Approved: 03-11-08
Date

MINUTES OF THE SELECT COMMITTEE ON ENERGY & ENVIRONMENT FOR THE FUTURE

The meeting was called to order by Chairman Don Myers at 1:30 PM on March 6, 2008, in Room 784 of the Docking State Office Building.

All members were present except:
Representative Robert Olson, Excused
Representative Jason Watkins, Excused
Representative Oletha Faust-Goudeau, Excused

Committee staff present:
Mike Corrigan, Revisor of Statutes Office
Melissa Doeblin, Revisor of Statutes Office
Raney Gilliland, Kansas Legislative Research Department
Mary K. Galligan, Kansas Legislative Research Department
Barbara Lewerenz, Committee Assistant

Conferees appearing before the committee:
Paul Genoa, Director, Environmental Policy, Nuclear Energy Institute, Washington, D. C.

Others attending:
See attached list.

Chairman Myers recognized students and teachers visiting from the science class of the Topeka Collegiate School.

Chairman Myers introduced Paul Genoa, Director, Environmental Policy, Nuclear Energy Institute, Washington, D. C., who presented a power-point presentation, "Planning for success: Reasoned Expectations for New Nuclear Plant Construction."

Mr. Genoa spoke about the reality of nuclear power and the future prospective for Kansas. There are 104 nuclear power plants in the United States that today present 20 percent of our electricity with 90 percent capacity factor (Capacity factors in the 1970s and 1980s was in the 50 percent range). The average cost is 1.68 cents per kilowatt hour. U.S. nuclear plants are approaching middle age. Half of those plants have had their licenses renewed to extend operations for another 20 years, extending operating time from 40 to 60 years. Today, in the U. S., three site permits for new plants are already approved and design certifications have been submitted and reviewed for standardized plants. Combined operating and construction licenses have been submitted for seven plants, and another 15 license applications are expected in the next year. All of this is being done by 17 companies in consortium (about 31 plants). Success will be on the order of four to eight plants on-line by approximately 2016, with new plants ready for construction at the time these plants are on line.

Today the industry has a more efficient and predicable licensing process; industry has a clear understanding of what went wrong in places such as Three Mile Island and Browns Ferry; and favorable public support is building. The potential benefits from one new nuclear reactor in Kansas would be 1,350 MW, which could meet more than half of the generation demand increase forecasted for 2030. (Attachment 1).

Discussion followed the presentation. Mr. Genoa said plants are built in areas where the residents are amenable to a nuclear power facility; uranium most likely will be available for the next several hundred years; technology is being developed to recycle fuel in the future; and waste material is normally stored near the plant. He said the Europeans primarily use the same technology in their plants as we do in the United States.

Chairman Myers provided handouts on nuclear power (Attachment 2).

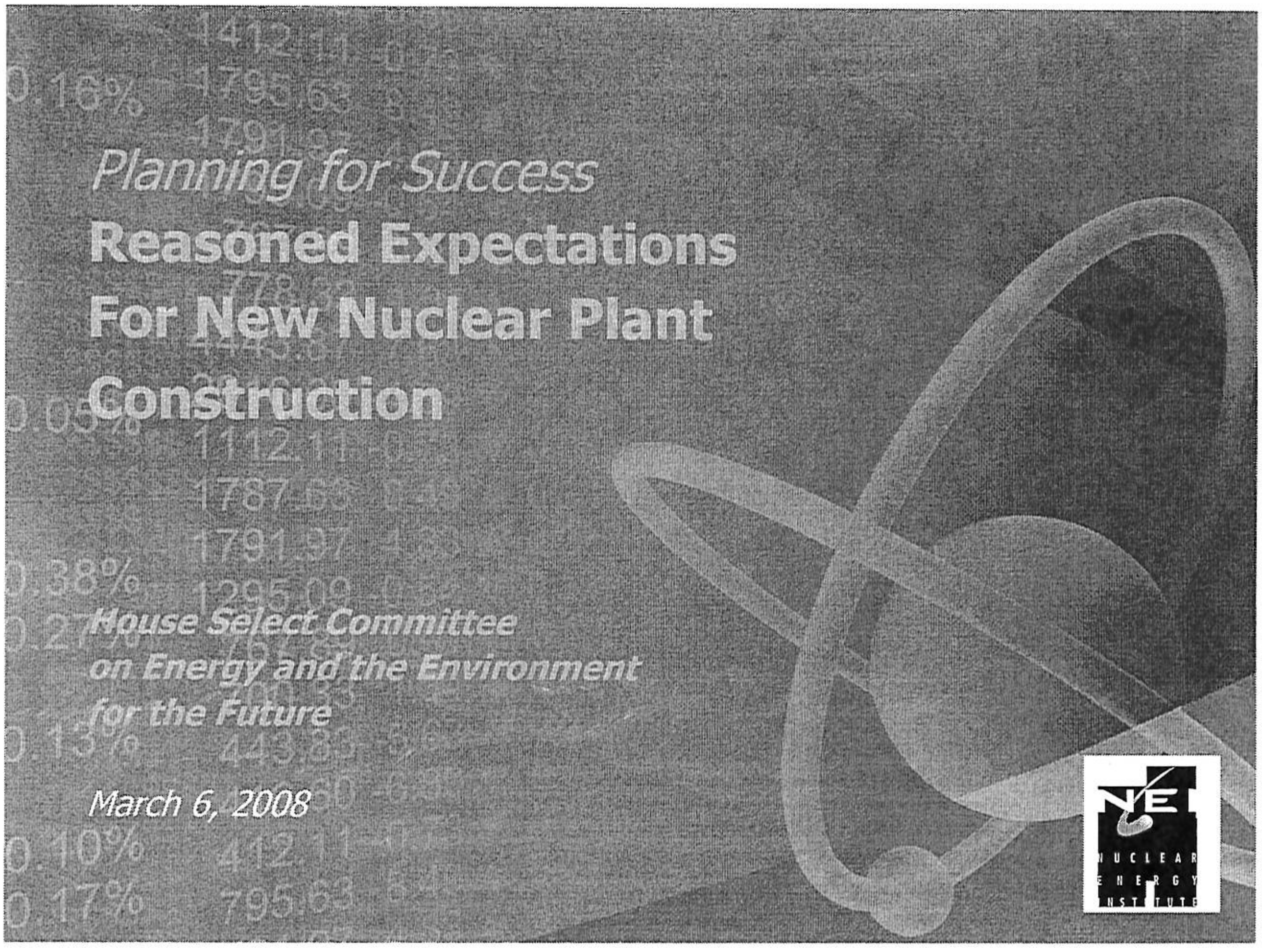
Meeting adjourned at 2:45 p.m.

The next meeting will be on March 11, 2008. Hearings will be held on **HB-2949**, An act concerning energy.

House Select Committee on
Energy and Environment for the Future

GUEST LIST **DATE** March 6, 2008

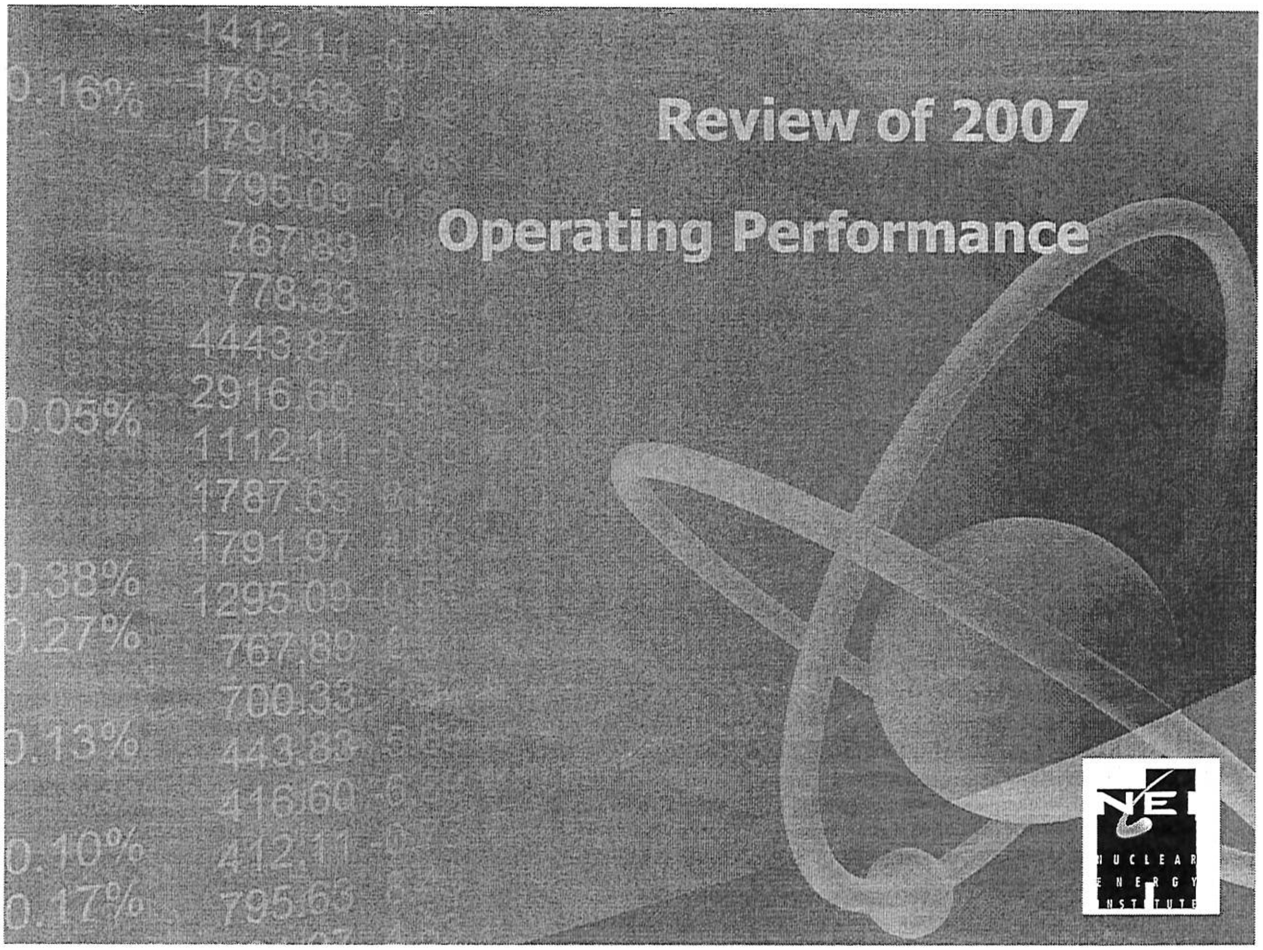
Your Name	Representing
Tom Thompson	Sierra Club



Select Committee on Energy & Environment for the Future
3/6/08
Attachment # 1

Today's Briefing

- Review of 2007 operating performance
- New nuclear plants: progress and expectations
- Understanding and managing the risks of new nuclear plant construction
- The challenges
- A future perspective for Kansas

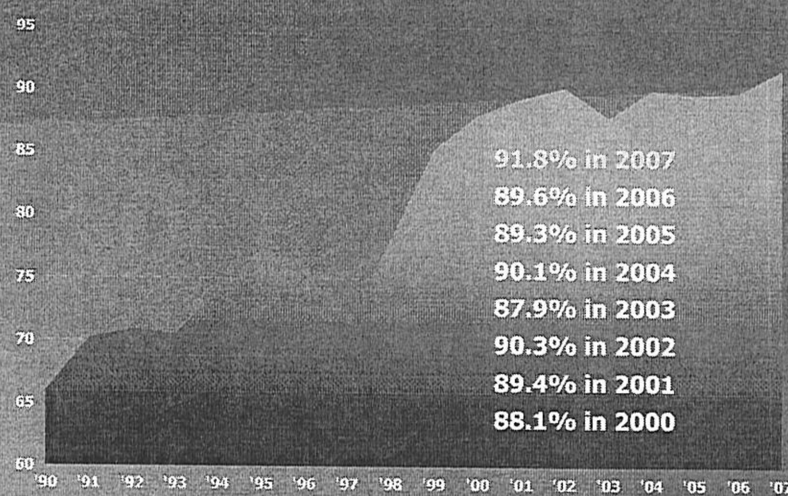

Review of 2007
Operating Performance

Sustained Reliability and Productivity

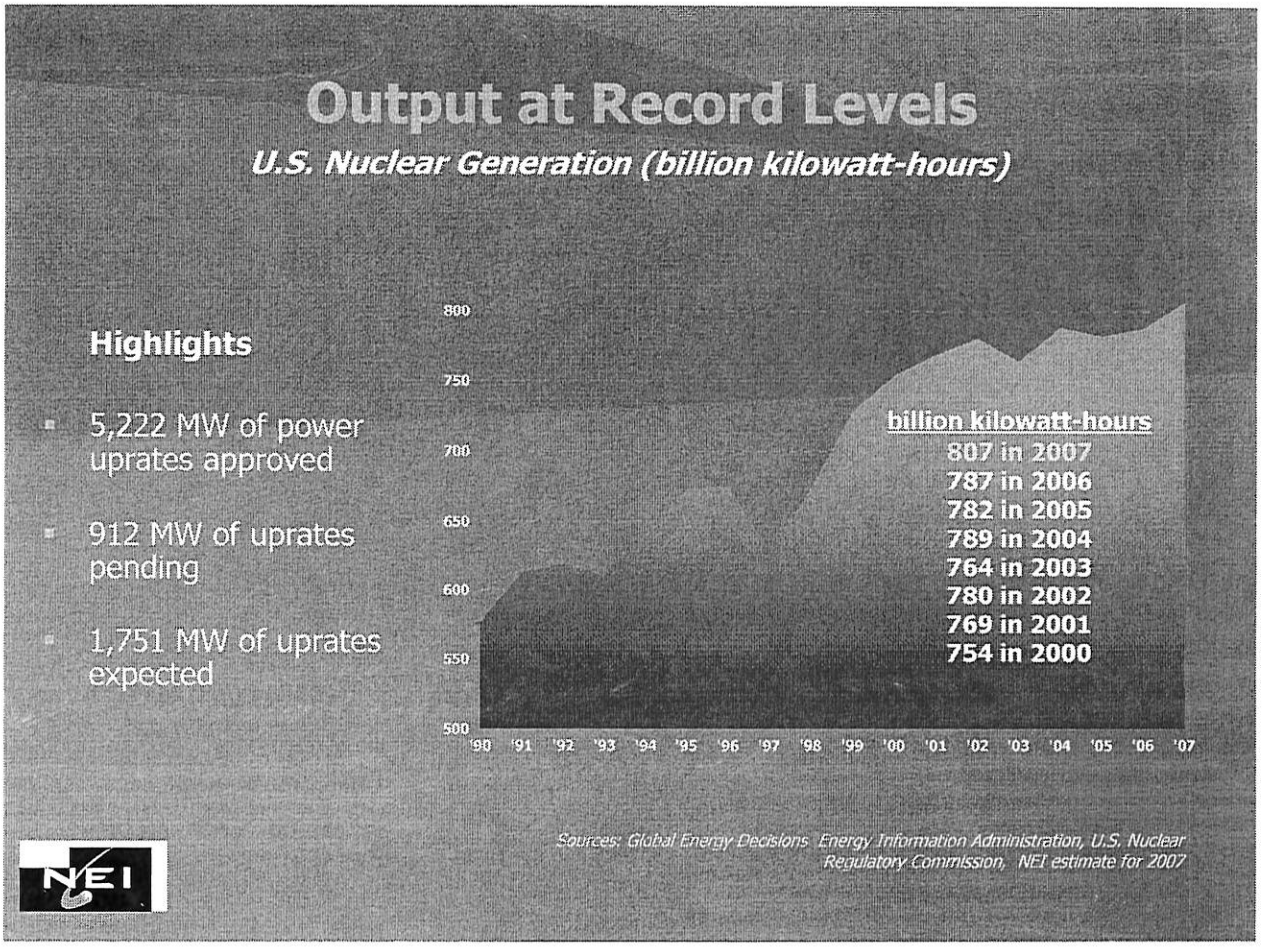
U.S. Nuclear Plant Average Capacity Factor

Highlights

- Fewer outages in 2007 (55 in 2007, 65 in 2006)
- Average outage duration in 2007 = 40.5 days

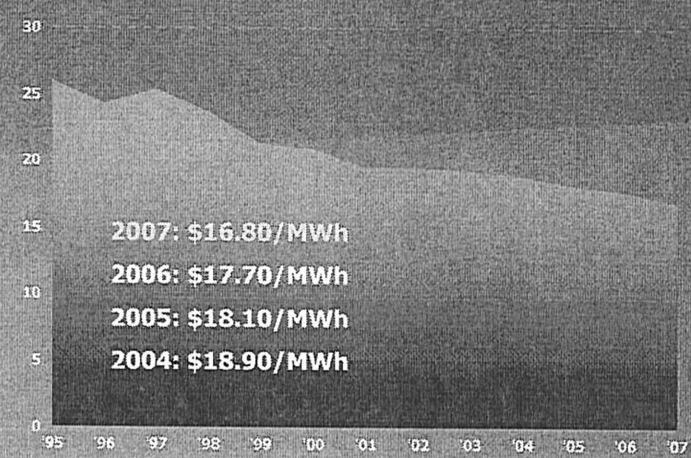


Sources: Global Energy Decisions, Energy Information Administration, NEI estimate for 2007


Output at Record Levels
U.S. Nuclear Generation (billion kilowatt-hours)
Highlights
5,222 MW of power uprates approved
912 MW of uprates pending
1,751 MW of uprates expected
800
750
700
650
600
550
500
'90 '91 '92 '93 '94 '95 '96 '97 '98 '99 '00 '01 '02 '03 '04 '05 '06 '07
billion kilowatt-hours
807 in 2007
787 in 2006
782 in 2005
789 in 2004
764 in 2003
780 in 2002
769 in 2001
754 in 2000
Sources: Global Energy Decisions Energy Information Administration, U.S. Nuclear Regulatory Commission, NEI estimate for 2007
NEI

Solid Economic Performance Continues

U.S. Nuclear Production Cost (2007 $ per MWh)



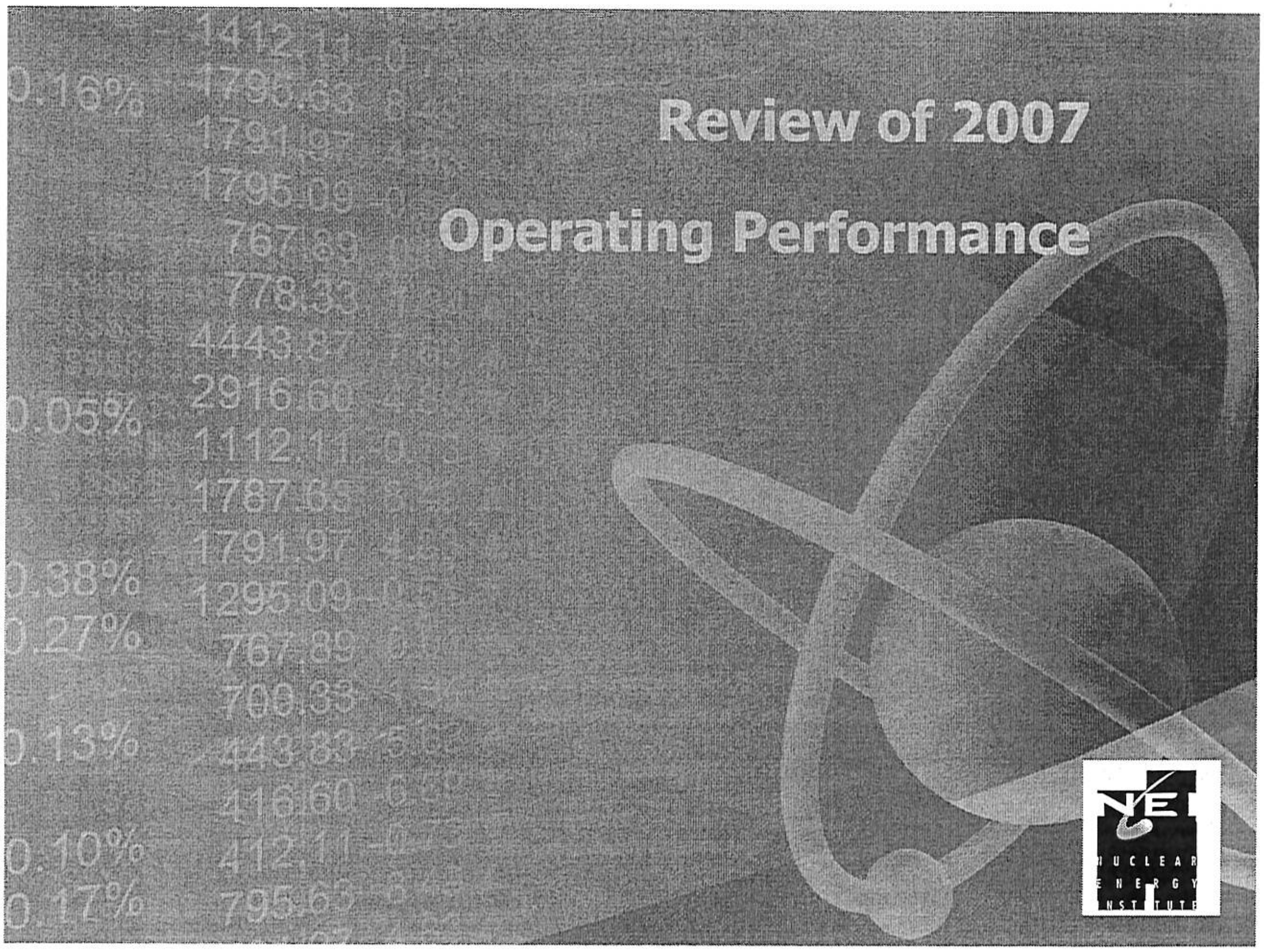
Sources: Global Energy Decisions, NEI estimate for 2007

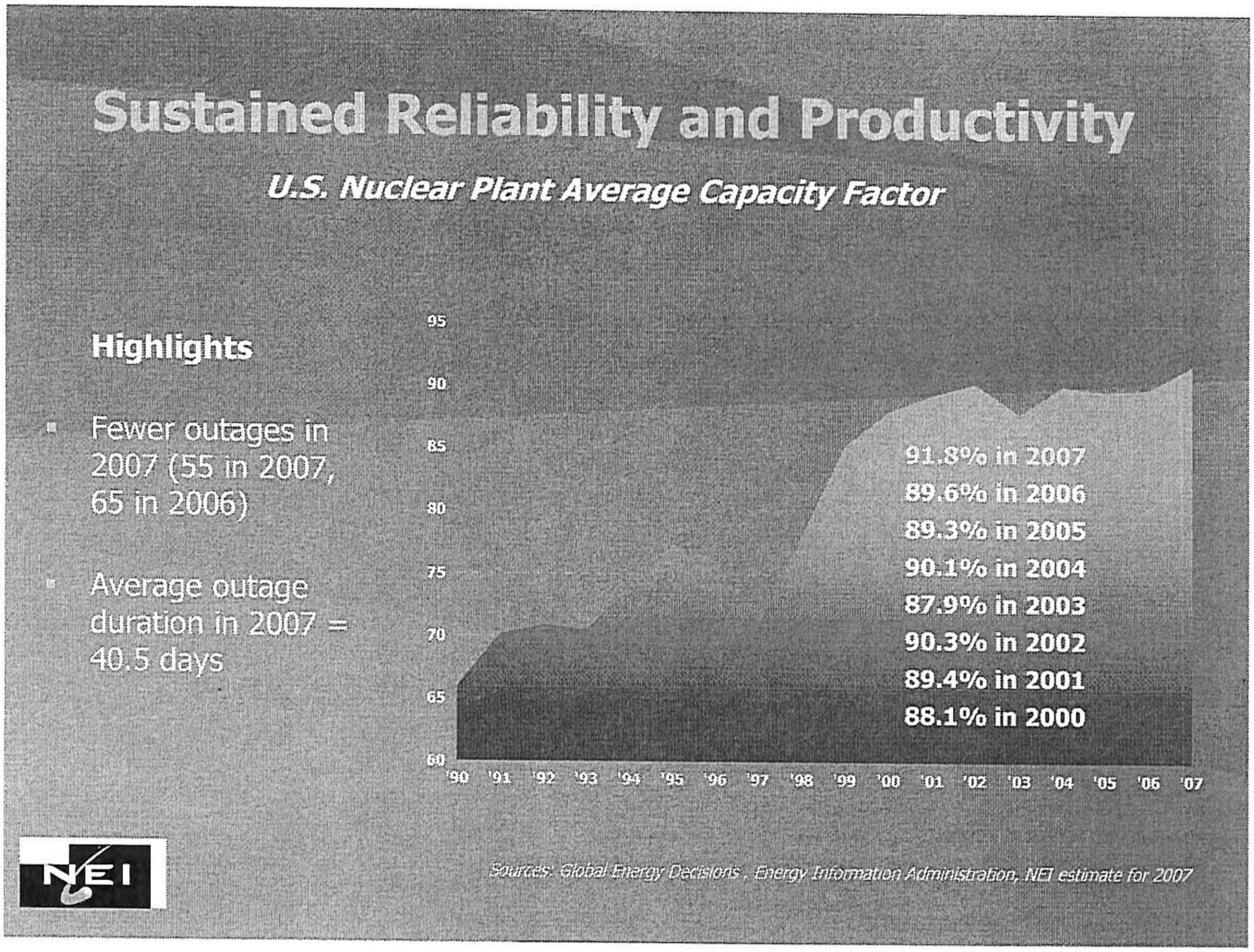
NEI

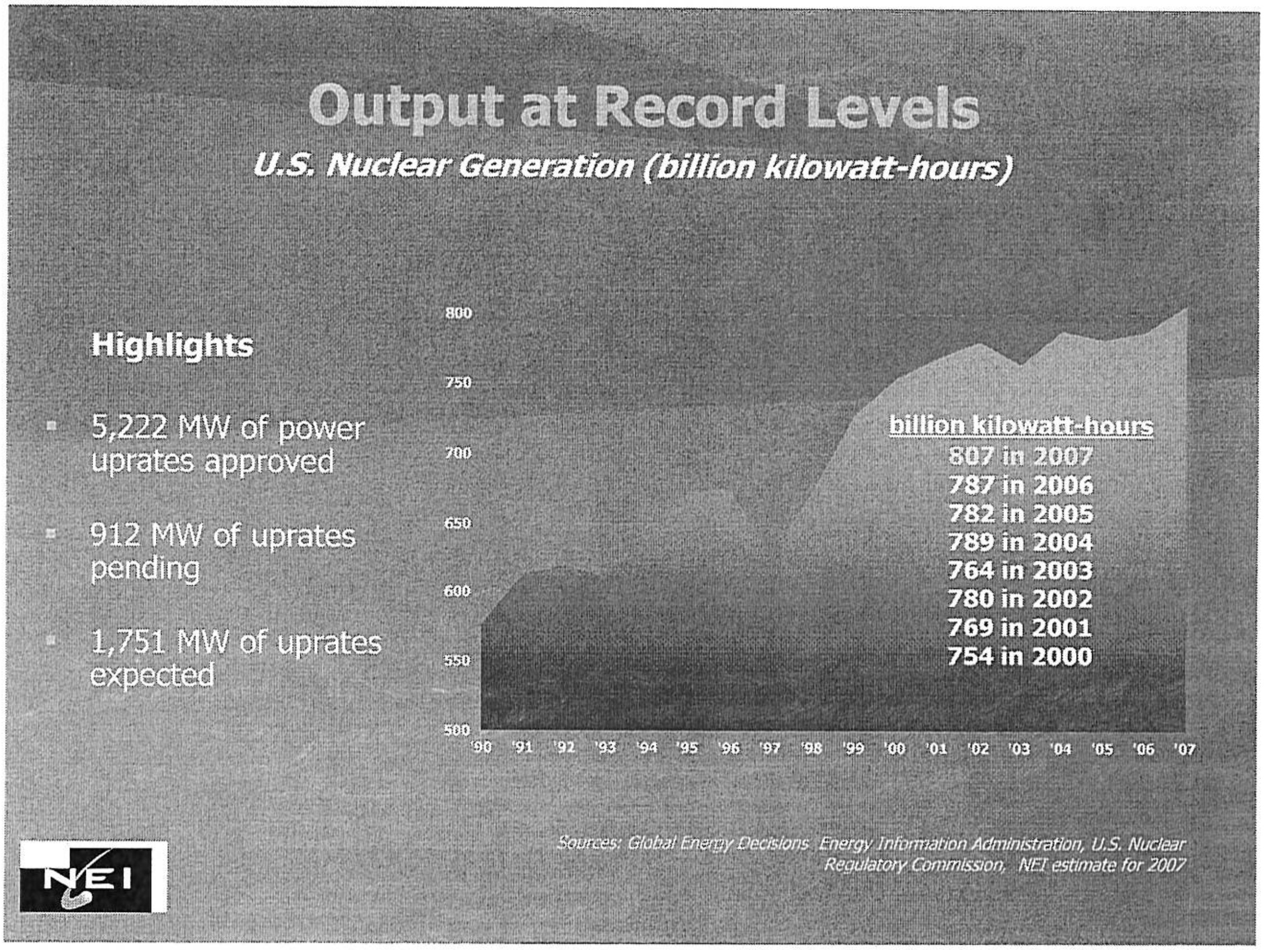
Solid Margins

- $16.80/MWh production cost implies busbar cost of $22-23/MWh
- Average prices in selected power markets in 2007:

Entergy	$46.71/MWh
ERCOT	$49.71/MWh
NEPOOL	$69.12/MWh
NYISO	$68.62/MWh
PJM West	$59.84/MWh


Review of 2007
Operating Performance
NEI
NUCLEAR
ENERGY
INSTITUTE


Sustained Reliability and Productivity
U.S. Nuclear Plant Average Capacity Factor
Highlights
Fewer outages in 2007 (55 in 2007, 65 in 2006)
Average outage duration in 2007 = 40.5 days
95
90
85
80
75
70
65
60
'90 '91 '92 '93 '94 '95 '96 '97 '98 '99 '00 '01 '02 '03 '04 '05 '06 '07
91.8% in 2007
89.6% in 2006
89.3% in 2005
90.1% in 2004
87.9% in 2003
90.3% in 2002
89.4% in 2001
88.1% in 2000
NEI
Sources: Global Energy Decisions, Energy Information Administration, NEI estimate for 2007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NEI

Solid Economic Performance Continues

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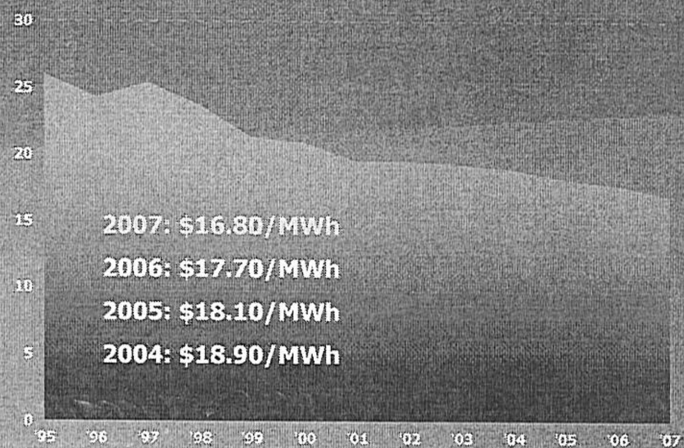

Sources: Global Energy Decisions, NEI estimate for 2007

NEI

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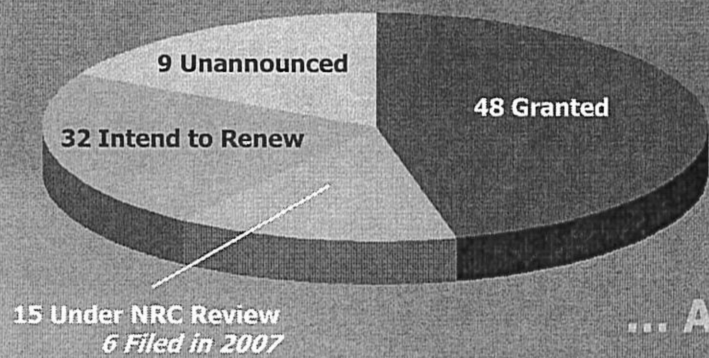
Other Key Highlights From 2007

License Renewals Continue ...



... And Plant Restarts

- TVA's Browns Ferry 1 back in service May 2007 (5-year, $1.8 billion project)
- TVA approved Watts Bar 2 completion August 2007 (5-year, $2.5 billion project)

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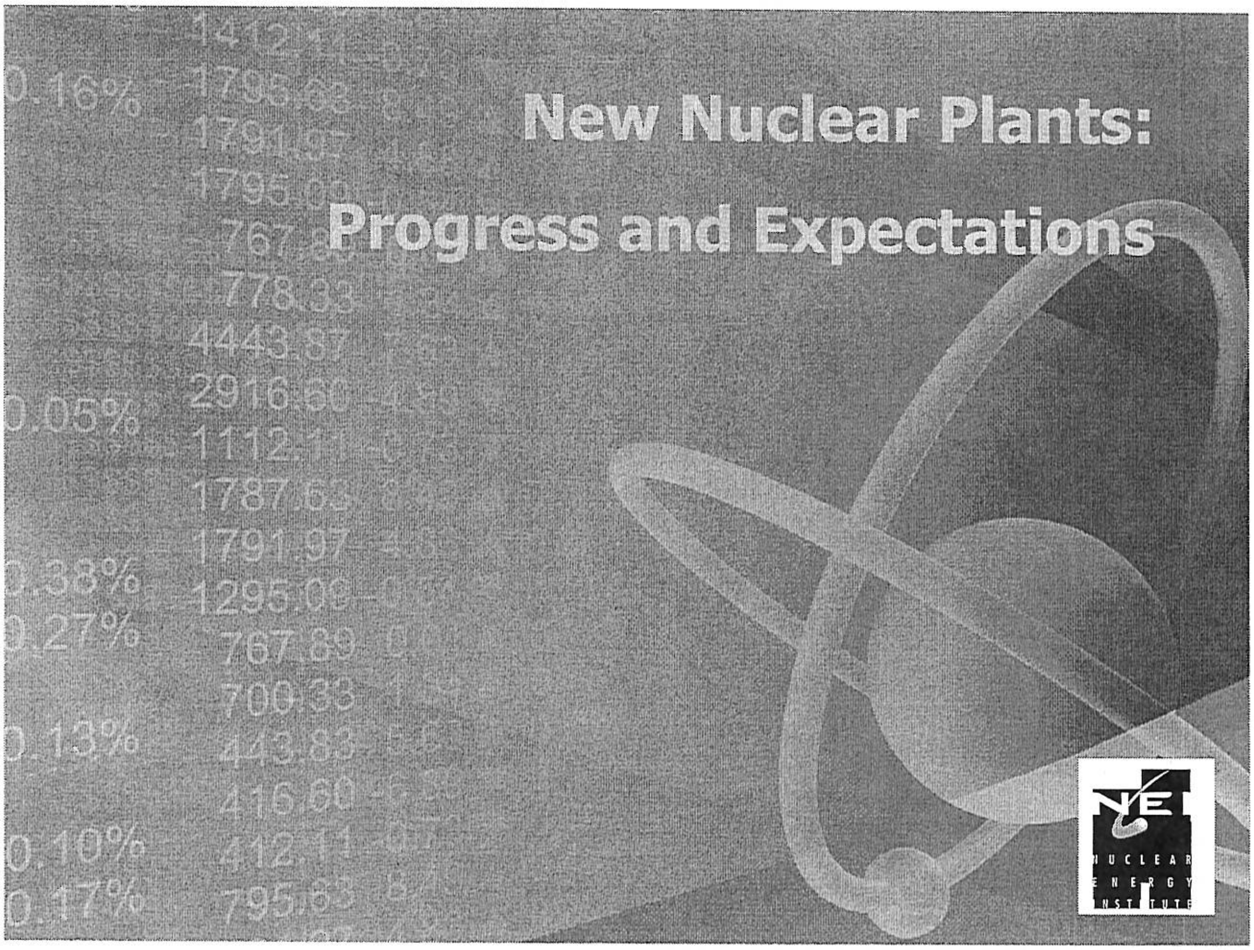
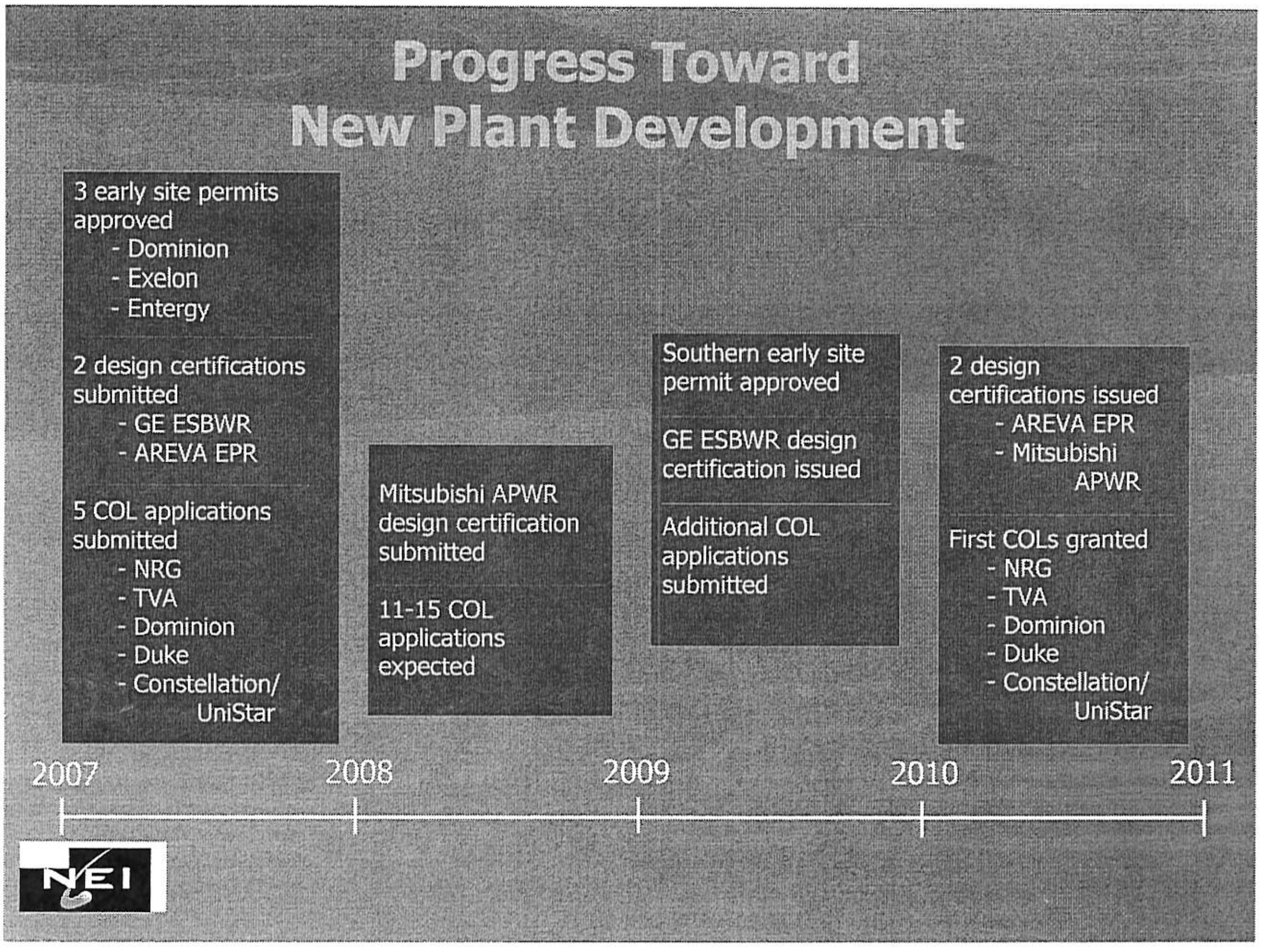
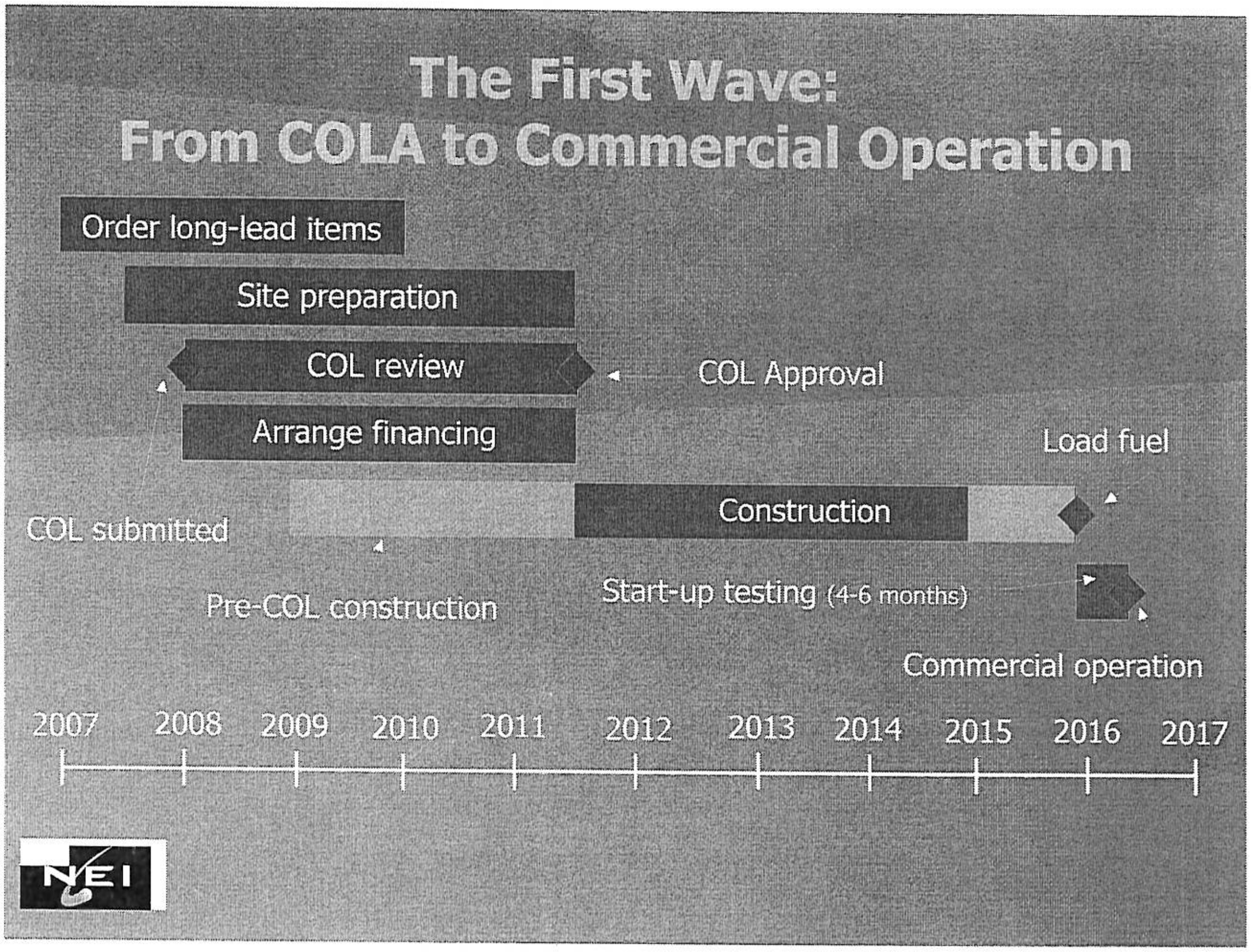
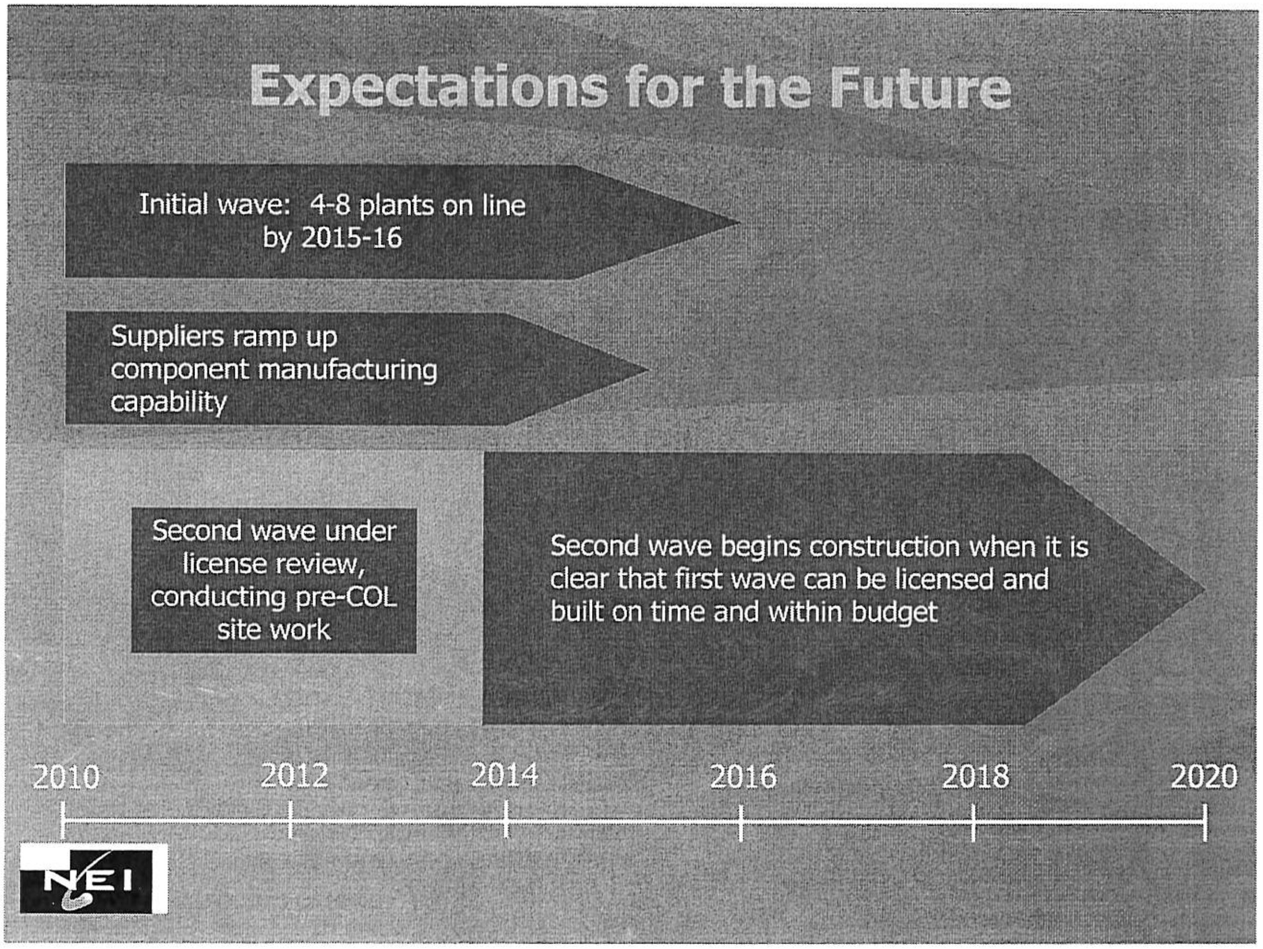
Source: U.S. Nuclear Regulatory Commission


New Nuclear Plants:
Progress and Expectations
NEI
NUCLEAR ENERGY INSTITUTE


Progress Toward
New Plant Development
3 early site permits approved
- Dominion
- Exelon
- Entergy
2 design certifications submitted
- GE ESBWR
- AREVA EPR
5 COL applications submitted
- NRG
- TVA
- Dominion
- Duke
- Constellation/ UniStar
Mitsubishi APWR design certification submitted
11-15 COL applications expected
Southern early site permit approved
GE ESBWR design certification issued
Additional COL applications submitted
2 design certifications issued
- AREVA EPR
- Mitsubishi APWR
First COLs granted
- NRG
- TVA
- Dominion
- Duke
- Constellation/ UniStar
2007
2008
2009
2010
2011
NEI


The First Wave:
From COLA to Commercial Operation
Order long-lead items
Site preparation
COL review
COL Approval
Arrange financing
Load fuel
COL submitted
Construction
Pre-COL construction
Start-up testing (4-6 months)
Commercial operation
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
NEI


Expectations for the Future
Initial wave: 4-8 plants on line by 2015-16
Suppliers ramp up component manufacturing capability
Second wave under license review, conducting pre-COL site work
Second wave begins construction when it is clear that first wave can be licensed and built on time and within budget
2010
2012
2014
2016
2018
2020
NEI

1-15

A Realistic Perspective

- Most projects still in early stages of development
- Should expect ...
  - changes in project ownership and structure
  - decisions deferred pending clarity on cost, other factors
  - decisions to suspend project development
- Positive signal: companies will not proceed unless they are confident that all risks identified, removed, mitigated

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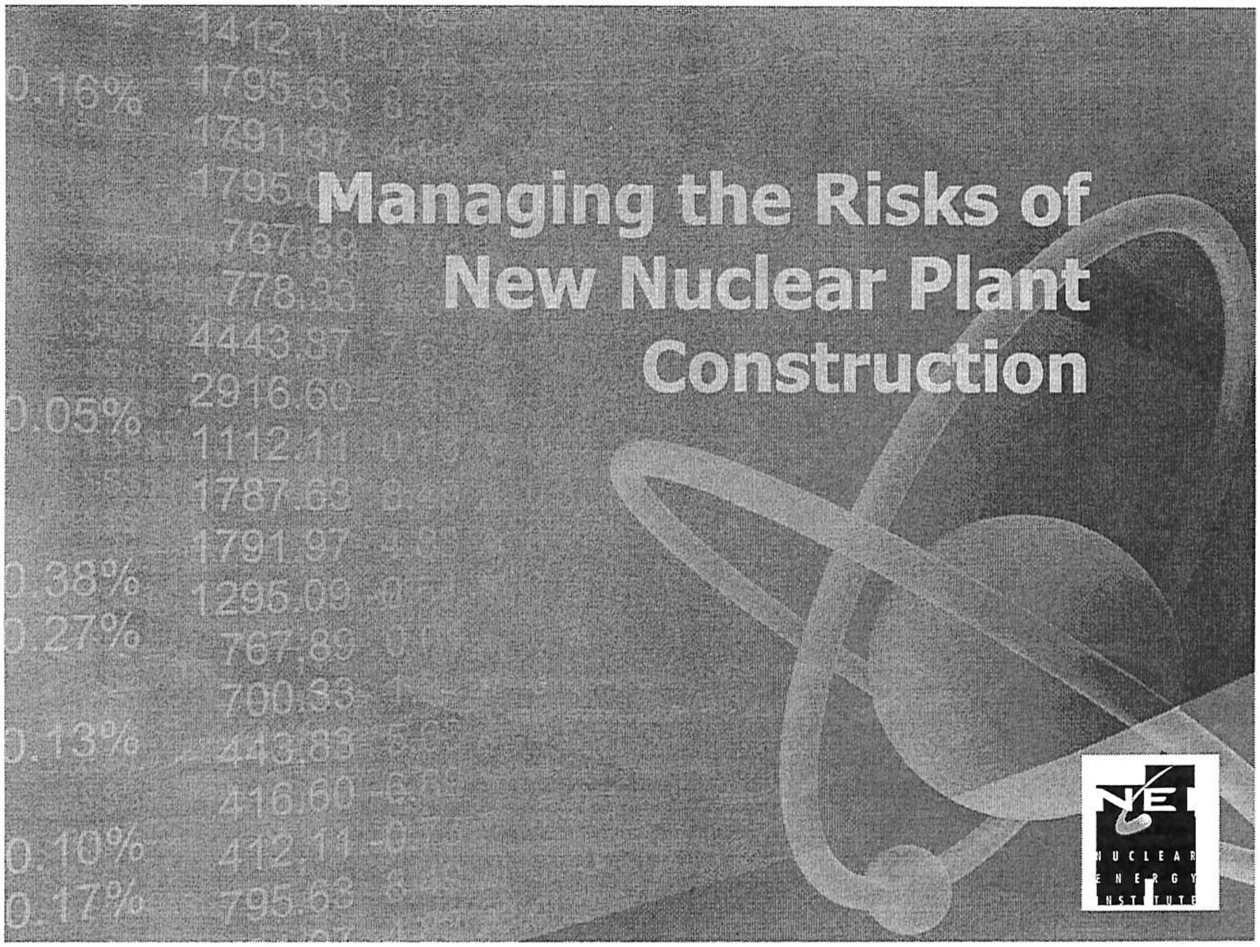
Managing the Risks of
New Nuclear Plant
Construction
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ENERGY
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In Retrospect ...
"The Perfect Storm"

- Rapidly changing technology and regulatory requirements
- Poorly designed, poorly implemented two-step licensing process
- Poor project management
- Adverse business conditions

Then and Now: The Biggest Difference

- The 1970s and 1980s
  - Cost overruns, schedule delays
  - Capacity factors in mid-50% range
  - Refueling outages 100-plus days
- Today
  - Major overhauls, plant restarts on time, on budget
  - Capacity factors in the 90% range
  - Refueling outages 20-30 days

The industry operating to today's high standards is the industry that will build new nuclear plants.

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Focused, Coordinated Program To Manage the Risks

- Started more than a decade ago
- Performed systematic assessment of what went wrong
- Approached new nuclear construction as risk-management exercise
- Assembled hundreds of industry experts in strategic areas

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Removing Risk From the Licensing Process

- Restructured licensing process
- Mature technology, stable regulatory requirements
- Streamlined hearing procedures
- More oversight of licensing boards
- Design-centered review groups and standardization
- "Sign-as-you-go" ITAAC verification
- High threshold, limited window for intervention after COL approval

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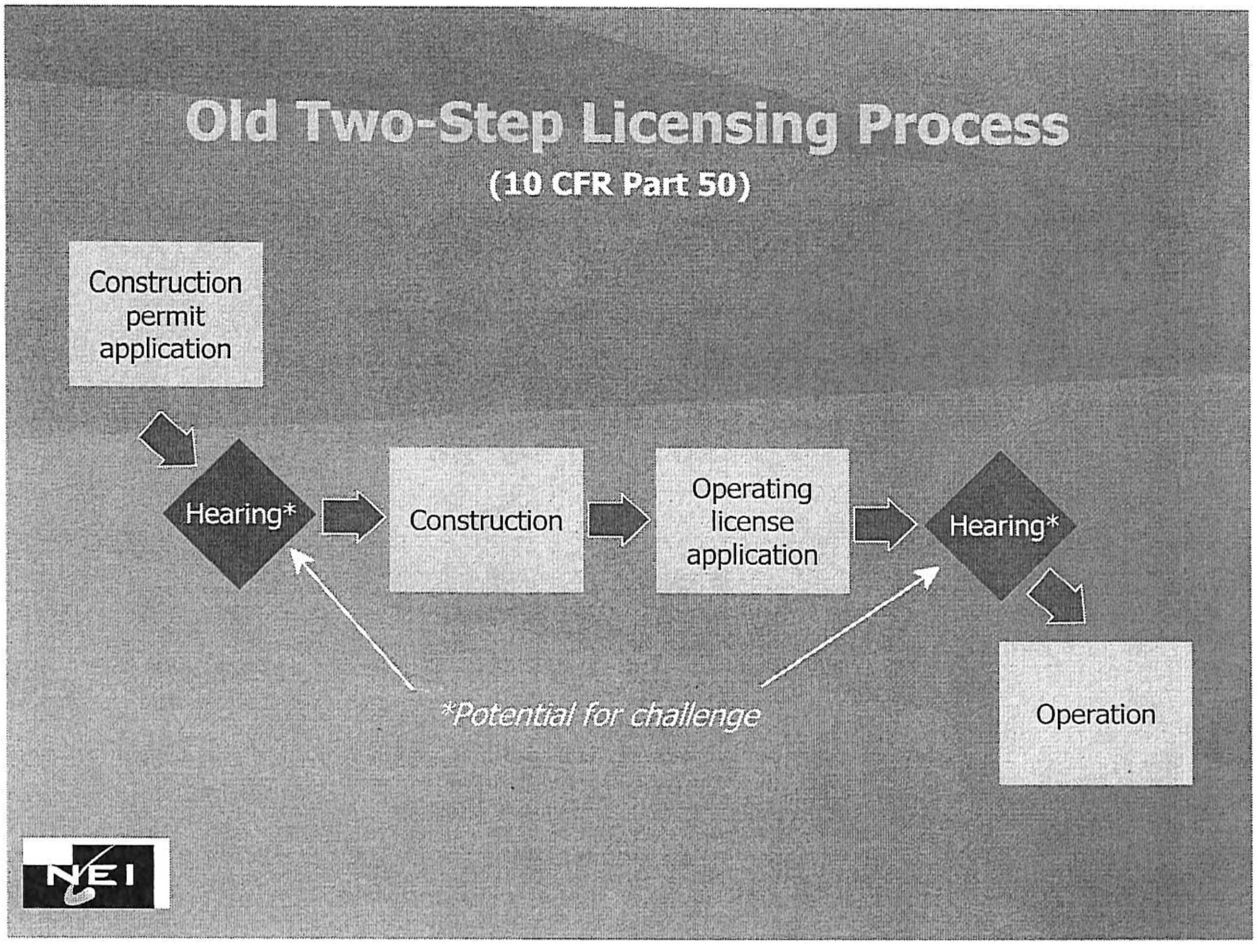
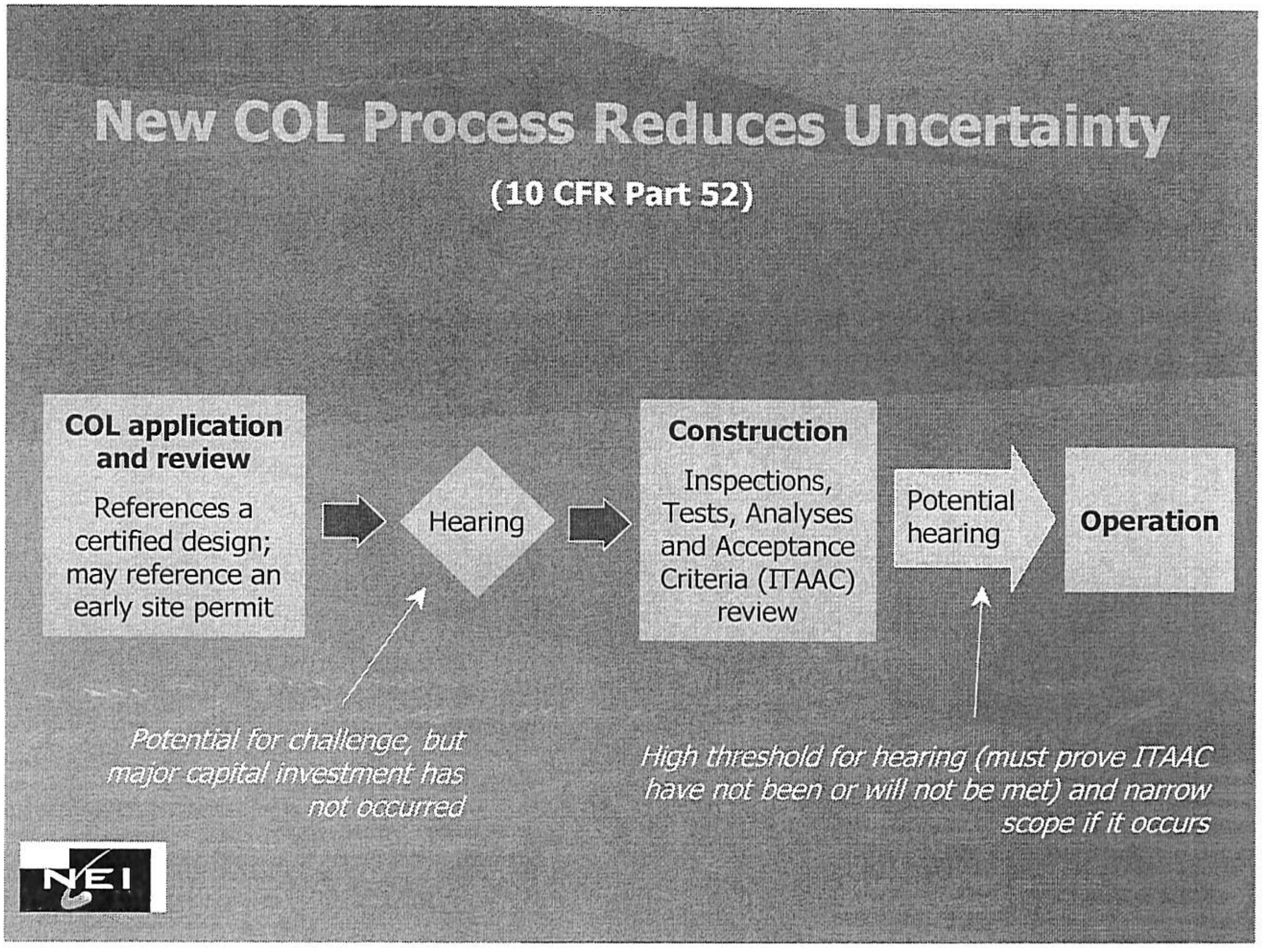

Old Two-Step Licensing Process
(10 CFR Part 50)
Construction permit application
Hearing*
Construction
Operating license application
Hearing*
Operation
*Potential for challenge
NEI


New COL Process Reduces Uncertainty
(10 CFR Part 52)
COL application and review
References a certified design; may reference an early site permit
Hearing
Construction
Inspections, Tests, Analyses and Acceptance Criteria (ITAAC) review
Potential hearing
Operation
Potential for challenge, but major capital investment has not occurred
High threshold for hearing (must prove ITAAC have not been or will not be met) and narrow scope if it occurs
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Project Management: Lessons Learned Provide Road Map for Success

- Detailed design complete before construction
- Integrated engineering and construction schedules
- Standardization
- Focus on quality assurance
- Safety-conscious work environment: effective corrective action, worker concern programs
- Improved planning and construction management tools
- Improved construction techniques

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Successful Project Management: Browns Ferry 1

- As complex as building a new plant
- 5-year, $1.834 billion project completed on time and within budget estimate
- Refurbished or replaced nearly all systems, components
- Simultaneously completed extended power uprate

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Successful Project Management: Fort Calhoun Overhaul

- Replaced many major components
- Completed refueling outage at the same time
- $417 million project completed approximately $40 million under budget, 5 days ahead of schedule

NEI

Supply Chain Starting to Respond

- Supply chain adequate for "first wave"
- Long-lead materials (e.g., forgings) already fabricated or ordered for first wave
- Component manufacturing will respond to sustained demand
- Early signs that suppliers are gearing up

Addressing the Work Force Challenge

- Nuclear engineering enrollments up dramatically
  - Undergraduate: from 470 in the 1998-99 academic year to 1,933 in 2006-07
  - Graduate: from 220 in the 1998-99 academic year to 1,153 in the 2006-07 academic year
- Joint initiatives with organized labor and the Departments of Labor, Education, Defense
- Industry-community college programs in 14 states
- Skilled crafts: collaborative programs in 10 states

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Economics of New Baseload

- New baseload capacity will be expensive
- With financial incentives, busbar costs for first new nuclear plants are in the $70-80/MWh range
  - Loan guarantees from the federal government
  - Supportive rate policies at the state level
- New nuclear plants will be competitive with other new sources of baseload electricity

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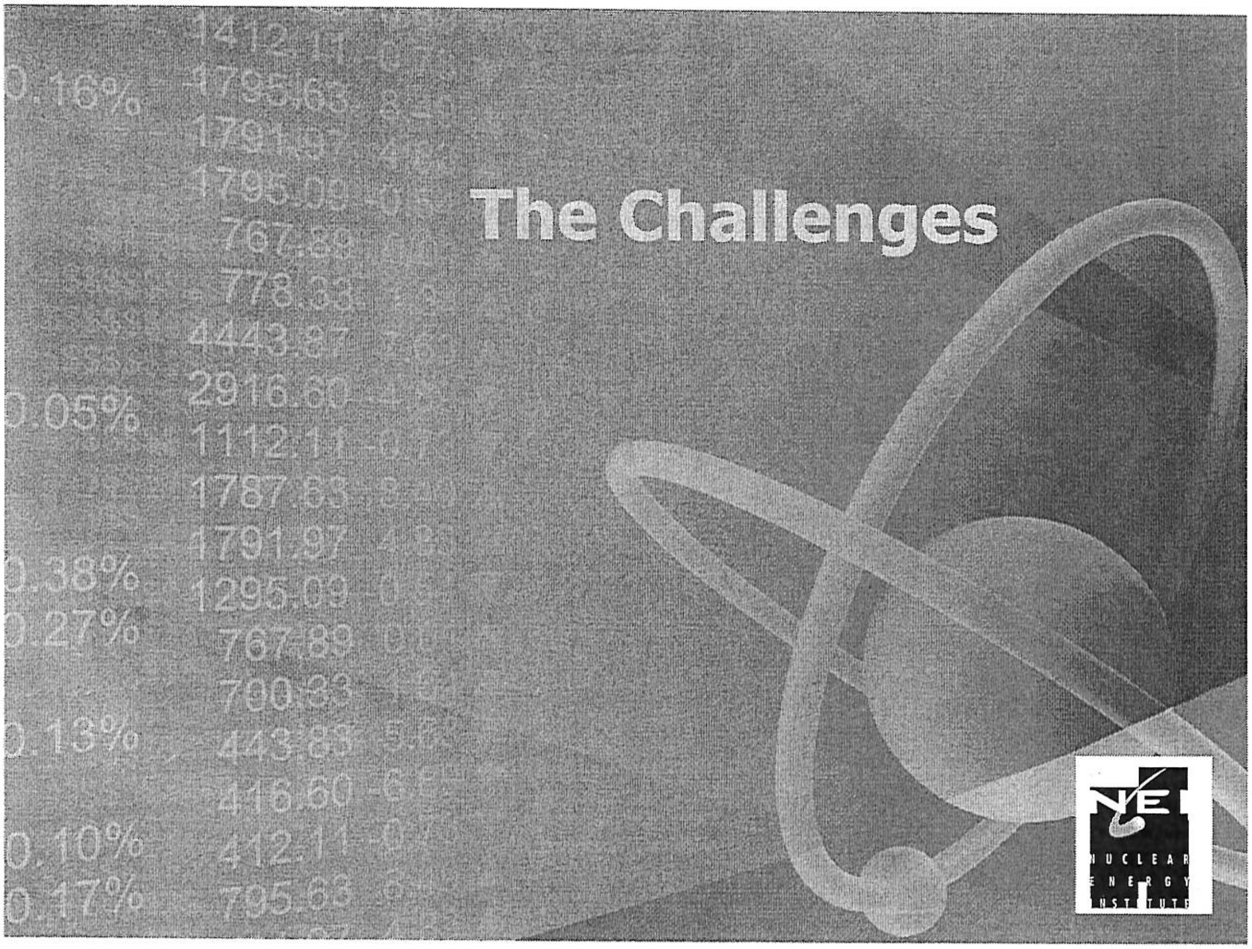
The Challenges
NUCLEAR
ENERGY
INSTITUTE

Uncertainties Remain ...

- New licensing process untested
- New administration, Congress in 2009
- Will escalation of input costs continue?
- No firm capital costs for nuclear (or anything else)
- Commercial terms (e.g., EPC contracts) tough to negotiate
- Large financial commitment for relatively small companies

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... But the Uncertainties Are Hedged

- More efficient, predictable licensing process
- Industry has clear understanding of what went wrong the last time
- Unmistakable need for new baseload capacity
- Bipartisan political support
- Strong public support
- Solid support from labor, growing support from environmental community
- Growing concern about carbon emissions

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The Bottom Line

- Measured approach to new nuclear plant construction
- New coal-fired capacity faces challenges
  - 28,500 megawatts announced 2006-07
  - 22,300 megawatts canceled
- No new nuclear capacity before 2015-16, and then ramps up slowly
- More gas-fired capacity to fill supply/demand gap
- Continued safe, reliable operation of existing plants, continued profitability

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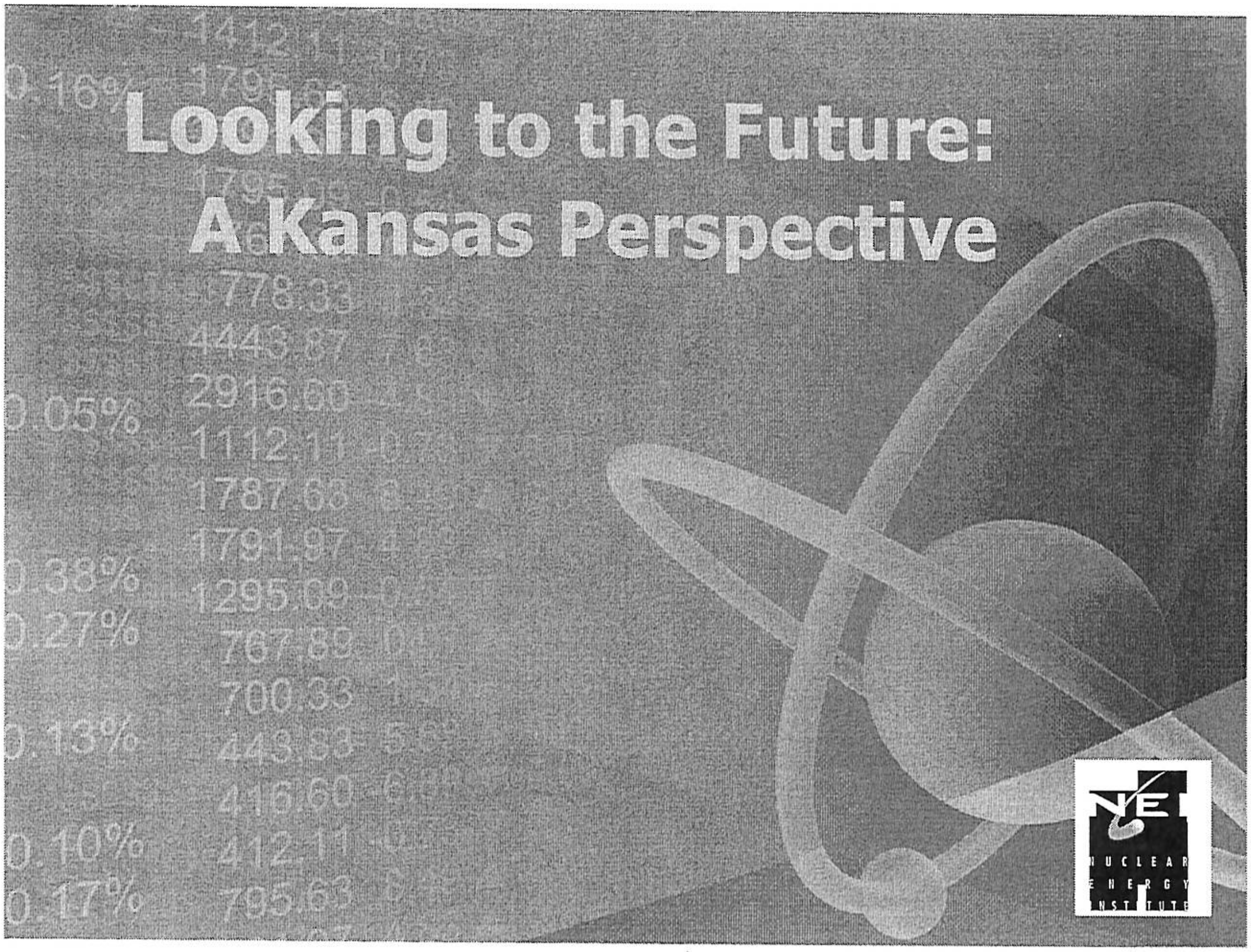
Looking to the Future:
A Kansas Perspective
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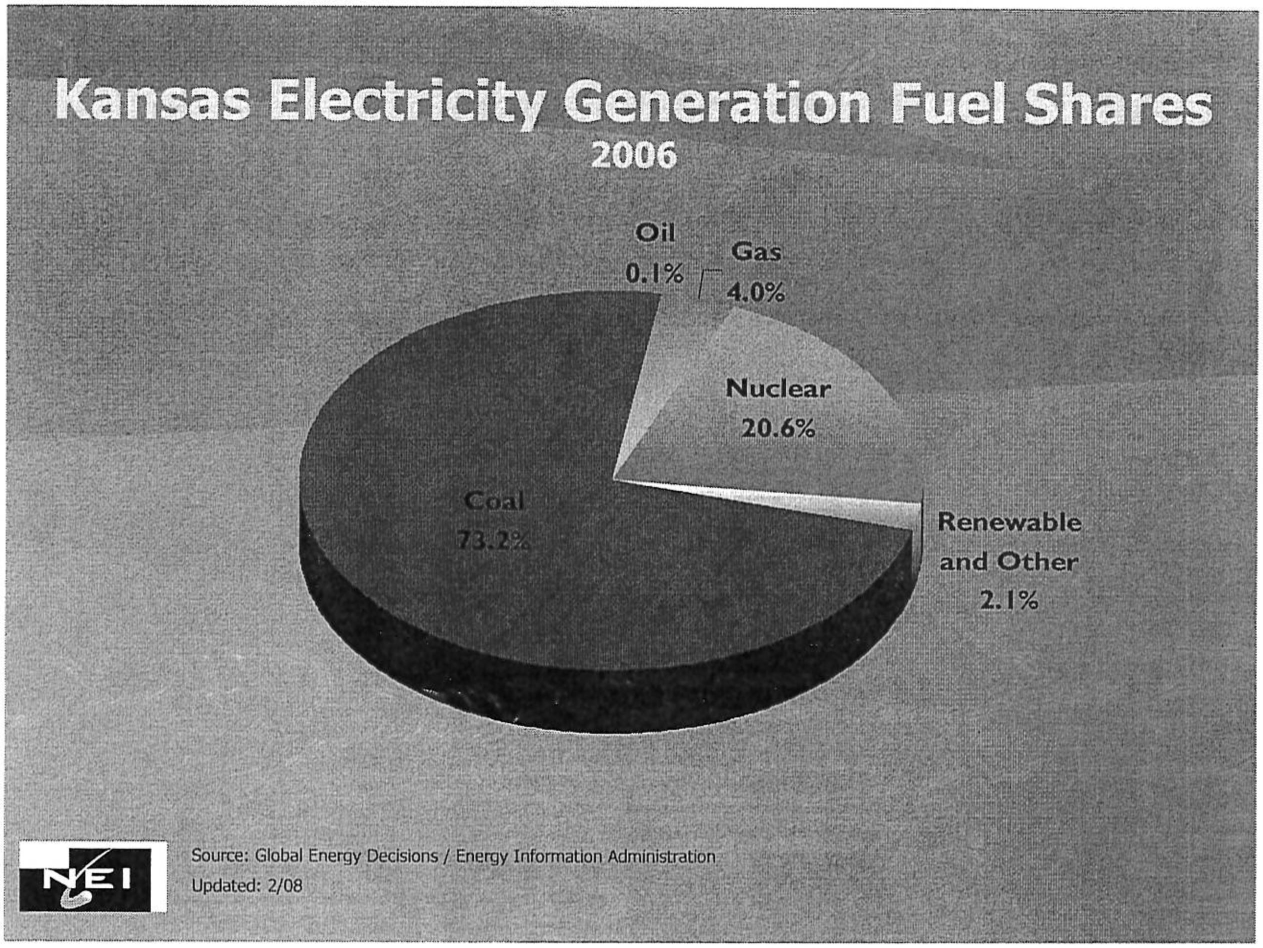
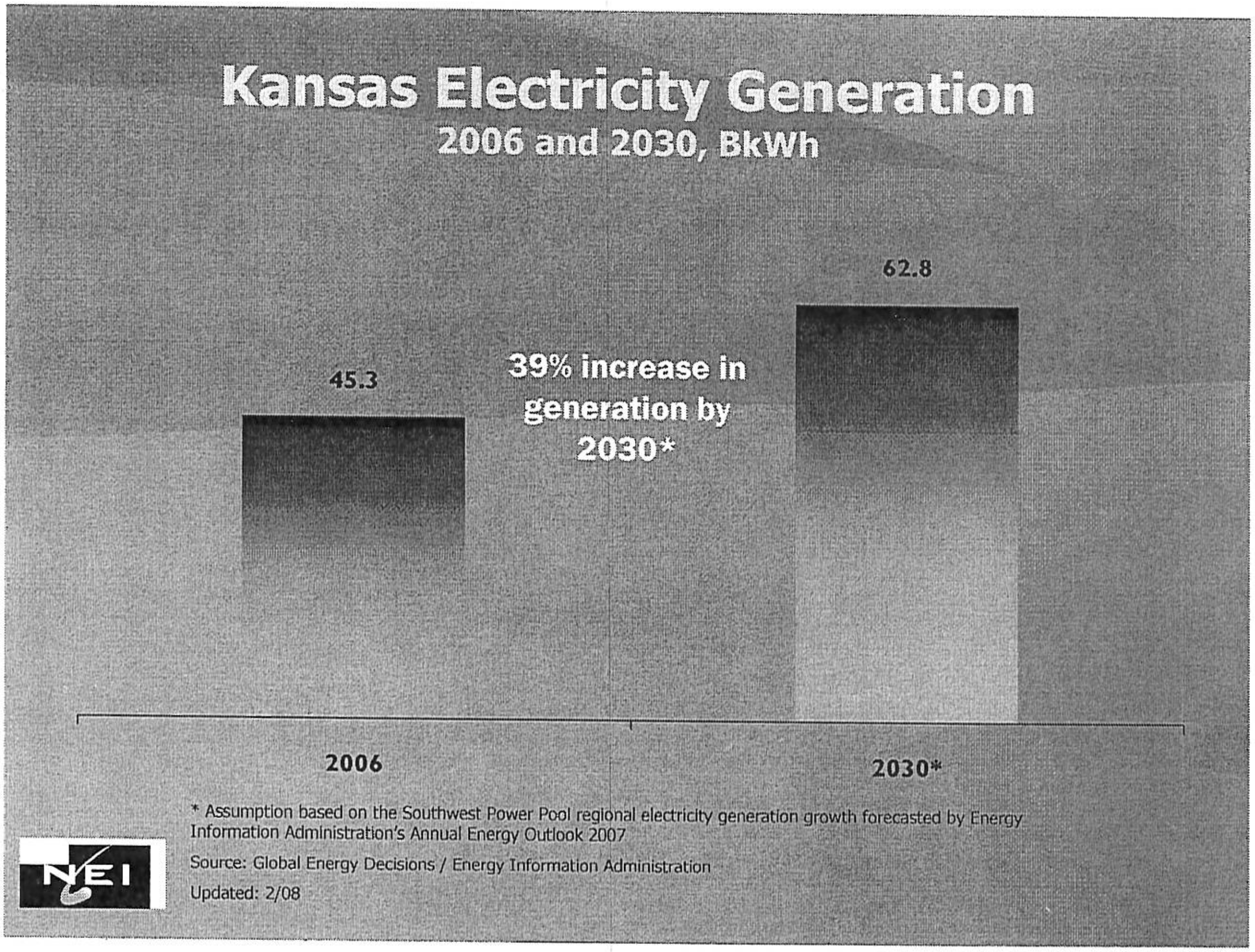
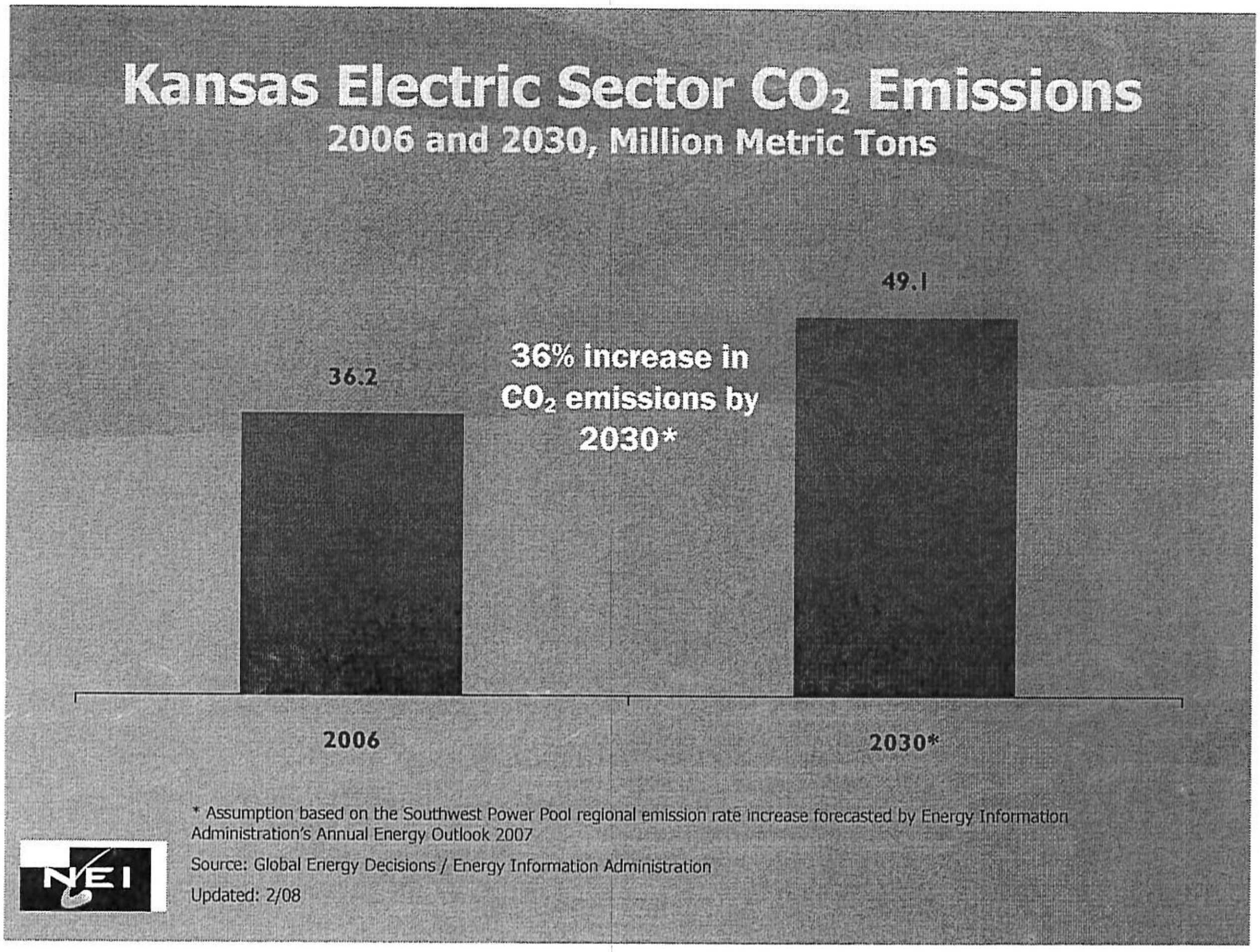

Kansas Electricity Generation Fuel Shares
2006
Oil
0.1%
Gas
4.0%
Nuclear
20.6%
Coal
73.2%
Renewable
and Other
2.1%
NEI
Source: Global Energy Decisions / Energy Information Administration
Updated: 2/08


Kansas Electricity Generation
2006 and 2030, BkWh
62.8
45.3
39% increase in generation by 2030*
2006
2030*
* Assumption based on the Southwest Power Pool regional electricity generation growth forecasted by Energy Information Administration's Annual Energy Outlook 2007
Source: Global Energy Decisions / Energy Information Administration
Updated: 2/08


Kansas Electric Sector CO2 Emissions
2006 and 2030, Million Metric Tons
49.1
36.2
36% increase in CO2 emissions by 2030*
2006
2030*
* Assumption based on the Southwest Power Pool regional emission rate increase forecasted by Energy Information Administration's Annual Energy Outlook 2007
Source: Global Energy Decisions / Energy Information Administration
Updated: 2/08

Potential Benefits From One New Nuclear Reactor in Kansas

- A new nuclear reactor (1,350 MW) for KS could meet more than half of the generation demand increase forecasted for 2030
- The new unit would avoid about 8 million metric tons of CO_2 annually, equal to the emissions from 1.6 million passenger cars!

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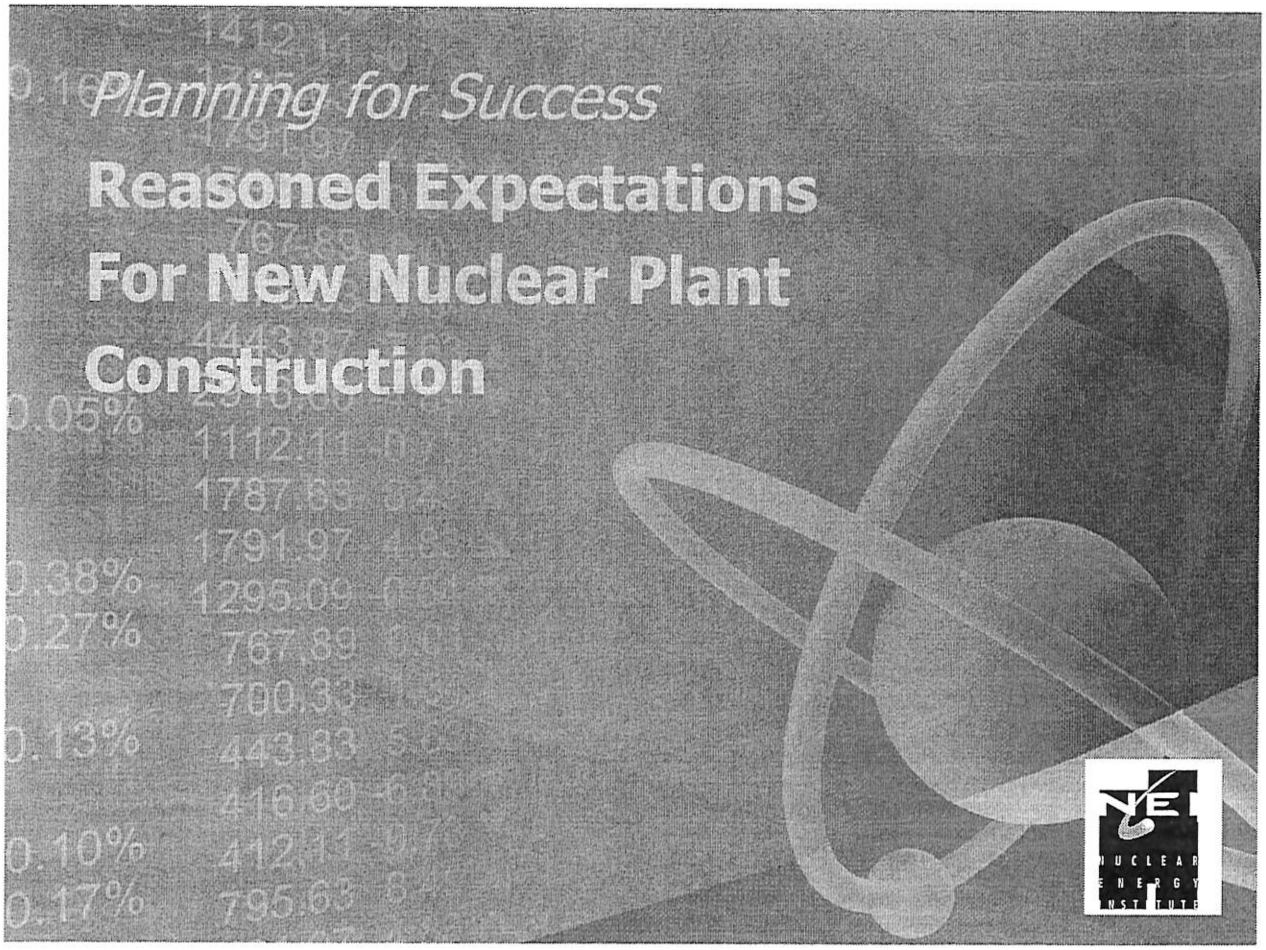
Planning for Success
Reasoned Expectations
For New Nuclear Plant
Construction
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NUCLEAR ENERGY INSTITUTE

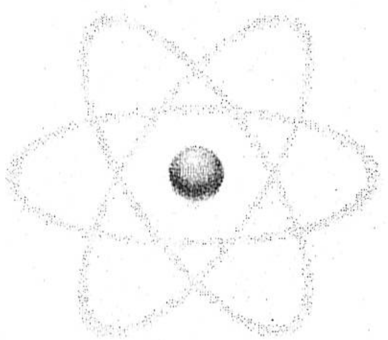
business

Nuclear power back in the spotlight

The power source is back in the spotlight with its low emissions and fuel costs, but safety concerns linger.

By Andy Vuong
The Denver Post

Article Last Updated: 02/11/2008 11:29:33 AM MST



Thirty years since a U.S. nuclear reactor was last ordered and more than a decade since the last plant opened, the controversial energy source is back on the radars of utilities across the country.

Federal regulators received four license applications for seven new nuclear power units in 2007 and expect to receive another 15 applications for 22 units this year.

Though none of those units is proposed by Xcel Energy or planned for Colorado, the state's largest utility says it will examine the power source in future resource acquisition filings, which detail how the company will meet consumer electric needs years down the road.

Xcel announced plans in December to boost generating capacity at its two nuclear plants in Minnesota.

Post Poll - Nuclear Power

"Nuclear power needs to be a part of the nation's portfolio to meet increasing demand for electricity while reducing carbon emissions," Xcel spokesman Mark Stutz said. "We have no plans at this time in Colorado to pursue additional nuclear power. But we don't discount its use in the future, and we will at least take a look at it in future resource filings."

Several factors are driving the renewed interest

Select Committee on Energy
+ Enviroment for the Future
3/6/08
Attachment 2

in nuclear energy.

Operations, maintenance and fuel costs for nuclear plants have dropped about 30 percent since 1995, according to the Nuclear Energy Institute. At the same time, the cost of operating a coal-fired plant has remained relatively flat, while natural-gas prices have surged.

"It's become a matter of economics," said Tom Johnson, an assistant professor in the department of environmental and radiological health sciences at Colorado State University. "Nuclear is starting to become a little bit cheaper than coal."

Another factor is the nation's focus on reducing carbon dioxide emissions, considered the main cause of global warming. Utilities are facing the threat of a tax on carbon emissions. Unlike coal and natural-gas plants, nuclear plants emit little, if any, greenhouse gas.

As part of the Energy Policy Act of 2005, the federal government offers tax credits and loan guarantees for the construction of new nuclear plants. The government also instituted a "Nuclear Power 2010 Program" to streamline the often onerous licensing process and encourage near-term reactor orders. The program also pays for some of the licensing and planning.

Still, despite the increase in applications, no new nuclear units have been ordered even as plants have opened around the world at an average rate of four per year since 1996, according to Congressional Research Services, the research arm for Congress.

Operation concerns Working against nuclear power is the cost of construction, which far exceeds the cost to build a coal or natural-gas plant.

A nuclear plant with 1,000 megawatts of capacity would cost about $2 billion to build if construction started in 2015, according to estimates by the research service. A similar coal-fired plant would cost about two-thirds of that, and a natural-gas unit about one-third. Coal and natural-gas plants generally are built with much lower generating capacity, further reducing construction costs.

One megawatt of generating capacity powers about 1,000 homes. The research service estimates it would take five to seven years to build a nuclear plant.

Concerns also remain about the safety hazards of using radioactive materials to generate power and the struggle to find proper storage for nuclear waste.

"Even though the waste is a really small quantity, it's very, very toxic, and it will be here for a very long time," Boulder environmentalist Leslie Glustrom said.

Though no deaths or injuries have been caused by a U.S. nuclear plant accident, a failure at the Three Mile Island plant in Pennsylvania in March 1979 heightened safety concerns. Regulators said the worst-case scenario of the failure would

2-2

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THE DENVER POST

have been the release of radioactive gases to the environment, which didn't happen.

Glustrom and others say utilities should focus on boosting safer alternative energy sources such as solar and wind power.

Renewed interest Nuclear-energy supporters argue that those technologies are taking too long to develop.

"For 30 years, people have been asking about solar and wind, but right now, they're only a tiny fraction of the power produced," Johnson said.

Today, 104 U.S. nuclear reactors are in operation, generating about 20 percent of the country's electricity. Coal accounts for more than half.

Denver-based energy industry consultant Peter Bryant said U.S. utilities may have no choice but to renew their investments in nuclear power.

"There's still no proven approach to carbon sequestration for coal, so coal plants will continue to be slowed down in their build-out," said Bryant, president of TransTech. "Energy needs will continue to increase despite advancements in the conservation of energy, and the renewables are just not going to fill that whole growth."

Though Bryant said it's possible for a nuclear plant to be placed in Colorado, the state's experience with the power source is rocky.

Colorado's lone nuclear plant, Fort St. Vrain near the Weld County town of Platteville, was decommissioned — taken out of service — in the 1990s after a long history of operating problems. Xcel converted it to a natural-gas-fired plant.

"A great source of energy" Platteville Mayor Steve Shafer said he would support the construction of a new plant or recommissioning Fort St. Vrain, though he believes that would be highly unlikely because the reactor has been taken apart.

"It's a great source of energy," Shafer said of nuclear power. "The capability could still be there (to recommission Fort St. Vrain), but it would probably be more cost effective to start from scratch."

Nuclear energy expert Bob Meyer said a plant could be placed in the area around the Rawhide coal-fired plant near Fort Collins or on the Eastern Plains.

"We have a lot of open-land area, and we' ve got enough cooling water available in a number of locations that we could certainly build one or more nuclear plants here," said Meyer, who lives in Fort Collins.

Colorado's abundance of sun and wind resources, however, could push Xcel toward those alternatives instead. Xcel said in its latest resource plan that it would roughly double its renewable generation in the state with solar and

2-3

wind power. The utility will file its next plan in two years.

Andy Vuong: 303-954-1209 or avuong@denverpost.com

2-4

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Published by The New American (http://thenewamerican.com)

Nuclear Waste: Not a Problem

By Ed Hiserodt
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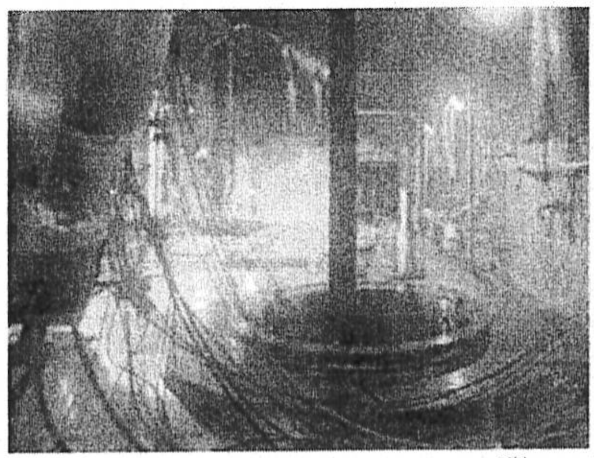
Yes nuclear energy is clean, but the waste is a problem. The life of the waste is 100,000 years no matter what you hear. The canisters that will hold this waste will disintegrate in 1,000 years or less, or so they say.
— From TNA "Letters to the Editor"



AP Images
Inside a nuclear waste treatment facility in France.

How ironic that the nuclear wastes of concern to the letter-to-the-editor writer have become the most serious problem with nuclear power generation. Six decades ago the birth of nuclear power was praised for lowering the volume of waste products by a factor of 10,000,000. As Petr Beckmann pointed out in his classic *The Health Hazards of NOT Going Nuclear,* the nuclear wastes for an individual for a year is about the size of an aspirin tablet — a minuscule price to pay for inexpensive, reliable, safe electrical power. Yet when nuclear power is mentioned as a clean alternative today, the problem of wastes invariably arises.

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The "Problem" of Waste in Context

The low volume of nuclear waste as compared to wastes from coal-fired power production is what attracted the early conservationists who saw nuclear power as an ideal way to protect our ecosystem. A 1,000 Megawatt coal-fired power plant produces solid wastes at a rate of 1,800 pounds *per minute*, waste that includes 19 toxic metals such as arsenic, carcinogens such as benzopyrene, and mutagens from the respirable coal fly ash. A coal-fired plant also produces 50 times the radioactive emissions of an average nuclear power plant. For those concerned about such things, going nuclear even reduces CO_2 emissions by 600 pounds *per second.*

The coal-fired plant also produces 30 pounds of sulfur dioxide *per second* (said to cause acid rain, amongst other problems) and as much nitrous oxide as 200,000 automobiles. Each year some 60,000 fellow citizens die early deaths from exposure to byproducts of coal combustion, according to studies by the Brookhaven National Laboratory, Divisions of Atmospheric Sciences and of Biomedical and Environmental Sciences. Note that unlike wastes from nuclear power plants, all products of coal combustion are either sent into the atmosphere or into landfills where they remain toxic forever.

Even with that extensive list of negatives, the danger from coal-fired power plants pales in comparison to a far more serious danger — a lack of access to electrical energy. If we opt for inconsistent sources of energy, such as wind power and solar generation instead of fossil or nuclear power, we have only to wait for the invariable brownouts and blackouts that will be the result. We see the toll from a lack of energy each time we have a natural disaster where people flee to the nearest place where the comfort, sanitation, and safety provided by electrical power is available. We also see this dramatically in countries where work is performed primarily by human labor and the combustion of wood is a primary source of energy — and the population lives in the squalor that we always see under such conditions. The surest way to a low standard of living is energy poverty.

What Are Nuclear Wastes?

There are many answers to this question, including smoke detectors in the landfill or gloves worn by a nuclear medicine physician. (A failed nuclear-waste disposal law proposed in the Colorado legislature would have made a trip to the restroom a criminal offense since urine is always radioactive with Potassium-40.) Here, however, we are addressing only the waste products from commercial nuclear power generating plants.

The fuel for a Light Water Reactor (LWR) as typically used in the United States is uranium — a relatively plentiful metal in the Earth's crust averaging three grams per ton, which is three times that of mercury, 36 times the abundance of silver, and outstrips gold by a factor of 675. Once the ore is mined, the percentage of the fissionable U-235 isotope is "enriched" to some 3.5 percent compared to its natural occurrence of 0.7 percent within the predominant U-238 isotope. To fuel a reactor, finger-sized pellets of enriched uranium held in special tubing are inserted into the reactor core along with control rods of neutron-absorbing materials. Plain water is a critical component of any LWR as it serves as a coolant, a heat-transfer agent, and a *moderator* to slow down neutrons so they can be captured by the U-235 isotopes causing them to *fission* or split into a number of new elements.

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The new elements created when the uranium atom "splits" are called the *daughters** of the reaction and consist of a number of isotopes that run the gamut from being highly radioactive — hence spawning future radioactive disintegrations — to being stable and nonradioactive. The radioactive *daughters* and their *progeny* are considered high-level wastes. They consist of about 3 percent of the volume of spent fuel and amount to approximately 7.5 cubic feet (about a quarter of a cubic yard) from a year's production from a 1,000 Megawatt power plant — considered to provide the electricity needs for 750,000 homes.

In rating the long-term dangers from these radioactive waste products, one must consider their half lives, i.e., the time required for an isotope to lose half its radioactivity. For example, radioactive iodine with an atomic weight of 131 (I-131) has a half life of about eight days, meaning a sample of I-131 will emit half of its initial radiation after eight days. In just over a month — 32 days — it will have lost 15/16th of its original intensity. After 30 half lives it is considered (by definition) to have completely disappeared.

The table below lists the half lives of significant *radionuclides*** found in spent nuclear fuel.

Gases	
Kypton-85	10.7 years
Xenon-133	5.3 days
Solids	
Strontium-90	28.1 years
Molybdenum-99	66.7 hours
Iodine-131	8.1 days
Cesium-137	30.2 years
Cerium-144	285 days

What About the Other 97 Percent?

We have addressed the 3 percent of spent fuel that can be considered extremely dangerous high-level waste, because of the intensity at which it releases its radiation. But we have also seen from the preceding table that the rapid decay of its components lessens its danger to relatively short periods of time. About 97 percent of spent fuel is not waste at all, but valuable uranium and plutonium that can and should be recycled for use as fuel. It seems odd that we are enjoined by "environmentalists" to recycle paper — a truly renewable resource — but be forbidden by government decree to recycle radioactive fuel that is many times more expensive than gold. After chemically removing the high-level wastes, the recoverable isotopes in spent fuels and their half lives are:

Uranium-235	710 million years
Uranium-238	4.5 billion years

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Plutonium-239	24.4 thousand years†
Plutonium-240	6.6 thousand years†
Plutonium-241	13.2 years†

Note that except for plutonium-240 and -241, these recyclable isotopes have very long half-lives and they emit their radiation slowly — so slowly, in fact, that they can safely be handled with bare hands. But there is no need for the public to come into contact with any of these since they can be used immediately as nuclear fuel. Already in LWRs, plutonium transmuted from U-238 provides nearly a third of the generated electrical energy. Stockpiled weapons-grade plutonium is being mixed with uranium in a "mixed oxide fuel" or MOX and "burned up" as fuel in the reactor. How better to beat a sword into a plowshare?

So why doesn't the United States, like other countries possessing nuclear power, reprocess its fuel, removing the high-level radionuclides and reusing the uranium and plutonium isotopes? It is owing to the perceived — rather misperceived — dangers of the plutonium in the "spent fuel." In 1977, the Carter administration canceled the Barnwell, South Carolina, reprocessing plant then nearing completion because of an exaggerated danger of terrorists stealing our nuclear fuel and chemically separating the plutonium from the uranium in order to build nuclear weapons with it.‡ France, Germany, Japan, and Russia continued with their reprocessing facilities and have assured themselves sources of readily available nuclear fuel for the foreseeable future. Our reprocessing efforts were limited to military purposes.

How Dangerous Are Nuclear Wastes?

Nuclear power plant wastes come in two distinct varieties: the dangerously radioactive *daughters* that are the remnants of the fission reaction, and the remaining recyclable isotopes that can be "burned" as fuel in the reactors to produce heat, steam, and electricity. *Those opposed to nuclear power would have us confuse these two*. A nuclear physics axiom is: "In general, the higher a radionuclide's specific activity, the shorter its half life (decay rate), and the more 'radioactive' it is when compared to one with a lower specific activity." If the "specific activity" stuff seems a bit confusing, you might think of short half-life isotopes to behave like gasoline thrown on the campfire, while the long half-life isotopes are analogous to the methane that seeps slowly up in the bayou and glows on those still, dark nights. High-level wastes give up their energy in a short period of time and then become stable and harmless, while the unused fuel (uranium and plutonium) are so weakly radioactive that their emanations are only dangerous in the minds of those who are dead set against nuclear power.

How long does it take for high-level wastes to become safe? For those interested in a definitive answer to this question, Bernard Cohen's article "The Disposal of Radioactive Wastes From Fission Reactors" in the June 1977 issue of *Scientific American* is a classic that delves deeply in to the subject. However, there are ways to attack the question using logic. The daughters of fission reactions are not only radioactively hot but are also thermally hot, since the energy from the decay is converted into heat energy. These decay products begin very hot and cool as they lose radioactivity. The decrease in the heat produced can therefore be equated to the decrease in radioactivity. A canister of waste that produces 30,000 watts of heat energy when removed (after one year) from a power plant cooling pond would have dropped to about 3,000 watts in 10 years, to 300 watts in 100 years, and to a barely detectable 3 watts in 1,000 years. We can see then that the

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radioactivity of the waste canister has decreased to 1/10,000th its initial value and is not likely to require the services of armed guards 24/7 for 100,000 years, as the more vocal anti-nuclear activists would have one believe.

Where Do We Bury Virginia?

Another interesting way for us to assess the dangers of radiation is to compare the radiation levels found in nuclear plant wastes to those of material found in nature. Numerous studies dating from the 1970s show that ores from which the uranium for fuel was mined have the same amount of radioactivity that nuclear wastes will emit after being sequestered from 400 to 900 years, depending on the quality of the ores and the timing of a power plant's refueling cycles. If we used the same philosophy about naturally occurring radioisotopes as we do nuclear power plant wastes, we would have to dig up, encase, and rebury the State of Virginia because of the large uranium deposits that have been found there. (And you can be certain Senator Harry Reid, whose fear-mongering about nuclear wastes knows no bounds, would not allow Virginia to be buried in Nevada!)

We don't attempt to sequester naturally occurring radioactive pitchblende and similar ores to protect humans and animals from cancers and mutations, nor should we. They've always been there. Many states besides Virginia — e.g., New Mexico, Wyoming, Colorado, Utah, Texas, Arizona, Florida, Washington, and South Dakota — have ore deposits that are sufficiently concentrated for commercial mining, without harm to the population or causing radioactive pollution of the groundwater. And, for the record, these naturally occurring ores aren't vitrified, encased in stainless steel, or stored in a dry environment.

Yucca Mountain

In the late 1950s, the National Academy of Science looked into the then-upcoming nuclear-waste disposal situation. At the time reprocessing of the fuel elements was a "given"; thus, it was just the high-level, short half-life decay products that were being considered as nuclear waste. Scientists decided that vitrifying them (making them into glass), encasing them in stainless-steel containers, and burying the canisters in geological formations that hadn't seen moisture in millions of years was the best way to keep them out of the biosphere and eliminate the possibilities of groundwater contamination. This also allowed for retrieval of the valuable radionuclides if that became desirable in the future.

In 1978, the Department of Energy began studying Yucca Mountain, a 4,950-foot ridge in the uninhabited desert 80 miles northwest of Las Vegas, as a site for the long-term storage of high-level nuclear wastes that by now were considered to include the recyclable fuel components. The facility, which has already been paid for by the nuclear power industry and its rate payers, was expected to begin accepting nuclear wastes in 1998. This did not happen due to a bitter fight over the issues of transportation dangers and the firm opposition by the anti-nuclear activists to even the most stringent safety measures to prevent migration of the waste products into the groundwater.

Yucca is now scheduled to begin receiving spent fuel in 2017, making it possible that some scientists and engineers will have spent their entire careers studying and constructing the repository. (In comparison, it took engineers and workers seven years to construct the 31-mile tunnel beneath the English Channel.) Yet even the 2017 start date is in jeopardy due to opposition from anti-nuclear activists and those who are swayed by their rhetoric.

Somehow we're expected to believe that rains will suddenly come to the desert, with water rushing through 2,500 feet of solid rock, dissolving the stainless steel shells of the glassified waste, leaching radioactive materials from the glass, and then gushing through another 1,500 feet of rock to the water table. Fast forward 100,000 years where some civilization with the technology to drill wells through several thousands of feet of rock will drink that water — water that would be only a fraction as radioactive as well water in parts of Maine or in health spas all over Europe. As noted, in much less than 100,000 years — 400 to 900 years to be precise — the waste will be no more radioactive that the natural ores that were mined for nuclear fuel.

To even imagine that a stainless-steel canister encasing glassified wastes and stored in a dry environment that has been studied in every particular for over 30 years would deteriorate seems a foolish prediction when there are innumerable cases of unprotected iron fasteners and structural members dating from the Middle Ages that are still serviceable after hundreds of years of exposure to wear, tear, and the elements.

Statistical Deception

The underlying cause of the nuclear-waste "problem" is an exaggerated fear of radiation. We have been conditioned for many years to accept the premise that even the slightest bit of radiation is dangerous — a premise that is not borne out by any experimental evidence.

It is certainly true that high doses of radiation can sicken or kill, and lower but still very substantial exposures can increase one's propensity for developing cancer. But contrary to "common knowledge," examination of the data shows that low levels of ionizing radiation often have a beneficial effect on human health known as *hormesis* — a fact that many scientists are striving to make public with little help from an uninformed and generally anti-nuclear news media. There is a very close parallel between ultra-violet (non-ionizing) radiation from exposure to sunshine and nuclear (ionizing) radiation. While extreme exposure to sunlight can lead to sunstroke and death, and lesser amounts cause sunburn and increase chances of skin cancer, moderate sunshine stimulates our bodies to create vitamin D that is necessary for good health.

We see this same phenomenon with trace elements such as arsenic and many vitamins. It is not unexpected then to see the same human reaction to ionizing radiation.

We have been deceived into believing that all radiation is bad because of the United States' policy reliance on the "linear no-threshold" theory, or LNT, which states that if large amounts of something cause death or sickness, fractional amounts of the same thing cause proportional amounts of death or sickness. If the LNT were applied to falling as it is to radiation, we might note that 100 percent of those falling onto concrete from 100 feet are killed, but only 50 percent of those falling from 50 feet die. With these data we would linearly extrapolate to say that 10 percent falling from 10 feet and one percent of those falling from one foot would die. Armed with this "linear no-threshold falling theory," we could confidently assert that jumping rope should be banned on all school playgrounds since statistically anyone making 100 one-foot jumps would die.

Neither experience nor evidence supports LNT theory, yet this same statistical ploy is used to make very small exposures of radiation to large numbers of individuals appear deadly. In 2005, by unanimous vote, both the French Academy of Medicine and the French Academy of Science deplored the use of this dose-response methodology in predicting effects of low-dose radiation. It is high time that the radiation professionals in this country did likewise, and many are doing just that.

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Unfortunately, the fact that thousands of workers in nuclear industries are outliving their unexposed peers is not considered newsworthy, but a leak of three quarts of reactor coolant water with less radioactivity than salad dressing makes the front page as a catastrophe.

Radioactivity surrounds us. Human beings and all we come into contact with contain radioisotopes. Uranium in the soil will still be radioactive in 10 billion years when our sun runs out of hydrogen. It is a natural part in our universe. To fear it is like fearing the warmth of a fireplace just because fire can also burn down the house. Yet people are still paralyzed with fright because few in this country understand anything about the measurement of radiation or its effects. Until we do we are defenseless against the posturing of radical environmentalists and destined to eventually lose the most incredible source of clean, safe, and reliable energy that man has ever been fortunate enough to enjoy.

* These *daughters*, if gathered together and weighed, would total a little less than the original uranium atom — and it is that "little less" that has been converted into energy according to Einstein's famous $E=mc^2$.

** Even these high-level "wastes" are valuable products for industry and medical diagnostics and treatment. Molybdenum-99 is the "cow" or source for producing Technetium-99 used in 30,000 "imagings" in European hospitals everyday.

† Not found in original fuel assemblies, only in recycled fuel.

‡ For why reactor-grade plutonium is not suitable for nuclear weapons, see "Iran and 'the Bomb,'" October 16, 2006. This article is available online at www.thenewamerican.com/node/1749 [1].

Transporting Wastes

Among the manufactured concerns of the anti-nuclear lobby is the hazard of used-fuel transportation. For those who haven't driven on the interstate highway system lately, there are already (gasp) hazardous materials being shipped. Nuclear-fuel shipments would amount to less than one-thousandth of one percent of the 1.2 million daily shipments of hazardous materials.

Nuclear Energy Institute Executive Vice President Angie Howard points out that shipments of used nuclear fuel "have been completed safely since the mid-1960s and will continue to be conducted safely in the future. A proven record of 3,000 shipments covering 1.7 million miles with no impact on public safety or the environment demonstrates we can transfer this material safely."

Used-fuel containers must pass rigorous tests by the Nuclear Regulatory Commission including:

- A 30-foot free fall onto an unyielding surface, which would be equivalent to a head-on crash at 120 miles per hour into a concrete bridge abutment;
- A puncture test allowing the container to fall 40 inches onto a steel rod six inches in diameter;

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- A 30-minute exposure to fire at 1,475 degrees Fahrenheit that engulfs the entire container; and
- Submergence of the same container under three feet of water for eight hours.

If that's not sufficiently comforting, there are also transportation tests to verify container integrity, consisting of:

- Running a flatbed tractor-trailer carrying a container into a concrete wall at 84 miles per hour;
- Placing a container on a rail car that was driven into a concrete wall at 81 miles per hour; and
- Placing a container on a tractor-trailer that was broadsided by a train locomotive traveling at 80 miles per hour.

In all cases, post-crash assessments showed that the containers — although slightly dented and charred — would not have released their contents. One wonders how the thousands of tanker trucks transporting deadly chlorine and bromine gases would stand up to such conditions.

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