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# Nuclear Power Plant Construction Activity 1988

**Energy Information Administration**
Office of Coal, Nuclear,
Electric and Alternate Fuels
U.S. Department of Energy
Washington, DC 20585



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# Preface

*Nuclear Power Plant Construction Activity 1988* presents cost estimates, chronological data on construction progress, and the physical characteristics of nuclear units in commercial operation and units in the construction pipeline as of December 31, 1988. This report, which is updated annually, was prepared to provide an overview of the nuclear power plant construction industry. The report contains information on the status of nuclear generating units, average construction costs and lead-times, and construction milestones for individual reactors.

This report was prepared using the responses provided by U.S. electric utilities to Form EIA-254, "Semiannual Report on Status of Reactor Construction." Response to the Form EIA-254 survey is mandatory, pursuant to the Atomic Energy Act of 1954 (Public Law 83-703) as amended and the Federal Energy Administration Act of 1974 (Public Law 93-275).

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# 1. Introduction

This annual report published by the Energy Information Administration (EIA) presents data on nuclear power plant construction activity. The previous report, *Nuclear Power Plant Construction Activity 1987,* included data for units that, as of December 31, 1987, were (1) in the construction pipeline,[1] (2) canceled, or (3) in commercial operation as of December 31, 1987. The data in this report, which were collected on Form EIA-254, "Semiannual Report on Status of Reactor Construction," update the data in the previous report to be current as of December 31, 1988.

Three types of information are included:

- Plant characteristics and ownership
- Construction costs
- Construction schedules and milestone dates.

Chapter 5 presents reactor-specific cost data as of December 31, 1988, as reported by the utilities. For each unit, the data include: estimated final costs for plants under construction, disbursed costs (funds already expended), and disbursed costs plus other commitments for each unit (funds already expended and funds committed but not disbursed).

The information in this report is intended for use by legislators, policymakers, and analysts in assessing nuclear power plant construction costs and schedules and in determining the current status of nuclear generating capacity and potential future requirements for uranium production and enrichment facilities.

With regard to the use of the data, the following considerations are emphasized. First, for units that will enter commercial operation after December 31, 1988, generating capacities and construction costs are estimates rather than actual values. Second, construction costs shown are nominal dollar values as reported by the utilities. The calculation of constant-dollar costs (by adjusting dollar values using inflation factors) is a difficult task requiring information that is not readily available.[2] Third, plant construction costs should be compared with caution because there may be differences in accounting practices among utilities.

Form EIA-254 is shown in Appendix A. The background and methodology of the survey are described in Appendix B.

The testing phases of nuclear power plants are summarized in Appendix C. This appendix is intended to be a guide to understanding the complex test procedures that must be completed for each nuclear power plant before commercial operation is achieved. It is simply an overview of some of the necessary procedures and does not cover every aspect of the testing process.

[1]Units referred to as being "in the construction pipeline" are those in the process of power ascension, those actively under construction, those for which construction permits are under review, and those that have been suspended or deferred but not officially canceled.

[2]See Energy Information Administration, *An Analysis of Nuclear Power Plant Construction Costs,* DOE/EIA-0485 (Washington, DC, March 1986), for further details on this aspect of nuclear power plant construction costs.

# 2. Description of the Data

## Unit Identification

Form EIA-254, Part A, "Unit Identification Data," includes the name and location of each unit, the net summer capability, and the name, mailing address, and telephone number of a contact person at the managing utility. Also included are the date of the information being reported, the status of the unit, the role of the reporting utility company, and the signature and title of a certifying official (Appendix A).

## Chronology and Labor

Form EIA-254, Part B, "Unit Chronological and Labor Data," includes the estimated dates for two significant milestones in the construction of nuclear power units. The first is the date on which fuel loading is scheduled to be completed. The second is the scheduled date of commercial operation. These two dates aid analysts in forecasting a probable date when the unit will be licensed for operation.

Part B also includes an estimate of the total labor required for construction of the unit and a report of the total labor expended to date. This information provides an approximation of the percentage of construction completed at the time of the survey. On the basis of the estimated amount of labor (reported in man-months), including direct and support labor that will be necessary to bring the unit to completion, these data provide a consistent formula for determining the construction status of a nuclear unit. Such a formula is useful for projecting future schedules of nuclear capacity and electricity generation, and for estimating the time-related impacts of changes in regulatory and safety procedures.

## Construction Costs

Form EIA-254, Part C, "Unit Cost Data at Completion," includes estimates of the costs that have been and will be incurred during the construction of the nuclear facility. These costs comprise the total cost of the nuclear plant and can be regarded as the fixed investment or capital costs of the plant. The requested cost estimates are disaggregated into direct costs, indirect costs, contingency costs, common facility costs, and Allowance for Funds Used During Construction (AFUDC). Estimates of direct costs are further disaggregated into the following categories:

- Land and land rights
- Structures and improvements
- Reactor plant equipment
- Turbogenerator units
- Accessory electric equipment
- Miscellaneous power plant equipment.

For each nuclear unit, the estimated cost data provide an indication of the total expected construction costs and a record of revised estimates.

## Actual Costs

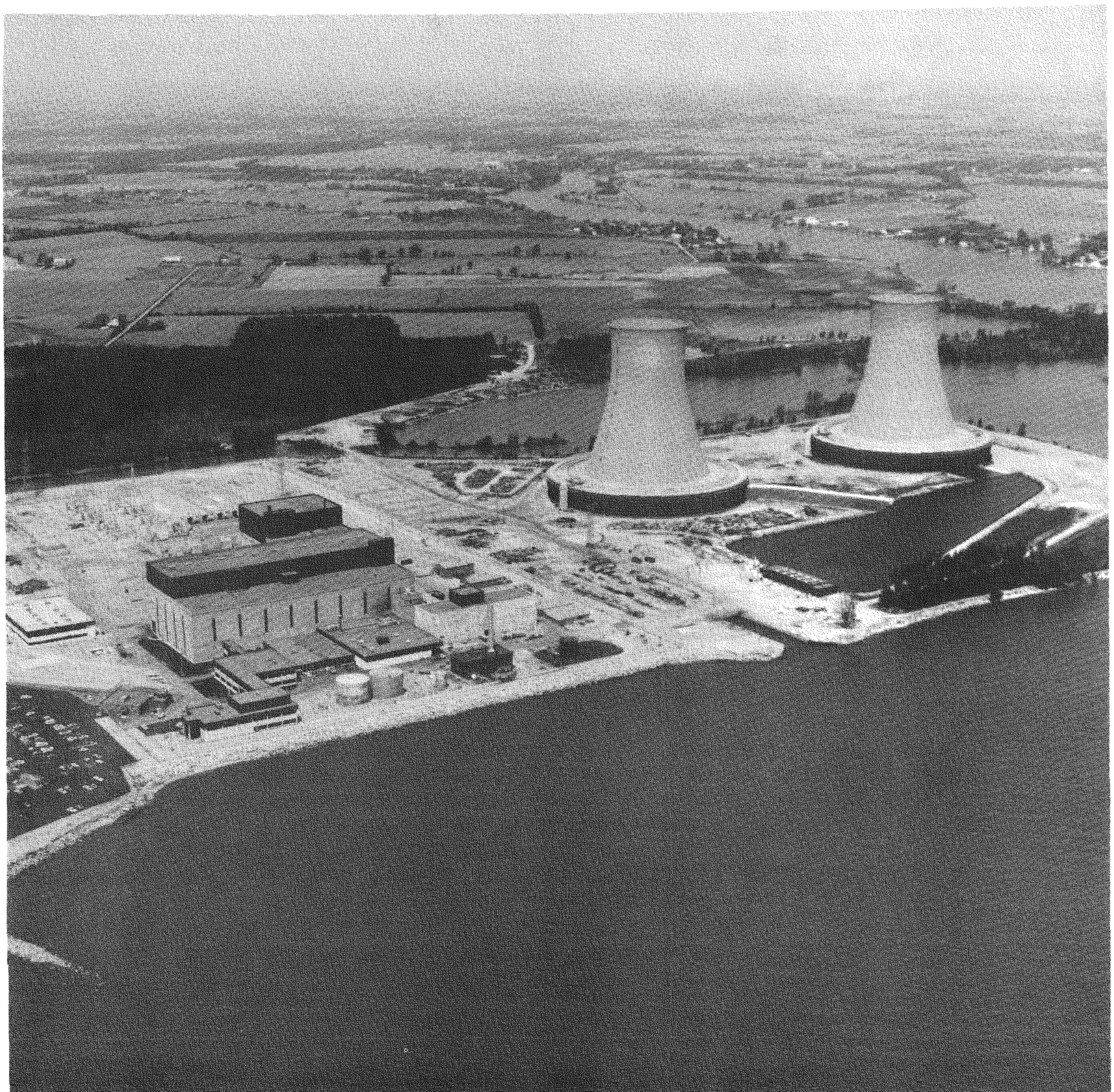
Form EIA-254, Part D, "Unit Cost Data to Date," includes the actual costs disbursed to date, with and without AFUDC. Disbursed costs plus other commitments to date, with and without AFUDC, are also requested in this section of the survey form.

## Data Limitations

Attempts have been made to encourage consistency in reporting by revising Form EIA-254 and requesting a report of disbursed and committed costs both with and without AFUDC. References to the Uniform System of Accounts (Title 18, Part 101, Code of Federal Regulations) in the instructions for the form represent another effort in this direction.

Another limitation results from the length of time over which the information on nuclear construction costs has been collected. It is difficult for utilities reporting on nuclear power plant construction to maintain consistency in reporting practices over the long lead-times required for these projects. Further, the survey form has been revised several times since this survey was initiated, and some of the resulting differences in the cost data reported may reflect the changed survey form.

Finally, the Energy Information Administration has documented that utility estimates of future costs and lead-times are optimistic.[3] Major revisions by the utility continue to occur even when a unit is 90-percent complete. The Final Reported Construction Costs shown in this report are only the costs incurred from the start of construction to commercial operation. *An Analysis of Nuclear Power Plant Operating Costs,* which was published by the Energy Information Administration in March 1988, discusses the capital costs for nuclear power plants after commercial operation is achieved. In 1984, postoperational capital expenditures were about $45 per electric kilowatt (kWe) of capacity, or about 5 percent of the original mixed-current dollar construction costs. Mixed-current dollars means that the costs are in current dollars of a number of different years. For example, if a plant were constructed over the 1971-1976 time period, then the expenditures made in 1971 would be in 1971 dollars, expenditures made in 1972 would be in 1972 dollars, and so on.



*An aerial view of Detroit Edison's Fermi plant in Newport, Michigan.*

[3]Energy Information Administration, *An Analysis of Nuclear Power Plant Construction Costs,* DOE/EIA-0485 (Washington, DC, April 1986).

# 3. Status of U.S. Nuclear Plant Construction

The status of nuclear reactor units from 1974 through 1988 is shown in Figure 1. The increase in operable reactors has been steady and gradual through 1988, growing from 48 operable units in 1974 to 108 by the end of 1988.[4] The number of units with construction permits, however, has slowly decreased since 1979. At that time, there were 91 permits, whereas by the end of 1988 there were only 13. Figure 1 shows that pending construction permits kept decreasing after 1974, with none pending since 1983. In 1974, 44 units were announced and planned for construction, whereas at the end of 1988, just 14 years later, no units were planned for future nuclear power sources in the United States. Various factors have worked to the detriment of the nuclear industry in the United States.[5] At the end of 1988, only 15 commercial nuclear power reactors remained to be completed.

During 1987, 7 units entered commercial operation, 16 units were under construction, 4 were deferred, and 2 reactors were planned. The status as of December 31, 1988, is shown in Figure 2. Of the 16 units under construction in 1987, 5 entered commercial operation during 1988, and 9 are still under construction. Two units, Bellefonte 1 and 2, were deferred in 1988, bringing the total to six deferred units.[6] The two planned units, Carroll County 1 and 2, were canceled during 1988.

Table 1 shows the changes in reported projections of commercial operation dates from the end of 1987 to the end of 1988. For example, of the four reactors scheduled to enter commercial operation between January and June 1988, as reported at the end of 1987, the 1988 survey indicates that no reactors were completed ahead of schedule, three were completed on schedule, and one was delayed less than 3 months. In summary, expected delays of 12 months or more were reported for 2 of the 16 reactors that were in the construction pipeline at the end of 1987, actual delays of less than 3 months were reported for 2 reactors, no changes in schedule were reported for 6, and for 6 reactors no expected dates of commercial operation were reported at the end of 1988.

During 1988, five nuclear units entered commercial operation: Palo Verde 3 (Arizona), Fermi 2 (Michigan), Nine Mile Point 2 (New York), Braidwood 2 (Illinois), and South Texas 1 (Texas). Palo Verde 3, Fermi 2, and Nine Mile Point 2 entered commercial operation in the first half of 1988. Braidwood 2 and South Texas 1 entered commercial operation in the second half of 1988.

For these five units, which have a net summer capability[7] of 5.8 electric gigawatts (GWe), the total cost reported as of December 31, 1988, was $17.8 billion. Figure 3 shows the location of the units, their total net summer capability, and the total cost--all by State.

For the nine nuclear units under construction as of December 31, 1988, the estimated net summer capability is 10.1 GWe, and the total estimated cost is $31.2 billion. Figure 4 shows, by Federal region, the location, estimated total cost, and net summer capability of these nine units.

Table 2 shows the percentage of completion for the nine nuclear units under construction at the end of 1988, compared with the percentage of completion for the units under construction at the end of 1987. The percentages are computed by dividing the total labor expended to date of report by the total labor required for construction, as reported by the utilities. As shown in Table 2, four units were reported in the 1988 survey as 100-percent complete but not in commercial operation.

In Table 3, the nine nuclear units actively under construction as of December 31, 1988, are grouped by year of commercial operation as reported by the util-

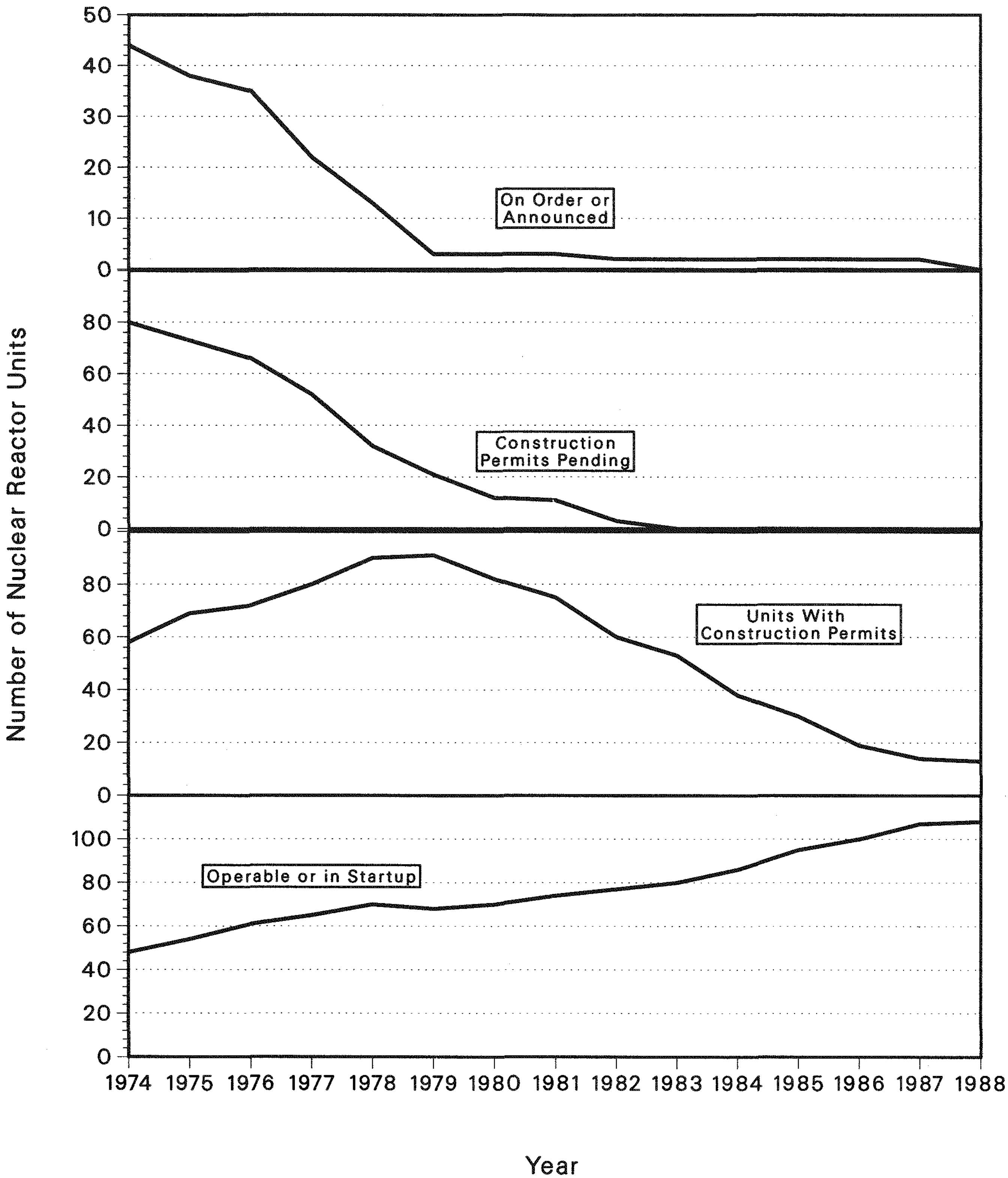
[4]For 1974 through 1979, units are defined as operable based upon the date they first produced electricity. For 1980 and following, operable units are those that have received operating licenses, completed low-power testing, and received full-power amendments from the Nuclear Regulatory Commission. Source: Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035 (Washington, DC, December 1988).

[5]See Energy Information Administration, *Commercial Nuclear Power 1988: Prospects for the United States and the World*, DOE/EIA-0438 (Washington, DC, September 1988) for further information.

[6]One additional deferred unit, Seabrook 2, was reported as canceled on the December 31, 1986, submission of Form EIA-254. Although the Nuclear Regulatory Commission has received a request from the utility to withdraw the unit's construction permit, action on this request is pending.

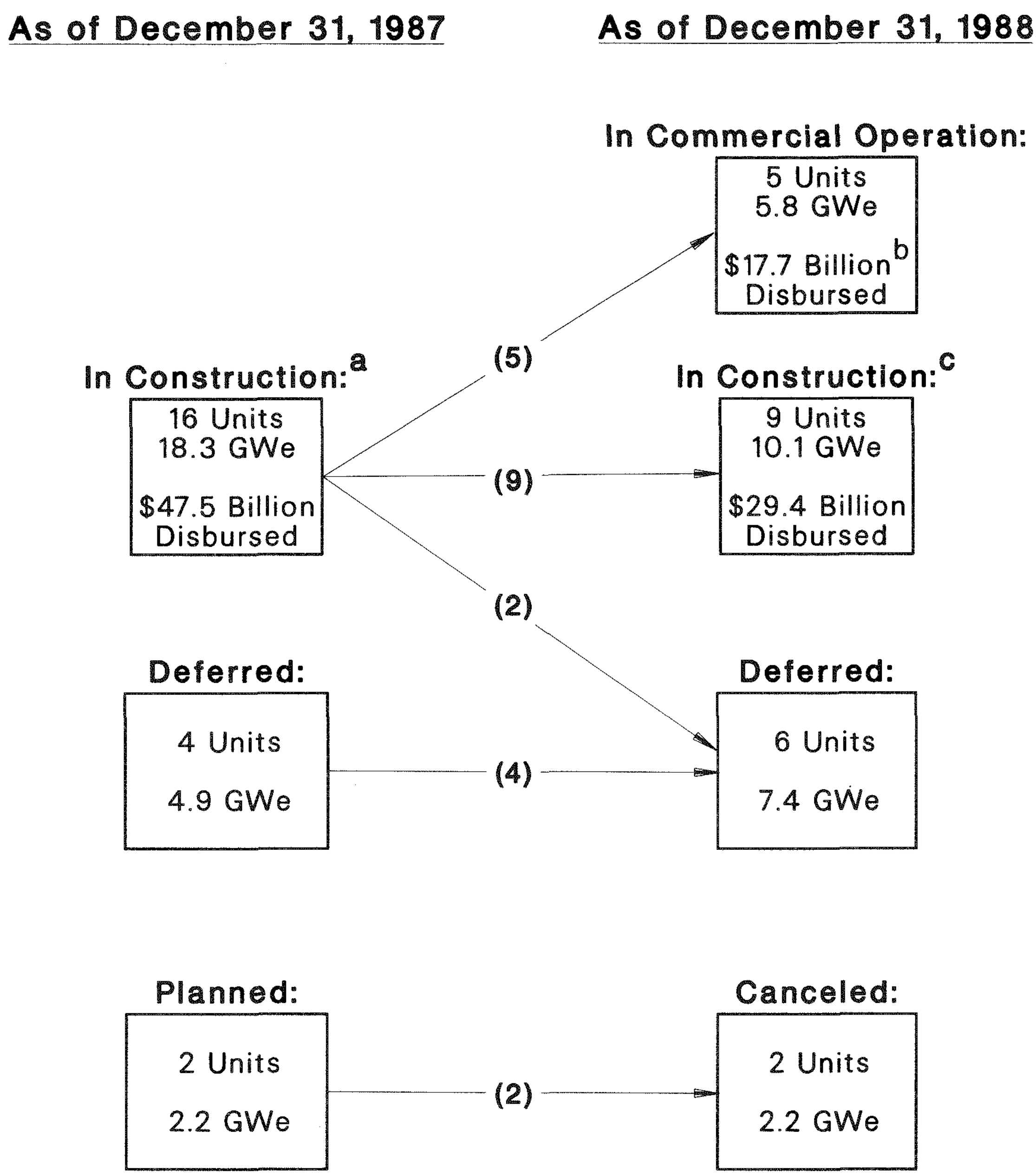
[7]Net summer capability is the steady hourly output that generating equipment is expected to supply to system load, exclusive of auxiliary power, as demonstrated by testing at the time of summer peak demand. Source of data on net summer capability throughout this report: Energy Information Administration, Form EIA-860, "Annual Electric Generator Report 1988."

**Figure 1. Status of Nuclear Reactor Units, 1974-1988**




Source: *Monthly Energy Review*, December 1988, Table 8.2 (Section 8), "Status of Nuclear Reactor Units."

**Figure 2. Status of Nuclear Plant Construction as of December 31, 1987, and December 31, 1988**




[a]Eight units were reported completed but not in commercial operation.

[b]Amount disbursed does not reflect the total cost of these units because not all funds were disbursed at the onset of commercial operation.

[c]Four units were reported completed but not yet in commercial operation.

Note: GWe means electric gigawatts of net summer capability.

Source: Energy Information Administration, Form EIA-254, 1988.

**Table 1. Changes in Reported Projections of Commercial Operation Dates During 1988**
(Number of Units)

| Expected Commercial Operation Date at the End of 1987 | No. of Units | 1988 Changes in Commercial Operation Date | | | | |
|---|---|---|---|---|---|---|
| | | Advances | No Change | Delays: Less Than 3 Months | Delays: 12 Months or More | Date Not Reported |
| 1988 | | | | | | |
| January-June | 4 | 0 | 3 | 1 | 0 | 0 |
| July-December | 1 | 0 | 0 | 1 | 0 | 0 |
| 1989 | | | | | | |
| January-June | 3 | 0 | 2 | 0 | 1 | 0 |
| July-December | 0 | 0 | 0 | 0 | 0 | 0 |
| 1990 | | | | | | |
| January-June | 0 | 0 | 0 | 0 | 0 | 0 |
| July-December | 2 | 0 | 1 | 0 | 1 | 0 |
| January 1991 and Later | 3 | 0 | 0 | 0 | 0 | 3 |
| Date Not Reported | 3 | | | | | 3 |
| **Total** | **16** | **0** | **6** | **2** | **2** | [a] **6** |

[a] For two units, the commercial operation dates were under review at the time of the survey. Two units were deferred in 1988 and no schedule exists for their completion. Commercial operation dates for the other two units were reported in 1988; however, no comparison could be made.

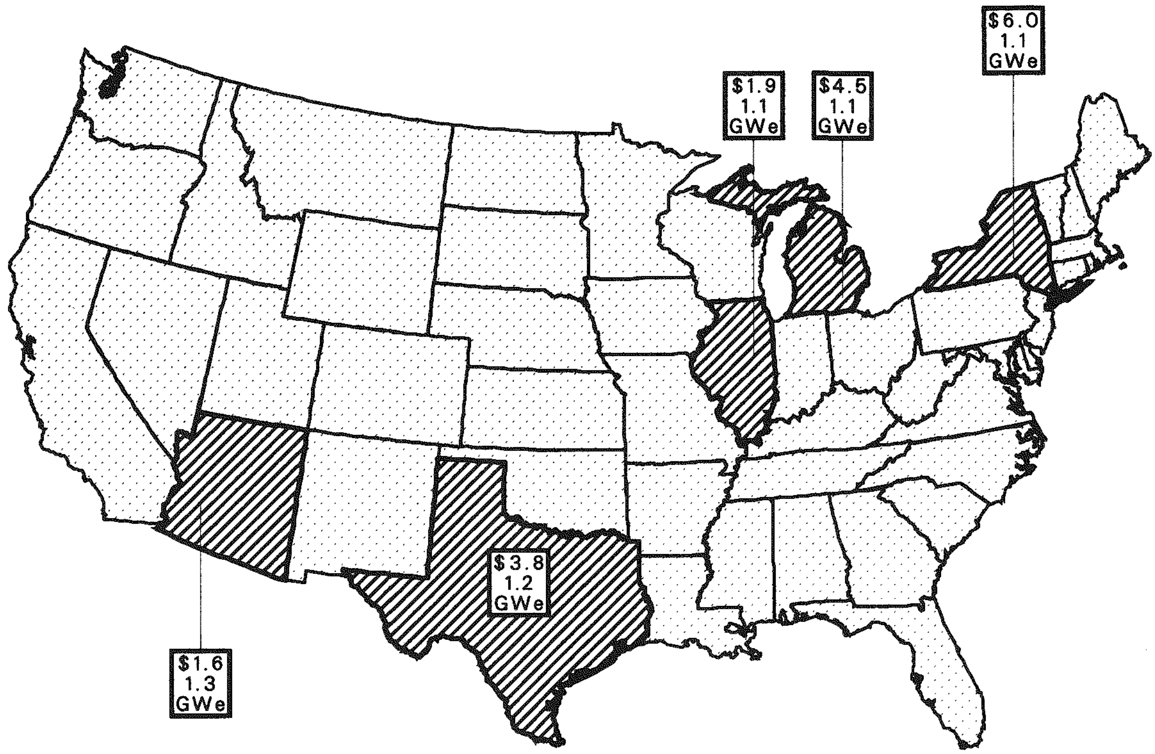
Note: These data apply to the 16 units under construction at the end of 1987.

Source: Energy Information Administration, Form EIA-254, "Semiannual Report on Status of Reactor Construction," 1988.

ities in the 1988 survey. Commercial operation dates are estimates by the utilities and are subject to change. These data show that three of the nine units under construction are scheduled to be in commercial operation by the end of 1989, representing a total net summer capability of 3.6 net GWe and estimated total expenditures of $9.4 billion (in mixed-current dollars). Two units are expected to enter commercial operation in 1990, representing a total net summer capability of 1.9 net GWe and estimated total expenditures of $8.7 billion.

Two additional units are expected to enter commercial operation in 1991 and two units did not report an expected commercial operation date. Some of the six units now deferred (not included in Table 3) may return to active construction status in the future; therefore, additional units not shown in this table may enter commercial operation later than 1991.

**Figure 3. Total Cost and Net Summer Capability of U.S. Nuclear Units That Entered Commercial Operation in 1988, by State**




Note: Costs are reported in billion dollars.
Net summer capability in GWe (electric gigawatts).

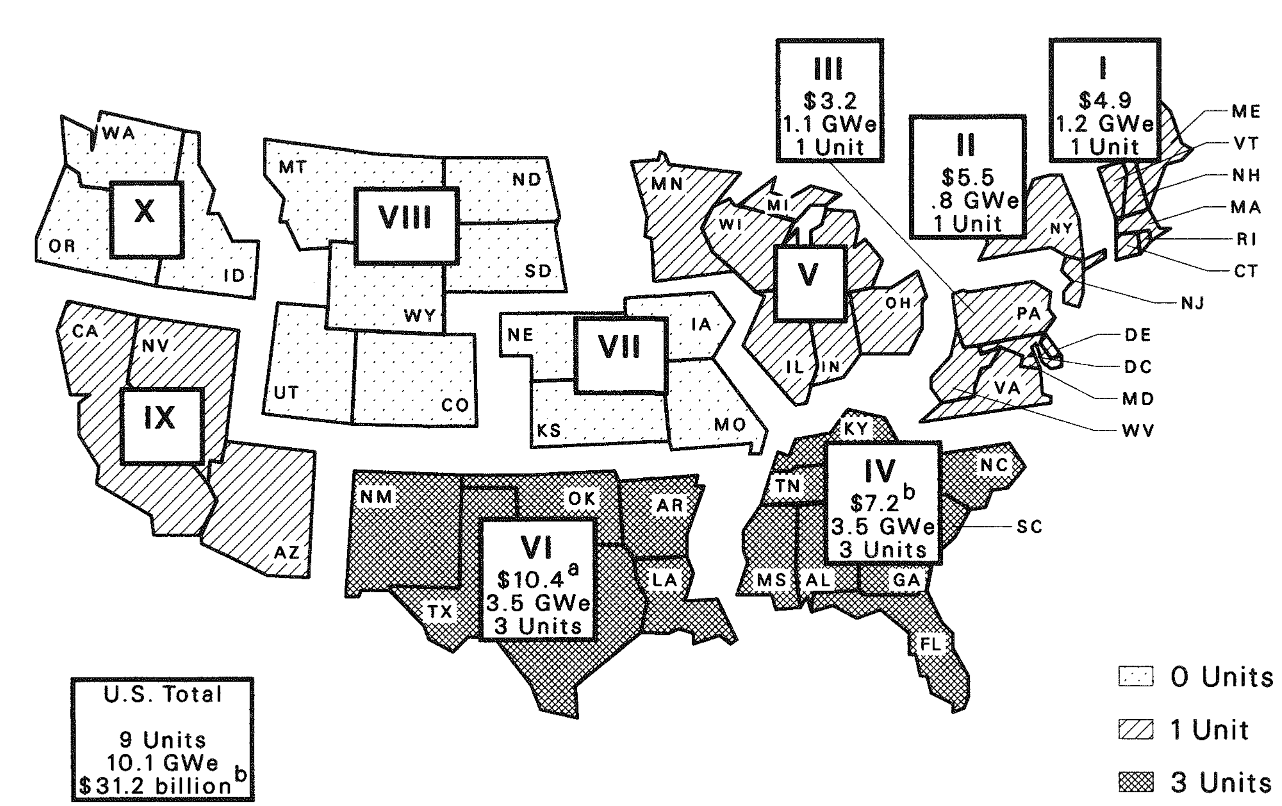
Source: Energy Information Administration, Form EIA-254, 1988.

**Table 2. Nuclear Units Under Construction at the End of 1987 and 1988, by Percent Complete**

| Percent Complete | At the End of 1987 | At the End of 1988 |
|---|---|---|
| 41-60 | 1 | 0 |
| 61-80 | 2 | 0 |
| 81-90 | 4 | 2 |
| 91-95 | 0 | 0 |
| 96-99 | 1 | 3 |
| 100 | 8 | 4 |
| **Total** | **16** | [a] **9** |

[a] This number does not include units that are deferred (Table 10).
Source: Energy Information Administration, Form EIA-254, "Semiannual Report on Status of Reactor Construction," 1988.

**Figure 4. Total Net Summer Capability and Estimated Total Cost of U.S. Nuclear Units Under Construction as of December 31, 1988, by Federal Region**




[a] Estimated total costs do not include parts of AFUDC. See Tables 8 and 9 for details.
[b] Does not include estimate for Watts Bar 2.
Note: Costs are reported in billion dollars, net summer capability in GWe (electric gigawatts).
Source: Energy Information Administration, Form EIA-254, 1988.

**Table 3. Total Net Summer Capability and Estimated Total Cost of U.S. Nuclear Units Actively Under Construction, by Year Expected by Utility to Enter into Commercial Operation**

| Expected Year of Entry Into Commercial Operation | Number of Units | Total Net Summer Capability (GWe) | Estimated Total Cost (billion dollars) |
|---|---|---|---|
| 1989 | 3 | 3.6 | [a] 9.4 |
| 1990 | 2 | 1.9 | 8.7 |
| 1991 | 2 | 2.3 | [a] 8.2 |
| Not Available | 2 | 2.3 | [b] 4.9 |
| **Total** | **9** | **10.1** | **31.2** |

[a] Estimated total costs do not include parts of AFUDC. See Tables 8 and 9 for details.
[b] Does not include estimated final costs for the Tennessee Valley Authority Watts Bar 2 unit.
Sources: **Net Summer Capability**--Energy Information Administration, Form EIA-860, "Annual Electric Generator Report 1988." **Cost Data**--Energy Information Administration, Form EIA-254, "Semiannual Report on Status of Reactor Construction," 1988.

# 4. Estimated Average Construction Costs

The estimated average costs per net electric kilowatt (kWe) of net summer generating capability are available for 101 of the nuclear units that entered commercial operation in the United States from 1968 through 1988 and for 9 of the units expected to enter commercial operation after 1988 (Table 4).

The data show that the average construction cost per kilowatt (kWe) of net summer capability increased from $161 (in mixed-current dollars) in the period from 1968 through 1971 for 11 units to $4,057 in 1987, for just 7 units. This is a greater rate of increase than the general rate of monetary inflation over the same period. In 1988, five units entered commercial operation. Their average construction cost was $3,085 per kWe. Four of these five units are from multistation sites, which generally cost less to build. Besides the fact that there are two fewer units in 1988 than in 1987, as shown in Table 4, two of these multistation units cost less than $2.0 billion to complete, resulting in a lower cost per kWe figure. One multistation unit in this category, however, cost over $6.0 billion to complete. For the three units expected to enter commercial operation in 1989, the average estimated cost is $2,631 per kWe.

For the nine units expected to enter commercial operation after 1988, the commercial operation dates shown in Table 4 are estimates, and the construction schedules are likely to be extended. Two units in this category are less than 90-percent complete, and the estimated costs of construction for these units are slightly less certain than the costs for units further into construction. Historically, utilities have revised these cost estimates upward. However, any future revisions could reflect not only increases due to lengthening construction periods and increases in the scope of plant, but also downward effects due to inflation factors that are lower than initially expected.

It is beyond the scope of this report to identify or analyze the specific causes of this escalation of construction costs. One interesting observation can be made,

**Table 4. Average Construction Costs for Nuclear Units Entering Commercial Operation From 1968 Through 1991**

| Period During Which Units Entered or Are Expected to Enter Commercial Operation | Number of Units | Average Construction Cost (mixed-current dollars[a] per kWe) |
|---|---|---|
| Historical | | |
| 1968-1971 | 11 | 161 |
| 1972-1973 | 15 | 217 |
| 1974-1975 | 19 | 404 |
| 1976-1978 | 12 | 623 |
| 1979-1984 | 17 | 1,373 |
| 1985-1986 | 15 | 2,416 |
| 1987 | 7 | 4,057 |
| 1988 | 5 | 3,085 |
| **Total** | [b] 101 | -- |
| Expected | | |
| 1989 | 3 | [c] 2,631 |
| 1990-1991 | 4 | 4,077 |
| Not Available | 2 | [d] -- |
| **Total** | **9** | -- |

[a] Costs are in current dollars of a number of different years. For example, for a plant constructed over the 1971-1976 period, expenditures made in 1971 are in 1971 dollars, expenditures made in 1972 are in 1972 dollars, and so on.
[b] Only 101 of the 109 units could be used for this analysis. Combined costs were reported for three units and could not be broken down accurately; and for five other units, no construction cost data were available.
[c] Does not include AFUDC for South Texas 2 and only part of AFUDC for Comanche Peak 1 (Tables 8 and 9).
[d] Since only one unit in this category reported an estimated total cost, no computation was made.
Sources: U.S. Atomic Energy Commission and U.S. Energy Research and Development Administration, Form HQ-254, 1968-1981; and Energy Information Administration, Form EIA-254, "Semiannual Report on Status of Reactor Construction," 1982-1988.

however: the mean construction time (that is, the average time from the start of construction to commercial operation) for nuclear units continued to increase in 1988, as it has since 1972. Such extensions in lead-times have increased financing costs.

Figure 5 shows the mean construction time for 69 units from Table 4 that began commercial operation from 1975 through 1988. Units that began commercial operation in 1975 and 1976 were under construction for an average of 7 years. By the early 1980's (1981 and 1982), the average elapsed construction time had increased to 11.1 years. In 1987 and 1988, the construction time for units entering commercial operation was more than 13 years, an increase of more than 96 percent from the average construction time for units that entered commercial operation in 1975 and 1976.

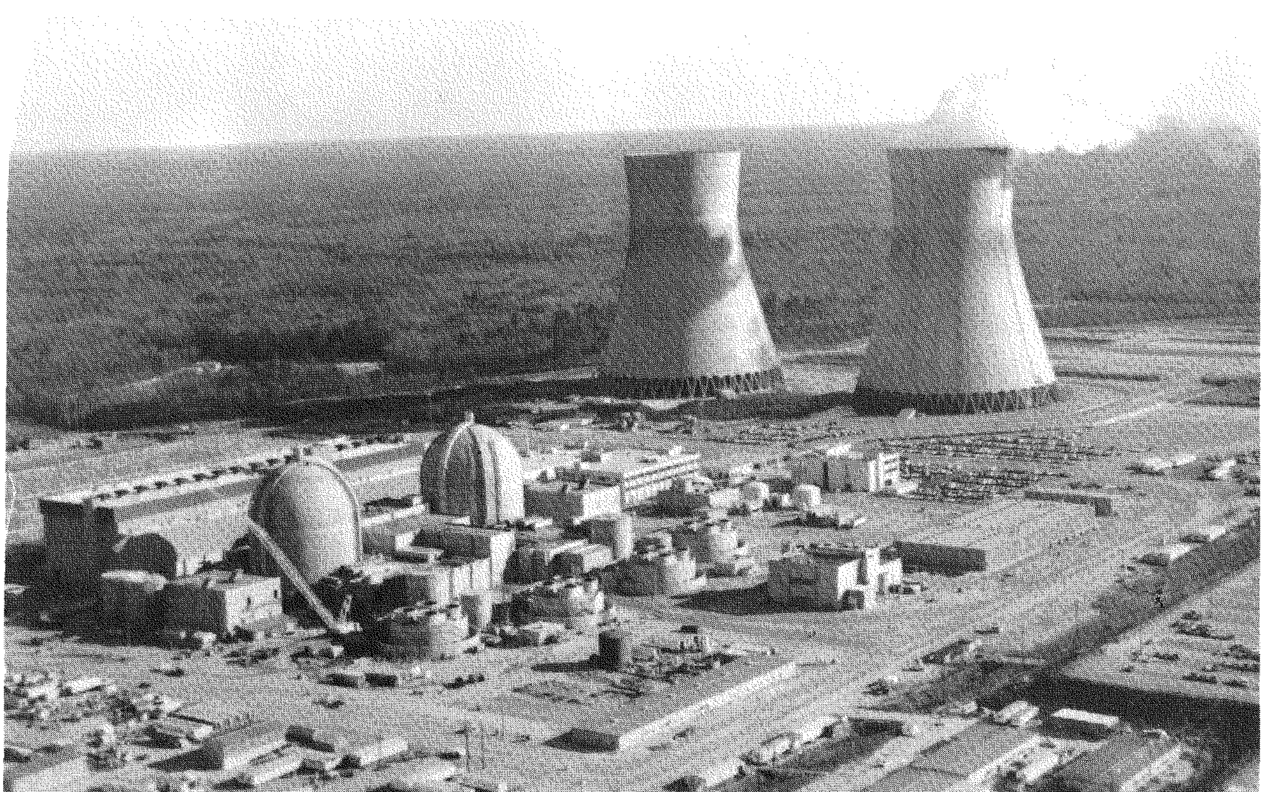
Figure 5 also shows the estimated mean construction time for seven of the nine units under construction at the end of 1988. The mean construction time for five units expected to be placed in commercial operation in 1989 and 1990 is approximately 17 years. One of these units has been 100-percent complete since 1983 but has not entered commercial operation because of an unresolved Emergency Response Plan issue. The mean increases to about 17.9 years in 1991 and 1992.

A report titled *An Analysis of Nuclear Power Plant Construction Costs* was published by the Energy Information Administration in March 1986. The report presents the results of a statistical analysis of nuclear power plant construction costs and lead-times. The analysis indicates that construction costs and lead-times may be influenced by such factors as design changes, safety and environmental retrofits required by regulatory change, and labor productivity.[8]

In the United States, there were 108 nuclear units in commercial operation as of December 31, 1988. These units have a combined total net summer capability of 95.1 GWe. Of these 108 nuclear units, 5 achieved commercial status during 1988. Three additional reactors, with a capacity of 3.6 net GWe, are expected to enter commercial operation by the end of 1989.

Table 5 shows the initial and final cost estimates for the 108 units in commercial operation as of December 31, 1988, as well as the dates these estimates were made. Table 5 also shows the initial estimates and final dates of commercial operation. For detailed information on individual units see Table 7.

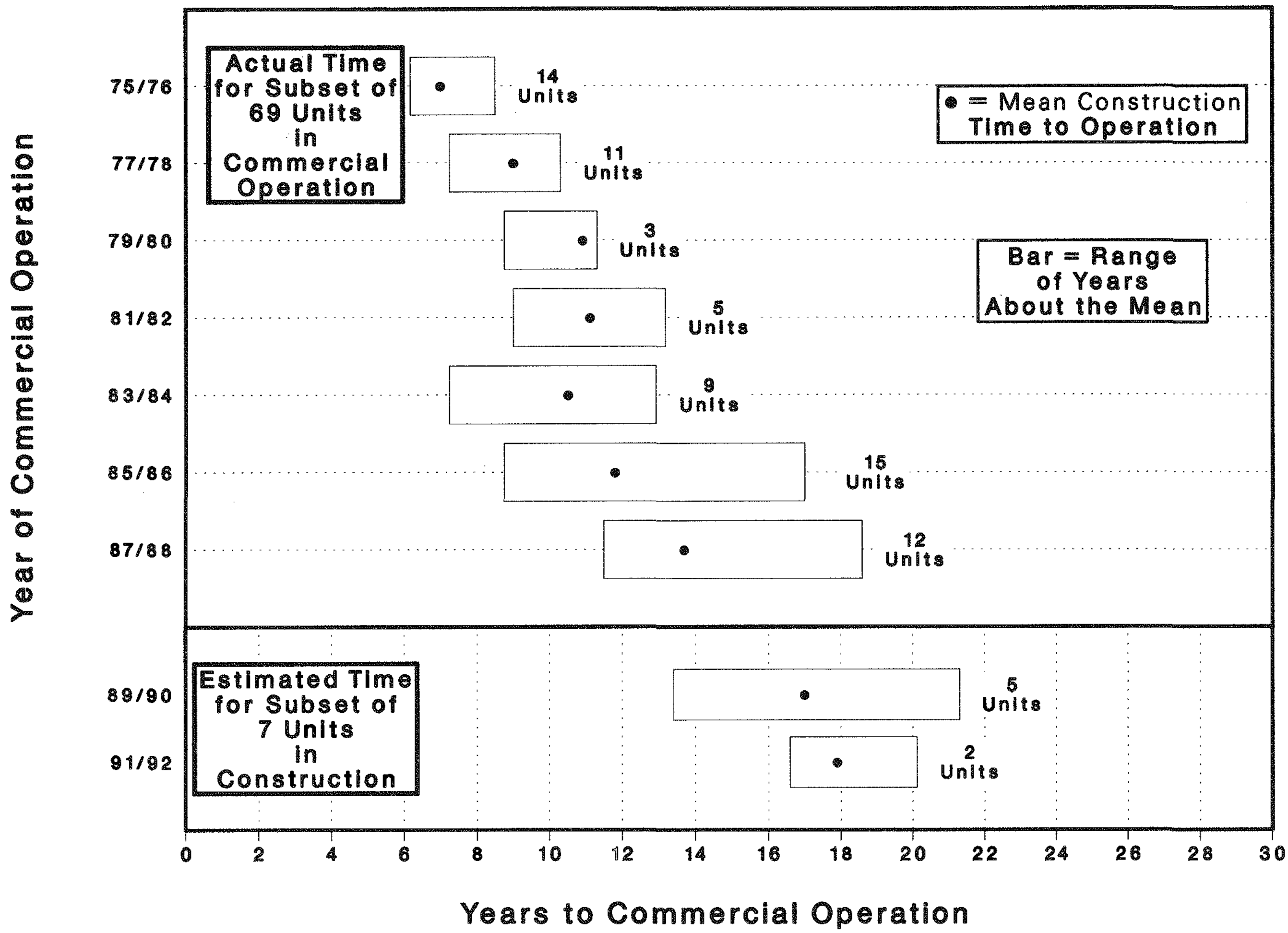
The 108 nuclear units in commercial operation as of December 31, 1988 (including units that are shut down for an extended period), are located in all 10 Federal regions. Figure 6 shows the number and total net summer capability of operating units in each region, ranging from 1 unit in Region VIII to 28 in Region IV.



*Georgia Power Company's Vogtle plant in Waynesboro, Georgia. Vogtle 1 has been operable since March 1987, and Vogtle 2 is expected to become operable in June 1989.*

[8]Energy Information Administration, *An Analysis of Nuclear Power Plant Construction Costs,* DOE/EIA-0485 (Washington, DC, March 1986).

**Figure 5. Nuclear Power Plant Construction Time: Actual and Estimated Means and Ranges, 1975-1992**




Source: Atomic Energy Commission and U.S. Energy Research and Development Administration (Form HQ-254), and Energy Information Administration, Form EIA-254.

## Table 5. Initial and Final Estimates of Construction Cost for U.S. Nuclear Units in Commercial Operation as of December 31, 1988

| Name of Unit | Net Summer Capability (MWe) | Date of Initial Cost Estimate | Initial Cost Estimate (million dollars) | Initial Estimate of Commercial Operation Date | Date of Final Cost Estimate | Final Estimate of Total Cost (million dollars) | Date of Commercial Operation |
|---|---|---|---|---|---|---|---|
| South Texas 1 | 1,239 | 12/73 | [a] 959.8 | 3/81 | 2/89 | 3,797.9 | 8/88 |
| Braidwood 2 | 1,107 | 2/73 | 446.5 | 10/80 | 8/88 | 1,882.3 | 8/88 |
| Nine Mile 2 | 1,080 | 1/72 | 370.0 | 7/78 | 6/88 | 6,030.4 | 3/88 |
| Fermi 2 | 1,093 | 3/69 | 220.7 | 2/74 | 7/88 | 4,542.8 | 1/88 |
| Palo Verde 3 | 1,259 | 10/74 | 605.3 | 5/84 | 8/88 | 1,572.2 | 1/88 |
| Perry 1 | 1,185 | 4/73 | [b] 1,234.0 | 1979 | 12/87 | 5,398.5 | 11/87 |
| Braidwood 1 | 1,107 | 2/73 | 501.4 | 10/79 | 2/88 | 3,265.6 | 11/87 |
| Beaver Valley 2 | 833 | 1/72 | 295.9 | 3/78 | 1/88 | 4,544.3 | 11/87 |
| Vogtle 1 | 1,079 | 1/73 | 570.1 | 4/80 | 9/87 | 6,286.0 | 6/87 |
| Shearon Harris 1 | 860 | 7/71 | [c] 934.6 | 3/77 | 7/87 | 3,816.4 | 5/87 |
| Byron 2 | 1,120 | 8/71 | 350.0 | 10/79 | 8/87 | 1,981.2 | 4/87 |
| Clinton 1 | 930 | 10/73 | 403.9 | 6/80 | 8/87 | 4,264.3 | 4/87 |
| Hope Creek 1 | 1,067 | 4/70 | [d] 573.9 | 3/75 | 12/86 | 4,495.0 | 12/86 |
| Palo Verde 2 | 1,270 | 10/74 | 586.4 | 11/82 | 3/87 | 1,646.2 | 9/86 |
| Catawba 2 | 1,145 | 1/73 | 317.4 | 3/80 | 1/87 | 1,623.0 | 8/86 |
| River Bend 1 | 919 | 2/73 | 390.0 | 10/79 | 8/86 | 3,802.6 | 6/86 |
| Millstone 3 | 1,142 | 7/74 | 641.7 | 5/79 | 8/86 | 3,825.0 | 4/86 |
| Diablo Canyon 2 | 1,079 | 1/69 | 150.5 | 7/74 | 9/86 | 2,727.8 | 3/86 |
| Limerick 1 | 1,062 | 5/70 | 251.8 | 3/75 | 6/86 | 3,822.0 | 2/86 |
| Palo Verde 1 | 1,270 | 7/74 | 605.7 | 5/81 | 9/86 | 2,641.3 | 1/86 |
| Wolf Creek | 1,128 | 7/74 | 782.3 | 4/81 | 12/85 | 2,992.4 | 9/85 |
| Waterford 3 | 1,075 | 10/70 | 230.0 | 1/77 | 12/85 | 2,840.2 | 9/85 |
| Grand Gulf 1 | 1,142 | 7/72 | 600.0 | 12/78 | 12/85 | 3,281.2 | 7/85 |
| Catawba 1 | 1,145 | 12/72 | 317.4 | 3/79 | 12/85 | 1,917.0 | 6/85 |
| Diablo Canyon 1 | 1,073 | 12/66 | 153.6 | 12/72 | 6/85 | 3,315.5 | 5/85 |
| Byron 1 | 1,120 | 6/71 | 400.0 | 10/78 | 12/85 | 2,558.4 | 4/85 |
| Susquehanna 2 | 1,050 | 7/68 | [a] 150.0 | 3/79 | 12/85 | 2,130.1 | 2/85 |
| Callaway 1 | 1,150 | 7/74 | 839.0 | 10/81 | 12/84 | 3,070.0 | 12/84 |
| WNP 2 | 1,100 | 5/71 | 187.4 | 9/77 | 12/84 | 3,200.9 | 12/84 |
| La Salle 2 | 1,048 | 6/70 | 300.4 | 10/76 | 12/84 | 1,080.5 | 6/84 |
| San Onofre 3 | 1,080 | 3/70 | [e] 378.5 | 6/76 | 6/84 | 1,796.2 | 4/84 |
| McGuire 2 | 1,150 | 3/70 | [a] 358.4 | 11/75 | 3/84 | 1,083.0 | 3/84 |
| Summer 1 | 885 | 7/71 | 234.0 | 1/77 | 6/84 | 1,283.0 | 1/84 |
| St. Lucie 2 | 839 | 12/72 | 360.0 | 10/78 | 6/84 | 1,465.0 | 8/83 |
| San Onofre 2 | 1,070 | 7/70 | [e] 378.5 | 6/76 | 3/84 | 2,694.3 | 8/83 |
| Susquehanna 1 | 1,050 | 7/68 | [a] 150.0 | 12/75 | 3/84 | 1,941.0 | 6/83 |
| La Salle 1 | 1,048 | 6/70 | 360.0 | 10/75 | 6/84 | 1,377.1 | 10/82 |
| Sequoyah 2 | 1,148 | 12/68 | [a] 321.9 | 10/73 | 9/83 | [f] 1,659.0 | 6/82 |
| McGuire 1 | 1,150 | 3/70 | [a] 358.4 | 11/75 | 3/84 | 919.0 | 12/81 |
| Joseph M. Farley 2 | 827 | 9/70 | 183.0 | 4/77 | 5/81 | 803.4 | 7/81 |
| Sequoyah 1 | 1,148 | 9/68 | [a] 321.9 | 10/73 | 9/83 | [f] 1,659.0 | 7/81 |
| North Anna 2 | 915 | 3/70 | 184.0 | 3/75 | 9/80 | 542.0 | 11/80 |
| Salem 2 | 1,106 | 9/67 | 127.6 | 5/73 | 11/80 | [f] 1,701.0 | 10/80 |
| Arkansas Nuclear One Unit 2 | 858 | 8/70 | 182.7 | 10/75 | 8/79 | 577.5 | 9/79 |
| Edwin I. Hatch 2 | 769 | 6/70 | 189.0 | NA | 9/78 | 511.8 | 12/78 |
| Donald C. Cook 2 | 1,100 | 11/67 | [a] 235.0 | 4/72 | 9/78 | 439.0 | 7/78 |
| North Anna 1 | 915 | 3/69 | 184.5 | 3/74 | 9/78 | 785.0 | 6/78 |
| Joseph M. Farley 1 | 828 | 8/69 | 163.5 | 4/75 | 10/77 | 666.2 | 12/77 |
| Davis-Besse 1 | 856 | 12/68 | 179.8 | 12/74 | 9/77 | 649.0 | 12/77 |
| Salem 1 | 1,106 | 11/66 | 138.9 | NA | 11/80 | [f] 1,701.0 | 6/77 |
| Calvert Cliffs 2 | 825 | 6/67 | 105.0 | 1/74 | 12/76 | 250.6 | 4/77 |
| Browns Ferry 3 | 1,067 | 9/68 | [a] 373.1 | 10/70 | 6/77 | [f] 894.5 | 3/77 |
| Crystal River 3 | 737 | 3/67 | 109.5 | 4/72 | 5/77 | 419.8 | 3/77 |
| Brunswick 1 | 790 | 4/69 | 281.8 | 3/73 | 3/77 | 328.4 | 3/77 |
| Beaver Valley 1 | 810 | 10/67 | 150.0 | 7/73 | 6/77 | 605.6 | 10/76 |
| Indian Point 3 | 965 | 6/67 | 156.4 | 6/71 | 10/76 | 400.0 | 8/76 |
| St. Lucie 1 | 839 | 8/69 | 123.2 | 5/73 | 11/76 | 463.0 | 6/76 |
| Millstone 2 | 857 | 12/67 | 150.0 | 4/74 | 12/75 | 416.3 | 12/75 |
| Trojan | 1,104 | 12/68 | 195.6 | 7/74 | 5/76 | 448.4 | 12/75 |
| Prairie Island 2 | 511 | 12/67 | 184.9 | 5/74 | 6/75 | 102.3 | 12/75 |
| Brunswick 2 | 790 | 4/69 | 281.8 | 3/74 | 3/77 | 398.8 | 11/75 |
| James A. Fitzpatrick | 794 | 12/68 | NA | 5/73 | 4/74 | 253.6 | 9/75 |
| Donald C Cook 1 | 1,030 | 11/67 | [a] 235.0 | 4/72 | 4/76 | 536.0 | 8/75 |

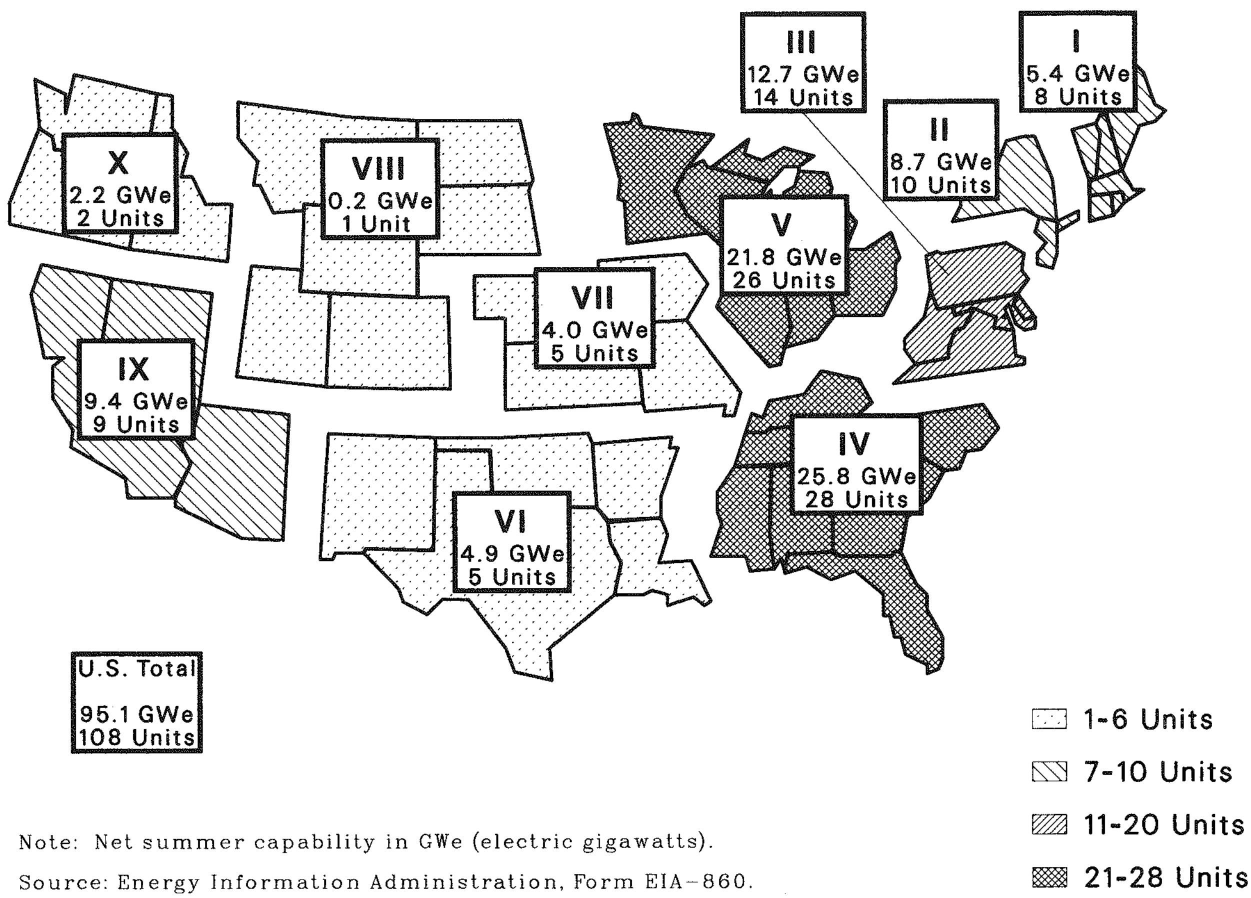
See footnotes at end of table.

**Table 5. Initial and Final Estimates of Construction Cost for U.S. Nuclear Units in Commercial Operation as of December 31, 1988 (Continued)**

| Name of Unit | Net Summer Capability (MWe) | Date of Initial Cost Estimate | Initial Cost Estimate (million dollars) | Initial Estimate of Commercial Operation Date | Date of Final Cost Estimate | Final Estimate of Total Cost (million dollars) | Date of Commercial Operation |
|---|---|---|---|---|---|---|---|
| Calvert Cliffs 1 | 825 | 6/67 | 118.1 | 1/73 | 9/75 | 349.7 | 5/75 |
| Edwin I. Hatch 1 | 755 | 3/69 | 151.0 | 6/73 | 12/74 | 377.0 | 5/75 |
| Rancho Seco 1 | 873 | 12/67 | 134.5 | 5/73 | 7/76 | 338.3 | 4/75 |
| Browns Ferry 2 | 1,067 | 9/68 | [a] 373.1 | 10/70 | 9/76 | [f] 894.5 | 3/75 |
| Duane Arnold | 500 | 5/68 | 102.7 | 12/73 | 2/74 | 277.0 | 1/75 |
| Oconee 3 | 860 | 12/67 | 263.6 | 5/71 | 7/76 | 165.6 | 12/74 |
| Arkansas Nuclear One Unit 1 | 836 | 11/67 | 132.0 | 12/72 | 4/77 | 245.4 | 12/74 |
| Peach Bottom 3 | 1,033 | 2/67 | 125.0 | NA | 3/75 | 226.0 | 12/74 |
| Fort St. Vrain | 217 | 12/65 | 53.3 | 10/71 | 6/74 | 274.1 | 10/74 |
| Three Mile Island 1 | 776 | 6/67 | 106.4 | 5/71 | 4/75 | 403.7 | 9/74 |
| Browns Ferry 1 | 1,067 | 9/68 | [a] 373.1 | 10/70 | 9/76 | [f] 894.5 | 8/74 |
| Peach Bottom 2 | 1,052 | 12/66 | 138.4 | NA | 3/75 | 537.0 | 7/74 |
| Cooper Station | 760 | 10/67 | 133.4 | 4/72 | 6/76 | 316.3 | 7/74 |
| Kewaunee | 525 | 10/67 | 83.0 | 6/72 | 1/75 | 201.2 | 6/74 |
| Oconee 2 | 860 | 10/66 | 75.4 | NA | 6/74 | 160.0 | 1974 |
| Prairie Island 1 | 512 | 3/67 | 92.6 | 5/72 | 12/74 | 142.5 | 12/73 |
| Zion 1 | 1,040 | 3/67 | 164.0 | 4/72 | 12/73 | 276.4 | 12/73 |
| Zion 2 | 1,040 | 6/67 | 153.0 | 5/73 | 12/73 | 274.6 | 12/73 |
| Indian Point 2 | 849 | 2/66 | 134.8 | 6/69 | 9/73 | 212.0 | 10/73 |
| Turkey Point 4 | 666 | 5/66 | [a] 141.7 | 9/70 | 10.73 | 106.2 | 9/73 |
| Fort Calhoun 1 | 476 | 9/67 | 70.2 | 5/71 | 8/73 | 161.5 | 9/73 |
| Oconee 1 | 860 | 10/66 | 76.0 | NA | 7/74 | 162.6 | 7/73 |
| Surry 2 | 781 | 12/66 | 108.0 | 3/72 | 6/73 | 148.9 | 5/73 |
| Dresden 3 | 773 | 5/66 | 80.8 | 2/70 | 3/73 | 130.7 | 12/72 |
| Surry 1 | 781 | 12/66 | 130.0 | 3/71 | 6/73 | 251.1 | 12/72 |
| Quad-Cities 1 | 769 | 6/66 | 90.4 | 3/70 | 3/73 | 159.8 | 12/72 |
| Quad-Cities 2 | 769 | 9/66 | 77.3 | 3/71 | 3/73 | 102.1 | 12/72 |
| Pilgrim 1 | 667 | 5/67 | NA | 10/71 | 12/75 | 120.0 | 12/72 |
| Turkey Point 3 | 666 | 5/66 | [a] 141.7 | 9/70 | 10/73 | 110.3 | 12/72 |
| Maine Yankee[g] | 845 | NA | NA | NA | NA | NA | 12/72 |
| Vermont Yankee | 496 | 10/66 | 87.6 | 10/70 | NA | NA | [g] 11/72 |
| Point Beach 2 | 485 | 3/67 | 54.3 | 4/71 | 12/71 | 54.3 | 9/72 |
| Monticello | 541 | 6/66 | 74.2 | 5/70 | 12/71 | 88.8 | 5/71 |
| Millstone 1 | 654 | 2/66 | 94.0 | 8/69 | 4/71 | 92.0 | 2/71 |
| H.B. Robinson 2 | 665 | 6/66 | 75.0 | 5/70 | 12/70 | 76.4 | 1/71 |
| Point Beach 1 | 485 | 6/66 | 61.3 | 4/70 | 3/71 | 60.6 | 12/70 |
| Palisades | 734 | 2/68 | 87.0 | 5/70 | 7/70 | 118.1 | 11/70 |
| Dresden 2 | 772 | 5/66 | 80.2 | 2/69 | 3/73 | 101.3 | 8/70 |
| Ginna | 470 | 12/65 | 80.3 | 6/69 | 6/70 | 64.9 | 1970 |
| Oyster Creek 1 | 620 | 6/64 | 68.0 | 10/67 | 6/70 | 91.4 | 12/69 |
| Nine Mile Point 1 | 610 | 4/64 | 101.0 | 11/68 | 6/70 | 150.5 | 12/69 |
| Haddam Neck | 543 | 3/64 | 94.3 | 10/67 | 6/72 | 109.3 | 1/68 |
| San Onofre 1 | 436 | 6/64 | 101.2 | 5/67 | 12/68 | 98.5 | 1/68 |
| Big Rock Point | 69 | 1/60 | 27.8 | 12/62 | NA | NA | 3/63 |
| Yankee Rowe | 167 | R6/58 | R55.5 | 1/61 | R7/61 | 52.4 | 7/61 |

[a] Initial reported cost estimate was a combined total for all units at the site.
[b] Initial reported cost estimate was a combined total for two units at the site. However, Perry 2 has been indefinitely deferred since August 1985.
[c] Initial reported cost estimate was a combined total for all units at the site. However, Shearon Harris 2, 3, and 4 were canceled.
[d] Initial reported cost estimate was a combined total for two units at the site. However, Hope Creek Unit 2 was canceled in December 1981.
[e] Initial reported cost estimate was a combined total for San Onofre 2 and 3. San Onofre 1 has a separate estimate.
[f] Final reported cost estimate was a combined total for all units at the site.
[g] The data shown were obtained from Form RW-859, "Nuclear Fuel Data Form."
NA=Not available.
Note: For detailed information on individual units, see Table 7.
Sources: **Net Summer Capability**--Energy Information Administration, Form EIA-860, "Annual Electric Generator Report 1988." **Cost Data**--U.S. Atomic Energy Commission and Energy Research and Development Administration, Form HQ-254, "Quarterly Progress Report on Status of Reactor Construction" (1961-1981), and Energy Information Administration, Form EIA-254, "Semiannual Report on Status of Reactor Construction" (1982-1988).

**Figure 6. Total Net Summer Capability and Number of U.S. Nuclear Units in Commercial Operation as of December 31, 1988, by Federal Region**




Note: Net summer capability in GWe (electric gigawatts).

Source: Energy Information Administration, Form EIA-860.

# 5. Reactor-Specific Data

Historical data from Form EIA-254 and HQ-254 for 103 nuclear-powered generating units in commercial operation as of December 31, 1988 (excluding units that have been shut down) are presented in Table 7. Table 8 lists four nuclear units that were completed but not in commercial operation on December 31, 1988.[9] Estimates of the construction cost and scheduled progress for five nuclear units actively under construction are presented in Table 9. Table 10 shows six units that were deferred as of December 31, 1988. Five units that have been shut down for an extended period are listed in Table 11. The data are presented alphabetically by State. In total there were 123 domestic nuclear generating units in all stages of construction, deferral, or operation as of December 31, 1988. Table 6 shows the number of units in each particular category and the table in which they can be found.

The cost data published here for units that have entered commercial operation are the total nuclear production plant costs, consisting of the sum of direct costs, indirect costs, contingency costs, common facility costs, and allowance for funds used during construction (AFUDC). Two additional financial items are included for units in the construction pipeline: (1) disbursed costs and AFUDC, and (2) disbursed costs and AFUDC plus other commitments. The disbursed costs and AFUDC consist of money that has already been paid for the construction of the unit, plus AFUDC. The disbursed costs and AFUDC plus other commitments include the disbursed funds and allowance for funds used during construction, plus funds that have been committed to be paid. Only the nonconfidential financial data collected on Form EIA-254 (total production plant costs and disbursed costs) are presented in these tables.

**Table 6. Index of Tables Displaying Reactor Data**

| Category | Number of Units | Display |
|---|---|---|
| In Operation | 103 | Table 7 |
| Complete but Not in Operation | 4 | Table 8 |
| Active Construction | 5 | Table 9 |
| Deferred | 6 | Table 10 |
| Extended Shutdown | 5 | Table 11 |
| Total | 123 | -- |

[9]Elsewhere in this report, those four units are grouped with reactors in construction. For example, Table 2 shows nine units in construction, including the four units completed but not in commercial operation.

## Table 7. U.S. Nuclear Power Units in Commercial Operation on December 31, 1988, by State and Reporting Utility

| | Alabama | | Arkansas | | Arizona |
|---|---|---|---|---|---|
| | Alabama Power Company | | Arkansas Power and Light Company | | Arizona Public Service Company |
| Unit Name | Joseph M. Farley 1 | Joseph M. Farley 2 | Arkansas Nuclear One Unit 1 | Arkansas Nuclear One Unit 2 | Palo Verde 1 |
| Location | Dothan | Dothan | Russellville | Russellville | Wintersburg |
| Reactor Type[a] | PWR | PWR | PWR | PWR | PWR |
| Net Summer Capability (megawatts electric) | 828 | 827 | 836 | 858 | 1,270 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | 666,247 | 803,418 | 245,427 | 577,500 | [c]2,641,313 |
| Date of Report | 10/28/77 | 5/1/81 | 4/15/77 | 8/7/79 | 9/8/86 |
| Date of First Criticality | 8/77 | 5/81 | 8/74 | 12/78 | [d]1/85 |
| Date When Plant Placed in Commercial Operation | 12/77 | 7/81 | 12/74 | 9/79 | 1/86 |
| | **Arizona (continued)** | | **California** | | |
| | Arizona Public Service Company | | Southern California Edison | | |
| Unit Name | Palo Verde 2 | Palo Verde 3 | San Onofre 1 | San Onofre 2 | San Onofre 3 |
| Location | Wintersburg | Wintersburg | San Clemente | San Clemente | San Clemente |
| Reactor Type[a] | PWR | PWR | PWR | PWR | PWR |
| Net Summer Capability (megawatts electric) | 1,270 | 1,259 | 436 | 1,070 | 1,080 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | [c]1,646,223 | [c]1,572,181 | 98,457 | 2,694,300 | 1,796,200 |
| Date of Report | 3/3/87 | 8/11/88 | 12/31/68 | 3/31/84 | 3/31/84 |
| Date of First Criticality | [d]12/85 | [d]4/87 | 6/67 | 7/82 | 7/83 |
| Date When Plant Placed in Commercial Operation | 9/86 | 1/88 | 1/68 | 8/83 | 4/84 |

See footnotes at end of table.

**Table 7. U.S. Nuclear Power Units in Commercial Operation on December 31, 1988, by State and Reporting Utility (Continued)**

| | California (continued) | | | Colorado | Connecticut |
|---|---|---|---|---|---|
| | Pacific Gas and Electric Company | | Sacramento Municipal Utility District | Public Service Company of Colorado | Northeast Utilities Service Company |
| Unit Name | Diablo Canyon 1 | Diablo Canyon 2 | Rancho Seco 1 | Fort St. Vrain | [e]Millstone 1 |
| Location | Avila Beach | Avila Beach | Clay Station | Platteville | Waterford |
| Reactor Type[a] | PWR | PWR | PWR | HTGR | BWR |
| Net Summer Capability (megawatts electric) | 1,073 | 1,079 | 873 | 217 | 654 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | 3,315,497 | 2,727,782 | 338,332 | 274,087 | 91,951 |
| Date of Report | 6/30/85 | 9/8/86 | 7/9/76 | 6/30/74 | 4/13/71 |
| Date of First Criticality | [d]11/83 | [d]5/85 | 8/74 | 1/74 | 10/70 |
| Date When Plant Placed in Commercial Operation | 5/85 | 3/86 | 4/75 | 10/74 | 2/71 |

| | Connecticut (continued) | | | Florida | |
|---|---|---|---|---|---|
| | Northeast Utilities Service Company | | Connecticut Yankee Atomic Power Company | Florida Power and Light Company | |
| Unit Name | Millstone 2 | Millstone 3 | Haddam Neck | St. Lucie 1 | St. Lucie 2 |
| Location | Waterford | Waterford | Haddam Neck | Hutchinson Island | Hutchinson Island |
| Reactor Type[a] | PWR | PWR | PWR | PWR | PWR |
| Net Summer Capability (megawatts electric) | 857 | 1,142 | 543 | 839 | 839 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | 416,343 | 3,825,000 | 109,257 | 463,000 | 1,465,000 |
| Date of Report | 1/13/76 | 8/8/86 | 6/30/72 | 11/3/76 | 6/30/84 |
| Date of First Criticality | 10/75 | [d]12/85 | 7/67 | 4/76 | 6/83 |
| Date When Plant Placed in Commercial Operation | 12/75 | 4/86 | 1/68 | 6/76 | 8/83 |

See footnotes at end of table.

## Table 7. U.S. Nuclear Power Units in Commercial Operation on December 31, 1988, by State and Reporting Utility (Continued)

| | Florida (continued) | | | Georgia | |
|---|---|---|---|---|---|
| | Florida Power and Light Company | | Florida Power Corporation | Georgia Power Company | |
| Unit Name | [e]Turkey Point 3 | [e]Turkey Point 4 | Crystal River 3 | Edward C. Hatch 1 | Edward C. Hatch 2 |
| Location | Florida City | Florida City | Red Level | Baxley | Baxley |
| Reactor Type[a] | PWR | PWR | PWR | BWR | BWR |
| Net Summer Capability (megawatts electric) | 666 | 666 | 737 | 755 | 769 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | 110,271 | 106,171 | 419,812 | 377,000 | 511,834 |
| Date of Report | 10/15/73 | 10/15/73 | 5/13/77 | 4/7/75 | 11/9/78 |
| Date of First Criticality | 10/72 | 6/73 | 1/77 | 9/74 | 7/78 |
| Date When Plant Placed in Commercial Operation | 12/72 | 9/73 | 3/77 | 5/75 | 12/78 |

| | Georgia (continued) | Illinois | | | |
|---|---|---|---|---|---|
| | Georgia Power Company | Commonwealth Edison Company | | | |
| Unit Name | Vogtle 1 | Braidwood 1 | Braidwood 2 | Byron 1 | Byron 2 |
| Location | Waynesboro | Braidwood | Braidwood | Byron | Byron |
| Reactor Type[a] | PWR | PWR | PWR | PWR | PWR |
| Net Summer Capability (megawatts electric) | 1,079 | 1,107 | 1,107 | 1,120 | 1,120 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | 6,286,000 | 3,265,600 | 1,882,300 | 2,558,400 | 1,981,200 |
| Date of Report | 9/3/87 | 2/11/88 | 8/12/88 | 2/25/86 | 8/20/87 |
| Date of First Criticality | [d]1/87 | [d]11/86 | [d]12/87 | [d]11/84 | [d]11/86 |
| Date When Plant Placed in Commercial Operation | 6/87 | 11/87 | 8/88 | 4/85 | 4/87 |

See footnotes at end of table.

## Table 7. U.S. Nuclear Power Units in Commercial Operation on December 31, 1988, by State and Reporting Utility (Continued)

| | Illinois (continued) | | | | |
|---|---|---|---|---|---|
| | Commonwealth Edison Company | | | | |
| Unit Name | [e]Dresden 2 | [e]Dresden 3 | La Salle 1 | La Salle 2 | [e]Quad-Cities 1 |
| Location | Morris | Morris | Seneca | Seneca | Cordova |
| Reactor Type[a] | BWR | BWR | BWR | BWR | BWR |
| Net Summer Capability (megawatts electric) | 772 | 773 | 1,048 | 1,048 | 769 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | 101,305 | 130,747 | 1,377,100 | 1,080,500 | 159,781 |
| Date of Report | 5/11/73 | 5/11/73 | 8/17/84 | 3/8/85 | 5/11/73 |
| Date of First Criticality | 1/70 | 1/71 | 4/72 | 6/82 | 10/71 |
| Date When Plant Placed in Commercial Operation | 8/70 | 12/72 | 10/82 | 6/84 | 12/72 |

| | Illinois (continued) | | | | Iowa |
|---|---|---|---|---|---|
| | Commonwealth Edison Company | | | Illinois Power Company | Iowa Electric Light and Power Company |
| Unit Name | [e]Quad-Cities 2 | Zion 1 | Zion 2 | Clinton 1 | Duane Arnold |
| Location | Cordova | Zion | Zion | Clinton | Palo |
| Reactor Type[a] | BWR | PWR | PWR | BWR | BWR |
| Net Summer Capability (megawatts electric) | 769 | 1,040 | 1,040 | 930 | 500 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | 102,089 | 276,441 | 274,577 | 4,264,300 | 276,952 |
| Date of Report | 5/11/73 | 2/13/74 | 2/13/74 | 8/11/87 | 2/22/74 |
| Date of First Criticality | 4/72 | 6/73 | 12/73 | [d]10/86 | 3/74 |
| Date When Plant Placed in Commercial Operation | 12/72 | 12/73 | 12/73 | 4/87 | 1/75 |

See footnotes at end of table.

## Table 7. U.S. Nuclear Power Units in Commercial Operation on December 31, 1988, by State and Reporting Utility (Continued)

| | Kansas | Louisiana | | Maine | Maryland |
|---|---|---|---|---|---|
| | Kansas Gas and Electric Company | Gulf States Utilities Company | Louisiana Power and Light Company | Maine Yankee Atomic Power Company | Baltimore Gas and Electric Company |
| Unit Name | Wolf Creek | River Bend 1 | Waterford 3 | Maine Yankee | Calvert Cliffs 1 |
| Location | Burlington | St. Francisville | Taft | Wicasset | Lusby |
| Reactor Type[a] | PWR | BWR | PWR | BWR | PWR |
| Net Summer Capability (megawatts electric) | 1,128 | 919 | 1,075 | 845 | 825 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | 2,992,403 | [f]3,802,637 | 2,840,200 | NA | 349,677 |
| Date of Report | 2/20/86 | 8/11/86 | 3/3/86 | NA | 4/1/76 |
| Date of First Criticality | [d]3/85 | [d]9/85 | [d]12/84 | NA | 1975 |
| Date When Plant Placed in Commercial Operation | 9/85 | 6/86 | 9/85 | [g]12/72 | 5/75 |

| | Maryland (continued) | Massachusetts | | Michigan | |
|---|---|---|---|---|---|
| | Baltimore Gas and Electric Company | Boston Edison Company | Yankee Atomic Electric Company | Consumers Power Company | |
| Unit Name | Calvert Cliffs 2 | Pilgrim 1 | Yankee Rowe | Big Rock Point | Palisades |
| Location | Lusby | Plymouth | Rowe | Charlevoix | South Haven |
| Reactor Type[a] | PWR | BWR | PWR | PWR | PWR |
| Net Summer Capability (megawatts electric) | 825 | 667 | 167 | 69 | 734 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | 250,587 | 120,000 | [h] 52,369 | NA | 118,054 |
| Date of Report | 4/6/77 | 12/9/75 | 7/25/61 | 3/31/69 | 7/9/70 |
| Date of First Criticality | 11/76 | 6/72 | 8/60 | 9/62 | 5/71 |
| Date When Plant Placed in Commercial Operation | 4/77 | 12/72 | 7/61 | 3/63 | 11/70 |

See footnotes at end of table.

## Table 7. U.S. Nuclear Power Units in Commercial Operation on December 31, 1988, by State and Reporting Utility (Continued)

| | **Michigan (continued)** | | | **Minnesota** | |
|---|---|---|---|---|---|
| | Indiana and Michigan Electric Company | | Detroit Edison Company | Northern States Power Company | |
| Unit Name | Donald C. Cook 1 | Donald C. Cook 2 | Fermi 2 | [e]Monticello | Prairie Island 1 |
| Location | Bridgman | Bridgman | Newport | Monticello | Red Wing |
| Reactor Type[a] | PWR | PWR | BWR | BWR | PWR |
| Net Summer Capability (megawatts electric) | 1,030 | 1,100 | 1,093 | 541 | 512 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | 536,000 | 439,000 | 4,542,849 | 88,800 | 142,500 |
| Date of Report | 4/7/76 | 11/1/78 | 7/7/88 | 1/14/71 | 12/31/74 |
| Date of First Criticality | 1/75 | 3/78 | [d]3/85 | 12/70 | 12/73 |
| Date When Plant Placed in Commercial Operation | 8/75 | 7/78 | 1/88 | 5/71 | 12/73 |

| | **Minnesota (continued)** | **Mississippi** | **Missouri** | **Nebraska** | |
|---|---|---|---|---|---|
| | Northern States Power Company | Mississippi Power and Light Company | Union Electric Company | Nebraska Public Power District | Omaha Public Power District |
| Unit Name | Prairie Island 2 | Grand Gulf 1 | Callaway 1 | Cooper Station | Fort Calhoun 1 |
| Location | Red Wing | Port Gibson | Reform | Brownsville | Fort Calhoun |
| Reactor Type[a] | PWR | BWR | PWR | BWR | PWR |
| Net Summer Capability (megawatts electric) | 511 | 1,142 | 1,150 | 760 | 476 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | 102,259 | 3,281,242 | 3,070,000 | 316,284 | 161,480 |
| Date of Report | 6/11/75 | 3/25/86 | 3/4/85 | 8/2/76 | 6/16/75 |
| Date of First Criticality | 12/74 | [d]8/82 | [d]6/84 | 2/74 | 8/73 |
| Date When Plant Placed in Commercial Operation | 12/75 | 7/85 | 12/84 | 7/74 | 9/73 |

See footnotes at end of table.

## Table 7. U.S. Nuclear Power Units in Commercial Operation on December 31, 1988, by State and Reporting Utility (Continued)

| | New Jersey | | | | New York |
|---|---|---|---|---|---|
| | Jersey Central Power and Light Company | Public Service Electric and Gas Company | | | Consolidated Edison Company of New York[i] |
| Unit Name | Oyster Creek 1 | Hope Creek 1 | Salem 1 | Salem 2 | [e]Indian Point 2 |
| Location | Forked River | Salem | Salem | Salem | Indian Point |
| Reactor Type[a] | BWR | BWR | PWR | PWR | PWR |
| Net Summer Capability (megawatts electric) | 620 | 1,067 | 1,106 | 1,106 | 849 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | 91,409 | 4,494,982 | [l]1,701,000 | [l]-- | 212,000 |
| Date of Report | 7/15/70 | 12/31/86 | 11/19/80 | 11/19/80 | 10/3/73 |
| Date of First Criticality | 5/69 | [d]4/86 | 12/76 | 8/80 | 5/73 |
| Date When Plant Placed in Commercial Operation | 12/69 | 12/86 | 6/77 | 10/80 | 10/73 |

| | New York (continued) | | | | |
|---|---|---|---|---|---|
| | Niagara Mohawk Power Corporation | | Power Authority of the State of New York | | Rochester Gas and Electric Corporation |
| Unit Name | Nine Mile Point 1 | Nine Mile Point 2 | Indian Point 3 | James A. Fitzpatrick | Ginna |
| Location | Scriba | Scriba | Indian Point | Scriba | Ontario |
| Reactor Type[a] | BWR | BWR | PWR | BWR | PWR |
| Net Summer Capability (megawatts electric) | 610 | 1,080 | 965 | 794 | 470 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | 150,500 | 6,030,378 | 400,000 | 253,587 | 64,896 |
| Date of Report | 7/15/70 | 6/30/88 | 10/7/76 | 4/24/74 | 7/21/70 |
| Date of First Criticality | 9/69 | [d]11/86 | 4/76 | 11/74 | 11/69 |
| Date When Plant Placed in Commercial Operation | 12/69 | 3/88 | 8/76 | 9/75 | 1970 |

See footnotes at end of table.

## Table 7. U.S. Nuclear Power Units in Commercial Operation on December 31, 1988, by State and Reporting Utility (Continued)

| | North Carolina | | | | |
|---|---|---|---|---|---|
| | Carolina Power and Light Company | | | Duke Power Company | |
| Unit Name | Brunswick 1 | Brunswick 2 | Shearon Harris 1 | McGuire 1 | McGuire 2 |
| Location | Southport | Southport | Newhill | Cornelius | Cornelius |
| Reactor Type[a] | BWR | BWR | PWR | PWR | PWR |
| Net Summer Capability (megawatts electric) | 790 | 790 | 860 | 1,150 | 1,150 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | 328,382 | 398,796 | 3,816,416 | 919,000 | 1,083,000 |
| Date of Report | 4/23/77 | 4/23/77 | 7/29/87 | 3/31/84 | 3/31/84 |
| Date of First Criticality | 10/76 | 9/75 | [d]11/86 | 8/81 | 5/83 |
| Date When Plant Placed in Commercial Operation | 3/77 | 11/75 | 5/87 | 12/81 | 3/84 |

| | Ohio | | Oregon | Pennsylvania | |
|---|---|---|---|---|---|
| | Toledo Edison Company | Cleveland Electric Illuminating Company | Portland General Electric Company | Duquesne Light Company | |
| Unit Name | Davis-Besse 1 | Perry 1 | Trojan | Beaver Valley 1 | Beaver Valley 2 |
| Location | Oak Harbor | North Perry | Prescott | Shippingport | Shippingport |
| Reactor Type[a] | PWR | BWR | PWR | PWR | PWR |
| Net Summer Capability (megawatts electric) | 856 | 1,185 | 1,104 | 810 | 833 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | 649,000 | 5,398,452 | 448,435 | 605,600 | 4,544,335 |
| Date of Report | 10/21/77 | 12/31/87 | 7/23/76 | 7/26/77 | 1/28/88 |
| Date of First Criticality | 8/77 | [d]3/86 | 12/75 | 5/76 | [d]6/87 |
| Date When Plant Placed in Commercial Operation | 12/77 | 11/87 | 12/75 | 10/76 | 11/87 |

See footnotes at end of table.

## Table 7. U.S. Nuclear Power Units in Commercial Operation on December 31, 1988, by State and Reporting Utility (Continued)

| | Pennsylvania (continued) | | | | South Carolina |
|---|---|---|---|---|---|
| | Metropolitan Edison Company | Pennsylvania Power and Light Company | | Philadelphia Electric Company | Carolina Power and Light Company |
| Unit Name | Three Mile Island 1 | Susquehanna 1 | Susquehanna 2 | Limerick 1 | [e]H.B. Robinson 2 |
| Location | Middletown | Berwick | Berwick | Pottstown | Hartsville |
| Reactor Type[a] | PWR | BWR | BWR | BWR | PWR |
| Net Summer Capability (megawatts electric) | 776 | 1,050 | 1,050 | 1,062 | 665 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | 403,661 | 1,941,000 | 2,130,141 | 3,822,000 | 76,350 |
| Date of Report | 4/11/75 | 3/31/84 | 2/5/86 | 3/27/87 | 12/22/70 |
| Date of First Criticality | 6/74 | 9/82 | 3/84 | [d]11/84 | 9/70 |
| Date When Plant Placed in Commercial Operation | 9/74 | 6/83 | 2/85 | 2/86 | 1/71 |

| | South Carolina | | | | |
|---|---|---|---|---|---|
| | Duke Power Company | | | | |
| Unit Name | Catawba 1 | Catawba 2 | [e]Oconee 1 | [e]Oconee 2 | [e]Oconee 3 |
| Location | Clover | Clover | Seneca | Seneca | Seneca |
| Reactor Type[a] | PWR | PWR | PWR | PWR | PWR |
| Net Summer Capability (megawatts electric) | 1,145 | 1,145 | 860 | 860 | 860 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | 1,917,000 | 1,623,000 | 162,559 | 160,000 | 165,557 |
| Date of Report | 2/12/86 | 1/29/87 | 7/31/74 | 7/31/74 | 7/13/76 |
| Date of First Criticality | [d]7/84 | [d]2/86 | 4/73 | 11/73 | 9/74 |
| Date When Plant Placed in Commercial Operation | 6/85 | 8/86 | 7/73 | 1974 | 12/74 |

See footnotes at end of table.

## Table 7. U.S. Nuclear Power Units in Commercial Operation on December 31, 1988, by State and Reporting Utility (Continued)

| | South Carolina (continued) | Tennessee | | Texas | Vermont |
|---|---|---|---|---|---|
| | South Carolina Electric and Gas Company | Tennessee Valley Authority | | Houston Lighting and Power Company | Vermont Yankee Nuclear Power Corporation |
| Unit Name | Summer 1 | Sequoyah 1 | Sequoyah 2 | South Texas Project 1 | Vermont Yankee |
| Location | Jenkinsville | Daisy | Daisy | Bay City | Vernon |
| Reactor Type[a] | PWR | PWR | PWR | PWR | BWR |
| Net Summer Capability (megawatts electric) | 885 | 1,148 | 1,148 | 1,239 | 496 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | 1,283,036 | [j] 1,659,000 | [j]-- | [c]3,797,934 | NA |
| Date of Report | 6/30/84 | 9/30/83 | 9/30/83 | 2/7/89 | NA |
| Date of First Criticality | 10/82 | 7/80 | 11/81 | 8/87 | NA |
| Date When Plant Placed in Commercial Operation | 1/84 | 7/81 | 6/82 | 8/88 | [k]11/72 |

| | Virginia | | | |
|---|---|---|---|---|
| | Virginia Electric and Power Company | | | |
| Unit Name | Surry 1 | Surry 2 | North Anna 1 | North Anna 2 |
| Location | Gravel Neck | Gravel Neck | Mineral | Mineral |
| Reactor Type[a] | PWR | PWR | PWR | PWR |
| Net Summer Capability (megawatts electric) | 781 | 781 | 915 | 915 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | 251,130 | 148,879 | 785,000 | 542,000 |
| Date of Report | 7/24/73 | 7/24/73 | 11/14/78 | 11/20/80 |
| Date of First Criticality | 7/72 | 3/73 | 4/78 | 6/80 |
| Date When Plant Placed in Commercial Operation | 12/72 | 5/73 | 6/78 | 11/80 |

*See footnotes at end of table.*

## Table 7. U.S. Nuclear Power Units in Commercial Operation on December 31, 1988, by State and Reporting Utility (Continued)

| | Washington | Wisconsin | | |
|---|---|---|---|---|
| | Washington Public Power Supply System | Wisconsin Electric Power Company | | Wisconsin Public Service Corporation |
| Unit Name | WNP 2 | [e]Point Beach 1 | [e]Point Beach 2 | Kewaunee |
| Location | Richland | Two Creeks | Two Creeks | Carlton |
| Reactor Type[a] | BWR | PWR | PWR | PWR |
| Net Summer Capability (megawatts electric) | 1,100 | 485 | 485 | 525 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | 3,200,931 | 60,587 | 54,317 | 201,221 |
| Date of Report | 3/6/85 | 4/20/71 | 10/11/72 | 1/7/75 |
| Date of First Criticality | [d]1/84 | 11/70 | 5/72 | 3/74 |
| Date When Plant Placed in Commercial Operation | 12/84 | 12/70 | 9/72 | 6/74 |

[a] Reactor types: BWR, boiling-water reactor; HTGR, high-temperature gas-cooled reactor.
[b] Costs are in current dollars of a number of different years. For example, for a plant constructed over the 1971-1976 period, expenditures made in 1971 are in 1971 dollars, expenditures made in 1972 are in 1972 dollars, and so on.
[c] Final reported completion cost does not include AFUDC.
[d] Date shown is first fuel loading date.
[e] Turnkey or partial turnkey reported costs do not reflect the generally higher actual final costs.
[f] Final reported completion cost includes the AFUDC portion of only the Gulf States Utilities Company. According to Form EIA-860, "Annual Electric Generator Report 1988," Gulf States Utilities has 70-percent ownership in River Bend 1.
[g] No Form HQ-254 or Form EIA-254 was received from this unit. Date was obtained from Form RW-859, "Nuclear Fuel Data Form" (1985).
[h] Reactor built under the Power Demonstration Program, which was jointly funded by the utility and the Atomic Energy Commission.
[i] Built by Consolidated Edison but now owned by the Power Authority of the State of New York.
[j] The cost estimate for the first unit represents the total for all units at the site.
[k] Data from Energy Information Administration, Form RW-859, "Nuclear Fuel Data Form" (1985).
NA=Not available.
Sources: Energy Information Administration, Form EIA-254, "Semiannual Report on Status of Reactor Construction" (1988). Energy Information Administration Form EIA-860, "Annual Electric Generator Report 1988."

## Table 8. U.S. Nuclear Power Units Completed but Not in Commercial Operation on December 31, 1988, by State and Reporting Utility

| Characteristics | New Hampshire | New York | Tennessee | Texas |
|---|---|---|---|---|
| | Public Service Company of New Hampshire | Long Island Lighting Company | Tennessee Valley Authority | Houston Lighting and Power Company |
| Unit Name | Seabrook 1 | Shoreham | Watts Bar 1 | South Texas Project 2 |
| Location | Seabrook | Brookhaven | Spring City | Bay City |
| Reactor Type[a] | PWR | BWR | PWR | PWR |
| Net Summer Capability (megawatts electric) | 1,186 | 804 | 1,152 | 1,239 |
| Final Reported Completion Costs[b] (thousand mixed-current dollars)[c] | 4,907,480 | 5,481,122 | 4,616,606 | [e] 1,629,537 |
| Date of Report | 12/31/88 | 1/26/89 | 2/7/89 | 2/7/89 |
| Date First Fuel Loading Completed[d] | 10/86 | 12/84 | 12/90 | 12/88 |
| Estimated Date of Commercial Operation[d] | NA | 1/90 | 10/91 | 6/89 |

[a] Reactor types: BWR, boiling-water reactor; PWR, pressurized-water reactor.

[b] Although the unit is 100 percent complete, this figure may not reflect the total unit cost. The total cost may still increase until the unit achieves full commercial operation.

[c] Costs are in current dollars of a number of different years. For example, for a plant constructed over the 1971-1976 period, expenditures made in 1971 are in 1971 dollars, expenditures made in 1972 are in 1972 dollars, and so on.

[d] All dates that are later than 12/31/88 are utility estimates.

[e] Estimated final cost does not include AFUDC.

NA=Not available.

Sources: Energy Information Administration, Form EIA-254, "Semiannual Report on Status of Reactor Construction" (1988); Energy Information Administration, Form EIA-860, "Annual Electric Generator Report 1988."

## Table 9. U.S. Nuclear Power Units Actively Under Construction on December 31, 1988, by State and Reporting Utility

| | Georgia | Pennsylvania | Tennessee |
|---|---|---|---|
| | Georgia Power Company | Philadelphia Electric Company | Tennessee Valley Authority |
| Unit Name | Vogtle 2 | Limerick 2 | [d]Watts Bar 2 |
| Location | Waynesboro | Pottstown | Spring City |
| Reactor Type[a] | PWR | BWR | PWR |
| Net Summer Capability (megawatts electric) | 1,198 | 1,051 | 1,152 |
| Percent Complete | 96 | 98 | 84 |
| Costs (thousand mixed-current dollars)[b] | | | |
| Disbursed Costs and AFUDC | 2,259,918 | 2,251,131 | 2,161,831 |
| Disbursed Costs and AFUDC Plus Other Commitments | 2,275,929 | 2,264,631 | 2,169,517 |
| Estimated Final Costs | 2,582,000 | 3,197,300 | NA |
| Date of Report | 12/31/88 | 12/31/88 | 2/7/89 |
| Date First Fuel Loading Completed[c] | 2/89 | 4/90 | NA |
| Estimated Date of Commercial Operation[c] | 6/89 | 10/90 | NA |

| | Texas | |
|---|---|---|
| | TU Electric Company | |
| Unit Name | Comanche Peak 1 | Comanche Peak 2 |
| Location | Glen Rose | Glen Rose |
| Reactor Type[a] | PWR | PWR |
| Net Summer Capability (megawatts electric) | 1,137 | 1,137 |
| Percent Complete | 99 | 87 |
| Costs (thousand mixed-current dollars)[b] | | |
| Disbursed Costs and AFUDC | 4,709,737 | 2,898,941 |
| Disbursed Costs and AFUDC Plus Other Commitments | 4,709,737 | 2,898,941 |
| Estimated Final Costs | [e] 5,192,006 | [e] 3,599,752 |
| Date of Report | 2/13/89 | 2/13/89 |
| Date First Fuel Loading Completed[c] | 6/89 | 1/91 |
| Estimated Date of Commercial Operation[c] | 12/89 | 6/91 |

[a] Reactor types: BWR, boiling-water reactor; PWR, pressurized-water reactor.
[b] Costs are in current dollars of a number of different years. For example, for a plant constructed over the 1971-1976 period, expenditures made in 1971 are in 1971 dollars, expenditures made in 1972 are in 1972 dollars, and so on.
[c] All dates that are later than 12/31/88 are utility estimates.
[d] Unit is in indefinite slowdown. No schedule exists for its completion.
[e] Estimated final cost includes the TU Electric portion of AFUDC only. According to Form EIA-860, "Annual Generator Report 1988," TU Electric Company had 97.8 percent ownership in Comanche Peak 1 and 2 as of December 31, 1988.

NA=Not available.

Sources: Energy Information Administration, Form EIA-254, "Semiannual Report on Status of Reactor Construction" (1988). Energy Information Administration, Form EIA-860, "Annual Electric Generator Report 1988."

## Table 10. U.S. Nuclear Power Units Deferred as of December 31, 1988, by State and Reporting Utility

| | Alabama | | Mississippi |
|---|---|---|---|
| | Tennessee Valley Authority | | System Energy Resources, Inc. |
| Unit Name | Bellefonte 1 | Bellefonte 2 | Grand Gulf 2 |
| Location | Scottsboro | Scottsboro | Port Gibson |
| Reactor Type[a] | PWR | PWR | BWR |
| Net Summer Capability (megawatts electric) | 1,223 | 1,223 | 1,239 |
| Percent Complete[b] | 85 | 56 | 24 |
| Date of Deferral | 6/88 | 6/88 | 9/85 |
| Costs (thousand mixed-current dollars)[c] | | | |
| Disbursed Costs and AFUDC | [d]4,260,163 | [d]-- | 1,008,461 |
| Disbursed Costs and AFUDC Plus Other Commitments | [d]4,272,017 | [d]-- | 1,009,462 |
| Estimated Final Costs | NA | NA | NA |
| Date of Report | 2/6/89 | 2/6/89 | 1/30/89 |

| | Ohio | Washington | |
|---|---|---|---|
| | Cleveland Electric Illuminating Company | Washington Public Power Supply System | |
| Unit Name | Perry 2 | WNP 1 | WNP 3 |
| Location | North Perry | Richland | Satsop |
| Reactor Type[a] | BWR | PWR | PWR |
| Net Summer Capability (megawatts electric) | 1,193 | 1,255 | 1,230 |
| Percent Complete[b] | 44 | 62 | 75 |
| Date of Deferral | 8/85 | 4/82 | 7/83 |
| Costs (thousand mixed-current dollars)[c] | | | |
| Disbursed Costs and AFUDC | NA | 2,239,000 | 2,460,000 |
| Disbursed Costs and AFUDC Plus Other Commitments | NA | 2,170,000 | 2,460,000 |
| Estimated Final Costs | NA | NA | NA |
| Date of Report | 2/9/89 | 1/17/89 | 1/17/89 |

[a] Reactor types: BWR, boiling-water reactor; PWR, pressurized-water reactor.
[b] Percent Complete is the percentage of construction completed at the time of deferral.
[c] Costs are in current dollars of a number of different years. For example, for a plant constructed over the 1971-1976 period, expenditures made in 1971 are in 1971 dollars, expenditures made in 1972 are in 1972 dollars, and so on.
[d] Cost data are sums for both units at the site.
NA=Not available.
Source: Energy Information Administration, Form EIA-254, "Semiannual Report on Status of Reactor Construction" (1988).

## Table 11. U.S. Nuclear Power Units Shut Down for an Extended Period, as of December 31, 1988, by State and Reporting Utility

| | Alabama | | |
|---|---|---|---|
| | Tennessee Valley Authority | | |
| Unit Name | Browns Ferry 1 | Browns Ferry 2 | Browns Ferry 3 |
| Location | Decatur | Decatur | Decatur |
| Reactor Type[a] | BWR | BWR | BWR |
| Net Summer Capability (megawatts electric) | 1,067 | 1,067 | 1,067 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | [c]894,500 | [c]-- | [c] -- |
| Date of Report | 9/30/76 | 9/30/76 | 6/30/77 |
| Date of First Criticality | 8/73 | 7/74 | 8/76 |
| Date Plant Placed in Commercial Operation | 8/74 | 3/75 | 3/77 |
| Date Unit Shut Down | 3/85 | 9/84 | 9/85 |
| Expected Date to Restart | Unknown | Unknown | Unknown |

| | Pennsylvania | |
|---|---|---|
| | Philadelphia Electric Company | |
| Unit Name | Peach Bottom 2 | Peach Bottom 3 |
| Location | Peach Bottom | Peach Bottom |
| Reactor Type[a] | BWR | BWR |
| Net Summer Capability (megawatts electric) | 1,052 | 1,033 |
| Final Reported Completion Costs (thousand mixed-current dollars)[b] | 537,000 | 226,000 |
| Date of Report | 4/8/75 | 4/8/75 |
| Date of First Criticality | 9/73 | 8/74 |
| Date Plant Placed in Commercial Operation | 7/74 | 12/74 |
| Date Unit Shut Down | 3/87 | 3/87 |
| Expected Date to Restart | Unknown | Unknown |

[a] Reactor types: BWR, boiling-water reactor; PWR, pressurized-water reactor; LGR, light-water-cooled, graphite-moderated reactor.
[b] Costs are in current dollars of a number of different years. For example, for a plant constructed over the 1971-1976 period, expenditures made in 1971 are in 1971 dollars, expenditures made in 1972 are in 1972 dollars, and so on.
[c] The cost estimate for the first unit represents the total for all units at the site.
Sources: Energy Information Administration, Form EIA-254, "Semiannual Report on Status of Reactor Construction" (1988); Form EIA-860, "Annual Electric Generator Report 1988"; *Status of Constructed Nuclear Generating Units in the United States* (April 1988).

# Appendix A

## Survey Form EIA-254: Semiannual Report on Status of Reactor Construction

# Appendix A

U.S. DEPARTMENT OF ENERGY
ENERGY INFORMATION ADMINISTRATION

FORM APPROVED
OMB NO. 1905-0163
(EXPIRES 12-31-87)

SEMIANNUAL REPORT ON STATUS OF REACTOR CONSTRUCTION

THIS FORM IS MANDATORY AND AUTHORIZED UNDER THE ATOMIC ENERGY ACT OF 1954 (P.L.83-703), AND THE FEDERAL ENERGY ADMINISTRATION ACT OF 1974 (P.L.83-275). SEE GENERAL INFORMATION FOR CONFIDENTIALITY STATEMENT.

PART A - UNIT IDENTIFICATION DATA

1. UNIT IDENTIFICATION:
   A. NAME: < >
   < >
   < >
   B. CITY: < >
   C. STATE: <

2. DESIGN ELECTRICAL RATING
   (NET MEGAWATTS): < >

4. CONTACT PERSON:
   A. NAME: < >
   B. TITLE: < >
   < >
   C. COMPANY: < >
   < >
   D. ADDRESS: < >
   < >
   < >
   E. PHONE #: < - - >

3. REPORT FOR 6 MONTHS ENDING (MONTH/DAY/YEAR): < / / >

5. UNIT IS (CHECK ONE):

< > A. PLANNED (CONSTRUCTION NOT STARTED):

< > B. UNDER CONSTRUCTION:

< > C. IN COMMERCIAL OPERATION (AS OF MONTH-YEAR): < / >

< > D. SUSPENDED/DEFERRED; (AS OF MONTH-YEAR): < / >

< > E. CANCELED; (AS OF MONTH-YEAR): < / >

6. RESPONDING UTILITY IS (CHECK ONE):

< > A. SOLE OWNER:   < > B. JOINT OWNER AND CONSTRUCTION MANAGER:
< > C. OTHER (SPECIFY): < >

7. CERTIFYING OFFICIAL: I CERTIFY THAT THE INFORMATION PROVIDED HEREIN IS TRUE AND ACCURATE TO THE BEST OF MY KNOWLEDGE.

A. NAME: < >   C. TITLE: < >

B. SIGNATURE: < >   D. DATE: < >

PART B - UNIT CHRONOLOGICAL AND LABOR DATA

| ITEM (A) | PREVIOUS ESTIMATE (B) | CURRRENT ESTIMATE (C) |
|---|---|---|
| 1.DATE FIRST FUEL LOADING IS SCHEDULED FOR COMPLETION (MONTH-YEAR): | | |
| 2.DATE UNIT IS SCHEDULED FOR COMMERCIAL OPERATION (MONTH-YEAR): | | |
| 3.TOTAL LABOR REQUIRED FOR UNIT CONSTRUCTION (MAN-MONTHS): SEE INSTRUCTIONS. | | |
| 4.TOTAL LABOR EXPENDED TO DATE (MAN-MONTHS): | | |

FORM EIA-254

PAGE 1

U.S. DEPARTMENT OF ENERGY
ENERGY INFORMATION ADMINISTRATION

SEMIANNUAL REPORT ON STATUS OF REACTOR (CONTINUED)

PART C - UNIT COST DATA AT COMPLETION

| ITEM (A) | ESTIMATED COST (THOUSANDS OF DOLLARS) PREVIOUS (B) | CURRENT (C) |
|---|---|---|
| 1. DIRECT COSTS: | | |
| A. LAND AND LAND RIGHTS: | | |
| B. STRUCTURES AND IMPROVEMENTS: | | |
| C. REACTOR PLANT EQUIPMENT: | | |
| D. TURBOGENERATOR UNITS: | | |
| E. ACCESSORY ELECTRIC EQUIPMENT: | | |
| F. MISCELLANEOUS POWER PLANT EQUIPMENT: | | |
| G. TOTAL DIRECT COSTS (LINES 1.A TO 1.F): | | |
| 2. INDIRECT COST: | | |
| 3. CONTINGENCY COST: | | |
| 4. COMMON FACILITY COST (FOR MULTIPLE UNIT CONSTRUCTION PROJECTS ONLY): SEE INSTRUCTIONS. | | |
| 5. ALLOWANCE FOR FUNDS USED DURING CONSTRUCTION (AFUDC): | | |
| 6. TOTAL UNIT COST (LINES 1.G + 2 + 3 + 4 + 5): | | |

PART D - UNIT COST DATA TO DATE

| ITEM (A) | ACTUAL COST THOUSANDS OF DOLLARS PREVIOUS (B) | CURRENT (C) |
|---|---|---|
| 1. DISBURSED COST TO DATE WITH AFUDC: | | |
| 2. DISBURSED COST TO DATE WITHOUT AFUDC: | | |
| 3. DISBURSED COST PLUS OTHER COMMITMENTS TO DATE WITH AFUDC: | | |
| 4. DISBURSED COST PLUS OTHER COMMITMENTS TO DATE WITHOUT AFUDC: | | |

FORM EIA-254 PAGE 2

SEMIANNUAL REPORT ON STATUS OF REACTOR (CONTINUED)

IF YOU HAVE ANY COMMENTS CONCERNING THIS SUBMISSION PLEASE ENTER THEM ON THIS PAGE:

FORM EIA-254 PAGE 3

## SEMIANNUAL REPORT ON STATUS OF REACTOR CONSTRUCTION

## GENERAL INFORMATION

### I. PURPOSE

Form EIA-254, "Semiannual Report on Status of Reactor Construction," collects data on nuclear units for electric power generation that are planned or under construction by an electric utility. The data are utilized by various DOE offices for analyses, in statistical publications, and to answer Congressional inquiries.

### II. WHO SHOULD SUBMIT

Each electric utility in the United States responsible (i.e., the sole owner or construction manager for jointly owned units) for planned nuclear units or nuclear units under construction must submit one form for each such unit. If the respondent is not the sole owner or joint owner and construction manager of the unit, please describe your involvement under Part A, item 6.

### III. WHERE AND WHEN TO SUBMIT

Mail one copy of Form EIA-254 in the enclosed envelope on or before the date indicated in the cover letter to:

Energy Information Administration
Nuclear and Alternate Fuels Division
Mail Stop BG-094 Forrestal Building
Washington, DC 20077-9381

Retain a completed copy of this form for your files. For additional information write to the above address or call Theresa Payne on (202) 586-1018.

### IV. WHAT TO SUBMIT

Submit data on the total cost of the unit, even if the unit is jointly owned. For the first filing, complete and submit all of Part A and column c in Parts B, C, and D. For subsequent filings a preprinted form will be sent. Update preprinted data in Part A by striking out incorrect data and entering correct data. Item 7 in Part A must be completed by a verifying official. Provide current data in column c of Part B, C, and D. If data from previous reporting period have not changed write "NC" (no change) in column c. The Form EIA-254 need not be completed for a nuclear unit after it is in commercial operation and construction is completed.

### V. SANCTIONS

Data on this survey are collected under authority of the Atomic Energy Act of 1954 (P.L. 83-703) and the Federal Energy Administration Act of 1974 (P.L. 93-275). Late filing, failure to keep records, or failure otherwise to comply with these instructions may result in criminal fines, civil penalties, and other sanctions as provided by law.

## VI. RELEASABLE DATA

In accordance with the DOE FOIA regulations, 10 CFR 1004.11 et seq., the EIA plans to release to the public upon request the following Form EIA-254 data: Part A, items 1 through 6, Part B, Part C, item 6, and Part D, items 1 and 3.

### PART A INSTRUCTIONS

| Item | |
|---|---|
| 1 to 7 | Self Explanatory. |

### PART B INSTRUCTIONS

| Item | |
|---|---|
| 1b | Date first fuel loading is scheduled for completion. |
| 1c | Date first fuel loading is scheduled for completion, if different from 1b. If estimate has not changed, write "NC" indicating no change. |
| 2b | Date the reporting utility estimates the unit will be considered "in commercial operation." Comment under NOTES on page 2, event(s) that satisfactory generated previously determined level of capacity (specify level) over a 24 hour period, date utility has submitted necessary forms and data to regional dispatcher and generation capability is made available for central dispatch). |
| 2c | Date estimated as of current reporting period, if different from 2b. If estimate has not changed, write "NC." |
| 3b | Report total labor in man-months, including direct labor (pipe fitters, electricians, etc.) and support labor (carpenters, general laborers, etc.), for construction from site clearance to full power licensing. Exclude administrative support labor. Assume 168 man-hours per man-month. |
| 3c | Actual expended as of current reporting period, if different from 3b. If estimate has not changed, write "NC." |
| 4b | Based on 3b, report that portion of man-months already expended. |
| 4c | Actual expended as of current reporting period, if different from 4b. If estimate has not changed, write "NC." |

# PART C INSTRUCTIONS

| Item | |
|---|---|
| 1 to 6 | All estimated costs should be for the unit at completion of construction. Figures should exclude costs that would be included (when the unit goes into commercial operation) in the Federal Energy Regulatory Commission Uniform System of Accounts (US of A) accounts 350 through 359 (Transmission Plant) 360 through 373 (Distribution Plant), 360 through 373 (Distribution Plant), and 389 through 399 (General Plant). Also exclude all fuel costs. |
| 1 to 6 | Enter the estimated capital unit cost (except item 4, see below) using a current dollar basis i.e., as disbursed). Report the total unit cost, even if the unit is jointly owned. Exclude all Allowance for Funds Used During Construction (AFDUC) costs, except in item 5. |
| 1a to 1g | Include the cost of escalation during construction due to inflation. All US of A references are to indicate the type of data request by line. Report as if construction work in progress amount were allocated to the indicated amounts when the unit goes into commercial operation. |
| 1a | Report per US of A account 320, Land and Land Rights. Include the cost of land and land rights used in connection with nuclear power generation. Include the cost of land owned in fee by the utility and rights, interests, and privileges held by the utility in land owned by others, such as leaseholds, easements, water, and water power rights, diversion rights, subversion rights, rights-of-way, and other like interests in land. |
| 1b | Report per US of A account 321, Structures and Improvements. Include the cost in place of structures and improvements used and useful in connection with nuclear power generation. Include vapor containers and nuclear production roads and railroads in this account. |
| 1c | Report per US of A account 322, Reactor Plant Equipment. Include the installed cost of reactors, reactor fuel handling and storage equipment, pressurizing equipment, coolant change equipment, purification and discharge equipment, radioactive waste treatment and disposal equipment, boilers, steam and feed water piping, reactor and boiler apparatus and accessories, and other reactor plant equipment used in the production of steam to be used primarily for generating electricity, including auxiliary superheat boilers and associated equipment in systems which change temperatures or pressure of steam from the reactor system. |
| 1d | Report per US of A account 323, Turbogenerator Units. Include the cost installed of main turbine-driven units and accessory equipment used in generating electricity by steam. |

1e Report per US of A account 324, Accessory Electric Equipment. Include the cost installed of auxiliary generating apparatus, conversion equipment, and equipment used primarily in connection with the control and switching of electric energy produced by nuclear power, and the protection of electric circuits and equipment, except electric motors used to drive equipment included in other accounts. Such motors shall be included in the account in which the equipment with which they are associated is included. Do not include transformers and other equipment used for changing the voltage or frequency of electric energy for the purpose of transmission or distribution.

1f Report per US of A account 325, Miscellaneous Power Plant Equipment. Include the cost installed of miscellaneous equipment in and about the nuclear generating plant devoted to general station use, and which is not properly includable in any of the foregoing nuclear power production accounts.

2 Enter the cost of general expense items that apply to the overall construction of a plant, not to a direct cost account. Indirect costs include construction management services, home office engineering and services, field office engineering and services, and owner's indirect costs. Exclude all operator training costs.

3 Enter the allowance for unforeseen or unpredictable costs resulting from design changes, work storages, overtime, and other such occurrences.

4 Enter the multiple-unit construction costs that cannot be attributed separately to each unit. Report all common facility costs in the Form EIA-254 of the unit that is expected to go into commercial operation first. Report under NOTES the unit number(s) of the other unit(s) for which common costs are being reported or, as appropriate, the unit number under which common costs are reported. Refer to the common cost section of US of A account 107, Construction Work in Progress - Electric.

5 Enter the amount of the AFUDC allowance to compensate utility debt and equity investors for the use of their money from the time funds for unit construction are spent until the unit goes into operation. Include the AFUDC for all the owners, if the unit is jointly owned. If the AFUDC data are not available from another owner, specify under NOTES the name(s) of the other owner(s) of the unit for which the AFUDC is not reported.

## PART D INSTRUCTIONS

<u>Item</u>

1 to 4 Enter the actual capital unit cost to date using a current dollar basis (i.e., as disbursed). Report the total unit cost, even if the unit is jointly owned. All costs should exclude the same US of A accounts noted in the first instruction in Part C, also exclude fuel costs.

1, 3 Include the amount of the AFUDC allowance (as per Part C, item 5 instruction) with the disbursed cost (item 1) and disbursed costs plus other commitments (item 3) figures. Include the AFUDC for all the owners, if the unit is jointly owned. If the AFUDC data are not available from another owner specify under NOTES the name(s) of the other owner(s) of the units for which the AFUDC is not reported.

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# Background and Me

## Background

The system of reporting construction costs and schec ules for nuclear electric generating units was estat lished in the early 1960's by the U.S. Atomic Energ Commission to fulfill various reporting requiremen as specified in Sections 3, 141, and 251 of the Atomi Energy Act of 1954 (Public Law 83-703), as amendec These reporting requirements were subsequently tran: ferred to the Energy Research and Development Ac ministration, and ultimately to the Energy Informatio Administration, under the authority of the Federal Eı ergy Administration Act of 1974 (Public Law 93-275

## Data Sources

Form EIA-254 is used to collect cost and schedulin data from all utility companies with nuclear powe units under construction. The mailing list of utilit companies to be surveyed is maintained by the EI/ When the Nuclear Regulatory Commission officiall announces that a utility company is planning to buil a nuclear power plant of one or more units, the con pany is added to the list of survey respondents. Aft a nuclear power unit has been granted a full-powe operating license and the unit has begun operatin commercially, the utility company ceases to report fc that unit on Form EIA-254.

## Data Collection

Form EIA-254 and the instructions for completing tl form are mailed to an official of each of the reportin utility companies. Data on the construction costs an the scheduling of nuclear power plants are requeste as of June 30 and December 31 of the survey yea The form and the instructions, along with preaddressed return envelope, are accompanied by cover letter dated within the week after the close ‹ the reporting period. Responses are requested to t sent no later than 6 weeks from the date of the lette



# Appendix B

# Background and Methodology of the Survey

Commonwealth Edison Company
P.O. Box 767
Chicago, IL 60690

Georgia Power Company
P.O. Box 282
Waynesboro, GA 30830

Houston Lighting & Power Company
P.O. Box 1700, ET-1219
Houston, TX 77001

Long Island Lighting Company
P.O. Box 628
Wading River, NY 11792

Philadelphia Electric Company
2301 Market Street
Philadelphia, PA 19101

Public Service Company of New Hampshire
P.O. Box 700
Seabrook, NH 03874

System Energy Resources, Inc.
5360 I-55 North
Jackson, MS 39211-4096

Tennessee Valley Authority
6N 38A Lookout Place
Chattanooga, TN 37401

TU Electric Company
400 N. Olive St., L.B. 81
Dallas, TX 75201

Washington Public Power Supply System
P.O. Box 968
Richland, WA 99352

# Appendix C

# Overview of Initial Test Programs for Nuclear Power Plants

# Appendix C

# Overview of Initial Test Programs for Nuclear Power Plants

This section explains the test procedures of nuclear power plants. Only the basic concepts of each test phase have been included. For a comprehensive view of nuclear power plant test procedures, see the documents listed on pages 58 and 59 of this appendix.[10]

## Background

The applicant for an operating license is responsible for ensuring that a suitable initial test program (preoperational and startup) will be conducted for the facility. The primary objectives of a suitable program are: (1) to provide additional assurance that the facility has been adequately designed and, to the extent practical, to validate the analytical models and to verify the correctness or conservatism of assumptions used for prediction of plant responses to anticipated transients and postulated accidents, and (2) to provide assurance that construction and installation of equipment in the facility have been accomplished in accordance with design. Other key objectives are to familiarize the plant operating and technical staff with the operation of the facility and to verify by trial use, to the extent practical, that the facility operating procedures and the emergency procedures are adequate. Initial test programs satisfying these objectives should provide the necessary assurance that the facility can be operated in accordance with design requirements and in a manner that will not endanger the health and safety of the public.

While it is required that all structures, systems, and components important to safety be tested, it is not required that all of them be tested to the same stringent requirements. Specifically, Criterion 1 of Appendix A to 10 CFR Part 50 requires, in part, that structures, systems, and components important to safety be tested to quality standards commensurate with the importance of the safety function to be performed.

These tests may be developed and implemented using a graded approach. The graded approach should ensure that the greatest attention is given to the most important structures, systems, and components, such as those considered engineered safety features.

## Initial Test Program Milestones

The initial test program consists of the following stages:

1. Preoperational Testing
2. Initial Startup Testing
    a. Initial Fuel Loading and Precritical Tests
    b. Initial Criticality
    c. Low-Power Testing
    d. Power-Ascension Testing.

## Initial Test Program

The initial test program, consisting of preoperational and initial startup tests, should be designed to demonstrate the performance of structures, systems, components, and design features that will be used during normal operations of the facility. The program should also demonstrate the performance of standby systems and features that must function to maintain the plant in a safe condition in the event of a malfunction or accident. It is very important that the sequence of startup tests be ordered so that the safety of the plant is never totally dependent on the performance of untested structures, systems, and components.

[10]This appendix is an edited version of the U.S. Nuclear Regulatory Commission's Regulatory Guide Number 1.68, "Initial Test Programs for Water-Cooled Nuclear Power Plants."

The satisfactory performance of a facility in approved test programs provides the confirmation that margins of safety are adequate to ensure that facility operation poses no undue risk to the health and safety of the public.

## Preoperational Testing

Preoperational testing consists of those tests conducted following completion of construction and construction-related inspections and tests, but prior to fuel loading. The tests should demonstrate, to the extent practical, the capability of structures, systems, and components to meet performance requirements to satisfy design criteria.

Tests following plant construction should demonstrate the proper performance of structures, systems, components, and design features in the assembled plant. To ensure valid test results, the preoperational tests should not proceed until the construction of the system has been essentially completed and the designated construction tests and inspections have been satisfactorily completed. Construction and preliminary tests and inspections typically consist of items such as initial instrument calibration, flushing, cleaning, wiring continuity and separation checks, hydrostatic pressure tests, and functional tests of components.

Preoperational tests should demonstrate that structures, systems, and components will operate in accordance with design in all operating modes and throughout the full design operating range. Testing should include, as appropriate, manual operation, operation of systems and components within systems, automatic operation, operation in all alternate or secondary modes of control, and operation and verification tests to demonstrate expected operation following loss of power sources and degraded modes for which the systems are designed to remain operational. Tests should also include, as appropriate, verification of the proper functioning of instrumentation and controls, permissive and prohibitive interlocks, and equipment protective devices whose malfunction or premature actuation may shut down or defeat the operation of systems or equipment. Test of system vibration, expansion (in discrete temperature step increments), and restraint should also be conducted. This testing should include verification by observations and measurements, as appropriate, that piping and component movements, vibrations, and expansions are acceptable.

The structures, systems, components, and tests in the following list are representative of the plant features that should undergo preoperational testing. Preoperational tests should not be limited to the following list since additional or different tests may be dictated by the particular plant design and/or the nomenclature applied to plant systems and features.

1. Reactor Coolant System
2. Reactivity Control Systems
3. Reactor Protection System and Engineered-Safety-Feature Actuation Systems
4. Residual or Decay Heat Removal Systems
5. Power Conversion System
6. Waste Heat Rejection Systems
7. Electrical Systems
8. Engineered Safety Features
9. Primary and Secondary Containments
10. Instrumentation and Control Systems
11. Radiation Protection Systems
12. Radioactive Waste Handling and Storage Systems
13. Fuel Storage and Handling Systems
14. Auxiliary and Miscellaneous Systems
15. Reactor Components Handling Systems

## Initial Startup Tests

Initial startup testing consists of those test activities scheduled to be performed during and following fuel loading. These activities include fuel loading, precritical tests, initial criticality, low-power tests, and power-ascension tests that confirm the design bases. The tests also demonstrate, to the extent practical, that the plant will operate in accordance with its design and is capable of responding as designed to anticipated transients and postulated accidents as specified in the Safety Analysis Report.

### *Initial Fuel Loading and Precritical Tests*

Licensees should conduct the initial fuel loading cautiously to preclude inadvertent criticality. The following specific safety measures should be established and followed: (a) ensure all applicable technical specification requirements and other prerequisites have been satisfied, (b) establish requirements for continuous monitoring of the neutron flux throughout the core loading so that all changes in the multiplication factor are observed, (c) establish requirements for periodic data-taking, and (d) independently verify that the fuel and control components have been properly installed.

Predictions of core reactivity should be prepared in advance to aid in evaluating the measured responses to specified loading increments. Comparative data of neutron detector responses from previous loadings of essentially identical core designs may be used in lieu of these predictions. Licensees should establish criteria and requirements for actions to be taken if the measured results deviate from expected values. Shutdown margin verifications should be performed at appropriate loading intervals (BWR), including full core shutdown margin tests. It should be established that the required shutdown margin exists, without achieving criticality.

To provide further assurance of safe loading, licensees should establish requirements for the operability of plant systems and components, including reactivity necessary to ensure the safety of plant personnel and the public in the event of errors or malfunctions. The initial core loading should be directly supervised by a Senior Licensed Operator having no other concurrent duties, and the loading operation should be conducted in strict accordance with detailed approved procedures.

After the core is fully loaded, sufficient tests and checks should be performed to ensure that the facility is in a final state of readiness to achieve initial criticality and to perform low-power tests. The list below illustrates the types of tests and verifications that should be conducted during or following initial fuel loading:

1. Shutdown margin verification for partially (BWR) and fully loaded core.

2. Testing of the control rod withdrawal and insert speeds and sequencers, control rod position indication, protective interlocks, control function, alarms, and scram lining (and friction tests for BWR's) of control rods after the core is fully loaded. Also the proper operation of decelerating devices used to prevent mechanical damage to the control rods should be demonstrated during this testing.

3. Final functional testing of the reactor protection system to demonstrate proper trip points, logic, and operability of scram breakers and valves.

4. Final test of the reactor coolant system to verify that system leak rates are within specified limits.

5. Measurements of the water quality and boron concentration (PWR) of the reactor coolant system.

6. Reactor coolant system flow tests to establish that vibration levels are acceptable, that differential pressures across the fully loaded core and major components of the reactor coolant system are in accordance with design values, and that piping reactions to transient conditions (for example, pump starting and stopping) and flows are as predicted for all allowable combinations of pump operation.

7. Final calibration of source-range neutron flux measuring instrumentation. Verification of proper operation of associated alarms and protective functions of source- and intermediate-range monitors.

## *Initial Criticality*

Licensees should conduct the initial approach to criticality in a deliberate and orderly manner using the same rod withdrawal sequences and patterns that will be used during subsequent startups. Neutron flux levels should be continuously monitored and periodically evaluated. A neutron count rate of at least 1 count per second should register on the startup channels before the startup begins, and the signal-to-noise ratio should be known to be greater than 2. All systems required for startup or protection of the plant, including the reactor protection system and emergency shutdown system, should be operable and in a state of readiness. The control rod or poison removal sequence should be accomplished using detailed procedures approved by personnel or groups designated by the licensee. For reactors that will achieve initial criticality by boron dilution, control rods should be withdrawn before dilution begins. The control rod insertion limits defined in the technical specifications should be observed and complied with.

Criticality predictions for boron concentration (PWR) and control rod positions should be provided, and criteria and actions to be taken should be established if actual plant conditions deviate from predicted values. The reactivity addition sequence should be prescribed, and the procedure should require a cautious approach in achieving criticality to prevent passing through criticality in a period shorter than approximately 30 seconds.

## *Low-Power Testing*

Following initial criticality, licensees should conduct appropriate low-power tests (normally at less than 5-percent power). The first purpose of these tests is to confirm the design and, to the extent practical, validate the analytical models and verify the correctness or conservatism of assumptions used in the safety analyses for the facility. These tests also can confirm the operability of plant systems and design features that could not be completely tested during the preoperational test phase because of the lack of an adequate heat source for the reactor coolant system and main steam system.

### *Power-Ascension Tests*

The power-ascension test phase of the initial test program should be completed in an orderly and expeditious manner. Failure to complete the power-ascension test phase within a reasonable period of time may indicate inadequacies in the applicant's operating and maintenance capabilities or may result from basic design problems. Design or construction-related problems disclosed during power-ascension testing can be more readily rectified if the reactor power production, and consequently the radioactive buildup, has been kept to a minimum during this testing phase. Baseline data on the performance of plant systems obtained and documented early in the plant life will permit early determination of degradation or undesirable trends.

Licensees should complete low-power tests, as described in the Final Safety Analysis Report (FSAR), and evaluate and approve the low-power test results prior to beginning power-ascension tests. Power-ascension tests should demonstrate that the facility operates in accordance with design both during normal steady-state conditions and, to the extent practical, during and following anticipated transients. To validate the analytical models used for predicting plant responses to anticipated transients and postulated accidents, these tests should establish that measured responses are in accordance with predicted responses. The predicted responses should be developed using real or expected values of items such as beginning-of-life core reactivity coefficients, flow rates, pressures, temperatures, pump coastdown characteristics, and response times of equipment and the actual status of the plant and not those values or plant conditions assumed for conservative evaluations of postulated accidents.

Tests and acceptance criteria should be prescribed that demonstrate the ability of major or principal plant control systems to automatically control process variables within design limits. This should provide assurance that the integrated dynamic response of the facility is in accordance with design for plant events such as reactor scram, turbine trip, reactor coolant pump trip, and loss of feedwater heaters or pumps. Testing should be sufficiently comprehensive to establish that the facility can operate in all modes for which it has been designed to operate; however, tests should not be conducted or operating modes or plant configurations established if they have not been analyzed or if they fall outside the range of assumptions used in analyzing postulated accidents in the FSAR for the facility.

Appropriate consideration should be given to testing at the extremes of possible operating modes for facility systems. Testing should take place under simulated conditions of maximum and minimum equipment availability within systems if the facility is intended to be operated in these modes, e.g., testing with different reactor coolant pump configurations, single loop reactor coolant system operation, operation with the minimum allowable number of pumps, heat exchangers, or control valves in the feedwater, condensate, circulating, and other cooling water systems.

## Inspection by the Office of Inspection and Enforcement

The U.S. Nuclear Regulatory Commission (NRC) Office of Inspection and Enforcement conducts a series of inspections of the initial test program beginning before preoperational testing and continuing throughout startup. These inspections are intended to determine, on a selective basis, whether the applicant's test programs, as described in the FSAR, are adequately implemented and whether the results of the tests demonstrate that the plant, procedures, and personnel are ready for safe operation. The inspection effort focuses on the manner in which the applicant has fulfilled commitments for ensuring that adequate programs have been developed and carried out, as exemplified by the methods the applicant has used for establishing procedures and the results that the methods have produced.

For the NRC to implement this inspection program, the applicant should have copies of the test procedures available for examination by the NRC regional personnel approximately 60 days prior to the scheduled performance of the preoperational tests, and, not less than 60 days prior to the scheduled fuel loading date, copies of procedures for fuel loading, initial startup testing, and supporting activities. Drafts of these procedures should be made available as early as practical. Examination by NRC personnel does not constitute approval of the procedures. The possession of such procedures by NRC personnel should not impede the revision, review, and refinement of the procedures by the applicant.

## Written Regulations

The NRC Advisory Committee on Reactor Safeguards has issued several documents stating the mandatory testing phases a nuclear powered reactor must complete before it can generate electricity for commercial use.

Section 50.34 "Contents of Applications: Technical Information," of 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," requires that an applicant for a license to operate a production or utilization facility include the principal design criteria for the proposed facility in a Safety Analysis Report. The Introduction to Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50 states that these principal design criteria are to establish the necessary design, fabrication, construction, testing, and performance requirements for structures, systems, and components that provide reasonable assurance that the facility can be operated without undue risk to the health and safety of the public.

Section 50.34 of 10 CFR Part 50 also requires that the applicant include plans for preoperational testing and initial operations in the final safety analysis report (FSAR). Chapter 14 of the Regulatory Guide 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants," provides guidance on the information pertaining to initial test programs to be included in both the preliminary safety analysis report and the FSAR for the NRC staff to perform its safety evaluations for construction permits and operating licenses.

Section XI, "Test Control," of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50 requires that a test program be established to ensure that structures, systems, and components will perform satisfactorily in service. Since all functions designated in the general design criteria are important to safety, all structures, systems, and components required to perform these functions need to be tested to ensure that they will perform properly.