Energy Transition in the Indo-Pacific: Thermal Coal and Gas Imports Under Different Levels of Climate Ambition

Insights from the Global Change Analysis Model

Zero-Carbon Energy for the Asia-Pacific ZCEAP Working Paper 08-22

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# Zero Carbon Exports for the Asia Pacific Grand Challenge

Keywords:
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Abstract

The low carbon energy transition in the Indo-Pacific will affect the demand for fossil fuels, with important implications for regional energy security. The Global Change Analysis Model (GCAM) is a useful tool for understanding how decarbonisation pathways in the Indo-Pacific could affect energy trade, with implications for Australian exports of carbon intensive fuels. GCAM results indicate that coal use will need to decrease to achieve climate targets consistent with less than 2°C warming by 2100. The extent of reduced gas use is strongly dependent on whether Carbon Capture and Storage (CCS) deploys at large-scale. Without large amounts of CCS, gas imports will be flat in China, peak in 2035 in India, and fall in Japan and South Korea. This would be replaced with a mix of renewable energy with storage, and nuclear power. The implications of regional decarbonisation for Australia's role as a supplier of energy security thus depends on secondary technology developments in CCS, and cost reductions in renewables combined with batteries and other storage technologies.

Acknowledgement

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INTRODUCTION

In 2018 the Foreign Affairs, Defence and Trade References Committee of the Australian Senate examined the implications of climate change for Australia's national security (Commonwealth of Australia 2018). The report identified climate change threats including extreme weather and other physical effects, threats to community health and wellbeing, and economic threats to industries such as agriculture and tourism. The report also summarised the potential for an increased need for overseas humanitarian assistance and disaster relief, the likelihood of human populations being displaced within and between countries, and the possibility of increased conflict due to climate change. The committee recommended Australia should prepare to manage the security implications of climate change, and that national security agencies should increase their knowledge of climate security and their capability of responding to climate risks. In addition to the impacts of climate change, the energy transition will change the dynamics of regional trade and associated relationships.

In this paper we address this additional aspect of the relationship between climate change and national security. Fossil fuel markets have historically been identified as having important national security dimensions due to problems of market power, and key importing countries have adopted economic and diplomatic strategies designed to diversify sources of supply and fuels (Hughes and Long 2015). For decades Australia has played an important role as a supplier of energy products to trading partners in the Indo-Pacific seeking to diversify fuel sources. More recently, exports of fossil fuels arguably led Australia to be targeted by an attempt at economic coercion (Skidmore 2022).

Policies that cut the use of fossil fuels thus have important diplomatic and security impacts for Australia, in addition to the implications for the economy. In this paper we focus on transition pathways for countries in the Indo-Pacific region and the implications for imports of carbon intensive commodities by major regional economies.

Our approach is to use an Integrated Assessment Model (IAM) to explore potential energy scenarios between now and 2050. In the area of energy transition there are well developed modelling strategies which analyse potential future worlds based on different assumptions for technologies and decarbonization pathways. We use scenarios developed using the Global Change Analysis Model (GCAM) model to examine transition pathways for major trading partners of Australia. We then discuss the potential security implications of these future modelled pathways, and the implications for Australia's role as a provider of energy security to our major trading partners.

AUSTRALIA'S ROLE AS AN EXPORTER OF ENERGY SECURITY

The energy transition has crucial implications for Australia as a major exporter of fuels to countries in the Indo-Pacific region. The Reserve Bank of Australia (RBA) notes fossil fuels account for about a quarter of Australia's exports by value, with two-thirds of these exported to the People's Republic of China, Japan and South Korea (Kemp, McCowage, and Wang 2021). Climate scenarios reviewed and reported by the RBA, which were developed by the Network for Greening the Financial System, show decreases in Australian exports of fossil fuels as major economies move to decarbonise their economies.

The economic implications for Australia's fuel exports are assessed across four scenarios, which assume: 1) governments only implement current climate policy settings ("Current Policies"); 2) governments also implement commitments made through their Nationally Determined Contributions ("Nationally Determined Contributions"); 3) governments reduce emissions to net zero by 2070, leading to a 67 percent chance of keeping global warming to 2°C ("Below 2°C"); and, 4) governments implement policies designed to limit global warming to 1.5°C by mid-century ("Net Zero 2050").

The scenarios suggest that more ambitious climate mitigation scenarios lead to a reduction in Australia's thermal coal exports on a volume basis, along with a less rapid reduction in the use of gas. This is consistent with academic research on how energy security risks will change as countries decarbonize, which finds climate policies are likely to lead to significantly lower trade in energy related products, reducing the energy imports of major economies such as China, India, the European Union, and the United States (Jewell et al. 2014).

Figure 1: The Importance of Australia's Fossil Fuel Exports by Value and Country

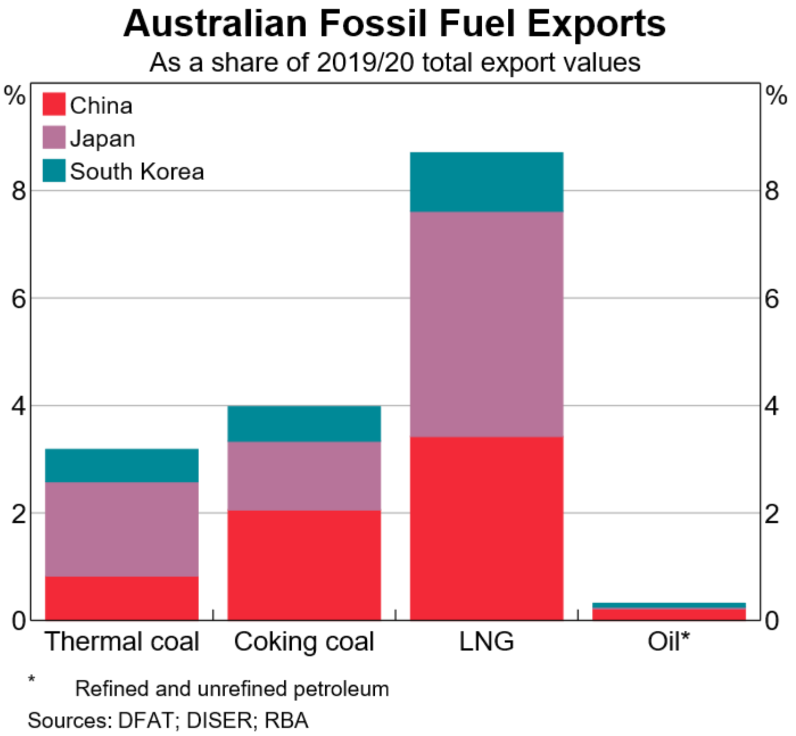
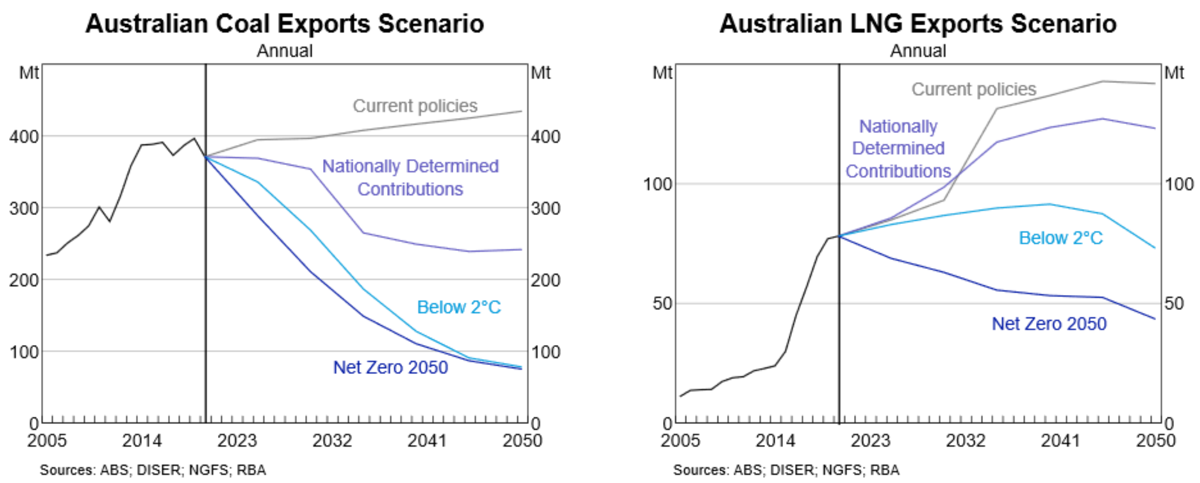


Figure 2: Australian Coal and Gas Exports Under Different Scenarios



MODELLING HOW REGIONAL DECARBONISATION WILL AFFECT REGIONAL ENERGY SECURITY

Integrated Assessment Models (IAMs), or Global Energy Models, are economic modelling tools that contain technology-based sectoral representations of energy, transport, and other sectors. They are used to develop assessments of how countries and regions can reduce emissions.

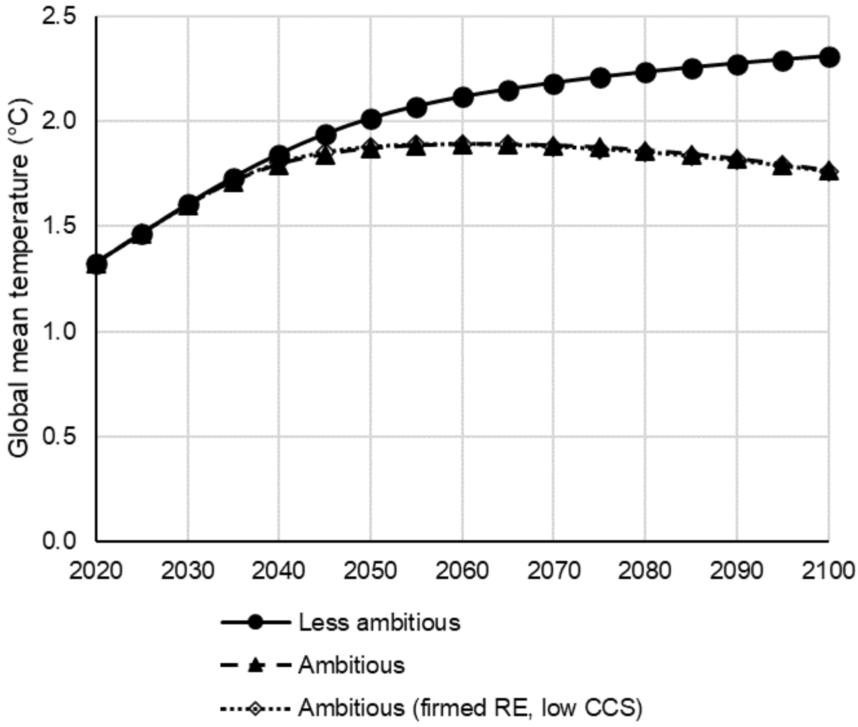
The Global Change Assessment Model (GCAM) is an integrated, multi-sector model that allows for the assessment of decarbonisation scenarios. It has five systems that are modelled at different geospatial resolutions. These systems are the: macro-economy, energy system, land system, water supplies, and the climate system. We focus on the energy system and the different levels of coal and gas demand that coincide with a range of emissions and technology scenarios.

We use GCAM in order to understand the implications of the regional energy transition for regional energy security. In the first analysis we assess model the primary energy use of Australia's major trading partners, specifically China, Japan, South Korea and India. The analysis examines the size and timing along which declines in thermal coal and gas exports could occur. In the second part of the analysis we consider the range of possible low carbon technologies substituting for carbon intensive fossil fuels, depending on levels of global climate ambition. This provides a view on how quickly energy security risks in the Indo-Pacific will change, and how much this is affected by levels of climate ambition globally.

We run two emission reduction scenarios, one less ambitious and one more ambitious that would lead to temperatures below 2°C in 2100. These emissions pathways are set using Representative Concentration Pathways (RCPs) that are associated with radiative forcing values in the year 2100. We use RCPs of 3.7W/m2 and 2.6W/m2, which coincide with temperatures of 2.3°C and 1.8°C (Figure 3). The GCAM model achieves these pathways by using carbon prices to increase the costs of fossil fuel intensive fuels.[1]

[1] The use of carbon prices is a convention in IAMs. Practically it is an abstraction of a suite of policies governments are likely to use in order to achieve different levels of climate ambition.

FIGURE 3: GLOBAL MEAN TEMPERATURE BY REPRESENTATIVE CONCENTRATION PATHWAY (RCP)



In addition to the RCPs, we also implemented different technology assumptions to gauge the sensitivities to key developments in technology options for decarbonisation. A September 2022 technology tracking report by the International Energy Agency identified the deployment of Carbon Capture, Utilisation and Storage (CCUS) as “not on track”. We nevertheless do not adopt a position regarding the long-term feasibility of these options. Rather, we use different assumptions about technology deployment to explore the implications of energy technology developments for fossil fuel imports and use in the Indo-Pacific region. Both of these ambitious scenarios achieve the same climate target, but the impacts on fossil fuels differs due to the nature of substitutability for these technologies.

Specifically, we identify the:

1) availability of storage sites for carbon emissions captured using CCS; and

2) firming of renewables

as key technological assumptions that will influence the future demand of coal and gas.

The first technological assumption is applied as a constraint in the model, which means that the availability of CCS is capped at the level associated with onshore storage sites.

The second technological assumption is an increase in the capacity factor for firmed renewables, which captures solar and wind projects that have storage to improve the reliability of this source of electricity (See Table 1). Note that this change reduces the abatement cost of achieving the ambitious climate target (see figure 1A in the annex).

All scenarios use updated capital costs for solar PV and wind, drawn from the GenCost database developed by the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO).

TABLE 1. DESCRIPTION OF SCENARIOS

Scenario	Radiative Forcing in 2100	Temperature in 2100	Technology Assumptions	Specification
Less ambitious	3.7W/m^2	2.3°C	GCAM usual settings with revised costs for renewables	GenCost capital costs for solar and wind
Ambitious	2.6W/m^2	1.8°C	GCAM usual settings with revised costs for renewables	GenCost capital costs for solar and wind
Ambitious (firmed RE, low CCS)	2.6W/m^2	1.8°C	Increased capacity factor for firmed renewables; Higher CCS costs and constraint on CCS sites with no offshore storage.	As above, but with: Capacity factor of 40% for firmed renewables from 2025; Higher onshore storage costs, no offshore storage.

SCENARIO 1: THE ROLE OF THERMAL COAL AND GAS IMPORTS IN MEETING ENERGY NEEDS UNDER DIFFERENT LEVELS OF CLIMATE AMBITION

In the first set of scenarios we examine the role of thermal coal and gas in transition pathways of the People's Republic of China, Japan, South Korea, and India. We also examine the projected levels of fuel imports in these countries, modelled as the gap between domestic production and demand.[2]

THE PEOPLE'S REPUBLIC OF CHINA

China is the largest producer and importer of coal globally. In 2021 China produced 85.15 Exajoules of coal, dwarfing Indonesia (13.91 EJ) and India (12.63 EJ) as the second and third largest producers.[3] For comparison, in 2021 Australia produced 13.18 EJ of coal. In the same year China consumed 86.17 EJ of coal. For comparison, in Australia total final energy consumption in 2019-20 was 4.27 EJ across all fuel types, and was 1.02 EJ for coal. China is a significant importer of coal despite the approximate balance in the demand and supply of coal, importing 6.54 EJ in 2021 while exporting 0.29 EJ. For comparison, Australia exported 9.63 EJ of coal in 2021.

China is also a large user and importer of gas. In 2021 consumed 378.8 billion cubic metres (bcm) of gas, while producing 209.2 bcm, It imported the difference as piped gas and Liquified Natural Gas (LNG), importing 109.5 bcm of the later. For comparison, in the same year Australia exported 108.1 bcm of LNG.

Taken together, China is thus a large importer across fossil fuel types. This is despite producing large volumes of coal, gas, and crude oil. Using GCAM, we assess how this may change depending on levels of global climate ambition.

Unsurprisingly, coal use falls over time in both the ambitious and less ambitious climate scenarios (see figure 2A in the annex). Continued coal demand crucially depends on technology. Specifically, if it becomes feasible to deploy Carbon Capture and Sequestration (CCS) technologies at scale, then total demand for coal is 36 EJ in 2050, from 94 EJ in 2020. The gap between domestic supply and demand is 7 EJ, made up for through imports (see Figure 4).

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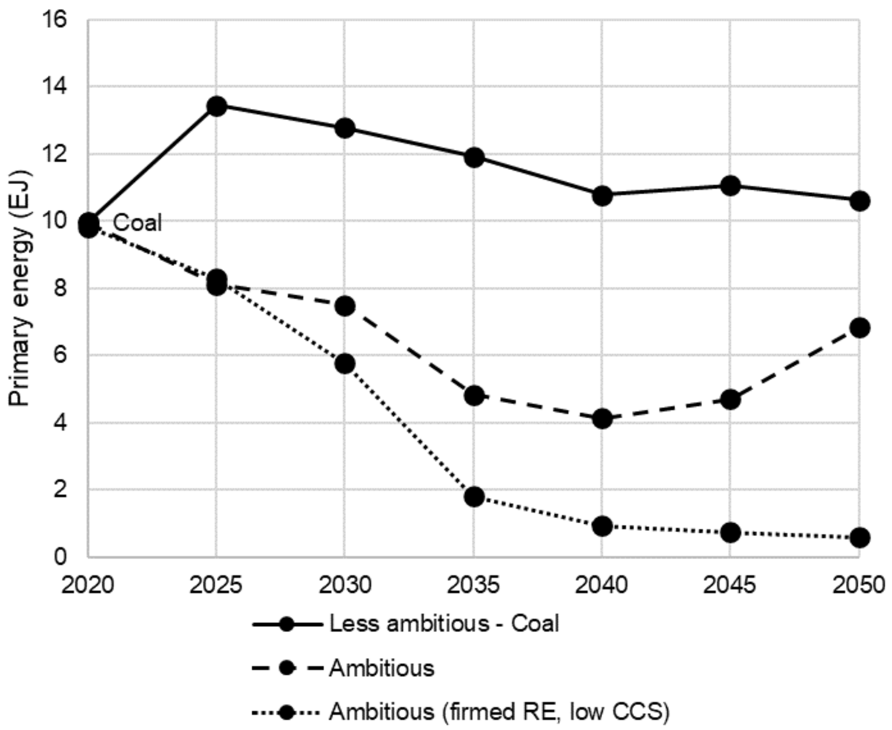
[2] Countries commonly both import and export fuels within global and regional markets. The import level is thus indicative, and is intended to suggest the degree to which each country is required to rely on imports in order to satisfy domestic demand under different scenarios.

[3] A Joule is a unit of energy. In electricity, one Joule is equivalent to the electrical energy needed to run a 1 Watt device for one second. Data reported here and below is from the *BP Statistical Review of World Energy 2022*. Here coal refers to bituminous coal and anthracite (hard coal), lignite, and brown (sub-bituminous) coal, as well as other commercial solid fuels.

If CCS is unable to be deployed at scale, on the other hand, with solar power and firming technologies playing a key the role of meeting supply, then coal use falls to 16 EJ in 2050 and the gap between supply and demand falls rapidly by 2035 (i.e. in 13 years), and is negligible by mid-century (i.e. in 28 years). In the less ambitious scenario, which equates with governments achieving a mean global temperature increase of 2.3°C by 2100, thermal coal consumption falls to 45 EJ by 2050, and the gap between modelled domestic supply and demand remains flat in the long run, increasing from 10 EJ today to 13.5 EJ in 2025, then back to 10.6 EJ by mid-century.

FIGURE 4: IMPORTS OF COAL IN CHINA



Taken together, this suggests that China's continued reliance on coal imports depends on a combination of the level of global climate ambition, and decarbonisation technology pathways:

- Less climate ambition leaves China reliant on international markets to supply domestic coal in order to meet demand.
- If CCS is unable to be deployed at scale it is replaced by firmed renewable energy in order to meet more ambitious climate goals, and coal rapidly exits China's energy system over the next ten years.

- If CCS is deployed at scale, then coal remains in the energy system although import requirements will still be less than half of 2020 energy requirements.

Notably, while domestic production within China is modelled to fall, under both scenarios China’s coal use falls below current domestic production in the near term. This suggests the Chinese government has the option to use policy instruments to become self-sufficient in coal production in the near-term.[4]

There is an important contrast when we focus on the use of gas. Gas remains an important part of the fuel mix to mid-century in both the ambitious and less ambitious climate scenarios (see Figure 3A in the Annex for total demand). As Figure 5 below shows, the gap between gas use and domestic supply is modelled to continue and grow, although the scale of this growth is once again highly contingent on the level of climate ambition and the successful deployment of CCS at scale. Absent large-scale CCS, gas imports increase marginally to mid-century, with firmed renewable energy playing a more important role in meeting domestic energy needs.

To summarise, China’s continued reliance on imports of coal and gas hinges on the future of CCS technologies that enable reductions of the associated emissions. Absent this, China is set to become far less reliant on coal, and gas imports will not grow as substantially.

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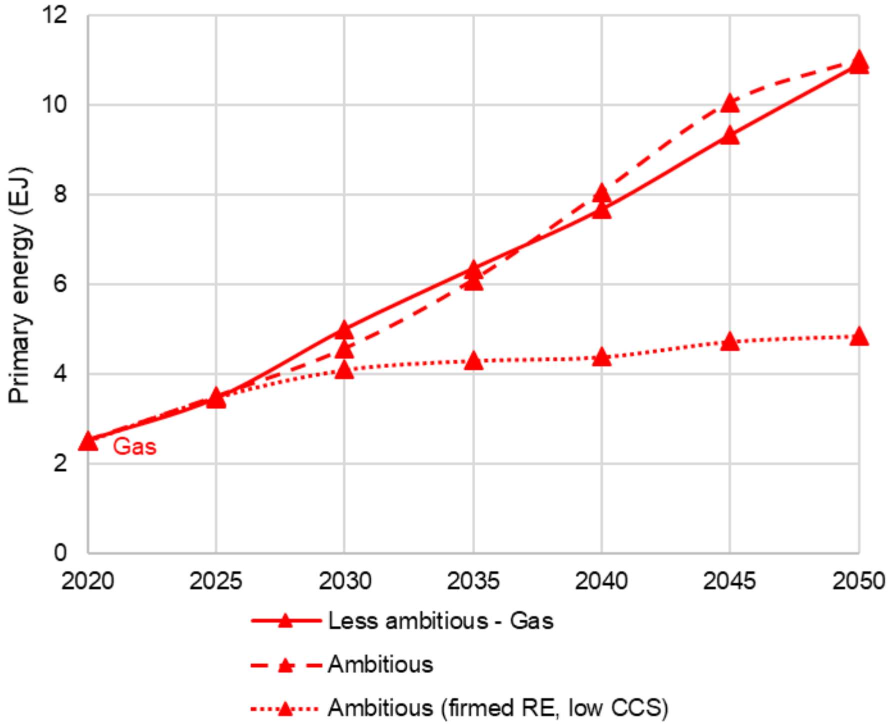
[4] A simple comparison of domestic consumption and production does not take into account issues such as domestic bottlenecks in transport infrastructure that could ensure imports continue even as aggregate consumption falls below domestic coal production. Nevertheless, recent research led by the Australian National University shows seaborne coal exports to China could fall rapidly in the near-term as a result of domestic infrastructure investments in transport networks, driven in part by energy security concerns, that have improved the ability of domestic suppliers to reach consumption locations. Relevant modelling results are available via (Gosens, Turnbull, and Jotzo 2022).

FIGURE 5: IMPORTS OF GAS IN CHINA

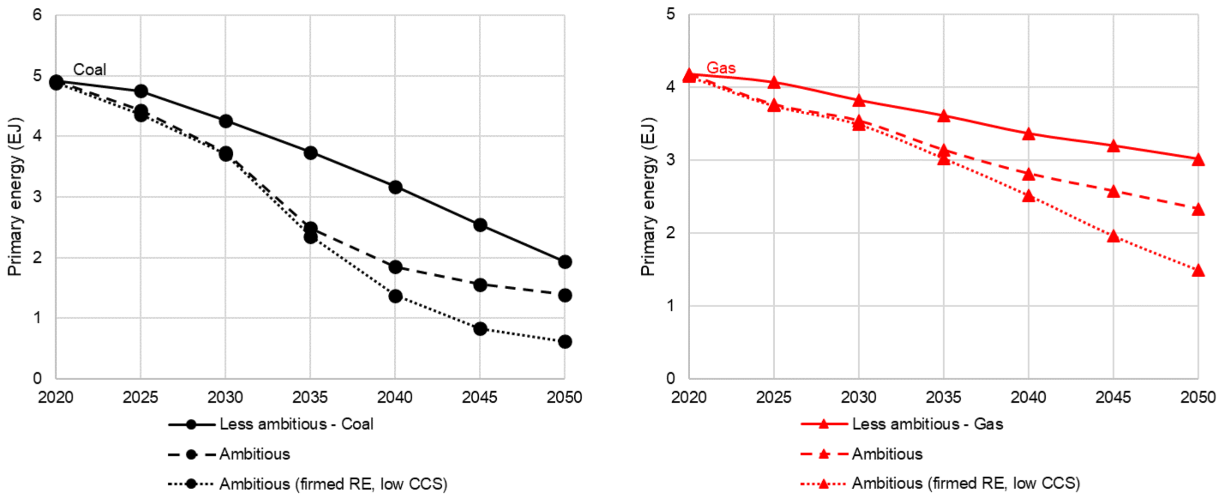


JAPAN

In contrast to China, Japan is almost completely reliant on imports to meet domestic energy needs. As Figure 6 shows, there is a large difference in the rate of decline of thermal coal use across the more ambitious and less ambitious scenarios. Under a less ambitious scenario, coal imports fall to 2 EJ by 2050 from 5 EJ in 2020. Under more ambitious climate scenarios continued coal use is once again contingent on CCS, although the difference is less stark and coal imports start to stabilise around 2035. The importance of coal to Japanese energy security strongly depends on the level of global (and Japanese) climate ambition, even though it falls across all scenarios.

If we shift to look at the role of gas, we can see that Japan will continue to be reliant on imports of gas across all scenarios. Even in the more ambitious scenario consistent with a mean global increase in temperatures of 1.8 degrees Celsius by 2100, gas continues to play an important role in Japan, although imports fall to less than 2.3 EJ by 2050. In the less ambitious scenario, imports of gas fall by 28% between now and 2050.

FIGURE 6: IMPORTS OF COAL AND GAS IN JAPAN

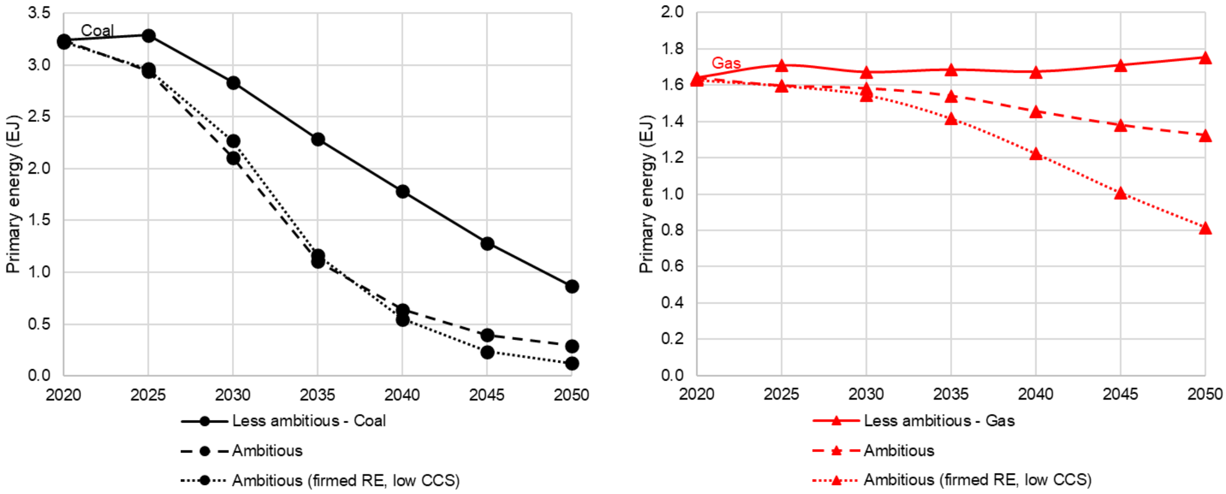


SOUTH KOREA

There are similarities between South Korea and Japan in the trajectories of thermal coal and gas use under different levels of global climate ambition. South Korea sees a sustained fall in coal imports and use across each of the scenarios, but the rate of change and overall use of coal mid-century is strongly affected by the decarbonization pathways the country adopts. Similar to Japan, across each of these scenarios South Korea remains reliant on imports in order to meet its domestic energy needs. In the least ambitious scenario total demand for thermal coal in 2050 falls to 27 per cent of demand levels in 2020 by mid-century, while under the ambitious scenario a more rapid reduction in thermal coal occurs.

If we consider gas (see Figure 7), we can see that imports remains part of South Korea's energy needs through to mid-century across decarbonization pathways. Under the less ambitious pathway gas imports increase by 7 per cent relative to 2020, while under the ambitious decarbonization scenario gas falls to 81 per cent of 2020 use. As in the other scenarios, absent deployment of CCS, the use of gas falls rapidly from 2035 to 50 per cent of 2020 use, and is replaced by firmed renewable energy. Like Japan, South Korea also continues to be heavily reliant on imports across all scenarios, reflecting the lack of domestic gas production at volume.

FIGURE 7: IMPORTS OF COAL AND GAS IN SOUTH KOREA

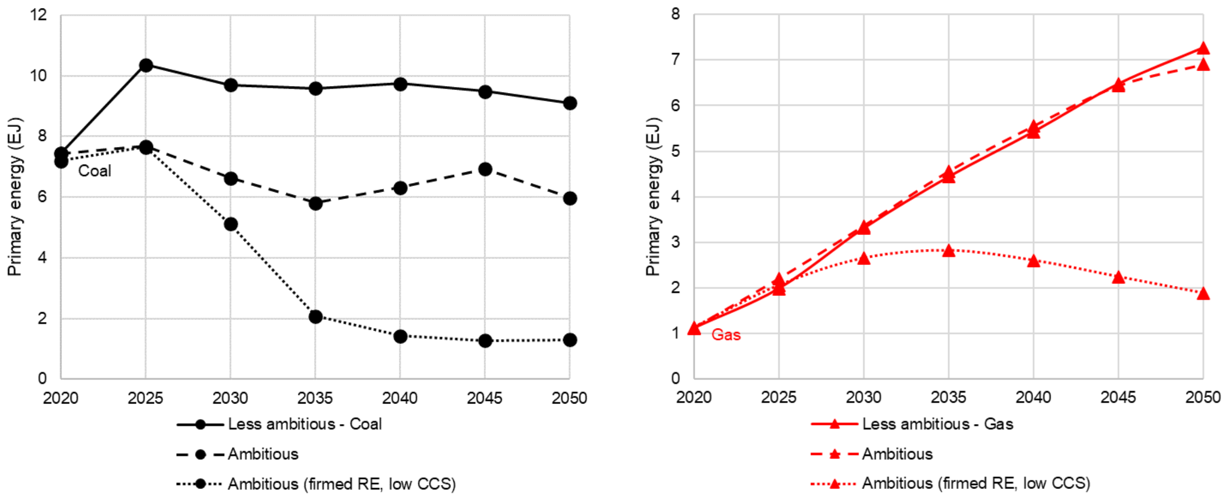


INDIA

The fuel choices India makes will be crucial to managing climate change. They will also be crucial for India's energy security. There is a large difference in the role of coal in the Indian energy mix to mid-century depending on the level of global climate ambition and technology developments (see Figure 8). In the more ambitious climate scenario with limited CCS, coal imports fall rapidly from 2035, and are negligible by mid-century. In contrast, with CCS deployed at scale, coal imports will remain at similar levels to 2020. Only under the less ambitious scenario do coal imports grow, increasing by 39% to 10.4 EJ in 2025 and falling to 9 EJ in 2050. We note, however, that this is again crucially dependent on the widespread availability of CCS technologies.

If we consider gas, India's future demand pathway is even more centrally determined by CCS technology deployment. With CCS India's reliance on imported gas shows sustained and rapid gains in both the more and less ambitious climate scenarios. Given the different suppliers of gas globally, this will have important implications for India's energy security concerns. In the absence of CCS, on the other hand, by 2050 gas imports are 66% higher than the 2020 level, but have declined after a peak in 2035.

Figure 8: Imports of Coal and Gas in India



Scenario 2: How Technology Innovation Affects Indo-Pacific Fossil Fuel Imports

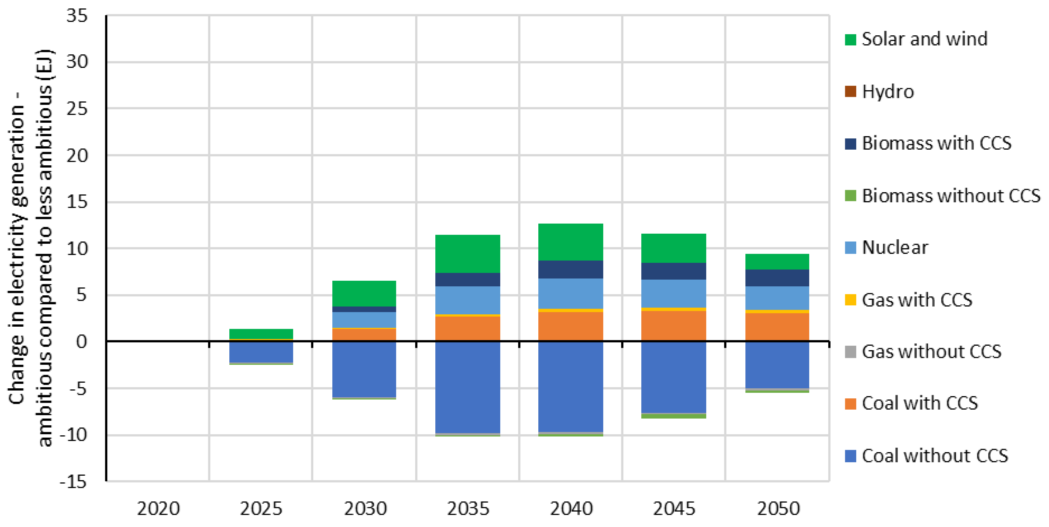
In addition to deploying low carbon technologies, electrifying transport and other parts of the economy currently supplied by fossil fuels is an important factor in overall decarbonisation of energy systems. In the second analysis we consider the energy mix used for electricity generation in the PRC, Japan, South Korea, and India. The purpose of the analysis is to examine how the technology mix changes as global climate ambition increases, and how this is affected by technology availability.

The analysis accomplishes this by comparing the electricity generated via different fuels and technologies in the ambitious scenario with that of the less ambitious scenario. This is done for a technology pathway where CCS is available at scale (first panel) and when it is not (second panel). By doing so it shows the how the technology mix changes over time as global climate ambition increases for different technology scenarios.

The results highlight a direct trade-off between CCS and renewable energy with storage. As global climate increases in China, for example, coal with CCS increases relative to the less ambitious scenario, along with nuclear power, solar photovoltaics (PV), and wind power. There is little change, on the other hand, with gas use as global climate ambition increases other than in Japan where unabated gas falls. Low deployment of CCS, on the other hand, see a much larger deployment of firmed solar PV and wind power, with similar amounts of nuclear power build between the two scenarios. Similar results can be seen in the other countries. By extension, regional trade in coal and gas is strongly dependent on the development of technology options for decarbonisation, and particularly CCS. These changes are evident by 2030, and become large in magnitude by 2035.

FIGURE 9: CHANGE IN ELECTRICITY GENERATION BY TECHNOLOGY IN CHINA

a) Ambitious



b) Ambitious (firmed RE, low CCS)

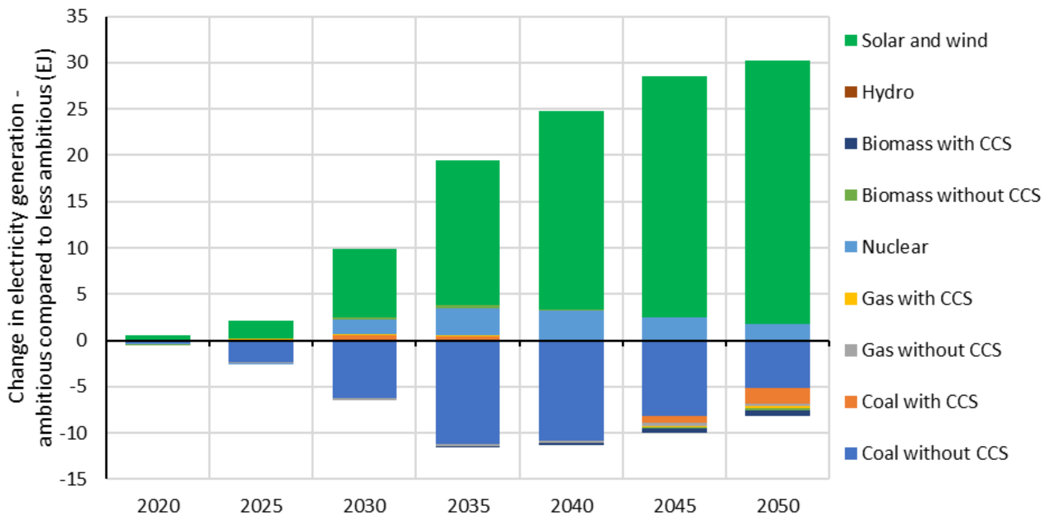
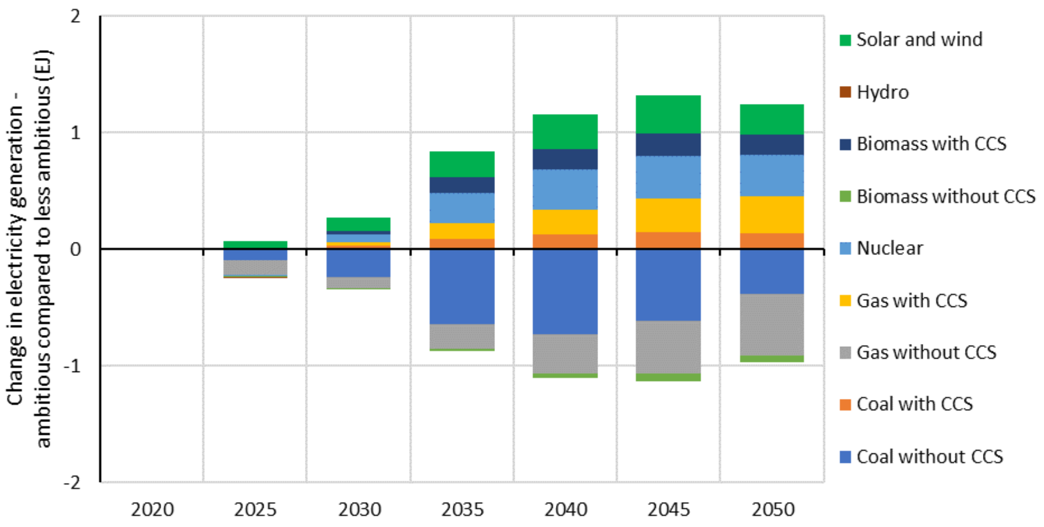


FIGURE 10: CHANGE IN ELECTRICITY GENERATION BY TECHNOLOGY IN JAPAN

a) Ambitious



b) Ambitious (firmed RE, low CCS)

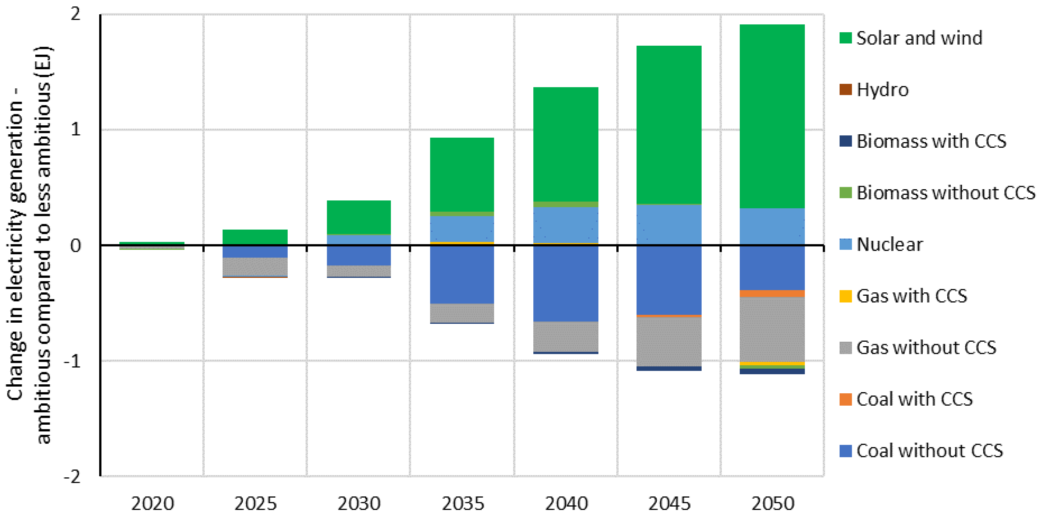
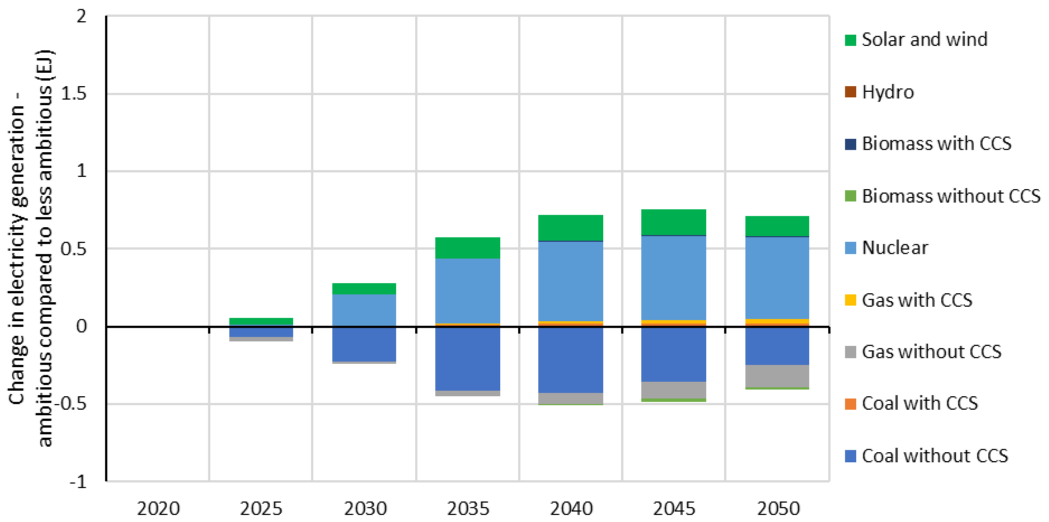


FIGURE 11: CHANGE IN ELECTRICITY GENERATION BY TECHNOLOGY IN SOUTH KOREA

a) Ambitious



b) Ambitious (firmed RE, low CCS)

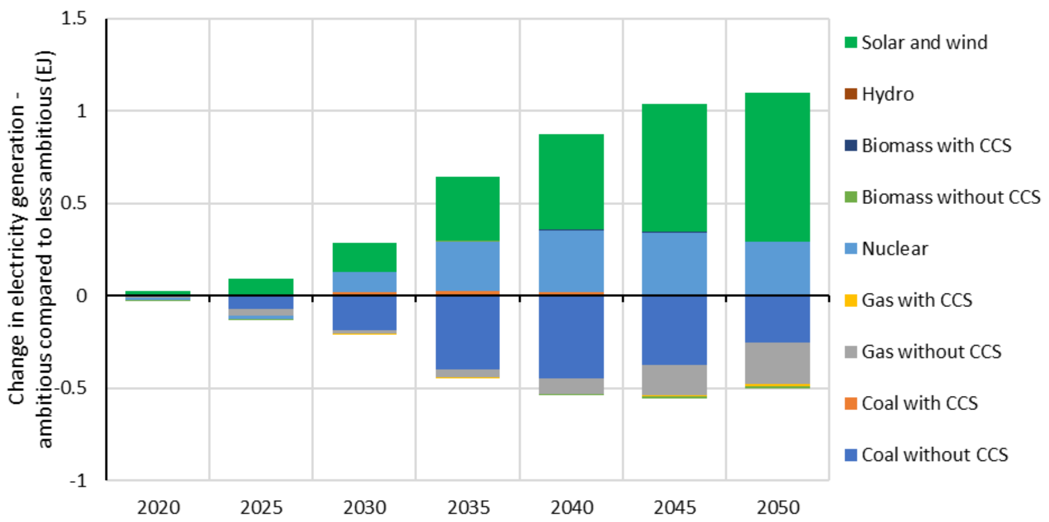
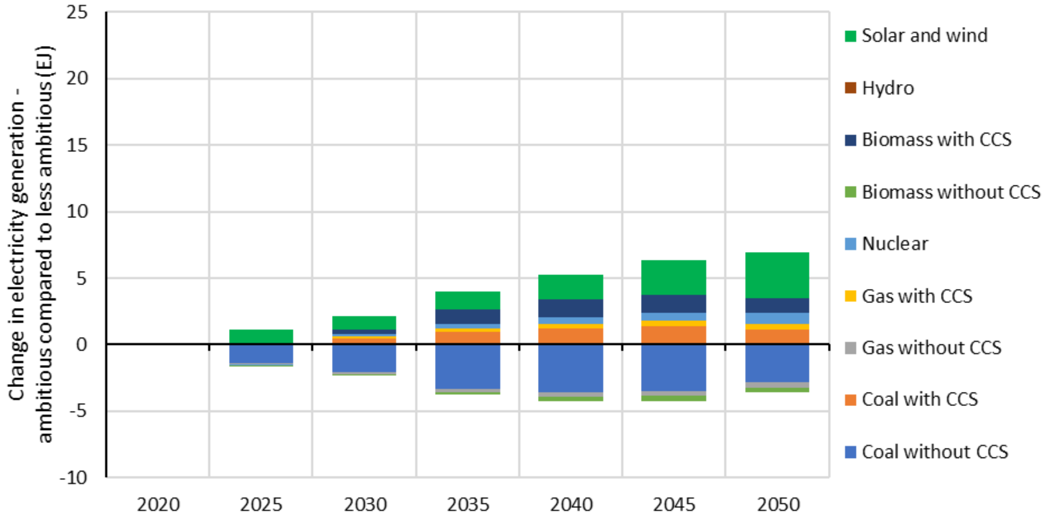
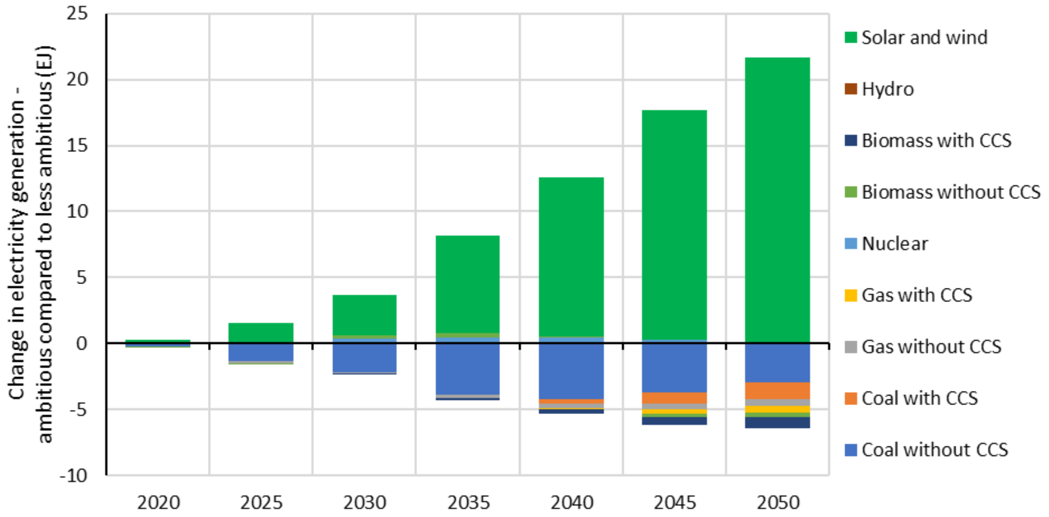


FIGURE 12: CHANGE IN ELECTRICITY GENERATION BY TECHNOLOGY IN INDIA

a) Ambitious



b) Ambitious (firmed RE, low CCS)



Implications for Australia As a Supplier of Energy Security

Fossil fuel markets have long been identified as having national security implications, given the importance of these fuels to economies and militaries. A reduction in the reliance on international markets for fossil fuels, other things being equal, implies an increase in energy security for key countries in the region, including Australia. The electrification of transport sector, for example, will reduce Australia's reliance on imports of oil and oil products, although it is important to note that a reduction in imports does not insulate domestic economies from price volatility in the absence of additional measures such as domestic reservation policies.

Australia is a supplier of energy security to regional trade partners. While it is intuitive that trade in fossil fuels is likely to fall regionally as countries decarbonize, this view elides important detail about the potential for different rates of demand reduction across countries and fuels. It also does not inform how fuels substitute for each another in countries' decarbonization pathways, and the impact of technologies like CCS on decarbonisation. Both issues matter to Australia given our role as an important supplier of both coal and gas to countries in the region.

Our modelled results suggest three implications for Australia's role as exporter of coal and gas to the region.

Implication One

Australia is a major exporter of thermal coal to the Indo-Pacific region. With climate action, all countries reduce unabated coal regardless of the level of climate ambition, with large decreases in unabated coal before 2035. In China and India there remains a residual role for coal power generation that uses Carbon Capture and Sequestration (CCS). By extension, residual demand for Australian coal depends on the deployment of CCS deployment at scale. If CCS is not deployed at scale, then Australia's major trading partners see a relatively near-term drop in thermal coal imports, to be replaced by firmed renewable energy.

Implication Two

Australia is a major exporter of gas to the Indo-Pacific region. Gas remains in the energy mix across Australia's major trading partners, but the magnitude of their imports is strongly affected both by the level of climate ambition, and the availability of CCS. This is most evident in China and India, where gas imports will grow markedly with less climate ambition, or with more climate ambition coupled with the availability of CCS at scale.

IMPLICATION THREE

All countries increase the use of solar PV and wind power in the electricity mix. The increase in solar PV and wind power is largest as global climate ambition increases, and when CCS does not become available as a scaled technology option. Countries will thus increase their exposure to supply chain risks associated with solar PV and wind technologies. Australia may also play a role in supply chains for these technologies, depending on the development of the critical minerals resource base.

The analyses here focuses on the fuel imports of the PRC, Japan, South Korea, and India that are required to meet their energy needs under two climate scenarios. The results do not identify what proportion of these required imports will be supplied by Australia, although the existing role in supplying coal and gas suggest Australia has the opportunity to continue to function as a supplier of energy security through exports in a decarbonizing world. The results suggest Australia's growing role as a provider of energy security to the Indo-Pacific through fossil fuel exports is contingent on technology innovation, chiefly the deployment of carbon capture and sequestration. Otherwise, a transition to critical minerals or products associated with renewable energy will be needed for Australia to remain a key trading partner in the Indo-Pacific in a decarbonizing world.

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ANNEX

FIGURE 1A: ABATEMENT COST BY LEVEL OF AMBITION AND YEAR

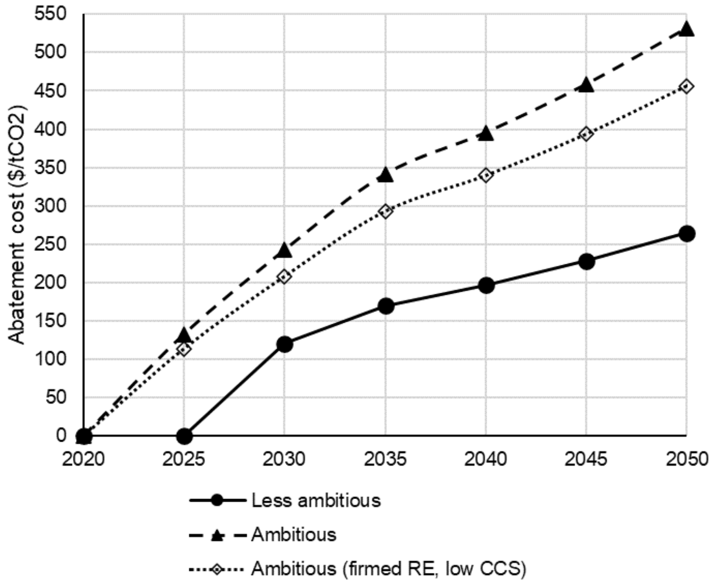
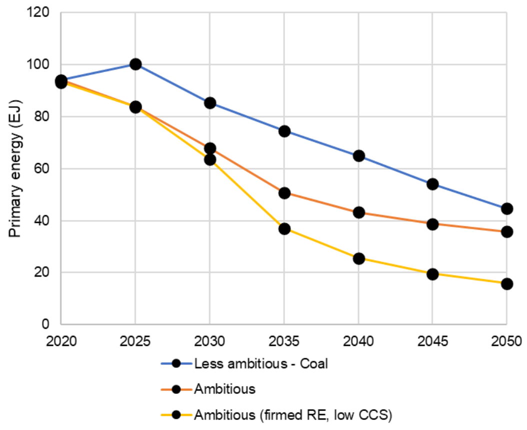
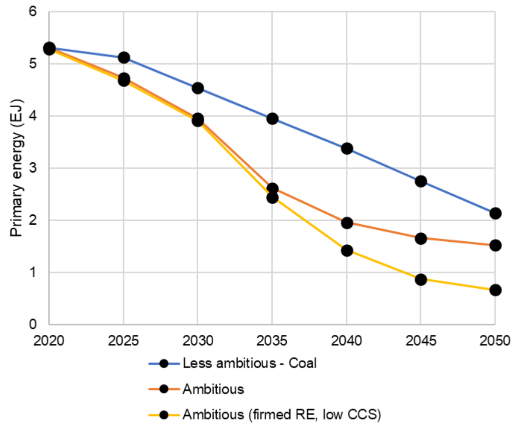


FIGURE 2A: TOTAL COAL USE IN SELECTED INDO-PACIFIC COUNTRIES

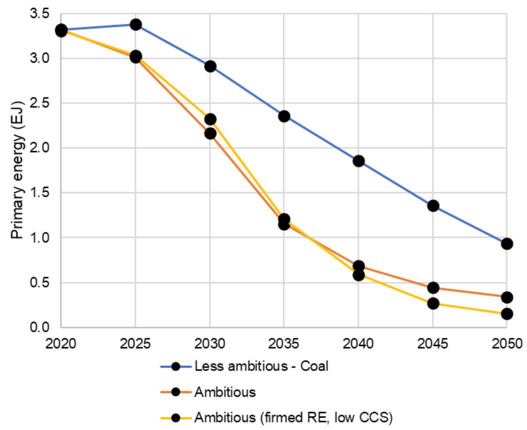
a) China



b) Japan



c) South Korea



d) India

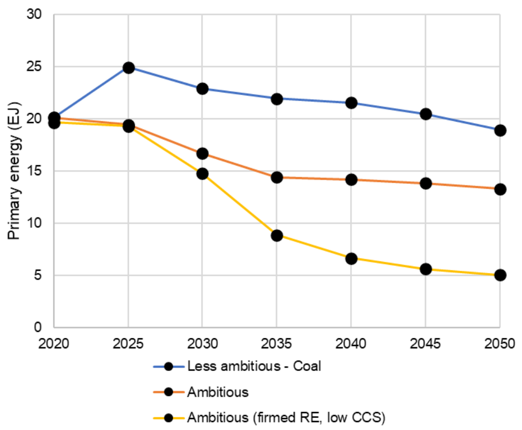
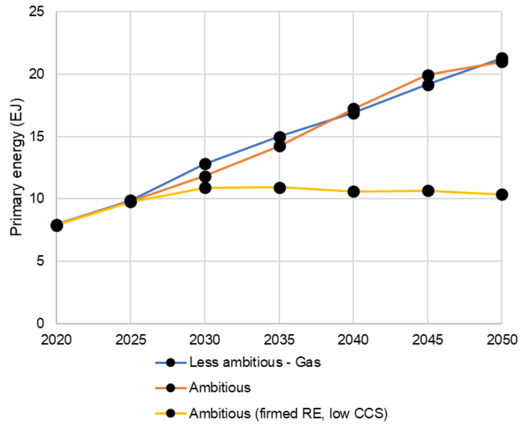
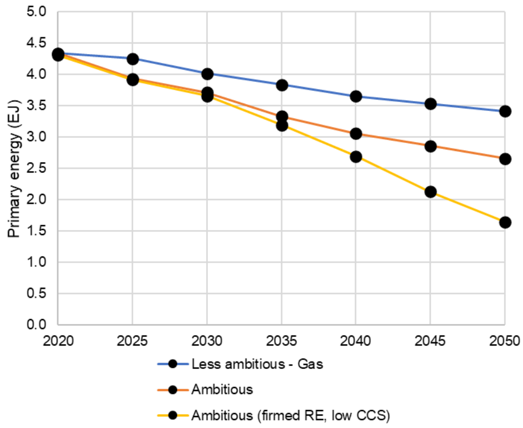


FIGURE 3A: TOTAL GAS USE IN SELECTED INDO-PACIFIC COUNTRIES

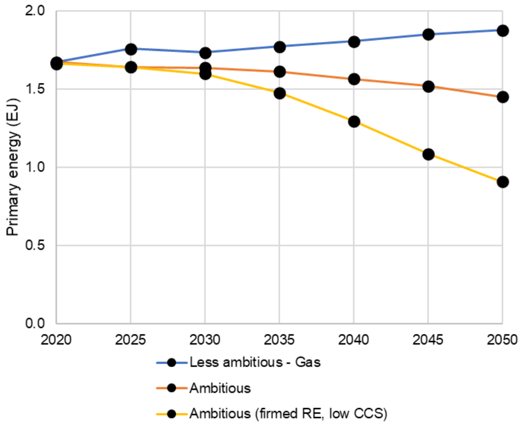
a) China



b) Japan



c) South Korea



d) India