Clean Energy Alternatives

The need for a new energy paradigm

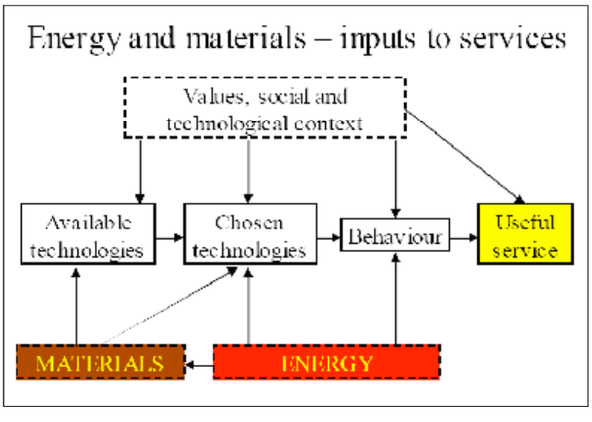
Clean energy solutions will be critical to Australia's progress towards a sustainable, low carbon emission future.

When considering energy options, most people ask the wrong question. They ask 'how do we continue to meet our energy demands?' instead of asking a series of questions along the lines of:

- What services (nourishment, shelter, comfort, transport, etc) do we need?
- How much energy, of what kind, is needed to deliver these services?
- How can we provide this energy in a sustainable manner?

The cleanest energy is the energy we avoid using so it is critical to examine how much energy is really required to satisfy our needs and desires.

Figure 1. The role of energy in delivery of services



Our thinking about energy is limited by our personal experience and is shaped by technology and our social context, as is shown in Figure 1. As an illustration, the advent of the computer and the internet has made the transfer of information around the world a lot quicker and less resource intensive than sending hand-written letters. We can now satisfy many service requirements in ways that were unimaginable a few years ago, using less materials, less energy and less money, while having less impact on the environment.

Many Australians aspire to live in centrally heated and cooled homes when in reality the service they require is a comfortable home. Advances in insulation, energy-efficient glazing, improved building design, more efficient heating and cooling equipment, and review of home size allow a home to be comfortable all year while requiring very little heating and cooling energy. Likewise, instead of mining resources and processing them into metal for containers, we can use recycled materials or much smaller quantities of materials sourced from renewable feedstocks to make containers with much lower environmental impacts that can be re-used, recycled or converted into useful energy.

In a recent paper I estimated that:

- Australian households could have a much higher standard of living than today using two-thirds less energy;
- The commercial sector – offices, hospitals, schools, shops, etc, could cut energy use per unit of economic activity by three-quarters;
- Our transport fuel consumption could be slashed through improved urban organisation, increased public transport, fuel efficient vehicles, lightweight electric vehicles and virtual travel; and
- Our industrial energy use could also decline dramatically, with improved energy efficiency, switching from processing virgin metals to recycling plastics and renewably-sourced materials, green chemistry and biomimicry in industrial processes. (Pears, 2007)

So a clean energy future involves producing and using a lot less energy for each unit of useful service. This changes the fundamentals of energy supply. Many homes

and businesses could produce their much reduced energy requirements on-site using solar cells, wind energy and cogeneration (the production of electricity and heat from gas, biomass or hydrogen), along with some energy storage. Indeed, it may not be economic for many homes and businesses to remain connected to the electricity or gas grids. Growth in population and affluence tend to drive up demand for useful services, adding to the challenges of shifting to a clean energy future. However, affluence also means we have more money to invest in a sustainable future.

Energy supply

Historically, energy suppliers have seen their role as providing as much energy as consumers want, whenever they want it. In the future, with the emergence of smart demand management systems, diversified energy sources and improved energy storage, we will see cooperative partnerships between suppliers and users. The challenge will be to satisfy our needs for energy services while matching demand to available supply, varying both energy production and energy demand and using energy storage systems.

Some advocates argue that Australia will continue to need large amounts of base load electricity generation capacity and that this can only be provided by coal or nuclear energy. But this reflects an outdated perspective. Base load power stations generate a constant amount of power 24 hours a day seven days a week. They typically have high capital costs and low running costs. But much of this electricity is generated when few people want to use it. And these power stations cannot increase output on hot summer afternoons when people want to be cool. In the past, electricity suppliers have offered discount prices to people and businesses using power overnight and on weekends but this has led to wasteful use of electricity. A large fraction of Australia's households heat water with electricity overnight; this would be much more sensibly provided by solar energy or gas. The large storage tanks needed to provide sufficient hot water over a whole day leak heat, adding to the waste. Shifting from wasteful off-peak electric storage hot water systems to solar can cut greenhouse gas emissions by up to 90 per cent; improvements in the efficiency of hot water use can cut emissions even more.

Base load power stations have a limited role in an efficient, post-industrial economy. Even the heavy industries that do need to run continuously are beginning to shift towards energy options such as biomass, energy from waste and cogeneration. Large power stations convert only 25-35% of the fuel they use into electricity and dump the rest as waste heat, while cogeneration occurs at the point of use so this heat can be captured and used, giving an overall efficiency of up to 80%.

Energy storage

Many forms of energy such as oil and other liquid fuels are easily stored. Solid fuels such as coal and biomass (eg wood) can also be easily stored although handling them is more complicated than liquid fuels. Gaseous fuels such as natural gas and hydrogen can be stored as compressed gases or liquefied. High pressure compression and liquification can, however, consume significant amounts of energy, and are technically more difficult. For hydrogen, storage in metal alloys is also under consideration.

Storing electricity has proved to be a challenge. Rapid development is, however, occurring, partly due to the need for low cost high performance batteries for hybrid cars. Recognition of the high costs of under-utilised energy supply capacity has also increased interest in larger energy storage systems such as flywheels and advanced batteries such as vanadium redox and zinc-bromine batteries. On a larger scale, it is becoming increasingly common to pump water uphill into a reservoir when there is excess power available and then use the stored water to generate hydroelectricity when it is needed. In Tasmania, the hydro-electric system output is reduced when wind energy or cheap power from the mainland is available, leaving more water available for other times. Production of hydrogen also offers a means of storing electricity, although it is relatively inefficient.

Cheaper and smarter sensors and controls offer greater scope to limit energy demand at times of peak load, and to shift demand to other times. For example, irrigation pumps can be operated when there is plenty of wind and solar electricity. Air conditioners can be cycled on and off in hot weather, and so on. Smart energy meters can charge different prices at different times, and give users feedback on their energy use and its cost.

Also, the more energy-efficient appliances are, the less electricity they need to deliver a service. So they need smaller and less costly energy storage systems.

Clean energy supply options

What forms of clean energy might Australia use in the future? First, we must consider what forms of energy we need. Today, around half of the energy used by Australians is for heat, a third for movement, and less than a fifth is electricity. These requirements are to some extent interchangeable; for example, some electricity is used to produce heat and transport (and 'virtual transport' using telecommunications), while waste heat from industry can be used to generate electricity.

The potential options include:

- many types of renewable energy including:
  - photovoltaic cells (which convert light energy directly into electricity)
  - wind energy
  - wave and tidal energy
  - solar thermal (heat) energy
  - geothermal energy – heat from deep within the Earth
  - bioenergy (from biomass, organic material such as wood, crops, organic wastes);
- natural gas, coal or oil with carbon capture and storage (see discussion below);
- uranium (subject to community acceptance and resolution of a number of major issues: see discussion below); &
- hydrogen (sourced from renewable energy or fossil fuels with carbon capture and storage).

Table 1 shows how each of these energy sources could provide heat, movement and/or electricity. In principle, we have many options. We can choose our preferences based on criteria such as cost, risk, flexibility, environmental impact, resource availability and compatibility with demand requirements and social values.

Table 1. Energy options and their potential to satisfy heat, movement and/or electricity requirements

	EXAMPLES OF HOW MAJOR ENERGY FORMS PROVIDE:		
Energy Source	Heat	Movement	Electricity
PV cells	Yes – via electricity driving heat pumps, by capturing waste heat from PV modules, or resistance heating	Yes – via electric vehicles or hydrogen	Yes
Wind	Yes – direct conversion to heat or via electricity	Yes – via electric vehicles or hydrogen	Yes
Wave and tidal	Yes – direct conversion to heat or via electricity	Yes – via electric vehicles or hydrogen	Yes
Solar thermal	Yes	Yes – eg via thermal conversion of biomass or via electricity	Yes
Geothermal heat	Yes	Yes – eg via thermal conversion of biomass or via electricity	Yes
Biomass	Yes – via combustion or gasification	Yes – biofuels, electricity or hydrogen	Yes
Natural gas (with CCS*)	Yes	Yes – compressed or liquefied gas, conversion to synthetic fuels, electricity	Yes
Coal (with CCS*)	Yes	Yes – conversion to synthetic fuels, electricity	Yes
Oil (with CCS*)	Yes	Yes	Yes
Uranium**	Yes –but only near reactors	Yes – via electric vehicles or hydrogen	Yes

Notes: * CCS= Carbon Capture and Storage – see text / ** see text below for a discussion of social, environmental and timing implications

Australia has enormous renewable energy resources. Each year the solar radiation falling on our continent alone far exceeds the total of all our fossil fuel and uranium resources. However, renewable energy resources are not necessarily distributed in ways that suit our present needs and they can be diffuse and variable in output. But with modern technologies, these issues can be managed.

The continuing use of fossil fuels, gas, oil and coal, is dependent on development of carbon capture and storage to limit global warming impacts. This is often called geo-sequestration; carbon dioxide from burning of the fuel is captured, then pumped deep underground into depleted gas or oil fields, or other stable formations. While there have been some CCS trials, it is expected to be 12 to 20 years before CCS technologies are available commercially. Capturing, compressing and transporting the carbon dioxide moreover consumes a large proportion of the energy produced, reducing overall energy supply efficiency (from 35% to 25%). There are also concerns about the risks of leaks from long term storage.

Uranium is used in some parts of the world to produce electricity; indeed, it generates around 16% of world electricity, similar to the amount generated by hydro-electricity. A recent study for the Australian government found it would take at least fifteen years to establish a nuclear power station in Australia. Two key problems are the risk of proliferation of nuclear weapons (as many of the countries that might use nuclear energy are also politically unstable or unfriendly towards some Western countries) and the management of wastes. Also, large amounts of energy (potentially generating substantial greenhouse gas emissions) may be needed to process poor quality uranium ores after high grade resources are consumed. Some also argue that the nuclear fuel cycle is fundamentally incompatible with human nature, as the high level of vigilance and security needed is difficult to maintain and the consequences of a single accident could be far-reaching. The location of reactors is another factor in the widespread opposition to nuclear power in Australia.

Energy costs

In recent years, the costs of many forms of energy have increased. Oil that used to cost less than US$20 has reached $100 per barrel. International natural gas prices have increased greatly since 2005, pushing up the price of liquefied natural gas exported from Australia, driving increased gas exports and reducing Australia's reserves of this precious transitional fuel. Coal prices have also increased. At the same time, the demand for billions of dollars of investment in new power stations and electricity networks is raising electricity prices.

It is generally believed that energy prices will increase, both for conventional energy sources and due to the shifts to new forms of energy. Further, the introduction of greenhouse gas emissions trading schemes will increase the prices of fossil fuels, as those who burn these fuels will have to buy permits for the greenhouse gases they emit. This does not necessarily mean we will pay more for energy overall. The cost of energy to a household or business depends on both the amount used and the price per unit. Energy efficiency improvement can therefore offset an increase in unit price; if you use half as much at double the price, the total cost remains the same.

As a result of innovation and economies of scale, emerging forms of energy such as solar electricity and wind energy are expected to become cheaper and more efficient. We have seen this pattern with items such as computers, flat screen TVs or mobile phones.

Broader issues

In Australia, energy plays several important roles. One is as an input to delivery of many essential or important services for households and business to maintain quality of life and run the economy. Another is as a generator of export revenue to offset the costs of goods we import.

Australia is importing increasing quantities of oil while exporting more liquefied natural gas, uranium and coal. Our dependence on imported oil is becoming a major issue as our local oil fields are being depleted. This is occurring at a time when world oil prices are increasing and having an amplified impact on our balance of payments. There is also increasing concern that world oil production has either peaked or will soon peak, due to resource limitations and geological and technical factors. Increasing demand from emerging economies such as China is adding to demand pressures. Since developed countries depend on a small number of oil producing countries for most of their oil, this could create political instability – as some analysts believe has already happened related to Iraq. The potential for rapid variations in price and shortfalls in supply of oil is increasing.

Energy is also an equity issue. At present, many low income households struggle to pay for enough energy to maintain comfort and provide access to essential services. Many live in areas without access to public transport, and many rental homes are not even insulated. As energy prices increase, we will need to work to improve equity of access to energy and services.

Australia's energy future will be very different from the energy experiences of our past. The good news is that we potentially have large amounts of low environmental impact energy, and efficient use of that energy will be affordable. But the choices we make about which forms of energy we use will shape our future, and that of generations to come. We need more people who understand energy issues and are engaged in the debate about our energy future.

Useful Sources

Websites

www.abare.gov.au (Australian Bureau of Agricultural and Resource Economics) many reports and statistics

www.aceee.org (American Council for an Energy Efficient Economy) – many useful reports and documents

www.acfonline.org.au (Australian Conservation Foundation) – reports and a detailed 'Green Home' section

www.cleanenergycouncil.org.au (Australian sustainable energy industry association) – many submission, reports etc

www.greenhouse.gov.au (Australian Government website – links to many aspects of energy)

www.mce.gov.au (Ministerial Council on Energy – Australian policy forum)

www.theclimategroup.org (International group focused on business response to climate change issues)

Publications

Department of Trade and Industry (2003), *Our Energy Future - Creating a Low Carbon Economy*. London, TSO: 138.

Diesendorf M (2007) *Greenhouse Solutions with Sustainable Energy* UNSW Press, Sydney.

Goldemberg J, Johansson T, Reddy A and Williams R (1987) *Energy for a Sustainable World* World Resources Institute.

House of Representatives Science and Innovation Committee, "Between a rock and a hard place: The science of geosequestration" **http://www.aph.gov.au/house/committee/scin/geosequestration/report.htm**

Monbiot, G (2006) *Heat: how to stop the planet burning* Allen Lane (Penguin), Melbourne.

Pears, A (2007) "Imagining Australia's Energy Services Futures" *Futures* Vol 39 253-271, Elsevier.

Saddler H, Diesendorf M, Denniss R (2007) 'Clean energy scenarios for Australia', *Energy Policy* 35(2): 1245–56.

Teske S, Zervos A, Schafer O (2007) *Energy [r]evolution: a sustainable world energy outlook* Greenpeace International/ European Renewable Energy Council.

Author

This Fact and Issue Sheet was written by Alan Pears, an engineer, environmental consultant and Adjunct Professor RMIT University. April 2008.