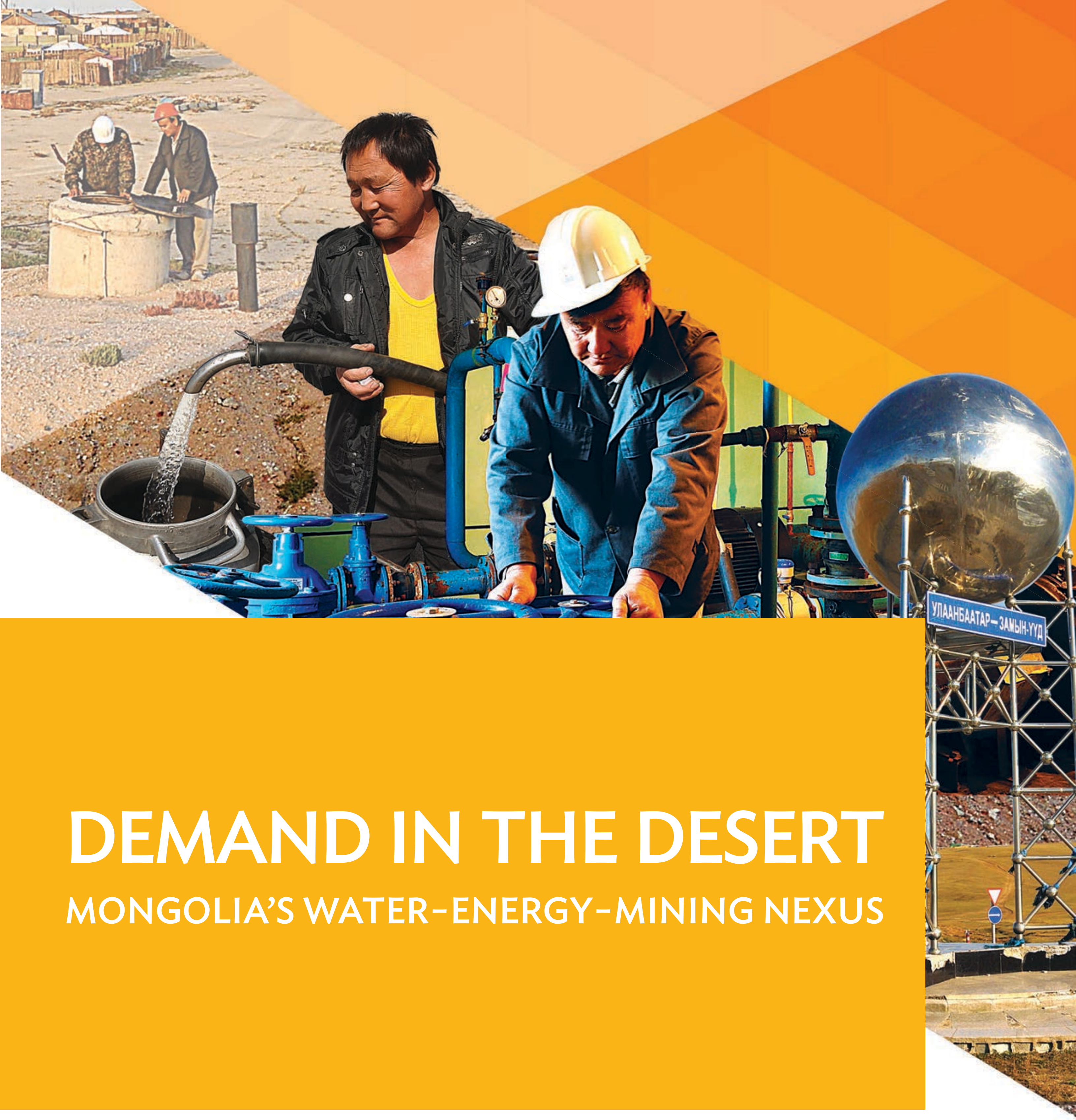


DEMAND IN THE DESERT

MONGOLIA'S WATER–ENERGY–MINING NEXUS

ASIAN DEVELOPMENT BANK

ADB

DEMAND IN THE DESERT

MONGOLIA'S WATER–ENERGY–MINING NEXUS

ASIAN DEVELOPMENT BANK

Printed in the Philippines

ISBN 978-92-9254-616-8 (Print), 978-92-9254-617-5 (e-ISBN)
Publication Stock No. RPT146700-2

Cataloging-in-Publication Data

Asian Development Bank.
Demand in the desert: Mongolia's water–energy–mining nexus.
Mandaluyong City, Philippines: Asian Development Bank, 2014.

1. Water–energy nexus. 2. Mining. 3. Mongolia. I. Asian Development Bank.

Note:
In this publication, "$" refers to US dollars.

6 ADB Avenue, Mandaluyong City
1550 Metro Manila, Philippines
Tel +63 2 632 4444
Fax +63 2 636 2444
www.adb.org

For orders, please contact:
Public Information Center
Fax +63 2 636 2584
adbpub@adb.org

Printed on recycled paper

Contents

Figures, Tables, and Maps v

Foreword vii

Acknowledgments ix

Abbreviations x

Executive Summary xi

A. Water–Energy Nexus xi

B. Will There Be Enough Water? xii

C. Strengthening Management of the Water–Energy Nexus xiii

D. Recommendations xiii

I. Introduction to Mongolia's Water–Energy Nexus 1

A. Water Scarcity in Mongolia 2

B. Energy Security in Mongolia 3

C. Mining and Water–Energy Security 3

D. Water Resources Management 3

E. Food Security 4

F. Reading this Report 4

II. National Water and Energy Context 6

A. Water Resources Overview 6

B. Water Management in Mongolia 11

C. Energy Sector Overview 12

D. The Water–Energy Nexus 14

III. Tuul River Basin: Meeting the Water and Energy Demands of a City 19

A. Existing Water Availability 19

B. Existing Water Use 21

C. Water Balance in the Tuul River Basin 21

D. The Water–Energy Nexus 23

E. Water Resource Management in the Tuul River Basin 29

F. Implications 31

IV.	South Gobi: Meeting the Water and Energy Needs for Mining		32
	A.	Existing Water Resource Availability	32
	B.	Existing Water Use in the Galba-Uush Doloodin Gobi Basin	32
	C.	The Water–Energy Nexus	34
	D.	Water Management in South Gobi	39
	E.	Implications	40
V.	Challenges and Recommendations		42
	A.	Challenges	42
	B.	Recommendations	43
Appendixes			
	1	Review of Literature	45
	2	Energy Scenario Factors	46
	3	Responsibilities and Authorities of River Basin Authorities and River Basin Councils	49

Figures, Tables, and Maps

Figures

1	Water–Energy–Food Security Nexus	2
2	Interrelationships between Water Management Institutions	12
3	Projected Mongolia Electricity Demand	14
4	Water Use in the Tuul River Basin, 2010	22
5	Existing and Projected Annual Water Use in Ulaanbaatar	23
6	Relative Contribution of Generating Facilities, Scenario Plan 1a (Low-Electricity Growth)	25
7	Relative Contribution of Generating Facilities, Scenario Plan 1c (High-Electricity Growth)	25
8	Water Use Projections for Low- and High-Electricity Growth Scenarios	26
9	Estimated Energy Consumption for Selected Water Facilities	29
10	Annual Water Use in the Galba-Uush Doloodin Gobi Basin, 2010 and 2015	34
11	Projected Annual Water Use of Mines in Mongolia	37
12	Projected Annual Water Use for Energy, Mining, and Other Users in the Galba-Uush Doloodin Gobi Basin	39

Tables

1	Mongolia Key Water and Energy Indicators	8
2	Projected Changes in Runoff	9
3	Estimated Annual Water Use in Mongolia, 2010	10
4	Annual Water Intensity of Coal-fired Thermal Power Stations	15
5	Electricity Production and Water Use of Thermal Power Plants in Mongolia	16
6	Water Consumption Factors for Coal Extraction	17
7	Calculation of Energy Intensity of Different Water Supply Facilities in Ulaanbaatar	17
8	Approved Groundwater Sources for Water Supply of Ulaanbaatar	21
9	Annual Water Use in the Tuul River Basin	22
10	Summary of Water Intensity of Selected Energy Facilities in Mongolia	24
11	Estimated Annual Water Consumption under Low- and High-Electricity Growth Scenarios	27

12	Summary of Energy Intensity of Selected Water Facilities in Mongolia	28
13	Estimated Annual Energy Consumption of Selected Water Facilities in Mongolia	28
14	Annual Water Use in the Galba-Uush Doloodin Gobi Basin, by Sector	34
15	Water Consumption Assumptions of Selected Power Plants and Mines in Mongolia	35
16	Production and Water Consumption of Major Mines in Mongolia	36
17	Projected Annual Water Use of Mines in Mongolia	36
18	Projected Annual Water Use by Energy Facilities in Mongolia	38
19	Projected Annual Water Use by Other Users in the Galba-Uush Doloodin Gobi Basin	38
20	Projected Total Annual Water Use in the Galba-Uush Doloodin Gobi Basin	38
21	Estimates of Energy Consumption for Water Withdrawals in the Galba-Uush Doloodin Gobi Basin, 2025	40

Maps

1	River Basins in Mongolia	7
2	Tuul River Basin in Mongolia	20
3	Galba-Uush Doloodin Gobi Basin in Mongolia	33

Foreword

The Ministry of Environment and Green Development (MEGD) of Mongolia and the Asian Development Bank (ADB) have prepared this knowledge product as a contribution to the "Eye on Asia" side event of the 2014 World Water Week in Stockholm, Sweden, which has as its thematic scope "Energy and Water."

The organizers of this important event attribute its choice of theme to the ADB-supported *Asian Water Development Outlook 2007*, in which the Prime Minister of India is quoted as saying that "if all members of society can have adequate access to energy and water, many of the societal problems can be solved." The *Asian Water Development Outlook 2013* further explored energy for water and vice-versa as a key determinant of economic water security. ADB is proud to have encouraged the development discourse to more closely connect the implications of the relationship between water and energy, and to have contributed to greater understanding of the "water–energy nexus" in the Asia and Pacific region.

The water–energy nexus is a paradigm that many scholars, policy makers, and development practitioners are beginning to adopt. It is a lens by which we can more broadly examine the integrated nature of a society's consumptive needs versus the finite and fragile natural resources at its disposal. Society's need for energy is nearly equal to its need for water, with food security linking the two inextricably. Energy is also a key input into many countries' growth strategies. Mongolia's dependence on mining and the need to sustain its urban economies would be equally impossible without both energy and water—water to produce energy, and energy as a key input into water.

Mongolia's development trajectory has been resource intensive. The exploitation of the country's vast mineral reserves has given thousands of people employment and lifted thousands more out of poverty. The growth of Ulaanbaatar, the capital city, is evidence of a country in transition. In response to environmental wear and tear, and local conflicts over water use, the government is beginning to shift from exploitation to management. This knowledge product looks at how the twin pressures of urbanization and mining have come to define the water–energy nexus in Mongolia, and what the government can do to relieve water stress.

The examination of the water–energy nexus in Mongolia in this report offers a primer in understanding how the two sectors may come to bear on each other. It provides a useful framework for thinking about many of the water–energy topics and sessions of the 2014 World Water Week. It is also a useful introduction to the two sectors in Mongolia and the country's general development trajectory. ADB is planning to assist Mongolia to develop agriculture, promote rural development, and enhance sustainable management of natural resources (i.e., water, land, forests, and peat lands). And because of the central importance of water to all development in Mongolia, ADB will assist Mongolia in preparing a country water security assessment that will examine five water security dimensions: household water security, economic water security, urban water security, environmental water security, and resilience to natural disasters.

The MEGD and ADB commend the Stockholm International Water Institute for bringing the water–energy nexus to the global stage. Our delegation looks forward to sharing ADB's regional and national perspectives and learning from the global community of practice. With 1.3 billion people without access to electricity and more than 800 million people without access to water from improved sources in the world, this year's theme at the World Water Week is essential to moving the global antipoverty agenda forward.

Ayumi Konishi
Director General
East Asia Department
Asian Development Bank
Manila, Philippines

Tulga Buya
Vice Minister
Ministry of Environment and
Green Development
Ulaanbaatar, Mongolia

Acknowledgments

This knowledge product examines the water–energy nexus in Mongolia and provides some useful information for the government in making policy decisions that relate to water, energy, and mining, which are inextricably linked.

This knowledge product is a joint effort by the Asian Development Bank (ADB) and the Ministry of Environment and Green Development (MEGD) of Mongolia to contribute to the "Eye on Asia" side event of the 2014 World Water Week in Stockholm, which covers the theme "Energy and Water."

ADB East Asia Department Director General Ayumi Konishi, ADB Lead Water Resources Specialist Qingfeng Zhang, and MEGD Vice Minister Tulga Buya provided overall guidance for conceptualization, production, and finalization of this knowledge product. ADB Young Professional Shahbano Tirmizi provided support during consultations. ADB former staff Robert Everitt and National University of Mongolia Senior Lecturer Enkhdul Tuuguu researched and analyzed the water–energy nexus in Mongolia and prepared the draft manuscript.

Several reviewers offered valuable comments at different stages during the preparation of this publication, including ADB Mongolia Resident Mission Country Director Robert Schoellhammer, Principal Water Resources Specialist Yasmin Siddiqi, Principal Energy Specialist Pradeep Perera, Senior Energy Specialist Teruhisa Oi, Environmental Specialist Ongonsar Purev, and MEGD Policy and Planning Department Director General Bulgan Tumendemberel, and its officer Chimid-Ochir Munkhzul.

Melissa Howell-Alipalo helped edit and design this knowledge product. Joy Quitazol-Gonzalez supported the full coordination and completion of the production processes—from initial formatting and editing, engagement of service providers, proofreading, map clearances, and through to final publication. Publication support were ably provided by the Department of External Relations Publishing Team.

Abbreviations

ADB	Asian Development Bank
CHP	combined heat and power
IWRM	integrated water resources management
kWh	kilowatt-hour
l/MWh	liter consumed per megawatt-hour
m^3	cubic meter
MEGD	Ministry of Environment and Green Development
MW	megawatt
MWh	megawatt-hour

Executive Summary

Mining is rapidly changing the water and energy landscape in Mongolia. Until recently, the agriculture sector was the dominant user of water. As of 2010, the agriculture sector share was 55%, with 31% for irrigation and 24% for livestock. Mining consumed just 13% and energy 11%. However, this situation is changing very quickly as the mining industry is developing rapidly. In 2013, mining accounted for 82% of exports and 18.5% of gross domestic product. The demand for electricity is projected to increase fivefold from 2012–2030. Most of the demand for power is expected to be met by coal-fired power stations, which use water for thermal electric cooling. Mining operations need water for production. Coal production also uses water for cleaning to enhance the thermal properties of coal. Both energy facilities and mining operations are thirsty for water. The new energy facilities and the new mining operations are to be located in water-scarce areas.

A. Water–Energy Nexus

This knowledge product examines the water–energy nexus in Mongolia and the stress factors of urbanization and mining. The water–energy nexus is the interdependency between water systems and energy systems. Water systems need energy for pumping, water treatment, wastewater treatment, transport and distribution, end use, and water system development. Energy production requires water for primary extraction and mining; fuel production (e.g., hydrogen, ethanol, and biofuels); thermal electric cooling; hydropower; and emission control.

The water–energy nexus is examined at a national level and in two basins that are indicative of Mongolia's challenges. The Tuul River Basin, the water resource base for the capital Ulaanbaatar, is expected to be the location for an additional 1,650 megawatts (MW) of coal-fired generating capacity for the Central Energy System. The energy is needed to power the continual growth of Ulaanbaatar and other densely populated areas. Yet the new facilities will compete with other major water users for scarce water in the basin. The South Gobi Energy System is expected to ultimately add 1,200 MW of coal-fired generating capacity to power the major mining operations in the region. The new energy facilities and mining operations are expected to further exacerbate conflicts with local communities and traditional herders in the Galba-Uush Doloodin Gobi Basin.

The water–energy nexus is best understood by examining the water use of individual energy facilities and the energy use of water facilities. The water intensity of energy facilities (i.e., the amount of water used per unit of energy produced) for existing major facilities in Mongolia does not compare favorably with international norms. Only CHP-4 of the Central Energy System falls within the acceptable range. However, it is expected that the new facilities will be much more efficient in their water use. Data on production and water consumption in the mining industry is difficult to come by. Therefore, it has been difficult to make estimates of water intensity of coal production. However, some estimates suggest that water intensity is similar to international norms.

Tuul River Basin Case Study. The Tuul River Basin has the highest population and population density in the country, as it services the capital city, Ulaanbaatar. To examine the future water consumption of energy facilities in the Tuul River Basin, two scenarios based on the 2013 update of the Mongolia Energy Sector Development Plan were examined: (i) a "low-electricity growth" scenario, which increased generating capacity by 1,650 MW by 2025; and (ii) a "high-electricity growth" scenario, which increased generation capacity by 2,450 MW by 2025. Under both scenarios, total water consumption by all users increases (low scenario by 87% and high scenario by 103%). Energy's share of the total water consumption increases under both scenarios (from 25% to 34% for the low scenario, and from 25% to 40% for the high scenario). While the estimation model used is simplified, this implies there is a strong need to examine the energy efficiency of households and throughout the economy. In addition, there is a need to reduce the water intensity of the planned generating facilities.

South Gobi Case Study. To examine future water consumption by energy and mining facilities in South Gobi, water consumption was estimated to 2025 for Tavan Tolgoi and Oyu Tolgoi as well as other large mines in the region. It was assumed that 900 MW of generating capacity will be added to the South Gobi Energy System by 2025 to meet the demands of the mining operations and local communities. Mining will be the dominant user of water (83 million cubic meters [m^3] per year) by 2025. The energy sector becomes a major water user by 2020 as the coal-fired power station comes on line, and by 2025, it will use 19.7 million m^3/year of water.

The other side of the water–energy nexus is the consumption of energy by water facilities. The energy intensity of water facilities, particularly the facilities needed to supply water for thermal electric cooling, is high by international standards. However, the energy intensity of the Ulaanbaatar water distribution system is within international norms. For the Tuul River Basin, the energy needs were estimated for the existing combined heat and power (CHP) plants, new coal-fired facilities, the four main well fields in Ulaanbaatar, and waste treatment plants. The total energy needs by 2025 were estimated to be 118,375 megawatt-hours (MWh)/year. This represents less than 1% of the total projected 2025 energy production of the Central Energy System. In the South Gobi, the energy needs were estimated for the Tavan Tolgoi coal-fired power plant and major mines. The total energy need by 2025 was estimated to be 108,244 MWh/year, which is approximately 1.3% the projected 2025 annual energy production of the proposed Tavan Tolgoi power station.

B. Will There Be Enough Water?

Based on the analysis of the *Tuul River Basin Integrated Water Management Plan*, Ulaanbaatar water demand will exceed its existing resources of 99 million m^3/year and will be facing water shortages as early as 2015 under the high-development scenario. It will be forced to draw on additional groundwater sources, which have already been identified and approved for use. These additional sources, estimated to be 37.1 million m^3/year, will be adequate until 2021, when there will again be water shortages under the high water demand scenario. While additional groundwater sources may be available, there are also plans to build reservoirs upstream of Ulaanbaatar to supplement drinking water supply and reduce pressure on groundwater resources.

In the Galba-Uush Doloodin Gobi Basin, it is estimated that there are 236 million m^3/year of renewable groundwater resources available. Based on estimates of water consumption of approximately 108.2 million m^3/year to 2025, there appears to be no immediate water shortage. However, it is notable that there is a plan for supplemental water supply with a surface water diversion from the Orkhon River and the Kherlen River. An Orkhon–Gobi water transfer project is planned for the water supply to mines from the Orkhon River to the South Gobi through a pipeline that is more than 700 kilometers (km) long.

C. Strengthening Management of the Water–Energy Nexus

The government's energy vision is one of increased energy security through a centrally managed integrated transmission network for all of Mongolia. Under this vision, electrical energy would be cost efficiently allocated throughout the country. The vision for water management is more decentralized, where all users participate in decision making on the management and protection of water resources and the environment. This creates a mismatch in both the scale for planning and management (national for energy versus river basin for water) and institutional clout (national Ministry of Energy and Mineral Resources versus newly created river basin authorities, river basin councils, and *aimag* and *soum* administrations).

The newly established water management organizations face a number of challenges, including (i) the need for strengthened stakeholder coordination through river basin councils; (ii) the need for better monitoring, research, data collection, and information management, which are now highly dispersed and poorly managed; (iii) the need for more financial resources and facilities for effective execution of water management; and (iv) the need for more and better trained personnel in water management organizations. There is also a critical need for more effective government coordination on water resources at all levels.

To ensure supply meets demand for water and energy in sustainable and viable ways, the current economic means and instruments must be strengthened. Water user fees, water service charges, and wastewater fees have been included in the Water Law (2012). However, current procedures setting the fees and charges are based on a complex and outdated methodology. Not all of the new economic instruments have been implemented. The new economic instruments that have been implemented require better enforcement and monitoring.

The government is currently planning to increase energy supply through new electricity generation and heating plants. However, the Mongolian energy sector has not made the transition to the green economy. At the commercial, industrial, and household levels, energy consumption remains highly inefficient. Demand side management has been limited, but some progress has been made. For example, the GIZ assisted the government through a project on insulation of old apartments to decrease the energy loss. It is also encouraging that the government is planning to renovate old buildings to improve insulation.

D. Recommendations

The following recommendations provide some general guidance for the national government to consider in decisions that relate to water, energy, and mining, which are inextricably linked.

Integrate water resource considerations into decisions on energy and mining development. Current programs and plans for mining development should undergo a strategic environmental assessment under the new Mongolia Environmental Impact Assessment Law. For example, the recently completed update to the Energy Sector Development Plan should have been subjected to a strategic environmental assessment that would have examined the potential environmental and social impacts of the proposed expansion and integration of the energy systems in Mongolia. In this context, the assessment should have examined water resources availability and the impacts on competing water resource users.

Support green procurement for water and energy technologies. Under the green development policy of Mongolia, 2% of gross domestic product will be allocated for green procurement in the water and energy sectors to develop greener technologies. These funds should be targeted on increasing energy efficiency at the industrial and household levels. To increase the sustainability of water supply, new and innovative projects for rainwater collection and recycling of wastewater should be developed.

Reduce the water intensity of energy production. Mongolia's existing thermal power stations are inefficient in their use of water. All new facilities should be designed to minimize water use and apply cooling technologies and practices consistent with international good practices. In addition, energy-efficient technologies for water use and good practices for energy efficiency should be adopted. It is also necessary to introduce environmentally friendly methods such as renewable energy (e.g., wind, solar) to reduce the water intensity of energy production.

Get the economic incentives right. Now is the time to improve the payment system for water services (i.e., water use fees, water service charges, pollution fees, and discharge fees) for water use by the energy and mining sectors. A transparent incentive structure that is clearly communicated to the public should be prepared, focusing initially on urban households, mining, and the energy sector.

Strengthen water management institutions. The newly formed water management organizations need to be strengthened so that they can fulfill their mandates under the new Water Law (2012). Better facilities, trained staff, financing, and support systems are needed for river basin authorities and river basin councils. Water information systems need to be developed, and scientific understanding of water resources in Mongolia needs to be improved. South–South cooperation should be undertaken to facilitate exchange of information on water management practices with other countries. This is already being addressed in the Tuul River Basin through the proposed Tuul River Improvement Project ($20 million) funded by the Asian Development Bank. In South Gobi, institutions are being strengthened through a groundwater management project funded by the World Bank and Australian Aid ($3.23 million).

I. Introduction to Mongolia's Water–Energy Nexus

Freshwater and energy are critical to human well-being and sustainable socioeconomic development. Globally, demand for freshwater and energy will continue to increase significantly over the coming decades to meet the needs of increasing populations, growing economies, changing lifestyles, and evolving consumption patterns. This will greatly amplify pressures on limited natural resources and ecosystems. The challenge will be most acute in countries undergoing accelerated transformation and rapid economic growth—especially where water resources are scarce or where water-related infrastructure and services are inadequate, and where modern energy services remain largely underdeveloped.[1]

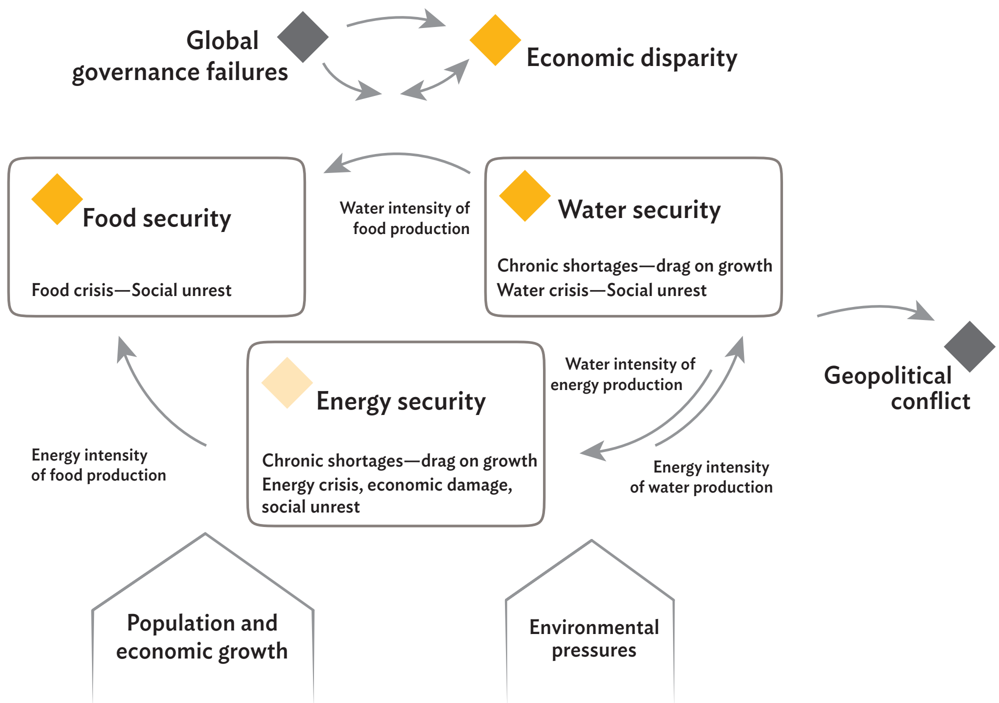
Mongolia's development trajectory depends on freshwater and energy, yet water scarcity is a major constraint to the country's sustainable development. Development in Mongolia has been greatly influenced by the country's rapid rate of urbanization and mining in recent years. The fast economic growth is evident from the rapid increase in demand for energy, but power systems are insufficient to meet them. The government is taking steps to relieve the country of its energy security risks with new thermal power plants, which require much greater water use for cooling and will be located in water-scarce locations. Water resources in Mongolia face a precarious future, which will surely affect all those that depend upon them. Climate models are also predicting lower river water levels, higher seasonal variations, and a decrease in groundwater levels due to decreased recharge.

This publication examines the relationship between water and energy, and the influencing factors of urbanization and mining, in particular. The water–energy nexus is the interdependency between water systems and energy systems.[2] It is most often examined with the additional variable of food security—a fundamental factor in social development that must be considered first and foremost in decisions on water use and energy production (Figure 1). Water systems need energy for pumping, water treatment, wastewater treatment, transport and distribution, end use, and water system development. Energy production requires water for primary extraction and mining; fuel production (e.g., hydrogen, ethanol, and biofuels); thermal electric cooling; hydropower; and emission control. A case in point is that of thermal electric plants, which require water for cooling, which in turn requires energy for pumping and, in some cases, water treatment, thereby reducing the net energy production of the thermal plant.

[1] United Nations World Water Assessment Programme. 2014. *The United Nations World Water Development Report 2014: Water and Energy.* Paris: United Nations Educational, Scientific and Cultural Organization (UNESCO). http://unesdoc.unesco.org/images/0022/002257/225741e.pdf

[2] Here interdependency is given a precise meaning, i.e., mutual dependency.

Figure 1: Water–Energy–Food Security Nexus



Source: Morgan Bazilian, et.al. 2011. Considering the Energy, Water and Food Nexus: Towards an Integrated Modelling Approach. *Energy Policy*. 39 (12). pp. 7896–7906.

A. Water Scarcity in Mongolia

Mongolia has an extremely cool continental climate with long cold winters. Most of the precipitation falls during the short summers. There is large spatial variability in rainfall.[3] Mongolia's annual renewable surface water resources are plentiful, but are scattered over large areas, mainly in the northern part of the country. Most water resources are not readily accessible to major population centers, mining operations, and other industrial operations. As a result, Mongolia has many localized water-stress situations. For example, there is high dependence on groundwater in the South Gobi region; an increasing dependence on recharged groundwater for Ulaanbaatar's water supply with potential problems during winter and spring months;[4] and high costs and other difficulties in transporting resources across the vast country. These potentially large in-region and in-basin deficits set constraints on Mongolia's economic and social development.

By the end of 2008, about 1.66 million people (roughly 60% of the total population) were living in urban areas in Mongolia. Increased demand by residential and commercial consumers for urban services (water supply and sanitation) has outstripped supply, particularly in Ulaanbaatar and in *aimag* (province) centers. Mongolia's fastest-growing urban area is Ulaanbaatar. The continued growth of Ulaanbaatar, in conjunction with increasing urban consumption, is projected to lead

[3] The annual average precipitation amount is around 200 to 220 millimeters (mm), ranging from 38.4 mm in some parts of the Gobi Desert region to about 400 mm in some areas in the north

[4] Ulaanbaatar obtains around 98% of its water from groundwater.

to water shortages as early as 2015. In addition, Ulaanbaatar's water security faces three other challenges. Industrial pollution is high particularly due to discharges with high pollution levels (e.g., tanneries). There is ineffective wastewater treatment with no recycling of wastewater. Finally, there is seasonal variation in the Tuul River water level resulting in reduced groundwater levels in spring. Water security has become a constraint on economic growth.

Mongolia is already seeing the impacts of climate change. Natural disasters such as drought, heavy snowfall, flood, snow and wind storms, and extreme cold and hot temperatures are becoming more and more frequent. The future under a climate change scenario is uncertain; however, climate models predict a decrease in river water levels, higher seasonal variations, and a decrease in groundwater levels due to decreased recharge.

B. Energy Security in Mongolia

Mongolia's growing demand for energy, heavy dependence on coal as its major energy source, and reliance on its two big neighbors—the People's Republic of China (PRC) and the Russian Federation—for oil challenge its economic development.[5] Rising demand for energy reflects rapid economic growth, the development of the mining industry, and the doubling of Ulaanbaatar's population since 1995. Mongolia has vast proven reserves of coal and some oil, but their exploitation has been either delayed or inefficient. Coal fuels 70% of electricity generation and 90% of heating but with poor energy efficiency. Facilities are old, and electricity tariffs below market rates put proper maintenance and investment in new plants beyond the reach of undercapitalized plant operators. Ulaanbaatar has no spare capacity for power and heat. Solving Mongolia's energy security problems will place strain on scarce water resources as the proposed facilities are either coal-fired thermal generating stations, which will require water for cooling, or hydropower stations, which will impound and/or divert water.

C. Mining and Water–Energy Security

Mining development in Mongolia is already stressing water security. Mining requires both energy and water. Both are in short supply in the areas where the mineral deposits are located. Major energy and water resource infrastructure is needed and is being planned to support mining development. The mining development in South Gobi has already created serious water use conflicts. For example, Umnogobi Province passed a resolution in July 2013 that prohibited groundwater extraction for mining purposes from 2016 onward and was to stop groundwater exploration from August 2013. This resolution would have affected the most significant mines for Mongolia's economic development—Tavan Tolgoi and Oyu Tolgoi. However, following protests from mining companies (which were disputed in the courts) and the national government, this resolution was suspended by the end of 2013.

D. Water Resources Management

The Government of Mongolia has made considerable progress in improving its legal and institutional framework for the integrated water resources management (IWRM) and environmental protection of river basins in Mongolia. In 2010, the country was divided into 29 river basins to improve water resources management. The institutions with formal responsibility in water resources management are (i) the Government of Mongolia—i.e., the Cabinet, the

[5] ADB. 2013. *Asian Development Outlook 2013.* Manila.

Ministry of Environment and Green Development (MEGD), and the Water Authority (part of the MEGD's Department for Coordination of Policy Implementation); (ii) the National Water Committee; (iii) the *aimag* and *soum* (district) governors; and (iv) river basin committees.

The new Water Law (2012) formally established river basin authorities throughout Mongolia. As of 2013, river basin authorities had been established for 23 out of the 29 river basins. The government has also approved a national IWRM plan; and, as of 2013, 13 IWRM plans have been prepared at the basin level.

E. Food Security

Agriculture and livestock are critical to ensure food security and provide social stability in Mongolia.[6] In the 1970s and 1980s, large investments were made in agriculture that increased the land under irrigation in 1990 to 80,000 hectares (ha) and made Mongolia a net exporter of crops. However, new investment stopped, and operation and maintenance were limited. As a result, by 2004, the area under irrigation shrunk to 53,000 ha with no modernization of the irrigation systems. Mongolian agriculture is now currently recovering from the recent lack of investment. To meet food security objectives, the area under irrigation needs to increase. This expansion of irrigation systems will require significant water withdrawals.

Dependence on mining-driven economic development has created economic vulnerabilities that may result in dislocation of the more labor- and skills-intensive nonmining sectors. Mongolia's biggest medium-term challenge is to bring about diversification of the economy and create employment by achieving competitiveness in the nonmining sector.[7]

There is significant potential for diversification of the economy through developing value chains for Mongolia's unique agricultural resources and serving northeast Asian markets. Agriculture accounted for 17.5% of gross domestic product and 35% of overall employment in 2013. Although the share of agriculture in the overall economy in Mongolia has been decreasing, it remains the backbone of the rural economy, and processing of agricultural products creates critical employment opportunities in urban areas. Agricultural production feeds through far more directly to the incomes of the most economically vulnerable Mongolians.

F. Reading this Report

This report examines the mechanics of the water–energy nexus at the national level and in two basins that are essential to Mongolia's immediate socioeconomic development and long-term prosperity. The first case study examines the Tuul River Basin, which is under pressure from high water demand coming from the economic and population growth of the capital city of Ulaanbaatar and the proposed expansion of the Central Energy System. The second case study is of the Galba-Uush Doloodin Gobi Basin, which is under rapidly increasing water strain due to mining in the South Gobi Desert and the planned coal-fired thermal electric plants to support the mining. Urbanization and mining are driving the demand for more water and more energy.

The river basin organizations for these two basins are at different stages of development. The Tuul River Basin has had to develop relatively sophisticated systems to deal with complex issues

[6] Water Resources Group. 2012. The Water Resources Group: Background, Impact and the Way Forward. Briefing report prepared for the World Economic Forum Annual Meeting 2012. Davos-Klosters, Switzerland. 26 January. http://www3.weforum.org/docs/WEF/WRG_Background_Impact_and_Way_Forward.pdf

[7] ADB. 2013. Mongolia: Draft Interim Country Partnership Strategy 2014–2016. Manila.

associated with Ulaanbaatar. Until recently, local government administrations in the Galba-Uush Doloodin Gobi Basin had little concern for water management, in general, and little need for sophisticated water management. That has now changed with large mining developments in the South Gobi Desert. The Tuul River Basin Authority and the Tuul River Basin Council were established in 2012, and they have prepared an IWRM plan. The Galba-Uush Doloodin Gobi River Basin Authority was only recently established, in October 2013.

To understand the realities and implications of Mongolia's urbanization and mining on its water and energy production, a number of international studies on the water–energy nexus were reviewed (Appendix 1), providing both data and analysis. A number of calculations and estimates also had to be made to derive impacts. Estimates of water intensity of energy for coal-fired thermal plants were derived based on empirical data on water consumption and power production. The estimates of water intensity of primary extraction of coal were derived from the international literature and limited empirical data on current water use in energy and mining sectors in Mongolia. Similarly, estimates of the energy intensity of water facilities were based on the international literature and the empirical data on current energy usage of water facilities in Mongolia. Water use projections are based on a simple estimation model of the water intensity of energy facilities and mining operations and estimates for future electricity generation and mining production. Energy use projection used a simple estimation model based on energy intensity of water facilities and estimates of future water withdrawals from water facilities.

II. National Water and Energy Context

A. Water Resources Overview

Mongolia's water resources are part of three major drainage basins: (i) the Northern Arctic, which drains northward through the Russian Federation into the Arctic Ocean; (ii) the Pacific, which drains westward into the Pacific Ocean; and (iii) the Central Asian internal basin. Mongolia has been divided into 29 river basins (Map 1) for water resources management purposes. The two focal basins selected for detailed study are the Tuul River and the Galba-Uush Doloodin Gobi.

Water Resource Availability

Total water resources. Mongolia's total surface water resources are estimated to be 598.5 cubic kilometers (km^3).[8] Rivers contain 34.6 km^3 of surface water, lakes contain 500 km^3, and glaciers contain 62.9 km^3. The surface waters are distributed unevenly over the country. For example, 380 km^3 (or 63%) of the total surface water is stored in Lake Khuvsgul in northern Mongolia. The total renewable groundwater resources have been estimated to be 23.6 km^3, with potentially exploitable resources of 10 km^3.[9] Previously, it was estimated that total exploitable groundwater resources were 10.79 km^3.[10]

Renewable water resources. The long-term average actual renewable water resources in Mongolia are estimated to be 34,800 million cubic meters (m^3) /year. This equates to actual renewable water resources per capita of 12,429 m^3/inhabitant. This may be compared with actual renewable water resources per capita for the United States (9,718 m^3/inhabitant) and the PRC (2,051 m^3/inhabitant).[11]

It is estimated that Mongolia's total water withdrawals in 2009 were approximately 550 million m^3/year (Table 1). Given a current (2012) population of about 2.8 million, this implies current water withdrawals of about 196 m^3/inhabitant. However, the geographic distribution of water resources relative to the location of the most highly populated areas and other water demand centers is such that there are localized water shortages in many parts of Mongolia. For example, Ulaanbaatar has a population approaching 1.3 million and has renewable water resources of 770 million m^3/year. This implies renewable water resources per capita of about 592 m^3/year. However, the 2012 *Integrated Water Management National Assessment Report* estimates that

---

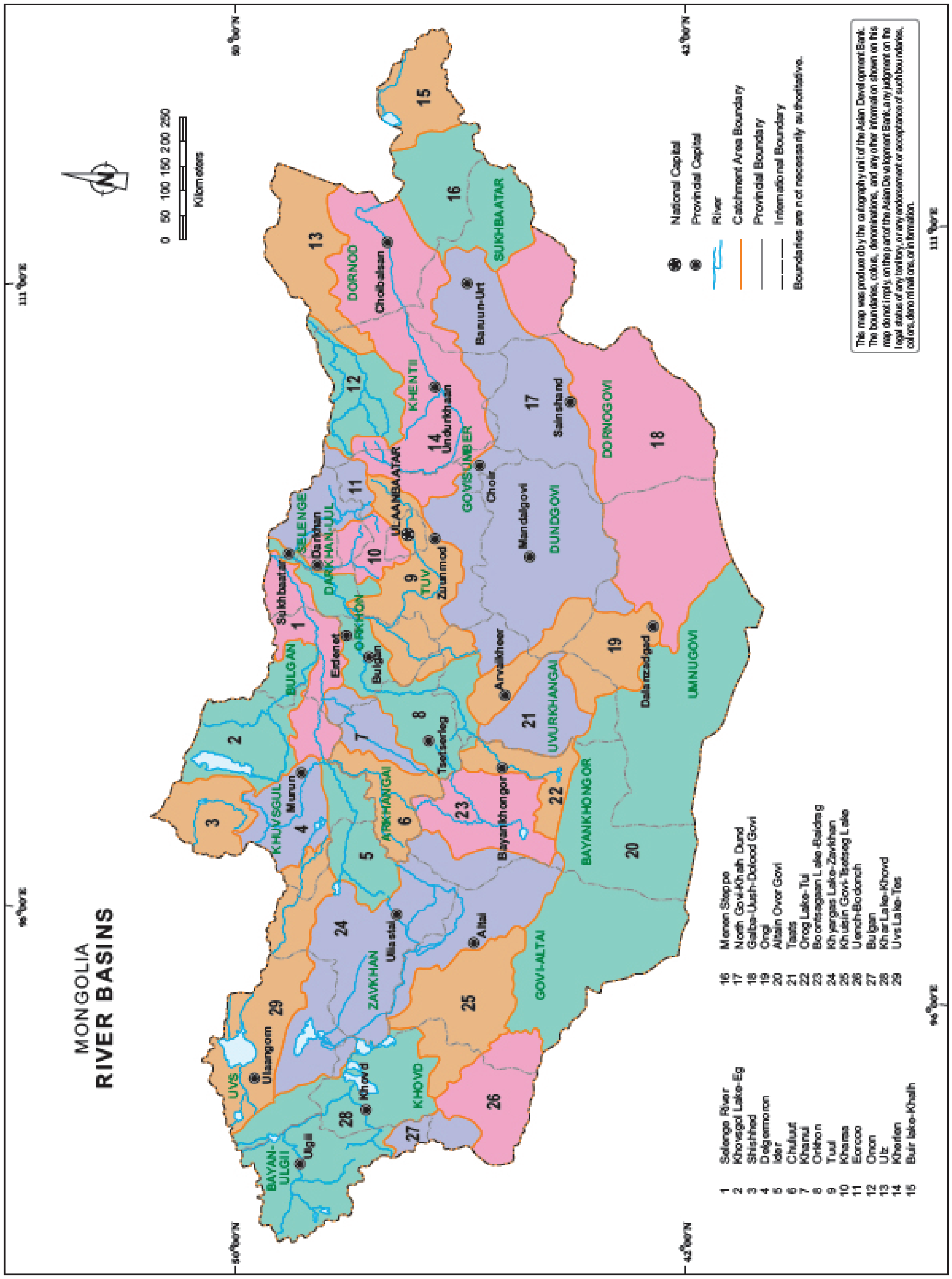
8 MEGD. 2012. Part 1: Surface Water Resources Assessment. *Integrated Water Management National Assessment Report.* Volume 1. Ulaanbaatar. Table 2.

9 MEGD. 2012. Part 4: Groundwater Resources Assessment. *Integrated Water Management National Assessment Report*. Volume 1. Ulaanbaatar. Table 2.

10 World Bank. 2010. *Mongolia: Groundwater Assessment of the Southern Gobi Region*. Washington, DC. Table 3 (estimate by N. Jadambaa and T. Tserenjav, 2003).

11 Food and Agriculture Organization of the United Nations (FAO). AQUASTAT Database. http://www.fao.org/nr/water/aquastat/main/index.stm

Map 1: River Basins in Mongolia



Source: ADB.

Table 1: Mongolia Key Water and Energy Indicators

Indicator	Value	Year
Total population (UN Population Division)	2.8 million inhabitants	2012
Total area	1.56 million km^2	
Population density	1.8 inhabitants/km^2	2012
Human development index (0 is lowest; 1 is highest)[a]	0.675	2012
Country rank (total 187 countries; 1 is highest)	108	2012
Proportion of population without access to safe drinking water sources[a]	27.4%	2010
Proportion of population without access to improved sanitation facilities[a]	76.8%	2010
Long-term average precipitation[b]	227.8 mm/year	2013
Long-term average actual water recharge (FAO AQUASTAT)	34,800 million m^3/year	
Actual water recharge per capita (FAO AQUASTAT)	12,429 m^3/inhabitant	2012
Total water consumption	550 million m^3	2012
% of total actual freshwater recharge consumption (FAO AQUASTAT)	1.6%	2009
Groundwater consumption	80%	2012
Area equipped for irrigation[c]	49,600 ha	2011
Decrease in number of dried up streams, lakes and springs since 2007 (Mongolia Ministry of Environment and Tourism)	17.4%	2011
Total installed capacity of energy (Mongolia Ministry of Energy)	827.4 MW	2012
Share of renewable energy in total energy production (Mongolia Ministry of Energy)	37.4 MW (4.5%)	2012
Share of hydropower energy contribution (Mongolia Ministry of Energy)	28.3 MW	2012
Potential capacity of water resources for renewable energy production (Mongolia Ministry of Energy)	6,417.7 MW (56.2 million kW/hour/year)	2012

AQUASTAT = FAO's global water information system, FAO = Food and Agriculture Organization of the United Nations, ha = hectare, km^2 = square kilometer, kW = kilowatt, m^3 = cubic meter, mm = millimeter, MW = megawatt, UN = United Nations.

[a] Government of Mongolia. 2013. Achieving the Millennium Development Goals. Fifth National Progress Report. (in Mongolian)

[b] National Agency for Meteorology and Environment Monitoring. 2013. Current Mongolian Meteorological and Environmental State 2013. *Annual Report*. Ulaanbaatar. p. 51.

[c] Government of Mongolia, National Statistical Agency. 2011. Result of Quantification of Agricultural Sector. (in Mongolian)

Source: FAO AQUASTAT. 2013. *Mongolia: UN-Water Country Brief*. June. Ulaanbaatar. http://www.unwater.org/downloads/WCB/finalpdf/MNG_pagebypage.pdf water resources available and approved for use are about 140 million m^3/year.[12] Approximately 100 million m^3/year are currently in use.

Climate change will impact on future water resource availability. The Mongolian climate will continue to change dramatically over this century. Study results are emerging on the likely pattern of this future climate. It is forecasted to include higher temperatures all year round, with more snow in winter and less rain in summer. It will also bring more variable weather conditions with longer and more frequent droughts.[13]

The projected changes in runoff vary among the major basins (Table 2). For the Arctic Basin, all climate models project, for both Special Report on Emissions Scenarios (SRES) A2 and B2, significant decreases in runoff by 2050 and substantially greater decreases by 2080. Similarly, for the Pacific Basin, all models project significant decreases in runoff by 2020 through 2050 and substantially greater decreases by 2080. For the Internal Basin, the projections are more variable in the short (2020) and medium term (2050). The HAdCM3 and ECHAM4 models predict substantial increases in runoff between 2020 and 2050. However, in the long term, all models project, for both scenarios A2 and B2, significant decreases in runoff.[14]

Changes in precipitation, evaporation, and temperature regimes, and in soil and other environmental factors, will affect groundwater resources throughout the country. Climate change will reduce aquifer recharge and water levels, especially in shallow aquifers. Higher temperatures and incidence of droughts will result in increased evapotranspiration. Aquifers will also suffer

Table 2: **Projected Changes in Runoff** (%)

	Scenario A2			Scenario B2		
Climate Model	2020	2050	2080	2020	2050	2080
Central Asian Basin (Internal Basin)						
HadCM3	–1.4	9.1	–8.6	7.2	9.6	–0.3
ECHAM4	15.3	10.9	–10.1	16.2	6.2	–2.8
CSIRO-Mk2b	–1.3	–0.6	–5.1	0.8	–1.7	–7.1
Arctic Basin						
HadCM3	–13.9	–5.4	–12.6	–0.5	–2.6	–19.2
ECHAM4	1.4	–7.3	–26.9	1.4	–3.2	–17.5
CSIRO-Mk2b	–6.4	–13.2	–24.7	–9.1	–14.6	–17.9
Pacific Basin						
HadCM3	–23.5	–20.9	–27.5	–19.1	–23.6	–29.1
ECHAM4	–9.8	–18.3	–24.7	–4.2	–18.8	–26.1
CSIRO-Mk2b	–17.5	–22.9	–35.6	–20.5	–24.2	–29.3

Source: Water Authority of the Government of Mongolia. 2011. *Urban Water Vulnerability to Climate Change in Mongolia*. Ulaanbaatar.

---

12 Footnote 8. Table 3. p. 23.

13 Water Authority of the Government of Mongolia. 2011. *Urban Water Vulnerability to Climate Change in Mongolia*. Ulaanbaatar. To make projections of future climate change, the study used the SRES greenhouse gas emission scenarios A2 and B2 that are described in Special Report on Emissions Scenarios by the Intergovernmental Panel on Climate Change, which was published in 2000.

14 Footnote 13.

from the increase in extreme rainfall events, during which rapid rates of runoff will reduce the amount of infiltration into groundwater.[15]

Water Use in Mongolia

In 2010, annual water use,[16] excluding withdrawals for hydropower, was estimated to be 321.0 million m^3/year (Table 3).[17] This implies annual water use of 114.6 m^3/inhabitant; the agriculture sector, with 55%, is the largest consumer (31% for irrigation and 24% for livestock). Drinking water makes up 20%. Water consumption for energy (thermal electric cooling) is 10% and consumption for mining is 13%.

In Ulaanbaatar, 2010 annual water use, excluding withdrawals for hydropower, was estimated to be approximately 80.6 million m^3/year (Table 3). This implies annual per capita water use of

Table 3: Estimated Annual Water Use in Mongolia, 2010

	Ulaanbaatar		Mongolia	
Water Use[a]	m^3	Percent of Total Use	m^3	Percent of Total Use
Drinking water				
Population consumption	38,506,863	47.8%	55,106,716	17.2%
Municipal services	6,831,754	8.5%	9,419,087	2.9%
Total drinking water	45,338,617	56.2%	64,525,803	20.1%
Industrial				
Light and food industries	2,988,964	3.7%	3,648,988	1.1%
Heavy industries	300,000	0.4%	1,286,835	0.4%
Construction	393,580	0.5%	1,181,615	0.4%
Energy	22,500,000	27.9%	33,246,000	10.4%
Mining	4,500,000	5.6%	41,457,158	12.9%
Total industrial	30,682,544	38.0%	80,820,596	25.2%
Livestock	886,651	1.1%	76,932,681	24.0%
Irrigation	3,731,654	4.6%	98,701,031	30.7%
Total water use	**80,639,466**	**100.0%**	**320,980,111**	**100.0%**

m^3 = cubic meter.

[a] Excluding withdrawals for hydropower.

Source: Government of Mongolia, Ministry of Environment and Green Development. 2012. Part 4: Water Supply Hydro Construction, Water Use and Demand. *Integrated Water Management National Assessment Report*. Volume 2. Ulaanbaatar.

---

15 Footnote 13.

16 "Use" in this report refers not to water diverted or withdrawn, but water use that "permanently withdraws water from its source; water that is no longer available because it has evaporated, been transpired by plants, incorporated into products or crops, consumed by people or livestock, or otherwise removed from the immediate water environment," as defined in Amy Vickers' *The Handbook of Water Use and Conservation: Homes, Landscapes, Businesses, Industries, Farms* (2001).

17 The water withdrawals for hydropower production are not considered as part of the water use estimates in Table 3. In Mongolia, the water withdrawals in the hydropower sector are estimated to be 170.2 million m^3/ year. While this represents a significant amount of water withdrawn, the actual consumption may be relatively small as the water is released back to water body after passing through the turbines. The main loss (not estimated) of water is from evaporation from the reservoirs.

62.0 m^3/inhabitant. The major use was for drinking water (56%). Energy sector consumption for thermal electric cooling accounted for 28%. Mining consumed 6%, and light and food industries consumed 4%. In contrast to Mongolia as a whole, the agriculture sector in Ulaanbaatar only accounts for 6%—irrigation (5%) and livestock (1%).

B. Water Management in Mongolia

The Government of Mongolia has made considerable progress in improving its legal and institutional framework for the integrated water resources management (IWRM) and environmental protection of river basins in Mongolia.[18] In 2010, the country was divided into 29 river basins to improve water resources management. The new Water Law (2012) formally established river basin authorities (RBAs) for river basins throughout Mongolia. As of 2013, RBAs had been established for 23 out of the 29 river basins. The government has also approved a national IWRM plan, and as of 2013, 13 IWRM plans have been prepared at the basin level.

The Water Law (2012) serves as an umbrella law for water resources management.[19] The law defines the mandates of the state organizations in charge of development and adoption of IWRM plans. It introduces the concept of river basin councils and river basin authorities, opening the way for decentralization of water management and facilitating involvement of citizens in water management. The law provides the legal basis for the introduction of IWRM and establishes an institutional framework that includes a better positioning of some vital IWRM organizations.

Organizational Arrangements

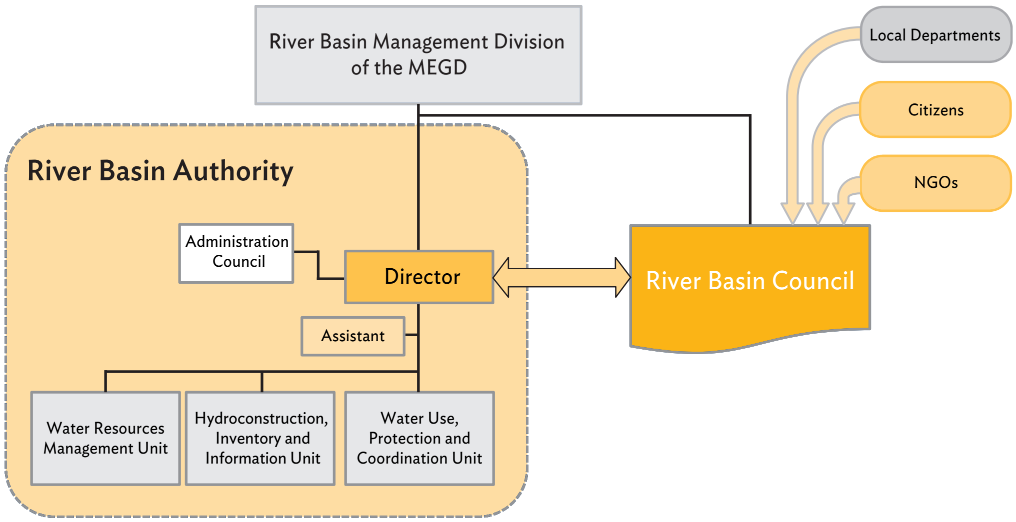
The institutions with formal responsibility in water resources management are (i) the Government of Mongolia—i.e., the Cabinet, the Ministry of Environment and Green Development (MEGD), and the Water Authority (part of the MEGD's Department for Coordination of Policy Implementation); (ii) the National Water Committee; (iii) the *aimag* and *soum* governors, and (iv) river basin committees. Water basin councils have been set up at the river basin level to enable public participation in water resource management (Figure 2). The Water Law (2012) sets out the responsibilities and authorities of river basin councils and river basin authorities (Appendix 3).

River Basin Management Division of the Policy Implementation Department of the Ministry of Environment and Green Development. This division is responsible for establishing river basin authorities and supervising and coordinating their activities; getting approval for and implementing the national integrated water management plan; reviewing environmental assessments prepared by river basin authorities, *aimags*, and capital cities; allocating water among users with river basins; and, where necessary, organizing rehabilitation activities. The division has four staff members including the director. The staff includes specialists with expertise in environmental flows in river basins, estimating consumptive use, and governance for river basins.

[18] To understand how the Government of Mongolia is responding to implications of the water–energy nexus, a survey of institutional capacity was undertaken for key water management agencies in the MEGD and the river basin organizations for the two case study basins: the Tuul and Galba-Uush Doloodin Gobi. The 2012 *Integrated Water Management National Assessment Report* and the *Tuul River Basin Integrated Water Management Plan* informed the institutional analysis and policy gap analysis of water management. The 2013 update of the Energy Sector Development Plan provided information on institutional issues in the energy sector.

[19] MEGD. 2012. Part 7: Institutional Analysis of Water Sector in Mongolia. *Integrated Water Management National Assessment Report*. Volume 1. Ulaanbaatar.

Figure 2: **Interrelationships between Water Management Institutions**



MEGD = Ministry of Environment and Green Development, NGO = nongovernment organization.
Source: Government of Mongolia, Ministry of Environment and Green Development.

The river basin organizations throughout Mongolia are at different stages of development. The contrast can be seen in this study's two focal basins. On one hand, the Tuul River Basin has had to develop relatively sophisticated systems to deal with complex issues associated with Ulaanbaatar. On the other hand, the local government administrations in the Galba-Uush Doloodin Gobi Basin had, until recently, little concern for water management, in general, and little need for sophisticated water management. That has now changed with large mining developments in the South Gobi Desert.

C. Energy Sector Overview

The government has a vision to interconnect the currently independent energy grid systems operating in the country.[20] Recently, the central and southern grids were integrated by connecting the Dalanzadgad area to Ulaanbaatar via Mandalgovi at 220 kilovolts (kV). The Russian Federation supplies the eastern and western grids, but their integration into the central grid will increase energy independence and improve energy security in an economical manner.

Currently, coal is the dominant source in primary energy (70%) and makes up over 95% of secondary energy (for electricity and heat generation). Mongolia hosts 10% of the world's known coal reserves at an estimated 163.2 billion tons in 2012 with 17 operating coal mines. The Tavan Tolgoi, the largest coal site in Mongolia, has high-grade coal deposits, which are expected to yield 6 billion tons of coal. Coal production in Mongolia increased from 10.6 million tons in 2008 to 32.9 million tons in 2011.[21] Mongolia exported 72% of the 22.5 million tons of coal

[20] This section is excerpted from ADB. 2013. *Updating the Energy Sector Development Plan*. Executive Summary. Final report. Manila (TA 7619-MON).

[21] Government of Mongolia, Mineral Resource Authority. 2013. *Statistics of Mining: Monthly Report (December-2013)*. Ulaanbaatar. p.19. (in Mongolian)

produced in 2010, making it the country's largest export (which had previously been copper).[22] The largest customer for coal was the PRC, accounting for over 82% of all exported coal.

There is no natural gas available in Mongolia, and all refined oil is imported mainly from the Russian Federation with some minor import from the PRC and the Republic of Korea. Mongolia has very high development potential in renewable energy sources (solar, wind, and hydro). A Mongolian private company successfully commissioned a 50-megawatt wind farm in Salkhit in 2013, which is the first megawatt-scale grid-connected wind farm in Mongolia. However, due to the intermittent nature of wind, development of dispatchable backing sources (i.e., hydropower plants) is required to support further development.

Energy intensity of the economy is more than two times higher than in member countries of the Organisation for Economic Co-operation and Development (OECD), but comparable to Kazakhstan due to energy-intensive industrial structure (mining) and cold climate (long heating season). Heat access is a matter of human survival for Mongolia's citizens. The demand for heating is over twice that of electricity due to climatic condition (8 months of heating season as winter temperatures range from below −20°C to −40°C). Combined heat and power (CHP) plants are the most suitable, efficient, and economical choice to provide electricity and heat in Mongolia, especially in Ulaanbaatar, where the population density is high. In Ulaanbaatar and in most *aimag* centers, it is economical to employ district heating systems to distribute heat.

Electricity and heating demand has almost doubled in the last decade due to mining developments and urbanization of Ulaanbaatar, and is expected to grow at the rate of 8% to 10% by 2020. However, no major investments have been made to date to meet the growing demand; as a result, the reserves of electricity and heat supplies are almost zero. If no capacity additions are made, an electricity and heat supply crisis may happen in the near future.

Electricity Growth

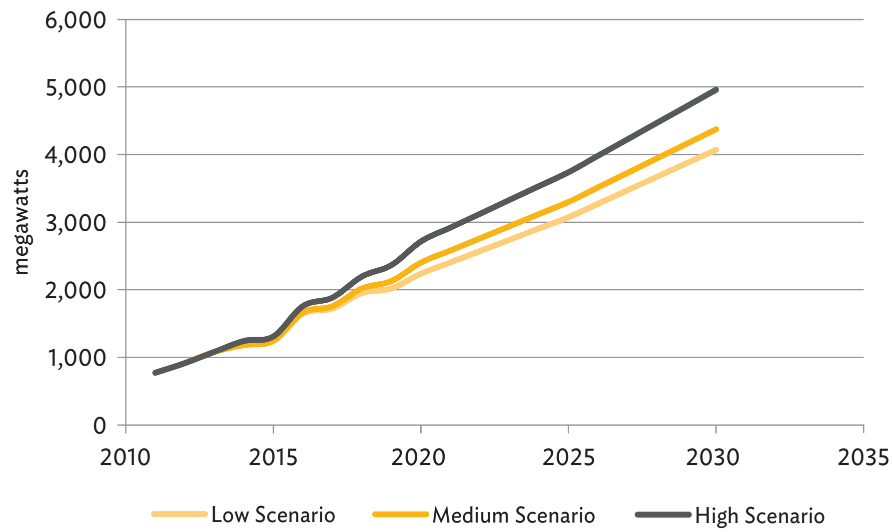
Mongolia's demand for electric energy is expected to increase fivefold under the high-electricity growth scenario from 2012–2030. The projected electricity demand for three different development scenarios is depicted in Figure 3. The low-electricity growth scenario includes "organic" growth associated with existing domestic, commercial, and industrial consumers, particularly in Ulaanbaatar. It also includes the demand associated with large mining operations in South Gobi, including copper mining at Oyu Tolgoi[23] and coal mining at Tavan Tolgoi. The medium-electricity growth scenario includes the developments of the low-electricity growth scenario and adds major industrial development to occur over a 30-year period located in three industrial zones: (i) northern zone (Erdenet, Darkhan); (ii) central zone (Choir, Sainshand); and (iii) southern zone (Dalanzadgad, Tavan Tolgoi, Oyu Tolgoi). The high-electricity growth scenario includes the low-electricity growth scenario and assumes that the industrial growth anticipated by the medium-electricity growth scenario will be accelerated to occur over the next 20 years.

The existing facilities for providing heating and electricity (power plants, transmission and distribution lines) are energy-inefficient and vulnerable since this infrastructure dates to the Soviet era. Two out of three CHP plants (CHP-2 and CHP-3) in Ulaanbaatar have been operating for over 40 years, and the largest CHP plant (CHP-4) in Ulaanbaatar has operated for more than 25 years. Coal-based heating facilities in *aimag* and *soum* centers are old and inefficient

[22] Government of Mongolia, Mineral Resource Authority. 2012. *Activity Report of the Mineral Resource Authority from 2008 to 2012*. Ulaanbaatar. (in Mongolian)

[23] Electricity for Oyu Tolgoi is currently supplied by the PRC.

Figure 3: Projected Mongolia Electricity Demand



Source: ADB. 2013. *Updating the Energy Sector Development Plan: Electricity Forecasts*. Final report. Manila (TA 7619-MON).

and mostly beyond refurbishment. Urgent replacement of heating facilities is needed to provide reliable and efficient heating services to the citizens.

Coal-fired thermal plants will be the primary type of new generating facilities for the proposed expansion of Mongolia's energy system. This will significantly increase water consumption for cooling. However, the rate of increase in water consumption will be less than the rate of increase in energy production. Efficiencies in cooling technology and in plant cooling water management are expected to reduce the water intensity of energy production.

It is expected that many of the new energy facilities will be located in the already water-stressed Tuul River Basin and South Gobi area. Under the low-expansion scenario, the Central Energy System will triple its coal-fired generating capacity from approximately 850 megawatts (MW) to 2,500 MW. The new facilities will compete with other major water users for scarce water in the Tuul River Basin, including the urban population of Ulaanbaatar and light and heavy industries. The South Gobi energy system is expected to initially add 750 MW and increase to 1,200 MW of coal-fired thermal generating capacity. These facilities will compete with mining operations at Oyu Tolgoi and Tavan Tolgoi for scarce water resources, and are expected to further exacerbate existing water conflicts with traditional herders.

D. The Water–Energy Nexus

To deconstruct the water–energy nexus, we must understand both the water intensity of energy production and the energy intensity of water production. Thermal electric cooling is a good example of the water–energy nexus. Thermal electric plants require water for cooling, which in turn requires energy for pumping that water and, in some cases, water treatment. This reduces the net energy production of the thermal plant. The amount of water consumed depends on the energy production and the type of cooling technology used. For example, the "once through" type of cooling technology requires large water withdrawals but has relatively low water consumption. "Closed loop" cooling systems have small water withdrawals but relatively high water consumption.

Water Intensity of Energy

The water intensity of energy is the amount of water needed to produce one unit of energy. Table 4 presents coal-fired thermal power generation values for two types of cooling: once through and closed loop.[24]

Water use intensity for thermal power plants in Mongolia (Table 5) is much greater than the annual water intensity presented in Table 4. Thermal plants with closed-loop cooling in Mongolia use 75%–77% of their water to remove ashes from the furnaces. The water-ash mixture collects into a pond and once the ash settles, some of the water is reused for technical purposes. CHP-4 power plant has a reverse osmosis system to reuse water and has had technical improvements. As a result, it has a water intensity rate of 2,872 liters per megawatt-hour (l/MWh) that falls within the range of 1,816–4,163 l/MWh for a generic closed-loop cooling tower. The Darkhan thermal power plant, with a water intensity of 4,130 l/MWh, is the only other facility that falls within the range for a generic closed-loop cooling tower.

Table 4: Annual Water Intensity of Coal-fired Thermal Power Stations

		Annual Water Intensity (l/MWh)[a]		
Cooling Type	Technology	Median	Minimum	Maximum
Tower–closed loop	Generic	2,600	1,816	4,163
	Subcritical	1,813	1,491	2,513
	Supercritical	1,866	1,684	2,248
	IGCC	1,438	1,203	2,248
Once through	Generic	946	378	1,199
	Subcritical	427	268	522
	Supercritical	378	242	469

IGCC = integrated gasification combined cycle, l/MWh = liter consumed per megawatt-hour.

[a] The original data was presented in units of US gallons per MWh.

Source: Macknick, J., et al. 2012. Operational Water Consumption and Withdrawal Factors for Electricity Generating Technology: A Review of Existing Literature. *Environmental Research Letters*. 7 (4). http://iopscience.iop.org/1748-9326/7/4/045802/pdf/1748-9326_7_4_045802.pdf

[24] A number of studies have presented data on water intensity of energy. These include (i) Mielke, et al. 2010. Water Consumption of Energy Resource Extraction, Processing, and Conversion. *Energy Technology Innovation Policy Discussion Paper Series*. No. 2010-15. Belfer Center for Science and International Affairs. Massachusetts: Harvard Kennedy School, Harvard University. October; and (ii) United States Department of Energy. 2006. *Energy Demands on Water Resources*. Washington, DC. However, the most recent and among the most comprehensive is Macknick, et al. 2012. Operational Water Consumption and Withdrawal Factors for Electricity Generating Technology. A Review of Existing Literature. *Environmental Research Letters*. 7 (4). http://iopscience.iop.org/1748-9326/7/4/045802/pdf/1748-9326_7_4_045802.pdf

Table 5: Electricity Production and Water Use of Thermal Power Plants in Mongolia

Power Plant	Electrical Generation (MW)		Year	Electrical Production (MWh)	Water Use (million m^3/year)	Annual Water Intensity (l/MWh)
	Capacity	Current				
CHP-2	24.0	21.5	2013	116,700	2.18	18,680
CHP-3	148.0	138.0	2013	692,996	8.40	12,121
CHP-4	540.0	560.0	2013	3,530,470	10.14	2,872
Darkhan TPP	48.0	48.0	2013	261,500	1.08	4,130
Erdenet TPP	28.8	28.8	2010	163,987	1.50	9,147
Dornod TPP	36.0	36.0	2010	204,984	3.10	15,123
Dalanzadgad TPP	6.0	5.4	2010	30,748	0.90	29,270

CHP = combined heat and power, l/MWh = liter consumed per megawatt-hour, m^3 = cubic meter, MW = megawatt, MWh = megawatt-hour, TPP = thermal power plant.

Sources:

(i) For CHP-2, CHP-3, and CHP-4, 2013 data are based on the 2013 annual report and interviews at plants with the following individuals: CHP-2, T. Batbaatar, engineer; CHP-3, L. Ireedui, water engineer; and CHP-4, B. Battuvshin, senior staff at research and development department. Darkhan TPP data is based on the 2013 annual report; water consumption was estimated based on a fee of MNT76.5 million (one cubic meter is equivalent to MNT70.8).

(ii) For the other plants, water consumption data is taken from the Government of Mongolia, Ministry of Environment and Green Development. 2012. Part 4: Water Supply Hydro Construction, Water Use and Demand. *Integrated Water Management National Assessment Report*. Volume 2. Energy production for 2010 was estimated at approximately 65% of current generation capacity.

Primary energy. Water is essential to the extraction and cleaning processes associated with primary energy production.[25] Coal is the primary energy resource currently being exploited in Mongolia. Increased coal mining production will be needed to fuel the coal-fired thermal plants that are planned to meet Mongolia's increasing demand for electricity. Various studies have made estimates for water use per unit of coal production (Table 6). The 2010 study by Mielke, et al., which is based on coal mining operations in the United States (US), gives a range of 150 to 900 liters per ton of oil equivalent (l/toe). The *World Energy Outlook 2012* study, which is based on international experience, gives a range of 150 to 2,000 l/toe.

Data on water consumption and production of major coal mines were not available. However, the Energy Resource LLC mine, which is in the Galba-Uush Doloodin Gobi Basin, introduced water-recycling technology in 2011. Based on 2013 estimates of coal production (9.7 million tons) and water use (2.4 million m^3), the water intensity of coal production for the mine was 247.4 l/toe, which compares favorably with the water consumption factors in Table 6.

Energy Intensity of Water Facilities

The other part of the water–energy nexus concerns the energy needed for supplying and treating water. Energy is needed for pumping, transporting, distributing, and collecting water. In addition, water treatment processes require energy.

[25] Primary energy is defined as "any energy source that is extracted from a stock of natural resources or captured from the flow of resources and that has not undergone any transformation or conversion other than separation and cleaning." Examples include coal, crude oil, natural gas, solar power, and nuclear power. Water is used to produce this energy during extraction and cleaning processes.

For example, Ulaanbaatar has 147.7 kilometers (km) of sewerage pipelines, a central wastewater treatment plant with treating capacity of 230,000 m^3/day, and the Khargia industrial wastewater treatment plant with treating capacity of 13,800 m^3/day. The average wastewater discharge to the Tuul River from wastewater treatment plants amounts to 155,000–160,000 m^3/day.[26] Table 7 presents the energy intensity of Ulaanbaatar's main water facilities. To compare the energy intensity of the city's water facilities with international estimates, the study used the value of 0.48 kilowatt-hour (kWh)/m^3 for energy intensity of water facilities.[27] The energy used for pumping and distributing water in Ulaanbaatar is estimated to be 0.30 kWh/m^3. The energy needed for the CHP-3 water supply system is 1.70 kWh/m^3, and for CHP-4 is 0.95 kWh/m^3.

Table 6: Water Consumption Factors for Coal Extraction (including cleaning of coal)

Unit	Minimum	Maximum	Reference
l/toe	150.1	900.6	Mielke, et al., 2010[a]
l/toe	150.0	2,000.0	*World Energy Outlook 2012*, Chapter 17[b]

l/toe = liter per ton of oil equivalent.

[a] The original data was in gallons per million metric British thermal units (gal/MMBtu).

[b] Values interpolated from graph (Figure 17.3 of Water for Energy. Excerpt from *World Energy Outlook 2012*).

Sources: (i) Mielke, E., et al. 2010. Water Consumption of Energy Resource Extraction, Processing, and Conversion: A review of the literature for estimates of water intensity of energy-resource extraction, processing to fuels, and conversion to electricity. *Energy Technology Innovation Policy Discussion Paper Series*. No. 2010-15. Cambridge, Massachusetts: Belfer Center for Science and International Affairs. Harvard Kennedy School, Harvard University. Table 5.3; and (ii) International Energy Agency. 2012. *World Energy Outlook 2012*. Paris. Chapter 17.

Table 7: Calculation of Energy Intensity of Different Water Supply Facilities in Ulaanbaatar

	Electricity Usage for Water Withdrawal (kWh)		Water Withdrawal (m^3)		Energy Intensity for Water Withdrawal (kWh/m^3)	
Water Supply Facility	2012	2013	2012	2013	2012	2013
Water supply (4 main wells)	15,837,687	16,392,864	54,804,052	54,992,362	0.29	0.30
Wastewater treatment	21,093,139	21,062,907	56,922,042	56,926,777	0.37	0.37
CHP-3 water supply[a]	8,865,000	8,415,000	5,062,000	4,948,000	1.75	1.70
CHP-4 water supply[a]	8,816,430	9,676,040	9,040,856	10,137,221	0.98	0.95
Total[b]	**54,612,256**	**55,546,811**	**125,828,950**	**127,004,360**		

CHP = combined heat and power, kWh = kilowatt-hour, m^3 = cubic meter.

[a] These are the water withdrawals for the existing combined heating power plants.

[b] Total is withdrawals less return flows.

Source: Interview with staff of the Water Supply and Sewerage Authority of Ulaanbaatar City.

[26] Water Supply and Sewerage Authority of Ulaanbaatar City. Various years (2012, 2013). *Annual Report*. Ulaanbaatar.

[27] Burton (1996) estimated a value of 0.48 kWh/m^3 for water from groundwater sources. (Burton, Franklin L. 1996. Water and Wastewater Industries. *Characteristics and Energy Management Opportunities*. Report CR 106941. Prepared by Burton Engineering for the Electrical Power Research Institute, Los Altos, CA. Quoted in Cooley, Heather and Robert Wilkinson. 2012. *Implications of Future Water Supply Sources for Energy Demands*. Alexandria, Virginia: Water Reuse Foundation.)

The energy consumption for water supply and wastewater treatment represents about 1.3% of the total current energy production of the three CHP plants. This is low compared with the US, where drinking water and wastewater systems account for approximately 3% to 4% of energy use.[28]

It should be noted that, in Mongolia, the sources of increasing energy demands from the water sector include (i) increased population growth, urbanization, and rising living standards; (ii) scarcer water supplies in proximity to population centers due to climate change; (iii) increased needs for water treatment and more stringent standards for water treatment; (iv) increased need for the application of recycled water for industries; and (v) increased area under irrigation and shift in energy practices that conserve water but require more energy.

[28] US Environmental Protection Agency. 2013. *Energy Efficiency in Water and Wastewater Facilities: A Guide to Developing and Implementing Greenhouse Gas Reduction Programs*. Washington, DC. http://epa.gov/statelocalclimate/documents/pdf/wastewater-guide.pdf

III. Tuul River Basin: Meeting the Water and Energy Demands of a City

Water consumption in the Tuul River Basin accounts for 27.6% of total water use in Mongolia. More people live in the Tuul River Basin than in any other basin in the country, as it services 65.5% of the Ulaanbaatar city area, 39.8% of Tuv *aimag*, 20.8% of Bulgan *aimag*, 6.0% of Uvurkhangai *aimag*, 4.4% of Arkhangai *aimag*, and 2.2% of Selenge *aimag*. The growing density of population and livestock and the development of the gold mining industry have significant influence on the water regime and the quality of this river.

The Tuul River Basin (Map 2) covers 49,774 square kilometers (km^2).[29] The Asralt Khairkhan Uul, at an elevation of 2,799.3 meters, forms the top of the basin. The name Tuul River appears downstream at the confluence point of the rivers Namya and Nergui. Downstream, its main tributaries are the Galtai, Khag, Khongor, Zuunbayan, Kholiin, Zuunbayan, Uliastai, Selbe, and Khar Bukh. At Ulaanbaatar, the long-term annual average discharge is about 26 m^3 per second (based on data from 1942 to 2010). Downstream of Ulaanbaatar, the valley of the Tuul River widens, permanent tributaries are scarce, and inflows are small. The result is decreased flow in downstream sections of the river.[30]

A. Existing Water Availability

Much of the surface water in Mongolia is required for minimum environmental flows and not available for consumptive use. The total potential annual renewable surface water resources of the Tuul River Basin is estimated at 1,490 million m^3/year.[31] However, it is estimated that only 63.13 million m^3/year or more are available half of the time, and that only 30.53 million m^3/year or more are available 90% of the time.

The Tuul River Basin is estimated to have 960 million m^3 of annual renewable groundwater resources, of which 641 million m^3 are considered to be exploitable. However, they are scattered throughout the basin. For example, approved exploitable groundwater resources for Ulaanbaatar are 271,120 m^3/day (99 million m^3/year); with another 104,408 m^3/day (37.1 million m^3/year) of determined but currently unused sources (Table 8).[32]

---

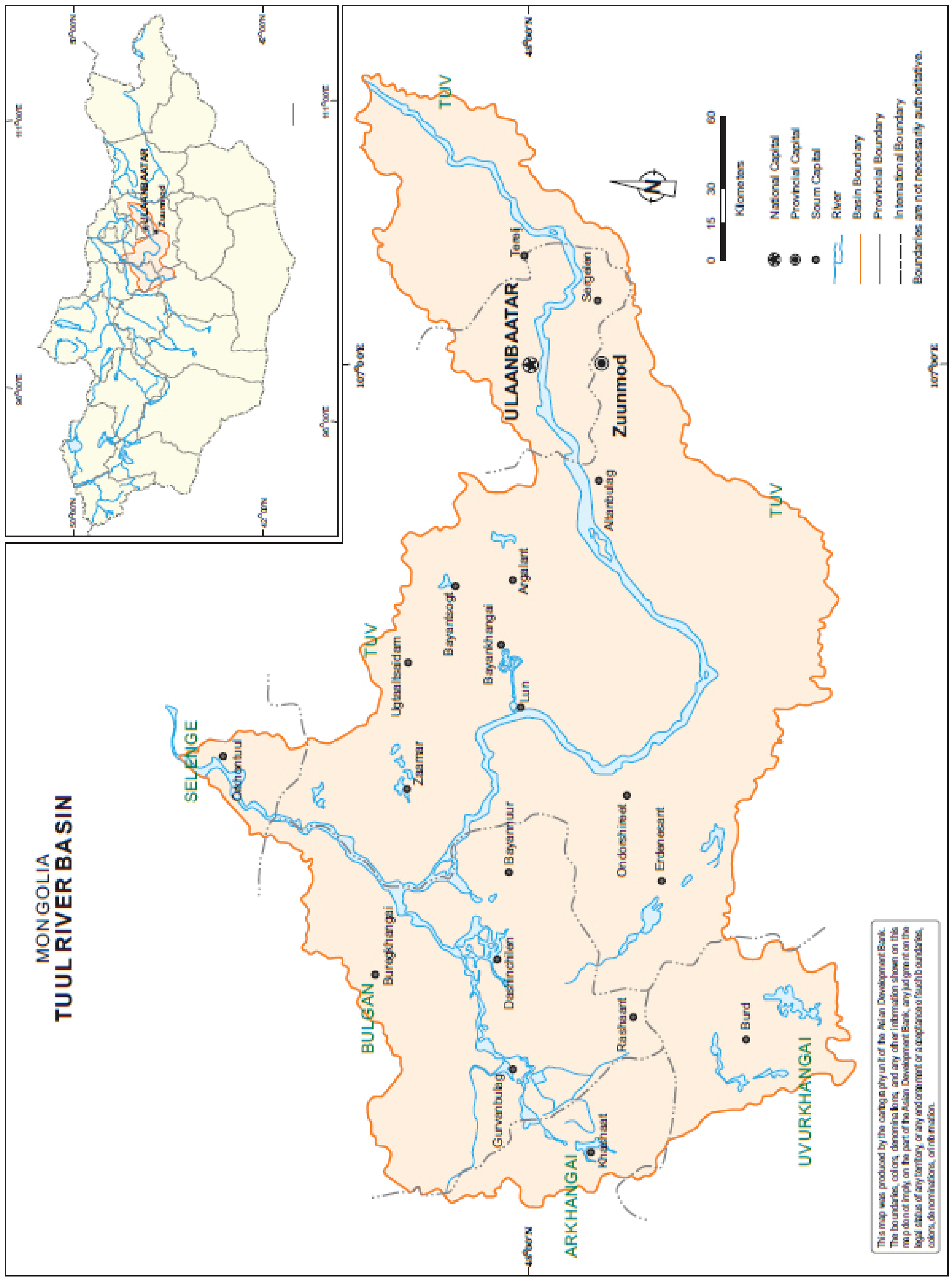
[29] MEGD. 2012. Chapter 1: Physical, Geographical and Natural Condition of Tuul River Basin. *Tuul River Basin Integrated Water Management Plan*. Ulaanbaatar.

[30] MEGD. 2012. Part 3: Climate Change. *Integrated Water Management National Assessment Report.* Volume 2. Ulaanbaatar.

[31] MEGD. 2012. Chapter 2: Tuul River Basin Water Resource and Water Quality. *Tuul River Basin Integrated Water Manageme nt Plan*. Ulaanbaatar.

[32] MEGD. 2012. Chapter 5: Water Use Balance of The Tuul River Basin. *Tuul River Basin Integrated Water Management Plan*. Ulaanbaatar.

Map 2: Tuul River Basin in Mongolia



Source: ADB.

Table 8: **Approved Groundwater Sources for Water Supply of Ulaanbaatar**

Source	Resources (m^3/day)
Tuul Valley of Yarmag, Sonsgolon (2011)	26,201
Buyant-Ukhaa new district (2010)	22,550
Confluence of Tuul and Uvur Gorhi (2003)	11,750
Confluence of Tuul and Terelj (2007)	40,062
Khui Doloon Khudag (2007)[a]	3,845
Total	**104,408**

m^3 = cubic meter.

[a] This deposit is located in the Kharaa River Basin but can be used for water supply of Ulaanbaatar.

Source: Government of Mongolia, Ministry of Environment and Green Development. 2012. Chapter 2: Tuul River Basin Water Resource and Water Quality. *Tuul River Basin Integrated Water Management Plan*. Ulaanbaatar. Table 20. p. 43.

B. Existing Water Use

Energy and heat consume 25% of total water use in the Tuul River Basin (mainly for thermal electric cooling at power plants), making it the second largest consumer sector. In 2010, total annual water use was estimated to be approximately 89.9 million m^3/year (Table 9). The major uses were for drinking water and municipal services (52%). Mining consumed 6% and light and food industries consumed 3%. Agriculture (i.e., livestock and irrigation) accounts for only 11% (Figure 4), in contrast to Mongolia as a whole where agriculture accounts for 55% of water use.

The approved exploitable groundwater resource of the municipal centralized sources is 278,000 m^3 per day. However, currently only 261,000 m^3 per day are being abstracted. The *ger* districts, summer tourist camps, and industries with noncentralized supplemental sources extract 78,000 m^3 daily from 576 boreholes. Total abstraction is 339,000 m^3/day from a total of 794 boreholes.[33]

C. Water Balance in the Tuul River Basin

Ulaanbaatar is facing water shortages as early as 2015, even with the contribution of the planned additional sources. The *Tuul River Basin Integrated Water Management Plan* conducted a water balance assessment to determine whether basin water resources are sufficient to supply existing consumption and future demand. The basin was divided into three sections:

i. the upstream section, which includes 4,084.4 km^2 watershed area of several *soums* of Tuv *aimag* and a small part of the Nalaikh and Bayanzurkh districts of Ulaanbaatar;

ii. the midstream section, which includes 5,242.2 km^2 of watershed area of seven districts of Ulaanbaatar and several *soums* of Tuv *aimag*; and

iii. the downstream section, which includes 40,447.7 km^2 of watershed area of *soums* of Arkhangai, Bulgan, Selenge, and Tuv , and Uvurkhangai *aimags*.

The current estimate of exploitable groundwater resources for Ulaanbaatar, from sources that are currently in use, is 99.0 million m^3/year. Low, medium, and high water demand scenarios to

[33] MEGD. 2012. *Tuul River Basin: Integrated Water Resources Management Assessment Report*. Ulaanbaatar.

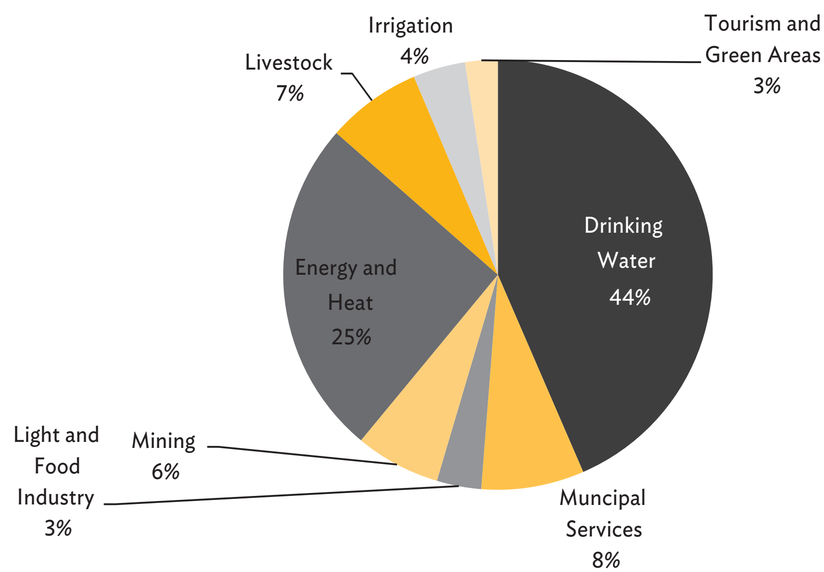
Table 9: Annual Water Use in the Tuul River Basin

Use	Water Consumption (000's cubic meters)		
	2010	2015	2021
Ulaanbaatar population	38,400.7	51,126.9	51,084.6
Zuunmod population	368.7	604.2	696.6
Soum center population	74.1	87.4	132.7
Rural population	86.9	107.0	164.9
Public services	3,340.9	3,581.3	3,892.8
Commercial services	3,591.7	5,180.4	8,039.6
Food industry	2,735.0	3,810.8	5,687.0
Light industry	260.2	370.5	553.0
Construction	394.3	550.3	821.3
Mining	5,735.8	7,396.4	6,952.3
Energy and heat	22,779.5	30,484.1	43,242.3
Livestock	6,390.0	8,805.9	10,315.4
Irrigation	3,535.7	6,083.4	9,341.6
Tourism	43.9	90.8	209.8
Green areas[a]	2,153.0	2,160.1	2,169.6
Total	**89,890.4**	**120,439.5**	**143,303.5**

[a] Green areas are parks and other municipal areas that are watered during the summer months.

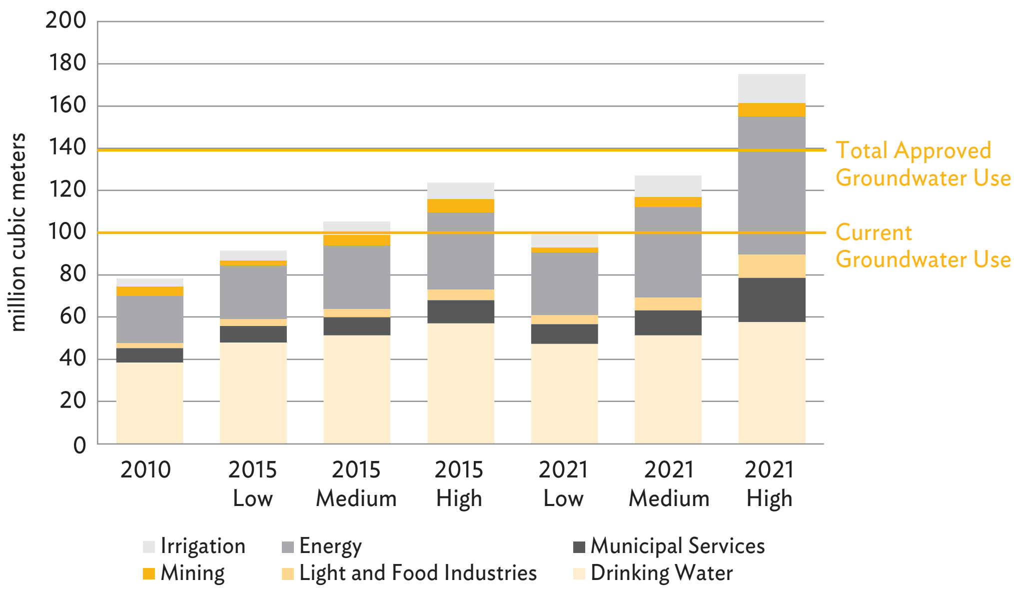
Source: Government of Mongolia, Ministry of Environment and Green Development. 2012. Chapter 4: Water Supply, Water Consumption-Use and Water Demand, Hydro-Constructions. *Tuul River Basin Integrated Water Management Plan*. Ulaanbaatar. Table 77. p. 136.

Figure 4: Water Use in the Tuul River Basin, 2010
(relative % shares of major uses)



Source: Government of Mongolia, Ministry of Environment and Green Development. 2012. Chapter 4: Water Supply, Water Consumption-Use and Water Demand, Hydro-Constructions. *Tuul River Basin Integrated Water Management Plan*. Ulaanbaatar. Table 77. p 136.

Figure 5: Existing and Projected Annual Water Use in Ulaanbaatar



Source: Government of Mongolia, Ministry of Environment and Green Development. 2012. Part 4: Water Supply Hydro Construction, Water Use and Demand. *Integrated Water Management National Assessment Report*. Volume 2. Ulaanbaatar.

2015 and 2021 were prepared.[34] Based on the medium water demand scenario (102.4 million m^3/year by 2015; and 122.1 million m^3/year by 2021), water shortages are expected to amount to 3.4 million m^3/year by 2015 and 23.1 million m^3/year by 2021. For the high water demand scenario (119.6 million m^3/year by 2015; and 165.1 million m^3/year by 2021), shortfalls of 20.6 million m^3/year by 2015 and 66.1 million m^3/year by 2021 are estimated (Figure 5). However, there are plans for additional resources of 38.1 million m^3/year from the already identified and approved sources for Ulaanbaatar's water supply, making total available resources of 137.1 million m^3/year. However, even with these additional sources, there will be a shortfall of about 28 million m^3/year for the high water demand scenario by 2021.

D. The Water–Energy Nexus

Two energy scenarios were developed to examine the impact on the Tuul River Basin. The basic assumptions are as follows:

i. Two energy development scenarios based on the Central Energy System facilities expansion were used to estimate energy production and associated water use based on water intensity assumptions (Table 10).
ii. Water use for sectors other than energy was based on estimates provided in the *Tuul River Basin Integrated Water Management Plan*.

[34] MEGD. 2012. Part 4: Water Supply Hydro Construction, Water Use and Demand. *Integrated Water Management National Assessment Report*. Volume 2. Ulaanbaatar.

Scenario Plan 1a: Combined Heat and Power (CHP) Reference Plan—Low-Electricity Growth.[35] This scenario includes committed plants: CHP-5, expansion of CHP-4, refurbishment of CHP-3, expansion of Darkhan thermal power plant (TPP), and the 50-megawatt (MW) Newcom wind farm. New capacity includes (i) addition of 300 MW of new CHP-5 power by 2018, increasing to 750 MW by 2025; (ii) new coal-fired condensing power plants starting with 300 MW in 2018 and increasing to 900 MW by 2025; and (iii) grid-connected wind power commencing at 50 MW in 2014 (Appendix 2). Most of the new capacity will come from CHP-5 (750 MW) and new coal-fired facilities (900 MW) (Figure 6).

Table 10: Summary of Water Intensity of Selected Energy Facilities in Mongolia

Energy Facility	Water Intensity (l/MWh)	Note
CHP-2	18,680	Based on 2103 energy production and water consumption
CHP-3	12,121	Based on 2103 energy production and water consumption
CHP-4	2,872	Based on 2103 energy production and water consumption
New coal-fired facilities	2,872	Based on CHP-4 water intensity
New HOB—heating plants	2,872	Based on CHP-4 water intensity

CHP = combined heat and power, HOB = heat-only boiler, l/MWh = liter consumed per megawatt-hour.

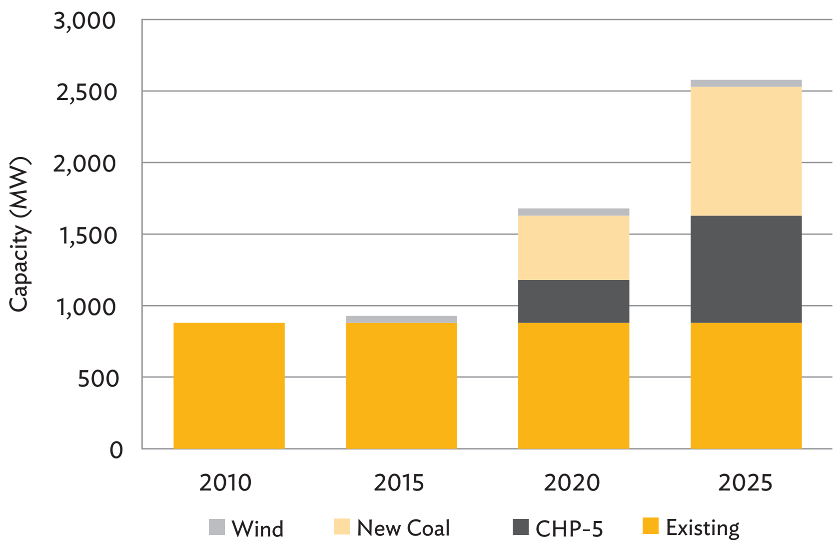
Source: Taken from figures in Table 5, which are based on the 2013 annual report and interviews at plants with the following individuals: CHP-2, T. Batbaatar, engineer; CHP-3, L. Ireedui, water engineer; and CHP-4, B. Battuvshin, senior staff at research and development department.

Scenario Plan 1c: CHP Reference Plan—High-Electricity Growth. This plan includes the facilities planned under Scenario Plan 1a plus an additional 800 MW capacity to 2025 (Appendix 2). Most of the additional capacity will come from CHP-5 (750 MW) and new coal-fired facilities (1,800 MW) (Figure 7).

The water use projections, under the low-growth scenario, show that the additional energy facilities make up most of the increase in water consumption. Total water consumption increases by 83% from 2010 to 2025. During that period, energy's share of water consumption increases from 25% to 34% (Figure 8, Table 11). Similarly, under the high-growth scenario, the additional energy facilities make up most of the growth in water consumption. However, total water consumption increases by 99% from 2010 to 2025. During that period, energy's share of water consumption increases from 25% to 40% (Figure 8, Table 11).

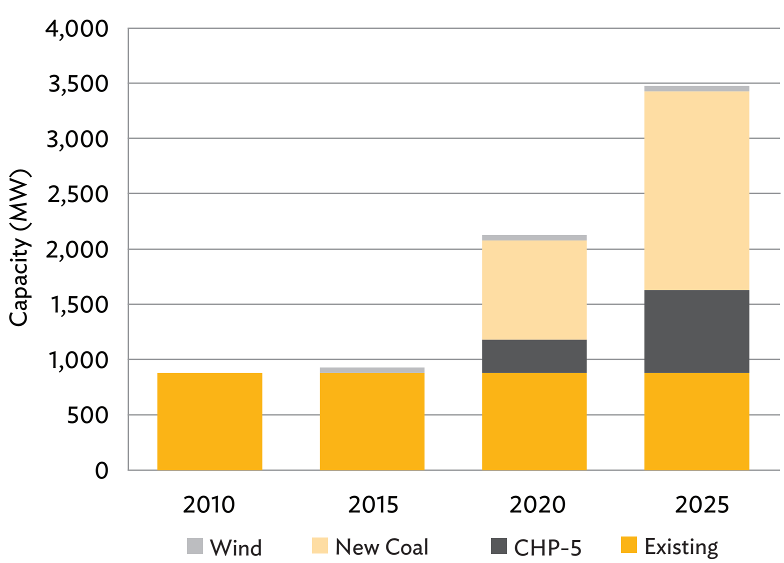
[35] ADB. 2013. *Updating the Energy Sector Development Plan*. CES Supply Expansion Plan. Final report. Manila (TA 7619–MON).

Figure 6: **Relative Contribution of Generating Facilities, Scenario Plan 1a** (Low-Electricity Growth)



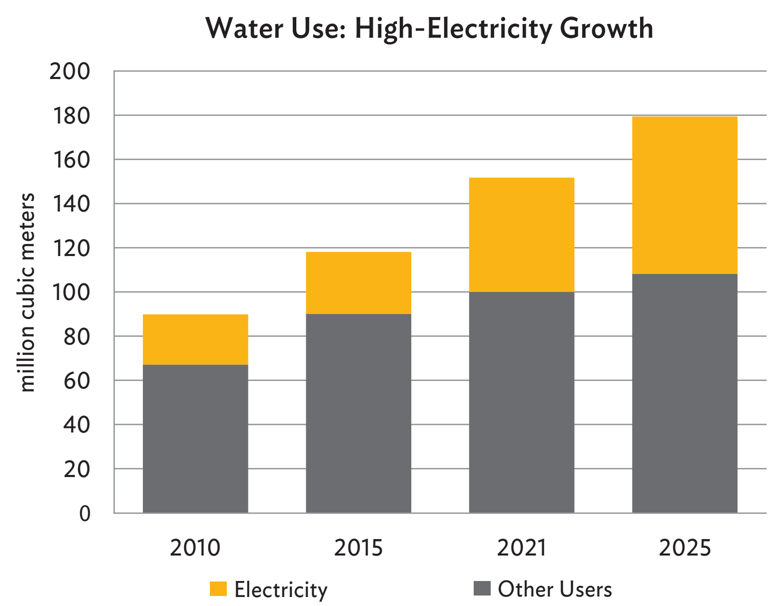
CHP = combined heat and power, MW = megawatt.
Source: Based on data in Appendix 2, Energy Scenario Factors.

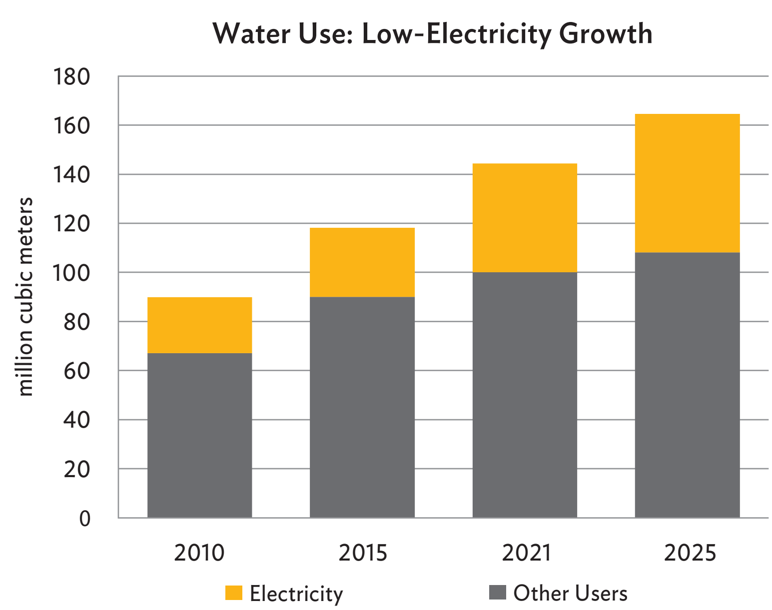
Figure 7: **Relative Contribution of Generating Facilities, Scenario Plan 1c** (High-Electricity Growth)



CHP = combined heat and power, MW = megawatt.
Source: Based on data in Appendix 2, Energy Scenario Factors.

Figure 8: Water Use Projections for Low- and High-Electricity Growth Scenarios





Source: Derived from estimates in Table 11, Estimated Annual Water Consumption under Low- and High-Electricity Growth Scenarios.

Table 11: Estimated Annual Water Consumption under Low- and High-Electricitiy Growth Scenarios

Year	Other Users (m^3)	Energy Facilities (m^3)	Total (m^3)	Rate of Increase	Energy Share
Low Scenario 1a					
2010	67,110,900	22,779,500	89,890,400		25%
2015	89,955,400	28,205,216	118,160,616	31%	24%
2021	100,061,200	44,275,474	144,336,674	61%	31%
2025	108,066,096	56,540,350	164,606,446	83%	34%
High Scenario 1c					
2010	67,110,900	22,779,500	89,890,400		25%
2015	89,955,400	28,205,216	118,160,616	31%	24%
2021	100,061,200	51,634,400	151,695,600	69%	34%
2025	108,066,096	71,258,201	179,324,297	99%	40%

m^3 = cubic meter.
Source: Author's calculations.

Energy Intensity of Water Facilities. The combined energy use for water withdrawals is estimated based on data for three kinds of facilities: (i) existing and proposed new water supply facilities in Ulaanbaatar, (ii) existing and proposed new wastewater treatment facilities in Ulaanbaatar, and (iii) existing and proposed new thermal generating facilities.

There are currently four large water supply facilities in the city of Ulaanbaatar: Central, Upper, Industrial, and Meat Complex. The structure and operation of all the sources are similar. Water is supplied to primary reservoirs by pumps, and the city is supplied by water through auxiliary water pumps and pipelines. As the four existing facilities are operating near maximum capacity, it was assumed that new water supply sources will be developed to meet the increasing demands for water. Similarly, with respect to wastewater treatment, it was assumed new water sources will be developed to meet the demands for wastewater treatment. Future water withdrawals for the facilities are assumed to grow at the same rate as water use by other users in the Tuul River Basin.[36]

Currently, there are three water sources for the existing power plants CHP-2, CHP-3, and CHP-4. These sources, located in the southeast part of the city, are under the control of the Energy Authority and were established based on groundwater in the alluvial aquifer of the Tuul River floodplain. To estimate future water consumption of water facilities and indicative water sources for thermal power plants, CHP-5, and other new coal-fired power plants, it was assumed the new water sources would be developed.[37]

The energy consumption of water facilities was estimated based on projected water withdrawals and the energy intensities of the water facilities (Table 12).

Based on the high-electricity growth scenario and the estimated water withdrawals needed to meet the demand, approximately 118,375 megawatt-hours (MWh)/year will be needed for the facilities (Table 13). This represents approximately 0.6% of the projected energy production

[36] "Other users" refer to all water users except for the energy sector.

[37] The exact location of these facilities within the Tuul River Basin is not known.

Table 12: Summary of Energy Intensity of Selected Water Facilities in Mongolia

Water Facility	Energy Intensity (KWh/m^3)	Note
CHP-2	1.70	Based on CHP-4
CHP-3	1.70	Based on 2013 energy and water use
CHP-4	0.95	Based on 2013 energy and water use
CHP-5	0.95	Based on CHP-4
New coal-fired facilities	0.95	Based on CHP-4
Four main sources for UB water supply	0.30	Based on 2013 energy and water use
New water supply sources	0.30	Based on four main sources
Wastewater treatment facilities	0.37	Based on 2013 energy and water use
New wastewater treatment facilities	0.37	Based on existing waste treatment facilities

CHP = combined heat and power, kWh = kilowatt-hour, m^3 = cubic meter, UB = Ulaanbaatar.

Source: Based on estimates in Table 7, Calculation of Energy Intensity of Different Water Supply Facilities in Ulaanbaatar.

Table 13: Estimated Annual Energy Consumption of Selected Water Facilities in Mongolia

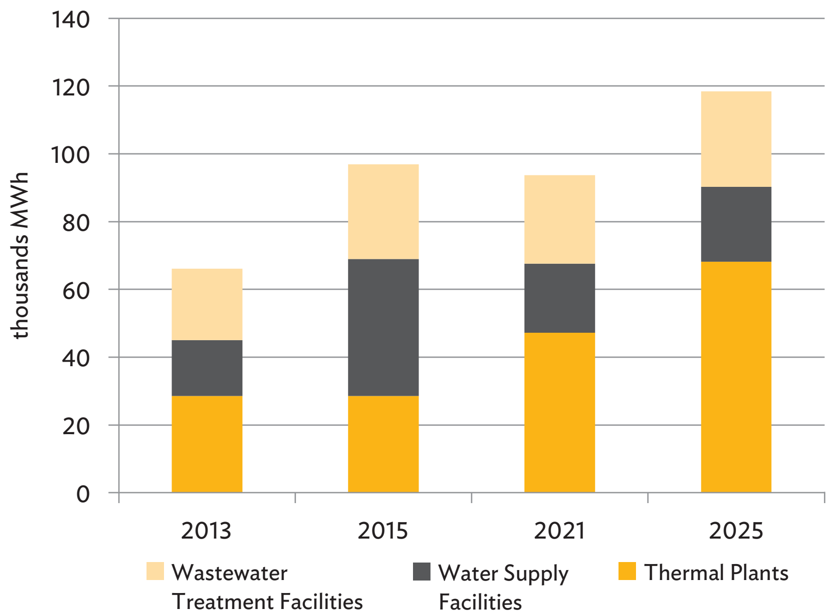
	Energy Consumed (MWh)			
Water Facility	2013	2015	2021	2025
CHP-2	4,622	4,622	4,622	4,622
CHP-3	14,306	14,280	14,280	14,280
CHP-4	9,630	9,633	9,633	9,633
CHP-5	n/a	n/a	4,661	11,652
New coal-fired facilities	n/a	n/a	13,982	27,964
Four main wells for UB water supply	16,498	16,498	16,498	16,498
New water supply sources	n/a	1,865	3,928	5,562
Wastewater treatment facilities	21,063	21,063	21,063	21,063
New wastewater treatment facilities	n/a	2,382	5,015	7,102
Total	**66,119**	**70,342**	**93,682**	**118,375**

CHP = combined heat and power, MWh = megawatt-hour, n/a = no data, UB = Ulaanbaatar.

Note: There may be slight discrepancies in the total due to rounding off.

Source: Energy consumption of water facilities was calculated based on projected water withdrawals and the energy intensities of the water facilities (Table 12).

Figure 9: Estimated Energy Consumption for Selected Water Facilities



MWh = megawatt-hour.

Source: Derived from estimates in Table 13, Estimated Annual Energy Consumption of Selected Water Facilities in Mongolia.

of the Central Energy System of 19.77 MWh for 2025. The energy needed to provide water for energy facilities is growing at a faster rate than the energy needed by the water facilities to provide for other uses (Figure 9).

E. Water Resource Management in the Tuul River Basin

The Tuul River Basin Authority, established in 2011, has three divisions: (i) water management and planning (11 staff); (ii) water consumption and coordination (5 staff); and (iii) information, monitoring and assessment (5 staff). The Division of Water Management and Planning is responsible for (i) integrated water resources management (IWRM) planning; (ii) provision of spatial information on water bodies; and (iii) socioeconomic development of the river basin. The Division of Water Consumption and Coordination is responsible for (i) conducting surveys of groundwater resources and consumption; (ii) establishing water facilities and distribution networks in the river basin; (iii) facilitating water consumption with respect to water facilities; and (iv) conducting surveys of surface water resources and consumption. The Division of Information Monitoring and Assessment in responsible for (i) conducting water quality monitoring, environmental analyses, and assessments; (ii) coordinating with water users on water tariffs; and (iii) collecting user fees.

The Tuul River Basin Council was established on 31 August 2010 based on Order A-268 of the Minister of Environment and Tourism.[38] The council has a director who organizes the council

[38] Strengthening Integrated Water Resources Management in Mongolia Project. http://iwrm.water.mn/index.php/mn/2011-11-08-08-13-33/2011-11-08-08-14-05/92-tuul-rbc

meetings, approves council decisions, and implements these decisions. The director represents the council in meetings with other councils, government organizations, nongovernment organizations, international organizations, and citizens. The council secretary manages all information and communication for the council. In addition to providing information to the council members, the secretary is responsible for dissemination, through the council's website, of information on natural conditions of the basin, natural resources, and protection of the basin. The council also has units for monitoring and inspection, and for training and awareness raising.

Khatan Tuul Program

The Government of Mongolia has approved a working plan for the Khatan Tuul program for the Tuul River Basin in June 2012.[39] The implementing agencies are the Ministry of Environment and Green Development; National Water Committee; Ministry of Roads, Transportation, Construction and Urban Development; and the governor of Ulaanbaatar.[40] The minister of environment and green development was charged to establish and appoint the director of the Tuul River Basin Authority.[41]

Within the program, the first measures will be taken to protect river headwaters, small rivers, and streams flowing into Tuul River. Also, a zone for the general protection of the Tuul River Basin and the pure water supply resources in Ulaanbaatar will be created, and, if needed, the basin will be taken under the state special protected area. All water purification plants in Ulaanbaatar along the Tuul River are to undergo technological innovations, and technical requirements of sewerage facilities will be satisfied in accordance with Mongolian standards. Plans have been made to stop the exploitation of such mineral resources as sand and gravel around the Tuul River, and to effectively complete the technical and biological rehabilitation works being implemented there.[42]

Tuul River Basin Integrated Water Management Plan

The objective of the *Tuul River Basin Integrated Water Management Plan* is to use water resources wisely, protect them from pollution and scarcity, and plan ecosystem balance issues in an integrated way to promote the well-being of the people.[43]

The strategic objectives of the plan are to

i. supply the population with safe drinking water, improve the treatment level of domestic wastewater, and improve sanitation;
ii. improve agricultural water supply;
iii. solve water supply and wastewater treatment of industry, mining, and energy;
iv. maintain river basin ecosystem balance; and
v. establish an effective institutional environment of river basin water management.

To achieve these objectives, the plan has a comprehensive set of activities to be implemented over the period to 2021. ADB is currently preparing the Tuul River Improvement Project ($20.0 million) to assist the Tuul River Basin Authority with the implementation of its IWRM plan. This project is expected to provide institutional strengthening of the basin and authority to help rehabilitate the Tuul River in the Ulaanbaatar area.

---

[39] Government of Mongolia. Decree of the Government of Mongolia No. 203. Khatan Tuul National Program.

[40] Footnote 39, section 3.

[41] Footnote 39, section 4.

[42] Footnote 39.

[43] MEGD. 2012. Chapter 7: Main Challenges and Strategic Objectives of the River Basin Water Management Plan. *Tuul River Basin Integrated Water Management Plan*. Ulaanbaatar. p. 206.

F. Implications

Future water consumption of energy facilities in the Tuul River Basin was estimated based on two scenarios from the 2013 update of the Mongolia Energy Sector Development Plan: (i) a low-electricity growth scenario, which increased generation capacity by 1,650 MW by 2025; and (ii) a high-electricity growth scenario, which increased generation capacity by 2,450 MW by 2025. Under both scenarios, total water consumption by all users increased (by 87% in the low scenario and 103% in the high scenario). It is of note that energy's share of total water consumption increased under both scenarios (from 25% to 34% under the low scenario and from 25% to 40% under the high scenario). While the estimation model used is simplified, this implies that water for energy production is increasing at a faster rate than water use for other economic sectors and drinking water. It may be that the amount of energy demand and use has been overestimated in the energy forecasts. However, this increased rate of consumption by the energy sector implies there is a strong need to examine the energy efficiency of households and use of energy throughout the economy. In addition, there is a need to reduce the water intensity of the planned generating facilities.

Will there be enough water? Based on the analysis of the *Tuul River Basin Integrated Water Management Plan*, Ulaanbaatar water demand will exceed its existing resources of 99 million m^3/year and will be facing water shortages as early as 2015 under the high water demand scenario. It will be forced to draw on additional groundwater sources, which have already been identified and approved for use. These additional sources, estimated to be 37.1 million m^3/year, will be adequate until 2021, when there will again be water shortages under the high water demand scenario. While additional groundwater sources may be available, there are also plans to build reservoirs upstream of Ulaanbaatar to supplement drinking water supply and reduce pressure on groundwater resources. However, the technical and economic feasibility as well as the environmental and social impacts of upstream reservoirs need careful study.

The other side of the water–energy nexus is the consumption of energy by water facilities. The energy intensity of water facilities, particularly the facilities needed to supply water for thermal electric cooling, is high by international standards. However, the energy intensity of the Ulaanbaatar water distribution system is within international norms. For the Tuul River Basin, the energy needs were estimated for the existing CHPs, new coal-fired facilities, the four main well fields in Ulaanbaatar, and wastewater treatment plants. The total energy needs by 2025 were estimated to be 118,375 MWh/year. This represents less than 1% of the total projected 2025 energy production of the Central Energy System. While this is a relatively small portion of the total energy use, efforts should be made to reduce the energy intensity of water facilities. Energy-efficient technologies should be adopted for pumping and transport of water.

One strategic objective of the *Tuul River Basin Integrated Water Management Plan* addresses the water–energy nexus directly: *to solve water supply and wastewater treatment of industry, mining, and energy.* To meet this objective, effort will be directed toward (i) resolving mining water supply problems by studying available water sources and development of tighter regulations; (ii) resolving the energy water supply problems, including investigating the technical and economic feasibility of the Tuul River upstream complex; (iii) resolving water supply for existing and soon-to-be constructed thermal plants, including introduction of water conservation technology; and (iv) examining possibilities for geothermal energy. While these options are a mix of supply-side options and water conservation measures for mining and energy production, additional demand-side management options should be considered.

IV. South Gobi: Meeting the Water and Energy Needs for Mining

The mining industry is rapidly emerging as the backbone and the leading sector of the country's economy. Large mines are developing and have started operations in the South Gobi Desert region along with planned value-adding industries that require the development of new water sources. Mines are the largest water consumer in the South Gobi region, and the water resource system is expected to support further mining developments while satisfying competing water demands from the mining–urbanization–herder nexus.[44]

The South Gobi region in southern Mongolia covers about 350,000 km^2 of three *aimags:* Dornogovi (East Gobi), Dundgovi (Middle Gobi), and Omnogovi (South Gobi). It is an area of extremely low rainfall, with surface water unavailable for most of the year. Water supply is almost solely from groundwater resources. While livestock raising historically has been the main economic activity, it has been replaced by mineral exploration and mine development. The increasing extraction of coal (in Tayan Tolgoi) and copper and gold (in Oyu Tolgoi) in Omnogovi *aimag* are integral to Mongolia's economic development, but are also expected to dramatically increase water use.

A. Existing Water Resource Availability

Most of the water resources in the South Gobi region are within the Galba-Uush Doloodin Gobi Basin, which covers territories of 15 *soums* of Umnogovi, Dornogovi, and Sukhbaatar *aimags* (Map 3). The renewable groundwater resources available in the Galba-Uush Doloodin Gobi Basin are estimated to be 236 million m^3/year.[45] However, due to high mineralization, the quality of groundwater is poor, below minimum drinking water standards in many locations.

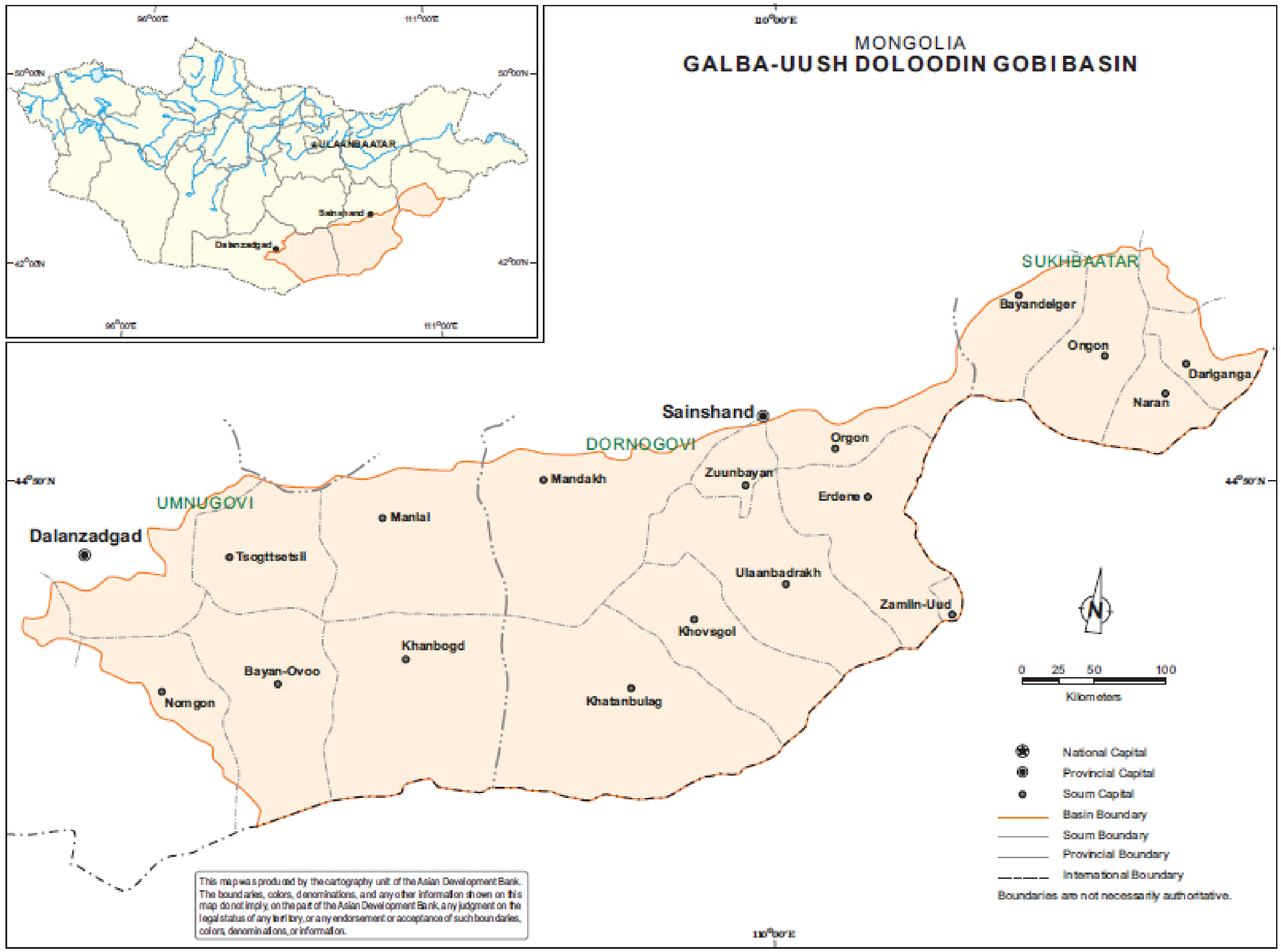
B. Existing Water Use in the Galba-Uush Doloodin Gobi Basin

The *Integrated Water Management National Assessment Report* (2012) provides estimates of water use for 2010 (Figure 10, Table 14). As of 2010, livestock (82%) was the major water user, along with mining (10%) and irrigation (5%). However, the projected water use for 2015 shows the large increase in the share of water use by the mining sector (84%). It should be noted that there is little urban development and industry. Currently, there are no energy facilities in the basin.

[44] 2030 Water Resources Group. 2014. *Targeted Analysis on Water Resources Management Issues in Mongolia*. Washington, DC.

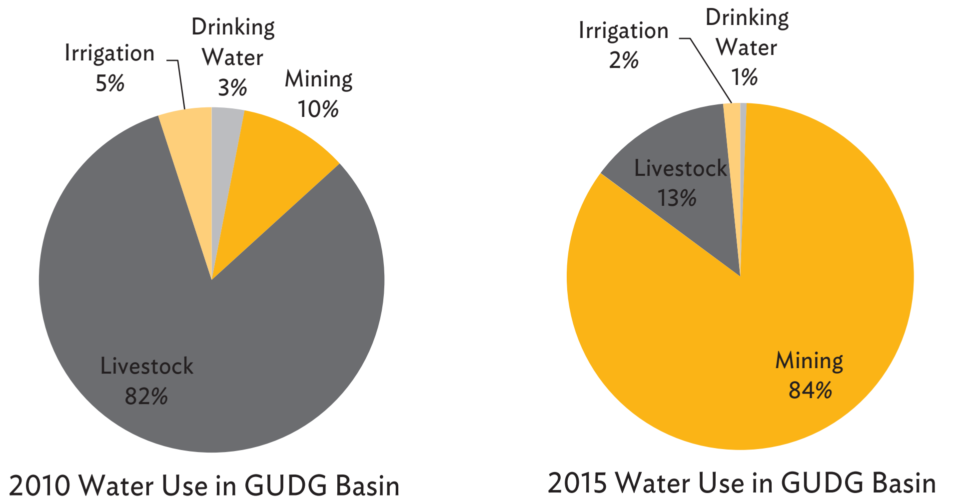
[45] MEGD. 2012. Part 4: Groundwater Resources Assessment. *Integrated Water Management National Assessment Report*. Volume 1. Ulaanbaatar.

Map 3: Galba-Uush Doloodin Gobi Basin in Mongolia



Source: ADB.

Figure 10: **Annual Water Use in the Galba-Uush Doloodin Gobi Basin, 2010 and 2015**



GUDG = Galba-Uush Doloodin Gobi.

Source: Derived from estimates in Table 14, Annual Water Use in the Galba-Uush Doloodin Gobi Basin, by Sector.

Table 14: **Annual Water Use in the Galba-Uush Doloodin Gobi Basin, by Sector**

Type of Use	2010 (m^3)	Projected 2015[a] (m^3)
Drinking water	152,394	187,000
Mining	509,540	26,747,000
Livestock	4,085,178	4,200,000
Irrigation	250,000	500,000
Total	**4,997,112**	**31,634,000**

m^3 = cubic meter.

[a] Based on the high development scenario.

Source: Government of Mongolia, Ministry of Environment and Green Development. 2012. Part 4: Groundwater Resources Assessment. *Integrated Water Management National Assessment Report*. Volume 1. Ulaanbaatar. Annexes 3 and 5.

C. The Water–Energy Nexus

This examination of the water–energy nexus will focus on the Galba-Uush Doloodin Gobi Basin. This provides a more localized view of water demand and supply. It better matches energy and mining facilities to potential water sources. The basic assumptions are as follows (Table 15):

i. The Oyu Tolgoi, Tavan Tolgoi, and other major mineral development will proceed as planned.

ii. The proposed 900-MW expansion of the South Gobi energy system by 2022 will proceed as planned. An additional 300 MW will be added by 2030. All of the additional capacity will come from the Tavan Tolgoi power plant, within Omnogovi *aimag*.

Table 15: Water Consumption Assumptions of Selected Power Plants and Mines in Mongolia

Facility	Water Intensity Unit	Water Intensity[a]
Coal-fired power stations at Tavan Tolgoi	m^3/MWh	2.500
Tavan Tolgoi (coal)	m^3/ton	0.600
Oyu Tolgoi mine (copper and gold)	m^3/ton	0.636
Nariin Sukhait/Ovoot Tolgoi (coal)	m^3/ton	0.600
Tsagaan Suvraga (copper)	m^3/ton	0.600
Energy Resource LLC (coal)	m^3/ton	0.247[b]

m^3 = cubic meter, MWh = megawatt-hour.

[a] Water intensity data for coal-fired stations is based on estimates for an existing combined heating and power plant (CHP-4). Water intensity figures for Tavan Tolgoi, Oyu Tolgoi, and Nariin Skhait/Ovoot Tolgoi are based on World Bank. 2010. Mongolia: Groundwater Assessment of the Southern Gobi Region. Washington, DC.

[b] Based on the mining company's (i.e., Energy Resource LLC) 2013 estimates of coal production (9.7 million tons) and water use (2.4 million m^3).

iii. Water use for sectors other than energy and mining will be based on estimates provided in the *Integrated Water Management National Assessment Report*, Volume 1, by the Ministry of Environment and Green Development (2012).

iv. Energy use for the provision of water to support all users will be estimated based on water consumption.

Water Use by Mining

The three main mining areas in the Galba-Uush Doloodin Gobi Basin are (i) Tsagaan Suvraga (copper) in Dornogovi; (ii) Oyu Tolgoi (copper and gold) in Omnigovi; and (iii) the coal mines in the area around Dalanzadgad (Tavan Tolgoi, Ovoot Tolgoi, Nariin Sukhait). The mines either abstract groundwater for mining operations and/or pump shallow groundwater to dewater the mines. The mining industry needs water for their operations; however, the new towns and new industries that grow around the mining sites also need water. The existing towns and settlements in the area and the nomadic herders generally use shallow groundwater for drinking water and livestock water supply.

Table 16 presents estimates of 2013 water consumption of the major mining operations. Maximum water consumption is calculated as the maximum production multiplied by the water intensity. Mining water use is expected to increase from about 40.4 million m^3/year in 2015 to 82.9 million m^3/year by 2025 (Table 17, Figure 11).

Proposed Expansion of the South Gobi Energy System

The South Gobi Energy System currently relies mainly on diesel generation and off-grid solar photovoltaic power.[46] There are major coal fields with capacity to support large coal-fired power generation plants. The current energy is supplied by the 5.4 MW plant at Dalanzadgad.

[46] This section is excerpted from ADB. 2013. *Updating the Energy Sector Development Plan: South Small Energy Region Expansion Plan.* Final report. Manila (TA 7619-MON).

Table 16: Production and Water Consumption of Major Mines in Mongolia

		2013 (actual)		Projected Maximum (2025)	
Mines	Mineral	Production (tons/year)	Water Consumption[a] (m^3/year)	Production (tons/year)	Water Consumption (m^3/year)
Tavan Tolgoi	coal	n/a	468,595	40 million	24.0 million
Nariin Sukhait	coal	3,580[b]	27,735	75,000[c]	12.0 million
Ovoot Tolgoi	coal	3,060,000[d]	n/a	15 million	n/a
Oyu Tolgoi	copper, gold	n/a	9,476,548	40 million	25.6 million
Tsagaan Suvraga	copper	n/a	n/a	n/a	11.7 million[e]

m^3 = cubic meter, n/a = no data.

[a] Data from water resource division of the Ministry of Environment and Green Development (2013).
[b] Mineral Resource Authority. 2013. *Statistics of Mining: Monthly Report (December-2013)*. Ulaanbaatar. p. 22.
[c] Mineral Resource Authority. www.mram.gov.mn/index.php?option=com_content&view=article&id=393%3A2013-05-22-06-09-08&catid=18%3Anews&Itemid=37&lang=mn
[d] Market Wired. 2014. *South Gobi Resources Announces Select 2013 Operating Results.* 16 January. www.marketwired.com/press-release/southgobi-resources-announces-select-2013-operating-results-tsx-sgq-1869678.htm
[e] World Bank. 2010. *Mongolia: Groundwater Assessment of the Southern Gobi Region*. Washington, DC.

Table 17: Projected Annual Water Use of Mines in Mongolia (cubic meters per year)

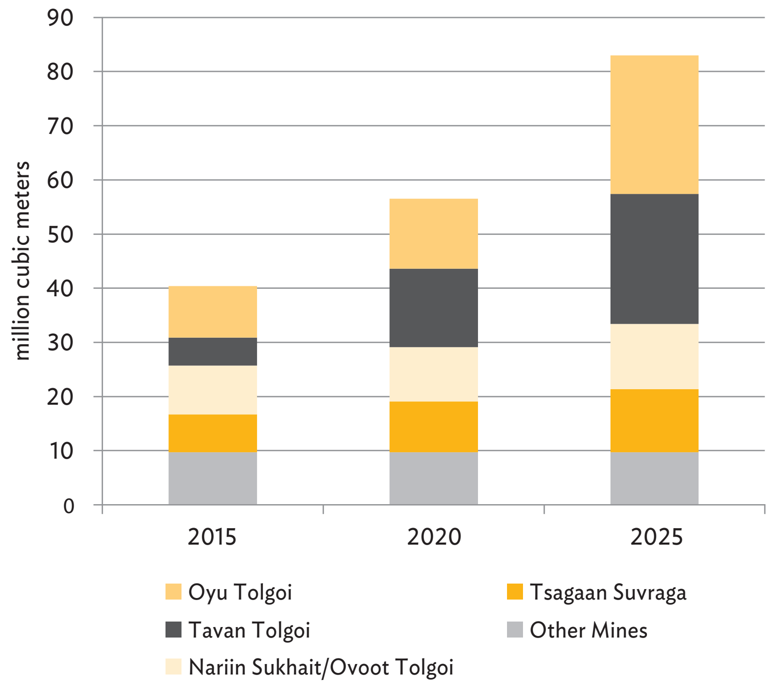
Year	Other Mines	Tsagaan Suvraga	Nariin Sukhait/ Ovoot Tolgoi	Tavan Tolgoi	Oyu Tolgoi	Total
2015	9,700,000[a]	7,000,000[b]	9,000,000[c]	5,200,000[b]	9,500,000[b]	**40,400,000**
2020	9,700,000[a]	9,400,000[b]	10,000,000[d]	14,500,000[b]	12,900,000[b]	**56,500,000**
2025	9,700,000[a]	11,700,000[b]	12,000,000[e]	24,000,000[e]	25,555,000[b]	**82,955,000**

[a] Energy Resource Coal Mine plus estimates for other mines in World Bank. 2010. Mongolia: *Groundwater Assessment of the Southern Gobi Region*. Washington, DC.
[b] 2030 Water Resources Group. 2014. *Targeted Analysis on Water Resources Management Issues in Mongolia*. Washington, DC.
[c] World Bank. 2010. *Mongolia: Groundwater Assessment of the Southern Gobi Region*. Washington, DC.
[d] Estimate interpolated between 2015 and 2025 water use values.
[e] Assumed maximum water consumption reached in 2025 based on Table 16, Production and Water Consumption of Major Mines in Mongolia.

New demand for electricity will be driven by the needs of the Oyu Tolgoi, Tavan Tolgoi, and other mines. The demand is expected to increase to more than 300 MW by 2015; 800 MW by 2018; 1,000 MW by 2020; and 1,300 MW by 2025.

The power will be provided by a mine-mouth coal-fired power plant at Tavan Tolgoi. This plant will be fueled by the coal middlings produced by the Tavan Tolgoi coking coal mining operation, which would otherwise be buried as overburden. The proposed plant will potentially develop to around 1,200 MW. There will be excess electricity to economically supply the local area, including other smaller mines. It is understood that enough coal middlings are available from the Tavan Tolgoi site to easily support generation of 1,200 MW.

Figure 11: Projected Annual Water Use of Mines in Mongolia



Source: Derived from estimates in Table 17, Projected Annual Water Use of Mines in Mongolia.

The timing of adding power plant units will be determined by the development schedule of Oyu Tolgoi and Tavan Tolgoi. In 2011, both mine owners were planning to build power plants, but they subsequently decided to develop a single power plant complex at Tavan Tolgoi. Mining electricity needs are expected to reach 900 MW by 2025 with potential for ultimate expansion to 1,200 MW. Mine development and power plant needs are related to the commodity markets, which affect the prices and demand for minerals. In this regard, it is not possible to be specific regarding the exact timing of power plant development. Nevertheless, an indicative schedule is shown in Appendix 2. The timing of transmission line development is also shown. The estimated water use is provided in Table 18.

Water Use by Other Users

Water use by users other than mines (based on the estimates in Table 19) is expected to increase from 4.9 million m^3 in 2015 to 5.2 million m^3 by 2021. This analysis assumes that total water use by other users will increase at a similar rate to 2025, reaching 5.6 million m^3.

Water Use Projections

Water use is projected to reach over 108.2 million m^3 in 2025 (Table 20), driven primarily by water consumption for mining from 2015 to 2025 and by the needs of the coal-fired power plant expansion during the period 2015–2025 (Figure 12).

Table 18: Projected Annual Water Use by Energy Facilities in Mongolia

Year	Capacity[a] (MW)	Energy Production[b] (MWh)	Water Intensity[c] (l/MWh)	Water Consumption (m^3)
2021	600	5,256,000	2,500	13,140,150
2025	900	7,884,480	2,500	19,770,150

l/MWh = liter consumed per megawatt-hour, m^3 = cubic meter, MW = megawatt.

[a] Capacity based on the South Gobi expansion scenario (Appendix 2).

[b] Energy production assuming year-round operation.

[c] Water intensity is assumed to be similar to other coal-fired thermal generating plants.

Table 19: Projected Annual Water Use by Other Users in the Galba-Uush Doloodin Gobi Basin (cubic meters)

Use	2010	2015[a]	2021[a]	2025
Drinking Water	152,394	187,000	314,000	n/a
Livestock	4,085,178	4,200,000	4,000,000	n/a
Irrigation	250,000	500,000	900,000	n/a
Total	**4,487,572**	**4,887,000**	**5,214,000**	**5,578,980**

n/a = no data.

[a] Based on the high development scenario.

Source: Government of Mongolia, Ministry of Environment and Green Development. 2012. Part 4: Groundwater Resources Assessment. *Integrated Water Management National Assessment Report.* Volume 1. Ulaanbaatar. Annexes 3 and 5.

Table 20: Projected Total Annual Water Use in the Galba-Uush Doloodin Gobi Basin (cubic meters)

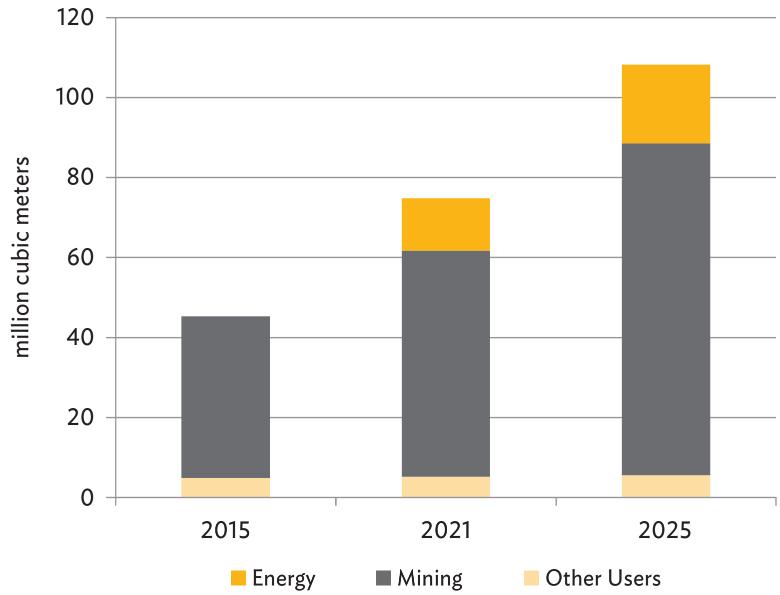
Year	Other Users	Mining	Energy	Total
2015	4,887,000	40,400,000	0	**45,287,000**
2021	5,214,000	56,500,000	13,140,150	**74,854,150**
2025	5,578,980	82,955,000	19,710,150	**108,244,130**

Source: Compilation of Tables 17, 18, and 19.

While there may be sufficient groundwater resources to meet future needs, there are also plans to transport water from the river basins in northern Mongolia.[47] The proposed Kherlen–Gobi pipeline will convey 1,500 liters per second (l/sec) from the Kherlen River through a 540-kilometer (km) long pipeline to Shivee Ovoo, Sainshand, and Zamin-Udd, with a side branch to Tsagaan Suvraga. The proposed Orkhon–Gobi pipeline will pump 2,500 l/sec from the Orkhon River through a 740-km long pipeline to Tavan Tolgoi and Oyo Tolgoi, with side branches to Mandalgobl and Dalanzadgad.

[47] World Bank. 2010. *Mongolia: Groundwater Assessment of the Southern Gobi Region*. Washington, DC.

Figure 12: **Projected Annual Water Use for Energy, Mining, and Other Users in the Galba-Uush Doloodin Gobi Basin**



Source: Derived from Table 20, Projected Total Annual Water Use in the Galba-Uush Doloodin Gobi Basin.

Energy Use by Water Facilities

The facilities needed to supply water to the mining and energy operations will require energy for pumping, transport, and disposal of wastewater. The estimated energy needed is 108,244 MWh per year (Table 21). This is approximately 1.3% of the 2025 annual energy production of the proposed Tavan Tolgoi facility. However, the estimates of energy intensity may be low. For example, the Oyu Tolgoi mine uses a 50-km pipeline to bring water to the mine.

D. Water Management in South Gobi

The Galba-Uush Doloodin Gobi River Basin Authority was formally established in October 2013 and began operation in January 2014. It currently has 12 employees, and its structure and responsibilities are similar to those of the Tuul River Basin Authority. However, the emphasis will be on groundwater management as there is little surface water in the Galba-Uush Doloodin Gobi River Basin. As yet, the basin council has not been established.

River basin management is being strengthened through a technical assistance program ($3.23 million) being provided by the Australian Aid and World Bank to develop capacities of the public bodies in groundwater resources management. One water basin council will be established. Water basin authorities will be established in the three *aimags* of Dornogovi, Dundgovi, and Omnigovi. A small groundwater management information unit will be created for coordination of activities. The water basin council will act as a coordinating body through which all relevant stakeholders will be represented to voice and protect their interests in groundwater management.

Table 21: Estimates of Energy Consumption for Water Withdrawals in the Galba-Uush Doloodin Gobi Basin, 2025

Facility	Energy Intensity[a] (kWh/m^3)	Water Consumption[b] (m^3)	Energy (MWh)
Tavan Tolgoi coal fired power plan	1.0	19,710,150	19,710
Tavan Tolgoi (coal)	1.0	24,000,000	24,000
Oyu Tolgoi Mine (copper and gold)	1.0	25,555,000	25,555
Nariin Sukhait/Ovoot Tolgoi (coal)	1.0	12,000,000	12,000
Tsagaan Suvraga (copper)	1.0	11,700,000	11,700
Other Mines	1.0	9,700,000	9,700
Other Uses	1.0	5,578,980	5,579
Total			**108,244**

kWh = kilowatt-hour, m^3 = cubic meter, MWh = megawatt-hour.

[a] Energy intensities are crude estimates. Estimates for Tavan Tolgoi are in line with estimates for existing thermal power stations in Mongolia.

[b] Water use estimates for Tavan Tolgoi and for mines are from Table 18, Projected Annual Water Use by Energy Facilities in Mongolia. Water use from other uses is from Table 19, Projected Annual Water Use by Other Users in the Galba-Uush Doloodin Gobi Basin.

E. Implications

Future water consumption will be driven by energy and mining facilities in South Gobi. Water consumption was estimated to 2025 for Tavan Tolgoi and Oyu Tolgoi as well as for other large mines in the region. It was assumed that 900 MW of generating capacity will be added to the South Gobi Energy System by 2025 to meet the demands of the mining operations and local communities. Mining will be the dominant user of water (83 million m^3/year) by 2025. Energy becomes a major water user by 2020 as the coal-fired power station comes on line, and by 2025, will use 19.9 million m^3 /year of water.

Will there be enough water? In the Galba-Uush Doloodin Gobi Basin, it is estimated that there are 236 million m^3/year of renewable groundwater resources available. Exploitable groundwater resources are estimated to be 352 million m^3/year.[48] The Galba-Uush Doloodin Gobi Basin is one of four basins in southern Mongolia with high water scarcity where the *Integrated Water Management National Assessment Report* (2012) has included nonrenewable resources in the estimate of total exploitable resources. Based on estimates of water consumption of approximately 108.2 million m^3/year to 2025, there appears to be no immediate water shortage in the aggregate. However, there is a concern that pumping of groundwater from deep aquifers will depress the water table and reduce shallow groundwater resources available to herders and irrigation systems, which will increase water use conflicts. There is a concern that dewatering of mine sites and the lowering of the water table may have negative impacts on vegetation and wildlife habitat, and may lead to desertification.[49]

[48] MEGD. 2012. Part 4: Groundwater Resources Assessment. *Integrated Water Management National Assessment Report*. Volume 1. Ulaanbaatar.

[49] MEGD. 2012. Part 3: Water Quality and Ecological Assessment. *Integrated Water Management National Assessment Report.* Volume 1. Ulaanbaatar.

While there may be enough groundwater to at least 2025, there are plans to supplement water supply with surface water diversions from the Orkhon River and the Kherlen River. The Orkhon–Gobi water transfer project is planned to supply water to mines from the Orkhon River to South Gobi through a pipeline that is more than 740 km long.[50] While this may be a long-term solution to deal with water scarcity in South Gobi, such projects need to be carefully assessed with respect to the hydrological and environmental impacts as well as their potential investment and high operational costs.

In South Gobi, the energy needs for water supply were estimated for the Tavan Tolgoi coal-fired power plant and major mines. The total energy requirement by 2025 was estimated to be 108,244 MWh/year, which is approximately 1.3% the projected 2025 annual energy production of the proposed Tavan Tolgoi power station. While this a relatively small portion of the total energy use, efforts should be made to reduce the water intensity of both mining and energy production. Energy-efficient technologies should be adopted for pumping and transport of water.

[50] Footnote 44.

V. Challenges and Recommendations

A. Challenges

This examination of the water–energy nexus at the national level and in two river basins reveals the challenges that Mongolia is facing.

Development of New Energy Facilities and Mining Operations in Water-Scarce Areas. The Tuul River Basin, the water resource base for the capital Ulaanbaatar, is expected to be the location for an additional 1,650 MW of coal-fired generating capacity by 2025 for the Central Energy System. The energy is needed to power the continual growth of Ulaanbaatar and other densely populated areas. Yet the new facilities will compete with other major water users for scarce water in the basin. The South Gobi energy system is expected to add up to 1,200 MW of coal-fired generating capacity to power the major mining operations in the region. The new energy facilities and mining operations are expected to further exacerbate conflicts with local communities and traditional herders in the Galba-Uush Doloodin Gobi Basin.

Mismatch between energy and water institutions. Where water resource management has been decentralized to the river basin level, energy sector planning and management is highly centralized. The government's energy vision is one of increased energy security through an integrated transmission network for all of Mongolia. Under this vision, electrical energy would be cost-efficiently allocated throughout the country. The vision for water management is more decentralized, where all users participate in decision making on the management and protection of water resources and the environment. This creates a mismatch in both the scale for planning and management (national for energy versus river basin for water) and institutional clout (national Ministry of Energy and Mineral Resources versus newly created river basin authorities, river basin councils, and *aimag* and *soum* administrations).

Overcoming Energy Inefficiency. The government is currently planning to increase energy supply through new electricity generation and heating plants. However, the Mongolian energy sector has not made the transition to the green economy. At the commercial, industrial, and household levels, energy consumption remains highly inefficient. Demand side management has been limited, but some progress has been made. For example, the GIZ assisted the government through a project on insulation of old apartments to decrease the energy loss. It is also encouraging that the government is planning to renovate old buildings to improve insulation.

Water management organizations. The water management organizations have been established based on the new Water Law (2012). However, the newly established organizations are facing challenges. These include (i) the need for strengthened stakeholder coordination through river basin councils; (ii) the need for better monitoring, research, data collection, and information management, which are now highly dispersed and poorly managed; (iii) the need for more financial resources and facilities for effective execution of water management; and (iv) the need for more and better-trained personnel in water management organizations. There is also a critical need for more effective governmental coordination on water resources at all levels.

Weak economic instruments. Water user fees, water service charges, and wastewater fees have been included in the Water Law (2012). However, the setting of fees and charges for use of water resources is based on a complex, less than transparent, and probably outdated methodology.[51] Not all of the new economic instruments have been implemented, including pollution fees. In addition, those instruments that have been implemented are poorly enforced, and there is a lack of monitoring.

B. Recommendations

The following recommendations provide some general guidance for the national government to consider in decisions that relate to water, energy, and mining, which are inextricably linked.

Integrate water resource considerations into decisions on energy and mining development. The new Water Law (2012) states that water is the strategic resource. There is a clear need to increase the strategic consideration of water resource issues in energy and mining development decision making. For example, the recently completed update to the Energy Sector Development Plan should be subjected to a strategic environmental assessment, which would examine the potential environmental and social impacts of the proposed expansion and integration of the energy systems in Mongolia. In this context, the assessment should examine the availability of water resources and the impacts on competing water resource users. In addition, current programs and plans for mineral development should undergo a strategic environmental assessment under the new Mongolia Environmental Impact Assessment Law.

Support green procurement for water and energy technologies. The Parliament of Mongolia ratified a green development policy of Mongolia in 2014. Under this policy, 2% of gross domestic product will be targeted for green procurement in the water and energy sectors to develop greener technologies. These funds should be targeted on increasing energy efficiency at the industrial and household levels. To increase the sustainability of water supply, new and innovative projects for rainwater collection and recycling of wastewater should be developed.

Reduce the water intensity of energy production. Mongolia's existing thermal power stations are inefficient in their use of water. Recent data on water use show that the water intensities of existing thermal plants are seven (CHP-2) and five (CHP-3) times the international norm.[52] Only CHP-4 is satisfactory, with water intensity of energy of 1.1 times the international norm. It is recommended that all new facilities be designed to minimize water use and apply cooling technologies and international good practices. In addition, energy-efficient technologies for water use and energy efficiency good practices should be adopted. It is also necessary to introduce environmentally friendly methods such as renewable energy (e.g., wind, solar) to reduce the water intensity of energy production.

Get the economic incentives right. The polluter pay principle, which was ratified in 2013, is guiding the development of standard approaches for setting fees and charges. This is expected to lead to efficient use of water resources and re-use of wastewater. This is an opportune time to improve the water payment system (i.e., water use fees, water service charges, pollution fees, and discharge fees) for water use by the energy and mining sectors. The target analysis by 2030 Water Resources Group (2014) recommended drafting a transparent incentive structure that can be clearly communicated to the public.[53] They recommended that the initial focus should be

[51] Footnote 44.

[52] The median value for generic coal tower closed-loop cooling systems is 2,600 l/MWh.

[53] Footnote 44.

on urban households and mining. However, it is equally important to focus on the energy sector, as it currently has unacceptable levels of water intensity.

Strengthen water management institutions. The newly formed water management organizations need to be strengthened so that they can fulfill their mandates under the new Water Law (2012). Better facilities, trained staff, financing, and support systems are needed for river basin authorities and river basin councils. Water databases need to be developed, and scientific understanding of water resources in Mongolia needs to be improved. South–South cooperation should be undertaken to promote exchange of information on water management practices with other countries. This is already being addressed in the Tuul River Basin through the proposed ADB-funded Tuul River Improvement Project ($20 million). In South Gobi, institutions are being strengthened through a $3.23 million project funded by the World Bank and Australian Aid to strengthen groundwater management.

Appendix 1

Review of Literature

A number of international studies on the water–energy nexus were reviewed to put Mongolia in context. The *United Nations World Water Development Report 2014 on Water and Energy* provided the global context for the water–energy nexus. In *Considering the Energy, Water and Food Nexus: Towards an Integrated Modelling Approach*, Morgan Bazilian et al. (2011) provided the conceptual model for the water–energy–food nexus. Macknick et al. (2012), in *Operational Water Consumption and Withdrawal Factors for Electricity Generating Technology*, provided estimates of water consumption for the thermal coal-fired plants. The Mielke et al. (2010) report, *Water Consumption of Energy Resource Extraction, Processing, and Conversion*, provided estimates for coal mining and thermal coal-fired plants. "Water for Energy," an excerpt from *World Energy Outlook 2012,* provided estimates on water consumption for energy facilities and mining operations. The Cooley and Robert Wilkinson (2012) report, *Implications of Future Water Supply Sources for Energy Demands,* provided estimate of energy use for facilities needed to extract, transport, distribute, and treat water.

In addition, recent relevant energy and water studies on Mongolia were examined. The *Integrated Water Management National Assessment Report* and the *Tuul River Basin Integrated Water Management Plan*, produced in 2012 by the Ministry of Environment and Green Development (MEGD), were invaluable in the estimation and assessment of existing surface water and groundwater availability. They also provided the projections of future water demand of water users in sectors other than mining and energy. The study *Urban Water Vulnerability to Climate Change in Mongolia,* produced in 2011 by the Water Authority of the Government of Mongolia, provided the basis for analysis of the impacts of climate change on availability of existing surface water and groundwater. The 2013 update of the Mongolia Energy Sector Development Plan, produced under ADB technical assistance, was the source for the identification of energy development scenarios. The 2030 Water Resources Group (2014) report, *Targeted Analysis on Water Resources Management Issues in Mongolia*, corroborated the estimates of water availability and water use and helped frame the key issues in the Tuul River Basin and the Galba-Uush Doloodin Gobi River Basin.

Appendix 2

Energy Scenario Factors

Scenario Plan 1a: CHP Reference Plan—Low-Electricity Growth

Thermal Power and Heating Plants				
Year	Energy Region	Facility	Facility Type	Capacity (MW)
2014	CES	CHP-2 (Existing)	Combined Heating—Coal	21.5
2014	CES	CHP-3 (Existing)	Combined Heating—Coal	138
2014	CES	CHP-4 (Existing)	Combined Heating—Coal	560
2014	CES	Darkhan TPP (Existing)	n/a	48
2014	CES	Erdenet TPP (Existing)	n/a	28.8
2016	CES	Existing Upgrades	Combined Heating—Coal	82.7
2014	CES	Amgalan	HOB—Coal (300 Gcal)	300[a]
2018	CES	CHP-5 (1 and 2)	Combined Heating—Coal	300
2018	CES	300-MW Coal Plant	Generation—Coal	300
2019	CES	150-MW Coal Plant	Generation—Coal	150
2021	CES	CHP-5 (3)	Combined Heating—Coal	150
2022	CES	150-MW Coal Plant	Generation—Coal	150
2023	CES	CHP-5 (4)	Combined Heating—Coal	150
2024	CES	150-MW Coal Plant	Generation—Coal	150
2025	CES	CHP-5 (5)	Combined Heating—Coal	150
2025	CES	150-MW Coal Plant	Generation—Coal	150
Total Thermal Power (MW)				2,529
2014	CES	50-MW Wind	Wind	50
Total Renewable Energy (MW)				50

CES = Central Energy System, CHP = combined heat and power, Gcal = gigacalorie, HOB = heat-only boiler, MW = megawatt, n/a = no data, TPP = thermal power plant.

[a] Not included in MW calculation; unit in Gcal.

Source: ADB. 2013. *Updating the Energy Sector Development Plan: CES Supply Expansion Plan*. Final report. Manila (TA 7619-MON).

Scenario Plan 1c: CHP Reference Plan—High-Electricity Growth

Thermal Power and Heating Plants				
Year	Energy Region	Facility	Facility Type	Capacity (MW)
2014	CES	CHP-2 (Existing)	Combined Heating—Coal	21.5
2014	CES	CHP-3 (Existing)	Combined Heating—Coal	138
2014	CES	CHP-4 (Existing)	Combined Heating—Coal	560
2014	CES	Darkhan TPP (Existing)	n/a	48
2014	CES	Erdenet TPP (Existing)	n/a	28.8
2014	CES	Amgalan	HOB—Coal (300 Gcal)	300[a]
2016	CES	Existing Upgrades	Combined Heating—Coal	82.7
2018	CES	CHP-5 (1 and 2)	Combined Heating—Coal	300
2018	CES	300-MW Coal Plant	Generation—Coal	600
2019	CES	150-MW Coal Plant	Generation—Coal	150
2020	CES	150-MW Coal Plant	Generation—Coal	150
2021	CES	CHP-5 (3)	Combined Heating—Coal	300
2022	CES	150-MW Coal Plant	Generation—Coal	150
2023	CES	CHP-5 (4)	Combined Heating—Coal	150
2022	CES	150-MW Coal Plant	Generation—Coal	150
2024	CES	150-MW Coal Plant	Generation—Coal	300
2025	CES	CHP-5 (5)	Combined Heating—Coal	150
2025	CES	150-MW Coal Plant	Generation—Coal	150
Total Thermal Power (MW)				3,429
2014	CES	50-MW Wind	Wind	50
Total Renewable Energy (MW)				50

CES = Central Energy System, CHP = combined heat and power, Gcal = gigacalorie, HOB = heat-only boiler, MW = megawatt, n/a = no data, TPP = thermal power plant.

[a] Not included in MW calculation; unit in Gcal.

Source: ADB. 2013. *Updating the Energy Sector Development Plan: CES Supply Expansion Plan*. Final report. Manila (TA 7619-MON).

Proposed Expansion of the South Gobi Energy System

Facility	Capacity	Year
Generating:		
Tavan Tolgoi unit nos. 1–3	450 MW	2018
Tavan Tolgoi unit no. 4	150 MW	2020
Tavan Tolgoi unit no. 5	150 MW	2022
Tavan Tolgoi unit no. 6	150 MW	2024
Tavan Tolgoi unit no. 7	150 MW	2026
Tavan Tolgoi unit no. 8	150 MW	2028
Transmission:		
Tavan Tolgoi–Oyu Tolgoi 220-kV	25 MW	2016
Tavan Tolgoi–Dalanzadgad–Nariin Suhkait 110-kV line	50–100 MW	2018

kV = kilovolt, MW = megawatt.

Source: ADB. 2013. *Updating the Energy Sector Development Plan: South Small Energy Region Expansion Plan*. Final report. Manila (TA 7619-MON).

Appendix 3

Responsibilities and Authorities of River Basin Authorities and River Basin Councils

1. River Basin Authorities

The Mongolian Water Law (2012) assigns the following responsibilities to river basin authorities:

i. to develop draft river basin management plans;
ii. to provide cross-sector and stakeholder coordination at different levels that is needed for effective implementation of the river basin management plan and to monitor its implementation;
iii. to provide local governors and local parliaments at the various levels with professional guidance and support;
iv. to annually organize a surface water inventory within the river basin in close cooperation with the local administration and to report the outcome to the water authority;
v. to operate and maintain a river basin database and to disseminate required information to the public;
vi. to process and prepare technical assessments for drilling requests for groundwater wells and for construction of drainage systems from individual citizens and economic entities for forwarding to the competent authorities. Assessments are to be made in the context of the river basin development plan, and the basin database requires updating accordingly;
vii. to prepare charges for water use fees and pollution fees, based on the law;
viii. to determine the locations for water supply abstraction and for disposal of wastewater within the river basin;
ix. to prepare technical recommendations for cancellation of licenses for water use and/or disposal of wastewater from citizens and economic entities who violate the legal requirements for water use and disposal of wastewater;
x. to continuously monitor the total available water resources for use as well as the water use within the basin;
xi. in close cooperation with the local administrations, prepare proposals for establishing a river basin council and to submit it to the water authority; and
xii. to estimate the needs for local protection of rivers, lakes, and groundwater deposits in the basin.

2. River Basin Councils

The Mongolian Water Law (2012) states that the river basin council will be established under the water basin authority. The main responsibilities of river basin councils are

i. to ensure decisions regarding the appropriate use and protection of water resources are taking into account the citizens‘ comments and opinions;

ii. to comment on all major development plans that have an effect on water such as mining, water use and storage, dam construction, drainage systems, etc.;
iii. to monitor and control the implementation of the river basin management plan by the river basin authorities and initiate procedures at competent offices to eliminate unlawful activities;
iv. to monitor implementation of water users' obligations regarding water restoration in accordance with the water use contract and the environmental impact assessment;
v. to monitor performance of a regime for special and ordinary protection and sanitary zones;
vi. to participate in organizing protection and afforestation activities of water sources supported or initiated by citizens or professional organizations;
vii. to recommend cancellation of a project or design for constructing water infrastructure when authoritative evaluations report adverse impacts on water resources; and
viii. to recommend to competent officials and organizations the withdrawal of authorizations for water use issued by the river basin authority.

3. Composition of River Basin Councils.

The Water Law (2012) states that river basin councils shall consist of members representing local administration, the environment department, professional inspection agency, nongovernment organizations, *soum* and district citizens, water users, scientists, researchers, and professional organizations related to water issues.

Demand in the Desert: Mongolia's Water–Energy–Mining Nexus

Mongolia's mining-based economic development and the sustainability of its urban economies depend on both water and energy. The examination of the water–energy nexus in two river basins in Mongolia shows that water availability is the binding constraint as energy facilities, mining operations, agriculture, and urban water users compete for scarce water resources. Development of new technologies for efficient water and energy use, introduction of renewable energy options, and water demand management through economic instruments are recommended. However, achieving greater water security requires integration of water resource considerations into energy and mining development decision making, while strengthening the capacity of newly formed river basin organizations.

About the Asian Development Bank

ADB's vision is an Asia and Pacific region free of poverty. Its mission is to help its developing member countries reduce poverty and improve the quality of life of their people. Despite the region's many successes, it remains home to approximately two-thirds of the world's poor: 1.6 billion people who live on less than $2 a day, with 733 million struggling on less than $1.25 a day. ADB is committed to reducing poverty through inclusive economic growth, environmentally sustainable growth, and regional integration.

Based in Manila, ADB is owned by 67 members, including 48 from the region. Its main instruments for helping its developing member countries are policy dialogue, loans, equity investments, guarantees, grants, and technical assistance.

ADB

ASIAN DEVELOPMENT BANK
6 ADB Avenue, Mandaluyong City
1550 Metro Manila, Philippines
www.adb.org