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Australian Retail Energy Prices in an International Context

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Authors:
Geoff Bongers PhD
Joshua Humphreys
Nathan Bongers

Gamma Energy Technology Pty Ltd

Introduction:
David Hughes

The Menzies Research Centre Limited

RG Menzies House
Cnr Blackall and Macquarie Streets
BARTON ACT 2600
PO Box 6091
KINGSTON ACT 2604

Executive Director: David Hughes

Phone: 02 6273 5608

Email: info@menziesrc.org

Designed by: Branded Graphics

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Executive Summary

With all the talk of Australia becoming a "renewable energy superpower", many would be surprised to learn how much we still rely on fossil fuels. Fossil fuels in aggregate (brown and black coal, and gas) remain the dominant source of electricity – except Tasmania which is dominantly hydropower.

Yet our energy markets are changing, and these adjustments have coincided with Australians paying more than the average across the developed world for electricity. Rising electricity prices hurt families, increase the costs of production and fuel inflation.

While policy settings and external factors differ across nations, one thing is clear – affordable and reliable power is the foundation of any successful economy and society. Our future prosperity depends on it.

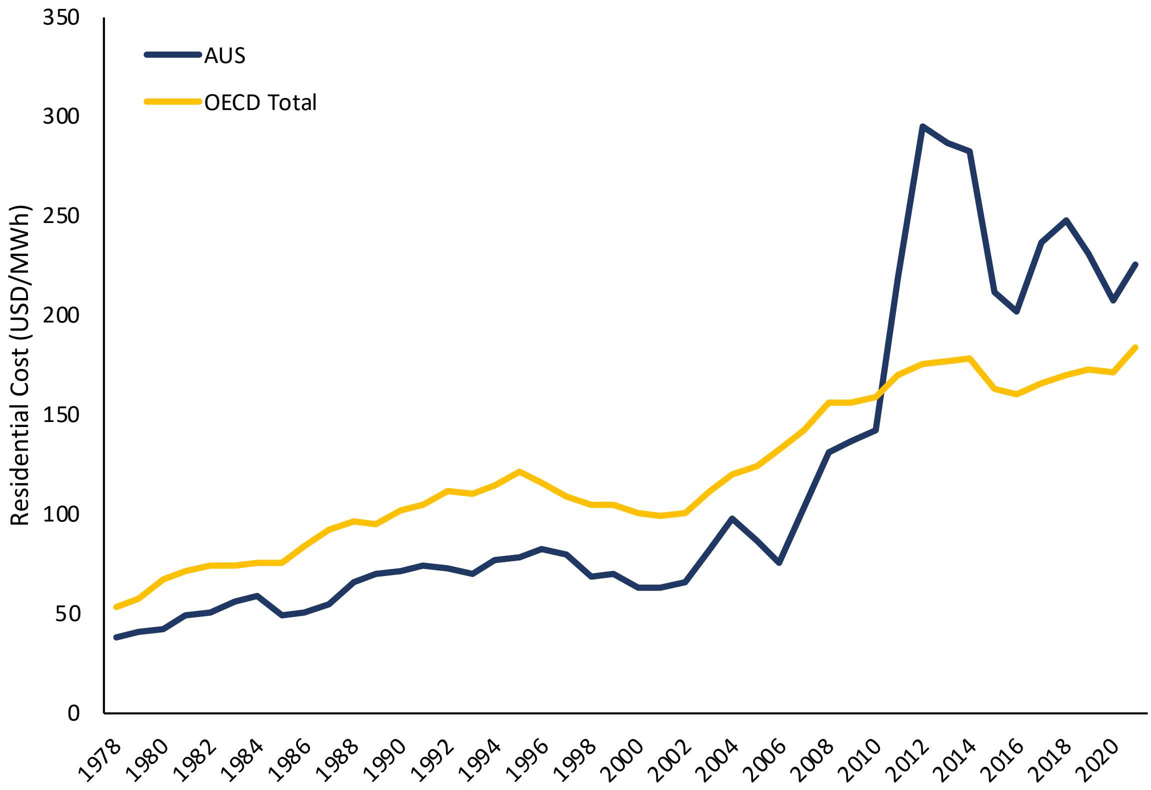
Australians are always eager to know how we compare to other countries. This report provides some comparisons that Australians will find confronting. The analysis demonstrates the distinct differences in generation technologies across Australia and selected competitor countries. Most importantly we investigate how our household energy prices stack up.

To provide an up to date and accurate analysis, the Menzies Research Centre commissioned experts at Gamma Energy Technology to analyse an immense collection of data from the International Energy Agency, which provides the most reliable central source for household electricity prices.

Our analysis found:

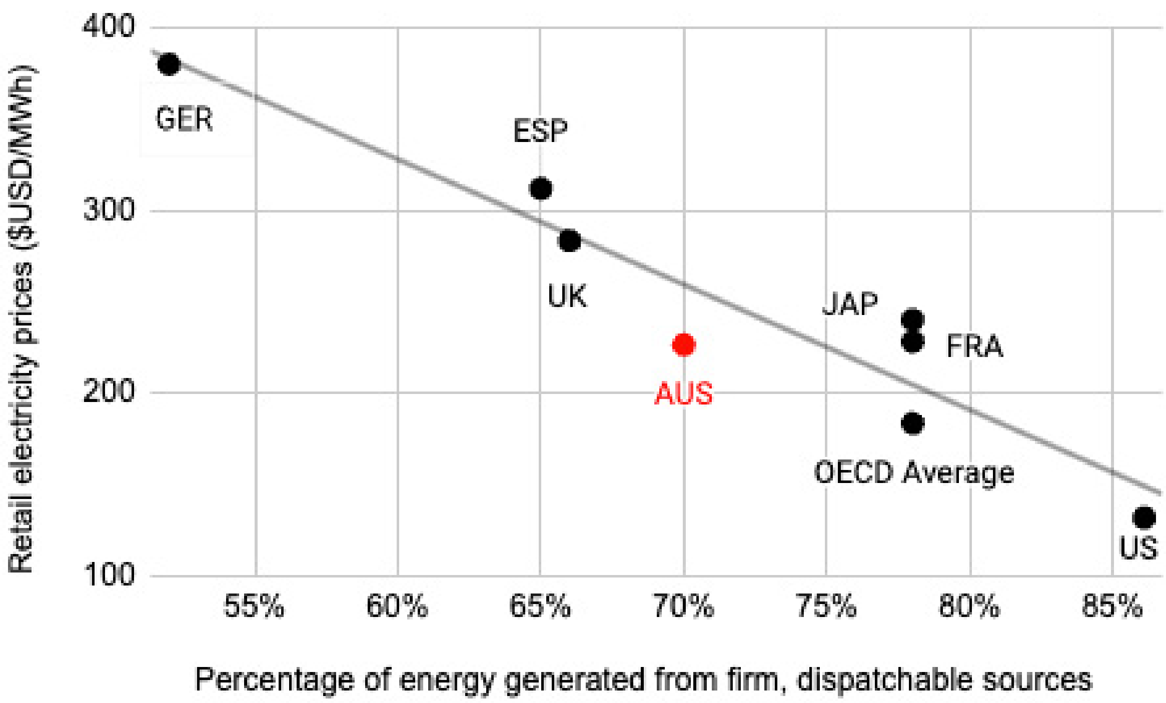
- From 1978 to 2010, household electricity prices in Australia were consistently lower than the average across developed economies (OECD average).
- Australia experienced a pivotal change around 2007 where residential electricity prices climbed sharply, never to recover. In the early 2000s, Australian households were paying the equivalent of less than $100USD/MWh for electricity. In the space of a few years it jumped to almost $300USD/MWh while the OECD average remained less than $200USD/MWh.
- With the exception of Queensland, Australia has an aging coal fleet which is progressively being decommissioned, a natural gas generation capacity which is remaining relatively constant in recent times and a substantial increase in both wind and solar, changing the generation landscape. The substantial decrease in firm, dispatchable capacity since the early 2000s has not been complemented by "grid-scale" intermittent wind and solar and has compromised available generation reserves.
- This sharp decline in reserve generation capacity has led to the increased prices experienced in Australia as this report demonstrates.
- Australia has had the greatest increase in the cost of residential electricity of the countries studied with a 32% increase from 2010 to 2020.
- Australia has a less diverse mix of technologies than most countries studied. In terms of generation mix, the most notable difference between Australia and the OECD countries studied was the absence of nuclear power.

OECD VERSUS AUSTRALIA: A COMPARISON OF ELECTRICITY PRICES



This report shows that systems with a larger portion of stable baseload power in their overall electricity mix tend to deliver cheaper power than those that are more heavily reliant on intermittent and peaking power.

IMPACT OF INTERMITTENT GENERATION ON ELECTRICITY PRICES



Historically, Australia had abundant reserves of baseload power in the system. We found that the decline in these reserves of baseload power has correlated with a sharp increase in the prices paid by households. In contrast, the US system examined in this report shows that a substantial proportion of baseload generation capacity has delivered stable and cheap electricity from the 1970s all the way through to today.

DAVID HUGHES
Executive Director
Menzies Research Centre
May 2024

Introduction

This report collates the household price of electricity for a range of countries to examine the impact of energy generation changes over the years on the price paid by consumers. The data for each individual country is recorded in US dollars for easier comparison between countries and the Organisation for Economic Co-operation and Development (OECD). The prices for individual country households are compared with the OECD end user prices [1].

All data collected from the International Energy Association (IEA) is presented as is, unless stated otherwise. All the assumptions for the data collection and methodology are based on the IEA's methodology [2].

To produce the most effective and useful national energy policies, utilising input data that is consistent and accurate is essential. The IEA provides the most comprehensive selection of this data from over 90% of the world's total energy production from over 140 different countries. Some gaps in the IEA data exist and are supplemented with other reputable sources and are cited where used.

Data Collection

Energy price and tax data are collected each quarter by the IEA from relevant official agencies in each target country, or from trusted secondary sources such as national banks and regulatory authorities. National sources include, but are not limited to, national energy ministries, central banks, ministries of economy, industry and finance, national competition authorities and national statistics agencies. Secondary sources include Eurostat and the European Commission for European countries, as well as country-specific sources detailed in the country notes [3].

Energy values for capacity and generation use a range of sources, varying by country. Both the IEA and the US Energy Information Administration (EIA) use data from the Department of Climate Change, Energy, the Environment and Water. The methodologies used by these organisations are covered in their annual reports and methodology registers [4, 5].

Case Studies

Australia

Key Points

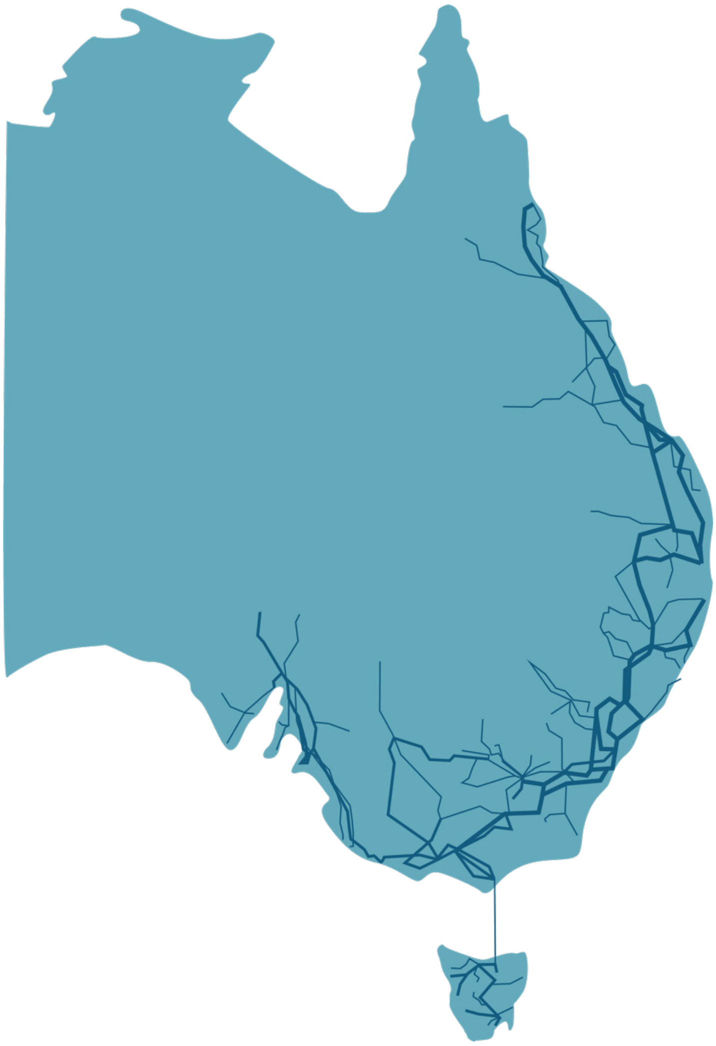
- Australia's two largest electricity grids are not connected. As islanded electricity systems they must be fully self-reliant and reliable.
- The overall capacity increased in both the National Electricity Market (NEM) and the South-West Interconnected System (SWIS) between 2010 to 2020. The NEM capacity is now at 65GW [6] and the SWIS at 6GW [7]. Both also saw retirements of fossil plants and a very large increase in both wind and solar capacity.
  - The NEM delivery of power is still dominated by black coal generation.
  - The NEM solar capacity (variable across daylight hours and impacted by cloud cover) when compared with our peers in the OECD represents a much larger portion of the grid.
  - Australia is the sole OECD country studied in this report which does not have nuclear power capacity.
- Since the 1970s generation has increased from approximately 50TWh to over 250TWh, however, since 2008 NEM generation has remained relatively constant.
- Fossil fuels in aggregate (brown and black coal, and gas) remain the dominant source of electricity (except Tasmania which is dominantly hydropower).
- Australia has had a 5% increase in generation from 2010 to 2020, the only OECD country studied to have had an increase. The total OECD showed a 1% decrease, with the UK having an 18% decrease in generation.
- Since around 2010, Australia has had a higher than average cost of residential electricity than its peers in the OECD.
- Australia had the largest increase in cost of residential electricity of the countries studied, with a 32% increase from 2010 to 2020.

Australian Grid Background

The NEM stands as one of the world's longest interconnected electricity systems, spanning across Queensland, New South Wales and Victoria linking separately to South Australia and Tasmania via undersea cables (Figure 1). It is the most complex single integrated capital infrastructure in the Southern Hemisphere.

The NEM began in 1998, integrating North Queensland with South Australia, connecting Victoria and NSW in between. Tasmania was added to the NEM in 2005 via a 370 km Basslink direct current undersea cable [8].

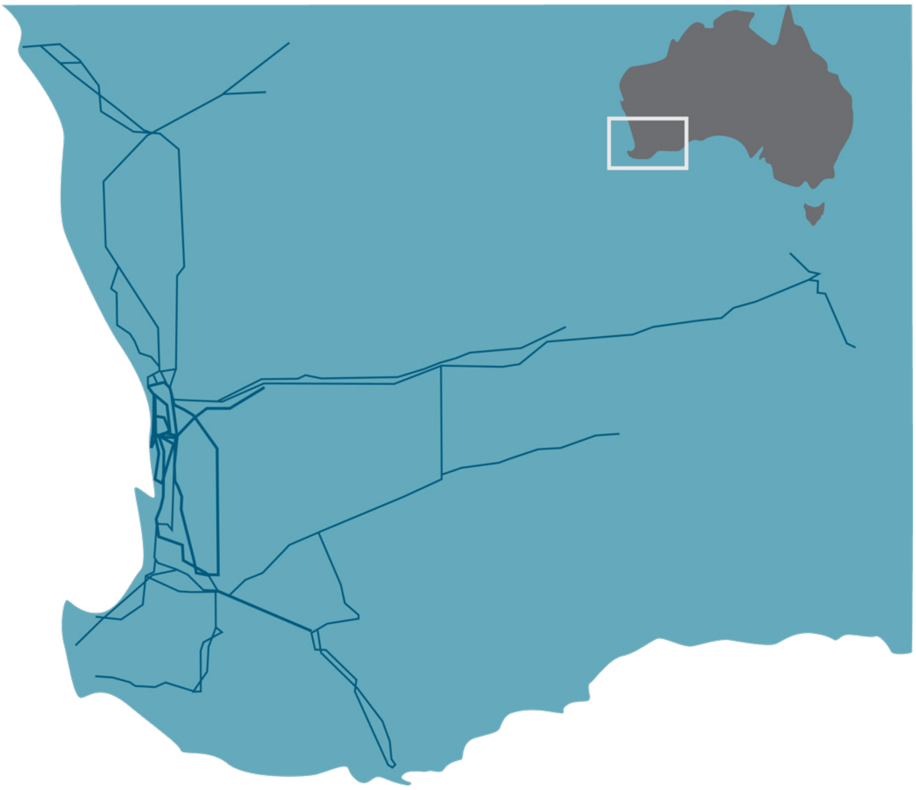
FIGURE 1 THE AUSTRALIAN EAST COAST ELECTRICITY GRID (NEM)



In terms of energy composition, the NEM relies on a diverse range of sources to meet its electricity demands. As of the most recent data available, approximately 64% of its energy generation is derived from coal, emphasising its role as a stable energy source [9]. Furthermore, renewables contribute significantly, accounting for 31% of the energy mix. However, the contribution from renewables can be less than 20% on account of weather conditions. Gas makes up the remaining 4%.

The SWIS is responsible for providing energy along Western Australia's coastal regions (refer to Figure 2). It operates under a capacity market model, focusing on maintaining a reliable power supply to meet the needs of its region.

FIGURE 2 THE WEST AUSTRALIAN SOUTH-WEST INTERCONNECTED SYSTEM (SWIS) ELECTRICITY GRID



In contrast to the NEM, the SWIS relies on a very different energy composition profile. As of September 2023 [7], the energy mix in the SWIS consists of 40% gas, 35% renewables, and 24% coal (though it is still 65% fossil fuel dependent). This generation mix reflects the unique energy landscape in Western Australia and its emphasis on gas as a primary energy source.

Australia's electricity grids, the NEM and the SWIS, play pivotal roles in supplying electricity to their respective regions. The NEM, with its extensive reach and diverse energy mix, operates on an energy-only market, while the SWIS focuses on capacity to ensure reliability along Western Australia's coast. Understanding the energy compositions and operational models of these grids is essential in comprehending Australia's intricate electricity infrastructure.

Australian Generation Capacity

The electricity generation capacity for the entire Australian grid network, including the NEM, SWIS and other minor networks (refer to Figure 3) shows a steady increase in renewable capacity throughout the years, thus increasing the overall capacity[1] significantly. A more recent decrease in fossil capacity has also contributed to a significant change in the overall mix of the generation portfolio.

1 It should be noted that the capacity factors of solar and wind plants are significantly less than the fossil fuel fleet.

FIGURE 3 AUSTRALIA TOTAL GENERATION CAPACITY (GW)

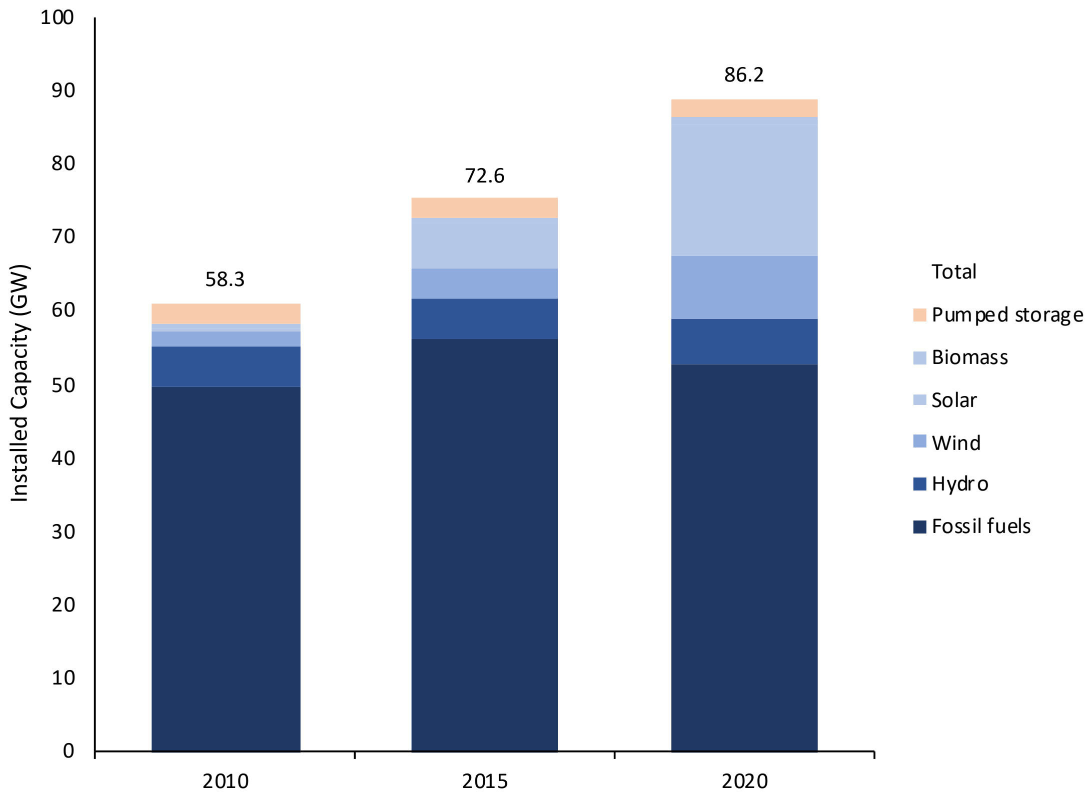


FIGURE 4 AUSTRALIA WIDE VERSUS NEM GENERATION CAPACITY (GW)

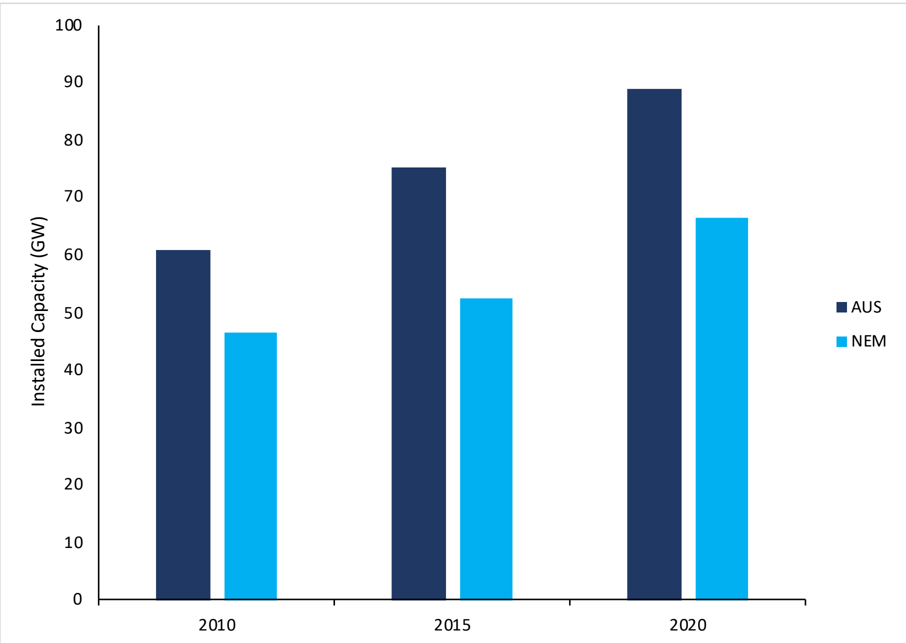
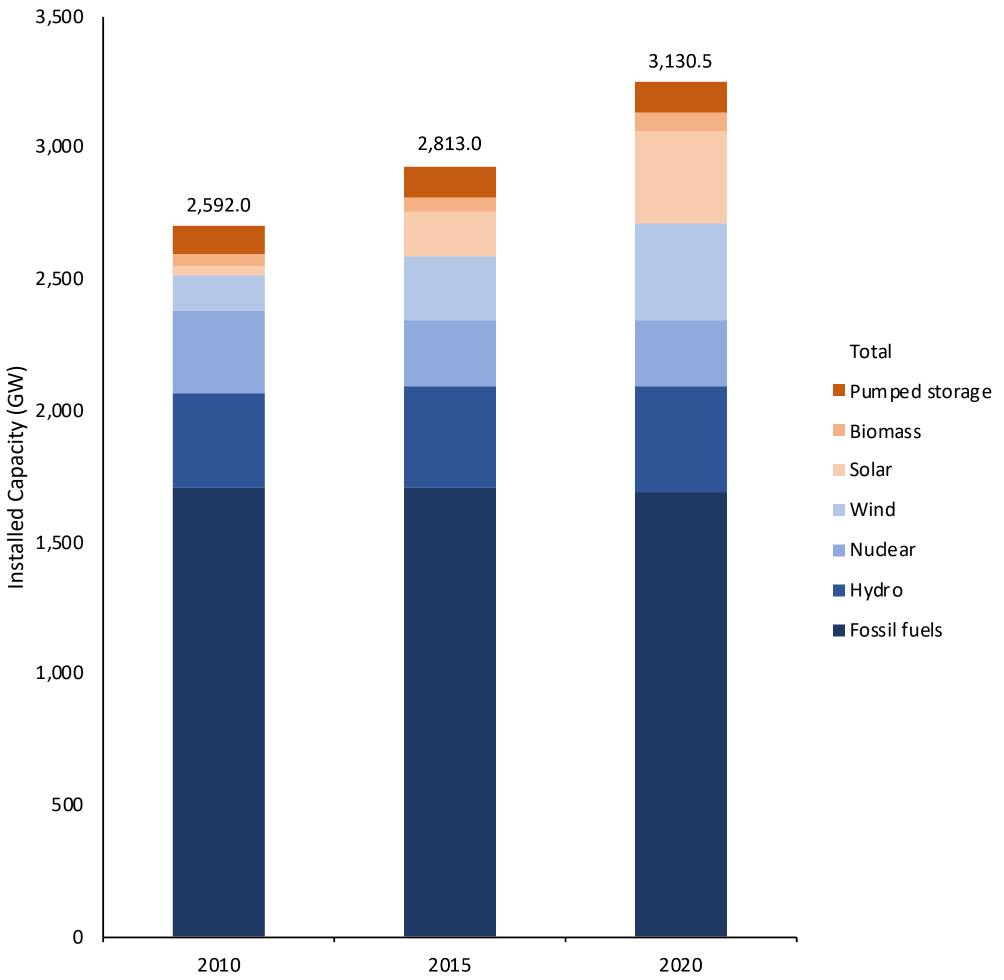


Figure 4 shows the difference between the 'all of Australia' installed generation capacity and the NEM. This figure utilises data from both the Australian Energy Market Commission (AEMC) for NEM and EIA for all of Australia [10, 11].

Australian Generation Capacity Compared with the OECD

Utilising EIA data [11], the generation capacity of the OECD by fuel types for the years 2010, 2015 and 2020 was examined (refer to Figure 5). This demonstrates that there has been little change since 2010 in fossil fuel capacity, a small decrease in nuclear capacity and a significant growth in both wind and solar capacity.

FIGURE 5 OECD TOTAL GENERATION CAPACITY BY FUEL SOURCE (GW)



The Australian capacities are compared with the OECD in both Figure 6 and Table 1. The table below shows the total generation capacity increased for both Australia and the OECD overall, but the trend in different technology capacity mix changes is best shown by percentage share in Figure 6 (with the data tabulated in Table 2).

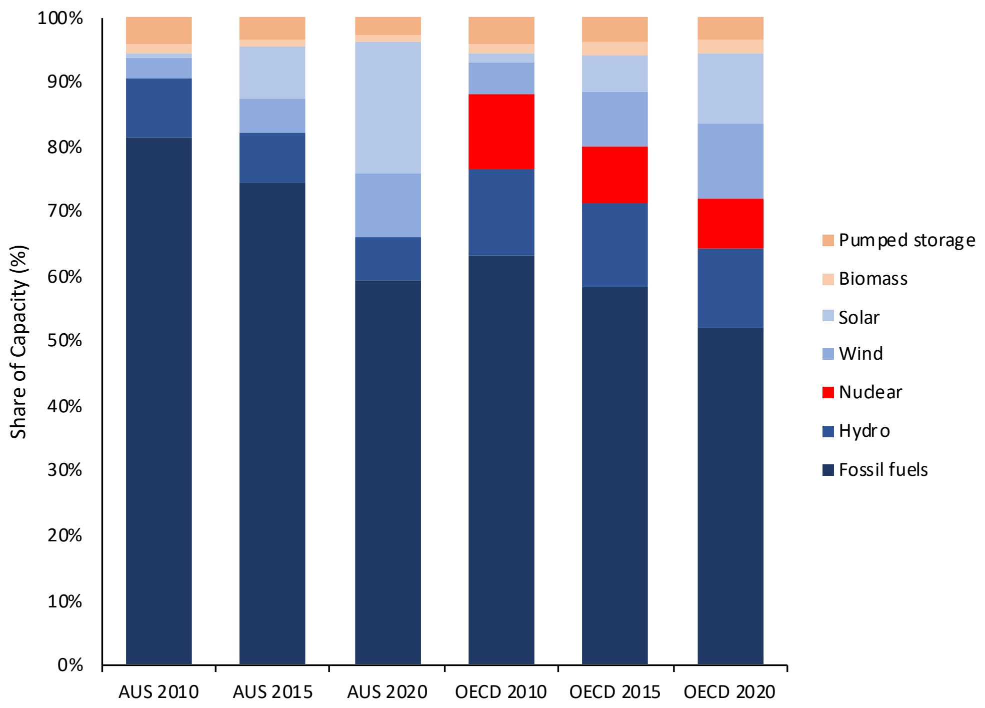
TABLE 1 ACTUAL GENERATION CAPACITY VALUES (GW) BY TECHNOLOGY FOR AUSTRALIA AND THE OECD

	AUS 2010	AUS 2015	AUS 2020	OECD 2010	OECD 2015	OECD 2020
Pumped storage	2.61	2.61	2.61	109.50	114.70	117.73
Biomass	0.83	0.83	0.88	44.11	58.68	69.56
Solar	0.40	5.95	17.99	36.72	168.03	351.59
Wind	1.86	4.18	8.60	134.12	239.42	366.36
Nuclear	0.00	0.00	0.00	311.56	256.95	255.63
Hydro	5.66	5.66	5.91	358.67	383.25	397.64
Fossil fuels	49.57	56.01	52.83	1706.81	1706.70	1689.76
Total	**57.10**	**65.86**	**67.34**	**2511.17**	**2586.32**	**2709.39**

TABLE 2 PERCENTAGE SHARE OF GENERATION CAPACITY BY TECHNOLOGY FOR AUSTRALIA AND THE OECD

	AUS 2010	AUS 2015	AUS 2020	OECD 2010	OECD 2015	OECD 2020
Pumped storage	4%	3%	3%	4%	4%	4%
Biomass	1%	1%	1%	2%	2%	2%
Solar	1%	8%	20%	1%	6%	11%
Wind	3%	6%	10%	5%	8%	11%
Nuclear	0%	0%	0%	12%	9%	8%
Hydro	9%	8%	7%	13%	13%	12%
Fossil fuels	81%	74%	59%	63%	58%	52%

FIGURE 6 AUSTRALIAN CAPACITY SHARE BY TECHNOLOGY TYPE VERSUS OECD (%)



Comparing only 2020 data, it is clear (Figure 7) that all countries studied have very diverse generation capacity portfolios. Table 3 tabulates the same data set, highlighting in bold the technology with the largest generation capacity.

FIGURE 7 SHARE OF INSTALLED GENERATION CAPACITIES FOR SELECTED COUNTRIES IN THE YEAR 2020 (%)

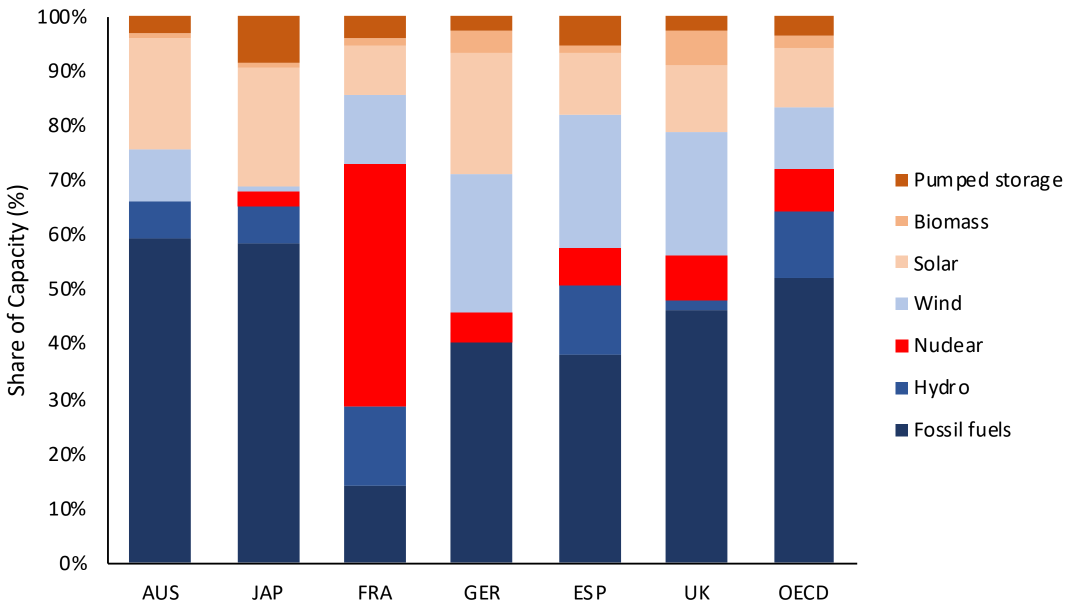


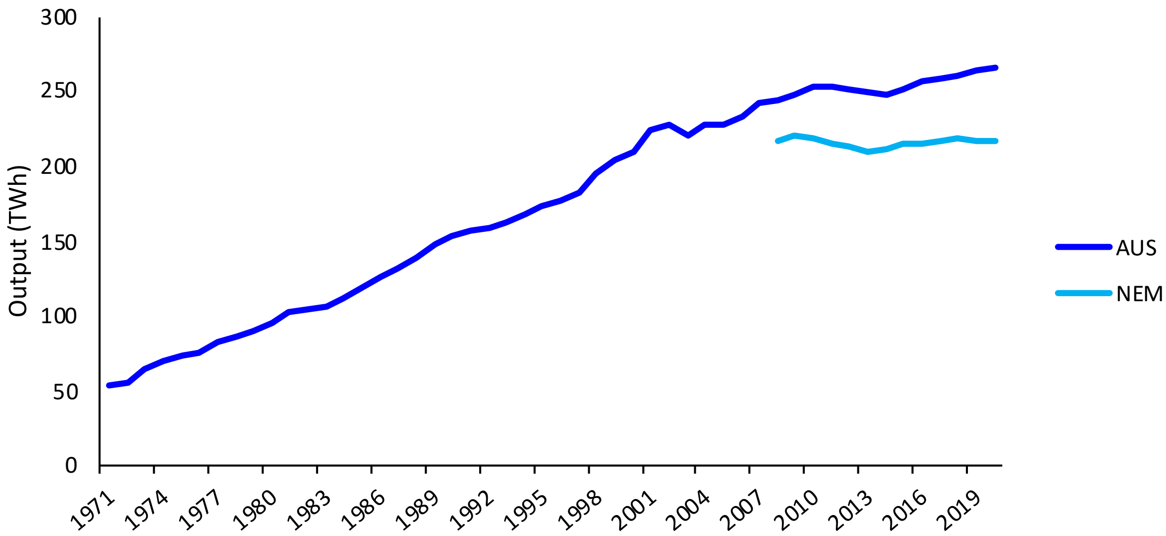
TABLE 3 PERCENTAGE SHARE OF INSTALLED GENERATION CAPACITY BY COUNTRIES FOR THE YEAR 2020

	AUS	JAP	FRA	GER	ESP	UK	OECD
Pumped storage	3%	**8%**	4%	3%	6%	3%	4%
Biomass	1%	1%	1%	4%	1%	**7%**	2%
Solar	20%	21%	9%	**22%**	11%	12%	11%
Wind	10%	1%	13%	**26%**	24%	22%	11%
Nuclear	0%	2%	**44%**	3%	6%	8%	8%
Hydro	7%	7%	**14%**	2%	13%	2%	12%
Fossil fuels	**59%**	58%	14%	40%	38%	46%	52%

Australian Electricity Generation

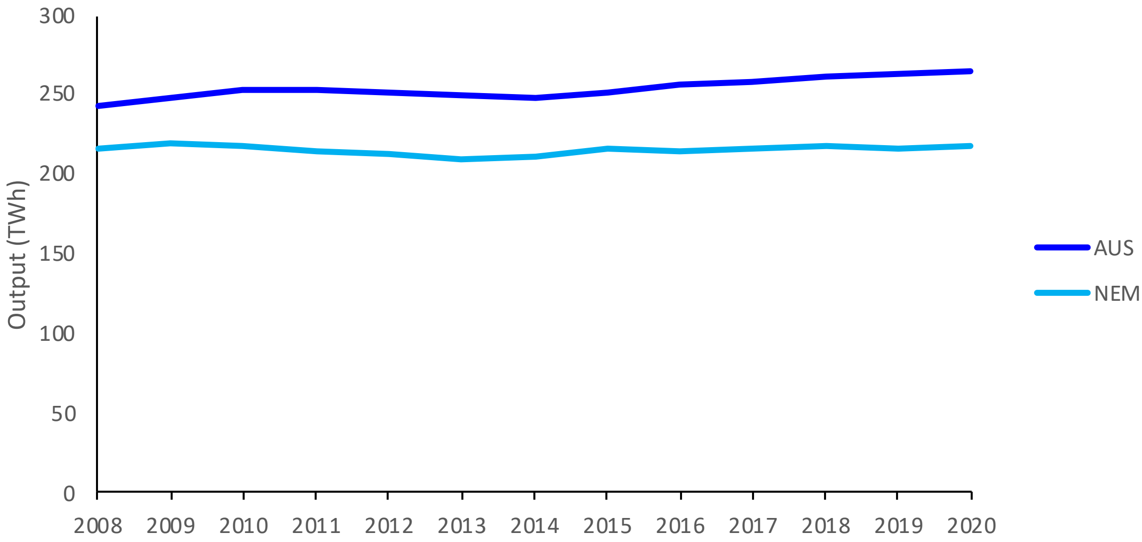
Australian electricity generation[2] has been steadily increasing over the last 50 years (refer to Figure 8) [12]. The East Coast grid (the NEM) has since its establishment in 1998 [13], been the largest portion of Australia's generation output. Its generation profile compared with the rest of Australia is highlighted in Figure 9. It can be seen in Figure 9 that the total generation within the NEM has remained relatively constant since its inception, with Australia's overall generation growing slightly.

FIGURE 8 AUSTRALIAN TOTAL ELECTRICITY GENERATION (TWH)



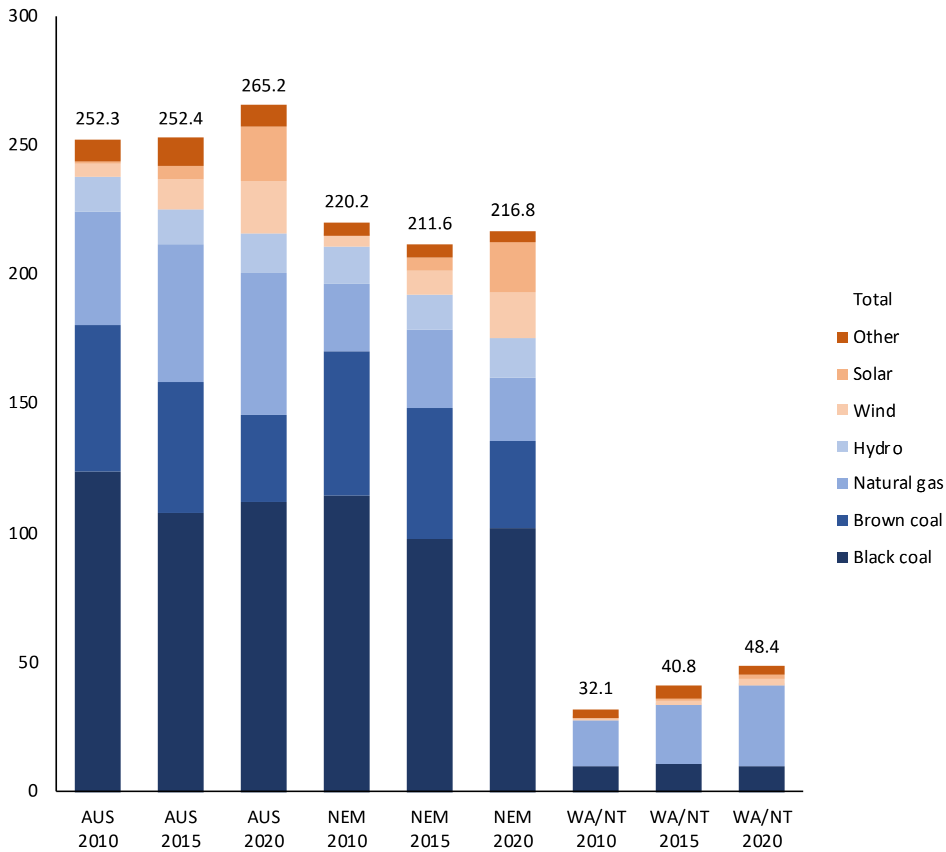
2 The Australian Government has generation data for Australia on a state-by-state basis. This data only goes back as far as 2008, whereas the overall generation for Australia using the IEA data goes back as far as 1971.

FIGURE 9 OVERALL AUSTRALIAN VS NEM GENERATION FROM 2008 TO 2021 (TWH)



The fuel types used to generate Australia's electricity (refer to Figure 10) differ between the various electricity grids. The NEM is dominated by black and brown coal generation and the SWIS by natural gas with some black coal support. The technology class 'other' in this work refers to all oil, bagasse/wood, biogas, geothermal and multifuel fired plants [4]. Solar includes large-scale and small-scale generation plants [5].

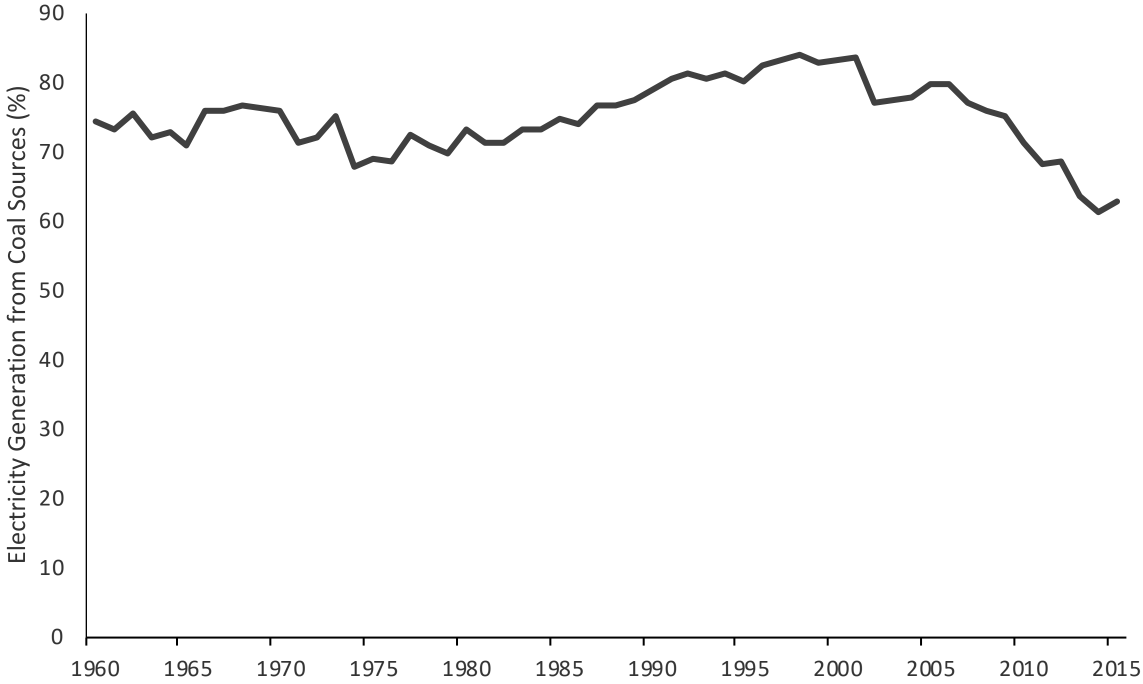
FIGURE 10 AUSTRALIA, NEM, WA/NT TOTAL GENERATION BY FUEL TYPE (TWH)



Coal's contribution to Australia's electricity mix from the 1960s to the late 1980s averaged around the 70% mark, peaking in around 2000 to just over 80% of electricity generation (refer to Figure 11) [14]. Australia has an aging coal fleet which is progressively being decommissioned, a natural gas generation capacity which is remaining relatively constant in recent times and a substantial increase in both wind and solar changing the generation landscape. Decommissioned coal-fired stations have not been replaced with new coal-fired power stations, with the last coal-fired power station being built in Western Australia in 2010 [15].

In 2010 Australia had 34 coal-fired power stations in operation [15]. The largest closures since then were Hazelwood power station (1,760 MW) in 2017 and Liddell power station (2,000 MW) in 2023. The substantial decrease in firm, dispatchable capacity since the early 2000s has seen a narrowing of available generation reserves.

FIGURE 11 COAL'S CONTRIBUTION TO AUSTRALIA'S ELECTRICITY MIX (% GENERATION)



Australian Generation Compared with the OECD

When comparing the generation profiles between Australia and the other selected countries, it's notable that Australia is the only country that has increased its overall generation in the decade since 2010 (refer to Figure 12 and Table 4). This is also the year COVID-19 had its most severe impact on the globe, but a decline in generation from these countries was also the trend before the impact of COVID-19 [16].

FIGURE 12 SELECTED OECD COUNTRY ELECTRICITY GENERATION COMPARISON FOR 2010 & 2020 (TWH)

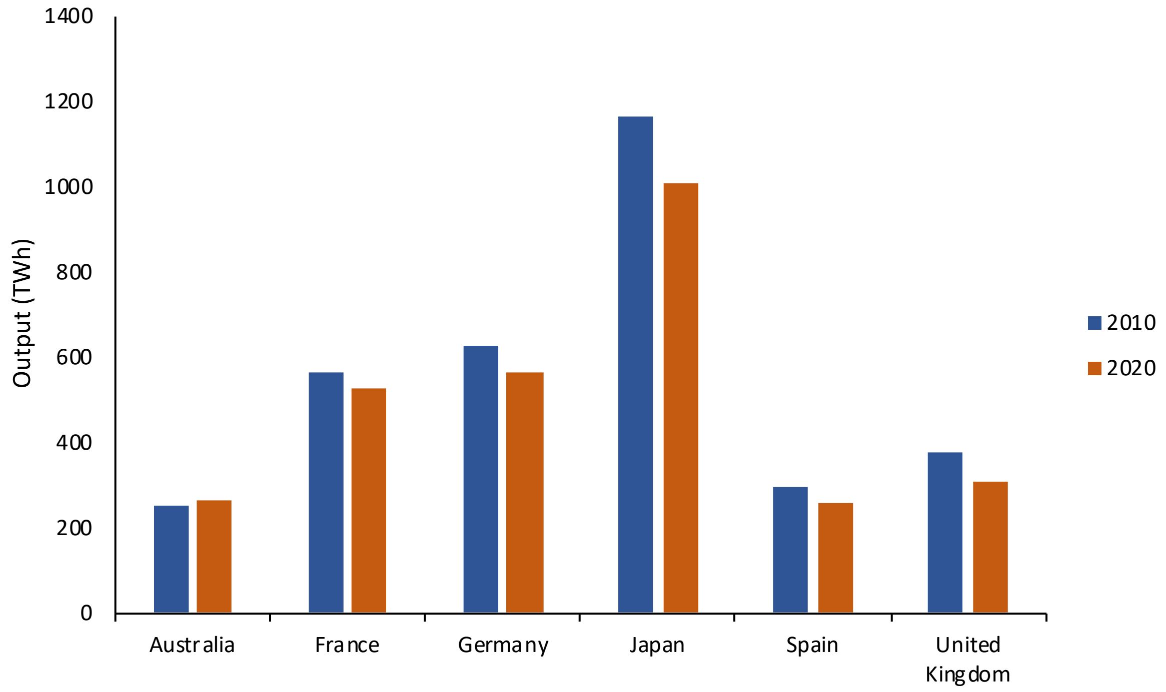


TABLE 4 AUSTRALIA VERSUS OECD, A COMPARISON OF ELECTRICITY GENERATION 2010 AND 2020 (TWH)

Generation (TWh)	2010	2020	Diff
Australia	253	265	5%
France	564	527	-7%
Germany	627	566	-10%
Japan	1164	1009	-13%
Spain	298	260	-13%
United Kingdom	380	310	-18%
OECD Total	11005	10846	-1%

FIGURE 13 AUSTRALIA TOTAL GENERATION SHARE VERSUS OECD (%)

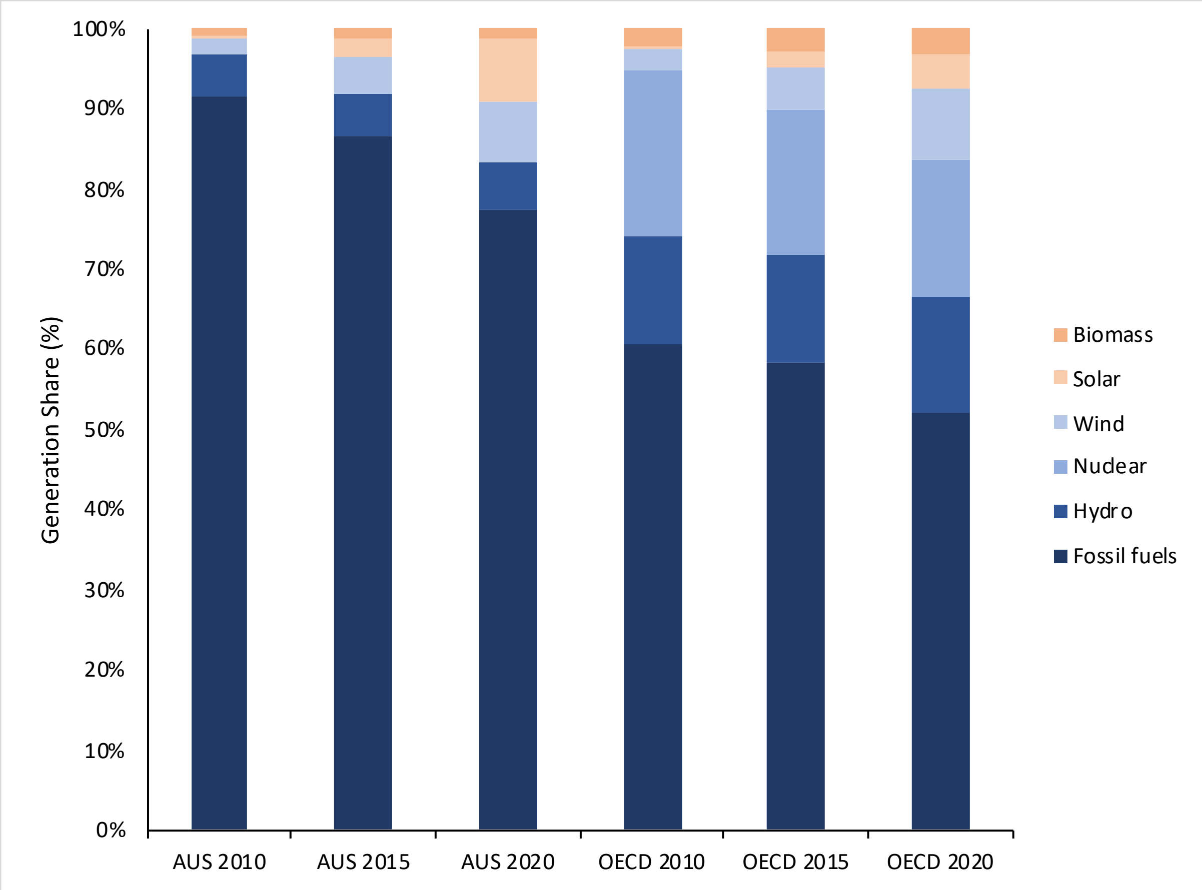


TABLE 5 SHARE OF GENERATION BY TECHNOLOGY FOR AUSTRALIA VERSUS OECD

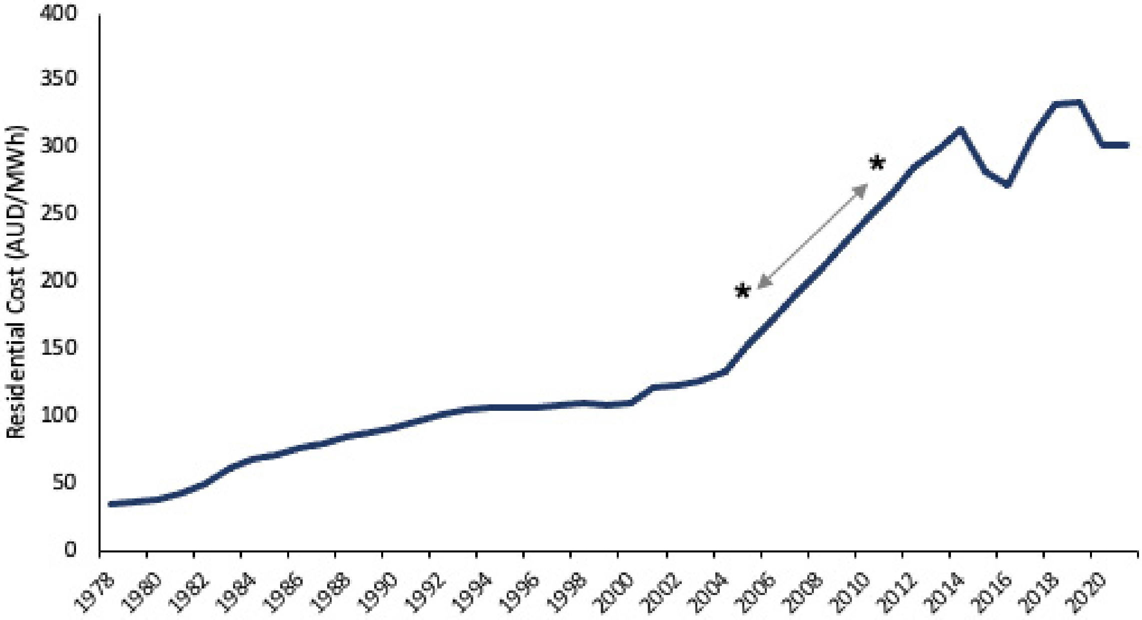
	AUS 2010	AUS 2015	AUS 2020	OECD 2010	OECD 2015	OECD 2020
Biomass	1%	1%	1%	2%	3%	3%
Solar	0%	2%	8%	0%	2%	4%
Wind	2%	5%	8%	3%	5%	9%
Nuclear	0%	0%	0%	21%	18%	17%
Hydro	5%	5%	6%	13%	14%	14%
Fossil fuels	91%	87%	77%	61%	58%	52%

Residential Electricity Prices for Australia

For most end users, the only relevant electricity metric is the cost of their household electricity consumption. As can be seen in Australia, the price of electricity has been increasing significantly from 1978 to now.

The IEA dataset for Australian prices only has been recorded annually. The data for Australia is presented in both Australian and US dollars. For the conversions to USD, a yearly average exchange rate was used from the OECD, as published in its *Main Economic Indicators, 2023* [17]. The prices shown for both USD and AUD are inflation adjusted.

FIGURE 14 RESIDENTIAL ELECTRICITY PRICES FOR AUSTRALIA (AUD/MWH)[3]



Things to note about the data presented in Figure 14:

- Not included in this data set, but recorded average price for Australian households in September 2023 was $329/MWh [18].
- Carbon credits were in effect in Australia from 1st July 2012.
- Renewables have multiplied nearly four times from 2010 to 2020, from 8.75GW to 33.38GW of install capacity.
- The NEM was integrated in December 1998.

3 * This data was not included in the IEA dataset, with the graph presenting a simple interpolation.

Australian Residential Price Comparison

For OECD member countries, energy prices in national currencies are converted to USD using yearly average exchange rates as published by the OECD *Main Economic Indicators, 2023* [17]. The OECD total used in the following graphs (Figure 15 to Figure 17) and table (Table 6) are a consumption weighted average.

FIGURE 15 OECD VERSUS AUSTRALIA, A COMPARISON OF ELECTRICITY PRICES[3]

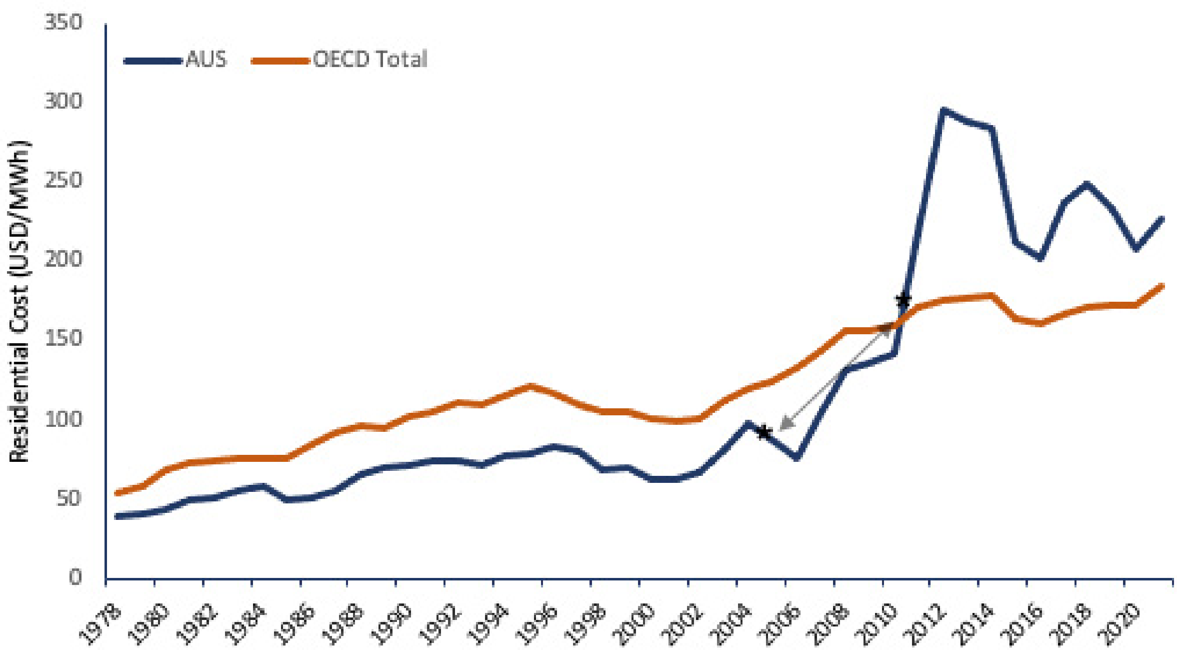


FIGURE 16 COMPARISON OF OECD PRICES FOR SELECTED COUNTRIES

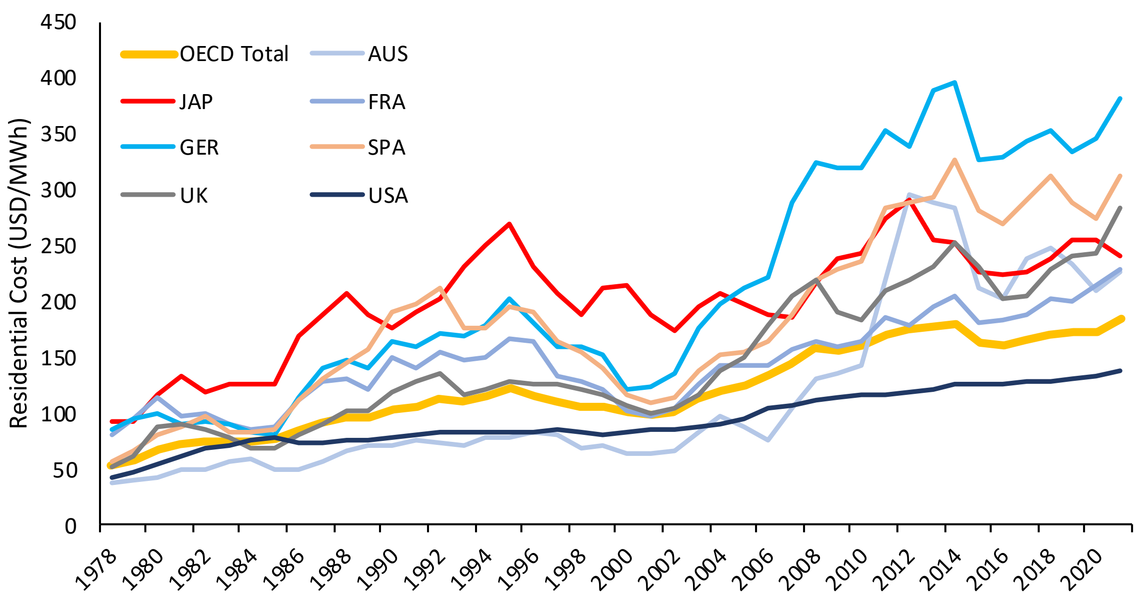


FIGURE 17 COMPARISON OF OECD PRICES FOR SELECTED REGIONAL AVERAGES

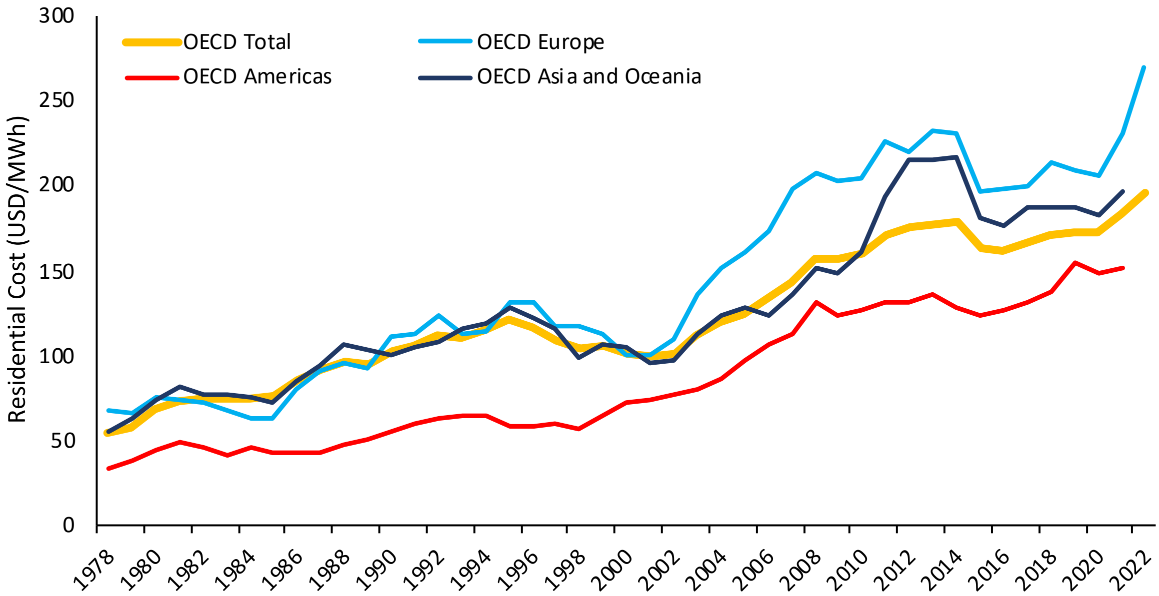


TABLE 6 OECD VERSUS AUSTRALIA, A COMPARISON OF ELECTRICITY PRICES 2010, 2020 & 2021 (USD/MWH)

Country	2010	2020	Increase 2010-20	2021
Australia	142.02	208.19	32%	226.61
France	164.80	214.98	23%	228.35
Germany	318.72	344.66	8%	380.05
Japan	243.76	255.21	4%	240.19
Spain	236.65	274.80	14%	312.02
United Kingdom	183.95	243.30	24%	283.49
United States	115.77	126.51	8%	131.96
OECD Average	159.33	172.47	8%	183.67

Japan

Japanese Grid Background

The Japanese electricity grid comprises two major interconnected systems: the Eastern Japan grid and the Western Japan grid (refer to Figure 18). These grids serve distinct areas of the country, each with its unique characteristics and energy compositions.

The Eastern Japan grid caters to the densely populated regions in the eastern part of the country, including Tokyo and its surrounding areas. Operating at a frequency of 50 hertz, this grid relies on a diverse energy mix to meet the demands of its extensive population. It draws a significant portion of its power from coal and natural gas sources. Nuclear power also plays a vital role in the energy composition of this grid, contributing to its reliability.

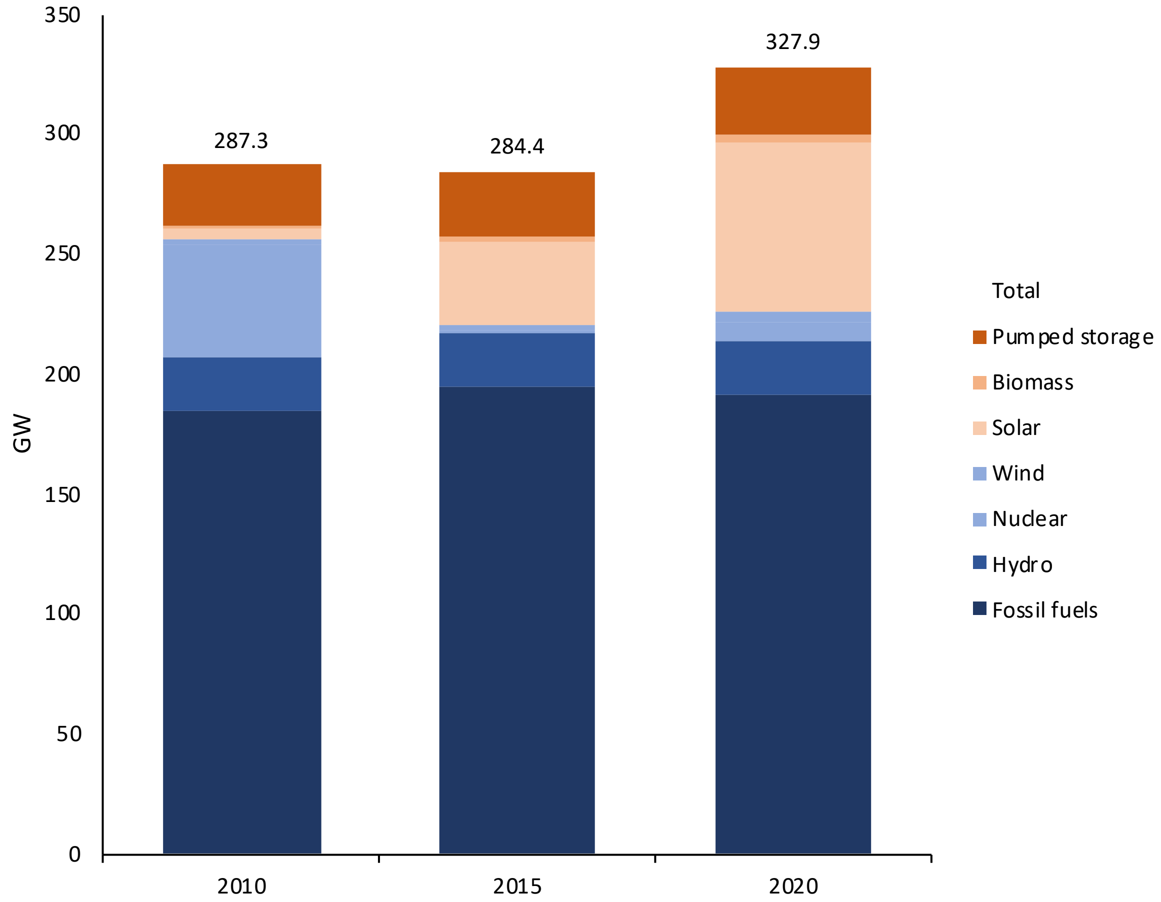
FIGURE 18 THE JAPANESE ELECTRICITY GRID

In contrast, the Western Japan grid covers the western part of the country and operates at a frequency of 60 hertz. Despite the difference in frequency, the Western Japan grid shares similarities in its energy composition. Like its eastern counterpart, this grid relies heavily on thermal fossil and nuclear power sources to meet electricity demands.

The historical development paths of the two grids have led to the frequency difference between them. However, this frequency gap is addressed using frequency converters at interconnection points. These devices enable the exchange of electricity between the Eastern and Western grids, ensuring a harmonious distribution system that spans the entire country.

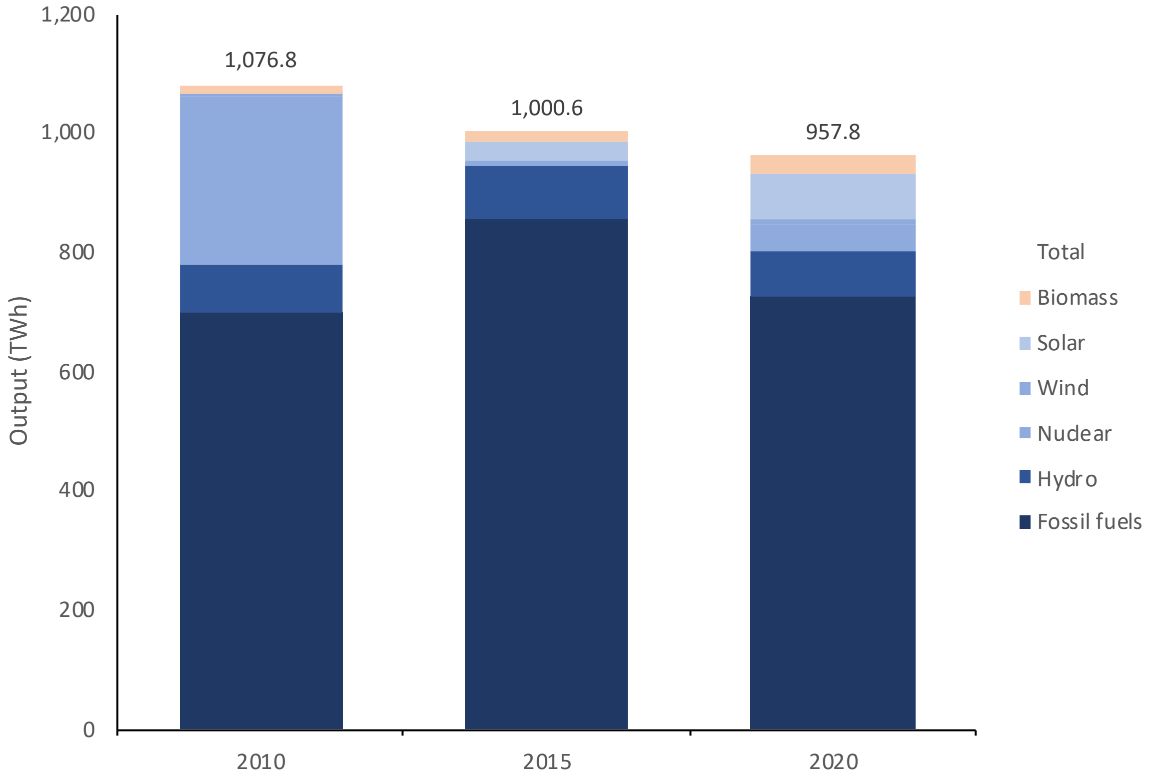
Japanese Generation Capacity

FIGURE 19 JAPAN ELECTRICITY GRID TOTAL CAPACITY (GW)



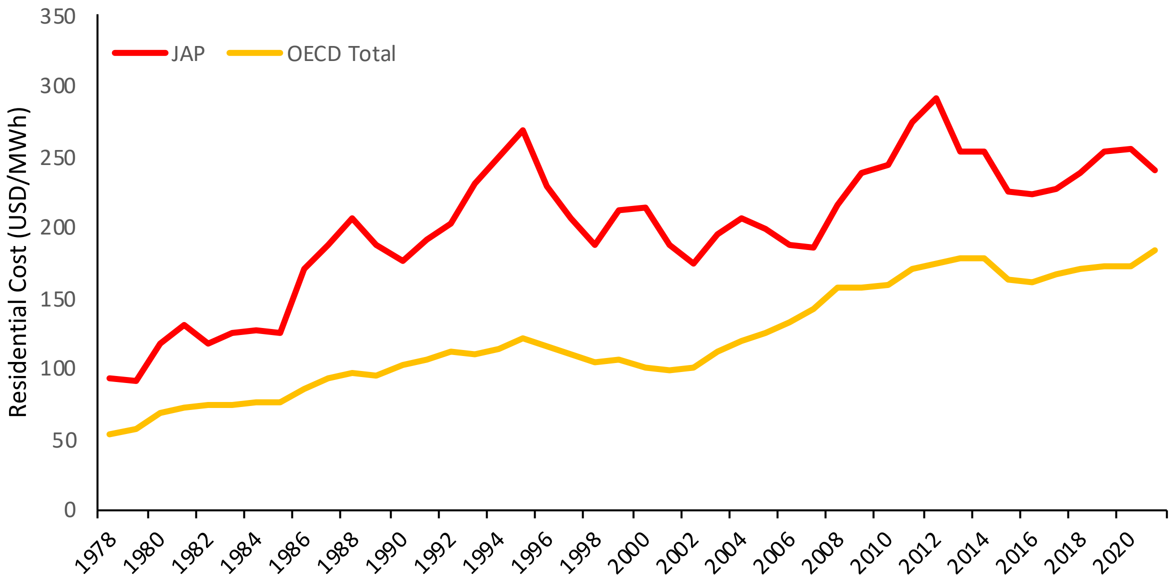
Japanese Generation

FIGURE 20 JAPAN ELECTRICITY GRID TOTAL GENERATION BY FUEL TYPE (TWH)



Japanese Retail Prices

FIGURE 21 OECD VERSUS JAPAN, A COMPARISON OF ELECTRICITY PRICES (USD/MWH)



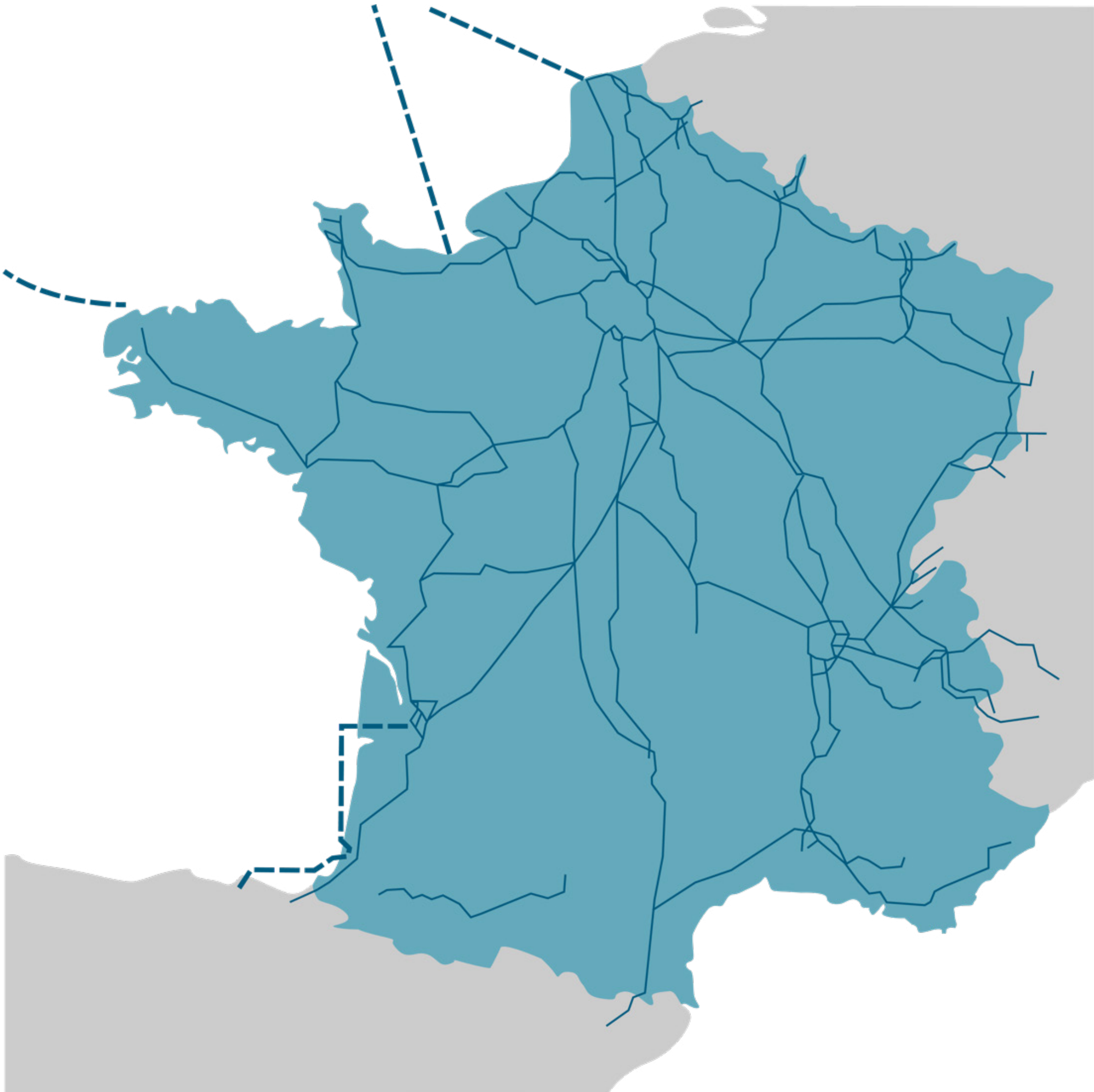
France

French Grid Background

The French electricity grid, a cornerstone of the nation's energy infrastructure, plays a pivotal role in delivering a reliable and consistent supply of electricity to its diverse regions. The French electricity grid consists primarily of one fully interconnected system (refer to Figure 22). It is managed and operated by Réseau de Transport d'Électricité (RTE), ensuring the efficient distribution of electricity across the nation.

The French electricity grid operates at a frequency of 50 hertz, aligning with the majority of continental Europe. It is a part of the broader European interconnected grid, allowing for the exchange of electricity with neighbouring countries. This interconnectedness fosters energy cooperation and helps balance supply and demand in real-time.

FIGURE 22 FRENCH ELECTRICITY GRID

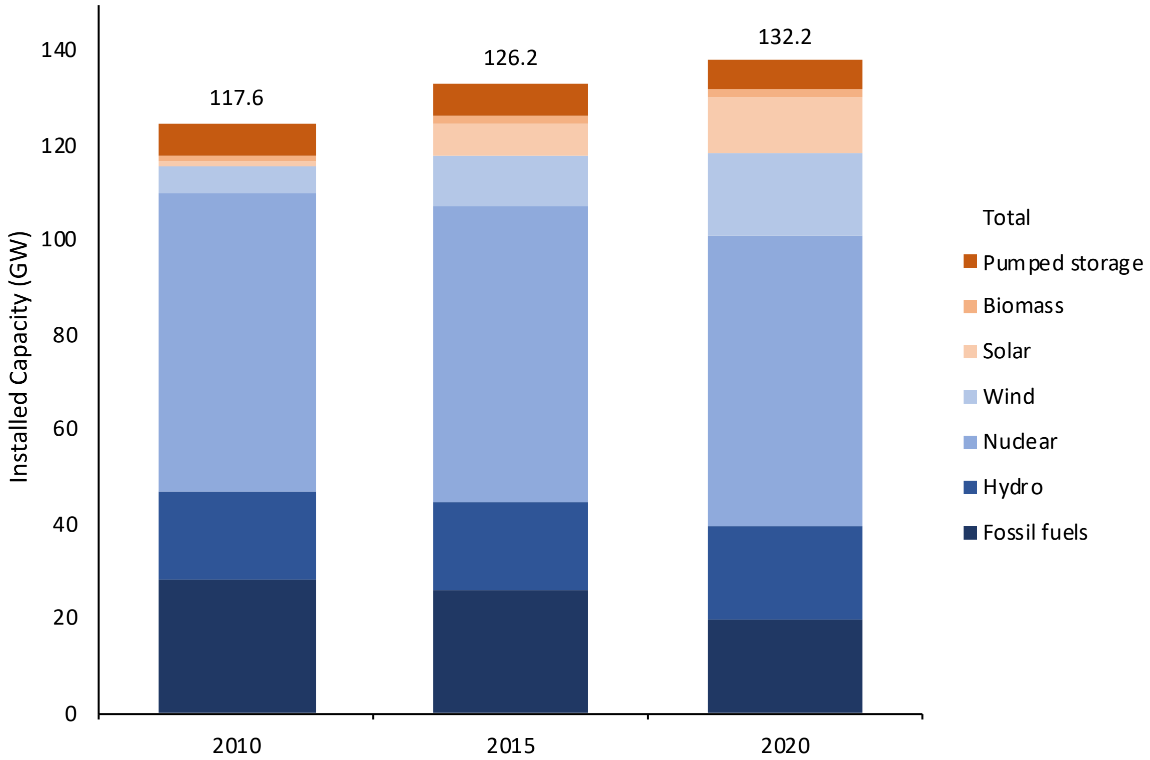


The integration of renewable energy sources and nuclear power showcases France's commitment to both environmental sustainability and energy security. The country has been a leader in the development of renewable energy projects, aiming to increase the share of renewables in its energy mix.

The French electricity grid is equipped with advanced technology and infrastructure to manage electricity supply efficiently. It incorporates smart grid solutions, grid interconnections with neighbouring countries, and an extensive network of transmission lines and substations. France promotes energy cooperation and contributes the largest amount of energy exports in all of Europe [19].

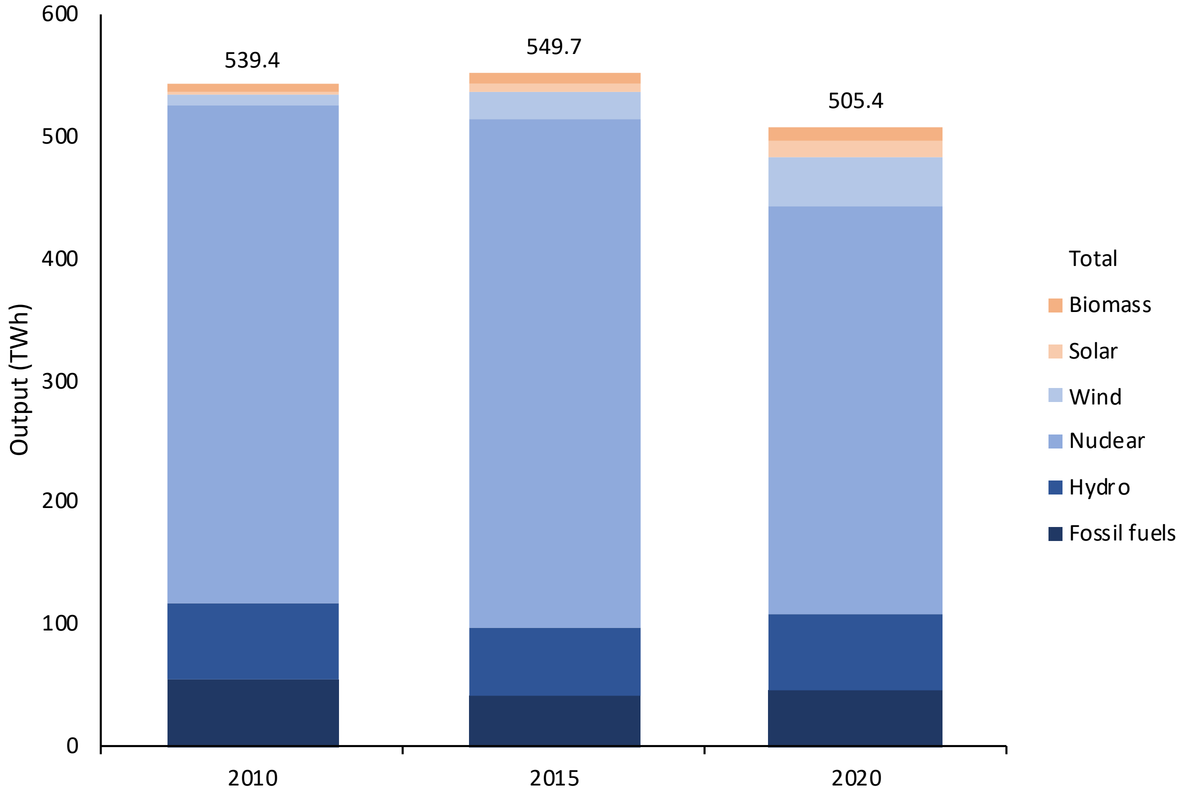
French Generation Capacity

FIGURE 23 FRANCE ELECTRICITY GRID TOTAL CAPACITY (GW)



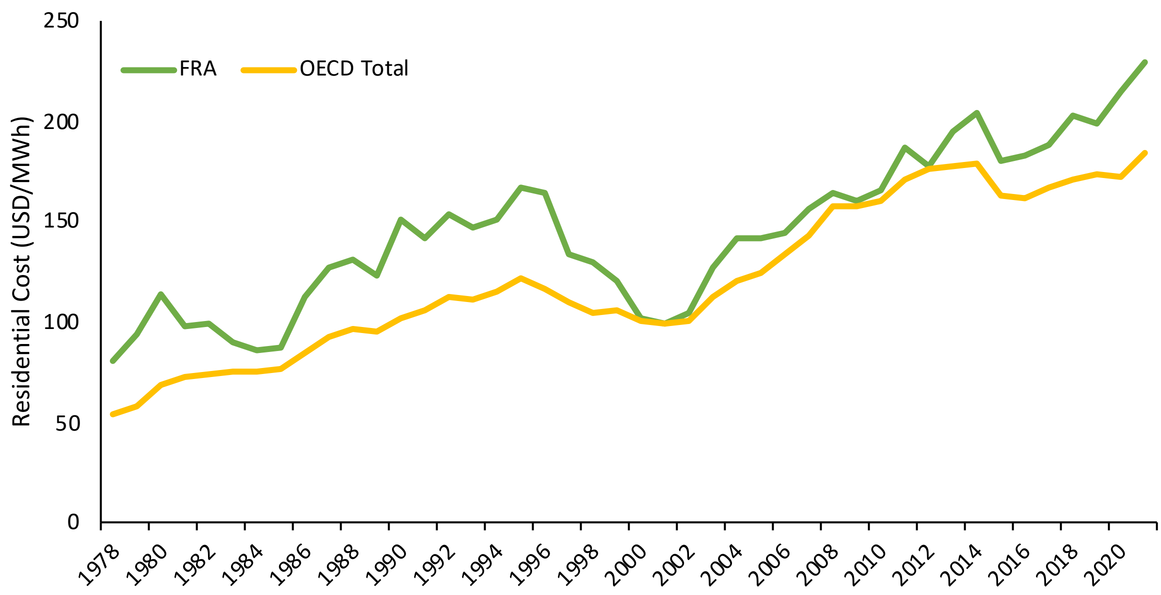
French Generation

FIGURE 24 FRANCE ELECTRICITY GRID TOTAL GENERATION BY FUEL TYPE (TWH)



French Retail Prices

FIGURE 25 OECD VERSUS FRANCE, A COMPARISON OF ELECTRICITY PRICES

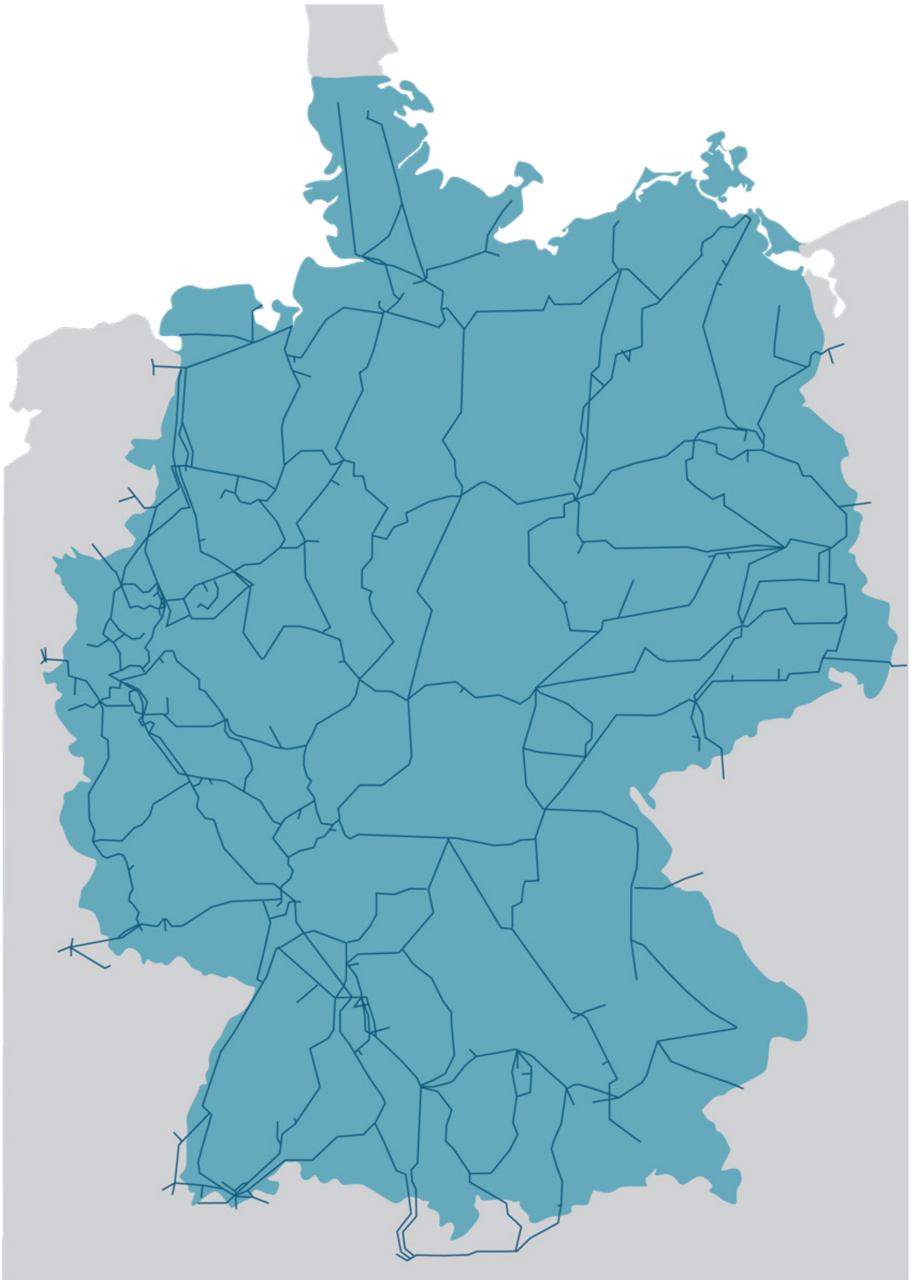


Germany

German Grid Background

The German electricity grid is a comprehensive and well-integrated electricity grid system that plays a pivotal role in powering the country. The grid is managed and operated by several transmission system operators (TSOs). Germany's electricity grid operates at a frequency of 50 hertz, in line with the majority of continental Europe. It is an integral part of the European interconnected grid, allowing for the seamless exchange of electricity with neighbouring countries (refer to Figure 26). This interconnectedness fosters cross-border energy trade, enhances energy security, and supports the integration of renewable energy sources.

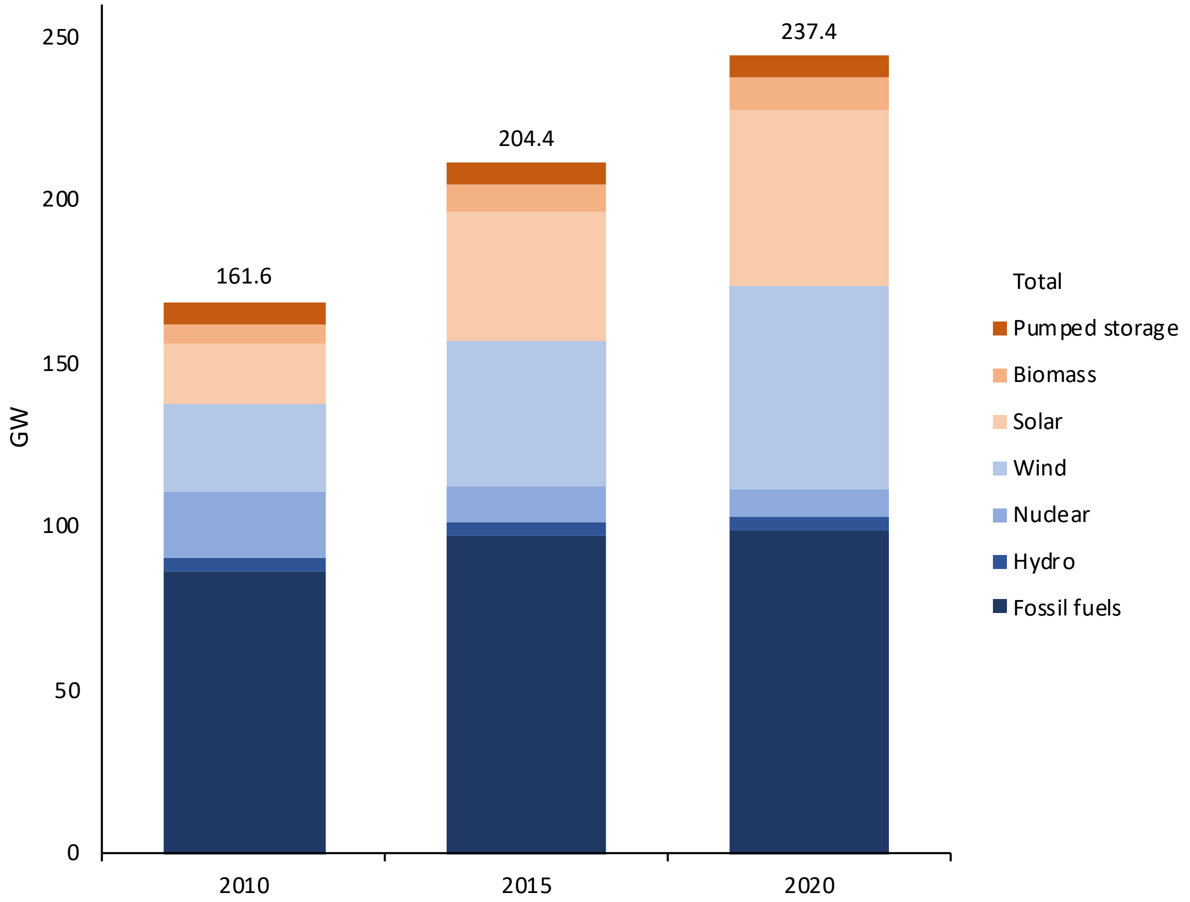
FIGURE 26 GERMAN ELECTRICITY GRID



Germany's commitment to renewable energy has led to impressive developments in the wind and solar sectors. The country has a significant installed capacity of wind turbines and solar panels, making it a leader in renewable energy adoption. The German electricity grid is equipped with advanced technology and grid management solutions, including demand response mechanisms and grid interconnections, which enhance the reliability and efficiency of electricity distribution. It also fosters the integration of intermittent renewable energy sources.

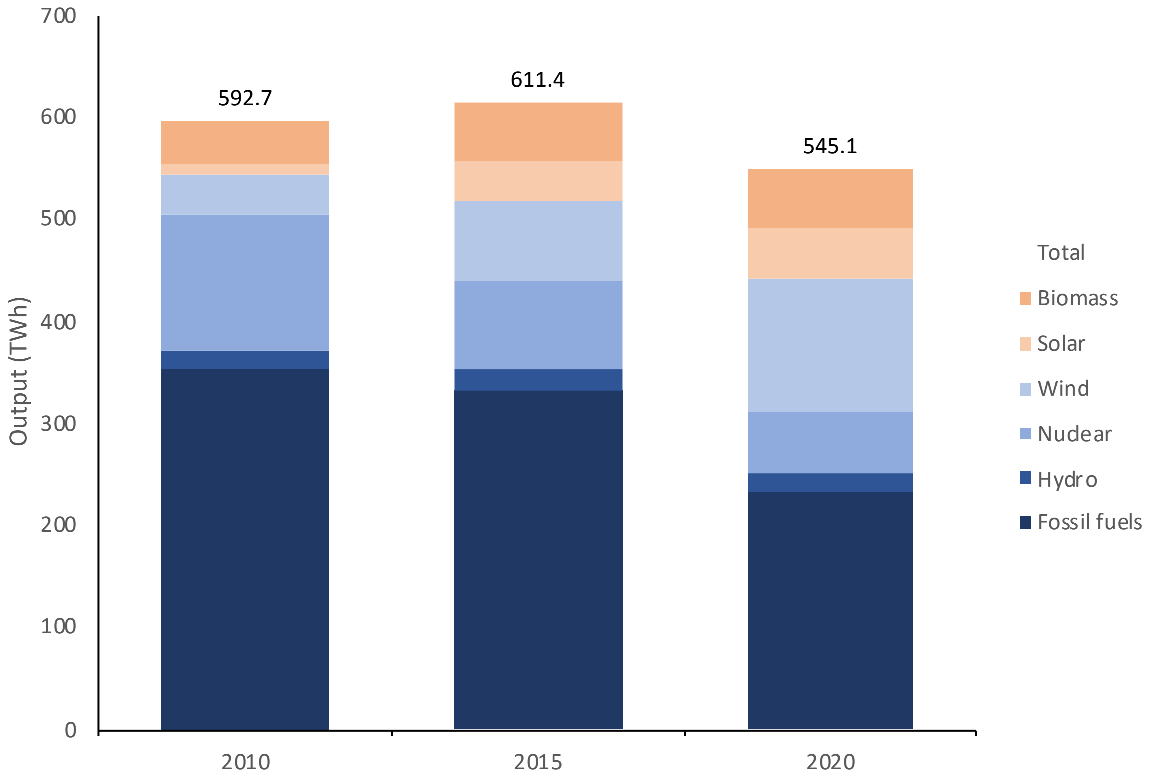
German Generation Capacity

FIGURE 27 GERMANY ELECTRICITY GRID TOTAL CAPACITY (GW)



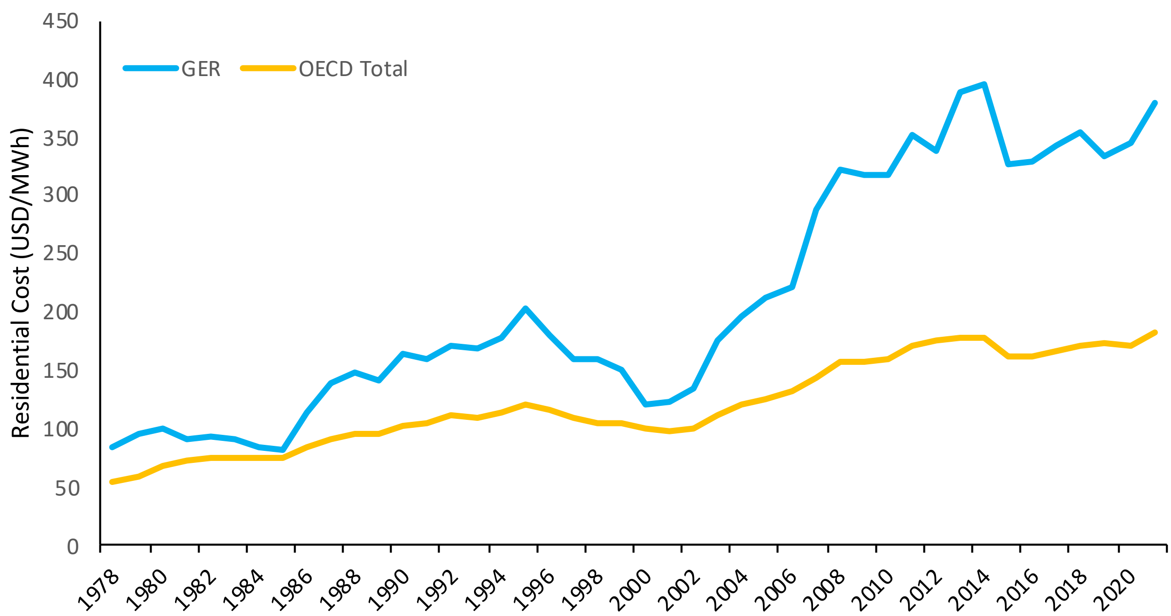
German Generation

FIGURE 28 GERMANY ELECTRICITY GRID TOTAL GENERATION BY FUEL TYPE (TWH)



German Retail Prices

FIGURE 29 OECD VERSUS GERMANY, A COMPARISON OF ELECTRICITY PRICES



Spain

Spanish Grid Background

The Spanish electricity grid is managed and operated by Red Eléctrica de España (REE), which plays a pivotal role in its maintenance and development.

The Spanish electricity grid operates at a frequency of 50 hertz, in alignment with most of continental Europe (refer to Figure 30). This connectivity allows for the smooth exchange of electricity with neighbouring countries and fosters energy cooperation and cross-border trade.

FIGURE 30 SPANISH ELECTRICITY GRID

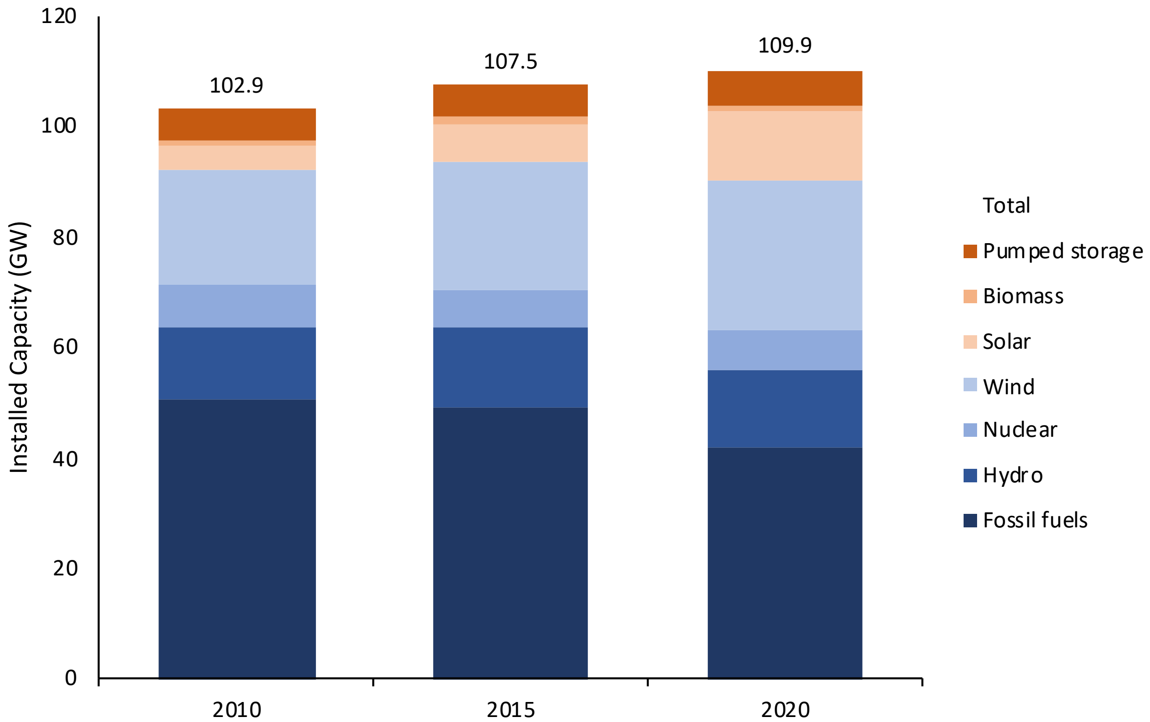
Spain has been actively investing in renewable energy projects and promoting energy efficiency to reduce its carbon footprint and transition towards cleaner energy sources. The country has also set ambitious targets for increasing the share of renewables in its energy mix.

The Spanish electricity grid is equipped with modern technology and infrastructure to ensure efficient grid management and electricity distribution. It includes an extensive network of transmission lines, substations and interconnections to maintain a reliable power supply.

In summary, the Spanish electricity grid is a robust and well-integrated system that plays a critical role in powering the nation. With a focus on renewable energy and sustainability, Spain's grid reflects its commitment to reducing carbon emissions and achieving a greener energy future. Its participation in the broader European interconnected grid enhances energy security and cross-border energy trade, contributing to regional energy cooperation.

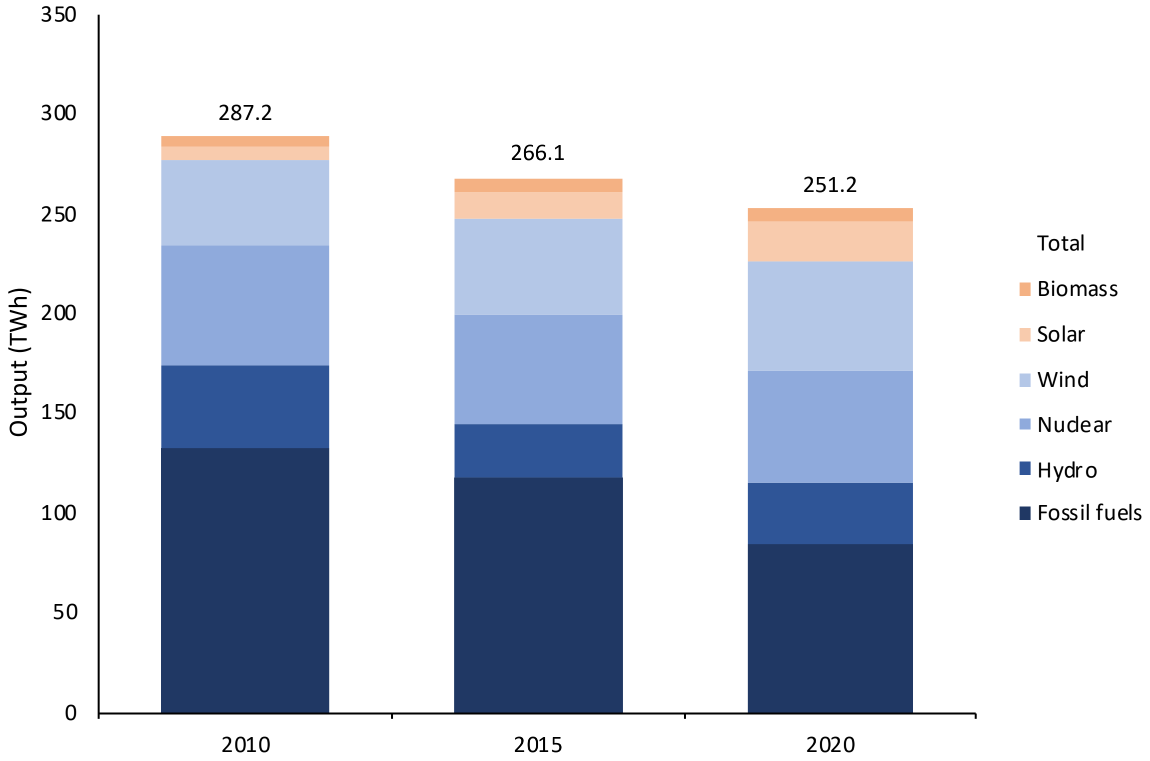
Spanish Generation Capacity

FIGURE 31 SPAIN ELECTRICITY GRID TOTAL CAPACITY (GW)



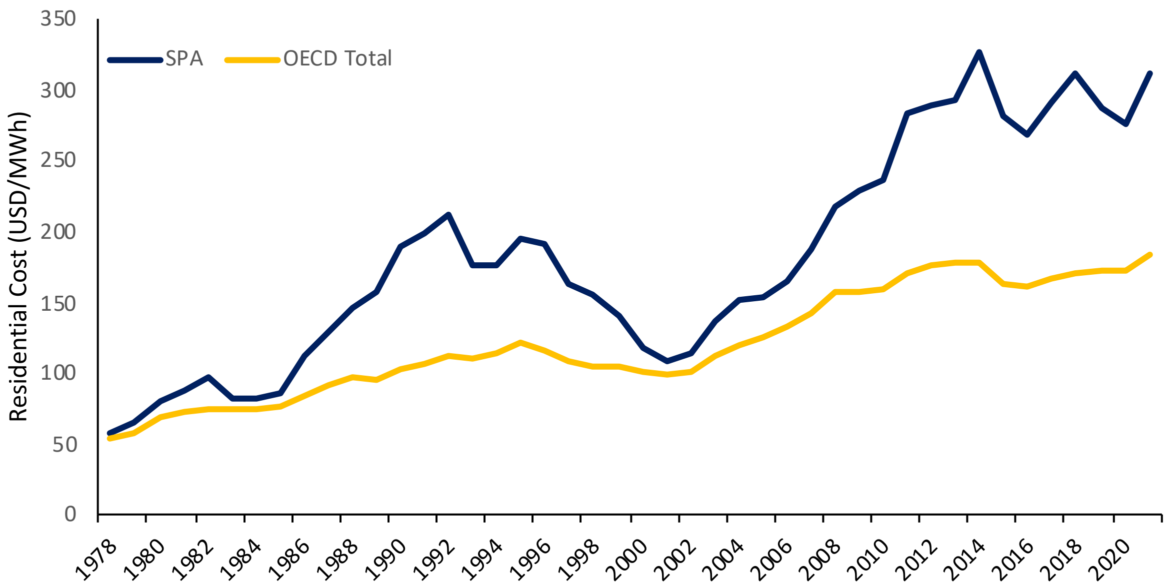
Spanish Generation

FIGURE 32 SPAIN ELECTRICITY GRID TOTAL GENERATION BY FUEL TYPE (TWH)



Spanish Retail Prices

FIGURE 33 OECD VERSUS SPAIN, A COMPARISON OF ELECTRICITY PRICES

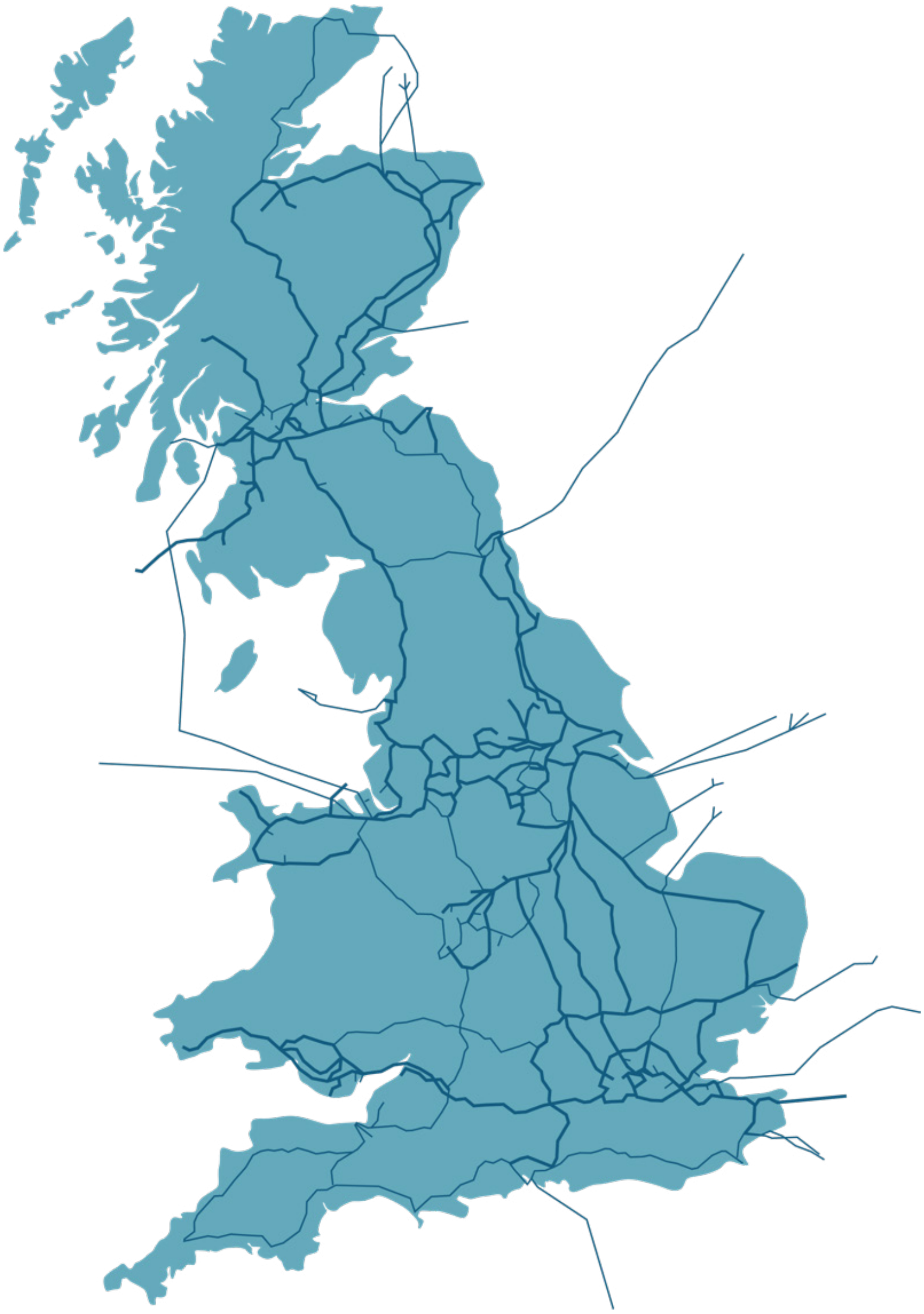


United Kingdom

UK Grid Background

The United Kingdom uses an advanced and integrated electricity grid system, overseen and managed by National Grid Electricity System Operator (ESO), ensuring the efficient transmission and distribution of electricity. Operating at a frequency of 50 hertz, the UK's electricity grid is synchronised with the majority of continental Europe, enabling seamless electricity exchange with neighbouring countries and supporting energy cooperation and cross-border trade (refer to Figure 34).

FIGURE 34 UNITED KINGDOM ELECTRICITY GRID

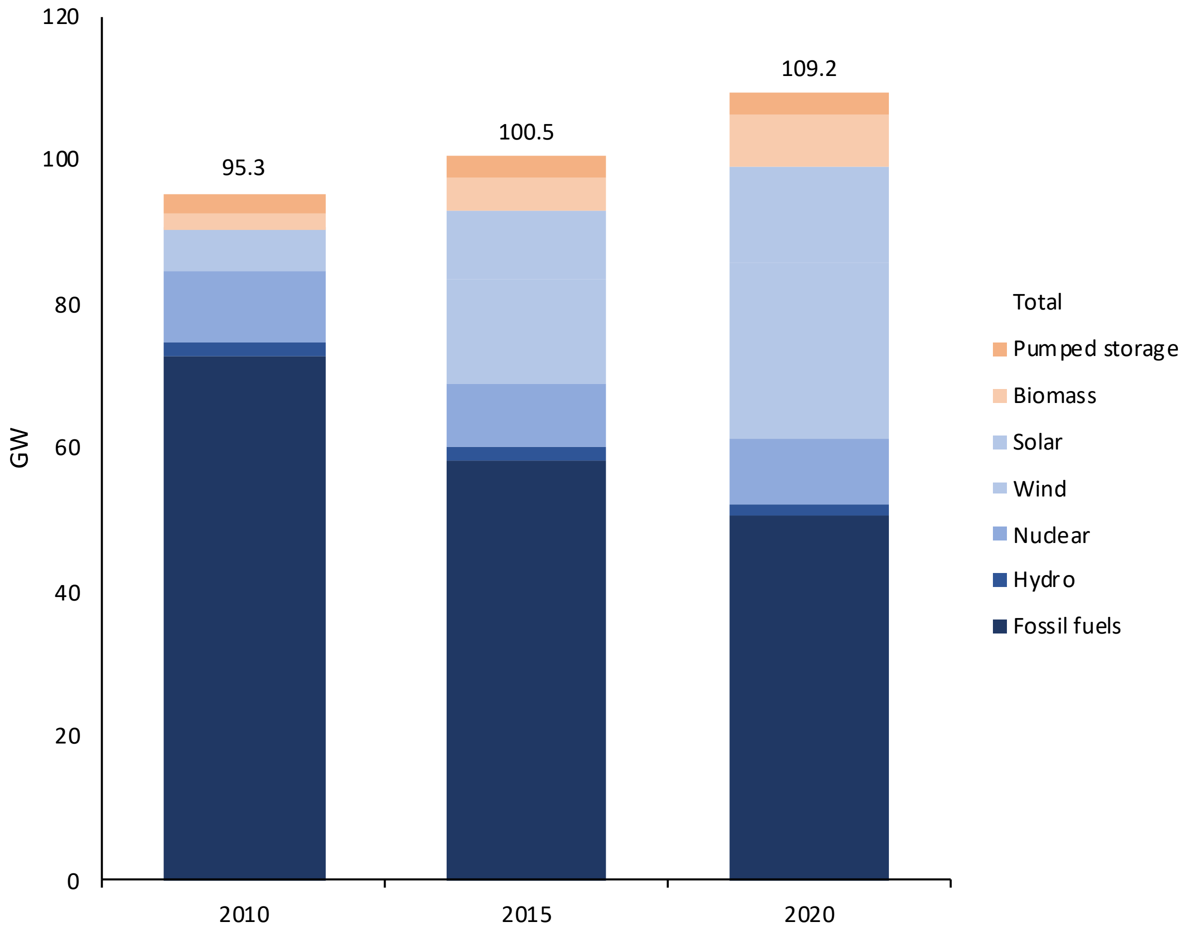


The United Kingdom's electricity grid is equipped with advanced technology and grid management solutions, including demand response mechanisms and smart grid features. These innovations enhance the reliability and efficiency of electricity distribution, particularly in managing the intermittent nature of renewable energy sources.

In summary, the United Kingdom's electricity grid is a robust and technologically advanced system that forms the backbone of the nation's energy infrastructure. With a strong emphasis on renewable energy and sustainability, the UK's grid reflects its commitment to reducing carbon emissions and transitioning towards a greener energy future. Participation in cross-border energy trade and cooperation further enhances energy security and market stability in the region.

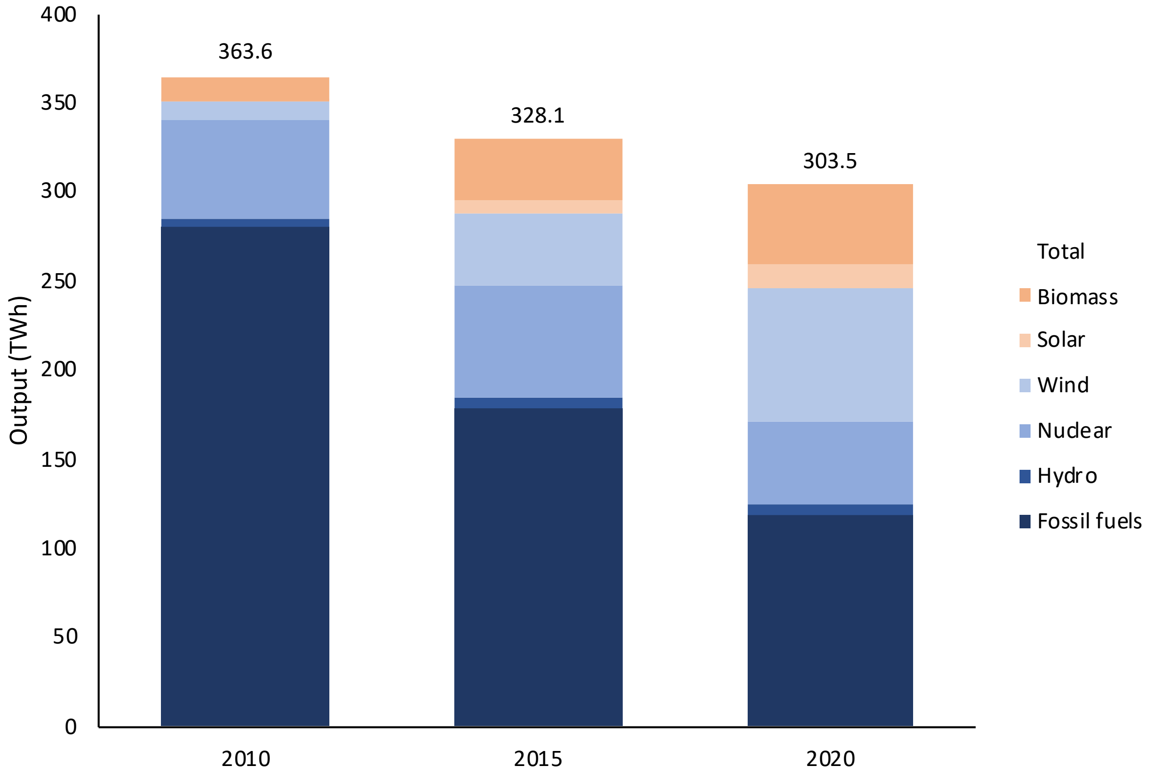
UK Generation Capacity

FIGURE 35 UK ELECTRICITY GRID TOTAL CAPACITY (GW)



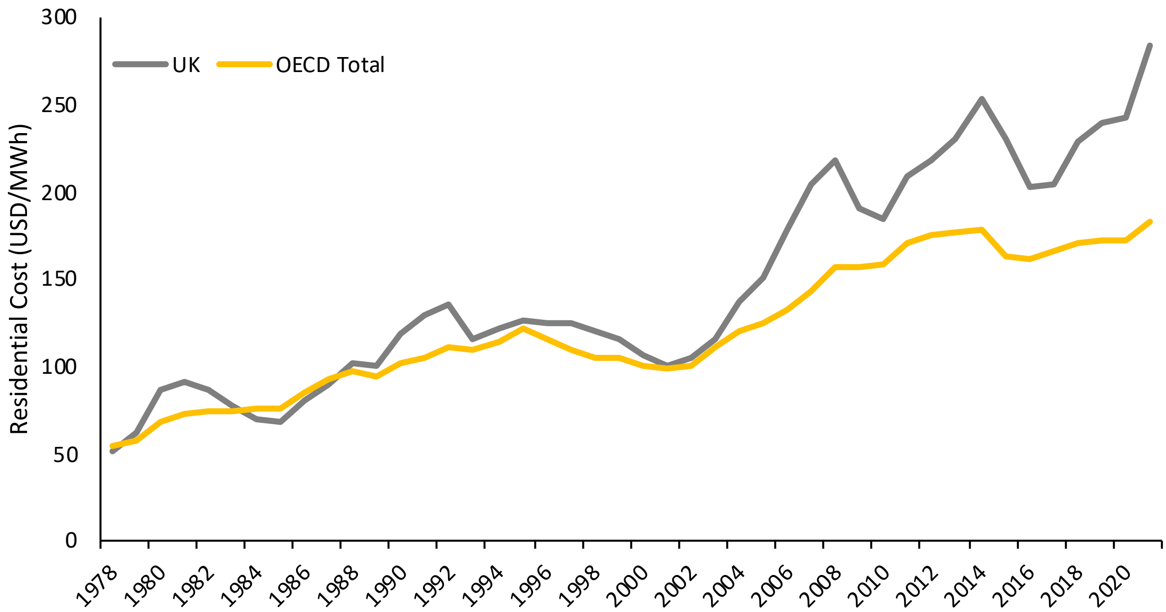
UK Generation

FIGURE 36 UK ELECTRICITY GRID TOTAL GENERATION BY FUEL TYPE (TWH)



UK Retail Prices

FIGURE 37 OECD VERSUS THE UNITED KINGDOM, A COMPARISON OF ELECTRICITY PRICES



IEA Electricity Price Background

End-user prices presented in this report reflect, as accurately as possible, the unit price effectively paid by consumers over a period in each country. The IEA World Energy Prices database [1] is the primary source of the end-user prices.

Australia

For Australia, the annual electricity prices for households correspond to fiscal years which run from 1 July to 30 June. For example, the annual price shown for 2013 refers to the period between 1 July 2012 and 30 June 2013. The IEA prices data for households are sourced from the Australian Energy Market Commission's (AEMC) Residential Electricity Price Trends. They refer to the average expenditures per MWh received via a survey that samples households Australia-wide. These averages are weighted by the number of residential connections in each jurisdiction and are therefore considered to be most closely representative of the most populous jurisdictions of Australia.

For the energy price indices, the annual and quarterly metrics are 12-month and 3-month averages, respectively. Indices are sourced from the Australian Bureau of Statistics (ABS).

Japan

Prices and taxes data for all energy products are provided to the IEA on a quarterly basis by the Ministry of Economy, Trade, and Industry (METI). Wholesale price indices are extracted from the Bank of Japan website. Retail price indices are extracted from the Statistics Japan website.

Household prices refer to fiscal years starting in April (i.e., 2015 data refer to 1 April 2015 – 31 March 2016). End-use prices are average revenues per MWh of the ten major electric power companies under contracts for "power" (industry and commercial) and for "light" (households).

After the liberalisation of the electricity market in 2000, large companies can purchase electricity directly in the open market. Prices shown do not consider electricity purchases in the free market, however, the general electricity utility companies covered by the survey are responsible for around 94% of total electricity sales as of May 2016.

France

Prices and taxes data for oil products, natural gas, and electricity, as well as all energy price indices, are provided on a quarterly basis to the IEA by the Ministry of Energy Transition.

National average prices are computed by the Ministry as consumption-weighted averages of the average prices per band published by Eurostat. The weights used for this calculation are biannual consumption figures per band collected through surveys. Eurostat data are biannual, therefore, prices for 1Q and 2Q are the same, as are those for 3Q and 4Q.

Annual and quarterly indices are 12-month and 3-month averages, respectively, of the price indices listed below, as published in the French National Institute of Statistics and Economic Studies' (INSEE) website.

Germany

Data for all energy products are provided to the IEA on a quarterly basis by the German Federal Ministry for Economic Affairs and Climate Action (BMWK). Retail energy price indices are derived from data extracted from the Eurostat website.

Prices and taxes data are based on surveys carried out by the Federal Statistical Office (DESTATIS).

Annual and quarterly indices are 12-month and 3-month averages, respectively, of the Harmonised Indices of Consumer Prices (HICP) published by Eurostat.

Spain

Prices and taxes data for oil products are derived from weekly data published in the European Commission's Weekly Oil Bulletin. Prices and taxes data for natural gas and electricity are provided on a quarterly basis to the IEA by the Ministry for the Ecological Transition and the Demographic Challenge (the Ministry). Retail energy price indices are based on data published by Eurostat.

For industry and households, annual electricity prices from 1979 to 2007 were provided to the IEA by the relevant Ministry, known under different names during this period.

National average prices are computed by the Ministry as consumption-weighted averages of the average prices per band published by Eurostat. The weights used for this calculation are bi-annual consumption figures per band collected through surveys. Annual and quarterly indices are 12-month and 3-month averages, respectively, of the Harmonised Indices of Consumer Prices (HICP) published by Eurostat.

United Kingdom (UK)

Data for all energy products, including energy price indices, are provided to the IEA on a quarterly basis by the Department for Energy Security and Net Zero.

For households, prices are based on annual surveys carried out among domestic electricity suppliers who provide average prices and customer numbers. Quarterly data are derived using the annual figures and the quarterly consumer price index growth rates for electricity. Ex-tax prices are derived by subtracting the applicable tax components from the end-use prices.

Annual indices are 12-month averages.

Organisation for Economic Co-operation and Development (OECD)

The OECD is an intergovernmental organisation with 38 member countries currently. These countries are located across the Americas, Europe, Asia, and Oceania. Many of these countries are regarded as high-income economies and rank highly as developed countries. The averages used from the OECD countries and regions are a great comparison tool to compare with singular countries or regions to determine the effectiveness of the countries' given metric.

Electricity Grid Summaries

Australia

The two major Australian electricity grids are the NEM (National Electricity Market) and the SWIS (South-West Interconnected System). The NEM is among one of the longest interconnected systems in the world, stretching across Queensland, New South Wales, Victoria, South Australia, and Tasmania. The SWIS is responsible for providing energy across Western Australia's coast. Both these systems use a diverse range of energy sources and must be able to keep up with peak demand and provide electricity constantly.

The NEM operates on an energy-only market and the SWIS operates as a capacity market. As of September 2023 [9], the NEM used a generation fuel mix consisting of approximately 64% coal, 31% renewables and 4% gas. These figures do not include rooftop solar. The SWIS utilised 40% gas, 35% renewables and 24% coal as of September 2023 [7]. Rooftop solar is included for the SWIS generation figures, likely due to being a smaller grid with easier solar installation to manage.

Japan

The Japanese electricity grid comprises two major interconnected systems: the Eastern Japan grid and the Western Japan grid.

The Eastern Japan grid serves the densely populated regions of eastern Japan, including Tokyo and its surrounding areas. This grid operates at a frequency of 50 hertz and relies on a diverse energy mix of mostly coal and natural gas, nuclear power, and renewables.

In contrast, the Western Japan grid, covering the western part of the country, operates at a frequency of 60 hertz. It shares a similar energy composition with an emphasis on thermal and nuclear power sources. This frequency difference between the two grids is a historical legacy stemming from their separate development paths. Equipment called frequency converters are used at interconnection points to enable the exchange of electricity between the Eastern and Western grids, ensuring a harmonious distribution system across the entire country.

Japan uses a generation fuel mix of 32% coal, 32% gas, 23% renewables and 6% nuclear as of September 2020 [20].

Germany

The German electricity grid consists of two major interconnected systems, the Continental European Synchronous Area, and the United Kingdom Synchronous Area.

Given Germany's location, grid interconnections with neighbouring countries are well utilised, which account for 10% of domestic capacity. In September 2023, renewable generation represented 42% of the total electricity with another 45% of the electricity being produced by coal and natural gas [21].

France

The French electricity grid is part of the same system that Germany is connected to. The major difference being that France is the world's largest net exporter of electricity. They also have the largest share of nuclear energy within the generation portfolio. As of September 2023, they obtain approximately 75% of their electricity from nuclear generation sources. The other 20% of their generation comes from renewables, with the remaining 4% coming from fossil fuels [21].

Spain

The Spanish Electrical Network (Red Eléctrica de España) is part of the European Synchronous Area and boasts the fifth largest generation within this network. This grid has recently relied primarily on a combined cycle gas generation (currently approximately 29% of its generation). In September 2023, Spain continues to build renewable generation with over 40% of their generation coming from renewable plants. The remaining 24% of their generation is sourced from nuclear power plants [21].

United Kingdom (UK)

The UK grid responsible for providing energy to England, Wales and Scotland is called 'The National Grid'. This grid operates at 50 hertz and produces over 300TWh annually. Historically, this grid was based on mostly coal and oil for much of their energy. Coal is now a very small percentage of their energy production share.

The current electricity generation mix is mostly reliant on gas at around a 36% share, with another 15% derived from nuclear and another 35% sourced from renewables [22].

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RG Menzies House
Cnr Blackall & Macquarie Streets
Barton ACT 2600

PO Box 6091, Kingston ACT 2604

www.menziesrc.org