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How to Reduce CO_2 Emissions by 50%

Mark Diesendorf explains how efficient energy use and existing renewable energy technologies could together replace most of Australia's coal-fired power stations cost-effectively by 2040, if there is sufficient political will.

It is sometimes claimed without justification that existing renewable energy sources -- such as wind, solar or biomass -- are not capable of substituting for coal-fired power stations. However, a recent set of studies for Australia and its states demonstrates the contrary.

A Clean Energy Future for Australia and the subsequent state studies were sponsored by the Clean Energy Future Group, a consortium of peak organizations from the renewable energy, energy efficiency and natural gas industries, in cooperation with the environmental organisation, WWF Australia. The team of consultants chosen to perform the national study comprises Dr Hugh Saddler from Energy Strategies Pty Ltd, Richard Denniss from the Australia Institute, and myself.

We were given 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 and 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 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 equipment apart from buildings to be phased out at the ends of their operating lives and replaced with cleaner and more efficient technologies.

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

In achieving the 50% reduction target for stationary energy in 2040, the national study actually obtained a reduction of 78% in CO_2 emissions from electricity generation. The growth in industrial heat, which can only be supplied to a small degree by existing renewable energy technologies, pushed the total reduction back to 50%.

The least-cost contributors to the clean energy scenarios are a myriad of cost-effective technologies for using energy more efficiently in the home, office and industry. Solar hot water also contributes 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 the customer at 10 cents per kilowatt-hour and upwards, rather than electricity generated at the power station for (typically) under 4 cents/kWh,.

The clean energy scenario assumes that a medium level of energy efficiency would be implemented, while growth in per capita GDP and population still drive up total stationary energy demand by 25%. However, if population growth could be reduced significantly, e.g. by cutting the business/professional component of immigration, the demand for energy could possibly be stabilised by 2040 and so the clean energy scenarios would be even more economically favourable.

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;
- petroleum 1%.

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.

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 station by 2010. Currently there are proposals for new base-load power stations in Western Australia with total capacity of 530 MW, a 1000 MW coal-fired power station in NSW, a 750 MW coal-fired power station (which has already been announced) in Qld, and a proposal to extend the operating life of Victoria's most greenhouse polluting old power station, Hazelwood, with 1600 MW of capacity. Here we focus on substituting for the latter, as the biggest challenge.

Our report, *Towards Victoria's Clean Energy Future* (see www.wwf.org.au), shows that both the contribution to peak-load (see box) and energy generation of a 1600 MW base-load, brown coal power station can be replaced by a mix of realistic supply-side and demand-side initiatives by 2010. The proposed supply-side mix involves wind power, bio-electricity and either natural gas or a reduction in exports of Victorian electricity to other States.

In replacing Hazelwood, the much cleaner energy system would reduce Victoria's carbon dioxide emissions by about 14 million tonnes per year. If adopted, it would be cost-effective, with the economic savings from efficient energy use paying for the additional costs of renewable energy and any gas-fired electricity.

Although the supply-side solution involving cleaner energy sources will increase the average price of a unit of electricity to the Victorian 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. Incidentally, aluminium smelting in Victoria already receives a subsidy on electricity of about $250 million per year.

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 Victoria as the result of having an electricity supply system that is based 97% upon brown 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 brown coal could become a major economic and environmental liability.

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

- a greenhouse intensity limit on all new power stations and on all proposals for major refurbishments and other life-extensions of old power stations;
- the requirement that energy retailers submit Renewable Energy Certificates (RECs) annually to State Governments as a licence condition. This would in effect expand the modest existing Mandatory Renewable Energy target (MRET) to a more realistic level, without any cooperation required from the Federal Government;
- in the longer term, either 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.

Recommended demand-side measures include:

- the extension of energy performance standards from new buildings to buildings with new renovations, all existing government-owned and government-tenanted buildings, and some other categories of existing buildings;
- substantial expansion of the use of solar hot water encouraged by both incentives and penalties;
- the wide dissemination of ‘smart’ meters and peak-load pricing to make users pay the full cost of air conditioning and other contributions to increases in electricity demand; and
- 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 this report would stimulate job growth and increased economic activity. The Victorian Government 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) be located in regions most affected by the gradual closure of coal fired power assets, such as the Latrobe Valley.

A sustainable energy future is technically feasible, based on existing technologies with small improvements, economically viable and environmentally essential. In my view the principal barrier is the political power of the huge CO_2-emitting industries, most notably coal and aluminium.

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[Box] **The Reliability of Wind Power**

Opponents of wind power often claim erroneously that, as an 'intermittent generator', wind power cannot be run as base-load to replace coal-fired power stations. For instance, Simon Grose's article ("Australia's Fossil Future", *Australasian Science*, August 2004) asserts that: "existing renewable energy sources cannot simply replace fossil or hydro sources. Despite popular claims to the contrary, delivering reliable baseload power requires conventional backup for renewable sources that cannot guarantee supply…"

However, no-one is proposing to run a whole electricity grid on wind power alone. The study on *A Clean Energy Future for Australia* proposes that 20% of Australia's electricity be generated from wind power in 2040, the same percentage that was achieved in Denmark in 2003.

The incorrect claims often confuse base-load and peak-load. In mainland Australia, hydro is peak-load and coal is base-load and sometimes intermediate-load. In each of our State studies the clean energy mix substitutes separately for *both* the contributions to peak-load (as measured by Equivalent Firm Capacity or Effective Load-Carrying Capability) and to base-load (i.e. annual electricity sent out) of a coal-fired power station.

Grose assumed that a single heat wave in western Europe, during which there was 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 out of action much longer than a typical wind calm.

The 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 myself in CSIRO and ANU in the 1980s. Using three different methods 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. For the special case of small penetrations of wind power into an electricity grid, the value of wind power as 'firm' (i.e. 100% reliable) capacity 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 a wind energy penetration of (say) 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.

For further reading see Martin B & Diesendorf M 1982, Optimal thermal mix in electricity grids containing wind power, *Electrical Power & Energy Systems* 4: 155-161, and references therein, and Grubb MJ 1988, The potential for wind energy in Britain, *Energy Policy* 16:594-607.