Prompt indicator of trends in Australian greenhouse gas emissions

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ABSTRACT

Our method for achieving a 'prompt indicator' of national emission trends is based on monthly electricity, petroleum and natural gas data. The resulting monthly time series is consistent with National Greenhouse Gas Inventory (NGGI). The national emissions prompt indicator runs only six weeks behind time - well within the typical lag of other Australian economic indicators. Our prompt indicator: the Carbon Emissions Index (CEDEX) is produced every six weeks by **pitt&sherry** and is available from www.pittsh.com.au/cedex .

Under commitments to the UNFCCC, national greenhouse inventories are calculated annually. In Australia the calculations are largely based on national data gathered by government agencies. Inventories are integral to tracking emissions trends and targets, yet Australian inventories are released 24 months after the end of the inventory period.

Emissions from stationary energy and transport account for about 70% of total Australian emissions from all sectors except forest and grassland conversion. Furthermore, these combustion emissions typically contribute more than 90% of annual increases in emissions.

The indicator is calculated monthly as follows:

(1) Emissions from all fuels consumed at all National Electricity Market (NEM) power stations

plus (2) Emissions from total national sales of petroleum products

plus (3) Emissions from consumption of natural gas in eastern and southern Australia, i.e. excluding Western Australia

There are known omissions and unwanted inclusions in the input data. The only explicit source of error is in change in the net value of omissions and inclusions from the end point of the NGGI up to the time of the indicator.

Our approach shows emissions and energy mix trends in sufficient detail to reveal the effects of above or below average seasonal temperatures, droughts, economic factors and the penetration of renewable generation. In tracking the progress of the greening of the electricity supply and transport emissions abatement, this method can provide a prompt indicator of carbon pollution mitigation.

INTRODUCTION

National inventories of greenhouse gas emissions and sinks are compiled under the rules applicable to the United Nations Framework Convention on Climate Change (UNFCCC). National inventories report greenhouse gas emissions in six sectors (Energy; Industrial Processes; Solvent and Other Product Use; Agriculture; Land Use, Land-Use Change and Forestry; and Waste). The complexities and bureaucracy associated with assembling and aggregating emissions activity data along with the UNFCCC reporting deadline means that national inventories give an account of emissions that occurred two to three years in the past.

Inventories are integral to tracking emissions trends and targets, yet Australian inventories lag behind the end of the inventory period by 23 to 35 months. Our prompt indicator is designed to provide an early indication of key greenhouse gas emission trends in Australia. This work has been published by **pitt&sherry** as its Carbon Emissions Index (CEDEX) since July 2009. It compiles data about emissions from energy combustion sectors including stationary energy and transport and allows analysis of monthly emissions trends less than two months after the emissions activity.

The stationary energy and transport sectors accounted for 61% of total Australian CO_2-e emissions from all sectors except land use change and forestry (LULUCF) in 1990, and 69% in 2008. Combustion for energy has accounted for 91% of the increase in Australia's annual emissions since 1990, while the combined emissions from all the other sectors (except LULUCF) have accounted for only 9% of the total increase (DCCEE 2010a).

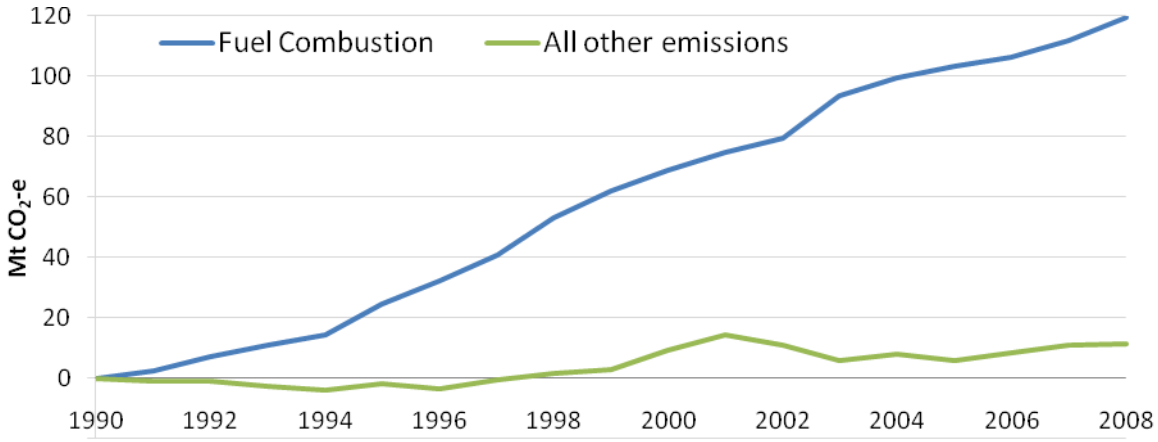

Figure 1. Increases in emissions since 1990 (data from DCCEE 2010a)

Fuel combustion emissions increased by 120 Mt CO_2-e between 1990 and 2008 (Figure 1). All other emissions (Industrial Processes, Agriculture, Waste and Fugitive emissions from fuels), had a combined increase of only 12 Mt CO_2-e over the same period. In terms of percent and absolute change the contribution of combustion emissions dwarfs emissions from all other sources.

The next section on emissions and energy series reports the results of our work. This is followed by relevant background on Australia's greenhouse gas emissions and energy supply together with details on our data sources and emissions calculations.

EMISSIONS AND ENERGY SERIES

The CEDEX covers approximately 82% of Australia's energy combustion emissions and is based on publicly available monthly electricity, petroleum and natural gas data and standard emission factors. Details of calculations and coverage are provided in the section on trend calculations on page 11.

The electricity, petroleum and natural gas energy and emissions series are annualised, that is, recorded each month for the sum of 12 months ending that month. Plotting monthly emissions on each month's activity shows too much variation for a number of obvious reasons including different number of days and weekends per month, public holidays and seasonal temperature variation. Building the data series as the sum of the 12 preceding months has a similar smoothing effect as a 'moving mean' - in which the average of a moving sub-set of a series is plotted on the mid-position of the sub-set. The NGGI is an annual series - in effect each activity is summed to the last day of each inventory year. Our moving 12 month series reveals annual trends, month by month.

The line graphs in this paper are plots of "change since". Because each plot point is the sum of the preceding twelve months of emissions or energy activity up to that point, plotting "change since" is essentially a plot of annual change updated each month. This method of plotting annualised data maintains enough variation to observe trends. Most of our graphs show changes since January 2006, chosen because this was the date when the eastern electricity grid was extended to include Tasmania.

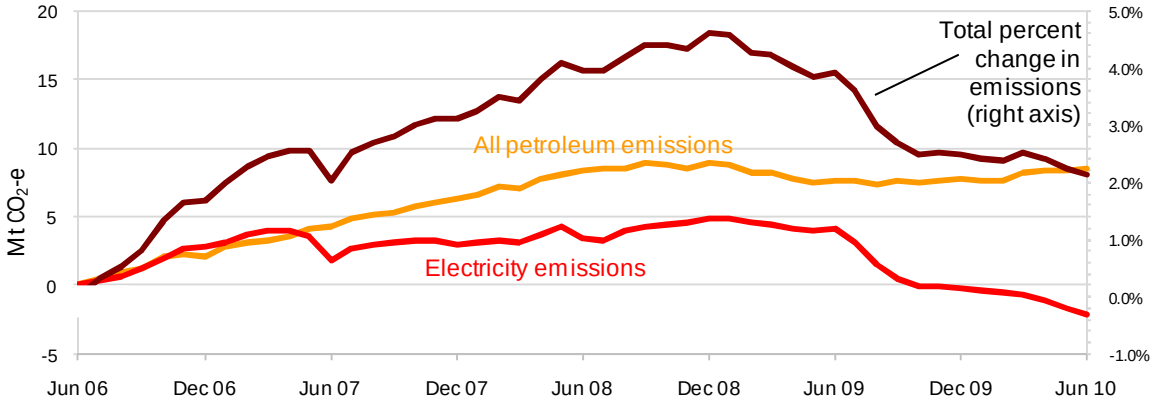

Figure 2. Changes in annual emissions since 2006

We can see in Figure 2 that emissions from these sources have been on a downward trend since December 2008, and that most of the reduction is in electricity. The next two graphs look at electricity in more detail followed by an analysis of changes in petroleum.

Electricity

The effect of the international economic downturn is the likely cause of the reduced electricity demand seen from December 2008. The dip in demand seen around August 2009 (Figure 3) is probably the effect of mild temperatures. The July and August 2009 (southern hemisphere winter) was milder than average, while the previous winter was colder than the long term average. This season on season temperature variation was most marked in NSW which has the largest population and a greater reliance on electricity to meet its heating load.

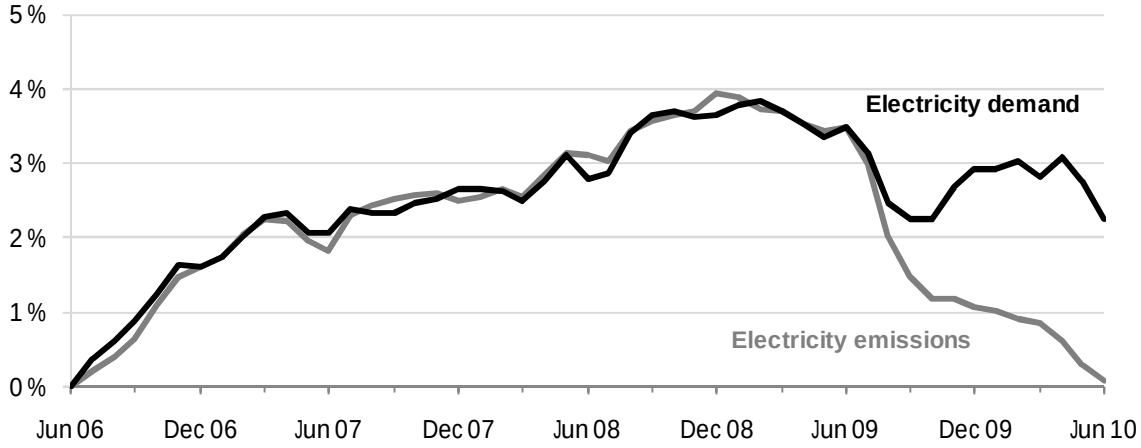

Figure 3. Changes in electricity demand and emissions since 2006 (eastern & southern states)

The marked divergence between demand and emissions where the quantity of electricity supplied by NEM power stations increased, while the associated greenhouse gas emissions fell can be explained by the changes in generation type shown in Figure 4.

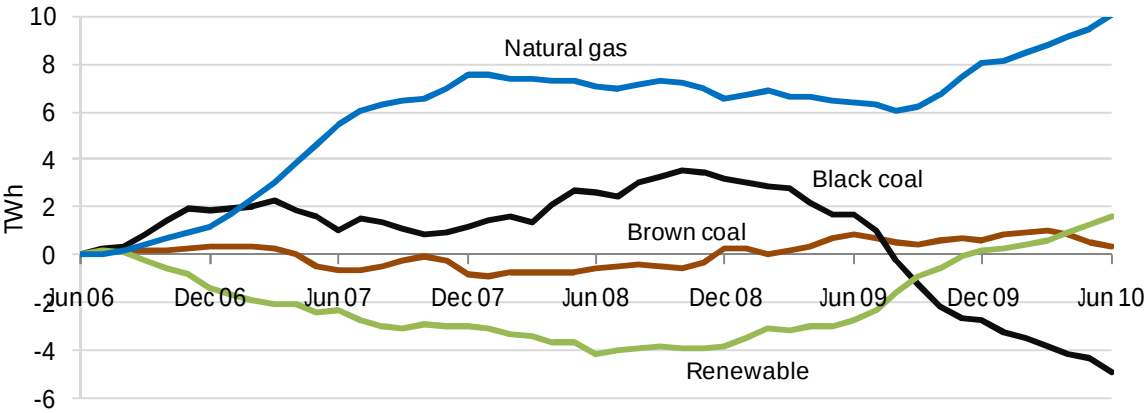

Figure 4. Changes in electricity generation type (from eastern and southern states)

The decrease in electricity emissions seen in since June 2009 (Figure 3) is explained by the fuel switching illustrated in Figure 4. Further analysis would probably confirm that the increase of renewable generation starting in mid 2009 was in line with the ending of a long term drought which had seen significantly reduced hydro output. The ongoing increase in renewable output also matches significant wind capacity coming online since the end of 2008. Annual renewable generation has increased by more than 5TWh since June 2008 and now supplies over 8% of eastern and southern states electricity demand.

The overall proportions of these four types of generation in the National Electricity Market (NEM) over the year to June 2010 were: black coal 56.8%, brown coal 23.7%, gas 10.6%, and renewable 8.8%. The four types of generation show a continuation of trends seen since around June 2009: black coal falling, brown coal almost unchanged, renewable and gas generation rising strongly. Background on the NEM is included on page 8. As a result of these changes, the annual emissions of electricity supplied in the NEM returned to the same level seen in 2006. The June 2010 emissions intensity of electricity (0.91 kg CO_2-e/kWh) was the lowest since the start of the NEM.

These changes are a tangible outcome of state and federal low emissions policy instruments. The Australian Mandatory Renewable Energy Target (MRET) is designed to ensure that 20 per cent of Australia's electricity supply will come from renewable sources by 2020. In effect it requires wholesale purchasers of electricity to proportionally contribute to an additional amount of renewable generation.

The Queensland Gas Scheme requires electricity retailers to source 15% of their electricity from gas-fired generation. Almost 3 TWh of the annualised increase in gas fired generation seen between June 2009 and June 2010 has been in Queensland. Australia might, at last, be on the way towards achieving sustainable emission reductions.

Petroleum fuels

Total emissions from petroleum products consumption for the year ended June 2010 continued the consistent increase seen since June 2009 (Figure 2). The rise in emissions is explained by the ongoing growth in consumption of retail road transport fuels and aviation fuels and the recent upturn in bulk diesel consumption (Figure 5). Consumption of other fuels, such as non-transport LPG and fuel oil (not shown here) fell slightly. Australia handled the global financial crisis better than most countries, and economic growth has picked up since one quarter of negative growth at the end of 2008.

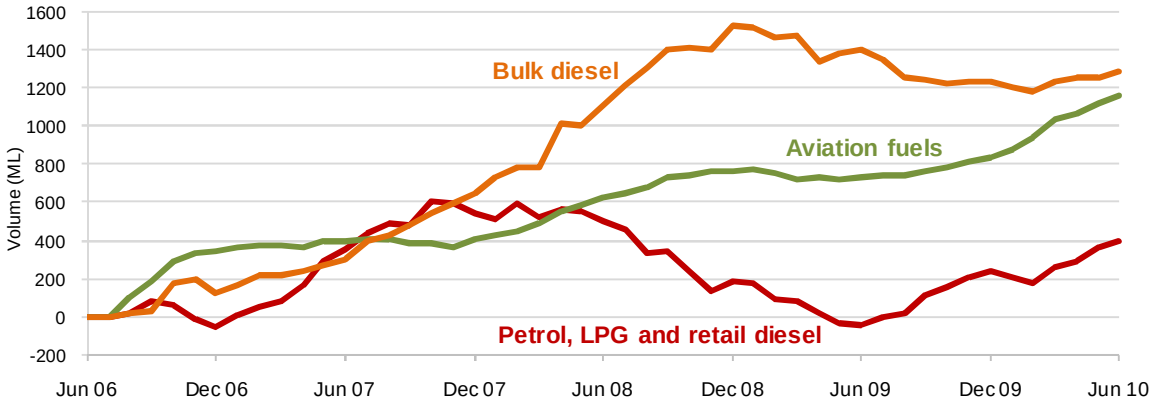

Figure 5. Changes in petroleum sales

Trends in annual emissions

The next three graphs show changes in annual emissions from electricity and petroleum. The first of these (Figure 6), shows changes in annual emissions from June 2007 to June 2008 and is essentially a reframing of the second twelve month period of Figure 2. The 2.1% increase in annual emission compares closely with the 2.3% combined increase in electricity and petroleum emissions in the most recently published NGGI (DCCEE 2010a).

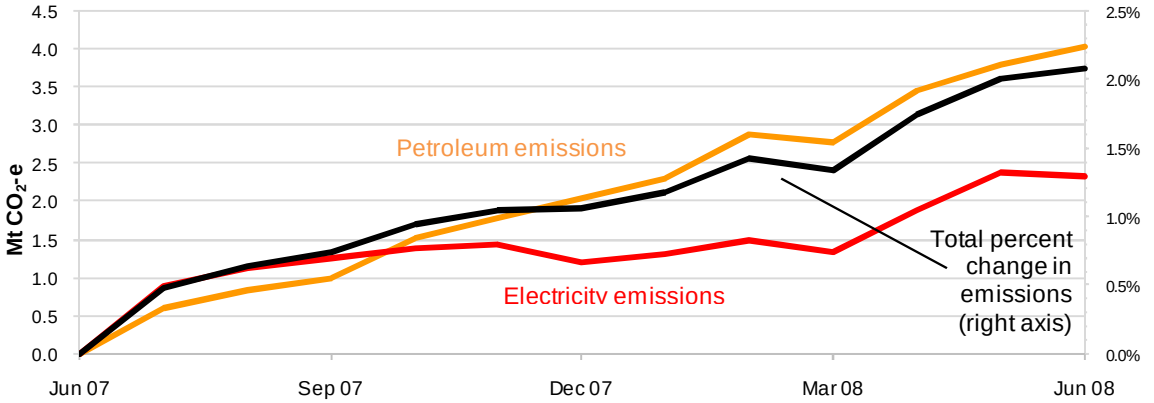

Figure 6. Changes in annual emissions, June 2007 to June 2008

The two following graphs show changes in annual emissions spanning the two most recent years to June. The data shown in Figure 7 suggests that Australia will report close to zero emissions growth when the 2008-09 NGGI is released next year.

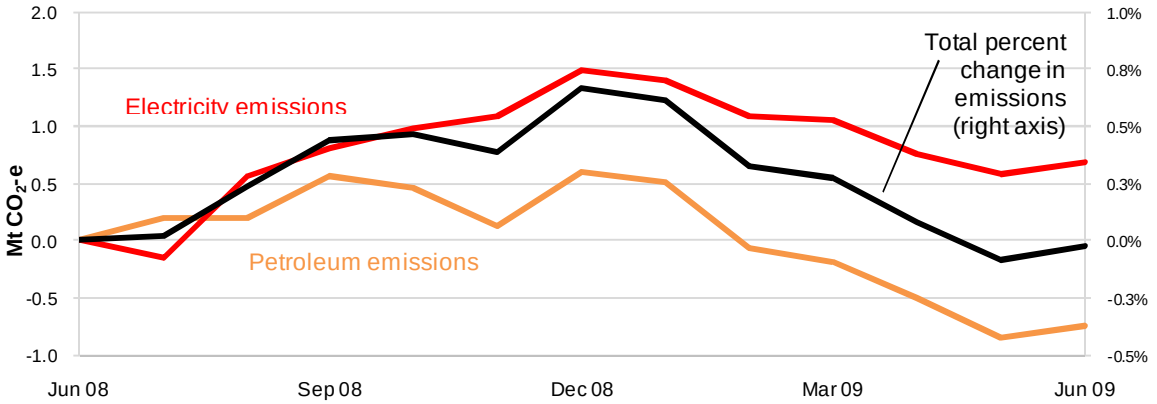

Figure 7. Changes in annual emissions, June 2008 to June 2009

Figure 8 below includes data for non-power station consumption of natural gas in the eastern and southern states (electricity emissions already include natural gas). The data for natural gas is available from July 2008; hence the first point of annualised emissions to be shown is June 2009.

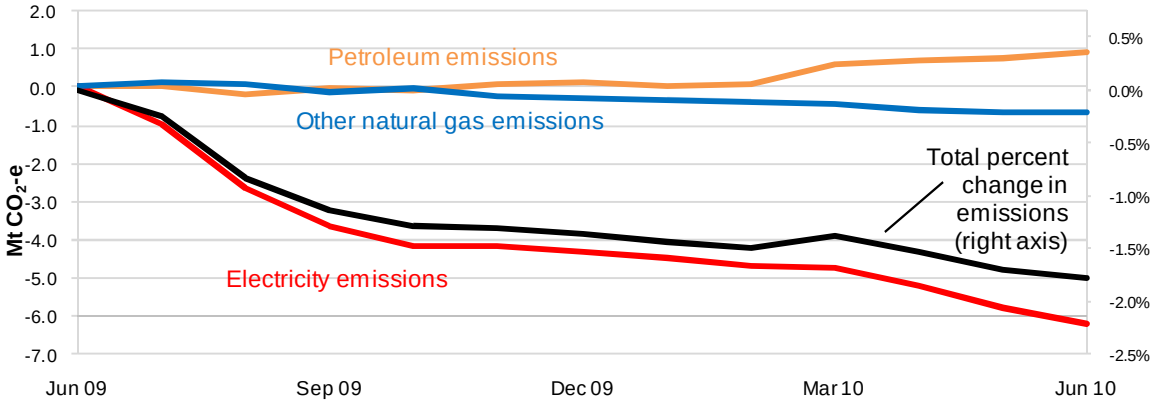

Figure 8. Changes in annual emissions, June 2009 to June 2010

The data shown in Figure 8 suggests that Australia will report a reduction in emissions when the 2009-10 NGGI is released in 2012.

BACKGROUND ON AUSTRALIA'S GREENHOUSE GAS EMISSIONS

Emissions from the energy sector dominate Australia's greenhouse gas inventory. Additional energy sector emissions since 1990 are almost equal to the sum of emissions from the other sectors (Figure 9).

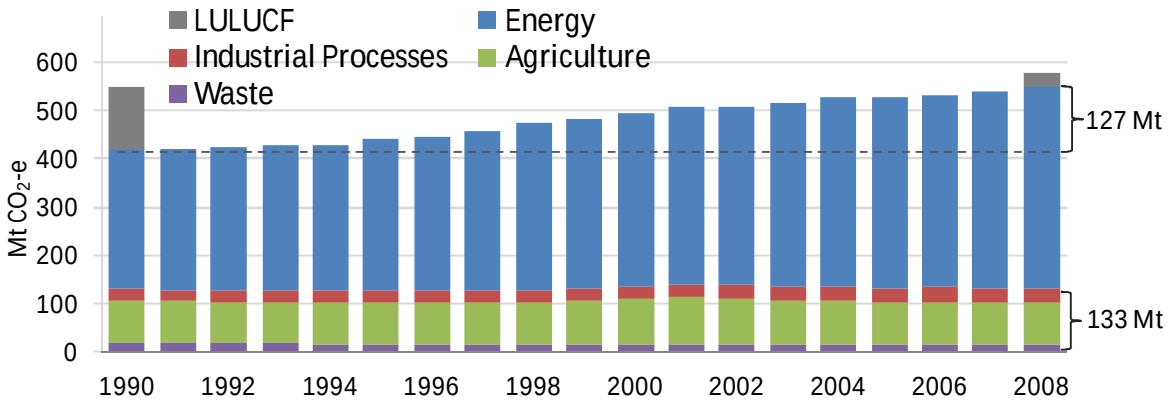

Figure 9. Australia's greenhouse gas emissions

The rate of energy sector emissions growth is even more marked when we consider only fuel combustion emissions; that is excluding energy sector fugitive emissions. In 1990 Australia's fugitive emissions stood at 32 Mt CO_2-e. Since that time fugitive emissions have increased by only 7.7 Mt CO_2-e or 1.3% per year. Australia's fuel combustion emissions have increased by 120 Mt CO_2-e or 47% since 1990.

Changes to the Kyoto Protocol accounting rules on LULUCF activities between the 1990 base year and the 2008-2012 commitment period mean that it is not possible to show a time-series of total emissions that incorporates LULUCF. The totals for 1990 and 2008 including LULUCF indicate that Australia will meet its +8% Kyoto target. Note that Solvent and Other Product Use emissions are reported within other sectors.

Fuel combustion emissions

Stationary energy combustion generated 296 Mt CO_2-e of greenhouse gas emissions or 54% of Australia's emissions in 2008. Stationary energy emissions increased by 52% between 1990 and 2008 (Figure 10). The growth in combustion of coal caused 63% of the increase. Greater use of gas accounted for 27.5% with oil contributing 9.8% of the increase.

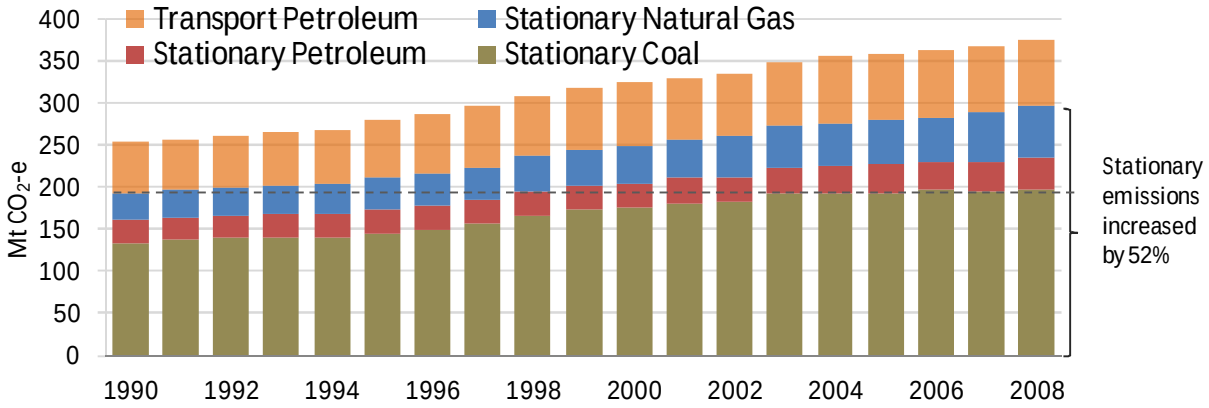

Figure 10. Emissions from stationary energy and transport fuels

Transport emissions make up 80 Mt CO_2-e of Australia's emissions and have increased by nearly 30% since 1990. Electricity generation contributes the largest absolute amount 204 Mt or 37% of Australia's emissions and has contributed the greatest growth: 75 Mt since 1990 (Figure 11).

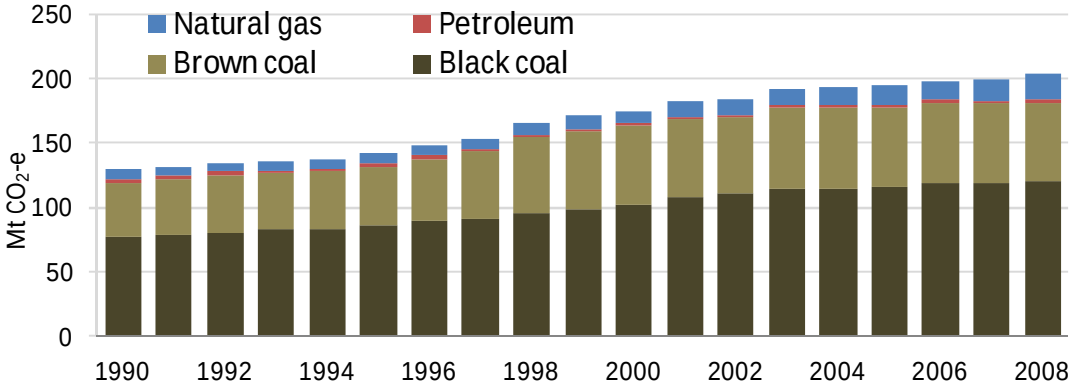

Figure 11 CO_2-e emissions from electricity generation

Black coal has the largest share of total energy and electricity generation emissions: 54% and 90% respectively. The share of natural gas emissions has increased from 1.9% in 1990 to 16.3% in 2008.

BACKGROUND ON AUSTRALIA'S ENERGY SUPPLY

Coal is the largest source of Australia's domestic energy supply and is also a major export. There are significant black coal resources in New South Wales and Queensland as well as brown coal (lignite) in Victoria. These coal resources are reasonably close to population centres and have been exploited for electricity generation.

Electricity

Australian electricity generation and supply industry was originally the responsibility of state government owned public utilities, with significant (in some states complete) vertical integration. Over the past two decades the industry has undergone major restructuring, which has encompassed complete vertical disaggregation, the introduction of full contestability in both generation and retailing (supply) and, in two of the six states, full privatisation of the original state owned public utilities.

A further very important development has been a strengthening of the transmission interconnections between the major demand and generation nodes in the five eastern and southern states. These interconnections allowed the establishment of a single wholesale National Electricity Market (NEM) across these states, including the island state of Tasmania, which is connected by a 290 km long 400 kV DC subsea cable. As at June 2009 total Australian generation capacity (excluding smaller scale distributed capacity, embedded in distribution networks) was around 51 GW, of which 88% was in the NEM. Total generation from this capacity was 230 TWh, of which over 90% was in the NEM. Of the total generation of 230 TWh, no less than 186 TWh was generated at coal fired plants, and over 95% of this was in the NEM. Most of the generation outside the NEM is in the state of Western Australia. Emissions from electricity generation in that state accounted for about 8% of total national electricity generation emissions in 2008.

Operation of the NEM is the responsibility of a single entity, the Australian Energy Market Operator (AEMO). AEMO provides the platform through which generators and retailers trade electricity, and is responsible for aggregating and dispatching supply to meet demand.

Petroleum

Australia is a net importer of both crude oil and refined products. Net imports account for about 30% of the crude processed at Australian refineries and net imports of products account for around 80% of consumption. Consumption of petroleum products is mainly for transport (about 74% of total consumption). Much of the remaining consumption is in mobile equipment used in the agriculture, mining and construction industries. Very little petroleum is used for electricity generation or space heating.

Natural gas

Over the past two decades, changes to the natural gas industry have paralleled, and lagged slightly behind, corresponding changes in the electricity industry. Construction of new pipelines in eastern and southern Australia has meant that gas from the four long established producing basins is accessible to all major markets in five states, albeit with appreciable capacity constraints in some interconnector pipelines. In addition, the last few years has seen rapid development of coal seam gas production, particularly in Queensland.

Simultaneously, institutional and policy changes have seen ownership of pipelines disaggregated from ownership of gas production and of utility businesses, and the application of common carrier obligations to both transmission pipelines and distribution network businesses. These institutional changes, together with the new pipelines have facilitated increased competition between producers. At the downstream end of the industry, mandatory structural separation of distribution network and ownership from retailing has meant that all natural gas customers are contestable, though the intensity of competition between retailers varies between regions of the country.

Unlike the electricity industry, all gas industry participants are effectively privately owned businesses, and there is no public ownership. A national government body, the Australian Energy Regulator, is responsible for regulating the industry in the five southern and eastern states, and ensuring that all markets are adequately competitive, while maintaining appropriate levels of supply security. Consumption in these states represents about 56% of total national natural gas consumption.

As with electricity, Western Australia constitutes a physically separate gas market, and the location of almost all the remaining national gas consumption. The state holds by far the largest natural gas resources in Australia. It is home to both a significant and rapidly growing LNG export industry and also to a number of very large gas consumers n the minerals processing and chemical. Regulation of the industry is the responsibility of the state government. LNG exports from WA represent about 50 percent of total Australian natural gas production.

DATA SOURCES

Australia suffers from a marked lack of reliable, comprehensive and timely national statistics on the production, processing and consumption of energy. The data used to compile our CEDEX carbon emissions index are drawn from a variety of different sources.

Electricity

The Australian Energy Market Operator publishes real time data on electricity dispatched from every individual generating unit in the NEM at 5 minute intervals. It also publishes aggregate electricity demand, dispatch and price at five regional nodes at the same 5 minute intervals. The dispatch data is the basic input used to compile the CEDEX. In the course of the original development of the indicator, a script written in-house was used to aggregate the 5 minute dispatch data to monthly total figures. A commercial provider of this service, NEM-Review, published by Global Roam, is now used. Power

station specific emission factor data, needed to convert dispatch to emissions, is sourced from a report published by AEMO (ACILTasman, 2009).

In the Western Australia electricity market, the system operator, the Independent Market Operator, treats all dispatch data as commercially confidential, meaning that there are no data available of electricity generation by power station in that state. Consequently, emissions for that source cannot be included in the CEDEX.

Renewable generation

Our classification Renewable includes large hydro and some of the larger wind farms and intermittent generation, which AEMO started reporting in 2007. Previous electricity supply data included only large hydro and a few large wind farms in South Australia. Intermittent generators are defined as generators over 30MW which have output that is not readily predictable including, solar generators, wave turbine generators, wind turbine generators and hydro generators without any substantial storage capability (AEMO 2009).

Petroleum

Australian government collects data on wholesale sales volumes (strictly, sales out of bond) of petroleum products from all businesses which produce or import refined petroleum products on a calendar month. They are published in *Australian Petroleum Statistics* published by the Department of Resources, Energy and Tourism, and appear with a lag of approximately six weeks after the end of the month to which the figures apply. Data are disaggregated by individual petroleum product and by the state in which the sales occur. The sales volumes are converted to CO_2 emissions by using the default CO_2 emission factors used in the Australian NGGI.

Natural Gas

As part of its monitoring role for the National Gas Market the Australian Energy Regulator publishes weekly gas market reports which quantify the volumes of gas supplied to the southern and eastern Australian market. Volumes of gas used to generate electricity are published separately from total consumption volumes, which make it possible to eliminate any double counting of gas consumption which has already been included under electricity generation. The data do not include gas consumed at gas processing facilities. We estimate that this accounts for between 1 and 2 Mt CO_2 p.a., but since production volumes are relatively constant, omission of this source will have little effect on the estimate of changes in energy combustion emissions measured by the CEDEX. The emission factors used to convert sales volumes to emissions are the default values published by the Department of Climate Change and Energy Efficiency (DCCEE 2010 b).

No data are available on natural gas consumption in Western Australia. As previously noted this is large, and is also growing rapidly. As noted above, this state currently accounts for over 40% of Australia's natural gas consumption, so the absence of data is a significant, though unavoidable, omission.

Coal

There is no source of timely data on general consumption of coal by industrial and other users. Although electricity generation is by far the largest user of coal, significant quantities are used in the production of steel, in cement kilns, in other mineral processing industries, and as a boiler fuel in the food, paper and other industries. These uses were estimated to account for about 250 PJ of coal consumption, contributing about 23 Mt of emissions, in 2008-09. However, the data also show that consumption of coal by these industries has generally been roughly constant or declining in recent years. Omitting this source of emissions for the CEDEX will therefore have the effect of slightly over-estimating any increase, or under-estimating any decrease in estimated total emissions.

PROMPT EMISSIONS TREND CALCULATIONS

Our method for achieving a 'prompt indicator' of national emission trends is based on monthly electricity, petroleum and natural gas data for the sources described above. The national emissions prompt indicator runs only six weeks behind time - well within the typical lag of Australian economic indicators.

Electricity

Emissions from coal, petroleum and natural gas consumed at each of the more than 50 coal and gas fired power stations in the NEM are calculated from data on sent out electricity reported by the AEMO, using the data service provided by NEM-Review. Sent out electricity data is multiplied by the emission factor (combustion emissions per MWh sent out) for each power station, sourced from the *Fuel Resource, New Entry and Generation Costs* (ACIL Tasman 2009) published by AEMO. Emissions are summed each month for each fuel type: black coal, brown coal and natural gas.

Petroleum

Petroleum sales data includes a number of fuel sales types the main ones being: LPG (automotive propane butane mix), Automotive Gasoline, Aviation Gasoline, Aviation Turbine Fuel and Automotive Diesel Oil. After applying fuel specific emission factors we aggregate these into a set that match the three largest typical activities: road use, aviation and bulk diesel. Bulk diesel is generally used for freight, and in the resource industries.

As implied in the preceding discussion, there are known omissions and unwanted inclusions in the input data. The main sources not covered are:

- consumption of fossil fuels for electricity generation in WA and the NT,
- consumption of natural gas in WA and the NT,
- consumption of coal in uses other than electricity generation (in industries such as steel, cement and alumina production),
- petroleum products used as fuel at oil refineries.

We estimate that emissions for these omitted sources currently account for about 66 Mt CO_2-e, equivalent to around 18% of Australia's total energy combustion emissions. Conversely, therefore, the CEDEX covers approximately 82% of Australia's energy combustion emissions. It is therefore able to provide reliable guidance to trends, and changes in trends, of emissions from energy combustion in Australia.

The calculation of the CEDEX includes emissions from jet fuel which is used in aircraft leaving Australia on international flights, because the source of data on sales of petroleum products does not separate sales to domestic flights from sales to international flights. This source of emissions is not reported in the National Greenhouse Accounts, which means that the CEDEX cannot be precisely aligned to the national greenhouse gas inventory. Jet fuels used by international flights were equivalent to nearly 2.5% of Australia's energy combustion emissions in 2008.

The emission factors used against petroleum and natural gas activity data are for CO_2 only. Meaning that our emissions calculations for petroleum and natural gas do not include CH_4 and N_2O. The emission factors used for NEM power stations are CO_2-e.

CONCLUSION

Trends in emissions from energy consumption are an important indicator of the extent to which Australia is succeeding in limiting its growth in greenhouse gas emissions. Using our prompt emissions indicator we can discern small but significant emissions reductions that are a result of government policy.

Current fuel use means that the dominance of energy combustion will continue for some years. In terms of percent and absolute change the contribution of combustion emissions dwarfs emissions from all other sources.

Our approach shows emissions and energy supply changes in sufficient detail to reveal the effects of above or below average seasonal temperatures, droughts, economic and policy factors. Trends in energy emissions are a reliable indicator of Australia's ability to achieve Australia's emissions mitigation and hold the key to reducing Australia's emissions as a whole.

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KEY WORDS

Emission Inventories
Energy
Area Sources
Trends