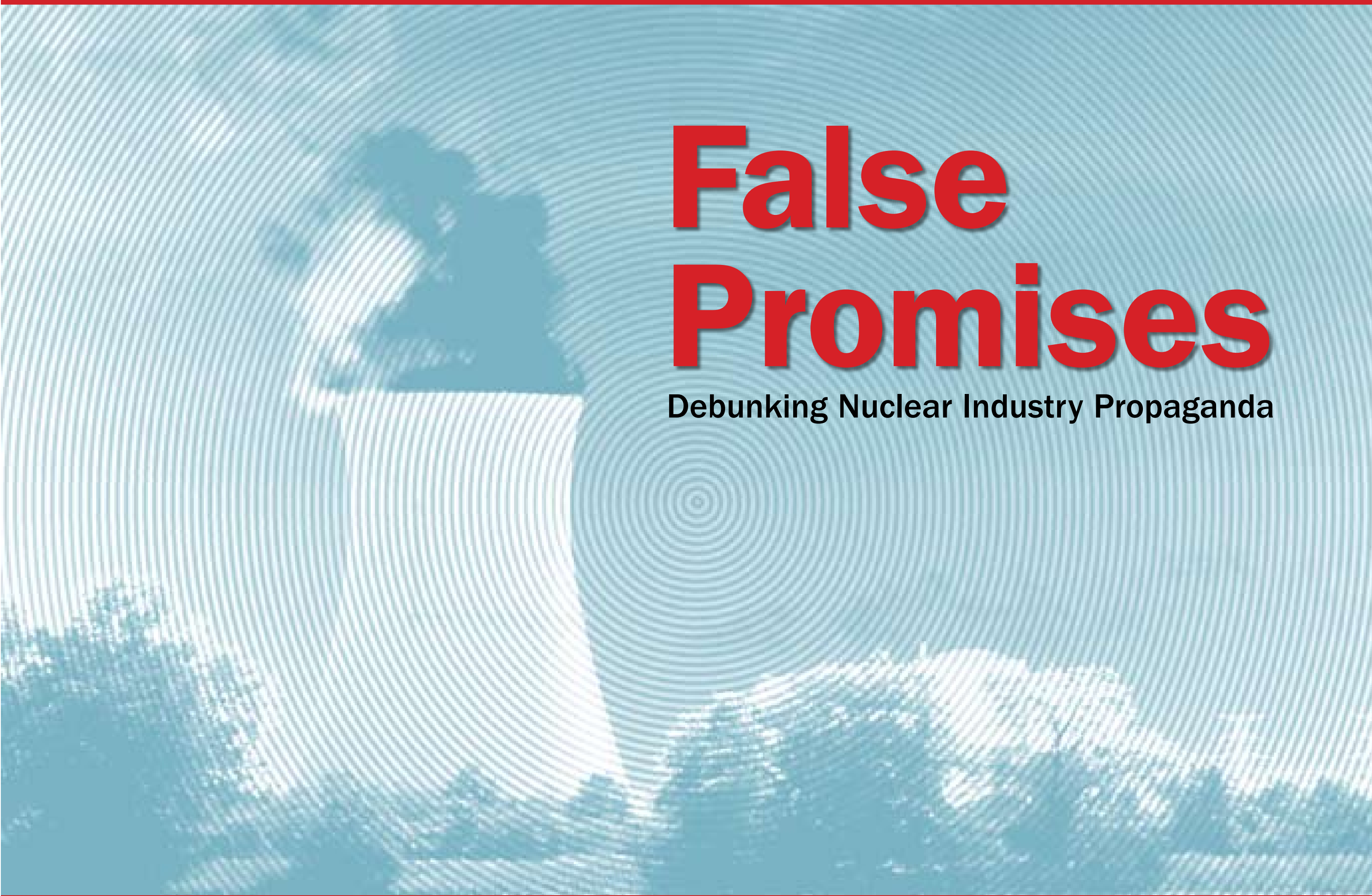

False Promises

Debunking Nuclear Industry Propaganda

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False Promises

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FOREWORD

By Michael Mariotte
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I wrote my first article on the potential resurgence of nuclear power in 1989, for the *Multinational Monitor*. Back then, I predicted that the nuclear power industry would seize upon the issue of climate change as its golden ticket to revival. Not that nuclear power has any useful role to play in addressing climate change, or, as we prefer to call it in 2007, the climate crisis (the climate hasn't exactly improved in the past 18 years), but it was obvious even then that nuclear reactors' relatively low carbon emissions would and could be the industry's only possible selling point.

Let's face it, by any objective measure, nuclear power has failed every possible market test: first and foremost, in market terms, it is and remains uneconomic. That's not only because nuclear power reactors are incredibly expensive to build because of their basic requirements of huge amounts of steel, concrete, engineering expertise, and so forth, but because of the basic nexus of factors that has made nuclear power the least desirable energy source on the planet: safety, waste, and nuclear proliferation. Add those three factors together, and add in measures to try to mitigate them, and you get the most expensive source of producing electricity ever.

And, for the nuclear industry, the problem is that all of these factors are inseparable.

But, oh, there is that climate crisis—we *need* nuclear power!

Actually, if we did need nuclear power, we'd be in big trouble. The major studies—from MIT, from IAEA, from the Commission on Energy Policy—all agree on the big numbers: if nuclear power is to play a meaningful role in addressing climate and reducing carbon emissions, we need a *big* nuclear program. In fact, we need to triple the number of reactors in the United States (currently 104) and probably quadruple or more the number across the world (currently about 440), all by the year 2050. Doing that would take care of one of the infamous carbon "wedges," meaning that doing so would reduce carbon emissions by about 20 percent.

Add up the numbers, and one understands this type of nuclear construction program means a new reactor coming online somewhere in the world every two weeks from now until 2050. Since there are no new reactors coming on line in the next two weeks (or virtually any two weeks that you may read these words), we are falling further and further behind even saving that 20 percent.

And, if the nuclear industry were honest, it would admit it can't possibly build that many new reactors. In fact, as of July 2007, as will be the case every July for the foreseeable future, the nuclear industry is capable of building only 12 reactors per year worldwide, because there is only one factory, in Japan, capable of building reactor pressure vessels. That's a physical limit, unless and until a new factory—at considerable cost and time to construct—can be built. So the reality is that the nuclear industry cannot possibly do better than fall far short of even a modest carbon emissions reduction goal, meaning that its contribution, under best-case circumstances, becomes negligible at best.

As I write this, in July 2007, the Nuclear Regulatory Commission claims there are 19 utilities, wanting to build 28 new reactors, lining up to submit the first new applications for reactor construction/operating licenses since the 1970s.

With costs, given the current experience of the world's most experienced nuclear power entity (the French company Areva, building a new reactor in Finland), likely to reach $4-5 billion per reactor, don't count on all those reactors being built.

The danger is not so much that we are about to enter a new nuclear era. The combination of economics, safety, proliferation, waste and simple physical realities preclude that. Rather, the danger is that some of these proposed reactors will get construction licenses, and some utilities will foolishly attempt to build them. And in doing so, they—and the federal government which has indicated its intent to subsidize the first few of them with taxpayer dollars—will squander billions of dollars that could be used to effectively address the climate crisis. Those billions of dollars, could, in fact, be the difference between an effective carbon reduction program, or one that dooms coastlines, Pacific nations, our agricultural heartland, and indeed, life as we know it.

Our choice is stark: we can address the climate crisis, or we can build new nuclear reactors. We can't do both. Fortunately, the choice is an easy one.

In this report you will find many more details to back up the assertions made in this foreword, and a lot more information on the sustainable energy technologies that can make a real difference. We can provide the electricity and energy we need to power a 21st century nation, and we can do it without destroying our planet. The technology exists and is there to be tapped; all that is lacking is the political will to take on the powerful utility, nuclear and fossil fuel industries that serve only their short-term self-interest. It is our hope that this report will provide a greater rationale for policymakers, the media, and organizations and individuals at all levels of society to take a good hard look at our current energy policy, and to do everything possible to create an energy framework that will work for our common future.

FOREWORD TO FIRST EDITION

By Robert Alvarez
Senior Policy Advisor to the US Secretary of Energy 1993-1999

President George W. Bush, a former oil industry executive from Texas, has declared "America is addicted to oil." This bold statement is undeniable: With about 5.5 percent of the world's population, the United States consumes more oil than any nation—about 20.6 million barrels per day, or a quarter of the world's total production.

"To keep our economy growing," Bush said, "we also need reliable supplies of affordable, environmentally responsible energy... including safe, clean nuclear energy."

Unfortunately, nuclear energy isn't safe or clean and it's too costly for the nation.

Bush's nuclear medicine prescription means addicting the country to, perhaps, an even more expensive and dangerous alternative. Unlike oil, this vice is not based on the thrill of driving gas-guzzling sport-utility vehicles, but rather on unfettered access to the US Treasury. Since the first commercial nuclear power reactor went on-line in 1959, this form of making electricity has depended on regular infusions of taxpayer subsidies. Even today, nearly three decades after the last new US reactor was ordered, subsidies remain necessary for the industry's survival.

Since 1948, about $80 billion was spent by the US government on nuclear energy research and development. Spending in 2006 by the US Energy Department was in excess of $800 million—nearly twice the money the government is investing in truly clean, renewable energy sources like conservation, solar and wind power.

This is on top of the enormous "balloon mortgage" payments of tens of billions of dollars to clean up the environmental mess at dozens of Energy Department and other nuclear sites across the country, which developed nuclear power with test reactors as well as uranium mining and processing sites.

As for cost, in some instances the price tag for nuclear reactors has run 10 times higher than originally promised. Despite the recent spate of congressional subsidies, Wall Street is still maintaining its almost 30-year moratorium on the financing of new nuclear power plants. At nuclear reactors, smart investors know, unlike at coal or gas plants, all it takes is a "minor" mistake, like a poorly welded pipe, to cause a multibillion-dollar loss.

In terms of safety, numerous "near-misses" at reactors do not inspire much confidence. In 2002, workers inadvertently discovered that boric acid ate through 6 inches of the solid steel reactor top at the Davis Bessie plant in Ohio. The problem went unattended for years—leaving a fraction of an inch to prevent the superheated reactor core from a potential meltdown.

Unfortunately, the prospect of solving the nuclear waste problem is getting dimmer. Recognizing that nuclear power spent fuel is among of the most dangerous material on the planet, Congress enacted legislation in 1982 requiring it be disposed so as to protect humans for at least hundreds of millennia. Twenty-four years later, the government's nuclear waste disposal program is plagued by scandal, legal setbacks and congressional funding cuts. As a result, the schedule for the proposed Yucca Mountain disposal site in Nevada has slipped for at least a decade or two. By the time the Yucca Mountain site can take the existing wastes, the Energy department estimates nuclear power plants will have accumulated about the same amount we have today. Right now, the waste continues to sit in densely compacted pools which the National Academy of Sciences warned are vulnerable to terrorism and might lead to a catastrophic radiological fire. Finally, in terms of proliferation, as beneficiaries of the "Atoms for Peace" program, Iran appears poised to make uranium for nuclear weapons, and North Korea now has them. Undeterred, we have plans to make the problem even worse by reprocessing this waste and allowing weapons-usable plutonium to enter into global commerce. The United States wisely decided against doing this in 1975, because, it would lead, as stated succinctly by Albert Wohlstetter (a mentor of the Bush national security team) to "live in a nuclear-armed crowd."

Therefore, it appears that the proposed cure for our dangerous dependence on foreign oil may prove worse than the disease.

Robert Alvarez served as Senior Policy Advisor to the US Secretary of Energy from 1993 to 1999 and is currently a Senior Scholar at the Institute for Policy Studies in Washington, D.C.

EXECUTIVE SUMMARY

The urgent need to curb greenhouse gas (GHG) emissions to avoid severe climate consequences has provided the nuclear industry with an ostensible opportunity to stage a comeback. Through an aggressive public relations campaign, the nuclear industry is attempting to portray nuclear power as safe, clean and necessary. It is none of these.

Regardless of the millions of dollars spent to win the hearts and minds of the American public, false promises cannot undo long-standing realities. Nuclear power is an expensive, high risk technology that poses unprecedented dangers and long-term environmental degradation.

Nuclear power remains a bad option and one that would divert precious resources from readily available technologies to reduce greenhouse gases that are both cheaper and can be deployed faster. This updated report debunks the misleading claims being made about nuclear power and shows why it is not part of the solution to our energy or climate crises. For instance:

- Nuclear power is not a useful solution to climate change
- Nuclear power is vulnerable to severe climate conditions, which prevent reliable operation
- Nuclear power is not the alternative to coal
- Nuclear power is not clean
- Nuclear power is not safe
- Nuclear facilities pose serious terrorism risks
- Nuclear power is expensive
- Nuclear waste remains an unsolved problem
- Nuclear power fosters weapons proliferation
- Nuclear power is not the solution to energy independence
- Nuclear power has negative health effects
- Nuclear power is not supported by the public at large

INTRODUCTION

"For the last 20 years, forecasts of an imminent revival of nuclear power plant orders have rivaled—in frequency[1] and in accuracy—forecasts of the second coming of the Messiah."[2] According to the Nuclear Energy Institute, the lobbying group for nuclear power interests, "we really do believe ... it's going to be a renaissance of nuclear power."[3] The Nuclear Regulatory Commission reported on June 29, 2007 that it expects 19 entities to apply for licenses for 28 new reactors from late 2007-2009.[4]

However, not a single new nuclear power plant has actually been ordered and the last reactors to come on-line had costs several times higher than the original estimates. The Shoreham reactor in New York was originally estimated at $350 million when it was ordered in February 1967, but ultimately cost roughly 15 times higher ($5.4 billion) when it was closed without ever generating commercial electricity in 1989. Similar cost overruns occurred at Nine Mile Point-2 (NY), Seabrook (NH), Vogtle (GA) and many others.

So why this renewed push for nuclear power?

According to one prominent nuclear spokesman, "nuclear energy may just be the energy source that can save our planet from another possible disaster: catastrophic climate change."[5] Even a cursory analysis of the industry advertising, statements and promotional materials make it apparent that the nuclear industry appears to rest its "revival" almost entirely on the proposition that nuclear power is essential to combating climate change. Instead of head-to-head economic competition, nuclear proponents are seeking to persuade us that their technology is the best option for averting climate change. To date, this strategy has had some success in Washington, with the Energy Policy Act of 2005 providing large subsidies for the construction of a limited number of new nuclear units.

It is indisputable that the world needs dramatic changes to our energy production and consumption framework. However, the focus should be on clean, fast, safe and renewable solutions. The proliferation and security risks alone should disqualify nuclear power from consideration. Most importantly, the cost of nuclear power per unit of carbon emissions reduced would actually impair our ability to abate climate change; public money should be buying more carbon-free energy per dollar spent than is possible with nuclear power. Wind power and other renewable energy technologies, coupled with energy efficiency, conservation and cogeneration working under distributed energy systems are much more cost effective and can be deployed much faster.

Our choice is stark: we can either effectively address the climate crisis, or we can use nuclear power. We can't do both. Fortunately, while stark, the choice is an easy one.

A DIALOGUE CLOUDED WITH MISINFORMATION AND MISREPRESENTATION

The public discourse surrounding nuclear power has been misinformed and inaccurate, for which advocates on both sides bear some responsibility. However, current arguments advanced by nuclear proponents are largely going unchallenged in the mainstream media and purported experts are advancing dubious arguments that are irresponsible at best.

In fact, the nuclear industry has sought to position one former environmental activist as representative of broad support for nuclear energy within the environmental movement.[6] However, this could not be further from the truth, and in response to these misrepresentations 313 national and regional environmental organizations signed onto a position statement that strongly opposes nuclear energy.[7] On October 6, 2006, more than 150 businesses, environmental organizations and other groups released the "Sustainable Energy Blueprint," a series of policy recommendations for reducing GHGs while phasing out nuclear power.[8] More than 460 environmental, religious, consumer and business organizations and more than 5400 individuals have signed a simple statement on nuclear power and climate change first posted in late August 2007 on the Nuclear Information and Resource Service website.[9]

Thus, the ongoing public discussion of nuclear power desperately needs more balance and the goal of this report is to provide history, context and a critical analysis of these arguments.

BRIEF HISTORY OF NUCLEAR POWER'S FALSE PROMISES

The origins of nuclear power stem from the development of the first nuclear weapons and the subsequent nuclear arms race between the United States and the Soviet Union. In December 1953, President Eisenhower announced the creation of the "Atoms for Peace" program before the United Nations. According to the Bulletin of Atomic Scientists, it "was supposed to distract other countries from pursuing nuclear weapons by sharing peaceful nuclear technology with them […]. Today, there are about 35 countries operating or building nuclear power plants worldwide. Eight have nuclear arsenals. At least two additional nations (North Korea and Iran) are believed to be pursuing nuclear weapons."[10]

In the initial aftermath of the Atoms for Peace announcement and through the 1970's, the United States government and corporations benefiting from federal largesse launched a widespread national public relations campaign. The Walt Disney Company published a children's book, "Uranium and other Miracle Metals," in which nuclear-powered cars, planes, and space shuttles would transport Americans on the highways, in the air and outer space. Nuclear home furnaces would not only heat houses, but also melt the snow on sidewalks. Nuclear desalination plants would create vast supplies of fresh water; while nuclear explosions would excavate canals rivaling that in Panama, create harbors and create underground storage reservoirs for oil and natural gas. A nuclear-powered dirigible would fly from city to city. Artificial hearts would tick thanks to plutonium.

None of these came to pass. But the legacies of these efforts remain at numerous federal sites around the country in the form of large contaminated areas and structures. The legacy of this nuclear heyday is contaminated workers, nuclear accidents, and large releases of radioactivity into the open air, all of which are costing the taxpayers tens of billions of dollars to clean up.

In the early 1970s, when the United States had a dozen nuclear power plants, the US Atomic Energy Commission (AEC) forecast that the American landscape would be dotted with 1000 reactors by the year 2000, which would have required a reactor construction permit and operating license to be issued once a week for 30 years.[11] In 1972, the AEC also projected that the world would run out of uranium to fuel nuclear power plants. To address this problem the AEC declared that the United States would need a new generation of reactors that would use plutonium as fuel made in existing reactors. At that time it was widely believed that the disposal of high level nuclear waste, as put by an AEC chair of that era to be "the biggest contemporary non-problem,"[12] would be under way no later than 1985.

Since then, the United States has 103 nuclear plants in operation. There are no breeder reactors, no reprocessing plants and no permanent solution for high-level nuclear wastes. However, over the past 50 years, nuclear energy subsidies have totaled close to $145 billion in the United States while government subsidies for wind and solar energy for the same period totaled only $5.49 billion.[13] In Fiscal Year 2006, nuclear power commanded $800 million—nearly half of all research and development subsidies in the US Department of Energy (DOE).

The following ten chapters refute the nuclear industry's false promises.

CHAPTER 1

Nuclear power is counterproductive for combating climate change

There is now international consensus within the scientific community that the world is getting warmer and that most of the warming is due to human activities, primarily associated with the combustion of fossil fuels.[14] Thus, there is scant debate that climate change is one of the most pressing threats of our time, and it is imperative that we take swift and decisive action to avert its most severe impacts. However, the attempt by the nuclear industry to anoint nuclear power as the solution to climate change is dangerous and threatens to squander the resources necessary to implement meaningful climate change mitigation policies.

According to a former US Nuclear Regulatory Commissioner, "nuclear power's asserted comeback rests not on a newfound competitiveness in power plant construction, but on an old formula: subsidy, tax breaks, licensing shortcuts, guaranteed purchases with risks borne by customers, political muscle, ballyhoo and pointing to other countries (once the Soviet Union, now China) to indicate that the US is 'falling behind.' Climate change has replaced oil dependence as the bogeyman from which only nuclear power can save us."[15]

The pro-nuclear rhetoric has been coming from all levels, including US Vice President Dick Cheney who has publicly stated as fact that nuclear power is carbon-free.[16] A leading industry group has even asserted that nuclear energy can produce electricity "*without polluting the environment*."[17] However, these claims are misleading because nuclear power is neither pollution nor emission free. The nuclear fuel cycle emits some carbon, while all nuclear facilities emit carcinogenic radiation into the air and water.

> ***The fundamental flaw in the argument that nuclear power can mitigate global climate change is that the technology simply takes too long to deploy.***

DEPLOYMENT TIME

Nuclear power is the slowest and costliest way to reduce CO_2 emissions when compared to efficiency, distributed generation and some renewable sources.

Currently, around 440 nuclear power stations provide approximately five percent of the global primary energy mix. Even if the number of reactors was doubled, nuclear energy's contribution to the primary energy mix would not have a large enough impact to warrant the associated expense.

A 2003 study by the Massachusetts Institute of Technology on the future of nuclear power determined that approximately 1500 new nuclear reactors would have to be constructed worldwide by mid-century for nuclear power to have even a modest impact on the reduction of GHG's.[18] A similar study concluded that a GHG emission reduction of 20 percent could be accomplished by 2100 if all projected coal power were displaced by 4900 GW of nuclear energy.[19] Likewise, the Institute for Energy and Environmental Research estimates that it would be necessary to build some 2,000 nuclear power plants of 1,000 MW each in the next few decades for nuclear power to make a substantial reduction in CO_2 emissions.[20]

In the UK, the government's advisory panel, the Sustainable Development Commission, found that if the country's existing nuclear capacity were doubled, it would only yield an eight percent cut in CO_2 emissions by 2035, and none before 2010. Indeed, the Commission concluded that the risks associated with nuclear power greatly outweigh its minimal contribution to reducing CO_2 emissions.[21]

Therefore, expert analyses all agree that nuclear power would require an infeasible schedule, as new reactors would have to come online every few weeks for the next fifty years to have even a modest impact on GHG emissions—new nuclear reactors cannot be built fast enough to address climate change. Indeed, outside of Russia, whose capacity is perhaps one reactor per year, there currently is only a single forging factory worldwide capable of producing reactor pressure vessels—and this Japanese factory can produce only 12 vessels per year at maximum capacity. To be able to build sufficient reactors to make a difference in emissions would first require construction of large new forging factories—an expensive and financially risky endeavor and one that further delays the nuclear industry's physical ability to build reactors.

Thus, a fundamental flaw in the argument that nuclear power can mitigate global climate change is that the technology simply takes too long to deploy. Moreover, in an age of terrorism, the large number of reactors necessary for nuclear power to meaningfully address climate change would only exacerbate proliferation risks and the perils of a nuclear accident or attack.

OPPORTUNITY COSTS

Financing nuclear power would divert scarce resources from investments in faster and more easily deployed solutions.

According to NASA's Head Climate Scientist, we have no time to waste in mitigating global climate change and "business as usual" will result in a dramatically different planet.[22] Therefore, aggressively tackling this issue will require the fastest, cheapest and safest solutions, and nuclear power is none of these. The vast amount of money needed to build the number of reactors necessary to meaningfully address global emissions would divert government subsidies and private investment from more effective solutions.

> *Each dollar invested in electric efficiency in the US displaces nearly seven times as much carbon dioxide as a dollar invested in nuclear power.*

Analysis by the Rocky Mountain Institute has shown that the enormous costs of nuclear power per unit of carbon emissions reduced would worsen our ability to mitigate climate change, as such an amount would be buying less carbon-free energy per dollar spent on nuclear power compared to the emissions we would save by investing those dollars in solar, wind or energy efficiency.[23] In fact, each dollar invested in electric efficiency in the US displaces nearly seven times as much carbon dioxide as a dollar invested in nuclear power, and nuclear power saves as little as half as much carbon per dollar as wind power and cogeneration.[24]

LIMITED ROLE IN REDUCING GHG EMISSIONS

Transportation is responsible for a large part of global emissions, which nuclear power cannot offset.

The nuclear industry claims that nuclear power is the only energy source that can effectively replace fossil fuels. But, building new nuclear facilities does nothing to address the transportation sector, which is responsible for a large part of GHG emissions. For example, electricity generation in the US is responsible for only 40 percent of the country's total CO_2 emissions.[25] Likewise, transportation is the primary sector responsible for global oil consumption (corresponding to more than half of the oil consumed worldwide everyday), generating a full 40 percent of global CO_2 emissions. As oil accounts for only seven percent of worldwide electricity generation, the transportation sector is a major source of GHGs and would not be affected by any changes in nuclear power generating capacity.[26]

NUCLEAR POWER IS NOT EMISSION FREE

The nuclear power generation cycle is fossil fuel intensive and produces large amounts of GHG emissions.

While atomic reactions do not emit CO_2 or other GHGs, the full fuel cycle of nuclear power generation is fossil fuel intensive and emits large amounts of these gases. The mining, milling, processing and transportation of uranium fuel for reactors are all carbon-intensive industries and must be included in fuel-cycle accounting. In fact, the total emissions of the nuclear fuel cycle are not typically assessed when compared with other energy alternatives, leading to this common misconception.

Indeed, a complete life-cycle analysis shows that generating electricity from nuclear power emits as much as 20-40 percent of the carbon dioxide per kilowatt hour (kWh) of a gas-fired system when the whole system is taken into account.[27] These estimates only hold true when high grade uranium ores are available. As uranium resources become increasingly scarce, recovery of uranium from lower grade ores would result in greater emissions. It has been shown that a nuclear life-cycle starting with low quality ores (less than 0.02 percent of U_3O_8 per ton of ore) produces equal amounts of CO_2 as those produced by an equivalent gas-fired power station.[28] Therefore, if nuclear electricity generation is further deployed, the likely consequence will be that lower grade ores will be required which will result in increased CO_2 emissions.

An analysis by the Oko Institute in Germany, based on the database of the GEMIS (Global Emission Model for Integrated Systems) indicates that a standard size nuclear power plant (1250 MW) will emit some 1.3 million tons of CO_2 per year. This emission level makes nuclear power a more polluting alternative, when compared to electricity saving, cogeneration or renewable energies.[29] Other studies have calculated the amount of emissions from the nuclear cycle to be in the range of 30-60 grams of CO_2 equivalent per kWh.[30]

Moreover, uranium enrichment is a highly polluting process and data provided by the DOE shows that in 2001 the US enrichment plants alone produced 405.5 metric tons of CFC-114, the equivalent of five grams of CO_2 per kWh.[31] (CFCs are not only a potent GHG, but also a potent destroyer of the ozone layer.) The only operating enrichment facility in the US, the Paducah enrichment facility in Kentucky, for example, consumes the power output of two 1,000 megawatt coal plants, contributing heavily to the emission of carbon dioxide and other pollutants.[32] Although Paducah is an old and inefficient plant, new alternatives have yet to prove themselves and could still be years away.

GLOBAL WARMING IS ALREADY AFFECTING NUCLEAR POWER PLANTS

Heat waves, severe storms and droughts expose the vulnerabilities of nuclear power.

Nuclear power stations are particularly affected by level changes in lakes and rivers due to drought, flooding or extreme heat waves because they are dependent on surface water for reactor cooling systems. Heat waves during the summer of 2006 in the US and Europe forced utilities to shut down some reactors and reduce output at others. In France, extreme heat and resultant plant shutdowns lead the country to import some 2000 megawatts of power per day from neighboring states to compensate for shortages in production. Additionally, several European countries were forced to override their own environmental standards for maximum temperature of water drained from the plants' cooling systems, creating a situation with harmful consequences for marine flora and fauna.[33]

In the US, nuclear operators were forced to reduce power output at several reactors due to high water temperatures including Xcel Energy Prairie Island 1 and 2, and Monticello units in Minnesota, Exelon's Dresden 2 unit in Illinois, and Exelon's plant in Quad Cities, Illinois.[34] As atmospheric and surface water temperatures continue to increase with extremes becoming more frequent, these fluctuations in power output from reactors will be of increasing importance in the electricity generation mix.

CHAPTER 2

Nuclear Power can be dangerously unreliable under severe weather or destabilized climate conditions

Electricity is largely provided by central plants that deliver power into a transmission grid that is comprised of a patchwork network controlled by regional entities. It is a system that is increasingly strained. Large baseload power additions increase this strain, where energy efficiency and some forms of distributed generation (DG) ease burdens on the system. Further, nuclear reactors have a unique set of reliability issues tied to climate variations and maintenance imperatives.

Our present system is extremely inefficient, and by the time electricity reaches the customer nearly two-thirds of the energy has been wasted through generation and transmission.[35] Moreover, analysis of the effects of power outages found that the US economy is estimated to be losing between $104 and $164 billion annually because of power outages.[36] Another $15 to $24 billion is lost because of power quality related losses (voltage sags, surges, etc.).[37]

Therefore, the wisdom of a large centralized system should be questioned and in the near term, a combination of distributed generation and central station generation would be a more prudent solution that could save transmission costs and grid strain. However, putting aside the debate about the wisdom of the "central generation paradigm," nuclear power is often cited as the only technology that can provide large amounts of base load power that is carbon free. This argument is based on a common misconception that renewable energy sources are unreliable due to uneven geographical distribution, weather variations, or changes in the season, also known as *variability* and *intermittency*.

> *According to the International Energy Agency, intermittency is not a technical barrier to renewable energy.*

However, there are a number of strategies that can compensate for days when the sun doesn't shine or the wind doesn't blow. A recent International Energy Agency (IEA) report concluded that intermittency is not a technical barrier to renewable energy.[38] One way to minimize intermittency is to integrate, or "mix," sustainable energy sources by both type and location so that they are mutually supportive. The IEA report noted that interconnection of renewable energy sources over a wide area is an important way of dealing with intermittency issues.[39] Wind farms, for example, can provide steadier and more reliable power when they are networked in areas with high average wind speeds.[40] In addition to centralized electricity generation, solar photovoltaics (PVs) can also produce electricity on-site, making it "harder to disrupt, more stable, and less brittle than full reliance on centrally generated power."[41] Furthermore, geothermal energy is unaffected by weather patterns and tidal patterns can be predicted centuries into the future.

NUCLEAR POWER RELIABILITY ISSUES

Nuclear power is debilitated by a host of unique and potentially costly and dangerous variability issues. Key to nuclear reactor operation is constant circulation of coolant in the system; if circulation stops, there is a relatively small window before nuclear fuel begins to melt from its own atomic heat, as it began to at Three Mile Island.[42] All nuclear power reactors in the US depend on off-site power for normal operations and on-site backup power for safety systems in the case of loss of off-site power. Both power systems are vulnerable to climate conditions such as flooding, hurricanes, tornados and severe storms.

In the aftermath of Hurricane Katrina, the Waterford reactor, located outside New Orleans, was forced to operate on diesel generators for four days because of instability in the off-site electrical grid.[43] Similarly, the Cooper nuclear power station in Nebraska was forced to shut down in the 1993 flood, when rising waters collapsed the dikes and levees around the site.[44] The Davis-Besse nuclear plant in Ohio was hit by a tornado in 1998, which caused the loss of off-site power used for the cooling system for the irradiated fuel storage pool.[45] Therefore, nuclear power is in fact seriously affected by climate conditions, and this vulnerability is exacerbated by the increasing effects of global warming, heightening the inherent safety risks of nuclear reactors.

Perhaps the most poignant way in which nuclear power cannot remedy the climate crisis is the fact that it does not work with hot water. In recent years elevated temperatures in rivers[46] and even ocean water[47] have caused nuclear power reactors to be taken off-line. Hot water not only may violate the technical specifications for reactor core cooling (requiring the fission reaction to stop)—hot water does not cool the reactor condenser—which takes the steam generated from the heat of fission and turns it back into water so the cycle can continue. In other words, the device simply does not work.

The shortcomings of nuclear power reliability were also evident in July 2006, when, in Sweden, backup generators malfunctioned during a power outage, forcing a shutdown of one of the reactors at Forsmark. In this incident, two of the facility's four backup generators malfunctioned when the plant experienced a major power outage. Plant workers reported to Swedish media that it had come close to a meltdown. Following the incident, Swedish officials shut down half of Sweden's ten nuclear power plants, triggering record price increases.[48]

The nuclear industry is currently planning to increase power output at some plants by up to 20 percent, a move which would run already brittle plants over capacity to increase profits. While the industry claims that there are no sacrifices in safety provisions associated with increased power output, an 18 percent increase at the Quad Cities plant in Illinois resulted in serious structural damage and radiation leaks.[49] Therefore, the reliability of the existing reactors operating under license extensions well beyond their intended life-spans is far from certain.

The frequency and duration of shutdowns for maintenance increase during the start-up and wear-down phases in nuclear plant lifecycle. Elevated risk of component failure and unforeseeable accidents during the start-up phase of reactors are attributable to limited experience with new designs, manufacturing defects and economic disincentives to fully test equipment before commencing operations.[50] Therefore, the prospect of bolstering reliability of electricity supply through new nuclear facilities is not realistic.

CHAPTER 3

There are many proven, sustainable alternatives to nuclear power and coal

The argument that we need nuclear power because it is the only environmentally viable alternative to coal is fallacious: alternatives exist and they are available right now; therefore the inverse—that if one rejects nuclear power, one is advocating use of coal is equally fallacious. As noted elsewhere, "switching from coal plants to nuclear power is like giving up smoking cigarettes and taking up crack."[51]

What we need to do is get rid of both of our addictions: carbon and uranium. A new study from the Institute for Energy and Environmental Research, *Carbon-Free and Nuclear-Free: A Roadmap for US Energy Policy*[52] shows how we can achieve what some might have thought an impossible task—implementing a completely carbon-free and nuclear-free energy society by 2050. Not only for electricity generation, but for transportation as well. Imagine the US meeting all of its energy needs without the problems of carbon emissions, radiation leaks and radioactive waste, or wars for oil—and without increasing the percentage of our Gross Domestic Product spent on energy. This study provides one roadmap—and there are others—to lead us to that necessary future.

Similarly, a new book by former Tennessee Valley Authority Chairman David Freeman also argues that all of our electricity needs can and must be met without the use of either coal or nuclear power.[53] Freeman argues persuasively that renewables are ready. He notes, for example, that there are 140 million acres of above-ground (rooftops, parking lots, etc.) potential solar resources in the US and that using just seven percent of this for solar power would match our current national electricity production.

These new far-reaching works follow several other recent studies that, while somewhat less ambitious, indicate the same trend. For example, a January 2007 study by Greenpeace and the European Renewable Energy Council showed that it is economically feasible and desirable to cut US CO_2 emissions by 72 percent by 2050.[54] This would be accomplished with increased energy efficiency to cut energy demand and greatly increased use of renewable fuels and power. According to the plan, these reductions can be achieved without nuclear power, while virtually ending US dependence on coal.[55]

There are numerous renewable energy technologies available which could be expanded and many more that have great potential and should be pursued and funded more aggressively. The Greenpeace/European Renewable Energy Council report states that 80 percent of US electricity can be produced by renewable energy sources. The following represent some brief examples.

SOLAR POWER

Every thirty minutes, enough of the sun's energy reaches the earth's surface to meet global energy demand for an entire year.[56] The Worldwatch Institute reports that already, "rooftop solar collectors provide hot water to nearly 40 million households worldwide."[57] Grid-connected solar PV has been cited as the world's fastest-growing energy technology.[58]

> ***The solar energy that is available in a 100-square mile area of Nevada could supply the United States with all its electricity needs.***

Solar PV is especially attractive for developing countries because it can be used in remote locations and power equipment as small as an individual laptop. Applications are also large, such as the 500-megawatt (MW)[59] generator currently under construction in California's Mojave Desert that will generate enough electricity to power 40,000 average American homes.[60]

It has been estimated that the solar energy available in a 100-square-mile area of Nevada could supply the United States with all its electricity needs.[61] In addition to large-scale, centralized projects like the one in Mojave, solar energy can be widely distributed and decentralized as well. Fitting the rooftops of America's homes and businesses with solar PV modules could accommodate as much as 710,000 MW of power, nearly 75 percent of current generating capacity.[62] A stunning break-though in the economic viability of distributed solar generation was reported in 2006 by *The New York Times*.[63] Investment bankers Goldman Sachs are selling 20 year shares in solar panels, similar to a bond investment—and then selling 20 year contracts to purchase the power (fixed or discount off of market rate) to the facility user, which simply pays a monthly bill-making no investment in the panels themselves.

WIND POWER

It has been estimated that wind energy has the potential to satisfy the world's electricity needs 40 times over, and could meet all global energy demand five times over.[64] One study concluded that, "good wind areas, which cover six percent of the contiguous US land area, have the potential to supply more than one and a half times the current electricity consumption of the United States"[bm]

> *Wind energy can satisfy the world's electricity needs 40 times over and can meet all global energy demand five times over.*

It is no wonder, then, that wind is one of the world's fastest growing energy sources. In 2005, wind energy in the United States grew by almost 2,500 MW of installed capacity—a 35 percent increase in just one year.[66] Total wind-generating capacity in the United States now stands at over 9,000 MW, enough to power more than 2.3 million average American homes.[67]

Globally, the wind energy market grew a staggering 40.5 percent in 2005.[68] In Europe, wind installed capacity has already exceeded the European Commission's goals of 40 GW by the end of the decade.[69] Germany is the European leader, with more than 18 GW of installed wind capacity.[70] In Navarra, Spain, half of the electricity consumption is met by wind power, and in Denmark wind represents 20 percent of electricity production.[71] Wind energy is also developing rapidly elsewhere in the world. India is now the world's fourth-largest producer of wind energy,[72] and in China, wind energy grew at a 60 percent rate in 2005 and the Chinese government plans to reach 30 GW of wind energy capacity by 2020.[73]

> *Globally, the wind energy market grew a staggering 40% in 2005 and wind power's generating capacity in Europe has already exceeded the European Commission's goals for 2010.*

Interest in developing offshore wind energy resources in the US is also growing. Europe has already deployed more than 600 MW of offshore wind energy and the technology is readily available and advancing with larger machines planned. Offshore wind could hold particularly great promise in the US. In fact, the US DOE has estimated that there is more than "900,000 MW of potential wind energy off the coasts of the United States, in many cases, relatively near major population centers"…which would "approach the total current installed US electrical capacity."[74] A February 2007 study by researchers at Stanford University and the University of Delaware found that wind power off the mid-Atlantic coast could meet the full electricity needs of nine nearby states plus Washington, DC, with a 50 percent cushion for future electrical demand.

GEOTHERMAL POWER

In regions without heavy geothermal activity, the regular heating of the ground by the sun can be harnessed to heat and cool homes. Geothermal heat pumps (GHP's) operate by transferring heat from the ground into buildings during the fall and winter, and reversing the process to keep buildings cool during spring and summer.

GHP's can operate more efficiently than the most energy-efficient conventional furnaces on the market today.[75] The potential energy yield from this simple technology is enormous. It has been estimated that the geothermal energy stored in the top six miles of the Earth's crust contains an estimated 50,000 times the energy of the world's known oil and gas resources.[76] It has also been estimated that geothermal energy can meet 100 percent of all electricity needs in 39 developing countries and could serve the needs of 865 million people around the world.[77]

Moreover, in many areas in the developing world, small geothermal projects have great potential to satisfy electricity demands of rural populations.[78] Perhaps the most dramatic example of geothermal power's potential is found in Iceland, which was largely dependent on imported fossil fuels only a few decades ago. Today, Iceland obtains more than 70 percent of its energy from domestic, renewable sources and geothermal accounts for more than half of its primary energy consumption.[79] Geothermal energy is also widely used in the western United States and Hawaii, where enough geothermal electricity was produced in 2003 to power two million average American homes.[80] This represents but a fraction of America's potential geothermal generating capacity, which could grow tenfold over the year 2000 levels using existing technoloy.[81]

> *The geothermal energy stored in the top six miles of the earth's crust contains an estimated 50,000 times the energy of the world's known oil and gas resources.*

There are approximately 500,000 GHP's currently in use in the United States, and they are becoming increasingly popular in countries like Germany, where purchases increased by 35 percent in 2005.[82]

TIDAL ENERGY AND SMALLER-SCALE HYDROPOWER

Both tidal, wave and smaller-scale hydroelectric projects represent a significant improvement over traditional, 'big dam' hydroelectric power. The use of rivers to generate electricity is already a proven technology, and accounts for 10 percent of America's electricity generation.[83] However, large-scale hydropower is constrained because most of the world's large rivers have already been exploited, leaving little room for sustainable growth

Wave power, however, has vast potential. The Carbon Trust, an organization set up by the British government to monitor the county's emissions, estimates that 20 percent of Britain's electricity could be supplied by wave and tidal energy.[84] One of the more innovative projects in the UK is a combination of waves and wind. Dubbed the Limpet,[85] an "L" shaped chimney was created in a cliff along the coast of Scotland. When waves impact the opening of the chimney, air is forced into the chimney— in the vertical portion a wind turbine is positioned that rotates in both directions—so as the wave recedes the air is pulled back downward, capturing the potential in both directions. A single Limpet powers 400 Scottish homes.

The US DOE's National Renewable Energy Laboratory estimates the potential of global wave power to be two to three million MW, with wave energy density averages of 65 MW per mile of coastline in favorable areas.[86] And the technology to harness the power of the waves is making headway – a new type of wave-power generator allows for high efficiency rates in extracting energy from the sea.[87]

In fact, the world's first commercial wave farm came on-line in the summer of 2007 in Portugal. The project, the Aguçadoura Wave Farm, was estimated to generate 24 MW of electricity and provide power to 15,000 households.[88] Preliminary tidal stream projects are also underway in the United States, Russia, and China. In New York City, just four sites in the East River have the potential capacity of nearly 40 MW, and a tidal turbine project being tested on Roosevelt Island is expected to generate 10 MW.[89]

STORING RENEWABLE ENERGY

The ability to store surplus energy for later use is a crucial step towards making sustainable energy widely available. One potential solution to intermittency is the use of hydrogen as a storage mechanism. Hydrogen, the most abundant chemical element in the universe, contains a tremendous store of energy that can be used to produce electricity. In order to tap into this potential, pure hydrogen must first be separated out from other materials, notably water. By passing electricity through water containing a catalyst in a process known as electrolysis, hydrogen can be produced from water at up to an 80 percent efficiency rate.[90]

Hydrogen fuel cells also have the potential to produce electricity to power homes, buildings, cars, and trucks and are attractive because their only emissions would be pure water vapor. While there are still some technical and economic barriers to the widespread application of hydrogen, the potential benefits make it worth pursuing.

Meanwhile, there are more conventional storage technologies that are readily available to store renewable energy until more efficient storage mechanisms are available. Compressed air storage can store electricity by powering a motor/generator that drives compressors to force air into an underground storage reservoir. According to the DOE this technology is already being used to help generate electricity at an 11-year-old plant in McIntosh, Alabama, and a 23-year-old plant in Germany.[91]

Furthermore, pumped hydro facilities are being used to store electricity by pumping water from a lower reservoir into one at a higher elevation and then passing the water through hydraulic turbines to generate electricity. According to the DOE, this technology is suitable for times of peak demand by providing low cost power and reserve capability.[92] Furthermore, pumped hydro can be used to smooth out the demand for base load generation making it well suited for application with certain renewable technologies.

ENERGY EFFICIENCY, DECENTRALIZED GENERATION AND COGENERATION

Each dollar invested in electric efficiency in the US displaces nearly seven times as much carbon dioxide as a dollar invested in nuclear power and nuclear power saves as little as half as much carbon per dollar as wind power and cogeneration.[93]

> ***For many utilities, energy efficiency can lower energy costs and supply more energy than expanding conventional supply strategies.***

For many utilities, energy efficiency can lower energy costs and supply more energy than expanding conventional supply strategies. Aggressive, coordinated and comprehensive energy efficiency programs are desirable and attainable. According to Amory Lovins, "a cost-effective *combination* of efficient use with decentralized (or even just decentralized renewable) supply is ample to achieve climate-stabilization and global development goals, even using technologies quite inferior to today's. For all these reasons, a portfolio of least-cost investments in efficient use and in decentralized generation will beat nuclear power in cost *and* speed *and* size by a large and rising margin. This isn't hypothetical; it's what today's market is proving decisively."[94]

Likewise, the British Department of Trade and Industry acknowledged that energy efficiency is likely to be the cheapest and safest way of addressing fundamental energy challenges: GHG emissions reduction; maintenance of a reliable energy supply; promotion of competitive markets; and assuring affordable power.[95]

A recent survey of energy efficiency programs in the US[96] shows that a number of states have instituted a surcharge on electric power bills that fund independent, third-party energy efficiency programs. Given the conflict of interest that utilities corporations have promoting significant reductions in power usage, such programs can be more credible.

Cogeneration, or the combined generation of heat and power (CHP), is also significantly more efficient than producing electric and thermal energy separately. Cogeneration refers to any system that simultaneously or sequentially generates electric energy and utilizes the thermal energy that is normally wasted for space heating, hot water, steam, air conditioning, water cooling, product drying, or for nearly any other thermal energy need. Byproduct heat at moderate temperatures can also be used for the production of cold in refrigerators and water cooling mechanisms. A plant producing electricity, heat and cold is sometimes called trigeneration.

Cogeneration already produces almost nine percent of the power consumed in the US at a total efficiency nearly twice that of the rest of the country's power grid.[97] A report commissioned by the Western Governor's Association concluded that cogeneration has the potential to exceed the stated goal of adding

30 MW of new, clean and efficient capacity in the Western states by 2015.[98]

SUSTAINABLE ENERGY: A GOOD CHOICE FOR THE ECONOMY

Consumers, politicians, workers, and business leaders are increasingly appreciating that the decision between economic growth and environmental sustainability is truly a false choice. In fact, dollar for dollar, the economic rewards from sustainable energy investments continue to outpace those from conventional energy sources.

A recent study by the University of California confirmed that sustainable energy sources provide more jobs "per MW of power installed, per unit of energy produced, and per dollar investment than the fossil fuel-based energy sector."[99] At the same time, sustainable energy is becoming more affordable to end-users and is attracting the attention of financial institutions and investors who are incorporating sustainable energy projects into their portfolios.

Across the board, the sustainable energy sector is experiencing virtually unprecedented financial success. Currently a $2.5 billion industry, solar PV is projected to grow an average of almost 20 percent per year through 2020.[100] Wind energy is also booming, with a record-setting $3 billion worth of new equipment installed in the US alone last year.[101] Some forecasts anticipate that solar and wind energy will each constitute a $40 billion to $50 billion industry by 2014.[102] Already a $1.5 billion industry in its own right, geothermal energy may grow by up to 15 percent annually in some sectors, and the DOE predicts that foreign governments will spend as much as $40 billion from 2003 to 2023 to build geothermal energy plants.[103]

Dollar for dollar, the economic rewards from sustainable energy investments outpace those from conventional energy sources.

The sustainable energy sector promises to boost the American and international job market just as many manufacturers and conventional energy providers are outsourcing or downsizing their workforces. The Union of Concerned Scientists estimates that 355,000 new jobs in American manufacturing, construction, operation, maintenance, and other industries can be created if the US obtained 20 percent of its energy from sustainable sources by 2020.[104]

Solar power alone is expected to provide more than 150,000 US jobs by 2020[105] and Germany already employs 170,000 people in its sustainable energy sector, and substantial future growth is anticipated.[106] In fact, on a global scale, over 1.7 million people are already directly employed in sustainable energy manufacturing, technology, and maintenance, with indirect employment believed to be several times higher.[107]

CHAPTER 4

Nuclear power pollutes

The nuclear power industry has invested a lot of money in marketing campaigns promoting nuclear power as "clean energy." In 1998, the Nuclear Energy Institute (NEI) ran advertisements claiming that nuclear power helps "protect the environment."[108] In response, fifteen environmental, consumer, public policy, and business organizations won an important judgment from the National Advertising Division of the Council of Better Business Bureaus (NAD). NAD ruled that the 1998 NEI ads were "misleading" and advised that they should be "discontinued."[109]

However, the NEI chose to ignore the warnings and continued with a new round of barely modified advertising messages, and the case was referred to the Federal Trade Commission (FTC). In December 1999, the FTC ruled that "because the discharge of hot water from cooling systems is known to harm the environment, and given the unresolved issues surrounding disposal of radioactive waste, we think that NEI has failed to substantiate its general environmental benefit claim."[110] The FTC also agreed with the NAD's decision "that NEI has not substantiated its statement that the production of nuclear power does not pollute the water."[111] The FTC warned the NEI that its advertising campaign, touting nuclear power as environmentally clean, was without substantiation and recommended that the NEI "take to heart the evaluation of its advertising that has been rendered by its peers."[112]

IMPACTS ON THE MARINE ECOSYSTEMS

Noted scientists and oceanic experts agree that the health of the world's oceans is in jeopardy. Yet, the nuclear industry is still permitted to destroy significant areas of marine habitat through the daily operations of its once-through coolant reactors. In general, the commercial fishing industry is highly regulated as to the manner of catch, quantity, and frequency. Conversely, the nuclear power industry is required to take very few precautions to avoid impacts on fish stocks and the larvae of numerous near-shore species. Indeed, two very different regulatory regimes control the environmental impacts of commercial fisheries and the nuclear power industry, while both industries have significant impacts on the marine environment.

Reactors that operate with once-through cooling systems typically use more than one billion gallons of water a day (500,000 gallons a minute). This enormous water use can have large impacts on the environment —trapping fish and other marine animals in their intakes and changing the temperature of local waterways through the discharge of heated water.[113]

In fact, fish, fish larvae, and fish eggs are harmed and destroyed upon entering the flow of reactor cooling water where they are sucked into and impinged on the water intake screens. Smaller fish, fish larvae, spawn, and a large number of other marine organisms are actually drawn into the reactor coolant system where up to 95 percent are scalded, killed and discharged as sediment. This indiscriminate killing can result in extensive depletion of the affected species and cause the community of species around a reactor to lose their capacity to sustain themselves.

The once-through cooling system also discharges water that is much hotter than when it is withdrawn. The hot discharge water damages and destroys fish and other marine life and dramatically alters the immediate marine environment. Warmer waters have been found to cause a fatal disease, known as "withering syndrome," in black and red abalone, which have been virtually eliminated around the Diablo Canyon reactor in California.

> ***The nuclear industry is permitted to destroy significant areas of marine habitat through the daily operations of its once-through coolant reactors.***

Kelp, unable to photosynthesize efficiently due to the shadowing effect of reactor discharge sediment, is also weakened by higher water temperatures. In the immediate discharge areas, the ocean floor is scoured clean of sediment by the force of the thermal discharge, resulting in bare rock and creating a virtual marine desert.

In theory, nuclear power plants are required to use water intake systems that "reflect the best technology available for minimizing adverse environmental impacts," according to the Clean Water Act (CWA). However, the site specific examples of environmental impacts are quite startling when examined. For example, the State of New York estimates that the Indian Point reactors cause the mortality of more than one billion fish a year, and that closed-cycle cooling would lead to at least a 98 percent reduction in fish mortality.[114] In the case of the Oyster Creek reactor in Tom's River New Jersey, the State Department of Environmental Protection estimates that the cooling system kills millions of small fish, shrimp and other aquatic creatures each year and that dead marine life expelled from cooling systems back into the source stream create a "shadow effect," blocking sunlight to underwater organisms and limiting oxygen uptake.[115]

IMPACTS ON ENDANGERED SPECIES

Four species of endangered and one threatened species of sea turtle present in US coastal waters are harmed and killed by nuclear power station operations. Loggerhead, green, and Kemp's Ridley sea turtles are the most common victims at nuclear reactors and are often entrained into the large-diameter coolant intake pipes used by coastal reactors.

A 1990 National Academy of Sciences study, "Decline of Sea Turtles, Causes and Prevention," examined the impacts on worldwide sea turtle populations and recommended protective measures to prevent their extinction.[116] The academy, in its investigation of power plant impacts, found that death and injury can occur in transit through a reactor's once-through intake pipes. Sea turtles are also impinged by the force of the intake water and become lodged on intake structures, barrier nets or against the power station's metal grate trash racks.

Thus, the marine impacts of nuclear power demonstrate that the nuclear industry and regulators value profit over reduction of harm to the marine ecosystem. In fact, there are numerous examples of take limits for endangered species being raised and adjusted in accordance with plant operating imperatives rather than species population maintenance.

> ***The reactors at the Indian Point power plant, north of New York City, are estimated to cause the mortality of more than one billion fish a year.***

The installation of cooling towers to once-through systems (which account for over half of the nations 103) would reduce water intake by 96 percent and greatly reduce the potential for marine species damage.[117] The towers would also function to cool waste waters before discharge, thereby reducing temperature induced ecosystem disruptions significantly. However, despite this proven and affordable mitigation measure, utilities, which claim to act as stewards of our natural heritage, continue to exact a devastating toll that in many cases may have no chance for reversal.

CHAPTER 5

Reactors remain dangerous; catastrophic accidents can and likely will occur

The fact that there has not been a Chernobyl-scale accident at a nuclear facility in the United States does not mean that reactors here are accident-proof or even have strong safety records. In actuality, the Nuclear Regulatory Commission (NRC) has documented nearly 200 "near misses" to serious reactor accidents in the US since 1986, eight of which involved a risk of a core meltdown that was greater than one in 1,000.[118] Most alarmingly, only one of those eight reactors was on the NRC's regulatory radar prior to the problems occurring.

While US designs use water to slow and cool the atomic chain reaction in the reactor core rather than the graphite absorption model of the infamous reactor at Chernobyl that exploded and burned in a radioactive fire on April 26, 1986, many US reactors continue to operate with serious design flaws and in violation of federal safety requirements today. One top safety concern is General Electric's 24 antiquated MARK I boiling water reactors that store highly radioactive and thermally hot nuclear fuel in densely packed storage pools located six to ten stories up in the reactor building outside and atop the primary containment structure for the reactor vessel. The design feature makes the GE BWR design vulnerable to rupture by an accidental heavy load drop or penetration by a deliberate terrorist strike.

While nuclear power proponents argue that there is no comparison between Chernobyl-style RBMK reactors and western reactors with the claim that the Soviet reactor had no containment, the containment structure for the MARK I is known to be a fundamentally flawed design. In the words of a former chief nuclear safety director for the NRC Office of Nuclear Reactor Regulation, "You'll find something like a 90 percent chance of failure" of the Mark I containment if challenged by a significant accident.[119] The Mark I design was later back-fit to give operators the option to deliberately vent radiation from the containment during an accident in order to save the reactor itself. However, despite these significant safety issues, the NRC is extending the operating licenses for these fatally flawed designs and approving extensive power increases for aged reactors under hasty and superficial technical reviews.

Other known and long standing design flaws make the boiling water reactor fleet and other US reactor designs prone to early containment failure in the event of an accident or successful attack.

LONG STANDING REACTOR SAFETY VIOLATIONS GO WITHOUT NRC ENFORCEMENT

Continued lack of NRC enforcement action on long standing safety violations increases the risk of the occurrence of a significant accident involving reactor core damage and a catastrophic release of radioactivity to the environment.

The example of long standing and widespread violations of fire protection law by a majority of nuclear power plant operators is disturbing. A fire set by a worker checking for air leaks along electrical cable trays with an open candle flame at Alabama's Browns Ferry nuclear power station on March 22, 1975 nearly caused a catastrophic radioactive accident. In just 15 minutes, the fire destroyed 1500 cables, more than 600 of which were vital to the control of the reactor and its shutdown. As a result, in 1980 NRC promulgated new regulations for fire protection to assure that no single fire could knock out the control room's ability to safely shut the reactor down in the event of fire. The law now requires that for areas in the plant where redundant safe shutdown electrical circuits appear in the same fire zone, qualified design features are required to protect safe shutdown cable functionality through rated time/temperature fire barrier systems or minimum separation used in conjunction with automated fire detection and suppression systems.[120]

In 1989, NRC was notified that the most widely deployed fire barrier system for such purposes in US reactors, Thermo-Lag 330-1, could not be relied upon to protect safe reactor shutdown in the event of a significant fire. By 1992, NRC declared the system inoperable for 89 reactor units.[121] NRC staff and the nuclear industry engaged in a six-year dialogue of technical meetings to bring operators back into compliance with fire protection law. By 1998, most of the industry had entered into agreements with NRC to upgrade inoperable fire barrier systems. However, 17 operators for 24 reactor units that had failed to enter into timely resolution were issued orders by the federal safety agency to bring their reactors into fire safety compliance by 2000. Subsequent inspections from 2000 through 2002 revealed that a substantially large number of reactor operators ignored their agreed-upon Corrective Action Programs. Instead many operators substituted unapproved and largely unanalyzed "operator manual actions" rather than fix the bogus fire barriers.

In the event of a significant fire, control room operators would instead allow unprotected electrical cables to be destroyed by the fire and send station personnel to remote plant locations to manually operate the end piece components (valves, circuit breakers, fuses, etc.) that were required by law to be protected for control room operation. Many of these manual actions would require workers to run a potentially hazardous gauntlet (smoke, fire, radiation, and possible attackers) with keys, tools, ladders and respirators in a heroic effort to save the reactor from meltdown. While design features such as fire barriers or minimum cable separation requirements can be qualified and inspected, manual actions raise a host of uncertainties on human reliability. There is unquestionably no equivalence between maintaining qualified passive design fire protection features and human actions.

The industry efforts have undermined reasonable assurance that vital reactor safety functions can be achieved before a meltdown could occur. While the agreements and orders for fire protection compliance are still in effect, NRC so far has refused to take any enforcement action for safety violations going back to 1992. Instead, the nuclear industry and NRC are seeking to amend the fire protection law to circumvent the requirement that prioritizes qualified physical fire protection features by substituting wholesale exemptions that rely upon these dubious operator manual actions.[122] Such regulatory maneuvers would codify a significant reduction in the defense-in-depth philosophy and set back the fire protection code for nuclear power stations to the days before the near catastrophic Browns Ferry fire.

In fact, an investigation by Nuclear Information and Resource Service (NIRS) found that the Browns Ferry-1 reactor restarted in May 2007, after a 22-year shutdown for a host of design safety problems—still does not comply with federal fire protection regulations put into place because of its near-catastrophic fire in 1975. Despite spending nearly $2 billion to bring the reactor back on line, the Tennessee Valley Authority ignored fixing violations for the protection of safe shutdown electrical circuits and instead adopted the dubious operator manual actions. The NRC gave its OK for the restart of the reactor under "enforcement discretion" for more than 100 violations with the federal fire safety law that the reactor was responsible for creating.[123]

NRC AND INDUSTRY SAFETY CULTURE

The NRC has historically fallen into a mind-set described in the post-Three Mile Island reports to the President as being a major contributor to the accident that occurred on March 28, 1979. As the Commission investigating the TMI accident described, "We find that the NRC is so preoccupied with the licensing of plants that it has not given primary consideration to overall safety issues… With its present organization, staff and attitudes, the NRC is unable to fulfill its responsibility for providing an acceptable level of safety for nuclear power plants."[124]

NRC safety regulation and oversight reflects a bias which all too often factors the financial interests of the nuclear industry at the expense of reduced safety and security margins at reactors.

The prioritization of corporate profit and production margins over public health and safety margins is clearly revealed by the failings of both the industry safety culture and NRC safety oversight to capture a near-miss accident at Ohio's Davis-Besse nuclear power station, a Three Mile Island-style Babcox & Wilcox pressurized water reactor. For years, First Energy Nuclear Operating Corporation (FENOC), the operator of the reactor just 20 miles from Toledo, Ohio, and the NRC onsite resident inspectors ignored clear signs of serious and ongoing corrosion of the reactor vessel component.[125] The reactor pressure vessel is an essential safety component which houses the highly radioactive reactor core under extreme pressure (over 2000 pounds per square inch) and high temperature (approximately 600˚ Fahrenheit). At one point, the reactor containment building air filters had to be changed out daily because they became clogged with iron oxide particulate (rust) floating around inside the building. A dusting of fine rust particles routinely settled and caked onto catwalks and stairways inside the reactor building. A photograph of the reactor pressure vessel taken by FENOC and given to NRC inspectors in April 2000 at the end of a regularly scheduled inspection, maintenance and refueling outage showed lava-like formations of red rust flowing off the top of the reactor vessel head.

In 2001, NRC staff became aware that inspections at six of the seven Babcox & Wilcox reactors operating in the US had revealed age-related cracking of stainless steel penetration sleeves in the reactor pressure vessel head where control rods pass through the 7-inch thick structure. Only Davis-Besse had not been inspected for cracking of the sleeves. Fearing that if the crack were to go completely through the sleeve's wall that the intense internal pressure could eject a control rod like a missile, the staff determined that this was an unacceptable safety risk and began drafting an Order for the early shutdown of the reactor for the necessary inspections. FENOC objected vigorously to NRC effort for the early shutdown.

Within just a matter of days before the Order was to be issued to FENOC to anticipate the date of the refueling shutdown, a NRC senior manager met with FENOC's president of operations. According to documents obtained by NIRS through the Freedom of Information Act, NRC was asked to consider, among other things, the adverse impact on the "financial markets" for FENOC and was requested not to issue the early shutdown Order.[126] NRC withdrew the Order for December shutdown in a compromise deal with FENOC to shutdown in February.

When the company conducted the NRC requested inspection, they not only discovered cracking in several of the control rod penetration sleeves but severe corrosion of the vessel head from caustic borated reactor coolant leaking through the cracks that had dripped down onto the vessel head over the course of several years. The concentrated and molten boron had eaten a cavity completely through the 6 ¾-inch steel outer carbon steel shell all the way down to a thin corrosive-resistant stainless steel inner liner of the vessel. As the load bearing outer shell was eaten away, the stainless steel liner was bulging out from the internal pressure like the inner tube on a bald bicycle tire, ready to burst.

Had the vessel burst, a jet of reactor coolant would have escaped out of the top with such force as to create a significant debris field that would have clogged the reactor building sump systems designed to re-circulate the water for the emergency core cooling system. The result likely would have been a Loss of Coolant Accident (LOCA) followed by the collapse of the Emergency Core Cooling System (ECCS), an accident that would likely have surpassed the Three Mile Island Unit 2 partial meltdown in 1979.

Investigative reports by both the United States Government Accountability Office (GAO)[127] and the NRC Office of the Inspector General[128] concluded that NRC had failed to maintain adequate safety oversight of the severely damaged reactor in a number of critical aspects. NRC did not have complete and accurate information on the condition of the reactor and completely misidentified Davis-Besse as a "good performer." The agency did not view years of accumulated evidence of a significant corrosion problem as an immediate safety concern. Contrary to NRC safety goals, NRC allowed an at-risk reactor to continue to operate far beyond the need for timely safety-related inspections and established reactor coolant leak rate requirements. Senior management at NRC ignored the studied judgment of its technical staff to consider the financial impacts of early shutdown for safety reasons. Moreover, "NRC appears to have informally established an unreasonably high burden of requiring absolute proof of a safety problem, versus lack of reasonable assurance of maintaining public health and safety, before it will act to shut down a power plant."[129]

According to an Argonne National Lab report issued to the NRC in 2004, Davis-Besse came to within as close as two months but most certainly within the next 24 month operational cycle before bursting the all important reactor pressure vessel.[130]

The near-accident at the Davis-Besse reactor demonstrated the eroded safety culture at reactors when both the utility and the NRC shunted aside warnings and opportunities to catch the advanced corrosion in the vessel-head that could have caused a major accident.[131] As a matter of practice, the NRC and nuclear utilities do not have measures in place to learn from past accidents, nor do they maintain an effective and rigorous inspection regime. A recent report by the Union of Concerned Scientists has shown that of the 104 nuclear power reactors in the United States, severe problems have caused 41 to shut down for a year or longer, with some registering multiple shut-downs.[132] Such extended shutdowns reveal the degree to which cumulative decay and unattended maintenance issues allow safety margins to deteriorate to levels so low that reactor operations must cease altogether. Thus, industry proposals to extend the operating licenses and increase power output represent serious and unacceptable safety hazards.

> *"The NRC is so preoccupied with the licensing of plants that it has not given primary consideration to overall safety issues."*

Further, a recent GAO report stated that despite industry assurances, oversight of safety procedures at the nation's 104 operating nuclear plants warrants aggressive attention from federal regulators, and described the NRC as "slow to react" to the deteriorating conditions of some plants.[133] Therefore, the evidence suggests that safety and security efforts by the NRC and the industry should be the subject of serious Congressional oversight. In fact, the NRC's predecessor, the AEC, was abolished and reorganized as the NRC for less egregious acts.

REACTOR VULNERABILITIES

In the wake of September 11th, NRC has trivialized the vulnerability of nuclear power plants to deliberate and malicious acts of sabotage. The findings of the National Commission on Terrorist Attacks upon the United States (also known as the 9-11 Commission) revealed that the original Al-Qaeda plan was to hijack ten domestic commercial aircraft and fly two of them into nuclear power stations.[134] Still, the NRC has entrenched itself in a ruling and an order that domestic terrorism directed against US reactors is so "remote and speculative" that it has disallowed any public licensing hearings on the vulnerabilities and consequences of such an attack.[135] This posture resulted in a June 2006 decision in the Ninth Circuit where the court ruled that the NRC erred in its determination that the National Environmental Policy Act (NEPA) does not mandate formal public hearings of the potential impacts of a terrorist attack at nuclear facilities.[136] The Ninth Circuit decision to hold such hearings under NEPA was upheld when the US Supreme Court refused to hear the appeal by the industry and NRC.[137] However, the Commission and the industry continue to oppose due process through public licensing hearings on reactor vulnerabilities and consequences in other federal court districts.

The Nuclear Energy Institute (NEI) continues to aggressively target policy makers in Washington and the general public alike with high-budget ad campaigns declaring that nuclear facilities are secure. In 2002, NEI sponsored a series of ads in Washington, D.C. which featured security officers standing guard outside of a nuclear facility with automatic weapons in hand. Titles of these ads included "Serious Business," "Tough Enough? You Bet" and "Vigilant." All six of these ads promoted the readiness of nuclear facilities in preventing terrorism.[138] However, according to the Project on Government Oversight, guards at twenty-four reactors nationwide say that morale is very low and that they are under-equipped, under-manned, and underpaid.[139] Moreover, the report concludes that neither utilities nor the NRC are making appropriate security modifications at reactors since September 11th. In fact, a 1982 technical memorandum published by Argonne National Laboratory, "Evaluation of Aircraft Crash Hazards for Nuclear Power Plants," which is now suppressed by NRC as "sensitive information," concluded that the current fleet of US nuclear power stations was never designed, constructed nor analyzed and evaluated for aircraft crash hazards. US reactors were licensed on the low probability, given such factors as pilot actions to avoid a crash into a nuclear power station, the location of nuclear power stations out of the direct take off and landing flight paths and air traffic factors, that the risk of an accidental aircraft crash was acceptable. The agency and the industry never considered a deliberate and malicious attack using aircraft of any sort. The technical report, available in public document rooms around the country until shortly after the September 11th attacks, identified a number of disturbing facts pertinent to national security:

"The major threats associated with an aircraft crash are the impact loads resulting from the collision of the aircraft with power plant structures and components and the thermal and/or overpressure effects which can arise due to the ignition of the fuel carried by the aircraft."

"It appears that for all US plants currently under construction it has been found that it is not necessary to require containments designed to take the impact of a large commercial jet aircraft. This practice is contrasted by the experience in the Federal Republic of Germany where it has been found necessary to design essentially all nuclear containments to withstand the crash of certain types of military and commercial aircraft."

"Based on the review of past licensing experience, it appears that fire and explosion hazards have been treated with less care than the direct aircraft impact and the resulting structural response. Therefore, the claim that these fire/explosion effects do not represent a threat to nuclear power plant facilities has not been clearly demonstrated."[140]

The claim is often made by industry and NRC that reactors are the best defended industrial facilities in the nation's civilian infrastructure. However, prior to September 11th, such claims were not supported by the evidence. NRC conducted site security evaluations through mock terrorist attacks at nuclear plants only once every eight years to detect vulnerabilities. Utilities were given six months advance notice of the mock attack and a night before review of table top exercises using the attack scenarios to be acted out. Often, reactor operators temporarily bolstered their security forces in anticipation of the exercise. Still, NRC inspectors found "a significant weakness" 46 percent of the time that enabled a small team of mock attackers to infiltrate the reactors and successfully attack key components to cause the core to melt with probable radioactive releases—the equivalent of what the head of the NRC security evaluation team described as an "American Chernobyl".[141] These security deficiencies were largely correlated with industry cost considerations for what was determined to be reasonably affordable security infrastructure.

The same security claims by NRC and industry that nuclear power stations are better defended following the September 11th attacks are further unsubstantiated by a report to Congress in 2006 by the GAO. The GAO in its report to the Subcommittee on National Security, Emerging Threats and International Relations, US House Committee on Government Reform, found that NRC staff recommendations to raise defense requirements around nuclear power stations were watered down by the Commission after protests from the Nuclear Energy Institute. While the NRC staff had recommended that nuclear power station security be augmented to defend against such weapons as rocket propelled grenades, 50-caliber rifles using armor-piercing and incendiary munitions and larger truck bombs, the industry rejected the increases because it would be prohibitively expensive.[142]

According to interviews conducted in 2002 with 20 guards at 24 reactors, guards at only a quarter of the plants believed they were adequately prepared to defend against a terrorist attack.[143] Even more troubling than poor performance in the past, after the attacks of September 11th the NRC suspended force-on-force tests until October 2004, and has declined to make results public under claims of national security protection.[144]

Many reactors also remain vulnerable from the water, primarily through cooling water intake structures. Available technologies, such as inflated cylinders of a rubber-coated textile, linked together or to a mooring buoy to form a security barrier around an exclusion zone, could be used to thwart small-boat terrorist attacks and are being deployed at several Naval bases, but have not been mandated for installation at vulnerable nuclear plants. Despite claims of security improvements, the high degree to which nuclear plants are vulnerable to terrorist attack is apparent.

While every attack and malfunction scenario cannot be envisioned or accounted for, there are countermeasures that must be afforded to better secure reactors and their waste from determined adversaries. Hence, claims that nuclear facilities are optimally defended are disingenuous at best. Clearly, in the interest of national security vulnerable nuclear power stations should be shutdown and no more of these pre-deployed weapons of mass destruction should be constructed and operated.

DANGERS OF TERRORISM AND IRRADIATED NUCLEAR FUEL

FBI director Robert S. Mueller testified before the Select Committee on Intelligence in the US Senate in February 2005 stating, "Another area we consider vulnerable and target rich is the energy sector, particularly nuclear power plants. Al Qaeda planner Khalid Sheikh Mohammed had nuclear power plants as part of his target set and we have no reason to believe that Al Qaeda has reconsidered."[145] Moreover, in October 2001, the Federal Aviation Administration temporarily restricted all private aircraft from flying over 86 nuclear facilities due to threats of terrorist attacks.[146]

Despite industry claims that concrete containment domes could withstand the impact of low-flying aircraft, the Swiss nuclear regulatory authority has stated that "Nuclear power plants (worldwide) are not protected against the effects of warlike acts or terrorist attacks from the air […] one cannot rule out the possibility that fuel elements in the fuel pool or the primary cooling system would be damaged and this would result in a release of radioactive substances."[147] German researchers have also used computer simulations for various jetliner crash scenarios indicating potential for considerable chaos and radiation release.[148]

Many irradiated-fuel pools are located high above ground level or above empty cavities and could be drained if their bottoms or sides were collapsed or punctured. Such an incident could result in a fire which could not be extinguished and could contaminate up to 188 square miles.[149] Moreover, according to a recent study by the National Academy of Sciences, a terrorist attack on a fuel pool could lead to the release of large quantities of radioactive materials to the environment.[150] Therefore, the issue is paramount as a national security priority, but the majority of irradiated fuel has not been placed in hardened on-site storage (HOSS) and is not any safer than on September 11, 2001 (see more detailed discussion in Chapter 7). Moreover, the US is no closer to a solution for this waste, and present proposals from Congress and the DOE raise more questions than answers.

EMERGENCY PREPAREDNESS AND EVACUATION PLANS ARE INADEQUATE AND OUTDATED

In accordance with NRC regulations, reactor owners are supposed to develop feasible evacuation plans in the event of a large radiological release from a reactor accident. However, as concerns over reactor safety have escalated since the attacks of September 11th, evacuation plans and emergency preparedness have increasingly come under scrutiny. In fact, emergency planning for the NRC now falls under the supervision of the Nuclear Security Incident Response Branch.

In an in-depth consideration of likely impacts of an attack on a nuclear facility in the US, Physicians for Social Responsibility (PSR) concluded that quick and effective evacuation would be the greatest challenge in casualty reduction.[151] The report made note that the US currently has no mechanism in place to respond to specific weather patterns that would dictate the spread of radiation in the event of an accident, thereby making comprehensive evacuation impossible.

A report for the State of New York by James Lee Witt and Associates, analyzed the emergency preparedness plan for the reactors at Indian Point and concluded that evacuation plans were woefully inadequate.[152] The report concluded that plans reflected a focus on complying with generic regulations rather than effective public health provision. While the report was specific to two nuclear facilities, its appraisal of the federal regulatory framework as inadequate, out-dated and ineffectual can be generalized across the industry. Furthermore, a 2001 report from the GAO found that significant weaknesses in the emergency preparedness at Indian Point went uncorrected for over a year after being identified.[153]

Many reactors are built near large population centers, especially along the eastern US which is more densely populated now than when plants were constructed. For example, the Oyster Creek reactor in New Jersey has seen local population triple in size since the plant was built, making safe and timely evacuation a non-reality for today's surrounding residents.[154] Moreover, existing plans are limited in that they only require utilities to plan for evacuation of residents in the 10-mile radius zone surrounding the reactor. This regulation again undershoots the mark of public protection, as the American Thyroid Association recommends that provisions be made for people within a 50-mile radius.[155]

On August 31, 2005 while Hurricane Katrina was demolishing both the Gulf Coast and the American public's confidence in the adequacy of federal emergency planning, the NRC, Department of Homeland Security along with the Federal Emergency Management Agency were meeting with public stakeholders from various reactor communities to discuss emergency preparedness concerns.[156] The NRC and the nuclear industry made clear at this meeting that they are in fact re-organizing their emergency plans to de-emphasize increasingly dubious evacuation plans for the recommendation that downwind populations would be better off to simply "shelter in place" in their homes, schools and businesses rather than be caught in traffic jams on the roads. Federal plans to turn our communities into "shelters of last resort" from a catastrophic nuclear accident underscore the need for public actions to move towards the most pertinent civil defense actions by permanently shutting dangerous nuclear power stations down and reducing the vulnerability to ill-prepared and unfeasible emergency plans for radiological catastrophes that could potentially dwarf the scale of the Chernobyl nuclear accident.

NEW NUCLEAR PLANT DESIGNS ARE NOT INHERENTLY SAFER OR CHEAPER

A key component of the proposed "nuclear renaissance" involves the drive for what is being called "Generation IV reactor designs," which are purported to be inherently safer, less expensive to build and more fuel efficient. However, it is important to note that these designs are unproven, making promised delivery time and cost unfounded.

In the case of one Generation IV design, promised cost advantages would be achieved by replacing the steel-lined, reinforced-concrete containment structures currently employed at most US reactors with less costly and a far less robust enclosure structure in spite of warnings from the NRC's own Advisory Committee on Reactor Safeguards, which described this cost-advantage as a "major safety trade-off." [157]

Proposed fast breeder reactors have a history of monumental safety lapses, accidental releases of radiation, extended shut-downs and exorbitant costs which has lead ultimately to the majority of them being forced into early closure. Most concerning, these reactors also come with the increased possibility of "prompt criticality" accidents.[158]

> *The NRC's own advisory committee on reactor safeguards described cost-cutting measures in a proposed reactor design as a "major safety trade-off."*

According to the US DOE, actual construction costs for reactors built between 1966 and 1977 were generally three times higher than projected.[159] Reactors that came later were even more expensive. Industry plans for nuclear power expansion are staked on uncertain resources and technologies from the unknown availability of high grade uranium ore reserves and fuel fabrication processes to reactor facilities and long term nuclear waste disposition. There is no techno-fix for nuclear power, and promises of future developments are not a sound basis for investment. The unavoidable truth is that nuclear technology is inherently dangerous. A sober look at the course of nuclear technology reveals a history wrought with uncertainty, compound risk factors, unpredictable accidents and ample opportunities for disaster.

Billions have been invested in researching new, better, so called "safer" nuclear technologies, and yet we have made scant progress toward accident risk abatement, waste disposal and public health provision. No other energy source has such extreme and prevalent safety risks and there are a wealth of renewable energy sources and efficiency innovations available without these attendant dangers.

CHAPTER 6

Nuclear power is expensive

While the nuclear industry argues that nuclear power is cheaper than some other forms of electricity generation, it counts only the price of operating the plants, not the full costs of building them. Operating costs of nuclear power plants are relatively low, but to argue these are the true costs of nuclear power is disingenuous, like arguing that it is cheap to drive a Rolls Royce counting only the price of gasoline and leaving out the purchase price.

In fact, the cost of nuclear power is extremely high at the beginning and end of the operational cycle of a nuclear power plant: construction costs for reactors built since the mid-1980's have ranged from $2-$6 billion, averaging more than $3,000 per kW of electric generating capacity (in 1997 dollars).[160] Historically, nuclear power has been anything but cost effective. The capital cost for construction of a reactor is very high, and cost overruns are highly probable for new reactors. Initial industry cost estimates of $1,500-$2,000 per kW of electric generating capacity for the new generation of nuclear plants appear to have been based on wishful thinking: the first actual applications (from Constellation Energy and NRG Energy) project costs about twice that. The prices of recently built nuclear power plants in Japan were much higher, ranging between $1,796 and $2,827 per kW, in 2003 dollars.[161] In October 2007, Moody's Investors Service estimated that new US reactors are likely to cost $5,000 to $6,000 per kW.[162]

The Congressional Research Service indicates that average construction costs have totaled more than $3,000 per kW, and that the nuclear industry's claims that new plant designs could be built for less than that amount (if a number of identical plants were built) have not been demonstrated.[163] Indeed, nuclear construction cost estimates in the US have been notoriously inaccurate. The estimated costs of some existing nuclear units were wrong by factors of two or more, The total estimated cost of 75 of today's existing nuclear units was $45 billion (in 1990 dollars).[164] The actual costs turned out to be $145 billion (also in 1990 dollars).

Recently built nuclear plants in Japan cost as much as $2,827 per KW, in 2003 dollars while the new Finnish EPR reactor could top $6 billion (US).

Perhaps, the most striking example of cost overruns was the Shoreham nuclear plant in New York. With an initial estimated cost of $350 million, the plant ended up costing $5.4 billion when it was completed 20 years later, about 15 times the original cost. The plant never produced a single kW of commercial power, and the cost overruns of the project contributed to saddling Long Island with some of the nation's highest electricity rates.

Europe's most recent nuclear project, the European Pressurized Water Reactor at Olkiluoto in Finland, is running over budget and causing financial losses for French builder Areva, which is building the reactor under a 3 billion euro fixed-price contract. The company's operating income for 2006 was severely affected by the construction delays, and the company took a loss of some $900 million (US) for the year. The loss is due to a "significant" provision the group made to account for past and expected future costs of delays at Olkiluoto. In November 2006, the French media reported the reactor was already 24 months behind schedule, despite only 20 months of construction undertaken![165] Construction costs already have reached 4.5 billion euros, and some independent economists such as Steve Thomas of the University of Greenwich in the UK predict final actual costs for the reactor could top 5 billion euros (about $7 billion (US)).[166]

COST EFFECTIVE COMPARED TO WHAT?

A 2003 study by MIT forecasted that the base case real levelized cost of electricity from new nuclear reactors with an estimated 85 percent capacity would be $.067 per kWh over a projected forty year operating life—

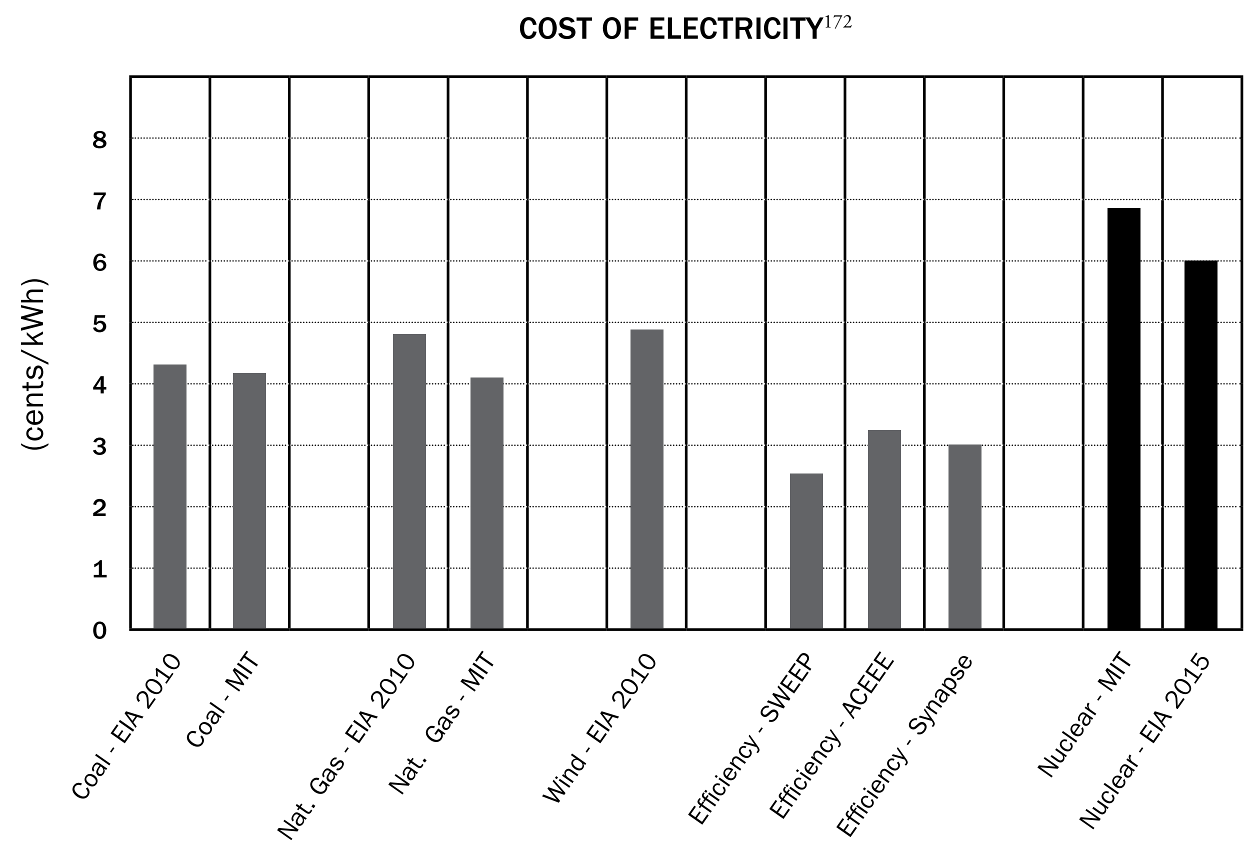
more expensive than from pulverized coal or natural gas. The study points out that "The bottom line is that with current expectations about nuclear power construction costs, operating costs and regulatory uncertainties, it is extremely unlikely that nuclear power will be the technology of choice for merchant plant investors in regions where suppliers have access to natural gas or coal resources. It is just too expensive."[167]

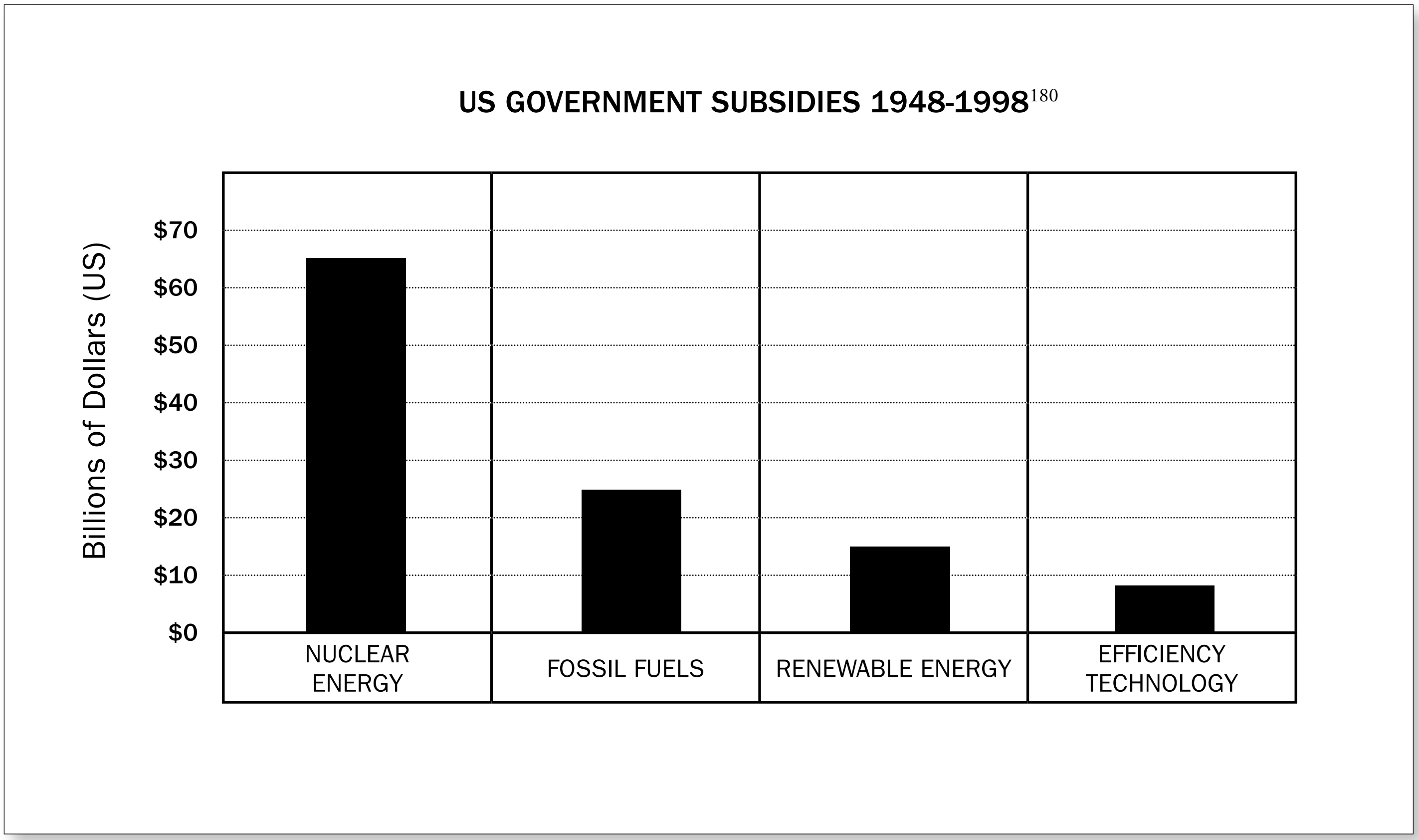
Additional studies have also concluded that overnight capital costs, lead construction times and interest rate premiums are likely to place the cost of electricity from any future nuclear power plants within the range of \$.06 to \$.07 per kWh.[168] In fact, even in France, the country with the highest percentage of nuclear power in its electricity supply mix, officials have admitted that natural gas combined cycle plants are more economical than nuclear plants.[169]

Several cost comparisons with wind and efficiency clearly demonstrate the economic disadvantages of nuclear power, including the Rocky Mountain Institute's analysis, which found that "in round numbers, electricity from new light water reactors will cost twice as much as from new wind farms, five to ten times as much as from distributed gas-fired cogeneration or trigeneration in buildings and factories (net of the credit for their recovered heat) and three to thirty times as much as energy efficiency that can save most of the electricity now used. Any of these three abundant and widely available competitors could knock nuclear power out of the market, with more on the way (ultimately including cheap fuel cells)."[170] Thus, because of the cost, nuclear power cannot compete with these cheaper, decentralized alternatives.[171]

COST OF ELECTRICITY FROM VARIOUS TECHNOLOGIES

Meanwhile, deployment costs and electricity prices for renewable energies continue to go down. The International Energy Agency predicts a cost reduction up to 25 percent for wind power and 50 percent for solar PV from 2001 to 2020.[173] And for part of 2005, utility costumers in Texas and Colorado already paid less for wind-generated electricity than for conventionally-produced power.[174]





THE NUCLEAR INDUSTRY IS NOT ABLE TO COMPETE IN THE MARKET WITHOUT HUGE GOVERNMENT SUBSIDIES

According to Entergy's CEO,…"whatever the government needs to spend, it's a small price to pay for weaning America off its addiction to foreign oil, reducing greenhouse gases and protecting our economy."[175] This statement mirrors five decades of nuclear industry demands for subsidies and, unfortunately, again and again, the government has come through for the industry.

Federal subsidies cover 60-90 percent of the generation cost for new nuclear plants, without which they would not be viable.[176] Market distortions, such as subsidies and the failure to account for the true societal cost of conventional energy, have unjustly benefited the nuclear and fossil fuel industries for decades. Worldwide, conventional energy sources (nuclear and fossil fuels) have received approximately $250 billion in 2003 in government subsidies,[177] while combined US and European government support for renewable energy sources totaled just $10 billion the following year.[178] Thus, the discussion of cost effectiveness cannot be divorced from that of the subsidies and incentives provided. Indeed, these handouts are the economic lifeblood of the nuclear industry. Nuclear power receives 61 percent of the European Union's energy-related R & D funding, even though it contributes only 13 percent of the region's energy.[179] The US government spent more than $110 billion on energy research and development between 1948 and 1998. The nuclear industry got the biggest share of this money, some $66 billion or 60 percent. Fossil fuels were allocated 23 percent of the funding, while renewable energies got only 10 percent and efficiency technologies received a mere seven percent.[180]

Energy subsidies are justified as incentives for the advancement of nascent technologies in their early stages of development. Yet, nuclear power is now a 50-year old industry and has even been classified by the International Energy Agency as "proven and mature."[181] However, in the Energy Policy Act (EPACT) of 2005, Congress provided the industry with a package of incentives worth some $13 billion, including:[182]

- $2.9 billion in research and development subsidies, including financing for the Nuclear Power 2010 program to build new plants and the Generation IV program to develop new reactor designs.

- $3.25 billion in construction subsidies, including unlimited loan guarantees for the construction of new plants, half of the costs of obtaining the necessary site permits and reactor licenses, and payments to the industry in case of delays in construction and operation licensing.

- $5.7 billion in operating costs, including production tax credits of 1.8 cents per kWh.

Moreover, EPACT 2005 reauthorized the Price Anderson Act for another 20 years, freeing existing and proposed reactors from prohibitively high insurance costs. Enacted in 1957, Price Anderson was originally intended to be a temporary incentive to the then nascent nuclear industry to address the difficulties of private investors in obtaining insurance to cover the risks associated with nuclear power. However, at this point, the extension of this incentive amounts to an enormous uncalculated subsidy to the nuclear industry. In fact, the law caps the liability of nuclear operators in case of an accident and passes the costs of damage compensations above $10 billion onto the taxpayers.

> *The unacceptably high cost of insurance, waste removal and storage, and decommissioning would make nuclear energy completely untenable in a truely equalized marketplace.*

It is indisputable that the unacceptably high cost of insurance, waste removal and storage, and decommissioning would make nuclear energy completely untenable in a truly equalized marketplace. Thus, despite the large incentives and subsidies to the nuclear industry, investors remain skeptical of putting their financial resources in new nuclear power plants. In fact, nuclear power is likely to be met with some skepticism on Wall Street and Standard & Poor's found that "an electric utility with a nuclear exposure has weaker credit than one without and can expect to pay more on the margin for credit. Federal support of construction costs will do little to change that reality. Therefore, were a utility to embark on a new or expanded nuclear endeavor, Standard & Poor's would likely revisit its rating on the utility."[183]

UNACCOUNTED COSTS: EXTERNALITIES

In addition to the assistance they receive through subsidies, the cost of nuclear power does not account for the toll it takes on human health and the environment. These costs are paid by society at large and include, but are not limited to, environmental costs, air pollution, climate change as well as health care costs. Because these costs are not taken into account in the calculations of the price of energy, economists call them "externalities."

It is true that the calculation of external costs is not a simple task because of the uncertainties and assumptions involved, but, as has been noted "…not to incorporate externalities in prices is to implicitly assign a value of zero, a number that is demonstrably wrong."[184] Nuclear power has been estimated to produce up to 2.7 billion euros a year in external costs in the EU-15 countries alone.[185]

This is an important distinction because consumers often pay higher prices for sustainable energy because the ecological benefits it provides are unaccounted for. In fact, the International Energy Agency considers these "unrewarded environmental characteristics" to be the principal barrier to increasing the market share for sustainable energy.[186] Therefore, despite the difficulty of calculating the costs, understanding the life cycle costs of our energy sources that are borne by society, is an essential part of the case for transition away from reliance on those sources.

CHAPTER 7

Radioactive waste remains a problem without a solution

Radioactive waste remains dangerous for millions of years, presenting an enormous challenge to health and environment provisions for future generations. There are multiple threats from atomic waste: ionizing radiation,[18] toxic elements, and heavy metals, many of which are fissile (most of these could be used to make nuclear weapons). Storage and handling of the waste is complicated for centuries by ambient radiation doses at lethal levels, and the waste itself is a significant thermal heat source. Further, in every storage and transport step, the possibility of unplanned criticality (nuclear chain reaction) is real. All claims of "neutralizing" this complex material are fictitious; most are processes that would only serve to break up the heaviest elements, reducing the concern that the waste could be "mined" for nuclear weapons materials; nonetheless, these processes multiply the potential health hazards by multiplying the mutagenic, ionizing radiation manifold.[188]

No country in the world has successfully developed a method for the safe disposition of radioactive waste. Moreover, the waste is extremely costly to safeguard and in 1996 the National Academy of Sciences calculated the cost of programs for radioactive waste disposal would "likely be no less than $50 billion and easily could be over $100."[189]

The nuclear energy cycle produces a complex array of radioactive wastes at every stage. While the majority of the volume is composed of so-called "low level" wastes, the complete fuel cycle includes uranium mining and mill tailings and depleted uranium from enrichment facilities, which have all resulted in contaminated water supplies and endangered the heath of surrounding populations. Irradiated fuel[190] in the United States contains more than 95 percent of the radioactivity (in waste) of the Atomic Age; wastes generated by nuclear weapons production, industrial applications, research and medicine, combined contain less than five percent of the radioactivity.[191] Reactor waste, unlike most radioactive waste from medical diagnosis and treatment, contains isotopes characterized by very long half-lives of radionuclides (for example, cesium-135 has a half-life of 2.3 million years and iodine-129, 15.7 million years).

As of 2005, US reactors had generated more than 53,000 metric tons of irradiated nuclear fuel, all of which is being precariously stored at 76 reactor sites across the US[192] Most of the "low-level" wastes are shipped to "disposal" sites—four of the seven US sites are now closed[193]—all leaking since "state of the art" is unlined surface trenches. Plutonium-laced "low-level" debris is dumped in barrels, boxes and sometimes (in the case of large reactor components) no container at all. Despite the absence of a long term waste strategy, the industry is re-licensing existing reactors as they approach assigned closure dates, and in some cases, planning new reactor units at existing sites.

> *US reactors have so far generated more than 53,000 metric tons of irradiated nuclear fuel, for which there is no long term-storage solution.*

The so-called "solution" to the irradiated fuel problem, the proposed high-level waste site at Yucca Mountain, Nevada, is riddled with technical, geological, administrative and legal problems. The assumption that it will ever open is no longer a reasonable one. Even if Yucca Mountain were to open, its storage capacity would be reached with existing waste production by 2010[194] (the current schedule for the site assumes opening in 2017, which is increasingly unlikely), underscoring the fact that any further radioactive waste production will simply be overflow with no new solution in sight.

"INTERIM STORAGE" PROPOSAL TROUBLING

In response to perpetual uncertainty and industry pressure to do something to address radioactive waste policy, Congress perennially considers "interim storage" of high-level atomic waste. This rush to consolidate the irradiated fuel in a "single site" is really a rush to get the waste off the utility sites—and to put ownership of and liability for the waste onto taxpayers. This plan would precipitate the transport of commercial irradiated nuclear fuel on roads, rails, and waterways. In the current version of this idea, the DOE would gain the authority to site a waste dump within a state over the objections of state and local governments. Thus, in the absence of a viable plan for moving the waste somewhere else, "interim" storage sites would become long-term "overflow parking" for high-level radioactive wastes with nowhere else to go. Historically, as well as presently, the nuclear industry and the federal government consistently promote waste storage options which unnecessarily compromise public health and security. The most widely supported method for radioactive waste management is hardened on-site storage that has security and accountability measures built into the design.[195] Key to the centralized interim storage concept is the idea that it is better to put the waste in one "temporary" place. The result, however, would be that one of the worst burdens ever created would be "temporarily" placed in a single congressional district without prior agreement on a permanent solution. Once moved somewhere, the likelihood that the US Congress would allocate time, interest, and most importantly *funds* to finding a real resolution to this problem would be greatly decreased.

> ***Yucca Mountain, the proposed long-term repository for US radioactive waste, sits atop 33 fault lines.***

PROSPECTS FOR LONG-TERM STORAGE AT YUCCA MOUNTAIN DUBIOUS

The designation of Yucca Mountain as the proposed site for a long-term waste repository is a clear example of political pressures overwhelming scientific realities. Despite being the only option under consideration by the US government, Yucca Mountain, located on Western Shoshone tribal land just 80 miles outside of fast-growing Las Vegas, NV, is not a scientifically sound solution for long-term waste disposal. In fact, due to the geology, hydrology and seismic activity specific to the site, Yucca Mountain would not be able to isolate waste for the requisite hundreds of thousands of years.[196]

The myriad site deficiencies have pushed the projected opening date back many times over, with the most recent DOE estimate at 2017. Despite the fact that more than 200 organizations called upon the Secretary of Energy to apply DOE's own site suitability criteria and in so doing, disqualify the site,[197] and that subsequently the original Environmental Impact Assessment for the site was deemed illegal by the US Environmental Proction Agency (EPA),[198] industry and the DOE alike continue to press for a speedy opening.

Yucca Mountain sits atop 33 fault lines and the State of Nevada ranks third in the nation for current seismic activity.[199] A large, fresh-water aquifer lies below the site. Scientists agree that radioactivity would inevitably reach the aquifer and independent review has shown that water can percolate through the mountain at a rate much faster than previously thought, and that water has welled up in the region in the not so distant geologic past.[200] This hydrogeologic activity, and other evidence (including the row of lava cones adjacent to the site, and GPS data) suggest the presence of a magma pocket below the site. In fact, DOE did analyze the scenario of a lava eruption through the site in the Yucca Mountain Environmental Impact Statement (EIS)—because it is credible. Unfortunately agencies like the US Geological survey have engaged in falsification of data[201] rather than support disqualification of this fundamentally flawed site.

DANGERS ASSOCIATED WITH "SUCCESSFUL" OPENING OF YUCCA MOUNTAIN

Transportation routes to Yucca Mountain would run through 44 states on existing highways, rails and waterways, with routes passing through most major metropolitan areas.[202] Inevitably, waste transportation accidents would occur:

- There are 60,000 tractor-trailer wrecks on interstates each year. This statistic, when applied to the estimated 22,000 shipments over the next 38 years[203] to deliver waste to Yucca Mountain, makes this scenario an unacceptable threat to public health.[204]

- Three quarters of the nation's first responders are volunteers and it is extremely unlikely that they would have received sufficient radiation training[205] to cope with the aftermath of an accident involving highly radioactive irradiated fuel.

"ADVANCED FUEL-CYCLE TECHNOLOGY—REPROCESSING—CANNOT SOLVE THE WASTE PROBLEMS AND IS INHERENTLY DANGEROUS

The claim is often made that radioactive waste still contains 95 percent of its useable content and can be "recycled" as fuel for new, proliferation-proof reactors. This "recycling", or reprocessing, would supposedly reduce the need for long-term storage and the associated quagmire of the Yucca Mountain site. However, these claims are being made outside the bounds of historical experience with reprocessing or the attendant economic considerations, technical barriers and geo-political realities.

The notion of reprocessing irradiated nuclear fuel is not a new one. The separation of plutonium and uranium from irradiated fuel was launched in the 1970s as part of a plan to make breeder reactors the dominant technology by 2000. However, this plan never materialized due to exorbitant costs, unmanageable pollution and the proliferation of weapons-useable nuclear materials as well as the unfulfilled promise of waste eradication.

Falling far short of the promised boom, worldwide only a handful of reprocessing facilities were ever built and even fewer have been able to remain operational. The only private commercial reprocessing facility to operate in the US, at West Valley, New York, was such an environmental and fiscal disaster that only one year's worth of fuel was reprocessed in six years of operation. The mess this activity left behind is estimated to eventually cost at least $5.2 billion[206] to clean up. The three federal reprocessing facilities which were used to separate plutonium for the US nuclear weapons program, the Hanford Reservation in Washington State, Idaho National Laboratories and the Savannah River Site in South Carolina, are often characterized as among the most toxic locales on the planet.

Just as no country has been able to engineer a solution for radioactive waste, no country has been able to safely or economically reprocess waste and achieve a closed-loop fuel cycle. Japan's Rokkasho reprocessing plant took 12 years to build and cost three times more than estimated to build.[207] A study commissioned by the French government found that reprocessing is indubitably uneconomical, having cost around $25 billion in excess of a typical once-through cycle, and cannot make even a meager contribution to the reduction of long-lived radionuclides in waste.[208] In fact, the reverse happens since the same radioactivity is spread out over a larger volume–resulting in massive increases in "low-level" waste. In "low-level" dumps these wastes are not sequestered from our environment, likely increasing the overall long term environmental impact.

> *The three facilities that were used to reprocess irradiated nuclear fuel in the US are among the most toxic sites on the planet.*

Despite these problems, nuclear proponents still describe reprocessing as "recycling," creating the false impression that 100 percent of wastes would be turned into reusable fuel, thereby eliminating the storage problem. Similarly, they have claimed that reprocessing would reduce the volume and radioactivity of resultant waste to such a degree as to render the legal capacity proposed for disposal at Yucca Mountain sufficient to solve the waste emergency currently facing the US. In actuality, waste storage capacity is determined by heat radiated rather than by volume, rendering this claim totally without substance.[209]

REPROCESSING AND PROLIFERATION

After India's 1974 test of a nuclear weapon derived from commercial reprocessing technology, the US declared a moratorium on commercial reprocessing, citing unjustifiable proliferation risks from the generation of separated plutonium in such quantities. While there has been negligible modification to the fuel separation process, referred to as PUREX, since the Cold War, industry proponents are declaring that new technologies will be proliferation-resistant.

Once plutonium is separated from irradiated reactor fuel, it loses what experts have termed its "selfprotecting" quality, meaning that the significantly lower temperature and radiation dose of separated plutonium allows for it to be safely carried on one's person in an airtight container.[210] Due to the high volume of fuel being handled at reprocessing facilities, it is virtually impossible to account for total plutonium output to within tens or even hundreds of kilograms, making it feasible for stolen plutonium to go undetected.[211] This is of concern because a simple nuclear device requires only six kilograms of plutonium, making the uncertainty in stockpile accounting of utmost concern.

According to figures released from the International Atomic Energy Agency (IAEA), seizures of illicit radioactive material have doubled over the past four years, with more than 300 incidents worldwide of smugglers being intercepted in that time period.[212]

Recommencing reprocessing in the United States would send a dangerous message to the rest of the world, negating any legitimacy in attempts to bar other countries from operating or obtaining this very technology in the name of non-proliferation.

CHAPTER 8

Nuclear weapons proliferation concerns are increasing worldwide

The risks of civilian nuclear programs being used for the development of nuclear weapons have been noted since the dawn of the nuclear era. As early as 1946, Robert Oppenheimer, speaking about the possibility of the US signing a treaty to abolish nuclear weapons, proclaimed that "we know very well what we would do if we signed such a convention: we would not make atomic weapons, at least not to start with, but we would build enormous plants, and we would call them power plants—maybe they would produce power."[213]

There is an inextricable link between nuclear power and nuclear weapons. The technology for producing nuclear fuel is the same technology used to produce nuclear weapons materials. Proliferation-resistant technologies provide some barriers to proliferation, but there is no proliferation-free nuclear technology. Reprocessing and enrichment activities cannot be safeguarded and international treaty obligations are clearly not enforceable.

> ***The nuclear non-proliferation treaty allows non-nuclear weapons states to benefit from the transfer of sensitive nuclear tehconology while parties to the treaty, and then withdraw when in possession of such technology.***

The associated dangers cannot be overstated. In fact, a high level panel of international experts convened by the United Nations Secretary General, identified nuclear proliferation as the number one threat to the international community, warning of "a real danger that we could see a cascade of nuclear proliferation in the near future."[214] The panel recommended the implementation of firm and urgent measures to reduce the risk of a nuclear attack, whether by State or non-State actors, and recommended States to "forego the development of domestic uranium enrichment and reprocessing facilities."[215]

Likewise, former Vice-President Al Gore has also expressed his concerns regarding proliferation risks associated with civilian programs: "For eight years in the White House, every weapons-proliferation problem we dealt with was connected to a civilian reactor program. And if we ever got to the point where we wanted to use nuclear reactors to back out a lot of coal —which is the real issue: coal—then we'd have to put them in so many places we'd run that proliferation risk right off the reasonability scale."[216]

The cornerstone of the international non-proliferation regime, the Nuclear Non-Proliferation Treaty (NPT), leaves non-nuclear weapons states free to use and develop sensitive technology such as uranium enrichment and spent fuel reprocessing.[217] Article IV of the NPT allows signatories to develop nuclear technology for "peaceful purposes", calling it an "inalienable right." The NPT constitutes a Faustian bargain by which non-nuclear weapons states agree not to develop or acquire nuclear weapons in return for access to nuclear technology. However, the NPT established the right of States parties to withdraw from the Treaty, providing only a 3-month advance notification to the Security Council. Therefore, this regime allows non-nuclear weapons States to benefit from the transfer of sensitive nuclear technology while parties to the Treaty and then withdraw in possession of such technology. North Korea, which withdrew from the Treaty in 2003, is a case in point.
Nuclear weapons use either enriched uranium or plutonium to create an explosion of huge magnitude, equivalent to thousands of tons of TNT.

> ***Nuclear proliferation has been identified by a United Nations high-level panel as the number one threat to the international community.***

Natural uranium must be enriched to increase the concentration of uranium-235 (the isotope essential for nuclear weapons), either in low concentrations to produce low enriched uranium, the fuel for power reactors, or in higher concentrations to produce high enriched uranium that can be used for weapons. The enrichment process constitutes the main barrier to producing weapons grade uranium and as the technology spreads around the world, so does the risk of state and non-state actors to overcome the technical barriers to producing uranium suitable for use in nuclear weapons. Indeed, the A. Q. Khan global proliferation network, which began with Khan's employment at the European uranium enrichment firm Urenco (which is now building a uranium enrichment plant in New Mexico) transferred sensitive nuclear technology to Iran, Libya, and other countries, demonstrating the proliferation risks associated with civilian nuclear programs.

Plutonium exists only in trace amounts in nature and it is generated as a by-product of nuclear reactor operations as part of the spent fuel mix. Under normal operating conditions, reactors produce low concentrations of plutonium-239, the isotope most useful for nuclear weapons. However, even if reactor-grade plutonium is not the most convenient isotope to effectively build a nuclear bomb, it can nevertheless be used to make weapons. According to the DOE, "Virtually any combination of plutonium isotopes… can be used to make a nuclear weapon. […] In short, reactor-grade plutonium is weapons-usable, whether by unsophisticated proliferators or by advanced nuclear weapon states."[218]

Plutonium can be separated from the rest of the reactor spent fuel by a chemical process called reprocessing. This separated plutonium is then mixed with other transuranic waste in a combination called mixed-oxide fuel or MOX. This mix can then be used again in a reactor.

But plutonium is also the preferred material to build a nuclear weapon and thus separating it from the rest of the spent fuel increases the risks of proliferation. While plutonium reprocessing technology is simpler than uranium enrichment (because it involves separating different elements rather than different isotopes of the same element), this process requires highly advanced technology as remote-handling equipment because of the high radioactivity of the spent fuel. In contrast, separated plutonium is not highly radioactive and is an easy target for theft. As noted by the MIT report, "Radiation exposure from spent fuel that is not reprocessed is a strong, but not certain, barrier to theft and misuse."[219]

Some eight kilograms of reactor grade plutonium are needed to make a bomb, while with weapons-grade plutonium that amount is reduced to five kilograms. The International Panel on Fissile Materials (IPFM), a group of independent nuclear experts from 15 countries, estimates that there are roughly 1,700 tons of highly enriched uranium (HEU) and 500 tons of separated plutonium in the world, enough for more than 100,000 nuclear weapons.[220] Most of the HEU and about half of the plutonium is a legacy of the Cold War nuclear arms race; the other half of the plutonium has been separated from spent nuclear power-reactor fuel—mostly in the UK, France and Russia. Two other countries, Japan and India, also have commercial reprocessing facilities. The IPFM acknowledges that one of the critical obstacles to reducing these stocks is precisely the uncertainty regarding the amounts of these weapons-grade materials held by various countries.

> ***There is now enough enriched uranium and separated plutonium in the world to make some 100,000 nuclear weapons.***

The planned "nuclear renaissance" raises serious proliferation concerns in an age of terrorism. If 2,000 new nuclear power plants were built over the next several decades, the stockpiles of commercial plutonium would increase to some 20,000 metric tons by 2050, presenting uncalculated proliferation risks.[221] Moreover, the Bush Administration plans to start developing a major international nuclear initiative, the Global Nuclear Energy Partnership (GNEP), which involves the reprocessing of the spent fuel from nuclear reactors and thus the separation of plutonium from other nuclear waste contained in the spent fuel mix. These plans should be regarded with extreme skepticism as they fly in the face of the conventional wisdom, as stated by the British Royal Society, that "the chance that the stocks of [civil] plutonium might, at some stage, be accessed for illicit weapons production is of extreme concern."[222] Likewise, the IPFM, in its recently released report, acknowledged that the growing global stockpile of civilian plutonium separated from power reactor spent fuel is a worsening problem because of the Bush Administration's endorsement of reprocessing as part of the GNEP program, ending 30 years of US opposition to reprocessing because of proliferation concerns.[223]

There are two main proliferation concerns regarding reprocessing and the separation of plutonium. On one hand, reprocessing increases the risk of plutonium being stolen by non-State agents and used for terrorism. On the other hand, States with access to reprocessing technology can use the separated plutonium to develop nuclear weapons in very short time periods.

The atomic test by North Korea in 2006 brought to nine the number of countries in the nuclear weapons club (US, Russia, UK, China and France are the five recognized nuclear weapons states, and are also the permanent members of the Security Council; India, Pakistan and Israel also possess nuclear weapons and are the only states which were never parties to the NPT). But, as the IAEA's Director General has restated just recently, it is believed that as many as 40 countries have the capability to produce nuclear weapons.[224]

So how far has the technology spread? Nobody knows for sure, but the British counter intelligence agency identified over 360 private companies, university departments and government organizations in eight countries as having procured goods or technology for use in weapons programs. The MI5 report, entitled "Companies and Organisations of Proliferation Concern", was compiled in an attempt to prevent British companies from inadvertently exporting sensitive goods or expertise to organizations covertly involved in weapons of mass destruction programs and identified connections with Iran, Pakistan, India, Israel, Syria, Egypt and the United Arab Emirates.[225]

Dr. ElBaradei, Director General of the International Atomic Energy Agency (IAEA), acknowledged the proliferation risks associated with civilian nuclear technology:

"Controlling access to nuclear-weapons technology has grown increasingly difficult. The technical barriers to designing weapons and to mastering the processing steps have eroded with time. [...]While high-enriched uranium is easier to use in nuclear weapons, most advanced nuclear arsenals favour plutonium, which can be tailored for use in smaller, lighter weapons more suited for missile warheads.

Plutonium is a by-product of nuclear-reactor operation, and separation technology ("reprocessing"), also not proscribed under the NPT, can be applied to extract the plutonium from spent fuel for re-use in electricity production. Under the current regime, therefore, there is nothing illicit in a non-nuclear-weapon state having enrichment or reprocessing technology, or possessing weapon-grade nuclear material. And certain types of bomb-making expertise, unfortunately, are readily available in the open literature.

Should a state with a fully developed fuel-cycle capability decide, for whatever reason, to break away from its non-proliferation commitments, most experts believe it could produce a nuclear weapon within a matter of months. [...] Now, with 35-40 countries in the know by some estimates, the margin of security under the current non-proliferation regime is becoming too slim for comfort."

"Towards a Safer World." *The Economist*. October 16, 2003. Available at: http://www.iaea.org/NewsCenter/Statements/2003/ebTE20031016.html

CHAPTER 9

Nuclear power does not lead to greater energy security or US energy independence

Increasing the share of nuclear power in the US energy mix would do nothing to reduce our nation's dependency on foreign sources of oil. The US is importing more oil each year—most of it from the world's most unstable regions—increasing the country's economical and political vulnerability and making oil dependency among the largest threats to our economy and national security.

In 2005, the US spent some $250 billion in oil imports, which is about $20 billion per month or $25 million per hour.[226] The US imports almost 60 percent of the 20 million barrels of oil it consumes daily, and these numbers are projected to go up to 70 percent by 2025.[227] Moreover, with only five percent of the world's population, and two percent of the world's oil reserves, the US consumes about 25 percent of global oil production.[228]

As staggering as these numbers may be, they would not be affected by an expanded reliance on nuclear power because only some three percent of the electricity produced in the US is from petroleum.[229] As noted by Former NRC Commissioner Peter Bradford, "Nuclear power's only substantial contribution to oil displacement in the US comes in regions in which natural gas displaced by nuclear power can penetrate further into oil's share of the markets, such as space heating in New England."[230] Indeed, transportation is the sector that accounts for most of US oil consumption—about two-thirds of the country's oil consumption is used by vehicles, which corresponds to roughly 13 millions barrels a day.[231] Thus, possible nuclear power development would not have any influence over these statistics.

Moreover, the nuclear industry portrays nuclear power as a domestic energy source. While most of the uranium originally used in US nuclear plants came from domestic sources, by 2004 over 80 percent of the uranium used in domestic reactors came from foreign countries, with 51.8 million pounds being imported.[232] Exporters of uranium to the US include Australia, Canada, Russia, Kazakhstan, Uzbekistan, South Africa and Namibia.

CHAPTER 10

Even routine operations of nuclear reactors result in radiation releases and health impacts

Although the nuclear industry asserts that levels of radiation emitted during normal reactor operations are not a public health threat, scientific evidence shows that no level of radiation exposure is safe. For years, concerns from the scientific community regarding the carcinogenic qualities and deleterious effects on chromosomes inherent in radiation routinely released from nuclear facilities have been pushed aside and relevant studies downplayed as anecdotal.

However, the body of evidence has mounted to a point which is irrefutable. There is strong evidence published in medical journals showing elevated cancer clusters around reactors, particularly among children who are most vulnerable to the detrimental effects of radiation on cellular development.[233] In fact, the risk from radiation exposure is now understood to have been initially underestimated by as much as ten to one hundred times.[234]

The US National Academy of Sciences, charged to investigate the dangers of low-energy, low dose radiation, has, after years of study, concluded there is no "safe dose" of ionizing radiation. Radiation in any amount will have serious cumulative risks.[235] Further, the EPA in 2003 officially acknowledged that accepted risk models which used "average humans" (adult males) functioned to diminish the severity of exposure to children under the age of 16, who have a cancer risk three to ten times higher than adults. In general, females are often more sensitive.[236]

The nuclear establishment purports that the science correlating cancer with radiation from nuclear facilities is inconclusive and consistently dismisses statistically significant appearances. However, over the past few decades there have been numerous studies which have enhanced our understanding of the carcinogenic properties of radiation. One universal property is that children and fetuses are exponentially more susceptible to its harmful effects and that low doses can cause serious cumulative effects. In 1990, the National Cancer Institute conducted the **only** government sponsored study of cancer in areas surrounding nuclear power stations, in which they revealed a significant increase in childhood leukemia in counties closest to reactors in the years after operations began.[237] However, despite these findings, the claim is repeatedly made that the health risks from small amounts of radiation, if any, are low *relative* to other health risks.

NUCLEAR REACTORS RELEASE RADIATION AS A PART OF NORMAL OPERATION

Even under optimal operating circumstances nuclear plants release radiation into the environment. According to the *Federal Register* notice, each re-licensing is expected to be responsible for the release

Oyster Creek, New Jersey, Nuclear Reactor
Airborne Emissions of Four Selected Radio-Isotopes (2003)

ISOTOPE	MICROCURIES	NATIONAL RISK
Strontium-90	62.3	1st
Strontium-89	6,233.0	2nd
Barium-140	8,672.0	2nd
Iodine-131	10,770.0	9th

Source: US Nuclear Regulatory Commission, Radiation Exposure Information and Reporting System. Available at: http://reirs.com/effluent/EDB_main.asp of 14,800 person-rem of radiation during its 20-year life extension.[238] The NRC calculates that this level of radiation release spread over the population will cause 12 cancer deaths per reactor. If the licenses for the entire fleet of 103 operable reactors in the USA are extended, the NRC will have authorized 1236 "premeditated" cancer deaths; assuming their risk assessment is correct—some critics estimate the yield of cancer to be higher per unit of radiation dose.[239] Thus, just because levels of radiation exposure are permissible under federal regulations does not mean that they are safe. The risk from exposure to radiation allowed at the regulatory limit can induce approximately one cancer in 100 members of the public exposed over a 70 year lifetime.

The Oyster Creek nuclear station consistently ranks among the top ten reactors for airborne emissions of radioactive isotopes (see table), but, as far as the NRC is concerned, it is still a strong candidate for a twenty year license extension without remediation measures.

REWRITING HISTORY: HEALTH IMPACTS FROM THREE MILE ISLAND AND CHERNOBYL

The nuclear accidents at Chernobyl in 1986 and Three Mile Island in 1979 are the two most significant radiation releases from nuclear reactors. However, as these events recede from public memory, the industry is attempting to rewrite the tragedies into success stories. Using compromised scientific methodology, it is now being claimed that the biological effects were minimal, and that the most significant health impacts from these major releases of radioactivity has been mental stress and paranoia.

Independent analysis of the diseases around Three Mile Island subsequent to the March 1979 accident concluded that the accident *did* increase cancer incidence among the local population, and that government reported radiation doses were grossly underestimated. This study used measurement of actual radiation-induced gene damage among the local populace to conclude that leukemia and lung disease increase was due to radiation exposure from Three Mile Island.[240] It was shown that people living within the 10 mile radius around the plant experienced an increase of 64 percent in new cancer rates during the years 1981-1985 as compared to pre-accident rates from 1975-1979.[241] However, this particular study team concluded that there was "no link" between the radiation exposure and cancer, suggesting instead that stress and diagnostic practices could account for such a rise.

In the explosion of the nuclear reactor at Chernobyl in April 1986, at least 100 times as much radiation was released as by the two atomic bombs dropped on Hiroshima and Nagasaki combined.[242] Twenty years later, the IAEA, an international promoter of nuclear power, released a report outlining the "true scale" of the disaster.[243] This report grossly understated impacts to health and the environment in the region, eliciting an outpouring of criticism from the scientific establishment and public health community alike. Among the most contentious conclusions of the report were that total casualties to date were only 50, and that 4000 more people were eventually expected to die as a result from the accident.[244]

Moreover, in a supreme statement of condescension and detachment, the report declared that the greatest health impacts were mental, induced by displacement, poverty and "paralyzing fatalism."[245] However, many of the health effects seen in humans and attributed to causes other than radiation (relocation, mental health, etc.) are also seen in birds nesting around the Chernobyl area. These effects include reduced reproduction and survival rates, abnormal sperm, increased incidence and type of external abnormalities (internal abnormalities were not researched) which were associated with lower survival prospects. Since animals cannot be said to suffer from the same types of stresses at Chernobyl as humans (displacement and poverty, etc.), similarity in abnormalities between humans and animals points to radiation, not mental anguish, as the cause of human health problems. According to the study on birds, "The cause of these effects is likely to be a combination of mutation rates having increased by up to more than a factor of 10… and elevated teratogenic effects of radioactive isotopes in the environment, possibly caused by depletion of antioxidants by radiation[246]" Proponents of nuclear power love to claim that the wildlife around Chernobyl is thriving without human habitation and therefore radiation effects are minimal. These studies show how international bodies like the IAEA continue to mask the truth with unsubstantiated assumptions, putting humans, animals and the environment at risk for their own gain.

In a parallel effort to uncover the health impacts of Chernobyl after 20 years, an independent paper authored by 52 respected scientists in the field and region projected nearly a 250,000 added cancer cases, with fatalities topping 100,000.[247]

Thus, the transparency of the nuclear establishment is called into question when the international agency responsible for ensuring nuclear technology and management deliberately misrepresents relevant science. Not only is this defense an affront to the memory of many who lost their lives and many more whose suffering continues, but it is made in contradiction to the larger body of scientific study and survivor testimony. Indeed, former UN Secretary-General Kofi Annan has said that "Chernobyl is a word we would all like to erase from our memory." But, "more than 7 million of our fellow human beings do not have the luxury of forgetting. They are still suffering, everyday, as a result of what happened." He also stated that the exact number of victims may never be known, but that three million children require treatment and "many will die prematurely… Not until 2016, at the earliest, will be known the full number of those likely to develop serious medical conditions" because of delayed reactions to radiation exposure, he said.[248]

TRITIUM: A CASE STUDY IN CONTAMINATION FROM NUCLEAR FACILITIES

As of August 2006, tritium leaks into groundwater have been detected at 19 reactors around the US, and experts contend that this is only the tip of the iceberg.[249] In the face of concerned communities and expert testimony to the contrary,[250] the nuclear industry and NRC hold that these unchecked radioactive releases pose no threat to human health or environmental protection. However, many of these leaks were identified after years of drainage and in one case the public was not made aware of a leak of millions of gallons of tritium-loaded water which seeped into groundwater, drinking wells and waterways.[215]

A recent report from the NRC revealed that tritium can reach the environment and drinking water supplies undetected through equipment that is not subject to regular inspection and maintenance.[252] In fact, the authors uncovered multiple reasons, from nonexistent regulatory oversight to sub-standard, underground reactor hardware, explaining the recent flood of leak detection.

However, in response to these incendiary findings, the NRC has proposed only voluntary guidelines, claiming that a voluntary initiative spearheaded by the industry lobbying group, NEI, will be sufficient to correct shortcomings and provide for public safety. Because there is no economically feasible way to filter tritium out of aqueous releases from reactors, the NRC has therefore not required any abatement practices or technology from the industry. While the Commission and industry alike maintain that there are no impacts from these unplanned and unmonitored releases, these assertions do not reflect the current body of scientific evidence on the subject or an institutional priority to protect public health from potential dangers. Nuclear utilities repeatedly state that tritium is one of the "least harmful" of radioactive particulates present in nuclear fuel and that NRC permissible limits for drinking water are not exceeded, thereby ensuring no potential for harm to the public.[253]

However, tritium has the same chemical behavior as hydrogen, meaning that it readily bonds with oxygen to form radioactive, or tritiated water, which when ingested, is readily absorbed into disparate organs and tissues, spreading radiation throughout the body quickly and effectively. Tritium is unique in that it can cross the placental barrier, exposing fetuses to dangerously high internal doses of radiation[254] and laboratory study has demonstrated significant cellular damage at extremely low doses to be more severe than previously thought.[255] This "extra" damage from tritium exposure remains unaccounted for in radiation exposure regulations.

"NEW SCIENCE" AND "NO SCIENCE": CELL STUDIES AND SYNERGISM

Since the early 1990s, a new body of primary scientific study has been devoted to certain radiation effects not previously recognized or accounted for in radiation regulation. These effects include the "bystander effect" and "genomic instability." Bystander effect describes a phenomenom where a cell not originally struck by radiation, shows damage from that radiation exposure. Genomic instability occurs after a cell seems to repair itself properly, but when the cell reproduces, its descendents nonetheless show damage from the radiation exposure of the parent cell. Neither of these effects are accounted for in radiation exposure protection standards because they were unknown until recently. Even now that they are known, accounting for their effects in radiation impacts is tricky. These cell study findings suggest that the concern that radiation is permanently and unpredictably mutating the gene pool should be taken seriously. The New Scientist quotes a report that calls genetic or chromosomal instabilities caused by radiation exposure a "plausible mechanism" for explaining illnesses other than cancer, including "developmental deficiencies in the fetus, hereditary disease, accelerated aging and such non-specific effects as loss of immune competence."[256]

Radiation regulations do not account for synergistic effects between radiation and other chemicals and toxic substances released into the biosphere. Accounting for this will be difficult because there are few studies on synergistic effects of radiation and other toxins such as organochlorides, heavy metals and even common substances. True to form, the International Commission on Radiological Protection (ICRP) does not account for any of these potential effects. There are some studies on increased damage from synergistic effects of radiation and common substances such as caffeine, chlorine and bacteria. Much more research is needed, but this need is no excuse for leaving the most vulnerable populations unprotected now.

Despite all of the unknowns of radiation exposure, and the sensitivity of certain populations such as women and children, regulators do not require protective measures commensurate with potential dangers, including permanent damage and contamination of the human gene pool. For these reasons, *precaution* should be the default regulatory position, with the burden to prove safety clearly on industry. As shown in a recent historical survey on the Precautionary Principle in public policy, regulatory and advisory bodies on radiation health impacts have always been slow to react to [...] "mounting incontrovertible evidence…where precaution has sometimes been lacking despite the clear warnings given..."[257] We must act to protect the most vulnerable; once releases of radioactivity and radiation exposures have occurred, there is no going back.

In the last few years, much of the public discourse about nuclear energy has been marked by stepped-up, bold claims by the industry. We hear that nuclear energy is clean, safe and a vital component in the battle against climate change. However, much of this misinformation has gone largely unchallenged in the media and the resulting public discourse has suffered from a lack of intellectual honesty. The US is the world's largest consumer of energy and we need drastic change, but this cannot happen until the issues are discussed and resolved honestly and objectively. Towards that end, this section is an analysis of some of the nuclear proponents and reasons why they should be more carefully questioned and scrutinized.

CLEAN AND SAFE ENERGY COALITION (CASE), PATRICK MOORE AND CHRISTIE TODD WHITMAN

The image of nuclear power understandably suffered from expense, cost overruns, accidents, the vulnerability to terrorism as well as the unsolved waste problem. One of the industry responses to these serious problems has been to launch public relations campaigns aimed at greening their image and obfuscating the facts.

As noted by the *Columbia Journalism Review*:

> "To that end the Nuclear Energy Institute, with the help of Hill & Knowlton, formed something called the Clean and Safe Energy Coalition. To co-chair it the institute hired a pair of environmental consultants, a duet to sing pro-nuclear songs. Christine Todd Whitman, of Whitman Strategy Group (which "can help businesses to successfully interact with government to further their goals," according to its Web site), and Patrick Moore, of Greenspirit Strategies, were hired for their résumés: Whitman, a former New Jersey governor, is known as the outdoorsy and moderate Republican who ran the Environmental Protection Agency for two years under George W. Bush; Moore was with Greenpeace in the 1970s and early 1980s. Part of the thinking, surely, was that the press would peg them as dedicated environmentalists who have turned into pro-nuke cheerleaders, rather than as paid spokespeople."[258]

> ***"It is maddening that Hill and Knowlton, which has an $8 million account with the nuclear industry, should have such an easy time working the press."***
>
> —Columbia Journalism Review

The effort had been successful. "*The Washington Post* quite properly noted in the bio box of an op-ed by Moore on April 16—going nuclear; a green makes the case—that he and Whitman co-chair a nuclear-industry-funded effort. But in a May 25 article the *Post* simply referred to Moore as an 'environmentalist' and a cofounder of Greenpeace—without mentioning any industry ties. *The Boston Globe* ran a Whitman/Moore op-ed on May 15, identifying them as 'co-chairs of the Clean and Safe Industry Coalition' without giving readers a clue to what that coalition is. And in some stories, columns, and editorials, the *San Francisco Chronicle*, the *Boston Herald*, the *Baltimore Sun*, the *Richmond Times-Dispatch*, the *Rocky Mountain News*, *The New York Times*, and CBS News all referred to Moore as either a Greenpeace founder or an environmentalist, without mentioning that he is also a paid spokesman for the nuclear industry."[259]

According to the *Columbia Journalism Review* it is "[...]maddening that Hill & Knowlton, which has an $8 million account with the nuclear industry, should have such an easy time working the press."[260] Therefore, given the obvious industry hand in this propaganda, it is clear that the issue of who is speaking and what they are saying in this discourse deserves greater scrutiny.

Patrick Moore was on board the inaugural Greenpeace voyage, and he remained with Greenpeace until 1986. This background has enabled the nuclear industry to position Mr. Moore as a symbol of wide environmentalist support for nuclear energy.

The media has been led to refer to Patrick Moore as the Greenpeace co-founder turned pro-nuclear advocate, crediting him as an environmentalist representing an independent perspective. But Mr. Moore left Greenpeace more than 20 years ago and has since apparently undergone a radical transformation of thought:

- In 1976: "Nuclear power plants are, next to nuclear warheads themselves, the most dangerous devices that man has ever created. Their construction and proliferation is the most irresponsible, in fact the most criminal, act ever to have taken place on the planet."[261]

- Now: "Nuclear energy is actually, if you look at the statistics, one of the safest industries in this world, and it also is one of the cleanest industries in this world, in that it does not release greenhouse gases."[262]

Such a radical change in thought deserves some analysis of a speaker's motivation. Thus, it is important to look at what Moore has been saying and doing. Since leaving Greenpeace in 1986, Mr. Moore has been the front man for several industry-backed public relations campaigns under the mantle of environmentalism. For example, in 1991, Mr. Moore was hired as a full-time paid director and spokesperson for the British Columbia Forest Alliance.[263] However, the Alliance was set up as a front group for timber companies as part of a pro-logging media strategy, and Moore admitted that most of the Alliance's budget, some $2 million annually, came from the forest industry.[264]

In 1991, Mr. Moore created Greenspirit Strategies, a consultancy firm "focusing on environmental policy and communications in natural resources, biodiversity, energy and climate change."[265] While Moore admits he is very well paid for his speaking and consulting services, he declines to disclose any specific amounts.[266] Thus, Moore cannot be simply presented as an environmentalist without any reference to his paid post with the nuclear industry. In a world of ever more sophisticated spin strategies, responsible media should do better.

Moore himself warned in 1976, "It should be remembered that there are employed in the nuclear industry some very high-powered public relations organizations. One can no more trust them to tell the truth about nuclear power than about which brand of toothpaste will result in this apparently insoluble problem." His words hold true today, even if he was essentially forecasting his own future.

PUBLIC OPINION POLLIING

Public opinion polls proffered by the nuclear industry show strong support for nuclear power. One recent poll suggests that a large majority of Americans agree that nuclear power will play an important role in meeting future electricity demand and agree with the construction of new reactors (86 percent and 73 percent, respectively, in the 2006 poll).[267]

However, these findings come from Bisconi Research, Inc. (BRi), which is run by a previous vice president of the Nuclear Energy Institute for 13 years, who is also a member of the Board of Directors of the American Nuclear Society.[268] Therefore, at a minimum, these affiliations should be noted by responsible media when referring to this polling.

Indeed, some of the surveys commissioned by media organizations and independent research centers reveal support for nuclear power, but with less expressive or extreme figures than the ones reached by BRi. A poll by Bloomberg/Los Angeles Times concluded that 61 percent of Americans support nuclear power as a source of energy in order to prevent global warming,[269] and a survey by Opinion Dynamics/Fox News showed that 47 percent of respondents favor building more nuclear power plants, while 43 percent oppose it.

Meanwhile, the greater body of public opinion polls show strong opposition to nuclear power:

- A May 2007 poll conducted by RBC Capital Markets found that 83 percent of respondents would oppose the construction or re-commissioning of a closed reactor near their homes, while 60 percent would support construction of a solar power plant and 57 percent would support a wind power plant near their homes.[270]

- Polling conducted by Yale University in 2005 found that 86 percent of Americans support greater funding for renewable energy research and development and only 36 percent favor constructing new nuclear power plants.[271]

- A poll conducted by ABC News/Washington Post in June 2005 shows that 64 percent of Americans oppose the building of more nuclear power plants.[272]

- A survey by the Bloomberg/Los Angeles Times from August 2006 shows that 52 percent of Americans believe that alternative energy sources are a better option when it comes to reducing American dependence on foreign fossil fuels—only six percent preferred nuclear power.[273]

- A 1999 poll on the benefits of science and technology concluded that nuclear weapons and nuclear power are the only scientific advances the American public does not embrace.[274]

- A 2005 pool found that 53 percent of Americans opposed the government promotion of increased use of nuclear power.[275] In February 2006, nuclear energy remained a relatively unpopular option with only 44 percent in favor, while 86 percent of respondents supported improved fuel efficiency for cars and trucks, 82 percent supported increased federal funding for research on wind, solar and hydrogen technology, and 78 percent favored tax cuts to energy companies conducting research on these alternative energy sources.[276]

- Even an IAEA report commissioned in 2005 shows that 49 percent of Americans are against the building of new nuclear plants compared to 40 percent who are in favor. The percentage of people against new nuclear power plants rises to 59 percent when analyzing the cumulative data from the 18 different countries involved in the survey.[277]

CONCLUSION

Our climate and energy crises are real, and we need a paradigm shift with an aggressive and rapid transition to sustainable energy. The barriers to this transition are political, not technological, and can be overcome. Indeed, failure to make the transformation to clean, safe, renewable energy sources would leave an inexcusable legacy for future generations.

Misleading nuclear industry propaganda, coupled with aggressive lobbying, is resulting in an enormous disservice to the public good because it impedes our nation's and the world's ability to address global warming. As Amory Lovins has pointed out, "every dollar invested in nuclear expansion will worsen climate change by buying less solution per dollar…" Quite simply, the proposed "nuclear renaissance" would divert precious resources from cheaper, faster solutions into a technology that has proliferation, terrorism, public safety and environmental concerns of unparalleled consequence.

Our choice is stark: we can effectively address the climate crisis or we can expand the nuclear industry. We can't do both. Fortunately, while stark, the choice is both clear and easy.

ENDNOTES

1 Searching the combination of "nuclear power" and "revival" in Google on September 21, 2006 produced 2,150,000 items up from 41,600 in January 22, 2005

2 Bradford, Peter A. "Nuclear Power's Prospects in the Power Markets of the 21st Century." *Nonproliferation Education Center*. February 2005. Available at: http://www.npec-web.org/Essays/Essay050131%20NPT%20Bradford%20Nuclear%20Powers%20Prospects.pdf

3 Nesmith, Jeff. "Utilities Plan Nuclear Revival." *Cox Washington Bureau*. August 6, 2006

4 Wald, Matthew L. "Slow Start for Revival of Nuclear Reactors." *New York Times*. 22 August, 2006, C1. Available at: http://select.nytimes.com/gst/abstract.html?res=F30D1EFB395A0C718EDDA10894DE404482

5 Moore, Patrick. "Going Nuclear: A Green Makes the Case." *Washington Post Sunday*. p. B01. April 16, 2006. Available at: http://www.washingtonpost.com/wp-dyn/content/article/2006/04/14/AR2006041401209.html

6 See discussion following on *Propaganda Machine: Misleading Pools and Pseudo Experts*, p. 47

7 "Environmental Statement on Nuclear Energy and Global Warming." June 2005. Available at: http://www.citizen.org/documents/GroupNuclearStmt.pdf

8 "145 Organizations Release *Sustainable Energy Blueprint* To Phase Out Nuclear Power, End Energy Imports, And Slash Greenhouse Gas Emissions." *Common Dreams Newswire*. October 6, 2006. Available at: http://www.commondreams.org/news2006/1006-10.htm

9 "We do not support the construction of new nuclear reactors as a means of addressing the climate crisis. Available renewable energy and energy efficiency technologies are faster, cheaper, safer and cleaner strategies for reducing greenhouse emissions than nuclear power." Statement at www.nirs.org. As of May 14, 2007, there were 7,470 individual signers, 432 U.S. organizations, and 153 international organizations.

10 Auer, Catherine. "Atoms for What?" *Bulletin of Atomic Scientists*. November/December 2003. Vol. 59, No. 06, pp. 42-43.

11 Bradford, Peter A. "Nuclear Power's Prospects in the Power Markets of the 21st Century." *Nonproliferation Education Center*. February 2005. Available at: http://www.npec-web.org/Essays/Essay050131%20NPT%20Bradford%20Nuclear%20Powers%20Prospects.pdf

12 Dixie Lee Ray as quoted by Edward Teller in a *Playboy Magazine* interview. August 1979

13 Goldberg, Marshall. "Federal Energy Subsidies: Not All Technologies Are Created Equal." *Research Report No. 11*. July 2000. Available at: http://www.crest.org/repp_pubs/pdf/subsidies.pdf

14 Y. Ding and J.T. Houghton, et al. editors. "Climate Change 2001: the Scientific Basis (Contribution of Working Group I to the Third Assessment Report of the IPCC)." *Intergovernmental Panel on Climate Change*. 2001. Available at http://www.grida.no/climate/ipcc_tar/wgl/index.htm

15 Bradford, Peter A. "Nuclear Power's Prospects in the Power Markets of the 21st Century." *Nonproliferation Education Center*. February, 2005. Available at: http://www.npec-web.org/Essays/Essay050131%20NPT%20Bradford%20Nuclear%20Powers%20Prospects.pdf

16 Vice President Dick Cheney was speaking on C-Span in 2004 when he made the statement that there is already an alternative fuel developed that "is carbon-free"—incorrectly referring to nuclear power.

17 "NEI Launches Campaign Promoting Environmental, Energy Security Benefits of Nuclear Energy." *Nuclear Energy Institute*. August 2000. Available at: http://www.nei.org/newsandevents/neilaunchescampaign/

18 Deutch, John and Ernest Moniz, Chairs, et al. "The Future of Nuclear Power: An Interdisciplinary MIT Study." *Massachusetts Institute of Technology*. 2003. Available at: http://web.mit.edu/nuclearpower/

19 Williams, Robert. "Nuclear and Alternative Energy Supply Options for an Environmentally Constrained World: A Long-Term Perspective" in Nuclear Power and The Spread Of Nuclear Weapons: Can We Have One Without the Other, Leventhal, Paul et al. eds., Brassey's Inc., Dulles, Va., 2002.

20 Makhijani, Arjun. "Nuclear Power: No Solution to Climate Change." *Institute for Energy and Environmental Research*. 2005. Available at: http://www.ieer.org/ensec/no-5/nuclr-no.html

21 "The Role of Nuclear Power in a Low Carbon Economy." *Sustainable Development Commission*. London. March 2006. Available at: http://www.sd-commission.org.uk/publications/downloads/SDC-NuclearPosition-2006.pdf

ENDNOTES

22 Milliken, Mary. "World has 10-Year Window to Act on Climate Warming - NASA Expert." *Reuters*. September 14, 2006. Available at: http://www.commondreams.org/headlines06/0914-01.htm

23 Lovins, Amory B. "Nuclear Power: Economics and Climate-Protection Potential." *Rocky Mountain Institute*. September 11, 2005. Available at: http://www.rmi.org/images/other/Energy/E05-08_NukePwrEcon.pdf

24 Reed, David. "Return of the Nuclear Salesmen: Global Warming Gives Them a New Sales Pitch." *Rocky Mountain Institute Newsletter*. Vol. XVI. No. 1. pp. 15 and 25. Spring 2000. Available at: http://www.rmi.org/images/other/Newsletter/NLRMIspring20.pdf

25 "Carbon Dioxide Emissions from the Generation of Electric Power in the United States." *U.S. Department of Energy and Environmental Protection Agency*. Washington, D.C. Available at: http://www.eia.doe.gov/cneaf/electricity/page/co2_report/co2emiss99.pdf

26 "Key World Energy Statistics 2005." *International Energy Agency*. Available at: http://www.iea.org/textbase/nppdf/free/2005/key2005.pdf

27 Storm van Leeuwen, J.W and Philip Smith. "Nuclear Power: the Energy Balance." *The CO2-Emission of the Nuclear Lyfe-Cycle*. 2005. Available at: http://www.stormsmith.nl/report20050803/Chap_1.pdf

28 Storm van Leeuwen, J.W and Philip Smith. "Can Nuclear Power Provide Energy for the Future; Would it Solve the CO2-emission Problem?" June 2002. Available at: http://greatchange.org/bb-thermochemical-nuclear_sustainability_rev.pdf

29 Fritsche, Uwe R. "Comparing Greenhouse-Gas Emissions and Abatement Costs of Nuclear and Alternative Energy Options from a Life-Cycle Perspective." *Oko Institut*. November 1997. Available at: www.oeko.de/service/gemis/files/info/nuke_co2_en.pdf

30 "Energy and the Environment: Transport Systems Responses in the OECD, Greenhouse Gas Emissions and Road Transport Technology." *International Energy Agency*. Paris. 1994

31 Storm van Leeuwen and Jan Willem. "Energy from Uranium." Reference document Q316. *Oxford Research Group, UK*. July 2006. Available at: http://www.stormsmith.nl/publications/Energy%20from%20Uranium%20-%20July%202006.pdf

32 Caldicott, Helen. "Nuclear Power is Not the Answer." *The New Press*. New York. 2006

33 Godoy, Julio. "European Heat Wave Shows Limits of Nuclear Energy." *International Press Service*. July 27, 2006. Available at: http://us.oneworld.net/article/view/137077/1/

34 "Exelon Reduces Power Output at Illinois Nukes." *Reuters*. August 1, 2006.

35 Munson, R. "Yes, in My Backyard: Distributed electric power." *Issues in Science and Technology*. p. 49. Winter 2006

36 The business sectors analyzed include digital economy, continuous processing manufacturing, and fabrication and essential services. "The Cost of Power Disturbances to Industrial & Digital Economy Companies." *Consortium for Electric Infrastructure to Support a Digital Society*. June 2001. Available at: http://www.epri-intelligrid.com/intelligrid/docs/Cost_of_Power_Disturbances_to_Industrial_and_Digital_Technology_Companies.pdf

37 Ibid.

38 Gül, Timur and Stenzel Till. "Variability of Wind Power and Other Renewables: Management Options and Strategies." *International Energy Agency*. P.48. June 2005. Available at: http://www.iea.org/textbase/papers/2005/variability.pdf

39 Ibid.

40 Archer, Cristina L. and Mark Z. Jacobson. "The Spatial and Temporal Distributions of US Winds and Windpower at 80m Derived from Measurements." *Journal of Geophysical Research*. Vol. 108. Part 9. Sect. 4. December 4, 2002. Available at: http://www.stanford.edu/group/efmh/winds/winds_jgr.pdf

41 "Solar Power Solutions: A Business Case for Capturing Total Value." *Solar Electric Power Association / Global Environment and Technology Foundation*. April 22, 2002. pp. 4. Available at: http://www.resourcesaver.com/file/toolmanager/O63F30134.pdf

42 There are many sources of information on Three Mile Island; for official confirmation that the fuel pellets did begin to melt, see: "Fact Sheet on the Three Mile Island Accident." *US Nuclear Regulatory Commission*. Available at: http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html

43 "Nuclear Reactors and Hurricanes." *Nuclear Information and Resource Service*. 2005. Available at: www.nirs.org/reactorwatch/natureandnukes/nukesandhurricanes092205.pdf

44 Ibid.

45 Ibid.

46 Jowit, Juliette and Javier Espanoza. "Heat Wave Shuts Down Nuclear Power Plants." *The Observer*. July 30, 2006. Available at: http://www.guardian.co.uk/environment/2006/jul/30/energy.weather

47 "Climate impact on Swedish NPP." *WISE/NIRS Nuclear Monitor, In Brief*. July 14, 2006. Available at: http://www10.antenna.nl/wise/index.html?http://www10.antenna.nl/wise/648/brief.php

48 "A Close Call With Catastrophe in Sweden?" *Die Spiegel*. August 4, 2006. Available at: http://www.spiegel.de/international/1,1518,430164,00.htm

49 "Letter from David E. Hills, Chief-Mechanical Engineering Branch, Nuclear Regulatory Commission, to John L. Skolds, President, Exelon Nuclear." *Quad Cities Nuclear Power Station NRC Integrated Inspection Report 50-254/03-02; 50-265/03-02.* January 31, 2003

50 Lochbaum, David. "US Nuclear Plants in the 21st Century: The Risk of a Lifetime." *Union of Concerned Scientists.* May 2004. Available at: http://www.ucsusa.org/assets/documents/clean_energy/nuclear04fnl.pdf

51 Statement by Dan Becker, Director of the Sierra Club's Global Warming Program. January 2005. http://www.sierraclub.org/pressroom/releases/pr2005-01-19.asp

52 Makhijani, Arjun. "Carbon-Free and Nuclear-Free, A Roadmap for US Energy Policy." *Institute for Energy and Environmental Research*. November 2007. Available at: http://www.ieer.org/carbonfree/

53 Freeman, David S. "Winning Our Energy Independence: An Insider Shows How." *Gibbs Smith, Publisher*.

54 Teske, Sven. "Energy Revolution: A Sustainable World Energy Outlook." *Greenpeace and European Renewable Energy Council.* 2007. Available at: http://www.energyblueprint.info/fileadmin/media/documents/energy_revolution.pdf

55 Ibid.

56 Calyton, Mark. "Greener, Cleaner…and Competitive?" Christian Science Monitor. December 4, 2006. Available at: http://www.csmonitor.com/2006/1204/p03s03-usec.html

57 Martinot, Eric. "Renewables 2005 Global Status Report." *REN21 Renewable Energy Policy Network / Worldwatch Institute.* October 2005. Available at: http://www.ren21.net/globalstatusreport/RE2005_Global_Status_Report.pdf

58 Ibid.

59 A megawatt (MW) is a unit of generating capacity. It represents 1000 kilowatts (kW). One million kilowatts is equivalent to one gigawatt (GW). When paired with a unit of time, the term watt is used for expressing energy production and consumption. Electricity output is measured in kW, MW or GW hours. This corresponds to the energy produced by one kW, MW, or GW of generating capacity running at maximum for one hour. A typical large scale conventional power station is around 1.2 GW

60 Upon its completion, the Mojave Desert project will produce more electricity than all other solar projects in the United States combined. "World's Largest Solar Energy Project Announced by Southern California Edison and Stirling Energy Systems, Inc." *Stirling Energy Systems, Inc.* August 10, 2005. Available at: http://www.edison.com/pressroom/pr.asp?id=5885

61 "Learning About PV: The Myths of Solar Electricity." *US Department of Energy.* January 5, 2006. Available at: http://www1.eere.energy.gov/solar/myths.html

62 "Energy Foundation Study Finds Residential and Commercial Rooftops Could Support Vast U.S. Market for Solar Power." *Energy Foundation*. March 1, 2005. Available at: http://www.ef.org/documents/PV_pressrelease.pdf

63 Deutsch, Claudia H. "Sunny Side Up." *The New York Times.* October 21, 2006

64 Archer, Cristina L and Mark Z. Jacobson. "Evaluation of Global Windpower." *Journal of Geophysical Research.* Vol. 110. p. 17. June 30, 2005. Available at: http://www.stanford.edu/group/efmh/winds/2004jd005462.pdf

65 Elliott, D. L. and M. N. Schwartz. "Wind Energy Potential in the United States." *Pacific Northwest Laboratory.* September 1993. Available at: http://www.osti.gov/bridge/servlets/purl/10189966-jo0aEC/native/10189966.pdf

66 "U.S. Wind Industry Ends Most Productive Year, Sustained Growth Expected for At Least Next Two Years." *American Wind Energy Association*. January 24, 2006. Available at: http://www.awea.org/news/US_Wind_Industry_Ends_Most_Productive_Year_012406.html

67 "Global Wind 2005 Report." *Global Wind Energy Council.* p. 28. 2005. Available at: http://www.gwec.net/fileadmin/documents/Publications/Global_WindPower_05_Report.pdf

68 "Global Wind 2005 Report." *Global Wind Energy Council.* p. 7. 2005. Available at: http://www.gwec.net/fileadmin/documents/Publications/Global_WindPower_05_Report.pdf

69 "European Record for Windpower: Over 6,000 MW Installed in 2005." European Wind Energy Association. February 1, 2006. Available at: http://www.ewea.org/fileadmin/ewea_documents/documents/press_releases/2006/060201_Statistics_2005.pdf

70 Ibid.

71 "Wind Energy: the Facts. An Analysis of Wind Energy in the EU-25. Executive Summary." *European Wind Energy Association.* p. 2. 2003. Available at: http://www.ewea.org/fileadmin/ewea_documents/documents/publications/WETF/Facts_Summary.pdf

72 "Global Wind 2005 Report." *Global Wind Energy Council.* p 36. 2005. Available at: http://www.gwec.net/fileadmin/documents/Publications/Global_WindPower_05_Report.pdf

73 Ibid.

74 "A Framework for Offshore Wind Energy Development in the United States." *Offshore Wind Collaborative Organizing Group.* September 2005. Available at: http://www.mtpc.org/offshore/final_09_20.pdf

75 Gagliano, Troy. "Geothermal Energy: A Primer on State Policies and Technology." *NCSL State Legislative Report.* Vol. 28, No. 1, p. 4. January 2003. Available at: http://www.eere.energy.gov/geothermal/gpw/pdfs/state_legislative_report.pdf

76 "Geothermal Energy." *U.S. Department of Energy and Sandia National Laboratories*. Available at: https://cfwebprod.sandia.gov/cfdocs/GPI/

77 Gawell, Karl et al. "Preliminary Report: Geothermal Energy, the Potential for Clean Power from the Earth." *Geothermal Energy Association*. Washington, D.C. 1999. Available at: http://www.geo-energy.org/publications/reports/PRELIMINARY%20REPORT.pdf

78 Vimmerstedt, L. "Opportunities for Small Geothermal Projects: Rural Power for Latin America, the Caribbean, and the Philippines." *National Renewable Energy Laboratory.* December 1998. Available at: http://www.nrel.gov/geothermal/pdfs/ruralpower.pdf

79 "Energy in Iceland: Historical Perspective, Present Status, Future Outlook." *National Energy Authority and Ministries of Industries and Commerce*. p.17. February 2004. Available at: http://www.os.is/Apps/WebObjects/Orkustofnun.woa/swdocument/932/EnergyinIceland.pdf

80 Gagliano, Troy. "Geothermal Energy: A Primer on State Policies and Technology." *NCSL State Legislative Report.* Vol. 28, no. 1, p. 4. January 2003. Available at: http://www1.eere.energy.gov/geothermal/gpw/pdfs/state_legislative_report.pdf

81 Masashi Shibaki, "Geothermal Energy for Electric Power." *Renewable Energy Policy Project.* pp. 7-8. December 2003. Available at: http://crest.org/articles/static/1/binaries/Geothermal_Issue_Brief.pdf

82 "Development of Renewable Energies in Germany in 2005." *German Ministry for the Environment, Nature Protection and Reactor Safety*. p. 3. February 2006.

83 "Overview - Electricity Generation." *Energy Information Agency*. Available at: http://www.eia.doe.gov/cneaf/electricity/page/prim2/chapter3.html

84 "Future Marine Energy. Results of the Marine Energy Challenge: Cost Competitiveness and Growth of Wave and Tidal Stream Energy." *Carbon Trust*. January 2006. Available at: http://www.carbontrust.co.uk/Publications/publicationdetail.htm?productid=CTC601

85 "How it Works: Wave Power." *BBC News Radio.* November 20, 2000. Available at: http://news.bbc.co.uk/1/hi/sci/tech/1032148.stm. See also "Limpet" site developer/owner: http://www.wavegen.co.uk/index.html

86 "Energy Efficiency and Renewable Energy: Wave Energy." *U.S. Department of Energy.*

87 "Making Waves." *The Economist*. pp. 11-12. June 10-16, 2006.

88 "Aguçadoura**."** Pelamis Wave Power. Available at: http://www.pelamiswave.com/content.php?id=149

89 "New York's Roosevelt Island Tidal Energy (RITE) Project." *Verdant Power 2002-2003*. Available at: http://verdantpower.com/what-initiative

90 Crabtree, George et. al. "The Hydrogen Economy." *Physics Today.* pp. 39-44. December 2004. Available at: http://www.aip.org/pt/vol-57/iss-12/p39.html

91 "Electricity Delivery and Energy Reliability: Technologies." *U.S. Department of Energy*. Available at: http://www.eere.energy.gov/de/compressed_air.htm

92 Ibid.

93 Reed, David. "Return of the Nuclear Salesmen: Global Warming Gives Them a New Sales Pitch." *Rocky Mountain Institute Newsletter*. Vol. XVI, No. 1, pp. 15 and 25. Spring 2000. Available at: http://www.rmi.org/images/other/Newsletter/NLRMIspring20.pdf

94 Lovins, Amory B. "Nuclear power: economics and climate-protection potential." *Rocky Mountain Institute*. p.12. September 11, 2005. Available at: http://www.rmi.org/images/other/Energy/E05-08_NukePwrEcon.pdf

95 Smith, Brice. "Insurmountable Risks: The Danger of Using Nuclear Power to Combat Global Climate Change." *IEER Press*. May 2006. Executive Summary Available at: http://www.ieer.org/reports/insurmountablerisks/summary.pdf

96 "Independent Administration of Energy Efficiency Programs: A Model for North Carolina." *Synapse Energy and Economics, Inc.* Available at: http://www.cwfnc.org/

97 "Combined Heat and Power White Paper." *Commissioned by the Western Governor's Association.* January 2006. Available at: http://www.westgov.org/wga/initiatives/cdeac/CHP-full.pdf

98 Ibid.

99 Daniel Kammen et. al. "Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Create?" *RAEL Report*. University of California, Berkeley. 2004. Available at: http://rael.berkeley.edu/files/2004/Kammen-Renewable-Jobs-2004.pdf

100 "Solar Power Solutions: A Business Case for Capturing Total Value." *The Solar Electric Power Association and the Global Environment and Technology Foundation*. pp. 2-5. April 22, 2002. Available at: http://www.resourcesaver.org/file/toolmanager/O16F34276.pdf

101 "Annual Industry Rankings Demonstrate Continued Growth of Wind Energy in the United States." *American Wind Energy Association*. March 15, 2006. Available at: http://www.awea.org/news/Annual_Industry_Rankings_Continued_Growth_031506.html

102 Martinot, Eric. "Renewables 2005 Global Status Report." *REN21 Renewable Energy Policy Network / Worldwatch Institute.* p.14. October 2005. Available at: http://www.ren21.net/globalstatusreport/RE2005_Global_Status_Report.pdf

103 Gagliano, Troy. "Geothermal Energy: A Primer on State Policies and Technology." *NCSL State Legislative Report.* Vol. 28, no. 1, p. 7. January 2003. Available at: http://www.eere.energy.gov/geothermal/gpw/pdfs/state_legislative_report.pdf

104 "Renewing America's Economy." *Union of Concerned Scientist*. pp. 1-2. September 2004. Available at: http://www.ucsusa.org/assets/documents/clean_energy/ACFoDbPiL.pdf

105 Allenn Barnett, et. al. "Solar-Electric Power: The U.S. Photovoltaic Industry Roadmap." *US Photovoltaic Industry.* January 2003. Available at: http://www.nrel.gov/docs/gen/fy03/30150.pdf

106 "Effects of the Development of Renewable Energies on the German Job Market with Special Consideration of the Foreign Trade: Preliminary Results." *Federal Ministry for the Environment, Nature Conservation and Nuclear Safety.* p. 3

107 Martinot, Eric. "Renewables 2005 Global Status Report." *REN21 Renewable Energy Policy Network / Worldwatch Institute.* p.14. October 2005. Available at: http://www.ren21.net/globalstatusreport/RE2005_Global_Status_Report.pdf

108 "Reliable, Proven, Safe, Clean," Nuclear Energy Institute print advertisement, 1999, published, among other places, in the New York Times, Washington Post, and Atlantic Monthly

109 Ruling regarding the NEI advertising campaign, National Advertising Division, *Council of Better Business Bureaus*, December 9, 1998, pp. 21–22, New York, NY

110 Federal Trade Commission letter to Joseph Colvin, president and CEO, NEI. December 15, 1999

111 Ibid.

112 Ibid.

113 Gunter, Linda et al. "Licensed to Kill: How the nuclear power industry destroys endangered marine wildlife and ocean habitat to save money." 2001. Available at: http://www.nirs.org/reactorwatch/licensedtokill/licensedtokill.pdf

114 "Draft State Pollutant Discharge Elimination System (SPDES) DISCHARGE PERMIT." *New York State Department of Environmental Conservation*. SPDES Number: NY- 0004472

115 Ibid.

116 "Decline of Sea Turtles: Causes and Prevention." *National Academy Press*. National Academy of Sciences, Committee on Sea Turtle Conservation, Board on Environmental Studies and Toxicology, Board on Biology. Commission on Life Sciences, National Research Council. Washington, DC. p. 112. 1990.

117 Ibid

118 "An American Chernobyl: Nuclear "near misses" at U.S. reactors since 1986." *Greenpeace International*. April 2006. Available at: http://www.greenpeace.org/usa/press-center/reports4/an-american-chernobyl-nuclear

119 "Comments of Harold Denton on June 9, 1986 in Making the Case for Closing Oyster Creek Inside NRC." *NIRS Reactor Watch Presentation.* October 30, 2003. Available at: http://www.nirs.org/reactorwatch/aging/agecaseforclosingoyst102003.pdf

120 10 CFR 50.48 and 10 CFR 50 Appendix R III.G.2.

121 "Failure of Thermo-Lag 330 Fire Barrier Systems to Perform Its Specified Fire Enduring Function." *US NRC Bulletin 92-01 Supplement 1.* August 28, 1992. Available at: http://www.nrc.gov/reading-rm/doc-collections/gen-comm/bulletins/1992/bl92001s1.html

122 "Regulatory Expectations with Appendix R, III.G.2 Operator Manuial Actions." *Regulatory Information Summary 2006-010.* June 30, 2006. Available at: http://www.nrc.gov/reading-rm/doc-collections/gen-comm/reg-issues/2006/ri200610.pdf

123 "Safety Evaluation Report Related to the Renewed Restart of Brown's Ferry Unit 1." *US NRC.* April 25, 2007. pp. 7-8.

124 "Report of the President's Commission on the Accident at Three Mile Island: The Need for Change." October 1979. pp. 51 and 56.

125 "Anatomy of a Flawed Decision: NRC has a brain but no spine." *Union of Concerned Scientists and Nuclear Information and Resource Service and Nuclear Information and Resource Service.* August 2002. Available at: http://www.ucsusa.org/assets/documents/clean_energy/ACF6rizAq.pdf

126 NRC email, November 21, 2001. Available at: http://www.nirs.org/reactorwatch/aging/db20011121comtaexchange.pdf

127 "Nuclear Regulation: NRC Needs to Aggressively and Comprehensively Resolve Issues Related to the Davis-Besse Nuclear Power Plan's Shutdown." *US Government Accountability Office*. May 2004. Available at: http://www.nirs.org/reactorwatch/aging/agedbgao2004nrcneeds.pdf.

128 "NRC Regulation of Davis-Besse Regarding Damage to the Reactor Vessel Head." *US NRC Office of Inspector General*. December 30, 2002. Available at: http://www.nirs.org/reactorwatch/aging/oigdavisbesse120302.pdf

129 Ibid. P. 23.

130 NRC Office of Public Affairs. No. 04-053. Note to Editors. May 4, 2004. Available at: http://www.ohiocitizen.org/campaigns/electric/2004/04-053.pdf

131 For more information, see the discussion of the Davis-Besse from Union of Concerned Scientists. Available at: http://www.ucsusa.org/clean_energy/nuclear_safety/davisbesse-retrospective.html

132 Lochbaum, David. "Walking a Nuclear Tightrope: Unlearned Lessons from Year-plus Reactor Outages." *Union of Concerned Scientists*. September 2006. Available at: http://www.ucsusa.org/clean_energy/nuclear_safety/unlearned-lessons-from.html

133 "Improved Guidance, Planning and Oversight Would Enable the Department of Homeland Security to Address Risks." *US GAO.*. September 2006. Available at: http://www.gao.gov/new.items/d06996.pdf

134 The 9/11 Comission Report. P. 154. Available at: http://www.9-11commission.gov/report/911Report.pdf

135 "Private Fuel Storage." *NRC Memorandum and Order CLI-02-27*. December 18, 2002. Available at: http://www.nrc.gov/reading-rm/doc-collections/commission/orders/2002/2002-27cli.html

136 "San Luis Obispo Mothers for Peace v. Nuclear Regulatory Commission." *US Court of Appeals for the Ninth Circuit No. 03-74628*. 2006. WL 1511889

137 "USA: NRC Must Review N-Terrorism In California Licensing." *WISE/NIRS Nuclear Monitor.* February 8, 2007. Available at: http://www10.antenna.nl/wise/index.html?http://www10.antenna.nl/wise/652/5782.php

138 "2002 Advertising Activity." *Annenberg Public Policy Center of the University of Pennsylvania*.

139 "Nuclear Power Plant Security: Voices from Inside the Fences." *Project on Government Oversight*. September 12, 2002. Available at: http://www.pogo.org/p/environment/eo-020901-nukepower.html#ExecSum

140 "Evaluation of Aircraft Crash Hazards for Nuclear Power Plants." *Argonne National Laboratory Technical Memorandum.* NUREG/CR-2859. September 30, 1982.

141 "The Differing Professional Opinions Regarding NRC's Reduction of Effectiveness and Efficiency in Staff Recommendations of the Follow-on OSRE Program for Nuclear Power Plants." Captain Dave Orrick, USN (Ret.), Director. US NRC Operational Safeguard Response Evaluations. February 3, 1999.

142 "Nuclear Power Plants have Upgraded Security, but the Nuclear Regulatory Commission Needs to Improve its Process for Revisiting the Design Basis Threat." US GAO Testimony Before the Subcommittee on National Security, Emerging Threats and International Relations, House Committee on Government Reforms. *US House of Representatives.* April 4, 2006.

143 "Homeland Unsecured: The Bush Administration's Hostility To Regulation and Ties to the Industry Leave America Vulnerable." *Public Citizen*. October 2004. Available at: http://www.citizen.org/documents/ACF1B7.pdf

144 Ibid.

145 Testimony of Robert S. Mueller, III, Director, Federal Bureau of Investigations Before the Senate Committee on Intelligence of the United States Senate. February 16, 2005. Available at: http://www.fbi.gov/congress/congress05/mueller021605.htm

146 "FAA restricts all private aircraft flying over nuclear facilities." *Federal Aviation Administration Press Release*. Washington, DC. October 2001. Available at: http://www.faa.gov/news/press_releases/news_story.cfm?newsId=5446

147 "Protecting Swiss Nuclear Power Plants Against Airplane Crash." *Swiss Federal Nuclear Safety Inspectorate (HSK), Memorandum,* undated. p. 7.

148 Hirsch, Dr. Helmut et al. "Danger to German nuclear power plants from crashes by passenger aircraft." *WISE/NIRS/Greenpeace.* November 2001. Available at : http://www10.antenna.nl/wise/index.html?http://www10.antenna.nl/wise/terrorism/112001gre.html

149 Alvarez, Robert and Jan Beyea, et. al. "Reducing the Hazards from Stored Spent Power-Reactor Fuel in the United States." *Science and Global Security.* Taylor and Francis, 2003. Vol. 11. pp. 1-51. Available at: http://www.princeton.edu/~globsec/publications/pdf/11_1Alvarez.pdf

150 "Safety and Security of Commercial Spent Fuel Storage: Public Report." *Committee on the Safety and Security of Commercial Spent Fuel Storage. National Research Council.* 2006. Available at: http://newton.nap.edu/catalog/11263.html#toc

151 Helfand, M.D., Ira, et al. "The US and Nuclear Terrorism: Still Dangerously Unprepared." *Physicians for Social Responsibility*. August 2006. Available at: http://www.psr.org/site/DocServer/PSR_NuclearTerr_rpt_full.pdf?docID=781

152 Witt, James Lee, et al. "Review of Emergency Preparedness in Areas Adjacent to Indian Point and Millstone." *James Lee Witt Associates, LLC.* 2003. Available at: http://www.wittassociates.com/upload/wysiwyg/NYReport.pdf

153 "Emergency Preparedness at the Indian Point 2 Nuclear Power Plant." *US GAO.* July 2001. Available at: http://www.gao.gov/highlights/d03528thigh.pdf#search=%22emergency%20preparedness%20%20nuclear%20FEMA%22

154 Vasavada, Jasmine and Emily Rush. "Unnecessary Risk: The Case for Retiring Oyster Creek Nuclear Power Plant." New Jersey Public Research Interest Group (NJPIRG). April 2003.

155 "ATA Public Health Statement." *American Thyroid Association*. Available at: http://www.thyroid.org/professionals/publications/statements/ki/02_04_09_ki_endrse.html

156 "Public Meeting on the Review of Emergency Preparedness Regulations and Guidance." Official Public Transcript. US NRC. August 31, 2005.

157 Lochbaum, David. "UCS safety of old and new reactors." *Union of Concerned Scientist* testimony on nuclear power before the Clean Air, Wetlands, Private Property, and Nuclear Safety Subcommittee of the U.S. Senate Committee on Environment and Public Works. May 8, 2001. Available at: http://www.ucsusa.org/clean_energy/nuclear_safety/safety-of-old-and-new-nuclear-reactors.html

158 Makhijani, Arjun. "Plutonium as an Energy Source." *Energy and Security, Institute for Energy and Environmental Research.* September 1996. Available at: http://www.ieer.org/ensec/no-1/puuse.html

159 Lochbaum, David. "UCS safety of old and new reactors." *Union of Concerned Scientist* testimony on nuclear power before the Clean Air, Wetlands, Private Property, and Nuclear Safety Subcommittee of the U.S. Senate Committee on Environment and Public Works. May 8, 2001. Available at: http://www.ucsusa.org/clean_energy/nuclear_safety/safety-of-old-and-new-nuclear-reactors.html

160 Holt, Mark. "Nuclear Energy Policy." *Congressional Research Service*. July 20, 2006. Available at: http://italy.usembassy.gov/pdf/other/RL33558.pdf

161 "Economic Future of Nuclear Power." *The University of Chicago for the US DOE.* August 2004. Available at: http://www.anl.gov/Special_Reports/NuclEconSumAug04.pdf

162 "New Nuclear Generating in the United States." *Moody's Investor Service*, *Corporate Service.* October 2007.

163 Holt, Mark. "Nuclear Energy Policy." *Congressional Research Service*. July 20, 2006. Available at: http://italy.usembassy.gov/pdf/other/RL33558.pdf

164 "An Analysis of Nuclear Power Plant Construction Costs." *Energy Information Administration of the U.S. DOE.* DOE/EIA-0485. 1986.

165 "L'EPR Finlandais accumule les difficultes." *La Tribune*. Paris, France. November 10, 2006.

166 Private conversation between Michael Marionette (NIRS) and Steve Thomas. Amsterdam. November 2006.

167 The MIT study does not include energy efficiency or renewable energies as alternatives to nuclear power. Deutch, John and Ernest Moniz, Chairs, et. al. "The Future of Nuclear Power – An Interdisciplinary MIT Study." *Massachusetts Institute of Technology.* 2003. Available at http://web.mit.edu/nuclearpower/pdf/nuclearpower-summary.pdf

168 Smith, Brice. "Insurmountable Risks: The Dangers of Using Nuclear Power to Combat Global Climate Crisis – Summary." *Institute for Energy and Environmental Research.* p. 6. 2006. Available at: http://www.ieer.org/reports/insurmountablerisks/summary.pdf

169 Launet, Edouard. "Nuclear Power's Future in Question as Relative Costs Rise." *Liberation.* Paris. April 17, 1997

170 Lovins, Amory, et. al. "Winning the Oil End Game: Innovation for Profits, Jobs and Security." *Rocky Mountain Institute.* 2004. Available at: http://www.oilendgame.com/

171 Lovins, Amory. "Nuclear Power: Economics and Climate-Protection Potential." *Rocky Mountain Institute*. 2006. Available at: http://www.rmi.org/images/other/Energy/E05-08_NukePwrEcon.pdf#search=%22nuclear%20power%20%2B%20%20lovins%20%2B%20economics%20and%20climate%20change%20protection%22

172 "The Future of Nuclear Power: An Interdisiplinary MIT Study, Table 5.1." *Massachusetts Institute of Technology*. 2003.

"Nuclear and other technology costs based on a 40-year lifetime and 85% capacity factor, Table 22 and Figure 71." *Energy Information Administration*.. All EIA figures represent levelized costs for technologies in 2010 except for nuclear power, which is based on a 2015 figure. Estimates do not include transmission-related costs.

Geller, Howard. "Utility Energy Efficiency Programs and Systems Benefit Charges in the Southwest." *Southwest Energy Efficiency Project.* April 2002.

Prindle, Bill et. al. "Cleaner Air Through Energy Efficiency: Analysis and Recommendations for Multi-Pollutant Cap-and-Trade Policies." *American Council for an Energy-Efficient Economy*. April 2005.

Biewald, Bruce, David White, Geoff Keith and Tim Woolf. "A Responsible Electricity Future: An Efficient, Cleaner and Balanced Scenario for the U.S. Electricity System." *Synapse*. June 11, 2004.

"Nuclear Power is Not the Solution to Global Warming." *US PIRG*. May 2005. Available at: http://static.uspirg.org/reports/synapsefactsheet.pdf

173 "Renewable Energy." *International Energy Agency*. p. 7. Available at: http://www.iea.org/textbase/papers/2002/renewable.pdf

174 Makower, Joel et al. "Clean Energy Trends 2006." *Clean Edge, Inc*. p. 12. March 2006. Available at: http://www.cleanedge.com/reports/trends2006.pdf and Brown, Lester. "Wind Energy Booming: Cost Dropping Below Conventional Sources Marks Key Milestone in U.S. Shift to Renewable Energy." *Earth Policy Institute*. March 22, 2006. Available at: http://www.earth-policy.org/Updates/2006/Update52.htm

175 Helman, Christopher, Chana R. Schoenberger and Rob Wherry. "The Silence of the Nuke Protesters." *Forbes.* January 31, 2005. Available at: http://www.forbes.com/forbes/2005/0131/084_print.html

176 Koplow, Doug. "Nuclear Power in the US: Still not Viable Without Subsidy." *Earth Track, Inc. for Nuclear Power and Global Warming Nuclear Policy Research Institute*. November 7-8, 2005. Available at: http://www.earthtrack.net/earthtrack/library/NuclearSubsidies2005_NPRI.ppt

177 "World Energy Assessment Overview: 2004 Update." *United Nations Development Programme*. p. 72. Available at: http://www.undp.org/energy/docs/WEAOU_full.pdf

178 Martinot, Eric et al. "Renewables 2005 Global Status Report." *REN21 Renewable Energy Policy Network / Worldwatch Institute*. 2005. p. 16. Available at: http://www.ren21.net/globalstatusreport/RE2005_Global_Status_Report.pdf.

179 Ward, Philip. "Unfair Aid: The Subsidies Keeping Nuclear Energy Afloat Across the Globe." *Nuclear Monitor. WISE/NIRS*. No. 630-631. p. 8. June 2005. Available at: http://www.nirs.org/mononline/nm630_31.pdf

180 "Running on Empty: How Environmentally Harmful Energy Subsidies Siphon Billions from Taxpayers." *Green Scissors Report*. 2002. Values in constant 1999 dollars. Available at: http://www.greenscissors.org/publications/runningonempty.pdf

181 "Nuclear Power: Sustainability, Climate Change and Competition." *International Energy Agency*, Paris, 1998

182 "Nuclear Giveaways in Energy Bill Conference Report." *Public Citizen*. Washington, DC. Available at: http://www.citizen.org/documents/NuclearEnergyBillFinal.pdf

183 Ibid.

184 Koomey, J. and F. Krause. "Introduction to Environmental Externality Costs." *Energy Analysis Program, Lawrence Berkeley Laboratory*. p. 11. 2003. Available at: http://enduse.lbl.gov/info/Externalities.pdf

185 Ward, Philip. "Unfair Aid: The Subsidies Keeping Nuclear Energy Afloat Across the Globe." *WISE / NIRS NuclearMonitor.*. No. 630-631. p. 8. June 2005. Available at: http://www.nirs.org/mononline/nm630_31.pdf

186 "Renewable Energy." *International Energy Agency*. Available at: http://www.iea.org/textbase/papers/2002/renewable.pdf

187 Basic information on ionizing radiation available at: http://www.nirs.org/radiation/radiationhome.htm

188 Plutonium and other weapons-usable elements in nuclear waste can be split into non-weapons-usable "fission products" in a reactor; however, these elements are "more radioactive" or emit more radiation per unit of time than what you start with and, for the most part, are more mobile in the environment in the event of a release.

189 Nuclear Wastes: Technologies for Separations and Transmutation. *National Academy of Sciences, Commission on Geosciences, Environment and Resources*. 1996. Available at: http://newton.nap.edu/catalog/4912.html#toc

190 The nuclear industry prefers the somewhat misleading term "spent fuel" when referring to nuclear fuel that has been removed from the reactor core. "Irradiated fuel" more correctly indicates the challenge that this material presents.

191 "Integrated Data Base Report." *US DOE.* 1994. p. and 15. 1996. p. 137.

192 Smith, Brice. "Insurmountable Risks: The Dangers of Using Nuclear Power to Combat Global Climate Crisis – Summary." *Institute for Energy and Environmental Research.* p. 6. 2006. Available at: http://www.ieer.org/reports/insurmountablerisks/summary.pdf

193 Basic information on so-called "low level" radioactive waste available in NIRS fact sheet at: http://nirs.org/factsheets/llwfct.htm.

Closed "low level" dumps: Beatty, Nevada; Sheffield, Illinois; Maxy Flats, Kentucky; West Valley, New York. "Low—level dumps still in operation: Barnwell, South Carolina, Envirocare, Utah (somewhat limited) and Richland, Washington (limited to certain states only).

194 "Remarks Prepared for Deputy Energy Secretary Clay Sell." *US DOE, Nuclear Energy Assembly*. May 18, 2006. Available at: http://www.doe.gov/news/3656.htm

195 Thompson, Gordon. "Robust Storage of Spent Nuclear Fuel: A Neglected Issue of Homeland Security." *Institute for Resource and Security Studies*. January 2003. Available at: http://www.nirs.org/reactorwatch/security/sechosses012003.pdf

196 Makhijani, Arjun. "Some Evidence of Yucca Mountain's Unsuitability as a Repository." *Science for Democratic Action*. Vol 3, No. 3. May 1999. Available at: http://www.ieer.org/sdafiles/vol_7/7-3/index.html

197 Letter to Secretary of Energy signed by 216 organizations requesting proper application of the DOE's site suitability guidelines thereby disqualifying Yucca Mountain from further consideration as a geologic repository. December 1998. Available at: http://www.nirs.org/radwaste/yucca/disqualifyyuccapetitionfinal.htm

198 "Court Rejects Yucca Mountain 10,000 Year Radioactive Safety Limit." *Environmental News Service*. July 12, 2004. Available at: http://www.ens-newswire.com/ens/jul2004/2004-07-12-02.asp

199 "Earthquakes in the Vicinity of Yucca Mountain." *State of Nevada, Nuclear Waste Project Office*. Available at: http://www.state.nv.us/nucwaste/yucca/seismo01.htm

200 Dublyansky, Yuri V. PhD. "Fluid Inclusion Studies at Yucca Mountain." *Institute for Energy and Environmental Research.* 1998. Available at: http://www.ieer.org/reports/yucca/summrec.html

201 "Radioactive Wreck." *Nuclear Monitor.* No. 643. March 17, 2006. Available at: http://www.nirs.org/mononline/nm643.pdf

202 "State-by-state maps of projected high-level waste transport routes." *State of Nevada.* Available at: http://www.state.nv.us/nucwaste/maps2002/roadrail/index.htm

203 "Proposed Yucca Mountain Nuclear Dump Should Not Be Built." *Pubic Citizen*. January 2005. Available at:Http://Www.Citizen.Org/Cmep/Energy_Enviro_Nuclear/Nuclear_Power_Plants/Nukewaste/Yucca/Articles.Cfm?Id=12788

204 "Marks the Spot: We Can't Solve America's Nuclear Waste Problem if We Keep Making More." *Environmental Working Group.* October 2004. Available at: http://www.ewg.org/reports/nuclearwaste

205 Ibid.

206 "Report to the Chairman, Sub-Committee on Oversight and Investigations, Nuclear Waste: Challenges to Achieving Potential Savings in DOE's High-Level Waste Cleanup Program, GAO-03-593." *US GAO*. June 2003. Available at: http://www.gao.gov/new.items/d03930t.pdf

207 Burnie, Shaun and Aileen Mioko Smith. "Japan's nuclear twilight zone." *Bulletin of the Atomic Scientists*. Vol. 57. No. 03. pp. 58-62. May/June 2001.

208 Charpin, Jean-Michel, Benjamin Dessus and René Pellat. "Étude économique propective de la filière électrique nucléaire, La Documentation française." July 2000. English analysis of report available at: http://www.ieer.org/sdafiles/vol_9/9-2/charpin.html

209 Peterson, Per F. and Frank N. von Hippel. "The Pros and Cons on Nuclear Fuel Recycling." *Science*. Vol. 294. No. 5549. pp. 2093 – 2094. December 2001. Available at: http://www.sciencemag.org/cgi/content/citation/294/5549/2093c

210 von Hipple, Frank N. "Plutonium and Reprocessing of Spent Fuel." *Science.* Vol. 293. No. 5539. pp.2397-2398. September 28, 2001. Available at: http://www.sciencemag.org/cgi/content/summary/293/5539/2397

211 Lyman, Dr. Edwin. "Reprocessing and Nuclear Terrorism." *Union of Concerned Scientists*. Updated November 2005. Available at: http://www.ucsusa.org/global_security/nuclear_terrorism/reprocessing-nuclear-terrorism.html

212 Smith, Lewis. "Seizures of radioactive materials fuel 'dirty bomb' fears." *The Times UK.* October 6, 2006. Available at: http://www.timesonline.co.uk/article/0,,3-2391574,00.html

213 Oppenheimer, J. Robert. "International Control of Atomic Energy." from The Atomic Age: Scientists in National and World Affairs. p. 55. *Basic Books.* Morton Grodzins and Eugene Rabinowitch, eds. New York. 1963.

214 "A More Secure World: Our Shared Responsibility. High Level Panel on Threats, Challenges and Change." *United Nations*. December 2004. Available at: http://www.un.org/secureworld/report2.pdf

215 Ibid.

216 Roberts, David. "Al Revere: An interview with accidental movie star Al Gore." *Grist Magazine***.** May 9, 2006. Available at: http://www.grist.org/news/maindish/2006/05/09/roberts/

217 "The Treaty on the Non-Proliferation of Nuclear Weapons" (text). Available at: http://disarmament.un.org/wmd/npt/npttext.html

218 "Nonproliferation and Arms Control Assessment of Weapons-Usable Fissile Material Storage and Excess Plutonium Disposition Alternatives." *US DOE*. p. 37-39. 1997. Available at: http://www.ccnr.org/plute.html

219 Deutch, John and Ernest Moniz, Chairs, et al. "The Future of Nuclear Power: An Interdisciplinary MIT Study." *Massachusetts Institute of Technology*. p. 22. 2003. Available at: http://web.mit.edu/nuclearpower/

220 "Global Fissile Material Report 2006." *International Panel on Fissile Materials*. Available at: http://www.fissilematerials.org/ipfm/site_down/ipfmreport06.pdf

221 Makhijani, Arjun. "Nuclear Power: No Solution to Climate Change." *Institute for Energy and Environmental Research.* 2005. Available at: http://www.ieer.org/ensec/no-5/nuclr-no.html

222 "Management of Separated Plutonium." *The Royal Society*. London. 1998. Available at: http://www.royalsoc.ac.uk/displaypagedoc.asp?id=18551

223 "Global Fissile Material Report 2006." *International Panel on Fissile Materials*. Available at:http://www.fissilematerials.org/ipfm/site_down/ipfmreport06.pdf

224 ElBaradei, Dr. Mohamed. "Towards a Safer World." *The Economist*. October 16, 2003. Available at: http://www.iaea.org/NewsCenter/Statements/2003/ebTE20031016.html

225 Cobain, Ian and Ewen MacAskill. "Nuclear Arms Supermarket Doing a Roaring Trade." *Sydney Morning Herald.* October 10, 2005. Available at: http://www.smh.com.au/news/world/nuclear-arms-supermarket-doing-a-roaring-trade/2005/10/09/1128796408410.html

226 "Monthly Energy Review: Table 1.5 Merchandise Trade Value." *Energy Information Administration*. p. 11. February 2006. Available at http://www.eia.doe.gov/mer/pdf/mer.pdf

227 "Annual Energy Outlook 2005: With Projections to 2005." *Energy Information Administration*. February 2005. Available at: http://www.eia.doe.gov/oiaf/archive/aeo05/pdf/0383(2005).pdf

228 World oil reserves: 1,025,000,000,000 barrels; U.S. oil reserves: 22,450,000,000 barrels. The U.S. consumes 20.8 Mbd of oil while global consumption is 83.3 Mbd of oil.

"Factbook: Oil Proven Reserves." *Central Intelligence Agency*. Available at: http://www.cia.gov/cia/publications/factbook/rankorder/2178rank.html.

"Country Analysis Briefs: United States." *Energy Information Administration*. November 2005.

"Oil Market Report." *International Energy Agency*. January 2006. Available at http://omrpublic.iea.org/currentissues/full.pdf

229 Total net electricity generation in 2005 was 4,054,688 thousand MWh; oil generation was 12,522 MWh."Electric Power Generation by Fuel Type (2004)." *Energy Information Administration*. Available at: http://www.eia.doe.gov/fuelelectric.html

230 Bradford, Peter A. "Nuclear Power's Prospects in the Power Markets of the 21st Century." *Nonproliferation Education Center*. February 2005. Available at: http://www.npec-web.org/Essays/Essay050131%20NPT%20Bradford%20Nuclear%20Powers%20Prospects.pdf

231 Hirsch et al. "Peaking of World Oil: Impacts, Mitigation and Risk Management." *Science Applications International Corporation*, Department of Energy, February 2005. pp. 4 and 21. Available at: http://www.netl.doe.gov/publications/others/pdf/Oil_Peaking_NETL.pdf

232 "2004 Uranium Marketing Annual Report." *US DOE Energy Information Administration.* Available at www.eia.doe.gov/cneaf/nuclear/umar/umar.html

233 Sharp, L., P.A. McKiney, and R.J. Black. "Incidence of childhood brain and other non-haematopoietic neoplasms near nuclear sites in Scotland, 1975-94." *Occupational and Environmental Medicine.* 56(5):308-314. 1999.

Busby C, Cato MS. "Death rates from leukaemia are higher than expected in areas around nuclear sites in Berkshire and Oxfordshire." *British Medical Journal.* 315(7103):309. 1997.

Black, R.J. and E.F. Harkness, et al. "Leukaemia and non-Hodgkin's lymphoma: incidence in children and young adults resident in the Dounreay area of Carthness, Scotland in 1968-91." *Journal of Epidemiology and Community Health.* 48(3):232-236. 1994.

Draper, G. J. and C. A. Stiller, R. A. Cartwright, et al. "Cancer in Cumbria and in the vicinity of the Sellafield nuclear installation, 1963-90." *British Medical Journal.* 306(6870):89-94. 1993.

Goldsmith, J. R. "Nuclear installations and childhood cancer in the UK: mortality and incidence for 0-9 year-old children, 1971-1980." *The Science of the Total Environment.* 127(1-2):13-35. 1992.

Kinlen, L.J. and C. M. Hudson, C.A. Stiller. "Contacts between adults as evidence for an infective origin of childhood leukaemia: an explanation for the excess near nuclear establishments in west Berkshire?" *British Journal of Cancer.* 64(3):549-554. 1991.

Ewings, P.D. and C. Bowie, M.J .Phillips, et al. "Incidence of leukemia in young people in the vicinity of Hinkley Point nuclear power station, 1959-86." *British Medical Journal.* 299(6694):289-293. 1989.

Cook-Mozaffari, P. J. and S. C. Darby, R. Doll, et al. "Geographical variation in mortality from leukemia and other cancers in England and Wales in relation to proximity to nuclear installations, 1969-78." *British Journal of Cancer.* 59(3):476-485. 1989.

Roman, E. and V. Beral, L. Carpenter et al. "Childhood leukaemia in the West Berkshire and Basingstoke and North Hampshire District Health Authorities in relation to nuclear establishments in the vicinity." *British Medical Journal (Clinical Research Edition).* 294(6572):597-602. 1987.

Forman, D. and P. Cook-Mozaffari, S. Darby, et al. "Cancer near nuclear installations." *Nature.* 329(6139):499-505. 1987.

Heasman, M. A. and I. W. Kemp, J.D. Urquhart, et al. "Childhood leukemia in northern Scotland." *Lancet.* 1(8475):266. 1986.

McLauthlin, J.R. and E.A. Clarke, E.D. Nishri, et al. "Childhood leukemia in the vicinity of Canadian nuclear facilities." *Cancer Causes and Control.* 4(1):51-58. 1993.

Viel, J.F. and D. Pobel, A. Carre. "Incidence of leukaemia in young people around the La Hague nuclear waste reprocessing plant: a sensitivity analysis." *Statistical Medicine.* 14(21-22):2459-2472. 1995.

Hoffmann, W., H. Dieckmann, I. Schmitz-Feuerhake. "A cluster of childhood leukemia near a nuclear reactor in northern Germany." *Archives of Environmental Health.* 52(4):275-280. 1997.

Zaridze, D. G. and N. Li, T. Men, et al. "Childhood cancer incidence in relation to distance from the former nuclear testing site in Semipalatinsk, Kazakhstan." *International Journal of Cancer.* 59(4):471-475. 1994.

234 Goodhead, D., Chair. "Report of the Committee Examining Radiation Risks of Internal Emitters (CERRIE)." *Crown (Pub).* 2004. Available at: http://www.cerrie.org/pdfs/cerrie_report_e-book.pdf

235 "Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2." *National Academy of Science.* 2006. Available at: http://www.nap.edu/books/030909156X/html

236 "Draft Final Guidelines for Carcinogen Risk Assessment (External Review Draft, February 2003)" *US EPA*. A/630/R-03/003. Available at: http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=55445

237 Jablon, S. et al. "Cancer in Populations Living Near Nuclear Facilities." *Journal of the American Medical Association.* 265(11), pp. 1403-1408. 1991.

238 The figure includes releases from the nuclear fuel chain that supports reactor operation, as well as from the reactors themselves.

239 Gofman, John. "Radiation Induced Cancer from Low-Dose Radiation: An Independent Analysis." *Committee for Nuclear Responsibility.* 1990. Available at: http://www.ratical.org/radiation/CNR/RIC/Bertell, Rosalie. "All Levels of Radiation Confirmed to Cause Cancer." *Inter-Church Uranium Committee Educational Cooperative* Available at: http://www.icucec.org/files/radiationbertell.pdf

"Background: The ECRR." *European Committee on Radiation Risk.* Available at: http://www.euradcom.org/

240 Wing, S. et al. "A reevaluation of cancer incidence near the Three Mile Island nuclear plant: the collision of evidence and assumptions." *Environ Health Perspectives.* Vol 105. pp. 52-57. 1997.

241 Hatch, Maureen C. et al. "Cancer Rates After the Three Mile Island Nuclear Accident and Proximity of Residence to the Plant." *American Journal of Public Health.* Vol. 81. No. 6. pp. 719-24. 1991.

242 "Worst Effects of Chernobyl Yet to Come." *Associated Press.* April 25, 2006. Available at: http://www.ratical.org/radiation/Chernobyl/042500.html

243 "Chernobyl's Legacy : Health, Environmental and Socio-Economic Impacts." *The Chernobyl Forum: 2003-2005. International Atomic Energy Agency, World Health Organization and United Nations Development Programme.* 2006. Available at: http://www.iaea.org/Publications/Booklets/Chernobyl/chernobyl.pdf

244 "Chernobyl: the true scale of the accident." *WHO/IAEA/UNDP Joint Press Release.* April 2006. Available at: http://www.who.int/mediacentre/news/releases/2005/pr38/en/index.html

245 Ibid.

246 Moller, A.P., T.A. Mousseau, et al. "Elevated frequency of abnormalities in barn swallows from Chernobyl." *Biology Letters.* April 17, 2007. Epublication ahead of print. Available at: http://cricket.biol.sc.edu/Chernobyl.htm

Ellegren, H., G. Lindgren, C.R. Primmer and A.P. Moller. "Fitness loss and germline mutations in bard swallows breeding in Chernobyl." *Nature*. Vol. 389. pp. 593-596. 1997. Available at: http://www.nature.com/nature/journal/v389/n6651/pdf/389593a0.pdf

Moller, A.P. and T.A. Mousseau. "Biological Consequences of Chernobyl: 20 years after the disaster." *Trends in Ecology and Evolution*. Vol. 21. Issue 4. pp. 200-207. 2006.

Feschenko, S.P., H.C. Schroeder, W.E.G. Muller and G.I. Lazjuk. "Congenital malformations among newborns and developmental abnormalities among human embryos in Belarus after Chernobyl accident." *Cellular and Molecular Biology*. Volume 48. Issue 4. pp. 423-426. 2002.

Lazjuk, G., P. Verger, B. Gagniere, Z. Kravchuk, I. Zatsepin, and E. Robert-Gnansia. "The congenital anomalies registry in Belarus: a tool for assessing the public health impact of the Chernobyl accident." *Reproductive Toxicology*. Vol. 17. Issue 6. pp. 659-666. 2003.

Scherb, H. and E. Weigelt. "Congenital malformation and stillbirth in Germany and Europe before and after the Chernobyl nuclear power plant accident." *Environmental Science and Pollution Research Special*. No. 1. pp. 117-125. 2003.

247 Vande Putte, Jan et al. "The Chernobyl Catastrophe: Consequences on Human Health" *Greenpeace International*. 2006. Available at: http://www.greenpeace.org/raw/content/international/press/reports/chernobylhealthreport.pdf

248 "Worst Effects of Chernobyl Yet to Come." *Associated Press*. April 25, 2006. Available at: http://www.ratical.org/radiation/Chernobyl/042500.html

249 Johnson, Jeff. "Leaks found at 19 Reactors." *Chemical & Engineering News*. August 25, 2006. Available at: http://pubs.acs.org/cen/news/84/i35/8435nuclear.html

250 Makhijani, Arjun. "Memo to Joseph and Cynthia Sauer re: Review of Braidwood Generating Station Groundwater Issue: Frequently Asked Questions (Last Updated March 1, 2006) by Exelon Nuclear" *Institute for Energy and Environmental Research*, March 20, 2006." Available at: http://www.ieer.org/comments/tritium060320.html

251 "Illinois Sues Exelon for Radioactive Tritium Releases Since 1996." *Environment News Service*. March 21, 2006. Available at: http://www.ens-newswire.com/ens/mar2006/2006-03-21-02.asp

252 "Liquid Radioactive Release Lessons Learned Task Force Final Report." *US Nuclear Regulatory Commission*. September 1, 2006. Available at: http://www.nrc.gov/reactors/operating/ops-experience/tritium/lr-release-lessons-learned.pdf

253 "Industry Closely Monitors, Controls Tritium at Nuclear Power Plants." *Nuclear Energy Institute*. October 2007. Available at: http://www.nei.org/resourcesandstats/document library/safetyandsecurity/factsheet/industrycloselymonitors controlstritium/

254 Harrison, J.D., A. Khursheed, and B.E. Lambert. "Uncertainties in Dose Coefficients for Intakes of Tritiated Water and Organically Bound Forms of Tritium by Members of the Public." *Radiation Protection Dosimetry*. Vol. 98. No. 3. pp. 299-311. 2002.

Zerriffi, Hishan. "Tritium: The environmental, health, budgetary, and strategic effects of the Department of Energy's decision to produce tritium." Institute for Energy and Environmental Research. January 1996. Available at: http://www.ieer.org/reports/tritium.html

255 Dobson, R. Lowry et al. "The Toxicity of Tritium." *International Atomic Energy Agency symposium: Vienna 1979: Biological Implications of Radionuclides Released from Nuclear Industries*. Vol 1. p. 203. Available at: http://www.nirs.org/radiation/tritium/abstr1.pdf

256 Edwards, R. "Radiation Roulette." *The New Scientist*. October 11, 1997. Available at: http://www.newscientist.com/article/mg15621035.700-radiation-roulette.html

257 Lambert, B. "'Radiation: Early warnings; Late effects.' in Late lessons from early warnings: the precautionary principle 1896-2000." *European Environment Agency*. Environmental Issue Report No. 22. January 10, 2002. Available at: http://reports.eea.europa.eu/environmental_issue_report_2001_22/en

258 "False Fronts: Why to look behind the label." *Columbia Journalism Review*. Issue 4. July/August 2006. Available at: http://www.cjr.org/issues/2006/4/editorial.asp

259 Ibid.

260 Ibid.

261 Watson, Paul. "The Strange Transformation of Dr. Patrick Moore." *Scoop Independent News*. April 27, 2006. Available at: http://www.scoop.co.nz/stories/HL0604/S00348.htm

262 Patrick Moore (debating Paul Gunter). "Lessons From Chernobyl." *On-line Focus – News Hour With Jim Lehrer on PBS.* April 26, 2006. Available at: http://www.pbs.org/newshour/bb/environment/jan-june06/chernobyl_4-26.html

263 "Patrick Moore." *SourceWatch.* Available at: http://www.sourcewatch.org/index.php?title=Patrick_Moore

264 Rowell, Andrew. Green Backlash: Global Subversion of the Environment Movement. Taylor and Francis (Pub). September 1996.

265 "About Greenspirit—Resume of Patrick Moore." *Greenspirit*. Available at: http://www.greenspirit.com/about.cfm?resume=1

266 Bennett, Drake. "Eco-Traitor." *Wired Magazine*. March 2004. Available at: http://www.wired.com/wired/archive/12.03/moore.html?pg=1&topic=&topic_set=

267 "Perspective on Public Opinion." *Nuclear Energy Institute*. May 2006. Available at: http://www.nei.org/filefolder/publicopinion_06-05.pdf

268 "Background for Ann Stouffer Bisconti, Ph.D., President, Bisconti Research, Inc." Available at: http://www.bisconti.com/background_bisconti.htm

269 "Polling Report: Energy." *PollingReport.com*. Available at: http://www.pollingreport.com/energy.htm

270 Nuclear News. American Nuclear Society. July 2007. p. 15.

271 "Survey on American Attitudes on the Environment – Key Findings." *Yale University School of Forestry and Environmental Studies.* May 2005. Available at: http://www.eurekalert.org/pub_releases/2005-06/yu-ypr060905.php

272 "Most Americans Oppose New Nuclear Reactors." *Angus Reid Global Monitor: Polls & Research.* June 9, 2005. Available at: http://www.angus-reid.com/polls/index.cfm/fuseaction/viewItem/itemID/7568

273 Polling Report: Energy." *PollingReport.com*. Available at: http://www.pollingreport.com/energy.htm

274 "Technology Triumphs, Morality Falters." *Pew Research Center for the People and Press.* July 3, 1999. Available at: http://people-press.org/reports/display.php3?PageID=279

275 "Economic Pessimism Grows, Gas Prices Pinch." *Pew Research Center for the People and Press.* September 15, 2005. Available at: http://people-press.org/reports/display.php3?PageID=998

276 "85% See U.S. Addicted to Oil – 50% Say We Can Quit." *Pew Research Center for the People and Press.* February 7, 2006. Available at: http://people-press.org/reports/pdf/269.pdf

277 "Global Public Opinion on Nuclear Issues and the IAEA Final Report from 18 Countries." *International Atomic Energy Agency and GlobeScan Inc.* October 2005. Available at: http://www.iaea.org/Publications/Reports/gponi_report2005.pdf

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