NUCLEAR POWER AND URANIUM FUEL

REQUIREMENTS IN THE WESTERN UNITED STATES

OCTOBER, 1975

WESTERN INTERSTATE NUCLEAR BOARD
PO Box 15038, Lakewood, Colorado 80215

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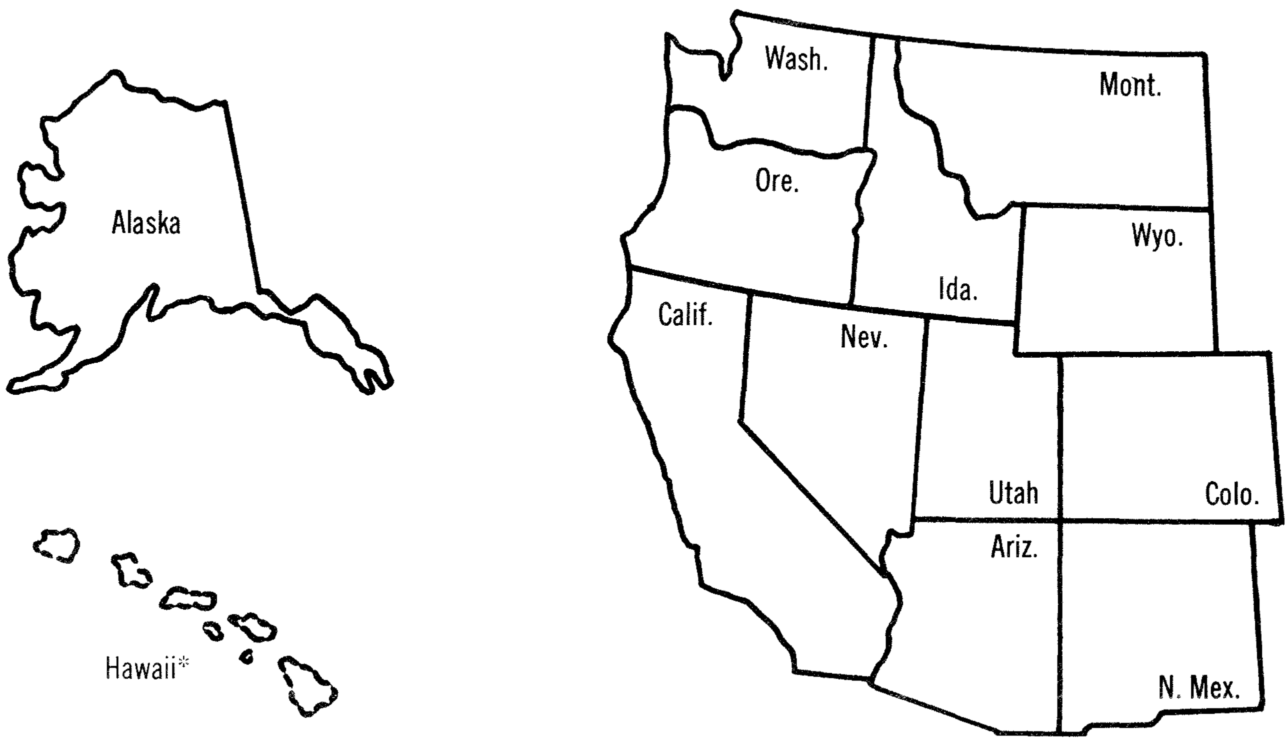
Western Interstate Nuclear Compact



*Eligible for membership, but had not enacted WINC as of June, 1975.

THE WESTERN INTERSTATE NUCLEAR BOARD (WINB) is the administrative unit for the Western Interstate Nuclear Compact, a statutory agreement among twelve (12) Western States to foster the sound and orderly utilization of nuclear energy in furthering regional development, public health and safety, and environmental quality. The Board consists of state representatives appointed by the Governor of each State.

WESTERN INTERSTATE NUCLEAR BOARD

P.O. Box 15038 **(303) 238-8383** **Lakewood, Colorado 80215**

Alfred T. Whatley .... *Executive Director*
Wyatt M. Rogers, Jr. .... *Associate Director*
Mary Ann Siekman .... *Administrative Coordinator*
Patsy Shown .... *Secretary*

FOREWORD

One of the responsibilities of the Western Interstate Nuclear Board (WINB) is to evaluate technological developments and commercial trends in the nuclear industry and the implications of such developments for the twelve (12) Western States which are statutory members of the Western Interstate Nuclear Compact.

In 1971, WINB issued a report, "Nuclear Energy in the West" describing nuclear activities and forecasts in the member States. Another report, "Energy Resource Development for the West", was released in early 1974 which discussed the overall energy resource production, and consumption patterns in the Region. The latter report examined all energy forms including nuclear energy, fossil fuels, hydroelectric, and others.

During the past year and a half, several developments have occured which tend to make obsolete some of the information contained in the above documents. First, the Region's electric energy demands have been reduced somewhat, down significantly in some areas, holding to earlier predictions in other locales. Second, delays in bringing new nuclear-electric generating plants on line is resulting in revised power plant scheduling in some utility systems. Difficulties in raising capital for new electric power facilities is a major problem area for many electric utility companies and is causing significant schedule slippages in some States.

In an attempt to determine current information on present and future nuclear power generation and related fuel requirements, WINB recently conducted a survey of the major electric utility systems in the Western Region. This report describes the results of this survey.

Alfred T. Whatley
Executive Director
Western Interstate Nuclear Board

ACKNOWLEDGEMENTS

The Western Interstate Nuclear Board gratefully acknowledges the assistance of the following companies which responded to the survey questionnaire and which provided supplemental information.

Alaska	- Alaska Power Administration
Arizona	- Arizona Public Service Company
California	- Pacific Gas and Electric Company Los Angeles Department of Water and Power Sacramento Municipal Utility District San Diego Gas and Electric Company Southern California Edison Company
Colorado	- Public Service Company of Colorado Tri-State Generation and Transmission Association
Nevada	- Nevada Power Company Sierra Pacific Power Company
New Mexico	- Public Service Company of New Mexico
Oregon	- Eugene Water and Electric Board Pacific Power and Light Company Portland General Electric Company
Utah	- Utah Power and Light Company
Washington	- Puget Sound Power and Light Company City of Seattle--Department of Lighting Washington Public Power Supply System Washington Water Power Company

WINB also appreciates the efforts of Mr. John McCurry of Exxon Nuclear Company and Dr. L. M. Richards of Atlantic Richfield Company in reviewing the draft report and in providing many helpful suggestions during the survey.

Wyatt M. Rogers, Jr.
Associate Director
(Project Director and Report Editor)

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I. INTRODUCTION

This report describes the results of the survey of nuclear power and associated uranium fuel cycle requirements in the Western Region recently conducted by the Western Interstate Nuclear Board (WINB). The survey covers the period 1975-1990 for electric energy and nuclear power except for uranium and other fuel cycle requirements which is limited to the period 1975-1985. This shorter time span coverage for fuel cycle requirements was chosen due to many uncertainties in future federal policy in such areas as uranium enrichment, plutonium utilization in light water reactors, spent fuel reprocessing, and high-level radioactive waste management. Geographically, the survey covered the twelve (12) Western States served by WINB.

Also contained in this report is information on projected national and western regional trends in electric energy demand and supply developed by the U.S. Energy Research and Development Administration (ERDA), the Western Systems Coordinating Council (WSCC), and other organizations. This information is presented as background material for assessing nuclear power in the West and nation in its proper perspective as one of several major energy sources available for general application during the period 1975-1990.

The principal objective of the WINB survey was to determine future development trends in nuclear-electric power generation and attendant fuel cycle requirements in the Western Region. In conducting this survey, WINB submitted questionnaires to major electric utility companies in the West requesting detailed information on nuclear power plants, costs, schedules, reactor types, and other pertinent information for all plants planned for operation by 1990. Also requested was data on fuel cycle requirements through the year 1985 for power plants identified in the survey. The latter included uranium feed, enrichment, fuel fabrication, spent fuel discharges and reprocessing, and plutonium recycle requirements. Appendix A is a sample questionnaire used in the survey.

All companies currently involved in nuclear power projects or those anticipating future nuclear projects responded to the inquiry. Individual data forms were compiled into the tables shown in later sections of this report.

Provisions have been made in the forecasts for additional plants that could be built within the 1975-1990 time period but which were not identified by individual companies.

II. SURVEY SUMMARY

Principal findings and conclusions from the WINB survey are summarized below:

A. Electric Power Growth in the West

Within the Western Region, electric generating capacity is projected to grow at an average annual rate of approximately 6 per cent during the period 1975-1984, and at a slightly lower annual rate to the year 1990. Generating capacity of the interconnected grid systems in the West is expected to increase from the 1975 total of 94,461 megawatts (MWe) to 161,883 MWe by 1984. Forecasts to 1990 indicate a total electric generating capacity of about 190,000 to 200,000 MWe.

The "mix" of electric generating plants will change markedly from the current emphasis on hydro-electric and fossil fuels to a more diversified one in which coal-fired and nuclear power plants will furnish a much larger fraction of the Region's electricity. Sharp reductions in the use of oil and natural gas as power plant fuels are expected. Hydro-electric power will grow in absolute terms, but will decline in relative importance. Other exotic electric technologies (geothermal, solar, wind, nuclear fusion, tidal energy, ocean gradients, magnetohydrodynamics, etc.) are not expected to achieve widespread application during the 1975-1990 time period.

B. Nuclear Power in the Region

Five (5) nuclear power units are licensed for operation in the West as of August, 1975. An additional 25 nuclear power plants are in various stages of planning and construction. Over and above these 30 plants are ten (10) other units planned by the utilities but not announced as to site, type of plant, unit size, etc. Further, some 10 to 12 additional nuclear power plants may be needed to reach the projected nuclear generating capacity in the West by 1990. This brings to 50-52 the total nuclear power units in the West by 1990.

	No. Units	Total MWe
In operation or licensed	5	2,596
Under construction or planned	25	30,346
Planned but not announced	10	12,970
Forecasted but not identified	10 to 12	14,688
Totals	50 to 52	60,600

The 30 nuclear reactors already announced in the Region are to be situated on 14 separate sites in five (5) Western States. At an average of 3 to 4 reactors per site, the additional 20 to 22 reactors forecasted but not announced will require 5 to 7 additional sites. Thus, by 1990, about 19 to 21 nuclear power plant sites may be needed in the WINB Region.

Aggregate capital investment for the 30 nuclear power plants publicly announced is expected to reach approximately $23.3 billion (in 1974 dollars). Capital investment for the 20 to 22 additional forecasted units is conservatively estimated at $27.7 billion (again in 1974 dollars), bringing the total to $51 billion by 1990.

C. Nuclear Fuels Requirements

Expansion in the "nuclear fuel cycle" (uranium mining, milling, conversion, enrichment, fuel fabrication, spent fuel reprocessing, and radioactive waste management) is expected to be needed to support both regional and national nuclear power generation. Since the Western Region is the locale for about 85% of the nation's proven uranium reserves, major growth in uranium mining and milling in the West is projected over the next decade.

Regional uranium enrichment requirements may justify construction of one or more enrichment plants in the West by around 1984-1986. If larger market regions are served, such plants may be needed somewhat earlier.

Uranium conversion plants represent another possibility for development in the West by around 1978-1980, the time when existing plants outside the Region are expected to be operating at full capacity.

Nuclear spent fuel reprocessing, as an industry within the nuclear fuel cycle, is currently facing uncertainties as to future federal policy concerning the recycling of plutonium into mixed oxide fuels for light water reactors. If Pu recycle is allowed within the near-term future, there appears to be a need for several reprocessing plants during the next two decades. Due to the relatively small reprocessing needs for Western nuclear power plants during the period 1975-85, such facilities may not be justified in the West until at least the late 1980's. On the other hand, if Pu recycle is prohibited, there may be an increased requirement for uranium mining, milling, conversion, enrichment, and fuel fabrication.

D. Implications for Government and Industry

1. Uranium exploration and development

To meet the uranium fuel requirements shown in this and other surveys, it will be necessary to locate and develop additional uranium reserves. ERDA's National Uranium Resource Evaluation program (NURE), carried out at a timely pace, could contribute substantially to private industry and state efforts to find, assess, and develop new uranium resources. State geological and natural resources agencies should be encouraged to expand exploration efforts in concert with industry and federal agencies.

2. Planning and siting of nuclear facilities

Electric utility firms; state energy, siting, and utility regulatory agencies; land-use, development, and other pertinent organizations having an interest in planning and siting of energy facilities should develop improved methods for determining siting requirements for nuclear and other energy facilities, transmission lines, and supporting industries. Improvements will be needed in siting and planning criteria, site certification procedures, and intergovernmental cooperation to facilitate timely and equitable decision-making.

Planning, economic development, and regulatory agencies should develop and maintain an awareness of siting requirements, socio-economic effects, and environmental considerations involved in future nuclear facilities development.

3. Federal nuclear energy policy

Policy decisions concerning uranium enrichment, spent fuels reprocessing, plutonium recycle, radioactive waste management, and related issues should be resolved at an early date to permit timely planning of future nuclear fuel supply.

Federal regulatory policy related to siting and licensing of nuclear facilities should provide for a high degree of cooperation with the states. Such cooperation might include provisions for joint or consolidated State-federal public hearings during the application review process, development of common State-federal siting criteria, and other measures intended to expedite governmental decision-making and regulatory processes.

Issues regarding the adequacy of safeguards for "special nuclear materials" (SNM; usually regarded as strategic quantities of plutonium, U-233, and highly enriched U-235) should be resolved at an early date to facilitate planning by state and local governments and the private sector.

III. NATIONAL NUCLEAR POWER FORECASTS

Recent projections by ERDA[1] provide four (4) scenarios for energy, electric power, and nuclear power to the year 2000. For electric energy futures, these scenarios are described as follows:

"High Case: electricity production resumes growth near historic rate of 7% per annum through the middle 1980's, then declines 6.4% per annum growth through the end of the century. Electric energy inputs increase to 50% of total resource consumption by 2000.

Moderate/High Case: This case postulates within the moderate energy case, while rising electricity prices cause reductions in expected future demands, the availability and prices of other fuels are such as to cause continuing substitution of electric energy for direct energy uses. Kilowatt-hour production grows at a 6.25% per annum rate through 1985 and at a 5.85% per annum rate through the last 15 years of the century.

Moderate/Low Case: Within the moderate energy case, the substitution of electric energy for direct energy use occurs at a more modest rate, reflecting that relative prices for electricity are not so advantageous and other fuels are more readily available. Kilowatt-hour production grows at 6.0% per annum through 1985 then declines to a 5.4 % per annum growth through 2000.

Low Case: The stringent conservation measures in the total energy situation are combined with an electric energy situation that continues to capture an increasingly larger portion of final demands. While kilowatt-hour growth is only 5.8% through 1985 and an even lower 4.75% for the latter part of the century, electric energy inputs rise to account for 51% of total energy inputs."

Projected electricity growth for ERDA's four scenarios is summarized below in Table A.

Table A

Electricity Growth (Billion kilowatt-hours)

	1973	1980	1985	1990	2000
High	1878	2780	3905	5290	9880
Moderate/High	1878	2675	3660	4820	8600
Moderate/Low	1878	2630	3570	4660	7925
Low	1878	2570	3500	4400	7020

Table B provides a forecast of per capita energy consumption for the period 1973 (actual) to 2000. Again, four scenarios are shown, except for population data.

In Table C, total national energy, electricity, and electric generating capacity by major types of plants are shown to the year 2000. ERDA's forecast shows a somewhat slower rate of nuclear power growth than did earlier forecasts reflecting a recognition of prevailing economic and energy conditions. By the year-end 1975, nuclear power capacity is expected to supply 37,200 to 43,300 MWe, or about 7.4 to 8.8 per cent of the total. Nuclear generating capacity is projected to rise to 24 to 48 per cent in 1990, and to around 39 to 50 per cent in the year 2000.

National projections for uranium feed, enrichment (separative work), "yellowcake" (U_3O_8), spent fuel reprocessing,

Table B

FORECAST OF ENERGY AND ELECTRICITY IN THE UNITED STATES
Per Capita

		1973	1980	1990	2000
TOTAL ENERGY (millions Btu)	Low	358	378	430	499
	Moderate Low	358	393	488	643
	Moderate High	358	393	488	643
	High	358	418	545	720
ENERGY FOR ELECTRICITY (millions of Btu)	Low	93.7	117	175	254
	Moderate Low	93.7	120	186	287
	Moderate High	93.7	122	192	311
	High	93.7	127	211	357
ELECTRIC ENERGY (kilowatt-hours)	Low	8900	11270	17500	25900
	Moderate Low	8900	11540	18600	29200
	Moderate High	8900	11730	19200	31700
	High	8900	12200	21100	36500
POPULATION (millions)		211	228	251	271

Source: U. S. Energy Research and Development Administration, February, 1975.

Table C

TOTAL ENERGY DEMAND, ELECTRIC ENERGY, AND ELECTRIC GENERATION
BY TYPE OF FACILITIES - 1973 TO 2000
UNITED STATES

	Case	1973	1980	1990	2000
TOTAL ENERGY (10^{15}BTU)	Low	75.56	86.1	107.9	135.3
	Moderate/Low	75.56	89.7	122.6	174.3
	Moderate/High	75.56	89.7	122.6	174.3
	High	75.56	95.3	136.8	195.0
ELECTRIC ENERGY (10^{15}BTU)	Low	19.8	26.7	44.0	68.8
	Moderate/Low	19.8	27.3	46.6	77.7
	Moderate/High	19.8	27.8	48.2	84.3
	High	19.8	28.9	52.9	96.8
KILOWATT HOURS (10^{9}KWR)	Low	1878	2570	4400	7020
	Moderate/Low	1878	2630	4660	7925
	Moderate/High	1878	2675	4820	8600
	High	1878	2780	5290	9880
TOTAL ELECTRICAL CAPACITY (GWE)	Low	436.0	605.0	980.0	1550.0
	Moderate/Low	436.0	620.0	1040.0	1750.0
	Moderate/High	436.0	630.0	1075.0	1900.0
	High	436.0	655.0	1180.0	2180.0
NUCLEAR GEN. CAPACITY	Low	18.4	70.5	285.0	625.0
	Moderate/Low	18.4	76.0	340.0	800.0
	Moderate/High	18.4	82.0	385.0	1000.0
	High	18.4	92.0	470.0	1250.0
HYDRO/PUMPED STORAGE GEN. CAPACITY	Low	61.3	72.5	99.0	125.0
	Moderate/Low	61.3	74.5	107.0	150.0
	Moderate/High	61.3	74.5	107.0	150.0
	High	61.3	77.5	114.0	165.0
INTERNAL COMBUST./GAS TURBINE	Low	37.8	51.0	64.0	85.0
	Moderate/Low	37.8	53.1	70.0	105.0
	Moderate/High	37.8	53.1	70.0	105.0
	High	37.8	55.1	75.0	115.0
FOSSIL (COAL, OIL, GAS)	Low	318.5	411.0	547.0	745.0
	Moderate/Low	318.5	416.4	533.0	695.0
	Moderate/High	318.5	420.4	513.0	645.0
	High	318.5	430.4	521.0	650.0

Source: "Total Energy, Electric Energy, and Nuclear Power Projections, United States", U. S. Energy Research and Development Administration, February, 1975.

Table D

FORECAST OF URANIUM FUEL CYCLE - UNITES STATES - 1975 to 2000

		UF-6 Conversion (MT of U)		Fuel Fabric. (MT of heavy metal)		U-Enrichment (Sep. Work) (Kilograms)		Spent Fuel Reprocessing (Metric Tons Heavy Metal)
Year	Scenario	Nat'l. U	Recovered Uranium	LWR UO_2	LWR Mix. OX	.20%	.30%	LWR Mixed OX
1975	High	8,000	0	1,560	0	7,000	5,500	0
	High/Mod.	7,100	0	1,180	0	5,300	4,200	0
	Low/Mod.	5,400	0	1,100	0	4,900	3,900	0
	Low	5,200	0	970	0	4,500	3,600	0
1980	High	22,800	2,100	5,000	110	67,200	53,300	2,200
	High/Mod.	18,800	2,100	4,100	117	13,800	10,900	2,200
	Low/Mod.	16,600	2,100	3,600	102	12,000	9,500	2,200
	Low	14,300	2,100	3,000	103	10,600	8,400	2,200
1990	High	80,600	8,900	13,400	1,950	430,900	344,000	9,200
	High/Mod.	64,500	7,100	10,800	1,500	46,700	37,300	7,300
	Low/Mod.	54,500	6,200	9,200	1,350	39,800	31,900	6,400
	Low	44,400	5,500	7,600	1,190	31,900	25,500	5,500
2000	High	173,700	21,600	28,500	890	1,403,500	1,123,900	22,100
	High/Mod.	132,200	16,800	21,800	800	101,100	81,100	17,100
	Low/Mod.	98,200	13,400	16,400	1,090	75,600	60,700	13,700
	Low	70,600	10,700	12,100	1,380	55,300	44,400	10,900

Notes: Plutonium recycle assumed to begin in 1981.
Data for HTGR and FBR omitted.
Data shown for LWR only.

Source: U. S. Energy Research and Development Administration, February, 1975.

and fuel fabrication are shown in Table D. These forecasts correspond to the projections for national nuclear power growth shown in Table C.

Several major issues which could have a strong influence on national nuclear power and fuel cycle growth are currently under intensive federal review. These include: (a) the extent of federal and private participation in future uranium enrichment operations; (b) reactor safety adequacy; (c) plutonium recycle for light water reactors; (d) nuclear safeguards for SNM; (e) spent fuel reprocessing technology; (f) radioactive waste management methods; and (g) development of the liquid metal fast breeder reactor (LMFBR).

In addition, problems of public understanding and acceptance of nuclear power in some areas are persistent and could significantly affect the rate of future nuclear development.

Another problem area potentially affecting nuclear power growth is the complex governmental regulatory structure imposed by the Atomic Energy Act, the National Environmental Policy Act, and a variety of other federal and state laws and regulations. Remedies to the lengthy and often overlapping and duplicative processes of reviewing and approving nuclear facilities licensing applications by federal, State, and local regulatory agencies are under study by several government and non-government organizations. Legislation has been introduced in the past two sessions of Congress which would streamline the siting-licensing review process, thus facilitating federal and State decision-making, reducing public costs of nuclear power regulation, and lowering "front-end" design costs and working capital requirements by fostering standardization of reactor designs and by shortening of the lead time for plant approval and construction. Currently, a 10 year lead time is typical for bringing a nuclear power plant on line. Only about one-half of this period constitutes actual construction.

IV. ELECTRICITY AND NUCLEAR ENERGY IN THE WESTERN REGION

A. Western Regional Electric System

The electric power supply system within the Western United States consists of numerous electric utility companies which are linked with other companies in several regional power pools. The power pools, in turn, are inter-connected into a large electric transmission system operating throughout the Western States and parts of British Columbia. This large, interconnected system comprises the Western Systems Coordinating Council, one of nine regional electric reliability organizations in the nation. By coupling the power resources of individual utility systems and regional power pools into the region-wide WSCC system, reliability of electric power service is enhanced and certain economies are made possible through power sharing, "wheeling"; and other cooperative schemes. Figure 1 describes the WSCC region and the major electric transmission corridors.

WSCC and its member utility systems prepare periodic reports on regional electric loads, demand, generating capacity, intra-regional power flows, reliability and stability, and related fuel information. This regional data is transmitted to the National Electric Reliability Council and the Federal Power Commission as required by the national Electric Reliability Act.

Since the WSCC constitutes a "natural" region for purposes of electric supply planning, much of the information regarding Western regional electric generating capacity is based on recent WSCC data.

B. WSCC Electric Generation Forecast

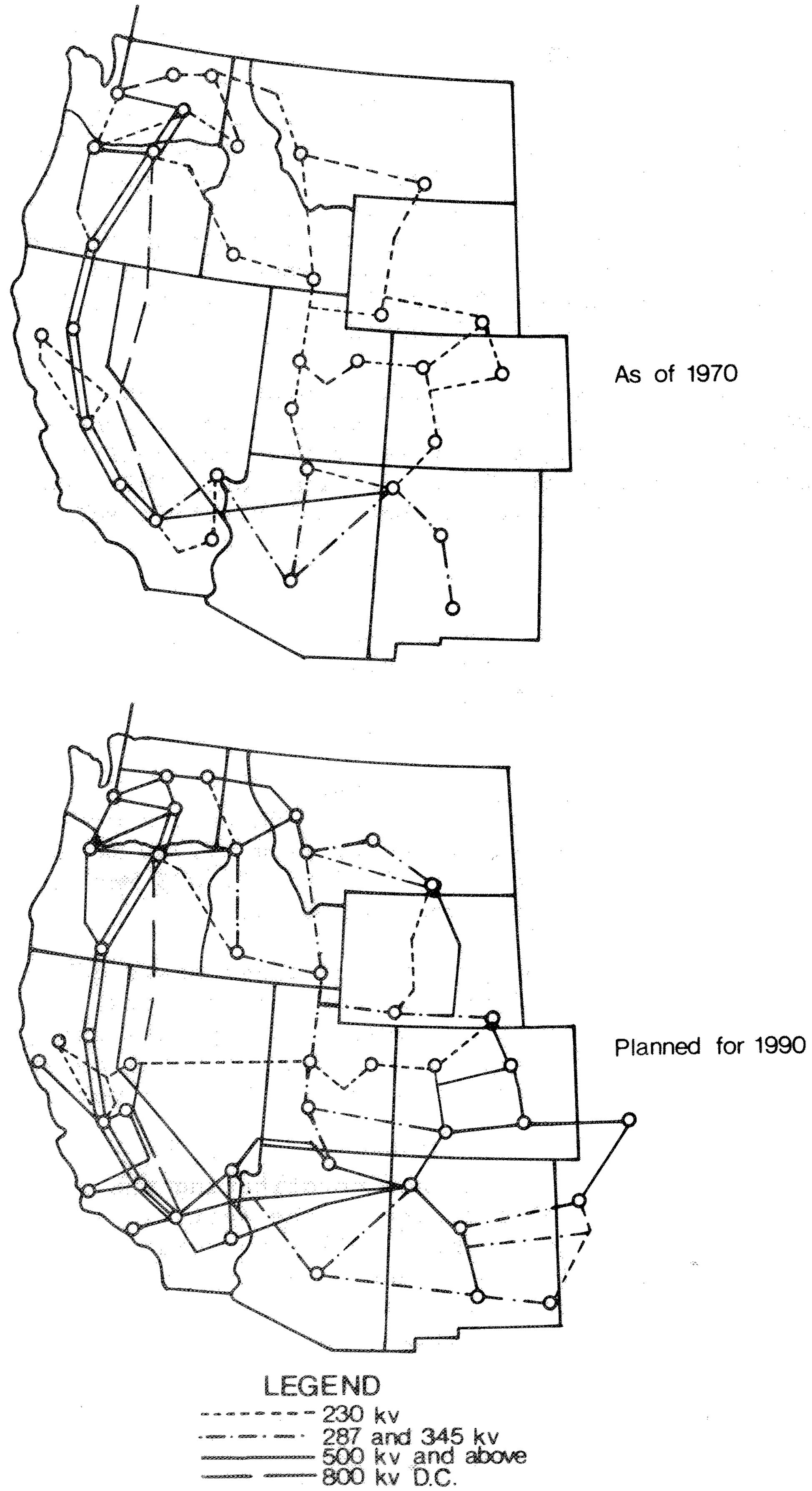
Regional projections by WSCC indicate a growth in overall electric generating capacity from 87,790 megawatts electric (MWe) in December, 1974 to 161,883 MWe in 1984, a growth of about 6 per cent annually.[2]

It should be noted that coal-fired power generation is expected to grow from 13.5 per cent of total in 1974 to about 23.1 per cent by 1984. Power plants using oil and natural gas comprise 31 per cent of total generation in 1974, but are expected to decline to 16.6 per cent by 1984.

Hydro-electric power, now constituting the single largest source of electricity in the West, is expected to grow in absolute terms, but decline in relative importance from the current 47.1 per cent to around 35.2 per cent by 1984. The scarcity of good sites for new dams and associated hydro-electric facilities and growing opposition by

Figure 1

ELECTRIC TRANSMISSION IN THE WEST REGION



conservation groups to large, new reservoir projects are primary reasons for the expected relative decline in hydro-electric generation.

Geothermal energy is under intensive study as a potential power source in the West. While a number of small geothermal power projects are anticipated over the next decade and beyond, current forecasts indicate that only a small fraction of total generation will be from geothermal sources during the forecast period.

Pumped-storage, combustion turbines, combined cycle and other electric sources comprise 7% in 1974 and will grow to about 11% in 1984, according to WSCC data.

Solar energy is expected to grow in regional importance for space heating and cooling of buildings, but is not expected to contribute an appreciable amount to the electric power systems by 1990.

Nuclear energy in 1974 comprised only 1.5 per cent of the West's electric power capacity. However, nuclear power is projected to grow significantly during the forecast period, rising from 2,596 Mwe (3%) in 1975, to 28,700 Mwe (18.5%) in 1985, and to 60,600 Mwe (31.9%) in 1990. This forecast is lower than the 76,797 Mwe estimates for 1990 contained in the 1971 WINB report, "Nuclear Energy in the West",[3] and other earlier forecasts,[4] reflecting a slightly reduced electric demand forecast and delays in nuclear power plant construction.

C. Nuclear Power Forecast--Western Region

Five nuclear power plants are now in operation in the Western Region with an aggregate electric generating capacity of 2,596 MWe. These facilities are listed below.

Table E

Existing Nuclear Power Plants in the Western Region*

State	Plant Name/Site	Generating Capacity (MWe)	Date of Operation
California	Humboldt Bay	63	1963
California	San Onofre-1	430	1968
California	Rancho Seco	913	1975
Colorado	Fort St. Vrain	330	1975
Washington	NPR	860	1966
		2,596	

*As of June, 1975

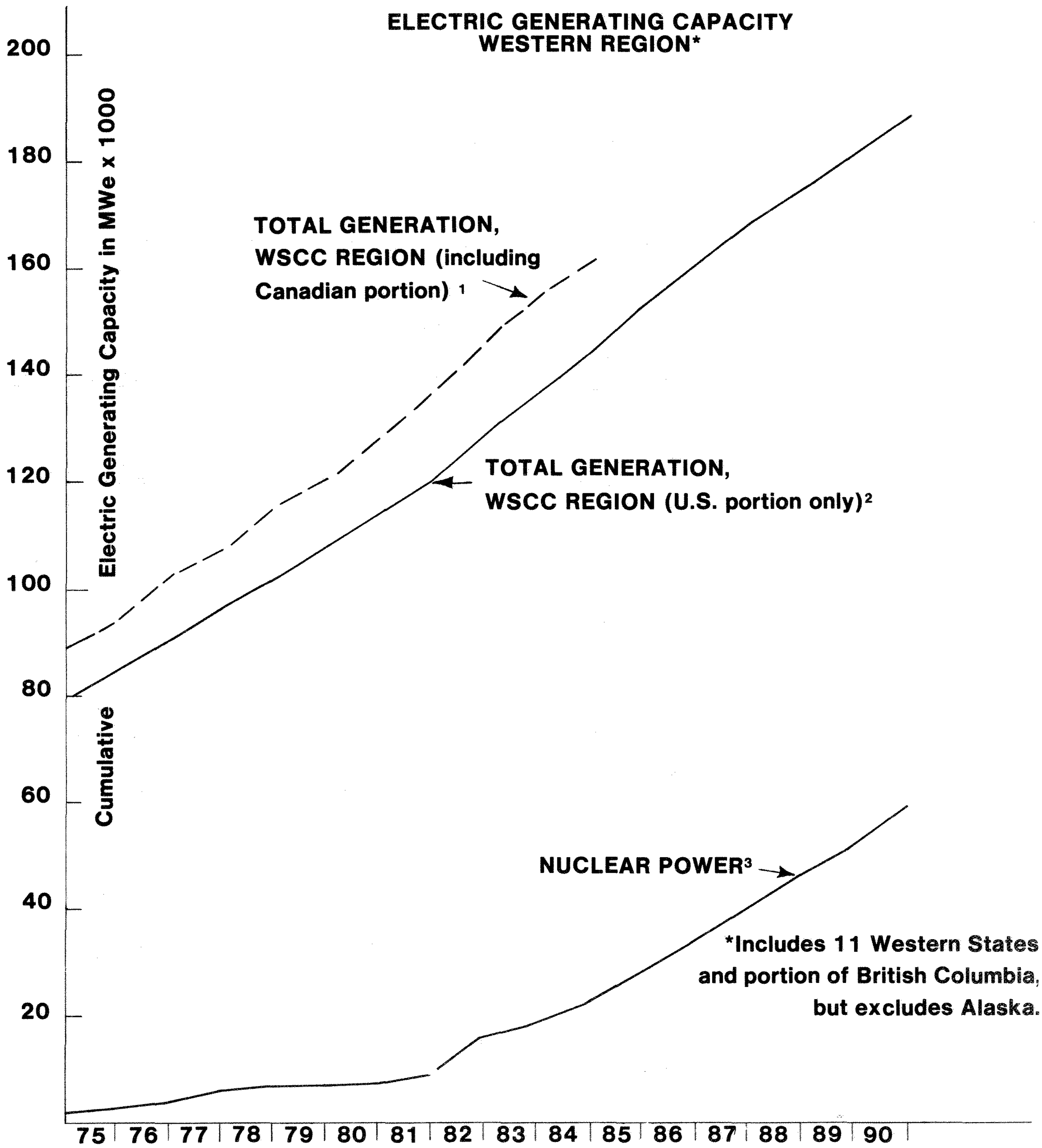
TABLE F

ELECTRIC GENERATING CAPACITY
WSCC REGION
1974-1984

Resource Type	Dec. 31, 1974 MWe	Dec. 31, 1974 % of Total	1984 MWe	1984 % of Total
Fossil-coal	11,823	13.5%	37,336	23.1%
Fossil-oil or gas	27,161	30.9	26,974	16.6
Nuclear	1,353	1.5	22,939	14.2
Hydro	41,297	47.1	57,030	35.2
Hydro-pump storage	1,106	1.3	3,431	2.1
Combustion turbine	4,050	4.6	6,724	4.2
Diesel	263	.3	263	.1
Combined cycle	304	.3	4,071	2.5
Geothermal	396	.5	1,568	1.0
Undefined	37	.0	1,547	1.0
TOTALS	87,790	100.0	161,883	100.0

Source: WSCC, May, 1975

Figure 2



[1]Western Systems Coordinating Council, May 1975
[2]Western Systems Coordinating Council, May 1975
[3]Western Interstate Nuclear Board, July 1975

Table G

ELECTRIC GENERATING CAPACITY

WSCC REGION - BY YEAR
(in Megawatts electric)

	Nuclear Additions	Nuclear Total(1)	Total Additions	Total Capacity(2)
1974	--	1,353	NA	87,790
1975	1,243	2,596	6,671	94,461
1976	2,254	4,850	7,608	102,069
1977	1,150	6,000	5,653	107,722
1978	1,100	7,100	7,739	115,461
1979	--	7,100	5,957	121,418
1980	1,220*	7,500	7,461	128,879
1981	2,380	9,880	8,853	137,732
1982	6,178	16,058	10,607	148,339
1983	2,540	18,598	8,575	156,914
1984	4,758	23,356	4,969	161,883

*400 MWe added; 820 is retired (NPR).

(1) WINB Survey NA--not available
(2) WSCC Plan -- May, 1975.

Figure 3

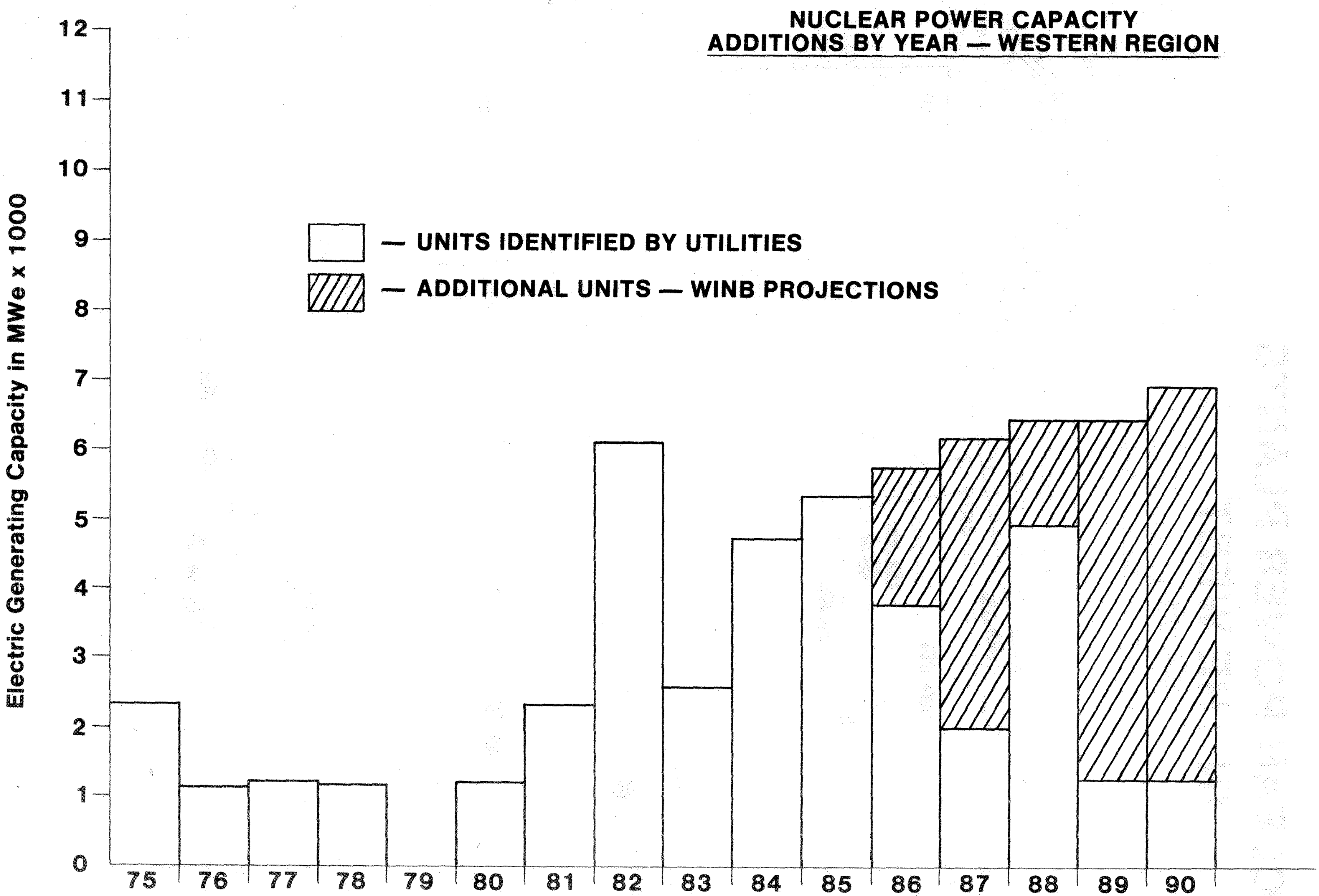
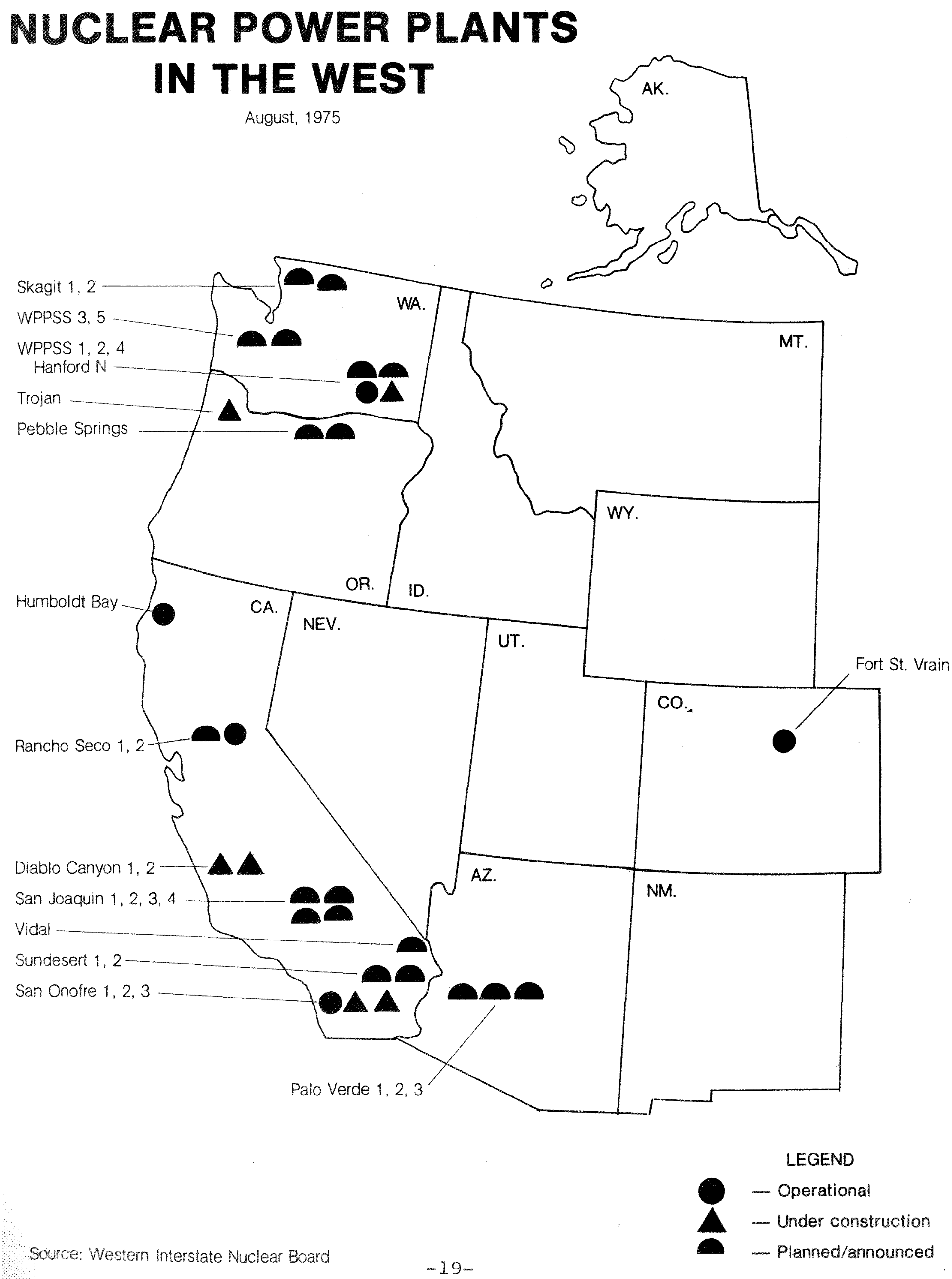

NUCLEAR POWER CAPACITY
ADDITIONS BY YEAR — WESTERN REGION
— UNITS IDENTIFIED BY UTILITIES
— ADDITIONAL UNITS — WINB PROJECTIONS
Electric Generating Capacity in MWe x 1000
0
1
2
3
4
5
6
7
8
9
10
11
12
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90

Figure 4


NUCLEAR POWER PLANTS
IN THE WEST
August, 1975
AK.
WA.
MT.
WY.
OR.
ID.
CA.
NEV.
UT.
CO.
AZ.
NM.
Skagit 1, 2
WPPSS 3, 5
WPPSS 1, 2, 4
Hanford N
Trojan
Pebble Springs
Humboldt Bay
Rancho Seco 1, 2
Diablo Canyon 1, 2
San Joaquin 1, 2, 3, 4
Vidal
Sundesert 1, 2
San Onofre 1, 2, 3
Palo Verde 1, 2, 3
Fort St. Vrain
LEGEND
— Operational
— Under construction
— Planned/announced
Source: Western Interstate Nuclear Board

As shown in Tables F, G, H, and I, nuclear power capacity is projected to grow at an accelerating rate in the West during the period 1975-1990. Total generation by nuclear sources is expected to be about 7,500 MWe in 1980, 23,356 MWe in 1984, and around 60,700 MWe in 1990.

To date, 30 nuclear power reactors totalling 32,942 MWe have been announced by the Western electric utilities. These include the five (5) existing plants shown earlier. Table H provides a detailed listing of these units.

Aggregate capital investment for these 30 plants is estimated by the utilities at $23.3 billion (1974) dollars). Capital costs for these units range from an average of $345 per kilowatt of installed capacity in 1975 to $684 per kilowatt for first operation in 1985.

Since normal licensing and construction lead times for nuclear units are on the order of ten (10) years, and since the forecast period of this survey extends to the year 1990, utilities participating in this survey were asked to identify all nuclear projects up to the year 1990. Some ten (10) additional units were identified by the utilities, but are not itemized in this report in order to respect the confidential nature of this information.

Provision has been made in the forecast for additional units which may be constructed in the post-1985 period, but which have not been specifically identified as to reactor type, unit size, siting, and date of operation.

It should be noted that several areas in the Rocky Mountain region are expected to be potential sites for nuclear power plants during the next 15 years. The West Coast, Northwest, and Southwest areas are, however, expected to be the locations for most future nuclear units.

D. Nuclear Fuel Requirements in the West

Figure 5 ("The Nuclear Fuel Cycle") shows the sequential steps in processing uranium ore into uranium fuel, and the recycling steps in extracting useable uranium and plutonium from irradiated reactor fuel. First, uranium ore is beneficiated into "yellowcake" (U_3O_8) in which impurities are

Table H

NUCLEAR POWER PLANTS
IN THE WESTERN REGION
(Includes only plants publicly announced as of August, 1975)

STATE	PLANT NAME	UTILITY COMPANY	GEN. CAPACITY (MWe)	DATE OF OPERATION	REACTOR TYPE
Arizona	Palo Verde	Arizona Public Service Co.	1,270	1982	PWR
"	Palo Verde	Salt River Project, N. M.	1,270	1984	PWR
"	Palo Verde	Public Service Co., El Paso Electric Co., Arizona Electric Power Coop.	1,270	1986	PWR
California	San Joaquin	Los Angeles Dept. of Water and Power and several other utilities	1,300	1983	
"	"		1,300	1985	
"	"		1,300	1986	
"	"		1,300	1988	
"	Humboldt Bay	Pacific Gas and Electric	63	1963	BWR
"	Diablo Canyon 1	" " " "	1,120	1976	PWR
"	Diablo Canyon 2	" " " "	1,150	1977	PWR
"	Rancho Seco	Sacramento Municipal Utility District	913	1975	PWR
"	" "		1,100	1984	
"	San Onofre 1	Southern California Edison Company, San Diego Gas & Elec.	430	1968	PWR
"	" " 2		1,140	1981	PWR
"	" " 3		1,140	1982	PWR
"	Vidal 1	Southern California Edison Company	1,540	1988	HTGR
"	Sundesert	San Diego Gas and Electric Company	950	1985	PWR
"	"		950	1988	PWR

Table H (Cont.)

STATE	PLANT NAME	UTILITY COMPANY	GEN. CAPACITY (MWe)	DATE OF OPERATION	REACTOR TYPE
Colorado	Fort St. Vrain	Public Service Co. of Colorado	330	1975	HTGR
Oregon	Trojan	Portland General Electric Co., Eugene Water and Electric Board, Pacific Power and Light	1,130	1976	PWR
"	Pebble Springs	Portland General Electric Co., and Pacific Power and Light	1,260	1982	PWR
"	" "	Portland General Electric Co.	1,260	1985	PWR
Washington	Skagit-1	Puget Sound Power and Light Co., Pacific Power and Light, Washington Public Power Supply System, the Washington Water Power Co.	1,288	1982	BWR
"	Skagit-2	" " " "	1,288	1985	BWR
"	WNP-1	Washington Public Power Supply System	1,220	1980	PWR
"	WNP-2	" " " "	1,100	1978	BWR
"	WNP-3	" " " ", and other utilities	1,240	1981	PWR
"	WNP-4	Washington Public Power Supply System	1,220	1982	PWR
"	WNP-5	" " " ", and other utilities	1,240	1983	PWR
"	NPR	Washington Public Power Supply System	860	1966	Dual-purpose
			32,942		

removed. Second, "yellowcake" is shipped to a "uranium conversion" plant where the U_3O_8 is converted into uranium hexafluoride (UF_6). This step is a prerequisite to enriching the fuel in the fissionable isotope U-235.

Next, the UF_6 is transported to an uranium enrichment facility in which the U-235 and U-238 isotopes are separated via the gaseous diffusion process. Natural uranium contains only 0.7% U-235; the remaining 99.3% is U-238. Modern nuclear power plants require enriched fuel with 2% to 4% U-235. (By contrast, nuclear weapons require U-235 content of well above 90%).

From the enrichment step, the enriched material is converted into the metallic oxide form, UO_2, from which it is fabricated into the hundreds of fuel rods and assemblies which, with various control mechanisms, comprise the "core" of the reactor.

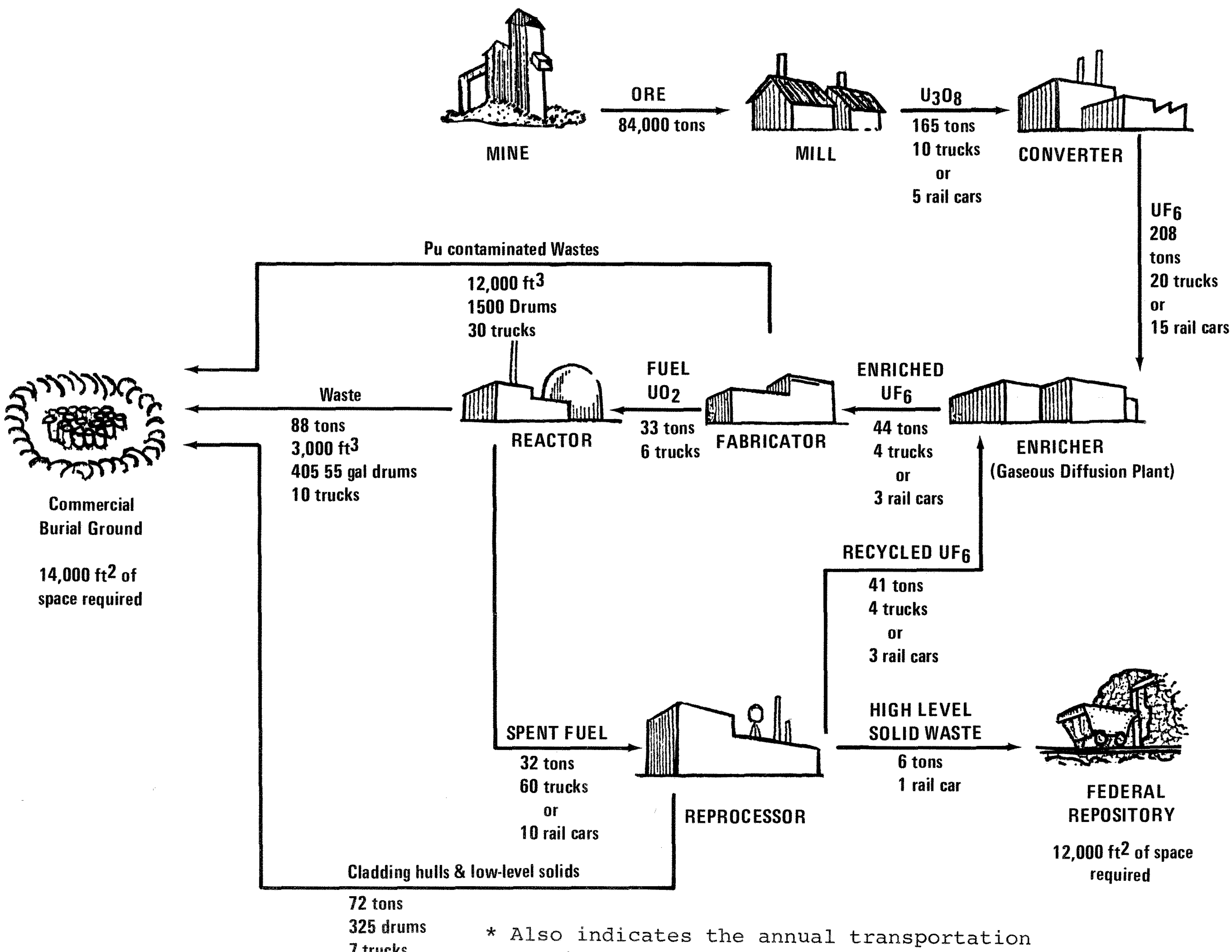
After irradiation in the reactor for periods of one to three years, "spent" nuclear fuel is removed from the core and, after temporary storage in the reactor's spent fuel pool to allow heat and radioactivity to decay to lower levels, is shipped to a nuclear spent fuels reprocessing plant. The reprocessing step accomplishes the dual purposes of: (1) extracting and separating uranium, "bred" plutonium, and other useable isotopes for subsequent recycling into replacement fuel and other uses; and (2) separating radioactive fission products ("radwastes") for storage or disposal.

Nuclear fuel requirements for the period 1975 to 1985 are tabulated in Table I and Figures 6 and 7. All figures are annual requirements taken from the respondents to the WINB survey questionnaire.

Uranium feed requirements are projected to increase from around 1,215 metric tonnes in 1975 to about 5,300 M. T. annually by 1985. Enriching needs will vary from 375 to 967 x 10^3 "separative work units" (SWU) annually in the latter 1970's, increasing gradually to about 2,500 x 10^3 SWU per year by 1985. Fuel fabrication and spent fuel discharges show similar trends during the forecast period.

Figure 5

NUCLEAR FUEL CYCLE *



* Also indicates the annual transportation requirements for one 1000 MWe light water reactor.

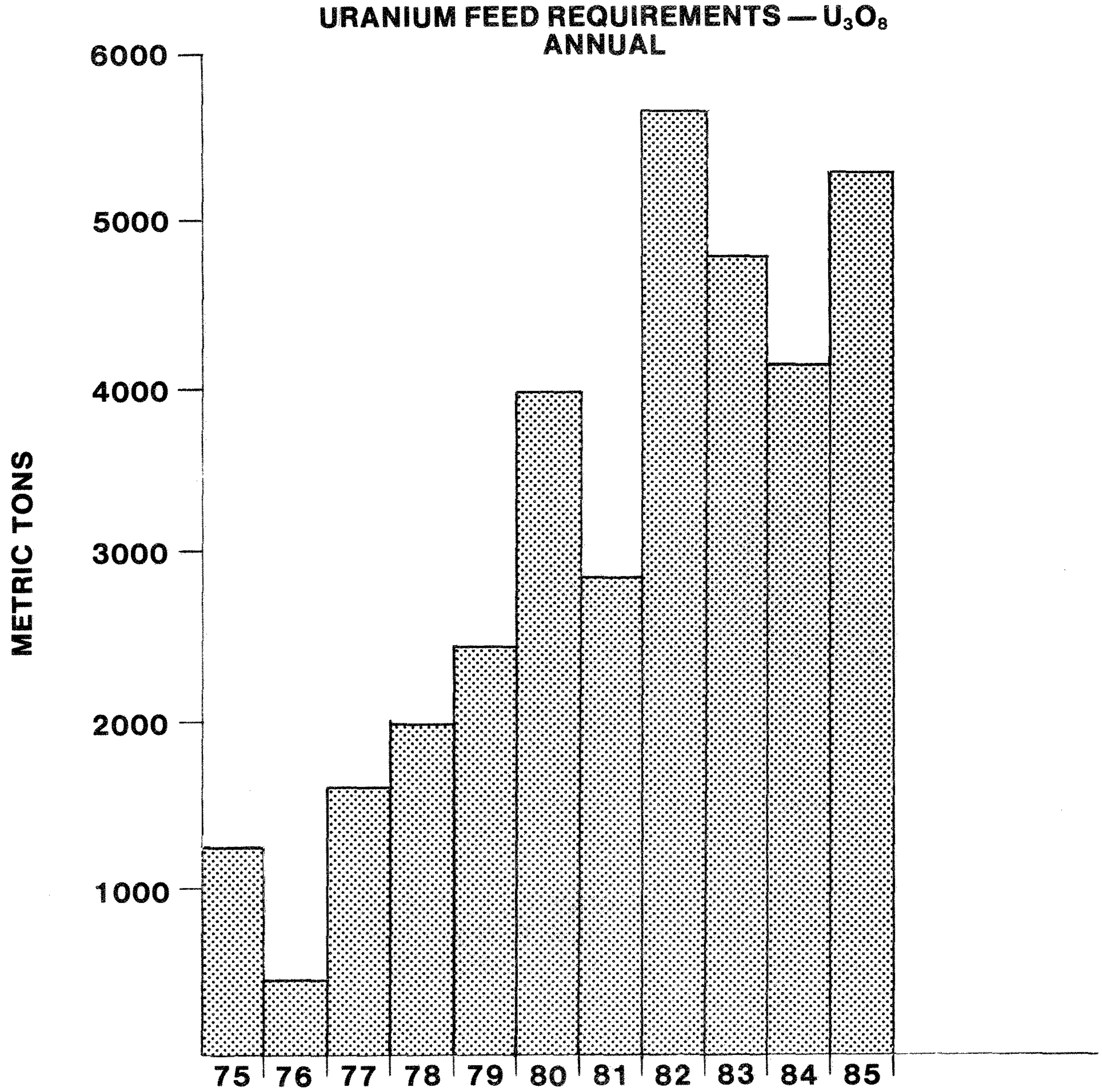
Table I

NUCLEAR POWER AND RELATED FUEL CYCLE REQUIREMENTS
WESTERN REGION -- 1975 to 1990

YEAR	CUMULATIVE: TOTAL ELECTRIC GENERATING CAPACITY (MWe)**	CUMULATIVE: NUCLEAR-ELECTRIC GENERATING CAPACITY (MWe)	ANNUAL: NUCLEAR CAPACITY ADDED IN YEAR (MWe)	ANNUAL: URANIUM FEED M. T.	ANNUAL: ENRICHING REQ'D. 1,000's S.W.U.	ANNUAL: URANIUM FUEL FAB. M. T. U.	ANNUAL: SPENT FUEL DISCHARGED M. T. U.
1975	94,461	2,596	1,243	1,215	623	181	33
1976	102,069	4,850	2,254	444	375	48	43
1977	107,722	6,000	1,150	1,609	967	281	85
1978	115,461	7,100	1,100	1,983	826	210	147
1979	121,418	7,100	--	2,467	723	321	129
1980	128,879	7,500	1,220*	3,942	1,409	464	151
1981	137,732	9,880	2,380	2,826	2,012	592	155
1982	148,339	16,058	6,178	5,633	1,990	546	217
1983	156,914	18,598	2,540	4,770	2,386	709	375
1984	161,883	23,356	4,758	4,132	2,128	705	460
1985	NA	28,676	5,320	5,301	2,535	758	478
1986	NA	34,476	5,800	NA	NA	NA	NA
1987	NA	40,676	6,200	NA	NA	NA	NA
1988	NA	47,176	6,500	NA	NA	NA	NA
1989	NA	53,676	6,500	NA	NA	NA	NA
1990	NA	60,676	7,000	NA	NA	NA	NA

*400 MWe net added; 820 MWe replaced. NA -- Not Available
**Total electric generating capacity data from WSCC. All other data taken from WINB survey.

Figure 6


URANIUM FEED REQUIREMENTS — U_3O_8
ANNUAL
METRIC TONS
6000
5000
4000
3000
2000
1000
75
76
77
78
79
80
81
82
83
84
85

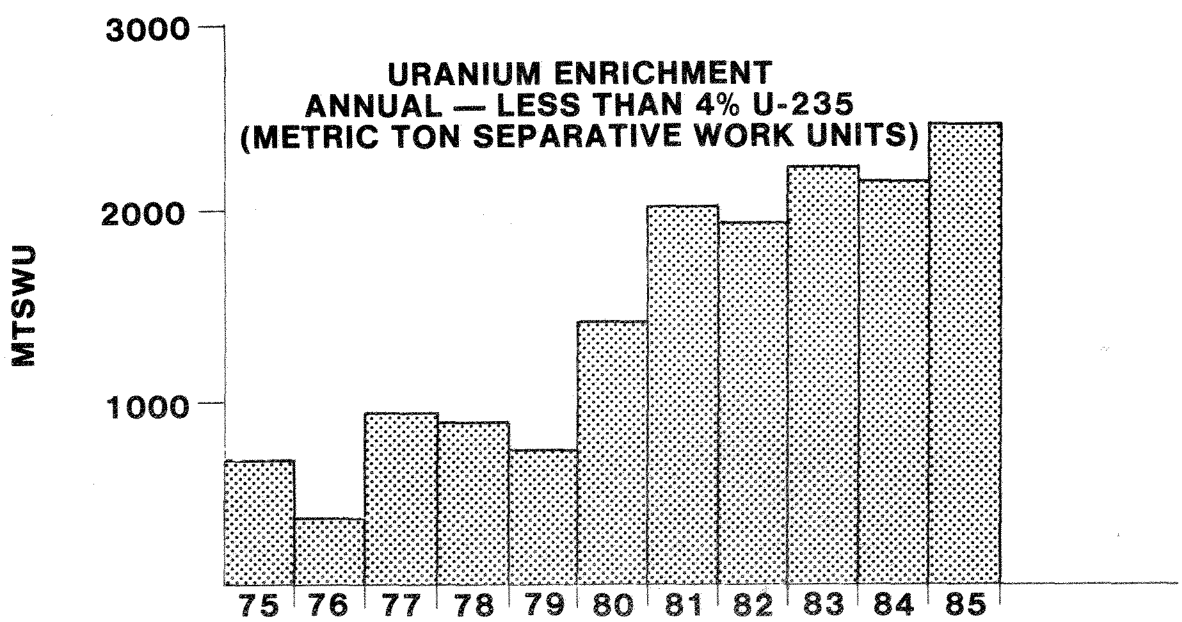
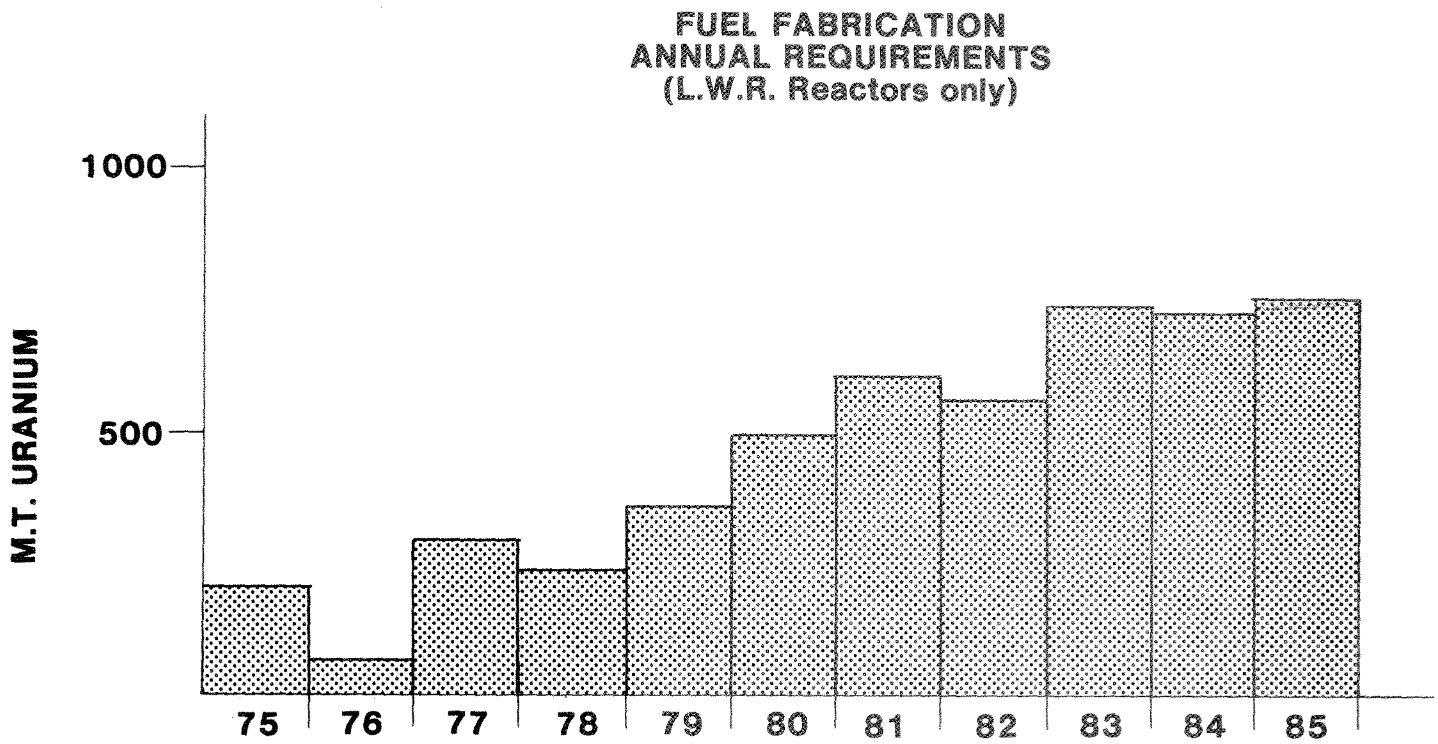
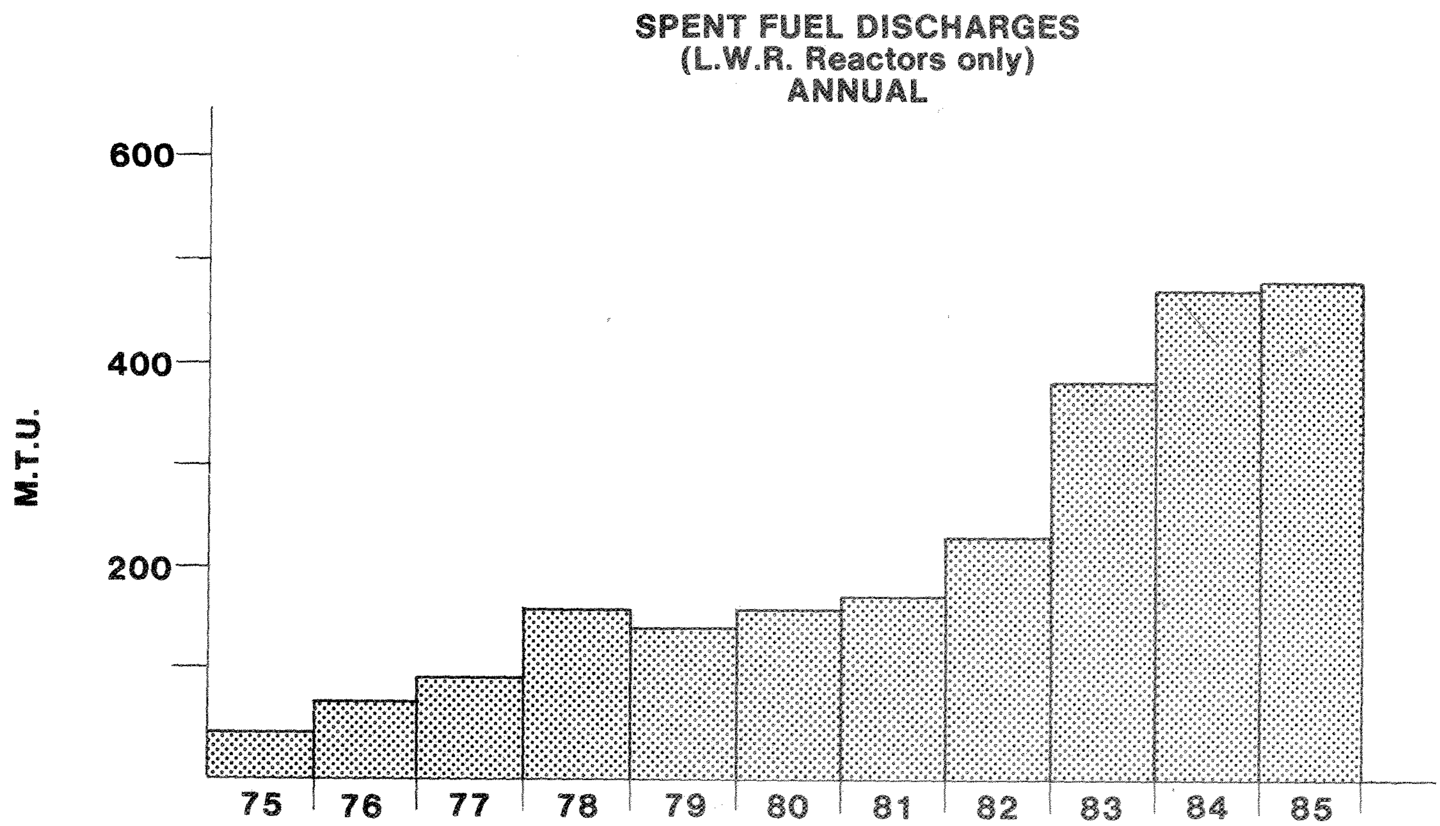

URANIUM ENRICHMENT
ANNUAL — LESS THAN 4% U-235
(METRIC TON SEPARATIVE WORK UNITS)
MTSWU
3000
2000
1000
75
76
77
78
79
80
81
82
83
84
85

Figure 7


FUEL FABRICATION
ANNUAL REQUIREMENTS
(L.W.R. Reactors only)
M.T. URANIUM
1000
500
75
76
77
78
79
80
81
82
83
84
85


SPENT FUEL DISCHARGES
(L.W.R. Reactors only)
ANNUAL
M.T.U.
600
400
200
75
76
77
78
79
80
81
82
83
84
85

E. Existing and Future Fuel Processing in the West

As of 1975, over 85% of the nation's proven uranium reserves and about 94% of the domestic uranium milling capacity is located in the Western Region. Table J provides a listing of uranium milling facilities with combined capacity of 26,800 tons of ore per day. One additional mill is located outside the WINB Region (in Texas) bringing the national capacity to 28,550 tons per day.

Table K lists other principal nuclear fuel processing facilities in the West. Of course, the current regional nuclear power industry does not provide sufficient markets for the total output of these plants; thus, they compete with facilities located outside the West in the national nuclear fuel markets.

Based on projections of future regional and national requirements, it would appear that additional nuclear fuel processing facilities will be needed in the West and elsewhere during the period 1975-1990. Many additional uranium mines and several new uranium mills are expected to be built in the West during the next several years. One or more uranium conversion (UF-6) plants may also be sited in the Region.

Uranium enrichment plants, particularly those employing gas centrifuge technology, are less dependent on proximity to raw materials, electric energy sources, and markets to achieve economic operation. Such plants are likely to be located where ample labor supply and construction and labor costs are competitive. As indicated previously, the national uranium enrichment demand is expected to require additional capacity by around 1984-85. Several additional plants of the gas centrifuge or gaseous diffusion types are anticipated during 1984 to 2000. Centrifuge plants may prove to be economical in the smaller sizes (1,000 to 3,000 MTSWU per year) as compared with gaseous diffusion plants which are competitive only in larger capacities (about 9,000 MTSWU per year). Centrifuge plants offer the advantages of more flexible siting and lower electric power consumption.

The Western region's enriching requirements are expected to reach about 2,500 MTSWU annually by 1985, possibly justifying an enrichment plant in the West of 3,000 MTSWU or

Table J

URANIUM MILLING PLANTS IN THE WESTERN REGION

Company	Plant Location	Nominal Capacity Tons Ore Per Day
The Anaconda Company	Grants, New Mexico	3,000
Atlas Corporation	Moab, Utah	1,500
Cotter Corporation	Canon City, Colorado	450
Dawn Mining Company	Ford, Washington	500
Federal-American Partners	Gas Hills, Wyoming	950
Exxon Nuclear Company, Inc.	Powder River Basin, Wyoming	2,000
Kerr-McGee Nuclear Corporation	Grants, New Mexico	7,000
Petrotomics Company	Shirley Basin, Wyoming	1,500[1]
Rio Algom Corporation	La Sal, Utah	500
Union Carbide Corporation	Uravan, Colorado	1,300
Union Carbide Corporation	Natrona County, Wyoming	1,000
United Nuclear--Homest ke Partners	Grants, New Mexico	3,500
Utah International, Inc.	Gas Hills, Wyoming	1,200
Utah International, Inc.	Shirley Basin, Wyoming	1,200
Western Nuclear, Inc.	Jeffrey City, Wyoming	1,200[2]
Total - Western Region		26,800
National Total		28,550

Sohio and Reserve Oil--Under construction to start up 1,000 tons per day mill in 1976.

[1]Currently closed.

[2]Currently closed for modifications.

Table K

NUCLEAR FUELS FABRICATING FACILITIES
IN THE WESTERN REGION

Company	Location	Nuclear Fuel Processing Capabilities
Atomic International Rockwell International	Canoga Park, California	Uranium and plutonium fuels fabrication
Exxon Company	Richland, Wash.	Uranium and plutonium fuels, uranium oxide pellets
General Atomic Company	San Diego, California	Carbide, thorium, special fuels
General Electric Company	San Jose, and Vallecitos, California	Plutonium fuels fabrication, uranium and plutonium scrap recovery

greater by the mid-1980's. Of course, such a plant could be sized to accommodate regional and national marketing conditions.

Uranium fuel fabrication technology and economics permit great flexibility in plant siting. It is unlikely that regional market requirements would be major siting determinants.

The technology of nuclear spent fuel reprocessing currently favors plants with annual capacities of up to 1500-2000 MTU, although a smaller plant of 300 to 500 MTU/year is planned for western New York State. The Western regional spent fuel reprocessing market does not appear to justify building a Western plant until at least the late 1980's.

The Western Region is the site of several radioactive waste storage facilities. Commercial burial sites for low-level radwastes are located at Richland, Washington and Beatty, Nevada. A similar facility is planned in Oregon. Facilities for storage of government-owned high-level radwastes are located at ERDA's Idaho National Engineering Laboratory and Hanford, Washington complex. Recently, sites in Idaho, Nevada, and Washington were considered by the federal government for a proposed high-level radwaste "retrievable surface storage facility" (RSSF), a federal repository for management of such wastes. As of this writing, both the RSSF and the bedded salt disposal concepts are under consideration by ERDA as potential means of isolating commercial high-level radwastes. Bedded salt formations near Carlsbad, New Mexico are being examined as potential sites.

REFERENCES AND NOTES

1. "Total Energy, Electric Energy, and Nuclear Power Projections, United States", U.S. Energy Research and Development Administration, February, 1975 (unpublished).

2. Ten-Year Coordinated Plan Summary, 1975-1984, Western Systems Coordinating Council, May, 1975.

3. Nuclear Energy in the West, Western Interstate Nuclear Board, June, 1971.

4. (a) Western States Water Requirements for Energy Development to 1990, Western States Water Council, November, 1974.

   (b) Nuclear Power Growth, 1974-2000, WASH-1139 (74), U.S. Atomic Energy Commission, February 1974, (and an up-dated version issued later in 1974).

   (c) Project Independence Report, Federal Energy Administration, November, 1974.

Confidential

APPENDIX A

QUESTIONNAIRE
NUCLEAR POWER AND FUELS SURVEY
WESTERN INTERSTATE NUCLEAR BOARD

Name of Utility Company: ______________________________

Address: ______________________________

Responsible Official and Title: ______________________________

Would you prefer that this information be kept confidential? Yes____ No____

I. NUCLEAR POWER GENERATION:

Current and Future Nuclear Power Projects: (Current to the Year 1990)

Plant Name*	Site	Gen. Cap. (MWE)	Actual/ Planned Commercial Operation (Year)	Reactor Type	Estimated (1974 $) Capital Investment
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
TOTALS					

II. NUCLEAR FUEL CYCLE REQUIREMENTS - (for above projects)

Step	Units	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Uranium feed	MT											
Thorium feed	MT											
Enrich. Req'd. 1. > 4% enrich.	1,000's SWU											
2. < 4% enrich.	"											
3. Amt. of Above Enrich. Reqm'ts Under ERDA Contract	"											
Fuel Fabrication	MT											
Spent Fuel Discharges	MT											
Pu Recycle Required	Kg											

*Please indicate which projects are jointly owned/operated with other utility firms: Plant______________ Cooperating Utility______________

Plant______________ Cooperating Utility______________

Plant______________ Cooperating Utility______________

Signed______________ Title______________

Phone No.______________ Date______________

Appendix B

KNOWN AND POTENTIAL URANIUM RESERVES AND PRODUCTION

The projected growth of nuclear-electric power generation over the next 25 years will require significant expansion of the nation's uranium mining and processing industry. Considerable uncertainties exist as to the future costs and availability of uranium, the need for and timing of the "breeder" reactor, future availability of adequate uranium enrichment and spent fuel reprocessing capabilities, economics and safeguards issues associated with recycling of plutonium as replacement fuel in light-water reactors, and appropriate radioactive waste management methods. The resolution of these interlocking issues will have a major influence on future operations of the uranium and nuclear power industries.

Current information on production of uranium ore and concentrates (U_3O_8), "yellowcake", is provided in Table I. Proven and potential uranium reserves at maximum forward costs of $8, $10, $15, and $30 per pound are shown in Tables J and K. Forward costs are those operating and capital costs yet to be incurred at the time an estimate is made. Profit and "sunk" costs are not included; therefore, the various forward costs are largely independent of the market price at which the estimated reserve would be sold.

Yellowcake prices as of June, 1975 were averaging about \$22/lb. for 1975 delivery. Long-term U_3O_8 contracts for delivery in 1980 were indicating price levels in the \$30-\$35/lb. range. Some uranium suppliers expect prices for delivery to escalate to \$50 to \$60/lb. Of course, price escalation would tend to stimulate further uranium exploration and production if total volume demand maintains its projected levels through the 1980's and beyond.

TABLE B-1

DISTRIBUTION OF 1974 U_3O_8 PRODUCTION IN ORE BY STATE

State	Tons of Ore	Tons U_3O_8	% of Total U_3O_8
New Mexico	2,997,000	5,400	43
Wyoming	2,458,000	4,000	32
Others: Colorado, Texas, Utah, & Washington	1,661,000	3,200	25
Totals	7,116,000	12,600	100

Proven reserves of \$8/lb. U_3O_8 were estimated at 200,000 tons as of January 1, 1975.(1) Reserves of 315,000 tons at \$10/lb., 420,000 tons at \$15, and 600,000 tons at \$30 were also estimated by ERDA as of January, 1975.

Potential reserves shown in Tables J and K do not include possible new resources in undiscovered resource areas. Such resource regions are expected to be more thoroughly explored under the recently-expanded National Uranium Resource Evaluation program of ERDA.

TABLE B-2

1/1/75 POTENTIAL RESOURCE ESTIMATES

Forward Costs (Cumulative*)	Tons U_3O_8 Probable	Possible	Speculative
$ 8	300,000	200,000	30,000
$10	460,000	390,000	110,000
$15	680,000	640,000	210,000
$30	1,140,000	1,340,000	410,000

*Each cost category includes all lower cost resources.

TABLE B-3

DISTRIBUTION OF 1/1/75 $15 POTENTIAL RESOURCES BY RESOURCE REGION**

Resource Region	Tons U_3O_8 Probable	Possible	Speculative
Colorado Plateau	290,000	415,000	50,000
Wyoming Basins	210,000	50,000	20,000
Others (W. Gulf Coast, Basin & Range, Sierra Nevada, W. Great Plains, Rocky Mountains, Columbia Plateaus	180,000	175,000	140,000
TOTAL	680,000	640,000	210,000

**The $10 and $15 cost categories each successively include all lower cost resources.

In addition to the known reserves of 200,000 tons U_3O_8 (at $8/lb.), an estimated 1,400,000 to 2,000,000 tons are contained in proven deposits outside the United States. Principal foreign reserves are located in Australia, Canada, South Africa and Sweden.[2]

References:

(1) "Statistical Data of the Uranium Industry," GJO-100(75), dated January 1, 1975, U. S. Energy Research and Development Administration.

(2) "Nuclear Fuels", United States Mineral Resources, Geological Survey Professional Paper 820, 1973, pp. 455-468.

WESTERN INTERSTATE NUCLEAR BOARD