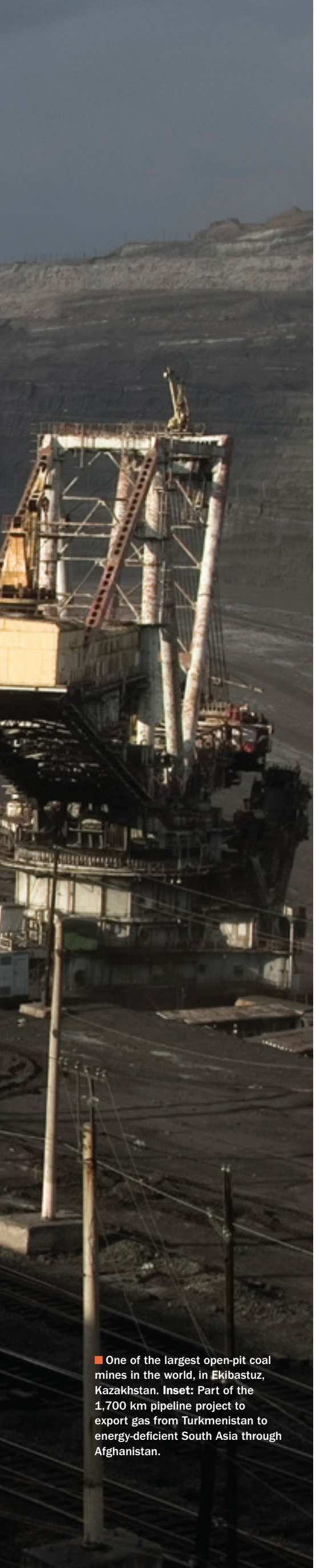
Energy Resources

Enormous Development Potential



Thanks to the immensity of its known energy reserves, potential for discovering more, and midpoint position between Europe and energy-hungry East Asia, Central Asia is on the threshold of exciting energy opportunities. Reserves of hydrocarbons, especially gas, are vast. Hydropower capacity and deposits of coal and uranium are additional sources. Excellent wind regimes make the region one of the world's best in wind power potential, while the abundant sunshine offers prospects for large-scale conventional and thermal solar power. Together, these resources could ensure self-sufficiency and help make the region an important market for trading, transport, and sales of energy far into the future.

Export potential is especially great close to home, where Asia's developing nations are experiencing the fastest industrial and energy growth rates in history. Kazakhstan, Turkmenistan, and Uzbekistan already export oil and natural gas via pipeline and as liquefied natural gas. The Kyrgyz Republic and Tajikistan hold significant hydropower resources that could be tapped to market electricity for Afghanistan, the People's Republic of China, Iran, Pakistan, and the Russian Federation. Kazakhstan is a world leader in coal production, and Kazakhstan and Uzbekistan are among the top 10 nations in known uranium reserves.

Each Central Asian country is actively developing its energy capacity and export capabilities. Energy security and expansion of energy resources are being pursued. Key to achieving these are investment in hydropower generating capacity, development of new oil and gas fields, rehabilitation of existing infrastructure, increases in petrochemical production, and regional cooperation. Plans are also being made to secure transport access for resources and expand pipeline networks and electricity grids to nations outside the region. Success in this process will be an important first step in reaching global markets, and attracting the kinds of foreign investment required to build the region's energy industry.

Energy Potential of Central Asian Countries

	Kazakhstan	Kyrgyz Republic	Tajikistan	Turkmenistan	Uzbekistan	Total	Share of Central Asia in World Reserves %
Oil,[a] billion barrels	30.000	0.040	0.012	0.600	0.594	31.246	2.37
Natural gas,[a] trillion cubic feet	100	—	—	100	65	265	4.28
Coal,[b] million short tons	34,502[d]	895[e]	—	—	3,307[f]	38,704	4.16
Uranium, thousand tons U	817	—	—	—	111	928	17.00
Hydropower[c], billion tons kilowatt-hours/ year	317	99	27	15	2	460	—

[a] Proved reserves; [b] World Energy Council definition of "Proved Recoverable Reserves": As per WEC definition are the tonnage within the Proved Amount in Place that can be recovered (extracted from the earth in raw form) under present and expected local economic conditions with existing available technology; [c] Economic hydropower potential; [d] 90% anthracite and bituminous, 10% lignite and subbituminous; [e] lignite and subbituminous; [f] 33% anthracite and bituminous, 67% lignite and subbituminous; — reserves missing or very insignificant
Sources: EIA, 2006 and 2008; WNO, 2008; and *EDB Industry Report* no.2.

One of the largest open-pit coal mines in the world, in Ekibastuz, Kazakhstan. Inset: Part of the 1,700 km pipeline project to export gas from Turkmenistan to energy-deficient South Asia through Afghanistan.

Energy Resources of Central Asia

1:10 000 000

200 100 0 200

Kilometers

N

55°0'E

75°0'E

50°0'N

40°0'N

RUSSIAN FEDERATION

KAZAKHSTAN

ASTANA

UZBEKISTAN

TURKMENISTAN

ASHGABAT

KYRGYZ REPUBLIC

BISHKEK

TASHKENT

TAJIKISTAN

DUSHANBE

PEOPLE'S REPUBLIC OF CHINA

AZERBAIJAN

IRAN

AFGHANISTAN

Caspian Sea

Aral Sea

Lake Zaisan

Lake Balkhash

Lake Issyk-Kul

Ishim

Nura

Irtysh

Emba

Ural

Syrdarya

Amu Darya

Chui

Ili

Naryn

Karakum Canal

Pyandzh

Hydropower plant

- < 1 million kilowatts
- 1–3 million kilowatts

Pipeline

- Existing gas
- Existing oil
- Proposed gas
- Proposed oil

Field

- Gas
- Gas and oil
- Oil
- Coal

- National capital
- International boundary
- Rivers and canals

Boundaries are not necessarily authoritative.

Data sources:
Oil and gas basin:
U.S. Geological Survey
World Petroleum Assessment 2000

Projection: Lambert Conformal Conic
Datum: WGS 1984

GIS/Cartography:
V. Sibagatulin, GIS-Service Ltd.
Kyrgyz Republic, 2009

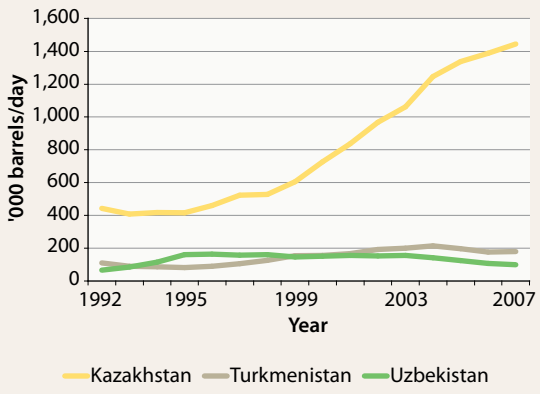
Petroleum – Fueling the Region's Growth

For more than a half century, one commodity has had the ability to transform developing economies like no other—oil. Kazakhstan is a prime example. Oil is Kazakhstan's fastest-growing industry sector. After years of foreign investment, the country boasts of an oil industry that has made it Central Asia's economic leader, with a gross domestic product greater than those of its four neighbors combined. Most encouraging is that the country's middle class is growing, suggesting that its hydrocarbon wealth is spreading widely. Kazakhstan's total oil production of roughly 1.4 million barrels per day ranked it among the top 20 oil producers in the world in 2007. And if its growth of more than 250% in crude petroleum production and 275% in exports between 1991 and 2007 is any indication, it could quickly move up in the rankings. In 2007, Kazakhstan exported about 80% of its oil production.

Kazakhstan has more than 100 oil-producing fields. Except for the Karachaganak field in the northwest, virtually all are within the Caspian Sea or just offshore. In recent years, Kazakhstan has had the Caspian region's greatest increases in oil production and has accounted for more than half of that region's total production. Caspian oil fields include Kashagan, the world's fifth largest in oil reserves, and Kurmangazy. In the low-lying wetlands along the Caspian's northeastern shores is the Tengiz field—the country's largest producer.

Turkmenistan and Uzbekistan have substantial oil industries as well, with each ranking within the top 50 oil producers in 2006. Although Turkmenistan was the only country in the region to show steady oil production increases after independence, its production began to decline after 2004. Still, the country is self-sufficient in oil, and exports as

Total Oil Production in Kazakhstan, Turkmenistan, and Uzbekistan; thousand barrels/day, 1992–2007



Note: Production of crude oil includes lease condensate, natural gas plant liquids, and other liquids, and refinery processing gain (loss).
Source: Based on EIA data US Government.
http://tonto.eia.doe.gov/country/index.cfm

Upper: Worker in the Kumkol oil fields in Kazakhstan. **Lower:** Oil is transported by pipeline and rail to the port of Aktau for export to neighboring countries.

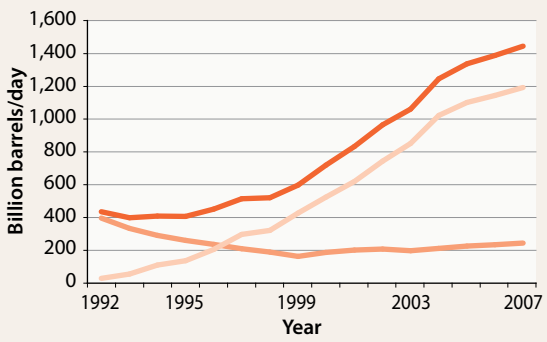
Oil exploitation in Tengiz, Kazakhstan. Workers inside a petroleum plant.

much as two-thirds of production. Key reserves are located in the Caspian's Cheleken oil field. Claims to other Caspian oil reserves are disputed by neighbor Azerbaijan, which could inhibit Turkmenistan's access to a substantial segment of its presumed oil reserves.

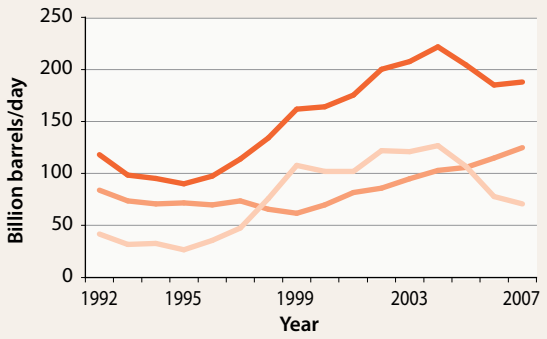
Not as oil endowed as its neighbors, Uzbekistan's oil production tripled during the 1990s, peaked in 1999, and has slid ever since. Today the country is a net oil importer. The majority of proven oil reserves are in the Bukhara-Khiva region, including the Kokdumalak deposit, which accounts for about two-thirds of production. Other fields are located in the Fergana Valley and Ustyurt plateau. Few high-yielding discoveries have been made since 1991. And local experts state more than two-thirds of oil has already been discovered. Lack of adequate investment and technical capacity for new oil field start-up has contributed to Turkmenistan's and Uzbekistan's waning oil production.

Oil Production, Consumption, and Exports/Imports
Billion barrels/day, 1992–2007

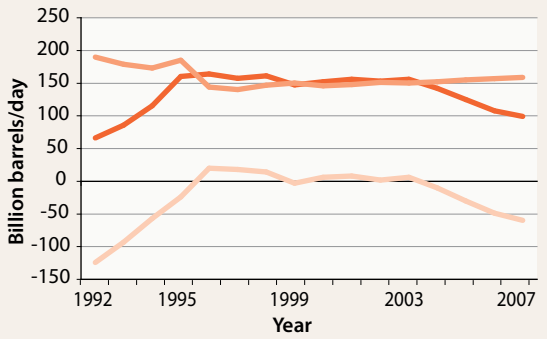
Kazakhstan



Turkmenistan



Uzbekistan



Production Consumption Net Exports/Imports

Notes: 2007 data for consumption and net imports/exports for all countries are forecast values.
Production of crude oil includes lease condensate, natural gas plant liquids, and other liquids, and refinery processing gain (loss).
Consumption includes petroleum products and direct combustion of crude oil.

Net Exports = Total Oil Production − Consumption. Negative numbers are Net Imports.
Source: Based on EIA data, US Government.
http://tonto.eia.doe.gov/country/index.cfm

The Caspian Sea's Newest Prize Catch

Long world famous for its bountiful sturgeon and their delicious caviar, the Caspian Sea region* now attracts world attention for its hydrocarbons. Surveys place proven (economically recoverable) oil reserves between 17 billion and 49 billion barrels, comparable to Libya on the high end. In 2005, oil production for the region was approximately 2.1 million barrels per day (mb/d), and could reach as high as 3.8 mb/d by 2010. Proven natural gas reserves are estimated at 232 trillion cubic feet (tcf), comparable to Nigeria. Regional production reached approximately 4.9 tcf in 2004, as much as the combined production of South America, Central America, and Mexico. In 2010, the governments of the countries in the Caspian Sea region expect their countries to produce a total of 8.1 tcf, more than the 2004 production of the entire Middle East.

*For purposes of measurement, the Caspian Sea region includes shoreline countries Azerbaijan, Kazakhstan, Iran, the Russian Federation, and Turkmenistan, as well as non-shoreline Uzbekistan.

Oil drilling platform in the Caspian Sea.

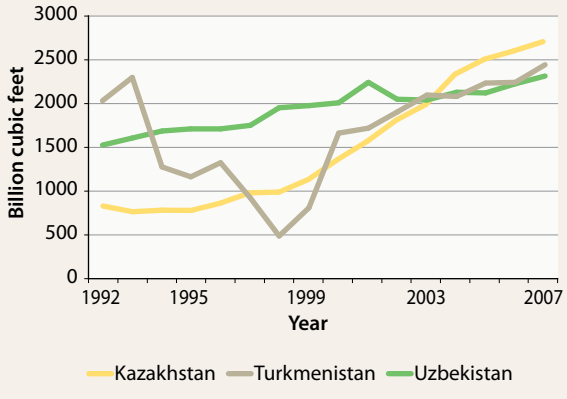
Natural Gas – Vast Potential Waiting to be Tapped

Because natural gas is more evenly spread throughout the region, it may hold even greater potential than oil. In 2005, Kazakhstan, Turkmenistan, and Uzbekistan all ranked among the top 25 world leaders in natural gas production, and top 20 in exports and proven reserves.

Kazakhstan's natural gas reserves measure approximately 100 trillion cubic feet, and are primarily located in the Caspian region. Nearly all gas is in associated (oil and gas) fields, such as the Caspian's Karachaganak and Tengiz fields, which contain the country's largest reserves. Other important fields include the Zhanazhol and Uritau deposits. While Kazakhstan currently consumes about as much gas as it produces, recent rehabilitation of the Karachaganak and Tengiz fields positions the country to become a significant net exporter once adequate pipeline infrastructure comes on line.

In possession of some of the world's largest gas fields, Turkmenistan's proven natural gas reserves are also about 100 trillion cubic feet. The Amu Darya basin is home to the largest deposits, with the giant Dauletabad-Donmez field containing roughly half of all reserves. Additional large reserves are found in the Murgab basin, of which the Yashlar deposit is the largest. There are also reports of new discoveries of deposits in the Deashoguzsky, Lebansky, and Maryinsky regions of the country. Since bottoming in 1998, Turkmenistan's gas production has increased steadily. Today, natural gas supplies virtually all the country's energy needs, and oil and gas together provide 80% of energy exports. Because

Natural Gas Production in Kazakhstan, Turkmenistan, and Uzbekistan
Billion cubic feet, 1992–2007



Source: Based on EIA data, US Government. http://tonto.eia.doe.gov/country/index.cfm (updated 30 June 2008).

Upper: The burning gas crater near Darvaza in Turkmenistan is 60 meters wide and is a result of Soviet gas exploration during the 1950s. **Lower:** Gas pipelines exposed by wind and movement of the desert sands in Gumdag, Turkmenistan.

Gazprom welders work on a pipe during reconstruction works on the pipeline in Alexandrov Gai village at the border between Kazakhstan and the Russian Federation. The pipeline is expected to increase the possibilities of gas transport from Central Asia to Europe.

Turkmenistan relies on the Soviet-era pipeline system, however; most of its natural gas exports are currently restricted to the region or go to the Russian Federation.

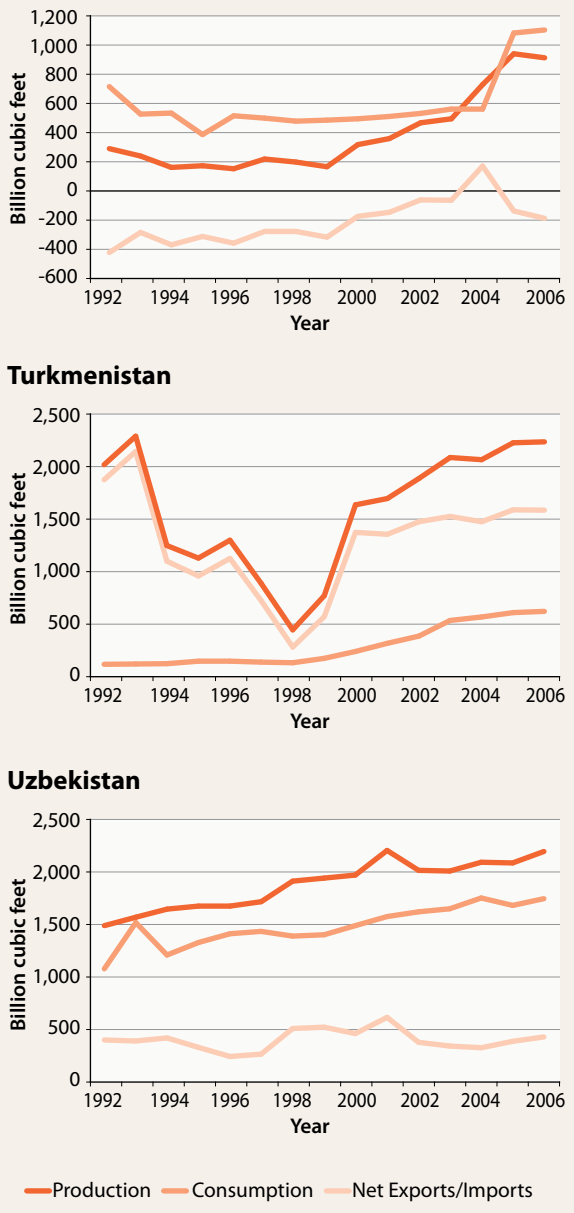
Uzbekistan's natural gas reserves measure roughly 65 trillion cubic feet. About two-thirds of proven reserves are found in nine large deposits, eight of which are under development. The Ustyurt region in the country's northwest holds the greatest promise. Gas provides most of the country's electricity production, and a large portion of the country's gas production is domestically consumed. Natural gas exports go to Kazakhstan, the Kyrgyz Republic, Tajikistan, and the Russian Federation, which purchases the overwhelming proportion of Uzbekistan's gas exports, pumped north through Soviet vintage pipelines.

Energy's Access To Global Markets

Central Asia's energy resources are there. The challenge is getting them out. Most of the region's oil and gas pipelines were constructed in Soviet times. Gas pipelines were built for regional use; oil pipelines, for regional use and for export to the former Soviet Union and Ukraine. This is one reason Kazakhstan is able to sell its oil internationally. Another reason is that because oil can be shipped almost anywhere—by pipeline, ship and truck—it is a true global commodity. By contrast, gas is "stranded" and—unless made liquid for ship transport—must be carried via pipeline networks. Gas without pipeline networks has little export value.

The region's hydropower is "stranded" in much the same way. This is because the Central Asia transmission system was built as a regional electric power grid to export hydropower from the Kyrgyz Republic and Tajikistan to the rest of the region and allow power interchange among all the countries. For the countries of Central Asia to take advantage of the global economy, new electricity transmission networks and gas and oil pipelines are being built, and many more are in the planning stage.

Natural Gas Production, Consumption, and Exports/Imports
Billion cubic feet, 1992–2006



Net Exports = Exports − Imports. Negative numbers are Net Imports.
Source: Based on EIA data, US Government.
http://tonto.eia.doe.gov/country/index.cfm

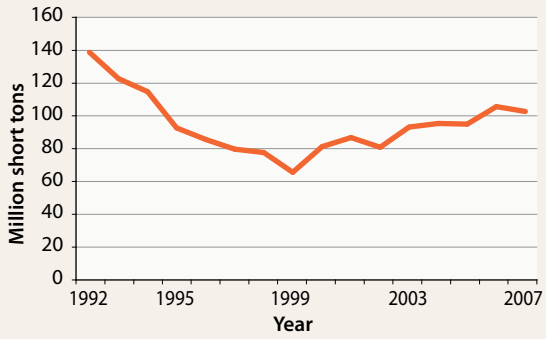
■ Coal mining by the road from Chaek to Song Kul, Kyrgyz Republic. The country produced nearly 5 million tons per year in 1979. Present production is less than a tenth of that amount but large reserves remain.

Coal – Energy Diamond in the Rough

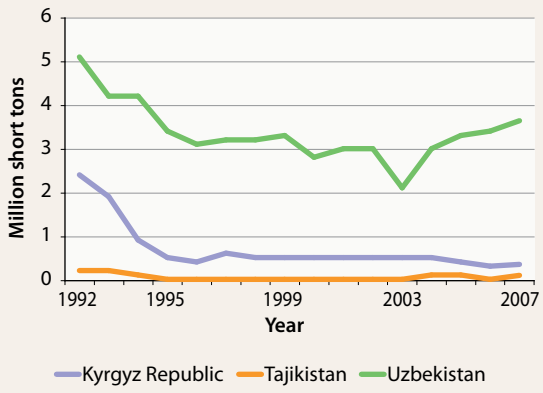
Coal is the most plentiful hydrocarbon on the planet. It is also the most widely distributed, and is likely to remain so for years to come. Coal powered the industrial revolution, and is helping power the growth of many developing nations today. Found throughout Central Asia, it is used to supply electrical power and as local fuel for cooking and heating. It is exported in small quantities as well. Regional coal production declined significantly in the years following the Soviet breakup.

However, Central Asia's coal production and investments are on the upswing. The Kyrgyz Republic and Tajikistan have locally exploitable coal and have shown modest production increases the past few years. The Kyrgyz Republic produced roughly 350,000 short tons of coal in 2007. Its coal is found in three areas: Alai, Alabuka-Chatyrkul, and Yuzhno-Issyk-Kul. Kara-Keche, an open-pit mine in the Dzhumgal district of Naryn region, contains roughly half of the country's deposits. Tajikistan produced about 90,000 short tons in 2007, roughly as much as it consumed. To meet winter demand for electricity and space heating, the Government of Tajikistan has been looking for investment to develop integrated coal mines and power plant complexes. Uzbekistan has nearly 3,307 million short tons of coal reserves, and produced 3.6 million short tons in 2007. There is a significant amount of high-grade black coal. However, roughly 70% of reserves are lower-grade brown coal (lignite). Coal is mined at the Angren deposit, which has brown coal reserves, and Shargun and Boysun deposits, which have black coal reserves. Except for small exports to Afghanistan, coal is used for domestic consumption, with 90% going to the power industry. Uzbekistan plans to increase coal production and coal's share in power production.

Coal Production in Kazakhstan
Million short tons, 1992–2007

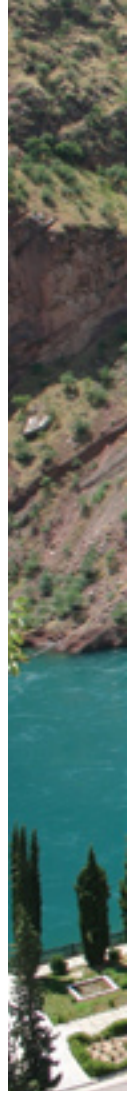


Coal Production in the Kyrgyz Republic, Tajikistan, and Uzbekistan
Million short tons, 1992–2007



Note: 1 short ton = 0.907 metric tons.
Source: Based on EIA data, US Government. http://tonto.eia.doe.gov/country/index.cfm (updated 17 October 2008).

The region's largest recoverable coal reserves are found in Kazakhstan—approximately 34,500 million short tons of primarily high-grade, anthracitic and bituminous coal. In 2006, the country produced roughly 106 million short tons



Above: Scientists inspect a nuclear reactor in the Baikal Reactor Research complex in Kurchatov, a facility hidden underground in Kazakhstan's desert region. **Right:** The Nurek hydropower station and reservoir in Tajikistan.

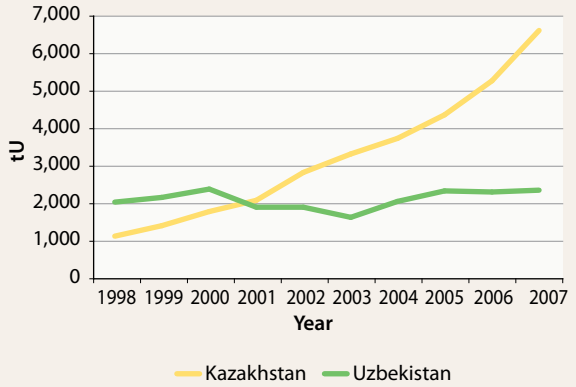
and exported about 28 million short tons, mostly to the Russian Federation and Ukraine. With coal powering more than 80% of Kazakhstan's electricity production, the country was also its own biggest consumer. Kazakhstan has several hundred coal deposits, with brown coal coming from the Karaganda and Ekibastuz region, and higher-grade coal from its Karazhir deposit. Foreign investment is involved with much of Kazakhstan's production, and more will be needed if Kazakhstan is to become a significant coal exporter.

A versatile mineral, coal has advantages: it is inexpensive, safe to transport and store, and is available from many sources. But it has disadvantages as well: it releases huge amounts of sulfurous pollution and carbon dioxide into the skies, and contributes significantly to acid rain and climate change. This makes clean coal production and consumption technologies prime considerations in any coal enterprise. Coal production also requires extensive road and railroad infrastructure, areas that need to be addressed for the region to reap the benefits of its vast coal reserves.

Nuclear Energy – A World Leader in Reserves

First heralded for its limitless potential, and later questioned for its risks to health and environment, carbon-free nuclear energy is once again catching the attention of planners worldwide, for two compelling reasons: world demand for electricity is increasing, and climate change requires a wide range of solutions. Storage of radioactive waste and other issues remain, but the new generations of nuclear reactors hold promise of greener and safer energy, with less residual waste. Nuclear energy already generates one-sixth of world electrical energy, placing it third behind coal and hydropower. Fueling nuclear plants takes uranium, and as the post–Cold War glut of military uranium runs out—possibly by 2010—and new reactors come on line, eyes are turning to the handful of areas with large uranium deposits.

Uranium Production in Kazakhstan and Uzbekistan, tons, 1998–2007



Source: Based on data from World Nuclear Association. www.world-nuclear.org/info/uprod.html (updated July 2008).

Kazakhstan with 15% and Uzbekistan with 2% of world reserves are second and eighth, respectively, among world leaders. Kazakhstan, whose uranium production dates back to 1953, also holds the greatest potential. In 2006, KazAtomProm, Kazakhstan's state-owned nuclear holding company, produced 8% of the world's mined uranium. The company puts uranium reserves at roughly 900,000 tons, and aims to produce 15,000 tons by 2010 and 30,000 tons by 2018.

Virtually all Kazakhstan deposits are located in the Chui-Sarysu and Syr Darya basins, though there are some deposits in the north and in the Caspian region. Kazakhstan has a long working relationship with the Russian Federation, and has signed nuclear agreements with Canada, the People's Republic of China, France, Japan, the Republic of Korea, and the United States. Though all mined uranium is exported, Kazakhstan hopes to develop its own nuclear power industry, and may begin constructing reactors and nuclear power plants.

Uzbekistan production began in the Fergana Valley and now comes entirely from the Kyzylkum district in Central Uzbekistan, where it has been produced since 1961. In the Soviet era, much of Uzbekistan's production went to the Soviet military–industrial complex and peaked in the 1980s. Since independence, there have been swings in production. However, the country has enjoyed production increases estimated at 25% between 2002 and 2007. The Kyrgyz Republic also has uranium reserves under production.

Nuclear infrastructure is costly, but once in place, atomic power can offer an inexpensive, greenhouse gas–free electricity alternative to fossil fuel. On a cautious note, long-term handling and storage of radioactive waste remain problematic. Uranium, like oil and gas, is also finite—at current usage (about 65,000 tons of uranium per year), the world's measured uranium resources (5.5 million tons) would be depleted in a little more than 80 years. And then there is this: short-term reliance on nuclear power could distract policy makers away from long-term renewable energy.

Renewable Energy

SUSTAINABLE HYDROPOWER POTENTIAL

Hydropower has been a key component of Central Asia's energy use for more than a half century. The region's water/energy nexus, however, is a complicated one. Put simply, the energy needs of upstream Kyrgyz Republic and Tajikistan, and the irrigation needs of downstream Kazakhstan and Uzbekistan have not always mixed well.

The Amu Darya and Syr Darya rivers and their tributaries provide the primary hydropower sources for the region. Hydroelectric stations using these sources are largely controlled by the Kyrgyz Republic and Tajikistan. More than 40 hydropower stations are installed among the largest reservoirs along the rivers. Major stations are in reasonably good condition. Largest are the Toktogul station on the Naryn River in the Kyrgyz Republic and Nurek station on the Vakhsh River in Tajikistan. Hydropower provides the Kyrgyz Republic with 83% and Tajikistan with 96% of total electrical energy. But this usage is a small percentage of potential capacity.

Hydroelectric potential for the region has been placed at more than 450 billion kilowatts per year, with an estimated 90% of this presently unused.

To exploit unused potential, the Kyrgyz Republic and Tajikistan are completing large hydropower stations begun during the Soviet era, and constructing new smaller ones. Projects include two Kambarata hydropower stations on the Naryn and a series of stations on the Sary Djaz River in the Kyrgyz Republic, and the Rogun station on the

The Irrigation or Hydropower Dilemma

Distribution of energy resources in Central Asia is highly skewed. The Kyrgyz Republic and Tajikistan possess great hydropower potential, but a scarcity of commercially viable fossil fuels. Kazakhstan, Turkmenistan, and Uzbekistan have significant and varying amounts of oil, gas, and coal.

In terms of actual need, the Kyrgyz Republic and Tajikistan require water in winter to generate power for heat and electricity. By contrast, Kazakhstan and Uzbekistan require water flow for summer irrigation. During Soviet times, water and energy were managed on a regional basis, with primary emphasis on irrigation. Soviet policy, therefore, mandated greater water volume release in summer than winter, leaving insufficient flow for winter power generation. Soviet central authorities managed this discrepancy by sending excess electricity produced in summer to the Central Asian power system so it could be used by Kazakhstan and Uzbekistan, that in turn were required to send fossil fuels to the Kyrgyz Republic and Tajikistan to make up for winter energy shortfalls.

Through mutual agreement, this summer/winter water arrangement still exists. However, with market pricing replacing the Soviet-style resource-trade system, cash-strapped upstream countries, further overburdened by costs from the management and maintenance of water infrastructure, have been unable to pay for thermal resources from their downstream neighbors. Lacking effective regional integration, countries have adopted policies of energy self-sufficiency. This has led the Kyrgyz Republic and Tajikistan to use great amounts of water for winter power generation, causing downstream water saturation problems in winter, and irrigation scarcities in summer that cause economic hardship for farmers.

A solution amenable to all countries is yet to come. Of note, however, is this: economic analysis in the Syr Darya Basin reports that net benefits to the region are significantly higher under an irrigation scheme of greater water release in summer than a power scheme of increased winter releases.

Central Asian Power System

The Central Asian power system comprises interconnected high-voltage links encompassing southern Kazakhstan, the Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan. The main transmission lines link the power systems of the five countries for parallel operation. The system shares common operational and service management, planning, information channels, and control, and connects more than 80 power plants, including 29 thermal and 48 hydropower plants, with a total installed capacity of about 25,000 megawatts. The system operates from the united dispatch center in Tashkent, Uzbekistan, which is responsible for maintaining the balanced and synchronized operation of the power transmission and distribution systems of the five countries. Following the dissolution of the Soviet Union in 1991, the countries have maintained synchronized operation, which permits the exchange of electricity among them.

Power lines in the steppe at sunset in Kazakhstan.

Hydroenergy Potential of the Rivers of Central Asia

Country	Hydroelectric Power Plant (HPP) installed capacity, Megawatts	Electricity production and HPP, 2005, Billion kilowatt-hours	Economic hydropower potential, Billion kilowatt-hours/year	Use of hydropower potential, %	Percentage of the hydropower potential of the Central Asian Rivers
Tajikistan	4,037	17.1	317	5	69
Kyrgyz Republic	2,910	14	99	14	22
Kazakhstan	2,248	7.9	27	29	6
Uzbekistan	1,420	6	15	49	3
Turkmenistan	1	0	2	0	0
Total	**10,616**	**45**	**460**	**10**	**100**

Source: Water and Energy Resources in Central Asia: Utilization and Development Issues. April 2008. *EDB Industry Report* no.2. www.eabr.org/media/img/eng/research-and-publications/AnalyticalReports/Report_2_water_and_energy_EDB.pdf

Largest Hydroelectric Power Plant Projects in the Kyrgyz Republic and Tajikistan

Project Name	Location / Country	Status (when completed/under construction)	Capacity, Megawatts	Average annual performance, Billion kilowatt-hours	Estimated cost, Billion $
Rogun HPP	Vakhsh River (Tajikistan)	Project	3600	13.1	2.2
Nurek HPP	Vakhsh River (Tajikistan)	Operational	3600	11.2	
Dashtijum HPP	Pianj River (Tajikistan)	Project	4000	15.6	3.5
Kambarata -1 and -2 HPPs	Naryn River (Kyrgyz Republic)	Project	1900+360	7.0	2.0
Toktogul HPP	Naryn River (Kyrgyz Republic)	Operational	1200	4.4	
Series of 5 HPPs on Sary Djaz	Sary Djaz River (Kyrgyz Republic)	Project	1500	5.0	2.5

HPP = hydroelectric power plant.
Source: Water and Energy Resources in Central Asia: Utilization and Development Issues. April 2008. *EDB Industry Report* no.2. www.eabr.org/media/img/eng/research-and-publications/AnalyticalReports/Report_2_water_and_energy_EDB.pdf

Vakhsh and Dashtijum station on the Pianj River in Tajikistan. These facilities should help ease regional demand, and create opportunities to meet rising demand for electricity in the People's Republic of China, Iran, Pakistan, and the Russian Federation—once export transmission networks are in place.

As with other energy resources, issues surrounding hydropower exist. Increased upstream water usage changes hydrological dynamics, which further affect severely downstream neighbors who may suffer from reduced amount and quality of water. Then there is the wild card called climate change: the region's glaciers are melting at an accelerating pace, making water flow predictions problematic. Still, Central Asia's untapped hydropower potential has much to offer. Managed properly and invested in wisely, it could provide a steady source of clean, sustainable electricity to the region as well as neighboring nations for a long, long time.

Left: This solar furnace in Parkent, Uzbekistan, once used for testing missile components, is now being used for making exotic ceramics. It is claimed to be one of the oldest solar furnaces in the world. **Upper right:** Windmill in Karaganda Oblast, Kazakhstan, used by a farmers' association to generate electricity for remote areas. **Lower right:** A biogas installation in the Kyrgyz Republic.

WIND AND SUN – ALMOST LIMITLESS ENERGY POSSIBILITIES

Most of Central Asia consists of wide open expanses and corridors through which winds highly favorable for energy production blow. To put this in perspective, Kazakhstan, for example, produced 76.3 billion kilowatt-hours (kWh) of electricity in 2007, 85% of which came from coal. In the east of the country, an area called the Djungar Gate—said to have the best wind climate in the world—could alone generate more than 300 billion kWh of electricity annually. Other excellent wind power sites are scattered through the country. Costs of a recent 5-megawatt plant are similar to those of a coal-fired plant and will become relatively cheaper if fossil fuels become taxed for their role in climate change. Kazakhstan has the opportunity to not only replace "dirty" coal with "clean" wind power for its domestic needs but also have a large excess for export.

Conventional solar energy, using photovoltaic cells, and thermal solar power, in which mirrors concentrate sunlight to heat a liquid substrate, which generates steam for thermal power, are also highly feasible options for the region, given its abundant sunlight. Production costs are estimated to be cheaper than for gas and less infrastructure is required. Development can take place in arid areas, offering almost limitless potential.

Despite its massive hydrocarbon reserves, Kazakhstan already has a wind power program and is exploring other energy sources. In Uzbekistan, the focus is on solar power, especially for remote areas where costs of solar power are now often cheaper than constructing high-voltage power lines. Small-scale solar power plants are spreading rapidly in the Kyrgyz Republic as costs relative to carbon-based fuels fall.

Other countries are slower to diversify their energy programs. Turkmenistan, for instance, also has very good areas for wind power generation along the Caspian Sea shores and throughout the central desert. Solar energy potential is also extremely good. Several geothermal reservoirs have been discovered with overall potential of some 6,000 megawatts. Yet, because of the country's abundant gas reserves, alternative energy sources have not been seriously considered. Tajikistan and the Kyrgyz Republic, already relying mainly on hydropower, see this source as having the best future energy potential and plan to augment large hydropower stations with small and micro hydropower plants.

Biofuel is being considered in Uzbekistan, where the big cotton-growing areas produce enough waste to produce up to 10 million gallons of ethanol per year.

Biogas generated from animal and agricultural waste is an energy source being used in the Kyrgyz Republic. Current facilities produce 2 million cubic meters of biogas and 70,000 tons of fertilizer annually. The country has potential for 100 times this amount and more than enough fertilizer to repair the damage caused by past land degradation—at attractive prices.

REAPING BENEFITS FROM ENERGY WEALTH

To ensure sustainable development and protect against effects of global climate change, Central Asia would benefit from focusing on energy efficiency and clean energy, for example, through retrofits for greenhouse gas mitigation, elimination of gas flaring, and development of renewable energy sources. Cleanup of and reduction in pollution from hydrocarbon and mineral extraction are further outstanding needs.

Economic reliance on one or a few resource commodities makes a nation susceptible to global price fluctuations. One way to ward against these and other potential consequences is to diversify energy production to include clean energy sources, particularly thermal solar and wind power.