Master's Thesis

Strategic Planning of Mongolian Coal Resource

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Declaration of Authorship

„I declare in lieu of oath that this thesis is entirely my own work except where otherwise indicated. The presence of quoted or paraphrased material has been clearly signaled and all sources have been referred. The thesis has not been submitted for a degree at any other institution and has not yet been published.”

Preface, Dedication, Acknowledgement

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- Mineral Resources and Petroleum Authority of Mongolia
- Ministry of Energy

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Abstract

Mongolian economy is highly dependent on mining and, in particular, coal industry is one of the major economic growth factors. In recent years, the need to conduct such study has been important because of the growing demand for coal due to the increase in coal consumption in developing economies. The study examined the possibility of increasing the economic potential of the country by identifying the long-term strategic planning of the coal sector and derived a solution for rapidly growing energy demand in neighboring countries and the East Asia region by exporting coal and electricity to foreign markets. Two options are considered in the study: refined coal export and coal-derived energy. The mathematical modeling was used to compare these alternatives.

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1 INTRODUCTION

1.1 Introduction

The progressive development of the mining sector in Mongolia has been positively influencing the economy of the country. In particular, the coal industry takes the predominance role in the sector. Mongolia's coal resource is 173.5 billion tonnes, ranking in the top 10 in the world. Ranked in the top 15 coal export nations in the world. In 2003, coal export was 0.5 million tonnes compared to 21 million tonnes in 2018[1].

Currently about 99% of Mongolia's coal export is solely directed at China, being unable to tap the world market. China is the leading coal consumer and producer in the world. China, rich in coal deposits, have had geological difficulties with more than 60% of their coal mines reaching 1000m or more in mine depth. Coal deposits sit in the north part of the country, Inner Mongolia, Shaanxi and Xinjiang, moving away from the market. Chinese state have increased coal import in recent years' closure of many coal mines due to unsafe work environments. Coal import is projected to grow even more. This can be a major indication China can be Mongolia's priority market for coal export.

The study forecasts that Mongolia's coal exports will continue to grow steadily in the coming year, or about 80 million tonnes by 2020, of which 50 million tonnes of coking coal are estimated. The importance of coal export in the country's economy cannot be overstated. For example, the sector's total production amounted to 184.6 billion MNT in 2008 or one percent of the state budget. In 2018, this amount reached 10 times, reaching 2.3 trillion or 18 percent of the state budget.

World Coal Association and International Energy Agency have estimated the production and consumption will grow in the coming years. Growing coal demand is explained by growing global population and economic growth, particularly in China, India and emerging economies. The oil reserves are decreasing, one of the main

[1] Export study, Mongol Bank, 2018

source of energy, which positively affects the coal price, and in turn handing Mongolia a slight advantage.

1.2 Reasoning behind the topic choice

The mining industry, especially the coal sector, has been a key player in Mongolia's growing economy, and the state have been paying special attention to this sector. With coal production and export growing year by year, major coal deposits are being discovered. If the state can manage to utilise such vast deposits Mongolia's economy will boom without fault.

Coal is still considered the best source of energy due to its low price and availability globally even with new technologies invented to produce energy on the cheap. Currently, only 5.8%[2] of total industrial output is in the processing sector, indication that Mongolia is primarily exporting raw coal. Therefore, exploring opportunities to increase exports by coal processing and energy production is crucial to ensuring the economic security and sustainable development of Mongolia.

With growing economies and their ever growing energy demand it is imperative for Mongolia to develop a general plan for fulfilling said demand by either exporting refined coal or exporting energy. In doing so, Mongolia will have many advantages such as increased competitiveness in foreign markets, creating new energy export products, and expanding economic efficiency and value added products.

1.3 Purpose of study

The purpose of this study is to determine the long-term strategic planning of the coal sector and to improve the country's economy by exporting coal and energy to foreign markets in line with the rapidly growing energy demand of neighboring countries and the East Asia region.

1.4 Study objectives

In order to achieve these objectives, the following have been considered.

[2] Study concluded by Ministry of Mining and Heavy Industry in 2018

- Survey of previously conducted research on the topic,
- Assessing the current climate of the coal industry, analyzing coal production, consumption, export and define future trends;
- Develop indicators for coal deposits utilized and unutilized that can affect the country's economy;
- Develop a mathematical model for determining the order of succession of the deposit into the economic cycle;
- Conclusion

1.5 Research methodology

Research will be conducted by using secondary sources such as electronic journals, electronic sources, books, printed materials, research papers, data collection, mathematical statistics, comparisons and hypotheses, econometric methods, EVIEWS 9.0 software and regression analysis.

1.6 Study significance

Research conducted on the topic is minimal in Mongolia, making this study a novelty.

It is in great hope, the senior authorities will be able to take into account the results of the research in their operations, in decision-making and policy development. With high anticipation this study will become a viable source for further researchers on the topic.

The new mathematical model of the multi-factor function determines the criteria for the economic circulation of the coal deposits and the mathematical expressions of the choice of the sequence stage of the deposit have been developed and furthermore, there is a newly developed mathematical model for multiple factors to determine the sequence of steps to enter any mineral deposit at different stages with scientific innovations. The importance of this research is the socio-economic development of Mongolia and the high-demand coal industry development strategy in foreign markets as the basis for a long-term state policy on coal industry development.

1.7 Previous work on the topic

After opening its economy to the world in 1990s, extensive research concerning the mining sector have been conducted by the state and in equal by international enterprises. In particular, the Mineral Resources Authority of Mongolia have been conducting research in this area continuously and in 2012 concluded a study outlining current situation and perspective of Mongolia's coal sector. Recently, dozens of researchers and scientists from the mining sector are primarily engaged in the development of technology, economic, planning and management strategies for development of coal industry.

An overview of papers, books and academic journals that have been previously studied domestically and in other countries are as follows.

№	Researcher	Research name and year	Content
1	ERC /Economic Research Center/	"Study on Mongolia's coal competitiveness" 2015	Mongolian coal is competitive with many advantages. For example, geographical location and coal quality. Coal price and export is hugely dependant on how the rail project will be solved. In other words, coal competitiveness can be achieved if mega projects take place.
2	Sc.D Ya. Gombosuren	"Feasibility study of coal mining in the People's Republic of Mongolia" 1972	Describes the relationship between economic and technical factors during open pit coal mining.

3	Ph.D L.Erdene	“Long term planning of the coal industry of People’s Republic of Mongolia” 1976	Coal industry development plan in line with current economic conditions
4	Ph.D L.Tsedevsuren	“Future of the coal industry of People’s Republic of Mongolia” 1983	Comparison of various new coal processing technologies.
5	Ph.D S.Tsedendorj	“Planning and optimisation of coal mining operations” 2000	Optimisation of coal mining operations, taking geological conditions, equipment choices production capacity into consideration.
6	Sc.D. P.Ochirbat	“Development Strategy for Mongolia's Mineral Resource Complex” 1999	Defines the long-term strategic planning of the mining sector’s development goals.
7	Sc.D. B.Laikhansuren	“Optimisation of blasting and drilling” 2001	Drilling and blasting new technology and optimisation.
8	Sc.D. S.Batkhuyag	"Theoretical and practical issues to develop Mongolia's energy development strategy in new socio-economic conditions" 2012	Designing and implementing the methodology to implement planning and management of fuels and energy supply in line with market relations.

9	Ph.D. L.Damdinsuren	“Current issues of the mining industry and possible solutions” 2008	Overview of the mining industry issues and ways to solve them.
10	Ph.D J.Byamba-Yu, Ph.D S.Tsedendorj	“Technique and methodology of feasibility studies”	Investigation in to different techniques and methodology applied to feasibility studies on various deposits.
11	Japan International Cooperation Agency (JICA)	"Master plan to develop Mongolia's coal sector until 2010" 1993-1995	Development of the coal industry by utilising 14 major coal deposits.

Table 1-1. Previous work related to the topic

1.8 Study structure

The Master's thesis is comprised of brief summary, introduction, 4 basic chapters, 16 subgroups, conclusions, references, and appendices. During the course of the research, more than 100 sources were used in Mongolian language and foreign languages, literature, other materials, legislation, and online sources.

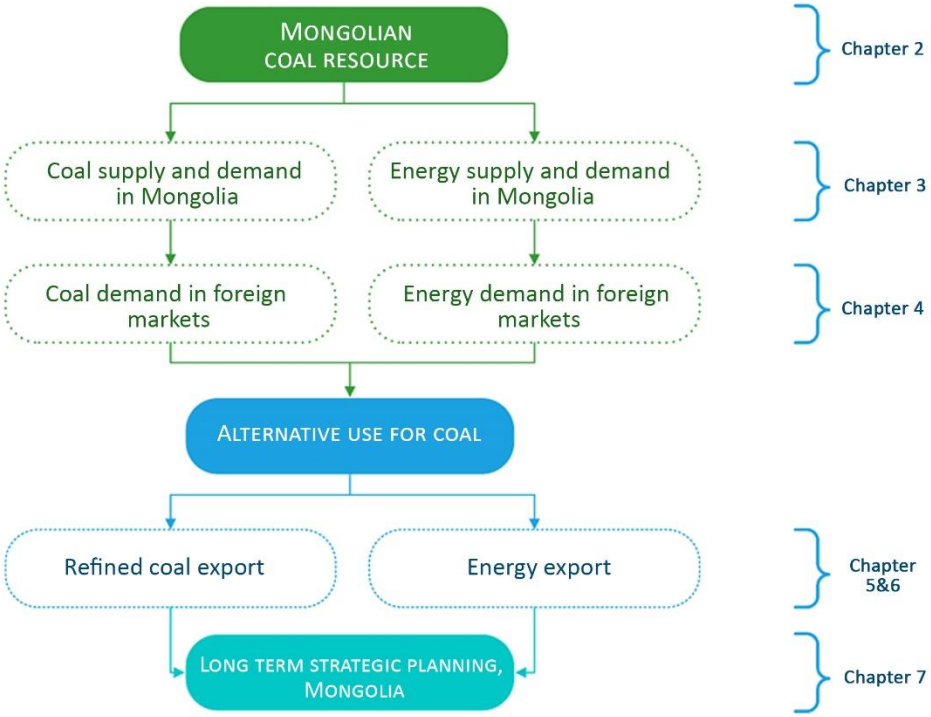


Figure 1-1. General structure of the study

2 Mongolian Coal Resources

2.1 Geological survey history and source

Currently, there are no documents which contain the full extent of Mongolia's fossil fuel reserves. There has been extensive exploration and prospection work carried out, but it did not cover the whole country.

The very first report on Tavan Tolgoi coalfield was completed in 1884 by P. Pompelli, Egiin Gol in 1890. Others were undertaken by N.S. Tugarinov and Choir coalfield in 1892-1894. The modern geological surveying started in the 1920s and reported 3 coalfields with approximately 200 coal reserves. (Punsalmaa, 1982) Between 1960 and 1970 almost all of the regions were surveyed to determine the supply of low cost energy for the more distant regions. About 30 coalfields were discovered, many still unutilized.

2.2 Coal reserves

Based on previous research on fossil fuel reserves, coal occurrences were explored in the 1960s, shown in Table 2. The geologists and the occurrences are shown in Table 3.

When a coalfield is in consideration for energy production, we must take a close look at its reserves, location and the region. This is to determine the best way for transportation of coal to its consumers, in most cases, coal thermal power plants. It is in the economic interest that we take a close look at the occurrences.

Surveyors	Survey year	Reserves, billion tonnes
Coal		
N.V Ivanov, Ch. Eebum, D. Bat-Erdene	1968	18
Chimid, Prusova	1980	25

D. Bat-Erdene, Tuya	1993	152
B. Erdene-Ochir	2017	176
Oil shale		
D. Bat-Erdene	1994	23
Natural Gas and Oil		
Sengee, Janchiv, Purevdorj, Tsedenbaljir	1990	0.15
U. Pentilla	1994	0.408
Rastegin	1996	1.6

Source: Development of Mongolian fuel and energy, 1982

Table 2-1. Fossil Fuel Resources

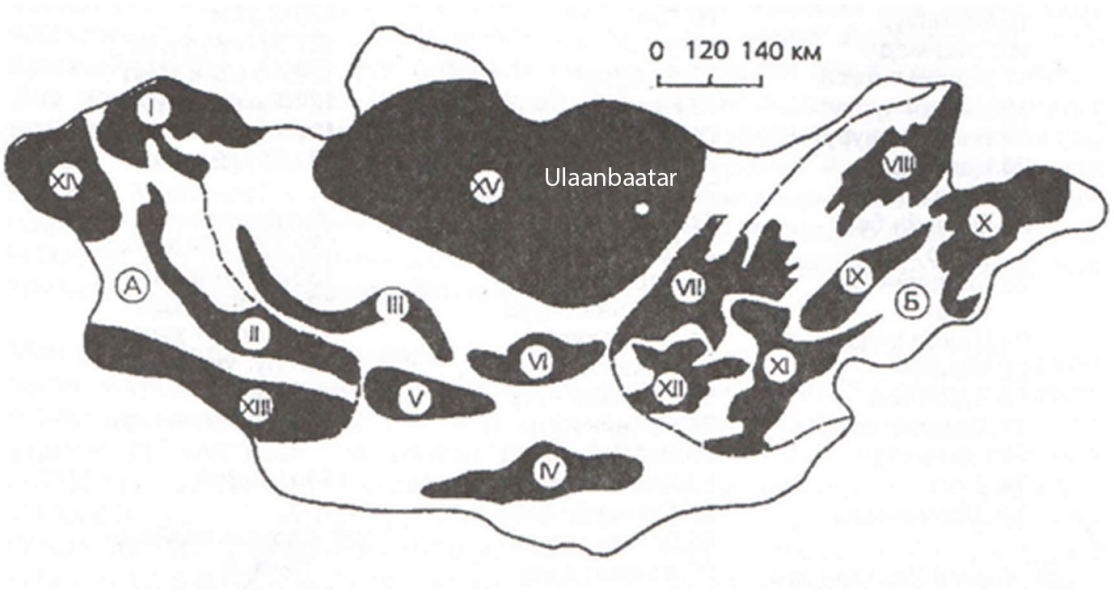
	Surveyors	Occurrence	Reserves, million ton
1	Ch. Eebum (N.V Ivan, V.F Cherepovskiy	Nalaikh	53.4
		Egiin Gol	2.5
		Gants Mod	0.44
		Hoshoot	7.8
		Gurvantes	0.7
2	D. Dashtseren (N.V Ivanov, Yakovlyev, Anyanov)	Nariin Suhait	88.9
		Zeegt	6.89
		Uvdug Hudag	169.2
		Ih Ulaan nuur	159.3
		Tsagaan - Ovoot	15.89
		Hoot	11.6

3	D. Damiran (N.V Ivanov, Yakovlyev)	Bulangiin hooloi	148.8
		Tal bulag	113.5
		Aduunchuluun	24.3
		Shariin gol	159.9
		Mogoin gol	14.2
4	R. Misyemhan (N.V Ivanov, Yakolyev)	Nalaikh	53.4
		Uvdug Hudag	169.2
5	D. Bat-Erdene (N.V Ivanov, Yakolyev, Anyanov, Tsader)	Ih ulaan nuur	159.3
		Shivee-Ovoo	873.8
		Tavan Tolgoi	596.6
		Gurvantes	0.7
		Nariin Sukhait	88.9
		Bayan teeg	26.7
6	S. Jagar (Yakolyev)	Rashaant	0.09
		Uvur Chuluut	3.6
		Bayan Tsogt	1.9
7	L. Munkhtogoo (Yakolyev, Anyanov, Shahov)	Tsaidam	1764.8
		Tugrug	49.1
		Tevshiin Gobi	768.7
		Humuult	425.5
		Shivee-Ovoo	873.8
		Maanit	18.2
		Uvdug Hudag	169.2

8	Z. Badamgarav (Ivanov, Yakolyev, Anyanov	Ih ulaan nuur	159.3
		Egiin gol	2.5
		Mogoin gol	15.4
9	Tumurbaatar (Shahov, Stepanov, Tsader)	Huden	51.1
		Tavan Tolgoi	596.6
		Olongiin uhaa	29.9
10	Chimiddorj (Shahov)	Hashaat hudag	129.0
		Hotgor	3.9
		Tavan Tolgoi	596.6
11	Erdenee (Tsader, Shahov)	Bayan teeg	26.7
		Saikhan Ovoo	7.1
		Huren gol	13.3
12	Dashhorol (Shahov, Tsader)	Ulaan Ovoo	6.63
		Tavan Tolgoi	596.6
13	Chuluun (Shahov)	Nuurs hotgor	16.2
14	Ganhuyag	Tavan Tolgoi	596.6
		Erdenebulag	13.4

Table 2-2: Coal Occurrences' Exploration

2.3 Coalfields in Mongolia



Source: Mineral Resources and Petroleum Authority, Mongolia

Figure 2-1. Coal basins in Mongolia

Harhiraan coal basin

I. Mongol Altai coal basin
II. Omnod hangain coal basin
III. Omnogobi coal basin
IV. Ih bogdiin coal basin
V. Ongiin gol coal basin
VI. Choir coal basin
VII. Choibalsan coal basin
VIII. Sukhbaatar coal basin
IX. Tamsag coal basin
X. Dornogobi coal basin
XI. Dundgobi coal basin
XII. Altain chanadah coal basin
XIII. Bayan Olgii coal basin
XIV. Orhon – Selenge coal basin
A. Western Mongolia
B. Dornod Mongolia

Western province, basin covers 280,000 square kilometers, bordering with Russia and China. The western province consists of Mongol Altai coal basin, Harhiraan coal basin, Altain chandahi coal basin and Bayan Olgii coal basin. Exploration results showed coal seams to be 35 to 85 meters thick, mainly anthracite coal. Coking coal occurrences were found in the Mongol Altai coal basin and Bayan Olgii coal basins. (Punsalmaa, 1982)

Omnogobi basin covers 40,000 square kilometers, 14 coal seams were detected with 0.2 to 62 meters thick. Notable coalfields such as Tavan Tolgoi, Nariin Sukhait and Tsagaan tolbo are located within the province, where most of the coking coal survey was initiated. The coal researched was found to be strong coking coal. (Punsalmaa, 1982)

Ongiin gol, Ih bogd basin consists of 60,000 square kilometers. An extensive survey was not done, but an initial survey found that it was from Jurassic era. Coal seam thickness differed between 14 to 54 meters. Compared with other coal basins this province has a coalfield rich in thermal coal with chemical applications. (Punsalmaa, 1982)

Dornod Mongolian basin consists of 450,000 square kilometers and continues into Northeastern and Southeastern China, as well as Russia. The province is made up of 6 basins: Choir-Nyalga, Choibalsan, Sukhbaatar, Tamsag, Dornogobi and Dundgobi. It is rich not only coal but shale oil, oil, bitumen and zeolite. With 20 crosscuts the coal seams were found to be very thick, for example, Tsaidam 110 meters, Ih ulaan nuur 90 meters. (Punsalmaa, 1982) Coal seams that are thick do not cover large areas. It was found that the estimated reserve is made up of brown coal.

Harhiraan basin was first called the “Coal Area” by D. Bat-Erdene, this was due to the thickness of coal seams, which at various points measured up to 1,800 meters. There are several areas consisting of thick coal seams, all are independent of each other. (Punsalmaa, 1982)

Mongol Altain basin is made up of several coalfields with differing seam thicknesses up to 1,330 meters. The deposits are thought to have major fractures.

Omnot hangain basin was not explored extensively. The coal found did not have great industrial use or value. Approximately 15 coal occurrences.

Omnogobi basin was known to have large deposits of high-value coal from the previous century. Tavan Tolgoi, Nomgon and Gurvantes have large coal seam thicknesses. At several seams, the thickness is up to 3,000 meters. (Punsalmaa, 1982)

The Orhon-Selenge basin was explored after 1970s, with the exception of Nalaikh coal mine. Coal formed from the Jurassic period is scattered over a large area. They do not have great economic value or usage.

Choir basin consists of large coal mines, such as Shivee-Ovoo and Baganuur. These are thought to be of great value. Coalfields such as Tsaidamnuur, Uvdug hudag, Ih ulaan nuur, and Tevshiin gobi are located within the basin, mainly providing thermal coal.

Choibalsan basin is thought to consist of over 20 coal occurrences.

Sukhbaatar basin was surveyed in the 1960s. Olziit and Talbulag coal deposits were documented.

Tamsag basin was explored in the 1930s, thanks to extensive surveying for oil.

Dornogobi basin has approximately 15 coal occurrences, which were documented during an extensive surveying for oil.

Dundgobi basin is thought to contain 10 coal occurrences.

3 COAL, ENERGY DEMAND AND SUPPLY IN MONGOLIA

3.1 Domestic Coal Market

3.1.1 Coal Demand Outlook

According to the National Statistics Committee Mongolian coal resources stands at 173.5 billion tonnes. In 2015, total coal production was 24.2 million tonnes and private owned mines produced 13.9 million tonnes compared to state owned mines at 10.3 million tonnes. In recent year, coal price has been on a downward trend.

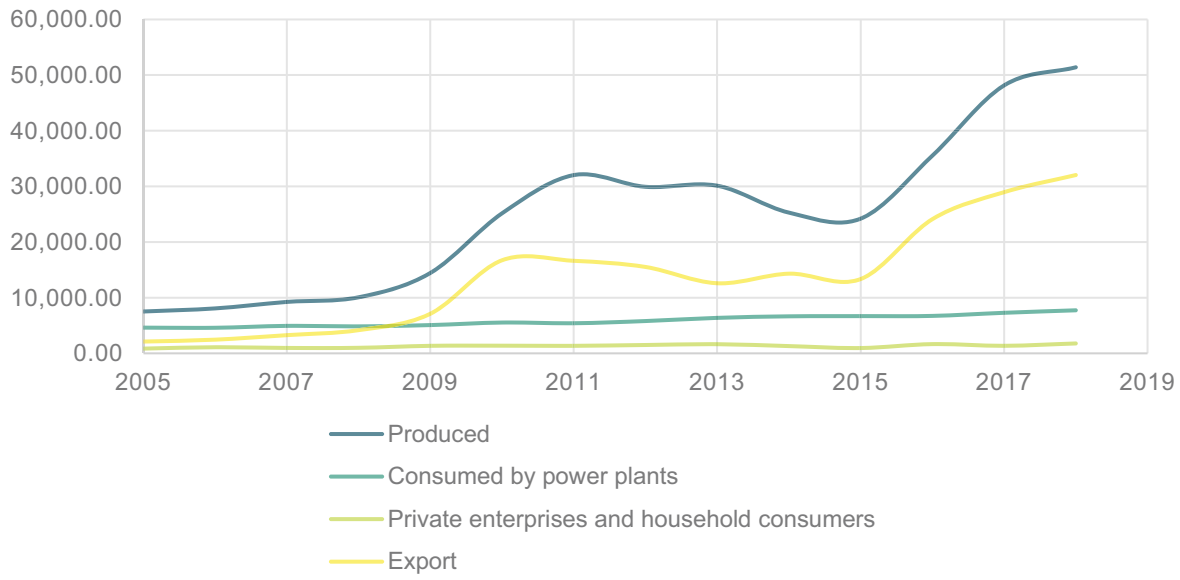
Coal accounts for majority of Mongolian export produces creating a coal heavy export dependent economy since 2011. Biggest importer of coal from Mongolia is China, accounting for 99% of total coal export.

		Thousand ton	Percentage
Export	Raw coal	32043.3	62.8%
Domestic consumption	Power Plant	7734.6	15.2%
	Private enterprise	9066.5	17.8%
	Household	1778.6	3.5%
Transport and storage loss		372.4	0.7%
Total		50995.4	100.0%

Source: Mongolian National Statistics Committee, 2018

Table 3-1. Mongolia's coal consumption, 2018

As shown in Table 3-1, total coal produced stands at 51 million tonnes, 32 million tonnes of coal were export and 18.5 million tonnes consumed domestically. Approximately 3.6 million tonnes were consumed by coal mines and about 0.37 million tonnes were accounted as transport and storage loss.



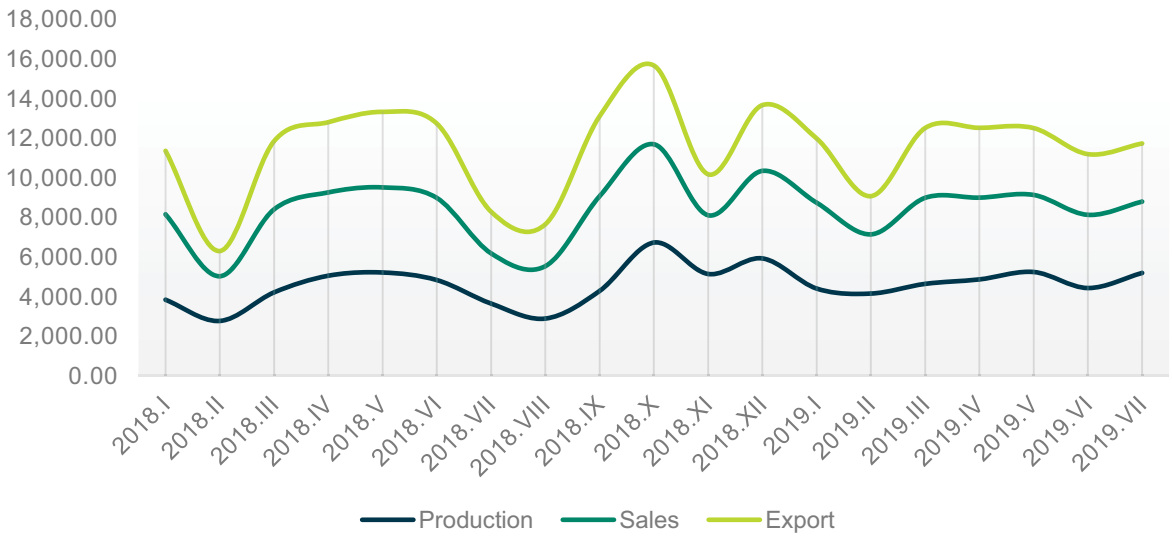
Source: Mongolian National Statistics Committee, 2018

Figure 3-1. Dynamic of coal balance, 2005-2019, thousand tonnes

Coal exports have peaked in 2011 and exported 21 million tonnes of coal. Coal exports continue to fluctuate since 2011. Domestic coal consumption is relatively stable and ranges from 6-8 million tonnes per year.

3.1.2 Coal consumption

Majority of Mongolian population resides in the capital, Ulaanbaatar, and in cold weather coal from mines Baganuur, Nalaikh and Shivee-Ovoo are primarily consumed. Sharyn Gol and Ukhaa Khudag coal mines were commissioned in 2010. Ukhaa Khudag coal mine is primarily export oriented. These coal mines accounted for 24 percent of the total coal produced and 33 percent in 2013.



Source: Mongolian National Statistics Committee, 2018

Figure 3-2. Coal export dynamics, 2005-2018, thousands tonnes

In recent years, fluctuating coal price have heavily affected the coal production.

3.1.3 Projected coal demand

The biggest coal consumers in Mongolia are the thermal power plants in operation. As of 2015, there are 17 major and minor thermal power plants in operation. Mongolian government have drafted a detailed proposal of building multiple thermal power plants in provincial centers in the next 10 years.

№	Name	Location	Mine 1	Mine 2	Annual capacity, mt
1	Thermal Power Plant	Bayanhongor, Bayanhongor sum	Uvurchuluun	Bayanteeg	28.0
2	Thermal Power Plant	Uvurkhangai, Arvaikheer sum	Bayanteeg		21.0
3	Thermal Power Plant	Khentii, Undurkhaan sum	Chandgana tal		27.6
4	Thermal Power Plant	Zavkhan, Uliastai sum	Mogoin gol		21.0
5	Thermal Power Plant	Arkhangai, Tsetserleg Sum	Bayanteeg	Ereen	24.0
6	Thermal Power Plant	Dundgovi, Mandalgovi sum	Tevshiin govi		32.2

7	Thermal Power Plant	Tuv, Zuunmod sum	Baganuur	Nalaikh	28.8
8	Thermal Power Plant	Govi Altai, Altai Sum	Zeegt	Maanit	29.8
		Total			211.6
9	Telmen	Zavkhan, Telmen Sum	Mogoin gol		270.0
10	Tavantolgoi	Umnugovi, Tsogttsetsii sum	Tavantolgoi		1420.0
11	Tsaidam	Tuv, Bayan sum	Tsaidam nuur		1530.0
12	Boorolj	Tuv, Bayan sum	Tugrug nuur		2490.0
13	Chandgana	Khentii, Murun Sum	Chandgana tal		3160
14	Erdenetsogt	Dornogovi, Altanshiree sum	Chandgana tal		2970
15	Shivee-Ovoo	Govisumber, Shiveegovi sum	Shivee-Ovoo		700
16	Erdenetsagaan	Sukhbaatar, Erdenetsagaan sum	Erdenetsagaan		72
		Total			12612

Source: Ministry of Mining and Heavy Industry, 2018

Table 3-2. Projected thermal power plants and their locations

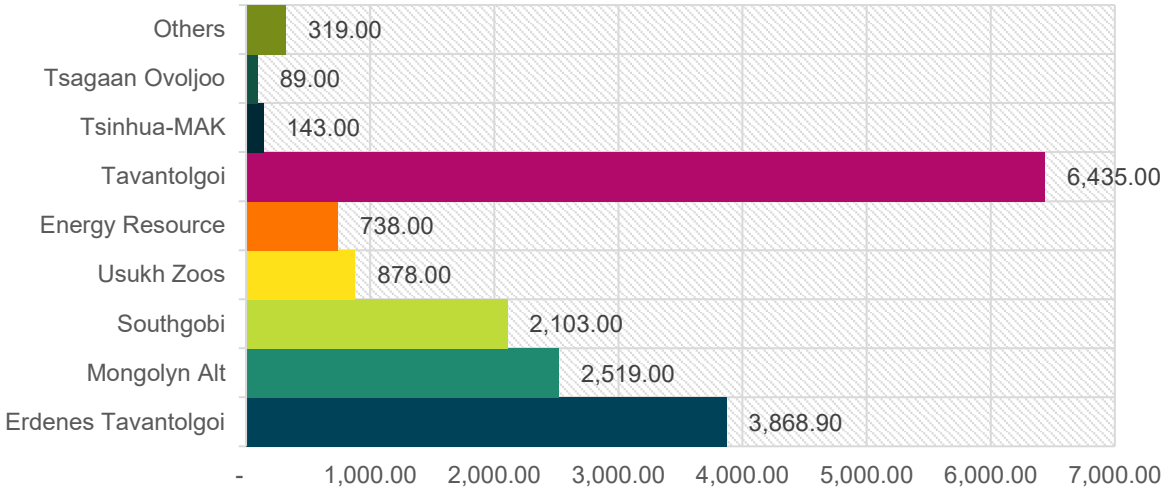
Half of the projected thermal power plants are to be erected alongside 8 major coal mines and the other half will be erected in provincial centers in the next 10 years. Thermal power plants that will be erected in the provincial centers will be state owned and as to the thermal power plants at the mines will be private enterprises. The annual coal demand of 700MW thermal power plant that will be built at Tavantolgoi coal mine is estimated to be at 1.42million tonnes.

The total coal demand of prospected thermal power plants in the next 10 years is estimated to be at 12.8mt. Therefore, Mongolian annual coal demand is to be increased by 12.8mt.

3.1.4 Coal supply capacity

Coal production in Mongolia have been on an upright trajectory in the last 10 years, hitting its maximum production of 32 million tonnes in 2011. In 2015, coal production was 24.2 million tonnes and the signs are that it will keep increasing for the foreseeable future. Biggest coal exporters such as Energy Resource, MAK, and other major coal mines

have concentrated their efforts towards Chinese and Japanese markets in recent years. Aspire Mining, Canadian invested coal mine, have exported to European markets through Russian ports in recent years. (Galsandorj, Tegshjargal, 2013)



Source: B. Gangaatar, Southern Mongolian energy demand and supply, forecast

Figure 3-3. Coal exports of major coal mines, thousand tonnes, as of 2017

As of 2019, 240 prospection licenses have been issued with 80 mining licenses all over the country. However, only 22 of the mining license owners are frequent submitters of their annual financial reports. As shown in Table 3-3, 3 of the major coal mines are suppliers of thermal power plants in the central power grid (Baganuur, Shivee Ovoo, Sharyn Gol). Total annual coal consumption of thermal power plants all over the nation stands at 6.7 million tonnes with 5.4 million tonnes consumed by the thermal power plants of the central grid.

№	Name	Capacity, mt	Deposit, mt	Location	Operation since
1	Baganuur	3.73	599	Ulaanbaatar, Baganuur	1978
2	Nalaikh	*	*	Ulaanbaatar, Nalaikh	1922
3	Sharyn Gol	0.76	146.3	Darkhan Uul, Sharyn Gol	1965
4	Shivee-Ovoo	1.74	564.70	Govisumber, Shiveegovi	1990

5	Tavantolgoi	757.2	Umnugovi, Tsogttsetsii	2005
***Out of 200 coal seams in only 26 are in artisanal operation and viable data cannot be acquired**				

Source: Moncoalia report, Renaissance capital

Table 3-3. Capacity and locations of major coal mines

Domestic coal supply is fulfilled mostly by Tavantolgoi and Sharyn Gol coal mines. National coal demand and supply can be allocated as the following:

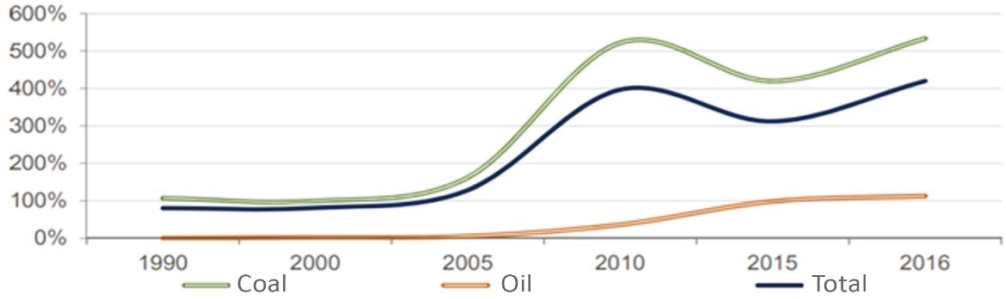
- Thermal power plant – Baganuur, Shivee-Ovoo, Sharyn Gol
- Enterprises and private sector – Nalaikh, Baganuur, Shivee-Ovoo
- Coal Producers– Tavantolgoi, Sharyn Gol

There is a growing sense among major coal players in Mongolia looking to export coal rather than focussing on the domestic market. Therefore, most of the coal mines can be found near the Mongolian and Chinese border, or in the Southern Gobi region.

3.2 Domestic energy market

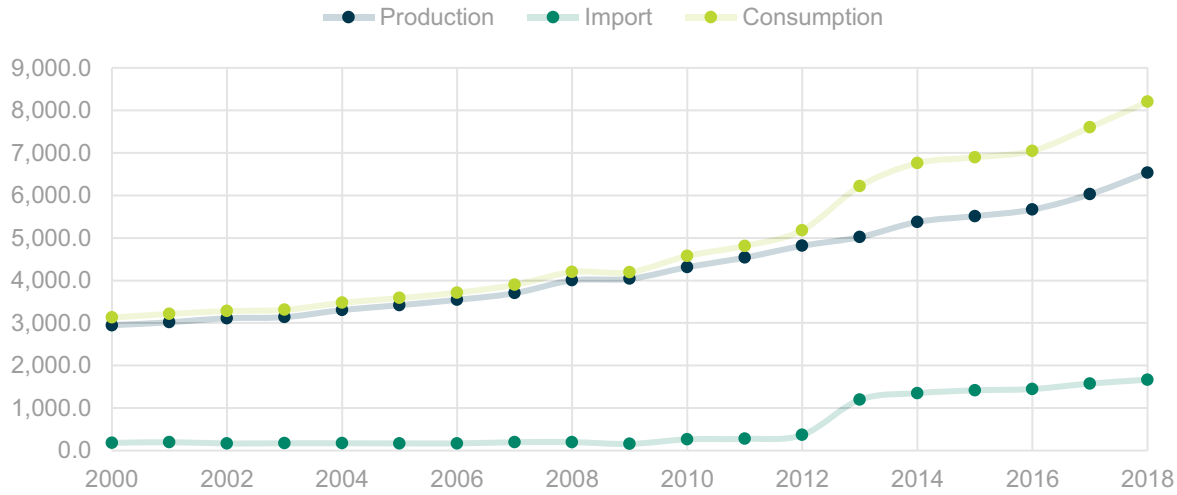
3.2.1 Energy consumption

Energy supply was inadequate between 1990 and 2000, but since 2005 the coal industry's production increase alone had surpassed the total domestic consumption, surpassed 4.2 times greater in 2016. The energy based export-oriented country is largely based on the mining sector, but the difference in productivity is different, Supply of petroleum products in Mongolia is 0 percent and its electricity supply is 76.4 percent.



Source: Source: IEA, Energy balance; Mongolian national statistics committee

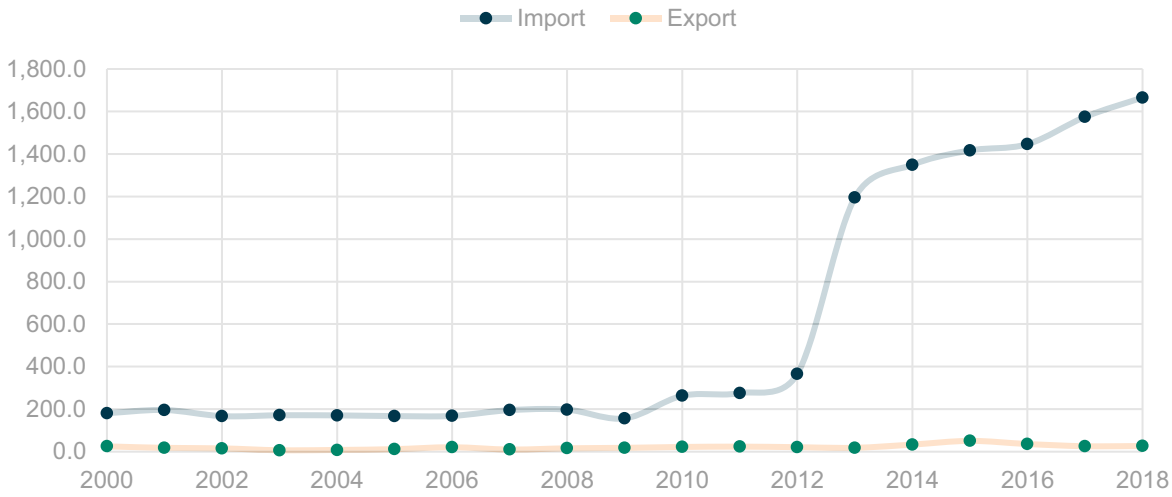
Figure 3-4. Energy supply, percentage, 1990-2016



Source: Mongolian National Statistics Committee, 2018

Figure 3-5. Energy production and demand, million kW*hr

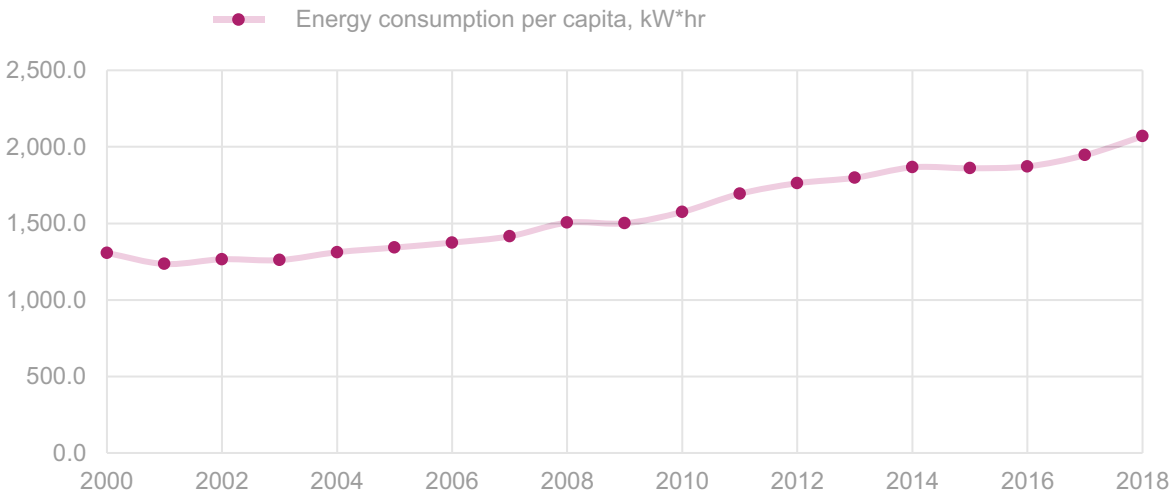
The following figure shows that the rapid increase in the commodity production since 2005 is largely dependent on import. Energy import increased by 18.6 times in 2005-2016, of which coal was 16.4 times higher and oil increased by 32.9 times. In the calculation of price, net imports are explained in net exports and in physical quantities.



Source: Mongolian National Statistics Committee, 2018

Figure 3-6. Electricity import and export, million kW*hr

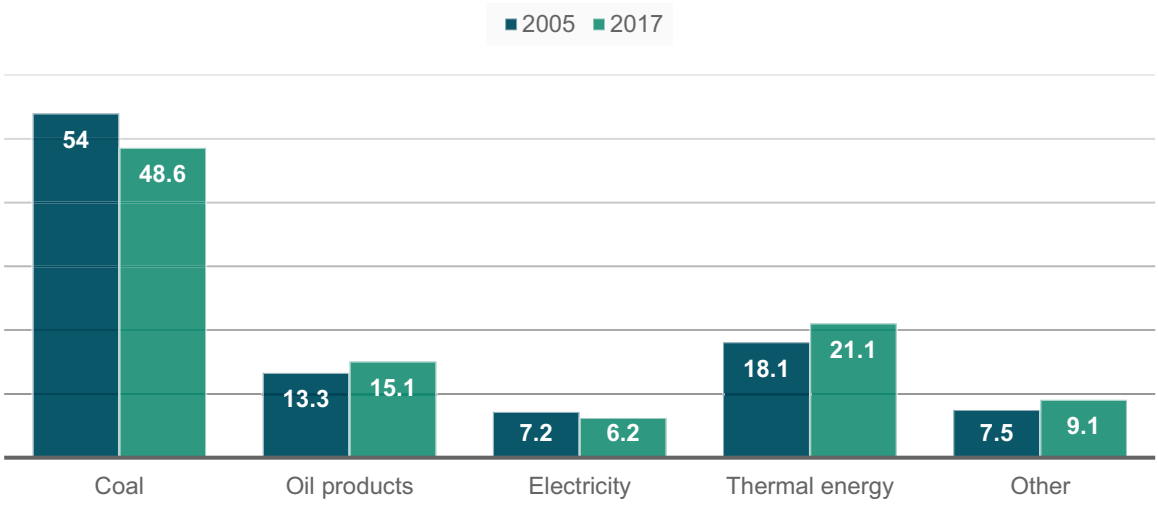
Energy consumption per capita increased by 57.4 percent since 2005 and electricity by 94.0 percent.



Source: Mongolian National Statistics Committee, 2018

Figure 3-7. Energy consumption per capita, kW*hr

Energy consumption have gradually increased over an 18-year period.



Source: IEA, Energy balance; Mongolian national statistics committee

Figure 3-8. Domestic energy source breakdown, percentage, by products, 2005 and 2017

3.2.2 Energy supply capacity

Mongolian energy grid is comprised of 3 grids: central, western and eastern grid. Thermal power plants in Ulaanbaatar, Darkhan and Erdenet make up the central energy grid. The aforementioned thermal power plants are operating in much higher capacity compared to the thermal power plants in western and eastern grids. There are total 17 thermal power plants and 4 retain highest of capacities in the country.

Note: Black dots represent active coal mines. Asphalt roads are in red, gravel in pink and railroad in black

Source: Economic Research Institute (ERI), 2017

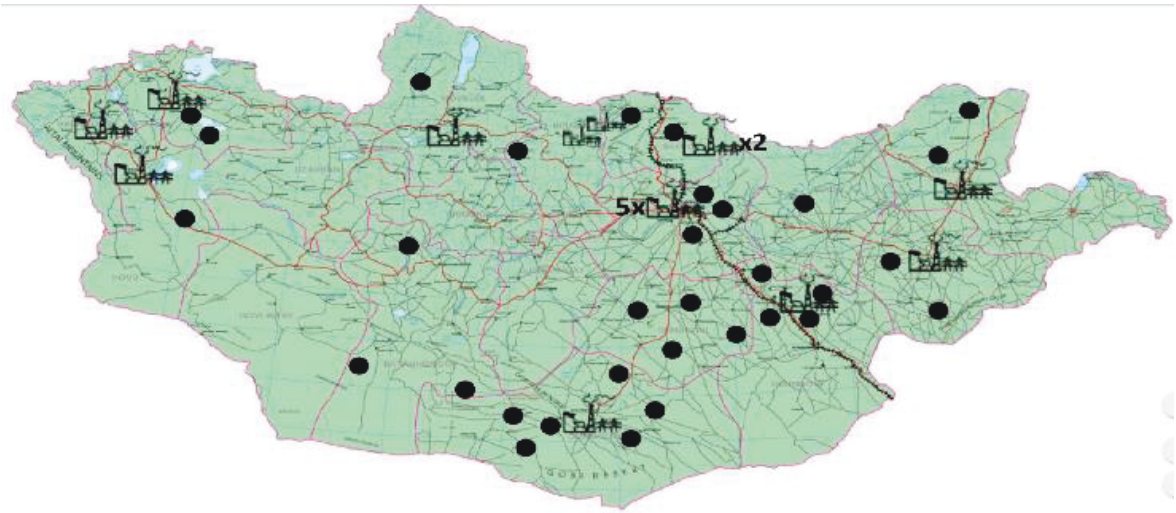


Figure 3-9. Mongolian road network, thermal power plant locations

№	Name	Ownership	Mine 1	Mine 2
1	Darkhan power plant	State owned	Sharyn Gol	Baganuur
2	Erdenet power plant	State owned	Sharyn Gol	Baganuur
3	Thermal power plant 4	State owned	Baganuur	Shivee Ovoo
4	Amgalan power plant	State owned	Shivee Ovoo	Baganuur
5	Thermal power plant 3	State owned	Baganuur	
6	Thermal power plant 2	State owned	Baganuur	
7	Choibalsan power plant	State owned	Aduun chuluu	
8	Dalanzadgad power plant	State owned	-	
9	Uvs power plant	Private	Hartarvagatai	
10	Bayan-Olgii power plant	Private	Nuurst hotgor	
11	Hovd power plant	Private	Hartarvagatai	
12	Selenge power plant	Private	Sharyn Gol	Ulaan ovoo
13	Sharyn Gol power plant	State owned	Sharyn Gol	
14	Dornogovi power plant	Private	Shivee Ovoo	
15	Sukhbaatar power plant	Private	Talbulan	
16	Huvsgul power plant	State owned	Mogoin gol	
17	Baganuur power plant	State owned	Baganuur	

Source: Economic Research Institute (ERI), 2017

Table 3-4. Relation between coal mines and power plants

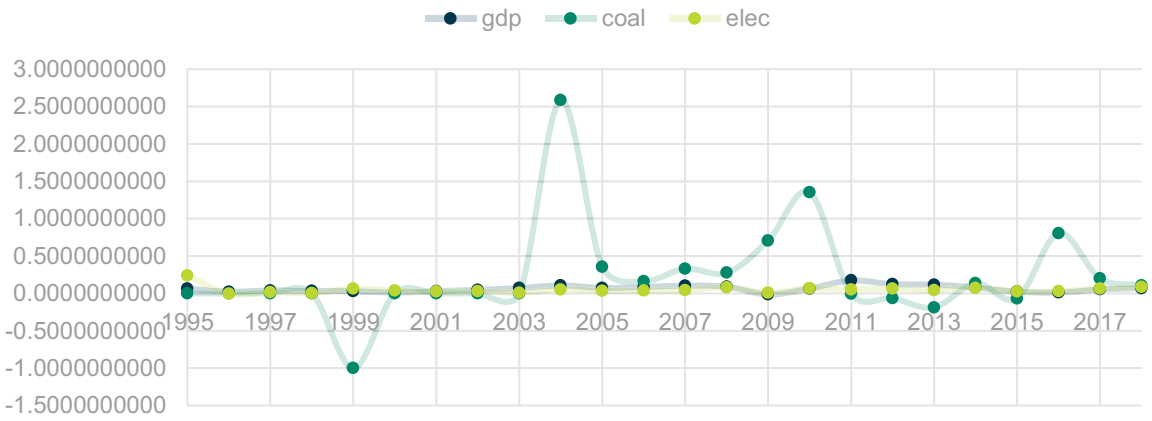
№	Power Plants	Supply percentage	Coal supply				Coal price per tonne, USD
			Thousand tonnes	Million tugrug	Coal price per tonne, tugrug	Coal production cost, tugrug per tonne	
			Baganuur				
1	TPP-4 JSC	60%	1635	43467	26588	29300	13.24$
2	TPP-3 JSC	100%	1267	33542	26480		
3	TPP-2 JSC	100%	225	5684	25321		
4	Darkhan TPP JSC	60%	108	2697	25069		
5	Amgalan power plant LLC	100%	39	1037	26590		
6	Baganuur TPP JSC	100%	59	1618	27612		
			Shivee-Ovoo				
1	TPP-4 JSC	40%	1700	35802	21060	21060	13.24$
			Sharyn Gol				
1	Darkhan TPP JSC		273	7664	28093	28065	13.24$
2	Erdenet TPP JSC		286	8026	28037		

Source: ERI, 2017

Figure 3-10. Capacity of operational power plants

3.3 Impacts on the mining industry

This section explores how the Mongolian industry and mining sector affects the economy.



Source: Mongolian National Statistics Committee, 1212.mn

Figure 3-11. Mongolia's GDP growth, coal exports and energy production growth

Covariance Analysis: Ordinary
Date: 09/15/19 Time: 22:44
Sample: 1995 2018
Included observations: 24

Correlation Probability	GDP	COAL	ELEC
GDP	1.000000 -----		
COAL	0.256617 0.0200	1.000000 -----	
ELEC	0.059198 0.0213	-0.014951 0.9447	1.000000 -----

Table 3-5. Correlation matrix

The above correlation matrix shows that coal exports are strongly correlated with gross domestic product, while electricity production has weak correlation.

4 SITUATION IN NEIGHBOURING COUNTRIES WITH RESPECT TO COAL/ ENERGY SUPPLY FROM MONGOLIA

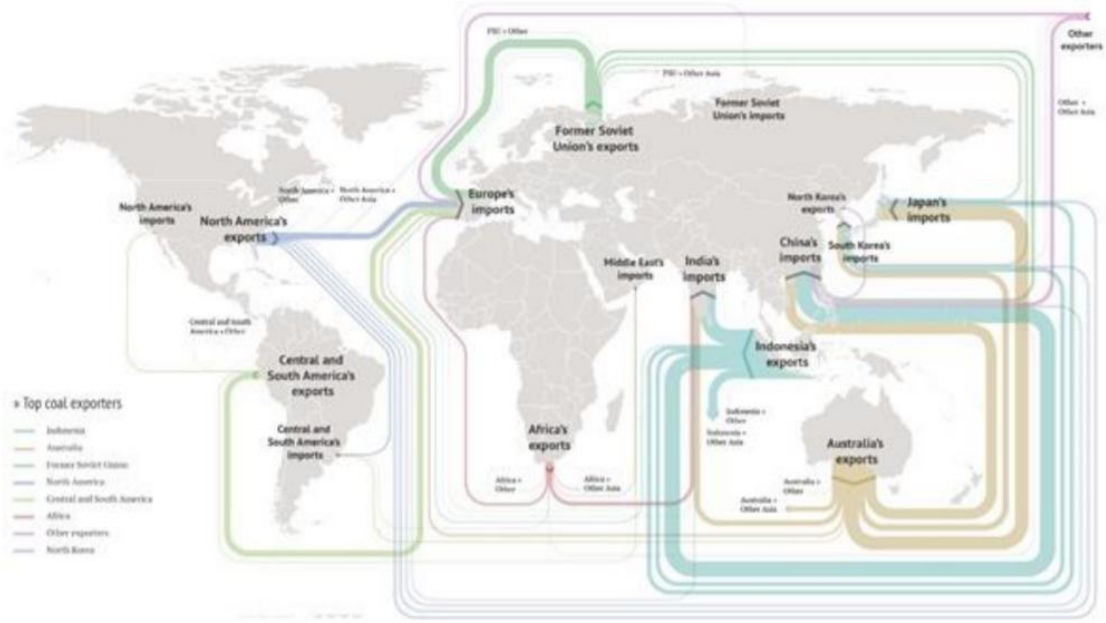
4.1 Outlook of coal demand in foreign markets

4.1.1 General information

The major coal exporters in the world are Australia, Indonesia, USA and Russia. On the other hand, major importers are China, Japan, Europe, USA, and South Korea, with contrasting consumers such as thermal power plants and steel plants.

China and India have become major coal producers, however, the domestic demand is so high the production do not cover it wholly. Therefore, coal import has increased enormously in recent years. World coal market is a highly competitive one that is regulated by differing coal consumers in Japan, China, USA and European countries.

In recent years, Japan has moved towards developing thermal power plants and renewable energy source due to high risk of nuclear power plants that have devastated the country. Coal has become the main source of energy to cope with increased energy demand in Indonesia and India. However, the US and China have become less reliant on coal as primary energy source by investing heavily on renewable energy source in recent years.

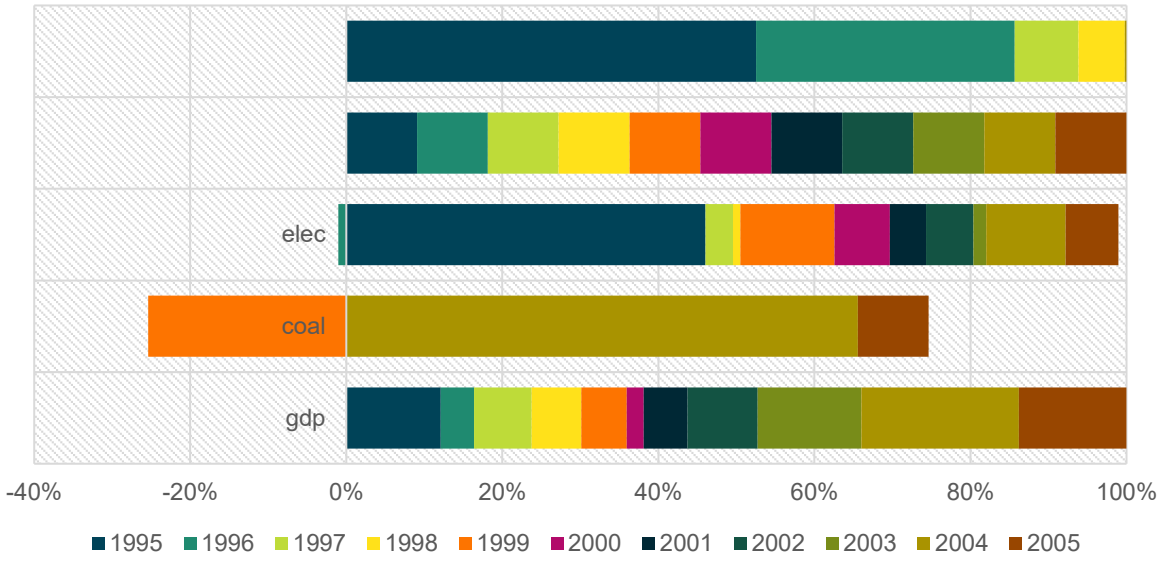


Source: International Energy Agency (IEA), 2018

Figure 4-1. World coal market

4.1.2 Coal import and export

Coal demand has decreased over the years around the world. In 2014, world coal consumption was 7,860 million tonnes and it decreased to 7,670 million tonnes in 2016, illustrating the decrease. The Chinese state have focused their efforts in decreasing coal consumption and in 5 years have successfully lowered consumption by 8.1%. The US have, in similar timeframe, decreased their coal consumption by 18.7%. India, on other hand, increased their consumption by 18.7% due to growing demand for energy caused by India's economic growth. There is a growing trend that economically developed countries are moving away from coal as primary energy source, however, growing economies are consuming more coal by the year.



Source: International Energy Agency, 2018

Figure 4-2. Coal demand, million tonnes

Countries	2014	2015	2016	2017	2018
China	3764	3625	3596	3542	3460
India	864	906	960	1008	1056
USA	835	730	666	676	679
Russia	227	230	234	240	247
Germany	227	225	220	217	215
Japan	205	202	203	202	201
South Africa	189	179	185	192	199
South Korea	131	131	135	138	142
Poland	134	135	135	135	135
Australia	122	127	127	128	128
Others	1161	1141	1149	1177	1208
World	7860	7631	7608	7656	7670
Increase, %	-0.2	-2.9	-0.3	0.6	0.2

Source: IEA, 2018

Table 4-1. Coal demand, million tonnes

Import	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Increase
Canada	16.1	8.5	8.7	5.6	5.5	5.2	6.1	5.2	4.4	5.2	5.5	5.8%
Mexico	3.1	4.2	5.2	4.9	5.2	4.8	5.3	5.4	5.1	8.2	5.8	-29.3%
USA	22.3	13.6	12.1	8.5	6.3	5.6	6.7	6.7	6	4.6	2.6	-43.5%
North and Central America	23.6	16	20.3	23.6	21	25.2	25.3	24	25.3	28.9	26.6	-8.0%
Europe	147.3	119.5	115.1	134.6	145.5	139.7	145.3	143.8	128.8	139.9	149.6	6.9%
CIS	16.3	12.4	8.9	14.1	12.6	13.3	13.3	12.7	11.6	13.4	14.5	8.2%
Middle East	11.9	9.6	8.4	10.3	11.6	10.5	11.7	8.9	8.2	8.2	7.9	-3.7%
Africa	6.6	5.3	7.6	8.3	7.4	19.7	9.2	10.9	11.8	13.5	14.4	6.7%
China	25	78.3	106.2	124.2	160.2	182.1	158.2	111.9	135	140.1	146.5	4.6%
India	30.9	36	47.8	56.6	73.7	87.3	110.5	115.1	110.8	113	141.7	25.4%
Japan	120.1	100.8	115.6	110.2	116.3	120.9	119.5	120.6	119.8	120.9	119.7	-1.0%
South Korea	63.8	65	74.7	80.1	76.3	77.6	81.1	84.4	85.7	92.2	92.7	0.5%
Pacific	70.1	66	76	78.6	87.2	86.3	65.2	94.7	109.5	118.5	131.1	10.6%
Total	557	535.3	606.6	659.7	728.8	778.3	757.4	744.2	762	806.6	858.8	6.5%
Export	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Increase
Canada	18.6	17	19.9	20.9	20.1	23.6	20.1	18.1	18.1	19.6	21	7.1%
USA	49.9	35.1	49.9	62.1	73.2	70	59	46.5	36.8	59.7	66.3	11.1%
Columbia	47.2	39	42.5	48.2	53.8	48.7	54.2	52.2	56.2	59.1	46.7	-21.0%

Europe	6	5.5	3	3.8	4.7	16.2	3.1	2.3	3.2	4.6	6.2	34.8%
Russia	56.5	58.6	59.8	68.2	77.2	84.9	90.3	98	106.8	120.5	136.2	13.0%
CIS	15.4	11.9	8.4	13.8	12	12.1	12.2	11.5	10.7	11.3	11.9	5.3%
North America	34.6	37.2	47	48.9	52.3	50.1	52.1	55.1	51.6	56.4	49.2	-12.8%
South Africa	0.7	0.6	2.6	1.1	3.1	2.7	4.1	4.3	4.7	7.7	5.3	-31.2%
Australia	156.7	167.7	178.8	168.8	190.7	220.2	218.6	238.4	236.3	232.2	249.4	7.4%
China	37.4	14.2	14	10.6	6.7	6.8	8.5	10.8	12.2	9.9	9.9	0.0%
Indonesia	110.4	121.1	148	171.6	195	204.7	201.2	178.7	184.7	193.1	220.3	14.1%
Mongolia	2.8	4.1	11.4	13.9	14.9	11.7	12.7	9.7	17.5	22.6	23.9	5.8%
Pacific	15.7	19.5	18.3	24	21.5	22.1	18.3	15.6	18.4	7.1	9.5	33.8%
Other	5.1	3.6	3.1	3.8	3.5	4.5	3.1	2.8	4.8	2.8	3.3	17.9%
Total	557	535.3	606.6	659.7	728.8	778.3	757.4	744.2	762	806.6	858.8	6.5%

Source: BP Energy Outlook, 2019

Table 4-2. Coal import and export, million tonnes oil equivalent

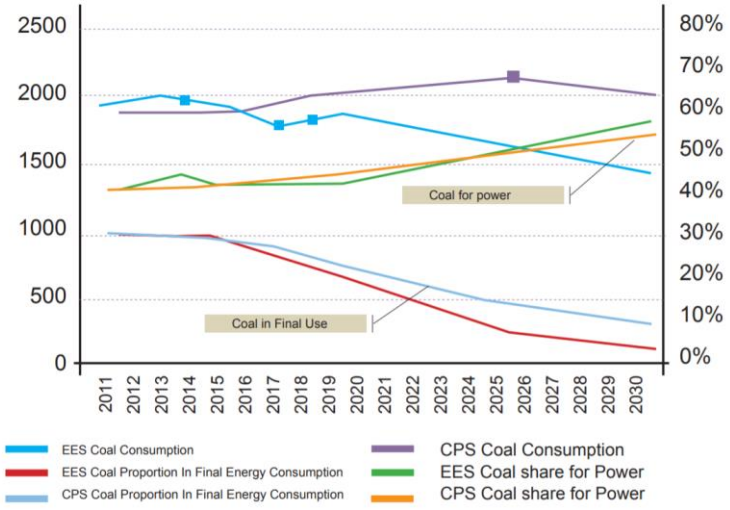
4.1.3 Coal consumption in China

China is the biggest coal consumer and producer in the world, and it look as though coal will play a pivotal role in Chinese economic growth.

However, coal's effect on the planets environment cannot be overstated. There is a global initiative to reduce greenhouse gas from burning fossil fuel especially coal as primary energy source. China, in recent years, have closed out of date power plants and small scale mining operations.

According to the current policy implementation, coal consumption will be stable until 2025. The energy-ecological approach proposed by the Chinese Academy of Sciences predict consumption will increase by small percentage until 2020 and decrease slowly afterwards. To achieve this, ultimately the reduction of coal consumption at the consumer level will result in a major outcome. Today, 28% of the total coal is consumed by the end users, it is hoped the percentage will reach 0% by 2020.

However, China is looking produce more energy from thermal power plants. Currently, 40% of coal produced is being used by power plants in China and it is estimated the number will increase to 50% to 60% by 2030.

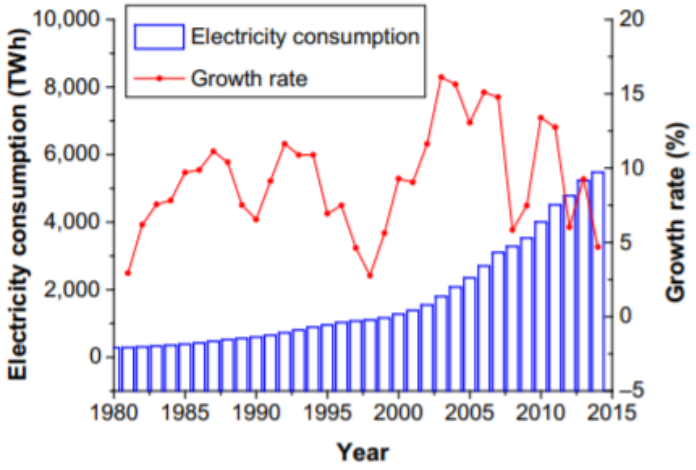


Source: Chinese national statistics committee, 2018

Figure 4-3. China's coal consumption, mtoe

4.2 Energy demand outlook in foreign markets

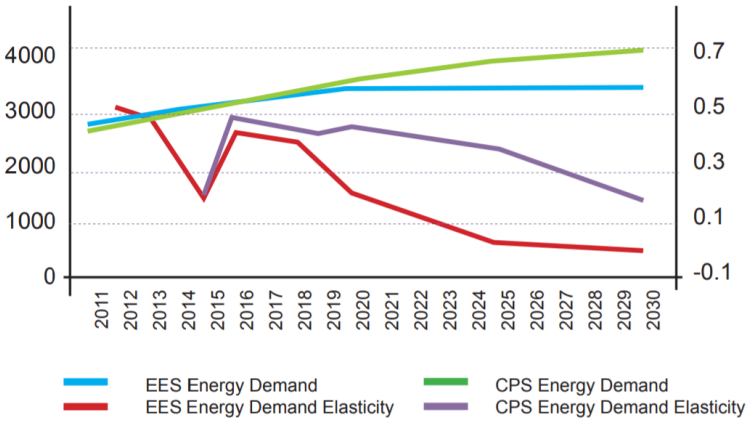
In the 35 years Chinese energy consumption was in constant increase. In recent years, energy consumption in China decreased moderately it is estimated the total energy consumption will hit 12,000 terawatt*hr by 2030.



Source: Chinese national statistics committee, 2018

Figure 4-4. China's energy consumption growth

Chinese energy consumption will reach its highest level in 2019 and further increase is not expected. According to researchers, energy consumption is about to be reduced due to slow economic growth, energy efficiency increase and energy sector restructures.

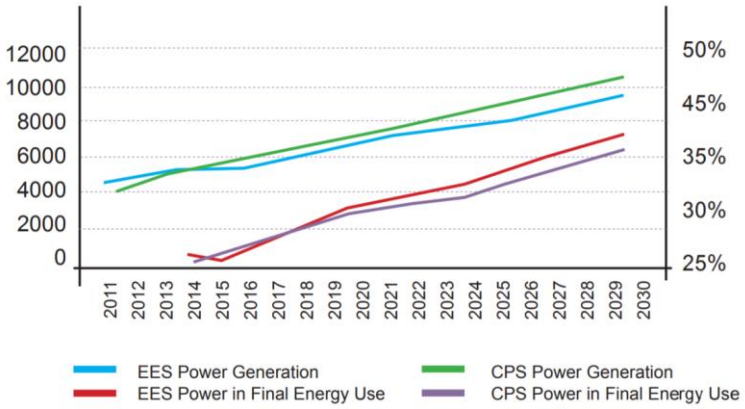


Source: Chinese national statistics committee, 2018

Figure 4-5. China's energy consumption forecast, million MW

Energy production in China have been stable in the last 2 years with a slight over production. Increase in energy production is not expected until 2030.

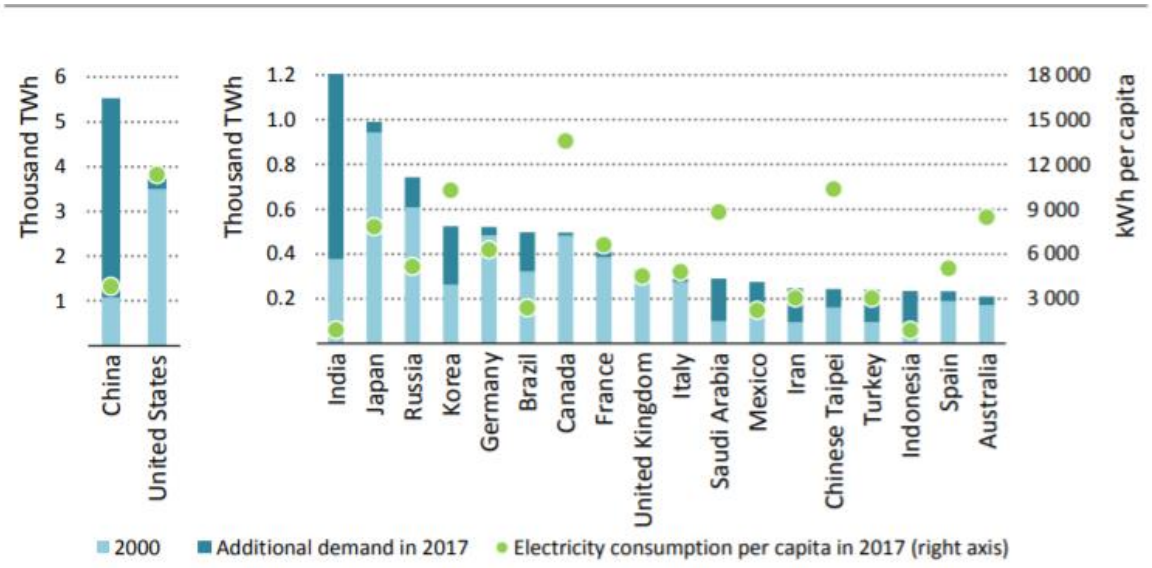
Therefore, the capacity of the power plants is not to be increased, but the capacity of the power plant is to be fully utilized to increase the energy consumption of end users or to "reduce energy demand and reduce energy production."



Source: Chinese national statistics committee, 2018

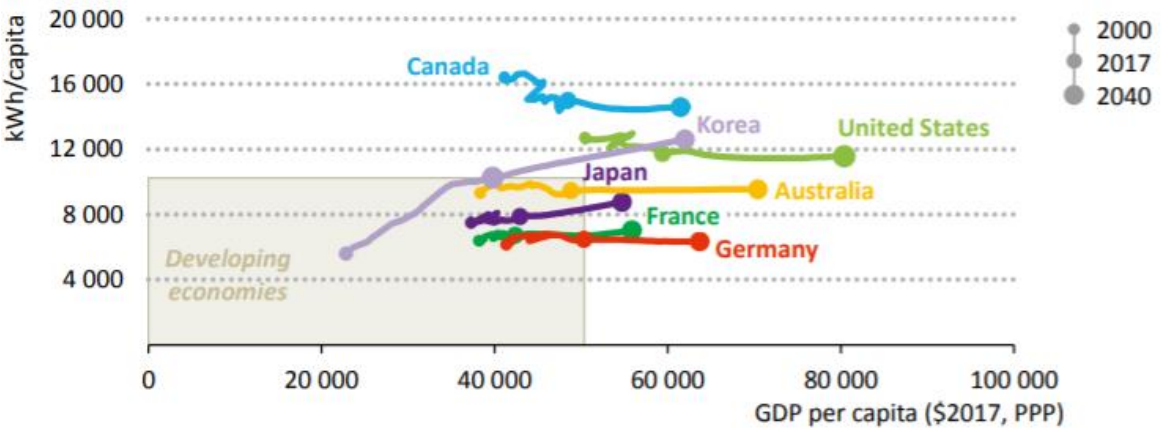
Figure 4-6. China's energy demand and supply forecast, TWh

Energy consumption in Asian countries have spiked in recent years especially in China and it looks as though the trend will continue. Similar trend is true when talking about India, South Korea and Japan.



Source: IEA, 2018

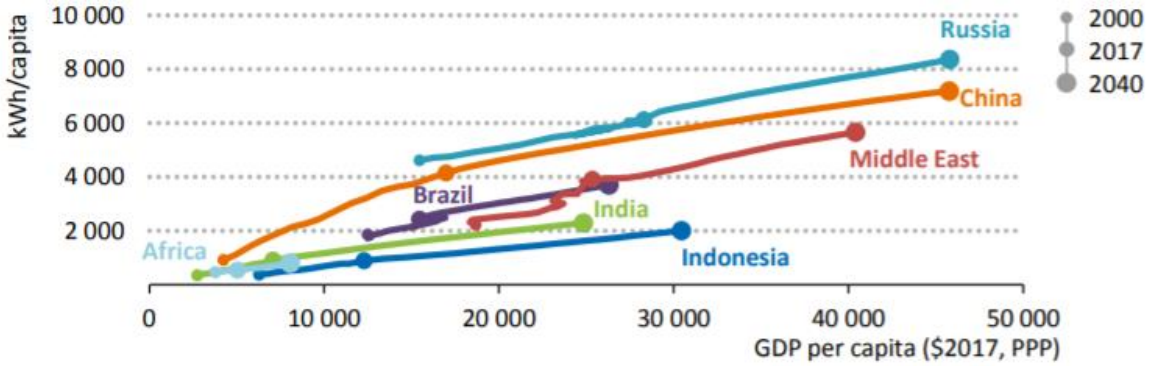
Figure 4-7. Top 20 energy consumers in the world, 2000-2017



Source: International Energy Agency, 2018

Figure 4-8. GDP growth in relation with energy demand in developed countries

Energy consumption in economically developed countries such as Japan and South Korea is expected to increase in the future. It is estimated South Korea's energy consumption will increase by 30% and Japanese energy consumption by 13% by the year 2040.



Source: IEA, 2018

Figure 4-9. GDP growth in relation with energy demand forecast in developing countries

The increase can be witnessed in developing economies even more. Energy consumption per capita in Russia will increase by 40% and in China by 90% by 2040.

5 EXPORT OPPORTUNITIES FOR REFINED COAL

5.1 Introduction

This chapter will provide a feasibility study for exporting coal efficiently in relation to the development of the Mongolian coal sector. It will examine the countries where there is potential for future cooperation from countries where coal can be exported. Because of long-term planning, coal price research is essential. Coal price surveys can be used to measure the economics of time series. Based on these items, a general export plan will be developed. Concentrated or washed coal export planning has been implemented in three scenarios, which is in line with the specific industry sector of the exporting country.

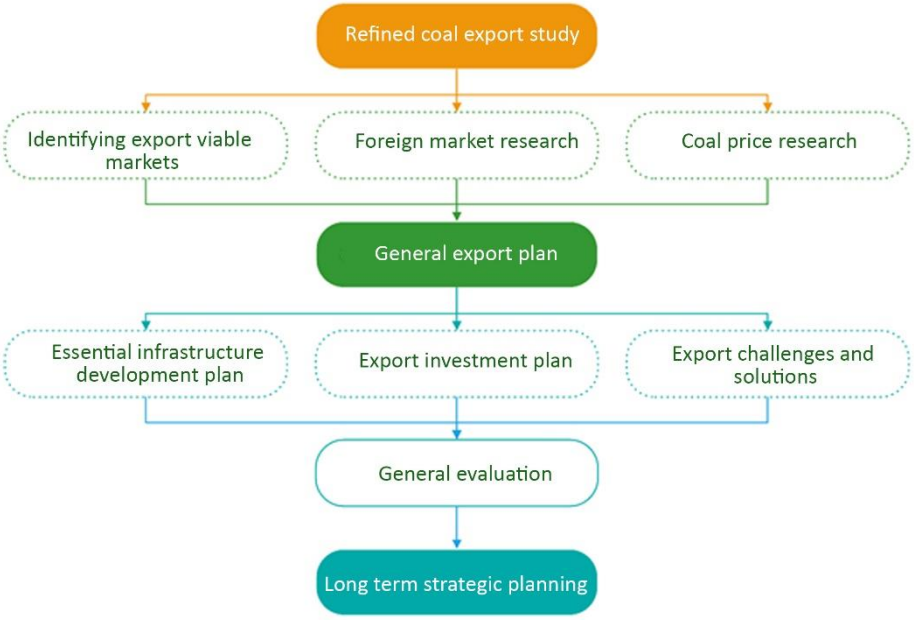


Figure 5-1. Chapter structure

In order to export refined coal, the processing factory and transport infrastructure are required and five routes are considered. Challenges that may be faced by the project was also investigated. The final conclusion of the refined coal export is presented in the final section of the chapter.

5.2 Study on export countries

Coal was previously exported to the countries in Table 5-1 therefore conditions for future export exists.

№	Country	Border share	Advantage	Disadvantage
1	China	Yes	Economy and industry growing intensively	Plans to reduce raw coal import
2	Russia	Yes	Economy and industry growing intensively	Industry based on natural gas and oil
3	Singapore	No	Economic capacity	High logistics cost
4	Japan	No	Growing coal demand	High logistics cost
5	Hong Kong	No	Economic capacity	High logistics cost
6	Great Britain	No	Economic capacity	High logistics cost

Table 5-1. Export countries

With current economic conditions and infrastructure China is the primary importer of Mongolian coal. Shipping and port costs of exporting coal to China and Russia can be seen in this chapter.

Coal market has changed over the years, shown in the 2018 report by the International Energy Agency.

From/To	Canada	Mexico	USA	South and Central America	Europe	CIS	Middle East	Africa	China	India	Japan	South Korea	Pacific	Total
Canada			0.4	0.9	3.6			0.1	1.8	2.4	5.2	3.4	3	20.8
USA	4.1	2.3		6.9	27.6		0.1	3.7	1.5	9.9	7.6	1.8	0.8	66.3
Columbia	1.2	2.7	1.2	10.5	23.1		3.2	0.3	0.2	0.4	0.8	2.6	0.4	46.6
Europe		0.1	0.1	0.3		2.6	0.2	0.6		1.8		0.1	0.5	6.3
Russia	0.1			1.7	66	2.2	1.7	2.4	17.1	2.9	11.7	17.8	12.6	136.2
CIS					2.2	9.6			0.1					11.9
South America			0.3	0.6	5.1		1.5	5.4		22	0.1	4.3	9.9	49.2
North Africa				0.4	2.2		0.8	0.6		0.1	0.4	0.1	0.7	5.3
Australia		0.5		4.1	14.6		0.2	0.6	51.8	30.2	73.1	37.2	37.1	249.4
China		0.2		0.5	0.7	0.1	0.2	0.4		1.3	2.2	1.6	2.5	9.7
Indonesia			0.4	0.6	3.2		0.1	0.1	45.9	66.7	17.8	22.9	62.6	220.3
Mongolia					0.3				23.3		0.1		0.2	23.9
Pacific				0.2	0.4			0.1	4.8	3.3	0.7	0.8	0.9	11.2
Other					0.5					0.7		0.1		1.3
Total	5.4	5.8	2.4	26.7	149.5	14.5	8	14.3	146.5	141.7	119.7	92.7	131.2	858.4

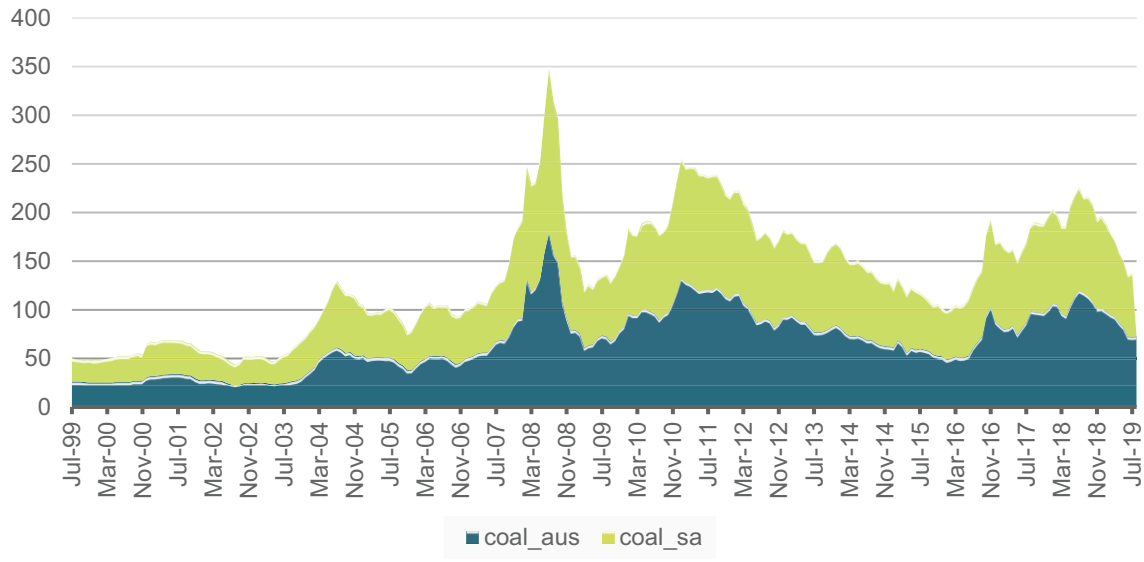
Source: IEA, 2018

Table 5-2. Coal trade movement, percentage

As shown in Table 5-2, China has been the primary import of coal from Mongolia and the cooperation can be assumed it will continue in the future. Coal export to Europe increased by 0.3%, to Japan by 0.1%, while to China 23.3% therefore import to China should take priority.

5.3 Coal market price study

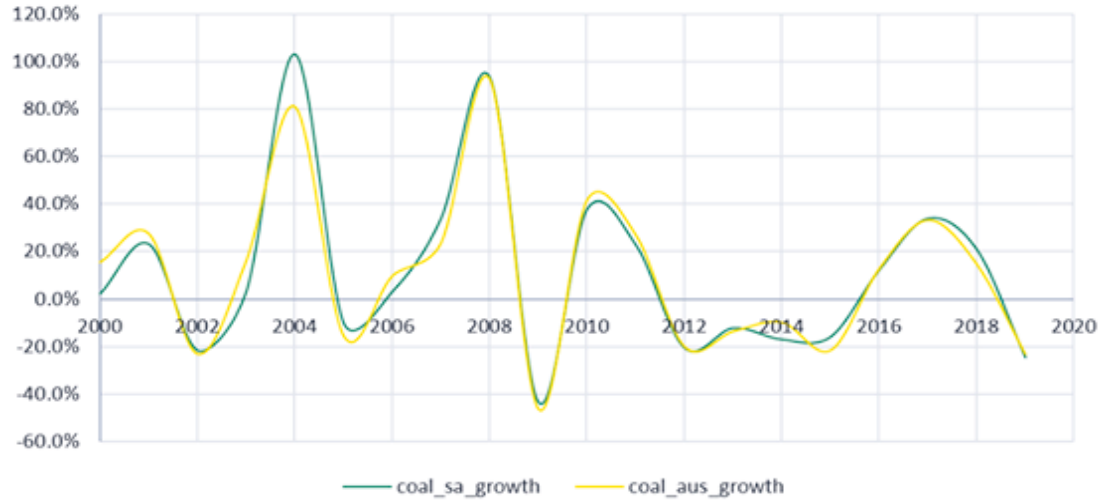
Coking coal price was highest in 2008 with peaks in 2011 and 2018. Coal price in 2019 have reached 80$ and international firms have predicted it will rise even further. (Fitch, 2018)



Source: tradingeconomics.com

Note: coal_aus – Australian coal, coal_sa – South African coal

Figure 5-2. Coking coal on the global market, USD/tonne



Note: coal_aus_growth – Australian coal, coal_sa_growth – South African coal

Figure 5-3. Coking coal price fluctuation, %

Coal price volatility was high in 2000 and the deviation of growth gradually reduced. The percentage change in average values is 11 percent, and it is necessary to examine the timeframe for the time series.

Null Hypothesis: D(COAL_AUS) has a unit root

Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=14)

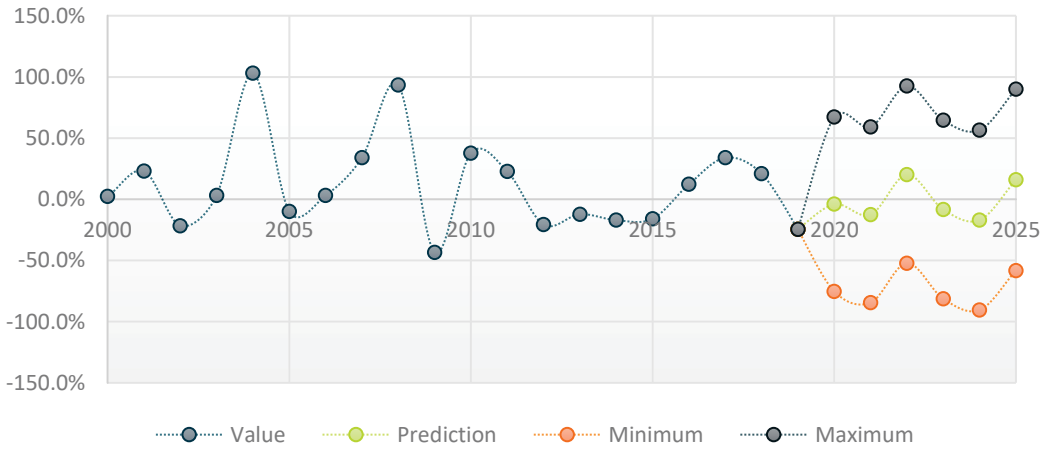
		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-11.58848	0.0000
Test critical values:	1% level	-3.457630	
	5% level	-2.873440	
	10% level	-2.573187	

*MacKinnon (1996) one-sided p-values.

Source: Calculation using Eviews 10

Table 5-3. Coal price time series unit root test

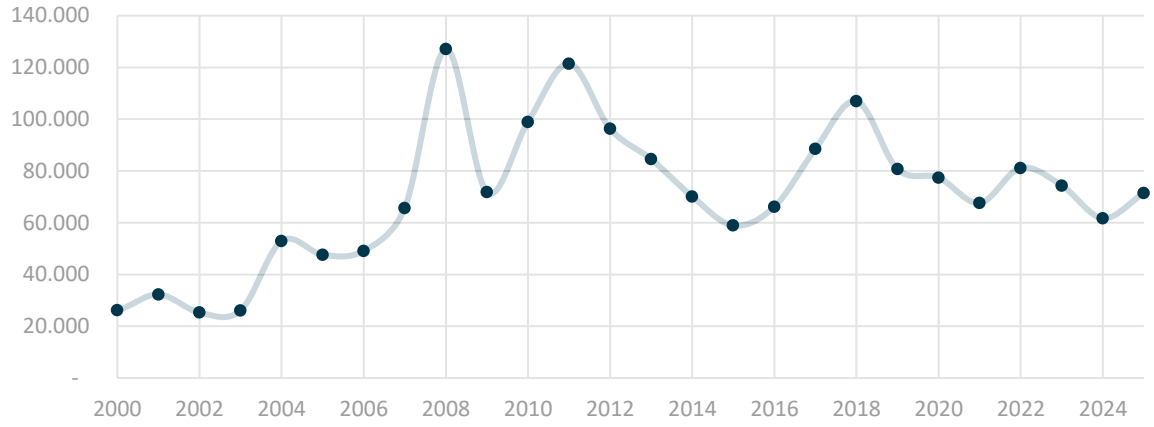
It is probable that the time series will be stable (100% -0%) = 0% and that price fluctuations are stable. Therefore, the Eviews econometric analysis program incorporates the time series of coal into the future price forecast.



Source: Calculation using Eviews 10

Figure 5-4. Coal price prediction, %

Time below shows the forecasted coal price.



Source: Calculation using Eviews 10

Figure 5-5. Coal price prediction, USD/tonne

5.4 General Export Plan

5.4.1 Scenario analysis

China's coking coal demand is highly dependent on steel industry. Therefore, coking coal demand Coking coal demand was estimated in 3 scenarios considering steel industry development. Results can be seen in the following table.

Scenario 1: Steel industry will decline

Scenario 2: Steel industry will rise

Scenario 3: Steel industry will decline after 2021.

Steel industry	2006	2010	2011	2019	2020	2025	2030	2035
Scenario 1	422,660	626,959	689,655	673,921	640,892	579,315	510,432	473,281
Scenario 2	422,660	626,959	689,655	689,655	689,655	689,655	689,655	689,655
Scenario 3	422,660	626,959	689,655	746,288	776,514	738,457	702,266	667,848
Coking coal demand	2006	2010	2011	2019	2020	2025	2030	2035
Scenario 1	408,130	527,100	583,930	565,913	534,663	483,795	429,648	398,889
Scenario 2	408,130	527,100	583,930	577,481	569,808	561,724	553,632	545,442

Scenario 3	408,130	527,100	583,930	651,812	701,692	660,754	622,497	586,669
Coking coal import	2006	2010	2011	2019	2020	2025	2030	2035
Scenario 1	4,662	47,269	44,658	56,591	53,466	45,961	38,668	31,911
Scenario 2	4,662	47,269	44,658	57,748	56,981	46,172	55,363	54,544
Scenario 3	4,662	47,269	44,658	67,788	76,484	69,379	62,782	56,907

Table 5-4. China's coking coal demand and import

5.4.2 Coal import

Table below shows the percentage of coking coal import in China's total import. The following was used for analysis:

Scenario 1: Coking coal demand drops with import share dropping.

Scenario 2: China's domestic demand drop by 10%.

Scenario 3: China's domestic demand rises until 2020 and drops afterwards.

	2011	2019	2020	2025	2030	2035
Scenario 1	8%	10%	10%	10%	9%	8%
Scenario 2	8%	10%	10%	10%	10%	10%
Scenario 3	8%	10%	10%	11%	10%	10%

Table 5-5. Coking coal import in relation to total import

5.4.3 Mongolia's export capacity projection

The table below shows the Mongolian export forecast and the share of Chinese imports. By 2020, the maximum export volume will reach 38 million tonnes and the second scenario the export is 45 million tonnes in 2025. In the third scenario, exports will reach 53.5 million tonnes in 2020. These figures are calculated for refined coal.

Scenario	Indicator	2019	2020	2025	2030	2035
Scenario 1	China's coking coal import	69,954	66,114	70,020	66,019	56,840
	Mongolian coking coal export	30,150	35,834	42,012	46,214	45,472
	Share	43.10%	54.20%	60.00%	70.00%	80.00%
Scenario 2	China's coking coal import	71,108	70,116	56,772	61,377	65,005
	Mongolian coking coal export	30,150	36,180	42,579	49,101	55,254
	Share	42.40%	51.60%	75.00%	80.00%	85.00%
Scenario 3	China's coking coal import	78,109	87,968	78,060	76,957	79,896
	Mongolian coking coal export	30,150	38,090	46,836	61,566	55,927
	Share	38.60%	43.30%	60.00%	80.00%	70.00%

Table 5-6. Export scenario analysis

5.4.4 Coal mines' export capacity study

The following table shows the capacity of major coal mines. As the previous section, China's exports of refined coal export is around 40-50 million tonnes.

№	Mine	2025 production, thousand tonnes	
		Raw coal	Refined coal
1	Shivee-Ovoo	6400	5120
2	Tavantolgoi	20000	16000
3	Baganuur	2400	1920

Table 5-7. Mine capacity prediction, thousand tonnes

5.5 Required infrastructure development plan

5.5.1 Comparison of railroad and road transportation

There are two possibilities to successfully transport refined coal to China via railroad and asphalt road. However, with railroad the amount of transport can be 4 times compared to asphalt road making railroad the more efficient choice.

Prerequisites:

- Construction cost of 1km railroad is 2 million USD, with asphalt road at 500,000USD per km.

- Operation costs will be 3 cents per tonne for railroad and 8.5 cents per tonne for asphalt road.

5.5.2 Railroad development plan

The State have developed a plan to build about 1800km of railroad within 2020, within two phases. If the project is completed it is estimated railroad capacity will reach approximately 66 million tonnes. The cost of completion stands at 4.5 billion USD.

Phase	Route	Distance	Annual transport capacity
1	Tavantolgoi – Sainshand	468	24.7
	Sainshand – Huut	450	15.7
	Huut – Choibalsan	155	0.5
2	Huut – Numrug	380	15.2
	Sainshand – Zamyn Uud		1.0
	Sainshand – Sukhbaatar		8.0
	Tavantolgoi - Gashuunsukhait	267	18.1
	Nariinsukhait – Shiveekhuren	46	23.2
	Total	1766	66.0

Figure 5-5. Railway development plan

Figure 5-6. Projected railroad network

5.5.3 Coal logistics

Proposed coal transport routes:

Route 1: Nariinsukhait – Shiveekhuren – Huang Hua

Route 2: Tavantolgoi – Gashuunsukhait - Tianjin

Route 3: Tavantolgoi – Gashuunsukhait - Qinhundao

Route 4: Tavantolgoi – Bichigt – Jinzhao

Route 5: Tavantolgoi – Sukhbaatar - Slavyanka

The routes are illustrated on the below figure, Railroad is comparatively low cost therefore, railroad is the primary choice of transport.

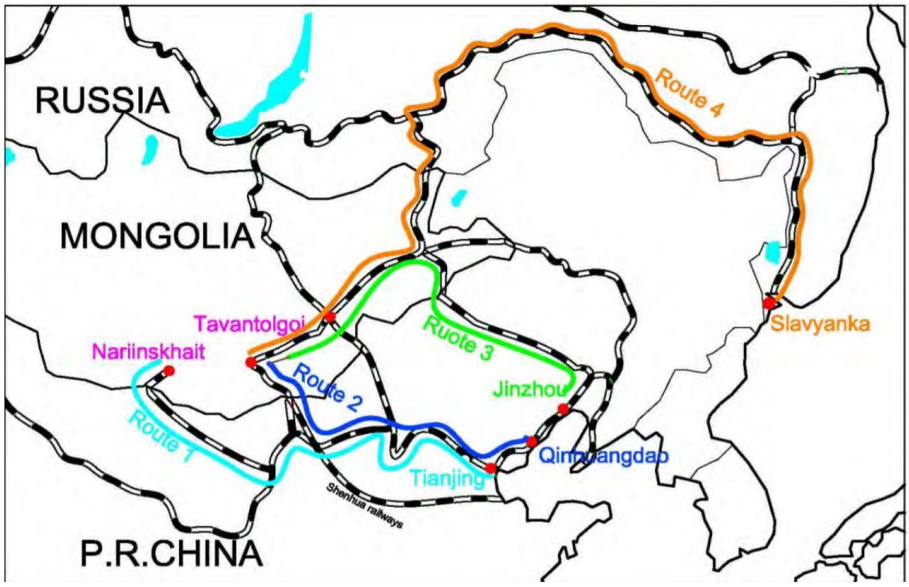


Figure 5-7. Coal transport routes

Prerequisite conditions:

1. Price. Coking coal price of 2019 at 80$ per tonne.
2. Railroad cost. The domestic railway transports 1 tonne to $0.036. The Chinese and Russian port costs are taken from respective customs statistics.
3. Tariff. Russia does not impose export and import tariffs. On the other hand, China will be subject to tariffs.
4. Cross-border transportation. It is necessary to use the Chinese railway in the Nariinsukhait and Gantsmod routes, and the additional transport costs of Bichigt will cost 3$

According to the following assessment, Russia's freight route is relatively expensive. When exporting to China, port fees are relatively cost-effective.

Route 1		
Process	Transit point	USD/tonne
FOR	Nariinsukhait	80
Railroad 45km	Shiveekhuren	1.66
Transport	Shiveekhuren	0.00
Export fee		2.41
Import fee		0.94
Railroad 2011km	Huang Hua	19.82
Port fee		33.75
Total FOB price, USD/tonne		138.58

Table 5-8. Price and cost of coal transport, Route 1

Route 2		
Process	Transit point	USD/tonne
FOR	Tavantolgoi	80
Railroad 267km	Gashuunsukhait	9.61
Transport	Gashuunsukhait	0.00
Export fee		2.41
Import fee		0.94
Railroad 1355km	Gashuunsukhait	13.93
Port fee	Tianjin	33.75
Total FOB price, USD/tonne		140.64

Table 5-9. Price and cost of coal transport, Route 2

Route 3		
Process	Transit point	USD/tonne
FOR	Tavantolgoi	80
Railroad 267km	Gashuunsukhait	9.61
Transport	Gashuunsukhait	0.00
Export fee		2.41
Import fee		0.94
Railroad 1539km	Gashuunsukhait	15.58
Port fee	Qinhundao	33.75
Total FOB price, USD/tonne		142.29

Table 5-10. Price and cost of coal transport, Route 3

Route 4		
Process	Transit point	USd/tonne
FOR	Tavantolgoi	80
Railroad 1118km	Bichigt	40.25
Transport	Bichigt	3.00
Export fee		2.41
Import fee		0.94
Railroad 1070km	Bichigt	11.37
Port fee	Jinzhou	33.75
Total FOB price, USD/tonne		171.72

Table 5-11. Price and cost of coal transport, Route 4

Route 5		
Process	Transit point	USD/tonne
FOR	Tavantolgoi	80
Railroad 1310km	Sukhbaatar	47.16
Transport	Sukhbaatar	0.00
Cargo		8.50
Railroad 4180km	Sukhbaatar	41.95
Port fee	Slavyanka	23.00
Total FOB price, USD/tonne		200.61

Table 5-12. Price and cost of coal transport, Route 5

5.5.4 Logistics evaluation

		Export	Further export possibilities	Connection to current railroad network	Open port	Non environmental challenges	Total
Russia	Slavyanka	0	2	1	2	2	7
China	Tianjin	2	2	2	2	2	10
	Qinhundao	2	2	2	2	2	10
	Tongxian	2	2	2	2	2	10
	Jinzhou	0	0	2	2	0	4

Table 5-13. Port evaluation

In table 5-13, it is noticeable that all Chinese ports except Jinzhou received evaluation of 10, regarding Russian port Slavyanka at 7 points.

Country	Port	Advantages and disadvantages
Russia	Slavyanka	Capable of handling up to 12 million tonnes of coal. Complicated to connect via railroad.
China	Tianjin	It is best to use the railway from Baotou to Sienhua, passing through Tavantolgoi to Gashuun Sukhait. It is worth mentioning that 15 to 25 million tonnes of transportation is applicable to Tianjin Free Trade Zone.
	Qinhundao	Capable of handling 10 million tonnes.
	Tongxian	Capable of handling 50 million tonnes annually. Currently, there is an extension to receive 100 million tonnes of coal and plans to increase to 200 million tonnes.
	Jinzhou	Most of the transportation costs are on the Mongolian side.

Table 5-14. Detailed evaluation of ports

Route	Annual capacity, million tonnes
Route 1: Nariinsukhait – Shiveekhuren – Huang Hua	18.1
Route 2: Tavantolgoi – Gashuunsukhait - Tianjin	14.0
Route 3: Tavantolgoi – Gashuunsukhait - Qinhundao	6.0
Route: Tavantolgoi – Bichigt - Jinzhou	23.2
Route: Tavantolgoi – Sukhbaatar – Slavyanka	3.0
Total	64.3

Table 5-15. Annual export volume and route

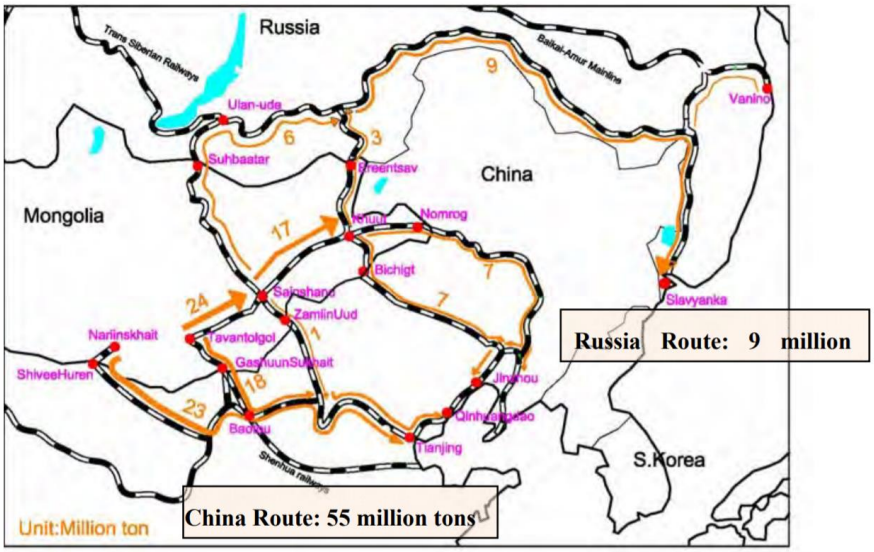


Figure 5-8. Route capacities

According to the Ministry of Mining, the annual capacity of Tavantolgoi and Nariinsukhait will increase up to 55 million tonnes. Gashuunsukhait and Shiveekhuren's coal exports are expected to reach 41 million tonnes a year. Based on the previous capacity, exports of coal to China have enough capacity.

5.6 Investment plan

5.6.1 Technical basis

There are two common methods for processing or enriching coal: wet and dry methods. Wet method is based on sedimentation technology in aquatic environments, but the dry method is usually the technology of sedimentation, which creates an artificial liquid environment.

№	Indicator	Wet		Dry		Difference	
		Million tugrug	%	Million tugrug	%	Million tugrug	%
1	Material costs	0.99	32.6%	0.89	33.3%	(0.09)	0.7%
	Additional material	0.16	5.4%	0.12	4.5%	(0.04)	-0.9%
	Magnetite	-	0.0%	0.07	2.2%	0.07	2.2%
	Flocculants	0.07	2.4%	0.10	3.8%	0.03	1.4%
	Electricity	0.21	7.0%	0.22	8.3%	0.01	1.3%
	Parts	0.61	20.2%	0.55	20.5%	(0.06)	0.3%
2	Labour costs	0.59	19.6%	0.54	20.1%	(0.05)	0.5%
3	Operational costs	0.20	6.7%	0.19	6.9%	(0.02)	0.2%
4	Depreciation	0.97	32.0%	0.82	30.6%	(0.15)	-1.4%

5	Other costs	0.27	9.0%	0.24	9.1%	(0.03)	0.0%
	Total	3.03	100%	2.69	100%	(0.34)	-0.1%

Table 5-16. Dry and wet coal processing comparison, in 1000 tonne coal

As you can see in Table 5-16, dry processing is more effective compared to wet processing. Material costs of dry is lower compared to wet processing. However, dry processing utilizes magnetite, which can be costly, but in overall cost dry is cost effective. Therefore, dry processing should be the primary choice of processing coal in Mongolia.

5.6.2 Economic reasoning

The 3 scenarios were evaluated for investment calculations and each economic estimate was made. The calculations have been made for a period of 10 years.

Prerequisite conditions:

- Using the following methodology to estimate the initial investment: the market capitalization of projects with similar objectives.
- Size of sales: Export assumptions mentioned in the preceding sections
- Coal price: Determined by an econometric analysis.
- Sales revenue: sales amount * sales price
- Coal production: Mining costs are estimated at 20$ per tonne of coal.
- Processing cost: cost is set at 3$ per tonne, according to International Energy Agency
- Depreciation: 1% annually.

- Tax expense is calculated in accordance with applicable Mongolian laws.

Table below shows the detailed analysis:

№	Indicator	Formula	Note
1	Future Value Interest Factor	$FVIF = \frac{1}{(1+r)^n}$	FVIF – Future value interest factor r – rate per period n – number of periods
2	Present Value	$\mathrm{PV} = \mathrm{FV} * \mathrm{FVIF}$	PV – Present value FV – Future value FVIF – Future value interest factor
3	Net present value	$\mathrm{NPV} = \sum PV_t - I_o$	NPV – Net present value $\sum PV_t$ – Total present value I_o – Initial investment
4	Internal rate of return	$\mathrm{IRR} = \sum \frac{PV_t}{(1+r)^n} - I_o$	IRR – Internal rate of return PV_t – Total present value r – rate per period n – number of periods I_o – Initial investment
5	Recoupment period	$\mathrm{RP} = \frac{I_o}{NPV} * T$	I_o – Initial investment NPV – Net present value T – Project implementation period

Note: The assessment methodology is used both for coal and for energy export projects.

Table 5-17. Project evaluation methodology

№	Indicator	Year 0	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
0	Initial investment, million tugrug	3,510,000											
1	Sales volume, thousand tonnes		29,000	31,602	34,205	36,807	39,410	42,012	41,090	40,167	39,245	38,322	37,400
2	Coal price, tugrug/tonne		152,533	146,323	127,756	153,436	140,574	116,677	135,101	124,804	121,277	117,749	114,222
3	Sales revenue, million tugrug		4,423,462	4,624,153	4,369,882	5,647,588	5,540,015	4,901,873	5,551,262	5,013,061	4,759,498	4,512,442	4,271,895
4	Production costs, million tugrug		2,237,143	2,437,904	2,638,665	2,839,426	3,040,187	3,240,948	3,169,787	3,098,626	3,027,465	2,956,304	2,885,143
5	Processing costs, million tugrug		234,900	255,980	277,060	298,140	319,220	340,300	332,828	325,356	317,884	310,412	302,940
6	Depreciation		23,877	26,019	28,162	30,305	32,447	34,590	33,831	33,071	32,312	31,552	30,793
7	Total profit		1,927,542	1,904,250	1,425,995	2,479,717	2,148,161	1,286,035	2,014,817	1,556,008	1,381,837	1,214,174	1,053,019
8	Tax expense		482,111	476,288	356,724	620,154	537,265	321,734	503,929	389,227	345,684	303,769	263,480
9	Net profit		1,445,432	1,427,963	1,069,271	1,859,563	1,610,896	964,301	1,510,888	1,166,781	1,036,153	910,406	789,539
10	Discount rate	1	0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39	0.35
11	Discounted cash flow	(3,510,000.00)	1,314,029	1,180,134	803,359	1,270,106	1,000,239	544,323	775,324	544,312	439,430	351,001	276,729
12	Net present value	8,498,987											
13	Internal rate of return	26%											
14	Repayment period	16.520											

Table 5-18. Estimated Capital Expenditure, Scenario 1

№	Indicator	Year 0	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
0	Initial investment, million tugrug	3,510,000											
1	Sales volume, thousand tonnes		24,500	26,520	28,540	30,560	32,580	34,600	35,660	36,720	37,780	38,840	39,900
2	Coal price, tugrug/tonne		152,533	146,323	127,756	153,436	140,574	116,677	135,101	124,804	121,277	117,749	114,222
3	Sales revenue, million tugrug		3,737,062	3,880,475	3,646,155	4,689,013	4,579,915	4,037,028	4,817,688	4,582,814	4,581,837	4,573,382	4,557,449
4	Production costs, million tugrug		1,890,000	2,045,829	2,201,657	2,357,486	2,513,314	2,669,143	2,750,914	2,832,686	2,914,457	2,996,229	3,078,000
5	Processing costs, million tugrug		198,450	214,812	231,174	247,536	263,898	280,260	288,846	297,432	306,018	314,604	323,190
6	Depreciation		20,172	21,835	23,498	25,161	26,824	28,487	29,360	30,233	31,106	31,978	32,851
7	Total profit		1,628,441	1,598,000	1,189,826	2,058,831	1,775,878	1,059,138	1,748,568	1,422,463	1,330,257	1,230,572	1,123,408
8	Tax expense		407,335	399,725	297,681	514,933	444,195	265,009	437,367	355,841	332,789	307,868	281,077
9	Net profit		1,221,106	1,198,275	892,144	1,543,898	1,331,684	794,128	1,311,201	1,066,622	997,467	922,704	842,331
10	Discount rate	1	0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39	0.35
11	Discounted cash flow	(3,510,000.00)	1,110,096	990,310	670,281	1,054,503	826,871	448,265	672,853	497,587	423,024	355,742	295,232
12	Net present value	7,344,764											
13	Internal rate of return	20%											
14	Repayment period	19.116											

Table 5-19. Estimated Capital Expenditure, Scenario 2

№	Indicator	Year 0	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
0	Initial investment, million tugrug	3,510,000.00											
1	Sales volume, thousand tonnes		26,200	29,100	32,000	34,900	37,800	40,700	42,280	43,860	45,440	47,020	48,600
2	Coal price, tugrug/tonne		152,533	146,323	127,756	153,436	140,574	116,677	135,101	124,804	121,277	117,749	114,222
3	Sales revenue, million tugrug		3,996,369	4,257,987	4,088,190	5,354,927	5,313,713	4,748,758	5,712,054	5,473,916	5,510,817	5,536,572	5,551,179
4	Production costs, million tugrug		2,021,143	2,244,857	2,468,571	2,692,286	2,916,000	3,139,714	3,261,600	3,383,486	3,505,371	3,627,257	3,749,143
5	Processing costs, million tugrug		212,220	235,710	259,200	282,690	306,180	329,670	342,468	355,266	368,064	380,862	393,660
6	Depreciation		21,571	23,959	26,347	28,734	31,122	33,510	34,811	36,111	37,412	38,713	40,014
7	Total profit		1,741,435	1,753,461	1,334,072	2,351,217	2,060,411	1,245,864	2,073,176	1,699,053	1,599,970	1,489,739	1,368,362
8	Tax expense		435,584	438,590	333,743	588,029	515,328	311,691	518,519	424,988	400,217	372,660	342,315
9	Net profit		1,305,851	1,314,871	1,000,329	1,763,188	1,545,084	934,173	1,554,657	1,274,065	1,199,752	1,117,079	1,026,046
10	Discount rate	1	0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39	0.35
11	Discounted cash flow	(3,510,000.00)	1,187,137	1,086,670	751,562	1,204,281	959,375	527,316	797,785	594,361	508,812	430,683	359,623
12	Net present value	8,407,605											
13	Internal rate of return	24%											
14	Repayment period	16.699											

Table 5-20. Estimated Capital Expenditure, Scenario 3

№	Scenario	1	2	3
1	Sales volume, thousand tonnes	409,261	366,200	427,900
2	Sales revenue, million tugrug	53,615,131	47,682,819	55,544,483
3	Production cost, million tugrug	31,571,600	28,249,714	33,009,429
4	Processing cost, million tugrug	3,315,018	2,966,220	33,009,429
5	Depreciation	336,959	301,505	3,465,990
6	Total profit	18,391,555	16,165,380	352,304
7	Tax expense	4,600,364	4,043,820	18,716,761
8	Net profit	13,791,191	12,121,560	4,681,665
9	Discounted cash flow	(3,510,000.00)	(3,510,000.00)	(3,510,000.00)
10	Net present value	8,498,986.68	7,344,763.73	8,407,605.15
11	Internal rate of return	0.26	0.20	0.24
12	Repayment period	16.52	19.12	16.70

Table 5-21. Scenario comparison

For each of the three scenarios, the economic benefits of each scenario are calculated and the first scenario is the most lucrative, and also high net present value. Scenario 2 is the least profitable and the repayment period is 20 years. The third scenario is similar to the first scenario. Even though China's economic growth is down, the coal revenue sector will not fluctuate significantly.

6 ENERGY EXPORT FEASIBILITY STUDY

6.1 Introduction

This chapter will explore the feasibility of exporting energy efficiently in relation to the development of the Mongolian energy sector. Potential energy import countries will be speculated. Due to long-term planning, energy price surveys are necessary. A general export plan will be developed on the basis of the aforementioned. Energy export planning was made in 3 scenarios

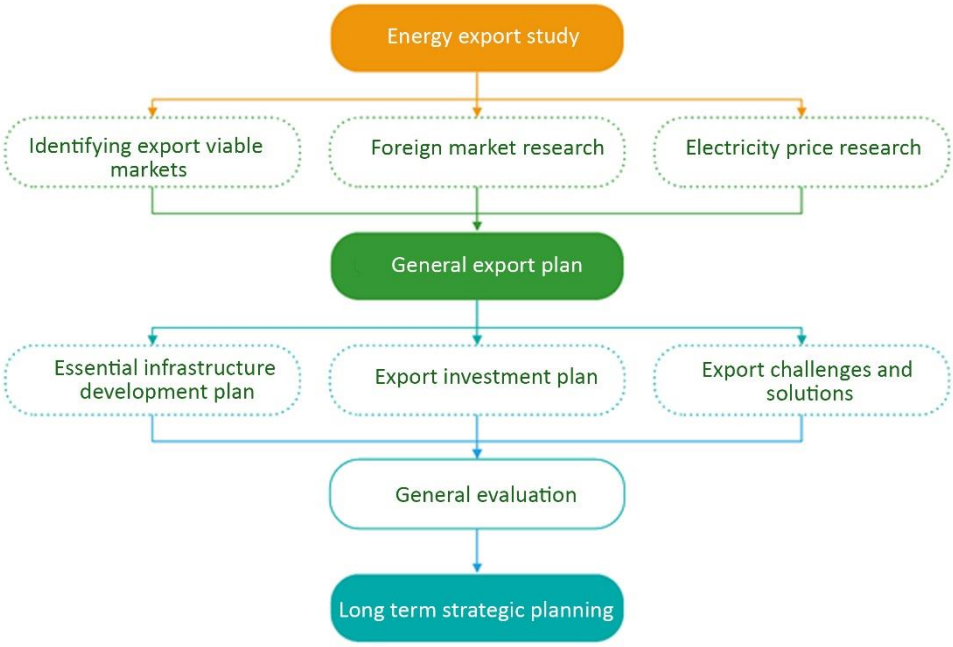


Figure 6-1. Chapter structure

The investment planning section was designed using the discounted cash flow model and scenario analysis. Challenges that may occur were investigated and a general conclusion for energy export was formulated.

6.2 Energy export infrastructure

High-voltage direct current (HVDC) transmission lines use direct currents to transmit energy over long distances with minimal loss. High-voltage direct current lines are

cost effective compared to alternating current transmission lines due to its minimal loss over long distances.

Direct current lines also allow connections with alternating current lines. Due to voltage and transformation of the line, energy loss can be reduced to 3% over 1000km. However, with alternating current lines the energy loss can be up to 50% over 1000km. Therefore, the energy source can be placed at a distant location to the end user.

The transmission capacity of the line equals the voltage multiplied by the current (P = U * I). The current can be reduced by increasing the voltage. Due to reduced current the line cross section can be relatively low, therefore, reducing material costs.

The main disadvantage of high voltage direct current line is converting to alternating current and then back to direct current. Apparatus that makes such transformation is very expensive and is calculated individually for each line.

6.3 Energy export market

Refined coal can be stored, transported by railway, road and by sea, however, energy cannot be stored efficiently. This is the main reason energy must be consumed directly by the end user. Energy can only be transported by transmission lines be it long or short distances.

Source: https://www.ft.com/content/e67a54e8-c09e-11e7-b8a3-38a6e068f464

Figure 6-2. Asian Super Grid

Asian Super Grid (ASG) is an energy grid covering countries in eastern Asia. The grid will connect China, South Korea, Mongolia and Japan initially and then moving onto Indonesia, Singapore, India and Thailand, whom are energy keen countries. The grid will grant Mongolia the ability to export energy to not only China or Russia but to a third country.

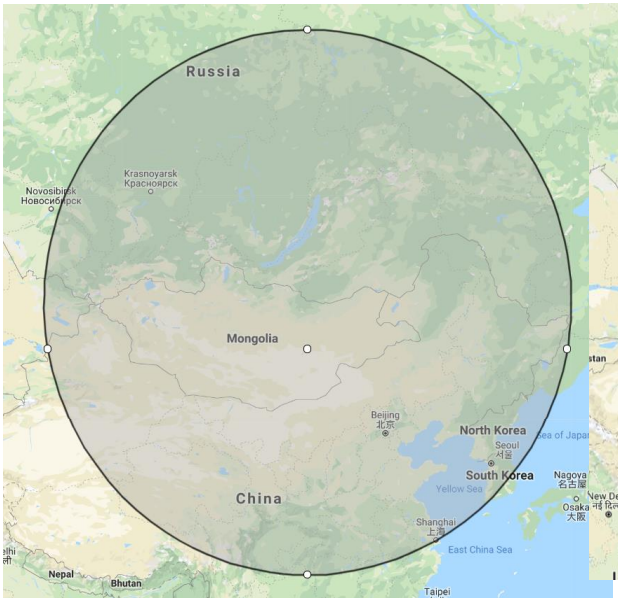


Figure 6-3. Shivee-Ovoo projected energy export capacity

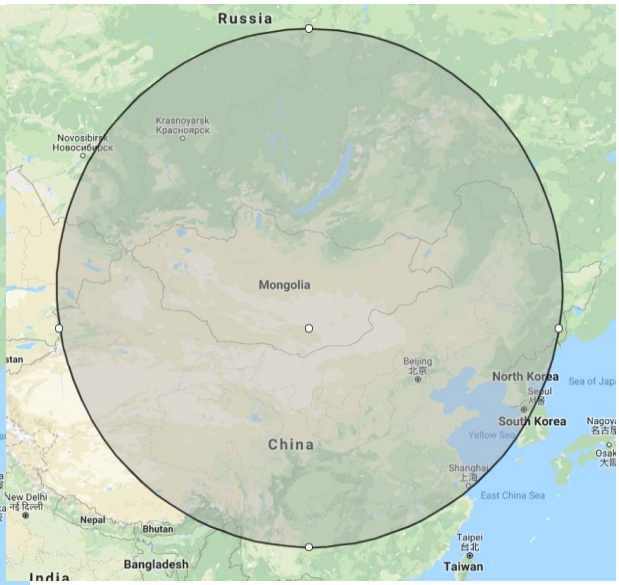


Figure 6-4. Tavantolgoi project energy export capacity

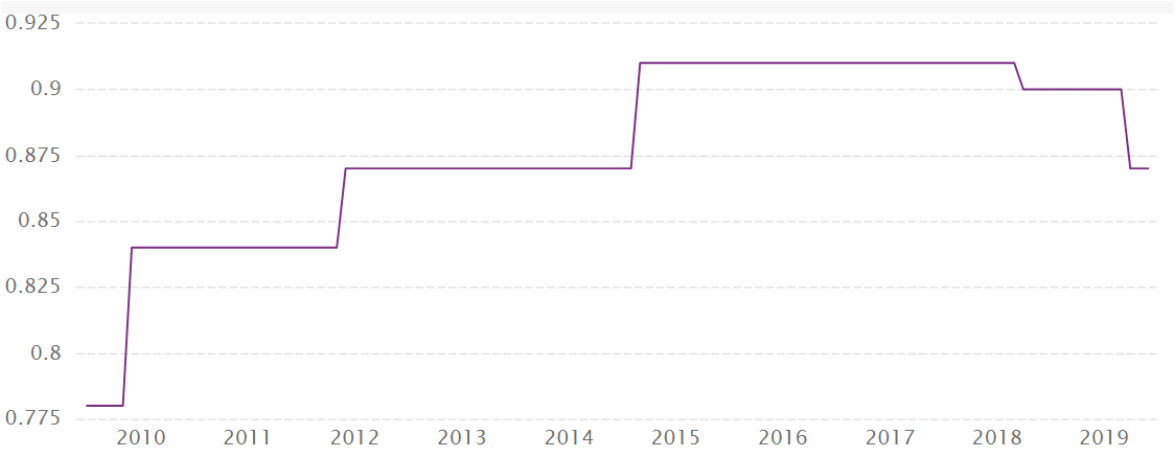
As shown in the figures above major coal mines in Mongolia, when linked to the Asian Super Grid, can export energy to wide variety of consumers. Beijing energy grid is well within the capacity of project major thermal power plants at coal mines Shivee-Ovoo and Tavantolgoi. If the projected plants are connected to the Beijing energy grid, countries beyond China could well be importers of energy produced in Mongolia.

Thermal power plant at Baganuur coal mine was not included in the study for energy export due to its role in fulfilling the domestic energy deficit. Therefore, plants at Shivee-Ovoo and Tavantolgoi were the main focus plants for the study.

6.4 Energy price research

6.4.1 China

The main exporter of energy at this moment is China therefore extended study is required for the Chinese market. The tariff for 35 kW or more in China was 910¥ for 1kW in 2015-2018, and it has gradually decreased to 860¥ from 2018. Energy prices in China are not projected to decrease lower than 800¥ in the next 10 years. Analysis was concluded with energy prices at 700¥/1kW, in other words 1MW would be 7000¥.

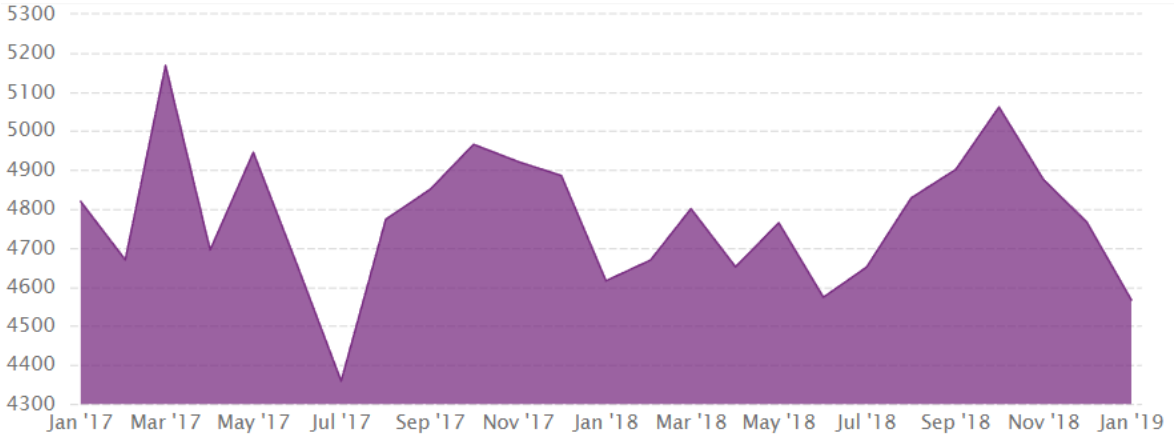


Source: ceicdata.com

Figure 6-5. Electricity prices in China, ¥/kW

6.4.2 Russia

Russia's industrial electricity demand has been volatile, with a maximum of 5100 ₽/MW down to at least 4400₽/MW. The price of electricity was relatively volatile, so it was estimated that the average 10-year average would be 4720₽ per 1MW.



Source: ceicdata.com

Figure 6-6. Electricity prices in Russia, ₽/MW

6.4.3 Other countries

The price of electricity in South Korea is fluctuating in seasonal terms, up from 80 to 120₩ per kW in the last 10 years. Over the last five years, it has been around 95 and 125₩ per kW at most. Therefore, the estimate is 1 kW for 90₩ or 1 megawatt for 90000₩.

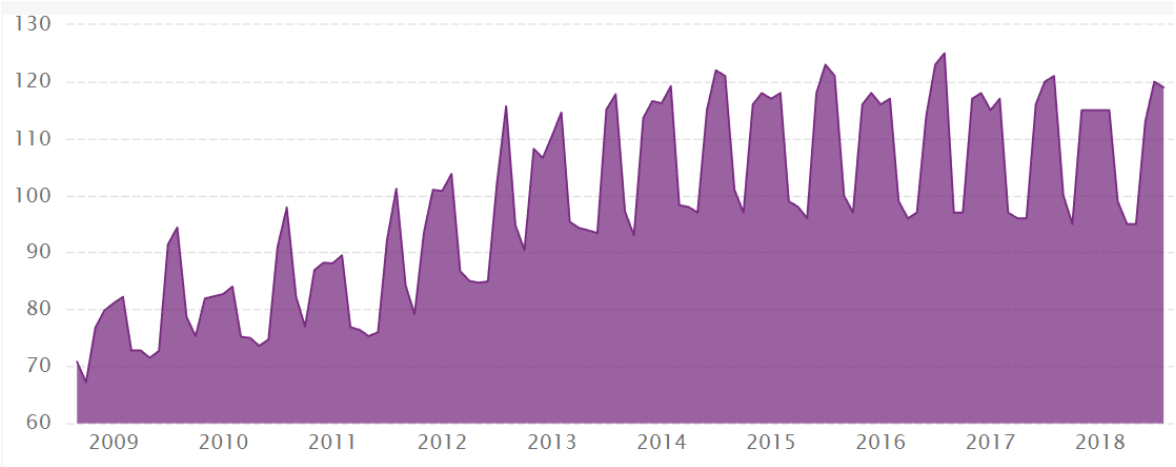


Figure 6-7. Electricity prices in South Korea, ₩/kW

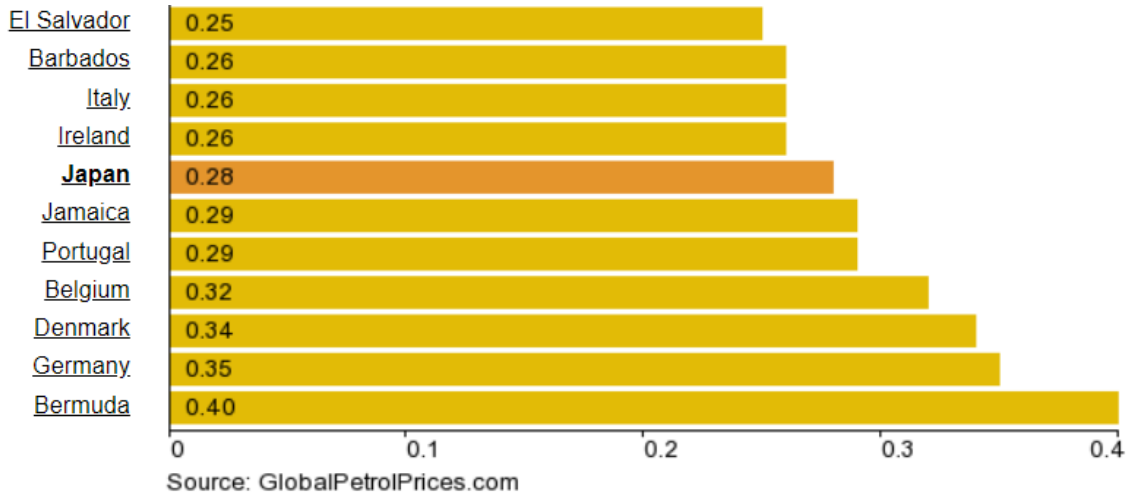


Figure 6-8. Electricity prices in Japan, $/kWh

6.5 General Plan

6.5.1 Coal quality

Coal resource of Mongolia is estimated to be approximately 173.5 billion tonnes. As of 2018, coal reserves A, B and C1 are 31.7 billion tonnes.

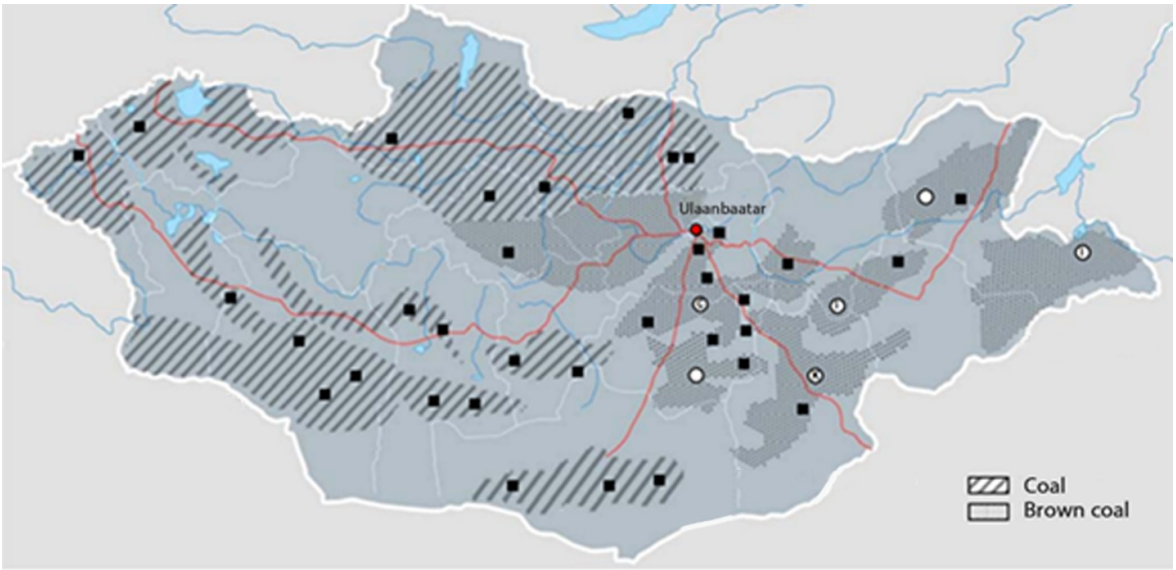


Figure 6-9. Coal quality

Coal quality is characterized by coal moisture, sulfur content, ash content and heat content.

№	Mine name	Location	Sum	Moisture	Ash content	Sulfur	Heat content	Carbon content
1	Tavantolgoi – Seam 10	Umnugovi	Tsogttsetsii	5.3	20.3	0.90	7790	83.5-86.9
2	Tavantolgoi – Zuun Tsankhi	Umnugovi	Tsogttsetsii	-	-	-	-	84.1-85.9
3	Tavantolgoi – Baruun Tsankhi	Umnugovi	Tsogttsetsii	-	17.0-25.6	0.90	8145-8503	87.4-88.9
4	Tavantolgoi – Zuun Tsankhi 2	Umnugovi	Tsogttsetsii	-	18.2-27.9	0.95	8479	84.7-88.0
5	Tavantolgoi – Ukhaa khudag	Umnugovi	Tsogttsetsii	-	23.2	0.66	8126	82-89
6	Shivee-Ovoo	Govisumber	Shiveegovi	42.9	15.2	0.78	6635	70.0

Table 6-1. Coal quality in Tavantolgoi and Shivee-Ovoo

Power Plant	Capacity	Cost	Feasibility
Baganuur	250	670 $/kw	Feasible
Tavantolgoi	750	580 $/kW	Export-oriented projects are likely to have risks beyond the government control.
Shivee-Ovoo	3600	827 $/kW	Export-oriented projects are likely to have risks beyond the government control.

Note: Energy costs are determined by the market reference method and are derived from the following sources: ADB Feasibility Report TA No.7502-MON, Mongolia: Ulaanbaatar Low Carbon Energy Supply Project Using a Public^Private Partnership Model, Oct.,2011

Table 6-2. Proposed power plants

6.5.2 Estimation choices

A total of 3 potential energy-efficient power plants will be conducted within the energy export study.

Power Plant	Fuel cost	Investment cost	Importance
Baganuur TPP	The power plant will be fueled by coal from Baganuur coal mine and the price fluctuation will be steady.	Price for thermal power plant have increased due to increased steel prices, however, Chinese technology is 30% cheaper.	Important. Fulfill the domestic energy deficit.
Tavantolgoi TPP	Tavantolgoi coal price with arbitrage cost is at 20$ per ton. In 2018, 5000kcal/kg coal in Shanxi, China was sold at 135$/ton. If the estimated transport and port costs are 30-35$/ton, then Tavantolgoi coal price is 80$/ton.	The Tavantolgoi TPP is planned to be 750MW. If Chinese technology is used, the cost of energy will be 580$/kW. According to the efficiency of the Chinese technology, the thermal efficiency coefficient is 33 percent.	Important. Compared to Shivee-Ovoo TPP the capacity is relatively smaller.
Shivee-Ovoo TPP	The TPP will be fueled by coal from Shivee-Ovoo coal mine and the coal price was set at 20$/ton.	With Ivanhoe's investment the price is set at 827$/kW.	Very important. Risk mainly associated with exportability.

Table 6-3. Thermal Power Plants

TPP	Unit, MW	Operational years	Capital Costs, $/kW	Operating costs, $/kW	Profitability	Fuel cost, $/ton	Fuel quality, kcal/kg	Electricity consumption	Average energy cost, $/MWh
Baganuur TPP	250	40	600	38,0	36%	14.2	5100	5.0%	31.2
Tavantolgoi TPP	750	40	580	33,0	33%	20.0	8200	7.6%	42.4
Shivee-Ovoo TPP	2980	40	827	33,0	32%	20.0	6635	7.6%	41.3

Table 6-4. Thermal Power Plant cost breakdown

The TPP will be in operation for over 40 years. According to Chinese technology, the efficiency of the thermal power plant is not more than 40 percent.

Investment calculations are the same principle as coal export analysis. The following are some of the other things that have changed in general:

- Initial investment: Costs are calculated in accordance with the capital cost presented in the previous table. For Baganuur TPP, the cost of a 1kW is 600$ and 600,000$ per 1MW capacity. The total capacity is 250 MW and the total cost is 250*600,000=150,000,00$. The TPP will be operating all year around.
- Electricity price was calculated by price set by Ulaanbaatar Electricity Station. On the other hand, Shivee-Ovoo and Tavantolgoi price was set at 7000¥ per MW.
- The cost of electricity is calculated using the price shown in the table above.

№	Indicator	Year 0	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
0	Initial investment, million tugrug	405,000											
1	Sales amount, MWh*hr		2,190,000	2,190,000	2,190,000	2,190,000	2,190,000	2,190,000	2,190,000	2,190,000	2,190,000	2,190,000	2,190,000
2	Electricity price, million tugrug/MWh*hr		0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129
3	Sales revenue, million tugrug		281,415	281,415	281,415	281,415	281,415	281,415	281,415	281,415	281,415	281,415	281,415
4	Electrical cost, tugrug/MWh*hr		84,240	84,240	84,240	84,240	84,240	84,240	84,240	84,240	84,240	84,240	84,240
5	Electrical cost, million tugrug		184,486	184,486	184,486	184,486	184,486	184,486	184,486	184,486	184,486	184,486	184,486
6	Total profit		96,929	96,929	96,929	96,929	96,929	96,929	96,929	96,929	96,929	96,929	96,929
7	Tax expense		24,457	24,457	24,457	24,457	24,457	24,457	24,457	24,457	24,457	24,457	24,457
8	Net profit		72,472	72,472	72,472	72,472	72,472	72,472	72,472	72,472	72,472	72,472	72,472
9	Discount rate	1	0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39	0.35
10	Discounted cash flow	(405,000.00)	65,884	59,894	54,449	49,499	44,999	40,909	37,190	33,809	30,735	27,941	25,401
11	Net present value	470,710											
12	Internal rate of return	3.10%											
13	Repayment period	34.42											

Table 6-5. Assessment of Baganuur TPP investment

№	Indicator	Year 0	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
0	Initial investment, million tugrug	1,174,500											
1	Sales amount, MWh*hr		4,572,720	4,572,720	4,572,720	4,572,720	4,572,720	4,572,720	4,572,720	4,572,720	4,572,720	4,572,720	4,572,720
2	Electricity price, million tugrug/MWh*hr		0.2695	0.2695	0.2695	0.2695	0.2695	0.2695	0.2695	0.2695	0.2695	0.2695	0.2695
3	Sales revenue, million tugrug		1,232,348	1,232,348	1,232,348	1,232,348	1,232,348	1,232,348	1,232,348	1,232,348	1,232,348	1,232,348	1,232,348
4	Electrical cost, tugrug/MWh*hr		114,480	114,480	114,480	114,480	114,480	114,480	114,480	114,480	114,480	114,480	114,480
5	Electrical cost, million tugrug		523,485	523,485	523,485	523,485	523,485	523,485	523,485	523,485	523,485	523,485	523,485
6	Total profit		708,863	708,863	708,863	708,863	708,863	708,863	708,863	708,863	708,863	708,863	708,863
7	Tax expense		177,441	177,441	177,441	177,441	177,441	177,441	177,441	177,441	177,441	177,441	177,441
8	Net profit		531,422	531,422	531,422	531,422	531,422	531,422	531,422	531,422	531,422	531,422	531,422
9	Discount rate	1	0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39	0.35
10	Discounted cash flow	(1,174,500.00)	483,111	439,192	399,265	362,969	329,971	299,974	272,704	247,912	225,375	204,886	186,260
11	Net present value	3,451,620											
12	Internal rate of return	31%											
13	Repayment period	13.611											

Table 6-6. Assessment of Tavantolgoi TPP investment

№	Indicator	Year 0	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
0	Initial investment, million tugrug	6,654,042											
1	Sales amount, MWh*hr		23,494,320	23,494,320	23,494,320	23,494,320	23,494,320	23,494,320	23,494,320	23,494,320	23,494,320	23,494,320	23,494,320
2	Electricity price, million tugrug/MWh*hr		0.2695	0.2695	0.2695	0.2695	0.2695	0.2695	0.2695	0.2695	0.2695	0.2695	0.2695
3	Sales revenue, million tugrug		6,331,719	6,331,719	6,331,719	6,331,719	6,331,719	6,331,719	6,331,719	6,331,719	6,331,719	6,331,719	6,331,719
4	Electrical cost, tugrug/MWh*hr		111,510	111,510	111,510	111,510	111,510	111,510	111,510	111,510	111,510	111,510	111,510
5	Electrical cost, million tugrug		2,619,852	2,619,852	2,619,852	2,619,852	2,619,852	2,619,852	2,619,852	2,619,852	2,619,852	2,619,852	2,619,852
6	Total profit		3,711,868	3,711,868	3,711,868	3,711,868	3,711,868	3,711,868	3,711,868	3,711,868	3,711,868	3,711,868	3,711,868
7	Tax expense		928,192	928,192	928,192	928,192	928,192	928,192	928,192	928,192	928,192	928,192	928,192
8	Net profit		2,783,676	2,783,676	2,783,676	2,783,676	2,783,676	2,783,676	2,783,676	2,783,676	2,783,676	2,783,676	2,783,676
9	Discount rate	1	0.91	0.83	0.75	0.68	0.62	0.56	0.51	0.47	0.42	0.39	0.35
10	Discounted cash flow	(6,654,042.00)	2,530,614	2,300,558	2,091,417	1,901,288	1,728,444	1,571,312	1,428,466	1,298,605	1,180,550	1,073,227	975,661
11	Net present value	18,080,144											
12	Internal rate of return	28%											
13	Repayment period	14.72											

Table 6-7. Assessment of Shivee-Ovoo investment

№	Thermal Power Plant	Baganuur	Tavantolgoi	Shivee-Ovoo
1	Initial investment, million tugrug	405,000	1,174,500	6,654,042
2	Sales amount, MWh*hr	24,090,000	50,299,920	258,437,520
3	Electricity price, million tugrug/MWh*hr	0.1285	0.2695	0.2695
4	Sales revenue, million tugrug	3,095,565	13,555,828	69,648,912
5	Electrical cost, tugrug/MWh*hr	926,640	1,259,280	1,226,610
6	Electrical cost, million tugrug	2,029,342	5,758,335	28,818,368
7	Total profit	1,066,223	7,797,494	40,830,544
8	Tax expense	269,031	1,951,848	10,210,111
9	Net profit	797,193	5,845,645	30,620,433
10	Net present value	470,710.39	3,451,620.20	18,080,143.57
11	Internal rate of return	0.03	0.31	0.28
12	Repayment period	34.42	13.61	14.72

Table 6-8. Present value estimation

According to the table above, Shivee Ovoo exports are the largest and the present value is the same. Baganuur TPP is the least efficient to produce energy because the tariffs were calculated as domestic. Tavantolgoi TPP is the most cost efficient and the repayment period is at 14 years. Shivee-Ovoo have repayment period of 15 years. Baganuur TPP should be commissioned by the State in the near future, as it can help decrease the energy demand deficit. Tavantolgoi and Shivee-Ovoo have similar repayment period and it can be assumed both should be commissioned. However, Shivee-Ovoo's initial investment is the highest of the three

thermal power plants. Regardless of the high investment, to successfully supply Chinese, Russian and third countries' energy demand the project should be initiated in the near future.

	Market	China		Russia		South Korea		Japan	
	TPP	Tavantolgoi	Shivee-Ovoo	Tavantolgoi	Shivee-Ovoo	Tavantolgoi	Shivee-Ovoo	Tavantolgoi	Shivee-Ovoo
1	Initial investment, million tugrug	1,174,500	6,654,042	1,174,500	6,654,042	1,174,500	6,654,042	1,174,500	6,654,042
2	Sales amount, MWh*hr	50,299,920	258,437,520	50,299,920	258,437,520	50,299,920	258,437,520	50,299,920	258,437,520
3	Electricity price, million tugrug/MWh*hr	0.27	0.27	0.19	0.19	0.20	0.20	0.68	0.68
4	Sales revenue, million tugrug	13,555,828	69,648,912	9,496,625	48,793,004	10,185,734	52,333,598	33,952,446	174,445,326
5	Electrical cost, tugrug/MWh*hr	1,259,280	1,226,610	1,259,280	1,226,610	1,259,280	1,226,610	1,259,280	1,226,610
6	Electrical cost, million tugrug	5,758,335	28,818,368	5,758,335	28,818,368	5,758,335	28,818,368	5,758,335	28,818,368
7	Total profit	7,797,494	40,830,544	3,738,290	19,974,636	4,427,399	23,515,230	28,194,111	145,626,958
8	Tax expense	1,951,848	10,210,111	937,048	4,996,134	1,109,325	5,881,282	7,051,003	36,409,215
9	Net profit	5,845,645	30,620,433	2,801,243	14,978,502	3,318,074	17,633,947	21,143,108	109,217,744
10	Net present value	3,451,620	18,080,144	1,654,022	8,844,208	1,959,190	10,412,142	12,484,162	64,488,719
11	Internal rate of return	0.31	0.28	0.08	0.06	0.12	0.10	1.40	1.27
12	Repayment period	13.61	14.72	28.40	30.09	23.98	25.56	3.76	4.13

Table 6-9. Project feasibility efficiency, by countries

7 STRATEGIC PLAN FOR EXPORTING ENERGY AND REFINED COAL

Coal is a significant source of electrical and thermal energy, however, refined coal be a major source of value added wealth. Mongolia is capable of implementing both targets. Successful coal sector development plan will consist of domestic coal consumption and foreign market demand research. Another important step is to evaluate whether exporting refined coal or energy is feasible. To achieve such results a strategic long term plan to develop Mongolia's mining industry until 2070 was developed. The following concept is the basis of this strategic plan: to create beneficial wealth(s) through the coal industry and its export. The strategy to develop the coal industry is formulated within the structure specified hereunder: (i) strategic targets; (ii) measures to be executed to reach the targets; (iii) implementation periods; and justification.

7.1 Strategic planning of the coal sector

The following strategic objectives have been developed in the framework of the general strategy for the development of the mining sector:

Strategic aim 1. Improve coal related polices

Strategic aim 2. Improve infrastructure development policies

Strategic aim 3. Implement sustainable development of coal industry

Strategic aim 4. Export refined coal

Strategic aim 5. Increase coal mines' capacities

Objective	Measures	Short term (2035)	Midterm (2050)	Long term (2070)	Remark
Improve coal related polices	Review coal related laws and policies	✓	✓		Mining companies are critical of the high tax demanded by the state. Private companies and state cooperation is essential in realizing more effective tax system.
	Improve state and private mine cooperation	✓			
	Improve public opinion through the media	✓	✓		

Table 7-1. Strategic aim 1

Aim	Measures	Short term (2035)	Midterm (2050)	Long term (2070)	Remark
Improve infrastructure development policies	Efficient infrastructure development	✓	✓		Mongolian economy is highly China dependent, therefore, different routes of coal export should be investigated. In order to export to countries other than Russia and China it is necessary to study the possibility of transporting via sea. Therefore, the government should negotiate with the Chinese and Russian policymakers and explore opportunities to use transit ports.
		✓	✓		Develop necessary infrastructure for minor mines to run efficiently. Number of minor mines will be neglected if the railroad is used by major mines only. Transport other than railroad will not be cost efficient therefore minor mining operations require the necessary infrastructure.

Table 7-2. Strategic aim 2

Aim	Measures	Short term (2035)	Midterm (2050)	Long term (2070)	Remark
	Substantial loan guarantee	✓			Developing countries like Mongolia have poor credit rating. Hence, financial institutions require a high degree of guarantee. For that reason, the government is very important.
Implement sustainable development of coal industry	Stability agreement	✓			Large scale investment with long repayment term is needed for the development of the coal industry. Therefore, investors will benefit long after the initial investment. In order to support investment, the M government must ensure the investors' returns are expected.
	Educated workforce	✓	✓		Educated workforce is essential in the development of the sector. Therefore, universities and colleges must produce high degree of workforce.

Table 7-3. Strategic aim 3

Aim	Measures	Short term (2035)	Midterm (2050)	Long term (2070)	Remark
Refined coal export	Stabilize coal price	✓	✓	✓	Mongolian export is mostly to China. Refined coal is more cost effective, therefore, it is important to study possibilities of producing coal products and its export.
	Implement dry processing technology	✓			Major coal mines face water issues constantly so it is important to choose dry processing. Exporting coal become a possibility for mines with water issues.

Table 7-4. Strategic aim 4

Aim	Mine	Short term (2035)	Midterm (2050)	Long term (2070)	Current situation
Increase coal mines' capacities	Tavantolgoi	✓	✓	✓	Located in Umnugovi, Tsogttsetsii. Owned by Tavantolgoi JSC, Energy Resources LLC, and Diesetsuki LLC .
	Nariinsukhait	✓	✓	✓	Located in Umnugovi, Gurvantes. Long term agreement with the Mongolian government.
	Baganuur	✓	✓		Located in Ulaanbaatar, Baganuur district.
	Shivee Ovoo	✓	✓	✓	Located in Govisumber, Shiveegovi.
Commission coal deposits	Ulaan Ovoo			✓	Located in Selenge, Tushig. Exploration by state budget .
	Huutiin Honhor			✓	Located in Dundgovi, Bayanjargalan. Exploration by state budget .
	Huut			✓	Located in Dornod, Matad. Exploration by state budget.

	Alag togoo	✓	✓	Located in Dornogovi, Dalanjargalan Initial exploration by state budget, secondary exploration privately funded.
	Tugrug nuur		✓	Located in Tuv, Bayan. Exploration by state budget.

Table 7-5. Increase capacities of coal mines

ɔlan to export energy

The following strategic objectives have been developed in the framework of the general strategy for the development of the mining sector:

Strategic aim 1. Improve energy related policies

Strategic aim 2. Energy export

Aim	Measure	Short term (2035)	Midterm (2050)	Long-term (2070)	Remark
Improve energy related policies	Increase efficiency of power plants		✓		Current power plants in Mongolia have not seen any repair and improvement since 2000 and to increase efficiency further improvements are needed.
	Construct power plants in alignment with energy demand		✓	✓	It is estimated Mongolian energy demand grow by 300 to 450MW in 2025. The supply needs to be sorted.
	Export energy		✓	✓	In considering the export potential, it is necessary to determine whether the thermal power plant could reach the target market. Long term plan should consist of power plants able to manage the energy demand as well produce additional energy to export.

Table 7-6. Strategic aim 1

Phase	Power plant	Short term (2035)	Midterm (2050)	Long term (2070)	Current situation
Energy export plan 1st phase	Tavantolgoi	✓	✓		Implement the project in the near future
	Baganuur	✓			Implement the project in the near future
	Shivee-Ovoo	✓	✓		Implement the project in the near future
Energy export plan 2nd phase	Power plant 5		✓		Power plant №5 will be fuelled with coal from Baganuur coal mine and projected to supply the growing energy demand in Ulaanbaatar.
	Oyu Tolgoi Power plant		✓	✓	Rio Tinto, operator of Oyu Tolgoi have initiated the project and the estimated cost is 650 to 750 million USD or about 1500 USD per kW.

Table 7-7. Strategic aim 2

8 CONCLUSION

8.1 General Conclusion

The study aims to make efficient use of Mongolia's coal resources and to explore opportunities for the development of the coal and energy sectors. The study identified Mongolia's coal reserves, studied demand and supply of coal and in Mongolia as well as abroad.

Refined coal and energy export possibilities were explored with the basis of developing Mongolian coal sector. Coal price research, market research, exploring exportable countries were the basis of the general strategic development plan of the coal sector. On that basis, overall long term export plan was developed. The export plan covers the areas of infrastructure development planning, investment planning, general assessment and long-term planning.

Mongolia deals with multiple countries on coal export but 95% of the export is to China. Quantitative studies indicate that transport costs are high in trade with third countries. Total of 5 routes of coal export was proposed, while the transport cost via Russian port is high transport via Chinese port is cost effective in today’s economic environment. Cost effective transport system is ultimately railroad as shown in the study. The volatility of coal prices is relatively stable but is expected to fluctuate around the price in the coming years. If the price declines, export volume must increase. The planned capacity of the infrastructure will be 64.2 million tons per year, which is sufficient for the long term. Mongolia’s coal export is highly dependent on China, therefore, 3 scenarios were considered.

Energy export has similar structure. Regardless, energy is a unique product that cannot be stored and the markets are limited by technique and technology. Currently, the world's most widely used high-voltage power lines are not effecicient. These networks have a high efficiency coefficient of 500 km, but when the distance reaches 2000 km electricity loss can be up to 50 percent, therefore new technology was considered. The high voltage direct current (HVDC) power transmission technology is widely used today in Europe and China and the electricity loss is 3% at 1000 km. Therefore, it was considered that electricity will be transported via the highly efficient HVDC transmission lines. There are no technological barriers to

exporting energy, as energy can be exported to two neighbors and other third countries through the Asian Integrated Network (AIN). The initial investment project is determined by the standard market price method. Calculations were made for each TPP and calculated by the present value of net economic value, repayment period, and internal rate of return. Economic calculation comparison was done for the project to selected countries and their respective markets.

8.2 Recommendation for future researchers

Two possibilities, I have considered, for Mongolia's development of the coal sector are restrictions on the study. Therefore, the following recommendations are given to future researchers:

- There are many different ways to utilise coal: production of coking coal, gas extraction, etc.
- Countries have started to restrict coal consumption through policies and therefore Mongolia should look into renewable energy source and production. Mongolia is a vast country that can be used as solar and wind farms, etc. There also exists the possibility of exporting renewable energy.
- Multiple nations are exploring the development of natural gas and renewable energy, so it is possible to explore ways of extracting gas from coal and then exporting said product.

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List of Abbreviations

U.N	United Nations
ITER	International Thermonuclear Experimental Reactor
WEC	World Energy Council
IIASA	International Institute for Applied Systems Analysis
Gtoe	Gigatonnes of Oil Equivalent
MRPAM	Mineral Resources and Petroleum Authority of Mongolia
GDP	Gross Domestic Product
GIO	Gross Industrial Output
BP	British Petroleum
TPP	Thermal power plant
IPO	Initial Public Offering
USA	United States of America
BOT	Build Operate and Transfer
Mtoe	Million tonnes of oil Equivalent
IEA	International Energy Agency
CNY	Chinese Yuan Renminbi
TPP	Thermal Power Plant
ERI	Economic Research Institute
JSC	Joint Stock Company
Mt	Million tonnes
ASG	Asian Super Grid