

China

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China is the country with the highest energy consumption worldwide. Due to its size and a population of roughly 1.4 billion inhabitants, the primary energy consumption totaled 4.26 billion tce in 2014, of which 2.81 billion tce (4.13 billion t) was sourced from coal, or 66% of the consumption of primary energy. The remaining contribution is covered by oil (17.5%), natural gas (5.6%), hydro power (8.1%), nuclear power (1.0%) and renewables (1.8%).

1. Structure of the energy supply by energy sources

The major part of the energy needs can be covered by indigenous production. The domestic production by energy sources is as follows due to the 2014 National Economic and Social Development Statistical Communique:

- Coal: 3.87 billion tonnes raw coal
- Crude oil: 211.43 million tonnes
- Natural gas: 130.16 billion m³

The share of imports in the total energy consumption is limited to 17%.

- Coal: 7% import dependence (domestic production:3.87 billion tonnes; imports: 0.29 billion tonnes)
- Crude Oil: 59.5% (domestic production: 211.43 million tonnes; imports: 310 million tonnes)
- Natural gas: 30.9% (domestic production:130.16 billion m³; imports: 58.3 billion m³)

The dominance of coal in China's energy mix is due to the high amount of availability domestically, coal has the highest self-sufficient rate among all energy sources in China. In recent years, it has been between 92% and 93% with the small remainder made up by imports. Imported coal is mainly used in the south-eastern coast because of its possible price advantage over domestic coal in this region including transport.

Since 2000, China has become increasingly reliant on oil imports, with 310 million tons of oil imported in 2014 representing 59.5% of the total consumption that year.

China plans to drastically increase the use of natural gas, aiming to reach 300 billion cubic meters of demand by 2020. To increase natural gas imports, is an important means to achieve this target.

China's reliance on imported natural gas will continue to grow as it is very difficult to increase the output of conventional natural gas and shale gas so quickly.

The energy mix in power generation is as follows:

Table 1: Energy mix in power generation in 2014

Total Power Generation Capacity in 2014

	Total	Thermal Power				Hydro	Wind	Nuclear	Solar	Others
		Coal	Gas	Oil	Others*					
GW	1370.18	832.33	56.97	5.12	29.2	304.86	96.57	20.08	24.86	0.19
%	100	60.75	4.16	0.37	2.13	22.25	7.05	1.47	1.81	0.01

Total Power Generation in 2014

	Total	Thermal Power				Hydro	Wind	Nuclear	Solar	Others
		Coal-fired	Gas-fired	Oil-fired	Others*					
TWH	5604.5	3951	133.3	4.4	138.7	1060.1	159.8	133.2	23.5	0.5
%	100	70.50	2.38	0.08	2.47	18.92	2.85	2.38	0.42	0.01

*(biomass ,garbage etc.)

Source: China Electricity Council (updated in 30/11/2015)

2. Coal supply

By 2013, China's proven coal reserves totaled 1.48 trillion tons according to the Ministry of Land and Resources and ranked 3rd in the world. Of the 114.5 bn tonnes of recoverable reserves, 62.2 bn tonnes were hard coal, 52.3 bn tonnes are lignite¹. Despite China's large amount of coal reserves, its production/reserve ratio is rather low. Coal, that can be exploited cost-efficiently, is being depleted.

¹ Source: 2014 BP World Energy Statistics

Table 2: Ranking of Recoverable Reserves by Country (2014)

	Country	Recoverable reserves /100million ton	%
1	USA	2372.95	26.5
2	Russia	1570.1	17.6
3	China	1145	12.8
4	Australia	764	8.6
5	India	606	6.8
6	Germany	405.48	4.5
7	<u>Kazakhstan</u>	336	3.8
8	Ukraine	338.73	3.8
9	South Africa	301.56	3.4
10	Indonesia	280.17	3.1
	Total	8915.31	100

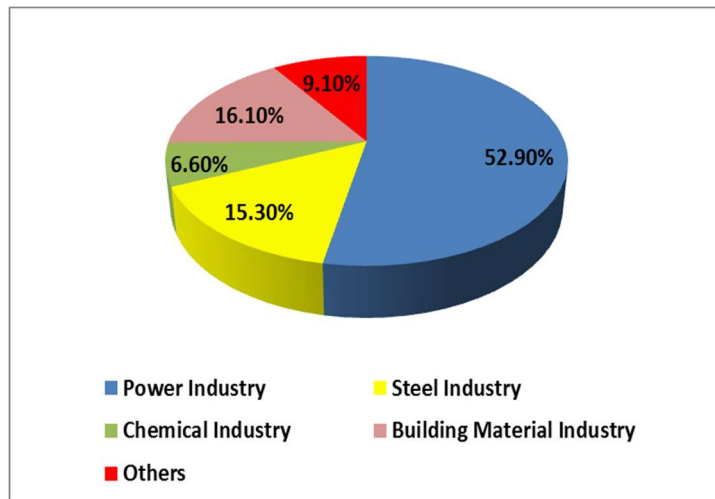
Source: BP Statistical Review of World Energy June 2014

China had been a net coal exporter until 2009 when it became a net importer. Nevertheless, its self-sufficiency via domestic sources still remains at 90% or higher. Coal is imported because of its competitive price in some coastal locations compared to domestic coal sources.

3. Role of coal in the energy supply market

Coal is used to generate 71% of China's electricity. 86% of the energy used in China's steel industry stems from coal as well as 79% in construction. 50% of the raw materials for the chemical industry are also sourced from coal.

Figure 1: China's Coal Consumption by Sectors (2013)



Source: China Coal Industry Planning and Research Institute

The Chinese Academy of Engineering estimates that between 2005 and 2010, coal production along with the main coal-consuming industries contributed 15% to China's overall GDP and 18% to the growth of the economy.

Only 53% of China's coal is used for power generation, lower than the world's average of 63%. The Chinese Government has proposed that coal will be mainly used to generate power but is to be utilised in an efficient and clean manner.

China's vast territory means that there are large differences the energy costs for power plants in the different regions. The cost for generating power is related to multiple factors and it is hard to apply uniform statistical standards. The following on-grid tariff ranges are used to provide an overview of cost differences.

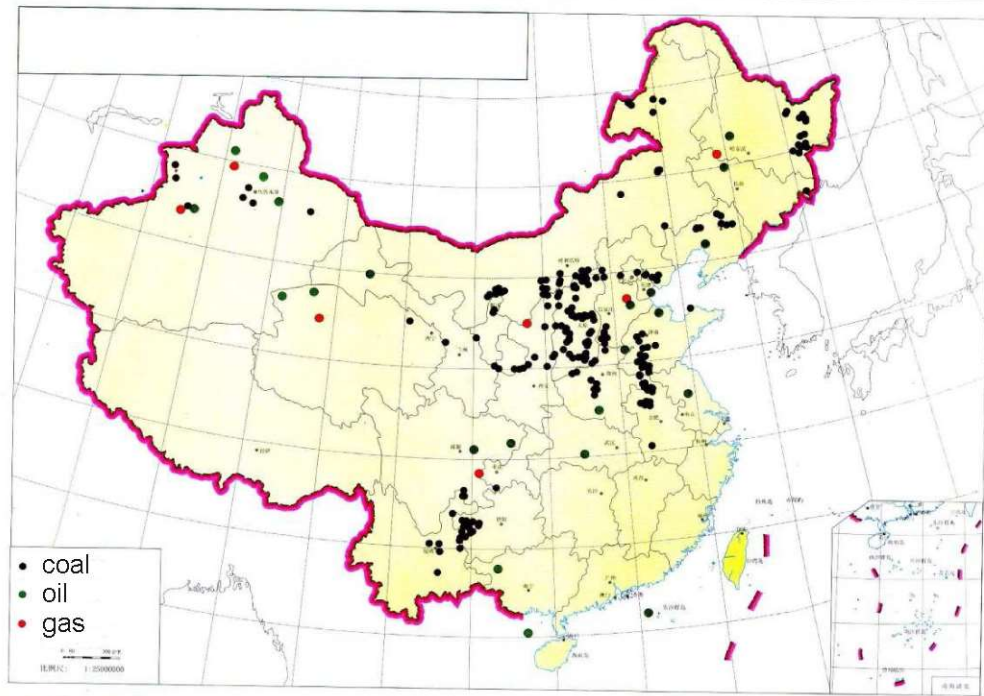
On-grid tariff range in different provinces and regions in China (yuan/kWh):

- Coal: 0.29~0.47
- Natural Gas: a maximum of 0.35 yuan can be added to the price of coal generated electricity
- Nuclear: 0.43
- Wind: 0.49-0.61
- PV: 0.80-1.10
- Hydro: 0.20-0.40

Generally speaking, the cost for coal generated electricity is a little higher than the cost of hydroelectricity, but it is much lower than other generation types. The cost decreases in the following order: hydroelectricity<coal<nuclear<>wind<PV along the merit order curve.

4. Coal supply infrastructure

Figure 2: Map of geographic distribution of coal, oil and gas resource in China



Source: Shenhua Group

Figure 3: Illustrative map of coal trade flows in China



Source: Shenhua Group

Sources for coal trade outflows: 1. Over 75% of the new production stems from Shanxi, Shaanxi, Inner Mongolia, Ningxia Gansu and Xinjiang

2. Yunnan, Guizhou

Areas for coal trade inflows:

3. Beijing, Tianjin, Hebei

4. North east (Heilongjiang, Jilin, Liaoning)

5. East (Shandong, Jiangsu, Shanghai, Zhejiang, Anhui, Jiangxi)

6. Middle (Guangdong, Guangxi, Hainan, Hunan, Hubei, Henan)

7. Sichuan, Chongqing, Qinghai

Major sources of international import coal:

overseas: Indonesia and Australia

inland: Mongolia and Russia

5. Relationship between technology and security of supply

In the past decade, China's technology of coal-fired power generation grew rapidly with the average coal consumption to produce 1 kW of electricity falling to 319 grams on par with levels

in the US. The dust control equipment installed on the furnaces can remove around 99.5% of the dust. The installed capacity with desulfurization and denitration facilities reaches 800 mn kW and 690 mn kW respectively. 95% of China's installed capacity is equipped with desulfurization facilities, compared with 12% in 2005. The number of plants with denitrified installed capacity has also increased to 82%. In 2014, the air pollutants emitted from power plants dropped drastically. According to the initial estimates of the China Electricity Council, the total amounts of soot, SO₂, and NO_x in 2014 are expected to be reduced to 980,000 tons, 6.2 million tons, and 6.2 million tons, or respective reductions of 31.0%, 20.5% and 25.7% lower than levels in 2013².

A new round of technological upgrades continues in efforts to control pollution from power plants which means that coal-burning power plants will continue to reduce any environmental impacts. The ultra-low emission technology of coal-burning power plants should reach the emission standards of their gas-fired counterparts in China. China's Shenhua Group has completed the technological upgrades on 29 coal-burning units in its portfolio to make them ultra-low emission. Long-term monitoring shows that major pollutants emitted from these units are all lower than those from equivalent gas units. Meanwhile, the cost mark-up of electricity remains controlled under 0.01 yuan per kW, or 2.5-3% of the total cost.

Table 3: Examples of Emissions Levels from Shenhua Group's coal-fired plants

		PM (mg/Nm ³)	SO ₂ (mg/Nm ³)	NO _x (mg/Nm ³)
		Emission	Emission	Emission
1	Natural Gas Emission Standard	5	35	50
2	GH Zhoushan No. 4 (new 350MW)	2.46	2.76	19.8
3	GH Sanhe No. 1 (conversion 350MW)	5.00	9.00	35.00
4	GH Dingzhou No. 3 (conversion 660MW)	2.00	6.00	17.00
5	GH Huizhou No. 1 (conversion 330MW)	1.40	8.00	18.00
6	GS Wanzhou No. 1 (new 1000MW)	3.50	9.00	23.00

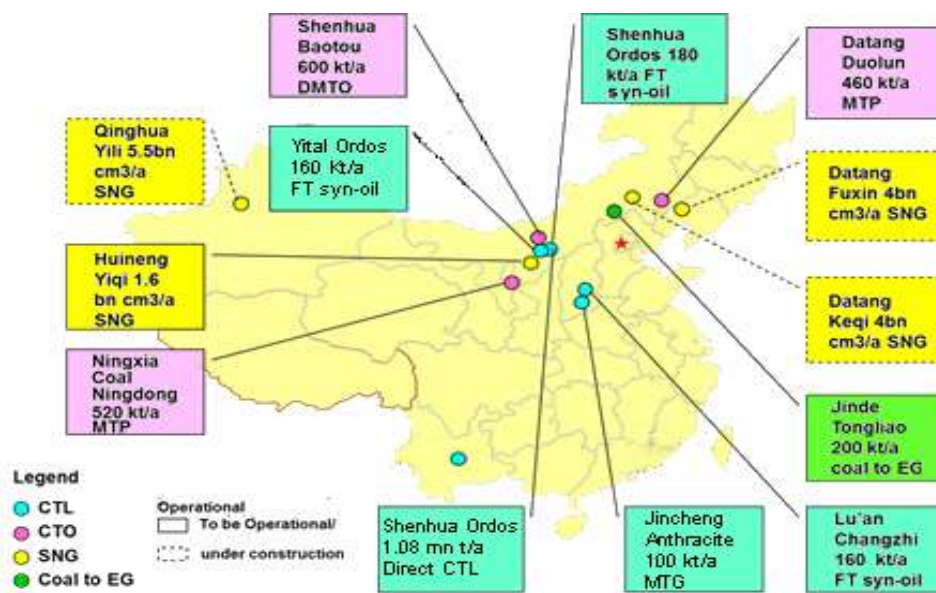
² Source: China Electricity Council

7	GS Dagang No. 3 (conversion 300MW)	2.96	17.88	30.45
8	GN Yuanyang Lake No.1(conversion 600MW)	4.27	22.57	29.28

Source: Shenhua Group

Since 2000, the import of crude oil has continued to increase leading to breakthroughs in clean coal conversion. China has worked hard to achieve a leadership role in global clean coal work.

Figure 4: Locations for some Modern Coal Based Projects in the Chemical Industry



Partial representation of Modern Coal Based Chemical Industry in China

Source: Shenhua Group

Key technology development status and Outlook (end of 2014)

- Coal to liquids (CTL): 1.63 MT capacity plant completed. 6.8 MT under construction. China still imports 60% of its oil needs. Demand from oil will continue to increase. The outlook for DCL is bright.
- Methanol to Olefins (MTO): 4.72 MT capacity plant completed which is 20% of China's total olefin production capacity. There are currently 8 MT capacity plants under construction, with an additional 13 MT capacity plants in planning stages. Demand may reach full market capacity in the near future and competition intensity is expected to increase.
- Synthetic natural gas (SNG): 2.7 bn m³ plant completed, 16.4 bn m³ under construction, demand for natural gas will continue to grow but this is dependent on the outlook for economic returns.

- Coal to Alcohol, Ether & Aromatics: Commercial scale plants already completed for alcohol and ether, 10K tonne scale aromatics pilot completed, there is an existing supply gap in the domestic market but further economic analysis is needed.

7. Governmental energy and climate policy and intergovernmental treaties – expected impacts on coal

According to the Action Plan for Energy Development Strategy (2014-2020) which was issued by the State Council, by 2020, total energy consumption in China will be controlled at the equivalent of 4.8 bn tons of standard coal, of which 4.2 bn are coal, or approximately 62% of the energy mix. In the future, the percentage of coal used to generate electricity will increase further, while the coal consumption for other purposes will gradually decrease.

Through 2030, coal will continue to fulfill the large role needed for electricity generation. Still it is important to realise, that the percentage of coal contributions to the total power generation will fall over the period.

Table 4: Coal-fired Power Generation (2014-2030)

	Installed capacity (GW)	Ratio	Annual power generation (TWH)
2014	832.3	60.8%	3951
2020	1100	55.2%	5800
2030	1450	45.7%	6700

Source: China Electric Power Planning and Research Institute

In November 2014, China and the US issued a joint statement on climate change. The Chinese Government says it plans to reach the peak level for CO₂ emissions around 2030 and will try to achieve that target at an early date if possible. Meanwhile, renewable energy will be increased to make up 20% of the energy mix. Under the assumption of economic growth of over 6%, the percentage of coal in the energy mix start to fall over the time period.

8. Summary

Coal will remain China's main energy source in the foreseeable future. However, its percentage in the primary energy mix will decline. If China continues to use coal, the key is to strengthen the clean utilisation of coal and reduce the emissions from all of the main pollutants, which includes the emission of SO₂, NO_x and PM. A continuous investment in R&D is necessary to support this energy transformation across the country.

Further References

For more information about China's coal-fired power plant and CCS, please check the following links from Shenhua's Cornerstone Magazine:

<http://cornerstonemag.net/the-development-strategy-for-coal-fired-power-generation-in-china/> (for the development status and strategy of coal-fired power generation in China)

<http://cornerstonemag.net/challenging-efficiency-limitations-for-coal-fired-power-plants/> (for HELE coal-fired power generation technology in China)

<http://cornerstonemag.net/moving-forward-with-the-huaneng-greeneng-igcc-demonstration/> (for IGCC technology in China)

<http://cornerstonemag.net/chinas-policies-for-addressing-climate-change-and-efforts-to-develop-ccus-technology/> (CCS technology development in China)

For more information about clean coal conversion please check the following links from Shenhua's Cornerstone Magazine

<http://cornerstonemag.net/clean-coal-conversion-road-to-clean-and-efficient-utilisation-of-coal-resources-in-china/> (for the clean coal conversion strategy in China)

<http://cornerstonemag.net/shenhuas-dcl-project-technical-innovation-and-latest-developments/> (DCL technology in China)

<http://cornerstonemag.net/the-momentum-of-chinese-developed-indirect-coal-to-liquids-technologies/> (IDCL technology in China)

<http://cornerstonemag.net/shenhua-groups-carbon-capture-and-storage-demonstration/> (CCS for coal base chemical industry in China)

Fact Sheets China

Energy Production in 2013 and 2014

Energy Source	Unit	2013	2014
Total Production	Mtce	3,587.8	3,600,0
thereof:			
Coal	%	75.4	73.2
Crude oil	%	8.4	8.4
Natural gas	%	4.4	4.8
Primary Electricity and Others	%	11.8	13.6

Primary Energy Consumption in 2013 and 2014

Energy Source	Unit	2013	2014
Total Consumption	Mtce	4,169.1	4,260.0
thereof:			
Coal	%	67.4	66.0
Oil	%	17.1	17.1
Natural gas	%	5.3	5.7
Primary Electricity and Others	%	10.2	11.2

Energy Balance 2013

	Mtce
Primary Energy Output	3,587.8
Imports	+ 734.2
Exports	- 80.0
Stock Changes	- 67.8
Total Energy Available for Consumption	= 4,174.2
Total Primary Energy Consumption	4,169.1

Coal Balance 2013

	Mt
Total Output	3,974.3
Imports	+ 327.0

Exports	- 7.5
Stock Changes	- 43.7
Total Coal Available for Consumption	= 4,250.1
Total Coal Consumption	4,244.3

Coal Consumption by usage 2013

	Mt
End-use Consumption	1,194.9
• Industry	982.2
Intermediate Consumption*	2,823.6
• Power Generation	1,951.8
• Heating	227.1
• Coking	625.4
• Petroleum Refineries and Coal to Liquids	4.6
• Gas Production	8.5
Losses in Coal Washing and Dressing	225.8
Total Coal Consumption	4,244.3

* consumed in conversion

Power capacity in GW at 31 December 2013 and 2014

	2013	2014
Coal	795.8	832.3
Natural gas	42.8	57.0
Oil	5.9	5.1
Other thermal power*	25.6	29.2
Nuclear energy	14.7	20.1
Hydro Power	280.4	304.9
Wind	76.5	96.6
Solar PV	15.9	24.9
Others	0.1	0.2
Total	1257.7	1370.2

* mainly afterheat, by-product pressure, garbage, biomass

Power generation (net) in TWh in 2013 and 2014

	2013	2014
Coal	3980.5	3951.0

Natural gas	116.4	133.3
Oil	5.2	4.4
Other thermal power*	119.5	138.7
Nuclear energy	111.5	133.2
Hydro power	892.1	1060.1
Wind	138.3	159.8
Solar PV	8.4	23.5
Others	0.3	0.5
Total	5372.1	5604.5

* mainly afterheat, by-product pressure, garbage, biomass

Source for all tables: China Statistical Bureau