SECTOR ASSESSMENT: ENERGY

Sector Road Map

1. Sector Performance, Problems, and Opportunities

1. Mongolia currently has 979 megawatts (MW) of installed capacity, of which combined heat and power (CHP) dominates above 90% of total capacity and power production. Due to aging power facilities that are well past the economic life, power supply is unreliable and the system losses exceed 30%. Despite a recent economic slow-down, the compounded annual demand growth rate is forecasted at 4.4% in electricity and at 3.4% in heat up to 2030. Such growing electricity and heat demand will result in generation capacity shortage by 2023.

2. Population and economic activities are concentrated in Ulaanbaatar, the capital city of Mongolia. Ulaanbaatar has absorbed 42% of the population and generated 49% of gross domestic product.[1] Increasing population influx and economic concentration pushes electricity and heat load demand growth further. Heat load demand in Ulaanbaatar grew by 35% between 2006 and 2016, and is projected to grow to 8,096 kilo giga calorie in 2030 from 5,059 kilo giga calorie in 2016. The central grid system, which covers Ulaanbaatar and other major cities, also witnessed 42% of electricity load demand growth during the same period and is projected to grow to 8,225 gigawatt hour by 2030 from 4,607 gigawatt hour in 2016. The updated demand forecasting concludes that generation capacity of 1,703 MW by 2030 for electricity, and of 3,093 kilo giga calorie by 2030 for heat are essential to meet the growing demand, while maintaining adequate reserve margin.[2]

Table 1: Medium-and Long-Term Demand Projections

	CES Electricity Demand Forecast (GWh)	Ulaanbaatar Heat Demand Forecast (kGcal per hour)	CES Necessary Electrical Capacity (MW)	Ulaanbaatar Necessary Heat Capacity (kGcal)
2016	4,607	5,059	823	2,313
2020	4,411	5,811	910	2,313
2025	6,471	6,914	1,349	2,833
2030	8,225	8,086	1,703	3,093

CES = clean energy system, GWh = gigawatt hour, kGcal = kilo giga calorie, MW = megawatt.
Notes: Numbers may not sum precisely because of rounding.
Source: ADB staff estimates

3. Coal is the dominant energy resource in Mongolia which accounts for 60% of primary energy and 95% of secondary energy, and it is the sole resource available at affordable cost in the country. Coal resource deposit in Mongolia is estimated at 179 billion tons: this could potentially generate 285,741 terawatt-hour of electricity which would meet the total electricity demands in the People's Republic of China, Japan and the Republic of Korea for the next 20 years. There is no petroleum or natural gas available in the country and all refined oil is currently imported from the People's Republic of China and Russia.

4. Mongolia's power system has a specific feature that it is inextricably linked to the heating

[1] The population of Ulaanbaatar grew by 32.5% during 2006–2016 and is expected to grow by about 32.3% during 2015–2020.
[2] The Government of Mongolia targets to maintain 20% of reserve margin for electricity, and 15% for heat by 2030.

system operation due to the country's climatic condition. The winter climate in Mongolia is extremely harsh with daytime temperatures ranging from -10 degrees Celsius (°C) to -30°C, and can drop to as low as -40°C at night. The heating season is unusually long at 8 months, therefore, energy demand for heat load is over two times that for electricity. Since coal is a dominant source for electricity and heat generation in Mongolia (para. 2), CHP is the most suitable, efficient, and economical technology choice to provide both electricity and heat in Mongolia.

5. However, existing facilities for providing heating and electricity (power plants and transmission and distribution lines) are energy inefficient and vulnerable because they are old and outdated. Two of three coal-based CHP plants in Ulaanbaatar, CHP plant number 2 (CHP 2), and plant number 3 (CHP 3) have operated for more than 45 years without proper emission control devices, and the largest plant, CHP plant number 4 (CHP 4), has operated for more than 25 years.[3] The existing power transmission and distribution infrastructure is inefficient and unreliable for lack of investment and maintenance, and is in urgent need of rehabilitation and upgrade. In Ulaanbaatar and surrounding districts, electricity distribution losses totaled 16.3% in 2016, which is much higher than the international best practice of about 5.0%. The average outage duration of the distribution network in Ulaanbaatar was 3,200 minutes per customer with more than 12 interruptions per customer in 2016, unacceptably high for any modern electricity distribution network.

6. Due to inadequate heat supply and coverage in Ulaanbaatar, *ger* areas surrounding Ulaanbaatar (60% of residents in Ulaanbaatar) have to use coal-based household stoves and small, inefficient, heat-only boilers (HOB) without proper emission control devices which are a major source of air pollution.[4] Lack of investment in expanding the coverage of the heating network is the primary cause for continued use of inefficient and polluting heat systems. The result is serious urban air pollution during the winter season in Ulaanbaatar, which is widely regarded as among the most polluted cities in the Asia and Pacific region.

2. Government's Sector Strategy

7. **Medium-and long-term energy sector strategy.** In 2015, the government issued the State Policy on Energy 2015–2030 which the energy sector development strategy with quantitative targets by 2030 (Table 2). It intends to achieve energy security with sufficient reserve margin, increase renewable energy capacity, improve financial health of state-owned utilities, enhance supply and demand side energy efficiency, while creating an enabling environment for private led investment in the energy sector. In September 2015, the government submitted an Intended Nationally Determined Contribution to the United Nations Framework Convention on Climate Change.[5] It targets to reduce carbon dioxide equivalent emission by 14% in 2030, comparing to business-as-usual scenario. The Intended Nationally Determined Contribution also proposed measures and additional actions in the energy sector which includes renewable energy capacity expansion, transmission and distribution loss reduction, and an improvement of net generation efficiency in CHPs.

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[3] Current installed capacities of the existing CHPs in Ulaanbaatar are: 24 MW (CHP 2), 148 MW (CHP 3), and 580 MW (CHP 4). Net generation efficiency of these CHPs is quite low due to aging.

[4] These contribute to more than 80% of annual average ambient particulate matter less than 10 micrometers and particulate matter less than 2.5 micrometers concentrations during winter time in Ulaanbaatar. Most of the raw coal burned in *ger* area households is low-quality coal from the Baganuur mine. This coal is characterized by high levels of contaminants (e.g., sulfur, ash, volatile organics, and moisture) and low energy content. As a result, burning raw coal produces significant emissions of particulates and sulfur dioxide.

[5] http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx

Table 2: Medium and Long-Term Energy Sector Targets

Target Indicators	Base Year 2014	First Stage 2023	Second Stage 2030
1. Reserve capacity for electricity supply	-10.0%	10.0%	20.0%
2. Reserve capacity for heat supply	3.0%	10.0%	15.0%
3. Net profit margin of state-owned utilities	-16.2%	0.0%	5.0%
4. Power own use of CHPs	14.4%	11.2%	9.1%
5. Transmission and distribution loss	13.7%	10.8%	7.8%
6. Renewable energy share in total capacity	7.6%	20.0%	30.0%
7. Carbon dioxide emission per Gcal generation	0.52 ton	0.49 ton	0.47 ton
8. Reduction of building heat loss	0.0%	20.0%	40.0%

CHP = combined heat and power, Gcal = giga calorie.
Source: Ministry of Energy.

8. **Policies to address air pollution in Ulaanbaatar.** In 2011, the government established the Clean Air Foundation which supplies funding assistance to improve household stove and small HOBs' energy efficiency. In parallel, the Ulaanbaatar Clean Air Project funded by the World Bank is being implemented since 2012 to support household stove and small HOBs' energy efficiency, air quality monitoring, and public awareness campaign. The Law on Air was also enacted in 2012 to reduce and control ambient air pollution and monitor air pollutants.

9. In January 2017, the government issued a zero-night time electricity policy for selected *ger* districts to encourage a switch from coal to electricity for space heating. It grants free of charge monthly electricity use up to 1,500 kilowatt-hour per customer during night time (between 9:00 pm–6:00 am) in winter season.[6] In April 2017, the government also issued the Air Pollution Action Plan (2017–2025) which includes (i) rolling out the zero-night time electricity policy to encourage population in *ger* districts to use electric heating stoves, (ii) diffusing clean coal technologies such as semi-coke briquette – or lower emitting fuel - for a use of household heating stoves to significantly reduce air pollutant emission, and (iii) expanding district heating networks while demolishing small inner city coal fired HOBs. The policy targets, with estimated implementation cost, are in Table 3.

Table 3: Energy Sector Targets in the Air Pollution Action Plan

	2017	2019	2025	MNT Billion
Zero-night time electricity tariff (household)	110,895	135,000	150,000	
Household with 2.5 kW electric household stoves	20,000	110,000	-	676.09
Household with 4 kW electric household stoves	3,000	20,000	80,000	
Household with alternative fuels (semi-cokes, etc.)	150	23,000	43,000	22.98
Small-coal fired HOBs demolished	33	106	121	729.60

HOB = heat-only boiler, kW = kilowatt, MNT = Mongolia togrog.
Source: Government of Mongolia. 2017. *Air Pollution Action Plan*. Ulaanbaatar.

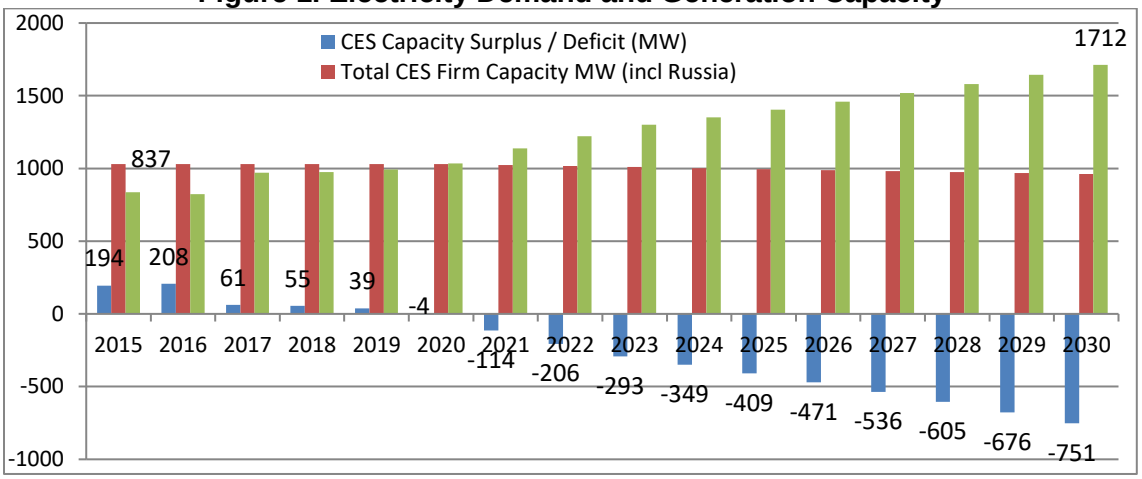
3. Challenges and Opportunities

10. **Energy system constraints**. Deploying electricity household stoves as targeted in the air pollution action plan will push up medium- and long-term electricity load demand (2017–2030) in the central energy grid system from 3.9% of compounded annual demand growth to 5.0%, and the domestic generation capacity including transmission capacity for electricity import from Russia

[6] It is applicable for residential electricity use only between 1 November and 1 April. Electricity consumption limits of the free night time tariff are 700 kWh per month for 230-watt costumers; and 1,500 kWh per month for 350-watt costumers.

will be diminished by 2020. To meet such growing demand and achieve the action plan target in 2025, 409 MW of generation capacity addition will be required before 2021 at least.[7] Strengthening transmission and distribution network is also essential to avoid system failure (Figure 1).

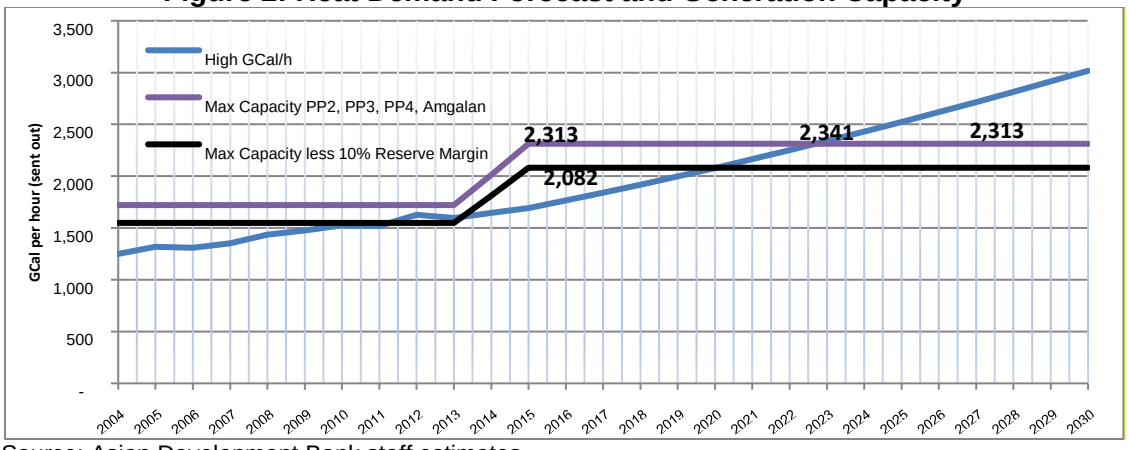
Figure 1. Electricity Demand and Generation Capacity



Source: Asian Development Bank staff estimates.

11. **Heat generation capacity constraint.** Similarly, expanding district heating network through demolishing 228 units of energy inefficient inner-city HOBs by 2025 will also face heat generation capacity constraints. It pushes up medium- and long-term annual heat demand growth rate in Ulaanbaatar from 3.2% to 3.9%, which starts biting 10.0% of safety reserve margin of the existing heat generation capacity in 2020 and diminishes entire heat supply capacity by 2023. Thus, 139 units of HOBs demolition by 2019 will be the allowable limit to maintain safety of district heating system network. To achieve the target by 2025, 522 MW thermal of additional heating capacity will be required at least (Figure 2).

Figure 2: Heat Demand Forecast and Generation Capacity



Source: Asian Development Bank staff estimates.

12. **Cleaner fuel diffusion**. A use of raw coal for cooking and heating in *ger* districts is major source of air pollution in Ulaanbaatar. Eliminating such coal use through deploying electric

[7] The needy generation capacity in the projection excludes the system safety requirement: 15% of reserve margin plus 50% of transmission line utilization ratio for power import from Russia.

household stoves could perfectly eliminate air pollution, but only 11% of population in *ger* district is in use of electric stove at present due to household affordability.[8] In addition, the government's target in use of electric household stoves by 2025 is less likely to be achieved without power generation capacity addition which requires at least 4–5 years for construction to start commercial operation. Fuel switch from raw coal to semi-coke briquette or other lower-emitting fuel for cooking and heating in the ger district will be an alternative but intermediate solution to effectively reduce air pollution emission at the least cost.

13. Semi-coke briquette is a type of clean coal technology in which moisture contents in the raw coal is substantially reduced through carbonization process to produce semi-cokes which is mixed with hydrated lime and clay to form semi-coke briquette. It contains higher calorie value (4,500 kcal at least) than raw coal currently in use for cooking and heating in *ger* districts (3,370 kcal in average) and can significantly reduce particulate matter emission up to 89%.[9] In addition to lower emissions, semi-coke briquettes have a higher energy content than raw coal, approximately 25% more energy per kilogram of fuel. As a result, less fuel is necessary for the same amount of heat. If the Government of Mongolia distributed 80,000 tons of semi-coke briquettes in Ulaanbaatar City's *ger* areas, it would replace approximately 100,000 tons of raw coal and reduce heating season of fine particulate matter 10 micrometers or less in diameter emissions by over 145 tons (per 6 months in winter). Upon successful performance of semi-coke briquette during winter season 2018–2019, it will be gradually rolled out in the other *ger* districts by 2025. Semi-coke briquette is also the least-cost policy option which costs MNT112,568 per household while MNT4,507,243 per household will be required for zero-night time tariff policy.

14. ADB estimates the costs of procuring 80,000 tons of semi-coke briquettes would be MNT3.75 billion, if the government subsidizes only the difference between the cost of semi-coke briquettes and raw coal, assuming the cost of semi-coke briquettes is MNT200,000/ton and raw coal is MNT125,000/ton. If the Government of Mongolia subsidizes the full cost of the semi-coke briquettes, ADB estimates it would cost MNT16 billion. However, during the 2016–2017 heating season, the Ulaanbaatar City Government provided semi-coke briquettes to approximately 1,500 low-income households in the most polluted areas. The city has again contracted to procure 1,600 tons of semi-coke briquettes for this heating season at a cost of MNT150,000/ton. If the government procured similar contractual terms, the cost of the procurement (for 80,000 tons) would decline to MNT12.5 billion (if the government subsidizes the full cost) or an incremental cost of MNT230 million. Unless the government chooses to provide 100% financial heating assistance for 26,000 households to 30,000 households, the government could distribute the semi-coke at a cost equal to the price of raw coal, costing the government only a fraction of the total procurement cost of the semi-coke briquettes.

4. Observation and Suggestion

15. **Bridging actions.** Since electric heating stoves deployment and district heating area

[8] Asian Development Bank carried out social survey for households in *ger* districts in August 2017 to assess socio-economic household conditions, current energy use practice such as type of fuels and stoves, household readiness and solutions for air pollution, and awareness and observations of the government policy for air pollution reduction. While 57% of respondents opted the use of electric stoves as short-term air pollution reduction measures, only 1% of the respondents will use electric heating stove, and 11% will use both electric heating stove and coal-fired household stoves because of the household affordability.

[9] Emission and calorie value of domestic semi-coke briquette refer to the results of the laboratory tests under the technical assistance of the Japan International Cooperation Agency. Particulate matters emission from semi-cokes briquette per household in 8 months' winter time is estimated at 100 kilograms as compared to 700 kilograms from raw coal burning.

expansion with HOBs retirement will face the generation capacity limit by 2019, distributing semi-coke briquettes or lower emitting fuel is the least cost policy option for the next several years to effectively reduce air pollution emission from the *ger* districts.

16. Strengthening institutional and regulatory framework should also be sought in parallel. An improvement in current semi-cokes or lower emitting coal quality standard in calorie value and air pollutant emission would lead to further coal consumption and emission reduction, upon monitoring and evaluation of actual semi-coke briquette or lower emitting coal performance. Improving the energy efficiency standard of home appliances including the electric stoves is also expected to gradually reduce residential electricity consumption while mitigating demand pressure upon the existing power supply system.

17. **An investment in energy infrastructure.** Generation capacity addition in both electricity and heat is critical to meet the policy target in 2025, and new energy efficient CHP plant construction is the recommended option to optimally supply both affordable electricity and heat while mitigating air pollution in Ulaanbaatar. The implementation of low cost apartment housing development should also be accelerated to move *ger* household into district served by district heating network. Distributed renewable energy system development, in areas which cannot be reached by the district heating, should also be tested for possible future deployment.