

Nuclear Revisited

Global Warming, Electric Power, and IBEW 1245

This on-line version of "Nuclear Revisited", the third installment in a series, displays footnotes to help interested readers find the specific reference materials for each specific fact and quotation. For on-line sources, the relevant web address is listed.

Two reactors nestled in the hills along the central California coast show what is right with America's nuclear power program.

Operated by members of IBEW Local 1245, the Diablo Canyon power plants have run at 80% of capacity during their lifetime compared to an average of 70% for the rest of the US nuclear fleet.¹ More recently, DCPD has operated at over 90% of capacity, and has achieved the top rating of the Institute of Nuclear Power Operations for overall performance.²

Together, Diablo's two 1100-megawatt units provide about 20% of the power supplied by Pacific Gas & Electric to its customers in California.³

There's a muscular ingenuity to the way that nuclear plants convert tiny quantities of fuel into large quantities of electric energy. It's a heavyweight technology that has inspired people to think big. In 1954, the head of the Atomic Energy Commission, Lewis Strauss, famously spoke of a nuclear future where electricity would be "too cheap to meter."⁴ President Richard Nixon in 1974 envisioned a nuclear age in which the US would have 1,000 reactors operating by the year 2000.⁵

These goals proved unrealistic. In the first decade of the 21st century there are just 104 nuclear plants operating in the US.⁶

But the new century has brought urgent concerns about catastrophic climate change, and nuclear power is once again inspiring big hopes. In a widely-noted study published in 2003, a team of scientists at MIT laid out a scenario for battling carbon emissions by tripling US nuclear capacity by 2050.⁷ Some nuclear advocates have even suggested that America should try to match France, where nuclear accounts for 77% of national power generation.⁸

Christine Todd Whitman, the former head of the Environmental Protection Agency who now consults for the Nuclear Energy Institute made the case for a nuclear renaissance in *Business Week* last fall. "With nuclear power," she wrote, "we get the chance to preserve the Earth's climate while at the same time meeting our future energy needs."⁹

But a nuclear renaissance will still have to deal with several unresolved issues from the earlier era—reactor safety, waste storage, arms proliferation, and cost—along with this fundamental question: Can nuclear power be deployed quickly enough to make a meaningful difference in the battle against global warming?

A Nuclear Renaissance

The industry appears ready to give it a try. On Sept. 25, 2007 NRG Energy, Inc. and the South Texas Nuclear Operating Co. filed for a license to build and operate two new nuclear plants in Texas—the first such application submitted in nearly 30 years.¹⁰ In the closing months of 2007, power companies filed applications or partial applications for

a total of six new nuclear plants in Texas, Virginia and Alabama.¹¹ The Nuclear Regulatory Commission is expecting applications for 28 new reactors over the next two years.¹²

It took some prodding to get the industry moving again. Investors still remember nuclear projects that saddled some utilities with ruinous costs.

The Shoreham nuclear project in New York, originally projected to cost \$65-75 million, ended up costing \$6 billion. It was closed without ever producing a single kilowatt of power, and led to the partial public takeover of the Long Island Lighting Co.¹³ In New Hampshire, the Seabrook nuclear project went \$4.5 billion over its original price tag of \$1 billion and sent its major backer, Public Service of New Hampshire, into Chapter 11 bankruptcy.¹⁴

To lure investors back to the nuclear industry, the Energy Policy Act of 2005 offered financial incentives that include \$3 billion in research subsidies, \$3 billion in construction subsidies, and about \$6 billion in operating tax credits.¹⁵ In December of 2007, Congress sweetened this package with another \$20 billion in loan guarantees for nuclear projects.¹⁶

These federal subsidies could help reinvigorate the nuclear industry. But there are skeptics.

Peter Bradford, a former member of the Nuclear Regulatory Commission and now vice chairman of the Union of Concerned Scientists, says the subsidies “will prove only that the government can compel the taxpayers to build nuclear plants.”¹⁷ Whether new nuclear plants can be competitive with other alternatives in the absence of massive federal subsidies will be known only after new plants have come on line and established an economic and safety track record—something that is at least 10 years away, and possibly much longer.

Harder and Faster

The existing fleet of reactors reinforces nuclear’s image as a powerful technology and a logical successor to coal.

Although the number of reactors has remained steady at just over 100 for many years, these reactors have increased their output from 673 billion kilowatt hours (kWh) in 1995 to 782 billion kWh in 2005.¹⁸ The industry has achieved these gains by running reactors at an average 90% of design capacity, compared to an 80% average in 1998.¹⁹ This improved performance owes much to the IBEW members who have helped perform refueling outages with ever-increasing efficiency, keeping plants on-line and producing power to the greatest extent possible.²⁰

In a further demonstration of strength, some reactors are now being pushed beyond their design capacity, a process known as “uprating.” More than 4,900 MW of power uprates since 1977 have added the equivalent of four to five nuclear reactors to the grid.²¹

In addition to running its plants harder, the nuclear industry is running them longer. Since 2000, the Nuclear Regulatory Commission (NRC) has approved 47 applications to extend the operation of nuclear plants beyond their original 40-year lifespans.²²

Running plants into their “golden years” offers the prospect of financial benefits for investors as well as consumers. Although costly to build, nuclear plants are relatively

cheap to operate. Power from PG&E's Diablo Canyon, for example, currently costs about 3.8 cents per megawatt hour.²³ A plant that runs 60 years is a far more attractive economic proposal than one that runs only 40.

Nuclear power currently provides about 20% of the nation's electric output, virtually carbon-free. US coal plants produce 50% of the nation's electric output, but they also produce 82% of carbon emissions from US power plants.²⁴

It will be a cause for rejoicing if nuclear power can eliminate the dire threat posed by climate change. But the obstacles are many and long-standing, and cannot be brushed aside. Our choices have consequences, and in the battle against global warming we may not have a second chance to get it right.

Reactor Safety

Nuclear proponents say reactors are safe. Opponents say reactors are capable of catastrophic accidents.

Both sides are right. Nuclear plants in the US have extraordinary safety features designed to protect the public against radiation exposure. Reactors operate safely virtually 100% of the time.

But so much attention is given to safety precisely because reactors have enormous destructive power. In a landmark study for the Atomic Energy Commission, the Brookhaven National Laboratory estimated that a "worst case" accident at a 1,000-megawatt reactor could kill as many as 45,000 people, cause property damage of nearly \$300 billion, and radioactively contaminate an area the size of the state of Pennsylvania.²⁵

The accident at Three Mile Island near Harrisburg, Pennsylvania in 1979 produced a partial melt down of the plant's nuclear core. The reactor containment building prevented a catastrophic release of radiation, but the accident undermined public confidence in the industry.

There have been other, more recent near-misses.

In 2002 officials investigating FirstEnergy's Davis-Besse plant in Ohio discovered that boric acid from leaky water nozzles had burned through the reactor's six-and-a-half inch thick carbon-steel head, leaving only the quarter-inch thick stainless-steel lining—which was starting to crack and bulge.²⁶

Scientists at Oak Ridge National Laboratory later determined that if the plant had continued operating, this liner would have burst.²⁷ David Lochbaum, a nuclear engineer with 17 years experience working in nuclear power plants, told Fortune magazine what this meant:

"They came very close to an accident that would have been much worse than Three Mile Island and not as bad as Chernobyl. You don't ever want to be in a place where those are your bookends."²⁸

The public is supposed to be protected by the Nuclear Regulatory Commission, which is responsible for enforcing nuclear safety. But the NRC failed to act on early warning signs of trouble at Davis-Besse. In late 2001, several months before the severity of the problem came to light, the NRC became concerned about steel nozzles in the reactor lid at Davis-Besse. The NRC legal team approved a rare shutdown order. But Sam Collins, the NRC's nuclear reactor regulation director at the time, refused to execute the

order—right after meeting with Robert Saunders, who was then chief nuclear officer for FirstEnergy.²⁹

In a trial last fall, another NRC official testified that Saunders “assured us he would not operate it unless he was convinced it would be safe.”³⁰

Andrew Siemaszko, an engineer at the plant, had photos of the rust-streaked reactor head from refueling outages in 1998 and 2000. During the 2000 refueling he says he wanted a complete cleaning of the head, but the utility simply re-started the plant instead.³¹ The damning photo from the 2000 refueling was turned over to an NRC inspector. The inspector took no action.³²

The utility later paid a record \$33.5 million in fines for lying to the government about Davis-Besse’s operating status in the fall of 2001, but no executives from FirstEnergy were held accountable.³³ No one at the NRC was held accountable for the agency’s negligence—at least not publicly.³⁴

Blame for this serious safety breach worked its way down the ladder to Siemaszko, the engineer. Although Siemaszko objected to re-starting the plant in 2000, he ultimately approved the restart, saying he feared losing his job if he refused. That proved to be a big mistake. Siemaszko was indicted by a federal grand jury in 2006 for “willfully causing material facts to be concealed from the NRC.”³⁵ His trial is scheduled to start May 18 of this year.³⁶

An investigation of the Davis-Besse near-miss by the federal General Accounting Office in 2004 found nuclear regulators failed to make plant owners cultivate a “safety culture” among reactor workers and managers.³⁷ This is the sort of criticism that rankles nuclear workers, who know how much time and effort go into safety in their industry. But a renewed public debate over reactor safety is inevitable if there is an effort to double or triple the number of US nuclear plants. The Davis-Besse incident and other near-misses will stiffen the resolve of local citizens trying to prevent new nuclear construction near their community.

Storing the Wastes

The problem of waste disposal has bedeviled the nuclear industry from the beginning. Much of the waste is extremely radioactive, some of it for tens of thousands of years.

Strontium-90 and cesium-137, two of the most dangerous products of nuclear fission, have half-lives of about 30 years, meaning that their radioactivity declines by half after 30 years. Ten years after removal from a reactor, a typical spent fuel assembly has a dose rate in excess of 10,000 rem/hour, 20 times the fatal dose rate for humans.³⁸

In the absence of a permanent solution, waste has been accumulating at fuel storage pools at US reactor sites. By 2015, nearly all of these pools will be filled to capacity.³⁹ Knowing that the waste has to go *somewhere*, about half of the country’s reactor operators are now turning to “dry cask” storage to supplement their fuel storage pools.⁴⁰

These temporary solutions carry known risks.

If water accidentally drains from a fuel storage pool, irradiated fuel could spontaneously combust. The resulting nuclear inferno could release catastrophic amounts of radioactivity, killing an estimated 25,000 people or more as far as 500 miles

downwind, according to the NRC.⁴¹ Another study for the NRC estimated such a fire could cause 2,000-7,000 square miles of land to be condemned, with economic losses due to evacuation ranging up to \$566 billion.⁴²

Understandably, the US government and the nuclear industry are keen to get these dangerous wastes under the ground. Federal legislation in the 1980s directed the Department of Energy (DOE) to locate, build and operate a nuclear waste repository, and essentially narrowed the potential locations to one: Yucca Mountain in Nevada.⁴³

Nevada politicians, hearing the protests of their constituents, have resisted the federal plan. When it comes to nuclear waste, almost everyone is a NIMBY (Not In My Back Yard). And the federal government's choice of Yucca Mountain has given the NIMBYs plenty of ammunition.

A nuclear waste depository has to be impervious to environmental disturbance for a very long time. But Yucca Mountain is in a seismically active area. Between 1976 and the late 1990s, 600 earthquakes registering 2.5 or greater on the Richter scale struck within 50 miles of the site. In 1992, a 5.6 quake with epicenter just 10 miles from the site did extensive damage to the DOE field office there.⁴⁴

Water samples collected at the DOE's own Exploratory Studies Facility later indicated that rainwater has deeply penetrated the site during the past 50 years, violating DOE's site suitability guidelines.⁴⁵ Rather than disqualifying the site, DOE changed the guidelines.⁴⁶

Transportation of Waste

Besides problems with the site itself, many Nevada officials are concerned about the potential for an accident during transportation of radioactive wastes. These concerns were delivered forcefully at a public hearing conducted by the DOE in December.

Roger Halstead, transportation adviser for the Nevada Nuclear Projects Agency, testified that each truck cask of spent nuclear fuel would contain 350,000 curies of radioactive cesium and strontium, about 20 to 30 times the amount of fission products released by the Hiroshima bomb.

Moving the accumulated tonnage of high-level radioactive waste to Yucca will require approximately 108,500 truck shipments, or more than 36,000 combined rail and truck shipments, according to a federal Environmental Impact Statement. To put this in perspective, a truck shipment of high-level radioactive waste would be required every 4 hours, around-the-clock, 365 days a year, for 38 years.⁴⁷

Accidents are inevitable, according to experts. The DOE itself estimates there would be 66 truck or 10 rail accidents during the transportation of this enormous quantity of waste. Based on the actual record of past spent fuel shipments, other experts estimate there would be 130 truck accidents or 440 rail accidents over 40 years.⁴⁸

These statistics are not lost on those who are nearest the proposed repository at Yucca Mountain. Las Vegas Mayor Oscar Goodman called the plans for transporting waste "a disaster waiting to happen."⁴⁹

Even if no accidents occur, the waste repository is a costly proposition. The DOE currently estimates the total cost—construction, transport of waste, storage—at \$58.5 billion. The project's publicity director predicts this figure will rise.⁵⁰

A project in the works for more than 20 years, still not built, costs rising, opposition unabated: this is far from a success story. A nuclear renaissance would make these problems worse by far.

Tripling global nuclear power capacity by 2050 would make it necessary to construct and license a new Yucca Mountain-size facility somewhere in the world every 3 to 4 years for the next half century.⁵¹ And yet, as the MIT study points out, “No country has yet successfully implemented a system for disposing of this waste.”⁵²

Reprocessing and Weapons Proliferation

Many have suggested that we should “recycle” some of the waste from nuclear plants rather than bury it.⁵³

The Bush Administration requested \$405 million for Fiscal Year 2008 for its Global Nuclear Energy Partnership.⁵⁴ GNEP aims to separate plutonium and uranium from spent nuclear fuel, a practice traditionally referred to as “reprocessing.” The separated plutonium, rather than being a waste product requiring burial, can be used as fuel for reactors.

Unfortunately, it can also be used to make nuclear bombs. That’s why President Gerald Ford banned reprocessing in 1976. India had just exploded its first nuclear weapon—a bomb constructed from plutonium that had been extracted from nuclear plant waste through a reprocessing program India had conducted in secret.⁵⁵

The US stand against reprocessing helped curb the spread of this dangerous technology. No non-nuclear weapon state has begun reprocessing since Japan in 1977. Programs have been shut down in Argentina, Belgium, Brazil, Germany, Italy, Taiwan and South Korea.⁵⁶

President Bush announced in 2004 that he wanted to limit new nuclear reprocessing and uranium enrichment plants to countries that already operate them.⁵⁷ But his announcement appears to have produced the opposite of its intended effect. The three years following his announcement brought “the greatest explosion of interest in uranium enrichment in the nuclear age,” according to Congressional testimony by Matthew Bunn, a researcher at Harvard’s Kennedy School of Government. States such as South Africa, Argentina, Australia, Canada, Ukraine and Belarus are all showing renewed interest in the technology.

If states perceive that a new line is being drawn between technology “haves” and “have nots,” Bunn told Congress, “they will rush to try to ensure that they are on the ‘have’ side of the line.”⁵⁸

Expanding the world’s supply of plutonium through an aggressive program of reprocessing increases the possibility of diversion to terrorists, “rogue” states, or others in the future who might wish us harm. Roughly 240 metric tons of separated plutonium are in storage around the world today. Reprocessing the current store of US spent fuel would triple this amount.⁵⁹

The bigger the world’s stockpile of potential bomb material gets, the harder the task of keeping track of it in a timely manner—“making it feasible that the theft of enough plutonium to build several bombs could go undetected for years,” says the Union of Concerned Scientists.⁶⁰

If reprocessing plutonium truly solved the waste storage problem, some might consider it worth the risks. But reprocessing itself produces several different types of radioactive waste, with a total volume substantially greater than the original waste.⁶¹

As noted by the Keystone Center—a federal, industry, academic, and non-profit collaborative process—a “fuel cycle with reprocessing and any type of separation will still require a geologic repository for long-term management of nuclear waste.”⁶²

Cost is also a concern. Existing reactors in the US create some 2,000 tons of spent fuel annually. A commercial scale reprocessing facility capable of handling that much material would cost an estimated \$7.5 to \$30 billion to build, excluding operating costs.⁶³ In November 2007, eight US Senators—Democrat and Republican—cautioned that DOE’s plans for reprocessing could end up costing taxpayers \$200 billion or more.⁶⁴

The MIT researchers, who favor the current “once through” fuel cycle, reject reprocessing categorically, saying it is not realistic to expect that problems of cost, proliferation risk and fuel cycle safety can be overcome by new reactor and fuel cycle technologies.⁶⁵

Enter Global Warming

The current nuclear fleet is helping the US avoid carbon emissions. If today’s nuclear output of 100,000 megawatts had been achieved using coal instead, an additional 600 million tons of carbon dioxide would be entering the atmosphere each year.⁶⁶ The logic is straightforward: building new nuclear plants could allow us to avoid building new coal plants, or to retire old coal plants.

But the overall contribution that nuclear plants can make in the battle against climate change will be limited by two major factors: How many can we build and how quickly can they be deployed?

Speed is of the essence. Warmer temperatures have already begun melting frozen tundra in the northern latitudes. Without rapid action to reduce emissions, warming tundra will release vast quantities of methane—a greenhouse gas 20 times more potent than carbon dioxide. Such a release could simply overwhelm human efforts to reduce carbon emissions.⁶⁷

Unfortunately, speed is not one of the virtues of nuclear construction. NRG Energy, first out of the box to apply for a combined construction and operating license, hopes its two proposed plants will come on line in 2014 and 2015.⁶⁸ Are those target dates realistic? The industry’s track record is not good. Many reactors in the existing fleet were completed years behind schedule.

Hoping to do better, several energy companies are looking at new reactor technology by AREVA, a company headquartered in France.⁶⁹ But AREVA has encountered significant problems with the nuclear plant it is now building in Finland. The project, begun in 2003, is already at least two years behind schedule due to flawed welds in the reactor’s steel liner, unusable water-coolant pipes, and faulty concrete in the foundation.⁷⁰

AREVA is catching these problems and trying to deal with them. But the delays only serve to confirm perceptions that nuclear projects—with their extraordinary safety requirements—cannot stay on schedule.

Cost is the other major barrier to large-scale deployment of new nuclear plants. Recent estimates of \$1.5 billion to \$2.1 billion per reactor⁷¹ are already giving way to much higher figures. Florida Power and Light, which plans a two-reactor project in South Florida, recently revised its estimate to a jaw-dropping \$6 billion to \$9 billion—*per reactor*.⁷²

The federal tax incentives enacted by Congress in 2005 and 2007 are designed to give a boost to the first few reactors by having taxpayers shoulder a large share of the costs. In addition, several state utility commissions have indicated they might ease the burden by letting utilities start charging ratepayers for the power before the plants start operating.⁷³

These subsidies—coupled with streamlined licensing procedures—could be enough to jump-start construction of the first few plants. As builders gain experience, the cost of subsequent plants might come down.

But maybe not. Costs for many power plant commodities—from steel and concrete to copper and nickel—are soaring. So is the cost of finishing them into components. The domestic nuclear industry is down to a single supplier for many components.⁷⁴ The nuclear workforce is aging and skilled labor is in short supply. Construction delays could increase the cost of borrowing money.

In 2005, the CEO of Dominion Resources, Thomas Capps, made this prediction about what would happen to his company's credit rating if he were to announce plans to build a \$2.6 billion nuclear plant: "Moody's would go bananas."⁷⁵ Congress has tried to remedy those credit concerns by enacting the new subsidies. But those subsidies will not last very long nor go very far, especially if reactors are going to carry price tags of \$6 billion or \$9 billion. Financing could become very hard to find.

Getting the Job Done

Nuclear plants are large, like most coal plants. It seems logical that we could simply substitute one technology for the other—and solve our carbon emissions problem at the same time.

But the math isn't encouraging. The MIT study found that a nuclear renaissance—300 plants in the US and 1,000 worldwide by mid-century—would not be enough to even freeze carbon emissions at their present level. In fact, it would offset only 12 to 25% of the expected *growth* in carbon emissions.⁷⁶ That may be better than nothing, but it would be a very expensive investment for a very limited return.

As IBEW members, of course, we will take the work and be glad for it. But at some point taxpayers and ratepayers are going to start asking if there's a cheaper, more effective way to fight global warming.

It appears there is. But the alternative is going to look different than what we're used to. The solution almost certainly will not consist of a heroic contribution by a single big technology, but the combined contributions of many technologies.

Individually, other available technologies seem scrawny compared to nuclear power. But collectively they carry far more potential to reduce carbon emissions.

- In the US, energy efficiency alone has the potential to deliver two to three times more energy than nuclear power currently provides, according to the Electric Power Research Institute (EPRI).⁷⁷

- Wind on readily available rural land could be harnessed with current technology to produce twice as much electricity as the nation now generates from *all* sources.⁷⁸
- Small hydro, biomass, geothermal, ocean waves, currents, solar thermal, and photovoltaic systems have “a practical economic potential many times total US electricity consumption,” according to Amory Lovins of the Rocky Mountain Institute, writing in *Nuclear Engineering International*.⁷⁹

Like nuclear power, some of these alternatives face technological and financial barriers to deployment. But unlike nuclear power, they generally do not require 10 to 20 years to start making a difference.

Energy efficiency is already having a profound effect on US energy consumption, although its contribution is often poorly-tracked and thus hard to measure.⁸⁰ But there is evidence that thousands of efficiency measures undertaken by individuals, industry, business and government have been contributing to a steady decline in the amount of electricity consumed per dollar of US Gross Domestic Product—a measure known as “electric intensity.”

The 2% drop in US electric intensity in 2003 amounts to a savings of 13.8 GW of electricity—the energy equivalent of a dozen nuclear plants. The 2.3% drop in US electric intensity in 2004 amounts to an even greater savings—more than 16 GW of electricity.⁸¹

California has been a pioneer in the promotion of energy efficiency. Between 1982 and 1985, solicitations by California’s three investor-owned utilities resulted in 23 GW of contracted-for electric end-use efficiency to be installed over the following decade. Unfortunately, utility deregulation sidetracked this effort before it could be fully implemented. Even so, by the early 1990s the utilities’ programs had saved about 10 GW of electricity, roughly equivalent to the output of nine nuclear plants.⁸²

Global warming has put efficiency back in the spotlight. But how much potential is left in the “efficiency resource”? At what point will we stop finding new ways to use energy more efficiently? Apparently no time soon. The discovery of new potential for end-use efficiency is actually outpacing the rate at which such improvements are being deployed.⁸³ In other words, the “efficiency resource” is growing, not diminishing—a viewpoint shared by Lovins at the Rocky Mountain Institute and Clark Gellings, Vice President of Innovation at the Electric Power Research Institute.⁸⁴

There are obstacles to achieving these savings. Here’s one: state utility regulators (California being a notable exception) penalize rather than reward utilities for investments in efficiency.⁸⁵ Here’s another: new buildings often fail to incorporate existing design and construction practices that could save much of the energy that is currently wasted.⁸⁶ But the good news is that harnessing power from improved efficiency does not require major technological breakthroughs. It only requires that we recognize the opportunities, and adjust local and national policies to capture them.

Can We Do It All?

It is fashionable these days in the utility industry to say that we need to pursue “all options” in the effort to curtail carbon emissions.⁸⁷

But does pursuing all options amount to the most effective strategy in battling global warming? Maybe so, if we could afford to do everything. But we cannot. The amount of money that can be squeezed from capital markets, taxpayer pockets, and electric consumers is finite. The very real threat of runaway global warming requires us to concentrate on the options that can quickly yield the greatest carbon reduction per dollar invested.

The chart at right, utilizing calculations by Lovins, shows the comparative value of investments in various technologies in terms of electricity produced. For ten cents we can get:⁸⁸

- 1.0 kilowatt-hour (kWh) of nuclear electricity
- 1.2-1.7 kWh of dispatchable windpower
- 0.9-1.7 kWh of gas-fired industrial cogeneration
- 2.2-6.5 kWh of building-scale cogeneration
- 2.4-8.9 kWh of waste-heat cogeneration
- Up to 10 kWh or more of end-use efficiency

A large-scale ramping up of nuclear construction, to have even a marginal impact on carbon emissions, could cost a trillion dollars in plant construction alone—perhaps significantly more.⁸⁹ Would this come at the expense of capital, expertise, and political initiative paid to faster, cheaper alternatives? The answer is almost certainly yes.

The IBEW has always been a strong supporter of nuclear power, the source of some of the best-paying jobs in the utility industry. Highly-skilled IBEW members have played an important role in bringing nuclear reactors closer to their full potential. Whatever the ultimate verdict on nuclear's possible value in fighting global warming, IBEW members are going to take nuclear work wherever it exists, and perform it with the diligence the public expects. As the nation retools its energy sector to reduce carbon emissions, the current fleet of reactors will be a significant plank in the bridge to our energy future.

At the same time, IBEW will increasingly represent the people who deliver energy efficiency, as well as those who deliver renewable power. If the battle against catastrophic climate change is to be won, these are the areas where the quickest and most affordable solutions are going to be found. Later this year, in our continuing series on global warming, the Utility Reporter will look at Local 1245 members already involved in harnessing these energy sources of the future.

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Sources for Photos and Graphics

Diablo Canyon Power Plants

The twin nuclear reactors at Diablo Canyon, located on the central coast of California, provide about 20% of PG&E’s electric power. *Source: Diablo Canyon Independent Safety Committee at www.dcisc.org/*

Capacity Factors

Nuclear plants have been operating at close to full capacity in recent years.

Source: Nuclear Energy Institute at www.nei.org/filefolder/us_nuclear_industry_capacity_factors.ppt

Generation by Fuel Source

Electric generation by fuel source, 2004.

Source: US Energy Information Administration, 2006 at www.ucsusa.org/assets/images/renewable_energy/electricity_gen_2004.GIF

Davis-Besse Reactor Head

A close-up of the 6-by-5-inch hole in the Davis-Besse reactor head. The hole, caused by a boric acid leak, left only a thin strip of stainless steel lining protecting the reactor from rupturing.

Source: www.wired.com/news/images/full/undercut-area-toward-nozzle_f.jpg

Davis-Besse Vessel Flange

Red rusty boric acid deposits on the Davis-Besse vessel flange.

Source: www.nirs.org/photogallery/davisbesse/davisbesseredphoto.jpg

Spent Fuel Storage

The Nuclear Regulatory Commission says virtually all of America's nuclear reactors will have run out of capacity in their spent fuel storage pools by 2015.

Source: www.nrc.gov/waste/spent-fuel-storage/nuc-fuel-pool.html

Refueling Outages

At the leading edge of a national trend, the Diablo Canyon workforce has conducted refueling outages with ever-increasing efficiency. The Unit 1 refueling outage at Diablo Canyon in the spring of 2007 was completed in just 29.8 days, the best time ever for Unit 1. The industry average in 2006 was 39 days.

Source: Nuclear Energy Institute at www.nei.org/filefolder/u.s._nuclear_refueling_outages_days_average.ppt

Electric Generation per 10-cent Investment

Electricity generation, in kilowatt-hours (kWh) per 10-cent investment.

IBEW Local 1245 graphic, based on "Nuclear power: economics and climate-protection potential," Amory Lovins, Rocky Mountain Institute, Jan. 6, 2006, page 15 at www.rmi.org/images/PDFs/Energy/E05-14_NukePwrEcon.pdf