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A Sustainable Energy Future for Australia

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In a nutshell: Results of recent studies show that existing renewable energy resources are capable of substituting for coal-fired power stations, in spite of claims to the contrary. Further, they show that combinations of energy efficiency, renewable energy, and gas as an interim bridging fuel, may be less expensive than continuing to build coal-fired plants, even without considering the environmental and health costs of burning coal.

In the face of global climate change from the enhanced greenhouse effect, it is essential that Australia and all other countries implement energy systems that are based primarily upon the efficient use of renewable energy sources. But, in the debate about commencing the transition to such a sustainable energy future, it is claimed by some, without adequate justification, that existing renewable energy sources – such as wind, solar or biomass – are not capable of substituting for coal-fired power stations.

This notion is refuted by a recent set of scenario studies for Australia and its States (see Further Reading at end of this feature). Furthermore, the results of these studies indicate that combinations of efficient energy use, renewable energy and, as a transitional fuel, natural gas, may be less expensive than continuing to build coal-fired power stations, even without taking into account the environmental and health costs of the latter.

National scenario study

The national study, *A Clean Energy Future for Australia*, had the challenging goal of achieving a 50% reduction in CO_2 emissions from stationary energy use (i.e. all energy use except transport) by 2040. This target is similar to official targets in the UK and Denmark. Applied globally this level of reduction is necessary, but possibly not sufficient, to stabilise CO_2 concentrations in the atmosphere at a level that is likely to be safe for future generations.

The study assumes that the economy grows 2.4 times in real terms between its starting date, 2001, and 2040, as set out in the Federal Government's *Intergenerational Report*. The choice of 2040 allows sufficient time for most existing power stations and all energy-using appliances and equipment (apart from buildings) to be phased out at the end of their operating lives and replaced with cleaner, more efficient technologies.

The study was restricted to small improvements to existing technologies. This means that the scenarios have no cheap solar electricity, no hot-rock geothermal energy[1], no storage and transportation of renewable energy in the form of hydrogen[2], no cheap and safe nuclear energy[3], and no cheap capture and geosequestration of CO_2 emissions from coal-fired power stations[4]. Of course, the task will be easier if one or more of these technologies is successful before 2040.

Energy use in 2040 is derived from projections of economic activity and population. The baseline scenario is one in which current modest programs to improve efficient energy use and disseminate renewable energy are projected forward in a 'weak' energy-efficiency scenario. This results in an increase in CO_2 emissions from stationary energy in 2040 of 18%, compared with the 2001 reference year.

Then a large number of additional cost-effective efficient energy use measures are applied across the economy, generating a 'medium' energy-efficiency scenario. Solar hot water also makes a significant reduction to the demand for electricity. These demand-side measures are particularly valuable in economic terms, because they substitute for electricity delivered to customers at 10-16 cents per kilowatt-hour, rather than electricity generated at the power station for (typically) under 4 cents/kWh. The medium-efficiency scenario succeeds in stabilising Australia's CO_2 emissions at a level 14% below the 2001 value by 2040.

The further reduction in emissions to 50% below the 2001 level is then achieved by means of cleaner energy supply (see Figure 1). The main component of CO_2 emissions from stationary energy comes from electricity generation, followed by industrial heat. The national study actually obtains a reduction of 78% below 2001 in CO_2 emissions from electricity generation by 2040. However, growth in industrial heat, which can only be supplied to a small degree by existing renewable energy technologies[5], returns the total reduction in CO_2 emissions from stationary energy to 50% below 2001.

In the principal clean electricity scenario, the supply side mix is:

- natural gas, the least polluting of the fossil fuels, used in both cogeneration (combined heat and power) and in combined-cycle power stations to supply 30% of electricity;
- bio-electricity generated mainly from crop residues (excluding those from native forests) and contributing 28% of electricity;
- wind power, contributing 20% of electricity;
- coal 9%;
- hydro 7%;
- solar, supplying about 5% of electricity, mainly during peak periods when its economic value is highest;
- petroleum (which could be replaced with biofuels) 1%.

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[1] Drilling to a depth of about 5 km by Geodynamics Ltd shows that there is a very large hot-rock geothermal resource in Australia – see www.geodynamics.com.au (accessed 25/9/2005) – but it may be a few years before the cost of electricity can be determined accurately.

[2] Service, R (2004) 'The hydrogen backlash', Science 13/8/2004, 958-61, summarises the reasons why a hydrogen economy based on renewable energy may be several decades away.

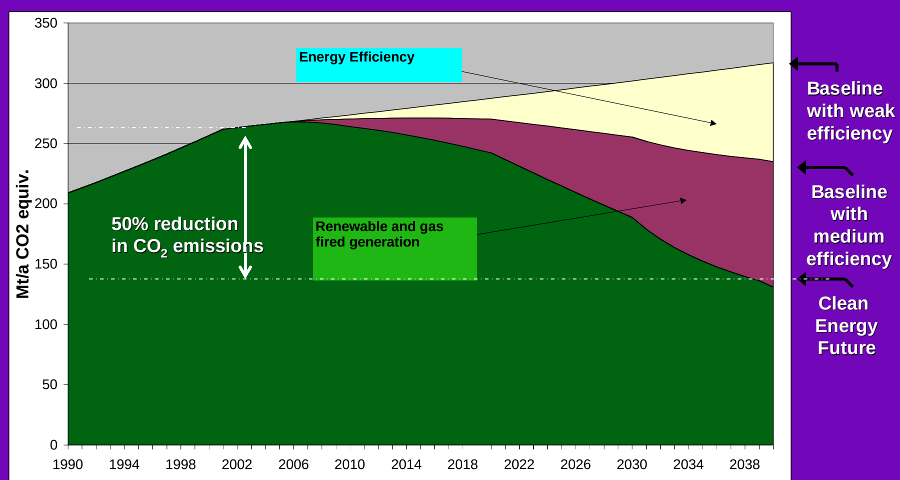
[3] Reserves of *high-grade* uranium are very limited. Van Leeuwen, JWS and P Smith (2003/5), *Nuclear power: the energy balance* – www.stormsmith.nl/ (accessed 21/9/2005) – show that CO_2 emissions from the mining, milling and enrichment of *low-grade* uranium are comparable with those of an equivalent gas-fired power station. Therefore, taking into account the economic collapse of the fast breeder and reprocessing cycle, nuclear power based on existing technologies does not appear to be a solution to the enhanced greenhouse effect.

[4] Saddler, H, C Riedy & R Passey (2004) *Geosequestration: What is it and how much can it contribute to a sustainable energy policy for Australia?* Discussion Paper No. 72, Australia Institute, Canberra - www.tai.org.au/. This paper presents the case that at best it would be at least 25-30 years before coal-fired power with geosequestration could make a significant contribution to Australian electricity generation.

[5] Heat below 200˚C is supplied by solar thermal technologies and higher temperatures mostly by natural gas.

All of the renewable energy sources except solar electricity are already less expensive than the International Energy Agency's projected costs of coal-fired electricity with capture and geosequestration of CO_2 emissions.

Fig. 1: Emissions from stationary energy in Australia, 1990-2040



The time path is a notional one, based on the assumption that policy recommendations are adopted.

Although transport was not part of the recent Australian clean energy futures studies, it is addressed together with stationary energy in a Canadian study with similar assumptions to our own[6]. Once again, based on small improvements to existing cleaner technologies, a 50% reduction in emissions could be achieved with a few decades. The transport component of the Canadian study utilises improvements in urban public transport and further dissemination of fuel-efficient vehicles (hybrids and clean diesels).

Thus, for both stationary energy and transport, 50% reductions in CO_2 emissions can be achieved from existing technologies, buying us time for developing new technologies and greatly improving existing clean technologies in the second half of the Century. During this latter period, it will also be vital for Australia to have achieved zero population growth and to have dematerialised its economic growth.

The transition to a sustainable energy future cannot be driven by the existing market structure and policies. It needs new policies and strategies, whose implementation must be commenced seriously now. One of the most urgently needed policy changes is to stop the construction of new coal-fired power stations. Not only are they Australia's biggest single source of greenhouse gas emissions, but their construction undermines substantial programs for efficient energy use that are incompatible with the economics of bringing on-line 1000-2000 MW power stations.

State studies

[6] Torrie R, R Parfett and P Steenhof (2002) *Kyoto and beyond: the low emission path to innovation and efficiency*, prepared for the David Suzuki Foundation and Climate Action Network Canada, September. See www.davidsuzuki.org.

While the national study takes a long-term perspective, the separate State studies examine the short-term problem of substituting for the next proposed coal-fired power stations by 2010. At the times of writing the State studies in 2004 and 2005, there were proposals for new coal-fired power stations with total capacities of 530 MW (Western Australia)[7], 1000-1500 MW (New South Wales)[8], and 750 MW (Queensland)[9]. There was also a proposal to extend the operating life of Victoria's most greenhouse polluting old power station, Hazelwood, with 1600 MW of capacity[10]. Despite the rhetoric of carbon capture and geosequestration from the Federal Government and the coal industry, all the proposals are for conventional 'dirty' coal-fired power stations. Here we focus on one of the New South Wales proposals.

Our report, *Towards New South Wales' Clean Energy Future* (see Further Reading at the end of this feature), shows that both the contribution to peak-load (see box) and annual electricity generation of a 1000 MW base-load coal-fired power station can be replaced by a mix of realistic supply-side and demand-side initiatives by 2010. As in the national study, the proposed supply-side mix involves natural gas, wind power and bio-electricity from organic residues.

The much cleaner energy system would have carbon dioxide emissions of about 4.7 million tonnes per year *less* than the coal option, a reduction of nearly 80%. If adopted, the cleaner system would be cost-effective, with the economic savings from efficient energy use paying for the additional costs of renewable energy and gas-fired electricity. Although the supply-side solution involving cleaner energy sources will increase the average price of a unit of electricity to the NSW community, the demand-side energy efficiency savings will reduce the number of units purchased by most consumers. The net result is that energy bills will either decrease or remain approximately the same, for all except possibly the largest industrial consumers of electricity, who may require special consideration.

Then the challenge in moving onto the clean energy pathway becomes neither technical nor economic, but rather organisational and institutional: namely, how to deliver cost-neutral packages of energy efficiency, renewable energy and natural gas to consumers. Since the State Government would have to play the leading role in making organisational and institutional changes, the key issue becomes one of political will.

The proposed substitution would reduce the socio-economic risk faced by NSW as the result of having an electricity supply system that is based 98% upon coal, the most greenhouse-intensive of all fuels. In the likely event that international greenhouse gas emission constraints are tightened over the next decade, this high dependence upon coal could become a major economic and environmental liability. At the current carbon trading price on the EU market of 23 euro (about A$35) per tonne of CO_2, a new 1000 MW coal-fired power station could, over its 40 year lifetime, incur a liability of about A$7.7 billion dollars.

Policies and strategies

Sustainable energy futures can only be achieved as the result of new policies and strategies implemented by all spheres of government. Policy measures required to deliver the cleaner supply mix include:

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[7] In August 2005, the WA Government announced that this power station would be gas-fired. This was stated to be on economic grounds – in WA (unlike the eastern States) coal power is more expensive than gas.

[8] There are two separate proposals to build a 1000 MW station near Ulan NSW, and a proposed extension to the capacity of an existing power station, Mt Piper, near Lithgow, by 1500 MW.

[9] The power station, Kogan Creek, has now been approved by the Qld Government and is already under construction. There are also informal proposals for several additional coal-fired power stations that have not yet been announced officially.

[10] Approved by the Victorian Government in September 2005.

- A greenhouse intensity limit on all new power stations and on all proposals for major refurbishments and other life-extensions of old power stations. This limit would be set to exclude conventional coal-fired power stations, while including combined-cycle gas-fired power stations. Until such a limit is put in place, State Governments should ensure that the greenhouse gas liability of all new and refurbished coal-fired power stations should be carried by the proponents.
- A requirement that energy retailers submit Renewable Energy Certificates (RECs) annually to State Governments as a licence condition. This would be a separate scheme from the Federal Government's modest existing Mandatory Renewable Energy Target (MRET), which is expected to be fully utilised by the end of 2006. Unlike the situation with MRET, existing hydro-electricity would not be eligible in the proposed State schemes, which are designed to assist the further development of the new renewable energy industries.
- In the longer term, a carbon levy or tradeable emission permits of the cap and trade type, either implemented by the Federal Government or a cooperating group of States.
- Introduction of 'smart' meters and time-of-day electricity pricing for all customers (see box).

Recommended demand-side measures include:

- The extension of energy performance standards, such as BASIX in NSW, from new buildings to several categories of existing buildings, starting with all tenanted buildings. State Government may have to provide some assistance to landlords on low incomes.
- Substantial expansion of the use of solar hot water encouraged by both incentives and by charging the real cost of electric hot water.
- The provision of low-cost packages of energy efficiency measures for householders.

An additional and very important benefit of undertaking the transition to a clean energy future is that the key policies detailed in the report would stimulate job growth and increased economic activity. Per kilowatt-hour of electricity generated, wind power creates 2-3 times the number of *local* jobs as coal, while bio-electricity generates 3.5 times. State Governments could provide incentives to ensure that the major proportion of these new jobs (e.g. in manufacturing components of wind turbines and bio-electricity power stations) would be located in regions most affected by the gradual closure of coal-fired power assets.

To conclude, a sustainable energy future is technically feasible, economically viable, and environmentally essential.

BOX 1

The Reliability of Renewable Energy

Based on the notion that renewable energy is "intermittent", critics of renewable energy often claim erroneously that renewable energy cannot replace base-load power stations, such as those fuelled by coal. However, not all renewable energy is intermittent and no-one is proposing to run a whole electricity grid on intermittent sources alone.

The principal scenario in *A Clean Energy Future for Australia* proposes that in 2040, 28% of Australia's electricity be generated from bioenergy, which is not an intermittent source, 20% from wind power and 5% from solar. The remainder comes from natural gas and demand reduction by means of efficient use of energy and solar hot water. The only intermittent sources in this mix are wind power and solar electricity. Since they have different statistical properties, they are examined separately.

Wind power

The proposed contribution by wind power of 20% of annual electricity generation is same percentage of wind power that was achieved in Denmark in 2003. This has not caused any major problems. Most of the minor problems that have occurred are the result of connecting a very large block of wind power (from off-shore wind farms) to a single point in western Denmark's transmission system. With properly planned dispersal of wind farm sites and reinforcement of the grid where necessary, a 20% (or more) penetration of wind energy is feasible.

It is sometimes claimed that occurrence of a heat wave, during which there is little wind, demonstrates that wind power is unsuitable for providing electricity to the grid. But, if this argument were valid, then a single breakdown of a coal-fired power station would also rule out coal. In practice all types of power station – fossil nuclear and renewable – are only partially reliable and all require some backup. Coal-fired power stations break down less frequently than there are calms in the wind, but when a coal station breaks down, it is generally off-line much longer than a typical wind calm.

Comparison of the reliability of wind and coal power cannot be done deterministically, based on a single peak event. The correct approaches consider the effects of three different probability distributions -- the availability of coal-fired power stations; wind power and electricity demand – and then use mathematical and/or computer models to calculate the reliability of electricity grids with different penetrations of wind power.

This was done by Brian Martin, John Haslett, John Carlin, David Gates and Mark Diesendorf in CSIRO and ANU in the 1980s. Using three different methods[11] we found that wind power is indeed partially reliable. It has economic value in substituting for the capital cost of coal-fired power stations, as well as for the fuel burnt in such stations. In other words, it is incorrect to assume that intermittent sources of electricity are completely unreliable.

For the special case of small penetrations of wind power into an electricity grid[12], the value of wind power as 'firm' (i.e. 100% reliable) capacity[13] is equal to the annual average wind power generated. As the penetration of wind power into a grid becomes very large, the value of wind power as 'firm' capacity tends towards a limit. At an intermediate degree of wind energy penetration (e.g. 20%), some additional peak-load (hydro or gas turbines) is indeed required to maintain grid reliability. But this peak-load plant is only a fraction of the wind capacity and does not have to be operated frequently. It is equivalent to reliability insurance with a low premium. And it does not diminish significantly wind's ability to reduce CO_2-emissions.

Solar electricity

Like wind power, solar power is considered to be an intermittent source; but, also like wind power, solar power may be considered partially reliable. This is because there is quite a good correlation between the peak demand for air conditioning in summer and the peak output from solar electricity. This correlation becomes even stronger when solar collectors are oriented towards the north-west or west rather than the usual north.

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[11] (i) Monte Carlo simulation using real hourly data; (ii) convolution of static numerical probability distributions in the special case when there is no correlation between wind power and load; (iii) approximate applied mathematical models.

[12] Typically a few percent in terms of energy generation

[13] Known as the 'capacity credit' (not to be confused with 'capacity factor') and measured by *inter alia* 'equivalent firm capacity' or 'effective load-carrying capability'.

This suggests that a pricing system capable of charging for electricity by time of day, may close a large part of the gap between cost and benefit for solar electricity. The technology to do this, the 'smart' meter, already exists and will be tested in the forthcoming Solar Cities program.

Further reading on Clean Energy Future studies:

All of the following reports can be downloaded from www.wwf.org.au. Go to "Publications" and then scroll back through the numbered links to pages for the respective months of publication.

Saddler, H, M Diesendorf and R Denniss (2004) *A Clean Energy Future for Australia*; Clean Energy Future Group, Sydney & Melbourne, March

Diesendorf, M (2004) *Towards Victoria's Clean Energy Future*; Clean Energy Future Group, Sydney & Melbourne, November

Diesendorf, M (2005) *Towards New South Wales' Clean Energy Future*; Clean Energy Future Group, Sydney & Melbourne, March

Diesendorf, M (2005) *Towards Queensland's Clean Energy Future*; Clean Energy Future Group, Sydney & Melbourne, April

Diesendorf, M (2005) *Towards Western Australia's Clean Energy Future*; Clean Energy Future Group, Sydney & Melbourne, August

Further reading on the reliability of renewable energy:

Martin, B & M Diesendorf (1982) Optimal thermal mix in electricity grids containing wind power, *Electrical Power & Energy Systems* 4: 155-161

Grubb, MJ (1988) The potential for wind energy in Britain, *Energy Policy* 16:594-607

Herig, C (2001) Using photovoltaics to preserve California's electricity capacity reserves; US National Renewable Energy Laboratory: www.nrel.gov/docs/fy01osti/31179.pdf (accessed 26/9/2005)

Grubb, M, L Butler & G E Sinden (2005) Diversity and security in UK electricity generation: The influence of low carbon objectives. Cambridge Working Papers in Economics: www.econ.cam.ac.uk/electricity/publications/wp/ep74.pdf (accessed 26/9/2005)