Section 3.1

# Climate Change and Nuclear Power

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**Recommendations of the WMD Commission**

It is widely expected that global reliance on nuclear power will increase in the next decades, as the price of fossil oil and gas goes up and the greenhouse gas-free nuclear energy becomes more attractive. If so, there will be a greater demand for uranium fuel, possibly leading to the construction of more enrichment plants. As reprocessing of spent fuel will allow a drastically better use of the energy content of the original uranium fuel, there may also be a demand for more reprocessing plants. The concern is that an increase in the number of enrichment and reprocessing plants and an increased flow of fissile material may increase the risk of misuse and diversion. (*Weapons of Terror*, 74)

[A]ll countries possessing an enrichment or reprocessing capability are technically able–just like the states that have nuclear weapons–to make nuclear material that can be used in weapons. (*Weapons of Terror*, 76)

It is often said these days that the most dire collective security threat facing the world, aside from nuclear annihilation, is the catastrophic effects of climate change. In recent decades the scientific community has compiled an alarming and incontrovertible collection of data describing the human causes of climate change and its dire consequences for human and other life. Recognized as a looming global security catastrophe, governments and civil society have struggled to find the means to mitigate the causes of climate change. These concerns have sparked renewed interest in nuclear power as a non-carbon dioxide ($CO_2$) emitting energy alternative. Scenarios anticipating the widespread growth of nuclear energy raise a number of serious concerns, most notably the threat of nuclear weapons proliferation due to the spread of nuclear fuel-cycle technologies. Ignoring the inextricable link between nuclear weapons and nuclear power, the WMD Commission does not offer a coherent and comprehensive set of recommendations taking into account the enormous risks and realities associated with the spread of nuclear technology. Like climate change, the problems of nuclear power are global in nature and thus require a global response which will only be sustainable if based on the principles of the rule of law and non-discrimination.

### *The Effects of Climate Change*

Due to human activities, the concentration of greenhouse gases in the atmosphere rose dramatically in the years between 1750, pre-industrial revolution, and 2000. The atmospheric concentration of $CO_2$ rose from a constant of 280 parts per million (ppm), in the period between 1000 and 1750, to 368 ppm in 2000.[1] By the end of this century the Intergovernmental Panel on Climate Change (IPCC) projects that the concentration of atmospheric $CO_2$ will increase to between 540 and 970 ppm, with the variance depending largely on demographic, social, economic, and technological factors. The projected increases in the global concentration of greenhouse gases will have a variety of consequences for global and regional climate, the environment and ecosystems, human security, and socio-economic development.

The 1990s were the hottest decade on record and, based on indirect environmental sampling, likely the hottest decade in the past 1,000 years.[2] And the pace of the warming trend is accelerating. Between 1990 and 2100 average surface temperature is anticipated to rise globally between 2.4 and 6.4°C, if fossil fuels remain a predominant source of energy.[3] This projected warming, popularized by the infamous "hockey-stick" graph, is between two and ten times larger than the increase experienced over the 20th Century and, moreover, "is very likely to be without precedent during at least the last 10,000 years."[4]

These alarming data have led the IPCC to conclude that "overall, climate change is projected to increase threats to human health, particularly in lower income populations, predominantly within tropical/subtropical countries."[5] The threats include loss of life due to direct causes such as increased extreme heat conditions, more frequent and intense floods and storms, and indirect causes like increases in water-born pathogens and decreases in water and air quality. While crop yields may increase in some temperate areas, in most tropical and sub-tropical regions they are expected to decrease. Populations inhabiting small islands and low-lying costal areas are at risk from the rise in sea level, expected to increase on average between 0.009 to 0.88 meters by 2100, primarily as a result of glacier and ice cap melting.[6] Less predictable are the social and economic effects of global warming, which are expected to adversely affect developing nations much more acutely than the industrialized societies.

This is only a select sampling of the predicted consequences facing humanity over the course of this century if immediate action is not taken globally to reduce greenhouse gas emissions. Taken as whole, some of the effects of climate change will be undeniably positive–for instance, fewer deaths expected from extreme cold. But the net effect of climate change will be resoundingly negative in regard to its impact on humans and global ecology. Furthermore, the IPCC has concluded that "the impacts of climate change will fall disproportionately upon developing countries and the poor persons within all countries, and thereby exacerbate inequities in health status and access to adequate food, clean water, and other resources."[7] Thus, the issue of climate also becomes one of justice, as those industrialized states that have contributed the most to the causes of climate change, and whose actions are required to mitigate these looming crises, will not be the nations to suffer the overwhelming bulk of these negative consequences.

### *Climate Change and Global Security*

If the most dire effects of climate change are to be mitigated, and their root causes eliminated, the solution can only be achieved through a global approach. While unilateral initiatives such as mandating tighter regulations on power plant and vehicle emissions can help reduce the sources of global warming, such policies will be insufficient to achieve the drastic reductions required to avoid potentially catastrophic consequences.

In this regard, the situation of climate change shares many similarities with the problem of NBC weapons. Both issues touch to the core of state security, and in extreme cases, even have implications for the survival of states. Likewise, both issues require an urgent shift in the conception and conduct of collective security if any progress is to be made. And indeed, both issues, and the corresponding global agendas and frameworks designed to address them, have recently suffered from stalemate and setbacks, largely attributable to the conduct of one actor, the United States.

Over the past several decades there have been two notable multilateral framework conventions aimed at coordinating global responses to human-caused environmental problems. One has proven to be largely successful and a model for future cooperation; the other has stagnated. The first is the 1985 Vienna Convention for the Protection of the Ozone Layer, a framework approach which led to the adoption and entry into force of the 1987 Montreal Protocol. The second is the 1992 UN Framework Convention on Climate Change (UNFCCC) and its 1997 Kyoto Protocol, which entered into force in 2005 upon Russian ratification. However, it represents merely a first step on the path toward addressing the causes of climate change, a path which may never be taken if the United States adheres to its policy of non-participation.

In a sense, Article VI of the NPT and its mandate for negotiations leading to nuclear disarmament is another example of a framework approach, similar to the Vienna Convention and the UNFCCC. Like the UNFCCC, the disarmament framework remains imperiled due largely to the intransigence of one state party, the United States, as detailed in section 2.1. In both cases the failure of the initiative stems from the abandonment of international legal norms and instruments as a tool to solve global problems (*see sections 1.1 and 2.5*).

A study by the Institute for Energy and Environmental Research (IEER) estimates that reductions in greenhouse gas emissions "on the order of 60 to 80 percent will be required by 2050 in order to avoid the more serious potential consequences of global climate change."[8] There are several commonly cited options available for all states to take in order to reduce emissions, including increased reliance on renewable energy, carbon sequestration, increased energy efficiency, and nuclear power. The conventional view is that none of these solutions alone will be sufficient to achieve the necessary reductions in emissions, but it is also true that not all measures must be taken. With the promotion of nuclear power as a means of combating climate change, there is now a cross-over between the global security problems of climate change and nuclear weapons. The remainder of this section and the next examine the problems associated with nuclear power and the nuclear fuel-cycle in general, particularly as a solution to climate change.

### *The Troubles with the Nuclear Option*

The nuclear industry, the Bush administration, and some environmental advocates are campaigning for a renaissance in nuclear power as a means to address climate change. The WMD Commission cites this future expansion of nuclear energy as a non-greenhouse gas emitting source of energy as a "concern" because of the security and proliferation risks posed by the potential spread of nuclear fuel-cycle technologies.[9] However, the Commission fails to adequately examine the problem.

The primary flaw in the WMD Commission's assessment of the nuclear fuel-cycle is its failure to anticipate how *and where* nuclear power might expand over the coming decades. A 2003 MIT study examined a plausible growth scenario for nuclear energy of a global expansion to 1,000 gigawatts of nuclear energy online by 2050, up from about 360 gigawatts today.[10] While the study foresees considerable expansion of nuclear energy in industrialized states with significant existing nuclear infrastructures, it also anticipates large-scale expansion in the developing world. By 2050, the MIT study predicts that the total combined nuclear capacity in the developing world will expand to 325 gigawatts, nearly the same capacity as the global total today. While most of the expansion in the developing world is expected to come from nuclear weapon-possessing China, India and Pakistan, other states are also expected to develop large-scale nuclear power industries, including Brazil, Mexico and Iran. In contrast to the MIT scenario, the IEER study found that in order to reach the 60%-80% reduction in greenhouse gas emission necessary to avoid the more catastrophic effects of climate change, nuclear energy would have to expand to the implausible level of 2,500 gigawatts by 2050.[11]

The spread of nuclear energy on either of these scales is risky and presents a great number of challenges and dangers. The foremost danger comes from the spread of nuclear fuel-cycle technology and its implications for the proliferation of nuclear weapons, discussed below and further examined in the case of Iran in section 3.2. While our report deals primarily with issues relating to nuclear weapons, there are several other dilemmas uniquely associated with nuclear energy which should not be underestimated, both in reality and as a matter of public perception. One such problem is the possibility of contamination due to the release of radioactive materials into the environment through catastrophic reactor accidents similar to those at Three Mile Island and Chernobyl, terrorist attack, or accidents involving the transportation of nuclear materials. Another problem is the disposal of nuclear waste. The MIT study projects that under its 1,000 gigawatt growth scenario, in order to permanently store the spent nuclear fuel, "new repository storage capacity equal to the currently planned capacity of the Yucca Mountain facility would have to be created somewhere in the world roughly every three to four years."[12]

The greatest danger from the spread of nuclear energy comes from the proliferation of technology used to make the nuclear fuel for power reactors. The vast majority of the world's power reactors use uranium fuel enriched to about 3.5% U-235. It is not feasible to use uranium enriched to this grade as fissile material for a bomb. However, with some adjustment the very same facilities and equipment used to produce the low-enriched uranium for power reactors can produce uranium with a concentration of over 90% U-235, suitable for direct use in a nuclear weapon. Unlike plutonium-based weapons, the designs for uranium-based nuclear explosives can be so simple that even a terrorist group, by stealing or otherwise acquiring adequate high-enriched uranium, could plausibly manufacture a weapon as powerful as the Hiroshima bomb.

There are presently 14 commercial scale uranium enrichment plants in operation around the world. In the view of the WMD Commission, these plants, together with existing reprocessing facilities, can satisfy the demand arising from a "considerable expansion" of nuclear power.[13] The enrichment plants are located in the nuclear weapon-possessing states China, France, Russia, the United Kingdom and the United States, and in non-weapon possessing states Brazil, Germany, Japan and the Netherlands. However, in order to meet the demand for enrichment services anticipated by the MIT study, the global enrichment capacity would have to be expanded by 120 to 165 percent over existing levels. This figure does not take into account the plans in France and the United States to close down their sole existing enrichment plants, representing nearly 50% of the global capacity, and to replace them with smaller, more efficient, and lower capacity plants.[14] Thus, the global capacity for producing material for nuclear fuel will need to expand to meet future demand, if nuclear power expands as well.

As nuclear power spreads, the technology for producing nuclear fuel will undoubtedly spread as well, notably in the developing world where such facilities are generally lacking. Beyond interest in acquiring a weapons capability, the IAEA notes that:

> States have sought such capabilities for a variety of reasons: to carry out entirely legitimate, peaceful programmes; to remove doubts about the reliability of fuel supply from foreign sources; …to achieve the

> prestige of possessing advanced, sophisticated fuel cycle facilities; to benefit from industrial, technological and scientific spin-offs; to sell enrichment or reprocessing services on the international market; and because the State considers it to be economically justifiable.[15]

Therefore, it can be reasonably assumed that as nuclear power continues to spread, interest in fuel-cycle facilities will continue to spread as well. With the spread of nuclear fuel-cycle technology comes the fear that such facilities might be misused and nuclear material diverted to use in weapons, or that the knowledge gained from operating such facilities might be employed in a clandestine bomb program. As these facilities spread into less stable regions of the world, another fear comes from the terrorist theft of nuclear materials, which could be used to make a crude nuclear weapon, or more likely used in a so-called "dirty bomb," a conventional explosive that spreads radioactive materials.

The reprocessing of spent reactor fuel, specifically in order to separate and recycle plutonium for re-use in reactors as mixed-oxide fuel (MOX), could lead to greater proliferation challenges than uranium enrichment. All commercial nuclear power reactors produce plutonium as a by-product. Plutonium separated from spent fuel is directly usable in a nuclear weapon. Moreover, it is estimated that a developing state with a relatively primitive weapons program can construct a bomb out of only eight kilograms of plutonium, compared to 25 kg of U-235 enriched above 90%. An estimated 238 tons of separated plutonium existed in civilian nuclear programs worldwide at the end of 2003, enough for nearly 30,000 nuclear weapons.[16]

Even safeguarded plutonium reprocessing facilities are risky from a non-proliferation perspective. Present difficulties in material accountancy at large-scale plutonium reprocessing plants create unacceptably large margins of errors in calculating the amount of material unaccounted for, complicating efforts to credibly and confidently apply safeguards.[17] For example, a 1990 study by MIT nuclear researcher Marvin Miller examined the effectiveness of material accountancy for the then-planned industrial scale Rokkasho reprocessing plant in Japan. Miller demonstrated that the annual measurement error for input material into the plant, calculated to be about 1%, amounts to the equivalent of 72 kg of plutonium, enough material for at least a dozen nuclear weapons.[18]

Fortunately, due to the high costs of operating reprocessing plants and the availability of inexpensive uranium, the spread of such facilities has been very limited. The only non-nuclear weapon possessing state to operate a commercial-scale reprocessing plant is Japan. This trend is likely to hold. The MIT study concludes that, based on the availability of uranium resources and expected technological advances aiding its recovery, resorting to reprocessing will be unnecessary to meet the fuel service needs of the world's nuclear reactors for the lifetime of the plants they envision in their 1,000 gigawatt growth scenario.[19] These factors point to the undesirability of spent fuel reprocessing in the near to midterm and should propel efforts to permanently limit its spread and phase out its use.

According to the MIT study, limitations in the NPT safeguards regime, as discussed in section 3.2, “raise significant questions about the wisdom of a global growth scenario that envisions a major increase in the scale and geographical distribution of nuclear power.”[20] We wholeheartedly agree with that assessment. Moreover, several near and mid-term energy options exist, both in the way of sustainable energy and advanced technologies, that could help move the world closer to the goal of achieving greenhouse gas reductions on the scale necessary to avoid the most severe consequences of climate change. Such options, if promoted and developed, provide an alternative to the use of nuclear energy to combat climate change.

A study by the Oxford Research Group found that for advanced industrialized societies, “there is no need to rely on nuclear energy as an alternative to the current dependence on fossil fuels.”[21] For the United States, the best near-term non-nuclear options include immediate deployment of wind turbines, which could account for 15%-20% of the domestic electrical generating capacity before intermittency becomes an inhibiting factor for the present grids.[22] While a variety of studies have concluded that integrating wind power to higher levels is technically feasible, geographical limitations, the nature of existing electricity markets, and more cost-effective non-carbon based alternatives present formidable economic and political barriers.[23] The greater utilization of energy efficient technologies and conservation practices can also contribute to reducing energy demand in both the near and midterm.

For the midterm, between now and the end of the period covered by the MIT scenario in 2050, several cleaner fossil-based technologies exist. IEER argues these technologies could serve as a transition away from energy sources such as pulverized coal plants, pending the development and commercialization of emerging sustainable solutions such as thin-film solar cells and the further exploitation of bio-mass. The transitional technologies include a switch to integrated gasification combined cycle coal plants, which emit less $CO_2$ and are more efficient than traditional coal plants, and the expanded use of natural gas through developing liquefied natural gas infrastructure. Coupled with carbon sequestration, these technologies may even be capable of achieving a net reduction in $CO_2$ emissions.[24] The IEER study explains that each of these technologies are commercially viable and are cost competitive compared to nuclear energy.

The MIT study observes that the expansion of nuclear power on the scale envisioned by the study “is not likely to happen without United States leadership. It also requires continued European commitment and the initiation or expansion of nuclear power programs in many developing countries around the world.”[25] The inverse of this statement is almost undoubtedly true as well, as it can be reasoned that the leadership of the United States and Europe will also be crucial in developing non-nuclear, sustainable energy solutions to combat climate change. This leadership can be exercised in many ways, most notably through the example set by domestic policy. Nuclear technology enjoys a strong reputation as a status symbol for the more advanced, developing states of the world.[26] Like railroads and steamships in the past, it is viewed as a benchmark of modernity, but also has appeal due to its connection to the weapons which still form the backbone of the security policies of the most powerful states. As long as this technology continues to be valued as essential in the most advanced states, its desirability will continue to spread and become entrenched throughout the developing world. Therefore, any move away from nuclear power globally must start with its greatest proponents.

Furthermore, multilateral approaches must be employed. Section 1.1 made the case for the necessity of employing treaty regimes and global norms to address the security challenges faced by the world. Indeed, the global nature of the consequences for either failing to do too little in the face of climate change, or for choosing the wrong set of solutions and increasing the likelihood of weapons proliferation, compels such an approach. Thus, renewed effort is required, especially by the industrialized states and particularly the U.S., to reinvigorate the multilateral frameworks addressing climate change and nuclear weapons, and to work toward just and sustainable solutions. Reformed or new international agencies may be necessary, such as a sustainable energy agency.[27]

### *Recommendations for U.S. Policy*

- The United States should accelerate and enlarge its support for development of commercially viable renewable and non-carbon emitting sources of energy, and for energy conservation.
- The United States should ratify the Kyoto Protocol and work within the UN Framework Convention on Climate Change to further establish norms and regulations on the emission of greenhouse gases.
- The United States should terminate subsidies for new nuclear power plants and phase out nuclear power, and should refrain from promoting nuclear energy as a means to combat climate change.