CHAPTER 2

Australia Country Report

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1. Background

Australia is the largest country in Oceania and the sixth largest in the world by total area (about 7.7 million square kilometres), with diverse geography and climate. It has six states and two territories. Its population grew at an average annual rate of 1.4%, from 17.1 million in 1990 to 25.4 million in 2019.[1]

Gross domestic product (GDP) increased at an average annual rate of 3.0%, from US$569 billion in 1990 to US$1.35 trillion in 2019 (constant 2015 US$ values), and per capita income increased from US$33,330 to US$53,080. Economic activities are focused on the eastern and south-eastern seaboard, where most of the population live. In 2019, three states generated 74% of Australia's GDP: New South Wales (with 32% of the national population), Victoria (26%), and Queensland (20%) (ABS, 2021a, 2021b).

1.1. Energy Situation

Australia has abundant, high-quality, and diverse non-renewable and renewable energy resources. Its non-renewable energy resources include fossil fuels (coal, gas, and oil) and nuclear energy fuels (uranium and, potentially, thorium). The country had 1.23 million tonnes of economically demonstrated resources of uranium, nearly one-third of the world's uranium resources, as of the end of 2020. It has a major share of the world's thorium, which could be an alternative to uranium as a nuclear fuel. It has 74.147 million tonnes or 10% of the world's recoverable black coal and 74,039 million tonnes or 23% of the world's brown coal (Senior et al., 2022). The substantial conventional and unconventional gas resources of Australia account for almost 1.3% of the world's gas resources, and it has a small share (0.1%) of the world's crude oil resources (BP, 2022). The amount of recoverable resources is expected to grow with further exploration, and to last for many more decades even if production increases.

Australia has large, widely distributed wind, solar, geothermal, hydroelectricity, ocean energy, and bioenergy resources. Wind energy technology is mature, and its uptake is growing fast. Generation capacity of solar electricity is increasing rapidly because of fast-decreasing solar technology costs. Australia has the highest solar radiation per square metre in the world. No substantial expansion of traditional hydropower will likely occur because of the dry climate and low water run-off over most of the country. Pumped hydro for electricity storage is being considered for existing hydropower installations and new sites.

Energy resources play a significant role in the country's economic prosperity. Coal and gas resources support not only domestic consumption but also significant export earnings. In 2019, Australia was the world's eighth-largest energy producer (444.8 million tonnes of oil equivalent [Mtoe]), accounting for 3.0% of global primary energy supply. It was the world's 21st-largest energy consumer, accounting for 0.9% (128.7 Mtoe) of world primary energy supply.

[1] Unless otherwise cited, all data in the report is attributed to the Institute of Energy Economics, Japan's economic modelling results for Australia, which are included in full as an appendix to the publication.

Australia's primary energy supply is largely based on fossil fuels. In 2019, coal contributed about 32% of its primary energy supply; oil, 34%; and natural gas, 27%. Renewables contributed the remaining 7%, consisting of hydropower (1%), solar and wind energy (2%), and biomass energy and biofuels (4%).

Australia plays a prominent role in meeting increasing energy demand not only in Asia and the Pacific but also in the rest of the world. In 2019, it was the world's fourth-largest energy exporter, exporting 80% of its energy production, consisting largely of coal and liquefied natural gas. It is the world's largest exporter of metallurgical coal, the second-largest exporter of thermal coal, and a large exporter of uranium. With limited crude oil resources, it is a net importer of crude oil and petroleum products. It is increasingly reliant on imported transport fuels with the closure of two refineries in 2021.

Australia's gross electricity generation increased at an average annual rate of 1.9%, from 154 terawatt-hours (TWh) in 1990 to 264 TWh in 2019. In 2019, coal accounted for 59% of total electricity generation, followed by natural gas, 20%; hydropower, 6%; oil, 2%; and 'others' (non-hydro renewables), 14%. Coal still dominates the electricity generation mix, although its share fell from 79% in 1990 to 59% in 2019. The share of natural gas and non-hydro renewables in the generation mix increased significantly over the period.

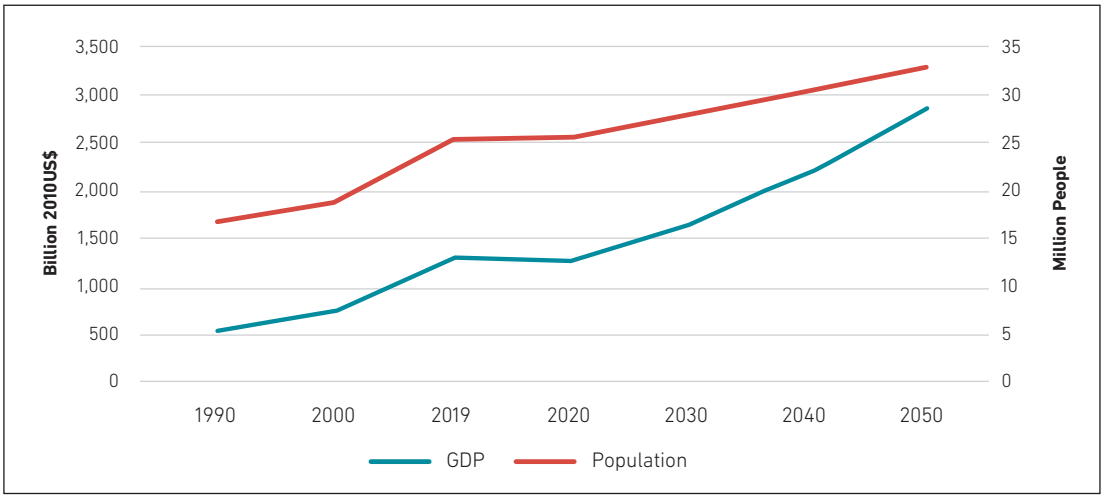
The coronavirus disease (COVID-19) pandemic and the measures taken to control its spread have had a notable impact on patterns of daily life and economic activity. In 2020, Australia went into its first recession in almost 30 years although its GDP contracted less than many other developed countries'. The pandemic impacted energy use and supply.

2. Modelling Assumptions

The study analyses long-term energy demand and supply by comparing the results from three scenario models: business as usual (BAU), alternative policy scenario (APS), and low carbon energy transition (LCET). The scenarios were developed before Australia's net-zero emission commitment.

All three scenarios apply the same GDP and population assumptions. Australia's population growth is driven primarily by its migration programme. The COVID-19 pandemic slowed the programme, impacting GDP growth. Australia's GDP is assumed to grow at an average annual rate of 2.5% over the outlook period (2019–2050), compared with average annual growth of 3.0% in 1990–2019. The population is assumed to grow at an average annual rate of 0.9% in 2019–2050, which is marginally slower than the average annual growth rate of about 1.4% in 1990–2019 (Figure 2.1).

Figure 2.1 Australia – Gross Domestic Product and Population (1990–2050)



GDP = gross domestic product.

Source: Authors.

BAU reflects the continuation of current trends of energy demand and supply, and existing goals, action plans, and policy commitments. No aggressive action to achieve the emission-reduction goal will be taken in BAU. The economy will gradually shift from energy-intensive industries to less energy-intensive ones. Fossil fuels will remain dominant in the primary energy mix because they are abundant and cheap. New coal plants will not be installed to generate electricity, and the share of coal-fired electricity will decrease because of the scheduled closure and/or retirement of a few coal-fired electricity plants. No nuclear power plants will be installed. Gas-fired electricity and non-hydro renewable electricity generation are assumed to rise to meet increasing demand over the projection period.

APS applies the same GDP and population assumptions as BAU. APS assumes improved efficiency of final energy consumption in end-use sectors. It will see more efficient thermal power generation and higher contribution of renewable energy to total supply with no nuclear power plants. The measures' combined effects are assumed to provide maximum energy saving over the projection period. Energy saving in industry is assumed to be achieved from improvements in large energy-intensive industries and closure of small, inefficient plants. Structural changes will gradually move the economy away from energy-intensive industries. In the residential and commercial sectors, efficient end-use technologies and energy management systems are assumed to further save energy. Transport is assumed to be more energy efficient because of improved vehicle standards and fuel economy. Rapid uptake of energy-efficient electric vehicles for private and public transport is assumed to occur during the second half of the projection period.

LCET applies the same GDP and population assumptions as BAU. LCET will see a further increase in thermal efficiency of power generation and greater contribution of renewable energy than in APS. LCET has no nuclear power plants and assumes substantial deployment of advanced technologies to decarbonise industry, power generation, and transport. Carbon capture and storage (CCS) in industry and power generation will begin by 2030. Hydrogen and ammonia, including co-firing in power generation and boilers in industry, will be used after 2040.

By comparing APS and BAU results, the study provides a basis for determining the impacts of promoting energy efficiency and increased use of renewable energy on energy saving and carbon dioxide (CO_2) emission reduction. LCET results provide a basis for exploring carbon neutrality pathways for the energy sector by 2050.

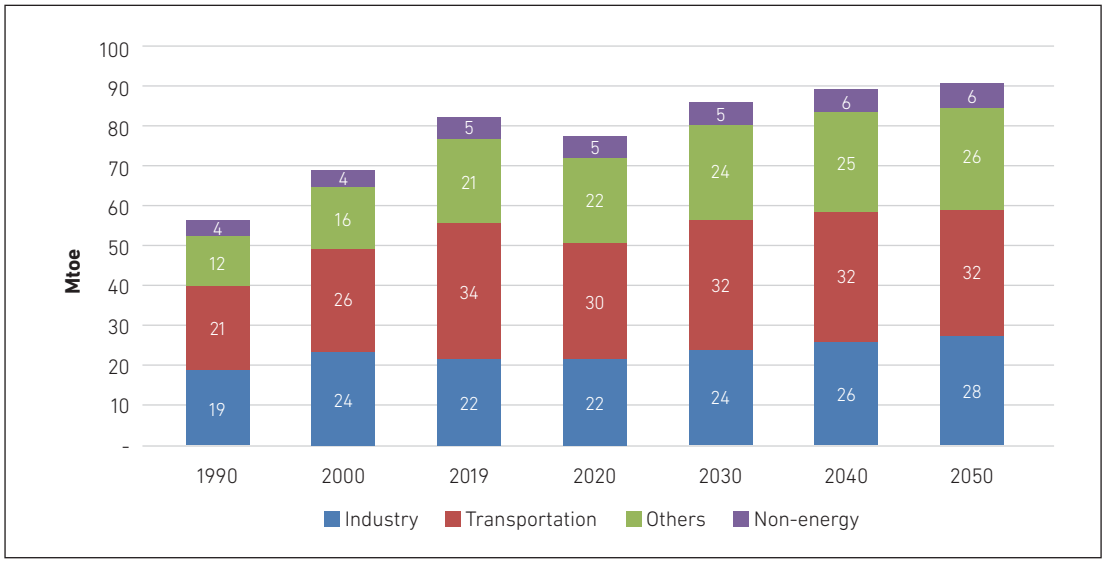
3.Outlook Results

3.1. Business-As-Usual Scenario

3.1.1. Final Energy Consumption

In BAU, total final energy consumption is projected to increase from 82.3 Mtoe in 2019 to 90.8 Mtoe in 2050, about 10.2% more than in the projection period and an average annual rate of increase at 0.3%. The strongest growth is projected in industry, increasing at 0.7% per year in 2019–2050. In BAU, transport is the only sector where energy consumption is projected to decline over the projection period (0.2% per year), although it saw relatively strong growth (1.6% per year) in 1990–2019. Efficiency improvements, fuel switching, and other structural changes within the sector, including remote working arrangements, will reduce transport fuel consumption despite continued growth in vehicle ownership over the projection period. Energy consumption in others (e.g. residential and service sectors) is anticipated to increase at 0.6% per year in 2019–2050 (Figure 2.2).

Figure 2.2 Australia – Final Energy Consumption by Sector, Business as Usual (1990–2050)

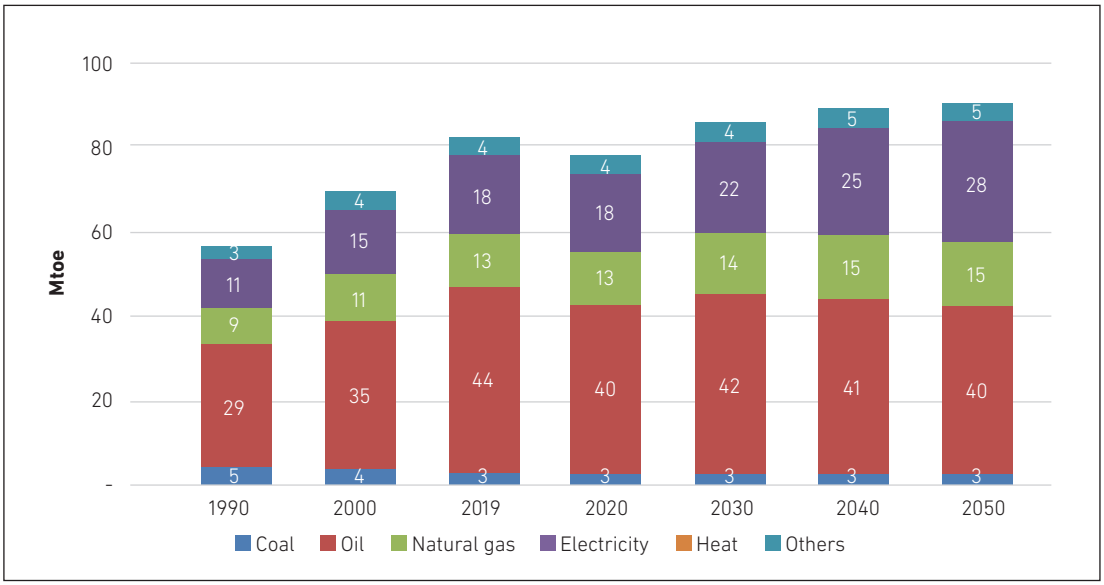


Mtoe = million tonnes of oil equivalent.

Source: Authors.

Electricity consumption is projected to grow fastest at an average rate of 1.4% per year in 2019–2050. Natural gas consumption will increase at the second-highest rate of 0.6% per year. Petroleum product consumption is projected to increase at 0.6% per year during 2020 and 2030, but will decline after, with an average rate of 0.3% per year. Coal consumption will decline at an average rate of 0.4% per year in 2019–2050 (Figure 2.3).

Figure 2.3 Australia – Final Energy Consumption by Fuel Type, Business as Usual (1990–2050)



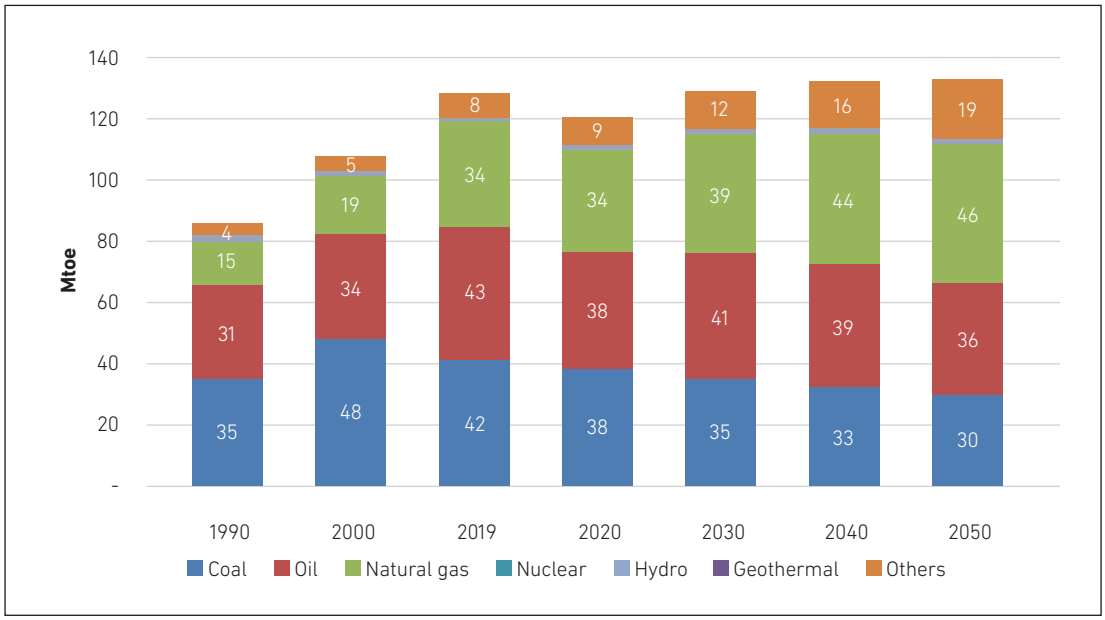
Mtoe = million tonnes of oil equivalent.

Source: Authors.

3.1.2. Primary Energy Supply

Primary energy supply is projected to increase from 128.7 Mtoe in 2019 to 133.1 Mtoe in 2050 at an average annual rate of 0.1%, with coal consumption expected to decline at an annual average rate of 1.1% and oil consumption at 0.6%. Natural gas supply will increase at 1.0% per year in 2019–2050, where its share in the primary energy mix is expected to increase from 26.6% in 2019 to 34.5% in 2050. The overall share of fossil fuels in primary energy supply will decline from 92.6% in 2019 to 84.3% in 2050. 'Others' (including non-hydro renewables) are projected to increase by 2.8% a year over the projection period. The share of 'others' is expected to increase from 6.3% in 2019 to 14.6% in 2050, with the biggest contribution coming from solar and wind energy, followed by biofuels and biomass. Solar, wind, and ocean energy together are expected to grow at an average annual rate of 4.3% in 2019–2050 (Figure 2.4).

Figure 2.4 Australia – Primary Energy Supply by Fuel Type, Business as Usual (1990–2050)



Mtoe = million tonnes of oil equivalent.

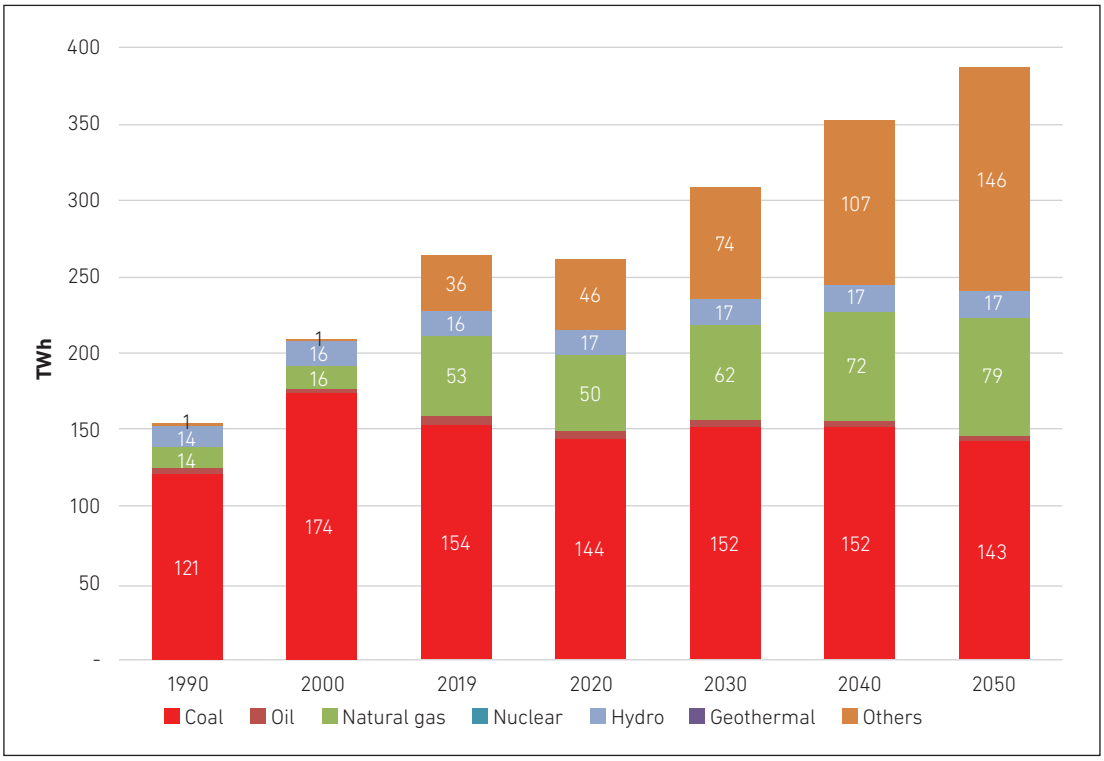
Source: Authors.

3.1.3. Power Generation

Electricity generation is projected to increase from 263.7 TWh in 2019 to 388.0 TWh in 2050 at an average rate of 1.3% per year. The share of coal in the power generation mix is projected to fall from 58.5% in 2019 to 36.9% in 2050. Coal's share will decline because of the scheduled closure and retirement of some old coal-fired generation plants. Generation from oil is projected to decline at an average rate of 1.9% per year, and the share of oil in the generation mix will decline from 1.9% in 2019 to 0.7% in 2050. In contrast, the share of natural gas in the generation mix will remain flat, with a slight increase from 20.0% in 2019 to 20.3% in 2050, and natural gas use in electricity generation is projected to grow at an average rate of 1.3% per year over the period.

Hydroelectricity's share in the power generation mix is expected to decline slightly from 5.9% in 2019 to 4.4% by 2050. Electricity generation from others (non-hydro renewables) is expected to grow faster, at an average rate of 4.6% per year in 2019–2050. Declining costs of wind and solar technology will partly contribute to the faster growth of electricity generation from others (including wind and solar energy) (Figure 2.5 and Figure 2.6).

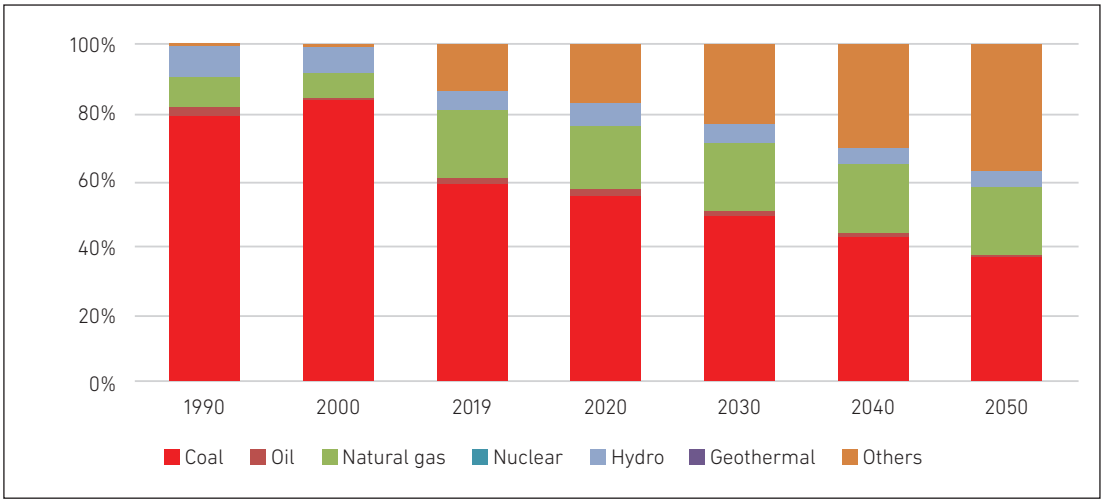
Figure 2.5 Australia – Power Generation, Business as Usual (1990–2050)



TWh = terawatt-hour.

Source: Authors.

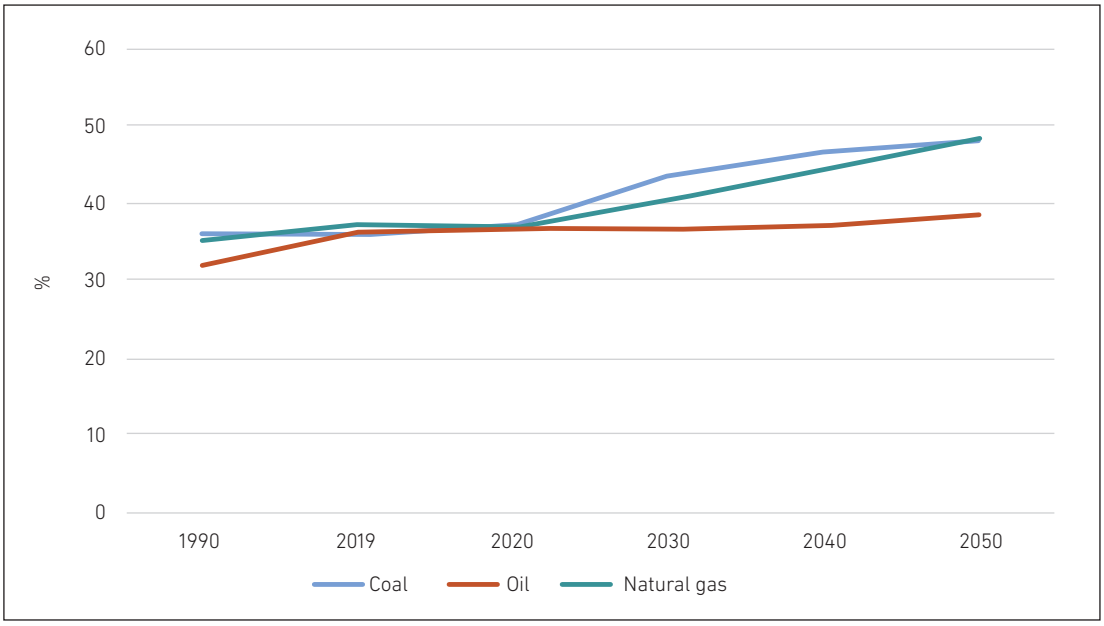
Figure 2.6 Australia – Share of Power Generation Mix, Business as Usual (1990–2050)



Source: Authors.

Thermal efficiency of power generation is projected to improve for coal-fired power plants, from 36.3% in 2019 to 48.4% in 2050. Similarly, gas power plants are expected to improve thermal efficiency, from 37.2% to 48.6%, whilst oil power plant will remain flat with a modest increase, from 36.7% to 38.6% over the outlook period under BAU (Figure 2.7).

Figure 2.7 Australia – Thermal Efficiency of Power Generation, Business as Usual (1990–2050)



Source: Authors.

3.1.4. Energy Indicators

Primary energy intensity (primary energy consumption per unit of GDP) and final energy intensity (final energy consumption per unit of GDP) improved by 36.9% and 38.6%, respectively, in 1990–2019. Strong GDP growth, the move to less energy-intensive industries, and energy efficiency improvement across economic sectors contributed to energy intensity improvements. Primary and final energy intensities are projected to improve by 51.5% and 48.3%, respectively, for the outlook period. Australia's CO_2 intensity decreased by 37.1% in 1990–2019. CO_2 intensity is projected to reduce by 59.3% over the outlook period. The increased share of renewable energy in the primary energy mix will reduce CO_2 emissions per unit of primary energy consumption (CO_2 per energy). CO_2 per energy is projected to decrease by 16.1%, and CO_2 per capita is projected to decrease by 33.4% for the period (Table 2.1, Figure 2.8).

Table 2.1 Australia – Energy Indicators, Business as Usual (1990–2050)

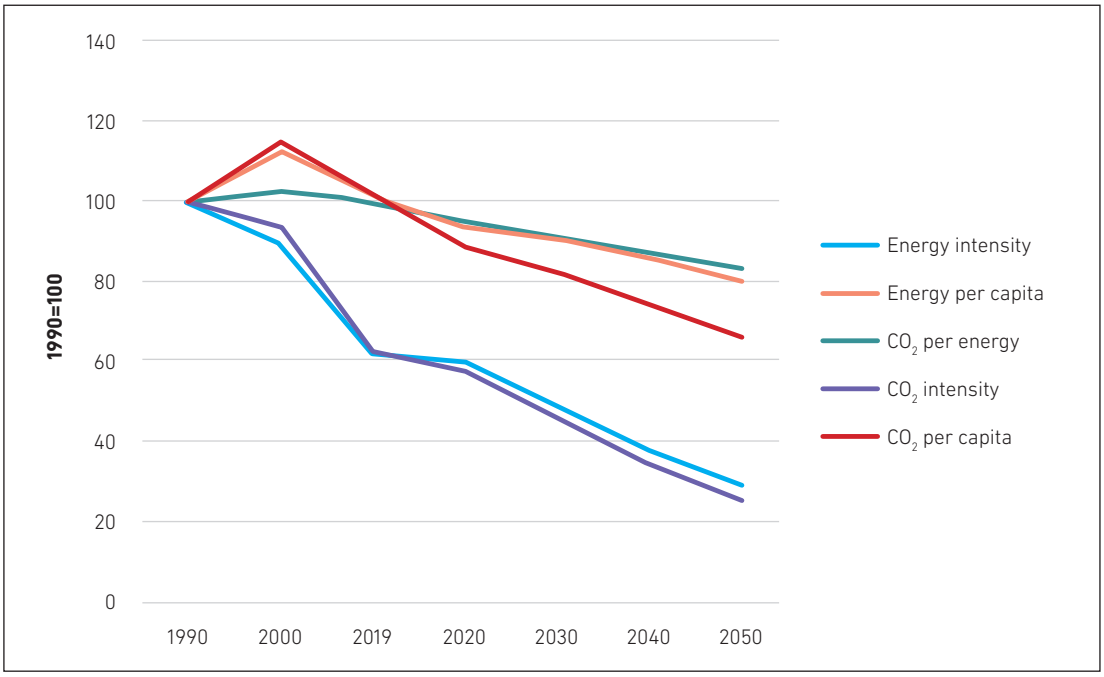
Energy Indicators	1990	2000	2019	2020	2030	2040	2050
Energy intensity[a]	151.4	137.2	95.6	92.1	76.4	59.3	46.4
Energy per capita[b]	5.0	5.6	5.1	4.7	4.6	4.3	4.0
CO_2 per energy[c]	0.81	0.83	0.81	0.77	0.74	0.71	0.68
CO_2 intensity[d]	122.7	114.4	77.1	70.8	56.4	42.0	31.4
CO_2 per capita[e]	4.1	4.7	4.1	3.6	3.4	3.1	2.7

[a] Primary energy consumption per unit of GDP (toe/million 2015 US dollars)
[b] Primary energy consumption per capita (toe/person)
[c] CO_2 emissions per unit of primary energy consumption (t-C/toe)
[d] CO_2 emissions per unit of GDP (t-C/million 2015 US dollars)
[e] CO_2 emissions per person (t-C/person)

GDP = gross domestic product, t-C = tonne of carbon, toe = tonne of oil equivalent.

Source: Authors.

Figure 2.8 Australia – Indices of Energy Indicators, Business as Usual (1990 = 100)



Source: Authors.

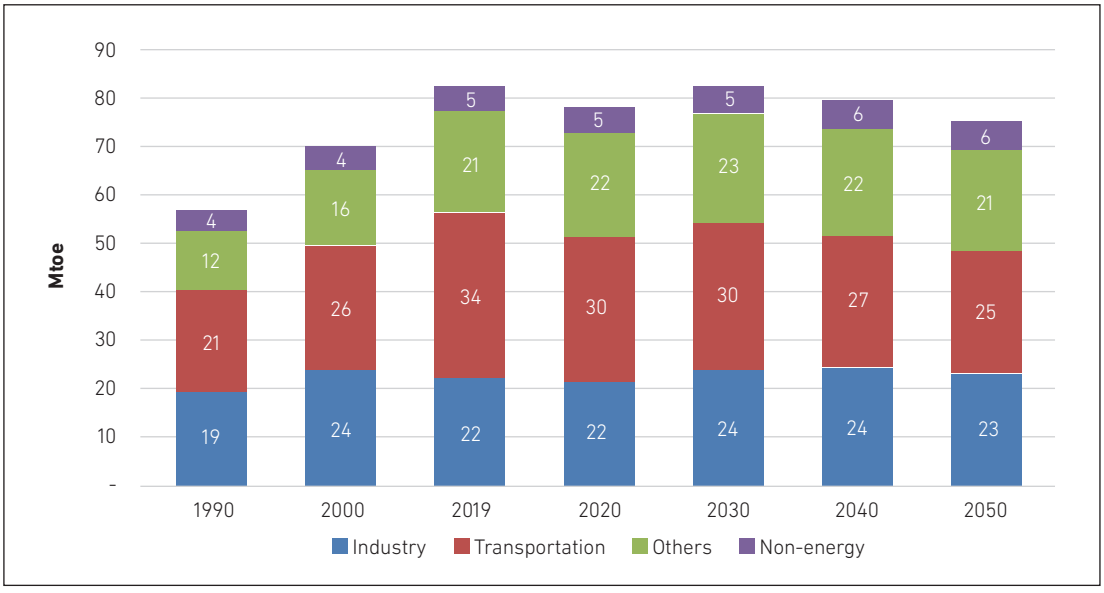
3.2. Energy Savings in Alternative Policy Scenario and CO_2 Reduction Potential

3.2.1. Final Energy Consumption

In APS, total final energy consumption is projected to decrease from 82.3 Mtoe in 2019 to 75.0 Mtoe in 2050, or by about 8.9% (0.3% per year). Consumption will decline steeply in transport, at an average rate of 1.0% per year in 2019–2050. In contrast, industry's consumption will grow at 0.2% per year, and the non-energy sector's at 0.3% per year during the same period. 'Others', mainly the residential and commercial sectors, will increase at 0.5% per year and peak in 2030, before declining to the 2019 level in 2050 (Figure 2.9).

Electricity consumption will grow at an average rate of 1.3% per year during the outlook period. Electricity's share will increase from 22.4% in 2019 to 37.0% in 2050. In contrast, oil consumption will decline at 1.2% per year and reduce oil's share from 53.4% to 40.1% during the same period. Natural gas consumption will peak in 2030 before declining nearly to the 2000 level in 2050. Coal consumption will decline at an average rate of 2.6% per year in 2019–2050, and coal's share in the final energy mix will decrease from 3.6% to 1.8% (Figure 2.10).

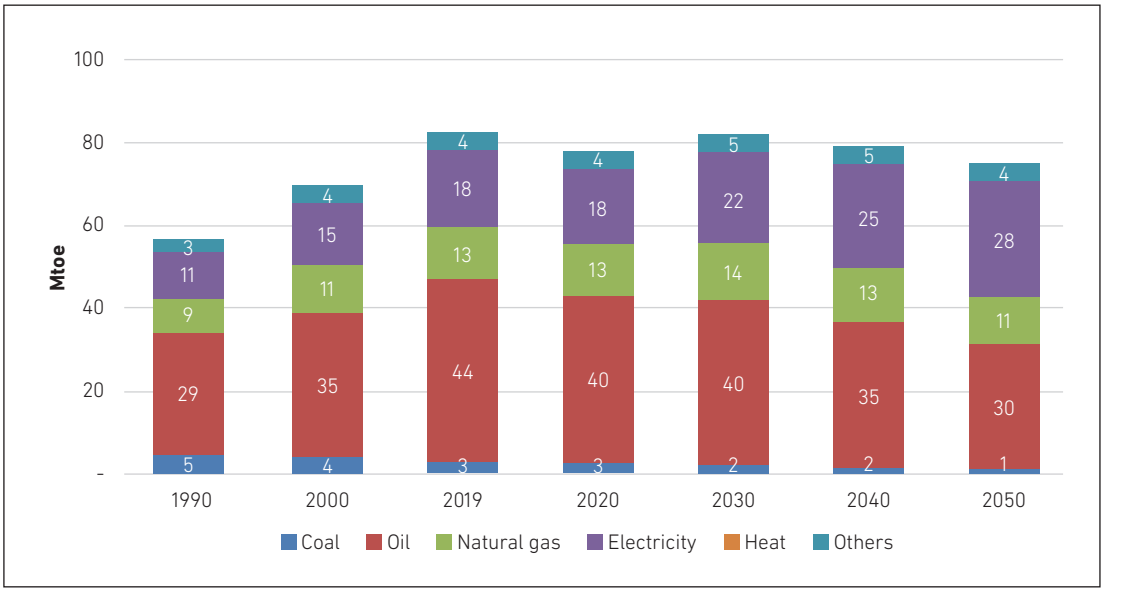
Figure 2.9 Australia – Final Energy Consumption by Sector, Alternative Policy Scenario (1990–2050)



Mtoe = million tonnes of oil equivalent.

Source: Authors.

Figure 2.10 Australia – Final Energy Consumption by Fuel Type, Alternative Policy Scenario (1990–2050)

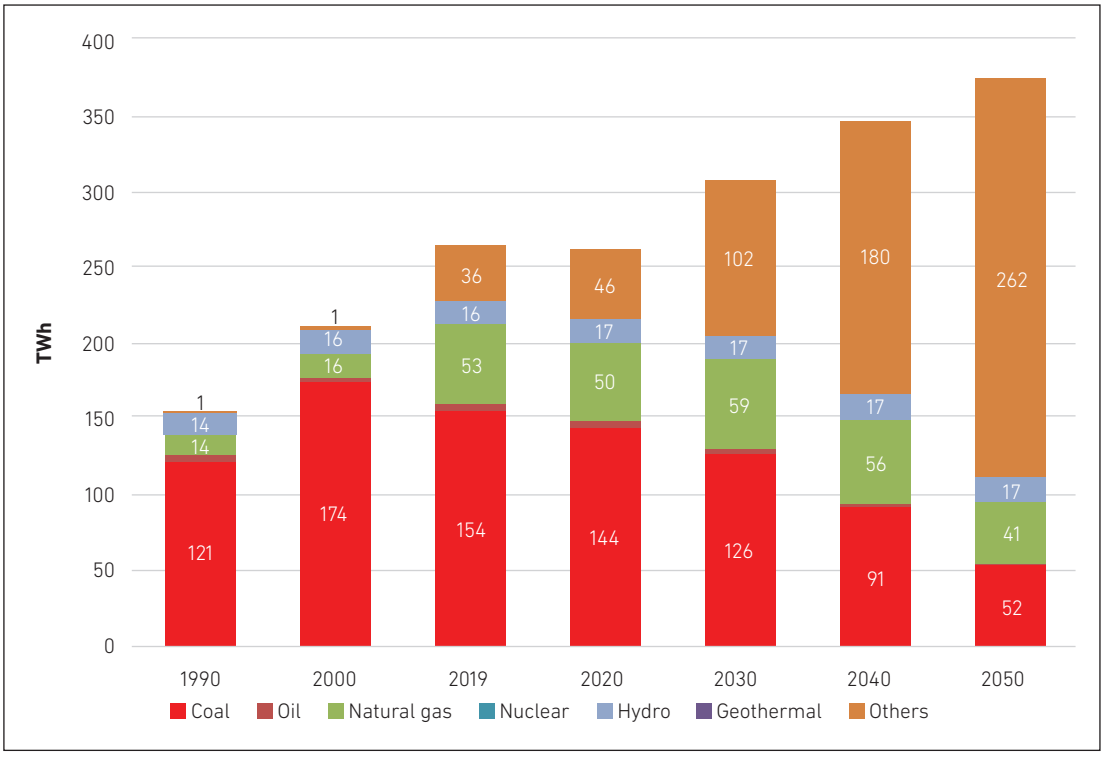


Mtoe = million tonnes of oil equivalent.

Source: Authors.

Electricity generation is projected to increase from 263.7 TWh in 2019 to 373.6 TWh in 2050, or at an average rate of 1.1% per year. The share of fossil fuels in the power generation mix is projected to fall sharply by the end of the outlook period. Electricity generation from non-hydro renewables ('others') is expected to grow faster at an average rate of 6.6% per year in 2019–2050. In 2050, about 74.8% of power generation will come from zero-carbon sources, whilst coal will make up 14.0% of the power generation mix; natural gas, 10.9%; and oil, only 0.3% (Figure 2.11 and Figure 2.12).

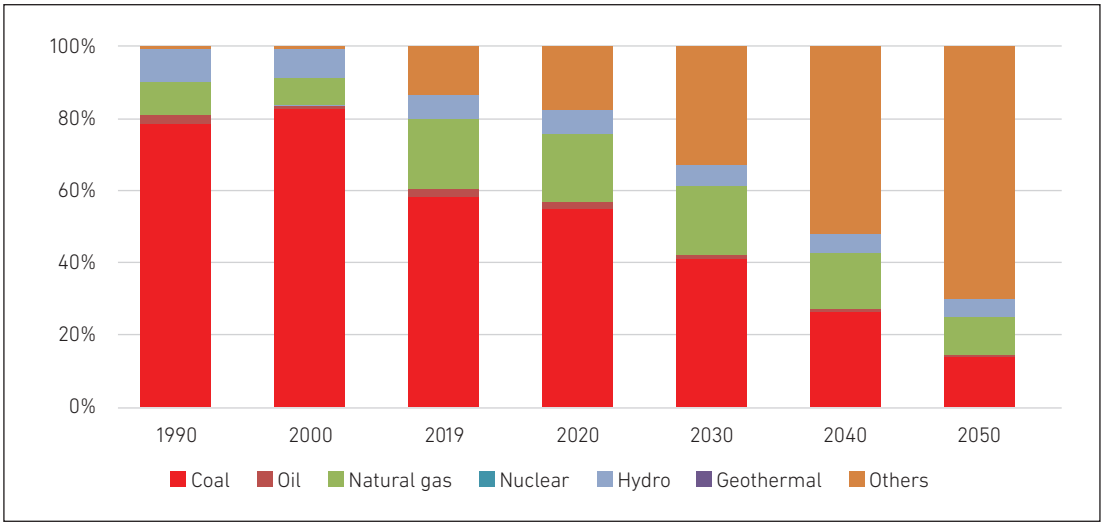
Figure 2.11 Australia – Power Generation, Alternative Policy Scenario (1990–2050)



TWh = terawatt-hour.

Source: Authors.

Figure 2.12 Australia – Share of Power Generation Mix, Alternative Policy Scenario (1990–2050)

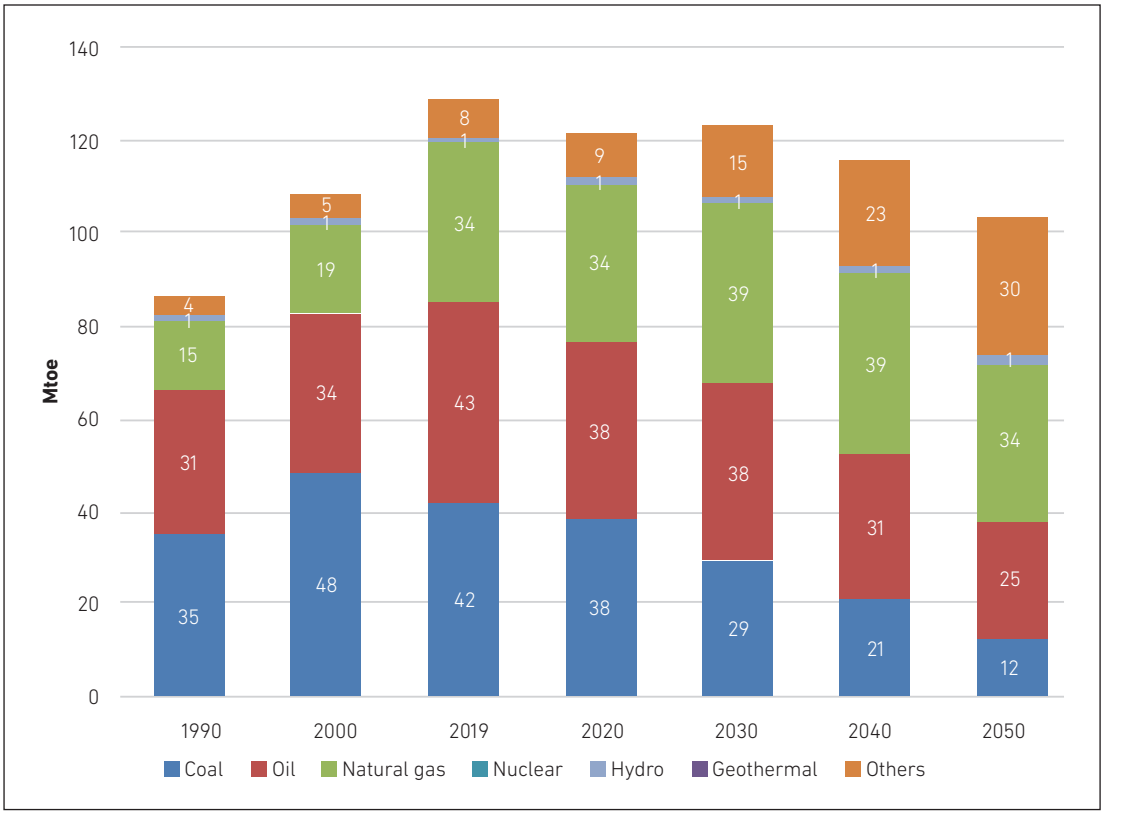


Source: Authors.

3.2.2. Primary Energy Supply

Total primary energy consumption is projected to decrease from 128.7 Mtoe in 2019 to 103.2 Mtoe in 2050, at an average rate of 0.7% per year. Coal consumption will decline sharply at 3.8% per year and oil consumption at 1.7% per year. Natural gas use will peak in 2040 before sharply declining to the 2019 level in 2050. The representation of fossil fuels in the primary energy mix will drop from 92.6% in 2019 to 69.6% in 2050. Hydropower will remain relatively flat, with a modest growth of 0.3% per year over the outlook period. In contrast, consumption of non-hydro renewables ('others') will grow rapidly at 4.3% per year during the period, supported mainly by the growth of solar and wind energy (6.3% per year) and biomass energy (1.7% per year) (Figure 2.13).

Figure 2.13 Australia – Primary Energy Supply by Fuel Type, Alternative Policy Scenario (1990–2050)



Mtoe = million tonnes of oil equivalent.

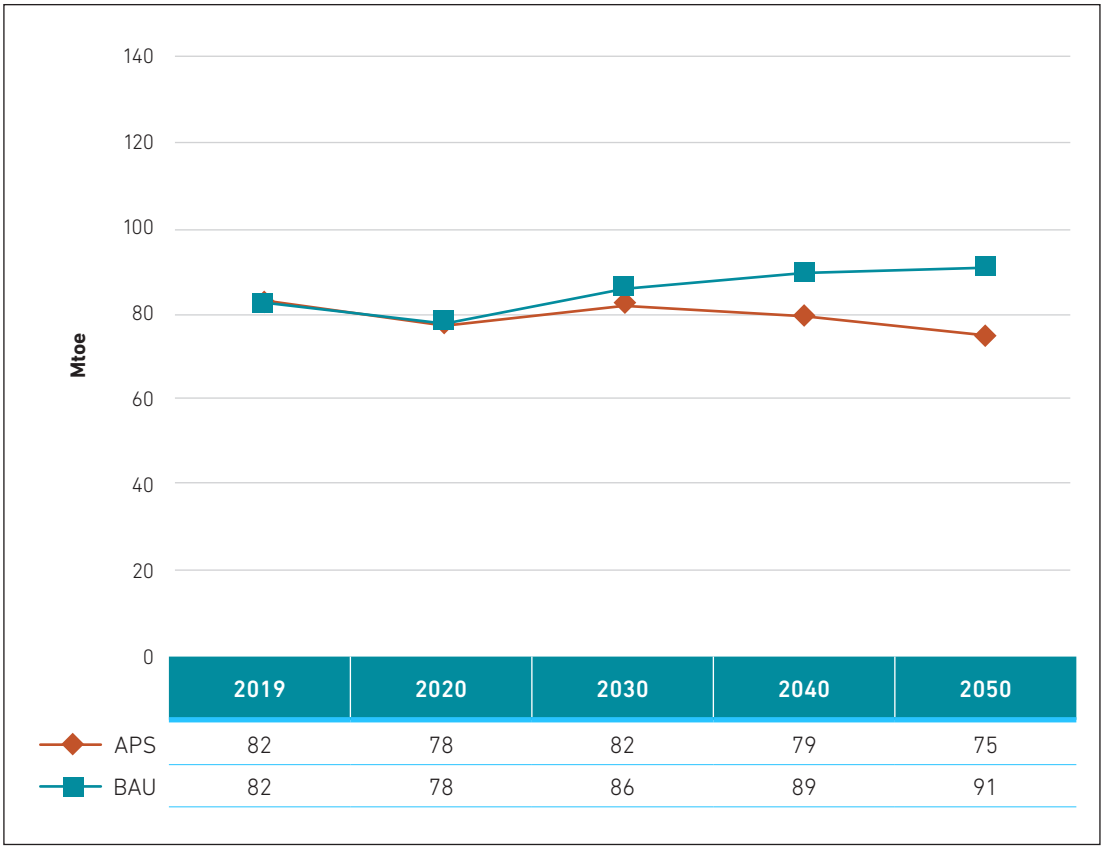
Source: Authors.

3.2.3. Projected Energy Saving

Total final energy consumption will decline from 82.3 Mtoe to 75.0 Mtoe over the outlook period, saving 15.8 Mtoe or 17.4% more energy in 2050 than in BAU (Figure 2.14).

Transport is projected to achieve the highest energy savings, 6.9 Mtoe (21.6%), followed by the residential and commercial sectors, 4.6 Mtoe (17.9%); and the industry sector, 4.3 Mtoe (15.7%) in 2050, compared with BAU. The savings reflect improvements in fuel efficiency in transport vehicles and end-use technologies (Figure 2.15).

Figure 2.14 Australia – Total Final Energy Consumption, Alternative Policy Scenario vs Business as Usual (2019–2050)

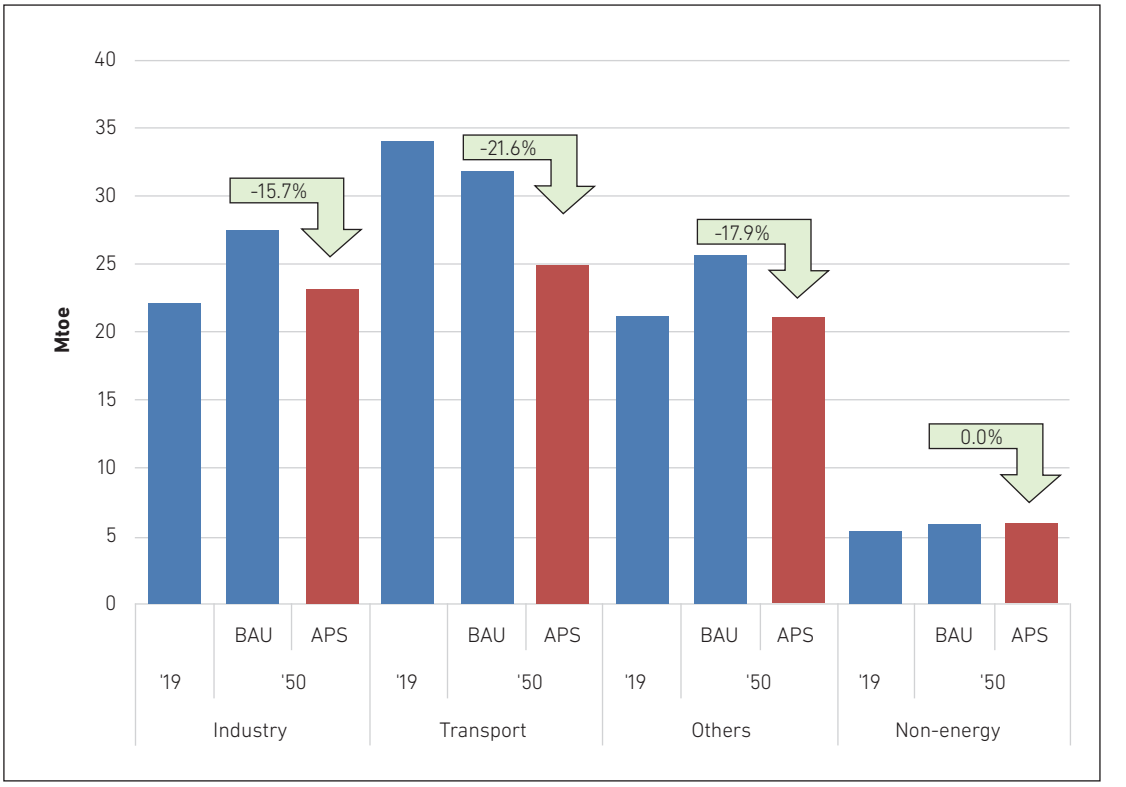


	2019	2020	2030	2040	2050
APS	82	78	82	79	75
BAU	82	78	86	89	91

APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Authors.

Figure 2.15 Australia – Final Energy Consumption by Sector, Alternative Policy Scenario vs. Business as Usual (2019 and 2050)

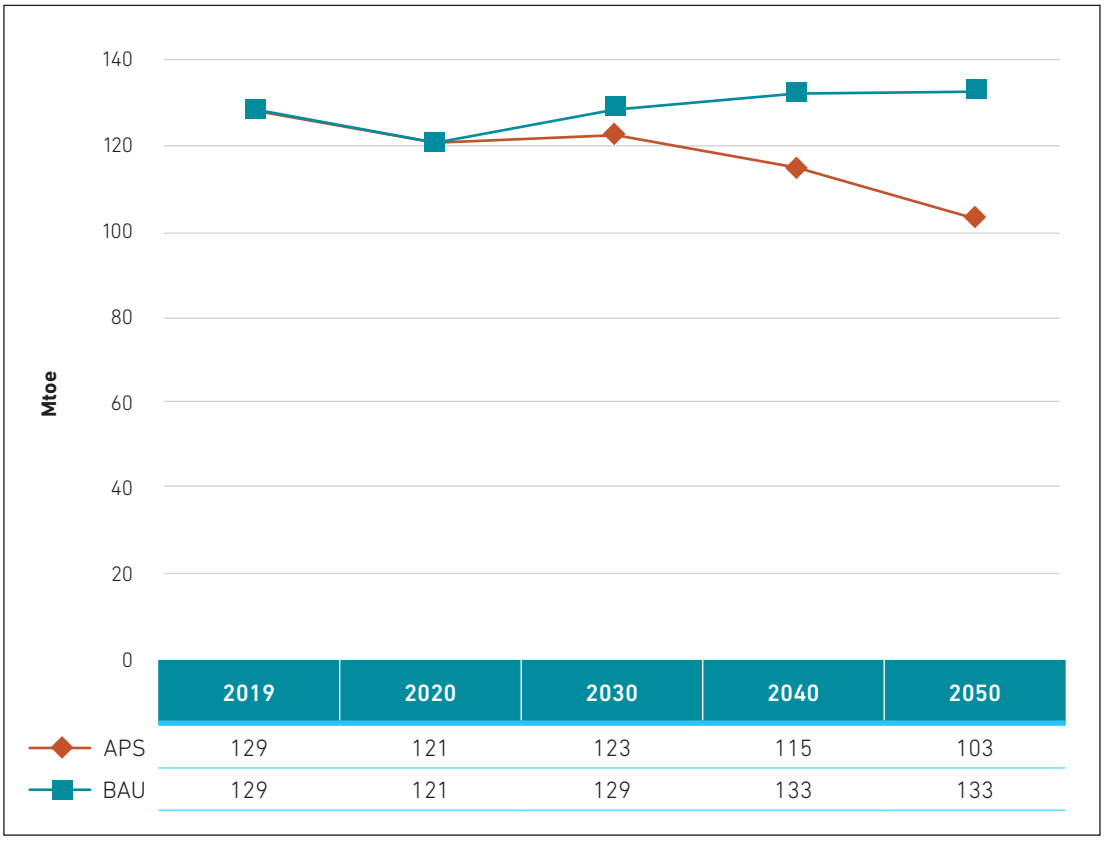


APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Authors.

Total primary energy consumption will decrease by 0.7% per year from 128.7 Mtoe in 2019 to 103.2 Mtoe in 2050, for a saving of 29.9 Mtoe or 22.4% primary energy consumption in APS in 2050, compared with BAU (Figure 2.16 and Figure 2.17).

Figure 2.16 Australia – Total Primary Energy Consumption, Alternative Policy Scenario vs Business as Usual (2019–2050)

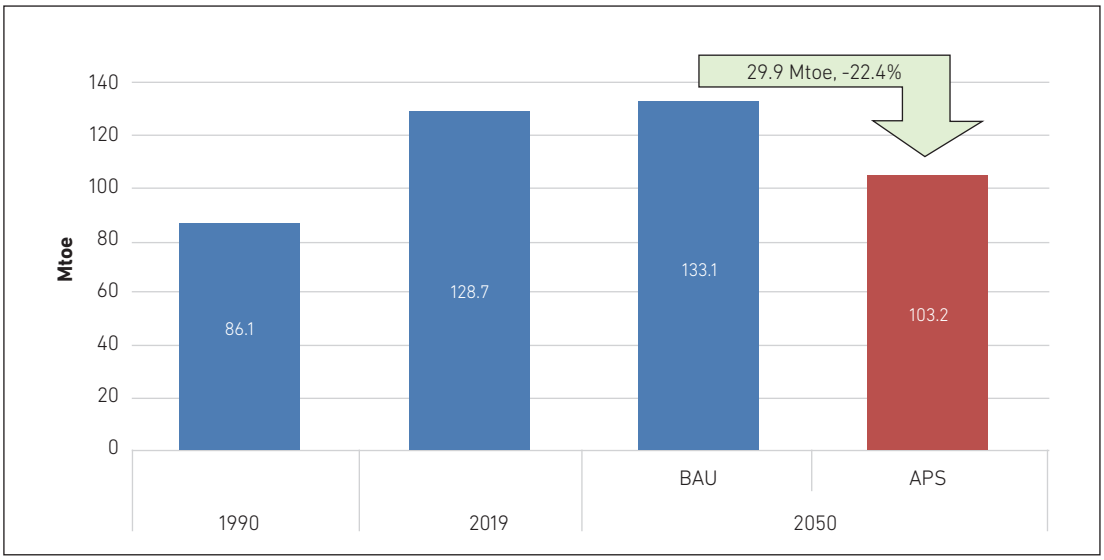


	2019	2020	2030	2040	2050
APS	129	121	123	115	103
BAU	129	121	129	133	133

APS = alternative policy scenario BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Authors.

Figure 2.17 Australia – Total Primary Energy Supply, Business as Usual vs Alternative Policy Scenario (2019 and 2050)

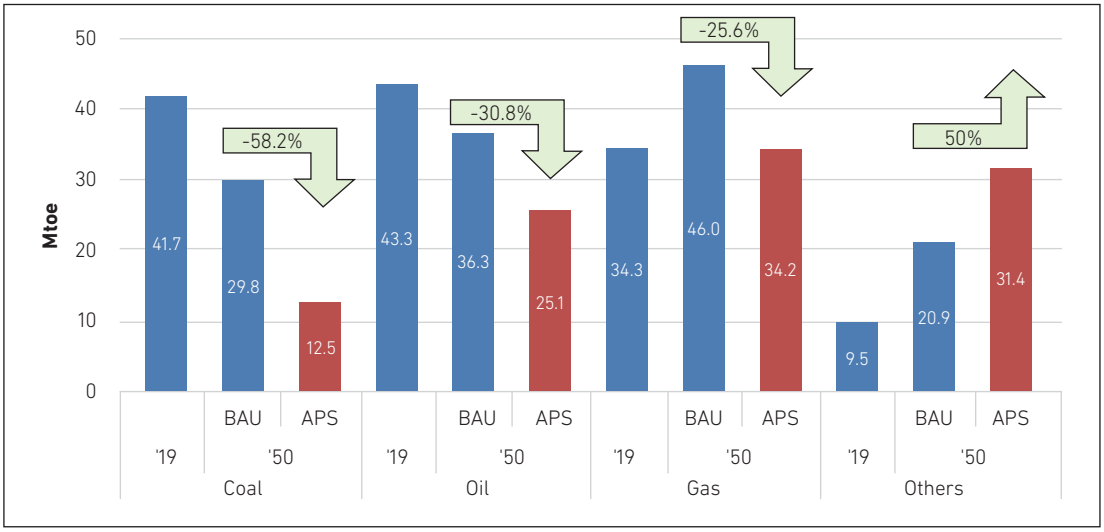


APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Authors.

Savings on coal in primary energy will be 17.4 Mtoe (or 58.2%) in 2050 compared with BAU. Savings on natural gas are 11.8 Mtoe (25.6%) and on oil, 11.2 Mtoe (30.8%) in 2050 compared with BAU. However, demand for renewable primary energy ('others') will increase by 10.5 Mtoe or 50.0% more in 2050 compared with BAU (Figure 2.18).

Figure 2.18 Australia – Primary Energy Supply by Fuel, Alternative Policy Scenario vs Business as Usual (2019 and 2050)



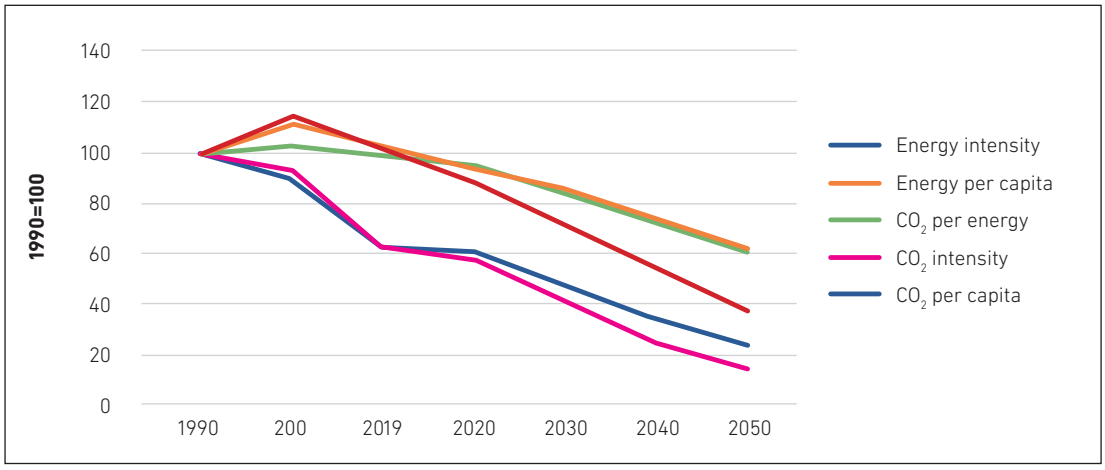
APS = alternative policy scenario, BAU = business as usual, Mtoe = million tonnes of oil equivalent.

Source: Authors.

3.2.4. Energy Indicators

Primary energy intensity and final energy intensity are projected to improve by 62.4% (51.5% in BAU) and 57.3% (48.3% in BAU), respectively, in 2019–2050. The improvement implies that greater energy efficiency is achieved across economic sectors in APS than in BAU. Primary energy consumption per person will be 3.1 toe in 2050, 22.4% lower than in BAU. Greenhouse gas (GHG) emissions per person will be 1.5 t-C in 2050, 44.1% lower than in BAU. CO_2 emissions per unit of primary energy consumption in 2050 will be 27.9% less than in BAU because of the greater share of renewable energy in the primary energy mix than in BAU (Figure 2.19).

Figure 2.19 Australia – Indices of Energy Indicators, Alternative Policy Scenario (1990 = 100)

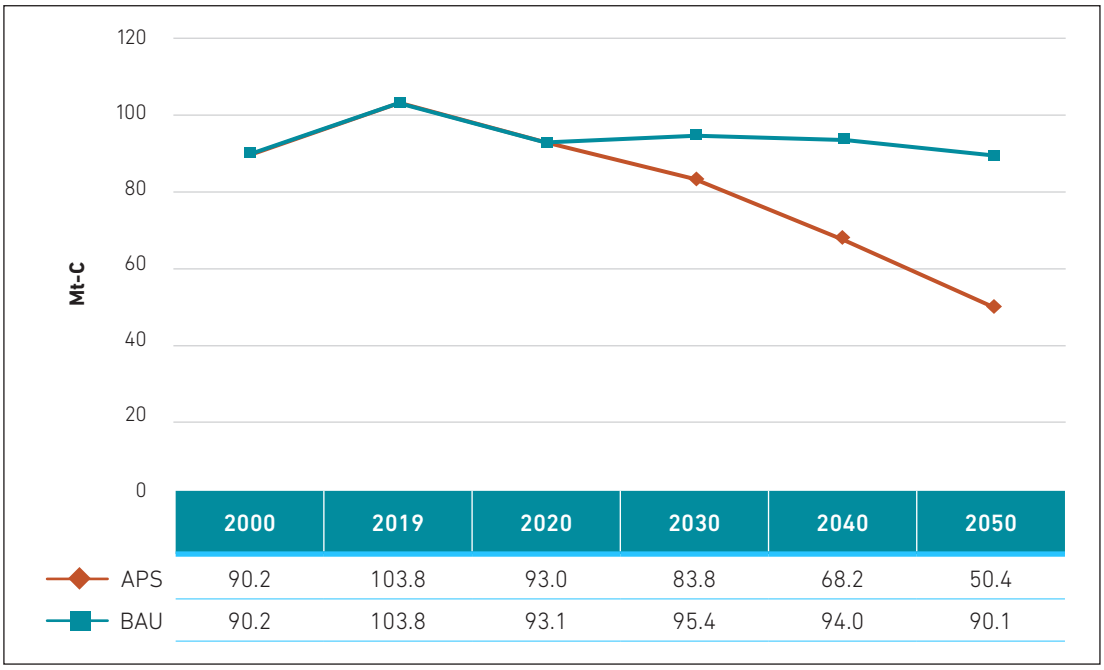


Source: Authors.

3.2.5. CO_2 Emission Reduction

CO_2 emissions from energy consumption will decline from 103.8 million tonnes of carbon (Mt-C) in 2019 to 50.4 Mt-C in 2050 or an equivalent decrease by an average rate of 2.3% per year. In 2050, emission saving is projected to be 39.7 Mt-C or 44.1% compared with BAU. The rate of emission reduction over the outlook period is faster than the declining rate of primary energy consumption in APS, reflecting the increased use of less carbon-intensive and renewable energy sources in the primary energy supply. The lower emission growth rate indicates that energy-saving options are effective in reducing CO_2 emissions. Reduced use of coal in power generation and reduced oil consumption in transport will contribute to the reduction of CO_2 emissions (Figure 2.20, Figure 2.21, and Figure 2.22)

Figure 2.20 Australia – CO_2 Emissions Trends for Domestic Energy Use, Alternative Policy Scenario vs. Business as Usual

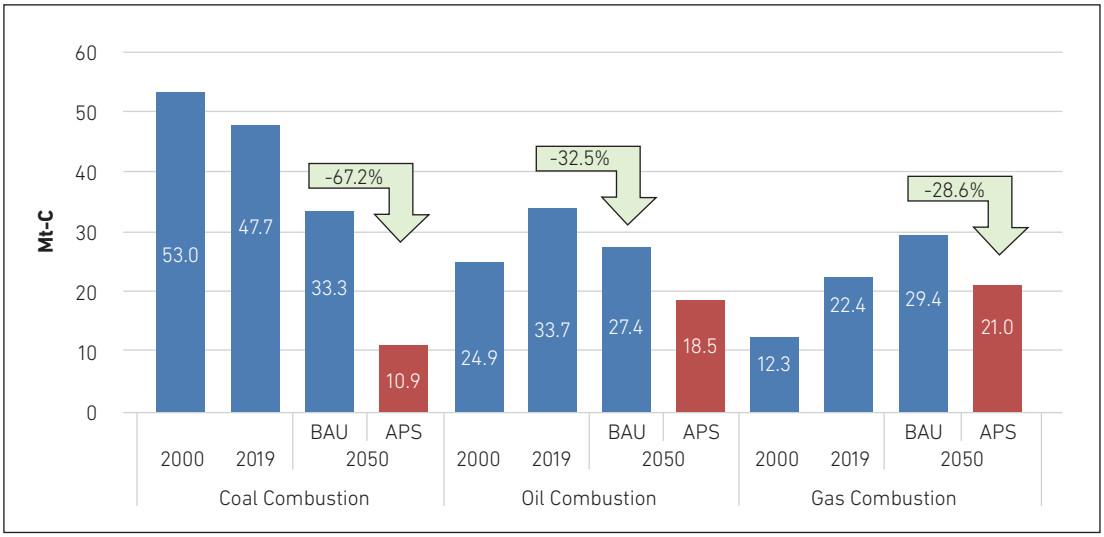


	2000	2019	2020	2030	2040	2050
APS	90.2	103.8	93.0	83.8	68.2	50.4
BAU	90.2	103.8	93.1	95.4	94.0	90.1

APS = alternative policy scenario, BAU = business as usual, Mt-C = million tonnes of carbon.

Source: Authors.

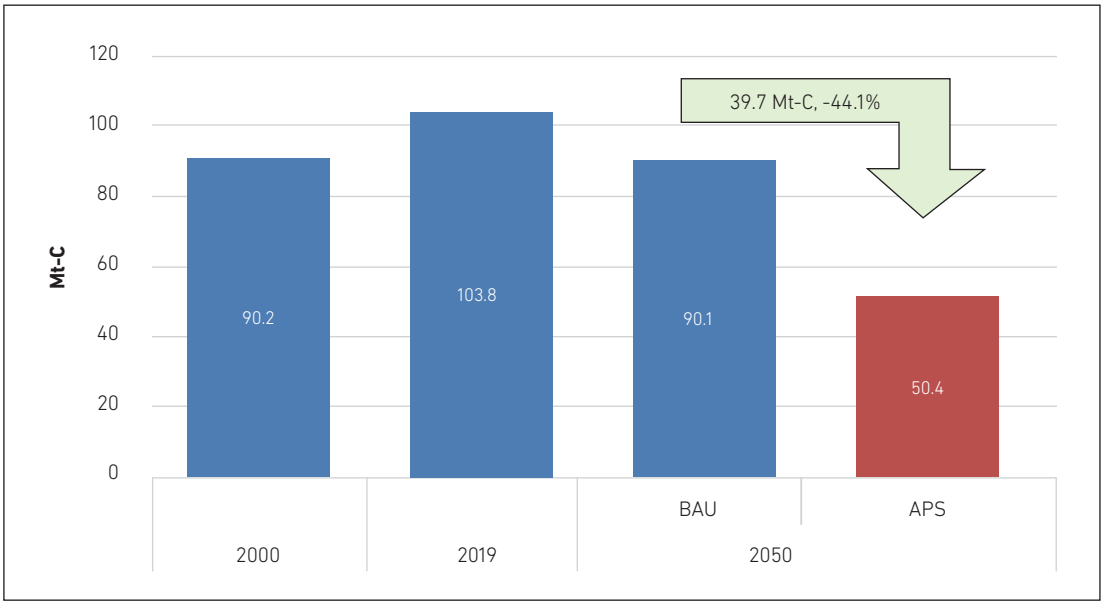
Figure 2.21 Australia – CO_2 Emissions from Fuel Combustion, Alternative Policy Scenario vs. Business as Usual



APS = alternative policy scenario, BAU = business as usual, Mt-C = million tonnes of carbon.

Source: Authors.

Figure 2.22 Australia – CO_2 Emissions Savings, Alternative Policy Scenario, 2050



APS = alternative policy scenario, BAU = business as usual, Mt-C = million tonnes of carbon.

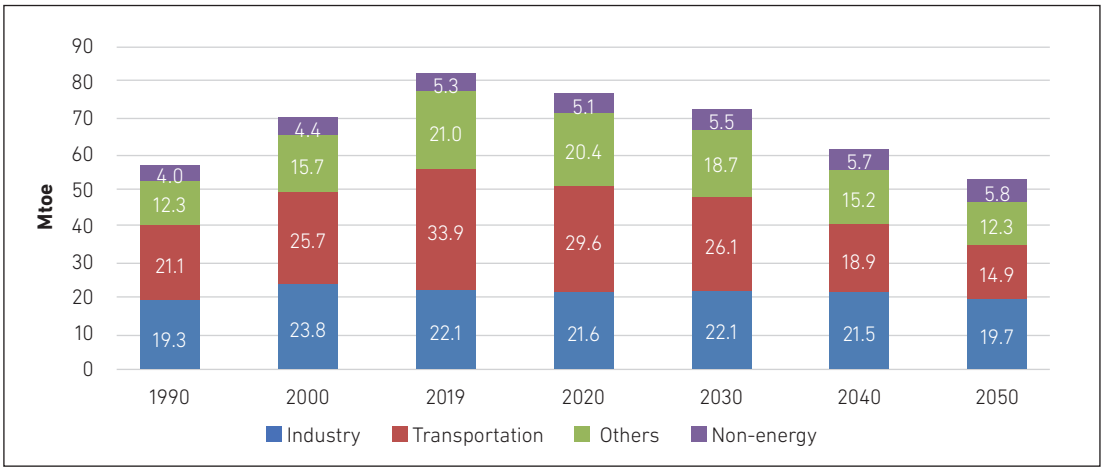
Source: Authors.

3.3. Low-Carbon Energy Transition Scenario

3.3.1. Final Energy Consumption

In LCET, total final energy consumption will decrease from 82.3 Mtoe in 2019 to 52.7 Mtoe in 2050, or by about 36.0% or an average of 1.4% per year. Transport's consumption will decline strongly (55.9%) because of efficiency improvements and other structural changes despite continued growth in vehicle ownership. Energy use in 'others', mainly residential and service sectors, will decrease at an average annual rate of 1.7%, from 21.0 Mtoe in 2019 to 12.3 Mtoe in 2050. Industry's energy use will decline by 0.4% per year during the same period but non-energy's will grow by 0.3% per year. Consumption of coal, oil, and natural gas will decline sharply, but demand for electricity and other renewables will grow. The share of hydrogen and ammonia in the final energy mix is expected to be the second highest (14.8%), behind electricity. Electricity's share will increase from 22.4% in 2019 to 57.8% in 2050 (Figure 2.23, Figure 2.24, and Figure 2.25).

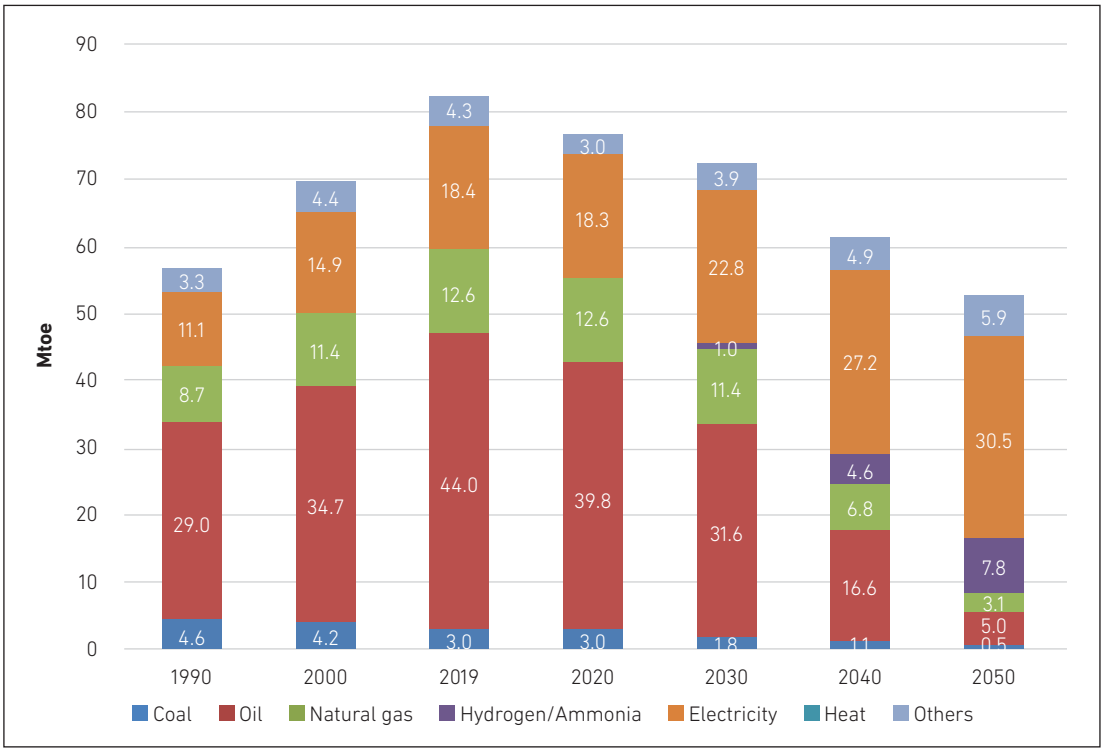
Figure 2.23 Australia – Final Energy Consumptions by Sector, Low-Carbon Energy Transition (1990–2050)



Mtoe = million tonnes of oil equivalent.

Source: Authors.

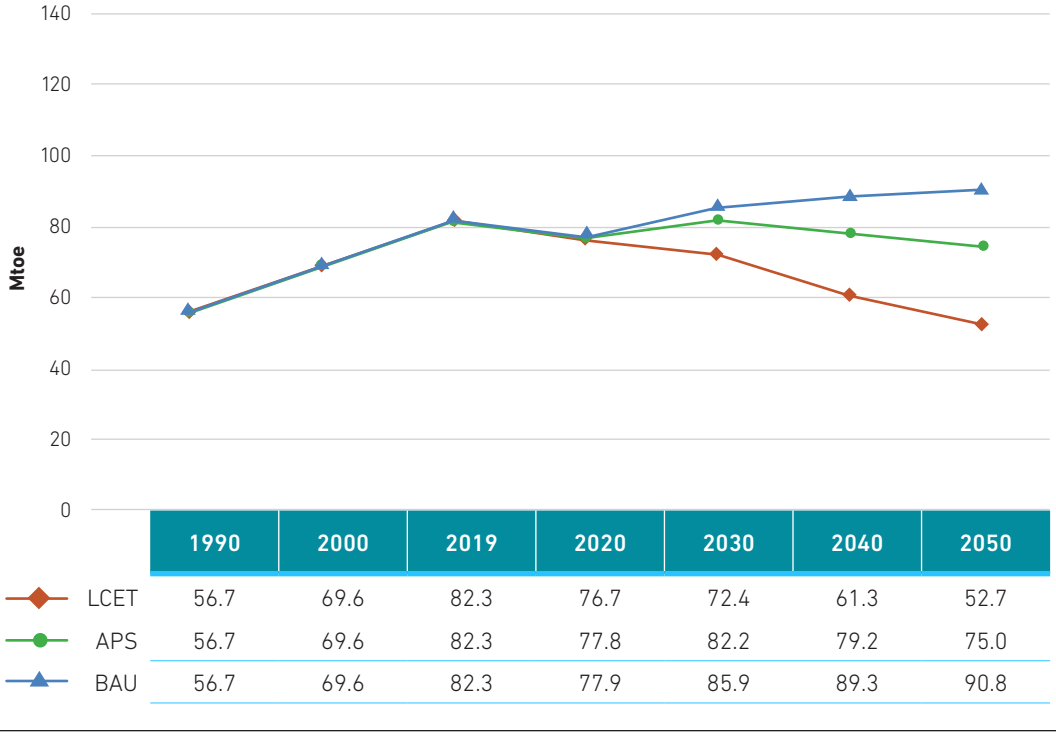
Figure 2.24 Australia – Final Energy Consumptions by Fuel Type, Low-Carbon Energy Transition (1990–2050)



Mtoe = million tonnes of oil equivalent.

Source: Authors.

Figure 2.25 Australia – Final Energy Consumptions, Low-Carbon Energy Transition, Alternative Policy Scenario, and Business as Usual (1990–2050)



	1990	2000	2019	2020	2030	2040	2050
LCET	56.7	69.6	82.3	76.7	72.4	61.3	52.7
APS	56.7	69.6	82.3	77.8	82.2	79.2	75.0
BAU	56.7	69.6	82.3	77.9	85.9	89.3	90.8

APS = alternative policy scenario, BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

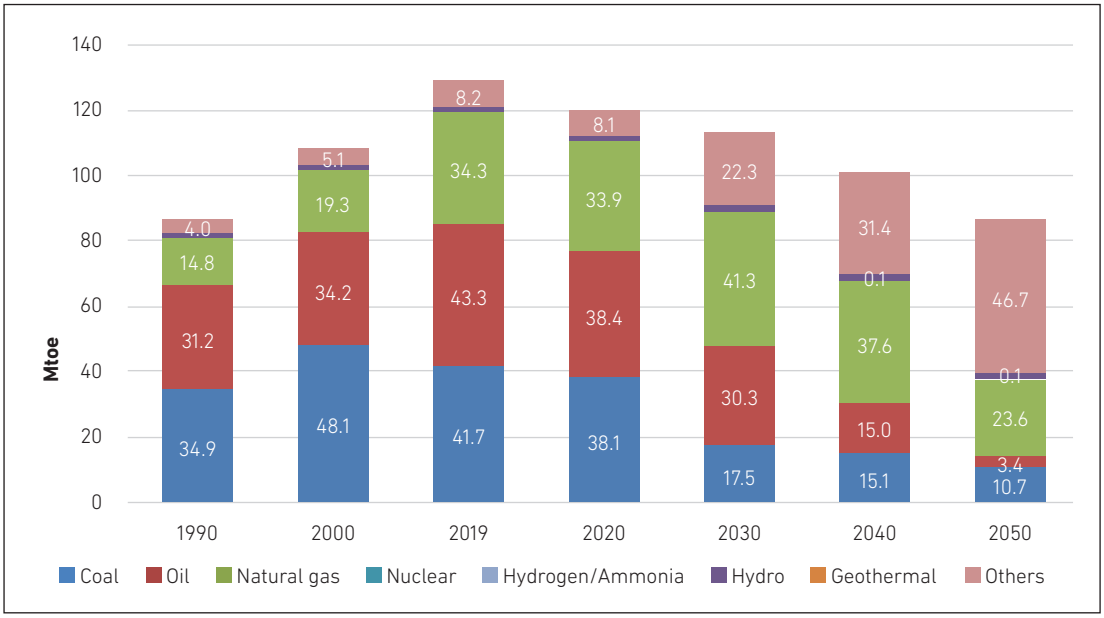
Source: Authors.

3.3.2. Primary Energy Supply

Total primary energy consumption is projected to decrease from 128.7 Mtoe in 2019 to 86.3 Mtoe in 2050, with an equivalent average rate of 1.3% per year. During the period, coal consumption will decline sharply at 4.3% per year and oil consumption at 7.9% per year. Use of natural gas will peak at 41.3 Mtoe in 2030 before declining to 23.6 Mtoe in 2050.

The share of fossil fuels in the primary energy mix will drop from 92.6% in 2019 to 43.6% in 2050. Hydropower's share will remain relatively flat with modest growth of 1.1% per year. In contrast, consumption of non-hydro renewables ('others') is projected to grow rapidly at 5.8% per year during the outlook period, supported by the growth of solar and wind energy (7.1%) and biomass (4.6%) (Figure 2.26 and Figure 2.27).

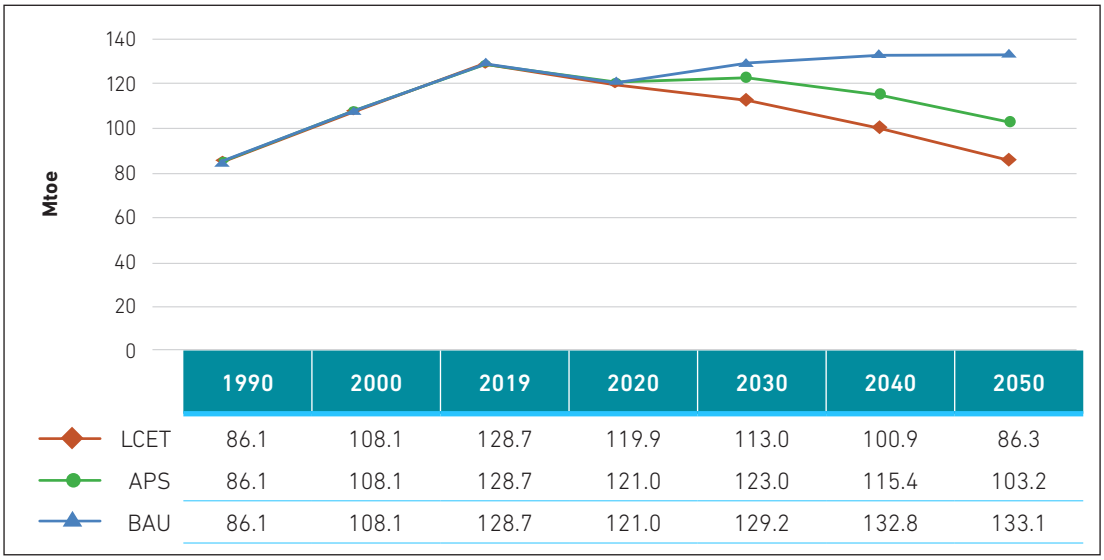
Figure 2.26 Australia – Primary Energy Supply by Fuel Type, Low-Carbon Energy Transition (1990–2050)



Mtoe = million tonnes of oil equivalent.

Source: Authors.

Figure 2.27 Australia – Primary Energy Consumptions, Low-Carbon Energy Transition, Alternative Policy Scenario, and Business as Usual (1990–2050)



	1990	2000	2019	2020	2030	2040	2050
LCET	86.1	108.1	128.7	119.9	113.0	100.9	86.3
APS	86.1	108.1	128.7	121.0	123.0	115.4	103.2
BAU	86.1	108.1	128.7	121.0	129.2	132.8	133.1

APS = alternative policy scenario, BAU = business as usual, LCET = low-carbon energy transition,

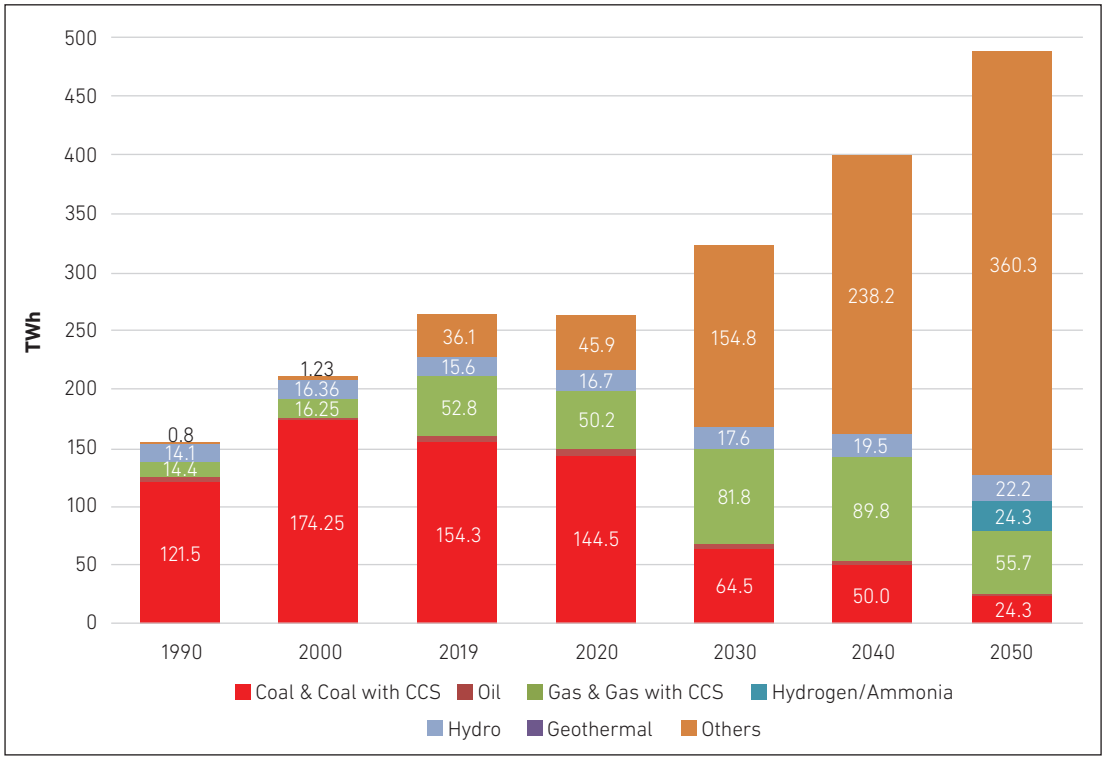
Mtoe = million tonnes of oil equivalent.

Source: Authors.

3.3.3. Power Generation

Electricity generation will grow from 263.7 TWh in 2019 to 487.0 TWh in 2050 at an equivalent average rate of 2.0% per year. The share of fossil fuels in the power generation mix will fall sharply from 80.4% in 2019 to 16.4% in 2050, of which 11.4% will be gas power plants with CCS and 5.0% coal power plants with CCS. All inefficient coal, gas, and oil power plants will be closed by 2040. In 2050, about 83.6% of power generation will come from zero-carbon sources. Green hydrogen and ammonia will take up 5.0% in 2050; solar energy, 31.2%; wind energy, 16.0%; hydropower, 4.5%; and other renewables, 26.8% (Figure 2.28 and Figure 2.29).

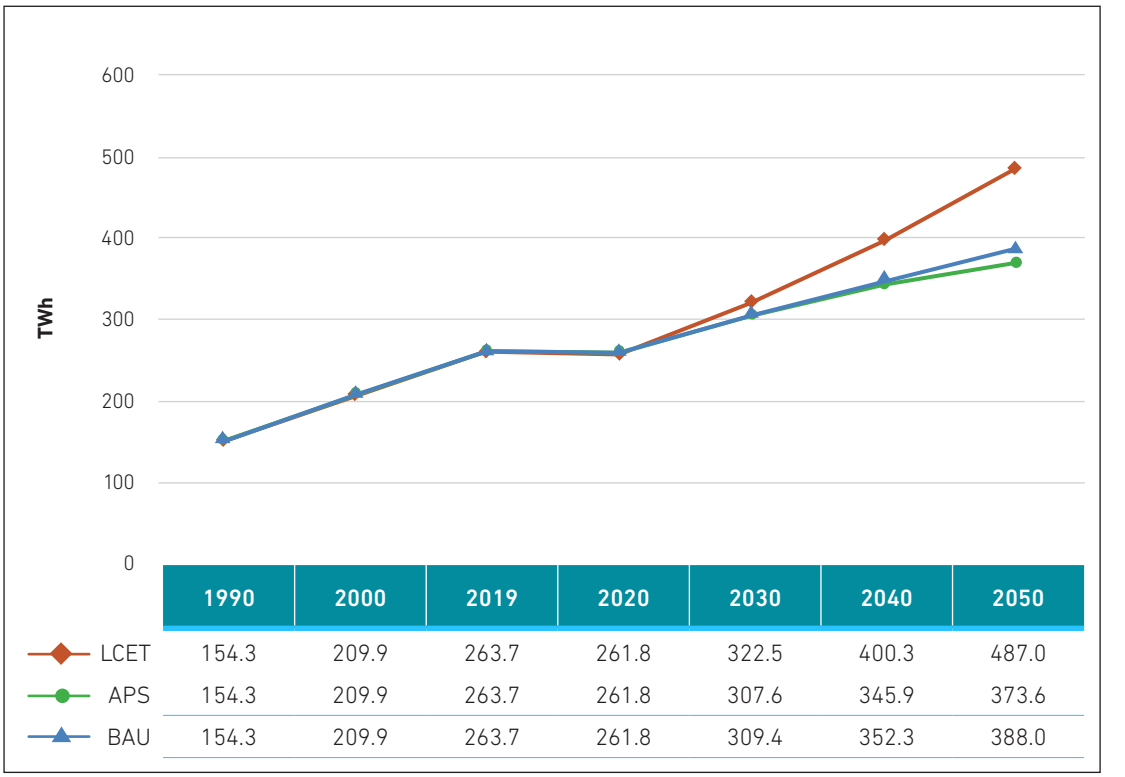
Figure 2.28 Australia – Electricity Generation by Fuel Type, Low-Carbon Energy Transition (1990–2050)



CCS = carbon capture and storage, TWh = terawatt hour.

Source: Authors.

Figure 2.29 Australia – Electricity Generation, Low-Carbon Energy Transition, Alternative Policy Scenario, and Business as Usual (1990–2050)



	1990	2000	2019	2020	2030	2040	2050
LCET	154.3	209.9	263.7	261.8	322.5	400.3	487.0
APS	154.3	209.9	263.7	261.8	307.6	345.9	373.6
BAU	154.3	209.9	263.7	261.8	309.4	352.3	388.0

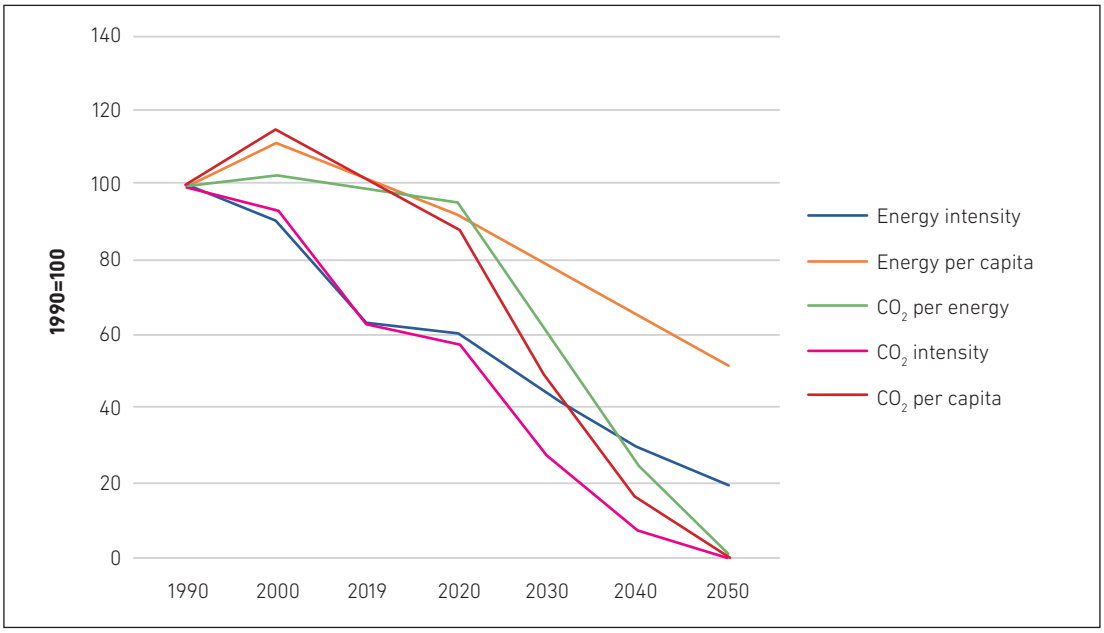
APS = alternative policy scenario, BAU = business as usual, LCET = low-carbon energy transition, TWh = terawatt hour.

Source: Authors.

3.3.4. Energy Indicators

Primary energy intensity and final energy intensity are expected to improve by 68.6% (62.4% in APS and 51.5% in BAU) and 70.0% (57.3% in APS and 48.3% in BAU), respectively, in 2019–2050. LCET will achieve more energy efficiency across economic sectors than APS or BAU. Primary energy consumption per person will be 2.6 toe in 2050, 16.4% lower than in APS and 35.1% lower than in BAU. GHG emissions per person will be nearly zero (0.03 t-C) in 2050, almost 98.9% lower than in BAU, whilst CO_2 emission per unit of primary energy consumption in 2050 will be 98.3% lower under LCET than in BAU (Figure 2.30).

Figure 2.30 Australia – Indices of Energy Indicators, Low-Carbon Energy Transition (1990 = 100)



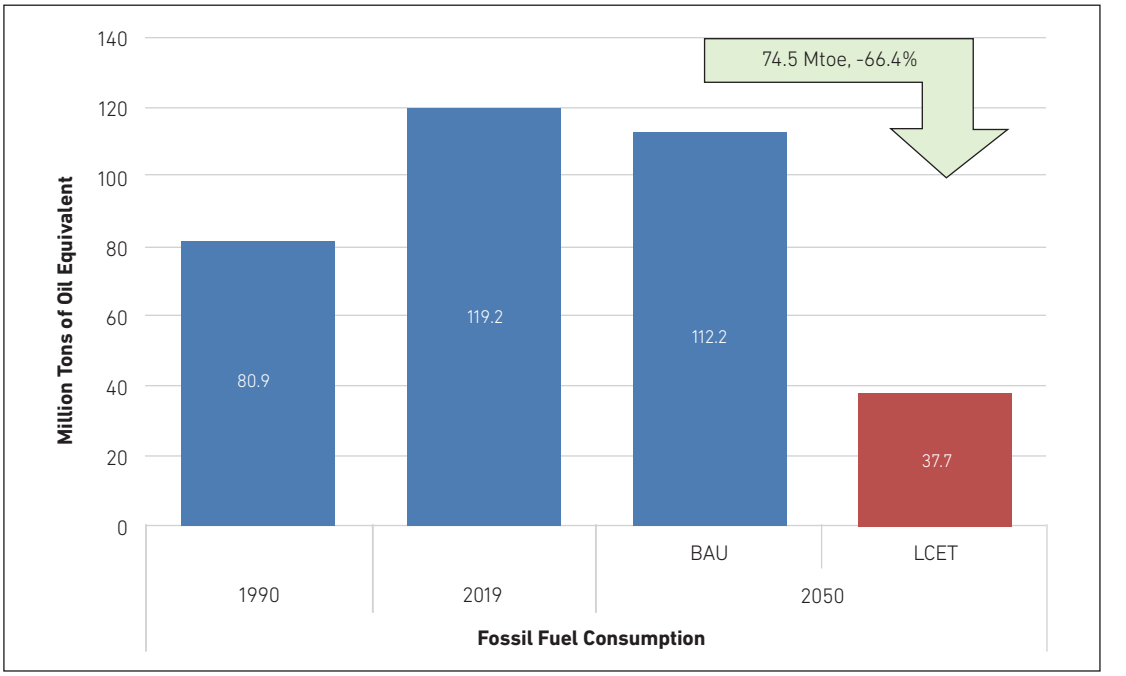
Source: Authors.

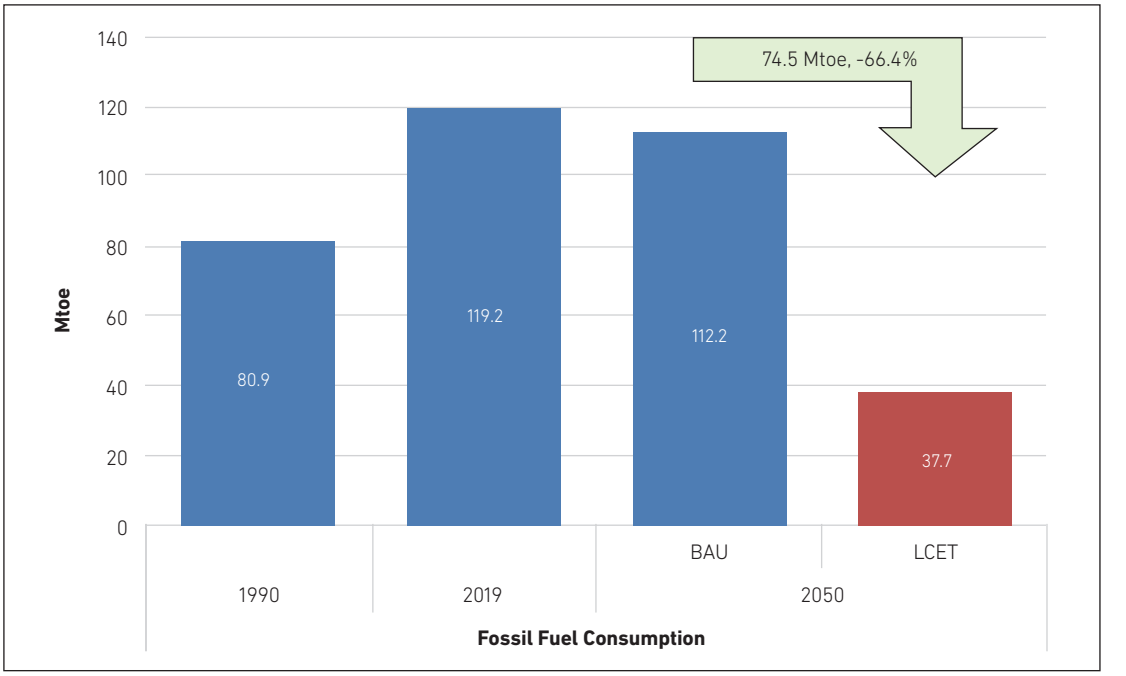
3.3.5. Saving of Fossil Fuel Consumption and CO_2 Reduction

Energy efficiency is projected to improve across economic sectors earlier and faster than in APS. Because of the greater penetration of renewables in the primary energy mix, the share of fossil fuels will fall from 92.6% in 2019 to 43.6% in 2050. Electrification of transport and adoption of electric vehicles will be faster in LCET than in APS. CCS will be implemented in coal and natural gas power plants and boilers in industry. Green hydrogen and ammonia will make up 5% of the generation mix by 2050. The share of renewables in the power generation mix will increase from 19.6% in 2019 to 83.6% by 2050. As a result, demand for fossil fuels will decline sharply at an average rate of 3.6% per year compared with a decline of 1.6% per year in APS and 0.2% per year in BAU.

Saving of fossil fuel consumption is projected at 74.5 Mtoe or 66.4% more than in BAU (Figure 2.31 and Figure 2.32).

Figure 2.31 Australia – Saving of Fossil Fuel Consumption in 2050, Low-Carbon Energy Transition

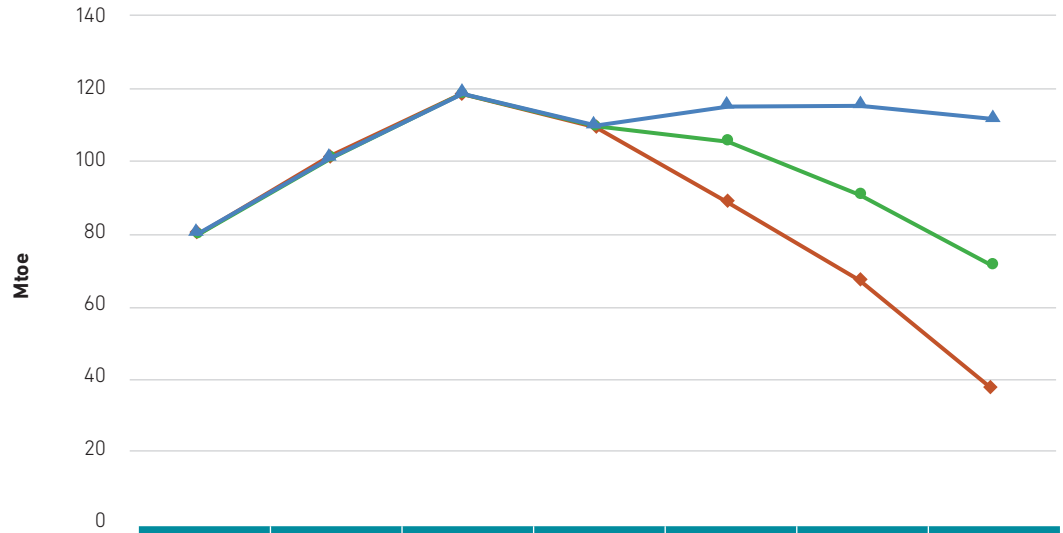




BAU = business as usual, LCET = low-carbon energy transition, million tonnes of oil equivalent.

Source: Authors.

Figure 2.32 Australia – Fossil Fuel Consumptions, Low-Carbon Energy Transition, Alternative Policy Scenario, and Business as Usual (1990–2050)



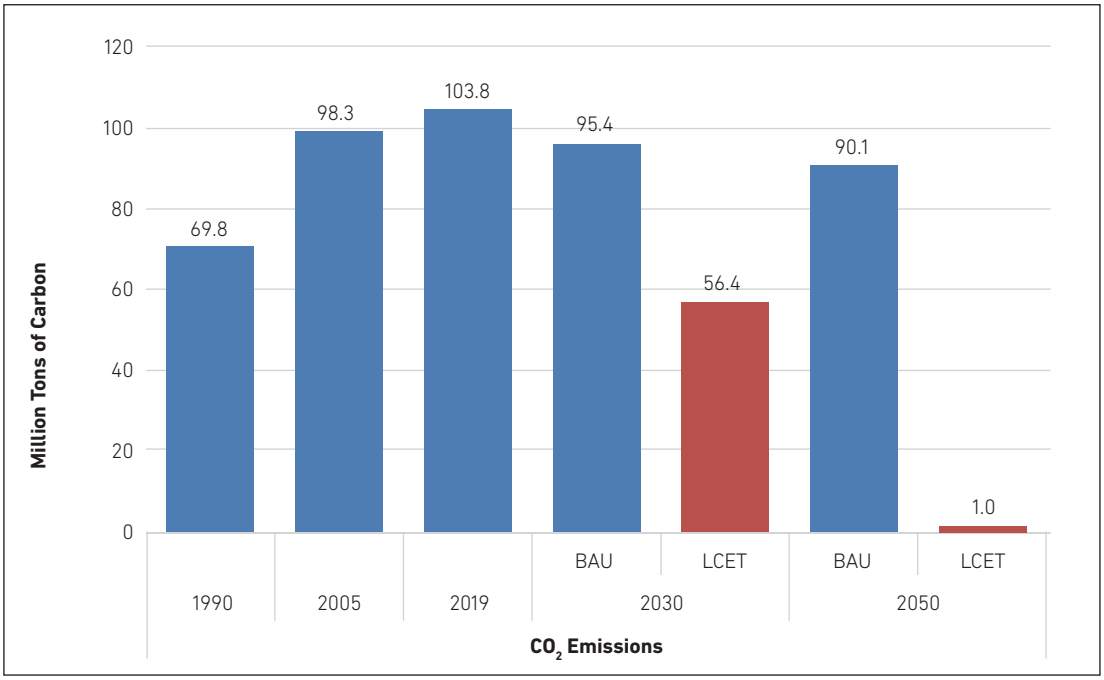
	1990	2000	2019	2020	2030	2040	2050
LCET	80.9	101.6	119.2	110.4	89.1	67.8	37.7
APS	80.9	101.6	119.2	110.4	106.3	91.4	71.8
BAU	80.9	101.6	119.2	110.4	115.5	115.7	112.2

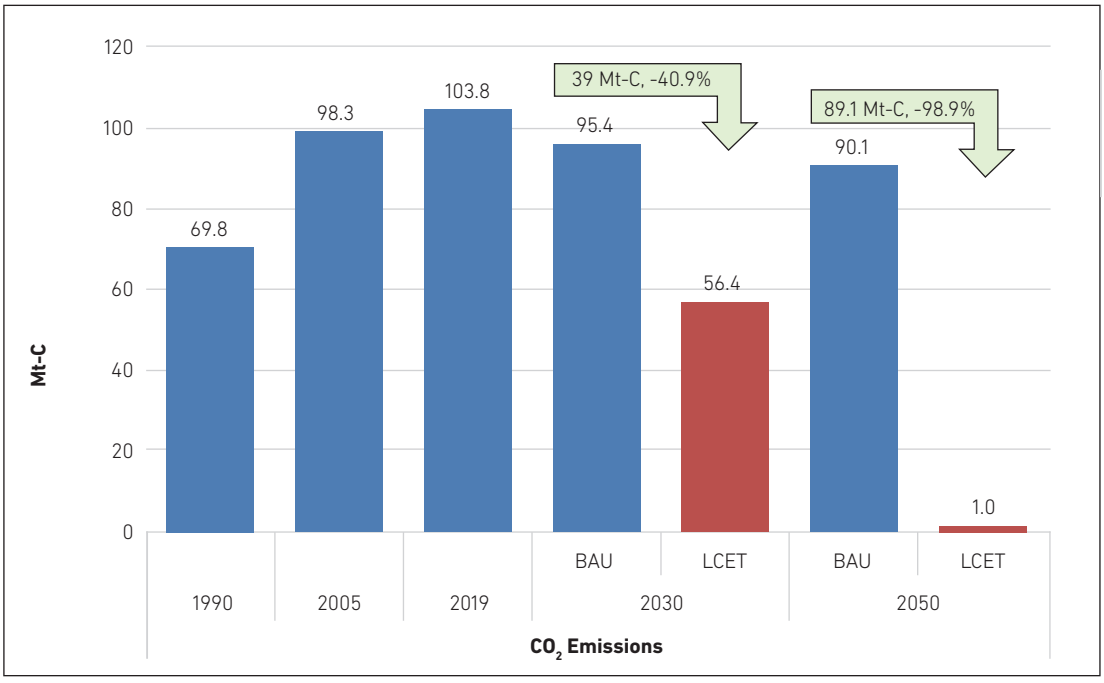
APS = alternative policy scenario, BAU = business as usual, LCET = low-carbon energy transition, Mtoe = million tonnes of oil equivalent.

Source: Authors.

Less fossil fuel use has a direct impact on CO_2 emission reduction. LCET was developed to analyse the decarbonisation pathway of energy in Australia. CO_2 emission reduction is projected at 39.0 Mt-C in 2030 and 89.1 Mt-C in 2050 compared with BAU. In contrast, the APS results show relatively lower CO_2 reduction for the same period (11.6 Mt-C in 2030 and 39.7 Mt-C in 2050) (Figure 2.33, Figure 2.34, and Figure 2.35).

Figure 2.33 Australia – CO_2 Reduction in 2030 and 2050, Low-Carbon Energy Transition

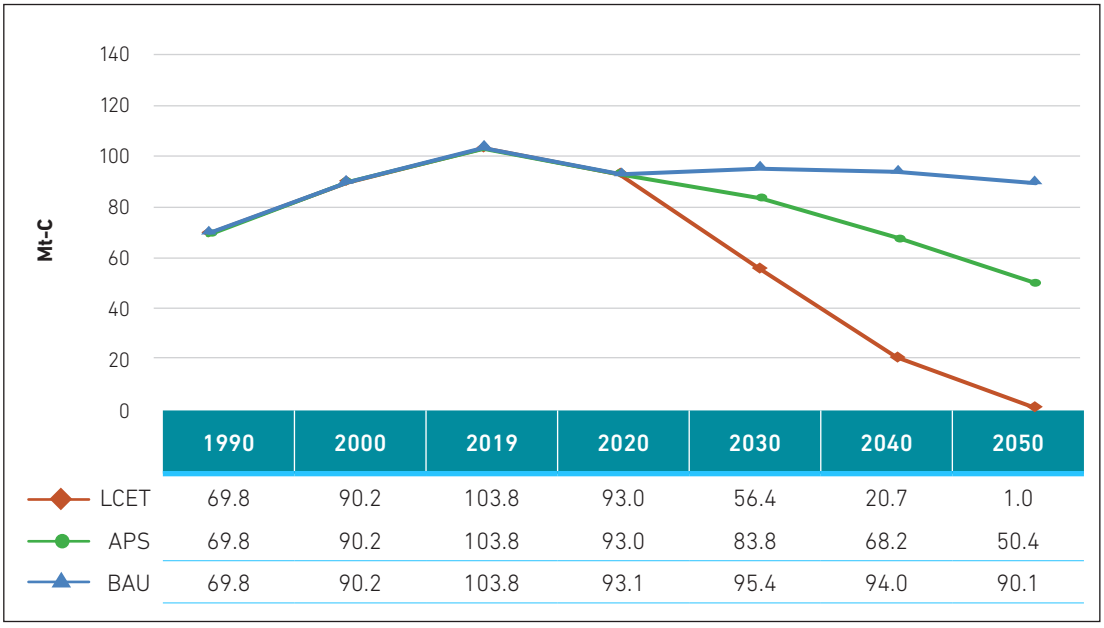




BAU = business as usual, LCET = low-carbon energy transition, Mt-C = million tonnes of carbon.

Source: Authors.

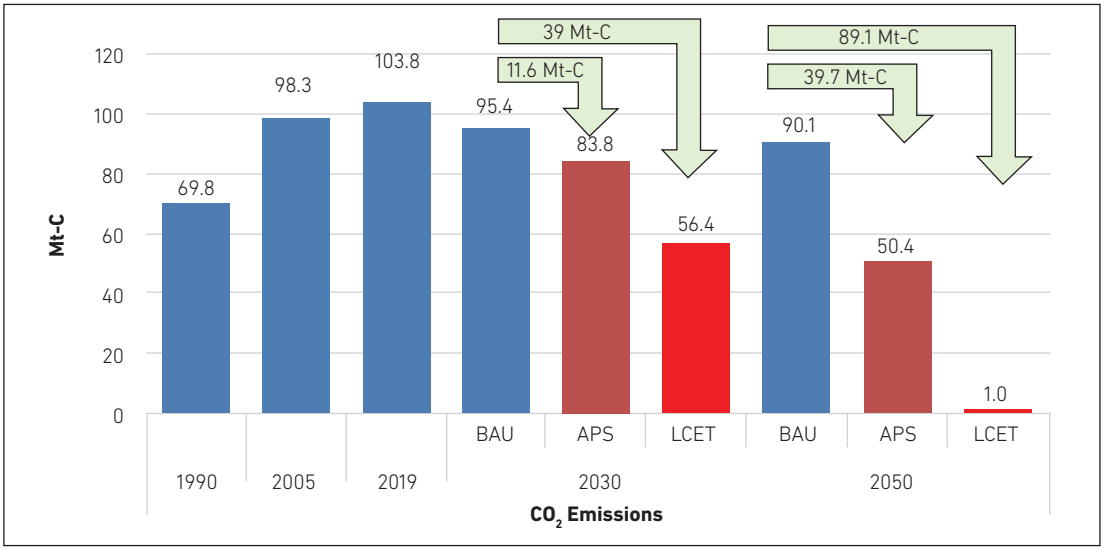
Figure 2.34 Australia – CO_2 Emissions, Low-Carbon Energy Transition, Alternative Policy Scenario, and Business as Usual (1990–2050)



	1990	2000	2019	2020	2030	2040	2050
LCET	69.8	90.2	103.8	93.0	56.4	20.7	1.0
APS	69.8	90.2	103.8	93.0	83.8	68.2	50.4
BAU	69.8	90.2	103.8	93.1	95.4	94.0	90.1

APS = alternative policy scenario, BAU = business as usual, LCET = low-carbon energy transition, Mt-C = million tonnes of carbon.
Source: Authors.

Figure 2.35 Australia – CO_2 Reduction in 2030 and 2050, Alternative Policy Scenario and Low-Carbon Energy Transition



APS = alternative policy scenario, BAU = business as usual, LCET = low-carbon energy transition, Mt-C = million tonnes of carbon.
Source: Authors.

4. Implications and Recommendations

In APS, the dominance of fossil fuels in the primary energy mix will drop from 92.6% in 2019 to 69.6% in 2050. Coal and oil consumption will decline sharply over the outlook period. Natural gas demand will peak in 2040 before sharply declining to the 2019 level in 2050. In LCET, a large drop in the share of fossil fuels in the primary energy mix will be seen in 2050. The share of non-hydro renewables in the primary energy mix will increase from 6.3% in 2019 to 54.1% in 2050, supported by a sharp increase in wind, solar, and biomass energy in LCET.

The share of renewables in power generation will increase from 19.6% in 2019 to 83.6% in 2050 whilst the share of renewables in power generation will increase to 74.8% in 2050 in APS. Solar and wind energy penetration in the power system is faster in LCET. Implementation of CCS in coal and gas power plants starting from 2030 and application of hydrogen and ammonia in power generation by 2050 will be seen in LCET. APS does not anticipate notable application of hydrogen, ammonia, and CCS in power generation during the outlook period.

Energy consumption in transport will decline in LCET and APS, but will be much faster in LCET. Energy consumption in the residential and service sectors will decline earlier and faster in LCET than in APS, and energy efficiency will improve across economic sectors earlier and faster than in APS. In LCET, 66.4% savings of fossil fuel consumption will be achieved, and in APS, 36.0% savings will be achieved compared with BAU in 2050.

The study shows that energy-saving options are effective in reducing CO_2 emissions. In 2050, CO_2 emissions are 98.9% lower in LCET and 44.1% lower in APS than in BAU.

Australia will achieve its intended nationally determined contribution target of emission reduction in LCET but not in APS. CO_2 emissions in 2030 are 42.7% lower than the 2005 level in LCET but 14.8% lower than the 2005 level in APS. In 2050, emissions are 99.0% lower than the 2005 level in LCET but 48.8% lower than the 2005 level in APS.

The LCET results suggest that decarbonisation of the power generation system requires earlier and faster closure of inefficient fossil fuel power plants. Australia needs to implement CCS technology in existing efficient coal and gas power plants. It requires greater attention to replacing ageing electricity infrastructure and storage technologies to achieve faster growth of non-hydro renewable technologies. Using green hydrogen and ammonia fuel in power plants is critical to decarbonise the power generation system.

Low-carbon technologies must be adopted earlier and faster to decarbonise the transport, industry, residential, and service sectors. Faster electrification is critical for transport and heavy industry.

Energy efficiency improvement is about 50% faster in LCET than in APS. Improved and efficient end-use technologies must be adopted to reduce final energy consumption in end-use sectors. Transport has more opportunities for energy saving. Energy saving in industry comes from improved efficiency in large energy-intensive industries.

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