Nuclear Energy Advisory Committee

Draft Report of Policy Subcommittee

September, 2008

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I. Introduction

More than 50 years since the launch of the Atoms for Peace initiative, the implications of US nuclear policy, in terms of our Nation's energy, environmental, and national security interests, are greater than ever. The choices the next president will make regarding nuclear energy will therefore be of the utmost importance. The mission of this Subcommittee is to explore the critical choices and implications in US nuclear energy policy, with a view to framing options for the next President to consider.

Nuclear energy is just one element of the broader energy picture. One cannot effectively address nuclear policy without reference to its role in the overall energy mix both domestically and internationally, and without acknowledging the costs and benefits of different approaches as well as the tradeoffs that must be considered among them. This Subcommittee, however, is confined by mandate to the charter of the Nuclear Energy Advisory Committee. Thus, our report will focus primarily on nuclear energy. While we will be informed by alternative energy options, we will not analyze them in depth, nor will we attempt to make definitive judgments about the relative merits or demerits of nuclear energy compared to any other energy source. We do not believe these parameters will impair our work, since we accept the premise articulated in numerous studies (such as the 2003 MIT nuclear study, IEA WEO 2007, National Energy Commission[1]) i.e. that it is unwise to exclude any alternative -- including renewable energy sources, carbon sequestration, increased energy efficiency, and nuclear power -- in the quest to reduce carbon emissions. The reality is that it is not just an oil, gas or nuclear issue but an energy issue and not just a US problem but a global one.

II. The Emerging Energy Picture and the Role of Nuclear Energy

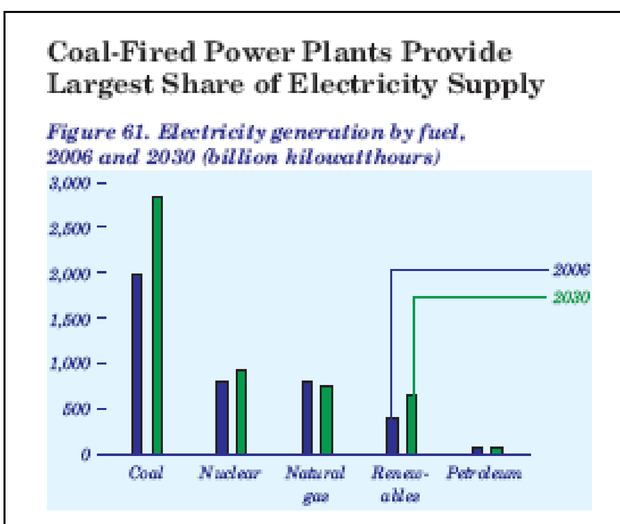
Projections reviewed by the Subcommittee suggest that demand for power generation is likely to continue to rise substantially in the coming decades, especially in the emerging markets of Asia, placing ever greater pressure on existing sources of supply. Many models were reviewed. All of them showed a trend toward increasing energy consumption and fossil energy carbon emissions.

All potential contributors to bridging the gap between electricity demand and supply -- hydrocarbons, renewables, hydropower, nuclear, and conservation -- will be needed to avoid electricity shortfalls becoming a major brake on domestic and international economic growth. In addition, given the long lead times of energy investments and lengthy service life of power generation assets, near-term decisions largely will shape the balance among these various energy sources and technologies for decades to come. The impact of these near-term decisions upon energy security and national and global efforts to reduce carbon emissions may be dramatic. For example, China is adding the equivalent of at least one 1000 MWe coal-fired power plant weekly, a pace of deployment that will drive up carbon emissions significantly over the long term.[2]

[1] "Ending the Energy Stalemate" , *The National Commission on Energy Policy*, 2004 (Appx. 1)
[2] "Can Coal and Clean Air Coexist in China?", *Scientific American* (Appx. 2)

Like other nations, the United States is grappling with the challenges posed by energy security, climate change, and the recent dramatic increase in hydrocarbon prices. Currently, fossil fuels account for over 80% of US energy consumption. Electricity is primarily supplied through large grids, with about half of that power coming from coal-fired plants, one-fifth each from nuclear and natural gas-fired plants, 7% from hydroelectric power, and 3% from other renewables. Between 2005 and 2030, based on current trends and policies, US electricity demand is expected to grow over 30 percent [EIA AEO 2008, 2008-2030], and the respective shares provided by fossil fuel, hydro/other renewables and nuclear power would be similar to today [EIA AEO 2008, 2008-2030]. But electricity demand growth could be much higher, if for example, there is a major move toward electric vehicles that are either plug-in hybrids or fully battery operated. The fuel mix for electricity generation also might be considerably different, depending on carbon policies, energy prices and technology changes. For example, nuclear reactors might be used to produce hydrogen for the transportation sector, and smaller reactors might be used to produce process heat to be distributed off grid for thermal applications and to offer more distributed nuclear generated electricity.[3] At the same time, advances in wind and solar technologies could enable those sources to play an increasing role in the total share of electric power generation.

Given that US hydroelectric capacity is not expected to provide significant additional power beyond what is already installed**,** additional increments of base load power will likely come from three sources, each with its advantages and disadvantages. Coal is plentiful, but its combustion releases the most greenhouse gases of all major power sources. In addition, coal prices have increased sharply over the past few years, for example more than doubling from $40-$60 to over $140 per ton of Appalachian coal[4]. Significant research and development efforts on clean coal technology and carbon sequestration are under way to try to reduce coal's carbon footprint. Natural gas is cleaner than coal, but natural gas prices also have substantially risen in the past five years and continue to fluctuate, [5] although it should be noted that natural gas developers have identified significant additional gas resources in the United States, which may help ease prices.[6] Natural gas is still viewed by utilities as being competitively priced versus coal or nuclear on a total installed basis, combined cycle gas plants have the additional appeal of relative quick installation and overall flexibility of operation.



What about nuclear power? One significant relative advantage for nuclear is that it produces zero greenhouse gases. With regards to relative costs, once amortized, nuclear power stations run cheaply, but this begs the question of the high capital costs to build a nuclear power station. While uranium prices have risen sharply in recent years, from $7 per pound of U3O8 yellowcake to over $100, before more recently settling back down to the $60 range[7], overall fuel costs represent a

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[3] ...hew Wald**,** *The NY Times***,** February 3, 2005. (Appx. 3)
[4] NCEMPA Appalachian Price Index (Appx. 4)
[5] EIA - http://tonto.eia.doe.gov/dnav/ng/ng_pri_sum_dcu_nus_a.htm (Appx. 5)
[6] Development of Alaska Gas Pipeline
[7] "Nuclear revival needs constructors to deliver", Anna Stablum, *Reuters News*, September 5, 2008. (Appx. 6)

relatively small percentage of the total-cost of nuclear generated electricity.

Consistent and predictable US public policy toward the electric power sector will be critical if that sector is to provide adequate generation capacity to securely meet expected future demand. This is especially important with respect to nuclear power.

Currently there is substantial risk and uncertainty surrounding the ability and length of time actually required to license and build a nuclear power plant, which does not exist with respect to other electricity options, although recent experience suggests that climate concerns has made it almost as difficult to site and build a coal power plant as a nuclear powered one. This risk and uncertainty makes it difficult to control the financial and material costs of building nuclear power plants and raises rates of return required by the private sector to invest in and build them. Removing such risk and uncertainty to level the playing field for new nuclear power plants with respect to these other alternatives is well within the purview of US government policy.

US government responsibility also applies to the management and disposition of civilian nuclear waste. Currently, because of historically inconsistent US government policy in this area, it is being stored onsite at nuclear power plants, and fees have been and continue to be collected from nuclear generating utilities to pay for waste disposition, which in turn has generated successful law suits against the US government.

In addition, in response to the Three Mile Island nuclear accident in Harrisburg, Pennsylvania, in March 1979, the Nuclear Regulatory Commission tightened safety standards and regulatory requirements for nuclear power plants which, while increasing costs, also contributed to the absence of further accidents to date. The NRC also undertook additional security measures following the terrorist attacks on the World Trade Center.

Nonetheless, a number of US utilities are now seriously considering the addition of nuclear power plants to their portfolios of power generation assets. They are attracted to the fact that amortized nuclear power plants produce electricity cheaply and reliably, and that such plants are not subject to the potential energy security fuel supply issues and price swings posed by imported OPEC/Russian oil and in the emerging future, imported liquefied natural gas. Nor are they subject to future potential policies that substantially could raise the price of domestic coal, natural gas and oil. At the same time, they see the nuclear option as providing the only widely available and expandable base load carbon-free option for generating electricity. Utility executives also realize that the likely introduction of a carbon tax or cap-and-trade regime will make nuclear an even more attractive alternative. To date, twelve US utilities have filed applications for combined construction and operating licenses (COLs) with the Nuclear Regulatory Commission.[8] This represents a sea change in attitudes toward nuclear power in this country.

And in one important sense, this sea change represents a broad consensus and change in attitude by the American people, or at least the people living in these utilities electricity service territories and/or having any investment interest in the utilities themselves. But as noted above, without consistent and predictable US government public policies toward the electricity sector and

[8] Specific COL application information available at http://www.nrc.gov/reactors/new-reactors/col.html (Appx. 7)

especially toward nuclear power, the availability and security of the US electricity sector, and all of the economic sectors that link to it may be put at risk. Interest in expanding the use of nuclear power has been driven by several factors, among them the growing international concern that excessive reliance on carbon-emitting fuels has brought unacceptable risks that Earth may experience potentially catastrophic climate change. When it comes to producing large quantities of base load electricity, nuclear power remains a viable option for continued investment, possessing certain relative advantages. Thus it is not surprising that over thirty commercial size nuclear power plants are under construction worldwide. Coupled with climate issues are additional concerns, such as the burdens that high-priced hydrocarbons impose in terms of driving inflation, curbing growth, and diminishing US energy independence. Nonetheless, these investments are too large in scale and too long in duration to be successfully managed without bipartisan support at the local, state, and national level, without patient and determined investments from public and private sources of capital, and without nourishing the technical and scientific basis for our nuclear enterprise.

III. US Nuclear Energy Future Scenarios - Three Cases

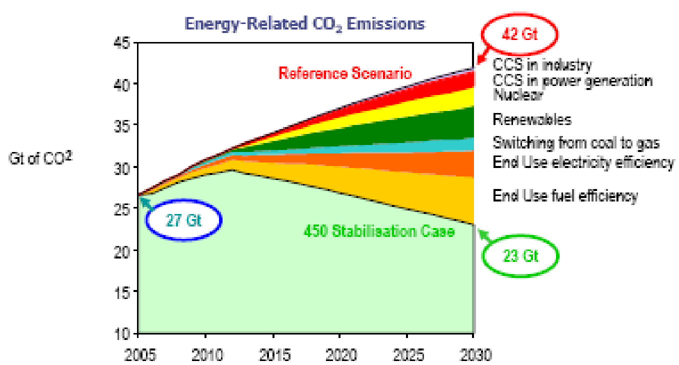
The Subcommittee reviewed a range of projections regarding the future deployment of nuclear power in the United States, and concluded that the uncertainties involved precluded any confident judgment regarding which projection or projections to use as the basis for our review. Moreover, the nature of the challenges facing nuclear power are more qualitative than quantitative, i.e. no matter how many or how few nuclear power plants will be built, the same policy issues regarding waste, security, safety, and environment will need to be addressed, and the same political consensus will need to be established. To be sure, the number of plants to be deployed *will* affect the marginal costs for each one, but that is an issue best left to utility executives and investors rather than to the NEAC to consider.

Case A. Low Scenario (0GWe new build): Even though public support for nuclear power has risen, utilities have filed applications for licenses, and politicians have demanded major greenhouse gas reductions, new build is *not* inevitable. Numerous hurdles remain, and no irrevocable commitments to new build have yet been made in the United States, unlike the dozen other countries now building nuclear power stations. This scenario does assume all reactors extend operating life to 60 years. If the United States ends up in the Low Scenario, then the share of nuclear power as a percentage of total electricity will decline from 19% currently to a smaller share (perhaps around 15% depending of course on overall total market demand assumptions) by 2030. Unless renewables and/or energy efficiency improvements can make up the difference, the likely consequence would be to worsen the US carbon footprint and to further marginalize US influence in the international nuclear scene. In addition, depending on other policies imposed by the federal government with respect to renewables and carbon emissions limitations, this scenario also to lead to increased electricity system failure and reduced economic growth, as well as potentially higher electricity prices as declining nuclear power drove up electricity prices.

Case B. Middle Scenario (17GWe new build): The Subcommittee relied upon the Energy Information Administration Reference case, which assumed no change in existing US policy, including nuclear, for the Middle Scenario. All currently operating reactors would have extension to 60 years. That would result in 17 GWe of new nuclear power stations entering service by 2030, which would hold nuclear roughly at its same share of US electricity generation, slipping only slightly from 19% to 18% of the total.[9] It is important to recognize that "just replacing existing nuclear power" or "just holding nuclear at its current share" of US electricity supplies will not happen by default. To the contrary, it would require over a dozen new reactors of one GWe or more to be ordered, reflecting major decisions by utility executives, investments by the financial community, regulatory and possibly commercial support from government, and an enormous effort involving thousands of engineers, manufacturers, technicians, and others. Even with that level of effort, however, this scenario would not itself make a significant dent on US greenhouse gas emissions, given the likely growth of fossil-fueled electricity and absent dramatic progress on clean coal technology over the same period.

Case C. High Scenario (45GWe new build): With high economic growth and strong electricity demand, and at least a neutral if not supportive nuclear public policy environment, nuclear growth could be much higher. This would be further supported if a significant price were placed on carbon dioxide either through a carbon tax or if a cap–and-trade system were established, as Senators Warner and Lieberman proposed last year.[10] Under these circumstances, a new deployment of up to 45GWe by 2030 could be considered, although it is important to note that available forecasts vary regarding the potential increase of nuclear's market share as a function of carbon tax rates. Expanding the use of nuclear power on that scale would begin to make significant inroads in the US carbon footprint, but the scale and pace of effort would substantially exceed that which the current nuclear infrastructure of the United States could support. If additional infrastructure support was started now it is possible to get to at least 30 new GWe by 2030. Note that in the EIA reference case, 18 GWe of electricity capacity on net were added between 2008 and 2030, and 176 net GWe were added for total electricity capacity (including the 18 for nuclear). For the EIA high case, 31 GWe of nuclear were added on net and 252 GWe for all electricity (including the 31 for nuclear) were added on net between 2008 and 2030.)

CO_2 Emissions – Carbon Tax Case



In this IEA Chart, by 2030, emissions are reduced to some 23 Gt, a reduction of 19 Gt compared with the Reference Scenario by enacting carbon restraints

[9] Annual Energy Outlook 2008, EIA, Page 11
[10] S.2191- The Lieberman-Warner Climate Security Act of 2007

IV. Domestic Policy Issues

The Subcommittee considered eight major policy issue categories in the context of one or more of the three scenarios above:

- Waste management
- Research and development
- Human resources
- Supply chain management
- Safety
- Security
- Reactor licensing
- Policy environment

A. Waste Management

In June 2008, the Department of Energy submitted to the Nuclear Regulatory Commission (NRC) an 8,600 page license application to construct and operate a repository for spent fuel and radioactive waste at Yucca Mountain. The NRC review and hearing process will take several years. On INSERT DATE, the NRC docketed the license application,, thus legally mandating the NRC to rule on the license in 3-4 years, barring any intercession by the next administration] The DOE in August 2008 reported to the Congress that the total system life cycle cost to operate the repository from 1983 to 2133 would be almost $100 billion, including an expansion to accommodate 120,000 tons of waste, up from a previously planned capacity of 70,000 tons.[11] The earliest opening of the repository is estimated to be after 2020. A repository is required to store US defense waste as well as spent fuel from commercial reactors. Meanwhile the USG is paying up to $500 million per year in damages to utilities from which it was to have begun accepting waste in 1998. These court-directed damages could total over $60 billion. The continuing legal liability adds urgency to the need to address the high-level waste management issue.

Repository science is one of the areas of the nuclear enterprise in which the US is considered a world leader, and proceeding with the Yucca Mountain NRC licensing process is important to the US nuclear energy program and electricity sector, as well as supporting a US leadership role in nuclear power globally.

In addition to proceeding with the NRC review and hearing process for Yucca Mountain, it is important to build consensus on interim storage with the US government taking title to the spent reactor fuel and, utilizing the Waste Fund, pay for security of the fuel, at volunteer locations or at existing plants, pending future use or final disposition. In addition, as a pragmatic step, consideration should be given to examining additional locations (e.g. WIPP, in New Mexico) for storage of spent fuel. Finally, other approaches (e.g., boreholes) should be explored as part of a comprehensive long term effort to scale management of nuclear waste (from thermal as well as fast reactors) with the challenges of reducing carbon emissions, and preventing proliferation,

[11] See DOE Press Release on Yucca (Appx. 8)

over the century. [See Appendix for a discussion of the strategic Case for the European deployment of fast reactors, contributed by NEAC member Sue Ion.]

In order for the United States to help mitigate proliferation risks, assure adequate fuel services to support the expanding number of nuclear reactors, and optimize the nuclear fuel cycle with respect to its objectives, it will be important to dedicate a significant research and development effort to improvements of the nuclear fuel cycle. The Subcommittee notes that these objectives are currently addressed in an Advanced Fuel Cycle Initiative (AFCI). AFCI was established by Congress in 2005 "to conduct an advanced fuel recycling technology research, development and demonstration program to evaluate proliferation-resistant fuel recycling and transmutation technologies" to meet waste management needs "as an alternative to aqueous reprocessing technologies".[12] The Subcommittee recommends that the AFCI program and alternative approaches be reviewed in terms of its abilities to meet the objectives cited above.

The longer term success of fuel cycle R&D could significantly change the challenges for the storage of nuclear waste at various locations, including Yucca Mountain. Some waste forms might better go to WIPP if the salt cavities were appropriate. The integrated operation of various approaches to nuclear waste management also can affect the feasibility of fuel leasing over time, thus improving the external security of the United States by helping prevent the spread of enrichment and reprocessing even as other nations acquire more reactors. While the US is not currently reprocessing, it is important to note that many governments see the United States as a valuable partner, at times looking for US leadership, while Europe and Japan are implementing closed fuel cycles and looking to the US to collaborate on advanced R&D.

- *The Subcommittee believes it is vital that the US should complete the NRC licensing process for the Yucca Mountain project to determine its acceptability as a disposal while it also explores all other options for waste management.*
- *The Subcommittee believes that the US should dedicate a significant research and development effort to improvements of the nuclear fuel cycle.*

B. Research and Development. The global nuclear marketplace is moving forward, with non-US companies providing the new power reactors. The US has been a leader in nuclear safety, and as noted above, a leader in repository science. It also has been a leader in non-proliferation and security. US research and development support for our nuclear program is not only necessary to continue to improve safety and waste disposition, but also to allow the US to once again begin to play meaningful role in reactor development and in other key elements of the global and domestic nuclear enterprise.

Establishing near-term and longer-term US nuclear R&D priorities must take account of the current state of our domestic nuclear infrastructure. The Department of Energy, under White House guidance and in consultation with other key agencies, should review current priorities in light of the new Administration and the Congress, and should clearly define and implement a roadmap of these priorities. Such a road map will help to advance the evolving missions for the DOE national laboratories and promote their modernization. In addition this road map development and implementation process should help to establish a consensus on the appropriate

[12] P.L. 105-98, August 8, 2005, Sec 953

roles of government and industry. Some specific near-term R&D priorities for the United States in the field of nuclear energy should include the following:

- Safety, life extension, decommissioning existing fleet;
- Issues related to new build of Gen III+ reactors;
- Gen IV reactors; and
- Back-end solutions to the nuclear fuel cycle.

The consequences of a weakened nuclear infrastructure in the United States include reduced domestic capability to support the role of nuclear energy as well as the related problem of the reduced ability to attract and retain workers at all levels, from technicians through engineers to Ph.D.s, needed to develop and sustain active US participation in the domestic and global nuclear marketplace. In that vein, the Subcommittee recommends that both university and industry programs in nuclear R&D be strengthened, and that laboratories and facilities in the DOE complex be modernized and made more efficient. These programs should be developed in consultation with concerned government agencies and scientists, DOE national laboratories, private industry, and the academic community

Growing world demand for nuclear energy presents new opportunities and challenges. There is a widely recognized need for "*Developing an international system to manage the risks of the nuclear fuel cycle. With the growing global interest in developing nuclear energy and the potential proliferation of nuclear enrichment capabilities, an international program should be created by advanced nuclear countries and a strengthened IAEA. The purpose should be to provide for reliable supplies of nuclear fuel, reserves of enriched uranium, infrastructure assistance, financing, and spent fuel management – to ensure that the means to make nuclear weapons materials isn't spread around the globe.*"[13]

The Global Nuclear Energy Partnership (GNEP) has since 2006 codified principles agreed by over 20 nations to begin the long term process to bring this about. The Partners share a common vision of the necessity to expand nuclear energy for peaceful purposes worldwide, to accelerate development and deployment of advanced fuel cycle technologies that do not separate plutonium and reduce the risk of nuclear proliferation. The partnership includes the five permanent members of the U.N. Security Council. It includes Japan and South Korea, and Australia and Kazakhstan. It includes developing countries yet to operate a reactor. It includes the IAEA and Euratom as permanent observers. Working groups have already been formed on reliable fuel services and infrastructure. An additional 42 countries will attend the GNEP Ministerial meeting in October 2008.

The Subcommittee recommends;

- *DOE-led establishment and implementation of a nuclear energy R&D roadmap*
- *University and industry programs in nuclear R&D be strengthened, and that laboratories and facilities in the DOE complex be modernized and more efficient.*

[13] "Toward a Nuclear-free World", George P. Shultz, William J. Perry, Henry A. Kissinger and Sam Nunn, *The Wall Street Journal*, January 15, 2008.

- *Participate in the development of an international system to manage the risks of the nuclear fuel cycle.*
- *Review existing nuclear fuel cycle research and development to assure that it is meeting US needs in the nuclear fuel cycle..*

C. Human Resources

The US nuclear workforce is aging and, as more and more head into retirement, it will become extremely difficult to recruit and retain technically qualified personnel. In order to ensure an adequate workforce it is essential that students see both intellectual challenge and attractive career paths in the nuclear field. At this point, satisfaction of neither criteria can be guaranteed. The current and projected pool of individuals with the qualifications to support the nuclear enterprise in the United States might be adequate to support the existing number of nuclear power plants and, thus, of the Low Scenario. (See American Physical Society report [citation needed.]) A significant expansion of the nuclear workforce, however, would be required to support either the Middle or High Scenarios.

Given the long lead-times in the development of human resources (longer still for faculty than for students, of course), in order to preserve the option for the Middle and High Scenarios, it is necessary that DOE (and NRC) review projected human resource requirements for engineers, technicians, operators, regulators, and scientists (physics, chemistry, radiochemistry) and develop options to promote career pathways in these fields. This would enable government, industry, and academia to work together to develop plans and programs to provide assurances that the US nuclear effort will be appropriately staffed by individuals qualified and motivated to support a successful growth of nuclear power, and to learn from existing programs to recruit and retain new talent.

It should be noted that expanding US human resources able to support an expanded number of nuclear reactors is a low-risk proposition, both for the nation and for the individuals, in light of the new build already proceeding or planned abroad. For the individuals, it is likely that some of the new nuclear programs will generate substantial requirements for new talent that could easily come from US programs. For the nation, it would be to our collective benefit if nuclear energy facilities the world over eventually could be staffed at least in part by US-trained personnel.

- *The Subcommittee recommends the DOE (and NRC) take steps to promote the development of a workforce will be able to meet the human resource requirements for engineers, technicians, operators, regulators, and scientists (physics, chemistry, radiochemistry) on a timely basis, keyed to the deployment of new nuclear power reactors and other parts of the nuclear fuels cycle (e.g. waste management).*

D. Supply Chain Management

It will be important to examine US domestic capabilities to support all links in the nuclear power plant and fuel cycle supply chain in order to identify any gaps that would need to be filled if utilities decide to build new domestic reactors. Recent studies have concluded that there are a number of potential chokepoints both in the nuclear fuel cycle and in the supply chain to support new reactor construction.[14] Potential fuel cycle chokepoints include fuel conversion and spent-fuel storage services. Reactor construction chokepoints include those that are material-related (heavy forgings) and those that are personnel-related (shortage of trained craftsmen with prior nuclear field experience). Expanding existing sources of supply and developing alternatives should both be explored in order to ease these possible chokepoints, and that the degree to which the US can rely on foreign suppliers for each of those gaps should also be analyzed.

- *The Subcommittee recommends the DOE evaluate what actions the USG could take to facilitate or enhance the adequacy of the U.S nuclear power plant and fuel cycle supply chain to identify any gaps that would need to be filled if utilities build new domestic reactors.*

E. Safety

The principle of "safety first" must guide all actions regarding the design, construction, and operation of nuclear power plants. In order to give that standard a practical meaning, it is necessary to ensure that nuclear manufacturers, operators, and regulators begin from the same basic analysis describing the kinds of risks that need to be mitigated as nuclear power continues to be safely deployed. That analysis must be not only rigorous in order to hold the nuclear industry to an appropriately high standard, but also realistic in order to ensure that safety efforts are properly focused on genuine areas of concern. In order to maximize the safety of the nuclear enterprise, it is essential that a "culture of safety" be promoted among all personnel, from maintenance crews to control room operators to senior management. It must also apply to all actors in the nuclear arena, from government or the private sector, reactors or fuel cycle facilities, transportation and storage depots.

- *The Subcommittee recommends that the "Safety First" must continue to guide all actions regarding the design, construction, and operation of all nuclear facilities. DOE should lead by example and build upon the experiences US industry -- including nuclear manufacturers, operators, and regulators – to begin from the same basic analysis describing the kinds of risks that need to be mitigated to assure that nuclear power continues to be safely deployed.*

F. Security

As with safety, security is critical to the successful operation of any nuclear facility. As with safety, the security plans and strategies for a nuclear facility should be premised on a solid threat analysis. The "design basis threat" (DBT) is not the maximum threat a plant may face but is the basic review criterion. New plants are designed for a more severe threat. Also, the DBT depends on location, since a major part of it is how many attackers can reach the plant undetected.

Aspects of security that need to adapt and respond to security threats include material control and accountability, safeguards, and cyber-security. Following the tragic events of 9/11, industry and the Nuclear Regulatory Commission engaged in a wide-ranging effort to ensure that the threat regarding possible attacks on nuclear reactors, fuel-cycle facilities, and transportation facilities

[14] "The World Nuclear Industry Status Report 2007," Mycle Schneider, with Antony Froggatt, January, 2008.

was properly analyzed and calibrated, and that the measures in place to confront those threats were adequate. These efforts, of course, must apply equally to both government and private-sector facilities. . Additionally, all operators of nuclear facilities should endeavor to adopt performance-based metrics for evaluating security system effectiveness, and rely less on mechanistic, compliance-base approaches.

- *The Subcommittee recommends that security be given top priority in DOE facilities, and be premised on solid threat analysis, which can be shared where appropriate with the US commercial nuclear industry. Security must be integrated into facility design, planning, construction and operation, not be grafted on top of an existing program.*

G. Reactor Licensing

In 1974, Congress reorganized the Atomic Energy Commission into two separate entities, on the theory that combining within the AEC the twin roles of promoting and regulating nuclear energy created an inherent conflict of interest between those two functions. Under the Energy Reorganization Act, the promotional mission of AEC went to the Energy Research and Development Administration, later to be absorbed into the newly-created Department of Energy. The regulatory functions were assigned to the Nuclear Regulatory Commission, an independent government regulatory agency, whose members are nominated by the President and confirmed by the Senate.

In 1979, the nuclear accident at Three Mile Island shattered US public confidence in nuclear power and led to a thorough review of NRC rules and procedures. While the intensified scrutiny was justified, at the same time the frequent revisions to licensing requirements and standards led to delays and confusion for operators of nuclear reactors subject to NRC jurisdiction. In recent years, the NRC and the nuclear industry have worked hard to streamline and improve the regulatory process. Standardization of reactor designs will help to support a more consistent approach to safety and regulation.

The question presented now is whether the NRC can further improve its licensing processes and, if so, how. The issue is particularly challenging since, as an independent regulatory agency, the NRC is not formally part of the Executive Branch. Thus issues of coordination and consistency of policy between NRC and other affected agencies (such as DOE, EPA, DOS, DHS, 50 states) will be important in determining what role nuclear will play in the expansion of the US installed power generation base.

Also of priority policy interest is the extent to which regulatory reviews and approvals are provided in a timely manner. Large investments in major base load nuclear power plants are affected as much (if not possibly more) by length of time of exposure of risk capital as by total installed costs ("time is money"). Further, if deployment of smaller (and more easily operable) "modular" plants are of importance to certain key markets either domestically or overseas, special (set-aside) resources may be needed for regulatory authorities to provide thorough and complete but also expedited licensing.

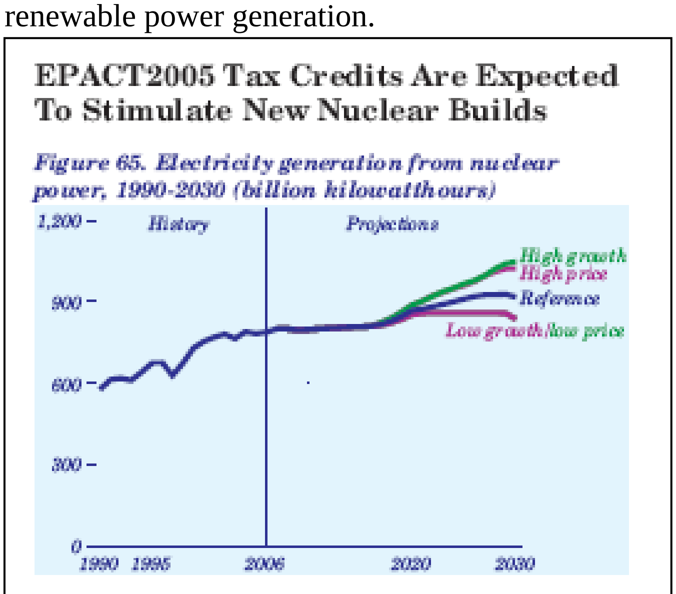
- *The Subcommittee recommends that the NRC, with support as needed from the Executive Branch and other parts of the US government, strive to further streamline and improve its licensing processes and coordination with other affected agencies".*

H. Policy Environment

Nuclear power stations take years to plan, finance, and build. Once operating, they run for decades. Their development and safe, efficient, and economical operation therefore depends on a consistent and sound policy environment. That policy environment must be scientifically grounded, publicly supported, and informed by the expectations of safety, security, nonproliferation, and environmental stewardship. It should be an environment that enjoys consistent support from political leaders regardless of party affiliation.

The United States had a fairly consistent policy environment until the 1970s. Then, a number of events, including India's diversion of civil nuclear assistance to explode a nuclear device (which triggered a major reassessment of US nonproliferation policy), followed by the 1979 Three Mile Island accident, comprised a one-two punch that left the US policy environment surrounding nuclear energy reeling. The United States, under Presidents Ford and Carter, abandoned a number of plans and policies (*e.g.*, those supporting recycle of mixed-oxide fuel in thermal reactors, pursuit of breeder reactors and commercial plutonium reprocessing), and sought to persuade other governments to follow suit. These efforts were not successful.

Added to (and, to some degree, influenced by) this changing political environment, nuclear power lost public support, even as climbing capital costs eroded its competitiveness as a source of electricity. Thus, in 1981, the Washington Public Power Supply System (WPPS) defaulted on $2.5 billion in bonds when it abandoned plans to build two nuclear power plants – the biggest municipal bond default in history. Today, whether nuclear power can be competitive in light of its large capital requirements remains among the biggest unanswered questions hanging over its future in the United States. Unfortunately, the key driver of whether nuclear power can be competitive is the complex, disjointed and largely uncertain state of pubic policies surrounding the electricity industry. Part of the uncertainty is due to unsettled federal and state electricity regulatory issues. But a key issue from a potential nuclear power investor point view is the uncertainty over how long it will take to get a nuclear power plant licensed, built and operating. This uncertainty raises the capital cost and the return required by the private sector to make the investment competitive. The Federal Government has a large role to play in reducing this critical uncertainty, and thereby to help put nuclear power on a more level playing field with fossil and renewable power generation.



The Energy Policy Act of 2005 provides for loan guarantees and related additional financial provisions to support the construction of the first few new nuclear plants in the United States, but it remains unclear whether the guarantees provided will be sufficient to induce utility executives to commit to building those plants. The loan guarantee program plays an important role in the building of any new nuclear power plants, especially in the deregulated states, as most banks won't invest in a new plant without it.

Last but not least, major stakeholders must be engaged in a pro-active manner to ensure a clear, transparent and positive policy environment. While top-down government leadership is essential, this leadership must be inclusive for long-term deployment objectives to be achieved. Industry involvement, academic review, and NGO participation will provide not only a thorough vetting of policy options but also the best opportunity to educate participants and openly discuss new or modified institutional innovations and well as the consequences of status quo (perhaps for example variations of the "Joint Program Office" concept for management purposes; also, identification of long-term multi-year sustainable R&D funding sources). The current extensive literature and high public interest on energy policy provides an opportunity to expand individual and collective responsibility for new ideas and approaches as well as a new and improved energy consensus.

V. International Implications of Increased Reliance on Nuclear Power

Regardless of what course is taken on nuclear power in the United States, other nations are moving ahead to expand the number of new nuclear power plants. Today, 36 reactors are already under construction in a dozen nations. According to the World Nuclear Association, another 93 reactors have been planned, and 218 more have been proposed. In addition, some number of reactors will also be retired, though far fewer than are projected to be built.

The fact that these reactors are being built in other countries does not relieve the United States of its responsibilities regarding nuclear power. In fact, in the absence of US presence, these other countries will be setting the standards and expectations for the nuclear energy industry, as well as controlling nuclear energy science and the safety, environmental and security issues arising from the use of nuclear power. Their economies also will benefit from the jobs created and income earned. Yet, the U. S will pay the price for any nuclear incident related to foreign leadership--a significant accident or incident anywhere in the world will affect acceptability of nuclear everywhere, including the United States.

Nuclear energy should only be pursued with full awareness of and attention to the need to minimize the risks of nuclear weapons proliferation. For example, if nuclear power plant expansion is accompanied by a linear expansion of countries engaged in enrichment and reprocessing, there will be an increased risk of proliferation. It is important to institutionalize fuel-cycle mechanisms to reduce that risk (*e.g.*, through multilateral arrangements, fuel assurances, leasing, and/or a fuel bank). It is urgent to finalize these mechanisms in time to encourage the establishment of a regime of restraint in fuel-cycle expansion. Life-cycle guarantees or nuclear fuel leases that offer cradle-to-grave fuel services, covering both front-end fuel assurances and stockpiles as well as back-end used-fuel management and disposal arrangements, may provide a number of governments sufficient confidence that they may forego the option of developing their own fuel cycles. Without the United States' providing leadership, it is far less likely that the international community will settle on international fuel-cycle arrangements that minimize the risks of nuclear proliferation. And if the United States is not itself engaged in building new nuclear power plants, including new reactor design and fabrication, it will be left with an ever-diminishing influence in international discussions relating to future fuel-cycle arrangements. In addition, the US will lose the potential benefits from nuclear power to domestic energy security and greenhouse gas emission control, as well as the benefits of nuclear industry related jobs and science and technology advancements.

It is imperative that the United States strengthen and restore the international agreements and institutions that underpin the global nonproliferation regime, beginning with the Non-Proliferation Treaty and the International Atomic Energy Agency. Those cornerstones have been reinforced over the years by regional nuclear weapons-free zones (*e.g.,* in Latin America and Southeast Asia), multilateral efforts (*e.g.,* Nuclear Suppliers Group, the Proliferation Security Initiative, and the Global Initiative to Combat Nuclear Terrorism), and other efforts. Overarching the nonproliferation regime is the UN Security Council, which has the authority to sanction governments that violate global nonproliferation norms. Those norms were strengthened in 2004 through the approval of Security Council Resolution 1540, which obligated member states to take effective steps to enforce nonproliferation commitments and to

> …take and enforce effective measures to establish domestic controls to prevent the proliferation of nuclear, chemical, or biological weapons and their means of delivery, including by establishing appropriate controls over related materials
> ….

In addition, the issues of nuclear weapons proliferation and nuclear energy remain intertwined in a number of critical cases, most notably in Iran and North Korea. Significant proliferation issues persist as well among other states that have declined to accede to the NPT, such as India, Israel, and Pakistan.

In order to succeed in curbing nuclear weapons proliferation, the United States must coordinate effectively with the other nuclear weapon states recognized under the NPT: the United Kingdom, France, Russia, and China. Cooperation with the last two of these nations is essential, yet often elusive. Progress, however, has been made. China, for example, has shown increasing leadership in dealing with the North Korean nuclear challenge. Russia has been difficult on some issues, yet cooperative on a number of others (*e.g.,* US-Russia HEU deal, Cooperative Threat Reduction, Bratislava initiative, plutonium production reactor shutdown agreement, etc.). Russia has been a critical partner in international efforts to reduce the Iranian nuclear threat, including through insistence of a cradle-to-grave fuel arrangement for the Bushehr reactor (eliminating the need for uranium enrichment and plutonium reprocessing facilities to support that plant) and through offering Iranian participation in the Angarsk nuclear fuel initiative, to the same end. Further, the two sides committed to wide-ranging nuclear cooperation in April 2008 at Sochi. Despite significant disagreements over Georgia and other issues, US-Russian cooperation in combating proliferation and nuclear terrorism should continue, as it is strongly in the mutul security interests of both nations and, indeed, of the entire international community.

A number of other proliferation issues need to be addressed: the modernization of US and multilateral export controls, the development of discrete threat-reduction strategies for state vs. non-state actors, deciding the appropriate US policy toward cooperation with various nations, how to monitor those bilateral and multilateral initiatives not officially involving the US but with significant nuclear power sector implications and coordinating US domestic nuclear policies with foreign and multilateral policies and efforts.

In late 2007, the Director General of the IAEA established a Commission of Eminent Persons to review the Agency's current activities and make recommendations regarding future priorities in the light of recent and expected developments.[15] The report noted that a substantial increase in the use of nuclear energy would result in calls for the Agency to give priority to promoting the efficient, safe and secure use of facilities in States, including those new to nuclear power, as well as helping to prevent and mitigate nuclear accidents. Its activities were deemed likely to continue to include the establishment of authoritative guidelines, as well as the dissemination of experience, new knowledge and best practices, the provision of training, and the organization of peer reviews. A global expansion in the civil use of nuclear technology, the report noted, would bring with it increasing concern about the risk of accidents and the threat of nuclear terrorism. The Agency would therefore continue to give high priority to strengthening prevention measures at both the national and international levels, and establishing measures to help ensure a coordinated response should prevention fail. The spread of nuclear material, technology and know-how could also pose increased proliferation risks in a globalized world and the IAEA was likely to remain a major actor in preventing the spread of nuclear weapons.

The Subcommittee recommends;

- *The US government develop and articulate its nuclear energy policy to assure a uniform level of excellence that will provide leadership for other nations, assure, environment and energy security, protect our Nation's prosperity, build on and extend its current leadership in nuclear safety, security, repository science, and non-proliferation.*
- *The US should work with the IAEA and other nations to institutionalize fuel-cycle mechanisms to provide strong assurances to governments hosting nuclear power facilities (e.g., through multilateral arrangements, fuel assurances, leasing, and/or a fuel bank) that their fuel needs will be met so long as they adhere to international nonproliferation standards. It is urgent to finalize these mechanisms in time to encourage the establishment of a regime of restraint in fuel-cycle expansion. Life-cycle guarantees or nuclear fuel leases that offer cradle-to-grave fuel services, covering both front-end fuel assurances and stockpiles as well as back-end used-fuel management and disposal arrangements, may provide a number of governments sufficient confidence that they may forego the option of developing their own fuel cycles.*
- *Recognizing the importance of safe development of nuclear energy globally and the importance of ensuring continued compliance with non-proliferation norms, a strengthening of the International Atomic Energy Agency is necessary with the resources required to do the job properly.*
- *The USG should take concrete steps to preserve and strengthen the NPT.*

- *The Subcommittee recommends that, while the US is currently not engaging in commercial domestic reprocessing of nuclear fuel, the USG should respect the existing commercial programs in countries that adhere fully to global nonproliferation norms (e.g., Europe and Japan) and should work with international partners to research and develop the most safe and secure forms and use of materials, as had been intended in the GNEP program.*

[15] Report available at http://www.iaea.org/NewsCenter/News/PDF/2020report0508.pdf

VI. Conclusion

The policy issues that arise out of the use of nuclear power can be complex and daunting. Yet, ironically, the expansion of nuclear power may make some of these problems easier to solve. Why? During the many years that nuclear energy was consigned to the backwaters of energy policy and power generation, vested interests in the success and expansion of nuclear power stagnated. Now the renewed interest in building nuclear power plants has reinvigorated efforts to ensure that the issues critical to the successful deployment of nuclear energy – including the supply chain, human resources, and regulatory infrastructure – are scaled properly to the task. The process of expanding the use of nuclear power also gives a wide variety of stakeholders – from ratepayers to equipment manufacturers to utilities to regulators – a far greater stake in the success of nuclear energy. Each stakeholder adds incrementally to the self-interested actions to increase the safe, secure and efficient operation of nuclear power plants, to adopt and execute a responsible waste management policy, and to minimize the risks that dangerous nuclear technology and materials may fall into the wrong hands.

Harnessing self-interest and the power of the marketplace to the interests of the commonweal in the safe and secure use of nuclear energy is not a pipe dream. It is a reality that has been operating successfully for more than a decade in the form of the US-Russian HEU deal, under which the United States agreed to purchase 500 metric tons of highly-enriched uranium from Russia's nuclear stockpile – enough for 20,000 nuclear warheads -- to be blended down for use as commercial nuclear reactor fuel. Each year, one half of the uranium fuel consumed in US reactors comes from the HEU deal. Since nuclear power accounts for one-fifth of the power generated in this country, that means that one out of every ten light bulbs is powered by material that used to sit atop Soviet ICBMs in warhead form targeting American cities.

If nuclear power can play such a positive role in making America safer from the dangers of nuclear Armageddon, perhspas it can also play a significant role in efforts to limit greenhouse-gas emissions. The United States has a lot of work to do to prepare domestically before nuclear power can play that role. It is important that domestic and international implications be analyzed and addressed if nuclear expansion is to be a viable option for the United States and other countries. If the United States does not expand the number of nuclear power plants on its soil but other nations do so, it will become increasingly difficult for the United States to carry significant weight in international efforts to manage global nuclear expansion. Given the stakes to the United States and the high US standards in safety, it is in United States' national interest to play a leadership role in global efforts to address the safety, security, environmental, and proliferation implications of nuclear power.

US decisions regarding nuclear energy may affect the global nuclear marketplace, both directly through nuclear commerce in equipment, technology, and materials, and indirectly, as a product of the US example. In that sense, lack of US decisions will also affect the global environment surrounding nuclear power. In either event, it is in the US national interest that our Government takes decisions cognizant of the impact of those decisions on other countries

In order to develop sound policies in the areas described above, it will be necessary for the US Government to engage not only with the relevant committees of the US Congress and with the many offices and bureaus within the Federal Government with expertise and responsibilities in this area, but also with the scientific community, industry, and nongovernmental organizations. For example, given the importance of nuclear power and the crosscutting nature of the issues that need to be addressed, one participant recommended that the Congress consider re-establishing the Joint Committee on Atomic Energy.

Framing all policy issues within the context of a Low, Middle, or High path for commercial nuclear power deployment provides a useful basis for understanding key policy alternatives. In order for either the Middle or High Case to become viable, however, significant progress would need to be made in all of the issue areas outlined in this paper. Before that can occur, extensive dialogue involving all stakeholders, from both public and private sector, will be required. At the same time, it is critical that domestic and international implications be analyzed and addressed if nuclear expansion is to be a viable option for the US and other countries. If the US does not expand the number of nuclear plants it has but other nations do so, it will become increasingly difficult for US to carry significant weight, on environmental, safety and security, and nonproliferation issues, in international efforts to manage global nuclear expansion. Given the stakes to United States, it is firmly in the US' national interest to play a leadership role in global efforts to address safety, security, environmental, and proliferation implications of nuclear power. US nuclear energy policy has been analyzed and debated for years. Now is the time for thoughtful action.

Appendix

The Strategic Case for European Deployment of Fast Reactors
By Sue Ion

The E.U. is taking steps to ensure options are kept open for Member States to lead the development and deployment of fuel cycle technology that will underpin the next generation systems, particularly fast reactors and high temperature gas cooled reactors and to ensure long term options for the pursuit of recycling for light water reactor systems operating in the E.U. remain available. France continues with very significant investment in future fuel cycle options.

China has continued to invest heavily in new nuclear power plants as part of its National Energy Plan, including the long term intention to deploy fast reactors and possibly high temperature gas cooled reactors with a recycling fuel cycle. India has also committed to a significant deployment of nuclear power plants, which has opened the door for international technology transfer (especially with the USA) and to the pursuit of a complete fuel cycle, including reprocessing. Japan has commenced operations at its Rokkasho reprocessing plant and remains committed to fast reactors and a long term reprocessing fuel cycle. South Africa has initiated a major investment program in new nuclear power plants, Gen III / light water reactors / next generation high temperature gas cooled reactors, and has expressed an interest in reprocessing in the long term. Russia remains committed to recycling long term and to the deployment of fast reactors.

Global trends for enhanced deployment of nuclear energy will lead to an increased demand for uranium and while the fissile/fertile resources available will not be a limiting factor in the deployment of nuclear power plants for the foreseeable future, the goal within the E.U. should be to strive for optimal utilization of the available and potential energy content. This means deploying both fast neutron and water reactors in a way that gets the best out of the fissile/ fertile resource while minimizing long term waste. Reprocessing and recycling are essential if a sustainable position is to be achieved for nuclear energy.

Most reactors of today are light-water reactors based on "once through fuel cycle" where almost 99% of the potential energy is unused and left in the depleted uranium from enrichment and the used fuel. Present light water reactor technology can be improved to achieve a better utilization of the fuel and its uranium. Increased burn-up, change of fuel mixture and similar measures would however increase costs, such as demands on materials and considerable administrative efforts.

Current reprocessing of fuel as applied in France and the U.K. will increase the utilization of energy content in the fuel by 10 to 15 % if the material is recycled as MOX fuel. As illustrated below, there is, however, potential to extend the resource base and increase the efficiency of its use by the introduction of more advanced fuel cycle technology both for traditional reprocessing and in particular through use of breeder-technology. Modern breeder-technology will increase the utilization of the energy of the uranium with a factor of more than eighty, which in turn would secure the availability of uranium fuel over centuries.

Europe has the opportunity to be self sufficient for centuries to come with respect to nuclear fission power if a closed fuel cycle, with the recycling of valuable fissile resources, is implemented rather than a once through and directly dispose cycle. In realizing advanced nuclear fuel cycles, Europe would be able to take advantage of the vast resources of depleted uranium arising from the uranium purification and fuel manufacturing processes and already held as long term strategic stocks, particularly in France and the U.K. For example, if the residual uranium resources in France were used in conjunction with plutonium extracted from used fuel from the existing reactors and recycled in fast reactors, there would be sufficient material to fuel a fleet equivalent in size to the present European nuclear power fleet, for over 2000 years.

Deployment of fast reactors, where Europe has the technological lead and over 30 years of operating experience, in conjunction with an appropriate advanced fuel cycle, taking full account of proliferation and waste minimization concerns, would enable the valuable energy resources residing in the used fuel from the existing generation of reactors to be combined with the much greater volume of material arising from the initial refining and manufacturing process. This would otherwise be designated as waste for costly treatment and disposal and it is the Euratom Science and Technology Committee's view that this would run counter to sustainable practice.