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A Capital Requirements Estimating Model (CREMOD) for Electric Utilities

Volume I: Methodology Description, Model Description, and Guide to Model Applications

January 1980

Prepared for:
U.S. Department of Energy
Energy Information Administration
Assistant Administrator for Applied Analysis
Under Contract No. EC-77-C-01-8558

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A Capital Requirements Estimating Model (CREMOD) for Electric Utilities.

Volume I: Methodology Description, Model Description, and Guide to Model Applications

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PREFACE

The "Capital Requirements Estimating Model for the Electric Utilities" (CREMOD) is a system of programs and data files used to estimate the capital requirements of the electric utility industry for each year between the current one and 1990. CREMOD disaggregates new electric plant capacity levels from the Mid-term Energy Forecasting System (MEFS) Integrating Model solution over time using actual projected commissioning dates. It computes the effect on aggregate capital requirements of dispersal of new plant and capital expenditures over relatively long construction lead times on aggregate capital requirements for each year. Finally, it incorporates the effects of real escalation in the electric utility construction industry on these requirements and computes the necessary transmission and distribution expenditures.

This model was used in estimating the capital requirements of the electric utility sector. These results were used in compilation of the aggregate capital requirements for the financing of energy development as published in the 1978 ARC.

Three volumes of the model documentation have been prepared. The first volume explains CREMOD's methodology, functions and applications. Volume II is the User's Manual describing specific data requirements and operating procedures. Volume III is a reference guide containing program and file listings.

Drs. Dwight E. Collins, Michael L. Shaw and Mr. Julian Gammon of Logistics Management Institute prepared the above three volumes. Their work was monitored by Dr. Suraj P. Kanhouwa in consultation with Mr. John Mitrisin, Director of the Financial and Industry Division. Mr. Gerald A. Price and Jeff Jones provided technical review of the model. Their comments were used to enhance the usefulness of CREMOD in its final version. Responsibility for running and updating this model has since been assumed by the Coal and Electric Power Analysis Division.

EXECUTIVE SUMMARY

The Capital Requirements Estimating Model (CREMOD) is a system of programs and data files used to estimate the capital requirements of the electric utility industry for each year between the current one and 1990. CREMOD was developed for the Energy Information Administration (EIA) by the Logistics Management Institute and is maintained on EIA's IBM/370-168 TSO operating system. Its primary function is to supply estimates of electric utility capital requirements for the annual Administrator's Report to Congress; it can also be used to estimate the effects of proposed DOE policies on such requirements.

Before CREMOD was developed, electric utility capital requirements were computed within the Mid-Term Energy Forecasting System (MEFS) by an off-line program known as the Capital Report Writer (CRW). The process was cumbersome, and the results obtained required substantial manual adjustment. CREMOD meets the need for realistic capital requirements estimates by year over the MEFS planning horizon and corrects certain of the CRW's misleading assumptions about the timing of capital expenditures. It uses plant commissioning dates as a basis for disaggregating activity level estimates generated by the Mid-Term Energy Market Model over time; computes the effect of the dispersal of new plant capital expenditures over 7-10-year construction lead times; and incorporates the effect of real cost escalation in the electric utility construction industry. CREMOD can be used interactively and can generate its estimates of annual capital requirements for user-specified aggregations of plant types quite rapidly.

Three volumes of CREMOD documentation have been prepared according to the Interim Model Document Standards issued by EIA's Office of Analysis, Oversight

and Access, in December 1978. This is the first volume, which explains CREMOD methodology, functions, and applications. Volume II is the User's Manual, describing specific data requirements and operating procedures for CREMOD. Volume III is a reference guide, containing program and file listings.

TABLE OF CONTENTS

	<u>Page</u>
PREFACE.....	iii
EXECUTIVE SUMMARY	vi
LIST OF FIGURES	viii
I. METHODOLOGY DESCRIPTION	I- 1
Introduction	I- 1
How CREMOD Works	I- 1
Modeling Improvements Provided by CREMOD	I- 2
II. MODEL DESCRIPTION	II- 1
Overview	II- 1
Input Data	II- 1
User Input Parameters	II- 3
Model Output Reports	II- 9
Model Functions	II-11
Compute Capital Requirements	II-11
Display BUILD Limits	II-13
Revise/Display Plant Type Master File	II-14
Revise/Display Capital Coefficients	II-14
Revise/Display Capital Expenditure Profiles	II-15
Display Interim MEFS Solution Files	II-15
Key Design Features	II-15
Access to MEMM Solutions	II-15
Design and Revision of Other Data Files	II-17
The Role of Alternative Economic Scenarios	II-19
Flexible Use of Annual BUILD Limits	II-20
Treatment of Transmission and Distribution Capital Expenditures	II-22
Error Checking Features	II-23
Mathematics Underlying the Capital Requirements Computation	II-26
The Basic Calculation of Direct and Interest Capital Components	II-26
Disaggregating MEMM-Generated Capacity Additions Over Time	II-29
Report Capacity Addition Quantities	II-30
Development of Annual Capital Expenditure Expressions	II-31

TABLE OF CONTENTS (Continued)	<u>Page</u>
Aggregate Capital Expenditure Quantities	II-35
Transmission and Distribution Capital Expenditures. . .	II-36
Transmission Capital Expenditures (Variable Component)	II-37
Transmission Capital Expenditures (Fixed Component)	II-38
New Distribution Capital Expenditures	II-38
Metering Capital Expenditures	II-39
III. GUIDE TO MODEL APPLICATIONS	III- 1
Introduction	III- 1
Development of a Sample Estimate	III- 1
Analysis of a Sample Estimate	III- 3
APPENDIX A: SUMMARY OF CREMOD INPUT DATA FILE CONTENTS	
APPENDIX B: CREMOD TERMS AND ACRONYMS	

LIST OF FIGURES

<u>FIGURE</u>		<u>Page</u>
I- 1	CREMOD Time-Phased Capital Expenditures	I- 3
II- 1	MEFS Activities Addressed by CREMOD	II- 5
II- 2	CREMOD Dictionary of Aggregate Plant Type/Region Combinations	II- 8
II- 3	Capital Requirements Report	II-10
II- 4	CREMOD Functions	II-12
II- 5	CREMOD Use of Solution Files	II-16
II- 6	CREMOD System Flow	II-18
II- 7	MEMM Solution Anomalies Under 1978 ARC Medium Supply Scenario	II-25
II- 8	CREMOD Capital Requirements Report	II-27
III- 1	Projected Capacity Additions and Capital Requirements ('78 ARC) for Scenarios B, C, and D (January 1, 1979 to January 1, 1990)	III- 2
III- 2	Listing of CREMOD Plant Type Aggregations	III- 4
III- 3	Scenario C--Nuclear Capital Requirements	III- 5
III- 4	Scenario C--Capital Requirements for All Builds	III- 6
III- 5	Scenario C--Scrubber Retrofit Capital Requirements	III- 8
III- 6	Scenario C--Plant Conversion Capital Requirements	III- 9
III- 7	Scenario C--Transmission and Distribution Capital Requirements	III-11
III- 8	"Capital Coefficients" Corresponding to Figure III-1. Estimates (\$/KW)	III-12
III- 9	Relative Nuclear Capacity/Capital Values Under Scenarios B and C (January 1, 1979 to January 1, 1990)	III-14

LIST OF FIGURES (Continued)

		<u>Page</u>
III-10	Scenario B--Committed Nuclear Capital Requirements	III-15
III-11	Scenario C--Committed Nuclear Capital Requirements	III-16
III-12	Scenario B--Deferrable Nuclear Capital Requirements	III-17
III-13	Scenario C--Deferrable Nuclear Capital Requirements	III-18
III-14	Scenario B--New Nuclear Capital Requirements	III-19
III-15	Scenario C--New Nuclear Capital Requirements	III-20
A- 1	Plant Type Master File (FMAST*) File Layout	A- 3
A- 2	Capital Coefficient File (FCOEF*) File Layout	A- 7
A- 3	Capital Expenditure Profile File (FCEP*) File Layout	A- 9
A- 4	Build Limit File (FBLD*) File Layout	A-12
A- 5	1978 ARC Contents of File FBLDM	A-13
A- 6	1978 ARC Values for Metering Cumulative Capital Costs	A-18
A- 7	1978 ARC Values for Electricity Distribution Cumulative Capital Costs	A-18
A- 8	1978 ARC Values for Cumulative Fixed Component of New Transmission Capital Costs	A-19
A- 9	1978 ARC Values for Cumulative Variable Component of New Transmission Capital Costs	A-19

I. METHODOLOGY DESCRIPTION

INTRODUCTION

This is the first of three volumes documenting the Capital Requirements Estimating Model (CREMOD), which estimates capital requirements for the electric utility industry for each year between the current one and 1990. It contains: (1) a methodology description explaining why CREMOD was developed and how it improves upon the Capital Report Writer (CRW) program of the Mid-Term Energy Forecasting System (MEFS); (2) a model description explaining the structure and key design features of CREMOD and the mathematics behind its capital requirements computations; and (3) a guide to its applications, including an example of how estimates are generated for the Administrator's Report to Congress (ARC). Two appendices summarize file contents and system definitions. This documentation assumes a working knowledge of how electric utility capital requirements are currently modeled within the overall MEFS framework.

HOW CREMOD WORKS

The basic concept underlying CREMOD is that, within a given future time period, capital requirements for new construction can be estimated by integrating the estimated amount of required new plant capacity for the period in megawatts (MW) with the estimated time-phased capital costs per MW of that capacity. The estimates of required new capacity are computed by the Mid-Term Energy Market Model (MEMM), and the capital cost coefficients (\$/MW) are those used in deriving the MEMM's objective function. These inputs are the basis for computing capital requirements disaggregated as required by year, plant type (nuclear, bituminous coal with or without scrubbers, etc.), and region.

CREMOD then aggregates the results over plant types and regions for each year as appropriate.

MODELING IMPROVEMENTS PROVIDED BY CREMOD

Prior to the development of CREMOD, electric utility capital requirements were computed within the MEFS framework by the off-line program CRW. The CRW multiplied estimates of new plant capacity additions--generated by the MEMM--by capital coefficients--generated outside the MEMM--to get estimated capital requirements by plant type and region for the period from the present through the MEFS target year. CREMOD was developed to supply realistic capital requirements estimates by year over the MEFS planning horizon and to supplement certain assumptions in the CRW computation about the timing of capital expenditures which seriously impeded its usefulness.

The CRW ignores the impact of plant commissioning schedules on yearly capital requirements within the MEFS planning horizon. It also provides no visibility into the impact of plant construction lead times on yearly requirements. Thus, if a plant is coming on line within the MEFS planning horizon (e.g., 1979-1985), the CRW assumes that all its capital costs are incurred within this horizon. This is a particularly misleading assumption for plants coming on line toward the beginning of the planning horizon, because most of the costs may already have been incurred. Likewise, in the case of a 1985 target year, the CRW ignores capital costs incurred up to January 1, 1985, for plants coming on line subsequent to that date.

CREMOD augments the CRW computation by disaggregating MEMM capacity addition estimates over time, in order to capture more realistically the impact of plant commissioning schedules on aggregated yearly capital expenditures (see Figure I-1). For committed, deferrable, and new nuclear plants and committed and deferrable coal plants, it uses estimates of unit

FIGURE I-1

CREMOD TIME-PHASED CAPITAL EXPENDITURES*

*Each of the four humped curves in Figure I-1 represents a profile of capital expenditures over a construction lead time for all commissionings of a given plant type occurring in a given year. The area outlined in red represents the sum of all areas under these curves between the MEFS base and target years.

commissioning dates and corresponding capacities as a basis for the temporal disaggregation. Remaining plant commissionings are assumed to be spread evenly over the appropriate MEFS planning horizon segment. Next, CREMOD spreads the estimated capital expenditure for each commissioning date backward over the construction lead time projected for the given plant type, in accordance with an S-curve shaped capital expenditure profile. In this manner, CREMOD incorporates the significant impact of the timing of unit-level capital expenditures during the unit construction period on aggregated yearly capital costs. This impact is particularly large for plant types having long construction lead times, such as nuclear and coal plants.

CREMOD also models the relative effects of direct capital costs, allowance for funds used during construction (AFDC), and cost escalation on yearly capital requirements more accurately than the CRW. While the capital coefficients used in the CRW incorporate these components, the CRW does not explicitly compute the effect of the interaction of AFDC and escalation with the profile of capital expenditures over the construction period on yearly capital requirements. CREMOD carries out this computation in detail. It divides each capital coefficient into its direct, AFDC, and escalation components. It then calculates the impact of each component on yearly expenditures, essentially on a plant-by-plant basis, and then aggregates results over plant types and regions within each year. In this manner, CREMOD accurately portrays the effect of the timing of each type of expenditure on total capital costs.

II. MODEL DESCRIPTION

OVERVIEW

CREMOD's programs and data files are maintained on DOE's IBM/370-168 TSO operating system. The model can be used interactively and can generate estimates of annual capital requirements for user-specified aggregations of plant types almost instantaneously.

Input Data

Four basic types of input data are required to operate CREMOD:

- 1) MEFS forecasts of electric utility capacity additions requiring capital expenditures for the period from the present to 1995
- 2) Maximum annual capacities of new unit commissionings (also called annual BUILD limits), computed as a function of capacity currently under construction and remaining construction lead times for certain plant types
- 3) MEFS estimates of unit capital costs (called capital coefficients, defined in terms of \$/KW) on a regional basis and including rates of interest during construction (IDC) and rates of real escalation in the electric utility construction industry where appropriate
- 4) Profiles of capital expenditures over construction lead times for the different plant types.

MEFS forecasts of capacity additions for the target years 1985, 1990, and 1995 are retrieved from MEFS packed solution files outside CREMOD and stored in interim solution files accessible to CREMOD.

Annual BUILD limits data, developed as a function of high, medium, or low supply economic scenarios, are available to the model for committed,

¹A comprehensive discussion of the role of IDC appears in Allowance for Funds Used During Construction, by Lawrence S. Pomerantz and James E. Suelflow (Lansing, Michigan: Michigan State University, Institute for Public Utilities, 1975).

deferrable, and new nuclear plants and for committed and deferrable coal-fired plants. These limits reflect estimates of maximum regional plant capacity coming on line in each year of the MEFS planning horizon as a function of construction already in progress. The nuclear data come from two existing files maintained by EIA's Nuclear Energy Analysis Division (NEAD). All annual BUILD limits for coal must be input manually to files accessed by CREMOD from hard copy reports compiled by EIA's Coal and Electric Power Analysis Division (CEPAD). This approach was chosen because several of the data items underlying the specific coal BUILD limits used by CREMOD, such as the scrubber/no scrubber categorization, are not readily accessible from the Generating Unit Reference ("383") File (GURF) and must be determined by CEPAD personnel via additional analysis, and, in some cases, interviews with utility personnel. The annual BUILD limit files can be revised as unit-level data affecting these limits are updated by NEAD and CEPAD.

The file of regional capital coefficients used by CREMOD contains the 1985 capital coefficients used in MEFS for all plant types, along with the real escalation rates used to compute the 1990 and 1995 MEFS coefficients and the real escalation rate already incorporated into the 1985 coefficients. The 1985 coefficients are the basis for developing an appropriate baseline dollar per unit of new plant capacity figure for each plant type and region. The real escalation data permit an accurate reflection of real escalation effects by year starting with the MEFS base year. For nuclear, coal, and other selected plant types having long construction lead times, the file also includes the IDC rate assumed in calculating the 1985 coefficient. This permits CREMOD to break out the component of total yearly capital requirements attributable to IDC for these plant types. CREMOD also can access alternative files of

capital coefficients, which permits the use of different sets of capital coefficients for high, medium and low supply scenarios.

CREMOD also accesses alternative files of capital expenditure profiles as a function of economic scenario. Each file includes, for each plant type, an estimated construction lead time in years and the estimated fraction of capital spent in each year. This profile can be obtained using the CONCEPT system operated by NEAD for two types of nuclear reactors and certain types of coal plants.² A list of profiles for all relevant plant types under different scenario assumptions is periodically prepared by CEPAD. The model also allows for additional, user-specified sets of capital expenditure profiles to incorporate hypotheses about the impact of tighter environmental standards, quicker issuance of permits, or increased average plant size on the timing of capital requirements.

User Input Parameters

Input parameters provided to CREMOD by the user include:

- Supply scenario
- MEFS base year
- User base year
- User inflation rate
- Set of plant types and regions to be addressed.

CREMOD uses the supply scenario designation to access files of annual BUILD limits, capital coefficients, and capital expenditure profiles and to identify the scenario-dependent normal inflation rate (which excludes electric utility industry real cost escalation). The MEFS base year is the year when the MEFS

²Descriptions of this modeling system appear in "CONCEPT: A Computer Code for Conceptual Cost Estimates of Steam-Electric Power Plants," Phase IV User's Manual (ERDA 108), Division of Reactor Research and Development, U. S. Energy Research and Development Administration, June, 1975, and "NEAD CONCEPT V System, User, Operation, and Maintenance Documentation, NUFUEL #5," Nuclear Energy Analysis Division, EIA, September 5, 1978.

planning horizon begins. It must be the same as the base year used to generate the MEFS solution accessed by CREMOD. The user base year is that year, equal or subsequent to the year in terms of which all capital coefficients are defined, to which all dollar amounts calculated by CREMOD are to be escalated. The user inflation rate is the yearly rate to be used to escalate coefficient base year (CBY) dollars to user base year dollars. It is independent of normal inflation or real escalation rates assumed by the MEFS. Plant Type may be either (1) any one of the MEFS electric utility sector activities requiring capital, or (2) any one of several CREMOD-defined aggregations of plant types for which aggregated capital requirements information is likely to be of particular interest to the user. Region may be any subset of the 10 MEFS utility regions.

Figure II-1 lists MEFS activities addressed by CREMOD. This includes most MEFS electric utility BUILD activities, all plant conversion activities with which capital is associated, retrofitting of existing coal plants with scrubbers, and transmission and distribution equipment. The model allows for additions to this list as MEFS utility activities are added.

Figure II-2 is a list of plant type/region aggregations available as user inputs as described in (2) above. These devices permit the CREMOD user to compute capital requirements estimates at numerous levels of aggregation within the electric utility sector. For example, by inputting the command sequence "ALL BUILDS/ALL/1, 2," the user obtains a MEFS estimate of capital requirements by year totalled over all committed, deferrable, and new BUILD activities in Regions 1 and 2. Alternatively, by specifying the aggregate combination, "ALL/ALL," s/he obtains MEFS estimates of capital requirements by year for the entire electric utility sector.

FIGURE II-1. MEFS ACTIVITIES ADDRESSED BY CREMOD

<u>MEFS DESCRIPTION</u>	<u>MEFS CODE</u>
<u>COMMITTED PLANTS</u>	
1. OIL FIRED STEAM	1Y
2. BIT/HI SUL/SCR	2Y
3. BIT/MED SUL/SCR	3Y
4. BIT/LOW SUL/SCR	4Y
5. GAS FIRED TURBINE	5Y
6. DISTILLATE TURBINE	6Y
7. COMBINED CYCLE/GAS	AY
8. COMBINED CYCLE/DIST	7Y
9. GAS FIRED STEAM	8Y
10. BIT/HIGH SUL/N SCR	JY
11. BIT/MED SUL/N SCR	QY
12. BIT/LOW SUL/N SCR	XY
13. SUB-BIT/MED SUL/SCR	PY
14. SUB-BIT/LOW SUL/SCR	EY
15. SUB-BIT/MED SUL/N SCR	MY
16. SUB-BIT/LOW SUL/N SCR	OY
17. LIG/MED SUL/SCR	VY
18. LIG/LOW SUL/SCR	ZY
19. LIG/MED SUL/N SCR	TY
20. LIG/LOW SUL/N SCR	YY
21. HYDRO PONDAGE	9Y
22. HYDRO PUMP STORAGE	KY
23. NUCLEAR	NY

<u>DEFERRABLE PLANTS</u>	
1. OIL FIRED STEAM	1Z
2. BIT/HI SUL/SCR	2Z
3. BIT/MED SUL/SCR	3Z
4. BIT/LOW SUL/SCR	4Z
5. GAS FIRED TURBINE	5Z
6. DISTILLATE TURBINE	6Z
7. COMBINED CYCLE/GAS	AZ
8. COMBINED CYCLE/DIST	7Z
9. GAS FIRED STEAM	8Z
10. BIT/HIGH SUL/N SCR	JZ
11. BIT/MED SUL/N SCR	QZ
12. BIT/LOW SUL/N SCR	XZ
13. SUB-BIT/MED SUL/SCR	PZ
14. SUB-BIT/LOW SUL/SCR	EZ
15. SUB-BIT/MED SUL/N SCR	MZ
16. SUB-BIT/LOW SUL/N SCR	OZ
17. LIG/MED SUL/SCR	VZ
18. LIG/LOW SUL/SCR	ZZ
19. LIG/MED SUL/N SCR	TZ
20. LIG/LOW SUL/N SCR	YZ
21. HYDRO PONDAGE	9Z
22. HYDRO PUMP STORAGE	KZ
23. NUCLEAR	NZ

FIGURE II-1, cont.

<u>MEFS DESCRIPTION</u>	<u>MEFS CODE</u>
<u>NEW PLANTS</u>	
1. OIL FIRED STEAM	10
2. BIT/HI SUL/SCR	20
3. BIT/MED SUL/SCR	30
4. BIT/LOW SUL/SCR	40
5. GAS FIRED TURBINE	50
6. DISTILLATE TURBINE	60
7. COMBINED CYCLE/GAS	A0
8. COMBINED CYCLE/DIST	70
9. GAS FIRED STEAM	80
10. BIT/HIGH SUL/N SCR	JO
11. BIT/MED SUL/N SCR	QO
12. BIT/LOW SUL/N SCR	XO
13. SUB-BIT/MED SUL/SCR	PO
14. SUB-BIT/LOW SUL/SCR	EO
15. SUB-BIT/MED SUL/N SCR	MO
16. SUB-BIT/LOW SUL/N SCR	OO
17. LIG/MED SUL/SCR	VO
18. LIG/LOW SUL/SCR	ZO
19. LIG/MED SUL/N SCR	TO
20. LIG/LOW SUL/N SCR	YO
21. HYDRO PONDAGE	90
22. HYDRO PUMP STORAGE	KO
23. NUCLEAR	NO

OIL/GAS-TO-COAL CONVERSIONS

1. CONVERT OIL TO BIT/HI SUL/N SCR	CF
2. CONVERT OIL TO BIT/MD SUL/N SCR	CG
3. CONVERT OIL TO BIT/LO SUL/N SCR	CH
4. CONVERT OIL TO BIT/HI SUL/SCR	CI
5. CONVERT OIL TO BIT/MED SUL/SCR	CJ
6. CONVERT OIL TO BIT/LO SUL/SCR	CK
7. CONVERT GAS TO BIT/HI SUL/N SCR	CL
8. CONVERT GAS TO BIT/MD SUL/N SCR	CM
9. CONVERT GAS TO BIT/MD SUL/N SCR	DN
10. CONVERT GAS TO BIT/HI SUL/SCR	CO
11. CONVERT GAS TO BIT/HI SUL/SCR	CP
12. CONVERT GAS TO BIT/LO SUL/SCR	CQ

NEW PLANT COAL-TO-COAL CONVERSIONS

1. CHANGE N BIT/LO S TO HI S/W SCR	DF
2. CHANGE N BIT/LO S TO MD S/W SCR	DG
3. CHANGE N BIT/MD S TO HI S/W SCR	DH
4. CHANGE N SUB-B/L S TO M S/W SCR	DI
5. CHANGE N LIG/LO S TO MD S/W SCR	DJ

FIGURE II-1, cont.

MEFS DESCRIPTIONMEFS CODESCRUBBER RETROFITTING OF EXISTING PLANTS

1. CONVERT BIT/LO S TO HI S/W SCR	CV
2. CONVERT BIT/LO S TO MED S/W SCR	CW
3. CONVERT BIT/MED S TO HI S/W SCR	CX
4. CONVERT SUB-B/LO S TO M S/W SCR	CY
5. CONVERT LIG/LO S TO MED S/W SCR	CZ

OTHER CONVERSIONS (COST $\neq$ 0)

1. CONVERT OIL TO GAS STEAM	CR
2. CONVERT NEW OIL TO GAS STEAM	CS
3. CONVERT GAS TO OIL STEAM	CT
4. CONVERT DISTILLATE TO GAS TURBINE	CU
5. CONVERT GAS TO DISTILLATE TURBINE	DK
6. CONVERT N DIST TO GAS COMB CYCLE	DL
7. CONVERT E DIST TO GAS COMB CYCLE	DM

EMERGING TECHNOLOGIES

1. WIND	(BUILD)	GE
2. PHOTOVOLTAICS	(BUILD)	GK
3. SOLAR THERMAL	(BUILD)	GG
4. BIOMASS-ELECTRIC	(BUILD)	GP
5. OCEAN THERMAL	(BUILD)	GN
6. HYDROTHERMAL I	(BUILD)	G1
7. HYDROTHERMAL II	(BUILD)	G2
8. HYDROTHERMAL III	(BUILD)	G3
9. BUILD CENTRAL ELECTRIC: AFB		LE
10. BUILD LOW-MED BTU GAS COMB CYCLE		LC

TRANSMISSION AND DISTRIBUTION

1. TRANSMISSION (VARIABLE)	TV
2. TRANSMISSION (FIXED)*	TF
3. NEW DISTRIBUTION*	TN
4. METERING COSTS*	TM

*Additions of these "Plant Types" are computed exogenous to CREMOD and are "hard wired" through the model for user convenience.

FIGURE II-2. CREMOD DICTIONARY OF AGGREGATE
PLANT TYPE/REGION COMBINATIONS*

PLANT TYPE	REGION
1. INDIVIDUALLY SPECIFIED	1, 2,, 10, ALL
2. NUCLEAR	
3. BITUMINOUS WITH SCRUBBER (Y, Z, O, ALL)	
4. BITUMINOUS WITHOUT SCRUBBER (Y, Z, O, ALL)	
5. SUB-BITUMINOUS WITH SCRUBBER (Y, Z, O, ALL)	
6. SUB-BITUMINOUS WITHOUT SCRUBBER (Y, Z, O, ALL)	
7. LIGNITE WITH SCRUBBER (Y, Z, O, ALL)	
8. LIGNITE WITHOUT SCRUBBER (Y, Z, O, ALL)	
9. COAL WITH SCRUBBER (Y, Z, O, ALL)	
10. COAL WITHOUT SCRUBBER (Y, Z, O, ALL)	
11. ALL COAL BUILDS (Y, Z, O, ALL)	
12. TURBINE (Y, Z, O, ALL)	
13. COMBINED CYCLE (Y, Z, O, ALL)	
14. HYDROELECTRIC (Y, Z, O, ALL)	
15. ALL FUEL GAS (Y, Z, O, ALL)	
16. ALL BUILDS (Y, Z, O, ALL)	
17. ALL OIL-TO-COAL CONVERSIONS	
18. ALL GAS-TO-COAL CONVERSIONS	
19. ALL NEW PLANT COAL-TO-COAL CONVERSIONS	
20. ALL EXISTING PLANT CONVERSIONS	
21. ALL OTHER CONVERSIONS	
22. ALL CONVERSIONS	
23. ALL EMERGING TECHNOLOGIES	
24. ALL UTILITY CAPITAL	
25. TRANSMISSION AND DISTRIBUTION	
26. ALL UTILITY CAPITAL NET OF T&D	

*Y → COMMITTED, Z → DEFERRABLE, O → COMPLETELY NEW

Model Output Reports

The main program of CREMOD generates a two-part output report: the first provides estimates of capital requirements and related new capacity data, and the second provides estimated capital requirements attributable to direct costs versus interest costs.

Figure II-3 summarizes the report format. Column 1 of the first part shows the given MEFS year (1979 through the MEFS target year) for which capital requirements are estimated. Column 2 shows the total estimated number of gigawatts (GW) of construction work in progress (CWIP) for the given MEFS year. Column 3 shows the total estimated number of GW of new construction work completed by the end of the given MEFS year. Column 4 shows the total estimated capital expended in millions of dollars for the given MEFS year. Column 5 shows the total estimated cumulative capital expended in millions of dollars through the given MEFS year.

The second part of the report is meaningful only for plant types or aggregations of plant types (e.g., all nuclear and coal BUILD categories) for which construction lead times are long and the IDC percentage used in computing the capital coefficient is known and resident in the capital coefficient file. Again, Column 1 reflects the given MEFS year for which capital requirements are estimated. Column 2 reflects the direct actual plant capital costs (including labor and materials) expended in millions of dollars for the given MEFS year. Column 3 reflects the IDC expended in millions of dollars. Column 4 reflects the total capital expended (the sum of Columns 2 and 3) in millions of dollars. Columns 5, 6 and 7 reflect these three quantities cumulatively through the given MEFS year.

CREMOD includes five additional output reports to display the status and content of the model's input data files.

FIGURE II-3 CAPITAL REQUIREMENTS REPORT

REGIONS: U1 U2 U3 U4 U5 U6 U7 U8 U9 UA

PLANT TYPES FOR OPTION 2

23	NUCLEAR	NY
46	NUCLEAR	NZ
69	NUCLEAR	NO

◆◆◆CREMOD CAPITAL REQUIREMENTS REPORT ◆◆◆
TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
INDICATED PLANT TYPES AND REGIONS

(1)	(2)	(3)	(4)	(5)
YEAR	CWIP (GW)	CUMULATIVE CW COMPLETED (GW)	CAPITAL EXPENDED (\$ MIL.)	CUMULATIVE CAPITAL EXPENDED (\$ MIL.)
1979	88.62	11.25	5545.21	5545.21
1980	89.94	17.73	5625.29	11170.50
1981	94.01	28.98	6137.00	17307.50
1982	94.17	38.71	6358.04	23665.54
1983	99.22	46.05	6354.78	30020.32
1984	95.74	55.73	5971.38	35991.70
1985	83.80	67.66	5492.66	41484.36
1986	74.93	76.54	5720.33	47204.69
1987	63.05	88.42	6814.98	54019.67
1988	56.19	95.28	7277.98	61297.65
1989	51.59	99.88	7233.92	68531.57
1990	43.79	107.67	6072.21	74603.78

TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
INDICATED PLANT TYPES AND REGIONS

(1)	(2)	(3)	(4)	(5)	(6)	(7)
YEAR	ANNUAL CAPITAL EXPENDITURE (\$ MIL.)			CUMULATIVE CAPITAL EXPENDITURES (\$ MIL.)		
	DIRECT	INTEREST	TOTAL	DIRECT	INTEREST	TOTAL
1979	4230.09	1315.12	5545.21	4230.09	1315.12	5545.21
1980	4375.67	1249.62	5625.29	8605.76	2564.74	11170.50
1981	4771.19	1365.81	6137.00	13376.95	3930.55	17307.50
1982	4985.11	1372.93	6358.04	18362.06	5303.48	23665.54
1983	4940.16	1414.61	6354.78	23302.23	6718.09	30020.32
1984	4491.95	1479.43	5971.38	27794.18	8197.52	35991.70
1985	4066.00	1426.66	5492.66	31860.18	9624.18	41484.36
1986	4385.02	1335.31	5720.33	36245.20	10959.49	47204.69
1987	5413.20	1401.78	6814.98	41658.40	12361.27	54019.67
1988	5856.91	1421.07	7277.98	47515.31	13782.34	61297.65
1989	5667.75	1566.16	7233.92	53183.06	15348.50	68531.57
1990	4400.42	1671.79	6072.21	57583.49	17020.29	74603.78

MODEL FUNCTIONS

When CREMOD is accessed, its program control module requests the user to choose one of the following seven functions:

1. Compute capital requirements
2. Display BUILD limits
3. Revise/display plant type master file
4. Revise/display capital coefficients
5. Revise/display capital expenditure profiles
6. Display interim MEFS solution files
7. Stop

The "Compute Capital Requirements" function is the central function of the model while the next five functions are provided to assist the user in analysis of the CREMOD Capital Requirements Report and in general maintenance of the CREMOD System.

The model logic flow, input data files, and output reports necessary to execute any one of the functions are shown in Figure II-4. Each function is executed by a logic module which accesses certain data files and prints a report. The model as a whole accesses seven data files during any given run.

Compute Capital Requirements (CCR)

The main computation function is executed by the MAINCOMP module. It produces the CREMOD Capital Requirements Report shown in Figure II-3. All seven input data files are accessed in the process as follows.

The plant type master file FMAST* contains a list of all relevant MEFS activity descriptions which is used by MAINCOMP in generating its output report.

The annual BUILD limit file FBLD* provides regional annual maximum capacities for committed, deferrable, and new nuclear plants and for committed and deferrable coal plants to aid in disaggregation of nuclear and coal plant activity levels over time.

FIGURE II-4
CREMOD FUNCTIONS

The MEFS interim solution files, SN85**, SN90** and SN95**, provide MEFS solutions for 1985, 1990 and 1995 runs, respectively, from the MEMM. All three files must be accessed during any given CREMOD run to fully capture the effects of overlapping construction lead times on aggregate yearly capital requirements through 1990. Also, these three files must be created prior to invoking CREMOD by accessing the proper MEFS packed solution files.³

The capital coefficient file FCOEF* provides capital coefficient values consistent with those used in the MEMM, to be multiplied by disaggregated activity levels from SN85**, 90** and 95**. It also provides IDC values for plant types having long construction lead times and electric utility industry real escalation rates for the various segments of the MEFS planning horizon and each plant type.

Finally, the capital expenditure profiles file FCEP* provides capital expenditure profiles for each plant type to be used in spreading the capital costs associated with each year's projected commissionings backward over an appropriate construction lead time.

Display BUILD Limits (DBL)

This function is performed as a check to ensure that the annual BUILD limits in file FBLD*, when aggregated over time, are consistent with the target year BUILD limits appearing in the MEMM preprocessor. DBL is executed by the module DYBLIM, which can produce either a summary-level BUILD limit report or a more detailed report for comparison with preprocessor output values. The MEMM preprocessor tables are revised periodically to incorporate updated estimates of plant construction progress and commissioning dates made by NEAD and CEPAD. It is important that the CREMOD annual BUILD limit files

³Procedures for creating these files are described in the next section.

also be periodically revised to incorporate these updated estimates so that the annual BUILD limits used by CREMOD to disaggregate MEMM activity levels are always completely consistent with the MEMM preprocessor BUILD limits. The DBL function should be executed, at a minimum, subsequent to any revisions to the CREMOD annual BUILD limit files and the results compared to MEMM preprocessor values.

CREMOD includes an option to spread projected capacity additions linearly over each of the three segments of the MEFS planning horizon for all plant types and regions. This can be used to compute approximate capital requirements estimates for plant types for which annual BUILD limit values are ordinarily available but are not up-to-date in FBLD*.

Revise/Display Plant Type Master File (RMF)

This function is executed by the module RVMAST, which accesses FMAST* in the process. FMAST* contains descriptions of all utility plant types addressed by CREMOD. Also it contains a code indicating the availability of annual BUILD limits for each plant type and a code indicating whether the construction lead time is long enough for IDC to be a major factor in the plant's capital cost. The display option generates a formatted display of the entire contents of FMAST*. Under the revise option, the user can update the contents of FMAST* on a plant type-by-plant type basis.

Revise/Display Capital Coefficients (RCC)

With this function, the CREMOD user may display the entire contents of FCOEF* for comparison with the MEMM preprocessor capital coefficient tables or perform limited revisions of the file. This function is executed by the module RVCDEF.

Revise/Display Capital Expenditure Profiles (RCE)

With this function, the CREMOD user may obtain a formatted display of the contents of the file FCEP* of capital expenditure profiles for verification or documentation purposes or perform limited revisions of the file. This function is executed by the module RVCEP.

Display Interim MEFS Solution Files (DMS)

This function provides a complete display of MEFS solution activity levels used by CREMOD to aid in analysis and interpretation of the Capital Requirements Report. It is executed by the module DYSOLN. This module retrieves the desired MEFS solution from the interim solution files SN85**, SN90**, and SN95**, and relevant plant type descriptions from the file FMAST*; it generates a formatted output report of these data.

KEY DESIGN FEATURES

Access to MEMM Solutions

Each time the MEMM is run for a given set of scenario assumptions and a given target year, the solution generated is stored in a file. This file is then packed to reduce storage requirements. A DOE-supported program called "PERUSE" can be used to access specific solutions in the packed file. PERUSE contains several accessing commands which permit the solution file user to access only information of interest. For example, the user can display all rows, all columns, or all of the solution matrix from a given run. S/he can also add columns or rows or compute averages of solution values.

Since PERUSE was designed exclusively for efficient accessing of MEMM solution files, it was determined to be the best mechanism for retrieving MEMM solutions to be used by CREMOD. The accessing is done in two steps (see Figure II-5). First, the user accesses the PERUSE program and uses a permanent file of commands in conjunction with PERUSE to access those portions of

FIGURE II-5

CREMOD USE OF SOLUTION FILES

CREATION OF INTERIM SOLUTION FILES*

USE OF INTERIM SOLUTION FILES

* PERUSE EXECUTED THREE TIMES TO CREATE 1985, 1990 AND 1995 INTERIM SOLUTION FILES FOR CREMOD USE.

the MEMM solution reflecting electric utility capacity additions. These solution values are stored in interim direct access files (one file for each different target year solution) for subsequent use within the CREMOD framework. Once a set of interim solution files has been created with respect to a given MEMM solution, it can be accessed directly by the CREMOD program over and over again.

Design and Revision of Other Data Files

Four remaining files of input data are used by CREMOD:

1. The plant type master file FMAST*
2. The capital coefficient file FCOEF*
3. The capital expenditure profile file FCEP*
4. The annual BUILD limit file FBLD*

FMAST*, FCOEF*, and FCEP* were designed as direct access files to permit interactive file revision during a CREMOD run. To provide this capability, a special program is used to prepare and format input data in the three files for processing by CREMOD. The program, called DIRECT reads character formatted versions of FMAST*, FCEOF*, and FCEP* entered through the TSO editor into binary formatted files to be accessed directly by CREMOD. The role of DIRECT in the CREMOD framework is shown in Figure II-6.

Given this capability, the CREMOD user may revise FMAST*, FCOEF* and FCEP* either within a CREMOD run or by use of the TSO editor and the DIRECT program.⁴ While internal revision is probably easier for the CREMOD user who is only minimally familiar with TSO editor procedures, it should be undertaken with considerable caution. If an error is made during revision within a CREMOD run, it can be most difficult to correct, thereby requiring re-creation of the entire direct access file from its physical sequential version using DIRECT and negating previous interactive revisions.

⁴Instructions for using the TSO editor can be found in the IBM publication entitled, "OS/VS2 TSO Terminal User's Guide," VS2 Release 3.7, GC28-0645-4, File No. S370-39.

FIGURE II-6
CREMOD SYSTEM FLOW

1. THE FILE NAME EXTENSION .PS STANDS FOR PHYSICAL SEQUENTIAL.
2. THE FILE NAME EXTENSION .DATA IS USED TO IDENTIFY THE DIRECT ACCESS VERSIONS OF THESE FILES.

Once the CREMOD user becomes familiar with a few simple commands in the TSO editor, this revision approach will probably be used most frequently for all four files listed above. It is unquestionably the most efficient approach for revising large quantities of input data and the only approach for creating alternative files of input data.

Regardless of the approach used, the user should ensure that revisions do not cause inconsistencies with MEMM solutions. For example, revision of capital coefficients in FCOEF* should be undertaken in general only to capture changes in corresponding MEMM preprocessor values. Otherwise, the capital coefficients used by CREMOD, if also used in the MEMM, would likely result in a different solution than that residing in SN85**, SN90**, and SN95**. This rule also applies to FCEP*. This file's contents should coincide with the capital expenditure profile values underlying the fixed charge factors utilized in producing the MEMM solutions operated on by CREMOD.

The Role of Alternative Economic Scenarios

A key refinement of the MEMM prior to its use in the 1978 ARC was the inclusion of alternative capital coefficients and generating plant BUILD limits as a function of economic scenario in its preprocessor raw data tables. There were three sets of capital coefficients and BUILD limits to reflect the following three scenarios:

- Scenario B (low supply - high demand)
- Scenario C (medium supply - medium demand)
- Scenario D (high supply - low demand).

Since these three alternative raw data sets now play a central role in MEMM analyses, LMI has defined a core set of three scenario-specific alternative files for each of the designations FMAST*, FCOEF*, FCEP*, and FBLD*.⁵

⁵Certain other elements of scenario specific data, e.g., normal escalation rates, used by the MEMM are also required by CREMOD. In most instances, these data elements are input to CREMOD using DATA statements.

This approach permits the CREMOD user to access the Scenario B, C, or D version of each of these files simply by specifying the desired scenario instead of having to request each file individually.

While the contents of FMAST* do not vary by scenario at present, the user can revise the file on a scenario-specific basis. The three scenario-specific versions of FCOEF* contain data corresponding to the scenario-specific capital coefficient data in the MEMM preprocessor tables and scenario-specific real escalation and IDC data provided by CEPAD personnel. The three versions of FBLD* are defined analogously with respect to preprocessor BUILD limit tables. However, at present, only nuclear BUILD limits vary by scenario, while coal BUILD limits currently in the preprocessor tables are the same for all scenarios. The three scenario-specific versions of FCEP* contain scenario-specific capital expenditure profiles developed by CEPAD personnel and used in the MEMM fixed charge factor computations.

In addition to the above scenario-specific file designations, CREMOD allows for the creation of non-scenario-specific versions of FMAST*, FCOEF*, FCEP*, and FBLD*. This provides the user with the flexibility to define additional versions of these files consistent with any given future set of MEMM solutions which s/he may wish to analyze in terms of its capital requirements.

Flexible Use of Annual BUILD Limits

One of the more important design features of CREMOD is that it is structured to use commissioning data for committed, deferrable, and new nuclear plants, and committed and deferrable coal plants as a basis for disaggregating MEMM-generated activity levels over time. Since nuclear and coal plants account for a very large proportion of future capital requirements, use of this commissioning data should add considerable realism to CREMOD estimates.

These data are input to CREMOD for each of the above plant types in the form of a BUILD limit in MW reflecting projected added capacity for each year and utility region. In general, each BUILD limit is computed by aggregating, by year, the same unit-level commissioning data that are aggregated over the multi-year MEMM planning horizon to arrive at the MEMM preprocessor BUILD limits. In the case of nuclear plants, development of the annual BUILD limits can be carried out automatically except for a manual adjustment to capture joint ownership of certain plants. This is done using the Nuclear Energy Analysis Division's INQUIRE data base. Coal plant annual BUILD limits must be computed by hand from the unit-level data maintained by CEPAD.

Since all committed plants by definition must be built in the MEFS, the MEMM solution always specifies an amount of committed capacity for each region equal to its planning horizon BUILD limit. In this case, CREMOD simply disaggregates this amount over the years of the horizon by the annual BUILD limit amounts since the sum of these annual limits equals the planning horizon limit. For deferrable plants on the other hand, the MEMM may suggest some amount of added capacity over the MEMM planning horizon which is less than the sum of the annual BUILD limits over the horizon. In this case, CREMOD spreads the deferrable capacity activity level over the planning horizon in proportion to the annual BUILD limits for the given region.⁶

CREMOD includes an important design feature by which, if annual BUILD limits are not available for a given plant type, the model can still be run and an approximate capital requirements estimate generated for that plant

⁶This spreading technique is also used for new nuclear plants. Analysis of several MEMM solutions indicated that in some instances, the MEMM will not use up all deferrable capacity specified for the period through 1984 but will use up all of this capacity in the period through 1989. In other words, it is implicitly deferring the remaining deferrable capacity to the interval 1985-1989. If this happens, CREMOD spreads the amount of implicitly deferred capacity evenly over the appropriate segment of the MEFS planning horizon, 1985-1989 in this case.

type. In this case, the MEMM-generated solution for each segment of the planning horizon is simply spread evenly over that segment, similar to the approach for most new plant types. This capability should be most useful to the CREMOD user in those instances when MEMM nuclear or coal BUILD limits have been revised but s/he has not yet revised/revalidated CREMOD's file of annual BUILD limits, FBILD*, accordingly.

Treatment of Transmission and Distribution Capital Expenditures

Four independent components of transmission and distribution (T&D) capital expenditures are addressed by CREMOD:

- a component of transmission capital cost for each utility region which varies as a function of added plant capacities in the MEMM solution,
- a component of transmission capital cost for each utility region which is fixed relative to the MEMM solution,
- a new distribution capital expenditure value for each region,
- a metering capital expenditure value for each region.

Of these four components, only the first is operated on by CREMOD in a manner similar to regular plant capacity additions. Computation of the second component requires certain MEMM preprocessor data but is independent of the MEMM optimization process. Computation of the third and fourth components is entirely independent of the MEMM optimization process. Because of these major differences in computational approach, all four components of T&D capital expenditures are computed by a separate subroutine in CREMOD. This permits analysis of these T&D expenditures, which are largely outside the framework of the MEMM, in conjunction with capital expenditures related to plant additions. Regional capital cost estimates for each element are input via DATA statements, spread over the appropriate planning horizon in a linear fashion, and

formatted for display in the standard CREMOD output report. As these exogenously derived data change over time, the appropriate CREMOD DATA statements must be revised accordingly.

Due to this approach to T&D computations, there is no requirement to maintain any T&D related data in the files FCOEF*, FCEP*, or FBLD*. While the variable component of transmission capital cost is computed using the MEMM solution (see section entitled, "MATHEMATICS UNDERLYING THE CAPITAL REQUIREMENTS COMPUTATION"), all remaining data for computing the four T&D components is either hard wired or input using DATA statements (see "DATA INPUT TO CREMOD USING DATA STATEMENTS" in Appendix A).

There is no real escalation in any of the elements of T&D addressed by CREMOD. At present, only the variable component of transmission capital cost is scenario dependent. All T&D capital requirements data computed exogenous to the MEMM has been provided by CEPAD personnel.

Error-Checking Features

CREMOD contains numerous error-checking routines. Many of the user responses required during a model run are checked against various standards or bounds. All capital expenditure profiles in FCEP* are checked to determine if they sum to 1 when the file is first accessed. Those plant types for which the condition is not met are reported to the user.

Since CREMOD operates on the 1985, 1990, and 1995 MEMM solutions simultaneously, these solutions must be monotone nondecreasing when moving from 1985 to 1990 to 1995 for each plant type to preclude the occurrence of negative net activity levels. Early experimentation with CREMOD isolated several anomalous instances in which this condition was not met because of the

strategy used to execute the MEMM (see example of solution anomalies in Figure II-7).⁷ After consultation with MEFS personnel, LMI added a heuristic to CREMOD which adjusts the MEMM solutions to be monotone nondecreasing in these few cases by increasing the later solution values as necessary. Logic was also added to report plant types in any given solution set for which this condition exists when the CCR module is first accessed (Figure II-7). These solution value increases will result in slight differences between CREMOD Capital Requirements Report cumulative capacity addition figures for 1990 and 1995, and both the corresponding solution displayed under CREMOD Function 6 and the analogous figures appearing in the MEFS COOKIE reports.

⁷The cause of these anomalies is described as follows in a November 6, 1979 letter from Mr. Jeffrey Jones of the Mid-Term Analysis Division of EIA's Office of Integrative Methods to Dr. Suraj Kanhouwa of the Financial and Industry Studies Division of EIA's Office of Economic Analysis:

"Regarding the anomalies in the capacity expansion schedules, three basic trends are observed.

- (1) the discrepancy was relatively small and occurs between the 1990 and 1995 solutions.
- (2) The discrepancy involved distillate turbines, or
- (3) The discrepancy involved plant conversions.

These three apparent problems arise from the strategy chosen to execute MEMM.

The 1990 case is run initially and the resulting capacity additions provide upper bounds for the 1985 builds and lower bounds for the 1995 builds. Because of computer round-off, the 1995 model becomes infeasible when a lower bound is binding. To circumvent this problem, the specified lower bounds are approximately 99 percent of the corresponding 1990 builds. Since CREMOD adjusts the lower 1995 figures to the 1990 solutions, it would perform the proper computations.

In the past, distillate turbines proved to be the exception. The new capacity was used primarily as a reserve and was not actually utilized. Consequently, the 1985, 1990, and 1995 solutions were not linked together. This has now been rectified.

The final anomaly concerns the plant conversions. The activities flagged by CREMOD are principally oil-gas and gas-oil conversions. These conversions involve a minimal expense and effort, so MEMM does not assign them a cost coefficient. The cost of the fuel is the dominant selection criterion so it is not unusual to convert a plant back to its initial type. Such reconversions would account for a lower quantity of converted capacity in a later forecast."

FIGURE II-7 MEMM SOLUTION ANOMALIES UNDER
1978 ARC MEDIUM SUPPLY SCENARIO

EXEC CREMOD

◆◆◆ CREMOD ◆◆◆

LOW, MEDIUM, HIGH OR INDIVIDUALLY SPECIFIED SUPPLY SCENARIO (L/M/H/I) M

ENTER PIES SOLUTION FILES (SN85◆◆, SN90◆◆, SN95◆◆): SN85M5, SN90M5, SN95M5

◆◆◆ CREMOD ◆◆◆

CREMOD FUNCTIONS

- (1) COMPUTE CAPITAL REQUIREMENTS
- (2) DISPLAY BUILD LIMITS
- (3) REVISE/DISPLAY PLANT TYPE MASTER FILE
- (4) REVISE/DISPLAY CAPITAL COEFFICIENTS
- (5) REVISE/DISPLAY CAPITAL EXPENDITURE PROFILES
- (6) DISPLAY INTERIM PIES SOLUTION FILES
- (7) STOP

ENTER FUNCTION DESIRED (0 TO LIST):

1

◆◆◆ COMPUTE CAPITAL REQUIREMENTS ◆◆◆

REGION: U2	MODE: 20	1985: 0.0	1990: 10522.496	1995: 10417.082
REGION: U4	MODE: V0	1985: 0.0	1990: 1.133	1995: 0.0
REGION: U1	MODE: 60	1985: 2610.333	1990: 0.0	1995: 0.0
REGION: U7	MODE: 60	1985: 0.0	1990: 2765.041	1995: 1498.250
REGION: U9	MODE: 60	1985: 3914.041	1990: 10595.414	1995: 0.0
REGION: U8	MODE: 60	1985: 2011.875	1990: 736.708	1995: 873.250
REGION: U1	MODE: 72	1985: 180.000	1990: 180.000	1995: 175.500
REGION: U4	MODE: 72	1985: 226.000	1990: 226.000	1995: 221.321
REGION: U5	MODE: 72	1985: 50.000	1990: 50.000	1995: 49.500
REGION: U9	MODE: 72	1985: 1344.000	1990: 1344.000	1995: 1313.042
REGION: U4	MODE: CT	1985: 2176.000	1990: 0.0	1995: 0.0
REGION: U5	MODE: CT	1985: 146.000	1990: 0.0	1995: 0.0
REGION: U7	MODE: CT	1985: 1248.458	1990: 718.958	1995: 0.0
REGION: U9	MODE: CT	1985: 0.0	1990: 537.000	1995: 0.0
REGION: U8	MODE: LA	1985: 0.0	1990: 12410.836	1995: 10154.582

ENTER SUPPLY SCENARIO LOW(1), MED(2), HIGH(3)

2

ENTER PIES BASE YEAR (YY)

79

ENTER USER BASE YEAR (YY)

75

ENTER INFLATION RATE (DEC.)

?

0

MATHEMATICS UNDERLYING THE CAPITAL REQUIREMENTS COMPUTATION

In this section, we define the various entries in Columns 1.2-1.5 and 2.2-2.7 of the CREMOD Capital Requirements Report (see Figure II-8) in mathematical terms. In the first section below, we present the basic formulas used to compute the direct and interest components of electric utility capital in terms of a simplified notation. In the following sections, we develop these same quantities and all remaining CREMOD Report quantities using the more comprehensive notation of the model.

The Basic Calculation of Direct and Interest Capital Components

Let us compute the direct and interest components of capital cost in real terms for each year of construction of a new electric utility plant for which construction is to begin subsequent to CREMOD's coefficient base year. We first define the following quantities:

- TDC = the total direct capital cost of the plant in coefficient base year dollars excluding all real escalation and AFDC,
- n = the number of years from the coefficient base year through the last year prior to the first year of the plant's construction lead time,
- CLT = the length of the plant's construction lead time in years,
- F_j = the fraction of the plant's total direct cost (in real terms) expended in year j of the construction lead time, $j=1,2,\dots,CLT$,
- r_1 = the annual normal inflation rate (assumed constant over all relevant years),
- r_{2j} = the real escalation rate for the plant in year j , $j=1,2,\dots,n+CLT$, and
- S = the nominal interest rate per year on funds borrowed for construction of the plant (i.e., the weighted average cost of capital in nominal terms (assumed constant over all relevant years)).

REGIONS: U1 U2 U3 U4 U5 U6 U7 U8 U9 UA

PLANT TYPES FOR OPTION 2

23	NUCLEAR	NY
46	NUCLEAR	NZ
69	NUCLEAR	NU

◆◆◆CREMOD CAPITAL REQUIREMENTS REPORT ◆◆◆
 TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
 INDICATED PLANT TYPES AND REGIONS

(1.1)	(1.2)	(1.3)	(1.4)	(1.5)
YEAR	CWIP (GW)	CUMULATIVE CW COMPLETED (GW)	CAPITAL EXPENDED (\$ MIL.)	CUMULATIVE CAPITAL EXPENDED (\$ MIL.)
1979	88.62	11.25	5545.21	5545.21
1980	89.94	17.73	5625.29	11170.50
1981	94.01	28.98	6137.00	17307.50
1982	94.17	38.71	6358.04	23665.54
1983	99.22	46.05	6354.78	30020.32
1984	95.74	55.73	5971.38	35991.70
1985	83.80	67.66	5492.66	41484.36
1986	74.93	76.54	5720.33	47204.69
1987	63.05	88.42	6814.98	54019.67
1988	56.19	95.28	7277.98	61297.65
1989	51.59	99.88	7233.92	68531.57
1990	43.79	107.67	6072.21	74603.78

TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
 INDICATED PLANT TYPES AND REGIONS

(2.1)	(2.2)	(2.3)	(2.4)	(2.5)	(2.6)	(2.7)
YEAR	ANNUAL CAPITAL EXPENDITURE (\$ MIL.)			CUMULATIVE CAPITAL EXPENDITURES (\$ MIL.)		
	DIRECT	INTEREST	TOTAL	DIRECT	INTEREST	TOTAL
1979	4230.09	1315.12	5545.21	4230.09	1315.12	5545.21
1980	4375.67	1249.62	5625.29	8605.76	2564.74	11170.50
1981	4771.19	1365.81	6137.00	13376.95	3930.55	17307.50
1982	4985.11	1372.93	6358.04	18362.06	5303.48	23665.54
1983	4940.16	1414.61	6354.78	23302.23	6718.09	30020.32
1984	4491.95	1479.43	5971.38	27794.18	8197.52	35991.70
1985	4066.00	1426.66	5492.66	31860.18	9624.18	41484.36
1986	4385.02	1335.31	5720.33	36245.20	10959.49	47204.69
1987	5413.20	1401.78	6814.98	41658.40	12361.27	54019.67
1988	5856.91	1421.07	7277.98	47515.31	13782.34	61297.65
1989	5667.75	1566.16	7233.92	53183.06	15348.50	68531.57
1990	4400.42	1671.79	6072.21	57583.49	17020.29	74603.78

Then if

$DCAP_j$ = the total direct capital expenditure for the plant in year j including real escalation from the coefficient base year through year j but excluding normal inflation, $j=n+1, n+2, \dots, n+CLT$,

we have

$$DCAP_j = (TDC) \left(\prod_{k=1}^j (\pi(1+r_{2k})) \right) (F_{j-n}), \quad j=n+1, n+2, \dots, n+CLT.$$

Similarly, suppose

$ICAP_j$ = the total capitalized interest paid in year j , including real escalation from the coefficient base year through year j (but excluding normal inflation) on funds borrowed through year j for construction of the plant.

Then the amount of money borrowed in year i in nominal terms for plant construction is

$$(TDC) \left(\prod_{k=1}^i (\pi(1+r_1)(1+r_{2k})) \right) (F_{i-n}), \quad i=n+1, n+2, \dots, n+CLT.$$

Hence, we have

$$\begin{aligned} ICAP_j &= S \left[(TDC) \left(\prod_{k=1}^{n+1} (\pi(1+r_1)(1+r_{2k})) \right) (F_1) + (TDC) \left(\prod_{k=1}^{n+2} (\pi(1+r_1)(1+r_{2k})) \right) (F_2) \right. \\ &\quad \left. + \dots + (TDC) \left(\prod_{k=1}^j (\pi(1+r_1)(1+r_{2k})) \right) (F_{j-n}) \right] / (1+r_1)^j, \quad j=n+1, n+2, \dots, n+CLT \\ &= (S)(TDC) \left[\sum_{i=n+1}^j F_{i-n} \left(\prod_{k=1}^i (\pi(1+r_1)(1+r_{2k})) \right) \right] / (1+r_1)^j, \quad j=n+1, n+2, \dots, n+CLT \end{aligned}$$

Note that the value of $ICAP_j$ for year j is built up in nominal terms and then normalized to coefficient base year dollars by dividing by $(1+r_1)^j$.

The above mathematical definitions of $DCAP_j$ and $ICAP_j$, $j=n+1, n+2, \dots, n+CLT$, serve as the basis for development of the CREMOD Capital Requirements Report capital entries.

Disaggregating MEMM-Generated Capacity Additions Over Time

The three solution files SN85**, SN90**, and SN95** contain MEMM generated capacity additions for each electric utility plant type and for the target years 1985, 1990, and 1995, respectively. In order to show how these solutions are used by CREMOD, we first define the following quantities:

- (P ≡ the set of all utility plant types listed in the Plant Type Master File FMAST*,
- AL_{ikn} ≡ The MEMM-generated capacity addition in gigawatts (GW) for plant type i in region k up to target year n , $i \in P$, $k=1,2,\dots,10, n=1$ (1985), 2 (1990), 3 (1995),
- T_i ≡ the construction lead time (contained in the Capital Expenditure Profile File FCEP*) in years for plant type i , $i \in P$,
- PBL ≡ the set of plant types for which annual BUILD limits are available (in the file FBILD*), e.g., committed nuclear, deferrable nuclear, etc.
- MBY ≡ the MEFS base year, i.e., the first year of the MEFS planning horizon (less 1900), e.g., 79, and
- CAP_{ijk} ≡ the capacity addition in GW defined by CREMOD for plant type i in region k and year j , $i \in P$, $k=1,2,\dots,10, j=1,2,\dots,(95-MBY)$

For those plant types for which annual BUILD limits are not available, the capacity addition for each year is computed by spreading the net activity level for each segment of the MEFS planning horizon ($\{1979-1984\}$, $\{1985-1989\}$, $\{1990-1994\}$) linearly over that segment, i.e.,

$$CAP_{ijk} = \begin{cases} AL_{ik1}/(85-MBY), & i \in P, i \notin PBL, k=1,2,\dots,10, \\ & j=1,2,\dots,(85-MBY), \\ (AL_{ik2}-AL_{ik1})/5, & i \in P, i \notin PBL, k=1,2,\dots,10, \\ & j=(85-MBY)+1,\dots,(90-MBY), \\ (AL_{ik3}-AL_{ik2})/5, & i \in P, i \notin PBL, k=1,2,\dots,10, \\ & j=(90-MBY)+1,\dots,(95-MBY). \end{cases}$$

For those plant types $i \in \text{PBL}$ for which annual BUILD limits are available, let

ABL_{ijk} $\equiv$ the annual BUILD limit in GW for plant type i , year j , and region k , $i \in \text{PBL}$, $j=1,2,\dots,(95-\text{MBY})$, $k=1,2,\dots,10$.

For these plant types, the capacity addition for a given year equals the net activity level for the planning horizon segment covering that year times the fraction formed by the annual BUILD limit for that year divided by the sum of all annual BUILD limits in the covering planning horizon segment, i.e.,

$$\text{CAP}_{ijk} = \left[\begin{array}{l} \text{AL}_{ik1} * (\text{ABL}_{ijk} / (\sum_{m=1}^{85-\text{MBY}} \text{ABL}_{imk})), i \in \text{PBL}, \\ j=1,2,\dots,(85-\text{MBY}), k=1,2,\dots,10, \\ \\ (\text{AL}_{ik2} - \text{AL}_{ik1}) * (\text{ABL}_{ijk} / (\sum_{m=85-\text{MBY}+1}^{90-\text{MBY}} \text{ABL}_{imk})), i \in \text{PBL}, \\ j=85-\text{MBY}+1,\dots,95-\text{MBY}, k=1,2,\dots,10, \\ \\ (\text{AL}_{ik3} - \text{AL}_{ik2}) * (\text{ABL}_{ijk} / (\sum_{m=90-\text{MBY}+1}^{95-\text{MBY}} \text{ABL}_{imk})), i \in \text{PBL}, \\ j=90-\text{MBY}+1,\dots,95-\text{MBY}, k=1,2,\dots,10. \end{array} \right.$$

In other words, the net activity level for each planning horizon segment is disaggregated in proportion to the annual BUILD limits. For committed plants, the sum of annual BUILD limits for a given planning horizon segment is equal to the net activity level for the segment. For deferrable plants, the sum is greater than or equal to the net activity level because the MEMM is not constrained to use all available deferrable plant capacity as it is committed capacity.

Report Capacity Addition Quantities

The capacity addition quantities in Columns 1.2 and 1.3 of the

CREMOD Capital Requirements Report can now be derived. Let the following quantities be defined:

SET1 $\equiv$ the set of all utility plant types (specified by the CREMOD user) over which capital requirements are to be aggregated,

SET2 $\equiv$ the set of all utility regions over which capital requirements are to be aggregated,

CWIP_m = entry m of Column 1.2
 $\equiv$ the construction work in progress in GW in year m for all indicated plant types and regions, and

CCWC_m = entry m of Column 1.3
 $\equiv$ the cumulative construction work completed by the end of year m for all indicated plant types and regions, m=1900+MBY, ..., 1990.

Then the derivation of these two quantities follows as shown from the definitions above:

$$CWIP_m = \sum_{i \in SET1} \sum_{k \in SET2} \sum_{j=m'+1}^{m'+T_i-1} CAP_{ijk}, \text{ and}$$

$$CCWC_m = \sum_{i \in SET1} \sum_{k \in SET2} \sum_{j=1}^{m'} CAP_{ijk}, \quad m' = m - 1900 - MBY + 1, \quad m = 1900 + MBY, \dots, 1990.$$

Development of Annual Capital Expenditure Expressions

In this section, we derive the basic expressions for the direct and interest components of annual capital expenditures. These form the basis for defining all dollar expenditure expressions in the output report. They are defined as follows:

DCAPTL_{ijk} $\equiv$ the total direct capital expenditure (\$) in year j including real escalation from the coefficient base year through year j but excluding normal inflation, for all new plants of type i in region k, i $\in$ P, j=1,2, ..., (95-MBY), k=1,2, ..., 10, and

ICAPTL_{ijk} $\equiv$ the total capitalized interest paid in year j, including real escalation from the coefficient base year through year j (but excluding normal inflation) on funds borrowed through year j for the construction of new plants of type i coming on line in region k in or subsequent to year j, i $\in$ P, j=1,2, ..., (95-MBY), k=1,2, ..., 10.

In order to develop these quantities as a function of capacity additions, capital coefficients, interest rates, real escalation rates, etc., we must first define the following quantities:

CBY $\equiv$ the coefficient base year (less 1900) i.e., the base year in which capital coefficients in the Capital Coefficient File FCOEF* are defined,

COEF_{ik} $\equiv$ the capital cost per GW of plants of type i in region k in coefficient base year dollars and including both direct and interest components of capital through 1984 as well as real escalation through 1984, i $\in$ P, k=1,2,...,10 (COEF_{ik} equals the capital coefficient in FCOEF* for plant type i and region k times 10⁶),

IDC_{2i} $\equiv$ the fraction of COEF_{ik}, k=1,2,...,10, comprising interest during construction (where this interest component also includes real escalation), i $\in$ P,

E4_i $\equiv$ that fraction of only the direct component of COEF_{ik}, k=1,2,...,10, comprising real escalation from the coefficient base year through 1984, i $\in$ P (the MEMM assumes that the prototypical plant with respect to which COEF_{ik} is defined comes on line on January 1, 1985)

CREMOD subtracts cumulative real escalation and interest components from the 1985 capital coefficient in the file FCOEF* in order to get a value in coefficient base year dollars to which real escalation and interest can be added, year by year. Letting

DCOEF_{ik} $\equiv$ the direct capital cost per GW of plants of type i in region k in coefficient base year dollars excluding all real escalation and interest during construction costs, i $\in$ P, k=1,2,...,10,

it follows that

$$\text{DCOEF}_{ik} = \text{COEF}_{ik} (1 - \text{IDC}_{2i}) (1 - E4_i), \quad i \in P, k=1,2,\dots,10.$$

Now let the following quantities be defined.

N $\equiv$ the number of years from the coefficient base year to the MEFS base year
 $= \text{MBY} - \text{CBY},$

r₁ $\equiv$ the annual normal inflation rate (a scenario dependent parameter developed by CEPAD personnel and input to CREMOD via a DATA statement), i $\in$ P,

$$r_{2ij} \equiv \begin{cases} \text{the real escalation rate for plant type } i \text{ in year } j, \\ i \in P, j=1,2,\dots,95\text{-CBY}, \\ \\ E1_i & \text{if } j=1,2,\dots,85\text{-CBY} \\ E2_i & \text{if } j=85\text{-CBY}+1,\dots,90\text{-CBY} \quad i \in P, \\ E3_i & \text{if } j=90\text{-CBY}+1,\dots,95\text{-CBY} \end{cases}$$

where $E1_i$, $E2_i$, $E3_i$ are average yearly escalation rates found under the column headings "E1," "E2," "E3," respectively, in the Capital Coefficient File FCOEF*.⁸ Also, let

$$F_{ij} \equiv \begin{cases} \text{the fraction in real terms of the total direct capital} \\ \text{expenditure for a prototypical plant of type } i \text{ in year } j \\ \text{of its construction lead time (found in the Capital Ex-} \\ \text{penditures Profile File FCEP*)}, i \in P, j=1,2,\dots,T_i. \end{cases}$$

By these definitions, $DCAPTL_{ijk}$ can be expressed as the sum of the dollar expenditures occurring in year j through $k + T_i - 1$, each a product of a capacity addition and some fraction of its cost per unit, appropriately escalated, i.e.,

$$DCAPTL_{ijk} = \sum_{m=j}^{j+T_i-1} CAP_{imk} * (DCOEF_{ik} * F_{i,T_i-(m-j)} * \prod_{n=1}^{N+j} (1+r_{2in})), \\ i \in P, j=1,2,\dots,(95\text{-MBY}), k=1,2,\dots,10.$$

In order to define the interest quantity, $ICAPTL_{ijk}$ analogously, we first define

$$S_i \equiv \begin{cases} \text{the (scenario dependent) nominal interest rate per} \\ \text{year (also developed by CEPAD personnel and appearing} \\ \text{in the file FCOEF* under the heading "IDC#1"), } i \in P. \end{cases}$$

⁸By this definition, we also have

$$DCOEF_{ik} = COEF_{ik} \prod_{j=1}^{85\text{-CBY}} (1 - IDC_{2i}) / (\pi(1+r_{2ij})), i \in P, k=1,2,\dots,10,$$

or, in other words,

$$E4_i = 1 - 1 / \left(\prod_{j=1}^{85\text{-CBY}} (1+r_{2ij}) \right), i \in P.$$

Then letting

$INT_{ijkm} \equiv$ the total interest paid in year j in nominal terms with respect to year j on funds borrowed through year j for each GW of plant of type i coming on line in region k and year $m=j, j+1, \dots, j+T_i-1$, and

$M \equiv$ the year, relative to the coefficient base year, in which construction on this plant is undertaken

$$= N+m-T_i$$

it follows that

$$\begin{aligned} INT_{ijkm} &= S_i (DCOEF_{ik}) \left(\prod_{n=1}^M (1+r_1)(1+r_{2in}) \right) \{ F_{i1} (1+r_1)(1+r_{2i,m+1}) \\ &\quad + F_{i2} \cdot \prod_{n=1}^2 (1+r_1)(1+r_{2i,m+n}) \\ &\quad + \dots + F_{i,T_i-(m-j)} \cdot \prod_{n=1}^{T_i-(m-j)} (1+r_1)(1+r_{2i,M+n}) \} \\ &= S_i (DCOEF_{ik}) \left(\prod_{n=1}^M (1+r_1)(1+r_{2in}) \right) \\ &\quad * \left(\sum_{q=1}^{T_i-(m-j)} F_{iq} \cdot \prod_{n=1}^q (1+r_1)(1+r_{2i,M+n}) \right) \\ &= S_i (DCOEF_{ik}) \left(\sum_{q=1}^{T_i-(m-j)} F_{iq} \cdot \prod_{n=1}^{M+q} (1+r_1)(1+r_{2i,M+n}) \right), \\ &\quad i \in P, j=1,2,\dots,(95-MBY); k=1,2,\dots,10, \\ &\quad m=j, j+1,\dots,j+T_i-1. \end{aligned}$$

Recalling that

$ICAPTL_{ijk} \equiv$ the total interest paid in year j in real terms with respect to year j on funds borrowed through year j for the construction of new plants of type i coming on line in region k in or subsequent to year j ,

we have that $ICAPTL_{ijk}$ is a sum of interest payments on plants coming on line

in years j through $j + T_i - 1$, where each payment is a product of a new capacity, CAP_{imk} , and an interest cost per GW of new capacity, INT_{ijkm} , appropriately de-escalated, i.e.,

$$ICAPTL_{ijk} = \sum_{m=j}^{j+T_i-1} (CAP_{imk}) (INT_{ijkm}) / (1+r_1)^{N+j}$$

$i \in P, j=1,2,\dots,(95-MBY), k=1,2,\dots,10.$

Aggregate Capital Expenditure Quantities

All capital expenditure quantities in the CREMOD Capital Requirements Report are easily expressed in terms of the two quantities derived above. Let

$CDEXP_j \equiv$ the total direct capital expenditure in year j for all user specified plant types and regions, $j=1,2,\dots,(95-MBY)$, and

$CIEXP_j \equiv$ the total capitalized interest expenditures in year j for all user specified plant types and regions, $j=1,2,\dots,(95-MBY)$.

Then it follows that

$$CDEXP_j = \sum_{i \in SET1} \sum_{k \in SET2} DCAPTL_{ijk}, j=1,2,\dots,(95-MBY), \text{ and}$$

$$CIEXP_j = \sum_{i \in SET1} \sum_{k \in SET2} ICAPTL_{ijk}, j=1,2,\dots,(95-MBY)$$

Next, let us define

$CEXP'_m =$ entry m of Column 1.4

$\equiv$ the total capital expenditure in millions of dollars for all specified plant types and regions,

$TCEXP'_m =$ entry m of Column 1.5

$\equiv$ the cumulative capital expenditure in millions of dollars through year m for all specified plant types and regions, $m=1900+MBY,\dots,1990$,

$CDEXP'_m =$ entry m of Column 2.2

$\equiv$ the direct component of $CEXP'_m$ (Column 1.4),

$CIEXP'_m =$ entry m of Column 2.3

$\equiv$ the interest component of $CEXP'_m$,

$TCDEXP'_m$ = entry m of Column 2.5

$\equiv$ the direct component of $TCEXP'_m$, and

$TCIEXP'_m$ = entry m of Column 2.6

$\equiv$ the interest component of $TCEXP'_m$

where $m = 1900 + MBY, \dots, 1990$ and Columns 2.4 and 2.7 are identical to Columns 1.4 and 1.5, respectively. Then

$$CDEXP'_m = CDEXP_m / 10^6,$$

$$CIEXP'_m = CIEXP_m / 10^6, \quad m' = m - 1900 - MBY + 1,$$

$$CEXP'_m = CDEXP'_m + CIEXP'_m$$

$$TCDEXP'_m = \sum_{n=1900+MBY}^M CDEXP'_n,$$

$$TCIEXP'_m = \sum_{n=1900+MBY}^M CIEXP'_n, \text{ and}$$

$$TCEXP'_m = \sum_{n=1900+MBY}^M CEXP'_n, \quad m=1900+MBY, \dots, 1990.$$

Transmission and Distribution Capital Expenditures

As mentioned above, there are four components of T&D capital expenditures addressed by CREMOD:

- a variable component of new transmission equipment
- a fixed component of new transmission equipment
- new distribution equipment
- meters

Of these, the last three are determined completely exogenous to the MEMM. These three are input to CREMOD as costs and operated on in only minor respects in order to provide CREMOD estimates of all T&D capital expenditures in the same format as expenditures for new generating capacity. CREMOD mathematical operations for each component of T&D are summarily described below (also see "DATA INPUT TO CREMOD USING DATA STATEMENTS" in Appendix A).

Transmission Capital Expenditures (Variable Component). This component of T&D is the only one which varies with the MEMM solution. Let

X_i = the value of the activity level in SN85**, SN90**, or SN95** representing the variable component of transmission capital expenditures up to target year 1985, 1990, or 1995, respectively, for a given utility region (MMKWH/CD), $i=85,90,95$.

Then if TV_i is defined to be the variable component of new transmission capital expenditures through target year i for the given region, we have

$$TV_i = (10^3 * \underbrace{TDCAPV}_{\$ / KW} * (\underbrace{X_i}_{MMKWH / CD} * 1/.024))$$

1975\$/MW
MW

where TDCAPV = the capital coefficient VAR85, VAR90, or VAR95 as appropriate from Table TDCAP of the MEMM preprocessor

Letting

Δ_j^1 = the portion of cumulative variable transmission capital expenditures allocated (linearly) to year j , $j=1,2,\dots,95-MBY$,

then Δ_j^1 is simply the product of the appropriate value of the capital coefficient, TDCAP (appropriately scaled), and the activity level apportioned to year j , i.e.,

$$\Delta_j^1 = \begin{cases} (10^3/.024) * VAR85 * X_{85}/(85-MBY), & j=1,\dots,85-MBY, \\ (10^3/.024) * VAR90 * (X_{90}-X_{85})/5, & j=85-MBY+1,\dots,90-MBY, \\ (10^3/.024) * VAR95 * (X_{95}-X_{90})/5, & j=90-MBY+1,\dots,95-MBY. \end{cases}$$

The CREMOD Capital Requirements Report quantities for this component of T&D are obtained by applying the two year turbine capital expenditure profile (.25, .75) to each of the quantities, Δ_j^1 , $j = 1, 2, \dots, 95 - MBY$, and aggregating as appropriate over regions and years.

source for this component of T&D is Table TDCAP in the MEMM preprocessor. Let

TF_i $\equiv$ the cumulative fixed component of new transmission capital expenditures (in 1975 \$) up to target year i for a given utility region, $i=85,90,95$.

Then

$$TF_i = \begin{cases} FIX85 * 10^6, & i=85, \\ FIX90 * 10^6, & i=90, \\ FIX95 * 10^6, & i=95, \end{cases}$$

where $FIX85$, $FIX90$, and $FIX95$ are found in Table TDCAP.

Letting

Δ_j^2 $\equiv$ the portion of cumulative fixed transmission capital expenditures allocated (linearly) to year j , $j=1,2,\dots,95-MBY$,

then it follows that

$$\Delta_j^2 = \begin{cases} (FIX85 * 10^6)/(85-MBY), & j=1,2,\dots,85-MBY, \\ (FIX90-FIX85) * 10^6/5, & j=85-MBY+1,\dots,90-MBY, \\ (FIX95-FIX90) * 10^6/5, & j=90-MBY+1,\dots,95-MBY. \end{cases}$$

CREMOD also applies the two year turbine capital expenditure profile (.25, .75) to each of the quantities Δ_j^2 , $j = 1, 2, \dots, 95 - MBY$, and aggregates as appropriate over regions and years in its Capital Requirements Report.

New Distribution Capital Expenditures. The three quantities,

DN_i $\equiv$ cumulative new distribution capital expenditures up to target year i (1975 \$) for a given utility region, $i=85,90,95$,

have been provided by CEPAD personnel for each utility region. Letting

Δ_j^3 $\equiv$ the portion of cumulative new distribution capital expenditures allocated (linearly) to year j , $j=1,2,\dots,95-MBY$,

we have

$$\Delta_j^3 = \begin{cases} DN_1/(85-MBY), & j=1,2,\dots,85-MBY \\ (DN_2-DN_1)/5, & j=85-MBY+1,\dots,90-MBY \\ (DN_3-DN_2)/5, & j=90-MBY+1,\dots,95-MBY \end{cases}$$

As in the previous case, CREMOD applies the two-year turbine capital expenditure profile (.25, .75) to each of the quantities Δ_j^3 , $j = 1, 2, \dots, 95 - MBY$, and aggregates over regions and years as appropriate in its Capital Requirements Report.

Metering Capital Expenditures. The three quantities,

$MC_i \equiv$ cumulative metering capital expenditures up to target year i (1975 \$) for a given utility region, $i=85,90,95$,

have also been provided by CEPAD personnel for each utility region. Letting

$\Delta_j^4 =$ the portion of cumulative metering capital expenditures allocated (linearly) to year j , $j=1,2,\dots,95-MBY$,

we have

$$\Delta_j^4 = \begin{cases} MC_1/(85-MBY), & j=1,2,\dots,85-MBY \\ (MC_2-MC_1)/5, & j=85-MBY+1,\dots,90-MBY \\ (MC_3-MC_2)/5, & j=90-MBY+1,\dots,95-MBY \end{cases}$$

CREMOD aggregates the quantities Δ_j^4 , $j = 1, 2, \dots, 95 - MBY$, over regions and years as appropriate in its Capital Requirements Report. A one year construction lead time is assumed.

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III. GUIDE TO MODEL APPLICATIONS

INTRODUCTION

Forecasts of electric utility industry capital requirements for the ARC represent an important application of CREMOD. With this information, Government policy makers can more effectively analyze the capital requirements of the different energy subsectors in terms of the availability of capital.

CREMOD can also be used to estimate the effects of DOE policy on the capital requirements of the electric utility industry. For example, the impact of candidate safety standards on the direct and interest components of individual plant costs can be incorporated into CREMOD, along with estimated impacts on construction lead times. Tradeoffs in terms of aggregate capital requirements effects under alternative time of day pricing scenarios can be examined. Aggregate capital requirements effects of promoting the construction of larger plants can be estimated.

DEVELOPMENT OF A SAMPLE ESTIMATE

This section briefly demonstrates how estimates of capital requirements for the entire electric utility industry for the period January 1, 1979, to January 1, 1990, are developed with CREMOD. These estimates are shown in Figure III-1. Their format is identical to that used in the 1977 EIA Annual Administrator's Report and 1978 ARC. The estimates themselves are precisely those appearing in the 1978 ARC (Table 7.2) except they appear below in 1975 base year dollars while they are inflated to 1978 dollars in the ARC.

FIGURE III-1. PROJECTED CAPACITY ADDITIONS
AND CAPITAL REQUIREMENTS ('78 ARC) FOR SCENARIOS B, C, AND D
(January 1, 1979 to January 1, 1990)

	<u>Capacity Additions (GW)</u>			<u>Capital Requirements (x 10⁹ '75 \$)</u>		
	<u>B</u>	<u>C</u>	<u>D</u>	<u>B</u>	<u>C</u>	<u>D</u>
Nuclear Generation	95.22	99.88	107.84	56.13	68.53	72.66
Other Generation	264.37	254.30	203.32	133.18	111.83	76.56
Conversions	15.89	15.18	14.53	1.25	1.25	1.25
Scrubber Retrofit	3.41	3.41	4.82	.31	.31	.44
Transmission and Distribution	-	-	-	81.55	80.28	79.13
TOTAL	378.89	372.77	330.51	272.42	262.20	230.04

Figure III-1 provides two kinds of information--capacity additions and capital requirements--for five electric utility subsectors: nuclear generation, other generation, plant conversions, scrubber retrofitting of existing plants, and T&D facilities. The estimates are developed for three scenarios: low supply - high demand (B), mid demand - mid supply (C), and high supply - low demand (D). For each scenario and subsector, the capacity additions and capital requirements values are simply the 1989 values of CUMULATIVE CW COMPLETED and CUMULATIVE CAPITAL EXPENDED, respectively, in the CREMOD Capital Requirements Report.

For any one of the scenarios, say Scenario C, estimates in Figure III-1 are generated as follows by means of the CREMOD plant type aggregations listed in Figure III-2. Nuclear generation figures are obtained from (2) NUCLEAR. The corresponding CREMOD Capital Requirements Report appears in Figure III-3. Other generation figures are obtained by subtracting these nuclear figures from the analogous figures generated with (16) ALL BUILDS (see Figure III-4), which includes the nuclear generation category as shown. Scrubber Retrofit figures are obtained with (20) ALL EXISTING PLANT CONVERSIONS (see Figure III-5). Conversion figures are obtained by subtracting scrubber retrofit figures from the analogous figures generated with (22) ALL CONVERSIONS (see Figure III-6). Finally, T&D figures are obtained with (25) TRANSMISSION & DISTRIBUTION (see Figure III-7). The sums over the five subsectors of capacity additions and capital requirements are equal to the analogous quantities under (24) ALL (UTILITY CAPITAL), less analogous values for all the emerging technologies.

ANALYSIS OF A SAMPLE ESTIMATE

It is possible that for several reasons, interscenario comparisons of

FIGURE III-2 LISTING OF CREMOD PLANT TYPE AGGREGATIONS

- (1) INDIVIDUALLY SPECIFIED
- (2) NUCLEAR
- (3) BITUMINOUS WITH SCRUBBER
- (4) BITUMINOUS WITHOUT SCRUBBER
- (5) SUB-BITUMINOUS WITH SCRUBBER
- (6) SUB-BITUMINOUS WITHOUT SCRUBBER
- (7) LIGNITE WITH SCRUBBER
- (8) LIGNITE WITHOUT SCRUBBER
- (9) COAL WITH SCRUBBER
- (10) COAL WITHOUT SCRUBBER
- (11) ALL COAL BUILDS
- (12) TURBINE
- (13) COMBINED CYCLE
- (14) HYDROELECTRIC
- (15) ALL FUEL GAS
- (16) ALL BUILDS
- (17) ALL OIL TO COAL CONVERSIONS
- (18) ALL GAS TO COAL CONVERSIONS
- (19) ALL NEW PLANT COAL TO COAL CONVERSIONS
- (20) ALL EXISTING PLANT CONVERSIONS
- (21) ALL OTHER CONVERSIONS
- (22) ALL CONVERSIONS
- (23) ALL EMERGING TECHNOLOGIES
- (24) ALL (UTILITY CAPITAL)
- (25) TRANSMISSION & DISTRIBUTION
- (26) ALL (NET OF T & D)

capacity additions and capital requirements estimates will not provide intuitively obvious results. For example, the cumulative capital requirements value through a given year may contain a large component of CWIP on plants to be commissioned beyond that year. A large amount of the capital expenditures for a given capacity addition may be sunk, resulting in a reduced capital requirement for that addition. Comparisons should therefore be made with care. In particular, the values (\$/KW) obtained by dividing cumulative capital requirements by corresponding capacity completed may not produce particularly meaningful measures of capital costs per unit. They may, however, be useful in deciding how to go about isolating the types of plant for which capital is required. In general, these sources can be found by making

FIGURE III-3 SCENARIO C--NUCLEAR CAPITAL REQUIREMENTS

REGIONS: U1 U2 U3 U4 U5 U6 U7 U8 - U9 UA

PLANT TYPES FOR OPTION 2

23 NUCLEAR NY
46 NUCLEAR NZ
69 NUCLEAR NO

◆◆◆CREMOD CAPITAL REQUIREMENTS REPORT ◆◆◆
TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
INDICATED PLANT TYPES AND REGIONS

YEAR	CWIP (GW)	CUMULATIVE CW COMPLETED (GW)	CAPITAL EXPENDED (\$ MIL.)	CUMULATIVE CAPITAL EXPENDED (\$ MIL.)
1979	88.62	11.25	5545.21	5545.21
1980	89.94	17.73	5625.29	11170.50
1981	94.01	28.98	6137.00	17307.50
1982	94.17	38.71	6358.04	23665.54
1983	99.22	46.05	6354.78	30020.32
1984	95.74	55.73	5971.38	35991.70
1985	83.80	67.66	5492.66	41484.36
1986	74.93	76.54	5720.33	47204.69
1987	63.05	88.42	6814.98	54019.67
1988	56.19	95.28	7277.98	61297.65
1989	51.59	<u>99.88</u>	7233.92	<u>68531.57</u>
1990	43.79	107.67	6072.21	74603.78

TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
INDICATED PLANT TYPES AND REGIONS

YEAR	ANNUAL CAPITAL EXPENDITURE (\$ MIL.)			CUMULATIVE CAPITAL EXPENDITURES (\$ MIL.)		
	DIRECT	INTEREST	TOTAL	DIRECT	INTEREST	TOTAL
1979	4230.09	1315.12	5545.21	4230.09	1315.12	5545.21
1980	4375.67	1249.62	5625.29	8605.76	2564.74	11170.50
1981	4771.19	1365.81	6137.00	13376.95	3930.55	17307.50
1982	4985.11	1372.93	6358.04	18362.06	5303.48	23665.54
1983	4940.16	1414.61	6354.78	23302.23	6718.09	30020.32
1984	4491.95	1479.43	5971.38	27794.18	8197.52	35991.70
1985	4066.00	1426.66	5492.66	31860.18	9624.18	41484.36
1986	4385.02	1335.31	5720.33	36245.20	10959.49	47204.69
1987	5413.20	1401.78	6814.98	41658.40	12361.27	54019.67
1988	5856.91	1421.07	7277.98	47515.31	13782.34	61297.65
1989	5667.75	1566.16	7233.92	53183.06	15348.50	68531.57
1990	4400.42	1671.79	6072.21	57583.49	17020.29	74603.78

REGIONS: U1 U2 U3 U4 U5 U6 U7 U8 U9 UA

PLANT TYPES FOR OPTION 16

1	OIL FIRED STEAM	1Y
2	BIT/HI SUL/SCR	2Y
3	BIT/MED SUL/SCR	3Y
4	BIT/LOW SUL/SCR	4Y
5	GAS FIRED TURBINE	5Y
6	DISTILLATE TURBINE	6Y
7	COMBINED CYCLE GAS	AY
8	COMBINED CYCLE DIST	7Y
9	GAS FIRED STEAM	8Y
10	BIT/HIGH SUL/N SCR	JY
11	BIT/MED SUL/N SCR	QY
12	BIT/LOW SUL/N SCR	XY
13	SUB-BIT/MED SUL/SCR	PY
14	SUB-BIT/LOW SUL/SCR	EY
15	SUB-BIT/MED SUL/N SCR	MY
16	SUB-BIT/LOW SUL/N SCR	OY
17	LIG/MED SUL/SCR	VY
18	LIG/LOW SUL/SCR	ZY
19	LIG/MED SUL/N SCR	TY
20	LIG/LOW SUL/N SCR	YY
21	HYDRO PONDAGE	9Y
22	HYDRO PUMP STORAGE	KY
23	NUCLEAR	NY
24	OIL FIRED STEAM	1Z
25	BIT/HI SUL/SCR	2Z
26	BIT/MED SUL/SCR	3Z
27	BIT/LOW SUL/SCR	4Z
28	GAS FIRED TURBINE	5Z
29	DISTILLATE TURBINE	6Z
30	COMBINED CYCLE/GAS	AZ
31	COMBINED CYCLE/DIST	7Z
32	GAS FIRED STEAM	8Z
33	BIT/HIGH SUL/N SCR	JZ
34	BIT/MED SUL/N SCR	QZ
35	BIT/LOW SUL/N SCR	XZ
36	SUB-BIT/MED SUL/SCR	PZ
37	SUB-BIT/LOW SUL/SCR	EZ
38	SUB-BIT/MED SUL/N SCR	MZ
39	SUB-BIT/LOW SUL/N SCR	OZ
40	LIG/MED SUL/SCR	VZ
41	LIG/LOW SUL/SCR	ZZ
42	LIG/MED SUL/N SCR	TZ
43	LIG/LOW SUL/N SCR	YZ
44	HYDRO PONDAGE	9Z
45	HYDRO PUMP STORAGE	KZ
46	NUCLEAR	NZ
47	OIL FIRED STEAM	10
48	BIT/HI SUL/SCR	20
49	BIT/MED SUL/SCR	30
50	BIT/LOW SUL/SCR	40
51	GAS FIRED TURBINE	50
52	DISTILLATE TURBINE	60
53	COMBINED CYCLE/GAS	A0
54	COMBINED CYCLE/DIST	70
55	GAS FIRED STEAM	80
56	BIT/HIGH SUL/N SCR	J0

FIGURE III-4 (CONT.) SCENARIO C--CAPITAL REQUIREMENTS FOR ALL BUILDS

57	BIT/MED SUL/N SCR	Q0
58	BIT/LOW SUL/N SCR	X0
59	SUB-BIT/MED SUL/SCR	P0
60	SUB-BIT/LOW SUL/SCR	E0
61	SUB-BIT/MED SUL/N SCR	M0
62	SUB-BIT/LOW SUL/N SCR	D0
63	LIG/MED SUL/SCR	V0
64	LIG/LOW SUL/SCR	Z0
65	LIG/MED SUL/N SCR	T0
66	LIG/LOW SUL/N SCR	Y0
67	HYDRO PONDAGE.	90
68	HYDRO PUMP STORAGE	K0
69	NUCLEAR	N0

◆◆◆CREMOD CAPITAL REQUIREMENTS REPORT ◆◆◆

TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
INDICATED PLANT TYPES AND REGIONS

~ YEAR	CWIP (GW)	CUMULATIVE CW COMPLETED (GW)	CAPITAL EXPENDED (\$ MIL.)	CUMULATIVE CAPITAL EXPENDED (\$ MIL.)
1979	188.46	43.35	11761.75	11761.75
1980	192.13	75.37	11221.17	22982.92
1981	206.86	103.86	12553.88	35536.80
1982	217.83	130.68	15434.62	50971.42
1983	239.03	149.86	17185.43	68156.85
1984	252.98	170.05	17726.30	85883.15
1985	241.00	209.98	17800.26	103683.42
1986	232.08	246.86	18095.54	121778.96
1987	220.15	286.73	19261.00	141039.96
1988	211.50	321.58	19719.24	160759.21
1989	179.84	<u>354.18</u>	19608.49	<u>180367.69</u>
1990	146.76	388.18	17199.98	197567.67

TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
INDICATED PLANT TYPES AND REGIONS

YEAR	ANNUAL CAPITAL EXPENDITURE (\$ MIL.)			CUMULATIVE CAPITAL EXPENDITURES (\$ MIL.)		
	DIRECT	INTEREST	TOTAL	DIRECT	INTEREST	TOTAL
1979	8759.84	3001.91	11761.75	8759.84	3001.91	11761.75
1980	8665.39	2555.79	11221.17	17425.22	5557.70	22982.92
1981	10037.36	2516.52	12553.88	27462.59	8074.22	35536.80
1982	12698.84	2735.78	15434.62	40161.42	10810.00	50971.42
1983	14079.22	3106.21	17185.43	54240.65	13916.21	68156.85
1984	14104.91	3621.39	17726.30	68345.56	17537.59	85883.15
1985	13772.84	4027.42	17800.26	82118.40	21565.02	103683.42
1986	14152.19	3943.35	18095.54	96270.59	25508.37	121778.96
1987	15239.82	4021.18	19261.00	111510.41	29529.55	141039.96
1988	15669.06	4050.18	19719.24	127179.47	33579.73	160759.21
1989	15409.28	4199.21	19608.49	142588.75	37778.94	180367.69
1990	12978.33	4221.65	17199.98	155567.08	42000.59	197567.67

FIGURE III-5 SCENARIO C--SCRUBBER RETROFIT CAPITAL REQUIREMENTS

REGIONS: U1 U2 U3 U4 U5 U6 U7 U8 U9 UA

PLANT TYPES FOR OPTION 20

87 CONVERT BIT/LO S TO HI S/W SCR CV
 88 CONVERT BIT/LO S TO MED S/W SCR CW
 89 CONVERT BIT/MED S TO HI S/W SCR CX
 90 CONVERT SUB-B/LO S TO M S/W SCR CY
 91 CONVERT LIG/LO S TO MED S/W SCR CZ

◆◆◆CREMOD CAPITAL REQUIREMENTS REPORT ◆◆◆
 TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
 INDICATED PLANT TYPES AND REGIONS

YEAR	CWIP (GW)	CUMULATIVE CW COMPLETED (GW)	CAPITAL EXPENDED (\$ MIL.)	CUMULATIVE CAPITAL EXPENDED (\$ MIL.)
1979	0.57	0.57	51.66	51.66
1980	0.57	1.14	51.66	103.33
1981	0.57	1.70	51.66	154.99
1982	0.57	2.27	51.66	206.66
1983	0.57	2.84	51.66	258.32
1984	0.0	3.41	51.66	309.99
1985	0.0	3.41	0.0	309.99
1986	0.0	3.41	0.0	309.99
1987	0.0	3.41	0.0	309.99
1988	0.0	3.41	0.0	309.99
1989	0.0	3.41	0.0	309.99
1990	0.0	3.41	0.0	309.99

TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
 INDICATED PLANT TYPES AND REGIONS

YEAR	ANNUAL CAPITAL EXPENDITURE (\$ MIL.)			CUMULATIVE CAPITAL EXPENDITURES (\$ MIL.)		
	DIRECT	INTEREST	TOTAL	DIRECT	INTEREST	TOTAL
1979	51.66	0.0	51.66	51.66	0.0	51.66
1980	51.66	0.0	51.66	103.33	0.0	103.33
1981	51.66	0.0	51.66	154.99	0.0	154.99
1982	51.66	0.0	51.66	206.66	0.0	206.66
1983	51.66	0.0	51.66	258.32	0.0	258.32
1984	51.66	0.0	51.66	309.99	0.0	309.99
1985	0.0	0.0	0.0	309.99	0.0	309.99
1986	0.0	0.0	0.0	309.99	0.0	309.99
1987	0.0	0.0	0.0	309.99	0.0	309.99
1988	0.0	0.0	0.0	309.99	0.0	309.99
1989	0.0	0.0	0.0	309.99	0.0	309.99
1990	0.0	0.0	0.0	309.99	0.0	309.99

REGIONS: U1 U2 U3 U4 U5 U6 U7 U8 U9 UA

PLANT TYPES FOR OPTION 22

70	CONVERT OIL TO BIT/HI SUL/N SCR	CF
71	CONVERT OIL TO BIT/MD SUL/N SCR	CG
72	CONVERT OIL TO BIT/LO SUL/N SCR	CH
73	CONVERT OIL TO BIT/HI SUL/SCR	CI
74	CONVERT OIL TO BIT/MED SUL/SCR	CJ
75	CONVERT OIL TO BIT/LO SUL/SCR	CK
76	CONVERT GAS TO BIT/HI SUL/N SCR	CL
77	CONVERT GAS TO BIT/MD SUL/N SCR	CM
78	CONVERT GAS TO BIT/MD SUL/N SCR	DN
79	CONVERT GAS TO BIT/HI SUL/SCR	CO
80	CONVERT GAS TO BIT/HI SUL/SCR	CP
81	CONVERT GAS TO BIT/LO SUL/SCR	CQ
82	CHANGE N/BIT/LO S TO HI S/W SCR	DF
83	CHANGE N BIT/LO S TO MD S/W SCR	DG
84	CHANGE N BIT/MD S TO HI S/W SCR	DH
85	CHANGE N SUB-B/L S TO M S/W SCR	DI
86	CHANGE N LIG/LO S TO MD S/W SCR	DJ
87	CONVERT BIT/LO S TO HI S/W SCR	CV
88	CONVERT BIT/LO S TO MED S/W SCR	CW
89	CONVERT BIT/MED S TO HI S/W SCR	CX
90	CONVERT SUB-B/LO S TO M S/W SCR	CY
91	CONVERT LIG/LO S TO MED S/W SCR	CZ
92	CONVERT OIL TO GAS STEAM	CR
93	CONVERT NEW OIL TO GAS STEAM	CS
94	CONVERT GAS TO OIL STEAM	CT
95	CONVERT DISTILLATE TO GAS TURB.	CU
96	CONVERT GAS TO DISTILLATE TURB.	DK
97	CONVERT N DIST TO GAS COMB CYCL	DL
98	CONVERT E DIST TO GAS COMB CYCL	DM

◆◆◆CREMOD CAPITAL REQUIREMENTS REPORT ◆◆◆
TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
INDICATED PLANT TYPES AND REGIONS

YEAR	CWIP (GW)	CUMULATIVE		CAPITAL EXPENDED (\$ MIL.)	CUMULATIVE CAPITAL EXPENDED (\$ MIL.)
		CW COMPLETED (GW)			
1979	6.18	2.86		300.69	300.69
1980	6.18	5.72		300.69	601.38
1981	6.18	8.58		300.69	902.07
~1982	4.52	11.44		300.69	1202.76
1983	2.86	14.30		217.76	1420.52
1984	0.29	17.16		134.84	1555.36
1985	0.29	17.44		0.0	1555.36
1986	0.29	17.73		0.0	1555.36
1987	0.29	18.02		0.0	1555.36
1988	0.29	18.30		0.0	1555.36
1989	0.12	<u>18.59</u>		0.0	<u>1555.36</u>
1990	0.12	18.72		0.0	1555.36

TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
INDICATED PLANT TYPES AND REGIONS

YEAR	ANNUAL CAPITAL EXPENDITURE (\$ MIL.)			CUMULATIVE CAPITAL EXPENDITURES (\$ MIL.)		
	DIRECT	INTEREST	TOTAL	DIRECT	INTEREST	TOTAL
1979	300.69	0.0	300.69	300.69	0.0	300.69
1980	300.69	0.0	300.69	601.38	0.0	601.38
1981	300.69	0.0	300.69	902.07	0.0	902.07
1982	300.69	0.0	300.69	1202.76	0.0	1202.76
1983	217.76	0.0	217.76	1420.52	0.0	1420.52
1984	134.84	0.0	134.84	1555.36	0.0	1555.36
1985	0.0	0.0	0.0	1555.36	0.0	1555.36
1986	0.0	0.0	0.0	1555.36	0.0	1555.36
1987	0.0	0.0	0.0	1555.36	0.0	1555.36
1988	0.0	0.0	0.0	1555.36	0.0	1555.36
1989	0.0	0.0	0.0	1555.36	0.0	1555.36
1990	0.0	0.0	0.0	1555.36	0.0	1555.36

REGIONS: U1 U2 U3 U4 U5 U6 U7 U8 U9 UA

PLANT TYPES FOR OPTION 25

115	TRANSMISSION (VARIABLE)	TV
116	TRANSMISSION (FIXED)	TF
117	NEW DISTRIBUTION	TN
118	METERING COSTS	TM

◆◆◆CREMOD CAPITAL REQUIREMENTS REPORT ◆◆◆
TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
INDICATED PLANT TYPES AND REGIONS

YEAR	CWIP (GW)	CUMULATIVE CW COMPLETED (GW)	CAPITAL EXPENDED (\$ MIL.)	CUMULATIVE CAPITAL EXPENDED (\$ MIL.)
1979	0.0	0.0	7194.77	7194.77
1980	0.0	0.0	7194.77	14389.54
1981	0.0	0.0	7194.77	21584.32
1982	0.0	0.0	7194.77	28779.09
1983	0.0	0.0	7194.77	35973.86
1984	0.0	0.0	7170.86	43144.73
1985	0.0	0.0	7422.50	50567.22
1986	0.0	0.0	7422.50	57989.72
1987	0.0	0.0	7422.50	65412.21
1988	0.0	0.0	7422.50	72834.71
1989	0.0	0.0	7440.49	80275.20
1990	0.0	0.0	7848.47	88123.67

TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
INDICATED PLANT TYPES AND REGIONS

YEAR	ANNUAL CAPITAL EXPENDITURE (\$ MIL.)			CUMULATIVE CAPITAL EXPENDITURES (\$ MIL.)		
	DIRECT	INTEREST	TOTAL	DIRECT	INTEREST	TOTAL
1979	7194.77	0.0	7194.77	7194.77	0.0	7194.77
1980	7194.77	0.0	7194.77	14389.54	0.0	14389.54
1981	7194.77	0.0	7194.77	21584.32	0.0	21584.32
1982	7194.77	0.0	7194.77	28779.09	0.0	28779.09
1983	7194.77	0.0	7194.77	35973.86	0.0	35973.86
1984	7170.86	0.0	7170.86	43144.73	0.0	43144.73
1985	7422.50	0.0	7422.50	50567.22	0.0	50567.22
1986	7422.50	0.0	7422.50	57989.72	0.0	57989.72
1987	7422.50	0.0	7422.50	65412.21	0.0	65412.21
~1988	7422.50	0.0	7422.50	72834.71	0.0	72834.71
1989	7440.49	0.0	7440.49	80275.20	0.0	80275.20
1990	7848.47	0.0	7848.47	88123.67	0.0	88123.67

additional CREMOD capital requirements runs or displaying the MEMM solution for carefully selected subsets of the plant types covered by the original estimates.

This kind of analysis can be illustrated with an example from Figure III-1. Dividing the capital requirements values for nuclear generation and other generation by corresponding capacity addition values leads to the capital coefficient values in Figure III-8.

FIGURE III-8 . "CAPITAL COEFFICIENTS" CORRESPONDING TO
FIGURE III-1. ESTIMATES (\$/KW)

	<u>B</u>	<u>C</u>	<u>D</u>
Nuclear Generation	589	686	674
Other Generation	504	440	377

These values should be interpreted carefully. First, they all appear somewhat lower than normal capital coefficients for the plant types covered in each category. This is probably due to a large component of sunk costs in all cases. Indeed, about 50 GW of committed coal plants are anticipated to come on line by 1983, and, depending on the scenario, these plants have either a six- or eight-year construction lead time. Hence, a substantial portion of the capital costs of this large amount of capacity is sunk, thereby reducing the other generation values in Figure III-8. There is a similar situation with committed nuclear plants. Additional runs exclusively for these two smaller plant type aggregations would permit a more precise explanation.

A more interesting result in Figure III-8 is that the capital coefficient for nuclear generation is higher in Scenario C than in Scenario B, while the nuclear coefficients in the CREMOD input file FCOEF* are generally unequal in the reverse direction due primarily to higher real escalation in Scenario B. Additional CREMOD runs were made exclusively for committed nuclear, deferrable

nuclear, and new nuclear plant aggregations in both Scenarios B and C. The results are summarized in Figure III-9, and the corresponding CREMOD output reports appear in Figures III-10 to III-15.

Examination of these results together with CREMOD input data indicates that the main cause of the reversal lies with the nuclear capital expenditure profiles, in particular, their impact on committed plant costs. Note that the same capacity of committed plants, 75.08 GW, is added by 1990 (about 75 percent of all nuclear capacity) in both scenarios. Note further that the capital coefficients for these plants are low, \$314/KW for Case B and \$377 for Case C. This is because a very large proportion of capital for these plants is sunk, due to relatively early commissioning dates and long construction lead times (see Figures III-10 and III-11). However, counter to our intuition, the B coefficient is lower than the C coefficient. The reason is that the capital expenditure profile is weighted further to the front end in the "B" case, due partly to an increased component of AFDC; hence, a considerably larger proportion of capital costs are sunk. For example, data in capital expenditure profile file FCEP* indicate that about 37 percent of costs occur in the first 4 years of the 10-year construction lead time in the Case B but only about 7 percent in the Case C. This greater front end weighting, together with the large proportion of total nuclear capital consumed by committed plants, is the primary cause of the nuclear generation coefficient being lower in Case B than in Case C.

The relative sizes of the deferrable nuclear plant capital coefficients are reasonable. Here, the effect of the more front end weighted expenditure profile in Case B is not significant because commissionings do not begin until 1986 or 1987.

FIGURE III-9. RELATIVE NUCLEAR CAPACITY/CAPITAL VALUES UNDER SCENARIOS B AND C
(January 1, 1979 to January 1, 1990)

<u>Plant Type</u>	(1) <u>"B" Capacity</u> (GW)	(2) <u>"C" Capacity</u> (GW)	(3) <u>"B" Capital</u> (x 10 ⁹ '75 \$)	(4) <u>"C" Capital</u> (x 10 ⁹ '75 \$)	(5) <u>"B" Coef.</u> (\$/KW) ((3)/(1))	(6) <u>"C" Coef.</u> (\$/KW) ((4)/(2))
All Nuclear	95.22	99.88	56.13	63.53	589	686
Com. Nuclear	75.08	75.08	23.55	28.27	314	377
Def. Nuclear	14.26	16.44	13.39	12.84	939	781
New Nuclear	5.89	8.36	19.19	27.42	3,258	3,280

FIGURE III-10 SCENARIO B--COMMITTED NUCLEAR CAPITAL REQUIREMENTS

REGIONS: U1 U2 U3 U4 U5 U6 U7 U8 U9 UA

PLANT TYPES FOR OPTION 2

23 NUCLEAR

NY

◆◆◆CREMOD CAPITAL REQUIREMENTS REPORT ◆◆◆
TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
INDICATED PLANT TYPES AND REGIONS

YEAR	CMIP (GW)	CUMULATIVE CM COMPLETED (GW)	CAPITAL EXPENDED (\$ MIL.)	CUMULATIVE CAPITAL EXPENDED (\$ MIL.)
1979	66.72	8.36	4761.77	4761.77
1980	61.54	13.54	3989.81	8751.58
1981	50.74	24.34	4372.47	13124.04
1982	41.94	33.13	3660.72	16784.76
1983	31.29	43.78	2480.76	19265.53
1984	29.02	46.05	1805.20	21070.73
1985	18.99	56.08	1302.52	22373.25
1986	6.28	68.80	759.36	23132.61
1987	3.25	71.83	263.31	23395.92
1988	0.93	74.14	127.77	23523.69
1989	0.0	75.08	27.30	23550.99
1990	0.0	75.08	0.0	23550.99

TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
INDICATED PLANT TYPES AND REGIONS

YEAR	ANNUAL CAPITAL EXPENDITURE (\$ MIL.)			CUMULATIVE CAPITAL EXPENDITURES (\$ MIL.)		
	DIRECT	INTEREST	TOTAL	DIRECT	INTEREST	TOTAL
1979	3374.17	1387.60	4761.77	3374.17	1387.60	4761.77
1980	2676.66	1313.15	3989.81	6050.82	2700.75	8751.58
1981	3008.03	1364.44	4372.47	9058.85	4065.19	13124.04
1982	2431.72	1229.00	3660.72	11490.57	5294.19	16784.76
1983	1398.59	1082.18	2480.76	12889.16	6376.37	19265.53
1984	950.50	854.70	1805.20	13839.66	7231.07	21070.73
1985	500.90	801.63	1302.52	14340.55	8032.70	22373.25
1986	246.24	513.12	759.36	14586.79	8545.82	23132.61
1987	81.90	181.40	263.31	14668.70	8727.22	23395.92
1988	33.59	94.18	127.77	14702.29	8821.40	23523.69
1989	6.84	20.46	27.30	14709.13	8841.86	23550.99
1990	0.0	0.0	0.0	14709.13	8841.86	23550.99

FIGURE III-11 SCENARIO C--COMMITTED NUCLEAR CAPITAL REQUIREMENTS

REGIONS: U1 U2 U3 U4 U5 U6 U7 U8 U9 UA

PLANT TYPES FOR OPTION 2

23 NUCLEAR

NY

◆◆◆CREMOD CAPITAL REQUIREMENTS REPORT ◆◆◆
TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
INDICATED PLANT TYPES AND REGIONS

YEAR	CMIP (GW)	CUMULATIVE CM COMPLETED (GW)	CAPITAL EXPENDED (\$ MIL.)	CUMULATIVE CAPITAL EXPENDED (\$ MIL.)
1979	63.82	11.25	5400.25	5400.25
1980	57.35	17.73	5375.86	10776.11
1981	46.09	28.98	5479.96	16256.07
1982	36.37	38.71	4626.53	20882.60
1983	29.02	46.05	3355.15	24237.74
1984	19.35	55.73	2168.85	26406.60
1985	7.41	67.66	1221.68	27628.28
1986	3.05	72.02	448.16	28076.44
1987	0.93	74.14	160.53	28236.98
1988	0.0	75.08	35.76	28272.73
1989	0.0	<u>75.08</u>	0.0	<u>28272.73</u>
1990	0.0	75.08	0.0	28272.73

TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
INDICATED PLANT TYPES AND REGIONS

YEAR	ANNUAL CAPITAL EXPENDITURE (\$ MIL.)			CUMULATIVE CAPITAL EXPENDITURES (\$ MIL.)		
	DIRECT	INTEREST	TOTAL	DIRECT	INTEREST	TOTAL
1979	4102.67	1297.58	5400.25	4102.67	1297.58	5400.25
1980	4159.07	1216.78	5375.86	8261.74	2514.37	10776.11
1981	4188.84	1291.12	5479.96	12450.58	3805.49	16256.07
1982	3439.95	1186.58	4626.53	15890.53	4992.07	20882.60
1983	2313.70	1041.45	3355.15	18204.22	6033.52	24237.74
1984	1283.48	885.37	2168.85	19487.71	6918.89	26406.60
1985	616.83	604.85	1221.68	20104.54	7523.74	27628.28
1986	205.51	242.65	448.16	20310.05	7766.39	28076.44
1987	61.36	99.18	160.53	20371.41	7865.57	28236.98
1988	12.32	23.43	35.76	20383.73	7889.00	28272.73
1989	0.0	0.0	0.0	20383.73	7889.00	28272.73
1990	0.0	0.0	0.0	20383.73	7889.00	28272.73

FIGURE III-12 SCENARIO B--DEFERRABLE NUCLEAR CAPITAL REQUIREMENTS

REGIONS: U1 U2 U3 U4 U5 U6 U7 U8 U9 UA

PLANT TYPES FOR OPTION 2

46 NUCLEAR

NZ

◆◆◆CREMOD CAPITAL REQUIREMENTS REPORT ◆◆◆
TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
INDICATED PLANT TYPES AND REGIONS

YEAR	CWIP (GW)	CUMULATIVE CW COMPLETED (GW)	CAPITAL EXPENDED (\$ MIL.)	CUMULATIVE CAPITAL EXPENDED (\$ MIL.)
1979	14.26	0.0	264.77	264.77
1980	15.16	0.0	459.44	724.22
1981	18.29	0.0	851.03	1575.25
1982	19.44	0.0	1244.14	2819.39
1983	21.65	0.0	1708.41	4527.80
1984	21.65	0.0	2134.72	6662.52
1985	21.65	0.0	1704.98	8367.51
1986	21.65	0.0	1552.84	9920.34
1987	18.19	3.46	1546.25	11466.60
1988	10.40	11.25	1147.05	12613.64
1989	7.39	<u>14.26</u>	773.11	<u>13386.76</u>
1990	6.49	15.16	397.53	<u>13784.29</u>

TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
INDICATED PLANT TYPES AND REGIONS

YEAR	ANNUAL CAPITAL EXPENDITURE (\$ MIL.)			CUMULATIVE CAPITAL EXPENDITURES (\$ MIL.)		
	DIRECT	INTEREST	TOTAL	DIRECT	INTEREST	TOTAL
1979	238.99	25.78	264.77	238.99	25.78	264.77
1980	401.89	57.56	459.44	640.88	83.34	724.22
1981	735.82	115.21	851.03	1376.70	198.55	1575.25
1982	1048.47	195.67	1244.14	2425.17	394.22	2819.39
1983	1406.86	301.56	1708.41	3832.02	695.78	4527.80
1984	1711.68	423.04	2134.72	5543.70	1118.82	6662.52
1985	1206.95	498.04	1704.98	6750.65	1616.86	8367.51
1986	1000.13	552.71	1552.84	7750.78	2169.56	9920.34
1987	945.98	600.28	1546.25	8696.76	2769.84	11466.60
1988	619.24	527.80	1147.05	9316.00	3297.65	12613.64
1989	448.18	324.94	773.11	9764.18	3622.58	13386.76
1990	166.53	230.98	397.53	9930.72	3853.56	13784.29

FIGURE III-13 SCENARIO C--DEFERRABLE NUCLEAR CAPITAL REQUIREMENTS

REGIONS: U1 U2 U3 U4 U5 U6 U7 U8 U9 UA

PLANT TYPES FOR OPTION 2

46 NUCLEAR

NZ

◆◆◆CREMOD CAPITAL REQUIREMENTS REPORT ◆◆◆
TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
INDICATED PLANT TYPES AND REGIONS

YEAR	CWIP (GW)	CUMULATIVE CW COMPLETED (GW)	CAPITAL EXPENDED (\$ MIL.)	CUMULATIVE CAPITAL EXPENDED (\$ MIL.)
1979	16.44	0.0	93.23	93.23
1980	18.29	0.0	153.88	247.11
1981	20.37	0.0	368.76	615.87
1982	21.65	0.0	1064.59	1680.46
1983	21.65	0.0	2025.31	3705.77
1984	21.65	0.0	2246.04	5951.80
1985	21.65	0.0	2030.52	7982.32
1986	19.49	2.16	1716.06	9698.38
1987	9.74	11.91	1536.02	11234.40
1988	7.39	14.26	969.30	12203.70
1989	5.21	<u>16.44</u>	635.71	<u>12839.42</u>
1990	3.36	18.29	353.83	13193.24

TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
INDICATED PLANT TYPES AND REGIONS

YEAR	ANNUAL CAPITAL EXPENDITURE (\$ MIL.)			CUMULATIVE CAPITAL EXPENDITURES (\$ MIL.)		
	DIRECT	INTEREST	TOTAL	DIRECT	INTEREST	TOTAL
1979	81.29	11.94	93.23	81.29	11.94	93.23
1980	132.63	21.25	153.88	213.92	33.19	247.11
1981	324.35	44.41	368.76	538.27	77.60	615.87
1982	951.35	113.24	1064.59	1489.61	190.84	1680.46
1983	1784.47	240.84	2025.31	3274.08	431.68	3705.77
1984	1877.10	368.94	2246.04	5151.18	800.62	5951.80
1985	1563.37	467.15	2030.52	6714.55	1267.77	7982.32
1986	1183.98	532.08	1716.06	7898.53	1799.86	9698.38
1987	1012.64	523.38	1536.02	8911.17	2323.24	11234.40
1988	696.24	273.06	969.30	9607.40	2596.30	12203.70
1989	413.68	222.03	635.71	10021.08	2818.33	12839.42
1990	188.82	165.00	353.83	10209.91	2983.33	13193.24

FIGURE III-14 SCENARIO B--NEW NUCLEAR CAPITAL REQUIREMENTS

REGIONS: U1 U2 U3 U4 U5 U6 U7 U8 U9 UA

PLANT TYPES FOR OPTION 2

69 NUCLEAR

N0

◆◆◆CREMOD CAPITAL REQUIREMENTS REPORT ◆◆◆
TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
INDICATED PLANT TYPES AND REGIONS

YEAR	CWIP (GW)	CUMULATIVE CW COMPLETED (GW)	CAPITAL EXPENDED (\$ MIL.)	CUMULATIVE CAPITAL EXPENDED (\$ MIL.)
1979	5.89	0.0	101.85	101.85
1980	7.07	0.0	216.22	318.08
1981	12.17	0.0	388.53	706.60
1982	20.37	0.0	729.66	1436.26
1983	24.97	0.0	1209.36	2645.62
1984	31.98	0.0	1731.16	4376.78
1985	31.98	0.0	2366.82	6743.60
1986	31.98	0.0	2614.97	9358.58
1987	30.83	1.15	3419.32	12777.89
1988	28.53	3.46	3491.80	16269.70
1989	26.10	<u>5.89</u>	2923.49	<u>19193.18</u>
1990	24.91	7.07	2594.85	21788.03

TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
INDICATED PLANT TYPES AND REGIONS

YEAR	ANNUAL CAPITAL EXPENDITURE (\$ MIL.)			CUMULATIVE CAPITAL EXPENDITURES (\$ MIL.)		
	DIRECT	INTEREST	TOTAL	DIRECT	INTEREST	TOTAL
1979	91.87	9.98	101.85	91.87	9.98	101.85
1980	191.02	25.20	216.22	282.90	35.18	318.08
1981	336.88	51.65	388.53	619.78	86.83	706.60
1982	628.86	100.80	729.66	1248.64	187.62	1436.26
1983	1028.97	180.39	1209.36	2277.61	368.01	2645.62
1984	1444.50	286.66	1731.16	3722.11	654.67	4376.78
1985	1939.70	427.12	2366.82	5661.80	1081.80	6743.60
1986	2046.02	568.96	2614.97	7707.82	1650.76	9358.58
1987	2666.16	753.16	3419.32	10373.98	2403.91	12777.89
1988	2604.89	886.92	3491.80	12978.86	3290.83	16269.70
1989	2008.29	921.20	2923.49	14981.15	4212.03	19193.18
1990	1662.08	932.76	2594.85	16643.24	5144.79	21788.03

REGIONS: U1 U2 U3 U4 U5 U6 U7 U8 U9 UA

PLANT TYPES FOR OPTION 2

69 NUCLEAR

NO

◆◆◆CREMOD CAPITAL REQUIREMENTS REPORT ◆◆◆

TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
INDICATED PLANT TYPES AND REGIONS

YEAR	CWIP (\$M)	CUMULATIVE CW COMPLETED (\$M)	CAPITAL EXPENDED (\$ MIL.)	CUMULATIVE CAPITAL EXPENDED (\$ MIL.)
1979	8.36	0.0	51.73	51.73
1980	14.31	0.0	95.55	147.28
1981	27.54	0.0	288.28	435.56
1982	36.15	0.0	666.93	1102.49
1983	48.54	0.0	974.33	2076.81
1984	54.74	0.0	1556.49	3633.31
1985	54.74	0.0	2240.46	5873.76
1986	52.38	2.36	3556.11	9429.87
1987	52.38	2.36	5118.42	14548.29
1988	48.80	5.94	6272.93	20821.22
1989	46.38	8.36	6598.20	27419.42
1990	40.43	14.31	5718.38	33137.80

TOTAL PIES CAPITAL REQUIREMENTS THROUGH 1990 SUMMED OVER
INDICATED PLANT TYPES AND REGIONS

YEAR	ANNUAL CAPITAL EXPENDITURE (\$ MIL.)			CUMULATIVE CAPITAL EXPENDITURES (\$ MIL.)		
	DIRECT	INTEREST	TOTAL	DIRECT	INTEREST	TOTAL
1979	46.13	5.59	51.73	46.13	5.59	51.73
1980	83.97	11.58	95.55	130.10	17.18	147.28
1981	258.01	30.27	288.28	388.11	47.45	435.56
1982	593.82	73.11	666.93	981.92	120.56	1102.49
1983	842.00	132.33	974.33	1823.92	252.89	2076.81
1984	1331.37	225.12	1556.49	3155.30	478.01	3633.31
1985	1885.80	354.66	2240.46	5041.09	832.67	5873.76
1986	2995.53	560.57	3556.11	8036.63	1393.24	9429.87
1987	4339.20	779.22	5118.42	12375.83	2172.46	14548.29
1988	5148.34	1124.58	6272.93	17524.17	3297.04	20821.22
1989	5254.07	1344.13	6598.20	22778.25	4641.17	27419.42
1990	4211.60	1506.79	5718.38	26989.84	6147.96	33137.80

The capital coefficients for new nuclear plants (\$3,258/KW and \$3,280/KW) are hardly meaningful at all, because there is a very large component of CWIP under both scenarios for plants coming on line subsequent to 1989. The C value is higher than the B value probably because the amount of CWIP is greater, i.e., there are about 46 GW of new nuclear plant commissionings in the 1990-94 period under Case C versus 26 GW under Case B (from CREMOD listings of the MEMM solution for both cases).

APPENDIX A
SUMMARY OF CREMOD INPUT DATA FILE CONTENTS

PLANT TYPE MASTER FILE FMAST*

FMAST* contains plant type names for use in CREMOD reports and optional codes indicating the role of annual BUILD limits in FBLD* and interest during construction (IDC) rates in FCOEF* in computing capital requirements for each plant type.

Contents

<u>Name</u>	<u>Definition</u>	<u>Source</u>	<u>Update Frequency</u>
PIES CODE	Two-digit code used by the MEFS (formerly called PIES) to identify each plant type; also called "mode"	MEMM preprocessor	Very infrequent (as dictated by MEFS revision of plant type definitions)
PIES DESCRIPTOR	Phrase describing the MEFS plant type	Same as above	Same as above
UNIT DATA CODE	Can be used to indicate how annual BUILD limits in FBLD* will be used (see Figure 2-3 in Volume II): 0 = Annual BUILD limits may or may not be in FBLD*; use determined exclusively by CREMOD user 1 = Annual BUILD Limits are in FBLD* and will definitely be used	Set as a function of FBLD* contents and user specification	Very infrequent (as dictated by user)
IDC CODE	Can be used to indicate that IDC has a major impact on capital cost: 0 = No IDC 1 = IDC (code purely informational)	Set as a function of FCOEF* contents and user specification	Same as above (as dictated by user)

Comments

1. The sequential ordering of plant types in FMAST* is critical since the definitions of CREMOD plant type aggregations (Figure II-2) depend on this ordering. Hence, no records in this file should be deleted. While new plant types can be added, further modification of CREMOD will be necessary if it is desired to have these new plant types added to certain of the existing CREMOD plant type aggregations.

2. The PIES DESCRIPTOR data in FMAST* should not vary by supply scenario. Ordinarily, the UNIT DATA CODE and IDC CODE will not vary by supply scenario either.

3. FMAST* data used in generating the 1978 ARC capital requirements estimates reside in the following files: low-supply data in FMASTL, mid-supply data in FMASTM, and high-supply data in FMASTH.

4. The file layout for FMAST* is depicted in Figure A-1.

FIGURE A-1 PLANT TYPE MASTER FILE
(FMAST*)

File Layout

<u>Relative Position</u>	<u>Field Name</u>	<u>Type</u>	<u>Format</u>	<u>Comments</u>
1. 1-32	Plant type descriptor	Alpha	8 A4	
2. 33-34	Plant type designator	Alpha	2 A1	Also known as the mode
3. 35	Unit data code	Alpha	A1	{ 0 = no build limit data in FBLD* 1 = build limit data in FBLD*
4. 36	IDC code	Alpha	A1	{ 0 = no IDC data available for plant type 1 = IDC data available for plant type

Naming Conventions

Character format file name: FMAST*.PS

Random binary file name: FMAST*.DATA

FMAST* = FMAST $\begin{bmatrix} L \\ M \\ H \end{bmatrix}$; L, M, H represent the low, medium and high supply scenarios, respectively

CAPITAL COEFFICIENT FILE.FCOEF*

FCOEF* contains (1) capital coefficient values (\$/MW) consistent with those used in the MEMM to be multiplied by disaggregated capacity additions (MW) from MEMM solution files, and (2) IDC values for plant types having long construction lead times and real escalation rates for each plant type and the various segments of the MEFS planning horizon.

Contents

<u>Name</u>	<u>Definition</u>	<u>Source</u>	<u>Update Frequency</u>
YR	Coefficient base year (year with respect to which all capital coefficients used in CREMOD computations are defined); must be identical to the base year used in the corresponding MEMM runs	MEMM preprocessor output value underlying MEMM solutions used by CREMOD	Normally infrequent; as dictated by MEMM preprocessor revision
PIES CODE	Two-digit code used by the MEFS (formerly called PIES) to identify each plant type; also called "mode"	MEMM preprocessor output	Very infrequent (as dictated by MEFS revision of plant type definitions)
U1,U2,....,UA	1985 capital coefficient values including IDC and real escalation from the coefficient base year to 1985, for utility regions U1,U2,....,UA	YH Tables CPSCZM85 OL of MEMM preprocessor output where: Y = committed plant Z = deferrable plant 0 = new plant and H = high cost (low supply) M = medium cost (med. supply) L = low cost (high supply)	As capital coefficients in MEMM preprocessor are revised) (normally at least annually)

<u>Name</u>	<u>Definition</u>	<u>Source</u>	<u>Update Frequency</u>
E1(-84/YR)	Average annual real escalation from the coefficient base year through 1984 (and reflected in corresponding capital coefficients)	Given that N = number of years from coefficient base year (CBY) to 1985 CRE = cumulative rate of real escalation from CBY to 1985 reflected in 1985 capital coefficients, then solve the following equation for E1: $(1+E1)^N = 1+CRE$ where CRE is obtained from CEPAD personnel	As capital coefficients in MEMM preprocessor are revised (normally at least annually)
E2(85-89/YR)	Average annual real escalation rate from 1985 through 1989 and reflected in 1990 and 1995 MEMM capital coefficients	Same source and computational approach as for E1	As capital coefficients in MEMM preprocessor are revised (normally at least annually)
E3(90-94/YR)	Average annual real escalation rate from 1990 through 1994 and reflected in 1995 MEMM capital coefficients	Same source and computational approach as for E1*	As capital coefficients in MEMM preprocessor are revised (normally at least annually)
E4(-84/TOTAL)	The fraction of the direct cost (excluding IDC) component of each 1985 capital coefficient that comprises real escalation from the coefficient base year through 1984	$1-E4 = 1/(1+E1)^N$ or $E4 = 1 - 1/(1+E1)^N$ where E1 is defined above	As capital coefficients in MEMM preprocessor are revised

*For certain emerging technologies such as wind, photovoltaics, solar thermal, biomass electric, and ocean thermal, E2 and E3 may be negative.

<u>Name</u>	<u>Definition</u>	<u>Source</u>	<u>Update Frequency</u>
IDC#1	Average annual rate of interest during construction or AFDC assumed by the MEMM; i.e., the weighted average after tax nominal cost of capital (only used with respect to plant types having long construction lead times)	Input tables for the Fixed Charge Program used in conjunction with the MEMM (see CEPAD personnel)	As Fixed Charge Program inputs are revised (usually simultaneously with capital coefficient revisions (the value of IDC#1 determines the amount of AFDC in the 1985 capital coefficients)
IDC#2	The fraction of each 1985 capital coefficient that comprises IDC (AFDC) (only used with respect to plant types having long construction lead times)	CEPAD personnel	Same as for IDC#1

Comments

1. Entries U1,U2,....,UA,E1,E2,E3,E4,IDC#1, and IDC#2 are all normally supply-scenario-dependent.
2. Capital coefficient, real escalation, and interest during construction data used to generate the 1978 ARC capital requirements estimates reside in the following files: low-supply data in FCOEFL, medium-supply data in FCOEFM, and high-supply data in FCOEFH.
3. The file layout for FCOEF* is depicted in Figure A-2.

FIGURE A-2 CAPITAL COEFFICIENT FILE
(FCOEF*)

File Layout

<u>Relative Position</u>	<u>Field Name</u>	<u>Type</u>	<u>Format</u>	<u>Comments</u>
1. 1-2	Coefficient base year	Integer	I2	Last two digits of year (YY)
2. 3-4	Plant type (mode) O	Alpha	2 A1	
3. 5-8	Capital coefficient for U1	Integer	I4	In \$/kw max allowed = \$9,999
4. 9-12	" U2	Integer	I4	"
5. 13-16	" U3	Integer	I4	"
6. 17-20	" U4	Integer	I4	"
7. 21-24	" U5	Integer	I4	"
8. 25-28	" U6	Integer	I4	"
9. 29-32	" U7	Integer	I4	"
10. 33-36	" U8	Integer	I4	"
11. 37-40	" U9	Integer	I4	"
12. 41-44	" UA	Integer	I4	"
13. 45-48	Real esc. rate to 1985	Integer	I4	Program multiplies by 10^{-3}
14. 49-52	Real esc. rate 1985-1990	Integer	I4	" 10^{-3}
15. 53-56	Real esc. rate 1990-1995	Integer	I4	" 10^{-3}
16. 57-59	IDC #1	Integer	I3	" 10^{-4}
17. 60-62	Composite esc. rate	Integer	I3	" 10^{-3}
18. 63-65	IDC #2 (through 1984)	Integer	I3	" 10^{-3}

Naming Conventions

Character format file name: FCOEF*.PS

Random binary file name: FCOEF*.DATA

FCOEF* = FMAST $\begin{bmatrix} L \\ M \\ H \end{bmatrix}$; L, M, H represent the low, medium and high supply scenarios, respectively

CAPITAL EXPENDITURE PROFILE FILE FCEP*

FCEP* contains, for each plant type, the fraction of total direct capital expenditures occurring in each year of the plant's construction lead time. Each profile serves as the basis for spreading the amount of new regional capacity for each year and plant type backward over its construction lead time.

Contents

<u>Name</u>	<u>Definition</u>	<u>Source</u>	<u>Update Frequency</u>
PLANT TYPE (same as PIES CODE)	Two-digit code used by the MEFS to identify each plant type; also called "mode"	MEMM preprocessor	Very infrequent (as dictated by MEFS revision of plant definitions)
LEAD TIME	Number of years (assumed by the MEFS and CREMOD) required for construction of this plant type and hence, over which capital construction costs should be spread	CEPAD personnel and the Fixed Charge Factor Program	Uncertain (should be checked when capital coefficients in MEMM preprocessor are revised)
PROFILE	Fractions of plant capital cost incurred in each year of the construction lead time	CEPAD personnel and the Fixed Charge Factor Program	Uncertain (should be checked when capital coefficients in MEMM preprocessor are revised)

Comments

1. A maximum construction lead time of 20 years is permitted.
2. The profile for a given plant type may vary significantly among supply scenarios.
3. Profile data used to generate the 1978 ARC capital requirements estimates reside in the following files: low-supply data in FCEPL, medium-supply data in FCEPM, and high-supply data in FCEPH.
4. The file layout for FCEP* is depicted in Figure A-3.

FIGURE A-3 CAPITAL EXPENDITURE PROFILE FILE

(FCEP*)

File Layout

<u>Relative Position</u>	<u>Field Name</u>	<u>Type</u>	<u>Format</u>	<u>Comments</u>
1. 1-2	Plant type (mode)	Alpha	2 A1	
2. 3-4	Lead time in years	Integer	12	Right justified
3. 5-8	% expenditure in first year	Integer	14	Program multiplies by 10^{-3}
4. 9-65	% expenditure in n th year	Integer	19(I3)	Program multiplies by 10^{-3} Up to 19 allowed

A-9

Naming Conventions

Character format file name: FCEP*.PS

Random binary file name: FCEP*.DATA

FCEP* = FCEP $\begin{bmatrix} L \\ M \\ H \end{bmatrix}$; L, M, H represent the low, medium and high supply scenarios, respectively

ANNUAL BUILD LIMIT FILE FBLD*

FBLD* contains annual BUILD limits in MW for committed, deferrable, and new nuclear plants and for committed and deferrable coal plants.

Display Formats. There are two display formats for the contents of FBLD*. The first, entitled BUILD LIMIT SUMMARY, shows the results of accumulating all annual BUILD limits from the coefficient base year through 1994 for each region and plant type. Its format is identical to that of the (cumulative) BUILD limit tables in the MEMM preprocessor, and its contents should be identical specifically to tables

H	H	H
BLCOMM95,	BLDEFM95,	and BLNEWM95.
L	L	L

A quick comparison of these two tables should alert the CREMOD user to any discrepancies in FBLD* relative to MEMM preprocessor values. The second, FBLD* display format, entitled BUILD LIMIT DATA, permits the user to isolate the source of any discrepancies.

Contents (of BUILD LIMIT DATA Format):

<u>Name</u>	<u>Definition</u>	<u>Source</u>	<u>Update Frequency</u>
PLANT TYPE (same as PIES CODE)	Two-digit code used by the MEFS to identify each plant type; also called "mode"	MEMM preprocessor	Very infrequent (as dictated by MEFS revision of plant type definitions)
YEAR	Year to which the annual BUILD limit applies; also includes three accumula- tion categories for comparison with specific columns of 1985, 1990, and 1995 MEMM preprocessor BUILD Limit Tables, respect- ively: "THRU '84," "THRU '89,"	Not Applicable	Not Applicable

<u>Name</u>	<u>Definition</u>	<u>Source</u>	<u>Update Frequency</u>
	and "THRU '94." The "THRU '94" row is identical to the corres- ponding column of the "BUILD LIMIT SUMMARY."		
U1,U2,....,UA	Annual BUILD limits for regions U1,U2,..,UA, respectively, in megawatts (MW)	Coal annual BUILD limits from CEPAD personnel and nu- clear annual BUILD limits from NEAD personnel	As MEMM preprocessor cumulative 1985, 1990, and 1995 BUILD limits are revised (at least annually)

Comments

1. Annual BUILD limits used in generating 1978 ARC capital requirements estimates varied considerably by supply scenario for nuclear plants but were invariant with supply scenario for coal plants.

2. Annual BUILD limits used to generate the 1978 ARC capital requirements estimates reside in the following files: low-supply data in FBLDL, medium-supply data in FBLDM, and high-supply data in FBLDH.

3. The file layout for FBLD* is depicted in Figure A-4 and the 1978 ARC related contents of FBLDM are shown in Figure A-5 to illustrate the file layout. Note that one record is defined for each (plant type, year) combination. It is important that (a) records be defined only for those (plant type, year) combinations for which there is at least one region having a positive BUILD limit, and (b) (region, BUILD limit value) data be entered only when the BUILD limit value is positive. In other words, there should be no BUILD limit values of zero in this file.

4. CREMOD spreads net activity levels linearly for all plant types and regions and then overlays this data with specified BUILD limits in FBLD* only for those (plant type, region) combinations for which there is at least one

FIGURE A-4 BUILD LIMIT FILE
(FBLD*)

File Layout

<u>Relative Position</u>	<u>Field Name</u>	<u>Type</u>	<u>Format</u>	<u>Comments</u>
1. 1-2	Plant type (mode)	Alpha	2 A1	
2. 3-4	Year of build limit	Integer	I2	Last two digits (YY)
3. 5-6	Region of build limit (e.g., VI)	Alpha	2 A1	Region may be in any order
4. 7-10	Build limit in MWE for preceeding region	Integer	I4	Must follow region, right justify
5-13. 11-64	Up to nine region/build limit combinations may follow in any order			

A-12

Naming Conventions

Character format file name: FBLD*.DATA

FBLD* = FBLD $\begin{bmatrix} L \\ M \\ H \end{bmatrix}$; L, M, H represent the low, medium and high supply scenarios, respectively

FIGURE A-5. 1978 ARC CONTENTS OF FILE FBLDM

00020 NY79U20784U33123U43115U51905U60912U80330U91084
 00030 NY80U20854U42317U52201U91106
 00040 NY81U31050U45730U51078U61150U91140U91103
 00050 NY82U31050U42064U53058U62415U91140
 00060 NY83U54811U61359U91098
 00061 NY83U30076
 00070 NY84U30207U20437U42350U51865U61250U72300U91267
 00080 NY85U11194U21710U31065U43192U52199U91098U91267
 00081 NY85U60209
 00090 NY86U11150U21067U40900U91242
 00100 NY87U31051U21070
 00110 NY88U60934
 00120 NZ86U30907U41250
 00130 NZ87U11194U30907U45690U50660U91098
 00131 NZ87U60209
 00140 NZ88U41100U91242
 00150 NZ89U42180
 00160 NZ90U40900U50950
 00170 NZ91U60934U71150
 00180 NZ92U41280
 00190 N086U62363
 00200 N087U91260
 00210 N088U41280U51150U61150
 00220 N089U21150U91270
 00230 N090U42533U51845U91260
 00231 N090U30181
 00240 N091U11180U22420U43813U52951U71469U91270
 00250 N092U11194U31200U41200U50931U62413U91277
 00251 N092U70269
 00260 N093U22370U31296U44549U53125U60918
 00270 N094U11194U42350U61250U91277
 00280 N095U21220U41159U52460U62118U91200U31115
 00281 N095U90974
 00290 2Y79U30626U40890U50978
 00300 2Y80U31451U41560
 00310 2Y81U40200U51000U70837
 00320 3Y79U40780U90350
 00330 3Y80U40280U90350
 00340 3Y81U40280
 00350 4Y79U80400U90827
 00360 4Y80U80400U90347
 00370 JY79U40870U51300
 00380 QY80U40720
 00390 XY79U40662U51477U60550U80200
 00400 XY80U31700U40550U50791
 00410 XY81U41900U51300U90250
 00420 PY79U60468
 00430 PY80U50500U81000
 00440 PY81U60472
 00450 EY79U70680U81268
 00460 EY80U70680
 00470 QY79U51117U65043U72401U80330
 00480 QY80U50580U63650U70931U80500U90530
 00490 QY81U60490U71422
 00500 VY79U62250U80490
 00510 VY80U60400U80490
 00520 VY81U60545U80410
 00530 2Z82U51365
 00540 4Z83U90347
 00550 JZ82U50650
 00560 XZ82U42842U51900
 00570 XZ83U41802
 00580 XZ84U90250U40720
 00600 PZ82U81200
 00610 PZ83U80700
 00620 PZ84U90330
 00630 QZ82U50880U63206U70980U80380
 00640 QZ83U51200U61240
 00650 QZ84U61208
 00660 VZ82U60400
 00670 VZ82U80455
 00680 VZ83U80455
 00690 VZ84U60750

annual BUILD limit. Thus, it assumes that if there are any annual BUILD limits in FBLD* for a given plant type and region, this represents all the potential capacity that needs to be considered for that plant type and region.

DATA INPUT TO CREMOD USING DATA STATEMENTS

DATA statements contain input data reflecting annual normal inflation rates and regional cost data for the four components of transmission and distribution cost (see ARC 1978 T&D data in Figures A-6, A-7, A-8, and A-9).

DATA Statement Contents

<u>Statement Number and Variable Name</u>	<u>Definition</u>	<u>Source</u>	<u>Update Frequency</u>
8310-RVAL	Scenarios B, C, and D values of the normal annual inflation rate (DRI '78-'95 CPIW)	CEPAD personnel and the Fixed Charge Factor Program	As Fixed Charge Factors and capital coefficients in MEMM preprocessor are revised (the AFDC fraction IDC#2 varies with RVAL)
16610-MC85	Cumulative metering capital expenditures from the MEFS base year to Jan. 1, 1985, for regions 1,2,....,10, respectively, (in millions of 1975 dollars)	CEPAD personnel	At least annually (see Figure A-6)
16630-MC90	Cumulative metering capital expenditures from the MEFS base year to Jan. 1, 1990, for regions 1,2,....,10, respectively, (in millions of 1975 dollars)	CEPAD personnel	At least annually (see Figure A-6)
16650-MC95	Cumulative metering capital expenditures from the MEFS base year to Jan. 1, 1995, for regions 1,2,....,10, respectively, (in millions of 1975 dollars)	CEPAD personnel	At least annually (see Figure A-6)

<u>Statement Number and Variable Name</u>	<u>Definition</u>	<u>Source</u>	<u>Update Frequency</u>
16670-DN85	Cumulative distribution capital expenditures from the MEFS base year to Jan. 1, 1985, for regions 1,2,....,10, respectively (in millions of 1975 dollars)	CEPAD personnel	At least annually (see Figure A-7)
16690-DN90	Cumulative distribution capital expenditures from the MEFS base year to Jan. 1, 1990, for regions 1,2,....,10, respectively (in millions of 1975 dollars)	CEPAD personnel	At least annually (see Figure A-7)
16710-DN95	Cumulative distribution capital expenditures from the MEFS base year to Jan. 1, 1995, for regions 1,2,....,10, respectively (in millions of 1975 dollars)	CEPAD personnel	At least annually (see Figure A-7)
16730-FIX85	Cumulative fixed component of new transmission capital expenditures from the MEFS base year to Jan. 1, 1985, for regions 1,2,....,10, respectively (in millions of 1975 dollars)	MEMM preprocessor Table TDCAP	At least annually (see Figure A-8)
16750-FIX90	Cumulative fixed component of new transmission capital expenditures from the MEFS base year for regions 1,2,....,10, respectively (in millions of 1975 dollars)	MEMM preprocessor Table TDCAP	At least annually (see Figure A-8)

<u>Statement Number and Variable Name</u>	<u>Definition</u>	<u>Source</u>	<u>Update Frequency</u>
16770-FIX95	Cumulative fixed component of new transmission capital expenditures from the MEFS base year to Jan. 1, 1995, for regions 1,2,...,10, respectively (in millions of 1975 dollars)	MEMM preprocessor Table TDCAP	At least annually (see Figure A-8)
16790-VAR85	Cumulative capital cost of transmission (in millions of 1975 dollars) per gigawatt of new capacity added by Jan. 1, 1985, Jan. 1, 1990, and Jan. 1, 1995, respectively, for regions 1,2,...,10, respectively	MEMM preprocessor Table TDCAP	At least annually (see Figure A-9)
16800-VAR90			
16810-VAR95			

Comments:

1. Values of VAR85, VAR90, and VAR95 for the same region used with respect to the 1978 ARC are equal.

FIGURE A-6. 1978 ARC VALUES FOR METERING CUMULATIVE
CAPITAL COSTS
(in Millions of 1975 Dollars)

<u>Region</u>	<u>1978-1985</u> (MC85)	<u>1978-1990</u> (MC90)	<u>1978-1995</u> (MC95)
I	125.4	318.6	610.9
II	248.6	631.6	1200.6
III	242.0	618.0	1181.8
IV	374.0	970.8	1884.3
V	451.0	1151.4	2195.4
VI	233.2	602.4	1171.4
VII	114.4	290.4	551.4
VIII	66.0	169.5	326.1
IX	270.6	701.8	1364.7
X	<u>74.8</u>	<u>195.6</u>	<u>383.5</u>
National	2200.0	5650.1	10870.1

FIGURE A-7. 1978 ARC VALUES FOR
ELECTRICITY DISTRIBUTION
CUMULATIVE CAPITAL COSTS
(in Millions of 1975 Dollars)

<u>Region</u>	<u>1978-1985</u> (DN85)	<u>1978-1990</u> (DN90)	<u>1978-1995</u> (DN95)
I	1951.7	3444.9	4911.7
II	4232.0	7336.4	10499.2
III	4089.9	7133.8	10266.1
IV	5524.9	9719.8	13969.2
V	4766.0	8284.6	11701.5
VI	3396.8	5926.2	8337.3
VII	1295.3	2244.8	3155.4
VIII	784.1	1373.8	1955.2
IX	2325.6	3986.7	5329.5
X	<u>639.0</u>	<u>1095.4</u>	<u>1472.2</u>
National	29005.3	50546.4	71597.3

**FIGURE A-8. 1978 ARC VALUES FOR
CUMULATIVE FIXED COMPONENT
OF NEW TRANSMISSION CAPITAL COSTS**
(in Millions of 1975 Dollars)

<u>Region</u>	<u>1978-1985</u> (FIX85)	<u>1978-1990</u> (FIX90)	<u>1978-1995</u> (FIX95)
I	129	222	314
II	227	389	552
III	157	269	381
IV	15	25	36
V	968	1659	2350
VI	363	622	881
VII	485	832	1178
VIII	525	900	1274
IX	1636	2805	3973
X	635	1089	1542

**FIGURE A-9. 1978 ARC VALUES FOR
CUMULATIVE VARIABLE COMPONENT
OF NEW TRANSMISSION CAPITAL COSTS**
(in Millions of 1975 Dollars per Gigawatt)

<u>Region</u>	<u>1978-1985</u> (VAR85)	<u>1978-1990</u> (VAR90)	<u>1978-1995</u> (VAR95)
I	59	59	59
II	63	63	63
III	68	68	68
IV	74	74	74
V	68	68	68
VI	77	77	77
VII	74	74	74
VIII	67	67	67
IX	67	67	67
X	67	67	67

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APPENDIX B

CREMOD TERMS AND ACRONYMS

Activity Level - the number of units of capacity additions for a given electric utility plant type and region in a MEMM solution for a given target year (usually measured in megawatts).

Administrator's Report to Congress (previously called the Annual Administrator's Report) - a report compiled annually for the Congress by the Energy Information Administration (EIA), which describes EIA's previous year's work and forecasts energy futures under various assumed conditions.

ARC

Allowance for Funds Used During Construction (also called Interest During Construction) - the dollar amount of costs of debt and equity required to finance electric utility construction. AFDC is typically included as part of the electric utility rate base due to the long lead times required for construction of new electric utility plants

AFDC

Annual BUILD Limit - the maximum expected capacity (typically measured in megawatts) of a given committed, deferrable, or new plant type anticipated to be commissioned in a given year and region by the CREMOD user.

Annual BUILD Limit File - the CREMOD System file containing all nuclear and coal annual build limits corresponding to a given economic supply scenario.

FBLD*

BUILD Limit - the cumulative maximum expected capacity (typically measured in megawatts) of a given plant type anticipated to be commissioned in a given region up to either January 1, 1985, January 1, 1990, or January 1, 1995, by the MEFS and listed in certain MEMM preprocessor tables.

BUILDS.DATA - a file of PERUSE commands which indicates the portions of a given MEMM solution to be transferred to an interim solution file accessible by CREMOD.

Capacity Addition - the amount of new (committed, deferrable, or completely new) generating capacity (typically measured in megawatts or gigawatts) specified by the MEMM to be commissioned in a given region between the MEFS base and target years.

Capital Expenditure Profile - a set of fractions (which sum to one) reflecting the relative amounts of capital expenditure occurring in each year of a given plant type's construction lead time.

Capital Expenditure Profile File - the CREMOD System file containing a construction lead time and capital expenditure profile for each electric utility plant type.

FCEP*

Capital Coefficient - the dollar amount of capital investment required per unit of new electric utility plant constructed for a given plant type and utility region (typically measured in \$/KW and sometimes defined in this report in terms of \$/MW or \$/GW).

Capital Coefficient File - the CREMOD System file containing 1985 capital coefficients and real escalation and interest during construction data for all relevant electric utility plant types.

FCOEF*

Capital Report Writer - an off-line computer program used prior to the development of the CREMOD System to multiply appropriate supply activity levels obtained from a given MEMM equilibrium solution by predetermined capital coefficients to arrive at aggregate capital requirements of the various energy subsectors.

CRW

Capital Requirements Estimating Model - an automated, interactive model developed by LMI for estimating the capital requirements of the electric utility sector using capacity addition estimates provided by the MEFS. CREMOD disaggregates new plant capacity activity levels from a MEMM solution over time, using actual projected commissioning dates. It computes the effect on aggregate capital requirements of the dispersal of new plant capital expenditures over relatively long (e.g., 7-10 years) construction lead times. It also incorporates the effects of real escalation and AFDC.

CREMOD

Coal and Electric Power Analysis Division - a division of EIA's Office of Energy Source Analysis responsible for analysis of data describing the coal and electric utility sectors.

CEPAD

Coefficient Base Year - the year (e.g., 1975) with respect to which each capital coefficient used in CREMOD computations is defined; this must be identical to the base year used in the corresponding MEMM runs.

CBY

<u>Construction Work in Progress</u> - the amount of new electric utility capacity (typically measured in KW, MW, or GW) under construction at a given point in time.	CWIP
<u>CREMOD Compilation and Linkage Programs</u> - programs used to recompile and link/edit the CREMOD Program after any DATA statements have been revised using the TSO Editor.	CREMOD
<u>CREMOD Program</u> - the computer program which computes capital requirements estimates using the formulas, assumptions, and decision rules comprising the Capital Requirements Estimating Model.	CREMOD
<u>CREMOD System</u> - the set of computer programs underlying CREMOD: PERUSE, DIRECT, CREMOD, and CREMOD compilation and linkage programs. The CREMOD System also uses the TSO Editor to create and revise certain CREMOD files.	CREMOD
<u>DATA Statement</u> - a FORTRAN statement used in the CREMOD Program to provide input data with respect to the supply-scenario-dependent normal inflation rates and transmission and distribution capital costs.	
<u>DIRECT</u> - the computer program used to transform the files FMAST*, FCOEF*, and FCEP* into direct access files after they have been either created or revised using the TSO Editor.	
<u>Economic Supply Scenario</u> - a set of macroeconomic assumptions upon which the contents of all CREMOD input data files and the MEMM solution in the CREMOD interim solution files are in general dependent. The three possible scenarios are low supply, medium supply, and high supply.	
<u>Energy Information Administration</u> - an administration of DOE responsible for collection, evaluation, assembly, analysis, and dissemination of energy data and information related to energy resource reserves and energy production, demand, and technology.	EIA
<u>Generating Unit Reference File</u> - an EIA-maintained file of generating-unit-level historical and forecast data accumulated to a large extent from FPC Forms 383; its contents are used as the basis for coal plant annual BUILD limits in FBILD*.	GURF
<u>Gigawatt</u> - 10^9 watts of power.	GW
<u>Interest During Construction</u> - generally used interchangeably with the term AFDC (see definition above).	IDC

Interim MEFS Solution Files - files accessible by the CREMOD Program which contain the portion of a given MEMM solution reflecting projected electric utility capacity additions to be operated on by CREMOD.

MEFS Base Year (previously called PIES Base Year) - the first year of the MEFS planning horizon; the value of MBY ("PIES BASE YEAR") input to the CREMOD Program must be precisely the value underlying the MEMM solution input to CREMOD. MBY

MEFS Planning Horizon - the set of years, beginning with the current year, with respect to which a MEFS forecast is generated.

MEFS Target Year - the first year following the MEFS planning horizon for which the MEMM is run; the MEMM can currently be run with respect to three target years: 1985, 1990, and 1995.

Megawatt - 10^6 watts of power. MW

MEMM Preprocessor - the MEMM computer program which generates tables of raw data used by the MEMM.

Mid-Term Energy Forecasting System - the system of computer models and data sets used by EIA for mid-term energy forecasting. MEFS

Mid-Term Energy Market Model - the integrating model of the MEFS. MEMM

Normal Inflation Rate - the general annual inflation rate (i.e., the DRI 'current year - '95 CPIW) used by CREMOD to compute aggregate dollar amounts of AFDC. The normal inflation rate excludes any real escalation in the electric utility construction industry.

Nuclear Energy Analysis Division - a division of EIA's Office of Energy Source Analysis responsible for analysis of data describing the nuclear energy sector. NEAD

PERUSE - an EIA-developed computer program used by the CREMOD System to transfer the portion of a given MEMM solution reflecting projected electric utility capacity additions from a packed solution file to an interim solution file accessible by CREMOD.

Plant Type - the type of electric utility plant construction activity as described by fuel (e.g., nuclear, coal, oil, gas), boiler type, stage of construction (e.g., committed, deferrable, or new), and class of construction (e.g., build versus convert). Plant types are designated in the MEFS and in CREMOD by a two-digit "mode" code.

Plant Type Master File - the CREMOD System file containing a listing of plant type codes addressable by CREMOD, each with a brief plant type description for use in CREMOD reports and certain optional codes.

FMAST*

Real Escalation Rate - the annual rate of escalation, in addition to the normal inflation rate for a given year, in the electric utility construction industry, which is used by the CREMOD System.

TSO Editor - the editor used to create or revise versions of the CREMOD System files FMAST*, FCOEF*, FCEP*, and FBLD*, or to change the content of certain DATA statements in the CREMOD program to reflect different transmission and distribution capital cost data or normal inflation rates. Instructions for using the TSO Editor can be found in the OS/VSZ TSO Terminal User's Guide (IBM), VS2. Release 3.7, GC28-0645-4, File No. S370-39.

User Base Year - that year, equal or subsequent to the year in terms of which all capital coefficients are defined (the coefficient base year) to which all dollar amounts calculated by CREMOD are to be escalated.

User Inflation Rate - the user-supplied annual rate to be used to escalate "coefficient base year" dollar amounts computed by CREMOD to "user base year" dollar amounts.

Utility region - any one of the ten geographic utility regions in the U. S. used by DOE as a basis for collecting utility data and by the MEFS as a basis for electric utility activity definitions; CREMOD operates on capacity addition estimates for each electric utility plant type and utility region.