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Energy and Population Policies in Australia

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ABSTRACT

The Australian Government is about to release Australia's first sustainable population policy. Sustainable population growth, among other things, implies sustainable energy demand. Current modelling of future energy demand both in Australia and by agencies such as the International Energy Agency sees population growth as one of the key drivers of energy demand. Simply increasing the demand for energy in response to population policy is sustainable only if there is a radical restructuring of the energy system away from energy sources associated with environmental degradation towards one more reliant on renewable fuels and less reliant on fossil fuels. Energy policy can also address the present nexus between energy consumption per person and population growth through an aggressive energy efficiency policy. This paper considers the link between population policies and energy policies and considers how the overall goal of sustainability can be achieved. The methods applied in this analysis draw on the literature of sustainable development to develop elements of an energy planning framework to support a sustainable population policy. Rather than simply accept that energy demand is a function of population increase moderated by an assumed rate of energy efficiency improvement, the focus is on considering what rate of energy efficiency improvement is necessary to significantly reduce the standard connections between population growth and growth in energy demand and what policies are necessary to achieve this situation. Energy efficiency policies can only moderate unsustainable aspects of energy demand and other policies are essential to restructure existing energy systems into on-going sustainable forms. Policies to achieve these objectives are considered. This analysis shows that energy policy, population policy and sustainable development policies are closely integrated. Present policy and planning agencies do not reflect this integration and energy and population policies in Australia have largely developed independently and whether the outcome is sustainable is largely a matter of chance. A genuinely sustainable population policy recognises the inter-dependence between population and energy policies and it is essential that this is reflected in integrated policy and planning agencies.

Keywords: Population; Energy; Energy Efficiency; Energy Intensity; Sustainability

1. Introduction

Australia is well endowed with energy resources and energy is relatively cheap and readily available to consumers and businesses. These are key factors underpinning Australian economic growth. In the last twenty years the energy sector has experienced an intense period of reform. State owned, vertically integrated, monopolies in the electricity sector were dismantled into separate generating, transmission and distribution and retail businesses operating in a competitive framework. There has been extensive privatisation of these businesses and the construction of integrated electricity grids, including one of the physically largest grids in the southern hemisphere, the NEM, National Electricity Market, covering New South Wales, Victoria, Queensland, South Australia and Tasmania facilitating trade in generating capacity.

The benefits of reform have been impressive and include applying a brake to electricity prices, rationalisation of excess generating capacity and over staffing and the capacity to effectively manage unanticipated breakdowns and other emergencies. Almost 90% of Australia's electricity generation is fossil-fuelled, mainly black and brown coal but a growing amount of natural gas.

In the natural gas sector, private sector ownership has been the norm from the outset and government's role has been to drive microeconomic reform through regulations that underpin construction and efficient operation of pipelines by the multiple operators. Early developments were focused on domestic markets, but most recent gas fields, especially those in remote locations, have been developed specifically for export markets. The historical pattern of gas field development has meant that domestic natural gas prices have been well below global prices, encouraging the take-up of gas by industry, businesses and consumers. There are signs that this is changing, particularly in Western Australia and for new coal seam gas fields in eastern Australia. There are abundant reserves of coal and gas in Australia and policy has been based on a preoccupation with utilising them.

Australia was self-sufficient in oil until about 2002 when the main source of supply for Australian refineries, the Bass Straight oil field, peaked. While the country's oil reserves overall have not peaked assisted by the development of new oil fields, particularly in Western Australia, this event changed the course of the oil industry in Australia. Australian refineries were geared to the lighter oil from Bass Strait and the heavier oils from the new fields were unsuitable as feedstock and have been exported instead. Australian refineries are comparatively small and no new refineries have been built for some time. Initially oil imports were necessary to fill the gap between local crude production and feedstock requirements. However, demand for liquid transport fuels has increased much faster than refinery capacity and now an increasing proportion of Australia's refined petroleum products demand is imported in addition to a growing volume of crude oil. Crude oil exports from newer fields have been unable to keep up with import growth and there is a growing deficit in trade of oil and petroleum products embedded within an overall positive energy trade balance. Australia needs high value exports of fossil fuels and other commodities to balance a voracious appetite for oil and petrol.

Energy reform has ensured that Australia's energy sector is highly competitive but ignored sustainability. Australia's dependence on fossil fuels is highlighted by per capita greenhouse emissions amongst the highest in the world. There is growing awareness and concern about this and concern about future susceptibility to supply and price instability of fuel supplies. Australia's capacity to meet persistent trade deficits in liquid fuels may change, especially as the world moves to lower global greenhouse emissions. But the immediate concern is that the demand for energy continues to grow strongly under the influence of strong population growth and policy settings that reinforce present consumption habits.

2. Australian Population Policy

Until 2010, Australia operated a *de facto* rather than a formal population policy. The release of a Treasury report exploring the implications of recent population growth highlighted the downside of this approach and led to a Government decision to develop a sustainable population policy. Of course, sustainable meant different things to different people. Some saw continuation of high population growth as essential to sustaining economic growth; others argued that skills shortages in key disciplines, including engineering, meant that increased skilled migration was essential to avoid bottle-necks. Engineers Australia has taken a conventional sustainable development approach and has argued that sustainable population growth is population growth that is consistent with sustainable development principles and practices and improvements in well-being of all Australians.

During the past forty years, Australia's population has grown from 12.5 million in 1970 to 22.2 million in 2010. On average population growth was 1.4% per annum, but attracted little attention because economic growth, both in terms of GDP, gross domestic product, (average 3.3% per annum) and per capita GDP (average 1.9% per annum) were relatively strong. More recently Australians have become more concerned about population growth. There has been increasing frustration about the consequences of persistent under-investment in infrastructure, particularly in the larger cities, intensified by the realisation that recent growth population rates in Australia have exceeded rates in many developing countries, as well as, in most developed countries. Concern has also developed about the consequences for economic growth and fiscal balances of the aging of Australia's population.

Sustainable economic growth is more complex than simply enlarging the economy to achieve economies of scale. It is about the optimisation of economic, social and environmental variables and raises questions about the viability of status quo policy settings. At present energy policy presumes that a larger population implies a commensurately larger demand for energy. But Australia's greenhouse emissions show this is not sustainable and alternative policies are necessary. The challenge will be to find policies that move Australia onto a sustainable pathway while still realising the economic and social benefits derived from energy consumption. In the Australian context, this also means better understanding the role of population growth. This paper examines the links between these concepts and shows that population and energy policies require stronger integration.

3. Population, Energy and Sustainability in Australia

This paper employs decomposition methodology to link sustainability, energy supply and consumption, economic progress and population growth. This technique has been used by Turton and Hamilton to examine the contribution migration makes to Australia's greenhouse emissions [1], by ABARE, Australian Bureau of Agricultural and Resource Economics, (now ABARE-BRS, having merged with the Bureau of Rural Sciences), to examine the relative contribution of economic structure and energy efficiency to changes in energy intensity [2,3] and by the IEA, International Energy Agency, to highlight developments in the global energy system [4].

Many countries now have greenhouse gas reduction targets, sometimes expressed as reductions from a historical emissions level and sometimes as reductions from a historical level of emission intensity. Although desired objectives were not achieved at the Copenhagen and

Cancun climate change conferences, there was a significant increase in the number of countries committing, in various ways, to reducing emissions. Australia has an unequivocal medium term target to reduce emissions by 5%, relative to 2000 levels, by 2020 and has indicated a willingness to strengthen this target to 15% to 25% of 2000 levels, depending on international actions. Australia has also committed to a long term target to reduce emissions by 60%, relative to 2000 levels, by 2050.

In this paper the growth of greenhouse emissions is used as a proxy for sustainable growth in the energy system. Sustainable population growth extends beyond energy but the key links are evident in the energy system and the concepts revealed apply more generally. The relationship between energy related greenhouse emissions, energy supply, energy demand and population can be expressed as:

$$G = (G/F)*(F/PE)*(PE/C) *(C/GDP)*(GDP/POP)*POP \quad (1)$$

where G is greenhouse emissions from energy use (millions tonnes); F is the consumption of fossil fuels (PJ); PE is total primary energy supply (PJ); C is the final consumption of converted energy (PJ); GDP is gross domestic product in 2008-09 prices (millions of Australian dollars) POP is the Australian population (millions)

In (1), greenhouse emissions are a proxy for sustainability and each term has a meaning conducive to policy development:

(G/F) is the emissions intensity of fossil fuel combustion and reflects the fuel mix between black and brown coal, natural gas and oil.

(F/PE) is the proportion of primary energy supply sourced from fossil fuels and reflects the diversification of primary energy supply.

(PE/C) is the ratio of primary energy supply necessary to deliver final consumption of converted energy and reflects primary energy conversion efficiency and to a lesser degree, the fuel mix.

(C/GDP) is the energy intensity of the economy and reflects both changing economic structure and end user energy efficiency.

(GDP/POP) is gross domestic product per person and is the conventional measure of economic well-being or affluence.

An approximation is used to estimate changes over time. Take the ratio of Equation (1) for time period "t" and for time period "1" and express each term as a percentage. Thus, (G_t/G_1), expressed as a per cent becomes the percentage change in emissions between periods "1" and "t". Similarly, $(G_t/F_t)/(G_1/F_1)$ expressed as a per cent becomes the percentage change in the emissions intensity of fossil fuels between period "1" and "t" and so on for the remaining terms. A more precise method is to differentiate the logarithm of (1) with respect to time but the approximation is a more practical way to proceed here. Cross-effects are ignored because they are typically small, but may be reflected in some summation errors that are not significant.

Turton and Hamilton's [1] examination of the period 1989 to 1997 was repeated using their energy and greenhouse emissions data but new data for GDP in 2008-09 prices and revised actual population statistics sourced from the ABS, Australian Bureau of Statistics [5,6]. The factors contributing to growth in greenhouse emissions during this decade were compared to the later period 1997 to 2008 to examine the changes that had occurred.

Energy statistics were sourced from ABARE [7], economic and population statistics from the ABS [5,8] and [6] and greenhouse statistics from the DCC & EE, Department of Climate Change and Energy Efficiency, national greenhouse inventory [9,10]. Since the connections discussed in the paper hinge on the energy and population projections, it is pertinent to comment on their derivation.

The energy projections were generated by the ABARE E4 cast econometric model comprising 19 energy sources, 5 energy conversion sectors, 19 energy end use sectors and 7 geographic regions. This model has been developed over several years and its projections provide are inputs to the Australian Government's energy policy deliberations. Given the structure of the model, its key "drivers" for the issues dealt with here are population growth and macroeconomic growth. Population projecttions are from the ABS whose methodology is a standard demographic approach applied to the best population data base in Australia. These projections were used as the basis for the development of Australia's sustainable population policy. The macroeconomic assumptions used are a variant of those used by the Australian Treasury in its annual budget projections. The common feature of these sources is they each are from credible organisations used by the Australian Government in its policy deliberations. This paper is a commentary on aspects of these deliberations and it is appropriate to draw on the same sources.

Projections to 2020 were used to examine whether policy settings had learnt from the past. Prevailing policy settings are the assumptions that shape projection scenarios. ABARE has published energy projections to 2030 [7] and growth rates from this work were used to estimate the values for relevant energy variables in 2020. In its estimation model, ABARE included the following policies to reduce greenhouse emissions:

- The Renewable Energy Target that aims to ensure that by 2020, 20% of Australia's electricity comes from renewable sources.
- An emissions trading scheme that set a price on car-

bon emissions consistent with Australia's unequivocal commitment to reduce emissions by 5% on 2000 levels by 2020.

- Several State energy efficiency and emissions reduction programs that have been in place for some time.
- National energy efficiency policies and programs.

Population projections were obtained from the ABS [6] and reflect present natural growth parameters and present migration policies. GDP growth rates from the Australian Treasury were used to estimate GDP in 2020 [11] and reflects present economic policy settings.

The DCC & EE has published projected greenhouse emissions for 2020 [9] based on greenhouse abatement policies and programs common to those used by ABARE for its energy projections but with one major difference that demonstrates the fluidity of Australian politics in this area. ABARE's energy projections were published when there was a consensus that legislation establishing an emissions trading scheme would be passed by the Australian Parliament. As events turned out, this legislation was rejected by the Senate. The DCC & EE projections of greenhouse emissions were completed much later and did not include emissions trading. The dichotomy between the two sets of projections was resolved by including a stochastic term when calculating the changes in the components of Equation (1).

Figure 1 shows the contributions to increases in greenhouse emissions for the three periods discussed above.

1) 1989 to 1997

During this period, illustrated by the blue bars in **Figure 1**, Australian greenhouse emissions per capita increased from 15.8 tonnes per capita to 17.0 tonnes per capita and from 265 Mt CO_{2-e} to 315 Mt CO_{2-e} overall, an increase of about 19%. The main contributions were an increase in GDP per capita from $A39,103 in 1989 to $A44,890 in 1997 (both in 2008-09 prices), an increase of about 15%, and an increase in Australia's population from 16.8 million to 18.5 million, an increase of about 10%.

Australia reduced its energy intensity from 3.58 TJ/$m

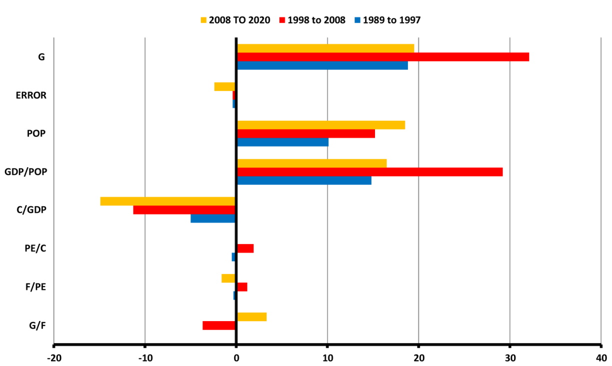

Figure 1. Contributions to Australian greenhouse emissions growth, actual 1987 to 2008 and projected 2008 to 2020.

GDP to 3.4 TJ/$m GDP, a fall in energy intensity of about 5%. Changes in energy intensity occur either as a result of structural change in the economy away from energy intensive industries towards less energy intensive industries or from improvements in end user energy efficiency. ABARE [2] explored the relative size of these effects using a time period that overlapped the one in question here and found that most of the change in energy intensity occurred during the second half of the period, with virtually no change during the first half. Averaged over the decade, about 60% of the reduction in energy intensity was the result of changed industry structure and about 40% was from improved energy efficiency. As engineers this distinction is important and shows that a focus on the improve energy efficiency of a machine, appliance or process is insufficient and the context in which change occurs is also important. Careful and comprehensive measurement and monitoring of progress is essential.

There was considerable inertia in the energy system itself. The emission intensity of fossil fuels increased marginally (about 0.1%); the proportion of fossil fuels in primary energy remained above 93% and barely changed and there was a small improvement in primary energy conversion efficiency (about 0.5%). These small changes show how strongly Australia was locked into fossil fuel consumption in electricity and in transport. The changes in the energy system and in energy efficiency were swamped by the effects of increased affluence and increased population and the result was a large and unsustainable increase in greenhouse emissions.

2) 1997 to 2008

During this period, illustrated by the red bars in **Figure 1**, Australia's per capita greenhouse emissions increased from 18.5 to 21.3 tonnes CO_{2-e}, and from 315 to 416 Mt CO_{2-e} overall, an increase of about 32%. Per capita GDP increased from $A44,890 to $A57,981 in 2008 (both in 2008-09 prices), an increase of 29% and the population increased from 18.5 million to 21.3 million, an increase of 15%.

Energy intensity fell to 3.0 TJ/$million GDP, about 11%. Further research by ABARE [7] has shown that over the longer period 1989 to 2008, Australian energy intensity fell by about 23% with over half the change (about 56%) due to changes in economic structure and the rest (about 44%) due to improved end user energy efficiency. Most of the change in energy efficiency has occurred since the early 1990s and there is a suggestion that the pace of change has been relatively steady.

During this decade there was an increase in the amount of natural gas and renewable energy used in electricity generation and some energy saving in transport. These changes are shown as a reduction of about 4% in the emission intensity of the energy sector in **Figure 1**. Although an improvement over the previous decade, emission intensity remains well above sustainable levels. The proportion of fossil fuels in primary energy increased to over 95% and the amount of primary energy required to supply final energy consumption increased reflecting growth in electricity consumption (the proportion of final energy consumed as electricity rose from 19.2% to 21.3%) and growth in the consumption of transport fuels. While the consumption of renewable energy also increased, this development was swamped by the large increase in consumption of fossil fuel energy resources. Conversion efficiency deteriorated reflecting aging of energy infrastructure. The energy system responded well to increases in the demand for energy but not to concerns about sustainability.

3) Comparing the last two decades

The pattern of events in Australia's energy system in each of the past two decades is very similar. Increased affluence and strong population growth resulted in strong and unsustainable increases in overall greenhouse emissions and in emissions per capita.

A range of policies and programs has been introduced in Australia designed to improve the sustainability of the energy system. At the margin, there is evidence of positive impacts from some of these policies but the Australian energy system remains highly dependent on fossil fuels, with little evidence of changes to reduce the system's contributions to greenhouse emissions. However, there is concrete evidence that end user energy efficiency policies are working and contributing energy savings that offset the impact of affluence and population on emissions growth. Research by ABARE suggests that the scale difference in impact between the two decades is probably because these programs began to realise results half way through the first decade.

4) The future to 2020

Extending this analysis into the future is not straightforward because available projections are based on different statistics. In **Figure 1** the yellow bars illustrate the pattern of events when available statistics are taken at face value.

What is immediately apparent is that the projections, based on present policy settings, show that continued economic growth and population growth will have similar unsustainable impacts on greenhouse emissions as occurred in the preceding two decades. Australia's GDP per capita is projected to increase from $A57,981 in 2008 to $A76,567 in 2020 (both in 2008-09 prices), an increase of 16.5%. The population is expected to increase from 21.3 million to 25.3 million, an increase of 18.5%. Greenhouse emissions per capita are projected to increase from 19.5 to 19.7 tonnes CO_{2-e} per capita and from 416 to 498 Mt CO_{2-e} an overall increase in emissions of 19.5%.

The energy intensity of the Australian economy is projected to continue its downwards path and by 2020 to be 2.5 TJ/$million GDP, reducing greenhouse emissions by 15%. It is important to realise that, in ABARE energy projections, energy efficiency improvements enter the model as exogenous variables assumed to reduce energy consumption by 0.5% per year for most fuels in the non-energy intensive industries and by 0.2% per year in energy intensive industries [7]. Some of this change will be contributed by current policies such as the National Strategy on Energy Efficiency but the connection between policy and assumed outcomes is far from clear.

Another issue is the acceptability of the reduced energy intensity from the standpoint of sustainable population policy. Even with a reduction of 15% in energy intensity, the net effect when growing affluence and population are considered is to contribute 20% to the growth of greenhouse emissions. The Prime Minister's Task Group on Energy Efficiency [12] believes that "Australia has not consciously or explicitly targeted world best practice in energy efficiency and, by comparison with other countries, has significant gaps in its energy efficiency policy armoury". The Task Force was asked to examine the feasibility of achieving a step-wise increase in energy efficiency in Australia and its key recommendation was that Australia should adopt an aspirational target of improving primary energy intensity by 30% by 2020. This objective is twice the reduction in energy intensity illustrated in **Figure 1**. Achieving such an objective would mean that the net addition of increased affluence, population growth and energy intensity to growth in greenhouse emissions would be limited to about 5%. My view is that this comparison shows that current policy settings are indeed inadequate and that adoption of stronger energy efficiency policies is implicit in the formulation of sustainable population policy.

Energy efficiency is an important technical matter for engineers. There are numerous examples in practically every aspect of engineering. However important, technical improvements are one thing but persuading households and businesses to adopt energy efficiency innovations is another. The simple analysis in this paper shows the importance of measuring and monitoring energy efficiency. Without significant improvement to data, analytical tools and widely available information on energy efficiency progress, energy efficiency policy will remain a hit or miss affair. The purpose of an energy efficiency target is to construct a framework to organise policy on energy efficiency to ensure the target is actually met. Other key aspects of a comprehensive energy efficiency framework are building an energy efficiency culture and overcoming non-market barriers to the adoption of energy efficiency. Many aspects of an energy efficiency framework involve considerations beyond the scope of engineering as most of us know it. My point is that to make real difference collaboration between the engineering profession and other disciplines is indispensable.

Although calculations relating to the energy system in **Figure 1** are complicated by the inconsistency in statistics described earlier, it is apparent that the inertia evident in the previous two decades is still part of the policy settings reflected in the projections. As important as it is ambitious energy efficiency is not sufficient to ensure that growth is sustainable. In 2000, energy sector greenhouse emissions were 361 Mt CO_{2-e} and a uniform 5% cut in emissions would mean that the sector emissions would be restricted to 343 Mt CO_{2-e} in emissions in 2020. This is equivalent to a 31% *reduction* in business as usual emissions and the net change from increased affluence, population growth and a 30% energy efficiency target is a 5% *increase* in emissions. In other words, the energy system will need to find ways to deliver about 36% reductions in emissions simply to meet a uniform 5% emissions reduction, relative to 2000 levels, by 2020. This can only be achieved through the structural adjustment brought about by a price on carbon emissions.

4. Policy Implications

This paper used decomposition analysis applied to reputable energy and population projections used by the Australian Government to demonstrate that population policy, sustainability and energy policy are inter-connected in such a way that sustainable development is possible only with integrated planning. The decomposition also demonstrated the critical role that energy efficiency has to play in achieving sustainable development. Finally, the decomposition demonstrates the pervasive inertia to change of Australia's fossil fuel based energy system.

Australia, like many countries has a Government energy policy, but it has at best vague connections to population policies. The Australian population policy is essentially a policy dealing with the quantum of migration and the type of immigrants that may be admitted and in the eyes of many is seen as a driver of economic growth through increasing demand for housing and other goods and services required by newly arrived migrants. What is not addressed is a key issue; although this approach to population "widens" demand by adding more of the same, it ignores "deepening" demand through innovation, improved efficiency and growing sophistication.

Certainly there is future work for engineers in this prescription, but such an approach fails to take advantage of the advances in engineering knowledge, particularly in energy systems and in energy efficiency, and simply perpetuates past problems rather than address them. Until Governments acknowledge that population growth, for example, increases greenhouse emissions through the simple medium of more people and by using outmoded technologies, change towards sustainable development outcomes will elude.

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