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Science for Democratic Action

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Securing the Energy Future of the United States

Photo credit: Honda, http://www.honda2000.com/models/insight/

The Honda Insight, a two-passenger hatchback with a gasoline-powered hybrid engine, has a fuel efficiency rating of more than 60 miles per gallon (mpg). The technology to manufacture passenger vehicles that achieve 100 mpg exists today. The current U.S. average fuel efficiency standard for cars is 27.5 mpg. The standard for light trucks, which includes minivans and sport utility vehicles, is 20.7 mpg.

BY ARJUN MAKHIJANI

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. The Bush administration's proposed energy plan — released in May 2001 and neither reviewed nor changed in light of the events of September 11 — would worsen these vulnerabilities.

In November 2001, IEER released a preliminary report presenting a plan for a more secure energy future for the United States. The report is part of IEER's energy project, which we began about two years ago to examine the feasibility and time span required for a complete phase-out of nuclear power and a substantial (on the order of 50 percent) reduction in carbon dioxide emissions worldwide. We released it in preliminary form earlier than planned in order to contribute to the national and international debate on energy and security that is now taking place. The report, *Securing the Energy Future of the United States: Oil, Nuclear, and Electricity Vulnerabilities and a post-September 11, 2001 Roadmap for Action*, is summarized here. References can be found in the report, which is available in its entirety online at http://www.ieer.org/reports/energy/bushtoc.html.

Vulnerabilities

Vulnerabilities to the U.S. energy system, especially those related to oil imports and

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Los Alamos Undergoes Clean Air Act Audits

First Independent Environmental Review of a U.S. Nuclear Weapons Plant

BY ARJUN MAKHIJANI AND JONI ARENDS[1]

In one respect, 1997 was an historic year for environmental issues in the U.S. nuclear weapons establishment. That year the first independent environmental audit of a nuclear weapons installation, conducted with public oversight and under court order, began. The installation was the world's best funded nuclear weapons laboratory, the Los Alamos National Laboratory (LANL) in New Mexico, owned by the U.S. Department of Energy (DOE) and operated for it by the University of California. Two audits of the compliance of LANL with the Clean Air Act have been completed. One more will take place in 2002, with the potential fourth audit in 2004 (as yet undecided). This is a brief summary of what led up to the audits and what has transpired to date. The reports of the audits are on the web at http://www.racteam.com/Experience/Projects/LANLAudit.htm. IEER's comments on those reports, made as part of the court-supervised process, are on the web at http://www.ieer.org/reports/lanl/audit1.html.

LANL is a complex operation, devoted primarily, but not exclusively, to nuclear weapons and associated scientific and techni-

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nuclear power, are greater today than ever. Table 1 summarizes oil and nuclear vulnerabilities and their potential severity.

Oil vulnerabilities

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. It remains one of the central aspects of the violent tangle of Middle Eastern, European, Soviet/Russian, U.S., and world politics. Much of World War II, including Pearl Harbor and the battle of Stalingrad, had the control of oil as a major factor.[1]

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.[2] U.S. actions after past crises, notably in the period between 1973

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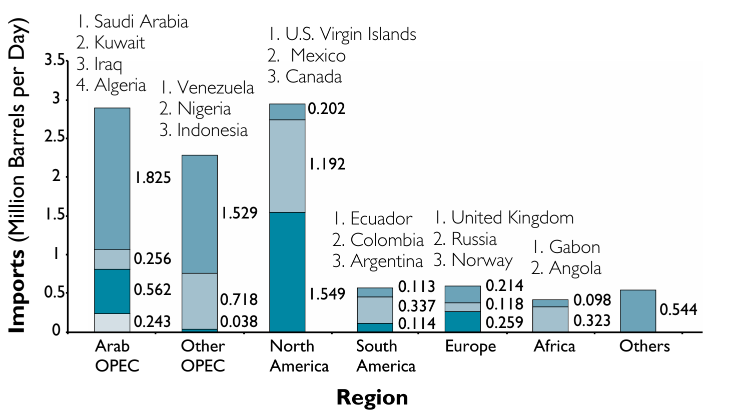
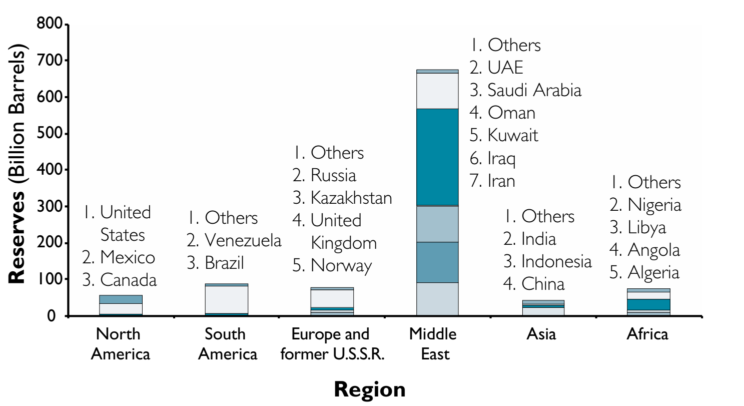
FIGURE 1: NET IMPORTS OF TOTAL PETROLEUM PRODUCTS INTO THE UNITED STATES BY REGION OF ORIGIN, AUGUST 2001



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. OPEC stands for Organization of Petroleum Exporting Countries. In August, 2001, the United States imported roughly 10.2 million barrels of oil per day.

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

FIGURE 2: 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

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Editor: Lisa Ledwidge

ENERGY FUTURE

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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.

Currently U.S. oil imports are at 11 million barrels per day with about 25 percent coming from the Persian Gulf area. 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. Figures 1 and 2 show U.S. petroleum imports and world oil reserves, respectively.

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.

Oil is also at the center of the global warming problem. Roughly half the emissions of carbon dioxide (the most important contributor to greenhouse gas buildup) from fossil fuels are attributable to oil. Most

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TABLE 1: 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 (see note)	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 fuel 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.	Explosion in 1957 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: We have not addressed Central Asian security vulnerabilities in detail in the 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, especially if the area becomes a focus for regional and global economic competition.

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urban air pollution comes from motor vehicles. Much of the pollution of the oceans comes from oil spills, both routine and accidental. Major disruption of the global climate may also bring serious security implications, whose character is difficult to anticipate.

Nuclear power and spent fuel vulnerabilities

Studies in the past have hypothesized the potentially catastrophic effects of accidents, war, or terrorist attacks on certain portions of the nuclear energy infrastructure.[3] Indeed, nuclear power plants in more than one country have been the objects of terrorist attacks, as have other nuclear facilities.[4]

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. 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. Releases of long-lived radionuclides from a massive spent fuel pool accident or attack can be larger than those from a reactor. 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.

Oil is at the center of the global warming problem

Spent fuel must be stored in pools for at least three years after discharge from the reactor in order to cool. 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 and thus 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 because 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.

Plutonium vulnerabilities

U.S. 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. Only a small part of the U.S. stock of plutonium is of commercial origin, while the rest is military. About 50 metric tons has been declared surplus to military needs.[5]

The U.S. government proposes to use the surplus plutonium as a fuel in nuclear reactors. IEER has discussed the proliferation-related vulnerabilities of plutonium fuel, also called mixed oxide or MOX fuel, at length in other publications.[6] 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.[7]
- The storage of MOX spent fuel in pools would make the consequences of an attack on spent fuel pools more catastrophic.

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Current methods of plutonium storage are sorely inadequate, particularly considering the consequences of an attack should one occur. Plutonium 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. Moreover, the two large reprocessing plants at the Savannah River Site are adding to the stock of high-level liquid radioactive waste (stored in large underground tanks) and the stock of separated plutonium.

Energy infrastructure vulnerabilities

The September 11 events have shown that vulnerabilities of the energy production and pipeline infrastructure to wartime or terrorist attack are not only theoretical for the United States. Indeed, there have been terrorist attacks on U.S. electricity infrastructure in the past.[8] 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.

The most vulnerable parts of the nuclear power system are reactors and spent fuel pools

The trend towards deregulated electricity systems with a national grid would exacerbate the vulnerabilities of the grid. 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.

The Bush Energy Plan

In May 2001, a task force led by U.S. Vice-President Dick Cheney published a National Energy Policy report, which has become the energy blueprint of the Bush administration.[9] The plan was already unsatisfactory in a number of respects on non-proliferation, safety, and environmental grounds even before the severe increases in certain risks pointed up by September 11. To date, the basic stance of the administration remains unchanged.

By far the most severe vulnerabilities in the Bush plan relate to oil imports and to various aspects of the nuclear power enterprise.[10] The nuclear vulnerabilities will, in many ways, be the most severe with the Bush plan.

The Bush plan contains 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. The plan would 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, would 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. Consequences of an attack on new advanced reactors like those implicit in the Bush plan could be even more catastrophic than with current commercial reactors.

Heavy reliance on oil imports carries a high risk of disruption of supplies. U.S. oil imports of less than five million barrels a day would essentially eliminate the potential for catastrophic disruption, particularly if they were accompanied by a decline in European imports as well. Under the Bush energy plan the United States would be importing an estimated 23 billion barrels of oil per day by the year 2040, much of it from the Persian Gulf region. Figure 3 compares U.S. oil production and import projections under the Bush and IEER plans through 2040.

The Bush energy plan 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 system reliability by

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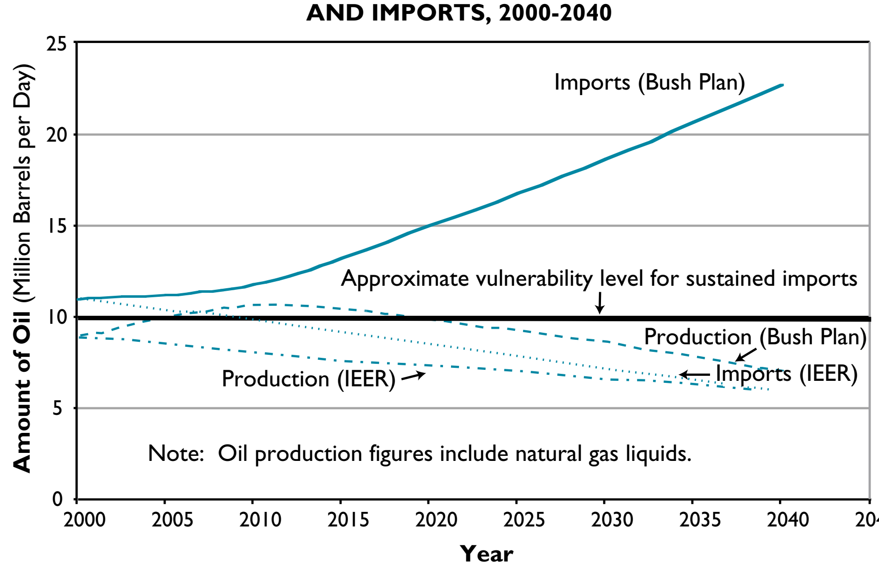
FIGURE 3: PROJECTIONS FOR U.S. OIL PRODUCTION AND IMPORTS, 2000-2040



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allowing generators to build plants anywhere they want. However, this will not necessarily address reliability problems and may aggravate them.

The administration also is continuing with a plan to develop commercial plutonium fuel as a normal part of the U.S. nuclear power system. This would exacerbate both proliferation pressures and vulnerabilities to attack. It would also reverse a quarter century of bipartisan nuclear non-proliferation policy though five previous administrations.

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

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IEER ENERGY PLAN: ASSUMPTIONS

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. Fifty percent efficiency is the norm for such plants today and 60 percent efficient plants are anticipated to be the norm in the near future. 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. (The use of a reference technology does not imply a universal adoption of that technology but rather indicates the average efficiency that can be expected to be achieved by a variety of methods.) The fuel-based coefficient of performance for heating would average 2.4 for heating and 3 for cooling. Geothermal heat pumps are commercially available today and have been used in recent years, including by the government, for energy efficiency improvements. President Bush's ranch in Crawford, Texas is equipped with such a device.

5. 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. A government regulation to that effect will be needed in the near future if this is to be realized.

6. Aircraft efficiency will improve by 2 percent per year over the whole period in terms of fuel per seat mile.

7. Cargo transport efficiency will improve by about 3 percent per year. This will probably require efficiency standards for truck transport.

8. A carbon dioxide emissions decline of at least 40 percent and preferably 50 percent by 2040 should be achieved and made compatible with other security goals.

9. Nuclear power will be phased out by 2030.

10. Local solar, hydropower, and some cogeneration plants are largely managed for peaking power provision. Inefficient gas turbine units now widely used for providing peaking power would be phased out by 2040.

11. About 40 percent of the hydropower capacity will be dismantled by the year 2040 for a combination of security and environmental reasons.

12. A 40 percent improvement in efficiency of electricity use in non-HVAC (heating, ventilation, air conditioning) 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.

13. Industrial heat requirements will be met by cogeneration systems wherever possible.

14. 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.

TABLE 2: COMPARISON OF CERTAIN ENERGY SYSTEM VULNERABILITIES IN THE BUSH AND IEER ENERGY PLANS, YEAR 2040

Vulnerability element	BUSH PLAN		IEER PLAN		Comments
	Quantitative measure	Degree of vulnerability	Quantitative measure	Degree of vulnerability	
Oil imports[a]	23 million barrels per 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 one 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-scale 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 power suddenly in the aftermath of an attack.
LEU spent fuel stored in pools[b]	About 20,000 metric tons in spent fuel pools	Catastrophic consequences possible from a variety of attacks	Zero	None	Long-lived radionuclide releases could be larger than Chernobyl in case of fires.
Plutonium storage[c]	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.[d]
Electricity transmission	Dependent on specific system characteristics	Higher risk than at present due to further grid centralization and deregulation. Higher attractivness 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.

Table notes:

a. Our main criterion for petroleum related vulnerabilities is oil imports, with high vulnerabilities being defined as sustained imports over 10 million barrels a day and very high vulnerabilities as those 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. 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 (LEU) 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 subsurface to minimize the consequences of an attack.

c. 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. 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.

d. Dual fuel capability not explicitly factored into the IEER plan. See Lovins and Lovins 1982 (footnote 8 on page 12) for a discussion of this topic.

relatively short time, compared to say, those related to existing nuclear reactors.

The IEER Energy Plan

The IEER energy plan is explicitly designed to address certain security vulnerabilities that have been revealed as far more serious than generally recognized prior to September 11. These vulnerabilities are not new; 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.

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 assumes for instance 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. This approach also has some defects, which we do not attempt to remedy in the report. For instance, 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, a system in which huge investments of time, energy, money, land, and ecosystem integrity are put into a car-centered transportation system. It also does not discuss lifestyle changes, nor the desirability of integrating the notion of "enough" at some level of consumption into the global social and economic framework.

The technological and policy-related assumptions of IEER's energy plan are described in the box on page 6, providing the plan's framework as well as a basis from which we can compare it to the Bush plan.

Findings

We assessed the IEER and Bush energy plans according to the energy system vulnerabilities discussed. Table 2, on page 7, provides a static comparison of the projected vulnerabilities of each plan in the year 2040.[11] Figures 4 through 7 illustrate over time the projected differences between the two plans on energy consumption by source, carbon emissions, and energy productivity.

In sum, the Bush administration's energy plan would worsen energy system vulnerabilities by:

- increasing the attractiveness of and number of targets for terrorism particularly in the nuclear, oil, and electricity systems;
- increasing oil imports in absolute amount and as a proportion of oil supply (even if domestic oil production is expanded by opening up environmentally sensitive areas like the Arctic National Wildlife Refuge to drilling); and,
- increasing risks of nuclear proliferation.

It will never be possible to eliminate all vulnerabilities and risks to terrorist attack, war, severe accidents, and mistakes. But it is possible to reduce the attractive-

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Deregulated electricity systems with a national grid would exacerbate vulnerabilities

FIGURE 4: BUSH ADMINISTRATION PROJECTIONS FOR U.S. ENERGY CONSUMPTION BY SOURCE, 2000-2040

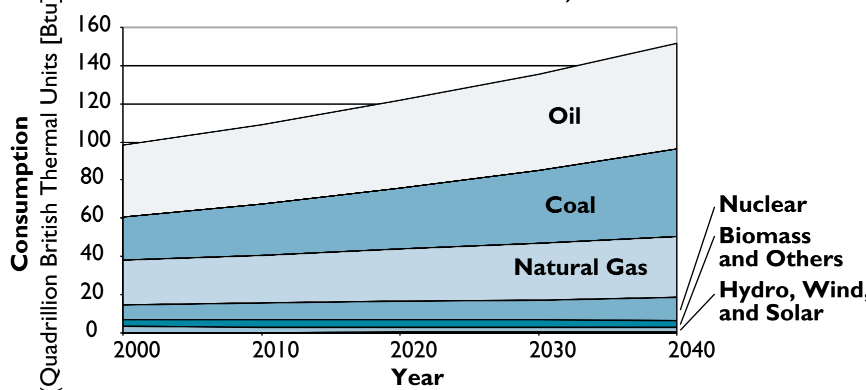
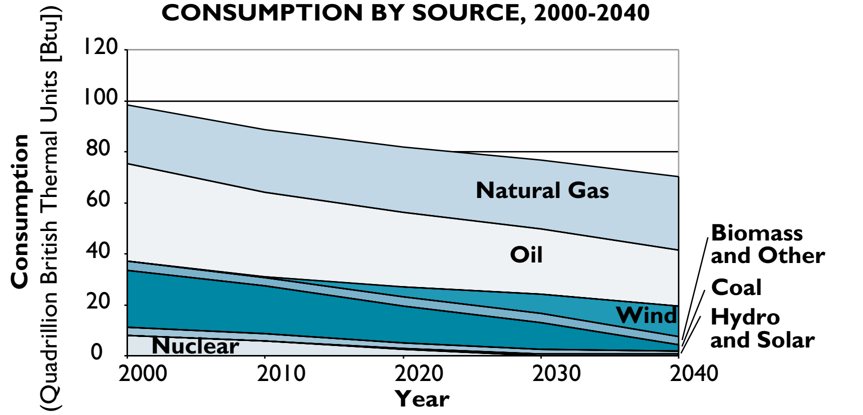


FIGURE 5: IEER PROJECTIONS FOR U.S. ENERGY CONSUMPTION BY SOURCE, 2000-2040



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ness of major elements of the energy system as targets of attack and also to reduce the consequences of an attack should one occur. For instance:

- A reduction of oil consumption of about 40 percent can be achieved in the next four decades provided stringent standards for efficiency in land-based transportation are set.[12] The current state of technology in relation to automobile efficiency is far in advance of the current average performance for passenger cars, which is about 27.5 miles per gallon for cars and 20.7 mpg for light trucks, minivans and sport utility vehicles. The Toyota Prius, a commercially available four-passenger gasoline powered car with a hybrid engine, gets nearly 50 mpg. General Motors' prototype fuel cell car gets 100 mpg of gasoline equivalent and goes from zero to sixty in about 9 seconds. It may be commercialized by 2010.
- The technologies to simultaneously reduce 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. The achievement of reduction of carbon dioxide emissions can be made compatible with a total phase out of nuclear power.[13]
- A number of technical advances have provided the basis for a completely revamped energy sector. Advances in the efficiency of electric power generation from natural gas have made it possible to increase efficiency, reduce carbon dioxide emissions, and maintain electricity generation levels all at the same time. Wind power technology improvements have made it economical in vast areas of the United States where the collective wind potential far exceeds current U.S. electricity generation.[14]

FIGURE 6: PROJECTIONS FOR TOTAL ANNUAL CARBON EMISSIONS, 2000-2040

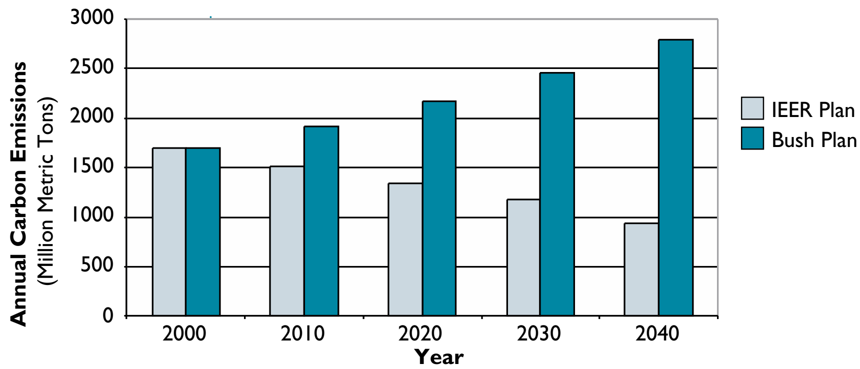
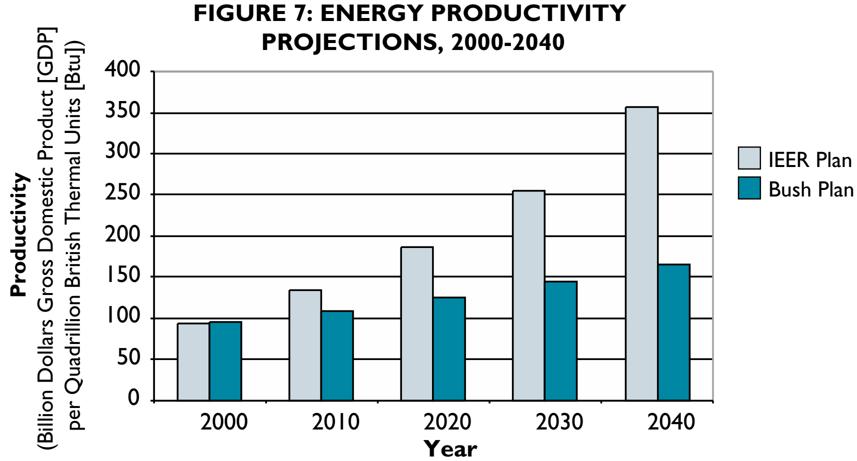


FIGURE 7: ENERGY PRODUCTIVITY PROJECTIONS, 2000-2040



> The Bush energy plan would worsen energy system vulnerabilities

Conclusions and recommendations

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. The scale of the 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.

IEER's recommendations for doing so are detailed on pages 10-11.

1 For a general history of oil see Daniel Yergin, *The Prize: The Epic Quest for Oil, Money, and Power* (New York: Simon and Schuster, 1991). An analysis of the recent Central Asian connection can be found in Michael Klare, *Resource Wars: The New Landscape of Global Conflict* (New York: Metropolitan Books, 2001).

2 One was an official review in 1952 by the Paley Commission, appointed by President Truman, which concluded that there may be oil shortages by the 1970s. The U.S. 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.

3 *Energy, vulnerability & war*, a 1980 report by the Federal Emergency Management Agency, 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. Its findings were

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Recommendations from *Securing the Energy Future of the United States*

Main recommendations

- 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 2040.
- A goal of an average efficiency of 100 miles per gallon for new passenger vehicles (including light trucks) 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 encourage the achievement of a distributed grid, rather than a centralized national grid of interconnected local and centralized electricity generation. Local and state governments and their regional and national associations 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. Nuclear Regulatory Commission should undertake a thorough review of reactors and spent fuel pools that may face special vulnerabilities and consider whether such reactors should be shut before their licenses expire. 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 becomes unattractive as a terrorist target.
- The U.S. government should commit about $10 billion per year to purchase renewable energy, fuel cells, efficient automobiles, efficient on-site electricity generation, highly efficient heating and air-conditioning technology, 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. The procurement program should be carried out annually on a performance-based bidding process similar to that used for leasing out tracts for oil and gas drilling. Tax breaks already promised for existing renewable energy and energy efficiency installations can continue.

Other recommendations

Federal level

1. The United States should set progressively more stringent carbon dioxide emissions limits per unit of electrical power generation.
2. The United States should commit itself to the Kyoto Protocol, the global agreement under which industrial countries pledged to reduce greenhouse gas emissions, 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 (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. The Kyoto Protocol currently requires only modest reductions in global greenhouse gas emissions, generally less than 10 percent for the most industrialized countries. It will be necessary to reduce such emissions on the order of 50 percent within several decades in order to mitigate the risks of severe catastrophe.
3. Natural gas should be regarded as the key transition fuel to a renewable energy future.
4. Create a national effort on public transportation as an urban utility (much like water, electricity or telephones) so as to ensure that public and multi-modal transportation get a far larger share of federal resources than at present. 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. We recommend that a comprehensive study be commissioned on the cost and feasibility 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. Such a study should 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.
5. 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 a severe attack. It is essential that an immobilization program (an approach

ROAD MAP FOR ACTION

Recommendations from *Securing the Energy Future of the United States*

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 particle) be re-instituted and implemented with urgency.

6. No new nuclear power plants should be licensed. Plans for use of plutonium as a fuel in nuclear reactors should be abandoned.
7. Spent nuclear fuel from power plants, which contains 95 percent of all radioactivity in nuclear waste, should be packaged in dry casks within a few years of discharge from the reactor, or when it is safe to do so, rather than waiting until the spent fuel pools at reactors are full. Dry storage should be onsite or close to site in subsurface facilities similar to those of the vitrified high level military radioactive waste stored at the Savannah River Site nuclear weapons plant in South Carolina. As nuclear power plants are closed, the storage can be consolidated within a state or region at a closed nuclear power plant site. Control of spent fuel should be transferred to the federal government. 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. (IEER has done extensive work on this subject. See Arjun Makhijani, "Considering the Alternatives," *Science for Democratic Action*, vol. 7 no. 4 (May 1999). Online at http://www.ieer.org/sdafiles/index.html.)
8. As a precautionary measure, the Nuclear Regulatory Commission should 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 while nuclear power plants are still in operation.
9. 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 would report to the government and the public each year.
10. Vigorous federal programs of renewable energy, energy efficiency and fuel cell 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.
11. The federal government should continue filling 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.
12. A program of research, development, and demonstration that couples hydrogen fuels to renewable energy sources and to a variety of end uses, including 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.

State and local level

In addition to the institution of their own procurement policies along the lines discussed above for their own facilities such as schools, colleges, state government buildings and vehicles, etc., 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 (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 and their regional and national associations should have adequate oversight and regulatory authority.
4. Institute rules requiring developers to consider on-site generation with best available technology for heating and cooling efficiency and to 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.

The full report, *Securing the Energy Future of the United States,* is online at http://www.ieer.org/reports/energy/bushtoc.html.

ENERGY FUTURE

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startlingly similar to those of the Paley Commission (see footnote 2). 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. Despite this, nuclear power was vigorously pursued and is still heavily subsided by the government via the Price Anderson Act. Renewable energy sources have, for the most part, languished.

4 On November 12, 1972, three men who did not know how to fly a plane and wanted money hijacked a commercial jet airliner and threatened the Oak Ridge nuclear weapons plant. The hijackers were promised money and taken to Cuba where they were arrested, tried, convicted, and later extradited to the United States. The crash of one of the airliners in Pennsylvania on September 11, 2001, 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, should heighten concerns about nuclear vulnerabilities.

5 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.

6 See Arjun Makhijani and Annie Makhijani, *Fissile materials in a glass, darkly: technical and policy aspects of the disposition of plutonium and highly enriched uranium* (Takoma Park, Maryland: IEER Press, 1995). Also see various articles on the IEER web site at http://www.ieer.org/latest/pu-disp.html.

7 For an analysis of the consequences of a meltdown accident in a light water reactor using plutonium fuel, see Edwin S. Lyman, "Public health risks of substituting mixed-oxide for uranium fuel in pressurized water reactors," in *Science & Global Security*, vol. 9, no. 1, 2001, pp.33-79. The same results would apply to a terrorist attack that would result in a meltdown.

8 Amory and L. Hunter Lovins cite several examples in *Brittle power: energy strategy for national security* (1982), p. 128. Online at http://www.rmi.org/sitepages/art7095.php (viewed 11-20-01).

9 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. IEER's critique of the plan was published in *Science for Democratic Action* vol. 9 no. 4 (August 2001) and is online at http://www.ieer.org/sdafiles/vol_9/9-4/cheney.html.

10 The May 2001 National Energy Policy does not make detailed projections, such as estimated levels of oil imports or types of power plants. It makes some projections to the year 2020. IEER has estimated details to the year 2040 from the projections provided in the Bush energy plan and from official data posted on the web site of the Energy Information Administration.

11 The time horizon we chose is approximately 40 years because it will take time to eliminate or greatly reduce some of the vulnerabilities. Because the Bush administration has not projected out the implications of its energy plan over four decades, we have done so. Assumptions we used are detailed in the report. In the IEER plan, the numbers for the first ten years 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 advocated are actually implemented and what in practice is the phasing of these policies in the first decade.

12 In practice, carmakers have been resistant to stringent efficiency standards without government action to set them.

13 IEER has compared the merits of nuclear power plants in reducing greenhouse gas emissions relative to combined cycle natural gas plants in SDA vol. 6 no. 3, online at http://www.ieer.org/ensec/no-5/sustain.html.

14 See "Large-scale Wind Energy Development in the United States," in *Science for Democratic Action*, vol. 9 no. 4 (August 2001), online at http://www.ieer.org/sdafiles/vol_9/9-4/windpotl.html.

ERRATA

The following sentence in "Dear Arjun" on page 15, column 2, line 6 of SDA vol. 9 no. 4 (August 2001),

> "While PBMRs would reduce the amount of waste volume per unit of power production, there would still be an enormous amount of radioactive waste that would result, posing the familiar problem of what to do with long-lived radioactive waste."

should have read:

> "While the amount of radioactivity present in the reactor at any time per unit of power produced would be less in PBMRs than in LWRs, the volume of spent fuel would be considerably greater, posing the familiar problem of what to do with long-lived radioactive waste."

A complete list of errata for all IEER print publications is online at http://www.ieer.org/errata.html.

Sharpen your technical skills with Dr. Egghead's
Atomic Puzzler

Dr. Egghead's canine friend Gamma has been thinking about U.S. oil consumption a lot lately. Can you help him answer these questions?

Note: To solve some of these problems, you will have to use exponents (GASP!). But fear not, Dr. Egghead is here to explain all. To figure out an amount of growth, simply take the rate of growth and raise it to the power of the number of years in the problem. If there is no growth, the growth rate is 1. If there is change, the rate is 1 +/- the rate of change. So, say you have 1000 widgets and the number of widgets grows at a rate of 5% per year for the next 10 years. The number of widgets in 10 years will be: $1000 \times (1.05)^{10} = 1628$ *(rounded). Likewise, if the number of widgets decreases at a rate of 5% per year for the next 10 years, the number of widgets in 10 years will be:* $1000 \times (0.95)^{10} = 599$ *(rounded). For more help on exponents, check out IEER's online technical classroom on our web site at http://www.ieer.org/clssroom/scinote.html.*

1. Assuming that, in the year 2000, the United States was consuming 20 million (2.0×10^7) barrels per day of petroleum. Also assume that this amount is expected to grow at 2% per year for at least 30 years. What will the daily oil consumption of the United States be in:

   a. 2010?

   b. 2020?

   c. 2030?

2. One way to measure the energy productivity of the United States is to determine the amount of Gross Domestic Product (GDP) generated (measured in dollars) per amount of energy consumed (measured in British Thermal Units, or Btu). The higher this ratio, thinking goes, the more productive the economy in relation to energy because there is more wealth being generated per unit of energy that is consumed.

   a. If the United States in the year 2000 was consuming 99 quadrillion Btu of energy, and GDP then was 10 trillion (10,000 billion) dollars, what was the energy productivity of the United States in that year in billion dollars of GDP per quadrillion Btu?

   b. What would the energy productivity of the United States be, in billion dollars of GDP per quadrillion Btu, in 2030 if since 2000 energy consumption grew at 2% per year while the GDP grew at 1.5% per year?

   c. What would the energy productivity of the U.S. be in 2030 if since 2000 energy consumption increased by 1% per year while the GDP grew at 1.5% per year?

3. In 1999, the world's total energy consumption was approximately 380 quadrillion Btu. The U.S. total energy consumption was approximately 97 quadrillion Btu. What percentage of the world's total energy consumption took place in the United States in 1999?

4. From which of the following countries does the United States NOT import any oil?

   a. Saudi Arabia

   b. Canada

   c. Mexico

   d. Iraq

   e. Iran

5. True or False: Over 60% of the world's proven oil reserves are located in the Middle East.

6. *Bonus question* (answer not found in this issue): Name the 11 countries that are members of OPEC (Organization of Petroleum Exporting Countries).

Send us your completed puzzler via fax (1-301-270-3029), e-mail (ieer@ieer.org), or post (IEER, 6935 Laurel Ave., Suite 204, Takoma Park, Maryland, 20912, USA), postmarked by March 27, 2002. IEER will award a maximum of 25 prizes of $10 each to people who send in a completed puzzler (by the deadline), right or wrong. One $25 prize will be awarded for a correct entry, to be drawn at random if more than one correct puzzler is submitted. International readers submitting answers will, in lieu of a cash prize (due to exchange rates), receive a copy of IEER's newest report, *Securing the Energy Future of the United States: Oil, Nuclear, and Electricity Vulnerabilities and a post-September 11, 2001 Roadmap for Action,* signed by the author.

AUDITS

FROM PAGE 1

cal experimentation, theoretical work, and computer modeling. Plutonium, uranium (in various enrichments), and tritium are stored and processed there (the last for both weapons and nuclear fusion power research). Large amounts of radioactive waste are also stored there. LANL has a small-scale capacity to manufacture nuclear weapons, mostly for prototyping purposes, as well as the associated chemical and physical processing facilities. It was the laboratory where the first nuclear weapons, tested in New Mexico and used on Hiroshima and Nagasaki in 1945, were made. It has also been designated as the site for future stockpile plutonium pit production and has an aggressive nuclear sub-critical hydrotesting program.

Experimentation at LANL involves many radionuclides and results in discharges to the air and water

Experimentation at LANL involves many radionuclides, and results in a variety of discharges to the air and water. In 1991, with ink hardly dry on the regulations implementing the 1990 Clean Air Act,[2] the Environmental Protection Agency (EPA) found LANL to be in violation of it. LANL had not done its dose calculations in the prescribed manner.[3] The required calculation method would have estimated the dose to the hypothetical individual residing at the site boundary at more than the allowable maximum of 10 millirem per year.[4] The use of a hypothetical individual to estimate a maximum dose is common practice in radiation regulations. If the location and circumstances of the maximum exposure are properly specified, such a regulatory procedure ensures that everyone else in the general public is also protected and will not be exposed to more than the allowable radiation dose limit.[5]

LANL's measurements of releases of radionuclides to the air, and its assessment of the impacts of unmeasured sources, also left much to be desired. A subsequent agreement between EPA and LANL, called the Federal Facilities Compliance Agreement, settled the issue for the two bureaucracies. But the Santa Fe-based public interest group Concerned Citizens for Nuclear Safety (CCNS) believed that the EPA had allowed LANL to remain in violation of the requirements of the Clean Air Act as regards making measurements and assessing radiation doses to the public.

Quite apart from the actual level of releases of doses, technical requirements regarding measurements and modeling are the heart of assurances to the public that a facility is in compliance. In 1994, CCNS filed a lawsuit alleging that LANL continued to violate the Clean Air Act and that its violations should stop.[6] Of legal importance in and of itself was that CCNS was granted the standing to sue, especially considering the Federal Facilities Compliance Agreement between DOE and EPA. IEER served as a technical consultant in the lawsuit.

Senior Judge Edwin Mechem issued a summary judgment that LANL was in violation of the Clean Air Act as alleged in CCNS's lawsuit. This was based largely on official documents issued by LANL itself. The judge ordered LANL to negotiate with CCNS to attempt to resolve the lawsuit. If not, LANL faced large fines and an order shutting down the facility until it could be brought into compliance. LANL chose to settle the case. It should be noted that LANL management consciously chose to keep operating while knowing that it was operating in violation of federal environmental law.

A Consent Decree embodying the settlement was filed in federal court in March 1997. It is a complex settlement, but its core provision relates to independent audits. CCNS and LANL agreed that the Risk Assessment Corporation, led by John Till, would set up an Independent Technical Audit Team, which would conduct up to four independent audits. CCNS would be able to retain its own consultant to monitor the audit – that is, to check whether the audit was being done in a thorough and competent manner. CCNS chose IEER to provide the scientific personnel for this monitoring function.[7]

The federal government was to pay for the audit and the monitoring function, but the DOE did not control the funds. The Risk Assessment Corporation was paid directly by the Department of Justice (DOJ). DOJ also paid CCNS, which then paid IEER and its own expenses in monitoring the audit. Making the audits even more historic, Dr. Till decided to open the whole audit process, including site visits, to state and tribal government representatives and the public. LANL and DOE personnel went to extraordinary lengths to ensure access to the monitoring equipment and facilities to everyone who went on the site visits.[8]

LANL was to provide all relevant records and documents and make its air monitoring facilities as well as personnel available to the auditors and monitors. The issues raised during the audits were:

- Were the environmental monitoring systems and the stack monitoring systems adequate for emissions monitoring and dose estimation?
- Was the record keeping for unmonitored sources appropriate and were the procedures for estimating emissions from hundreds of these sources appropriate?
- Were the computer models used by LANL appropriate for assessing doses, given the complex terrain,

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consisting of canyons and mesas, and the patterns of emissions?

- Did the assumptions about releases of radioactivity reflect the reality of operations in the various facilities?
- Were the procedures for sampling and analysis, both at LANL and at the laboratories to which the stack samples were sent, appropriate and adequate?
- Were quality control and assurance procedures adequate and were they being followed?
- Was the location of the hypothetical maximally exposed individual appropriate or might it underestimate radiation doses under certain circumstances?

The main source of emissions (over 90%) at LANL during the 1990s was a proton accelerator, known as LANSCE (Los Alamos Neutron Science Center). After the EPA cited LANL in 1991 for emissions relating to this facility, measures were taken to reduce those emissions. Yet, the conclusion of the first audit, which examined LANL compliance for 1996, was that LANL was out of compliance with the Clean Air Act and, in addition, that there were scientific deficiencies in LANL's compliance program. The main findings in this regard were:

1. "Lack of documentation of radionuclide inventory. An inventory for 1996 could not be determined from documentation that currently exists. The lack of inventory data in certain buildings was a primary deficiency that prevented the audit team from verifying what sources may have existed and, therefore, quantitatively verifying compliance."
2. "Absence of independent verification of calculations."
3. "Certain environmental sampling techniques and assumptions are not well described or documented."
4. "Sample losses. An evaluation of aerosol particle loss in the sample transport systems is required by the effluent sampling guidance in the regulation. However, LANL has failed to analyze losses in probes and transport lines for three sampling systems that do not employ shrouded probes."

The finding of non-compliance was issued in May 1998, midway through the first audit process, to allow LANL to fix the problems that were identified to that point.

The funds allocated for the first audit turned out to be insufficient and the audit was admittedly incomplete. IEER issued its assessment of the audit, agreeing with the finding of non-compliance. However, IEER disagreed with the audit team's "considered judgment" that the 10-millirem dose limit had not been exceeded. IEER found that, since a number of issues relating to measurements and models had not been resolved and no uncertainty analysis had been performed, such a conclusion by the audit team was unwarranted. IEER did not make any claim that doses were higher than the limit of 10 millirem, just that the analysis performed by the audit team did not permit such a statement of compliance with the dose limit. LANL disputed the audit's non-compliance finding, but nonetheless began to implement many of its recommendations.

The main concerns that IEER raised early on about LANL's approach to compliance and EPA's agreement with LANL as to how LANL was to demonstrate compliance were:

- The model used by LANL for making dose calculations, and approved by the EPA, is a "flat earth model" while the terrain at Los Alamos is anything but. The model is called CAP-88. Until the flat earth assumption could be shown to be uniformly conservative (that is, providing overestimates of doses under all prevailing conditions), the model was not scientifically appropriate.
- The CAP-88 model estimates annual average doses, and assumes uniform releases throughout the year. However, some releases are not uniform and could result in doses to individuals higher than those estimated by the annual average model.
- IEER also raised the question as to whether a passer-by, known as a transient receptor in technical jargon, such as a jogger passing by a radionuclide-emitting facility, might not under certain circumstances be exposed to a higher dose than the facility-designated hypothetical maximally exposed individual. This inquiry also led to the question of how the hypothetical maximally exposed individual was to be identified.

LANL was in violation of the Clean Air Act

The second audit was conducted in the year 2000 for data relating to the year 1999. LANSCE, the main radiation source, was not in operation during 1999. As a result, the maximum estimated dose was 0.32 millirem. There are uncertainties associated with this number, which continue to be unquantified. But there was general agreement that LANL was in compliance with the Clean Air Act radiation regulations for 1999. This finding of compliance was expected and also not as significant as it would have been had LANSCE been in full operation. It should be noted that LANL has taken steps to reduce LANSCE emissions.

The audit team also did a check of the kinds of results that might be anticipated if a model that reflected the actual terrain at Los Alamos were to be used. It was found, based on admittedly limited modeling, that the

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flat earth model gave conservative results under most, but not all, circumstances. According to IEER, since the complex terrain model showed doses that were higher than the flat earth model under some circumstances, a more detailed and thorough investigation was needed before the continued use of the flat earth model could be justified.

Overall, the audit and monitoring process allowed sound science that the public could trust to emerge as regards one environmental aspect of the nuclear weapons complex. Of course, its limitation, understood by all parties from the start, was that the process could not be used one way or another to promote nuclear disarmament, a treaty-related obligation of the United States as well as a declared goal of some of the parties involved including IEER. On the other hand, the process has allowed us to raise some crucial national environmental questions in the context of an official process. In particular, CCNS and IEER have taken up the question of the inappropriateness of the flat terrain model under circumstances similar to LANL elsewhere, both at government-owned and privately-owned installations. We have also raised the question of the transient receptor. So far the EPA has agreed to look at the question of the flat terrain model and how it should be validated.

The audit and monitoring process allowed sound science that the public could trust

The third audit is scheduled to begin in June 2002 and will examine LANL's 2001 compliance. An additional focus of the audit will be to develop a working model for independent audits and monitoring of audits for the public to use at government-owned and industrial sites regulated under the Clean Air Act.

1 Joni Arends is the Waste Programs Director at Concerned Citizens for Nuclear Safety.

2 The part relating to radionuclide air emissions is in the Code of Federal Regulations at 40 CFR 61 Subpart H.

3 LANL used an unapproved "building shielding" factor. EPA disallowed it after John Stroud of Concerned Citizens for Nuclear Safety formally questioned its use to the EPA.

4 The Clean Air Act does not limit all radiation doses via the air pathway, only those delivered by radionuclides. Specifically, neutron doses are excluded since neutrons are, technically speaking, not radionuclides in that they are not in the periodic table of elements.

5 See Section 2 of *Setting Cleanup Standards to Protect Future Generations*, by Arjun Makhijani and Sriram Gopal, IEER, December 2001, online at http://www.ieer.org/reports/rocky/2critgp.html. A dose less than the regulatory limit does not mean zero cancer risk. It means less than the risk specified in the regulations. The risk of a fatal cancer to an adult from exposure to radiation is considered to be proportional to exposure. The official risk factor is equal to about 4 in 10 million risk of a fatal cancer per millirem of exposure.

6 Jay Coghlan, Caron Balkany, Esq., and Carol Oppenheimer, Esq., played leading roles in the strategy and litigation. John Stroud was the originator of the lawsuit.

7 Bernd Franke (as a consultant to IEER) and Arjun Makhijani served as IEER's monitoring team on the audit process.

8 Of course, access to classified areas was restricted to those with appropriate security clearances.

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