Stormy Weather: Grid-connected Solar and Wind Energy in Victoria*

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ABSTRACT *This article deals with the treatment of grid-connected solar and wind energy in the Australian state of Victoria during the period from the mid-1970s to 1994. Traditionally, electricity authorities and governments tend to dismiss these options claiming that they are too expensive and only produce intermittent power. Proponents of solar and wind energy dispute this, arguing that such assessments ignore the significant environmental benefits of renewable energy. In this article it is argued that an explanation for the treatment of renewable energy needs to start from an analysis of the structure and development of the electricity supply industry, and the political processes which have shaped the industry. This history shows that the neglect of solar and wind energy in Victoria was influenced more by electricity planning considerations and the political agenda of the Victorian ALP government than by economic and technical criteria.*

Keywords: electricity industry, energy policy, renewable energy.

Introduction

Over the past two decades there has been much debate about the unsustainable nature of current patterns of energy supply. Concerns about urban air pollution, oil shortages, acid rain and more recently global warming have increasingly cast doubt on the wisdom of continuing our high dependence on fossil fuels, and popular interest in alternative energy sources is burgeoning.

The energy alternatives undoubtedly attracting the most interest are those classified as renewable: solar, wind, wave, tidal, biofuel and hydro energy. The benefits of developing these renewable energy resources to displace fossil fuels—benefits which include the conservation of finite resources, environmental quality and climatic stability—are significant, yet they will mostly accrue to future generations. But despite these long-term benefits, and widespread popular support for renewable energy, there is little evidence of any serious move in this direction; in countries like Australia, fossil fuels still dominate energy supplies, and apart from hydro, renewable energy remains the 'Cinderella option'.[1]

The case study described in this article deals with the treatment of solar and wind energy[2] in the electricity sector within the Australian state of Victoria during the period from the mid-1970s to 1994.[3] As the vast majority of electricity used in Victoria is

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supplied from the main electricity grid, I have chosen to limit this study to *grid-connected* solar and wind energy.[4] In confining the study thus, by excluding hydro energy and stand-alone power supplies, I have chosen an area in which renewable energy plays an almost nonexistent role. This absence needs to be explained.

Why do some technologies succeed while others wither or are only sporadically adopted? Conventional explanations often take for granted that a technology which is successful must surely be superior; thus it is assumed that renewable energy technologies must be currently inferior, and cannot be adopted until further developments ensure that they 'make the grade'. This article argues that these explanations are simplistic. Moreover, such explanations can also be deceptive as they mask the roles played by the various groups who, to varying degrees, seek to control how a technological system develops. The developments of all technological systems, and certainly those as politically important as energy systems, are shaped by a wide range of factors. We should not underrate or overlook the role of social, political and institutional influences if we wish to develop comprehensive explanations for the form of existing technological systems or to influence future developments.

Developing an explanation for *absent* technologies, however, may present us with one problem: there needs to be some justification for considering these technologies in the first place. Fortunately, in the case described in this article the problem does not arise; not only do solar and wind energy enjoy popular support, they are both well suited to power generation. Wind generators represent an established and reliable technology, the energy conversion process is simple and direct, and large wind farms have been built in a number of countries. Wind power is considered by many to be currently economically viable, although favourable economics require a high-quality wind resource—as is found along much of Australia's southern coast.

Solar energy can be used to generate electricity using two different methods: photovoltaics; or solar thermal electricity conversion. Photovoltaic (PV) cells convert light directly into DC electricity, and are currently used for many stand-alone applications such as powering remote telecommunication stations. PV cells are expensive to produce, although production costs have dropped dramatically and continue to do so. Solar thermal electricity plants operate in a similar manner to conventional steam power plants, except that solar energy replaces fossil fuels as the heat source. This technology is at an earlier stage of development than are PVs and wind energy, and is expected to be economically viable in the near future.

The most common explanation given for the exclusion of these technologies in Australia's electricity sector is that they are currently too expensive, and impractical due to their intermittent nature. But neither of these assertions is a straightforward matter. The economics of different energy sources depend greatly on the assumptions embodied within the economic calculations. What value should be put on the environmental, social and health costs associated with power generation? (Typically a zero value is assigned.) What discount rate should be used? How do we account for uncertainty in demand forecasts? Likewise, concerns about the intermittent nature of renewable energy seem to overlook that these technologies will most likely be integrated into a larger system comprising other energy sources, demand side measures, energy storage facilities and cogeneration.[5]

Although it can be useful to point out these 'distortions', as do many supporters of renewable energy, there is a danger that by focusing on only these we do not expose the underlying premises of these standard explanations: that there exist objective economic and technical criteria for deciding between energy supply options; and that choices about energy systems are made primarily on the basis of these criteria. Both of these premises

are highly disputable. First, the choice of economic framework is itself political, and this framework is used selectively to benefit certain ends. Secondly, decisions about energy supply are often made more on the basis of political expediency.

Rather than explaining our current energy supply systems on the basis of their economic and technical characteristics, this article takes as its starting point the structure of the energy industry and broad political processes, and shows how these shape decisions about energy supply technologies. This account reveals the range of factors which influence the development of energy industries, in this case the electricity supply industry, factors which often serve to exclude renewable energy. These include the role of the state in developing energy resources; the tendency of governments to use energy industries for political purposes; the technocratic and supply-oriented ideology within the electricity industry; the scepticism, ignorance and entrenched institutional interests of the various decision makers; the tension between conservation and development within Labor governments; the role of renewable energy lobby groups and organisations; and broader developments in the environmental movement.

Although this is mainly a story about the scant attention paid to renewable energy, there were some positive developments, particularly in the area of wind energy. There was an extensive study of Victoria's wind resources, a demonstration wind generator was built and monitored, and a large wind farm was planned—even passing the tendering stage—and then shelved. Although these events could be portrayed as part of a natural progression, as part of a grand plan for wind energy in the state, what this history shows is that there was minimal, if any, planning for grid-connected renewable energy: each of the developments was an isolated event instigated by its own specific set of circumstances.

From Oil Crisis to Greenhouse—the Changing Fortunes of Solar and Wind Energy in the Victorian Electricity Sector

Australia's electricity supply industry is essentially state-based,[6] and the traditional fuel choice in each state can be partly explained by the fossil fuel and hydro energy resources located within the state's borders, and the desire of earlier state governments to develop these resources. Victoria lacks black coal, but within its Latrobe Valley there are vast quantities of brown coal—a low-grade fuel with a high moisture content. The State Electricity Commission of Victoria (SECV) was established in 1921 to develop this resource for electricity generation thereby ending Victoria's dependence on interstate black coal supplies. Today brown coal is the major fuel used for power generation in Victoria, supplemented by hydro energy and natural gas. There are no grid-connected solar or wind power generation systems of any significant size in Victoria; the few small systems that exist are each rated at less than 100 kW. In the rest of Australia the story is only marginally better: a small isolated wind farm operates in Western Australia, and several wind farms are being planned in other states.

Victoria's self-sufficiency in conventional energy resources partly explains the grim fortunes of renewable energy. But Victoria has not been immune from significant national and international issues affecting energy supply; thus the treatment of renewable energy within Victoria needs to be analysed within this broader context.

In the 1970s the 'energy crisis', brought on by the OPEC oil embargo, ushered in a period of intense and widespread concern about energy supplies. The prospect of fossil fuel resources being rapidly depleted led to a surge of interest in renewable energy, particularly in Denmark and the USA. However, in Australia there was little interest, presumably because fossil fuels were cheap and abundant. By the early 1980s the crisis environment had eased, and within Australia the federal government was promoting a

'resources boom': attracting energy intensive industries and furthering export opportunities for coal, gas and uranium. In Victoria the 1982 election of a Labor (ALP) government brought changes to energy policy including the promise of community involvement in energy planning and professed support for renewable energy, neither of which lasted long.

In 1988, the prospect of future global warming became a significant political issue locally and internationally, calls for a reduction in fossil fuel use took on a tone of urgency, and renewable energy once again entered the limelight. In some European countries, mechanisms to support the development of renewable energy were introduced, but in Australia the federal government saw little role for such intervention. The Victorian government, however, did respond, proposing that a 10 MW wind farm be developed. In 1992 a conservative government came to power in Victoria bringing sweeping changes to the electricity supply industry and the subsequent cancellation of the wind farm project.

This analysis of the treatment of grid-connected renewable energy in Victoria is thus divided into three sections using the years 1982 and 1988 as convenient dividers.

The Mid-1970s to 1982—Aftermath of the Energy Crisis

In 1973–74 OPEC imposed a fourfold increase in the price of their crude oil, and countries dependent on oil imports entered a painful era of uncertainty about energy supplies. In Australia the effect was less pronounced. Indigenous oil supplies were readily available, so the development of appropriate energy policies was not considered urgent. This energy crisis had little effect on Australia's electricity sector; on the contrary, with its abundant black and brown coal resources Australia was considered by the federal government to be in a favourable position to attract energy-intensive industries such as aluminium smelting,[7] a plan which was expected to require a large increase in electricity-generating capacity.

At this juncture, some other countries deliberately embarked on a strategy to encourage the development of renewable energy. In Denmark a wind power industry was fostered through capital grant and tax refund mechanisms, and in the USA tax credits were introduced for investors in renewable energy and legislation was passed requiring electricity utilities to buy renewably generated power at favourable prices. Australia chose *not* to go down this road. The study of Australia's renewable energy resources undertaken by the National Energy Advisory Committee (NEAC) did recommend the removal of subsidies applied to some fossil fuels, but rejected the need for 'more forceful measures of encouragement' being pursued elsewhere:

> The most effective encouragement for renewable energy would be to support research, development and demonstration projects rather than by special tax incentives designed to assist market penetration by renewables.[8]

Renewable energy also figured poorly in research funding. In 1978 the federal government established the National Energy Research, Development and Demonstration Council (NERDDC) to advise on the allocation of funds for energy projects. NERDDC was significantly oriented towards fossil fuel supply technologies, particularly those of coal. Over NERDDC's 12-year life, coal utilisation and mine site technologies received over 50% of NERDDC funds, while only 0.4% of funds went to wind energy. Photovoltaics fared slightly better with 1.8% of the funding, but this reflects their use in stand-alone applications rather than grid connection.[9]

In Victoria the state government was taking an increasing interest in the energy

sector, forming in 1977 a new government department with responsibility for energy policy: the Department of Minerals and Energy (DME). However, the department's Energy Division was not established until 1979, and for the next few years this division consisted of only a few staff.[10] Since one of the division's main tasks was the promotion of oil conservation,[11] its control over the Victorian energy sector was probably minimal. This government also took action to promote renewable energy—for *heating* applications—establishing in 1977 the Victorian Solar Energy Research Committee, later a statutory authority, the Victorian Solar Energy Council.[12] But, like its federal counterpart, this government had little interest in the development of solar and wind energy for power generation. It expected brown coal to remain the chief energy source,[13] a stance which simply reflected the attitude of the Victorian electricity utility—the SECV.

Indeed, the neglect of grid-connected renewable energy in Victoria cannot be comprehended without an understanding of the nature of the SECV. This largest player in the Victorian energy sector was a statutory authority with direct administrative control over the generation, transmission and most of the distribution of electricity. It also actively promoted the use of electricity, and built power stations to meet the expected growth in demand. The SECV was overridingly supply-oriented: demand, although clearly influenced by the SECV's promotion of electricity, was seen primarily as an independent variable. Despite being ultimately responsible to the Victorian Minister for Minerals and Energy, the SECV apparently dominated electricity planning,[14] as the DME had very few staff available to examine the SECV's activities and did not have the SECV's vast array of information and technical expertise.[15]

During this period, the SECV had no intention of developing solar or wind power generation;[16] but it was pursuing a vigorous construction programme of brown coal power plant. In the late 1970s construction of the 2000 MW Loy Yang A project began, and in 1980 the SECV released a discussion paper in which it proposed to build another 21 similar sized brown coal power stations over the following 50 years.[17] This would have represented a sevenfold increase on its 1980 electricity supply capacity. Most of this capacity was intended to supply the anticipated influx of energy-intensive industries, particularly aluminium smelting.[18] Such expansion plans raised concerns in the Latrobe Valley over the issue of land use;[19] the people of Yallourn had already lost their township to brown coal mining during the 1970s, and now whole areas feared the loss or degradation of their land.[20]

The SECV's single-minded attitude towards electricity planning and its disregard for community and environmental concerns—factors hardly conducive to the development of renewable energy—are illustrated by one particular episode, an episode which also contributed to the transformation of the SECV in the next decade. This was the Newport Power Station dispute. This issue arose in the early 1970s when the SECV announced its intention to build a 1000 MW peak-load[21] gas-fired power station in an inner suburb of Melbourne—the Victorian capital. Environmentalists became concerned about air pollution and subsequently union bans were invoked. The dispute lasted until 1977 when the Newport Review Panel released its findings. The panel did recommend that the power station be built—with a reduced capacity—but was also critical of the SECV for its unwillingness to concede that any of its decisions might be open to challenge, warning that such an 'inflexible attitude does not bode well for the future'.[22]

Two of the outcomes of this dispute were to influence the post-1982 period: the environmental movement developed an interest in energy issues, and members of the Australian Labor Party (ALP) who had been involved in the dispute became critical of the SECV's decision-making processes.[23] But the Newport dispute also brought to light several aspects about the SECV's approach to planning, factors which would later lead

to a glut of generating capacity and hence reduced opportunities for renewable energy in the following decade. First, not only did the SECV fail to consider demand management strategies, particular peak load reduction. According to opponents of the Newport Power Station, the SECV were employing marketing strategies which served to *increase* the peak demand by aggressively competing with the Gas and Fuel Corporation of Victoria (GFCV) for the cooking and space-heating market.[24] Secondly, the SECV was still forecasting a high growth rate. The growth in electricity demand had been very high until the early 1960s, such growth rates masking any forecasting errors. By the early 1970s the growth rate had dropped significantly.[25] The opponents to Newport expected that it would continue to decline—and they were correct. The SECV, however, expected a clear reversal of this trend.[26] Such an optimistic outlook suggests that the SECV was not willing to concede that the days of high growth were over and was not prepared to risk being caught with insufficient generating capacity. Meeting demand at all times was sacrosanct.

Today we might criticise the SECV for placing such a high value on increasing electricity supply with little consideration of community and environmental costs, but this attitude needs to be placed in context. Before the 1970s there had been an enormous push to complete the electrification of Victoria; and at the same time the SECV had striven to build up a reserve of generating plant after being left with none following the Second World War.[27] After such a long period of almost exclusive concern about supply, it is not surprising that the SECV found it difficult to adjust to the changes of the 1970s.

The SECV's attitude may also be partly attributable to the legislative framework governing its operation. Before 1982 this framework was determined by The State Electricity Commission Act 1958 (Vic.), which required the SECV:

> [to provide a] safe economical and effective supply of electricity throughout Victoria, ... [to inquire into] the prospects of establishing in Victorian new industries requiring large quantities of cheap electrical energy ... [and] to encourage and promote the use of electricity and especially the use thereof for industrial and manufacturing purposes.[28]

Such wording, according to Hugh Saddler, was effectively an instruction to adopt a cost-minimising approach to the management of the industry, thereby giving little weight to environmental and social considerations.[29] Other analysts of the electricity industry confirmed that such an 'engineering' attitude prevailed: Phillip Gleeson described the SECV as placing 'technocratic rationality' above other values, resulting in energy matters being depoliticised;[30] Aynsley Kellow claimed that such technical rationality was typical of the electricity supply industry in general.[31]

But changes were in store for the Victorian energy sector, particularly the SECV. The long reign of the Victorian conservative government was drawing to a close. The 1982 state election was won by the ALP, who had campaigned partly on the issue of public sector administration, calling for greater accountability of public bodies including the SECV.

1982 to 1987—Conservation Versus Development

The ALP's 1982 Minerals and Energy election platform had two main themes: improved management of the energy sector, and increased energy conservation and development of renewable energy.[32] The main vehicle for these changes would be The Victorian Energy Plan.[33] This represented an attempt to involve the community in the formulation of energy policy: funding was provided to community groups working in the energy field,

a regular newsletter was published, and a large number of publications on energy planning were released for public comment.

However, this 'green' energy policy would be short-lived: with the release of *Victoria: The Next Step* in 1984,[34] energy policy became aligned to the goals of the government's economic strategy. This strategy was geared towards maximising economic and employment growth in Victoria. It focused on Victoria's areas of competitive strength, including its abundant brown coal deposits and reserves of natural gas and oil, resources which would be used to attract energy-intensive industries.

This overshadowing of environmental issues by economic imperatives was evident in the government's statements about renewable energy, which emphasised technologies considered to be commercially viable, principally solar heating. In its election platform the ALP stated: 'renewable energy resources must be harnessed for the long-term prosperity of Victoria.... Greater use of solar power for low-grade heating ... will be actively encouraged'.[35] Two years later this sentiment was even stronger, with the Minister for Minerals and Energy stating that there was potential for establishing a Victorian manufacturing industry in solar heating appliances, but other renewable sources such as wind were merely 'interesting'.[36]

The Minister's remark summed up what had become a key focus of the new government's renewable energy policy: the development of a Victorian-based manufacturing industry of solar products. The Solar Council was directed to reorient itself to focus on the commercialisation and promotion of solar equipment.[37] The government's Renewable Energy Strategy, released in 1985, presented a plan to stimulate the growth of new Victorian industries based on renewable energy, but the targeted areas did not include grid-connected solar or wind energy.[38]

The release of this Renewable Energy Strategy might seem to indicate that this government was serious about developing renewable energy. However, the government's overall energy policy outlined in the document *Victoria's Energy: Strategy and Policy Options* had a different emphasis, namely the importance of Victoria's fossil fuel resources and electricity-generating capacity for stimulating economic growth in Victoria.[39] This document included only a small section on renewable energy and in the rest of the document it was virtually ignored. The government thus seemed more concerned with declaring its environmental credentials, than with developing renewable energy strategies with substance.

In keeping with another election theme—improved management of the energy sector—the government brought the SECV under closer scrutiny, addressing many of the problems that had arisen during the Newport dispute. The new State Electricity Commission (Amendment) Act 1982 required the SECV to achieve:

> Efficient use of the State's natural resources in the production of electricity (including its production by co-generation) and the substitution of more plentiful or renewable resources for less plentiful resources; ... giving of due consideration to environmental factors; ... the implementation of energy conservation goals; ... [and] operation in accordance with economic and social objectives established from time to time by the Government.[40]

But this strong environmental focus belied what was happening in the electricity sector. The 1980 proposal for 21 new power stations had been jettisoned, and indeed by the mid-1980s it was clear that earlier electricity forecasts had greatly overestimated the growth in demand,[41] yet the SECV was still planning a large increase in its brown coal-fired generation capacity. This led to a significant oversupply in the later part of the

decade, making it more difficult to countenance a further increase of supply from renewable energy sources.

How was the SECV able to justify this expansion? At the beginning of the decade, there probably was a shortage of generating capacity, after industrial disputes had left the SECV's construction programme behind schedule. By the winter of 1981, the SECV was forced to impose minor power restrictions on several days. Although such restrictions had been common throughout the 1970s due to frequent industrial unrest in the industry, these were the first restrictions in more than 20 years that were caused by insufficient generating capacity.[42] For an industry which believed that demand must be met at all times, this was intolerable. However, such restrictions would not be repeated; an additional 2750 MW of generation capacity was under construction, including the Loy Yang A power station.

Despite this large increase in plant, and evidence that growth in electricity demand was diminishing, in 1984 the SECV proposed that it should proceed with the first stage of Loy Yang B.[43] In developing its 1984–99 forecast, the SECV had to juggle the government's conflicting goals of growth and conservation. The government's economic strategy stressed the importance of an assured electricity supply in attracting energy-intensive industries to Victoria,[44] but the SECV was also expected to encourage cogeneration, conservation and renewable energy, measures which would reduce the need for further supply from brown coal. Finding a balance between growth and conservation was not an easy task, and based on their previous actions, one might expect the SECV to err on the side of growth. Thus it appears that the SECV uncritically accepted those factors which would lead to growth, while possibly underestimating the potential of factors which would decrease the requirement for new brown coal plant. The potential of cogeneration had been estimated by a consultant,[45] yet the SECV was not prepared to accept these estimates.[46] Assessment of increased conservation activities were limited to those deemed 'cost effective',[47] yet it is unlikely that the avoided capital cost of new supply was included in their definition of cost effectiveness.[48] Likewise, any major contribution from renewable energy was quickly dismissed for economic reasons.[49]

But the resolution of this contradiction between conservation activities and expansion of supply went beyond the SECV's preoccupation with supply issues. It also reflected the priorities of the Victorian ALP government, since by this time SECV decision-making was intertwined with that of government. The ALP could be portrayed as a party divided between those advocating development and those advocating conservation of resources. It was also a party with strong ties to the union movement, and thus amenable towards job creation projects in the Latrobe Valley, such as the building of new power stations. By the mid-1980s energy conservation and renewable energy were considered unimportant, and the ALP became more focused on industry development. The DME had merged with the Industry Department to form the Department of Industry, Technology and Resources (DITR), reflecting a reduced priority for energy conservation and renewable energy.

In such a climate, it is difficult to imagine how any grid-connected solar or wind system could develop. Yet wind power did made some headway, and indeed some of the work from this period formed a foundation for developments during the 1990s. In late 1982 the Solar Council approached the SECV about conducting an investigation of wind resources in Victoria.[50] This resulted in a joint wind monitoring study whereby 10 sites along the coast of Victoria were monitored from 1985 to 1987 to assess the potential for electricity generation from wind power. Although one of the monitored sites was later selected as the preferred location for the development of a wind farm, there was no clear intention of this at the time. The original study proposal from the SECV Planning

Investigations Department did make recommendations about further developments—including a medium-sized experimental wind generator in 1987/88 and a large capacity wind generator in 1990—but severe (and perhaps unrealisable) criteria were applied, with developments conditional on a complete review of all environmental and economics factors.[51]

In the end, a medium-sized grid-connected wind generator was installed, but it was neither an outcome of the wind monitoring study, nor an initiative of the SECV. In 1985, the Wodonga-based company Wind Technology Pty Ltd received a NERDDC grant to built a 75 kW grid-connected wind generator.[52] The wind generator would be installed near Breamlea, south of Geelong, a site not included in the wind monitoring study, but with a reasonable wind regime. The SECV, DITR and the Solar Council all cited this project as evidence of progress being made in wind power,[53] so when the company Wind Technology withdrew from the project in late 1986, it could have been quite an embarrassment. Subsequently, the Solar Council and the SECV agreed to proceed with a jointly funded 60 kW unit at the Breamlea site.[54] The wind generator commenced operation in 1987.

During 1987, the SECV also opened up opportunities for private developers to invest in renewable energy technologies and sell power back to the grid. Through the 'cogeneration and renewable energy incentives package', launched by the SECV and DITR in 1987, investors in cogeneration or renewable energy projects could sell power to the grid at attractive rates.[55] A total of 150 MW of projects would be accepted, with a maximum capacity of 10 MW from any project.[56] The majority of the registrations of interest received for renewable energy projects were for small and mini hydro-power, and landfill gas/biogas. Although several registrations were received for wind power projects, none were considered economically viable within the incentives package.[57]

Meanwhile, the federal government was conducting a major review of its energy policies entitled Energy 2000.[58] The review lasted two years, with the final policy paper released only a matter of months before the arrival of the greenhouse effect as an energy policy issue. In the paper's statements on renewable energy, it was remarkable to see how little had changed since the NEAC report of 1981.[59] Although it acknowledged that the increased utilisation of renewable energy technologies might have some benefits—reduced environmental impact, increased security of energy supply, and development of industries supplying renewable energy technologies—the report rejected government intervention to accelerate the development of renewable energy:

> The most effective means by which renewable energy technologies can achieve sustained growth is as a result of normal market forces rather than government intervention. Subsidies or price support for renewables would place a financial burden on the public and would not necessarily result in the optimum allocation of resources.[60]

1988 to 1994—The Greenhouse Effect and Energy Policy

In 1988 the 'greenhouse effect', or global warming, became a political issue, and the 'climate' for renewable energy changed significantly. The issue was hardly new: for many years scientists had been warning of future climate change resulting from increases in atmospheric concentrations of certain greenhouse gases (mainly carbon dioxide and to a lesser extent methane, chlorofluorocarbons and nitrous oxide). While there was certainly no scientific consensus about the existence of this phenomenon, evidence seemed to mount during the late 1980s: increasingly sophisticated computer models of world

climate were predicting unprecedented global warming; and during this decade the world experienced the five hottest years on record. In 1988 there was extensive media coverage of the issue, leading to heightened public concern and calls for urgent policy responses.

This interest in the greenhouse effect focused attention on energy supply, the combustion of fossil fuels being the principal source of carbon dioxide. In June 1988 an international conference on global warming, held in Toronto, called for a reduction in carbon dioxide emissions, proposing a target of 20% reduction of 1988 emissions by the year 2005 (often referred to as the 'Toronto target').[61] Subsequently, the Intergovernmental Panel on Climate Change (IPCC) was set up to conduct an international assessment programme. The IPCC's Working Group on Scientific Assessment affirmed that increased greenhouse gas emissions would lead to global warming.[62] Despite this, and the acknowledgment that the feasibility of targets fell within its mandate, the IPCC Working Group on Response Strategies refused to set a specific target for reduction of carbon dioxide emissions, instead recommending that all nations 'take steps now to attempt to limit, stabilize, or reduce the emission of energy-related greenhouse gases'.[63]

Like many other countries, Australia delayed making a decision on setting greenhouse gas emission targets until the IPCC reports were released in 1990. In choosing its response, the federal government was caught in a contradictory position. The state of the environment had been a major issue in the 1990 federal election, won by the ALP who had eagerly courted the green vote. On the other hand, throughout the 1980s the federal government had sought to attract energy-intensive industries. Australia was also greatly dependent on coal for power generation and export earnings. After much deliberation, the federal government chose to adopt as an interim planning target:

> ... to stabilise greenhouse gas emissions ... based on 1988 levels, by the year 2000 and to reduce these emissions by 20 per cent by the year 2005 ... subject to Australia not implementing response measures that would have net adverse economic impacts nationally or on Australia's trade competitiveness, in the absence of similar action by major greenhouse [gas] producing countries.[64]

After announcing this target, the federal government set about commissioning studies to assess the wisdom of this move. Two of these merely endorsed the federal government's 'do nothing' response. A study by the Industry Commission—a body known for its commitment to deregulation and nonintervention by governments—noted that the emergence of an international consensus on greenhouse gas reductions was unlikely and declared that there would be substantial costs if Australia either took unilateral action or joined a few other countries in a plurilateral agreement to reduce emissions.[65] The study by the Ecologically Sustainable Development (ESD) Working Groups,[66] recommended that government action be mainly limited to measures considered *no regrets*—measures that would be economic and beneficial even if there were no global warming.[67]

Neither study dealt in any great length with the positive aspects of emission targets such as increased opportunities for Australian renewable energy technology industries. But one federal department did take this issue seriously: the Department of the Arts, Sport, the Environment, Tourism and Territories (DASETT). It engaged consultants to investigate industry opportunities in wind energy, photovoltaic solar energy and solar thermal energy.[68] The consultants identified various nontechnical barriers that were preventing more widespread use of renewable energy, barriers such as the widely different discount rates used by the electricity utilities compared with private generators, and the failure to include social and environmental externalities in energy prices. They

recommended that governments should not only remove these barriers, but should guarantee a market for renewable energy technologies.

However, such intervention was not on the agenda of a federal government so wedded to economic rationalism. The government declared that such matters should generally be left to the free market; governments should only intervene if the free market was unable to deliver ecologically sustainable development, and intervention should be limited to the imposition of constraints in particular circumstances. Subsidies and government financial assistance to renewable energy technology industries were considered to be of questionable value.[69]

This attitude of the Australian federal government was not shared by many other developed Western countries. From 1989 onwards, a large number of European countries introduced various support mechanisms for renewable energy.[70] For example, the UK introduced the Non-Fossil Fuel Obligation, whereby some of the funds raised by a fossil fuel levy were directed to renewable energy projects—although most of the levy was used to subsidise nuclear power.

Of all governments in Australia, state and federal, the Victorian government seemed to be the most serious about reducing greenhouse gas emissions[71]—although its enthusiasm for attracting energy-intensive industries had not abated.[72] Over a year before the federal government had announced its emissions target, the Victorian government released a draft greenhouse strategy in which it—rather hesitantly—proposed to aim for the Toronto target 'as an interim target for planning purposes, subject to review in 1991'.[73] It acknowledged the important role of renewable energy, and proposed the development of a 10 MW grid-connected wind farm.[74] If built, this wind farm would have been the largest of its type in Australia.

In 1990 the Victorian government updated its Renewable Energy Strategy, releasing a Green Paper on *Renewable Energy and Energy Conservation*.[75] Despite being launched with much fanfare, the Green Paper was somewhat disappointing, being mainly a discussion of work in progress and containing few new ideas. However, targets were set for renewable energy power generation: 10 MW of wind power by 1995, and 80 MW by 2000.[76] The 10 MW wind farm, proposed the previous year, would therefore be built and was expected to be operational in 1992.[77]

Clearly the SECV would need to be involved in such a project, but at first the SECV seemed somewhat noncommittal.[78] The government's enthusiasm for this project was probably due to its electoral appeal, badly needed by a government which by now was under fire over its record on economic management, and it is understandable that the SECV would not want to be involved in any political exercise. Indeed, there seemed to be no clear consensus about who would subsidise this project. The wind farm would be privately owned with electrical power sold to the SECV, but at a higher price than the SECV had estimated for power generated from brown coal. Therefore a subsidy was required, and the SECV was unwilling to provide it, stating that: 'The project is dependent on Government support'.[79]

By mid-1991 this apparent reluctance of the SECV had been overcome; a project manager was appointed and work on the wind farm project started in earnest. The wind farm was now described as a demonstration project: a means of giving the SECV operating experience with a commercial-scale wind farm, and of adequately preparing the SECV should it need to increase the amount of wind generation as part of a future greenhouse strategy.[80] In its 1989 document on the greenhouse effect, the SECV had described scenarios for meeting the Toronto target requiring between 450 MW and 650 MW of installed wind generating capacity.[81] A wind farm of size 10 MW was considered sufficiently large to provide economy of scale and spread of maintenance costs.[82]

Suitable sites for the wind farm were selected from the locations monitored during the wind monitoring study. Two sites were singled out for further investigation: Kilcunda North and Toora. Both sites had average wind speeds of about 8 m/s,[83] speeds which were comparable with those at Californian wind farms,[84] and both were agricultural areas mainly used for grazing, and so could accommodate a wind farm with little disruption to agricultural production.[85] It was intended that the landowners would still have full access to their land and would be paid for a percentage of the power generated from their site.[86]

The SECV carried out extensive consultation with the local councils, landowners and residents at both locations. At Kilcunda North they struck hostility. A group of residents opposing the wind farm development argued that it would ruin the area's natural beauty.[87] Landowners occupying some of the best sites for a wind farm were among those who opposed the development, and so refused to grant the necessary leases.[88] In contrast, the Toora community were mainly in favour of the project, regarding it as both a development opportunity and a possible tourist attraction.[89] Toora was therefore selected as the preferred location.

The wind farm was to be a Build–Own–Operate plant, with the SECV guaranteeing to buy the electrical power at an agreed price. The tendering process was protracted; the initial call for registration of interest was in October 1991, and after several bidding stages the preferred bidder was announced in June 1993.[90] The selected company was ADI Engineering (formerly Australian Defence Industries) with turbines to be supplied by the Danish company Vestas.

However, the contract was not to be signed. In 1994, the wind farm became a casualty of the fundamental changes that would befall the SECV as part of the restructuring of the Australian electricity industry.

The prospect of changes to the electricity supply industry throughout Australia had been raised in 1990, when the federal government requested the Industry Commission to inquire into the scope for improving efficiency in the Australian electricity and gas industries. The Industry Commission recommended sweeping changes to the structure of the Australian electricity supply industry (ESI). The ESI comprised utilities which were state-based, state-owned, and in most cases vertically integrated, that is, the utility was responsible for generation, transmission and distribution. There was a major transmission link between New South Wales and Victoria, and a minor (500 MW) link between South Australia and Victoria, but otherwise the states operated independently. The Industry Commission's main recommendations included the formation of a national grid controlled by a separate body, the breakup of generation, transmission and distribution activities within utilities, and the corporatisation and subsequent privatisation of generation and distribution assets.[91]

The federal government endorsed most of these recommendations, apart from perhaps the privatisation of utilities.[92] However, such changes to the electricity industry would require the cooperation of the states and territories. In Victoria, the SECV supported its corporatisation, but still wished to retain a vertically integrated structure.[93] After referral to a parliamentary committee,[94] it seemed likely that the SECV would continue to exist, but as a corporation—that is, until late 1992 when a Victorian state election swept the ALP from office. A new conservative government came to power with a firm agenda to 'reform' the public sector, and to completely restructure the electricity supply industry. By 1994 this restructuring was well underway.[95] The SECV was first divided into three independent businesses corresponding to its generation, transmission and distribution activities, and then distribution was divided between five companies which were to be privatised. Individual generation units were also to be sold to the private sector.

To survive in such a environment, the Toora wind farm needed the firm support of the new state government. Initially such support was forthcoming. In June 1993, the government had given approval for the SECV to enter into a power purchase contract with the successful bidder ADI, but by May 1994, the government had changed its mind, refusing to provide a subsidy calculated to be $1.3 million per year.[96] And so the Toora wind farm was never built.

However, one wind generator did survive—the one at Breamlea.[97] When the SECV was broken up, some of its assets, including the Breamlea wind generator, were sold. The generator was bought by a nonprofit community group with a long-term interest in renewable energy—the Alternative Technology Association. They bought the wind generator for a mere $18,000, about one tenth of its original cost, and started selling power to one of Victoria's new distribution companies, Citipower.[98]

Conclusion

This account of the treatment of solar and wind energy in Victoria's electricity sector shows that an adequate explanation for the absence of these technologies needs to go well beyond the customary economic and technical justifications. But it is also unsatisfactory to portray the neglect of these technologies as merely an outcome of the intransigence of the SECV. Rather, this neglect needs to be seen in the broader context of the energy sector and government policies.

In the main, the option was rarely taken seriously by governments or the electricity industry. Renewable energy probably had wide community support, but its main institutional base, the Victorian Solar Energy Council, was small, relatively powerless, and had been directed by the government to pursue priorities other than power generation. The SECV, however, was a large, powerful organisation with a history steeped in brown coal and a reputation for disregarding community and environmental concerns. Is it any wonder that it gave scant consideration to the development of solar and wind energy?

Although the SECV claimed that solar and wind energy could not compete economically with existing fuels, decisions about future power plant options were not based on simple economic assessments. For example, part of the impetus for the Loy Yang B project was the need to ensure continuity of employment in the Latrobe Valley, and plentiful electricity supplies to attract energy-intensive industries to the state. In their planning for this project the SECV failed to consider more flexible options; rather, they were able to justify large 'lumpy' additions to their generating plant.[99] While large generating units may offer economy of scale, they also represent a very costly exercise should demand forecasts not be met. On the other hand, wind farms are much more flexible: they can be built quickly and in a range of sizes. Because they reduce the cost of uncertainty, wind farms have economic advantages that are not considered under conventional planning practices.[100]

And what of the role of governments, particular the Victorian ALP government, which had from the outset proclaimed its support for renewable energy? Despite the Victorian ALP government's rhetoric about community involvement in energy planning, despite their amendment of the SECV Act, their renewable energy policy documents, and their endorsement of the Toronto target, they actually achieved very little in the way of grid-connected renewable energy systems. Even their late push for the Toora wind farm was probably an attempt to salvage electoral support, after a series of crises in Victoria's financial sector had severely damaged the government's credibility, rather than a wholehearted commitment to the ideas behind the scheme.

On the surface, we could portray the ALP as a party which attempted to balance conservation and development issues in the electricity sector, with development finally prevailing. Such an explanation presupposes a pluralist model of political power, whereby public policy is deemed to be influenced by the various pressure groups which lobby governments to have their policies adopted. In this case a pluralist model would lead us to the conclusion that the lobby groups which advocated energy conservation and renewable energy were not strong enough, were not able to gain enough public support to persuade politicians to take up the issue.

While this conclusion may well be true, this type of pluralist analysis barely scratches the surface. What it fails to do is to address the structural biases within the energy sector, biases which nearly always act in favour of certain dominant groups. In this case we see that the close relationship between government and business leads to a pro-development ethic in which environmental concerns come a distant second. Thus the Victorian ALP government's early support for energy conservation lasted only a short time; by 1984 energy policy had become aligned with industry policy and was a means of attracting industry to Victoria.

Postscript

This history has covered the period from the mid-1970s to 1994. Since then the Victorian electricity sector has witnessed unprecedented upheaval. The SECV no longer exists, having been split into a number of separate generating and distributing companies, now privatised, and a transmission company. The new government seems firmly committed to deregulation of the electricity market. On the other hand, international pressure on Australia to reduce greenhouse gas emissions will probably intensify over the next few years. Such targets would militate against further development of brown coal power generation, and may advantage renewable energy. The political landscape of the energy industry is changing rapidly. By seeking to understand the treatment of renewable energy in terms of social and political processes, we are better placed to develop strategies for intervention.

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Notes and References

1. Michael Grubb, 'The Cinderella options: a study of modernized renewable energy technologies', *Energy Policy*, 18, 6, 1990, pp. 525–542.
2. Hence the term 'renewable energy' will here be used mainly to refer to solar and wind energy. Apart from where it is specifically mentioned, I do not include hydro energy.
3. Australia has six states and two territories. With a population of about 4.5 million, Victoria is Australia's second most populous state. It is not as sparsely populated as Australia's other states, so there are very few communities isolated from the main grid.
4. The term 'grid' is used to describe the electricity distribution network. The term is sometimes used to describe the high voltage electricity transmission system, and later when describing the national electricity grid I have used the term grid in this second sense. Apart from this instance, the term is always used in the first sense.
5. For a discussion on this see Michael Grubb, 'The integration of renewable electricity sources', *Energy Policy*, 19, 7, 1991, pp. 670–688.

6. The recent restructuring of Australia's electricity market does not fall within the period of this case study.
7. Australia, Department of National Development, *Australian Energy Policy: A Review*, AGPS, Canberra, 1979.
8. National Energy Advisory Committee, *Renewable Energy Resources in Australia*, AGPS, Canberra, 1981, p. 1.
9. Australia, Department of Primary Industries and Energy, and Centre for Technology and Social Change: University of Wollongong, *Evaluation of National Energy Research, Development and Demonstration Program*, AGPS, Canberra, 1990. In the late 1980s additional programme funds were made available for renewable energy and energy conservation projects, but this did not include grid-connected solar or wind energy.
10. Interview with Alan Pears, September 1996. This point was also made in Victoria, Department of Minerals and Energy. *Annual Report*, 1980–81.
11. Victoria, Department of Minerals and Energy, *Annual Report*, 1978–79.
12. The Victorian Solar Energy Council is often referred to by its acronym VSEC. This is very similar to the acronym SECV, so to avoid confusion I have used the term 'Solar Council'.
13. Victoria, Department of Minerals and Energy, *Energy Policy for Victoria*, 1979.
14. Patricia Whately, *The Restructuring of the Victorian Industry and Energy Portfolios Under the Cain Labor Government and its Effect Particularly on the State Electricity Commission of Victoria*, MA thesis, University of Melbourne, 1992; and Centre for Urban Research and Action, *A Review of Commonwealth and Victorian Government Energy Policies*, Centre for Urban Research and Action, Fitzroy, 1982.
15. Interview with Alan Pears, September 1996.
16. State Electricity Commission of Victoria, *Proposed Driffield Project: Planning and Approval Processes*, 1982. In this report, renewable energy was dismissed with the sole explanation of 'not meet[ing] the needs', p. 3.
17. State Electricity Commission of Victoria, Planning Department, *Latrobe Valley Power Station Sitting. Task Force Report*, Vol. 1, 1980.
18. In this period, the federal government was expecting a resources boom and the states were vying to attract aluminium smelters.
19. Victoria's brown coal reserves and power stations are located in the Latrobe Valley, near the town of Morwell. Open-cut mining is used.
20. Brown Coal Study Group, *Fuel for Unrest: People, Power and Planning in the Latrobe Valley*, Conservation Council of Victoria, Melbourne, ?1981.
21. Electricity demand varies significantly during each day with peak demands occurring in the morning and early evening. Brown coal power stations are best operated continuously and at full load, so they are suitable for supplying base load. Peak load can be met using hydroelectric stations or gas turbines; these can be started and stopped quickly and are suitable for operation at part load.
22. Victoria, Newport Review Panel, *Final Report to the Government and the Trades Hall Council*, Government Printer, Melbourne, April 1977, p. 17.
23. Whately, *op. cit.*, Ref. 14.
24. Anti-Newport Power Station Coalition, *Newport: Abuse of Power*, 1974, pp. 40–45. However, the SECV was also promoting the use of off-peak appliances, such as water heaters. In 1975 the government directed the GFCV and the SECV to cease competition.
25. Victoria, Newport Review Panel, *Report to the Government and the Trades Hall Council*, Government Printer, Melbourne, March 1977, p. 26.
26. *Ibid.*, p. 14.
27. C. Edwards, *Brown Power: A Jubilee History of the State Electricity Commission of Victoria*, State Electricity Commission of Victoria, Melbourne, 1969.
28. Victoria, State Electricity Commission Act 1958, s 20.
29. Hugh Saddler, *Energy in Australia: Politics and Economics*, Allen & Unwin, Sydney, 1981, pp. 116–117.
30. Phillip Gleeson, *The Technological Society: Experts, Government and People: A Study of the State Electricity Commission of Victoria*, M. Env. Sci. thesis, Monash University, 1980.
31. Aynsley Kellow, *Transforming Power: The Politics of Electricity Planning*, Cambridge University Press, Cambridge, 1996.

32. Australian Labor Party, *Labor Profile: Minerals and Energy*, Labor Resource Centre, Melbourne, 1982.
33. For a discussion of this development see Leigh Glover, *The Victorian Energy Plan*, M. Env. Sci. thesis, University of Melbourne, 1984.
34. *Victoria: The Next Step* was the cover title of Victoria, Department of Management and Budget, *The Economic Strategy for Victoria*, 1984.
35. Australian Labor Party, *op. cit.*, Ref. 32.
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37. Victoria, Department of Minerals and Energy, *Victorian Energy Plan. Progress Report on Energy Planning*, Department of Minerals and Energy, Melbourne, 1984.
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39. Victorian Energy Planning Program, *Victoria's Energy: Strategy and Policy Options*, Department of Industry, Technology and Resources, Melbourne, 1985.
40. Victoria, State Electricity Commission (Amendment) Act 1982, s 4.
41. Victorian Energy Planning Program, *op. cit.*, Ref. 39, p. 45.
42. State Electricity Commission of Victoria, *Annual Report*, 1980–81, p. 9.
43. State Electricity Commission of Victoria, *Electricity Supply and Demand to the Mid 1990s: Draft Government Energy Policy*, 1984.
44. See for example the state government's marketing package: Victoria, Department of Industry, Technology and Resources, *Victoria: A Powerful Business Partner*, n.d.
45. Deni Greene, *Congeneration in Victoria*, State Electricity Commission of Victoria, Melbourne, 1984.
46. State Electricity Commission of Victoria, *op. cit.*, Ref. 43, p. 28.
47. State Electricity Commission of Victoria, *Energy Conservation in Victoria: SEC Objectives, Policies and Programs, An Update Paper*, 1984.
48. This and other criticisms of the SECV's estimates of conservation were included in the document: Conservation Council of Victoria, *Energy Conservation in Victoria: SEC Objectives, Policies and Programs. Comments by the Conservation Council of Victoria*, November 1984.
49. State Electricity Commission of Victoria, *op. cit.*, Ref. 43, p. 29.
50. State Electricity Commission of Victoria, Planning Investigations Department, *Wind Generation for Victoria*, Vol. 1, 1983, pp. 1–2.
51. *Ibid.*, pp. 8–9. The SECV's lack of enthusiasm for wind energy was also evident in its State Electricity Commission of Victoria, *op. cit.*, Ref. 47.
52. Victorian Energy Planning Program, *op. cit.*, Ref. 38, p. 16.
53. State Electricity Commission of Victoria, *Annual Report*, 1984–85, p. 66; State Electricity Commission of Victoria, *Annual Report*, 1985–86, p. 86; Victorian Solar Energy Council, *Annual Report*, 1984–85, p. 14; Victorian Energy Planning Program, *op. cit.*, Ref. 38, p. 16.
54. State Electricity Commission of Victoria, *Annual Report*, 1986–87, p. 85.
55. This package was originally proposed by the government as a cogeneration package only. Victorian Government, *Victoria: The Next Decade*, F.D. Atkinson Government Printer, Melbourne, 1987. In reality, this 'incentives' scheme represented an amendment of the SECV's standby and buy-back tariffs to arguably more appropriate levels. In an inquiry on future power options, it was recommended that after reviewing the effects of this incentives package, the SECV might further restructure its standby and buy-back tariff to increase the number of small-scale power supply options. See Victoria, Parliament, Natural Resources and Environment Committee, *Report on Electricity Supply and Demand Beyond the Mid 1990s*, 1988, p. 81.
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58. Australia, Department of Primary Industries and Energy, *Energy 2000: A National Energy Policy Paper*, AGPS, Canberra, 1988.
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61. Conference Statement, The Changing Atmosphere: Implications for Global Security, Toronto, Canada, 27–30 June 1988.
62. Cited in Michael Grubb, *Energy Policies and the Greenhouse Effect. Vol. 1: Policy Appraisal*, The Royal Institute of International Affairs and Dartmouth, Aldershot, 1990, pp. 8–9.
63. Intergovernmental Panel on Climate Change, *Climate Change: The IPCC Response Strategies*, Island Press, Washington, 1991, p. 69.
64. Australian Government, *National Greenhouse Response Strategy*, AGPS, Canberra, 1992, p. 8. Note that the target set by the Australian government was not the same as the Toronto target. The Toronto target referred specifically to carbon dioxide emissions, whereas the Australian target included carbon dioxide, methane and nitrous oxide. (Restrictions to emissions of chlorofluorocarbons were covered by the Montreal Protocol of 1987.) Methane and nitrous oxide are in much smaller concentrations in the atmosphere, but molecule for molecule they are both far more effective at trapping heat than is carbon dioxide. It is unclear whether the Australian government made this subtle change to lessen the impact on fossil fuel use.
65. Australia, Industry Commission, *Costs and Benefits of Reducing Greenhouse Gas Emissions. Vol. 1: Report; Vol. 2: Appendixes*, AGPS, Canberra, 1991.
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67. Australia, Ecologically Sustainable Development Working Group Chairs, *Greenhouse Report*, AGPS, Canberra, 1992.
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69. Australia, Department of Primary Industries and Energy, *Issues in Energy Policy: An Agenda for the 1990s*, AGPS, Canberra, 1991, pp. 6–17.
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73. Victoria, Ministry for Planning and Environment, *The Greenhouse Challenge: The Victorian Government's Response, A Draft Strategy for Public Comment*, 1989, p. 27.
74. *Ibid.*, p. 32.
75. Victoria, Department of Industry, Technology and Resources, *Renewable Energy and Energy Conservation: Green Paper*, 1990. The 'White Paper' was released the following year: Victoria, Department of Manufacturing and Industry Development, *Victoria's Energy Efficiency Strategy, Parts I and II*, 1991.
76. Victoria, Department of Industry, Technology and Resources, *op. cit.*, Ref. 75, p. 29.
77. *Ibid.*, p. 23.
78. See the SECV's statement about the project in State Electricity Commission of Victoria, *The SEC and the Greenhouse Effect: A Discussion Paper*, 1989, p. 6.
79. State Electricity Commission of Victoria, *Annual Report*, 1989–90, p. 72.
80. State Electricity Commission of Victoria, Environmental Management, *10 MW Windfarm Project: Statement of Need and Related Information*, October 1991.
81. State Electricity Commission of Victoria, *op. cit.*, Ref. 78. In its later greenhouse document, the

SECV stated that 600 MW was the maximum amount that could be generated at sites that had been identified as having wind speeds of 7 m/s or more. State Electricity Commission of Victoria, *The SECV and the Greenhouse Effect: Discussion Paper Number 2*, 1992, p. 31.

82. State Electricity Commission of Victoria, Environmental Management, *op. cit.*, Ref. 80.
83. State Electricity Commission of Victoria, and Loder & Bayly Consulting Group, *Windfarm Planning and Environmental Study*, Vol. 1, 1992, Appendix 2. Wind speeds are usually quoted at a standard height of 10 metres. The wind speed increases with height, and can be estimated using the one-seventh power law.
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88. State Electricity Commission of Victoria, and Loder & Bayly Consulting Group, *op. cit.*, Ref. 83, p. 53.
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98. See the Alternative Technology Association's World Wide Web page on the Breamlea wind generator at http:SUBURBIA.NET/~ATA/BREAMLEA.HTM
99. Each unit of Loy Yang was rated 500 MW. With a total installed plant capacity of about 6000 MW (1983 data), each unit of Loy Yang represented about an 8% increase in capacity. Loy Yang A and B was intended to comprise eight units, i.e. 4000 MW.
100. Aynsley Kellow, *op. cit.*, Ref. 31, p. 4. Kellow makes this point about nonconventional electricity supply sources in general. Utilities which adopted least-cost utility planning, an approach which incorporates the cost of uncertainty, gave greater prominence to nonconventional sources of supply.