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APERC COAL REPORT

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Inui Building, Kachidoki 11F, 1-13-1 Kachidoki
Chuo-ku, Tokyo 104-0054 Japan
Tel: (813) 5144-8551
Fax: (813) 5144-8555
E-mail: master@aperc.or.jp (administration)
Website: https://aperc.or.jp

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Foreword

Major consumers and producers of coal exist in the APEC region. In 2023, the APEC member economies consumed 124 exajoules (EJ) of coal, accounting for 76% of global coal consumption. At the same time, they produced 144 EJ of coal, exporting 14% of their production to the rest of the world.

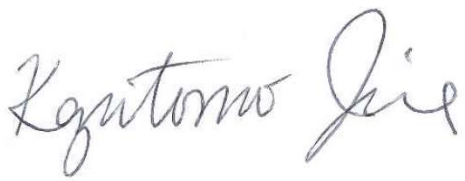
Coal consumption trends within the APEC economies are not uniform. While coal use has significantly declined in the United States, Canada, and Australia, it continues to grow in other economies, such as China, Indonesia, and Viet Nam. These trends could continue, and the timing of peak coal consumption in the APEC region remains uncertain.

Decarbonization of coal-fired power generation has become a priority across APEC economies, particularly those with relatively young or mid-life coal power fleets. Since coal-fired power plants are major sources of CO_2 emissions in the power sector, economies such as China, Indonesia, and Viet Nam are expected to continue operating their existing coal-fired power plants for their full economic and technical lifetimes while simultaneously exploring decarbonization solutions to achieve their net-zero targets.

Key strategies for reducing emissions from coal-fired power generation include fuel switching, improving thermal efficiency, co-firing with biomass or ammonia, and carbon capture, utilization, and storage. This report highlights the importance of these technologies in enabling decarbonization of APEC's coal power sector. Notably, Japan's successful demonstration of 20% ammonia co-firing in a large-scale coal-fired power unit marks a significant milestone. This project could pave the way for higher ammonia co-firing ratios in coal plants across Japan, China, and other Southeast Asian economies in the future.

The APERC Coal Report 2024 provides updated insights into current coal policies, consumption, production, trade, pricing, decarbonization technologies, and greenhouse gas emissions across the APEC economies. This report is a part of the APERC Fossil Fuel Reports Series, published annually to support discussions within the APEC Expert Group on Clean Fossil Energy (EGCFE) and the broader APEC Energy Working Group (EWG).

I extend my sincere gratitude to the authors and contributors for their dedication in producing this report. I also appreciate the support of APEC member economies for providing updated data through the APEC Expert Group on Energy Data and Analysis (EGEDA) and supplying valuable comments.



Dr Kazutomo IRIE
President
Asia Pacific Energy Research Centre

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We would like to thank the APEC Expert Group on Energy Data and Analysis for supplying data. We also thank the administrative staff of APERC for their joint supportive role.

Author:

- Phung Quoc HUY

Editors:

- Glen E. SWEETNAM
- Munehisa YAMASHIRO

Cover designer:

- Phung Quoc HUY

Contents

Abbreviations and Acronyms

Abbreviations

CAD	Canadian Dollar
EJ	Exajoules
GW	Gigawatt
Gt	Gigatonne
Mt	Million tonnes
Mtpa	Million tonnes per annum
PJ	Petajoules
TWh	Terawatt hour
USD	US Dollar

Acronyms

APEC	Asia-Pacific Economic Cooperation
APERC	Asia Pacific Energy Research Centre
CCS	Carbon Capture and Storage
CCUS	Carbon Capture, Utilisation and Storage
CFB	Circulating Fluidized Bed
CFPP	Coal-Fired Power Plant
CH_4	Methane Gas
CMM	Coal Mine Methane
CN	Carbon Neutrality Scenario
CO_2	Carbon Dioxide
COP26	The 26th United Nations Climate Change Conference
EOR	Enhanced-Oil-Recovery
EPA	U.S. Environmental Protection Agency
IEA	International Energy Agency
IGCC	Integrated Coal Gasification Combined Cycle
IGFC	Integrated Coal Gasification Fuel Cell Combined Cycle
REF	Reference Scenario
SC	Supercritical
USC	Ultra-supercritical

List of Figures

List of Tables

Executive Summary

More economies have committed to phasing out coal-fired power plants by a certain year, while they are being built at some economies.

- Australia, Canada, Chile, 'Hong Kong, China', Korea, Malaysia, New Zealand, Peru, Singapore, Chinese Taipei plan to phase out coal.
- Coal-fired power plants are being built in China, Viet Nam, and Indonesia. In 2024, China began building 94.5 GW of new coal-power capacity, the highest level of new construction in the past 10 years.

Four key technologies are expected to be game changers in decarbonizing the existing coal-based plants.

- Enhancing thermal efficiency in coal-fired power generation or coal-based boilers can reduce coal consumption and lower CO_2 emissions. Compared to ultra-supercritical technology, the Integrated Coal Gasification Combined Cycle technology improves thermal efficiency and reduces CO_2 emissions by 15%.
- Co-firing biomass in existing coal-fired power plants can reduce CO_2 emissions by lowering the amount of coal input. Several APEC economies have considered utilizing this technology.
- Co-firing ammonia with coal at a ratio of 20% has been successfully tested and demonstrated in several coal-fired power plants in Japan with positive results. This technology is also being explored by other APEC economies in Asia, including Korea, China, Indonesia, and Viet Nam.
- Carbon capture, utilization, and storage technology is another potential option to deeply decarbonize coal-based plants. The United States, Canada, and China are leading advancements of this technology in the power and industrial sectors.

APEC-wide coal consumption rose slightly in 2023 but was not uniform across all economies.

- Coal consumption in China, the world's largest coal consumer, grew by 4.7% in 2023. It was the highest growth in coal consumption over the last five years.
- Coal consumption in Indonesia fell slightly in 2023 after a notable increase in 2022. However, it remained considerably higher than levels recorded in 2021, primarily due to the introduction of new coal-fired power plants and the growth of the nickel industry.
- In the United States, coal consumption continued to fall in 2023, declining by 17.3% compared to the previous year.
- Viet Nam coal consumption grew by 22.2% in 2023, the highest growth among APEC economies, mainly due to heatwaves in summer driving up cooling demand and low hydropower electricity production.

APEC coal production rose approximately 2.6% in 2023, though the rising trend was not uniform across all economies.

- In China, the world's largest coal producer, coal production increased by approximately 2% in 2023, the lowest growth over the last three years.
- Indonesia's coal production rose 12.7% in 2023, the highest growth among APEC economies. The increased coal production was both for export and domestic use.
- Coal production in Australia increased by 3.8% in 2023, the highest growth over the last four years due to high coal demand for exports.
- Viet Nam, the United States, and Russia showed a drop in coal production in 2023.

In 2023, thermal coal exports from the United States, Australia, and Indonesia grew, but exports from Russia dropped.

- Indonesia increased coal exports by 29 Mt in 2023 due to high coal demand for power generation in China, India, and some Southeast economies.
- Australia's thermal coal exports increased by 15Mt as the result of ending the unofficial ban of the Chinese government on coal imports from Australia in early 2023.
- The United States's thermal coal exports increased by 5Mt in 2023, while Russia's coal exports dropped by 3 Mt in the same year.

Coal prices dropped substantially in the second half of 2023 and 2024, but they were still much higher than they were before the energy crisis.

- Thermal coal spot prices reached a record high in September 2022, reaching approximately USD 450 per tonne, a nine-time higher than in September 2020. In 2023, thermal coal spot prices dropped dramatically from USD 400 per tonne in early 2023 to around USD 130 per tonne in July. In 2024, thermal coal spot prices varied between USD 100 per tonne and USD 150 per tonne.
- Metallurgical coal prices surged to an unprecedented level of about USD 630 per tonne in March and then fell to around USD 200 per tonne in June 2022. In 2023, coking coal prices fell during the first quarter and eased further in June as Australian supply picked up but increased again in the second half of the year. In 2024, coking coal prices dropped dramatically from USD 330 per tonne in early 2024 to around USD 200 per tonne in December 2024.

Chapter 1: APEC coal policies and decarbonisation technologies

Recent coal policy developments

In the APEC region, 19 economies have made commitments to achieve net-zero or carbon neutrality targets within this century. Most of these economies aim to meet their targets by 2050, while China, Indonesia, and Russia have set their goal for 2060. Thailand plans to reach net-zero emissions by 2065 (Net Zero Tracker).

Several APEC economies have reduced or eliminated their proposed coal projects after signing "the Global Coal to Clean Power Transition Statement" at COP26 or joining the "No New Coal Power Compact". At COP26, nine APEC economies signed the Global Coal to Clean Power Transition Statement, wherein they committed to rapidly scale up technologies and policies in this decade to achieve a transition away from unabated coal power generation in the 2030s or the 2040s, depending on each economy's situation. These economies include Brunei Darussalam, Canada, Chile, Indonesia, Korea, New Zealand, the Philippines, Singapore, and Viet Nam.

APEC economies are on different paths to achieving their net-zero targets, influenced by their economic strength, energy mix, and availability of domestic energy resources. Advanced technologies, renewable energy, nuclear energy, and the circular carbon economy play a significant role in many APEC economies. However, some APEC economies prioritize the need for affordable and reliable energy supply sources. In the power sector, coal-fired power plants remain the primary choice for several developing and emerging APEC economies due to their reliable baseload characteristics.

In most APEC economies, switching from coal to cleaner or renewable energy is in progress. Fourteen economies have been improving thermal efficiency in coal-fired power plants to reduce coal consumption. While Australia, Canada, China, Indonesia, Japan and the United States are advancing CCS/CCUS technology in the coal-based plants, five additional economies (Korea, Malaysia, Chinese Taipei, Thailand, and Viet Nam) have plans to deploy CCS/CCUS projects in the coming years, considering coal-based plants. Twelve economies are approaching clean coal technologies.

Table 1.1: Current and planned measures to support decarbonising in coal combustion users

Economies	Fuel switching	Thermal efficiency improvement	CCS/CCUS	Clean coal technologies[1]
Australia	●	●	●	●
Brunei Darussalam	●			
Canada	●	●	●	●
Chile	●			
China	●	●	●	●
Hong Kong, China	●			
Indonesia	●	●	●	●
Japan	●	●	●	●
Korea	●	●	●	●

[1] Clean coal technologies include co-firing biomass/ammonia with coal, coal-to-gas, coal-to-liquid with carbon capture and storage, hydrogen/ammonia production from coal with carbon capture and storage.

Malaysia	●	●	●	●
Mexico	●	●		
New Zealand	●			
Papua New Guinea				
Peru	●			
Philippines	●	●		
Russia	●	●		●
Singapore	●			
Chinese Taipei	●	●	●	●
Thailand	●	●	●	●
USA	●	●	●	●
Viet Nam	●	●	●	●

Source: compiled by the authors based on Boom and Bust Coal (2022), Global Energy Monitor, EGEDA, E3G (2022), and IEA (2023c).

Note: 'Hong Kong, China', Singapore, Peru, Brunei Darussalam, and New Zealand have small-scale coal pipelines, while Papua New Guinea is not using coal in its energy system.

Table 1.2: Notable developments of coal policies in APEC economies

Economy	Notable developments
Australia	Australia could export coal to China since China lifted all restrictions on Australian coal imports on March 13, 2023 The 2024 draft of the Integrated System Plan proposed moving up the target to shut down all coal-fired power plants across the economy between 2037-2038. However, due to issues of power shortages, it is difficult to shut down coal-fired power plants immediately. Therefore, the current outlook is that some coal-fired power plants may remain in operation beyond 2040.
Brunei Darussalam	Coal has been imported since 2019 to generate electricity and heat for Hengyi Industries' refinery and petrochemical complex in Pulau Muara Besar. Coal imports are expected to increase due to an increase in the size of the facility.
Canada	Coal will likely be phased out of its electricity mix well before the 2030 deadline. The federal Government's phase-out plan of thermal coal by 2030, together with its 2030 moratorium on thermal coal exports, will restrict thermal coal development over the coming decade. In October 2023, the Government of Canada has announced nearly CAD 20 million in federal funding to support the provinces of Nova Scotia and New Brunswick to help enable a phase-out of coal-fired electricity generation by 2030.
Chile	The AES Andes shut down its two-unit Norgener Power Plant in Tocopilla, in the northern region of Antofagasta, with a total capacity of 276 MW. On 16 April 2024, it was disconnected from the national electricity system[2].

[2] AES Andes, formerly AES Gener S.A., is a producer and distributor of electricity based in Santiago, Chile. It is a subsidiary of American Company AES Corporation which operates in South America's Andes region.

China	On March 13, 2023, China lifted all restrictions on Australian coal imports, allowing all domestic companies to import coal from Australia. This ended the trade restrictions that had been in place since late 2020. China began building 94.5 GW of new coal-power capacity and resumed 3.3GW of suspended projects in 2024. It is the highest level of new coal-power construction in the past 10 years.
Hong Kong, China	The economy plans to stop investing in coal-fired capacity additions now and to phase out coal by 2050.
Indonesia	Indonesia plans to implement co-firing for coal-fired power plants using biomass and producing dimethyl ether fuel from coal. Indonesia still implements the domestic market obligation policy for coal, though the domestic coal ceiling price mechanism is under review[3]. At COP28, Indonesia agreed to shut the Cirebon-1 coal-fired power plant almost seven years earlier than planned under the ADB's Energy Transition Mechanism program.
Japan	In 2023, Japan's government announced that all new coal-fired power plants must have emission reduction measures in place. At COP28, Japan pledged to take necessary measures to reduce Japan's reliance on coal-fired power generation, aiming to achieve its commitment to realizing carbon neutrality by 2050. Japan will terminate the construction of new coal-fired power plants.
Korea	According to the 10th Basic Plan for Long-Term Electricity Supply and Demand, Korea plans to close 28 coal-fired power plants by 2036 and switch to LNG. Korea plans to promote ammonia co-firing through technological development and demonstration with targets of 20% co-firing demonstration by 2027, 20% co-firing commercialisation by 2030 and 100% ammonia-fuelled firing by 2050.
Malaysia	On June 25, 2024, Malaysia's Deputy Prime Minister Fadillah Yusof revealed the country's timeline for phasing out coal-fired power plants to achieve its net-zero commitment by 2050. By 2035, Malaysia aims to reduce its coal power plants by half and retire all of them by 2044.
Mexico	Mexico has been a member of the Power Past Coal Alliance (PCCA) since 2017, which implies a phase-out from unabated coal by 2030. However, there is no specific federal strategy to attain the goal as of 2023.
New Zealand	The government intends to ban new low—and medium-temperature coal boilers and phase out those already in use by 2037.
Papua New Guinea	There is no production or consumption of coal in Papua New Guinea.
Peru	The 135 MW Ilo coal-fired power plant was already retired in 2022. Coal is mainly consumed in the cement industry and plays a minor role in the power sector.

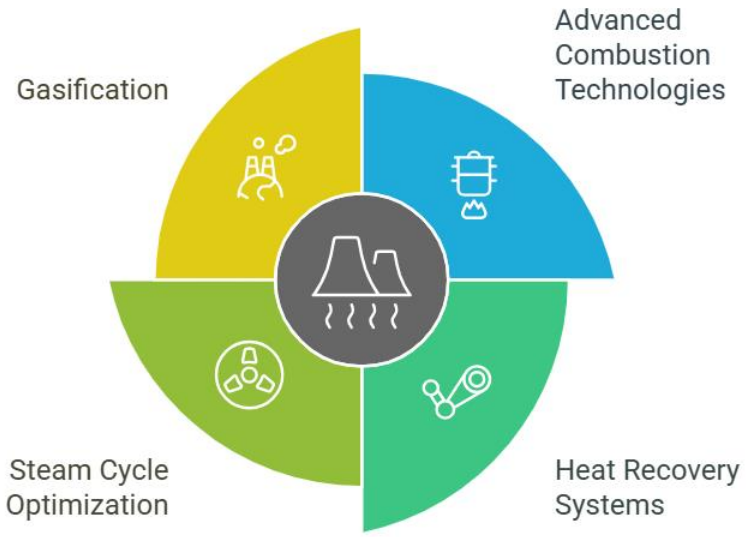
[3] Indonesia's Domestic Market Obligation policy for coal mandates that a certain percentage (currently set at 25%) of the country's coal production must be sold within the domestic market, ensuring a stable supply of coal for domestic power plants and industries

The Philippines	The Philippines Department of Energy has issued a moratorium (October 2020) on the endorsement of greenfield coal-fired power projects. In June 2024, the Climate Investment Funds endorsed a new investment plan presented by the Government of the Philippines, allocating $500 million to facilitate the early retirement or repurposing of the Mindanao plant and other privately owned coal-fired power plants. In total, the economy plans to accelerate the retirement of up to 900 MW of existing coal generation capacity by 2027.
Russia	The draft of Russia's Energy Strategy up to 2050 is currently under discussion and synchronization with the General Scheme for the Development of the Electric Power Industry until 2042. It is expected that the document will be approved in the first quarter of 2025. According to the General Scheme for the Development of the Electric Power Industry until 2042, approved by Russian Government Order No. 4153-r dated December 30, 2024, the share of coal-fired power plants in installed capacity is expected to decrease from 15.1% in 2023 to 12% in 2042. However, coal-based electricity generation is expected to be nearly unchanged. Therefore, coal consumption will remain a significant part of the energy mix.
Singapore	The Development Bank of Singapore has become the first Singaporean bank to commit to a phase-out of coal exposure by 2039.
Chinese Taipei	Taichung Power Plant plans to replace coal with gas, reducing coal usage by 3 million tons annually starting in 2032 and completing coal phase-out by the end of 2034 at the latest.
Thailand	Thailand does not plan to issue new permits for coal-fired power plants. Under its new Power Development Plan, Thailand aims to further reduce the use of coal-fired power to 12% by 2037.
USA	The United States has not built a new coal plant in over a decade and is on track to close more than half of its peak unabated capacity in the next several years. The Biden Administration has committed to creating a carbon pollution-free power sector by 2035. The U.S. Environmental Protection Agency (EPA) announced new rules on April 25, 2024. These rules will significantly reduce greenhouse gas emissions from existing coal-fired power plants, ensuring that all long-term coal-fired plants control 90% of their carbon emissions.
Viet Nam	In the Power Development Plan (PDP8), coal-fired power plant capacity increases gradually to 30 GW by 2030, and no new coal-fired power plants will be built after 2030. Viet Nam plans to phase out coal in the power sector by 2050. At a COP28 side event, Viet Nam's prime minister Pham Minh Chinh has mapped out how Viet Nam aims to spend the $15.5 billion pledged by G7 nations to boost the deployment of renewables and cut dependence on coal.

Decarbonisation technologies[4]

Thermal efficiency improvement

Figure 1.1: Methods for improving thermal efficiency in coal-fired power plants



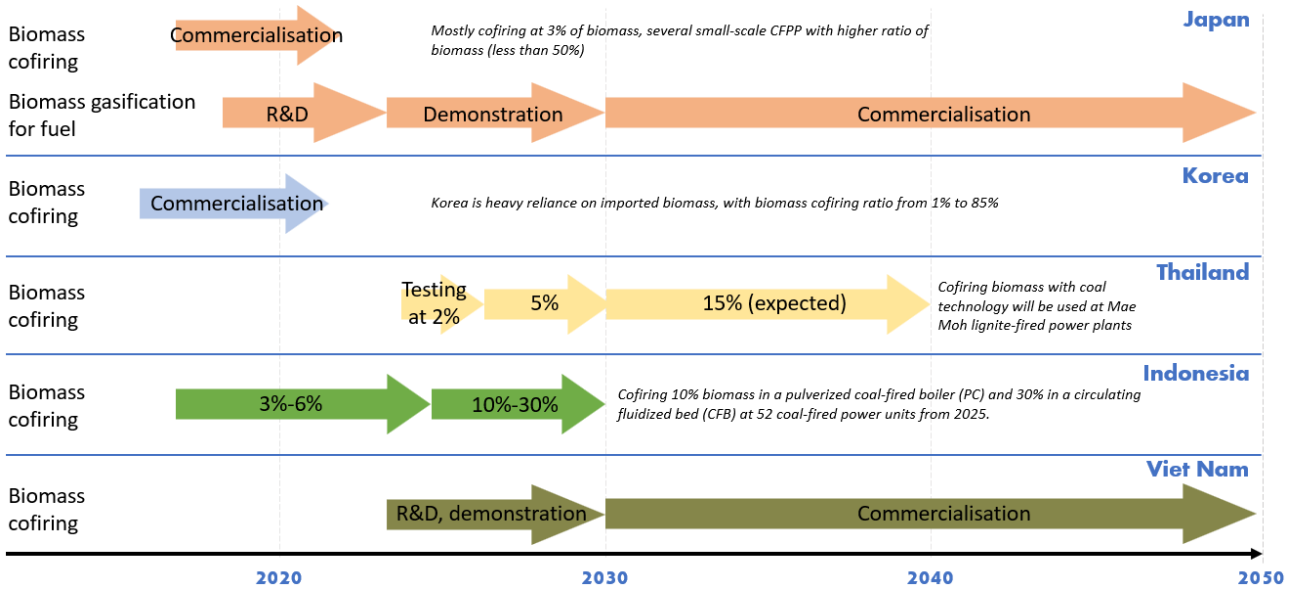
Key points

- Advanced Combustion Technologies: Advanced combustion technologies like supercritical and ultra-supercritical boilers greatly enhance efficiency. Operating at higher temperatures and pressures, USC plants can achieve efficiencies over 45%, compared to about 33% for conventional subcritical plants.
- Heat Recovery Systems: Heat recovery steam generators capture waste heat from the flue gas and use it to generate additional steam, which can then be used to drive turbines and generate more electricity. This can improve overall plant efficiency and reduce fuel consumption.
- Steam Cycle Optimization: Optimizing the steam cycle by increasing temperatures and pressures can enhance power plant efficiency. This includes upgrading turbines, improving condenser performance, and using advanced materials. Refurbishing older steam turbines also aids in boosting efficiency.
- Gasification: Gasification transforms coal into synthesis gas for burning in combined cycle turbines, enhancing efficiency and reducing emissions. Future IGCC systems aim for efficiencies of nearly 45%, with a goal of 60%.
- China's Pingshan Phase II power plant has been recognized as the world's most efficient coal-fired power plant. The 1.35 GW USC unit achieved a net efficiency of 49.37%. This efficiency was confirmed by an independent assessment led by Siemens and Steinmueller (Power, 2023).

[4] In this session, we provide only updated information compared to last year's coal report. Detailed technological explanations can be found in the APERC Coal Report 2023 on our APERC website.

Co-firing biomass and coal

Figure 1.2: Development status in co-firing biomass and coal at selected APEC economies



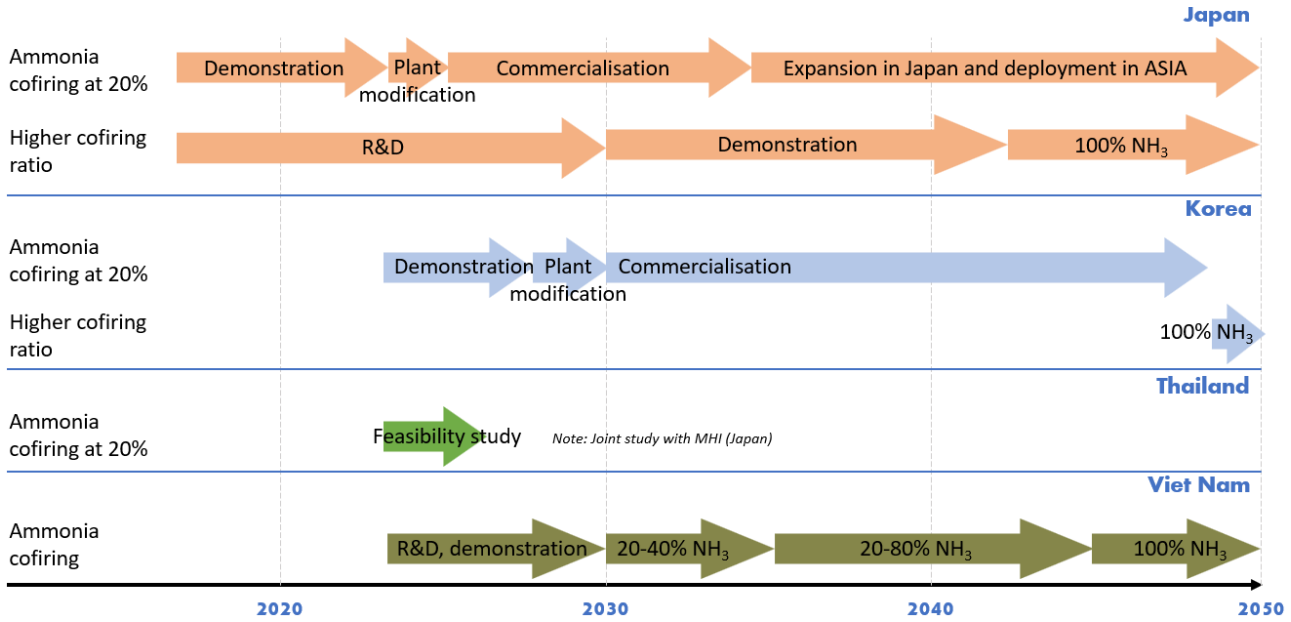
Sources: compiled by authors based on ERIA (2023), IEA (2023c), Mongabay (2022), PDP8 (2023), Argus (2024).

Key points

- Japan has commercialised biomass co-firing in coal-fired power plants with a biomass ratio of less than 10%, except for some projects with special designs, which can introduce a higher biomass ratio.
- In Korea, many coal-fired power plants have used biomass to cofire with coal since 2017. Two units of the KOSPO Green Power Plant in Sam Cheok operated in 2016 and 2017, with a 5% biomass co-firing ratio on an energy basis (ICSC, 2022). As of the end of 2024, four state-owned and five private utilities with a total installed capacity of over 20 GW coal-fired power plants have been cofired with biomass. The co-firing rate ranges from 1% to 85% on an energy basis. However, Korea's biomass supply is heavily reliant on imports from other countries such as Viet Nam, Russia, Indonesia, and others (Solutions for Our Climate, 2024).
- Thailand started testing 2% biomass co-firing at Mae Moh lignite-fired power plant, and the co-firing ratio is expected to increase to 5% and 15% in the coming years (Argus, 2024).
- In Indonesia, 48 coal-fired power units had conducted biomass co-firing by the end of 2024, with 3% of biomass in a pulverized coal-fired boiler and 6% of biomass on an energy basis in a circulating fluidized bed. Rice husks and sawdust waste were the most common biomass sources. The PLN, an Indonesian government-owned corporation, plans to conduct biomass co-firing at 52 coal-fired power units in Indonesia from 2025, with a co-firing rate between 10% and 30%.
- Viet Nam issued a new Power Development Plan (PDP8) in May 2023, which includes the consideration of biomass co-firing technology in existing coal-fired power plants after 2030. Owners of coal-fired power are currently drafting a detailed roadmap for implementing biomass co-firing. Recently, Erex Company announced plans to conduct co-firing tests at the Na Duong coal-fired power plant, beginning with 5% biomass and gradually increasing to 20% on an energy basis.

Co-firing ammonia and coal

Figure 1.3: Development status in co-firing ammonia and coal at selected APEC economies



Sources: compiled by authors based on METI (2020), ERIA (2023), IEA (2023c), Mongabay (2022), PDP8 (2023), MHI (2023).

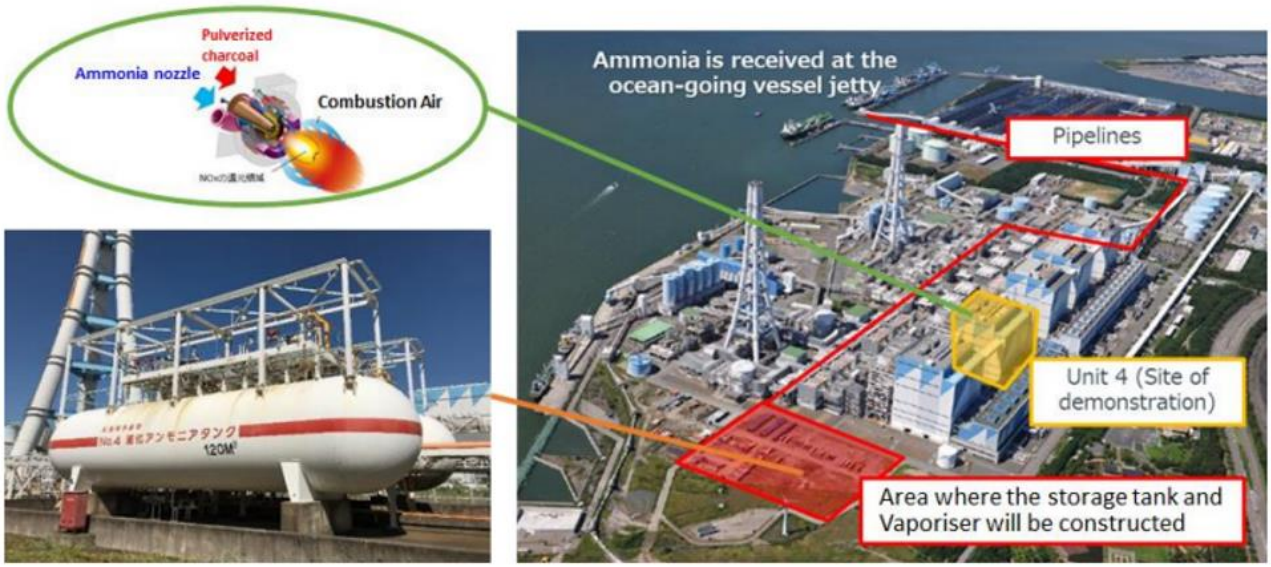
Key points

- In Japan, co-firing ammonia in the existing USC coal-fired power plants is implemented at the demonstration phase with 20% of ammonia on an energy basis. The Japanese government intends to spread 20% ammonia co-firing to the Asian region in the middle of the 2030s.
- Korea aims to advance ammonia co-firing through technological development and demonstration, with goals of 20% co-firing demonstration by 2027, 20% co-firing commercialization by 2030, and 100% ammonia-fueled firing by 2050.
- In Thailand, the cooperation between the Thai's power company and Mitsubishi Heavy Industries (MHI) has been made in a feasibility study of ammonia co-firing at a coal-fired thermal power plant operated by BLCP Power Limited[5]. JERA[6] will examine the procurement and transportation of ammonia fuel, whereas JERA and Mitsubishi Corporation will investigate the port facilities and ammonia receiving and storage facilities (MHI, 2023).
- Viet Nam plans to deploy ammonia co-firing in the existing coal-fired power plants after 2030, starting from 20% of ammonia on an energy basis, targeting 100% of ammonia firing by 2045. To prepare for the ammonia supply, Viet Nam started constructing a 200 MW electrolysis plant last year in Tra Vinh province, which will produce 150 000 – 180 000 tonnes of ammonia and 30 000 tonnes of green hydrogen per year.

[5] BLCP Power Ltd. is an independent power producer in Thailand and a joint-venture (50:50) between Banpu Power Public Company Limited and Electricity Generating Public Company Limited.

[6] JERA is a 50-50 joint venture between TEPCO Fuel & Power, a wholly owned subsidiary of Tokyo Electric Power Company, and Chubu Electric Power, founded in April 2015

Figure 1.4: Demonstration of ammonia co-firing in existing Hekinan coal-fired power plant, Japan



Source: JERA (2022).

Key points

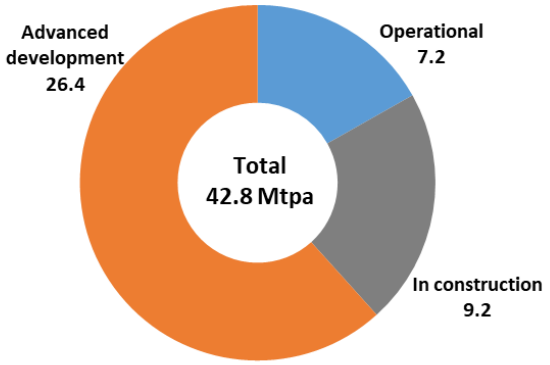
- On April 10, 2024, the co-firing demonstration test of 20% of fuel ammonia and coal at Unit 4 of the Hekinan Thermal Power Station was successful. It is confirmed that CO_2 emissions at the unit fell around 20%, nitrogen oxide (NOx) emissions were equal to or less than when mono-firing coal before ammonia substitution, and sulfur oxide (SOx) emissions were down about 20%. Emissions of the potential greenhouse gas nitrous oxide (N_2O) were undetectable. IHI[7] and JERA[8] also confirmed that operability was equivalent to that before the conversion to fuel ammonia (IHI, 2024).
- IHI will apply the knowledge gained through the demonstration test to establish a combustion technology that increases the ammonia ratio to more than 50% at thermal power plants and develop burners for 100% ammonia combustion. IHI will leverage its advanced clean fuel substitution technologies to help reduce carbon dioxide emissions and tailor solutions for communities and customers to drive the achievement of carbon neutrality by 2050.
- With 20% of ammonia co-firing, 600 000 tonnes of ammonia will be required annually to fuel this plant. Therefore, the establishment of the ammonia supply chain is significantly important.
- Under its "JERA Zero CO_2 Emissions 2050" objective, JERA has been working to reduce CO_2 emissions from its domestic and overseas businesses to zero by 2050, promoting the adoption of greener fuels and pursuing thermal power that does not emit CO_2 during power generation. JERA continues to contribute to the decarbonisation of the energy industry through its proactive efforts to develop decarbonisation technology while ensuring economic rationality.

[7] IHI stands for IHI Corporation, a Japanese engineering corporation headquartered in Tokyo.

[8] JERA is an electric utility company in Japan.

Carbon Capture, Utilization, and Storage

Figure 1.5: Capacity of CCS facilities equipped at coal-related plants in APEC[9]



No	Facility title	Economies
1	Boundary Dam Carbon Capture and Storage	Canada
2	Petra Nova Carbon Capture	US
3	Great Plains Synfuels Plant and Weyburn-Midale	US
4	Sinopec Qilu-Shengli	China
5	Yangchang Yulin CO2-EOR	China
6	China National Energy Taizhou	China
7	China National Energy Ningxia	China
8	Huaneng Longdong Energy Base	China
9	Yulin intergrated coal-to-liquid	China
10	Baotou Steel	China
11	Xinjiang Jinlong Shenwu	China
12	Minkota Power Project Tundra	US
13	Sinopec Shengli Power Plant	China
14	Gerald Gentleman Station	US
15	Prairie State Generating Station	US
16	Four Corners Power Plant Integrated CCS	US

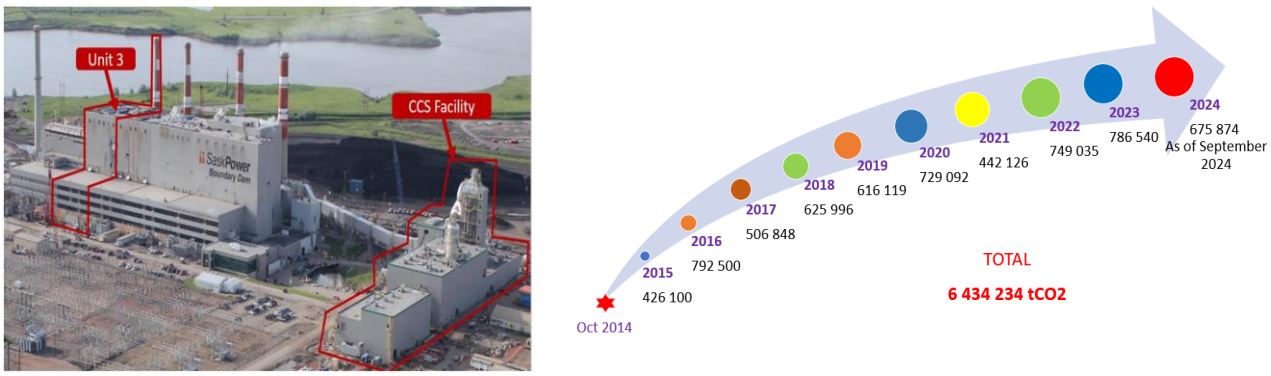
Source: compiled by the authors based on Global CCS Institute (2024).

Key points

- As of December 2024, there are 16 coal-related CCUS projects in different development stages in the APEC region, with a total capacity of 42.8 Mtpa. Of these, six projects are operational with a capacity of 7.2 Mtpa (one in Canada, two in the United States, and three in China).
- There are currently five coal-related CCUS projects under construction with a total capacity of 9.2 Mtpa, coming online in the coming years. All the above projects are located in China. Additionally, five coal-related CCUS projects are in advanced development with a total capacity of 26.4 Mtpa.
- Among six coal-related CCUS operational facilities, three are associated with coal-fired power plants, and the other three projects include coal-to-syngas, coal-to-hydrogen, and coal-to-chemical plants.
- In the coal power sector, the Boundary Dam and the Petra Nova are the only two coal-fired power plants in the world with retrofitted CCUS facilities with a total capacity of 2.4 Mtpa.
- The Boundary Dam CCUS facility in Saskatchewan (Canada) is currently operational. Captured CO_2 from this facility is used for EOR, which involves injecting CO_2 into oil reservoirs to recover incremental oil from producing wells.
- The Petra Nova is another coal-fired CCUS facility used for EOR in Texas, United States, that was suspended in May 2020 due to operational problems and unfavourable economics. However, this facility was restarted in September 2023.

[9] Coal-related plants include coal-fired power, coal-to-syngas, coal-to-hydrogen, coal-to-liquid, and iron & steel plants.

Figure 1.6: CCUS-equipped coal-fired power plant - The Boundary Dam, Canada



Source: compiled by the authors based on SaskPower, International CCS Knowledge Centre.

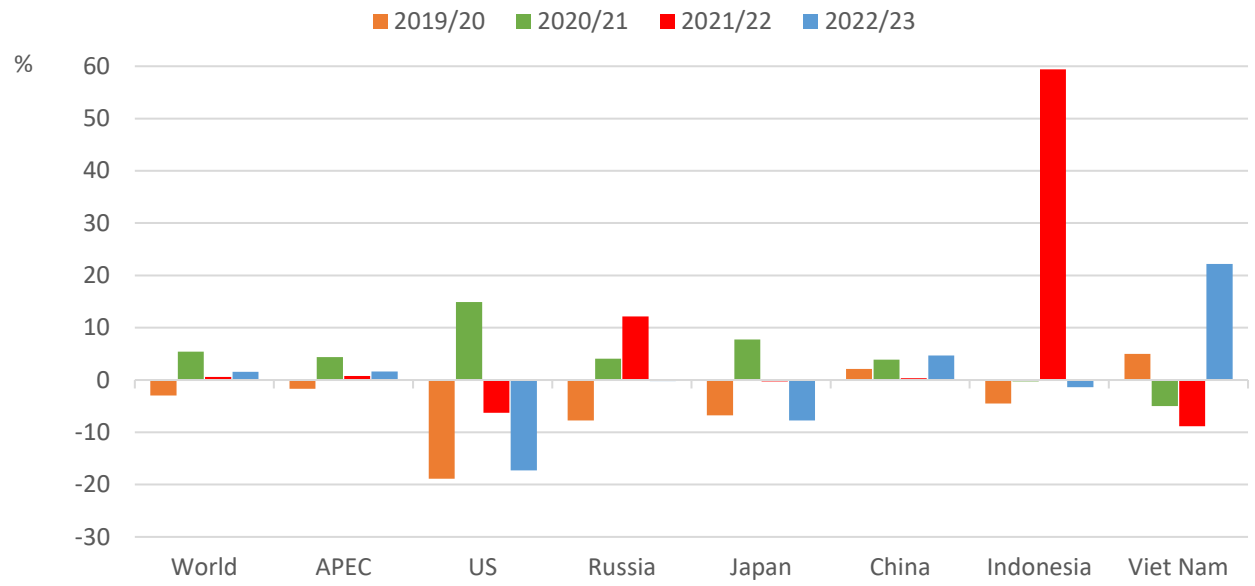
Key points

- The Boundary Dam is an 824 MW coal-fired power plant located in Saskatchewan, Canada. Generation Unit 3, which opened in 2014, is the world's first commercial-scale CCUS at a coal-fired power plant.
- Unit 3 was originally scheduled for closure in 2013 after 45 years of service. A retrofit was undertaken to transform the unit into a reliable long-term producer of 110MW of clean baseload electricity and simultaneously supply CO_2 to an EOR project in the province. Unit 3 is expected to have an increased life expectancy of 30 years and has the potential to capture one million tonnes of CO_2 a year (Sask Power).
- The Unit 3 retrofit included the replacement of the existing steam turbine generator with a new one that could be integrated with the CO_2 and SO_2 capture mechanism. The captured CO_2 is compressed and transported through a 66 km-long pipeline to an EOR project near Weyburn, which is part of an agreement signed with Cenovus Energy to purchase the full volume of one million tonnes of CO_2 a year.
- Unused CO_2 is transported to an injection well and storage site belonging to an Aquistore research project that is managed by the Petroleum Technology Research Centre. The SO_2 provides feedstock to a 50-tonne per-day sulphuric acid plant, which will be built next to Unit 3. A flue gas desulphurisation (FGD) system was put in place to allow the installation of carbon capture equipment, which reduces CO_2 emissions by approximately 90%.
- The year 2024 marks 10 years of operation at the Boundary Dam Unit 3 CCS facility. The total captured CO_2 has reached 6.4 Mt by the end of September 2024 since it began operating in 2014.
- Emerging economies will continue to consume more energy. Therefore, governments need to maintain the value of existing generation assets from diverse fuel sources, especially low-cost fuels such as coal. The Boundary Dam unit 3 project paves the way for continuing to rely on coal while simultaneously striving to lower greenhouse gas (GHG) emissions. Coal with CCUS can help coal become a sustainable, reliable, and clean energy source.
- Today, the Boundary Dam Unit 3 remains a significant part of Sask Power's generating fleet, producing enough low-carbon emission electricity for 110,000 Saskatchewan households.
- CCUS is applicable beyond the power sector and can be applied to hard-to-abate sectors such as iron and steel and cement.

Chapter 2: Coal consumption

World and APEC coal consumption

Figure 2.1: Coal consumption growth rate for the world and selected APEC economies

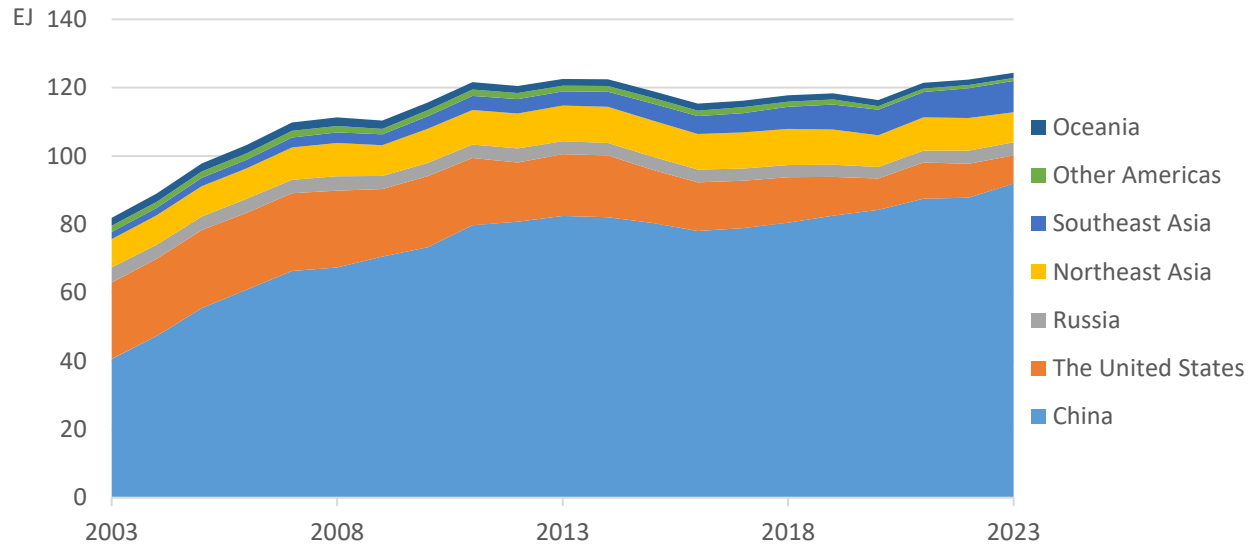


Source: compiled by the authors based on Energy Institute (2024).

Key points

- Global coal consumption increased only marginally by 1.55% in 2023. The main driver for this increase is the strong growth of coal demand for coal-fired power generation partly due to low hydropower output in China, India, and some ASEAN economies.
- APEC coal consumption also showed a slight change, a 1.64% increase in 2023 relative to the 2022 level. The change in coal consumption is often driven by the five largest coal consumption economies (China, United States, Japan, Russia, and Indonesia), which account for almost 90% of APEC coal consumption.
- The United States' coal consumption dropped 17.3% compared to the previous year, returning to the declining trend in coal consumption observed during the last two decades except the year 2021.
- Coal consumption in China, the world's largest coal consumer by far, grew by approximately 4.7% in 2023. It was the highest growth in coal consumption over the last five years.
- Coal consumption in Indonesia dropped by 1.36% in 2023 relative to the previous year. Coal consumption in Russia and Japan in 2023 declined by 0.2% and 7.7%, respectively, relative to the previous year. The drop in coal consumption in Japan is due to the increased use of renewable energy and the restart of nuclear power plants.
- Viet Nam coal consumption grew by 22.2% in 2023, the highest growth among APEC economies, mainly due to heatwaves in summer driving up cooling demand. Additionally, low hydropower electricity caused by low water levels further pushed coal consumption for coal-fired power generation.

Figure 2.2: APEC coal consumption by region

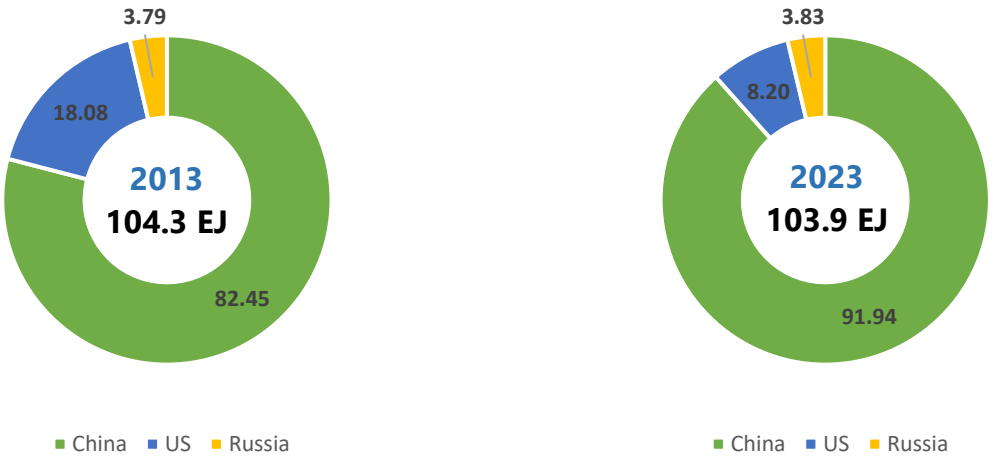


Source: compiled by the authors based on Energy Institute (2024).

Key points

- APEC-wide coal consumption rose 1.5-fold over two decades, reaching over 124.4 EJ in 2023, surpassing its previous peak in 2014.
- China, the largest coal consumer in the APEC and the world, continued to increase consuming coal over the decades. China's coal consumption reached an all-time record high in 2023, accounting for approximately 74% of the total coal consumption in the APEC region.
- Coal consumption in the United States has declined gradually since 2007. In 2023, the United States consumed around 6.6% of the total APEC-wide coal consumption.
- Northeast Asia, including Japan, Korea, Chinese Taipei, and Hong Kong (China), accounted for 7.1% of the total APEC coal consumption in 2023, mainly consumed by Japan and Korea.
- The Southeast Asia economies accounted for 7.3% of APEC coal consumption in 2023. Indonesia consumed the most, followed by Viet Nam.
- Oceania, including Australia and New Zealand, accounted for 1.2% of the APEC-wide coal consumption in 2023. Australia consumes over 95% of coal consumption in the Oceania region.
- Other Americas, namely, Canada, Chile, Mexico and Peru, consumed less than 1% of APEC coal consumption.
- Russia consumed 3.1% of total APEC coal consumption in 2023, which has plateaued over the last two decades.

Figure 2.3: Coal consumption in China, US, and Russia, 2013-2023

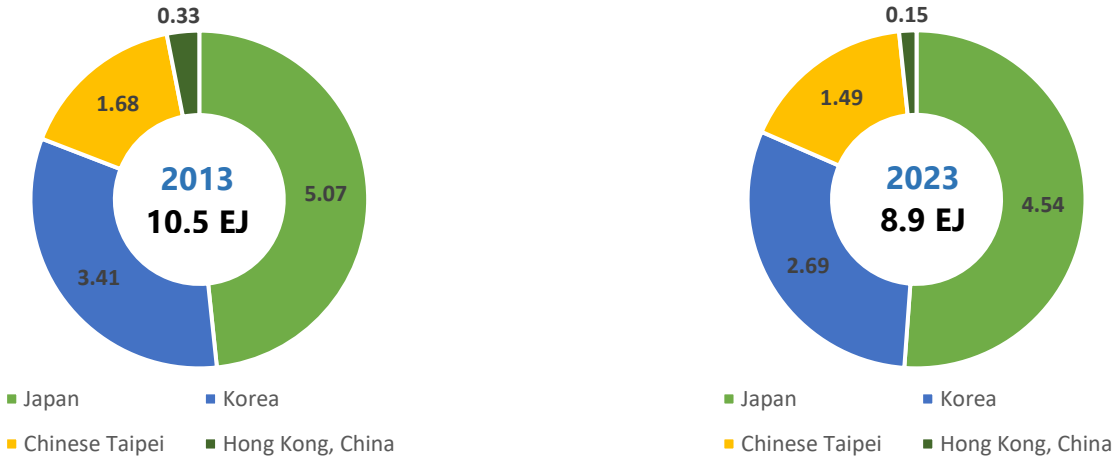


Source: compiled by the authors based on Energy Institute (2024).

Key points

- China's coal consumption rose 11.5% over the last decade, from 82.45 EJ in 2013 to 91.94 EJ in 2023. Approximately 64% of coal was used for power generation, and around 24% was used for energy-intensive industries such as steelmaking, aluminium smelting, cement manufacturing and fertiliser production. The power sector in China is still highly dependent on coal. In recent years, coal-fired power generation accounts for approximately two-thirds of total electricity generation in China.
- In contrast, the United States' coal consumption fell by 54.7% over the 2013-2023 period, from 18.08 EJ in 2013 to approximately 8.2 EJ in 2023. Coal consumption has substantially fallen since 2007 due to competitive prices of shale gas relative to coal and the widespread deployment of renewable energy despite a temporary surge in coal consumption in 2021. Coal consumption in the United States is expected to continue declining due to coal-to-gas switching in the power sector.
- Russia's coal consumption slightly rose by 1.2% over the 2013-2023 period. Even though coal phase-out is not a priority for Russia, the global low-carbon trend is affecting the Russian coal sector. Coal consumption is expected to gradually decline in the coming decades due to the competition with natural gas (Korppoo, A. et al., 2021).

Figure 2.4: Coal consumption in Northeast Asia, 2013-2023

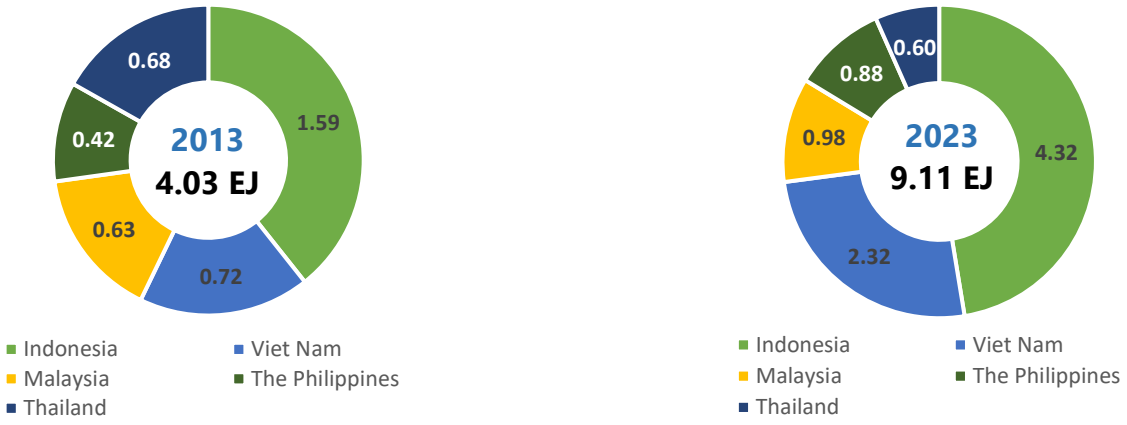


Source: compiled by the authors based on Energy Institute (2024).

Key points

- Coal consumption in the Northeast Asia economies declined from 10.5 EJ to 8.9 EJ over the 2013-2023. The fall in coal consumption has recently been seen due to the environment-related issues and net-zero commitments of economies in this region.
- Japan was the largest coal consumer in Northeast Asia, with 4.54 EJ in 2023. Although Japan plans to reduce reliance on coal power generation, with plans to phase out inefficient coal power plants by 2030, Japan did not sign the Global Coal to Clean Power Transition Statement at COP26 to phase out all coal-fired power plants by the 2030s or 2040s. Coal power technologies are still a significant business for major Japanese power plant makers and power utilities. As a long-time supporter of this industry, the Government has not yet moved away from coal (Japan Beyond Coal). However, Japan agreed with a declaration from the G7 Italia 2024 meeting to achieve a fully or predominantly decarbonized power sector by 2035 and to phase out existing unabated coal power generation in the energy system during the first half of 2030s, or in a timeline consistent with keeping a limit of 1.5 ^{o}C temperature rise within reach, in line with countries's net-zero pathways (G7 Italia, 2024).
- Korea's coal consumption declined by 21.2% from 3.41 EJ in 2013 to 2.69 EJ in 2023, contributing to carbon emissions reduction to realize the carbon neutrality target by 2050. Improved energy efficiency, increased share of renewable energy, and the emergence of a hydrogen industry are expected to offset the reduction in coal consumption.
- Chinese Taipei's coal consumption declined by 11.5% over the last decade due to the Government's efforts to reduce reliance on coal-fired generation.

Figure 2.5: Coal consumption in Southeast Asia, 2013-2023

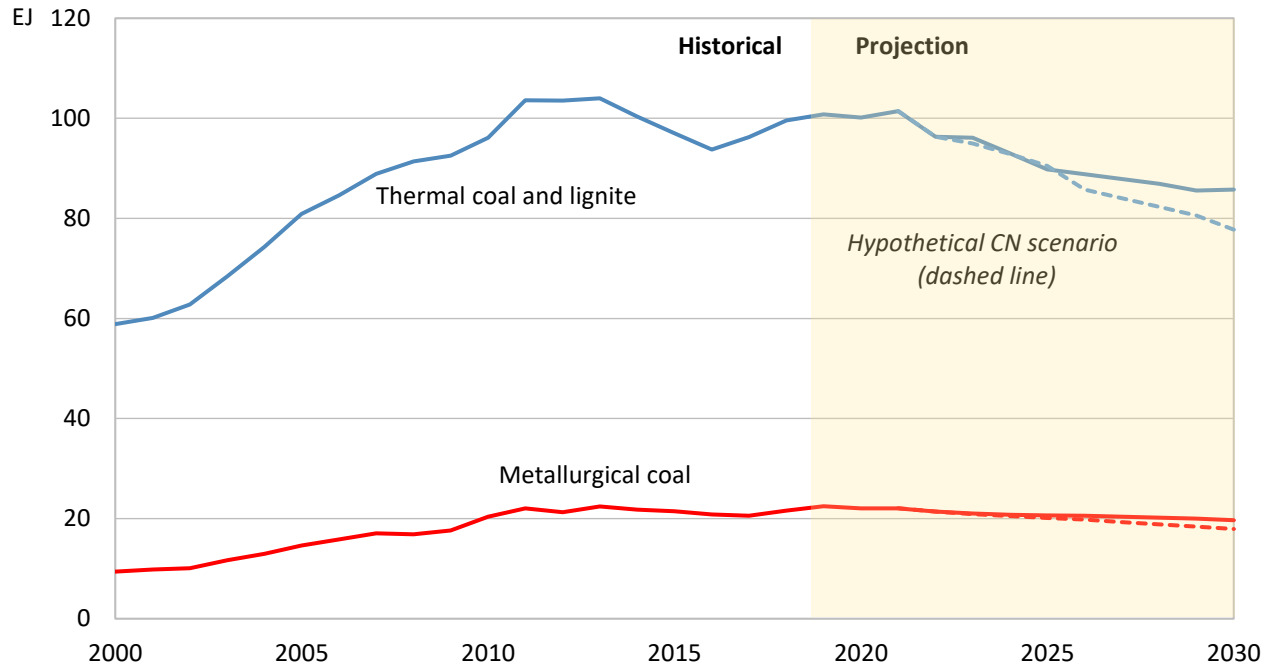


Source: compiled by the authors based on Energy Institute (2024).

Key points

- Due to high energy demand caused by rapid economic growth, coal consumption in Southeast Asia over doubled from 2013 to 2023, from 4.03 EJ in 2013 to 9.11 EJ in 2023. Coal is mainly used in the power sector as most economies in Southeast Asia rely on coal-fired power generation.
- Indonesia was the largest coal consumer among Southeast Asia economies, with 4.32 EJ in 2023, a 2.7-fold increase relative to 2013. Coal is used mainly in the power sector, accounting for around 70% of the total coal consumption in recent years. Coal-fired power generation for nickel smelters has significantly increased by approximately 8 times, from 1.4 GW in 2013 to 10.8 GW in 2023 (IESR, 2024).
- Viet Nam was the second-largest coal-consuming economy in the region in 2023. The coal consumption increased over three-fold from 0.72 EJ to 2.32 EJ to meet the high coal demand for coal-fired power generation and industry over the 2013-2023 period. Approximately 70% of coal is consumed in coal-fired power plants, and the remainder is for heavy industries and other sectors. The electricity production from coal-fired power plants has increased approximately six times over the last decade. Although Viet Nam is a coal-producing economy, Viet Nam has started to import a large amount of coal since 2014 to supplement its domestic production.
- Coal consumption in Malaysia rose by 1.55 times over the last decade due to a high increase in coal-fired power capacity. Coal dominates the power sector, which makes up 92% of Malaysia's coal consumption. However, coal also provides heat for industrial processes, particularly cement, iron, and steel.
- Coal consumption in the Philippines rose approximately 2.1 times over the 2013-2023 period, mainly used for power and industrial sectors. Although coal is the single biggest source of carbon emissions, coal continues to be supported by both the Government and businesses in the Philippines as it is the cheapest fuel option.
- Thailand's coal consumption has reduced by approximately 11% over the last decade, the only economy in Southeast Asia that has reduced coal consumption. Unlike other ASEAN economies, Thailand uses just above 50% of total coal consumption for the power sector, while the remainder is used for industrial processes.

Figure 2.6: APEC coal consumption: history and outlook



Source: compiled by the authors based on EGEDA (2021) and APEC Outlook 8th (2022).

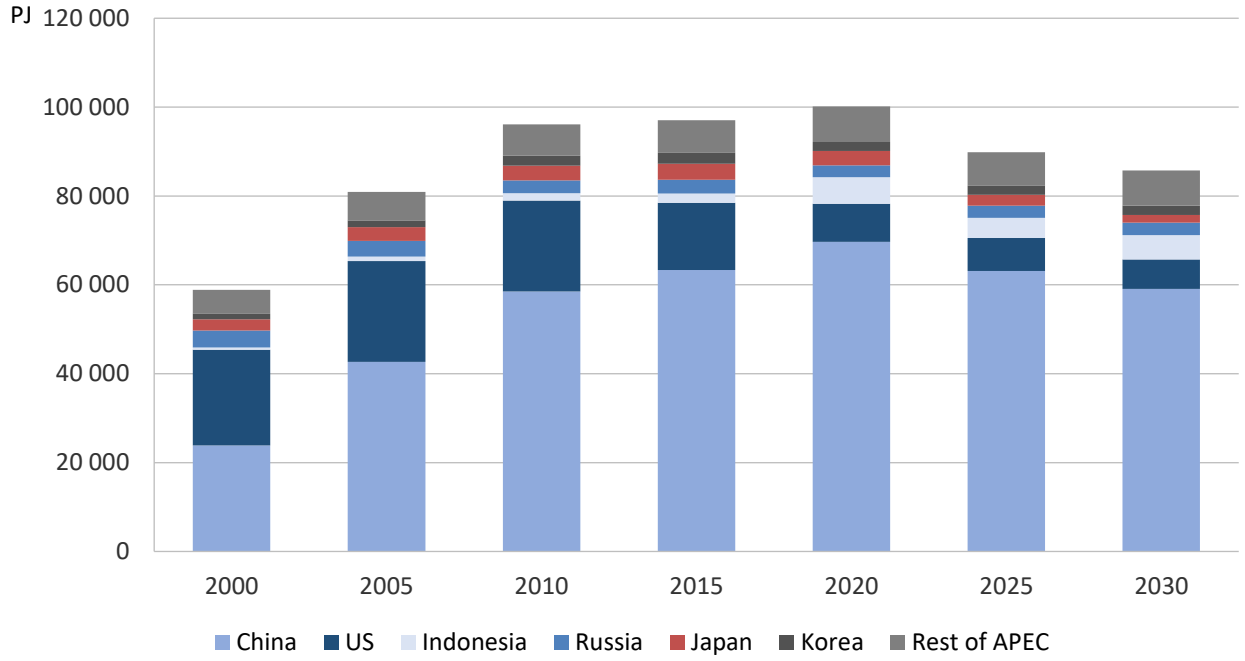
Key points

- While there has been a rebound in APEC thermal coal consumption in the latter half of the 2010s, thermal coal consumption is projected to decline through the 2020s. The pace of decline will increase as many economies aim to achieve greater emissions reduction. In contrast, metallurgical coal demand will maintain a high plateau, with consumption only decreasing by a small amount in the hypothetical carbon neutrality (CN) scenario of the 8th APEC Energy Outlook.[10]
- Nine APEC economies signed the Global Coal to Clean Power Transition Statement at COP26 in Glasgow, wherein they committed to not building any new coal-fired power plants from the 2030s or 2040s, depending on their economic situation.
- In the next decade, coal consumption is expected to decline mainly in the power sector, while metallurgical coal is still significant for heavy industrial sectors such as iron and steel manufacturing.

[10] The medium and long-term projection data was modelled in August 2021. Therefore, it did not cover the recent change in coal consumption due to the Russian-Ukraine conflict.

Thermal coal

Figure 2.7: APEC thermal coal (including lignite) consumption by economy: history and outlook

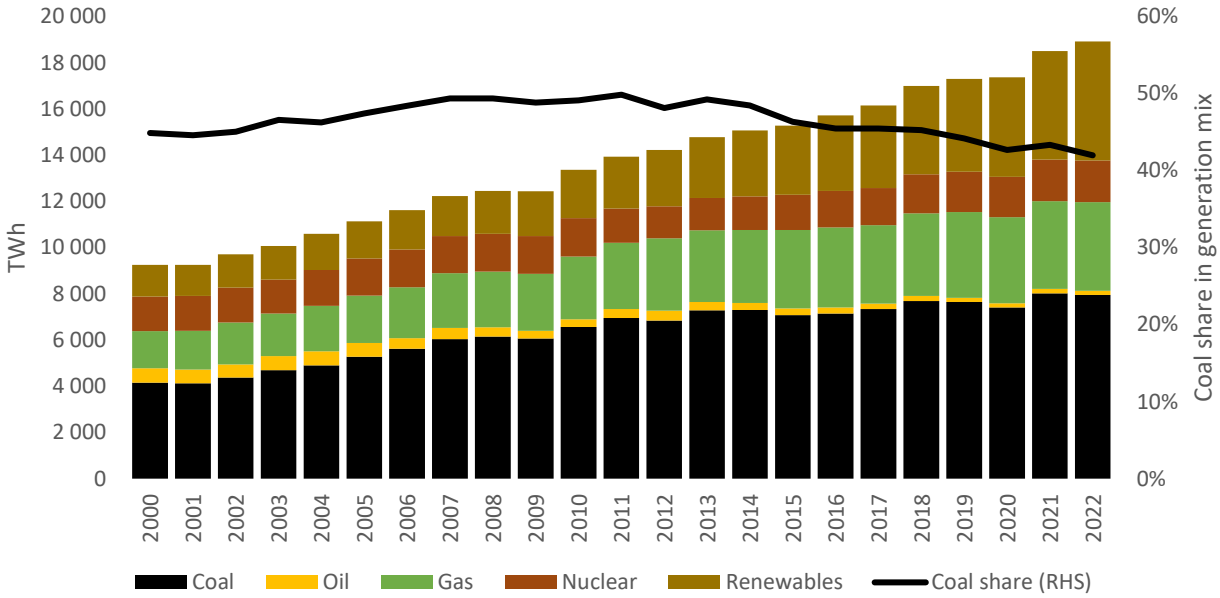


Source: compiled by the authors based on EGEDA (2021) and APEC Outlook 8th (2022).

Key points

- In the APEC region, China remains the largest consumer of thermal coal (including lignite). China's share has increased from about 40% in 2000 to approximately 70% of APEC thermal coal consumption in 2019. The power sector drives this consumption, though coal-fired heating in the non-power sector has also accounted for a significant portion of this consumption. In recent years, natural gas has replaced coal-fired heating extensively, particularly in northern Chinese cities. This will contribute to lower levels of thermal coal demand growth moving forward.
- In contrast, the United States' share has declined from 36% of APEC thermal coal consumption in 2000 to 11% in 2019 (IEA, 2021). This represents a halving in absolute consumption for the period.
- APEC thermal coal consumption is projected to decline through the 2020s in the reference scenario that has been modelled for the APEC Energy Demand and Supply Outlook 8th Edition. While there is likely to be an absolute decline in thermal coal consumption, certain APEC economies in Southeast Asia have posted strong growth in recent years, such as Indonesia and Viet Nam.
- While almost all APEC economies are expected to decrease their coal consumption through 2030, thermal coal consumption is projected to rise in Indonesia and Viet Nam by 2030.

Figure 2.8: Coal share in the APEC generation mix

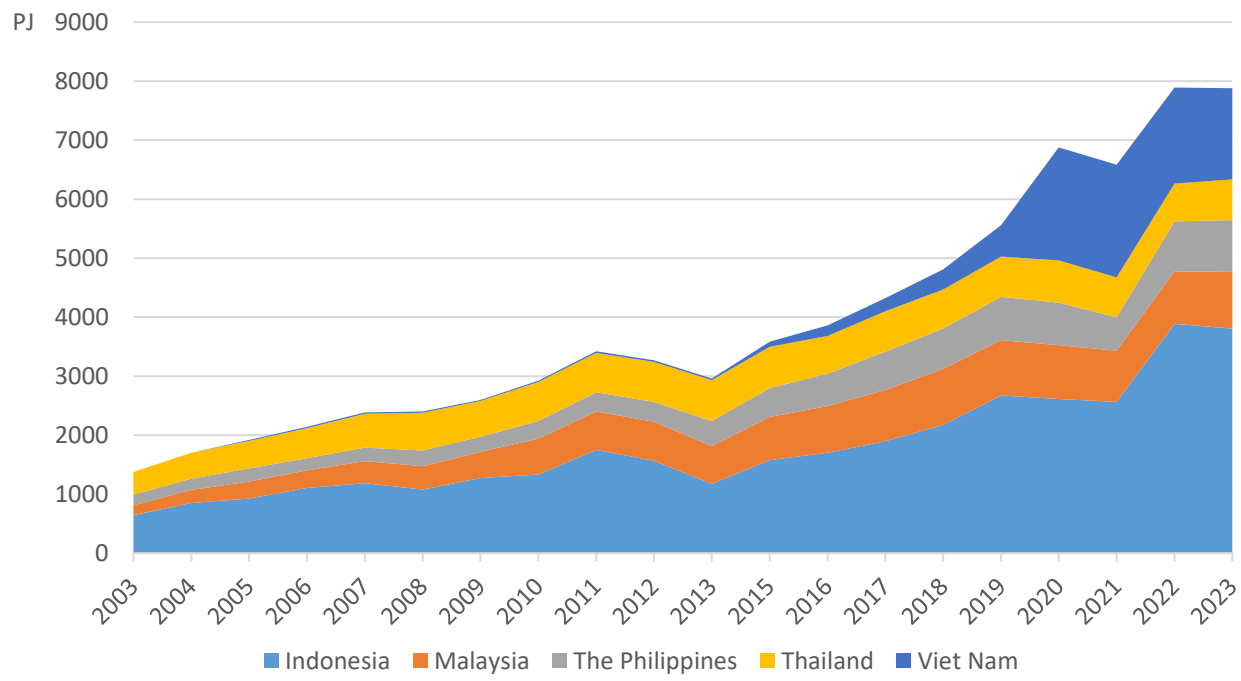


Source: compiled by the authors based on EGEDA (2024).

Key points

- Coal is still the largest contributor to the APEC-wide generation mix. However, coal share in the total generation has been gradually declining from 49% in 2013 to 42% of total power generation in 2022.
- In 2021-2022, the high gas prices and energy supply disruptions prompted several APEC economies to increase coal use in power generation. Electricity generation from coal increased by 8.2% in Indonesia in 2022 compared to the 2021 level, followed by the Philippines (+7.1 %) and China (+0.8%).
- The declining trend of coal share in the generation mix mainly occurred in several APEC economies, such as the United States, Canada, and Australia, while Southeast Asia economies still rely on coal in their power sector. Phasing out coal will be extremely challenging, but a handful of economies are already proving that a rapid, sustained shift is possible. While each one must chart its own path forward, other coal-power-reliant economies can learn from these economies.
- There are two typical examples in the APEC economies. The United States reduced the share of electricity from coal generation by half, from 39% in 2014 to 19% of the total generation mix in 2022, replacing it with a combination of natural gas, solar, and wind. In Chile, coal plants were booming as recently as a decade ago, but the economy has quickly reversed course; it is now supporting the early retirement of coal plants and replacing them mainly with solar and wind power (World Resources Institute, 2023).

Figure 2.9: Thermal coal (including lignite) consumption in selected Southeast Asia economies



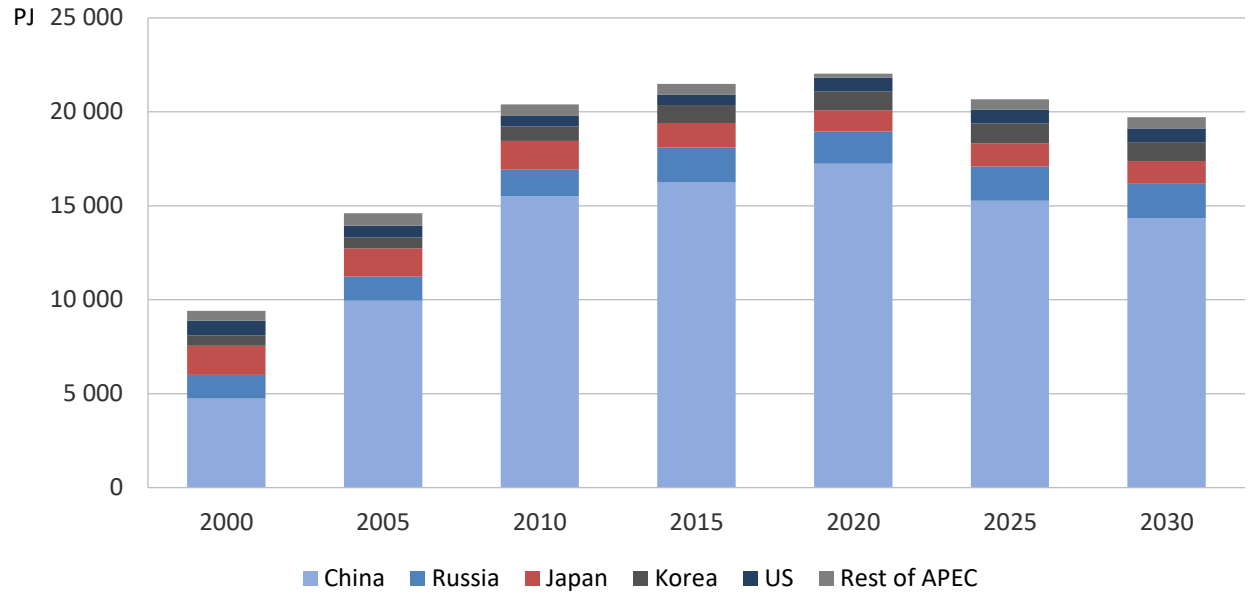
Source: compiled by the authors based on IEA (2024).

Key points

- Thermal coal (including lignite) consumption in the Southeast Asia economies has risen noticeably over the last decade, particularly in Indonesia and Viet Nam. Southeast Asia economies will likely continue to rely on coal for at least the next decade to meet their growing electricity demand.
- Indonesia's thermal coal consumption increased sharply in recent years due to the operation of some new coal-fired power plants and high coal demand for nickel and aluminum smelting plants.
- Viet Nam's Power Development Plan 8 (PDP8) limits the total coal power capacity to 30 GW by 2030 from the current installed capacity of 25.4 GW. However, the surging consumption of thermal coal is being driven by new coal-fired power plants that have been commissioned in recent years.
- Announcements by Japan, Korea, and China in 2021 to no longer provide state-based financing for overseas unabated coal projects are likely to slow the coal power deployment in developing economies. In June 2022, the Japanese government announced the halt of financial aid for constructing coal-fired plants in Indonesia (the Indramayu plant) and Bangladesh (the Matarbari plant) in response to international criticism of coal-fired power (Nikkei Asia).

Metallurgical coal

Figure 2.10: APEC metallurgical coal consumption by economy: history and outlook



Source: compiled by the authors based on EGEDA (2021) and APEC Outlook 8th (2022).

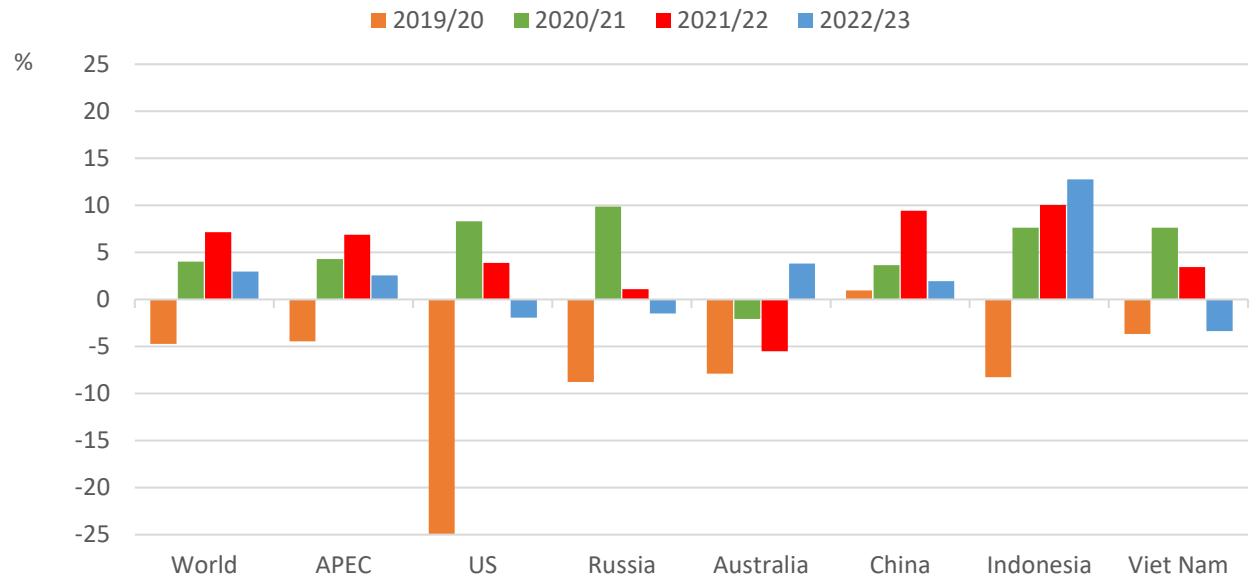
Key points

- China remains the dominant consumer of metallurgical coal in APEC, owing to its global leadership in steel production. Even in the face of a global slowdown in steel production of 0.9% in 2020, China posted steel production growth of 5.2%. This large increase in production when the rest of the world was contracting meant that China accounted for 57% of global steel production in 2020, up from 53% the year before (WSA, 2021).
- China's metallurgical coal consumption increased from 15 500 PJ in 2010 to over 17 000 PJ in 2020, representing 78% of APEC metallurgical coal consumption. Russia was the next largest consumer of metallurgical coal in 2020, though the consumption is an order of magnitude less than China's, at 1709 PJ. Japan, Korea, and the U.S. are the next most prominent metallurgical coal consumers in APEC, consuming coal at levels closer to 1000 PJ in 2020.
- Higher levels of steel production only partly explain China's greater metallurgical coal consumption. It is also due to a larger proportion of steel production being reliant on oxygen furnaces relative to other APEC steel-producing economies. The proportion of oxygen-based steel production processes in China was 91% in 2020. In contrast, Russia (66%), Japan (75%), Korea (69%), and the United States (29%) relied less on oxygen-based processes, instead consuming higher levels of electricity via electric arc furnaces, which are reliant on scrap metal (WSA, 2021).
- It is expected that China will remain the largest metallurgical coal consumer, accounting for 73% of the APEC metallurgical coal consumption by 2030, followed by Russia and Japan.

Chapter 3: Coal production

World and APEC coal production

Figure 3.1: Coal production growth rate for the world and selected APEC economies

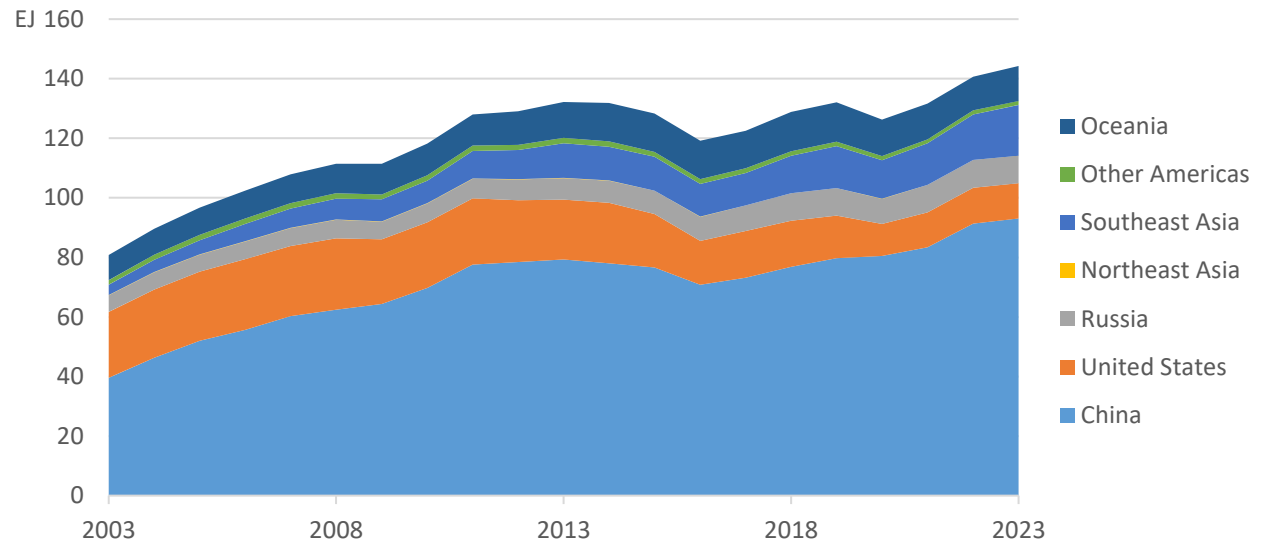


Source: compiled by the authors based on Energy Institute (2024).

Key points

- Global coal production rose 3% in 2023 to meet the continued high coal demand. Coal production reached a record-high level in 2023. In the APEC region, coal production rose 2.6% in 2023 compared to 2022, though the rising trend was not uniform across all economies.
- China, the world's largest coal producer, increased coal production by approximately 2% in 2023 compared to the previous year in response to the high demand for coal, particularly for power generation. After the coal crisis in 2021, China increased its coal production at existing coal mines and reopened the closed coal mines in the Inner Mongolia and Shanxi areas to meet the rising domestic coal demand.
- Indonesia's coal production rose 12.8% in 2023, the highest growth among APEC economies. The increased coal production was both for export and domestic use.
- Coal production in Australia rose by 3.8% in 2023 compared with 2022, a strong recovery from coal exports ban and weather issues in the last several years.
- Viet Nam, the United States, and Russia showed a drop in coal production in 2023. Viet Nam's coal production fell by 3.4%, followed by the United States (-1.9%) and Russia (-1.5%).

Figure 3.2: APEC coal production by region

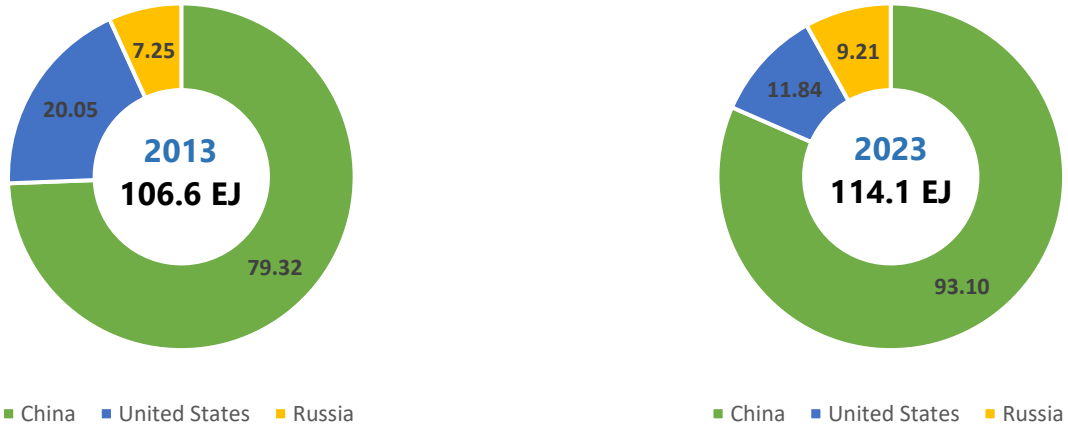


Source: compiled by the authors based on Energy Institute (2024).

Key points

- APEC coal production reached an all-time record high of approximately 144 EJ in 2023, a 2.6% increase relative to the previous year.
- China, the largest coal producer in the APEC and the world, produced 93.1 EJ, accounting for approximately 65% of APEC coal production in 2023. Many coal mines have been closed in the last five years due to mining safety and land-use rights for mining issues. In order to offset the coal production shortage from closed coal mines, the Chinese Government boosted the coal production from existing large mines.
- Southeast Asia produced 17 EJ in 2023, accounting for 11.8% of the total APEC coal production. Indonesia has dominated coal production in the region for decades, followed by Viet Nam and Thailand.
- Oceania produced 11.7 EJ, accounting for 8.1% of APEC coal production in 2023, while other Americas accounted for less than 1%.
- The United States and Russia were the third and fifth largest coal producers in 2023, accounting for 8.2% and 6.4% of APEC coal production, respectively.

Figure 3.3: Coal production in China, US, and Russia, 2013-2023

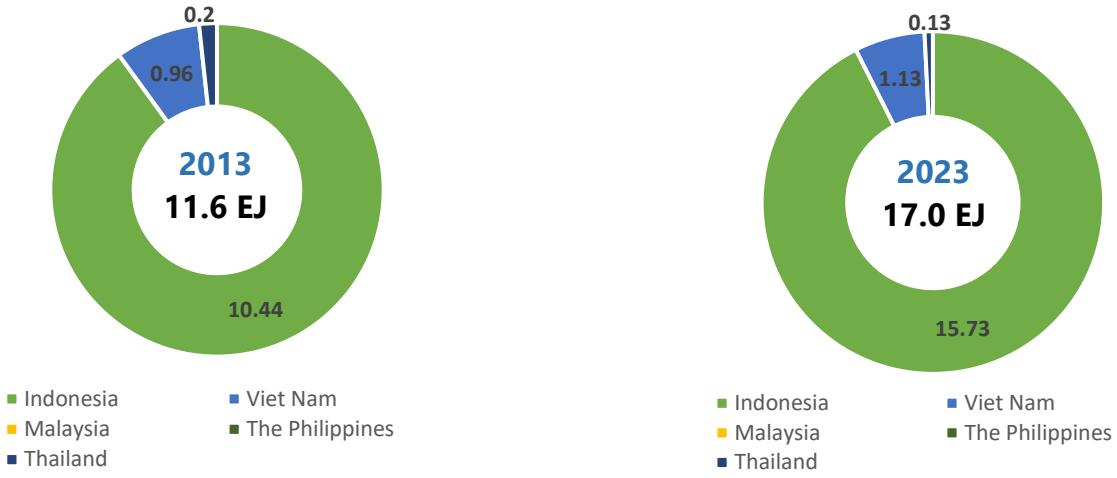


Source: compiled by the authors based on Energy Institute (2024).

Key points

- Coal production in China grew substantially over the last decade, with an increase of 17.4%. Although high domestic coal production was achieved in 2023, China is still the largest thermal and metallurgical coal importer.
- In 2023, China's coal production reached a new record-high level of 93 EJ due to high coal demand for both coal-fired power and industrial plants. The coal crisis in the second half of 2021 caused electricity blackouts in four provinces (Liaoning, Hei Longjiang, Jilin and Guangdong), disrupting the daily lives of 10 million people. In response, the authorities asked coal enterprises to rapidly increase coal production at existing coal mines while reopening closed coal mines in the Inner Mongolia and Shanxi areas.
- Russia achieved substantial growth in coal production over the last decade (+27.1%), with production increasing from 7.25 EJ in 2013 to 9.2 EJ in 2023. As the third largest coal-exporting economy in APEC, over half of its coal production has been used for exports in recent years.
- In contrast, coal production in the United States fell by approximately 41% in the 2013-2023 period, responding to declining coal demand except in 2021 and 2022.

Figure 3.4: Coal production in Southeast Asia, 2013-2023.

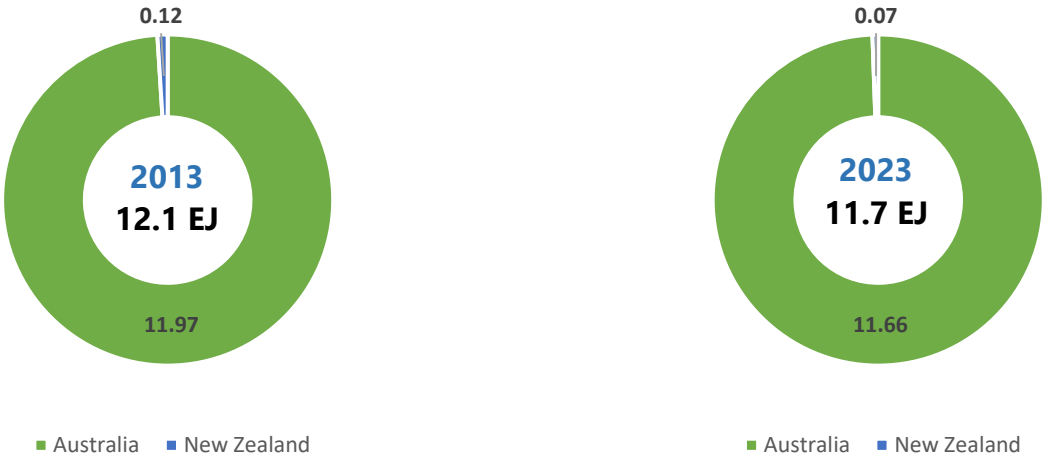


Source: compiled by the authors based on Energy Institute (2024).

Key points

- Southeast Asia showed the fastest growth in coal production among subregions in APEC, rising from 11.6 EJ to 17.0 EJ over the 2013-2023 period. This growth was driven by Indonesia, an economy possessing abundant coal reserves and favorable geological conditions for coal mining. Over 90% of coal mines are mined by the opencast mining method, which makes coal prices competitive with those of other economies.
- Indonesia, the largest coal producer and exporter in Southeast Asia, increased its coal production by 50.7%, from 10.44 EJ in 2013 to approximately 15.73 EJ in 2023. Most of Indonesia's coal production is low-quality coal (sub-bituminous coal), which is mainly used for electricity generation. Therefore, Indonesia still imports higher coal types such as bituminous, anthracite, and metallurgical coal to use for industrial processes.
- Viet Nam increased its coal production slightly over the last decade, mainly mined in the northern provinces and Quang Ninh anthracite coal basin. However, the complex geological conditions and deep coal seams hinder the significant growth of coal production in these coal fields. The Red River Delta coal basin is a newly discovered sub-bituminous coal resource in Viet Nam, but it has not been mined due to technical and economic obstacles.
- Thailand’s coal production fell by 33.6%, from 0.2 EJ in 2013 to 0.13 EJ in 2023. Currently, the Mae Moh coal mine is the only operational mining facility in Thailand, producing lignite, with the lowest calorific content as compared to other types of coal. According to Thailand's long-term low-emission development strategy, the economy aims to phase out coal in the power sector by 2050 as part of its goal to achieve carbon neutrality by 2050 and net-zero emissions by 2065.

Figure 3.5: Coal production in Oceania, 2013-2023



Source: compiled by the authors based on Energy Institute (2024).

Key points

- In the Oceania region, coal is primarily produced by Australia. Over the last decade, coal production declined slightly from 12.1 EJ in 2013 to 11.7 EJ in 2023. Only a small portion has been used domestically; the remainder was exported. Australian coal production has declined over the past decade mainly due to a global shift away from coal-fired power generation. This change is driven by environmental concerns, which have decreased the demand for Australian coal exports. Additionally, policy changes and community opposition to new coal mine developments also contributed to this decline.

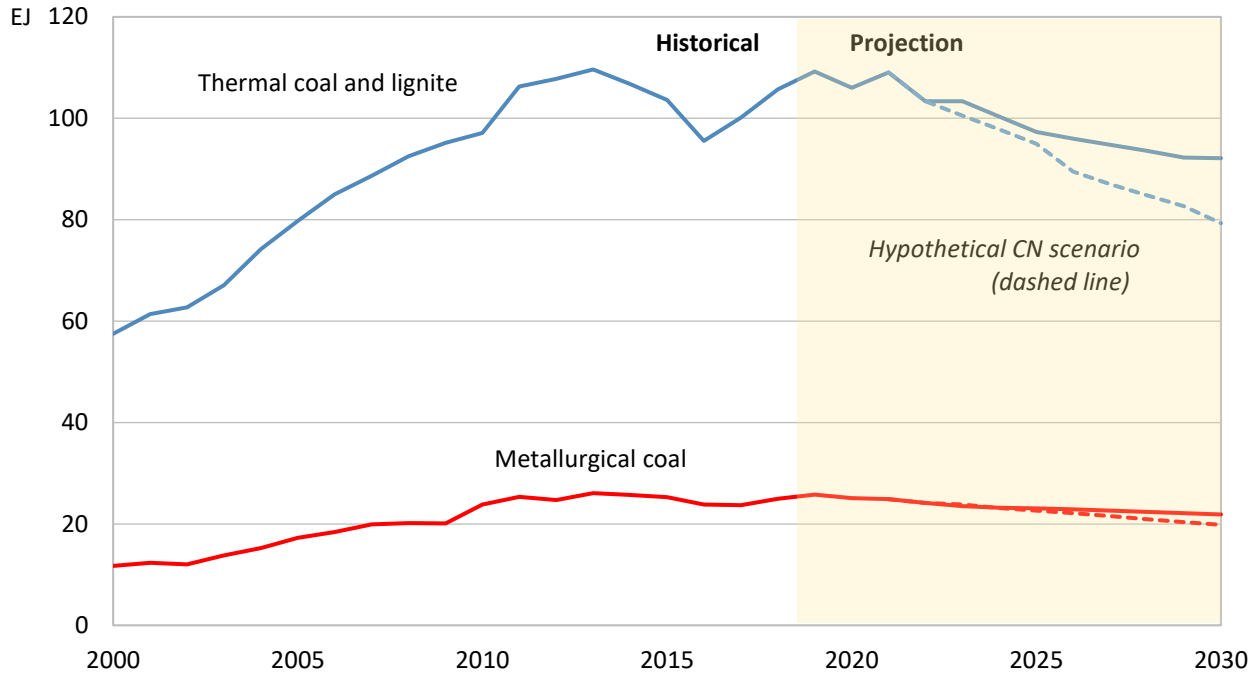
- Australia's coal production declined slightly from approximately 12 EJ to 11.7 EJ over the last decade. Most of its coal production is used for exports due to strong ongoing coal demand from Asia. Supplier reliability, proximity to key markets, and good infrastructure availability put Australia in a strong position to take advantage of growing demand from customers in Japan, China, India, Chinese Taipei, and Korea, as well as newer buyers in Viet Nam, Malaysia, the Philippines, and Thailand. In 2023, Australia exported 9 EJ of coal, accounting for about three-quarters of Australia's total coal production.

- The majority of Australia's black coal basins are in New South Wales and Queensland, while the main brown coal basins are in Victoria[11].

- Open-cut coal mines are the most visible sign of coal mining in Australia. In New South Wales open-cut mines now make up 80% of coal production, increasing from 75% just a few years ago. It's a similar situation in Queensland, with the top 10 producing mines being open-cut. Data released by Global Energy Monitor indicates that Australia is out of step with the rest of the world, which is closer to a 50/50 balance between open-cut and underground mining.

[11] Black coal refers to several coal types, including bituminous, sub-bituminous, and anthracite, used as a fuel for electricity generation, in iron and steel making, and in cement, alumina, and paper manufacturing. Brown coal, commonly referred to as lignite, is a soft, brown sedimentary rock. It is classified as low-rank coal and has low heat content. It is often used for power generation.

Figure 3.6: APEC coal production: history and outlook



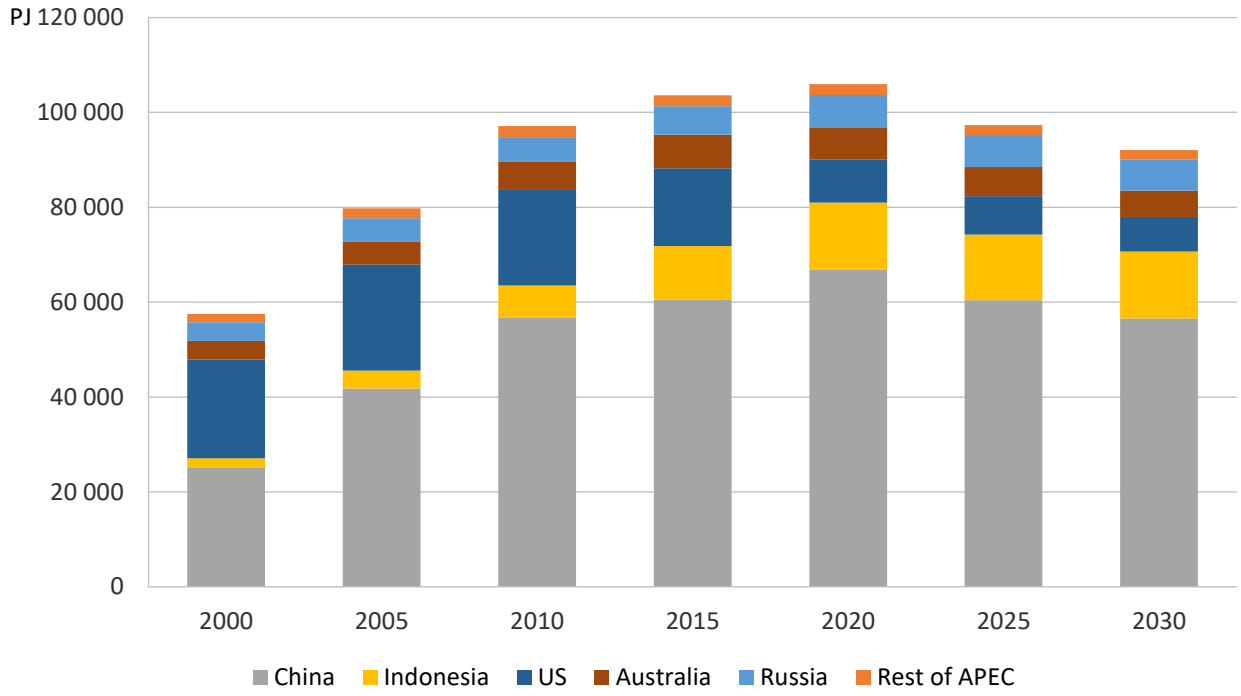
Source: compiled by the authors based on EGEDA (2021) and APEC Outlook 8th (2022).

Key points

- In the Reference Scenario (REF) of the 8th APEC Energy Demand and Supply Outlook, APEC-wide coal production is projected to fall by 13% in 2030 relative to 2018. The decline in thermal coal production occurs at a faster pace than for metallurgical coal.
- The difference in the pace of decline is due to many APEC economies developing and deploying fuel-switching strategies (to natural gas and renewables) to achieve greater emissions reduction from electricity generation. However, fuel switching is not viable for metallurgical coal consumption.
- In the Carbon Neutrality scenario (CN) of the 8th APEC Energy Demand and Supply Outlook, APEC coal production falls by 24% for the 2018-2030 period. Recent commitments and policies regarding coal phase-out, renewables, fuel switching, and low CO_2 emission coal combustion technologies are more ambitious than those assumed in the REF scenario for most APEC economies. If those commitments and policies are realized, the outlook for APEC coal production will likely be closer to the CN projection.
- Thermal coal production falls faster in the CN scenario than in the REF, while metallurgical coal production remains robust in the medium term due to high steel demand. There is potential to switch to innovative new steel production technologies that do not rely on metallurgical coal, though most of these alternatives will not be available at scale until after 2030.

Thermal coal

Figure 3.7: APEC thermal coal (including lignite) production by economy: history and outlook



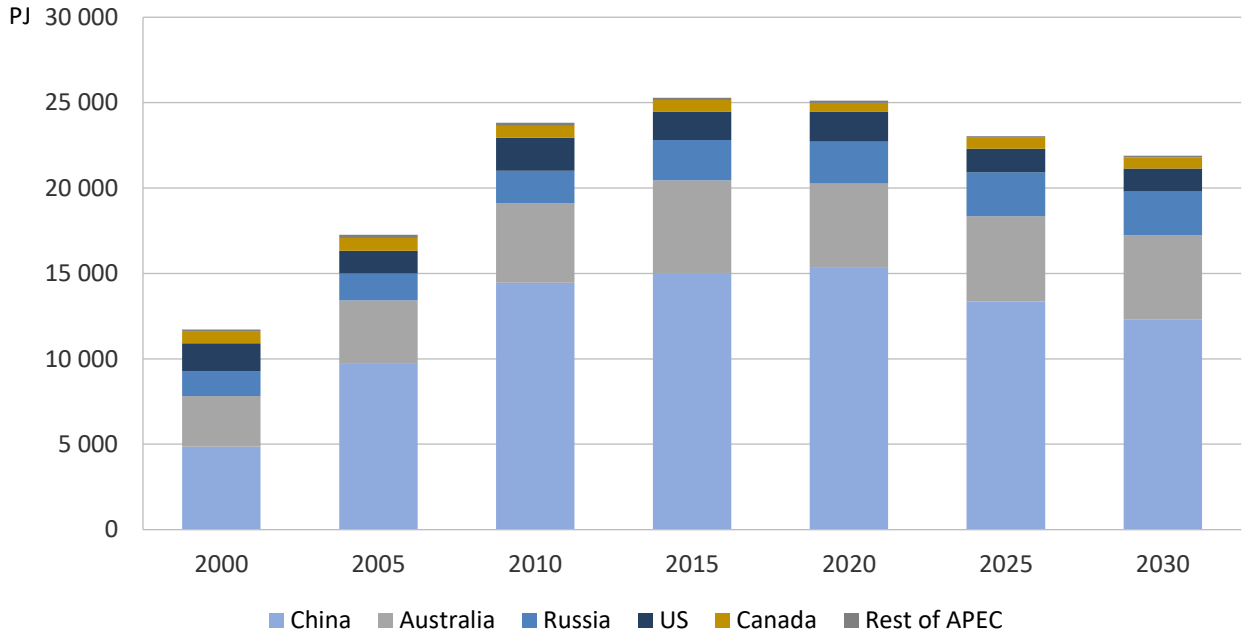
Source: compiled by the authors based on EGEDA (2021) and APEC Outlook 8th (2022).

Key points

- APEC thermal coal production in REF is expected to decline by 13%, from 105 EJ in 2018 to 92 EJ in 2030. The largest drops are projected to be in the US, followed by Australia, Russia, and China. In contrast, thermal coal production in Indonesia is forecast to grow.
- With rising concerns over pollution and CO_2 emissions from coal-fired power plants in China, thermal coal production growth is projected to slow noticeably through 2030. China reduced the coal share in the total generation mix from 77% in 2010 to 67% in 2018 (EGEDA, 2021). This decreasing trend is expected to continue during the forecast period, falling to 39% by 2030.
- Indonesia's thermal coal production is expected to grow by approximately 3% over the 2018 to 2030 period. This projected production growth will indicate Indonesia as the second-largest producer of thermal coal in APEC.
- The United States thermal coal production is projected to decline by approximately 46% over the 2018-2030 period. Coal production in the United States has declined due to several factors. The shale revolution has made natural gas cheaper to produce, which has reduced coal's competitiveness. Additionally, the growth of wind and solar power has increased competition for coal, and federal regulations have raised the costs associated with burning coal.
- Australia’s thermal coal production is expected to decrease due to lower global thermal coal demand in the medium term.

Metallurgical coal

Figure 3.8: APEC metallurgical coal production by economy: history and outlook



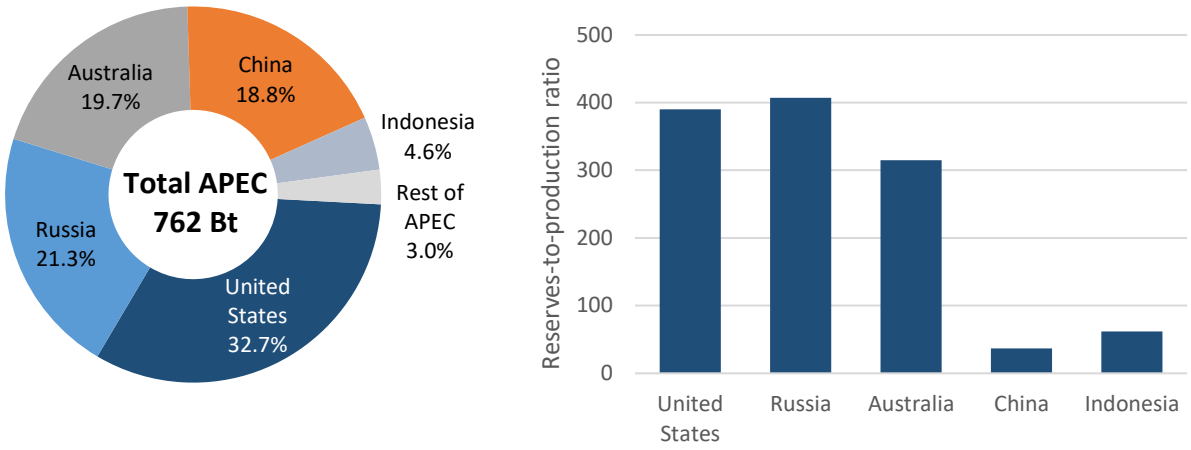
Source: compiled by the authors based on EGEDA (2021) and APEC Outlook 8th (2022).

Key points

- APEC metallurgical coal production in REF is projected to decline from 25 EJ in 2018 to 22 EJ in 2030, led by declines in the United States (-34%), Canada (-18%) and China (-13%). Australia and Russia are projected to post a small reduction in metallurgical coal production by 2030.
- Metallurgical coal is still significant for steel production. Technical issues still constrain the substitution of metallurgical coal with other fuels in the steelmaking industry. Therefore, metallurgical coal production is expected to decline in the medium and long term, but at a slower pace than thermal coal.
- Almost all of China's metallurgical coal production is used by its domestic steel industry. A softening steel production outlook drives the projected decreasing trend out to 2030. However, China is still expected to be the largest metallurgical coal producer in the APEC and the world in 2030, accounting for 56% of the total APEC metallurgical coal production.
- Metallurgical coal production in Australia is estimated to rebound strongly in 2022. However, both Australian and Russian metallurgical coal production is expected to post small declines thereafter.

APEC coal reserves

Figure 3.9: APEC coal reserves and R/P ratio of the top five APEC coal producers[12], 2020



Source: compiled by the authors based on Energy Institute (2024).

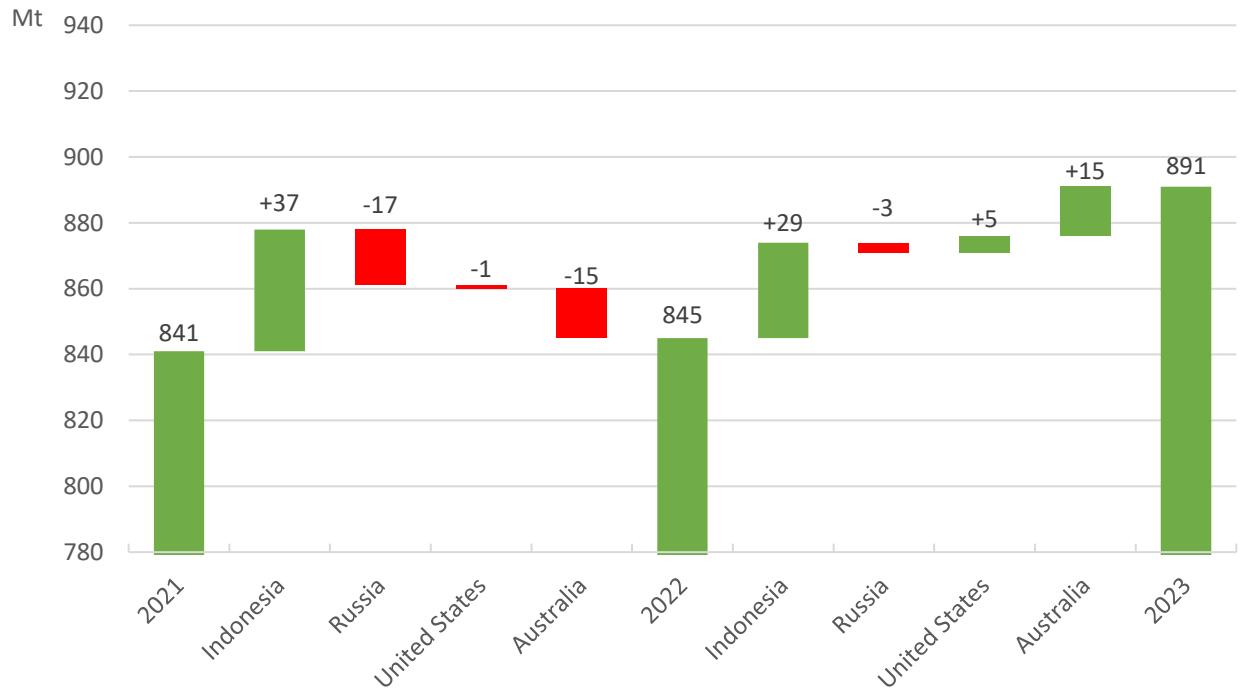
Key points

- APEC economies accounted for 71% of global proved coal reserves in 2020 (Energy Institute, 2024), with 762 billion tonnes (Bt). The United States, Russia, Australia, China, and Indonesia hold over three-quarters of APEC-proved coal reserves.
- The vast coal reserves located in the United States (249 Bt, 32.7%) are distributed among three main regions: Appalachian, the Midwest, and the West.
- Russia ranks second in proved coal reserves behind the United States (162 Bt, 21.3%). Its major coal reserves include the Donetskii coal fields in Moscow, the Pechora basins in Western Russia, and the Kuznetski, Kansk-Achinsk, Irkutsk, and South Yakutsk basins in Eastern Russia.
- Australia holds the third rank (150 Bt, 19.7%). Australia holds black coal (including anthracite, bituminous and sub-bituminous) and brown coal (lignite). Black coal reserves are in New South Wales, Queensland, South Australia, Tasmania and Western Australia, while brown coal is found in South Australia, Western Australia, Tasmania, Queensland and Victoria (Geoscience Australia).
- China's 143.2 Bt of proven coal reserves accounted for over 18.8% of total APEC coal reserves. Deposits of anthracite, bituminous, sub-bituminous and lignite are mainly located in the north and north-west regions.
- Indonesia holds approximately 35 Bt, accounting for 4.6% of APEC's total proven coal reserves, with deposits mostly located in South Sumatra, East Kalimantan, and South Kalimantan.
- The United States, Russia, and Australia have reserves that are multiple hundreds of years of current production. China's very high current production levels, combined with lower reserves, mean the R/P is significantly lower.

[12] The reserves-to-production ratio represents the number of years that current reserves would last if the production remained constant.

Chapter 4: Coal trade and prices

Figure 4.1: Change in thermal coal exports from major APEC coal exporters

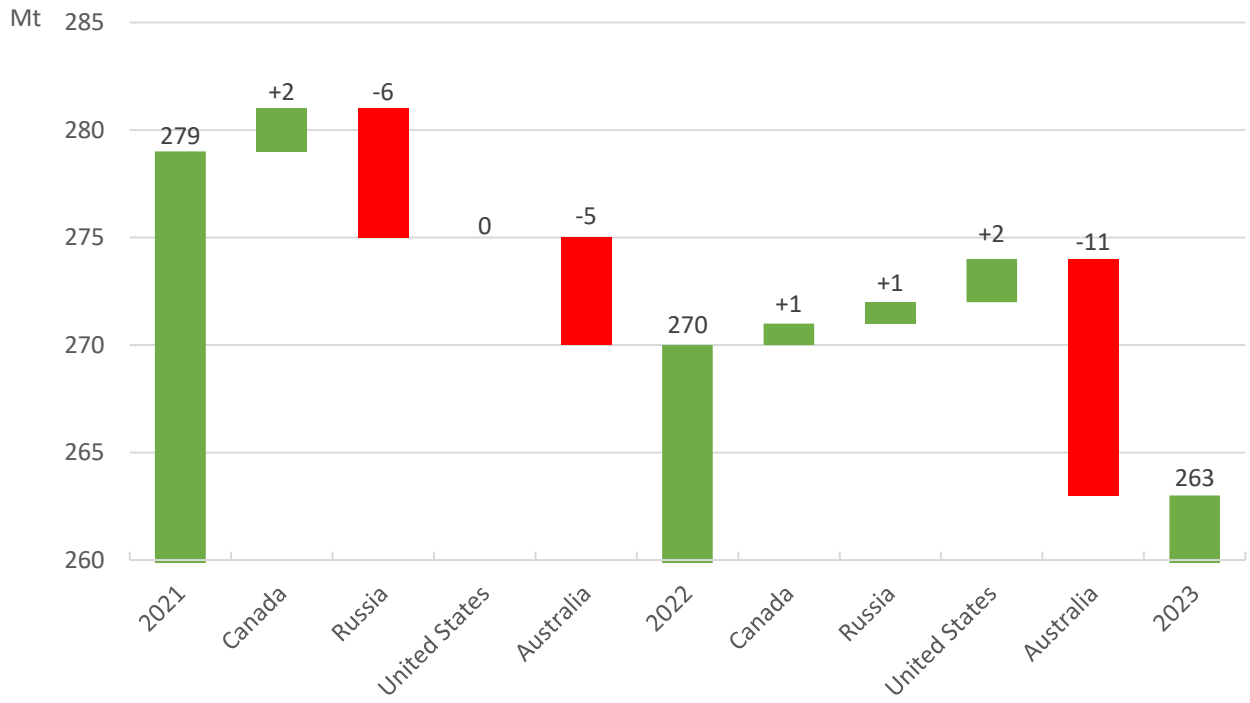


Source: compiled by the authors based on IEA (2023a) and IEA (2023b).

Key points

- Trading flows had already shifted since 2020, when China banned Australia's coal imports, but it changed further after February 2022 due to the Russian-Ukraine conflict. Russia experienced the largest drop in thermal coal exports in 2022 (-17 Mt) due to international sanctions. Australia's thermal coal exports declined by 15 Mt in 2022 because of the floods in New South Wales and Queensland, which led to a declaration of force majeure at the Port Kembla Coal Terminal (Australian Government, 2022).
- In 2022, Indonesia's thermal coal exports increased by 37 Mt, making it the only economy among APEC to experience a growth in coal exports. The growth in coal exports is due to increased global demand for coal, particularly from major importers and pricing and geographical advantage. In 2023, Indonesia continues to increase thermal coal exports by 29 Mt compared to 2022 due to high coal demand for power generation in China, India, and some Southeast Asia economies.
- Australia's thermal coal exports increased by 15Mt as the result of ending the unofficial ban of the Chinese government on coal imports from Australia in early 2023.
- The United States's thermal coal exports increased by 5Mt in 2023, while Russia's coal exports dropped by 3 Mt in the same year.

Figure 4.2: Change in metallurgical coal exports from major APEC coal exporters



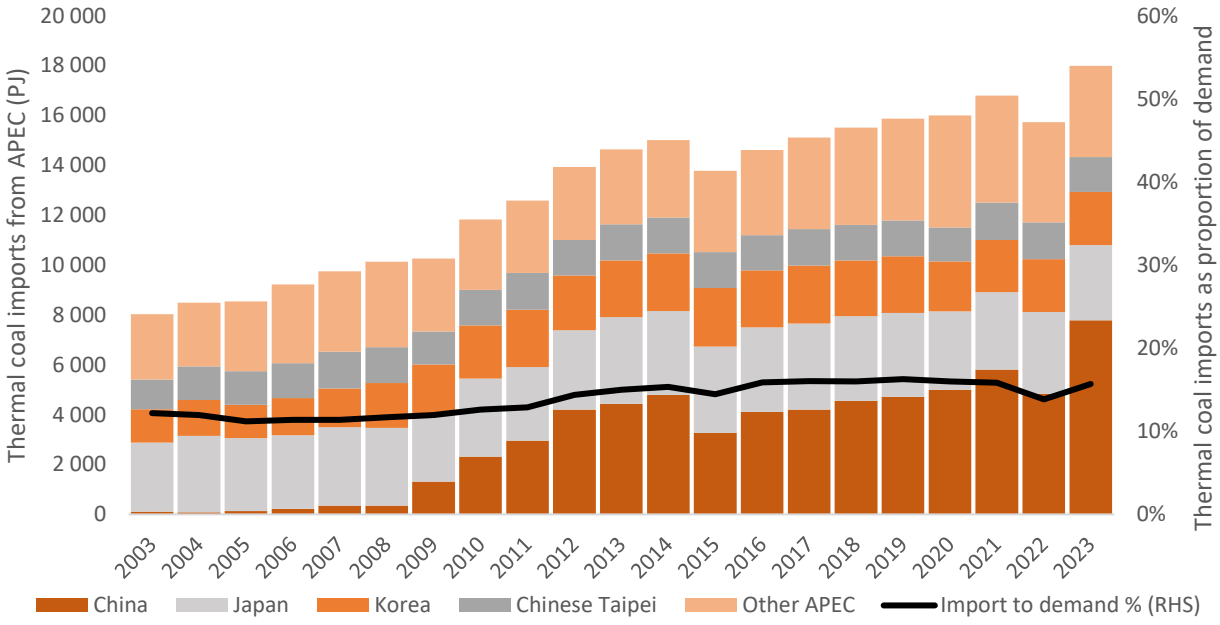
Source: compiled by the authors based on IEA (2023a) and IEA (2023b).

Key points

- In 2022, Canada's metallurgical coal exports increased (+2 Mt), driven by the reopening of a 2 Mt metallurgical coal mine in Western Alberta, which had been closed in response to the COVID-19 pandemic (IEA, 2022), while the United States maintained the metallurgical coal exports at the 2021 level (41 Mt).
- After the Russian-Ukraine conflict started in February 2022, Western countries refused to buy Russian coal, causing its metallurgical coal exports to fall by 6 Mt in 2022. Although Russia has shifted the metallurgical coal trading flow to China, India, and other Southeast countries, the increase did not fully offset the loss of markets in Europe, Japan, and Korea.
- Metallurgical coal exports from Australia fell by 5 Mt in 2022. There were several reasons, such as unprecedented high coal prices, weather issues impacting coal supply, and a drop in global steel production.
- In 2023, while metallurgical coal exports growth has been seen in Canada, Russia, and the United States, Australia's metallurgical coal export dropped by 11 Mt. The fall in metallurgical coal exports in Australia is mainly due to continuous weather disruptions that weigh on Australian metallurgical coal exports.

APEC thermal coal trade

Figure 4.3: Thermal coal imports and their proportion to thermal coal consumption

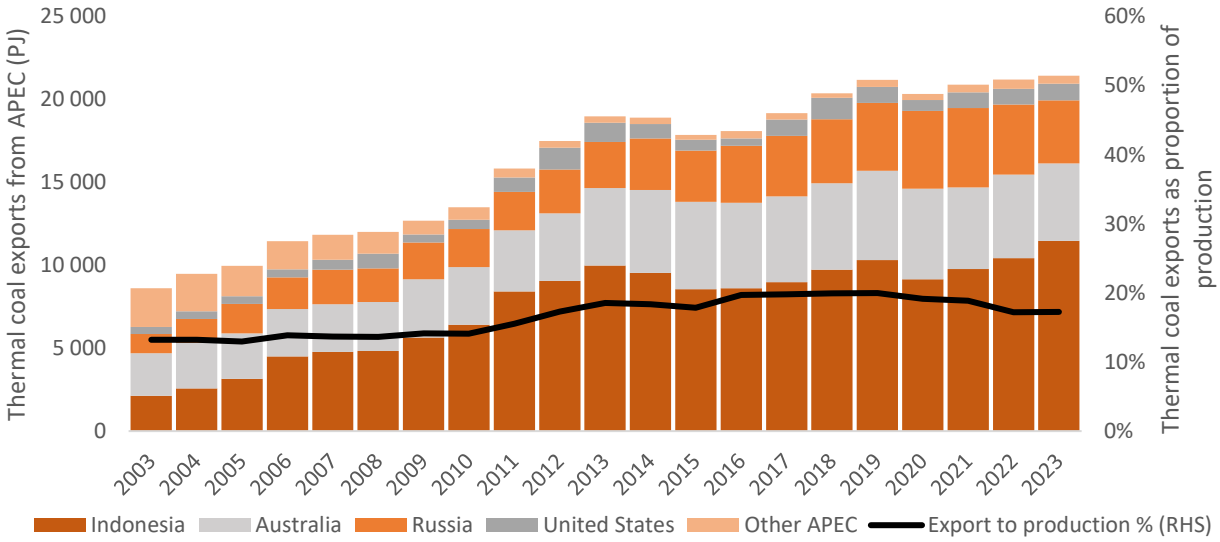


Source: compiled by the authors based on IEA (2024).

Key points

- APEC thermal coal imports rebounded in 2023 due to high thermal coal demand from China, Viet Nam, Malaysia, and The Philippines.
- China has significantly ramped up its thermal coal imports since 2009, when it could no longer satisfy its domestic demand, while Japan, Korea, and Chinese Taipei have consistently imported thermal coal for over two decades.
- In 2023, China's thermal coal imports surged compared to the previous year due to strong demand, high domestic coal prices, and affordable coal from Russia.
- APEC thermal coal imports as a proportion of APEC thermal coal consumption was 16% in 2023, steadily increasing from 12% in 2002. This shows that APEC thermal coal-consuming economies have increasingly relied on overseas sources to meet their demand.

Figure 4.4: Thermal coal exports and their proportion to thermal coal production



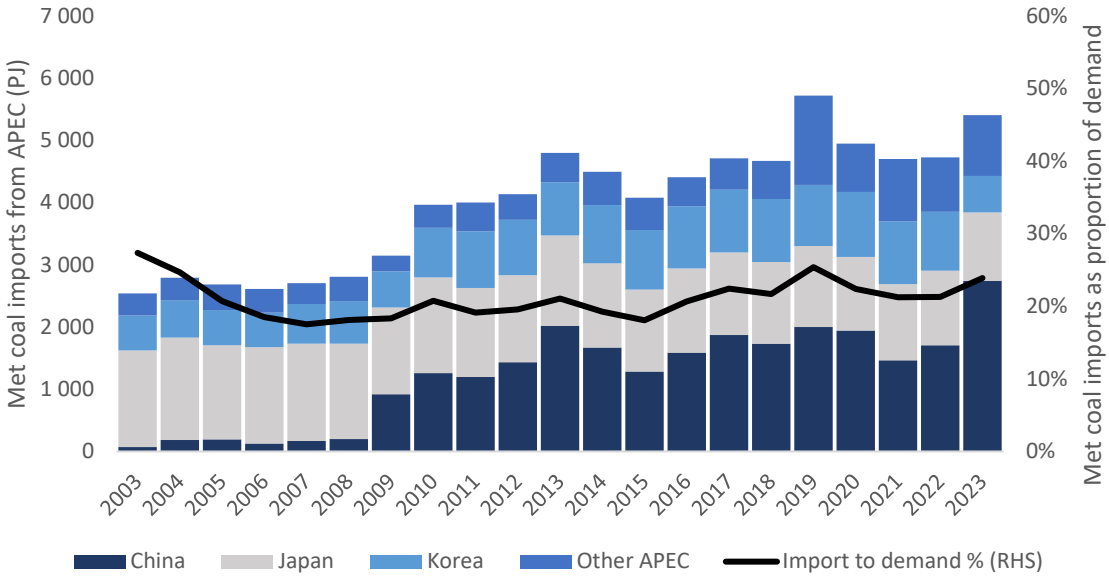
Source: compiled by the authors based on IEA (2024).

Key points

- APEC thermal coal exports were 21 400 PJ in 2023. Indonesia has continued to ramp up its thermal coal exports significantly over the last two decades, accounting for over half of APEC thermal coal exports in 2023. Australia is the next most prominent thermal coal exporter, accounting for approximately 22% of APEC thermal coal exports in the same year.
- These exports were predominantly headed to other APEC economies, though significant volumes were also destined for non-APEC economies, such as India.
- APEC thermal coal exports as a proportion of APEC thermal coal production was 17% in 2023. This has increased from 13% in 2003, though it shows that most APEC thermal coal production is consumed domestically (83%). This APEC-wide statistic is mostly driven by China's pattern of overwhelming domestic consumption.

APEC metallurgical coal trade

Figure 4.5: Metallurgical coal imports and their proportion to metallurgical coal consumption

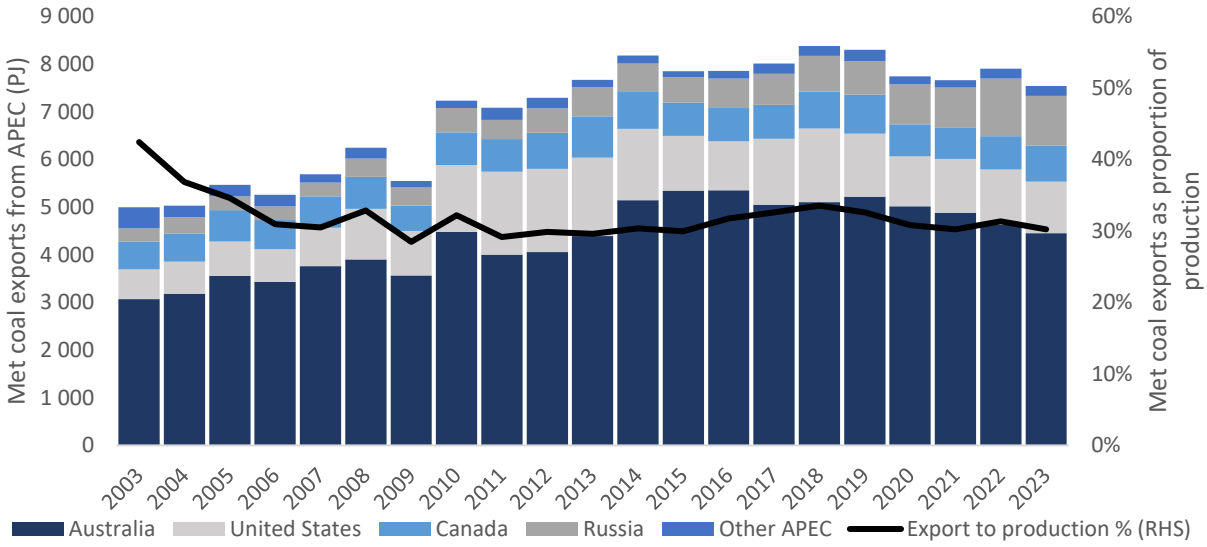


Source: compiled by the authors based on IEA (2024).

Key points

- The quantity of metallurgical coal trade is significantly lower than the thermal coal trade on an energy content or weight basis. Historically, the market for thermal coal has been at least three to four times larger. Metallurgical coal imports peaked at 5 700 PJ in 2019 and declined dramatically in 2020-2022 before rebounding to around 5 400 PJ in 2023. The decline in metallurgical coal imports between 2020 and 2022 was primarily driven by several factors. These included trade tensions between China and Australia, which led to import restrictions on Australian coal. Additionally, a global economic slowdown due to COVID-19 affected steel production.
- China is the largest metallurgical coal importer, significantly ramping up its metallurgical coal imports since 2009, given that its domestic resources were insufficient to meet the needs of its rapidly growing steel industry. However, a big drop in metallurgical coal import was seen in 2021 due to the ban on coal import from Australia and limited supply from Mongolia due to surging COVID-19 cases in Mongolia. In 2023, metallurgical coal imports reached a record-high level of 2 700 PJ due to increased domestic steel production, a shift towards sourcing coal from cheaper suppliers such as Russia and Mongolia, and the lifting of prior restrictions on imports of Australian coal.
- Japan is still a major metallurgical coal importer, accounting for around 20% of APEC metallurgical coal imports. However, the volume of metallurgical coal imported by Japan has declined from a peak of 1 600 PJ in 2004 to 1 100 PJ in 2023.
- Korea is the other major APEC metallurgical coal importer, with nearly 600 PJ imported in 2023.
- APEC metallurgical coal imports as a proportion of APEC metallurgical coal consumption have fluctuated around 20-25% for over a decade, having fallen from 32% since 2003.

Figure 4.6: Metallurgical coal exports and their proportion to metallurgical coal production



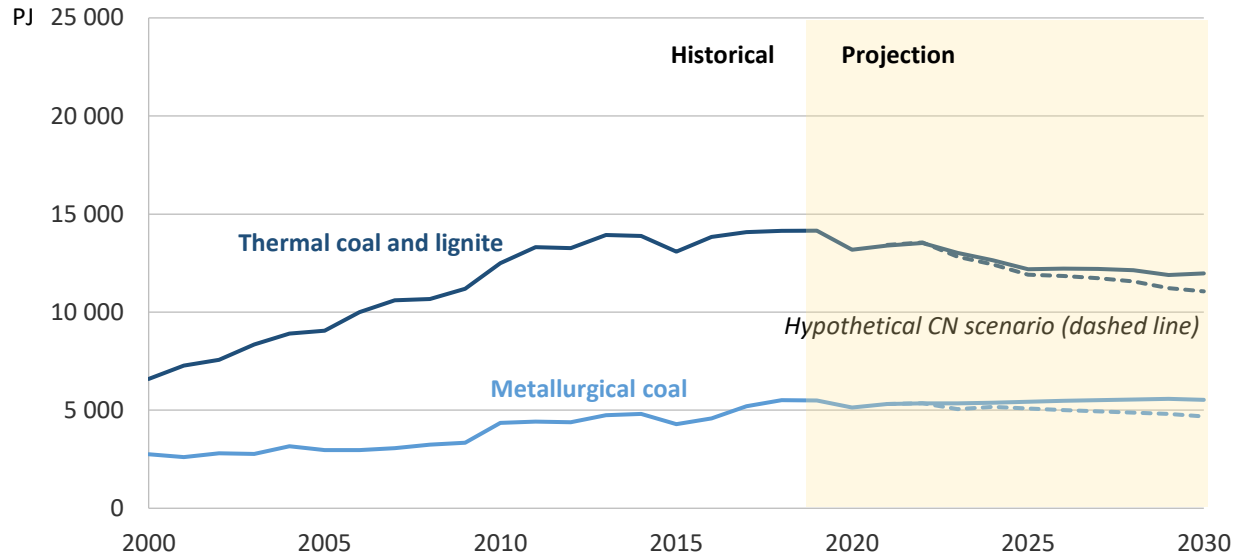
Source: compiled by the authors based on IEA (2024).

Key points

- APEC metallurgical coal exports declined to 7 500 PJ in 2023 from 7 900 PJ in 2022.
- Australia is by far the largest metallurgical coal exporter in APEC in 2023, accounting for 59% of APEC metallurgical coal exports. Even with smaller export volumes than thermal coal exports, metallurgical coal exports brought more revenue to the Australian Government.
- The United States, Russia, and Canada are the next most prominent metallurgical coal exporters, accounting for 14.3%, 13.8%, and 10.1% of APEC metallurgical coal exports in 2023, respectively.
- APEC metallurgical coal producers exported 30% of their production in 2023. This portion is down from a high of almost 50% of production destined for export near the beginning of the millennium. The reduction in metallurgical coal export is primarily due to the high demand for metallurgical coal export in several APEC economies such as China, Russia, and Korea over the last decade.

APEC coal trade projections

Figure 4.7: APEC coal imports: history and outlook

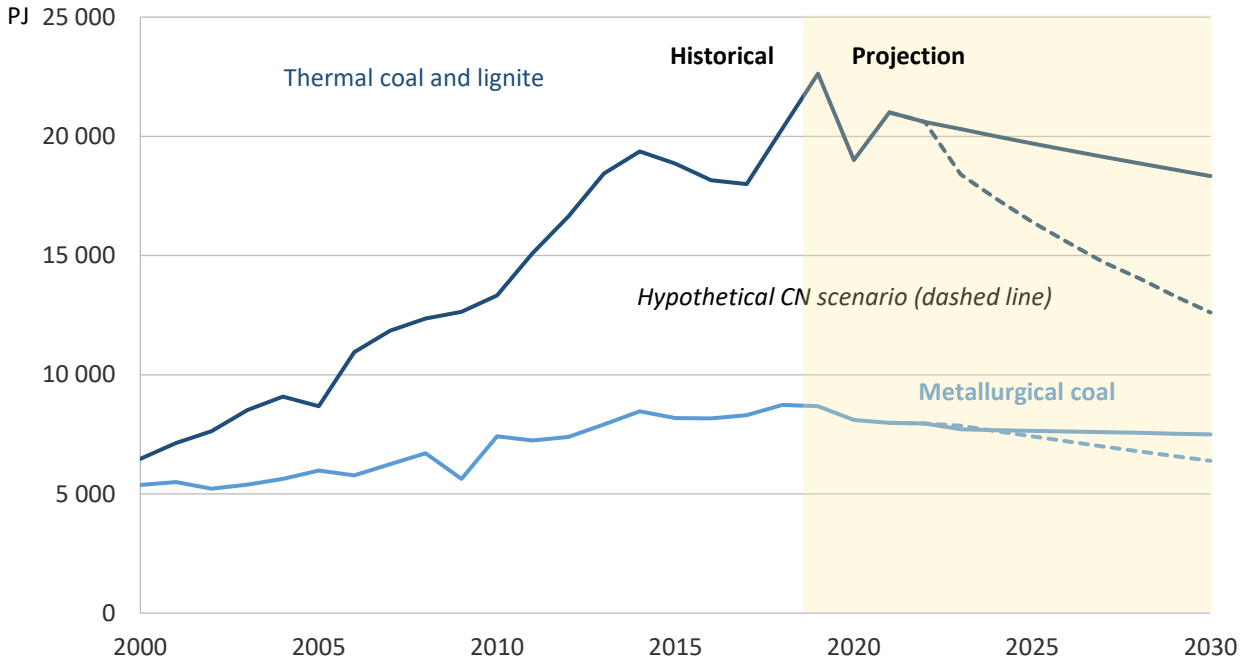


Source: compiled by the authors based on EGEDA (2021) and APEC Outlook 8th (2022).

Key points

- Moving beyond the short-term volatility brought on by the pandemic, the APEC Energy Demand and Supply Outlook 8th Edition estimates that thermal coal imports will decline slowly while metallurgical coal imports will increase slowly out to 2030. Assumed robust steel production explains metallurgical coal's resilience. The decline in thermal coal imports aligns with the planned move away from coal for power generation in many APEC economies.
- In the hypothetical CN scenario of the APEC Energy Demand and Supply Outlook 8th Edition, APEC thermal coal imports will fall away more rapidly. APEC metallurgical coal imports will also fall due to greater material efficiency (less demand for steel) and improved scrap utilisation (recycling). While thermal coal consumption will fall in many economies, the demand is still robust in China and Southeast Asia APEC economies, such as Viet Nam and Malaysia, which will continue to rely on thermal coal imports to meet the supply for newly constructed coal-fired power plants.
- Regulations and policies related to coal mining activities are also likely to boost coal imports. In some APEC economies, carbon taxes, environmental protection legislation, and post-mining flora rehabilitation significantly increase the cost of domestic coal production. For these economies, imported thermal coal may be the most cost-competitive supply source, even when domestic reserves are significant.

Figure 4.8: APEC coal exports: history and outlook



Source: compiled by the authors based on EGEDA (2021) and APEC Outlook 8th (2022).

Key points

- APEC coal exports are significantly larger than APEC coal imports. The figure shows that there will be a slow decline in APEC thermal coal exports in the REF scenario of the APEC Energy Demand and Supply Outlook 8th Edition as APEC thermal coal producers begin to slow their production due to declining global demand. APEC metallurgical coal exports will maintain the current level to meet supply requirements for large steel-producing economies.
- In the hypothetical CN scenario, thermal coal exports are expected to fall dramatically by 2030. In this scenario, the assumed rapid movement worldwide away from coal-fired power means less global demand for coal. Metallurgical coal exports will decline marginally due to material efficiency and the use of a higher proportion of scrap in steel production mentioned above.

Coal prices

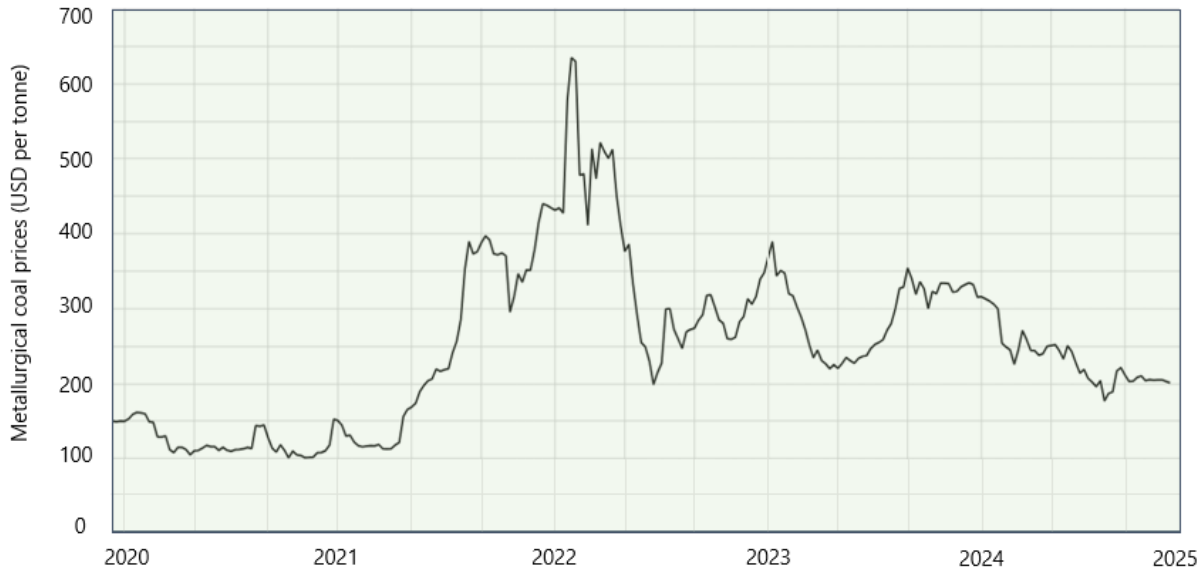
Figure 4.9: Newcastle benchmark thermal coal spot prices, January 2020 to December 2024

Source: compiled by the authors based on Trading Economics.

Key points

- In 2021, the COVID pandemic led to a significant increase in global demand for goods, partly driven by the absence of consumer access to services, such as travel and hospitality. China's immense industrial sector responded by increasing production through most of 2021, which led to a very large increase in thermal coal demand for industry. Therefore, thermal coal prices started to rise and reached a peak in October 2021.
- In 2022, the impacts of sanctions against Russia due to the Russian-Ukraine war drove thermal coal prices to another record high of USD 420 per tonne on 9 March 2022. With the measures to stabilise the global energy markets from developed countries, thermal coal spot prices softened briefly in April. However, Newcastle benchmark thermal coal spot prices surged again to the next record high of about USD 425 per tonne in May due to coal transportation disruption in Australia.
- In September 2022, an all-time record high of thermal coal spot prices occurred, reaching approximately USD 450 per tonne, nine times higher than the prices in September 2020. Strong thermal coal demand from APEC Northeast Asia economies such as Japan, Korea and Chinese Taipei caused the price surge. In addition, extreme weather in Australia in 2022 hindered the coal transportation route from coal mines to seaborne port, causing a decline in coal export volume.
- In 2023, thermal coal spot prices dropped dramatically from USD 400 per tonne in early 2023 to around USD 130 per tonne in July. In some of the last months of the year, thermal coal spot prices fluctuated at around USD 150 per tonne. Lower demand from major consumers like Europe due to mild winters, increased gas supply, high coal stockpiles, and a shift towards renewable energy sources, which led to an oversupply in the market and, subsequently lower prices.
- In 2024, thermal coal spot prices were relatively steady compared with the previous year, varying between USD 100 per tonne and USD 150 per tonne.

Figure 4.10: Australian premium hard coking[13] coal spot price, January 2020 to December 2024



Source: compiled by the authors based on Barchart.

Key points

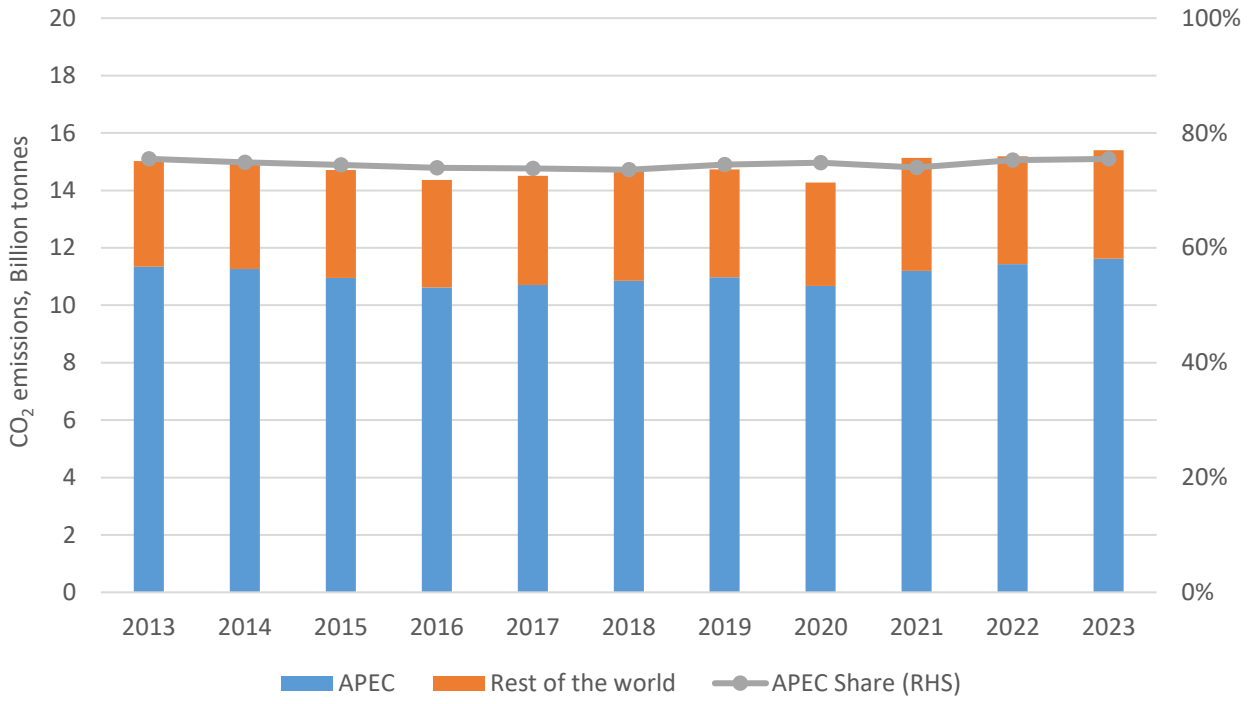
- With the coal crisis in China in September 2021, the Chinese government compelled multiple steel producers to limit production temporarily[14]. This had the dual impact of meeting the challenge of the energy crisis at the expense of economic growth and reducing emissions and pollution to meet environmental commitments by the Chinese government. The fall in steel production has yet to translate to lower metallurgical spot prices, which spiked at around USD 400 per tonne at the beginning of October 2021.
- In early 2022, the Australian coking coal spot prices climbed up again, even before the Russian-Ukraine war. With the impact of the war and volatile energy prices, coking coal prices surged to an unprecedented level of about USD 630 per tonne on 21 March 2022. Coking coal prices then eased somewhat and remained at around USD 500 per tonne until the end of May.
- In June 2022, coking coal prices dropped again due to the weak demand from China's steelmaking industry. As a result, the Australian coking coal spot prices declined to USD 200 per tonne in August 2022. In the last quarter of 2022, coking coal spot prices rebounded to around USD 300 per tonne to a small extent, partly due to a met-to-thermal coal switch and high demand at the end of the year[15].
- In 2023, coking coal prices fell in net terms during the first quarter and eased further in June as Australian supply picked up, global steelmaking showed signs of softening, and strong post-COVID Chinese demand failed to emerge. The limited supply of Australian high-quality raw coking coal explains the price increase for coking coal in the third quarter. Coking coal prices dropped dramatically from USD 330 per tonne in early 2024 to around USD 200 per tonne in December 2024.

[13] "Coking coal" and "metallurgical coal" can be used as interchangeable terms.
[14] A "coal crisis" in China refers to a recent period of significant coal shortages, leading to power cuts and electricity disruptions.
[15] A "met-to-thermal coal switch" refers to the practice of a coal mining company or trader switching from producing or selling metallurgical coal (met coal), primarily used in steelmaking, to producing or selling thermal coal, which is used for electricity generation, due to market factors like higher demand or price for thermal coal compared to met coal

Chapter 5: Greenhouse gas emissions from the coal value chain

Carbon dioxide emissions

Figure 5.1: Coal-related CO_2 emissions in APEC and the rest of the world, 2013-2023

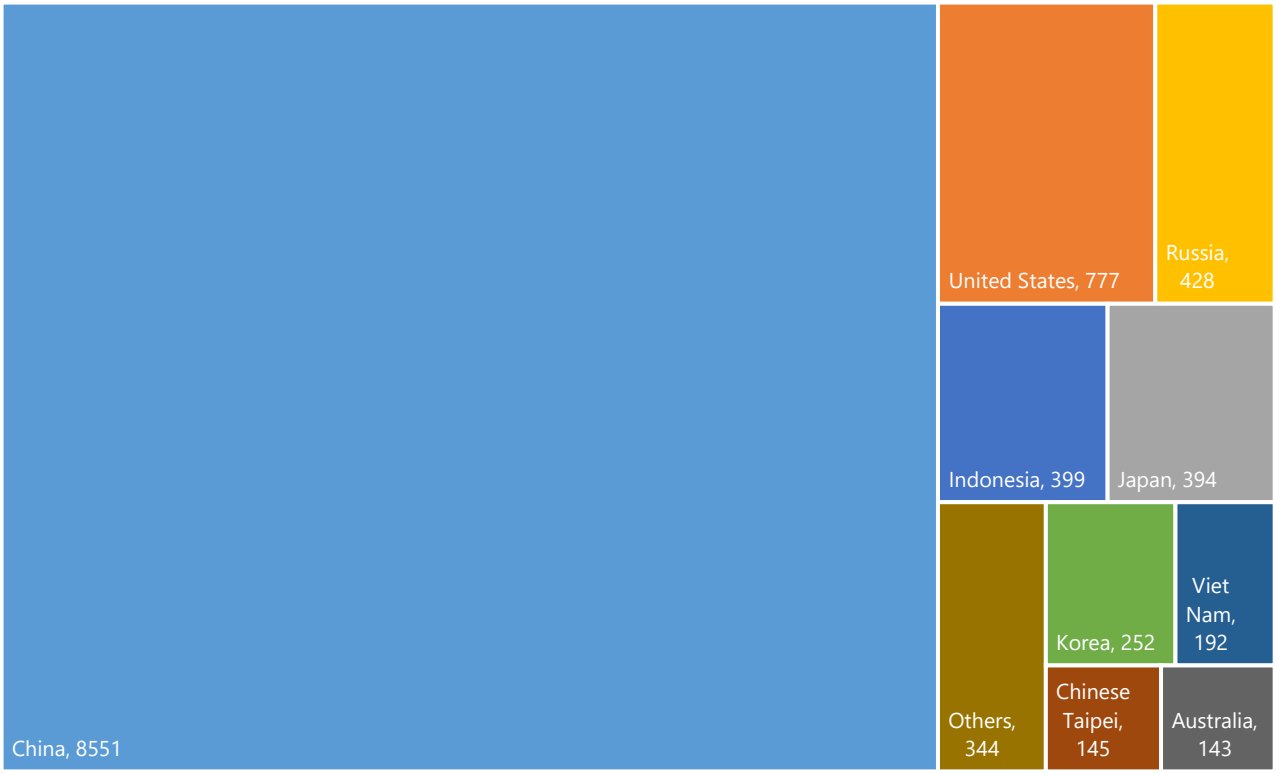


Sources: compiled by the authors based on Our World in Data.

Key points

- When coal is burned, the carbon in the coal combines with oxygen to form CO_2. One molecule of CO_2 is 3.67 times heavier than a molecule of carbon due to the additional weight of the two oxygen atoms. Basically, coal is not 100% of carbon. Therefore, burning a tonne of coal emits 2.07 tonnes of CO_2.
- CO_2 emissions from coal combustion processes in the APEC region accounted for around three-quarters of the global coal-related CO_2 emissions over the last decade because four APEC economies (China, the United States, Japan, and Russia) were often in the top five largest coal consumers worldwide for many years.
- APEC coal-related CO_2 emissions plateaued at 11.3 Gt in 2013 and 2014, declined in 2015 through 2018 and increased again to 11.6 Gt in 2023 after a substantial drop in 2020. CO_2 emissions from coal were roughly proportional to the coal consumption profiles in each region.

Figure 5.2: CO_2 emissions from coal combustion in APEC economies in 2023



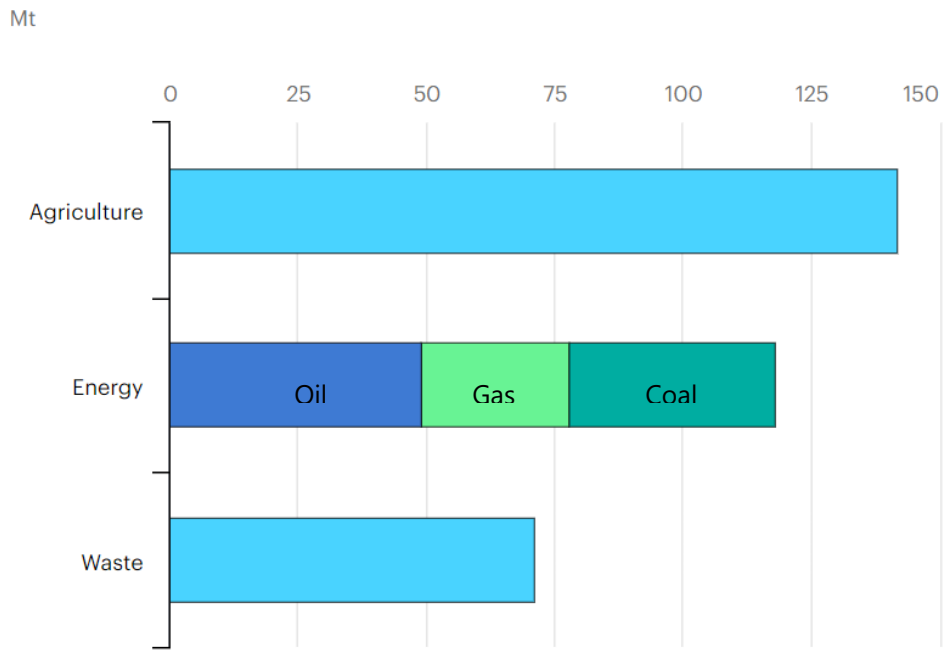
Sources: compiled by the authors based on Our World in Data.

Key points

- In 2023, APEC economies emitted 11.6 Gt of CO_2 from coal combustion processes, accounting for 75.5% of the global coal-related CO_2 emissions.
- Among APEC economies, China is the largest emitter, releasing 8 551 Mt, followed by the United States (777 Mt), and Russia (428 Mt).
- Indonesia and Japan emitted 399 Mt and 394 Mt in 2023, respectively. Korea emitted 252 Mt of CO_2 from coal combustion processes.
- Viet Nam, Chinese Taipei, and Australia emitted around 480 Mt, while the remaining economies emitted 344 Mts in 2023.

Methane emissions

Figure 5.3: Global methane emissions and sources of emissions, 2023



Source: IEA (2024).

Key points

- Two key characteristics determine the impact of different greenhouse gases on the climate: the length of time they remain in the atmosphere and their ability to absorb heat. Methane has a much shorter atmospheric lifetime than CO_2 but absorbs much more heat while it exists in the atmosphere.
- Estimates of methane emissions are subject to a high degree of uncertainty, but according to IEA Global Methane Tracker 2024, the global methane emissions from different sources are 331 Mt in 2023. This includes emissions from agriculture, energy, and waste (IEA, 2024).
- The largest anthropogenic source is agriculture, which is responsible for around 43% of emissions, followed by the energy and waste sectors.
- In the energy sector, IEA estimates that the production and use of fossil fuels resulted in nearly 120 million tons of methane emissions in 2023. Additionally, approximately 10 million tons of methane emissions came from bioenergy, primarily due to the traditional use of biomass. Emissions have remained roughly at this level since 2019, when they peaked at a record high.
- In 2023, methane emissions from coal mines are one-third of total emissions from fossil fuels. Accordingly, coal mine methane emissions were 40 Mt, compared to 49 Mt from oil and 29 Mt from natural gas production.

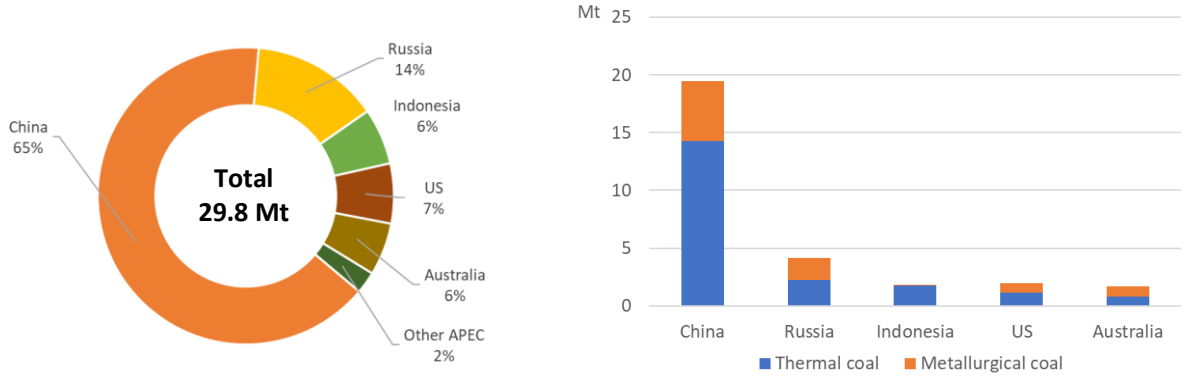
Figure 5.4: Sources of coal mine methane emissions

Source: Authors

Key points

- Coal seams naturally contain methane, which can be released during or after mining operations and is referred to as coal mine methane (CMM).
- Sources of CMM emissions include underground coal mines, open-pit coal mines, coal preparation plants and abandoned mines.
- In the open-pit coal mines, methane is released as coal seams are broken up and coal is extracted for processing.
- In underground mines, methane is mainly released into the atmosphere via mine ventilation system, with methane concentration often less than 2%. In gassy coal mines, methane is drained from target coal seams prior to mining operations because the gas is highly explosive and poses a significant safety risk. CMM emissions tend to be higher from underground mines than from surface mines, as deeper coal seams tend to contain more methane than shallower coal seams.
- Coal mine methane continues to be released for decades after mining stops, as the gas gradually permeates from the underground formations and escapes through disused mine shafts to the surface.
- A total of 41.8 Mt of CMM was released into the atmosphere in 2022, representing an estimated 10% of total methane emissions from human activity. Thermal coal and lignite accounted for around 75% of CMM emissions, and coking coal for the remaining 25%. Underground mines were responsible for around 70% of emissions, and surface mines were responsible for the remainder. Emissions from abandoned coal mines are not included in these estimates but could represent a significant source of emissions.

Figure 5.5: Coal mine methane emissions in the selected APEC economies, 2023



Source: compiled by the authors based on IEA (2023d).

Key points

- In 2023, APEC coal-producing economies released 29.8 Mt of methane during their coal mining activities, accounting for approximately 75% of the global CMM emissions (IEA, 2024).
- The five largest CMM emitters accounted for almost all of the total APEC CMM emissions. China was the largest emitter, corresponding to the large amounts of coal it produces, accounting for 65% of total APEC CMM emissions. Around three-quarters of Chinese CMM emissions came from thermal coal mining activities, while the remainder of CMM emissions came from metallurgical coal mining.
- Russia's share accounted for 14% of the total APEC CMM emissions. Approximately 60% of CMM emissions came from thermal coal mines, and the rest of CMM emissions came from metallurgical coal mining activities.
- Indonesia was responsible for 6% of the total APEC CMM emissions. Thermal coal production dominated the mining industry in Indonesia. Therefore, most of the CMM emissions came from thermal coal mining activities.
- The United States and Australia accounted for 7% and 6%, respectively. The share of CMM emissions from thermal and metallurgical coal mines was roughly equal in the Australian coal mining industry, while CMM emissions from thermal coal mining activities in the United States were slightly higher than those from metallurgical coal mines.
- Most CMM in China and Indonesia were emitted from thermal coal mines, while half of CMM emissions in Russia, the United States, and Australia were released from metallurgical coal mines in 2023.

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