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Nuclear Reprocessing: A Crucial Part of Our Future

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by

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Abstract

The United States must alter its nuclear policy; the challenges facing the nation demand it. However, the required changes cannot be achieved in the current dominant market paradigm. I argue that Rousseau's Social Contract offers the proper foundation needed to evoke the necessary changes in nuclear policy. The General Will provides a framework for responsible and responsive government to make the best possible choices for its present and future citizens. Coupled with spent fuel reprocessing, nuclear power can provide an optimal source of power so that the United States can protect its future generations by addressing the serious issue of long-lived nuclear waste, cutting its greenhouse gas emissions, and simultaneously lessening its reliance upon foreign energy sources. A General Will would demand that these crucial problems receive immediate attention due to their potential for crippling the General Will of future generations.

Current nuclear policy in the United States is fundamentally flawed. It is misguided by the market paradigm and plagued by political inaction due to difficult and controversial decisions that must be made regarding what should be done with the radioactive waste that is a byproduct of nuclear power plants. These wastes, as they currently exist, will need to be safeguarded for an unfathomable amount of time before they no longer pose a risk to society and the environment. Additionally, there is irrefutable evidence concerning the negative impacts fossil fuel use has on the environment and climate yet the United States continues to rely upon these fuels as its primary source of energy. Our nation also fails to acknowledge the need to invest in viable alternative energies despite the increasingly limited nature of fossil fuels. However, this course of action cannot continue indefinitely; the country is entering a period of increased climatic variability that demands course corrections be made in order to minimize or avoid undesirable future outcomes and ensure a stable supply of energy.

I will argue that it is crucial for the United States to embrace a paradigm that is guided by Rousseau's *Social Contract* so that the nation must invest in and expand its capabilities to reprocess spent nuclear fuel because current nuclear policy is blinded by the market paradigm, which provides no legitimate solution for addressing the problems associated with the immense quantities of long-lived radioactive waste that will persist for countless generations and because the interwoven issues of climate change and energy security demand a change in current power generation methods.

A Brief Overview of Nuclear Power

Past events have greatly impacted American public perception of nuclear power, and without taking these events and their implications into consideration, it is difficult to see how an alternative paradigm guided by Rousseau's Social Contract could improve United States' nuclear policy by fostering a government that is more aligned with intergenerational equity.

The study of nuclear fission began in the late nineteenth century and progressed throughout the twentieth century. Largely funded by the United States Department of Defense, the most rapid advancements occurred during World War II.[1,2,3] Before the United States involvement in the war, the majority of work being done on nuclear physics was purely academic with the hopes of eventually harnessing a new, unmatched, powerful energy source. However, upon the United States entrance into the war following the attack on Pearl Harbor, all resources were diverted from civil applications of nuclear power to the development of nuclear weapons.

The United States military feverishly pursued the development of a nuclear weapon under their secret nuclear research and development program, the Manhattan Project, headed by General Leslie Groves.[4] The war effort required the development of nuclear enrichment technologies to provide enough fissile material to create an atomic

[1] James Mahaffey, *Atomic Awakening* (New York, Pegasus Books LLC, 2009).
[2] *The History of Nuclear Technology*, http://www.icjt.org/an/tech/zgod/zgod.htm (2001)
[3] Richard Rhodes, *The Making of the Atomic Bomb* (New York: Simon and Schuster, 1995).
[4] Robert S. Norris, *Racing for the Bomb: General Leslie R. Groves, The Manhattan Project's Indispensable Man* (South Royalton, VT: Steerforth, 2002).

weapon. This enrichment technology was pivotal to the success of the program and the viability of nuclear fission as an energy source after the war.

A fissile element, or an atom that can be split, is required to fuel a fission reaction. During this time, physicists focused on the naturally occurring element Uranium as a fuel source. There are several different forms, or isotopes, of Uranium, and not all of them are fissile, or sufficient to initiate a fission reaction. The vast majority of the Earth's Uranium is known as Uranium 238, or simply U-238. The number following the element name designates the isotope's atomic weight. Unfortunately, despite being plentiful in the Earth's crust, U-238 is not fissile and therefore cannot be used as fuel for a nuclear fission reaction. However, Uranium 235, or U-235, is fissile but is much less common. Naturally occurring U-235 only accounts for 0.7% of mined Uranium.[5] Therefore, the relative rarity of U-235 necessitated the development of enrichment and processing technologies to increase the proportion of U-235 in nuclear fuel. It is worth mentioning at this point that fissile Plutonium is created in fission reactions but that this element does not otherwise occur naturally.

Due to the top-secret nature of the United States nuclear program, there was limited public understanding of nuclear power and its potential during this time. However, the general public became acutely aware of the power of nuclear fission after the destruction of the Japanese cities of Hiroshima and Nagasaki by two atomic bombs. The vast destruction wrought by these newly developed weapons left an indelible mark on the collective United States psyche for generations to come.

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[5] Jan Forsythe, Ph.D., *3 R's of Nuclear Power: Reading, Recycling, and Reprocessing ...Making a Better Tomorrow for Little Joe* (Bloomington, IN: AuthorHouse, 2009), 64.

> I think there was a sense of shock and horror that greeted the dropping of the bombs in Japan… But there was definitely a sense of shock and terror that the Americans had unleashed something totally new and unheard of with this weapon. And what did it mean for the fate of the world? What did it mean for the country? What did it mean in a moral sense, that the United States had used this weapon of mass destruction and dropped it on cities and killed civilians by the many, many thousands? And Americans had a very, very tough time absorbing the reality of that.[6]

Following the end of World War II and the onset of the Cold War, a nuclear arms race occurred between Western and Soviet nations. In response to this environment of fear, President Eisenhower gave his "Atoms for Peace" speech at the United Nations in 1953. With this speech, the President aimed to realign public opinion of nuclear power so that its peacetime benefits would be recognized and better accepted. "The United States pledges before you--and therefore before the world--its determination to help solve the fearful atomic dilemma--to devote its entire heart and mind to find the way by which the miraculous inventiveness of man shall not be dedicated to his death, but consecrated to his life."[7] Despite this address, development of newer, more powerful nuclear weapons continued in secret throughout the Cold War. However, research and development for civilian and naval propulsion nuclear reactors also occurred during this time. It was during this period that the majority of the US reactor fleet was designed and constructed.

As the "atomic age" progressed, concerns about nuclear proliferation increased. Only a select few nations possessed the technology and know-how to build their own nuclear weapons. The US adopted various policies and tactics to minimize the likelihood of non-nuclear states gaining access to nuclear materiel and knowledge. Among these

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[6] *Elaine Tyler May on: American Reaction to Hiroshima and Nagasaki*, http://www.pbs.org/wgbh/amex/bomb/filmmore/reference/interview/tylermay1.html.
[7] *Atoms for Peace*, http://www.iaea.org/About/history_speech.html (December 1953).

policies was President Carter's 1977 Nuclear Non-Proliferation Treaty, which drastically altered US nuclear policy by banning the reprocessing of spent nuclear fuel.

> As part of the World War II effort to develop the atomic bomb, reprocessing technology was developed to chemically separate and recover fissionable plutonium [and Uranium] from irradiated nuclear fuel. In the early stage of commercial nuclear power, reprocessing was thought essential to supplying nuclear fuel. President Carter terminated federal support for reprocessing in an attempt to limit the proliferation of nuclear weapons material.[8]

By banning reprocessing, spent nuclear fuel remains highly radioactive for hundreds of thousands of years so that no person is able to easily abscond with it and develop a nuclear weapon. The half-life, or time it takes for the radiation to decrease by half, of non-reprocessed waste, is on the scale of millennia. However, banning reprocessing burdened subsequent administrations and policy makers with the question of what to do with the now growing Plutonium-filled stockpiles of highly radioactive waste. In addition, strong anti-nuclear feelings were increasing throughout the United States.

In 1979, the Three Mile Island nuclear power plant near Harrisburg, Pennsylvania experienced a loss of coolant accident that eventually led to a partial meltdown of the reactor core and venting of radioactive steam into the atmosphere. The accident was later attributed to a malfunctioning pressure relief valve and a failure by the plant operators to initially diagnose the problem correctly. The President's Commission on the Accident at Three Mile Island found that "[t]he equipment [referring to the reactor design and control room instrumentation] was sufficiently good that, except for human failures, the major

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[8] Anthony Andrews, Federation of American Scientists, *Nuclear Fuel Reprocessing: U.S. Policy Development. Rep. no. RS22542*, http://fas.org/sgp/crs/nuke/RS22542.pdf (27 March 2008).

accident at Three Mile Island would have been a minor incident."[9] Thankfully, the reactor had a reinforced containment structure built around it that contained the vast majority of the radioactivity. There were reports of varying severity at the time of the incident, which led to increased levels of fear throughout the population. The Three Mile Island (TMI) event can be seen as the definitive turning point in American public perception of nuclear power in the following decades. Up until this point, the threat of a nuclear accident was a remote possibility; Three Mile Island made that possibility a probability. Following the accident, studies were conducted to determine whether the radiation that was released from the reactor into the atmosphere posed a significant threat to the public.

> The effects on the population in the vicinity of Three Mile Island from radioactive releases measured during the accident, if any, will certainly be nonmeasurable and nondetectable… These releases resulted in an average dose of 1.4 mrem to the approximately two million people in the site area. This average dose is less than 1% of the annual dose from both natural background radiation and medical practice.[10]

Despite the evidence showing no significant impact on human health as a result of the TMI accident, the public relations debacle that took place during the incident had already severely damaged the public's opinion of nuclear power safety.

Only a few years later, in 1986, the Soviet nuclear power plant, Chernobyl, had a severe meltdown and explosion and released very large quantities of radioactive material into the atmosphere. Later investigation discovered the accident was caused by a combination of the fatally flawed reactor design and plant operator's ineptitude coupled with their acting outside of normal operating procedures. Unlike Three Mile Island, the

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[9] John G. Kemeny, et al., *The President's Commision on the Accident at Three Mile Island,* http://www.threemileisland.org/downloads/188.pdf (October 1979), 8.

Chernobyl reactor had no containment structure, so when the accident occurred and the reactor ruptured, there was nothing to prevent the plant from continually spewing radioactivity into the atmosphere until the fires were extinguished and the site was brought under some level of control. This horrible disaster is widely considered to be the worst nuclear disaster and it could have been avoided or largely minimized with better plant design or a competent reactor staff.

Most recently, in March of 2011, the Fukushima Daiichi nuclear power plant in Japan experienced catastrophic damage as a result of a 9.0 earthquake and subsequent tsunami that hit the plant. The plant was severely damaged as a result of the tsunami, which destroyed the plant's backup generators that are needed to keep coolant pumping through the reactor core in the event of an emergency. With these backup generators inoperable, several reactors at the Fukushima plant melted down and have been damaged to varying degrees. The events are still unfolding in Japan and comprehensive investigations of the situation have yet to be completed. However, one could argue that the nuclear disaster in Japan could have been avoided if the plant had not been sited on the coast where a tsunami could cripple it the way that it did.

These three nuclear accidents, Three Mile Island, Chernobyl, and Fukushima, have been and will continue to be the examples that anti-nuclear activists cite as reasons for abandoning all current and future attempts to increase the use of nuclear power. These nuclear power detractors ground their opinions and assumptions in the market paradigm, which they have grown accustomed to. Without broadening the scope of the nuclear argument to include the risks posed by nuclear waste, climate change, and energy

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[10] Mitchell Rogovin, *Three Mile Island A Report to the Commissioners and to the Public*

security, it will be very difficult to convince people to reevaluate their positions. A grounding in public interest, such as that provided by the Rousseau's General Will, is necessary for citizens to fully grasp the gravity of the problems the United States is confronted with. To only focus on unfortunate nuclear accidents without considering the more substantial challenges facing society today would be short sighted indeed.

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With a basic understanding of the major events in the history of nuclear power established, it is now necessary to begin focusing in on the argument of this paper. The following section aims to define the terms of the argument to minimize confusion amongst readers. Since the core of this piece revolves around questions involving the reprocessing of spent nuclear fuel, it only makes sense to clarify this concept first.

Reprocessing of highly radioactive nuclear waste broadly refers to a number of different processes, each of which aim to separate the different elements and isotopes that are found in spent fuel once it has been removed from a nuclear reactor so that useful fissile isotopes may be recycled. The longer nuclear fuel remains in a reactor, the less efficient it becomes due to the build up of various elements and isotopes, e.g. transuranic elements. This is not to say that used nuclear fuel is completely expended of its energy; it is just more difficult for the fuel to sustain the fission reaction that is at the heart of a nuclear power plant's ability to generate electricity. As a result, it becomes necessary to refill reactors periodically with fresh, uncluttered fuel. Reprocessing methods are essentially ways of recycling used nuclear fuel so that more energy can be extracted from it and the quantity and radiotoxicity of waste material leftover can be minimized.

Vol. I, http://www.threemileisland.org/downloads/354.pdf (January 1980), 153.

However, current United States nuclear policy does not allow for reprocessing of nuclear material for commercial power generation purposes.

The science regarding the effect greenhouse gases have on the climate is well established. The scientific community broadly agrees that increased levels of greenhouse gases in the atmosphere correlate with increased atmospheric temperatures and that the globe is already in the early stages of climate change.[11,12] The rise in global temperature will lead to more frequent, unpredictable, and severe weather events and shifts in the climatic regions of the globe. Unbearable droughts will cripple certain regions while the sea will inundate other areas. Infectious diseases will be able to spread into previously unaffected regions. Unprecedented rapid glacial melt is occurring. These changes and more will force the widespread relocation of people, especially those living in developing nations that will be ill-equipped to grapple with the hard truths of climate change. Everything society has grown accustomed to about the climate and its potential impacts will need to be reevaluated. It goes without saying that climate change poses significant challenges to future generations if left unaddressed.

The industrial revolution ushered in the age of fossil fuel dependency that has led to the largest short-term increase in greenhouse gases, such as carbon dioxide, on record. CO_2 "levels have grown since the start of the Industrial Revolution from around 280 parts

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[11] Intergovernmental Panel on Climate Change, *IPCC Fourth Assessment Report: Climate Change 2007 (AR4)*, http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml (2007).

[12] National Science Foundation, *Solving the Puzzle: Researching the Impacts of Climate Change Around the World*, http://www.nsf.gov/news/special_reports/climate/pdf/NSF_Climate_Change_Report.pdf (2009).

per million by volume (ppm) to 385 ppm (by 2009)."[13] Greenhouse gas levels, particularly CO_2, are expected to continue to rise in the coming decades unless drastic changes are made. Consider the IEA's assertion that "the power-generation and transport sectors contribute over 70% of the projected increase in world energy-related CO_2 emissions to 2030."[14] In light of this projection, it makes sense to address how power generation and transportation harness energy and attempt to minimize their collective greenhouse gas emissions. Minimizing fossil fuel use would largely address this issue. However, cutting these heavily relied upon energy sources from society is less than practical without offering a viable alternative. The challenges presented by climate change demand that action be taken to avert as much catastrophic change as possible. Drastically reducing fossil fuel use will be a critical step in achieving this goal.

Climate change aside, the United States is dangerously dependent on fossil fuels and its energy security is not well thought out. Society operates based on the assumption that energy is and always should be inexpensive and easily accessible. Unpleasant as it may be, fossil fuels, by virtue of their limited nature, cannot be either endlessly cheap or easy to obtain. As developing nations increase their demands for fossil fuels to drive their economic growth, these energy sources will become more expensive and difficult for the United States to obtain. Alternative sources of energy must be developed so that as global demand for traditional energy sources increases, the United States can have well-developed energy sources to transition to.

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[13] Scott L. Montgomery, *The Powers That Be: Global Energy for the Twenty-first Century and beyond* (Chicago: University of Chicago, 2010), 266.
[14] International Energy Agency, *World Energy Outlook 2008*, http://www.iea.org/textbase/nppdf/free/2008/weo2008.pdf (2008), 381.

The insatiable appetite for cheap energy is largely attributable to the fact that society is currently dominated by the market paradigm. This collective mindset influences every aspect of United States affairs, from the seemingly insignificant daily decisions of individual citizens to high-level negotiations between law and policy makers. Little, if anything, is unaffected by the pervasive nature of the market and its goal of wealth maximization.[15] For all of its power and influence though, there are shortcomings and undesirable aspects of the predominant paradigm. For example, the market is unable to holistically value anything. Be it an individual, a tree, or ecosystem, or the climate, the market is only able to value these things in terms of those components that are instrumentally valuable to it. Since the market paradigm's goal is wealth maximization, it has the tendency to discount future generations by focusing on short-term gains. Obviously, it can prove to be difficult to gauge the instrumental value of someone or something that does not yet exist. Additionally, due to its shortsightedness, there is no feasible way for the market to behave in such a way that will not conflict with the preferences of future generations. The market is anchored in the present and is not oriented to accommodate or plan for large-scale future changes. Markets will not seek sustained, long-term growth when short-term, immediate profits are possible.

The market paradigm is fundamentally rooted in the concept of Kaldor efficiency. This understanding of efficiency asserts that a choice, transaction, or policy decision meets the requirements of efficiency if the individuals who are positively affected by the change could hypothetically compensate those who are negatively affected so that no one

[15] John Martin Gillroy, et al., *A Primer for Law and Policy Design: Understanding the Use of Principle & Argument in Environmental & Natural Resource Law* (St. Paul: Thomson West, 2008), 159.

person is any worse off than before the change was made; such a situation is also known as a potential Pareto improvement. This concept of efficiency is fundamentally flawed since in reality it is very uncommon for a person who experienced a net gain in a situation to suddenly distribute his gains amongst the people who experienced net losses.

An alternative to the market paradigm can be found in the writings of Jean-Jacques Rousseau. His work in *The Social Contract* outlines the underpinnings of a society in which government is strictly accountable and responsive to the citizens by their collective consent. Rousseau uses the term, General Will, to refer to the collective consensus among citizens that always acts in their best interest.

> 'Find a form of association which will defend and protect, with the whole of its joint strength, the person and property of each associate, and under which each of them, uniting himself to all, will obey himself alone, and remain as free as before.' This is the fundamental problem to which the social contract gives the answer.[16]

Now that the terms of this argument are explained, there is one last piece of the thesis that must be defined so that all readers may approach the argument from the same starting point. The norm by which the issue-at-hand will be judged is the term "crucial." The dictionary defines crucial as "extremely significant or important; or vital to the resolution of a crisis."[17] This understanding of the word is sufficient for the intent, purpose, and scope of this paper.

Some may argue that the United States must not pursue the reprocessing of nuclear material because doing so would lead to a greater reliance on nuclear power, an energy source that is believed to be fraught with danger and cannot be implemented

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[16] Jean-Jacques Rousseau, *The Social Contract*, trans. Christopher Betts (New York: Oxford Press, 2008), 54.

[17] *Crucial*, http://www.thefreedictionary.com/crucial.

safely and because reprocessing of nuclear waste and thus increasing the use of nuclear power is unnecessary given the new renewable energy technologies that are now being utilized across the United States. I contend that this is not the case.

Additionally, reprocessing separates the fissile uranium and plutonium from the remaining transuranic waste products with the intention of later using them as fuel in nuclear reactors. Some of these separated plutonium isotopes could potentially be used to construct a nuclear weapon if an organization with the requisite technology and know-how were to obtain them. By removing plutonium from the rest of the waste material, it becomes more feasible that someone could steal fissile plutonium since it emits much lower levels of radiation than the other transuranic waste that is generated in a nuclear reactor. The half-life of the remaining waste material drops substantially once plutonium is removed since plutonium has the longest half-life of all of the spent fuel material. The real risk does not lie in the possibility of a group constructing a nuclear weapon from reprocessed plutonium though; it is much more likely that a terrorist organization would attempt to use stolen nuclear material to create a “dirty” bomb. Such weapons would not be able to create a cataclysmic fission reaction but they could be used in conjunction with an improvised explosive device to spread harmful radiation over large areas. This is a serious risk and should not be taken lightly.

With adequate security and tracking of nuclear materials however, it would be unattractive for enemies of the United States to attempt to steal American nuclear waste material. Terrorist organizations are more likely to exploit weaknesses in security and strike at parts of society that are not well defended, e.g. pre-9.11 airline industry security. If the United States implements a strict, comprehensive security protocol for storing, tracking, and transporting nuclear materials, it will be unlikely that terrorist organizations or rogue nations will be able to successfully steal radioactive materials. By setting the bar for securing nuclear material, the United States and other exemplar nuclear nations can lead the way in radioactive material security. Through international agreements, less organized nations with nuclear material can follow the example set by the United States and its peers. That said, the unlikelihood of terrorist groups or rogue nations acquiring radioactive material should not give citizens a false sense of security. It is important for people to take emergency preparedness seriously so that they may take steps to minimize their risk and protect themselves in the event of such an attack.

Despite the aforementioned risk associated with separating the isotopes of spent nuclear fuel through reprocessing, it is a manageable risk. Dealing with long-lived radioactive waste, on the other hand, may not be manageable for future generations. The market paradigm prefers to continue the status quo by focusing on short-term gains as opposed to looking toward and planning for the future. Nuclear policy should be amended to manage the risks that could arise through reprocessing of spent nuclear fuel instead of "kicking the can down the road" and leaving future generations to deal with the nuclear waste that has already been generated by the present generation.

Long-lived Radioactive Waste

Currently, the United States implements an "open" nuclear fuel cycle. This practice enriches and refines fissile nuclear fuel, uses it within a nuclear reactor to generate electricity, and later removes the highly radioactive, spent fuel with the intent of eventually depositing it at a permanent storage location. Before internment at the yet-to-be-determined permanent storage facility, spent nuclear fuel is stored on-site at the reactor that generated the waste. This used fuel must be safely stored for countless generations due to the hazardous nature and long half-life periods of the isotopes within the spent nuclear fuel. In a "closed" fuel cycle, rather than sending all spent fuel material to a permanent long-term storage site, the spent fuel could be reprocessed and the remaining fissile isotopes could be recycled back into the nuclear fuel cycle. The waste that would remain after reprocessing is still radioactive but its radioactivity subsides within hundreds of years as opposed to the hundreds of thousands of years required by waste that does not undergo reprocessing. This timeframe is much more realistic for the United States to safely store this material and decreases the political pressure associated with siting an adequate long-term storage facility that meets the demanding requirements imposed by high-level, long-lived radioactive waste.

While it is true that reprocessing of spent nuclear fuel would likely make nuclear power more appealing to American utility companies and lead to its expanded use due to the ability of reprocessing to increase fuel reserves and decrease waste volume and longevity, detractors of reprocessing and nuclear power fail to address the fact that nuclear power has been in use for several decades now and the United States has still not come up with a safe, long-term solution for disposing of nuclear waste. Current nuclear policy, misguided by the market paradigm and Kaldor efficiency, has saddled countless generations with the responsibility of safeguarding these stockpiles of high level nuclear waste that have been generated through the inefficient and short-sighted use of nuclear power. The cat is out of the bag; enormous quantities of high-level waste have already been created. The debate should not be narrowly focused on whether nuclear power should be used but rather what should be done to lessen the risk and longevity of the radioactive waste that has *already* been generated. The well-being of future generations requires us to address this issue. Unfortunately, this change in focus does not seem likely given the current paradigm.

Society today exists within the market paradigm, which functions upon Kaldor efficiency. This type of efficiency merely requires that total benefits outweigh total costs. "The Kaldor efficiency criterion asserts that a policy is efficient if those who benefit as a consequence of the policy could hypothetically compensate those who experience losses as a consequence of the policy."[18] In the context of long-term nuclear waste storage it is impossible for the current generation to compensate future generations for the burden of dealing with nuclear waste; the hazards associated with such waste, as it is currently handled, shall persist for millennia. Future generations will need to safeguard high-level waste storage facilities to ensure that they are not compromised and that their hazardous contents are not released into the environment. If, or when, storage safeguards are compromised, there is no contingency plan in place for how to address the problem; much faith is placed in the "infallible" nature of long-term storage options. The engineering demands of such long-term storage are unlike anything humankind has ever been tasked with accomplishing; this endeavor requires far more than simply burying nuclear waste in a remote location and hoping for the best. The market paradigm treats the long-term costs of nuclear waste as externalities that future generations will have to eventually confront. Its foresight is extremely limited due to its focus on short-term gains

[18] John Martin Gillroy, et al., *A Primer for Law and Policy Design: Understanding the Use of Principle & Argument in Environmental & Natural Resource Law* (St. Paul: Thomson West, 2008), 287.

and profit maximization. The long-lived nature of nuclear waste demands more stringent requirements than those currently upheld by the market paradigm.

Rousseau's conception of the General Will in *The Social Contract* is akin to modern day public interest. These two principles should be considered inextricably linked. By consenting to the social contract, citizens of the United States would gain a connection to public interest; they would all become equally invested in society's collective well being. I contend that Rousseau's Social Contract, if it were to become the dominant paradigm, would extend citizens' public interest beyond the present generation and allow for the government to act in the best interest of future generations by permitting nuclear reprocessing.

The General Will can become the cornerstone of a responsible government that considers intergenerational issues when making decisions. If a citizen is willing to consent to the Social Contract, it would follow that he understands the benefit to be gained by unifying himself with the other members of his society. Through his acceptance of the Social Contract, the citizen gains greater power over his government; the collective interest of all citizens is much more effective for influencing government than the individual interests of any particular citizen. By understanding this benefit, he would presumably wish to see this level of commitment to his country and its people extend beyond his living years and become instilled in the following generation so that future iterations of government are held equally accountable to the people. A citizen who is engaged in the General Will has a strong belief that government must be accountable and responsive to the people. An issue that could damage the Social Contract in the future could not go on unaddressed by present citizens because damaging the Social Contract and voiding the General Will would effectively cut the link between the citizens and their government. Such a scenario would give the government immoral power over the people, something a citizen who is invested in the General Will could never accept for any present or future citizen. Consent to the Social Contract and understanding of public interest by citizens is central to redirecting United States nuclear regulatory policy. A citizen engaged in society, and thus embedded in the General Will, will not allow unsolved intergenerational issues, such as nuclear waste storage problems, to burden future members of society nor will she allow promising technologies that may benefit future generations, like nuclear reprocessing, to go unused.

It is a mistake for society to default to reliance upon the market paradigm. The market has proven, time and again, that it is grounded in short term gains for select members of society. Look at, for example, the boom and bust nature of the United States economy. Generations that were fortunate enough to live during prosperous times lacked the foresight or genuine care to plan ahead for the needs of future generations. The great depression and the current economic recession can be considered examples of this characteristic. The risks associated with long-term, high-level radioactive waste demand a paradigm that has at least not proven its inability to recognize long-term potential problems and react accordingly to prevent them. Rousseau's Social Contract could allow for a society in which government can more easily recognize what is best for its citizens, present and future.

Current handling of nuclear waste in the United States is inadequate for valuing future generations. Kaldor efficiency depends on those who benefit most to compensate those who do not benefit. The market paradigm, through Kaldor efficiency, discounts people on a regular basis but in the context of nuclear waste, this discounting crosses generational boundaries and harms the opportunities of future generations. A paradigm built upon the General Will as the public interest would allow the government to recognize the problems posed by long-lived nuclear waste and force them to implement solutions, such as spent nuclear fuel reprocessing, that do not de-value future generations. If the government fails to recognize the threats posed by nuclear waste, the General Will gives citizens the power to redirect government decisions through the collective power of a united citizenry.

At its core, the market paradigm is grounded in self-interest. This is akin to a dominance of passion over reason. Kaldor efficiency segregates the "haves" from the "have-nots" by focusing on short-term gains and profit maximization. In the context of nuclear regulatory policy, the "haves" can be considered the present generation and the "have-nots" are future generations; the present generation has the benefit of electricity generated from nuclear power and minimal waste problems whereas future generations will be burdened with all previous generations' nuclear waste. Issues with long-term implications, such as nuclear regulation, require a paradigm with a focus on the essential public interest. Self-interest and passion do little to serve future generations; once you are dead and gone the benefits you acquired for yourself do little to elevate the next generations' standing. This sentiment is not to say that today's generation should be solely focused on tomorrow's generation. It acts as more of a reminder that we have a duty to those unborn to do whatever possible to leave the world in such a state that future generations can lead fulfilling lives that are not detrimentally impacted by the actions of previous generations. This duty can be realized through the General Will and by applying the practical reason upon which it is based. The market paradigm is unable to meet this need because of its self-interested nature. Rousseau's General Will is a promising candidate for meeting the demands of long-term accountability due to its firm grounding in reason; "the common good is obvious everywhere, and all that is required to perceive it is good sense."[19] The General Will aligns members of a society with what is best for that society's prolonged existence.

The market paradigm's focus on short-term gains and personal advancement fails to acknowledge the burden imposed upon future generations by nuclear waste as it is currently handled. The market cannot look beyond the current generation to plan for the needs of future generations. Nuclear waste is currently left on-site at nuclear power plants until a long-term storage location can be decided upon. This waste is not reprocessed and as a result contains materials with extremely long half-life characteristics. This waste will need to be safely stored for hundreds of millennia until the radioactivity subsides. This stark fact is the reason it has been so difficult to decide upon a repository location for the waste. It is unrealistic to try and sequester such volatile waste and expect it to be secure for a period that is greater than recorded history.

Okrent summarizes the non-feasibility associated with long-term nuclear waste storage and the difficulties in ensuring fairness for future generations.

> ...a health-based risk standard could be specified to apply uniformly over time and generations, and that this would be consistent with the principle of intergenerational equity... Only for the geologic disposal of high-level radioactive wastes are large expenditures made to protect generations tens to hundreds of

[19] Jean-Jacques Rousseau, *The Social Contract*, trans. Christopher Betts (New York: Oxford Press, 2008), 134.

> thousands of years into the future. This is singular — no other activity posing far-future risks faces such a goal.[20]

By reprocessing, the time scale that Okrent mentions can be drastically reduced to just several hundred years. This reduced timeframe makes the goal of intergenerational equity, in regard to radioactive waste management, much more feasible. Any additional benefits of reprocessing beyond the reduction of waste levels and toxicity, should be considered supplemental and not primary motivating factors since they do not address the dilemma of future generations being burdened with the nuclear waste of today.

Ian Hore-Lacy, the former head of the World Nuclear Association, asserts "the principal reason for reprocessing [of spent nuclear fuel] is to recover unused uranium and plutonium in the discharged fuel elements. A secondary reason is to reduce the volume and/or radioactivity of material to be disposed of as high-level waste."[21] Obviously, Hore-Lacy's second reason to reprocess spent nuclear fuel is the focus of this argument due to the positive implications it has for future generations. Most advocates of reprocessing share Hore-Lacy's sentiment and ordering of priorities but this ordering is most certainly influenced by the current market paradigm. If a paradigm shift were to take place and create a societal foundation based upon the General Will as opposed to profit maximization, it is very likely that Hore-Lacy's secondary reason of reducing the volume and radioactivity of waste would become the primary reason for pursuing the reprocessing of spent nuclear fuel. Citizens would demand this of the government due to their General Will and associated commitment to what is best for the collective citizenry,

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[20] David Okrent, *Comment: Pigford, Shrader-Frechette & the NRC Report on Yucca Mountain Risk: Health, Safety & Environment 9.1*, http://www.piercelaw.edu/risk/vol9/winter/okrent.pdf (1998).

present and future. Hore-Lacy's current ordering of priorities mistakenly places efficiency above public welfare and safety. Regardless of how these reasons to reprocess are prioritized, the fact remains that the benefits of reprocessing spent nuclear fuel are in fact, two fold. Reprocessing should be pursued primarily for its ability to reduce the radiotoxicity and longevity of nuclear waste so that the intergenerational problems stemming from long-term nuclear waste storage can be minimized.

Climate Change & Energy Security

The issues of whether to reprocess spent nuclear fuel and how to mitigate climate change while still providing adequate energy are closely tied together and have serious implications for future generations despite their seemingly unrelated subject areas. Simply put, nuclear power can become significantly more attractive to policy makers when they are given a viable solution to the unanswered question of what to do with the growing levels of nuclear waste. With the issue of spent fuel largely addressed through reprocessing, there can be less hesitancy about expanding the use of nuclear power. By expanding nuclear power's role in the United States energy portfolio, the country can become less reliant upon greenhouse gas emitting energy sources such as coal and natural gas. By minimizing the use of fossil fuels, the United States can mitigate the impact of climate change and lessen its potential impacts on future generations. Hence, there exists a transitive relationship between the reprocessing of spent nuclear fuel and mitigating climate change.

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[21] Ian Hore-Lacy, *Nuclear Energy in the 21st Century: the World Nuclear University Primer*. 8th ed. (London: World Nuclear UP, 2006), 79.

The benefits of nuclear power and spent fuel reprocessing are further realized when the limited nature of fossil fuel reserves is taken into consideration. The United States' energy security is uncertain because it imports much of its energy and relies heavily upon other nations to meet American fossil fuel demand. The fossil fuels that are extracted domestically typically come at a great cost to the environment and those that live near mining or drilling operations.[22] Supply chain disruptions due to geopolitical strife, natural disasters, or various other unforeseen events can, as evidenced by past events, cause mayhem in the prices and availability of fossil fuels in the United States and elsewhere in the world. Uranium, currently the primary fuel for United States nuclear reactors, is also a limited resource but it is far more energy-rich than any of the other resources society currently utilizes. "A single uranium fuel pellet the size of a fingertip contains as much energy as 17,000 cubic feet of natural gas, 1,780 pounds of coal or 149 gallons of oil."[23] Much less uranium fuel is needed to generate a certain level of power than if that same level of power were generated from a fossil fuel source. If the United States were to reprocess the spent nuclear fuel that it is currently storing, it could stretch its domestic energy supply significantly and avoid much of the havoc that is caused by disruptions in global energy supply chains.

The connection between climate change and energy security becomes even more clear with a comprehension of the role fossil fuels play in economic development. The industrial revolution was largely made possible by fossil fuels. For the first time in history, large amounts of energy could be harnessed with minimal man or animal power.

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[22] *Gasland*, dir. by Josh Fox (2010; New Video Group, DVD).
[23] Nuclear Energy Institute, *Nuclear Power Plant Fuel*, http://www.nei.org/howitworks/nuclearpowerplantfuel.

This presented a sea change for the United States in nearly every facet of life. Obviously, as evidenced by the current state of affairs, the economies of the developed nations benefited greatly from the harnessing of fossil fuels and the industrial revolution advanced these nations to the high statuses that they currently hold. Unfortunately, burning fossil fuels is also the primary factor accelerating climate change, a problem that greatly endangers future generations due to its potential for wide-spread, dramatic change that society is ill-prepared to handle. There are many nations still developing throughout the world that did not have the opportunity to partake in the economic benefits of rapid industrialization. These nations are now eager to harness the power of fossil fuels to accelerate their own development and economic growth. If these countries go through their own fossil fuel-based industrial revolution, their demand for fossil fuels will increase drastically and global greenhouse gas emissions will skyrocket, thus exacerbating and prolonging the effects of climate change. The increased global demand for fossil fuels will cause strain on the supply of these fuels to the United States. Prices will increase and the United States will need to invest in other forms of energy or risk potential political or military conflicts with other nations in order to secure access to reliable sources of fossil fuels. Rousseau's General Will provides the requisite lens through which to view the issues of climate change and energy security so that government takes the necessary steps to minimize the prolonged problems these issues will cause in the future if left unaddressed. Nuclear power, coupled with spent fuel reprocessing can lessen the effects of climate change by drastically reducing greenhouse gas emissions while simultaneously providing an abundant and reliable domestic supply of energy that circumvents the energy security issues associated with fossil fuels.

Anti-nuclear activists claim that nuclear power is far too dangerous to be used and by extension, that there is no need to invest in reprocessing capabilities. Unfortunately, many that share this mindset fail to account for the implications of continuing to rely upon conventional fossil fuel energy sources. There are obvious risks associated with the use of nuclear power, however, conventional methods of power generation are fraught with risk as well. Not only do fossil fuels pollute and harm people in the present, they also will exacerbate global climate change and by doing so, will endanger the well-being of future generations.

Debates surrounding fossil fuel power plants versus nuclear power plants inevitably raise questions of environmental risk management. Typically, fossil fuel plants are seen as sources of traditional air or water pollution without considering their inherent characteristics of environmental risk such as the external transfer of costs, collective risk, latency, stealth, or irreversibility of undesired effects.[24] Traditional pollution is relatively easy to notice and as a result, it is often addressed relatively quickly. Environmental risk on the other hand, is much more difficult for people to recognize and is therefore easier to write off as inconsequential.

Fossil fuel burning power plants have more diffuse and difficult to ascertain characteristics of risk, whereas a nuclear power plants have much more concentrated risk. Fossil fuel burning power plants spread their emissions across large swathes of land so that the risk of health problems and environmental degradation is dispersed throughout the population and environment. A coal-fired power plant "disperses about twenty-seven

[24] See J.M. Gillroy's commentary on the characteristics of environmental risk in his chapter entitled "The Theory of Environmental Risk: Preferences, Choice, and Individual

metric tons of radiological material a year, exposing people to much more low-level radiation than a nuclear plant would."[25] A nuclear power plant, on the other hand, releases no pollutants into the environment and with substantial containment safeguards in place to prevent the release of radioactivity should present less overall risk. It comes down to a question of whether society would rather accept increased cancer rates and other health and environmental problems due to fossil fuel power plant emissions or alternatively acknowledge the dangers that come along with the growing American appetite for energy and contain that risk in centralized locations such as nuclear facilities.

Given the varying degrees of risk associated with both fossil fuels and nuclear power, some would say the United States would be better off investing in the risk-free energy alternatives provided by renewable energy technologies. However, American life is firmly dependent upon a constant supply of electricity, so much so that society would cease to function properly if electricity availability was suddenly decreased. Such a scenario would not be acceptable to citizens guided by the General Will. If there is a choice that maintains the quality of living standards that citizens have grown accustomed to that does not needlessly endanger the opportunities of future generations, the General Will shall guide citizens toward that choice. With this in mind, it is important to address why the alternative energy options currently available are not sufficient for meeting the demands of the General Will.

Renewables?

Welfare" from *Justice & Nature Kantian Philosophy, Environmental Policy, & the Law* (Washington, D.C.: Georgetown University Press, 2000).

Many argue that renewable energy sources can provide the power our society demands without the risks associated with nuclear power or fossil fuels. Unfortunately, this is not possible given the limitations of the current technologies. Renewable energy technologies such as wind, solar, tidal, etcetera most often come to mind when thinking about clean, alternative energy, and for good reason; renewables circumvent the emissions problems associated with fossil fuels by harnessing the power of the sun or wind. However, as impressive as these technologies are, they currently suffer from one major drawback. This downside has to deal with renewable technologies ability, or lack thereof, to meet what is known as baseload electricity demand. Gwyneth Cravens explains this concept concisely:

> 'Baseload' refers to the minimum amount of proven, consistent, around-the-clock, rain-or-shine power that utilities must supply to meet the demand... That power comes from energy stored in coal, natural gas, oil, uranium, and inherent in falling water. Wind and sunshine are weak, intermittent, and less efficient than other sources. They can't provide baseload now, because the technology for storing energy remains in its infancy.[26]

Any fluctuations above the baseload are supplemental and only required during periods of peak electricity demand. Fossil fuel or nuclear plants excel at generating baseload electricity. Once baseload boundaries are recognized, it is relatively easy for electricity grid operators to figure out how much coal must be burned or what reactor output needs to be in order to meet this demand consistently. The reason for renewables inability to meet baseload electricity demand is simply due to the fact that they are dependent upon environmental factors to generate electricity. If the sun is not shining or the wind is not

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[25] Gwyneth Cravens, *Power to Save the World: The Truth About Nuclear Energy* (New York: Alfred A. Knopf, 2007), 196.
[26] Gwyneth Cravens, *Power to Save the World: The Truth About Nuclear Energy* (New York: Alfred A. Knopf, 2007), 16.

blowing, solar panels and wind turbines are not going to be very useful in meeting baseload electricity demand.

There is currently a technology gap between the capabilities of renewable energy technologies and energy storage capabilities. Battery technology cannot yet store large enough quantities of electricity to meet baseload demand during times when renewable energy sources are not generating enough electricity. The environmental factors that renewable technologies depend upon can be fickle, making it difficult judge how much electricity needs to be stored in order to sustain electricity levels through periods of low generation such as night time or cloudy or windless days. Due to this severe limitation, renewable energy technology is unable to meet baseload electricity demand. Instead, it provides supplemental power that can be unreliable but can generally limit the need to increase output from coal or nuclear plants during times of increased demand.

Renewable energy technologies are also limited by location requirements. Not all areas are optimal for solar or wind farms. Consider that "windmill farms have to cover nearly a hundred square miles to generate as much electricity as one conventional power plant."[27] In many instances, ideal renewable siting locations are in remote areas such as the Southwest United States and will require significant advancements in energy transmission capabilities in order to transmit the electricity long distances to points of high demand. It is one thing for a solar farm to generate large quantities of electricity, it is something entirely different, however, to transmit that electricity long distances to where it is needed. Until electricity from renewable sources is able to be stored long-term

[27] William Tucker, *Terrestrial Energy: How Nuclear Power Will Lead the Green Revolution and End America's Energy Odyssey* (Savage, MD: Bartleby, 2008), 165.

in high quantities and transmitted long distances for on-demand use, renewable energy technology is not yet mature enough to displace the current reliance on fossil fuels.

Transitioning to an energy infrastructure based on inadequate renewable energy technologies would lead to a drastic change in the quality of life. Not all citizens would agree to this kind of change. Without collective consent, a renewable energy technology infrastructure would go against the General Will. For this reason, only nuclear power, coupled with fuel reprocessing, can be a viable alternative to break American dependence on fossil fuels and thus be a large part in mitigating climate change.

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The three major nuclear accidents, Three Mile Island, Chernobyl, and Fukushima, go to show that nuclear accidents can happen without careful site selection and planning as well as adequate training of facility personnel. These two considerations should supplement and buttress the containment capabilities of nuclear power plants. In the case of Three Mile Island, containment was successful in preventing an uncontrolled release of harmful radioactivity. In this sense, TMI is not the full-fledged, run-away catastrophe that the media led many to believe it was. Chernobyl, with its complete lack of containment, was a disaster just waiting to happen. In retrospect, it is mind boggling that such a plant was built without any form of reinforced containment. There were a laundry list of other issues with Chernobyl, such as the dangerously flawed graphite reactor design and the inexperienced control room staff but building containment around the reactors could have largely mitigated these other issues. The recent Fukushima disaster raises questions of site selection and emergency preparedness. One could question why a nuclear power plant was sited so close to the shore when it was well known that Japan is at risk of frequent tsunamis. What is happening in Japan is a terrible tragedy but a greater level of scenario planning would have been very beneficial in minimizing the damage that has ensued since the initial disaster. Containment should be considered the last line of defense in the event of a nuclear accident. Knowledgeable staff must be ever-present to react quickly and minimize problems should an issue arise. Prompt and accurate diagnosis is the best tool for avoiding a reactor meltdown incident. Additionally, plants must be sited and built adequately so that they can avoid or minimize the impacts of natural disasters.

Three Mile Island, Chernobyl, and Fukushima provide emotional anchor points for citizens to latch onto and galvanize their collective opinion against the use of nuclear power and the reprocessing of spent nuclear fuel. In a society that is guided by the General Will, government would do everything possible to prevent such accidents from occurring. Citizens would demand that their government implement the most robust security measures, require only the most highly trained reactor operators, and make certain that adequate scenario planning is conducted before siting a reactor. If an accident were to occur these three precautions would minimize risk to the public. Without these precautions, a nuclear accident of great enough severity would be reason enough for citizens to revoke their consent to the government. Hence, it is in the government's, as well as citizens', best interests to take every possible step to minimize long-term risks, such as those associated with nuclear power. By bringing the issues of climate change and energy security into the equation, nuclear power and reprocessing, with their manageable risk, begin to look like a much more reasonable alternative to continued fossil fuel use.

Based on current data "we will need 15 TW of emission free power by 2050 to stabilize atmospheric CO_2 at 550 ppm. [Studies] indicate that fission based nuclear power is the only presently developed technology that could deliver this performance [and that] known reserves of uranium are inadequate to sustain this level of power production if we utilize only the fissile uranium that is present… it is imperative that development begin immediately… to close the nuclear cycle."[28] Advocating to "close the nuclear cycle" is synonymous with supporting the reprocessing of spent nuclear fuel. By reprocessing its spent fuel, the United States would be acting in accordance with the General Will of the people by taking steps to address the problems posed by climate change and energy security vulnerabilities, both of which threaten future generations. Nuclear power plants do not emit carbon dioxide or other greenhouse gases and therefore are an ideal solution for the climate-related energy challenges facing the United States and its future citizens. Climate change, above all else, requires that the United States modify the ways in which it generates its electricity. If it does not act and prepare for the new reality climate change will impose, the United States will have difficulty maintaining its current position as a world leader and meeting the expectations and needs of its citizens, both present and future.

The current dependence on fossil fuels is largely responsible for the challenging circumstances society will be faced with in the coming years. The planet is only just beginning to experience the negative effects of this oncoming era of increased climatic uncertainty and it will likely worsen for a considerable amount of time to come. Greater

[28] Underscoring included in original document. Gregg J. Lumetta, Kenneth L. Nash, Sue B. Clark, and Judah I. Friese, eds. *Separations for the Nuclear Fuel Cycle in the 21st Century* (Washington, DC: American Chemical Society, 2006), 4.

reliance on nuclear can offset the damage caused by the burning of fossil fuels and ensure that the government abides by the General Will and does not hinder future generations of citizens.

> There is little doubt that human activities associated with energy production, primarily of fossil fuels, have…altered the composition of atmospheric gases. World carbon emissions are expected to exceed 1990 levels by 39 percent in 2010. By 2020, this figure will be closer to 70 percent.[29]

Without taking serious steps to curtail these carbon emission projections, the United States government will be partly responsible for the negative impacts that future citizens experience because it failed to acknowledge the General Will and act accordingly. A populace aligned with the General Will cannot allow intergenerational problems to persist unaddressed because doing so would fracture the Social Contract and sever future citizens' power over their government. As a world leader, the United States is in a position to set a positive example for other nations to follow. Climate change is a global problem but it has been difficult to address thus far with international efforts. For this reason, it is imperative that the United States consider the threats posed by climate change seriously and shows the rest of the world that it is willing to take earnest steps to mitigate the projected climatic impacts and protect its citizens.

Reprocessing of spent fuel addresses the important issue of United States energy security and maintains government obedience to the General Will by ensuring access to plentiful electricity for future citizens. After the World War II and the subsequent Cold War push to develop and expand the United States nuclear weapons arsenal subsided, there was no longer an impetus to continue the large-scale uranium mining that had been

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[29] Ernest J. Moniz, *The Challenges to Nuclear Power in the Twenty-First Century* (New York, NY: Kluwer Academic Publishers, 2002), 35.

taking place throughout the country. Currently, the United States mines very little of it own Uranium; much of it is purchased from other nations such as Canada and Australia. “Reactors are incredibly profligate with the earth's endowment of potential nuclear fuel. The once-through, ‘throw-away’ cycle [currently] in favor in the United States uses less than a hundredth of the energy potential of the mined uranium.”[30] Such wasteful use of a resource that could greatly benefit future generations would be contrary to the General Will. By reprocessing its large amounts of spent fuel the United States could become less dependent on foreign nations for its fissile Uranium supply by extracting all of the fissile isotopes that remain in the waste material that is stored at nuclear power facilities so that future generations will have an adequate supply of domestic energy. By decreasing dependence on foreign energy suppliers, the United States can make decisions in accordance with the General Will of its citizens rather than being concerned with how its actions will affect its energy supply trade relationships.

The United States has been able to considerably expand its supply of nuclear fuel by tapping into the fissile material that was enriched during the Cold War. The Megatons to Megawatts program was aimed at safely and peacefully decreasing the quantity of nuclear weapons in the former Soviet and American weapons arsenals. To date, “412 metric tons of [weapons grade uranium] have been recycled into 11,905 metric tons of [reactor grade uranium].”[31] The United States would purchase recycled weapons-grade fissile material from Russia with the purpose of using it as fuel in power plant reactors.

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[30] George S. Stanford, *National Policy Analysis #378: Integral Fast Reactors: Source of Safe, Abundant, Non-Polluting Power - December 2001* (National Center for Public Policy Research, 2001).
[31] USEC Inc., *Nuclear Nonproliferation - Megatons to Megawatts*, http://www.usec.com/megatonstomegawatts.htm

Further decommissioning of nuclear weapons has the potential to greatly expand nuclear fuel reserves. Considering the vast arsenal of nuclear weapons that were constructed during the Cold War and the costs of maintaining these aging weapons of mass destruction, it was mutually beneficial to the United States and member states of the former Soviet Union to downsize their nuclear weapons stockpiles in this way. A government guided by the General Will would find a program such as this absolutely necessary. Publicly interested citizens would see little benefit in maintaining an excessively large nuclear arsenal and would rather see valuable fissile material put toward benefiting the lives of current and future citizens. Unfortunately, the Megatons to Megawatts agreement expired and has yet to be renewed but there is little reason why the United States should not use it's own nuclear warhead supply to fuel its reactors with quality fissile material. Of course, doing so would require a government that is guided by the general will, otherwise the principles imposed by the market paradigm will cause the government to default to more immediate sources of energy. Technically speaking, harvesting nuclear warheads would require extensive reprocessing capabilities to downgrade the highly enriched weapons-grade fissile material to a lower level of enrichment so that it could be used as fuel in existing American reactors. Reprocessing technology can be used to secure long-term, clean energy for the United States and its citizens while simultaneously eliminating hazardous material.

Nuclear power and spent fuel reprocessing is used successfully elsewhere in the world. France has a highly developed nuclear power industry that is focused on a closed fuel cycle through mandatory reprocessing. "France, which is about 80% nuclear, decreased its CO_2 emissions by almost 30% in the 1980s... This drop in CO_2 emissions is more than any country has achieved with any other strategy."[32] France could decrease its CO_2 emissions even further if it decouples its transportation sector from fossil fuels and switches to electric vehicles that could be recharged by its robust reactor fleet. Additionally, the country regularly generates electricity surpluses that it is able to sell to neighboring countries, thus further offsetting carbon emissions.

France seems to have a nuclear power program that is aligned with the General Will of its people. The French have a strong governmental nuclear regulatory agency, the EDF, which oversees the construction of standardized reactor designs, the reprocessing of spent fuel, and the deposition of radioactive waste in the country's central radioactive waste repository. This strong, centralized agency seems critical in implementing a successful, large-scale nuclear program that incorporates reprocessing. "By standardizing the reactors, France made it possible to link, expeditiously and effectively, those involved in research and development, industry, and the oversight and safety authorities."[33] This minimizes confusion due to the lack of differences between plants and allows for any qualified person to quickly operate one of the nation's reactors in the event of an emergency, thus fulfilling the desire of the General Will for nuclear power to be as safe as possible. All told, France has created a blueprint for what a successful, nation-wide closed-fuel cycle nuclear power program can look like and how such a program can maintain the support of citizens. The United States would do well to take note and follow suit.

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[32] Judith Wright, James Conca, *The GeoPolitics of Energy Achieving a Just and Sustainable Energy Distribution by 2040* (Charleston, SC: Book Surge, 2007).

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In conclusion, the United States is facing a multitude of problems, each of which individually threaten the foundation upon which society is based. When taken together, the issues of long-lived radioactive waste, climate change, and long-term energy security can appear to be insurmountable due to the market paradigm principles that have perpetuated indecision when it comes to the matter of nuclear policy reform. Despite the adversity presented by these challenges however, it is important to recognize that there are established technologies that can and should be used to counteract these undesirable situations. Unfortunately, to take full advantage of these technologies would require a paradigm shift toward a society that is guided by the General Will as it is understood in *The Social Contract*. Without the emphasis on public interest that the General Will fosters, it is impossible for citizens to recognize the threats facing the United States and petition the government to act responsibly and in the best interest of the people, both present and future. Nuclear power, if guided by the General Will, would be paired with spent fuel reprocessing so that it can act as the centerpiece in the United States' response to all three of the aforementioned problems. The General Will guides citizens' engagement with the government and no citizen who has consented to the Social Contract can allow for intergenerational problems to negatively impact future citizens. Doing so would tacitly acknowledge the illegitimacy of the future government and its immoral power over the people. A publicly interested citizen cannot allow such a potential for future injustice to go on unaddressed.

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[33] Jan Forsythe, Ph.D., *3 R's of Nuclear Power: Reading, Recycling, and Reprocessing ...Making a Better Tomorrow for Little Joe* (Bloomington, IN: AuthorHouse, 2009), 21.

Reprocessing is the only feasible way to drastically reduce the longevity and radiotoxicity of the massive quantities of spent nuclear fuel that the United States is currently storing without a long-term plan. Without reprocessing, these wastes will persist for millennia and burden future generations with the task of safeguarding them, thus going against the General Will. The timeframe that this waste material will need to be safely stored is unfathomable; it will be impossible to ensure that these wastes do not negatively impact future generations. For this reason, a society guided by the General Will would deem it crucial that spent nuclear fuel is reprocessed so that the high level nuclear waste can be minimized and safely stored for a reasonable amount of time.

Nuclear power also circumvents the primary causing factors of climate change due to the fact that it releases no greenhouse gases. Nuclear power, as with any technology, is not without risks. However, with thoughtful planning, modern reactor designs, and the reprocessing of spent nuclear fuel, nuclear power can provide an ideal source of clean and abundant electricity while steering the United States away from its fossil fuel dependency. The United States cannot idly wait for renewable energy storage technology to advance to the point where it is finally able to meet the majority of electricity demands. Doing so would allow for the negative impacts of climate change to be even greater for future generations and signal a violation of the General Will. A transitional power source is needed to act as an intermediary between carbon-based fuel sources and renewable energy technologies. Nuclear power coupled with spent fuel reprocessing, can fit this niche perfectly by remaining in accordance with the General Will.

Additionally, United States has a large reserve of Uranium that can be tapped into to provide abundant and reliable energy for generations to come. By reprocessing its spent fuel, the United States can greatly extend its fissile fuel supply. As fossil fuel reserves continue to diminish, the cost of and competition for remaining fossil fuels will increase. The people and their General Will have become accustomed to a steady and affordable supply of electricity. Disruptions in this supply or factors that may lead to future disruptions will not be acceptable to a government that bows to the General Will. The United States would do well to remove itself as much as possible from the volatility of the fossil fuel market and focus on clean, domestic sources of energy to avoid disruptions. Once again, nuclear power and reprocessing can meet this demand perfectly.

The United States must alter its nuclear policy; the challenges facing the nation demand it. However, the required changes cannot be achieved in the current dominant market paradigm. I argue that Rousseau's Social Contract offers the proper foundation needed to evoke the necessary changes in nuclear policy. The General Will provides a framework for responsible and responsive government to make the best possible choices for its present and future citizens. Coupled with spent fuel reprocessing, nuclear power can provide an optimal source of power so that the United States can protect its future generations by addressing the serious issue of long-lived nuclear waste, cutting its greenhouse gas emissions, and simultaneously lessening its reliance upon foreign energy sources. A General Will would demand that these crucial problems receive immediate attention due to their potential for crippling the General Will of future generations.

Bibliography

"American Experience . Race for the Superbomb . Elaine Tyler May On: American Reaction to Hiroshima and Nagasaki." *PBS: Public Broadcasting Service*. Web. <http://www.pbs.org/wgbh/amex/bomb/filmmore/reference/interview/tylermay1.html>.

Andrews, Anthony. "Nuclear Fuel Reprocessing: U.S. Policy Development." Federation of American Scientists. Web. <http://fas.org/sgp/crs/nuke/RS22542.pdf>.

Berger, John J. *Nuclear Power--The Unviable Option: A Critical Look at Our Energy Alternatives*. Palo Alto, CA: Ramparts, 1976. Print.

Blees, Tom. *Prescription for the Planet: The Painless Remedy For Our Energy & Environmental Crises*. Charleston, SC: Book Surge, 2008. Print.

Brown, Charles E. *World Energy Resources*. Berlin: Springer, 2002. Print.

Caldicott, Helen. *Nuclear Power Is Not the Answer*. New York: New, 2006. Print.

"Clean Energy Realism : Green Living : Green Power : Green Electricity." *World Nuclear Association | Nuclear Power - a Sustainable Energy Resource*. Web. 15 Nov. 2010. <http://www.world-nuclear.org/why/cleanenergy.html>.

Cohen, Bernard L. *The Nuclear Energy Option: An Alternative for the 90s*. New York: Plenum, 1990. Print.

Cravens, Gwyneth. *Power to Save the World: The Truth About Nuclear Energy*. New York: Alfred A. Knopf, 2007. Print.

Forsythe, Ph.D., Jan. *3 R's of Nuclear Power: Reading, Recycling, and Reprocessing ...Making a Better Tomorrow for Little Joe*. Bloomington, IN: AuthorHouse, 2009. Print.

Friedman, Thomas L. *Hot, Flat, and Crowded: Why We Need a Green Revolution-- And How It Can Renew America*. New York: Farrar, Straus and Giroux, 2008. Print.

Geller, Howard S. *Energy Revolution: Policies for a Sustainable Future*. Washington, D.C.: Island, 2003. Print.

Gillroy, John Martin, Breena Holland, and Celia Campbell-Mohn. *A Primer for Law & Policy Design: Understanding the Use of Principle & Argument in Environmental & Natural Resource Law*. St. Paul, MN: Thomson/West, 2008. Print.

Gillroy, John Martin. *Justice & Nature Kantian Philosophy, Environmental Policy, & the Law*. Washington, D.C.: Georgetown UP, 2000. Print.

Hayden, Howard C. *The Solar Fraud: Why Solar Energy Won't Run the World*. 2nd ed. Pueblo West, CO: Vales Lake Pub., 2004. Print.

Hecht, Gabrielle. *The Radiance of France: Nuclear Power and National Identity after World War II*. Cambridge, Mass: MIT, 1998. Print.

Herbst, Alan M., and George W. Hopley. *Nuclear Energy Now: Why the Time Has Come for the World's Most Misunderstood Energy Source*. Hoboken, NJ: John Wiley & Sons, 2007. Print.

"History: Atoms for Peace Speech." *International Atomic Energy Agency (IAEA): The Nuclear Safety Culture: Strengthening Safety at Nuclear Installations*. Web. <http://www.iaea.org/About/history_speech.html>.

"The History of Nuclear Technology." *ICJT.org*. Web. <http://www.icjt.org/an/tech/zgod/zgod.htm>.

Hore-Lacy, Ian. *Nuclear Energy in the 21st Century: the World Nuclear University Primer*. 8th ed. London: World Nuclear UP, 2006. Print.

"IPCC Fourth Assessment Report: Climate Change 2007 (AR4)." *IPCC - Intergovernmental Panel on Climate Change*. Ed. Rajendra Pachauri and Andy Reisinger. Web. <http://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml >.

Larsson, Mats. *Global Energy Transformation: Four Necessary Steps to Make Clean Energy the Next Success Story*. New York: Palgrave Macmillan, 2009. Print.

Lumetta, Gregg J., Kenneth L. Nash, Sue B. Clark, and Judah I. Friese, eds. *Separations for the Nuclear Fuel Cycle in the 21st Century*. Washington, DC: American Chemical Society, 2006. Print.

Mahaffey, James A. *Atomic Awakening: A New Look at the History and Future of Nuclear Power*. New York: Pegasus, 2009. Print.

Makhijani, Arjun. *Carbon-Free and Nuclear-Free: A Roadmap for U.S. Energy Policy*. Takoma Park, MD: IEER, 2007. Print.

Moniz, Ernest J. *The Challenges to Nuclear Power in the Twenty-First Century*. New York: Kluwer Academic, 2002. Print.

Montgomery, Scott L. *The Powers That Be: Global Energy for the Twenty-first Century and beyond*. Chicago: University of Chicago, 2010. Print.

Montgomery, Scott L. *The Powers That Be: Global Energy for the Twenty-first Century and beyond*. Chicago: University of Chicago, 2010. Print.

Morris, Robert C. *The Environmental Case for Nuclear Power: Economic, Medical, and Political Considerations*. St. Paul, MN: Paragon House, 2000. Print.

Norris, Robert S. *Racing for the Bomb: General Leslie R. Groves, The Manhattan Project's Indispensable Man*. South Royalton, VT: Steerforth, 2002. Print.

Nuclear Energy Agency. *Infrastructure for Nuclear Energy Deployment: Proceedings of an NEA Workshop, Paris, France, 10-11 June 1996*. Paris: Organisation for Economic Co-operation and Development, 1996. Print.

"Nuclear Energy Institute - Nuclear Power Plant Fuel." *Nuclear Energy Institute - Clean-Air Energy*. Web. 6 Apr. 2011. <http://www.nei.org/howitworks/nuclearpowerplantfuel/>.

"Nuclear Power Plant Fuel." *Nuclear Energy Institute - Clean-Air Energy*. Nuclear Energy Institute. Web. <http://www.nei.org/howitworks/nuclearpowerplantfuel>.

Okrent, David. "Comment: Pigford, Shrader-Frechette & the NRC Report on Yucca Mountain Risk: Health, Safety & Environment 9.1." Pierce Law. Web. <http://www.piercelaw.edu/risk/vol9/winter/okrent.pdf>.

Rhodes, Richard. *The Making of the Atomic Bomb*. New York: Simon & Schuster, 1995. Print.

Rousseau, Jean-Jacques. *The Social Contract*. Trans. Christopher Betts. New York: Oxford UP, 2008. Print.

"Solving the Puzzle: Researching the Impacts of Climate Change Around the World." National Science Foundation. Web. <http://www.nsf.gov/news/special_reports/climate/pdf/NSF_Climate_Change_Report.pdf>.

Stanford, George S. "National Policy Analysis #378: Integral Fast Reactors: Source of Safe, Abundant, Non-Polluting Power - December 2001." *National Center for Public Policy Research - A Conservative Organization*. Web. 1 Apr. 2011. <http://www.nationalcenter.org/NPA378.html>.

Tucker, William. *Terrestrial Energy: How Nuclear Power Will Lead the Green Revolution and End America's Energy Odyssey*. Savage, MD: Bartleby, 2008. Print.

United States. Nuclear Regulatory Commission. *Three Mile Island A Report to the Commissioners and to the Public*. By Mitchell Rogovin and George T. Frampton. Vol. 1. Washington, D.C., 1980. Threemileisland.org. Web. <http://www.threemileisland.org/downloads/354.pdf>.

United States. The President's Commission on the Accident at Three Mile Island. *The Report of The President's Commission on the Accident at Three Mile Island*. By John G. Kemeny, Bruce Babbitt, Patrick E. Haggerty, Carolyn Lewis, Paul A. Marks, Cora B. Marrett, Lloyd McBride, Harry C. McPherson, Russell W. Peterson, Thomas H. Pigford, Theodore B. Taylor, and Anne D. Trunk. Washington, D.C., 1979. Threemileisland.org. Web. <http://www.threemileisland.org/downloads/188.pdf>.

"USEC Inc. - Nuclear Nonproliferation - Megatons to Megawatts." *USEC Inc. - A Global Energy Company*. Web. 5 Apr. 2011. <http://www.usec.com/megatonstomegawatts.htm>.

"World Energy Outlook 2008." International Energy Agency, 2008. Web. <http://www.iea.org/textbase/nppdf/free/2008/weo2008.pdf>.

"World Energy Outlook 2008." International Energy Agency. Web. <http://www.iea.org/textbase/nppdf/free/2008/weo2008.pdf>.

Wright, Judith, and James Conca. *The GeoPolitics of Energy Achieving a Just and Sustainable Energy Distribution by 2040*. 1st ed. Charleston, SC: Book Surge, 2007. Print.

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Education

- Ithaca College, Ithaca, New York Graduated: May 2008, Magna Cum Laude
  Major: Environmental Studies, concentration in Environmental Law & Policy
  Minor: Legal Studies
  Cumulative GPA: 3.726/4.000 Program GPA: 3.736/4.000
  Honors: Dean's List – 2005, 2006, 2008

- Lehigh University, Bethlehem, Pennsylvania Graduated: Sept 2011
  M.A. in Environmental Policy Design

- Living Routes "Permaculture at Ecoversidade" study abroad program, Pirenopolis, Brasil
  Summer 2006
  Participated in a hands-on experiential learning course regarding permaculture and green building at the IPEC ecovillage

Experience

Environmental Not-For-Profit Intern, Green Resource Hub of the Finger Lakes, Ithaca, NY August 2007 – May 2008

- Wrote and revised grant for creation of green business database
- Maintained and updated Hub website
- Assisted the programming committee in planning and executing consumer education seminars

Teaching Assistant for Legal Environment of Business I & II, Ithaca College, August 2007 – May 2008

- Aided students with research, writing assignments and exam preparation
- Researched information for scholarly papers my supervisor was submitting for publication
- Offered consistent office hours for extra help and made myself available when called upon by a student

Monster Remotes, Cranford, New Jersey, Director of Operations, December 2008 – present

- Tracked outgoing and incoming rental equiptment
- Oversaw daily running of office environment
- Interacted with clientele to ascertain their specific needs

Law Intern, Lama Law Firm, Ithaca, NY, June – August 2007

- Conducted legal research for current cases
- Interviewed new clientele
- Delivered court documents

Teach For America 2008 Corps Member, Denver Corps, May 2008 – August 2008: Emergency leave of absence granted after both my parents were killed in an auto accident in August. I had to leave the corps and move back to New Jersey to care for my younger brother.

- Taught eighth grade Chemistry at Yes Prep Central summer school program in Houston Texas
- Participated in Teach For America's summer long, intensive training institute
- Developed year long, unit, and lesson plans for curriculum.
- Developed year end, unit, and lesson assessments for curriculum
- Aligned curriculum to state education standards
- Passed the Praxis II Science and Praxis II Elementary Education tests

Fifth Grade Teacher, Vanguard Classical School, Denver Colorado, July 2008 – August 2008: Emergency leave of absence, see aforementioned.

Resident Assistant, Ithaca College, Ithaca, NY, August 2005 – June 2007

- Shaped the social dynamic between residents in dormitory and resolved conflicts
- Organized activities for residents at regular intervals throughout semesters
- Enforced college policy and educated residents about responsible behavior
- Relayed information pertaining to atmosphere of dormitory dynamic to Residence Director
- Informed residents of available on campus resources and activities