Sustainable Energy Policy for Australia

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Summary

This article presents the good news that an ecologically sustainable and healthy energy system, based on efficient energy use and renewable energy sources, is now technologically and economically feasible for Australia. Given the political will, it could possibly be achieved by 2030 without major disruption to the economy and society. But this energy system is being held back by political and cultural barriers, manifest in part by misinformation circulated by vested interests and ineffective government policies. None of the existing policies of federal and state governments and oppositions is capable of taking more than tiny steps towards the goal of sustainable, healthy energy. The federal government's proposed emissions trading scheme would actually be a backward step, locking in the big greenhouse polluters. Effective policies recommended in this article include a science-based greenhouse target; mandatory energy efficiency standards for all inhabited buildings, appliances and equipment; a national system of gross feed-in tariffs for renewable electricity sources of all sizes; and a carbon price with no exemptions and a very limited number of overseas offsets. There should be an immediate ban on new conventional coal-fired power stations and on major refurbishments and expansions of existing ones.

1. Introduction

Leading climate scientist Dr James Hansen presents a convincing scientific argument that the key actions needed to avert dangerous climate change with a high degree of probability are to phase out CO_2 emissions from coal-fired power stations by 2030 and to stop the introduction of high-emission substitutes for oil, namely shale oil, oil from coal and oil from tar sands (Hansen et al. 2008; Hansen 2009, chap. 8). Since so-called 'clean coal', that is coal with carbon capture and storage, is unlikely to be commercially available on a significant scale before 2030 (if ever), this first action entails that all coal power must be phased out within 20 years. There would be multiple health benefits in doing this, because the mining and combustion of coal is a large source of air and water pollution, land degradation and occupational health hazards (ExternE website).

Nuclear power technologies would take a long time to implement. They are still highly dangerous in terms of their contribution to the proliferation of nuclear weapons and their risks of rare but devastating accidents; there is still no facility on the ground (or underground) for the long-term storage of high-level nuclear wastes; their costs have escalated very rapidly during the 2000s so that they are now more expensive than wind power and the lowest cost forms of bioelectricity from crop and forestry residues; and in the long-term, as high-grade uranium is used up, they will become significant CO_2 emitters as they will involve the mining and milling of low-grade uranium ore using fossil fuels.

Fast neutron reactors, which are still at the demonstration stage, are potentially even more dangerous and expensive than conventional reactors, because they can be designed to breed much more plutonium that can be used as a nuclear explosive; furthermore, just one-millionth of a gram of plutonium inhaled into the lung has a high probability of initiating lung cancer. Nuclear power is discussed in more detail in Diesendorf (2007a, chap. 12).

The integral fast reactor, which in theory combines a fast reactor with on-site reprocessing of spent fuel, has only ever operated at the R&D stage and, like conventional nuclear power, could not make a significant contribution to electricity generation before 2030. Contrary to the claims of its proponents, it could still be used by those who control it to create and separate vast quantities of plutonium for nuclear weapons. If we are serious about creating an ecologically sustainable, healthy future society, then there is only one pathway to follow: genuine sustainable energy.

Diesendorf (2007a) presents the status of energy demand reduction by energy efficiency and conservation, and energy supply from renewable sources of energy. These are the only very low-carbon energy technologies that could make substantial contributions to cutting Australia's greenhouse gas emissions before 2020. The present article first shows how we can put together these technologies into a dynamic system that grows until it substitutes for all coal power in Australia by 2030. It then recommends policies needed to achieve this sustainable energy future.

2. Status of technologies

To achieve 100% renewable energy, we must address all three of the principal uses of energy: electricity; heating (non-electrical); and transportation. Electricity generation is the largest source of Australia's internal greenhouse gas emissions, because of the high percentage of coal in the energy mix. It is also the easiest to transform to renewable energy. Furthermore, a large fraction of transportation could be provided by electric vehicles for both public and private transport, together with smaller contributions from biofuels sourced sustainably and gas during a transitional period (Diesendorf et al. 2010). For these reasons, the principal emphasis in this article is on renewable electricity (RElec).

RElec technologies are currently at different stages of development and commercialisation, as shown in table 1. The research and development (R&D) stage has to prove the concept and so the technology used in this stage bears very little relation to the final product that could enter the market. The demonstration stage shows how the concept would work on a larger scale, while considering some of the requirements of future mass production. The pre-commercial stage has strong input from production engineers and involves limited mass production for the first time. What it still needs is optimisation of various features and the whole system. For instance, two different types of concentrated solar thermal power station (trough and central receiver systems) are in the pre-commercial stage in Spain and only one type of thermal storage is being used there (molten salt) out of several possible ones (eg, water; graphite blocks; dissociation of ammonia into nitrogen and hydrogen). While the existing Spanish systems could be mass-produced in Australia, they could turn out to be slightly less efficient than some of the alternatives that are being developed elsewhere.

The commercial stage is not defined here in terms of economic competitiveness, because this depends on government policies, such as a carbon price, a renewable energy target, or feed-in tariffs. Instead, 'commercial' describes an optimised system in mass production that can be ordered and installed at a fixed price.

Table 1: Global status of some electricity generation and energy efficiency technologies

Stage of development	Explanation of stage	Technology
Research & development	Experimental technology or systems on laboratory or small field scale; not at all designed for mass production	Novel PV; some advanced batteries; hot rock geothermal; coal+CCS; integral fast reactor with pyroprocessing; nuclear fusion
Demonstration	Only a few medium-scale units exist; designed with future mass production in mind	Wave; ocean current; other advanced batteries; some fast neutron reactors (GenIV)
Pre-commercial	Limited mass production	Solar thermal electric with thermal storage; off-shore wind; micro-scale combined heat & power; GenIII nuclear
Commercial	In large-scale mass-production. 'Commercial' does not mean 'economically competitive with dirty coal power', since competitiveness is determined by government policies.	On-shore wind; conventional PV; biomass co-firing and direct combustion; landfill gas; large and small hydro; conventional tidal; combined heat & power; conventional geothermal; 1st generation biofuels; GenII nuclear; conventional coal and gas power; many energy efficiency technologies

The boundaries between the different stages are somewhat fuzzy, progression between stages is not always smooth and some technologies (or types of technologies) fail on the way. For instance, demonstration fast neutron reactors have had many failures and accidents over the past several decades, one of the reasons why expert groups such as the authors of the MIT report consider that they will not be commercial before 2030, if ever (Ansolabehere et al. 2003). So-called Generation III nuclear reactors, which are slightly improved versions of the existing Generation II reactors, are likely to remain at the pre-commercial stage for several years. Hot rock geothermal power is classified as R&D because the only systems currently generating electricity are each very small: only several megawatts in electrical capacity. Successful operation of a 50 megawatt system would lift this technology to the demonstration stage, while the commercial stage could be as large as 500 megawatts.

The following RElec technologies have low or no potential in Australia: landfill gas; conventional geothermal power; additional large hydro; conventional tidal (in the absence of a trans-Australian transmission link); and offshore wind (based on existing shallow-water technology).

For renewable sources of heat (not tabulated), commercial technologies are passive solar design of buildings and solar hot water. At the pre-commercial stage are space heating and cooling of buildings with solar heaters or with geothermal energy. (The latter only requires digging to depths of several metres to tens of metres to run heat pumps, while hot rock geothermal power, ie, electricity, requires much higher temperatures obtained from wells of depth 3–5 km, a very different technology.)

The main point of this section is to explain that energy technologies are at different stages of development and that a technology at an early stage cannot simply be rushed into mass production without substantial risks of technological failure, financial losses and, in some cases, health hazards. Even the Spitfire, which was developed rapidly during World War II and eventually manufactured in huge numbers, was based on a series of successful racing aircraft developed by the Supermarine company throughout the 1930s.

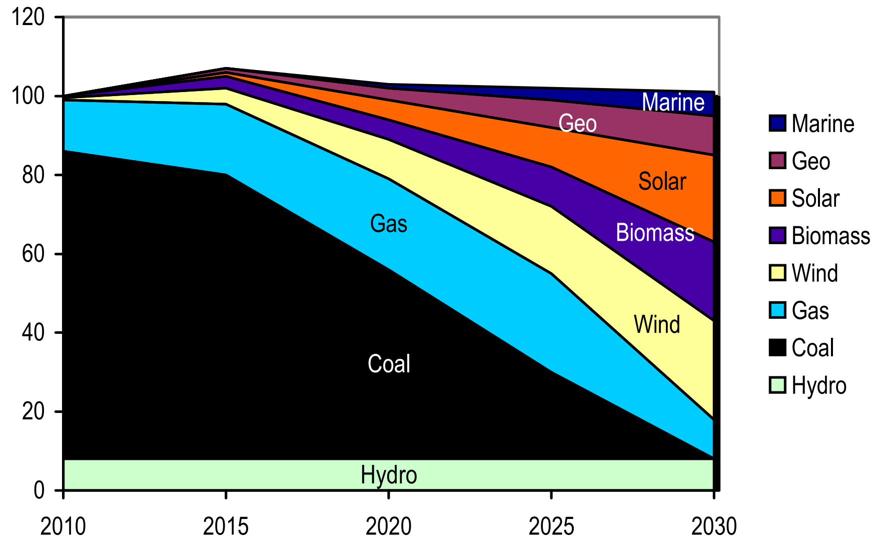

Figure 1: Electricity scenario phasing out coal, Australia, 2010–2030
Note: An emergency program, with even more rapid dissemination of solar and geothermal, could possibly phase out gas as well as coal by 2030.
Source: Diesendorf (to be published)

3. Renewable energy scenarios

3.1 Australian scenarios

In the Australian context, the greatest new RElec contributions from 2010 to 2020 can come from (1) on-shore wind power and (2) biomass residues fuelling combined heat and power and combined-cycle power stations. During this period, solar thermal could be brought to commercial stage and into the number 3 position. By 2030 solar thermal and solar PV together could contribute as much as wind or biomass and would overtake both wind and bio-electricity post-2030. It is likely that hot rock geothermal power will reach the demonstration stage by 2015 and pre-commercial stage by 2020. By that time, marine sources of power – wave and ocean current – could also be pre-commercial and possibly commercial. However, in view of the current status of geothermal and marine power, they have minor roles in this scenario.

Figure 1 illustrates such a RElec scenario for Australia from 2010 to 2030, in which coal power is phased out by 2030 by means of:

- energy efficiency and conservation, which stop demand growth temporarily against the pressures of population growth and economic growth;

- natural gas, which initially expands in use and then contracts as the global peak in gas production is reached; and
- renewable energy.

By 2020 most economically feasible energy efficiency improvements should have been implemented. By then, if we have not stabilised population and economic growth, we could be fighting a losing battle against greenhouse gas emissions. Beyond 2030, we can expect further expansion of solar power (both thermal and photovoltaic), possibly reaching 50% of all electricity generation, and the complete phase-out of gas power. Geothermal has enormous potential in terms of the vast area of hot rocks under the Great Artesian Basin, but, because of its early stage of development, it plays a minor role in this scenario. With or without this source, the electricity supply system could be 100% renewable by 2040. My personal view is that a crash program and some good luck with geothermal development could bring this forward to 2030, if the climate science demands it and governments are genuinely responsive.

In this energy future, it is envisaged that residential and commercial buildings would be far more energy efficient than they are today and that the majority of low buildings (three stories or less) would be powered mainly by solar photovoltaic (PV) modules and would also have most of their hot water supplied by solar, from collectors for both systems on their rooftops. This would provide for the majority of electricity demand and hot water by the residential and commercial sectors (excluding high-rise buildings). The industrial sector – including mining, processing and manufacturing – is the greatest component of electricity demand, with aluminium smelting alone being responsible for 13–15% of Australia's electricity demand and highly subsidised as well. Therefore, if we are aiming for 100% RElec, the principal contribution will have to come from large-scale systems. The transformation cannot be achieved on rooftops alone.

Other Australian greenhouse/energy scenarios include Saddler, Diesendorf & Denniss (2007), Diesendorf (2007b) and Teske & Vincent (2008).

At present most high-temperature heat is supplied on-site by the combustion of natural gas, with a smaller contribution from on-site combustion of coal. While most low-temperature heat could be supplied by solar collectors, it would be quite difficult to supply high-temperature heat in this way. Some could be supplied by RElec, some from the combustion of biofuels sourced sustainably and possibly some by solar concentration to high temperatures by dish collectors. More detailed studies are needed.

Before discussing the key policies needed to remove the barriers to RElec, it is worth addressing briefly the principal fallacies about renewable energy disseminated by the proponents of coal and nuclear power.

3.2 Fallacy: There isn't sufficient renewable energy to meet the needs of modern industrial society.

This fallacy has been refuted by the 'centralised' renewable global scenario for 2050 developed by Sørensen and Meibom (2000). While keeping many small-scale decentralised energy systems such as residential solar PV, the 'centralised' renewable scenario obtains its principal contributions from large-scale systems. It places some types of renewable energy system on non-arable land and off-shore and transmits the energy to consumers by transmission lines or pipelines. Its energy mix comprises energy efficiency, bioenergy from residues, wind power (both on-shore and off-shore) and solar power. The authors use a geographic information system to assess the extent to which renewable energy resources match energy demand in different regions of the world. In regions where there is a poor match between supply and demand, import and export of energy via transmission line and pipeline are added. The results are encouraging: there is in total a global oversupply of renewable energy potential and good matches between supply and demand can be achieved in all regions. Furthermore, food production is not compromised by using biomass *residues* to produce bioenergy.

3.3 Fallacy: RElec is too unreliable to provide base-load (24-hour a day) power.

This fallacy is refuted in detail for the special case of wind power, in Diesendorf (2007a, chap. 6) and more generally for RElec in Diesendorf (2008). The essence of the argument is as follows. Some sustainable energy sources and measures are at least as reliable as coal power. These include demand reduction by means of energy efficiency, energy conservation and solar hot water, and RElec supply by hydro with large dams, bioenergy, solar thermal power with thermal storage and geothermal power. They can all be used to reduce the demand for base-load coal without reducing the reliability of the generating system.

What about fluctuating RElec sources, such as wind, run-of-river hydro, solar without storage, and wave power? They simple add fluctuating sources to an electricity supply system that is already designed to handle fluctuations in demand and conventional supply. All base-load power stations, including coal and nuclear, are partially reliable and therefore require some back-up. Breakdowns of coal and nuclear power stations occur less frequently than fluctuations in the wind and sunshine, but when coal and nuclear do break down, they are off-line for longer periods than lulls in the wind or periods of overcast and darkness. To compare the reliability of coal and nuclear with that of wind and sun in an electricity grid, we have to compare the reliability of the whole generating system with and without the RElec sources.

Both computer modelling and practical experience show that the existing system can handle small penetrations of fluctuating RElec sources into the grid. For large penetrations, wind in particular can substitute for base-load coal-fired power stations, provided either some additional peak-load plant is installed or the grid is interconnected into a larger neighbouring grid, in order to return the generation reliability to the original level. For instance, Denmark is planning to increase its wind energy contribution to 50% of total annual electricity generation by increasing the capacity of its transmission link to Norwegian hydro. Since Australia cannot do this, it will need some additional peak-load capacity, in the form of gas turbines or hydro. The amount of additional back-up increases with increasing wind penetration, but decreases as the geographic dispersion of the wind farms increases. For a geographically-dispersed wind energy penetration of 25% of total generation, the additional peak-load capacity required to maintain reliability would be a small fraction of the wind capacity. Since the back-up only has to be operated infrequently, it can be considered to be reliability insurance with a low premium. By the way, the gas turbine could be fuelled with biofuels produced sustainably.

4. Recommended energy policies for Australia

Different policies are needed for different stages of technological development. While all stages must be supported simultaneously, as explained below, the pace of climate change demands that we put the greatest resources into expanding the dissemination of commercial and appropriate pre-commercial technologies. We must put many runs on the board by 2020.

What kinds of policies do we need? While it is necessary to implement a carbon price, in order to take account of the environmental and health damage caused by the use of fossil fuels, this is by no means sufficient. Market failures are endemic in attempts to disseminate cost-effective energy efficiency measures. The market also fails to drive the construction of essential infrastructure, such as transmission lines, gas pipelines, railways and cycleways. It is inadequate for funding R&D. And, it only tends to give incentives to the next cheapest technologies in the short-term. Yet, in developing a transition to a new energy system in the long-term, we must give incentives to a whole portfolio of technologies at different stages of technological development.

For instance, gas power is the next cheapest source after conventional coal power, yet its reserves are limited and demand for it as an oil substitute will increase rapidly over the next decade, with the result that it could be in short supply and expensive by 2030. If we failed to expand wind power and other renewable sources now, we would be in a dire situation in 2030. Similarly, solar thermal power with thermal storage has been proven to the pre-commercial stage overseas and has huge potential in Australia, but it is still relatively expensive compared with wind power. Is it wise to allow the market to delay solar thermal until it can compete with wind power? Clearly the market, which addresses incremental improvements, is a poor mechanism for providing for our long-term future.

Essential policies are now discussed, starting with the market mechanism, carbon pricing.

4.1 Carbon tax or emissions trading?

A carbon price is designed to make dirty (in terms of greenhouse gas emissions) industries and products more expensive, in order to encourage a shift in national economic structure towards cleaner industries and products. The price increases can be achieved via two alternative principal mechanisms, emissions trading and a carbon tax (Garnaut 2008; Diesendorf 2007a, chap. 14 and appendix C).

The federal government has proposed an emissions trading scheme (ETS). The government has misnamed it as the Carbon Pollution Reduction Scheme, since it has little in common with the ideal ETS. Its severe failings are:

- It would give free emission permits worth billions of dollars to the biggest greenhouse gas polluters, namely coal-fired power stations and energy-intensive trade-exposed (EITE) industries. Once the permits have been allocated, they gain a market value, giving these industries and their (mostly) overseas shareholders windfall profits of billions. Furthermore, CPRS has provision for the number of permits allocated to the EITE industries to expand over time until 2020, if the industries wish to expand. Thus increasing greenhouse gas emissions are locked in. Instead of being a ‘polluter pays’ system, as is the ideal ETS, CPRS would be a ‘pay-the-polluter’ scheme.

- Medium-sized polluters, who receive fewer free emission permits, can offset all of their emissions overseas in schemes of dubious effectiveness. As a result, there is no guarantee that there would be any reduction in Australia's emissions, not even by 5% (the official national target for 2020), and it is even doubtful whether there would be any reduction in global emissions as a result of Australia's ETS.

- Emissions permits would be permanent property rights. Therefore, if a future acceleration of climate change or growth in public pressure made it necessary for the government to speed up reductions in emissions, the government would have to buy back permits from the polluters at a cost to taxpayers of more billions of dollars.

- The financial services industry would create many products out of the permits that would enable widespread speculation without necessarily reducing emissions at all.

- Emissions trading schemes are so complicated that most people cannot understand them. The schemes are ideal for manipulation by vested interests in greenhouse pollution. They can be made ineffective in many different ways. They give perverse incentives to polluters to put large resources into lobbying government and public relations, instead of into cutting emissions.

For these and other reasons, I have come reluctantly to the conclusion that the proposed ETS is actually a Carbon Pollution *Reinforcement* Scheme, which is designed in such a way that it cannot be strengthened in the future without enormous cost. Therefore, it should be opposed firmly.

A carbon tax, with no exemptions and with gradual increase in tax level over time, is much simpler and hence less open to manipulation. It would offer far less opportunity to the financial services industry to waste public money. It would allow reductions in emissions to be speeded up or slowed down as the science demands. The problems faced by emissions-intensive trade-exposed industries could be addressed with border tax adjustments. Such a carbon tax is the best way of introducing a carbon price, one of the necessary policies for climate change mitigation.

Until a carbon tax or improved ETS is implemented, I support the Australian Greens' proposal of an interim carbon tax of $23 per tonne of CO_2 for two years. I suggest that half the tax be returned to Australian adults in equal shares as a dividend, and the remainder be used to help build essential infrastructure. While the proposed level of tax is too low to make any RElec technologies competitive with dirty coal, it would at least send a message to investors that new dirty coal-fired power stations would be very risky business propositions.

4.2 Feed-in tariffs or renewable energy target?

As discussed above, a carbon price is necessary but not sufficient for effective greenhouse gas mitigation. Specific policies are needed to encourage the rapid growth of energy efficiency and renewable energy technologies. This is not 'picking winners', but supporting the only very low-carbon energy supply technologies with capacity to achieve substantial reductions in Australia's emissions before 2020 and very large reductions by 2030.

For RElec, the most successful policy overseas has been 'gross' feed-in tariffs (FiTs) to support the expansion of both small-scale and large-scale systems. As a result, large-scale wind power is booming in Germany, Denmark and Spain; large-scale solar thermal is growing rapidly in Spain; and small-scale solar PV is widespread in Germany, despite the low amount of sunshine there. FiTs are successful because they give specified electricity prices to investors.

In Australia, with the exception of NSW and the ACT, the present FiTs are 'net' tariffs, that is, they only pay premium electricity prices for the *difference* between RElec generated at home and electricity purchased from the grid, provided that difference is positive. In practice since most households buy more electricity than they generate, they receive negligible amounts from FiTs. Furthermore, in all states and territories except possibly the ACT, large-scale systems do not qualify.

In my view, the best option is for the federal government to scrap the renewable energy certificate scheme associated with the Renewable Energy Target (RET) and replace it with a system of gross FiTs, which pay a premium price for all RElec fed into the grid, covering both small- and large-scale systems. Each RElec technology receives its own price that is chosen to take into account its economics at present and in the foreseeable future. To encourage technological improvement and to take account of the economic benefits of expanding markets, all FiTs decline over time.

I have recommended the replacement of the certificate system associated with RET, because it is designed in such a way that it cannot reach its official goal, namely 20% of Australia's electricity from RElec by 2020. In brief, the reasons are (Diesendorf 2010):

- The RET scheme allows hot water from solar and electric heat pumps to be counted towards the target. There are better ways of assisting hot water systems than making them compete with RElec.
- The RET scheme counts towards the target 'phantom' RElec systems, created on paper under the Solar Credits scheme, even though they don't exist as physical systems. Initially there are four phantom systems for every real RElec system installed; they will only be phased out in 2015.
- The RET scheme supports the cheapest qualifying systems first. These are solar and heat pump hot water, followed by small-scale solar PV.

The net effects of these design flaws are that:

- A low price for the tradable renewable energy certificates (RECs) created under RET, which means inadequate subsidies for even the lowest cost large-scale RElec sources such as wind power and bioelectricity from crop or forest residues. As I write, wind turbine component manufacturers in Australia are set to lay off hundreds of workers and the bio-electricity power stations at Condong and Broadwater are on the verge of bankruptcy.

- With the RET mainly taken up with hot water and phantom solar PV systems, there will be little room in the target for large-scale wind power and bioelectricity before 2015. The more expensive RElec sources, such as large solar power stations, will receive no support at all from the RET scheme.

If the federal government declines to replace the RET scheme, then another option is to remove all large-scale RElec technologies from the RET scheme, keeping it for hot water and small-scale RElec. Then, if the RET target is maintained at the equivalent of 20% of electricity by 2020, it could really boost the use of solar hot water and residential solar PV. Large-scale RElec would then be assigned FiTs. Thus the RET and FiTs could operate side by side.

4.3 Expanding and strengthening the transmission network

The existing transmission network is designed primarily to bring coal-fired electricity from a few generation regions, such as the Latrobe and Hunter Valleys, to the cities. If RElec is to grow to a significant fraction of its full potential, new high-voltage transmission lines are needed. For instance South Australia has huge potential for wind and geothermal power, far more than could be utilised in that state. To tap this potential, new transmission lines are needed to link South Australia to NSW and Victoria, and the existing low-capacity existing links need to be upgraded. These improvements would act as a 'backbone' to which other RElec sources, such as solar thermal, could be connected.

4.4 Policies for energy efficiency and conservation

Energy efficiency (using less energy to provide the same energy services) and energy conservation (using less energy by reducing energy services) have huge potential in a sustainable energy strategy. Both offer many low and negative net cost options. For consumers the very large economic savings from energy efficiency can pay for a major part of the additional costs of renewable energy (McKinsey and Company 2008).

Both energy efficiency and conservation are subject to market failure. Hence regulation and standards must play an important role in improving energy efficiency. The changing of cultural norms towards a Conserver Society is vital for both efficiency and conservation.

Buildings are the major users of energy in the residential and commercial sectors. Although there are various state-based mandatory energy performance standards, such as the BASIX scheme in NSW, they only apply to new buildings. The states, in cooperation with the federal government, should set mandatory energy performance standards and mandatory energy labelling for *all* existing habitable buildings. Of course, the standards for existing buildings would not be as strong as for new buildings. In addition, mandatory standards and labelling should be implemented for all energy-using appliances and equipment.

4.5 Other policies

Research, development and demonstration (R,D&D) need a strengthened system of government grants. The federal government has promised to fund demonstration grants for solar power stations by the *Solar Flagships Program* ($1.5 billion over about 5 years). This is a slow process that demonstrates the weakness of relying on government expenditure as the major component of renewable energy policy. The Flagships program is designed to fund partially ($1 from the Program for every $2 raised by the project developer) up to four large solar power stations. The first round of grant applications for one PV and one solar thermal power station is open in 2010 and the second round is planned for 2013–14. In practice the Program's partial funding is unlikely to be sufficient to make any demonstration solar power station economically viable before 2020, unless either high FiTs or a high carbon price are introduced. Until this has occurred, demonstration projects should be funded on a dollar for dollar basis. In order to reduce financial risk of individual projects, the minimum capacity of each demonstration solar power station should be reduced from 150 MW to 50 MW and the maximum number of solar power stations to be funded increased from 4 to 12. To help achieve these improvements in the Program, total funding should be increased from $1.5 to $3 billion.

The government's proposed changes to the existing R&D tax deduction schemes will reduce incentives to industry for R&D in energy efficiency, renewable energy and other technologies. These changes should be resisted strongly.

Other existing sources of R,D&D funding are the *Renewable Energy Demonstration Program* ($300 million over an unspecified period), the *Geothermal Drilling Program* ($50 million), the *Advanced Electricity Storage Technologies Program* ($20 million), the *Wind Energy Forecasting Capability Program* ($14 million) and, to provide venture capital, the *Renewable Energy Equity Fund* ($18 million). Of these, REDP should be increased to $1 billion and REEF to $0.5 billion, both to be funded over 5 years.

For R&D, the recent formation of the Australian Solar Institute ($100 million) is a step in the right direction. However the solar funding should be doubled and additional R&D funding of $25 million allocated to marine energy.

Government funding is also needed for universities and TAFEs to educate/train more renewable energy engineers, electric power engineers and installers. Without them, it would be impossible to meet a significant RElec target for 2020. Also the federal industry department (DIISR) should fund a program to assist the growth of renewable energy industries in Australia.

The government could obtain part of the additional funding for RElec recommended in this article (at least $5 billion per year) by terminating subsidies to the production and use of fossil fuels. Additional funding could be obtained from a carbon price.

Additional energy policies are discussed in Diesendorf (2007a, chaps 14 & 15) and some broader greenhouse mitigation policies in Diesendorf (2009, chap. 4).

All the above energy policies must be implemented within the framework of strengthened greenhouse gas emission targets, both short-term and long-term. Relative to the 1990 level, I recommend at least a 30% reduction by 2020 and 80% by 2050.

5. Relationships between the recommended policies

Until there is a carbon price of at least $23 per tonne of CO_2, all proposals for new dirty coal-fired power stations should be banned. The carbon price of $23 per tonne should sufficient to allow gas to compete with coal for base-load (24-hour) generation.

Once the carbon price has reached a sufficiently high level and remains there consistently, the RECs and FiTs could be phased out. The author's rough estimates of the critical levels of the CO_2 prices are given in table 2.

Table 2: Carbon prices to allow RElec technologies to compete with dirty coal power

RElec technology	Carbon price ($/tonne CO2)
Wind	50 in 2010

Biomass residue combustion	60–80 in 2010
Solar thermal electric	100–120 in 2015, declining to 60–80 by 2020
Solar PV (large-scale)	100–150 in 2015, declining to 60-90 by 2020
Solar PV (residential)	200 in 2010, declining possibly to 0 in 2020.

Note: Residential solar PV competes with the ***retail*** grid electricity price. The former is decreasing and the latter is increasing. The cross-over could occur around 2020 in Australia .

6. Discussion and the way forward

Basing an energy system on fossil fuels is a recipe for huge environmental and health impacts from global climate change, air and water pollution and land degradation (ExternE website www.externe.info). The need for a rapid transition to a sustainable energy system is urgent. The only low-carbon, genuinely sustainable, energy sources that could make a substantial contribution before 2020 are demand reduction by means of energy efficiency and conservation, and clean energy supply from renewable sources. With the temporary assistance of gas, energy efficiency and renewable energy are now sufficiently advanced technologically to substitute for all use of coal in Australia by 2030. Furthermore, the economic savings from demand reduction could pay for the major part of the additional costs of renewable energy.

The barriers to this essential transition are vested interests in greenhouse gas emissions: coal, oil, electricity generation, aluminium, steel, cement, forestry based on logging native forests, and some types of agriculture. These vested interests are disseminating fallacies about greenhouse science and greenhouse mitigation. Common fallacies are that making the transition to renewable energy will cost jobs and that renewable electricity is not sufficiently reliable for providing a national electricity supply system. These and many other fallacies are refuted in Diesendorf (2009, chap. 2). However, heavy lobbying by the vested interests has resulted in both major political parties having ineffective policies for mitigating greenhouse gas emissions. Therefore, this article has proposed some new, potentially effective policies.

At this stage, the main hope for getting effective policies implemented is pressure upon power-holders by the climate action movement, which has been growing rapidly since 2006. This movement is diverse – it includes professional groups (eg, doctors, lawyers and engineers), faith groups, environmental NGOs both large and small, hundreds of dedicated community climate action groups, some businesses, some trade unions, student groups and individual academics. This diversity of groups is generating a diversity of tactics: lobbying, education and information, bulk buying of energy efficiency and renewable energy products, legal actions, media items and various forms of non-violent direct action. All these tactics, used appropriately, have valid roles. (Diesendorf 2009, chaps 5 & 6).

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About our organisation:
The EnergyScience Coalition <www.energyscience.org.au> is a co-operative production by a group of concerned scientists, engineers and policy experts that seek to promote a balanced and informed discussion on the future energy options for Australia. With increasing concern over the looming impact of global climate change the community needs to be aware of the issues involved. energyscience aims to provide reliable and evidence based information to our whole community.