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LNG is not displacing coal in China's power mix

China is leapfrogging to renewables without relying on LNG as a "bridge fuel"

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Key Findings

In China, LNG will play a minimal role in supporting the clean energy transition in the largest coal-consuming sectors. The growth of renewables generation, rather than gas or LNG, has eroded the share of coal generation in the country's power mix.

Over the past decade, the share of gas-fired electricity in China's power mix has remained at just 3%, while the share of wind and solar has quadrupled to 16%. The growth of renewables has contributed more than gas to a reduction in coal's market share from 70% to 61%.

China is relying on domestically produced resources for energy security and reliability. Recent policies aim to control coal-to-gas switching while setting limits on LNG imports.

LNG is too expensive to meaningfully replace coal in power generation. Coal-generated power is US$30-40 per megawatt-hour cheaper than natural gas, while onshore wind and solar are the cheapest power sources. Falling costs for renewables and storage technologies pose the biggest risk to gas-fired generation.

Executive Summary

One of the most common arguments to justify investments in liquefied natural gas (LNG) infrastructure and promote consumption globally is that LNG provides a "bridge" to clean energy by displacing carbon-intensive coal usage. Proponents often point to China — the world's largest coal consumer and LNG importer — as a key example of where LNG can supplant coal-fired generation, while life-cycle assessments associated with natural gas and LNG typically focus on coal displacement in the power sector.[1, 2, 3, 4, 5, 6, 7]

This report examines claims about the role of LNG in displacing coal in China's power mix — the country's largest coal-consuming sector — by focusing on national energy sector developments over the past decade. It finds little evidence to support arguments that LNG imports to China will meaningfully displace coal usage in the country's power mix due to the following reasons:

1. Rising LNG imports to China over the last decade have not reduced or slowed the country's coal consumption.

Although China is the world's largest LNG importer, the country's coal demand has increased more than LNG imports every year since 2017. Claims about the role of LNG in displacing coal usage appear to be based on hypothetical arguments that coal generation would be even higher without gas-fired power. Yet, the share of natural gas in the country's power generation mix has remained at just 3% since 2015, while annual coal-fired power capacity additions continue to surpass new gas-fired power plants.

[1] *"…U.S. natural gas is a far cleaner option than coal for electricity generation, especially in key markets in China, Germany and India."* American Petroleum Institute. Study: New Lifecycle Analysis of U.S. LNG exports. 2020.
[2] *"China will continue to demand liquefied natural gas as it continues its program of coal-to-gas switching…Our liquefied natural gas (LNG) exports to Asia are an important part of the climate solution. For every tonne of carbon dioxide emitted during production in Australia, LNG saves between three and ten tonnes of emissions when it replaces coal in power generation in Asia."* Santos. Climate Change Report. 2020. Page 20.
[3] "*Producing energy by burning coal remains cheaper than natural gas, but countries including China are already establishing policies and incentives that encourage the use of LNG to generate electricity.*" Vancouver Sun (sponsored by LNG Canada). LNG Canada's export terminal will enable coal-reliant customer nations to reduce GHG emissions. 29 November 2018.
[4] "*So what we're doing is trying to clean the air in China by delivering natural gas that can displace the coal and the oil that they're currently using for generation*." *– Cheniere CEO Jack Fusco.* Hart Energy. Cheniere CEO Talks LNG Exports As Trade War Continues. 23 October 2018.
[5] "Venture Global spokesperson Shaylyn Hynes said, '*American LNG is the best weapon in our arsenal to quickly displace global coal use and combat climate change*.'" Reuters. Oil, gas lobby group warns against US slowing LNG approvals. 10 January 2024.
[6] "*Unleashing U.S. LNG and replacing international coal with American natural gas is the largest green initiative on the planet and the world's best weapon to address climate change.*" EQT. Unleashing U.S. LNG. Accessed: 10 June 2024.
"*China's Current Electricity Mix Mirrors that of Pennsylvania and Ohio in 2005. With Natural Gas, China Could Replicate the U.S. Model for Emissions Reduction*." EQT. Unleashing U.S. LNG – The Largest Green Initiative on the Planet. Accessed: 10 June 2024. Page 28.
[7] Several examples of life-cycle emissions assessments for coal and natural gas usage in power generation are listed here: Boersma, Tim and Jordaan, Sarah M. Whatever happened to the Golden Age of natural gas? 21 August 2017.

2. The growth of renewables generation, not gas or LNG-fired power, has eroded the share of coal generation in China's power mix.

As the share of gas-fired electricity has remained flat, the share of wind and solar in China's power mix has quadrupled over the past decade. In absolute terms, generation from wind and solar has increased by 1,250 terawatt-hours (TWh) since 2015, while natural gas-fired generation has increased by just 140TWh. Although coal generation has increased 1,700TWh over the same timeframe, its market share has fallen from 70% to 61%. This suggests that although coal-fired power is not being displaced in absolute terms, wind and solar contribute more than gas to reducing coal's share in the generation mix.

3. China relies on domestically produced resources, rather than LNG, for energy security and reliability.

Recent policies aim to "strictly control" coal-to-gas switching and promote domestic production of coal and natural gas[8], while setting limits on LNG import dependence. As a result, coal capacity additions have far outpaced additions of gas-fired power plants, and both are dwarfed by wind and solar installations. National energy sector development plans have called for coal plants to provide flexible operations to integrate variable renewables sources.

4. On a cost basis, LNG is too expensive to materially displace coal in power generation.

In 2023, the average LNG import price was nearly three times the average cost of coal supply in China. Although LNG prices are expected to decrease in the coming years due to a surge in new supply, prices are unlikely to fall to levels that are competitive with coal. Power generated from coal in China has tended to be US$30-40 per megawatt-hour cheaper than from natural gas. Meanwhile, onshore wind and solar are the country's cheapest sources of power. Falling costs for renewables and storage technologies pose the biggest risk to gas-fired generation.[9]

LNG is doing little to displace coal consumption even outside China's power sector. Chinese investments in coal-based iron and steelmaking capacity still far exceed natural gas-based processes, and full decarbonization will require non-fossil fuel alternatives rather than a shift from coal to gas. In urban areas, efforts to replace coal-fired stoves with gas heaters have been reasonably successful but have largely run their course, and extending these efforts into rural areas will prove challenging. Other policy factors weigh heavily against widescale coal-to-gas switching, including the perceived energy security and cost benefits of domestically sourced coal, as well as recent achievement of urban air quality targets that have reduced the air quality arguments for curbing coal use.

[8] National Development and Reform Commission (NDRC). Report on the Implementation of the 2022 Plan for National Economic and Social Development and on the 2023 Draft Plan for National Economic and Social Development. 05 March 2023. Page 66.
[9] Wood Mackenzie. The future of China's gas demand. 05 October 2021.

Ultimately, policymakers in both LNG exporting and importing countries should approach industry arguments about the necessity of LNG as a "bridge fuel" from coal to renewables with skepticism. Evidence from China — touted by the industry as a key market for LNG displacement of coal — shows that LNG is expected to play a minimal role in supporting the clean energy transition in the country's largest coal-consuming sectors.

I. Introduction

China's Production and Consumption Trends for Coal, Natural Gas, and LNG

China is the world's largest energy consumer, and coal accounts for 55% of its total primary energy demand. Natural gas, hydroelectricity, and non-hydro renewables each provided 8% of primary energy consumption in 2022.[10]

China is also the world's largest coal producer and the fourth largest natural gas producer.[11] Between 2012 and 2022, China's natural gas production grew at a faster annual rate than the United States (albeit from a lower base).[12] In 2023, the country's annual coal production rose to an all-time high of 4.7 billion tonnes, 14% above 2021 levels.[13, 14]

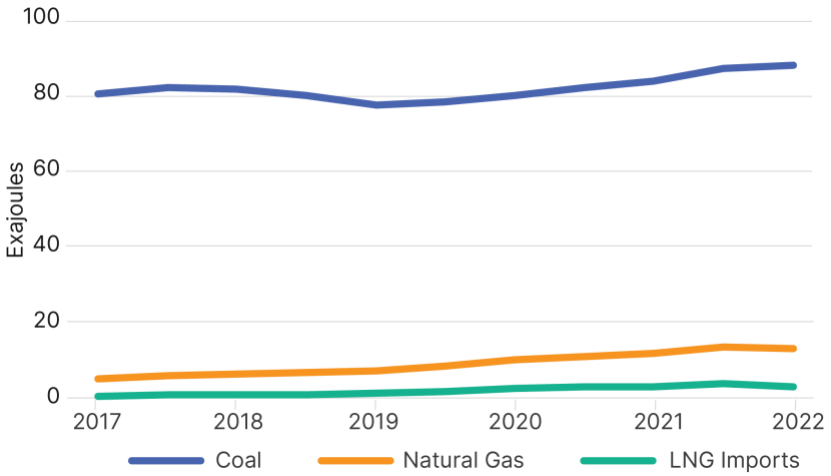
Despite rising coal and natural gas production, rapid increases in the country's total energy demand are also causing a greater reliance on imported energy. China is the world's largest coal importer, with imports accounting for roughly 10% of the country's total coal supply. In 2022, China was the second largest importer of pipeline gas after the United States. In 2023, China reclaimed its spot as the world's largest LNG importer, surpassing Japan. However, national energy plans and recent policies emphasize domestic energy production, rather than imports, to achieve energy security and reliability (discussed in Section III).

Rising LNG imports to China have not reduced or slowed the growth of coal consumption. The country's coal, natural gas, and LNG demand have all increased since 2016. China consumes nearly seven times more coal than natural gas, though consumption of both fuels increased by roughly the same amount (8 exajoules) between 2012 and 2022 (Figure 1). China also consumes 26 times more

[10] Energy Institute. Statistical Review of World Energy. 2023. Page 9.
[11] China produces six times more coal than India, the world's second largest coal producing country. Energy Institute. Statistical Review of World Energy. 2023.
[12] China's natural gas production grew 7.1% per year from 2012 to 2022. Energy Institute. Statistical Review of World Energy. 2023.
[13] IEEFA calculations based on: National Bureau of Statistics (NBS). Monthly Data - Output of Coal. 15 May 2024.
[14] The country is also establishing a back-up production system with 300 mt of dispatchable coal production capacity by 2030. Reuters. China to set up coal production reserve to stabilise prices. 06 December 2023.

coal than LNG. Although LNG imports have grown at a faster rate than coal in recent years (from a significantly lower baseline), coal demand has increased more than LNG imports in absolute terms every year since 2017.

Figure 1: China Coal, Natural Gas, and LNG Consumption



Note: The "LNG Imports" category represents a subset of overall natural gas consumption.

Source: Energy Institute (EI). Statistical Review of World Energy. 2023. [15]

The country's largest coal consuming sectors are power generation (60% of total coal consumption), industry (33%), and buildings (3%).[16, 17] Given industry claims about the competing role for LNG and coal in power generation, Sections II through IV examine displacement of coal in the power sector. Displacement in non-power sectors is discussed briefly in Section V.

II. Power Trends

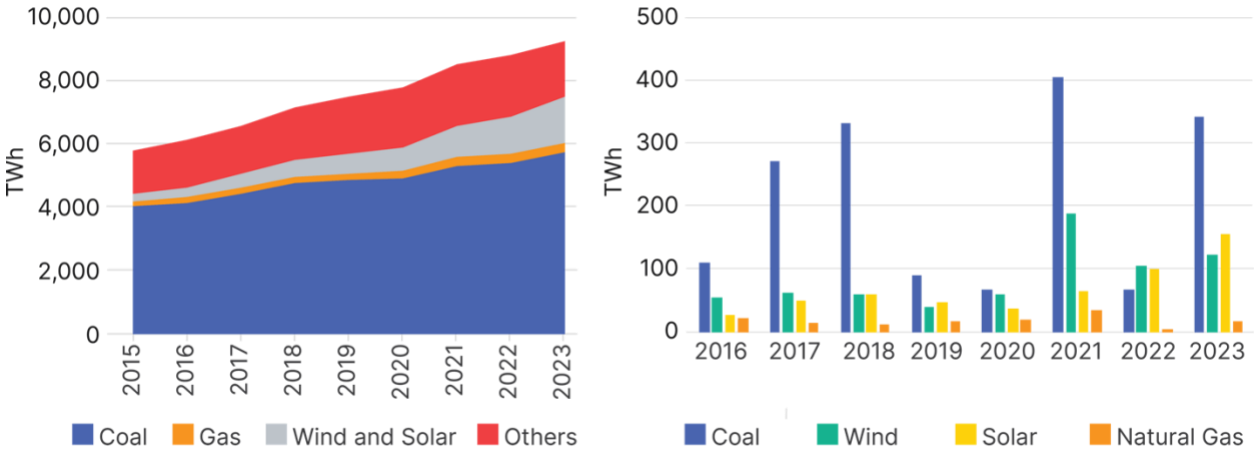
Renewables and Coal are Squeezing the Role for Natural Gas

China's electricity generation has grown at an average annual rate of 6.3% since 2015.[18] Generation from coal, natural gas, wind, solar, and nuclear have all increased every year over that timeframe.

[15] CORRECTION: This chart was amended on 7 October 2024. The dates ranged from 2022 to 2027; they should range from 2017 to 2022. We regret the error.
[16] International Energy Agency (IEA). An Energy Sector Roadmap to Carbon Neutrality in China. September 2021. Page 23.
[17] Statista. Consumption of coal in China in 2019, by sector. 2021.
[18] IEEFA calculations based on Ember data. Ember. Electricity Data Explorer. Date accessed: 10 May 2024.

However, increasing renewable power generation has eroded coal's dominant market share, while the share of gas has remained stagnant. Wind and solar generation have increased by a combined 1,250 terawatt-hours (TWh) since 2015, at a compound annual growth rate (CAGR) of 26%.[19] Over that time, natural gas generation increased just 140 TWh. Annual increases in solar and wind generation have outpaced increases in gas-fired generation (Figure 2).

Figure 2: China's Power Mix (left); Annual Generation Growth of Select Technologies (right)

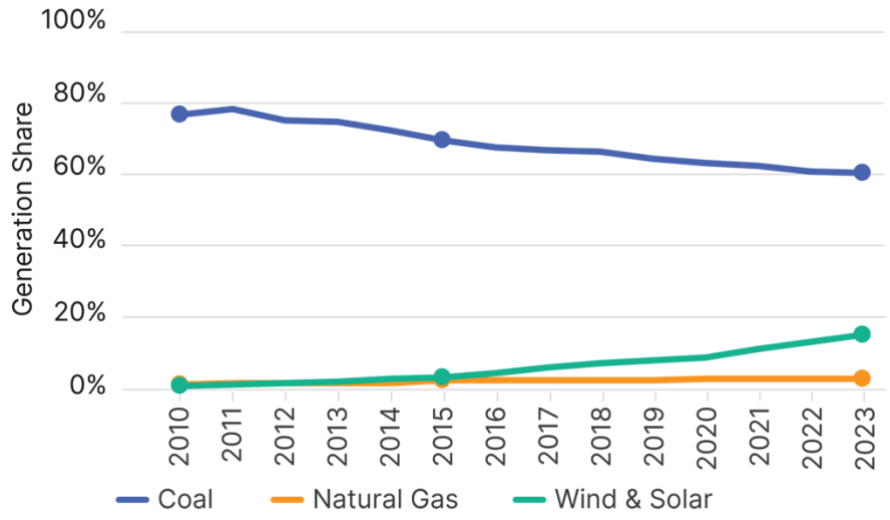


Source: Ember.

As a result, the market share of wind and solar has quadrupled, from 4% in 2015 to 16% in 2023. Meanwhile, the share of gas generation has remained at 3% over the same period (Figure 3).[20] Annual increases in coal generation continue to exceed growth from all other sources, indicating that coal displacement is not occurring in absolute terms. However, the market share of coal-fired generation has declined from 70% in 2015 to 61% in 2023, suggesting that the growth of wind and solar is contributing to an erosion of coal's dominant position in the power mix.[21]

[19] Ember. Electricity Data Explorer. Date accessed: 10 May 2024.
[20] Data concerning the relative contribution of domestic gas, pipeline imports, and LNG to overall gas-fired power generation is limited, but LNG is assumed to account for a subset of the 3% power market share of natural gas.
[21] Note that the market share of nuclear has increased from 3% to 5% since 2015, while the share of hydropower has fallen from 19% to 13%. Ember. Electricity Data Explorer. Date accessed: 10 May 2024.

Figure 3: Generation Share of Coal, Natural Gas, Wind, and Solar



Source: Ember.

Looking ahead, generation from coal and renewables will continue to exceed gas-fired generation, and capacity investments suggest that LNG and gas will continue to play a limited role in coal displacement. In recent years, gas plant capacity additions have paled in comparison to coal and renewables additions.

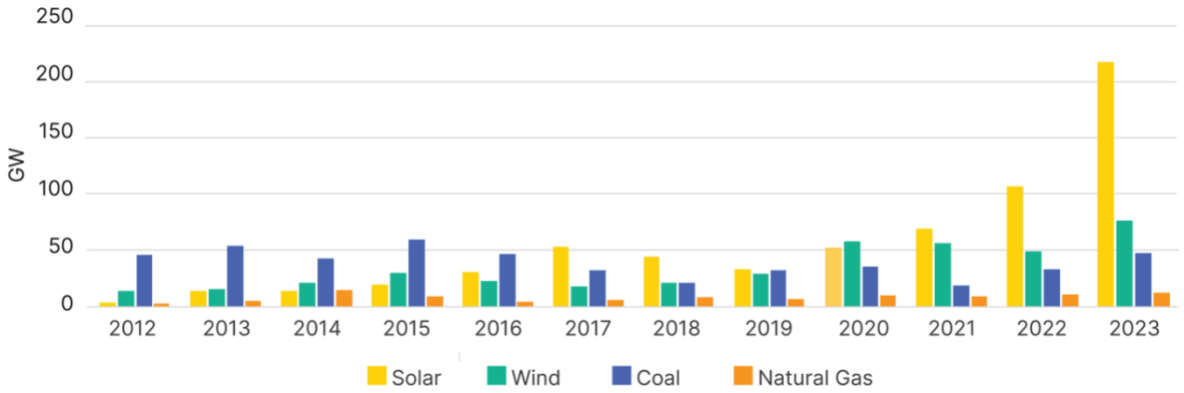
In 2022 and 2023, for example, China added 11 gigawatts (GW) and 12GW of natural gas power plants, respectively.[22] The country also added 33GW of coal in 2022 and 47.4GW in 2023.[23, 24] Last year, China approved 114GW of new coal capacity and began construction on 70GW[25], while instituting policies designed to limit the nation's gas-fired power expansion (discussed in Section III).[26]

Meanwhile, the pace of China's renewables buildout is unprecedented. In 2022 alone, the country added over 106GW of new solar capacity and nearly 49GW of wind (including 5GW offshore).[27] In

[22] Ember. Electricity Data Explorer. Date accessed: 10 May 2024.
[23] Data from Bloomberg New Energy Finance (BNEF).
[24] Global Energy Monitor. Boom and Bust Coal 2024. April 2024. Page 5.
[25] Centre for Research on Clean Air and Global Energy Monitor. China risks missing multiple climate commitments as coal power approvals continue. January 2024. Page 1.
[26] Notably, Shell's 2024 LNG Outlook forecasts that capacity additions from coal, nuclear, renewables, and other sources all exceed gas-fired power capacity additions in 2040. Shell. 2024 LNG Outlook. February 2024. Page 10.
[27] Figures are from BNEF.

2023, solar and wind capacity additions roughly doubled to 217GW and 76GW, respectively, according to China's National Energy Administration (NEA).[28, 29, 30]

Figure 4: China Annual Capacity Additions of Solar, Wind, Coal, and Natural Gas



Source: Bloomberg New Energy Finance (BNEF), Global Energy Monitor, Ember.

According to the China Energy Council, the country's combined wind and solar capacity could surpass 1,300GW this year, up from 1,051GW at the end of 2023.[31, 32] This means that China could potentially achieve a 2030 target to complete 1,200GW of wind and solar in 2024[33], six years ahead of schedule.

As a result, the International Energy Agency (IEA) anticipates that nearly 50% of China's electricity generation could come from renewable energy sources by 2028.[34] Meanwhile, electricity generation from natural gas is expected to remain nearly flat in both the IEA's stated and announced policy trajectories through 2030.[35, 36] S&P Global notes that China may achieve net-zero before its 2060 target.[37]

[28] Bloomberg. China Added More Solar Panels in 2023 Than US Did In Its Entire History. 26 January 2024.
[29] National Energy Administration (NEA). The installed capacity of solar power generation exceeded 600 million kilowatts, and the proportion of installed coal power generation fell below 40% for the first time. 02 February 2024.
[30] In 2023, China commissioned more solar capacity than the entire world combined in 2022. International Energy Agency (IEA). Renewables 2023. – Analysis and forecasts to 2028. January 2024. Page 7.
[31] South China Morning Post. China's wind and solar power generation capacity to surpass coal in 2024. 01 February 2024.
[32] IEEFA calculations based on BNEF data and Bloomberg. China Added More Solar Panels in 2023 Than US Did In Its Entire History. 26 January 2024.
[33] Yale Environment 360. How China Became the World's Leader on Renewable Energy. 13 March 2024.
[34] International Energy Agency (IEA). Renewables 2023 – Analysis and forecasts to 2028. January 2024. Page 8.
[35] On the difference between the IEA's Stated Policies Scenario (STEPS) and Announced Policies Scenario (APS): "The STEPS provides a more conservative benchmark for the future than the Announced Pledges Scenario (APS), by not taking for granted that governments will reach all announced goals. Similarly to the APS, it is not designed to achieve a particular outcome." International Energy Agency (IEA). Stated Policies Scenario (STEPS). Accessed: 08 May 2024.
[36] Notably, curtailment rates for renewable technologies have declined rapidly since 2017. In 2022, curtailment rates for solar and wind were just 2% and 3%, respectively — down from peaks of 11% and 17% in 2016. IEA. Renewables 2023 – Analysis and forecasts to 2028. January 2024. Page 82.
[37] S&P Global Ratings. Asia-Pacific's Different Pathways to Energy Transition. 30 March 2023. Page 21.

In the long term, China's non-fossil infrastructure investments will dwarf fossil energy investments. According to S&P Global, capital expenditures for China's power system upgrade through 2060 are expected to total RMB62 trillion (US$8.63 trillion), with just 9% allocated to fossil energy compared to 91% for transmission, clean energy, and energy efficiency.[38]

In early 2024, China's National Development and Reform Commission (NDRC) and the National Energy Administration (NEA) released a policy notice that called for the construction of new gas-fired peak-shaving facilities. However, it specifies that gas supply must be secure and affordable. Section IV discusses the relative costs of LNG compared to other fuels and power sources, illustrating that these conditions are difficult for LNG to achieve. Moreover, the policy calls on refurbished coal assets to provide grid flexibility, along with dispatchable renewable energy.

Importantly, the power sector is China's largest source of energy-related greenhouse gas (GHG) emissions.[39, 40] Due to the rapid penetration of renewable power, China's emissions are anticipated to go into "structural decline" beginning in 2024, according to the Centre for Research on Energy and Clean Air (CREA).[41] Similarly, the IEA expects China's coal consumption and GHG emissions to peak in 2025 under the stated policy scenario. Despite significant new planned coal capacity, the utilization rates of coal plants have fallen roughly 20% since 2005 and are likely to continue declining as generation from coal falls and renewables generation surges.[42] The displacement of coal with renewables will likely allow China to achieve its nationally determined contributions (NDCs) to peak CO_2 emissions by 2030, en route to carbon neutrality before 2060.[43]

[38] S&P Global Ratings. Asia-Pacific's Different Pathways to Energy Transition. 30 March 2023. Page 23.
[39] Climate Transparency. China. 2021. Page 5.
[40] International Energy Agency (IEA). An Energy Sector Roadmap to Carbon Neutrality in China. September 2021. Page 14.
[41] Carbon Brief. Analysis: China's emissions set to fall in 2024 after record growth in clean energy. 13 November 2023.
[42] Sustainability By Numbers. China is building more coal plants but might burn less coal. 14 February 2024.
[43] UNCCC. China's Achievements, New Goals and New Measures for Nationally Determined Contributions. June 2022.

III. Energy Security Goals Support Domestic Resources, not Imported LNG

Chinese energy security policies strongly favor domestic energy sources, including coal, renewables, and domestic natural gas, over imported fuels such as LNG. President Xi Jinping has articulated the need for national self-reliance in energy,[44] and in 2023, the NDRC said it would aim to "strictly control" projects designed to replace coal with natural gas.[45]

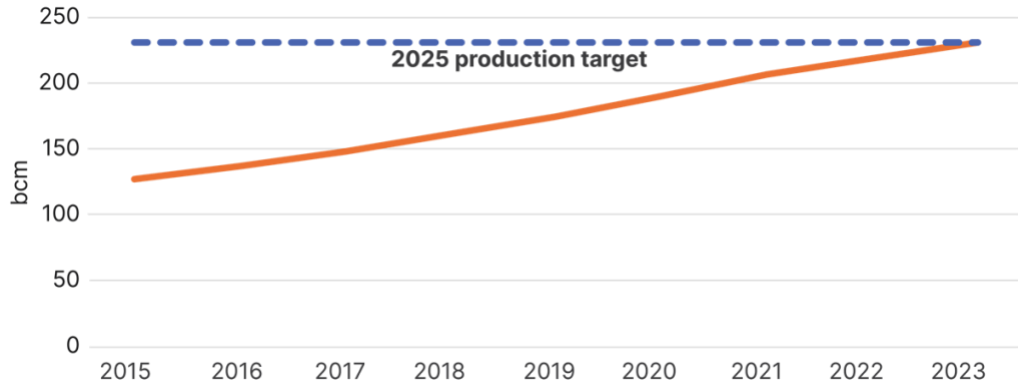
Limitations on coal-to-gas switching in the power sector are also reflected in the country's 14th Five-Year Plan for a Modern Energy System (14th FYP)[46], which centers coal, not gas, as the cornerstone of energy security and electrical reliability. The plan outlines China's priorities for energy sector development from 2021 to 2025 and calls for coal power to become a flexible energy source to support the integration of variable solar and wind generation. The plan aims to retrofit 200GW of existing coal capacity to accommodate more flexible operations and establishes a target for 24% of the country's coal capacity to offer flexible services by 2050.[47]

Though the 14th FYP does not contain a specific coal production target, China sanctioned multiple new coal mines following a prolonged power deficit in 2021 to reduce the likelihood of future energy supply disruptions. Production rose to an all-time high in 2023.[48, 49] Although China is the world's largest coal importer, imports account for less than 10% of total coal demand.

The 2023 Natural Gas Development Report highlights China's focus on developing domestic resources, managing demand, and investing in gas storage to ensure that imports do not exceed 50% of total gas demand. In 2022, investment in domestic oil and gas exploration and development increased 19%, targeting unconventional resources like shale, coalbed methane, and ultra-deep onshore gas reserves.[50] As a result, China's gas production reached 229 billion cubic meters (bcm) in 2023. Output should surpass the 14th FYP production target of 230bcm in 2024 and could reach 250bcm by mid-decade.[51, 52]

[44] Financial Times. Fortress China: Xi Jinping's plan for economic independence. 14 September 2022.
[45] National Development and Reform Commission (NDRC). Report on the Implementation of the 2022 Plan for National Economic and Social Development and on the 2023 Draft Plan for National Economic and Social Development. 05 March 2023. Page 66.
[46] NDRC. 14th Five-Year Plan for a Modern Energy System. 22 March 2022.
[47] NDRC. Clean coal efficiency utilization benchmark levels in key areas (2022 edition). 09 April 2022.
[48] Weixin. NDRC is here to respond to your concerns! 18 January 2022.
[49] The country is also establishing a back-up production system with 300 million tonnes (mt) of dispatchable coal production capacity by 2030. Reuters. China to set up coal production reserve to stabilise prices. 06 December 2023.
[50] Center on Global Energy Policy (CGEP). Inside China's 2023 Natural Gas Development Report. 11 September 2023.
[51] Center on Global Energy Policy (CGEP). Inside China's 2023 Natural Gas Development Report. 11 September 2023.
[52] National Energy Administration (NEA). China Natural Gas Development Report 2023. 21 July 2023.

Figure 5: China Gas Production Will Overshoot its 14th FYP Target for 2025

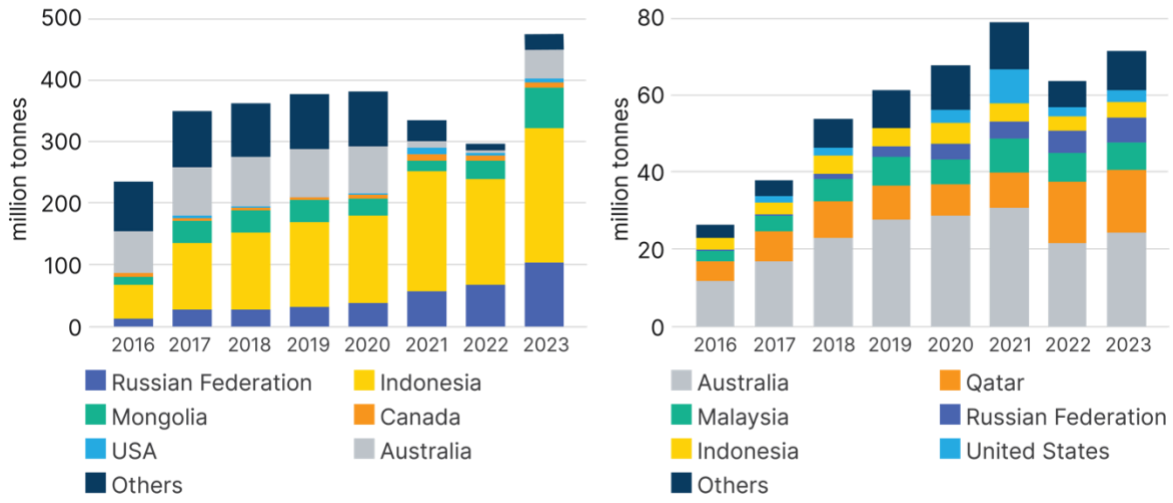


Source: China's National Bureau of Statistics (NBS). National Data. 2024; Energy Institute (EI). Statistical Review of World Energy. 2023.

China has several policy measures to limit the likelihood and severity of gas supply disruptions. The draft Natural Gas Utilization Policy outlines potential pathways for managing gas demand growth, including constraints on gas-fired expansion in the country's coal-producing regions. China aims to limit its vulnerability to imports by developing flexibility via demand-side management capabilities and investments in storage infrastructure.[53] The country is also striving to power its oil and gas activities with renewable energy to limit own-use consumption of natural gas.[54]

[53] The 14th FYP also set a 2025 gas storage target range of 55-60bcm, up from 35bcm currently.
[54] Center on Global Energy Policy (CGEP). Inside China's 2023 Natural Gas Development Report. 11 September 2023.

Figure 6: Chinese Coal Imports (left) and LNG Imports (right) by Supply Country



Source: United Nations (UN). UN Comtrade Database. 2024; General Administration of Customs of the People's Republic of China (GACC). Customs Statistics. 2024; IEEFA calculations; Kpler.

LNG imports also involve greater geopolitical risks for China since a large share of its LNG supply comes from countries with delicate trade relationships, including the United States and Australia (Figure 6). By contrast, 90% of China's coal imports come from members or observers of the Non-Aligned Movement. In February 2024, the U.S. government paused authorizations for new LNG exports to countries without a free trade agreement. The pause was partly designed to reevaluate the sale of LNG to "competitor countries that don't align with [U.S.] interests."[55] Chinese buyers account for nearly a quarter of the LNG contracts affected by the U.S. export pause.[56] In addition, U.S. lawmakers have proposed legislation to ban LNG exports to non-allied countries, including China, Russia, Iran, and North Korea.[57]

China is actively pursuing a diversified portfolio of long-term LNG contracts to support its energy security. The country's active LNG contracts are set to reach 100 million tonnes per annum (MTPA) by 2026, though depending on the extent of demand growth, this may exceed domestic requirements. Importers are already reselling sizable surplus volumes to other countries[58], and estimates suggest that China's surplus of contracted LNG volumes could grow significantly through 2030.[59, 60]

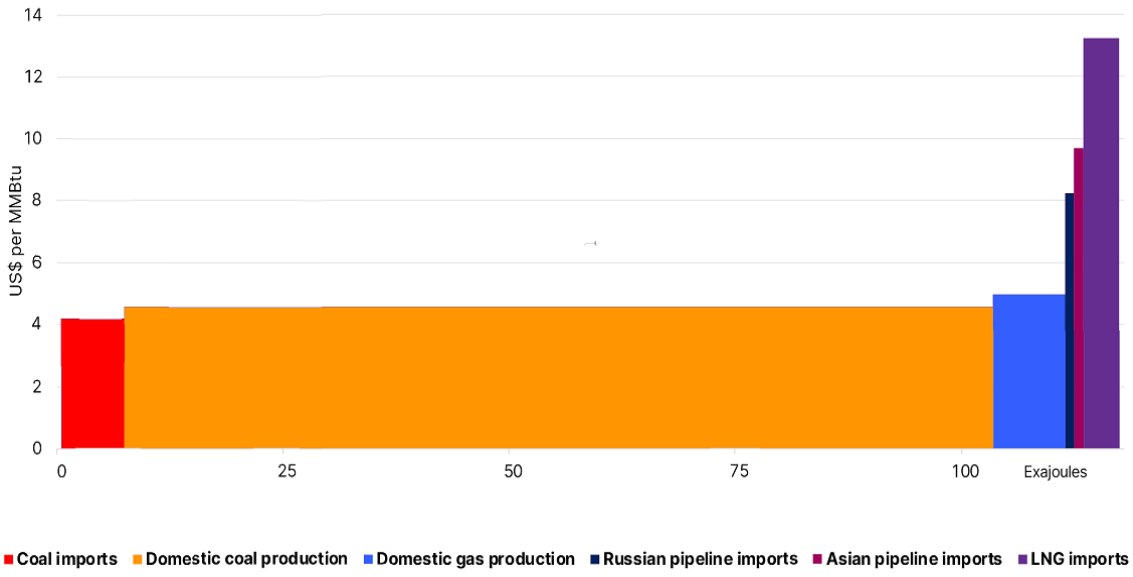
[55] United States Department of Energy. The Temporary Pause on Review of Pending Applications to Export Liquefied Natural Gas. February 2024.
[56] Foreign Policy. Is the U.S. Preparing to Ban Future LNG Sales to China?. 23 April 2024.
[57] Jeff Merkley. Merkley, Brown Introduce Legislation Banning LNG Exports to China. 28 February 2024.
[58] Bloomberg. PetroChina to Build Up Its LNG Fleet and Expand Global Trade. 09 April 2024.
[59] Reuters. China LNG buyers expand trading after adding more US, Qatari contracts. 21 August 2023
[60] International Energy Agency (IEA). World Energy Outlook 2023. October 2023. Page 238.

IV. LNG Costs are Not Competitive with Coal

Along with energy security policies designed to limit LNG dependence, cost incentives are driving China's push for renewables and coal, rather than natural gas. At a wholesale level, LNG is too expensive to materially displace coal in power generation.

A cost comparison of China's various coal and gas sources helps illustrate this displacement challenge (Figure 7). According to Chinese customs data, in 2023, the average LNG import cost was roughly three times that of domestically produced coal and gas. Moreover, the cost of LNG imports was between 37% to 61% higher than pipeline imports from Asia and Russia.

Figure 7: Wholesale Cost of China's Coal and Gas Supplies in 2023



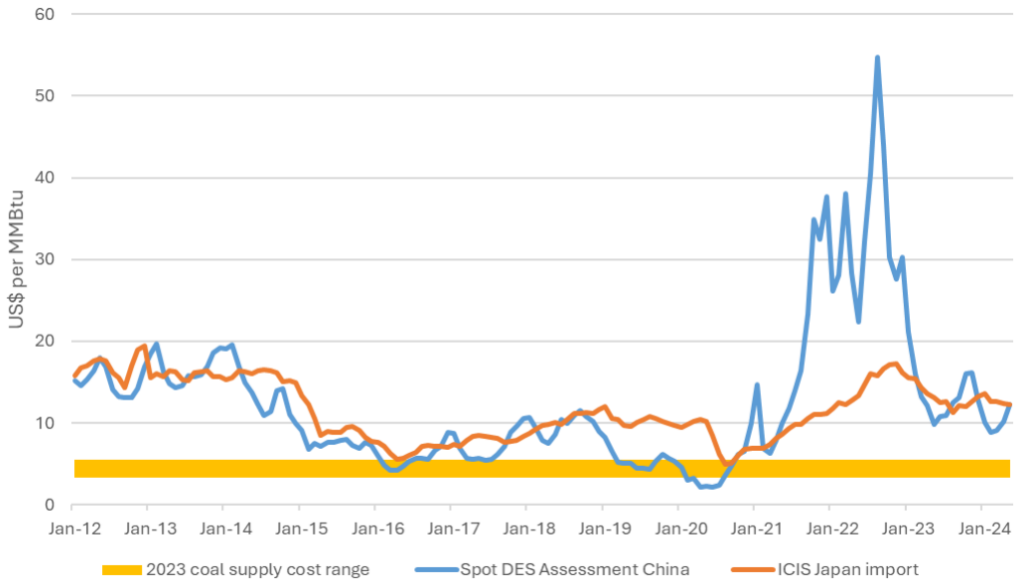
Note: "MMBtu" stands for metric million British thermal units.

Source: General Administration of China Customs (GACC). Customs Statistics. 2024; UN. UN Comtrade Database. 2024; National Bureau of Statistics (NBS). National Data. 2024; Energy Institute. Statistical Review of World Energy. International Energy Agency (IEA). Coal 2023 – Analysis and forecast to 2026. 15 December 2023; Company financial statements; IEEFA calculations.[61]

[61] Coal import prices are estimated from UN Comtrade data. The domestic coal supply price is assumed to be US$10/tonne higher than the import price, which is consistent with the average observed differential during the first 9 months of 2023. Gas production costs are an average of costs reported by various Chinse producers. Pipeline and LNG import prices are estimated using value data from GACC.

Global LNG prices have rarely fallen to levels that are competitive with China's coal supply (Figure 8). Only during periods of global LNG oversupply — notably the 2015-2016 downturn and the COVID-19 pandemic in 2020 — have prices briefly fallen within range of Chinese coal prices in 2023.[62, 63]

Figure 8: China's Coal Supply Costs versus Historical Spot and Long-term LNG Prices



Note: Japan's LNG import prices are used as a proxy for LNG imports to Asia based on long-term contract prices. Actual delivered contract prices to China will depend on pricing formulas in the country's own portfolio of LNG procurement contracts.

Source: ICIS; UN Comtrade; IEEFA calculations.

Global LNG prices are also expected to decline in the years ahead due to a flood of export capacity coming online through 2028, primarily in the United States and Qatar.[64] However, prices are unlikely to fall to levels competitive with coal, because the delivered cost of LNG to Asia from export markets like the United States and Australia is typically above that of coal.

Delivered costs typically include cost components for gas feedstock, liquefaction, transportation, and regasification. For example, the largest U.S. LNG company, Cheniere Energy, charges its customers

[62] While using a static 2023 price range ignores coal market variation, prices in 2023 were above those before the Russian invasion of Ukraine, and Newcastle coal benchmarks remain 65% higher than long-term average prices since 1990. Centre for Research on Energy and Clean Air (CREA). What is causing the record rise in both China's coal production and imports? 08 June 2023; International Energy Agency (IEA). Coal 2023 – Analysis and forecast to 2026. 2023. Page 77; International Monetary Fund (IMF). Primary Commodity Prices. 03 April 2024.

[63] Chinese utility Guangdong Energy Group said it expects coal prices to decline in 2024. Reuters. China coal industry doesn't expect imports to rise this year. 10 March 2024.

[64] IEEFA. Global LNG Outlook 2024-2028. 25 April 2024.

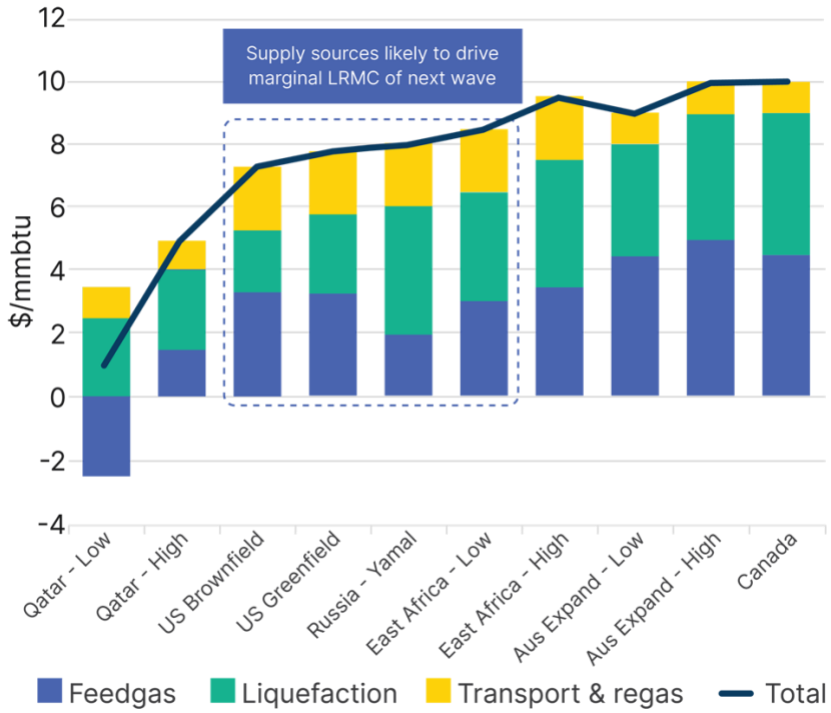
the Henry Hub price for gas feedstock plus a 15% markup for delivering gas to the terminal. Fees for U.S. liquefaction facilities are set by contracts and typically range from US$2.50-3.50 per metric million British thermal units (MMBtu).[65] Transportation and regasification costs to Asia are roughly US$2/MMBtu.

Adding these components together, the delivered cost of U.S. LNG to Asia is likely to be US$7-8/MMBtu.[66, 67, 68, 69, 70, 71] This is still 43% to 63% higher than China's average coal price in 2023. Cost estimates typically assume Henry Hub gas prices of between US$2-3/MMBtu, but U.S. liquefaction fees and transport costs alone may exceed China's coal prices, excluding feedgas costs.

Meanwhile, costs for LNG delivered from Australia, East Africa, and Canada are likely to be even higher due largely to higher feedgas and liquefaction costs. According to the Canadian Energy Centre, the delivered cost of North American LNG to Asia would range from US$7.80-10.40/MMBtu.[72] Only Qatar — the world's lowest cost LNG producer — could possibly deliver LNG at a price competitive with China's coal supply (Figure 9).

[65] Certain U.S. facilities may use a tolling structure, in which an LNG buyer arranges to purchase the feedstock and have it delivered to the LNG terminal; the LNG projects only receive a fixed liquefaction fee. In practice, the two pricing structures arrive at roughly the same place.
[66] Timera Energy. Where will the next wave of LNG supply come from? 30 October 2017.
[67] Reuters. Estimated break even costs of new LNG projects. Accessed: 02 May 2024.
[68] RBN Energy. Are You Gonna Go My Way - U.S. LNG Projects Face Steep Challenges In Replacing Coal Abroad. 26 March 2024.
[69] Global LNG Hub. The LNG Shipping Forecast: costs rebounding, outlook uncertain. 2018.
[70] Canadian Energy Centre. North America LNG project cost competitiveness. 30 April 2024.
[71] Offshore Magazine. Qatar in pole position to ease long-term LNG shortfall. 06 July 2018.
[72] Canadian Energy Centre. North America LNG project cost competitiveness. 30 April 2024.

Figure 9: Delivered Costs of LNG to Asia



Note: Source assumes US$2.00/MMBtu liquefaction fees for U.S. brownfield sites and US$2.50/MMBtu for greenfield. Source: Timera Energy.

Although LNG prices can fall below the final delivered cost, sales below cost pose a risk of margin erosion and financial losses for exporters. This is unlikely to be financially sustainable for LNG exporters over extended periods. In this sense, delivered costs required for capital cost recovery of export projects may serve as a long-term anchor for LNG prices.

In addition, LNG will also have to compete with pipeline gas imports, which were roughly US$4-6 cheaper in 2023. The Power of Siberia pipeline will reach its peak capacity of 38bcm by 2025, bringing in more supply from Russia.[73] Proposed pipeline expansions with Russia and Turkmenistan could add imports of 100bcm in the next decade, hindering China's longer-term LNG demand growth.

Lower global LNG prices in the coming years may induce some demand rebound from Chinese buyers in non-power sectors. However, additional LNG imports are unlikely to result in any meaningful displacement of coal in the country's power mix. According to Wood Mackenzie, "From a pure fuel cost perspective, gas-fired power cannot compete against coal for baseload generation."[74] A 2018 study by

[73] Reuters. Russian pipeline gas exports to China to exceed 22.5 bcm in 2023 – Gazprom. 28 December 2023.
[74] Wood Mackenzie. The future of China's gas demand. 05 October 2021.

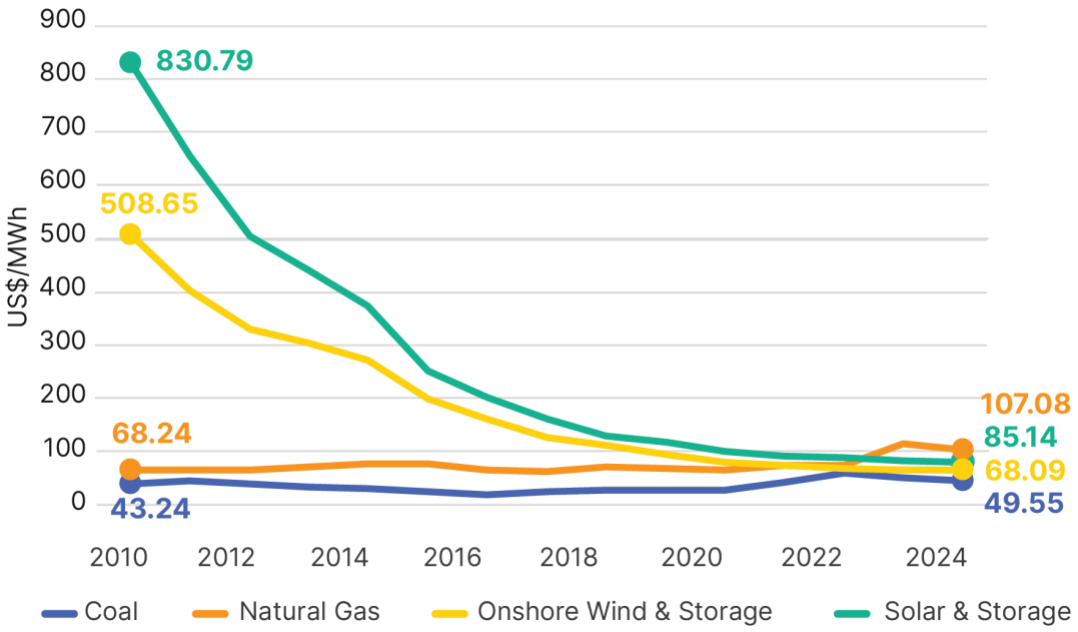
researchers from Princeton University and the Energy Research Institute of China's NDRC also notes, "end-use natural gas prices are still not competitive with cheap coal. This has consequently hindered a large-scale coal-to-gas end use transition."[75]

The large differential between coal and LNG fuel prices correlates to discrepancies in the cost of power generation. According to various sources, the levelized cost of coal generation is in the range of US$40-60 per megawatt-hour (MWh), while the cost of gas generation has been in the range of US$70-110/MWh.[76, 77, 78, 79, 80, 81] The IEA notes a cost gap of US$30-40/MWh between coal and gas-fired power.[82] The Oxford Institute for Energy Studies (OIES) found that even during 2020, when China's LNG import costs declined significantly, fuel costs for gas plants were still not competitive with coal-fired power generation.[83]

Moreover, recent data from think tank Transition Zero has shown that the cost of solar plus storage and onshore wind plus storage, has fallen below the levelized cost of natural gas (Figure 10). This supports Wood Mackenzie's view that, "longer-term, integrated renewables-plus-storage projects will pose the ultimate threat to gas power. We expect annual utilization hours of gas power to drop as gas power plants become reserve capacity in the power system."[84]

[75] Qin, et. al. Challenges of using natural gas as a carbon mitigation option in China. 2018. Page 460.
[76] Qin, et. al. Challenges of using natural gas as a carbon mitigation option in China. 2018.
[77] Wood Mackenzie. Sprint or marathon: China provincial renewable power competitiveness report 2019. 14 August 2019.
[78] Smart Energy International. Renewables will be cheaper than coal by 2026 in China – study. 15 January 2020.
[79] Carbon Brief. Guest post: How China and South Korea could save money by steering clear of gas. 02 August 2022.
[80] Transition Zero. Coal-to-Clean Price Index. Accessed: 03 May 2024.
[81] Oxford Institute for Energy Studies (OIES). Natural gas in China's power sector: Challenges and the road ahead. December 2020. Page 5.
[82] International Energy Agency (IEA). The Role of Gas in Today's Energy Transitions. 2019. Page 87.
[83] Oxford Institute for Energy Studies (OIES). Natural gas in China's power sector: Challenges and the road ahead. December 2020. Page 6.
[84] Wood Mackenzie. The future of China's gas demand. 05 October 2021.

Figure 10: Levelized Costs of Select Dispatchable Technologies in China

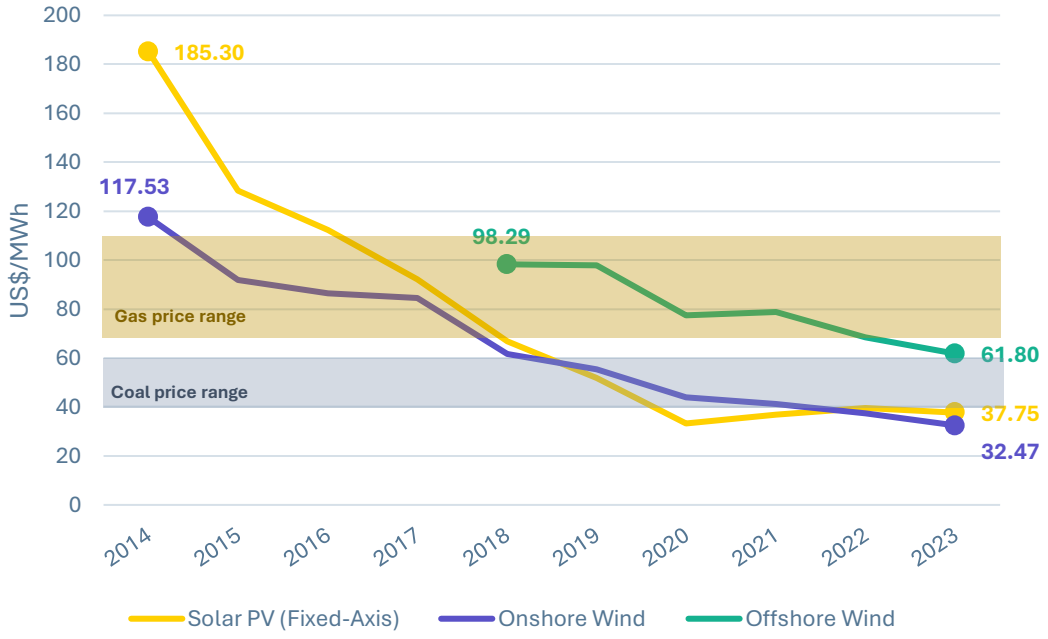


Source: Carbon Brief based on data from Transition Zero. Carbon Brief. Guest post: How China and South Korea could save money by steering clear of gas. 02 August 2022.[85]

According to recent data from Bloomberg New Energy Finance (BNEF), standalone solar photovoltaic (PV) and onshore wind are now the cheapest sources of power generation in China (Figure 11). BNEF found that the levelized cost of best-in-class onshore wind in China was US$23/MWh, followed by US$31 for fixed-axis solar photovoltaic, and US$50 for offshore wind.[86] Figure 11 shows the mid-range levelized cost estimates for these technologies.

[85] CORRECTION: This chart was amended on 7 October 2024. The legends did not correspond to the correct lines in the chart. We regret the error.
[86] Bloomberg New Energy Finance (BNEF). Cost of Clean Energy Technologies Drop as Expensive Debt Offset by Cooling Commodity Prices. 07 June 2023.

Figure 11: Levelized Cost of Solar PV, Onshore Wind, and Offshore Wind in China



Note: Coal and gas price ranges are discussed on page 19.

Source: Bloomberg New Energy Finance (BNEF). 2H 2023 LCOE Update: An Uneven Recovery. 18 December 2023.

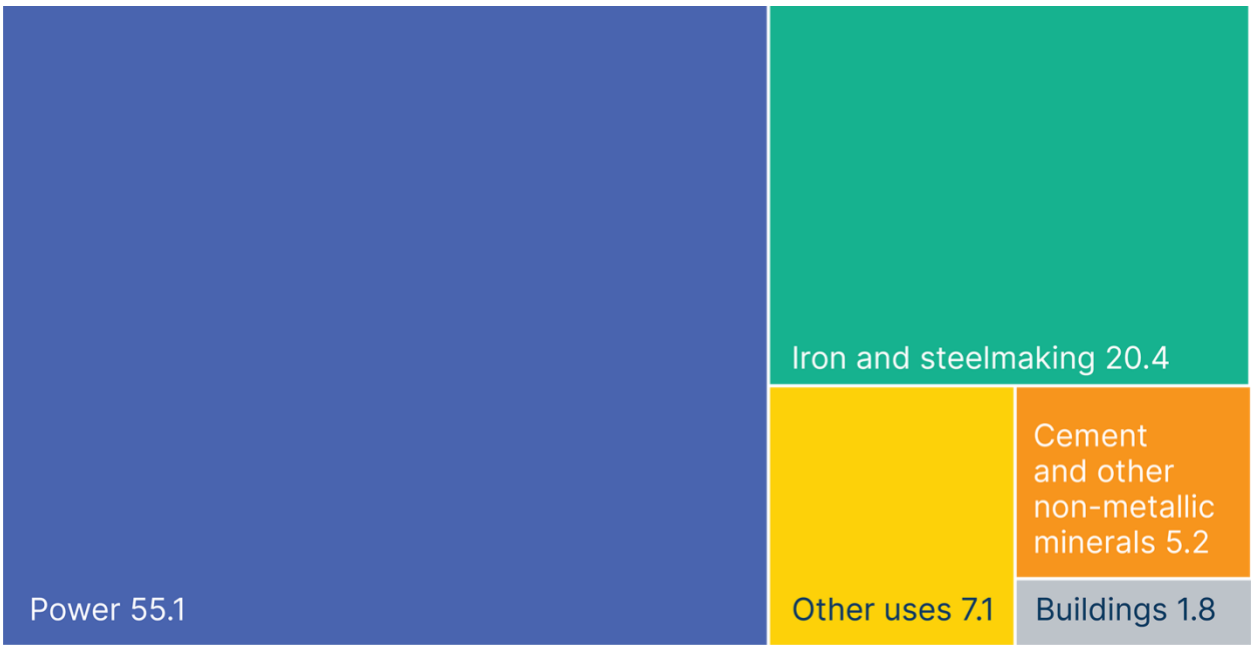
Although China's carbon pricing system might narrow the gap between coal and natural gas-fired power costs, the carbon price would have to be in the range of US$60-85 per tonne of carbon dioxide (CO_2).[87] In 2023, the average trading price for China Emission Allowances was US$9.62 per metric tonne of CO_2 equivalent.[88] Moreover, the Massachusetts Institute of Technology (MIT) has noted that "because the cap-and-trade system penalizes carbon emissions…it would have the effect of decreasing natural gas consumption as well."[89] Ultimately, a higher carbon price would boost the competitiveness of renewables and storage at the expense of coal and natural gas in the power mix.

[87] International Energy Agency (IEA). The Role of Gas in Today's Energy Transitions. 2019. Page 87.
[88] S&P Global. Commodities 2024: China's domestic carbon market set for revamp; Article 6 in limbo. 17 January 2024.
[89] Massachusetts Institute of Technology (MIT). Enabling China to shift from coal to natural gas. 21 November 2016.

V. Coal-to-Gas Switching in Non-Power Sectors

LNG proponents assert that coal-to-LNG switching will also play an important role in decarbonizing China's non-power sectors.[90] However, this view conflicts with current investment trends in coal-intensive industrial sectors, structural economic shifts, gas sector development policies, and non-power decarbonization pathways.

Figure 12: China's 2021 Sectoral Coal Consumption (Exajoules)



Source: Expert Group on Energy Data and Analysis (EGEDA). Energy Balance Tables. May 2024.

China's industrial sectors account for 33% of the country's coal consumption. A large share of industrial coal use is in iron, steelmaking, and cement — sectors closely tied to China's real estate market through construction and centrally planned infrastructure developments.

As a result, the country's ongoing real-estate downturn[91], declining population[92], and pivot away from a property-driven economic growth model should peak activity from these coal-consuming sectors this decade.[93] For example, the Rocky Mountain Institute (RMI) and China Cement Association predict cement production falling 25% this decade and 70% by 2050.[94] In another study, RMI estimates that

[90] Shell. Shell LNG Outlook 2024. 14 February 2024. Page 7-8.
[91] The Conversation. China: why the country's economy has hit a wall – and what it plans to do about it. 19 March 2024.
[92] Victoria University. China's population shrinks again and is set to more than halve. 18 January 2024.
[93] Carbon Brief. Analysis: Clean energy was top driver of China's economic growth in 2023. 25 January 2024.
[94] Rocky Mountain Institute (RMI). Toward Net Zero: Decarbonization Roadmap for China's Cement Industry. September 2022. Page 6.

steel output will fall 8% this decade, while a net-zero pathway could see another decrease of 40% by 2050.[95] Structural shifts to the Chinese economy will phase out coal use without the aid of gas displacement.

Decarbonizing industrial sectors will require significant coal displacement, but gas may play little to no role in that transition. China's Cement Association sees solid-waste fuels, biomass, hydrogen, and electricity replacing coal as a heat provider in cement production processes.[96] RMI's net-zero pathway for China's steel sector envisions coal reductions occurring through electricity and hydrogen pathways that involve electric arc furnace (EAF)-based secondary steelmaking and hydrogen-based direct reduced ironmaking (DRI).[97]

As the sector waits for green sources of hydrogen to gain traction, some see a role for natural gas as a transition fuel to be used in hydrogen-based DRI capacity.[98] While possible, much of the existing iron and steel supply chain uses coal as a non-combustible feedstock. Therefore, for gas to replace this coal use, coal-based steelmaking capacity would need to be retired and replaced with gas-based DRI.

However, current investments in China's iron and steelmaking capacity are still predominately coal-based. There will be 389 million tonnes (mt) of new or replacement coal-based blast furnace capacity this decade, compared to 4.3mt from non-blast furnaces.[99] Even if all 4.3mt of non-blast furnace additions use natural gas, displacement of coal in iron and steelmaking will probably remain limited. Moreover, as outlined in previous sections, China's iron and steelmaking sectors will continue to have cost and energy security incentives favoring coal usage over natural gas.

In the residential sector, China has previously aimed to replace coal-fired stoves with gas and electric heaters in urban areas, in pursuit of national air quality targets.[100] However, gas supply shortages in the winter of 2017-18, as well as city gas procurement issues in the winter of 2023 in Hebei[101], have prompted limits to coal-to-gas switching in rural areas that either require additional distribution lines or cannot afford to purchase gas.[102, 103, 104, 105]

[95] Rocky Mountain Institute (RMI). Pursuing Zero-Carbon Steel in China. September 2021. Page 15.
[96] Rocky Mountain Institute (RMI). Toward Net Zero: Decarbonization Roadmap for China's Cement Industry. September 2022. Page 7.
[97] In these pathways, carbon, capture, and storage (CCS) is used to decarbonize remaining coal-based steel production. RMI. Pursuing Zero-Carbon Steel in China. September 2021. Page 31.
[98] Global Efficiency Intelligence. Net-zero Roadmap for China's Steel Industry. March 2023. Page 24.
[99] Centre for Research on Energy and Clean Air (CREA). Steel sector decarbonisation in China stalls, with investments in coal-based steel plants since 2021 exceeding USD 100 billion despite overcapacity and climate goals. March 2024. Page 16-17.
[100] International Energy Agency (IEA). The Role of Gas in Today's Energy Transitions. 16 July 2019. Page 81.
[101] Note: "City gas" refers largely to natural gas demand from the residential and commercial sectors.
[102] Bloomberg. China's Anti-Pollution Efforts Get a Reality Check. 10 December 2017.
[103] Reuters. China policy reform to end losses for city-gas firms on household sales. 26 July 2023.
[104] International Energy Agency (IEA). Gas Market Report, Q1-2024. January 2024. Page 20.
[105] Reuters. China calls for "orderly" growth in natural gas use draft policy. 28 September 2023.

Changes to pipeline tariffs and a cost-passthrough mechanism in residential gas pricing could increase LNG supply to households, though the impact of higher prices on residential demand remains to be seen.[106, 107] Moreover, decarbonization pathways for the buildings sector will rely more on electric heat pumps rather than gas-based heating systems.[108] Overall, prior achievement of the 13th FYP air quality targets, energy security implications, and the high costs of gas and LNG consumption have likely closed the door on the air quality-driven coal-to-gas displacement trend observed in the buildings sector during the last decade.[109]

IV. Conclusion

The global oil and gas industry frequently champions LNG as a "bridge fuel" to help economies transition from coal to renewables, promoting new investments in the natural gas value chain. Proponents point to China — specifically its coal-dominated power sector — as a key opportunity for LNG to displace coal-fired electricity generation.

These arguments ignore fundamental trends in China's coal, natural gas, and power markets, as well as the country's policy and cost incentives limiting the role that imported LNG plays in electricity generation. As China builds an unprecedented amount of low-cost renewables capacity, policymakers are turning to coal — not more expensive gas and LNG — to support the integration of new wind and solar. China has clear reasons to rely on domestically available resources for energy security and reliability rather than basing its power sector development on global LNG markets that have proven wildly unpredictable over the past three years.

As a result, policymakers in both LNG exporting and importing countries should approach industry arguments about the necessity of LNG as a "bridge fuel" from coal to renewables with a high degree of skepticism. Evidence from China — touted by the industry as a key market for LNG displacement of coal — shows that LNG will likely play a trivial role in supporting the clean energy transition in the country's largest coal-consuming sectors.

[106] Reuters. Chinese cities raise residential gas prices after policy reform. 11 July 2023.
[107] Natural Gas World. Winners and losers from Chinese pricing reform [Gas in Transition]. 02 January 2024.
[108] International Energy Agency (IEA). The Future of Heat Pumps in China. March 2024
[109] Centre for Research on Energy and Clean Air (CREA). What's next for the energy sector in China's battle against air pollution?. 20 March 2020.

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