Energy issues for Mongolia

Dr Andrew J Minchener

CCC/215 ISBN 978-92-9029-535-8

January 2013

Abstract

Mongolia is a very large, landlocked country, with a small population, located between Russia and China. In the last two decades, it has begun reforms to move from a centrally-planned economy towards one with market characteristics. At the same time, geological surveys have shown it is rich in natural resources, especially coal, copper and gold, as well as silver, uranium, molybdenum, iron, tin, nickel, zinc, tungsten, phosphates, fluorspar, and some oil. The Mongolia Government recognises that exploitation of its mineral wealth is essential if the economy is to grow; however, its GDP is too small to underwrite major investments to develop the mines and so there is a need for external assistance. This is creating problems as the government attempts to provide an attractive opportunity for external investors while maximising the material benefit to the country by establishing a stable process to manage mineral revenues for the public good. In order to both export the coal and use it within the country, there is a need to establish a major infrastructure development programme as well as reach an accord with China and Russia. The infrastructure needs include extensive rail/road links, an uprated and integrated power transmission and distribution grid, new power plant facilities, other industrial facilities, and townships in mining regions. It is essential that such developments should be undertaken with due regard for minimising environmental damage, to limit adverse impact on air quality in the cities, loss of water supplies and destruction of the fragile ecosystem. There are associated social problems, especially for the nomadic part of the population, as well as indigenous animal populations, both of whose migration routes are affected by some of the industrial developments. The country faces some difficult challenges with its need to establish mining-based commercial initiatives while at the same time seeking to establish a sustainable long-term future.

Acronyms and abbreviations

%	per cent
°C	degree Celsius
CBM	coal bed methane
CHP	combined heat and power
CO_2	carbon dioxide
CTL	coal-to-liquids
cv	calorific value
GDP	gross domestic product
GHG	greenhouse gas
GJ	gigajoule
Gt	gigatonne
GWe	gigawatt electric
GWh	gigawatt hour
HV	high voltage
IPO	international public offering
kg	kilogramme
kJ	kilojoule
km	kilometre
km^2	square kilometre
kt	kilotonne
kV	kilovolt
kWh	kilowatt hour
LHV	lower heating value
LPG	liquefied petroleum gas
m	metre
m^2	square metre
m/s	metre per second
mm	millimetre
MoU	Memorandum of Understanding
Mt	million tonnes
Mtoe	million tonnes of oil equivalent
PV	photovoltaic
SNG	synthetic natural gas
US$	United States dollar
W	watt

Contents

1 Introduction

Mongolia is a very large, landlocked country, with a small population, located between Russia and China. In the last two decades, it has established a democratic political system and has begun reforms to move from a centrally planned economy towards one with market characteristics. At the same time, geological surveys have shown it is rich in natural resources, especially coal, copper and gold, as well as silver, uranium, molybdenum, iron, tin, nickel, zinc, tungsten, phosphates, fluorspar, and some oil. The Mongolia Government recognises that exploitation of its mineral wealth is essential if the economy is to grow; however, its GDP is too small to underwrite major investments to develop the mines and so there is a need for external assistance. This is creating problems as the government attempts to provide an attractive opportunity for external investors while maximising the material benefit to the country by establishing a stable process to manage mineral revenues for the public good, with plans to improve health services, education and socioeconomic infrastructure. Accordingly, this study provides an in-depth review of the status and prospects for energy production and utilisation in Mongolia, with a focus on coal in comparison to alternative energy sources.

Following this introduction, Chapter 2 provides a geographical description of the country, together with an overview of its political, administrative and economic development.

Chapter 3 provides information on the fossil energy resources and reserves together with the potential renewable energy and other non-fossil energy sources, such as uranium.

Chapter 4 examines the role of government in establishing and implementing national energy initiatives, with a close consideration of the relevant policies that have been developed in order to underpin the country's economic development.

Chapter 5 considers the national energy issues, including the likely near- to medium-term development targets, the energy related infrastructure deployment needs that would be required in order for such projections to be realised, the current and planned overall energy utilisation mix, the environmental issues that could arise and projections for CO_2 emissions from industrial sources.

Chapter 6 focuses on the existing coal production capacity and the potential for expansion. This includes a review of the major coal deposits identified so far for exploitation, the various co-operation agreements being set up, together with the potential domestic and international coal markets for the end products, including the political problems that are occurring in some instances. This is complemented by an examination of the social issues arising as coal production increases and the steps being taken to counter the negative aspects.

Chapter 7 provides an analysis of the scope to improve energy efficiency and environmental performance through the introduction of cleaner energy systems, comparing clean coal technologies with alternative and lower carbon intensive options.

Finally, in Chapter 8, possible ways forward for Mongolia are considered, in terms of the overall challenges and opportunities, with some emphasis on knowledge transfer and capacity building.

2 Overview of Mongolia

2.1 Geographical description

Mongolia is a landlocked country within East and Central Asia, bordered by Russia to the north and China to the south, east and west, Figure 1. It is the 19th largest and the most sparsely populated country in the world. There are about 2.75 million people, of which some 60% live in urban areas while a further 30% maintain either a nomadic or semi-nomadic lifestyle, traditionally dependent on herding livestock across the steppes. About 1.2 million people live in or around the capital and largest city, Ulaanbaatar (Embassy of Mongolia in Belgium, 2012).

The country has an average height of 1580 metres, ranging from mountains in the west and north to plains and depressions in the east and the south. The landscape includes freshwater lakes, many salt lakes, marshes, sand dunes, rolling grasslands, alpine forests, and permanent glaciers. The northern and western regions are seismically active zones, with many hot springs (Asian Info, 2012). About 1% of the country is classed as arable, 8% to 10% as forest, and the rest either as pasture or desert. The Gobi Desert zone to the south comprises some 41% of the entire land area.

Mongolia has an extreme continental climate with long, cold winters and short summers. Average temperatures over most of the country are either at or below freezing from October through April, while in the summer they can reach 38°C. Ulaanbaatar has an average annual temperature of –2.9°C and a frost-free period typically extending only from mid-June to late August (About.com, 2012).

The country has on average 257 cloudless days a year, and it is usually at the centre of a region of high atmospheric pressure. The Mongolian steppe and desert-steppe zones are very windy, with an annual average wind speed in these areas of 4–6 m/s, compared to 2–3 m/s elsewhere. Annual precipitation is highest in the north, in the range 200–350 mm, and lowest in the south, which receives 100–200 mm. In the extreme south of the Gobi Desert there is no precipitation at all in some regions for most of the time.

Figure 1 Map of Mongolia (About.com, 2012)

The country is rich in natural resources, including thermal and coking coal, copper, gold, molybdenum, silver, iron, phosphates, tin, nickel, zinc, tungsten, fluorspar, uranium, and oil (EIA, 2012). However, as most of Mongolia is covered by discontinuous permafrost, grading to continuous at high altitudes, this makes the mining of such resources, together with the construction of the supporting infrastructure such as roads and utilities, difficult.

Because of its location, the fragile natural ecosystems, the lifestyle of the people and the economic situation, Mongolia is sensitive to changes in environmental conditions, especially with regard to ecological and socio-economic impacts (Embassy of Mongolia in Belgium, 2012).

2.2 Political issues

Mongolia was established as an independent nation in 1921, and for some seventy years operated a centrally planned economy with close, long-standing supervision from the former Soviet Union. In 1991, the nation adopted new constitutional rules and began a transition towards a parliamentary democracy and market-based economic system (Dumbaugh and Morrison, 2009). That transition is still under way, with the ongoing development of the country very dependent on establishing major mining-based sectors for coal and other mineral resources such as copper and gold (World Bank, 2011a). The Government of Mongolia recognises that exploitation of its mineral wealth is essential if the economy is to grow. However, it also wants to diversify and foster economic clusters around its key mining activities, while also developing a more robust agricultural sector, so as to ensure that the opportunities to improve the economic wellbeing of the nation and its people are not wasted.

2.3 Administrative structures

Mongolia's administrative structure comprises the capital city of Ulaanbaatar together with 21 provinces (United Nations, 2004). The former is divided into nine districts while the provinces are each divided into counties (aimags), which are sub-divided into soums and then into gers. A soum will always have a permanent settlement as its administrative centre while many gers do not.

The capital and provinces each have a governor, appointed by the prime minister, and a local parliament that is elected every four years. Local administrations provide support for the governors. In principle, Mongolia's constitution provides autonomy to these local governments and their administrative structures. However, in practice, barriers include inertia left from decades of central planning, and a lack of local revenues to enable any self-reliance, as such funds are very small compared to those from central sources. Another centralising tendency is the fact that experienced civil servants are in short supply in the country, and most of them work for the central government (United Nations, 2004).

2.4 Economic issues

Mongolia's economy has developed rapidly over the last decade, showing typical year-on-year GDP increases of 10%. Indeed, while annual GDP was US$1.1 billion (1.47 trillion Mongolian Tugruks) at the end of 2000, by the end of 2010 it had reached US$6.2 billion. The major contributors were agriculture (16%) and industry (31%), of which two thirds of the latter came from the mining sector (US Department of State, 2012).

However, in overall terms over that time period, the country has remained relatively poor and, while the GDP per capita has increased correspondingly to US$2257, more than 32% of households are still below the poverty line, with Mongolia remaining dependent on international assistance and support. From 1991 to 2009, official assistance to Mongolia from bilateral and multilateral donors was over US$4 billion.

The economy is also fragile, having recently become too dependent on exports from coal, gold and copper mining. In 2008, mining contributed 28% of the GDP, 65% of industrial output, 69% of export earnings and 56% of foreign direct investment (Energy Charter Secretariat, 2011). This dependence resulted in major financial problems later that year since the global financial crisis subsequently led to sharp drops in the price of Mongolia's export commodities, with associated major declines in those revenues. This led to the International Monetary Fund having to provide a US$224 million loan in 2009 so that Mongolia could meet its balance of payments needs.

The economy remains vulnerable to volatility in global mineral prices. At the same time, it has become increasingly evident that the country is abundantly rich in natural resources. Consequently, with demand for coal, gold and copper again rising, Mongolia is beginning to expand its mining operations, which will lead to greater demand for additional power- and oil-based products as well as increased infrastructure requirements. These opportunities have led to considerable interaction with its neighbours as well as numerous international resource companies, all of whom are keen to work with Mongolia to share in these significant commercial prospects.

However, the small population and the lack of an effective infrastructure, as well as the need for a consistent national long-term strategic plan and implementation approach, has meant that as yet Mongolia has not readily exploited these resources, both for its own growth and to provide significant exports. Indeed, in recent years, this Government uncertainty as to how best to proceed for the benefit of the country as a whole has led to several reverses of policy. The outcome is that both potential domestic and international investors are wary of committing the level of funds that would be required to comprehensively exploit the energy and other mineral mining opportunities.

Mongolia's geographical location also means that its economy continues to be heavily influenced by its neighbours. Although Mongolia has expanded political and financial ties with the USA, Japan and the European Union, it purchases 98% of its petroleum products and a substantial amount of electric power from Russia, leaving it vulnerable to price increases and associated security of supply issues. More than half of Mongolia's external trade is with China while 90% of Mongolia's exports currently have to pass through that country. China is also especially keen to exploit Mongolia's mineral and energy resources because of its continuing and increasing demand. This is creating certain challenges for the Mongolian government, with several schemes now being examined to better establish energy self-sufficiency (Sourcewatch, 2012).

3 Energy resources and reserves

The full extent of energy resources and reserves in Mongolia has not been determined, due to limited exploration using modern, reliable techniques. However, what is clear is that for coal, in particular, the prospects are very significant. Table 1 lists the known fossil energy resources and reserves at the end of 2009.

The overall energy use balance for Mongolia shows that coal accounts for about 81% of the primary energy source, with petroleum products accounting for most of the remainder (IEA, 2011a).

Table 1 National fossil energy sources and demand within Mongolia as of end 2009 (BGR, 2010)

Fossil Energy	Resources, Mt	Reserves,* Mt	Production, Mt	Domestic demand, Mt
Oil	50	2	0.2	n/a
Natural gas	–	–	–	–
Hard coal	39,854	1,170	8.3	~0.7
Lignite	119,426	1,350	4.8	4.8

* Based on exploration and field discovery to date. It should be noted that coal exploration is proceeding rapidly and, for example, proven reserves information through to 2011, but not yet published by BGR, is significantly higher, as is presented later in the report. These estimates do not include allowance for unconventional gas sources, such as shale gas.

3.1 Oil

There is extraction of crude oil from conventional deposits in Mongolia, but so far the annual quantities are insufficient to justify the investment needed to establish a refinery for a domestic downstream oil industry (Swedish Trade Council, 2008). Consequently, all the crude oil is exported to China, while Mongolia imports all its refined petroleum products, mostly petrol and diesel, from Russia. Although the quantities of oil being extracted are increasing each year, it has been estimated that at the current rate of progress it would not be economically viable to set up a domestic oil refinery until around 2025, by which time the annual extraction rate might be about 1 Mt (MRPA, 2007).

The imported oil products are used mostly in the transportation, construction and mining sectors, as well as to fuel off-grid electricity generators in regions of Mongolia that are not connected to the various electricity transmission grids.

For the future, Mongolia is believed to have large resources of bitumen and oil shale, the latter being mostly in the central and western regions of the country. However, detailed geological surveys have yet to be undertaken and consequently little is known about the likely extractable reserves and whether such processes would be economically viable.

3.2 Natural gas

Currently, no significant gas deposits have been found and there is almost no consumption of any gaseous fuels in Mongolia, except for some small amounts of liquefied petroleum gas (LPG), which are imported from Russia for use either as a vehicle fuel or for cooking purposes in household and restaurants.

3.3 Coal

Coal is the only fossil fuel for which geological surveys have been undertaken to any significant extent in Mongolia, although it is understood that until recently these covered only about 35% of the total coal resource (Euromoney, 2006). On such a basis, an estimated 150–160 Gt of resources have been located in 15 major coal basins. The proven reserves to date are over 20 Gt, of which so far some 2.5 Gt have been determined to be commercially viable. It must be stressed that the likely proven and commercially viable reserves will be far greater than the levels currently quoted, this being dependent on further geological surveys being undertaken and on cost effective export routes being established.

In association with the coal, initial surveys indicate a relatively large potential for coal bed methane (CBM) production in the country, although there is a need for further geological exploration and surveys to ascertain if such reserves can be extracted from virgin seams economically.

3.4 Uranium

Mongolia is believed to have some 1400 kt of uranium resources, of which some 38 kt are classed as economically viable reserves (BGR, 2010).

3.5 Renewable energy

Mongolia has abundant renewable energy resources, with an overall potential power generation capacity of 2.6 GWe, based on data collected by the US National Renewable Energy Laboratory (NREL) and the Mongolian National Renewable Energy Center (REC). There is scope to utilise biomass, hydropower, geothermal, solar and wind resources, although further research is needed to determine the more promising options and locations (Euromoney, 2006).

With regard to biomass for heating purposes, sources originating from livestock (dried cow dung, pellets, horse-dung, hardened dung and urine of sheep and goats) and crop residues such as straw, wood and shrubs, are used by the nomadic tribes. As currently burned, all of these materials create significant local pollution, especially within the tribal dwellings. However, systematic studies for the efficient use of such materials have not been undertaken.

For geothermal energy resources, there are 43 hot springs within Mongolia, most of which are located in the undeveloped western mountain regions. To date, a detailed assessment of their exploitation potential has not been undertaken.

In the case of hydropower, the majority of resources are located in the mountainous areas in the western and northern parts of Mongolia. The theoretical potential has been estimated at 5–6 GWe although it is not known how much of that might prove to be commercially viable.

For solar energy, there has been at least a preliminary study, which has examined the solar intensity within Mongolia and the relative coverage at different levels, as presented in Table 2. This suggests that the potential is quite high.

NREL also developed a wind energy resource map for Mongolia in co-operation with REC and the National Institute of Meteorology, which is summarised in Table 3. This suggests that some 10% of the country could offer good wind resources.

However, as with all the other renewable energy options, there remains a need to ascertain the realistic deployment potential within Mongolia, given the very small population, its dispersion within such a large country and the extremely limited infrastructure arrangements.

Table 2 Solar energy resources in Mongolia (Euromoney, 2006)

Region	Annual solar energy intensity, kWh/m^2	Area coverage	
		km^2	%
I	1200 (low)	109,900	7.0
II	1200–1400	800,700	51.0
III	1400–1600	392,500	25.0
IV	1600 (high)	266,900	17.0

Table 3 Potential wind power opportunities within Mongolia (Euromoney, 2006)

Category	Wind at 30 m height		Total area coverage		Total potential capacity, MWe	Potential annual power production, GWh
	Power , W/m^2	Speed, m/s	km^2	%		
3	300–400	6.4–7.1	130,665	81.3	905,500	1,975,500
4	400–600	7.1–8.1	27,165	16.9	188,300	511,000
5	600–800	8.1–8.9	2,669	1.7	18,500	60,200
6	800–1000	8.9–9.6	142	0.1	1,000	3,400
Total			160,641	100	1,113,300	2,550,100

4 National energy initiatives

4.1 The role of government

Following the 2012 general election, the new ruling coalition government has reorganised the various national ministries and commissions (PMIS, 2012). Those that directly affect the energy sectors now include: the Ministry of Economic Development; Ministry of Energy; Ministry of Environment and Green Development; Ministry of Industry and Agriculture; Ministry of Foreign Affairs; and the Ministry of Mining (UB Post, 2012a; EBRD, 2012).

The State Parliament formulates state policy on energy and will also make decisions regarding the construction of nuclear power plants at such time as proposals might be put forward.

The Ministry of Economic Development, which has replaced the Mongolian National Development and Innovation Committee, is in charge of the strategic development of the economy. This includes encouraging private investment, such as public private partnerships, as a means to enhance GDP growth.

The Ministry of Energy sets policy for coal and renewable-based power generation, covering the development, conservation and use of these energy resources, import and export of coal, while also approving investment plans for electricity transmission and distribution developments. It is also responsible for overseeing international co-operation on energy issues. Specific operational responsibilities include (Energy Charter Secretariat, 2011; Sonompil, 2012):

- organisation of technical projects and activities funded by the 'State Budget and Development Fund of Mongolia';
- implementation, supervision and monitoring of programmes and projects in accordance with the Government's policies;
- development and implementation of projects and activities for efficiency improvement of utilities and companies in the power sector;
- development of feasibility studies for projects to be financed by technical assistance from overseas and international organisations;
- provision of guidance and studies for the development of policy and strategy appropriate to the power sector, including regulations to ensure policy implementation;
- introduction of environmentally friendly technologies and new energy sources, including the utilisation of solar, wind, biomass and geothermal energy resources:
- tariff methodology;
- tariff levels;
- licensing and establishing licence conditions;
- authorisation of new generating capacity; service quality; wholesale market structure;
- penalties against energy enterprises for failure to comply with energy legislation and licensing;
- maintaining conditions for fair competition among the generation and supply companies; and
- monitoring overall sector activity.

The need to meet environmental standards for mining and utilisation of energy is addressed by the Ministry of Environment and Green Development, in accordance with the requirements of Environmental Protection Law of Mongolia (Investmongolia, 1995; Oyun, 2012). This deals with the need to avoid adverse ecological effects on:

- land and soil;
- underground resources and mineral wealth;
- water;
- plants;
- animals;
- air.

The Ministry of Mining has responsibilities regulated by the Mineral Laws of Mongolia, covering exploration and mining of all types of mineral resources (Investmongolia, 1997). The mineral resources naturally occurring on and under the earth's surface and in natural water courses in Mongolia are the property of the state, which as owner of all such resources has the right to grant exploration and mining licences to other persons. Thus the Ministry covers: policy for coal exploration, extraction and production; oil production, supply, distribution, imports and exports; safety issues associated with the use of natural gas and the exploration and possible extraction of unconventional oil/gas shale and coal bed methane (Erdenepurev, 2012). It is supported by the Mineral Resources Authority (Buyanbat, 2012) which:

- issues licences related to all mining activities
- provides guidance and studies for the development of policy and strategy appropriate to the sector;
- is responsible for the organisation, implementation, supervision and monitoring of technical projects and activities funded by the 'State Budget and Development Fund of Mongolia'.

In addition, there is a Nuclear Energy Agency, which is the State Administrative Authority in charge of nuclear energy, covering health care, mining, energy production and scientific research (Government of Mongolia, 2000).

4.2 Energy and environmental policies and development plans

Mongolia ratified the Kyoto Protocol to the United Nations Framework Convention on Climate Change in 1999.

In 2001, the Mongolian Parliament approved the national 'Law on Energy', which created the legal framework for energy sector reform, including the scope to open it up to the private sector (Batbayar and Purevbayar, 2010). This was followed in 2002 by the 'Programme on Integrated Power Energy System of Mongolia', which comprised the long-term strategic plan to create an integrated power system over the period 2007 to 2040. The main objective is to create a financially sustainable energy sector that will be able to provide cost-effective energy access, with the benefit of enabling poverty reduction, as well as greater private sector and civil society participation. This includes taking advantage of new technologies and sources of energy that might further promote economic and environmental sustainability (Tsevegmid, 2003). A key part of this is to create favourable conditions for sustainable social development through increasing the share of renewable energy in the electricity supply of Mongolia by improving the scope for widespread usage of renewable energy for rural electrification in regions remote from the high voltage (HV) power transmission grid.

In June 2005, the Parliament approved a 'National Renewable Energy Programme', the aim of which is to facilitate the wider use of renewable energy over the period 2005 to 2020 (Resource Investor, 2012). This was followed in 2007 by the 'Renewable Energy Law' to regulate generation and supply of power through utilising renewable energy sources. This sets out the ranges of feed-in tariffs for renewable energy, the levels depending on the type to be used (EBRD, 2012). Subsequently, the basis for a long-term Power Purchase Agreement was developed, to be signed between the state-owned 'Central Regional Electricity Transmission Network' and any private investors that might wish to establish renewable energy projects.

In 2008, the Government approved the 'State Policy on Fuel and Energy', which identified strategies, priorities, and actions for the energy sector for the period through to 2015. In line with the 2002 legislation, this comprised a commitment to establish an integrated power system with a reliable and affordable energy supply, in order to contribute to regional development and improve overall energy security (Tserenpurev, 2010). In terms of overall energy development, the government intends to:

- supply domestic consumers with electricity from national sources, thereby eliminating the need for imports from Russia;

- introduce economies of scale and greater efficiency into the power sector for the Central Energy System;
- enhance the use of renewable energy, both for centralised and off-grid applications;
- meet the growing energy demand of the mining industry within the country by building new energy complexes; and
- build modern, large capacity coal-fired power plants, solely to export electricity to China

These plans were presented in an international context at the COP15 Copenhagen talks with a listing of some mitigation actions appropriate for Mongolia, although this did not give any consideration as to how such actions might be funded (United Nations, 2009). This included:

- increasing renewable options, such as large-scale PV systems in the Gobi region and large-scale wind farms;
- building various sized hydropower plants up to 220 MWe capacity;
- establishing various coal beneficiation systems, including coal washing, coal briquetting;
- improving the efficiency of heating boilers, including retrofitting and introducing higher efficiency designs.

In view of the lack of significant national oil and gas supplies, the Government recognises that its policy for sustainable energy security will have to be based on coal, at least in the near- to medium-term. Consequently, the strategic aim is to meet the majority of its energy requirements through 'the introduction of economic and environmentally sound coal production coupled with the establishment of clean coal technologies' (Tserenpurev, 2010). The objectives are:

- to increase the capacity of the newer mining operations while introducing more efficient and ecologically friendly technology into mining processes;
- to identify further potentially viable deposits and establish the necessary related infrastructure to ensure efficient exploitation;
- to export high quality coal and coke to regions of north-east and south-east Asia;
- to manufacture synthetic petroleum, chemical products and fuel gas from coal, both to meet domestic demand and to fulfil export opportunities.

The Parliament has also passed several laws that address environmental protection, including the State Policy on the Environment (1997), which forms the legal basis for the protection of the environment and natural resources. The country's priorities for environment and resource management are covered by the Mongolian Action Programme for the 21st Century (MAP 21), which includes recommendations for adaptation to climate change and mitigation of GHG emissions. These are supported by the Law on Air and the Law on Environmental Protection, which were established in 1995 and 2007 for the protection of air and environment in the country respectively.

There also is an intention to privatise and restructure various State assets. In 2001, the national integrated utility enterprise was broken up into state-owned generation, transmission and distribution companies. Currently, the combined heat and power generation companies sell electricity at regulated tariffs to the central regional energy transmission company, which then sells the purchased electricity to ten distribution companies, at wholesale prices. These distribution companies supply electricity to the end-users at retail prices. All the tariffs along this chain are set by the government. In addition to the single buyer market, a spot market has been operating since 2006 and an auction market has been operating since 2007. The previous government had plans for the five combined heat and power plants to be operated by national investors under a 100% public service concession, and the ten electricity distribution companies to be fully privatised to national Mongolian enterprises. The central regional distribution company, which functions as the single buyer, was expected to remain state owned.

Although there has been a change in government following the 2012 elections, it is expected that the main thrust of energy policy as set out above, will be maintained in accordance with the overriding national plan. Thus the coal and other mineral resources will be exploited, much of it via exports, while also building a substantial renewable energy portfolio across various sectors. There is expected

to be an examination of the effectiveness of financial incentives (tax breaks) to encourage the introduction of international investment and technologies that will help to establish the national vision. It has also been stated that the government will seek to simplify the permitting process to avoid bottlenecks in the development activities.

5 National energy utilisation issues

The intention to set up a fully integrated energy system by 2040, including links between the various power transmission and distribution systems, and establishing a considerable expansion of coal-fired combined heat and power plant capacity together with additional hydropower plants as well as localised solar and wind power plants, is intended to be a three phase process.

Thus, between 2000 and 2008, structural changes within the energy sector were made, with programmes initiated to provide electricity to the rural aimags and soums, while nomads were provided with small-scale renewable energy sources. From 2008 to 2011, the focus has been on starting the upgrading and renovation of existing equipment and technologies while preparatory work for comprehensively expanding regional electricity systems has been initiated. The period between 2011 and 2016 is intended to be the beginning of a new development era in which larger-scale energy supply networks and main power lines will be built to establish an Integrated Energy Transmission System, which will meet the country's growing energy demand 'using modern and environmentally friendly technologies' (Mongolian, Economy, 2011).

Alongside these intended technical developments, the State Parliament has approved plans to improve the financial and economic capacity of energy industries and companies, to index energy tariffs and ultimately to implement a transition into a market-based commercial system from 2014 onwards.

However, while the overall plan remains strategically valid and there continues to be much discussion about the introduction of new energy sources as part of the overall plan for new reconstruction and growth, progress has been slow due to the lack of finance and other constraints. At the same time, the original schedule for implementation now appears to be outdated, due to the national energy demand rising far more quickly than was projected originally. This is, in part, a result of the increasing urbanisation of the population but also because the various large mineral resource mining projects that are being developed with government support will require significant energy usage. Currently, unless ways are found to address this growing energy requirement, there is likely to be a major energy shortfall, which will limit the country's ability to establish these major projects, with adverse impacts on GDP growth.

At present, the national GDP is small and, although assistance is being offered by multilateral donors, this will not be enough to take forward all the key infrastructure development challenges within the energy, water, sanitation, and transport sectors. Consequently, there is a need for public-private partnerships to take things forward, with a focus on the various international mining companies that are eager to gain access to the major minerals exploitation opportunities as a source of revenue generation.

5.1 Overview of energy infrastructure development needs

The need to improve the infrastructure for the energy and related sectors has become critical for Mongolia as a result of the economic and social developments during the last few years, especially around the capital city of Ulaanbaatar and in the major mining areas being established in the Southern Gobi region (World Bank, 2007). The existing systems are outdated, with insufficient investments having been made to renew and expand them, and are unable to meet increasing demand (Ganbaatar, 2008).

From an energy perspective, there is a need for additional power and heat capacity, enlarged and more efficient power transmission systems, access to additional water sources (both for industrial use and for associated personal consumption), as well as road and rail transport infrastructure to accommodate the intended increase in bulk supply of coal and other mineral exports (Eurasia Capital, 2009).

5.2 Power transmission and distribution grids within Mongolia

For power supply to urban populations, there are four relatively small, independent transmission grids, namely the Central Energy System (CES), the Western Energy System (WES), the Eastern Energy System (EES) and the Altai-Uliastai Energy System (AUES).

The CES is the main grid system with input from five generation, one transmission and four distribution companies. It supplies power to the cities of Ulaanbaatar, Darkhan, and Erdenet and to the centres of 13 aimags and about 150 soums in central Mongolia, which together account for over 90% of the country's total energy consumption. The CES power supply comprises five coal-fired CHP plants (*see* Table 4) with an available total electrical capacity of 646 MWe, ie three plants in Ulaanbaatar plus one each in Darkhan and Erdenet (*see* Figure 1 for respective city locations). The five units are interconnected by a 220 kV line that also links to the Russian-Siberian grid for peak load needs (REEEP, 2005).

The WES has a capacity of some 12 MWe, which is mostly provided by electricity imported from Russia, and supplies three aimag centres and 22 soum centres.

The EES capacity is 36 MWe (Energy Charter Secretariat, 2011) and comprises one CHP plant in Dornod that supplies the eastern provinces with much of their power.

The AUES, close to the western border of the country, essentially comprises a group of diesel-fired generators, with a total capacity of 11 MWe. It supplies power to 19 soums. There is some hydropower capacity available although its availability is vulnerable to water deficiencies arising from droughts in the summer and freezing of the rivers in the winter.

There is also a self-contained heat and power plant at Dalanzadgad in the South Gobi region of the country, which could provide the basis for a subsequent southern energy system in due course.

The grid systems suffer from significant losses in transmission and distribution. Together with the high internal consumption of electricity by the power stations themselves (*see* Table 4) the losses can be nearly 30% of the total gross generation (Seeking Alpha, 2012a).

In terms of overall energy utilisation, by 2010, all 21 aimags and 318 of the 331 soum centres had been connected to these various grid systems under the ongoing 'Integrated Power System' programme.

Table 4 Current coal fired power plants linked to the Central Energy System (Seeking Alpha, 2012a)

Plant	Period of construction	Capacity, MWe	Internal power consumption, %	Available capacity, MWe	Load factor, %
Unit 2*	1961-69	21	16.4	18	62.2
Unit 3*	1973-79	136	21.0	107	49.3
Unit 4*	1983-91	580	14.8	460	52.6
Darkha TPP	1965	48	18.5	39	62.0
Erdenet TPP	1987-89	29	22.8	22	56.5
		Total 814		Total 646	

* Located in Ulaanbaatar

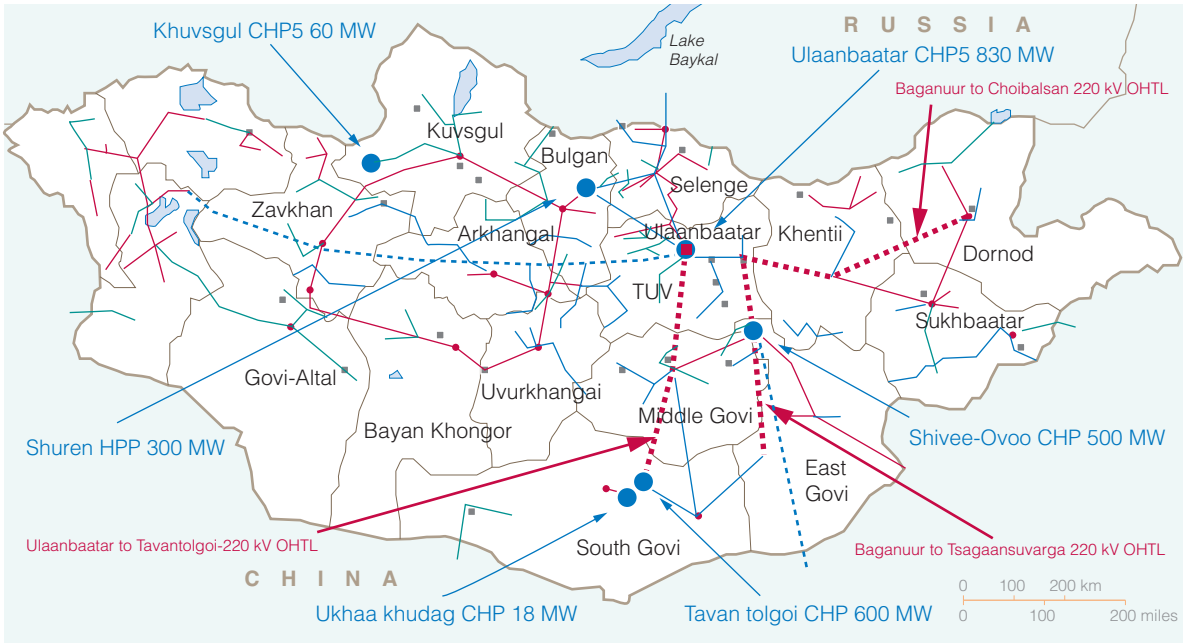

Figure 2 Proposed CHP capacity increases and electricity transmission upgrades
(Yeren-Ulzii, 2012)

Several projects have been proposed to improve this infrastructure, some of which are indicated in Figure 2 (Yeren-Ulzii, 2012). These include:

- a new coal-fired CHP plant within Ulaanbaatar together with an increased capacity for the district heating systems of the city;
- the construction of a significant CHP scheme in order to create a reliable and stable source for the AUES in Western Mongolia;
- the extension of the 220 kV power line and substations from Ulaanbaatar in order to supply electricity to mining operations within the South Gobi region, to be complemented with the construction of a nominal 400 MWe power plant close to the Tavan Tolgoi coal deposit, which will also enhance the reliability of the CES;
- the construction of a large power plant close to the Shivee Ovoo coal deposit near the Chinese border, from which the power will be transmitted to China without any link to the national energy systems (Batrenchin, 2010).

There are also tentative plans to expand the capacity of the EES, either by building a new coal-fired power plant or expanding the existing CHP, while also installing a 220 kV line between Baganuur and Undurkhaan.

5.3 Heat and power supply systems within Mongolia

There are seven main types of supply sources for electricity and/or space heating in Mongolia, namely:

- coal-fired combined heat and power (CHP) plants, which provide electricity, heat, and hot water to the urban centres in Ulaanbaatar and a few other cities that support about 50% of the total population, with almost all the power being supplied through two of the four grids, CES and EES, as described above;
- imported electricity supplies from Russia to meet peak demand and to help balance the demand and supply needs of the CES and WES grids;
- diesel-fired systems that are linked in the AUES grid to supply power and some heat to smaller communities in the far western part of the country;
- local (non-grid) heat and power systems, which are diesel-fired, that supply small communities;

- coal-fired heat-only boilers, which meet the heating and hot water needs of a small central network of several buildings, including about 10% of urban regions;
- individual heat stoves, which burn coal and/or wood to meet residential heating needs in the locations where nomadic people have set up their individual tents, often around the edge of the cities (ger areas);
- solar PV units that so far have been introduced for use in these nomadic households.

There have been boiler and steam turbine retrofits to the coal-fired CHP plants in the past fifteen years, which have been funded by various international donors. While these have resulted in plant efficiency increases of 1 to 8 percentage points, the overall efficiency levels have remained low, in the range 28–34% (LHV basis), with the top of that range applying to the Ulaanbaatar Unit 4 (Seeking Alpha, 2012a). This low efficiency is compounded by ongoing reliability problems, due to most units being over 30 years old, as noted above.

At present, about 95% of the country's power production needs are met by the coal-fired CHP plants, 4.7% via imports and the rest is supplied from diesel generators, small- to medium-sized hydropower plants and other renewable energy sources. The electricity imports from Russia have been used to meet the power demands of the CES during peak hours and to provide close to 70% of total power consumption in the WES. To put that in context, in 2010, the total production of the coal-based thermal power plants reached 4256.1 million kWh, together with 31 million kWh from hydro-electric units, 0.6 million kWh from solar and wind power units and 13.2 million kWh from diesel-fired units. Some 214.1 million kWh of power were imported, while 20.7 million kWh were exported. Overall energy supplied to customers from these networks totalled 3023.5 million kWh of electricity and 27.1 million GJ of heat (Mongolian Economy, 2011).

The government recognises that further reliance on costly and unreliable electricity imports is not a viable way forward (Resource Investor, 2012), which puts the onus on establishing new capacity based on coal-fired power generation (Business-Mongolia, 2012). Thus, additional coal-based plants will be needed to:

- supply heat and power to the expected new mining sites, especially in the South Gobi region;
- provide additional heat and power in the Ulaanbaatar region, both to meet growing demand and to replace the older existing units as they are retired.

5.4 Non grid-based power

The government has made it a priority to connect as many of the population centres to the grids as possible. However, while considerable progress has been made, as noted above, the remoteness of much of the country, with small rural centres well away from the grid-based power systems and a large proportion of the population leading a nomadic lifestyle, offers some unique challenges for the provision of electricity to all.

At present, there are numerous diesel-fired power generators throughout the more remote parts of Mongolia, with a total capacity of some 42 MWe, which are not connected to the various grid systems. However, these are expensive to operate, being dependent on imported fuel from Russia. The government is seeking to address this through the introduction of renewable energy, based on hydropower, solar and wind (Resource Investor, 2012). In overall terms, there are ambitious objectives to:

- increase the share of renewable energy in the total energy supply from 0.9% in 2005 to 3–5% by 2010 and to 20–25% by 2020;
- increase decentralised electrification of remote rural villages to provide electricity to 100,000 households by 2010 and for all rural families by 2020.

For the period 2005-10, the target was to supply power to at least eight regional centres, which are remote from the power grid, with either hybrid wind-diesel generator systems or wind-PV-diesel

generator systems, together with hybrid PV-diesel generator systems for at least five regional centres. For the period to 2020, the intention is to complete the introduction of renewable energy power to the remaining regional centres that are remote from the HV power grids. By late 2010:

- the total installed power generation capacity from renewable sources was at about the 3% level;
- various localised renewable energy sources and other hybrid systems had been installed in 15 soum centres, comprising 11 small-scale hydropower plants, five solar and wind hybrid electricity units, eight solar energy units, together with one wind power unit; and
- some 80,000 nomadic families throughout Mongolia had received portable 200W PV solar energy systems with measurement equipment, with a further 20,000 to be supplied by early 2012.

In addition, two larger hydropower plants at Durgun (12 MWe) and Taihsir (11 MWe) are now operational and providing power within the western provinces of Mongolia.

5.5 Transport

The strategic location of Mongolia between China and Russia has increased demand for transportation services; however, at present, the transport sector of Mongolia is unable to cope with increased demand, which is impacting adversely on the economic development of the country (Eurasia Capital, 2009). In particular, since various coal and precious metals resources are starting to be exploited, not only will Russia and China be among the biggest consumers of those minerals, they will be the only countries through which international markets for the Mongolian goods can be reached. Consequently, the need to develop major transport routes represents a major problem for the government of Mongolia, both in terms of attracting financial support and in implementing the various transport projects. The current total road network is some 49,000 km, of which just over 11,000 km are state roads with the remainder being either provincial or local roads. In total, only 3.5% of roads are paved. As for much of the country's development, establishing an adequate road system is likely to require support from international financial institutions. There is also the expectation that railway networks will be developed, even though the construction costs are some four times higher than for roads

5.6 Water

The quality of water services in the country is inadequate, with only 35% of the population having satisfactory access to supplies. The intended development of major mines within the country, especially in the drier Southern Gobi region, will create even more significant water supply challenges. The water demand in Southern Mongolia is expected to increase sevenfold by 2020.

Although the government has set a target to increase to 70% the proportion of the population having access to acceptable quality water supplies by 2015, this will require annual investment levels rising from the current US$14 million to US$200 million, excluding the need to establish similar infrastructure levels in the intended mining locations (Eurasia Capital, 2009). It is understood that the source of such investments has not yet been identified.

5.7 Current energy utilisation mix and likely future changes

For 2009, total energy production was given as 7.69 Mtoe (IEA, 2011a), based on the utilisation of a mix of domestic sourced coal together with imported oil and oil products. For the future, the expectation is that coal use will continue to dominate, with some imported oil/oil products being replaced by synthetic coal to oil and there being a relatively small but steady increase in the use of renewable energy. The proportion of energy use to be provided by synthetic oil and renewables will be dependent on the government establishing appropriate financing mechanisms backed up by strong policies and robust legal and regulatory frameworks.

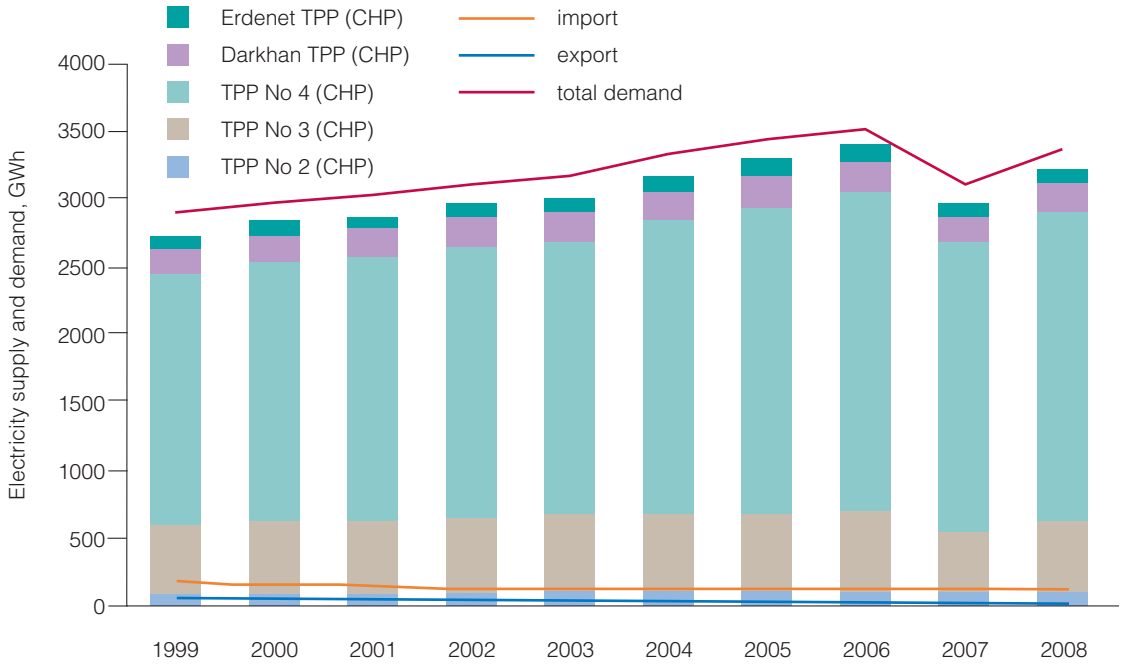

Figure 3 Electricity supply and demand in Mongolia (Eurasia Capital, 2009)

At the same time, there is expected to be a major increase in overall energy utilisation. For example, in the period to 2008, national electricity demand was rising at a steady rate, as given in Figure 3. This shows the total and mix of power generated by the various coal-fired CHP units that currently comprise almost all the domestic capacity available, together with the imports from Russia. This increase in power demand primarily reflects the need to address the urbanisation issues as many previously nomadic travellers have settled close to the various cities, especially Ulaanbaatar. It also indicates that the performance and availability limitations have resulted in an ongoing and increasing domestic power shortage, which has had to be met by the costly and unreliable electricity imports from Russia.

However, this steady rate of increase in power demand is now starting to accelerate, due to changes in the South Gobi region. Currently, the new mines that are in operation are dependent on individual diesel-fired generating systems. However, it is expected that there will be a significant requirement for much greater levels of heat and power, as various larger new mining developments are taken forward. Government sources had suggested that total power demand from major customers in the South Gobi region over the next decade would reach some 870 MWe to 1130 MWe, as indicated in Table 5 (Seeking Alpha, 2012a).

Table 5 Projected electricity demand from proposed major South Gobi mining projects (Seeking Alpha, 2012a)

Likely major mining project	Projected power capacity, MWe
Oyu Tolgoi (copper)	200–310
Tavan Tolgoi (coal)	100–250
Tsgaan Suvarga (copper/molybdenum)	50
Dalanjargalan (coal)	80
Zamyn Uud free zone	40
Sanshuyan Industrial Park	400
Total	870–1130

In addition, the Mongolian Government continues to talk up the prospects for building a 4.8 GWe coal-fired power station at its Shivee Ovoo coal mine, with some 4 GWe of the power being exported to China and the remainder being used to meet some of the increased domestic demand. Such a power station would burn approximately 20 Mt of

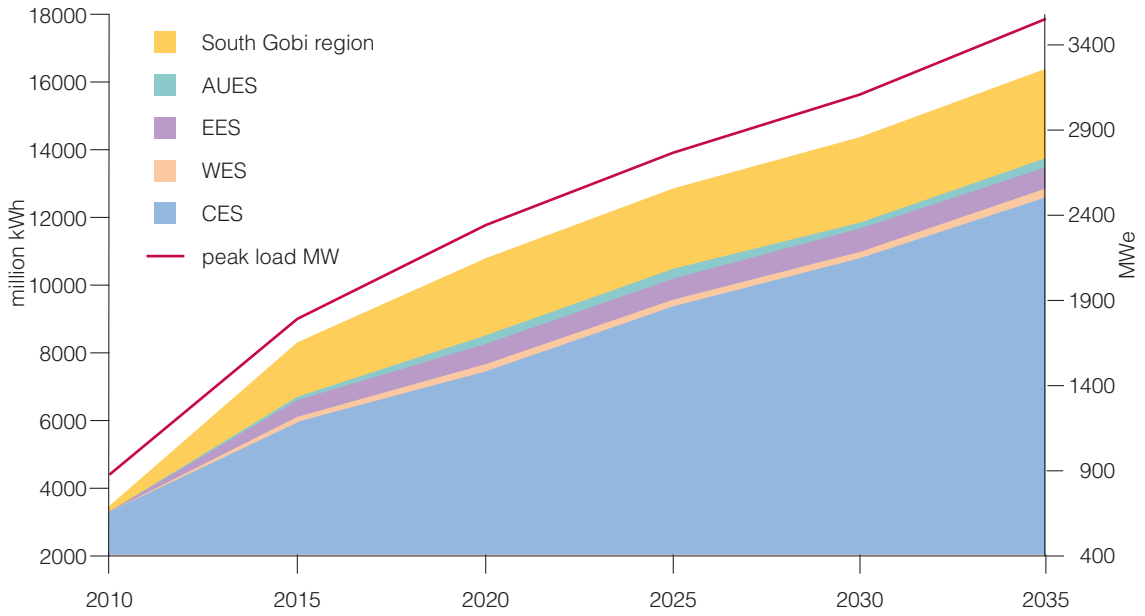

Figure 4 Projected electricity consumption through to 2035 for Mongolia (Eurasia Capital, 2009)

coal a year. It would also require the construction of the 1400 km long 630 kV DC transmission line from Shivee Ovoo to Erlian (at the border between Mongolia and Inner Mongolia) and then to Shouguang in Shandong Province, China (Sourcewatch, 2012).

Figure 4 shows the possible growth in power generation (left hand axis in million kWh) and capacity (right hand axis in MWe) through to 2035. This suggests that while power production in the EES, WES and AUES will remain broadly unchanged, there will be a major upturn in power production within the CES and that there will be a very significant introduction of new capacity to meet power demand for mining projects in the South Gobi region. Depending on exactly how many projects go ahead and the timing for implementation, power demand could more than double for the period 2010 to 2020.

Mongolia's future domestic coal demand will be determined by the increase in coal-fired heat and power production, as well as the extent to which coal to synthetic oil and other conversion processes are introduced. According to estimates by the Ministry of Energy, annual production of coal in Mongolia could potentially reach 70 Mt by 2020. Of this total, some 20 Mt could be exported and the remainder used within Mongolia (Mongolian Economy, 2011). This projection is not especially robust due to the uncertainty as to exactly how many coal mining projects will be established, the realistic potential for exporting coal to a number of Asian markets, and whether domestic coal conversion schemes will be commercially viable.

There are also several estimates regarding the future domestic demand for oil and oil products in Mongolia. According to projections made by the former Energy Research and Development Centre of Mongolia (now part of the Ministry for Economic Development), the total demand for oil in Mongolia will increase from 0.6 Mtoe in 2004 to close to 1.4 Mtoe by 2020. The increase will be used mainly for industrial and transportation purposes, with the latter sector expected to remain the largest oil consumer in coming years. Oil demand in the industrial sector is projected to increase at an average annual rate of 5% between 2004 and 2020, with the main use in the new mining projects. In contrast, oil (ie diesel) use for small-scale power generation is expected to decrease as such units are replaced by grid-based coal-fired CHP units.

5.8 Environmental issues arising

While Mongolia remains a country with a mainly rural environment, in places that is now changing due to localised but increasing urbanisation and the start of what is likely to be a major shift to a mining-based economy, especially in the southern part of the country. Urban air quality is deteriorating due to increasing pollution from household heating, power generation, industry, and transport. In Ulaanbaatar and secondary cities, high levels of particulates and other pollutants pose serious health risks, while water pollution due to contamination of surface and groundwater by sewerage is a growing problem (World Bank, 2004). The population of Ulaanbaatar has grown significantly to about 1.2 million in recent years, with some 20% of that population comprising former nomadic herders setting up their tents (gers) in areas around the city proper, without piped water, sanitation or basic city infrastructure (*see* Figure 5).

Figure 5 View of one of the elderly coal fired CHP plants in Ulaanbaatar together with various dwellings established by former nomads on the edge of the city (Prophecy Coal, 2012a)

The World Bank has assessed Ulaanbaatar's air pollution and its impact on health, including the monitoring of air quality in the ger areas. The calculated exposure of the population to $PM_{2.5}$ in the city was found to be, on average throughout the year, ten times higher than the Mongolian Air Quality Standards and six to seven times higher than the most lenient World Health Organization targets. These problems arise from many sources, including dust from the desert, unpaved roads and open soil surfaces, and lack of vegetation. While the emissions from the elderly coal-fired CHP plants, which have minimal emissions control systems installed, contribute to the problem, the primary source of the pollution is the burning of lignite, wood and various waste materials, both for heating and cooking, in inefficient stoves by the 175,000 households in the ger areas (World Bank, 2011b,c).

The resulting, deteriorating environmental situation is exacerbated by poor co-ordination among ministries and agencies, inadequate monitoring of natural resource conditions and the need for stronger enforcement of environmental regulations (World Bank, 2004). Indeed, while new environmental legislation with upgraded standards had been put forward in May 2012, a strong legal and regulatory framework needs to be established and enforced if there is to be a positive impact.

There is work under way with support from various multilateral donors to replace stoves and low-pressure boilers currently used by ger area families with new models that are more energy-efficient and burn fuel more cleanly. At the same time, efforts are under way to establish medium- and long-term solutions. These include exploring options such as the construction of affordable, energy efficient housing and to improve the environmental performance and efficiency of the urban district heating system, which supplies apartments with heat and hot water (World Bank; 2012a,b; US Department of State, 2012).

For power generation, there will be a need to introduce adequate emission control systems on any new plants that are built and if possible on the existing units as part of a retrofit and upgrading programme.

The development of Southern Mongolia will involve a host of individual mining projects, to which will be linked towns, roads, possibly railways, and power distribution facilities. Various studies have strongly recommended that each individual component should be subject to an environmental impact assessment (EIA) and environment management plan (EMP). The Ministry of Environment and Green Development needs to have an important role in ensuring the quality of EIAs, appropriate responses to EIAs, as well as appropriate monitoring and enforcement of EMPs. It is probable that there will be a need for significant capacity building in order for the Ministry to adequately fill that important role (World Bank, 2009).

In these intended new mining areas, the construction of major roads and, possibly, railways will have regionally significant impacts on the movement of wildlife. At present, not enough is known about the migration routes that are used by animals, and studies to identify appropriate wildlife crossing arrangements are considered by many to be a high priority (World Bank, 2009). Where feasible, transport networks should be planned to minimise disruption to major migration routes.

The other major problem is water management. Should mining increase significantly, these new mining projects, primarily in the water-scarce south Gobi region, will require large amounts of water both for operations and to meet the needs of a large influx of employees. This will either have to be piped in over long distances or be supplied primarily from underground aquifers. There are major concerns that the latter approach will damage an already arid environment (Guardian, 2011), and potentially lead to degradation of both surface and groundwater quality and quantity (US Department of State, 2012). Indeed, the development to date is already threatening the livelihoods of herders due to pressure on available water supplies and the decrease of viable vegetation through increased dust caused by trucks (CEE Bankwatch Network, 2011).

5.9 Current and projected future CO_2 emissions

In 2009, Mongolia's CO_2 emissions were 12.0 Mt (IEA, 2011b), which comprised 9.7 Mt and 2.3 Mt from the use of coal and oil/petroleum products respectively. This represented an increase of over 26% compared to 2005 levels. In terms of sectoral contributions, the great majority came from power and heat production (7.4 Mt) with a broadly even spread of the remainder between manufacturing/construction (1.2 Mt), transport (1.4 Mt) and others (1.9 Mt). Although projections for future CO_2 emission levels vary considerably, depending on assumptions made regarding the basis for economic growth and the likely time by which significant mining activities get under way, it is generally assumed that the levels will rise rapidly. For example, based on a growth scenario that assumes little additional mining activity, it is projected that by 2020 total emissions will be about five times the 2005 total. If the probable mining developments are included, this could result in emissions increasing by a factor of ten.

6 Current and potential coal production capacity within Mongolia

6.1 Coal resources and reserves

Figure 6 provides an outline of the coal-bearing basins, which shows that the hard, bituminous coals are located in the southern and western provinces while the lower-grade, subbituminous coals and lignites are generally located towards the northern and eastern parts of the country (Tserenpurev, 2010). Based on the Russian assessment system, Mongolia has some 160 Gt of coal resources, comprising both hard coal and lignite with the latter accounting for some 75% of the total. Over 300 coal deposits have been identified, most of which have only recently begun to be defined with modern exploration techniques. About 80 have been explored but not in all cases mapped in detail. To date, over 23 Gt of technically viable reserves have been determined in 15 basins, with about 12 Gt so far having been economically proven. In general, these reserves are shallow, and suitable for opencast extraction, with good mining conditions. They comprise some 2 Gt of coking coal and 10 Gt of thermal coal, with the hard coal proportion mostly in the South Gobi region.

However, since there has not been a driver to ascertain in detail all the coal quantities available, in overall terms, there is limited information on the future exploitation potential of Mongolian coals, the diversity of qualities, size of deposits and what infrastructure is needed to bring the coals to market (Tserenpurev, 2010).

Figure 6 Locations of main coal deposits in Mongolia (Tserenpurev, 2010)

Table 6 provides some data on coal deposits surveyed prior to 2010. It is important to note that definitions of resources and reserves are not entirely in line with international practice and that some information is missing. However, the table does provide a reasonable snapshot of the situation prior to 2010 and gives an indication of the extent of mineable coal that had been determined, which is significant, although much of it is brown coal that is not suited for export.

Table 6 Summary data for coal reserves identified before 2010 (based on Purevsuren and Drebenstedt, 2004; Daly, 2008; Ganbaatar 2008; Mongolian Alt Corporation, 2010)

Region	Coal deposit	Coal basin	Coal rank	Estimated reserves, Mt	Mineable reserves, Mt
Central	Shivee Ovoo	Choir-Nyalga	Brown	2700	564
	Tevshin Govi	Choir-Nyalga	Brown	–	588
	Tugrugnuur/Tsaidannuur	Choir-Nyalga	Brown	2000	–
	Baganuur	Choir-Nyalga	Brown	700	511
	Khoot	Choir-Nyalga	Brown	–	85
	Sharyn Gol	Choir-Nyalga	Brown	–	32
	Ulaan-Ovoo	Choir-Nyalga	Brown	–	24
Eastern	Adduunchuluun	Choybalsan	Brown	330	230
	Tugalgatai	Choir-Nyalga	Subbituminous	3000	–
	Chandgana Tal	Choir-Nyalga	–	–	123
	Talbulag	Sukhbaatar	–	–	49
Western	Hushuut	Mongol Altay	Bituminous (thermal and metallurgical)	300	–
	Uvurchuluut	Big Bogdyn	–	–	4
Southern	Tavan Tolgoi	South Gobi	Bituminous (thermal and metallurgical)	–	7500
	Baruun Naran	South Gobi	Bituminous (thermal and metallurgical)	155	–
	Nariin Sukhait	South Gobi	Bituminous (thermal and metallurgical)	250	220
	Ovoot Tolgoi	South Gobi	Bituminous (thermal and metallurgical)	150	–

6.2 Current production and utilisation

Coal production was steady between 2000 and 2004 (*see* Table 7) with the coal mines at Baganuur, Sharyn Gol and more recently Shivee-Oboo producing the majority of the output. Their annual production capacities were 2.8 Mt, 0.5 Mt and 1.2 Mt respectively and they mostly supplied the fuel needs of the CHP units in Ulaanbaatar, Erdenet and Darkhan, and for home heating (Davaatsedev and Tunga, 2005).

By way of an example, the Baganuur open cast mine, with 1000 employees, is located close to Ulaanbaatar. It was established in 1978 since when it has produced over 89 Mt of lignite, which is suitable for use in thermal applications (Bazar, 2012). The coal has a calorific value (cv) of

Table 7 Coal production in Mongolia (Index Mundi, 2011; EIA, 2012; Buyanbat, 2012)

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Annual production, Mt	5.4	5.4	5.4	5.4	5.4	7.7	8.1	8.5	9.9	14.2	25.1	32.1

14,700 kJ/kg, with an ash content of 15–16% and 30–32% moisture. There is also a coal-fired boiler on site that provides heat both to the mine buildings and to the nearby town where there is a population of 30,000.

The coal deposit comprises three seams, each about 20–30 m thick, covering an area in excess of 15 km^2. The top seam is but a few metres below ground level, with the middle seam a further 30 m below that. The lowest seam is at a depth of 120 m and is not being extracted as this would require the establishment of a deep mine system. Although a definitive production cost was not provided for the two seams being extracted, it is understood that the average is below 10 US$/t. The coal is crushed then transported by rail to the end users. The mine provides sufficient output to meet some 70% of demand within the central region of the country, particularly for Ulaanbaatar's various CHP plants, which use some 90% of the output, with most of the remainder going to Darhan and Erdenet as well as various smaller municipalities. Production will be increased to ~5 Mt by 2016 in order to also supply most of the coal for the new CHP unit that is due to be built by that time.

In those areas where both the upper and middle coal seams have been extracted, there is an ongoing restoration programme to re-establish the steppe terrain. This is being undertaken by a company from South Korea (Bazar, 2012).

In the last decade, some 200 special mining licences have been issued within Mongolia, including 60 for coking coal, with 60% of the total currently being active (Erdenepurev, 2012). Coal production levels have risen rapidly to some 32 Mt in 2011, through newer operations being introduced, with exports of hard (coking and thermal) coal close to 25 Mt, all of which have been sent to China.

For 2012, the projected production level is 41 Mt; however, by the end of August, only 17 Mt had been produced, of which 11 Mt were exported. This is, in part, a result of market problems due to China not requiring as much coal because of a downturn in the economy. However, it also reflects the energy security issues arising from China trying to buy out various international mining company holdings within Mongolia, as discussed in Section 6.4.

6.3 Future production prospects

The increase in domestic coal utilisation could be significant should major coal conversion activities and additional power production become established. The former requirements and much of the latter would be met through the use of subbituminous and brown coal utilisation, drawing on the mines located in the northern, central and eastern regions of the country.

In addition, the prospects for new coal production should be very positive in Southern Mongolia,

Table 8 Potential major coal mines in Southern Mongolia (adapted from World Bank, 2009)

Mine	Expected life, years	Expected annual production, Mt	Possible/actual start date
Tavan Tolgoi	>200	15	2012
Uhaahudag	40	10	2009
Baruun Naran	20	6	2012
Tsagaan Tolgoi	20	2	2015
Nariin Sukhait	40	12	2013
Ovoot Tolgoi	50	5	2008
Sumber	50	5	2015

where initial assessments have identified some attractive opportunities. Table 8 sets out the preliminary estimates of future production volumes from the existing major and future intended mines, which suggest that annual coal production in this region could well be in excess of 45 Mt within a few years. Figure 7 identifies the respective geographical locations, with the the coal mining prospects marked in green. It is stressed that many of these deposits contain significant quantities of both coking and thermal coal, with the former in particular offering major export possibilities.

Figure 7 Locations of major mine opportunities in Southern Mongolia (World Bank, 2009)

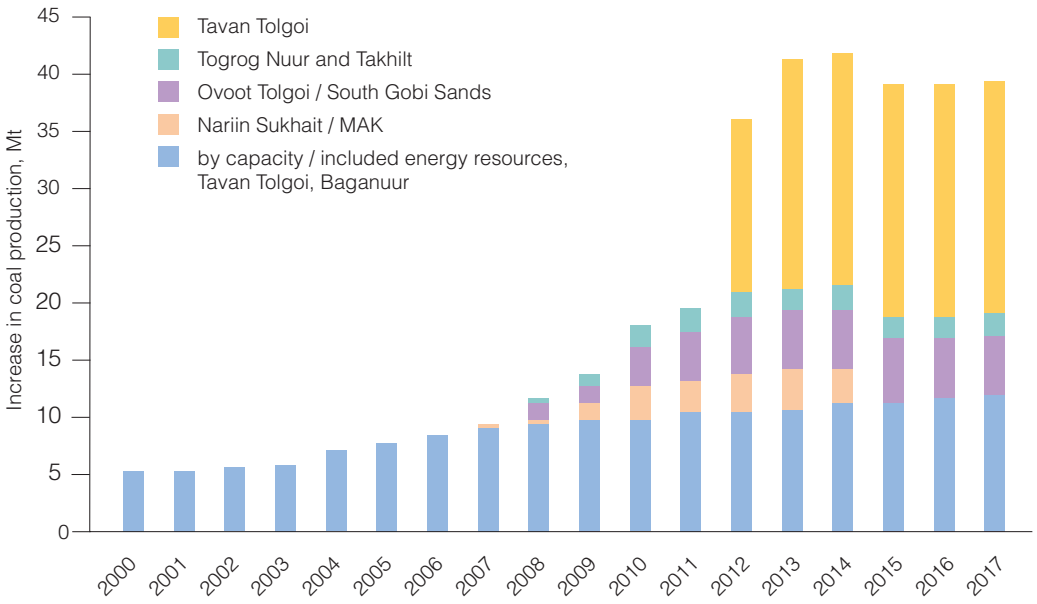

Figure 8 Projected increases in coal production (ACI, 2011)

The Ministry of Energy (then the MMRE) had made projections that indicate Mongolia will significantly increase its annual coal production to over 40 Mt from 2015 onwards, which represents over four times the level of 2008 (ACI, 2011). The 2025 target is 90 Mt. However, as shown in Figure 8, achieving this target would be dependent on bringing new production centres on line, especially Tavan Tolgoi, from about 2012. The reality is that this has not yet happened due to differing views on a resources exploitation strategy, which is discussed below.

6.4 Exploitation issues

There are many international mining companies working in Mongolia, either operating or developing coal mining projects. The major organisations and the location of their stock market listing are shown in Table 9 (Mongolia Today, 2012). Some of these are majority owned by other major mining corporations, with some closely linked to Chinese companies.

In the past, with hindsight, the Mongolian Government had been rather naïve about the requirements applied to the mining licences that were awarded to foreign companies and in some instances this approach led to some gross abuses of the terms and conditions (Sonompil, 2012). The reaction to this is that such a position for any new mine developments and some existing operations is no longer viewed as necessarily either economically or politically acceptable by the government, with calls for tighter regulation including a retrospective approach on existing contracts. However, this is causing considerable uncertainty within the mining sector and has led to long delays in many potential coal mining projects being established, while an appropriate way forward is devised.

The Tavan Tolgoi coalfield appears likely to provide a template for future exploitation plans within the coal mining sector although to date the approach adopted has been inconsistent. It offers very significant potential as it is ranked as the world's largest proven but undeveloped coal resource. It comprises six deposits, which contain over 6 Gt of surveyed reserves, containing some 1.8 Gt coking coal with the remainder being good quality, hard, thermal coal (Erdenepurev, 2010). It is located in the South Gobi desert near China's northern border (*see* Figure 7) although it is some 400 km from the nearest railway line.

Currently, there are two existing, relatively small-scale mines. One is a joint venture between the provincial government and Qinhua, and is located close to the Chinese border. This has operated for nearly ten years and produces some 3 Mt annually, of which 1 Mt is exported by truck to the border (World Bank, 2009). The other is owned by Energy Resources LLC, a subsidiary of the Mongolian Mining Corporation, which was granted a mining licence in 2006 and has been in operation since 2009, also producing coking coal for export to China (Mbendi, 2010).

Table 9 International coal mining companies active in Mongolia (Mongolia Today, 2012)

Company	
Aspire Mining (Australia)	Mongolian Investment Group (Hong Kong)
Banpu (Thailand)	Mongolian Mining Corporation (Hong Kong)
Draig Resources (Australia)	Mongolian Resource Corporation (Australia)
Guilford Coal/Terra Energy (Australia)	Nova Resources Ltd (Bermuda exempted company)
Lucky Strike Resources (Canada)	Prophecy Coal (Canada)
Modun Resources (Australia)	South Gobi Resources (Canada)
Mongolia Energy Corporation (Hong Kong)	Xanadu Mines (Australia)

The rights to mine the remainder of the Tavan Tolgoi deposits remain owned by the government through its company Erdenes MGL, which has formed a wholly-owned subsidiary, Erdenes Tavan Tolgoi (ETT), to be the company that controls any subsequent development. The government did consider using contract miners to exploit the entire coalfield but abandoned this approach because of funding problems. It then held a bidding contest (Erdenepurev, 2010) to choose a mining group to develop the area of greatest near-term interest, namely the Tsankhi block, which contains most of the coking coal in the area. In mid-2011, subject to ratification by parliament, the winning consortium was announced as Peabody Energy, Shenhua Group and a Russian-led group (Taipei Times, 2011a,b), on the basis that the development would be undertaken in conjunction with ETT. However, in September 2011, the Mongolian parliament rejected these plans, in part because of complaints from other bidders in South Korea and Japan that had been unsuccessful (Asia Times Online, 2012).

The government subsequently announced that it would offer 50% of ETT for public sale in 2012. The original intention was that ETT would hold a 50% stake in the project, with 10% of the equity to be provided to all Mongolian citizens equally, free of charge, with a further 10% to be sold to Mongolian national entities, and 30% to be sold through an international public offering (IPO) at international stock exchanges. The aim was to raise funds to develop infrastructure for the whole of the Tavan Tolgoi coalfield, including roads, rail routes, site construction, a coal handling and preparation plant that should boost the value of the coal once mined, together with the overall provision of water and electricity. Subsequently, there was an adjustment, with 20% of shares to be issued without charge amongst all Mongolian citizens while between 20% and 30% would be open to foreign investment to raise some US$3 billion development capital (Bloomberg, 2011). A three-way listing in London, Hong Kong and Ulaanbaatar was proposed. However, this flotation has been delayed to 2013, as ETT cannot complete listing plans until Mongolia's parliament passes a key securities law to determine the equity structure of the company (Reuters, 2012a). At the same time, in the run-up to national elections, the government allowed its citizens the choice of either cashing in their shares in advance of the listing at the declared opening value or to hold them and seek to gain from subsequent rises in value once the listing has been completed (FT.COM, 2012).

This has inadvertently resulted in a major shortfall in mining revenues, with the timetable for coal extraction showing further significant slippage. The issue of whether external companies will be invited to work with ETT in developing the Tsankhi coking coalfield remains unresolved and discussions with a range of companies are ongoing (Reuters, 2012b).

Alongside this slow listing process, there have been other developments that have created further investment uncertainty within this sector. The company, South Gobi Resources, owned by Turquoise Hill (formerly Ivanhoe) of Canada, is licensed to mine coking coal at sites that are close to the Chinese border. The state-owned company, Aluminium Corporation of China (Chalco), agreed to buy a majority stake in South Gobi Resources and so take control of its projects in Mongolia. However, this prompted the Mongolian Government to introduce legislation (Reuters, 2012c) requiring both government and parliamentary approval for any foreign investments worth more than US$76 million that would buy a stake of more than 49% in businesses in designated strategic sectors, namely minerals, banking and finance, media and telecommunications (Wall Street Journal, 2012). Certain other transactions would also need approval, such as those that may affect Mongolia's commodity exports or create a monopoly in certain commodities markets (Financial Times, 2012a).

This was followed by the suspension of the South Gobi Resources mining licences pending an investigation into the Chinese takeover approach. The Mongolian legislation is similar to those applied in Australia and Canada, where there are requirements to protect the national interest, with close scrutiny on deals where overseas state-owned enterprises plan to acquire strategic assets. Even so, Chalco continued to pursue another deal to buy a major but minority share in a coal trading company that is a big buyer of coking coal with rights to transport the product into China (Reuters, 2012c,d). However, with the realisation that Mongolian approval would not be forthcoming, Chalco formally announced that it would not be proceeding with either of the intended deals (Financial

Times, 2012b). Consequently, although it has prevented China from establishing a major direct mining presence in the country, the Mongolian Government has created further problems in the sector. It does not yet have a workable framework for large foreign investments under the new law, which is a deterrent for both mining companies and investors, until some precedence has been set.

6.5 Opportunities for coal exports to China, Russia and beyond

There are bulk imports and exports of commodities, such as oil and grain, through established routes within Russia and China. However, establishing the basis for the export of coal through either of these countries to alternative markets is proving problematical.

The Mongolian Coal Association has suggested that annual coal export volumes could reach 50 Mt by 2015 and 80–100 Mt by 2025, with likely markets being China, Russia, Japan and South Korea. However, this will be dependent on the necessary infrastructure being established and agreement being reached with either China or Russia that coal (and other minerals and precious metals) can be exported through rather than just to that country. The other factor that must be considered is the costs of such exports relative to offerings by competitors. The commercial viability of such an enterprise will be dependent on the price at which it can supply the coal. This will be based on the costs of its production and transport, together with the terms for which it can negotiate an export route via a port belonging to either of its neighbours in order to offer its products to other countries (Seeking Alpha, 2011). At present, the production cost of the coal is low, while the transport costs will be high, especially if the export route is via Russia.

The hard coal that would be exported is located in the South Gobi region. As such, the nearest potential customer is China, with its well known drive to secure major energy resources on a global basis. The World Bank estimated that Mongolian coal production costs could be of the order of 10–30 US$/t, with similar costs being incurred for freight into China. In 2009, at the time of the study, China was paying premium prices for coking coal due to domestic supplies being limited, and so a deal to supply would appear potentially attractive to both parties. As noted in the previous section, various foreign developed mines have already been selling coking coal to China from near the South Gobi border and there are also similar operations in a number of locations further to the west. In contrast, for thermal coal supplies, Chinese companies were paying in the range of 18–55 US$/t via domestic sources, depending on the calorific value. This would appear to make Mongolian thermal coal at best a marginal option, ultimately depending on the transport costs from Mongolia to Chinese customers (World Bank, 2009).

With regard to markets beyond China, much higher prices would be possible both for thermal and coking coals in other Asian countries, which would more than offset the transport costs. However, this would depend entirely on striking a deal for access to a port, while the distances involved would make railway transport the only credible option. The World Bank concluded that the lowest cost approach would be a railway from Tavan Tolgoi directly to Baotou in the Chinese autonomous region of Inner Mongolia. At 2009 prices, if 20 Mt of coal should be exported annually via this route, then a profit of US$1460 million for Mongolia should be possible. In contrast, selling the same quantity of coal by way of a new railway through Russia might generate profits of around US$246 million per year.

6.6 Social issues

The expansion of coal and precious metals mining offers the prospect of long-term development for Mongolia that will underpin the broader development of the economy, with sustainable benefits for the nation as a whole (Guardian, 2011). For this to happen, the government needs to ensure that the mining operations meet all the environmental regulations and standards, while it allocates sufficient of its share of the proceeds to the development of essential services. These include education and health

care, as well as creating capable workers with equal access to opportunities to fill jobs in the mining and construction sectors (US Department of State, 2012). This creates a challenge for the government to ensure that its mineral wealth benefits the whole nation rather than just certain sectors of society, as has been the case in some other resource-rich countries (Brookings, 2012).

Currently, close to 30% of Mongolia's urban population lives below the poverty line (UNDP, 2007) and, in principle, this mining boom should provide the means to raise people's living standards. However, as yet, the relationship between exploitation of the country's coal and other natural resources and the wealth of its people has still to be determined (Guardian Environmental Network, 2011). In 2008, the government created a Human Development Fund with the ambitious goal of bringing Mongolia's human development status to the same level as that of the developed countries by 2020. Initial capital for the Fund was drawn from the Ovoot Tolgoi gold and copper mine project, which will be supplemented with revenue from the various major coal projects and other mining activities when they are established, especially that at Tavan Tolgoi.

There has been extensive consultation on how best to use the fund, with the consensus being that the focus should be on improving access to basic services and housing conditions, reducing inequality in life expectancy and material standards of living, and maintaining environmentally sustainable income flows to meet Mongolia's most significant development challenges. With this in mind, the Human Development Fund is expected to provide pension, health, housing, and educational benefits but the government has also used it to make cash payouts to all citizens. The initial reactions to the inclusion of cash payouts have been mixed, with many multilateral donors concerned that these will create inflationary pressures and also provide the government of the day with the means to buy votes in national elections. Indeed there were significant payouts in advance of the June general election to the extent that the fund has now run out of money, which has been compounded by a major drop in mining-based revenues due to the sector slowdown and the problems arising with control of the various companies.

Notwithstanding these presumed temporary problems, on a broader level, there have been various recommendations on how to ensure adequate human development for the good of Mongolian society as a whole, which incorporate ideas on how best to develop the Fund. These include suggestions (UNDP, 2011) to:

- strengthen the capacity of national and local institutions with the formation of a National Human Development Commission, with members from government, academia, NGOs and civil society to establish policy guidelines based on international best practice for the use of the Fund, while also providing opportunities for information sharing, decision-making, and dispute resolution;
- reduce vulnerability of rural households, including establishing community-based forest conservation and biodiversity protection institutions;
- develop the organisational and leadership capacity of regional administrative institutions to track changes in environmental vulnerability and use the human development approach in policy making;
- develop the necessary statistical measures, including poverty and environmental statistics, access to water, sanitation and energy and the key indicators of human development to enable the regional administrative organisations to monitor progress;
- use international co-operation to promote technology transfer within a market context.

Many of the social impacts that are beginning to arise will need to be addressed by local governments. For example, with regard to town and social services, as local populations grow, there will be a need to ensure adequate accommodation, town infrastructure, education, health, law and order, and town administration. The current administrators in the local communities may well have little expertise and awareness about the health impacts from the development of the new mining industry, with no means to monitor local air and water quality, these being most affected by mining activities and which pose the highest risk to community health. This suggests the need for investment in capacity-building of local government, preferably before there is a population influx arising from mines being established (CEE Bankwatch Network, 2011).

There is also a need to improve employment opportunities for Mongolian people through education and training. This includes the need to set up such facilities that can address the needs of the mining industry, for the benefit of local residents. Linked to this issue is the possible displacement of nomadic herders due to the new mining developments. Not only is there the question of compensation arrangements for such persons, it will be important to also ensure that adequate livelihoods can be retained, which will link into possible training activities.

7 Introduction of cleaner energy technologies

To date, coal utilisation within Mongolia has been inefficient and polluting, based on outdated technologies for power, domestic and industrial applications, all of which were introduced via the links imposed by the former Soviet Union. Consequently, there is a need to introduce alternative, cleaner, coal-based systems, with a major need to build capacity to ensure suitable equipment selection and subsequent effective operation. At the same time, there is a growing interest in renewable energy technologies as a possible means to enhance cleaner energy use.

7.1 Role of international co-operation

There has been co-operation through capacity-building via multilateral donors and bilateral agreements, much of which has been focused on poverty alleviation and environmental improvements at local levels. With the expected upturn in both coal-based and renewables technologies as the economy expands, the scope of such activities has begun to grow, some examples of which are given below.

7.2 Coal preparation for upgrading

There is much that can be done to improve coal quality including coal washing, which can increase calorific value and reduce ash content and sulphur content. For example, at the Sharyn Gol mine, run of mine air dried coal has a calorific value of 21 kJ/kg with an ash content of 20%. After washing, this can be improved to 25 kJ/kg and 10% ash (Chapman, 2012).

7.3 Coal-based heat and power technologies

The efficiency and environmental performance of the existing CHP plants is low, due to outdated designs and less than optimum operational practices.

In Ulaanbaatar, recent efforts have been focused on how best to improve the performance of Unit 4 (ADB, 2006) as this is the only one that is not yet scheduled for closure. For the near term, the proposed way forward is to implement further energy efficiency improvements, which are likely to include the introduction of coal cleaning technologies and additional uprating of the steam turbine. For the longer term, the unit will reach its design lifetime in 2020 and it has been suggested that repowering with circulating fluidised bed combustion (CFBC) together with various reliability improvements should then be introduced (ADB, 2006). However, while all of these actions will improve the efficiency of energy utilisation and to some extent address pollutant emissions, so far there do not appear to be any announcements about the introduction of specific gas cleaning technologies.

As well as uprating Unit 4, there are plans to close CHP Units 2 and 3 by end 2015, which is long after the original intended date during the previous decade. In recognition of the expected growth in demand, the government has also agreed to proceed with the establishment of a new CHP plant (Unit 5) in Ulaanbaatar, which will be based on the continued use of the lignite that is used to fuel the existing units. The expectation is that it will be built at the eastern end of the city to complement the existing units that are located on the western side (Mongolia Economy, 2012). A bid process has been implemented for the construction of this new unit and a preferred bidder has been identified. This is a consortium, which comprises International Power, a subsidiary of GDF Suez (power, gas, environmental and energy services), Sojitz Corporation (Japan's sixth largest trading corporation),

Posco Energy (South Korea's largest private power producer) and Newcom LLC (a leading Mongolian conglomerate involved in civil aviation, telecommunications, renewable energy, real estate and construction, and mining equipment). Subject to financial closure and the signing of a 25-year Power Purchase Agreement for the entire output from the plant with the Mongolian Government, this consortium will build and operate a coal-fired CHP plant with an electricity capacity of 415 MWe and a heat output of 587 MWth. Total investment has been reported as US$1.3 billion, which will be financed by the consortium through a mixture of debt and equity.

The plant will include three CFBC boilers that should be a more appropriate technology for firing the lignite. The plant will incorporate some as yet undefined efficient pollutant control measures to significantly reduce emissions of particulates, which will contribute to improving urban air quality. The plant is expected to start operation by 2016 and will supply about half of the city's energy needs.

There are several other coal-fired power plant projects being developed, which are targeted either at improving the CHP systems in other cities linked to the various grids or to meet the likely power demands in the South Gobi region. The status of many of these is unclear and only a limited number will proceed beyond the pre-feasibility stage.

One high profile prospect was put forward by Prophecy Coal, which is an active mining company in Mongolia. Previously, it announced that it planned to establish an environmentally friendly, independently-owned coal power plant and that this had been endorsed by the then MMRE and approved by the Mongolian Energy Regulatory Authority (PennEnergy, 2011). Their stated intention was to build and operate a modern 600 MWe coal power plant at Chandgana in Eastern Mongolia for connection to both the Central and Eastern Energy Systems, thereby providing a link. There were also longer-term outline plans for scaling up capacity to 4200 MWe, subject to an agreement being achieved to export surplus power to China, for which an independent transmission line study was started in 2012. Prophecy Coal has been in discussion with various investment banks that might be interested in providing the US$800 million project financing (Prophecy Coal, 2012b), with full 600 MWe operation suggested for mid-2017. However, even at this lower capacity level, unless there is a deal to sell power to China, it is difficult to see how a power purchase agreement will be reached with the Mongolian Government as the amount of power available would appear to be well in excess of what could be accommodated, given the announcement about the new CHP unit in Ulaanbaatar. Consequently, it seems very questionable that this power plant project can proceed.

There are also several other provincial projects at various stages of development, mostly focused on providing power to possible new mining ventures in the southern part of the country. For example, Erdenetsogt LLC is a privately-held Mongolian company, which 'seeks to develop, implement and adhere to a comprehensive and best-practice stakeholder approach' (Bayasgalan, 2012). It has received permission to establish a lignite-fired power plant in Altanshiree, in SE Mongolia, close to the South Gobi mining region. The expectation is that overall capacity will be 600 MWe, based on two equal-sized 300 MWe modules to be introduced sequentially. There is also strong interest in a poly-generation approach, to produce heat, power and possibly synthetic fuels, which would require the selection of a gasification-based technology. Pre-feasibility studies are being undertaken, in order to assess the options, prior to any firm investment decisions being made (Bayasgalan, 2012).

7.4 Coal-based industrial boilers

These small units, which provide heat to townships and small industrial facilities, are inefficient and locally polluting, due to the poor quality coal and other materials used as fuel. At present, little is being done to address this issue.

7.5 Coal bed methane extraction

Since all of Mongolia's coal production is from surface mines, the coal mine methane (CMM) development potential in Mongolia is linked to pre-mine drainage in advance of surface mining operations (Tulga, 2011). With regard to coal bed methane (CBM) extraction from virgin coal seams, some of the basins in Southern and Western Mongolia may be suitable (Schwochow, 1997). However, since there are no natural gas imports, there is no existing infrastructure to support the use of CBM. It may be possible to establish possible applications through on-site heat and/or power generation at coal mines, although at present there would appear to be far greater market certainty for investing in coal-based systems to supply such sites.

There should be scope to expand the existing energy exploration and geological surveys, as this would be valuable in determining the potential of the larger CBM sites. However, notwithstanding these technical challenges, at present Mongolia lacks a legal framework to provide flexible economic incentives in order to attract foreign direct investment and expertise for the development of such unconventional energy resources.

7.6 Coking

Although the focus has been on exporting coking coal, since 2009 there has been one small-scale coking plant, which is located in the South Gobi region and is owned primarily by ENK Limited. This produces some 300,000 t/y of end product using Tavan Tolgoi coal, with all the coke being exported to China.

The government has also signed a MoU with ThyssenKrupp Uhde relating to the development, engineering and construction of a heat recovery coking plant, for which a feasibility study, based on ThyssenKrupp Uhde's proprietary technology, had previously been prepared (American Fuels Coalition, 2012). No cost details appear to be publically available.

The Mongolian Government has examined options to link coal supply to technology introduction. Thus the Steel Authority of India has signed a MoU with the Mongolian Government to establish a steel plant in the country on condition that Mongolia allocates a coal mine to supply the required quantities of coal (Hindu Times, 2012). Subject to the project proceeding as planned, this would be the first steel mill to be established in Mongolia. The Steel Authority also wishes to export surplus coal from the mine to India in order to take advantage of lower costs compared to importing from Australia. This would need to be through Chinese ports although it is not clear how this latter step would be achieved.

The government has also announced that it intends to establish an Industrial Park at Sanshuyan, which is some 50 km from the Chinese border in the South Gobi region. The aim is to produce added value products, either from coal or using coal as an energy source, for export into China. There is a railway link to a station nearby in China so there should be scope for ready access. Likely products include coke as well as cement and construction materials. As yet, there is no detailed plan and no firm deadline for implementation.

7.7 Underground coal gasification

Underground coal gasification (UCG) is the in situ gasification of coal in the seam, which is achieved by injecting oxidants, gasifying the coal and removing the product gas through boreholes drilled from the surface. The gas can be used either for power generation, industrial heating or further processed for the manufacture of hydrogen, liquid products, synthetic natural gas and other chemicals. Consequentially, UCG offers the potential for maintaining an acceptable level of security and diversity

of energy supply while also reducing emissions of environmental concern. There have been several major international large-scale trials undertaken, from which the basic feasibility of UCG has been proven (Couch, 2009). Further detailed studies are required to prove the technology of precision drilling process control and to fully evaluate any possible environmental impact on underground aquifers and adjacent strata. Such work is now getting under way, with trials in China and the UK, while in Australia there are plans being implemented to test UCG with coal liquefaction as a possible means to improve the attractiveness of both technologies (Couch, 2009; UKERC, 2011).

There is interest in UCG in Mongolia, particularly for the link to coal liquefaction as a means to produce synthetic petroleum products in order to reduce the import dependency from Russia. This has included interaction with overseas technology suppliers and potential investors. In 2010, Envidity of Canada made an agreement with Live Energy LLC of Mongolia and its subsidiary, Shine Shivee LLC, to undertake an UCG project to transform low quality coal into domestic fuel (Live Energy, 2012). The intention is to transform underground sources of brown coal, which are within areas of the Shine Ovoo deposit licensed to Shine Shivee, to syngas via UCG. The gas will then provide the feedstock for a gas to liquids transformation using a Japanese process. In August 2011, Envidity announced its commitment to a specific US$1 billion project, with an initial potential output of 1000 barrels per day of synthetic diesel. It was stated that this project would create some 3000 construction and 150 permanent higher salaried jobs for the Mongolian people. Following what would be a commercial prototype demonstration, there were projections for some seven commercial plants in the next 15 years (Wire Service, 2011). However, since that time, there has not been further information as to whether this project will actually move forward.

Meanwhile, Cougar Energy of Australia is also looking at possible UCG sites in Mongolia**,** as well as China, in conjunction with major mining and exploration companies, although its initial focus appears to be on the latter country (Oilvoice, 2009).

7.8 Coal liquefaction and gasification

Mongolia's annual petrol and diesel consumption is in excess of 1 Mt and is expected to reach 1.5 Mt by 2015, for which it is currently paying 1000–1100 US$/t for imports from Russia. This is not only expensive but also raises significant security of supply issues. Consequently, the Mongolian Government has expressed considerable interest in establishing coal liquefaction either with or without UCG as a coal to oil production technology. The short-term goal is to establish a liquefaction plant for coal extracted from the various large-scale mines that are being established (Mongolia Investment, 2012). The government has specified that a coal-to-liquids unit should be built and operational in three to four years. However, given the limited background of these companies, the early stage in technology awareness, the infrastructure issues such as transportation of end products to potential users, and the expected cost, this must be considered optimistic.

Six national companies, Tsetsens Mining and Energy, MCS, MAK, Petrovis, Energy Resources and the Industrial Corporation of Mongolia, have been looking at options and all are involved in various initial technical and economic assessments of the technology and its applicability to Mongolia, in collaboration with international companies. There have been laboratory-based trials undertaken in Germany to check the likely performance of candidate coals, for which the results are understood to be encouraging.

There are prospects, with proposed product outputs of 0.5–1.0 Mt/y (Mongolia Investment, 2012). Information on the economics of these processes is limited. It has been stated that the capital investment for a CTL plant would be some US$1–2 billion for a plant that will process 2–6 Mt of coal each year, to produce 0.4–0.8 Mt of petrol and diesel, up to 0.1 Mt of LPG, and 0.02–0.05 Mt sulphur, with the possibility of generating 200–300 MWe of power. On this basis, given the very low extraction costs for coal, the production costs for one tonne of petrol would be US$600–700. However, the level

of capital investment required for each project would be the equivalent of some 20% of Mongolia's 2011 annual GDP. Consequently, financial closure on such projects would appear very difficult. The proposals are being reviewed by the National Security Council.

Although Mongolia recognises that China has established a large direct coal demonstration unit, with 1 Mt products annual capacity, there is a reluctance to work with its neighbours, in part because of concerns regarding China's growing influence on their country and because there remain questions as to exactly how successful the Chinese technology has been during its two to three year period of operation (Minchener, 2011). Instead, as part of an intended programme of co-operation on mining and environmental protection, Mongolia and Germany have signed a memorandum of understanding to build an indirect coal liquefaction plant. This was agreed with ThyssenKrupp and its subsidiary ThyssenKrupp Uhde (Bassett, 2012). Various individual company partnership agreements have also been agreed, between Mongolian MCS and Petrovis with Siemens, and Tsetsens Mining and Energy with Lurgi (American Fuels Coalition, 2012). At the same time, ThyssenKrupp Uhde signed a licensing agreement with the Industrial Corporation of Mongolia to provide their proprietary coal gasification technology. The likely companies to establish the technologies, including Industrial Corporation Mongolia, MAK, Tsetsens Mining and Energy, all own mining rights to very extensive coal deposits.

In addition to co-operation with Germany, Japan has already proposed to build a coal liquefaction plant based at Tavan Tolgoi. Mongolia has also made a request to Korea to consider co-operation, and the two sides agreed to sign a MoU on clean coal and energy resource development, with a focus on the production of synthetic oil, gas and unrefined chemical products from low-grade coal in Mongolia. The expectation from South Korea is that it will work on technology development and demonstration in Mongolia, with the host country providing the coal (Zhushui, 2011). There appears to be initial interest in a coal to SNG unit, with likely Korean investment given as US$0.9 billion for a SNG plant with a capacity close to 0.5 Mt. It is not clear as to the destination of the end products as both countries require significant quantities and, as yet, Mongolia does not have an export route to a seaport.

For all these possible CTL and SNG plants, the government has pledged to provide financial support for any construction projects, including tax breaks plus ensuring domestic buyers for the products (Mongolia Investment, 2012).

There should also be scope to establish gasification-based coal-to-chemicals units, for which there ought to be ready markets for the products in Russia and possibly China (Seeking Alpha, 2012b).

7.9 Alternative and lower carbon intensive options

Mongolia has significant potential for diversifying its energy utilisation sources and, as noted above, has several plans to undertake a range of such initiatives although not all are proceeding as quickly as was suggested originally.

For example, the expectation is that the very ambitious National Renewable Energy Program will be achieved in part through bilateral and multilateral international collaboration in order to establish a market for renewable energy in Mongolia, to be underwritten with long-term soft loans for the initiation of financially viable projects (Greengrowth, 2010; Bloomberg, 2012a). There is also a desire to establish public-private partnerships (ADB, 2011).

However, while there has been significant positive progress with the introduction of decentralised power generation for remote rural villages, and especially the provision of solar power sources to 100,000 ger households by 2010, the hoped for introduction of larger-scale renewable energy resources has not proceeded as intended (UNESCAP, 2010). The main problems facing such

renewable energy deployment in Mongolia has been a lack of:

- financial and technical management expertise;
- knowledge for developing system configurations and selecting system components;
- domestic private companies specialising in renewable energy systems deployment;
- expertise for using energy efficiently;
- regard for international standards;
- technical monitoring during installation and performance test evaluation; and
- training for operators.

Besides renewable energy, energy efficiency initiatives should have significant potential although these have yet to be realised to any significant degree. All such options are considered below.

7.10 Energy efficiency initiatives

Major sources of financing for energy efficiency activities in Mongolia have been provided through international co-operation with a number of multilateral institutions such as the World Bank, the ADB, the European Union and the United Nations Development Programme (UNDP), as well as through bilateral agreements with countries such as the USA (via USAID), Japan (via the Japan International Cooperation Agency), Germany and Norway. The Mongolian Government has provided co-financing, including in-kind contributions, on a project by project basis, and the achievements have been positive.

However, although various laws have been drafted, currently there are no formally adopted energy efficiency priorities and policies in Mongolia, and there is no national budget allocated for broader national energy efficiency activities. This reflects the low priority given to such activities when energy use is subsidised, a situation compounded by frequent changes of governments and restructuring of Ministries (Dorjsuren, 2011).

7.11 Nuclear power

Mongolia's significant uranium resources are among the top ten in the world, and the previous government had expressed interest both in establishing a nuclear power capability and supplying fuel to other countries in north-east Asia that operate nuclear power plants (Reuters, 2011). As with all its other mining and utilisation prospects, in order to proceed, Mongolia would have to obtain international investment to develop its nuclear energy sector, with the most likely favoured countries being the USA, Japan and France, in part to balance the already high involvement of Russia and China in other energy and resources ventures.

In 2009, the government passed The Nuclear Energy Law, which designated all uranium reserves, regardless of size, as 'strategic' reserves, to be controlled by the government through the Nuclear Energy Agency and its related organisations (World Nuclear Association, 2011). The legislation is designed to ensure that the country gains a significant equity stake (at no cost to Mongolia) in any mining venture and has control over the board structure and any transfer of shares above 5%, and a separate approval structure for uranium exploration separate from other minerals (Sachs and Agvaanluvsan, 2009). This has now been complemented by the law that requires government and parliament approval for any external investor to buy more than a 49% stake in any company within a strategically important sector such as mining.

From a Mongolian perspective, this ensures that regulators will be able to directly influence company actions and that only approved parties will take part in uranium projects. From a private company perspective, this has a significant impact on profitability although there is likely to be an advantage in the marketing and sale of mined uranium, especially for the Chinese market, from which direct investment is unlikely to be allowed.

However, with the change in government, the Ministry of Energy has noted that there is currently no case to develop a nuclear power plant within Mongolia. There has been no public message regarding extraction of uranium for export and it remains to be seen how the situation develops, although the expected major demand for uranium from India and China presents a potentially attractive opportunity (Sonompil, 2012).

7.12 Geothermal energy

A geophysical study has identified 42 small hot springs in the central northern region of Mongolia; however, no commercial power or heat development projects have been taken forward so far.

7.13 Hydropower

There are already some 13 small hydropower plants in the capacity range 150 kWe to 12 MWe, in the western and northern mountain areas of the country, for which those at the smaller end of the range are run-of-river designs that provide electricity to local rural areas where demand is limited (Energy Charter Secretariat, 2011). At the other end of the current scale, there are 11 MWe and 12 MWe units at Taishir and Durgun respectively that are connected to some local aimag centres within the AUES. These are registered as CDM projects with Japan as a partner, as they can displace electricity that would otherwise be generated by the local diesel generators. Consideration is being given to further develop small hydropower plants in order to reduce diesel imports.

There are also plans for developing larger projects including a 220 MWe plant at Egiin Gol, subject to a viable financing plan being determined. However, one complicating factor is that many rivers freeze over during the winter and so the hydropower plants cannot provide year-round electricity, especially when it would be most needed (UNESCAP, 2010). A second problem is that all rivers in Mongolia flow into either Russia or China. Russia, in particular, has expressed concern that any major hydropower projects in north-western Mongolia could have a possible adverse impact on water supplies to their country.

7.14 Solar power

There is a significant solar power potential across some 70% of the country, for which larger-scale solar energy applications to be connected to the grids should be attractive. However, so far, there is little progress with implementing this option due to the very high costs involved compared to fossil fuel alternatives (Resource Investor, 2012). However, there are some signs that this situation might change, as indicated in the following section.

7.15 Wind power

Up to 70% of the country has wind resources that may be suitable for development, and the government has declared that wind power could play a major role in the rural electrification programme. This includes the possible siting of units in the Southern Gobi desert for export of power to China. However, although the target for the National Renewable Energy Programme was to achieve at least 54 MWe wind power installed capacity by 2010 and 110 MWe by 2020, progress to date has been disappointing. By the start of 2010, there was just 3.8 MWe wind power installed capacity and operational experience has been poor. All individual units were in the kW size range. Performance problems occurred frequently, with village expectations being unfulfilled. This was due to inadequate contractual arrangements, and a lack of adequate government financial support, which resulted in poor quality equipment being installed by unreliable manufacturers. This meant that the national companies

made significant losses due to frequent repair needs. Problems included wind turbine blade failure, battery failures, incorrect selection of inverter and other components, inadequate operating procedures and maintenance schedules (Batbayar and Purevbayar, 2010).

Despite these problems, there are plans to establish a 50 MWe wind farm close to Ulaanbaatar, which is to be implemented by a private investor, Clean Energy, a local company wholly-owned by the Mongolian Newcom Group, with partial financial support from the European Bank for Reconstruction and Development (Climate Action, 2012). In addition, Newcom has set up a joint venture, Clean Energy Asia LLC, with the Softbank Corporation of Japan to conduct renewable energy resource exploration and project development in Mongolia (Newcom, 2012). Four sites in the Gobi Desert are initially being considered, with a total potential capacity of over 7000 MWe, of which the most promising option, with a capacity of 300 MWe, could b operational by 2014 (Bloomberg, 2012b).

Softbank is promoting the concept of an 'Asia Super Grid' to connect power grids in much of Asia as a means to establish a stable power supply while boosting the use of renewable energy in the region. Mongolia is seen to have the potential to become a net energy supply station through wind power and possibly solar power in due course. That said, the Gobi desert region is very isolated and establishing an Asian Super Grid would be challenging, with the need to ensure low levels of power loss from the distribution lines that will need to be several thousand kilometres long.

8 The way forward

Mongolia has just over twenty years experience of democracy and, with assistance and advice from various multilateral and bilateral donors, it has made significant progress towards establishing an open and market-based economy. It is now showing rapid growth, which is based primarily on the exploitation of its mineral resources. At the same time, the sheer scale of coal and other minerals that have been and still are being quantified means that it is absolutely essential that Mongolia establishes a sustainable way forward if it is to avoid the problems that have affected several other resource rich developing countries in the past. In this regard, while there is a strong vision of how the country should be developed, the lack of a consistent approach to implementation of policies together with weak legal and regulatory frameworks means that the country continues to face severe development challenges.

8.1 Overall challenges to grow the economy of Mongolia

If Mongolia is to successfully exploit its mineral wealth so as to take forward its plans to ensure sustainable and broad-based development throughout the country (Namibian, 2006), it needs to ensure that it establishes robust, consistent economic policies and has the means to unambiguously implement the associated development plans (World Bank, 2011a). This will require a clear legal and regulatory framework to be put in place, which will give both domestic and international companies the confidence to invest. In particular, it should establish an investment culture that prevents the country being vulnerable to a shorter-term venture capitalist mindset. This includes encouraging its investment partners to accommodate the national requirements of Mongolian society by engaging in long-term investments that include and cater to the Mongolian concerns, including the provision of jobs for Mongolians. Such a long-term approach offers the prospect that the country can gain added value from its coal and other resources as a key step to establishing a viable environmentally sound energy infrastructure, and can fulfil a crucial and beneficial role in the country's overall development.

This aspiration is linked to the ongoing and growing exploitation of its energy and other resources. There is a global demand for such products, especially in China, which appears to have adopted a policy of capping national energy production and seeking to achieve its overall needs by using imports to make up the balance. Consequently, there are likely to be major and long lasting opportunities for Mongolia. In the past, certain mining agreements were made without due regard to Mongolia's best interests and this recognition has created a reaction, with the possible involvement of Chinese companies in some of the proposed and existing investments being a further cause for Mongolian concern. However, the possible renegotiation of various existing coal production agreements, as well as other resource agreements such as the Oyu Tolgoi copper and gold mine contract, is likely to be detrimental to Mongolia's ultimate best interests (UB Post, 2012b). While it is understood that Mongolia is determined to obtain a fair share of mining revenues (E&MJ, 2010), such a retrospective approach is likely to lead to either a significantly more cautious or negative attitude by international investors at a time when a massive influx of capital is needed to ensure adequate infrastructure development throughout the country.

Indeed, the retrospective approach that is being adopted is creating considerable uncertainty in the mining sectors. Whereas the investment climate in Mongolia was previously seen as highly favourable (Oxford Business Group, 2012), it is now seen as being overtly risky. This is resulting in an unwillingness to support new projects until it is clear that a consistent approach is to be established that will cover both new and existing contractual commitments.

While it is essential to maintain foreign investment, it is also important to manage the economy as far as is practicable to limit vulnerability due to the impact of cyclical mineral prices. For example, GDP

growth accelerated to 17.3% in 2011 from 6.4% in 2010, with government spending rising by 56% in 2011. Forward payments have been made to various cities in anticipation of continuing future revenues, which will not be achieved due to flaws in the current implementation plans within the mining sector. A further 32% increase in GDP growth was expected in 2012, but this is not now likely to be achieved as the global economy is facing a substantial slowdown in growth due to the continuing European sovereign debt crisis. This situation is made worse by China's further cutback in coal imports due to the ongoing disputes over market accessibility. It seems that in the near term there will be a sharp drop in the Mongolian Government revenues (World Bank, 2012c).

In the medium term, it should be possible to achieve some level of economic diversification, through sustainable management of Mongolia's rich natural and cultural resources although it seems unlikely that such tourism related activities can be anything but a relatively minor contributor to GDP compared to minerals extraction and sales.

8.2 Social development within Mongolia

The Government's declared aim is to build the infrastructure required for industries, mining, and cities to flourish, while improving the business environment by developing smart and flexible investment policies, in order to give the Mongolian people employment and healthy, prosperous, successful lives. This admirable approach to ensuring that all citizens of Mongolia get to benefit in the proceeds of the mining boom, will need to be developed further, for which the funding and disbursement from the Human Development Fund is one aspect to be considered.

This includes addressing the wealth disparity between rural and urban populations (US Department of State, 2012). At the same time, there are growing concerns about environmental pollution and the ecological imbalances that are arising with increased mining activities. Much of the eco-system in Mongolia is vulnerable, especially in the southern part of the country where many of the mining opportunities appear to be most attractive. The environmental impacts associated both with mining and rapid urbanisation, including air pollution, can be severe and improving the management of rural pasture land, biodiversity, and water supply will be important for sustaining broad-based growth. It is essential that a robust and rigorous regulatory framework is established to ensure sustainable exploitation of such resources, including high efficiency of utilisation and acceptable environmental impact.

8.3 Coal and its role in the energy mix

The development of several major coal deposits to generate income for the greater good of the country is at the forefront of the resource exploitation boom. In this regard, Mongolia's location between two very large countries, with major economies, offers some very complex challenges. While China is seen as an obvious market for its coal, there are very strong doubts about letting its state-owned companies gain a direct input into the country's energy (and other minerals) sectors. At the same time, Mongolia also remains dependent on Russia for petroleum products, and its industries, including the agricultural sector, remain vulnerable to any interruptions to that supply chain. Consequently, Mongolia needs to continue to establish a balanced relationship with the two, not least as both are keen to improve bilateral trade and both can determine whether Mongolia can establish a route to establish its own significant export routes for bulk commodities (The Diplomat, 2011). The steps taken so far have not necessarily worked to Mongolia's advantage. It remains to be seen whether it can reach a financially and economically viable accommodation with its two neighbours and beyond them to the many international mining groups that can actively assist Mongolia to establish a sustainable coal-based economy.

It is also appropriate to strike a cautionary note. This coal export plan is based on the expectation of a

continuing growth in international demand, with Asia now becoming the focal point for that increased coal use, and Mongolia, with its low cost coking and thermal coals, being well placed to exploit this market opportunity, subject to establishing an accord with its neighbours. In general terms, this plan remains sound, with the IEA predicting that world demand for steam coal could rise by over 1 Gt in 2016 from 2010 consumption levels, particularly throughout Asia (IEA, 2011c) while demand for coking coal will continue to represent a strong market, at least once the current global market downturn is resolved.

However, while Mongolia attempts to ensure sufficient investment to establish a growing export market for both coking and thermal coals, other suppliers are moving to seize the opportunities. In particular, the USA, which already exports large quantities of coking coal to Asia, is poised to become a low cost producer of thermal coal for the export market. This position has arisen very quickly due to the surge in US shale gas production combined with new environmental regulations that are limiting growth in coal's use for domestic power generation (EPRINC, 2012). Consequently, with global demand expected to rise, the USA is seeking to maintain its coal production by exporting coal rather than using it domestically

In the first eight months of 2012, coal exports from the USA to Asia were 23 Mt, of which 16 Mt were for metallurgical applications and the remainder for thermal use, with almost all being shipped from the eastern seaboard close to the coking coal sources (PennEnergy, 2012). While this market level is likely to be either maintained or increased, there is strong evidence that the USA intends to also become a major exporter of thermal coal, using the north-western ports to ship Power River Basin coal to Asia and other regions of high demand (EPRINC, 2012). Initially exports are poised to be shipped from British Columbia ports in Canada (Chinadialogue, 2012) while ports in Oregan can be uprated as demand rises.

There would appear to be a market for Mongolian coking coal either in China or, from a Mongolian perspective, preferably in other Asian countries where current prices are 200–220 US$/t. However, for thermal coal the situation is not clear cut. As coal production from the Powder River Basin can be produced and delivered to Asian markets for 60 US$/t, this should be very competitive as delivered thermal coal costs to Asian markets are likely to remain between 90 US$/t to 110 US$/t in the near term and by 2016 are expected to rise by some 30 US$/t over current prices (EPRINC, 2012). However, even though Mongolian coal can be extracted very cheaply, its high transport costs will counter this potential market advantage and it would appear that the USA could be a major competitor. This likely increase in US coal exports has arisen very quickly, which contrasts with the extremely long and still ongoing lead times to readily increase Mongolian coal exports to significant levels.

8.4 Knowledge transfer

Mongolia has a small population and until recently has had little major industrial input. As such, as it embarks on this mining boom, there is a need to build up its own capacity to ensure sufficient scope for its people to take on more than unskilled jobs within the sector. It also needs to gain expertise and experience in the introduction and application of coal utilisation technologies if it is to establish a growing energy economy based on clean coal, which can be supplemented with renewable energy as appropriate.

UNESCO has collaborated with the Mongolian Academy of Sciences (MAS), and with various Ministries, to develop a Science and Technology Master Plan (2007-20), working on the basis that economic development for newly industrialising countries is generally enhanced by promoting national systems of innovation. The study identified that, in Mongolia, the scientific and technological activities need to be integrated with other sectors in order to underpin development across the country's various regions (UNESCO, 2007). As a result, the current stage of economic transition and

development in Mongolia holds significant challenges for achieving equitable and sustainable socio-economic progress, with an urgent need to build and maintain the country's innovation capacity.

Accordingly, UNESCO and the MAS established a plan for implementation by the government, as part of a broader national development strategy to increase the innovation system effectiveness. This includes:

- promoting industry-academia collaboration;
- contributing to the economic growth by establishing an enabling social, economic and legal environment;
- establishing a basis for national technology development;
- promoting the growth of high technology-based industries;
- establishing the foundation for a knowledge-based economy.

With specific regard to mining, a broad agreement has been made between Mongolia and Germany to set up a mining academy that will cover joint research, workshops and advanced training. This will broaden the experience of existing Mongolian engineers who until now are only familiar with Russian technology, while also starting to establish an international perspective for university-based students and graduates.

When clean coal utilisation is considered, there is considerable scope for Mongolia to engage with various independent expert bodies, such as the IEA Clean Coal Centre, which is the foremost knowledge transfer organisation in this field. There is a significant need for techno-economic-based capacity building and associated technology awareness training to be provided, covering the efficiency and environmental impacts of clean coal and alternative technologies. This is necessary both to assist the nation in its near-term development plans and also to build up the national capacity from a longer-term sustainable perspective. Such a capacity building approach could readily be developed and it has been strongly suggested that developed countries should consider full support for such efforts as part of their foreign aid strategies to assist the developing countries and emerging economies (Morse, 2012).

9 References

About.com (2012) *Map of Mongolia*. Available from: http://geography.about.com/library/cia/blcmongolia.htm (2012)

ACI (2011) *Mongolia*. Available from: http://www.mongoliagrowthgroup.com/MGG_Presentation.pdf. Presentation to the Financial Markets Association, Mongolia Growth Group (November 2011)

ADB (2006) *Energy efficiency study of thermal power plant #4, Ulaanbaatar, Mongolia*. Available from: www.adb.org/Clean-Energy/.../MON-TS-Ulaanbaatar-Power-Plant.pdf Asian Development Bank (February 2006)

ADB (2011) *Mongolia: Ulaanbaatar low carbon energy supply project using a public-private partnership model*. Appendix 7: Policy Note and Investment Guidance Document, Asian Development Bank, Project Number 43357 (October 2011)

American Fuels Coalition (2012) *Germany partners with Mongolia on coal to liquids.* Available from: http://www.americanfuelscoalition.com/2012/04/17/germany-mongolia/ (17 April 2012)

Asia Times Online (2012) *Mongolian coal's long road to market*. Available from: http://www.atimes.com/atimes/China/NE25Ad01.html (25 May 2012)

Asian Info (2012) *Mongolia's geography and climate*. Available from: http://www.asianinfo.org/asianinfo/mongolia/pro-geography.htm (2012)

Bassett B (2012) *Commercially proven Prenflo and High Temperature Winkler gasification*. Presented at the 4th EU-SA Coal and Clean Coal Working Group Meeting, Johannesburg, South Africa (6 November 2012)

Batbayar C, Purevbayar D (2010) *Small wind energy in Mongolia*. Available from: www.energyforall.info/files/wind%20energy%20in%20Mongolia%20project%20proposal.pdf Energy Authority of Mongolia (2010)

Batrenchin S (2010) *Energy projects in Mongolia*. Available from: http://www.carecinstitute.org/uploads/events/2010/ESCC-Jul/ESCC2-Energy-Projects-in-Mongolia.pdf Ministry of Mineral Resources and Energy of Mongolia (July 2010)

Bayasgalan S (2012) Erdenetsogt Energy LLC, Ulaanbaatar, Mongolia, *personal communication* (September 2012)

Bazar B (2012) Baganuur JSC, Mongolia, Ulaanbaatar, Mongolia, *personal communication* (September 2012)

BGR (2010) *Reserves, resources and availability of energy resources 2010*. Available from: http://www.bgr.bund.de/EN/Themen/Energie/Produkte/annual_report_2010- summary_en.html Published by Federal Institute for Geosciences and Natural Resources (2010)

Bloomberg (2011) *Mongolia says $3B coal IPO likely next year*. Available from: http://www.bloomberg.com/news/2011-09-05/mongolia-says-3b-coal-ipo-likely-next-year.html (6 September 2011)

Bloomberg (2012a) *Mongolia's renewables belittle world's nuclear supply*. Available from: http://www.bloomberg.com/news/2012-01-05/mongolia-s-renewables-belittle-world-s-nuclear-supply.html (5 January 2012)

Bloomberg (2012b) *Softbank plans to develop wind power in Mongolia with Newcom.* Available from: http://www.bloomberg.com/news/2012-10-24/softbank-plans-to-develop-wind-power-in-mongolia-with-newcom.html (24 October 2012)

Brookings (2012) *Mongolia's quest to balance human development in its booming mineral-based economy.* Available from: http://www.brookings.edu/research/opinions/2012/01/10-mongolia-campi (January 2012)

Business-Mongolia (2012) *Prophecy Coal to raise USD 800 million for Mongolia power plant*. Available from: http://www.business-mongolia.com/mongolia/2012/04/04/prophecy-coal-to-raise-usd-800-million-for-mongolia-power-plant/ (4 April 2012)

Buyanbat T (2012) Mineral Resources Agency, Ulaanbaatar, Mongolia, *personal communication* (September 2012)

CEE Bankwatch Network (2011) *Spirited away: Mongolia's mining boom and the people that development left behind*. Available from: http://bankwatch.org/sites/default/files/spirited-away-mongolia-mining.pdf (December 2011)
Chapman G (2012) Sharyn Gol, Ulaanbaatar, Mongolia, *personal communication* (September 2012)
Chinadialogue (2012) *US tax loopholes driving up coal exports to Asia*. Available from: http://www.chinadialogue.net/article/show/single/en/5405-US-tax-loopholes-driving-up-coal-exports-to-Asia (4 December 2012)
Climate Action (2012) *EBRD to pioneer investment in Mongolia's other natural resource wind* Available from: http://www.climateactionprogramme.org/news/ebrd_to_pioneer_investment_in_mongolias_other_natural_resource_wind/http://www.climateactionprogramme.org/news/ebrd_to_pioneer_investment_in_mongolias_other_natural_resource_wind/ (22 March 2012)
Couch G (2009) *Underground coal gasification.* CCC/151, London, UK, IEA Clean Coal Centre, pp 129 (Jul 2009)
Daly J (2008) *Mongolia, coal, and inflation*. Available from: http://www.upi.com/International_Security/Energy/Analysis/2008/05/14/analysis_mongolia_coal_and_inflation/1654/ United Press International (14 May 2008)
Davaatsedev L, Tunga G (2005) *Mongolia country profile*. Available from: www.globalmethane.org/documents/toolsres_coal_overview_ch22.pdf (2005)
Dorjsuren P (2011) *Mongolia: energy efficiency*. Available from: http://www.unescap.org/esd/Energy-Security-and-Water-Resources/energy/efficiency/2011/EGM_17_Oct_Beijing/documents/III-c-Mr-Dorjsuren-Mongolia.pdf Presented at the Expert Group Meeting on Energy Efficiency in North-East Asia, Beijing (17 -19 October 2011)
Dumbaugh K, Morrison W (2009) *Mongolia and U.S. policy: political and economic relations*. Available from: www.fas.org/sgp/crs/row/RL34056.pdf (18 June 2009)
E&MJ (2010) *Mongolia: open for business*. Available from: http://www.gbreports.com/admin/reports/EMJ_MongoliaReport2010.pdf (July/August 2010)
EBRD (2012) *Mongolia*. Available from: www.ebrd.com/downloads/legal/irc/countries/mongolia.pdf European Bank for Reconstruction and Development (2012)
EIA (2012) *Mongolia energy statistics*. Available from: http://205.254.135.7/countries/country-data.cfm?fips=MG United States Energy Information Administration (2012)
Embassy of Mongolia in Belgium (2012) *The Mongolian geography*. Available from: http://www.embassyofmongolia.be/node/66 (2012)
Energy Charter Secretariat (2011) *In-depth review of energy efficiency policies and programme for Mongolia*. Available from: www.encharter.org/index.php?id=518 Brussels, Belgium ISBN: 978-905948-092-6 (2011)
EPRINC (2012) *The economic value of American coal exports*. Available from: http://eprinc.org/?p=929 (August 2012)
Erdenepurev A (2010) *Brief update on Tavan Tolgoi coal project*. Available from: http://www.unescap.org/esd/Energy-Security-and-Water-Resources/energy/trade_and_cooperation/cooperation/gbd3/documents/II05-MrAErdenepurev-MMRE.pdf Presentation to the Government Business Dialogue-3 Moscow, Russian Federation, (23 November 2010)
Erdenepurev A (2012) Ministry of Mining, Ulaanbaatar, Mongolia, *personal communication* (September 2012)
Eurasia Capital (2009) *Infrastructure in Mongolia: challenges and opportunities*. Available from: http://www.eurasiac.com/infrastructure-mongolia-challenges-and-opportunities (April 2009)
Euromoney (2006) *Mongolia investors forum 2006.* Available from: http://www.investmongolia.com/forum/t4a.htm Ulaanbaatar, Mongolia (14-15 September 2006)
Financial Times (2012a) *Mongolia's new investment law: deterrent or clarification?* Available from: http://blogs.ft.com/beyond-brics/2012/05/18/mongolias-new-investment-law-deterrent-or-clarification/#axzz28EqlcWIq (18 May 2012)
Financial Times (2012b) *Chalco ends Mongolia coal bid*. Available from:

http://blogs.ft.com/beyond-brics/2012/09/03/chalco-ends-mongolia-coal-bid/#axzz28Ft8Oh00 (3 September 2012)
FT.COM (2012) *Mongolia flooded with millionaires*. Available from: http://www.ft.com/cms/s/0/d20bfd5e-b866-11e1-a2d6-00144feabdc0.html#axzz1yuykskNd (19 June 2012)
Ganbaatar B (2008) *Current status of and prospects for energy resources and infrastructure development of South Gobi in Mongolia.* Available from: http://www.keei.re.kr/keei/download/seminar/080703/s1-4.pdf Presented at International Symposium on Energy Resources Cooperation and Corporate Strategy in Northeast and Central Asia, (3 July 2008)
Government of Mongolia (2000) *Mongolia's nuclear-weapon-free status*. Available from: http://www.opanal.org/NWFZ/Mongolia/Mlaw_en.html (3 February 2000)
Greengrowth (2010) *Mongolia National Renewable Energy Programme: MNRE*. Available from: http://www.greengrowth.org/download/GGPD_CD_resources_for_website/6_Mongolia.pdf (2010)
Guardian (2011) *Gobi mega-mine puts Mongolia on brink of world's greatest resource boom*. Available from: http://www.guardian.co.uk/environment/2011/nov/07/gobi-mega-mine-mongolia (7 November 2011)
Guardian Environmental Network (2011) *Mongolia's wilderness threatened by mining boom*. Available from: http://www.guardian.co.uk/environment/2011/jan/11/mongolia-wilderness-mining-boom (11 January 2011)
Hindu Times (2012) *India to acquire coking coal mine in Mongolia*. Available from: http://www.thehindu.com/business/Economy/article3404225.ece (10 May 2012)
IEA (2011a) *2009 energy balance for Mongolia*. Available from: http://www.iea.org/stats/balancetable.asp?COUNTRY_CODE=MN International Energy Agency, Paris, France (2011)
IEA (2011b) *CO_2 emissions from fuel combustion: highlights*. Available from: http://www.iea.org/co2highlights/CO2highlights.pdf International Energy Agency, Paris, France (2011)
IEA (2011c) *Medium-term coal market report 2011*. Available from: http://www.iea.org/w/bookshop/add.aspx?id=418 International Energy Agency, Paris, France (2011)
Index Mundi (2011) *Mongolia coal production by year*. Available from: http://www.indexmundi.com/energy.aspx?country=mn&product=coal&graph=production (2011)
Investmongolia (1995) *Environmental protection law of Mongolia*. Available from: http://www.investmongolia.com/fifta/law/law12.pdf (30 March 1995)
Investmongolia (1997) *Minerals law of Mongolia*. Available from: http://www.investmongolia.com/fifta/law/law40.pdf (5 June 1997)
Live Energy (2012) *Live Energy LLC*. Available from: http://www.liveenergygroup.mn/index.php?menuID=71&lang=eng (2012)
Mbendi (2010) *Coal mining in Mongolia*. Available from: http://www.mbendi.com/indy/ming/coal/as/mn/p0005.htm (2010)
Minchener A (2011) *Coal-to-oil, gas and chemicals in China*. CCC181, London, Uk, IEA Clean Coal Centre, pp 49 (Feb 2011)
Mongolia Today (2012) *Non-Mongolian mining companies*. Available from: http://blogs.ubc.ca/mongolia/links/non-mongolian-mining-companies/ (2012)
Mongolian Economy (2011) *The current state of the energy sector in Mongolia, development trends*. Available from: http://mongolianeconomy.mn/en/d/1371 (2 December 2011)
Mongolian Economy (2012) *International Power plc : preferred bidder for 415MW power plant in Mongolia*. Available from: http://mongoliaeconomy.blogspot.co.uk/2012/07/international-power-plc-preferred.html (September 2012)
Mongolia Investment (2012) *Mongolian government will provide generous assistance in the building of a coal liquefaction plant*. Available from: www.mongolia-investment.com/en/news/political-news/3330-mongolian-government-will-provide-generous-assistance-in-the-building-of-a-coal-liquefaction-plant (16 April 2012)
Mongolyn Alt Corporation (2010) *Mongolyn Alt Corporation*. Available from: http://www.mak.mn/ (February 2010)

Morse R (2012) *Cleaning up coal: from climate culprit to solution*. Available from: http://www.foreignaffairs.com/articles/137685/richard-k-morse/cleaning-up-coal Foreign affairs, volume 91, number 4 (July/August 2012)
MRPA (2007) *Energy sector of Mongolia and role of transit corridor in its development*. Available from: http://www.nagpf.info/conference/Outline.htm Mineral Resource and Petroleum Authority of Mongolia, Presentation at the 10th International Conference on North Asian Natural Gas and Pipeline, Novosibirsk, Russia, 18-19 September (2007)
Namibian (2006) *Mongolia seeks more from coal*. Available from: http://www.namibian.com.na/index.php?id=28&tx_ttnews%5Btt_news%5D=30043&no_cache=1 (13 September 2006)
Newcom (2012) *Clean Energy Asia LLC has been established*. Available from: http://newcom.mn/en/media/news/186 (26 October 2012)
Oilvoice (2009) *Cougar Energy signs MoU for UCG projects in China and Mongolia*. Available from: http://www.oilvoice.com/n/Cougar_Energy_Signs_MoU_for_UCG_Projects_in_China_and_Mongolia/9d19ee06b.aspx (14 December 2009)
Oxford Business Group (2012) *The Report: Mongolia 2012*. Available from: http://www.oxfordbusinessgroup.com/product/report/report-mongolia-2012 (2012)
Oyun S (2012) Ministry of Environment, Ulaanbaatar, Mongolia, *personal communication* (Sep 2012)
PennEnergy (2011) *Mongolian government endorses 600 MW coal-fired Chandgana Power Plant Project*. Available from: http://www.pennenergy.com/index/articles/display.articles.pennenergy.power.coal.2011.september.mongolian-government.QP129867.dcmp=rss.page=1.html (5 September 2011)
PennEnergy (2012) *Europe, Asia lead destinations for U.S. coal exports in 2012*. Available from: http://www.pennenergy.com/articles/pennenergy/2012/11/europe-asia-lead-destinations-for-us-coal-exports-in-2012.html?cmpid=EnlDailyPowerNovember192012&hq_e=el&hq_m=20756&hq_l=30&hq_v=z149 994180 (16 November 2012)
PMIS (2012) *Website of the State Institutions of Mongolia*. Available from: http://www.pmis.gov.mn/pmis_eng/index.php (2012)
Prophecy Coal (2012a) *Ethical coal: Mongolia's sparkling potential amidst regional energy demand.* Available from: http://www.mining.com/ethical-coal-mongolia%E2%80%99s-sparkling-potential-amidst-regional-energy-demand/ (6 February 2012)
Prophecy Coal (2012b) *Powering Asia's future*. Available from: http://www.prophecycoal.com/pdf/PCY_Coal_Presentation.pdf (June 2012)
Purevsuren and Drebenstedt (2004) *Actual aspects of lignite mining in Mongolia*. In: *Mine Planning and Equipment Selection,* edited by Hardygora, Paszkowska and Sikora, Thirteenth International Symposium on Mine Planning and Equipment Selection, Wroclaw, Poland, (1-3 September 2004)
REEEP (2005) *Power sector of Mongolia*. Available from: http://toolkits.reeep.org/file_upload/10303046_4.pdf (25 October 2005)
Resource Investor (2012) *Crucial coal: powering Mongolia's future***.** Available from: http://www.resourceinvestor.com/2012/03/19/crucial-coal-powering-mongolias-future?page=7 (19 March 2012)
Reuters (2011) *Mongolia eyes first nuclear power plant by 2020: MonAtom*. Available from: http://www.reuters.com/article/2011/04/07/us-mongolia-nuclear-idUSTRE73625A20110407 (April 2011)
Reuters (2012a) *Mongolian coal group Tavan Tolgoi eyes 2013 market debut*. Available from: http://uk.reuters.com/article/2012/04/30/uk-tavantolgoi-ipo-idUKBRE83T0KN20120430 (30 April 2012)
Reuters (2012b) *Resource-rich Mongolia plays populist card in run-up to polls*. Available from: http://in.reuters.com/article/2012/05/18/mongolia-investment-idINDEE84H05L20120518 (18 May 2012)
Reuters (2012c) *Chalco in new Mongolia coal deal even as Mongolia government balks.* Available from: http://www.reuters.com/article/2012/04/24/us-chalco-winsway-idUSBRE83N03620120424 (24 April 2012)

Reuters (2012d) *Mongolia policy worries hit South Gobi deal*. Available from: http://www.reuters.com/article/2012/04/26/southgobi-chalco-idUSL2E8FPMF720120426 (26 April 2012)
Sachs R, Agvaanluvsan U (2009) *Mongolian uranium and nuclear power plant growth in China and India*. Available from: http://iis-db.stanford.edu/pubs/22637/Uranium_Report___Final.pdf Stanford University, California, USA (1 September 2009)
Schwochow S (1997) *The international coal seam gas report*, Cairn Point Publishing, Stephen Schwochow, editor (1997)
Seeking Alpha (2011) *Coal In Mongolia: the China factor*. Available from: http://seekingalpha.com/article/310680-coal-in-mongolia-the-china-factor-part-i?cache=0.4362542010419952 (29 November 2011)
Seeking Alpha (2012a) *Crucial coal: powering Mongolia's future*. Available from: http://seekingalpha.com/article/435841-crucial-coal-powering-mongolia-s-future (15 March 2012)
Seeking Alpha (2012b) *New vision: the potential for coal gasification and coal chemical industry development in Mongolia*. Available from: http://seekingalpha.com/article/850891-a-new-vision-the-potential-for-coal-gasification-and-coal-chemical-industry-development-in-mongolia (6 September 2012)
Sonompil M (2012) Ministry of Energy, Ulaanbaatar, Mongolia, *personal communication* (September 2012)
Sourcewatch (2012) *Mongolia and coal*. Available from: http://www.sourcewatch.org/index.php?title=Mongolia_and_coal (2012)
Swedish Trade Council (2008) *Private sector opportunities in the oil, gas and coal sectors in Mongolia.* Available from: http://www.swedishtrade.se/PageFiles/138252/Private%20sector%20opportunities%20in%20the%20oil,%20gas%20and%20coal%20sectors%20in%20Mongolia.pdf (December 2008)
Taipei Times (2011a) *Mongolia picks trio to develop coal field*. Available from: http://www.taipeitimes.com/News/biz/archives/2011/07/06/2003507503 (6 July 2011)
Taipei Times (2011b) *Shenhua hopes to restart talks on Tavan Tolgoi after Mongolian Parliament election.* Available from: http://www.taipeitimes.com/News/biz/archives/2011/07/06/2003507503 (6 July 2011)
The Diplomat (2011) *Mongolia eyes Russia ties*. Available from: http://the- diplomat.com/flashpoints-blog/2011/06/10/mongolia-eyes-russia-ties/ (10 June 2011)
Tserenpurev T (2010) *Energy policy and programmes on energy development of Mongolia*. Available from: http://www.unescap.org/esd/Energy-Security-and-Water-Resources/energy/trade_and_cooperation/cooperation/epp8/documents/Agenda2-Mongolian%20policy%20on% 20energy%20development%20compiled.pdf Presented at the *Working Group on Energy Planning and Policy Cooperation in North-East Asia, Phuket, Thailand*, United Nations Economic and Social Commission for Asia and the Pacific (29-30 June 2010)
Tsevegmid T (2003) *Mongolia energy sector: developing framework for energy cooperation in North East Asia*. Available from: www.neasiaenergy.net/download/Seminar030905/TTsevegmid.pdf Presented at Expert Workshop 'Towards multinational energy cooperation in North East China', Seoul, South Korea (5-6 September 2003)
Tulga G (2011) *Coal resources of Mongolia: some assumptions and suggestions for coal bed methane gas recovery*. Available from: http://www.mnec.org.mn/Files/books/Coal%20Resources%20of%20Mongolia%20Tulga.pdf MCS International Co. Ltd. (2011)
UB Post (2012a) *New government of Mongolia expands ministers and ministries*. Available from: http://ubpost.mongolnews.mn/?p=511 (15 August 2012)
UB Post (2012b) *International and domestic commentary on investors fleeing Mongolia*. Available from: http://ubpost.mongolnews.mn/?p=1222 (28 September 2012)
UKERC (2011) *Energy research landscape: coal conversion.* United Kingdom Energy Research Council (31 December 2011)
UNDP (2007) *Mongolia human development report, employment and poverty in Mongolia*. Available

from: http://hdr.undp.org/en/reports/nationalreports/asiathepacific/mongolia/Mongolia_NHDR-2007-Eng.pdf United Nations Development Programme (2007)
UNDP (2011) *Mongolia human development report*. Available from: http://hdr.undp.org/en/reports/national/asiathepacific/mongolia/NHDR_Mongolia_EN_20112.pdf (2011)
UNESCO (2007) *Science & technology master plan for Mongolia 2007-2020*. Available from: http://unesdoc.unesco.org/images/0015/001514/151490e.pdf (2007)
UNESCAP (2010) *Mongolia renewable energy report*. Available from: http://recap.apctt.org/Countries/PDF/Mongolia_CountryReport.pdf (2010)
United Nations (2004) *Mongolia public administration country profile*. Available from: http://unpan1.un.org/intradoc/groups/public/documents/un/unpan023238.pdf (March 2004)
United Nations (2009) *Mongolia: nationally appropriate mitigation actions of developing country parties*. Available from: http://unfccc.int/files/meetings/cop_15/copenhagen_accord/application/pdf/mongoliacphaccord_app2.pdf (December 2009)
US Department of State (2012) *Background note: Mongolia*. Available from: http://www.state.gov/r/pa/ei/bgn/2779.htm Bureau of East Asian and Pacific Affairs (6 January 2012)
Wall Street Journal (2012) *South Gobi to halt mining at flagship coal mine*. Available from: http://online.wsj.com/article/SB10001424052702304870304577489532992045456.html (26 June 2012)
Wire Service (2011) *Envidity launches USD $ 1 billion coal gasification project in Mongolia*. Available from: http://www.wireservice.ca/index.php?module=News&func=display&sid=6269 (19 August 2011)
World Bank (2004) *Mongolia environment*. Available from: http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/EASTASIAPACIFICEXT/EXTEAPREGTOPENVIRONMENT/0,,contentMDK:20266325~menuPK:537827~pagePK:34004173~piPK:34003707~theSitePK:502886,00.html Washington DC World Bank (November 2004)
World Bank (2007) *Foundation for sustainable development: rethinking the delivery of infrastructure services in Mongolia*. Available from: http://lnweb90.worldbank.org/ext/epic.nsf/ImportDocs/3934E485D786D06248257582004CBA59?opendocument&query=PH Washington DC World Bank (2007)
World Bank (2009) *Southern Mongolia infrastructure strategy*. Available from: http://documents.worldbank.org/curated/en/2009/01/15098729/southern-mongolia-infrastructure-strategy Washington DC World Bank (2009)
World Bank (2011a) *Diversifying the Mongolian economy*. Available from: http://wbi.worldbank.org/sske/case/enhancing-capacity-diversify-mongolian-economy Washington DC World Bank (5 October 2011)
World Bank (2011b) *Mongolia overview*. Available from: http://www.worldbank.org/en/country/mongolia/overview Washington DC World Bank (2011)
World Bank (2011c) *Air quality analysis of Ulaanbaatar: improving air quality to reduce health impacts*. Available from: http://documents.worldbank.org/curated/en/2011/12/15633946/air-quality-analysis-ulaanbaatar-improving-air-quality-reduce-health-impacts-vol-1-2-main-report Washington DC World Bank (December 2011)
World Bank (2012a) *Ulaanbaatar clean air project*. Available from: http://web.worldbank.org/external/projects/main?pagePK=64283627&piPK=73230&theSitePK=40941&menuPK=228424&Projectid=P122320 Washington DC World Bank (16 March 2012)
World Bank (2012b) *Curbing air pollution in Mongolia's capital***.** Available from: http://www.worldbank.org/en/news/2012/04/25/curbing-air-pollution-in-mongolia-capital Washington DC, World Bank (25 April 2012)
World Bank (2012c) *Mongolia quarterly economic update - February 2012*. Available from: http://www.worldbank.org/en/news/2012/02/28/mongolia-quarterly-economic-update-february-2012 (28 February 2012)
World Nuclear Aassociation (2011) *Uranium in Mongolia*. Available from: http://www.world- nuclear.org/info/inf125-mongolia.html (October 2011)
Yeren-Ulzii B (2012) *Current and future prospects of the electricity sector of Mongolia*. Available

from: http://www.unescap.org/esd/Energy-Security-and-Water-Resources/energy/security/workingpmeeting/documents/Ulzii.pdf Ministry of Mineral Resources and Energy, Presentation given at the Tenth Meeting of the Working Group on Energy Planning and Policy (5-6 April 2012)

Zhushui (2011) *South Korea and Mongolia initiate collaboration for clean energy.* Available from: http://www.zhushui.com/en/index.php?c=news&a=show&id=216&pid=42 (17 January 2011)