# TOPIC PAPER #25

# NUCLEAR POWER

On July 18, 2007, The National Petroleum Council (NPC) in approving its report, *Facing the Hard Truths about Energy,* also approved the making available of certain materials used in the study process, including detailed, specific subject matter papers prepared or used by the Task Groups and their Subgroups. These Topic Papers were working documents that were part of the analyses that led to development of the summary results presented in the report's Executive Summary and Chapters.

**These Topic Papers represent the views and conclusions of the authors. The National Petroleum Council has not endorsed or approved the statements and conclusions contained in these documents but approved the publication of these materials as part of the study process.**

The NPC believes that these papers will be of interest to the readers of the report and will help them better understand the results. These materials are being made available in the interest of transparency.

The attached Topic Paper is one of 38 such working document used in the study analyses. Also included is a roster of the Subgroup that developed or submitted this paper. Appendix E of the final NPC report provides a complete list of the 38 Topic Papers and an abstract for each. The printed final report volume contains a CD that includes pdf files of all papers. These papers also can be viewed and downloaded from the report section of the NPC website (www.npc.org).

**NATIONAL PETROLEUM COUNCIL**

**NUCLEAR POWER SUBGROUP**
**OF THE**
**TECHNOLOGY TASK GROUP**
**OF THE**
**NPC COMMITTEE ON GLOBAL OIL AND GAS**

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# Nuclear Power

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Date submitted: December 25, 2006

## I. Executive Summary

Nuclear power is a significant producer of the world's electricity, generating approximately 16% of global electricity supply. The majority of nuclear power installations occurred in the 1970s and 1980s, and in the past decade, the additions in nuclear power have been outpaced by other forms of generation.

Nuclear power plants, like coal power plants, provide base load, whereas natural gas power plants can respond to rapid changes in power needs. Because of this, growth in nuclear generation of electricity displaces five times the amount of coal-supplied electricity than natural gas-supplied electricity. The outlook for nuclear power is less than the growth in other types of generation and we see the percent of electricity from nuclear power declining over the next 20 years.

Growth in nuclear power is forecast by the EIA and IEA to be between 0.6% and 1.4%; this reflects the retiring of older nuclear power plants globally.[1] There are four reasons that impact the growth of nuclear power: one of the primary reasons is uncertainty of costs, as well as time to construct; another is spent-fuel storage; the third is concerns around safety; and lastly there are concerns globally around proliferation of nuclear materials. If there are larger-than-forecast increases in nuclear power usage, then further quantification of supply and economic impacts of increased price need to be evaluated.

[1] International Energy Agency (IEA): *World Energy Outlook* (2006).
Energy Information Agency (EIA): *Annual Energy Outlook* (2006)

One of the significant factors that could sway the forecasts for more nuclear power growth would be a pricing mechanism for $CO_2$ that would effectively lower the cost of nuclear power plants.

In light of all of the factors impacting nuclear power over the next 20 years it is not viewed to have a significant impact of demand for oil and gas.

# II. Overview of Methodology

The information in this report was generated by surveying literature available in the public domain. The most relevant publications dealing with the effects of technology on nuclear power supply are listed in Table II.1.

| Nuclear Power Study References |
|---|
| International Energy Agency: *World Energy Outlook* (2006) |
| Energy Information Agency: *Annual Energy Outlook* (2006) |
| DOE Office of Nuclear Energy: *Business Case for New Nuclear Power Plants* (2002) |
| University of Chicago: *The Economic Future of Nuclear Power* (2004) |
| *United Nations World Energy Assessment 2004* |
| Moniz E: "A Plan for Nuclear Waste," *Washington Post* (January 2006) |
| International Atomic Energy Agency: *Analysis of Uranium Supply to 2050* (2001) |

**Table II.1. Primary reports utilized for the nuclear power study.**

Active discussion among members of the Nuclear Power subgroup was established through email and phone calls. The participants are listed in Table II.2.

| Team Member | Affiliation |
|---|---|
| Scott Hoyte | General Electric |
| Dr. Ernie Monix | MIT |
| John Stamos | DOE |
| Will Van der Zalm | Fluor |
| Chris Maslak | General Electric |
| Michael Campbell | General Atomics |

**Table II.2. NPC Nuclear power subgroup team members**

# III.Background

## *A. Size and Impact of Nuclear Power Generation:*

Nuclear power is a significant contributor in the world's energy supply, which represents approximately 6% of all energy utilized and approximately 16% of the world's electricity. Nuclear power is projected to grow in the future, but this growth could be hampered due to public perception, policy, and economics.

In power generation, nuclear power is an asset that provides base-load power, meaning that nuclear power plants are operating at or near capacity all of the time. This type of power generation does not typically impact generation from tradition oil and gas power plants, which are typically load-following, as they respond to fluctuations in electricity demand by their ability to quickly increase the amount of power supplied. It is because of these different types of power systems that nuclear power displaces a much greater amount of growth in coal-power generation and a smaller amount of oil and gas generation.

Many models forecast this displacement of coal similarly, which is shown by Figure IIIA.1. This chart is from the EIA AEO 2006 Advanced Nuclear Cost case, which assumes that the capital and operating costs in 2030 are 20% lower than they are today. The vendor estimate case assumes 18% lower than the reference case initially and 44% lower in 2030, which are consistent with the Westinghouse estimates for the AP1000. The "Reference" case is a business-as-usual scenario.

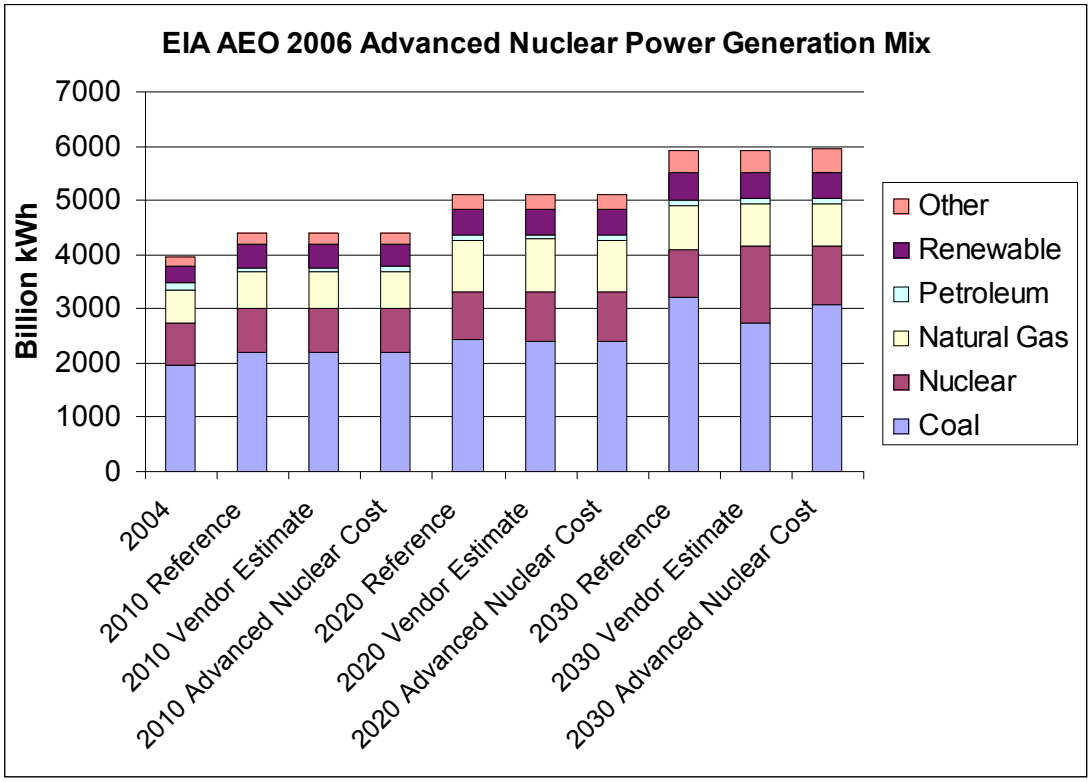


**Figure IIIA.1. Nuclear power interactions.**[2]

# IV. Forecasts

## *A. Forecast of Nuclear Power Growth*

Over the past 40 years, nuclear power has emerged as a significant source of electricity. The majority of nuclear power plants were constructed during the 1970s and 1980s. However, because of high capital costs and lack of public acceptance due to safety concerns, construction of nuclear power plants has significantly declined from its peak of 200 GW in the 1980s (See Figure IVA.1).

[2] EIA, reference 1.

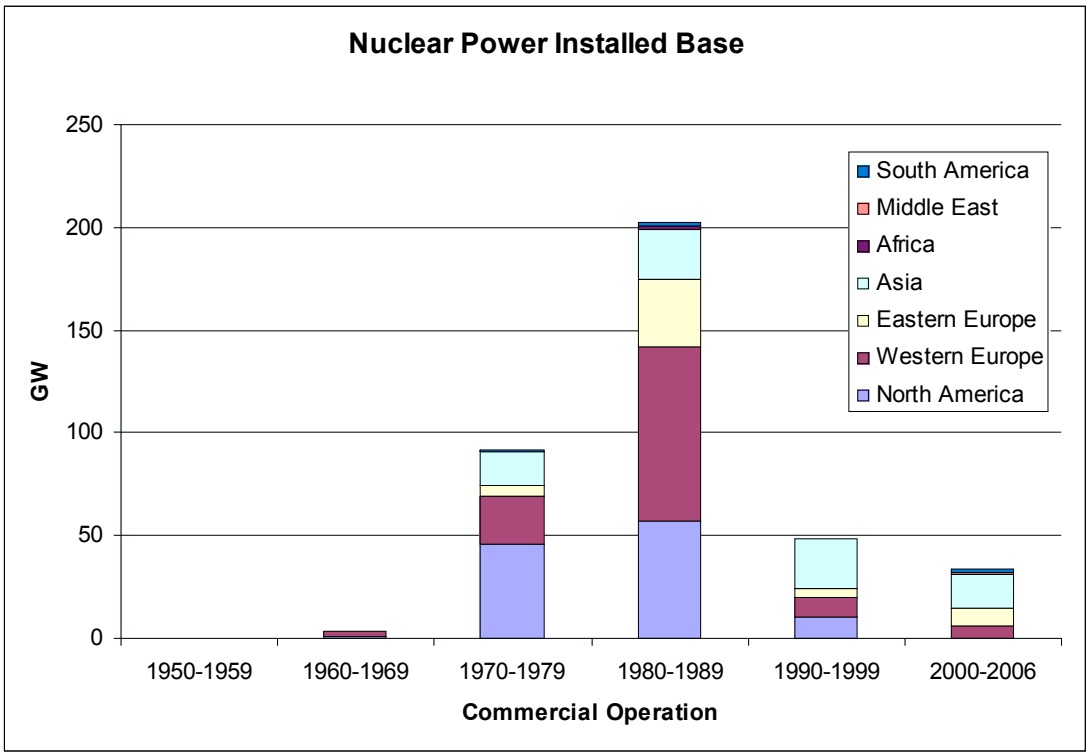


**Figure IVA.1 Nuclear installed base [courtesy General Electric].**

Many of the forecasts show nuclear plants increasing in power generation, but declining in the percent of total electricity generated. The majority of nuclear power plant construction is projected to be in non-OECD countries, with the majority of growth forecast in Asia.

The period before 2030 forecasts nuclear power to be using the existing technology of fissile reactors, with more advanced technologies coming online after 2030 (See Figure IVA.2.).

The 2030 IEA Reference forecast follows a "business as usual" scenario. In this forecast, nuclear power trails alternative methods of power generation by approximately 3 to 1, and thus declines in percent of total electricity produced from 16% to 10%. In the IEA Alternative Policy forecast, nuclear power grows at a more rapid rate, but it is outpaced by alternative power generation technologies, declining from 16% to 14% of total electricity generated. The Alternative Policy case assumes that there is an effort to curtail global warming that includes measures to boost the role of nuclear power. The EIA International Energy Forecast is a "business as usual"

scenario, with growth in non-OECD countries offset by decommissioning of nuclear power plants elsewhere.

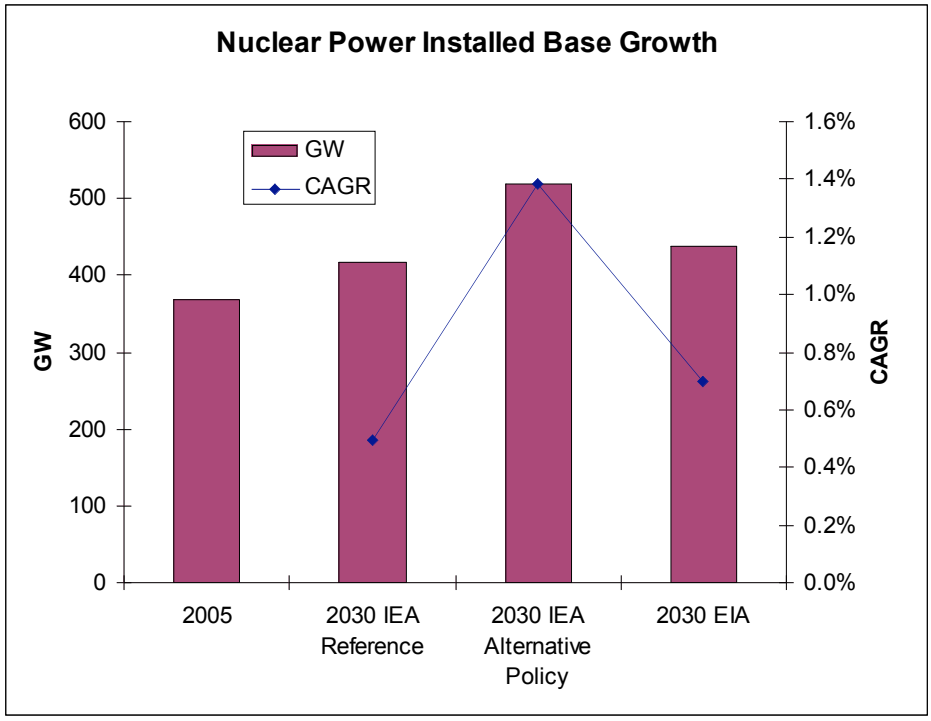


**Figure IVA.2. 2005–2030 nuclear growth.**[3]

For the forecasted growth, the International Atomic Energy Agency believes that there is enough uranium to support the high-growth cases; it is only a matter of uranium price that will bring on this supply.[4] If there are larger-than-forecast increases in nuclear power usage, then further quantification of supply and economic impacts of increased price need to be evaluated.

# V. Discussion

With the current forecasts for nuclear power growth, it is believed that there is sufficient uranium as fuel and the infrastructure could be constructed to support the

[3] IEA, reference 1.
EIA, reference 1.
[4] International Atomic Energy Agency: *Analysis of Uranium Supply to 2050* (2001).

level of growth indicated in the forecasts. If growth is significantly higher than the forecast, there is a possibility that the supply chain for critical nuclear components will need additional time to increase manufacturing of these components.

Additionally, the forecasts do not account for the use of smaller (100–250 MW) blocks of nuclear power from either pebble-bed reactors or other technologies. It is possible that these types of systems, when proven, could reduce the risks associated with nuclear power construction and increase the growth of nuclear power. There is also the possibility that nuclear energy be used to displace other methods for generating process steam in a co-generation scheme. This was not investigated as part of this survey, but it is recognized as a potential displacing technology to conventional techniques.

There are four issues that can delay the nuclear new build. First, the high capital costs for nuclear power plant construction, the financing required to construct these plants, and the resulting cost of energy often make nuclear new build a difficult investment decision for a utility. There are government measures, both domestically and abroad, to encourage new construction of nuclear plants. One significant measure that would increase the competitiveness of nuclear power would be a pricing mechanism on $CO_2$. If a $CO_2$ mechanism were enacted it is possible that nuclear energy would be adopted at a faster rate than the forecasts above.

The second issue facing nuclear power is the storage and processing of spent fuel; waste management must be a strategic part of any nuclear development plan. The third issue is public perception around nuclear power safety, and lastly there are global concerns about the proliferation of nuclear materials. Without addressing these four issues, it is possible that nuclear power grows at a global rate that is slower than the forecasts.