NUCLEAR POWER & CLIMATE CHANGE

DEBUNKING THE MYTHS

Choose Nuclear Free www.choosenuclearfree.net
an initiative of
the Medical Association for Prevention of War www.mapw.org.au
the International Campaign to Abolish Nuclear Weapons www.icanw.org.au
and Friends of the Earth, Australia www.foe.org.au/anti-nuclear

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1. SUMMARY

The nuclear option does not make sense on any level: economically, environmentally, politically or socially. It is too costly, too dangerous, too slow and has too small an impact on global warming.
-- Prof. Ian Lowe, 2007, 'Reaction time: climate change and the nuclear option', www.abc.net.au/news/stories/2007/09/14/2032596.htm

"There are serious problems that have to be solved, and they are not limited to the long-term waste-storage issue and the vulnerability-to-terrorist-attack issue. Let's assume for the sake of argument that both of those problems can be solved. We still have other issues. For eight years in the White

House, every weapons-proliferation problem we dealt with was connected to a civilian reactor program. And if we ever got to the point where we wanted to use nuclear reactors to back out a lot of coal − which is the real issue: coal − then we'd have to put them in so many places we'd run that proliferation risk right off the reasonability scale. And we'd run short of uranium, unless they went to a breeder cycle or something like it, which would increase the risk of weapons-grade material being available."
-- Al Gore, 2006, Grist Magazine, <www.grist.org/article/roberts2>

Nuclear power has no part in a climate-friendly, sustainable future for the following reasons:

Nuclear power is a blunt instrument: Building 12 reactors in Australia would reduce emissions by 8% if they replaced coal-fired plants yet reductions ten times as large are required. Doubling global nuclear power output at the expense of coal would reduce emissions by just 5%. Those figures are halved if nuclear power displaces gas, and there is no reduction in greenhouse emissions if nuclear power displaces renewable energy sources. In any realistic nuclear expansion scenario, nuclear power makes only a modest contribution to climate change abatement – and then only if we assume that nuclear power displaces fossil fuels.

There are better options: Global renewable energy capacity – mostly hydroelectricity – already exceeds nuclear capacity. Energy efficiency measures are capable of generating large reductions in greenhouse emissions and can do so more cheaply and quickly than nuclear power – therefore, investing in nuclear power instead of energy efficiency measures exacerbates and accelerates climate change. Renewable energy sources can also be deployed more rapidly than nuclear power, and credible clean energy scenarios have been developed which sharply reduce emissions from the electricity sector without recourse to nuclear power (see www.choosenuclearfree.net/clean)

Cost: Nuclear power is more expensive than some (but not all) renewable energy sources. Nuclear power is typically a far more expensive means of reducing greenhouse emissions than energy efficiency measures.

Greenhouse emissions: Claims that nuclear power is 'greenhouse free' are false. Nuclear power is more greenhouse intensive than some renewable energy sources and most energy efficiency measures. Life-cycle greenhouse emissions from nuclear power will increase as relatively high-grade uranium ores are mined out.

Too slow: Expanding nuclear power is impractical as a short-term response to the need to urgently reduce greenhouse emissions. The industry does not have the capacity to rapidly expand production as a result of 20 years of stagnation. Limitations include bottlenecks in the reactor manufacturing sector, the dwindling and ageing workforce, and the considerable time it takes to build a reactor and to pay back the energy debt from construction.

Weapons of Mass Destruction: There is a long history of peaceful nuclear programs providing political cover and technical support for nuclear weapons programs. An expansion of nuclear power is likely to exacerbate the problem. Other risks include catastrophic accidents, terrorism and sabotage, nuclear theft and smuggling, and conventional military strikes on nuclear plants.

Nuclear-induced climate change: A regional nuclear war involving 100 Hiroshima-size bombs – a tiny fraction of the global arsenal – would directly result in catastrophic climate change.

Nuclear power *and* climate change: Countries and regions with a high reliance on nuclear power also tend to have high greenhouse gas emissions. For example, the US operates 104 power reactors, accounting for around 20% of its electricity, yet the US is one of the world's worst greenhouse polluters both in *per capita* and overall terms.

Consequences of climate change for nuclear hazards: Nuclear power plants around the world have already experienced many problems caused by phenomena which are likely to become more frequent and more severe as a result of climate change − in particular flooding and severe storm events. The nuclear industry has been very slow to address these problems.

Developing nuclear power in order to increase fossil fuel exports: Some countries are planning to replace fossil fuel-fired power plants with nuclear power in order to increase fossil fuel exports. In such cases the potential climate change benefits of nuclear power are lost.

Environmentalists do not support nuclear power: There is a widespread perception that there is a considerable degree of support for nuclear power among environmentalists. However the evidence leads to the opposite conclusion: there is strong and unwavering environmental opposition to nuclear power – and that includes environmental organisations primarily concerned with climate change.

2. NUCLEAR POWER IS NO PANACEA

"Saying that nuclear power can solve global warming by itself is way over the top".
-- Senior IAEA energy analyst Alan McDonald, quoted in The Independent, 28 June, 2004.

Summary: The potential for nuclear power to reduce greenhouse emissions is often overstated. Building 12 reactors in Australia would reduce our emissions by 8% if they replaced coal-fired plants yet reductions ten times as large are required. Doubling global nuclear power output at the expense of coal would reduce emissions by just 5%. In any realistic nuclear expansion scenario, nuclear power makes only a modest contribution to climate change abatement – and then only if we assume that nuclear power displaces fossil fuels.

The Switkowski (2006) report found that even a major nuclear power program in Australia – 25 reactors coming online from 2020 to 2050 – would reduce emissions by a modest 17% relative to business-as-usual (assuming nuclear displaces black coal). The Switkowski report found that 12 reactors coming online from 2025-2050 would reduce emissions by 8% relative to business-as-usual (assuming nuclear displaces black coal).

By extrapolation, a more modest (and realistic) program of six power reactors would reduce Australia's overall emissions by just 4% if they displaced coal.

All of the above figures are approximately halved if nuclear power displaces gas-fired power plants: 25 reactors would reduce emissions by 8.5%, 12 reactors would reduce emissions by 4% and 6 reactors would reduce emissions by just 2%.

Greenhouse emissions from renewable energy sources vary but are typically similar to nuclear power. Thus, displacing renewables with nuclear power does not generate any reductions in greenhouse emissions whatsoever. If nuclear power displaces those renewable energy sources that are less greenhouse intensive than nuclear power and/or the many energy efficiency measures which are less greenhouse intensive than nuclear power, nuclear power will result in increased greenhouse emissions.

Doubling global nuclear power output by mid-century at the expense of coal would reduce greenhouse emissions by about 5%. (The basis for that calculation is as follows: the Uranium Information Centre claims that a doubling of nuclear power would reduce greenhouse emissions from the power sector by 25% (Hore-Lacy, 2006). But that figure falls to just 7.5% if considering the impact on overall emissions rather than just the power sector as electricity generation accounts for about 30% of global anthropogenic greenhouse emissions (30% of 25% = 7.5%). If we assume that the doubling of nuclear power takes some decades and that global emissions increase by 50%, the overall reduction in greenhouse emissions is just 5%. If global emissions double over the period of time that it takes to double nuclear output, the emissions reduction of 7.5% would be halved to 3.75%.)

A much larger expansion of nuclear power would have a greater impact on greenhouse emissions to the extent that it displaced fossil fuels. But the weapons proliferation risks would also grow. The Intergovernmental Panel on Climate Change maps out a scenario whereby nuclear capacity would grow to about 3,300 gigawatts in 2100 (approximately nine times more than current capacity as at 2010), and the accumulated plutonium inventory would rise to 50-100 thousand tonnes (IPCC, 1995). That amount of plutonium would suffice to build 5−10 million nuclear weapons.

The safeguards challenge is still greater as a result of the practice of plutonium stockpiling. Japan's plutonium stockpiling, for example, clearly fans proliferation risks and tensions in north-east Asia. Diplomatic cables in 1993 and 1994 from US Ambassadors in Tokyo questioned the rationale for the stockpiling of so much plutonium since it appeared to be economically unjustified. A 1993 diplomatic cable posed these questions: "Can Japan expect that if it embarks on a massive plutonium recycling program that Korea and other nations would not press ahead with reprocessing programs? Would not the perception of Japan's being awash in plutonium and possessing leading edge rocket technology create anxiety in the region?" (Greenpeace, 1999)

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3. GREENHOUSE EMISSIONS FROM NUCLEAR POWER AND URANIUM MINING

"If one takes into consideration the mining of resources, the transportation, the building and maintaining of nuclear power plants, the distribution of the electricity and the necessary additional production of heat, then nuclear power does often look worse for climate protection than other forms of energy production. A modern gas-fired power station in connection with heat production [co-generation] can be more favourable for the climate. Even better for the climate are renewable energies and most of all the efficient use of energy."
-- German Environmental Ministry, March 2006, 'Atomkraft: Ein teurer Irrweg. Die Mythen der Atomwirtschaft'.

Summary: Claims that nuclear power is 'greenhouse free' are false. Nuclear power is more greenhouse intensive than some renewable energy sources and most energy efficiency measures. Life-cycle greenhouse emissions from nuclear power will increase as relatively high-grade uranium ores are mined out and gradually give way to the mining of lower-grade ores.

The following table is taken from the Switkowski report (2006, p.93), based on commissioned research:

Technology	Emissions intensity (grams CO_2-equivalent /

	Kilowatt-hour	
	Best estimate	**Range**
Brown coal (subcritical)	1175	1011–1506
Black coal (subcritical)	941	843–1171
Black coal (supercritical)	863	774–1046
Natural gas (open cycle)	751	627–891
Natural gas (combined cycle)	577	491–655
Solar photovoltaics	106	53–217
Nuclear (light water reactor)	60	10–130
Wind turbines	21	13–40
Hydro (run-of-river)	15	6.5–44

Greenhouse emissions arise across the nuclear fuel cycle – uranium mining, milling, conversion, and enrichment; reactor construction, refurbishment and decommissioning; and waste management (e.g. reprocessing, and/or encasement in glass or cement). In addition, transportation is extensive – for example, Australian uranium may be converted to uranium hexafluoride in Canada, then enriched in France, then fabricated into fuel rods in Japan, and the spent fuel may be reprocessed in the UK or France resulting in plutonium, uranium and waste streams which may be subject to further international transportation.

Academic Benjamin Sovacool (2008) states that the front end of the nuclear fuel cycle (uranium mining, milling, and enrichment) is responsible for 38% of the emissions of the entire nuclear fuel cycle; plant construction is responsible for 12%; decommissioning and plant operation, including the use of fossil-fueled generators to backup nuclear plants when they offline for servicing, account for 35%; and the back end of the fuel cycle, which includes storing spent fuel and fuel conditioning, accounts for 15%.

Sovacool (2008) states: "To provide just a rough estimate of how much equivalent carbon dioxide nuclear plants emit over the course of their lifecycle, a 1,000 MW reactor operating at a 90 percent capacity factor will emit the equivalent of 1,427 tons of carbon dioxide every day, or 522,323 metric tons of carbon dioxide every year. Nuclear facilities were responsible for emitting the equivalent of some 183 million metric tons of carbon dioxide in 2005. Assuming a carbon tax of $24 per ton − nothing too extreme − and that 1,000 MW nuclear plant would have to pay almost $12.6 million per year for its carbon-equivalent emissions. For the global nuclear power industry, this equates to approximately $4.4 billion in carbon taxes per year."

Life-cycle greenhouse emissions from nuclear power will increase as relatively high-grade uranium ores are mined out and gradually give way to the mining of lower-grade ores. Metals and mining consultancy firm CRU Group (2009) calculates that the average grade of uranium projects at the feasibility study stage around the world is 35% lower than the grades of current mines, and that exploration projects have average grades 60% below existing operations.

The extent of the increase in the greenhouse intensity of uranium mining is the subject of debate and considerable uncertainty. It depends not only on declining ore grades but also on other variables such as the choice of tailings management options at uranium mines. Nuclear power is already more greenhouse intensive than some renewable energy sources (wind, hydro) and is likely to become more greenhouse intensive than solar PV (indeed it already is according to some studies − see Sovacool 2008b). Emissions from nuclear power could possibly rise to the extent that they would be equivalent with those from an efficient gas-fired plant.

In a paper prepared for the Australian Uranium Association, Sydney University academic Manfred Lenzen (2009) concludes that life-cycle greenhouse gas emissions for nuclear power range from 10−130 g/kWh with the main variables being ore grades, enrichment technology (gaseous diffusion is highly greenhouse intensive, centrifuge enrichment less so), reactor fuel re-load frequency and burn-up, and to a lesser extent enrichment level, plant lifetime, load factors, and enrichment tails assay. Lenzen calculates a "worst case" – 0.01% ore grade, 75% load factor, 25 year lifetime, only diffusion enrichment, and a carbon-intensive background economy – resulting in emissions of 248 g/kWh.

Others calculate still higher values, for example by assuming energy- and emissions-intensive burial of large volumes of low-level ore, waste rock, and mill tailings, rather than the current practice of surface storage.

Dr Mark Diesendorf from the University of NSW argues: "In the case where high-grade uranium ore is used, CO2 emissions from the nuclear fuel cycle are much less than those of an equivalent gas-fired power station. But the world's reserves of high-grade uranium are very limited and may only last a few decades. The vast majority of the world's uranium is low-grade. CO2 emissions from mining, milling and enrichment of low-grade uranium are substantial, and so total CO2 emissions from the nuclear fuel cycle become greater than or equal to those of a gas-fired power station."

GREENHOUSE EMISSIONS AND URANIUM MINING

"So the real choice is between nuclear power and a mix of renewable energy technologies combined with efficiency measures. If that is the choice, it would take creative arithmetic to make a case that our uranium is doing anything at all to save the world from climate change. I would be more impressed by the integrity of those arguing for us to export uranium to slow global warming if they were also calling for us to reduce our coal exports. Australia could do much more to help the global atmosphere by cutting our coal exports than we could by the most fanciful estimate of the potential benefits from our uranium. Of course, many of those urging uranium exports are also in the vanguard of calls to export even more coal than we do today. This shows that they are actually more interested in the short-term economic benefits of mineral exports than in any effect on the global environment."
-- Prof. Ian Lowe, September 7, 2007, 'Heeding the warning signs', Sydney Morning Herald, <www.smh.com.au/news/national/heeding-the-warning-signs/2007/09/06/1188783415604.html>

The uranium industry and its supporters often claim that Australia's uranium exports are responsible for large reductions in greenhouse emissions. To give one example, the Australian Uranium Association (2010) claims that current annual exports of around 10,000 tonnes "help avoid around 400 million tonnes of greenhouse gases that would otherwise be emitted each year by fossil-fuelled power stations."

However that argument assumes that uranium and nuclear power displaces coal-fired plants – an arbitrary and unlikely assumption and one which is too infrequently made explicit. Australia's uranium exports are not responsible for any reduction of greenhouse emissions if simply displacing uranium from other sources (ignoring marginal variations in the emissions intensity of different mines). Moreover, uranium mining companies want to take credit for the alleged greenhouse benefits of uranium exports but not for the WMD proliferation risks or the high-level nuclear waste legacy.

Emissions (or alleged emissions savings) from the end use of Australia's energy exports are not counted in Australia's greenhouse emissions figures. If they were, the accounting would include emissions-intensive fossil fuel exports as well as uranium. Companies such as BHP Billiton want to take credit for the alleged emissions 'savings' from their uranium exports but accept no responsibility for emissions from the burning of their fossil fuel exports.

Some companies with financial interests in both uranium and fossil fuels have been vocal climate change sceptics and have used political donations, corporate front groups and a myriad of other tactics to prevent action being taken to address climate change by reducing fossil fuel usage. WMC Ltd., the former owner of the Olympic Dam mine, is one notorious example (Green, 2002).

While indirect or end-use emissions from energy exports are not factored into Australia's greenhouse accounts, the direct emissions associated with uranium mining do count in Australia's emissions accounting. For the proposed Olympic Dam mine expansion, BHP Billiton (2009) projects that emissions will increase from 1.14 million tonnes (Mt) annually to at least 5.24–5.84 Mt annually by 2020. An independent assessment by Dr Gavin Mudd (2009) from Monash University estimates emissions of 4.5–6.6 Mt. Thus the mine expansion will make it all but impossible for South Australia to reach its legislated target of 13 Mt of greenhouse emissions annually by 2050 as Olympic Dam alone will account for one-third to one-half of the target.

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More information:

* Gavin M. Mudd and Mark Diesendorf, 2008, 'Sustainability of Uranium Mining and Milling: Toward Quantifying Resources and Eco-Efficiency', Environ. Sci. Technol., 42 (7), 2624–2630, <http://pubs.acs.org/cgi-bin/sample.cgi/esthag/2008/42/i07/html/es702249v.html>.

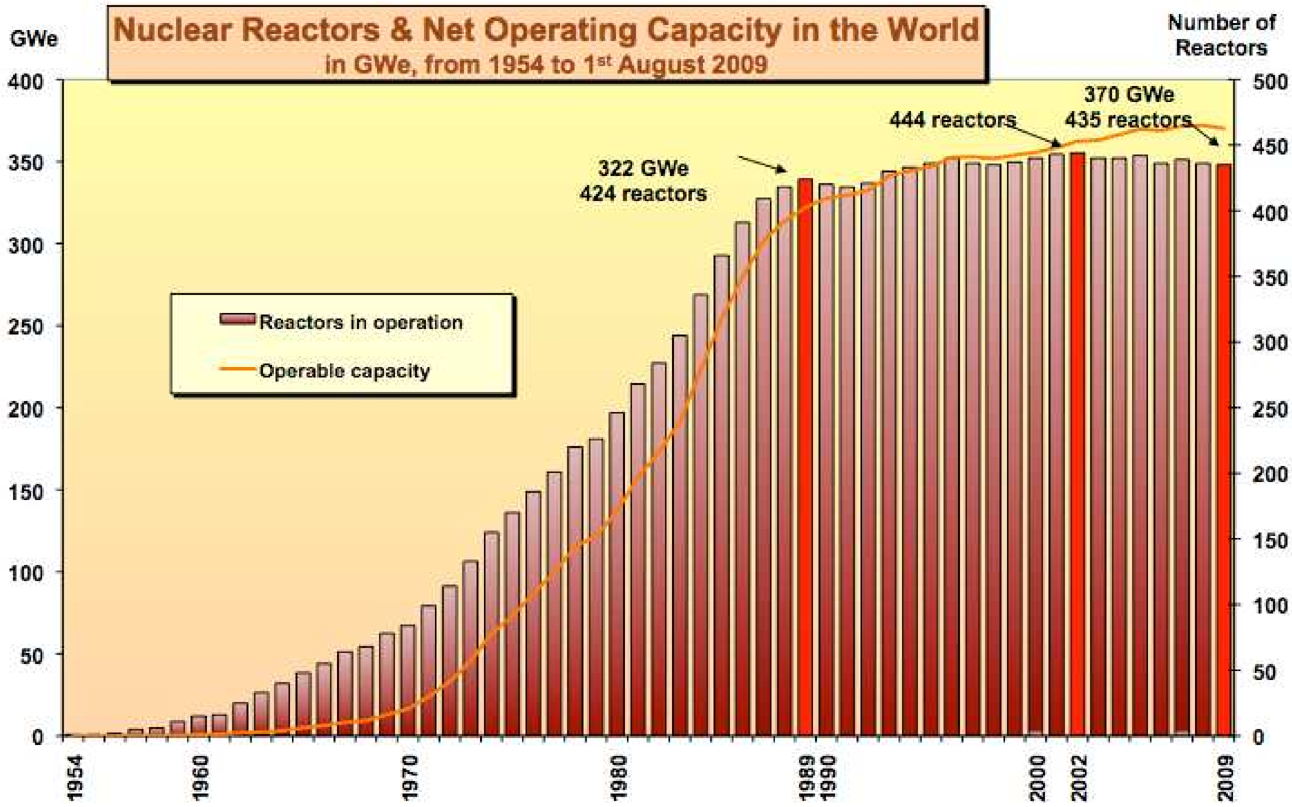
4. NUCLEAR POWER – A SLOW RESPONSE TO AN URGENT PROBLEM

"The Switkowski report says at least 10 and possibly 15 years would be a realistic time scale for building one nuclear power station in Australia. It would take more time still to "pay back" the energy used in construction and fuelling, so it would take 15 to 20 years for any such station to make any contribution to cutting greenhouse pollution. Fifteen to 20 months is a more realistic time scale for

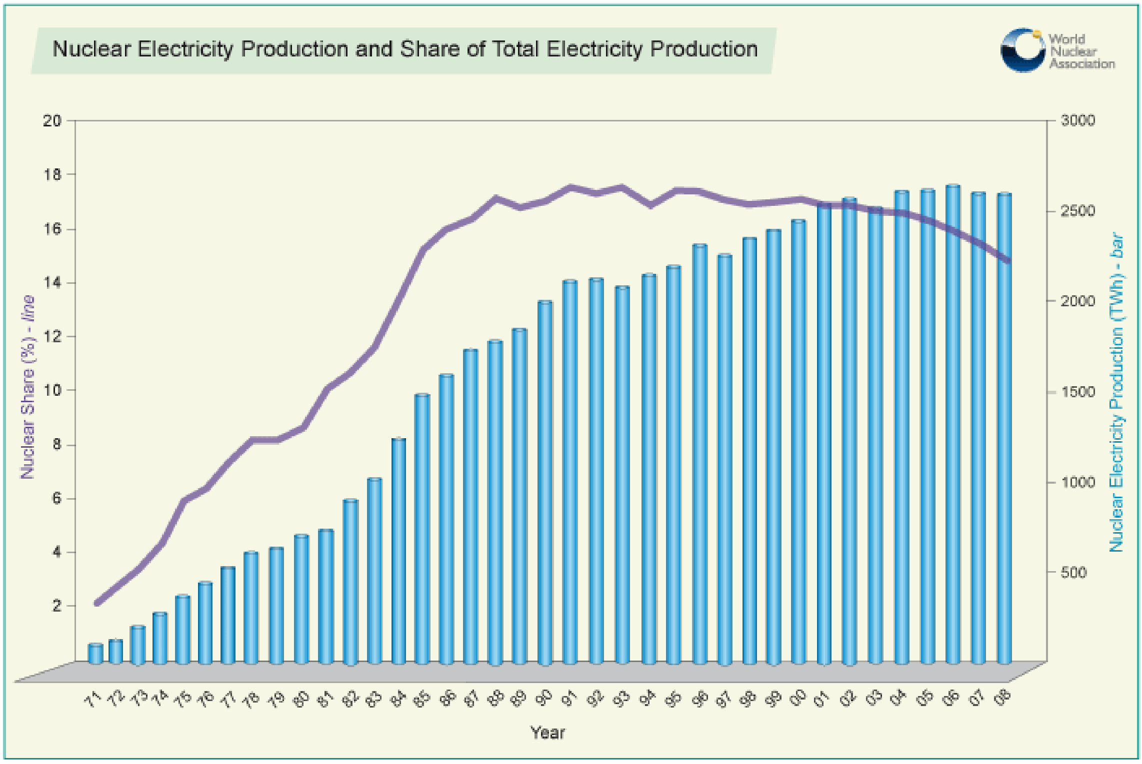
large-scale renewables. Global warming is an urgent problem that demands a concerted response now, not a half-baked response after 2020."
-- Prof. Ian Lowe, September 7, 2007, 'Heeding the warning signs', Sydney Morning Herald, <www.smh.com.au/news/national/heeding-the-warning-signs/2007/09/06/1188783415604.html>

Summary: Expanding nuclear power is impractical as a short-term response to the need to urgently reduce greenhouse emissions. The industry does not have the capacity to rapidly expand production as a result of 20 years of stagnation. Limitations include bottlenecks in the reactor manufacturing sector, dwindling and ageing workforces, and the considerable time it takes to build a reactor and to pay back the energy debt from construction.

Nuclear power generating capacity has been stagnant for the past 20 years as the following two graphs illustrate:



Source: Mycle Schneider et al., 2009, 'The World Nuclear Industry Status Report 2009', <www.bmu.de/english/nuclear_safety/downloads/doc/44832.php>.



Source: World Nuclear Association <www.world-nuclear.org/info/inf01.html>

In recent years:
* In 2007 world nuclear electricity generation fell by 2% – more than in any other year since the first reactor was connected to the grid in 1954. (Schneider et al., 2009)
* In 2008 not a single new plant was connected to the grid – the first time that happened since 1955; and uprates were offset by plant closures resulting in a net world nuclear capacity decline of about 1.6 gigawatts. (Schneider et al., 2009; BP, 2009)
* In 2009 there were two reactor start-ups but four permanent shut-downs and net capacity fell by 0.86 gigawatts. (World Nuclear News, 2010)
* In 2010, new nuclear capacity entering commercial operation amounted to 2839 MWe net − an increase of 0.7%. (World Nuclear News, 2011)

A large, short-term increase in nuclear power generation is impossible for the following reasons.

One constraint is the considerable time it takes to build reactors. An average construction timespan is nine years based on the 14 most recent grid connections as at late 2009 (Schneider et al., 2009). There is great variation in reactor construction times, from five years to well over 20 years.

Construction delays are common. Schneider et al. (2009) noted in late 2009 that of the 45 reactors then under construction around the world, 22 had encountered construction delays and 13 had been listed as under construction for over 20 years.

For Australia and other countries without existing nuclear power plants, the lead time for planning, licensing and construction would likely take 15-25 years. As Prof. Ian Lowe (2007) notes: "[N]uclear power is far too slow a response to the urgent problem of climate change. Even if there were political agreement today to build nuclear reactors, it would be at least 10 years before the first such reactor could deliver electricity, while some have suggested that between 15 and 25 years is a more realistic estimate. We can't afford to wait decades for a response given the heavy social, environmental and economic costs that global warming is already imposing. If we were to start today expanding the use of solar hot water in Queensland to cover half the households in that state – a similar level to the Northern Territory – we could save about as much electricity as a nuclear power station would provide, and do it years before any reactor would be up and running.

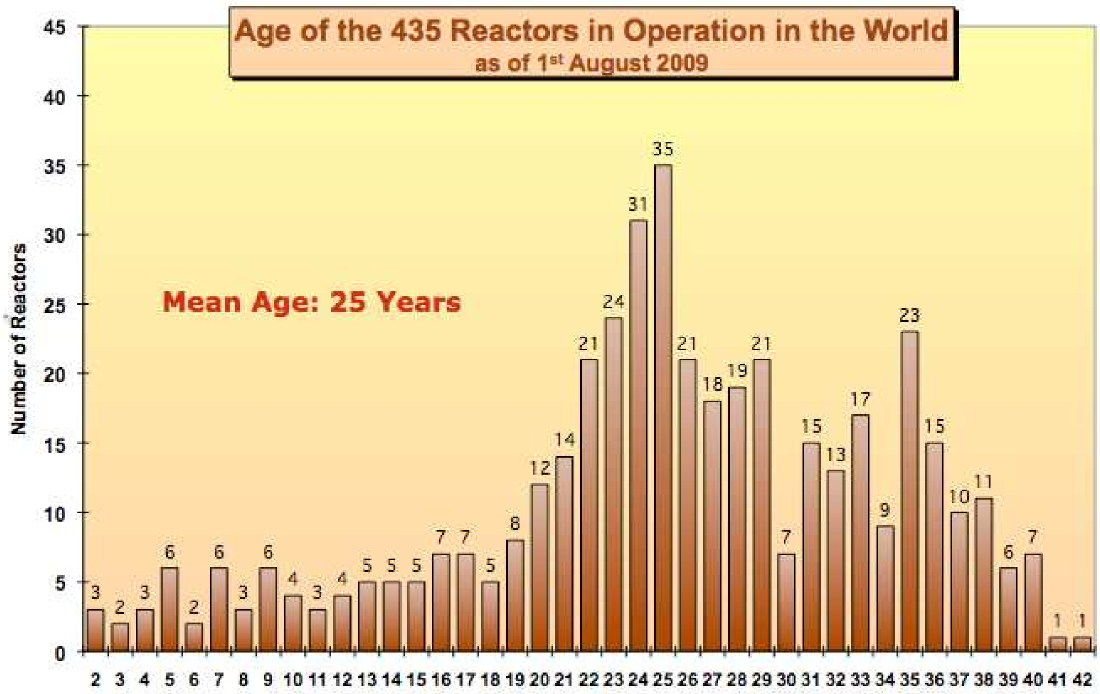
In addition to reactor construction, some further years elapse before nuclear power has generated as much as energy as was expended in the construction of the reactor. A report commissioned by the Switkowski Review states that: "The energy payback time of nuclear energy is around 6½ years for light water reactors, and 7 years for heavy water reactors, ranging within 5.6–14.1 years, and 6.4–12.4 years, respectively." (University of Sydney, 2006) By contrast, construction times for renewable energy sources are typically months not years, and likewise the energy pay-back period is typically months not years.

Another constraint is bottlenecks in the reactor manufacturing sector. (Schneider et al., 2009, section II.5; Ferguson, 2007). Squassoni (2009) notes that: "A significant expansion will narrow bottlenecks in the global supply chain, which today include ultra-heavy forgings, large manufactured components, engineering, and craft and skilled construction labor. All these constraints are exacerbated by the lack of recent experience in construction and by aging labor forces. Though these may not present problems for limited growth, they will certainly present problems for doubling or tripling reactor capacity."

Another constraint is the general pattern of ageing nuclear workforces. In addition, research and training facilities and courses have been on the decline. (Schneider et al., 2009, section II.6).

Another constraint is that significant new build will be required simply to maintain existing nuclear generating capacity let alone to expand that capacity. The reason is that the global fleet of reactors is ageing. The mean average age of operating reactors is 25 years, older than the average age of all shut-down reactors – 22 years. By the year 2019, 135 reactors will have operated for 40 years or more. In the following decade no less than 216 reactors – more than half of the global fleet – will have their 40th birthday (apart from those that are shut down before that time). In total, 351 reactors – over 80% of the current global fleet of 436 reactors – will be at least 40 years old by 2029.

The average lifespan of reactors currently operating or under construction is a matter of considerable uncertainty. Schneider et al. (2009) assume 40 years and they note that the OECD's World Energy Outlook 2008 estimates a 40-50 year time frame with an average 45 years expected operation.



Source: Mycle Schneider et al., 2009, 'The World Nuclear Industry Status Report 2009', <www.bmu.de/english/nuclear_safety/downloads/doc/44832.php>.

Reactor databases show growing numbers of reactors listed as 'under construction', 'on order or planned' and 'proposed'. However a very large number of reactor projects have been cancelled over the years – at least 253 cancelled orders in 31 countries, including 138 cancellations in the US alone (Schneider et al., 2009).

'Next generation' or 'generation 4' reactors are still far off. For example the Generation 4 International Forum website states that "commercial deployment of Gen-IV reactors is not foreseen before 2030 at the earliest, and all current activities involving Gen-IV designs are at the level of R&D." The World Nuclear Association (2009b) is also downbeat, noting that "progress is seen as slow, and several potential designs have been undergoing evaluation on paper for many years."

Uranium resources

Nuclear power expansion is impractical as a short-term response to the need to urgently reduce greenhouse emissions. A significant expansion of nuclear power is theoretically possible over the medium- to long-term. However a major expansion of nuclear power may be constrained by limited uranium reserves. According to the World Nuclear Association (2009), "the world's present measured resources of uranium (5.5 Mt) in the cost category somewhat below present spot prices and used only in conventional reactors, are enough to last for over 80 years."

There are numerous ways to extend the 80 year period – new uranium discoveries, mining higher-cost conventional uranium deposits not included in the above calculations, more efficient use of uranium in conventional reactors, greater use of uranium from reprocessing plants, re-enrichment of depleted uranium, etc. It can be reasonably anticipated that conventional uranium resources can be stretched to 200-300 years at the current rate of consumption. Nevertheless those resources would be exhausted much more rapidly in the event of a major expansion of nuclear power. For example, they could be depleted by the end of this century in the event of a three-fold increase in nuclear power. Unconventional uranium sources (e.g. phosphate, seawater) could further extend uranium resources. Other options to extend the use of nuclear power include the use of alternative nuclear fuels or nuclear fuel cycles (e.g. fast neutron reactors or thorium-fuelled reactors).

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5. NUCLEAR-INDUCED CLIMATE CHANGE

Summary: Recent research demonstrates that severe global climatic consequences would follow a limited regional nuclear war involving 100 Hiroshima-size bombs targeting cities.

Prof. Alan Robock from Rutgers University and Prof. Brian Toon from the University of Colorado summarise recent research on the climatic impacts of nuclear warfare:

> *A nuclear war between any two countries, each using 50 Hiroshima-sized atom bombs, such as India and Pakistan, could produce climate change unprecedented in recorded human history. This is less than 0.05% of the explosive power of the current global arsenal.*
>
> *Nuclear arsenals with 50 nuclear weapons can produce a global pall of smoke leading to global ozone depletion. The smoke, once in the stratosphere, heats the air, which speeds up reactions that destroy ozone, and also lofts reactive chemicals by altering the winds.*

More information:
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6. NUCLEAR POWER *AND* CLIMATE CHANGE

Summary: Countries and regions with a high reliance on nuclear power also tend to have high greenhouse gas emissions. For example, the US operates 104 power reactors, accounting for around 20% of its electricity, yet the US is one of the world's worst greenhouse polluters both in per capita and overall terms.

Nuclear analyst Mycle Schneider notes that countries and regions with a high reliance on nuclear power also tend to have high greenhouse gas emissions. While his paper was written 10 years ago the general arguments still hold:

> *The largest generators of nuclear power also have energy sectors with the highest CO2 emissions. Western Europe and the United States produce about two-thirds of the nuclear electricity in the world [yet] their energy sectors also produce 39% of the world's energy-related CO2 emissions.*
>
> *The same analysis applies to overall CO2 emissions per country or region. There is an interesting correlation between nuclear generation and CO2 emissions. The United States alone, [with] less than 5% of the world's population, accounts for 25% of the world's total CO2*

emissions and generates 29.4% of the world's nuclear electricity. Western Europe, with only 6.5% of the world's population accounts for about 15% of global CO2 emissions and 34% of the nuclear power production.

China is the counter example. With 21.5% of the world's population, the country emits 13.5% of global CO2 and generates 0.6% of the world's nuclear power. The example of China illustrates well the potential role of energy efficiency in greenhouse gas abatement. Analysis of developments between 1980 and 1997 shows that while the country reduced its CO2 emissions through penetration of "carbon-free fuel" by hardly more than 10 million tonnes of carbon, the reduction due to energy efficiency measures delivered savings of more than 430 million tonnes of carbon over the same period.

Projections for Germany, produced by Prognos, suggest that while nuclear power output is expected to decrease by 40% by 2020, CO2 emissions per kilowatt-hour are expected to decrease significantly (probably by around 20% or more). This is not only because of a lower coal content in the fuel mix, but also especially because of an expected 22% decrease in the energy intensity of the German economy.

It seems obvious that there is no forced correlation between a high level of nuclear generation and low CO2 emissions of a given country. So far France is the exception. France is also the most nuclear-intensive country in the world, apart from Lithuania. France operates 59 nuclear reactors that produce 75% of its electricity while nuclear plants represent about 55% of the installed capacity. At the same time, France has a relatively low level of greenhouse gas emissions. The question is therefore justified whether a combined policy of nuclear power and energy efficiency is a possible alternative over the long run and whether it is cost efficient.

A recent major study carried out by the French national planning commission (Commissariat général au plan) which looked into three different scenarios ("market oriented", "industrial", "environmental") came up with some interesting results:
** even in the "environmental" scenario, France's final energy consumption would increase by 9% by 2020 (compared to a reduction of at least 5% projected by Prognos for Germany);*
** the scenario with the lowest greenhouse gas emissions is not the most nuclear and "there is no evident correlation, even in France, between emissions and nuclear power", according to Benjamin Dessus, Chairman of the Long Term Working Group undertaking the study.*

Reference:
* Schneider, Mycle (WISE Paris), April 2000, "Climate Change and Nuclear Power", published by World Wide Fund for Nature, <www.panda.org/downloads/climate_ change/fullnuclearreprotwwf.pdf>.

7. CONSEQUENCES OF CLIMATE CHANGE FOR NUCLEAR HAZARDS

Hirsch et al. (2005, section D2) document numerous examples of problems experienced at nuclear plants by phenomena which are likely to become more frequent and more severe as a result of climate change − in particular flooding and severe storm events. These events can directly jeopardise the safe operation of nuclear plants and can lead to intermediary problems with safety implications, such as electrical grid failure. Grid failure raises another problem − emergency power systems at nuclear plants using diesel generator are notoriously trouble-prone.

Hirsch et al. (2005) state: "In spite of the fact that the hazards of climate change are becoming more and more obvious, safety reassessments and improvements generally are only implemented – if at all –

after an event occurred. This practice is aggravated by the fact that an event in one [nuclear power plant] does not necessarily lead to backfits in another plant, let alone to backfits worldwide."

Reference:
* Hirsch, Helmut, Oda Becker, Mycle Schneider and Antony Froggatt, April 2005, "Nuclear Reactor Hazards: Ongoing Dangers of Operating Nuclear Technology in the 21st Century", Report prepared for Greenpeace International,
<www.greenpeace.org/international/press/reports/nuclearreactorhazards>

8. DEVELOPING NUCLEAR POWER TO INCREASE FOSSIL FUEL EXPORTS

Some countries are planning to replace fossil fuel-fired power plants with nuclear power in order to increase fossil fuel exports. In such cases the potential climate change benefits of nuclear power are lost. World Nuclear News (2010) reports that Venezuela, Russia, and some Middle East countries such as the UAE and Iran would prefer to export oil and gas rather than use them in domestic power plants.

Reference:
* World Nuclear News, 11 November 2010, 'Venezuela puts nuclear over oil', <www.world-nuclear-news.org/NN_Venezuelas_puts_nuclear_over_oil_1111101.html>

9. ENVIRONMENTALISTS DO NOT SUPPORT NUCLEAR POWER

There is a widespread perception that there is a considerable degree of support for nuclear power among environmentalists. Typically such claims refer to people such as James Lovelock and Greenpeace founder Patrick Moore. Yet Lovelock is a self-confessed eccentric who has always supported nuclear power. Moore has been on the payroll of corporate polluters for the past two decades and is currently funded by the Nuclear Energy Institute − a connection which is rarely made explicit in media commentary.

Beyond the dubious examples of Lovelock and Moore, there is precious little support for nuclear power among environmentalists (Friends of the Earth, 2007). Tim Flannery is held up as an Australian pro-nuclear environmentalist. Flannery has made pro-nuclear and anti-nuclear statements, and he has said that: "What I know about uranium you could write on the back of a postage stamp." (Blue, 2008)

In 2006, Channel 9's 'Sunday' program in Australia hosted a debate on nuclear power including someone claiming to be a representative of 'Environmentalists for Nuclear Energy', who acknowledged that the organisation has no existence in Australia and that to the best of his knowledge the organisation has no other supporters in Australia. Yet this phantom group gets a platform on a national, televised debate! This highlights one feature of the 'pro-nuclear environmentalist' phenomenon – it is to a considerable extent media-driven. For every self-described pro-nuclear environmentalist there are at least as many people who have shifted in the opposite direction – but this is not considered newsworthy.

A micro-party called 'Environmentalists for Nuclear Energy' was formed in 2009 but it was deregistered in April 2010. Despite claims by the party that it had more than 600 members, the Australian Electoral Commission found that it did not have the minimum of 500 members required to maintain federal registration. The party was previously known as Conservatives for Climate and Environment and was described by Labor strategists as a "Coalition front organisation". (Dorling, 2010)

There is abundant evidence of strong and unwavering environmental opposition to nuclear power – and that includes many environmental organisations primarily concerned with climate change. The Climate Action Network, an international network of 340 non-governmental organisations, opposes nuclear power and has waged an ongoing battle against proposals to subsidise nuclear power through Kyoto Protocol mechanisms and other avenues such as international financial institutions and export credit agencies. Likewise, in June 2005 a statement from over 270 environmental groups was released rejecting nuclear power as a 'solution' to climate change (<www.nirs.org>).

In Australia, a December 2010 statement opposing nuclear power was endorsed by all major national environment groups, all state conservation councils, and key climate groups such as Climate Action Network Australia. (www.choosenuclearfree.net/energy/joint-statement)

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* Blue, Tim, 25 January 2008, 'Save the world - but you can still have fun', The Australian.
* Dorling, Philip, 7 April 2010, 'Pro-nuclear party runs out of energy', <www.canberratimes.com.au/news/local/news/general/pronuclear-party-runs-out-of-energy/1796166.aspx>
* Friends of the Earth, 2007, 'Environmentalists Do Not Support Nuclear Power: Critique of James Lovelock and Patrick Moore', <www.foe.org.au/anti-nuclear/issues/nfc/power/nuke-enviros/view>

10. REPORTS ON THE NUCLEAR POWER AND CLIMATE CHANGE DEBATE

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