PLANNING, EVALUATION AND SELECTION
OF
NUCLEAR POWER PLANTS

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Need For Nuclear Power

The need for nuclear power plants must, of course, be based upon the major criteria - namely economics. Economics, however, not in the narrow sense of lowest generation cost, but rather on a broad economic picture such as delivered cost of power, financing, balance of payment, as well as fuel resources. In any economic evaluation there are tangible costs as well as intangible costs whose magnitude may be difficult to measure accurately.

In any cost comparison of nuclear with fossil or hydroelectric power there are the tangible costs of such factors as transmission, thermal and air pollution, and even availability. Hydroelectric plants, as we know, have high capital costs, zero fuel costs, and high transmission costs, since they are generally not located near the populated load centers. Even oil and coal fired thermal plants have transmission cost penalties either in the form of transportation to the load centers or electrical transmissions from plants near the fuel supplies to the load centers. Nuclear fuel, on the other hand, is easily transported and, except for siting consideration of plants, can be located near the load centers. Even limited cooling water supplies can be solved by use of cooling towers.

Similarly, availability and air pollution are tangible costs for both nuclear and fossil plants. The air pollution control systems to solve these problems are known and can be quantified. In the U.S. we are now experiencing decreasing availability of fossil plants in the large sizes of 800 MW and greater. Recent coal plants of large capacity are operating at availabilities of 50-60% while nuclear plants are showing availabilities of over 80%. Therefore, these factors are indeed tangible numbers one might consider in planning nuclear power projects.

There are a number of intangible cost penalties between fossil and nuclear that are now becoming apparent to many countries and although difficult to predict accurately, they are large and significant. The recently negotiated crude oil prices have led to 25-33% cost increases in residual fuel. Furthermore, these increases may indeed increase 50% within a few years with the emphasis on low sulfur residual oil. Further concern has been the increasing cost of oil transportation and the ever present fear of wars and embargoes which would stop all deliveries. Finally, the growing concern in balance of payment in world trade may be a factor in favoring nuclear plants over imported coal and oil which does create a drain upon a country's economy. All the factors are admittedly difficult to predict and yet do have a major influence on planning the needs of nuclear power by any country.

Forecasting

Nuclear power is a reality. There is presently about 100 nuclear plants under design and construction in the U.S. which will be equivalent to over 100,000 MW of capacity by 1978 and projected to 300,000 MW by 1985. There are presently nuclear power plants in operation throughout the world generating power economically and reliably. The first slide (1) is a summary of operating nuclear plants taken from a recent issue of Nucleonics Week.

The U.S. AEC recently published a comprehensive forecast of the growth of nuclear power throughout the world (WASH-1139). The next slides (2a, b, c) taken from this report shows the present nuclear power and capacity and the projected installed capacity by 1985. The growth in all far eastern countries is expected to be rapid within the next few years.

Some countries, you will note, consider installing enriched uranium or natural uranium reactors. The enriched uranium reactors are represented by pressurized water, boiling water and gas cooled. The natural uranium fueled reactors use heavy water. The use of natural uranium reduces the balance of payment for a country and permits greater flexibility in fuel procurement. However, this savings is somewhat reduced because of the need to buy heavy water.

Initial Planning

The experience with nuclear power plants in the U.S. and throughout the world has shown that initial planning must be

NUCLEAR ELECTRICITY GENERATION FOR AUGUST, 1971

	Capacity (Mw)	August Mwh	Cumulative Mwh
U.S.: (net)			
Shippingport	90	4.418	3.811.769
Dresden-1	200	65.461	10.743.705
Yankee, Rowe	175	123.565	11.791.878
Indian Point-1	260	58.800^{r}	9.631.576
Big Rock Point	71	37.299	2.775.603
Humboldt Bay	63	3.210^{fm}	2.695.774
Hanford-1 (N reactor)	793	293.355	13.975.734
Peach Bottom-1	40	22.630	668.606
Connecticut Yankee	575	392.427	13.276.021
San Onofre-1	430	279.465	9.465.674
Oyster Creek	580	390.830	6.852,372
Nine Mile Point	500	344.899	3.762,158
Ginna	429	306.094	3.737.991
Dresden-2	771	255.922	2.530.645
LaCrosse BWR	50	23.904	383.463
Millstone-1	650	378.197	2,428.543
Point Beach-1	497	331.212	2.287,626
Monticello	546	247.896	646.327
BRITAIN: (gross)			
Calder Hall (4 units)	219	174.721	22,181.536
Chapelcross (4 units)	228	168.018	19.595,010
Berkeley (2 units)	334.4	191.095	19,983,796
Bradwell (2 units)	374.1	95,202	20,666,814
Hunterston (2 units)	360	187.723^{x}	13,263.740
Hinkley Point (2 units)	663.9	0	21,548,175
Trawsfynydd (2 units)	584.8	176,697	18,994,804
Dungeness-A (2 units)	576.6	221,476^{m}	20,238,976
Sizewell (2 units)	652.5	308,749	17,624,073
Oldbury (2 units)	633.5	199,579	9,285,583
Windscale AGR	41	24,815	1,972,554
Dounreay DFR	13.5	0^{f}	356,509
Winfrith SGHWR	100	72,257	1,446,304
FRANCE: (gross)			
Marcoule (2 units)	80	56,644	6,082,036
Chinon-1	82	1,117	2,573.978
Chinon-2	242	159.697	7.616.336
Chinon-3	489	194.295	4.405.415
St. Laurent-des-Eaux-1	500	259.197	2.592.233
Chooz (SENA)	282	57.716	3,075.333
Monts d'Arree (EL-4)	73	17.020	116,126
St. Laurent-des-Eaux-2	530	69.781	69,781
ITALY: (net)			
Latina	200	85,506	9,737,209
Garigliano	150	108,034	6,729,993
Trino	247	0^{f}	5,324,008
W. GERMANY: (net)			
Gundremmingen	250	175,002	6,142,452
Lingen	240	57,023	4,360,357
MZFR	52.5	36,838	1,044,884
Obrigheim	300	68,630	5,764,470
JAPAN: (net)			
Tokai, Japco	159	98,211	3,966,252
Tsuruga, Japco	340	239,318	3,290,445
Mihama-1, Kansai Elec.	320	213,514	1,883,980
Fukushima-1, Tepco	439.3	291,009	1,248,038
CANADA: (gross)			
Douglas Point	220	7,281^{m}	3,078,169
Pickering-1	540	226,707	979,229
SWEDEN: (net)			
Agesta, R-3/Adam	12	0^{m}	278,546
SPAIN: (gross)			
Zorita-1	160	109,200	2,372,500
Garona	460	133,440	642,000
NETHERLANDS: (net)			
Dodewaard	51.5	37,555	900,671
SWITZERLAND: (gross)			
Beznau-1	364	0^{fr}	3,611,330
INDIA: (gross)			
Tarapur-1	200	0^{f}	4,360,549
Tarapur-2	200	131,660	

^{c}down for modification ^{d}dual-purpose ^{f}down for refueling ^{m}down for maintenance, inspection ^{p}in power testing
^{r}down for repair ^{t}down for training ^{x}five weeks to August 27

Slide 2-a

ESTIMATE OF CUMULATIVE CAPACITY OF NUCLEAR POWER PLANTS IN FOREIGN COUNTRIES OF THE FREE WORLD

Country	Fuel Type	Thousands of Electrical Megawatts at End of Calendar Year															
		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Argentina	Enriched									0.3	0.3	0.6	0.6	1.0	1.0	1.4	1.4
	Natural				0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Australia	Enriched							0.5	0.5	1.1	1.1	1.8	2.4	3.0	3.7	4.4	5.3
Austria	Enriched							0.6	0.6	0.6	0.6	1.3	1.3	1.3	2.0	2.0	2.0
Belgium	Enriched	0.1	0.1	0.1	0.1	0.5	0.9	1.3	1.3	1.9	1.9	2.6	2.6	3.3	3.3	4.2	4.2
Brazil	Enriched								0.5	0.5	1.0	1.0	1.5	1.9	2.3	2.9	3.5
Canada	Natural	0.2	0.8	1.6	2.1	2.6	2.6	2.6	3.4	4.8	6.3	7.8	9.4	11.1	13.0	14.9	17.0
China (Taiwan)	Enriched							0.6	0.6	0.6	1.2	1.2	1.2	1.8	2.2	2.7	3.2
Denmark	Enriched									0.4	0.4	0.8	0.8	1.4	1.8	2.2	2.6
Finland	Enriched								0.4	0.4	1.0	1.0	1.0	1.4	1.4	1.9	1.9
France	Enriched	0.2	0.2	0.2	0.2	0.8	1.2	2.0	3.0	4.0	5.2	6.3	7.6	9.1	10.8	12.5	14.4
	Natural	1.3	1.3	1.8	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Germany, West	Enriched	0.8	0.8	0.9	2.2	2.2	5.9	7.0	8.9	11.0	13.3	15.6	18.1	21.1	24.3	27.7	31.3
Greece	Enriched							0.4	0.4	0.8	0.8	1.2	1.2	1.7	2.1	2.6	3.1
India	Enriched	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.8	0.8	1.3	1.3	1.9	1.9	2.6	2.6
	Natural			0.2	0.2	0.4	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Israel	Enriched										0.3	0.3	0.3	0.6	0.6	0.9	0.9
Italy	Enriched	0.4	0.4	0.4	0.4	0.4	0.4	1.2	2.0	2.7	3.4	4.1	4.8	5.6	6.8	8.1	9.4
	Natural	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Slide 2-b

Country	Fuel Type	Thousands of Electrical Megawatts at End of Calendar Year															
		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Japan	Enriched		1.1	1.1	1.6	2.8	4.9	7.6	10.8	13.9	17.1	20.6	23.7	27.9	34.2	41.2	48.8
	Natural	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Korea, South	Enriched						0.6	0.6	1.1	1.1	1.1	1.6	1.6	2.1	2.6	3.0	3.5
Mexico	Enriched							0.6	0.6	1.3	1.7	2.1	2.6	3.2	3.7	4.3	5.0
Netherlands	Enriched	0.1	0.1	0.1	0.1	0.5	0.5	1.0	1.0	1.5	1.9	2.3	2.8	3.3	3.9	4.5	5.2
New Zealand	Enriched									0.3	0.3	0.6	0.6	1.1	1.1	1.6	1.6
Norway	Enriched										0.5	0.5	0.5	0.5	1.1	1.1	1.6
Pakistan	Enriched							0.2	0.2	0.4	0.4	0.7	0.7	1.0	1.0	1.5	1.5
	Natural		0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Philippines	Enriched									0.4	0.4	0.8	0.8	1.2	1.6	2.0	2.5
Portugal	Enriched										0.3	0.3	0.3	0.3	0.6	0.6	0.6
South Africa	Enriched												0.4	0.9	1.4	1.9	2.5
	Natural									0.5	0.5	1.0	1.0	1.0	1.0	1.0	1.0
Spain	Enriched	0.6	0.6	0.6	0.6	0.6	0.6	2.1	2.6	3.6	4.6	5.6	6.8	8.0	9.7	11.5	13.4
	Natural				0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Sweden	Enriched	0.4	0.4	0.4	0.4	1.2	2.7	3.3	4.1	6.3	7.9	9.5	11.1	12.4	13.7	15.1	16.6
Switzerland	Enriched	0.4	0.4	0.7	1.0	1.4	2.0	2.4	2.9	3.4	3.9	4.4	5.0	5.6	6.2	6.8	7.5
Thailand	Enriched											0.5	0.5	0.9	0.9	1.4	1.4
Turkey	Enriched											0.4	0.4	0.7	0.7	1.1	1.1

Slide 2-c

Country	Fuel Type	Thousands of Electrical Megawatts at End of Calendar Year															
		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
United Arab Rep. . . .	Enriched . . .										0.3	0.3	0.3	0.6	0.6	1.0	1.0
United Kingdom	Enriched . . .	0.1	0.1	0.8	2.2	4.1	5.4	6.6	9.6	12.7	16.1	19.6	23.4	27.4	32.3	37.6	43.1
	Natural	4.6	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2	5.2
Total (rounded), without U.K.	Enriched . . .	3.4	4.5	4.9	7	11	20	32	42	57	72	89	103	125	147	175	200
Total (rounded), with U.K.	Enriched . . .	3.5	4.6	5.7	9	15	25	38	51	70	88	109	126	152	179	212	243
	Natural	6.5	7.8	9.3	11	12	12	12	13	15	16	18	20	22	24	26	28

Slide 3

INITIAL PLANNING OF NUCLEAR POWER PROJECT

1. Selection of consultants
2. Prepare Economic Studies
3. Site surveys, evaluation, selection
4. Plan project organization and establish procedures re: licensing, compliance, Q/A
5. Screen bidders - briefing sessions
6. Explore financing possibilities
7. Develop preliminary schedules
8. Train personnel
9. Survey local industries
10. Survey uranium resources
11. Visit nuclear plants
12. Initiate site borings, geological studies, meteorological studies, monitoring environment

started now if a plant is to be in commercial operation by 1980. It takes about six years from award of reactor contract to design, construct and to bring to commercial operation. One year is needed preceding the award of contract to prepare bidding documents, invite bids and to select the major contractor for the plant. Therefore, there is only about one year left for planning, if the plant is to be on the line by 1980.

I've listed on the next slide (3) some of the activities that should be undertaken during the planning period in order to initiate a nuclear power program. (Details of various items to be discussed).

Turnkey vs Non-Turnkey

The early nuclear power plants in the U.S. were built on turnkey - firm price bid with the total plant under the responsibility of one contractor. This contractor (G.E. or Westinghouse) supplied the equipment, built the plant and started its operation. This approach was necessary in order to assure the utility that the constructed cost was known and minimized the involvement of the utilities since they had no experience in bidding these plants.

After 15 turnkey plants and possibly one billion dollar loss by the two bidders, all nuclear power plants are being built in the U.S. on a non-turnkey basis. In non-turnkey, the utility with their engineers purchase the reactor, turbine generator and all major equipment on a competitive basis and similarly award construction contracts for the plant based upon plans and specifications. In Europe, turnkey is still in use, although there is a noticeable trend starting away from it. In Europe, turnkey has been a way of life even on fossil fueled plants and therefore the large engineering companies such as those in the U.S. do not exist for non-turnkey projects. In the Far East, nuclear plants have been turnkey and non-turnkey. I believe, the Far East may shift its practice to non-turnkey as plants are built and utilities develop greater knowledge of the plant requirements.

Under the non-turnkey approach, the risk is spread amongst many contractors, selected under competitive conditions and therefore should reduce the total constructed cost. The non-turnkey permits a shorter construction schedule since a complete design is not necessary for the single contractor in the turnkey approach. The non-turnkey most importantly involves the utility in the project so their operators are better qualified to operate the plant and their engineers can better understand the plant design. It also allows the utility to spread its financing, particularly from overseas suppliers. The major handicap in the non-turnkey is in the greater involvement by the utility in management of the project and thereby requiring a larger staff to implement the work.

Call For Bids

The bidding documents for nuclear power plants must be in sufficient detail to define the scope of the project, but not in such great detail so as to restrict the bidders from offering their most economic designs. The request for bids can be for turnkey or non-turnkey or combination of both as for example turnkey nuclear island and non-turnkey balance of the plant.

The preparation of specifications for any of the alternates can be prepared and issued within four months. However, the turnkey bidders will probably need at least six months to prepare bids because of their greater complexity whereas the non-turnkey bidders can usually respond within three months. The evaluation of the turnkey bid can generally be completed in less time than the non-turnkey because there are less bidders and less combinations to consider. For overall planning, at least one year should be allowed for preparation of bids, bidding period and evaluation of offering. Obviously, this assumes no political problems to slow down the effort. Unfortunately, this can occur as recently exhibited in Australia and Mexico.

Since all the reactor and turbine generator manufacturers are experienced in world-wide bidding, there is generally no problem with using engineering standards or codes from the U.S., U.K., Germany, Japan, Canada, etc. The bidding document can also be any language, although English is best known by all the bidders. However, the legal and contract terms should probably be in English as well as the language of the country involved, since translation of legal terms into English may change the meaning. Therefore, the language of the country should be the prevailing one.

The bidding documents should clearly specify the scope of hardware, whether piping and instrumentation is included and most important specify what is not included. The bidders should be asked to define criteria of satellite equipment that they do not supply, particularly those items related to reactor operations, including safety systems and cooling systems.

It is most important to tell the bidders the bases for evaluation in order to improve his responsiveness. The kilowatt ratings of all the bids will be slightly different and there may be bonuses or penalties for capacities above or below requested ratings. It is also desirable to request bidders to include in their offering financing terms and terms of payment as well as any delayed payment since these also have significant bearing on the total cost. In case of reactor bids, it is also a good idea to ask for safety information, proven previous experience with the reactor of the same design, as well as any training program the bidder may have.

Bid Evaluations

The simplest bid evaluation is the total turnkey firm price bid for the total plant. It is also the easiest to evaluate provided the bids have been completely responsive to the specifications. If the specifications are not well defined and the bidders only give fragmentary information with their price, the evaluation will take probably the longest. We had such an experience in recent years in the Far East whereby we spent over a year in detail negotiation with the lowest price bidder defining his offer because of inadequate information. It is dangerous to give the bidders complete freedom to substitute subcontractors without client's approval since it may result in poor quality of material, equipment and faulty construction. The successful bidder only has to warrantee his plant during the early years of operation, whereas the utility must live with the plant for years.

The classic procedure in any evaluation is to prepare and to request completed evaluation forms. The specifications have data sheets for the bidders to complete and these responses are recorded on large sheets for purposes of comparison of the responses. The technical data supplied for a turnkey bid should be as complete and detailed as the bidding for the separate pieces of equipment. A typical technical data sheet for comparing various nuclear steam supply systems are shown on slide 4. As can be seen, the data includes information on the thermal rating of the reactors, steam conditions, details on the containment, fuel handling, as well as core configuration. The thermal and mechanical designs of the core are important to evaluate from a safety viewpoint and permits comparison with other reactors in operation to assure the bidders are not exceeding experience.

Similar types of technical comparisons should be made for the turbine generators, nuclear fuel and such major equipment as the condenser, steam generators, primary pumps, safety systems, containment designs, feedwater heaters, circulating water systems, water treatment, and radioactive waste treatment facilities. Key information in such evaluations are the proposed suppliers of major equipment and the experience of these suppliers on similar designs. Again, the bidders are primarily interested in submitting the lowest price that meets specifications without necessarily considering the capabilities and experiences of the suppliers.

All bidders, whether it is turnkey or for pieces of equipment, attempt to minimize the risk to them and so exceptions are freqently taken to the specifications. It is very important that a separate section of the bid be allowed for identification of bidding exceptions - otherwise the bidders tend to slip them into their offering in fine print or indirect reference in hopes it might be overlooked by the evaluator. Experienced engineers are aware of these techniques and either ask for exceptions to the bids or carefully examine the offering for these exceptions.

It is also perfectly proper and recommended that the bidders be given an opportunity to make a technical presentation of their offering after the bids are submitted. This gives the bidders the opportunity to emphasize features of their designs which they feel are important to the client and gives the evaluators an opportunity to clarify any details that are not well defined or misleading. It is not unusual that amendments to the specifications followed by amendments to the bids are conducted during the evaluation. As long as the basic price bids are not changed, technical amendments are important to clarifying the completeness of the offerings.

In the non-turnkey bids, much of the dollar differences between alternate nuclear steam supply system (NSSS) proposals and the turbine generator proposals are found in areas that must be designed and estimated by the evaluator. Proposals for reactors and turbine generators can be evaluated equitably only by considering all components and structures required for a complete power station. Hence it is imperative that balance-of-plant designs and drawings, sufficiently complete to study construction and cost differences, be prepared for each proposal.

The detailed scope of equipment submitted with each proposal determines the extent of additional cost estimated required. These may range from simply adding the installation cost to the quoted price for complete systems to estimating entire satellite systems where only design criteria are given.

Slide 4

COMPARATIVE NSSS TECHNICAL DATA

1.	Case	A	B	C
2.	NSSS Manufacturer	Co. "X"	Co. "Y"	Co. "Z"
3.	Reactor Type	BWR	PWR	Gas Cooled
4.	At Warranteed Power			
a.	NSSS Thermal Power Mwt	3573	3425	2783
b.	Core Thermal Power Mwt	3567	3411	2808
c.	Steam Flow, lbs/hr	$15.339\text{x}10^6$	$15.14\text{x}10^6$	$7.303\text{x}10^6$
d.	Steam Pressure at Reactor or Steam Generator Outlet, psia	984.7	999.7	2515
e.	Steam	Saturated	544.6	955
f.	Steam Moisture Content %/Superheat, °F	0.3%	0.25%	286°F
g.	Feedwater Inlet Temperature, °F	420	440	340
h.	Reheat Steam Flow, lb/hr	-	-	$7.21\text{x}10^6$
i.	Reheat Temperature, °F	-	-	1002
j.	Reheat Pressure, psia	-	-	589.7
5.	Type of Containment	Dry	Dry	Dry
6.	Reactor Vessel Type	Carbon Steel w/cladding	Carbon Steel w/cladding	Carbon Steel w/cladding
7.	Number Steam Generators	None	4	6
8.	Number of Reactor Coolant Pump or Circulators	2-Recirc.	4	6
9.	Fuel Handling	Underwater Transfer	Underwater Transfer	Refueling Machine
a.	Reactor Cavity Pool	Not Required	Required	-
b.	Spent Fuel Pool	Required	Required	-
c.	Fuel Storage Wells	-	-	Required
10.	Core Parameters			
a.	Core Diameter (Equivalent), in	194	132.7	326
b.	Core Height (Equivalent), ft	12	12	20.81
c.	Number of Fuel Assemblies	820	193	3800 (blocks)
d.	Number of Fuel Rods/Assembly	49	204	210 or 120(Stacks/Blocks)
e.	Rod Arrangement	7x7	15x15	Triangular
f.	Fuel Rod Pitch, in	0.738	0.563	0.74
g.	Number of Control Rods	197	61	73 pr
h.	Effective Heat Transfer Surface Area, ft^2	71,067	52,200	160,000
i.	Average Heat Flux, Btu/hrft^2	164,400	217,200	59,500
j.	Maximum Heat Flux, Btu/hrft^2	428,100	580,000	193,400

#2 of Slide 4

COMPARATIVE NSSS TECHNICAL DATA

	A	B	C
	Co. "X"	Co. "Y"	Co. "Z"
10. Core Parameters (Cont'd)			
k. Maximum/Average Heat Flux Ratio	2.60	2.67	3.26
l. Average Linear Heat Rate, kw/ft	7.1	7.03	1.40
m. Maximum Linear Heat Rate, kw/ft	18.5	18.8	4.55
n. Power Density, kw/liter	51.1	104.5	8.23
11. Coastdown Capability			
a. After 2 months after core life, %	85	80	60
b. After 3 months after core life, %	75	70	50
c. After 4 months after core life, %	66	60	40
d. Minimum after core life, %	20	15	25
12. Departure from Nucleate Boiling			
a. DNB Correlation	Hench-Levy	W - 3	NA
b. Steady State Ratio	1.904	1.89	NA
c. Transient	≥1.0	1.30@12%	NA
d. Percent Overpower of which DNBR=1	24%	≥12%	NA
e. Hot Channel Exit Quality, (% by weight)	22.8	Subcooled	NA
f. Average Exit Quality, (% by weight)	14.0	Subcooled	NA
13. Load Following Capability			
a. Ramp Change, (% full load/minute)	30/60	5	5
b. Ramp Change Range, (% full load)	25-65/65-100	15-100	25-100
c. Step Change, (% full load)	20/35	10	10
d. Step Change Range, (% full load)	25-65/65-100	15-100	25-100

Nuclear steam supply systems, other than those included as part of a turnkey project, have been offered in varying degrees of completeness including:

1. Complete NSSS, including all satellite systems and interconnecting piping, with erection by the supplier.

2. Major NSSS plus basic satellite systems-but without piping or erection.

3. Basic NSSS only, with design criteria offered for associated satellite systems.

Good specifications and responsive proposals are vital to the purchaser of an NSSS. A thorough evaluation of alternates requires examination of engineering, safety and performance aspects; determining any features which are deficient or exceed the owner's needs; assessing the balance-of-plant requirements to achieve a complete nuclear station; and, finally, estimating total capital costs for each alternative, often using designs based on criteria furnished with the proposal.

Major items outside of the NSSS requiring at least preliminary design for cost estimating during evaluation include the reactor building, primary and secondary containment (where applicable), radwaste and auxiliary buildings, and fuel-handling facilities. These structures must be delineated sufficiently to place alternate bids on a par and to furnish sufficient detail for material takeoffs in estimating costs. The next slide (5) is a summary of balance of NSSS that is priced out to put the nuclear islands on comparable basis.

The principal factors which determine the capital cost of a nuclear power station, and which must keep cost fluctuations among alternates to a minimum are:

Scope of supply:- The scope of items or work included in each proposal must be examined in detail. Items which will be only manufactured and delivered for erection by the owner must be clearly identified. Any differences in actual design capability from the nominal output must be adjusted for, so that a true cost comparison may be made between alternative designs.

Slide 5

BALANCE OF NUCLEAR ISLAND COSTS

1.	Case	A	B
2.	NSSS Manufacturer	Co. "X"	Co. "Y"
	A. NSSS Structures		
3.	Unloading Facilities		
4.	Reactor Containment Building		
5.	Auxiliary Buildings		
6.	Nuclear Service Water Pump House		
7.	Elevated Release Point & Gas Holdup Piping		
8.	Refueling Water Storage Tank		
	A. Subtotal (Structures)		
	B. NSSS Systems		
9.	NSSS Equipment Installation		
10.	Primary Coolant System		
11.	Control Rod Drive System		
12.	Reactor Coolant Purification System		
13.	Emergency Core Cooling Systems		
14.	Shutdown Cooling System		
15.	Redundant Reactivity Control System		
16.	Tools and Servicing Equipment		
17.	Waste Management System		
18.	Main Circulator Service System		
19.	Auxiliary Circulator Service System		
20.	PCRV Seal and Purge System		
21.	Components Cooling System		
22.	Core Auxiliary Cooling System		
23.	Containment Spray & I_2 Removal System		
24.	Containment H_2 Removal System		
25.	Containment Air Cooling/Filtering System		
26.	Spent Fuel Pool Cooling System		
27.	NSSS Auxiliary Building H/V System		
28.	NSSS Cranes		
29.	Total Plant Instrumentation		
30.	Nuclear Service Water System		
31.	Helium Storage System		
32.	Helium Purge System (Fuel Storage Area)		
33.	Reactor Equipment Service Facility Tools		
34.	Nitrogen Storage System		
	B. Subtotal (Systems)		

Where the NSSS proposer furnishes equipment only, and the cost of installing this equipment as well as the cost of furnishing and installing piping must be estimated, experience determines whether the proposed equipment is complete. For example, a boric-acid recovery loop is desirable in the chemical and volume-control systems for pressurized-water reactors employing chemical shim. Not all suppliers include the recovery system in their proposals; therefore, where this system is missing, the cost of evaporators, concentrate hold-tanks, pumps, gas-stripper, and other recovery items must be added. In other cases, the proposal may omit equipment called for by the specification; the cost of such equipment must be added to equalize the offerings.

Other factors to consider are:- Necessary reserve of fuel assemblies, equipment redundancy required to guarantee reaching comparable load factors, and outside power to replace any generation loss because of an inherent design feature.

Contract price data:- Escalation factors and payment terms must be adjusted for a proper comparison among contract prices and dates. Price escalation by a prearranged index has often been required in recent years.

Guarantees:- Guarantees should be carefully related to specific systems rather than the plant as a whole. For a complete power plant the cost will be higher if separate guarantees are called for on components, because this may place unnecessary restrictions on the supplier as well as increase overall margins.

Operating cost differentials:- Estimates of operating and maintenance costs must be considered separately and appropriate penalties or credits applied. Such other items as the differential cost of demineralizer resins and of refueling must be evaluated.

Instrumentation and controls:- In addition to the equipment scope per se, instrumentation and controls, including nuclear process and in-core instrumentation as well as the data-processing computer offered, must be factored in the evaluation. In this category, the type, number and location of the startup, intermediate and power level instrumentation are important considerations. Where all or most of these are located in the core, greater sensitivity is possible and this desirable feature should be credited. The instrumentation package must be checked for such miscellaneous items as withdrawal mechanisms, external detector wells, detector housings, shield plugs, and interconnecting cables for externally located detectors. Estimates for any of these, if missing from the base bid, must be added.

Generally, process instrumentation and control equipment included in NSSS proposals is of comparable quality. Process instrumentation is usually evaluated separately for different types of reactors, e.g., PWR and BWR. Direct comparison is not feasible because of differences in quantity and control philosophy inherent in the system design for PWR and BWR reactors. Within each concept, however, the control method, number of channels used, extent of redundancy, supply of primary elements, and type of logic (e.g., combining three pressure channels with three level channels to get 2-out-of-3 logic for actuating a safety injection system) are factors to consider.

When evaluating data-processing computer systems, offered in a NSSS proposal, one should consider:

1. Will the computer system handle specified functions?
2. Will the supplier furnish a software package to fulfill the specified functions?
3. Will the supplier furnish adequate equipment for the specified functions?
4. Will the supplier provide training, testing manuals, and installation?
5. Can the computer be expanded to handle other plant functions?

Where deficiencies exist, e.g., failure to provide a sequence monitoring program called for in the specification, it is estimated cost must be charged against the proposal.

Balance of Plant Costs and Other Cost Factors

Actual bid prices vary because of the conditions under which they are submitted. Proposed prices may include escalation; if not, it must be added by extrapolating applicable indices. In addition, cancellation charges and delivery schedules must be considered. Delivery schedules are vital because they must be compatible with construction and commercial operation schedules. If delivery dates are inordinately stretched out, proposed commercial operation date may force premium construction costs and other problems because of the shorter time allowed.

Another important item is the guarantee of licensability.

The same procedure is followed for the balance of the power plant. In addition to the turbine generator bids, the balance of the power plant has to be designed and priced out to match each of the reactor types evaluated as the nuclear islands. Since the steam conditions for the various reactor types are known, the turbine generator manufacturers can supply the price for their units at the nominal ratings with price adjustments for incremental capacities based upon the cycle studies.

The balance of the power plant can be optimized based upon the cooling water temperatures, regenerative heater arrangements and final feed water temperatures. The costing of these items are all added as the balance of the turbine generator plant costs shown on slide (6). In addition, the balance of electrical plant cost must be added to include the high voltage side of the station as shown on slide (7).

Finally, all the costs of NSSS, T-G, balance of nuclear island, balance of turbine generator plant, balance of electrical plant cost are added together to give a total direct plant cost. However, the final total constructed cost of the plant must include such major cost items as escalation, contingency, interest during construction, sales taxes, and such miscellaneous cost factors as performance bonds and possible cost penalties. These items are summarized in slide (8).

I deliberately did not show costs for various reactor power plants in order to avoid economic comparisons of the various types. The pricing of reactors, fuels, turbine generators and the balance of plant construction are so varied depending upon the country, construction practices, financing, and the bidders' interests, that results can be quite different.

BALANCE OF TURBINE GENERATOR PLANT COSTS

1.	Case	A	B
2.	NSSS Manufacturer	Co. "X"	Co. "Y"
3.	TG Building		
4.	TG Pedestal		
5.	TG Erection		
6.	TG Room Crane		
7.	Condenser		
8.	Circulating Water Pumps		
9.	Circulating Water Pumphouse, Tunnels & Piping		
10.	Feedwater Heaters		
11.	Turbine Cooling Water System Equipment		
12.	Condensate Polishing Units		
13.	a. Condensate Pumps		
	b. Condensate Booster Pumps		
14.	a. Reactor Feed Pumps		
	b. Reactor Feed Pump Drives		
15.	Drain Forwarding Pumps		
16.	Miscellaneous Tanks		
17.	Deaerator & Storage Tanks		
18.	Makeup Water Treatment		
19.	a. Cooling Ponds		
	b. Cooling Pond Makeup Pumps		
	c. Makeup Pump House		
20.	Turbine Building Heating & Ventilating		
21.	Piping		
	a. Main Steam		
	b. Condensate		
	c. Condensate Booster		
	d. Feedwater		
	e. Extraction & Heater Drains		
	f. Service Water		
	g. Closed Cooling Water		
	h. Reactor Reheat		
	i. Condensate & Demineralizer Water		
	j. Cooling Pond Makeup		
	Total Balance of Turbine Generator Plant Cost		

BALANCE OF ELECTRICAL PLANT COST

1.	Case	A	B
2.	NSSS Manufacturer	Co. "X"	Co. "Y"
3.	Main Transformer		
4.	Auxiliary Transformer		
5.	Startup Transformer		
6.	Emergency Transformer		
7.	Isolated Phase Bus		
8.	Non-segregated Bus		
9.	4160 V Switchgear		
10.	480 V System		
11.	Control Panels		
12.	Rotary Invertors		
13.	Static Invertors		
14.	Containment Electrical Penetrations		
15.	Emergency Diesel-Generators System		
16.	Miscellaneous Electrical Installations		
17.	Offsite Auxiliary Power Supply		
18.	Switchyard		
	Total Balance of Electrical Plant Costs		

Slide 8

CAPITAL COST SUMMARY

1.	Case	A	B
2.	NSSS Manufacturer	Co. "X"	Co. "Y"
3.	NSSS Price with Options		
4.	Turbine Generator Price		
5.	Balance of Nuclear Island Cost		
6.	Balance of Turbine Generator Plant Cost		
7.	Balance of Electrical Plant Cost		
8.	Total Direct Cost (3+4+5+6+7)		
9.	Sales Tax		
10.	Total Indirect & Misc. Costs		
11.	Subtotal (9+10)		
12.	Escalation		
	a. NSSS (including Sales Tax)		
	b. Turbine Generator (including Sales Tax)		
	c. Balance of Plant		
	d. Total Escalation		
13.	Contingency		
14.	NSSS Performance Bond		
15.	Interest During Construction		
	a. Plant Except NSSS		
	b. NSSS		
	c. Total I.D.C.		
16.	Total Plant Cost (11+12d+13+14+15c)		
17.	Reserve Penalty		
18.	Total Evaluated Plant Cost (16+17)		

Suffice to say, all types are being built throughout the world so that the economic factors are indeed variable. The next slide (slide 9) (H. Vann paper Geneva Conf., Vol. 1, p.1.4-6) gives a good summary of construction cost in the U.S. of water reactor type power plant operating in 1978. This tabulation clearly shows the danger of turnkey firm price bidding by any organization since the reactor and turbine generator are not the major cost item, but rather construction and escalation as well as other intangibles.

Slide 9

FOSSIL AND NUCLEAR PLANTS INITIAL INVESTMENT COST ESTIMATES
FOR APRIL 1977 AND 1978 SERVICE DATES
NOMINALLY RATED 1000 MWe PLANTS

COST ACCOUNT	COST IN MILLIONS OF DOLLARS					
	NUCLEAR			FOSSIL		
	1977	% of Total (1977)	1978	1977	% of Total (1977)	1978
NUCLEAR STEAM SUPPLY SYSTEM	45.8	14.2	---	---	---	---
BOILER	---	---	---	28.0	11.8	---
TURBINE GENERATOR UNIT	32.7	10.1	---	24.0	10.2	---
CONSTRUCTION MATERIALS AND EQUIPMENT (includes indirects)	47.0	14.5	---	44.8	19.0	---
CONSTRUCTION CRAFT LABOR (includes indirects)	55.8	17.3	---	41.0	17.3	---
TOTAL DIRECT COST (1971 BASE COSTS)	(186.7)		165.7	(136.4)		135.4
TRENDS, ESTIMATED ADDITIONAL COSTS FOR 1978 PLANTS						
A. REGULATION & SAFETY			5.0			---
B. NEAR-ZERO RADIATION RELEASE			5.0			---
*C. SO_2-REMOVAL SYSTEMS (CAT-OX)			---			33.0
*D. COOLING TOWERS (NATURAL DRAFT)			13.0			8.0
E. PLANT AVAILABILITY			2.0			4.0
F. QC/QA (ADDITIONAL)			1.0			2.0
G. AESTHETICS			0.8			0.4
TRENDED TOTAL DIRECT COST			192.5			182.8
PROFESSIONAL SERVICES	20.7	6.4	20.7	10.2	4.3	10.2
OTHER INDIRECT COSTS	(Included above as indicated)		15.6	(Included above as indicated)		2.4
BASE CONSTRUCTION COST	202.0	62.5	228.8	148.0	62.8	195.4
CONTINGENCY	12.9	4.0	15.0	9.5	4.0	13.3
ESCALATION (DURING CONSTRUCTION & TO 1978 OPERATING DATE)	59.4	18.4	93.1	49.2	20.8	85.3
INTEREST DURING CONSTRUCTION	48.8	15.1	60.0	29.8	12.6	42.3
TOTAL INITIAL INVESTMENT COST	323.1	100.	**396.9	236.5	100.	336.3

*OPERATING COSTS, CAPACITY PENALTIES & BY-PRODUCT CREDITS NOT INCLUDED.

**THE MARKET PLACE $ KW CAN BE ESTIMATED BY REDUCING THE DIRECT NSSS COST BY $5M AND THE CORRESPONDING TOTAL DUE TO CONTINGENCY, ESCALATION AND IDC BY $4.6M THUS REDUCING THE TOTAL COST TO $387.3M, AND DIVIDING BY 1,050,000 KW RESULTS IN 369 $ KWe.

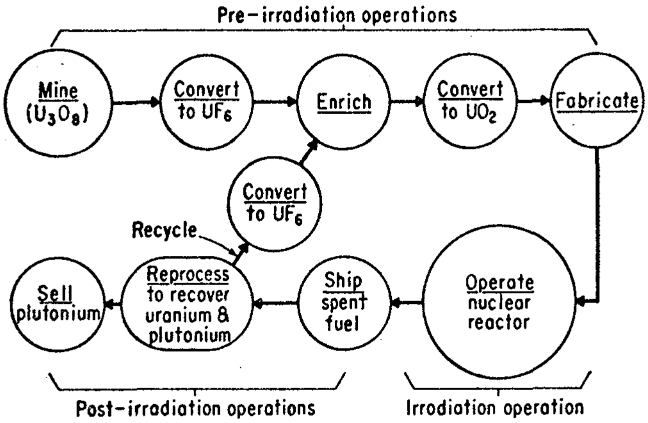
Fuel Offering

The main reason for increased nuclear plant construction is the attractiveness of low fuel costs. Unlike a fossil-fired plant, the cost of fuel plays a major role when evaluating nuclear because fuel costs vary with the choice of steam supply system. Before decisions on competing reactors can be made, their relative fuel costs must be fully understood.

Evaluating nuclear fuel proposals is a relatively new art which will undergo many transformations with experience. Methods and suggestions herein will help a utility achieve its primary purpose, selecting the most efficient and economical offering. Because of many unknowns, particularly in future costs, any decision must be a matter of careful evaluation, tempered by years of experience and power-generation judgement.

To establish a background for understanding the nuclear fuel cycle, its pattern is traced on slide 10 from raw ore

Slide 10



Nuclear fuel cycle comprises series of steps several of which, in some proposals, may be purchaser's responsibility

through its re-entry into the cycle. Refined uranium ore comes in the oxide form (U_3O_8) termed "yellowcake". Natural U_3O_8 contains only about 0.7% fissionable uranium-235.

Before enrichment, U_3O_8 is refined and chemically converted to uranium hexafluoride (UF_6). This UF_6, in gaseous form is processed through the diffusion plant which removes part of the non-fossile UF_6 and enriches the remainder to 2 to 4% of the U-235 isotope for typical light water reactors.

The fuel fabricator converts enriched UF_6 to UO_2, presses it into pellets, sinters them, and then precision-grinds them to final dimensions. The pellets are loaded into Zircalloy tubes to form fuel rods which are combined into fuel assemblies. Once completed, the fuel assemblies are shipped to the power plant.

In the reactor, most of its U-235 is destroyed by the energy-producing fission process. Plutonium is produced by interaction of neutrons with U-238, and part of it is fissioned in the reactor to produce power. Hence the fuel assembly, when removed, contains some unburned U-235, a large amount of U-238, and a significant quantity of unburned plutonium. Because these substances are valuable, the spent-fuel assemblies are stored underwater at the reactor site until their radioactivity is low enough to permit economic transportation to a reprocessing plant. Here reusable uranium and plutonium are recovered.

Fuel offerings from reactor manufacturers presently are based on one or more of these options:

1. Complete fuel cycle service - The manufacturer is responsible for all aspects of nuclear fuel cost except reactor operating costs and inventory carrying charges on fuel while in possession of the utility.

2. Front end service - Similar to complete fuel cycle service except that the utility is responsible for spent-fuel transportation and reprocessing costs.

3. Fuel fabrication service - The manufacturer is responsible only for fuel design, conversion of uranium hexafluoride to uranium dioxide, and fuel fabrication. All other fuel cycle costs, i.e. procurement of ore, conversion to UF_6 enrichment, reactor operation, inventory carrying charges, spent-fuel transportation, and reprocessing will be the utility's responsibility.

Simplest to evaluate is the complete-fuel-cycle service. Here the process is usually one of simple arithmetic. To place costs and credits on a time basis, apply the proper escalation and evaluation factors and then make comparisons on either a present worth or levelized-annual-cost basis. The principal variables in complete-fuel-cycle-service offerings are usually escalation in labor and material costs and the cost of uranium ore.

Labor and material escalation can be forecasted by obtaining histories of the indices specified by the manufacturers and plotting trends of their historical values. The least-mean-square method of curve fitting is useful in plotting these trends. It may then be assumed that the historical trend will continue over the evaluation period. Escalation in labor and materials is particularly significant where manufacturers base their proposals on different indices or where one manufacturer bids a firm price and another reserves the right to add escalation.

Fluctuations in the cost of uranium ore also present a problem in that the utility must estimate future market trends in making an evaluation.

Depending on the manufacturer, there may be other protective clauses in a complete-fuel-cycle offering. Some variations are in provisions for the cost of separative work and of converting ore to UF_6. Here again, the purchaser's judgement with regard to future market trends enters the picture.

The evaluation of fuel-fabrication-service offerings is much more complex. Fabrication cost alone does not present a complete picture. Offerings will be based on a fuel enrichment unique to each reactor. Differing utility carrying charges will vary the relative value of inventory charges, which are sensitive to enrichment. Also, reprocessing costs, credits and shipping costs - borne by the utility - will vary with reactor type. Hence the only valid method of comparing fuel-fabrication-service offerings is to make them equivalent to a complete-fuel-cycle service offering with the utility inserting estimates for those items which are not the manufacturer's responsibility.

A nuclear-fuel-cost computer program is almost indispensable for making such calculations; by hand, the calculations would be much too costly and time-consuming. An example of the divided responsibility in calculating fuel-fabrication-service costs, with typical values in parentheses for items which are the utility's responsibility follows in slides (11) and (12).

In evaluating fuel-fabrication service, escalation clauses in manufacturer's proposals must be carefully considered.

Evaluating front-end service is a combination of the methods described previously, with items in each manufacturer's proposal supplemented by values calculated by the utility. Slide (13) is a typical example of fuel offerings by reactor types as well as by different manufacturers.

Evaluations mentioned thus far have been for comparing one manufacturer's offering with that of another for similar service. If the utility desires to compare different types of service from the same or alternate manufacturers, all elements of fuel-cycle costs must be included. For example,

Slide 11

FUEL DATA FURNISHED BY MANUFACTURER

1. Percent enrichment into the reactor
2. Percent enrichment out of the reactor
3. Burn-up, megawatt-days per ton of U
4. Plutonium concentration in discharged fuel
5. Rated power level
6. Initial fuel weight
7. Weight of fuel discharged
8. Suggested reloaded schedule
9. Fabrication costs

Slide 12

FUEL DATA SUPPLIED BY UTILITY

1. Predicted plant operating factor (80 to 85%)
2. Shipping time, AEC to fabricator and fabricator to reactor (60 days)
3. Shipping time, reactor to reprocessor (30 days)
4. Conversion and fabrication plant through-put (30 MTU/month)
5. Time interval, fuel delivery to loading (60 days)
6. Spare fuel on hand at all times (1% of a core load)
7. Irrecoverable losses during fabrication, 0.2%
8. Minimum decay period, irradiated fuel, (160 days)
9. Irrecoverable U loss in reprocessing (1.0%)
10. Irrecoverable Pu loss in reprocessing (1.0%)
11. Irrecoverable U loss in conversion (0.3%)
12. Separative work ($ 28-32/Kg U)
13. Shipping charge ($6 to $9/kg U)
14. U_3O_8 cost ($6 to $8/lb)
15. Conversion UNH to UF_6 ($5.00 to $5.60/kg U)
16. Pu credit ($9/gram)
17. Conversion U_3O_8 to UF_6 ($1.60 to $2.30/kg U)
18. Reprocessing ($25 to $35/kg U)
19. Extra time, conversion plant (10 days)

EXAMPLE OF FUEL OFFERINGS

	PWR-U.S.	PWR-JAPAN	PWR-GERMANY	BWR	HWR	AGR
Fabrication						
1st Core	$132/Kg firm	$135/Kg firm	$126/Kg firm	$65/Kg Escalate(1970)	$25/Kg firm	$72/Kg firm
Reload	$105/Kg Escalate (1969)	$127/Kg firm	$101/Kg Escalate (1970)	$55/Kg Escalate	$22/Kg Escalate (1975)	$64/Kg Escalate (1970)
Core Design						
Regions	3 and 4	3	4	many-variable	shuffled	shuffled
Refueling	9 mo. & 11 mo.	11 mo.	10 mo.	12 mo.	on line	on line
Enrichment	3.3% 3 region 3.2% 4 region	3.4%	3.1%	2.65%-2.55%	Nat'l U	2.6%-2.03%
Cladding	Zr-4 He pressurized	Zr-4 He pressurized	Zr-4 no press. free standing	Zr-2 free standing	Zr	S.S.
Fuel Management						
Front End	$22,000	none	$82,000	$50,000	none	$34/Kg
Back End	$56,000	none	none	none	none	none
Financing	7%/yr+0.5% fee 5yrs-90% of fabrication cost	6%/yr for 15 yrs. 90% of fabrication cost	6½%/yr for 5yrs. 90% fabrication cost	7%/yr+0.5% fee 5yrs-90% of fabrication cost	6½%/yr for 15 yrs. 90% fabrication cost	5½%/yr-5yrs 100% fabricatio cost
Escalation	1969 60% (labor) 30% (material) 10% (firm)	none	1970 70% (labor) 30% (firm)	1970 55% (labor) 35% (material) 10% (firm)	1975 60% (labor) 40% (material)	1970 60% (labor) 40% (material)
Warrantees	Burnup-not enrichment - penalty+reward licensability at award	Average burnup - no licensability	Enrichment within 1% - average burnup limit risk $800,000	Average energy for 2+more cores-not enrichment-no proprietary info.	Burnup-150day limit risk of $1,200,000 no seismic	Burnup - no mechanical risk

EVALUATION OF REACTOR TYPES

1200 MW SIZE

		Type A	Type B	Type C
1)	Fixed charges at 7.3% (interest & amortization) 64% capacity factor	3.69 mills/KwHr	3.88 mills/KwHr	3.77 mills/KwHr
2)	Fuel Costs	1.87	1.82	1.84
3)	Interim Replacement & Property Insurance	.30	.32	.31
4)	Nuclear Liability Insurance	.06	.06	.06
5)	Operating & Maintenance Labor	.21	.22	.23
6)	Operating & Maintenance Materials & Supplies	.05	.04	.05
7)	Administrative & General Costs	.19	.19	.20
	Total Energy Cost	6.37 mills/KwHr	6.53 mills/KwHr	6.46 mills/KwHr
	Rank	(1)	(3)	(2)

if the utility wishes to compare complete-fuel cycle service with fuel-fabrication service, the utility must include its own costs and/or its fuel-management consultant's fees.

Thus far no mention has been made of the reactor's thermal output. In calculating fuel cost, it is necessary to consider the present worth of thermal output as well as of dollar costs and credits. The need for this is more easily understood by remembering that thermal output represents revenue. Revenue several years hence is not as valuable as revenue today because of the cost of money. This is particularly important when the annual thermal output is expected to vary.

Another factor to consider is the possibility of other suppliers furnishing fuel for later cores. Presently, a reactor manufacturer furnishes fuel for one to four cores under any of the types of services cited above. Subsequent cores may be obtained from other sources if the original fuel supplier will furnish adequate information for others to design and bid future reload batches.

In evaluating nuclear fuel costs, expected plant life must be considered even though fuel calculations may be based on a shorter period. This avoids the error of equating the capitalized value of, say, a 10-year fuel cost with the investment in a 30-year plant. One method of handling this disparity assumes a constant cost of fuel after the evaluation period for all offerings. The rationale for this assumption is that an outside supplier can furnish fuel for any of the alternates at the same price. A second method assumes that the cost reaches equilibrium at the end of the evaluation period and that these equilibrium costs continue throughout the plant life.

Conclusions:

The final step in the bid evaluations is the addition of capital, fuel, maintenance and operation as well as insurance costs either as annual costs or in unit power costs. The projected load factors for the plant have to be considered in the write-off of annual charges as well as factoring in the annual financing charges offered by the bidders as well as other financing arrangements for the plant. A typical summary is shown on slide (14) based upon the bid comparison of various reactor types. Although the differences may seem small for a 1200 MW plant, 0.1 mill/KwHr is equivalent to over $600,000 per year in generating cost differences.