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Australian Energy Emissions Monitor

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Australian Energy Emissions Monitor

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Key Points

- The most recent data show that moving annual consumption of both electricity and gas remains almost constant.
- Moving annual consumption of petroleum products, by contrast, increased sharply, as both passenger vehicle road transport and air transport rebounded towards pre-pandemic levels.
- On current longer term trends, within less than two years, consumption of petroleum fuels will overtake electricity generation as the largest source of fossil fuel greenhouse gas emissions in eastern Australia.
- In the whole month of November 2022, the renewable share of generation was 78% in SA, 45% in Victoria, 44% in the whole NEM (including Tasmania), 39% in NSW and, lagging well behind, 33% in Queensland.
- Furthermore, in Queensland, rooftop solar, i.e. investments by consumers, rather than electricity industry investor participants (of which the largest are state government owned businesses), contributed over half the total renewable generation, which is a much higher share than in any other state.
- The largest sources of methane emissions in 2019-20, in decreasing size order, were beef cattle, coal mining and sheep, contributing over 70% of total emissions.
- It is possible that improved methods for estimating coal mine methane emissions, now well underway, result in an increase in estimated emissions from open cut coal mines.

Introduction to the December 2022 issue

Welcome to the December 2022 issue of the *Australian Energy Emissions Monitor*, which is a bi-monthly publication of the ANU Institute for Climate, Energy and Disaster Solutions (ICEDS), providing timely analysis of the most recent trends in energy related greenhouse gas emissions. The publication is intended as a service to Australia's energy community.

This issue contains three sections. The first section, common to every issue, updates trends in energy consumption and the consequent fossil fuel emissions, using the most recent monthly data available at the start of December. This means electricity consumption and emissions to the end of November, and consumption of and emissions from petroleum products and natural gas to the end of September.

The second section presents graphical data on shares of the different fuels used to generate electricity in the NEM as a whole and in each mainland NEM region (state). The data are presented in average daily generation by month, rather than moving annual total previously shown, in order to show the seasonal variations in renewable generation.

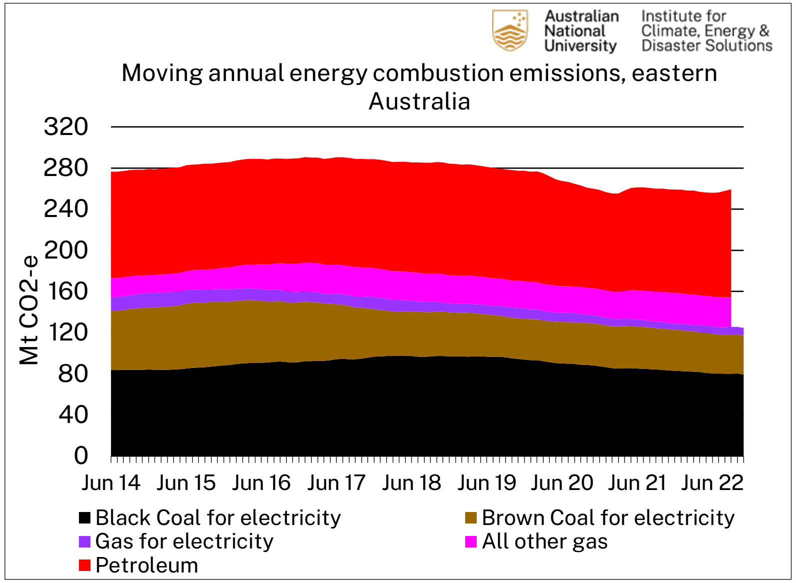
The third section is a response to the government's recent decision to sign on to the Global Methane Pledge by presenting graphs of sectoral source trends in Australia's methane emission since 2005. It also explains improvements being made to the methods used to estimate methane emissions from one of the largest sources - coal mining.

Hugh Saddler (author and analyst) and Frank Jotzo (Head of Energy, ICEDS)

Update on energy combustion emissions in eastern Australia

Figure 1 updates the trend in emissions in eastern Australia, i.e. Australia excluding Western Australia (WA) and the Northern Territory, arising from energy consumption to the end of November 2022 in the case of electricity generation, to the end of September for gas and petroleum product emissions. The steadily declining trend in emissions for coal and gas used to generate electricity continues, while, on a moving annual basis, emissions from all other uses of gas and petroleum products remain almost unchanged.

Figure 1: Moving annual energy combustion emissions, eastern Australia, 2011-21



The starting date for the graph, previously the year ending June 2011, has been moved forward to the year ending June 2014. This is the second and last year of the previous Labor government's transitional price on emissions, which while in place, caused a reduction in coal generation. Hence the graph shows, apart from the last few months, only emission changes while the previous Coalition governments were in office. Apart from a modest reduction in gas generation, almost all the observed energy combustion emission reductions were caused by the closure of two brown coal fuelled power stations – Northern in South Australia (SA) and Hazelwood in Victoria. Since then, electricity generation emissions have continued to fall steadily, as coal generation is displaced by wind and solar.

Figure 2: Moving annual energy consumption, eastern Australia, 2011-22

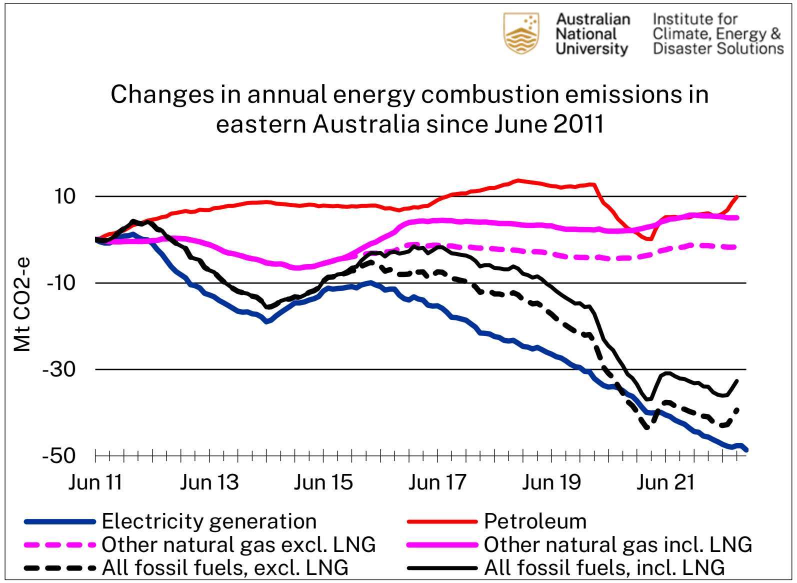


Figure 2 shows the same data but expressed as changes from the earlier starting date of June 2011. For electricity emissions it clearly shows the effect of the application, then removal of the price on emissions, followed by steady decrease as coal generation decreases and renewable generation increases. For gas, the effect on emissions of LNG production is easy to see. Also easy to see is a sharp increase in emissions from use of petroleum fuels in recent months. Underlying data show clearly that this was caused by increased consumption of aviation fuels and petrol, as air transport and passenger vehicle use revert to their pre-pandemic levels.

As previous *Monitor* issues have stressed, reducing emissions from use of petroleum fuels is the one of Australia's largest emission reduction challenges. On the basis of trends over the last year or so, emissions from use of petroleum fuels will become a larger source of emissions than electricity generation within the next two years. The very first steps have been taken towards delivering comprehensive policies and programs to reduce road transport emissions. Some established mining enterprises, mainly iron ore mines in the Pilbara, have been implementing the switch from diesel to electricity. Overall, however, reduction in emissions from petroleum fuels is currently at about the same stage that reducing electricity generation emissions was about 12 years ago.

Turning to domestic gas consumption, underlying data not shown here indicate that moving annual consumption, other than gas used to generate electricity and produce LNG, increased gradually from mid-2020 until the end of 2021, having previously decreased over several years. During 2022, however, annualised consumption has gradually decreased again.

It would be unwise to over-interpret these trends, because of the sensitivity of gas consumption to weather during winter months. What can be said, however, is that the recent data show no evidence of increasing consumption, contrary to the publicly expressed opinions of the gas industry peak body, the Australian Petroleum and Production Association. The governments of both Victoria and the ACT have recently introduced policies and programs to replace gas used for space and water heating with electricity in both residential and commercial properties, directed at supporting the displacement gas used for buildings. At the beginning of December, the Australian Sustainable Built Environment Council (ASBEC) released a report entitled *Unlocking the pathway: Why electrification is the key to net zero buildings*. This report is based on a detailed engineering and economic study which identified that electrification will be a significantly cheaper route to rapid decarbonisation of building energy use than either decarbonisation of reticulated gas using either hydrogen of biogas, or the purchase of offsets for continuing emissions form use of gas (I was a member of the consulting team which undertook this study). ASBEC is a peak body for a wide range of professional and industry associations, including the Property Council, Engineers Australia, and the Australian Institute of Architects.

These and other developments suggest that Australia may be embarking on a path towards steady reduction of gas consumption, and associated emissions, across large sectors of the economy. They make the persistent calls for incentives to encourage exploration for and subsequent development of new onshore gas resources in eastern Australia, coming from the industry, conservative politicians, and not a few Labor politicians also, absurd. Should such activities occur, any resources developed would be at significant risk of becoming stranded assets.

This argument is also illogical on the basis of fundamental economics. In any efficiently operating market, increasing supply, relative to demand, lowers prices to consumers by forcing suppliers to compete with each other. Until a year ago, spot wholesale gas prices in eastern Australia were never higher than $11 per GJ. Why then do the gas producers oppose a regulated price of $12 per GJ.? Is it because the wholesale market is not properly competitive?

The contrast with WA, where the gas reservation policy obliges producers to make LNG producers make a fixed proportion of their total production preferentially available to the domestic market, is stark. According to EnergyQuest, a specialist oil and gas industry consultancy business, spot wholesale gas prices in WA were less than $6/GJ, while in eastern Australia corresponding prices were almost $30/GJ. Major producers, such as Woodside, which is dominant in WA but is not a major producer in the east, and Santos, which is a major supplier to both WA and the eastern Australia wholesale markets, are clearly prepared to operate, presumably profitably, in WA.

State by state progress in the transition towards totally renewable generation

Seasonal factors mean that, in the spring months of October and November solar generation reaches relatively high levels, while electricity demand for both heating and cooling is relatively low. Consequently, it is in these months that renewable generation usually reaches its highest annual share of total generation, facilitated of course by continuing growth in total installed capacity. In SA, renewable generation exceeded 100% of demand for brief periods on a number of occasions this year, and in Victoria it came close on several occasions. This is particularly problematic for system operation, because at these times rooftop solar is supplying a large proportion of total supply, meaning that grid level demand falls to very low levels.

These short term peaks are very important tests of the ability of the electricity system to remain secure and stable while operating under these conditions. However, it is much more of a test for SA than Victoria, where brown coal generators have to keep operating, though at low levels, with large surplus generation being exported to each of the three neighbouring states. Trends totalled over a longer period, such as a month, provide a much clearer picture of how each mainland National Electricity Market (NEM) state and NEM as a whole is transitioning towards a totally renewable generation system.

Figure 3: Average daily generation by month, 2019 to 2022, whole of NEM

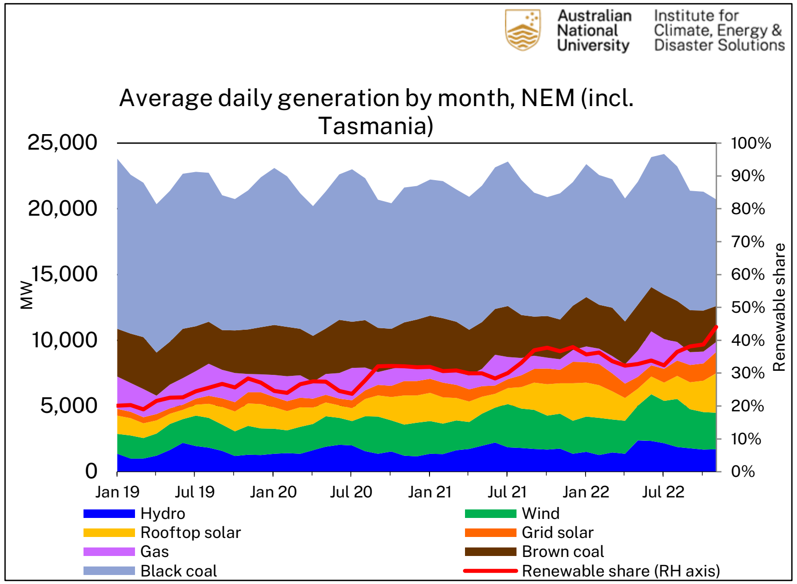


Figure 4: Average daily generation by month, 2019 to 2022, NSW

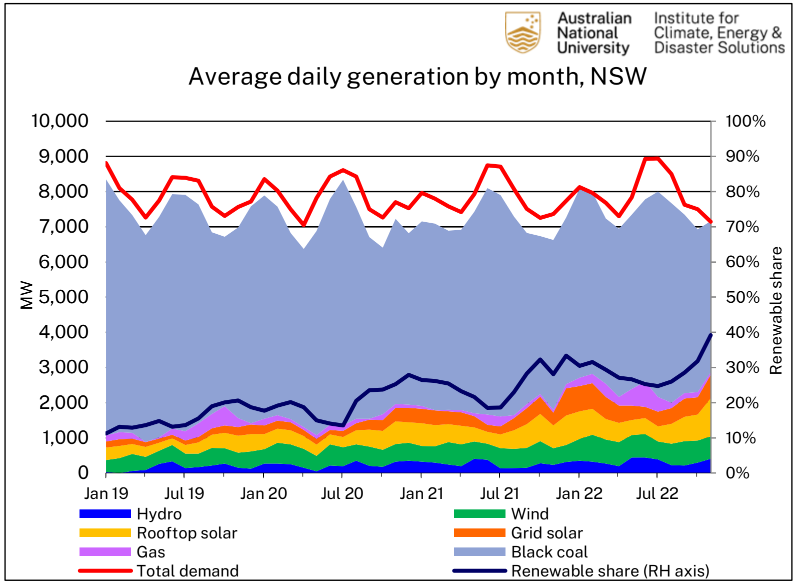


Figure 5: Average daily generation by month, 2019 to 2022, Queensland

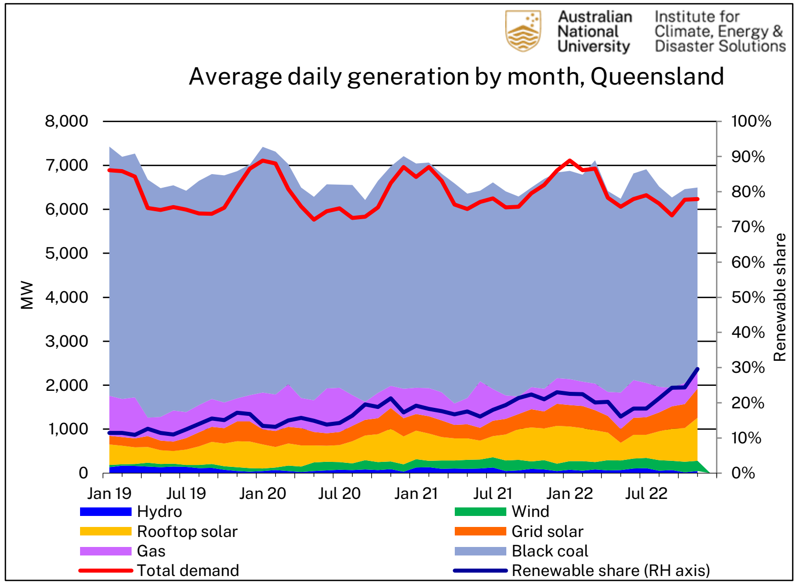


Figure 6: Average daily generation by month, 2019 to 2022, Victoria

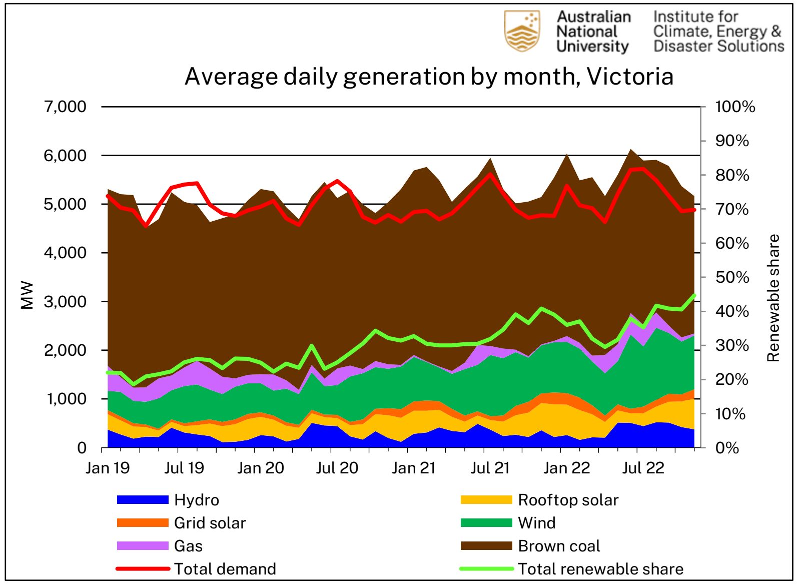
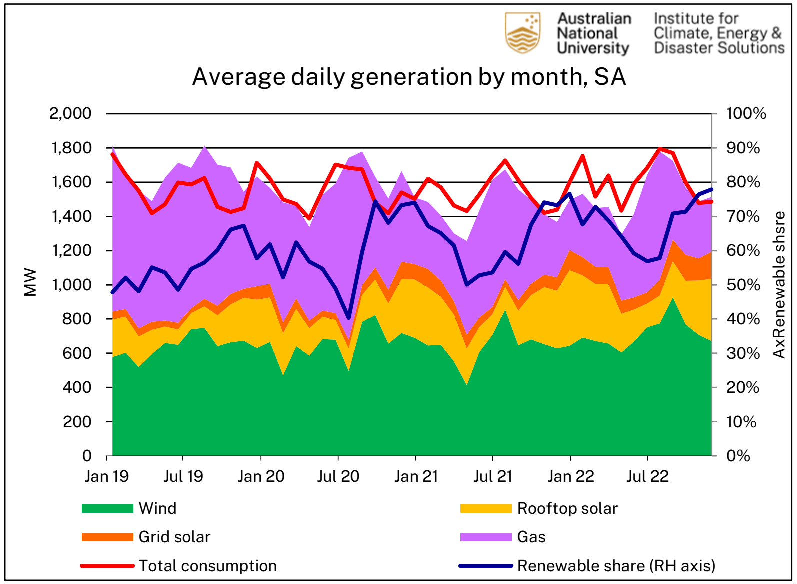


Figure 7: Average daily generation by month, 2019 to 2022, South Australia



It can be seen that in the NEM as a whole, and in every individual state the renewable share of electricity generation reached its highest level for the year in November. In Queensland, however, this level is likely to be exceeded on a mild sunny day next January, where very high levels of grid and rooftop solar generation are supplying lower than average demands for air conditioning. Note that in each graph, and excess of generation over demand means that energy is being exported to neighbouring states, while a gap between generation and demand means that energy is being imported. Note also that all these figures are daily averages for the month and exports and imports do not usually occur on the same day in the month.

It can be seen that the average renewable share of sent out generation in November reached 44% in the NEM, assisted of course by Tasmania, where it was 99.8% (there was a tiny amount of gas generation). Shares in the other states were 78% in SA, 45% in Victoria, 39% in NSW, and 30% in Queensland. Queensland actually lags the other states further than these figures imply, because grid scale renewables accounted for only 15% of renewable generation in

November, compared with 24% in NSW, 33% in Victoria, and 54% in SA.

It is clear that Queensland, the so-called sunshine state, is lagging badly behind all other states. The comparative Queensland performance looks even worse by comparison, because rooftop solar accounts for over half the total renewable generation in the state. This is a much higher share than in any other state, showing that growth in renewable generation in Queensland is much more dependent on investments by individual electricity consumers. In the other three mainland states, investments by electricity industry participants, supported and encouraged by state government policies, have made larger contributions, (much larger in the case of NSW and Victoria) in absolute terms and much larger in relative terms in all three states.

Methane emissions

In October, a few weeks prior to COP27, the government announced that it would be signing the Global Methane Pledge, which was launched one year previously at COP26. It is therefore appropriate to look more closely at Australia's methane emissions.

According to Australia's National Greenhouse Gas Inventory, emissions of methane, expressed in CO_2-e (CO_2-equivalent) terms, accounted for 24.8% of Australia's total emissions in 2020. CO_2-e is a unit called Global Warming Potential (GWP). Among other factors, the GWP of a gas depends on how long it remains in the atmosphere. Methane is removed from the atmosphere at a faster rate than CO_2, mainly by being oxidised to CO_2. The GWP of methane therefore depends on the length of time it is assumed to remain in the atmosphere. In 2007, parties to the UNFCCC, adopted a GWP value of 25 for methane, based on an atmospheric life of 100 years.

Because of its shorter atmospheric life, methane is a relatively less important problem over the very long term, i.e. more than 1000 years. Conversely, however, it is a much greater problem than the GWP value implies in the short term. That is the main consideration behind support for the Global Methane Pledge.

Australia's decision to sign naturally led to a flurry of public commentary about methane, understandably mainly focussed on agriculture, because that is Australia's largest source of methane emissions. Figure 8 shows trends in the components of Australia's methane emissions since 2005. It can be seen that agriculture and coal mining account for the great majority of emissions.

Figure 8: Australia's methane emissions, 2005 to 2020

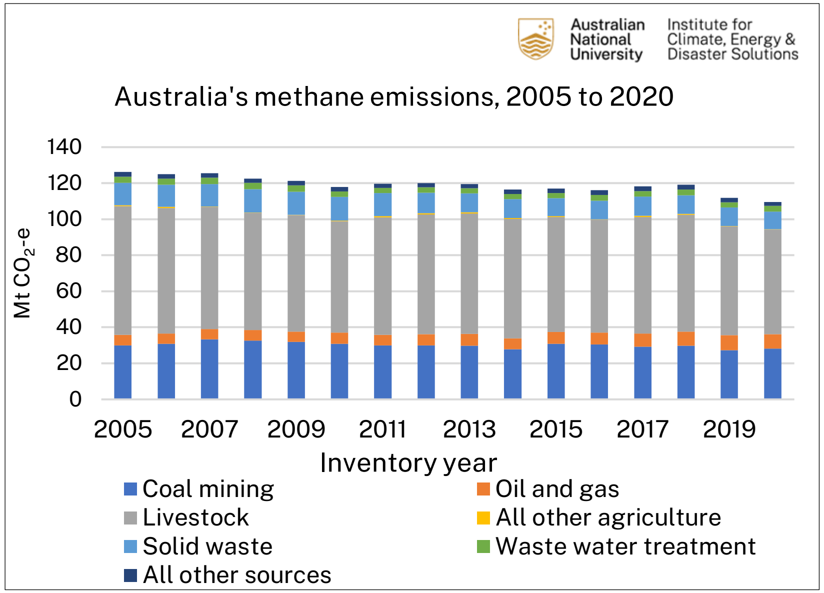


Figure 9 shows how the various emissions from agricultural livestock. Livestock methane emissions arise from the digestive metabolism of ruminant animals, and are released to the atmosphere through two main mechanisms: belching as the animals digest their food and, subsequently, the breakdown of manure. Year to year variations are almost entirely determined by variations in estimated livestock numbers. This means that, usually, emissions are lower in drought years, such as 2019 and 2020, and increase again in good years. Obviously, it is very difficult to control livestock methane emissions.

Scientific research has resulted in the development of various feed supplements, which show promise of changing animal digestion in ways which reduce methane generation. However, it will obviously be logistically difficult to supply such supplements to pasture raised beef cattle and sheep. It will be simpler to supply supplements to feedlot raised animals, but, as can be seen, feedlot cattle currently account for only a very small proportion of emissions. Moreover, feedlot operations have other undesirable environmental impacts, notably the activities used to produce the enormous volumes of animal feed required.

Figure 9: Methane emissions from agricultural livestock, 2005 to 2020

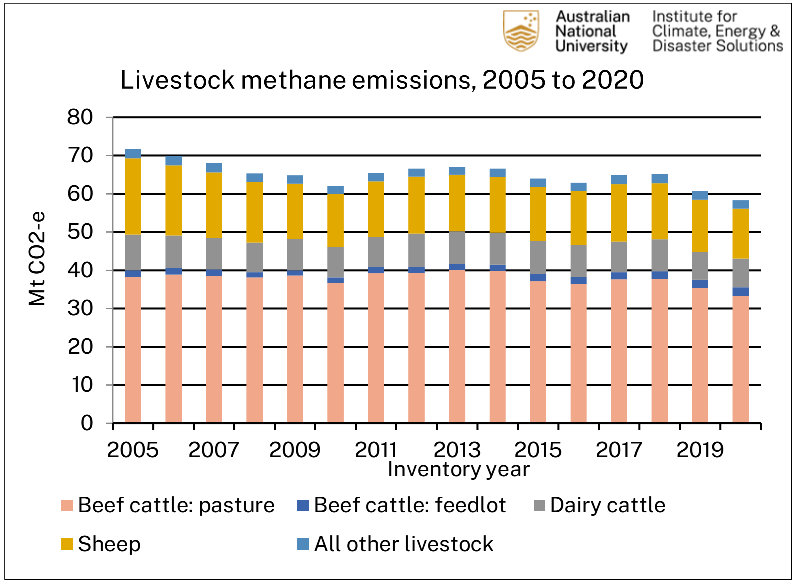
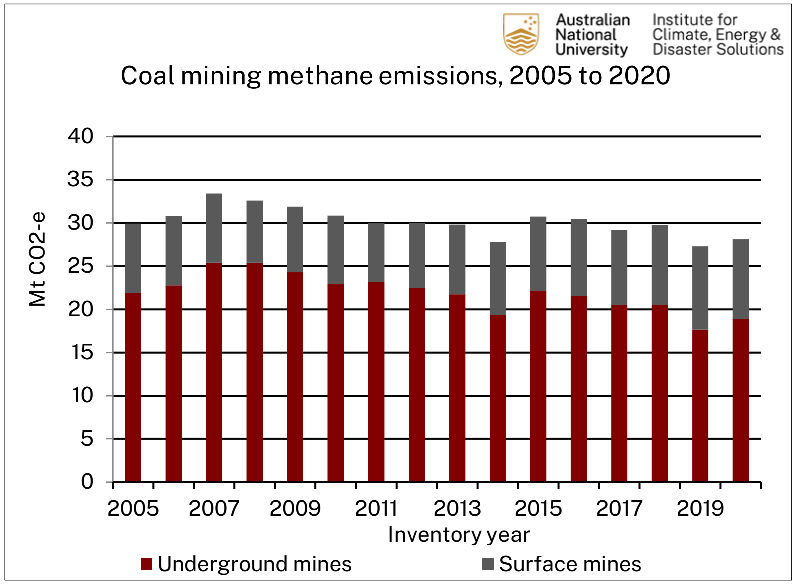


Figure 10 shows how coal mining methane emission are distributed between underground and open cut coal mines. Although underground mines account for a smaller volume of total Australian coal productions, they contribute a large share of methane emissions, for two main reasons. Firstly, higher rank, (hard) coking coals, which typically contain higher levels of methane, account for a larger proportion of underground than of open cut proportion. Secondly, coal produced from open cut mines is, by definition, located closer to the earth's surface, meaning that, over geological time, there has been more opportunity for methane to escape into the atmosphere.

Figure 10: Methane emissions from coal mining



The great majority of coal mining companies are required to report their emissions under the National Greenhouse and Energy Reporting Scheme (NGERS), and these reports are used to estimate total emissions for the national inventory. Companies operating underground mines are required to estimate their emissions by monitoring methane concentrations in mine ventilation exhaust gas streams, which should be a relatively accurate procedure, provide that all equipment is functioning correctly.

By contrast, companies operating open cut mines have two options for estimating emissions. The less accurate method, used for all open cut mines for a number of years, uses very simple default methane emission factors per tonne of coal mined. A single factor is used for all coal in a state, but factors differ between states. This is obviously an extremely crude method. Moreover, the emissions factors used are themselves based on a very limited set of field measurements made by CSIRO scientists over a few weeks, at a small sample of coal mines, about 30 years ago. This method is still used by open cut coal mines in Queensland.

The second, more accurate method requires coal mining companies to measure the methane concentration in samples of *in situ* coal prior to mining, and use these data to estimate the total volume of methane released as the coal is subsequently broken up and extracted. This method is now used by open cut coal mines in NSW.

Over the past year, satellite observations have been used to estimate atmospheric methane concentrations over the Queensland coal fields, and the results have been published in several scientific papers. These generally indicate that methane emissions are probably significantly higher than previously estimated by the method described above. Caution should be exercised in drawing firm conclusions, because of the very complex dispersion of methane once released into the atmosphere, depending on wind changes and other factors.

The emissions inventory team within the Department of Climate Change, Energy, the Environment and Water is currently developing a new method for estimating emissions from open cut coal mines in Queensland. The method uses available methane concentration data taken from numerous bore hole samples over a number of past years, of coal currently being extracted in open cut mines. The results, when finalised, are likely to be used in a revised national greenhouse gas emission inventory, and may well result in an upward revision of methane emission estimates.

Appendix: Notes on methodology and data sources

Data on electricity generation and electricity consumption is for the five states constituting the National Electricity Market (NEM) only, i.e. data exclude Western Australia and the Northern Territory. All data are monthly totals, sourced from Australian Energy Market Operatory (AEMO), accessed through NEM-Review. Data on gas consumption are also for the five eastern states only; sourced from the Australian Energy Regulator's weekly *Gas Market Report*. The main source of petroleum consumption data is monthly sales of petroleum products, compiled by the Department of Industry, Science, Energy and Resources and published as *Australian Petroleum Statistics*. Unlike the sources used for electricity and gas data, petroleum data covers the whole of Australia at the state level. The emission factors used for petroleum products and gas are based on *National Greenhouse Accounts Factors* and, in the case of petroleum products, are CO_2-emission factors only, because the (much smaller) emission factors for methane and nitrous oxide depend on the type of equipment in which the petroleum products are used.

Many of the graphs in *Australian Energy Emissions Monitor* are presented as moving annual totals. This approach removes the impact of seasonal changes on the reported data. Annualised data reported in the *Monitor* will show a month-on-month increase if the most recent monthly quantity is greater than the quantity in the corresponding month one year previously. Most data are presented in the form of time series graphs, starting in June 2011, i.e. with the year ending June 2011. Some graphs start in June 2008. These starting dates have been chosen to highlight important trends, while enhancing presentational clarity.

Defining the meaning of the various terms used to describe the operation of the electricity supply system will help in understanding the data discussed.

Demand, as defined for the purpose of system operation, includes all the electricity required to be supplied through the grid level dispatch process, operated by AEMO. This includes all the electricity delivered through the transmission grid to distribution network businesses, for subsequent delivery to consumers. It also includes energy losses in the transmission system and auxiliary loads, which are the quantities of electricity consumed by the power stations themselves, mostly in electric motors, and which power such equipment as pumps, fans, compressors and fuel conveyors. Both demand and generation, as shown in the *Monitor* graphs, are adjusted by subtracting estimates of auxiliary loads. Thus demand, as shown, is equal to electricity supplied to distribution networks (and a handful of very large users that are connected directly to the transmission grid) plus transmission losses. Large users include the three pumped hydro schemes in the NEM, but since these both consume and generate electricity, net consumption, averaged over time, is only the difference between consumption and generation.

Generation is defined to include only electricity supplied by large generators connected to the transmission grid. The numbers reported by AEMO are "as generated" generation, meaning the generation required to supply total demand, including auxiliary loads. However, most of the analysis and results presented in the *Monitor* show sent out generation, meaning as generated generation, minus auxiliary loads. To estimate auxiliary loads, the *Monitor* uses auxiliary load factors for each power station, published by AEMO and used in all its modelling work. This includes the modelling supporting the Integrated System Plan. Similarly, the *Monitor* uses AEMO figures for the emissions intensity (emissions per unit generated) of each power station.

Demand does not include electricity generated by rooftop PV installed by electricity consumers, irrespective of whether that electricity is used on site ("behind the meter") by the consumer or exported into the local distribution network. This has been growing very rapidly and in the year to December 2021 totalled over 16 TWh. Also excluded is generation from landfill and sewage gas plants, and various other small generators, totalling about 2 TWh. All these types of small generators supply into their local distribution network, not the NEM grid. From the perspective of the supply system as a whole, the effect of this generation, usually termed either “embedded” or “distributed” generation, is to reduce the demand for grid supplied electricity below the level it would reach without such distributed generation.