Modeling of Mongolian Electric Energy Systems Using MESSAGE

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1. Introduction

The purpose of this study is to perform a comprehensive supply analysis of the national electric system of Mongolia on a local and regional basis for the period of 2011-2030. The MESSAGE model was used to investigate the role of SMART in the Mongolian Electric System. Considering that almost all of the power plants in Mongolia are CHP (Combined Heat and Power) plants, MESSAGE is suitable because it is capable of dealing with CHP.

2. Methods and Results

The study uses MESSAGE ((Model for Energy Supply Strategy Alternatives and their General Environmental Impacts), the IAEA's tool for analyzing the supply options for covering future energy demands. MESSAGE is a model designed for the optimization of an energy system. The basic principle of MESSAGE is to build an energy flow network that describes the whole energy system, starting from the level of domestic energy resources (oil & gas, uranium, coal mines etc.) passing through the primary and secondary levels, and ending by the given demand at the final level, which is distributed to such consumption sectors as households, industry, and transportation. In the defined system network, both existing and candidate technologies are included. Each technology is defined based on the activity and capacity variables, which include investment and O&M costs, efficiency, plant factor, operation time, and other additional technical specifications [1].

2.1 Electricity system

The energy sector of Mongolia consists of four independent electrical power systems: Central Energy System (CES), Western Energy System (WES), Eastern Energy System, and Gobi region.

2.2 Electricity Demand

The demand for electricity and heat in Mongolia for the period of 2000 – 2010 is shown in Table I.

Table I: Average Growth Rate of Electricity and Heat Demand

	2000	2005	2010	Growth rate	
				`00-`05	`05-`08
Electricity demand	154	216	290	7.0%	6.1%
Heat demand	663	718	782	1.6%	1.7%

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2.3 Demand forecast

The analysis assumes that electricity demand in the Central Energy System (CES) grow at the average rate of GDP growth annually for the period of 2011-2030 (Fig.1). Heat demand is assumed to grow at 2.5% annually.

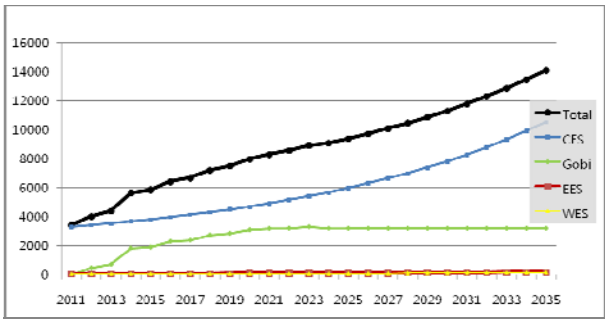

Fig.1. Mongolia Electricity Demand Forecasting (MWyr)

2.4 Economic and technical parameters for the existing and committed power plants

Table II shows the technical and economic data for existing and committed power plants.

Table II: Existing and planned Power Plant

Technology	Efficiency	Operation Time	Life Time (Year)	Fixed Cost $/kw/yr	Contructed Year	Expected Retirement Year	Capacity MW
CHP#2	0.23	0.62	43	174.3	1969	2012	21.5
CHP#3	0.34	0.49	37	230.4	1979	2016	136
CHP#4	0.39	0.53	40	98.7	1991		540
CHP_Dark	0.28	0.62	50	221.4	1965		48
CHP_Erdnet	0.44	0.57	50	263.1	1989		28.8
Tashir_HP	1	0.3	50	263.1	2009		11
CHP#5_1	0.36	0.5	40	38	2015	2055	150
CHP#5_2	0.36	0.5	40	38	2020	2060	150
CHPChoiEES	0.18	0.5	50	174.3	1969	2019	36
CHP_DALnUk_Gobi	0.18	0.5	50	263.1	2001	2051	6
Total(MW)							1127.3

2.5 Reference Supply Scenario Assumption

The transmission grid is assumed to be available between the CES and Gobi region from 2020. Transmission costs between CES and Gobi is assumed to be 30% of the average electricity price. Mongolia imports electricity from Russia. In this study, the

constraints are given to the total electricity imports in a way that it cannot exceed 5% of the total generation of CES. A discount rate of 10% was used.

CHP#5 was already committed to be introduced, as shown in Table III with an investment cost of 1,240 ($/kW):

Table III: Committed plants

CHP#5	Capacity (MW)
2014	300
2015	300
2019	150

SMART is assumed to be available in 2020 with 200MW and in 2025 with 100MW (investment cost 4,068($/kW), fixed cost 58.5($/kW/yr)), whereas Tavan Tolgoi coal power plant (investment cost of 1,690($/kW), fixed cost of 33($/kW/yr)) is assumed to be available in 2020 with 300MW and in 2025 with 150MW in the Gobi region (Table IV).

Table IV: Power Candidate (MW)

	2020	2025
SMART	200(100×2)	100
Tavan Tolgoi	300(150×2)	150

To fulfill the electricity demand mentioned above, , SMART with capacity of 100 – 200MWe will start operation in the year 2020, and is compared without SMART.

2.6 Energy flows: energy carriers and technologies

The Mongolian electric energy system is described in Fig. 2. All of the technologies, which are represented by rectangles, contain technical and economic data. MESSEGE gives you the optimal technical choice by minimizing the total system cost while meeting the given demand.

Energy demand, exogenous to the model, is given at the first level of each energy chain, and the model computes the corresponding productions of each techonologies at the following levels of the chain up to the energy resource level.

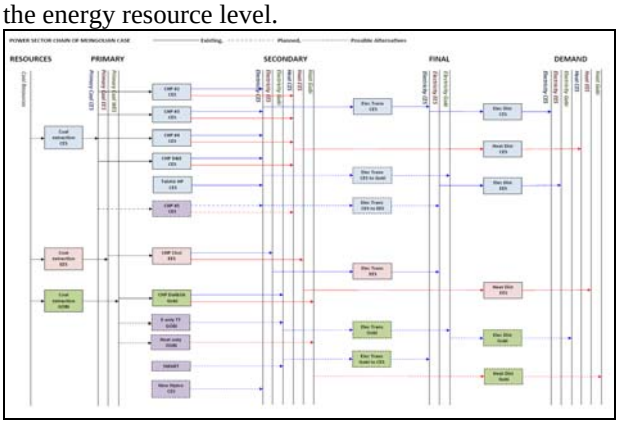

Fig.2. Power Sector Chain of Mongolia Case

MESSAGE chose SMART and Tavan Tolgoi power plant with all the available capacities as offered in Table IV. In terms of coal consumption, this reference case is compared with “Without SMART” case, where SMART is excluded as a candidate.

Mongolia is endowed with coal resources with large reserves estimated at about 152 billion tons, of which over 22.3 billion tons have been identified by preliminary and comprehensive geological prospects [2]. The amount of saved coal consumption attributable to the introduction of SMART was estimated, and its value was calculated by applying market price of coal (Table V).

Table V: Coal Consumption

	Reference(A)	Without SMART(B)	Difference (B-A)	Difference in Money- metric Value($)
2021	5,420,708	6,953,611.6	1,532,904	114,967,772
2022	5,604,684	7,036,984.0	1,432,300	107,422,525
2023	5,734,585	7,024,030.0	1,289,445	96,708,404
2024	6,018,392	7,300,301.2	1,281,910	96,143,217
2025	6,333,642	7,607,134.9	1,273,493	95,512,004
2026	6,179,059	7,931,878.5	1,752,819	131,461,426
2027	6,530,648	8,275,149.7	1,744,501	130,837,590
2028	6,901,827	8,638,106.7	1,736,280	130,220,981
2029	7,294,092	9,022,347.7	1,728,255	129,619,142
2030	7,661,033	9,252,382.5	1,591,349	119,351,187
2031	7,474,463	9,129,579.7	1,655,116	124,133,720
2032	7,311,205	9,367,691.3	2,056,487	154,236,510
2033	7,976,675	9,631,791.5	1,655,116	124,133,721
2034	8,247,841	9,902,957.0	1,655,116	124,133,720

3. Conclusions

MESSAGE turned out to be a useful tool to address a Mongolian electric energy system analysis. SMART was identified as a promising candidate for meeting the future electricity demand in Mongolia. Potential contributions to the savings of coal reserve were estimated around 1.3–2.1 million tons a year, which means around 100–150 million dollars a year, which would be a great contribution to the Mongolian economy.

REFERENCES

[1] IAEA, Model for Energy Supply Strategy Alternatives and their General Environmental Impacts User Manual, 2008.
[2] Purevsuren and Drebenstedt, Actual aspects of lignite mining in Mongolia, in Mine Planning and Equipment Selection, Wroclaw, Poland, 2004