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Back of the pack

An assessment of Australia's energy transition

The Australian Government claims that Australia is leading the world in achieving climate targets and transitioning to renewable energy.

New analysis finds Australia's energy emissions continue to rise, while productivity and decarbonisation rankings fall.

Since 2005 Australia has maintained, if not slipped further behind, its OECD counterparts when it comes to the energy transition.

Hugh Saddler

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Summary

The 26th UN Climate Change Conference of the Parties (COP26) in Glasgow is fast approaching, and Australia is facing increasing scrutiny on its claims made, and performance delivered, on climate action. If the Australian Government is to be believed, Australia is leading the world in achieving its climate targets, reducing greenhouse gas emissions, and transitioning to a renewable energy system.

However, when Australia's emissions reduction and energy transition performance is assessed across a number of key indicators of decarbonisation, it is not leading the world, its trailing it. When compared to 22 OECD economies and Russia, selected due to comparable wealth, population, and development, it becomes clear that Australia is significantly behind in the energy transition (Table A1).

Table A1: Performance ranking of Australia against 23 other countries for key energy transition indicators in 2005 and 2019

	Indicator	Australia ranking 2005 (of 24)	Australia ranking 2019 (of 24)	Improved?
1	Primary energy consumption per capita	19th	21st	**Worse**
2	Primary energy productivity	18th	21st	**Worse**
3	Total energy combustion emissions per capita	23rd	23rd	**No change**
4	Total energy combustion emissions per $ of GDP	23rd	23rd	**No change**
5	Emissions intensity of primary energy consumption	23rd	23rd	**No change**
6	Non-fossil fuel share of electricity generation	22nd	23rd	**Worse**
7	New renewables share of electricity generation	13th	14th	**Worse**
8	Transport emissions per capita	22nd	22nd	**No change**

The comparison begins in 2005, the year nominated by the Australian Government as the baseline for its current Paris Agreement targets. It is also the first year of obligatory emissions reductions under the previous climate agreement, the Kyoto Protocol.

In 2005, the Australian economy had the second highest share of coal in its primary energy supply. Of the 24 countries, Australia consumed more energy per person, with higher energy emissions per person than the majority. Australia also had low levels of energy productivity and low levels of non-fossil fuel use, including in transport. Off such a low base, and with a higher-than-average population growth and renewable potential compared to most in the OECD, Australia should have significantly increased its place in the pack. With a poor level of performance in 2005, Australia achieved less improvement than any of the other poor performers.

By 2019, Australia had either maintained its back of the pack position or slipped even further on all metrics. Australia is among the worst emitters on a per capita and per dollar of GDP basis, and the rate of improvement is nowhere close to the claim to be a 'leader' in the decarbonisation race.

The Australian economy has, with the exception of Poland, the most emissions intensive energy system among OECD countries. It is arguable that, based on the combination of the level of the non-fossil fuel share and the increase in that share from 2005 to 2019, Australia has performed worse than any of the other 23 countries at reducing its dependence on fossil fuel generation.

Key findings include:

- Despite prioritising productivity as one of the key policies to help Australia meet its Paris Agreement goal, energy productivity in Australia slipped back four places in the rankings.
- Australia was one of only three countries in which emissions from energy use actually increased between 2005 and 2019.
- Despite a growing population and good economic growth, in 2019 Australia ranked second last on energy emissions per capita and per GDP, behind the USA and Russia respectively.
- Emissions intensity of Australia's energy system in 2019 was second only to that of Poland, primarily because both countries were, and still are, heavily reliant on coal for electricity generation and also, to some extent, for supplying industrial heat.
- Australia also performed poorly in terms of transport emissions per capita (22nd out of 24) and have only reduced these emissions by 1% since 2005, placing 17th out of 24 in this regard.
- By 2019 Australians were consuming more energy per person than 20 (of the 23) other countries. Australia is unique in being the only country of the top energy consuming nations to have exhibited an increase in energy use per person over the period 2005-2019.

The transition towards a low (and eventually zero) emission energy system requires "greening" electricity generation with renewables and electrifying other energy consumption. The proxy indicator of electrification used here is the ratio of electricity generated in a country to total primary energy consumption.

Altogether, Australia's electrification performance is the worst of the twenty-four countries, just as its decarbonisation performance has also been amongst the worst. On this basis, Australia's overall energy transition performance has been worse than that of any of the other 23 countries.

Beyond the comparison with other countries, this paper indicates that Australia's so-called 'gas-fired economic recovery'[1] runs absolutely counter to the needs of Australia's energy system transition, and would worsen, not improve, Australia's emissions reduction performance.

[1] Prime Minister Morrison (2020), *Gas-fired recovery*, Media Release 15 September 2020, https://www.pm.gov.au/media/gas-fired-recovery

Introduction

Prime Minister Scott Morrison has often described Australia as playing a leading role in addressing climate change and doing more than many similar countries in relation to renewable energy. For example, earlier this year he claimed that:

> We are deploying renewable energy ten times faster than the global average per person. We have the highest uptake of rooftop solar in the world.
>
> Australia is on the pathway to net zero. Our goal is to get there as soon as we possibly can, through technology that enables and transforms our industries, not taxes that eliminate them and the jobs and livelihoods they support and create, especially in our regions.[2]

Similarly bold claims have been repeated by the Australian Minister for Energy and Emission Reductions, Angus Taylor:

> In 2019, Australia deployed new renewable capacity at least ten times faster per person than the global average and four times faster per person than China, Europe or the United States.
>
> In 2020, Australia invested $7.7 billion or $299 per person in renewable energy. This places us ahead of countries like Canada, Germany, Japan, Korea, New Zealand and the United States on a per person basis.
>
> Australia now has the highest solar capacity per person of any country in the world (644 watts per person) and the highest wind and solar capacity of any country outside of Europe (804 watts per person).[3]

AUSTRALIA'S CLIMATE CLAIMS

Minister for Energy and Emissions Reduction Angus Taylor has said Australia is playing its part in the global response to climate change by meeting and beating its self-nominated targets. He also claims that Australia is tracking well, and should be a source of national pride:

[2] Prime Minister Morrison (2021) *Remarks, Leader's Summit on Climate*, 22 April 2021, https://www.pm.gov.au/media/remarksleaders-summit-climate

[3] Minister Angus Taylor (2021), Media Release, *Australia sets new renewables records in 2020*, 2 February 2021, https://www.minister.industry.gov.au/ministers/taylor/media-releases/australia-sets-new-renewables-records-2020

> "We have a clear plan to meet and beat our 2030 target and the updated projections reflect Australia's strong performance. Action and outcomes are what matter, and our track record is one that all Australians can be proud of."[4]

In November 2021 the 26th Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCCC COP26) will be held in Glasgow, having been postponed from 2020 due to the COVID-19 pandemic. An important part of the conference proceedings will be the postponed five-year review of the Paris Agreement pledges, formally called Nationally Determined Contributions (NDCs). Countries that submitted NDCs for 2025 are expected to now submit 2030 NDCs, and those that already have 2030 NDCs are encouraged to consider more ambitious actions to reduce greenhouse gas emissions.

This impending five-year review is why targets have recently achieved such prominence in Australia's political debate, and why Australia is coming under increasing pressure from its allies, including the US and the UK, to increase its climate ambition ahead of the Glasgow COP.[5]

It is also why Prime Minister Morrison and Minister Taylor are making increasingly emphatic claims about the roll out of renewables and emissions reduction in Australia (while simultaneously casting doubts on the claims made by other countries).

Ahead of the G7 Summit in June 2021 Prime Minister Morrison stated that Australia has reduced its emissions by 20 per cent on 2005 levels, bringing the country over three quarters of the way to meeting Australia's Paris target of 26-28 per cent by 2030.[6]

However, the legitimacy of this achievement is disputed even by members of the federal government. According to former Minister for Resources, Liberal-National Senator Matt Canavan, this 'achievement' has solely been the result of emission reductions in a single sector of the economy, not an economy-wide transition as the Prime Minister implies:

> The only reason we've met our emission reductions targets is that we stopped farmers from clearing their own land…[7]

[4] Minister Angus Taylor (2020) *Media Release*, 10 December 2020, https://www.minister.industry.gov.au/ministers/taylor/media-releases/projections-confirm-australia-track-meet-and-beat-2030-target

[5] Guardian (2021) https://www.theguardian.com/environment/2021/jul/05/us-urges-australia-to-adopt-more-ambitious-climate-goals-as-pressure-mounts-on-morrison-to-act

[6] Guardian (2021) https://www.theguardian.com/australia-news/2021/jun/08/scott-morrison-digs-in-against-deeper-cuts-to-emissions-ahead-of-g7-summit

[7] Senator Matt Canavan, interview with Fran Kelly, *ABC Radio National Breakfast*, 24/06/2021, https://www.abc.net.au/radionational/programs/breakfast/nationals-split-with-liberals-over-the-murray-darling-basin-plan/13410298

Senator Canavan is right in claiming that all of Australia's emission reductions since 2005 have been related to farming activities. The largest reductions have been in the land sector (officially referred to as Land Use, Land Use Change and Forestry (LULUCF)); there have also been reductions in emissions from livestock management and cropping activities, defined as the agriculture sector. According to the Department of Industry, Science, Energy and Resources, since 2005 emissions from the land sector have fallen by 114 Mt CO_2-e due mainly to a very large decrease in land clearing, while emissions from the agriculture sector have fallen by 11 Mt CO_2-e.[89]

However, the problem lies in the fact that the very large land sector emission reductions, most of which occurred over the ten years from 2007 to 2017, are the result of a one-off change in land use practices and therefore cannot provide ongoing reductions. Since this big reduction in land clearing, total land sector emissions over the past few years have been steady at relatively small negative values (CO_2 removals through growth in vegetation and soil carbon build-up are now larger than CO_2 emissions from land clearing and related activities). Large one-off reductions in land clearing are in no way evidence of a trend towards the decarbonisation of the Australian economy. For the purposes of international comparison, it is important to note that most other developed countries have no capacity to benefit from large reductions in land clearing, for the simple reason that they cleared most of their land centuries ago.

Research by the Australia Institute, *Banking on Australia's Emissions*, shows that if LULUCF is not included in the national inventory, Australia's emissions have actually increased by 7 per cent since 2005.[10]

Including emission reductions from the land sector is allowed under UNFCCC accounting rules. However, it is generally accepted that emissions reductions in this sector are variable, with high uncertainty, and difficult to measure. [11] This makes a like-for-like comparison of Australia's efforts to reduce emissions with other countries also difficult. Indeed, in recognition of this ambiguity, in May 2021 the Norwegian Ambassador in Canberra stated that his country does not include land sector sequestration in its inventory because it would make it "too easy" to meet reductions targets.[12]

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[8] Department of Industry, Science, Energy and Resources (2021) *Australian Greenhouse Emissions Information System*. https://ageis.climatechange.gov.au/

[9] *Ibid*. (2021) *National Greenhouse Gas Inventory Quarterly Update: December 2020*, https://www.industry.gov.au/data-and-publications/national-greenhouse-gas-inventory-quarterly-update-september-2020

[10] Merzian & Hemming (2021) *Banking on Australia's Emissions*, https://australiainstitute.org.au/report/banking-on-australias-emissions/

[11] Iverson, Lee & Rocha (2014), *Understanding land use in the UNFCCC*, https://ghginstitute.org/wp-content/uploads/2015/04/Understanding_Land_Use_in_the_UNFCCC.pdf

[12] O'Malley (2021), Foreign diplomats hear critical report on Australian climate policy, https://www.smh.com.au/environment/climate-change/foreign-diplomats-hear-critical-report-on-australian-climate-policy-20210523-p57uf5.html

ENERGY EMISSIONS – A CLEARER VIEW OF THE SITUATION

While emissions from land clearing have fallen by 114 Mt CO_2-e since 2005, in stark contrast, emissions from energy generation in Australia have risen by 18 Mt CO_2-e over the same period. In 2018-19, the year of the most recent completed national emissions inventory, energy sector emissions (electricity generation, energy used on-site called stationary energy, and transport) accounted for 72 per cent of Australia's total emissions, having increased from 58 per cent in 2005.

It is no accident that the Australian Prime Minister and Minister for Emission Reductions choose to make broad generalisations about investments in some forms of renewable energy, and on Australia's track record of 'meeting its commitments' generally. It is to conceal the fact that Australia's energy emissions are rising, and that Australia has agreed to much weaker emission reduction targets than other wealthy countries.

To get a clearer picture of the true extent of Australia's climate performance, and efforts to genuinely decarbonise its economic activity, this paper focuses on Australia's energy transition since 2005 – the baseline nominated by the Australian government for its current targets. It also examines the amount of energy used in Australia and the emissions from those sources, and compares Australian investment in zero emission sources with the efforts of other countries.

For the world as a whole, and for each individual country, the faster and further the energy transition proceeds, the faster and further greenhouse gas emissions will fall.

The paper compares Australia's energy transition with the performance of 23 other comparable countries (all of which, with the exception of the Russian Federation, are members of the OECD). Transition performance is assessed in terms of ten indicators, covering emissions from energy generation, primary energy consumption, fuel mix for electricity generation, and transport emissions. Choice of indicators is limited to those which can inform understanding of energy transition progress and for which reliable and comparable data can be obtained on a consistent basis for all 24 countries. Readers will be able to use the indicators to form their own judgements as to whether Australia is indeed "playing its part in the global response to climate change", as Minister Taylor has claimed.

Methodology

THE COUNTRIES

Countries were chosen for the comparison with Australia based on GDP per capita in 2018, using World Bank figures[13] based on international purchasing power parity. Very small countries, such as Luxembourg, Singapore, Iceland and Malta, were excluded from the comparison, as were the petro-states of the Gulf, plus Brunei.

The list of countries then became Ireland, Switzerland, Norway, the USA, Denmark, the Netherlands, Austria, Germany, Sweden, Belgium, Australia, Finland, Canada, France, the UK, Italy, New Zealand, the Czech Republic (Czechia), Republic of Korea (South Korea), Japan, Spain and Portugal. Poland and the Russian Federation (Russia) were added because of their size, in terms of population, energy consumption and emissions, although they have a lower per capita income than a number of much smaller countries in eastern and south-eastern Europe, and a handful in other parts of the world. The list was therefore 23 OECD countries and the Russian Federation.

In terms of GDP per capita, Australia sits eleventh from the top, that is, close to the middle, of the selected list of 24 countries. Population data is for 2019, sourced from the United Nations Department of Economic and Social Affairs.[14]

In most of these countries, energy combustion emissions account for a larger share of total emissions than Australia (which sits at 72 per cent). Consequently, all countries are seeking to reduce emissions by changing their energy system through increasing supply from renewable sources and decreasing supply from fossil fuels, and by increasing the efficiency with which the energy supplied is used to deliver the energy services demanded by businesses and households. This change is becoming widely referred to as the energy (or energy system) transition.

THE INDICATORS

Ten indicators of progress in energy consumption and energy emissions transition have been quantified in terms of both their level in 2019 and the change between 2005 and 2019

[13] World Bank (2021), *Data Bank, GNI per capita, PPP*. https://data.worldbank.org/indicator/NY.GNP.PCAP.PP.KD. Accessed 3/05/2021.

[14] United Nations, Department of Economic and Social Affairs, Population Division (2021). *World population prospects 2019*.

(except for South Korea, for which emissions data is available only to 2016[15]). Every graph contains data for all 24 countries, and graphs are designed so that countries are displayed in order from left to right, with the values representing the most rapid or most advanced transition for the applicable indicator on the left, and the slowest or least advanced on the right.

The indicators can be explained as follows:

Primary energy consumption: The total primary (coal, oil, gas, renewables) energy demand of a country. It covers consumption of the energy sector itself, losses during transformation (for example, from oil or gas into electricity) and distribution of energy, and the final consumption by end users[16]. Primary energy consumption can be distinguished from final energy consumption, the total energy used by end consumers such as households and businesses. The emissions intensity of primary energy consumption (emissions per unit of primary energy) is a direct measure of how well a country is succeeding in decarbonising its energy system.

Total energy combustion emissions: The emissions from the combustion of fuels to generate electricity, the emissions from the combustion of fuels to generate steam, heat or pressure (other than for electricity and transport), and the emissions from the combustion of fuels for transport.

Primary energy productivity: The measure of the amount of economic output derived from each unit of energy consumed. Often confused with energy efficiency, energy productivity is the total value gained from using a unit of energy, while energy efficiency aims to use less energy to achieve the same, or increase, this economic output.

Non-fossil fuel share of electricity generation: The shares of electricity generated using primary energy resources other than fossil fuels. Non-fossil fuel electricity generation comprises both 'new' sources (primarily wind, solar and biomass) and 'legacy' non-fossil fuel generation (primarily hydro and nuclear)**.**

Transport emissions: The direct combustion of fuels for road, rail, domestic aviation and domestic shipping.

[15] The reason for this difference is that South Korea has less strict requirements for reporting annual emissions to the UNFCCC than the other countries, because it was classified as a non-Annex I country in 1997, under the Kyoto Protocol to the UNFCCC.

[16] Eurostat (2018), Glossary: Primary energy consumption, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Primary_energy_consumption#:~:text=Primary%20energy%20consumption%20measures%20the,final%20consumption%20by%20end%20users

THE DATA

Emissions data is taken from the UNFCCC *Detailed Greenhouse Gas Inventory Data by Party*, for which the most recent year available at the time of writing is 2018. Energy consumption data is taken from the *BP Statistical Review of World Energy 2020,*[17] for which the most recent available year is 2019. Although not an official source of data, this is a very longstanding and respected source. Importantly, it uses an input-equivalent basis for calculating the primary energy equivalent value of renewable and nuclear generated electricity. It is widely accepted that this method provides the best representation of the contribution that these energy sources make to the supply of useful energy.[18] The input-equivalent calculation approach, often called the substitution method, is explained in another report on energy transition indicators.[19]

[17] bp (2021), *Statistical Review of World Energy 2020*, https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html

[18] Finkel (2021), *Getting to zero: Australia's energy transition*, Quarterly Essay #81.

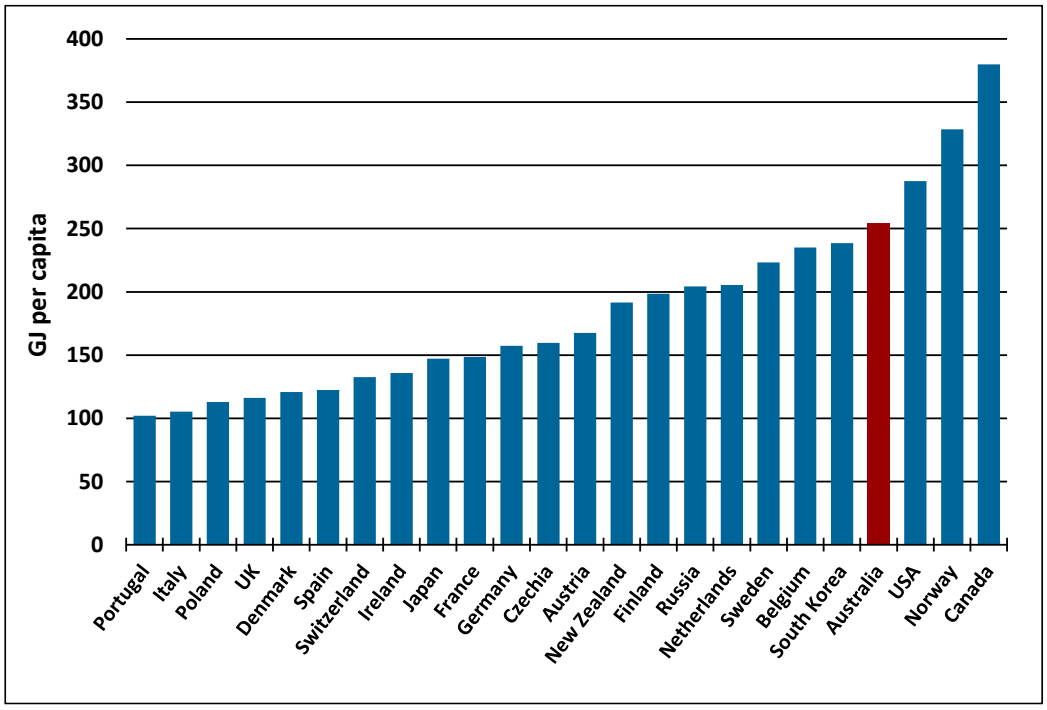
[19] Saddler (2021), *Australian energy transition indicators*. CCEP Working Paper 2106, Crawford School of Public Policy, Australian National University.

Total primary energy consumption

The data presented in this section highlight the amount of energy consumed in the 24 countries under examination. All of the data used in this section is based on use of the input-equivalent method for calculating renewable and nuclear energy.[20]

Figure 1 shows that in 2019 Australia had the fourth highest level of primary energy consumption per head of population of the 24 countries under examination, behind only Canada, Norway and the USA. High per capita energy consumption reflects both industry composition, energy productivity, and consumer choices.

Figure 1: Primary energy consumption per capita in 2019



While Figure 1 shows per capita energy consumption in 2019, Figure 2 shows how energy consumption per person has changed since 2005. It shows that Australia is unique in being the only country which is in the top four energy consuming nations to exhibit an increase in energy use per person over the period 2005-2019. Since 2005, primary energy consumption per person has increased by 1 per cent while it fell in Canada, Norway and the USA. Since 2005 the only countries to increase their energy consumption per person more than Australia were Russia, Poland and South Korea.

[20] Ibid (see for further discussion)

Of the four other countries which increased per capita primary energy consumption, three, Russia, Poland, and Portugal have the lowest levels of GDP per capita of the 24 countries being examined and South Korea, whose economy has grown much more rapidly than the other countries, still has a GDP per capita well below that of Australia.

Figure 2: Relative changes in primary energy consumption per capita, 2005 to 2019

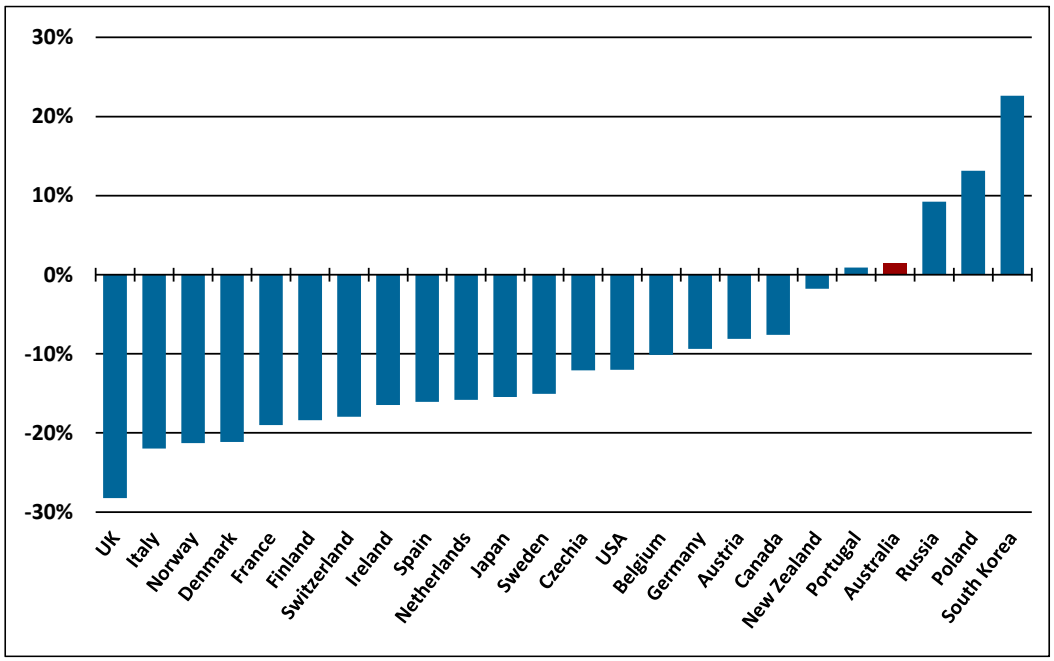
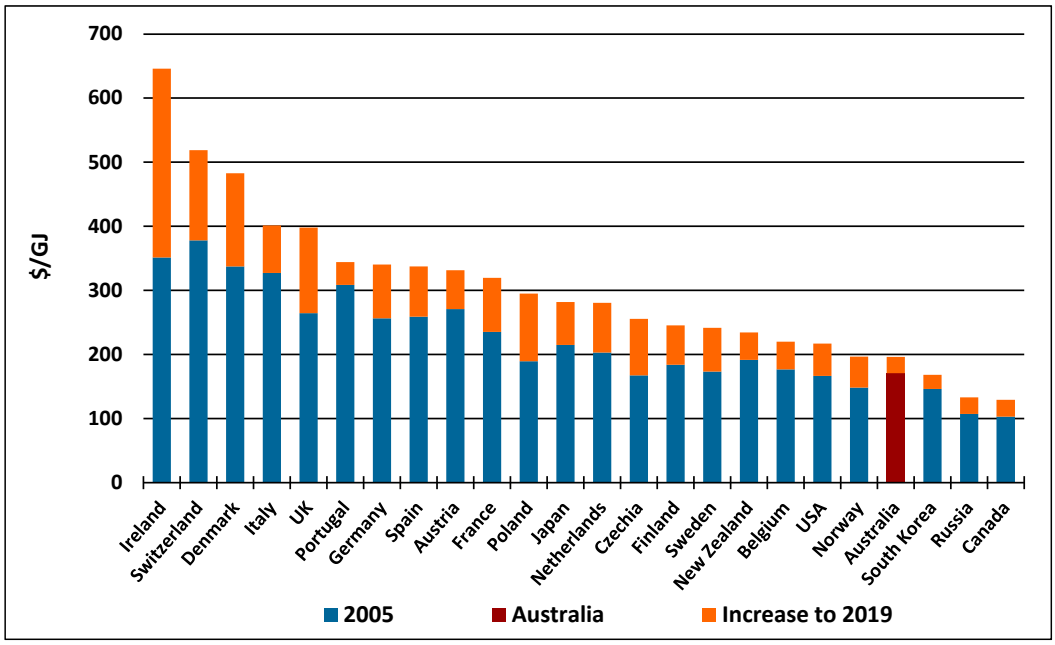


Figure 3 compares energy productivity, measured as dollars of GDP per GJ of primary energy consumed in 2005 and 2019. Both the changes in, and levels of, primary energy productivity show Australia's dismal performance even more clearly. In 2005 Australia ranked 18th out of 24 in primary energy productivity, while in 2019 it fell to 21st place in the ranking.

Figure 3: Primary energy productivity in 2005 and 2019



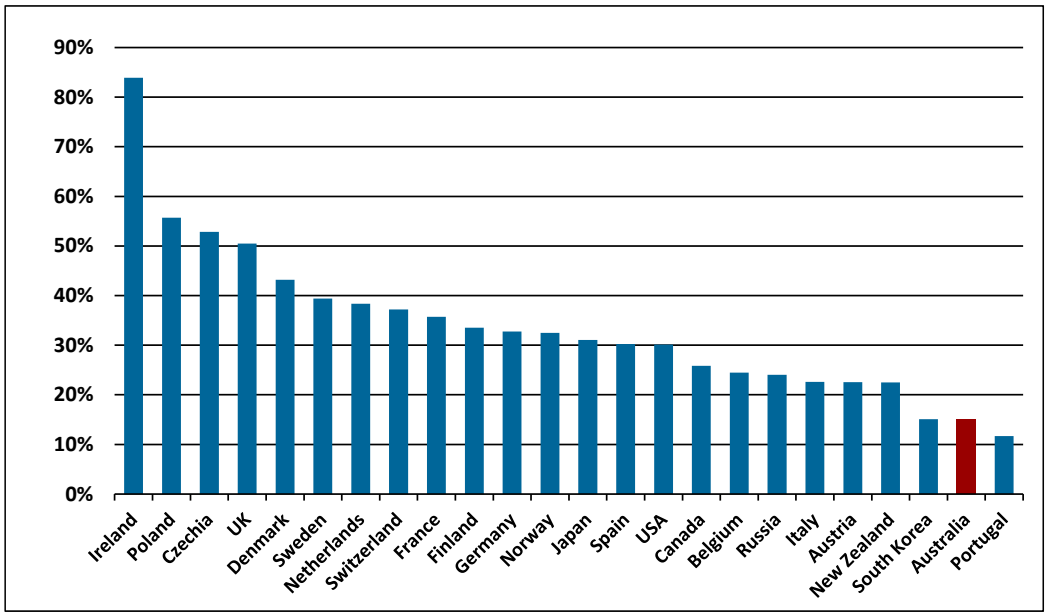
As Figure 4 shows, Australia's increase in energy productivity between 2005 and 2019 was second last in both absolute terms and relative to its level in 2005. Given this dismal background, it is no wonder that in 2015 the then Energy Council (the Australian Minister for Energy together with the corresponding state and territory ministers) adopted the *National Energy Productivity Plan*. The aim of this plan is to deliver a 40 per cent improvement in Australia's energy productivity by 2030 relative to 2015.[21] On the basis of the most recent available data, this is not going well, having increased by only 5 per cent[22] over the four years from 2015 to 2019.[23]

[21] COAG Energy Council (2015), *National Energy Productivity Plan 2015-2030*, https://www.energy.gov.au/government-priorities/energy-productivity-and-energy-efficiency/national-energy-productivity-plan

[22] Less than 4 per cent if the input equivalent method is used to calculate primary energy consumption

[23] Saddler (2020). *Energy productivity, gas consumption and employment: trends in the Australian economy 2008-09 to 2018-19*. CCEP Working Paper 20-08 Nov 2020, Crawford School of Public Policy, Australian National University.

Figure 4: Relative increase in primary energy productivity, 2005 to 2019



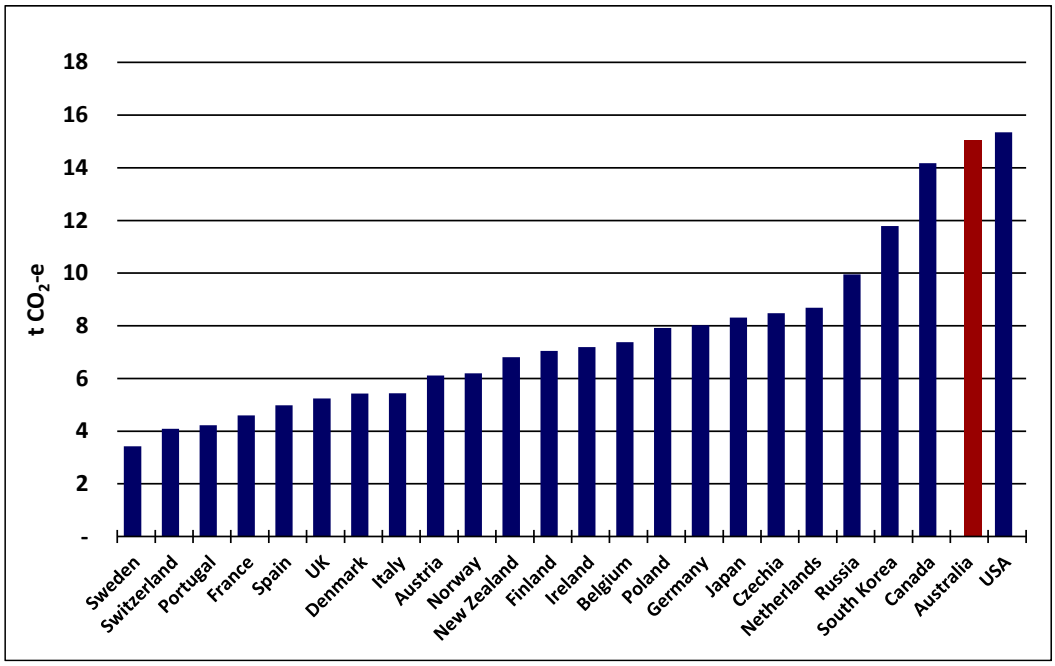
Total energy combustion emissions

Whereas the previous section compared the amount of primary energy consumed in Australia with 23 other countries this section considers the emissions associated with producing that energy.

Given that Australia has failed to reduce energy consumption on a per capita basis, and has rapid population growth compared to other developed countries, the only way for Australia to 'lead' other countries in terms of emission reductions would be for it to transition towards low and zero carbon sources of energy significantly faster than other countries. But as the following section shows, Australia not only lags behind other developed countries in reducing energy demand, but it also lags in decarbonising the production of that energy as well.

Australia has long been known as having some of the highest per capita greenhouse gas emissions in the world, and, as Figure 5 shows, this remains the case, with Australia second only to the USA as the country with the highest energy combustion emissions per capita.

Figure 5: Total energy combustion emissions per capita in 2019



Furthermore, Figure 6 shows that Australia is second only to Russia as the country with the highest energy combustion emissions per $ of GDP. It is important to note that in terms of GDP per capita Russia is at the bottom of the selected list of 24 countries, with a GDP per capita just over half that of Australia. The Australian economy, therefore, has by a wide margin the most emissions intensive energy system among OECD countries.

Figure 6: Total energy combustion emissions per $ of GDP in 2019

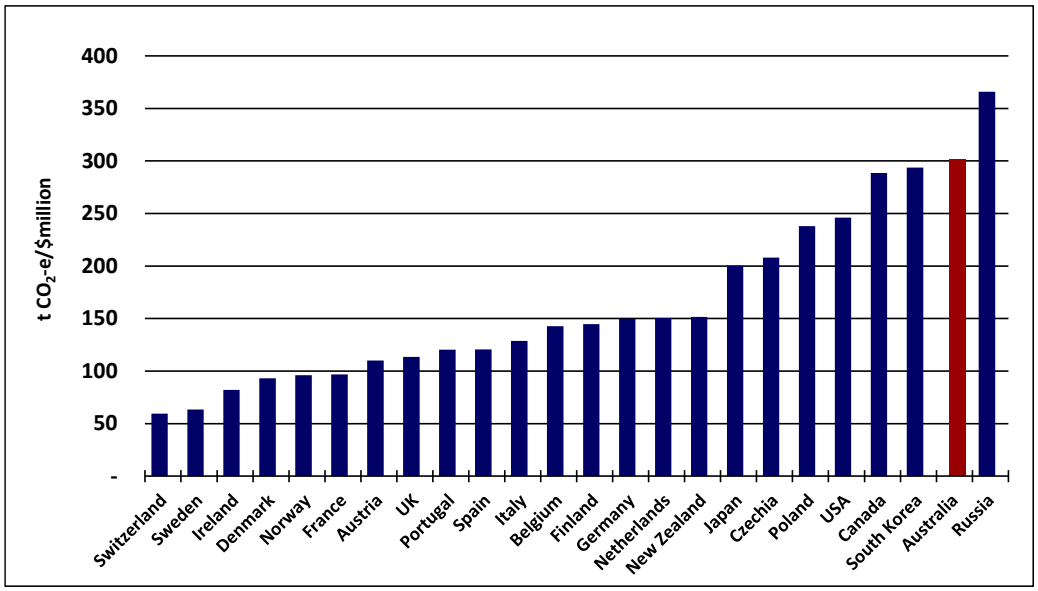
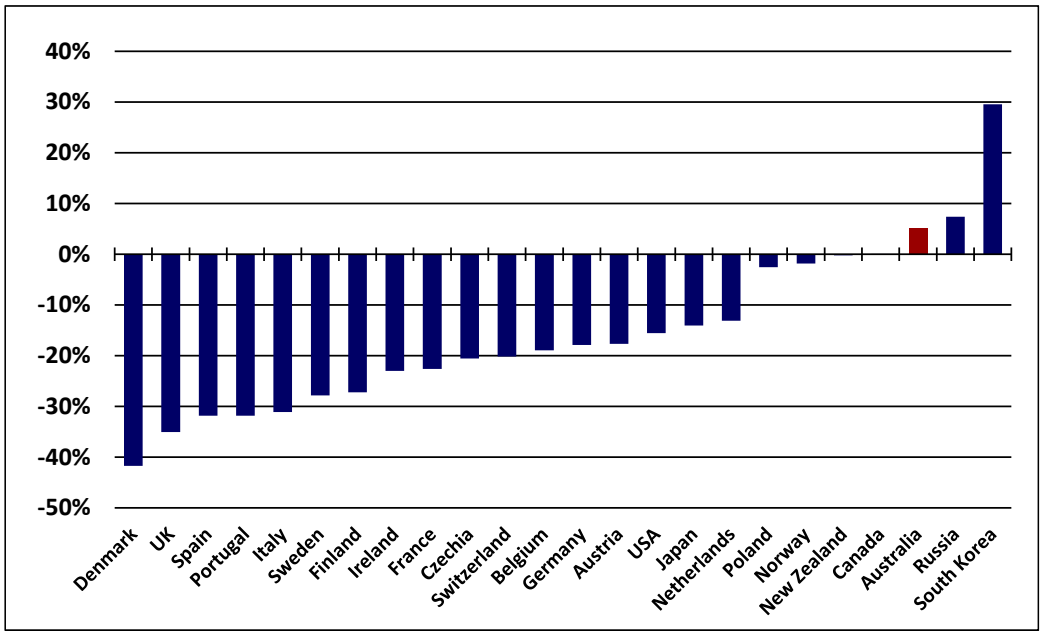


Figure 7 shows that among the 24 countries included in this comparative analysis, Australia was one of only four countries in which energy combustion emissions actually increased between 2005 and 2019. Australia's total energy combustion emissions increased by 5 per cent which is consistent with the increase in total energy consumption shown in Figure 2 and a small increase in zero emission generation described in the following section.

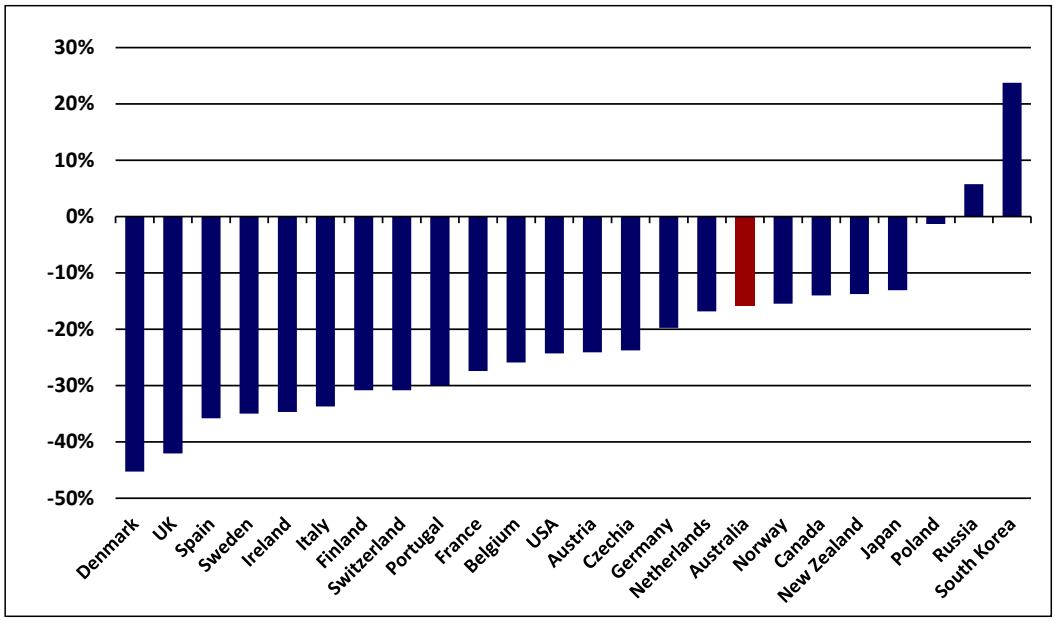
South Korea recorded by far the largest increase in energy emissions over the period from 2005. It is also the country which experienced much faster GDP growth, much faster growth in total primary energy consumption, and much faster growth in coal consumption over that period than any of the other countries to which Australia is being compared in this paper. In 2019 South Korea was the sixth ranked country in the world, in terms of coal consumption, though consumption did decrease in both 2018 and 2019.

Figure 7: Relative change in total energy combustion emissions, 2005 to 2019



Australia performs slightly better on a per capita basis due to the fact that it has a higher rate of population growth than any of the other counties in this analysis. That said, even on a per capita basis the reduction in Australia's total emissions from energy combustion are well below our Paris target of 26-28 per cent. Countries such as Denmark, the UK, Spain, Sweden, Ireland, Italy, Finland and Switzerland have all managed to reduce their per capita emissions from energy combustion by more than 40 per cent between 2005 and 2019. Australia is not even close to being a leader on this measure.

Figure 8: Relative change in total energy combustion emissions per capita, 2005 to 2019



Australia has also done somewhat better in reducing energy combustion emissions when measured on a per $ of GDP basis. That said, Australia still finds itself in the bottom one third of countries being examined in this paper. Given the data presented in Figures 5 and 6 that show Australia is among the worst emitters on a per capita and per $ of GDP basis, the rate of improvement shown in Figures 8 and 9 would need to be much higher if Australia was to make any meaningful claim to be a 'leader' in the decarbonisation race.[24]

Figure 9: Relative change in total energy combustion emissions per $ of GDP, 2005 to 2019

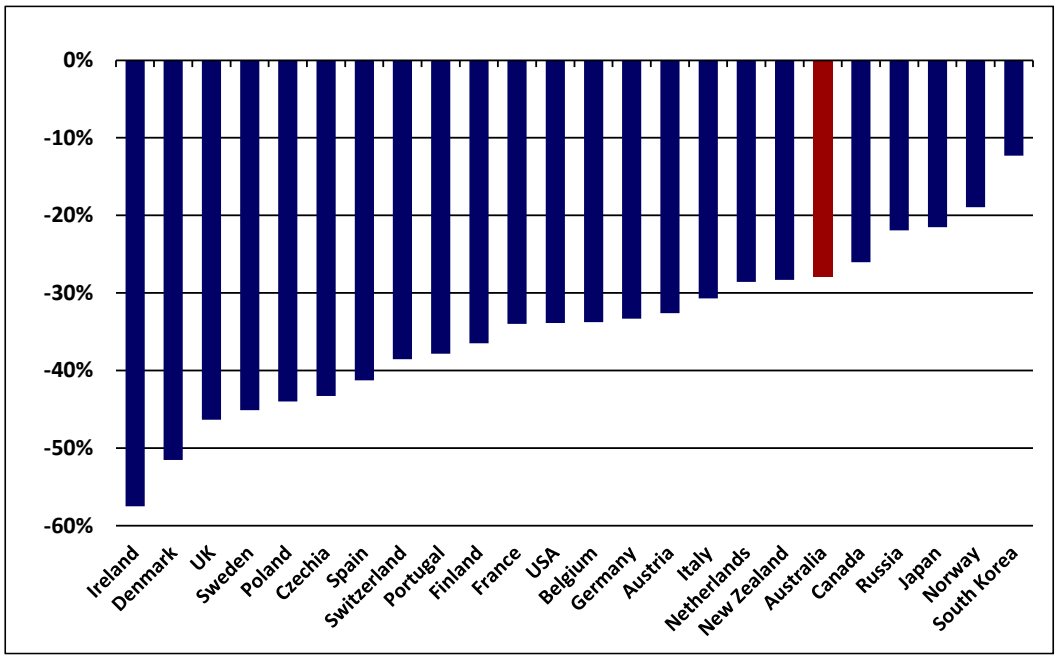


Figure 10 shows that in 2005 the emissions intensity of Australia's energy system was second only to that of Poland, primarily because both countries were, and still are, heavily reliant on coal for electricity generation, and to some extent for supplying industrial heat. In 2019 Australia was still second only to Poland.

[24] Note that the very large reduction shown for Ireland in Figure 5 is the result of using conventional GDP as a measure of income. Conventional GDP is widely considered to represent a misleadingly high estimate of the level of Irish domestic economic activity, because of some distinctive features of the Irish economy (see https://www.cso.ie/en/interactivezone/statisticsexplained/nationalaccountsexplained/grossdomesticproductgdp/). An adjusted GDP value would presumably result in a somewhat, though not drastically lower reduction value, but the required adjustment has not been undertaken for this paper.

Figure 10: Emissions intensity of primary energy consumption, 2005 and 2019

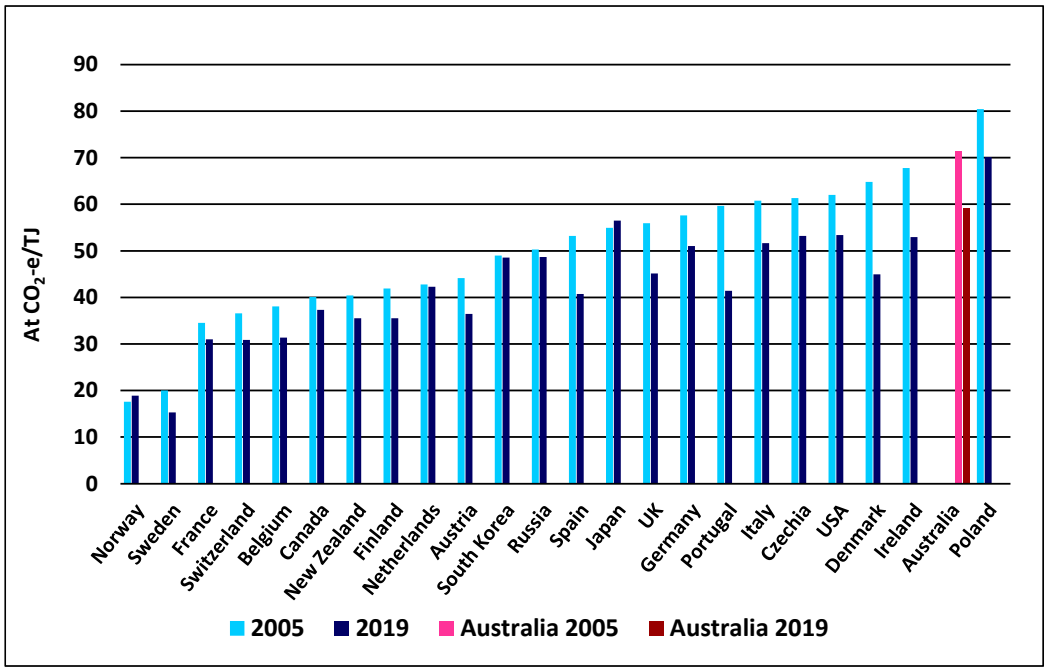
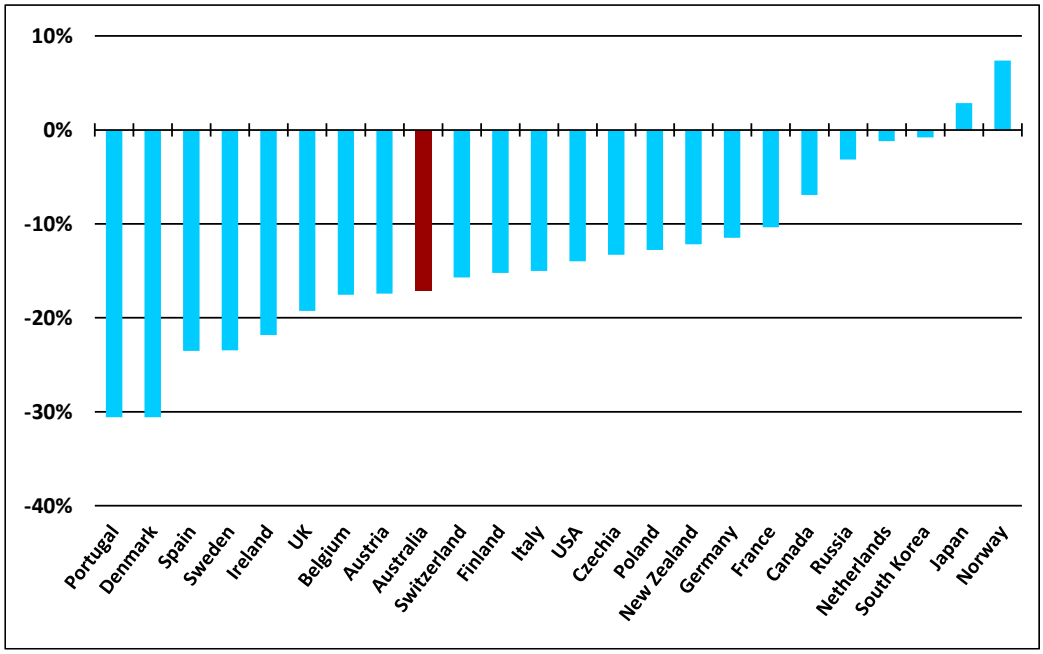


Figure 11 shows that Australia has achieved a larger relative reduction in the emissions intensity of its primary energy generation than many countries. While this is the only indicator in which Australia performs in the top half of the 24 countries being compared, Australia's improvement can in no way be described as 'leading' and, as shown in Figure 10, Australia's reductions in primary energy emission intensity come off a very high base. At the other extreme, the emissions intensity of energy consumption in Norway is extremely low – 19 kt CO2-e/PJ in 2019, compared with 59 kt CO2-e/PJ for Australia. This means that a small absolute increase in Norway's emissions intensity translates into a relatively large relative increase. As it happens, between 2005 and 2019 Norway decreased emissions from all sectors of its domestic energy consumption, including transport. A large increase in the volume of gas produced and processed for export was its only major source of energy emissions increase.

Figure 11: Relative change in emission intensity of primary energy consumption, 2005 to 2019

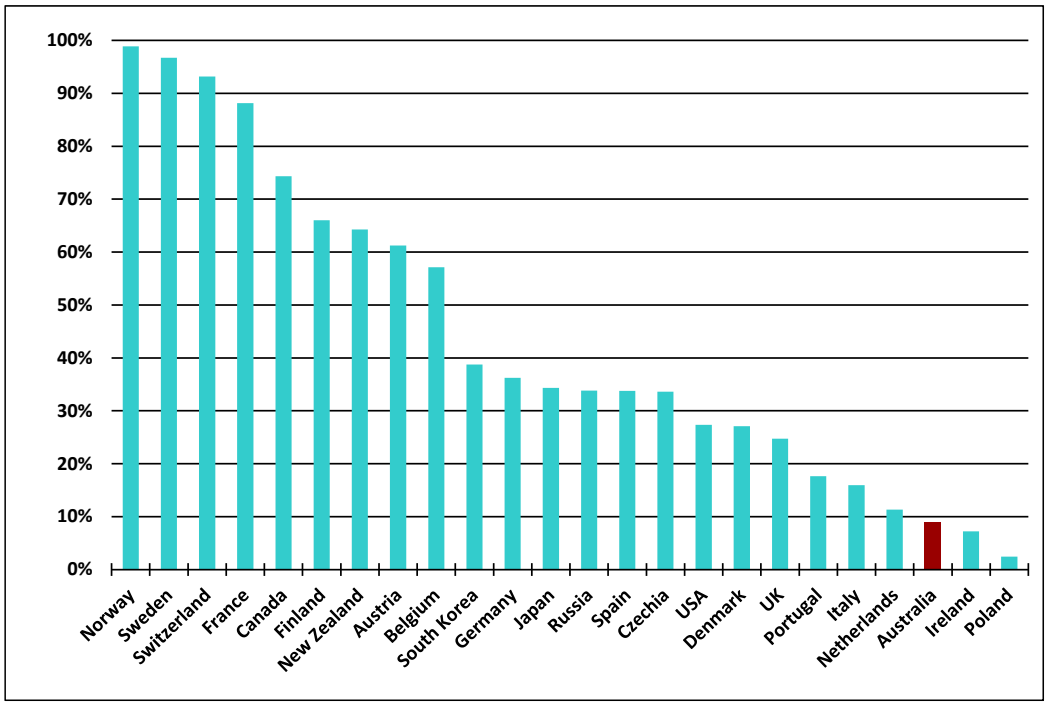


Shares of zero emission electricity generation

There is now near universal recognition amongst policymakers and analysts that the centrepiece of energy transition is increasing the share of zero emissions primary energy, meaning, in practice, renewable sources of primary energy. Since current technologies are technically and economically best able to supply renewable energy in the form of electricity, the transition will comprise two elements: increasing the share of renewable electricity generation and using electric technologies to replace direct combustion of fossil fuels for road transport and for the supply heat to buildings and to manufacturing activities, other than processes requiring very high temperature heat. To summarise, the transition towards a low (and eventually zero) emission energy system requires “greening” electricity generation and electrifying other energy consumption.

Figure 12 and Figure 13 show the shares of electricity generated in each country in 2005 and 2019 from primary energy resources other than fossil fuels. Non-fossil fuel electricity generation comprises both ‘new’ sources (primarily wind, solar and biomass) and ‘legacy’ non-fossil fuel generation (primarily hydro and nuclear). One or often both ‘legacy’ non-fossil fuel generation sources are the main sources of electricity in most of the countries with high shares of non-fossil fuel generation in 2005, as shown in Figure 12. These countries include Sweden, Norway, France, Switzerland, New Zealand, and Canada, but, notably, not Denmark. Australia’s modest hydro generation and very small wind generation in 2005 meant it ranked it 22nd in terms of its share of non-fossil fuel generation in that year.

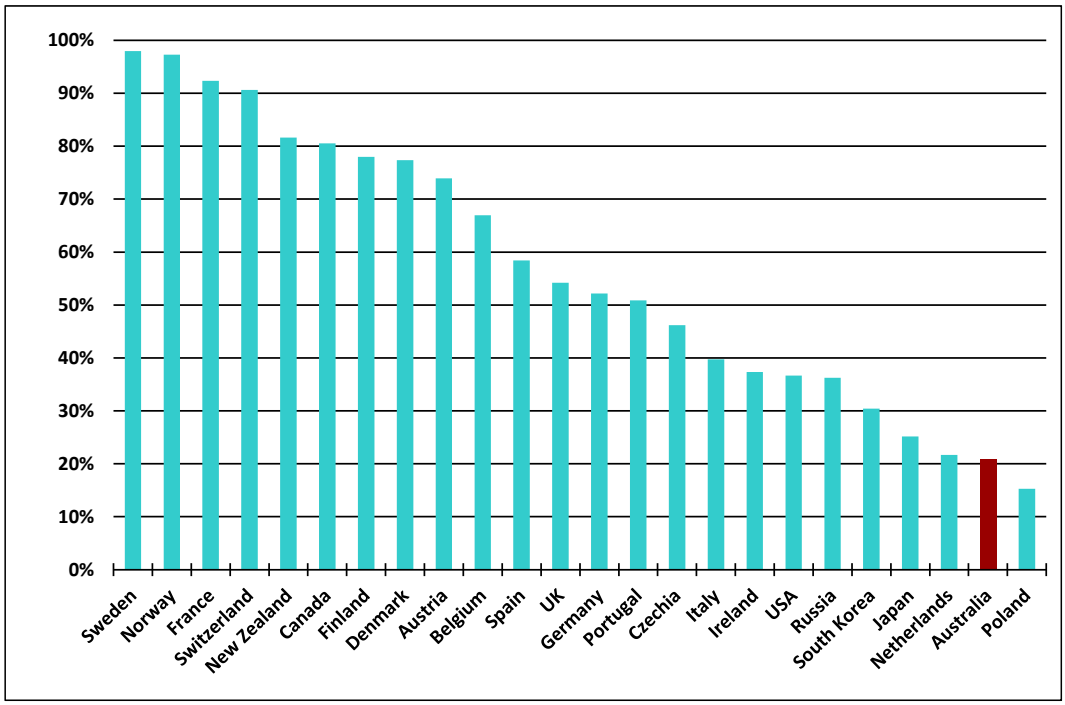
Figure 12: Non-fossil fuel shares of total electricity generation in 2005



By 2019 Australia's ranking, as shown in Figure 13, had fallen to 23rd; that is, the second lowest share of non-fossil fuel generation ahead only of the Netherlands and Poland. Both these countries have far smaller wind and solar resources than Australia, and Poland also has a much lower per capita GDP. The Netherlands used gas to supply 59 per cent of its electricity generation, while Poland depended on coal for 74 per cent of its primary energy, roughly the same as Australia. Both these countries also had lower non-fossil fuel shares than Australia in 2005.

In that year Norway, Sweden, France, Switzerland and Canada all had non-fossil fuel shares more than four times larger than Australia, i.e., above 80 per cent, compared with Australia's share of about 20 per cent. Of course, with the exception of Norway, these countries all have large legacy shares of nuclear generation. That should not be in any way be viewed as a justification for Australia's feeble performance. On the contrary, Australia should have been using the years since 2005 to catch up with these other countries in de-carbonising electricity generation. It is arguable that, based on the combination of the level of the non-fossil fuel share, and the increase in that share from 2005 to 2019, Australia has performed worse than any of the other 23 countries at reducing its dependence on fossil fuel generation.

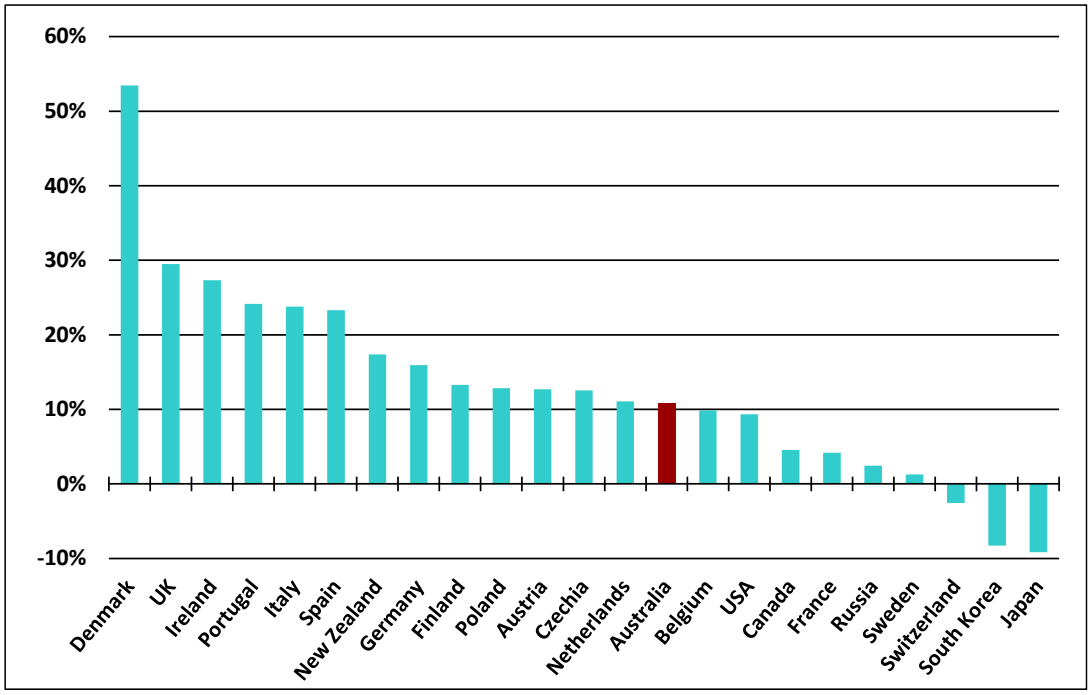
Figure 13: Non-fossil fuel shares of total electricity generation in 2019



Countries with high dependence on nuclear generation will face major challenges over coming years as their ageing nuclear plants have to be shut down. That is the same challenge which Germany and Japan are both currently addressing. Almost all of Japan's large fleet of nuclear power stations were closed in the aftermath of the Fukushima earthquake disaster, while Germany also decided to close about half of its nuclear stations on safety grounds. In Germany the share of nuclear generation fell from 26 per cent in 2005 to 12 per cent in 2019, while the corresponding fall in Japan was from 25 per cent in 2005 to 6 per cent in 2019. As Figure 15 shows, both countries have been increasing their shares of wind and solar generation, to offset the reductions in nuclear generation. Germany has been considerably more successful in this than Japan, and in 2019 ranked second only to Denmark in terms of its share of wind and solar (and also including some biomass) generation.

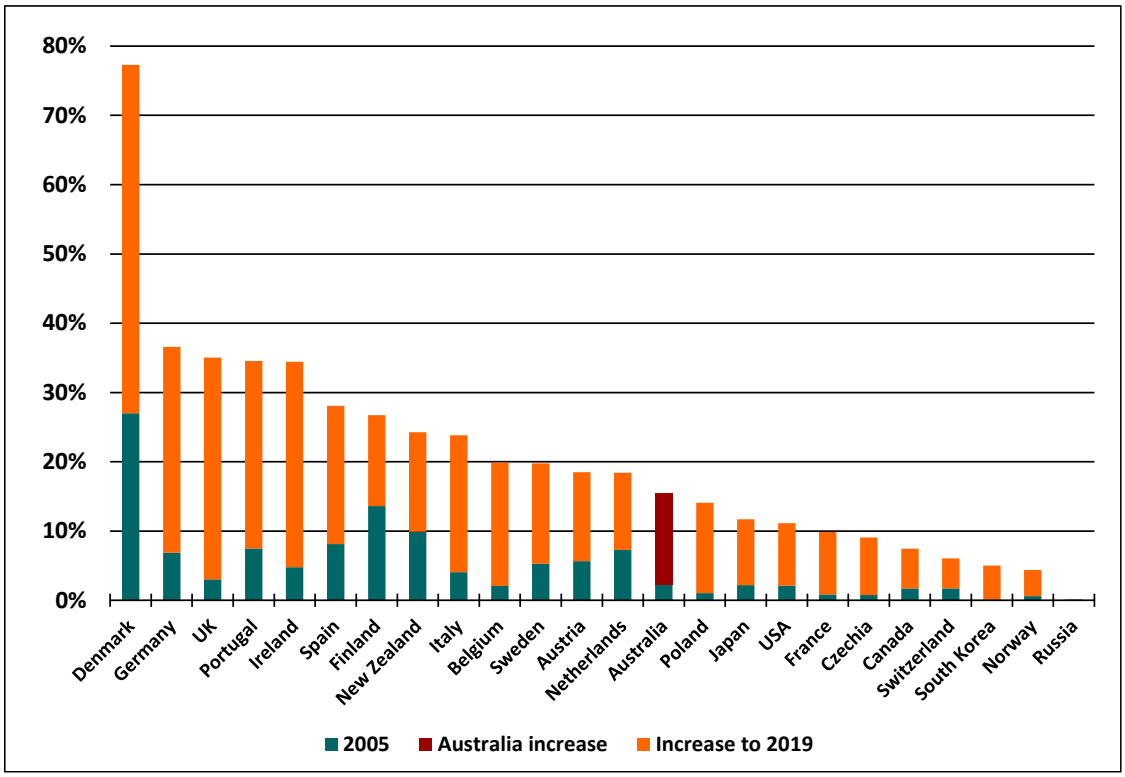
Figure 15 shows the growth in the share of generation from new renewable sources in each country between 2005 and 2019. As previously noted, new renewables in this context mean mainly wind and solar, but also include biomass and geothermal. Strictly speaking, neither biomass not geothermal are "new", though some European countries have increased biomass generation quite substantially in recent years. Currently, however, total generation from biomass is very much lower than generation from wind and solar in almost all countries, while New Zealand is the only country amongst the 24 in which geothermal account for a non-negligible share of generation.

Figure 14: Changes in non-fossil fuel shares of electricity generation between 2005 and 2019



Apologists for Australia's lacklustre performance in decarbonising its electricity system often claim that Australia has a strong record of growth in wind and solar generation. However, as Figure 15 shows, in 2019 Australia ranked 11th in terms of the increase between 2005 and 2019, and 14th out of 24 in terms of the total share of new renewable generation in 2019. Countries ahead of Australia include the UK, Ireland and Belgium, none of which have either significant solar energy resources, or expansive land areas, though they do have excellent offshore wind resources. Even Poland in 2019, normally regarded in Europe as a laggard in terms of decarbonisation due to its heavy dependence on coal, ranked only just behind Australia in 2019 in terms of its share of (mainly) wind and solar.

Figure 15: Shares of new renewables in total electricity generation, 2005 and 2019



Turning to the second element of transition to a low emission energy system, electrification of final energy consumption, Figure 16 shows a proxy indicator of electrification, the ratio of electricity generated in a country to total primary energy consumption. This is not a perfect indicator; it makes no allowance for electricity consumption differing from generation, because of cross-border transfers of electricity, and final energy consumption would be preferable to primary energy consumption. However, the preferred data are more difficult to extract and compile. While the absolute value of the ratio of electricity generation to total primary has no particular significance, relative values do have real meaning. All else being equal, a country with a higher ratio of electricity generation to total primary energy will have a higher share of electricity in total final energy consumption. Similarly, for an individual country, an increase in the ratio will be indicative of increased electrification of final energy consumption, and conversely for a decrease.

Figure 16 shows that Australia ranked 19th out of 24 for this indicator in 2019. Gas consumption is a key factor affecting this ratio. The highly ranked Nordic countries use very little gas, while the large volume of gas used to produce LNG is a major reason for Australia's low ranking. This is seen more clearly in Figure, where the fall in the ratio between 2005 and 2019 is undoubtedly the main reason that Australia is one of only four countries in which this ratio fell between 2005 and 2019.

Figure 16: Total electricity generation expressed as a share of total primary energy consumption in 2019

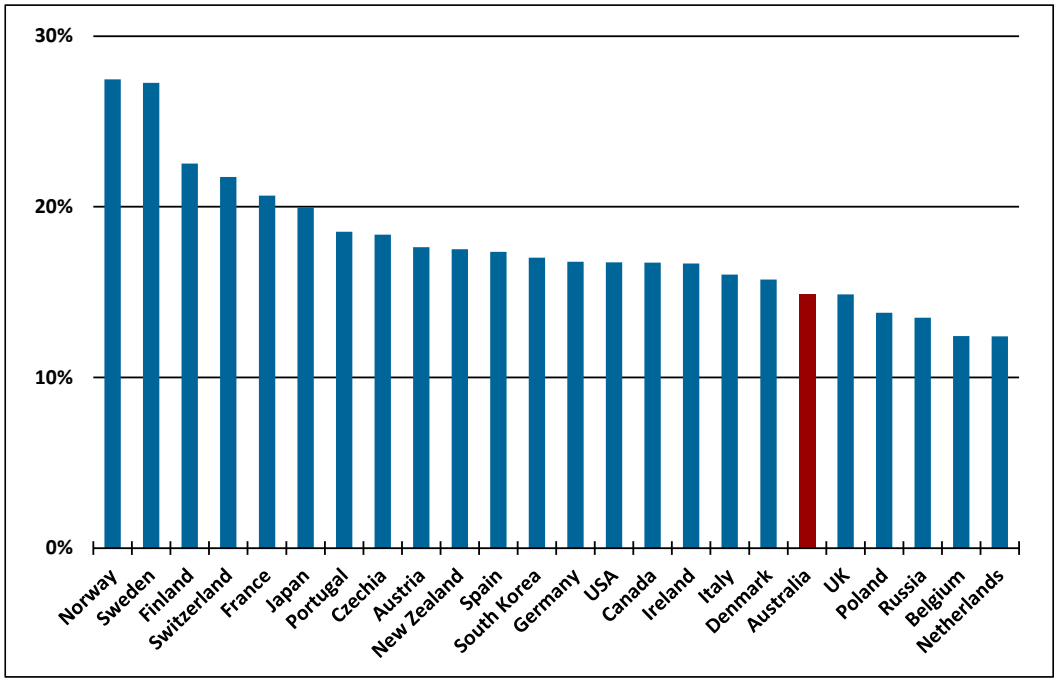
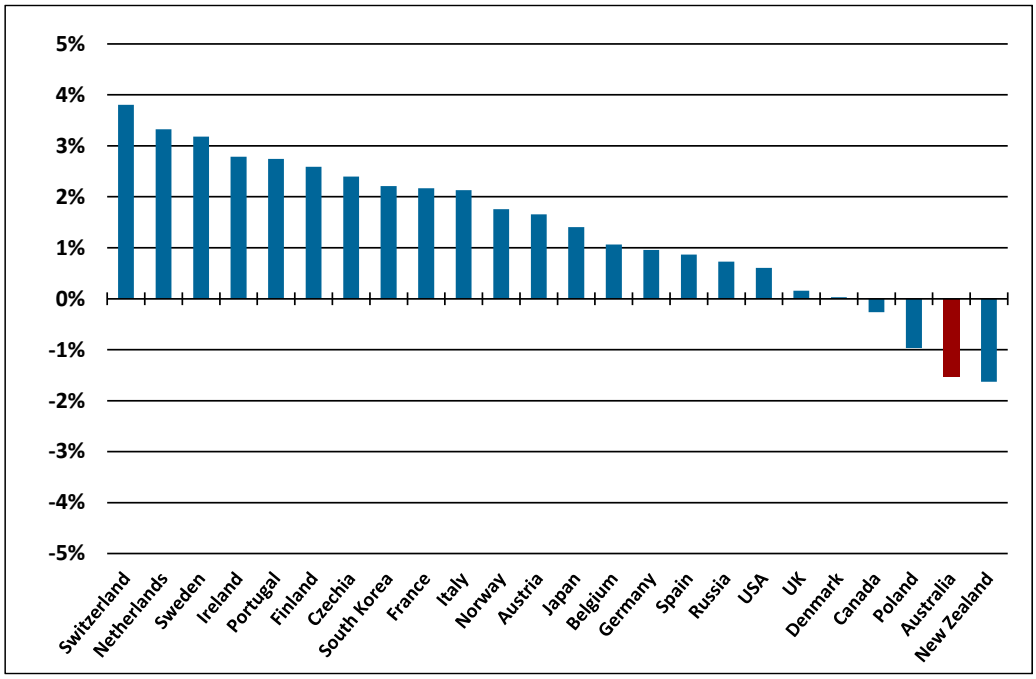


Figure 17: Change in the ratio of electricity generation to total primary energy consumption, 2005 to 2019

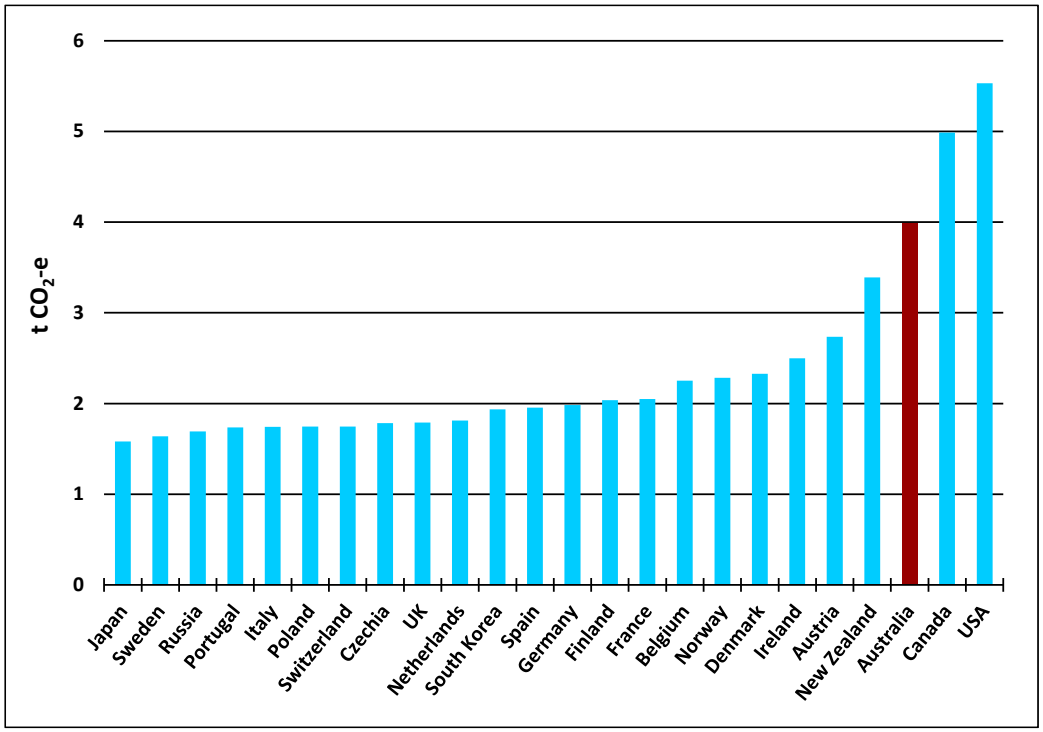


Transport emissions

Transport emissions are a large part of the energy combustion emissions of almost all countries, mainly because transport is dominated by road transport and, until now, road transport has been almost totally dependent on petroleum fuels as its source of energy. Per capita transport emissions vary widely between countries, largely because of differences in geographical extent and population density. However, whatever their level of per capita transport emissions, every country should be seeking to reduce emissions.

Figures 18 and 19 highlight changes in per capita transport emissions between 2005 and 2019. They show that most countries have succeeded in reducing per capita transport emissions, by amounts ranging from a high of nearly 29 per cent in Sweden to just slightly less than zero in Australia and Germany. Figure 18 shows that in 2019 Australia had the third highest per capita transport emissions, lower than only the USA and Canada.

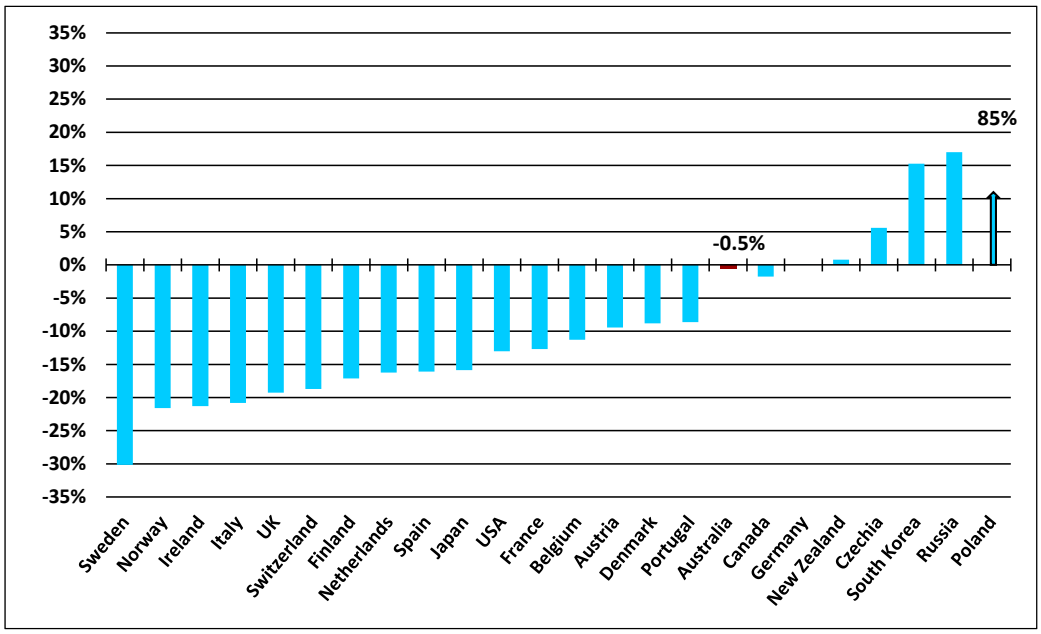
Figure 18: Per capita transport emissions 2019



However, despite having the third least efficient transport sector in the world, Figure 19 shows that Australia achieved a much smaller reduction in per capita transport emissions than either the USA or Canada between 2005 and 2019.

Again, it is noteworthy that most of the countries where transport emissions increased are those with much lower per capita GDPs than Australia. As with most of the other indicators, Australia stands out because it started with a poor level of performance in 2005 and achieved less improvement than any of the other poor performers.

Figure 19: Relative change in per capita transport emissions, 2005 to 2019

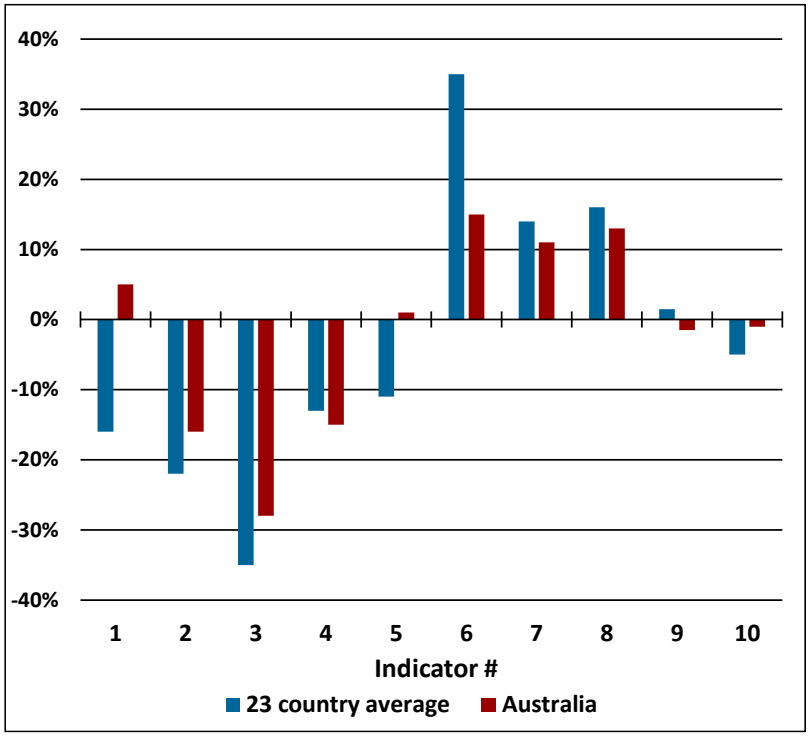


Conclusion

This paper compares Australia's energy transition and energy emissions reduction performance with the performance of 23 other countries.

Figure 20 shows Australia's performance, compared with the average performance of all the other countries, for the seven most important of the indicators examined in this paper. The indicators themselves, and their values, are listed in Table . In Table 2, the changes between 2005 and 2019 in the values of each of these indicators, plus two other indicators, are compared.

Figure 20: Australian performance against ten key indicators of energy transition, relative to 23 other high-income countries



Looking at Table 1, it can be seen that, for seven of the eight indicators listed, Australia's performance in 2005 ranked in the bottom quintile of countries, and this overall ranking was the same in 2019. Australia ranked higher for Indicator #7, the share of wind and solar generation in new electricity generation, but this was because a number of the lower ranked countries already had very high legacy shares of other sources of non-fossil fuel generation, mainly hydro and/or nuclear. These countries are therefore placing a higher priority on options for reducing emissions from other energy combustion sources, such as electrification of road transport.

Table 1: Performance ranking of Australia against 23 other countries for key indicator values in 2005 and 2019

	Indicator	Australia ranking	
		In 2005	In 2019
1	Primary energy consumption per capita	19	21
2	Primary energy productivity	18	21
3	Total energy combustion emissions per capita	23	23
4	Total energy combustion emissions per $ of GDP	23	23
5	Emissions intensity of primary energy consumption	23	23
6	Non-fossil fuel share of electricity generation	22	23
7	New renewables share of electricity generation	13	14
8	Transport emissions per capita	22	22

Table 2: Comparative performance of Australia and the other 23 country average for key energy transition change indicators

	Indicator	23 country average	Australia	Australia ranking
1	Relative change in primary energy consumption per capita	-11%	+1%	21st
2	Relative change in primary energy productivity	+35%	+15%	23rd
3	Relative change in total energy combustion emissions	-16%	+5%	22nd
4	Relative change in energy combustion emissions per capita	-22%	-16%	17th
5	Relative change in total energy combustion emissions per $ of GDP	-35%	-28%	19th
6	Relative change in emissions intensity of primary energy consumption	-13%	-17%	9th
7	Change in non-fossil fuel share of electricity generation	+14%	+11%	15th
8	Change in new renewables share of total electricity generation	+16%	+13%	14th
9	Change in the ratio of electricity generated to total primary energy consumed	+1.5%	-1.5%	23rd
10	Relative change in per capita transport emissions	-6%	-1%	17th

Turning to Table 2, it can be seen that Australia's performance ranks in the bottom quintile for five of the ten indicators, and in the bottom half for the remainder. In every case but one, Australia's performance was below average, which of course in the reason that its overall ranking in terms of all ten indicators was lower in 2019 than in 2005.

Against most of the indicators, the countries ranking lower than Australia are countries such as Russia and Poland, which have a much lower per capita GDP, and South Korea, which is a relatively newly industrialised country which has recently undergone rapid economic growth.

Considering the two sets of indicators separately gives a better understanding of how Australia compares with other countries.

Indicators measuring the level of performance in 2005 are heavily affected by the legacy of the energy system of each country in 2005, as well as the overall structure of its economy, in particular its reliance on energy intensive bulk material processing industries including primary metals, basic chemicals, pulp and paper, and cement and ceramic products. Geography and population density are more or less unavoidable legacies affecting, in particular, transport energy use and emissions.

Australia's energy system legacy is that in 2005 its share of coal in total primary energy supply was the second highest, at 45 per cent, behind only Poland amongst the 24 countries, and just slightly higher than the Czech Republic (Czechia). Its slowness in shifting away from coal is the reason that in 2019 it remained second only to Poland in emissions intensity of primary energy consumption. In terms of structure, Australia has a relatively heavy dependence on primary metal production. Since 2005 its dependence on energy intensive industries has increased with the expansion of the LNG industry and, to a lesser extent, ammonia production. It is the importance of energy intensive industries which largely explains why Canada, Russia, Norway, South Korea and Australia are the five countries with the lowest primary energy productivity. In Norway the main energy intensive industry, aluminium smelting, uses only hydroelectricity, which is the reason it has one of the least emissions intensive GDPs. In Australia, only the smallest of its four aluminium smelters uses hydro-electricity – the other three use exclusively coal fired electricity. Canada powers its numerous aluminium smelters almost exclusively with hydro, but highly emissions intensive oil sands processing is a very large source of greenhouse gas emissions,

The initial emissions intensity of the energy system and GDP is only indirectly relevant to a country's energy transition performance; it is the rate of emissions reduction which is of crucial importance. Table 2 shows that in most cases Australia has achieved a somewhat higher performance ranking for the indicators which measure size and rate of change since 2005. Nevertheless, a more detailed comparison of comparative performance shows that for all but one of the ten change indicators, Australia's performance is below the average level achieved by all the other 23 countries.