Nuclear Power's Emission Reduction Potential in Utah

by
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Abstract

In the spring of 2007, Utah signed onto the Western Climate Initiative (WCI), pledging to meet an aggregate GHG emission reduction goal of 15% below 2005 levels by the year 2020. This followed closely on the heals of the release of the Blue Ribbon Advisory Council on Climate Change's Final Report, which identified 72 different options Utah could potentially undergo to reduce state-wide emissions. These potential mitigation actions where analyzed focusing on Utah specific costs and benefits, feasibility, and emissions reduction potential, with the outcome of turning those options into viable State policies sorted by priority and costs.

One such policy option was the possibility of building the State's first commercial nuclear power plant. Four separate categories that encompassed Utah's history with nuclear and general U.S. nuclear capabilities were researched before a recommendation could be made. First were the political issues including Utah citizens' past experiences with nuclear bomb fallout, the near avoidance of storing nuclear waste on an in-state Indian reservation, the development of a permanent nuclear waste storage in a neighboring State and the Nuclear Regulatory Commission's permitting and licensing scheme for new nuclear plants. The next category analyzed was the economical costs and benefits building a nuclear plant would impose on Utah. The third category and the one most in support of continuing nuclear power plant construction in the U.S. was recent technological progress. This section detailed new plant designs, as well as highlighting the advanced plant safety features and shorter construction timelines. The last and possibly most important category was assessing whether or not Utah's environment was able to sustain a nuclear plant's intense water demands throughout its lifetime.

After a Utah specific assessment it seems that if a utility can get past the political opposition, the other three sectors combined allow for the feasibility of building a commercial nuclear power plant. Unfortunately it would not be completed in time to make an impact on emissions levels before the WCI deadline. Therefore while the policy recommendation states that building a nuclear power plant in Utah would be beneficial for GHG emission reductions, only if the WCI enforces a second goal past 2020, would building a nuclear plant aid in the mitigation goals.

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Table of Contents

Introduction

According to the Intergovernmental Panel on Climate Change (IPCC), global greenhouse gas emissions (GHG) due to human activities have grown 70% between 1970 and 2004. In particular, annual emissions of carbon dioxide (CO2) increased approximately 80% from 1970 to 2004. The increases in global CO2 concentrations are primarily due to fossil fuel use (IPCC, 2007). In 2005 alone, 2,162.4 million metric tons (mmt) of CO2 was emitted by U.S. coal energy consumption processes; coming in second only to petroleum fuel source emissions at 2,597.1mmt CO2 (Emissions, 2007). The IPCC is at least 90% confident that climate change has already greatly impacted North America. North America has undergone both localized, severe economic damages, as well ecosystem, social and cultural disruption due to weather related extremes including severe storms, floods, droughts, heat waves and wildfires. The IPCC has the same percentage of confidence that climate change will negatively affect North America's already over-allocated water resources, increasing competition amid agriculture, municipal, industrial and ecological uses (Field, 2007).

As the effects of climate change are being realized, individual states are grouping together, cooperatively pledging to reduce their state's anthropogenic GHG contribution by considerable levels. The most recent state coalition is the Western Climate Initiative (WCI). Founded in February of 2007 by the Governors from Arizona, California, New Mexico, Oregon and Washington, the WCI set both individual state short and long term GHG emissions reduction goals and an aggregate reduction goal of 15% below 2005 levels by the year 2020 (Western, 2007). To date, two Canadian provinces and the state of Utah have also signed onto the WCI.

Utah's journey towards improving their climate change stewardship began on August 25, 2006 when Governor Jon M. Huntsman Jr. and the Department of Environmental Quality (DEQ) established the Blue Ribbon Advisory Council on Climate Change (BRAC) to provide an opportunity for government, industry, environment and community representatives to identify proactive measures Utah could implement if Utah decided to mitigate its GHG contributions. The stakeholder working group initially devised over 100 different mitigation policy options from all sectors that were reviewed and whittled down to 72 in the final BRAC report. Stated in the final BRAC report, the Energy Supply sector evaluated policy options that would reduce GHG emissions from the generation and transmission of electricity, and the extraction and transmission of oil and gas. This sector accounted for 26 percent of Utah's gross GHG emissions in 2005, excluding electricity exports [electricity created in Utah and transmitted for use in California]. The two policy strategies that have the largest potential to reduce GHG are encouragement of renewable energy resources and development of Carbon Capture and Sequestration (CCS) technologies (Blue, 2007). Soon after the BRAC report was released in May 2007, Utah became the sixth state to join the WCI, placing the Division of Air Quality in charge of helping to determine which of the BRAC report's policies and program options to document and reduce current and future GHG emission are feasible and economical

The U.S. Census Bureau predicts that from 2000 to 2030 the combined states in the Arid West, including Utah, are expected to increase their population at a rate not quite twice that of the national average, at 45.8% and 29.2% respectively (Percent, 2004). The western region is expected to maintain an increase in population greater then 6% through 2030, the highest augment of all four U.S. regions (Figure 1). The 2000 Census ranked the five fastest growing states in the nation as (1) Nevada, (2) Arizona, (3) Colorado, (4) Utah and (5) Idaho. The only state not bordering Utah is Wyoming, which ranked 32nd (Utah's Water Resources, 2001). Utah alone is expected to increase its population from 2,233,169 people recorded in the 2000 census to 3,485,367 people by July of 2030, an increase of 56.1% (Table 1). Utah's projected swell in population is concerning, particularly if energy consumption continues to increase linear with population growth. Population increased by 890,430 people between 1980 and 2003, an average annual growth of only 2.1%. But the energy consumption increased by 220 trillion British Thermal Units (Btu) from 1980-2001, an average annual increase of 1.7%. To put that into electricity terms, during the same time period, electricity consumption increased by 12,502 million kilowatt-hours (kWh), an average annual increase of 3.8%. Furthermore, of that increase in energy demanded, less then 1% was generated by non-hydroelectric renewable energy (Utah Energy, 2008). 2002 data shows a capacity total of 329,855 kW from renewable energy sources, most of which from hydrological and geothermal plants, with 284,729 kW and 39,300 kW respectively (Number, 2002).

Figure 1. Percent Change in Population by U.S. Region (Percent, 2004)

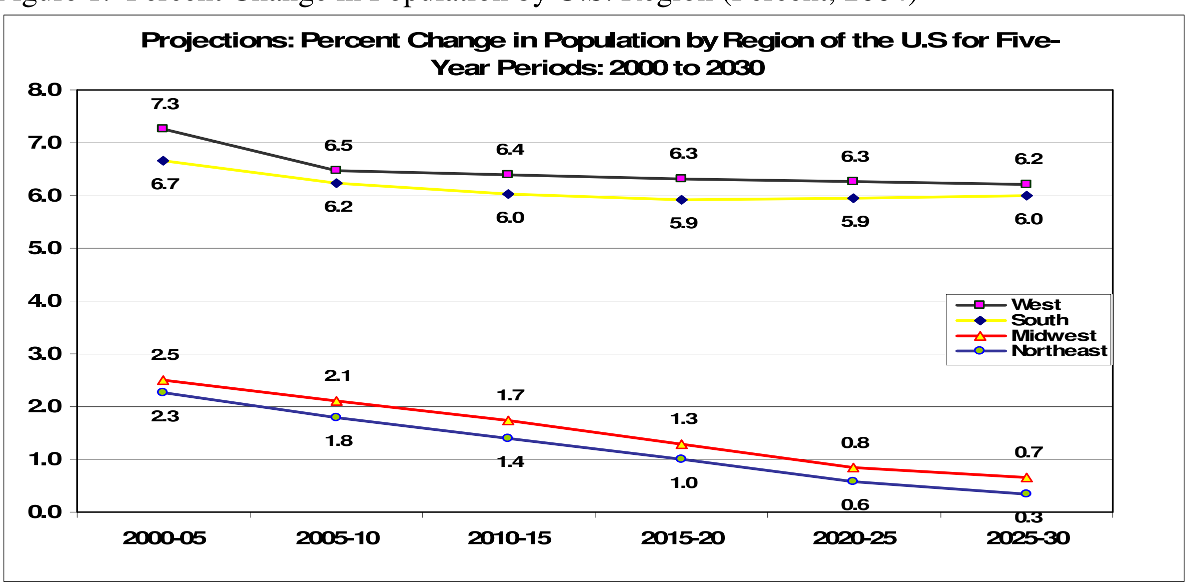


Table 1. Projections: Total Population for Regions, Divisions, and States: 2000 to 2030 (Percent, 2004)

Region, division, and state	Census April 1, 2000	Projections July 1, 2005	Projections July 1, 2010	Projections July 1, 2015	Projections July 1, 2020	Projections July 1, 2025	Projections July 1, 2030
United States	281,421,906	295,507,134	308,935,581	322,365,787	335,804,546	349,439,199	363,584,435
Mountain Total	*18,172,295*	*20,005,440*	*21,740,479*	*23,585,039*	*25,557,049*	*27,668,947*	*29,909,432*
Montana	902,195	933,005	968,598	999,489	1,022,735	1,037,387	1,044,898
Idaho	1,293,953	1,407,060	1,517,291	1,630,045	1,741,333	1,852,627	1,969,624
Wyoming	493,782	507,268	519,886	528,005	530,948	529,031	522,979
Colorado	4,301,261	4,617,962	4,831,554	5,049,493	5,278,867	5,522,803	5,792,357
New Mexico	1,819,046	1,902,057	1,980,225	2,041,539	2,084,341	2,106,584	2,099,708
Arizona	5,130,632	5,868,004	6,637,381	7,495,238	8,456,448	9,531,537	10,712,397
Utah	**2,233,169**	**2,417,998**	**2,595,013**	**2,783,040**	**2,990,094**	**3,225,680**	**3,485,367**
Nevada	1,998,257	2,352,086	2,690,531	3,058,190	3,452,283	3,863,298	4,282,102

As Utah's population continues its growth spurt, it is imperative that new sources of energy be constructed to meet the state's growing needs. Currently, renewable energy sources play such a small role in Utah's energy portfolio, leaving carbon intensive natural gas and coal power plants to meet demand. Utah has considerable fossil fuel energy sources, including three of the nation's 100 largest oil fields and two of the U.S.'s 100 largest natural gas fields (Energy State, 2008). Even so, coal fired power plants remain the dominate provider of electricity at 95% of total generation (Utah Coal, 2003). Coal's supremacy of net electricity generation is tremendous. In 2006 alone, 35,668 gigawatt-hours (GWh) of electricity were generated from coal power plants, followed by 2,965 GWh from natural gas and 30 GWh from petroleum (Net Generation, 2006). Those power plants combined have already emitted impressive amounts of GHG. Table 2 shows the EPA estimated CO2 emissions based on energy consumption for each of Utah's five sectors: commercial, industrial, residential, transportation and electric power. Each year, the CO2 emissions from the electric power sector accounted for over half of the state's total CO2 emissions. As for the other GHGs, in 2006 the electric power industry emitted 33,912 metric tons of sulfur dioxide and 69,463 metric tons of nitrogen oxides (Energy State, 2008). To meet increasing electricity demand, the building of two more coal power plants has been proposed. The Sierra Club has estimated the yearly potential CO_2 emissions for each of the plants: Deseret Power's proposed waste coal 110 MW Bonanza plant is estimated to emit 715,000 metric tons of CO_2 per year; and NEVCO's 270 MW Sevier Power Project is estimated at 1,755,000 metric tons CO_2 per year. Add to that the three proposed supercritical coal plants in Nevada (total est. 34,100,000 tons CO_2 per year), and Wyoming's proposed a total of six new plants: two supercritical coal, one IGCC, one pulverized, one waste coal and one coal to liquids plant (total est. 21,222,500 tons CO_2 per year), the GHG emissions produced in and around Utah will continue increase at a dramatic rate (Stopping, 2008).

Table 2. CO_2 Emissions from Fossil Fuel Combustion, million metric tons ($MMTCO_2$) (Energy CO_2, 2008)

State	Sector	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Utah	Total	56.93	57.14	57.86	60.45	62.31	61.05	63.79	61.76	61.18	61.76	64.38
	Commercial	1.89	1.84	2.00	2.16	2.18	2.20	2.05	2.22	2.54	2.12	2.41
	Industrial	8.93	10.11	9.56	10.15	11.21	8.89	10.31	9.29	6.33	6.54	7.74
	Residential	2.89	2.86	3.12	3.39	3.25	3.24	3.28	3.40	3.58	3.25	3.62
	Transportation	11.91	12.91	13.48	14.06	14.29	14.79	15.63	14.99	15.56	15.70	16.45
	Electric Power	**31.31**	**29.42**	**29.70**	**30.68**	**31.38**	**31.92**	**32.51**	**31.87**	**33.17**	**34.15**	**34.16**

Considering the relatively short time frame Utah has to comply with the WCI emission reduction goals, the addition of traditional coal power plants to meet future electricity demand will be counterproductive, and possibly even derail Utah's reduction efforts. Utah's gross GHG emissions are projected to climb to 96.1 $MMtCO_2e$ per year by 2020, 95% above 1990 levels (Blue, 2007). Meeting the WCI goal is more then just reducing Utah's current energy consumption. While some of the policy options being analyzed do focus on energy efficiency and reducing public and private use, the predicted increases in state population and energy demand will also require policy recommendations detailing how to generate electricity while emitting fewer GHG. One policy option being considered to help Utah meet the WCI emission reduction goals is to develop and build a nuclear power plant. Formally called ES-15 in the BRAC report, adding nuclear power plants was assigned medium priority and received 14 out of 22 supporting votes during the final BRAC policy decision making. Nuclears' priority level was established based on consideration of the amount of CO2 reduction potential, the criticality of the option to enable the related reduction pathway, the apparent cost/benefit, and the implementation time horizon (long-term vs. short-term). The bin ranking was assigned after consideration of cost (dollar amount, effort, and benefits,) and political and technical feasibility. Some of the energy policy options with more votes then nuclear were carbon capture and sequestration R&D (20 votes), efficiency improvements (18), creating a renewable portfolio standard (17), landfill gas/waste to energy that yield carbon reduction benefits (17) and retrofitting plants w/CO2 capture technology (15) (Blue, 2007)

The BRAC gives the following thoughts regarding the evaluating nuclear power's WCI potential. "Nuclear energy has a potential to provide substantial carbon emission reductions. "Nuclear energy should be evaluated as part of our long-term energy strategy (with due consideration of responsible waste disposal);" and "Although there has been some renewed interest in nuclear because of its low carbon emissions, the questions about waste disposal and safety make it unlikely that nuclear energy development will result in near-term reductions in CO2" (Blue, 2007). The average nuclear power plant, when compared to the average size coal plants, avoids the annual emissions of approximately 10,000 tons of nitrogen oxides, 32,000 tons of sulfur dioxide and 7 million metric tons of carbon dioxide (Nuclear Power Plant, 2008).In determining whether to recommend the policy option of building a nuclear power plant in Utah, four main potential barriers (political, technological, economical and environmental concerns) have to be researched and evaluated to determine if collectively, there would be no overall significant barriers to nuclear power.

Political

One of the biggest political concerns is the potentially negative impacts that building a nuclear power plant could have on the health of Utah's citizens. Radiation poisoning and related illnesses from contact with spent fuel, or exposure to radiation leaks at a nuclear plant or storage facility are huge public concerns. These concerns are persistent whether discussing fuel transportation, spent fuel storage and even the daily operation of nuclear power plants themselves. People's faith in the protective safety mechanisms for nuclear power plants was shattered late April 1986, with Ukraine's Chernobyl nuclear power plant meltdown. On April 25th prior to performing a low power turbine electricity generation test, a series of operator actions where performed, which included disabling the automatic shutdown mechanisms. In turn the coolant water decreased, increasing the power output. As the operator attempted to shut down the reactor, a peculiarity of the plant design caused a dramatic power surge, resulting in an explosive blast of steam lifting the cover plate off the reactor, releasing fission products into the atmosphere. The introduction of air into the core led to the graphite moderator bursting into flames and burned for nine days. The burning is responsible for the main release of radioactivity into the environment. The accident destroyed the reactor and initially killed 30 people, 28 of which were caused by radiation or thermal burns in the first four months afterwards. A further 209 people on site and involved in the clean up were treated for acute radiation poisoning. 19 of these people subsequently died throughout the years from effects attributable to the accident. An additional nine deaths from thyroid cancer have also been linked to radiation, totaling, as of 2004, 56 radiation related fatalities (Chernobyl, 2007). Regardless of the fact that this disaster is the only accident in the history of commercial nuclear power where radiation-related fatalities occurred (Chernobyl, 2007), it can be seen as one of the significant factors contributing to the concern of public radiation poisoning, a considerable barrier to gathering support for building new nuclear power plants. Because of this fear of radiation exposure from either nuclear meltdown or general plant operations, people do not want to live in close proximity to a nuclear power plant. However, according to the Oak Ridge National Laboratory, Americans living near coal-fired power plants are exposed to higher radiation doses then those living near nuclear power plants that meet government regulations. A fact not often discussed when describing coal plant emissions is the fact that releases from coal combustion contains naturally occurring radioactive materials, in the form of uranium and thorium (Gabbard, 1993). At least 73 elements found in coal-fired plant emissions are distributed in millions of pounds of stack emissions each year. They include: aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chlorine, chromium, cobalt, copper, fluorine, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, selenium, silver, sulfur, titanium, uranium, vanadium, and zinc (Gabbard, 1993).

Regardless of the potential radiation risks from a nuclear accident, nuclear power plants are still being built worldwide for reasons beyond basic electricity protection. Nuclear plants do not contribute to climate change in the sense that during electricity generation they create neither carbon dioxide emissions nor notable amounts of sulfur dioxide, nitrogen oxides or particulate matter due to the lack of fossil fuel burning during the heating process (EIA, 2008). The minimal GHG emissions produced by nuclear power plants compared to coal, oil, and natural gas power plants makes increasing nuclear power a very tempting option for states looking to lower the GHGs emitted from their electric sector without reducing generation capacity (Table 3).

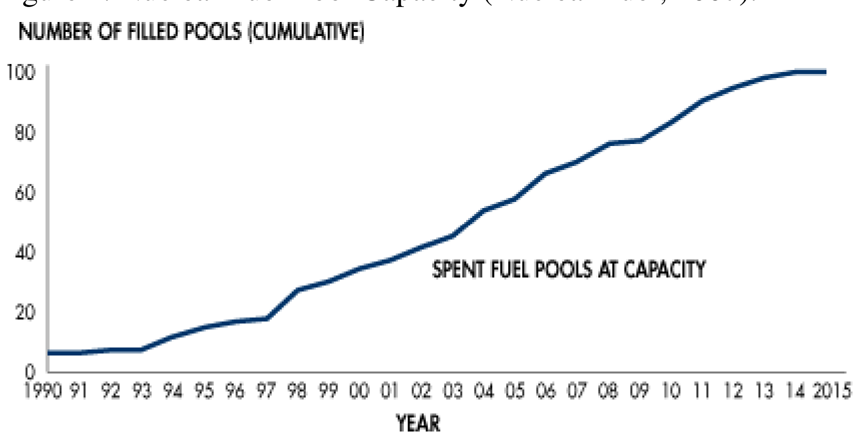
Table 3. Average Emission Levels in the Production of 1 MWh of Electricity (Pounds of Emissions per MWh) (Air Emissions, 2000)

	Coal	Oil	Natural Gas	Nuclear
Carbon Dioxide	2249	1672	1135	0
Sulfur Dioxide	13	12	0.1	0
Nitrogen Oxides	6	4	1.7	0

This is not to say that nuclear power plants are waste free. The waste that nuclear power plants do create is in the form of solid waste, spent fuel, some process chemicals, steam, and heated cooling water (EIA, 2008). Spent fuel is uranium-bearing fuel elements that have been used at commercial nuclear reactors and are no longer producing enough energy to sustain a nuclear reaction. Once the spent fuel is removed from the nuclear reactor it still generates significant amounts of radiation and heat (Transportation, 2007). Fortunately, the volume and mass of waste is small relative to the amount of electricity produced (EIA, 2008). To try to put this in perspective, one of the part owners of the Palo Verde nuclear plants, PNM of New Mexico, states that if all the electricity used throughout one person's life was produced solely by nuclear power, that person's share of waste from nuclear facilities would fit in a soda can (Palo Verde, 2002). This is because of the immense energy given off during nuclear fission. An average value for thermal energy of coal is approximately 6.150 kWh per ton. The thermal energy released in nuclear fission produces about 2x10E9 kWh per ton (Gabbard, 1993). This translates to a single nuclear reactor fuel pellet, one cm long, able to produce the same amount of electricity as 1.5 metric tonnes of coal (Norman, 2007). Nuclear power creates approximately 0.006 lbs of spent fuel per MWh. A typical nuclear power plant's generating capacity is 1000 MW, which if operated 91% of the time would produce 45,758 lbs of waste per year, slightly less then 23 tons. If a similar capacity of electricity was generated from a coal plant, with on average 10% ash content in the coal, more then 300,000 tons of ash, pre scrubbers would be produced. The ash remnants from burned coal often include metal oxides and alkali, which generally requires disposal by burying in a land fill. Coal plant scrubbers are highly successful in removing the ash from coal plant emissions, but the process results in an even larger volume of limestone solid waste then the volume of ash removed (EIA, 2008).

As aforementioned, there is unease surrounding the safety of nuclear waste disposal. Waste from nuclear power plants is viewed as dangerous to the environment because of its hazardous material status. However, the waste is managed from the time it is removed from the power plant to its disposal by the plant that created it. This is markedly different in fossil fuel plants where large a portion of their wastes, in the form of GHGs and particulate matter, are unmanaged after they are emitted through the smoke stacks (EIA, 2008). Every twelve to eighteen months one fourth to one third of a nuclear plant's total nuclear fuel load becomes spent, is removed from the reactor, and replaced with fresh fuel (Spent Fuel, 2007). There are two storage options for spent fuel rods. Most spent fuel rods are stored in spent fuel water pools at the nuclear reactor site where it was generated. The purpose of the water is to remove any remaining heat generated by the spent fuel and act as a radiation buffer to the ambient environment (Spent Nuclear, 2007). To shield the plant workers from radiation, the spent fuel rods are moved into the water pools from the reactor via water canals and placed under a minimum of 20 feet of water. If the pools reach capacity, above ground dry storage caskets are used. Spent fuel that has been cooled in the aforementioned pools for a minimum of one year can be removed, surrounding by inert gas inside a container called a cask. The casks are steel cylinders that are either welded or bolted closed once the fuel is in place, providing a leak tight containment. Each cylinder is then surrounded by additional steel, concrete or other material that will serve as a radiation shield to workers and the public alike. The casks are then placed into the dry cask storage system. Dry cask storage systems either remain onsite or are moved to an interim facility located at the Idaho National Environmental and Engineering Laboratory. The dry casks are becoming more abundant as more and more spent fuel pools are reaching capacity (Figure 2) (Dry Cask, 2007). The transportation of spent fuel casks is also becoming more prolific through time. The U.S. Nuclear Regulatory Commission (NRC) states that over the past 30 years thousands of shipments of spent fuel have been made throughout the U.S. without causing any radiological releases to the environment or harm to the public. Most of these were done between different reactors that were owned by the same utility as a means of sharing storage space, while other transfers have been to research facilities that perform tests on the spent fuel itself (Transportation, 2007).

Figure 2. Nuclear Fuel Pool Capacity (Nuclear Fuel, 2007).



Due to the impending need for a secure, large scale, permanent spent fuel storage location, a deposit site 90 miles Northwest of Las Vegas, Nevada called Yucca Mountain, has been studied since 1987 and has been in development since 2002. At that time Congress approved Yucca Mountain as a final storage facility for 77,000 tons of the nation's most radioactive military, industrial, and commercial waste. Since then the Energy Department has proposed increasing the volume to 150,000 tons to compensate for the continuing waste production from nuclear power plants (Ritter, 2008). The Energy Department official in charge of the Yucca project has projected 2017 as the earliest that the storage site would open, and with a price tag of $77 billion (Ritter, 2008). In the mean time, nuclear power plant waste is stored in 126 sites in 39 different states. Presently there is only one nuclear waste storage site in Utah, a TRIGA (Training, Research, Isotopes, General Atomics) Mark I plant owned by the University of Utah. This operating reactor is used for research and educational training purposes (Waste Locations, 2007).

Because of the scattered location of the nuclear waste storage sites, eight electric utilities, whose energy portfolios includes nuclear power, formed a limited liability company called Private Fuel Storage (PFS) to locate and license a centralized interim nuclear waste storage facility to be used until the federal government's permanent storage site was available. These utilities originally included Xcel Energy, Genoa Fuel Tech, American Electric Power, Southern California Edison, Southern Nuclear Company, First Energy, Entergy, and Florida Power and Light (Jack, 2005). PFS was set up as a limited liability corporation so should an accident occur during transportation, storage or removal, the utilities making up the association would not be legally or financially liable (Keller, 2001). PFS chose the small Skull Valley Band of Goshute Indians Reservation for their storage location. In May of 1997 tribal leaders initially convinced of the safety provided by nuclear waste repository technology by Leon Bear, who at the time was the Executive-Committee Chairman of the Skull Valley Goshutes, agreed to lease 40 acres to PFS to store 40,000 tons of commercial high level radioactive waste for a 20 year period, with an additional 20 year renewal option. In June of that year, with approval granted the following year, PFS applied to the NRC's Atomic Safety Licensing Board for the permits required to build the storage facility. The waste would be kept in above ground concrete vaults until Yucca Mountain's permanent storage facility was available. Upon completion the waste would be transported to its final, permanent storage site. While the exact value was not disclosed, each member of the tribe was expected to be given over $100,000. Tooele County, where Skull Valley is located, was also expected to benefit financially, as PFS agreed to pay the county $500,000 a year in lieu of property taxes and $3,000 for each cask brought to the sight. The county was also going to receive money prior to the completion of the facility to fund education. Heavy opposition to this plan was spearheaded by then governor Michael Leavitt, who formed a special task force called the High Level Nuclear Waste Storage Opposition office aimed at stopping the Skull Valley nuclear waste dump project. The opposition was joined by over half of the Goshute tribe members themselves in early 1999, joining a lawsuit against the Department of Interior's Bureau of Indian Affairs to overturn the lease agreement using the claim that the federal government failed to look after the wellbeing of the entire tribe (Keller, 2001).

In Utah, resistance for developing Skull Valley was closely linked to a person's support for Yucca Mountain's development. Many people feared that Skull Valley would turn into a permanent storage facility. As it currently stands, Yucca Mountain will not be able to house all of the nations spent fuel and radioactive military waste. The NRC estimates, as of December 2005, there was 53,440 metric tons of spent nuclear fuel waste, with an additional 22,000 canisters of defense-related solid radioactive waste. This amount would fill Yucca Mountain almost to capacity, meaning that either Yucca will have to be expanded before any waste is deposited there, or a second permanent storage facility will be needed almost immediately to house the growing supply of nuclear waste. By 2035, the total amount of nuclear waste is expected to increase to an estimated 119,000 tons (How Much, 2007). Moving nuclear waste twice, once to Skull Valley and then to Yucca seemed unlikely. By some statements, Utah officials dropped their original opposition to Yucca when they realized that if the facility wasn't completed soon, Skull Valley would be the only viable, permanent storage alternative (Mountain, 2002). Even if Yucca was completed, it was feared that Skull Valley would still be utilized as a supplement when the mountain site was full. Also, once a utility sends its waste to Skull Valley, it can shut down its nuclear power reactors and decommission the power plant. If that is to occur, the spent nuclear fuel could not be returned to the power plant location, and if Yucca Mountain was to be left incomplete, or be built and lack sufficient capacity, the spent waste would be stuck at Skull Valley (Draft, 2002). Popular belief held that since the waste was not created in Utah, it should not be housed there either. Goshute tribe member Bear however claims that the Goshutes are facing environmental in-justice by not being allowed to use their own land to gather financial support, and maintained that after the PFS contract ended the waste would not stay onsite if it was against the tribe's wishes. Legally, Utah has no jurisdiction over the Goshute's land according to the treaty of 1863, which granted the tribe sovereignty over their land (Keller, 2001).

Since the State has no authority over Skull Valley, revoking PFS's permit would prove to be a struggle. After a decades worth of permitting battles, in 2006 president Bush signed the Fiscal Year 2007 Defense Authorization Bill which included a provision that created the Cedar Mountains Wilderness Area in Utah. This blocked the preferred route for a 30 mile railway extension that PFS required to deliver the nuclear waste to Skull Valley (Utah Wilderness, 2006). In order for PFS to continue with the Skull Valley storage facility they had to find an alternative transportation method which required the Bureau of Land Management (BLM) to issue a right of way (Bennett, 2006). Around the same time Southern Company completely withdrew from PFS and Xcel Energy determined it no longer needed Skull Valley and would not provide further funding for the storage facility (Jack, 2006). In late 2006 not only did BLM deny the right of way to transport high level nuclear waste to Skull Valley but also the Bureau of Indian Affairs denied the lease for a nuclear waste storage facility on Indian trust lands (Bennett, 2006). These measures combined effectively preventing the land from turning into a nuclear waste storage facility.

While Utah politicians were given the majority of the credit for stopping the development of Skull Valley, citizens also played a vital part in its defeat. In particular, joining the political opposition to developing Skull Valley was a group of citizens called the Downwinders, who have personally been harmed by nuclear activities preformed by other states. The Downwinders earned their name from the description of the location of the residents living in the prevailing wind pattern surrounding the Nevada Test Site in southwest Utah. This area was consistently exposed to radioactive fallout from the nuclear tests conducted in Nevada (About Downwinders, 2007). Between 1951 and 1963 there was more then 100 above ground nuclear tests in Nevada (Spangler, 2001). The actual rate of cancer exposure varies throughout the numerous studies that have been published on this topic. One of the best ways to conceptualize the incidents of increased cancer exposure is to look at the claims filed against the government for nuclear fallout exposure compensation (Table 4). On October 5, 1990 Congress passed the Radiation Exposure Compensation Act (RECA) to provide compensation to individuals who developed certain cancers and other serious diseases due to their radiation exposure. People who can be considered for RECA are individuals who resided or worked downwind of the Nevada Test Site, workers who participated in above ground nuclear weapons tests and uranium mine workers. For Downwinders in particular, a payment of $50,000 is available to an eligible individual who was physically present in one of the affected areas: the Utah counties of Beaver, Garfield, Iron, Kane, Millard, Piute, San Juan, Sevier, Washington, and Wayne; during the period from January 21, 1951 to October 31, 1958 or June 30, 1962 to July 31, 1962 (Radiation Exposure, 2004).

Table 4. Summary of Radiation Exposure Compensation Claims as received by 2 Nov 2008 (Radiation Exposure, 2004).

Claim Type	Pending	Approved	% Approved/ of Disposed	$ Approved	Denied	Total
Downwinder	*406*	*11,809*	*77.9*	*$590,420,000*	*3,356*	*15,571*
Onsite Participant	69	1,175	44.6	$83,895,573	1,461	2,705
Uranium Miner	186	4,745	63.1	$473,774,560	2,780	7,711
Uranium Miller	55	1,063	79.5	$106,300,000	274	1,392
Ore Transporter	17	222	73.8	$22,200,000	79	318
Total	**733**	**19,014**	**70.5**	**$1,276,590,132**	**7,950**	**27,697**

The negative health repercussions from Nevada's nuclear testing fallout helped to raise Utah resident's opposition to storing nuclear waste, with a fear of the possibility of leakage. And there are places in the U.S. where stored nuclear waste has leaked, contaminating ground water and the surrounding ecosystem. The biggest U.S. nuclear waste leak is located at the Hanford Nuclear Complex in Southeast Washington State. Originally created in 1943 as part of the Manhattan project to produce plutonium for use in the bomb dropped on Nagasaki, by 1963 the site developed into the home of nine nuclear reactors making plutonium, one of which was also used to made steam for generating electricity (Hanford History, 2008). Since its closing in 1989, 55 million gallons of high level radioactive sludges, salts and liquid wastes were stored in 177 underground tanks. The Department of Energy states that at least 68 tanks have already leaked as of 1998, with the potential of an additional 81 tanks springing a leak. Those 81 tanks all have single shells and all are expected to leak at some point (Wald, 1998). The most recent spill at Hanford occurred just this past July when a pump used to remove radioactive waste from a leaking tank to a new double walled tank less likely to leak became clogged spilled an estimated 50 to 100 gallons (Clogged, 2007). Besides the immediate health hazard from any spillage directly contaminating workers or being evaporated and transported by the wind to the nearby population, the waste leaking from the underground tanks is slowly making its way toward the Columbia River (Murphy, 2000). While Hanford is primarily filled with military nuclear waste, it is a prime example of a nuclear waste storage system failing to maintain its integrity over time and needing to be transferred to another storage facility. This further illustrates that safely storing nuclear waste is a never ending process, and it is not likely that there will ever be a one hundred percent guaranteed safe permanent storage facility.

Nuclear power plants and their ensuing waste is presently a hotly contested issue in Utah. Referring back to the recent 2006 defeat of using Skull Valley as a nuclear waste storage site, it is clear that the majority of Utah's citizens do not want nuclear waste in their "backyard", which is exactly what would happen if a nuclear plant was built. The Downwinders and their families have already been personally injured by nuclear activity which has helped to raise State awareness, and even opposition towards nuclear power. Overall, the politically based nuclear power concerns are strong against building a nuclear plant in Utah, regardless of the ease that the Federal Government has made the politics and requirements of nuclear plant permitting and licensing.

Originating in 1956, the NRC new nuclear plant licensing was a two step process. First the utility had to apply for a construction permit, based on a preliminary plant design. Safety issues were not completely resolved until the plant was almost fully constructed, usually because plant regulations were able to be changed during plant construction, requiring major retrofitting after the plants completion. Also, because of the last minute construction changes, the public was not given access to design details until the plant was nearly completed. Once the plant neared completion the utility had to apply for an operating license, which was a permit granting the plant the ability to become functional and produce electricity. During the operating license reviewing phase public litigation regarding plant construction was permitted. While the litigation hearings took place, a completed plant would be left to sit idle for months or even years. This cost the utilities additional large sums of money as they had to pay the interest on the construction loans for their idle plants when they should have been earning revenue. Some utilities could not afford the delays and abandoned nearly finished nuclear plants. The old licensing process created delays that would end up doubling or even tripling a plants total cost (Testa, 2007). The last completed nuclear reactor (1996), Watts Bar 1 in Tennessee, took 24 years to complete (Nuclear Power, 2003). The permitting process was so difficult and costly, that it is blamed as one of the main reasons for halting the planning and construction of new nuclear plants in the U.S.

In 1989 the NRC redid the licensing procedures to speed up the process, and created the 10 CFR Part 52. Congress acknowledged and strengthened the new licensing process in the 1992 Energy Policy Act (Licensing New, 2007), establishing the permitting procedure to be used if/when nuclear plants start being built again in the U.S. The new processes allow for a utility to design and license and then build and operate. The public hearing for litigation will now take place well ahead of construction, allowing utilities to no longer worry about losing money daily on a compete but idle plant (Testa, 2007). The new structure is now a three stage process: the reactor design certification, the early siting permit (ESP), and the combined construction and operating process (COL). The reactor design certification process is when the plant designers secure advance NRC approval of the nuclear plant designs. Later on, utilities can order those certified plant designs, license them for a particular site and build and run them. Once a design certification application has been submitted, the NRC predicts it will take between 36 and 60 plus months to complete the review and rulemaking. To date, the NRC has certified four advanced plant designs, including General Electric's Advanced Boiling Water Reactor (ABWR) and Westinghouse's AP1000. GE's Economic Simplified Boiling Water Reactor (ESBWR) is under NRC review, while the AREVA intends to submit for design review in the upcoming months (Licensing New, 2007). The ESP is granted when a utility researches the site for a future nuclear power plant and seeks the NRC permit approval for the safety of the site (New Nuclear, 2007). ESP applications have three parts, a site safety analysis, an environmental report and emergency planning information. During this time, the federal, state and local government officials as well as the public have opportunities to participate in each of the three parts (Licensing New, 2007). This permit takes into consideration the proposed sites potential flooding, wind and snow loads, hurricanes, tsunamis and seismic activity. In Utah, for example, seismic activity is of particular interest for ESPs. In 1995 80% of Utah's population lived within six to ten miles of the Wasatch Fault Zone, a number which has increased over the years as Utah's population grows (Programs, 1995). Moderate, potentially damaging earthquakes (magnitude 5.5 to 6.5) occur on average every 10 to 15 years in. The largest earthquakes expected in Utah (magnitude 7.0-75) take place roughly every 150 years (Earthquakes and Utah, 1997). Earthquakes are possible almost everywhere in Utah but most, including the larger ones, are more likely to occur in the Intermountain Seismic Belt which extends from Montana to Northern Arizona. The Wasatch fault presents the greatest risk to Utah citizens. The 240 mile long fault extends from Malad City, Idaho to Fayette, Utah (Earthquakes and Utah), and is roughly 100 miles wide extending north-south along the Wasatch Front, through Richfield to Cedar City and St. George (Earthquakes, 2007). When applying to an ESP permit, citing an area farther away from the seismic belt is vital for permit approval. Overall, ESPs attempt to be all encompassing, as it even looks at public safety issues from an emergency planning point of view. However this permit does not allow for actual construction (Testa, 2007). Developing an ESP application takes between 12 and 24 months, depending if the site is a Greenfield or adjacent to an existing nuclear facility. Once developed and submitted, the NRC review process and public hearing takes approximately 33 months (Licensing New, 2007).

Both design certification and early site approval can be done years in advance of plant construction. ESP can actually "bank" sites approved by the NRC for up to 20 years, and build when the time is right (Licensing New, 2007). As for Utah meeting its emission reduction goal, this is particularly important. Utah can start looking for early sites any day now and have them approved, that way if they do decide to build a nuclear power plant; some of the licensing work is already completed, speeding up the total process. If using a design already certified by the NRC, and not waiting for one of the Gen III's still in the review process, a utility would then just have to get a COL before construction can begin. Lastly, the biggest change from the original process to the updated process is the COL. This permit allows for both the construction and upon completion operation. The issuance of this permit certifies that the proposed plant has resolved all of the safety issues associated with the plant (New Nuclear, 2007). To date, no company has completed a COL, with the expected time needed of 42 months. The last step is to verify if once the plant is built whether or not it conforms to the requirements of the license and is ready to operate. An ITAAC process is then required, which specifies the inspections, tests, analyses and acceptance criteria that are used to asses the completed plant. The ITAAC elements are decided upon during the certification process and the COL license (Licensing New, 2007).

Economical

A second set of issues that could be a potential barrier to building a nuclear power plant in Utah are the economical concerns. Even if a utility is willing to assume liability for their nuclear waste creation and storage, they have to first overcome the huge capitol cost required to build the actual nuclear power plant. The cost of building new nuclear power plants has historically been much higher than the cost of building fossil fuel based power plants (EIA, 2008). According to the Department of Energy's Energy Information Administration (EIA), the costs for building nuclear power plants rose from approximately $1,500 per kilowatt for units beginning construction in the 1960s to roughly $4,000 per kilowatt for units beginning construction in the 1970s (2002 dollars). The construction lead time also increased from eight years to over ten during that time. Because the accelerated growth in both the cost and lead time was not expected, the overruns in realized costs ranged from 70% to 250% (Nuclear Power Plant, 2004). Design vendors of the new types of nuclear power plants, classified as Generation III's, are saying that the construction costs for building new nuclear plants would cost less per MW than new coal plants, especially coal plants with full emission controls in place (EIA, 2008). Some of the emissions from fossil fuel plants can be limited or managed via pollution control equipment or other procedures. These controls generally increase the costs of building and managing coal plants for either the plant owner or to the public. The waste disposal for nuclear power plants would also increase the plant owner's capitol cost except that the cost for nuclear waste disposal is passed onto the consumers. Spent fuel disposal costs are paid for by a surcharge on the cost of nuclear fuels, at a rate of 0.1 cent per kWh. The funds are sometimes referred to as a public subsidy to the nuclear power industry (EIA, 2008).

The large price tag on nuclear plants comes from the initial building costs. A new nuclear plant represents an investment of $3 billion to $4 billion (depending on plant size), including interest during construction (Nuclear Power Plant, 2008). To lessen that cost in hopes of farther increasing nuclear proliferation in the U.S., the Energy Policy Act of 2005 (EPAct 05) included numerous incentives to encourage new nuclear plant production. One of the large provisions was the loan guarantees for various forms of innovative and new low emission energy generation [nuclear power plants]. EPAct05 also provides a standby insurance, underwritten by the federal government, to protect the companies building new reactors from the risk of regulatory delay and other unforeseen setbacks in advancing first-of-a-kind reactor technology. Lastly, EPAct05 authorizes almost $3 billion in nuclear research and development to support among other things, the testing of the new licensing processes (Licensing New, 2007).

As aforementioned, venders' claim that new reactors will cost less to build compared to the cost for those currently in operation. The new reactor types have simplified, standardized and pre-approved designs that result in cost savings. For most of the current plants there were no standardized designs to use models, so construction was started before the unit was totally designed. Because these were essentially customized units, with the designing process unfolding along side the construction, the building costs grew increasing expensive. But today new Generation III (Gen III) reactors designs, discussed in more detail farther on, will be pre-approved by the NRC, ensuring the design work will be done before construction begins, allowing for little customization and lower overall costs (Nuclear Power Plant, 2004). While most Gen III plants have yet to receive reactor certification in the U.S., this has had no bearing on the decision for foreign countries to start constructing Gen III plants in the recent years.

The next generation of U.S. nuclear power plants will benefit from foreign learning (Nuclear Power Plant, 2004), both in shaping cost estimates as well pinpointing any potential plant design flaws. Because no nuclear plants have been ordered in the U.S. in nearly three decades, the costs of a construction a new plant are uncertain. Fortunately, the new Gen III plants being built over seas, enables the EIA to project future cost estimates for when nuclear plants are built in the U.S. When the EIA was formulating their study, there were two marketable Gen III units in operation, and four more being constructed in Asia with an expected completion date over the next five years (Nuclear Power Plant, 2004). Since then, more Gen III plants have been built over seas, providing the U.S. even more economical data. Based on the two overseas operating plants, the EIA estimates an initial U.S. baseline cost to be around $2,083 per kilowatt. This estimate is comparable to the $2,000 per kWh costs that have been realized in the Far East and elsewhere overseas (Nuclear Power Plant, 2004). In 2005, the total assumed capital cost of a pulverized coal plant was $1,170 per kilowatt, more then the costs the manufacturer predicts for one of the Gen III plants, the AP1000 (Nuclear Power Plant, 2004). As learning increases with each reactor built, the cost will continue to decline. The EIA predicts that if ten new reactors were built in the U.S. the cost for the next reactor would drop to $1,719 per kWh. Even if the U.S. did not build any new plants and therefore did not learn first hand, the EIA still assumes that costs would fall to $1,752 per kilowatt by 2019 due to knowledge sharing from other countries. These predicted costs are much less then the realized costs for both older U.S. plants and new units currently being built abroad (Nuclear Power Plant, 2004). One EIA future cost scenarios, created in 2004, projects that with the cost for a new nuclear reactor falling to $1,081 per kW in 2019, that 26 GW of new nuclear power plant capacity would be built and operational by 2025. These hypothetical 26 GW would displace 19 W of coal fired capacity and 7 GW of mainly fossil fuel fired capacity. Under a second EIA future cost scenario, where costs drop to $1,149 per kW in 2019, 12.8 GW of new nuclear power capacity would be built and become operational by 2025, displacing about 9.4 GW of coal-fired capacity. If the $1,080 per kW scenario was realized it is possible that in the future, nuclear power could eventually supply all of the baseload electricity demand in the U.S. (Nuclear Power Plant, 2008). EIA's Annual Energy Outlook 2008 (AEO2008) predicts that nuclear generating capacity will increase from 100.2 GW in 2006 to 118.8 GW in 2030. This increase is made up of 20 GW of capacity from newly built nuclear power plants and

2.7 GW expected from uprates (increasing a current unit's power generating ability) of existing plants. The AEO2008 also predicts that during the same time period there will be 4.5 GW of nuclear capacity retired (Electricity Generation, 2007).

EPAct05 also provides tax credits for the first 6000 mega watt (MW) of electricity from a new advanced reactor at 1.8 cents per kWh, which is comparable to the tax credits provided to wind energy producers. Including this credit, nuclear plants will produce energy for roughly 1.7 cents per kWh (Licensing New, 2007). The majority of the cost comes from the production, operation and maintenance costs, as nuclear fuel costs average less then one half cent per kWh, well below the costs of major fossil fuels. Nuclear power plants have low daily marginal costs, most of which is the cost of fuel (Nuclear Power, 2003). Nuclear fuel costs account for about 25% of production costs, while the other 75% of production costs are the fixed cost of operation and maintenance. This makes nuclear power production much less sensitive to variations in fuel costs compared to fossil-fuel plants, where fuel costs can account for 75% or more of the production cost (AP1000, 2008). Because nuclear power's marginal costs are lower that coal's marginal costs, nuclear power plants tend to use their full output capacity before coal plants. This gives nuclear power an advantage in base load operations and results in a higher capacity factor. Nuclear plants increased their capacity factor from 56% in 1980 to 90% in the 2000s (Nuclear Power, 2003).

A State does not bear the brunt of the aforementioned costs, that burden falls primarily onto the utility, which makes it seem unusual to research the costs for an independent utility when writing a policy memo for a particular State. However, it is the pollution created from each type of power plant that is of importance to Utah. An environmental component of the decision between building a nuclear or a fossil fuel plant are the differences between nuclear waste management and emission controls, and how they might effect the costs of building and operating either power plant (EIA, 2008). While the costs for building a nuclear plant are predicted close to the costs for a coal fired plant, the overall economic issues are neutral; they neither promote nor deter a Utah from building a nuclear power plant in the future. However, if the nuclear construction cost estimates turn out to be wrong, and much higher then predicted, that price will play a big factor in the utilities decision regarding what type of plant to make, with the more economical choice being the coal plant. But as it stands now, the construction's economic issues should not be of a big concern when Utah decides whether or not to pursue nuclear power.

The economic issue that Utah should consider is the amount of revenue adding a new nuclear power plant can bring into both the surrounding community and state as a whole. Based on an economic analysis of 22 U.S. nuclear power plants, using numbers calculated per MW of installed capacity for a 1,000MW plant size, the Nuclear Energy Institute (NEI) calculated the expected enhancement to a local economy from building and operating a new nuclear plant. As new nuclear plants are expected to be larger then 1,000MW the economic benefits in the study are potentially understated. According to NEI, the operation of a U.S. nuclear power plant creates 1,400 to 1,800 construction jobs, and 400-700 permanent operational jobs, which pay 36% more than the average salaries in the local area. The average nuclear plant produces roughly $430 million annually in expenditures for goods, services and labor though subsequent spending because of the presence of the plant and its employees. NEI also states that for every dollar spent by the average nuclear plant results in the creation of $1.07 in the local community (Nuclear Power Plant, 2008).

Technological

The Generation III reactor technology is not new to the world. Over the past two decades, in an attempt to make nuclear plants both safer for the public as well as cheaper for the owner to build, new Gen III reactors were developed. Some countries are already building and operating Gen III plant designs with much success. This newer nuclear technology is now just waiting for the first U.S. utility to find a willing location to be able to fully commit to adding new nuclear and start construction on the first domestic plant construction in decades. Because of the overseas use of the Gen IIIs, the technological sector is the one area of study that overwhelmingly supports nuclear power plants in Utah. These light water reactors are, in general, simpler with more passive safety designs features (Nuclear Power Plant, 2004). There are four different types in particular that could possibly be built in Utah. Two of these types are already operational overseas, with three of the four either already having U.S. Design Certification or in the process of waiting for NRC certification approval.

The first one, designed by Westinghouse, is the 1154 MW Advanced Passive 1000 (AP1000) pressurized water reactor with an expected 60 year lifetime. While it has already received the NRC's Design Certification (AP1000, 2008), it has yet to be built in the U.S. or overseas (Nuclear Power Plant, 2004). The AP1000 attempts to up the ante on nuclear power plant safety features because in the event of a design-based accident, such as a coolant pipe break, the plant is designed to achieve and maintain a safe shutdown condition without any operator action nor the need for ac power or pumps. Instead of relying on active components such as diesel generators and pumps, the AP1000 relies on the natural forces of gravity, natural circulation and compressed gases to keep the core and containment area from overheating. These changes have enabled the AP1000 to have a very low core damage frequency (CDF), one which is 1/100 of the CDF of currently operating plants. Along with the advanced safety features, compared to the current nuclear power plant models, the AP1000 has 35% fewer pumps and 85% less control cables, which translates into an accelerated construction time period of approximately 36 months, from the first pouring of concrete to the initial loading of the fuel (AP1000, 2008). An additional six months have to be added to the lead time for construction completion to account for the time it takes between the fuel loading and actual commercial electricity generation (Nuclear Power Plant, 2004). The AP1000's manufacturer estimates that the construction cost for the first two 1,100 MW reactors will range from $1,210 to $1,365 per kW (2000 dollars), lower then the aforementioned EIA estimates. However AP1000's manufacturer estimates include the assumption that the government will pay for all of the first-of-a-kind costs. The manufacturer also assumes that due to knowledge learned from building AP1000s, the third two-unit plant would only cost $1,040 per kilowatt (2000 dollars) (Nuclear Power Plant, 2004). The AP1000's generating costs are expected to be less then 3.5 cents per kWh (Advanced Nuclear, 2008).

The second new type of nuclear power plant is the 1520 MW ESBWR boiling water reactor by General Electric. The ESBWR, with its 60 year lifetime, is designed to create as much electricity annually as is consumed by 1.1 million average U.S. households (ESBWR, 2007). Similar to the AP1000, the ESBWR also replaced the usual recirculation and safety pump system with natural, gravity driven water circulation and passive safety features such as passive containment cooling, isolation condensers, natural circulation and debris resistant fuel. With 25% of the pumps, valves and motors eliminated from previous nuclear plants designs, the ESBWR also references a construction schedule from first concrete poured to first load of fuel taking just 36 months. The plant is currently in the NRC Design Certification Process and expected to apply for its COL in the near future, with a hope of proceeding with commercial operations by 2015 (ESBWR, 2007).

The third type is the 1350-1600 MW (Advanced Boiling, 2007) ABWR light water reactor also by General Electric with a 24 month refueling cycle (Advanced Nuclear, 2008). The first ABWR began commercial operation at Kashiwazaki-Kariwa, Japan in 1996, the first Gen III reactor to begin commercial operation anywhere in the world. There are now four units in operation in Japan, with another three under construction combined in Taiwan and Japan, and an additional nine units have been planned but are not in the construction phase in Japan (Advanced Boiling, 2007). ABWR's Design Certification Application was submitted in 2008 and is expected to be approved by 2011 (Advanced Nuclear, 2008). Since the approval process has already begun, it is expected that as early as 2012 an ABWR plant could be built in the U.S. (Advanced Boiling, 2007). GE estimates that when constructed in the U.S. the costs would fall between $1,400 and $1,600 per kW (2000 dollars) for a single unit plant with a capacity of at least 1350 MW. However, this estimate was given under that assumption that the government will pay for 50% of the first-of-a-kind engineering costs (Nuclear Power Plant, 2008). This is the type of plant that Energy Future, Formerly TXU Corp, is considering using to expand its Comanche Peak Facility in Glen Rose, Texas. Energy Future hopes to have two new 1700 MW nuclear reactors online around the year 2020 (Souder, 2008).

The fourth type, Areva NP, goes by the name of Evolutionary Pressurized Water Reactor (EPR) in the U.S. The 1600 MW EPR is a mix of conventional and advanced plant designs, with considerable emphasis placed on reactor safety. The design is currently being built in Finland, with the French government also authorizing the building of an EPR. France expects that the EPR will replace some of their currently operating commercial reactors starting in the late 2010s. In the U.S. if the EPR passes the design certification, Constellation Energy is looking to build an EPR at both its Nine Mile Point and Calvert Cliffs locations (New Reactor, 2006).

One reason for the complete overhaul of plant safety features in the new Gen III designs was the 1979 closing of Middletown, Pennsylvania's Three Mile Island (TMI) Unit 2 after experiencing the most serious accident in U.S. commercial nuclear power plant operating history. This meltdown is also blamed for being one of the main reasons nuclear power plants are not currently being built in the U.S. On the morning of March 28, 1979 TMI's Unit 2 experienced a failure in a non-nuclear section of the plant that stopped the main feedwater pumps from running, which in turn prevented the steam generators from removing heat. As the turbine and then reactor automatically shut down, the pressure in the nuclear portion of the plant began increasing. The pilot operated relief valve opened to prevent a pressure overload. While the value should have automatically closed when the pressure decreased to a certain level, it malfunctioned and stayed open. This resulted in cooling water pouring out of the open value causing the core reactor to overheat. Even though the operators where receiving warning signals, they were unaware they were experiencing an accidental loss of coolant. When the operators attempted to correct the situation, they reduced the flow of coolant to the core they not realizing they were actually exacerbating the problem. This miscommunication led to half of all the metal tubes holding the nuclear fuel pellets in the core to rupture and melt. Once the error was realized and coolant was reintroduced to the fuel rods, any chance of farther melting was curtailed. Although this severe core meltdown is the most dangerous kind of nuclear power accident, it did not produce the worst case consequences that could have happened. According the NRC, the accident led to no deaths or injuries to plant workers or members of the nearby community. While the accident increased public fear and distrust in nuclear power plant safety measures, the partial meltdown actually forced the nuclear industry to make drastic changes in its emergency response planning, reactor operator training, radiation protection and the NRC broadened its regulatory oversight (Fact Sheet, 2007).

Even though this was the only unit shut down permanently due to a potential health risk, problems with nuclear power plants that require permanent shutdown, while fortunately few and far between, does occur in the United States. 92%, or 104 of all commercial reactors built in the U.S. since 1968 are still operable (When Do, 2006). Most of the plants that were decommissioned were non commercial or smaller test plants, any state currently considering building a nuclear power plant should realize that the plants do have finite lifetimes and cannot operate forever. Before 1999 23 nuclear reactor units were closed in the U.S. Four of these units were prototypes for designs that are no longer in commercial use in the U.S. and reached the end of their research usefulness. The remaining 19 reactors were all light water reactors, ten of which were smaller than the smallest reactor still in operation in the U.S. It is only these last nine closed reactors units that were of any commercial value. Of these nine reactors, it is also of note that it is the oldest reactors that have been shut down (Table 5) (When Do, 2006). Reasons for the closing of these nine commercial reactors can be separated into two different broad categories, economics and policy. Economics means that the decision for closing the reactor was initiated by the reactor owner or operator, based on an evaluation of the continued profitability of operating the reactors. Policy means that the decision for closing the reactor was initiated by a government decision or by an agreement between the government and international institutions (When Do, 2006). The potential for shutting down currently operating reactors, while remote, is increasing in probability as the years continue and the plants age. Half of the commercial nuclear reactors operating in the U.S. are less then 24 years old. Of the commercial reactors completed since 1976 only TMI's Unit 2, has been permanently closed after the 1979 accident. The last three reactors closed, Zion 1 and 2 and Millstone 1, were closed in 1998. These three plants were closed because of the expensive investments that would have been required to bring each reactor up to the necessary performance standards (When Do, 2006). There have been no commercial nuclear reactor closings since 1998 (Nuclear Power, 2003).

Table 5. Operating U.S. Light Water Reactors, by License Year (Nuclear Power, 2003).

License Year	Reactors Licensed	Share of Reactors	Closed Reactors	Operable Reactors	Share of Operable
1968-74	38	33.6%	6	32	30.8%
1975-78	23	20.4%	3	20	19.2%
1979-96	52	46.0%	0	52	50.0%
Total	113	100.0%	9	104	100.0%

Environmental

The last and least negotiable potential barrier to building a nuclear power plant in Utah is whether or not the environment has the ability to support and sustain a nuclear plant throughout its lifetime. "Electricity production requires a reliable, abundant, and predictable source of water, a resource that is in limited supply" (Feely, 2003). Water withdrawals for thermoelectric power, (plants burning oil, gas, coal, using nuclear or geothermal energy) accounts for 48% of total U.S. water withdrawals (Thermoelectric Power, 2006). Due to insufficient water supplies caused by population growth and extended droughts, water use permits for new U.S. power plants have been denied recently, causing construction projects to be put on hold. The limited amount of available water has also reduced plant outputs in several U.S. regions. Overall water withdrawals, water which after use is recycled back to its source of origin, by thermoelectric power plants is expected to decline over 3.5% by 2030. Unfortunately the percent of water consumed, water lost through evaporation before it can be returned to its origin, during thermoelectric power generation is predicted to increase by 35.7% by 2030, with vast regional differences. Currently the power industry withdrawals most of its water, 40%, from freshwater sources and consumes 3% of all U.S. freshwater. When the thermoelectric power assemblage is separated by different power sources, coal fueled plants are expected to show the most drastic change in water required. Due to the water intensity of carbon capture technologies, when they are nationally added to coal fired power plants, water withdrawals is projected to increase from 4.1 to 6.0 billion gallons a day by 2030, which averages out to a 7% increase. Water consumed by coal plants nationally is also expected to rise from 2.2 to 4.3 billion gallons a day (DOE Estimates, 2007). The water withdrawals are vital to fossil fuel power plants, performing two very important functions. Electricity is generated with the fossil fuel is burned creating heat to turn water into steam. This high pressure steam them rotates turbines to create electricity. While the plant would be useless without the steam creation, it is actually the secondary use for water. The primary use of water is in the cooling system. This system uses lower temperate water to condense the steam as it flows through the cooling towers after it has served its electricity generating purpose. Lastly, water is also used to purge boilers, wash stacks and provide water for employee use (Last Straw, 2003).

There are two different types of cooling systems, the once–through system and the closed loop system. The less expensive once-through cooling system withdraws water from a source, circulating it through heat exchangers and afterwards returns the water back to the surface-body water it was taken from. While it is more water intensive, with the constant cycles of withdrawing water and returning to its source, it generally consumes less water then the closed loop system. Closed loop systems withdraw water, circulate it through heat exchangers, discharge heat through evaporation in cooling towers cooling the water and then recycle it back through the plant. The constant inflow of water needed for this system is comparatively small, as any additional water added to a closed loop system is to make up for water lost to evaporation, blowdown (where water is periodically used to flush mineral deposits and slurry out of the cooling towers), drift and leakage. Since closed loop systems require less water withdrawals, they are often used in water scarce states and areas where water is strictly managed (Hutson, 2004). Utah in particular solely uses closed loop systems, filled by fresh water withdrawals (Table 6).

Table 6. Thermoelectric Power Water Withdrawals by Cooling Type, 2000 (million gallons per day) (Hutson, 2004).

State	Withdrawals: Once through cooling			Withdrawals: Closed loop cooling						
Utah	Surface water			By source and type				Totals		
				Groundwater	Surface Water					
	Fresh	Saline	Total	Fresh	Fresh	Saline	Total	Fresh	Saline	Total
	0	0	0	13.1	49.2	0	49.2	62.2	0	62.2

Because of the water intensity of both the once through and closed loop systems, the amount of water needed for coal power plants compared to the requirements of other types of power plants, comes in second only to nuclear (Figure 3). While most of the water used is recycled back out into the lake or stream it originated from, a smaller amount of water is constantly consumed via evaporation loss. Once again, nuclear consumes the largest quantity of water per kilowatt hour; with coal power plants coming in close second (Table 7). Water is vital to nuclear power plants because the cool river or lake water is pumped into the plant and passed through the reactors to condense the steam produced from water heated by nuclear fission (Drought Could, 2008). For example, the Harris nuclear reactor in North Carolina withdrawals 33 million gallons of water each day, with 17 million gallons of that consumed by evaporation through its cooling towers (Drought Could, 2008).

Figure 3. Water Use by Source Generation (Gallons/MWh) (Adverse Effects, 2008).

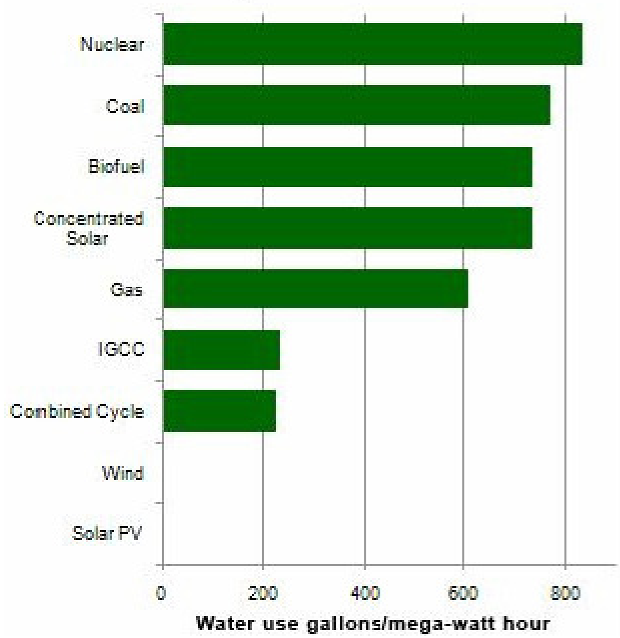


Table 7. Water Consumption by Power Plant Type (How Much Water, 2007).

Technology	Gallons/kWh	Liters/kWh
Nuclear	0.62	2.30
Coal	0.49	1.90
Oil	0.43	1.60
Combined Cycle	0.25	0.95

Possibly due to its water intensity, as this map from the International Nuclear Safety Center shows (Figure 4), nuclear power plants are not the electricity source of choice for the arid west (Maps of Nuclear, 2000). Excluding Oregon, northern California and the western portion of Washington, the western U.S. is arid, receiving less precipitation annually then the rest of the nation (Why Should, 2007). As of 2003, the primary electricity generators (coal and natural gas) for Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah and Wyoming cumulatively withdraw over 650 million gallons of water daily, with a significant portion of this water also being consumed (Figure 5). This volume of water withdrawals is equivalent to the amount of water needed to meet the municipal demand of 3.64 million people (Last Straw, 2003). In 2003, 75% of water for the arid west's power plants came from surface waters (mostly rivers) and only 20% was from groundwater (Last Straw, 2003). Water withdrawal origins are divided into two categories, surface sources: lakes, rivers, and streams; or from ground sources: springs and wells (Utah's Water Resources, 2004).

Figure 4. (Maps of Commercial Nuclear Power Plants, 2000)

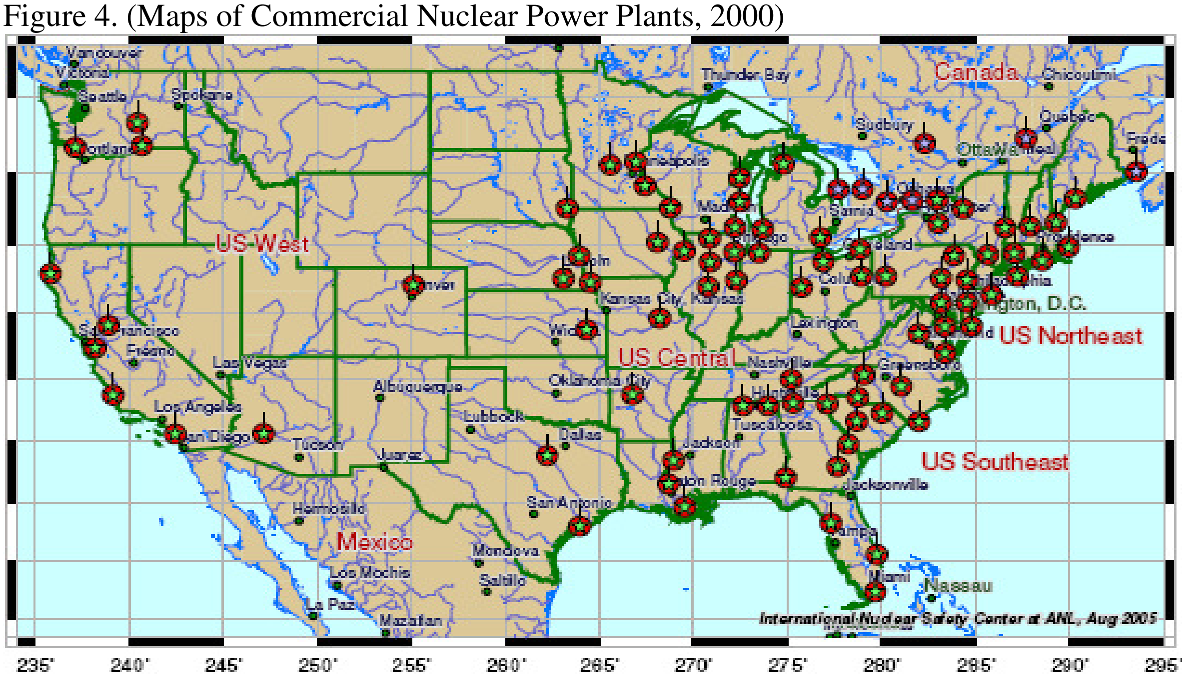
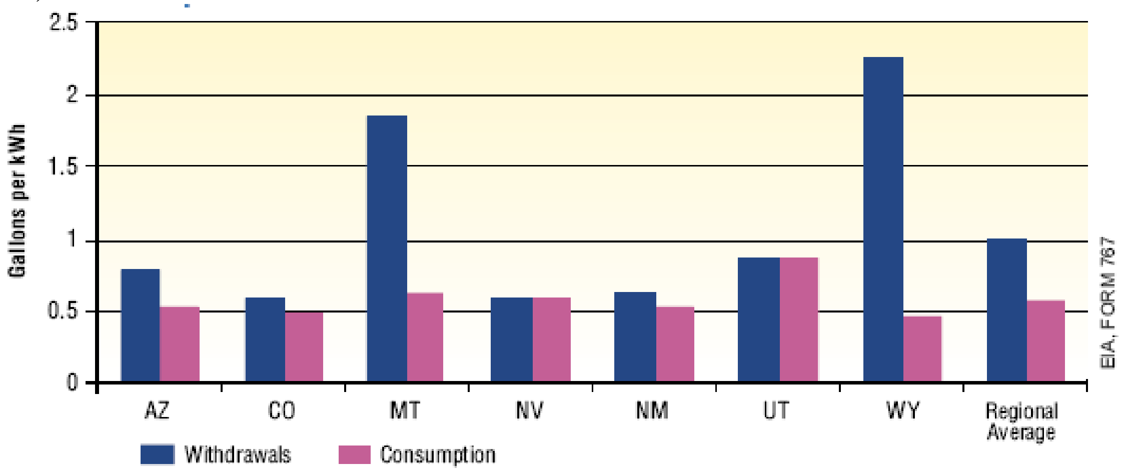


Figure 5 Regional water withdrawals and consumption at fossil plants, 2000 (Last Straw, 2003)



Utah's hydrologic conditions vary across the state due to its topography, geology, changing seasonal atmospheric conditions and yearly changes in climatic conditions. The mountain ranges and plateaus filling Utah's landscape have steep slopes, sparse vegetation, and thin soils (Wilberg, 2006). Utah's overall climate is semiarid, meaning that in most of the state, most of the precipitation that falls returns to the atmosphere through evaporation (Utah's Water Resources, 2001). Next to Nevada, Utah receives the least precipitation in the nation, a state average of 13 inches a year (Why Should, 2007). In the mountains, most of the precipitation falls as snow. This snow is extremely important in Utah, because it serves as a storage reservoir, releasing water into streams and aquifers when the temperature rises (Utah's Water Resources, 2001). Tables 8 and 9 breaks down Utah's water use by dividing each category by either ground or surface water source (Hutson, 2004), showing that in 2000, the majority of total water withdrawals, 78.6%, were from surface sources (Utah Water Use, 2004).

Table 8. Ground water withdrawals by water-use category, 2000. [Values in millions gallons per day, -, data not collected] (Hutson, 2004).

State	Public Supply	Domestic	Irrigation	Live-stock	Aqua-culture	Industrial		Mining		Thermo-electric	Water Totals		
Utah	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Saline	Fresh	Saline	Fresh	Fresh	Saline	Total
	364	16.1	469	-	116	34.3	5.08	8.6	21.5	13.1	1,020	26.5	1,050

Table 9. Surface water withdrawals by water-use category, 2000. [Values in millions gallons per day, -, data not collected] (Hutson, 2004)

State	Public Supply	Domestic	Irrigation	Live-stock	Aqua-culture	Industrial		Mining		Thermo-electric		Water Totals		
Utah	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Saline	Fresh	Saline	Fresh	Saline	Fresh	Saline	Total
	274	0	3,390	-	0	8.38	0	17.7	177	49.2	0	3,740	177	3,920

As Table 10 shows, in 2000, most of Utah's water withdrawals where from freshwater sources, as opposed to saline sources (Huston, 2004). Table 11 farther elaborates on Utah's freshwater needs, breaking down by percentage how the water is divided between the seven uses. One area of water demand in particular that has the potential to drastically increase throughout time which could decrease water availability for power generation is domestic use. In 1995 each person in Utah used 269 gallons of water, increasing to 293 gallons per person in 2000 (Utah's Water Situation, 2004), the second largest state per capita usage in the nation, only behind Nevada at 315 gallons (Houston, 2006) Utah had one of the largest increases in the nation (Utah's Water Situation, 2004), accounted for by the drought during the late 1990s to early 2000s along with a rapid increase in state population (Houston, 2006). Only Colorado, Hawaii, Texas and Louisiana had larger increases in the amount of public water used per person (Utah's Water Situation, 2004).

Table 10. Total water withdrawals by water-use category, 2000. [Values in millions gallons per day, -, data not collected] (Hutson, 2004).

State	Public Supply	Domestic	Irrigation	Live-stock	Aqua-culture	Industrial		Mining		Thermo-electric		Water Totals		
Utah	Fresh	Fresh	Fresh	Fresh	Fresh	Fresh	Saline	Fresh	Saline	Fresh	Saline	Fresh	Saline	Total
	638	16.1	3,860	-	116	42.7	5.08	26.3	198	62.2	0	4,760	203	4,970

Table 11. Utah freshwater usage by category in 2000 (Utah Water Use, 2004)

Freshwater category	Percent usage
Irrigation	81.1%
Public supply	13.4%
Aquaculture	2.4%
Thermoelectric	1.3%
Industrial	0.9%
Mining	0.6%
Domestic	0.3%

As of 2007, 97% of Utah's population got their water from municipal or public suppliers, while only the other 3% of the population relies on personal wells of private companies. This places Utah first in the nation in percent of their state population that gets their water from municipal sources (Table 12). The differences in amount of municipal water used are correlated to differences in agriculture and urbanization. States such as Arizona, Utah, Nevada and Colorado which have most of their population concentrated in an urban core, have a higher rate of publicly supplied water more that the rural, farming and ranching states (Houston, 2006). Utah's per capita use of public supplied water can be separated into four categories, residential, commercial, institutional and industrial. Residential makes up the largest section, with 66%, or 213 gallons per capita per day (gpcd). 143 gpcd of the residential consumption is used outdoors, with the other 70 gpcd used indoors. One reason for the dramatic increase in per capita water consumption in the four aforementioned states was that they were all experiencing drought conditions in 2000, which would increase the demand for outdoor water use (Utah's Water Situation, 2004). The second largest use category of public supplied water at 55gpcd is institutional uses, which includes schools, churches, parks, cemeteries and city-owned properties. Commercial use consumes roughly 39 gpcd and public supplied industrial uses consume 14 gpcd (Utah's Water Resources, 2001).

Table 12. Percent of Water Supplied by Public Systems (Houston, 2006).

State	Population (%)	National Rank
Arizona	95%	2
Colorado	87%	17
Idaho	72%	43
Montana	74%	41
Nevada	94%	3
New Mexico	80%	31
Utah	97%	1
Wyoming	82%	26
U.S. Total	85%	NA

Two of the "smaller" uses of water are the municipal and industrial sectors. This area is another section that is expected to increase substantially as Utah's population grows. Table 13 breaks downs the present and projected total M&I water use by major basin, based on present use rates and future population predictions, and measured in acre-feet/year (Utah's Water Resources, 2001). An acre foot is the volume of water it would take to cover one acre with one foot of water, which is 43,560 cubic feet or 325,850 gallons. One acre-foot is roughly the same amount needed to supply a family of four, assuming a use rate of 225 gpcd, for one year (Utah's Water Resources, 2001). These estimates predict the largest percentage increase in M&I water demand will be in the Kanab Creek/Virgin River Basin, where demand is expected to more than quadruple (Utah's Water Resources, 2001).

Table 13. Present and Projected Total M&I Water Use by Basin (Acre-feet/year) (Utah's Water Resources, 2001).

	Acre-feet/year		
Basin	Present*	2020†	2050†
Jordan River	332,000	449,000	650,000
Weber River	170,000	267,000	358,000
Utah Lake	134,000	207,000	338,000
Bear River	50,000	71,000	103,000
West Colorado River	51,000	55,000	62,000
Sevier River	48,000	55,000	64,000
Kanab Creek/Virgin River	42,000	86,000	183,000
West Desert	24,000	35,000	53,000
Uintah	24,000	27,000	31,000
Cedar/Beaver	20,000	33,000	51,000
Southeast Colorado River	9,000	10,000	12,000
Total	904,000	1,320,000	1,950,000

* The exact year of data shown varies from 1992 to 1998
† Actual demands will likely be less, depending on the level of conservation that can be achieved.

Utah gets most of its water from aquifers, rivers and streams. Utah's available water supply is approximately 7.3 million acre feet per year. One main source of water is the Colorado River. According to the Colorado River Compact, Utah is allocated 1.73 million acre feet per year (Utah's Water Resources, 2001). This negotiation was done in 1922, a period of above average precipitation. During average precipitation levels it equates to 1.37 million acre-feet a year. Current depletions though consumption, exportation to the Wasatch Front by the Bonneville Unit of the Central Utah Project and to the Provo River and Strawberry projects, and other uses, add up to 950,000 acre-feet per year. While most of Utah's available water supply is already used, the Division of Water Resources estimates that there is still 790,000 acre-feet that has yet to be developed based on current legal, political economic and environmental constraints. Developable water is defined as the portion of available water supply that while yet to be developed has the potential to be developed. In this state, most of the developable water is from surface water sources. Most of this water, 420,000 acre-feet per year, is in the Colorado River drainage. The next largest supply of developable water is from the Bear River drainage with roughly 250,000 acre-feet per year. It is projected that annual water demand from the Colorado River will continue to increase so that by the year 2020 194,000 acre-feet per year would remain unused and only 43,000 acre-feet would remain by 2050. Steady increases in M&I uses along with small scale irrigation projects will contribute to the reduction in water levels. Fortunately, in the Bear River Basin, about 75,000 acre-feet per year could be made available without building additional storage reservoirs by using the Willard Bay more efficiently. However, applications to appropriate most of this water have already been filed with the State Engineer. The Board of Water Resources holds senior water right applications for available Bear River water as well as a large portion of the Upper Colorado River Basin water. These rights are being held in trust for benefits of the Utah citizens and are to be used as "needed project are identified" (Utah's Water Resources, 2001).

Utah's undeveloped water can be calculated by analyzing a snapshot of the current water budget, which can be broken down into the following inflows and depletions (Table 14). The average annual precipitation that falls on Utah amounts to 61.5 million acre-feet. After subtracting the initial evaporation and transpiration amount of 53.789 million acre-feet, 7.711 million acre-feet is left to make its way to Utah's river and aquifer systems each year. This amount is termed the Basin Yield (Row 3). The combined decreases from the Colorado River Compact and increases from the Bear River Compact sum up to a decrease in The Basin Yield's available water by 535,000 acre-feet per year (Row 4). Ground water mining increases and other inflows add up to an increase of 135,000 acre-feet per year to the Basin Yield (Row 5). 100,000 acre-feet of that are inflow from Nevada into the West Desert, and the remaining 35,000 acre feet is from ground water mining in the Beryl-Enterprise area. This all adds up to an available water supply of 7.311 million acre-feet per year (Row 6). Annual depletions for agricultural and municipal and industrial (M&I) uses amount to 2.175 million and 433,000 acre-feet respectively; which equates to 30% and 6% respectively, of Utah's available water supply. More depletions from the Basin Yield, mostly from Great Salt Lake evaporation combine to deplete an additional 3.998 million acre-feet per year. This leaves roughly 695,000 acre-feet, less then 10% of the available water supply to flow out of state unused (Row 11), making up a huge portion of Utah's undeveloped water. (Utah's Water Resources, 2001).

Table 14. Estimated Statewide Water Budget (Utah's Water Resources, 2001).

Row	Category	Water Supply (acre-feet/year)*
1	Total Precipitation	61,500,000
2	Used by vegetation and natural systems	53,789,000
3	*Basin Yield*	*7,711,000*
4	Interstate Compact Decreases	(535,000)
5	Ground Water Mining Increases & Other Inflow	135,000
6	*Available Supply*	*7,311,000*
7	Agricultural Depletions	2,175,000
8	M&I Depletions	443,000
9	Great Salt Lake Evaporation	3,000,000
10	Other Depletions‡	998,000
11	*Yield that flows out of state*	*695,000*

* Values based on the 1961-1990 period of record.
‡ Wetland and riparian depletion and reservoir evaporation

State population growth and water demand are closely intertwined. Water is not expected to be a limited factor in population growth, but it the water used by the increasing population will effect the rest of the future water demands. It should be noted however, that this does not mean that each community has ample water for its future population needs. It does mean that in most places water could be made available for population growth if necessary water transfers, agreements and infrastructure were put into place (Utah's Water Resources, 2001). As for the rest of the water demands, numerous state plans for water conservation are being developed, including weather modification, water development projects and upgrading and enhancing existing infrastructure. Utah has developed a Water Conservation Plan, with a state goal of reducing per capita water demand from public community systems by 12.5% by 2020, and a total of 25% before 2050. This equates to a total decrease in demand of roughly 400,000 acre-feet per year by the year 2050 (Utah's Water Resources, 2001).

One very important depletion this snap shot does not include, due to it inconsistency and the variation in severity and time scale, are droughts. Future water conservation efforts are very important, particularly as climate change alters both snow pack levels and local amounts of precipitation. Climate change is currently reducing the amount of mountain snowpack, the deep accumulation of high altitude winter snow that melts each spring to provide the western states most of its water, decreasing water supplies for those states (Adverse Effects, 2008). This is a potentially serious problem in the west because with reduced snowpack melt, the chances of droughts increase. Because of the vital link between power generation and water availability, even if a region has enough average annual water to run their power plants, there is still the possibility of a severe drought affecting generating capacity. According to a National Oceanographic Atmospheric Administration (NOAA) analysis of climate data regarding U.S. river basins from 1896 to 1995, some part of the nation experienced an extreme or severe drought in every year of that period. In seventy two of those years, the drought conditions affected at least 10% of the U.S. NOAA also found during the study period the Pacific Northwest river basins experienced extreme or severe drought eighty six of the years, while the California river basins had the same conditions fifty three times (Where Water, 2008). Droughts have different impacts in different regions, depending on the States' particular energy portfolio. Droughts have severe impacts on states that get a large portion of their energy from hydroelectric power plants. Lower levels of water reduce the amount of hydropower able to be produced which dramatically increases the demand on fossil fueled, greenhouse gas emitting power plants (Last Straw, 2003). In states using nuclear power, droughts can negatively affect the price of a communities electricity bills. For example, the current yearlong drought in the southeast U.S. could potentially force a temporary shutdown of nuclear reactors if the precipitation does not drastically increase, as the lakes and rivers supplying the cooling water are drying up. NRC permits declare a minimum water depth for the body of water supplying the cooling water, and mandates the plant be shut down if the water level drops below that specified limit. The shut downs force the utility companies to buy expensive replacement power from other energy companies and sources, and passes the increased costs to their customers. Already this past summer in Alabama there has been a drought-forced reactor shutdown. A study by the Associated Press found that of the 104 U.S., reactors 24 are in areas experiencing the most severe levels of drought. All but two of those 24 plants rely on submerged intake pipes to draw in cooling water from the lakes and rivers they are built next to. The water level in those lakes and rivers are getting dangerously close to the minimums set by the NRC, with the fear that over the next few months the levels could drop completely below the intake pipes altogether. A second fear is that the shallow water could become too hot under the sun to be used as a coolant. As an example, in January Progress Energy Inc, who operates the Harris reactor in North Carolina is warning of a possible shut down as the water in Harris

Lake is a mere three and a half feet above the limit set in the plant's license. Duke Energy Corp.'s McGuire nuclear plant draws its back up water from Lake Norman, which is less then a foot above the minimum requirement (Drought Could, 2008).

Conclusions

After analyzing the political, economical, technological and environmental issues related to nuclear power plant construction, if a utility can get past the strong political opposition, it seems possible that with the help of the current technology, Utah's economy and environment can support a nuclear power plant. The one major caveat to this being the potential for increased drought as time goes on. The IPCC states that it is more likely than not (>50%) that human influence has contributed to a global trend towards increases in area affected by drought since the 1970s (IPCC, 2007). So while Utah's environment, and water availability in particular, can currently support a nuclear power plant, it is not certain whether or not the arid west can sustain a traditional plant over its 60 year lifetime.

However, it is possible for the arid west to support an atypical nuclear power plant, one that does not have such strict dependence on the natural environment. Technology does exist that make it possible to run a nuclear power plant on limited freshwater resources. A great untapped water resource for nuclear power plant cooling water would be treated sewage effluence. The largest nuclear plant in the U.S., which generates 3,810 MW, is the Palo Verde plant, located 50 miles west of Phoenix in Tonopah, Arizona. It location lacks an accessible freshwater source, making it is the only nuclear energy facility that uses treated sewage effluence for cooling water. The plant uses effluent water from the City of Phoenix, where it is treated in an 80-acre reservoir, which equates to more than 20 billion gallons of effluent water recycled each year (Palo Verde, 2002).

Despite the available technology the Palo Verde plant utilizes, nuclear plants are still being marketed to areas with an available supply of freshwater. Two senators, Rep. Aaron Tilton, R-Springville and Rep. Mike Noel, R-Kanab believe that Utah does have enough developable water to enable Utah to be one of the next U.S. cites to build a nuclear power plant. They are both members of the Public Utilities and Technology Interim Committee, which hopes to have a bill drafted for the 2008 session of Legislature facilitating the construction of a nuclear power plant. They also support the efforts of Transition Power Development (TPD). Formed in Feb 2007 TPD is reviewing potential sites for a nuclear plant in Utah. Even though TPD plans on selling the license to another company to perform the actual construction and operation, TPD plans on spending at least $100 million to obtain a license from the NRC to construct a 1500MW plant (Nuclear Power Plant, 2007). The plant will expected to take at least five years to finish its regulatory reviews, with construction starting soon after the licensing is complete. TPD gives a timeline of at the earliest, the plant could be operating in ten years, but Rep. Tilton says 15 years may be more realistic (Bauman and Roche, 2007). The first step in siting a plant in the Arid West is securing the future water supply required for plant operation. TPD signed an agreement with the Kane Country Water Conservancy District (KCWCD) in September 2007 to secure water rights for a future plant, to be drawn from Lake Powell. The agreement stipulates that TPD paid $10,000 for signing the agreement and will pay $500,000 annually until power generation begins (Nuclear Power Plant, 2007), roughly five years. Once power generation begins, TPD would pay KCWCD $1 million a year for the 30,000 acre-feet of water needed (Bauman and Bernick, 2007). Rep. Tilton has said that if a new nuclear plant was to go online the constructed nuclear plant will have a facility to store spent fuel roods for 100 years (Bauman and Roche, 2007).

Regardless of the support from members of the Public Utilities and Technology Interim Committee, on large source of political opposition comes from the governor himself. The opposition from current governor Jon Huntsman Jr. comes from his concern over spent fuel management. Preventing radiation exposure from spent waste is a huge concern for Utah citizens. Governor Huntsman Jr. said that no nuclear power plant should be built in Utah until the plant could reprocess its waste on site. Reprocessing, a practice currently used in other countries such as France, the UK, Japan and Germany, could eventually be in the U.S.'s future (Reprocessing, 1996). In 2001, President G. H. W. Bush's Nation Energy Policy included the recommendation to consider technologies to develop reprocessing and fuel treatment technologies that are cleaner, more efficient, less waste intensive and more proliferation-resistant (Andrews, 2006). Reprocessing is done through a chemical process of dissolving the spent fuel in nitric acid and then separating out the un-used uranium and plutonium. The unused uranium and plutonium can then be recycled and re-used in the nuclear plant it came from, reducing the amount of uranium that has to be mined and processed to make fresh fuel. Reprocessing spent fuel also decreases the volume of waste. The radioactivity of the waste stays the same after reprocessing, but the quantity that has to be stored is smaller after the chemical process is completed. There are two concerns with reprocessing though. First is the local concern regarding the fact that most reprocessing is done off site from the plant. This creates worry about potential accidents during transportation, via rail, truck and sea, of the spent fuel to a reprocessing center, and then when the reprocessed fuel and unusable wastes are transported back to the power plant. The second concern making reprocessing controversial is due to the fact that it is the only way to get plutonium for nuclear weapons (Reprocessing, 1996). Because of the pros and cons for reprocessing, while it is under consideration by the federal government, very few agencies or power plants have made any attempts to move forward with reprocessing in the U.S.

Nuclear and the WCI

Agreeing with Rep. Tilton and Rep. Noel, based on the aforementioned research it could be possible for Utah's ecosystem to support a nuclear power plant, and it remains to be seen if it will have both the political and public support as well. However, the main reason for building a nuclear power plant is to help Utah meet its WCI goal of reducing emissions 15% below 2005 levels by the year 2020. It does not seem likely that a nuclear power plant will be able to help achieve there goal. The timeline for permitting and construction, although promised to be markedly shorter then previous U.S. plants, will still take too long for any impact. There is roughly just over eleven years from present to the deadline and it is assumed that a nuclear plant will not be operational in Utah by then. To better understand why the timeline is so long, it can be broken down into several basic components. First an ESP has to be developed before the licensing process can begin, which takes between 12 and 24 months (one to two years) to complete. In Utah, the ESP will most likely be towards the longer end, as the site chosen will probably be a Greenfield. The NRC ESP review process and public hearing takes roughly 33 months (approx three year). If using a one of the plant designs that does not already has NRC design certification, the average licensing process will take 36 to 60 months (three to five years). If the utility chooses the AP1000 which already has NRC approval a utility can skip to the next step, speeding up the process. Applying for the COL takes an additional 42 months (three and a half years). Construction is expected to take between 36 and 48 months (three to four years), although since no Gen. III plants have been built in the U.S., this timeline is based off of vendor statements and timelines of plants built in other countries. If ESPs are started right now, it will take ten and a half to years to seventeen and a half until a plant is built, plus the required six months needed from the time of fuel loading to actual commercial electricity production. This estimate is provided that all timelines listed are accurate and there are no unexpected delays. Some of the certified designs have yet to be built anywhere in the world, and the first few models are expected to take even longer to build, to work out any remaining logistics or kinks that were not foreseen in the plant design. This timeline also assumes that the public input does not delay any part of the process, and as aforementioned, citizen groups such as the Downwinders and well as the Governor have strong opposition to Utah nuclear power plants. If Utah plans on reducing their GHG emissions even farther after they meet their 2020 deadline, building a nuclear power plant would be able to make a significant impact on such a future goal, but not anytime before then.

The conclusions reached in this paper will differ from the tone of the official BRAC report policy memo that is directed to the Governor and other fellow state policy makers. Because nuclear power is such a controversial topic, the policy memo is more of an outline of pros and cons as apposed to a directive memo advising whether or not to build (Appendix I). Because the memo is not prescriptive, it will not follow the tone of the other 72 memos, but its purpose is to lay out the nuclear facts as they pertain to Utah with the hope of enabling the Governor to make a complete and informed decision in regard to expanding Utah's energy portfolio.

Appendix 1.
Draft of Nuclear Policy Memo For Review by BRAC and Governor Jon Huntsman Jr., as of 24 April 2008.

Nuclear Development (ES-15)

BRAC Strategy

"Although there has been some renewed interest in nuclear because of its low carbon emissions, the questions about waste disposal and safety make it unlikely that nuclear energy development will result in near-term reductions in CO2.

Nuclear energy has a potential to provide substantial carbon emission reductions. Nuclear energy should be evaluated as part of our long-term energy strategy (with due consideration of responsible waste disposal)."

BRAC Priority: Medium
BRAC Bin: C
BRAC Final Vote: 14

Strategy Background

No new nuclear power plants have been built in the United States in the past three decades. However, both in Utah and the United States more generally, many seem to be rethinking making investments in nuclear energy.

In Utah, the legislature had before it a bill this past session that would have facilitated building a nuclear power plant within the state. Transition Power Development is currently reviewing the possibility of building Utah's first nuclear power plant in Utah. Transition Power Development has in fact agreed with Kane County Water Conservancy District to secure water rights for this potential plant (EnerPub, 2007).

It should be noted that in addition to opposition that typically faces siting of nuclear power plants, Utah has particular sensitivity to nuclear power due to the nuclear fallout that impacted the Downwiders in southwestern Utah during the 1950s and 1960s. Additionally, the politics of nuclear siting may also face push back because the potential siting of nuclear waste in Utah is also associated with much political significance.

With that as a statewide backdrop, it should be said that nuclear power has changed quite dramatically since the United States last built a nuclear plant. Over the past two decades new Generation type III nuclear reactors have been designed with advanced public safety controls to reduce the risk of a nuclear meltdown. (EIA, 2006). The new Generation III designs rely on the forces of gravity and natural circulation to keep the core and containment area from overheating, instead of relying solely on operator action and AC-power. Some of these Generation III designs have already been built and are successfully operating in other countries, specifically Finland and Japan.

While there is some opposition to building nuclear power in Utah, adding new nuclear power to Utah's energy portfolio is being increasingly discussed as a way to meet increasing demand without contributing to climate change.

Refinement to BRAC Strategy

[Insert assumptions from modeling exercise related to:
Technology characteristics
Timeline
Costs]

Strategy Costs

[Insert output from model]

Societal Costs/Externalities

- Nuclear power plants consume significant amounts of water. For example, the average nuclear plant consumes 0.62 gallons/kW-hours as opposed to 0.49 gallons/kW-hour for the average coal plant. (California Energy Commission, 1979 at A-4; American Wind Energy Association, 2007).
- Assuming that a typical nuclear power plant is a 1000 MW plant and operates rough 90% of the time, the EIA has estimate that this would lead to slightly less that 23 tons of nuclear waste per year (EIA, 2004).
- Introducing a nuclear power plant introduces the risk associated with a plant melt down, certainly a rare but potentially very dangerous event.

Strategy Carbon Reduction Potential

[Insert output from model]

Other Benefits Associated with Strategy

- Nuclear power, unlike some of the other less carbon-intensive forms of energy, has the capacity to ramp up on demand and thereby provide energy demand, which aids in reliability and in meeting peak demand.
- Nuclear power does not have the emissions stream associated with energy often used to reliably meet peek demand, such as those associated with coal or natural gas derived energy. Some of these are detailed in the Utah-specific context in charts _____.

Implementation

As aforementioned, no State has built a nuclear power plant for three decades. However, several States are considering doing so and may serve as a model or at least a helpful case study in the case the Utah adopts this as a strategy. Constellation Energy is looking to build two Generation type III plants, one each at its Calvert Cliffs and Nine Mile Point locations (EIA, 2006). Energy Future, formerly TXU Corp, is looking expand its Comanche Peak Facility in Glen Rose, Texas, and hopes to have two new 1700 MW nuclear reactors online around the year 2020 (Souder, 2008).

Policy Interaction

Building a nuclear power plant would increase the electricity supply, decreasing the demand of building other sources of electricity generation that emit greenhouse gases. In particular, it would reduce the urgency for establishing carbon sequestration for the current fossil fuel fired plants, which has no finite operational timeline.

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