NUCLEAR ENERGY: AN OVERVIEW

Around the world, nuclear energy is once again being regarded as a viable source of electricity due to its dependability, affordability, and efficiency to meet rising energy demand. Additionally, in today's carbon constrained world, governments and power companies are turning to nuclear energy as a key source of zero emissions electricity.

Nuclear energy is in the news every day, and this new focus is often referred to as the "Nuclear Renaissance," and many companies and consortia are looking seriously at new nuclear plant construction. Worldwide, fifty nuclear reactors are under construction in 13 countries.[1] China currently has 20 reactors under construction with plans to begin construction of more in 2009.[2] In the United States, the last nuclear reactor to come on line in the Twentieth Century was the Tennessee Valley Authority's (TVA) Watts Bar 1, which became operational in 1996.[3] TVA's Browns Ferry nuclear reactor was restarted in 2007, making it the first reactor to come online in the U.S. in the Twenty-first Century.[4] TVA is also working on a second reactor at its Watts Barr facility planned for operation in 2012,[5] and the U.S. Nuclear Regulatory Commission (NRC) has received applications for 17 new reactors.[6] Discussions in Washington, D.C. surrounding proposed federal energy legislation include initiatives to promote the development of nuclear energy, including more federal loan guarantees for new plants, studying spent fuel reprocessing, and federal assistance in training nuclear operators.[7]

Nuclear power plants produce energy by using a controlled nuclear reaction to generate electricity. Though nuclear energy was originally used for military purposes, interest shifted to new commercial uses for the technology. In 1951, after several years of research, nuclear energy was used to produce enough electricity to power four light bulbs. Just under four years later, that capacity was expanded to provide power to the town of Arco, Idaho.[8]

Since then, nuclear energy has become an important part of the electric power industry. Presently there are 104 nuclear power plants operating in the United States[9] that generate more than 19 percent of the country's electricity.[10] This is lower than the high of 112 plants that were operational in 1990.[11]

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[1] "Plans for Nuclear Reactors Worldwide." World Nuclear Association. September 2009. http://www.world-nuclear.org/info/inf17.html

[2] "Nuclear Power in China." World Nuclear Association. November 6, 2009. http://www.world-nuclear.org/info/inf63.html

[3] "Nuclear Power: 12 percent of America's Generating Capacity, 20 percent of the Electricity." U.S. Energy Information Administration: http://www.eia.doe.gov/cneaf/nuclear/page/analysis/nuclearpower.html

[4] "Browns Ferry Nuclear Plant." Tennessee Valley Authority. http://www.tva.gov/sites/brownsferry.htm

[5] "TVA charging up new nuclear reactor; opponents fear disaster." WBIR. November, 5, 2009. http://www.wbir.com/news/local/story.aspx?storyid=103692&provider=gnews

[6] "Combined License Applications for New Reactors." U.S. Nuclear Regulatory Commission. Accessed November 6, 2009. http://www.nrc.gov/reactors/new-reactors/col.html

[7] Mufson, Steven. "A nuclear power boost for bill." *The Washington Post.* October 28, 2009. http://www.washingtonpost.com/wp-dyn/content/article/2009/10/27/AR2009102704081.html

[8] "The History of Nuclear Energy." U.S. Department of Energy. http://nuclear.gov/pdfFiles/History.pdf

[9] "Unique Reactors." U.S. Energy Information Administration. http://www.eia.doe.gov/cneaf/nuclear/page/nuc_reactors/superla.html

[10] "Figure ES 1. U.S. Electric Power Industry Net Generation." U.S. Energy Information Administration. Accessed on November 4, 2009. http://www.eia.doe.gov/cneaf/electricity/epa/figes1.html

The Benefits of Nuclear Energy

Economic

For consumers, nuclear energy costs much less and is more stable than electricity derived from other fuel sources. For example, the cost of natural gas increased from $4.25 per Btu in 1996 to $9.62 per Btu in 2006 – an increase of 126 percent. Nuclear energy, on the other hand, cost $.51 per Btu in 1996 and had decreased to $.44 per Btu in 2006 – a decrease of 15.9 percent.[12]

In addition to providing much needed electricity, nuclear power plants also provide jobs and economic benefits for surrounding areas. According to the Clean and Safe Energy Coalition, an industry trade group, the economic activity of a nuclear plant generates around $20 million in state and local treasuries. Additionally, for every position created at a nuclear plant, four new jobs providing goods and services are created, and employees at nuclear plants earn around 36 percent more than the average salary in local communities.[13]

Here in Mississippi, the Grand Gulf Nuclear Power Station employs more than 700 people, though the plant is directly responsible for creating over 1,300 jobs statewide, according to the Nuclear Energy Institute (NEI). The plant provides more than $12 million in annual economic activity in Claiborne and Warren Counties and more than nearly $64 million statewide. In 2003, Grand Gulf generated $29.5 million in state and local tax revenues.[14]

Nuclear energy is also more cost-effective than other energy sources. Capacity factor is one way of measuring the efficiency of a source of electricity. A 100 percent capacity factor means that an energy source is producing power at 100 percent of its capacity, 100 percent of the time. Nuclear power plants have an extremely high capacity factor compared to other energy sources. Grand Gulf, for example, has a capacity factor of more than 90 percent, while wind and solar energy have capacity factors of 33[15] and 25[16] percent, respectively.

Environmental

Nuclear energy emits near zero air pollution or greenhouse gases. Nuclear energy also reduces utility companies' reliance on fossil fuels, which improves air quality. According to the Nuclear Energy Institute, in the United States "nuclear energy prevented the emission of nearly 1 million tons of [nitrogen oxide] in the year 2006."[17] In the same year, nuclear energy also

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[11] "Unique Reactors." U.S. Energy Information Administration.
http://www.eia.doe.gov/cneaf/nuclear/page/nuc_reactors/superla.html
[12] "Consumer Price Estimates for Energy by Source, 1970-2006.
http://www.eia.doe.gov/emeu/aer/txt/ptb0303.html
[13] "Economic Benefits." Clean And Safe Energy Coalition.
http://casenergy.org/nuclear-energy/why-nuclear/economic-benefits/
[14] "Economic Benefits of Grand Gulf Nuclear Station: An Economic Impact Study by the Nuclear Energy Institute in Cooperation with Energy." Nuclear Energy Institute.
http://www.nei.org/resourcesandstats/documentlibrary/reliableandaffordableenergy/economicbenefitsstudies/economicbenefitsgrandgulf
[15] "Wind Energy Basics." American Wind Energy Association. Accessed November 5, 2009.
http://www.awea.org/faq/wwt_basics.html
[16] "Assumptions to the Annual Energy Outlook 2006." U.S. Energy Information Administration. Accessed November 5, 2009. http://www.eia.doe.gov/oiaf/archive/aeo06/assumption/renewable.html
[17] "Nuclear Energy's Importance in Reaching Clean Air Act Goals." Nuclear Energy Institute.
http://www.nei.org/keyissues/protectingtheenvironment/policybriefs/cleanairactgoalspage3

avoided the release of 3.12 million tons of [sulfur dioxide].[18] These toxins have been shown to have negative effects on the environment and human health.

Energy discussions in Washington, D.C. and around the globe have centered on reducing greenhouse gas emissions, namely carbon dioxide (CO_2) – a byproduct of burning fossil fuels. Nuclear energy produces absolutely no carbon dioxide. According to Dr. Patrick Moore, a co-founder and former leader of Greenpeace, nuclear energy avoids the release of more than 700 million tons of CO_2 in the U.S. each year, which is equal to the exhaust of more than 100 million vehicles.[19]

Nuclear Power in Mississippi

Mississippi's sole nuclear facility is the Grand Gulf Nuclear Power Station in Port Gibson, Mississippi. Systems Energy Resources, a subsidiary of Entergy Corporation, owns 90 percent of Grand Gulf while South Mississippi Electric Power Association (SMEPA) owns the remaining 10 percent.[20] The electricity from the plant flows based on these percentages, and customers of the utility co-owners of Grand Gulf pay for the plant's electricity based on the respective share of ownership. Since it came online in 1985, Grand Gulf has been a high performing plant and provides around 23 percent of the electricity generated in Mississippi.[21]

Recently, Entergy Mississippi, Inc. made a filing with the Mississippi Public Service Commission seeking an uprate, which would increase the nuclear reactor's capacity at Grand Gulf. If approved, the plant's output would increase by 178 megawatts – enough electricity to power up to 178,000 additional average homes. This would be the plant's third uprate and the largest uprate of any reactor in the U.S. After the process is completed in 2012, Grand Gulf will be the largest capacity reactor in the nation.[22]

There has been discussion of the addition of a new reactor at Grand Gulf to increase the state's base load power supply. While the idea is being researched, there are many challenges ahead before a new reactor at the Grand Gulf facility can become operational.

Nuclear Power Plant Safety

There are many facets of safety at nuclear plants, one of which is operational. Plant operations are closely monitored by the U.S. Nuclear Regulatory Commission (NRC), the federal agency tasked with overseeing the fleet of U.S. commercial nuclear power plants. In an effort to ensure safety, each nuclear plant has on-site NRC inspectors that closely monitor plant operations and maintenance, as well as operator training.[23]

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[18] Ibid.
[19] Moore, Patrick. "Going Nuclear: A Green Makes The Case." *The Washington Post.* April 16, 2006. 2009. http://www.washingtonpost.com/wp-dyn/content/article/2006/04/14/AR2006041401209.html
[20] "Grand Gulf Nuclear Station." Entergy Nuclear. http://www.entergy-nuclear.com/plant_information/grand_gulf.aspx
[21] "Electric Power and Renewable Energy in Mississippi." U.S. Department of Energy. http://apps1.eere.energy.gov/states/electricity.cfm/state=ms
[22] Barrett Jr., Danny. "Entergy: Grand Gulf output hike best option." *Vicksburg Post*. October 30, 2009. http://www.vicksburgpost.com/articles/2009/10/30/news/doc4aeb2137d473a981667897.txt
[23] "Inspection." U.S. Nuclear Regulatory Commission. http://www.nrc.gov/about-nrc/regulatory/safety-oversight.html

Groups like the Institute of Nuclear Power Operations (INPO) and the World Association of Nuclear Operators (WANO) are important to nuclear safety as well. The INPO sets industry guidelines for plant operations and conducts reviews of nuclear plants to determine if standards are being met. The WANO "collects information on the performance of nuclear plants in the United States as well as other countries. WANO consolidates the best practices and operating experience of nuclear plants worldwide to enhance the safety and reliability of operating nuclear plants."[24]

Each nuclear power plant must have and test emergency response scenarios, both on and off-site. These plans are subject to approval by the NRC and the state in which the plant is located. Every plant is required to conduct a full-scale emergency response exercise every two years in director coordination with state and local authorities.[25]

Another safety concern at nuclear plants, especially after the attacks of September 11, 2001, is the threat of a terrorist attack. After these attacks, the NRC, along with other nuclear experts from across the country, began a comprehensive review of security practices, and experiments were done to see if nuclear plants are indeed able to withstand a 9/11-type attack. The studies showed "that there is a very low likelihood that an airplane attack on a nuclear plant would affect public health and safety, thanks in part to the inherent robustness of the structures."[26] The NRC's 2008 annual security report states, "The commission is confident that nuclear power plants…continue to be among the best protected private sector facilities in the nation."[27]

Spent Fuel and Reprocessing

A large part of the ongoing debate over nuclear energy deals with how to store spent fuel. Spent nuclear fuel still contains radioactive particles and must be stored so that the particles cannot affect the surrounding areas. There are two types of storage approved by the NRC – spent fuel pools and dry cask storage. In the first method spent fuel rods are submerged in at least 20 feet of water, which prevents the radiation from affecting any area outside of the pool.[28] Dry cask storage came about when the pools at existing plants began to get full. This method "allows spent fuel that has already been cooled in the spent fuel pool for at least one year to be surrounded by inert gas inside a container called a cask."[29] These air-tight containers, typically made of steel, are then surrounded by additional material to shield plant workers from the remaining radiation.[30]

Spent fuel, once thought to be useless waste, is now being reprocessed into usable fuel. This process involves separating the remaining uranium and plutonium from the nuclear waste. Plants are able to get 20 to 30 percent more use from the fuel. France and Japan currently

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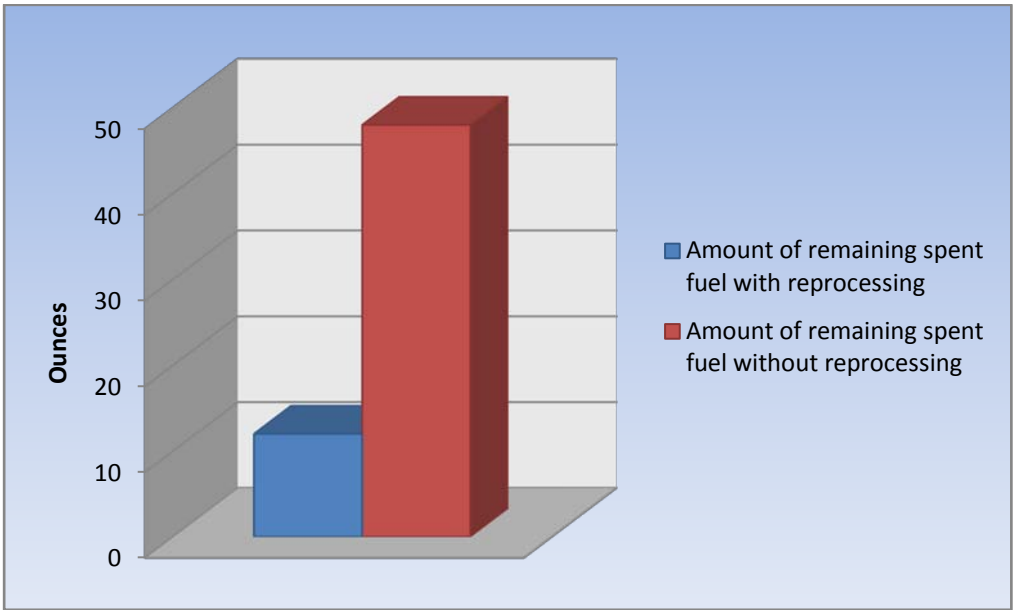
[24] "Operational Safety." Nuclear Energy Institute.
http://www.nei.org/keyissues/safetyandsecurity/operationalsafety/
[25] "Emergency Preparedness." Nuclear Energy Institute.
http://www.nei.org/keyissues/safetyandsecurity/emergencypreparedness/
[26] "Security Spotlight: Protecting Against Aircraft." U.S. Nuclear Regulatory Commission. Accessed November 5, 2009.
http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/security-spotlight/aircraft.html
[27] "Nuclear Power Plant Security." Nuclear Energy Institute.
http://www.nei.org/keyissues/safetyandsecurity/factsheets/powerplantsecurity
[28] "Spent Fuel Pools." U.S. Nuclear Regulatory Commission.
http://www.nrc.gov/waste/spent-fuel-storage/pools.html
[29] "Dry Cask Storage." U.S. Nuclear Regulatory Commission.
http://www.nrc.gov/waste/spent-fuel-storage/dry-cask-storage.html
[30] Ibid.

reprocess spent nuclear fuel.[31] While there are opponents who say it is too costly, it certainly has promise and the potential to help with the challenge of spent fuel storage.

Though most assume there are vast amounts of spent fuel to be stored, research shows there is a manageable amount. According to Gwyneth Cravens, author of *Power to Save the World: The Truth About Nuclear Energy*, all spent fuel from every reactor since nuclear energy was first used for electricity generation would fit stacked 9 feet deep in a CostCo warehouse.[32] To use another example, the U.S. Department of Energy (DoE) states that all of the spent fuel in the U.S. would fit between the goal posts of a football field, stacked to a depth of 5 yards.[33] Ms. Cravens also states that a if person received all of his or her power over the course of their lifetime from nuclear energy, their total share of nuclear waste would fit into a typical soft drink can. In France, where waste is reduced by reprocessing spent fuel, the waste for a family of four would fit into a small coffee cup.[34] The chart below demonstrates the difference in remaining spent fuel with and without reprocessing.



[31] "Reprocessing is Real." *EnergyBiz.* October 21, 2009.
[32] Cravens, Gwyneth. "What about nuclear waste?"
http://www.cravenspowertosavetheworld.com/content/view/13/30/
[33] "What are spent nuclear fuel and high-level radioactive waste?" Office of Civilian Radioactive Waste Management. Accessed November 6, 2009.
http://www.ocrwm.doe.gov/factsheets/doeymp0338.shtml
[34] Cravens, Gwyneth. "What about nuclear waste?"
http://www.cravenspowertosavetheworld.com/content/view/13/30/

A national storage facility or repository for spent fuel was first proposed in the 1950s. Since then, researchers across the country have searched for the best location. In 1986 Yucca Mountain, located in Nevada, was announced as the best of the nine sites that were originally considered for spent fuel storage. Between 1987 and 2002, the DoE spent $3.8 billion to further study the site, and in February 2002, the DoE recommended that a spent fuel storage facility be built at Yucca Mountain.[35] States with nuclear plants pay into the Nuclear Waste Fund, which is set aside for the creation of a spent fuel repository, such as the proposed Yucca Mountain site. To date Mississippi has paid over $200 million to this fund.[36] Though the facility is currently stalled, the United States needs a secure site to store spent nuclear fuel, and currently, Yucca Mountain remains the most viable option.

Conclusion

Our nation and state need more energy, and that must be balanced with the need for a clean environment. Nuclear energy can provide the electricity we need and do so in a way that is safe, environmentally friendly, and affordable. Advance Mississippi supports the expansion of nuclear energy, including new plants and upgrades at existing facilities, like the proposed uprate at Grand Gulf. New nuclear technology must be a component of the nation's energy future.

[35] "Yucca Mountain: The Most Studied Real Estate on the Planet." U.S. Senate Committee on Environment and Public Works, Majority Staff. March 2006.
http://epw.senate.gov/repwhitepapers/YuccaMountainEPWReport.pdf

[36] "U.S. State by State Commercial Nuclear Used Fuel and Payments to the Nuclear Waste Fund." Nuclear Energy Institute.
http://www.nei.org/resourcesandstats/documentlibrary/nuclearwastedisposal/graphicsandcharts/nuclearwastefundpaymentinformationbystate/

Additional Resources

U.S. Nuclear Regulatory Commission
http://www.nrc.gov/

U.S. Department of Energy – Nuclear
http://www.nuclear.gov/

A History of Nuclear Energy
http://nuclear.gov/pdfFiles/History.pdf

Nuclear Energy Institute
http://www.nei.org/

Clean and Safe Energy Coalition
http://casenergy.org/

CNBC – *The Nuclear Option*
http://www.cnbc.com/id/26868716

PBS Frontline – *Nuclear Reaction*
http://www.pbs.org/wgbh/pages/frontline/shows/reaction/

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