Strategy 7:

Examine the Use of Nuclear Power for Electricity Generation in Kentucky

GOAL **Nuclear power will be an important and growing component of the nation's energy mix, and Kentucky must decide whether nuclear power will become a significant part of meeting the state's energy needs by 2025.**

INTRODUCTION

In a carbon-constrained world, the interdependencies among energy, the environment and the economy will lead to broad sweeping economic transformation in the 21st century. To find solutions that address the climate challenges, use of our abundant natural resources to gain energy security and provide the power needed to drive our economy will require us to pursue a diversified portfolio of energy alternatives. In weighing the benefits and limitations of potential solutions we must be willing to fully assess and understand the societal, technical, and financial trade-offs involved. Nuclear power is one such option that deserves full attention.

Nuclear Power in the World

Nuclear power production has no direct carbon dioxide emissions and is already a significant component of the global energy system. Today there are 443 nuclear power reactors in operation in 31 countries around the world with another 30 in construction. Generating electricity for nearly one billion people, they account for approximately 17 percent of worldwide electricity generation (365 gigawatts).

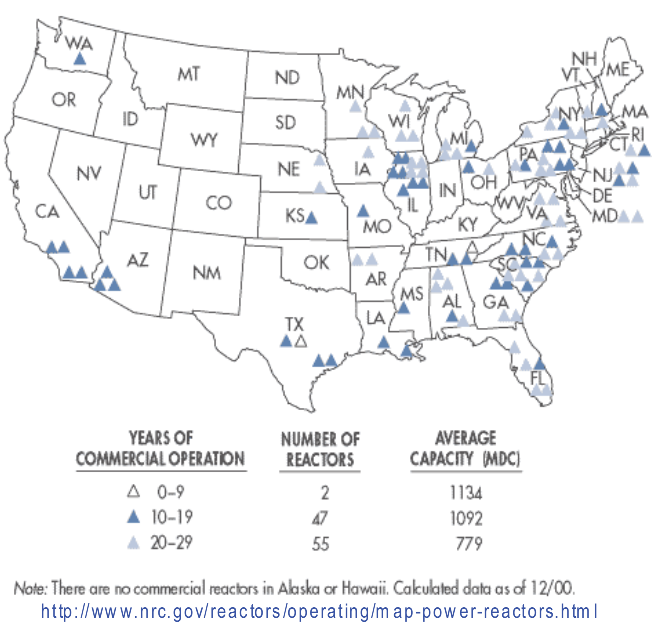


Figure 23: Power Reactors Operating in the United States

There are 104 commercial nuclear generating units that are fully licensed by the Nuclear Regulatory Commission (NRC) to operate in the United States where they account for approximately 20 percent of our nation's base-load electricity generation (101 gigawatts). Although the United States has the most nuclear capacity of any nation, no new commercial reactor has come on line in this country since May 1996 (EIA, 2008).

The current fleet of nuclear power plants has shown a steady increase in capacity factor over the past two decades. This improved efficiency and reliability has allowed the industry to maintain its approximately 20 percent share of the growing U.S. electricity market without adding any new generating stations. As an industry the median net capacity factor is now over 90 percent (Blake, 2008). In addition to outstanding reliability, the operation of these plants has amassed an outstanding record for safe and environmentally

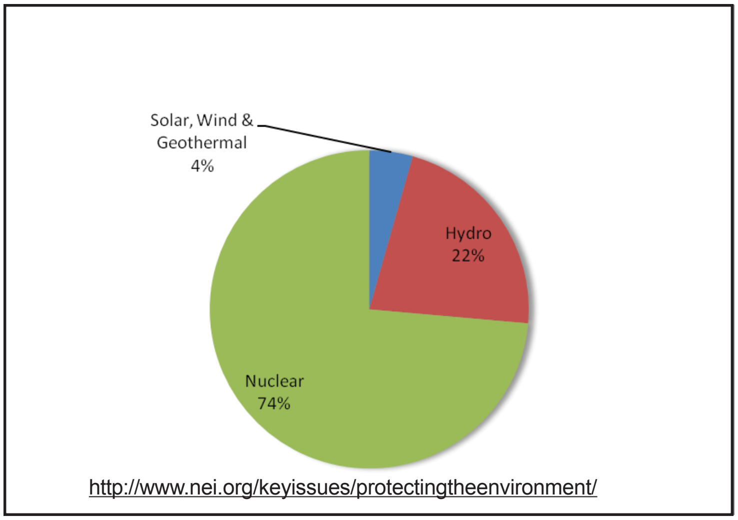


Figure 24: Sources of Emission-Free Electricity 2007

secure operations. Five of the seven states surrounding Kentucky have operating nuclear power plants and much of the eastern half of the U.S. relies on nuclear power as an essential element of their overall electric energy portfolio.

Total U.S. greenhouse gas (GHG) emissions increased from the 1990 baseline of 6,100 million metric tons of carbon dioxide-equivalent to 7,200 million metric tons in 2005. Nuclear-generated electricity avoids almost 700 million metric tons of carbon dioxide per year in the U.S. (over seven times the amount of carbon dioxide emissions from electricity generation in Kentucky). Worldwide nuclear energy avoids on average the emission of more than two billion metric tons of carbon dioxide per year.

Figure 24 illustrates the current sources of carbon dioxide emission-free electricity within the United States (Nuclear Energy Institute, 2008).

Nuclear Power Challenges

To further capitalize and expand on the climate benefits of nuclear power, the potential trade-offs must be well understood. In general, there are four issues that must be addressed in the U.S. in order for nuclear energy growth to be supported economically, publicly and politically.

Safety and Security

The nuclear safety record on an international scale must be maintained while expediting the licensing application/review process for siting and constructing new power plants. The nation's nuclear power plants are among the safest and most secure industrial facilities in the United States. Multiple layers of physical security, together with high levels of operational performance, protect plant workers, the public and the environment. U.S. nuclear plants are well-designed, operated by trained personnel, defended against attack and prepared in the event of an emergency. However, a major nuclear accident anywhere would drastically affect public acceptance and support, based upon historical precedence.

The NRC has implemented stringent federal regulations requiring automated, redundant safety systems, along with the industry's commitment to comprehensive safety procedures to keep nuclear power plants and their communities safe. Operators receive rigorous training and must hold valid federal licenses. All nuclear power plant staff are subject to background and criminal history checks before they are granted access to the plant. Each nuclear power plant has extensive security measures in place to protect the facility from intruders. Since September 11, 2001, the nuclear energy industry has substantially enhanced security at nuclear plants. In addition, every nuclear power plant in the country has a detailed plan for responding in the event of an emergency. Companies test that plan regularly, with the participation of local and state emergency response organizations. In addition, the next generation of certified reactor designs feature advanced passive safety systems further enhancing the safety of these plants.

Spent Fuel Storage, Transportation, and Disposition

To generate electricity nuclear power plants use uranium oxide fuel (in the form of small ceramic pellets) contained inside metal fuel rods which are grouped into bundles called assemblies. The uranium undergoes the process of fission (the splitting of uranium atoms in a chain reaction) which produces a tremendous amount of heat energy for the amount of material consumed. For example, one pound of uranium produces the same amount of heat energy as approximately 20,000 pounds of coal. Like a coal plant, this energy is used to boil water into steam, which drives a turbine generator to produce electricity. Every 18 to 24 months, the plant is shut down and the oldest fuel assemblies (which have released a considerable amount of energy but have become radioactive as a result of fission) are removed and replaced. All the used nuclear fuel from nuclear power plants is in solid form. A typical 1,000-megawatt nuclear power plant produces enough electricity for 740,000 homes and about 20 metric tons of used uranium fuel each year.

The country's 104 commercial nuclear reactors together produce about 2,000 metric tons of used fuel annually. Today, this used fuel is stored safely at plant sites, either in steel-lined vaults filled with water or steel-and-concrete dry storage containers. The NRC has determined that used fuel could be stored safely at power plant sites for 100 years. Monitoring and maintenance of safety systems ensure public health and safety are protected. Commercial reactor sites have the capability to deploy additional steel-and-concrete containers in on-site facilities. Many of these containers are licensed for both storage on-site and transport to the repository. As an example, if all of the electricity generation in Kentucky were from nuclear power plants, approximately 320 metric tons of used uranium fuel would be produced each year.

Eventually, the U.S. Department of Energy will be required to move the used fuel from plant sites to a centralized federal storage facility or federal geologic repository. Congress and the President approved Yucca Mountain, Nevada, as the site of a federal geologic repository for used nuclear fuel and high-level radioactive defense waste in 2002. In June 2008, the DOE submitted a license application to the NRC for the construction and operation of the repository. The protracted delays in the Yucca Mountain program have prompted considerable interest in a redirection of the nation's used fuel management strategy. Several approaches have been proposed, including additional on-site dry storage, centralized dry storage, and possible recycling of the spent fuel. But all approaches call for increased flexibility in how the government will manage used fuel in the future.

Used nuclear fuel will be transported from nuclear power plants to storage and disposal facilities by rail, truck or barge. The transportation containers used to ship used fuel typically have walls one foot thick, with radiation-shielding materials sandwiched between outer and inner metal shells. To ensure the transportation containers retain their integrity even in the event of an accident, they are designed to withstand a consecutive series of highly destructive tests. In these tests, containers have been crashed into concrete walls at more than 65 miles per hour (mph) and hit by locomotives traveling at 80 mph. Researchers also exposed the containers to fully engulfing fires, dropped massive weights on them and detonated gas tanks next to them. The containers used in these tests survived intact, verifying the integrity of their design. During the past 40 years, more than 3,000 shipments of used fuel have been completed safely in the United States, covering 1.7 million highway, rail and barge miles. Although vehicle accidents have occurred, there has been no release of radioactive materials from the containers or a single injury attributed to the cargo's radioactive nature.

Non-proliferation Safeguards

The increased global use of nuclear energy for peaceful purposes must not increase the risk of nuclear proliferation or terrorism. This will require preventing the further spread of enrichment and reprocessing technologies, avoiding the separation of weapons-usable material, and deployment of more proliferation-resistant technologies with improved safeguards. To combat the threat of proliferation, the international nuclear energy community has put in place rigid, redundant controls to ensure that it can fully account for nuclear materials manufactured for the production of electricity, along with their byproducts. The industry does so through the entire fuel cycle, from the mining of uranium to the safe and secure disposal of used nuclear fuel. These controls include global monitoring by international inspectors and stringent national inspection programs. Commercial reactor fuel poses no risk of proliferation; it cannot be used to make a nuclear weapon. The principal materials of concern in the nuclear-weapons production cycle include highly enriched uranium (HEU) and plutonium. Uranium as mined from the earth poses no risk of proliferation. Before its use in reactors, mined uranium must undergo an enrichment process that concentrates isotopes necessary for power production. This process creates low enriched uranium (LEU) through a lengthy and complex process. It is impossible to create a nuclear weapon from LEU without further enrichment.

Nuclear reactors, once in operation, create plutonium as a byproduct. However, the separation of plutonium contained in used fuel pellets requires complex chemical reprocessing. Like enrichment, reprocessing calls for highly sophisticated chemical processing infrastructure.

Economic Sustainability

Nuclear energy that meets safety, waste disposition, and nonproliferation goals must remain economic and sustainable. Next generation reactors must be selected and developed accordingly. The Energy Policy Act of 2005 (EPAct) established a number of incentives (discussed below) to encourage development of new nuclear power plants in the United States. Along with these incentives, the inevitability of climate legislation (involving a carbon cap or tax, or requiring carbon capture and sequestration for fossil fuel power plants) make nuclear power even more cost-competitive. The economics of nuclear energy for electricity generation are discussed in greater detail below.

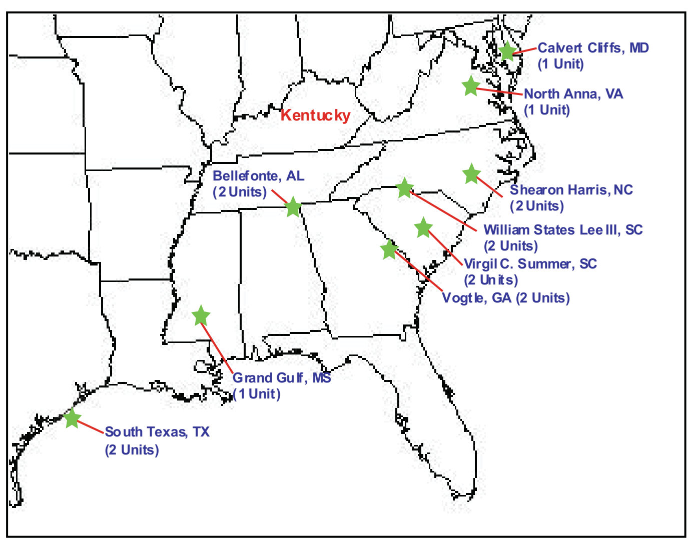


Figure 25: Location of New Power Reactors Sites (COL Applications Submitted to NRC)

New Reactor Deployment in the United States

In order to simplify licensing of new power plants, the NRC can certify standardized reactor designs for 15 years through the rulemaking process. The NRC review of a design certification application addresses the safety issues of an essentially complete nuclear power plant design, independent of a specific site. Site-specific environmental and safety reviews are conducted once an applicant submits its combined construction and operating license (COL) application. The new generation

Table 10: Next Generation of Reactor Designs Identified for Possible Deployment

Reactor Design	Vendor/ Reactor Type	Capacity (MWe)	NRC Certification Status	Description
AP1000 (Advanced Passive 1000)	Westinghouse/ Pressurized Water Reactor	1117	Certified	The AP1000 is Westinghouse's advanced PWR design. Westinghouse anticipates that operating costs should be below the average of reactors now operating in the United States. The AP1000 includes innovative, passive safety features and a much simplified design intended to reduce the reactor's material and construction costs while improving operational safety. http://www.ap1000.westinghousenuclear.com/
ESBWR (Economically Simplified Boiling Water Reactor)	General Electric/ Boiling Water Reactor	1550	Undergoing Certification	The ESBWR is a new simplified BWR design promoted by General Electric and Hitachi. The ESBWR constitutes an evolution and merging of several earlier designs including the ABWR. The ESBWR, which includes new passive safety features, is intended to cut construction and operating costs significantly from earlier ABWR designs. http://www.gepower.com/prod_serv/products/nuclear_energy/en/new_reactors/esbwr.htm
EPR (Evolutionary Pressurized Water Reactor)	AREVA NP/ Pressurized Water Reactor	1600	Undergoing Certification	AREVA NP announced in early 2005 that it would market its EPR design in the United States and has recently begun design certification activities. The EPR is a conventional, though advanced, PWR in which components have been simplified and considerable emphasis is placed on reactor safety. The proposed size for the EPR has varied over time, but is most frequently placed around 1600 MWe. Earlier designs were as large as 1750 MWe. http://unistarnuclear.com/
ABWR (Advanced Boiling Water Reactor)	General Electric/ Boiling Water Reactor	1371	Certified	Four ABWRs operate in Japan and more are planned there and in Taiwan. While the ABWR design is usually associated in the United States with General Electric, variations on the design have also been built by Toshiba and Hitachi. Hitachi also hopes to associate with General Electric for building additional ABWRs at the South Texas Project. http://www.gepower.com/prod_serv/products/nuclear_energy/en/new_reactors/abwr.htm
US APWR (US Advanced Pressurized Water Reactor)	Mitsubishi/ Pressurized Water Reactor	1700	Undergoing Certification	The US-APWR is a U.S.-marketed variation on APWR design sold in Japan by Mitsubishi Heavy Industries. The 1700 MW US-APWR was only recently (June 2006) announced for the U.S. market. Pre-application design certification activities before the NRC began during July 2006. Mitsubishi submitted a design certification application in March 2008 and hopes to complete the process during 2011. http://www.mhi-r.jp/english/new/sec1/200607031122.html

of reactor designs offers significant advancements in both safety and economics over the existing light-water reactor designs. Table 10 provides a summary of the advanced reactor designs currently under consideration for possible deployment in the United States.

Nine COL applications covering 15 new reactors have been submitted through June 2008 to the NRC for review. Integrated environmental review teams have been assembled for each COL, and the acceptance and scoping phases of these projects has commenced. In addition, up to six more COL applications are expected before the end of the year. Appendix E provides a complete listing of potential new reactor projects identified to the NRC. For each COL application a comprehensive Environmental Impact Statement (EIS) is prepared and public input is sought.

National and State Legislation Affecting the Expansion of Nuclear Power

Energy Policy Act of 2005 (EPAct)

To meet the national energy policy objectives of energy independence, affordability, and reliability, the Energy Policy Act of 2005 (EPAct) set forth supply-side policies that are designed to increase the availability and diversity of fuel sources, develop technologies that use fuels more efficiently, and address fuel constraints through the development of alternative energy sources. In addition, the EPAct also sets demand-side policies to encourage energy conservation. Many of the EPAct policies and programs are designed to take greater advantage of domestic energy sources and alternative energy sources to displace oil imports.

The EPAct provides several investment incentives for nuclear power, including:

- Loan guarantees for new nuclear plants.
- Production tax credits (1.8 cent per kilowatt-hour) for new plants.
- Standby support for new reactor licensing delays (investment risk protection).
- Renewal of the Price-Anderson Act insurance indemnification.

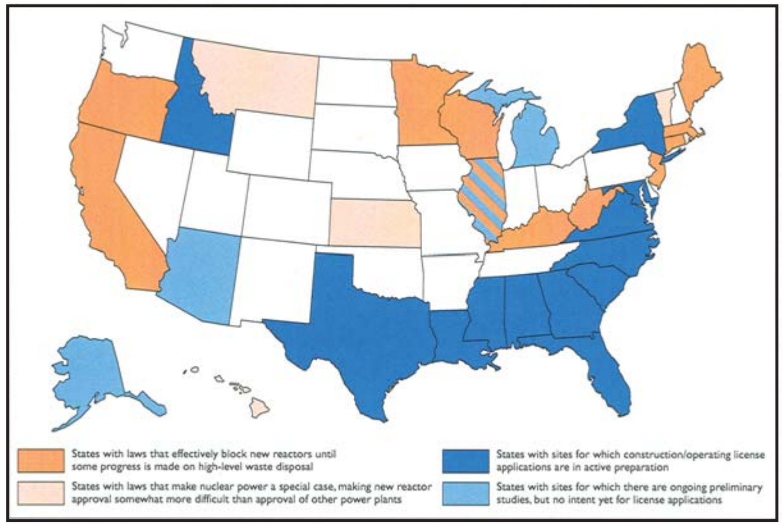
Similar incentives were provided for clean coal initiatives, coal-to-liquids development, renewable energy, alternative fuels, energy efficiency programs, and oil and gas development. One important result of this bill and the subsequent Energy Independence and Security Act of 2007 was to provide an investment climate where the risks to financial institutions and equity investors in developing new energy sources (including the next generation of nuclear power plants) was reduced. This enables companies to more easily obtain financing and equity investments needed to develop new domestic energy supplies.

Future Climate Legislation

Policy makers are considering various legislative proposals that would impose charges on entities that emit carbon dioxide, the most common greenhouse gas. Such policies could further encourage the use of nuclear power, which emits no such gases, by increasing the cost of generating electricity with competing fossil-fuel technologies.

State Legislation

Even with the likely resurgence in nuclear power, there remain a number of states, including some with significant nuclear power assets, which have passed legislation that would block new reactor projects. Generally these involve developments over which the nuclear community has no control such as the opening of a high-level waste (HLW) repository for spent fuel. Several of these states have recently introduced legislation or considered referendums to repeal or change these laws.



http://www.ans.org/pubs/magazines/nn/docs/2006-11-2.pdf

Figure 26: State Laws Pertaining to Nuclear Energy

Kentucky has one such law, KRS 278.600-610, on the books. Kentucky law states that a power reactor cannot be certified by the state's Public Service Commission (PSC) unless a disposal site for HLW either already exists or would be available by the time the plant needs disposal capacity. The PSC also could not certify the project unless it finds that the cost of HLW disposal "is known with reasonable certainty." During the 2008 legislative session, two bills were introduced (SB 156 and HB 542) to "allow construction of such plants provided that the PSC certifies that the facilities' plan for disposal of high level nuclear waste is in conformity with the technology approved by the U.S. Government and that the cost of disposal can be calculated in order that an accurate economic assessment can be completed." These proposed bills did not make it out of committee, but revised versions will likely be reintroduced soon.

Economics of Nuclear Power

A number of recent studies have been published comparing the life-cycle costs of nuclear power to other sources of electric power, and the potential impacts of climate legislation on these costs. These include:

- Congressional Budget Office (CBO), "Nuclear Power's Role in Generating Electricity." May 2008.
- The Keystone Center, "Nuclear Power Joint Fact Finding," June 2007.
- Congressional Reporting Service Report, "Nuclear Energy Policy," Updated January 2008.
- World Nuclear Organization (WNO) Report, "The Economics of Nuclear Power," May 2008.
- International Energy Agency, "Energy Technology Perspectives, In Support of the G8 Plan of Action, Scenarios and Strategies," 2008.
- Global Energy Technology Strategy Program, "Global Energy Technology Strategy, Addressing Climate Change, Phase 2 Findings from an International Public-Private Sponsored Research Program," May 2007.

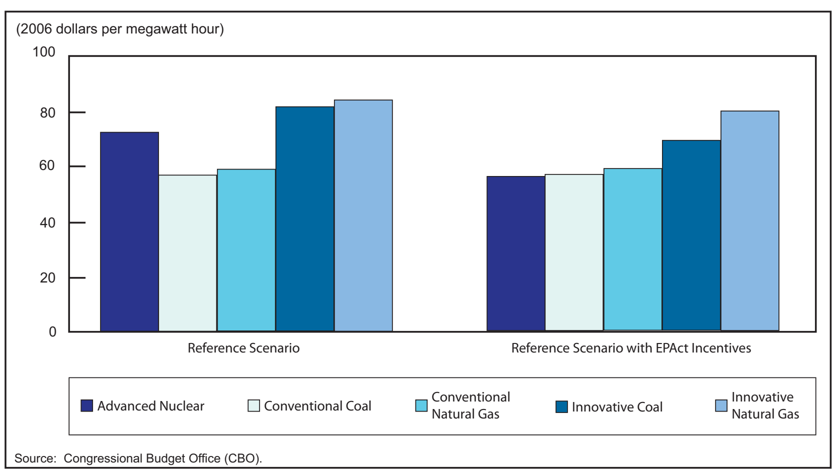
These studies provide a wealth of information relative to the cost of nuclear power, both globally and within the United States. To understand the likelihood of nuclear power expansion within the U.S. one must look at the economics under current conditions, with the incentives provided by the EPAct of 2005, and under a range of likely scenarios involving capping greenhouse gas emissions.

World-wide nuclear power is cost competitive with other forms of electricity generation, except where there is direct access to low-cost fossil fuels. Capital costs of nuclear power plants are greater than those of traditional fossil-fired plants, with construction costs for nuclear power plants built in the mid-1980s historically ranging from $2 billion to $6 billion, averaging more than $3,000 per kilowatt of electric generating capacity (Holt, 2008). The nuclear industry predicts that new standardized plant designs can be built for considerably less (on the order of $1,500 per kilowatt), but this assertion has yet to be demonstrated. However, fuel costs (including uranium ore, conversion, fabrication, enrichment and waste fund) are much lower than fuel costs for fossil plants and the costs are much easier to reliably predict.

In order to compare various forms of electricity generation, the concept of levelized life-cycle cost is used. Levelized life-cycle cost is the total cost of a project from construction to retirement and decommissioning, expressed in present value and then spread evenly over the useful output (kilowatt-hours) of the project. It includes the cost of capital and other financing charges as well. In assessing the cost competitiveness of nuclear energy, decommissioning and waste disposal costs must also be included.

From the CBO reference scenario, the levelized cost of nuclear power in the U.S. is 7.2 cents per kilowatt-hour without EPAct incentives. Adding in the impact of EPAct production tax credits, loan guarantees, and investment tax credits, the levelized cost of nuclear power in the U.S. is 5.8 cents per kilowatt-hour. The levelized cost of conventional coal power is comparable to nuclear power with the EPAct incentives, or 5.5 cents per kilowatt-hour. Most studies project the levelized cost of innovative coal power plants (pulverized coal or integrated gasification combined cycle with CCS) to be at least 15 percent greater than nuclear power. The CBO analysis predicts such costs to be 8.2 cents per kilowatt-hour without EPAct incentives and 6.2 cents per kilowatt-hour with incentives.

One can find a variety of levelized cost estimates. The CBO provides a wide range of estimates, based on variations in future market conditions (fuel costs and construction costs) and variations in future carbon dioxide policy. For nuclear energy the range is 4.8 to 12.1 cents per kilowatt-hour. For conventional coal the range is 4.0 to 12.8 cents per kilowatt-hour. The National Energy Technology Laboratory



http://www.cbo.gov/ftpdocs/91xx/doc9133/05-02-Nuclear.pdf

Figure 27: Levelized Cost of Alternative Technologies to Generate Electricity With and Without EPAct Incentives

report (NETL, 2007) estimates the levelized costs of innovative coal power (with CCS) to range from 10.6 to 11.7 cents per kilowatt-hour. Figure 27 from the CBO study illustrates the relative costs of various energy generation technologies, both with and without the EPAct incentives.

The world's reliance on nuclear power is expected to grow whether or not there are constraints on greenhouse gas emissions. However, in the long run, carbon dioxide charges will increase the competitiveness of nuclear technology and could make it the least expensive source of new base-load capacity. More immediately, EPAct incentives by themselves could make advanced nuclear reactors a competitive technology for limited additions to base-load capacity.

Over the past few years, most likely in response to both the prospect of carbon dioxide charges and the incentives offered in EPAct, several utilities have begun planning new nuclear projects, which may signal the end of a 30-year hiatus in financing the construction of nuclear power plants. As discussed above, over a dozen utilities have announced their intention to file COL applications for about 30 nuclear plants. Those plants would provide approximately 40,000 megawatts of new capacity. Although the announcements reflect renewed interest in building new nuclear power plants, they do not indicate how much capacity utilities will ultimately build. Completing the revised design and licensing process is expected to cost about $100 million per plant, about five percent of the anticipated cost for constructing a nuclear plant. Filing a COL application by the end of 2008 may be necessary for those projects to remain eligible for a share of the $7.5 billion (in nominal dollars) in production tax credits, but filing does not obligate an applicant to build the proposed plant.

Key findings in the CBO's analysis (as illustrated in Figure 28) include:

- In the absence of both carbon dioxide charges (an unlikely scenario) and EPAct incentives, conventional fossil-fuel technologies would most likely be the least expensive source of new electricity-generating capacity.
- Carbon dioxide charges of about $20 per metric ton (for coal) and about $45 per metric ton (for natural gas) would probably make nuclear generation competitive with conventional fossil fuel technologies as a source of new capacity, even without EPAct incentives. At charges below these thresholds, conventional gas technology would probably be a more economic source of base-load capacity than coal technology. Below about $5 per metric ton, conventional coal technology would probably be the lowest cost source of new capacity.

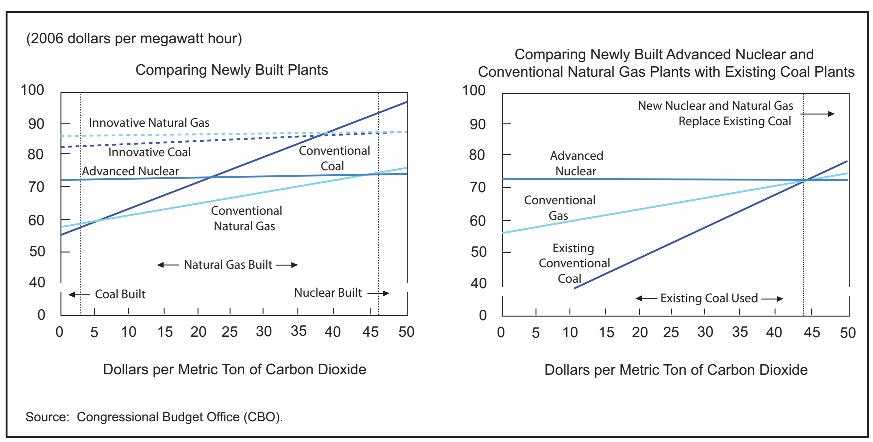


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Figure 28: Levelized Cost of Alternative Technologies to Generate Electricity Under Carbon Dioxide Charges

- Also at roughly $45 per metric ton, carbon dioxide charges would probably make nuclear generation competitive with existing coal power plants and could lead utilities to a position to build new nuclear plants that would eventually replace existing coal power plants.
- EPAct incentives would probably make nuclear generation a competitive technology for limited additions to base-load capacity, even in the absence of carbon dioxide charges. However, because some of those incentives are backed by a fixed amount of funding, they would be diluted as the number of nuclear projects increased; consequently, the CBO anticipates that only a few of the 30 plants currently being proposed would be built if utilities did not expect carbon dioxide charges to be imposed.
- Uncertainties about future construction costs or natural gas prices could deter investment in nuclear power. In particular, if construction costs for new nuclear power plants proved to be as high as the average cost of nuclear plants built in the 1970s and 1980s or if natural gas prices fell back to the levels seen in the 1990s, then new nuclear capacity would not be competitive, regardless of the incentives provided by EPAct. Such variations in construction or fuel costs would be less likely to deter investment in new nuclear capacity if investors anticipated a carbon dioxide charge, but those charges would probably have to exceed $80 per metric ton in order for nuclear technology to remain competitive under either of those circumstances.
- The U.S. Energy Information Administration found that the cost of generating electricity from coal-fired power plants with CCS would exceed the cost of power generated by nuclear power plants by 15 percent.

ACHIEVING THE GOAL

Nuclear power will be an important and growing component of the nation's energy mix, and Kentucky must decide whether nuclear power will become a significant part of meeting the state's energy needs by 2025.

Four major long-term drivers are reshaping the energy industry in the U.S. and in Kentucky. They include:

- Increasing focus on climate change.
- Economic and energy security concerns driving the need for energy reserve and supply diversification.
- Increased electric power intensity of the economy.
- Increasing pressures to revitalize an aging power and fuels infrastructure.

Nuclear power could have an important role in responding to these drivers and could provide the commonwealth with an economically sustainable means to address climate change and power Kentucky's economy, while enabling optimal use of coal resources for advanced coal conversion processes.

Near-Term Actions (1-3 years)

1. Examine legal hurdles to successful inclusion of nuclear power in Kentucky's energy mix and specifically address removal or revision of the ban on new nuclear power plants (K.R.S. 278.600-610).

2. Develop and implement a public engagement plan to gather and address stakeholder feedback and concerns.
3. Promote industry partnerships, where Kentucky utilities are introduced to potential partners in the nuclear industry. A strong team at the EEC could drive this initiative to attract the right mix of potential companies and investors. Introduction of nuclear power in Kentucky would require a unique team with demonstrated experience in the industry and capable of managing large multi-billion dollar projects. Participants would include reactor vendors, engineering, procurement and construction (EPC) contractors, and owners/operators. Consideration could be made in potentially joining or engaging the industrial consortium NuStart Energy (of which Duke and TVA are members).
4. Consider integrating nuclear power into an overall electric power industry transition plan.
5. Conduct a state-wide analysis of carbon dioxide allocations over time and assess economic and transition options under likely climate cap-and-trade scenarios. Recommend policies that minimize the economic impact to rate payers, provides incentives for advanced coal-conversion processes, and exceeds carbon dioxide emission reduction goals.
6. Conduct research to assess the desirability of collocating nuclear power plants with advanced coal conversion plants to assess the effects on reducing carbon dioxide emissions, providing ready access to electricity and/or steam, and possibly using waste heat in the conversion process.
7. Develop criteria and prepare a bank of potential sites for nuclear power plants.

Mid-Term Actions (3-7 years)

1. Consider creating a program of incentives that reduce the risk of capitalizing and financing a new power plant, include assured rates, recovery of a portion of construction costs prior to operation, and tax incentives (refunds, credits, etc.) to attract nuclear power plants to Kentucky.
2. Develop an effective and consistent oversight program that could Include expeditious permitting, providing needed infrastructure, and working with local communities and interest groups to ensure the potential concerns are identified early and that involved parties are fully informed of the considerations for siting and operations.
3. Investigate a partnership with the Nuclear Regulatory Commission to understand their licensing process and the interface with the commonwealth's permitting activities.

Long-Term Actions (> 7 years)

1. Work with vocation training institutes in Kentucky to ensure that trained personnel are available to staff the construction and operation of nuclear power plants.
2. Explore with state universities the possibility of adding nuclear engineering, health physics, and radiological science programs to their curriculum.

IMPLEMENTATION SCHEDULE

In order to assess the possible implementation of a nuclear power program by 2025, it is important to understand Kentucky's current electric power industry and recent trends. It is interesting to note that the natural gas generating capacity (currently 23 percent of Kentucky's overall peak capacity of 20,000 megawatts) built during the early part of the decade is only seeing marginal use for peaking power due to current high natural gas prices.

A moderate investment in nuclear power (8 plants at four sites) could be considered as part of an overall strategy to diversify Kentucky's future electrical energy portfolio, reduce carbon dioxide emissions, and position the state to take advantage of advanced coal conversion opportunities. Kentucky couldutilize nuclear power to generate a significant percentage of the state's energy needs, with coal-based and nuclear power for electricity generation being roughly equal. With the likelihood of carbon dioxide penalties, a significant portion of the coal power generation is likely to be new plants with CCS processes implemented.

The assumptions and planning basis behind this case are provided in Figure 29. Assumptions include:

- Annual growth in base-load power is 1.7 percent (which already accounts for efficiency and conservation goals).
- Hydroelectric power stays at the 2006 level.
- Renewable energy rapidly increases to become 10 percent of the portfolio in 2025.
- Natural gas capacity market share remains constant.

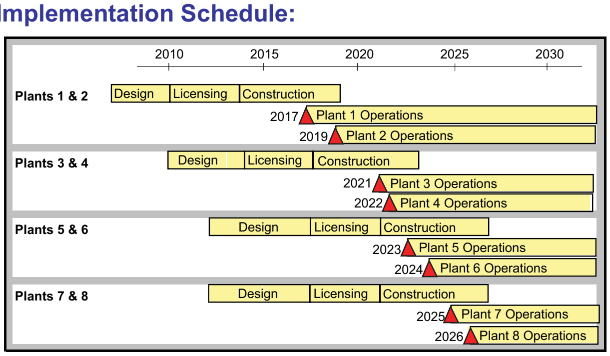
Description:

This scenario implements a moderate investment in nuclear power (8 plants) as part of an overall strategy to diversify Kentucky's future electrical energy portfolio, reduce CO_2 emissions, and position the state to take advantage of Coal-to-Liquid (CTL), Coal-to-Gas (CTG), and/or Biomass opportunities

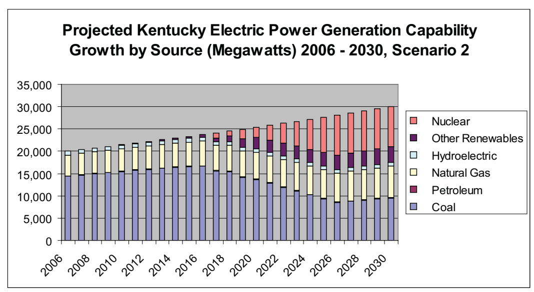
Assumptions & Planning Basis:

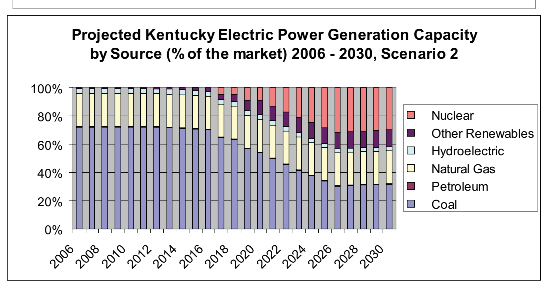
- Real **growth** in base-load power of 1.7%, which already accounts for expected gains in efficiency and conservation goals.
- **Nuclear Power** Basis:
  - Eight - 1117 MW (AP-1000) reactors would be built
  - Four sites would be needed, each site would be licensed to support two plants
  - Start-up is staggered by two years, beginning in 2017 and converts to annual startups in 2021
  - Kentucky Site Bank Evaluation (8/07) used to assess potential sites and possible co-location with a CTL/CTG production plant
- **Hydroelectric power, renewable energy, and natural gas assumptions are the same as Scenario 1.**
- **Coal** is assumed to make up the remainder of power needs and, over time, at least a portion of the conventional coal plants will be replaced and/or upgraded with carbon capture & sequestration (CCS) systems

Implementation Schedule:

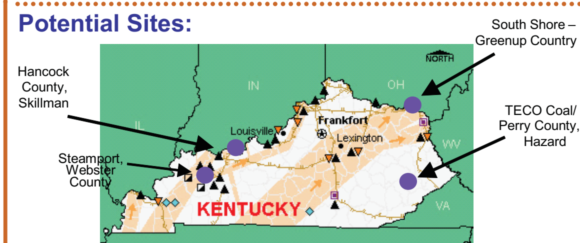


Projected Kentucky Energy Portfolio:





Potential Sites:



http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=KY

Figure 29: Moderate Investment in Nuclear Power (~30% by 2025)

For this scenario, the use of the AP1000 reactor (1117 megawatts) has been arbitrarily assumed. If alternative (larger) reactor designs are selected the number of plants and sites could be reduced while still meeting the overall capacity needs. Potential sites are provided for illustrative purposes only and have not undergone rigorous evaluation or been subject to the NRC process needed for formal siting. These potential sites were identified using the criteria and analysis provided in the August 2007 Kentucky Site Bank Evaluation for advanced coal conversion processes.

ENVIRONMENTAL BENEFITS & LIMITATIONS

In light of the incentives provided with the EPAct and the potential financial impacts of climate change legislation, nuclear power is an economically viable zero-emission alternative for Kentucky's electric energy mix. The impact on carbon dioxide reductions and their potential economic value are 48 million metric tons of carbon dioxide avoided at $2.16 million annual economic value assuming carbon dioxide credits of $45 per metric ton.

In addition to the benefits of reducing Kentucky's carbon dioxide emissions, the addition of nuclear power into the states electric energy mix also supports:

- Competitive power costs – Lowers average cost of power in a carbon constrained world.
- Forward price stability – 60 percent of total costs are fixed.
- Energy Security – Less dependence on imported oil and gas (high reliability).
- Coal conversion processes (coal-to-gas and coal-to-liquids) – Allows the judicious use of carbon dioxide allowances available to Kentucky (trading emissions from power generation to emissions for CTL and CTG development) and possible co-location of plants.
- Enhanced economic development – For the local communities hosting a nuclear power plant thousands of jobs would be created. During the 4-6 year construction period as many as 4000 construction workers would be needed. During operations, 400-700 jobs would be created for each new reactor. Operating life of each reactor is assumed to be 60 years. In addition to the direct workforce benefit, the communities also would benefit through the direct expenditures for goods, services, and labor (CASEnergy Coalition 2008).

Public perception of nuclear power plant safety and the effective disposition of spent nuclear fuel remain two potential concerns that must be effectively addressed. These issues are not unique to Kentucky and are being addressed at a national level. The safety record of existing power plants, including the on-site storage of spent fuel, has been excellent. These issues were explored in detail earlier in this document and should be explicitly covered as part of a public education and engagement program.

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- Nuclear Regulatory Commission – http://www.nrc.gov/
- Department of Energy (DOE) – Nuclear Energy Home Page – http://www.ne.doe.gov/
- Nuclear Energy Institute - http://www.nei.org/