Securing the Energy Future of the United States:
Oil, Nuclear, and Electricity Vulnerabilities and a post-September 11, 2001 Roadmap for Action

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A preliminary report of IEER's energy assessment project

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Preface

This is a preliminary report of IEER's energy project, which we began about two years ago to examine the feasibility and time span that it would require for a complete phase out of nuclear power and a substantial (on the order of 50 percent) reduction in carbon dioxide emissions, worldwide. We chose to approach this problem by doing three case studies – France, India, and the United States. India and the United States are heavily dependent on coal for their electricity generation. India also has nuclear power ambitions, while France has already achieved them, since it generates almost 8o percent of its electricity in nuclear power plants.

Our work on the technical feasibility aspects for the United States was almost complete early this fall, when the September 11 attack took place. In view of the many infrastructure vulnerabilities, many associated with energy, that have been revealed to be much more serious than generally realized, IEER decided to publish a preliminary report on our project as soon as possible. An examination of IEER's past research, other past assessments of energy vulnerabilities, and the Bush energy plan,[1] which was not reviewed or changed in light of September 11, led us to this decision. The evaluation of energy system vulnerabilities in this report shows that existing vulnerabilities are serious and that the Bush plan would make them far more so.

We decided to publish this preliminary report because the United States is at a crossroads, and is set to make major decisions on energy policy at least as momentous, possibly far more so, than were made in the 1970s during the two energy crises of that period (1973-74 and 1979-80). Vulnerability assessments prepared as a result of those crises, notably the second one, have been all but ignored in official policy as energy receded from the center of the scene with the decline of oil prices that began in the early 1980s and the collapse of oil prices in 1986.

The 1991 Gulf War brought oil back to the center of the picture, but only very briefly. Energy policy continued to fade as a subject of coherent, central debate in the U.S. body politic, until the advent of the Bush-Cheney administration in January 2001.

It will never be possible to eliminate all vulnerabilities and risks to terrorist attack, war, severe accidents, and mistakes. But it is possible to achieve objectives that will greatly reduce the attractiveness of major elements of the energy system as targets of attack and also to reduce the consequences of an attack should one occur. These two goals are mutually reinforcing in that reducing the consequences of an attack also reduces the risk of one. Terrorists such as those who perpetrated the mass murders of September 11, seek to create fear, damage, and havoc on a large scale. Such vulnerabilities can be eliminated in many cases and greatly reduced in others. Unfortunately, the course advocated by the Bush administration would greatly increase those vulnerabilities. We present this preliminary report as a contribution to the national and international debate on energy and security that is now taking place.

This report is also limited in scope in that we have compared the Bush and IEER energy plans under the assumption of a similar overall economic evolution of major social systems. For instance, we assume no change from business-as-usual on transportation, whether by car or aircraft. We assume continued growth at historical levels in both these areas, for three decades for cars and four decades for air travel. We do not assume that there will be major changes in the

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[1] Bush Energy Plan 2001

approach to agriculture even though the increase of urban agriculture, using the land associated with single family homes, would greatly reduce some food system vulnerabilities. We do not assume that multiple modes of transport: walking, bicycles, public transport, and cars in a mixed mode on a wide scale in cities, even though this would provide resilience in the face of a severe attack on any one mode. These and other changes should be debated far more intensively and seriously than they have been in light of September 11. Changes in these directions will have great collateral benefits for the urban environment, reducing greenhouse gas emissions, and making the energy system more flexible, in addition to potential security improvements. But they are beyond the scope of this report.

We also do not include detailed considerations of some parts of the infrastructure such as refineries, liquid natural gas terminals, and pipelines. The vulnerabilities of such parts of the infrastructure have been discussed in prior works, notably that commissioned by the Federal Emergency Management Agency, published in 1980, and the book by Amory Lovins and L. Hunter Lovins, *Brittle Power*, published in 1982.[2] The IEER plan would result in a reduction in vulnerabilities in these areas, due to a reduction on dependence on both oil as a whole and on imported oil in particular, but some vulnerabilities in relation to natural gas will remain at about the same level as the Bush plan. We have not attempted to devise additional scenarios in this preliminary report. The reduction of fossil fuel related infrastructure vulnerabilities is to a substantial extent related to the greater use of hydrogen derived from local renewable energy sources, which will be a component of IEER's final report.

IEER's staff research on the energy report is being done by Sriram Gopal, Staff Scientist, and by Annie Makhijani, Project Scientist. I thank them both for their fine work, without which this report could not have been prepared in a short time. I have particularly used the research done by Sriram Gopal, who has been collecting and doing write-ups on the technologies associated most with the US case study. He also prepared the graphs and charts published in this report. Special thanks also go to Lois Chalmers, IEER's librarian, who helped secure the documents and prepared the bibliography. Of course, as the author, I am responsible for the contents of this report, including any errors and omissions that may remain in it.

This report has undergone internal review as well as brief external review, which is considerably short of the normal review for such projects. That is, while we have carefully checked our overall approach and calculations, we have not subjected them to intensive external review. We will perform that review as part of the completion of IEER's work on energy and publication of our case studies. The unusual publication of this preliminary report has been occasioned by the gravity and urgency of the present situation in the United States.

This report is a part of IEER's global outreach project, which is funded by grants from the W. Alton Jones Foundation and the John D. and Catherine T. MacArthur Foundation and by general support grants for IEER's work on nuclear issues from the Ford Foundation, the HKH Foundation, the Turner Foundation, the Rockefeller Financial Services, the New Land Foundation, and Colombe Foundation. We thank them for their generous support of our work.

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[2] *Brittle Power* can be downloaded in full from the web site of the Rocky Mountain Institute, www.rmi.org.

Chapter 1: Summary and Recommendations

The United States is at a crossroads in energy and security policy. The attacks of September 11, 2001 have revealed, as nothing has done before, the vulnerability of the U.S. energy system to a variety of disruptions. While the events of the 1970s demonstrated the vulnerability of the global system to disruption of oil supplies, those of September 11 have pointed up the need to urgently reconsider the domestic energy infrastructure, even as it has dramatically reinforced consideration of security of oil supplies. For instance, September 11 has exposed the vulnerability of the Saudi Arabian government, the most important U.S. ally in the region. The Saudi Arabian government, whose ruling family includes thousands of princes, is subject to many discontents stemming from a variety of domestic and foreign sources. Moreover, the presence of U.S. troops in Saudi Arabia is making the Saudi government more vulnerable to those discontents because of the perception that a government that has advertised itself as the guardian of Islam has subjugated that responsibility to money, oil, and a foreign power. A large part of the vulnerability of the world's oil system at the present time stems from the historical accident that the two most holy shrines of Islam are in the same country as the world's largest reserves of oil.

The politics of Central Asia, the Caspian region, the Caucasian region, and the Middle East, are becoming ever more tangled with the politics of terrorism and with the nuclear politics of Pakistan and India. Of course, this is in addition to the old-time nuclear powers, the United States, Russia, and China, who are present in the region. U.S. policy in Central Asia, like that of the other major powers, is closely tied to the immense oil and gas resources in the region.[3] Since September 11, the United States has introduced troops into Uzbekistan. The U.S. military presence in Central Asia is already showing signs of becoming prolonged, in the same manner as that in Saudi Arabia after the 1991 Gulf War. This could become a bone of contention between Russia and the United States, adding to the danger and complexity of the present crisis in the region.

Oil, of course, is also at the center of the global warming problem. Roughly half the emissions of carbon dioxide emissions from fossil fuels are attributable to oil. Most urban air pollution comes from motor vehicles. Much of the pollution of the oceans comes from oil spills, both routine and accidental. Yet the United States stood aside from the recent completion of the negotiations on the Kyoto Protocol to reduce greenhouse gas emissions. Major disruption of the global climate is not only likely to produce adverse health and economic consequences but also serous security implications, whose character is difficult to anticipate.

The vulnerability of nuclear power plants, spent fuel storage, and plutonium storage facilities to attack, has also been revealed as never before. Studies in the past have hypothesized the potentially catastrophic effects of accidents, war, or terrorist attacks on certain portions of the nuclear energy infrastructure.[4] There have also been some attempts at attacks on nuclear

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[3] Klare 2001

[4] FEMA 1980, Lovins and Lovins 1982.

facilities. Yet, these concerns have not been taken as seriously as they might have been. They can no longer be ignored.

The crash of one of the airliners in Pennsylvania, not far from the Three Mile Island nuclear power plant, as well as statements by a Taliban prisoner held in Afghanistan showing his awareness of nuclear power plants as potential targets, [5] should greatly heighten serious concerns about nuclear vulnerabilities. Most spent fuel storage sites as well as storage sites of other nuclear materials, notably plutonium, also have severe vulnerabilities. A breach of spent fuel containment or a meltdown in a nuclear reactor could cause catastrophic releases of radioactivity and immense disruption of energy, environmental, and financial systems.

U.S. actions after past crises, notably in the period between 1973 and 1980, have mitigated problems temporarily, but they have not been stringent enough to make the U.S. energy system more secure for the long-term. U.S. oil import and nuclear vulnerabilities are greater today than they have ever been despite the recommendations of studies done as a result of earlier crises regarding security, which were for the most part not adopted.[6]

The scale of the September 11 events and the vastness of the economic impact makes it imperative that the United States take urgent and tough action to reduce energy system vulnerabilities, notably those related to oil imports, nuclear power plants and associated infrastructure, and the electricity grid. It is stunning that the Bush administration has not revisited its energy plan proposed four months prior to September 11 in light of the events of that day.[7] Our analysis shows that the Bush energy plan would result in a great increase in energy vulnerabilities, including oil import insecurities, even if domestic oil production is expanded by opening up environmentally sensitive areas to drilling, including the Arctic National Wildlife Reserve. It would also keep nuclear vulnerabilities high and most likely increase them considerably.

The tables below on energy plan vulnerabilities show clearly that the Bush administration is on an unsound course of recommending an energy policy to the people of this country in the post September 11-period without revisiting its key vulnerabilities. Figures 1 through 7 which follow show some of the energy data and the vulnerabilities over time.

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[5] Branigin, 2001.

[6] See FEMA 1980, for instance.

[7] Bush Energy Plan 2001. This plan was published in May 2001 by a task force led by Vice-President Cheney, and submitted to President Bush. Prior to its official adoption as administration policy it was widely known as the Cheney Plan.

Vulnerabilities of the oil and nuclear elements of the energy system

Energy System Element	Type of vulnerability	Worst case consequences	Comments
Oil Imports	Political, wartime, or terrorist disruption of Persian Gulf oil (Note 1)	Depends on long-term level of oil imports and nature of disruption. Severe and prolonged global economic disruption and possibly expanded war in the Persian Gulf region are possible.	Nuclear consequences possible in case of large-scale political and military instability in the region. Several nuclear-armed states involved in the region.
Light Water Reactor	Only to massive attack	Catastrophic radioactivity releases, comparable to Chernobyl. Massive, long-term economic losses and environmental damage.	Secondary containment designed to contain all but the worst attacks
Spent fuel pools	Variety of attacks for those pools outside secondary containment	In case of a fire, catastrophic radioactivity releases, larger than Chernobyl for long-lived radionuclides. Massive, long-term economic losses and environmental damage	
Pebble Bed Modular Reactors	Variety of attacks, reactors proposed without secondary containment	Fires of the graphite coated would disperse radioactivity over wide regions. Massive, long-term economic losses and environmental damage	Reactor in development stage. Not licensed as yet.
Advanced sodium cooled reactor	Vulnerability will depend on exact design of containment	Sodium fires or explosions as well as loss of coolant accidents could cause catastrophic dispersal of radioactivity. Higher proliferation vulnerabilities and potential for higher plutonium dispersal in accidents or attacks.	Prototype Reactor type was cancelled in 1994 but may be re-instituted by Bush plan.
Plutonium separation – all types	proliferation	Spread of nuclear weapons usable materials and possibly of nuclear weapons including to non-state groups	Even impure separated plutonium can be used to make nuclear weapons
Plutonium separation, current technology	Variety of attacks, depending on nature of processing and waste facilities	Wide, catastrophic dispersal of highly radioactive waste in air and water, dispersal of plutonium, diversion of plutonium	1957 explosion of high-level waste tank in Soviet Union resulted in catastrophic radioactivity dispersal
Plutonium use or storage	Vulnerability varies by location	Potential severe dispersal of large amounts of plutonium. Potential for diversion of plutonium for weapons purposes	Vulnerability increases if plutonium used as a fuel and decreases if plutonium is immobilized and stored in subsurface facilities.

Note 1: We have not addressed Central Asian security vulnerabilities in detail this report due to the very fluid nature of the situation in the area, the evolving nature of the U.S.-Russian relationship, and the uncertainty about the future of oil politics in the region. But the potential for serious problems exists if the area becomes a focus for regional and global economic competition.

Comparison of Certain Energy System Vulnerabilities in the Bush and IEER Energy Plans, Year 2040

Vulnerability element	**Bush plan**, quantitative measure	***Bush Plan: Degree of Vulnerability***	**IEER plan:** quantitative measure	**IEER Plan Degree of Vulnerability**	**Comments**
Oil imports	23 million bbl/day	Very high risk of disruption	6 million barrels per day	Low risk	Bush plan: high Persian Gulf imports
Strategic Petroleum reserve	700 million barrels, or about 1 month of imports	Moderate buffer in case of disruption	700 million barrels, or almost 4 months of imports	Substantial buffer in case of disruption	Additional supplies can be procured from alternative sources in weeks to months, if physically available
Nuclear power reactors, LWRs	About 200 Operating reactors	Powerful September 11 attack would create catastrophic consequences	Zero nuclear power reactors	None	Chernobyl-scale radioactivity dispersal possible. Risk of large-scale disruption increased due to pressures to abandon nuclear suddenly in the aftermath of an attack.
LEU Spent fuel stored in pools (Note 1)	About 20,000 metric tons in spent fuel pools	Catastrophic consequences possible from a variety of attacks	Zero	None	Long-lived radionuclides releases could be larger than Chernobyl incase of fires.
Plutonium storage(Note 2)	Amount at high risk cannot be projected – highly policy dependent	Risk of catastrophic consequences in case of plutonium fuel diversion, accident or attack	All surplus plutonium (50 metric tons or more) immobilized in subsurface storage	Low risk of catastrophic consequences, serious local environmental results in case of attack;	Bush plan reprocessing, breeder reactor, and plutonium fuel policy evolution over the decades is unclear, making quantitative projection speculative.
Electricity power stations (non-nuclear)	300 megawatt projected unit size poses lower risks than typical present generator size	Low to moderate risk of major disruption from single attack	Lower than Bush plan due to greater reliance on wind energy and dispersed generation	Low risk of major disruption.	Dual fuel capability at some key plants would reduce security vulnerability. (Note 3)
Electricity transmission	Dependent on specific system characteristics	Higher risk than at present due to further grid centralization and deregulation. Higher attractiveness as a target due to greater centralization and damage potential	Two-fifths distributed generation	Some vulnerability from attacks on the grid will remain. Much lower attractiveness as a target compared to present	Larger scale introduction of solar energy, locally generated hydrogen energy resources in the distributed grid system, as well as management of reserve capacity to provide quick response to disruption could nearly eliminate large-scale vulnerability

1. Amount of spent fuel stored in spent fuel pools assumes that an average of five years worth of discharged fuel will be in pools. The rest is assumed to be put into dry subsurface storage. This row refers to spent fuel resulting from the use of low enriched uranium fresh fuel. The spent fuel typically contains just under one percent plutonium. We assume that all spent fuel that is more than five years old is stored in subsurface soils to minimize the consequences of an attack.
2. Plutonium storage vulnerabilities in the Bush plan would derive from surplus military plutonium use in the commercial sector as well as possible development of commercial plutonium use.
3. Dual fuel capability not explicitly factored into the IEER plan. See Lovins and Lovins 1982 for a discussion of this topic.

A. Plan comparison summary

Figures 1 and 2 summarize the Bush and IEER energy plans respectively, and Figures 3 through 7 show how some of the vulnerabilities in the two plans would evolve over time.

List of figures:

Figure 1: Bush Administration Projections for U.S. Energy Consumption by Source, 2000-2040

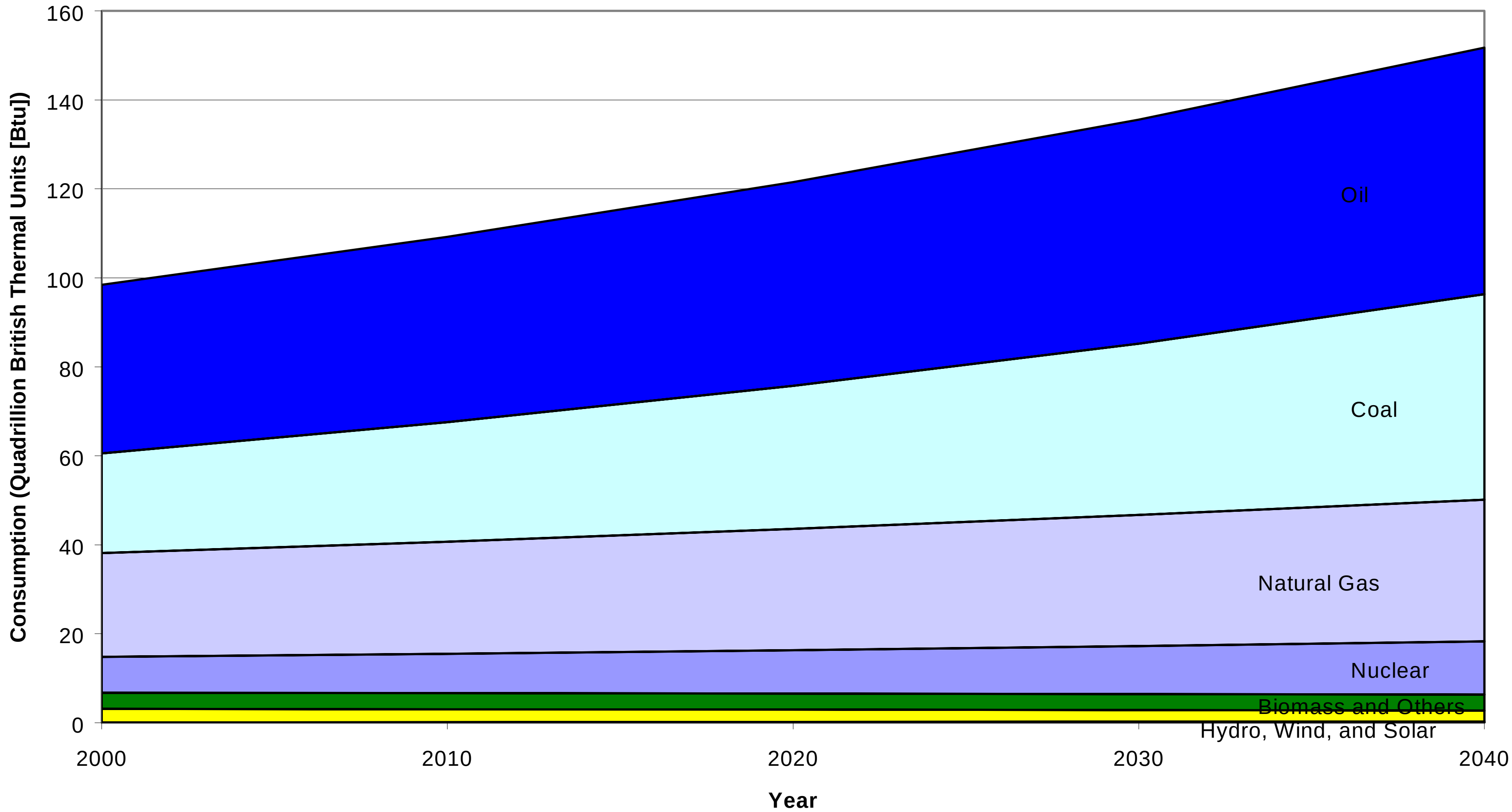


Figure 2: IEER Projections for U.S. Energy Consumption by Source, 2000-2040

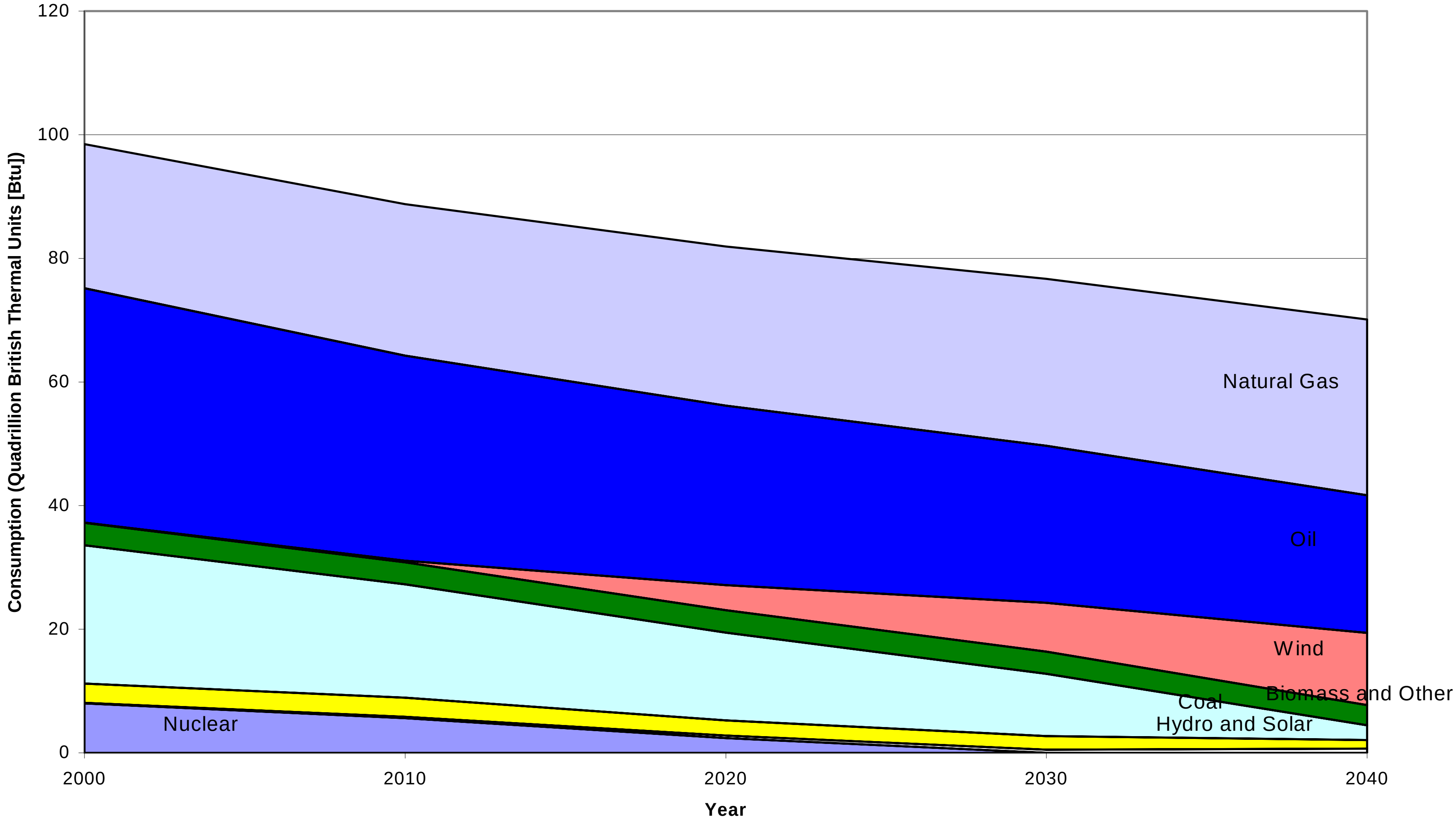


Figure 3: Projections for U.S. Oil Production and Imports, 2000-2040

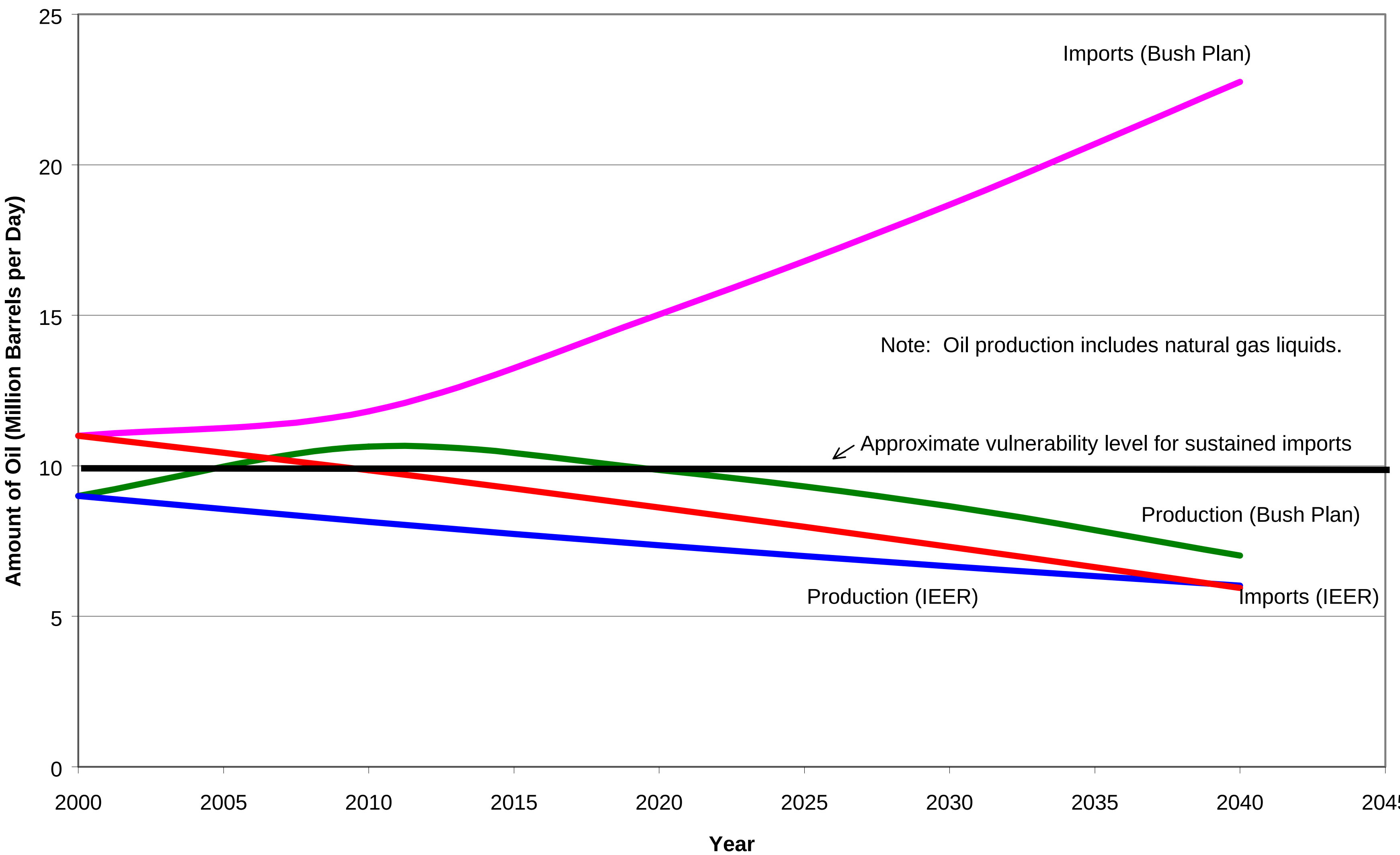


Figure 4: Energy Productivity Projections, 2000-2040

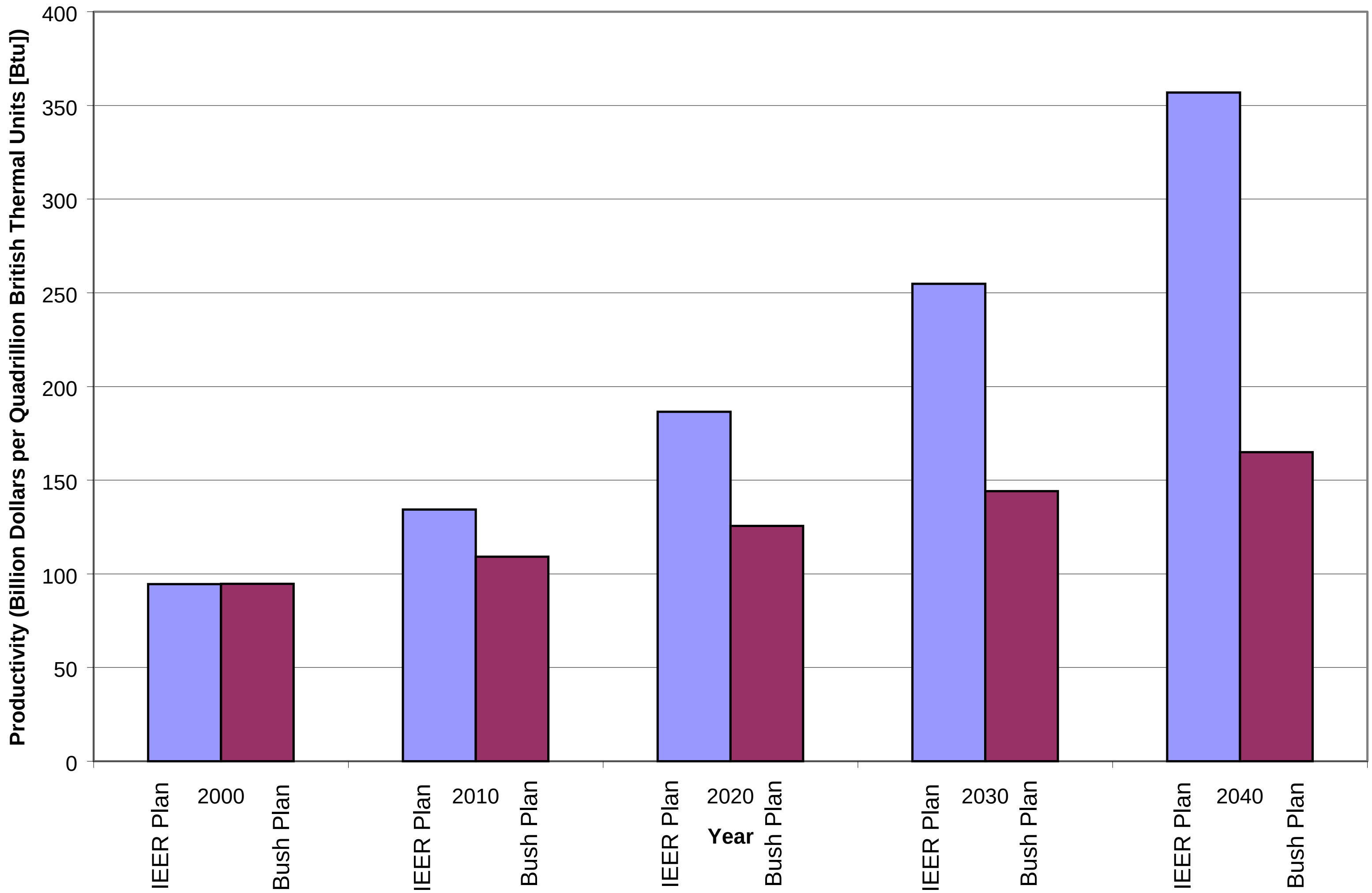


Figure 5: Projection for the Number of Nuclear Power Reactors On-line, 2000-2040

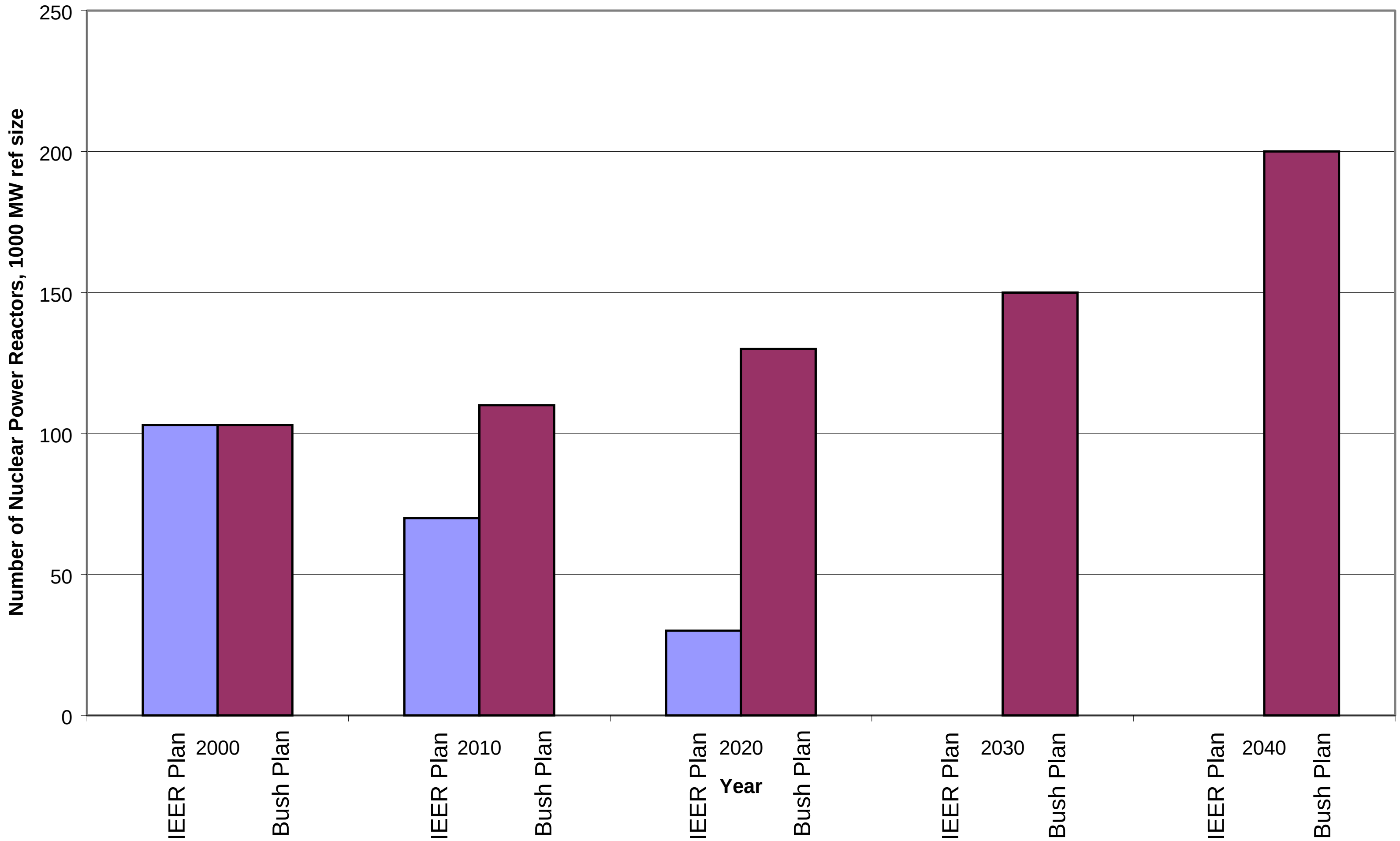
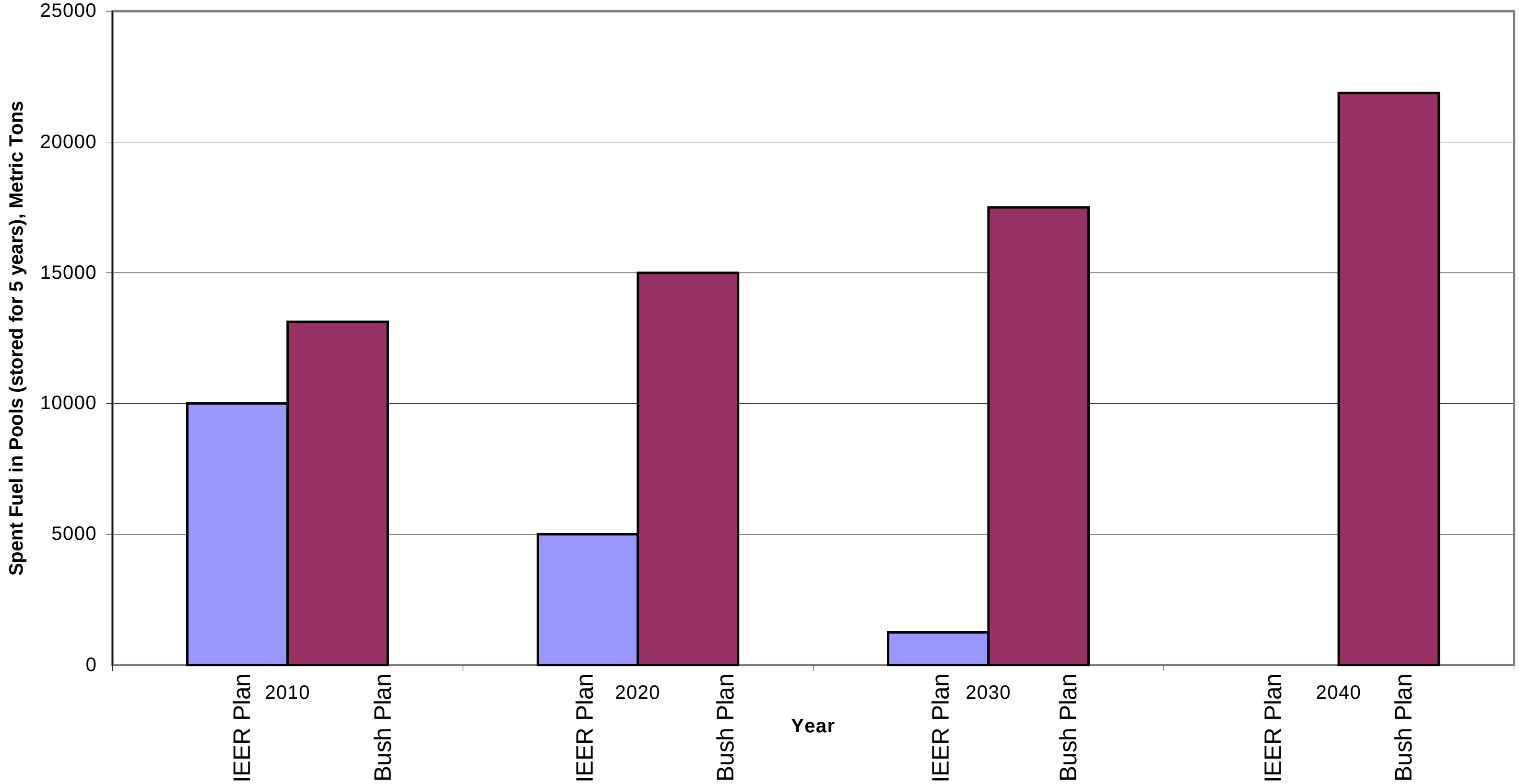
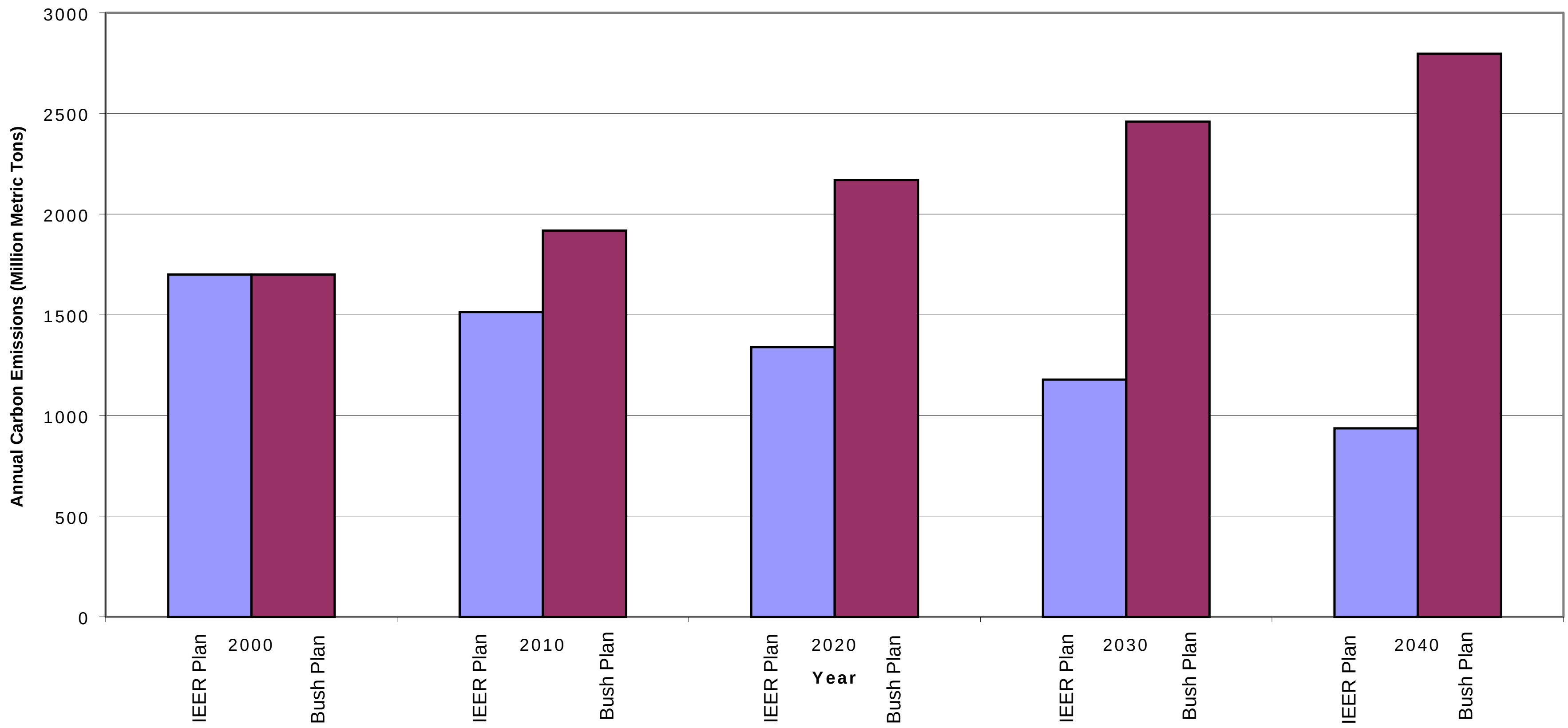


Figure 6: Projections for Amount of Nuclear Spent Fuel Stored in Pools, 2010-2040



Note: We assume that over the next 10 years the spent fuel now stored in spent fuel pools will all be put into dry storage. The numbers given here assume wet storage for five years and are for spent fuel created from 2005 onward.

Figure 7: Projections for Total Annual Carbon Emissions, 2000-2040



B. Main recommendations

The five most important recommendations of the report are:

- The United States should adopt an energy plan that would set goals for the long-term – a four-decade period. During this period, it must seek to essentially eliminate the most severe vulnerabilities to attack and reduce carbon dioxide emissions by about one-half by about 2040.
- A goal of an average efficiency of 100 miles per gallon for new passenger vehicles should be set for the year 2020. The efficiency goal should be accompanied by safety and emissions goals, so that all three issues can be coherently and simultaneously addressed. The technologies to achieve the mileage goal already exist.
- A national policy decision should be made to create regional distributed electricity grids in the next three to four decades. In these regional grids, a large proportion of the electricity would come from relatively dispersed generators, where installation of generation systems would be accompanied by efficiency improvements. Regulatory changes should be geared to encouraging the achievement of a distributed grid, rather than a centralized national grid of interconnected local and centralized electricity generation. Local and state governments as well as regional and national associations of local and state governments should have sufficient authority and funding to oversee these distributed grids and to regulate them for performance using economic, reliability, security, and environmental criteria.
- Nuclear power should be phased out. In general, the power plants can be decommissioned as they reach the end of their original license lifetimes. Some might need to be retired earlier if they have particular vulnerabilities.
- The U.S. government should commit about $10 billion per year to purchase renewable energy, fuel cells, efficient automobiles, and other leading edge technologies that are not fully commercial in order to promote their commercialization. Another $10 billion per year should be given to state and local governments for the same purposes. Direct subsidies for renewables and efficiency should be eliminated for new capacity replaced by this procurement program, which should operate consistently and reliably for at least a decade, and preferably for 20 years. Tax breaks for plants that have already been built or under construction, under the assumption that they will be available, can continue.

C. Main findings

1. The Bush administration's energy plan will result in greatly increased vulnerabilities by (i) increasing the attractiveness of and number of targets for terrorism particularly in the nuclear, oil, and electricity systems, (ii) increasing oil imports in absolute amount and as a proportion of oil supply, (iii) increasing risks of nuclear proliferation.

2. The Bush energy plan will result in an increase of greenhouse gas emissions by roughly fifty percent by the year 2030.
3. A reduction of oil consumption of about forty percent can be achieved in the next four decades, even if air transportation continues to rely completely on petroleum and continues to grow significantly, provided stringent standards for efficiency in land-based transportation are set.
4. It is possible to eliminate most nuclear power related vulnerabilities and greatly reduce others by a more diversified approach to electricity, by adopting sound approaches to nuclear waste and plutonium management, and by precluding the use of plutonium as a fuel.
5. A sound government procurement policy and other policies can result in a reduction of greenhouse gas emissions by about one-third by the year 2030 and by forty to fifty percent by the year 2040, relative to the year 2000.
6. A prolonged period of near complete phase-out of coal use can help provide the time for restructuring the energy industry in a way that would minimize its impact on workers. A transition period away from coal of four decades is compatible with a reduction of about half in carbon dioxide emissions by the year 2040. However, the maintenance of a relatively small coal sector of 50 to 100 million tons per year would provide the energy system with flexibility in case of disruption of energy supplies and this should be done unless other means of similar flexibility are put into place.
7. The achievement of reduction of carbon dioxide emissions can be made compatible with a total phase out of nuclear power.
8. The technologies to achieve the goal of simultaneously reducing carbon dioxide emissions and vulnerabilities to attack already exist. Some, such as wind energy and cogeneration, are already economical. Others will need suitable government procurement policies to make them economical. All of the needed technologies are advanced enough that they can be commercialized within the next five to ten years. Combined cycle power plants fueled by natural gas, fuel cells, cogeneration of various types, wind power, and highly efficient heating and cooling systems are the key technologies to achieving a substantial growth in the services that energy provides and reducing greenhouse gas emissions at the same time.
9. Additional reductions in oil consumption and greater use of renewable energy can be achieved in the next three to four decades if a vigorous program of research, development, and procurement for technologies that are not close to commercialization is put into effect. The central elements of the supply aspect of these technologies is coupling renewable energy sources with hydrogen fuel, as well as development programs to couple hydrogen fuel with renewable biomass sources to obtain hydrocarbon feedstocks for industry.

D. Other Policy recommendations

1. Federal level

1. Enactment of progressively more stringent carbon dioxide limits per unit of electrical power generation.

2. Transfer of spent fuel out of pools into dry storage when it is safe to do so rather than waiting until the pools are full.
3. Storage of dry casks containing spent fuel in sub-surface storage on-site at operating nuclear power plants.
4. A transfer of the control of spent fuel to the federal government at closed plants, with some consideration given to in-state consolidation of spent fuel at a single power plant in case of special vulnerabilities.
5. Creation of a national effort on transportation as an urban utility so as to ensure that public transportation and multi-modal transportation get a far larger share of federal resources than they now do.
6. An adoption of a policy to encourage distributed grids, and the orientation of a portion of the proposed federal procurement program to helping states and regions achieve distributed grids.
7. The United States should commit itself to the Kyoto Protocol process by taking the leadership in announcing a long-term goal of reducing carbon dioxide emissions by forty to fifty percent in the next four decades, with intermediate goals to be specified in forthcoming negotiations.
8. Natural gas should be regarded as the key transition fuel to a renewable energy future.
9. Public transportation in urban areas should be regarded as a utility, much like water, electricity or telephones. A diverse system of transport that includes cars, motorized and rail public transport, bicycle lanes and sidewalks would reduce vulnerabilities to terrorism by diversifying the modes by which people could travel in cities. By making public transportation safe, efficient, economical, frequent, and convenient, energy use as well as time for commuting could be greatly reduced with all the attendant social, economic, and environmental benefits.
10. Surplus weapons plutonium and all commercial separated plutonium should be immobilized and stored at a large nuclear weapons plant in subsurface silos in order to reduce the consequences of even a severe attack. Spent nuclear fuel from power plants, which contains 95 percent of all radioactivity in nuclear waste can also be packaged in dry casks for storage on site or close to site in subsurface silos. As nuclear power plants are closed, the storage can be consolidated within a state or region at a closed nuclear power plant site. The present highly unsatisfactory nuclear repository program should be scrapped and replaced by one that will result in a deep geologic disposal program that will better safeguard natural resources and future generations and also be less vulnerable to deliberate or inadvertent human intrusion.
11. The United States should request the National Academy of Sciences to create a standing committee to evaluate the energy system from the points of view of supply, efficiency, environment, and vulnerabilities, which reports to the government and the public each year.
12. Vigorous federal programs of research and development as well as energy policy, such as those at the National Renewable Energy Laboratory, Oak Ridge National

Laboratory, and the Lawrence Berkeley Laboratory should be maintained and reinforced.

13. Continued filling of the Strategic Petroleum Reserve, as is currently being pursued.
14. A program of research, development, and demonstration that couples hydrogen fuels to renewable energy sources and to a variety of end uses including pipeline fuel uses, industrial feedstocks, and air transportation should be undertaken as an investment in a long-term sustainable energy system. One near term focus of such an effort could be to use wind-generated hydrogen to replace industrial and transportation uses of petroleum as fuel in highly polluted areas.[8]

2. State and local actions

In addition to the institution of their own procurements policies along the lines discussed above for their own facilities such as schools, colleges, state government buildings, state and local vehicles, etc. the state and local governments should:

1. Create or maintain state level regulation of electricity systems in order to achieve the overall goals of system reliability, reserve margins, and transmission and distribution capacity.
2. Establish state and locally owned utilities with public oversight and transparency safeguards, with the goal of promoting high efficiency, secure distributed grids, and adequate capacity of the transmission and distribution system to withstand attacks on critical electricity infrastructure without massive prolonged disruption.
3. Institute regulation at the regional reliability council that correspond to the regional grids to provide the overall framework for achieving secure and reliable transmission and generation, including maintenance of adequate reserve margins and transmission capacity.
4. Institute rules requiring developers to consider on-site generation with best available technology for heating and cooling, efficient devices and justify why these technologies should not be used.
5. Put in place requirements for energy audits to be part of the re-sales of residential and commercial buildings with information about best practices during resale and consequences for the new owners of buildings.
6. Enact stringent efficiency standards for appliances, buildings, and vehicles, should the federal government fail to do so.
7. Create task forces on transportation as an urban utility that would analyze the security, environmental, and economic benefits of regarding public transportation as a public utility, especially when connected with efforts on public safety and excellence in schools.

[8] Caldwell 2001.

Chapter 2: Energy System Security Criteria

In 1980, the Federal Emergency Management Agency (FEMA) published a report that it had commissioned on energy with the prescient title: *Energy, Vulnerability and War*. The potential disruption of oil imports, the potential for attacks on nuclear reactors and the damage that they could cause were studied in detail. The report also set forth recommendations that would reduce energy sector vulnerabilities and the consequences in case of accident, terrorist attack, or war. The findings were startlingly similar to those that a commission appointed by President Truman, known as the Paley Commission after its chairman, had recommended, looking ahead to potential oil import vulnerabilities.

Both reports found that nuclear power would not be very helpful in addressing oil security issues and that security considerations required vigorous development and implementation of renewable energy sources. While the 1980 FEMA report was prepared and written well after environmental protection had become a major item in the U.S. and world political consciousness, that was not the case for the 1952 Paley Commission report.

Despite the Paley Commission's analysis, nuclear power was vigorously pursued. It is still heavily subsided by the government via an insurance program known as the Price Anderson Act, which would likely not cover the public for even ten cents on the dollar in case of a massive accident or attack. Plutonium and highly radioactive waste are stored in vulnerable ways that could result in catastrophic damage in case of attack. Such a vulnerability makes these facilities more attractive as terrorist targets. Renewable energy sources have, for the most part, languished.

In the meantime, the U.S. has become enmeshed in anti-democratic alliances and opportunistic politics and practices for the sake of oil. Ironically, these very alliances have contributed to long-term instability and insecurity. Even a diversification of U.S. oil imports has left the United States is more vulnerable today than it was during the 1973 energy crisis. This is because the United States imports a far larger proportion of its oil requirements and the absolute level of net imports, at 11 million barrels a day is immense accounting for almost a quarter of world oil imports. There are also other vulnerabilities in the form of nuclear power plants, storage of spent fuel in pools, and of plutonium that has become surplus to military requirements.

We will examine the energy system according to criteria that correspond to the following three questions:

1. Are the core functions resilient to supply, transportation, transmission, and economic shocks? Those shocks may come from accidents, terrorist attacks, war, or natural disasters.
2. Is the value of any single target so high as judged by the potential for catastrophic consequences that it would be an attractive target? By the same token, is it possible to reduce the consequences of an attack by technical measures so that major systems would become unattractive as targets?

3. What is the potential scale and duration of disruption for the U.S. and global economy should an attack on vulnerable installations be carried out?

We will examine the following areas in which energy system vulnerabilities exist:[9]

- Oil, focusing on oil imports.
- Nuclear power – existing plants
- Vulnerabilities of new nuclear power proposals.
- Plutonium and highly enriched uranium vulnerabilities.
- Emissions of carbon dioxide, the most important contributor to greenhouse gas build up.
- The potential for massive disruption of the energy system by single point attacks on the infrastructure, in particular on the electricity system.

A. Oil

Oil has been at the center of security and military issues ever since it became a crucial fuel in the conduct of war during the first part of the twentieth century. After World War II, the transportation systems of the wealthy countries became centered on oil, with everyday life and commerce completely intertwined with easy and assured availability of increasing amounts of oil. For these reasons, oil is and has been, through much of the twentieth century, one of the central aspects of the violent tangle of Middle Eastern, European, Soviet/Russian, U.S., and world politics.

For instance, the Japanese attack on Pearl Harbor came after the U.S. imposed an oil embargo to prevent Japan from getting access to and eventual control of Indonesian oil,[10] which belonged neither to Japan, nor to the United States, nor to the Dutch colonialists who then ruled Indonesia. The battle for Stalingrad during World War II, which proved to be a decisive turning point in the war for the Allies, was also centered on oil. Hitler had insisted on stopping the siege of Moscow and opening a second front toward Stalingrad so as to be able to seize the Caspian Sea oil fields that had been the prize for oil magnates, such as Rockefeller and Nobel, since the end of the nineteenth century.

Oil has also entangled the western powers in alliances with repressive regimes, such as the former Shah of Iran or the vast Saudi royal family with its thousands of princes. The long-term consequences of this approach to energy have been considerable. For instance, the CIA-supported overthrow of an elected government in Iran in 1953 (in reaction to nationalization of the Iranian oil industry) and its replacement by the Shah of Iran[11] led to two and a half decades of repression in which substantial dissent was only possible in the mosques. The process was part of the dynamic that led up to the 1979 Islamic revolution

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[9] See Lovins and Lovins 1982 and Makhijani and Saleska 1995 for further discussion of system criteria.

[10] Yergin 1991.

[11] For a history of oil politics, see Yergin 1991.

in Iran. The same pattern of alliances with undemocratic regimes has been re-emerging in Central Asia[12] and is being accelerated by the post-September 11 crisis.

Several past military crises, with nuclear implications, have been around the question of oil:

- Iran right after World War II
- the 1956 Suez crisis (involving a principal oil transport route)
- Lebanon-Iraq crisis in 1958
- the Israel-Egypt war and the associated Arab oil embargo in 1973
- the 1979 revolution in Iran followed by the Soviet invasion of Afghanistan
- the 1991 Gulf War.

The present war in the South Asian-Central Asian region also has oil-related considerations as well as potential nuclear dimensions. There has been much great power rivalry in the region, dating back to Victorian and Czarist times. One British and U.S. goal in modern times, for instance, was to prevent the Soviet Union from gaining access to an Indian Ocean warm water port in the region or a strong political foothold so close to the world's largest oil reserves. Much of the mess in the Persian Gulf, Central Asian, South Asian regions, including some of the motivation for the U.S. support of the Islamic opposition to the Soviet intervention in Afghanistan at the end of 1979, had that as a motive.

The war in Afghanistan has nuclear terrorism implications, the possibility for U.S.-Russian rivalry in Central Asia, and higher nuclear tensions between India and Pakistan. Depending on its effect on the general situation in the Middle East, the war also has possible long-term implications for nuclear proliferation in the region.

Security concerns related to oil have been of two types. First there has been the issue of reliance on oil imports from areas of the world, notably the Middle East, where there has been repeated military conflict. Second, there have been concerns about the security of oil-related facilities (and other large-scale energy related facilities in the United States), in the event of an attack inside the United States. We consider the first kind of vulnerability in this section.

One of the strengths of the US position in the 1930s and most of the 1940s was that it was either an exporter or virtually self sufficient in oil.[13] But the enormous growth in the number of automobiles in the decade as well as the rapid growth of other uses of petroleum resulted in the United States becoming a consistent net importer by the end of the 1940s. By 1960, the U.S. was importing almost one-fifth of its consumption. This trend was clearly evident in the 1950s. Moreover, it was occurring at a time when Western Europe was also becoming highly dependent on imported oil. Imports of other resources were also growing, including strategic commodities like aluminum.

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[12] Klare 2001 and Allison and Jonson eds. 2001.

[13] This section on the Paley Commission is drawn mainly from Makhijani and Saleska 1999.

One of the official reviews of the resource situation in the early 1950s was conducted by a commission appointed by President Truman, called The President's Materials Policy Commission, which came to be known as the Paley Commission, after its chairman. In the energy sector, the prime area of concern that the Paley Commission addressed was petroleum. It concluded in its 1952 report that there may be oil shortages by the 1970s. While it did not devote a great deal of attention to non-fossil fuel energy sources, its conclusions about them were as follows:

> Nuclear fuels, for various technical reasons, are unlikely ever to bear more than about one-fifth the load.
>
> We must look to solar energy....
>
> ...
>
> Efforts made to date to harness solar energy economically are infinitesimal. It is time for aggressive research in the whole field of solar energy -- an effort in which the U.S. could make an immense contribution to the welfare of the free world.[14]

The recommendations of the Paley Commission were motivated principally by security, not environmental, considerations. Yet the United States government did not focus on the problem until after the predicted vulnerabilities had been dramatically demonstrated by the Arab oil embargo of 1973 and the rapid jump in oil prices during and after the 1973 Arab-Israeli war. Shortly after that war, the Energy Policy Project of the Ford Foundation produced an analysis that showed that economic growth could be de-coupled from energy growth.[15] That report also focused considerable attention on security problems associated with oil imports. Efforts in the 1970s resulted in considerable efforts to reduce energy vulnerabilities, notably in relation to increasing efficiency of cars (via the Corporate Average Fuel Efficiency (CAFE) standards, better standards for appliances, and better housing codes). However, there was not a thorough and consistent follow-through. A sharp increase in economic output per unit of energy input kept energy use approximately flat between 1973 and 1985. By the mid 1980s, energy policy disappeared as a crucial issue on the U.S. agenda, with a concomitant resumption of energy use growth.

Currently U.S. oil imports are at 11 million barrels a day, with about 25 percent coming from the Persian Gulf area (see Figure 8.) Overall, about 40 percent of the world's oil exports come from the Persian Gulf region, which holds two thirds of the world's proven oil reserves (see Figure 9 – world oil reserves).

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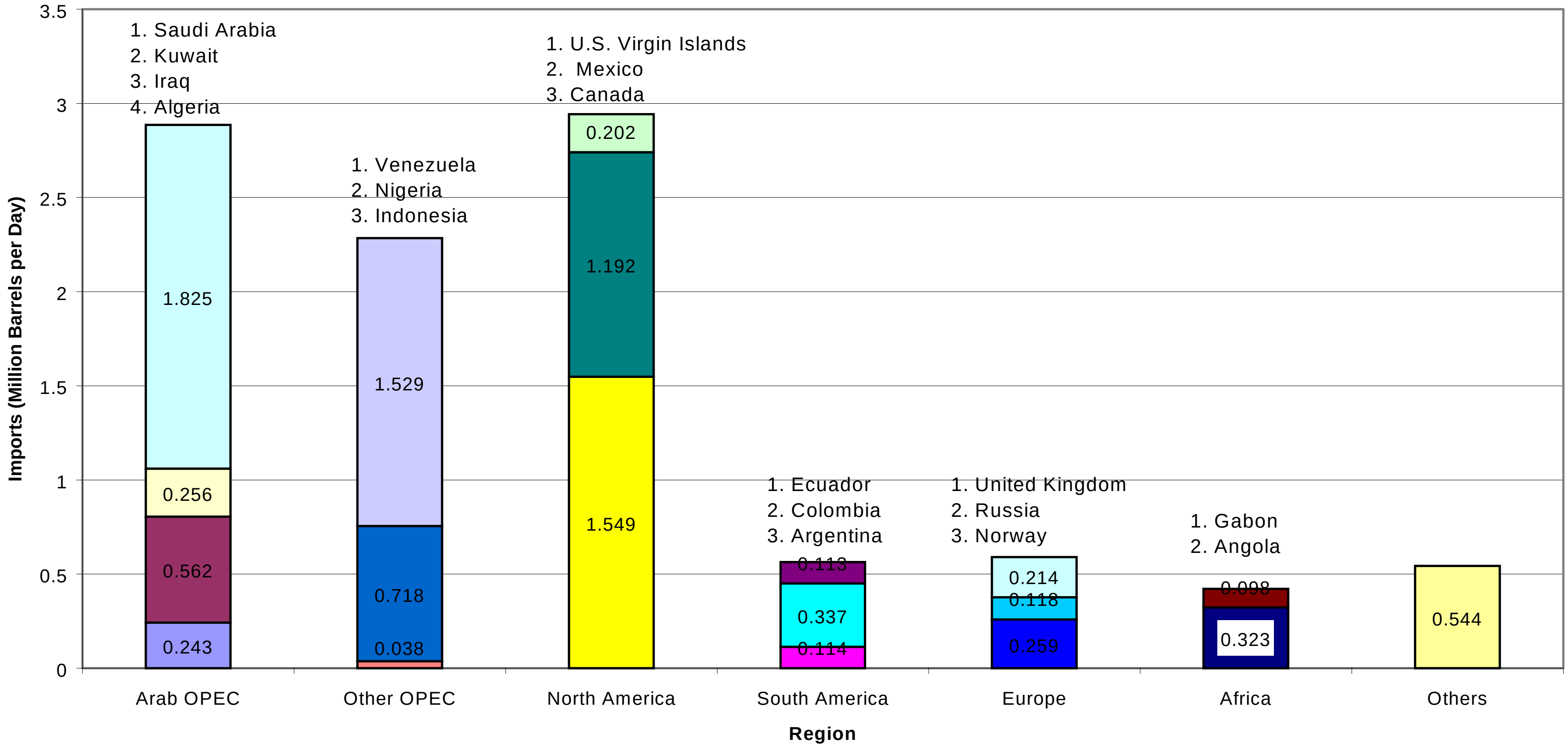
[14] Paley Commission 1952, Vol. IV, p. 220.

[15] Energy Policy Project 1974. The author of the present report was one of the co-authors of the 1974 Energy Policy Project report.

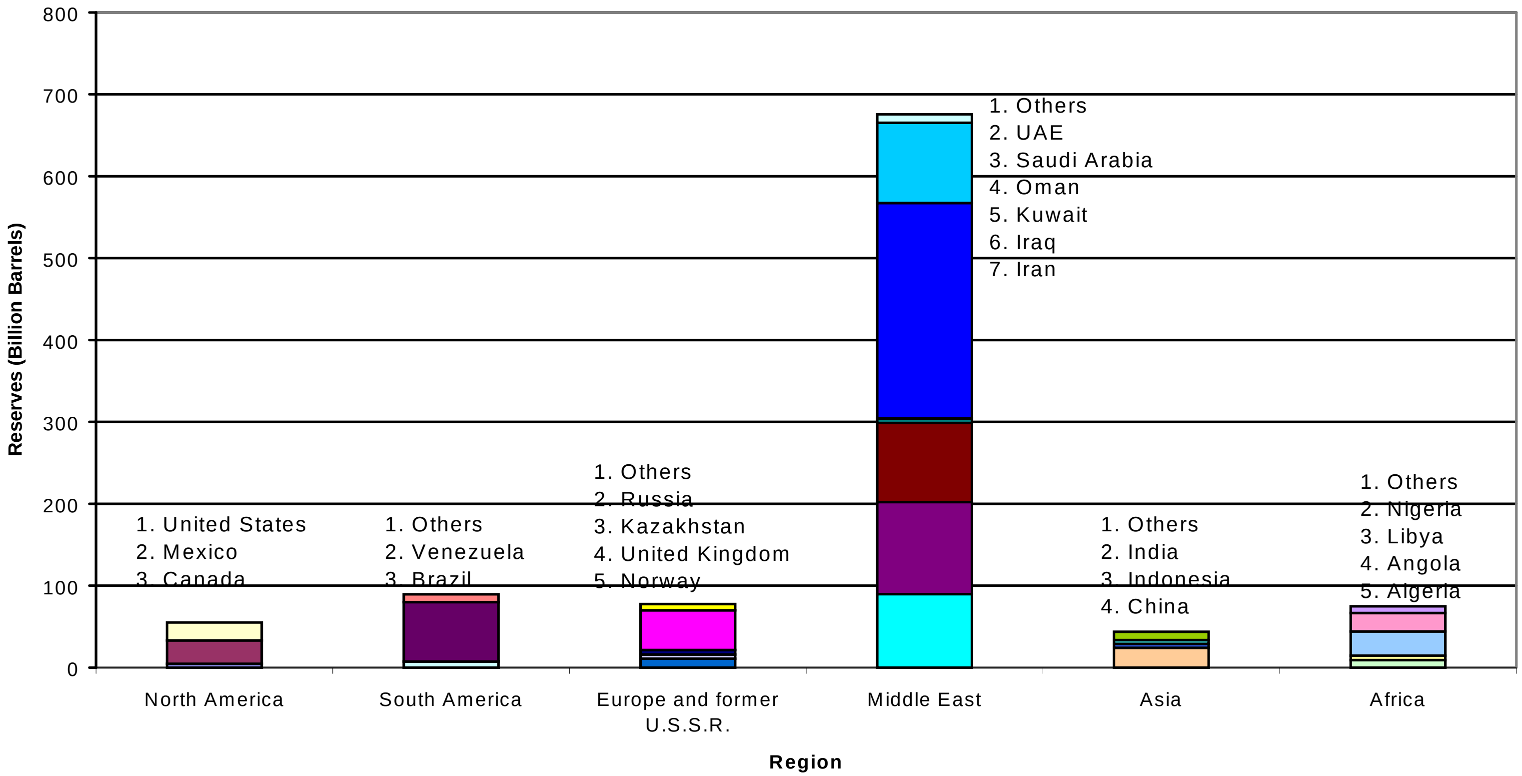
Figure 8: Net Imports of Total Petroleum Products into the U.S. by Region of Origin, August 2001



Source: USDOE, Energy Information Administration, Petroleum Supply Monthly, October 2001, Table 49

Note: Countries within regions are listed above each column. The first country on each list corresponds to the first country within that column. Countries that import less than 100,000 barrels per day were placed in the "Others" column. In August, 2001, the United States imported roughly 10.2 million barrels of oil per day.

Figure 9: Crude Oil Reserves by region as of January, 1999



Note: Countries included within each column are listed at the top of that column. Countries whose reserves were less than 5 billion barrels were placed in "Others." The world's total reserves are roughly 1 trillion barrels. Source: USDOE, Energy Information Administration, International Energy Annual 1999 Table 8.1

Rising U.S. oil imports in the context of growing oil imports in developing countries will create greater dependence on Persian Gulf area supplies worldwide. Sustained U.S. oil imports over 10 million barrels per day raise the risk of severe disruptions that could have grave military and economic consequences. At 10 million barrels a day, US imports would consume 10 percent of the entire world's recoverable oil reserves in three decades. By the same token, a direction of declining US imports to well below 10 million barrels per day would not only greatly reduce the impact of a disruption but also the threat of one. It is not necessary to have zero imports to greatly reduce oil-related vulnerabilities.

It is possible that the Caspian Sea and Central Asian regions have far greater oil reserves than are currently formally recognized in oil industry and official energy data. But the tapping of such reserves may not reduce security vulnerabilities and may, indeed, increase them. These are regions in which there is U.S.-Russian competition for influence, despite the cooperation between the two countries over the Afghanistan war and reductions in strategic nuclear arsenals.[16] Indeed, large-scale exports of oil from the Central Asian and Caspian Sea regions hold the potential for new, possibly equally serious vulnerabilities, since these regions could become arenas for competition between two or more nuclear weapons states, including the United States, Russia, China, and possibly Pakistan, and India.

Our main criterion for petroleum related vulnerabilities will be oil imports, with high vulnerabilities being defined as sustained imports over 10 million barrels a day and very high vulnerabilities as over 15 million barrels a day. U.S. oil imports of less than five million barrels a day would essentially eliminate the potential for catastrophic disruption, particularly if it were accompanied by a decline in European imports as well.

B. Nuclear power and nuclear materials

In 1980, the Federal Emergency Management Agency commissioned a report on the security vulnerabilities associated with the energy system.[17] This study identified a host of security vulnerabilities associated with the energy system, with oil imports and nuclear power plants being identified as the ones with the potential for the most severe negative impacts in case of war, attack, or disruption.

For instance, in regard to nuclear power plants it noted:

> Since nuclear power plants constitute less than 200 potential targets (including near-term and proposed additions) and have the added risk in some cases of

[16] See Klare 2001 and Allison and Jonson eds. 2001 for discussions of security issues, great power politics, regional rivalries, and oil-related questions in Central Asia.

[17] FEMA 1980.

> being very close to population centers, they are prime candidates for strategic nuclear targeting or conventional bombing.[18]

The report also discusses sabotage of nuclear power plants, or using threats of attacks on nuclear power plants "as a means of coercion."[19] The Paley Commission had also been very critical of nuclear energy and took a dim view of its potential.[20] Like the Paley Commission, the FEMA report recommended greater reliance on renewable energy sources of security reasons. (Global warming was not yet a major policy concern in 1980 though the problem was getting greater attention in some scientific circles.)

1. Existing reactors

The most vulnerable parts of the nuclear power system currently, in terms of catastrophic consequences, that would cause long-term disruption are nuclear reactors and nuclear spent fuel pools. We will discuss power plants in this section and spent fuel pools in the next.

The potential catastrophic consequences associated with nuclear power plants and spent fuel storage in pools, which is an essential component of present reactor design, cannot be mitigated by technical measures. Nuclear power plants provide over 20 percent of the electricity generated in the United States and cannot all be shut down overnight. And even if they could, the vulnerabilities relating to spent fuel storage in pools will persist for a few years.

Nuclear power plants in more than one country have been the objects of terrorist attacks both during construction and after commissioning.[21] Evidently, in the short-term better preventive security measures are needed and are being implemented. In the long-term the only solution is to shut down the existing nuclear power plants and to not grant them license extensions. The consequences of a complete loss of containment by accident or attack could very well be on the same scale as the 1986 Chernobyl accident. If the secondary containment is breached, the total releases of iodine-131, could for instance, be in the millions of curies, compared with the official estimate of 15 curies for the 1979 Three Mile Island accident. The official estimate for release of iodine-131 after the 1986 Chernobyl accident in the Soviet Union, was 7.3 million curies. There are persuasive arguments that this is an underestimate. [22]

Many reactors are relatively close to populated areas. The health, environmental, and economic damage would be immense. Moreover, a single successful attack would bring about a crisis in the electricity sector since it would create severe pressures for a precipitous shut down of all nuclear power plants. That would present choices that would be immeasurably worse than the ones that are involved in an orderly phase out. A plan

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[18] FEMA 1980, p. 12.

[19] FEMA 1980, p. 13, in a quote from Bennett Bamberg.

[20] Paley Commission 1952, Vol. III, p. 39.

[21] Lovins and Lovins 1982, pp. 142-146.

[22] Makhijani and Saleska 1999, pp. 154-155

for phase out can be accelerated if it exists. But if nuclear power is in the process of being expanded, the economic damage would be compounded because the choices would be far more limited and each would exact a heavy price.

Extending power plant licenses would only extend the vulnerability for prolonged periods of time, which is entirely unnecessary, given that goals in relation to reductions of greenhouse gas emissions can be accomplished by other means, as we will discuss. An orderly phase out of nuclear power plants as their licenses expire has long been desirable for a host of proliferation, safety, and environmental reasons, even though nuclear power plants can help to reduce greenhouse gas emissions. The Nuclear Regulatory Commission should also undertake a thorough review of reactors and spent fuel pools (see below) that may face special vulnerabilities and consider whether such reactors should be shut before their licenses expire.

As a precautionary measure, the Nuclear Regulatory Commission should also order the distribution of potassium iodide tablets to public health institutions, such as hospitals, for distribution in case a massive accident or attack on a nuclear power plant results in large iodine-131 releases. A public education campaign about when and how such tablets might be used is an important public health safeguard in the interim while nuclear power plants are still in operation. Within about three months of closure, iodine-131 ceases to be a risk at closed power plants, when only spent fuel is stored, since it has a half-life of only about 8 days.

2. New nuclear power proposals

The Bush administration's energy plan contains four major proposals for new nuclear facilities that, if implemented, would greatly increase nuclear vulnerabilities, in addition to those associated with the prolongation of the licenses of existing nuclear power plants. They are:

1. The Pebble Bed Modular Reactor (PBMR)
2. New Advanced Reactors (implicitly including a new type of sodium-cooled breeder reactor called the Integral Fast Reactor or the Advanced Liquid Metal Reactor).[23]
3. New reactors associated with transmutation of certain components of nuclear waste.[24]
4. Reprocessing of spent fuel either in association with scheme 2 and/or 3 above, as well as possible reprocessing as currently done for light water reactor spent fuel in France.[25]

We will discuss these briefly. In addition to safety issues associated with PBMR, it is proposed to be built without a secondary containment.[26] That would make it highly

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[23] The Bush Energy Plan 2001 does not make an explicit reference to sodium-cooled reactors, but the implication is clear enough, since it does mention advanced reactors and a reprocessing technology known as pyroprocessing, which is associated with some liquid metal cooled reactor designs, including the Integral Fast Reactor..

[24] For a discussion of transmutation technology see Makhijani, Zerriffi, and Makhijani 2001.

[25] Makhijani 2001a and Makhijani 2001b.

vulnerable to a variety of terrorist attacks far more feasible than the massive attacks of September 11. While its detailed design has not been revealed, gas reactors of this general type that depend on natural convective cooling in case of loss of coolant accidents are understood to be more vulnerable to certain kinds of attack than current light water reactors.

Sodium-cooled reactors can have explosive accidents if there is contact between water and the liquid sodium. Liquid sodium catches fire on contact with air. These reactors are designed to contain far more plutonium as a fuel than current reactors, which generate plutonium in the course of their operation, but in which the percentage of plutonium is generally under 1 percent at any time (unless they are fueled with plutonium fuel – see below). As a result, the consequences of an attack on such reactors could be even more catastrophic than with current commercial reactors.

It is possible to build nuclear reactors underground, but the cost, safety, and siting issues related to such proposals are largely unknown. The only long-term practical experience with large underground reactors is in Russia, where three reactors that produced power as well as plutonium for military purposes were built inside a mountain in Siberia (Krasnoyarsk-26).[27] New vulnerabilities would likely be created, for instance to groundwater resources, in case of accidents, natural disasters, or attacks. Resistance to siting may lead to large number of reactors at a few sites, reviving old nuclear energy "park" proposals. Moreover, such highly centralized underground facilities would be attractive targets because of the scale of potential damage. For the same reason, the surface transmission facilities associated with such plants would also be vulnerable. Interconnected power sources that are less centralized are essential to increasing electricity system security and decreasing economic vulnerability to attack.[28]

In sum, the number of operating nuclear reactors, the variety of attacks that can result in catastrophic releases of radioactivity, and the degree of concentration of generation and key transmission facilities are crucial vulnerability criteria.

3. Spent fuel pools

Spent fuel pools are large pools of water where the discharged used nuclear fuel from commercial nuclear reactors is stored. All commercial U.S. nuclear reactors use ordinary water as a coolant and moderator ("Light water reactors, or LWRs) and require spent fuel pools.

Releases of long-lived radionuclides radioactivity from a massive spent fuel pool accident of or attack can be larger than those from a reactor. This is because the inventory of log-lived radionuclides in spent fuel pools is typically far larger than in reactors. For instance, Gordon Thompson, a physicist, has calculated that a fire at a spent

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[26] Makhijani 2001c.

[27] Makhijani, Hu, and Yih., eds. 1995, p. 300.

[28] FEMA 1980.

fuel pool of the Millstone power plant in Connecticut could result in a release of cesium-137 larger than the estimated release from the Chernobyl accident.[29]

The length of time for which spent fuel must be stored in pools is at least three years. Spent fuel pools in the United States contain most of the 40,000 metric tons or so of spent fuel discharged so far from U.S. power reactors, though increasing amounts of spent fuel are now in on-site dry storage casks.

Most spent fuel pools are not inside reactor secondary containment buildings. As a result they are vulnerable to a variety of potential attacks, unlike the reactors, which are vulnerable only to the most severe ones. Dry storage is less vulnerable for several reasons. First, it is not subject to meltdown in case of containment breach since only relatively cool fuel can be stored in dry casks. The consequences of an attack can still be very severe however, especially in case of the dispersal of radioactivity that would be attendant on a petroleum fire in case of an aircraft attack. Above surface dry storage of spent fuel also is a vulnerable form, but this can be addressed by on-site or near to site subsurface storage. We assume that whatever the policy in relation to nuclear power that retrievable subsurface storage of dry casks will be implemented.[30] Therefore the main vulnerability arising from spent fuel will be associated with the spent fuel stored in the pools. We assume that reactors will be of the light water reactor design, the only one licensed to date in the United States, and that, on average only about 5 years of spent fuel discharges will be stored in pools. In practice, economic pressures will be great to store more of the fuel in spent fuel pools in order to avoid the costs of dry cask storage. We assume that dry casks will be stored in subsurface silos, so that this would be a relatively small source of vulnerability within the context of a nuclear energy system.

PBMRs would not have spent fuel in pools. However, the use of graphite-coated fuel the lack of a secondary containment mean that the spent fuel inventory associated with the reactor would be, roughly speaking, as vulnerable to attack as LWR spent fuel pools. The graphite-coated fuel could catch fire, resulting in a catastrophic spread of radioactivity. A modular graphite reactor of the type proposed would have a considerably smaller inventory of radionuclides than current LWRs. Underground power plants would mitigate the spread of radioactivity via the air pathway, but may not prevent it. Moreover, they may possibly aggravate the water-related long-term contamination problems.

Advanced sodium-cooled reactors would be accompanied by reprocessing and fuel fabrication facilities, and associated spent fuel storage. There would be some degree of vulnerability in such facilities, but the degree would depend on the designs, which have not been explicitly proposed in the Bush energy plan. All plutonium separation plants

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[29] Thompson 2001.

[30] IEER has published many analyses of the proposed U.S. deep repository for spent fuel and military high-level waste at Yucca Mountain in Nevada. For a variety of reasons, many of which are not repeated in this report, this is a poor project that should be replaced by a scientifically sound repository program. See various issues of *Science for Democratic Action* at www.ieer.org and Makhijani and Saleska 1992.

and plutonium fuel use is accompanied by special proliferation vulnerabilities, as discussed below.

4. Plutonium vulnerabilities

United States stocks of plutonium and highly enriched uranium are almost entirely held within the nuclear weapons complex or by the Pentagon, the latter in the form of nuclear weapons. Consideration of nuclear materials inside nuclear weapons is beyond the scope of this report. Only a small part of the U.S. stock of plutonium (1.5 metric tons) is of commercial origin, while the rest is military. About 50 metric tons has been declared surplus to military needs and more may be put into the surplus category, if the recent tentative U.S.-Russian agreement during the November 2001 summit of Presidents Bush and Putin to reduce strategic nuclear arsenal to about 2,000 warheads each is implemented.

The U.S. government proposes to use most of the surplus plutonium as a fuel in nuclear reactors. This plutonium fuel would be a mixture of weapons-grade plutonium (roughly five percent) and depleted uranium, both in oxide chemical form, with the physical form being ceramic pellets. IEER has discussed the proliferation-related vulnerabilities of plutonium fuel, also called mixed oxide or MOX fuel, at length in other publications.[31] The main points to be highlighted in the context of September 11, 2001 are:

- Transporting fresh plutonium fuel increases the chances of diversion in cases of terrorist attack. It is relatively simple to re-extract the weapons-grade plutonium from the mixed oxide ceramic pellets and obtain material suitable for use in nuclear weapons. This cannot be done with present low-enriched uranium (LEU) fuel. It would take massive enrichment facilities to make highly enriched uranium (HEU) from LEU.
- Storage of fresh plutonium fuel at nuclear power plants would increase the attractiveness of nuclear power plants as a target.
- Use of plutonium fuel would make the consequences of an accident or attack more serious.[32]
- The storage of plutonium spent fuel in pools (a necessity for some years after discharge) at nuclear power plants would make the consequences of an attack on spent fuel pools more catastrophic.

Prolonged storage of plutonium without making that storage more secure carries its own risks. Many of these risks have been analyzed from an environmental and security

[31] Makhijani and Makhijani 1995 and various articles in *Science for Democratic Action* at www.ieer.org.

[32] Lyman 2001 has analyzed the consequences of a meltdown accident in a light water reactor using plutonium fuel. The same results would apply to a terrorist attack that result in a meltdown. Gerald Pollack in pointed out in a 1987 study (Pollack 1987) that "the kinds of damage that a terrorist attack could cause are similar in many ways to that which could result from a reactor accident occurring during normal operations."

standpoint prior to September 11, 2001.[33] September 11 has pointed up more vulnerabilities. There is precedent for a commercial airliner having been hijacked to threaten a nuclear weapons facility. On November 12, 1972 three men hijacked a Southern Airways, DC-9 commercial jet airliner and threatened the Oak Ridge nuclear weapons plant, a site with nuclear reactors, radioactive waste, a huge uranium enrichment plant, and stores of highly enriched uranium and other radioactive and non-radioactive hazardous materials. The hijackers did not know how to fly a plane, wanted money.[34] They were promised money and taken to Cuba where they were arrested, tried, and convicted (and later also extradited to the United States). Today, large amounts of surplus plutonium are stored at various sites. While the degree of the problem varies, plutonium storage sites are vulnerable to attack, much as even heavily reinforced nuclear power plants are vulnerable.

While prevention of attack through improved security is imperative, it is not enough where plutonium storage is concerned. Unlike nuclear power plants, plutonium cannot simply be phased out.[35] It is like long-lived radioactive waste, and it is necessary to minimize the consequences of an attack should one occur. By the latter criterion, current methods of plutonium storage are sorely inadequate. It is stored in a variety of buildings, mostly above ground in forms that could catch fire (metal) or that are relatively easily dispersible in air, such as plutonium oxide.

Besides storage vulnerabilities, the two large reprocessing plants at the Savannah River Site are still open, though they are running at very low capacity, processing very small amounts of materials. In doing so they are adding to the stock of high-level liquid radioactive waste (stored in large underground tanks) and the stock of separated plutonium.

Instead of initiating an urgent review of plutonium storage and reprocessing plants with a view to shutting down unnecessary facilities and improving storage forms and methods, the Bush administration is continuing with its plan to spend money on developing commercial plutonium fuel as a normal part of the U.S. nuclear power system. This would reverse a quarter century of bipartisan nuclear non-proliferation policy though five previous administrations. It would exacerbate both proliferation pressures and vulnerabilities to attack, rather than reduce them.

It is shocking that the momentous events of September 11 have not led to an urgent reappraisal of plutonium-related energy policies, especially since this is an area where the consequences of an attack would be among the most severe and where solutions to greatly reducing vulnerabilities can be implemented within a relatively short time, compared to say, those related to existing nuclear reactors.

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[33] NAS 1994, Makhijani and Makhijani 1995.

[34] See Blair with Hass 1977 for an account of the hijacking. Chapter 5 recounts the Oak Ridge related aspects.

[35] Transmutation can reduce the inventory of plutonium over the long term but it greatly increases proliferation risk since it involves reprocessing. See Makhijani, Zerriffi, and Makhijani 2001.

C. Global warming and security vulnerabilities

The most intense present debate concerning global warming over the past few years has occurred over the Kyoto Protocol, the global agreement under which industrial countries pledged to reduce greenhouse gas emissions by modest amounts relative to 1990 by about the year 2010. There are a variety of greenhouse gases, including carbon dioxide, methane, nitrous oxide, and chlorinated hydrocarbons known collectively as halocarbons, which are widely used in air-conditioning, refrigeration, and various industrial applications. The United States signed the Kyoto Protocol, but did not ratify it. The Bush administration has announced that it will not abide by this treaty, but the other signatories have gone ahead and negotiated specific targets for greenhouse gas emission reductions as well as how they might be achieved.

Global warming, which would likely lead to a severe disruption of the Earth's climatic and hydrologic system, among other things, is not only an environmental issue. Drastic climate change in a short period time could have disastrous implications for human health, for the health of ecosystems on which the global economy depends, on coastal countries and populations, on property values, and on jobs. Any one of these factors could have unpredictable security implications. For instance, massive refugee crises caused by severe weather and flooding of coastal lands could result in tensions between countries, as for instance between Bangladesh and India, or Mexico and the United States. More locally, a recent report of the Natural Resources Defense Council provides an example of the kinds of disruptions to local ecosystems and economies that could occur.[36]

Reducing the build up of carbon dioxide, the main greenhouse gas, is therefore imperative not only for environmental reasons, but also for reasons of human health, economy and security.
While the current stage of the Kyoto Protocol, a treaty to reduce emissions of greenhouse gases, requires very modest reductions, generally less than 10 percent for the most industrialized countries, it will be necessary to reduce global greenhouse gas emissions on the order of 50 percent within several decades if we are to mitigate the risks of severe catastrophe. Yet the Bush administration has rejected the treaty and failed, to date, to present an alternative plan for reducing greenhouse gas emissions.

D. Energy infrastructure

Several studies, including the 1980 FEMA study and the 1982 book *Brittle Power*, discuss the vulnerabilities of the energy production and pipeline infrastructure to wartime

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[36] Fiedler, Mays, and Siry, eds., 2001.

or terrorist attack.[37] Generating stations, electricity transformer and switching stations, and transmissions lines are also potential targets. Such facilities have been targets of U.S. bombing in recent years in wartime, for instance in Yugoslavia. Indeed, they have been targets since World War II when bombing of industrial infrastructure was a central part of the goal of strategic bombing. The vulnerabilities of such facilities have been discussed in detail in the 1980 FEMA study and we will not discus them in detail here. The September 11 events have shown that those vulnerabilities are not only theoretical for the United States.

Indeed, there have been terrorist attacks on U.S. electricity infrastructure in the past. Amory and L. Hunter Lovins cite several examples, among them three 1970 attacks on the Pacific Intertie (a major electricity transmission line) and the 1974 bombing of transmission towers in Oregon forests "by two extortionists threatening to black out Portland if they were not paid a million dollars."[38] Of these vulnerabilities, the potential for a highly centralized, increasingly interconnected grid to crash if a strategic portion of it collapses due to overload, accident, weather, or attack, is arguably the most important non-nuclear vulnerability of electrical systems.[39] Almost all high-voltage electricity transport is overhead lines, as are the main switching and transformer facilities. Such vulnerabilities were also discussed in detail in the 1980 FEMA report.

The trend towards de-regulated electricity systems with a national grid would exacerbate the vulnerabilities of the grid. This is because the siting of power plants would be determined significantly by local environmental, regulatory, and land use considerations. Closeness to energy supplies or consumers would decline in relative importance as siting factors. The financial vulnerability of electric power systems may also grow in case an attack disrupts a major portion of the electricity supply. Since electricity cannot be stored, this vulnerability is far greater with electric power systems than with any other portion of the energy system. The chaotic financial situation around electricity deregulation and sales in California would be much more complex were the shortages to result from a physical disruption of the electricity system as a result of an attack on one or more key elements of a national transmission grid.

Lovins and Lovins have also noted that:

> "Electrical grids and their components seem to be far more frequently attacked than oil and gas grids – perhaps because power failures are so much more immediate and dramatic that interruption of [domestic] oil or gas supply, and offer so few options of substitution in the highly specialized end-use devices."[40]

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[37] FEMA 1980; Lovins and Lovins 1982.

[38] Lovins and Lovins 1982, p. 128.

[39] The 1965 New York City black out and the more recent ones in 1998 in Montreal and in Auckland, New Zealand are examples of system failures for technical and (in the case of Montreal) weather-related reasons.

[40] Lovins and Lovins 1982, p. 124.

E. Oil and Nuclear Vulnerability Summary

The table below summarizes oil and nuclear vulnerabilities and their potential severity.[41] New reactors vulnerabilities could be reduced by requiring secondary containment that would withstand an attack of the scale of September 11. But there is no indication to date that such a requirement will be imposed..

Energy System Element	**Type of vulnerability**	**Worst case consequences**	**Comments**
Oil Imports	Political, wartime, or terrorist disruption of Persian Gulf oil	Depends on state of oil imports and nature of disruption. Severe and prolonged global economic disruption and possibly expanded war in the Persian Gulf region are possible.	Nuclear consequences possible in case of large-scale political and military instability in the region. Several nuclear-armed states involved in the region.
Light Water Reactor	Only to massive attack	Catastrophic radioactivity releases, comparable to Chernobyl. Massive, long-term economic losses and environmental damage.	Secondary containment designed to contain all but the worst attacks
Spent fuel pools	Variety of attacks for those pools outside secondary containment	In case of a fire, catastrophic radioactivity releases, larger than Chernobyl for long-lived radionuclides. Massive, long-term economic losses and environmental damage	
Pebble Bed Modular Reactors	Variety of attacks, reactors proposed without secondary containment	Fires of the graphite coated would disperse radioactivity over wide regions. Massive, long-term economic losses and environmental damage	Reactor in development stage. Not licensed as yet.
Advanced sodium cooled reactor	Vulnerability will depend on exact design of containment	Sodium fires or explosions as well as loss of coolant accidents could cause catastrophic dispersal of radioactivity. Higher proliferation vulnerabilities and potential for higher plutonium dispersal in accidents or attacks.	Prototype Reactor type was cancelled in 1994 but may be re-instituted by Bush plan.
Plutonium separation – all types	Proliferation	Spread of nuclear weapons usable materials and possibly of nuclear weapons including to non-state groups	Even impure separated plutonium can be used to make nuclear weapons
Plutonium separation, current technology	Variety of attacks, depending on nature of processing and waste facilities	Wide, catastrophic dispersal of highly radioactive waste in air and water, dispersal of plutonium, diversion of plutonium	1957 explosion of high-level waste tank in Soviet Union resulted in catastrophic radioactivity dispersal[42]
Plutonium use or storage	Vulnerability varies by location	Potential severe dispersal of large amounts of plutonium. Potential for diversion of plutonium for weapons purposes	Vulnerability increases if plutonium used as a fuel and decreases if plutonium is immobilized and stored in

[41] The merits of nuclear power plants in reducing greenhouse gas emissions relative to combined cycle natural gas plants are compared in IEER's web page at http://www.ieer.org/ensec/no-5/sustain.html

[42] IPPNW and IEER 1992.

			subsurface facilities.

Chapter 3: The Bush Administration and the IEER Energy Plans

In this chapter, we will examine the vulnerabilities of the Bush administration's energy plan, which is essentially the same as that recommended by a task force led by Vice-President Cheney in May 2001. We will then design an energy plan to address the main vulnerabilities relating to oil imports, nuclear power and materials, and electricity infrastructure. The time horizon we choose is about 40 years. This is because it will take time to eliminate some of the vulnerabilities or reduce them greatly. One result of reducing vulnerabilities and the consequences of an attack, should one take place, is to reduce the attractiveness of any particular portion of the system to attack. We will assess each plan according to the vulnerabilities that we have discussed in the previous chapter.

A. The Bush administration's energy plan

In May 2001, a task force led by Vice-President Cheney published a National Energy Policy report, which has become the energy blueprint of the Bush administration.[43] The basic stance of the administration has not changed in light of the events of September 11. Yet, it is essential that a more stringent standard be applied to security-related issues and to greenhouse gas emissions.

The Bush administration plan was unsatisfactory in a number of respects on non-proliferation, safety, and environmental grounds even before the severe increases in certain risks that have been pointed up by September 11. The following list of bullet points shows the highlights of the National Energy Policy, as noted in an earlier IEER review:[44]

- *Oil and natural gas*: The proposed policy would (i) open up federal lands to drilling for oil and gas, notably by reducing "restrictions" currently placed on such drilling; (ii) open a part of the Alaska National Wildlife Refuge (ANWR) for oil and gas drilling (estimated to contain several billion barrels of recoverable oil reserves (up to about 10 billion barrels); (iii) encourage drilling in offshore Arctic areas off Alaska; (iv) consider measures for reducing "risk associated with production [of oil and gas] in frontier areas," and "incentives" such as reduction of royalty payments to the government from new offshore oil and gas production; (v) promote "enhanced oil and gas recovery from existing wells through new technology."
- *Coal*: The proposed policy would provide $2 billion for research on clean coal technologies and "provide regulatory certainty" that would make it easier to invest in coal burning for electricity generation. This appears to be an implicit reference to potential regulations on carbon dioxide emissions that have been a source of concern to the coal industry.

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[43] Bush Energy Plan 2001. This was called the Cheney Plan at the time it was issued as a recommendation to President Bush. The Bush administration has since adopted this report as the basis of its energy policy.

[44] Makhijani 2001a.

- *Nuclear power*: The proposed policy would "support the expansion of nuclear energy in the United States as a major component of our national energy policy." This support would include (i) easier re-licensing of existing nuclear power plants beyond their design lifetimes, (ii) encouragement of new nuclear power plants at existing nuclear power plant sites, possibly without any new environmental impact statement process, (iii) encouragement of research in a new form of reprocessing called pyroprocessing, in order to promote development of "advanced nuclear fuel cycles and next generation technologies for nuclear energy" (p. 5-17). This is an implicit reference to the Integral Fast Reactor, which is a sodium-cooled breeder reactor with a pyroprocessing plant attached to it. The plan also advocates foreign collaboration on commercial nuclear fuel reprocessing, with countries such as France. The nuclear energy part of Chapter 5 also states that a new reactor type called the Pebble Bed Modular Reactor has "inherent safety features" (p. 5-16), but does not mention any of its safety vulnerabilities.
- *Electric power plants*: The plan advocates that the United States should build between 1,300 and 1,900 new electric power plants by the year 2020 based on projected demand. (The standard power plant size assumed appears to be 300 megawatts.)
- *Infrastructure*: New natural gas and electricity transmission lines would be encouraged by granting rights of way on federal lands and by new "legislation to grant rights-of-way for electricity transmission lines, with the goal of creating a national transmission grid." This would create federal power to acquire land for interstate commerce on a basis similar to current law for natural gas pipelines (pp. 7-7 and 7-8).

The plan also tilts the federal decision-making process towards energy supply since it recommends that the president "[i]ssue an executive order directing all federal agencies to include in any regulatory action that could significantly and adversely affect energy supplies a detailed statement on the energy impact of the proposed action." (p. xiv). Yet it has no similar provision for energy demand or efficiency.

The Bush administration has not projected out the implications of its approach over a four-decade timetable. We have done so, with the following assumptions that are consistent with its central policy and economic premises.

- Economic and demographic parameters, such as economic and population growth, will be at the long-term historical averages. Car use will continue to grow, air transportation will quadruple by 2040, demand for space heating and even more so for cooling will grow faster than population (1.5 and 3 percent respectively).
- The focus of energy policy will be on supply, notably increasing domestic oil supply including the Alaska National Wildlife Refuge, nuclear power plants, and coal supplies. The Bush plan mentions new kinds of nuclear power plants. These have not been proved or licensed as yet and it will be some time before they may be. As a base case, we have assumed that the reference plant designs will be large light water reactors of the present basic types that have been approved by the Nuclear Regulatory Commission.

- Energy efficiency – that is economic production per unit energy input – will grow approximately at historical rates.
- There will be no major coordinated governmental effort to reduce carbon dioxide emissions beyond those achieved by the business-as-usual increases in energy efficiency and a doubling of nuclear power by 2040. As a result there will be major increases in carbon dioxide emissions.
- There will be no major effort on transportation efficiency beyond that implied in business-as-usual efficiency increases, to impose strict efficiency standards on automobiles, trucks or aircraft.
- After September 11, the Bush administration has asked Congress to pass its energy plan in essentially the same form as it was before that date. We assume therefore that the main approach to security will be what one might call the "guns-and-guards" approach, with no major effort to re-shape the energy or transportation system in light of the vulnerabilities revealed by September 11.

The outline of energy supply over time for the Bush plan is shown in Figure 1 in Chapter 1. We assume that the Bush administration will be successful in opening up ANWR as well as many other areas to oil exploration and production. We assume also that such exploration will add as much as two-and-a-half million barrels a day of oil production by 2010 for about two decades, declining to about 1 million barrels per day by 2040. This added production is superposed on the declining trend of production from existing U.S. fields and areas now open for new exploration and production (See Figure 3 in Chapter 1).

The Bush administration's current plan includes a filling of the strategic petroleum reserve to its capacity of 700 million barrels. This would provide some needed additional cushion in case of import disruption. The IEER plan also includes this goal. The same reserve would stretch much farther as a strategic reserve, if cars and other oil using equipment were more efficient.

B. The IEER Energy Plan

IEER's energy plan uses the same economic and demographic parameters as the Bush plan. Only the ways in which the energy services are provided for the economy are different – that is the IEER plan has the same number of car miles and degree of lighting or heating or cooling. But the energy system that provides these services would be structured differently. This approach allows a direct comparison of the vulnerabilities of the two plans given the same overall economic outcomes. But this approach also has some defects, which we do not attempt to remedy in this report. It does not allow the factoring in of major economic initiatives to change the underlying structure of entire energy using systems, such as the transportation system. The present system is one in which huge investments of time, energy, money, land, and ecosystem integrity are put into a car-centered transportation system, especially for urban and suburban living. This system is also at the center of urban pollution problems. Public transportation that is safe, economical, and frequent should be seen as a utility necessary for urban living, which deserves public resources at least in the same measure as roads. The long-term impact of such an approach would be to change patterns of living in relation to school, work and shopping. We do not attempt to assess the energy implications of that in this report though we do discuss an approach to metropolitan area transportation policy.

The technological assumptions behind IEER's plan are described below. The governmental policies needed to bring them about are discussed after that. The overall assumption about technology is that only those technologies that have already been tried and tested will be in widespread use enough to greatly affect energy efficiency and the energy production structure in the next two to four decades. We have not included many technologies that are highly desirable where public development expenditures should play a role, and which could make major contributions should they become more economical. Specifically, we have not included a significant role for a hydrogen economy based on wind and solar energy, even though this is a desirable direction for the energy system for a number of reasons.

1. Local electricity generation through high efficiency use of natural gas along with cogeneration of heat will be the basic approach enabling the creation of a distributed grid as well as an increase in efficiency of heating and cooling. A 60 percent electricity generation efficiency is assumed. This can be achieved with fuel cells today (though not on very small scales at present) and with advanced combined cycle natural gas fired power plants.
2. Large scale wind energy generation, notably in Midwestern states, will be the mainstay of wind energy supply. A relatively small role is assumed for solar energy.
3. Coal consumption is only marginally reduced for the first decade, then reduced to 45 percent of the year 2000 level by 2030 and then reduced to ten percent of current levels by the year 2040. Natural gas would be the main fossil fuel used in centralized electricity generation, with combined cycle plants of 60 percent efficiency being the norm in the year 2000. The large reduction of the use of coal provides a corresponding reduction in carbon dioxide emissions. A significant use of coal for three decades will allow time for transition in a vital industry and also provide for flexibility in the energy system that will provide for additional security. For instance, a decision to phase out nuclear power plants faster for security reasons would be more feasible if a coal industry is maintained at a substantial level until all nuclear power plants are closed. The maintenance of a coal industry at the 50 to 100 million tons per year would provide for flexibility in the energy system, for instance, in preventing exclusive reliance on natural gas as an interim fuel during the transition to renewables.
4. The reference technology for space heating and cooling and water heating is the geothermal heat pump, which would be used in conjunction with high efficiency local electricity generation with heat recovery.[45] The fuel-based coefficient of performance for heating would average 2.4 for heating and 3 for cooling. Geothermal heat pumps

[45] The use of a reference technology does not imply a universal adoption of that technology. It indicates the average efficiency that can be expected to be achieved by a variety of methods. The use of geothermal heat pumps as a reference technology here is meant to set the efficiency bar for various cogeneration and space conditioning technologies. As with other technologies, the actual achievement of high efficiencies will depend on the implementation of appropriate public policies, including procurement programs.

are commercially available today and have been used in recent years, including by the government for energy efficiency improvements.[46]

5. New passenger vehicles will average 100 miles per gallon in the year 2020. A government regulation to that effect will be needed in the near future if this is to be realized.[47]
6. Average fuel efficiency of all new passenger vehicles will be 100 mpg by the year 2020 and the average for the whole fleet will be 100 mpg by 2030, improving 2 percent per year after that for 10 years.
7. Aircraft efficiency will improve by 2 percent per year over the whole period in terms of fuel per seat mile.
8. Cargo transport efficiency will improve by about 3 percent per year. This will probably require efficiency standards for truck transport.
9. A CO2 decline of at least 40 percent and preferably 50 percent by 2040 should be achieved and made compatible with other security goals.[48]
10. Nuclear power will be phased out by 2030.
11. Local solar, hydropower, and some cogeneration plants are largely managed for peaking power provision. Inefficient gas turbine units now used for peaking power would be phased out by 2040.
12. About 40 percent of the hydropower capacity will be dismantled by the year 2040 for a combination of security and environmental reasons.
13. A forty percent improvement in efficiency of electricity use in non-HVAC sectors is possible relative to the Bush administration's supply side plan, through government procurement policies, appropriate regulations for new developments, appliance standards, and the general use of high efficiency lighting and motors.
14. Industrial heat requirements will be met by cogeneration systems wherever possible.

The resulting energy use pattern by 2040 is shown in Figure 2 in Chapter 1. Figures 3 through 7 in Chapter 1 compare the Bush and IEER plans using various vulnerability measures.

There have been a number of technical advances that provide the basis for a completely revamped energy sector. They include:

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[46] See for instance, Hughes and Shonder 1998. Geothermal heat pumps use the relatively constant temperature of soil a few feet beneath the surface to provide much or most of the heating requirements in the winter and cooling requirements in the summer. This requires pipe to be buried in the earth to extract the energy in the soil. For large buildings in very densely built-up areas, cogeneration can be used instead.

[47] For a chronology of high efficiency vehicles, statement by manufacturers about capabilities, recent actual history of high mileage cars, see the Rocky Mountain Institute web page at http://www.rmi.org/sitepages/pid414.php

[48] We used EPA published emissions of CO2 per unit of fuel: Coal: 207 lbs./Million Btu; Oil: 168 lbs./Million Btu ; natural gas: 117 lbs./Million Btu Source: http://www.lanl.gov/projects/cctc/climate/Coal_CO2.html, which bases the data on the Clean Coal Technology Compendium.

- Advances in electric power generation efficiency from natural gas have made it possible to increase efficiency, reduce carbon dioxide emissions, and maintain electricity generation levels all at the same time.
- Advances in electronics have made it possible to economically interconnect the smallest household level electricity generation systems to electricity grids.
- Advances in wind power technology have made it economical in vast areas of the United States where the collective wind potential far exceeds current U.S. electricity generation.
- Advances in solar energy have brought it to the point where consistent, long-term procurement program by various levels of government could spur changes to make it competitive, possibly in less than a decade, for a significant portion of the electricity supply. It is currently competitive only in very selected situations in the United States.
- Advances in automobile technology, notably hybrid cars and vehicles powered by fuel cells, have made it possible to have enormous increases in efficiency that are as yet untapped.
- Developments in a variety of fields from microturbines to fuel cells to geothermal heat pumps could enable drastic reductions in energy supply requirements.
- Highly efficient lighting systems and motors are available but have not yet come into general use.

Chapter 4: Vulnerability Comparison: The Bush and IEER Energy Plans

The September 11 attacks have pointed up severe vulnerabilities in the energy system. As discussed above, studies, one of them going back to 1952, and many dating from the 1970s and early 1980s, have discussed energy system vulnerabilities to accidents, import disruption, war, and terrorist attacks. Every portion of the infrastructure has been covered. The comparison on vulnerabilities between the IEER and Bush plans provides measures of key vulnerabilities. In general the Bush plan vulnerabilities would intensify the weaknesses of the existing system, which are considerable in many areas, with one exception. That exception relates to the assumption in the Bush plan that the unit size of a central station electric power generation unit would be 300 megawatts, which is lower than the present typical size of baseload plants.

By far the most severe vulnerabilities in the Bush plan relate to oil imports and to various aspects of the nuclear power enterprise. The nuclear vulnerabilities will, in many ways, be the most severe with the Bush plan. The proposed expansion of nuclear power will result in a need to store spent fuel in pools for the indefinite future. A change to Pebble Bed Modular Reactors (PBMRs), which do not require spent fuel pools, will mean the widespread adoption of reactors that are proposed to be built without secondary containment, making them far more vulnerable to attack than present light water reactors. PBMR vulnerabilities may be comparable to that of most spent fuel stored in pools, since much, though not all, of the vulnerability of the latter arises from the fact of storage outside the secondary containment structure.

We cannot at present quantify what role plutonium may have in the energy system in the year 2040. This is because at present the only specific plutonium fuel plan relates to surplus weapons plutonium, which would presumably have passed through the reactor by then and stored as spent fuel. There is the non-quantifiable vulnerability in the Bush plan that by pursuing plutonium fuel, the United States will encourage other countries to do so. The United States is also obligated, under Article IV of the Nuclear Non-Proliferation Treaty (NPT) to provide commercial nuclear technology to non-nuclear weapons states that are parties to the treaty. The pressures to do so will be great. The diplomatic and consequences from a prolonged failure to do so could be substantial, even if the denial were motivated by non-proliferation. It would also encourage the Russian nuclear establishment in its ambition to pursue a plutonium fuel based electricity system. A great deal will depend on the evolution of nuclear energy in the next decade.

Spent fuel pool vulnerabilities for existing reactors cannot be reduced significantly in case of a successful attack. For new reactors, spent fuel pool vulnerabilities can be reduced by requiring them to be inside the secondary containment in all cases. New reactors can also be required to withstand large aircraft crashes, which is not a requirement at present. The Bush administration's energy plan did not contain such proposals. No such requirement has been added since September 11.

Comparison of Certain Energy System Vulnerabilities in the Bush and IEER Energy Plans, Year 2040

Vulnerability element	Bush plan, quantitative measure	Degree of Vulnerability	IEER plan, quantitative measure	IEER Plan Degree of Vulnerability	Comments
Oil imports	23 million bbl/day	Very high risk of disruption	6 million barrels per day	Low risk	Bush plan: high Persian Gulf imports
Strategic Petroleum reserve	700 million barrels, or about 1 month of imports	Moderate buffer in case of disruption	700 million barrels, or almost 4 months of imports	Substantial buffer in case of disruption	Additional supplies can be procured from alternative sources in weeks to months, if physically available
Nuclear power reactors, LWRs	About 200 Operating reactors	Powerful September 11 attack would create catastrophic consequences	Zero nuclear power reactors	None	Chernobyl-scale radioactivity dispersal possible. Risk of large-scale disruption increased due to pressures to abandon nuclear suddenly in the aftermath of an attack.
LEU Spent fuel stored in pools (Note 1)	About 20,000 metric tons in spent fuel pools	Catastrophic consequences possible from a variety of attacks	Zero	None	Long-lived radionuclides releases could be larger than Chernobyl incase of fires.
Plutonium storage(Note 2)	Amount at high risk cannot be projected – highly policy dependent	Risk of catastrophic consequences in case of plutonium fuel diversion, accident or attack	All surplus plutonium (50 metric tons or more) immobilized in subsurface storage	Low risk of catastrophic consequences, serious local environmental results in case of attack;	Bush plan reprocessing, breeder reactor, and plutonium fuel policy evolution over the decades is unclear, making quantitative projection speculative.
Electricity power stations (non-nuclear)	300 megawatt projected unit size poses lower risks than typical present generator size	Low to moderate risk of major disruption from single attack	Lower than Bush plan due to greater reliance on wind energy and dispersed generation	Low risk of major disruption.	Dual fuel capability at some key plants would reduce security vulnerability. (Note 3)
Electricity transmission	Dependent on specific system characteristics	Higher risk than at present due to further grid centralization and deregulation. Higher attractiveness as a target due to greater centralization and damage potential	Two-fifths distributed generation	Some vulnerability from attacks on the grid will remain. Much lower attractiveness as a target compared to present	Larger scale introduction of solar energy, locally generated hydrogen energy resources in the distributed grid system, as well as management of reserve capacity to provide quick response to disruption could nearly eliminate large-scale vulnerability

1. Amount of spent fuel stored in spent fuel pools assumes that an average of five years worth of discharged fuel will be in pools. The rest is assumed to be put into dry subsurface storage. This row refers to spent fuel resulting from the use of low enriched uranium fresh fuel. The spent fuel typically contains just under one percent plutonium. We assume that all spent fuel that is more than five years old is stored in subsurface soils to minimize the consequences of an attack.
2. Plutonium storage vulnerabilities in the Bush plan would derive from surplus military plutonium use in the commercial sector as well as possible development of commercial plutonium use.

3. Dual fuel capability not explicitly factored into the IEER plan. See Lovins and Lovins 1982 for a discussion of this topic.

The table above shows a static picture of vulnerabilities in the year 2040. Figures 3 through 7 in Chapter 1 show the evolution of these vulnerabilities between the years 2000 and 2040. Note that the numbers for the first ten years in the IEER plan have not been worked out in detail and should be treated as notional. They will depend a great deal on how the long-term policies that are advocated here are actually implemented and what the phasing of these policies in the first decade is in practice.

Chapter 5: Policy Recommendations

The IEER energy plan is not a business-as-usual plan. It is explicitly designed to address certain security vulnerabilities that have been revealed as far more serious than generally recognized prior to September 11. However, these are not new vulnerabilities. They have been discussed in past official and non-governmental studies. The difference is that September 11 has made the potential for severe attacks and terrible human and economic consequences tragically palpable.

Prior warnings about the dangers of excessive reliance on Persian Gulf region oil imports, going back as far as 1952, and then many times in the 1973-1982 period, and then again briefly during the Gulf war period have resulted only in sporadic and modest action. Even that level of action, such as appliance standards, improvements in building efficiency, the government's encouragement of energy efficiency through voluntary programs such as the Energy Star Program,[49] and the Corporate Average Fuel Economy standards for cars have produced substantial results. Energy consumption between 1973 and 1985 stayed about the same, despite substantial economic growth.[50]

The failure of available technologies to be in more widespread use in the market place has several broad causes:

1. Institutional (whether governmental or corporate or both) roadblocks to the use of efficient technology, despite the fact that it is economical.
2. Corporate resistance to government-set standards combined with a corporate failure to pursue vigorous voluntary approaches to improving efficiency for motor vehicles, with some notable exceptions, such as the marketing of hybrid cars by Toyota and Honda.
3. The lingering of nearly commercial technologies at the margins of implementation by the lack of a steady market and the inertia of vast and powerful vested interests in present inefficient technology.
4. The lack of adequate governmental standards that would combine security, environmental, safety, and economic criteria.
5. Lack of widespread business and institutional structures to implement energy efficiency technologies in the residential and commercial marketplace that are economical today.

We will not analyze these problems in detail here. Many studies have covered them in detail. For instance, the DOE published a study in May 2000[51] that provided considerable detail on the institutional obstacles to distributed grid technology, despite its economic and environmental advantages. These impediments have been sufficient to

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[49] Energy Star 2001.

[50] There were fluctuations due to variations in economic conditions, phasing of regulations within this period.

[51] Alderfer, Eldridge, and Starrs 2000.

cause what might be termed as massive market failures. Indeed, the dominance of a centralized, supply-biased energy system is evidence of a massive market failure.

One of the most important problems in the lack of rapid integration of new technologies into the market place is lack of a consistent market that would allow a new technology to become established. The traditional method for attempting to overcome this market barrier has been to provide tax breaks, such as credits per unit of fuel or electricity generation. We view this approach as inferior to the provision of a steady market by the federal, state, and local governments for desirable technologies that are already technically feasible. The federal government should dedicate a fixed sum each year to an open-bid performance based purchase of energy from designated renewable sources generated in specified areas, new electricity generation technologies for its buildings, efficiency improvements for its buildings, and highly efficiency new vehicles that are beyond what is available in the marketplace. An expenditure of $20 billion per year for a ten-year period, with the option of continued expenditures for another ten-year period would provide wind energy, solar energy, fuel cell vehicles, efficient on-site generation using fuel cells, combined microturbine fuel cell plants, and other similar cutting edge technologies, with a reliable market. Such an $20 billion per year program would, over ten-years, amount to just about 15 percent of the ten-year tax reduction enacted in 2001 prior to September 11, or on the order of 5 percent of planned Pentagon spending. While this is very substantial commitment, the results in higher security as well as environmental benefits would be incalculable great. Moreover, the net outlay would be considerably lower, since the investment would reduce federal, state, and local energy expenditures.

We provide here the broad outlines of policy action at the federal, state, and local levels that are needed in order to transition to a far more secure energy system that will also result in a substantial reduction of carbon dioxide emissions over the four decades. Since the reduction of oil and nuclear vulnerabilities is central to the IEER plan, we will first discuss these issues in some detail before listing the broad policy actions needed at the federal, state, and local levels.

A. Oil

1. Personal passenger vehicles

The current state of technology in relation to automobile efficiency is far in advance of the current average performance for passenger cars. The average performance for cars is about 27. 5 mpg miles per gallon and that for sport utility vehicles is 20.7 miles per gallon. Currently manufactured and commercially available cars can give far more than that:

- The Honda Insight (2-passenger) gasoline powered hybrid engine gives about 60 mpg
- The Toyota Prius, 4-passenger gasoline powered car with a hybrid engine gives almost 50 mpg.

- The Audi A2 1.2 TDI diesel gives 78 miles per equivalent gallon of gasoline.[52]

GM has made a prototype fuel cell car that gives 100 miles per gallon of gasoline equivalent, which it believes, can be commercialized by about 2010. It goes from zero to sixty in about 9 seconds.[53] A number of other manufacturers also can make cars of 75 miles per gallon or more. What is needed is a steady, significant market to bring these into general use rapidly. Volkswagen has announced that it will make a car that would get over 280 miles per gallon.[54]

Carmakers are resisting rapid change in part because of the costs and uncertainties in regard to consumers. An appropriate purchasing policy for federal, state, and local government fleets would remedy this problem and provide the incentive to build vastly more efficient cars as a matter of routine.

A mileage goal for all new cars and light trucks by 2020 should be 100 miles per gallon is feasible and should be set now. This goal should be buttressed by a sound government purchasing policy. This is admittedly a stringent goal and goes far beyond what has been advocated so far. But if energy vulnerabilities relating to oil imports are taken seriously, a stringent goal that would rapidly reduce dependence on imports is required. Given that society in the United States continues to depend on private vehicles and that an adequate public transportation structure will take decades to develop and is less likely to have political support, it is imperative that very stringent standards be set for passenger vehicles.

Such a goal would result in the average fuel efficiency performance of the U.S. passenger vehicle fleet of about 100 miles per gallon by the year 2030. Gasoline use would decline from the represent 8.5 million barrel a day to about 3.5 million barrels a day, given the same assumptions about use of cars. Current trends of rising gasoline consumption would put use at about 11 million barrels a day by that date. Oil imports would rise to 70 percent of consumption even if the Alaska National Wildlife Refuge and other sensitive areas were to be used as additional domestic sources of oil.

The policy for stringent standards would relieve long-term upward pressure on oil prices due to rising consumption in the developing countries and also create opportunities for export of technology that would reverse or reduce the rate of oil consumption increases there. If the decision to adopt a 100 mpg standard were accompanied by an announcement that any attack on oil export infrastructure would be accompanied by a response that would reduce oil use even more by accelerating efficiency standards (because that is well within the realm of technical achievability), the attractiveness of oil infrastructure as a target would be greatly reduced.

Of course, the immediate vulnerability of the world economy to an attack on oil infrastructure cannot be greatly reduced in this way. The Bush administration has proposed filling the Strategic Petroleum Reserve to its full capacity of 700 million

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[52] Alpha Newspapers 2001(?).

[53] Evanoff 2000.

[54] For information on efficient cars, safety, and latest technical developments see, for instance, the web site of the Rocky Mountain Institute, http://www.rmi.org.

barrels, which is currently enough for about two months of imports. That cushion would decline under the Bush plan slowly at first (due to rising oil production but faster rising consumption) and then rapidly, declining to about one month of imports by 2040. The same reserve would last for almost four months of imports under the IEER plan, providing far greater resilience against shocks in the crude oil supply system.

There has been great resistance among motor vehicle manufacturers to stringent efficiency standards. Historical experience shows that car makers seem to remember safety when the issue of mileage standards is raised and seem to remember mileage when the issue of reducing emissions of noxious gases, like nitrogen oxides or hydrocarbons, is raised. In practice they have needed government action to set standards for all three -- emissions (other than carbon dioxide), mileage, and safety. All three can and should be simultaneously mandated by the government. *Setting achievable, stringent standards well in advance also encourages research and development on new technologies, such as new strong materials to reduce the weight of cars and increase safety at the same time.*[55]

High efficiency standards can achieve a collateral benefit in terms of security relating to oil pipelines, refineries and storage facilities. A 10 gallon equivalent tank in a vehicle getting 100 mpg would give it a theoretical range of 1,000 miles, or about two to three times the present range. The time for which cars could be driven in case a major refinery were attacked would be lengthened, in a typical case, to several weeks, allowing time for repair and recovery. This means that high efficiency standards provided considerably increased resilience to the system in case of some kinds of attack. That resilience can be increased if parts of fleets of governments and corporations are dual-fuel capable. This means that they could switch from gasoline to, say, propane. This technology is already commercial.

2. Public transportation policy

Public transportation has been viewed in relation to oil consumption question mainly as a matter of efficiency. However, we believe that public transport in large cities should first of all be viewed as a public utility, in the same manner as electricity, water, sewage, and telephones. A functioning, reliable, safe, and economical public transport system is essential for cities to be livable and for people of all economic classes to have equal opportunity for jobs. People who use public transport subsidize people who use cars at rush hour for the latter use up far more of society's resources and cause far more pollution. Users of automobiles also give rise to far more security vulnerabilities and indirect security-related costs in terms of oil imports. If major cities had pubic transport systems that functioned as well as that in, say, Paris, and issues relating to schools and safety were addressed, cities would be far more attractive for the very people who have been the prime factor in the explosive growth of sprawl with all its implications for oil, environment and security.

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[55] See www.rmi.org

The above considerations of public transportation as a public utility means that the direct fuel efficiency considerations should be secondary to frequency, convenience, safety, and cost of public transportation. The gains in reduction of oil use and other environmental benefits would occur only over the long-term thorough reduced use of personal vehicles for commuting and through different settlement patterns and reduced sprawl.

A second consideration relating to security is diversity of transportation modes. Choices of transport modes -- cars, bicycles (which would require more bicycle lanes), public motorized transport (buses, trains), or walking (which could require more sidewalks) – would not only make cities and urban areas generally more livable. They would have considerable security advantages. Were any one means to be disrupted, others would continue to be available. Such resilience within the system also reduces the attractiveness of any particular mode to attack.

We therefore recommend that a comprehensive study on the cost and feasibly of approaching public transport as an essential public utility to be maintained at reasonable cost, with a portion of revenues arising from taxation of gasoline or personal vehicles be carefully investigated. Such a study should also carefully consider the various security vulnerabilities of an automobile based urban transport system compared to one in which cars, trains, buses, bicycle paths, and sidewalks are in a better balance.

B. Nuclear power and spent fuel

The damage from a single attack on a nuclear power plant that results in a severe accident would be so catastrophic that it must be avoided. In the short term there is no substitute for increased vigilance. But given that contamination on the scale of Chernobyl can occur in far more populated areas, immense damage in the hundreds of billions of dollars is within the realm of credibility, with loss of life potentially far larger than that which occurred on September 11, 2001.

Spent fuel storage vulnerabilities are in some ways lower and in others far greater than reactor vulnerabilities. Spent fuel is stored outside the secondary containment in most cases, so that there is no substantial buffer against an attack. Given that fresh spent fuel must be stored underwater, the option of dry, subsurface storage for all spent fuel cannot be realized unless existing nuclear power plants are phased out. It may be possible to add barriers to spent fuel pools to make them less vulnerable, but the reduction would be unlikely to be of a magnitude comparable to the reactor core itself, which is itself vulnerable at least in some degree. Phasing out nuclear power in a manner compatible with electric grid stability is imperative if nuclear vulnerabilities, especially from spent fuel storage are to be reduced to a point where the entire installation become unattractive as a terrorist target.

In the context of such a program, spent fuel storage vulnerabilities can be greatly reduced. Spent fuel can be transferred to dry storage within a few years of discharge from the reactor. Such casks can be put into subsurface facilities that are similar to the way in which vitrified high level military radioactive waste is stored at the Savannah River Site, which is a nuclear weapons plant in South Carolina. In our judgement, an attack comparable to September 11 on these subsurface facilities would cause grievous harm to the site and many people working on it, but it not cause the kind of catastrophe that would result from a comparable attack on a spent fuel storage pool, or even above ground storage in dry casks.

We recognize that, in the long-term on site storage is not desirable. The events of September 11 have reinforced that view. We also recognize that the phase out of nuclear power will result in ending the revenue stream for nuclear utilities. The federal government should take over the responsibility for storage of spent fuel, once nuclear power plants are closed. Nuclear utilities have paid into a nuclear waste fund since 1982, but the federal government's program for taking the waste and having a viable repository program is faced with a host of delays and difficulties, not least because it is focused on a single, poor site, Yucca Mountain in Nevada.[56] That program should be ended and replaced with a sound repository and engineering program, such as the one recommended by IEER.[57]

It will take time to create and implementing a repository program of the necessary characteristics that will enable both environmental protection and the achievement of security goals. In the interim, the government should take control of the spent fuel at closed nuclear sites. In some cases, the spent fuel may need to be stored close to the site rather than at the site for safety reasons. Consideration should be given to consolidation of spent fuel from closed nuclear power plants at one site in a state, in those cases where there are several closed power plants near each other and special storage vulnerabilities exist.

C. Plutonium

It is necessary to put plutonium into a different physical form that would (i) limit the damage to as small an area as possible, (ii) resist fire, and (iii) enable easier clean-up and recovery of plutonium with less danger to workers and the public, even in case of an attack similar in scale to that of September 11.

Immobilization is an approach that mixes plutonium with a non-radioactive material and puts the mixture into a ceramic form that is highly resistant to fire and dispersal in the form of fine particles. The ceramic hockey-puck like storage form is put into a steel cylinder and molten glass is then poured around it. The resulting steel canisters with glass logs containing the plutonium-laced ceramics can then be stored underground on-site at one or more large nuclear weapons plants in silos a few tens of feet deep. With carefully thought out technical specifications, the offsite consequences could be minimized even in case of an attack on the scale of September 11. Minimizing the potential for severe offsite impacts would also be the best preventive measure against

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[56] IEER has done extensive work on this subject. Many articles and references can be found on IEER's web site at www.ieer.org

[57] Makhijani 2001d.

attack, since it would make plutonium storage sites unattractive as targets. The risk of theft or illicit sale would also be greatly reduced.[58]

Plutonium immobilization uses technology that is reasonably well understood and is similar to that now used for high-level radioactive liquid waste, which is, in some ways, more difficult to process than plutonium. For instance, glass logs containing high-level waste are produced and stored in individual silos at the Department of Energy's Savannah River Site in South Carolina.

The Bush administration eliminated funding for immobilization of plutonium because it wanted to focus on the conversion of surplus weapons plutonium into a nuclear reactor fuel. Not only that, the U.S. also proposed to finance a similar plutonium fuel program in Russia. The entire policy was already problematic before September 11. But to persist now with a plan that would put plutonium fuel on the highways and in commercial nuclear power sites in the United States and Russia is very risky, to say the least. It is to disregard one of the most important lessons of September 11 – worst case scenarios that are plausible should not be ignored.

The problem of current U.S. plutonium policy goes even deeper. The Bush administration is not only persisting with a plutonium fuel program it inherited from the Clinton administration, but it proposes, as part of its energy plan, to spend money on developing commercial plutonium fuel as a normal part of the U.S. nuclear power system. This would reverse a quarter century of bipartisan nuclear non-proliferation policy though five previous administrations and exacerbate both proliferation pressures and vulnerabilities to attack.

It is essential that an immobilization program be re-instituted and implemented with urgency.

D. Electricity system restructuring

The Bush administration's energy plan, which was published in May 2001 and the details of which have been re-affirmed since September 11 would create a national electricity grid to facilitate the transmission of electricity by large-scale generators. It has been presented as part of plan to increase electricity systems reliability by allowing generators to build plants anywhere they want. However, this will not necessarily address reliability problems and may aggravate them. Low reliability arising from a lack of reserve capacity was the main reason for the power problems in California. Deregulation created

[58] The National Academy of Sciences has recommended a "spent fuel standard" for immobilizing plutonium to reduce the risk of theft or re-use in nuclear weapons (NAS 1994). While this level of diversion resistance is desirable, it would take far longer. It is more urgent to put the plutonium into a non-dispersible, not-easily-usable form and obtain more proliferation resistance through joint monitoring and verification programs.

a situation in which power producers had no responsibility to maintain reserve capacity, and the regulators had no resources to do so either.

A completely unfettered electricity generation sector that has no responsibility for transmission or for reserve capacity would increase costs and be prone to unanticipated breakdowns. A free-for-all in generation on a large scale, across the continental United States, is a recipe for continued economic and technical problems. The Bush energy plan does not propose to impose any rules of good behavior on large-scale generators. Therefore, it is unlikely to create a reliable system that will have reasonable and predictable costs. Transmission capacity and location, reserve capacity, and the consuming system need to be coordinated with generation in order to get a reliable system overall. Reliability requires that large-scale private (and public) power producers have a responsibility for providing or paying for the maintenance of reserve capacity and for channeling power along efficient, relatively predictable routes.

The lack of responsibility of generators for reserve margins and the increasing complexity of system requirements for reserve capacity would add to the security concerns relating to potential attacks on the system. The changing pattern of generation would introduce new vulnerabilities that would be difficult to characterize at any time due to the rising complexity of the national grid, the locations of electricity generation stations, and the varying patterns of electricity flows based on spot markets.

The September 11 attack adds to the already growing sentiment for some regulation of the system and for more local control of electricity system that arose of the California energy crisis of late 2000 and early 2001. Instead of a national electricity grid, the United States should announce the achievement of regional distributed electricity grids, with a high standard of reliability. A distributed grid is one in which very local (household, small business) to medium scale local electricity generation (large buildings, most industry), or of heat and electricity combined (cogeneration), is achieved. Local generators consume some of their own electricity (solar, fuel cells, cogeneration), purchase some at some times, and sell at other times. While such an approach has now been feasible for some time, a variety of institutional and regulatory obstacles still stand in the way.

Currently almost all electricity is generated in large-scale centralized plants connected to regional grids. It would be far better to mix small-scale plants that are close to the consumer or are on the consumer's premises and interconnect them to regional grids, which also have large-scale plants on them. Regional grid systems, which already exist and only need modest improvement, as for instance between southern and northern California. Such a system of regional distributed grids can be joined with regional renewable energy sources on a large scale. In particular, the wind energy resources of the Midwestern region can be fed into existing transmission corridors. Given the fuels used for space and water heating in households and commercial establishments, as well as solar energy availability, and offshore wind power availability in coastal areas, it should be possible to have an interconnected electricity structure that relies a combination of central station power plants, local consumer-based small-scale generation systems, and medium-scale local or regional generation. Regulatory changes on both the generation and consumption side would be required to make such an outcome possible. Were it done, the share of renewables in the electricity supply could be increased to about fifty percent in the next forty years. In the long term research and development of hydrogen derived from renewable sources is important to continued reduction of greenhouse gas emissions. This technology needs considerable development and is not necessary to the achievement of short and medium term security and environmental goals. However, it should be part of the government's procurement policies. See below.

E. Policy recommendations

1. Purchase of renewable energy, efficient on-site electricity generation, highly efficiency motor vehicles, highly efficient heating and air-conditioning technology to the tune of $10 billion per year by the federal government, with an commitment to continue the program for at least ten years. The procurement program should be carried out on annually on a performance based bidding process similar to that used for leasing out tracts for oil and gas drilling.
2. Allocation of $10 billion per year of federal money to state and local governments for their own procurement programs.
3. 100 miles per gallon for all new passenger vehicles (including light trucks) by 2020, with simultaneous safety and emissions standards.
4. Continued filling of the Strategic Petroleum Reserve. The Bush administration is pursuing this important policy. Its impact on security would be greatly increased if stringent mileage standards were adopted.
5. Enactment of progressively more stringent carbon dioxide limits per unit of electrical power generation.
6. A phase out of nuclear power, with plants being shut down as their original licenses expire, or sooner in those cases where special vulnerabilities exist.
7. Abandonment plans for new nuclear power plants and for use of plutonium as a fuel in nuclear reactors.
8. Transfer of spent fuel out of pools into dry storage when as it is safe to do so rather than waiting until the pools are full.
9. Storage of dry casks containing in sub-surface storage on-site at operating nuclear power plants.
10. A transfer of the control of spent fuel to the federal government at closed plants, with consideration given to in-state consolidation of spent fuel at a closed power plant in case of special vulnerabilities.
11. An adoption of policies to encourage distributed grids, and the orientation of the federal procurement program that is devoted to the electricity sector to helping states achieve distributed grids.

12. A re-commitment of the United States to the Kyoto Protocol process, with the starting point being a commitment to reduce carbon dioxide emissions by between forty and fifty percent over the next four decades (without international trading but possibly with some internal trading of credits in the electricity sector). The achievement of intermediate goals would be negotiated with the those who have ratified the treaty.

F. State and local actions

In addition to the institution of their own procurements policies along the lines discussed above for their own facilities such as schools, colleges, state government buildings, state and local vehicles, etc. the state and local governments should:

1. Create or maintain state level regulation of electricity system in order to achieve the overall goals of system reliability, reserve margins, and transmission and distribution capacity.
2. Establish state and locally owned utilities with public oversight and transparency safeguards, with the goal of promoting high efficiency, secure distributed grids, and adequate capacity of the transmission and distribution system to withstand attacks on critical electricity infrastructure without massive prolonged disruption.
3. Institute regulation at the level of regional reliability councils (which correspond to regional grids) to provide the overall framework for achieving secure and reliable transmission and generation on a system-wide basis, including adequate reserve margins and transmission capacity. Local and state governments as well as regional and national associations of such governments should have adequate oversight and regulatory authority to ensure reliable, economic, secure, and environmentally sound distributed grids.
4. Institute rules requiring developers to consider on-site generation with best available technology for heating and cooling, efficient devices and justify why these technologies should not be used.
5. Put in place requirements for energy audits to be part of the re-sales of residential and commercial buildings with information about best practices during resale and consequences for the new owners of buildings.
6. Enact stringent efficiency standards for appliances, buildings, and vehicles, should the federal government fail to do so.
7. Create task forces on transportation as an urban utility that would analyze the security, environmental, and economic benefits of regarding public transportation as a public utility, especially when connected with efforts on public safety and excellence in schools.

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