AC 2007-156: NUCLEAR POWER: MUCH SWEETER THE SECOND TIME AROUND

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Introduction

It's time we take the wraps off the major successes achieved in the nuclear power industry. Almost 20% of the electricity generated in the United States comes from nuclear power plants. All over the world (in 30 countries) nuclear power is a low-cost, secure, safe, dependable, and environmentally friendly form of electric power generation. Nuclear plants in these countries are built in five to seven years using technology developed in the US, with good performance and safety records.

Nuclear fuel (uranium) is readily available in America. This treatise addresses the successes experienced by the nuclear industry over the last half century, and makes the case that this reliable, cost-competitive source of electric power can help support the economic engine of the country, reduce greenhouse gas emissions and global warming, and minimize our dependence on foreign oil.

The economics of nuclear power have changed dramatically in the new environment of deregulation in the US. Seventeen states with 50 nuclear plants enjoy a deregulated nuclear operating atmosphere. There were 54 utility companies operating nuclear plants in the US in 1989. There are only 26 now, and this number will probably decrease as more states deregulate. This concentration of operating experience enhances plant performance.

Fossil fuel fired plants all over the world discharge about 800 tons of carbon dioxide every second (NEI, 2004). The Kyoto Protocol notwithstanding, we will surely soon require fossil fueled plants to install greenhouse minimizing equipment. This will more closely equate nuclear and fossil fuel economic analysis.

The alternatives for the generation of large quantities of electricity are narrowing. Nuclear power has proven its cost effectiveness and safe operation through its success over almost five decades. Herein are the data that support this contention.

There are over 440 nuclear power plants operating around the world, and another 28 under construction. Over 100 of these are in the United States. Only two other nations in the world have half that many (France and Japan).

Nuclear Risk

Nuclear power generation technology utilized throughout the world is based primarily on that developed in the US. The nuclear industry has accumulated over 2800 reactor-years of operating experience in the US, and about 10,000 reactor-years worldwide. In all of those reactor-years of experience, the most serious operating problem in the United States was the 1979 Three Mile Island (TMI) failure. That failure resulted in damage to the power plant; but, no injuries to plant operators or the public.

When it was finally necessary to vent the TMI containment vessel in order to allow work crews inside, there was a great hue and cry from the press. Unfortunately, the industry and the media failed to convey to the public that it was more dangerous to drive to the TMI site to protest this release, than to be exposed to the release itself!

The risks associated with any potential accident may be calculated. The loss of life expectancy associated with exposure to TMI radiation for residents of the area was approximately two minutes. The loss of life expectancy from being struck by lightning for these same people was 20 hours (Cohen, 1990).

The most serious nuclear power incident worldwide was the 1986 Chernobyl disaster in the Ukraine. There was extensive physical damage and loss of life associated with the Chernobyl accident. Its reactor safety systems were, however, completely different from those used in the western world. The Chernobyl plant had no containment vessel to trap toxic gasses and dust particles escaping from the reactor to the atmosphere. The reactor designs in the west have a containment vessel to preclude the type of accident which occurred at Chernobyl. The Ukraine and Russia are currently removing from service their Chernobyl-type nuclear plants.

We all receive daily background amounts of radiation from the natural environment. To this is added the technology dosage from x-rays and cathode ray tubes (TV and computer monitors) to which we regularly subject ourselves. The likelihood of experiencing a health problem as a result of radiation is far greater from this natural and self-inflicted exposure than from that which might escape from a nuclear power plant.

Risks associated with living in poverty, smoking, working as a coal miner, being overweight, drinking alcohol, driving automobiles, contracting pneumonia or influenza, abusing drugs, contracting AIDS, drinking coffee, utilizing birth control pills, and flying on airplanes each are more apt to shorten our lives than living near a nuclear power plant (Cohen, 1990).

Operating Success

Traditionally, the evaluation of electric power generation facility performance has focused on the ability of plants to produce at design capacity for high percentages of the time. Successful operation of nuclear facilities is determined by examining capacity or load factors. Load factor is the percentage of design generating capacity that a power plant actually produces over the course of a year.

Table 1 indicates cumulative load factors for nuclear power producing nations through 2005 (International Atomic Energy Agency Power Reactor Information System database). The numbers in parenthesis indicate the number of nuclear power plants operating in the country. This information is corroborated by the Nuclear Regulatory Commission (NRC) Reliability and Availability Data System (RADS).

When comparing US data with that of other nations, it is important to note that many of the other countries have only one operating utility organization. The US has 26 independent

companies operating nuclear power facilities. Each of these companies is subject to its own management and operating vagaries.

A review of Table 1 indicates that the four nuclear power plants operating in Finland were able to generate at a cumulative average of 91.1% of design capability during their years of operation through 2005. The seven Belgian plants had a cumulative load factor of 88.1%.

The 103 plants operating in the US during the same time frame achieved a cumulative load factor of 77.8%. The US, with almost twice as many plants as any other nation and 26 independent operating entities, is achieving very well. Annual load factor for American plants has increased by almost 15 percentage points in the last 15 years. This is an impressive performance indicator.

Table 1 also indicates the percent of electric generation that is nuclear in the 30 countries listed. Eighteen (18) countries are more dependent on nuclear power than the US, some relying almost entirely on nuclear energy.

The cumulative load factor for all 442 nuclear plants on-line worldwide at the end of 2005, for their then approximately 10,000 reactor-years of operation, was about 79%. The NRC RADS data base indicates that the average availability factor for the 100+ nuclear plants in the US from 1980 through 2004 is 84.5%. This is slightly higher than the IAEA/PRIS data, since it does not consider earlier years of less than spectacular operating experience prior to 1980.

Several generating firms in the US that operate three or more nuclear plants exceed or were close to the IAEA/PRIS cumulative average. These are listed in Table 2 and represent operating performance for nearly 75% of US nuclear plants. The Southern Nuclear Operating Co. has the best performance data based on cumulative load factor.

The bottom line is that the 100+ nuclear plants currently operating in the US are a source of safe, affordable, reliable electric energy for their customers and the 20% of the economy that they support.

Cost

Accurate cost and schedule projections will be necessary in order for utilities to undertake nuclear power plant construction projects in the future. This should be a realistic expectancy, since the federal licensing process has been reformed.

These reforms will allow the NRC licensing process to continue to provide effective regulation of construction and operation of plants; and will preclude the uncertainties utilities faced on construction projects in the 1970s and ‘80s. Congress has also enacted legislation that calls for NRC issuance of a single license prior to construction to provide for both construction and operation of plants. Previously, two separate licenses were required. Single licensing will help assure a stable environment for construction of nuclear plants.

The NRC has worked with utility operating companies, equipment suppliers and engineering firms to develop several standardized plant designs. These standardized designs have been certified for construction and operation. The NuStart Energy Consortium of eight operating firms and two equipment suppliers will spawn a new approach for the industry. The federal government is offering significant incentives to utilities which elect to build nuclear plants.

The cost of oil remains relatively high. The prices charged for coal and natural gas tend to follow that of oil. Nuclear plants are more costly to build than their fossil fueled counter parts; but, their fuel costs are much less. The higher the cost of fossil fuels, the more economically competitive is the nuclear option.

It then becomes the responsibility of the utilities to assure that they do not request customized changes to pre-approved equipment and plant designs. Such changes would place at risk the licensing process, schedules and budgets for the particular installation. Adoption of standard equipment and plant designs will expedite the safety and environmental licensing processes and render predictable the construction schedule and cost of nuclear power plants. This approach has proven successful in Belgium, France, Japan, Sweden, Switzerland, and the United Kingdom. It has compromised neither safety nor the environment.

Toxic Waste

The fossil fuels (coal, oil, and natural gas) all have toxic wastes. Combustion of coal in power plants results in a number of noxious emissions. These include particulate matter and toxic gasses. In addition, hot carbon dioxide emissions contribute to the "greenhouse effect" which warms the atmosphere

Over 30 million tons of toxic chemical waste are produced in the US every year by various industries (US Council for Energy Awareness). This compares with a total of approximately 40,000 metric tons of highly irradiated nuclear fuel utilized by all the commercial nuclear power plants in the US during the last 50 years. This amount is so small that it could be stacked less than 30 ft. high on top of a football field. Additional low level radioactive waste is processed at several sites in the nation and rendered harmless.

The US Department of Energy is developing the Yucca Mountain storage site for spent nuclear fuel in corrosion resistant canisters to be buried in a natural salt dome formation for permanent storage. Since this waste is in such small quantity, it can be rendered safe in this fashion.

Nuclear plants produce far fewer toxic substances than their coal-fired counterparts. And, this waste may be disposed of safely.

Siting

Many of the 26 utility firms which operate nuclear power facilities have space on their existing plant sites for additional nuclear units. This will help avoid the NIMBY (not in my back yard) scenario. It makes sense to site as many new plants as possible at existing nuclear

facilities.

Alternatives

Global warming has raised serious concerns about adding coal-fired electric generating capacity. Oil is potentially unavailable and subject to the pricing whims of the OPEC, and it should be reserved for transportation.

Natural gas is clean and safe, and should be reserved for residential and commercial/institutional heating. It is also subject to dramatic price fluctuations.

Hydroelectric power is clean and renewable, but dam sites are environmentally sensitive. Solar, geothermal, and fuel cells are either insufficient to support the expanding US economy, or their technology is not adequately developed for use at this time. Wind power is re-emerging, but, again, not in the scale that will support significant economic growth.

The only substantial, readily available, and reasonably priced natural resources for new base-load electric generation in the US are coal and uranium. The reserves of both are large in America.

The position of many electric utility companies has been that if potential shortages of electricity occur, they will attempt to deal with these by:

1. Encouraging conservation of energy use by both residential and industrial consumers;
2. Implementing load management programs which provide incentives for consumption of electricity in off-peak hours (generally between midnight and 6:00 a.m.);
3. Purchasing power from pools with excess capacity or from industrial producers;
4. Use of “peaking” combustion turbines which are relatively inexpensive and may be installed quickly and easily; but, which don’t provide base-load support for an expanding economy; and
5. Installation of traditional coal-fired or nuclear power plants.

Design, Construction and Operation

In the 1960s and 70s, the space and nuclear power industries competed for the best engineering minds in America. When no new nuclear power plants were ordered after 1980, educators and students turned their collective backs on nuclear power careers. If the US is to enjoy a resurgence of nuclear power, nuclear engineering education must step up with renewed vigor. Challenging and lucrative career opportunities will await graduates with expertise to design, construct and operate these complex facilities.

Conclusion

Usage of electricity in the US now approaches generating capacity. The NRC has pre-approved construction and operating licenses for several nuclear plant designs. Performance of nuclear plants has improved consistently for decades with no serious safety challenges. Utility deregulation by the states is creating a more favorable environment for plant construction and

operation. The economy is strong and inflation is minimal. It's time, once more, to turn to the safe, reliable, environmentally friendly nuclear power alternative.

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Table 1
Load Factors For Nations with
Nuclear Power Programs

Rank[1]	Nation (#)[2]	% of Electric Generation that is Nuclear	Cumulative Load Factor thru 2005 (%)
1	Finland (4)	33	91.1
2	Belgium (7)	56	88.1
3	Netherlands (1)	4	87.8
4	Romania (1)	9	87.5
5	Switzerland (5)	32	87.3
6	South Korea (20)	45	86.1
7	Spain (8)	20	85.9
8	Germany (17)	31	85.4
9	Hungary (4)	37	84.7
10	Slovenia (1)	43	83.8
11	China (10)	2	83.5
12	Mexico (2)	5	82.0
13	Czech Republic (6)	31	81.4
14	Sweden (10)	45	81.4
15	Argentina (2)	7	81.0
16	France (59)	79	79.3
17	Slovak Republic (6)	56	79.3
18	Canada (18)	15	78.4
19	United States (103)[3]	19	77.8
20	United Kingdom (23)	20	77.3
21	South Africa (2)	6	76.1
22	Japan (55)	29	73.8

[1] In order of highest Cumulative Load Factor.
[2] No. of nuclear plants.
[3] Not counting Browns Ferry #1, which hasn't operated in several years.

Table 1
Load Factors For Nations with
Nuclear Power Programs

Rank[1]	Nation (#)[2]	% of Electric Generation that is Nuclear	Cumulative Load Factor thru 2005 (%)
23	Lithuania (1)	70	73.2
24	Bulgaria (4)	44	72.1
25	Russia (31)	16	71.6
26	Ukraine (15)	49	70.9
27	India (16)	3	67.4
28	Armenia (1)	43	66.9
29	Brazil (2)	3	66.9
30	Pakistan (2)	3	50.9

[1] In order of highest Cumulative Load Factor.
[2] No. of nuclear plants.
[3] Not counting Browns Ferry #1, which hasn't operated in several years.

Table 2

Operator	No. of Nuclear Plants	Cumulative Load Factor thru 2005 (%)
Southern Nuclear	6	82.5
Arizona Public Service	3	78.9
Duke Power	7	78.9
Florida Power & Light	4	78.9
Nuclear Management	8	78.4
Constellation Nuclear	5	76.5
Entergy Nuclear	10	75.2
Exelon	17	74.2
Progress Energy	5	73.0
Dominion Virginia Power	6	72.2
First Energy Nuclear	4	71.7