Summary
Statement of Mary J. Hutzler
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Department of Energy
before the
Subcommittee on Energy and Air Quality
Committee on Energy and Commerce
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Nuclear power is the second largest supplier of U.S. electricity generation, accounting for 20 percent of all generation by electricity producers and cogenerators in 2000. No new nuclear capacity has been completed in the United States since 1996. However, generation has continued to grow since that time due to improved performance at existing plants. The average time required for refueling and regular maintenance has dropped considerably, and unplanned outages have been reduced. Existing plants are also making technical improvements that can increase their maximum capacity by up to 15 percent, and therefore provide more electricity.

The contribution of nuclear power to the U.S. electricity supply is expected to decline over the next 20 years, as some existing nuclear units begin to retire. Nuclear power is projected to provide 11 percent of the nation's electricity generation in 2020, less than coal and natural gas. No new nuclear construction is projected to come on line by 2020 due to the higher cost of new nuclear construction relative to coal- and gas-fired technologies. Twenty seven units of existing capacity are projected to operate beyond the initial 40 year license period. Currently 5 nuclear units have received approval by the Nuclear Regulatory Commission to extend their licenses for an additional 20 years. Another five units have submitted applications for license renewal, and 28 units have scheduled future submittals with the NRC through 2004.

The nuclear power industry and the Department of Energy face challenges in the area of disposing of the high-level nuclear waste. The Department of Energy is tasked with siting a final repository for the spent fuel generated by nuclear power, and to take title to the existing waste beginning in 1998. However, the final site has not yet been approved, and an amendment to the Nuclear Waste Policy Act prohibits the Department from creating an intermediate storage site prior to siting the final repository. Therefore, there is no central temporary storage site available, and nuclear generators must continue storing spent fuel at the reactor site. A number of utilities have filed suit against the Department due to its delay in beginning to accept spent fuel. The Department has entered into a settlement with one utility to compensate it for costs the utility incurred related to the Department's delay. Another potential regulatory issue for nuclear power is the expiration of the Price-Anderson Act in 2002, which will revisit the issue of liability in the event of a nuclear accident, as well as the amount of coverage required for each nuclear power plant.

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Mr. Chairman and Members of the Committee:

I appreciate the opportunity to appear before you today to discuss current and future prospects for nuclear power in the United States.

The Energy Information Administration (EIA) is an autonomous statistical and analytical agency within the Department of Energy. We are charged with providing objective, timely, and relevant data, analysis, and projections for the use of the Department of Energy, other Government agencies, the U.S. Congress, and the public. We do not take positions on policy issues, but we do produce data and analysis reports that are meant to help policy makers determine energy policy. Because we have an element of statutory independence with respect to the analyses that we publish, our views are strictly those of EIA. We do not speak for the Department, nor for any particular point of view with respect to energy policy, and our views should not be construed as representing those of the Department or the Administration. However, EIA's baseline projections on energy trends are widely used by Government agencies, the private sector, and academia for their own energy analyses.

The Committee has requested information about current and future utilization of nuclear power for electricity generation, statutory and regulatory provisions that impact the use of nuclear power, the prospects for using nuclear power to meet future generation needs, and the role of nuclear power in a comprehensive national energy policy. EIA collects and interprets data on the current energy situation, and produces both short-term and long-term energy projections. The projections in this testimony are from our

Annual Energy Outlook 2001, released late last year. The *Annual Energy Outlook* provides projections and analysis of domestic energy consumption, supply, and prices through 2020. These projections are not meant to be exact predictions of the future, but represent a likely energy future, given technological and demographic trends, current laws and regulations, and consumer behavior as derived from known data. EIA recognizes that projections of energy markets are highly uncertain and subject to many random events that cannot be foreseen, such as weather, political disruptions, strikes, and technological breakthroughs. In addition, long-term trends in technology development, demographics, economic growth, and energy resources may evolve along a different path than assumed in the *Annual Energy Outlook*. Many of these uncertainties are explored through alternative cases.

The Current Situation

Supply, Demand and Prices

The United States currently has 104 operable nuclear units, totaling 97.5 gigawatts of capacity. Electricity generation from nuclear power increased in 2000 to 754 billion kilowatthours, and the average capacity factor for U.S. nuclear power plants in 2000 was the highest in history at 89% (Figure 1). Through 1990, the average annual capacity factor was less than 70%. Increased performance has been achieved through improved operations resulting in shorter and fewer outages. During 1999, the average time required to refuel a nuclear reactor was 42 days, and nearly all nuclear plants operate for 18 months between refuelings. During the 1970's and 80's the average refueling cycle was more typically 12 months, resulting in more frequent outages. The industry's median unplanned capacity loss factor was just two percent in 1999.

In 1999, the production costs (expenditures for fuel and operations and maintenance) at nuclear power plants averaged 1.9 cents per kilowatthour (kwh), roughly the same as the operating costs of coal-fired power plants, and about two-thirds the operating costs of oil and natural gas-fired steam plants.

Fuel costs are a small part of the operating costs of a nuclear power plant. In 1999, U.S. utilities purchased a total of 47.9 million pounds of U_3O_8e (equivalent) at an average price of $11.63 per pound U_3O_8e. Foreign sources supplied 76 percent of the deliveries, mainly from Canada, Australia and Russia. Nuclear operators tend to purchase uranium on long-term contracts and the prices are not particularly volatile. Utilities loaded fuel assemblies containing 58.8 million pounds U_3O_8e into reactors during 1999, and had inventories of 58.2 million pounds at year-end. U.S. suppliers had 68.8 million tons of uranium inventories at year-end 1999. EIA estimates of U.S. uranium reserves total 1,182 million pounds, although the estimated costs of mining and milling the uranium are higher than current market prices. During 1999, a total of 4.5 million pounds U_3O_8e of uranium were produced by mining, and there were nine commercially operating uranium mines in the United States. Once the uranium is purchased, it must then be enriched (increasing the concentration of the fissionable isotope) before it can be used as nuclear fuel. U.S. facilities provided 46 percent of U.S. utilities enrichment services in 1999, and foreign enrichment plants the remaining 54 percent. Enrichment services are also primarily obtained through long-term service contracts.

Legislative and Regulatory Challenges

The Nuclear Regulatory Commission (NRC) oversees the licensing and operation of nuclear power plants. The typical operating license for a nuclear plant was issued for 40 years. With the first wave of current plants brought online in the 1970s, many of these units could be facing retirement in the near future. However, the NRC has provided a process for nuclear plant owners to apply for renewal of their operating licenses, adding another 20 years to the licensed lifetime. In March of 2000, Baltimore Gas and Electric’s two Calvert Cliffs units were the first nuclear reactors to receive license renewal, extending their license expiration dates to 2034 and 2036, respectively. Also in 2000, three units at Oconee received license renewal approval, and five other units have applications submitted. Future submittals have been scheduled for roughly 40 percent of current plants through 2004. The NRC has created a streamlined process to review applications, and the total time from application submitted to approval has been just under two years. The cost to the owner of pursuing a license renewal has been estimated at between $10 million and $20 million per reactor, and requires detailed descriptions of expected aging effects and how they will be addressed to maintain safe operation. The renewal approval does not require the company to undertake potential capital expenditures to keep the plant running the additional time, which could be substantially more than the cost of obtaining the license. So the eventual retirement date of any plant will likely be based on the economics of its operation rather than the actual date on the license. To date, the longest a commercial nuclear plant in the United States has operated is 33 years.

Nuclear waste disposal is a challenge that is faced primarily when the plant is shut down and waiting to be decommissioned. Low level waste (LLW) disposal is the responsibility of the states where the waste is generated. Interstate compacts have been created to jointly develop sites for disposal; however, no new sites have been opened even though the Low Level Radioactive Waste Policy Act stated that disposal facilities could refuse to accept waste from outside their compacts beginning in 1992. Currently, only three low-level waste sites exist: one in Hanford, Washington, which only accepts waste from states in the Northwest Compact in which it resides, and the neighboring Rocky Mountain Compact; one in Clive, Utah, which is only licensed to accept the lowest level - Class A - waste, and one in South Carolina, which is still accepting all classes of LLW from all states except North Carolina. States that do not have access to disposal facilities are likely to require the waste generators to store their waste on-site until new disposal sites are available. South Carolina has recently joined a compact with Connecticut and New Jersey, and has enacted a state law to phase out acceptance of non-compact waste by 2008. The site in Utah, operated by Envirocare, has applied for a license to accept the higher classes of waste, and has no plans to limit acceptance of the waste. Low-level waste disposal issues are important because they affect the cost and timing of decommissioning nuclear power plants.

The Department of Energy is working on siting a repository for spent nuclear fuel and high-level waste. The proposed waste site at Yucca Mountain, NV is still undergoing site characterization, to determine if the site is suitable and should be recommended for development. The soonest this proposed facility could begin accepting the waste is 2010. The initial storage of the spent fuel assemblies, once removed from a reactor, is in steel lined pools at the reactor site. However, these are quickly being filled to capacity at most reactors. For temporary storage, dry cask containers have been developed and licensed by the NRC to store the used fuel assemblies. Some of these storage containers should be suitable for transporting the waste once the final repository is sited. The lack of a final repository is not likely to force any operating nuclear reactors to shut down early, but will require the owners to purchase, and receive approval to install, the temporary storage containers on-site.

Finally, the Price-Anderson Act expires in 2002 and could create barriers to new construction if it is not extended in its current form. The Price-Anderson Act was enacted into law in 1957, as part of the Atomic Energy Act, to meet two objectives: to remove any deterrents to private sector participation in nuclear energy due to the threat of large liability claims in the event of a catastrophic nuclear accident, and to ensure that adequate funds are available to the public if such an accident were to occur. The Act limits liability to third parties in the event of a nuclear accident to $9.43 billion. It also provides for a series of retroactive assessments paid by all nuclear utilities if the total liability exceeds the amount of primary coverage. If the Act is not extended, coverage for existing units would continue as provided by the Act, but any new nuclear units would not be covered. The Price-Anderson Act has been extended three times since 1957, and current legislation has been proposed in the Senate that includes the extension of the Act through 2012.

The Outlook

The Annual Energy Outlook 2001 (AEO2001) reference case projects U.S. energy supply, demand and prices through 2020. It assumes a continuation of current laws and regulations, and provides alternative scenarios to deal with uncertainty in the assumptions. It is expected that recent trends in improved performance will be maintained, resulting in average capacity factors for operating plants of 90 percent by the last years of the forecast. The long-term projection, however, is for a decline in total generation from nuclear power as some existing nuclear reactors are retired and replaced by other, mainly gas-fired, generating units (Figure 2).

Electricity demand is projected to grow at an annual average rate of 1.8 percent between now and 2020. To meet this demand, and to replace retirements of older generating units, EIA projects 413 gigawatts of new generating capacity will be needed (including cogeneration capacity). Of this new capacity, 92 percent is projected to be combined-cycle or combustion turbine technology fueled by natural gas. About five percent of the new capacity is expected to be coal-fired, and the remaining three percent renewable technologies. The projected operating cost of a new nuclear reactor (including capital recovery) is about 6 cents per kilowatthour, higher than that for coal or combined-cycle capacity which are roughly 4 cents per kilowatthour (Figure 3). Gas-fired units are favored particularly in restructured electricity markets due to their lower capital costs, higher efficiencies, shorter construction times, and better load following characteristics.

Within the EIA forecast, nuclear units are forecast to retire when their operation is no longer economic relative to replacement capacity. The forecast incorporates future aging-related costs that could be incurred as plants consider operating beyond 40 years. In the reference case, nuclear plants are assumed to incur additional capital costs of $14 per kilowatt (kw) per year after 40 years, and increase to $25/kw per year after 50 years. These costs are reduced significantly for individual units if they have already incurred major capital investments related to plant upgrades. The aging related costs are similar in magnitude to annual capital additions assumed for existing fossil plants ($4-5/kw for gas plants, $10/kw for oil/gas steam units and $16/kw for coal plants, on average). In the reference case, 27 percent of current capacity is forecast to retire by 2020, mainly after 2010. Of this retiring capacity, one nuclear plant is projected to retire before the end of its 40 year life, 30 units are forecast to retire at the end of their current license expiration and 2 units are projected to retire ten years after their current license expiration (implying a license renewal was received). Another 25 units have original licenses that expire by 2020, but are forecast to receive license renewal and extend their operation beyond 2020.

Because the U.S. nuclear industry has no experience operating reactors beyond 40 years (the oldest operating reactor today is just over 30 years old), future operating costs and capital investments required are unknown. Due to the uncertainties surrounding future aging-related costs, several cases were developed to further analyze the effects on electricity supply due to differing assumptions regarding the costs of future operation (Figure 4). These results provide a range of possible futures for existing nuclear power. In the low nuclear case it was assumed that aging related costs would begin earlier, with capital additions of $5/kw per year starting at age 30. A total of 18 additional units were projected to be retired through 2020 relative to the reference case. Additional fossil-fired capacity was projected to be built to replace the retiring nuclear capacity, and the carbon emissions from electric generators increased by two percent (16 million metric tons carbon equivalent) above the reference case in 2020. In the high nuclear case, aging related costs were assumed to be lower by 25 percent, resulting in more plants projected to operate beyond their initial license life. In the high nuclear case only 11 units were projected to retire through 2020 (9 percent of current capacity). About 14 gigawatts of fossil-fired capacity (roughly 47 units at 300 megawatts each) would no longer be required, relative to the reference case, and carbon emissions from electric generators would be reduced by two percent (16 million metric tons carbon equivalent) by 2020.

There are additional uncertainties affecting other generating industries that could change the competitiveness of nuclear power. Current natural gas prices are much higher than normal in response to low levels of gas storage, unusually cold weather and supply issues. The AEO2001 forecasts that this situation will reverse over the next few years, as increased drilling and production occurs, and that gas prices will return to more typical levels by 2004. Therefore, forecasts of the cost of new gas-fired capacity later in the forecast are based on gas prices below the current levels. More existing nuclear power plants would be economic if current gas prices remained throughout the forecast period, resulting in fewer retirements. However, it is expected that this tight supply situation for natural gas will dissipate before 2010, when the retirement decisions for nuclear units start being made.

The electric generation sector may also face restrictions on the emissions of various pollutants in the future. Since the AEO2001 forecast incorporates current laws and regulations, it requires the electric sector to meet sulfur dioxide and nitrogen oxide restrictions as specified in the Clean Air Act. The summer season cap on nitrogen oxide (for 22 states) will be imposed in 2004 by the Environmental Protection Agency (EPA). Because these reductions are being met by existing fossil plants by adding the necessary control equipment, their operation and costs are not greatly affected. If additional emissions were targeted in the future for reduction, such as carbon dioxide, a large number of coal plants would be retired and replaced mainly by gas-fired technology, leading to higher natural gas prices. This situation would provide an economic incentive to continue operating more of the existing nuclear power plants.

For example, the EIA recently performed an analysis of strategies for reducing multiple emissions at power plants, at the request of then-Representative David M. McIntosh, Chairman of the Subcommittee on National Economic Growth, Natural Resources, and Regulatory Affairs of the House Government Reform Committee. In this report, EIA was asked to provide an analysis of proposals to reduce sulfur dioxide (SO2) and nitrogen oxide (NOx) by 75 percent from 1997 levels, and carbon dioxide (CO2) to either 1990 levels or 7 percent below 1990 levels, similar to the general requirements of the Kyoto protocol, but restricted to emissions by electric generators. In order to comply with the CO2 cap, the industry was projected to dramatically shift away from coal to natural gas, and to a lesser extent, renewables. This analysis also showed fewer nuclear retirements (9 percent of current capacity) by 2020, as the higher natural gas prices (as much as 63 percent higher than the reference case in 2010) and CO2 allowance prices made it economical to continue operating more of the existing capacity. This scenario assumed the AEO2001 reference case aging-related costs for nuclear plants, however, the nuclear capacity forecast was similar to the high nuclear case due to the emissions targets and higher natural gas prices. At the request of the Subcommittee, this analysis assumed that no new nuclear power plants would be built throughout the forecast period.

Projections of the cost of building new nuclear capacity is difficult, due to the length of time since a new unit has been ordered in the United States, and the lack of experience in building new designs. The AEO2001 reference case bases the cost of a new nuclear unit on the advanced passive reactor design (AP600), which has been approved by the NRC as part of its standardized design certification. This design has evolved from the current operating designs, but also includes passive safety features and is based on a smaller size (600 megawatts). The initial overnight capital cost (in 1999 dollars) of the AP600 is assumed to be $1730 per kilowatt, compared to $1020 to $1220/kw for a coal-fired unit and $420 to $530/kw for a gas-fired combined cycle unit. Contingency factors are applied to the costs of all new capacity, and are made up of two components - a project contingency factor, which is applied throughout the forecast to account for delays during construction due to unforseen problems such as weather or labor issues, and a technological optimism factor, which is only applied to the first four units built of a new design to account for the tendency to underestimate costs for new technologies. Capital costs decline over time as new capacity is built and experience is gained. However, because the initial cost for the advanced nuclear technology is much higher than other available technologies, it is not economic to build nuclear units in the reference case.

The Department of Energy's Office of Nuclear Energy has developed long-term cost goals for these evolutionary designs that are lower than current estimates. An alternative nuclear cost case was developed assuming the cost of the new nuclear technology was $1500/kw initially, falling to $1200/kw by 2015, with a ten percent project contingency factor applied to these costs. In addition, cases were considered assuming both 3 and 4 year construction times. In these cases the nuclear technology was closer to being competitive with coal and gas-fired capacity (Figure 5); one new unit was projected to be built in the last years of the forecast under the assumption of a 3 year lead time. (Nuclear units were not economic under a four year lead time assumption.)

Worldwide, work has been developing on a more revolutionary new commercial nuclear power technology, known as the pebble bed modular reactor. South Africa's state-owned utility has been working on the technology since 1993, but it has recently gained the interest of foreign energy policymakers as well as potential investors. One U.S. based company, PECO Energy, has joined with British Nuclear Fuels Corporation in making financial commitments to the venture. PECO's parent company, Exelon Corporation, has begun discussions with the NRC about building PBMRs in the United States. The economics are expected to improve for this technology because of the plant's small, modular design (110 megawatts each). The design incorporates passive safety features and would have higher thermal efficiency than existing nuclear plants, requiring less fuel and producing less waste. The estimates of construction costs ($1000/kw) would be very competitive with new coal-fired technologies available in the United States, if they could be attained. The construction costs would still be almost double that of a new gas combined-cycle unit ($530/kw). Ultimately, this design is still untested, and its future will be determined in large part by the success or failure of the South African demonstration project, scheduled for completion in 2005.

Conclusion

While nuclear power today provides roughly one-fifth of the nation's electricity generation, that share is expected to drop over the next two decades as some existing units are retired and replaced by other generating technologies. Coal will remain a large supplier of electricity, and natural gas is expected to greatly increase its proportion of electricity generation. While operating performance at individual nuclear units is expected to remain high, total output from nuclear plants is expected to decline by about twenty percent between now and 2020, as units are removed from service.

The ability to relicense existing nuclear plants for an additional twenty years of operation could extend the operating lives of current reactors, and delay retirements. However, achieving new orders for nuclear plants based solely on economics is unlikely at this time due to the high construction costs of the technology, as well as uncertainties related to costs, safety and waste. The challenge of waste disposal is faced by existing nuclear power plants as they continue to store high level waste on-site, waiting for site approval and construction of the permanent waste repository required by the Nuclear Waste Policy Act.

Thank you, Mr. Chairman and members of the Subcommittee. I will be happy to answer any questions you may have.

Figure 1. Nuclear Power Plant Capacity Factors, 1973-2000 (percent)

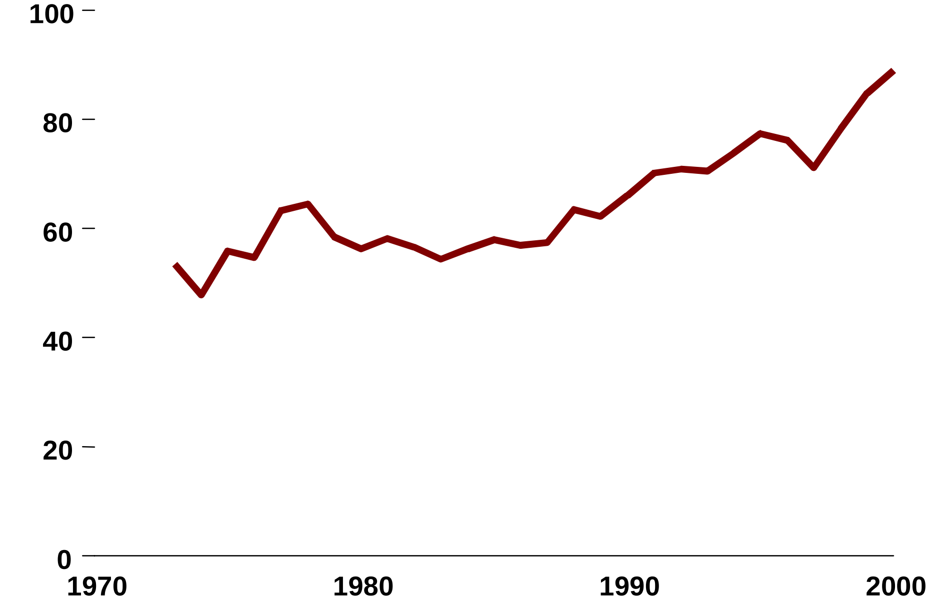

Figure 2. Projected Electricity Generation by Fuel, 1999 and 2020 (billion kilowatthours)

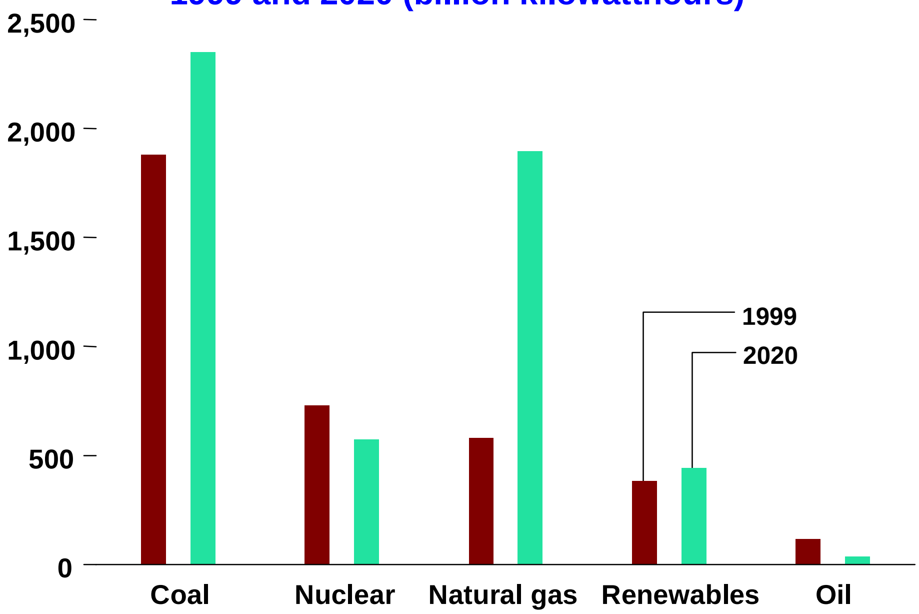

Figure 3. Projected Electricity Generation Costs, 2005 and 2020 (1999 mills per kilowatthour)

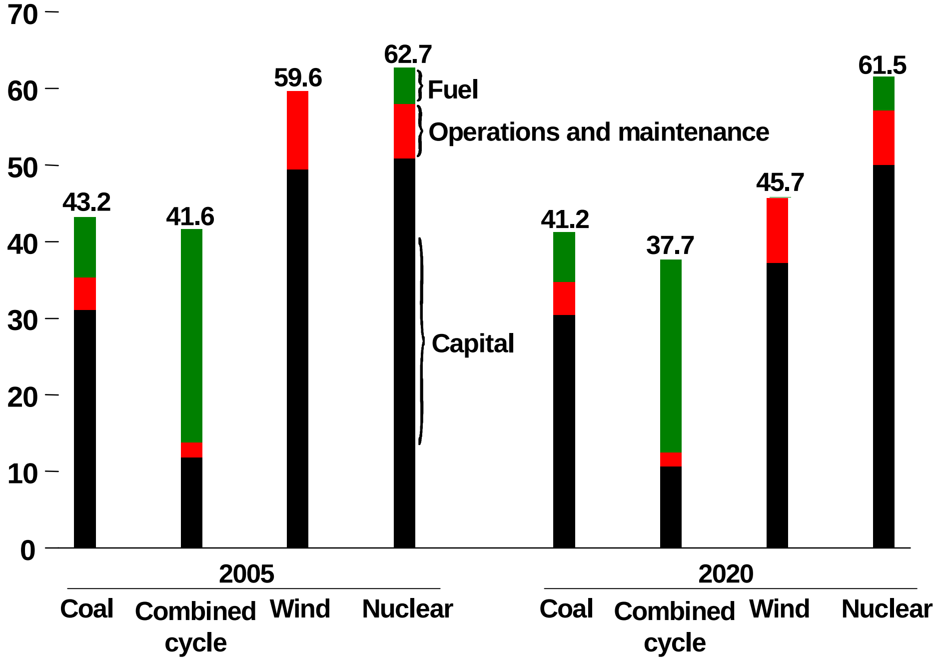

Figure 4. Projected Operable Nuclear Capacity in Three Cases, 1995-2020 (gigawatts)

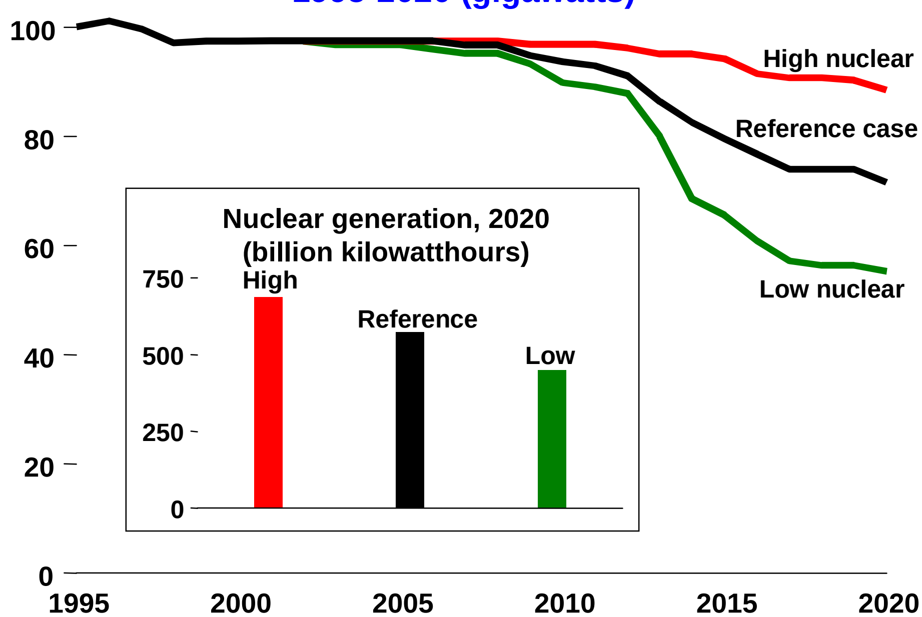

Figure 5. Projected Electricity Generation Costs by Fuel Type in Two Advanced Nuclear Cost Cases, 2005 and 2020 (1999 cents per kilowatthour)