Section 2: Industry Analysis

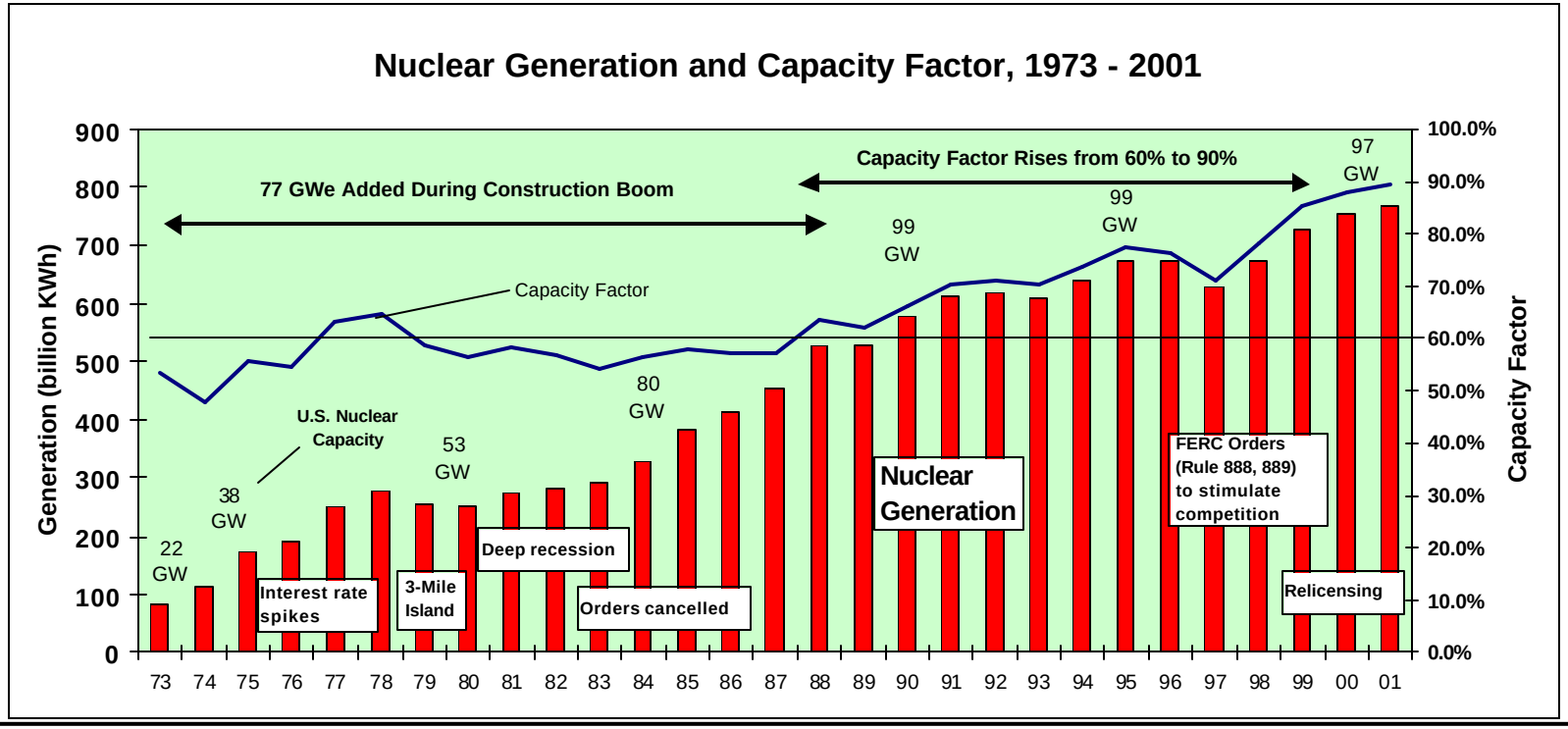
***Disclaimer*: This draft report was prepared to help the Department of Energy determine the barriers related to the deployment of new nuclear power plants but does not necessarily represent the views or policy of the Department.**

Introduction to Industry Analysis

- This section and Appendix A summarize results from the industry analysis task. Information from the industry analysis helped in defining the factors that affect risks associated with nuclear power, identifying the leading executives who participated in the interview process and roundtable discussions, and building the financial model.
- Material in this section introduces the reader to the highlights of the following subjects, which have implications for the future of nuclear power:
  - The position of nuclear power in U.S. electricity markets today and over the past three decades.
  - The structure of the nuclear power industry worldwide.
  - Overall trends in U.S. electricity markets in terms of baseload capacity and electricity generated by fuel type.
  - The regional nature of electricity in the United States and Canada.
  - The status of deregulation activity in the United States by state and region. The purpose of deregulation is to improve market function, in part by increasing competition.
  - NERC (North American Reliability Council) projections for the balance between electricity supply and demand through 2010.
  - The pattern of consolidation of nuclear power plant capacity in the United States and the financial position of nuclear utilities.
- The section then presents an abbreviated SWOT analysis for nuclear power in the United States. This summary of nuclear energy's strengths (S), weaknesses (W), opportunities (O), and threats (T) brings to the forefront the competitive context for nuclear power.
- Finally, the section summarizes recent changes in the market position of nuclear power, both in the United States and worldwide.
- Additional details from the industry analysis are contained in Appendix A. These details also support our evaluation of the risk framework (explained in Section 3).

U.S. Nuclear Power Generated and Capacity Factor Improved, 1973 – 2001

- The 768 billion KWh produced by nuclear power in 2001 is up from less than 100 billion KWh in 1973, driven by the addition of 77 GWe of capacity between 1973 and 1987. U.S. commercial nuclear plants operate as baseload units.
- Commercial orders were cancelled in the early 1980s, in part due to high interest rates, the TMI accident, and recession. Some units were finished in the mid-1980s, but no net capacity was added after 1989.
- The fleet-wide capacity factor rose from 60% in 1987 to over 90% in 2001in the United States due to advances in management systems and practices and much shorter fuel outages. Upratings could add another 7 GWe before 2010.
- Because the U.S. nuclear fleet is now approaching a real capacity-factor ceiling, future gains in KWh generated will be limited unless new reactors are built.



World Market for Reactors: Types Operating and Under Construction

- The nuclear power industry operates in a global market; a small number of companies supply equipment or build plants on a worldwide basis.
- The table below shows reactors by country and type. The United States and France lead the world in number of nuclear units and capacity, but Asia is building them now and acquiring the construction and deployment edge.
- A large majority of existing units are light water reactors (LWRs) of two types: pressurized water reactors (PWRs), and boiling water reactors (BWRs).
- Subsequent to construction planned today, the proportion of reactors will stay virtually the same through 2010: PWRs in the majority (>55%), followed by BWRs (22%).
- Most new reactors will be PWRs, while some advanced BWRs are being built in Japan. China, Russia and Ukraine are also building units.

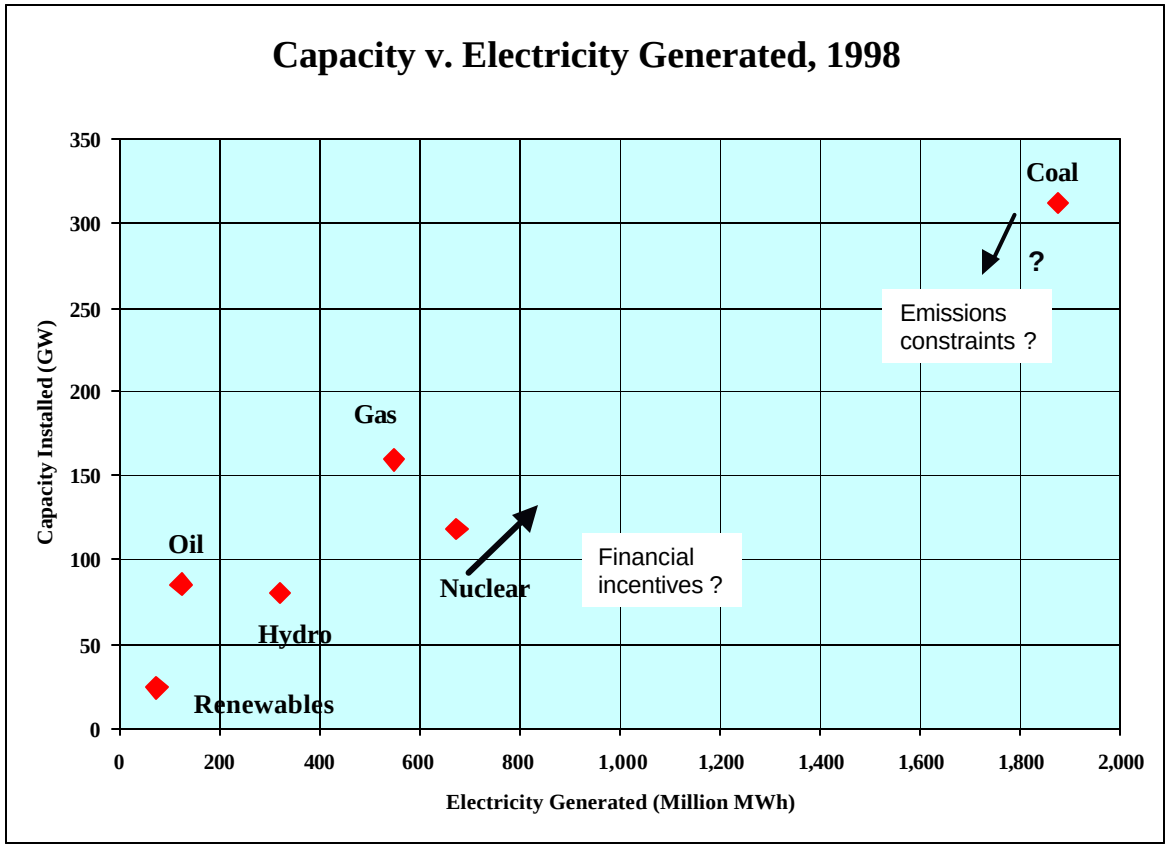
	Reactor	Operating			Under Construction		
Country	**Type (A)**	**Units**	**MWe**	**%Total**	**Units**	**MWe**	**%Total**
OECD	PWR	208	198,355	56.1%	2	1,863	7.0%
OECD	BWR	90	77,878	22.0%	1	1,067	4.0%
Russia/Ukraine	WWER (Russia)	51	32,834	9.3%	5	5,675	21.3%
Canada, Korea	PHWR (Candu)	31	14,307	4.0%	4	3,800	14.3%
Russia	RBMK	17	12,589	3.6%	1	925	3.5%
U.K.	AGR	14	8,380	2.4%	0	0	0.0%
U.K.	GCR	18	2,930	0.8%	0	0	0.0%
China	PWR	3	2,188	0.6%	8	6,320	23.8%
Japan	ABWR	2	2,630	0.7%	2	2,640	9.9%
Japan	FBR, HWLWR	4	1,187	0.3%	0	0	0.0%
Others				0.0%	9	4,300	16.2%
	Total	**438**	**353,278**	100.0%	**32**	**26,590**	100.0%
United States	PWR	68	64,603	18.3%	0	0	0.0%
United States	BWR	35	33,000	9.3%	1	1,000	3.8%

(A) Reactors that are not either PWRs or BWRs are listed separately from OECD totals. Otherwise, reactors from the UK and Japan that are PWRs or BWRs are included in the OECD totals. French reactors are included in the OECD totals.

Source: IAEA as of May 2002

Note: TVA has started engineering evaluation for completing the construction of a conventional BWR (1065 MWe) at Brown's Ferry 1 that was licensed in 1974. A recent estimate by Bechtel of the cost for recovering the unit from fire damage is $1.8 billion.

U.S. Electricity Capacity v. Generation: Gas Share Is Surging



Source: EIA

- Coal, with more than 300 GWe of capacity, still delivers >50% of U.S. electricity. However, a number of old coal plants (>30 years) could face increasing constraints on emissions (e.g., SOx, NOx, mercury) in coming years.
- Most planned new capacity in the United States will be gas-fired, but these plants will be used for intermediate demand rather than baseload. New nuclear plants would be baseload.
- Additions in renewables and biomass will barely offset the decline in hydropower projected by EIA through 2020. But, hydropower has been used as baseload, and renewables, which are vulnerable to weather disruptions, are not well-suited to baseload.

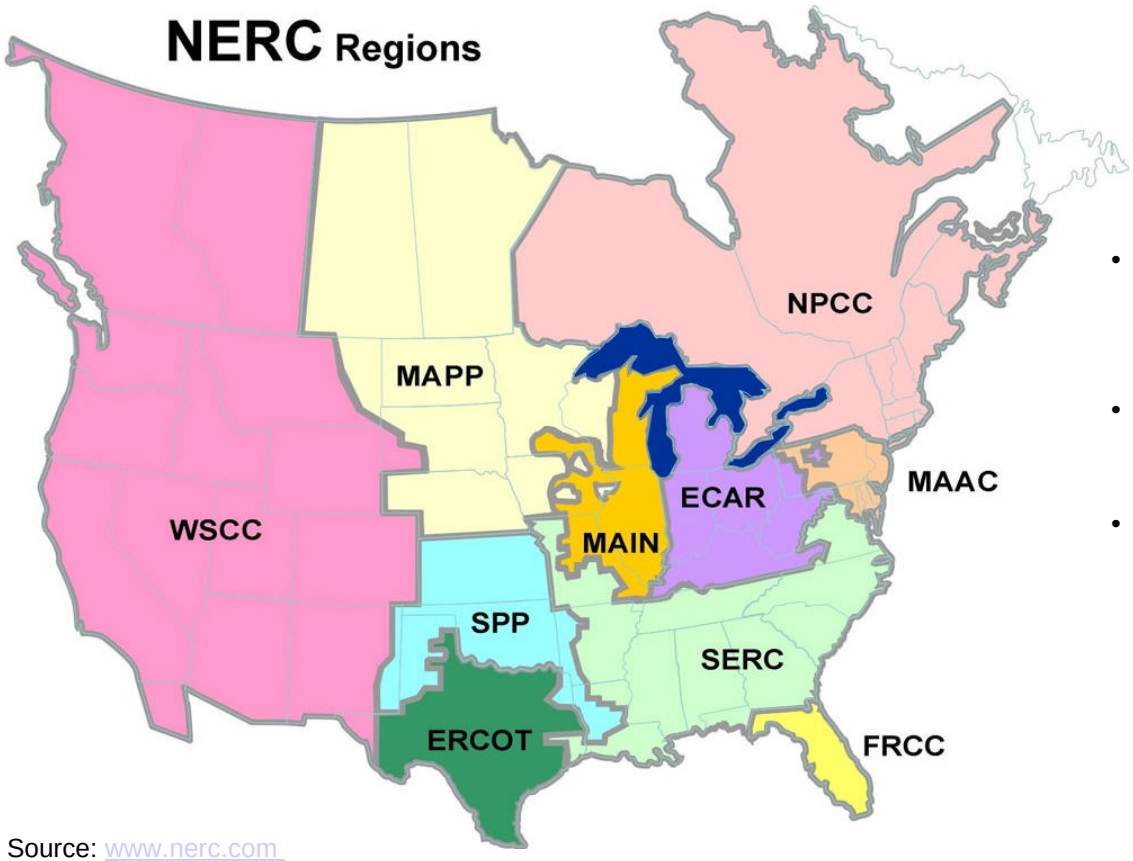
Nuclear Capacity and Trends by NERC Region (United States and Canada)

- Nuclear power plants provide 20% of the nation's electricity (2,928 billion KWh), even though they have only 13.5% of the nation's total capacity (767,500 MWe).
- The reliance on nuclear power varies by region of the country, from 7% to 25%, and is even higher in some metropolitan areas (e.g., Chicago, Baltimore).
- Regional population and urban growth trends also vary widely, so different demand drivers for adding new power plant capacity operate in each region.
- The status of electricity deregulation varies widely by region, as shown on page *2-8*. Many states and regions are not deregulating and have no plans to do so.
- The regional grids under the North American Electric Reliability Council (NERC) include Canada, which operates 10,000 MWe of nuclear power (CANDU units) and is contemplating building more units. So, planning for new electricity generation capacity must be addressed regionally, including Canada. (Note that more CANDU reactors are being built overseas, potentially reducing their cost of construction in North America.)

		MWe	MWe			billion KWh
NERC Region (HQ) U.S. & Canada	**NERC**	**Nuclear Capacity**	**2000 Total Capacity**	**Capacity Nuclear %**	**(Million) Pop'n**	**Power Generated**
Mid-American (IL)	MAIN	14,475	58,600	24.7%	21	259
Mid-Atlantic Area (PA)	MAAC	12,796	60,700	21.1%	23	234
Southeastern (GA)	SERC	29,103	159,400	18.3%	45	801
New England (NY)+ E.Canada	NPCC	11,483	62,900	18.3%	51	102
Mid-Continent (MN)+ SK, MB	MAPP	4,439	31,200	14.2%	12	166
Western (CO) + BC, AB	WSCC	11,749	136,500	8.6%	65	178
Florida (FL)	FRCC	3,046	38,500	7.9%	15	158
East Central (OH)	ECAR	8,707	112,200	7.8%	36	590
Texas (TX)	ERCOT	4,800	64,800	7.4%	18	256
Southwest (AR)	SPP	2,932	42,700	6.9%	18	184
U.S. + Canada	U.S.	103,530	767,500	13.5%	304	2,928

www.nerc.com

NERC Regions Include Canada *(North American Electric Reliability Council)*



Source: www.nerc.com

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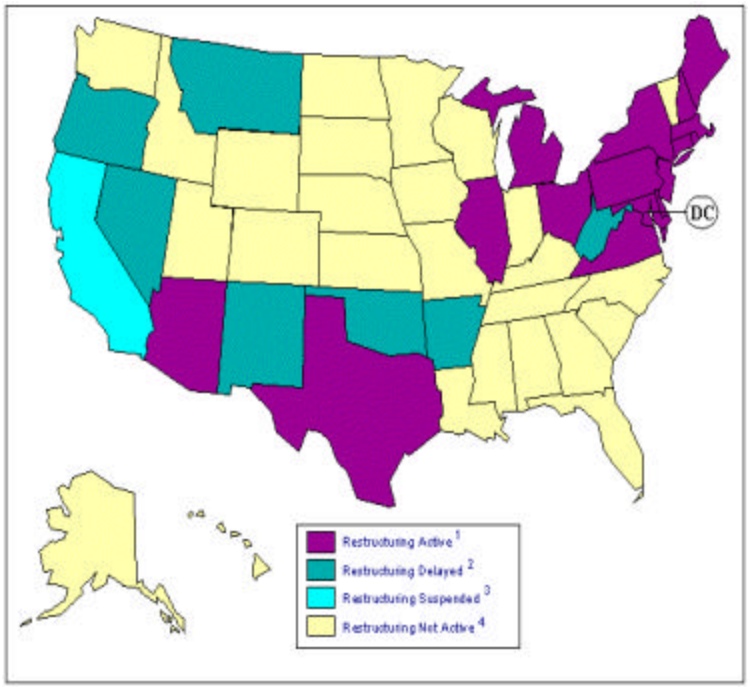
- Although most consumers and voters are not aware of these facts, the United States does not have a national grid and the U.S. grid is integrated with Canada. NERC coordinates power delivery and reliability within and between ten regional grids in North America (Alaska, Hawaii, and Mexico excluded).
- Three major NERC regions include Canadian provinces that also provide power to the United States.
- Regional grid operations also provide some insulation from a nationwide power shutdown.
- Hence, regional developments in Canada, beyond gas supply, have an impact in planning for U.S. electric capacity. For example, power from nuclear units built in Canada (e.g., CANDU reactors) could be "wheeled" into the United States, as hydropower now is in the NPCC region.

Restructuring and Deregulation Activities Vary Widely by State and Region

- Restructuring and deregulation involve separating power generation from power distribution to create competition. However, these processes create uncertainty in planning for new baseload power plants.
- Restructuring and deregulation are focused in certain states and NERC regions, particularly New England (NPCC), except in VT, and MAAC, plus the "Rust Belt" industrial states (IL, MI, OH, PA) in ECAR, and MAIN. Deregulation continues in Texas (ERCOT) and NM.
- Restructuring has been limited in the Southeast (SERC, FPCC, SPP) and in the Plains states (MAPP).
- Restructuring has been suspended or delayed in much of the West (WSCC), including California.

Status of State Electric Industry Restructuring Activity Map

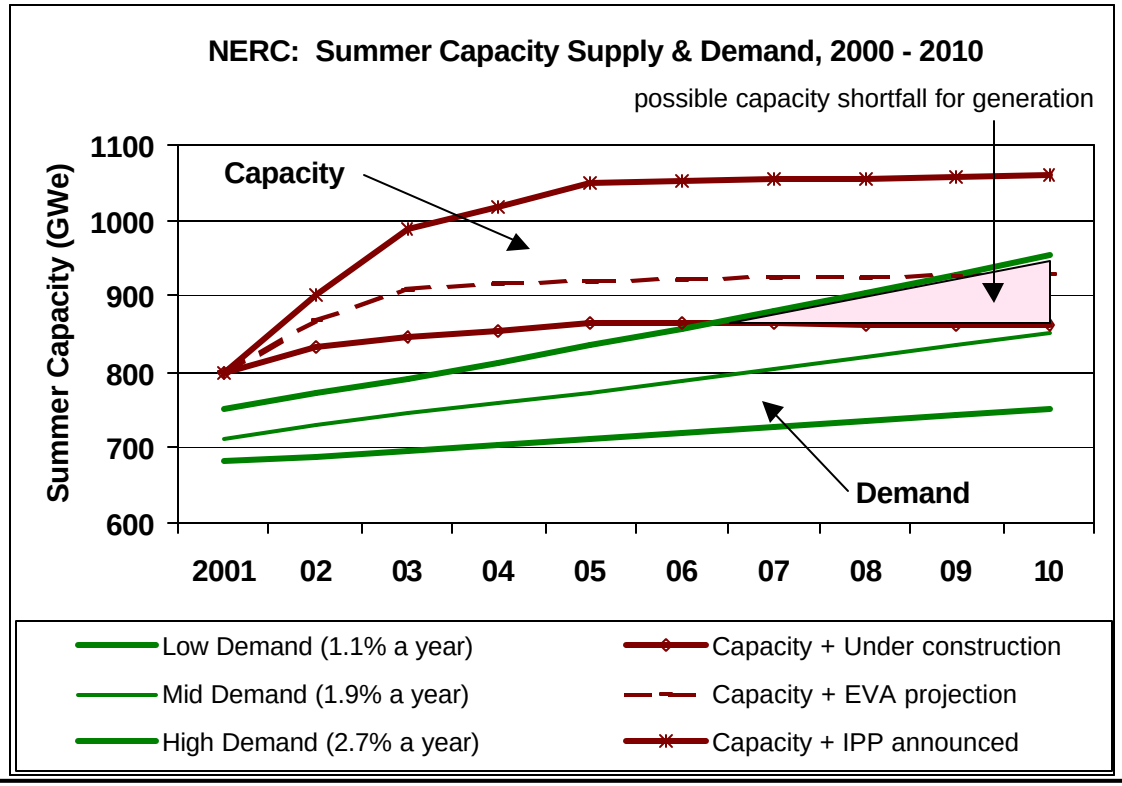


Retail Access: Twenty-four states and the District of Columbia have either enacted enabling legislation or issued a regulatory order to implement retail access. Retail access programs are a primary tool for creating competition in power distribution. In retail access programs, the local distribution company continues to provide transmission and distribution (delivery of energy) services. Retail access allows customers to choose their own supplier of generation services. Retail access schedules vary state by state according to the terms of legislative mandates or regulatory orders. The information in the adjacent "Status of State Electric Industry Restructuring Activity Map" was gathered from state public utility commissions, state legislatures, and utility company web pages.

Source: EIA, May 2002

NERC: Outlook for Electricity Peak Supply and Transmission, 2000 – 2010

- Each year, the North American Electric Reliability Council (NERC) publishes its reliability assessment review for both electric capacity and transmission capacity for the next decade, based on input from the regional grids.
- NERC projects that, with gas plants now planned or under construction, electricity capacity appears adequate through 2005; reserve margins may narrow as 2010 nears.
- NERC notes, however, that "transmission congestion" is likely to continue. Only 7,300 miles of transmission capacity expansion is currently proposed (as of October 2001) for a U.S. system comprised of nearly 157,000 miles, plus 45,000 in Canada. Transmission status varies by region, but load relief requests were up sharply (3x – 5x) in 2000 and 2001 versus levels in 1996 – 1997.



Source: NERC Reliability Assessment report, October 2001

www.nerc.com

Major U.S. Nuclear Owner / Operators Remain Financially Healthy in 2002

- Nuclear plant ownership is increasingly concentrated. Twelve utilities, plus TVA, now own and operate more than 75% of total nuclear capacity and two-thirds of the reactors.
- Consolidation of the current nuclear fleet under the management of fewer utilities has improved overall technical and financial performance. The larger owners, which now have 75% of U.S. capacity, manage a portfolio of units. These companies can consider financing new units based on the total asset value of their larger balance sheets.
- Stock prices of nuclear utilities outperformed those of non-nuclear utilities from January 2000 to June 2002, and credit ratings for these companies have remained sound.

Symbol	(Source: NEI) Nuclear Utility	Region, States	2001 ($B) Revenues	Units PWR / BWR	MWes Nuclear Capacity	Stock Price 1/1/00	Stock Price 7/1/02	Stock Price Change
EXC	Exelon (PECO, Unicom)	PA, IL	$15.10	4P / 10B	14,191	$30	$52	73%
ETR	Entergy Nuclear	LA, AR, MS, NY, MA	$9.60	5P / 4B	8,314	$25	$42	68%
DUK	Duke	SC, NC	$59.50	7P	7,054	$25	$30	20%
PGN	Progress Energy	SC, FL	$8.40	6P / 2B	6,220	$30	$51	70%
SO	Southern Nuclear	GA, AB	$10.20	4P / 2B	5,659	$15	$27	80%
	TVA	TN, MS, AB	$7.00	3P / 2B	5,635	Gov't	Gov't	
D	Dominion Generation	VA, CN	$10.50	6P	5,405	$40	$66	65%
XEL	Nuclear Mgmt Co.	WS, MN, MI, IA	$15.00	5P / 2B	4,353	$21	$17	-19%
FE	First Energy	PA, OH	$8.00	3P / 1B	3,726	$25	$33	32%
CEG	Constellation Nuclear	MD, NY	$3.90	2P/2B	3,363	$30	$28	-7%
FPL	Florida Power Group	FL, NH	$8.47	4P	3,306	$42	$59	40%
PEG	PSEG Nuclear	NJ	$9.80	1P / 2B	3,243	$35	$43	23%
TXU	Texas Utilities	TX	$27.90	2P	2,310	$35	$51	46%
	S&P 500 Index					1,470	990	-33%
	Subtotal		**$193.37**	**40P / 25B**	**72,779**			
	Others		$ billions	38 units	23,481			
	Nuclear Total (NEI)			103 units	96,260			

SWOT Analysis Summary: Nuclear Industry Strengths and Weaknesses

Major Strengths

- **Competitiveness:** Capacity factors, operations, and safety records have improved since 1990; many reactors are very competitive, even in deregulated power markets.
- **Value:** With utility divestitures and consolidation since 1999, asset transactions have quantitatively demonstrated the real financial value of current nuclear reactors.
- **Life extension:** Since 1998, NRC has relicensed six reactors, each for an additional 20 years. Fourteen more are under review, and another 24 are in the pipeline.
- **Financial performance**: Since 2000, stock prices of nearly every nuclear utility outperformed the S&P 500 and many non-nuclear utilities.
- **Regulatory support:** The NRC, with NE support, has embarked on a "certified design" approach to reduce licensing uncertainties for new reactors. NRC has certified three reactor designs, including the GE ABWR and the Westinghouse AP-600.
- **Waste reduction**: Utilities have reduced low-level waste volumes from 3 million cubic feet in 1982 to <300,000 cubic feet a year, while generating twice as much electricity.
- **Safe waste transportation:** Hundreds of shipments of DOE radioactive waste (transuranic waste from DOE facilities) have been made safely to the Waste Isolation Pilot Plant (WIPP) depository for radioactive waste in NM.
- **Fuel Supplies:** Affordable and stable uranium supplies continue to be available from allies Canada and Australia, plus the U.S. nuclear warhead blend-down program.

Major Weaknesses

- **Transmission uncertainty:** Investment in transmission capacity has not kept pace with electricity demand. Large centralized generating plants of all kinds are highly dependent on efficient and sufficient transmission.
- **Aging workforce:** New nuclear plants have not been built in the United States for a generation. Nuclear talent is aging, and prospects for new workers are not good, a problem even if new plants require smaller operation staffs:
  - The number of university research reactors, which are vital for training nuclear engineers, has dropped from 60 in 1982 to less than 30.
  - Undergraduate enrollment in nuclear engineering programs dropped from 1700 in 1982 to just 500 in 1999 in our university programs, before rebounding to about 700.
  - U.S. engineering firms comment that skilled crafts training needs to be rejuvenated to support nuclear plant construction.
- **Energy security challenges:** Nuclear power could provide an important aspect of energy supply diversification, reinforcing a major strategic theme in the National Energy Policy. However, no new plants are being built here. New plants are needed just to sustain current market share (20% of generation) for nuclear power.

SWOT Analysis Summary: Nuclear Industry Opportunities and Threats

Major Opportunities

- **Low interest rates:** Interest rates are at lows since the 1970s energy crisis, when interest rates rose above 15%.
- **Low, stable fuel prices:** Uranium fuel prices have dropped to historic lows (~5 mils / KWh or $10 – $15 per pound of U) and are more stable than natural gas prices.
- **Improved safety, efficiency:** New reactor designs, benefiting from prior experience, have new passive safety features, plus efficiency gains from advances in design and materials, CAD design, and modular construction.
- **Public views:** The public's view of nuclear power is more positive in recent surveys, due largely to power outages, electricity price volatility, and nuclear power's enhanced safety record since Three-Mile Island (1979).
- **Disposal**: In February 2002, President Bush began the ten-year construction and licensing process for the Yucca Mountain depository for spent nuclear fuel.
- **Energy security:** Reliance on oil imports is >55% (v. 40% in 1980), and growing. Electric vehicles could offset foreign crude, as could hydrogen from nuclear power.
- **Hydrogen production:** Thermo-chemical (v. electrolytic) production of hydrogen at nuclear plants could reduce refinery emissions, boost energy values in gasoline, and provide a non-carbon fuel source.
- **Climate change:** Nuclear energy is a key to a climate-change energy portfolio. No other non-emitting fuel source boosts U.S. energy diversity in GWe increments.

Major Threats

- **Terrorist attack:** Terrorists have threatened to attack nuclear power plants (Washington Times, May 4, 2002). Attack simulation exercises on nuclear plants during the last several years—much of it before the attack of September 11—have shown mixed results in success by nuclear operators.
- **Commissioning uncertainty:** Improved commissioning procedures are not yet fully clarified and court-tested. Utilities will not invest in nuclear plants if high uncertainty continues relative to turning the plant on after construction.
- **Electricity restructuring**: Deregulation of electricity in some regions brings market pricing to more utilities, which then favor generating assets with low capital costs and short construction periods. In contrast, regulated generating assets are allowed capital cost recovery, plus a reasonable rate of return as negotiated with a public utility commission. All prior nuclear units were built under regulated situations.
- **U.S. R&D budget flat:** While the NE R&D budget proposed for FY2003 was boosted for the Nuclear Power "2010 Initiative", U.S. R&D budgets for nuclear power have fallen behind our those of our trading partners, jeopardizing the U.S. technology and engineering edge in nuclear power.

Summary: Nuclear Plants Being Built Worldwide, But Not in United States

- This table below summarizes recent changes in the position of nuclear power. Although some issues have turned positive for nuclear power, a number of important issues need to be resolved.
- Unless these key issues are resolved *(highlighted in red italics)*, the future of nuclear power faces clear doubts from a financial standpoint, despite its strong advantages.

Historic Issue to be Addressed	Status in 2002
Technology: Are nuclear reactor systems (Generation III) ready for commercial scale deployment?	Three system designs were certified by NRC in the 1990s; two types were built in Asia (GE ABWRs).
Capital costs: Are nuclear power plant construction costs still too high (>$1200 / KWe) for first units, posing high risks for capital recovery in deregulating regions? How much impact results from lower interest rates?	Projected costs on early units remain >$1200 / KWe, but some units are being built in Asia. *Modular construction advances bring costs down, but require multiple orders*. Interest rates are 50% lower than rates in the early 1980s.
Construction: Can U.S. engineering fims retain the talent and experience needed to reliably build units?	U.S. firms are actively building units overseas, learning from foreign partners. Supply is global. *Recruitment of skilled labor remains an issue.*
Regulatory: How can certainty and finite timing be built into NRC approval processes?	NRC is defining better approval approaches, *but has not completed procedures (COL, ITAAC).*
Fuel supply: What are the trends in uranium fuel prices, sources, and reserves?	Uranium prices are much more stable than gas, and inventories and supply are from stable allies (e.g., Canada, Australia).
Transmission: How are regional grids dealing with capacity constraints, and a lack of investment during the last twenty years?	FERC is working to encourage voluntary formation of four RTOs. *Grid control remains an area of uncertainty, since large nuclear units require significant transmission capacity.*
Market status: How do regional variations in electricity deregulation create uncertainty about rates and revenues, affecting willingness to invest in new plants?	*Deregulation remains incomplete.* Momentum reversed in several states after bankruptcies in California. The southeast is not moving on deregulation at all now.
Competition: What competition will nuclear plants face from new gas plants and new baseload coal plants?	Highly volatile gas prices in 2000 – 2001 caused some utilities to consider other fuels, such as nuclear.
Siting & Public support: What impact will anti-nuclear groups have nationally and in regions where support for nuclear power is stronger?	In April 2002, three utilities announced they would file for Early Site Permits. Public opinion polls are more positive toward nuclear (>65%) since the California electricity crisis, and due to better operating records for nuclear since 1990.
Energy Policy: What is the current nature of the U.S. political consensus regarding nuclear power, as compared to France, Japan, Korea, and others?	Several regions of the country have no problem supporting nuclear power. Six reactors were relicensed since 1999 without much opposition.
Finance: How financially strong are utilities after the collapse of Enron and defaults by PG&E in California.	Energy trading markets survived the collapse of Enron, and nuclear utility stocks are outperforming other utilities.