Ethics of Nuclear Energy Technology

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Further contributions and case studies are invited.

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Part 1: Introduction

1.1 The focus and scope of nuclear energy in this report

Nuclear technology can be applied for many different purposes. These include electricity production, weapons manufacture, production of medical isotopes, transportation (ranging from military submarine propulsion and space-based vehicle propulsion), industry (e.g., food irradiation and production of electronic components), and basic and applied research. While issues arising from all of these applications have significant consequences for society, the Ethics of Energy Technologies in the Asia and the Pacific (EETAP) project focuses on energy technologies. We therefore have foregone in-depth discussion of many of the applications mentioned above.

The EETAP project focuses on energy technologies for general consumption. As nuclear energy is generally applied when converted to electricity, the focus of this Working Group report is on the ethics of nuclear energy technologies for general electricity production. This includes the vast majority of nuclear technology use today. However, this does not eliminate discussion of other nuclear technologies. To the extent they are important to the focus of this report, they are discussed.

In this report on the ethics of nuclear energy technologies currently it does not include within its scope the question of whether nuclear energy should be used or not, and if it should be used, to what extent. Instead, it is an ethical analysis, and it is not the function of this report to determine specific and contextually-sensitive decisions.

1.2 The global significance of nuclear energy technology

Nuclear energy accounts for about 6% of primary energy supply and 15% of electricity generation (IEA, 2008). Coal and hydroelectric sources dominate the market with about 40 and 20 percent shares respectively of world electricity production (IEA, 2008). Nuclear energy accounts for about 15 percent and gas and oil produce about 25 percent (IEA, 2008). Renewable energy, such as solar and wind, accounts for less than 2 percent (IEA, 2008). States that use nuclear energy to provide a significant portion of their electricity (15% or more) include Armenia, Belgium, Bulgaria, Canada, the Czech Republic, Finland, France, Germany, Hungary, Japan, the Republic of Korea, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, the United Kingdom, and the United States (World Nuclear Association, 2009). Thus, while nuclear energy does not produce the level of electricity and energy of traditional fossil fuels, it is currently a significantly utilized alternative energy source. Moreover, it is important to numerous countries.

As of early 2009, global nuclear energy capacity was approximately 350 gigawatts, with 438 nuclear power reactors operating in 31 countries (European Nuclear Society, 2009). Of these, nearly half the reactors are found in three countries: the U.S., France, and Japan, which generate about 56% of the electricity originating from nuclear energy (IEA, 2008). Another 44 plants in 14 countries are under construction with a total capacity of approximately 39 GW (Figure 1). As Figure 1 shows, developing countries are planning to or are already building many new reactors.
1.3 Increased importance of nuclear energy technology

The following are some of the number of reasons why nuclear energy technology has become increasingly important in recent years.

First, it is widely accepted that rapid changes in energy prices can cause volatility in local and global economies. In fact, this idea is introduced routinely in microeconomics courses. Anecdotal evidence suggests that many countries are reassessing their energy security policies and contemplate including greater use of nuclear energy in the future because it may be more economically stable than fossil fuels (OECD, 2005).

Second, an increased focus on the effects of greenhouse gas (GHG) emissions and climate change has led to greater consideration of nuclear energy use because nuclear reactors do not emit GHGs, and in particular, carbon dioxide. The Kyoto Protocol to the UN Framework Convention on Climate Change (UNFCCC) created legally binding average greenhouse gas emission reductions between 6 to 8 percent below 1990 levels between the years 2008-2012 for many countries (UNFCCC, 2009). As countries look for clean alternatives to current energy sources, nuclear energy may help states achieve their targets under the Protocol (or other international and national commitments) and/or subsequent environmental agreements.

Third, civilian nuclear technology can be used for military purposes, and increased proliferation concerns in recent international events focus attention on this “dual-use” aspect of nuclear technology. Recent disagreements between intergovernmental organizations, such as the International Atomic Energy Agency (IAEA) and the UN Security Council (Sagan, 2006; Hagel, 2008; Crail, 2008; Ikenberry, 2007), with particular states over safeguards highlight these concerns. Proliferation issues are a concern to all political entities, including governments, civil society, and individuals.
Fourth, countries without previous nuclear energy experience are showing interest in developing nuclear energy capacity for various reasons. Twenty-five countries have shown interest in building at least one large nuclear reactor by 2030 (Sokolski 2009). This will cause a different international relations picture with regards to nuclear technology, including nuclear fuel supply, in the future.

1.4 Ethics of nuclear energy technology

The importance of nuclear energy technology is not limited to its widespread use nor the complex political and economic issues often present. While all of these issues are important, the focus of this report is on the ethical analysis of nuclear energy technology.

The ethical analysis applied in this report is pluralistic, which is neither absolute nor relative. It “accepts different moral convictions and backgrounds while at the same time suggesting that a consensus on basic principles and rules in a certain social context can, and should, be reached” (Crane and Matten, 2007). This pluralistic view is informed by both traditional and contemporary normative theories. Traditional theories, which are absolute in intention and theoretically provide unequivocal solutions, can be divided into teleological and deontological theories. The former includes ethical egoism and utilitarianism, while the latter includes theories of duties, rights, and justice. As traditional theories are very abstract and reductionist, contemporary theories are more practical. Contemporary theories include virtue ethics, the ethics of care, discourse ethics, and post-modern ethics.

Pluralistic approaches have been often been applied in fields such as bioethics, business ethics, and environmental ethics. In bioethics, one textbook series has often crystallized ethical theories into four basic principles (autonomy, beneficence, nonmaleficence, and justice) (Beauchamp and Childress, 2001). A prima facie approach to resolving a bioethical dilemma is often used in conjunction with these principles (Beauchamp and Childress, 2001). In the field of business ethics, a pragmatic use of all ethical theories is used, which is similar to the school of ethical pragmatism (Crane and Matten, 2007). Environmental ethics also applies various ethical theories to environmental issues, but the most significant issue therein involves who to include in ethical considerations. One expert has summarized the field into four schools of thought: enlightened (or weak) anthropocentrism, animal liberation/rights theory, biocentrism, and ecocentrism (Yang, 2006).

1.5 The goal of this report

This report attempts to depoliticize debates over nuclear energy issues by examining aspects of nuclear technology from an ethical perspective. However, as it is beyond the scope of this report to exhaustively analyze all ethical issues of all aspects of nuclear energy technologies, it only analyzes selected aspects from selective ethical perspectives. Rather, it aims to provide an idea of the kind of ethical analysis necessary when examining nuclear energy technologies such that it can be applied for the reader’s particular situation.

By examining these issues from a more fundamental level, it is hoped that greater consensus can be reached on actions going forward regarding nuclear energy and reduce political tensions which are often hamper discussion efforts. Each ethical perspective, however, is only one perspective and carries with it sets of assumptions, which need to be supplemented with other perspectives as a policy direction is formed. Part of the purpose of
this report itself is that given the relatively small focus on the ethical perspectives, this report may help governments in the Asia-Pacific region consider the policy options after an analysis of the ethical dimensions.
Part 2: The ethics of nuclear energy technology

2.1 Nuclear science

Nuclear energy is harnessed from one of two types of nuclear reactions, fusion and fission. In nuclear fusion, atoms are fused or combined to form different atoms. This reaction powers stars such as the sun. It is currently uneconomical as a source of electricity, although it has been harnessed in thermonuclear weapons. Current projects, such as the ITER fusion research collaboration (ITER, 2009), are working on developing nuclear fusion as an electricity source. While estimates vary, this technology is several decades away from commercial use (see for example Sharp, 2007). Moreover, even if and when it arrives for commercial electricity production, it may be expensive (Nuttall, 2008). However, fusion has the potential to generate larger amounts of electricity at lower prices and with minimal impact to the environment. In addition, the source of fuel, tritium, is extremely abundant and inexpensive; very little radioactive waste would be produced; and it will not use uranium nor plutonium which can be diverted for weapons manufacture unlike nuclear fission (Nuttall, 2008).

The second type of nuclear reaction is fission. In nuclear fission, atoms are split and energy is generated. This form of energy has been utilized in both electricity production and weapons. It is the focus in the remainder of this report.

Nuclear fusion and fission have not given rise to any significant intrinsic ethical debate. The lack is in contrast to fields such as biology and the life sciences, where complex ethical issues involving stem cells, DNA, cloning, and others, arise.

However, when nuclear science is applied as an energy technology, many ethical concerns are generated. Most of these stem from the potentially dangerous effects of radiation, the reactor technology used to harness nuclear energy, potential diversion for military use, the cost of such technology, and international control of nuclear technology.

2.2 Nuclear radiation

The risks of radiation from nuclear technology are difficult to assess. While general agreement exists on the dangerous effects of high-dose radiation, effects of radiation at low-dosages (less than 100 millisieverts) remain uncertain. One hypothesis, the linear no-threshold (LNT) hypothesis, posits that harmful radiation effects are linearly proportional to the radiation dose (IAEA, 2007). Competing hypotheses posit that radiation is harmless below certain thresholds but harmful above them. Yet another hypothesis, called radiation hormesis, posits that low radiation doses are actually beneficial below a certain threshold and harmful above it (Kaiser, 2003). Thus, it is difficult for policy-makers and the general public to understand radiation safety options when even experts cannot agree on low-dose radiation effects.

The International Council for Radiation Protection (ICRP) is one guidance setting authority for radiation protection, comprising biologists, physicians, and physicists, among others (ICRP, 2009). The ICRP proposes “as low as reasonably achievable” (ALARA) as being a goal for risk assessment and management (ICRP, 2005). However, the precise definition is unclear, and varied legal and ethical interpretations can be applied. A common understanding on ALARA or safety level of low radiation doses may therefore assist policy-
makers, the general public, and even workers in the nuclear industry, to understand and formulate policy options.

2.3 Nuclear Energy Plants

The nuclear energy plant generates electricity from nuclear energy. More specifically, the nuclear reactor, housed within the plant, converts the heat energy generated from nuclear fission to electricity. Nuclear fuel is formed into pellets that are stacked inside fuel rods (WNA, 2009). Nuclear reactors can contain tens of thousands of such fuel rods. The heat is captured by moderators, which also cool the fuel rods and prevent them from melting (WNA, 2009). The most common moderator is pressurized water, because it has a high capacity to absorb heat. The pressurized water, which travels in a primary loop, moves through a heat exchanger, transmits the heat energy to a secondary water loop. The water in the secondary loop is then turned to steam, which drives a turbine in a heat engine. The turbine generates electromagnetic energy, which is converted to electricity. The steam is often seen evaporating from the large cooling towers of nuclear energy plants.

Control rods are used to regulate the amount of energy produced by the reactor. Usually, the more the control rods are inserted into the core, the more the fission reaction is inhibited. They are also able to stop the nuclear reaction in the reactor in an emergency. One design has them hanging over the cores by a mechanism such as magnetic clamps such that when an emergency occurs, the magnets automatically turn off and the control rods fall into the core, stopping the nuclear reaction (Online Ethics Center, 2009).

Nuclear plants are considered an ethical issue because of this possibility of a nuclear meltdown. A nuclear meltdown can occur if fission creates too much energy and overheats, causing damage to the surrounding structures and releasing radiation into the environment. It can also occur if the structures surrounding the nuclear reactor themselves suffer a malfunction, allowing radiation leaks. Finally, it can occur if cooling systems, such as the pressurized water moderator, malfunctions, damage the structures surrounding the nuclear reactor, and release radiation into the environment. Accidents at Three-Mile Island in the United States (1979) and Chernobyl in Ukraine (1986) have prompted the public to raise serious questions about nuclear safety (OECD, 2005).

It may be difficult to argue that nuclear energy should be absolutely prohibited simply because accidents can occur. It is equally difficult to argue that such accidents should be downplayed and are “rare”. Utilitarianism may consider a simple multiplication product. The magnitude of the harm is multiplied by the probability of its occurrence. In the case of nuclear meltdowns, the magnitude of the harm can be enormous. While Three-Mile Island did not produce any direct recorded deaths from radiation, the indirect health and environmental damage was inconclusive. Chernobyl, however, resulted in over 50 confirmed deaths due to radiation burns or developing cancer after the accident (WNA, 2009). The number of unconfirmed deaths or health effects could be very large (WNA, 2009). The probability of an accident, however, can be very slim. Chernobyl and Three-Mile Island are the only major accidents of nuclear meltdown (WNA, 2009). Moreover, safety systems have evolved, and are now considered very comprehensive, embracing defense-in-depth, multiply redundant safety systems, and inherent and passive safety systems (WNA, 2009). Moreover, many ethical documents and guidelines exist, such as those from the World Association of Nuclear Operators (WANO) and the International Atomic Energy Agency (IAEA). However, perhaps more comprehensive, integrated, and measurable safety cultures can to be
implemented through mechanisms ranging from safety guidelines to employee performance appraisals.

A second issue arising from nuclear plants is the low level radiation leaks into the environment. There have been studies showing that there are such possible leaks, but the overall results have been inconclusive. For instance, a recent German study found that children under the age of five living less than five kilometres from nuclear plant exhaust stacks had twice the risk for contracting leukemia as those residing more than five kilometres (Nussbaum, 2009). However, such studies are contracted by the conclusions of other studies, as the report admits (Nussbaum, 2009). The scientific issue may revolve around study methodologies and what “statistically significant” really means. As to the scientific cause, this may be from the water being used to drive the turbines in the secondary loop may contain low levels of radiation which are carried away into the environment or the waste produced by the plant which may inadvertently be leaked into the surroundings. These are also subject to an ethical calculation, but the information for magnitudes and probabilities are inconclusive. Nuclear fallout from accidents decades ago may have also resulted in low level radiation, although this would be at a reduced level today. For instance, strontium-90, which is considered hazardous, was dispersed from Chernobyl (EPA, 2009).

The above issues should, however, be considered in light of zero GHG emissions of nuclear plants. In the case of a developed country such as France, from 1980 to 1986, harmful \( \text{SO}_2 \) and \( \text{NOX} \) emissions in the electric power sector were reduced by 71% and 60% respectively, causing reductions of 56% and 9% respectively, in total \( \text{SO}_2 \) and \( \text{NOX} \) emissions in France (Trudeau xxx). The environmental benefits of nuclear energy can be seen clearly in France. In the 1980s, because of concerns over imported oil, France more than tripled its nuclear energy production. During the same period, total pollution from the French electric power system dropped by 80-90 percent (Nuclear Energy Institute, 2009).

2.4 Nuclear Fuel

Uranium, the most commonly used nuclear fuel, exists as one of several isotopes, or atomic species, in nature. The nuclear fuel extracted from nature is \( \text{U-235} \), which is present in small percentages in uranium ore. Most of the uranium in the ore is found as \( \text{U-238} \), which will not fission with current technology.

It is useful to speak of the nuclear fuel cycle, which traces the steps of nuclear fuel from its inception to its eventual destruction. Nuclear experts often divide the nuclear fuel cycle into two parts, the “front end” and the “back end”. Before it can be used in a nuclear reactor, the \( \text{U-235} \) is mined, milled, converted, enriched, and fabricated into fuel assemblies. Collectively, these steps comprise the front end of the nuclear fuel cycle (WNA, 2009). The fuel assemblies fission in a nuclear reactor, produce electricity, and become “spent fuel”. Spent fuel enters the back end of the nuclear fuel cycle (WNA, 2009). The back end comprises the steps of temporary storage, reprocessing, and recycling, and waste disposal (WNA, 2009).

\( \text{U-235} \) is found within ore deposits around the world. More than 50% of the world’s uranium production is derived from mines in Canada, Australia, and Kazakhstan (Tradetech, 2009). The uranium ore is mined from the ground using conventional mining techniques: open-pit, underground, \textit{in-situ}, and as a byproduct of mining other minerals such as phosphates (Tradetech, 2009). As such, uranium extraction is subject to all of the ethical
issues that conventional mining entails, as it can inflict harm on human health and the environment.

Although different mining techniques produce different effects, there are three general categories of direct detrimental effects. The first is physical, and includes unstable waste rock piles, old buildings, open mine workings, pits and tunnels, derelict buildings and machines, and water filled voids (IAEA, 2008). The second is chemical, and includes ponds of contaminated water, acid drainage from reactive waste, old processing chemicals and residues (IAEA, 2008). Physical and chemical hazards can represent significant human health and environmental problems to the local community and surrounding areas, especially if they are not addressed immediately. Chemical problems, in particular, can cause large ecological and economic damage if not properly treated and/or remediated.

A third detrimental effect of uranium mining, which is not shared by conventional mining, is radiological, and includes uranium mill tailings, unprocessed uranium-bearing ore, scale and sludge in old plants, contaminated scrap metal, and release of uranium dust and radon gas into the environment (IAEA, 2008). Some radiological hazards can be addressed as with physical and chemical problems, but if they are not addressed quickly, can cause economic and ecological damage to the local community and surrounding areas. Other radiological hazards require specialized methods of remediation and treatment.

One widely documented study showed the radiological effects of uranium mining on human health. During the 1950s, many Navajo uranium miners in the U.S. later developed cancer due to radon gas exposure (Miller, 2007; Brugge, 2002). While former miners have been partially compensated, there have been reports that hundreds of abandoned mines have not been cleaned up and present environmental and health risks in many communities (Los Angeles Times, 2006). There have been other instances where radioactive contamination has affected uranium miners. For instance, Areva, a French state-owned nuclear power company, did not inform its affected mine workers in Niger about the health risks of uranium mining despite detrimental health effects (Public Eye, 2008).

Aside from the human health and environmental effects of uranium mining, there are also equity issues. Although many formulations of equity exist, one divides intragenerational equity from intergenerational equity (see for example Okrent, 1999). Intergenerational equity, a concept popularized by the Brundtland Commission Report (WCED, 1987), can be formulated as being equivalent “to the rejection of a ‘time preference’ that would allow the living to take advantage of their position and strength” (Agius, 2006) over future generations. If uranium mines are not remediated, a cost is imposed on future generations. In terms of intragenerational equity, which is similar to the concept of economic equity, it may not be fair or just for those who benefitted from nuclear power, who are in one part of the world (e.g. certain parts of the US, Japan, and France) and who benefit from the relatively clean generation of nuclear power, to be exempt from the relatively dirty, and sometimes dangerous, effects of uranium mining. This is a problem which is shared with other power sources. For instance, wind turbines (in wind power) are generated on land close to those who must endure the noise and obstruction to their visual scenery. However, the effects are particularly acute for uranium mining due to radiological effects. A counter consideration, however, is that mining villages and towns may benefit economically from mining activities.

A fourth detrimental effect of uranium mining is GHG emissions. Although nuclear reactors themselves do not emit GHGs, uranium mining is not completely GHG emission free.
Mining occurs using fossil fuel energy. Heavy machinery is often operated using fossil fuels, for instance. However, in comparison to fossil fuel production and consumption, the levels are likely significantly lower.

A fifth detrimental effect, and one perhaps criticized as being a luxury, is that of aesthetics. The source of such an ethic can be found in various philosophies, including that of Immanuel Kant, in *Critique of Judgment* of 1790, as well as environmental ethics. It has been summarized this way: “the beauty of places in the natural word – in this view exists but cannot be reduced to rational concepts of the sort sought by empirical science” (Sagoff, 2006). Actions such as open-pit mining reduce the visual appeal of the landscape, disrupt natural biodiversity and the local ecosystem, and can prevent interaction with nature occupied by the uranium mine.

Soon after uranium ore is mined, it is crushed and ground to a slurry in the milling process. It is then recovered as uranium oxide (U$_3$O$_8$) concentrate (WNA, 2009). Because uranium needs to be gasified before it can be enriched in gas centrifuges, the uranium oxide is converted to gaseous uranium hexafluoride (UF$_6$) in the conversion process (WNA, 2009). While there are small amounts of radioactivity and chemicals produced into waste, there do not appear to be significant and particular ethical concerns with the technology.

While some kinds of nuclear reactors, such as the Canadian CANDU reactors (Deffeyes, 2005), do not require enriched uranium, the vast majority of reactors in operation do. As the proportion of U-235 present in uranium hexafluoride is low (about 0.7%), it must be enriched to about 3.5% where it becomes usable in conventional nuclear energy reactors (WNA, 2009). This is almost always accomplished by a cascade of gas centrifuges, which successively increase the concentration of U-235 in the gas until it reaches an acceptable level (WNA, 2009). The remaining U-238 is called “tails" and they are often referred to as “depleted uranium”, or DU, and known for high density. DU is often used to form yacht keels (WNA, 2009), counterweights in aircraft, and radiation shielding (Wikipedia). It is also used in weapons manufacture as defensive armour plating and armour-piercing rounds (Wikipedia).

Enrichment is one of the most ethically controversial areas of the nuclear fuel cycle. Two ethical issues relate to its possible use in producing weapons-grade uranium and the use of depleted uranium.

Gas centrifuges are a bottleneck technology to producing weapons-grade uranium, as the technology is highly complex (Burton, 2008). However, once mastered for the purposes of producing reactor-grade uranium, it can be easily modified to produce weapons-grade uranium. If the gas centrifuges used by Pakistan for its uranium weapons were to be used to make enough fuel to power Iran’s Bushehr 1-GWe reactor, an estimated 100,000 centrifuges would be required. However, it only takes about 1,500 more such centrifuges to produce 90%-enriched uranium (i.e., weapons-grade uranium) in one year (Burton, 2008). A centrifuge three times more efficient would require 35,000 centrifuges to produce reactor-grade uranium, and only 250 additional centrifuges to produce one weapon (Burton, 2008).

The ethics of so-called “dual-use” technologies has been debated. On the one hand, restraining civilian use of nuclear energy is difficult for a number of reasons. It is guaranteed under the so-called third pillar of the Nuclear Non-Proliferation Treaty (NPT), Article IV, which provides the “inalienable right of all Parties to the Treaty to develop research,
production and use of nuclear energy for peaceful purposes without discrimination”, a quasi-deontological ethic. It even provides for “due consideration for the needs of the developing areas of the world”, which includes states such as Iran. It would appear that restraining access to an abundant source of energy from persons in the developing world would be ethically challenging. Moreover, such nuclear energy may displace use of fossil fuel consumption, which may be beneficial to the environment considering nuclear energy’s non-existent GHG emission. Finally, energy security in the form of enrichment is not considered to be morally objectionable per se, especially when other nations possess such capabilities.

On the other hand, such technology can bring nuclear energy-using countries which enrich their own uranium into nearly de facto nuclear weapon-possessing states. This may catalyze a regional arms race in volatile regions of the world, which may more than offset its initial advantages of reducing GHG emissions.

The possibility of proliferation-prone enrichment has led to a discussion on how to render it more proliferation-resistant. Here, the focus has been on preventing new nations from enriching and creating attractive alternatives (Burton, 2008). For instance, South Korea obtains 39% of its electricity from nuclear power and elects not to enrich nuclear fuel itself because it is a financially more sound decision. However, other states such as Malaysia, Indonesia, and Brazil are suspicious of their potential suppliers (Burton, 2008).

The ethics of DU weapons is also controversial. It is weakly radioactive and due to a long half-life, remains radioactive. The aerosol produced by DU weapons can potentially contaminate wide areas as they become scattered and can be inhaled (Mitsuakou, 2003). At least one scientific study has shown that DU has carcinogenic potential (Miller, 2007). International NGOs, such as the International Campaign to Ban DU, have taken up the cause to ban such weapons. As further information, the appendix contains a response to the Depleted Uranium (DU) Resolution adopted at the United Nations General Assembly that was developed at the EETAP Conference held in 2008 in Hiroshima, Japan.

Once the uranium is enriched, it is transferred to a fuel fabrication plant, where it is eventually formed as part of nuclear fuel rods and fuel rod assemblies (WNA, 2009). While there are small amounts of radioactivity and chemicals produced into waste, there do not appear to be significant and particular ethical concerns with the technology.

Once the nuclear fuel assemblies have been produced, the front end of the nuclear fuel cycle comes to an end, and the nuclear fuel assemblies enter the reactor. The U-235 fissions and produces heat which is converted to electricity. It is eventually turned into plutonium and wastes (WNA, 2009). Depending on the reactor design, fuel, and operation, about one-third of the spent fuel is removed every year or 18 months, to be replaced with fresh fuel (WNA, 2009).

Freshly spent nuclear fuel assemblies are highly radioactive and are stored in ponds usually located at the power plant. The rods stay in the ponds for several years. The ponds act as a barrier against radiation and absorbs the heat from the fuel (water has a high capacity to absorb heat). Eventually, the spent fuel becomes less radioactive. The longer it is stored, the easier it is to handle, due to the decay of radioactivity (Richter, 2008). However, there is enough radiation leftover to act as a deterrent against nuclear theft or diversion (Richter, 2008). There are two alternatives for spent fuel. The first is to reprocess, and the second is long-term storage.
During reprocessing, the uranium and plutonium are separated from the wastes. The uranium is returned to the nuclear fuel cycle at the point of conversion (WNA, 2009b). This fuel contains about 50% Pu-239 (WNA, 2009b). The 3% wastes are eventually turned into solid wastes (WNA, 2009b). This waste can be a source of concern as it needs to be stored.

Reprocessing has been criticized for being expensive, posing security threats, harming the environment and not eliminating the need for geological repositories. Non-government organizations (NGO) quote the economic and environmental disaster of the West Valley reprocessing facility in the U.S., the fuel leak from the Sellafield THORP reprocessing plant in the U.K. and the massive cost overruns of the Rokkasho reprocessing plant in Japan as some of the examples to highlight the risks of the reprocessing option (Public Citizen, 2008). A standard 1-GWe reactor produces roughly 200 kg of plutonium per year, enough in principle for about 20 weapons (Richter, 2008). Reactor-grade plutonium can be in theory used to build a “dirty bomb” which is a sub-nuclear or non-nuclear weapon causing significant loss of life and environmental damage. If the reactor-grade plutonium were available to rogue elements, it could also be used to manufacture a fission weapon, although it may be unreliable (Richter, 2008).

If the spent fuel is not reprocessed, it must be stored. This raises several ethical issues, which include the inadequacies of current waste management decision-making, underutilized ethical principles including intergenerational equity concerns, and the perceived lack of information by the public.

First, current waste management decisions\(^1\) are often criticized because they do not incorporate social uncertainties. Current radiation waste risk modeling is based on probabilities of equipment and structural failures, natural disasters, and other physical variables. They often do not consider constantly changing attitudes and ethical opinions, and when they do, it is often subjective. For instance, a detailed study of three different participative decision-making processes employed by France, U.K. and Korea for their long-term radiation waste management showed that current methods of determining social risk perceptions are predominantly subjective (Rao, 2008).

Second, ethical principles such as the precautionary principle are often underutilized when applied to radiation waste management. For instance, in the UK, some of the criteria in formal decision-making models used by the Committee on Radioactive Waste Management (CoRWM) correspond to the precautionary principle, but this was more an *ad hoc* approach (Rao, 2008). The principle is not explicitly acknowledged and modeled into the decision-making process (CoRWM, 2006). In fact, a study of long-term radiation waste management decisions involving geological repositories in the UK, France, and Korea reveal there is no systematic and objective consideration of all the Rio Declaration principles. The study also found that there is inadequate consideration of risk issues, legal principles, and ethical standards. With respect to risk issues, countries did not use objective risk trade-off considerations. With respect to legal principles and ethical standards, key legal principles and ethical standards were discussed on an *ad hoc* basis but not objectively incorporated into their decision-making (Rao, 2008).

\(^1\) For example, cost benefit analysis (CBA), best available technology (BAT), and best available technology not entailing excessive costs (BATNEEC).
Yet, radioactive waste lasts a long time and therefore, intergenerational equity is one of the prime considerations for waste management. As an illustration, the intergenerational ethical issues posed by repositories span risks pertaining to underground aquifer layers, agriculture in the vicinity of the repository site, radiation risks in the event of accidents, earthquakes, and other natural calamities. The IAEA’s principles on radioactive waste management (IAEA, 1995) have two specific references to intergenerational equity. Principle 4 states that “radioactive waste shall be managed in such a way that predicted impacts on the health of future generations will not be greater than relevant levels of impact that are acceptable today”. Principle 5 states that “radioactive waste shall be managed in such a way that will not impose undue burdens on future generations”. Yet, implementing these principles in radioactive waste policy decision-making, given the scientific uncertainties associated with long-term health risk assessment in principle 4, and ethical considerations of what constitutes “undue burden” in principle 5, is a challenge. On the one hand, medical research is progressing on radiation induced diseases such as cancer, and on the other hand, the health profile of the population as a whole is changing due to changing food and lifestyle habits. To avoid imposing an ethical burden on future generations with a legacy of wastes buried underground, reversibility and retrievability technologies are frequently positioned as a solution, but the costs of such options are substantial.

Third, the general public often feels that it does not have access to appropriate safety information. For instance, a 2002 joint study of the French nuclear research agency Institut de Radioprotection et de Surete Nucleaire (IRSN) and the Belgian nuclear research agency Studiecentrum voor Kernenergie (SCK), based on interviews of over 1000 members of the public each in France and Belgium, revealed that more than 60% of the population do not believe that they possess truthful knowledge about nuclear waste risks (Carle et al., 2003). Moreover, while experts can process nuclear information, have access to the latest information, and can ask for the opinions of their colleagues, the general public does not. It may therefore be difficult for the public to grasp the complexity and extremely long timeframes involved in radioactive waste management. To provide an example of the complexity, the US Department of Energy developed a Probabilistic Risk Assessment of the proposed Yucca Mountain repository which involved 177 variables (Cohen, 2001). The timeframes are also an issue for the public. For instance, it takes thousands of years for the high level waste which is produced by the reactor to reach the radioactivity levels of the original uranium ore (WNA, 2001). Further, the media often negatively portrays the generation of radioactive waste.

All of this may result in low social acceptability of radiation waste management decisions. Public protests ranging from mild demonstrations to violence on the streets have been observed (Choi et al., 2008). To improve societal acceptability, many stakeholder models are evolving, especially with reference to long-term geological disposal. Despite these efforts however, much of the public is not yet persuaded.

2.5 Nuclear fuel supply

A closely related issue to the nuclear fuel cycle is the supply of nuclear fuel. The main source of nuclear fuel is U-235 as mentioned before. While plutonium-239 (Pu-239) is used in reactors, it is derived ultimately from U-235 and is not considered an originating fuel. It cannot be extracted as part of an ore, and its supply depends on U-235. Another possibly nuclear fuel for commercial use in the future is thorium, to be used in commercial breeder reactors.
The following chart obtained from the World Nuclear Association shows the known recoverable amount of uranium (from mines) as of 2007.

**Known Recoverable Resources* of Uranium 2007**

<table>
<thead>
<tr>
<th>Country</th>
<th>tonnes U</th>
<th>percentage of world</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>1,243,000</td>
<td>23%</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>817,000</td>
<td>15%</td>
</tr>
<tr>
<td>Russia</td>
<td>546,000</td>
<td>10%</td>
</tr>
<tr>
<td>South Africa</td>
<td>435,000</td>
<td>8%</td>
</tr>
<tr>
<td>Canada</td>
<td>423,000</td>
<td>8%</td>
</tr>
<tr>
<td>USA</td>
<td>342,000</td>
<td>6%</td>
</tr>
<tr>
<td>Brazil</td>
<td>278,000</td>
<td>5%</td>
</tr>
<tr>
<td>Namibia</td>
<td>275,000</td>
<td>5%</td>
</tr>
<tr>
<td>Niger</td>
<td>274,000</td>
<td>5%</td>
</tr>
<tr>
<td>Ukraine</td>
<td>200,000</td>
<td>4%</td>
</tr>
<tr>
<td>Jordan</td>
<td>112,000</td>
<td>2%</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>111,000</td>
<td>2%</td>
</tr>
<tr>
<td>India</td>
<td>73,000</td>
<td>1%</td>
</tr>
<tr>
<td>China</td>
<td>68,000</td>
<td>1%</td>
</tr>
<tr>
<td>Mongolia</td>
<td>62,000</td>
<td>1%</td>
</tr>
<tr>
<td>other</td>
<td>210,000</td>
<td>4%</td>
</tr>
<tr>
<td>World total</td>
<td>5,469,000</td>
<td></td>
</tr>
</tbody>
</table>

Reasonably Assured Resources plus Inferred Resources, to US$ 130/kg U, 1/1/07, from OECD NEA & IAEA, Uranium 2007: Resources, Production and Demand (“Red Book”).

Because about 65,000 tonnes of uranium per year are used, the amount of uranium available may be expected to last for approximately 80 years at current rates. However, such a forecast leaves out many considerations. It does not reflect the significant percentage of nuclear fuel traditionally derived from the highly-enriched nuclear fuel of decommissioned nuclear weapons (from the year 2000 the dilution of 30 tonnes of military high-enriched uranium has been displacing about 10,600 tonnes of uranium oxide per year from mines, which represents about 13% of the world’s reactor requirements) (WNA, 2009c). It does not also factor in unknown uranium deposits (which is expected to increase significantly (WNA, 2009c)) which typically increase when energy prices increase and exploration is intensified; increasing efficiency of nuclear reactors; and new technology (WNA, 2009c). Finally, greater and more efficient reprocessing is likely to extend the amount of usable nuclear fuel (WNA, 2009c). Nuclear experts have expressed confidence in the supply (see for e.g. Deffeyes 2006).
Most of the world’s uranium is obtained from Canada (20.5%), Kazakhstan (19.4%) and Australia (19.2%) (WNA, 2009d). The current supply of uranium is therefore stable, as these countries tend to have lower political and economic risk. For instance, the UN Conference on Trade and Development Index (TDI) in 2007 ranked Canada as 10th and Australia as 16th (data on Kazakhstan was not available) (WNA, 2009d).

However, there will be significant political differences in the manner in which such resources are controlled. For instance, some states, such as Malaysia, Indonesia, and Brazil which are suspicious of their potential suppliers (Richter, 2008). The GNEP and Nuclear Supplier’s group, present complex issues because is it fair that the GNEP supplier nations are the only states to supply? In the same way, is it fair that the Nuclear Supplier’s Group is fair?

There have been many proposals to guarantee fuel supplies to countries without uranium enrichment facilities or those who must purchase their uranium fuel. One such proposal is the Global Nuclear Energy Partnership (GNEP). Another well-known proposal which has recently gained momentum is the private Nuclear Threat Initiative (NTI). Mohammed ElBaradei, the director-general of the International Atomic Energy Agency (IAEA), has laid out three principles a fuel guarantee framework (Pomper, 2009). First, the fuel bank mechanism should be nonpolitical, nondiscriminatory, and open to any state in compliance with its IAEA safeguards obligations (Pomper, 2009). This ensures that nuclear material and technology are not diverted from peaceful to military uses (Pomper, 2009). Second, any release of the material should be determined by nonpolitical criteria established in advance and applied objectively and consistently (Pomper, 2009). Third, "no state should be required to give up its rights under the nuclear Nonproliferation Treaty (NPT) regarding any part of the nuclear fuel cycle." (Pomper, 2009). Finally, "one part of a possible new framework is to reach agreement that all new enrichment and reprocessing activities should be placed exclusively under multilateral control, to be followed by agreement to convert all existing facilities from national to multilateral control as well‖ (Pomper, 2009).

Another way to control nuclear fuel export and transfer is through less formal political groups, such as the Nuclear Suppliers Group (NSG), which according to its website is a “group of nuclear supplier countries which seeks to contribute to the non-proliferation of nuclear weapons through the implementation of Guidelines for nuclear exports and nuclear related exports‖ (NSG, 2009). Nuclear fuel, along with nuclear technology, is the group’s focus.

2.6 Nuclear proliferation

Nuclear energy is intimately linked to nuclear weapons, as the science and engineering for civilian purposes can be adapted for military uses. The issue of such “dual-use technologies” and proliferation is an issue which is unambiguously absent in discussions of the ethics of other energy technologies. For some, nuclear proliferation should be absolutely prohibited. For others, over-reaction to such concerns may conflict with their rights to civilian nuclear energy use.

Using proliferation-resistant nuclear technologies may play a key role in seeking to minimize proliferation risks. Since there is no completely proliferation-resistant fuel cycle or nuclear facility, proliferation resistance is evaluated in relative rather than absolute terms. In nuclear fission, proliferation resistance means getting state actors to stop or reduce uranium
enrichment and reprocessing and the spread of these technologies, and preventing non-state actors from obtaining fuel at any point in the nuclear fuel cycle.

The Nuclear Non-Proliferation Treaty (NPT) guarantees peaceful use of nuclear technology, and enrichment and reprocessing fall under this category. Moreover, the spread of these technologies, when used for purely civilian purposes, is also allowed under the NPT. Thus, the reduction of these activities and spread of the technology must be built-in to the technology itself, such as the GNEP plans to research, and/or international political pressure must be applied. The use of export controls and IAEA technical verifications are also tools to be used in this regard.

The use of export controls and technical verifications here may also reduce any risks of proliferation, chiefly directed at non-state actors such as terrorists. Advancements in proliferation-resistant technologies may also help. While Nunn (2008) and others have proposed steps to curtail nuclear terrorism, such risks and prevention measures as well as technological investments may be costly, and the risk still is non-zero. It may be beneficial to take a more integrated approach to countering this threat. For instance, tactics may need to shift from a predominantly technology and fissile material stock monitoring approach to targeting terror financing and social capital.

The IAEA (2007) has released an advisory on countering nuclear terrorism. Apart from providing an overview of legal instruments, this advisory also includes initiatives of international organizations such as WCO, Interpol, Europol, and the Universal Postal Union in countering terrorism. A paradigm shift in terms of how the world community looks at the security of nuclear assets and material, ranging from technological advancements in material detection to raising social capital, may be underway. Governments may benefit from designing a complex fabric of nuclear security on a socio-technical basis. This may involve educating citizens, politicians, and policy-makers to the security implications of nuclear technologies and implementing complex security measures without causing alarm.

2.7 Costs

There are various economic and financial forecasts on how much different energy sources cost. Often, these compare the traditional fossil fuels, such as oil and gas with hydropower and nuclear, for instance. More recently, many calculations including solar, wind, geothermal, and other sources have been published.

Perhaps more important than the calculation themselves is the assumptions under which they are made. While there are many accusations of “hidden costs” in nuclear energy, such as the cost of decommissioning plants and insurance guarantees, this depends on what this term embraces, or what “total costs” include. Nuclear energy production might include such considerations, as well as any non-monetary “safety” costs and environmental costs. It may also need to include the enormous investments made in basic and applied research, at least in comparison with other energy technologies. However, sources such as solar and wind may also have hidden costs. For instance, wind turbines can kill birds and bats. It is estimated that about 100,000 birds are killed each year in the United States from wind turbines, and if wind power increases to 20 percent of electricity, the number will increase 30 times (Cohn, 2008). Although this is a relatively small number in comparison to other sources of inadvertent bird deaths (e.g. from communication towers), it still represents a significant concern. Hydroelectric dams may release more GHG emissions than many coal plants (see
for example Beam, 2005), although actual comparisons are not conclusive. Both wind and solar require upgraded electrical grids in places such as the United States, as they are intermittent power sources. The current generation of electrical grids has inefficient high-voltage long-distance transmission lines, may not be able to deal effectively with demand and supply effectively, and have outdated monitoring and control technology (see for instance, Hendricks, 2009). Although recently called into question (Winters, 2009), solar and wind may not be able to effectively integrate with such grids at high capacity levels, while nuclear already does.

2.8 Nuclear politics

Theories of international relations (IR) explain the way international politics works, but each of the currently prevailing theories is incomplete when taken alone (Snyder, 2004). In particular, none of these theories provide a means to discern proliferation intentions and behaviours of states. This suggests that rather than forcing nuclear driven policies based on a particular approach, policy-makers may benefit from modelling international impacts using multi-disciplinary inputs. According to one defence expert, “[w]hat technologies must we develop to understand and influence nation states...WMD proliferators...the path to understand people, their cultures, motivations, intentions, opinions and perceptions lies in applying interdisciplinary quantitative and computational social science methods from mathematics, statistics, economics, political science, cultural anthropology, sociology, neuroscience, and modeling and simulation” (Popp 2005). Innovative computer modeling approaches based on complex social computing could be developed that could serve as an ethical platform to objectively evaluate proliferation intentions of states (Rao, 2008).

Nuclear technology cooperation between developed and developing countries exists in various fields, most notably technology transfer and funding. Such cooperation, however, come with proliferation concerns. Collective approaches such as the GNEP (Global Nuclear Energy Partnership) were purportedly designed for peaceful purposes while simultaneously minimizing the attendant risks. Through GNEP, the United States will work with other nations possessing advanced nuclear technologies to develop new proliferation-resistant recycling technologies in order to produce more energy, reduce waste and minimize proliferation risks. Partner nations will develop a fuel services program to provide nuclear fuel to states not possessing enrichment and reprocessing capabilities, which tend to be mostly developing countries, allowing them access to sources of nuclear energy in a cost effective manner in exchange for their commitment to forgo enrichment and reprocessing activities (Department of Energy, 2006). However, the envisaged mechanism of establishing a group of fuel supplier states raises ethical questions of selective technology sharing and dominance which discriminate between states. As the fuel recipient states tend to be mostly developing countries, a further ethical dilemma is raised: whether nuclear energy cooperation really provides enhanced energy security for developing states or merely shifts their dependencies from fossil fuel countries to nuclear fuel countries.

Dependency of developing countries on the developed countries for nuclear fuel, funding, and nuclear commerce inevitably influences recipient states. In the event of increased use of nuclear energy, in particular as envisaged in developing countries such as India, and in the simultaneous event of denial of reprocessing technology transfers and rights under regimes such as GNEP, the issue of how to deal with spent fuel would create regional concerns with complex geopolitical issues. Such developments should perhaps be monitored and an environment for free and positive relations among states be fostered.
2.9 Nuclear agreements

There are currently numerous nuclear laws, agreements, guidance documents, and regulations which occupy the field of nuclear regulation. There are several ethical issues which should be addressed in these agreements, as the following illustrate.

First, nuclear agreements can often create new ethical challenges. They may do this by creating post-ratification issues. For instance, Article IV of the NPT states that research and production of nuclear energy for peaceful purposes is an “inalienable right” of signatories. The ethical implications of the treaty, by creating a nuclear divide between the “haves” and the “have-nots”, have been widely debated. Another example concerns the proposed Fissile Material Cut-off Treaty (FMCT), which relies on the ability to physically verify stocks accurately (Sanders, 2004; Squassoni, 2005; Zhang, 2004). Physical verification challenges exist in terms of drawing the line between permitting access to inspection and intrusion into a country’s nuclear programme.

Second, definitional issues may hinder the implementation of treaties. In the case of the FMCT, what constitutes ‘stock’ and ‘fissile material’ is itself debated. Some countries have proposed limiting stipulations to “weapons-grade” rather than “weapon-usable” material (WILPF, 2009; IPFM, 2008). Even within the category of weapons-grade material, clarity does not exist on what constitutes “stock”. In particular, it is not clear whether existing stocks are covered or not. Lack of consensus in definition and also scope for varied interpretations weaken the spirit of the law, and especially in relation to arms control treaties. For example, the thin dividing line between NATO’s ‘nuclear sharing’ arrangements with Belgium, Germany, Italy, The Netherlands and Turkey and non-proliferation obligations under the NPT have been questioned (WILPF, 2005). Whether NATO’s arguments and legal interpretations that ‘nuclear sharing’ is compatible with the NPT, and in particular Article I and II of the NPT, has been questioned by many countries. Therefore, to the extent possible, all key nuclear terms should be governed by internationally accepted definitions.

Third, various nuclear agreements can benefit from integration in a more cohesive and unified regime. For instance, the Comprehensive Test Ban Treaty (CTBT) bans nuclear test explosions leading to science-based “stock pile stewardship” programs which are expected to maintain stockpiles of nuclear-weapons based on computer simulations. The ethical risks of methods that simulate nuclear weapons performance from “first principles” erode the security purpose of NPT (Paine and McKinzie, 1998).

Fourth, the combination of “hard” and “soft” law poses unprecedented legal challenges. For example the radiation protection precept of “as low as reasonably achievable” (ALARA) elaborated by the International Council for Radiation Protection (ICRP) and in various hard and soft law documentation is regarded as a minefield for lawyers and judges who are forced to work in a combination of hard and soft law. The softer form of self-regulation is at the top of the ALARA legal ladder and hard law, in terms of regulations and acts, are at the bottom (Veuchelen, 2008).

Fifth, with all of the nuclear agreements currently in existence, there are still issues which agreements do not adequately address. For instance, there is an increased role for international regulation and reduction of nuclear weapons. For the period 1940-1996, the United States alone is estimated to have spent an amount $5.5 trillion (in 1996 USD) on its
nuclear weapons program (Schwartz, 1998). The ethical debates of allocating social resources
to the military at the cost of developmental expenditure should be considered by governments
as well as intergovernmental organizations. With respect to the latter, article 26 of the Charter
of United Nations states that “in order to promote the establishment and maintenance of
international peace and security with the least diversion for armaments of the world's human
and economic resources, the Security Council shall be responsible for formulating, with the
assistance of the Military Staff Committee referred to in Article 47, plans to be submitted to
the Members of the United Nations for the establishment of a system for the regulation of
armaments”. The formulation of workable procedures is a prerequisite policy outcome.
However, as the economic allocation role and mechanisms are not clear, this needs to be
clarified.

2.11 Nuclear justice and equity

One of the unique and particular issues of nuclear energy technology ethics concerns
equity and justice issues. Developing countries are spending considerable sums on nuclear
energy as compared to developed countries, as mentioned before. When a significant
proportion of the population suffers from the lack of basic needs this may represent an
injustice to the poor and the marginalized of a given society. This runs contrary to the
principle of justice.

This is particularly true with respect to nuclear weapons spending. Renner (2007)
notes that the number of nuclear warheads held in 2006 by five of the world’s nuclear
powers— the United States, Russia, the United Kingdom, France, and China—was estimated
at about 27,000, down from a peak of about 70,000 in 1986. The US and Russia stockpiles
account for over 97% of the warheads. Renner also provides estimates that around 2500
nuclear warheads remain on high alert status. Examples of costs of maintaining nuclear
weapons are given below:

- The 1972 Strategic Arms Limitation Treaty I (SALT I) led to a sharp curtailment of any
  further anti-ballistic missile (ABM) development efforts. In 1974, a treaty revision allowed
  the U.S and the Soviet Union to retain only one ABM site each. The American site became
  operational in 1975 but Congress ordered its termination within four months. Before site
  shutdown, the cost was 21.3 billion USD (Garrison, 2006).

- The total incurred costs of the U.S. nuclear weapons program exceed $5.8 trillion in the
  period between 1940 and 1996. This includes $320 billion in estimated future-year costs for
  storing and disposing of more than five decades' worth of accumulated toxic and radioactive
  wastes, and $20 billion for dismantling nuclear weapons systems and disposing of surplus
  nuclear materials (Schwartz, 2008).

- The average French nuclear defence budget per annum for 2003-2008 was planned to be
  $3.8 billion. For comparison purposes, the defence budget for 2006 was $49 billion (Tertrais,
  2007).

Comparing nuclear defence spending and budgets with country’s budgets for education
and development reveals that military intentions are often higher (GPF, 2009). The ethics of
distributing societal financial resources for nuclear military expenditure versus
developmental expenditure is a perpetual question in national governance. The governments
involved, which are for the most part developed economies, may consider the opportunity cost to the impoverished when considering such spending.

Turning attention now to a developing country such as India, more than half of the population lives below the poverty line, and there have been many suicides by farmers in 2008 due to an inability to grow enough food (Lohan, 2009). While the immediate cost of generating energy from a nuclear power plant is higher than the thermal or hydroelectric methods of power generation, the justice principle would likely dictate that the relative cost of energy, whether nuclear or not, should be comparatively less, rather than more, in comparison to developed countries. To meet this ethical obligation of justice, developed countries may provide funding and development assistance or technology transfers and cooperation with developing countries.

However, even if such policies from developed countries are not forthcoming, or such policies are less than adequate, the justice principle still has further application. Since its independence, the issue of poverty within India has remained a prevalent concern. According to the common definition of poverty, when a person is unable to meet the minimum requirement of acceptable living standards, he or she is considered to be living in poverty. For example in India, millions of people are unable to meet the basic standard: according to Indian government estimates, in 2007 there were nearly 220.1 million people living in poverty. Poverty, in India or elsewhere, has dire downstream effects (World Bank, 2009; Mehta, 2003). If the cost of nuclear energy is relatively more for countries with high poverty rates, there will be less funding available to be spent on education, basic health and living.

Thus, in this further application of the justice principle, justice is relative for each country because it depends on the wealth of the given country. For example, nuclear technology development in India may not be justified if basic amenities of the people are not fulfilled. Basic amenities represent high value per dollar of investment, and if such money funds nuclear technology development, a large opportunity cost is imposed. However, in the case of developed countries such as France, nuclear technology development is more justifiable because basic amenities of a large proportion of the population is met.

2.12 A human-rights based approach

A case for a right to a particular energy source such as nuclear energy remains ambiguous. For instance, while Article IV of the NPT states that signatories have a substantive and “inalienable right” to peaceful use of nuclear energy, it is subject to conditions. While the right to broader sustainable energy arguably deserves to be recognized as a fundamental human right, there is some consensus that this right exists not as a substantive right by law or constitution but rather as procedural right (Wilson and Anderson 2005). The application of procedural rights to nuclear energy in particular is ambiguous. For example, the United Nations Framework on Climate Change (UNFCCC) excludes nuclear technologies in two of the three flexibility mechanisms under the Kyoto Protocol.

Given the complexity of applying “rights” to nuclear energy, it may be useful to examine the imperatives of policies, treaties, and programmes on nuclear energy in light of a human-rights based approach, which can be found among the countless documents and understandings produced.
As an example which shows the human-rights based approach at work, the outcome of the Interagency Workshop on a Human Rights based Approach in the context of UN reform 3-5 May 2003 might be used. A common understanding was reached at the workshop entitled, “The Human Rights Based Approach (HRBA) to Development Cooperation Towards a Common Understanding Among UN Agencies”. It outlined various principles to be followed in all phases of programming, including: universality and inalienability, indivisibility, interdependence and inter-relatedness, non-discrimination and equality, participation and inclusion, accountability, and the rule of law.

Further, UN High Commission on Human Rights (UNHCHR) guidance (UNHCHR, 2006) can be adapted to HRBA in policies and programmes pertaining to nuclear technologies. Such guidance is helpful because it provides additional ethical support for a human-rights based approach. The following are principles that may be derived from including such guidance into the approach:

- The main objective of nuclear policies and programmes should be to fulfill human rights, in particular the right to sustainable energy.
- Nuclear policies and programmes should identify the right-holders and their entitlements, corresponding duty-bearers and their obligations, and work towards strengthening the capacities of rights-holders to make their claims and of duty-bearers to meet their obligations (the current emphasis in the nuclear context in many countries is on ‘stake-holders’, not ‘right-holders’).
- Principles and standards derived from international human rights treaties should guide all policies and programmes in the nuclear sector and in all phases.

In addition, ethical issues are encountered from experience. For instance, in the human-rights based approach, individual and collective rights aspects also require special attention. Collective rights are called into question during various circumstances such as individual versus collective radiation doses, rights of the local community waste hosting repositories, and rights of the communities during transportation of nuclear material. Nuclear energy policies need to be explicit in addressing both individual and collective rights in a human-rights based approach.

Further declarations and sources of law and authority will need to be included. For instance, according to the 1997 declaration by the UNESCO Director-General, on the human right to peace, lasting peace is a prerequisite for the exercise of all human rights and duties (The Human Right to Peace: Declaration by the Director-General (SHS-97/WS/6)). This right needs to be at the centre of all developmental and military research budgets that feed into nuclear technologies. This also requires a rights-based approach to international obligations arising out of treaties such as the Nuclear Non-Proliferation Treaty (NPT) and Strategic Arms Reduction Treaty (START).
Part 3: Policy Options and Conclusions

The use of nuclear energy is associated with a complex set of issues requiring many ethical considerations. As nuclear energy technology becomes a more prominent issue, governments are urged to consider these issues and their attendant ethical considerations. To that end, the following policy options and conclusions are made. These options and conclusions are considered the most significant ones following the body of the report.

First, an improvement in the overall process of creating guidelines to implementing them is an option for creating more ethical and safe nuclear plants. More guidelines regarding definitions may be beneficial. The use of terms such as “as low as reasonably achievable” (ALARA), while undoubtedly context-sensitive, may benefit from greater detail and standardization. When several guidelines are available, these should be integrated into work cultures. As mentioned above, many ethical documents and guidelines exist for nuclear facility operators, but states may benefit from more integrated guidelines. These guidelines can in turn be integrated into nuclear safety cultures through mechanisms ranging from safety guidelines to employee performance appraisals.

Second, any ethical or policy analysis of nuclear energy technology would greatly benefit from considering the entire nuclear fuel cycle. This report shows that there are more considerations than the nuclear plant when considering effects on the environment. While the nuclear reactor itself does not produce GHG gas emissions, it produces radioactive waste, as well as various environmental effects from mining. The front end and the back end should be considered to avoid an incomplete social analysis. If uranium mining is not considered when deciding nuclear energy technology policy, it can lead to states not considering the health and environmental effects on uranium-mining countries and their populations in, for instance, Kazakhstan.

Third, states may consider “safer” options when using nuclear energy technology. With respect to nuclear reactor design, states may wish to provide consideration for meltdown-resistant designs. With respect to enrichment, states may wish to consider purchasing enriched uranium or having it enriched elsewhere. This is a difficult choice for states, as they may wish to increase energy security by developing their own enrichment capacities. Nevertheless, they are options. With respect to reprocessing, states may wish to consider not reprocessing fuel or taking extra security precautions when doing so. Alternatively, they may consider increasing funding for more proliferation-resistant reprocessing technologies and/or consulting groups such as GNEP. With respect to depleted uranium, states may wish to consider restricting its use to civilian purposes and disallow military use. States may also wish to consider supporting the banning of depleted uranium weapons.

Fourth, societies may benefit from greater exchange and transparency of nuclear information. It was mentioned in this report that the general public often feels that it does not have enough access to nuclear safety information, making it difficult for them to take part in policy and ethical debates. The public may further not feel comfortable with nuclear energy if there are suspicions that information is being hidden. To therefore increase the efficacy of public discourse and improve acceptability of nuclear decisions by policy-makers, it may benefit states if nuclear information is provided with greater transparency.

Fifth, while most states take concrete steps to curb nuclear proliferation, there are other steps that may be underemphasized. As mentioned in this report, a more integrated approach
to countering this threat may be beneficial. Tactics may need to shift from a predominantly technology and fissile material stock monitoring approach to targeting terror financing and social capital. Moreover, states may benefit from designing a complex fabric of nuclear security on a socio-technical basis. This may involve educating citizens, politicians, and policy-makers to the security implications of nuclear technologies and implementing complex security measures without causing alarm.

Sixth, the cost of nuclear energy should be more completely assessed by taking into consideration the opportunity cost vis-à-vis other energy sources and all “hidden” costs. These were mentioned in this report, and include insurance guarantees, the cost of decommissioning plants, regulatory oversight, non-monetary “safety” costs, and environmental costs, among others. The total costs for other energy sources should also be considered.

Seventh, the ethical issues present in international relations should be tackled with greater ethical considerations in mind. It may benefit the international community to provide consideration for the perspectives of developing countries, which are not technologically advanced. These countries’ needs are often overshadowed by security concerns (for instance, in the GNEP), but greater measures to provide for equality may result in more stabler international relationships.

Eighth, nuclear agreements should be analyzed with significant emphasis on ethical aspects. The ethical issues should be identified, common definitions developed and standardized, and various nuclear agreements can benefit from integration in a more cohesive and unified regime.

Ninth, greater application of ethical principles such as justice and equity may provide a reason to consider the opportunity cost to the impoverished when considering such spending. This may also prompt developing countries to spend comparatively less on nuclear technology and provide greater financial attention to the impoverished. Finally, to meet the ethical obligation of justice, developed countries may provide funding and development assistance or technology transfers and cooperation with developing countries.

Tenth, given the complexity of nuclear energy, it may be useful to examine the imperatives of policies, treaties, and programmes on nuclear energy in light of a human-rights based approach, which can be found among the countless documents and understandings produced. The human rights-based approach is able to simplify some of complexity resulting from international politics as well as the complexities due to myriad nuclear agreements and regulations.
6. References


Deffeyes, Kenneth S. Beyond Oil: The View from Hubbert’s Peak, (Hill and Wang, New York, 2006).


Lohan, Tara. 2009. 1500 Indian Farmers Commit Mass Suicide: Why We are Complicit in These Deaths. AlterNet. Available at http://www.alternet.org/workplace/137059/1,500_indian_farmers_commit_mass_suicide:_why_we_are_complicit_in_these_deaths/?comments=view&cID=1190532&pID=1190419.


Rao., P.S. Role of soft law in the development of international law: some random notes Fifty Years of AALCO Commemorative Essays in International Law


UNESCO, Ethics of Science and Technology as accessed at www.unesco.org/shs/est


WILPF Article 26, A neglected instrument for sustainable disarmament and sustainable development, A project of Women’s International League for Peace and Freedom (WILPF)
As can be accessed at http://www.reachingcriticalwill.org/political/article26/background.html.


Appendix

A response to the Depleted Uranium (DU) Resolution adopted at the United Nations General Assembly on 5 December, 2007

In response to the Depleted Uranium (DU) Resolution adopted at the United Nations General Assembly on 5 December, 2007, the participants of the Joint UNESCO-UNITAR Asia-Arab Interregional Philosophical Dialogues on the Roles of Philosophy in War and Peace, and the Joint UNESCO-UNITAR Workshop on the Ethics of Nuclear Energy Technologies, noted that they are deeply concerned about the DU issue especially because it is understood that children are most susceptible to toxic radioactive materials.

Thus, the participants considered it is urgent to:

1. To alert the peoples and children living particularly in the DU-affected areas to the dangers caused by DU weapons;
2. To give serious consideration to the harmful effects of DU weapons by setting up an expert committee on the DU issue as quickly as possible;
3. To place an international moratorium on the use of DU weapons to prevent further DU-caused harms on human health and contamination of the environment.
4. To establish a Body to transport DU polluted war machinery and ammunition away from populated areas, and to properly dispose of them in remote and safe locations.

Agreed in Hiroshima, Japan, 27 July, 2008