CRITICAL HOUR:
THREE MILE ISLAND, THE NUCLEAR LEGACY, AND NATIONAL SECURITY

Update *2004 through May 2006*

by Mary Byrd Davis and Albert J. Fritsch

CONTINUING DOWN THE ROAD TO DISASTER:

An Update on Chapters VII and VIII of Critical Hour

Mary Byrd Davis

SAFETY

Safety Problems at Operating Reactors

The safety of US commercial reactors remains as dubious now as it was in 2003 when we completed our research for *Critical Hour*. For the twentieth anniversary of the Chernobyl accident, Greenpeace released the report "*An American Chernobyl: Nuclear 'Near Misses' at U.S. Reactors since 1986."* The report lists incidents that could have led to a core meltdown and subsequent failure of containment at nuclear power reactors, as determined by the NRC (US Nuclear Regulatory Commission) through its Accident Sequence Precursor (ASP) program. In the time period covered, US reactors experienced 8 "significant" precursors or near misses, 49 "important" near misses, and 142 additional near misses. The most recent "significant" precursor was the corrosion of the reactor head at Davis Besse, which was discovered in 2002.

In 2004, the most recent year covered, there were no "significant" or "important" near misses, but 17 additional near misses occurred. These included a reactor trip (shut down) with complications at Calvert Cliff 2, January 4; loss of off site power at St Lucie 1 and 2, September 25; and loss of off site power with complications at Palo Verde 1, 2, and 3, June 14.

Over the years, most of the events that could have led to a meltdown have been associated with four initiators, the NRC has found:

1. Reactor trip (which includes loss of main feed water);
2. Loss of Off Site Power or LOOP;
3. Small Break Loss of Coolant Accident or LOCA; and
4. Steam Generator Tube Ruptures.

An alarming feature of the NRC's study of precursor events is that it shows that the NRC is unable to predict accidents. Most of the reactors that have experienced precursor events were not on the NRC's watch list of problem reactors or the object of special oversight at the time that the events occurred. Furthermore, most reactors that experienced a near miss, were not subsequently given the increased attention that they needed.

For a precursor incident to deteriorate into a major release of radioactivity, the containment of the reactor must fail. The Greenpeace report cites NRC documents and observations that indicate that the containment on General Electric Mark 1 and 2 reactors and Westinghouse ice condenser reactors are particularly susceptible to failure under accident conditions. Forty US reactors that are licensed to operate have such containments, and these forty reactors experienced fifty of the near misses [Riccio 2006].

The NRC is not expected to release an analysis of precursor incidents that occurred in 2005, until the autumn of 2006. For 2005 and early 2006 we therefore describe four incidents that involve loss of off-site power or problems with cooling systems.

Waterford 3, in Louisiana some twenty miles west of New Orleans, lost off-site power when hurricane Katrina swept through the area August 29, 2005. The plant, which had been shut down as a precautionary measure August 28, was not directly damaged; but, *Nuclear Fuel* reports:

> In the aftermath, external communication systems were wiped out. Entergy reported to NRC Aug. 31 that it had lost the communications system to its Emergency Operations Facility, reactor auxiliary building, and emergency notification system. The utility said, however, that it had limited capability to use an "industrial hotline to a circuit" in St. Charles Parish. It was communicating with the NRC over satellite telephones, NRC and Entergy officials said.
>
> [Weil 2005]

The plant remained unconnected to the grid for several days after the hurricane had passed, because of voltage fluctuations in the electricity service, but diesel generators kept safety systems at the plant in operation. The NRC approved the plant's restart September 9.

Pumps have recently been at the center of sets of incidents at least two plants: FirstEnergy's Perry Plant in Perry, Ohio, and Dominion's Kewaunee Plant in Kewaunee, Wisconsin. Perry was shut down twice in 2004 for problems relating to its recirculation pumps. In January, 2005, Perry was shut down after "'one of the recirculation pumps went from high to low speed' and abruptly tripped off," impacting the flow of cooling water around the reactor [FirstEnergy's 2005].

In February 2005 Kewaunee had to shut down due to the discovery of a problem with the design of the auxiliary feed water system. As the result of this shut down another design flaw was discovered, "a flood in the turbine building could spill into areas containing safety-related equipment" [Horner 2005]. Kewaunee officials had to modify the design of the plant before they could restart it. Then, April 26, 2006, when operators

were getting ready to shut the plant down because of a leak in the cooling system piping of an emergency diesel generator, “a pump in the secondary cooling system stopped unexpectedly while the plant was at about 35 percent power. The pump stoppage should have caused the main steam turbine to shut down, which, in turn, would have led to an automatic reactor shutdown.” However, the main steam turbine did not shut down, and operators shut the reactor down manually [Nuclear Regulatory 2006].

May 20, 2006 at Duke Energy’s Catawba plant, both reactors lost off-site power and automatically shut down. At this point the diesel generators took over and supplied backup power. The *Charlotte Observer* reported that the incident occurred when an electrical fault in the plant’s switchyard caused a circuit breaker to open. Subsequently twelve other circuit breakers opened. It was the first time since the plant began operating that both reactors tripped at the same time. “’This is a type of event that we would not expect to occur,’” NRC spokesperson Ken Clark told the *Observer* [Henderson 2006]. The reactors at Catawba have ice-condenser containments, and Unit 1 included among its fuel at the time of the accident four test assemblies of mixed oxide fuel (Mox) with plutonium. Edwin Lyman of the Union of Concerned Scientists is of the opinion that the Mox assemblies did not help to initiate the incident, but that if it had progressed to a serious accident, the Mox assemblies might have been more likely to suffer damage than the other fuel [Lyman 2006].

Two incidents in 2005 and early 2006, affected the level of security against sabotage or terrorism at least as much as they did safety. At the Crystal River plant in Florida in March, 2005, operators learned that three illegal aliens, who had used false identification, were working for a contractor inside the plant [Dopp 2005]. January 14,

2005 a small, half-hour fire in unit 2 turbine building at Dominion's Millstone-2 plant shut down some security systems by damaging a control panel. The Connecticut Coalition against Millstone (CCAM) charged that, from what CCAM had earned from a whistleblower, the fire disabled "the perimeter security system" and prevented electronic monitoring of staff within the plant. Compensating measures included assignments of guards to patrol the fence [Dolley 2005].

Davis Besse

The NRC has calculated that the long-undetected corrosion of the reactor cover or head at the Davis Besse plant near Cleveland, Ohio, is one of two situations that have posed the greatest risk of a meltdown at a US plant since Chernobyl. (The other was the operation of Shearon Harris for a year without a system for injecting cooling water into the reactor, a situation discovered in April 1991.) The NRC has calculated that the reactor vessel at Davis Besse was only sixty days away from failing [Riccio 2006].

Davis Besse, which had been shut down since February 2002, returned to full power in March 2004. Meanwhile, its owner, FirstEnergy Corporation, had spent $605 million repairing it and buying replacement electricity. Repairs included installation of a new reactor head, since the old head had been nearly eaten through by boric acid. In April 2005 the NRC imposed a civil penalty of $5.45 million on FirstEnergy for safety violations, the most important of which was the condition of the reactor head. Of the total fine, $450,000 was levied because FirstEnergy furnished misleading information to the NRC [Henry, NRC 2006]. FirstEnergy also had to pay an additional $28 million fine

to avoid being criminally prosecuted for lying to the NRC about the condition of the plant in 2001 [Henry, FirstEnergy 2006].

In January 2006 a federal grand jury issued criminal indictments against two former midlevel managers at the plant and a consultant, all of whom they charged with concealing the truth about the plant. One, Andrew Siemaszko, who had been responsible for inspections of the reactor head, claimed that his superiors ignored his request for more repairs to the plant during its routine shutdown for maintenance in 2000 and that he was being made a scapegoat. US Rep. Dennis Kucinich (D., Cleveland), who had tried to get the operating license for the plant revoked, stated that senior utility officials should have been held accountable [Henry, Reactor 2006].

Dangers of Plant Aging

The corrosion of the reactor head at Davis Besse is an example of plant aging, a phenomenon discussed at some length in *Nuclear Reactors Hazards*: *Ongoing Dangers of Operating Nuclear Technology in the 21st Century*, a report by Helmut Hirsch and others. The International Atomic Energy Agency defined aging in 1990 as "a continuous time-dependent loss of quality of materials, caused by the operating conditions" [quoted in Hirsch et al. 2005]. As a rule of thumb, aging begins after a reactor has been in operation for twenty years. The most important causes are "irradiation, thermal loads, mechanical loads, and corrosive, abrasive and erosive processes." Aging may be impossible to detect by processes that do not physically break into equipment, i.e. non-destructive processes, because they "usually occur on the microscopic level of the inner structure of materials." Thus they often become apparent only when components break

down. As reactors grow older, they show aging through an increase in the number of "small" incidents such as cracks, small leaks, and circuit failures. They may, however, eventually also show aging through catastrophic failure and major radioactive releases. One of the most severe of such failures would be the bursting of the pressure vessel of a light water reactor due to irradiation by neutrons having made the reactor vessel brittle.

The most important component of a light water reactor that is subject to aging is the reactor vessel. Besides embrittlement of the walls of the vessel, problems can include cracking of welds due to repeated changes in temperature and pressure, cracks and corrosion around vessel head penetrations (as at Davis Besse), corrosion of bolts and nuts, and embrittlement of the core internals. Other important components that are impacted by aging are pipelines, main coolant pumps, steam generators (many entire generators have had to be replaced), turbines, concrete structures, cables, and electronic devices.

The nuclear industry and its regulators worldwide try to ignore the subject of aging, although they have to address actual breakdowns as they occur. No nation has a set of technical standards that provide objective criteria for determining when aging of a specific reactor is such that the reactor can no longer continue to operate [Hirsch et al. 2005]. In the United States the NRC is issuing twenty-year extensions of licenses that will allow plants to operate for sixty years, far beyond the length of life for which they were originally built. It is also allowing many reactors that are approaching around forty years in age to increase their power, thus putting additional pressure on aging components.

License Extensions

From August 2003 through late May 2006, twenty-six reactors received twenty-year extensions of their original forty-year operating licenses. These extensions brought to a total of forty-two the number of US reactors that are licensed to operate for sixty years. As of May 25, utilities had requested extensions for nine additional reactors, and they were expected to request extensions for twenty-seven additional reactors within the next six years [NEI, License 2006].

The NRC did reject one application for extension: FirstEnergy's application for twenty-year renewals of the licenses for Beaver 1 and 2 in western Pennsylvania. Charging that information provided by FirstEnergy was too vague for evaluation, the agency told the utility that it could rewrite the application or drop it. FirstEnergy notified the NRC that it would resubmit the application in early 2007. The rewriting will have to be extensive. In response to a request for a list of materials to be reviewed in regard to aging, for instance, FirstEnergy had simply written "ANY" [Beaver 2005].

Increases in Output

Between March 2003 and May 2006, the NRC granted power uprates to sixteen reactors. The largest are 3.26% to Indian Point 2 and 4.85% to Indian Point 3, 5.2% to Seabrook, 8.0% to Waterford, and 20% to Vermont Yankee. The last was hotly contested by many Vermont residents. A total of 108 uprates have been granted to individual reactors since the practice began in 1977. As of April 2003, ten applications for uprates were pending with the NRC [US NRC, Power 2006].

Generation/Capacity

According to the Web site of the Nuclear Energy Institute, in the United States in 2005, 103 commercial reactors generated 782.0 billion kilowatt hours of electricity or 19.4% of the total electricity produced. The average net capacity factor for US plants in 2005 is estimated to have been 89.6%. This figure represents a slight decrease since 2002 when it was 90.4% [NEI, U.S. 2006]. A bigger decrease might have been better from a safety standpoint, as raises in capacity have been achieved since the 1980s and 1990s by running plants with fewer and/or shorter shutdowns for refueling and maintenance.

New Roles for Reactors

Production of tritium for nuclear weapons continues in the Tennessee Valley Authority's Watt's Bar and Sequoyah reactors, and construction of the Savanna River Tritium Extraction Facility is expected to be completed in 2006. However, the plan to render military plutonium useless by incorporating it in mixed oxide (Mox) fuel for civilian nuclear reactors is faltering.

Construction has not yet begun on the Mox fuel fabrication plant slated to be built at the Savannah River Site, and the future of the plant is in doubt. The plant at Savanna River was to be constructed in parallel with a plant in Russia, with each to turn into fuel for civilian nuclear reactors 34 tons of its nation's surplus military plutonium. Problems with plans for the plant in Russia have caused delays in building the US plant. The Bush administration has requested $600 million for the US plant in FY 2007, but in May 2006 the energy appropriations bill passed by the House eliminated funding for the Mox

program. Congress still has months in which to restore the money, but whether or not it will do so is uncertain [Gilliland 2006].

One reason for the doubts is that the project will be more costly than expected. DOE's (US Department of Energy's) inspector general reported in December 2005 that, as of July 2005, the National Nuclear Security Agency's (NNSA's) estimate for the cost of design and construction was $3.5 billion, up $2.5 billion from its previous estimate.

Safer reactors?

Utilities planning to construct new nuclear reactors in the near future will use what are known as Generation III or Generation III+ designs and appear to be particularly interested in the AP-1000 from Westinghouse and the Economic Simplified Boiling Water Reactor (ESBWR) from General Electric. However, one joint venture, Unistar, which includes the French company Areva, intends to build EPRs (European Pressurized Water Reactors). The NRC certified the AP-1000 in January 2006 and is in the process of certifying the ESBWR. The EPR is going through pre-certification procedures [NEI, Industry 2006]. None of the three reactors is in operation anywhere in the world, although an EPR is under construction in Finland.

Generation III reactors, for which there are many designs in addition to the three mentioned above, are based on the designs of operating boiling water and pressurized water reactors. The EPR, for instance, has been developed from the French N4 and the German KONVOI reactors, the most recent Generation II reactors in their respective nations. Their promoters claim that the new reactors will be safer than Generation II reactors, but, since none are in operation, the vaunted advantages have not been tested

and some already appear questionable. EPR has a core catcher intended to hold melted fuel in the case of a core meltdown. However, a steam explosion could take place before or after the melted fuel reaches the core catcher, and it is not clear that the fuel that is caught by the catcher will not eat through it. The AP-1000 is praised for having passive safety features (safety features that function automatically and without electricity), but it nevertheless relies on valves and on active heating, cooling, and ventilating units.

To "burn" fuel made from plutonium and other transuranic elements, the Bush administration plans to develop Generation IV reactors. The Advanced Burner Reactor (ABR), its current preference, would be similar to a plutonium-fueled breeder reactor, but without the blanket of uranium that these reactors use to create plutonium. Breeder reactors are not safe. They are generally cooled with liquid sodium, which catches fire in contact with air and explodes in contact with water [Hirsch et al. 2005]. The few breeders that have been operated have a history of accidents. Due to an impressive series of "mishaps," the French Superphénix breeder reactor functioned for the equivalent of only 174 days of full-time service between its startup in 1974 and its official shut down in 1997 [Davis 2001].

HEALTH AND THE ENVIRONMENT

Low-Level Radiation

June 29, 2005, the National Academy of Sciences' Research Council released a long-awaited report on radiation risk, the seventh in a series of reports known as Biological Effects of Ionizing Radiation (BEIR). BEIR VII, as the new report is referred

to, focuses on low-level doses of ionizing radiation, which it defines as doses ranging from nearly zero to about 100 millisievert (mSv). Based on a review of biological and biophysical data, it supports a "linear, no-threshold" risk model, according to which even "the smallest dose of ionizing radiation has the potential to cause an increase in health risks to humans" [National Academies, Low 2005]. In other words there is no threshold of exposure below which ionizing radiation can be considered to be harmless. Ionizing radiation is radiation strong enough to break biomolecular bonds; a sievert measures radiation energy deposited in living tissue. On average residents of the United States are exposed to 3 mSv of "natural background" radiation each year. Current evidence shows that exposure to low levels of radiation can damage DNA, which eventually causes cancer. More research needs to be done to find out if low doses can cause other health problems like heart disease and stroke, the report states.

BEIR VII estimates risks for cancer and for death for men and for women according to age at exposure. Women have on average a 37.5% higher risk of dying from cancer due to a given exposure than men do. Children are even more sensitive to radiation. Boys in their first year of life have three to four times the cancer risk from a given exposure that men ages twenty to fifty do. Infant girls have almost twice the risk of infant boys [Committee, Health 2006; IEER 2005].

The report is significant for the nuclear industry in that nuclear power plants release low levels of radioactivity even when they are operating correctly, in particular in the form of tritium, carbon 14, rare gases, and iodine. The industry cannot claim that its releases, even those that are routine, have no effect on the health of people living or working near the plants.

Chernobyl

The catastrophic accident at Chernobyl Unit 4 in the Ukraine April 26, 1986, was much in the news in 2006 due to activities and reports connected with the twentieth anniversary. The number of deaths that have resulted and will result from that event was hotly disputed, as in the past. The Chernobyl Forum, which included the International Atomic Energy Agency, the World Health Organization, and other UN organizations, reported in October 2005 that, in the three most contaminated areas of Belarus, Russia, and Ukraine, no more than 50 deaths can be directly attributed to acute radiation syndrome and that the accident will eventually cause only some 4000 deaths from cancer [Chernobyl Forum 2003-2005]. On the other hand, a report commissioned by Greenpeace and released April 18, 2006, estimated that, worldwide, Chernobyl will cause 270,000 cases of cancer, of which 93,000 will prove fatal. Greenpeace is looking at illnesses other than cancer that are likely to have been caused by the accident, but says that the only accepted methodology for estimating the health impact is calculating excess cancers [BBC 2006].

Whatever the actual toll in terms of health, the situation in 2006 in the area of the reactor, as detailed by a report from Large Associates, is deplorable. The problems there, though complicated by the fact that they are in the former Soviet Union, suggest how intractable the consequences of any major nuclear accident would be.

-- The three Chernobyl reactors that remained in operation after the accident at Unit 4 have been shut down, but they remain fueled, because there is nowhere to put the irradiated fuel if it is removed.

-- A dry storage facility, known as Vector, is to be constructed at the site with financing from the European Union. It was to be ready to receive the fuel in 2003, but will not open until 2010. The reasons for the delay are in dispute.

-- The site's cooling lagoon, which was heavily contaminated by fall-out and in which contaminated materials were dumped during clean-up activities, is leaking radioactivity into the basin of the Dnieper River, on which most of the people of Ukraine rely for water. If a retaining embankment gives way, highly contaminated sediment could enter the basin. A study concludes that the cooling lagoon could be allowed to drain naturally and the contaminated sludge bulldozed into the depressed areas of the lagoon where it would remain. The lagoon cannot be drained, however, until the fuel has been removed from the reactors at the site and the cooling water is no longer needed for cooling.

-- Complete decontamination of the Exclusion Zone would require removing 21 million cubic meters (m3) of contaminated material. Since such decontamination would be extremely difficult and expensive to accomplish, the decontamination goal has been reduced more than once, and the material now said to be in urgent need of management is 600,000 m3 of waste suitable for storage and 7,500 m3 suitable for incineration. The waste that is to be stored will go into Vector, but no study has been done of the level of exposure of the workers who will be needed to package and transport the waste.

-- The sarcophagus shielding Unit 4 is in poor condition, but whether or not a new sarcophagus is needed is a matter of debate. The scientific community in the Ukraine would prefer to use the money that would be spent on a sarcophagus for stabilizing and ultimately recovering the radioactive materials remaining within the damaged reactor.

Meanwhile, 7,500 people work in the Exclusion Zone (within a 30 km radius of Unit 4), where they are needed to monitor the shut-down reactors and the eight hundred or so waste dumps that were hastily built after the accident, maintain the barriers that prevent heavy contamination of the Dnieper Basin, and work on construction projects including Vector. In the "contaminated territories" around the Exclusion Zone some 1.3 million Ukrainians live. (Others people live on contaminated land in Belarus.) Most are farm families who eat the food that they produce. The workers and the farmers receive some financial compensation for working and living in irradiated areas; but the government is not doing enough to prevent the farm families from eating food that is contaminated, although the cost of preventing such contamination would be relatively small [Large 2006].

Environmental Contamination in the United States

Leaks of contaminated water from reactors are in the news in 2006. In March 2006, workers at the Palo Verde plant in Arizona discovered tritium in an underground pipe vault. That same month, Exelon's Braidwood nuclear plant in Illinois experienced a leak of tritiated water; and at Entergy's Indian Point plant on the Hudson River in New York State, not only tritium but also radioactive strontium and nickel-63 have been found to be leaking [Wald, Nuclear 2006].

March 16 the attorney general of Illinois and the state's attorney of Will County filed a lawsuit against Exelon Corporation for a series of tritium leaks at Braidwood going back to 1996. Tritium, a radioactive form of hydrogen, which increases the risk of developing cancer, has reportedly contaminated the well of one family. The suit alleges

that six releases were caused by “inadequate maintenance and operation” of the pipe carrying waste water to the Kankakee River, and that the plant has a history of not reporting leaks to officials and the public when they occur [Madigan 2006]. Private citizens have also filed suit [Exelon 2006]. As the result of publicity over the leaks at Braidwood, Exelon has surveyed its nine other nuclear plants and found tritium contamination at two of them [Wald, Nuclear 2006].

At Indian Point the nickel-63 may come from the cooling pool of Unit 1, which is shut down; but the tritium and strontium stem from Unit 2, which is operating, and have leaked to within a few hundred feet of the Hudson River [Wald, More 2006]. The tritium and strontium were discovered in August, 2005, but elected officials were not informed of them for a month [Clary, Nuclear 2006]. The strontium, a carcinogen, is at concentrations three times higher than the drinking water standard; tritium is also at levels above the standard. In mid-April the environmental organization Riverkeeper filed papers stating its intent to sue to involve EPA in investigation of the strontium leak and to increase public involvement in the cleanup. The strontium comes from a holding tank and thus can be considered to be a hazardous waste, the domain of the EPA, Riverkeeper maintains [Clary, Riverkeeper 2006].

Forced to act by the hubbub over Braidwood, the NRC (US Nuclear Regulatory Commission) announced March 19 that it would investigate leaks of tritium from nuclear plants and determine whether stricter regulations on monitoring are necessary. May 9 the nuclear energy industry’s Nuclear Energy Institute (NEI) announced new guidelines on leaks that will go into effect July 31, before the NRC’s task force on leaks reports its findings. In the words of an industry spokesperson, they require utilities “to better detect,

measure and report inadvertent releases to groundwater" [Industry 2006; Clary, Nuclear 2006].

RADIOACTIVE WASTE

Mill Tailings

In September 2005, the US Department of Energy (DOE) released a Record of Decision on remediation of the tailings that the Atlas Corporation Mill dumped next to the Colorado River near Moab, Utah. Groundwater at the site is to be actively remediated and the tailings taken, largely by train, to the Crescent Junction Disposal Site [US DOE 2005]. Crescent Junction is more than thirty miles from the river and, according to the US Environmental Protection Agency, is in a geologically stable area [US EPA 2006]. Congress had required DOE to assume ownership of the Moab site after a series of unsuccessful remediation proposals and the bankruptcy of the Atlas Corporation.

A report by Paul Robinson, *Uranium Mill Tailings Remediation Performed by the US DOE,* summarizes and evaluates the DOE's cleanup program for the sites that provided uranium exclusively to the nuclear weapons program. He states that surface remediation is "essentially complete" at the twenty-four sites in the program, but that most of the sites still have a problem with groundwater contamination [Robinson 2004].

High-Level Waste

Preparations for establishing a deep underground repository for irradiated fuel at Yucca Mountain, some ninety miles northwest of Las Vegas, are in increasingly serious trouble. As of April 2006, DOE is more than three years behind schedule in filing with the NRC (US Nuclear Regulatory Commission) a license to operate the facility. Meanwhile, irradiated fuel is accumulating at the rate of approximately 2000 tons a year.

DOE secretary Samuel W. Bodman told nuclear industry executives February 13, 2006, that DOE can no longer estimate when the repository will open. DOE's last stated estimate was 2012 [Wald Big, 2006].

Bodman also said that DOE may never be able to give an accurate advance estimate of the cost. (A week previously deputy energy secretary Clay Sell indicated for the first time that funding available for the repository may not be sufficient.) DOE (US Department of Energy) has already spent $8 billion to $9 billion on the repository. As of 2004 a Nuclear Waste Fund into which consumers of nuclear-generated electricity pay one cent for every ten kilowatt hours of electricity used had accumulated nearly $15 billion [NEI 2004]. DOE's last public estimate of the total cost was $60 billion, announced in 2001 [Wald and Janofsky, Questions 2006].

Bodman pointed to three problem areas that have come to light in the last two years and that are causing delays: EPA standards, the work of the US Geological Survey, and DOE's own planning [Wald, Big Question 2006].

-- In July 2004 the US Court of Appeals for the DC Circuit ruled that EPA had acted illegally in setting 10,000 years as the period during which radiation in drinking water at the site's boundary cannot exceed drinking water standards. The National Academy of Sciences (NAS) had determined that radiation in drinking water should not

exceed standards at the time when the dose to the public would be at its highest; and the 1992 Energy Policy Act requires EPA to comply with the National Academy's recommendations. The peak would occur about 300,000 years, not 10,000 years, after site closure [Boyd 2005]. EPA has now lengthened the time period covered by its standards to one million years, but it allows future generations to receive at least twenty-three times more radiation than is acceptable for the current generation. Thus, the standard is open to another court challenge [Kamps 2006].

-- In early 2005 DOE announced the discovery of e-mails written by employees of the US Geological Service (USGS) under contract to the Yucca Mountain project indicating that scientific findings relating to water infiltration at the proposed site may have been falsified and expressing scorn for the quality assurance program at Yucca Mountain. The Government Accountability Office (GAO) notes that these e-mails cast doubt on the reliability of hydrological studies of the site and raised suspicions about other aspects of the quality assurance program. As a result, DOE is reworking technical documents written by USGS personnel to ascertain whether there is a scientific basis for the conclusions on water infiltration in the documents and is also attempting to review some 14 million e-mails to learn whether they contain indications of other problems [Wells 2006].

-- DOE project managers have decided that they need to space wastes more widely than DOE had planned in order to prevent temperatures inside the mountain from reaching the boiling point.

Actions recently taken by DOE reflect the stresses within the project. DOE in December 2005 ordered management contractor Bechtel SAIC (known as BSC) to stop

work on “engineering and pre-closure safety aspects of repository designs” until deficiencies in the design control process could be corrected [Tetreault 2006]. Then DOE announced that it would not renew Bechtel-SAIC’s management contract, which was to expire in March 2006. Sandia National Laboratories has taken over many aspects of BSC’s work, a change that will cause further delays [Kamps 2006]. Furthermore, DOE in October 2005 embarked on a reorganization plan, which it called a New Path Forward. The Government Accountability Office is not impressed. GAO reports that the DOE has a history of quality assurance problems and that efforts to solve them have been unconvincing. The agency’s attempts to improve its performance tend to fall apart, because DOE does not have the management tools to track progress in addressing problems. Furthermore, the changes that it initiated in October 2005 may lead to confusion and cause earlier problems to recur [Wells 2006].

Congress appears to be losing faith in Yucca Mountain, as its appropriations are faltering. It appropriated $557 million for the project for 2005; $445 million for FY 2006. The projected budget for 2007 is $544.5 million. Three years ago the budget for 2007 was predicted to be $2 billion [Kamps 2006].

As a means of storing irradiated fuel until a permanent repository opens, the consortium Private Fuel Storage, LLC (PFS) wants to operate a temporary above-ground storage facility on the reservation of the Skull Valley band of the Goshute. In March 2006 the NRC licensed the consortium to operate the site, although it is located 60 miles west of Salt Lake City and next to an Air Force bombing range. Also in March, the consortium proposed to Congress that DOE avoid having to pay financial compensation to utilities for not accepting their irradiated fuel for storage in 1998 by taking title to the

utility fuel now and paying to store it at the site or alternatively allowing the utilities to continue to own their fuel but reimbursing them for storing their fuel at PFS [Wald, Utilities 2006].

Nevertheless, the PFS site may never go into operation. Construction cannot start until the Bureau of Land Management (BLM), the Bureau of Indian Affairs, and the Surface Transportation Board approve of the plans and until PFS proves that it can finance the project. Financing became doubtful after Southern Company withdrew from the project and Xcel, which owns 33% of PFS, froze its financial contribution [Xcel 2005]. Furthermore, transportation has become a major problem, because the establishment of the 100,000-acre Cedar Mountain Wilderness Area on BLM land in January, 2006, prevents PFS from building a spur railroad to the plant, as it had planned to do. The alternative would entail switching transportation canisters from trains to trucks for the last twenty-six miles of the trip to the storage site [Struglinski 2006]. The governor of Utah is fighting the site, which residents of Utah fear will become a permanent storage area.

In part in response to the problems at Yucca Mountain, the Bush administration is pushing ahead with reprocessing, which it promotes as a means of managing irradiated fuel. Reprocessing is the technology that President Jimmy Carter decided in 1977 not to implement in the United States, because it would increase stocks of separated plutonium. The process involves dissolving irradiated fuel in acid and separating the uranium and plutonium from the resulting liquid and then from each other.

Under the Bush administration research and development on reprocessing have, in part, been combined with research and development on fast neutron reactors in what the

administration terms the Advanced Fuel Cycle Initiative (fast neutron reactors would be fueled with plutonium separated from irradiated fuel by reprocessing). For FY 2006 DOE received $50 million for a pilot reprocessing program and some $80 million for research on reprocessing under the Advanced Fuel Cycle Initiative. The pilot reprocessing program was to go towards building an engineering-scale demonstration reprocessing plant, selecting sites for full-scale reprocessing plants by FY 2007, and beginning construction on one or more plants by 2010 [UCS, Congress 2006]. For FY 2007 the administration requested $250 million for the Advanced Fuel Cycle Initiative as part of a total request of more than $1 billion for programs related to reprocessing and reuse of plutonium [Cochran 2006].

In the area of reprocessing, DOE is working with both pyroprocessing, a dry process, and Urex+ (Uranium extraction plus), a variation of the aqueous Purex process used in commercial plants overseas. Pyroprocessing, DOE says, is suitable for treating fuel from fast breeder reactors, none of which operate in the United States at present but which the administration would like to construct in the future; Urex+ is designed to treat oxide fuel from light water reactors, the type of reactors at US power plants today.

The Bush administration claims that both processes would produce plutonium contaminated with other transuranics (americium, curium, and neptunium), which would render the plutonium unsuitable for use by terrorists or aggressor nations in nuclear weapons or improvised explosive devices. Critics disagree with the administration about the proliferation resistance of fuel resulting from Urex+, as about the proliferation resistance of fuel resulting from pyroprocessing. Edwin Lyman of the Union of Concerned Scientists points out that the findings of two of DOE's own scientists

undermine DOE's claim. E. D. Collins of DOE's Advanced Fuel Cycle Initiative showed that the mixture of plutonium and other elements would not be sufficiently radioactive to kill or seriously hurt terrorists who steal and use it. Moreover, Bruce Goodwin of Lawrence Livermore National Laboratory found that nuclear weapons could be made from the mixture of plutonium and additional isotopes [UCS, Department 2006]. Thomas Cochran and Christopher Paine of the Natural Resources Defense Council sum up the situation:

> [Urex+] produces a mixture of plutonium and minor transuranic elements with a total radiation dose-rate far below the International Atomic Energy Agency's (IAEA) threshold for "self-protection" (i.e. a level of radioactivity making even short exposures to the material very hazardous to human health). Moreover, the critical mass of the UREX-plus mixed product is intermediate between weapon-grade plutonium and highly-enriched uranium, and therefore can be used in nuclear weapons.
>
> [Cochran 2006]

Reprocessing, moreover, is a dirty technology. Operating plants using the aqueous method emit gaseous effluents in quantity, particularly tritium, krypton, and iodine 129; produce as byproducts a large volume of low-level radioactive effluents and a highly radioactive acidic liquid containing the fission products and the transuranic elements except plutonium; and generate solid wastes, including the remains of the cladding from the irradiated fuel and various technological waste [Davis 2001]. The Urex+ method would separate out most of the transuranic elements along with the plutonium and uranium rather than leave them with the fission products, but management of the plutonium and other transuranic elements will require an entire new industry. Reprocessing is a creator of waste rather than an efficient method of managing existing waste. Furthermore, as even the Bush administration is forced to admit, reprocessing will not do away with the need for deep underground disposal. Even if plutonium and certain

transuranic elements can be transformed into elements with short radioactive lives, other transuranic elements will remain to be disposed of. The best that the administration can hope for in regard to repositories is that, with the help of reprocessing, there will be a smaller volume of waste to dispose of underground than if irradiated fuel were place underground as is.

Low-Level Waste

The three low-level waste sites in operation at the end of 2003 are still receiving waste in 2006. However, Envirocare of Utah, apparently seeking to improve its image, has changed its name to EnergySolutions. Barnwell, the only disposal site that currently accepts low-level radioactive waste classified as "B" and "C," will still stop accepting wastes from states other than South Carolina, Connecticut, and New Jersey (members of the Atlantic Low-Level Radioactive Waste Management Compact) June 30, 2008.

The only possible successor to Barnwell is still the site near Andrews, Texas, owned by Waste Control Specialists (WCS) of Dallas. Opening of this site is not a foregone conclusion. WCS filed an application for a license with the Texas Commission on Environmental Quality (TCEQ) August 4, 2004. The commission's Radioactive Material Licensing Team is scheduled to complete its technical review of the application by August 31, 2006.

Meanwhile, the WCS site has become a de facto radioactive waste storage site, as 1.5 million cubic yards of waste from DOE's Fernald site in Ohio are being sent there. The Ohio waste can remain only until October 2007 if TCEQ does not license the WCS site [Campbell 2005].

In March 2006 the National Academies' Research Council released a report calling for an overhaul of the regulations covering management of low-level radioactive waste. The current regulations are a "patchwork that has evolved over almost 60 years," the report states. Wastes are managed according to the type of industry that produced them rather than according to the risks or hazards that they represent. "A risk-informed approach" is needed. Changing the entire regulatory system rapidly would be difficult, if not impossible. Therefore agencies should adopt the new approach through incremental steps such as working together "to change licenses and permits for specific waste generators or disposal sites" [Committee, Improving 2006].

"Slightly" radioactive waste

Activists won a victory on the issue of "slightly" radioactive waste, which the authorities have referred to over the years under the terms "de minimis," "Below Regulatory Concern" (BRC), and "Incidental Radioactive Material." The NRC voted in March 2005 to reject a proposed regulation that would have eliminated the requirement that "slightly" radioactive waste be disposed of in licensed radioactive waste facilities. The commission's staff had prepared the proposed regulation in response to a request from the commission in 2002. In unanimously rejecting the proposal, the commissioners indicated that they may at some future date reopen the question of allowing "slightly" radioactive waste to be used, recycled, and disposed of in landfills not licensed for radioactive materials.

In the meantime the NRC continues to release radioactive waste on a case-by-case basis, according to procedures that "are not readily open to public notice, comment, or

intervention." Furthermore, the NRC has deregulated the transportation of the nuclear materials that would have been covered by the rejected regulation [NIRS, NRC 2005].

Depleted Uranium

Under pressure from the US Congress, DOE issued Records of Decision to construct and operate depleted uranium hexafluoride conversion plants at its Paducah, Kentucky, and Piketon, Ohio, enrichment sites July 20, 2004. A groundbreaking ceremony was held at the sites later in the month, and site preparation and related activities began immediately. September 30, 2005 DOE approved the final design of the plants and authorized full construction to proceed. Uranium Disposition Services, LLC (UDS), holds the contract to design, build, and operate the conversion facilities.

DOE is shipping the containers of uranium hexafluoride at Oak Ridge to Portsmouth for conversion of their contents. The transfer is expected to be completed during 2006. Before shipment began, Paducah stored 39,000 cylinders, Portsmouth/Piketon, 16,000 cylinders, and Oak Ridge, 5900 cylinders.

The plants will use a dry conversion technology based on technology in current use at Framatome's plant in Richland, Washington. It will produce uranium oxide "for disposal, storage, or re-use" and aqueous hydrogen fluoride to be sold commercially [UDS 2006]. The NRC ruled January 18, 2005, that depleted uranium from a uranium enrichment facility, i.e. in large quantities, can be categorized as low-level radioactive waste rather than Class A radioactive waste, the least radioactive and hazardous waste category (Memorandum and Order CLI-05-05). The decision was made in the context of licensing procedures for the LES enrichment plant, proposed for New Mexico.

Intervenors had argued that LES had no plausible strategy for disposing of the depleted uranium produced by enrichment. NRC's formal classification of the depleted uranium as low-level waste removed this contention, as turning the waste over to DOE then became a plausible strategy. The USEC Privatization Act (Section 3113[a]) requires DOE, if requested, to accept for disposal depleted uranium, if it is determined to be low-level radioactive waste.

Decommissioning

No nuclear power reactor has been shut down since Millstone 1 in 1998; and the total number of reactors greater than 100 MW that have been shut down remains at fourteen. Estimated dates of license termination, after the completion of decommissioning, are 2007 for Haddam Neck – Connecticut Yankee, 2008 for Yankee Rowe, 2009 for Rancho Seco, and 2034 for Peach Bottom 1. License termination dates for the other reactors have yet to be determined.

In addition to power reactors, various uranium recovery sites, test and research reactor sites, complex materials sites, and fuel cycle facilities sites are undergoing decommissioning [US NRC, Find 2006].

SECURITY

Design Basis Threat

The Nuclear Regulatory Commission (NRC)'s design basis threat (DBT), which describes the level of threat that protective forces at nuclear plants must be prepared to defend themselves against, remains grossly inadequate. The most obvious deficiency is the size of the attacking force. The DBT is still classified, but the Project on Government Oversight (POGO) has learned that in 2003, when the NRC approved changes to the DBT, it raised the number of outside attackers from three to five [POGO, Letter 2006]. The Government Accountability Office (GAO) in a report released March 14, 2006, *Efforts Made to Upgrade Security, but the Nuclear Regulatory Commission's Design Basis Threat Process Should Be Improved* (GAO-06-388), states more discreetly that the DBT, as revised in 2003, limits the maximum number of attackers to its staff's estimate of the size "of most known terrorist cells worldwide." The NRC, the report states, discarded the idea that multiple cells might attack a plant and requires defense only against a single cell.

As we write, through a rulemaking process on the DBT, the NRC is in the process of codifying the security requirements that it put into effect in 2003—in the words of POGO, five people, and in those of the GAO, a single cell. The attack of September 11, 2001 was made by multiple cells working together, and there is no reason to exclude the possibility of a multi-cell attack on a reactor. POGO, after talking to personnel in the military and in federal agencies, is convinced that "a serious terrorist attack on a nuclear plant would involve no less than a 'squad size'" force, between twelve and fourteen people [POGO, Letter 2006].

Attack could also come from inside the plant or from insiders working with outsiders. As of 2001, "no more than a single insider" was posited. The 2003 revision

downgrades even that threat. In the words of the GAO, the DBT states that "the likelihood of an active insider can be reduced by a human reliability program . . . designed to help ensure the reliability of personnel."

Terrorists attacking from the outside would likely be carrying weapons against which the DBT does not require a plant to defend itself: rocket-propelled grenades (RPGs); bangalore torpedoes, which can speedily open up a double fence; platter charges that can penetrate at least six feet of reinforced concrete; and 50 caliber armor-piercing incendiary (API) rounds, which could destroy bullet-resistant-enclosure guard towers from outside the plant's perimeter fence.

Alternatively they might use a vehicle bomb, larger than the bomb that the DBT specifies that plants must be prepared to counter [POGO, Testimony 2006]. According to the GAO, "The [NRC] staff considered [specifying in the DBT] a larger vehicle bomb size but decided against the larger size after obtaining comments from stakeholders, including the nuclear industry." The DBT ignores the possibility that an attack on a nuclear plant could be made by air.

A major reason for the weakness of the DBT appears to be lobbying of the NRC by the nuclear industry. The 2006 GAO report on the DBT shows that industry lobbying impacted decision making at two levels. The threat assessment staff made changes to the draft DBT after meetings with industry representatives. Thus the recommendations that the staff made to the NRC commissioners were watered down because of industry input. Then the commissioners "made some significant changes to those recommendations. These changes reflected the commissioners' policy judgments on what is reasonable for a private security force to defend itself against." Because the commissioners did not

identify to the GAO any criteria that they used in making these changes, their reasoning is suspect, the GAO states. The two levels of influence are obvious in relation to weapons. The staff decided against including certain weapons in the DBT after talking to industry; the commission then further watered down the draft by removing certain weapons that the staff had retained.

The NRC's DBT, in effect, describes the threat of an attack in terms of what the NRC and/or the nuclear industry believes that the private guards can do. However, private guards defend DOE installations, where the number of possible attackers is regarded as three times that of the NRC's DBT and where such weapons as rocket-propelled grenades must be protected against. For the civilian facilities, the price of protection in terms of dollars seems to be the limiting factor, and the true basis of the perceived threat seems to be what the industry thinks that it can afford to pay, POGO points out.

Despite the inadequate DBT, security has improved at nuclear plants since September 2001. The GAO report enumerates various positive changes, "including adding security barriers and detection equipment, implementing new protective strategies, enhancing access control, and hiring additional security officers." However, the GAO states that it cannot say whether the sites can defend themselves against even the unrealistic DBT, because the force-on-force tests that the NRC has conducted since such tests were reinstated in 2003 are not true tests and, in some cases, have, nevertheless, revealed significant inadequacies.

The NRC conducted force-on-force tests at twenty sites prior to November 1, 2005, the cut off date for the GAO study. Tests are scheduled and announced eight to

twelve weeks before they occur; and guards can tell within minutes when they will begin. The referees who decide who is killed in the exchange are sometimes volunteers from the plant rather than security experts. At approximately half the sites the security force and the people playing the role of attackers are employed by the same company, Wackenhut.

Even with the forewarning and the dubious background of the attackers, at some of the sites where the GAO observed tests, it saw attackers entering protected areas. At one site they succeeded in destroyed "three out of four targeted components." At another, they did not even attempt to reach the control room or irradiated fuel pool.

The NRC operates under a 1967 policy that it need not defend against "enemies of the state" [POGO, Testimony 2006]. The federal government must defend against such enemies. However, in the case of a terrorist attack, forces stationed outside the plant would likely not have the opportunity to intervene. A terrorist attack would either succeed or be quashed within three to eight minutes after it begins. According to the DOE, it would take one and a half to two hours for a SWAT team to go into action, since the team would first have to be assembled, to gather their equipment, to be transported to the site, and then briefed [POGO Testimony, 2006]. The public depends on the NRC's assuming the responsibility for defense.

The period for comments on NRC's proposed rule on the "Design Basis Threat" printed in the Federal Register (70 FR 76,380) November 7, 2005, has ended; but the final version of the rule has not been published as of late May. Despite comments from NGOs and individuals, no significant changes from the proposed version are expected.

Fuel Pools

A report by the National Academies' Board on Radioactive Waste Management, *Safety and Security of Commercial Spent Fuel Storage: Public Report* confirmed that "an attack which partially or completely drains a plant's spent fuel pool might be capable of starting a high-temperature fire that could release large quantities of radioactive material into the environment" [National Academies, Spent 2005]. The committee recommended that two measures be implemented "promptly" to reduce the likelihood of such fires: fuel in the pools should be reconfigured so that the freshest and most radioactive fuel is surrounded by older fuel, and sprinkler systems should be installed to cool fuel in the event of damage to a pool or the building housing it.

The committee, in fact, recommended that the NRC conduct additional study of the risks posed by fuel pools to better understand them and to make sure that operators take steps to reduce the possible consequences of attacks on the pools. Since risks vary with the design of plants, the study should be conducted on a plant by plant basis. While noting that civilian power plants have taken steps to increase security since September 2001, the committee stated that it could not obtain enough information to judge their effectiveness. Thus it recommended that an organization independent of the industry and the NRC assess them.

In response to a request to compare the value of dry cask storage to pool storage, the committee found that pools must be used to cool fuel for some five years after the fuel's removal from a reactor, but that for older fuel the casks have two advantages: passive cooling by air circulation and the fact that their use disperses the fuel by putting it into numerous "robust containers." The committee stopped short of recommending that fuel be shifted from pools to casks, as suggested by Robert Alvarez et al. in 2003; but

said that further analysis by the NRC may lead to the agency's finding that such a move would be wise at certain plants [Board 2006].

The Committee's report was essentially a review of security analyses already performed by the NRC, Department of Homeland Security, nuclear energy industry, and independent experts. It was released in a classified version to Congress, the NRC, and the Department of Homeland Security in July, 2004; but a declassified version was not available to the public until April 2005. In March 2005, the Nuclear Security Coalition, an alliance of forty-seven non-governmental organizations, had publicly decried the fact that the report was apparently being deliberately kept from the public [Citizens 2005].

Lack of Security at Research Reactors

An investigation of research reactors at twenty-five US universities in the summer of 2005 found glaring gaps in security. At various reactor buildings, doors were not locked, guard posts not manned, and vehicles able to park as little as fifty feet away without having been inspected for explosives. Visitors at some sites were given tours without showing identification or having their tote bags examined.

Eight of the reactors were fueled by highly enriched uranium, the material most desirable to terrorists for nuclear devices. These reactors will be converted to low-enriched uranium, but conversion is not expected to be finished before 2014. (Meanwhile, the University of Texas) Sandia National Laboratory, and other parties have signed an agreement to design a small high-temperature gas-cooled test reactor [GTMHR] that would be fueled with highly enriched uranium. The uranium would be

coated with a ceramic layer and dispersed in a graphite block. The reactor would be built in Andrews County, Texas [Critical, Andrews 2006].

Research reactors are smaller and less powerful than electricity generating reactors, and they use much less fissile material. The NRC and safe-energy organizations differ in their views of how damaging an explosion at such a reactor would be. Doubtless, the protection that the structure would offer varies from university to university. Their location on densely populated university campuses, often in urban areas, would increase the seriousness of any consequences.

The study was conducted by ABC News and ten graduate students from schools of journalism and government. The NRC subsequently investigated at least five of the universities for possible breaches of security protocol, and the agency promised to take enforcement action if action was found to be needed. As the result of the investigation, the NRC also reviewed security at additional schools [ABC News 2005].

Transportation Risks

In February 2006 the National Academies Press released a report entitled *Going the Distance? The Safe Transport of Spent Nuclear Fuel and High-Level Radioactive Waste in the United States* by a committee of its National Research Council. The committee concluded that, if terrorist attacks are excluded, the transportation of nuclear waste by truck and train is probably safe. However, it admitted that terrorism is a big exception. The committee had to make this exception, it said, because the NRC refused to give the researchers access to information that would have enabled them to evaluate the terrorist risk. The committee "recommends that an independent examination of the

security of spent fuel and high-level waste transportation be carried out with an investigation team made up of people with security clearances,
prior to the commencement of large-quantity shipments to a federal repository or to interim storage" [Committee, Going 2006].

Dirty Bombs and Cleanup

January 4, 2006, the Department of Homeland Security issued new guidelines for response to a "dirty" bomb that in effect increases the harm that such a bomb could wreak on the American public. The guidelines permit radioactivity from a "dirty" bomb to remain in place indefinitely at doses up to 10,000 millirems per year. A dose of 10,000 millirems per year is a thousand times higher than that permitted by EPA after cleanup at a Superfund site, and is so high that thirty years of exposure to it would lead to cancer or leukemia in one in four people.

Proponents of the measure have likened the permitted doses to existing "background" radiation. However, 10,000 millirems is thirty times higher than background radiation, and background radiation is not harmless. The government estimates, in fact, that background radiation leads to cancer in one in thirty people in the United States.

The public was able to comment on the guidelines, but they took effect as soon as they were issued. Furthermore, protests from some one hundred organizations against leaked versions of the guidance did not result in any major changes [NIRS, Department 2006].

NUCLEAR "RESURGENCE"

Energy Policy Act of 2005

The Bush administration is forging ahead with its attempts to revive the nuclear industry. The Energy Policy Act of 2005, for which the President campaigned, authorized more than $13 billion of financial support for the effort. The Nuclear 2010 program and an Advanced Fuel Cycle Initiative are moving forward and have been folded into a yet more ambitious program the Global Nuclear Energy Partnership (GNEP), which Bush announced in 2006.

A precise total for the subsidies authorized by the Energy Policy Act cannot be calculated, because some of the items are open-ended. However, Critical Mass assesses the subsidies at more than $13 billion.

According to Critical Mass's calculations, research and development received $2.9 billion, with the largest item being $1.1 billion over three years for nuclear fusion. More than $432 million over three years was authorized for DOE's Nuclear Power 2010 program to further construction of new nuclear reactors using existing designs and its Generation IV program to design advanced reactors. Nuclear reprocessing and transmutation were authorized to receive $580 million over three years. Other funding including authorizations for education in the nuclear field and for various commercial applications of radioactivity.

For construction subsidies $3.25 billion was authorized, with $2 billion allocated to "risk insurance," which would compensate the nuclear industry for delays in

construction and authorization of new reactors, including delays caused by the Nuclear Regulatory Commission and interveners in licensing proceedings. (The insurance program is known as the Standby Support program [US DOE, Global 2006].) Loan guarantees for up to 80% of the cost of a project, including building new power plants, were authorized. No dollar limit was given; the only specification was "such sums as are necessary." As with all other items in the legislation, the actual funds must be appropriated by Congress. If Congress grants loan guarantees for six nuclear reactors, the cost to taxpayers would be $6 billion, based on a default rate of 50%, the rate projected by the Congressional Budget Office [NIRS, Nuclear 2006], and a construction cost of $2.5 billion per reactor. A third item in the construction category was authorization of $1.25 billion and necessary additional sums to pay for construction of a prototype nuclear plant at Idaho National Engineering and Environmental Laboratory (INEEL) to generate hydrogen to serve as an alternate fuel.

Operating subsidies total $5.7 billion plus. This figure includes reauthorization of the Price Anderson Act to cover reactors built in the following twenty years. Industry liability would be capped at $15 billion per accident, well below actual costs of a major accident. The industry was also authorized to receive production tax credits of 1.8 cents for each kilowatt hour of electricity generated by each new reactor in the first eight years of operation. This tax credit could cause a loss of $5.7 billion to the federal government.

Critical Mass's final category is shut-down subsidies. It calculates a cost to the federal government of $1.3 billion by changes in the rules for funds set aside by the nuclear industry for decommissioning shut-down plants [Critical, Nuclear Giveaways 2006].

Nuclear Power 2010

As of early 2006, the NRC is still considering the three applications for Early Site Permits that it received in 2003: from Dominion Generation for one or two reactors at its North Anna site in Mineral, Virginia; from Entergy for one or two reactors at its Grand Gulf site in Port Gibson, Mississippi, and from Exelon for one reactor at its Clinton site in central Illinois. According to the Nuclear Energy Institute, the NRC is expected to grant Dominion an Early Site Permit in 2006 and Entergy and Exelon, early site permits in 2007.

Early Site Permits are intended to resolve site safety, environmental protection, and emergency preparedness issues independent of a specific nuclear plant design. NRC presents its findings in the form of a Safety Evaluation Report and Draft and Final Environmental Impact Statements. A public hearing is mandatory after the safety review is complete.

Granting of an Early Site Permit will allow the recipient to perform "non-safety site preparation activities, subject to redress" before receipt of a Combined Construction and Operating License (COL) [US NRC, NRC 2006]. Although an Early Site Permit is not a prerequisite for a COL, obtaining a permit will give the applicant a head start on its application for a COL, as the applicant can reference in the COL application, information in its application for the site permit. An Early Site Permit will be valid for 10 to 20 years and renewable for 10 to 20 years.

A consortium, led by Dominion and including General Electric and Bechtel, has entered into the Dominion North Anna Construction and Operating License

Demonstration Project and is expected to file a COL application for North Anna in 2007. NuStart Energy Development, a group of nuclear utilities and reactor vendors, which includes Entergy, owner of the Grand Gulf site, and Exelon, has entered upon the Nustart Energy Construction and Operating License Demonstration Project. Part of the Nustart Project's work was to select a site for a COL application. It is expected to file an application for a COL for Grand Gulf in 2007 or 2008.

Nustart has also taken over from the Tennessee Valley Authority (TVA) a project at TVA's Bellefonte site in Alabama. In 2004 a consortium led by TVA asked DOE for and was granted $2.1 million to perform a *Cost and Schedule Study for Deployment of an Advanced Boiling Water Reactor Plant at TVA's Bellefonte Site*. TVA was to use the results of the study, which it completed in September 2005, to decide whether to apply for a COL [Critical, TVA 2006]. However, Nustart, to which TVA belongs, jumped the gun by signing a cost-share agreement with DOE in May 2005 for the licensing of both North Anna and Bellefonte [Critical, NuStart 2006]. An application for a COL for Bellefonte is expected in 2007 [NEI, New 2006].

In the midst of the signings, there is one cautionary note. As of May 2006 Exelon had not submitted an application for a COL for its Clinton site.

Apart from the four sites, named above as the subject of Early Site Permit applications or COL Demonstration Projects, utilities or groups of utilities are talking about possibly constructing new reactors in eleven additional locations. All except three counties singled out by Duke Energy are already the sites of nuclear reactors. The additional locations are:

-- River Bend, Louisiana (Entergy)

-- Vogtle, Georgia (Southern Company);

-- Shearon Harris, North Carolina (Progress Energy);

-- Crystal River or another site in Florida (Progress Energy);

-- Summer, South Carolina (SCANA and Santee Cooper);

-- Cherokee County, South Carolina (Southern and Duke Energy);

-- Calvert Cliffs, Maryland (Unistar);

-- Nine Mile Point , New York (Unistar);

-- Davie County, North Carolina (Duke Energy);

-- Oconee County, South Carolina (Duke Energy).

Applications for COLs for River Bend, Vogtle, Shearon Harris, Summer, Cherokee County, and Calvert Cliffs or Nine Mile Point are expected in 2007 or 2008. These six applications, along with the three for North Anna, Bellefonte, and Grand Gulf would mean a total of nine filed before 2009 [NEI, New 2006].

Under its Nuclear Power 2010 program, DOE is paying up to 50% of the cost of each of the three Early Site Permit Projects. For Clinton, for example, DOE agreed to pay 45%, $6.3 million out of a total cost of $13.9 million through 2006 [Critical, Clinton 2006]. It is also paying up to 50% of the cost of each of the three COL projects. Dominion received an initial $9 million, but the amount of money it has since received is unclear. Nustart negotiated a 50% cost-share agreement, $260 million from taxpayers and $260 million from Nustart, for the licensing process for one reactor each for Grand Gulf and Bellefonte. Its initial payment was $4 million. Critical Mass Energy Project, which is following the question of federal subsidies, has had to file Freedom of Information Act (FOIA) requests to try to find out how much taxpayer money is being

provided. The organization does know that from FY2001 to FY2006 the Nuclear Power 2010 program was appropriated more than $186 to disburse [Kemp 2006].

If utilities actually order and begin building reactors, they will be eligible for risk insurance, loan guarantees, and production tax credits, as listed under the Energy Policy Act of 2005 at the beginning of this section. Details of these subsidies are being "worked out" as we write. Critical Mass believes that they will have a greater influence on the plans of utilities than will the payments to help with licensing applications.

The licensing activities that DOE is funding under the Nuclear 2010 program are aimed at putting into operation "advanced" light water reactors, what DOE terms Generation III+ reactors such as Westinghouse's AP-1000 and General Electric's ESBWR. According to DOE, the program is based on "expert industry recommendations documented in *A Roadmap to Deploy New Nuclear Power Plants in the United States by 2010* and the *Business Case for New Nuclear Power Plants in the United States*" [Office 2006]. No new nuclear power plants can possibly be deployed by 2010, because the COL process alone is expected to take between twenty-seven and sixty months [Detailed 2006] and construction to take an additional four years. Reactors that start the COL process in 2007 and 2008 are expected to be deployed in the mid 2010s.

The first reactor to be added to the nation's operating fleet, however, is likely to be none of the above; but TVA's Unit 1 at Browns Ferry, Alabama. Browns Ferry 1 began operating in 1973, but was heavily damaged in a fire in 1975. In 1984 it and the two other reactors at the site were shut down because of safety concerns. Units 2 and 3 restarted in the 1990s, but Unit 1 is only now being overhauled. As of May 2006,

changes to the hardware were 83% complete, and TVA hopes to receive authorization to put the reactor back on line in early 2007 [Faulk 2006].

Global Nuclear Energy Partnership

February 6, 2006 the Bush administration announced the Global Nuclear Energy Partnership, a multi-faceted plan to promote nuclear energy worldwide while supposedly preventing the proliferation of fissile material. Its key elements are:

-- expanding the use of nuclear power within the United States;

-- developing, demonstrating, and deploying reprocessing technology that the administration claims will be proliferation proof;

-- decreasing the volume of radioactive waste to be stored at Yucca Mountain by reusing at least the transuranic elements extracted from irradiated fuel by reprocessing;

-- developing and deploying reactors that can use fuel made from the transuranic elements;

-- in partnership with other nuclear nations, lending fissile material to countries now without enrichment and reprocessing facilities and receiving back the fuel after it has been irradiated;

-- developing and deploying small-scale nuclear reactors suitable for developing countries;

-- to safeguard nuclear materials, incorporating advanced safeguards procedures into the planning and building of new nuclear facilities [US DOE Global, 2006].

The problems with nuclear power in general and with reprocessing of irradiated fuel, as discussed in the section on Radioactive Waste, are carried over into this program. Furthermore, the international dimension of the program is wildly unrealistic. The administration has presented it as an answer to nuclear proliferation. Problems of nuclear proliferation are occurring today. The United States and other nuclear nations have the ability to ship enriched uranium to other countries at present, but they do not have in place the back-end of the chain that they are designing. It may well be impossible to develop reprocessing technologies that are proliferation proof, but even if it were possible to do so, they would, after being perfected, require the construction of an array of new facilities: reprocessing plants to separate the plutonium and transuranic elements from the irradiated fuel, vitrication plants to solidify the highly radioactive liquid waste that would be produced, fast neutron reactors to "burn" the fuel in such a way that certain actinides would be rendered less or non-radioactive; fuel fabrication plants to make the fuel for these reactors. Although DOE intends to complete a prototype fast reactor by 2015, implementing the entire program will take decades, if indeed all aspects can be realized. Furthermore, whether or not the program is successful, it will absorb vast sums of money. Thomas Cochran and Christopher Paine of the Natural Resources Defense Council estimate that the "initial demonstration phase of the GNEP will cost $30 to $40 billion over the next 15 years without generating a single kilowatt of commercially available electric power" [Cochran 2006]. The administration, it is to be noted, did not estimate the cost of the program when it introduced it. And, the kicker, what country will want to take back the irradiated fuel, reprocess it, and dispose of the resulting highly

radioactive liquid and voluminous and varied low-level wastes? Does the United States really want to start importing other nations' waste?

Nevertheless, the administration is rushing to implement the new program. March 17, 2006, DOE announced that it was seeking, by the end of the month, expressions of interest (EOIs) in proposing and evaluating sites for demonstration of GNEP technologies. The agency received thirty-six EOIs and plans to issue a request for proposals later in the spring. It plans to award contracts for the preparation of site evaluation studies for "engineering scale demonstrations" of advanced recycling technologies (a reprocessing plant, a reactor that can be used for transmutation, and a fuel fabrication facility) in the summer. Results of these studies are to be used to help prepare an Environmental Impact Statement (EIS) [Horner 2006].

March 22, 2006, DOE published in the Federal Register an advance Notice of Intent to prepare an EIS for the GNEP technology demonstration program. It plans to issue a final Notice of Intent in the summer of 2006 [US DOE, DOE 2006].

Washington Savannah River Co. (WSR), the private company that manages the Savanna River Site for DOE, was among the entities that sent an expression of interest in the GNEP demonstration facilities to DOE. *Greenwire* reports that DOE on March 3 directed WSR to prepare a project management plan by June 30 [O'Driscoll 2006]; and *Nuclear Fuel* states that DOE has asked WSR to do preliminary work on an engineering scale demonstration of the reprocessing facility [Horner 2006]. DOE has admitted that the F-Canyon reprocessing plant at Savanna River, which separated plutonium for nuclear weapons from irradiated fuel, is under consideration for GNEP. The facility was in the process of being deactivated but deactivation has been halted [Clements 2006]. As

mentioned earlier, the Bush administration intends to build a facility to produce Mox fuel at SRS.

Fortunately there are signs that Congress may apply the brakes. In May, 2006, the House Appropriations Committee cut $30 million and an appropriations subcommittee cut $100 million from the Bush administration's request for $250 million for the Advanced Fuel Cycle program for FY 2007. The Appropriations Committee gave the $30 million that it cut to other energy-related programs including weatherization and energy-efficient building technologies [UCS, House 2006; Olson 2006].

Media are Pushing the Idea of the Resurgence

The media are pushing the idea that a nuclear renaissance is about to occur, and that, in the face of global warming, environmentalists are dropping their antinuclear position. Headlines like "Nuclear Power Critics Reviving More Slowly than Industry" (Associated Press, January 13, 2006), "Old Foes Soften to New Reactors" (*New York Times*, May 14, 2005), and "Nuclear Moves to Front Burner; Bush Push for Energy Reactors May Not Get Much Heat from Former Foes of Atomic Power" (*San Francisco Chronicle*, February 12, 2006) have become commonplace. Writers of these articles and presenters of the same theme on television and radio like to quote examples of the greens who are turning nuclear. A few names crop up repeatedly: James Lovelock, Stewart Brand, Hugh Montefiore . . ., but none more often than Patrick Moore, who is always presented as a co-founder or, if the publication is really carried away, as the founder of Greenpeace. Moore heads a company called Greenspirit Strategies Ltd., which describes itself on its web site as working "with leading organizations in forestry, biotechnology,

aquaculture, plastics and mining, developing sustainability messaging in the areas of natural resources, biodiversity, energy and climate change. . . . During the past 15 years, we have managed the environmental reputation of leading global industries. . ." [Greenspirit 2006]. According to SourceWatch, a project of the Center for Media & Democracy, Moore "has worked for the mining industry, the logging industry and in defense of the use of biotechnology" [Patrick 2006].

Now he is working for the nuclear industry. April 16, 2006, he published in the *Washington Post* an opinion piece that was particular offensive to opponents of nuclear power. It was headed, "Going Nuclear: A Green Makes the Case." April 21, 2006 the Post published pointed answers from Edwin S. Lyman of the Union of Concerned Scientists; Jack C. Star, host of a Web site on solar energy; John Passacantando of Greenpeace; and Helen Caldicott of the Nuclear Research Policy Institute. "The only thing that is 'green' about Patrick Moore these days are the dollar bills lining his pocket from corporate interests," Passacantando began.

April 24, 2006, as if in direct corroboration of Passacantando, the formation of the Clean and Safe Energy Coalition was announced. The Coalition will be funded entirely by the Nuclear Energy Institute (NEI), composed of nuclear power plant owners and others supporting the industry, Steve Kerekes, spokesperson for NEI told the press. Patrick Moore and Christie Todd Whitman, President Bush's first head of the Environmental Protection Agency, will speak for the Coalition and with it the industry--and they will be paid for their time and work [Koff 2006].

Resistance to Nuclear Construction

Despite the predictions that environmentalists and safe energy activists will acquiesce to a nuclear renaissance, the opposition is very much alive. To mention just a few examples, the New Jersey Public Interest Research Group (PIRG), other citizen organizations, and the New Jersey Department of Environmental Protection are fighting to prevent renewal of the license of Oyster Creek in New Jersey, the oldest operating commercial reactor in the United States. The South Carolina Chapter of the Sierra Club is actively opposing reprocessing of irradiated fuel at Savannah River or elsewhere. The Blue Ridge Environmental Defense League (BREDL), the Nuclear Information and Resource Service (NIRS), and Public Citizen are interveners in the application of Dominion Generation for an Early Site Permit for additional reactors at its North Anna site. They filed two contentions, one of which has been dismissed, but the second contention, on water impacts, has already resulted in Dominion's changing the design of the proposed cooling system and is still unresolved. The change in design will delay NRC's decision on the license for at least nine months. Meanwhile, the People's Alliance for Clean Energy (PACE) has formed as a local chapter of BREDL to fight the proposed reactors [Critical, North Anna 2006]. Changes in regulations and other decisions by the NRC, including a determination in late 2002 that the risk of terrorism cannot be raised in licensing proceedings [Wald 2003], have reduced opportunities for intervention in these proceedings, but the opposition is making the best use it can of the remaining opportunities.

Furthermore, the Nuclear Industry Is Actually Dying

In the United States the NRC is in the midst of extending operating licenses, reactor by reactor, to sixty years. However, trying to operate reactors for sixty years raises significant safety issues. Already 108 reactors worldwide have shut down; these units had an average operating life of 21 years. As of March 25, the average age of operating reactors worldwide was 21 years. If one hypothesizes that the average lifetime can be doubled to 40 years, the lifetime assumed for commercial power plants at the time that they were built, approximately "80 reactors would have to be planned, built, and started up over the next ten years—one every month and a half—and an additional 200 units over the following 10-year period—one every 18 days in order to maintain the reactor fleet worldwide at its current level" [Schneider 2005].

Moreover, the Bush administration is more excited about the supposed nuclear renaissance than is Standard & Poor's. The credit rating agency released a report entitled *Credit Aspects of North American and European Nuclear Power* in February 2006. It suggests that nuclear power plants present a higher business risk than do other commercial means of generating energy. "New federal legislation has helped to create interest in the USA." The resurgence of interest here has come "mainly from generation owners and supportive legislation from the federal government" and may not be sufficient to overcome the risks associated with operation and high capital costs [Credit 2006].

Given the fact that licensing and constructing a new reactor is a lengthy and expensive process and given constraints on financing, reactors are not likely to be constructed at the level necessary to maintain the worldwide fleet. What lies ahead for

the nuclear industry, despite the taxpayers dollars being thrown in its direction, is more likely a decline than a renewal.

And climate change?

Proponents of nuclear energy tout it is as an answer to climate change. This is far from the case. Setting aside such problems as terrorism and radioactive waste, nuclear energy is not the answer to climate change because it cannot conceivably make a rapid enough difference in the world's output of greenhouse gases to stem the changes that are already taking place. If catastrophe is to be avoided, a sharp decrease in emissions of greenhouse gases must begin now. The United States will not have a single new nuclear reactor until around 2015, and few will be constructed elsewhere before that date. To make a significant impact, the nuclear park would need to be maintained at the current level and at least 2000 new reactors put into operation [Makhijani 2006]. Imagine the industrial infrastructure needed to support 2440 reactors. Furthermore, the production of nuclear-generated electricity necessitates the use of fossil fuels for mining, transportation, and other activities along the fuel chain.

At present nuclear power accounts for only 6% of the world's supply of commercial primary energy. How much of a difference can 6% make? The spokesperson for a French antinuclear organization has put the situation of nuclear power succinctly. Nuclear power is not attacking climate change; climate change is attacking nuclear power, because intense storms, droughts, and floods increasingly threaten reactors [Lhomme 2006]. The answer to climate change lies not in nuclear power but in energy efficiency and mature renewable energy technologies. Arguably the most

disturbing aspect of the current push to revive the nuclear industry is that it is absorbing the financial and human resources that should be directed to implementing measures to cut greenhouse emissions that could go into effect virtually immediately as will be discussed in the next chapter.

CONVERSION FROM NUCLEAR POWER:

An Update to Chapter IX of Critical Hour

Albert J. Fritsch

In Chapter IX of *Critical Hour* we described the possibility of rapid conversion to a national nuclear-free economy. Our hopes were that such a program could be implemented in a relatively short time (one decade). That vision was perhaps far too optimistic. Since the United States has considerable energy waste and some leeway in curbing energy use, we restricted ourselves to focusing on two areas: reducing energy consumption through energy efficiency/conservation measures and increasing clean renewable energy's availability through development of wind and solar applications. Conservation and energy efficiency measures could compensate for energy produced by the current nuclear power industry (about 20% of electricity) due to the enormous energy waste of over twice that amount. Expanding wind and solar energy would meet additional authentic energy needs while not increasing the amount of carbon dioxide being emitted into the atmosphere through the combustion of fossil fuels (coal, petroleum and natural gas).

Our initial outline was reasonably possible if backed by the determination of our citizens to use energy in a sensible fashion. Other nations are seeking similar goals. In May, 2006, the Institute for Energy and Environmental Research (IEER) proposed a program for France that would phase out nuclear power over 30-40 years (80% of French electricity is currently derived from that source or four times the American contribution) and still reduce greenhouse gas emissions through greater reliance on sustainable energy technologies. Germany and Belgium are considering proposals to become nuclear free in the first half of the 21st century. Sweden, now being supplied with one-quarter of its energy

from renewable energy sources, seeks to be the world's first oil-free economy by 2021 and to phase-out nuclear power during this period.

The will to change is what is crucial in any conversion to a nuclear-free energy policy. The American "addictive" energy behavior (even President Bush's term) makes it imperative to modify our initial choices; profound change is difficult if left to the individual choices of addicted people who have grown accustomed to relatively low-priced and plentiful supplies of conveniently obtained energy. Use of electricity is certainly less bothersome than going outside in winter and splitting wood; hidden costs to the environment do not immediately present themselves; heating and cooling of common space do not demand immediate payment by the comfortable user; comfort means everything and people are willing to spend money for it. This lack of will to change forces us to modify our proposal to include more governmental regulation and incentives and to rely less on voluntary lifestyle changes.

Conservation measures in *Critical Hour* included a very wide variety of practices, all of which are environmentally beneficial or benign. Many of them, such as summer ventilation and home cooling practices, require a regimentation by individuals that is not practical for people addicted to wasteful energy use. It is like saying that the untidy room would be clean if the person starts at the door and methodically straightens the place. Disorderly people could do so, but for all practical reasons will not unless a disciplinarian stands over them. Discipline is needed and not hoped-for changes in practices by the other fellow, if we are to arrive at a nuclear-free, low-carbon dioxide emissions world. Hanging out clothes on the line saves energy but it means bucking local ordinances against such practices in many places; cooking in batch portions may reduce kitchen heat, but it's easier

to buy the meal at the fast food drive through; turning off the computer or television may save energy, but there are other things on our mind. And America has no police to enforce energy conservation. Addicts lack the wherewithal to initiate behavioral change. Another approach is needed.

A mix of energy sources is a sound policy provided the playing field is level and traditional sources are environmentally benign. A variety in menu, of friends or forms of entertainment is good. When the mix includes sources that cause greenhouse gases or nuclear wastes, variety can be problematic. Today as petroleum reserves become limited and world demand increases, it is natural to look about for other sources, those already developed (geothermal and hydropower) and those in the rather distant future such as ethanol from switchgrass or hydrogen with its lack of harmful emissions. But dwindling available petroleum should not bring on a national panic attack, or will it?

The current national energy policy, if there is such a thing, is to promote energy independence because of the insecurity of foreign energy sources. Currently about 29 quadrillion Btu of energy (mainly petroleum) are imported compared to 72 produced domestically and 4 exported; in other words, imports amount to about 30% of our total energy (2000 figures). Energy independence apparently is to be achieved using a mix of traditional energy sources where possible and thus the emphasis on plentiful coal and natural gas and nuclear power. Phoenix rises again!

In this atmosphere minor sources, which have enjoyed little of the past governmental support awarded to big oil and coal, are relegated to the futuristic category reserved for the "hydrogen economy." And such reasoning makes the immediate sources of energy (conservation, wind and solar) seem remote and impractical to the hard-nosed legislator and

administration. Both wind and solar in some ways have been used for centuries, are environmentally benign, are readily available, and can become major players in the energy mix if our nation has the will power to go "green energy." Yesterday's windmills are replaced by today's highly efficient wind generators. The current White House policy of promoting a traditional energy mix contains the major flaw of not considering all environmental consequences -- global warming and nuclear safety. The previous chapter covered the downside of nuclear energy. Here we look briefly at fossil fuels.

Coal, the Bush administration's current fuel of choice, for energy independence may be cleaned up to remove the air pollutants; a "clean" coal-burning powerplant costing more than one billion dollars is currently being designed and sites evaluated. The plant is expected to be built at the end of this decade. Likewise, converting coal to a liquid to replace petroleum is talked about; this would mean a vast increase in coal production. Ignored are the facts that an increase in utilization, already booming, would bring with it environmental and safety disadvantages: mining hazards and black lung disease, massive disturbance in strip mine territories especially in highland regions, continued air pollutants even at a reduced degree in the combustion process, global warming from carbon dioxide emissions, dangerous coal haul traffic in coal producing regions, and failure to reclaim stripped lands properly.

Petroleum and natural gas extraction is generally less environmentally costly than removing coal. Seventy-five dollar a barrel petroleum is leading to the reopening of old spent fields and further extraction from existing ones using new technologies. New fields of less polluting natural gas are being sought everywhere. Unimaginable profits to the industries are protected as means to further exploration and development of processing

plants -- and these are assisted by generous governmental subsidies and lenient environmental regulations. With over half of current petroleum supplies coming from overseas, our current energy addiction requires massive military expenditures to safeguard foreign oil supplies. When these defense measures are included, the net gain from imported petroleum is quickly reduced and other native fossil fuel sources seem more enticing.

M.K. Hubbert predicted in the 1950s that US oil production would peak about 1970 and that has been the case. Using the same methods, others have predicted that world oil production would peak about 2004-2012. That is most likely the case except that some major oil-producing nations are notoriously inaccurate in their estimates of projected reserves -- and their lack of transparency is augmented by regulations protecting national secrets.

Tar sands and shale oil are regarded as future fossil fuel reserves. An *Economist* article (December 3, 2005) spoke about Canada having a reported 180 billion barrels of proven oil reserves, of which 95% are in oil sands. The oil sands are being processed with a reasonable degree of success, but the extraction and processing are more difficult than for petroleum. Is another alternative fuel for the increasingly outmoded internal combustion engine a pie-in-the-sky? Oil shale, an energy possibility touted since the early 1980s as a fuel of the future, is even harder to process than tar sands. Estimates range to the trillions of barrels of hydrocarbons trapped in both eastern and western North American oil shale fields. The first experimental plant in western Colorado was closed down in 1982 due to operating costs and water shortages; considerable attention was given to the Devonian Shale outcropping in Kentucky, Indiana, Ohio, and Tennessee, which was estimated to contain 400 billion to 2.6 trillion barrels of shale oil. Unanswered questions were raised about

massive waste overburden (a ten to one ration of waste materials to fossil fuel product) from strip mining operations that disturb farmland and water aquifers, and about the seriousness of additional air pollution. And is shale oil a net energy gain (after considering all processing and environmental reclamation expenditures) or the epitome of our dysfunctional national energy policy with its governmental research and development subsidies?

ENERGY EFFICIENCY AND CONSERVATION MEASURES

In *Critical Hour* we proposed the rapid implementation of a nuclear-free economy through use of short- and longer-term energy conservation/efficiency measures. Short-term measures included: domestic electric lighting, window areas, insulation and weathering, modular space heating and cooling, regulating the use of electronics, ventilation and other cooling suggestions. Longer term measures included reduction of building size and siting, landscaping (especially planting trees), efficient electric appliances, cogeneration, public and private transportation options and resource recycling. We continue to support all, but here focus attention on two short-term and two longer-term practices with incentives to hasten their implementation.

Short-Term Prospects

Compact fluorescents: a utility measure. Since electric lighting, both indoor and outdoor, is a major energy user in our modern world, we reemphasize that at least ten percent of domestic electricity could be conserved through conversion to energy-saving compact fluorescent lighting (CFL). CFLs are a quick, efficient, easily implemented way to

initiate energy conservation in home, school, and office. CFLs are steadily improving in longevity, affordability, lumens, durability, and color tone. They can be inserted directly into standard incandescent bulb sockets. CFLs, qualified by the ENERGY STAR program of the US Environmental Protection Program, use up to 75% less energy than standard incandescent bulbs, which lose much of their energy in the form of heat. Improved CFLs last ten times longer than incandescent bulbs. Replacing a 100-watt incandescent bulb with a 32-watt CFL can save at least $30 in energy cost over the life of the bulb. If every residence put Energy Star qualified lighting into its five most used light fixtures, the reduction in greenhouse gases would be one trillion pounds per year (US government calculations). Over and above replacement in frequently used lighting areas, one receives large benefits in CFLs' efficiency where lighting is left on, such as exit lighting or night lighting areas. The replacement with CFLs needs to happen all across the board.

A governmental or utility subsidy system could expand the use of CFLs much in the fashion that past insulation programs have worked in some areas of the country. A nationwide campaign of giving each household five free CFLs for their most used fixtures and giving more CFLs to institutional establishments would simply halt the need for new power plants. An alternative non-governmental approach is for utilities to supply these conservation devices (some already do) and then regain the costs through rate adjustments.

*** Comfort zones: a national war mandate.** Many non-Americans cannot believe that many of our homes and businesses are cooled to lower temperatures in summer than we feel comfortable with in winter and heated to higher temperatures in winter than we consider comfortable in summer. What results is actual discomfort on the part of a few (who do not like the warmer or cooler temperatures), more respiratory and other illnesses in both

seasons, and enormous increases in energy consumption for heating and cooling. Often -- and it is well documented -- those in air-conditioned areas who want a more personally comfortable temperature simply turn on electric heaters in summer to raise inside temperatures to more healthy levels -- resulting in a massive waste of energy from space heating and air conditioning running simultaneously in the same building. Institutional comfort zones are hard to establish, even though spatial thermostats are the best means of meeting most comfort requirements. A sufficient comfort zone could be five degrees higher than the ideal in summer and five degrees lower than the ideal in winter (say 73 in summer and 63 in winter).

Let's work for the establishment of comfort zones as a national priority and stick by them all year. A national wartime mandate (yes we are at war on terror) is in keeping with the patriotic spirit of the First and Second World Wars and may give those who are uncomfortable with over-heating and cooling the courage to speak out openly for institutional and residential comfort zones. Adjusting clothing to the season would assist the comfort factor more than using individual space heaters in summer in an overly cooled office or residence.

Longer-term outlook

Certain longer term conservation measures such as building siting and size are more remote due to current cultural expectations for increased commercial, educational, residential and worship space (doubling of per person space in the past two decades). While energy and economic savings through space reduction are dramatic, getting current users to change is virtually impossible, except perhaps in families where youth have flown the coop.

Using more energy efficient refrigerators is of value but about 15% of households with second units retain the inefficient one as a backup storage appliance -- more refrigeration energy expenditure, not less. Here we reemphasize two longer term measures:

*** Energy efficient vehicles and national standards** -- With three-dollar-a-gallon gasoline, the popularity of hybrid cars and other energy conserving vehicles could possibly become a consumer-driven energy efficiency measure even without additional governmental regulations. Recent polls show 63% of consumers plan to buy a more energy-efficient vehicle -- but the sales of gas-guzzling models of sports vehicles are still high as of this writing. Consumer-driven selection would mean about a 5% more efficient auto fleet per year and a slow rise in total automotive energy efficiency; the selection and number of hybrid cars sold are rising and their prices are expected to approach those of comparable non-hybrid models. The public may be starting to get the message.

Some regard the government's standards called Corporate Average Fuel Economy (CAFE), as irrelevant when fuel is high priced, because consumers buy fuel-efficient vehicles without being prompted. The CAFE requirement for 2005 was projected to be 27.5 miles per gallon, and the US Environmental Protection Agency estimated the actual rate for that year to be 28.9 m.p.g. (www.nytimes.com/2006/05/07/us/07mileage.html). Special attention must still be given to removing tax incentives from gas-guzzling SUVs and pickups. Automotive fuel efficiency improved through the 1980s and then stalled and declined in the next decade and now will be improving with or without CAFE. Even smaller non- hybrid vehicles maintaining 40-mile-per-gallon averages are appearing at the foreign and domestic car showrooms, for efficient vehicles of all types deserve tax incentives. The study of France cited earlier calls for 100 miles-per-gallon vehicles in a few

decades. The time has come for solar electric vehicles, especially for the short commute and errand runs by many drivers.

*** Shade and wind barrier trees** -- Growing trees for shade and wind barriers (25 to 50 year time frame) is definitely a longer- term conservation investment, but planting trees helps instill a conservationist ethic in the general population both young and old. Participants in tree planting projects learn the many advantages of trees beside shade and wind breaks (fruit and nuts, wildlife refuge, uptake of carbon dioxide, water and soil retention, natural beauty, increase in property value, personal soothing effects for neighbors, sound muffling, etc.); they may inadvertently become aware of a conservation "feedback loop," influencing other personal lifestyle practices.

Conservation groups and forestry personnel are readily available to help promote tree planting. The state and federal government could continue to furnish seedlings and disseminate maintenance advice especially focused on annual arbor day events. Planting and maintaining trees, when a participative activity, treats the conservationist ethic as a team project. While immense energy gains will take a few decades to occur, tree plantings may, in the short term, increase citizen pressure for more conservation measures and change individual practices. A model for action is that of spreading the word about the benefits of recycling at all levels of society.

WIND ENERGY: LEVEL THE PLAYING FIELD

Without political support, wind energy remains at a competitive disadvantage due to distortions in the world's electricity markets created by decades of massive financial, political and structural support to conventional technologies.

- Arthouros Zervos, President, European Renewable Energy Council

Wind, our energy source of choice, has had tremendous growth through the first years of the 21st century with the promise of equal advances throughout 2006 and the following years. The Global Wind Energy Council reports 11,531 megawatts (MW) of new wind installations in 2005, a 40.5% increase in annual additions with large percentage increases in North America and Asia. A more "modest" European wind capacity growth of 18% is understood by recognizing that over two-thirds of total capacity is on that continent (40,500 MW: Germany 18,428 MW; Spain 10,027 MW; Denmark 3,122 MW; and Italy, United Kingdom, the Netherlands and Portugal over 1,000 each). In fact, the European Union (EU) goal of 40,000 MW was reached five years ahead of time, and wind now accounts for 3% of total energy utilization on the continent.

Nation by nation, the United States with 9,149 MW is in third place, with a 37% growth in 2005 making it the leading country in actual new wind power (equivalent to three medium-size power plants). Canada is also coming up fast (53% additional growth) from a much lower base, but this land of immense wind potential is now taking this energy source seriously. Asia is gaining in wind utilization as well; India advanced to fourth place with 4,430 MW total capacity and 1,430 MW, of which it gained in one year; China doubled its capacity in the single year over the previous and targeted 5,000 MW total capacity by 2010. The Australian capacity nearly doubled in 2005 as well, with a number of developing nations taking wind seriously.

Few proponents of multiple energy sources will fault the use of more wind. It has many advantages: a long history of proven efficiency and cost savings; utility in a wide variety of places especially on the Great Plains, near seacoasts, and in many highland areas (one-fifth of American people live within fifty miles of higher wind potential areas); non-polluting operations, not contributing to the greenhouse effect; the ability to mitigate hydrocarbon cost volatility; improvement of energy independence and the security of energy supply; growth in job opportunities and economic improvement; less threat from terrorist attacks; and general acceptance by most electric consumers. The minor irritants of bird kills from whirling blades and marring of pristine viewscapes can be addressed to some degree. Pollution caused by fossil fuel plants affects far more bird populations, and smog and air pollutants from these power plants affect far larger numbers of people.

Solar Energy Applications

I'd put my money on solar energy. What a source of power! I hope we don't have to wait until oil and coal run out before we tackle that. I wish I had more years left.

- Thomas Alva Edison

Solar energy is being accepted but not at the rapid rate of wind power. However, within a few years energy generated from solar photovoltaic roof tiles will be as competitive as electricity from conventional sources. In *Critical Hour* we described solar photovoltaic arrays, net metering (feeding excess electricity back into the electric grid), solar hot water heating, ornamental and decorative lighting, and solar greenhouses. All have a bright future and use is growing in this emerging solar age. While wind power is utilized at some residential sites, the emphasis is on wind farms. On the other hand, many solar applications

involve individuals who practice conservationist lifestyles, such as those who use solar food cookers and food dryers. Centralized solar systems are less popular than wind farms, but solar recharging stations for solar electric cars may be in the offing.

Utility-installed solar water heaters. Solar water heating is widely regarded as the most cost effective solar energy application (quite capable of reducing residential energy consumption by ten percent). Solar hot water systems produce four to five times more thermal watts of energy per square foot than a solar electric (PV) system and at far lower cost. These solar units can be installed by the do-it-yourselfer or as commercial devices installed on roofs or near buildings and have proven quite dependable in the past decade. A host of state or regional incentives currently exist: personal income tax credits (8 states), sales tax exemption (4 states), property tax exemption (13 states), rebates (in California, Florida, Hawaii, Oregon, Texas, Wisconsin), utility metered programs (Lakeland, Florida), financing loans (7 states), certifying equipment (11 states), licensing installers (11 states), demand-side management (4 states -- require utilities to manage electricity demand by promoting the use of renewables), requirements for state buildings schools and housing projects (Arizona, Colorado, Florida, Hawaii, Maryland, Montana), and solar access laws (14 states).

Nationally, more utilities could prove to be the prime furnishers of these solar hot water systems. The advantage to the utility is that their installation would reduce the need for more expensive and worrisome power plants. These utilities could take a rather proactive stance on promoting solar hot water systems. Hawaii has a very successful program that uses a surcharge to fund a rebate program for solar hot water heaters. Involving utilities has the advantage of their furnishing expertise to residents who in the past

were subjected to fly-by-night operators who did not guarantee the performance of the products. The solar hot water system could be installed, maintained, and guaranteed by the utility, which could furnish professional trouble-shooters and financial managers as needed. The savings accrue to both utility and resident user -- and electricity is conserved.

Other Renewable Sources

Going beyond *Critical Hour* involves mentioning other forms of proven and functioning renewable energy sources: those non-combustion energy sources (geothermal and hydropower) and those that burn renewable organic matter (wood and plant materials). Even this second category is divided into those combusting waste products and those that involve native (wood) or cultivated plants (corn or sweet potatoes) for conversion to ethanol to use as fuels. The last category includes those on which further research and development is necessary (switchgrass) and those fairly well developed. Not all these renewable sources are free of environmental concerns: hydropower involves damming free-flowing rivers and corn-based ethanol involves diverting valuable food-producing farmland to fuel purposes. And on top of this in the cultivated areas, the somewhat disputed question of net energy gains is an additional consideration.

Geothermal is a small but significant contributor to the renewable energy picture (though strictly not always a renewable source because the heat at given locations can eventually be exhausted). This source is environmentally friendly, essentially non-polluting, and in certain places like the western United States has a potential to contribute significantly to the total energy mix. The process of mining Earth's heat can be subdivided into two major applications: electrical generation from hydrothermal fluids (steam or water) and

direct applications of the heated fluids in residential, industrial and commercial uses such as greenhouses and fish farms; geothermal (ground source) heat pumps are highly efficient and regarded as an excellent way to concentrate naturally existing heat rather than using fossil fuels.

Electricity generated from geothermal energy is potentially available in various parts of the world. Iceland gets 17% of its electricity from its geothermal sources, and about two dozen other nations are taking a serious look as global petroleum prices rise. Total US electricity production from geothermal sources as of this writing is about 2,700 MW. About half of this comes from the Geysers (a dry steam field) in northern California with 1,360 MW installed capacity and netting about 1,000 MW from 21 plants. Treated sewage effluent is injected into the geothermal field and replenishes the steam that is tapped for power generation. South central California areas have geothermal plants producing 570 MW, and plants in Nevada now produce 235 MW with new plants being built at this time. Western states centering on Nevada have a large amount of areas with 200 degree-plus temperatures at six kilometer depth (www1.eere.gov/geothermal/maps.html), and thus are quite suitable for geothermal utilization.

Heat exchange systems in residences and commercial establishments have gained in popularity; these use ground or water temperatures of a minimum of 40 degrees to concentrate heat. Actually the application is not that new, for the Greeks used geothermal heat to furnish hot baths over two thousand years ago. The current exchange systems are becoming more efficient, but these require other sources of electricity to run the systems though at far lower energy use levels. In fact, the US Department of Energy identifies

water-based geothermal heat exchange systems as the most efficient and cost effective way to heat and/or cool the building.

Hydropower currently supplies about 3% (3 quadrillion Btus) of our American energy needs each year; this is a renewable energy source that does not contribute to global warming. Once the free-flowing rivers are dammed (we admit that larger-scale hydropower is and environmental problem because of disruption of marine life and flooding of land), the renewable hydro potential should continue to be utilizable for years. Most major river sites have long been utilized in this country, and smaller dams are being removed in the Northeast to allow for free-flowing streams. Massive hydropower projects are under construction in China, India, Brazil and other countries. Besides being renewable, hydropower has no toxic emissions, and can furnish relatively low-priced electricity to consumers.

Micro hydropower is a small-scale form of hydropower that produces electricity for individual customers in parts of Appalachia and the Rockies. This source does not disrupt waterways to the degree that many large dams do and, if properly designed, does no environmental harm to streams. The payback is longer-term, but it takes some technical sophistication to install and maintain such systems. The amount of electricity generated is often far more than needed for a particular household and so the net metering programs mentioned for solar and wind energy should be extended to this renewable source as well.

Industrial and other waste materials. As traditional fuel prices increase, a noticeable effort is being made to take combustible waste materials and supply some industrial or space heating needs through their combustion. Immense amounts of agricultural waste products, wood, paper and other industrial wastes, slag and mining wastes

from slag piles, and wood wastes from forestry extracting and processing operations exist. The use of organic materials in composted form as soil amendment is still the best environmental approach for the mountains of such waste products, especially those derived from cattle feedlots (having many other disadvantages such as unhealthy conditions for livestock).

Methane is naturally generated in organic waste piles, and even though one would prefer that discarded materials be recycled, still a certain portion of our massive consumer economy ends up on these growing mountains called "landfills." In recent years efforts have been made to collect and process the emitted gas and combust it rather than allowing it to escape and increase the greenhouse gas load in the environment. Though the waste gas is not of high quality, it does contribute to some industrial processes and furnishes fuel for space heating. Methane is also collected in some deep coal operations; slag or solid coal mining wastes are being used; so are other wastes because their presence can be detrimental to the environment in so many ways (smell, sight, water pollution, etc.).

Wood and forest wastes often accumulate near sawmills and wood processing plants and are routinely burned as an industrial heat source. In certain parts of the nation agricultural wastes are converted to cellulosic ethanol or burned for industrial heat. Wood has been used since human beings began heating the indoor space and cooked meals; it is still the source of heating in many rural and wooded portions of our nation. However, wood burning has disadvantages such as indoor smoke and the memorable smell of wood smoke in rural areas. When wood burning occurs in congested areas, the result is air pollution. This can be reduced through the use of modern heat efficient USEPA-approved wood stoves. In the 19th century wood, like whale oil for lighting, first powered railroad

locomotives, but was soon replaced by coal; wood fueled 19th century iron furnaces and when nearby supplies were exhausted, small iron furnaces closed down. Burning fuel wood and waste supplies will most likely continue to supply about 3% of America's energy (3 quadrillion Btus per year).

Plant-Growing for Energy Supplies

Just talking about using productive farmland to grow crops for making ethanol fuel to be burned by our wasteful society is horrifying, to say the least, in a world of desperately hungry folks.

- A simple lifestyle American farmer

A variety of plants furnish sugars that can be converted into ethanol for various uses. Very early in American history, grain growers realized that shipping bulky grain crops great distances was not profitable; whiskey was easier to transport than bulk grain. In 2005, some 320,500,000 gallons of gasoline were burned per day or about 1.1 gallons per person or 117 billion gallons a year. To replace the petroleum used without a noticeable change in consumption would take 110 million acres of switchgrass and even more valuable corn land (that is more than the entire area of Illinois and Iowa) just to supply the gasoline burning vehicles. Many plant alternatives require further development such as gamma grass. Sweet potatoes yield 40% more than Jerusalem artichokes, both high ethanol yielding agricultural crops slated for our voracious fuel appetite. Various plants are regional favorites and boons to specific producers and processors; these are at the research and development stage gorging at the feeding trough of governmental grants.

Switchgrass, mentioned by President Bush in his 2006 State of the Union message, is considered a model herbaceous crop species for energy; it can grow with relatively little fertilization in repeated yields, and has a broad growing range from the black soils of Alabama and Mississippi to the croplands of Iowa. Auburn University researchers find that test plots of switchgrass produce 15 tons of dry biomass per acre with five year yields of 11.5 tons or enough to make 1,150 gallons of ethanol per acre per year, with dry leftovers to be burned in power plants. Switchgrass is fast-growing, deep-rooted, drought resistant, can be cut once or twice a year with regular hay and silage equipment, is pest tolerant and can be established through no-till farming methods and grown on poor soils for erosion control. Since it is a perennial when properly managed, switchgrass need not be replanted year after year. But switchgrass more R&D money before we see it at the pump. And its combustion emits carbon dioxide.

Biodiesel has hidden problems, and optimists and pessimists see it differently. The EU wishes to make this about 6% of the total energy mix in the next decade, just as Brazil wants to power four out of five of its transport fleet from ethanol derived from sugar cane in five years. Gathering the waste cooking oil from a variety of restaurants and food processing industries is time consuming; the inconvenience is gladly undertaken by advocates or "green missionaries," and the burning can occur with no engine damage and a fast food restaurant fragrance. The fuel burns with added efficiency over petrodiesel, but overlooked problems persist. George Monbiot (www.monbiot.com) cites Jeffrey Dukes who says carbon is being combusted at 400 times the net primary productivity of the planet's current biota (www.monbiot.com/archives/2005). A firestorm of critics attacked him for questioning the use of biodiesel as a fuel of choice. Monbiot admits his first column was

wrong but only because he underestimated the environmental impact; he does not advocate throwing waste vegetable oil away but condemns biodiesel processing plants that are sprouting up in Europe and Asia and using oil from palm plantations. This practice is rapidly denuding the rain forests and wetland areas in Malaysia and other parts of southeast Asia.

Ethanol, used successfully for years to enhance octane ratings, can be made from petroleum-based agricultural production (e.g., corn) as well as from cellulosic feedstocks, biomass wastes, native fast-growing plants like switchgrass, and short-rotation woody crops like poplar trees. With recent legislation allowing generous federal subsidies for ethanol production as an alternative fuel source, we need a definitive analysis of total resource gain and loss including soil depletion and non-renewable fuel used for growing, gathering and processing the ethanol.

A major controversy has erupted between David Pimentel of Cornell and Tad W. Patzek of Berkeley on one side and a sizeable contingent of the agricultural R&D community on the other, over the former's reporting that biofuel requires more energy to produce than it supplies in the form of ethanol (e.g., corn by 29%, soybeans by 27% etc.)(*Earth Island Journal,* Winter 2006, p. 9.) The question remains: should valuable agricultural land be diverted from food production for limited quantities of fuel for inherently wasteful internal combustion engines?

Nuclear phase-out: wishful thinking?

Our double goal has been to phase out nuclear power facilities and reduce fossil fuel emissions. Energy conservation and efficiency together with various types of renewable

energy sources will do just that. Small-scale energy production sites are inherently safer, locally controlled, and, when net metering occurs, economical for all parties. On hot summer days when air conditioners are draining the electric distribution system, small solar units can alleviate the heavy demand. A national consensus on energy source and production, which allows a more thoughtful approach to energy independence, is called for. Perhaps an energy crisis is in the offing, if several major oil exporters coalesce and cut oil supplies. Likewise, as the nation becomes more fiscally conscious, the cost of defending sources that are far away and subject to sabotage such as the Niger delta or Iraq adds indirectly to ever-increasing fuel costs.

Can a conservationist and renewable energy economy prosper while our nation simultaneously phases out nuclear power facilities and reduces fossil fuel consumption? Yes, and without harming the economy one iota. That is because the replacement of nuclear and fossil fuel plants will require the hiring of equal numbers of workers by renewable energy facilities. In *Critical Hour,* we merely described a number of conservation practices and solar applications, but here we advocate energy independence and less energy waste through both push and pull mechanisms -- regulations and promotion. People imbued with maximizing the profitability of fossil fuel extraction can hardly be expected to encourage less energy waste through conservation measures; thus we must turn elsewhere.

Motivation can come through enlisting institutions. Confronting America's addictive behavior towards energy must become a concerted effort on the part of governmental, civic, conservation, educational and religious institutions. Wasteful habits in times of national crisis are unpatriotic, disrespectful to those who defend our country, and sinful. Thus our government, civic, conservation, educational and religious institutions

should enter the picture. Our government should champion conservation in the style that it promoted Victory Gardens during the Second World War. The curbing of energy waste alone could solve impending energy shortages and move us towards energy independence, compliance with the Kyoto Accord, and a nuclear-free nation.

Conservation pays and helps our nation be both physically and economically healthy. Some conservation measures worth sponsoring include: dramatic environmental enactments, tree planting events, conservation essays, and classroom decorations and displays. Annual Sun Days and Earth Days need to be highlighted. Faith-based initiatives are in style; sinful wasting of God-given resources could be the subject of church attention. These institutions could teach energy conservation through installing and promoting CFLs, using energy efficient cars, creating and teaching about comfort zones in worship space, and planting trees. If the churches were instrumental in the first American War for Independence, why not in the struggle for energy independence as well?

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