Crawford School of Public Policy
Centre for Climate and Energy Policy

Energy productivity, gas consumption and employment: trends in the Australian economy 2008-09 to 2018-19

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Abstract

This paper uses the most recent update of *Australian Energy Statistics* to examine two separate though related questions. First, how is Australia's National Energy Productivity Plan, launched in 2015, progressing? It finds that primary energy productivity has increased, but the increase is almost entirely attributable to the shift from fossil fuel to renewable generation of electricity, meaning that final energy productivity has been almost static. However, factorisation analysis shows that lack of progress in final energy productivity is mostly caused by recent rapid growth in the very energy intensive production for export of large volumes of LNG. Modest but non-negligible energy productivity improvements have been achieved in most other sectors of the economy. The second question is whether, as the government proposes, increased supply and consumption of gas will boost employment and revive the economy. The paper concludes that it will not, because almost all employment is found and almost all GDP is created in sectors of the economy which use relatively very little gas. Three sectors of manufacturing use about two thirds of total commercial gas consumption in Australia (excluding electricity generation and the LNG industry), but employ less than 2 per cent of the workforce and contribute about 3 per cent of GDP. In fact, most of this two thirds is used at just fourteen large industrial sites spread across Australia.

Keywords:
energy productivity, final energy consumption, factorisation, gas consumption, employment, sectoral value added

JEL Classification:
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Introduction

In December 2015 the Council of Australian Governments (COAG) Energy Council agreed to “work together to develop the National Energy Productivity Plan (NEPP)” (COAG Energy Council, 2015). The centrepiece of the NEPP is a commitment to increase Australia’s primary energy productivity over the 15 years to 2030 by 40 per cent. Energy productivity is defined as Gross Domestic Product (GDP) divided by total national energy consumption. National energy consumption may be expressed as either primary energy or final energy; the NEPP target is defined in terms of primary energy. This choice has important implications, which are examined later in this paper.

The Plan itself consists of 34 separate measures, organised into the following hierarchy.

Encouraging more productive consumer choices	Efficient incentives	2 measures
	Empowering consumers	3 measures
	Helping businesses compete	7 measures
Promoting more productive energy services	Innovation support	6 measures
	Competitive modern markets	11 measures
	Consumer protection	5 measures

The Plan document includes the following statement: “The COAG Energy Council will publish its first detailed review of the NEPP’s progress before 2020.” (p. 7). Given the enormous disruptions of 2020, it is unclear whether this review will in fact be published or, indeed, whether it is being prepared. The plan document does not mention annual reports, but two have in fact been published – one in 2017 and one in 2018. For the 2018 report, the most up to date national annual energy consumption data were for 2016-17; the report notes that energy productivity was flat between 2014-15 and 2015-16 and increased by 0.9 per cent between 2015-16 and 2016-17 (Department of Environment and Energy, 2018).

Adoption of the NEPP was the first occasion on which all Australian governments collectively agreed to the same detailed plan. It was, however, far from the first policy or set of measures intended to boost energy productivity to be adopted by either Commonwealth or individual state and territory governments. The history of formal energy efficiency policies and programs can be traced back to at least the early 1990s and, by some definitions, to 1980, when both Commonwealth and state governments introduced measures intended to increase the efficiency with which petroleum fuels were used, in response to the global disruption of petroleum supply arrangements constituting the Second Oil Price Shock.

Starting in 1993, the Commonwealth agency responsible for applied energy economic research (the name of the relevant agency has changed several times since then) has published detailed analyses of Australia's progress in improving energy productivity (which the reports usually expressed as energy intensity, which is the reciprocal of energy productivity). The most recent such report was published in June 2015 by the Office of the Chief Economist in the (then) Department of Industry and Science (Stanwix, Pham and Ball, 2015). Note that this report (and all of its predecessors) analyses end-use of final energy intensity, not primary energy intensity. The findings of this report are discussed later in this paper.

On 2 October 2020 the Commonwealth Government released *Australian Energy Statistics 2020*, containing annual data up to 2018-19. This is Australia's major annual energy statistics publication, with a history of over forty years. Its publication, which in most previous years has occurred in July rather than October, provides the opportunity to update analysis of Australia's energy productivity performance. That is the major focus of this paper. The paper starts by examining the difference between primary energy productivity and final or end-use energy productivity. It then undertakes a detailed analysis of sectoral changes in final or end use productivity and an estimation of the various factors contributing to the observed outcome. The contributory factors are quantified using the energy decomposition analysis approach used by Stanwix *et al*. (2015) and the corresponding preceding reports published in 2009 and 2010. Finally, the paper examines the relationship between end use energy consumption and employment and also employment and natural gas consumption in the 2018-19 year.

All the analyses use annual data from *Australian Energy Statistics*, and most extend back only to 2008-09. The reason for this rather limited time span is that there is a major discontinuity in the sectoral energy consumption data between 2007-08 and 2008-09. This discontinuity re-allocates estimated energy consumed in "behind the meter" generation of electricity at industrial and commercial facilities (in Australia, usually termed cogeneration) from the economic sector where the cogeneration occurs to the electricity generation sector, in conformity with IEA conventions for energy statistics. The overall affect is to reduce final energy consumption and increase energy used in conversion, relative to the values which would have been calculated using the previous convention.

All the energy data presented in this paper have been calculated using various combinations of the highly disaggregated (by economic sector and fuel type, as well as year) consumption data presented in Table F of *Australian Energy Statistics 2020*.

Primary and end-use energy consumption and productivity trends

Figure 1 plots relative changes, since 2008-09, in primary and final energy consumption, and also in GDP. The difference between primary and final energy consumption is the quantity of energy lost (mostly as waste heat) in the course of the various processes used to convert primary fuels to final energy products. These losses includes energy lost at oil refineries, which convert crude oil into petroleum products, and energy lost at various types of industrial facilities used to convert coal into other solid fuels, including coke ovens (associated with steel mills) and brown coal briquetting. By far the largest source of conversion energy loss, however, is thermal electricity generation.

Typically, depending on the type, size and age of a thermal power station, the energy content of the electricity generated is only about one third of the energy content of the primary fuel supplied to the power station. The proportion is somewhat higher at a modern combined cycle gas turbine power station, and lower at a smaller, older coal fired steam power station, particularly if it uses brown coal. By contrast, under the accounting conventions used in compiling energy statistics, the primary energy used by hydro, wind and solar generators is defined as being equal to the quantity of electricity the power station produces. This means that the statistics show much more primary energy being used to produce one unit of electricity supplied to final consumers from a thermal power station than from a renewable power station. Additionality, some of the electricity generated at thermal power stations, referred to as auxiliary load, is consumed to drive pumps, compressors, fans, conveyors and other equipment, without which the power station could not function. Auxiliary load required by hydro, wind and solar generators, by contrast, is very small to negligible. Finally, some of the electricity generated by any type of power station is consumed, in the form of transmission and distribution losses, between the power station terminal and the consumer's meter; these losses are incurred irrespective of the type of generator.

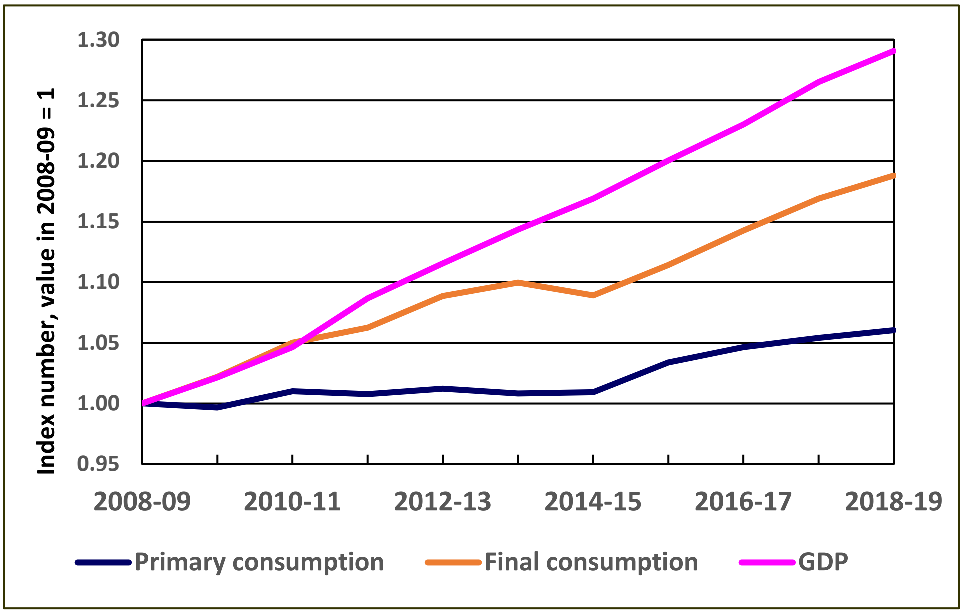

Figure 1: Relative changes in primary and final energy consumption, and GDP, since 2008-09

It can be seen in Figure 1 that consumption of final energy grew much faster than consumption of primary energy throughout the ten year period examined. To better understand the reasons for the changes in primary energy consumption, Figure 2 separates primary energy into that related to electricity generation and all the rest (related to the production of petroleum and coal products, as described above). In addition, a counterfactual trend is presented for electricity related primary energy.

This counterfactual is calculated by assuming that the quantity of electricity generated from renewable sources stays constant at its level in 2008-09, as does the ratio of primary energy input to electricity output at thermal power stations (a rough average measure of the efficiency with which primary power station fuels are converted to .electricity). It can be seen that these assumptions have a most dramatic effect on the trend in primary energy consumption in the electricity sector. Under the counterfactual assumptions, the primary energy consumed to generate electricity for five years from 2008-09 until 2013-14 is almost unchanged, after which it steadily increases. By contrast, actual primary energy consumed to generate electricity falls rapidly until 2013-14, then increases for two years, before resuming a steady fall. What this means is that the observed decrease in primary energy consumed to generate electricity is caused by two fundamental changes in Australia's electricity supply industry: increases in the efficiency of thermal generation and decreases in the share of total electricity supplied by thermal power stations. It is not directly related to the actual quantities of electricity generated.

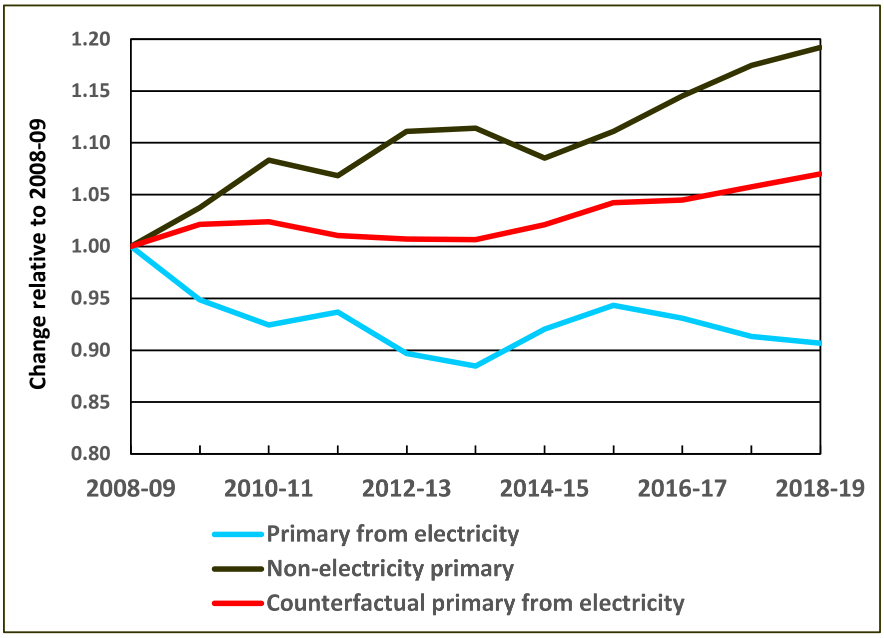

Figure 2: Disaggregation of trends in primary energy consumption

Between 2010 and 2015 in the National Electricity Market (NEM), supplying over 80 per cent of Australia's electricity consumption, nine old, inefficient coal fired power stations, with a total combined capacity of 3.4 GW, were closed, while and four new combined cycle gas power stations, with a total combined capacity of just under 1.5 GW, were opened. The share of electricity supplied from coal fired stations fell from 81 to 76 per cent, while the share of renewable generation increased from 8.8 to 12.2 per cent. There was an additional, short-lived fall in coal fired generation during 2012-13 and 2013-14, caused by the price on emissions. This enabled hydro generators to achieve a temporary increase in output, at the expense of coal generators. This change was reversed over the two years after the emissions price was removed. This effect outweighed the effect of a rapidly growing share of renewable generation, which came to dominate during the final three years shown, from 2017 to 2019, and continues. Over the four years from 2015 to 2019 the renewable generation share increased further and faster, to 18.4 per cent.

Less coal but more efficient coal, and more renewable generation, both have the effect of increasing the quantity of electricity generated per unit of primary energy consumed, meaning that consumption of primary energy per unit of final electricity energy supplied decreases. When initial year (2008-09) values for both thermal generation efficiency and renewable generation are assumed to remain unchanged, in the counterfactual case, primary energy consumed to generate electricity gradually increases, more or less in line with the gradual increase in electricity consumption.

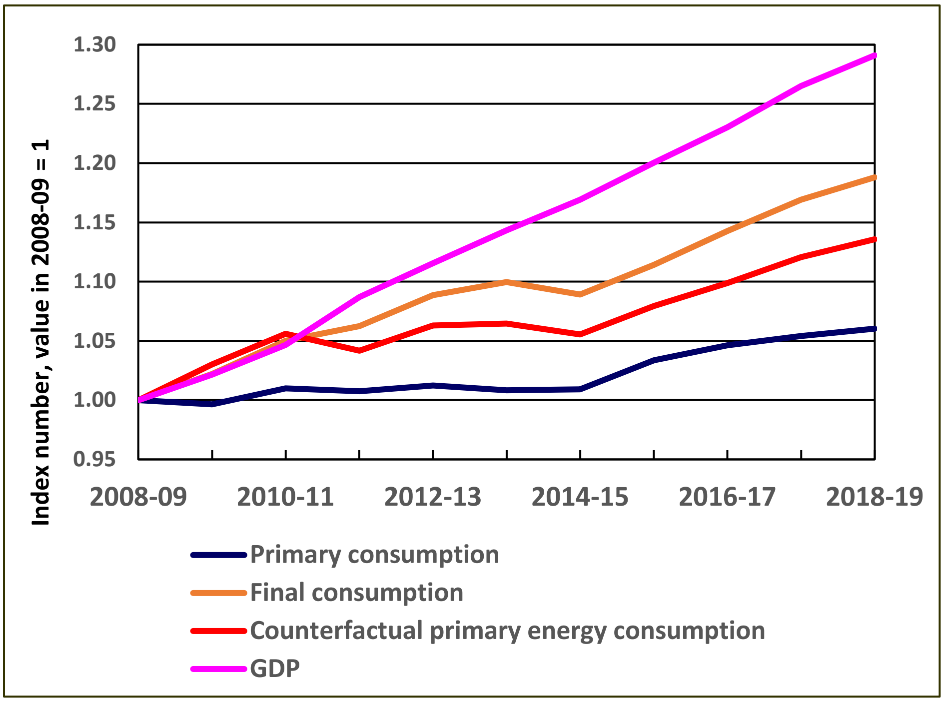

Figure 3: Relative changes in actual and counterfactual primary and final energy consumption and GDP since 2008-09

The effect on total primary energy consumption of the counterfactual assumptions is shown in Figure 3, which is otherwise identical with Figure 1. It can be seen that the counterfactual assumptions reduce the difference in growth rates between primary and final energy.

Two other factors also contributed to slow the growth in primary energy consumption over the four years from 2010-11. Firstly, steel production fell by 34 per cent between 2010-11 and 2012-13 (Office of the Chief Economist, 2020), reducing primary energy used in coke production. Secondly, three of Australia's previously seven oil refineries shut down in 2012 (Clyde), 2014 (Kurnell) and 2015 (Bulwer Island).

Energy productivity is equal to GDP divided by total national energy consumption, either primary or final. Final energy productivity is equal to GDP divided by total national final energy consumption. Figure 4 shows trends in energy productivity, calculated from the data shown in Figure 3.

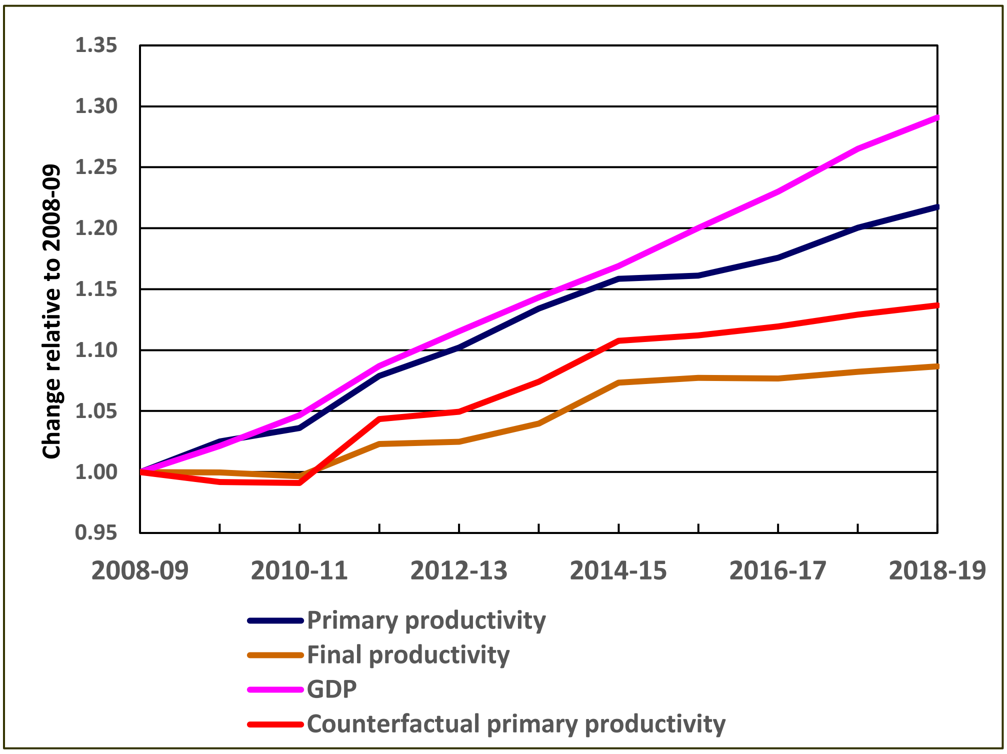

Figure 4: Trends in energy productivity: primary, final and counterfactual primary

Over the entire period, primary energy productivity increased by 22 per cent, whereas final energy productivity increased by only 9 per cent. Counterfactual primary energy productivity increased by 14 per cent, which is obviously more than final energy productivity, but substantially less than the growth in counterfactual primary energy productivity. Over the most recent four years, from 2014-15 to 2018-19, the relative difference between growth in final and primary energy productivity, and the similarity between counterfactual final and counterfactual primary energy productivity have both been even more marked. Final energy productivity has increased at an average rate of only 0.3

per cent per year; primary energy productivity has increased by 1.3 per cent per year on average, but counterfactual primary energy consumption by only 0.9 per cent per year. Energy productivity is used as an indicator of the efficiency with which energy is used to produce goods and services; the total value of all goods and services produced constitutes GDP. What this analysis shows is that much of the increase in primary energy productivity is not attributable to increased energy use efficiency, but to changes in the mix of technologies used to generate electricity and the conventions used to record those changes in energy statistics. Thus, the increase in primary energy productivity is attributable, not to increases in economic output per unit of energy used, but to the transition of the electricity industry towards a low emissions future, a transition which so much of national government policy seems to be oriented towards slowing, rather than encouraging. A further contribution to increased primary energy productivity has come from the major closures in blast furnace steel production and oil refining, both of which are highly energy intensive, meaning that their value of output per unit of energy consumed is very low.

It follows from these considerations that primary energy productivity is a highly inappropriate indicator of progress in increasing national energy productivity. What is worse, the gap between primary and final energy productivity growth is increasing, with the rapid growth in both grid scale and distributed solar generation, together with wind generation. The next section of this paper focuses on trends in final energy consumption and productivity, and the factors contributing to the changes which have occurred.

Factors affecting trends in Australian final energy consumption and energy intensity

The analysis presented here decomposes changes in national final energy consumption as the outcome of changes in total economic activity, changes in the energy intensity of the various economic sectors making up the total economy, and changes in the structure of the economy, defined by the shares of total economic activity contributed by each sector. This approach is commonly termed factorisation. This paper follows Stanwix *et al*. (2015) in using the Log Mean Divisia Index Method 1 (LMDI-1) approach to factorisation. The data inputs to the analysis are sectoral final energy consumption, as specified in *Australian*

Energy Statistics Table F, and sectoral value added, as specified in the national accounts (Australian Bureau of Statistics, 2020). For the road transport sector, a special adjustment was made to the reported energy consumption, which includes the very substantial fuel consumed by private motor vehicles. Data presented in the *Survey of Motor Vehicle Use* (Australian Bureau of Statistics, 2019) provided estimates of annual fuel used by each of the main types of road vehicle. It was then assumed that all fuel consumption by light commercial vehicles, rigid trucks, articulated trucks, and buses was for commercial use, while all consumption by passenger vehicles and motor cycles was for private use.

The explanatory power of the analysis will be strongly affected by the level of sectoral disaggregation used – the more detailed the disaggregation, the more detailed will be the understanding of explanatory factors. In particular, the greater the level of disaggregation, the more closely individual sectoral energy intensity will approximate to "pure" energy efficiency. The sectoral disaggregation available for energy statistics differs from the disaggregation available for the economic value added statistics. Consequently, aligning the two means that a high level of disaggregation cannot be achieved, and the number of individual sectors used in the analysis is quite small. ANZSIC Division D, consisting of electricity generation and supply, gas supply (not production), water supply and waste services, is excluded. Energy used in petroleum refining was also excluded. It was not possible to exclude petroleum refining value added because in the economic data it is grouped with chemical product manufacture, but it is likely to be small, given that low profitability has caused three of seven refineries to be closed in recent years.

The sectors used in the analysis are shown in Table 1, which also shows the energy intensity of each sector in 2018-19. It can be seen that the most energy intensive sector (aviation) is in excess of 100 times more energy intensive than the least intensive sector (manufacture of machinery and equipment).

Table 1: Energy intensity of economic sectors in 2018-19

ANZSIC Division	Sector	Energy intensity ((kJ/A$ value added)	Share of combined total value added	Share of total final energy consumption
ANZSIC Division A	Agriculture, forestry and fishing	2.6	2.6%	3.5%
ANZSIC Division B	Coal Mining	3.6	2.8%	5.2%
	Oil and gas extraction	9.9	3.0%	15.3%
	Iron ore and other mining	3.3	4.1%	6.9%
ANZSIC Division I	Road transport	21.8	1.6%	18.7%
	Aviation	36.2	0.6%	4.3%
	Rail, shipping and pipeline transport	10.3	0.8%	4.2%
ANZSIC Division C	Food and beverages	2.7	1.7%	2.3%
	Chemical products	10.0	1.3%	6.9%
	Metal products	25.2	1.2%	15.3%
	Machinery and equipment	0.30	1.3%	0.2%
	All other manufacturing	7.4	1.3%	5.2%
ANZSIC Division E	Construction	0.18	8.8%	0.8%
ANZSIC Divisions F, G, H, J to S	All commercial and services	0.30	68.9%	11.2%

Note: *Final energy consumption excludes residential sector energy consumption*

The result of the factorisation analysis is shown in Figure 5. The trend in final energy consumption is of course the same as that shown in Figures 1 and 3 above. However, the factorisation illuminates the contributions of the key factors responsible for the changes which have occurred over the ten years covered by the analysis. Three separate periods can be identified. During the first two years the average energy intensity of the various sectors increased, meaning that energy consumption grew faster than GDP, only slightly offset by an overall structural shift towards less energy intensive economic sectors. During the next four years both decreasing energy intensity and continuing structural shift led to much slower growth in total energy consumption. This was a period during which there were large increases in consumer electricity prices and, in addition, for two years, a price on emissions from electricity generation (which had a small additional impact on electricity prices) and gas, but not on transport fuels. During the last four years, changes in both energy intensity and structural change effectively ended. Consequently, energy consumption increased at a rate which almost exactly matched the rate of economic growth. The result of this combination of factors is, of course, almost no increase in total national final energy productivity, as shown in Figure 4.

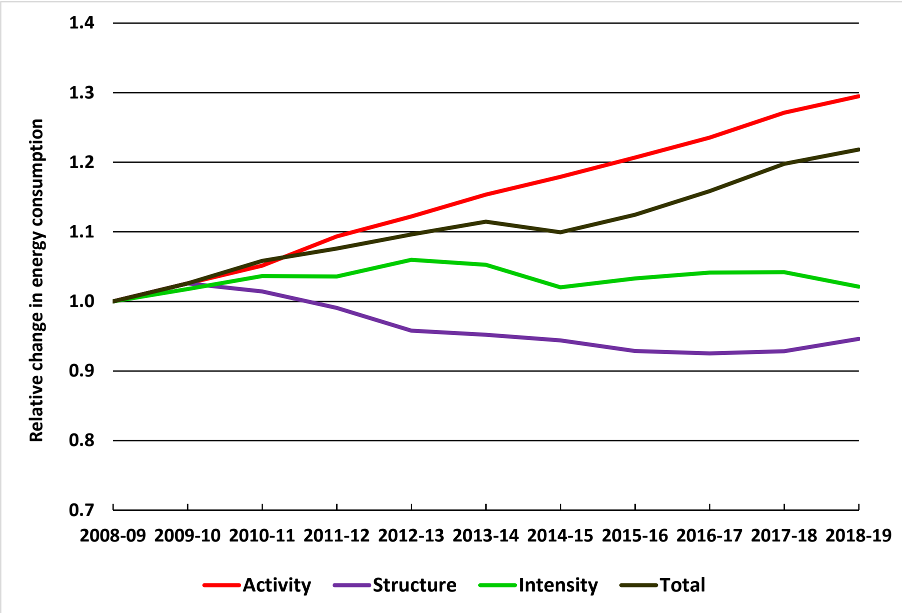

Figure 5: Factors contributing to changes in Australian final energy consumption since 2008-09

A deeper understanding of these changes can be gained by examining individual economic sectors, looking at trends in energy intensity and in sectoral shares of total economic activity. As a generalisation, if an individual sector increases both its energy intensity and its share of the total economy, it will contribute to an increase in the energy intensity of the whole economy. Conversely, if both energy intensity and sectoral share decrease, the sector will tend to make the economy less intensive. If the two factors move in opposite directions, the outcome will of course depend on the balance between the two trends.

Figure 6, which shows these trends for the three mining industry sectors, provides a good illustration of these observations. Since 2010-11, the oil and gas extraction industry, the main component of which is extraction and processing of gas to LNG for export, has increased in both relative size, i.e. sectoral share, and energy intensity by about 40 per cent. This means that, not only is it one of the more energy intensive sectors, but its contribution to national final energy intensity almost doubled over the eight years to 2018-19. By contrast with the LNG industry, coal mining increased in energy intensity up to 2011-12, since when there has been a small decrease, while its share of the national economy has remained almost constant throughout.

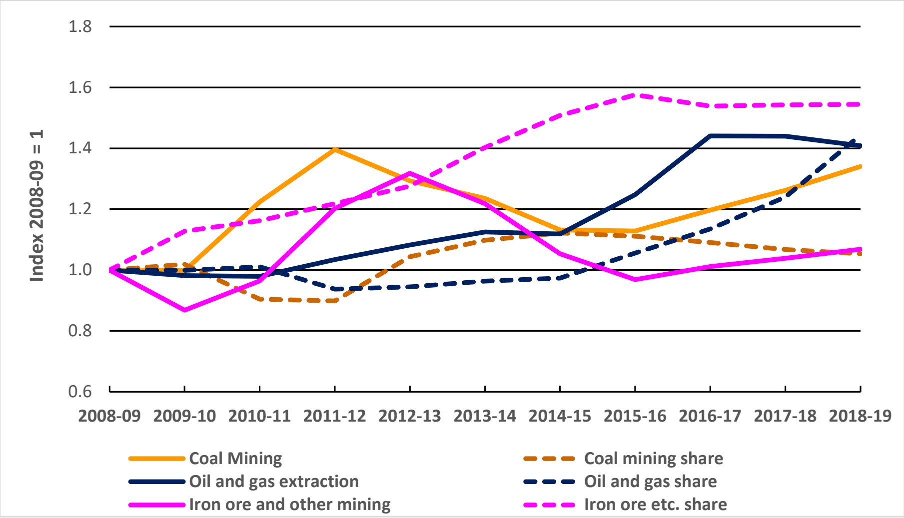

Figure 6: Trends in energy intensity and sectoral shares of mining industry sectors

Mining of iron ore and other minerals increased in both energy intensity and sectoral share until 2012-13, since when its share has continued to increase, while its energy intensity has decreased. This sector includes not only iron ore mining, but also mining of gold, copper, zinc, lead, nickel, mineral sands and many other commodities. It is therefore a good illustration of the important point about factorisation analysis: changes in energy intensity (or its reciprocal, energy productivity) cannot be interpreted as changes in technical efficiency of energy use. Any such changes could, instead, be caused by changes in the mix of activities within different sub-sectors. That said, in the context of energy system transition and climate change policy, any marked change in energy intensity at the sectoral level, whether it is an increase or a decrease, should be a pointer to the need for more detailed examination of the changes which may have been occurring.

Figure 7 shows energy intensity and sectoral shares for the five separable parts of manufacturing industry. Limited disaggregation in the economic statistics, mentioned above, means that, with the exception of the food and beverage sector, each is a grouping of several smaller, and very disparate, manufacturing sectors. For example, chemicals includes the very energy (and fossil fuel) intensive manufacture of ammonia, as well as the manufacture of pharmaceutical products. The all other grouping includes the very energy intensive manufacture of cement clinker, as well as the manufacture of clothing and furniture. Consequently, it cannot be concluded with confidence, that the steady decline in energy intensity of all sectors, at least since 2013-14, means that manufacturing is becoming more energy efficient. However, the very obvious decline in the manufacturing share of total economic activity means that since 2012-13 the share of total final energy used in manufacturing has fallen significantly.

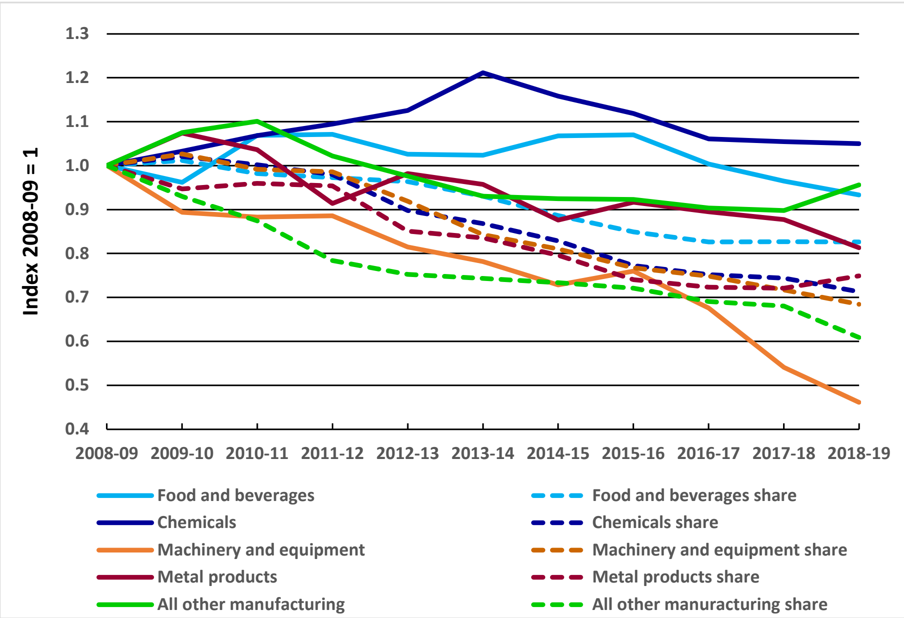

Figure 7: Trends in energy intensity and sectoral shares of manufacturing industry sectors

Overall, as Table 1 shows, transport is the most energy intensive part of the economy. Moreover, for most of the period both road transport and rail, shipping and pipeline transport have seen their energy intensity increase. However, Figure 8 includes two additional trends, of the energy intensity of the freight task, expressed as energy consumed per tonne-km transported, which is obviously an indicator which better represents the energy efficiency of providing a freight service. Data for annual freight task by mode (road, rail, coastal shipping) was sourced from the Bureau of Infrastructure, Transport and Regional Economics (2019). Using this metric, the energy intensity of rail and coastal shipping freight transport has fallen substantially, while the energy intensity of road freight transport has remained roughly constant, rather than increasing when defined in terms of value added (road and rail freight task data for the most recent few years is not available).

Data for the road and rail passenger transport task are available but have not been included, because of the difficulty of determining a basis on which to combine them with freight task data. This means that the estimates of task energy intensity shown in Figure 8 are conservative on the downside, i.e. task energy intensity would be lower if passenger transport were included in the task.

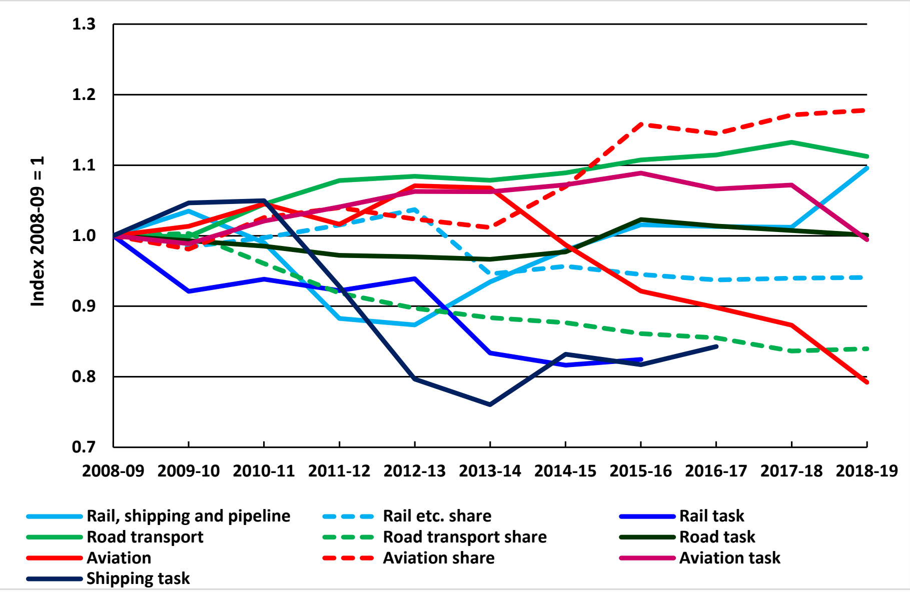

Figure 8: Trends in energy intensity and sectoral shares of transport industry sectors

Changes such as larger road freight vehicles and automation of rail transport of bulk minerals (an activity responsible for well over half of Australia's total rail freight task) are likely to have reduced energy use per tonne-km. However, these changes would also decrease employment and value added, which would explain the increase in energy intensity per $ of value added.

Aviation, by contrast with road and rail transport, has shown consistent growth in its share of the national economy up to 2018-19, with a particularly large increase between 2013-14 and 2015-16, and also decreased energy intensity since 2013-14 (both value added and energy use will show a large fall in 2019-20). However, these figures may be misleading because the value added of the aviation industry includes activities related to international aviation, whereas the energy consumption is confined to fuel used for domestic flights. Hence value added will be over-stated, relative to energy consumption, making the energy intensity of economic activity in the industry appear to be lower than it actually is.

A domestic aviation task energy intensity has therefore been estimated to provide a better measure of the energy intensity of domestic aviation. Task activity is defined by total annual domestic Revenue Passenger Kilometres (RPKs), as reported by the Bureau of Infrastructure, Transport and Regional Economics (2020). Using this task measure, the energy intensity of domestic aviation gradually increases until 2017-18, then appears to fall sharply in 2017-18 as a result of a reported 7 per cent drop in annual fuel consumption.

Finally, Figure 9 shows energy intensity and sectoral economic shares of the two least energy intensive sectors, commercial and services, and construction, as well as the fourth least energy intensive, agriculture, forestry and fishing. Commercial and services, which is covered by thirteen separate ANZSIC Divisions, but is treated as a single sector in the energy statistics, accounts for almost 70 per cent of total national economic activity , but only 11.2 per cent of total final energy consumption. It can be seen that this huge sector has been gradually increasing its share of national GDP and decreasing its energy intensity. For agriculture, by contrast, since 2014-15 economic share has decreased and energy intensity increased. Broad acre cropping activities and water pumping account for a large proportion of energy use in agriculture; reduced farm income, because of drought, particularly in 2017-18 and 2018-19 is likely to have driven both increased energy intensity and decreased share of national economic activity. Construction is the least energy intensive of all the major economic sectors. Driven largely by the boom in construction of LNG plants, construction peaked as a share of national income in 2012-13 and 2013-14, and has steadily declined since then.

The preceding detailed examination of individual economic sectors provides deeper understanding of the components contributing to the twin trends shown in Figure 5 – energy intensity and structural change. Since 2014-15 these have been almost equal and opposite.

As a result, total national final energy consumption has increased at almost precisely the same rate as GDP, and there has been no significant change in national final energy productivity. Given the establishment of the NEPP, these most recent five years are of particular relevance.

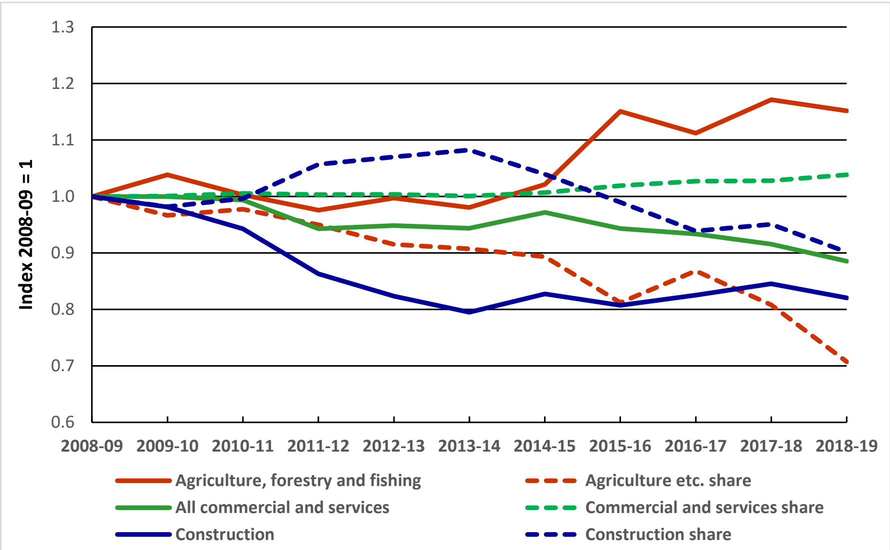

Figure 9: Trends in energy intensity and sectoral shares of the agriculture, construction and commercial and services sectors

The analysis presented here has shown that the now longstanding shift in economic structure away from manufacturing (30 per cent of total final energy consumption) has continued unabated during the past five years, and the shift towards services (11 per cent of total final energy consumption) has, if anything, accelerated. Moreover, during the most recent three years, service sector energy consumption was almost unchanged, meaning that the already low energy intensity, fell even further. Similarly, energy consumption by manufacturing as a whole has fallen faster than manufacturing economic activity, meaning than the energy intensity of most sectors of manufacturing has been decreasing.

On the other hand, the energy intensity of road, rail and coastal shipping transport (23 per cent of total final energy consumption) has been increasing, while their economic share has been decreasing. The outcome has been that their energy consumption has increased at about the same rate as GDP, though road transport energy growth slowed somewhat in 2018-19.

By far the largest source of final energy consumption growth over the past few years has been the mining industry, which includes oil and gas extraction and processing to LNG. Over the four years 2014-15 to 2018-19 these industries increased their share of final energy consumption from just under 20 per cent to over 27 per cent; oil and gas alone increased its share from 8 per cent to 15 per cent. Value added attributable to all of these industries is highly sensitive to the prices they receive for the mineral commodities which they produce. If prices rise, but production and production processes remain unchanged, energy intensity will decrease, but sectoral share will decrease, and vice versa if commodity prices fall. In each case, the contribution of the industries to total national final energy consumption will remain unchanged.

The significant contribution made by the oil and gas sector to national energy productivity is most easily seen by repeating the analyses described above, but with the exclusion of both energy consumed by the oil and gas industry and the value added it contributes to GDP. Figure 10 is the same as Figure 4, but with the counterfactual primary energy productivity replaced by final energy productivity without the oil and gas industry. Figure 11 is the same as Figure 5, but with oil and gas industry energy consumption and value added again excluded.

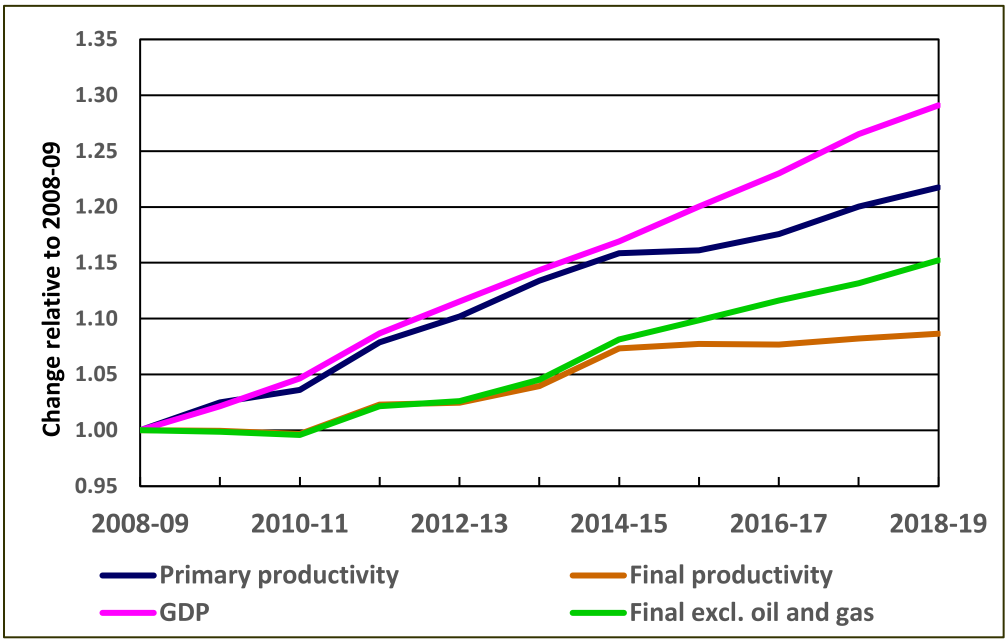

Figure 10: Trends in energy productivity: primary, final, and final without the oil and gas industry

It can be seen in Figure 10 that final energy productivity in this counterfactual grows as fast or faster than as primary energy productivity – 6.5 per cent compared with 5.1 per cent over the four years from 2014-15, and 4.9 per cent in both cases over the three years from 2015-16. In Figure 11, the structural shift away from manufacturing and towards services is no longer outweighed by the rapid growth of the oil and gas industry, while overall average energy intensity also falls steadily. As a result, total final energy consumption stays roughly constant, rather than steadily growing. Total final energy consumption in 2018-19 is reduced by 15 per cent, but GDP is also reduced, by 3 per cent.

The final section of this paper tests the political claims that increasing gas consumption will drive economic recovery, by examining the relationships in the various sectors of the economy, between gas consumption value added and employment.

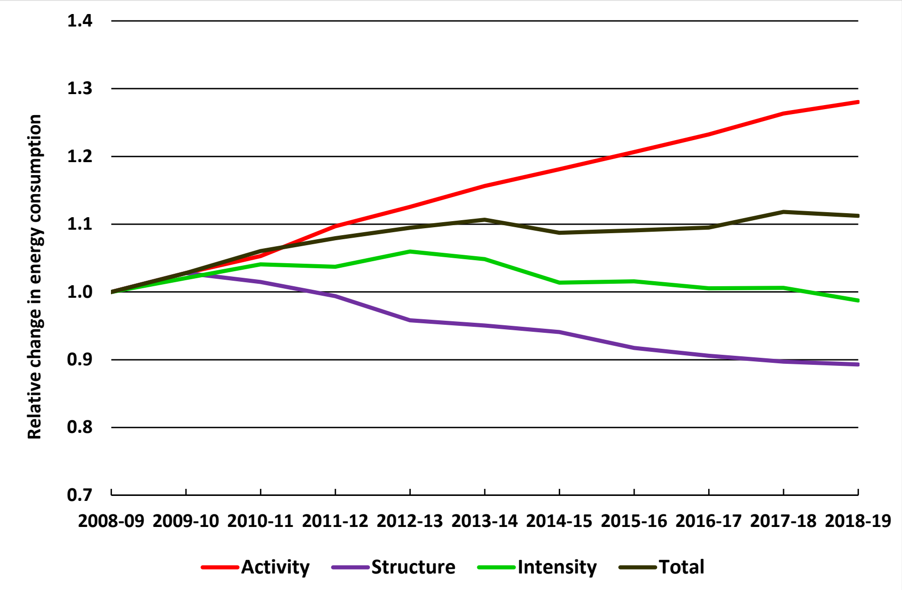

Figure 11: Factors contributing to changes in Australian final energy consumption since 2008-09, with oil and gas industry excluded

Gas consumption, economic activity and employment

The Australian government has stated that it intends to stimulate economic recovery from the pandemic-caused recession by increasing the availability and lowering the cost of gas, an approach which has been called a gas-led recovery. The effectiveness of this approach will depend, at least in part, on how important gas consumption is as an input to economic activity and increased employment across the whole Australian economy. This section of the paper examines the relationship between gas consumption, sectoral value added and sectoral employment, at the most disaggregated level allowed by the available data.

In 2018-19 total national gas consumption was 1,593 PJ. Figure 12 shows how this is distributed across the various major sectors of the entire economy, and how this distribution has changed over the past ten years. Total gas consumption has increased significantly, but almost all of the increase is attributable to two sectors: oil and gas processing, i.e. mainly LNG, and electricity generation. There have also been increases in the commercial and services sector and in residential consumption, but the total volumes of gas are much smaller than in the other two sectors. If these two major consuming sectors, and also residential consumption are excluded, the total volume of gas used to support economic activity, other than LNG production, in 2018-19 was 458 PJ. Figure 13 shows how this has been changing. Two points are particularly important. Firstly, gas consumption peaked in 2013-14, and has been falling steadily since then, and, secondly, although manufacturing accounts for the great majority of total consumption, its share of the falling total consumption has also been falling.

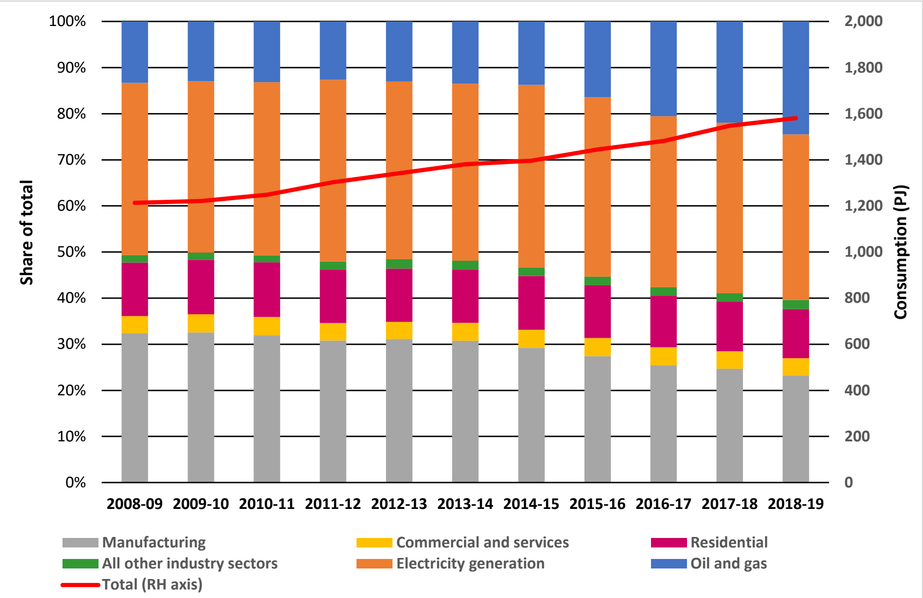

Figure 12: Total gas consumption by economic sector

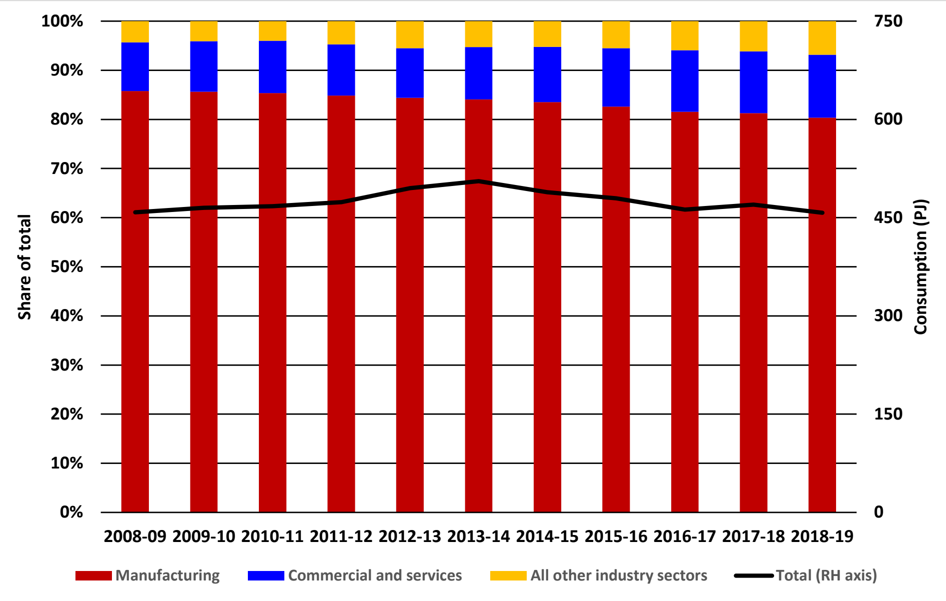

Figure 13: Gas consumption by major economic sector

Note that the “Other” group includes agriculture, mining (other than oil and gas), construction, and all forms of transport. Use of gas by these industries is largely in specialist parts of the various sectors. For example, the main use in agriculture is space heating of buildings used for intensive horticulture and livestock raising, in transport its main use is in pipeline transport of natural gas, and in mining its use is almost entirely confined to Western Australia, where the production of certain metallic mineral concentrates requires thermal processes.

The commercial and services sectors of the economy employed 76 per cent of the entire employed workforce in 2018-19, but used only 13 per cent of the 458 PJ of gas consumption shown in Figure 13. Moreover, gas consumption in these sectors is almost all used for space heating and water heating in buildings, and is thus, while necessary to the functioning of all the people employed, is essentially incidental to the activities on which they are engaged. In this respect it differs from consumption of electricity, which is of fundamental importance. Indeed, a great many buildings, including many in cities with colder climates, such as Melbourne and Canberra, and especially in the whole of Tasmania, use no gas at all, and the share of such buildings is certain to grow, as a growing number of businesses commit to reducing their greenhouse gas emissions.

It follows from this overview that any boost to employment and economic activity from increased gas consumption will have to come from manufacturing. Trends in gas use in manufacturing, by industry sector, are shown in Figure 14. The most striking feature of this graph is how much of manufacturing gas consumption is concentrated in a small number of industries; in 2018-19 three industry sectors – primary metals, chemicals and non-metallic mineral products – used 85 per cent of all gas used in manufacturing.

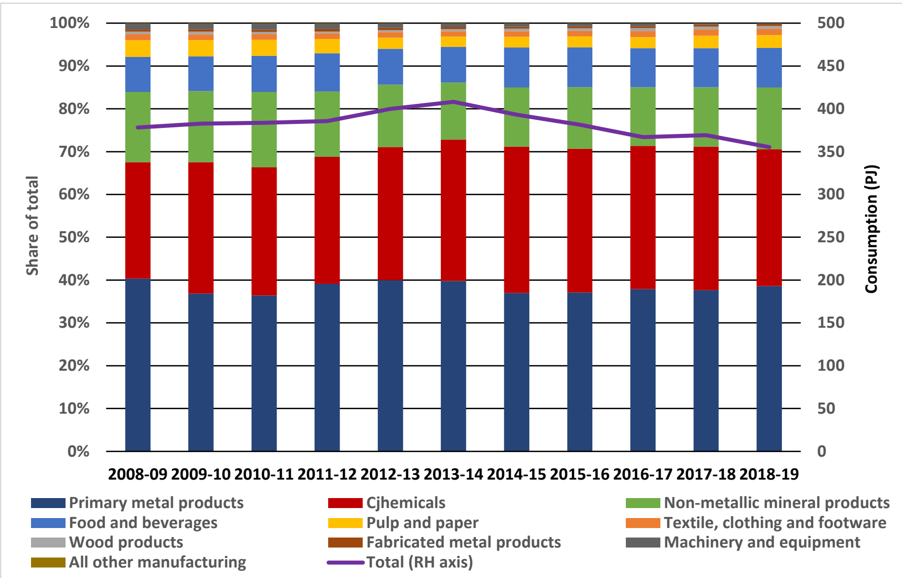

Figure 14: Trends in gas consumption by sectors of manufacturing industry

Figure 15 shows that these three industries account for only 22 per cent of total employment in manufacturing. More detailed examination of these industries suggests that the lack of correlation between gas consumption and employment in manufacturing is even more extreme than the bare numbers imply. Most gas used in the primary metals sector occurs at six alumina plants – four in Western Australia and two in Queensland, each closely linked to a bauxite mine or mines. Gas is used, in smaller volumes, in the processing of some other metal ores, but, in general, any significant expansion of these operations will be more dependant on the development of new mines than on additional supplies of gas. Use of gas in the chemicals industry is equally concentrated, with by far the biggest consumer being the manufacture of ammonia, which occurs at seven sites – two in Western Australia, one in New South Wales, and four in Queensland. In addition, about one fifth of what is recorded in the statistics as natural gas is in fact ethane, not methane; ethane is used as a feedstock for the manufacture of polyethylene at two plants, one in Sydney and one in Melbourne. Gas use in the non-metallic minerals sector is almost equally concentrated, at one large cement plant (the other three large plants in Australia use coal), some brick and tile kilns, and a small number of glass factories.

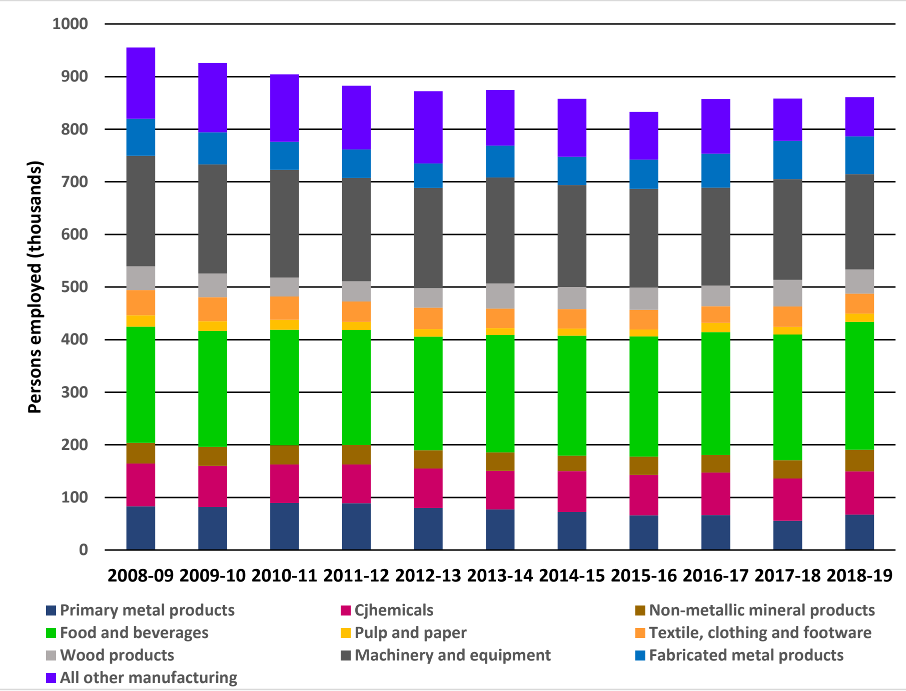

Figure 15: Trends in employment by sectors of manufacturing industry

Another relevant factor is that two ammonia and four alumina plants would be unaffected by any policy to enhance gas supply in eastern Australia, because they are located in Western Australia, which has a completely separate gas supply system. Manufacturers have also been protected since 2006 by a so-called gas reservation policy, a policy which has been supported by both the then ALP which introduced the policy and by subsequent Liberal state governments. For this reason, the Commonwealth's gas-led recovery plan is not relevant to Western Australia. In 2018-19, total final consumption of gas in Western Australia, i.e. excluding electricity generation and LNG, and also excluding residential consumption, was 164 PJ, equivalent to about one-third of total national consumption. Gas consumption in the Northern Territory, other than for electricity generation and LNG, is about 3 PJ. Hence the current volume of gas supporting general economic activity in eastern Australia in 2018-19 was about 302 PJ. Total gas production in Australia in that year was about 5,300 PJ (*AES* Table A).

The one manufacturing sector which is both a large user of gas and a large employer is food and beverages. In 2018-19 this sector used 9.2 per cent of manufacturing gas consumption and, at 28 per cent of the manufacturing workforce, was, by a wide margin the largest employing sector. It also contributed 24 per cent of total manufacturing value added in 2018-19, and is one of the relatively few parts of manufacturing to have increased both employment and value added between 2008-09 and 2018-19. Many businesses in this sector have been adversely affected over the past few years by the large increase in gas prices. In theory, such businesses might be able to benefit from enhanced supply of gas and lower prices. However, the fact that the food and beverages sector has been able to grow over the past ten years, unlike some other much less gas and energy dependent sectors, suggests that the cost or availability of gas is not the most important cause of the decline in Australian manufacturing.

One important characteristic of manufacturing energy which the food and beverages sector shares with alumina production, and also the wood products and pulp and paper sectors, is that: much of the energy they consume is used to produce low temperature process heat in the form of hot water and/or low pressure steam. Specifically, this is a major use of the gas they consume. The food and beverages, wood product and pulp and paper industries have for many years made significant use of organic solid wastes and biofuels for steam raising. Extensive use of low temperature heat makes all these industry sectors promising candidates for moves towards greater use of low and zero emission energy sources, including heat pumps powered by renewable electricity and solar thermal heat. Investigation of the potential for these energy technologies is of interest to ARENA, which has supported relevant studies and trials (ITP Thermal 2019, ARENA 2020). Advancing this work may be a better candidate for public funding than subsidies for gas producers.

The other six manufacturing industry sectors for which data is separately available, as graphed in Figures 14 and 15, are textiles, clothing and footwear, wood products, pulp and paper, fabricated metal products, machinery and equipment, and all other manufacturing.

In 2018-19 these sectors employed 50 per cent of the manufacturing workforce, but required only 6 per cent of the gas consumed. Furthermore, over the ten years their share of total manufacturing gas consumption fell from 8 per cent to 6 per cent, while their share of employment fell by a relatively smaller amount, from 56 per cent to 50 per cent. This suggests that the high cost of gas is unlikely to be the most important factor contributing to the decline of manufacturing in Australia.

Conclusions

Any policy which aims to achieve deep and sustainable reductions in Australia's greenhouse gas emissions must work strongly and decisively towards two fundamental changes in the national energy system. It must rapidly increase the efficiency with which energy is used to deliver goods and services right across the economy, and also steadily reduce the extent to which fossil fuels are being used, not just to generate electricity but to deliver the whole range of energy services.

This paper has used the most up to date detailed national energy supply and demand data for Australia to assess some aspects of how Australia is progressing with these two fundamental changes.

First, in the absence of any recent official progress report, the paper looks at how, after five years, the National Energy Productivity Plan (NEPP)s progressing towards its eventual 2020 target. It finds that data for the first four years – 2014-15 to 2018-19 – shows that primary energy productivity, which is the metric specified for the NEPP, has increased by 5 per cent. However, the analysis also finds that almost all of this increase is not the result of more efficient use of energy, but a consequence of the shift from coal fired to renewable generation in Australia's two main electricity supply systems. If final energy productivity is calculated instead of primary productivity, the productivity increase over the four years is found to be only 1.5 per cent. In other words, very little progress has been made in increasing the productivity of energy consumption, if productivity is measured using final energy productivity, which is the most widely accepted international measure of energy productivity.

Deeper understanding of the changes in energy consumption and energy productivity since 2008-09 and, in particular, since 2014-15, was gained by combining sectoral value added data with sectoral energy consumption and applying factorisation analysis. The results show almost no net change for the economy as a whole in either average energy intensity (the reciprocal of energy productivity) or economic structure affecting energy consumption. This explains why final energy consumption has grown at almost the same rate as GDP, meaning virtually no change in energy productivity. Further understanding was gained by examining changes in value added and energy consumption in each of the fourteen sectors into which economic activity was separated for the purpose of this analysis. It was found, somewhat surprisingly, that over the years since 2014-15, the energy intensity of almost all sectors either fell or stayed roughly constant. The only sector to record a very large increase in energy intensity was oil and gas, which means, in effect, the LNG industry, which increased strongly in both energy intensity and share of GDP. In 2018-19 the oil and gas industry was responsible for over 15 per cent of Australia's total final energy consumption, but delivered only 2.4 per cent of GDP. The industry's very strong growth over recent years was sufficient to almost completely offset the reductions in most other sectors.
However, given that there is no short term prospect of more growth in LNG production (there are no new projects currently under construction), this would mean that the next few years should see the level of final energy consumption stabilise, and energy productivity gradually increase. This statement is made on the assumption of all else being equal which, of course, because of the pandemic, is not the case. A more confident statement cannot be made because there is currently insufficient detailed information about how the impact of the pandemic has affected either sectoral energy consumption or sectoral value added, or about how sectors may recover in the aftermath.

The final part of the paper considers the prospects for success of the government's plan to use increased domestic consumption of gas to drive economic recovery from the pandemic. For this purpose, it examines the relationship between sectoral gas consumption in 2018-19 and sectoral employment. It is assumed that for greater availability or lower prices of gas to provide decisive stimulus for economic activity and employment within an industry sector, gas must be an important input for the sector. This means that, putting aside the oil and gas (LNG) industry itself, that the stimulated economic activity must emerge from manufacturing industries. In 2018-19, manufacturing accounted for 80 per cent of gas consumption (excluding electricity generation and LNG). However, manufacturing accounted for only 6.8 per cent of employment, having declined from 7.5 per cent in 2014-15. Looking in more detail at the various sectors of manufacturing, it is found that three sectors, chemicals, primary metals and non-metallic mineral products, account for 85 per cent of total final gas consumption by manufacturing, but employ only 22 per cent of the manufacturing workforce. Other considerations, discussed in that part of the report, further decrease the likelihood that increased gas availability will lead to significant employment growth in these industry sectors.

The only manufacturing sector which is both a significant employer and a significant gas user is food and beverages. It is conceivable that more abundant and cheaper supplies of gas could stimulate some growth in the food product manufacturing sector. On the other hand, a large proportion of gas consumption in this sector is used to supply heat at relatively low temperatures, in the form of hot water and low pressure steam. Many businesses are examining options to decrease their emissions by shifting towards use of heat pumps, powered by renewable electricity or, in some cases, greater use of processing waste streams, as an alternative to gas. Greater government support for making such changes would be a better way to place these businesses on the road to a sustainable long term future and secure or increase the number of people they employ. Some of the larger businesses in the primary metals and chemicals sectors are examining the feasibility of making analogous changes. In the case of chemicals, where the largest use of gas is for manufacturing ammonia, there is strong interest, and some support through ARENA for trials, for replacing gas with hydrogen made by zero emission processes.

Most manufacturing employment, including much of the employment which has been lost over the past decade, is located in industries which make very little use of gas. If the policy intention is to revive manufacturing, it is more likely to be successful if based on a good understanding of the factors which can contribute to the success of businesses in the relevant sectors. Arbitrary choice of a single input, and one, such as gas, which is far from the most important input to the majority of manufacturing businesses, is most unlikely to be a successful strategy for economic recovery.

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