



Nuclear Power

Unsustainable, Uneconomic, Dirty and Dangerous

Commission on Sustainable Development CSD-14

Energy for Sustainable Development

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EXECUTIVE SUMMARY

The world needs safe, clean and affordable renewable energy. The Johannesburg Plan of Implementation (JPOI) called for energy that is “reliable, affordable, economically viable, socially acceptable and environmentally sound”. Nuclear power does not meet these criteria.

The dilemma between building nuclear power or suffering the effects of climate change is a false dilemma. Nuclear energy is slow to build, dirty, dangerous and expensive. Nuclear energy, with its inflexibility, generation of waste, inherent danger and security implications, as well as its hidden costs, undermines economic development, social development and environmental protection. Investments of human and economic resources are far better placed into energy efficiency and the numerous renewable technologies available to guarantee the right to safe, clean and affordable energy. In diverting resources from sustainable and renewable energy, investment in nuclear energy and associated subsidies would erect obstacles to sustainable energy.

Problems with reactor safety, radioactive waste management, the proliferation of fissile material and life cycle cost all mean that nuclear power has no place in the energy mix. Resources and efforts must instead go to the clean and renewable energy and energy efficiency technologies, which have shown remarkable growth since 2000.

Rather than to include nuclear power in the ‘mix’, countries need to focus on implementing the commitments made in the World Summit in September 2005 to take action to promote clean energy and energy efficiency and conservation, accelerate the development and dissemination of affordable and cleaner energy efficiency and energy conservation technologies, and promote and support greater efforts to develop renewable sources of energy, such as solar, wind and geothermal. Nuclear power is a problem, not a solution, as recent analyses such as the UK’s Sustainable Development Commission (SCD) show. The SCD gave a unanimous ‘no’ to the question ‘Is nuclear the answer to tackling climate change or energy security?’ Their reasons included long-term waste, cost, inflexibility, undermining energy efficiency and international security issues, including accidents, terrorism and nuclear proliferation.

Nuclear energy relies on subsidies, including underwriting for construction cost or caps on construction costs, operating performance, non-fuel operations and maintenance cost, nuclear fuel cost and decommissioning cost, liability caps and guarantees that the output will be purchased at a guaranteed price. Usually absent from consideration are decommissioning costs, the long-term costs of dealing

with waste and external costs such as environmental damage, effects on human health and social costs. Nuclear power plants are particularly risky for developing countries, with exposure to cost overruns, downtime, the cost of dealing with waste and dependence on foreign technology. Nuclear power is quite simply the wrong answer, and would divert scarce resources from investing in renewable energy and energy efficiency.

Both the JPOI and the World Summit speak of economic development, social development and environmental protection as interdependent and mutually reinforcing pillars. Renewable energy is reinforcing of these themes, while nuclear energy undermines them all. Investment of human and economic resources would be far better placed into renewable energy and energy efficiency from all perspectives. We now have numerous renewable technologies available to guarantee the right to safe, clean and affordable energy: energy which is reliable, affordable, economically viable, socially acceptable and environmentally sound.

INTRODUCTION

The world needs safe, clean and affordable renewable energy. The Johannesburg Plan of Implementation (JPOI)¹ calls for action to improve access to “reliable, affordable, economically viable, socially acceptable and environmentally sound” energy. This analysis assesses nuclear power against each of these criteria in turn and the conclusion is clear: nuclear power is not an acceptable source of energy for sustainable development.

It is clear from both the JPOI and the World Summit held in September 2005 that clean and renewable energy is vital to all themes of CSD-14: energy for sustainable development²; industrial development³; air pollution⁴; and, climate change.⁵ Efficient renewable energy is the only source that can advance each of these goals.

The JPOI and the World Summit⁶ also argue for the need to integrate the three components of sustainable development — economic development, social development and environmental protection — as interdependent and mutually reinforcing pillars.⁷ Renewable energy has the inherent capacity to advance all these goals. It is a cross-cutting theme running through them all. Nuclear energy, on the other hand, undermines them, with its cost, inflexibility, generation of waste, inherent danger and security implications. Moreover, consideration of nuclear energy must weigh the opportunity costs: every dollar invested in nuclear is a dollar that could be invested in the solutions – clean and renewable energy. In the context of these sustainable development criteria, it is clear that human and economic resources are best invested into renewable energy and energy efficiency.

Economic development, social development and environmental protection are interdependent and mutually reinforcing and fundamental principles of sustainable development.⁸ These principles, together with those of peace, security, economic justice, and human rights, require that the right to safe, clean and affordable energy be recognized and implemented. Nuclear power is neither necessary nor capable of meeting the world’s energy needs. Renewable technologies, in contrast, are available to implement the right to affordable energy – cleanly, safely and sustainably.

ENERGY IN THE CSD

The need for clean energy was made clear at the September 2005 World Summit held in New York. Countries then committed to:

- Take action to promote clean energy and energy efficiency and conservation,⁹
- Accelerate the development and dissemination of affordable and cleaner energy efficiency and energy conservation technologies,¹⁰ and
- Promote and support greater efforts to develop renewable sources of energy, such as solar, wind and geothermal.¹¹

The World Summit particularly highlighted the shipment of nuclear materials,¹² and the JPOI pointed to the problems of nuclear waste, including shipments of nuclear material.¹³

In the JPOI, countries agreed to take joint actions and improve efforts to work together at all levels to improve access to reliable and affordable energy services for sustainable development to achieve the Millennium Development Goals. States also called for the implementation of CSD-9 recommendations and conclusions, which did not include references to nuclear power.¹⁴ In CSD-9 in 2000, the Group of Experts stated that acceptable responses be found to the ongoing concerns of reactor safety, radioactive waste management, proliferation of fissile material and life cycle cost.¹⁵ Acceptable responses have not been found to these inherent and intractable problems, particularly those stemming from nuclear waste. Consequently, there is no place in the energy mix for nuclear power.

Decision 9/1 of CSD-9¹⁶ observed that energy is central to achieving the goals of sustainable development and, while repeating the mantra of ‘advanced fossil fuel technologies’, noted that renewable energy sources such as wind, solar, wave, biomass, fuel cells and hydrogen were supported by all participants.¹⁷ The Decision was highly equivocal on nuclear power. While noting that nuclear power currently accounts for 16 per cent of the world’s electricity generation,¹⁸ the Decision noted that nuclear energy is associated with a number of concerns, regarding nuclear safety, spent fuel, waste management, transboundary consequences and decommissioning.¹⁹ Decision 9/1 made the following recommendations:²⁰

Governments, taking into account their national circumstances, are encouraged to:

- a. Support their national efforts, including research, and international cooperation as an effective tool in addressing the issues of nuclear safety and spent fuel and waste management;
- b. Strengthen independent national regulatory agencies and promote international cooperation in nuclear safety;
- c. Promote a high level of nuclear safety;
- d. Improve the transparency of nuclear safety-related decisions, inter alia, through public participation, where appropriate;
- e. Promote public education and participation as well as capacity-building of human resources, in the areas of nuclear energy and waste management;

- f. Further develop technological solutions for long-lived radioactive waste;
- g. Address the safety of their nuclear energy installations, as deemed appropriate, after assessment by national regulatory authorities, including consideration of the option of phasing out and closing, as appropriate, such installations;
- h. Recalling paragraph 8 of the Governing Council of the International Atomic Energy Agency (IAEA) resolution GC (44)/RES/17 and taking into account the very serious potential for environment and human health impacts of radioactive wastes, make efforts to examine and further improve measures and internationally agreed regulations regarding safety, while stressing the importance of having effective liability mechanisms in place, relevant to international maritime transportation and other transboundary movement of radioactive material, radioactive waste and spent fuel, including, inter alia, arrangements for prior notification and consultations done in accordance with relevant international instruments.

These recommendations express significant apprehensions with nuclear power. The concerns are well founded: the intervening years have only underscored that nuclear power does not – and cannot – meet the JPOI criteria of “reliable, affordable, economically viable, socially acceptable and environmentally sound” energy services.²¹ The JPOI further calls²² for development and dissemination of alternative energy technologies, in order to give a greater share of the energy mix to renewable energies, improving energy efficiency and greater reliance on advanced energy technologies. On all these fronts, renewable energy and energy efficiency present a clear and viable way forward.

Clearly, more needs to be done to increase the share of renewable energies in the mix. This year, the Secretary-General’s report points to 19 new nuclear power plants commissioned since 2000, and cites “public apprehensions about the safety, proliferation, terror risks and waste disposal of nuclear reactors” as ongoing constraints on expansion.²³ We should note that these are substantial constraints and that the public apprehensions are well founded. In addition, we must note the poor economic performance of many existing power plants²⁴

It is not appropriate for nuclear energy to be included in the ‘mix’. The deliberate effort to legitimize nuclear energy by placing it in lists of “broad based energy mixes” or “complex mixes of energy resources” is inappropriate and misplaced. Neither the grave threat of climate change, nor the nuclear industry’s opportunistic public relations efforts, can transform a problematic, expensive and unsafe industry into an acceptable and appropriate source of energy.

Significant expansion has occurred in the use of non-hydro renewable energy for power generation in all regions from 2000 to 2003,²⁵ with the Secretary-General’s report noting that under suitable conditions, with optimized system design, siting and resource availability, modern biomass, small hydropower, wind and geothermal plants can produce electricity in the cost range of US \$.02-.05 /kWh. Wind and solar photovoltaic energy each show an annual growth rate of 29%.²⁶

Renewable energies and efficiency are ready, they are viable and they are increasingly competitive.

- Every day, more energy falls on the US than it uses in an entire year, and every day more falls on the Earth than its 5.9 billion inhabitants use in 27 years²⁷
- Solar generated power could provide 10,000 times more energy than the world currently uses²⁸
- Sweden achieves 29% of its total energy supply from renewable energy, and 51% of its electricity (2001), compared to EU averages of 5,8% and 15.5% respectively.²⁹ 9% of US electricity comes

from renewable energy.³⁰ In California the figure is 27%.³¹ The US expects renewables to supply 6.7% total energy in 2030.

- Offshore wind in the North Sea has the potential to produce nearly twice the electricity needs of the North Sea countries. Realizing only 20% of that potential would supply one third of these countries electricity.³²
- One of the first solar thermal power plants built since the 1980s will come on line in 2007 at El Koraimat, near Cairo. In two decades, electricity from solar thermal power plants could be equivalent to that from 72 coal-fired power stations, supplying enough electricity each year for Israel, Morocco, Algeria and Tunisia combined.³³

The International Renewable Energy conference held in Beijing in December 2005 invited the CSD to consider an effective arrangement to review and assess progress towards substantially increasing the global share of renewable energy as foreseen in paragraph 20(e) of the JPOI,³⁴ stating that this would provide a long-term prospective and encourage prompt action. The Declaration emphasized the multiple benefits of increased energy efficiency and the use of renewable sources of energy for improving access to energy services. Renewables and efficiency could thus contribute to the eradication of poverty as called for in the UN Millennium Development goals (MDGs) – increasing job opportunities, improving air quality and public health, reducing greenhouse gas emissions and combating climate change, enhancing energy security, and offering a new paradigm for international co-operation.³⁵

Also crucial is a move towards decentralised energy systems, which are more secure, more efficient and create more jobs. Turning Britain's homes and workplaces into power stations with solar thermal, combined heat and power boilers, micro-wind and solar photo-voltaics could cut UK carbon emissions by at least 15%.³⁶ The British town Council of Woking has cut its emissions of carbon dioxide by almost 80% with such a system. Germany's potential for decentralized energy (CHP and RE) by 2050 is as high as 90%.³⁷

Nuclear Power is neither safe nor reliable

Some argue that Chernobyl was simply the result of poor Soviet design and cannot re-occur, and also that design and safety procedures have improved since 1986.³⁸ This does a great disservice to the tens of thousands of victims of Chernobyl³⁹ and attempts to minimize or justify the permanent contamination of food, land and water and ongoing genetic damage. It also is misplaced. The UK's Sustainable Development Commission Chair noted that "Chernobyl remains a powerful symbol of just how serious and long-lived the consequences of a nuclear accident can be, however 'remote' such a risk is."⁴⁰

There are numerous ongoing problems of reactor safety which include inherent safety flaws, the number of aging reactors, poor safety management, the storage of spent fuel and the threat of nuclear terrorism.⁴¹

In addition to Chernobyl, the Windscale fire, and Three Mile Island we must also note:

- Japan, as one of the largest operators of nuclear power, had its worst nuclear accident in 1999 at the Tokai-mura nuclear fuel plant when two workers received lethal doses of radiation; one year later, it was revealed that vital safety data and inspections had been manipulated at tens of reactors to avoid 'expensive' repairs and lengthy closure. Despite claims that the nuclear industry and government had adopted higher safety standards, in 2006 a district court ordered the shut down of a

nuclear reactor as it could not withstand severe earthquakes – all of Japan’s reactors are sitting on top of one of the world’s most active geological faults.

- The United States, with the world’s largest fleet of nuclear power plants, only just avoided a catastrophic accident at the Davis-Besse reactor in 2002, when it was discovered that corrosion had come very close to penetrating the vital pressure vessel – an accident scenario that can lead to a complete reactor core meltdown. Greenpeace ten years before had filed a complaint to the U.S. nuclear regulator warning of the risk of corrosion at all U.S. nuclear power plants. The warning was ignored; following the discovery at Davis-Besse, it was shut down for two years (costing US\$600 million), but then given a license to operate until 2017.
- In France, the nuclear safety agency activated its emergency response center in December 2003 in response to torrential rainfall along the lower Rhone River, following the emergency shut down of two reactors (Cruas-3 and –4) due to flood affected damage.
- In 2000, the UK Sellafield nuclear fuel processing site was found to have a fundamental failure of safety culture by Government inspectors – but only after public disclosure of violations of quality control and safety standards at its newest nuclear plant (Sellafield MOX Plant). Following British Nuclear Fuels’ falsification of quality-control checks on at least ten lots of uranium and plutonium mixed-oxide (MOX) cylindrical pellets,⁴² the Government of Ireland decided to launch a legal challenge against the UK government at the International Tribunal for the Law of the Sea in Hamburg on the issue of nuclear safety at Sellafield.
- In 1992, a steam line safety relief valve inadvertently opened in the Barsebäck-2 nuclear power plant in Sweden. The steam jet stripped fibrous insulation from adjacent piping system.⁴³ Part of that insulation debris was transported to the wetwell pool and clogged the intake strainers for the drywell spray system after about one hour. A serious accident might have been avoided just because the reactor wasn’t operating at full capacity when the accident happened.

These are just a few examples of the global and systemic nature of nuclear reactor problems.

Notwithstanding the threats posed by accidents, nuclear power facilities are also a security threat. They are attractive terrorist targets, and are vulnerable to the theft or diversion of fissile material.⁴⁴

Nuclear facilities, in particular spent fuel reprocessing facilities, also create pollution while they are operating. Liquid waste is discharged into the sea and gaseous waste is released into the atmosphere. This pollution is not only a cause for environmental concern but also for public health. When communities are exposed, workers are contaminated and sometimes even their families are exposed.

Every radiation exposure increases our risk of cancer. Research published in 2002 found that children of men exposed to radiation while working at Sellafield nuclear complex have twice the normal risk of developing certain types of cancer such as leukemia and non-Hodgkins lymphoma.⁴⁵

Nuclear Power is not an answer to climate change

Nuclear power is not the answer to tackling global climate change. In fact, it is a negative factor: resources spent on trying to advance nuclear power seriously detract from effective measures to reduce the threat of global warming, such as investments and supports for renewable energies and energy efficiency programs. A dollar invested in energy efficiency in the United States has been estimated to displace nearly seven times as much carbon dioxide as a dollar invested in nuclear power,⁴⁶ and nuclear power saves as little as half as much carbon per dollar as wind power and cogeneration.⁴⁷

Nuclear energy is resource-intensive, expensive, inefficient and dirty. Nuclear energy actually stands in the way of real solutions to climate change. The dilemma between building nuclear power or suffering the effects of climate change is a false dilemma, a public relations contrivance.

About 440 nuclear power stations provide approximately 6% of the global primary energy mix, as calculated by the IEA.⁴⁸ To even double this figure, over 1000 nuclear reactors would have to be on constructed within 25 years,⁴⁹ requiring approximately one reactor to be put into operation each one or two weeks, assuming to be starting this year – clearly not a feasible schedule. Each reactor would require a construction time of 5 to 9 years. In addition to the long construction lead times and limited industrial capabilities for building nuclear power plants and fuel-cycle facilities, any expansion of nuclear power would also involve extensive deployment of nuclear technology, including radioactive waste dump sites and fuel cycle facilities around the world and accompanying transportation of nuclear fuel and nuclear waste. In 2004, the International Atom Energy Agency presented its scenarios for the future of nuclear energy.⁵⁰ Ironically, the high-growth scenario that assumed higher growth for new nuclear reactors, rather than the low growth scenario, would also result in higher greenhouse gas emissions.

As one paper noted, “its higher cost than competitors, per unit of net CO₂ displaced, means that every dollar invested in nuclear expansion will worsen climate change by buying less solution per dollar.”⁵¹ Nuclear power is quite simply the wrong answer, and would divert scarce resources from investing in renewable energy and energy efficiency.⁵² An effective climate strategy – one that envisages timely and sustainable solutions – must, by necessity, preclude nuclear power.⁵³

The UK Sustainable Development Commission⁵⁴ asked the question ‘Is nuclear the answer to tackling climate change or energy security?’ Its answer was a clear ‘no.’ They found that even if the UK’s existing nuclear capacity were to be doubled, it would only yield an 8% cut in CO₂ emissions by 2035, and nothing before 2010. On the risk side, the Commission’s report identified five major disadvantages to nuclear power:

Long-term waste: safety over the long-term disposal of waste cannot be guaranteed;

- Cost: the economics of nuclear plants are highly uncertain, and the taxpayer may have to pay any shortfalls;
- Inflexibility: nuclear would lock the UK into a centralised distribution system, against growing opportunities for microgeneration and local distribution network;
- Undermining energy efficiency: a new nuclear programme would give out the wrong signal to consumers and businesses; and
- International security: plants internationally bring higher risks of accidents, radiation exposure, proliferation and terrorist attacks.

On balance, the Commission found that these problems outweigh any advantages of nuclear power.

When it comes to development, we know that the poorest peoples in the developing countries are the most vulnerable to climate change, and will be the hardest hit by its impacts. To compound this vulnerability by adding the nuclear risk – and call it a solution to their energy needs – is unconscionable.

Nuclear Power is not environmentally sound

Toxic materials and nuclear waste are produced at every stage of the nuclear fuel cycle, from uranium mining to the reprocessing of spent nuclear fuel, which causes cancer and genetic mutations. Much of this waste will remain hazardous for thousands or tens of thousands of years, imparting a deadly radioactive legacy to future generations.

One of the substances in spent nuclear fuel is plutonium. It is one of the most radiotoxic and dangerous substances in existence. A single microgram, smaller than a speck of dust, can cause fatal cancer if inhaled or ingested, while a sphere of plutonium smaller than a tennis ball can be used to make a nuclear bomb capable of killing many thousands of people.

There is no known way to permanently contain it or dispose of nuclear waste. Whilst a variety of disposal methods have been under discussion for decades, there is still no demonstrated method for isolating nuclear waste from the environment for adequate time periods.

The nuclear waste issue has become a real crisis for the nuclear industry. Over almost three decades, one waste proposal followed the other, either stemming from the International Atomic Energy Agency (IAEA) itself, or from groups of governments, the EU or even private groups. All failed on a combination of legal, political, technical and ethical factors.

Another important on-going problem posed by the nuclear industry is the shipment of radioactive waste and nuclear materials. Countries in the World Summit resolved on this issue:⁵⁵

- (o) To note that cessation of the transport of radioactive materials through the regions of small island developing States is an ultimate desired goal of small island developing States and some other countries and recognize the right of freedom of navigation in accordance with international law. States should maintain dialogue and consultation, in particular under the aegis of the International Atomic Energy Agency and the International Maritime Organization, with the aim of improved mutual understanding, confidence-building and enhanced communication in relation to the safe maritime transport of radioactive materials. States involved in the transport of such materials are urged to continue to engage in dialogue with small island developing States and other States to address their concerns. These concerns include the further development and strengthening, within the appropriate forums, of international regulatory regimes to enhance safety, disclosure, liability, security and compensation in relation to such transport.

This wording reflected the decision reached by Small Island States in the Mauritius Strategy⁵⁶ to implement the Barbados Programme of Action⁵⁷ for their sustainable development. The SIDS, including the Caribbean, the Pacific, and the AIMS (Atlantic, Indian Ocean, and Mediterranean and South China Seas) regions, were united in their opposition to the transport of radioactive material through their regions. These coastal States cannot be expected to sit idly by while shipments of nuclear waste and nuclear material are massively increased by the international community.

Nuclear power is neither affordable nor economically viable

Nuclear power is an expensive energy source, the true full costs of which are seldom adequately considered. Early hopes of cheap nuclear energy were based on an expectation that whilst nuclear power stations would be more expensive than fossil fuel plants, their running and maintenance costs would be extremely low. Experience has shown that the early optimism was badly misplaced.

Nuclear power stations are highly capital intensive and take years to construct. A 1000 megawatt light-water reactor plant can cost from US \$2-3 billion⁵⁸ or more or up to US \$2,000/kW.⁵⁹ When faced with such enormous figures, we must ask what renewable, clean, and democratic forms of energy could have been created with such resources. Nuclear power plants have taken longer than estimated to build and have been subject to many unforeseen technical problems, running costs have been much less

predictable than projected, and the costs of increased safety demands exceeded expectations. Current estimates range from 5-9 years.⁶⁰ All these factors are compounded by the enormously expensive cost of dealing with nuclear waste, the escalating cost of decommissioning nuclear power stations and the difficulty of estimating the costs of a nuclear accident.⁶¹

Meanwhile, renewable technologies are outstripping nuclear power in development and performance, while energy efficiency measures remain the most cost effective way to address the need for new power. New-build nuclear power has been estimated to cost about US 7 c /kWh,⁶² while wind power, other renewable sources and energy efficiency are getting cheaper.⁶³ A recent paper⁶⁴ found that efficiency gains plus decentralized sources already add far more capacity per year than nuclear power. By diverting scarce resources from renewable sources and energy efficiency, nuclear power far from solving the problems of energy shortages and climate change, will make the situation worse.

Nuclear power demands significant subsidies. Studies as recent as 2002 have concluded that in a liberalized electricity market, electric utilities will not build nuclear power plants without government subsidies and guarantees capping costs.⁶⁵ Government guarantees and subsidies could include underwriting for construction cost, operating performance, non-fuel operations and maintenance cost, nuclear fuel cost and decommissioning cost, as well as guarantees that the output will be purchased at a guaranteed price.

Subsidies include limited liability under international treaties – estimated to be worth some €20 billion a year for the EU-15.⁶⁶ If a nuclear operator were required to fully cover the potential cost of a nuclear accident, the cost of operating a nuclear power plant would increase significantly. Studies have suggested that if no ceiling was in place, insurance premiums to French operator EdF would increase the cost of generation by around €0.05 /kWh.⁶⁷ Additionally, the scale of costs from a nuclear accident such as Chernobyl, being in the tens or hundreds of billions of pounds, means that insurance cover may not even be available without the limitations offered by the limited liability conventions.⁶⁸

Nuclear power plants are particularly risky for developing countries, which are often unable to afford the cost overruns, down time and escalating cost of dealing with waste. They would pay the price for their nuclear power facilities in higher interest rates on their international loans and would increase their dependence on the west for technology and capital.⁶⁹

The true cost of any power source must include external costs.⁷⁰ Too often such costs do not appear on the operators' balance sheets. The external costs of nuclear power include the cost of environmental damage, the effect on human health and society following an accident, damage to human health and the environment during routine operation of nuclear facilities and also long term costs and problems associated with nuclear waste and decommissioning of nuclear facilities. No monetary compensation can make up for damage to the environment, to human health or to quality of life.

Apart from nuclear power's risks of accidents, inherent proliferation dangers, and problems with its waste, human and economic resources wasted on nuclear power will not be spent on renewable energy – which is cheaper and more effective in producing electricity and reducing carbon.

It must also be noted that the production of new generating capacity is not the only way of meeting the expanding demand for new power. The growth in demand for energy can and must be addressed directly through energy efficiency initiatives.

Nuclear power is not socially acceptable

The Asian Development Bank in 1995 cited “issues related to transfer of nuclear technology, procurement limitations, proliferation risks, fuel availability and procurement constraints, and

environmental and safety aspects” to justify its policy of non involvement in the financing of nuclear power generation.⁷¹ Proliferation is a problem that will not go away. The link between nuclear power and nuclear weapons is well known and is one of the most disturbing aspects of the nuclear age. Israel, India, Pakistan, North Korea have all demonstrated the link. As nuclear technology spreads around the globe, so does the risk of nuclear weapons proliferation.

It has been estimated that at the end of 2003 there were about 1,830 tonnes of plutonium in the world – enough for over 225,000 nuclear weapons.⁷² Reactor-grade plutonium can be used to make nuclear weapons, as was noted in a US Department of Energy study:⁷³ “Virtually any combination of plutonium isotopes -- the different forms of an element having different numbers of neutrons in their nuclei -- can be used to make a nuclear weapon. In short, reactor-grade plutonium is weapons-usable, whether by unsophisticated proliferators or by advanced nuclear weapon states. Theft of separated plutonium, whether weapons-grade or reactor-grade, would pose a grave security risk.”

Nuclear reactors in India, Pakistan, Israel, and DPRK have produced nuclear materials, which were used to make nuclear weapons. Countries pursuing research, production and the use of nuclear energy for ‘peaceful purposes’ are contributing to the proliferation of nuclear materials and technology, which can all too easily lead to the development of nuclear weapons. Declarations by the G-8 and others to restrict the spread of nuclear material were shown to be as meaningless as the United States granted nuclear technology to India just this year.

Safeguards have shown themselves time and again to be inherently fallible, while the availability of raw material for nuclear weapons continues to grow and itself poses a proliferation and security threat. The ‘finger in the dyke’ is simply not a sustainable and comprehensive solution, as was seen by the revelations surrounding the A.Q. Khan network supplying nuclear technology and materials to third parties on the black market.⁷⁴ IAEA Director-General Dr ElBaradei acknowledged as much in his *Economist*⁷⁵ article:

[C]ontrolling access to nuclear-weapons technology has grown increasingly difficult. The technical barriers to designing weapons and to mastering the processing steps have eroded with time.... Under the current regime there is nothing illicit in a non-nuclear-weapon state having enrichment or reprocessing technology, or possessing weapon-grade nuclear material. And certain types of bomb-making expertise, unfortunately, are readily available in the open literature. Should a state with a fully developed fuel-cycle capability decide, for whatever reason, to break away from its non-proliferation commitments, most experts believe it could produce a nuclear weapon within a matter of months.

In 1970, it was assumed that relatively few countries knew how to acquire nuclear weapons. Now, with 35-40 countries in the know by some estimates, the margin of security under the current non-proliferation regime is becoming too slim for comfort.

A panel of international experts convened by the UN Secretary General to look into existing and future security threats to the international community, the *High Level Panel on Threats, Challenges and Change*, identified further nuclear proliferation as the number one threat to the international community, warning that “we are approaching a point at which the erosion of the nuclear regime could become irreversible, and result in a cascade of proliferation.”⁷⁶

With the threat of nuclear terrorism and nuclear proliferation, the very foundations of the civil nuclear industry are being seriously questioned. The reliance of the industry on highly enriched uranium and

the production of plutonium in reprocessing brings about an inherent contradiction with non-proliferation objectives as know-how is spread along with the technology.

The IAEA is thus faced with crucial dilemmas: should it support Iran or India in its 'inalienable right' to develop nuclear energy for peaceful purposes? And how to address the IAEA's historical role in facilitating the proliferation of dual-use nuclear technology to 'sensitive' countries? Should the IAEA accept criteria that holds that plutonium separation is acceptable for Japan and western countries and not for others? The IAEA received answers to these questions recently when its own public opinion poll, conducted in 18 countries, found that the majority of people oppose the expansion of the nuclear power industry, and prefer that currently operating plants be phased out.⁷⁷

The so-called multilateral nuclear approaches or MNA⁷⁸ is no answer. The idea would move the world away from the real solution, explicitly acknowledged by its own Director-General, which is that not having plutonium and highly enriched uranium is 'the way to go.'⁷⁹ Instead, it would increase and enhance reprocessing and enrichment, and in doing so would add to the environmental and security risks posed by nuclear energy. Multilateral, centralized nuclear facilities will certainly result in an increase in the number of radioactive waste and nuclear fuel transports, exposing coastal states and the marine environment to escalating risks, to which they have shown increasing resistance in past years, and will still result in increasing plutonium in commerce and in stocks worldwide.⁸⁰ The proposed US Global Nuclear Energy Partnership or GNEP⁸¹ suffers from similar implausibilities.

It is estimated that countries involved in reprocessing currently hold more than 215 metric tons of weapons-usable plutonium. It would take as little as 5 kilograms of this commercial plutonium for a state or terrorist organisation to build a nuclear bomb: the global community must address the threat posed by the mere existence of plutonium. A recent Carnegie Endowment for International Peace report found that enough civil and military weapons-usable materials exists globally to produce over 100,000 nuclear weapons⁸² and called the continued processing of highly enriched uranium (HEU) and the separation of plutonium a global anomaly: "acutely dangerous, expensive, and wholly unnecessary."

Nuclear Waste: A Toxic Legacy

Global spent fuel stocks amounted to 220,000 tonnes in the year 2000, and the stockpile is growing by approximately 10,000 tonnes each year.⁸³ Nuclear waste remains radioactive for tens or hundreds of thousands of years. The environmental, health and social impacts of nuclear waste all too frequently end up being borne by states and communities least able to resist and bear them.

The nuclear industry and nuclear weapons frequently develop at the expense of poor and indigenous communities. Of the eight nations in the world that have detonated nuclear weapons during the last 55 years, five have used the land of indigenous peoples.⁸⁴ As one survivor of nuclear testing said, "[s]ecurity for indigenous people means healthy land, resources and body - not the presence of weapons and the dangers they engender."⁸⁵

Indigenous peoples suffered from the health and environmental impacts of uranium mining. As Australian Aboriginal leader Jacqui Katona said of uranium mining,⁸⁶ "[o]ur sacred sites are desecrated, our economies are destroyed, our communities are overwhelmed and marginalised and our ceremonies to honour our land are prevented. The deaths in our communities resulting from "peaceful use" deplete the foundations of our society. The outcomes of indigenous contact with the nuclear fuel cycle is a generational impact of cultural destruction. The global community cannot aim to build a sanctuary of peace through disarmament only – uranium mining, testing and storage of toxic waste must be eliminated."

Similarly, the poor often bear disproportionate health, safety, economic and social costs of nuclear waste dumping.⁸⁷ Mayak,⁸⁸ in Russia's Ural Mountains, the key Soviet and Russian facility for the production of weapons plutonium and reprocessing of spent nuclear fuel, has leaked five times more radiation than the Chernobyl accident, Britain's Sellafield nuclear plant and all the world's atmospheric bomb tests combined.⁸⁹ Generations of residents suffering from sterility, cancer, asthma, and other illnesses, since more than 270,000 people⁹⁰ have been exposed to high levels of radiation as a result of releases of radioactive material from Mayak.⁹¹

Now the Russian Government plans to import 20,000 tonnes of radioactive waste. In March 2000, Greenpeace revealed a Russian White Paper proposing an initial import of 20,500t Spent Nuclear Fuel (SNF). The Russian Ministry for Atomic Energy (Minatom) White Paper envisages nuclear reprocessing of the bulk of the imported SNF. In this way, the West would inflict nuclear waste on one country for short-term economic gain and long-term liability, to ease pressure on national waste dumps and address the refusal of western democracies to accept nuclear waste in their territory. While the Russian government is actively promoting Russia as an international SNF storage and disposal country, like other countries, Russia doesn't have a final repository for SNF. Imported SNF would be first transported for interim storage to Mayak and/or Krasnoyarsk.

Reprocessing will only compound Russia's nuclear nightmare, as it leads to an increase in the volume of radioactive wastes requiring long-term management, much of which is in a highly volatile liquid form.⁹² Greenpeace opposes the establishment of a multilateral nuclear waste dump in Russia. As there is no current solution for spent nuclear fuel final storage, countries operating nuclear power reactors should move as early as possible to a phase out of nuclear power. They should establish national, monitored, above ground dry stores, instead of irresponsibly dumping their nuclear waste on a country with a disastrous record for managing nuclear waste. Large-scale contamination of the environment such as at Mayak and Tomsk, and resultant human impacts, will far outweigh any short-term financial benefits for Russia.

CONCLUSION

Nuclear power does not meet the JPOI criteria of "reliable, affordable, economically viable, socially acceptable and environmentally sound" energy. The world needs safe and clean renewable energy. Nuclear energy, with its cost, inflexibility, generation of waste, inherent danger and security implications, far from furthering the world's need for energy, undermines economic development, social development and environmental protection. Investment of human and economic resources are far better placed into energy efficiency and the numerous renewable technologies available to guarantee the right to safe, clean and affordable energy.

The World Summit Outcome rightly sees nuclear power as a problem, not a solution. Problems with reactor safety, radioactive waste management, the proliferation of fissile material and life cycle cost all mean that nuclear power has no place in the mix. Resources and efforts must instead go to the clean and renewable energy and energy efficiency technologies, which have shown remarkable growth since 2000.

Nuclear power, far from being any kind of solution, is unsustainable, unsafe, unclean, uneconomical and, unnecessary.

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¹ Plan of Implementation of the World Summit on Sustainable Development, at http://www.johannesburgsummit.org/html/documents/summit_docs/2309_planfinal.htm. All internet references are as at 20 April, 2006.

² See JPOI para. 18 (sustainable development strategies and programmes, including in decision-making on investment in infrastructure and business development) and 19(d) (a combination of energy resources to achieve sustainable development), (k) (research and development), (l) (networking between centres of excellence on energy for sustainable development), (p) (reduce market distortions), (q) (phasing out subsidies that inhibit sustainable development), (r) (improve the functioning of national energy markets in such a way that they support sustainable development), (s) (strengthening institutions and arrangements), (u) (cooperation between institutions and bodies), para. 53 (energy including renewable energy in SIDS) and numerous other references.

See World Summit Outcome, para. 50 (we face serious and multiple challenges in tackling climate change, promoting clean energy, meeting energy needs and achieving sustainable development, and we will act with resolve and urgency in this regard) and 56(i).

³ See JPOI para. 9 (the contribution of industrial development to poverty eradication and sustainable natural resource management, including the transfer of environmentally sound technologies.)

⁴ See JPOI para. 49(c)(reduction of emissions through cleaner fuels and modern pollution control techniques) and (d)(affordable energy to rural communities). See also the polluter pays principle and the internalization of environmental costs in paragraph 18(b).

⁵ JPOI esp. para.20(a) and 36 (the need to reduce greenhouse gas emissions).

⁶ World Summit Outcome, para.48.

⁷ JPOI para. 2.

⁸ Declaration on the Occasion of the Fiftieth Anniversary of the United Nations, at <http://www.un.org/UN50/dec.htm>.

⁹ World Summit Outcome, A/RES/60/11, 24 October 2005, at <http://www.un.org/summit2005/>, Para.55(a).

¹⁰ World Summit outcome, para.56(i)

¹¹ World Summit outcome, para.60(d)

¹² World Summit Outcome, para. 56(o): “To note that cessation of the transport of radioactive materials through the regions of small island developing States is an ultimate desired goal of small island developing States and some other countries and recognize the right of freedom of navigation in accordance with international law. States should maintain dialogue and consultation, in particular under the aegis of the International Atomic Energy Agency and the International Maritime Organization, with the aim of improved mutual understanding, confidence-building and enhanced communication in relation to the safe maritime transport of radioactive materials. States involved in the transport of such materials are urged to continue to engage in dialogue with small island developing States and other States to address their concerns. These concerns include the further development and strengthening, within the appropriate forums, of international regulatory regimes to enhance safety, disclosure, liability, security and compensation in relation to such transport.”

¹³ JPOI, para.33.bis: “Governments, taking into account their national circumstances, are encouraged, recalling paragraph 8 of resolution GC (44)/RES/17 of the General Conference of the International Atomic Energy Agency (IAEA) and taking into account the very serious potential for environment and human health impacts of radioactive wastes, to make efforts to examine and further improve measures and internationally agreed regulations regarding safety, while stressing the importance of having effective liability mechanisms in place, relevant to international maritime transportation and other transboundary movement of radioactive material, radioactive waste and spent fuel, including, inter alia, arrangements for prior notification and consultations done in accordance with relevant international instruments.”

¹⁴ See JPOI, paragraph 19.

¹⁵ Report of the Ad Hoc Open-Ended Intergovernmental Group of Experts on Energy and Sustainable Development, New York 6-10 March 2000, E/CN.17/2000/12, at <http://www.un.org/esa/sustdev/sdissues/energy/intergov/enexpert.htm>.

¹⁶ Decision 9/1, Energy for Sustainable Development, at <http://www.un.org/esa/sustdev/csd/ecn172001-19e.htm>.

¹⁷ Decision 9/1 para. 15. The Secretary-General's report notes that 19 of 442 existing nuclear reactors were commissioned after 2000: "Energy for sustainable development, industrial development, air pollution/atmosphere and climate change: integrated review of progress in meeting the goals, targets and commitments of Agenda 21, the Programme for the Further Implementation of Agenda 21 and the Plan of Implementation of the World Summit on Sustainable Development," E/CN.17/2006/3, at http://www.un.org/esa/sustdev/documents/docs_csd14.htm ("Integrated Review"), para.60. See also Secretary-General, "Overview of progress towards sustainable development: a review of the implementation of Agenda 21, the Programme for the Further Implementation of Agenda 21 and the Johannesburg Plan of Implementation", E/CN.17/2006/2, at http://www.un.org/esa/sustdev/documents/docs_csd14.htm.

¹⁸ That figure has apparently remained static at 16% as of 2004: see IAEA's *Annual Report 2004*, 1, at http://www.iaea.org/Publications/Reports/Anrep2004/anrep2004_full.pdf.

¹⁹ The Decision noted in para. 20 that some countries have been using nuclear energy technologies safely and see no inordinate concern in using and developing additional technology for properly managing and controlling spent fuel and other nuclear materials, and some of these countries consider that the use of nuclear energy should be increased. From their perspective, nuclear power is a sustainable energy source with both economical and environmental advantages. In their view, the removal of the option of nuclear power would remove an important element of flexibility and diversity in energy supply. For those countries that choose nuclear energy, the challenge lies in ensuring environmentally sound, socially acceptable and cost-effective solutions and in addressing nuclear safety and spent fuel and waste management as well as public concerns on these issues. Many countries seek the promotion of international cooperation in the peaceful use of nuclear energy. Some other countries have decided to phase out nuclear energy from their energy supply mix. Other countries, including several developed countries as well as small island developing States, do not use nuclear energy and do not consider nuclear energy as an appropriate or acceptable source of energy. Many of these countries are of the view that nuclear energy is not compatible with the objectives of sustainable development, and that risks related to safety, waste management and transport and stranded costs remain unsolved. Some are also of the opinion that the use of nuclear energy in general should be phased out as soon as practically possible.

²⁰ Decision 9/1, para.21.

²¹ These criteria were repeated in JPOI paras. 8(a), 8(e), 8(f), 8(g), 19(k), 19(n), 19(o), and 19(s).

²² JPOI, para. 19(c)

²³ E/CN.17/2006/3 Report of the Secretary General, 17 February, paragraph 60.

²⁴ See discussion on page 8 below and see for instance Steve Thomas, "The economics of nuclear power: analysis of recent studies", (July 2005), 24.

²⁵ Secretary-General's Integrated Review, para.51, page 25. The report cited a significant increase in renewable energy from world geothermal, solar, wind, and wood and waste for electric power consumption by region for 2000 and 2003 for Western Europe of 75 to 110.4 billion kWh, and overall from 249.5 to 310.1.

²⁶ Integrated Review, Table 3, 26.

²⁷ http://www.nrel.gov/documents/solar_energy.html.

²⁸ <http://www.greenpeace.org.uk/climate/solution/solar.cfm>

²⁹ IEA Renewables Information 2003, http://www.erec-renewables.org/documents/RES_in_EUandCC/Policy_reviews/EU_15/Sweden_policy_final.pdf

³⁰ http://www.eia.doe.gov/cneaf/solar.renewables/page/non_hydro/nonhydrorenewablespaper_final.pdf

³¹ http://www.eia.doe.gov/cneaf/solar.renewables/page/non_hydro/nonhydrorenewablespaper_final.pdf

³² http://archive.greenpeace.org/earthsummit/news_26june.html

³³ Or half the electricity demand of Australia - <http://www.greenpeace.org/international/press/releases/greenpeace-report-proves-solar>.

³⁴ See Beijing Declaration on renewable energy for sustainable development, at http://www.birec2005.cn/news_show.asp?ClassId=16&id=35, para. 12.

³⁵ Beijing Declaration, para. 3.

³⁶ <http://www.greenpeace.org.uk/climate/media/pressrelease.cfm?ucidparam=20050719100223>

³⁷ BMU-Scenario/ DLR

³⁸ See for instance NEA, *Chernobyl: Assessment of Radiological and Health Impact: 2002 Update of Chernobyl: Ten Years On*, at <http://www.nea.fr/html/rp/chernobyl/c01.html>.

³⁹ The most recently published figures indicate that in Belarus, Russia and the Ukraine alone the accident resulted in an estimated 200,000 additional deaths between 1990 and 2004. However, a complete evaluation of the human health consequences of the Chernobyl accident is therefore likely to remain an almost impossible task, such that the true extent of morbidity and mortality resulting may never be fully appreciated. See recent Greenpeace report, *The Chernobyl Catastrophe: Consequences on Human Health*, ed. A. Yablakov, I. Labunska and I. Blokov, April 2006, at <http://www.greenpeace.org/international/press/reports/chernobylhealthreport>. One cited report estimated 270,000 cancers and 93,080 fatal cancers in all countries. See page 21, citing Malko M.V. (2006). Estimations of the Consequences of the Chernobyl Catastrophe, under the title Public Centre of the Independent Environment Assessment of the Russian Academy of Sciences, ISBN 5-94442-011-1. The report notes that the most recently published figures indicate that in Belarus, Russia and the Ukraine alone the accident could have resulted in an estimated 200,000 additional deaths in the period between 1990 and 2004: page 25. These numbers contrast strongly with IAEA Chernobyl Forum estimates of 4,000 deaths, which are limited to the ‘liquidators’, or those sent in to clean up after the accident, evacuees from the 30 km zone and residents of SCZ (strict control zones). *Health Effects of the Chernobyl Accident, and Special Health Care Programs: Report of the UN Chernobyl Forum Expert Group “Health”*, Table 12, 108, at http://www.who.int/ionizing_radiation/chernobyl/who_chernobyl_report_2006.pdf. See WHO Press Release, 5 September 2005, stating that “The international experts have estimated that radiation could cause up to about 4000 eventual deaths among the higher-exposed Chernobyl populations, i.e., emergency workers from 1986-1987, evacuees and residents of the most contaminated areas.” <http://www.who.int/mediacentre/news/releases/2005/pr38/en/index.html>.

See also Greenpeace report, Large Associates, *Chernobyl – A Nuclear Catastrophe 20 years on*, at <http://www.greenpeace.org/international/press/reports/chernobyl-a-nuclear-catastro>.

⁴⁰ “Is Nuclear the Answer? A Commentary by Jonathan Porritt, Chairman, Sustainable Development Commission.” March 2006. At <http://www.sd-commission.org.uk>.

⁴¹ In 2005, Greenpeace updated its international reactor hazards study. One conclusion reached was that the standard western design nuclear reactors (light water), the most common type operating today worldwide, in an accident could release up to 10 times more radioactivity than the Chernobyl disaster. See Greenpeace report by Helmut Hirsch, Oda Becker, Mycle Schneider and Antony Froggatt, *Nuclear Reactor Hazards: Ongoing Dangers of Operating Nuclear Technology in the 21st Century* (April 2005), at <http://www.greenpeace.org/international/press/reports/nuclearreactorhazard>.

The main findings of Greenpeace International *Nuclear Reactor Hazards Study* were that

- All operational reactors have very serious inherent safety flaws which cannot be eliminated by safety upgrading;
- A major accident in a light-water reactor – the majority of reactors operating worldwide – can lead to radioactive releases equivalent to several times the release at Chernobyl and about 1000 times that released by a fission nuclear weapon. Relocation of the population could be necessary for large areas (up to 100.000 km²). The number of cancer deaths could exceed 1 million;
- The average age of the world's reactors is 21 years and many countries are planning to extend the lifetime of their reactors beyond the original design lifetime. This leads to the degradation of critical components and the increase of severe incidents and could lead to a major accident;
- De-regulation (liberalisation) of electricity markets has pushed nuclear utilities to decrease safety-related investments. Utilities are also upgrading their reactors, e.g. by increasing reactor pressure and temperature. This accelerates ageing and decreases safety margins. Nuclear regulators are not able to cope with this new reality;

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- Highly radioactive spent fuel mostly is stored employing active cooling. If this fails, this could lead to a major release of radioactivity.
 - Reactors cannot be sufficiently protected against a terrorist threat. There are several scenarios – aside from a crash of an airliner on the reactor building – which could lead to a major accident. Highly radioactive spent fuel at reactor sites or reprocessing plants needs constant cooling, if this fails, this could lead to a major release of radioactivity, climate change impacts, such as flooding, sea level rise and extreme droughts, seriously increase nuclear risks.

⁴² Shipments of MOX fuel containing pellets of dubious quality reached Japan, Japanese authorities pressed the British to take them back, and in July 2000, the British Energy Director agreed that the MOX fuel with falsified data would be returned to the United Kingdom and that 6.4 billion yen would be paid to Japan for damages incurred because of the falsification. See *Inspectors Sent in as Sellafield Admits to Serious Safety Lapses*, The Independent (London), Sept. 14, 1999 and Alan Cowell, *Nuclear Plant in Britain Admits Sabotage*, N.Y. Times, March 27, 2000, at A8, col. 3 (nat'l ed.).

⁴³ See description at <http://www.nea.fr/html/nsd/workshops/debris>.

⁴⁴ There have been a number of important assessments of security vulnerabilities and consequences of deliberate attacks on nuclear facilities, as well as the use of fissile materials in terrorist attacks, including: *Dirty Bombs and Primitive Nuclear Weapons* by Dr. Frank Barnaby, of the Oxford Research Group, June 2005; and a UK parliamentary report assessed the risk of attack on nuclear facilities, its. Its findings included: The events of September 11th 2001 heightened concerns over the potential for terrorist attacks on nuclear facilities. The purpose of this report is to provide Parliamentarians with an overview of what is publicly known about the risks and the consequences of such an attack, either at a facility in the UK, or overseas, with very direct impacts in the UK. This report identifies the main issues of concern according to reports in the public domain, and highlights areas where understanding is limited due to lack of publicly available information. The key points made in this the report are as follows:

- There is sufficient information in the public domain to identify possible ways terrorists might bring about a release of radioactive material from a nuclear facility. However this information is not sufficient to draw conclusions on the likelihood of a successful attack, or the size and nature of any release.
- After September 11th 2001 additional protection measures have been put in place to increase security and to strengthen emergency planning at and around nuclear facilities. However, full details are not in the public domain.
- Nuclear power plants were not designed to withstand some forms of terrorist attack, such as large aircraft impact, but existing safety and security regimes provide some defence.
- Published reports suggest that, in a worst case scenario, the impact of large aircraft on certain facilities could cause a significant release of radioactive material with effects over a wide area. However, some analysts question the accuracy of these reports, and argue that accurately targeting these facilities would be difficult.
- A successful attack would be highly unlikely to cause large numbers of instant fatalities. Although it would have the potential to affect extensive areas of land and cause large numbers of cancers, its impact would depend on how effectively appropriate contingency plans were implemented.
- Even an unsuccessful attack could have economic and social repercussions and affect public confidence in nuclear activities such as power generation.
- Published reports draw widely different conclusions about the consequences of attacks on nuclear facilities, due to differing assumptions about the size and nature of the release, weather conditions and efficiency of countermeasures.
- Media coverage of the risk of releases of radioactive material from nuclear facilities focuses mainly on the consequences of worst case scenarios, without discussing the likelihood of their occurrence or explaining assumptions made.
- Analyses carried out by UK nuclear operators to investigate the consequences of accidents at nuclear plants could be used to further understanding of the potential consequences of terrorist attacks. However these analyses are largely not publicly available. The scope of further work would be limited without such information.

See, *Assessing the risk of terrorist attacks on nuclear facilities*, July 2004 Report 222, Parliamentary Office of Science and Technology, April 2004, www.parliament.uk/post at <http://www.parliament.uk/post>.

⁴⁵ Heather O. Dickinson, Louise Parker, "Leukaemia and non-Hodgkin's lymphoma in children of male Sellafield radiation workers," *International Journal of Cancer*, Volume 99, Issue 3, Date: 20 May 2002, Pages: 437-444. At <http://www3.interscience.wiley.com/cgi-bin/fulltext/92013261/PDFSTART>.

See BBC, "Sellafield Increases Cancer Risk", 19 June 2002, at <http://news.bbc.co.uk/1/hi/health/2054694.stm>. The researchers compared the records of 9,859 children fathered by men exposed to radiation at Sellafield with those of 256,851 children born to other fathers in Cumbria between 1950 and 1991. Throughout the whole of Cumbria, they found that the incidence of leukaemia and non-Hodgkin's lymphoma was twice as high among the Sellafield children.

⁴⁶ Dave Reed, "Return of the Nuclear Salesmen: Global Warming Gives Them a New Sales Pitch," Rocky Mountain Institute, at <http://www.rmi.org/sitepages/pid642.php>, W. Keepin and G. Kats, "Greenhouse Warming: Comparative Analysis of Nuclear and Efficiency Abatement Strategies", *Energy Policy*, pp 538-561, 1988, December, and Bill Keepin's evidence to the US House of Representatives hearing in 1988 at http://www.rmi.org/images/other/Energy/E88-28_GreenhouseWmg.pdf.

⁴⁷ Amory Lovins, "Nuclear power: economics and climate-protection potential," (2005), at <http://www.rmi.org/sitepages/pid171.php>, 15.

⁴⁸ See Greenpeace, *Nuclear Energy No Solution to Climate Change*, at <http://archive.greenpeace.org/comms/no.nukes/nenstcc.html>. Nuclear power's share is expected to decline, while renewables are growing faster than any other energy source: *World Energy Outlook 2005*, at <http://www.worldenergyoutlook.org>.

⁴⁹ In absolute terms, world energy demand is expected to increase by at least one half in the next 25 years. To double nuclear energy's share in the "business as usual" scenario, would in fact require not a doubling, but a tripling, of the number of reactors. Not 440 but about 1,100 nuclear reactors would have to be on the grid in 25 years' time. Assuming an 85% load factor, something in the order of 1031 new reactors of 1000 MWe would need to be built and producing electricity by 2030 in order to double the existing percentage of electricity supplied by nuclear energy, taking into account the older nuclear facilities that would need to be decommissioned in the meantime. Calculations by Greenpeace and for a similar estimate see Greenpeace, *Nuclear Energy No Solution to Climate Change*.

⁵⁰ International Atomic Energy Agency, *Nuclear Technology Review 2004*, Vienna, page 6. At http://www.iaea.org/About/Policy/GC/GC48/Documents/gc48inf-4_new.pdf.

⁵¹ Amory Lovins, note 47 ii.

⁵² See Greenpeace, "Nuclear Energy No Solution to Climate Change: A background paper", at <http://archive.greenpeace.org/comms/no.nukes/nenstcc.html>.

⁵³ Felix Chr. Matthes, "Nuclear Energy and Climate Change," 2005, at http://www.boell.de/en/04_thema/3862.html.

⁵⁴ Website at <http://www.sd-commission.org.uk>.

⁵⁵ World Summit outcome, para.56(o).

⁵⁶ The Mauritius Strategy for the Further Implementation of the Programme of Action for the Sustainable Development of Small Island States (Port Louis, 13 January 2005), at found at http://www.un.org/smallislands2005/pdf/sids_strategy.pdf.

⁵⁷ Programme of Action for the Sustainable Development of Small Island Developing States (Bridgetown, 6 May 1994) ('BPOA'), in *Report of the Global Conference on the Sustainable Development of Small Island Developing States (Bridgetown, Barbados, 25 April-6 May 1994)* (A/CONF.167/9, October 1994).

⁵⁸ Britain's 1188 MW Sizewell B, completed in 1995, was estimated to have cost about £3 billion, or about £2900 /kW. See Steve Thomas, 14 and UK Sustainable Development Commission, "Paper 4: The economics of nuclear power", 17.

⁵⁹ J. Deutsch & E.J. Moniz (Co-Chairs), *The Future of Nuclear Power*, MIT, 2003 ("MIT"), page 39-40, at <http://web.mit.edu/nuclearpower>. The UK Sustainable Energy Commission cites various costs including DTI's £1070-1,400 /kW: Paper 4, page 19.

⁶⁰ UK Sustainable Development Commission, "Paper 4: The economics of nuclear power", 16.

⁶¹ The IAEA has noted that the costs of decommissioning nuclear plants or the costs of long-term storage of nuclear waste can be estimated, but potential costs from accidents are difficult to factor into the equations. IAEA *Nuclear Technology Review 2004*, page 88. See also Greenpeace, “Nuclear Energy No Solution to Climate Change: A background paper”, at <http://archive.greenpeace.org/comms/no.nukes/nenstec.html>.

⁶² MIT, page 42, assuming 85% capacity factor and a 25 year economic life (7.9 c/kWh assuming 75% capacity factor, for 25 year economic life). Of course to this must be added externalities and subsidies, including limited liability regimes.

UK’s Sizewell B has a total generating cost in today’s money of over 6p/kWh: see UK Sustainable Development Commission, “Paper 4: The economics of nuclear power”, 3.

⁶³ Amory Lovins, note 47., 7.

⁶⁴ Amory Lovins, note 47..

⁶⁵ See Steve Thomas, 17 and studies cited therein. A British White Paper stated that “the current economics of nuclear power make it an unattractive option for new generating capacity and there are also many important issues for nuclear waste to be resolved.” Department of Trade and Industry (2003), “Our energy future – creating a low carbon economy,” Cm 5761, HMSO, London.

⁶⁶ A. Froggat, “Invest in a Clean Energy Future,” Greenpeace International, July 2005, 15, citing a 2001 report for the EU Parliament on energy subsidies. The actual value of the subsidy depends on variables including the probabilistic risk of an off-site release of radiation, the location of a plant and its proximity to urban populations and the local meteorological conditions.

⁶⁷ CE, “Environmentally harmful support measures in EU Member States, Solutions for Environment, Economy and Technology,” report for DG Environment, January 2003, 132, cited in A. Froggat, “Invest in a Clean Energy Future,” Greenpeace International, July 2005, 15. Even being required to insure to €420 million would increase EDF’s cost of generation by 8%, increasing insurance premiums from 0.0017 c€/kWh to 0.019 c€/kWh. *Ibid*.

⁶⁸ See Steve Thomas, 17.

⁶⁹ Benjamin K. Sovacool, “See Think Again: Nuclear Energy”, in Foreign Policy, September 2005, at http://www.foreignpolicy.com/users/login.php?story_id=3250&URL=http://www.foreignpolicy.com/story/cms.php?story_id=3250.

⁷⁰ Quantifiable social costs (e.g. economic effects, employment, environment, environmental impacts, health effects & government subsidies) must be added to the core price of electricity. Pearce, D. W., Bann, C. & Georgiou, E. (1992). *The Social Cost of Fuel Cycles*. Report to the Department of Trade and Industry, HMSO publications. ISBN 011-4142-882 and Grubb, M. & Vigotti, R. (1997). *Renewable Energy Strategies for Europe, Volume II*. Royal Inst. of International Affairs, Energy and Environment Program. Earthscan Publ’ns. ISBN 1 85383 284 7. See graphs at <http://archive.greenpeace.org/comms/no.nukes/nenstec.html#f12>.

⁷¹ Asian Development Bank (1995) Bank Policy for Energy Sector. May 1995, at http://www.adb.org/Documents/Policies/Energy_Initiatives/energy_ini313.asp. An updated report from 2000 cited, but did not alter, these conclusions: at <http://www.adb.org/Documents/Policies/Energy/energy-review.pdf>.

⁷² ISIS, “Plutonium Watch: Tracking Plutonium Inventories,” by David Albright and Kimberly Kramer,, July 2004, at http://www.isis-online.org/global_stocks/end2003/plutonium_watch2005.pdf. The authors estimate that the amount of plutonium grows at about 70 tonnes per year.

⁷³ U.S. Department of Energy, *Nonproliferation and Arms control Assessment of Weapons-Usable Fissile Material Storage and Excess Plutonium Disposition Alternatives*, (1997), 37, excerpted in <http://www.ccnr.org/plute.html>.

⁷⁴ See Greenpeace International, “A.Q. Khan, Urenco and the proliferation of nuclear weapons technology :- The symbiotic relation between nuclear energy and nuclear weapons,” May 2004, at http://www.greenpeace.org/multimedia/download/1/467536/0/URENCO_final_29-4-04.pdf.

⁷⁵ Mohamed ElBaradei, “Towards a Safer World,” *Economist*, October 18, 2003.

⁷⁶ “A More Secure World: Our Shared Responsibility”, the High Level Panel on Threats, Challenges and Change, United Nations, December 2004, para 111.

⁷⁷ http://www.iaea.org/Publications/Reports/gponi_report2005.pdf

⁷⁸ See Multilateral Approaches to the Nuclear Fuel Cycle: Expert Group Report submitted to the Director General of the International Atomic Energy Agency, INFCIRC/640, 22 February 2005.

⁷⁹ “A race against Time,” Gregory Beals, Newsweek, May 20, 2004, at <http://msnbc.msn.com/id/5024764/site/newsweek/>.

⁸⁰ Citing a 1977 IAEA study, the Regional Nuclear Fuel Cycle Centres study (REGIONAL NUCLEAR FUEL CYCLE CENTRES, Vol. 1, Summary, 1977 Report of the IAEA Study Project, IAEA, Vienna (1977)), the Pellaud report stated on page 62 that “There was recognition that fewer, bigger sites would probably mean more shipping and transporting of nuclear material and, other things being equal, more transport would mean more chances for accidents. However, these risks were judged to have been outweighed by the risk reduction attributable to having fewer sites.” It also noted that “The additional establishment of regional arrangements could reduce the transportation risk for separated fissile material and enhance security, in comparison to intercontinental shipments, but could increase the transportation risk in comparison to national facilities.” (page 65.) Almost all scenarios suggested increased transportation requirements (see pages 68, 69, 79, 81, 89, 90.) It acknowledged that “Regional facilities would involve transportation of spent fuel over long distance with its associated obstacles.” The Pellaud Report went on to state that “therefore, in the views of some States, it is desirable to co-locate nuclear power plants, reprocessing plants, MOX fuel (or mixed metal fuel) fabrication plants and fast reactors to use the MOX fuel. Transportation of spent fuel, if any, should be over short distances.” (page 92)

⁸¹ See NRDC, “Peddling Plutonium: an Analysis of the President’s Global Nuclear Energy Partnership”, at <http://www.nrdc.org/nuclear/gnep/agnep.asp>.

⁸² Carnegie Endowment for Peace, Universal Compliance: A Strategy for Nuclear Security, March 2005, at <http://www.carnegieendowment.org/publications/index.cfm?fa=view&id=16593>, page 91.

⁸³ See more discussion at <http://www.greenpeace.org/international/campaigns/nuclear/waste>.

⁸⁴ The land of the Western Shoshone nation of North America, the Marshall and other South Pacific Islanders, Australian Aboriginals, the Kazakhs, and Tibetans have been contaminated with nuclear tests. See <http://www.reachingcriticalwill.org/technical/factsheets/indigenous.html>.

⁸⁵ Tony de Brum, of the Marshall Islands, in his presentation to the 2005 Non Proliferation Treaty (NPT) Review Conference, at <http://www.reachingcriticalwill.org/legal/npt/RevCon05/NGOpres/indigenous5.pdf>.

⁸⁶ Ms. Jacqui Katona, of the Gundjehmi Aboriginal Corporation, at 2000 NPT Review Prepcom, at <http://disarm.igc.org/newkatona.htm>.

⁸⁷ See in the US, Nuclear Waste and Environmental Justice, at <http://www.fguide.org/Bulletin/nuclwaste.htm>.

⁸⁸ See more details about Mayak at <http://archive.greenpeace.org/mayak/index.html>.

⁸⁹ According to a joint Russian and Norwegian study, the Mayak nuclear complex has leaked 8,900 petabecquerels of strontium-90 and cesium-137 into the environment as a result of accidents and the deliberate discharge of liquid waste. See further details at <http://www.nti.org/db/nisprofs/russia/fissmat/pumayak/nucwaste.htm>.

⁹⁰ See their stories at <http://archive.greenpeace.org/mayak/testimonies/index.html>.

⁹¹ See Alik Gilmullin, “Russia: Living -- And Dying -- In The Shadow Of Mayak” (2005), at http://www.rferl.org/features/features_Article.aspx?m=12&y=2005&id=629F9FFF-943C-45E8-A5CA-72CF21D1B768.

⁹² The reprocessing of one ton of spent fuel results in 45m³ of high level waste, 150 m³ of medium level waste and 2,000 m³ of low level liquid waste. The process also generates a further 7,500kg of solid radioactive waste.