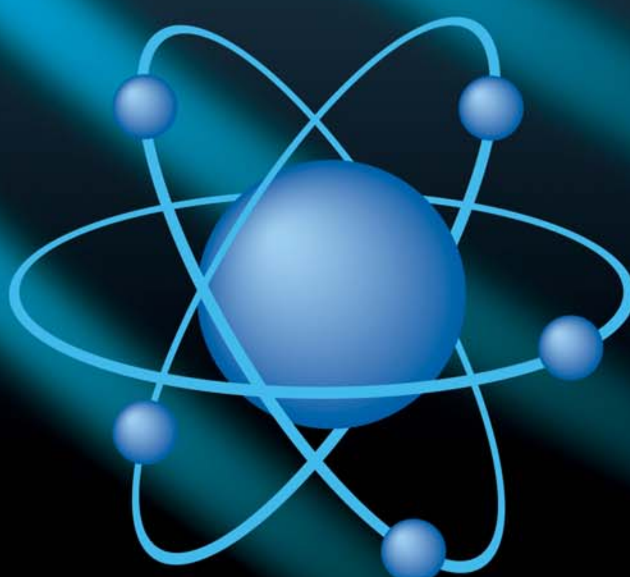
# The Future of Nuclear Energy: Shaping a Western Policy



Western Governors' Association
June 2011

## The Future of Nuclear Energy: Shaping a Western Policy, Western Governors' Association, June 2011

*Western Governors have long recognized the importance of having a clean, safe, reliable and affordable generation system for the West. Along with other traditional and non-traditional sources, nuclear power has played an important role in the West's electricity supply portfolio for the past 40 years. We agree that to serve a vibrant and growing population and economy in the West, we should continue to consider all the tools in our energy toolbox.*

*In April 2011, the WGA convened a workshop on Nuclear Energy in the West with experts from the U.S. Department of Energy, U.S. Nuclear Regulatory Commission, Electric Power Research Institute, national laboratories, utilities, state and local governments, and public interest groups. We asked the participants to provide perspective on how the West could best position itself to consider the how nuclear energy can be a part of the clean energy future the West supports. The result of that work is contained in this document, "The Future of Nuclear Energy: Shaping a Western Policy."*

*This report focuses on the role for and challenges associated with nuclear energy, and how states can contemplate the potential development of new, advanced nuclear energy production in the West. This includes education programs, job- and career-growth, economic expansion, environmental and public health and safety benefits and the path towards energy independence and security. We commend the report to our constituents, colleagues and all those working to ensure that we have an abundant, affordable and environmentally friendly energy future. We are sure you will find it to be a valuable tool as you develop state energy programs, policies and plans.*

*Gov. C.L. "Butch" Otter*
*Chairman*

*Gov. Christine Gregoire*
*Vice Chair*

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# Executive Summary

Western Governors strongly believe that a clean, diverse, reliable and affordable energy supply that moves us toward greater energy security is among the highest of our nation's priorities. Traditional and renewable resources, including oil, natural gas, coal, nuclear, hydropower, wind, solar, geothermal and biomass, have played and will continue to play a significant role in meeting future energy needs. The combination of these resources provides the foundation for a clean, diversified and secure energy future for the West.

In April of 2011, as part of a continuing effort to explore clean energy issues, the Western Governors' Association convened a workshop to discuss the potential role for nuclear energy in the West in the coming years. Participants included representatives from the U.S. Department of Energy, the U.S. Nuclear Regulatory Commission, the President's Blue Ribbon Commission on America's Nuclear Energy Future, national labs, utilities, local government officials and public interest groups. This report summarizes the information presented at the workshop and includes actions that could be taken at the local, state and federal levels in an effort to fuel the West's future population and economic growth with appropriate development of new, advanced nuclear energy as a source of electricity.

Of the 440 operational nuclear plants across the globe, 104 are in the U.S. There are an additional 109 plants in various stages of development worldwide. Nuclear power plants produce 20 percent of the nation's electrical energy supply. In the Western states, 15 plants produce 10 percent of the region's electricity supply.[1] Clearly, nuclear energy has been and continues to be an important source of electrical generation.

There has not been a new nuclear power plant approved for construction in the United States in more than 30 years. There are a variety of reasons for this related to perceived business investment risk, nuclear industry maturation and an emphasis on increasing the capacity and reliability of existing nuclear power plants. More recently, important uncertainties have emerged regarding the direction of government policies in the areas of greenhouse gas emissions, energy security, power generation portfolio standards, and the volatile nature of fossil energy prices, all of which make investments in capital intensive, long-lived energy production, such as nuclear energy, currently less attractive. There was also a large drop in electricity generation in 2008 and 2009, primarily as a result of decreased demand associated with the economic slowdown, and a very slight increase in 2010,[2] creating an excess of baseload generating capacity in some areas. Decisions to build new electric power generating capacity, including nuclear energy production, will be expected to weigh the current and projected electric power needs of each state and region, the extent of power import and export desired, the long term economic tradeoffs, the relative environmental effects of the technology alternatives, and the indigenous resources required, including land, water and fuel resources. The historically high capital costs of building a new nuclear reactor and the length of time it takes to permit and construct a new facility are both stiff impediments. The last completed nuclear reactor, Watts Bar-1 in Tennessee, was commissioned in 1996. The current estimate for construction of a new facility is 10-12 years as represented by the Braidwood Nuclear Generating Station, which came on line in 1988. Finally, policy issues directly related to nuclear generation have to be considered, including spent fuel disposal methods and associated liability uncertainties, and public perceptions about overall safety.

Braidwood Nuclear Generating Station

[1] U.S. Energy Information Administration, Annual Energy Outlook 2011

[2] Electric Power Monthly, Energy Information Administration, April 2011

There are numerous reasons for closely and carefully examining the potential role of nuclear power in the decades to come. Among them are uncertain fossil fuel prices, a desire to achieve long-term energy security, speculation about the potential reduction of carbon emissions, and the desire to foment an expanding economy that relies on a clean, safe, reliable and affordable electrical energy supply. In order to meet the future energy demands of the West, potential energy futures must be analyzed to determine the optimal mix of sources in our energy portfolio.

While the construction of a new nuclear energy facility is expensive and takes many years, once completed it can provide competitively priced electrical energy.[3] Nuclear energy currently constitutes more than 66 percent of the U.S. electricity production that does not produce greenhouse gases during generation.[4] Like coal and many natural gas power plants, nuclear is a "baseload" source of electricity, typically operating 24 hours a day, 7 days a week, 365 days a year. In fact some nuclear plants have operated for 700 days or more before shutting down for short periods to refuel and perform standard maintenance tasks.

## *Considering New, Advanced Nuclear Energy*

There are notable obstacles associated with the development of new, advanced nuclear power plants. While nuclear delivers significant amounts of low-carbon electricity at stable costs, it involves putting large amounts of capital at risk. There are also decommissioning, waste management and security issues that have to be built into the nuclear plant energy production costs. Developing a facility is lengthy and complex. Like all large thermoelectric facilities, plants must be sited in areas of stable geology and where there is adequate water supply, access to high voltage transmission lines, sufficient electrical demand and, perhaps most importantly, public and political support at the state and local levels.

Advanced technology nuclear plants are designed to provide clean, reliable electricity for 60 years or more. Importantly, nuclear plants can be constructed and fueled using domestic resources and technology. As with other power stations, nuclear facilities can also lead to economic development, attracting businesses, as well as a highly paid and well-educated workforce of up to 4,000 during construction and 400 during permanent operations.

On average, each facility generates $430 million in sales of goods and services within the community and $40 million in annual labor income, resulting in $20 million annually for the state and local tax base.[5] An adequate supply of reliable, zero-emission energy will also position the economies of the West to have sufficient electrical supply to support any future growth in generating capacity to power electric vehicles.

Because nuclear power plants do not actually combust their fuel, they are both carbon free and free of any byproducts associated with carbonaceous fuel combustion. They also consume relatively small amounts of land per megawatt of electricity generated. A 1,000 megawatt facility has a footprint between one and four square kilometers.[6]

## *The Process for Developing Nuclear Energy Projects*

Before any respective plant design is commercially available, it must be submitted by one of the technology design companies to the Nuclear Regulatory Commission for certification. Typically, this design certification process requires four to five years and costs $300-500 million. Once the design has

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[3] According to FERC Form 1 filings submitted by regulated utilities for 2009, production costs for nuclear average around two cents a kilowatt hour at currently operating plants. This amount would likely be higher at new plants.

[4] Electric Power Annual, Energy Information Administration, Revised Aril 2011

[5] The Economic Benefits of New Nuclear Power Plant Development, Nuclear Energy Institute, October 2009

[6] American Nuclear Society, Nuclear Power: A Sustainable Source of Energy

been certified, a utility or merchant developer choosing that design for their project can initiate the process of obtaining a Combined Operating License (COL) by submitting a COL Application (COLA).

Once a company decides to pursue a new facility, the development of the COLA can take several years and five to eight thousand pages of documentation at a cost of around $150 million. The license must be issued before any construction can begin. The costs associated with these efforts are substantial and cannot be offset by sales from generated electricity until the plant is operational, some 10 or more years after a project's conception. Accordingly, financial incentives and structures can be an important way to help reduce the costs associated with interest and financing these mega-projects, and in encouraging banks and other lending institutions to invest.

### *Water Needs for Nuclear Energy Production*

As with any thermal power plant that uses heat to boil water, turn it to steam and drive a steam turbine to generate electricity, nuclear energy using Light Water Reactor Technology requires significant volumes of water to cool and condense the steam. Nuclear power compares similarly for consumptive water use to other thermal electrical generating technologies. However, one issue that can be especially critical in the interior West is the return of warmed water from a thermal electric power plant to the source of the water. It is important to evaluate the impacts on stream ecology as part of any thermal plant siting.

With the West comprising some of the most water deficient areas and some of the highest population growth areas in the country, management of water for all uses will continue to be a major challenge. Use of grey-water, hybrid cooling or dry cooling may eventually become an imperative as the inextricable link between water, energy, agriculture and population growth results in growing competition for dwindling water resources. One advanced next generation nuclear technology is the high temperature gas-cooled reactor, based on dry cooling technology that is enabled by the considerably higher thermal efficiencies achievable with this reactor design. Hence, water withdrawal and consumption are dramatically reduced, and there is no increase in temperature to bodies of water.

Opportunities to spur the advancement of low-water technologies could upgrade the viability of nuclear as a developing energy source that fits well in the West.

### *Used Nuclear Fuel*

Nuclear fuel typically spends about five years generating electricity, after which only about five percent of its usable energy has been expended. Thermally hot and highly radioactive, it is stored in used fuel pools and dry storage facilities at nuclear plants around the world. Many countries use a process (invented in the U.S.) to recycle used fuel and extract the remaining value for further nuclear energy production.

Nuclear reprocessing technology was developed to chemically separate and recover fissionable plutonium from irradiated nuclear fuel. Originally, reprocessing was used to extract plutonium for producing nuclear weapons, but with the commercialization of nuclear power, the reprocessed plutonium was recycled back into mixed oxide nuclear fuel for thermal reactors. Breeder reactors (a type of nuclear reactor) can use a greater percentage of the recycled spent fuel, closing the nuclear fuel cycle and potentially multiplying the energy extracted from natural uranium by more than 60 times.

Although there are energy and waste disposal benefits obtainable through nuclear reprocessing, reprocessing has been politically controversial because of concerns about nuclear proliferation, the potential vulnerability to nuclear terrorism, and because of its higher cost compared to the once-through fuel cycle.

Considerable attention is being given to whether and how to close the nuclear fuel cycle and manage high-level waste.[7] A recent MIT study[8] concluded that the current open fuel cycle is the preferred economic option in the U.S. for the remainder of the century. To support fuel cycle decisions several decades from now, parallel enabling research, development and prototypical demonstration should occur. In any case, long-term, managed storage should be an integral part of the nuclear fuel cycle design.

## *State Incentives for Advanced New Nuclear Energy Facilities*

Because nuclear projects are capital intensive and have a long gestation period, when there is interest in locating a facility, states and the federal government will need to assemble incentive packages for developers. Production tax credits, investment tax credits, short-term income tax breaks and lending support are potential mechanisms that will help to establish projects that will be financeable on the credit market.

States can help simplify siting and permitting processes and expedite construction and operation. States and local agencies can also be helpful in getting transmission sited, obtaining sufficient land to develop the projects and securing sufficient water rights to operate the plant. States can be instrumental in developing educational programs that will become a source of trained employees for the design, construction and operation of a nuclear plant.

State financial incentives for the development of nuclear industry manufacturing infrastructure are another potential opportunity to support the domestic nuclear industry. The industrial infrastructure that can manufacture the high quality, complex and often large components needed to build nuclear energy facilities is primarily located offshore, mainly western Europe and eastern Asia. Redeveloping this infrastructure in the U.S. can provide greater energy security and bolster the economy.

Finally, given the lengthy approval and construction process, some ability for states to provide certainty throughout that time period will be an important consideration.

## *Federal Program Support for Energy Development*

The energy Policy Act of 2005 established a structure to incentivize early movers in the development of new nuclear power facilities. Federal production tax credits were established for the first 6,000 megawatts of new nuclear plants to go on line. In order to share in these credits, a project has to meet several other key milestones. It currently does not appear that there will be enough qualifying projects to use all the available credits. Standby credit support and new simplified licensing regulations were also put into place to assist new nuclear project developers as they navigate the lengthy and complex development process. Finally, a federal loan guarantee program was put into place to help with obtaining tolerable interest rates on project financing. Given the slow rate at which new loan guarantee applications are being processed, it may be necessary to extend and expand the program in order to give new nuclear projects the maximum opportunity to take advantage of it.

## *Summary*

The governors realize there is no set formula for establishing an appropriate mix among electricity production methods. However, they are committed to examining the benefits and impacts of all the clean energy options in the toolbox. Nuclear energy is one potential source of reliable, clean power. By understanding the issues associated with nuclear facility development, the governors will be better positioned to determine the best course of action for the West.

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[7] Blue Ribbon Commission on America's Nuclear Future, Advisory Committee Charter, January 20, 2010

[8] The Future of the Nuclear Fuel Cycle, An Interdisciplinary MIT Study, 2010

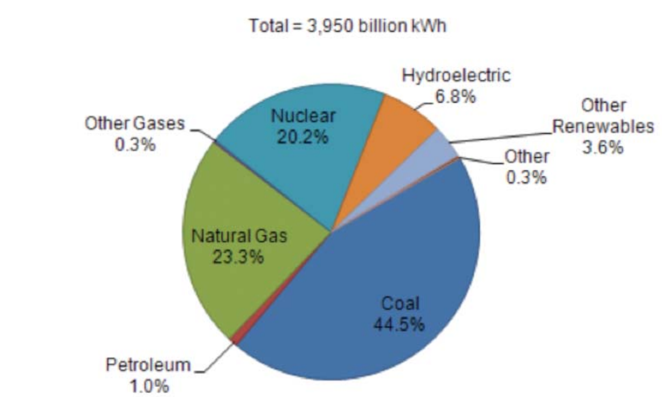
## Introduction

Nuclear energy is an important part of the United States electricity supply portfolio, providing 20 percent of the electricity generated nationally and 10 percent in the WGA states. However, the ability of nuclear energy to maintain its percentage of the generating portfolio is not easily predicted.

There has not been a new nuclear power plant approved for construction in the United States in more than 30 years. There are a variety of reasons for this related to perceived business investment risk, nuclear industry maturation and emphasis on increasing the capacity and reliability of existing nuclear power plants. More recently, important uncertainties have emerged regarding the direction of government policies in the areas of greenhouse gas emissions, energy security, power generation portfolio standards, and the volatile nature of fossil energy prices, making investment in capital intensive, long-lived energy production, such as nuclear energy, currently less attractive.

There was also a large drop in electricity generation in 2008 and 2009, primarily as a result of decreased demand associated with the economic slowdown, and a very slight increase in 2010,[9] creating an excess of baseload generating capacity in some areas. Decisions to build new electric power generating capacity, including nuclear energy production, will be expected to weigh the current and projected electric power needs of each state and region, the extent of power import and export desired, the long term economic tradeoffs, the relative environmental effects of the technology alternatives, and the indigenous resources required, including land, water and fuel resources. The historically high capital costs of building a new nuclear reactor and the length of time it takes to permit and construct a new facility are both stiff impediments. The last completed nuclear reactor, Watts Bar-1 in Tennessee, was commissioned in 1996. The current estimate for construction of a new facility is 10-12 years as represented by the Braidwood Nuclear Generating Station that came on line in 1988. Finally, policy issues directly related to nuclear generation have to be considered, including spent fuel disposal methods and associated liability uncertainties, and public perceptions about overall safety.

**U.S. Electric Power Industry Net Generation, 2009**




Electric Utility Plants = 60.1%
Independent Power Producers and Combined Heat and Power Plants = 39.9%

Source: U.S. Energy Information Administration, Form EIA-923, "Power Plant Operations Report."

In April 2011, the Western Governors' Association convened a workshop to discuss the potential role for nuclear energy in the West in the coming years. Participants included representatives from national labs, the U.S. Department of Energy, the U.S. Nuclear Regulatory Commission, the President's Blue Ribbon Commission on America's Nuclear Energy Future, utilities, local government officials and public interest groups. This report summarizes the information presented at the workshop. It also provides perspective that focuses broadly on the potential actions that can be employed at the local, state and federal levels that will allow the West to consider the value of new, advanced nuclear energy as a source of electricity that can be used to fuel the future population and economic growth of the region.

This report will focus on those topics the participants generally agreed had the greatest potential to provide answers to the questions surrounding development of new advanced nuclear energy facilities in the West:

- Considering New, Advanced Nuclear Energy
- The Process for Developing Nuclear Energy Projects
- Water Needs for Nuclear Energy Production
- Used Nuclear Fuel

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9 Electric Power Monthly, Energy Information Administration, April 2011.

- State Incentives for Advanced New Nuclear Energy Facilities
- Federal Support for Energy Development

# Considering New, Advanced Nuclear Energy

## *Economic Elements*

According to the Energy Information Administration U.S. electricity demand is expected to increase by one percent per year, or 28 percent total, between 2010 and 2035.[10] Meeting this growing demand will almost certainly necessitate construction of new, clean generating sources.

Nuclear generated electricity as baseload power is currently competitive and stably priced, largely as a result of improved operating efficiencies; capacity factors in excess of 90 percent and the amortization of initial capital costs from existing plants. Because fuel costs make up only about a quarter of total production costs, it is likely generating costs for existing facilities will remain stable into the future. The table below shows the levelized costs[11] of new generation resources scheduled to come on line in 2016. This table accounts for regional differences by showing both minimum and maximum costs. For comparison purposes, since much of the best wind and solar resources are in the West, it is likely that for these technologies, the levelized costs in the West are much closer to the minimum than the maximum.

**Regional Variation in Levelized Cost of New Generation Resources, 2016**

| **Plant Type** | **Range for 2009 Total System Levelized Costs $/megawatt hour** | | |
|---|---|---|---|
| | **Minimum** | **Average** | **Maximum** |
| Conventional Coal | 85.5 | 94.8 | 110.8 |
| Advanced Coal | 100.7 | 109.4 | 122.1 |
| Advanced Coal with CCS | 126.3 | 136.2 | 154.5 |
| Natural Gas-Fired | | | |
| Conventional Combined Cycle | 60.0 | 66.1 | 74.1 |
| Advanced Combined Cycle | 56.9 | 63.1 | 70.5 |
| Advanced Combined Cycle with CCS | 80.8 | 89.3 | 104.0 |
| Conventional Combustion Turbine | 99.2 | 124.5 | 144.2 |
| Advanced Combustion Turbine | 87.1 | 103.5 | 118.2 |
| Advanced Nuclear | 109.7 | 113.9 | 121.4 |
| Wind | 81.9 | 97.0 | 115.0 |
| Wind – Offshore | 186.7 | 243.2 | 349.4 |
| Solar PV | 158.7 | 210.7 | 323.9 |
| Solar Thermal | 191.7 | 311.8 | 641.6 |
| Geothermal | 91.8 | 101.7 | 115.7 |
| Biomass | 99.5 | 112.5 | 133.4 |
| Hydro | 58.5 | 86.4 | 121.4 |

Source: Energy Information Administration, Annual Energy Outlook 2011, December 2010

[10] Annual Energy Outlook 2010, U.S. Energy Information Administration

[11] Levelized cost is an economic assessment of the cost of the energy-generating system including all the costs over its lifetime: initial investment, operations and maintenance, cost of fuel, cost of capital, and is very useful in calculating the costs of generation from different sources.

While the generating costs are important as an indicator of the competitiveness of nuclear and the relative cost differences between fuels, the retail delivered price is set by the marketplace, and varies by sector (residential, commercial, industrial, transportation).

Nuclear energy facilities have positive economic benefits in those communities where they are located. A typical nuclear plant generates $430 million in annual sales of goods and services in the local community (primary, secondary and tertiary generated sales), and $40 million in total labor income. During construction, peak employment levels will be approximately 4,000 workers. The typical plant also adds about $20 million in state and local tax revenues annually and $75 million in federal tax revenues. These benefits begin in the planning stages and span the anticipated 60-year operating life, plus an additional five to ten year decommissioning cycle.[12]

## *Nuclear Energy and Future Costs*

No technology holds a consistent economic advantage at a global level under all circumstances. Domestic energy policy is a critical consideration, and the ability of any generating technology to compete will depend on a number of factors, most significantly the cost of capital and the price of carbon. Given a carbon constrained scenario, the International Energy Agency Report, Projected Costs of Generating Electricity: 2010 Edition,[13] concluded that when financing costs are low (five percent or less) nuclear energy followed by coal with carbon capture are the most competitive solutions. As financing costs increase (10 percent and higher), coal-fired generation followed by coal with carbon capture and gas-fired combined cycle turbines are the cheapest sources of electricity. The production costs of renewables are most dependent on the quality of the resources available and the potential for continuous improvements in technology, but renewables can remain a competitive part of the generation portfolio, most significantly as a local source of electricity.

The cost of generating electricity from nuclear power plants is currently very competitive with other fuels, primarily as a result of low fuel costs per kilowatt hour (nuclear fuel is 20-25 percent of the cost of coal, and 10-15 percent of the cost of natural gas) and the fact that the operating nuclear power plants have amortized most of their much larger initial capital investment. However, in terms of business risk, the relatively low capital investment in conventional natural gas combined cycle plants compared to nuclear (at least five times more costly) makes natural gas-fired plants considerably more attractive even given the current uncertainties in energy prices and national energy policies. Even assuming stable nuclear fuel costs into the future, new facilities will have higher per kilowatt costs than existing plants after operations commence, at least until they have been able to amortize the initial capital costs. Current capital costs for a new nuclear energy facility are considerable, driven by the investment in equipment and facilities and the necessarily stringent regulatory process to ensure safety and security. There will continue to be uncertainties regarding the best choice of generation technology depending on national energy policies placing a cost on carbon, prescriptive energy portfolio requirements and financial incentives for renewable options.

## *Environmental and Land Use Elements*

On April 17, 2009 the U.S. Environmental Protection Agency announced that greenhouse gas emissions constituted a threat to public health, moving the agency one step closer to regulating $CO_2$ emissions under the Clean Air Act. This action is certain to accelerate consideration of carbon-free electrical generation technologies.

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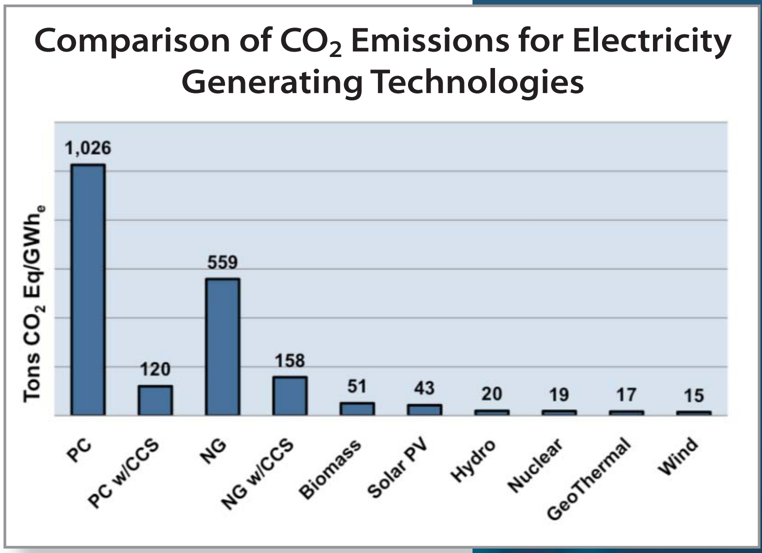
[12] The Economic Benefits of New Nuclear Power Plant Development, Nuclear Energy Institute, October 2009.

[13] OECD/ IEA NEA 2010, Projected Costs of Generating Electricity

In addition to being carbon free, because nuclear power plants do not actually combust their fuel, the byproducts associated with carbonaceous fuel combustion (particulates, nitrogen oxides, sulfur oxides, hazardous air pollutants) are also absent. The following chart compares emissions for alternative electric power generating technologies.[14]




Another important characteristic of nuclear power plants is that they generate a large amount of electricity from a fairly small amount of land. A 1,000 megawatt facility has a footprint between one and four square kilometers.[15] As a result of lower land use, there is less impact to natural habitats and land.

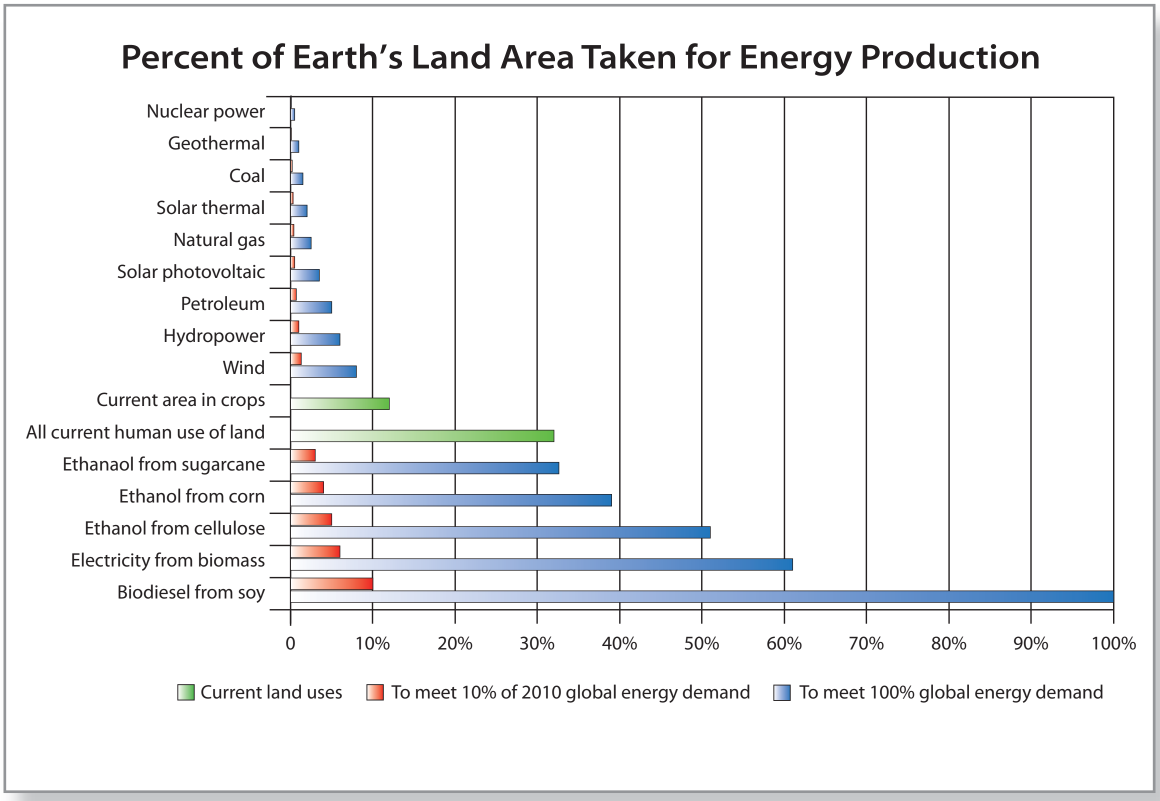
Finally, as the country considers the value of electric vehicles as a means to reduce carbon emissions from the transportation sector, having reliable sources of clean electrical generation will become even more important. It would make little environmental sense to fuel electric vehicles from sources with a high carbon-emitting footprint.

**Sources for Comparison of $CO_2$ Emissions:**

DOE/NETL-2010/1397, "Cost and Performance Baseline for Fossil Energy Plants", November 2010

EIA 2011 early release tables for 2010 emissions and generation for current coal and natural gas plants

"Life-Cycle Assessment of Electricity Generation Systems and Applications for Climate Change Policy Analysis," Paul J. Meier, University of Wisconsin-Madison, August 2002




Source: "Alternative Energy and Land Use", Clinton Andrews, Rutgers University

## *Public Safety*

The nuclear industry is one of the most highly regulated industries in the country. It provides rigorous training for its workforce, and is required to comply with strict legal standards for safety and radiation protection of its workforce and members of the public. Independent and transparent regulatory agencies, including the U.S. Nuclear Regulatory Commission and the Institute of Nuclear Power Operations, provide

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[14] PC is pulverized coal, CCS is carbon capture and sequestration, NG is natural gas, PV is photovoltaic, and GeoTh is Geothermal.

[15] American Nuclear Society, Nuclear Power: A Sustainable Source of Energy

oversight of every aspect of nuclear energy production.

The U.S. nuclear industry has a historically strong record of plant safety. According to the Bureau of Labor Statistics and the world association of nuclear operators, the 2008 incident rating for non-fatal occupational injuries and illnesses is the lowest by a factor of three or more for electrical generation industries.[16] In fact, the U.S. nuclear energy industrial safety and regulatory process is being used as the model for new regulatory processes being developed for the offshore oil drilling industry in the wake of the horizon oil platform accident.

The health and safety of the public, and protection of the environment continues to be assured through stringent regulation by the U.S. Government's Nuclear Regulatory Commission and the industry's self-regulatory agency, the Institute of Nuclear Power Operations. There has been a continuing upgrade in the depth and resilience of U.S. nuclear power plant capabilities, well beyond original license requirements, based on continuing lessons learned from the accidents at Three Mile Island Unit 2 in 1979 and Chernobyl in 1986, the industry-wide response in the 1980s to the potential for loss of all sources of electric power and the potential terrorist threat after the September 11, 2001 attacks. In the aftermath of the Fukushima Dai-ichi nuclear energy disaster in Japan, there has been an immediate response by all U.S. nuclear plants to ensure that the level and responsiveness of current capabilities are assured. Further, as the detailed sequence of events and a better understanding of the design and operational failures at Fukushima Dai-ichi become available, the historical safety measures in the U.S. can be evaluated. There may also be additional emphasis on developing alternative fuel designs for light water reactor technology and new nuclear technologies that can further improve the safety of nuclear energy.

### *Education and Workforce Development*

As with any highly technical industrial facility, a highly skilled, trained and compensated workforce is critical to the success of the venture. In order to prepare the next generation of engineers and plant operators, the nuclear workforce industry and the Department of Energy have embarked upon programs to train replacements for retiring members of the workforce as well as the increase in workers that will be required to support new nuclear plant development. These efforts include technology certification programs at 44 community colleges, 28 state energy workforce development consortia, over 30 universities, and involve over $90 million in federal education grants and the national academy of nuclear training.

In 2009, more than 2,800 students were enrolled in nuclear engineering degree programs. However, having a fully qualified workforce into the future remains a concern and priority within the nuclear industry.

### *Energy Security*

An important aspect of nuclear power is that it can be constructed and fueled using domestic resources and technology. Western Governors have long emphasized the importance of moving the country toward energy security, and along with domestic coal, natural gas, and renewable power, nuclear energy adds to the potential of meeting that goal.

Although the events at Fukushima Dai-ichi have heightened the need for proper siting and safety, the global marketplace for nuclear reactors is expanding. A number of countries have embarked on nuclear expansion programs. For example, China aims to at least quadruple its nuclear capacity by 2020 from that currently operating or under construction.[17] While power companies are being diligent in planning new facilities, this expanding fleet of new, advanced technology plants will provide even greater opportunities to assess the value of nuclear power in providing domestic energy security.

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[16] 2008 Incident rating for nonfatal occupational injuries and illnesses, Bureau of Labor Statistics

[17] World Nuclear Association, January 2011

# The Process for Developing Nuclear Energy Projects

Developing a new, advanced nuclear energy facility is expensive, complex and time consuming. Nuclear energy is highly regulated and scrutinized by transparent regulatory processes that are designed to ensure that all aspects of nuclear safety are properly incorporated in the resulting facility to produce clean, safe, reliable and economical electricity for 60 years or more.

## *Previous Generation*

Nuclear plants in operation today in the United States were licensed under a two-step licensing process that required the developer to apply for and obtain a construction license, then build the plant and, once complete, apply for and obtain an operating license. It was often the case in this process that as new regulatory revisions and technology advances had to be incorporated and legal challenges were sometimes lodged, the process became extraordinarily lengthy. Given the many potential pitfalls and uncertainties in the process, developers became hesitant to initiate new licensing applications.

The 104 plants in the current operating fleet were designed in the sixties and seventies. These plants are generally one of three types of pressurized water reactors (PWR's) designed by Westinghouse (now owned by Toshiba), Combustion Engineering (purchased by Westinghouse), Babcock and Wilcox, or Boiling Water Reactors (BWR's) designed by General Electric. The Combustion Engineering and Babcock and Wilcox PWR designs are no longer commercially available, but Westinghouse has developed a new, advanced generation PWR currently under construction in multiple locations worldwide. Areva and Mitsubishi also offer advanced PWR designs in the U.S. and abroad. Finally, GE has developed two different advanced-design BWR's which are being offered in the commercial market.

## *The New Generation*

The 2005 Energy Policy Act incorporated several important changes to stimulate new nuclear energy projects and to remove some of the uncertainty associated with the previous processes. These changes included production tax credits for the first 6,000 megawatts of new nuclear projects, federal loan guarantees to a maximum of $18.5 billion to cover up to 80 percent of the project cost,[18] standby credit support for the first six approved reactors to offset financial delays beyond an applicant's control, and the establishment of the one-step licensing process in which an applicant applies for and receives a license to construct and operate the plant in a single step.

Although these changes are recent, it will be important to monitor their effectiveness in stimulating new facility applications, with a view that if these programs are effective, they should be made a continuing part of the application and licensing process.

## *Licensing*

The licensing process, although simplified from earlier years, is still lengthy and expensive. The first step is for a plant design to be submitted by one of the technology design companies to the Nuclear Regulatory Commission for certification. Typically, this design certification process requires four to five years and costs $300 to 500 million. Once the design has been certified, a utility or merchant developer choosing that design for the project can initiate the process of obtaining a Combined Operating License (COL) by submitting a COL Application (COLA). The COLA itself may be 5,000 to 8,000 pages long. If everything stays on schedule, this part of the process will take approximately 42 months and cost around $150 million. While nobody has yet navigated all the way through this process, there are several projects

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[18]One award has already been granted to the Southern Company Vogtle project in Georgia for $8.2 billion.

in the U.S. that have performed significant "pre-construction" activities with more than one billion dollars expended. The actual construction of a facility can take between five and six years, making the timeframe from design certification to power generation 12 to 14 years.

An important development for the nuclear industry has been the establishment of the NP2010 (Nuclear Power 2010) program by the Department of Energy. This program is intended to stimulate design and development of advanced new nuclear energy plants by demonstrating the certification of advanced reactor designs and site licensing using the new one-step COL process. Through a competitive process, both Westinghouse and General Electric were awarded matching funds to complete new plant designs that could be commercially available within the next decade. This program is effectively completed. The final demonstration for licensing using the new one-step process will be part of the licensing for an advanced plant, such as at Plant Vogtle in Georgia.

## *Standardization*

A critical concern for nuclear developers is the ability to take advantage of standardization. Economies and efficiencies of scale can be achieved in design, licensing, procurement, construction, operations and maintenance if substantially similar subsequent plants are planned. It is estimated that a $10 billion nuclear plant can be built in replica the second time for less than $8 billion, and the larger the standardized fleet, the greater the potential savings. Unlike some other countries, the current U.S. fleet of 104 plants contains no two alike. A move toward greater standardization has the potential to eliminate some of the timing and cost disadvantages of nuclear.

## *Large Reactors and Small Reactors*

All reactors in the current operating fleet are in the 800 to 1200 MW (electrical generating capacity) range. The reactor designs in current NRC design certification processes are all large reactors, representing a new generation with regard to respect safety, efficiency and operational simplicity. These new generation reactor designs include a variety of advanced features, including digital control systems, passive safety shutdown systems, additional multiple back-up safety systems, core-melt catchers and dual 4.5-foot-thick steel reinforced containment domes among others.

There is also a new generation of much smaller reactor designs being prepared for licensing. Coined Small Modular Reactors (SMR's), these reactors are in early stages of design and will provide output ranging from 25 to 450 megawatts. SMRs may ultimately prove to be a cost-effective option to provide power for applications where large plants are not needed or sites lack the infrastructure to support a large unit. This might include smaller electrical markets, isolated areas, smaller grids, sites with limited water and acreage, or unique industrial applications. One design advantage of SMRs is that they are modular, meaning single reactors can be grouped with other modules to form the right-sized nuclear power plant. Even though current large nuclear power plants incorporate factory-fabricated components (or modules) into their designs, a substantial amount of field work is required to assemble components into an operational power plant. SMRs are envisioned to require limited on-site preparation and are expected to essentially be ready to "plug and play" when they arrive from the factory. Those working on SMRs expect them to provide simplicity of design, enhanced safety features, and the economics and quality afforded by factory production. It is envisioned that additional modules can be added incrementally as demand for energy increases.

Most SMRs are expected to be built below ground level for safety and security reasons and may be designed to operate for decades without refueling. These SMRs would be fabricated and fueled in a factory, sealed and transported to sites for power generation or process heat, and then returned.

Much like the NP 2010 program discussed earlier, DOE has requested in the FY 2012 budget matching funding for licensing of two SMR designs. Although there are advantages to SMRs, nuclear energy facilities have substantial infrastructure requirements for safety and security. Even with the cost savings associated with modular units, SMR's and the cost per installed megawatt capacity may be similar to that of larger plants.

### *Siting Requirements*

Siting requirements for nuclear facilities are similar to those for other large thermal generation plants. A footprint of 1,000 acres (including buffer area) with satisfactory hydrology, seismology, meteorology, biology and archeology is essential. Another important consideration is the ability to transport the equipment necessary to construct the plant. The highway or rail system must be capable of moving the large equipment to build a traditional large light water reactor, an issue in parts of the Intermountain West. Alternatives such as SMRs or assembling the large vessels on site as contemplated for the high temperature gas-cooled reactors might be more viable. Completed plants will need sufficient water for cooling, access to transmission lines, sufficient electricity demand and perhaps most importantly, state, local, political and public acceptance and support.

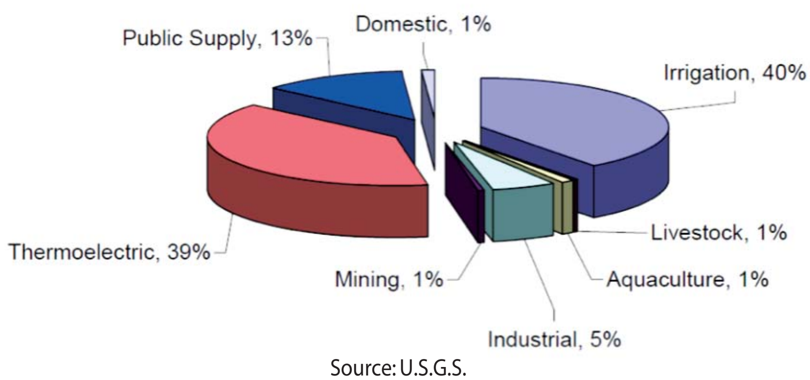
### *Project Costs*

With the cost of a new, large reactor of $10 billion dollars or more and a lead time to operation of 10 to 12 years, financing costs are a large cost consideration. This underscores the importance of federal loan guarantees and acceptable interest rates that will make a project a viable business proposition. States that have regulations allowing recovery of construction costs (Construction Work in Process—CWIP) from within the rate base can also help reduce interest costs by hundreds of millions of dollars. Even with the improvements to the licensing procedure, there is still a need to lower barriers to commercial investment if nuclear power is to be a part of the clean energy future.

## Water Needs for Nuclear Energy Production

Water and energy are inextricably linked and they both represent a fundamental part of supporting human life, growth and prosperity. Water is used in large amounts both to generate electricity (via hydro-electric stations) and to provide cooling for thermo-electric power plants, such as coal, natural gas, oil and nuclear powered generating stations. Some of the electricity generated is used to move quantities of water to locations where it is needed for household consumption, agricultural needs, and to generate more electricity.

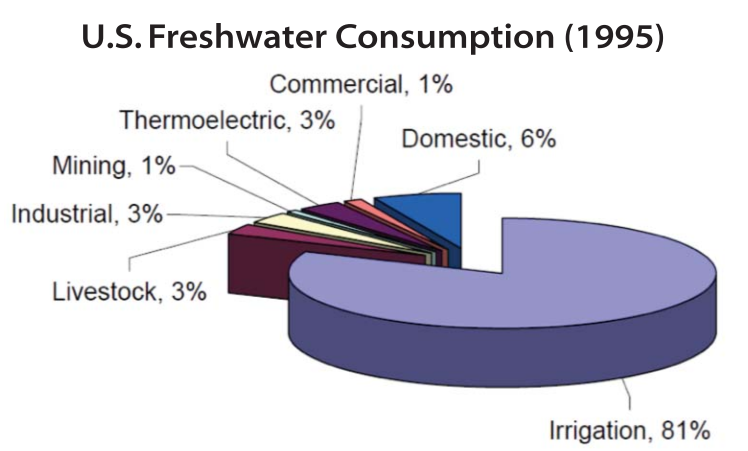
**U.S. Freshwater Withdrawal (2000)**




Source: U.S.G.S.

It is not often easy or cost-effective to take water from one place and transport it to distant locations. The complex interdependency between water and energy is, and will continue to be, crucial to analyze and understand.

Water use is described both in terms of withdrawal and consumption. Withdrawn water in thermo-electric processes can be and often is returned to the source of origin unchanged in quality or after passing through a filtration process. However, one issue that can be especially critical in the interior West



Source: U.S.G.S.

is the return of warmed water from a thermal electric power plant to the source of the water. It is important to evaluate the impacts on stream ecology as part of any thermal plant siting. Consumed water is incorporated into electricity generation or evaporated as steam, and therefore cannot be returned to the source for reuse.

What the charts demonstrate is that while withdrawals are high for thermoelectric power needs, consumption is relatively low. This is in part a result of the increasing use of once-through cooling processes that withdraw water (between 25,000 and 60,000 gallons per megawatt hour produced depending on technology) from a source, cycle it through a series of filters and heat exchangers, and return most of it to that source. In contrast, closed cycle cooling processes that use large cooling towers withdraw much less water (500 to 1100 gallons per megawatt hour) than once-through cooling, but consume most of what is withdrawn (400 to 720 gallons). Two disadvantages associated with constructing closed cycle cooling towers are the higher capital costs associated with construction and an electricity output penalty of two to five percent, since the towers require a large amount of energy to run them. Sixty percent of U.S. nuclear plants in operation today use once-through cooling and the other 40 percent use closed loop cooling with cooling towers.

The table on page 15 provides a comparison of the various withdrawal and consumption factors associated with common electricity generating technologies.

Source: Developing a Tool to Estimate Water Use in Electrical Power Generation in the United States, M. Wu and M.J. Peng, Argonne National Laboratory, December 22, 2010

It is not necessarily the case that all cooling must be fresh water. For example, the Palo Verde Nuclear Station located in Tonapah, Arizona (West of Phoenix), uses gray water (non-potable waste water) for cooling, some dry cooling, closed-loop wet cooling and hybrid cooling, which combines dry and wet cooling. While these approaches are a good alternative to freshwater cooling, both dry cooling and hybrid cooling come with higher capital costs and an output penalty due to the energy required to power the cooling processes.

An alternative is next generation nuclear technology such as the high temperature gas-cooled reactor based on dry cooling technology that is enabled by the considerably higher thermal efficiencies achievable with this reactor technology. Hence, water withdrawal, and consumption is dramatically reduced and there is no increase in temperature to bodies of water.

All wet-cooled thermoelectric plants have substantial water withdrawal needs, but with the greater use of once-through cooling, gray water, and hybrid cooling methods, there are opportunities to consider location of these plants even in the water sensitive West.

## Used Nuclear Fuel

### *Nuclear Fuel*

The ability to harness nuclear energy for domestic power production represented a major technological advance. A single fuel pellet, about the size of the tip of the little finger, produces as much energy as 149 gallons of

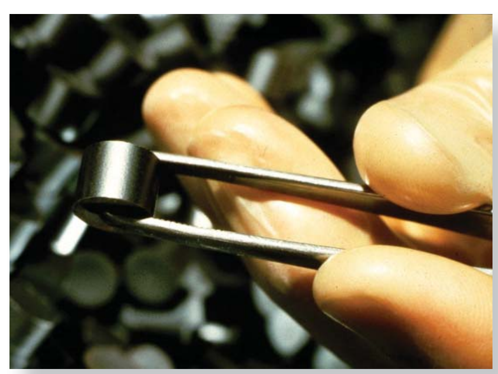


Photo Right:
Nuclear Fuel Pellet

## Value of Water Withdrawal and Consumption Factors in Electricity Generation

| Fuel Source | Cooling Type | Withdrawal Factor (gal/kWh) | Consumption Factor (gal/kWh) |
|---|---|---|---|
| Coal – Conventional | Once-through | 22.55 – 50.50 | 0.06 – 0.39 |
| Pulverized | Wet Recirculating | 0.46 – 1.20 | 0.39 – 1.04 |
| | Cooling Pond | 0.45 – 27.40 | 0.00 – 0.80 |
| Coal IGCC | Once-through | 11.67 – 22.81 | 0.10 – 0.25 |
| | Wet Recirculating | 0.23 – 0.75 | 0.17 – 0.69 |
| | Cooling Pond | 0.20 – 0.39 | 0.20 – 0.31 |
| Natural Gas – | Once-through | 22.74 – 35.00 | 0.09 – 0.30 |
| Steam Turbine | Wet Recirculating | 0.25 – 0.55 | 0.16 – 0.69 |
| | Cooling Pond | 0.45 – 7.89 | 0.11 – 0.39 |
| Natural Gas – | Once-through | 9.01 – 11.67 | 0.02 – 0.11 |
| Combined Cycle | Wet Recirculating | 0.15 – 0.50 | 0.13 – 0.50 |
| | Cooling Pond | 5.95 | 0.24 |
| Nuclear | Once-through | 31.50 – 48.00 | 0.14 – 0.40 |
| | Wet Recirculating | 0.95 – 2.60 | 0.59 – 0.85 |
| | Cooling Pond | 0.80 – 13.00 | 0.50 – 0.75 |
| Geothermal – | Once-through | NA | 3.43 |
| Steam Turbine | Wet Recirculating | 2.00 | 0.38 – 1.80 |
| Geothermal – | Once-through | 15.00 | NA |
| Binary Turbine | Wet Recirculating | -- | 4.65 |
| Solar – Parabolic Trough | Wet Recirculating | 0.84 | 0.84 – 1.06 |
| Solar - Photovoltaic | Wet Recirculating | -- | 0.03 |

Source: Developing a Tool to Estimate Water Use in Electrical Power Generation in the United States, M. Wu and M.J. Peng, Argonne National Laboratory, December 22, 2010

oil, one ton of coal or 17,000 cubic feet of natural gas. Five pellets meet the electricity needs of an average American household for an entire year. The used nuclear fuel required to provide the energy used by the average American for an entire lifetime would fit into a beverage can. All the used fuel from 50 years of civilian electricity production in the U.S. weighs 63,000 metric tons and could be stacked 30 feet high on a football field.

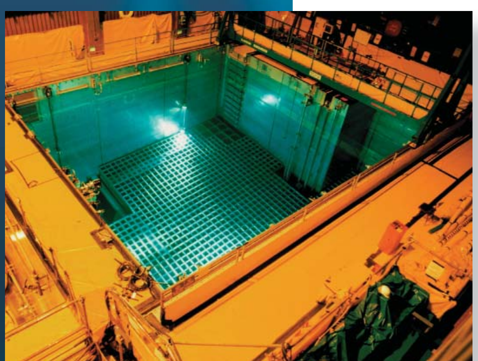
Nuclear fuel for electricity production consists of small solid ceramic pellets stacked in long cylindrical zirconium tubes (fuel rods) and grouped into what is referred to as a fuel assembly. The pellets contain Uranium 235, which is enriched to about five percent purity. By contrast, weapons grade enrichment requires a purity of 98 percent.

Multiple fuel assemblies are loaded into a reactor and become the reactor core. The assemblies generate nuclear fission reactions, creating heat to turn water to steam, which in turn rotates a turbine and generates electricity. Fuel assemblies stay in the reactor for four and a half to six years, after which they have only used up about five percent of the fissionable uranium. It is possible to reprocess the assemblies to get additional power.

The current operating U.S. nuclear fleet was designed with spent fuel pools to accommodate roughly 10 years worth of discharged fuel from the reactor, with the ideal solution to eventually ship the used fuel to a commercial recycling facility for reprocessing into new fuel assemblies, or to a permanent geological storage facility.

### *Nuclear Fuel Storage*

Nuclear fuel emerges from the reactor thermally hot and highly radioactive, necessitating special handling and equipment. Generally, a third of the fuel assemblies are removed from the core during a scheduled refueling outage, typically every 18 or 24 months. The fuel is moved underwater and stored in a deep pool known as a spent or used fuel pool. Spent fuel pools are strong structures constructed of very thick steel-reinforced concrete walls with stainless steel liners, generally located underground inside protected areas.



Used Fuel Pool

The fuel stays in the pool for a minimum of five years where it cools thermally and radioactively. Under current NRC rules, it can continue to be stored in the used fuel pool or moved to an NRC-approved dry storage cask. Casks typically consist of a sealed metal cylinder containing the spent fuel enclosed within a metal or concrete outer shell. Approved casks must be designed to resist floods, tornadoes, projectiles, and temperature extremes, and are intended to store used fuel safely for at least 60 years. The NRC is examining the potential for even longer-term, on-site fuel storage.

Until a permanent repository for spent fuel and other high-level nuclear waste is available, spent nuclear fuel will continue to be stored primarily in specially designed, water-filled pools or NRC-approved dry casks at individual reactor sites around the country.

### *Recycling of Used Fuel*

In the mid-1970s, reprocessing of nuclear fuel was banned due to concern for the derived plutonium that could be used for nuclear weapons. Although this ban was removed in the early 1980s, reprocessing and recycling of used nuclear fuel has not been pursued by private industry based primarily on fuel cycle economics. Today, only those countries that made large investments in reprocessing infrastructure continue to reprocess spent fuel.

The Nuclear Waste Policy Act of 1982 required the DOE to identify a suitable site as a permanent repository for used fuel. It also created the Nuclear Waste Fund, which collected a fee from all nuclear power plant operators. Although Congress identified Yucca Mountain as the site in 1987, a number of issues make it less and less likely it will ever operate as a waste storage facility. In 2010 President Obama created a Blue Ribbon Commission to study the issue of waste disposal and propose a solution. While the initial report from this group will be issued in the summer of 2011, current discussions indicate that the Blue Ribbon Commission is likely to recommend the development of a deep geological storage facility as well as several interim storage facilities.

Used fuel is safely and efficiently recycled in many other countries (Japan, France, UK, Russia) using processes that were largely developed in the U.S. Unlike coal, oil or natural gas, used nuclear fuel is not fully consumed during the process of electrical generation. Rather, it becomes “used” and is discharged from the reactor when its enrichment level has been reduced below the point at which it can efficiently maintain a nuclear chain reaction. But it still contains usable fissile materials that, once recycled, can be returned to the reactor for additional fuel cycles and electrical generation by fission.

Used fuel management is a complex subject. On the one hand, used nuclear fuel does not have to be considered waste since it contains valuable energy reserves which can be extracted via proven recycling technologies to continue to generate additional electricity. However, the continued concerns about the cost of reprocessing and the value of reprocessed fuel for weapons proliferation must be dealt with before reprocessing can be reasonably considered. A recent MIT study[19] concluded that the current open fuel cycle is most likely in the U.S. for the remainder of the century given economic considerations. Also, there is a more than adequate supply of fissionable uranium available to supply anticipated needs. To support fuel cycle decisions several decades from now, enabling research, development and prototypical demonstrations should be conducted. In the long run, it is necessary to develop policies that will ensure effective used fuel management, including storage, transportation, recycling and permanent disposal.

## State Incentives for New, Advanced Nuclear Energy Facilities

A new, advanced nuclear energy facility is a long-term asset, spanning at least 75 years from the start of project development through the final decommissioning of the plant at the end of its operating life. Plant developers realize that no power plant can be licensed and constructed without state governments taking a leading role in creating the supportive environment to facilitate development.

This report outlines the complex and time-consuming process of nuclear development, and the many uncertainties associated with it, including the licensing and permitting processes, financing costs, electrical energy market economics, carbon legislation, and public support. For those states interested in considering a nuclear power plant, the ability to adequately manage these uncertainties may ultimately determine the success of any project.

State tax incentives are one way to encourage project development. These can include shorter term, front-end reductions in state taxes. With a nuclear plant adding an average of $20 million annually to the state and local tax base ($1.2 billion over the 60 year life of the project), a 10 to 15 year tax reduction could help offset some of the enormous capital investment. State production tax credits or investment tax credits can also support the financial viability of any project development efforts.

Equally important considerations are land use and water rights. States can work with plant developers to identify areas that have the right siting characteristics, including water availability and access to high voltage transmission lines, and where there is strong local support for the facility.

The financing costs associated with a $10 billion, 10- to 12-year project can make up as much as 10 percent of the total project costs. One option that state public utility commissions have (where authorized by law) is to allow for rate recovery of a portion of those costs through Construction Work in Progress (CWIP) allowances during that time. Given the ever increasing cost of facility construction, it simply may not be possible for facilities to obtain such large loans without some amount of guarantees or subsidies. While there has historically been some resistance to having current ratepayers subsidize future customers, CWIP provides an opportunity to lessen the potential for rate shock to electricity bills once the plant goes operational, and potentially lead to lower consumer bills once the capital costs are amortized.

Educational institutions will provide an important source of trained employees for the design, construction, commissioning and operation of a nuclear plant. Encouraging science, technology, engineering and math (STEM) as elements of the higher educational system will stimulate local workforce development and encourage companies to consider locating facilities in that state.

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[19]The Future of the Nuclear Fuel Cycle, An Interdisciplinary MIT Study, 2010

Renewable Portfolio Standards (RPS) are being used in many states to increase the use of solar, wind, biomass, wave and geothermal energy. Besides promoting renewable energy projects and energy security, one of the other objectives of an RPS is to have a greater percentage of the generation portfolio be zero-carbon sources. Since nuclear power is carbon free, states may want to consider how to allow new, advanced nuclear energy to be integrated into meeting the RPS as a way to increase the percentage of carbon-free generating sources.

State financial incentives for the development of nuclear industry manufacturing infrastructure are another potential opportunity to support the domestic nuclear industry. The industrial infrastructure that can manufacture the high quality, complex and often large components needed to build nuclear energy facilities is primarily located offshore, particularly western Europe and eastern Asia. Redeveloping this infrastructure in the U.S. can provide greater energy security and bolster the economy.

The bulk of incentives for nuclear development are at the federal level. Still there are a number of programs available for those states wishing to encourage development of a nuclear facility.

## Federal Support for Nuclear Energy Development

The U.S. Federal Energy Policy Act (EPAct) of 2005 included a variety of mechanisms designed to stimulate and encourage the development of clean energy technologies, including nuclear, solar, wind, clean coal and carbon sequestration. These mechanisms included loan guarantees, production tax credits, streamlining the nuclear licensing process, and standby credit support.

*A loan guarantee is a contractual obligation between the government, private creditors and a borrower—such as banks and other commercial loan institutions—that the Federal Government will cover the borrower's debt obligation in the event that the borrower defaults.*

*Loan guarantee programs allow the Federal Government to share some of the financial risks of projects that employ new technologies that are not yet supported in the commercial marketplace or where private investment has been inhibited. In the case of nuclear, if guaranteed projects are delayed by government-related issues like safety regulation or planning, the DOE would ensure the utility does not have to pay extra finance costs on guaranteed debt.*

*This offer could cover up to 90 percent of loans, as long as they don't exceed 80 percent of a project's cost, which could greatly help the utility raise the cash. If there are no overruns, the DOE would not have to pay anything. On the other hand, because of credit cost requirements, the Federal government would receive a percentage of the loan value.*

As the banking sector has become more risk averse, loan guarantees may turn out to be the most important federal mechanism for realizing new plant construction. While loan guarantees are not loans, their purpose is to essentially provide a government co-signer to a loan issued by another party. The EPAct authorized $18.5 billion for new nuclear project loan guarantees to be used to guarantee up to 80 percent of the debt for any new, advanced power plant.

The loan-guarantee application and evaluation process by the Department of Energy has been in place for a little over three years. To date, the loan guarantee program includes 19 applications by 17 electric power companies to construct 21 reactors at 14 different sites. These applications represent $122 million in loan guarantee requests, more than six times the available amount. This demonstrates a strong interest on the part of utilities to embark on a new era of nuclear power plant construction, but at the same time, it offers limited opportunities for financing assistance.

The first conditional commitment by DOE to guarantee the loan was offered in February 2010 to Southern Company for its Georgia-based Vogtle project. In accordance with the loan guarantee conditions, the Southern Company will be able to apply the loan guarantee once it receives its Construction/Operations License and begins construction.

The backing provided by the Federal government is critical to incentivize financial markets to loan money to utilities. As states and utilities decide to include more clean energy generation in their portfolios, including new, advanced nuclear energy, the availability of loan guarantees and other incentives are essential to making that happen. Loan guarantees for any clean energy source, whether renewable energy, fossil fuels or nuclear, should be adequate to meet the potential for viable applications, and available to help advance the clean energy objectives of states and the country as a whole.

Spring 2011 construction activity at the Vogtle Power Plant in Georgia. Photo courtesy of Southern Company, Inc.

Furthermore, the credit costs (conceptually similar to a loan origination fee on a home mortgage) associated with the nuclear loan guarantee program must remain reasonable. DOE Secretary Stephen Chu has stated that the conditional commitment rate should be one percent plus or minus a half percent.[20] For example, on a loan guarantee of $8.2 billion a one percent credit cost amounts to a fee of $82 million, paid at the time the commitment is finalized and full construction is authorized through the issuance of a combined construction and operating license. In the case of the Vogtle project in Georgia, this fee would be expected to be paid sometime in mid to late 2012. By that time, the Southern Company will have invested nearly two billion dollars in the project.

A second offer of a conditional commitment for a nuclear project loan guarantee was extended to UniStar Nuclear for Unit 3 at Calvert Cliffs in Lusby, Maryland, about 40 miles from Washington D.C. However, the credit cost requested by the Department of Energy for this was 11.6 percent, far higher than the Vogtle offer. This translated into a project fee of about $880 million due at the start of construction. Constellation Energy (the co-owner of UniStar Nuclear at that time) decided that the credit cost was too burdensome and decided not to move forward with the loan guarantee process, selling their interest in the project to Electricite de France (EDF). EDF is still working to bring the project to fruition.

Part of the variability of credit cost may be related to DOE efforts to assess the viability of individual projects. All guaranteed loans must be paid back in full, and there is no cost to the taxpayers unless there is a default, a scenario that is less likely because of the stringent financial requirements in the nuclear guarantee program. Many of the current incentives for nuclear facilities, including the use of CWIP allowances, increase the potential of new plants to become operational and maintain an ability to repay any loans. While it is important for DOE to consider project viability when determining the appropriate credit cost, high credit costs will limit applications for loan guarantees and effectively slow new nuclear plant development.

Production tax credits were included in the Energy Policy Act of 2005, providing incentives of up to $125 million per year for the first eight years of operation to the first 6,000 megawatts of new nuclear energy plants meeting particular plant development milestones to come on line. The first of these milestones was to have a combined operating license application (COLA) submitted to the NRC by the end of 2008. The final milestone is for the reactor to be placed into service by the end of 2021. The Energy Policy Act also provided standby credit support for the first six reactors constructed in order to

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[20] U.S. Government Loan Guarantees for New Nuclear Construction, Nuclear Fissionary, May 21, 2010

protect against certain types of delays in the construction process. Given that a number of projects with initial COLA submittals have suspended or postponed further activity while waiting for clarification of uncertainties associated with finance costs, carbon legislation, and the licensing process, it is less likely that six projects will reach the milestones on time to qualify for the incentives, making an extension of the milestone deadlines a potential consideration.

The recently introduced Nuclear Power 2021 Act would authorize the DOE to implement programs to develop and demonstrate two small-scale reactors of less than 300 MW capacity by 2021. This type of legislation and federal support has previously been successful, spurring the development of the current advanced technology for new large reactors. Continuation of such programs will improve and advance nuclear technology.

A recent federal action has been the introduction of legislation to accelerate investment in low-carbon energy technologies by a bipartisan group of representatives in May 2011. Titled the "Infrastructure Jobs and Energy Independence Act," this legislation would authorize $50 billion in federal loan guarantees for electricity generating technologies that provide low carbon diversification for America's electric grid, and would establish a $110 billion fund that can be used in part to assist in reprocessing and recycling used nuclear fuel.

There are questions about the prospects for nuclear energy given the uncertainty surrounding passage of any carbon-reduction legislation, low natural gas prices, the impacts of the recent accident at Fukushima Dai-ichi, and currently depressed demand because of the sluggish economy. To determine how nuclear energy figures in to our clean energy future, the U.S. needs to clearly define clean energy objectives. Without such certainty, whether considering nuclear, traditional fossil fuels, or renewable energy, entrepreneurs and financiers are likely to act very slowly.

## Leadership for a Safe, Clean, Independent and Economic Energy Future

The existing role of the U.S. Nuclear Regulatory Commission in ensuring the health and safety of the public, and protecting the environment remains essential. Ongoing development of nuclear technology programs and expansion of funding for safety reviews and licensing efforts will be essential to ensure any new, advanced plants continue to be built to the highest safety standards. As always, the efforts of the NRC must be fortified with scientists and engineers in sufficient numbers to work with their counterparts in industry to ensure continued safe operation of our nation's fleet and development of ever-safer nuclear energy facilities.

The future of the United States depends on the availability of safe, clean, affordable and domestically produced electrical energy to fuel our economic growth, create jobs and provide for future generations in a way that will maintain a high quality of life. Continued development of state and federal policies that will be conducive to improving the safety and reliability of a new generation of even better new, advanced nuclear energy facilities has the potential to be an important part of that future.

# Acknowledgements

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