp-en.pdf

[6] https://www.adb.org/countries/mongolia/overview

Accelerating Energy Efficiency and ESCO Market development

Energy efficiency market development

Accelerating energy efficiency and ESCO market development is one of GGGI's core activities in Mongolia. Various financial modalities, such as Energy Service Companies, energy performance contracts and upfront financing in energy efficiency market has been explored and activated. GGGI not only works in project development but also supports ERC to set up enabling regulatory and institutional tools and incentive mechanisms to stimulate market development.

In December 2016, the first batch of so-called "Designated Entities" were announced by the Government whose consumption of heat and/or electricity exceeded the Government threshold. In 2017, GGGI, in partnership with Pricewaterhouse Coopers (PwC), carried out a first of its kind of investment-grade energy efficiency audit at 15 selected DEs. It estimated the market per sector, gap analysis of Mongolia's policy, regulatory, and financial framework, and developed a pipeline of pilot energy efficiency projects. Possible annual electricity savings of these 15 companies equal the annual electricity production of Darkhan Power Plant, with 10 percent savings in a year calculated to save electricity of 259 million kWh and additional 701 thousand GCal of heat energy. The project implementers estimated that investment of MNT 50,819 million per year (equal to US$19 mln, as of 2017) will be required for realization of electricity savings in Mongolia and the investment will be recovered only in three years. The electricity savings would reduce carbon dioxide emissions by 620 thousand tons CO2eq per year.

As of November 2019, the country has 299 designated entities with total energy consumption of 4,590 million kWh. The mining sector alone consumes 55 percent of the total energy (8,308,3 million kWh) supplied to 685,237 energy consumers in the country (ERC, 2019).

GGGI supports MoU signing between China and Mongolia to promote collaboration of two countries in fields of energy efficiency

Within the framework of the implementation of the Law on Energy Conservation and other relevant legal acts, the ERC is aiming to develop cooperation between Mongolia and China on energy conservation and efficiency, including possible investment to be made at the benefit of energy conservation and identify potential other areas of collaboration.

GGGI has facilitated the signing of a bilateral Memorandum of Understanding (MoU) between the ERC of Mongolia, and the Chinese National Institute of Standardization (CNIS) and the National Energy Conservation Center (NECC) of the People's Republic of China. Two countries will collaborate in several areas, particularly joint project implementation, harmonizing of relevant energy efficiency standards for electric appliances and equipment, explore possibilities for the setting up of a joint testing laboratory, and knowledge and experience exchange for the capacity building.

ERC has successfully hold initial discussions about the foundations of a structured cooperation with the NECC, the CNIS and the Energy Management Companies Association (EMCA). Scope of the discussions are:

- Identify collaboration areas in Energy Efficiency between the Government Organizations of China and Mongolia;
- Identify potential investments and collaboration between energy companies of China and Mongolia in reducing electricity distribution network losses (for instance, Smart metering and Transformer Applications of Amorphous Alloys in Power Distribution Systems); and
- Capacity building and knowledge sharing between the Chinese and Mongolian energy management companies.

Development of the National Green Financial Vehicle

As a National Financing Vehicle, GGGI has developed proposal to set up the Mongolia Green Finance Corporation (MGFC). The proposal sought $27m from GCF, comprised of $5m in equity, $20m in loans and $2m in grants. A further $23m was committed by other partners, namely $5m each from the Ministry of Finance and the Mongolian Sustainable Finance Association, and $13m in loans from MET. It is also seen as the most important project to facilitate green PPP as well as the first example of climate finance in the country.

The MGFC will be a public, private, IO partnership between line ministries, the MSFA and GCF, where government ensures policy alignment and leverages on the contribution of the private sector to finance its green growth and climate ambitions, where private sector ensures sound independent, professional management and IOs bring the necessary level of capacity building and technical expertise. In terms of green financing, the MGFC's business plan targeted markets such as Cleaner Alternative Heating Solutions for the Ger Segment; Energy Efficiency Products for Large Energy Consumers; and Affordable Green Housing and Mortgage Schemes.

The MGFC could facilitate the reduction of more than 3.3M tons Co2Eq which converts into +630,000 tons of raw coal, 2000 jobs created and 104000 people benefitedover 15 years and will come as a tool to displace the barriers identified above. MGFC has gained the support of the Green Climate Fund, with a proposal submitted by XacBank to the GCF for additional project preparation. The project proposal is planned to be reviewed and approved by GCF in 2020.

Key Findings

The following are key lessons of GGGI's efforts in improving energy efficiency and promoting green energy systems in Mongolia:

- ***Alignment with National Objectives and Priorities Promotes Strong Government Ownership***

  GOM has made a strong political commitment towards green development, adoption of renewable energy and improving of energy efficiency. Last decade from 2009 to 2019 has been critical for Mongolia to design and adopt key policy documents that aligns with the Paris Agreement and Sustainable Development Goals. It includes the Sustainable Development Vision 2030, Renewable Energy Law with its Amendments, Energy Conservation Law, the National Green Development Policy, and the NEEAP. Moreover, during the same period, Mongolia approved its first INDC in 2015 and revised accordingly in 2019 by increasing its commitments to reduce GHG emissions from 14.0 percent to 22.7 percent. Mongolia has the ambitious target of increasing installed capacity of the renewable electricity to 20 percent by 2023, and to further increase this to 30 percent by 2030.

  GGGI has established a strong partnership with national institutions, such as Ministry of Environment and Tourism, Ministry of Energy, Ministry of Construction and Urban Development, Energy Regulatory Commission, and the Municipality of Ulaanbaatar city and acts as trusted advisor in supporting national efforts in clean energy development, planning and implementation. This helped into achievement of realistic outcomes in the joint GOM and GGGI initiatives, such as NGDP and its Outcome Indicators, Green Development Strategic Plans of Khovd, Bulgan and Khentii, demonstration of green kindergarten and small-scale green heating systems, designing and implementation of the NEEAP, ESCO market development and energy efficient standards and methodologies.

  GGGI supports GOM commitments to achieve Sustainable Development Goals and fulfill its obligation under the Paris Agreement. Strategic Objectives of the GOM has been reflected in 2015-2020 Country planning Framework of GGGI in Mongolia with core operation areas of Sustainable Energy and Green Cities.

- ***Adopting Systematic Approach in Policy Introduction: Assessment, Planning and Implementation (Evidence-based)***

  GGGI work in green energy development started with assessment and long-terms planning of energy systems in Mongolia which supported energy sector plans within the NDGP and its Action Plan of Implementation.

  Further heating system assessment in Arkhangai, Bulgan and Khovd provinces and proposed recommendation on transforming the heating systems in the Provincial centers is catalyzed in the Provincial Green Development Strategic Plans. Annually the Provincial Government commits their human and budgetary resources for implementation of the Strategies and Plans.

- ***Strong Analysis Facilitates Good Policy Decision-Making***

  In formulation of the Strategies for Development of Green Systems in Mongolia, LEAP tool was used by employing a broad range of socio-economic, environmental and energy sector data for use in bottom-up techno-economic analysis of energy and GHG-reduction scenarios. Use of good quantitative data and solid analysis and evidence-based assessment facilitated GoM's policy decision making, formulation and planning processes.

  Assessment of alternative heating systems in Arkhangai, Bulgan and Khovd provinces used assessment of available technology options along with LEAP tool, which provide recommendations of systematic planning and design of heating system transformation and its investment requirements.

In demonstration of green kindergarten, with support of GTC-K, the model options were developed used environmental, economic and technology analyses. The options were further advanced by local green building advisory companies to reflect available technology options in Mongolia. With request from the Government, cost benefit analysis was conducted to demonstrate long-term benefits of green public infrastructure for investment decision making by the Government and potential investors.

Collaboration with the National Academia, the Mongolian University of Science and Technology, in various level of technical projects related to the space heating contributed to successful engagement with the key stakeholders.

- ***Focusing from National to Provincial and Sectoral Green Energy Development***

GGGI's work in energy sector started at the national level - *designing long-term energy systems scenarios* for Mongolia and continued in promoting energy efficiency policies, planning and implementation, including improvement of energy efficient norms, standards, labeling and auditing.

From the national level, the focus was expanded into supporting regional and provincial government, collaborating with the Provincial Governments of Arkhangai, Bulgan and Khovd in helping to transform their energy systems.

Further, the demonstration of green kindergarten project aims to improve energy efficiency in public infrastructure with an initial focus of education sector. There is a growing need to construct hundreds of kindergarten facilities in Mongolia, as there are about 60,000 preschool children who have no access to pre-school education due to shortage of kindergarten buildings and facilities.

- ***Continuity and Building on Results***

The Strategies for Development of Green Systems in Mongolia, Alternative Heating Systems in the Provincial Centers, Demonstration of Green Kindergarten, Energy Efficiency Pilot Audits, Low Carbon Alternative Heating Solution for Public Educational Facility provided comprehensive analysis and recommendations on necessary policies, measures, technology options and financial requirements, including necessary investments.

For example, the green kindergarten demonstration project has been highly emphasized by GoM, as it can be replicated in construction of hundreds of public infrastructures, such as kindergartens, schools, hospitals and government offices. GoM will start construction of the green kindergarten with US$0.6 million funding support from ADB in 2020.

The business case study on low carbon space heating for the Public School #122 in Ulaanbaatar city was implemented with the State budget to replace old coal boiler with the GSHP successfully in 2019. It was one of other alternatives of electric and gas heating piloted in the country for the first to mitigate air pollution in Ulaanbaatar city.

GGGI collaborates closely with the Mongolian Renewables Industries Association in supporting renewable energy development in the country. GGGI supports organization of the National Renewable Energy Forums and the International New Energy Summit since 2015. In average, these events attract attendance of at least 600 representatives from academia, civil society organizations, government, private sector, and development partners.

Finally, but not the least, role of the national financial vehicles such as the MGFC is designed to enable and support transformation of energy systems and energy efficiency measures prioritized for the country. This will also help policy makers, development organizations and investors in their decision-making and facilitate in design of bankable projects.

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The Global Green Growth Institute was founded to support and promote a model of economic growth known as "green growth", which targets key aspects of economic performance such as poverty reduction, job creation, social inclusion and environmental sustainability.

Headquartered in Seoul, Republic of Korea, GGGI also has representation in a number of partner countries.

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