GECF

GECF Expert Commentary

Role of Natural Gas in China 2050

Dr. Hussein Moghaddam
Senior Energy Forecast Analyst

Energy Economics and Forecasting Department

Disclaimer:

This report is not intended as a substitute for your own judgment or professional advice for your business, investment, finance, or other activity. The analysis and views presented in this report are those of the GECF Secretariat and do not necessarily reflect the views of GECF Member and Observer Countries.

Role of Natural Gas in China 2050

23 October 2019

Dr. Hussein Moghaddam, Senior Energy Forecast Analyst, Energy Economics and Forecasting Department (EEFD), GECF

China energy facts

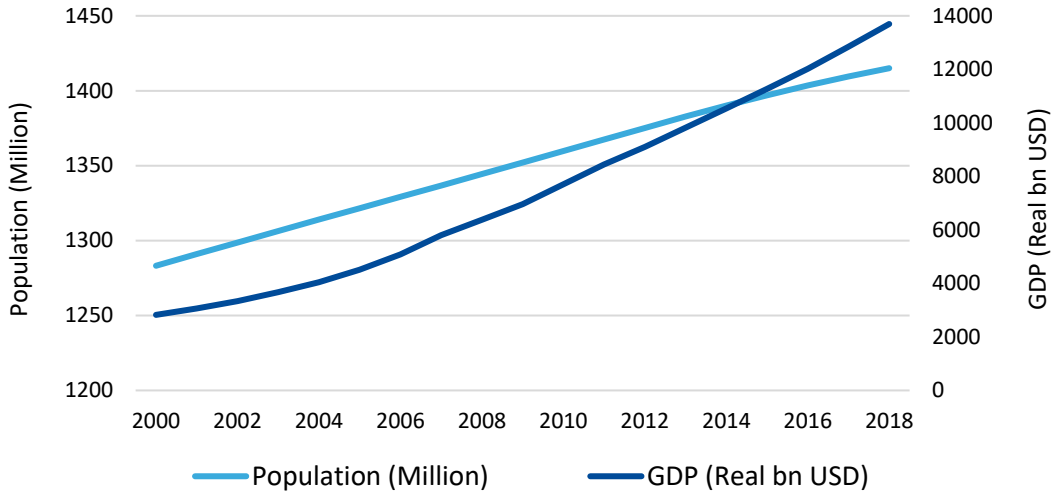
- In 2018 China accounted for 22% and 52% of global and Asia energy demand, respectively.
- Coal dominates Chinese energy demand. Its share weakened in the Chinese energy mix to 61% last year, from 70% in 2007.
- Gas plays a relatively small role in China's energy mix at just 7%, but it is the only fossil fuel that continues to rise and will constitute 15% of its energy generation in 2050.
- Renewables grew faster than other energy sources in China from only 4 Mtoe in 2000 to more than 124 Mtoe in 2018.
- Currently 67% of China's power sector is derived from coal-fired power stations that will fall to 31% in 2050.
- Nuclear power generation capacity soon rising to 83 GW by 2025, then rising again to 230 GW in 2050.
- China accounts for about 43% of Asia's natural gas demand in 2018 and with 688 bcm consumption in 2050 will account for more than half of Asia's gas demand.
- China is the world's fourth-biggest producer of natural gas and will keep its position by 2050, with unconventional resources to the fore.
- China has imported 123 bcm of gas in 2018 and imports expected to be nearly doubled by 2050.
- Import dependency in China is estimated to reach 40% in 2050. Due to the energy security, the country is maximizing its pipeline gas and LNG imports by diversification from multiple sources.

Introduction

China with a population of about 1.415 billion in 2018, is the most populous country in the world. Over 59% of the country's population lives in urban areas and it is estimated that the urban population will reach 1.092 billion in 2050.

The country has a steadily growing economy, with an average growth rate of 9.2% per annum between 2000 and 2018. China's GDP amounted to 13,695 billion USD in 2018, or 16.1% of the world economy. As measured by nominal GDP, China has the second-largest economy in the world, after the United States. Furthermore, China is the world's largest energy consumer and the largest emitter of greenhouse gases. Around 90% of China's natural assets are rare earth metals and coal, giving the country a high potential for coal and lithium production.

Figure 1. China population and GDP



Source: GECF Secretariat based on data from the GECF GGM

Primary energy demand

Primary energy demand grew steadily between 2000 and 2018 by an average of 6.0% per annum, reaching 3,218 Mtoe in 2018. Thus far, the country is the world's largest energy consumer, accounting for 22% of global primary energy demand. The GECF forecasts that primary energy demand in China is to slow to 0.5% per annum by 2050, peaking at about 4,452 Mtoe in 2038, and then falling to 4,413 Mtoe in 2050. Population and urbanization growth, improving living standards, and strong policy push to electrify Chinese end-users are the main drivers behind this 17% incremental growth in primary energy demand per head.

Regarding the slowdown in energy demand growth, the Chinese economy is shifting from an energy-intensive industry to a service-focused industry with lower energy intensity. Therefore, energy demand growth from industrial sectors will decline, and consequently energy intensity per unit of GDP will improve. Rising energy efficiency will also contribute to reducing energy demand.

Coal

Coal accounts for over 90% of fossil energy proven reserves and it takes the largest share in the country's energy demand. Moreover, energy demand for all fuels except coal, is forecast to expand over the outlook period. Although China consumed 51% of all coal produced globally in 2018, and coal constituted 61% of the country's energy mix, the country's coal demand is expected to decline from 1,978 Mtoe in 2018 to 1,173 Mtoe in 2050. The National Development and Reform Commission (NDRC) of China aims to reduce 5,800 coal mines with an average production capacity of 920,000 tonnes per year in 2018 to less than 800 mines by 2021. In addition, the NDRC will shut down all coal mines with capacities below 300,000 tonnes per year by the end of 2019. Even though China is pushing forward to close low-reserve-quality mines

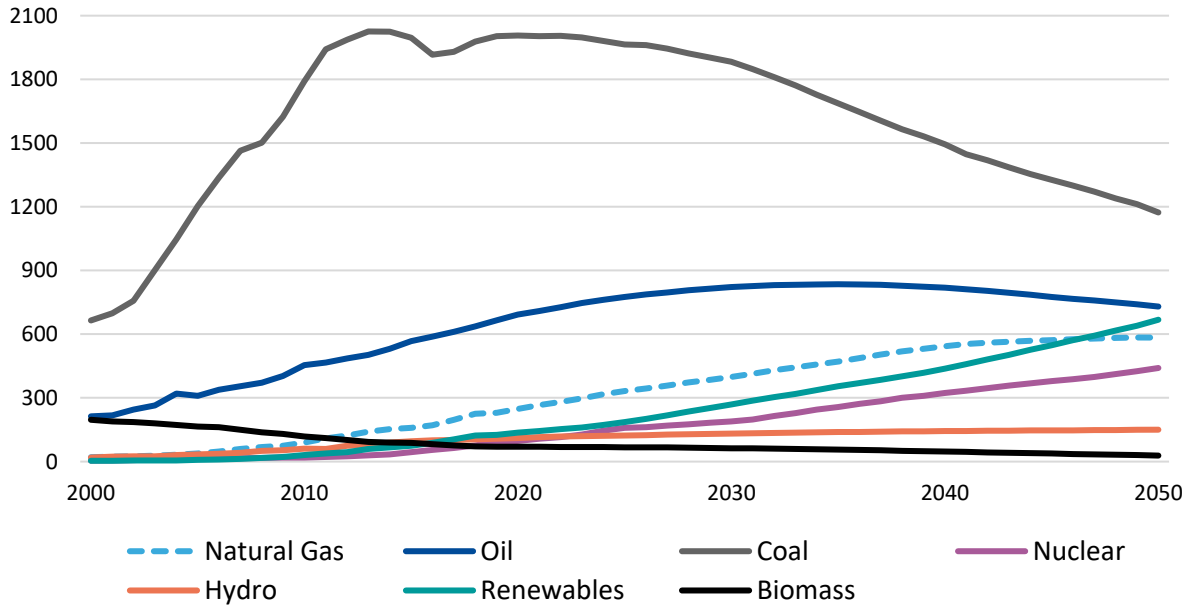
with low safety, coal will remain a key component over the medium- and long-term, and it is forecast to account for 31% of the country's energy mix in 2050.

Oil

China's oil demand growth has been the main contributor to the global oil demand growth in recent years, amid an expanding middle class and overall economic growth in the country. Indeed, the country consumed around 637 Mtoe or 14% of global oil demand in 2018. Total oil demand grew by nearly 400,000 barrel per day year on year in 2018, on the back of expanding demand for lighter oil products, including LPG, naphtha, gasoline and jet/kero. The former two products performed well, as the country's petrochemical sector exhibited rapid expansion. In fact, the trend to integrate refining and petrochemical facilities has been pronounced – the 400,000 barrel per day Dalian refining and petchem facility was launched in early 2019, while the 402,000 barrel per day Rongsheng refining and petchem plant is expected to commence commercial operations in Q4 2019. Growth in the transportation fuels (gasoline and jet/kero) came amid rising car ownership (expanding middle class) and increasing flight hours.

Looking forward, China is expected to continue being a key factor in the world oil demand growth. However, its prospects are limited by a multitude of factors, including an expanding electric vehicles fleet, predominantly public transportation, e.g. buses, which would have an effect on middle distillates demand, a growing services sector at the relative expense of industrial oil demand, which would have an impact on middle distillates and heavy oil products' demand. Furthermore, trade-related disputes could also put a dent in oil demand growth. Therefore, this report projects that oil demand will peak between 2034 and 2036 at around 835 Mtoe and then will fall to 731 Mtoe in 2050.

Figure 2. China primary energy demand trends by fuel type (Mtoe)



Source: GECF Secretariat based on data from the GECF GGM

Nuclear

Nuclear increases by 17.3% per annum from just 4 Mtoe in 2000 to 77 Mtoe in 2018, which is 11% of global nuclear energy consumption. Since 2016, the country has developed 16 high power reactors, and currently there are 47 nuclear power plants in China, with another 11 plants under construction. The initial plan is to build 6 to 8 new nuclear reactors every year, to have 110 operational reactors by 2030. Over medium-term, the country aims to produce 58 GW of total installed nuclear capacity by 2020 and to have another 30 GW under construction. China has also plans to build up 30 nuclear reactors under its worldwide Belt and Road nuclear projects. The GECF expects that nuclear demand in China will increase by an overall of 474% to 441 Mtoe in 2050.

Renewables

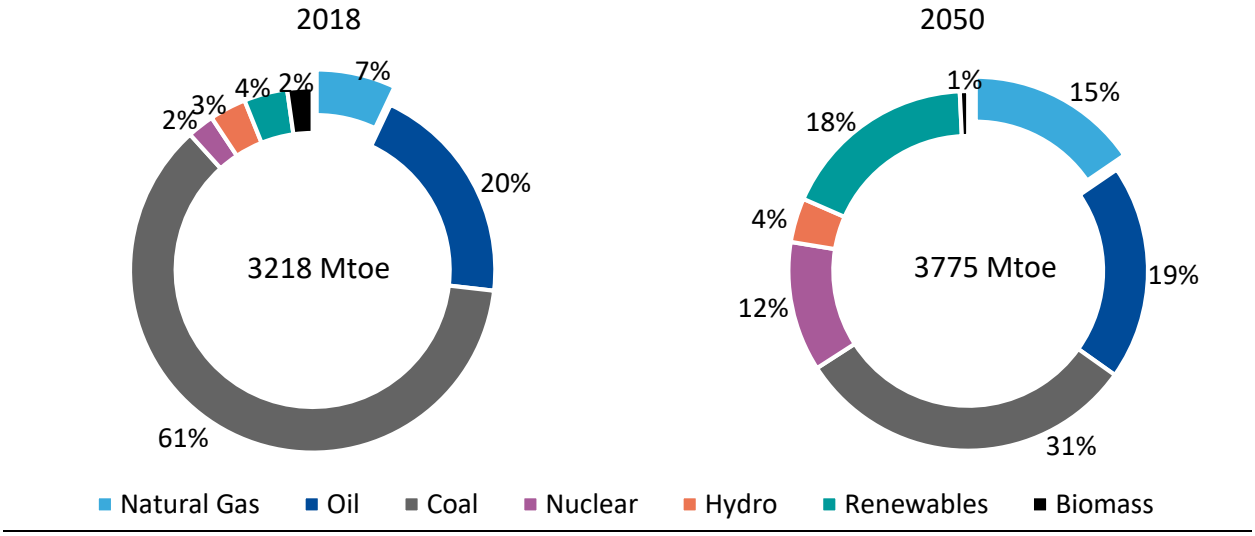
China is the leading country in electricity production from renewable energy sources. Indeed, the country sees renewables not just as a way to reduce its GHG emissions, but also as a way to enhance its energy security. Between 2000 and 2018, renewable energies demand grew faster than other fuels with an annual average growth rate of 21.2%, from only 4 Mtoe in 2000 to more than 124 Mtoe in 2018.

In recent years, significant investments in renewable energy sectors have been made by China. Just in 2019, the government plans to allocate USD 248 million in subsidies for centralised solar projects. Hence, more than 3,900 large-scale PV centralized - corresponding to a total capacity of 22,790 MW projects- in 22 Chinese provinces have received an approval. The National Energy Administration (NEA) regulator has also decided to allocate a maximum USD 435 million subsidies for new solar projects, including USD 325 million for large-scale and USD 109 million for rooftop solar power plants projects, with a combined capacity of 3.5 GW. Notwithstanding, the newly-constructed solar PV capacity will be connected to the Chinese grid and thus its capacity will rise from the current 186 GW and to more than 400 GW by 2025.

Despite these investments, China has progressively cut its financial support for onshore wind and solar projects and has promoted subsidy-free projects. According to the NEA press, in 2019 the NDRC and the NEA regulators approved 250 renewable power projects totaling 20,760 MW in 16 Chinese provinces to be developed without financial support. For instance, in an attempt to ease, a USD 14-17 billion-payment backlog, China is setting an annual cap on solar subsidies. Furthermore, the NDRC decided in 2019 to cut feed-in tariffs (FiTs) for onshore wind projects in July 2019 and 2020 and for new onshore wind projects in January 2021.

All things considered, in this report Chinese renewables demand is projected to grow at a slower pace over the outlook horizon compared to that observed in the historical period, by 5.4% per annum and an overall increase of 441%, to reach about 668 Mtoe in 2050.

Figure 3. China primary energy demand in 2018 and 2050 by fuel type (%)



Source: GECF Secretariat based on data from the GECF GGM

In 2018, natural gas played a relatively small role in China's energy mix at just 7% of total demand. Natural gas is the only fossil fuel that will continue to exhibit continuous y-o-y growth by 2050, which is projected to translate into a 358 Mtoe increase in demand over the next 30 years from 226 Mtoe in 2018 to 584 Mtoe. Furtermore, combined, natural gas and oil are still expected to account for more than a third of China's primary energy demand in 2050.

Natural gas demand

Natural gas consumption grew rapidly between 2000 and 2018 by an annual average growth rate of 13.3%, from 28 bcm to 268 bcm and is expected to exceed 300 bcm in 2019. China accounted for about 43% of Asia's natural gas demand in 2018.

Over the forecast period, gas demand growth will slow at an annual average rate of 3.0%. With concerns over air quality issues, the Chinese government sees gas as a key part of the transition to cleaner energy and is targeting natural gas demand to meet 8-10% in its energy mix by 2020, and 15% by 2030. Hence, the GECF expects that China's gas demand will continue to remain significant, with more than double in 2030, reaches to around 553 bcm at which point it will make up around 11% of the country's energy mix, and then increases to 688 bcm by 2050 accounting for more than half of Asia's gas demand.

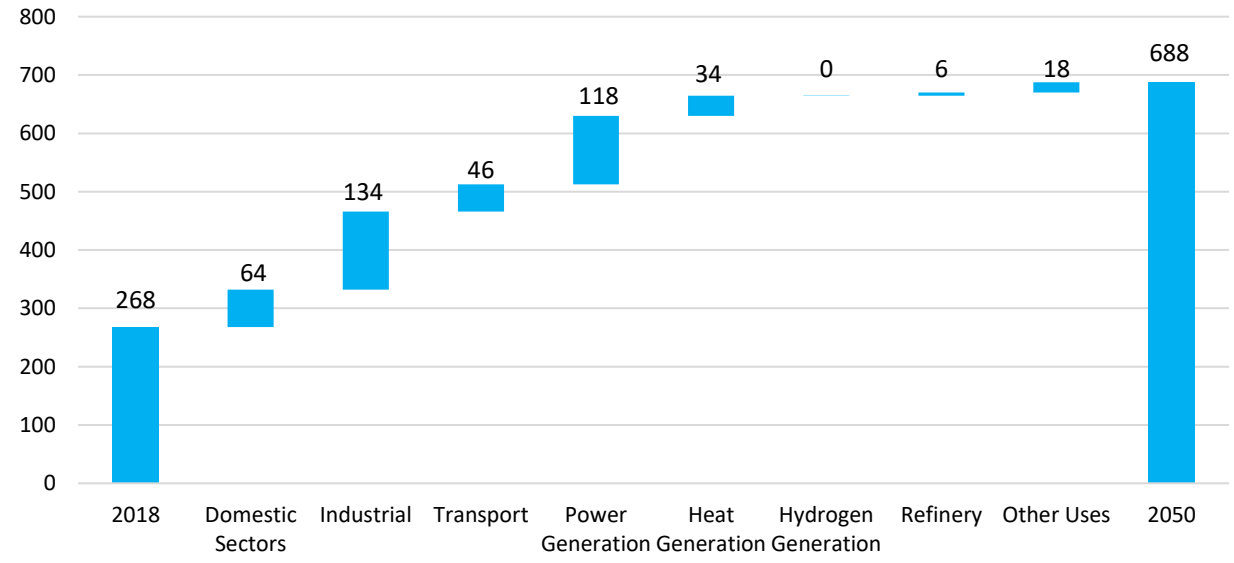
Switching from coal to gas, expansion of gas pipeline networks in the country, economic growth, urbanisation and urban gasification will be the main drivers of demand growth over 2018-2050 period.

Looking ahead, the power generation sector (+310%), will be the biggest driver of overall growth, followed by the industrial (+204%), heat generation (+199%), transport (171%) and domestic (city gas) (+87%) sectors.

In the Chinese power generation, coal is the dominant fuel and it constituted 67% of the generation mix in 2018. The country had about 1,050 GW of coal-fired power generation capacity by the end of 2018. In the last development plan for the power sector, the government aims to increase gas-fired power generation capacity to 110 GW by 2020. As domestic gas production is not sufficient to meet demand by gas-fired power generation capacity, China has to rely on pipeline and LNG gas imports to meet its surging electricity demand. This development bears reliability of supply and energy security risks. The higher prices of gas imports compare with the coal prices and Chinese targets to become the world's renewable energy superpower, have also impact on the development of the gas-fired power generation units. As a result, it is unrealistic to expect the government to eradicate all coal-fired power units from its power generation mix over medium or long-term.

Reasoning from this fact, to meet its pledge at the Paris COP21 to reduce carbon intensity by 60-65% from 2005 levels by 2030, the country set emissions and efficiency standards for reducing emissions from coal-fired power plants as a part of China's the 13th Five Year Plan (FYP). Therefore, in the short-term as a part of its efforts to curb GHG emissions, the country aims to shut nearly 8.7 GW of aged coal-fired power plants by the end of 2019. Also all provinces should shut their old coal-fired power units with a capacity of less than 50,000 kilowatts. Over the medium- and long-term, China aims to establish a clean coal-power generation system and the largest power producers in China have already asked the government to review the FYP to add new ultra-low emission coal-fired capacity to peak by 2030 with a cap below 1,300 GW.

Figure 4. China natural gas demand by sector (bcm)



Source: GECF Secretariat based on data from the GECF GGM

Nevertheless, gas consumption in the power generation sector will rise slowly with an annual average growth rate of 4.5% from 38 bcm and 85 GW capacity in 2018, to 156 bcm and close to 400 GW in 2050 and that will make up 23% of total Chinese gas demand. Therefore, its share in the power generation sector will increase from 3% now to about 8%. As mentioned above, the growth is attributed primarily to China's environmentally driven policy of switching from coal to gas that has an impact on air quality.

Throughout the outlook period, natural gas demand from the industrial and heat generation sectors will grow at a slower pace compared to the 14.6% and 15.0% recorded accordingly over 2000-2018 period. Industrial gas demand will be the key driver and is forecast to increase from 66 bcm in 2018 to around 200 bcm in 2050, corresponding to an annual average growth rate of 3.5%, which constitutes 29% of total Chinese gas demand higher than all sectors. Heat generation sector is also increasing from 17 bcm in 2018 to 52 bcm in 2050.

The 168 bcm additional consumption in the industry and heat generation sectors drives by coal-to-gas switching policies. Key users in the industry sector are nonmetallic minerals for the production of about 92 different kinds of products (e.g. cement, ceramics, glass,…) with 56 bcm, and chemicals with 26 bcm gas consumption.

In the heat generation sector, also a large number of industrial boilers, furnaces and kilns will be converted to gas, in particular in north, east, and coastal areas of China, which are covered with hazardous coal-fueled smog for much of the winter season.

Gas usage in the transport sector is also expected to be a significant component of demand growth in China. Thanks to the government support the use of gas and LNG in the transport sector as a competitive alternative to petroleum, the consumption will increase by an average rate of 3.2% annually from 27 bcm in 2018 to 74 bcm in 2050. More than 85% of the demand will be in the road transport sector, as heavy-duty trucks will run on LNG. The country presently has about 326,000 heavy-duty trucks, sets to bring extra 115,000 units by the end of 2019, and has almost 4,100 LNG filling stations. Moreover, the consumption of domestic and international marine bunker vessels will increase the demand by around 10 bcm in 2050 as well.

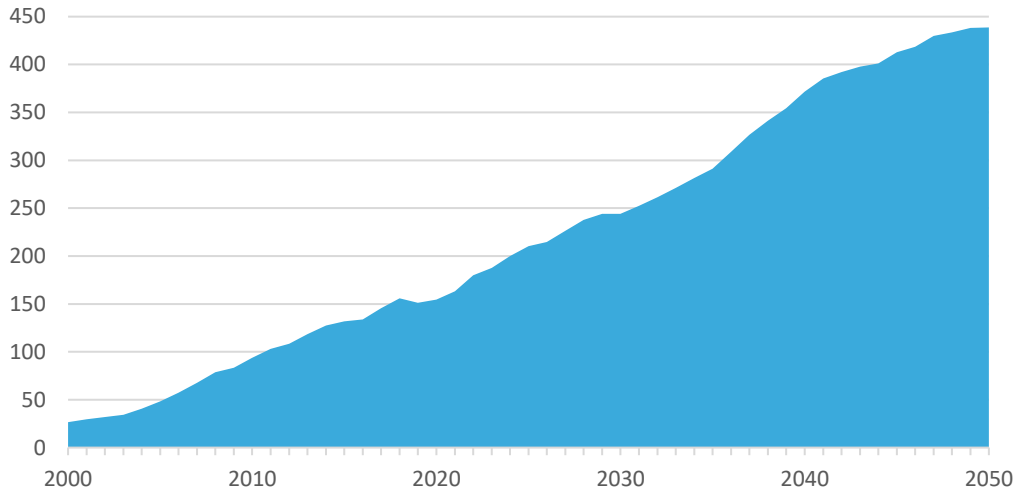
Natural gas production

Currently China is the world's fourth-biggest producer of natural gas and will keep this position by 2050. Gas production in China will remain impressive and is forecasted to increase by an overall of 181% between 2018 and 2050, with unconventional gas resources to the fore. The GECF expects that additional supply from both conventional and unconventional sources will increase China's domestic gas production from 156 bcm in 2018 to 439 bcm in 2050.

Regarding shale gas production, recently the NDRC has removed restricted items for foreign companies and allowed them to operate and invest in the oil and natural gas upstream sectors. Moreover, the government has reduced resource tax on shale gas and is considering extending subsidies for unconventional gas projects to incentives unconventionals production that be in effect through 2023. In 2018 almost 41% of total domestic gas production came from unconventionals of tight gas, shale gas, and coalbed methane, while just the shale gas production targets for 2030 are sets at 100 bcm shows China targets to boost domestic gas production.

The state oil and gas companies are developing shale gas in China. Since 2014, four shale gas fields have been discovered in the Sichuan basin: Fuling, Weiyuan, Changning and Weirong. China National Petroleum Corporation's (CNPC) and China Petroleum and Chemical Corporation (Sinopec) companies had made significant progress in cutting development costs and improving the efficiency of shale fracking technologies.

Figure 5. China natural gas production by type (bcm)



Source: GECF Secretariat based on data from the GECF GGM

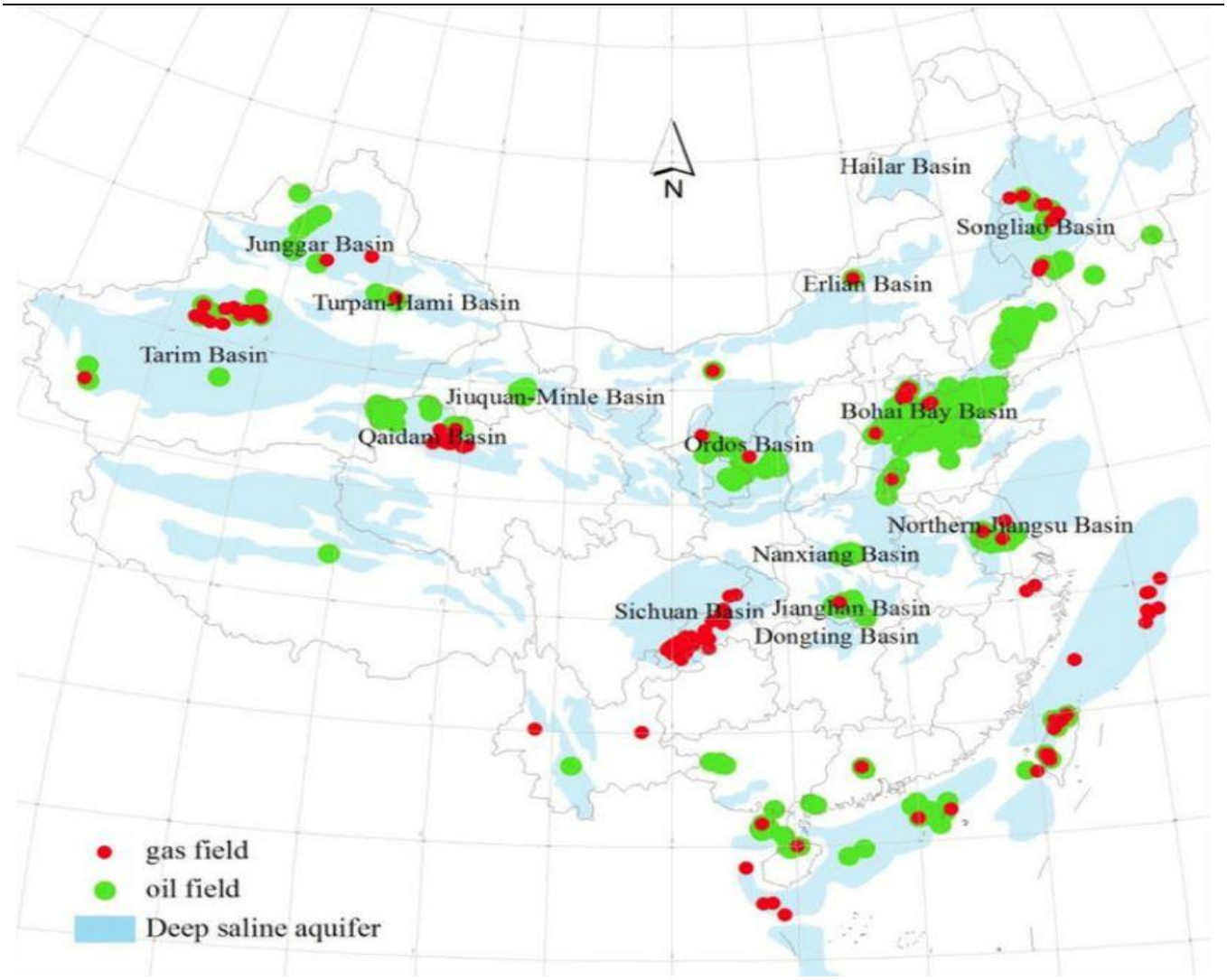
Sinopec operates one of the largest fields, the Fuling shale gas field, located in Chongqing in central southwest of China. The first phase of the Fuling shale went into the production in 2015. Thus far Sinopec has drilled 402 wells and produced more than 6 bcm of shale gas in 2018. The company is aiming to raise production to 10 bcm by 2020.

Sinopec also is operating the Yuanba gas field. Currently the field produces 11 mcm per day of raw gas, which is equivalent to meeting the gas demand of more than 10 million households per day in China. The field, located in southwestern China's Sichuan province. The construction of the Yuanba field started in 2011 and became operational in 2014. Yuanba is China's first ultra-deep reef gas reservoirs with high-sulfur gas and proven reserves of 220 bcm gas.

PetroChina operates the Changning-Weiyuan and Zhaotong projects with proven shale gas reserves of over 1 tcm. Changning shale gas field is in the southern part of the Sichuan basin and is one of the first pilot experimental shale gas projects in southwest China. Hitherto Petrochina drilled 148 wells in the field and by the end of 2019 will surpass 200 drilled wells. Hence, the production capacity will reach around 10 bcm, while the company's shale gas output is expected to be at about 7.7 bcm.

CNPC operates the Changqing oil field that is located in Inner Mongolia. The field is one of the biggest available fields and accounts for about a quarter of the total China's gas production. In 2018, CNPC produced around 38.7 bcm gas from Changqing. In addition, CNPC operates the Sulige gas field for coalbed methane development and the production of synthetic natural gas from coal, in central Ordos basin, which is a part of the Changqing oil field, with about 860 bcm of proven gas reserve. In 2018, the field produced about 24 bcm of natural gas.

Figure 6. China oil and gas fields



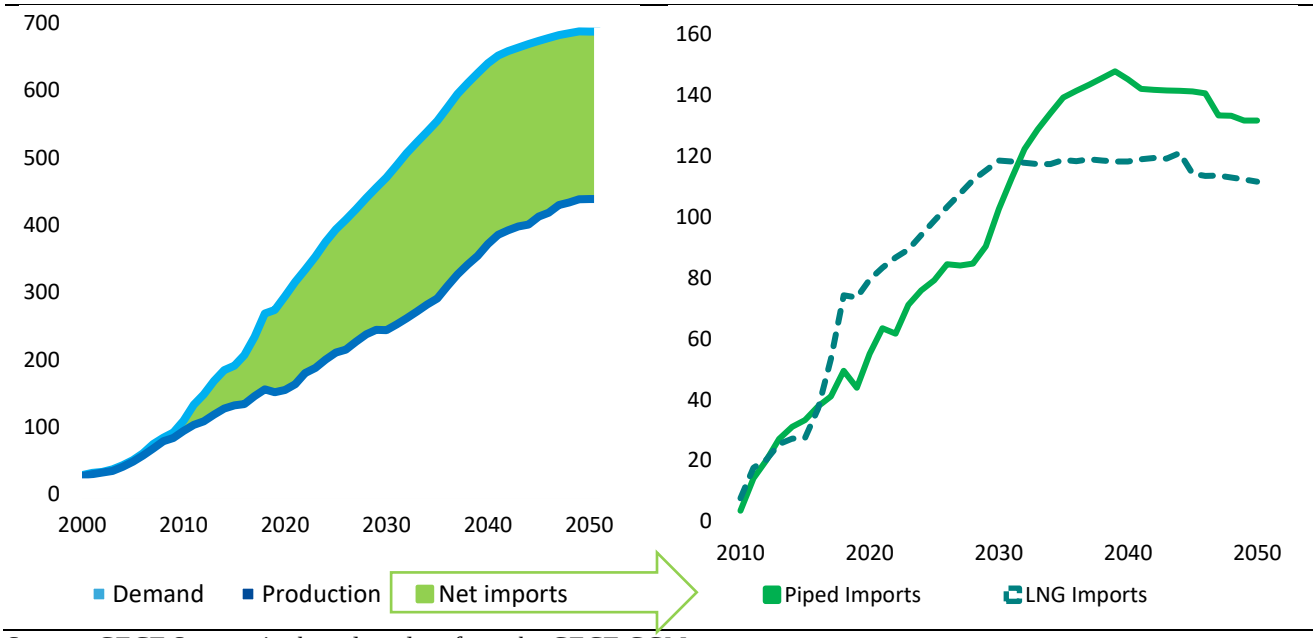
Source: https://www.researchgate.net/figure/Map-of-oil-and-gas-fields-in-China_fig2_257692045

Natural gas trade

China is a leading country in importing gas by pipeline and LNG. The country has imported around 123 bcm of gas (49 bcm by pipeline and 74 bcm by LNG) in 2018 and it is expected that this amount will nearly double by 2050 to about 244 bcm (132 bcm by pipeline and 112 bcm by LNG). Over the outlook period, gross domestic gas production is projected to account for about 60% of gas demand, and thus the country's import dependency is estimated to reach around 40% in 2050. Due to the energy security, China is maximizing its pipeline gas and LNG imports by diversification from multiple sources.

The country now has around 13 bcm of gas storage capacity with the effective operational volume of about 9 bcm. Compared to over 260 bcm natural gas demand, storage levels are relatively low. However, due to the increasing gas demand, gas infrastructure continues to expand rapidly to absorb imported gas.

Figure 7. Chinese gas production, demand and imports (bcm)



Source: GECF Secretariat based on data from the GECF GGM

Pipeline imports

China has begun importing gas by pipeline from three Central Asian countries, Turkmenistan, Uzbekistan, Kazakhstan, and Myanmar. In addition, the country has few projects underway to import gas by pipeline from Russia. At the end of 2018, the operational capacity of China's import pipelines was around 67 bcm per year, with the total length close to 120,000 kilometers. By 2025 the country planned to expand its pipeline infrastructure to over 240,000 kilometers.

One major development is the government policy on gas market liberalization and unbundling pipeline control from the three national oil companies, namely PetroChina, Sinopec, and CNOOC that control over 85% of the gas infrastructure. That will result in falling gas prices and hence has potential to stimulate gas demand.

Table 1. Capacity and status of natural gas import by pipelines to China

Line		Capacity (bcm)	Status
Central Asia	Line A	13	Operational
	Line B	17	Operational
	A to B upgrade	10	Planned 2020
	Line C	25	Operational
	Line D	30	Planned for 2020-2022 but apparently stalled
Myanmar		12	Operational but with actual sales of 3-4 bcm
Russia	Power of Siberia-1	38	Planned for December 2019 with full supply between 2025 and 2030
	Power of Siberia-2	30	Timing to be decided
	Far East	42	On stream in 2021 with full 42 bcm per year supply in 2024

Source: Various sources

The Central Asia Gas Pipeline (CAGP) Lines (A, B, C)

The three major Central Asian pipeline networks with 55 bcm capacity per year, flow from Turkmenistan to China, via Uzbekistan and Kazakhstan. Since 2009, launch of the first branch of the CAGP, China has imported 277 bcm gas. There is a plan to boost the volume by an additional of 10 bcm per year between Kazakhstan and China, but progress appears stalled. If the pipeline is completed, it will raise the capacity to 65 bcm per year.

The CAGP Line (D)

It was an agreement regarding the construction of Line D with the 30 bcm per year capacity from eastern Turkmenistan to China through Uzbekistan, Tajikistan, and Kyrgyzstan. Following that, the Central Asia-D line is scheduled for completion between 2020 and 2022. Nevertheless, so far the project appears to have stalled, especially in the Uzbek section as a result of gas demand uncertainty in China.

The Myanmar Line

The Myanmar line has entered into the operation in 2013, and despite its 12 bcm per year transportation capacity, it has supplied about 3-4 bcm to China in 2018. 2 bcm per year of the line is used to supply gas within the Myanmar itself.

From Russia

An eastern route (Power of Siberia 1): The Power of Siberia will be essential to solve future gas shortages in northern China. The imports will jump when volumes from the Russian Chayandinskoye gas field in Yakutia, with around 1.4 tcf gas reserves, start flowing through the Power of Siberia line 1 by December 2019 in a 30-year contractual period with CNPC. The flow will be peaked at 38 bcm per year between 2025 and 2030.

A western route (Power of Siberia 2): An extra 30 bcm per year via Power of Siberia-2 line or the Altai pipeline has been under discussion with Russia. This line would allow Russia to send gas to China from western Siberian fields using the short section of Russia-China border that exists between Kazakhstan and Mongolia to deliver the gas.

Far east: By expanding gas transmission in Blagoveshchensk, in the eastern route of the Power of Siberia, it is expected that the Sakhalin gas via the Sakhalin-Khabarovsk-Vladivostok pipeline, supply up to 42 bcm per year gas to the northern China by 2024.

The rest of China's gas demand will have to be supplied by LNG imports.

Figure 8. Russian gas pipelines to China

Source: Gazprom

LNG imports

Currently China has 22 operational LNG import terminals and state-run oil and gas companies own most of them. Almost 68 Mt capacity was operational at the end of 2018 and government has ambitious plan for the expansion of LNG import capacities by nearly four-fold within two decades with total annual import capacity of 247 Mt by 2035.

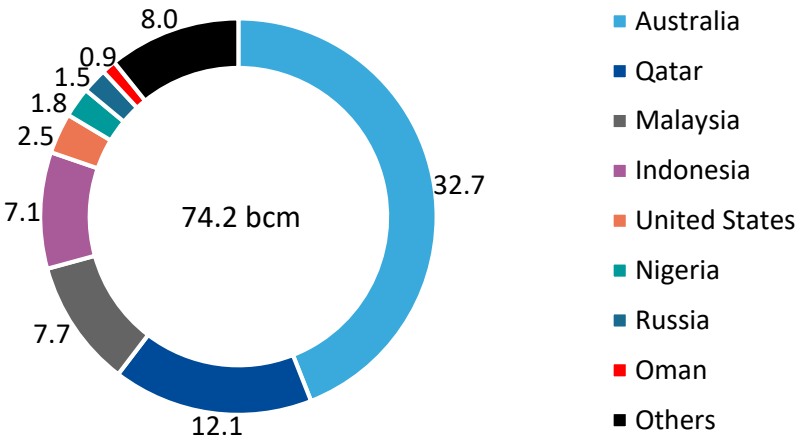
In 2006 it was just Australia that supplied less than 1 bcm LNG to China's first LNG import terminal in Guangdong Dapeng province. Chinese LNG imports increased rapidly since then to 74.2 bcm (54 Mt) in 2018 from different 25 countries. China's industrial coal-to-gas switching policy, especially when LNG

distributed via ISO containers trucks to the final industrial users, phasing out coal in the power generation sector, as well as in the residential heating sectors led to the LNG demand growth.

In 2018 LNG terminals received record amounts of LNG in China. Australia dominates China's LNG supply with 32.7 bcm, following by Qatar 12.1 bcm, Malaysia 7.7 bcm and Indonesia 7.1 bcm in 2018. US LNG provided 2.5 bcm of total LNG imports and is expected to be less over the short-term as China imposed a 10% tariff on the US LNG.

The ongoing policies to improve air quality continue the LNG demand growth and China is going to be a massive markert for LNG, although the rate of growth is slowing. LNG import will be peaked between 2040 and 2045 at around 121 bcm (87 Mt) and then is expected to fall to about 112 bcm (80 Mt) in 2050.

Figure 9. Chinese LNG imports by country in 2018 (bcm)



Source: GECF Secretariat based on data from the GECF GGM

Conclusion

China's energy demand is forecast to grow substantially by 2050, whereas the country's energy supply mix is expected to undrgo some changes. Coal, which currently constitutes the largest share in the country's energy mix, is expected to lose both in absolute, as well as in relative terms. At the same time, gas is forecast to gain in importance, as the country puts priority of clean energy development. A rise in domestic gas demand would translate into higher import requirements for the blue fuel, as the prospects for domestic supplies currently seem to be limited. Consequently, the country will see its gas import infrastructures (both pipline and LNG terminals) expand.

Looking into the global energy market features, in particular oil and gas sectors shows that there is a number of prominent factors affecting the market disciplines beyond supply-demand classical relationships. China is one of the best instances (if not the only one) of such markets. Its energy behavior needs to be constantly monitored and analyzed by gas exporting countries. Growing in natural gas

demand, boosting in gas production (both in conventional and unconventional), and setting ambitious plans for reducing GHG emissions by converting to gas-fired power plants on one hand, high bargaining power as a buyer, geopolitical position and tension, and lower prices of substitutable energies such as oil and coal on the other hand, make the country a giant influential player in the global gas market. In other words, China's objective is to become the largest global economy after the US in the long-term. Achieving this goal requires an increase in its energy demand that will consequently increase China's bargaining power against energy prices such as natural gas. Being informed timely, China's current energy suppliers like some of the GECF member countries might make a better decision for their trade policies toward China. In fact, they might have a more comprehensive overview of the advantages or disadvantages of trading natural gas with China. For instance, the gas industry suppliers may shrink costs speedily in either pipeline transmission or shipping LNG carriers. They may negotiate contracts in a more competitive way not to lose the ground to Pacific or East Asian suppliers such as Australia. Thus, at least with the current situation it seems China's market is attractive enough to bear the costs of some optimizations in future both in process and in production.

Contact: Hussein.Moghaddam@gecf.org