PROF. BARRY BROOK − BRAVE NEW CLIMATE

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1. INTRODUCTION

This is a review of the nuclear power advocacy of Prof. Barry Brook, a conservation biology / climate change scientist/academic at Adelaide Uni who runs the Brave New Climate (BNC) website. Prof. Brook has over 170 peer-reviewed publications to his name and expertise across a range of scientific disciplines and sub-disciplines.[1] His interest in energy debates stems from his interest in and concern about climate change. He isn't in any way connected to − or in the pay of − the nuclear industry.

2. ENERGY OPTIONS

Prof. Brook's view is that "it's nuclear power or it's climate change".

Here is a brief outline of how greenhouse emissions can be sharply reduced without recourse to nuclear power in Australia. One of the most practical Australian studies was produced by a group of scientists for the Clean Energy Future Group (CEFG).[2] It is practical in that it makes virtually no allowance for technical innovation, restricting itself to technologies that were commercially available in 2004. It factors in official projections of economic growth and population growth. It stands at the opposite end of the spectrum to studies which make heroic assumptions about technological developments and cost reductions, and those which assume heroic reductions in energy consumption through energy efficiency and conservation.

The CEFG proposes an electricity supply plan that would reduce greenhouse emissions from the electricity sector by 78% by 2040 compared to 2001 levels with small contributions (5−10%) from solar, hydro and coal and larger contributions (20−30%) from wind, bioenergy and gas (the research was done before concentrated solar thermal power (CST) with thermal storage became commercially available). Bioenergy and gas are used for co-generation of electricity and heat. Bioenergy comes primarily from crop wastes so it is not competing with alternative land uses.

[1] By contrast, the reviewer has a few unremarkable peer-reviewed publications and no scientific qualifications (a PhD in the humanities/science bridging discipline of Science and Technology Studies).
[2] Saddler H, Diesendorf M, Denniss R, 2007, 'Clean energy scenarios for Australia', Energy Policy 35 (2): 1245-56. See also http://wwf.org.au/ourwork/climatechange/cleanenergyfuture

The CEFG study can be thought of as a baseline or worst-case study because it makes no allowance for developments in important areas like solar-with-storage or geothermal power. University of NSW academic and former CSIRO scientist Mark Diesendorf, who contributed to the CEFG study, has proposed a more ambitious scenario (PDF) that replaces all coal and gas used in electricity generation with renewables. He and his colleagues at UNSW have performed computer simulations of 100% renewable electricity in the National Electricity Market, in which hourly demand is supplied reliably with mixes of CST, wind, solar PV, biofuelled gas turbines and existing hydro.

CSIRO scientist Dr John Wright has proposed a scenario in which renewables generate over three-quarters of Australia's electricity by 2050: wind provides 19.4%; geothermal 19.0%; solar thermal 18.3%; solar PV 12.8%; bioenergy 5.1%; and ocean energy 0.7%. Dr Wright states: "Overall, increasing renewable energy technology will take out in the order of 200 million tons of CO2 by 2050 under this scenario. That is equal to about all of our major stationary energy CO2 emissions now. This is a major, major change."

Siemens Ltd., a company with extensive involvement in the energy sector, has mapped out an energy plan for Australia in which the contribution of fossil fuels to electricity generation falls from 93% to around 10%, with the remainder generated by a mix of renewable technologies consisting mainly of solar (35%), wind (18%), and geothermal (17%). Large-scale energy storage is provided by a mix of solar thermal and hydrogen. In the Siemens plan, most large-scale transmission interconnectors are High Voltage Direct Current (HVDC), providing significant reduction in losses and thus allowing for efficient, long-distance transmission of renewable energy-generated electricity around the country. Siemens also proposes the development of HVDC links to South East Asia to export renewable electricity.

Other relevant studies are listed at: www.choosenuclearfree.net/clean

Australia's energy problem is broader and more difficult than the electricity problem − and the global energy/climate problem is broader and more challenging than Australia's problem. Suffice it here to note that there is a body of expert opinion more optimistic about the potential of renewables and energy efficiency (and more critical of nuclear power) than Prof. Brook's expert opinion.

3. NUCLEAR POWER AND WEAPONS PROLIFERATION

Prof. Book trivialises the repeatedly-demonstrated connections between nuclear power and weapons.

He doesn't know much about the topic, for example claiming that North Korea never signed the Nuclear Non-Proliferation Treaty although Pyongyang's accession to then withdrawal from the NPT is central to the story − a story which has been in the media constantly for the past two decades.

Prof. Brook claims to be concerned about nuclear weapons proliferation but the evidence suggests otherwise. For example, asked at a public forum what needs to be done to fix the flawed nuclear safeguards system and what role he sees for academics/scientists such as himself to help address the problem, Prof. Brook responded: "That's a political and legal question and I have no further comment."

Prof. Brook treats nuclear weapons proliferation as a joke:

- this in response to a comment about the use of reactors to produce weapons material: "Nyah nyah, I can't hear you!" (mercifully that 'joke' was removed from the BNC website).
- 'joking' at a public debate that he envisages me waking up in the middle of the night fretting about nuclear weapons proliferation.

Prof. Brook's favourite argument to trivialise the proliferation problem is to claim that the weapons "genie is out of the bottle". He argues that countries which already have the capacity to produce fissile (weapons) material account for a large majority of global greenhouse emissions (USA, China, Japan, Germany, France and others). That's true, but it tells us little of significance. To get a handle on the proliferation risks of the nuclear 'renaissance', if it eventuates, here are some relevant figures:

- of the 65 or so countries with a nuclear program of any significance (involving power and/or research reactors), about one-third have used their 'peaceful' programs to advance weapons ambitions.
- of the 10 countries to have built nuclear weapons, six did so with support and political cover from their 'peaceful' programs (India, North Korea, South Africa, Pakistan, France and Israel).
- about 45 countries have the capacity to produce significant quantities of fissile material (more or less depending on where you draw the line with small-medium research reactors), and a vast majority of those countries acquired their fissile material production capacity through peaceful (or ostensibly peaceful) nuclear research or power programs.

(Some other WMD myths promoted by nuclear advocates are debunked here and in section 3.9 of this report.)

As former US Vice President Al Gore has argued, a major (horizontal) expansion of nuclear power will "run the proliferation risk off the reasonability scale". In addition to the extraordinary destructive potential of nuclear weapons, another concern is the potential for a nuclear exchange involving the detonation of 50−100 nuclear weapons (targeted at cities) to cause catastrophic climate change.

Prof. Brook claims that the (non-existent) 'integral fast reactors' he champions "cannot be used to generate weapons-grade material." That claim is false. George Stanford, who worked on an IFR research program in the US, states: "If not properly safeguarded, they could do [with IFRs] what they could do with any other reactor – operate it on a special cycle to produce good quality weapons material." Likewise IFR advocate Tom Blees notes that: "IFRs are certainly not the panacea that removes all threat of proliferation, and extracting plutonium from it would require the same sort of techniques as extracting it from spent fuel from light water reactors." Depending on the design it might be difficult to use IFRs to produce fissile material for weapons or it might be simple − and some IFR advocates promote designs that would (inadvertently) be ideal for weapons production.

Prof. Brook acknowledges that his advocacy of 'Generation IV' fast reactors is sometimes a smokescreen for the promotion of conventional reactors: "Although it's not made abundantly clear in the article, I'm actually increasingly of the view that Gen III+ reactors will have a major role to play in large-scale nuclear deployment over the next two to three decades, to support the ramp up of the Gen IV fleet ... But making this point credibly in a short Op Ed like this would have left room for nothing else, and also would have risked been seen as 'same old, same old' by the nuclear power fence sitters (or those who are 'weak antis'). Hence an emphasis on Gen IV, to try to hook the fresh fish."

Prof. Brook states (5AA radio, 7 July 2009): "In terms of turning a nuclear fuel rod into a bomb, that's impossible … if you took a spent fuel rod from a reactor all you could do with it would be to irradiate a few worms in the dust, there's no way you can make a nuclear bomb out of it." That claim is false, as is this: "plutonium that comes out of reactors ... is contaminated with different isotopes of plutonium which means that even if you had all of the facilities available to you that the Manhattan bomb designers had, you still wouldn't be able to use it to create a nuclear bomb."

Prof. Brook states: "I'm not aware of any plutonium that has actually gone missing apart from the hyperbole of anti-nuclear groups claiming that it has."

However plutonium accounting discrepancies have been documented in the UK, Japan and elsewhere (although accounting discrepancies do not necessarily mean that diversion or theft has occurred). North

Korea has diverted plutonium from an 'experimental power reactor' to produce weapons. India has diverted plutonium from research reactors (and probably also power reactors) for weapons. Israel has diverted plutonium from its French-supplied research reactor for weapons. A small number of incidents of theft/smuggling of plutonium have been detected and reported (and there are probably other incidents which have not been detected or reported).

4. IONISING RADIATION AND CHERNOBYL

Prof. Brook states: "Prior to the Fukushima Daiichi accident, caused when a 14 metre tsunami crashed into a 40-year old power station in Japan, no member of the public had ever been killed by nuclear power in an OECD country."

However the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) has estimated the collective effective dose to the world population over a 50-year period of operation of nuclear power reactors and associated nuclear facilities to be two million person-Sieverts (it does not provide OECD figures separately). Applying a standard risk estimate (0.05 fatal cancers per Sievert of exposure to low-dose radiation) gives an estimated 100,000 fatalities. The International Atomic Energy Agency (IAEA) gives a collective effective dose figure of 400,000 person-Sieverts for "nuclear power production"[3] – five times lower than the UNSCEAR estimate. Notwithstanding the considerable uncertainties with the dose and risk estimates, and whatever the OECD/non-OECD breakdown, Prof. Brook's statement doesn't hold up.

Prof. Brook states that the linear no-threshold theory of radiation exposure and cancer causation is "discredited" and has "no relevance to the real world". However:

- The 2005 report of the Committee on the Biological Effects of Ionising Radiation (BEIR) of the US National Academy of Sciences states that: "The Committee judges that the balance of evidence from epidemiologic, animal and mechanistic studies tend to favor a simple proportionate relationship at low doses between radiation dose and cancer risk." The report further states that: "... the risk of cancer proceeds in a linear fashion at lower doses without a threshold and ... the smallest dose has the potential to cause a small increase in risk to humans."
- A study published in the Proceedings of the National Academy of Sciences (US) in 2003 concluded that "the most reasonable assumption is that the cancer risks from low doses ... decrease linearly with decreasing dose. ... Given that it is supported by experimentally grounded, quantifiable, biophysical arguments, a linear extrapolation of cancer risks from intermediate to very low doses currently appears to be the most appropriate methodology."
- And to give one other example (there are many), the most recent (2010) UNSCEAR report states that: "Radiation can simultaneously damage both strands of the DNA double helix, often resulting in breakage of the DNA molecule with associated complex chemical changes. This type of complex DNA damage is difficult to repair correctly, and even at low doses of radiation it is likely that there is a very small but non-zero chance of the production of DNA mutations that increase the risk of cancer developing. Thus, the current balance of available evidence tends to favour a non-threshold response for the mutational component of radiation-associated cancer induction at low doses and low dose rates."

Prof. Brook states: "The credible literature (WHO, IAEA) puts the total Chernobyl death toll at less than 60. The 'conspiracy theories' drummed up against these authoritative organisations rings a disturbingly similar bell in my mind to the crank attacks on the IPCC, NASA and WMO in climate science."

[3] IAEA Bulletin, Vol.38, No.1, 1996, 'Long Term Committed Doses from Man-Made Sources', http://foe.org.au/sites/default/files/Chernobyl%20600k%20p-Sv%20IAEA%20Bull.pdf

No study − by the World Health Organization, the IAEA or anyone else − estimates a Chernobyl death toll of less than 60. Indeed no study estimates a death toll of less than several thousand (although an UNSCEAR report, discussed below, declines to provide any estimate at all of the long-term cancer death toll). Prof. Brook is referring to studies by the UN Chernobyl Forum (PDF) and the World Health Organisation in 2005-06 which estimate up to 4,000 long-term cancer deaths among the higher-exposed Chernobyl populations and an additional 5,000 deaths among populations exposed to lower doses in Belarus, the Russian Federation and Ukraine. The Chernobyl Forum includes UN agencies such as the IAEA, UNSCEAR, and WHO.

A study published in the International Journal of Cancer in 2006 estimates 16,000 long-term cancer deaths from low-level radiation exposure from Chernobyl. Research published in 2006 by UK radiation scientists Ian Fairlie and David Sumner estimates 30,000 to 60,000 deaths. A 2006 scientific study commissioned by Greenpeace estimates a death toll of about 93,000.

Studies such as those listed above typically use a risk estimate derived from the linear no-threshold theory (LNT). There is uncertainty about the accuracy of the LNT-derived risk estimate in relation to low doses and low dose rates. However that does not mean − as many nuclear advocates state or imply − that the LNT-derived risk estimate overstates the true risk. It may be accurate or it may understate or overstate the true risk. Thus the BEIR report cited above states (p.6) that "combined analyses are compatible with a range of possibilities, from a reduction of risk at low doses to risks twice those upon which current radiation protection recommendations are based." Epidemiologists / statisticians deal with the uncertainty by providing a range of estimates based on 'confidence intervals' − in simple terms, the wider the estimate, the greater the confidence.

Another report (PDF) by UNSCEAR argues that the long-term cancer death toll from Chernobyl cannot be meaningfully estimated because of "unacceptable uncertainties in the predictions", i.e. the limitations of epidemiological studies, and the uncertainties of applying a risk estimate (e.g. based on the LNT theory) to the collective radiation dose estimate (e.g. the IAEA's collective dose estimate of 600,000 person-Sieverts[4]).

That approach is of no use to anyone who wants an estimate of the Chernobyl death toll, however uncertain. It sits uneasily with UNSCEAR's involvement in the Chernobyl Forum study which estimates a death toll of 4,000 among the higher-exposed populations. It sits uneasily with UNSCEAR's view that "the current balance of available evidence tends to favour a non-threshold response for the mutational component of radiation-associated cancer induction at low doses and low dose rates."Another problem is that many nuclear advocates (such as Prof. Brook's colleague Ben Heard) repeatedly misrepresent UNSCEAR by conflating UNSCEAR's unknown long-term cancer death toll with a long-term cancer death toll of zero − obviously they are two very different propositions.

5. SAFETY AND FUKUSHIMA

Prof. Brook states that "nuclear power is the safest energy option". Nuclear power safer than wind and solar? He could only arrive at that unlikely conclusion by using the nuclear industry's 'methodology':

- only consider accidents at nuclear power plants rather than accidents across the nuclear fuel chain;
- understate the death toll from accidents by several orders of magnitude (see the above discussion regarding Chernobyl);
- only consider accidents rather than routine emissions (see the above discussion regarding the collective effective dose to the world population);
- ignore the greatest hazard associated with nuclear power − its repeatedly-demonstrated connection to WMD proliferation (most recently with North Korea's use of an 'experimental power reactor' to

[4] IAEA Bulletin, Vol.38, No.1, 1996, 'Long Term Committed Doses from Man-Made Sources', http://foe.org.au/sites/default/files/Chernobyl%20600k%20p-Sv%20IAEA%20Bull.pdf

produce plutonium for weapons) and related problems such as conventional military strikes against nuclear plants (which has been a recurring problem in the Middle East since 1980 and may spread to other parts of the world, especially if a nuclear power renaissance eventuates), nuclear terrorism and sabotage, and nuclear theft and smuggling. Can anyone imagine Israel destroying wind turbines in Iran or Iraq, or the US inflicting long-lasting public health hazards in Iraq with depleted wind munitions, or terrorists stealing solar panels, or North Korea building secret solar water heating systems, or Pakistan's A.Q. Khan network stealing and on-selling designs for energy-efficient buildings?

There is a compelling case for tighter regulation and greater public scrutiny of the nuclear power industry, yet Prof. Brook states: "The UK wisely plans to cut through this red tape by reducing planning permission times from seven to one year, and vetoing the right of local authorities to block construction." Yet the US Atomic Energy Commission has noted that public participation in reactor licensing processes is of clear benefit: "Public participation in licensing proceedings not only can provide valuable assistance to the adjudicatory process, but on frequent occasions demonstrably has done so." The US Nuclear Regulatory Commission has endorsed that view and listed specific examples of improved outcomes as a result of public participation.[5]

Fukushima

As the Fukushima nuclear disaster unfolded in March 2011, Prof. Brook maintained a running commentary in the media and on his BNC website insisting that the situation was under control and that there was no reason for concern.

On March 12, Prof. Brook said: "There is no credible risk of a serious accident".

That afternoon, as nuclear fuel meltdown was in full-swing, he said: "The risk of meltdown is extremely small, and the death toll from any such accident, even if it occurred, will be zero. There will be no breach of containment and no release of radioactivity beyond, at the very most, some venting of mildly radioactive steam to relieve pressure. Those spreading FUD [fear, uncertainty and doubt] at the moment will be the ones left with egg on their faces. I am happy to be quoted forever after on the above if I am wrong… but I won't be. The only reactor that has a small probability of being 'finished' is FD unit 1. And I doubt that, but it may be offline for a year or more."

There was no correction from Prof. Brook until after he had been publicly held to account for those statements.

Later on March 12, after the explosion in the reactor #1 building, Prof. Brook said: "When the dust settles, people will realise how well the Japanese reactors − even the 40 year old one − stood up to this incredibly energetic earthquake event."

On the morning of March 13, he said: "I don't see the ramifications of this as damaging at all to nuclear power's prospects" and that "it will provide a great conversation starter for talking intelligently to people about nuclear safety." Yet the Japanese government's Investigation Committee (PDF) found that TEPCO's preparations for and protections against a disaster were "quite inadequate". TEPCO failed to prevent an easily preventable disaster. Every step of TEPCO's response to the disaster was "a day late and a dollar short" according to a former vice-chairman of Japan's Nuclear Safety Commission. The Fukushima disaster has further exposed long-standing patterns of corruption and collusion in Japan's nuclear industry.

[5] Lochbaum, David, 2004, 'U.S. Nuclear Plants in the 21st Century', Union of Concerned Scientists, www.ucsusa.org/assets/documents/nuclear_power/nuclear04fnl.pdf, pp.8-9

Then Prof. Brook was congratulating himself on his 'just the facts' approach in media interviews. He pondered: "What has this earthquake taught us? That it's much, much riskier to choose to live next to the ocean than it is to live next to a nuclear power station." However the impacts of the earthquake, tsunami and nuclear disaster have been cumulative and areas affected by the nuclear disaster stretch much further inland than areas reached by the tsunami.

On March 14, when the second explosion at Fukushima occurred, Prof. Brook was still insisting that "the nuclear reactors have come through remarkably well".

One contributor to the discussion on the BNC website said: "Unfortunately, Prof. Brook has really abdicated a neutral position on this event. His clear support of nuclear power seems to have impacted his critical thinking skills. ... Every time he states something in this crisis is 'impossible', it seems to happen the next day."

Prof. Brook wrote an ABC opinion piece in December 2011 which states that "no-one was killed by radioactivity from the event" but is silent on the problem of long-term cancer deaths from exposure to radioactive fallout from Fukushima. One preliminary estimate is that Fukushima will result in "around 1000" fatal cancers, another preliminary estimate is "~100s cases". The long-term cancer death toll may rise significantly if large numbers of people resettle in contaminated areas (which is not to say that people should not have that option). Tens of thousands of Japanese people are grappling with a dilemma that never should have been forced upon them − whether to (eventually) return to live in contaminated areas or to permanently abandon their old homes.

6. TERRA NULLIUS

Near-complete silence from Prof. Brook about the racism that is common in the nuclear industry and he has provided no constructive, concerted action − or any action at all − to help redress the problems.

Coalition and Labor governments have targeted Muckaty in the NT for a national radioactive waste dump for low- and intermediate-level waste despite the clear opposition of most Traditional Owners. Key legislation has been overridden (the Aboriginal Heritage Act) or side-stepped (the Aboriginal Land Rights Act). Democratic rights of all Australians are being tossed aside with legislation (PDF) allowing the Minister to override any state/territory laws (and a raft of Commonwealth laws) in order to push ahead with the dump.

Resources minister Martin Ferguson has refused countless requests to meet with Traditional Owners opposed to the dump. They are challenging the dump plan in the Federal Court. Muckaty Traditional Owner Dianne Stokes says: "All along we have said we don't want this dump on our land but we have been ignored. Martin Ferguson has avoided us and ignored our letters but he knows very well how we feel. He has been arrogant and secretive and he thinks he has gotten away with his plan but in fact he has a big fight on his hands."

The silence from nuclear advocates is not only disappointing in and of itself, it is also counter-productive from their pro-nuclear-power standpoint. It is highly unlikely that nuclear power will be developed in Australia for so long as there are compelling reasons to believe that racism and undemocratic thuggery will be the 'principles' informing nuclear waste management, as is the case with the Muckaty plan, the previous plan to dump on Aboriginal land in SA, and the 'clean up' of radioactive waste at Maralinga in the 1990s.

Prof. Brook side-steps the problem by promoting 'next generation' reactors that could potentially leave a much smaller waste legacy − but he himself has acknowledged that he aims to "hook the fresh fish" with his promotion of 'next generation' reactors and that he supports the construction of a fleet of conventional reactors.

The uranium mining industry is another case in point. In the mid-1990s, Olympic Dam mine owner WMC Resources used divide-and-rule tactics against Traditional Owners leading to one person being accidentally shot dead, extensive violence and several people being imprisoned. Some of the company executives responsible for that atrocity are still involved in the industry. The 1982 SA Roxby Downs Indenture Act, which sets the legal framework for the operation of the Olympic Dam mine, was amended in 2011 but it retains exemptions from the SA Aboriginal Heritage Act (and from environmental protection laws as well). Traditional Owners were not even consulted. The SA government's spokesperson in Parliament said: "BHP were satisfied with the current arrangements and insisted on the continuation of these arrangements, and the government did not consult further than that." Silence from Prof. Brook despite the fact that he is well placed to be raising these concerns, for example during his presentations at uranium industry conferences.

On the treatment of the Mirarr Traditional Owners in the NT (Ranger mine and Jabiluka deposit), see: http://mirarr.net/duress1.htm.

On the treatment of Adnyamathanha Traditional Owners (Beverley and Beverley Four Mile mines), see: http://yurabila.wordpress.com

7. RADIOACTIVE WASTE

Some comments from an article by Ben Heard and Barry Brook (BH/BB) and my responses.

BH/BB: "The best start for responsible management of any hazardous waste is to capture and contain it at the source. Nuclear power does this."

About one-third of the spent fuel produced in power reactors has been reprocessed and this results in considerable releases of radioactive materials (it is "environmentally dirty" according to the Deputy Director General of the World Nuclear Association). Then there are accidents and leaks − for example in April 2005 it was revealed that 83,000 litres of highly-radioactive liquid containing dissolved spent nuclear fuel (and 160 kgs of plutonium) had leaked from the THORP reprocessing plant in the UK, and the leak went undetected for at least eight months.

Uranium mine tailings waste isn't captured and contained, nor is the liquid waste from in-situ leach mining.

Hanford, Dounreay, Sellafield, Chelyabinsk/Mayak − these are synonymous with environmental pollution as a result of serious, protracted nuclear waste management problems.

BH/BB: "[R]adioactive waste is perceived as complex. This is far from the truth. Radioactive material is one of the most predictable, easily monitored and best understood forms of waste. We know what it does, and how it does it, forever, and we manage it accordingly."

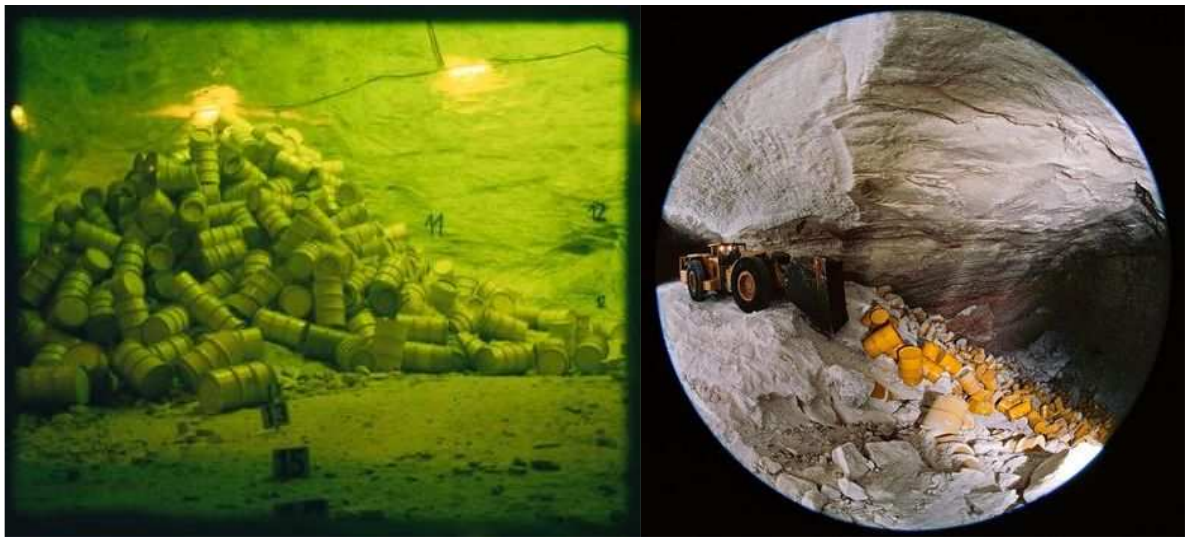
Obviously there is no experience with the management of high-level nuclear waste over periods of centuries or millenia let alone "forever". Research continues to throw up surprises, e.g. colloidal migration of plutonium, and studies from the Äspö Hard Rock Laboratory in Sweden suggesting that copper-encapsulated canisters will corrode much faster than previously expected.

BH/BB: "The material in Dry Cask Storage at Fukushima bore the full brunt of the tsunamis, with no damage."

True, but the spent fuel in the reactor buildings was responsible for a significant fraction of the radioactive releases.

BH/BB: "The image of the leaky, rusty barrel being stuffed into a tree by Mr Burns is, quite appropriately, a joke."

Here are two photos of the Asse radioactive waste dump in north-western Germany − 126,000 barrels of radioactive waste are being exhumed.



BH/BB: "[T]he quantities in question are relatively very small. ... A large-scale 25 GW nuclear power industry would add a mere 50 tons, taking up just 250 m3 (six-and-a-half standard shipping containers)."

BH/BB ignore waste streams across the nuclear fuel cycle − mine tailings waste, depleted uranium, etc. Over a 50-year lifespan, a 25 GW nuclear power industry would be responsible for:

- 900 million tonnes of low-level radioactive tailings waste − assuming the uranium came from the Olympic Dam mine in SA. (If the uranium came from in-situ leach mines, there would be no tailings waste but there would be many aquifers polluted with radionuclides, heavy metals and acid.)
- 215,000 tonnes of depleted uranium waste, a by-product of the uranium enrichment process.
- 37,500 tonnes of high-level nuclear waste (spent fuel).
- 375,000 cubic metres of low-level and intermediate-level waste.

(The Switkowski report is the basis for most of the above calculations. The figure on tailings waste comes from BHP Billiton's literature regarding the Olympic Dam open-cut mine plan.)

The figures for one reactor (1 GW) for one year are: 720,000 tonnes of radioactive tailings waste (Olympic Dam), 170 tonnes of depleted uranium waste, 30 tonnes of high-level nuclear waste (spent fuel) and 300 cubic metres of low-level and intermediate-level waste.

Volume and mass are not the only parameters to consider. High-level nuclear waste (spent fuel) produced in power reactors around the world contains enough plutonium to build about 200,000 nuclear weapons. Heat generated by high-level nuclear waste is another concern.

The interesting part of the BH/BB article (and of Prof. Brook's nuclear advocacy generally) concerns fast reactor technology. In theory fast reactor technology is attractive (potentially consuming more waste and weapons-useable material than the reactors produce) but in practice it has been highly problematic − fast reactor programs have contributed to several nuclear weapons programs; they have been leak-prone, fire-prone, and accident-prone; and there are multi-billion-dollar white elephants such as the French Superphenix fast reactor. (On fast reactor technology see this report (PDF) by the

International Panel on Fissile Materials, and on the WMD proliferation risks associated with the 'integral fast reactors' championed by Prof. Brook see here.)

Likewise the theory of conventional reprocessing is attractive but in practice it has been highly problematic.

Keeping in mind the distinction between theory and practice is essential to understanding Prof. Brook's nuclear advocacy. He conflates theory and practice, for example claiming that Friends of the Earth and Greenpeace "ignore technological developments that solve the long-lived nuclear waste problem (it is burned as energy in fast spectrum reactors)." And much of his nuclear advocacy involves making questionable and untestable claims about non-existent reactor types, in particular 'integral fast reactors', while at the same time ignoring and trivialising the highly problematic track record of fast reactor technology.

BH/BB conclude their fast reactor promo: "So nuclear waste stops being a major headache, and turns into an asset. An incredibly valuable asset, as it turns out. In the US alone, there is 10 times more energy in already-mined depleted uranium (about 700,000 tonnes) and spent nuclear fuel, just sitting there in stockpiles, than there is coal in the ground. This is a multi-trillion dollar, zero-carbon energy resource, waiting to be harnessed."

Nuclear utilities around the world disagree − they are keen to dump their nuclear waste in Australia or anywhere else that will take it and they are prepared to pay billions of dollars to get rid of it. In theory, nuclear waste is a multi-trillion dollar asset; in reality it is a multi-billion dollar liability.

More information on nuclear waste: www.choosenuclearfree.net/waste

8. THE RESPONSIBLE NUCLEAR ADVOCATE

Perhaps a new species will evolve over time − the responsible nuclear power advocate. For the time being we're stuck with nuclear advocates who − with few exceptions − do nothing to try to improve the inadequate nuclear safeguards system, who do nothing about the racism of the industry they support, who do nothing about inadequate regulation, and so on. They do however spend an inordinate amount of time attacking NGOs who are working constructively to address those problems.

To give one specific example, a number of NGOs made detailed, constructive contributions to the 2009 parliamentary 'Inquiry into Nuclear Non-proliferation and Disarmament' (e.g. Friends of the Earth, Australian Conservation Foundation, Medical Association for Prevention of War and others). You'd struggle to find a single constructive contribution from nuclear advocates. The Australian Uranium Association set the tone by spending the first part of its submission trying to convince the parliamentary committee to ignore the issue of safeguards altogether, and the so-called Australian Safeguards and Non-proliferation Office was peddling its usual misinformation about 'strict' safeguards 'ensuring' peaceful use of Australian uranium.

The problems are touched upon in this letter published in *The Advertiser* on 18 November 2009:

> *Old-style spin*
>
> *Barry Brook promotes what he optimistically labels "next generation" reactors with old-style spin ("Follow Britain's lead on nuclear power", The Advertiser, 10/11/09).*
>
> *For example, he repeatedly has claimed the non-existent "integral fast reactors" he champions "cannot be used to generate weapons-grade material". Unfortunately, that simply is not true. Worse still, Brook persists with that claim although he knows it has been contradicted by,*

among others, a scientist with hands-on experience working on a prototype integral fast reactor in the US.

Brook and other promoters of "next generation" reactors have another credibility problem. They acknowledge the need for a rigorous safeguards system to prevent the use of peaceful nuclear facilities to produce weapons of mass destruction, and they acknowledge the existing safeguards fall well short of being rigorous.

None of them, however, is willing to get off his backside to support important, ongoing efforts to strengthen safeguards. This simply is irresponsible. Moreover, it is hypocritical for Brook to criticise Friends of the Earth and other groups which have worked long and hard to strengthen safeguards − with absolutely no help from such people as him.

Brook also berates Friends of the Earth for failing to acknowledge "technological developments that solve the long-lived nuclear waste problem". Those developments, however, involve another non-existent technology, called pyroprocessing.

South Korea recently announced its intention to embark on a research and development program which aims to provide a "demonstration" of the viability of operating reactors in conjunction with pyroprocessing by the year 2028. That is almost 20 years − just to demonstrate the concept.

Brook offers nothing but false and extravagant claims based on non-existent technology. We deserve better.

− Jim Green, Friends of the Earth, Melbourne, Victoria.

9. CONCLUSION

Many people concerned about climate and energy are wrestling with some enormous dilemmas:

- Coal burning is a major cause of climate change, and efforts to develop 'clean coal' technology have been half-hearted and progress has been glacial.
- Widespread nuclear power proliferation will run the WMD proliferation risks "off the reasonability scale" as Al Gore puts it. There is no reason to believe that the industry will seriously improve its performance on this front − it refuses even to address relatively simple problems such as stopping the stockpiling of separated plutonium. There is no reason to believe that fast reactor technology will come to the rescue − attractive theories notwithstanding − given that fast reactor programs have to date contributed to several WMD proliferation programs (e.g. India, France, Yugoslavia) without contributing in any way to the resolution of any WMD proliferation problems anywhere.
- Renewables are generally benign but there are limitations to consider (and hopefully overcome through concerted R&D) and interrelated cost issues.

Some people live in a parallel universe where global warming is a myth, or clean coal technology is just around the corner.

Some people live in a parallel universe where a global transition to renewables is simple, cheap, and potentially quick.

Prof. Brook lives in a parallel universe where nuclear power is benign − the WMD connection is trivialised, nuclear waste is a multi-trillion-dollar asset, nuclear power is the safest energy source, low-level ionising radiation is harmless, Chernobyl killed less than 60 people, 'integral fast reactors' can't produce fissile material for weapons, reactor-grade plutonium can't be used in weapons, and problems such as inadequate safeguards and the (further) disempowerment of Aboriginal people are ignored.