The energy debate part 2

This month's opinions continue the debate commenced in the October issue of *Chemistry in Australia*.

Keeping energy options open

Australia has an abundance of natural energy resources with the exception of oil and hydropower. As indigenous oil production declines, we are forced to increase imports of oil products to meet our ever-increasing thirst for transport fuels and lubricants. Every time there is an oil shock our attention turns briefly to what we ought to be doing to reduce our dependence on foreign oil, before returning to our former 'she'll be right' state once the crisis abates.

This time around, however, we face another threat: predicted global warming, with carbon dioxide from fossil fuel combustion identified as a major culprit.

Our other major fossil-energy resource use is in power generation, which is mainly coal-based but moving increasingly towards more environmentally friendly methane. But much of our established power generation infrastructure is old and inefficient by modern standards, and this has serious environmental implications – unnecessarily high greenhouse gas emissions which currently attract no penalty to encourage early replacement.

So, what should we be doing now to overcome these related problems?

Continued high oil prices will have some beneficial side effects: reduced consumption, increased investment in exploration and the release of higher cost extractable oil. In addition, vehicle manufacturers have an increased incentive to improve fuel economy by more efficient drive systems (particularly hybrids) and vehicle weight reduction by greater use of modern light-weight alloys. Governments must support these developments with worthwhile incentives, as well as imposing penalties for operators of old inefficient and polluting vehicles to accelerate their replacement.

Regarding alternative transport fuels, we should not delude ourselves into thinking that temporarily subsidised biofuels and LPG will save the day. Even if the government's 2010 production target is met, biofuels will make up a very small fraction of the market. Conventional conversion of crops (sugar, grain) to ethanol consumes a great deal of energy with only marginal overall saving in carbon dioxide emissions. As well as the associated adverse environmental consequences (land, water degradation), there is an investment risk associated with possible falling oil prices as has occurred in the past. New 'emissions-to-biofuels' technology, which utilises carbon dioxide from power stations to generate high oil-yielding algae, is typical of new thinking that needs to be applied. Although LPG is preferable to ethanol on a mass-equivalent energy basis, it has supply and application limitations that restrict its wider use. Modern processes for converting remote natural gas, coal-bed methane and cheap coal (for geosequestration) to liquid fuels are preferable options for achieving substantial import replacement.

Hydrogen, commonly touted as the ultimate transport fuel, carries a heavy carbon dioxide penalty when conventionally produced from fossil fuels by gasification/steam reforming. Carbon-free nuclear or solar energy could theoretically be applied to extraction of hydrogen from water, but costly production, distribution, storage and utilisation problems weigh heavily against this option.

Advanced power generation technologies currently available and actively being developed for gas and coal (e.g. gasification combined-cycle) can provide low-cost power at much higher efficiency and greatly reduced environmental impact than plants now operating.

Whether we build nuclear power plants should depend on economic, environmental and social considerations, just like any other industrial development. With some of the world's richest uranium and thorium reserves, we would be stupid to ignore their potential for local energy use. Nuclear fuel enrichment must also be given legitimate status with other resource-processing industries if we are to extract maximum benefit from these resources. Proposals for waste fuel reprocessing and disposal should likewise receive sensible consideration. Central to achieving any of these options will be community education and government leadership.

Australia needs to keep all reasonable energy options open to take advantage of the resources and new technologies at our disposal in an environmentally responsible manner. It is the only sensible path to follow.

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The carbon market

The spectre of global warming is haunting the energy market – a spectre carrying two big sticks, called respectively Greenhouse Emissions Trading and Carbon Tax. Depending on how they are used, these sticks may turn out to be lighter than feared.

The European Community's Emissions Trading Scheme began in 2005. In a recent review, the *Economist*[1] held that the emissions certificates should have been auctioned, not freely issued, and that recent monitoring has shown that excessive emissions were permitted. The initial trading price rose to €30 a tonne, but now has halved, and the industries involved have no incentive to curb emissions, with carbon credit in the bank. The new German government of Angela Merkel has nevertheless decided to issue the same amount of emissions certificates for the next period (2008–2012) as for the current (2005–2007).[2]

Carbon taxes have been advocated since the early 1990s. Finland, Norway and Sweden have carbon taxes and the oft-quoted example of geosequestration in the North Sea Sleipner gas field is economically viable due to the Norwegian carbon tax, a point sometimes overlooked by the Kyoto revisionists who put their faith solely in technology. D. Pearce reviewed some of the early proposals[3] when oil was $20 per barrel – several economic models assumed carbon taxes varying from $3 to $516/tonne. Most interesting were the cases for the UK and the USA, economies comparable with ours. For the UK, Barrett in 1990[4] assumed a $59/tonne tax (57% of the oil price in 1990) and found a carbon dioxide reduction of 35% by 2005. In the USA, the Congressional Budget Office calculated reductions of 10–20% from 1990 emission levels by 2000 with a $113/tonne tax.

The oil price has risen nearly fourfold since then, so there should now be evidence of how effective some of these proposals might have been. Petrol sales data show seasonal spikes, but smoothing the Vicroads plot quoted in the *Age* in July[5] suggests a decline in Victorian petrol sales of 20% between 2004 and 2006 (prices rose from 95 cents/litre to $1.30). However, the Bureau of Transport and Regional Economics sales data for the whole of Australia is more ambiguous (see the Statistics section at www.btre.gov.au), suggesting a 5% decline.

A carbon tax would most likely replace many current taxes. Thus the economy would tax goods and services on carbon intensity, not wholesale value. A recent Australia Institute paper[6] examines the possible effects of a $35/tonne carbon tax on Australian industries. The industry most vulnerable is aluminium smelting, where the cost of production would rise 14.1%. This would be a problem if there were no offsetting government policies, as much of this sector's output is traded internationally, with many competitors being either category B Kyoto countries (with no emissions targets) or the USA.

Tax is a four-letter word in Australia, so we may expect opposition to an effective carbon tax for some time. But the world has a habit of catching up with us, and then the process may be painful, for individuals as well as industries. One alarming prospect for energy-intensive lifestyles is the UK suggestion of a domestic tradable quota in greenhouse gases.[7] This proposes that individual carbon use be rationed with annual allocations of points on a credit card. Shades of the World War II ration cards, which I carried every Friday to the local shop to buy two ounces of mint imperials!

References

1 Gaming gases. *The Economist*, 10 June 2006, p. 69.

2 Kyoto in crisis. [Editorial] *New Scientist*, 8 July 2006, p. 3.

3 Pearce D. *Economic Journal* 1991, **101**, 938.

4 *Economic Instruments for Global Climate Change Policy*. Environment Directorate of the OECD, Paris, 1990.

5 Tourism feels bite as fuel costs soar. *The Age*, 13 July 2006, p. 5.

6 Saddler H., Muller F., Cuevas C. Competitiveness and carbon pricing. Discussion Paper 86. Australia Institute, Canberra, April 2006.

7 McErlean N. Pay as you pollute. *The Observer*, 24 January 2006.

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Why is nuclear power back on the agenda?

On 26 April 1986, a major accident at the Chernobyl nuclear power plant dispersed radioactive material over vast areas of Europe. This disaster, together with the relatively minor Three Mile Island accident in the USA, was instrumental in bringing the expansion of nuclear power in many western countries to a halt. Twenty years later, the nuclear power option is being re-examined in several countries, and an expansion of the global nuclear power industry seems likely. Prominent environmentalists and scientists from a range of backgrounds have expressed the view that nuclear power should make an increased contribution to the world's electrical energy requirements.[1]

The resurgence of nuclear energy is largely attributable to widespread concern about climate change due to the greenhouse effect, primarily caused by the burning of fossil fuels.[2] Modern western societies are heavily reliant on fossil fuel plants as base-load sources of electrical power, and energy requirements in the countries of the developing world are increasing. Detailed studies have concluded that the full life cycle release, per unit energy produced, of carbon dioxide from nuclear power is much less than fossil fuel plants.[3] Therefore, increased utilisation of nuclear power could form part of a global strategy to reduce climate change. It is even conceivable that Australia may eventually adopt nuclear power, given that its present reliance on coal power makes it, on a per-capita basis, one of the world's leading carbon dioxide-producing countries.

One of the obstacles for the expansion of nuclear power production is that it is perceived as being more hazardous than other sources of electrical energy. This is despite the fact that many experts have concluded that, when all risks are fully included, nuclear power has the best safety record of all major electricity sources.[4] The few accidents that have occurred in the nuclear power industry have received a large amount of media attention. By far the largest accident

occurred at Chernobyl in 1986. Many readers would be surprised to learn that the total number of fatalities attributed to this accident has been less than 100.[5] While there was severe local environmental damage and dispersion of radionuclides over a large part of the globe, the health consequences have been less serious than many predictions. Furthermore, the Chernobyl accident did not occur during routine operations, but as a result of a poorly conceived experiment that involved disabling some of the reactor's key safety systems.

The design of the Chernobyl reactor was inferior to that of western reactors of the time,[6] and there have been further improvements in reactor design in the subsequent decades. Nevertheless, nuclear energy continues to be criticised because it is 'not 100% safe'. Similar impossible standards of safety are demanded of diverse human activities (e.g .air travel), but, unfortunately, no activity has 'zero risk' associated with it. The various risks associated with modern living have been elegantly compared in the book *What is Safe: The Risks of Living in a Nuclear Age*.[7] Detailed studies have shown that no method of electricity generation is without its human costs. These include numerous deaths associated with dam failures (in the case of hydro-electric power), thousands of fatalities of coal miners worldwide, and the long-term health damage from air pollution arising from fossil fuel burning. However, doing without energy is not a risk-free strategy. Numerous people died during recent heat waves in Europe, and many also die from the cold. There is indeed no such thing as a free lunch when it comes to providing power for an energy-hungry world.

The safe disposal of nuclear waste has been problematic and controversial, and has often been portrayed in the popular media as being virtually impossible. Nuclear waste requires isolation from the biosphere for extremely long periods, and geological formations in tectonically stable regions offer appropriate characteristics for isolating it for the required time scales. Although providing a major technical challenge, dealing with nuclear waste is arguably more feasible than underground disposal of the vast quantities of carbon dioxide resulting from coal burning.

For many countries worldwide, nuclear energy is becoming increasingly attractive, in part because the disadvantages and limitations of other sources of energy are becoming more apparent. Balancing the issues requires complex judgments to be made, some of which are environmental, and some that are ethical or behavioural choices. For example, is it more justifiable to leave a legacy of a damaged earth atmosphere or a deeply buried repository of nuclear waste? Can the possibility of diversion of nuclear materials into weapons be adequately addressed by a combination of improved technology and international enforcement? How will the increasing energy requirements of developing countries be met? How much energy can be provided by alternative sources, and what are the environmental costs associated with these? Can alternative sources provide the base-load electricity that we rely on to maintain a comfortable room temperature, keep computers running, facilitate communications and provide entertainment? Do we prefer to utilise electrical energy, no matter how high the environmental cost, or can we do without? These are complex issues and there are no simple answers. However, it is a promising sign that these questions are beginning to receive greater public discussion.

References

1 These include the environmentalist James Lovelock (see Lovelock, J. *The Revenge of Gaia*. Penguin Books, 2006). Similar views have been expressed by the Australian scientist Tim Flannery (*Sydney Morning Herald* magazine, 5 August 2006 pp.22–5).

2 For some countries, energy security and economic arguments are significant drivers for nuclear energy programs.

3 The releases of carbon dioxide for entire energy chains, including construction, operation and decommissioning, are estimated by Spadaro J., Langlois L., Hamilton, B. *IAEA Bulletin* 2000, **42**(2),19–24. Available online at www.iaea.org/Publications/Magazines/Bulletin/Bull422/article4.pdf. Accessed 20 July 2006. An opposing viewpoint has been put forward by Jan Willem Storm van Leeuwen and Phillip Smith (www.stormsmith.nl/; accessed 22 August 2006), who argue that the carbon dioxide advantage of nuclear energy will quickly subside as high-grade uranium resources become exhausted.

4 See, for example, Williams (ref. 7, p. 38ff) or Lovelock (see ref. 1, p.102).

5 It is estimated that there may be several thousand additional cancer deaths globally, spread over the next few decades, as a result of the Chernobyl accident (Chernobyl Forum. *Chernobyl's Legacy: Health, Environmental and Socio-economic Impacts and Recommendations to the Governments of Belarus, The Russian Federation and Ukraine*. 2nd edn. Report of the Chernobyl Forum. International Atomic Energy Agency, Vienna, 2006). This increase in fatal cancers will be difficult to detect by statistical studies, even in the populations closest to the reactor. In comparison, the World Health Organisation attributes five million deaths worldwide annually to smoking.

6 Hirschberg S., Burgherr P., Spiekerman G., Dones R. *J. Haz. Mat.* 2004, **111**, 57–65.

7 Williams D.R. *What Is Safe? The Risks of Living in a Nuclear Age*. Royal Society of Chemistry, London, 1998.

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