CLIMATE ANALYTICS

Evaluating the significance of Australia's global fossil fuel carbon footprint

July 2019

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Evaluating the significance of Australia's global fossil fuel carbon footprint

Report prepared by Climate Analytics for the Australian Conservation Foundation (ACF)

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Summary

Australia's share of global CO_2 emissions from domestic use of fossil fuels was about 1.4% of global fossil fuel combustion emissions in 2017. We find that accounting for fossil fuel exports lifts Australia's global carbon footprint from domestic use and export of fossil fuels to about 5%. This carbon footprint is equivalent to the total emissions of Russia, which is ranked the fifth biggest CO_2 emitter globally.

Australia is the world's largest coal (thermal + metallurgical) exporter, accounting for about 29% of traded coal globally in 2016 and will soon be the world's largest natural gas (LNG) exporter. As a consequence, Australia's global carbon footprint is very significant, with exported fossil fuel emissions currently representing around 3.6% of global emissions. In 2017, Australian coal and gas exports produced around 2.9% and 0.6% of global CO_2 emissions from fossil fuel combustion respectively.

Australia is one of the highest per capita CO_2 emitters in the world. On a per capita basis, Australia's carbon footprint, including exports, surpasses China by a factor of 9, the US by a factor of 4 and India by a factor of 37.

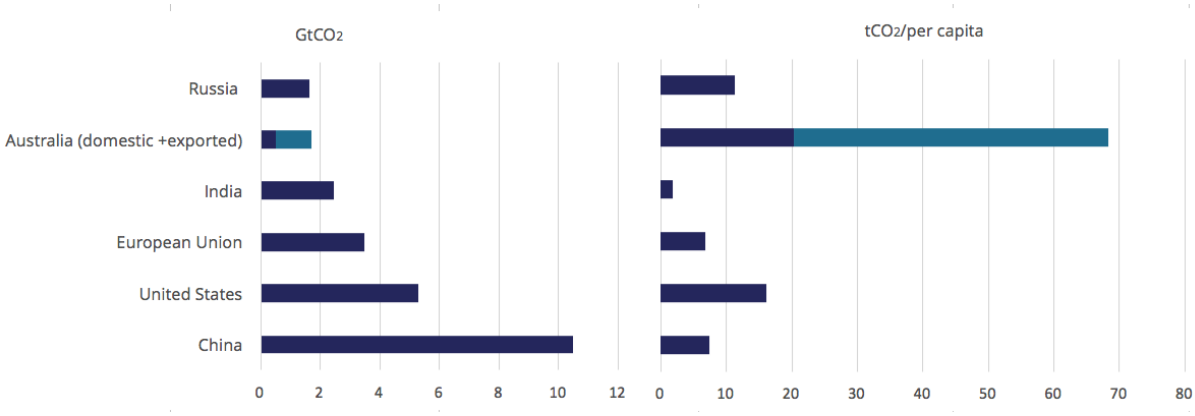


Figure 1 – Main CO_2 emitters 2017 total and per capita (exported emissions added for Australia in light blue). Values in the left panel correspond to $GtCO_2$ and values in the right panel are expressed as tCO_2 per capita.

The results of this analysis show that if current government and industry projections for fossil fuel exports are realised, Australia could be responsible (including both domestic and exported emissions) for about 13% (between 11.9% - 17.4%) of Paris Agreement compatible global CO_2 emissions in 2030[1]. By far the largest growth would be coming from coal exports.

[1] This estimate assumes a CO_2 emissions pathway with 45% reduction by 2030 from 2010 CO_2 emission levels. This is the median point in the IPCC 1.5°C scenario interquartile range of 40-59% and is used as a reference point throughout this report. . Values in brackets represent the upper and lower end of the interquartile range. (See Figure SPM.3b and CO_2 reductions in 2030 interquartile range of 40-59% reduction from 2010 levels, after peaking in 2020).

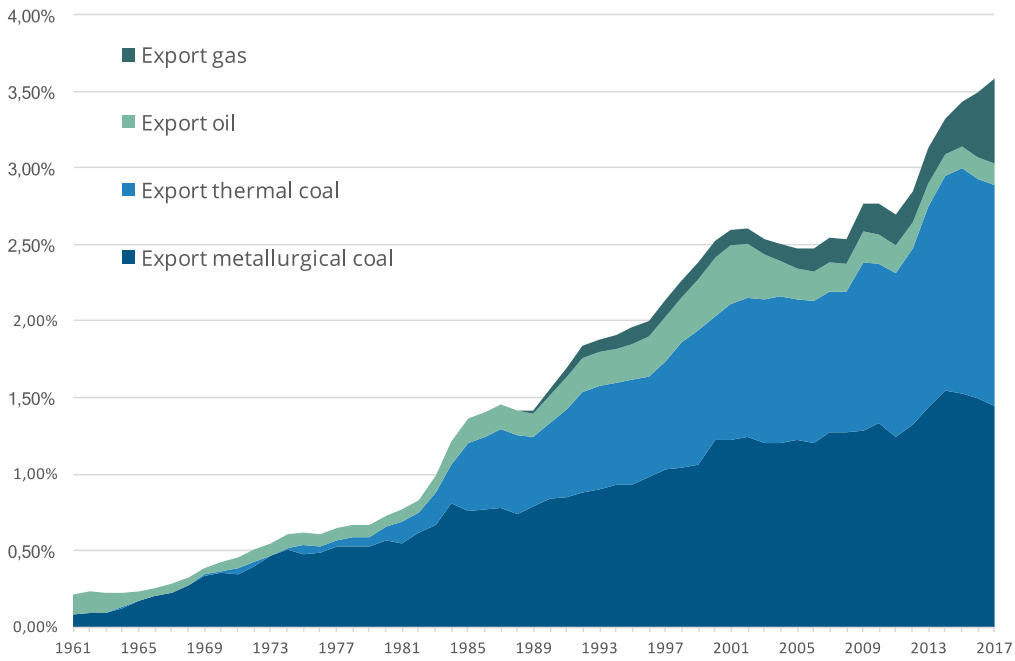


Figure 2 - Australia's exported emissions 1961-2017 as share of global CO_2 emissions from fossil fuels. Source: Climate Analytics' calculations based on nationally reported quantities of fuels consumed domestically and exported, national inventory emissions factors, and global CO_2 estimates from the Global Carbon Project.

Having ratified the Paris Agreement, Australia must reduce domestic greenhouse gas (GHG) emissions quickly to be in line with the climate treaty's long-term temperature goal. Contrary to this, Australia's emissions are increasing and will likely continue to increase through to 2030, falling far short of the current government's insufficient 26-28% reduction below 2005 target under the Paris Agreement. We find that Australia´s domestic total direct CO_2 emissions from fossil fuel combustion (excluding fugitive emissions) will be about the same as 2005 levels by 2030. Including fugitive emissions, the emissions from fossil fuel use are projected to be about 15% higher by 2030 than in 2005.

Fugitive emissions from the production (extraction and processing) of coal, gas and oil accounted for about 35% of the emissions growth (excluding land use change and forestry) in the period from 2005 to 2017, making it the second largest source of emission growth after the transport sector. The largest source of fugitive emissions increase in this period has been from the expansion of LNG and gas production. LNG production in Australia has grown rapidly and could double its contribution to global emissions compared to present levels by 2030.

Fugitive emissions are projected to increase by around 32% by 2030 above 2017 levels, with the largest growth coming from expansions of coal extraction and the second largest coming from scaling up of LNG production. This is higher than the December 2017 government projections, primarily due to government projections assuming lower (and likely less realistic) methane loses[2] in natural gas extraction than in our calculations.

Meeting the Paris Agreement's long-term temperature goal of keeping warming well below 2°C and pursuing efforts to limit warming to 1.5°C means that carbon dioxide (CO_2) emissions from

[2] Current greenhouse gas inventory estimates for fugitive emissions in Australia assume a much lower leakage rate of 0.48% (without venting or flaring) and 0.59% (with venting and flaring) than current international estimates.

fossil fuels need to peak soon and decline rapidly afterwards. According to the IPCC 1.5°C Special Report, CO_2 emissions globally need to be 40-59% below 2010 levels (33- 54% below 2005 levels) by 2030 under scenarios compatible with the 1.5°C limit. Projecting forward, it is important to ask: what fraction of Paris Agreement compatible global CO_2 emissions is Australia planning to put on the market internationally?

Because CO_2 emissions need to be decreasing under a Paris Agreement compatible scenario, each tonne of carbon dioxide that Australia places in the international market will take a greater share of the allowed emissions in each subsequent year. If a global reduction in CO_2 emissions close to the median projected by the IPCC in 2030 were realised — 45% (from a range of 40% - 59%) reduction below 2010 levels or 38% below 2005 levels — then, under present policies and export projections, Australia would be responsible for about13% (between 11.9% - 17.4%) of Paris Agreement compatible global CO_2 emissions in 2030. Australia's fossil fuel exports would be responsible for about 10.4% (between 9.5% - 13.9%)[3]. By far the largest growth would be coming from coal (thermal and metallurgical) exports, which could be responsible for as about 8.1% (between 7.4% - 10.9%) — of which 3.9% corresponds to thermal coal — of Paris Agreement compatible global emissions in 2030, followed by LNG with about a 1.8% (between 1.7% - 2.4%) responsibility.

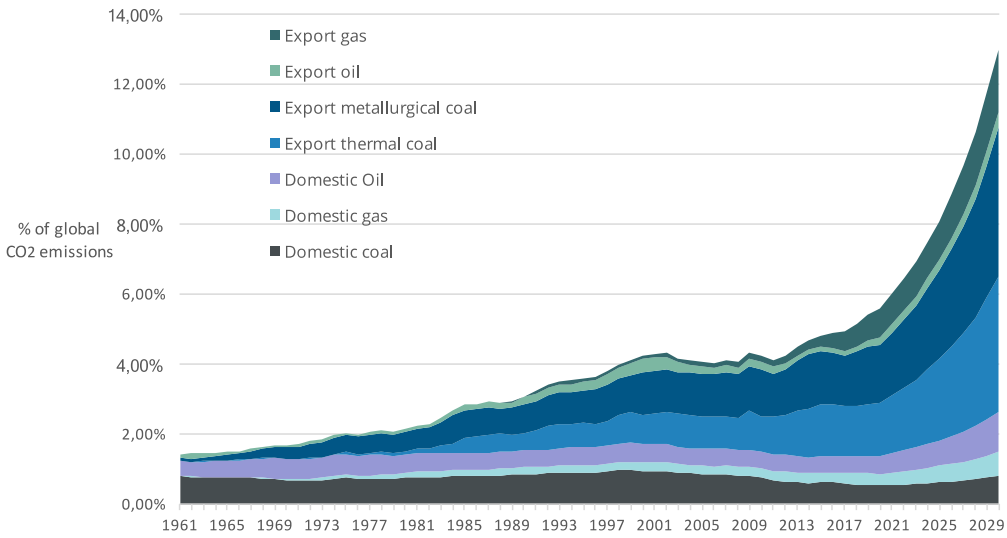


Figure 3 - Australia's domestic and exported emissions as share of global emissions. The percentage of global emissions prior to 2017 are historical and with respect to global CO_2 emissions from fossil fuels in each year as estimated by the Global Carbon Project. After 2017 emissions are based on domestic and export projections as described in the report and are expressed with respect to a global CO_2 emissions pathway consistent with the Paris Agreement 1.5°C limit as reported in the IPCC Special Report on 1.5°C. This emissions pathway indicates a range of 40-59%, with a median point of 45% reduction in CO_2 emissions by 2030 from 2010 levels. In addition to CO_2 combustion emissions, fugitive CO_2 and methane (CH_4) emissions related to fossil fuel production and use in Australia are included.

Against this background, an important question is whether it is at all plausible that Australia's presently projected fossil fuel exports can be absorbed by a global market that is implementing the Paris Agreement?

[3] Central estimates assuming a CO_2 emissions pathway with a 45% reduction by 2030 from 2010 CO_2 emission levels, which in line with the IPCC 1.5oC scenario interquartile reductions (See Figure SPM.3b and CO_2 reductions in 2030 interquartile range of 40-59% reduction from 2010 levels, after peaking in 2020). Values in brackets represent the upper and lower end of the interquartile range.

For coal the answer is clearly that these projected exports cannot be absorbed. Thermal coal is projected to exit the power market rapidly as the world implements the Paris Agreement. Overall, the IPCC 1.5° Special Report found that Paris Agreement compatible energy transformation pathways reduced total primary energy contribution from coal by 59 -78% below 2010 (53-75% below 2005) levels by 2030 (IPCC, 2018). For OECD countries, the reductions in coal generation need to be much faster, reaching close to zero levels by 2030 (Climate Analytics, 2016). Assuming the mid-range of these reductions, the projected 2030 emissions from the forecasts of Australian coal exports (thermal and metallurgical) amount to about 32% (between 25% - 46%) of the estimated Paris Agreement compatible emissions from coal[4] for that year[5].

With international coal trade representing about a fifth of total coal demand, a substantial reduction in global coal use as required by the implementation of the Paris Agreement will likely quickly force a decline in the need for countries to import coal. The major expansion of demand for thermal coal projected by Australia (Australian Government (BREE), 2014; Department of Industry Innovation and Science, 2018)
is completely inconsistent with global implementation of the Paris Agreement.

A more nuanced picture emerges in relation to the LNG market and the Paris Agreement implementation. It is broadly expected that over the next decade, natural gas demand in the power sector globally will remain close to or slightly below present levels before beginning a decline from the late 2020s. Furthermore, Australia's LNG exports in 2030 would be about 4% of the estimated Paris Agreement compatible emissions from natural gas[6] for that year[7]. This implies that while the market may soften for LNG, it is not implausible that the market could absorb Australia's projected LNG exports while implementing the Paris Agreement through 2030. Beyond 2030 this seems much less likely.

The market for natural gas in the power and heat sectors will likely decline rapidly from the 2030s, as the world meets the Paris agreement goals. In other words, there is a transitional role for gas, but it is limited and does not require further expansion of gas production capacity. This implies that the exploration for additional reserves that Australia is planning in response to their expected large scale demand beyond the late 2020s will very likely become a stranded asset under Paris Agreement implementation.

In this context, the expansion in the exploitation of fossil fuel resources that Australia is planning goes against the global efforts to combat climate change and is not consistent with the global energy transition required to meet the Paris Agreement goals. The majority of the existing global fossil fuel reserves should remain on the ground.

Australia's focus on coal and gas-intensive development stands in stark contrast to its high vulnerability to climate change. Significant impacts of climate change are projected already internationally and for Australia for a warming of 1.5°C above pre-industrial levels, including

[4] Assuming a 69% reduction which is the middle point of the IPCC 1.5°C compatible scenario interquartile reductions (59 -78% below 2010 levels by 2030). Values in brackets represent the upper and lower end of the range.
[5] The projected cumulative coal export emissions over the period from 2019 to 2030 would amount to about 12% of the total Paris Agreement compatible cumulative coal related CO_2 emissions for the same period and 4% of total cumulative fossil fuel Paris Agreement compatible CO_2 emissions.
[6] Assuming stabilisation of emissions from gas at 2010 levels by 2030.
[7] For LNG exports, we follow a conservative approach and scale up the last reported yearly exports (2016-17) until 2030, using the growth rate of the LNG processing capacity. Using this methodology, we get to slightly lower total export figures than the official AEMO projections (94,7 Mt vs 95Mt in 2030). The projected cumulative gas export emissions over the period from 2019 to 2030 would amount to about 4% of the total Paris Agreement compatible cumulative gas related emissions for the same period and 1% of total cumulative fossil fuel Paris Agreement compatible CO_2 emissions for the same period.

temperature extremes, extreme precipitation and dry spells, water availability, crop yield reduction risks for major staple crops, coral reef bleaching and increased risk of flood due to extreme precipitation and sea-level rise. The IPCC 1.5 SR has shown that the future climate-related risks and impacts are substantially larger if global warming exceeds the 1.5°C temperature limit, which enables greater opportunities for adaptation in the human and ecological systems. Under scenarios with higher warming, some impacts may be long-lasting or irreversible, such as the loss of some important national and international ecosystems like the Great Barrier Reef and loss and extinction of thousands of fauna and flora species.

Analytical Approach

We evaluate carbon dioxide (CO_2) combustion and fugitive CO_2 and methane (CH_4) emissions from the production of coal (thermal and metallurgical), oil and gas in Australia since 1961 and compare this to global fossil fuel related CO_2 emissions since that time. CO_2 emissions from combustion of these fuels are estimated using Australian specific emission factors unless otherwise indicated.

Consumed and exported quantities

For historical quantities of fuel used domestically and exported, we rely on the latest version of the Australian Energy Statistics), which provide information for all fuels for the period 1961-2017[8]. For exports we use Table N - energy exports, by fuel type, and we derive the domestic consumption as the residual from the total production (Table I1) after subtracting quantities exported (Table N). This mass-based approach to estimate domestic consumption results in slightly higher but more accurate domestic emissions estimates than the ones that would be derived from the net energy consumption by fuel in PJ (Table D).

For domestic coal use until 2030 we use fuel specific electricity sector projections in the official December 2017 GHG projections and based on recent trends we assume coal use outside the power sector constant at recent levels. For coal export projections we rely until 2020 on the Government Projection Quarterly update for September 2018 (Department of Industry Innovation and Science, 2018). For the period 2020-2030, in absence of more recent official projections, we apply the growth rates projected by Australian Energy Projections to 2050 (Australian Government (BREE), 2014).

For natural gas, projections for domestic use until 2030 are drawn from Australian Energy Market Operator (AEMO) "2018 Gas Statement of Opportunities" for Eastern Australia (AEMO, 2017b) and the "WA Gas Statement of Opportunities - December 2017" (AEMO, 2017a). For LNG exports, we follow a conservative approach and scale up the last reported yearly exports (2016-17) until 2030, using the growth rate of the LNG processing capacity. Using this methodology, we get to slightly lower total export figures than the official AEMO projections (94,7 Mt vs 95Mt in 2030).

For oil exports, while according to the most recent official projections, Australia's oil export volumes are expected to increase slightly until 2020, supported by rising condensate output at new LNG projects (Department of Industry Innovation and Science, 2018). For this report we follow a conservative approach and assume oil derivatives exports (except for LPG) remain at current levels until 2030. For condensate and LPG, until 2020 we use the projections from the Resources and Energy Quarterly Update (September 2018) and after 2020 we assume the maximum output from the LNG processing capacity.

Emissions estimates

For coal combustion, we use Australia's national inventory fuel specific CO_2 emission factors. Fugitive CO_2 emissions for coal are inferred from Australian emission inventories and we include these emissions in the national emissions footprint, whether the coal is used domestically or not. We also estimated fugitive CH_4 emissions from coal mining using national inventory information.

[8] See Tables and Annexes for update 2018: https://www.energy.gov.au/publications/australian-energy-update-2018

For natural gas we use national inventory CO_2 emission factors for gas used domestically and for LNG export we apply the approaches developed in exploring the carbon footprint of Western Australia gas extraction and the NT gas inquiry, which account for CO_2 losses from reservoirs and for methane related losses (see for instance: Western Australia's Gas Gamble - Implications of natural gas extraction in WA).

Natural gas used for LNG production and emissions associated with these resources (all CO_2 combustion emissions, reservoir and fugitive CO_2 emissions, and a share of CH_4 emissions) are included in the domestic emissions footprint. Reservoir CO_2 emissions are estimated based on reservoir specific factors for historical emissions, and for projections an Australia average factor is used. Emissions from the combustion of LNG, along with transport losses, and a share of CH_4 emissions are assigned to the export emissions footprint of Australia. For CH_4 emissions from natural gas production we use the IEA global estimate of 1.7% losses, recognising that loss rates could be higher or lower, but that data is quite uncertain. This produces larger fugitive emissions than in the Australian inventories however several lines of evidence indicate CH_4 loss rates are higher than presently estimated.

Current greenhouse gas inventory estimates for fugitive emissions in Australia assume a much lower leakage rate of 0.48% (without venting or flaring) and 0.59% (with venting and flaring) than current international estimates. The Northern Territory Scientific Inquiry into Hydraulic Fracturing has expressed concern that present inventory estimates appear too low, stating "These values underestimate field based measurements, which range from 1.6 - 1.9%. Further research is required to better understand the differences between these inventory and field based estimates". The International Energy Agency estimate a global average methane leakage rate of 1.7%. For reference, a loss rate of 0.5% for CH_4 would produce similar overall fugitive emissions as are found in recent Australian inventories and government projection data sources.

For oil and oil products we apply standard national inventory CO_2 emission factors for combustion, and use a similar method as for natural gas to estimate reservoir and fugitive CO_2 losses. We have also estimated fugitive CH_4 emissions from oil production based on national inventory information and our own analysis for projections.

Our approach estimates total fugitive emissions at 19% higher for the period 1990-2017 than the estimates contained in the December 2017 government projections. The approach taken here to estimates fugitive CO_2 and CH_4 emissions from oil, gas and coal production with the reported national inventories, including data in the most recent projections for fugitive emissions over the historical period.[9]. For the projection period (2018-2030) however, the differences between the national projections and our approach are much bigger, with our cumulative estimates being 100% higher[10] than the official projections. The main driver behind this difference is the higher methane losses from natural gas production (1.7%) than assumed in the national inventory, which as discussed above may reflect better field based estimates.

Putting together the figures described above, we estimate Australia's total contribution to global carbon dioxide emissions from both its domestic use, fossil fuel production and export.

[9] Applying a 0.5% CH_4 loss rate within our methodology results in total fugitive emissions about 10% lower for the period 1990-2017.

[10] Applying a 0.5% CH_4 loss rate within our methodology results in total fugitive emissions about 46% higher for the period 2018-2030 than the December 2017 government projections.

In the second stage, we evaluate how Australia's projected expansion of fossil fuel exports - coal and natural gas - compare with the trajectory of the needed emission reductions under the Paris Agreement for carbon dioxide. The IPCC Special Report on 1.5°C indicated that CO2 emissions need to decline by 40-59% percent by 2030 from 2010 levels (33- 54% below 2005 levels) (IPCC, 2018). To estimate the projected share of global emissions for Australia, we assume a median point 45% reduction below 2010 levels by 2030 (38% below 2005 levels), which falls within the IPCC interquartile reductions. The figures in this report use the central estimate which is a 45% reduction, but for reference, we also provide (values in brackets) the estimates for the upper and lower end of the IPCC interquartile range.

Results for domestic emissions from fossil fuels combustion

We have projected domestic emissions of coal, oil and gas under current policies to 2030 using the same approach described above for historical emissions for each type of fuel.

As the Australian Government's greenhouse gas (GHG) projections do not publish a full breakdown of energy carriers we have projected domestic coal use until 2030 based on the fuel specific electricity sector projections in the official December 2017 GHG projections and based on recent trends with coal use outside the power sector constant at recent levels.

For natural gas, we have adopted recent AEMO projections for domestic use in eastern and western Australia along with the AEMO assumption that 8% of LNG gas is used for feedstock. Consistent with the national inventory emissions from gas used as feedstock LNG are counted as domestic emissions.

Petroleum and oil use follow the December 2017 transport energy GHG projections, noting the very strong correlation in recent decades between non-transport and transport use of petroleum and oil.

This results in total direct CO_2 emissions from fossil fuel combustion (excluding fugitive emissions) about the same as 2005 levels by 2030 (see figure below). Including fugitive emissions, the emissions from fossil use are projected to be about 15% higher by 2030 than in 2005. This is higher than the December 2017 government projections which have total emissions from energy related areas (Electricity, Direct combustion, Transport, Fugitives) about 7% above 2005 levels by 2030 (Australian Government, 2017)[11]. The main reason for this is that we have assumed, as explained above, higher methane losses from natural gas production than assumed in the national inventory. If we assumed a lower loss rate of 0.5% then the growth in the emissions from fossil use would be about 8% higher by 2030 than in 2005, closer to the official December 2017 projections.

[11] The 2018 emissions projections show an 11% increase in energy related emissions about 7% above 2005 levels by 2030, which is still lower than our estimate. Under the new projections, LNG fugitive emissions went up to 12,6MtCO_2e in 2030 from the 8,1MtCO_2e in the 2017 projections (which are the basis for our analysis). The latest version of the emissions projections (2018) was published after the elaboration of this report and therefore excluded from our analysis.

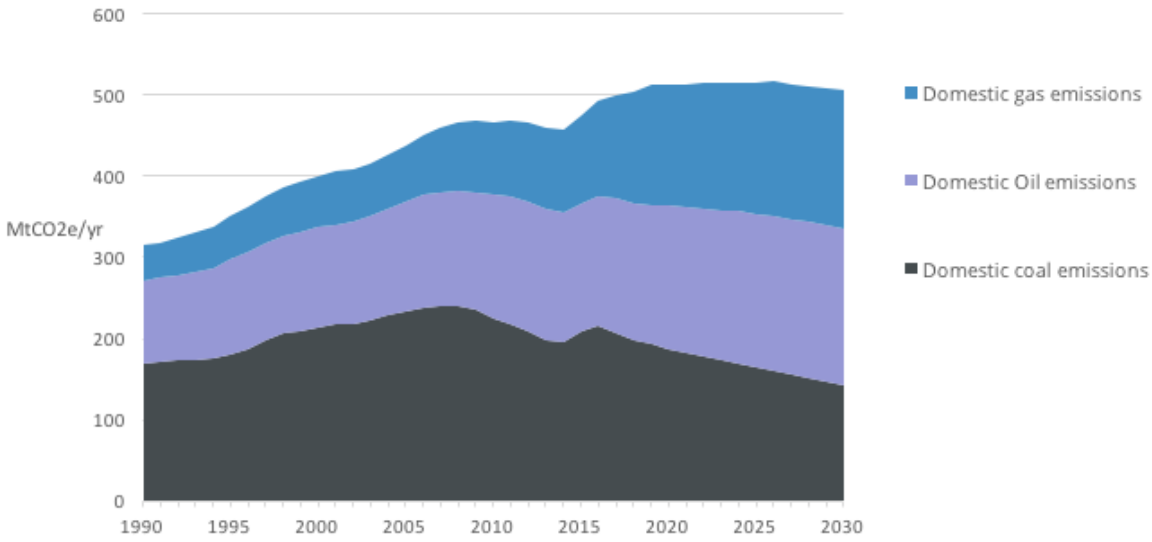


Figure 4 – Australia's CO_2 emissions from domestic coal, oil and gas. Source: Climate Analytics' calculations based on nationally reported quantities of fuels consumed domestically and exported, and national inventory emissions factors. Projections based on Climate Analytics' assessment of national projections as described in the report.

The official December 2017 Australian GHG projections for 2030 result in a 5% reduction by 2030 from 2005 levels due to large reductions in the LULUCF area by 2030. The more recent 2018 emissions projections show a 7% decrease in 2030, mostly thanks to reduced LULUCF projections (Australian Department of the Environment, 2018). These reductions are in stark contrast with Australia's Paris Agreement Nationally Determined Contribution (NDC) target of a 26-28% reduction by 2030, which itself is far from a Paris Agreement compatible pathway that would involve emissions reductions of 35-55%% below 2005 levels by 2030 according to cost-effective emissions reductions pathways and 47-85% below 2005 levels by 2030 according to equity-based[12] emissions reduction pathways (Climate Analytics, 2018). Australia's Paris Agreement 2030 target put forward under its NDC has been rated by international experts as "Insufficient", meaning that Australia's climate commitment is not a fair contribution to the global effort, and is not consistent with the Paris Agreement's 1.5˚C limit, unless other countries make much deeper reductions and comparably greater effort(Climate Action Tracker, 2018).

Coal domestic and exported emissions

Historical

Australia holds the world's fifth-largest black and brown coal reserves, with around 10% of the world's economically recoverable black coal and 24% of the world's economically recoverable brown coal. At the end of 2015, Australia's black coal reserves were estimated at 68 billion tonnes and brown coal at 77 billion tonnes (Commonwealth of Australia, 2017). Using standard CO_2 emission factors, if these reserves were fully exploited and burned this would amount to 178 $GtCO_2$ (billion tonnes of CO_2) and 73 $GtCO_2$ respectively for black and brown coal, totalling about 251 $GtCO_2$ added to the atmosphere.

Due to its vast resources, Australia is the world's third largest coal producer, the largest exporter of metallurgical (coking) coal, and the second largest exporter of thermal coal, reaching around

[12] As estimated by the Climate Action Tracker (https://climateactiontracker.org/countries/australia/). The Climate Action Tracker takes into account a wide range of interpretations of a "fair" contribution of Australia to global mitigation efforts, including historical responsibility, capability, equal emissions per capita, among others.

9% of global coal production and 29% of global coal exports in 2016 (International Energy Agency, 2017). The majority (77%) of production being exported, mostly to eastern Asia (Minerals Council of Australia, 2018).

Coal is mined in almost every state of Australia[13], but over 90% of Australia's coal exports are from the Sydney & Bowen basins. Coal exports have almost doubled in the last decade (Department of Industry Innovation and Science, 2016), reaching 179 Mt of metallurgical coal and 203 Mt of thermal coal in 2017-18 (Department of Industry Innovation and Science, 2018). Japan is by far the major destination for Australian thermal coal, but China, Korea and Taiwan are also important destinations. Smaller markets include India, Malaysia, Philippines, Thailand and Vietnam.

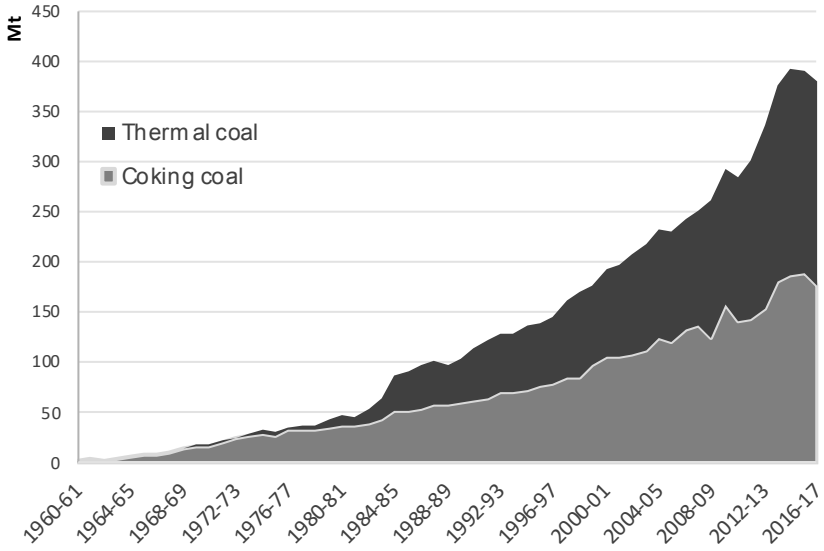


Figure 5 - Australian coal exports 1961-2017. Source: Update 2018 Australian Energy Statistics - Table N

Domestic consumption of coal is also significant, as coal fired power stations continue to provide the majority of Australia's electricity generation, and are not projected to drop below 50% until well after 2025. The sector is the single largest contributor to greenhouse gas emissions, and contributes approximately a third of Australia's total emissions (Australian Government, 2017).

Using the assumptions described in the previous section, we estimate that in 2017 Australia's coal emissions (both domestic and exported) contributed to about 3.5% of global CO_2 emissions from fossil fuels, with exported emissions accounting for about 2.9% of global CO_2 emissions (of which 1.4% corresponds to thermal coal exports).

[13] With the closure of the Leigh Creek mine in 2015 there are no longer any operating coal mines in South Australia.

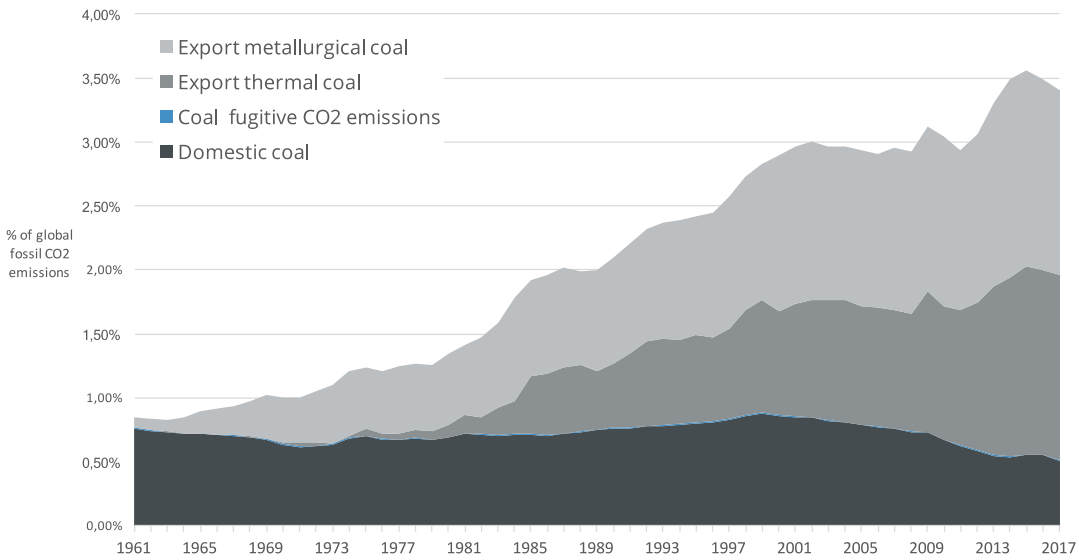


Figure 6 - Australia's domestic and exported coal emissions as share of global emissions. Source: Climate Analytics' calculations based on nationally reported quantities of coal consumed domestically and exported, national inventory emissions factors, and global CO_2 estimates from the Global Carbon Project. Climate Analytics' estimates of fugitive CO_2 emissions are also included.

Projections

Further large-scale expansion of coal mining for export is under discussion. In the Galilee Basin alone, proposed coal mega-mines together make it the second biggest fossil fuel expansion proposed anywhere in the world (330 Mt of coal per year) after Western China (620 Mt of coal per year) (Greenpeace International, 2013) – see Text Box.

For metallurgical coal, resilient prices have led to a lift in global supply through increased production, the restart of idled operations, and decisions to proceed with the development of new mines around the world, including in Australia. According to the most recent government projections, Australia's metallurgical coal export volumes are forecast to grow from 179 Mt in 2017–18 to 198 Mt in 2019–20 with several idled mines expected to restart over the outlook period, including Gregory Crinum, Baralaba North, and Bounty Mining's Cook operations (Department of Industry Innovation and Science, 2018). The key export destinations for Australia's metallurgical coal are India, China, and Japan.

Over the last decade, China has emerged as a key market for Australian thermal coal, and in 2017 was the second largest market behind Japan. Korea and Taiwan remain key markets. Smaller markets include India, Malaysia, Philippines, Thailand and Vietnam. According to the most recent government projections, Australia's thermal coal export volumes are forecast to grow from 203 Mt in 2017–18 to 208 Mt in 2019–20 (Department of Industry Innovation and Science, 2018).

Galilee Basin

There are currently nine coal mega-mines proposed for the Galilee Basin, which together at full production would produce 330 Mt of coal per year (Greenpeace, 2012)(Sanzillo & Buckley, 2013) (approximately 87% of Australia´s total coal exports in 2017). Using standard CO_2 emission factors, if these reserves were fully exploited and burned this would amount to around 857 $MtCO_2$ per year added to the atmosphere, as shown in the table below. This estimate is slightly higher but consistent with previous studies looking at the carbon impact of the proposed projects in this Basin (Greenpeace, 2012). Assuming that all mines reach full production by 2030, the Galilee Basin alone would account for about 4.9% (between 3.72% - 5.45%) of the Paris Agreement compatible global CO_2 emissions in 2030.

Table 1 – Estimated carbon impact of coal projects in the Galilee Basin at full production

Owner	Project	Type	Targeted net coal yearly output	Estimated CO_2 emissions
Adani Group	Carmichael Coal	Open cut & U/G	60	156
Waratah Coal P/L	Alpha North	Open cut & U/G	40	104
GVK Coal	Alpha	Open cut	30	78
GVK Coal	Alpha West	Underground	24	62
GVK Coal	Kevin's Corner	Open cut & U/G	27	70
Waratah Coal P/L	China First	Open cut & U/G	40	104
AMCI Group & Bandanna	South Galilee Coal	Open cut & U/G	14	36
Macmines Austasia	China Stone	Open cut & U/G	60	156
Vale SA	Degulla	Open cut & U/G	35	91
Galilee Basin total			**330**	**857**

Source: Climate Analytics' calculations based on information at the project level as compiled by (Sanzillo & Buckley, 2013) and average emissions factors from Australia's GHG inventories.

The most recent government projections, show total coal exports reaching 410 Mt in 2020 (Department of Industry Innovation and Science, 2018), and longer term projections, which do not account for climate policy, assume a continued increase of coal exports until at least 2050 (Australian Government (BREE), 2014).

Based on the demand increase projected by the Australian Government total coal exports would reach about 538 Mt/year by 2030.

If the domestic demand and projected export growth were to be realized by 2030 Australia's coal emissions (both domestic and exported) could contribute to about 8.9% (between 8.2% - 12%) of Paris Agreement compatible global CO_2 emissions from fossil fuels, with exported emissions accounting for about 8.1% (between 7.4% - 10.9%) of Paris Agreement compatible global CO_2 emissions, of which about 3.9% (between 3.57% - 5.23%) would correspond to thermal coal). The cumulative coal export emissions over the period from 2019 to 2030 could amount to about 12%

(between 11.7% - 13.3%) of the total Paris Agreement compatible coal[14] related CO_2 emissions in the same period.

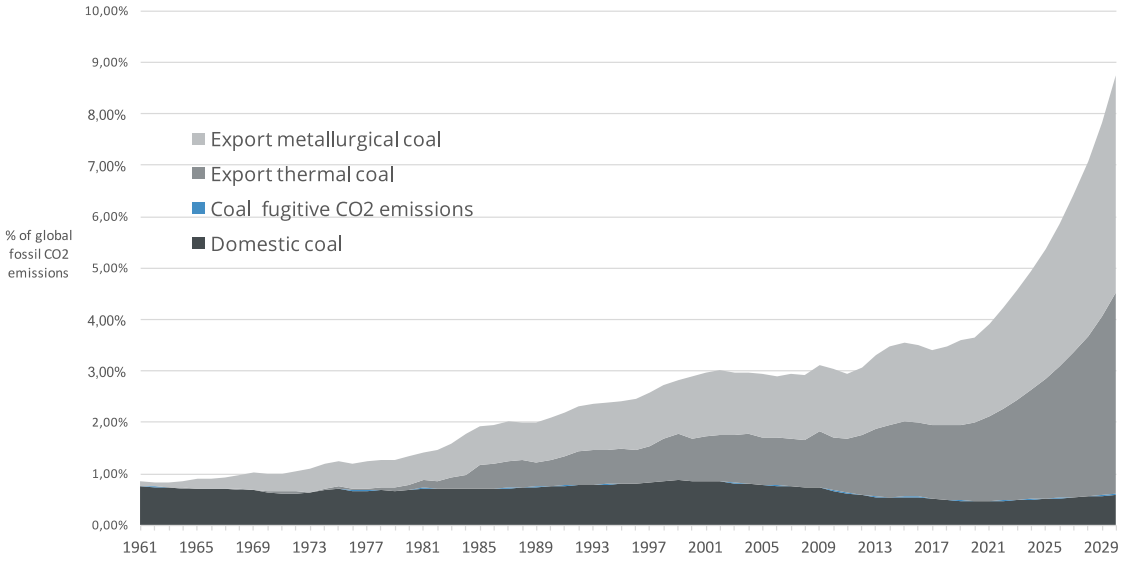


Figure 7 - Australia's projected domestic and exported coal emissions as share of global emissions. The percentage of global emissions prior to 2017 are historical and with respect to global CO_2 as estimated by the Global Carbon Project. After 2017 emissions are based on domestic and export projections as described in the report and are expressed with respect to the middle point in a global CO_2 emissions pathway range consistent with the Paris Agreement 1.5°C limit as reported in the IPCC Special Report on 1.5°C. The middle point is a 45% reduction in CO_2 emissions by 2030 from 2010 levels.

Given the scale and significance of coal exports for Australia, as well as the uncertain international market for coal it is important to look at the likely future of coal demand globally.

Australia assumes a substantial expansion of the international market for coal as a justification for the expansion of national coal related infrastructure development. However, these market projections ignore completely currently observed trends in the power markets in Asia, as well as the implications of the Paris Agreement for international coal demand.

Global energy scenarios consistent with the Paris Agreement, show quickly decreasing demand for coal globally in the next decade, as the world implements the Paris Agreement (see figure below as illustrative example). Overall the IPCC 1.5°C Special Report found that Paris Agreement compatible energy transformation pathways reduced total primary energy contribution from coal by 59 -78% below 2010 (53-75% below 2005) levels by 2030 (IPCC, 2018). According to our estimates, the projected cumulative emissions from the forecasts of Australian coal exports over the period from 2019 to 2030 would amount to about 12% (between 11.7% - 13.3%) of the Paris Agreement compatible cumulative emissions from coal in the same period[15].

The expected decline in international demand for coal under the Paris Agreement in the next 10-15 years puts in question the economic viability of investments into further coal exports. This confirms earlier studies (McGlade & Ekins, 2015) that concluded that even **for a scenario that**

[14] Assuming a 69% reduction which is the middle point of the IPCC 1.5°C compatible scenario interquartile reductions (59 -78% below 2010 levels by 2030). Values in brackets represent the upper and lower end of the range.

[15] Assuming a 69% reduction which is the middle point of the IPCC interquartile reductions (59 -78% below 2010 levels by 2030).

keeps global warming below 2°C with at least a 50% probability, globally, over 80% of coal reserves would have to remain unused. One way to put this in the Australian context is to note that even if the above projected exports and domestic use would occur until 2030, and then drop to zero by 2050, more than 80% of Australian black coal would remain unexploited.

This shows that if Australia continues with its current support towards the expansion of fossil fuel related infrastructure, there is a large risk of asset stranding.

The former conclusion also holds when looking at specific regional markets for Australia's coal exports. In its commodity projections for thermal coal, the Mineral council of Australia project an annual growth in thermal coal imports in Asia of 3.4% until 2030 (Minerals Council of Australia, 2018). However, similar to the global trend, energy scenarios consistent with the Paris Agreement, show unabated coal generation peaking around 2025 and quickly decreasing afterwards in the ASEAN region in the next decades.

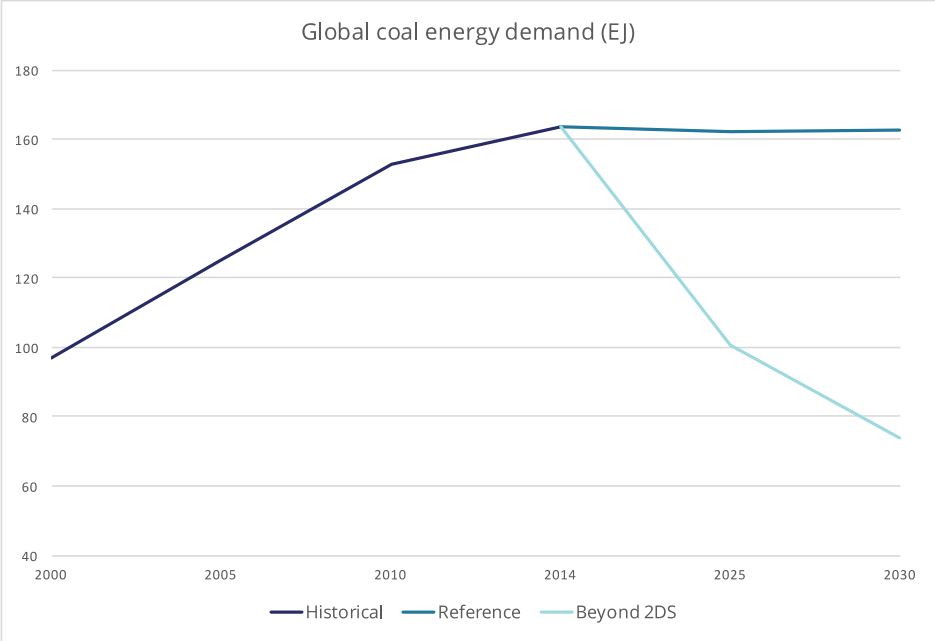


Figure 8 - Global coal energy demand projections until 2030 from the International Energy Agency's (IEA) report Energy Technology Perspectives (ETP) (IEA, 2017). *The Reference Technology Scenario (RTS) is the baseline scenario, assuming the implementation of present day climate change mitigation commitments (NDCs and other). The Beyond 2°C scenario (B2DS) achieves an average warming of 1.75°C above pre-industrial with 50% likelihood.*

Recent observed market trends confirm the overall findings of energy models regarding coal power generation, both globally and for the ASEAN region. Reports from organisations monitoring global coal fleet find that the pace of retirements of older plants is steadily rising, and cancellation of planned projects is also increasing ((Shearer, Mathew-Shah, Myllyvirta, Aiqun, & Nace, 2018).

These market trends are of special relevance for Asia, where new coal capacity is increasingly being cancelled, with particularly rapid falls in China and India. Japan has called off 3.6 GW of proposed coal capacity since 2017, while South Korea will stop issuing permits for new coal plants (Shearer et al., 2018). Analyst have revised the coal export projections from the Minerals Council

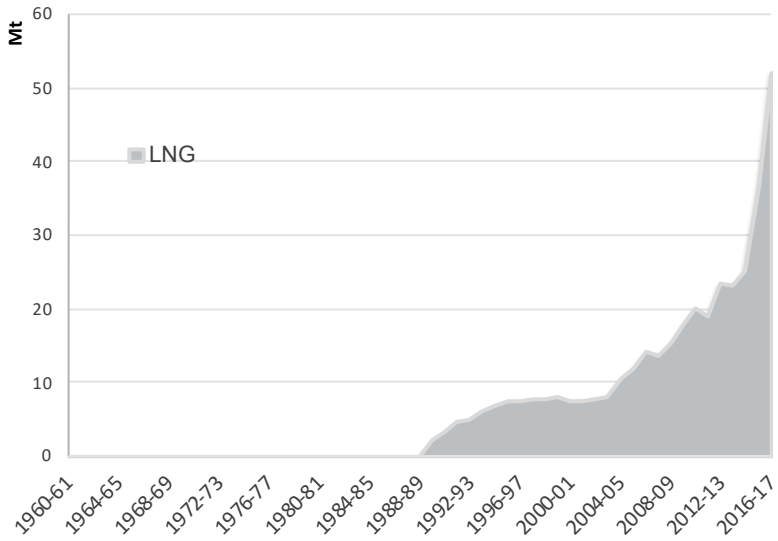
of Australia report and have found that, under more realistic assumptions, import need for Australian coal would be much lower than currently projected(IEEFA, 2019). With these market developments in Australia's target destination for coal exports, it is highly questionable that there is need to expand any further coal related infrastructure in Australia.

Gas domestic and exported emissions

Historical

Australia has globally significant natural gas resources and reserves. Natural gas production has increased steadily since 1990 and a steep increase in production for export has been observed since 2012, with national production going from 20 Billion cubic meters (Bcm) in 1990 to around 123 Bcm in 2018, of which around 70% was exported (Australian Government, 2017).

Australia could become the world's largest exporter of LNG from 2018, with a total of around one-fifth of total global LNG capacity (AEMO, 2016). In 2017-18, Australia exported 62 Mt of LNG, with Asia being the main destination (Department of Industry Innovation and Science, 2018). Currently, the largest share of exports is going to Japan but China in particular is projected to grow in importance (Cassidy & Kosev, 2015). The completion of the final two LNG projects in Australia's recent wave of LNG investment (Ichthys and Prelude projects) will underpin strong



growth in export volumes and bring total export capacity to 88 Mt.

Figure 9 - Australia's LNGs exports 1961-2017. Source: Update 2018 Australian Energy Statistics - Table N

Domestically this resource has been used to develop an export-oriented mining and processing industry, as well as for use in domestic electricity generation (gas represents around 11% of electricity generation in Australia). Emissions related to gas production and processing are substantial and rapidly increasing (about 15 $MtCO_2$ e in 2015 or 3% of national GHG emissions in 2015). These emissions are projected to increase 45% by the early 2020s according to official government projections, as new LNG plants ramp up to full production.

Using the assumptions described in the previous section, we estimate that in 2017 Australia's natural gas emissions (both domestic and exported) contributed to about 0.85% of global CO_2

emissions from fossil fuels, with exported emissions accounting for about 0.55% of global fossil fuel combustion CO_2 emissions.

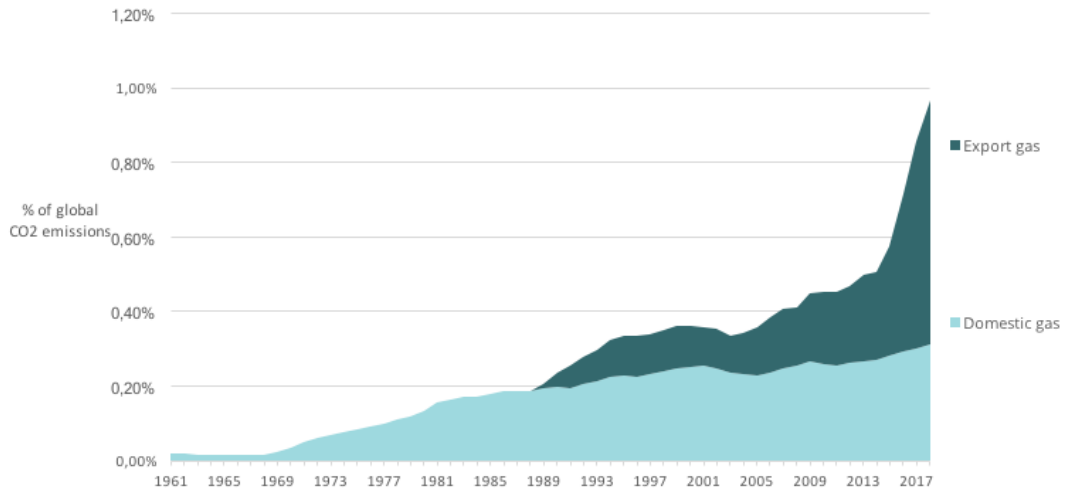


Figure 10 - Australia's domestic and exported gas emissions as share of global fossil fuel combustion emissions. Source: Climate Analytics' calculations based on nationally reported quantities of gas consumed domestically and exported, national inventory emissions factors, and global CO_2 estimates from the Global Carbon Project. Climate Analytics' estimate of reservoir and fugitive CO_2 emissions, and a share of CH_4 emissions are also included.

Projections

Australia has experienced a surge in LNG investment in the last decade, with 8 new projects commissioned between 2007 and 2012 (Department of Industry Innovation and Science, 2018). This surge in investment was mirrored around the world, with a major expansion of global LNG supply capacity underway, driven primarily by the US, followed by Australia and Russia. The expansion in global LNG supply capacity is soon expected to outpace growth in LNG demand, resulting in a period of overcapacity starting in 2019 and lasting at least until 2020.

In addition to conventional gas resources in Australia, there are vast resources of unconventional (shale) gas, in particular in the Canning Basin in the Kimberley region, a large remote region in the north of Western Australia renowned for unique and globally significant terrestrial and marine ecosystems, and its cultural significance for its traditional owners (Edelman, 2009). These unconventional gas resources have not been developed for production yet, given the high cost compared to developing conventional gas resources. However, with the rise of hydraulic fracturing (fracking), developing these additional resources is under active discussion (WAtoday, 2017).

According to the most recent AEMO projections, Western Australia's LNG exports are forecast to grow from 1.9 EJ in 2017–18 to 3.8 EJ in 2029–30 (AEMO, 2017a), and Eastern Australia's exports are expected to grow from 1.2 EJ to 1.5 EJ in the same period (AEMO, 2017b).

Using the assumptions described in the previous section, we estimate that by 2030 Australia's gas emissions (both domestic and exported) could contribute to about 2.51% (between 2.3% - 3.4%) of Paris Agreement compatible global CO_2 emissions from fossil fuels if current projections are realised, with exported emissions accounting for about 1.8% (between 1.7% - 2.4%) of Paris Agreement compatible global CO_2 emissions.

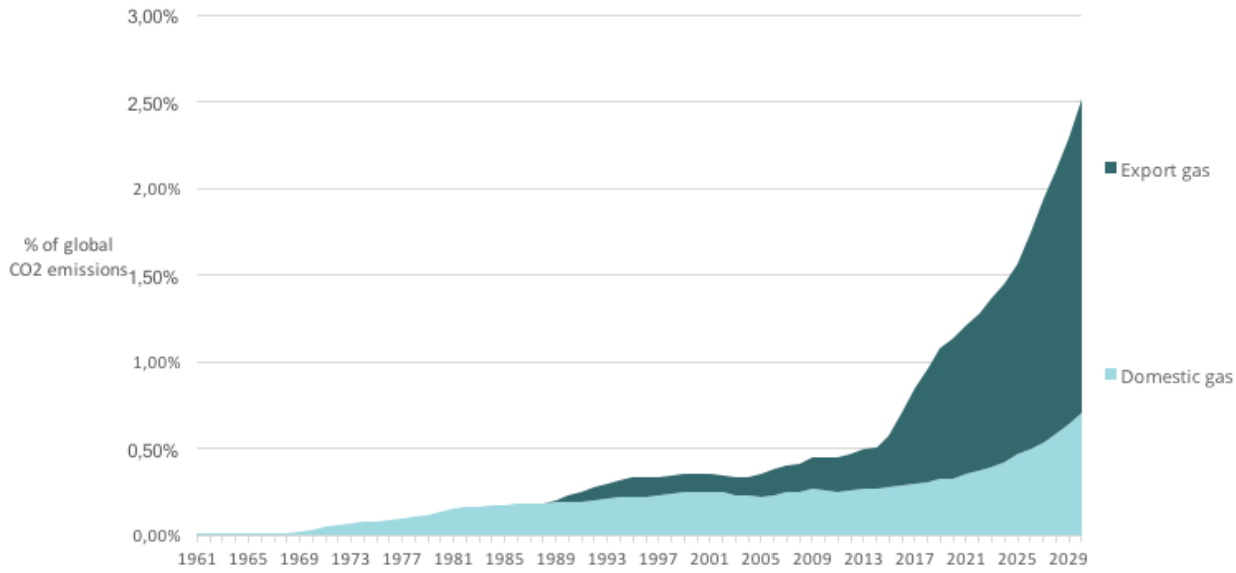


Figure 11 - Australia's projected domestic and exported gas emissions as share of global fossil fuel emissions. The percentage of global emissions prior to 2017 are historical and with respect to global CO_2 as estimated by the Global Carbon Project. After 2017 emissions are based on domestic and export projections as described in the report and are expressed with respect to a global CO_2 emissions pathway consistent with the Paris Agreement 1.5°C limit as reported in the IPCC Special Report on 1.5°C, involving a 45% reduction in CO_2 emissions by 2030 from 2010 levels.

Given the scale and significance of LNG exports for Australia, as well as the uncertain international market for LNG it is important to look at the likely future of gas demand globally.

Whilst there are a range of outcomes in the scientific literature, it is broadly true that over the next decade natural gas demand in the power sector is likely to remain close to or only slightly below present levels before beginning a decline from the late 2020s. According to our estimates, Australia's LNG export projections until 2030 would amount cumulatively to about 4% of Paris Agreement compatible natural gas CO_2 emissions for the period 2019-2030[16].

What is important to understand here is that the market for natural gas in the power and heat sectors will likely decline from the 2030s as the world meets the Paris agreement goals (IPCC, 2018). Global energy scenarios consistent with the Paris Agreement, show that demand for gas peaks globally around 2025-2030 and declines thereafter, as the world implements the Paris Agreement. In general, the closer the scenarios get to being in line with the Paris Agreement temperature goal, the faster the decline in gas demand, in particular after 2035.

[16] Assuming stabilisation of emissions from gas at 2010 levels by 2030.

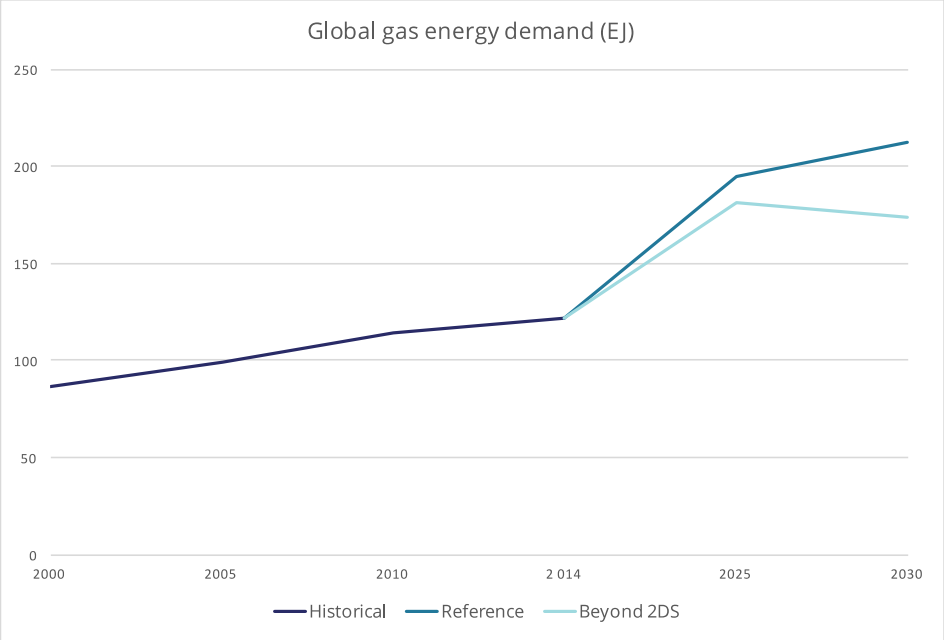


Figure 12 - Global gas energy demand projections until 2030 from the International Energy Agency's (IEA) report Energy Technology Perspectives (ETP) (IEA, 2017). *The Reference Technology Scenario (RTS) is the baseline scenario, assuming the implementation of present day climate change mitigation commitments (NDCs and other). The Beyond 2°C scenario (B2DS) achieves an average warming of 1.75°C above pre-industrial with 50% likelihood.*

The expected decline in demand for gas under the Paris Agreement in the next decades puts in question the economic viability of investments into further LNG exports. Currently planned and projected rates of LNG exports (about 1.5 EJ/a from Eastern and South Eastern Australia until 2030 (AEMO, 2017b), and increasing from 1.9 EJ/a in 2017 to between 3.8 EJ/a in 2030 from WA (AEMO, 2017a), may not be able to be sustained economically if global gas demand peaks in the 2020s, before declining by 2030 (as in the Beyond 2D scenario). As a consequence, there is a risk of asset stranding late in the 2020s. The present high likelihood of global LNG overcapacity starting in 2019 and lasting at least until 2020 (Department of Industry Innovation and Science, 2018) does not appear to be related to the Paris Agreement implementation however it is an example of what could become a more systematic issue within a decade.

Oil domestic and exported emissions

Historically, Australia has been a net importer of crude oil and refined petroleum products (see figure below). Australia's demand for oil has risen steadily over recent decades, largely driven by increasing demand in the transport sector, which is Australia's second largest energy consumer (behind the electricity sector).

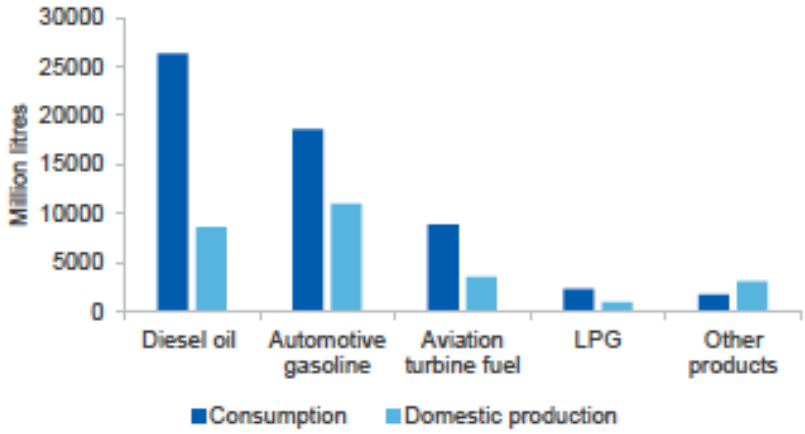


Figure 13 - Australia's refined product balance, 2016-17. Source: Resources and Energy Quarterly September 2018

Australia's largest export markets for crude oil and other refinery feedstock are Singapore, Thailand and Korea. However, Australia also imports crude oil and other refinery feedstock from a wider range of countries including Malaysia, United Arab Emirates, Vietnam and Nigeria while refined products are imported from countries including South Korea, Japan and Indonesia (Parliament of Australia, 2017)

The only oil product for which Australia is a net exporter is LPG (liquefied petroleum gas), used in light vehicle transportation, forklifts, household appliances and heating. Around 70% of Australia's LPG is naturally occurring and is co-produced at gas fields. Australia's LPG production was around 50 thousand barrels a day in 2017–18, around 80% of which is exported (Department of Industry Innovation and Science, 2018).

While according to official projections, Australia's export volumes are expected to increase slightly, supported by rising condensate output at new LNG projects (Department of Industry Innovation and Science, 2018). For this report we follow a conservative approach and assume oil derivatives exports (except for LPG) remain at current levels until 2030. For condensate and LPG, until 2020 we use the projections from the Resources and Energy Quarterly Update (September 2018) and after 2020 we assume the maximum output from the LNG processing capacity.

Using the assumptions described in the previous section, we estimate that by 2030 Australia's oil emissions (both domestic and exported) could contribute to about 1.6% (between 1.4% - 2.1%) of global Paris Agreement compatible CO_2 emissions from fossil fuels in that year, with domestic emissions accounting for the large majority (1.1%) of this carbon footprint, as it is expected for a net oil importer.

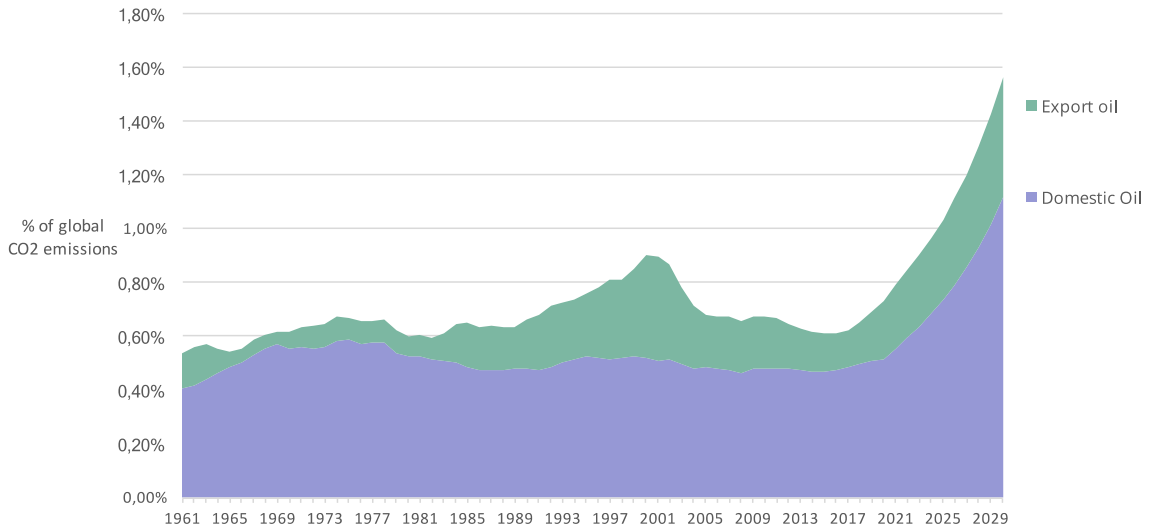


Figure 14 - Australia's projected domestic and exported oil emissions as share of global emissions. The percentage of global emissions prior to 2017 are historical and with respect to global CO_2 as estimated by the Global Carbon Project. After 2017 emissions are based on domestic and export projections as described in the report and are expressed with respect to a global CO_2 emissions pathway consistent with the Paris Agreement 1.5°C limit as reported in the IPCC Special Report on 1.5°C, involving a 45% reduction in CO_2 emissions by 2030 from 2010 levels.

Australia's global fossil fuel carbon footprint

As examined in this report, Australia's global carbon footprint is larger than usually thought. Whilst Australia's share of global CO_2 emissions from fossil fuel is relatively small at about 1.4% of global emissions in 2017, accounting for fossil fuel exports lifts this global footprint to about 5%. Our estimates show that in 2017 Australian coal and gas exports produced around 2.9% and 0.6% of global CO_2 emissions respectively.

If exported emissions were to be included, Australia's carbon footprint would be equivalent to the total emissions of Russia, reaching the fifth position in the ranking of biggest CO_2 emitters globally. On a per capita basis, Australia's carbon footprint would be the largest among top emitters, surpassing China by a factor of 9, the US by a factor of 4 and India by a factor of 37. This highlights the importance and responsibility Australia has for global mitigation efforts.

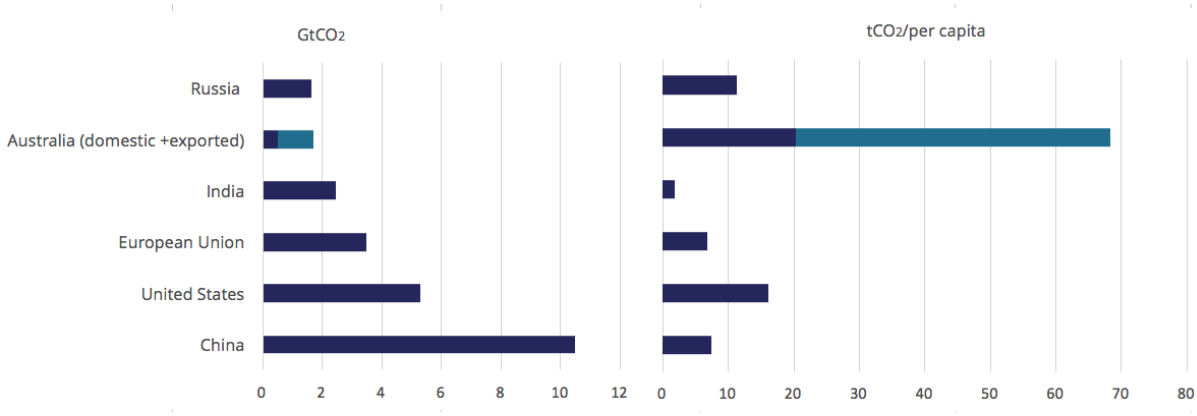


Figure 15 – Main CO_2 emitters 2017 total and per capita (exported emissions added for Australia in light blue). Values in the left panel correspond to $GtCO_2$ and values in the right panel are expressed as tCO_2 per capita.

Having ratified the Paris Agreement and considering its high responsibility in global CO_2 emissions, Australia needs to reduce domestic greenhouse gas emissions to be in line with the climate treaty's long-term temperature goal. Instead of decreasing, Australia's emissions are increasing and will likely continue to increase through to 2030, falling very short of the current government´s insufficient 26-28% reduction below 2005 Paris Agreement NDC target.

Meeting the Paris agreement's long-term temperature goal of holding warming well below 2°C and pursuing efforts to limit warming to 1.5°C means that carbon dioxide emissions from fossil fuels need to peak soon and decline rapidly afterwards.

The results of this analysis show if current government and industry projections for fossil fuel exports are realised, Australia could be responsible (including both domestic and exported emissions) for about 13% (between 11.9% – 17.4%) of Paris Agreement compatible global CO_2 emissions in 2030[17]. By far the largest growth would be coming from coal exports.

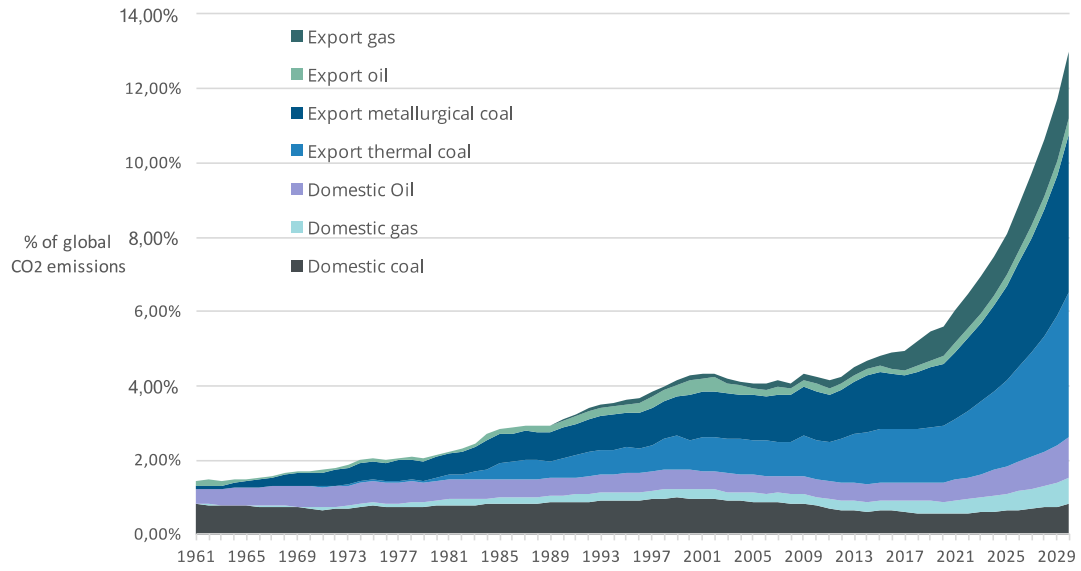


Figure 16 - Australia's domestic and exported emissions as share of global emissions. The percentage of global emissions prior to 2017 are historical and with respect to global CO_2 emissions from fossil fuels and cement in each year. After 2017 emissions are based on domestic and export projections as described in the report and are expressed with respect to a global CO_2 emissions pathway consistent with the Paris Agreement 1.5°C limit as reported in the IPCC Special Report on 1.5°C involving a 45% reduction in CO_2 emissions by 2030 from 2010 levels. In addition to CO_2 combustion emissions, fugitive CO_2 and CH_4 emissions related to fossil fuel production and use in Australia are included.

In this context, the expansion in the exploitation of fossil fuel resources that Australia is planning goes against the global efforts to combat climate change and is not consistent with the global energy transition required to meet the Paris Agreement goals, for which the majority of the global fossil fuel reserves should remain on the ground[18].

[17] Assuming a CO_2 emissions pathway with a 45% reduction by 2030 from 2010 levels, which in line with the IPCC interquartile reductions (See Figure SPM.3b and CO_2 reductions in 2030 interquartile range of 40-59% reduction from 2010 levels, after peaking in 2020). Values in brackets represent the upper and lower end of the interquartile range.

[18] Estimates based on the former 2°C temperature limit estimate that only about half of the existing global fossil fuel reserves, if not less, can be used (McGlade & Ekins, 2015). For the Paris Agreement 1.5°C limit, an even larger share of reserves should be kept on the ground.

Australia's focus on coal and gas-intensive development stands in stark contrast to its high vulnerability to climate change. Significant impacts of climate change are projected already internationally and for Australia for a warming of 1.5°C above pre-industrial levels, including temperature extremes, extreme precipitation and dry spells, water availability, crop yield reduction risks for major staple crops, coral reef bleaching and increased risk of flood due to extreme precipitation and sea-level rise. The IPCC 1.5SR has shown that the future climate-related risks and impacts are substantially larger if global warming exceeds the 1.5°C temperature limit, which enables greater opportunities for adaptation in the human and ecological systems (IPCC, 2018). Under scenarios with higher warming, some impacts may be long-lasting or irreversible, such as the loss of some important national and international ecosystems like the Great Barrier Reef and loss and extinction of thousands of fauna and flora species (IPCC, 2018).

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