Towards New South Wales' Clean Energy Future

A plan to cut New South Wales' greenhouse gas emissions from electricity by 2010

A Report for the Clean Energy Future Group

By Dr Mark Diesendorf

March 2005

This Clean Energy Future Group Report is an initiative of:

WWF

BCSE Australian Business Council for Sustainable Energy

AusWEA Australian Wind Energy Association

AEPCA

The Clean Energy Future Group came together in 2003 to commission a study investigating how to meet deep emission cuts in Australia's stationary energy sector. The Group published a Clean Energy Future for Australia Study in March 2004.

The Clean Energy Future Group comprises:

- Australasian Energy Performance Contracting Association – www.aepca.asn.au
- Australian Business Council for Sustainable Energy – www.bcse.org.au
- Australian Gas Association
- Australian Wind Energy Association – www.auswea.com.au
- Bioenergy Australia – www.bioenergyaustralia.org
- Renewable Energy Generators of Australia – www.rega.com.au
- WWF Australia – www.wwf.org.au

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The Renewable Energy Generators of Australia Ltd (REGA) support the endeavour to investigate alternative opportunities for the long term sustainable supply of power generation in NSW, particularly through the increased penetration of renewable energy sources and energy efficiency measures.

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FRONT COVER IMAGES – LEFT TO RIGHT:

Sydney Gas Rosalind Park Gas Plant: Australian energy company Sydney Gas opened the first major gas plant in NSW in December 04. Rosalind Park gas plant in Campbell town, one hour south-west of Sydney is sized to supply up to 10% of the current NSW gas market. Gas from the Sydney Basin is gathered into the plant where it is dried and pressurised before being sold to AGL via a high pressure underground steel sales line connected to the main gas transmission line.
Courtesy of Sydney Gas

Wind: Currently there is 17 MW of wind power installed in New South Wales. It is estimated that there are over 1,000MW of wind energy projects under consideration in New South Wales that could be readily integrated into the existing NSW grid.
Courtesy of WWF

EarthPower Technologies food waste processing facility: Australia's first food energy-from-waste plant opened at Camellia, near Parramatta, NSW. It uses anaerobic digestion to process up to 80,000 tonnes of food waste per year from commercial and industrial food wastes. The plant produces a biogas that is used to generate electricity and drying the digestion residue. Electricity is exported to the grid qualifies as "Green Power". The residue is converted into high nutrient solid organic fertiliser.
Courtesy of EarthPower

State Waters Small scale Hydro: State Water is developing small scale hydro dams on Murrumbidgee River Weirs in south west New South Wales. APW Ltd was awarded the rights to seek to develop these projects in a competitive State Water tender in 2004. Courtesy of APW Ltd

Solar Panels – Solar hot water can contribute to energy efficiency savings in New South Wales. Courtesy of BCSE

Energy efficient appliances: Energy performance ratings and labelling on energy-using appliances like fridges, dishwashers and washing machines help consumers choose the most energy efficient appliance. Courtesy of SEDA

Why this report was commissioned

The NSW Premier, Bob Carr, has been a prominent spokesperson on the necessity of reducing greenhouse gas emissions, most recently as part of a 14-member international taskforce that recommended:

> *"a long-term objective be established to prevent global average temperature from rising more than 2°C above the pre-industrial level, to limit the extent and magnitude of climate-change impacts."*

Global average temperature has already increased by 0.6°C with a further 0.4-0.7°C rise locked in from greenhouse gases already emitted by human activity. According to findings from the recent Avoiding Dangerous Climate Change Conference convened by British Prime Minister Tony Blair, to be confident of limiting the temperature increase to less than 2°C we need to keep the concentration of greenhouse gases to 400 parts per million. Unfortunately we are only ten years away from reaching this critical threshold. The solution is to act immediately in order to cut our greenhouse gas emissions by 60% by 2050 (Coleman et al., 2004).

In the interests of achieving a more sustainable Australia, one that could meet its international obligation to reduce greenhouse gases, a coalition of organisations known as the Clean Energy Future Group came together to examine how the nation might achieve these critical emission cuts. Last year, the group produced a report entitled *A Clean Energy Future for Australia,* which explained how Australia could reduce its CO_2 emissions from stationary (i.e. non-transport) energy by 50% by 2040, compared with the 2001 level (Saddler, Diesendorf & Denniss, 2004).

Right now, the NSW Government is on the threshold of making its most important decision since coming into office. The implications of this decision will be felt for generations to come. The State is at a cross-road of two very different paths for meeting its energy needs. It can continue its dependence on coal, an energy source that heavily pollutes the atmosphere with climate-altering greenhouse gases. Or it can begin the task of weaning itself off this inherently unsustainable fuel by choosing cleaner but equally reliable alternatives.

This report, by Dr Mark Diesendorf, builds on last year's study by focusing on an immediate and pressing need for NSW – how to avoid building a power station that will lock the State into producing between six and seven million tonnes of additional greenhouse gases every year for the next 40 years. This is equivalent to putting an additional 1.5 million cars on the road, which would completely dwarf greenhouse emission reductions undertaken to date. This is completely incompatible with the recommendation of Bob Carr's taskforce to limit temperature rise to 2°C.

So far there has been a lack of detailed analysis by Australian governments that seriously examines alternatives to the status quo. The Clean Energy Future Group is concerned that a lack of serious study is creating a preponderance amongst governments for using past solutions – not because they are the most appropriate but because they are familiar. There seems to be a mentality that "if it ain't broke don't fix it" but this is a system that is badly broken.

This report is an attempt to broaden people's thinking about how we meet NSW's electricity demands. It is not intended to be a comprehensive study – rather it is a first attempt at providing a glimpse of what is possible and to break the mindset that the only viable way we can meet energy needs is by doing what we've done in the past.

Dr Diesendorf proposes a mix of energy efficiency and cleaner electricity supply measures that could substitute a 1000 MW coal-fired power station by about 2010.

It must be stressed that the Clean Energy Future Group does not put forward this report as a comprehensive statement of what could be achieved. Rather it is to be taken as just one conceivable approach that would deal with the immediate issue of substituting for 1000 MW of coal fired power by 2010.

More detailed work is required but this report takes a first step by illustrating that there is a viable and affordable alternative. The onus is upon government to undertake a detailed examination of how it could achieve a cleaner, more sustainable energy supply.

The policy recommendations in this report are those of the author but are not inconsistent with many of those put forward by the members of the Clean Energy Future Group and their common aims. For more information on each member's policy position, readers should visit our respective websites.

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Executive summary

In New South Wales there are at least two separate proposals for a new coal-fired power station of 1000 MW to be located in the Ulan region of the upper Hunter Valley. There is another proposal to extend the Mt Piper power station by 1500 MW.

This report considers the replacement of 1000 MW of proposed coal-fired capacity with much cleaner energy options. Specifically, the report shows that a mix of energy supply from natural gas, wind power and bioenergy, together with firm implementation of substantial demand-side energy efficiency policies and strategies, could economically substitute for both the energy generation and the contribution to the peak load of a new 1000 MW of coal-fired power station by 2010. The proposed alternative energy system has CO_2 emissions in 2010 of 4.7 Mt per year less than those of the coal option, and creates many more local job-years, especially in rural areas.

To achieve this, the following demand-side measures are recommended:

- Strong energy performance standards for new buildings, new renovations for existing buildings, all existing government-owned and government-tenanted buildings, and some other categories of existing buildings.
- Substantial expansion of the use of solar hot water, gas boosted wherever possible, 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 contributors to increased electricity demand.
- The provision of low-cost packages of energy efficiency measures for householders.

Recommended policy measures by the State Government to support the cleaner energy supply mix include:

- A greenhouse intensity limit on all new power stations and on all major refurbishments and other life-extensions of existing power stations.
- Either tradeable emission permits of the cap and trade type, or a carbon levy, implemented jointly with other States.
- The requirement that energy retailers submit Renewable Energy Certificates (RECs) annually to the State Government as a licence condition, in addition to RECs that they must surrender to the Commonwealth Government's Office of the Renewable Energy Regulator.

Members of the Clean Energy Future Group have developed additional policy proposals that look beyond the focus of this paper. They can be accessed by contacting the individual member organisations.

The additional costs to the community of the recommended supply-side measures would be offset by the economic savings achieved from demand-side energy efficiency. Furthermore, the proposed substitution for a 1000 MW base-load coal-fired power station would reduce the socio-economic risk faced by NSW as the result of having an electricity supply system that is based overwhelmingly on coal. In the event that international greenhouse gas emission constraints are tightened over the next decade or so, high dependence upon coal would become a major liability.

A very important benefit of undertaking the transition to a clean energy future is that the key policies detailed in this report will stimulate job growth and increased economic activity. We strongly advocate that the NSW Government provide incentives to ensure that the major proportion of these new jobs be located in regions most affected by the closure of coal-fired power assets.

In short, there is no technical or economic barrier to ceasing to build new coal-fired power stations and commencing the transition to a much cleaner electricity system based on efficient energy use, renewable energy and natural gas. The real barriers are institutional, organisational and political.

1. Introduction

There is widespread and growing international concern about global climate change resulting from the human-induced greenhouse effect. We know that our planet's average temperature is rising at an unusually rapid rate. Climate change impacts in NSW have the potential to threaten lives, agriculture, the availability of fresh water, the control and spread of disease, the survival of native species and the weather, including the frequency and severity of floods and droughts. The solution is to act immediately to cut our greenhouse gas emissions by 60% by 2050 (Coleman et al., 2004).

In Australia, the Commonwealth Government has declined to expand the Mandatory Renewable Energy Target (MRET) and is directing most of its resources for combating climate change into making coal 'clean'. These efforts range from research into alternative methods of combustion to increase efficiency and lower greenhouse gas emissions to the as yet unproven and possibly expensive technologies for the capture and geosequestration (underground burial) of CO_2 emissions from coal-fired power stations.

In NSW, the recently released Greenhouse Strategy (NSW Greenhouse Task Force, 2004) contains no commitment to a ceiling on total greenhouse gas emissions. Yet the recent scenario study, *A Clean Energy Future for Australia*, explains how Australia can achieve a 50% reduction in CO_2 emissions from stationary (i.e. non-transport) energy by 2040, compared with the 2001 level (Saddler, Diesendorf & Denniss, 2004).

That study assumes continuing economic growth and only utilises existing technologies with small improvements. It identifies a myriad of cost-effective technologies for using energy more efficiently, together with cleaner energy supply based on natural gas (the least polluting fossil fuel), crops and crop residues (excluding those from native forests) and wind power. Proposed 'clean coal' technologies and coal-fired power stations with geosequestration are shown to be unnecessary for achieving this scenario, even if they could become safe and affordable.

A Clean Energy Future for Australia suggests that achieving the 2040 target requires a wide range of new policies and strategies to be implemented immediately. These include a maximum greenhouse intensity for new conventional[1] coal-fired power stations, an expansion of the Commonwealth Government's MRET, the introduction of either tradeable emission permits or a carbon levy, and some mandatory requirements to drive efficient energy use under circumstances of market failure. In essence, the study proposes a roadmap for implementing the much-cited principle of *think globally and act locally*.

At present, in several States, including NSW, there are proposals for either new conventional coal-fired power stations or extensions of the lifetimes of old ones. Newly built coal-fired power stations will have lifetimes of 35 to 40 years and will undermine our society's ability to make the

[1] Conventional (pulverised fuel) coal-fired power stations have the highest greenhouse gas intensities (Mt of CO_2 emissions per TWh of electricity sent out) of all types of power station. They also emit large quantities of sulphur dioxide, sulphuric acid, nitrogen oxides, hydrochloric acid, fluoride, boron, particulate matter and mercury, and contribute to significant land degradation.

transition to a much cleaner energy future with much lower CO_2 emissions by 2040. Consequently the Clean Energy Future study suggests that another principle must be put into practice, namely one of *think long-term, but act now*.

This report focuses on the potential for cleaner energy sources to substitute initially for a 1,000 MW base-load coal-fired power station in NSW. Such a coal-fired power station would burn annually about 3.7-4.0 million tonnes (megatonnes or Mt) of coal, sending out about 7,000-7,500 GWh of electricity and emitting into the global atmosphere 6-7 Mt of CO_2. Such a coal-fired power station would over its lifetime lock in another 210-280 Mt of NSW's CO_2 emissions, swamping any possible greenhouse gas savings envisaged under current government policies.

This report proposes a mix of energy efficiency and cleaner electricity supply measures that would substitute for a 1000 MW coal-fired power station by about 2010.[2] In making this substitution, this report matches the two principal contributions that a base-load power station makes to electricity supply:

- Annual energy that is measured here in GWh/yr, where 1 GWh = 1 gigawatt-hour = 1,000 megawatt-hours (MWh); and
- Capacity to contribute to peak demand, that is measured here in megawatts (MW).

This report commences with a concise background on NSW's electricity system and existing government policies and strategies to reduce greenhouse gas emissions from electricity use (Section 2). In Section 3 it proposes an alternative mix of demand-side energy efficiency and supply-side renewable energy measures to substitute for the hypothetical 1,000 MW coal-fired power station. Section 4 shows that there are more than enough energy reserves for the cleaner supply mix, and Section 5 proposes policies and strategies for achieving the substitution. The allocation of costs is discussed in Section 6 and the employment implications are addressed in Section 7. The environmental impacts of bioenergy and wind power are discussed in the appendix.

[2] Because conventional power stations generate large blocks of power, they are brought on line several years before their full capacity and electricity generation are actually required. Clean energy options are generally provided in much smaller blocks and so they can be brought on line as required by electricity demand.

2. New South Wales electricity backgrounder

2.1 NSW's electricity industry

NSW has a population of 6.7 million (December 2002). On the principal electricity grid, scheduled generation capacity in 2001 was 12,217 MW (and rated to be the lightly lower capacity of 12,030 MW in summer). In addition, the State can draw on about 2,000 MW from Snowy Hydro and 710 MW from non-scheduled capacity. Average demand in 2004 was about 8,500 MW, the most recent peak demand was 12,838 MW and occurred on 19 July 2004. Electricity sent out from NSW power stations in the financial year 2001/02 was about 65,000 GWh. Over the past five years average demand has grown at 2.8% p.a. while summer peak has grown at 3.8% p.a. and has almost overtaken the winter peak. (NSW Greenhouse Office, 2004; NSW Government, 2004; ESAA, 2002)

Table 1 shows that 98% of fuel used in the State's main power stations in 2000/01 were coal.

Table 1: Fuels used in NSW's electricity generation, main grid, 2000-01

Fuel	% of generation
Black coal (sub-bituminous)	98
Gas	1.5
Hydro	0.5
Total	100

Source: ESAA (2002)

The demand for primary energy has been increasing steadily since the early 1980s. Drivers of this growth are:

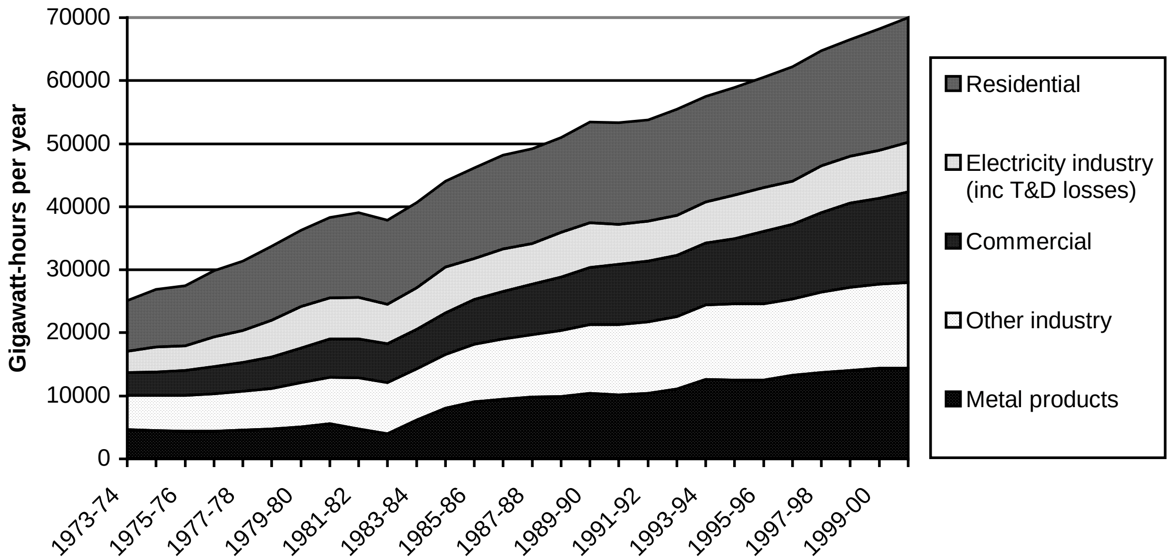
- Population growth;
- Economic growth from industrial and commercial development -- NSW has several electricity intensive industries, such as metal smelting;
- Changing lifestyles, including the trend towards larger houses, smaller households (i.e. number of persons per house) and the rapid increase in the use of electrical appliances and equipment, including air conditioners.

The most recent greenhouse gas inventory of NSW was conducted in 1995. At that time total emissions from stationary energy were about 68 Mt CO_2.equivalent (NSW Greenhouse Office, 2004). Of this the vast majority was from electricity generation.

2.2 Electricity use in NSW

Trends in NSW electricity usage are shown in Figure 1. It can be seen that there has been strong growth in the commercial sector, both in absolute terms and in its share, which has increased by 39% since the early 1970s. The residential share has declined slightly in percentage terms from 32% to 28%. The residential sector still dominates NSW electricity use, while the commercial sector including metal production and other industry categories are now all similar in size, each being around 20% of total electricity generation. The commercial sector dominates the NSW economy and employment, while the metal products sector is a small contributor to both the economy and employment.

Figure 1. Electricity use in NSW by sector (ABARE, 2004)



2.3 State government policies and strategies

The NSW Government has put in place the following policies and strategies that are expected to reduce slightly the rate of growth of greenhouse gas emissions:

- The ***Sustainable Energy Development Authority*** (SEDA) was created in 1996. SEDA successfully levered significant investments in efficient energy use and renewable energy in NSW with relatively low investment costs. Ongoing programs set up by SEDA include Energy Smart, Business, Government and Homes. SEDA also managed the Green Power scheme in NSW. The incorporation of SEDA into the Department of Energy, Utilities and Sustainability (DEUS) in 2004 appears to have made some of SEDA's excellent programs less accessible. Furthermore the ongoing budget for such action-focussed activities appears to be in doubt.

- ***BASIX*** (Building Sustainability Index) was introduced into the NSW development approval process on 1 July 2004. BASIX is a web-based planning tool that measures the potential performance of new residential dwellings against a range of sustainability indices: energy, water, thermal comfort, stormwater and landscape. For energy, BASIX requires each dwelling design to meet the NSW Government's target of a 25% reduction in greenhouse gas emissions, compared with the average home (to increase to a 40% reduction from July 2006). See www.basix.nsw.gov.au.

- The Independent Pricing and Regulatory Tribunal (IPART) of NSW has introduced measures to remove ***barriers to energy efficiency in network price regulation*** (IPART, 2004). The measures include permitting network businesses to:
    - Retain the benefits of capital and operating expenditure avoided through demand-side management during the 2004-09 regulatory period;
    - Recover revenue foregone as a result of energy efficiency programs during the regulatory period;
    - Pass on to consumers the energy efficiency program costs incurred during the regulatory period, up to a maximum value of the avoided distribution costs.

- ***Greenhouse Benchmarks Scheme:***
  (See www.deus.nsw.gov.au/eeg/gb/ and www.greenhousegas.nsw.gov.au.)
  From 1 January 2003, NSW electricity retailers and certain other parties ('benchmark participants') are required to meet mandatory targets for abating the emission of greenhouse gases from electricity production and use for the period 2003 to 2012. Benchmark participants have to reduce their average emissions to the pre-set benchmark levels or pay a penalty of $10.50 per tonne of carbon dioxide equivalent (CO_2 –e) emissions above their targets. Benchmark participants may offset their excess emissions by surrendering to the IPART abatement certificates bought from low-emission electricity generators and other persons accredited by the Scheme Administrator as certificate providers. The benchmark target is 7.27 tonnes of carbon dioxide equivalent (tCO_2-e) per capita by 2007, which is 5% below the baseline year of 1989-90. The 7.27 tCO_2-e benchmark level will then be maintained until at least 2012. Each benchmark participant is allocated a share of the electricity sector benchmark based on the level of their electricity sales as a proportion of the total State electricity demand.

  The scheme has been criticised on the grounds that it will not necessarily reduce emissions and that the principal beneficiaries are brown coal-fired power stations in Victoria that sell electricity to NSW. These Victorian power stations gain certificates by making small improvements in generation efficiency, thus lessening the resources available to participants that implement efficient energy use and renewable energy.

In addition, the following programs are listed by NSW Greenhouse Office (2004, pp.13-14) as being the responsibility of the NSW Department of Energy, Utilities and Sustainability:

- Cogeneration program;
- Solar rebate program;
- Waste coal mine gas program.

3. Reducing demand growth and cleaning up energy supply

It takes six to eight years to build and commission a new 1000 MW coal-fired power station. Therefore it could not contribute to the problem of meeting the growth in peak demand within four years. Once a new coal-fired station is operational, it would of course contribute continuously. Generally speaking the cheapest and fastest measures for reducing greenhouse gas emissions from stationary energy are improvements in the efficiency of energy use.

3.1 Efficient energy use

Detailed studies have been made on how to improve substantially the energy efficiencies of certain technologies (e.g. some office equipment, vending machines, refrigerators and washing machines), but a much wider range of studies is needed. Many of the barriers to implementation are neither technical nor economic but arise from market failures such as the divergent interests of landlords and tenants, and the lack of appropriate organisations or institutions (such as energy service companies) to facilitate large-scale implementation of energy efficient technologies.

The economic potential is large but to capture it policies, strategies and action plans are needed at all levels of government and business (Greene and Pears, 2003; BCSE, 2003a; Energy Efficiency and Greenhouse Working Group, 2003; Saddler Diesendorf & Denniss, 2004).

To estimate the potential for energy efficiency, this report examines separately the principal sectors of electricity consumption: industrial, commercial and residential. There is no recent comprehensive study for the potential for efficient energy use in NSW spanning all three sectors. Hence the report draws on two separate reports:

- The recent report by EMET (2004) on the residential and commercial sectors of NSW; and
- The comprehensive, detailed, 1991 SRC Australia report for Queensland that covered all three sectors of energy use.

EMET report for Australia as a whole

The study by EMET (2004) obtains for the whole of Australia in 2010 a reduction in *residential* electricity consumption beyond business-as-usual, of 6,400 GWh/y, and of summer demand by 1324 MW, assuming a payback period of 6.5 years. To rescale these results so that they apply to NSW, we multiply them by 0.36 (the ratio of electricity consumptions in NSW and Australia), obtaining electricity savings of 2,304 GWh and summer demand reductions of 477 MW (see Column 3 of Table 2).

For the *commercial* sector EMET (2004) only considers a four-year payback period and obtains a reduction, beyond business-as-usual measures, of 1800 MW in Australia's summer peak, which becomes 648 MW when rescaled to NSW. EMET's corresponding estimate of savings in Australia's commercial electricity consumption is 7,639 GWh/y, which becomes 2750 GWh/y for NSW (see Column 3 of Table 2). Larger reductions would be expected from a 6.5-year payback period. EMET (2004) does not investigate the electricity saving in the industrial sector.

SRC Australia report for Queensland

For comparison, the earlier study by SRC Australia (1991) for Queensland found that through efficient energy use (including solar hot water) in the residential, commercial and industrial sectors, total savings of 1094 GWh/y could be achieved, including demand reductions of 392 MW in winter and 263 MW in summer after six years. The energy and demand savings did not stop after six years but increased in magnitude for each year until 17-18 years after the commencement of the proposed program when the energy savings reached about 3760 GWh/y, while the demand savings were 950 MW in summer and 1454 MW in winter.

Towards New South Wales' Clean Energy Future considers here a period of six years, in order to compare the SRC results with the potential energy savings for the period between 2004 and 2010 over which the proposed 1000 MW of coal-fired power could be replaced.

Table 2: Annual energy and capacity reductions by sector, achieved six years after commencement of an energy efficiency program

Study →	SRC rescaled to NSW in 2010	EMET rescaled to NSW in 2010
Residential sector		
Energy reduction (GWh/y)	1596	2304
Summer peak reduction (MW)	195	477
Winter peak reduction (MW)	846	477
Commercial Sector		
Energy reduction (GWh/y)	1380	2750
Summer peak reduction (MW)	453	648
Winter peak reduction (MW)	228	462
Industrial Sector		
Energy reduction (GWh/y)	306	ND
Summer peak reduction (MW)	141	ND
Winter peak reduction (MW)	102	ND
Total: All Sectors		
Energy reduction (GWh/y)	3282	ND
Summer peak reduction (MW)	789	ND
Winter peak reduction (MW)	1176	ND

Note: 'ND' denotes 'no data'; EMET results for residential sector have 6.5 year payback, but EMET results for commercial sector have four-year payback.

The NSW electricity supply industry was rather different in the starting period for the SRC study of 1990/91 compared with the current situation. At that time, Queensland electricity consumption was only about 21,000 GWh/y, the maximum demand of 4,090 MW occurred in winter and there was no significant use of gas by consumers. Nevertheless, until the equivalent of the SRC study is repeated for NSW, a rough estimate of the potential for efficient energy use can be obtained by simply rescaling the SRC results for 1997 to NSW for 2010. So, to first approximation, we multiply the Queensland savings in energy generation and also the Queensland savings in summer peak (which was considerably lower than the savings in the winter peak of the early

1990s) by the ratio of electricity consumptions, a factor of three. Since the summer and winter peaks in NSW are now approximately the same, we assume that the savings in the NSW winter peak equal those of the NSW summer peak. The results are shown in Column 3 of Table 2.

In total, using the rescaled SRC estimates, in the sixth year (2010), efficient energy use could achieve a reduction in NSW electricity consumption of 3282 GWh and a reduction in summer and winter peak demands of 789 MW and 1176 MW respectively.

Energy efficiency assumptions in this report

If we took the EMET estimates for the residential and commercial sectors and the SRC estimates for the industrial sector, then in total during the sixth year (2010) efficient energy use could achieve a reduction in NSW electricity consumption of 5306 GWh and a reduction in summer and winter peak demands of 1266 MW and 1041 MW respectively.

This contribution is considerable but by no means an overestimation. All of the energy efficiency measures incorporated in these studies provided attractive commercial returns and probably under report the full extent of savings that could be achieved. In addition it should be noted that the generating capacity avoided due to energy efficiency measures is actually greater than stated because it doesn’t take into account the avoided line losses that are associated with centralised large coal-fired electricity generation.

However, this study has taken a particularly conservative approach, by using the rescaled SRC data for all sectors. This is more than adequate for substituting for a substantial part of a 1000 MW coal-fired power station. However, this greatly underestimates the economic potential for energy efficiency in NSW.

Furthermore, this approach could well lead to an even greater underestimation of the percentage reduction in CO_2 emissions, because the SRC study does not take into account the substitution of gas at the point of use in the place of electricity for heating and cooling. Because of the low thermal efficiency of electricity generation from the combustion of coal (typically 35-36%) and the lower CO_2 emissions from burning gas, such fuel substitution could reduce emissions for these particular energy services by a factor of about four.

3.2 Cleaner energy supply

Meeting the peaks

NSW meets its peak demand with hydroelectricity supplemented by gas turbines. While there is no physical problem in meeting the peaks from existing natural gas supplies, the cost of augmenting the distribution system to meet increasing peak demands are expected to be substantial. For example, the NSW Government (2004) estimates that $4.8 billion would need to be spent on network augmentation (both capital upgrades and new projects) over five years commencing in 2004.

Base-load supply

Within a six- to eight-year timescale a new base-load power station could contribute both to peak demand and electrical energy demand. This power station does not have to be a single coal-fired power station. Rather, it could comprise several smaller power generation units using natural gas, biomass and waste streams, together with wind power. The latter can be included as base-load provided it is well distributed geographically in NSW and the National Electricity Market (NEM). For large penetrations of wind power into the grid, wind is best complemented by gas turbines in order to maintain the reliability of electricity supply at the pre-wind power level (see subsection on reliability of the generating system).

On a short timescale (10 years or less), it is assumed that there will be no cheap solar electricity, geothermal or hydrogen storage and transport of renewable energy, or capture and geosequestration of CO_2 from coal-fired power stations.

Renewable sources of electricity are growing steadily. On 31 December 2003, Australia's operating non-hydro renewable energy generating capacity was comprised mainly of 368 MW bagasse cogeneration, 197 MW wind power[3], 100 MW landfill gas, 77 MW black liquor and 26 MW sewerage gas (BCSE, 2004).

Tables 3 sets out a possible mix of demand-side and supply side measures that could remove the need for a 1,000 MW coal-fired power station by 2010. As mentioned above, on the demand side this report uses the rescaled results of SRC (1991) to obtain the reduction in peak load and electricity consumption resulting from efficient energy use (see Table 2, column 2). A more accurate calculation must consider fuel substitution at the point of use and boosting of solar hot water[4].

The contributions to grid electricity sent out or saved come from efficient energy use (including end-use fuel substitution and solar hot water), gas (both natural gas and coal seam methane), bioenergy and wind energy, in that order of importance.

Capacity factor (Column 3) is annual average power generated divided by rated power. Column 4 of the table gives the approximate contributions to Equivalent Firm Capacity, i.e. to peak load --see subsection on reliability of the generating system.

The cost in millions of dollars per year of electricity generated or saved is given in Column 9. However, this could be misleading with regard to the costs of efficient energy use, especially in the residential and small business categories. The latter costs should *not* be compared with the prices of electricity sent out from the coal-fired power station, but rather with the respective

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[3] By 31 December 2004, Australia's wind power capacity had reached 380 MW, with an additional 1350 MW approved or under construction.

[4] While gas boosting of solar hot water avoids peak electricity demand contributions, for electrical boosting there is the option of smart booster controllers or an off-peak tariff. Controllers could be set up to give users feedback (via a display inside) as to the water temperature in the storage tank and a suggested best boost and shower time. This would give feedback to users to maximise solar contribution and allow for minor behaviour change.

prices of electricity delivered to end-users in these categories. Typical prices for NSW, as given by ESAA (2002, Charts 5.1-5.4) and adding GST, are:

Sydney residential 9.8 c/kWh;
Sydney small business 11.5 c/kWh; and
Sydney big business 6.6 c/kWh).
Rural NSW (non-domestic tariff) 14.6 c/kWh.

For simplicity this report uses Sydney prices of electricity to calculate the value of electricity saved by efficient energy use in Column 10. This cuts dramatically the total cost of electricity delivered by our supply-side and demand-side mix in 2010, bringing the cost far below that of a typical black coal-fired power station of 3.5-3.75 c/kWh. This assumes that the price of gas-fired electricity at the power station is 4.5 c/kWh. The price of coal-fired electricity would have to be less than about 1 c/kWh (including both annualised capital charges and operation and maintenance costs) before the total cost of the cleaner energy scenario of Table 3 in 2010 exceeded that of the hypothetical new 1,000 MW coal-fired power station. Currently the generation price is 3.5-3.75 c/kWh. This conservative calculation does not take into account that cogeneration has similar economic benefits to efficient energy use, in substituting for electricity delivered to consumers.

In substituting for 1,000 MW of baseload coal-fired power stations by means of cleaner energy supply and efficient energy use, there is a reduction in CO_2 emissions in 2010 of 4.7 Mt per year in the scenario of Table 3.

The clean energy scenario offers measures that are additional to those installed or under construction at 30 June 2004. It supplies the annual energy generation in GWh/y equivalent to a 1,000 MW coal-fired power station and more than such a power station's Equivalent Firm Capacity in MW. This concept is explained in the next subsection.

Reliability of the generating system

One approach to the reliability of power stations has been to classify fossil fuel and nuclear power stations as 'reliable' or 'dispatchable' and wind and solar energy without storage as 'unreliable' or 'not dispatchable'[5]. But the use of the terms 'reliable' and 'unreliable' is simplistic. On one hand even a coal-fired power station has a significant probability of forced outage (unplanned failure) that generally varies between 3% and 10%. NSW's average forced outage rate was 8.7% in 2000/01 (ESAA, 2002). Thus coal-fired power is dispatchable, but not completely reliable. Therefore, it requires partial backup in the form of 'reserve plant'.

[5] In this context 'dispatchable' means 'available upon demand'. To describe wind power, we prefer not to use the term 'intermittent', because it could imply incorrectly that the source generally switches on and off abruptly. This is rarely the case for geographically dispersed wind farms.

On the other hand a wind farm can be considered to be partially reliable, because wind speeds are predictable over hours or days with a probability that is substantially above that of pure randomness. Furthermore, a group of wind farms located at geographically dispersed sites provides a net contribution which considerably less variable than each of the wind farms alone.

As a rough approximation, the capacity of a coal-fired power station to meet peak demand with 100% reliability[6] is considered to be its rated power x 0.93 /1.07. The factor 0.93 allows for a typical forced outage rate, while the factor 1.07 takes account of the fact that about 7% of the electricity generated is consumed in the operation of the power station. For the hypothetical 1,000 MW base-load power station this becomes 1000 x 0.93 /1.07 MW = 869 MW. To substitute for this station's capacity and energy generation, a mix of energy supply and demand-reducing technologies is required with equivalent firm (or 100% reliable) capacity of at least 869 MW and annual energy sent out of at least 6959 GWh.

The wind energy penetration into the NSW grid in our scenarios is less than 1% of electrical energy sent out in 2003/04. This penetration corresponds to an Equivalent Firm Capacity of wind power of that is equal to the average wind power, to very good approximation (Martin & Diesendorf, 1980, Table 3; Haslett & Diesendorf, 1981)**.**

On the demand side the calculation of the contribution to peak load is more complex and uncertain, because we must consider fuel substitution at the point of use and boosting of solar hot water[7]. Therefore, the contributions to peak load from efficient energy use have been taken from SRC (1991) with rescaling as indicated above.

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[6] This is the definition of Equivalent Firm Capacity.

[7] While gas boosting of solar hot water avoids peak electricity demand contributions, for electrical boosting there is the option of smart booster controllers or an off-peak tariff. Controllers could be set up to give users feedback (via a display inside) as to the water temperature in the storage tank and a suggested best boost and shower time. This would give feedback to users to maximise solar contribution and allow for minor behaviour change.

Table 3: Energy mix to substitute for a 1,000 MW coal-fired power station in 2010: scenario with efficient energy use, gas and medium renewable energy

Technology	Rated power (MW)	Capacity factor	Contrib. to peak[h] (MW)	Elec. sent out or saved (GWh/y)	Emission Intensity[g] (Mt CO_2/TWh)	CO_2 emissions (Mt)/y	Price of unit of elec. gen. or saved in 2010 (c/kWh)	Cost[b] of elec. gen. or saved in 2010 ($M/y)	Cost of elec. delivered[c] in 2010 ($M/y)
Bio-electricity	206	0.8	173	1349	0	0	8.0	107.9	107.9
Gas CC & cogen. [d]	220	0.8	164	1441	0.4	0.62	4.5	64.8	64.8
Gas turbine	0	0.1	0	0	0.67	0	6.3	0	0
Wind	375	0.27	101[e]	887	0	0	8.5	75.4	75.4
EE[a]: residential	N/A	N/A	195	1596	0.2	0.32	4.9	78.2	-77.9
EE[a]: commercial	N/A	N/A	453	1380	0.2	0.28	4.9	67.6	-91.6
EE[a]: industrial	N/A	N/A	141	306	0.2	0.06	4.9	15.0	-5.1
Total	**801 + EE**	**N/A**	**1228**	**6959**	**N/A**	**1.27**	**N/A**	**409.0**	**73.5**
1,000 MW baseload coal[f]	1000	0.85	869	6959	0.8	5.96	3.75 3.5	261.0 243.6	261.0 243.6

Notes:

a. EE denotes efficient energy use and includes fuel substitution at point of use and solar hot water. The EE contributions are calculated from rescaling SRC (1991) results from Queensland as indicated in Section 3.1. We assume that EE has an average cost of 4.9 c/kWh saved, which corresponds to the value after 6 years of EE implementation given by SRC (1991) adjusted for inflation. By the experience of 2004, this appears to be conservative.

b. Cost (column 9) is for 2010 only, the 6th year after implementing the program. EE contributions calculated by SRC (1991) increase with time from 6th to 18th year, then decline gradually up to 30th year.

c. In Column 10, we have adjusted the residential, commercial and industrial energy efficiency costs to take account of the situation that they are saving electricity delivered to consumers at 9.78, 10.49 and 5.98 c/kWh respectively, instead of electricity generated at 3.5-3.75 c/ kWh.

d. It is assumed that by 2010 sufficient gas reserves, comprising both CSM and natural gas, will have been established and connected to the State pipeline system.

e. For 375 MW of wind power capacity in the NSW grid, the Equivalent Firm Capacity is approximately equal to the average wind power (see text).

f. For this hypothetical coal-fired power station it is assumed that wholesale price of electricity generated will be either 3.75 or 3.5 c/kWh.

g. Energy efficiency measures have been arbitrarily given an emission intensity of 0.2 Mt CO_2/TWh saved. In practice it could be much less than this.

h. More precisely, the Equivalent Firm Capacity (see text).

4. Energy reserves

4.1 Gas

In the short and medium term gas is valuable as a significant transitional fuel in the move towards an energy system with much lower CO_2 emissions than present. It can be used to fuel combined cycle and cogeneration power stations and as back-up for solar hot water, solar thermal electric power stations and wind farms.

'Gas' includes natural gas; coal seam (coal bed) methane, which is identical to natural gas; coal mine gas (waste mine gas) which may have a much lower concentration of methane than the above two gases and so may have to be used on-site at the coal mine; and waste gas from petroleum refining. Firm estimates of the reserves of these gases are notoriously difficult to obtain, both because of corporate confidentiality and the uncertainties inherent in proving these resources. Drilling for coal bed methane is in its infancy in NSW, with production at about 9 PJ per year in 2002. Coal bed methane from the Southern Coalfield of the Sydney Basin is used to fuel two small power stations with total capacity 97 MW to generate electricity which is fed into the NSW grid (Petrie et al., 2003).

NSW obtains most of its natural gas from the Cooper/Eromanga Basins in Central Australia, which also serves South Australia, the Australian Capital Territory and Victoria. This is supplemented by gas from the Surat/Bowen Basin (in Queensland) and the Gippsland Basin (in Victoria).

Geoscience Australia estimates that the Category 1 (i.e. both 'proved and probable'[8] commercial) reserves of sales gas (i.e. cleaned up natural gas) in the Cooper-Eromanga Basins amounted to about 58 billion cubic metres and Gippsland Basin to 146 billion cubic metres on 1/1/2003 (Petrie et al., 2003). In total this is equal to about 7,000 PJ, which could fuel 2566 MW of base-load combined cycle power stations for 30 years. Although NSW may only receive a small fraction of this gas, it would certainly be adequate for the 220 MW combined-cycle power station considered in this report. Over the past several decades, official estimates of Australia's natural gas reserves have proven to be very conservative.

4.2 Biomass

This study envisages 206 MW of capacity supplying 1349 GWh of electricity per year. This is readily deliverable and highly conservative considering that the NSW Bioenergy Handbook (Rutovitz and Passey, 2005) estimated potential capacity of 1577 MW, as detailed in Table 4, from a broad mix of currently available biomass sources. Its estimates are conservative because, for instance, it only considers a tiny contribution (33 MW) from wheat straw, preferring to retain almost all the straw in the field as a soil conditioner.

[8] i.e. reserves established at the median value – that is with a 50% cumulative probability of existence.

Table 4: Potential electricity generation capacity for NSW bioenergy

Feedstock	Current generation capacity (MW)	Estimated potential capacity (MW)
Agricultural residues	17.5 (bagasse only)	740
Energy crops[a]	0	550
Plantation residues (thinnings & sawmill wastes)	4	105
Sawmill wastes (from native forest sawlog production)	16	42
Wet wastes	23	40
Municipal, industrial & commercial wastes	29 (landfill gas)	100
TOTAL	**89.5**	**1,577**

Source: Rutovitz and Passey (2005), Table 3, p.29.
a. See Stucley et al. (2004).

However, for biomass residues in NSW a much larger contribution could be obtained from wheat stubble and other grain crops. Following Kelleher (1997) and based on NSW's total planted land area of 6 million ha, stubble yield of 2.0 t/ha (leaving 1.4 t/ha on the land as a soil conditioner) and thermal efficiency of conversion to electricity by combustion of 30% gives an annual electricity generation of about 9,900 GWh, corresponding to an installed capacity of about 1400 MW from grain stubble alone.

For higher conversion efficiencies it is possible to gasify biomass before combustion. For instance, dry biomass can be gasified by heating it with a limited supply of air or oxygen, sometimes in the presence of steam. This process is more efficient and cleaner than direct combustion, so our calculation based on direct combustion is conservative. As noted in Table 4 wet biomass can be converted to biogas by anaerobic digestion, a process that has a number of environmental advantages and also produces an excellent organic fertiliser.

Correspondence with industry indicates that there is already over 100 MW of biomass capacity under development in NSW.

4.3 Wind

At the end of 2004 there was 17 MW of wind power installed in NSW, with an expected annual energy generation of about 45 GWh, which is enough electricity to power about 5,000 households. By the end of 2004 there were also proposals for another 1083 MW (see www.auswea.com.au) but much of this will not be built unless MRET is expanded. According to Outhred (2003) up to 3,100 MW of wind power could be readily integrated into the existing NSW grid. Outhred does not present this capacity as an upper limit because it is based on the assumptions that no significant changes are made to the electricity grid and that there is no dedicated backup for wind. Table 3 of the present report assumes a wind energy capacity of 375 MW, which is readily achievable by 2010.

5. Recommended policies and strategies for NSW

To substitute for 1,000 MW of base-load coal power and at the same time to achieve significant reduction in CO_2 emissions within the framework of electricity markets, it may be necessary to introduce economic instruments and/or constraints on generation sources to allow cleaner energy sources to compete with highly polluting coal.

This report proposes several such strategies that can be justified on the grounds that the price of coal-fired electricity does not include externalities, such as the environmental and health costs of its use, and that existing market signals fail to fully reflect important costs. For example, the pricing of transmission and distribution is averaged over large areas, so that the cost of supplying some customers is underpriced. This undermines the economic utilisation of sustainable energy alternatives in rural areas, even though, from society's perspective, they offer a lower cost solution. Economic instruments and/or emission constraints will encourage gas-fired generation, in the form of combined cycle or cogeneration, and several renewable energy technologies to compete with conventional coal. The increased price of a unit of electricity can be offset by programs to encourage efficient energy use and hence to reduce the number of units consumed.

Therefore, to set NSW on a pathway to a clean energy future, the following new policies and strategies are recommended.

5.1 Set a greenhouse target for the 'local' economy

The NSW Greenhouse Benchmarks scheme sets a mandatory per capita greenhouse target for energy retailers and certain other parties for the period 2003-2012 (see Section 2.2). Although this is in advance of several other States, a stronger target is required for a genuine program to control greenhouse gas emissions. This report recommends that, in addition to this per capita target, the NSW Government set targets for total[9] greenhouse gas emissions for 2012, 2015 and 2020 for the 'local' (i.e. non-export) component of the economy. This would cover the residential, commercial and part of the industrial sectors.

Setting a local target would not mean that greenhouse gas emissions from the export component of the economy would be ignored. To the contrary, this report recommends that they be addressed by setting mandatory energy efficiency best practice requirements, as well as by several of the other policy recommendations put forward below. In the long run, it is likely that energy intensive exports will be regulated separately by international agreement.

5.2 Expand the Mandatory Renewable Energy Target (MRET)

The only significant existing driver of low-cost, commercially available, renewable energy is MRET. However, the current Australian target of 9,500 GWh/year in 2010 is very small, corresponding to less than 1% of projected electricity demand for 2010. Furthermore, several electricity generators are either failing to create Renewable Energy Certificates[10] (RECs) for

[9] i.e. not just a per capita target

[10] 1 REC = the generation of 1 MWh of electricity from a renewable source or the saving or 1 MWh of electricity through the use of solar hot water.

parts of their renewable energy generation or accumulating RECs that they have created until their price increases. This has the effect of limiting the market for RECs and increasing REC prices. As a result, MRET is expected to be fully utilised by 2007. This means there is a serious risk that the renewable energy industry will face a ‘boom and bust’ situation as MRET demand dries up from 2007.

An expansion of MRET is especially important to:

- Assist the establishment of bioenergy; and
- Encourage the wind power industry to utilise the numerous inland sites that have lower wind speeds than the best coastal sites.

This report supports the recommendation of the Business Council for Sustainable Energy for the Commonwealth Government to expand MRET for Australia to 21,600 GWh/y by 2010 and to 33,800 GWh/y by 2020. BCSE’s recommendation that projects installed prior to 2020 to be guaranteed 15 years to produce RECs, is also supported. (BCSE, 2003b)

The expansion of MRET is best driven nationally by the Federal Government. However, in the absence of Federal action, it has been suggested by leading industry organiations that State Governments, either individually or collectively, could resolve this situation by setting their own separate and additional renewable energy targets above and beyond the Commonwealth MRET target, applying to electricity within their State boundaries.

A State target could be imposed as a licence condition for electricity retailers to annually submit additional RECs to the State Government. Thus each energy retailer would have to surrender RECs to a State agency for the State scheme as well as RECS to the Office of the Renewable Energy Regulator (ORER) for the Commonwealth MRET scheme. In effect this would expand the existing MRET scheme without imposing additional complexity.

Bioenergy has larger employment potential than other renewable sources of electricity (see Section 7) yet it has only benefited slightly from MRET. Consequently the State Government could consider ways to increase the number of RECs coming from bioenergy as a stimulus to rural employment.

An advantage to a State Government of expanding MRET is that the costs do not come out of the State budget but are covered by all electricity consumers through a small increase in electricity prices.

The details of how this scheme would work depend on how the Commonwealth Government responds to the MRET Review Panel (2003) recommendation relating to extinguishment of RECs. At present, only a Liable Party (ie retailer or wholesale buyer of electricity) can extinguish RECs. However, the MRET review proposed that the owner of an REC (regardless of who they are) should be able to extinguish it. If the Commonwealth Government legislates to allow this, then a State Government could become the owner of the retailer’s RECs and could then simply extinguish them. Since these RECs would no longer exist for compliance with MRET, this would effectively increase the number of RECs that had to be generated beyond those required for MRET target.

On the other hand, if the Commonwealth Government does not change the legislation, a State Government could still set up a mechanism to acquire and quarantine RECs so that they were not available at any time in the future for surrender to ORER. A precedent exists: the Green Power administrators have already set up such a mechanism, so that all renewable electricity used for Green Power is additional to the MRET target. Unlike the NSW Greenhouse Benchmarks scheme, the proposal in Section 5.2 focuses specifically on expanding the contribution of renewable energy.

5.3 Place a greenhouse intensity constraint upon base-load power stations

Conventional (pulverised fuel) power stations burning black coal typically emit greenhouse gases at a rate of 0.8-1.0 Mt CO_2 per TWh of electricity sent out, depending upon such as factors as age, choice of technology, quality of coal, capacity, etc.

The low end of the range could be achieved by new power stations with supercritical boilers but even these have emission intensities double those of new combined cycle gas-fired power stations. The use of conventional coal-fired power stations as major sources of electricity is incompatible with the goal of achieving large reductions in CO_2 emissions. In NSW these power stations currently generate electricity at prices in the range 3.5-4.0 c/kWh. These prices do not reflect the substantial environmental and health damage produced by coal-fired power stations.

Australian Power and Energy Ltd has suggested that the Victorian Government should initially set a maximum allowable emission intensity of 0.7 Mt of CO_2/TWh, reduced to 0.1 Mt CO_2/TWh after 2020 (APEL, 2003). However, given the growing global concern and action to reduce carbon emissions, this report takes the position that the initial allowable intensity for new power stations in all States should be 0.5 Mt of CO_2/TWh sent out and then 0.1 Mt CO_2/TWh after 2020. This would entail that in the short term the only power stations that would be built would be either renewable energy or combined cycle natural gas or cogeneration natural gas. Beyond 2020 the only power stations that would be built would be either renewable energy or fossil fuels with geosequestration (assuming that geosequestration proves to be permanent, safe, cost-effective compared with renewable energy, suitable for the location in question, etc.).

For existing power stations in NSW a phased reduction in emission intensities is recommended to 0.7 Mt CO_2/TWh of electricity sent out after 10 years, then to 0.6 after 15 years and 0.5 after 20 years. For existing power stations, but not for new ones, it would permissible to achieve all or part of these reductions by installing renewable energy and cogeneration plants.

The Federal Government could assist the States by including a ‘greenhouse trigger’ in the Environmental Protection and Biodiversity Conservation (EPBC) Act 1999 leading to assessment of proposals generating more than 0.5 Mt of greenhouse gas emissions per year.

5.4 Implement other measures to encourage renewable sources of electricity

NSW should set a 20% renewable electricity target for 2010 and implement a range of initiatives designed to encourage additional investment in renewable energy projects, such as to:

- Develop planning guidelines for wind energy developers (similar to those produced in some other states) and a process for selecting sites for wind farms;
- Develop planning guidelines for biomass projects, noting that uncertainty is harming investment in a number of projects;
- Fund R&D support to create the knowledge base for the conversion of grain residues into useful energy and for new woody crop industries in the wheat belt. The Western Australian oil mallee project indicates that such industries may be commercially viable (for grower and processor) and also make a substantial contribution to salinity control and sustainable agricultural systems.

5.5 Implement tradeable emission permits or a carbon levy

Provided a cap on emissions is established and the cap is reduced annually, tradeable emission permits would assist in allowing gas, renewable energy and efficient energy use to compete with polluting coal. In the long run, if the price of tradeable permits increases sufficiently, it may be possible to phase out MRET. The permits should be applied to all industry sectors. The method of allocation of permits should strike a balance between encouraging new entrants with new technologies into the market and recognising that some emitting businesses have previously made investment decisions that produce high levels of emissions. Tradeable emissions would best be implemented as a national scheme. However, it would still be of value if implemented by a group of cooperating States.

A carbon levy would be a possible alternative to tradeable emission permits. The funds raised by the levy could be invested in funding the transition to a clean energy future and addressing social equity e.g. by substituting for payroll tax and assisting low-income earners to reduce energy waste.

5.6 Remove subsidies for fossil fuels and energy wastage

In Australia, over $5 billion a year is paid as ‘perverse’ subsidies to the production and use of fossil fuels (Riedy and Diesendorf, 2003; Riedy, 2003). These subsidies are ‘perverse’ in the sense that they are both economically inefficient and environmentally damaging. Most of these subsidies go to liquid fuels and the use of motor vehicles. However, in several States there are large subsidies to aluminium smelting (Turton, 2002) and in every State there is a large *de facto* subsidy to the use of air conditioning, the use of which is rising in NSW.

When someone purchases and uses an air conditioner, all electricity users in the State have to pay for the costs of the additional infrastructure required: power stations and power lines. Rough estimates suggest that, for a single-phase 5 kW residential air conditioner, the real costs could be of the order of $1500 a year based on a 10-year simple payback. However, at present the customer may be paying only $60 a year (BCSE, 2003c).

One way of dealing with the subsidy could be to require air conditioners to be purchased with a ‘smart’ meter that measures electricity consumption by time of day and allows the use of the air conditioner to be controlled by both the customer and the energy retailer. The meter should provide instant feedback to the household, and should have a feature that allows the householder to program load shedding if the electricity price goes above a specified level. The energy retailer would be required by law to charge for electricity consumed according to cost by time of day. This would:

- Encourage some prospective purchasers to install energy efficiency measures, such as shading of windows and insulation, instead of air conditioners;
- Discourage unnecessary use of air conditioners that have been purchased;
- Encourage the use of evaporative coolers and fans, which use much less electricity than air conditioners; and
- Assist solar electricity systems, that tend to generate most during the hottest times of day, to compete with conventional peak-load electricity generation.

There is also a historical subsidy to centralised power, as the whole electricity infrastructure was built using low-interest government-guaranteed finance, and until the 1980s, no dividends were paid by publicly owned electricity suppliers. It is suggested that to compensate for this historical subsidy the State Government should subsidise new powerlines or upgrades of existing powerlines required for bioenergy and wind power in rural areas.

5.7 Encourage the purchase of solar hot water

In Australia, hot water accounts for about 27% of residential energy use and on average only about 5% of households have solar (or, for shaded roofs, electric heat pump) hot water systems. It is clear that existing incentives (i.e. the inclusion of solar hot water in MRET) are not sufficient. In terms of achieving greenhouse gas reductions, a large shift from electric resistance hot water to solar and electric heat pump hot water, could achieve a large reduction in emissions. The problem is that electric resistance hot water is more quickly and easily installed, and has a lower upfront cost than solar, even though the lifetime cost of electric resistance hot water is higher than that of solar in NSW.

Therefore, it is proposed that the following additional measures be implemented to enable consumers to avoid the barriers to solar and heat pump hot water:

- State Governments should require *all* new buildings and renovations involving hot water supply to have solar, heat pump or solar-compatible gas hot water systems. At present NSW is moving towards this measure through the BASIX (Building Sustainability Index) scheme, while Victoria will require new homes to achieve 5-Star energy efficiency in the building envelope and to have either solar hot water or a water tank. Where both sunshine and natural gas are available, it is recommended that only gas-boosted solar hot water be permitted.
- For existing buildings, purchasers of electric resistance hot water systems should be required to take out mandatory Green Power and purchase and install a ‘smart’ meter on the hot water circuit. This would bring consumers closer to the ‘user pays’ requirement. Furthermore, all replacement electric hot water systems should be solar compatible.
- State Governments should pass legislation making it illegal for local governments to require planning permission for installing solar hot water. At present, some local governments do and others don’t. Obtaining planning permission takes so much time that it discourages home owners from replacing an existing hot water system at the end of its life with solar.

5.8 Mandate key energy efficiency measures

There is a wide variety of cost-effective measures to implement substantial amounts of efficiency in energy use, however their wide dissemination is impeded by market failure (Greene and Pears, 2003). This is an area where regulation must play an important role. The following measures are recommended:

- Mandatory energy rating and labelling of all new and existing buildings and all new energy-using appliances and equipment. Energy labelling of buildings must be disclosed whenever the building is put onto the market or leased. This should not just cover the heating and cooling energy but also include the energy efficiency of major fixed appliances within the building such as water heaters, cooking stoves, air conditioners and lighting.

- Mandatory energy performance standards for all new energy-using appliances and equipment. (Current standards are limited to only a few appliances).

- State Governments should make it illegal for local government, developers or the body corporate of residences under strata title to ban solar powered equipment such as solar water heaters, photovoltaic power systems, or solar clothes driers (i.e. clothes lines). This should also apply to developers' covenants.

- The subsidy should be removed from electricity prices in remote and rural areas. This would assist cost-effective energy efficiency, solar hot water and local renewable sources of electricity (especially solar) to compete with the grid. This would be more economically efficient and have wider scope than the existing rebates (Section 2.2). State Governments could still pay a fixed subsidy to households and businesses in rural areas by means of an annual or quarterly cheque and by offering incentives and assistance programs to improve energy efficiency and install solar hot water.

- 'Smart' meters should be introduced as soon as possible to measure electricity demand by time of day and to allow both the energy retailer and the consumer to switch the circuits where the meters are installed. For buildings with smart meters, energy retailers should be required to charge by time of day. These meters should allow the occupant to program load management strategies and give them feedback on electricity use. This will allow time-of-day pricing and widespread load-shedding to be introduced.

- Inverted electricity tariffs (i.e. the more you use, the cheaper the price of a unit of electricity) should be banned.

- The practice of some electricity retailers of charging customers, who have a small to average electricity consumption, a large fixed component of the bill and a small variable component, should be banned. In the interests of energy conservation it is important that the largest component of the bill be the variable charge and that this be proportional to energy consumed. Indeed, for very large consumptions, the unit price should be stepped up.

- Expand BASIX to include mandatory energy performance standards for all renovated buildings. Extensions should meet existing performance standards, while the older existing parts of renovated buildings should be required to be upgraded to a lesser extent.

- Mandatory energy performance standards for all rental, Government-owned and Government-leased buildings. Existing buildings would be required to achieve less stringent energy ratings than new buildings. There would be government assistance to low-income building owners, such as pensioners, who are landlords.

- The NSW Government should establish a Clean Energy Fund or Demand Management Fund that provides incentives and resources to overcome barriers to efficient energy use and accelerates the adoption of energy efficiency in homes and businesses. The fund should be set at a reasonable level (no less than 1% of total energy bills) and should be independent of the NSW budget by being raised directly from electricity bills. The NSW Government has established a high level taskforce to report on creating such a Demand Management Fund.

- Energy Performance Contracting[11] has been operating for years in Australia, mainly for large industrial and commercial energy consumers. The State Government could assist in extending this process to a large number of smaller energy consumers by providing support for the development of project aggregation by performance contractors, thus reducing the transaction costs of capturing energy opportunities in homes and small business.

5.9 Encourage voluntary energy efficiency measures

The State Government or energy/water retailers could offer householders a package of low-cost energy efficiency measures for appliances and equipment that are not part of the building envelope. The package could include compact fluorescent lamps, water efficient shower heads and tap fittings, insulation wraps, adjustment of thermostats on hot water systems, and replacement of compressors and seals on refrigerators. This package would include a service-call by an electrician or plumber. If implemented on a mass scale, the cost per household would be low, the reductions in energy consumption and CO_2 emissions would be significant and so would the reductions in energy and water bills. Thus the scheme would be attractive to many households.

This proposal would have value both by reducing greenhouse gas emissions and by educating the community about simple energy efficiency measures in the home. It is further justified by the results of a pilot project by Moreland Energy Foundation (2004), which found that:
- The energy efficiency of most old fridges could be improved by up to 25% by simple low-cost measures;
- Improvements in energy efficiency of greater than 50% could be attained by slightly more expensive measures, such as compressor replacement;
- There is a large unfilled demand for refurbished fridges in low-income households;

[11] An energy efficiency business A contracts with an energy consumer B to reduce B's energy waste. B pays A an agreed fraction of the dollar savings achieved.

- The removal of unrepairable fridges from the market could reduce emissions of greenhouse gases significantly (because of both high electricity use and CFC emissions), while saving low-income households the high running costs of using these inefficient appliances. A scheme to remove unrepairable fridges has been developed by Moreland Energy Foundation in Victoria.

Recently Sydney Water ran a more limited version of the proposed package of low-cost energy efficiency measures by providing a plumber to assist households to fit water efficient shower-heads and tap aerators and fix leaks for a service charge of only $22. Governments could consider whether to provide low-interest loans to assist low-income householders to make these and other improvements. Governments could encourage energy retailers to run the scheme by putting in place revenue caps on the amount of revenue a retailer could earn per household on sales of electricity. There would be no cap on sales of energy efficient products and services.

5.10 Give incentives for local jobs in appropriate regions

To establish cleaner energy industries in NSW, the State Government should encourage renewable energy installations and equipment manufacturing (e.g. components for wind turbines and bioelectricity power stations) in rural and regional areas. This will facilitate a transition of skills for workers from industries dependent on coal and electricity generation.

6. Allocation of costs of the alternative mix

It is necessary to distinguish between the cost to State Government and the cost to State electricity consumers.

6.1 Cost to government

The present report considers the responsibility of State Government to maintain social equity, to regulate the market and to administer some of the proposed strategies. Of these, the only significant costs are for those items in the social equity category, as listed in Table 5.

Table 5: Items of State Government expenditure to maintain social equity

Item	Strategy	Cost
1	Upgrading energy efficiency of government housing	State Government to estimate
2	Low-interest loans to low-income owners of buildings for upgrading energy efficiency of their buildings. Cost is for interest subsidy only.	Cap to be chosen by government.
3	Low-interest loans to low-income tenants for package of energy efficiency measures. Cost is for interest subsidy only.	Cap to be chosen by government
4	Contribution to the cost of new and upgraded transmission/distribution lines for distributed, renewable energy sources.	Political decision

The government could cap its costs by limiting the measures taken under Items 2 and 3 to those with a payback period of a specified number of years, or by funding them from an electricity levy or other new sources. There would also be cost-savings to both the State and Federal Governments from reduced medical, hospital and environmental management costs resulting from the reduction in air and water pollution and land degradation caused by coal-fired power stations.

6.2 Cost to electricity consumers

For electricity consumers there will be additional costs per unit of electricity from expanding MRET and implementing tradeable emission permits or a carbon levy.

On the other hand there would also be reduced costs resulting from removing the need for a new coal-fired power station and its associated reserve plant, the reduced number of units of electricity consumed after implementation of efficient energy use measures, and from the requirement to install solar hot water systems, which are cost effective over their lifetimes in NSW. Electricity consumers who do not purchase air conditioners (and/or who install energy efficiency measures such as insulation or window shades for summer) would also share in the savings in infrastructure (power stations, transmission lines and distribution lines) that would be avoided.

A much more detailed study would be required to investigate whether there is any net cost to electricity consumers of the State's cleaner energy mix. The long-term national scenario study, *A Clean Energy Future for Australia*, found that it is possible there may be no net costs in 2040

(Saddler, Diesendorf & Denniss, 2004, chap. 10). This result depends on the future costs of electricity from fossil fuels and renewable energy and the amount of demand reduction that can be achieved with short payback periods from efficient energy use. Depending on the outcomes, the cost savings from efficient energy use will partially or completely offset the additional costs of renewable energy.

In the early 1990s, when the State Electricity Commission of Victoria was running a demand management program, it found that it delivered net financial benefits to Victoria, even though it reduced net revenue for the SECV (Gilchrist, 1994). That result was obtained when programs were being trialled and energy efficiency technologies were nowhere near as effective as they are today.

The present study (Column 10 of Table 3) suggests that our energy supply and demand-side substitution would be much less expensive in 2010, if we implemented these measures now, rather than building and operating another coal-fired power station. However, the benefits of the recommended efficient energy use measures will increase with time, well-beyond 2010.

7. Employment gains from substituting new coal generation with renewable energy

One of the economic advantages of substituting coal-fired energy with renewable energy is that there is a net gain in jobs within the State per kilowatt-hour of electricity generated. This is particularly important at a time when the numbers of jobs in coal mining and the centralised electricity industry are falling rapidly.

To assess employment in the coal-fired electricity industry completely, it would be necessary to examine coal-mining, power generation, transmission, distribution and retailing. Unfortunately a complete database covering all these aspects together does not exist. However, there is data for the electricity industry as a whole (without coal mining) showing that employment in the industry decreased by 50% to 32,700 over the period 1991 to 1999 (Australian Bureau of Statistics, 2000). Other statistics from the ABS (2004), representing coal mining Australia-wide, shows a 45% decline in mining jobs from about 35,000 in the mid-1980s to about 19,000 in 2004.

The employment losses in the electricity industry are the result of industry restructuring that commenced in the early 1990s, while those in the coal industry are mainly the result of increasing automation.

MacGill, Watt and Passey (2002) compared direct employment involved in the manufacture, construction and operation of a coal-fired power station, a biomass cogeneration plant and a wind farm, each commissioned in Australia since 2000 (Table 6).

Table 6: Case studies of total Australian employment for different types of base-load power station

Power station (name)	**Description**	**Australian content (% of cost)**	**Total Australian employment** (job-yr/TWh)
Tarong North	Coal-fired, rated 450 MW, baseload	26	49
Albany wind farm	Wind farm, rated 21.6 MW	44[a]	120
Rocky Point	Cogeneration, rated 30 MW, fuel: bagasse + sawmill waste	50	220

Source: MacGill et al. (2002).
a. More recently commissioned wind farms have a higher Australian content and it seems likely that, if the industry continues to expand in Australia at the global average rate, it may be possible to manufacture most of the components in Australia, thus reaching an Australian content of about 80%.

A more detailed analysis of data on coal and wind power employment reached the following conclusions, among others (Diesendorf, 2004):

- The coal-fired electricity industry, including the contribution of coal mining, provides a total of about 63 job-years/TWh around Australia. However, taking into account the low Australian content of 26%, world jobs could be about 240 job-years/TWh;

- In wind power, there are about 117-184 job-years/TWh in Australia (with 44% Australian content) and about 265-418 job-years/TWh in the world. Most of these jobs are in manufacturing and installation, not in operation and maintenance;

- With 80% Australian content, employment in wind power in Australia could rise to 213-335 job-years/TWh;

- So, with current Australian content, there could already be 2-3 times the job-years/TWh in Australia from wind power compared with coal power. If the Australian content of wind farms can be increased to 80% as projected, 3.6-5.6 times more job-years would be created per TWh in Australia from wind compared with coal;

- It seems unlikely that the Australian content of coal-fired electricity could be increased, because the Australian market is too small for the large imported items, such as the huge dredges used in open-cut mining and turbo-generators rated at hundreds of megawatts.

It is sometimes argued that the higher job creation potential of renewable energy is merely a reflection of the low productivity of jobs in renewable energy. It is indeed possible that over a period of decades the total number of *global* job-years/TWh in renewable energy will decline until it converges to that of coal. However, our main point is that a much higher Australian (and indeed NSW) content can be achieved in the renewable energy technologies that are likely to make the main contributions to the clean energy mix -- namely solar hot water, bioenergy and wind power -- than in coal-fired electricity. In other words, the number of *local* job-years/TWh in renewable energy will always be much higher than in coal.

There are some fundamental principles underlying the higher employment intensity of sustainable energy. The dispersed nature of energy efficiency improvement and many renewable energy technologies means that they involve the services and light manufacturing sectors (which are employment intensive). The increased complexity and 'value added' increases the labour content of manufacture, installation, training, etc. For some renewable energy technologies such as biomass, the labour content of harvesting of resources is fundamentally more labour intensive than digging up coal.

Another common objection with an erroneous basis is that distributed, renewable energy technologies will always be more expensive and less efficient economically than coal, because of the smaller scale and resulting labour-intensive nature of renewable energy technologies. Therefore, it would be more efficient in economic terms for Australia to continue to export primary produce and purchase coal technologies (with capture and geosequestration of CO_2 if required for environmental reasons) from overseas. Investing in renewable energy is simply a "make work scheme".

This argument is fallacious because the low price of coal-fired electricity is not simply a measure of its economic efficiency, but mainly of the failure to include in its price the very real environmental and health costs of its use. Projections by the International Energy Agency of the minimum future costs of coal-fired electricity with capture and geosequestration of CO_2 put it at about 9 c/kWh, that is, higher than the *current* costs of electricity from wind power and biomass residues (Diesendorf, 2003; Saddler, Riedy & Passey, 2004). The European ExternE study found that just a few of the environmental and health costs of coal-fired electricity amounted over 70 Euro/MWh (about 12.3 c/kWh), which are additional to the economic costs (Rabl & Spadaro, 2000). Even allowing for the lower population density and hence lower exposure to pollutants in Australia compared with Europe, this yields an environmental and health cost of over 7 c/kWh. A cleaner energy scenario, if implemented in the form of packages of cost-effective efficient energy use offsetting the additional costs of renewable energy, could turn out to be much less expensive than continuing with coal (Saddler, Diesendorf & Denniss, 2004, Table 10.5).

There are additional points that can be made here:

- Sustainable energy often captures economies of scale via replication (ie mass production) rather than by building bigger. In fact, the potential cost reduction is very great, as seen from the mass production of cars, household appliances, and so on;
- Sustainable energy systems (especially energy efficiency but increasingly renewable energy) piggy back both on existing equipment and on technology development being driven for other reasons. So, improving the energy efficiency of a refrigerator for example, can be very cost-effectively deployed;
- Because distributed sustainable energy systems compete with the retail price of energy, even if they are more expensive than central power generation, they may still reduce total energy costs.

It must also be emphasised that the cost of energy to a customer is determined by both the cost per unit and the number of units of energy required. If less energy is required, higher cost per unit need not increase the total cost of delivery of the service.

8. Conclusion

To allow the construction of new conventional coal-fired power stations would severely undermine our ability to make the transition to a much cleaner energy future by 2040.

For NSW it is feasible to remove the need for a new 1,000 MW coal-fired power station by substituting with an energy mix comprising efficient energy use (including solar hot water), natural gas, bioenergy and wind, in that order of importance (see Table 3). New policies would be required. Our proposed alternative energy system is much cleaner in terms of greenhouse intensity than the coal option, reducing CO_2 emissions in 2010 by 4.7 Mt per year and creating many more local job-years, especially in rural areas.

Furthermore, once it is taken into account the fact that efficient energy use substitutes for the price of electricity delivered to the consumer, rather than the cost of generating electricity, it appears likely that our cleaner energy supply/demand mix may be much less expensive than an equivalent coal-fired power station. The challenge is to deliver to consumers packages of energy services, comprising efficient energy use measures together with renewable energy supply, so that the cost savings from energy efficiency offset the additional costs of renewable energy.

In mainland Australia, employment in coal mining and in the conventional electricity generating industry (almost all coal-fired) has been declining rapidly as a result of automation and industry restructuring. If the State Government policy options recommended in this report are implemented, and if a future Federal Government or present State Governments expand MRET and implement tradeable emission permits or a carbon levy, then both bioenergy and wind power can be expected to continue to grow and reach high levels of local content. Under these conditions there will be several times the number of local job-years per kWh of electricity compared with the jobs associated with coal mining and coal-fired electricity generation combined.

State Government policies would be needed to encourage some of the new energy efficiency and renewable energy industries to locate their manufacturing facilities in regions that are currently losing jobs in coal and conventional electricity generation. Thus a win for the environment could be achieved simultaneously with a win for employment.

More work is required on the development of efficient energy use strategies and specific measures for NSW, to update and extend the excellent work done by SRC Australia (1991) in Queensland and EMET (2004). The implications of expanding energy efficiency and renewable energy industries for employment in the State also need further investigation. However, this suggested research should not be used as an excuse for delaying implementation of the proposed policies and strategies for a clean energy future.

The foregoing conclusion can be summarised as follows: There is no technical or economic barrier to ceasing to build new coal-field power stations and commencing the transition to a much cleaner electricity system based on efficient energy use, renewable energy and gas. The real barriers are institutional, organisational and political.

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Appendix A: Environmental impacts of bioenergy and wind power

Bioenergy and wind power are significant contributors to the energy mixes in the national and State Clean Energy Future Studies. Because there are some popular misconceptions about the environmental impacts of these technologies, this appendix offers a brief discussion of these impacts. The appendix is not limited to the scenario presented in Sections 3 and 4 of this report, but also looks to a longer timescale when possibly quite large amounts of bioenergy and wind power may be required.

A.1 Bioenergy

There is a wide variety of methods of converting biomass to useful energy and a wide range of potential sources. The main physical and chemical processes are discussed by Sørensen (2000, Chap. 4) and Stucley et al (2004). In the short term, i.e. before 2010, it is likely that the principal use of biomass in Australia will be from the direct combustion of agricultural and forest residues. However, beyond 2010 it is expected that there will be a much greater use of more efficient conversion technologies in which biomass is gasified, or converted to biogas, or liquefied. Then it could be converted into electricity either by combustion or by electrochemical means (e.g. a fuel cell).

International R&D of biomass energy conversion and its environmental impacts is coordinated by IEA Bioenergy (www.ieabioenergy.com) – see especially the work of Tasks 30, 31, 32 and 38. Bioenergy Australia (www.bioenergyaustralia.org) has collected a wealth of information. CSIRO Sustainable Ecosystems is working on a sustainability framework for bioenergy projects.

The principal environmental impacts that must be considered in using biomass to generate electricity are greenhouse gas emissions (including those from energy inputs), air pollution, solid waste management, land use and soil nutrient loss. A brief summary follows.

Greenhouse gas emissions

Biomass is a renewable energy source, while coal is not. Under the Kyoto Protocol and from a scientific point of view, sustainably managed biomass is carbon neutral, in that the CO_2 liberated during combustion is recaptured through photosynthesis during the regrowth of an equivalent amount of biomass. On the other hand, coal releases fossilised carbon and is not replenished (at least not within millions of years).

In general some energy inputs to the use of bioenergy may come from fertiliser use and transportation of the biofuels produced. There is no doubt that, if a large fraction of Australia's petrol and diesel were replaced with biofuels, energy inputs (for transportation of the biofuel to service stations) would be a significant fraction of the energy content of the biofuel. However, putting this case aside, significant life cycle analyses on the use of biomass have been conducted by IEA Bioenergy and the US National Renewable Energy Laboratory (NREL), among others. Generally the results are that, for a typical bioenergy project, the energy inputs in the form of fossil fuels tend to be only a small percentage of the bioenergy produced.

For the current proposal for producing bioelectricity in NSW, there would be no additional fertiliser use and to meet 193 MW of capacity there would be no need to put in place biomass power stations with transportation of biomass from field to power station greater than distances of 50 km. Therefore, the corresponding energy inputs and associated CO_2 emissions would be negligible.

Air pollution

According to the National Pollutant Inventory (http://npi.gov.au), coal-fired electricity (including coal mining) is a very big emitter of nitrogen oxides, sulphur dioxide, fluoride, hydrochloric acid, boron, particulate matter, mercury and sulphuric acid. In comparison, if biomass is combusted under appropriate conditions of temperature and pressure, it emits much less[12] gaseous and particulate air pollution than coal, per unit of electricity generated. Very small quantities of dioxin are emitted from the combustion of some types of biomass, however this can be minimized by appropriate system design. The exception is dioxin emitted by the incineration of municipal solid waste, which contains plastics—this is a serious problem and in the opinion of this author all such incineration should be banned.

As mentioned above, biomass can also produce energy through more efficient conversion technologies in which biomass is gasified, or converted to biogas, or liquefied, and then converted into electricity either by combustion or by electrochemical means (e.g. a fuel cell). In these circumstances air pollution is virtually negligible and far lower than the alternative of coal-fired generation.

Solid waste management

Ash disposal from biomass combustion is generally not a problem, since for instance stem wood contains as little as 0.4% ash, compared to bituminous coal which can contain over 20% ash. In some instances fly ash from biomass combustion is certified as a soil amendment. Bottom ash is also sometimes used as road base, displacing quarried material. The amount of wood ash is very little —and biomass power plants do not require ash dams or major works required for coal-fired power. Biomass ash is generally free of toxic metals prevalent in coal ash. In addition if biomass energy is released through anaerobic digestion, the by-product is actually a valuable fertiliser.

Land use

As discussed in Section 4.2, NSW has huge biomass reserves from both crop residues from existing wheat and other grain crops, animal wastes and from the potential for short-cycle tree crops grown in the wheat belt for multiple environmental and economic benefits. None of these sources requires a significant area of additional land. Coal mining on the other hand uses and degrades large areas of land.

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[12] The main exception is the typical domestic wood-burning heater used in Australia. However, the latest technology of burning wood pellets reduces these domestic emissions substantially.

Soil nutrient loss

To supply the 193 MW of biomass power envisioned in this report, there would be no need to use sources that would lead to significant soil nutrient loss. Wet wastes, bagasse, and crop residues that are already removed from the land could easily supply this capacity, and if short-cycle tree crops were used on the wheat belt, it would be expected that they would share in the fertiliser received by the wheat.

Going beyond the State scenario discussed in Sections 3 and 4 of this report, tree crops and residues of grain crops are large potential sources of bioenergy. In such cases it is possible to backload biomass ash from power stations to the fields on the same trucks that collect the biomass from the fields. Nevertheless, this issue requires further research.

In summary, the environmental impacts of well designed bioelectricity systems are in general much less than those of coal-fired electricity.

A.2 Wind

Wind power is one of the most environmentally sound of all renewable energy sources. But, one of its fundamental characteristics is that the power in the wind is proportional to the cube of the wind speed. This means that a site with a 25% higher wind speed will produce double the wind power. As a result, wind turbines are often sited in prominent places such as on ridges, hill-tops and near the coast, where they can catch the best wind.

Some opponents of wind power deny the scientific evidence of human-induced climate change and bolster their subjective aesthetic judgements (to which they are entitled) by disseminating exaggerated and in some cases false notions about the alleged environmental impacts and technical performance of wind power. This appendix addresses the myths and misunderstandings that opponents regularly disseminate.

During operation modern wind turbines emit essentially no chemical pollution and their only physical emission, noise, is inaudible beyond several hundred metres, except under very rare topographical and weather conditions.

Of the thousands of existing wind farm sites around the world, there are very few (notably Altamont Pass in California and Tarifa, Spain) where bird kills have been a serious problem and only two (both in West Virginia, USA) where bat kills are a problem[13]. Australian studies on the impacts of windfarms on birds show that there is an even lower level of impact than was predicted on the basis of northern hemisphere experience and approved by planning authorities prior to the wind farm being built. This may be because Australia's geography and bird ecology are different from in the northern hemisphere, and so we do not experience the same concentrations of migrating birds found in Europe and the USA. With modern wind turbines and careful siting, both bird and bat kills are rare. In comparison, on a single foggy night, about 3,000

[13] Fortunately the bats concerned do not belong to an endangered species.

birds were killed when they collided with the chimneys of a thermal power station in Florida, USA (Maehr et a., 1983).

To assess the biodiversity impacts of coal versus wind power, the global impacts, as well as the local, must be taken into account. Global climate change resulting from the anthropogenic greenhouse effect is predicted to wipe out many species of animals and plants. Australian ecosystems are some of the most vulnerable to climate change. In Australia the biggest single source of greenhouse gas emissions is coal-fired power stations. By substituting for coal and other fossil-fuel power stations, wind power reduces carbon dioxide emissions and therefore saves global biodiversity.

To reduce local biodiversity impacts of windfarms, planning guidelines for the siting of wind developments have been put into place by Federal, State and Local Governments. Proposed wind developments have to receive Federal planning approval under the Environment Protection and Biodiversity Conservation Act and also under any local regulator. This addresses the protection of wetlands and other specific areas of environmental importance and sensitivity.

Wind farms are highly compatible with agricultural and pastoral land, spanning approximately 25 ha per MW of installed capacity, but actually occupying only about 1-3% of that land (0.25-0.75 ha/MW) with towers, access roads and other equipment. The Australian Wind Energy Association has developed *Best Practice Guidelines for the Implementation of Wind Energy Projects in Australia*. The industry is further refining these guidelines with regard to landscape and bird assessment protocols in partnership with environmental groups and Federal and State Governments.

The energy required to build a wind turbine is generated in 3-5 months of operation, so, with a 20-year lifetime, a wind turbine generates 48-80 times the energy required to construct and install it. Wind turbines are highly efficient in capturing renewable energy, since blades occupying only about 5% of the swept-out area can in practice extract about 40%[14] of the wind energy flowing through that area. As a result the material inputs to a wind farm are modest and indeed are similar in quantity to those used in the construction of an equivalent fossil-fuelled power station.

Some of the incorrect technical claims about wind power are that:

- Wind farms cannot replace a coal-fired power station without expensive, dedicated long-term storage;
- Because of wind power's variability, it has no value in meeting peak demand;
- To maintain a steady state of voltage and frequency from a wind farm requires much additional expense.

These claims are refuted by Saddler, Diesendorf and Denniss (2004, Section 7.2) Here the refutation of the first two dot points is summarised:

> 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 for a much longer period

[14] In theory the maximum possible extraction is 59%.

than the length of a typical wind calm. Therefore 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;
- Electricity demand.

They then use mathematical and/or computer models to calculate the reliability of electricity grids (measured by e.g. Loss of Load Probability) with different penetrations of wind power.

This was done by a multidisciplinary research team from CSIRO and ANU in the 1980s. Three different methods gave the consistent result 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 (Martin & Diesendorf, 1980; 1982; 1983; Haslett & Diesendorf, 1981; Haslett, 1981; Martin & Carlin, 1983; Gates, 1985). These results were confirmed by overseas researchers (e.g. Grubb, 1986).

For the special case of small penetrations of wind power into an electricity grid, the value in megawatts 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 reduction of CO_2-emissions.

One of the most peculiar arguments by some opponents of wind power is that the technology is contributing only a fraction of 1% of electricity in Australia and globally, and consequently it can never make a significant contribution. But, averaged over the past 15 years or so, wind power has been the fastest growing energy technology in the world, with an typical growth rate in capacity of about 25% per year. If it continues to grow steadily, wind power will be able to contribute 20% of Australia's electricity generation by 2040, as envisaged in *A Clean Energy Future for Australia*.

Interestingly, in Denmark, where wind power already contributes 20% of electricity, there is very little community opposition. Apart from a few electricity utility managers who object to the 'inconvenience' of being required by law to accept into the electricity grid wind power from many distributed sources, Danes support wind power as an environmentally sound, job-creating technology that has already substituted for coal-fired power stations in Denmark.

For further reading on the technical capabilities and environmental impacts of wind power see:
Australian Wind Energy Association (AusWEA), fact sheets (www.auswea.com.au);
American Wind Energy Association (www.awea.org/faq/index.html**,** go to *Wind Energy and the Environment*);
European Wind Energy Association's fact sheet, *Wind Energy and the Environment* (www.ewea.org); and
Saddler, Diesendorf and Denniss (2004, Section 7.2)

Units and Conversion Factors

Powers of 10

Prefix	Symbol	Value	Example
kilo	k	10^3	kilowatt kW
mega	M	10^6	megawatt MW
giga	G	10^9	gigajoule GJ
tera	T	10^{12}	terawatt-hour TWh
peta	P	10^{15}	petajoule PJ

SI units

Basic unit	Name	Symbol
length	metre	m
mass	kilogram	kg
time	second	s
temperature	Kelvin	K

Derived unit	Name	Symbol
energy	joule	J
power	watt	W
potential difference	volt	V
pressure	pascal	Pa
temperature	degree Celsius	˚C
time	hour	h

Conversion factors

Type	Name	Symbol	Value
energy	kilowatt-hour	kWh	3.6×10^6 J = 3.6 MJ
energy	terawatt-hour	TWh	3.6×10^{15} J = 3.6 PJ
energy	litre of petrol	L	3.2×10^7 J
energy	m^3 of natural gas at STP		3.4×10^7 J
energy	tonne of NSW black coal	t	23 GJ
energy	tonne of Vic brown coal	t	10 GJ
energy	tonne of green wood	t	10 GJ
energy	tonne of oven-dried wood	t	20 GJ
power	kWh per year	kWh/y	0.114 W
time	year	y	8760 hours
pressure	atmosphere		101.325 kPa