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Extensions and Revisions of the MIT Regional Electricity Model

by

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I. Introduction

This paper reviews some of the changes we have made in the M.I.T. Regional Electricity Model (REM)[1] during the period September 1976 through May 1978. These changes were made either to better evaluate some energy policy questions or to better represent energy sector behavior.

For those changes of the Regional Electricity Model discussed in this paper we found that the basic model could be modified without undue difficulty to more accurately represent certain types of behavior and answer specific questions. But we were not able to accomplish everything that we wanted with this model, in some cases because of the limitations of the model itself, and in other cases because the model was so complicated that it would take many weeks of work to make the required changes. Thus those changes described here are what were found possible with the model without a major effort.

Most of the changes and revisions that were made to the model are fairly straightforward and could be easily implemented by others. We also hope that the extensions that we have made will also encourage others to develop their own modifications and extensions to the model.

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1 Developed originally by Martin Baughman and Paul Joskow and also known as the Baughman-Joskow (B-J) Model.

II. Extensions and Revisions

This section discusses the changes that were made to the original version of the Regional Electricity Model. Each subsection discusses a specific change that was implemented. The format of each section starts with a discussion of the motivation for the change, followed by a description of its implementation and results. Suggestions for future work are also included.

Listings of the computer code are included in the Appendix.

II. A Present Value of Future Energy Costs

Since our purpose in using the model was to evaluate the impacts of changes in technologies, prices and policies, we needed some measures to use for the comparison of different cases. Some economic measures seemed especially useful, such as the cost of electricity, the average cost of energy, etc., all of which are available with the model. But it was also felt that a single net present value figure would also be especially useful in comparing different scenarios as well as providing some single overall economic measure of value.

The economic measure decided upon was the net present value of delivered energy costs which was calculated in the following manner. In each year of the simulation, the demand model (FUELS) calculates the current price of each delivered energy type for each customer category as well as the actual quantities demanded. The sum of all of the price-quantity products then gives the total cost of delivered energy in the given year. The discounted time stream of these costs gives the net present value of the delivered energy costs.

Thus scenarios with higher energy costs have a higher net present value cost and thus can be considered economically inferior. If the demand were inelastic, then the negative difference in net present value energy costs would be equal to the difference in producer-consumer surplus and thus a direct economic benefit measure. However because the demand is elastic, and thus decreases with higher prices, the absolute differences in net present value of delivered energy costs are less than the differences in the net present value of the producer-consumer surplus.

The procedure calculates the total purchased energy costs for each year and then discounts them at some specified rate. One can specify the starting and ending year of the series as well as the discount rate.

Samples of the standard output are shown on the following page. The computer code is listed in the Appendix.

II. B Time Weighted Maximum Usage Factors

An important factor affecting the economics of power plants are the plants' operating times. This is typically represented as the Usage Factor which us the percentage of power actually generated over a given time period (typically a year) compared to the total possible power if the plant were run at full capacity for the entire period. With higher usage factors the capital cost of the plant is less per unit of energy produced.

High usage factors are especially important for plants with high capital costs and low operating costs (e.g. nuclear and coal plants). A difference in maximum usage factor of 5 to 10% can determine whether any construction at all of a particular plant type is economical.

ANNUAL REPORT

ENERGY CONSUMPTION IN 1997.0

TOTAL DELIVERED ENERGY AND COSTS
COSTS ARE EXPRESSED IN 1977 DOLLARS

ENERGY TYPE	QUANTITY (BTU)	DELIVERED PRICE (¢/E6 BTU)	CONSTANT DOLLAR COST
OIL	0.6321E+16	354.6099	0.2242E+11
GAS	0.8748E+16	406.2839	0.3554E+11
COAL	0.3371E+16	117.7220	0.3968E+10
ELECTRICITY	0.1756E+17	829.8582	0.1458E+12
TOTAL	0.3600E+17	576.8313	0.2077E+12
		DISCOUNTED PRESENT VALUE COST	0.7828E+11

PETROLEUM PRODUCT CONSUMPTION IN 1997.0
ELECTRICAL 0.3591E+16 TOTAL 0.1866E+17

SUMMARY

PRESENT VALUE COSTS OF DELIVERED ENERGY

THE NET PRESENT VALUE OF DELIVERED ENERGY COSTS FOR THE YEARS 1977.0 to 1997.0 DISCOUNTED AT A RATE OF 5.00% ON CONSTANT 1977 DOLLARS IS: 0.1799E+13

THE PETROLEUM USED FOR ELECTRICAL GENERATION WAS 0.1462E+11 BBL
THE TOTAL PETROLEUM CONSUMPTION WAS 0.7983E+11 BBL

THE ABOVE FIGURES ARE BASED ON DELIVERED ENERGY PRICES TO RESIDENTIAL/COMMERCIAL AND INDUSTRIAL USERS AS CALCULATED IN THE BJ/REM MODEL AND ARE EXCLUSIVE OF TRANSPORTATION AND FEED STOCK REQUIREMENTS THUS THEY ONLY REPRESENT A PART OF THE TOTAL U.S. ENERGY CONSUMPTION.

The original version of REM allowed one to specify a maximum usage factor for each plant type which was then held constant for all time periods. An existing modification allowed one to change the maximum usage factor for all nuclear plants in a specified year. This affected all existing plants as well as all new ones.

We wanted a way of exercising finer control over the maximum plant usage factors. One case we were interested in studying was a change in technology which would increase the usage factors for new plants but not for existing ones.

This was accomplished by adding a subroutine SDUTMX which, with the parameter of time, can be used to produce a variety of time varying maximum usage factors. One use of this was to study the effects of increasing the usage factor for new nuclear plants. The subroutine allows one to specify the year that the change is made, and then keeps track of the existing and new capacity and calculates a weighted maximum usage factor which is then used for electrical generation. Other applications are also possible. A listing is included in the Appendix.

II. C Construction Work in Progress

Also of interest were some changes in the financial regulatory structure. One such change is the financing of new plants. Currently most utilities are required to finance new plant construction themselves and are only allowed to charge customers for the cost of new plants once the plants start operation. One proposal has been to allow utilities to add construction expenses to the rate base as they are incurred thus increasing current electricity prices and easing the utility's financing burden with the expectation of lowering future electricity costs.

The subroutine FINMOD was modified so that one can specify the year in which construction work in progress (CWIP) is added to the rate base with the option that it be added immediately or that it be phased in over a five-year period.

In our runs with this option, adding CWIP to the rate base produces a higher initial cost of electricity which reduces demand so that future electrical generation is less. Also over the time period of the model (to 1997) the price of electricity continued to be higher compared to the non-CWIP case.

II. D Exponential Forecasting Procedures

In planning new plant construction REM estimates future costs and electricity demands. The forecasting subroutines are FOCAST, FCAST1 and FOCAS2. All of these subroutines use the same forecasting algorithm.

The algorithm used is an exponential smoothing method which uses the current and previous values and a trend to estimate future values. The procedure was originally used in REM to produce a straight line estimation of future values. Since all the variables being forecast (capital cost, fuel costs, electricity demand) were growing at an exponential rate, this procedure was substantially under-estimating future values. Therefore the forecasting equations were modified so that an exponential rather than a linear projection was made. In comparing the new estimates of several variables with their future values, a much better match was found.

The forecasting algorithm is shown on the following page. Equations 1, 2, 3 are in the forecasting subroutines and remained unchanged. One can see that the trend estimator T is a linear estimator of the variable

V, (i.e., the slope, not the rate of increase of the slope).

Equation 4 represents the way this estimator was originally used in the model. One can see quite clearly that this is a linear extrapolation of a trend. This will always underestimate variables which are increasing exponentially.

The model was modified by replacing equation 4, the linear extrapolation, by equation 5, an exponential approximation. This will still underestimate any constant exponential trend but not as seriously. As mentioned before this procedure was found to produce better predictions than the original linear extrapolation.

FORECASTING ALGORITHM

V	Current actual value
F	Smoothed Forecast value
T	Trend estimator
E	Estimated value
A	Smoothing parameter

1. $F_t = V_t + (1 - A) F_{t-1}$

2. $T_t = (F_t - F_{t-1}) + (1 - A) T_{t-1}$

3. $E_t = F_t + \frac{1 - A}{A} T_t$

Linear Estimation:

4. $E_{t+n} = E_t + n T_t$

Exponential Estimation:

5. $E_{t+n} = E_t \left(1 + \frac{T_t}{E_t}\right)^n$

If we know that some trends tend to be exponential, then an explicit exponential forecasting algorithm will better predict future values. The following equations 6-9 present such an algorithm. This algorithm will not consistently under-estimate exponential trends, and its sensitivity to changes in growth rates may also be adjusted through the parameter (alpha). This form has not been implemented in the model, but test runs with some generated data indicate that it is a good predictor.

Proposed Exponential Forecasting Algorithm

R Rate estimator

6. $F_t = V_t + (1 - A) Ft_{-1}$

7. $R_t = \frac{F_t - F_t-1}{F_{t-1}} + (1\text{-}A)\, R_{t-1}$

8. $E_t = F_t \left(1 + \frac{1 - A}{A} R_t\right)$

9. $E_{t+n} = E_t (1 + R_t)^n$

Although we have discussed better prediction algorithms for the planning procedures of the model, an even more important consideration is that real planning goes on in the face of uncertainity. The model itself predicts future values and then plans as if they were precise. There is no uncertainty in making decisions and a marginal difference in predicted prices could build or eliminate a plant type. There is the need to find some way of reflecting uncertainties in the planning process and producing a more realistic mix of decisions. The actual prediction algorithms are but one part of this larger task.

II. E New Plant Construction Limits

Because the model plans new plant construction based solely on given and predicted costs, sometimes the amount of new plant construction may exceed reasonable expected manufacturing capability. This appears to be especially true in the case of nuclear power plants when, for certain choices of prices, the model might decide to build these plants far in excess of the industry's capabilities.

To impose some upper limit on nuclear plant construction, especially in earlier years the model originally incorporated a build limit table with the limiting values specified at ten year intervals. This capability was extended by adding the subroutine function "CAPNEW".

The subroutine 'CAPNEW' contains tables which allow one to specify the build limits year by year, region by region. This gives a much finer control over new nuclear construction and has enabled us to run moratorium scenarios where no new nuclear plants are started during specified years.

This subroutine has also been used to benchmark nuclear construction to its historical values, both for currently existing plants and for those actually committed to start operation some time in the future. Since the model is usually run with a nuclear plant leadtime of ten years this then benchmarks nuclear construction out to 1987 and thus more accurately simulates the utility plant up to that time.

This change is easy to implement by adding the subroutine and a few lines of instructions in the major program.

II. F New Output Procedures

One limitation found in using this model was the standard form of output. While the data is in most ways complete, it is sometimes awkward to use and does not display well the changes over time of various factors. In preparing analyses and reports, we found that much human time was devoted to extracting particular numbers from the full listing and then creating tables and graphs.

It was felt that some way of automating this procedure would save a lot of manual work, eliminate copying errors and improve our analytical capabilities. We could not know ahead of time, exactly which data we might want displayed in which form, so there was also a definite need for flexibility.

The solution then was to select all the variables for which we might have some use and then to save them all in a data file each time the model was run. The selected variables are stored in a standard array form including all the selected national and regional data annually from 1970 to 1997. The model run is also fully identified in this data file. This data array file may then be used immediately after a run or saved for later use.

An interactive user-oriented, program was written to read these data files and produce selected output tables and graphs. Data arrays from different runs can also be handled concurrently and their values compared in the same tables and graphs.

The program is fully flexible in the variables that are displayed. One sits at a computer terminal and specifies the data case, the region and the variables that one wishes and then either asks for a table or a graph which is then immediately displayed on the terminal. Then one can also decide whether or not to have this table or graph printed as well. All the data is identified on each graph and table, so there is no confusion later as to what is represented.

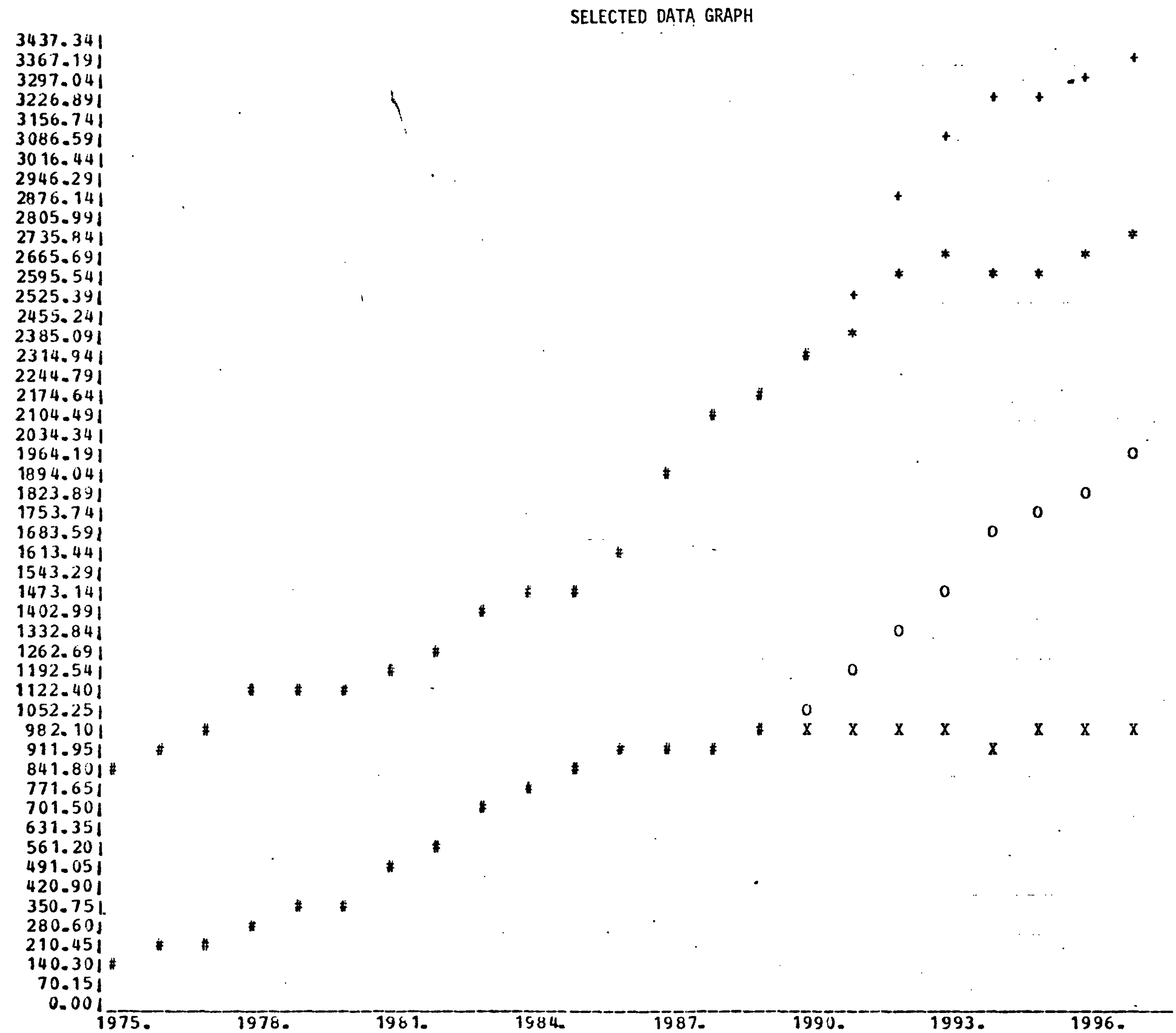
A sample of some of the output is shown. This data table contains two variables each from two different model runs. The variables are the national generating capacity of coal and nuclear (LWR) power plants in gigawatts (GW). Each model run is identified at the bottom of the table. Note that the table is not for the full time span from 1970 to 1997; one can specify any interval within the total range for each table one produces.

The following graph uses the same data as in the table. The graph is automatically scaled to the maximum data values and the data points are identified with unique characters. The '#' symbol indicates that two or more data values occupy the same point. It can be seen here that there is no observable difference between the two model runs for these

SELECTED DATA TABLE

CASE REGION VARIABLE	BG-0 NATIONAL GEN COA	BG-9 NATIONAL GEN COA	BG-0 NATIONAL GEN LWR	BG-9 NATIONAL GEN LWR
YEAR				
1985.	1501.647	1501.556	899.518	899.518
1986.	1643.246	1642.725	973.228	973.228
1987.	1909.019	1907.139	967.185	967.185
1988.	2111.515	2106.284	976.794	976.794
1989.	2227.729	2215.761	1014.204	1014.204
1990.	2321.319	2345.057	1089.006	1029.345
1991.	2403.634	2543.144	1209.724	1018.776
1992.	2606.922	2877.152	1363.779	1007.027
1993.	2679.103	3102.244	1525.650	994.121
1994.	2660.976	3250.268	1686.622	980.098
1995.	2642.256	3279.236	1811.216	988.710
1996.	2683.698	3322.921	1887.588	1024.203
1997.	2773.028	3437.336	2002.322	1043.147

BG-9 LWR CONSTRUCTION MORATORIUM 1980-84
BG-0 BASE CASE 11 APRIL W/REVISED ARRAY



REFERENCE LIST

* BG-0	NATIONAL GEN COA		+ BG-9	NATIONAL GEN COA	
O BG-0	NATIONAL GEN LWR		X BG-9	NATIONAL GEN LWR	

variables until 1990. The graphs have been found to be a very useful aid in the analysis of the model results.

A copy of a terminal session and the program listings are included in the appendix. A warning: because of the large size of the data arrays involved, it has been found that the reading and transferring of this data can be expensive, and recommend 1) that anyone using this program keep close control over those costs 2) that smaller data arrays be used where practical, e.g. eliminating the regional data would produce a 90% reduction in array size.

One option allows the automatic production of cross-sectional data tables, first showing each model run with the selected variables and then producing tables comparing for each variable the results from the different model runs. (e.g. four variables for three model runs produce three 'case' tables of four variables, and four 'variable' tables with the three run results). This is quite useful for comparing scenario results.

II. G Regional Fuel Costs

The model uses regional fuel costs for oil, gas and coal both for residential-commercial-industrial and utility consumption. As originally specified in the model a national minemouth/wellhead price is given along with regional transportation/refining costs.

When we were specifying future time series of energy prices we found it more convenient to compute a national average price and regional differences. Therefore we modified the fuel price tables from 1975 on and also corrected fuel price calculations in the demand subroutine 'FUELS' to calculate the price properly.

This is a minor change to make but it is important to know that some equations as well as the data tables must be changed.

Revised tables and equations are shown in the appendix. The data is described in the paper by Marlay.

III. Summary, Recommendations and Conclusions

For the model revisions and extensions discussed here, we found that the Regional Electricity Model, while already containing a detailed representation of the electric utility sector, could also be modified to do more than originally intended. Although in some cases the very complexity of the model made understanding and modification difficult. But in all, short of developing a new model tailored for our specific needs, REM served quite well.

Some changes which could be quite useful in this model are:

1) Revision of the forecasting procedures to produce better estimators for the types of data that the model is predicting.

2) Revision of the planning procedures incorporating uncertainity, or some other approach of better reflecting the soft nature of the planning decisions as made by the electric utilities.

3) Further research to determine the long-term elasticity coefficients in the energy demand equations, as it is essentially these equations which drive the model.

REM is currently probably the most complete and best documented model of the electric utility industry and was quite useful as an analysis tool in our studies. But its very completeness and complexity was at times a handicap as we attempted to understand the results.

Recommendations for future models for energy analysis would be far simpler, more easily understood models designed to illuminate critical assumptions and interactions. As an example capital and fuel costs are critical factors in the choice of new plants, but the final decision is made under uncertainty influenced by other factors as well. Little is known about the exact nature of this decision process. As another example the econometric equations used to calculate demand are very important, and how sensitive are the final results to changes in the equation coefficients?

In conclusion, REM served well in this project. But future modeling may best be done with models specifically designed to explore critical assumptions and interactions.

References:

1. Paul L. Joskow, M.L. Baughman, "The Future of the U.S. Nuclear Energy Industry", Bell Journal of Economics, Vol. 7. no. 1. Spring 1976.

2. M. Baughman, P. Joskow and D. Kamat, Electric Power in the United States: Models and Policy Analysis. Monograph. Cambridge: MIT Press (forthcoming).

3. R. Marlay, "A Comparative Analysis of Fuel Price Forecasts," Energy Laboratory Working Paper

In Fuels;

APPENDIX IV. A

PRESENT VALUE OF FUTURE ENERGY COSTS

```
C   FOLLOWING PROCEDURE CALCULATES THE NET PRESENT VALUE
C   OF DELIVERED ENERGY COSTS FOR THE SPECIFIED YEARS
C   AT THE SPECIFIED DISCOUNT RATE APPLIED TO CONSTANT
C   DOLLAR COSTS -               D E WHITE 28 JULY 1977
C
C   THE COMPUTATION STARTS IN 'PVYS' (DEFAULT 1977)
C                  AND ENDS   IN 'PVYE' (DEFAULT 1997)
C   THE 1977 CONSTANT DOLLAR COST IS DISCOUNTED AT A RATE OF 'PVRT'
C       WHOSE DEFAULT VALUE IS 5.00%  BUT WHICH MAY BE CHANGED THROUGH
C       THE PROCEDURE 'MASTER'
C
C   THE TOTAL PETROLEUM CONSUMPTION AND FINAL OUTPUT ARE IN 'MAIN'
C
      TQOIL=0
      TQGAS=0
      TQCOAL=0
      TQELEC=0
      TCOIL=0
      TCGAS=0
      TCCOAL=0
      TCELEC=0
C
      DO 120 J=1,49
      TQOIL=TQOIL+QOIL(J)+QINOIL(J)
      TCOIL=TCOIL+XRCPR(J)*QOIL(J)+XIOPR(J)*QINOIL(J)
      TQGAS=TQGAS+QGAS(J)+QINGAS(J)
      TCGAS=TCGAS+XRGPR(J)*QGAS(J)+XIGPR(J)*QINGAS(J)
      TQCOAL=TQCOAL+QINCOL(J)
      TCCOAL=TCCOAL+XICPR(J)*QINCOL(J)
      TQELEC=TQELEC+QELEC(J)+QINELE(J)
      TCELEC=TCELEC+(QELEC(J)+QINELE(J))*DPELE(J)
  120 CONTINUE
C
C  CONVERTING TO 1977 DOLLARS
      XCONVC=1.6899
      TCOIL=XCONVC*TCOIL
      TCGAS=XCONVC*TCGAS
      TCCOAL=XCONVC*TCCOAL
      TCELEC=XCONVC*TCELEC
C
C CALCULATING AVERAGE COSTS IN ¢/E6 BTU
      ACOIL=1.0E08*TCOIL/TQOIL
      ACGAS=1.0E08*TCGAS/TQGAS
      ACCOAL=1.0E08*TCCOAL/TQCOAL
      ACELEC=1.0E08*TCELEC/TQELEC
C
C  TOTAL QUANTITIES AND COSTS
      TQEN=TQOIL+TQGAS+TQCOAL+TQELEC
      TENC=TCOIL+TCGAS+TCCOAL+TCELEC
      ACEN=1.0E08*TENC/TQEN
C  DISCOUNTED ENERGY COSTS
      DENC=TENC/((1.+PVRT/100.)**(RTIME-1977.))
      TDENC=TDENC+DENC
C
C  OUTPUT SECTION
      WRITE(11,903) RTIME
  903 FORMAT(/,'1   ENERGY CONSUMPTION IN',F7.1,/)
      WRITE(11,905)
  905 FORMAT(' TOTAL DELIVERED ENERGY AND COSTS',/,
     1 '   COSTS ARE EXPRESSED IN 1977 DOLLARS')
      WRITE(11,907)
```

```
  907 FORMAT(/,
     1' ENERGY              QUANTITY     DELIVERED    CONSTANT',/
     2' TYPE                 (BTU)       PRICE        DOLLAR',/
     3'                                  (¢/E6 BTU)    COST',/)
      WRITE(11,909) TQOIL,ACOIL,TCOIL
  909 FORMAT(' OIL            ',E12.4,F12.4,E12.4)
      WRITE(11,911) TQGAS,ACGAS,TCGAS
  911 FORMAT(' GAS            ',E12.4,F12.4,E12.4)
      WRITE(11,913) TQCOAL,ACCOAL,TCCOAL
  913 FORMAT(' COAL           ',E12.4,F12.4,E12.4)
      WRITE(11,915) TQELEC,ACELEC,TCELEC
  915 FORMAT(' ELECTRICITY ',E12.4,F12.4,E12.4)
      WRITE(11,917) TQEN,ACEN,TENC
  917 FORMAT(/,' TOTAL          ',E12.4,F12.4,E12.4)
      WRITE(11,919) DENC
  919 FORMAT(/,8X,'DISCOUNTED PRESENT VALUE COST',E12.4)
C
C  PETROLEUM USE AND ACCUMULATED NET VALUE OUTPUTS ARE IN MAIN
C
  150 CONTINUE
C  END OF NET PRESENT VALUE CALCULATOR
C
   in main program:
C
C  PETROLEUM PRODUCT CONSUMPTION  -  D E WHITE 28 JULY 1977
      IF (RTIME.LT.PVYS) GO TO 14
      IF (TIME-FLOAT(NT)-.0001 .GT. 0.0) GO TO 14
      PELE=(USFCON(2)+USFCON(3)+USFCON(8))*1.0E15
      APELE=APELE+PELE
      PTOT=USTOIL+USTGAS+PELE
      APTOT=APTOT+PTOT
      WRITE(11,971) RTIME, PELE,PTOT
  971 FORMAT(/,' PETROLEUM PRODUCT CONSUMPTION IN ',F7.1,
     1/,' ELECTRICAL',E12.4,'          TOTAL',E12.4,/)
C

C
C
C
C  PRINTING NET PRESENT VALUE DATA IN FINAL YEAR - D E WHITE 27 JUL 77
      IF (RTIME.NE.PVYE) GO TO 17
C  PRINTING ACCUMULATED RESULTS
      WRITE(6,931)
  931 FORMAT('1    PRESENT VALUE COSTS OF DELIVERED ENERGY')
      WRITE(6,933) PVYS,PVYE,PVRT,TDENC
  933 FORMAT(/,' THE NET PRESENT VALUE OF DELIVERED ENERGY COSTS FOR THE
     1 YEARS',F7.1,' TO',F7.1,/,' DISCOUNTED AT A RATE OF',F7.2,
     2'%  ON CONSTANT 1977 DOLLARS IS:',E12.4)
C  CONVERTING TO BARRELS
      APELEB=APELE/5.8E06
      APTOTB=APTOT/5.8E06
      WRITE(6,935) APELEB,APTOTB
  935 FORMAT(/,' THE PETROLEUM USED FOR ELECTRICAL GENERATION WAS',E12.4
     1,' BBL',/,13X,' THE TOTAL PETROLEUM CONSUMPTION WAS',E12.4,' BBL')
      WRITE(6,937)
  937 FORMAT(/,' THE ABOVE FIGURES ARE BASED ON DELIVERED ENERGY PRICES
     1TO RESIDENTIAL/COMMERCIAL AND INDUSTRIAL',/,' USERS AS CALCULATED
     2IN THE BJ/REM MODEL AND ARE EXCLUSIVE OF TRANSPORTATION AND FEED S
     3TOCK REQUIREMENTS', /,' THUS THEY ONLY REPRESENT A PART OF THE TOT
     4AL US ENERGY CONSUMPTION',/)
C  END OF NET PRESENT VALUE OUTPUTS
C
```

APPENDIX IV. B
TIME VARYING USAGE FACTORS

```
C
      SUBROUTINE SDUTMX(ALTIME)
C
C     VERSION OF 27 MAY 77 BY DEW
C
C ***************************************************************
C    THIS SUBROUTINE CALCULATES TWO FORMS OF MAXIMUM DUTY CYCLE
C      1) THE MAXIMUM DUTY CYCLE FOR NEW PLANTS - USED FOR PLANNING
C           PURPOSES
C      2) THE VINTAGE WEIGHTED DUTYCYCLE FOR EXISTING PLANTS - USED
C           FOR GENERATION
C
C    THE SWITCH IS KEYED BY THE PARAMETER 'ALTIME' WHICH WHEN EQUAL
C      TO ZERO PERFORMS 2 ABOVE, OR WHEN GREATER THAN ZERO LOOKS
C      THE APPROPRIATE TIME INTO THE FUTURE FOR 1 ABOVE
C
C    PERFECT KNOWLEDGE OF THE FUTURE MAXIMUM DUTY CYCLE IS IMPLIED
C      FOR PLANNING PURPOSES
C
C    CURRENT VERSION OF THE PROGRAM ONLY CHANGES DUTMAX(4) LWR BY
C      MULTIPLYING BY A FACTOR 'SMDM4' FOR PLANTS AFTER YEAR 'YRDM4'
C
C *****************************************************************
C
C   COMMON FOR MAXIMUM DUTY CYCLE 'DUTMAX'
      COMMON /DDD/ DT,DUTMAX(10),DEMBAS(9),DEMANF(9),DEMANZ,DUTYCY(9,9)
C   COMMON FOR CURRENT CAPACITY 'USTCAP'
      COMMON /UUU/ USAGE(9,9),USTCAP(10),USACOS(10),USTGEN(10),
     *  UTC(10),USFCON(10),USUSAG(10),URANUS,USAGEF,UFACTT(8,9)
C   COMMON FOR REAL TIME 'RTIME'
      COMMON /RRR/ RTIME,RTIME2,REGPCD,REGDEM(9),REGEFC,REGGEN(9),REGCAP
C   COMMON FOR SUBROUTINE SPECIFIC VALUES
      COMMON /SDM/ YRDM4,SMDM4,KEY1,BDTMX4,PCAP4,PWDTF4
C
C   INITIAL AND DEFAULT DATA VALUES
C   VALUES SET IN MAIN DATA ARE:
C     YRDM4=2050,SMDM4=1.0,KEY1=0,BDTMX4=0,PCAP4=0
C   VALUES MAY BE CHANGED THROUGH MASTER USING
C     THE KEYS: 'YDM4' , 'SDM4'
C
C
C
    1 IF (KEY1.EQ.1) GO TO 5
C STORING INITIAL DUTMAX VALUE
      BDTMX4=DUTMAX(4)
      KEY1=1
C
    5 FTIME=RTIME+ALTIME
      IF (ALTIME.LE..001)  GO TO 20
      IF (FTIME.GE.YRDM4) GO TO 10
      DUTMAX(4)=BDTMX4
      RETURN
C
C   FUTURE MAXIMUM DUTY CYCLE
   10 DUTMAX(4)=SMDM4*BDTMX4

      RETURN
```

```
C
C
C  VINTAGE WEIGHTED MAXIMUM DUTY CYCLE
   20 IF (RTIME.GE.YRDM4) GO TO 25
      DUTMAX(4)=BDTMX4
      RETURN
C
   25 IF (PCAP4.NE.0) GO TO 30
C  ESTABLISHING BASE DATA IN YEAR OF CHANGE
      PCAP4=USTCAP(4)
      PWDTF4=BDTMX4
      WDTF4=BDTMX4
      DUTMAX(4)=WDTF4
      RETURN
C
   30 IF (USTCAP(4).EQ.PCAP4) GO TO 50
C  CALCULATE NEW WEIGHTED DUTY FACTOR
      WDTF4=(PWDTF4*PCAP4+SMDM4*BDTMX4*(USTCAP(4)-PCAP4))/USTCAP(4)
      PWDTF4=WDTF4
      PCAP4=USTCAP(4)
C  RETURNS WEIGHTED MAX DUTY CYCLE AS DUTMAX
   50 DUTMAX(4)=WDTF4
      RETURN
C
      END
```

End of SDUTMX

In main program:

```
C  CALCULATE PROJECTED NUCLEAR FUEL COSTS
C     CALCULATE DUTMAX FOR PLANTS TCONSN YEARS IN THE FUTURE
----> CALL SDUTMX(TCONSN)
      CALL NUKE(CFULM2,CFULK2,URANUS,THORUS,TAILSP,PLUTSP,PHEATR,
     * IURAN,ITHOR,BURN4,BURN5,BURN6,BURN7C,BURN7B, CSWU,PPUFAB,PPPUFB,
     * PPHFAB,PPBFAB,PP29,PPUREP,PPPURP,PPHREP,PPBREP,PP49,CU308,SWTOT,
     * DCAPIT,CUENR4,CUENR6,DPTANU,DPTADL,CHRATE,NPASS,VPLUTO,VBPLUT,
     * DOAMC)
C CALCULATE NUCLEAR FUEL COSTS FOR CURRENT TIME PERIOD
      IF(ISUB.GE.55) DEFL=WPI(M)/WPI(15)
      DO 144 N=1,9
      DCAPIT(N)=CAPIT(N)/DEFL
      DOAMC(N)=OAMCOS(N)/DEFL
  144 CONTINUE
C  CALCULATE NUCLEAR FUEL COSTS FOR CURRENT YEAR
----> CALL SDUTMX(0.0)
      CALL NUKE(CFULM1,CFULK1,URANUS,THORUS,TAILSP,PLUTSP,PHEATR,
     * IURAN,ITHOR,BURN4,BURN5,BURN6,BURN7C,BURN7B,CSWU,PCUFAB,PCPUFB,
     * PCHFAB,PCBFAB,PC29,PCUREP,PCPURP,PCHREP,PCBREP,PC49,CU308,SWTOT,
     * DCAPIT,CUENR4,CUENR6,DPTANU,DPTADL,CHRATE,NPASS,VPLUTO,VBPLUT,
     * DOAMC)
```

Appendix IV C

Construction Work in Progress

In FINMOD:

```
C
C  CONSTRUCTION WORK IN PROGRESS - DRW 27 MAY 77
C PROVISION FOR INCLUDING CONSTRUCTION WORK IN PROGRESS IN THE RATE BASE
C  TIME FOR INCORPORATION IS 'TWRKS' WITH A DEFAULT VALUE OF 2050
C  SWITCH IS 'IWRKS' WHICH WHEN EQUAL TO :
C                      '1'  INCORPORATES IMMEDIATELY IN YEAR 'TWRKS'
C                      '2'  INCORPORATES INCREMENTLY AT 0.2 PER YEAR
C
      IF (RTIME.LT.TWRKS) GO TO 60
      IF (IWRKS.EQ.1.AND.RTIME.EQ.TWRKS) RFRAC=1.0
      IF (IWRKS.NE.2) GO TO 60
      IF (IREG.EQ.1.AND.RTIME.LE.(TWRKS+4.)) RFRAC=RFRAC+0.2
C
```

Appendix IV D
Exponential Forecasting

In Main Program:

```
      POAMCO(J,K)=OAMEX + OAMTR*MULR
C   EXPONENTIAL FORECAST- DEW 21 NOV 77
      PCAPIT(J,K)=CAPEX*(1+CAPTR/CAPEX)**MULR
      PHEATR(J,K)=HEATEX*(1+HEATTR/HEATEX)**MULR
      POAMCO(J,K)=OAMEX*(1+OAMTR/OAMEX)**MULR
    2 CONTINUE
      IF(RTIME.LT.CLIPT.OR.RTIME.GE.1981.)GO TO 56
      DO 58 J=4,7
```

```
      PREDEM(K)=DEMEX + DEMTR*MULX
C    EXPONENTIAL GROWTH FORECASTER - DEW 21 NOV 77
      DEMGR=1+DEMTR/DEMEX
      PREDEM(K)=DEMEX*DEMGR**MULX
C
   33 PREPCD(K)=PREDEM(K)/(8.76*PUSAGE(K))
```

Appendix IV E
New Plant Construction Limitations

In Main Program:

```
  195 CNUMAR=PLMTB2(NREG,CAPNMT,TIME,8,IREG)
C     FOR NEW BUILD LIMITS - DEW 28 NOV 77
      IF  (NBL.GT.0.0) CNUMAR=CAPNEW(TIME,IREG)
      SUMFOS=0.0
      SUMNUC=0.0
      DO 79 J=1,4
```

```
      FUNCTION CAPNEW(TIME,IREG)
C
C  REVISED LIMITS TO MATCH HISTORICAL LWR GROWTH
C
C   THIS FUNCTION INTRODUCES LWR NEW CAPACITY LIMITS FOR EACH REGION AND
C     TIME PERIOD.  THE DATA IS CONTAINED IN THE TABLE CAPTAB'.
C   THE SWITCH IS 'NBL' WITH DEFAULT VALUE OF 0 WHICH IS CHANGED THROUGH
C     THE PROCEDURE 'MASTER'.
C   THE CHANGE ONLY OCCURS IN 'MAIN' AFTER STATEMENT 195.
C
      DIMENSION CAPTAB(9,51)
      DIMENSION CAP1(9,10), CAP2(9,10), CAP3(9,10),CAP4(9,10),CAP5(9,11)
      EQUIVALENCE (CAPTAB(1,1),CAP1),(CAPTAB(1,11),CAP2)
      EQUIVALENCE (CAPTAB(1,21),CAP3),(CAPTAB(1,31),CAP4)
      EQUIVALENCE (CAPTAB(1,41),CAP5)
C REGIONS
C     I      II      III     IV      V      VI      VII     VIII    IX
C 1947
      DATA CAP1/
     *  0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,
     *  0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,
     *  0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,
     *  0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,
     *  0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,
     *  0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,
     *  0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.065,
     *  0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,
     *  0.0,   0.0, 0.072,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,
     *  0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0 /
C 1957
      DATA CAP2/
     *  0.575, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.450,
     *  0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,
     *  0.690, 1.750, 1.357, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000,
     *  0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,
     *  1.991, 0.000, 2.927, 0.545, 2.267, 0.000, 0.000, 0.000, 0.000,
     *  0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,
     *  0.000, 3.795, 3.481, 2.295, 4.225, 1.065, 0.850, 0.000, 0.000,
     *  0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,
     *  0.828, 3.728, 1.060, 0.538, 3.262, 1.065, 0.000, 0.000, 2.403,
     *  0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0,   0.0 /
```

```
C 1967
      DATA CAP3/
     *  0.000, 0.906, 3.044, 0.000, 3.389, 3.042, 0.912, .330, 2.184,
     *  0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000,
     *  0.000, 2.984, 4.101, 0.000, 4.944, 5.544, 2.400, 0.000, 1.103,
     *  0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000,
     *  3.506, 4.072, 8.539, 2.270, 3.213, 2.463, 4.444, 1.240, 2.318,
     *  0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000,
     *  3.530, 6.772, 6.439, 2.256, 5.680, 7.415, 2.084, 1.240, 7.029,
     *  0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000,
     *  1.300, 4.432, 6.196, 0.000, 5.499, 3.803, 2.300, 1.240, 3.487,
     *  0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000 /
C 1977
      DATA CAP4/

     *  2.5,   2.5,   2.5,    2.5,   2.5,  2.5,    .367,   2.5,  2.5,
     *  3.450, 3.450, 3.450, 3.450, 3.450, 3.450, 0.546, 3.450, 3.450,
     *  4.400, 4.400, 4.400, 4.400, 4.400, 4.400, 0.726, 4.400, 4.400,
     *  5.350, 5.350, 5.350, 5.350, 5.350, 5.350, 0.905, 5.350, 5.350,
     *  6.300, 6.300, 6.300, 6.300, 6.300, 6.300, 1.084, 6.300, 6.300,
     *  7.250, 7.250, 7.250, 7.250, 7.250, 7.250, 1.264, 7.250, 7.250,
     *  8.200, 8.200, 8.200, 8.200, 8.200, 8.200, 1.443, 8.200, 8.200,
     *  9.150, 9.150, 9.150, 9.150, 9.150, 9.150, 1.622, 9.150, 9.150,
     *  10.10, 10.10, 10.10, 10.10, 10.10, 10.10, 1.801, 10.10, 10.10,
     *  11.05, 11.05, 11.05, 11.05, 11.05, 11.05, 1.980, 11.05, 11.05 /
C 1987
      DATA CAP5/
     *  12.00, 12.00, 12.00, 12.00, 12.00, 12.00, 2.160, 12.00, 12.00,
     *  13.20, 13.20, 13.20, 13.20, 13.20, 13.20, 4.344, 13.20, 13.20,
     *  14.40, 14.40, 14.40, 14.40, 14.40, 14.40, 6.500, 14.40, 14.40,
     *  15.60, 15.60, 15.60, 15.60, 15.60, 15.60, 8.700, 15.60, 15.60,
     *  16.80, 16.80, 16.80, 16.80, 16.80, 16.80, 10.90, 16.80, 16.80,
     *  18.00, 18.00, 18.00, 18.00, 18.00, 18.00, 13.10, 18.00, 18.00,
     *  19.20, 19.20, 19.20, 19.20, 19.20, 19.20, 15.30, 19.20, 19.20,
     *  20.40, 20.40, 20.40, 20.40, 20.40, 20.40, 17.40, 20.40, 20.40,
     *  21.60, 21.60, 21.60, 21.60, 21.60, 21.60, 19.60, 21.60, 21.60,
     *  22.80, 22.80, 22.80, 22.80, 22.80, 22.80, 21.80, 22.80, 22.80,
C 1997
     *  24.0,  24.0,  24.0,  24.0,  24.0,  24.0,  24.0,  24.0,  24.0 /
C
C  START OF EXECUTION
C
      ITIME=IFIX(TIME+1.0001)
      IF (ITIME.LT.1) ITIME=1
      IF (ITIME.GT.51) ITIME=51
C  HALF OF BUILD LIMIT PER SIX MONTH PERIOD
      CAPNEW=CAPTAB(IREG,ITIME)/2.0
      RETURN
      END
```

Appendix IV F
New Data Output Procedures

In Main Program:

```
      TYD=1.0
C
C  ITITIALIZATION FOR DATA ARRAY OUTPUT   D E WHITE  28 FEB 78
C
      ARYR=1970
      JA=15
      ZER=0.0
      TEN=10.0
C
      IF (ARYR.GT.1997) GO TO 13
C
C     FORMATS
 2000 FORMAT(80X)
 2002 FORMAT (10F8.2)
 2003 FORMAT (10F8.3)
 2009 FORMAT (-15P10F8.3)
C
C  CREATION OF ARRAY IDENTIFERS
      WRITE(5,2005)
 2005 FORMAT('* ENTER RUN ID')
      READ (5,2006) INPNAM
 2006 FORMAT (A8)
      WRITE (5,2007)
 2007 FORMAT('* ENTER SHORT DESCRIPTION')
      READ(5,2008) INPT1,INPT2,INPT3,INPT4,INPT5
 2008 FORMAT (5A8)
      L=1997-ARYR+1.1
      WRITE (JA,2010) L,INPNAM,INPT1,INPT2,INPT3,INPT4,INPT5
 2010 FORMAT ('IRANGE(1)=',I5,', IRANGE(2)=10,IRANGE(3)=128,',
     * 'NAMELIST(3)=1  ','NAMELIST(2)=1  ',/,
     *'INPNAME=''',A8,''' INPTITLE=''',5A8,' ''',
     *   /,' ;')
C
C  THE NAME IDENTIFER LIST
      WRITE(JA,2031)
 2031 FORMAT('NEW ENG MID ATL E-N CTL W-N CTL SOU ATL E-S CTL ',
     *        'W-S CTL MOUNTAINPACIFIC NATIONAL')
      WRITE (JA,2011)
 2011 FORMAT(' YEAR    ','LOCATION','ELE DMD ','PEAK DMD',
     * 'AVG COST','RES COST','IND COST','        ','FOS CAP ',
     * 'FOS GEN ')
      WRITE (JA,2012)
 2012 FORMAT('CAP COA ','CAP GAS ','CAP OIL ','CAP LWR ',
     * 'CAP LWRP','CAP HTGR','CAP MFBR','CAP I.C.',
     * 'CAP HYDR','CAP TOT ')
      WRITE (JA,2013)
 2013 FORMAT('OPT COA ','OPT GAS ','OPT OIL ','OPT LWR ',
     *        'OPT LWRP','OPT HTGR','OPT MFBR','OPT I.C.',
     *        'OPT HYDR','OPT TOT ')
      WRITE (JA,2014)
 2014 FORMAT('NEW COA ','NEW GAS ','NEW OIL ','NEW LWR ',
     *         'NEW LWRP','NEW HTGR','NEW MFBR','NEW I.C.',
     *         'NEW HYDR','NEW TOT ')
```

```
      WRITE (JA,2015)
 2015 FORMAT('GEN COA ','GEN GAS ','GEN OIL ','GEN LWR ',
     *        'GEN LWRP','GEN HTGR','GEN MFBR','GEN I.C.',
     *        'GEN HYDR','GEN TOT ')
      WRITE (JA,2016)
 2016 FORMAT('UF COAL UF GAS  UF OIL  UF LWR  UF LWRP UF HTGR',
     *        ' UF MFBR UF I.C. UF HYDR UF TOT ')
      WRITE (JA,2017)
 2017 FORMAT('UFC COALUFC GAS UFC OIL UFC LWR UFC LWRPUFC HTGR',
     *        'UFC MFBRUFC I.C.UFC HYDRUFC TOT ')
      WRITE (JA,2018)
 2018 FORMAT('FOM COA FOM GAS FOM OIL FOM LWR FOM LWP FOM HTG',
     *        ' FOM MFB FOM I.C FOM HYD FOM TOT')
      WRITE (JA,2019)
 2019 FORMAT('ECB COA ECB GAS ECB OIL EPB COA EPB GAS EPB OIL',
     *        ' CST U308CUM U308CON U308')
      WRITE (JA,2020)
 2020 FORMAT('ECU COA ECU GAS ECU OIL EPU COA EPU GAS EPU OIL',
     *        ' SWU COSTSWU DMD')
      WRITE (JA,2021)
 2021 FORMAT('RC TOT  RC GAS  RC OIL  RC ELE  IND TOT IND GAS IND OIL',
     *        ' IND ELE IND COA')
      WRITE (JA,2022)
 2022 FORMAT('RCI TOT RCI GAS RCI OIL RCI ELE RCI COA ',
     *        'TOT ENG TOT OIL TOT GAS TOT COA TOT O&G')
      WRITE (JA,2023)
 2023 FORMAT('CAP INV T&D INV RAT BAS WIC     TOT AST SPA CAP OPR REV')
C
C
   13 CONTINUE
C

   85 CONTINUE
C
C  REGIONAL OUTPUT FOR DATA ARRAY       D E WHITE  28 FEB 78
C
      IF ((RTIME+.6).LT.ARYR) GO TO 89
C      SKIPS IF NOT YET YEAR TO START REPORT
C
      IRYR=RTIME
      ISW=3*(RTIME-IRYR)
C       ISW IS ZERO FOR ANNUAL PERIODS, ONE FOR SEMIANNUAL PERIODS
C
C  CALCULATIONS OF NEW PLANT ADDITIONS
      IF (ISW.EQ.0.0) GO TO 305
C     SUMMATION DURING NON-REPORTING PERIOD
      DO 301 J=1 , 3
  301 ANCAP(IREG,J)=CTOBC2(IREG,J,1)+CTOBC2(IREG,J,2)
      DO 302 J=1, 4
  302 ANCAP(IREG,J+3)=CTOBC3(IREG,J,1)+CTOBC3(IREG,J,2)
      ANCAP(IREG,8)=CTOBC1(IREG,1,1)+CTOBC1(IREG,1,2)
      ANCAP(IREG,9)=CTOBCH(IREG,1,1)+CTOBCH(IREG,1,2)
      ANCAP(IREG,10)=0.0
      DO 303 J=1, 9
  303 ANCAP(IREG,10)=ANCAP(IREG,10)+ANCAP(IREG,J)
  305 CONTINUE
```

In Main Program:

```
C
      IF (ISW.NE.0.0) GO TO 89
C      SKIPS OUTPUT IF NOT REPORTING PERIOD
C
      RIREG=IREG
      WRITE (JA,2042) RTIME,RIREG,REGDEM(IREG),REGPCD,PELEC(IREG),
     *  ZER,ZER,ZER,TCCAP,ZER
 2042 FORMAT(2F8.0,8F8.2)
      WRITE (JA,2003)  (EXSCAP(IREG,J),J=1,9),REGCAP
      WRITE (JA,2003) (OPTCAP(IREG,J),J=1,9),ZER
      WRITE (JA,2003) (ANCAP(IREG,J),J=1,10)
      WRITE (JA,2003) (GENELE(IREG,J),J=1,9), REGGEN(IREG)
      WRITE (JA,2003) (USAGE(IREG,J),J=1,9), ZER
      WRITE (JA,2003) (FUECON(IREG,J),J=1,9)
      WRITE (JA,2003) (COSTOP(J),J=1,9)
      COALCB=FUECON(IREG,1)
      GASCB=FUECON(IREG,2) + FUECON(IREG,8)*(1-FOIL(IREG))
      OILCB=FUECON(IREG,3) + FUECON(IREG,8)*FOIL(IREG)
      WRITE (JA,2003) COALCB,GASCB,OILCB,CFULB1(1),CFULB1(2),CFULB1(3)
      COALCN=COALCB*38.17
      GASCN=GASCB*0.9709
      OILCN=OILCB*0.1591
      COALPN=CFULB1(1)*0.261
      GASPN=CFULB1(2)*1.103
      OILPN=CFULB1(3)*0.058
      WRITE (JA,2003) COALCN,GASCN,OILCN,COALPN,GASPN,OILPN
      WRITE (JA,2000)
      WRITE (JA,2000)
      WRITE (JA,2003) CAPINV(IREG),TADINV(IREG),RBASE,WRKINC,ASSETS,
     *  SPA(IREG),REVENU(IREG)
C
   89 CONTINUE
C
```

```
  777 WRITE (IW,956) USDEBT,USYCON
      WRITE (IW,957) USCAPZ,USTINV
      WRITE (IW,958) USANDT
      WRITE (IW,959) USADTX
      WRITE (IW,960) USLIAB
C  SET UP OUTPUT TO BE RETURNED TO IFC MODEL BEFORE INTEGRATING TO
C  NEXT TIME PERIOD
C
C
C
C  NATIONAL OUTPUT FOR DATA ARRAY     D E WHITE 28 FEB 78
C
      IF (RTIME.LT.ARYR) GO TO 780
C       SKIP IF NOT YET REPORTING PERIOD
C
C  SUMMATION OF NEW PLANT ADDITIONS
      DO 312 J=1, 10
C       BY PLANT TYPES
      ANCAP(10,J)=0.0
      DO 312 K=1, 9
C       BY REGIONS
      ANCAP(10,J)=ANCAP(10,J)+ANCAP(K,J)
  312 CONTINUE
C
C
      WRITE (JA,2042) RTIME,TEN,USDG,USDC,USELPR,PRCRES,PRCIND,ZER,
     * USTCCA,USTCGE
      WRITE (JA,2002) USTCAP(1),USTCAP(2),USTCAP(3),USTCAP(4),USTCAP(5),
     * USTCAP(6),USTCAP(7),USTCAP(8),USTCAP(9),USK
      WRITE (JA,2000)
      WRITE (JA,2003) (ANCAP(10,J),J=1, 10)
      WRITE (JA,2003) USTGEN(1),USTGEN(2),USTGEN(3),USTGEN(4),USTGEN(5),
     * USTGEN(6),USTGEN(7),USTGEN(8),USTGEN(9),USG
      WRITE (JA,2003) USUSAG(1),USUSAG(2),USUSAG(3),USUSAG(4),USUSAG(5),
     * USUSAG(6),USUSAG(7),USUSAG(8),USUSAG(9),USU
      WRITE (JA,2003) USFCON(1),USFCON(2),USFCON(3),USFCON(4),USFCON(5),
     * USFCON(6),USFCON(7),USFCON(8),USFCON(9),USF
      WRITE (JA,2000)
      URAR=URANUS*1000.
      WRITE (JA,2003) TCOALB,TGASCB,TOILCB,ZER,ZER,ZER,CU308,URAR,ZER

      ASR=ASEPT/1E+06
      WRITE (JA,2003) TCOALN,TGASCN,TOILCN,ZER,ZER,ZER,CSWU,ASR,ZER,ZER
      WRITE (JA,2009) RCTEGY,RCTGAS,RCTOIL,RCTELE,TINECO,TINGAS,TINOIL,
     * TINELE,TINCOL,ZER
      TOTOIL=USTOIL+1.0E15*(USFCON(3)+USFCON(8))
      TOTGAS=USTGAS+1.0E15*USFCON(2)
      TOTOAG=TOTOIL+TOTGAS
      TOTCOA=USTCOL+1.0E15*USFCON(1)
      TOTENG=USTGAS+USTOIL+USTCOL+1.0E15*USF
      WRITE (JA,2009) USTENG,USTGAS,USTOIL,USTELE,USTCOL,
     * TOTENG,TOTOIL,TOTGAS,TOTCOA,TOTOAG
      WRITE (JA,2003) USINV,USTDIN,USRBAS,USWRKC,USASST,USSPA,USREVG
C
C
  780 CONTINUE
```

```
 BJDISP:  PROCEDURE OPTIONS(MAIN);

 /*    ARRAY DATA DISPLAY PROGRAM

      THIS PROGRAM IS DESIGNED TO READ DATA STORED IN AN ARRAY FORM
 ON THE INPUT FILE 'INDATA' AND TO PRODUCE SELECTED DATA TABLES AND
 GRAPHS.  THE PARAMETERS OF THE DATA ARRAY ARE OBTAINED THROUGH A
 GET DATA COMMAND WHICH INITIALLY READS THESE FROM THE SAME INPUT FILE.
 THE PROGRAM ALSO PROVIDES THE OPTION OF READING IDENTIFYING DATA NAMES
 AS WELL AS THE DATA ITSELF AND INCORPORATING THESE IN THE SELECTED
 OUTPUT.  THE PROGRAM IS DESIGNED TO BE OPERATED INTERACTIVELY FROM A
 TERMINAL WITH THE OUTPUT SENT EITHER TO THE TERMINAL OR A PRINTER.

      THE DATA IS STORED IN A FOUR-DIMENSIONAL ARRAY.  THE LEVELS
 ARE AS FOLLOWS:      1.  DATA CASE
                      2.  DIMENSION 1
                      3.  DIMENSION 2
                      4.  DIMENSION 3.
 THE DATA IS READ UP IN THE SEQUENCE, I.E. THE HIGHER LEVELS ARE SPECI-
 FIED AND THE LOWEST LEVEL IS THEN READ IN SEQUENCE, ETC.

     BY SETTING THE NAMELIST VARIABLES TO 1, ONE CAN ALSO READ IN NAMES
 IDENTIFYING THE INDICES AT EACH DIMENSION LEVEL.  THE NAME FOR THE CASE
 IS SPECIFIED USING THE 'INPNAME' AND 'INPTITLE' VARIABLES IN THE INPUT
 DATA FILE.

 THE GENERAL FORM OF AN INPUT FILE WOULD BE AS FOLLOWS:
     1. THE DATA IDENTIFICATION WHICH IDENTIFIES THE DATA WHICH FOLLOWS
        AND IS READ USING THE 'GET DATA' STATEMENT WHICH READS ONLY THE
        VARIABLES ACTUALLY IDENTIFIED THERE.
         E.G.  INPNAME='CASEA2', INPTITLE='TEST CASE OF 31 JUNE',
               IRANGE(1)=5, IRANGE(2)=10, IRANGE(3)=15,
               NAMELIST(1)=1   ;
     2. THE NAME LIST SECTION WHICH CONTAINS THE NAMES FOR ANY
        DIMENSIONS WHOSE 'NAMELIST' WAS SPECIFIED AS 1.
        E.G.   ACCOUNT1  ACCOUNT2 ACCOUNT3 .....  TOTAL
        THE FORMAT IS 10 A(8), I.E. TEN 8-CHARACTER NAMES TO A RECORD.
     3. THE DATA SECTION WHICH CONTAINS THE ACTUAL DATA TO BE READ IN.
        THE ORDER IS SEQUENCED UPWARDS THROUGH THE DIMENSION LEVELS.
        I.E.  VAR(1,1,1,1), VAR(1,1,1,2), VAR(1,1,1,3), ....
              VAR(1,1,1,IRANGE(3))
              VAR(1,1,2,1), VAR(1,1,2,2), .... ETC.
        THE FORMAT IS 10 F(8,4), I.E. TEN 8-DIGIT NUMBERS PER 80-CHAR
        RECORD.   WHEN THE LOWEST DIMENSION REACHES ITS LIMIT,
        THE NEXT READ SEQUENCE THEN STARTS ON A NEW RECORD.

  THE PERSON TO CONTACT WITH ANY QUESTIONS IS:
      DAVID E. WHITE
      MIT  RM E38-422
           TEL X3-8029

 END OF DESCRIPTIVE HEADER  */


1/******  INITIAL DATA AND STRUCTURES  ****************************/
```

```
 DCL MAXCASE INITIAL(4);  /*  MAXIMUM NUMBER OF CASES ALLOWED  */
 DCL NCASE   INITIAL(0);  /* NUMBER OF CASES AVAILABLE */
 DCL MAXRANGE(3) INITIAL((3)0);  /* RANGES OF ARRAY DIMENSIONS */

 DCL CASENAME(MAXCASE) CHAR(8) CTL;
 DCL CASETITLE(MAXCASE) CHAR(40) CTL;
 DCL DNAME1(MAXRANGE(1))  CHAR(8)  CTL;
 DCL DNAME2(MAXRANGE(2))  CHAR(8) CTL;
 DCL DNAME3(MAXRANGE(3))  CHAR(8)  CTL;

 DCL DATA(MAXCASE,MAXRANGE(1),MAXRANGE(2),MAXRANGE(3)) CTL;

 /* DATA SELECTED FOR DISPLAY */
 DCL DISPDATA(10,MAXRANGE(1)) CTL;
 DCL 1 ISD(10),    /* DISPLAY INDEX KEYS */
       3 ICN,
       3 ID2,
       3 ID3;
 DCL NSEL INITIAL(0);  /* NUMBER OF ITEMS SELECTED */
 DCL KS,KF FIXED; /* TABLE TIME RANGES */

 DCL INDATA FILE INPUT  STREAM ENV(FB RECSIZE(80) BLKSIZE(800) );
 DCL POUT   FILE OUTPUT STREAM PRINT ENV(FB RECSIZE(133)); /* PRINTER */
 DCL TOUT   FILE OUTPUT STREAM PRINT ENV(FB RECSIZE(133)); /* TERMINAL*/
 DCL DOUT FILE VARIABLE; /* SELECTED OUTPUT FILE */
 DOUT=TOUT;

 /*  END OF INITIAL BLOCK  */


1/******  PROGRAM CONTROL BLOCK  ***********************************/
 /*                                                                  */

 CALL DATARD;   /*  READ DATA  */

 /* INTERACTIVE SECTION */
 DCL ISW CHAR(1);  /* SELECTION CHARACTER */
 NSEL=0;  /* NO ITEMS IN SELECTION LIST AT THE START */
 M12:  DISPLAY(' ');
       DISPLAY('YOU HAVE THE FOLLOWING OPTIONS');
       DISPLAY('0. DISPLAY THIS LIST AGAIN.');
       DISPLAY('1. LIST DATA DIRECTORY.');
       DISPLAY('2. SELECT DATA FOR A DISPLAY.');
       DISPLAY('3. PRODUCE A TABLE.');
       DISPLAY('4. PRODUCE A GRAPH.');
       DISPLAY('5. CROSS-SECTIONAL TABLES');
       DISPLAY('9. TERMINATE THE PROGRAM.');

 M14:  DISPLAY('  ');
       DISPLAY('SELECT A PROCEDURE') REPLY(ISW);

       IF ISW='0' | ISW='L' THEN GO TO M12;
       IF ISW='1' | ISW='D' THEN CALL DIRTS;
       IF ISW='2' | ISW='S' THEN CALL SELS;
       IF ISW='3' | ISW='T' THEN CALL TABS;
```

```
      IF ISW='4' | ISW='G' THEN CALL GRAPS;
      IF ISW='5' | ISW='X' THEN CALL CROSS;
      IF ISW='9' | ISW='Q' THEN CALL QUITS;

 GO TO M14;  /* REPEATS REQUEST */
 /* END OF PROGRAM CONTROL BLOCK */


1/******  READING THE DATA  ***************************************/
 DATARD:  PROCEDURE;
 DCL IRANGE(3);  DCL NAMELIST(3);
 DCL D1KEY CHAR(8); DCL D2KEY CHAR(8) ;
 DCL INPNAME CHAR(8);  DCL INPTITLE CHAR(40);
 ON ENDFILE(INDATA) BEGIN;
    NCASE=NCASE-1;
    DISPLAY(' ');
    DISPLAY('DATA READ TERMINATED ON ENDFILE');
    GO TO DR99;
    END;

 DR2: NCASE=NCASE+1 ;
 IF NCASE>MAXCASE THEN DO;
    NCASE=MAXCASE;
    DISPLAY('DATA READ TERMINATED ON MAXIMUM NUMBER OF CASES');
    RETURN;
    END;

 /*  GET DATA CASE IDENTIFIERS */
 IRANGE(*)=1; NAMELIST(*)=0; INPNAME='  '; INPTITLE='  ';
 GET DATA FILE(INDATA);
 PUT FILE(TOUT) DATA(INPNAME,INPTITLE,IRANGE(1),IRANGE(2),IRANGE(3));

 IF NCASE = 1 THEN DO;
    MAXRANGE(*)=IRANGE(*);
    CALL ALLOC;
    END;

 DO I=1 TO 3;
    IF IRANGE(I)>MAXRANGE(I) THEN DO;
       DISPLAY('DATA READ TERMINATED BY INVALID DIMENSION RANGE');
       NCASE=NCASE-1;
       RETURN;
       END;
    END;

 CASENAME(NCASE)=INPNAME;
 CASETITLE(NCASE)=INPTITLE;

 IF NAMELIST(1)=1
    THEN GET FILE(INDATA) EDIT
    ((DNAME1(I) DO I=1 TO IRANGE(1)))
    (COLUMN(1),10 A(8));

 IF NAMELIST(2)=1
    THEN GET FILE(INDATA) EDIT
```

```
   ((DNAME2(I) DO I=1 TO IRANGE(2)))
   (COL(1),10 A(8));

IF NAMELIST(3)=1 THEN DO;
   (NOCONVERSION): GET FILE(INDATA) EDIT(D1KEY,D2KEY) (COL(1),2 A(8));
   GET FILE(INDATA)
       EDIT((DNAME3(I) DO I=1 TO IRANGE(3))) (A(8));
   END;

DO I1=1 TO IRANGE(1);
   DO I2=1 TO IRANGE(2);
      GET FILE(INDATA) EDIT (D1KEY,D2KEY) (COL(1),2 A(8));
      IF DNAME1(I1)='        ' THEN DNAME1(I1)=D1KEY;
      IF DNAME2(I2)='        ' THEN DNAME2(I2)=D2KEY;
      GET FILE(INDATA) EDIT
      ((DATA(NCASE,I1,I2,I3) DO I3=1 TO IRANGE(3)))
      (F(8,4));
      END;
   END;

DISPLAY('DATA CASE READ.');

GO TO DR2;  /*  REPEATS DATA READ UNTIL END CONDITIONS */

DR99: RETURN;

END DATARD;
/*  END OF DATA READ SECTION  */

/******  STORAGE ALLOCATION PROCEDURE  ***************************/
ALLOC: PROCEDURE;
ALLOCATE DATA;
ALLOCATE CASENAME;
ALLOCATE CASETITLE;
ALLOCATE DNAME1;
DNAME1=' ';
ALLOCATE DNAME2;
DNAME2=' ';
ALLOCATE DNAME3;
DNAME3=' ';
ALLOCATE DISPDATA;
DISPDATA(*)=0;
END ALLOC;
/*  END OF ALLOCATION PROCEDURE  */

1/******  DATA DIRECTORY  *****************************************/
DIRTS: PROCEDURE;
DCL ARSP CHAR(1);
DISPLAY('DO YOU WISH TO HAVE A DATA DIRECTORY?')
     REPLY(ARSP);
IF ARSP¬='Y' THEN RETURN;

DOUT=TOUT; /* OUTPUT TO TERMINAL */
PUT FILE(DOUT) PAGE EDIT('DATA DIRECTORY')(A);
PUT FILE(DOUT) SKIP(2) EDIT('DATA CASES') (A);
```

```
     (COL(1),11 (X(3),A(8)));
 PUT FILE(DOUT) SKIP(1)
     EDIT('VARIABLE',(DNAME3(ISD.ID3(I)) DO I=1 TO NSEL))
     (COL(1),11 (X(3),A(8)));
 PUT FILE(DOUT) SKIP(2);
 PUT FILE(DOUT) EDIT('YEAR') (COL(3),A);
 /* WRITING THE DATA */
 DO J=KS TO KF;
    PUT FILE(DOUT)
        EDIT(DNAME1(J),(DISPDATA(I,J) DO I=1 TO NSEL))
        (COL(1),A(8),X(3),10 (F(11,3)));
    END;

 /* PRINTING DATA CASE TITLES */
 PUT FILE(DOUT) SKIP(2);
 DO I=1 TO NCASE;
    DO J=1 TO NSEL;
       IF ISD.ICN(J)=I THEN DO;
          PUT FILE(DOUT) EDIT(CASENAME(I),CASETITLE(I))
              (COL(1),X(5),A,A);
          GO TO T20; /*NEXT CASE*/
          END;
       END;
    T20: ;
    END;


 DISPLAY(' ');
 DISPLAY('DATA TABLE COMPLETED');

 IF DOUT=TOUT THEN DO;
   DISPLAY('DO YOU WISH TO PRINT THIS TABLE?') REPLY(SRSP);
   IF SRSP='Y' THEN DO;
      DOUT=POUT;
      GO TO T18;
      END;
   END;

 RETURN;

 END TABS;


1/******  GRAPH PROCEDURE  ******************************************/
 /* PLOTS 'DISPDATA' (Y-AXIS) VS. DIMENSION 1 (TIME ON X-AXIS) */
 GRAPS:  PROCEDURE;

 DCL SRSP CHAR(1); /* RESPONSE CHARACTER */

 IF NSEL<1 THEN DO;
    DISPLAY('NO DATA CURRENTLY SELECTED');
    RETURN;
    END;

 /* GRAPH TIME SPANS (X-AXIS) */
```

```
      IF KD3<) | KD3>MAXRANGE(3) THEN GC TC S20;

 /* ASSIGNING DATA INDICES */
 NSEL=NSEL+1;
 ISD(NSEL).ICN=KCN;
 ISD(NSEL).ID2=KD2;
 ISD(NSEL).ID3=KD3;
 /* ASSIGNING DATA */
 DO I=1 TO MAXRANGE(1);
    DISPDATA(NSEL,I)=DATA(KCN,I,KD2,KD3);
    END;
 DISPLAY('ACCEPTED');

 IF NSEL=10 THEN DO;
    DISPLAY('MAXIMUM NUMBER OF VARIABLES SELECTED.');
    RETURN;
    END;

 GO TO S20; /* FOR NEXT SELECTION */

 END SELS;


1/******  TABLE PROCEDURE  *******************************************/
 TABS:  PROCEDURE;
 DCL SRSP CHAR(1);  /* SHORT RESPONSE WORD */
 DCL ARSP CHAR(4);  /* LONGER RESPONSE */
 T1: DISPLAY('DO YOU WISH TO PRODUCE A TABLE?') REPLY(SRSP);
     IF SRSP¬='Y' THEN RETURN;

 IF NSEL=0 THEN DO;
    DISPLAY('NC DATA SELECTED.');
    RETURN;
    END;

 T10: DISPLAY('ENTER STARTING TIME INDEX NUMBER.') REPLY(ARSP);
      KS=ARSP;
      IF KS<1 | KS>MAXRANGE(1) THEN GO TO T10;

 T15: DISPLAY('ENTER FINAL TIME INDEX NUMBER.') REPLY(ARSP);
      KF=ARSP;
      IF KF<KS | KF>MAXRANGE(1) THEN GC TO T15;

 DOUT=TOUT; /* OUTPUT TO TERMINAL */

 TAB2:  ENTRY;  /* DEPENDENT ENTRY POINT */
 T18: ;  /* LABEL FOR REPEAT OUTPUT */

 /* TABLE DISPLAY */
 PUT FILE(DOUT) PAGE EDIT('SELECTED DATA TABLE') (A);
 PUT FILE(DOUT) SKIP(2)
     EDIT('CASE',(CASENAME(ISD.ICN(I)) DO I=1 TO NSEL))
     (COL(1),11 (X(3),A(6)));
 PUT FILE(DOUT) SKIP(1)
     EDIT('REGION',(DNAME2(ISD.ID2(I)) DO I=1 TO NSEL))
```

```
 PUT FILE(DOUT)
     EDIT(((I,CASENAME(I),CASETITLE(I))DO I=1 TO NCASE))
     (COL(1),F(6),X(1),A(8),X(2),A(40));

 PUT FILE(DOUT) SKIP(2) EDIT('DIMENSION-1 NAMES') (A);
 PUT FILE(DOUT)
     EDIT(((I,DNAME1(I))DO I=1 TO MAXRANGE(1)))
     (COL(1),10 (F(4),X(1),A(8)) );

 PUT FILE(DOUT) SKIP(2) EDIT('DIMENSION-2 NAMES') (A);
 PUT FILE(DOUT)
     EDIT(((I,DNAME2(I))DO I=1 TO MAXRANGE(2)))
     (COL(1),10 (F(4),X(1),A(8)) );

 PUT FILE(DOUT) SKIP(2) EDIT('DIMENSION-3 NAMES') (A);
 PUT FILE(DOUT)
     EDIT(0,' ',0,' ',((I,DNAME3(I))DO I=1 TO MAXRANGE(3)))
     (COL(1),10 (F(4),X(1),A(8)) );

 PUT FILE(DOUT) SKIP(2) EDIT('END OF DATA DIRECTORY') (A);

 END DIRTS;
 /*  END OF CONTENTS SECTION  */


1/******  SELECTION PROCEDURE  ****************************************/
 SELS:  PROCEDURE;
 ON CONVERSION GO TO S1;
 NSEL=0;

 DCL SRSP CHAR(4); /* SELECTION WORD */

 S1: DISPLAY('DO YOU WISH TO SELECT DATA FOR DISPLAY?') REPLY(SRSP);
 IF SRSP¬='Y' & SRSP¬='YES' THEN RETURN;

 IF NSEL=0 THEN DISPLAY('NO DATA CURRENTLY SELECTED.');

 DISPLAY('YOU WILL BE ASKED TO GIVE THE DATA INDEX NUMBERS FOR:');
 DISPLAY('1. THE CASE, 2. THE REGION, 3. THE VARIABLE.');
 DISPLAY('USE THE INDEX NUMBERS FROM THE DATA DIRECTORY');
 DISPLAY('ENTER 0 (ZERO) TO RETURN TO THE NEXT HIGHEST INDEX LEVEL.');

 S10: DISPLAY('CASE INDEX?') REPLY(SRSP);
      KCN=SRSP;
      IF KCN=0 THEN GO TO S1;
      IF KCN<0 | KCN>NCASE THEN GO TO S10;

 S15: DISPLAY('REGION INDEX?') REPLY(SRSP);
      KD2=SRSP;
      IF KD2=0 THEN GO TO S10;
      IF KD2<0 | KD2>MAXRANGE(2) THEN GO TO S15;

 S20: DISPLAY('VARIABLE INDEX?') REPLY(SRSP);
      KD3=SRSP;
      IF KD3=0 THEN GO TO S15;
```

```
KS=6; KF=MAXRANGE(1);

/* DATA VALUE RANGES */
YMAX=1; YMIN=0;
DO I=1 TO NSEL;
   DO J=KS TO KF;
      IF DISPDATA(I,J)>YMAX THEN YMAX=DISPDATA(I,J);
      IF DISPDATA(I,J)<YMIN THEN YMIN=DISPDATA(I,J);
      END;
   END;

/* CREATING THE PLOT GRID */
DCL GRID(120,50) CHAR(1); /* GRAPH GRID */
GRID(*,*)=' ';
GRID(*,1)='_'; /* BOTTOM LINE */
DCL PT(11)CHAR(1) INITIAL('*','+','O','X','E','F','G','H','J','K','#');

XAXIS=100;
JXSTEP=XAXIS/(KF-KS+1);    JXMAX=(KF-KS+1)*JXSTEP;
DO J=KS TO KF;
   JX=1+(J-KS)*JXSTEP;
   DO I=1 TO NSEL;
      IY=1+49*(DISPDATA(I,J)-YMIN)/(YMAX-YMIN);
      IF GRID(JX,IY)=' ' | GRID(JX,IY)='_'
         THEN GRID(JX,IY)=PT(I);
         ELSE GRID(JX,IY)=PT(11);
      END;
   END;

/* PRINTING THE GRAPH */
DOUT=TOUT; /* OUTPUT TO TERMINAL */
G50: PUT FILE(DOUT) PAGE EDIT('SELECTED DATA GRAPH') (COL(1),A);

DO I=50 TO 1 BY -1;
   RI=I;
   YVALUE=YMIN+((RI-1)/49)*(YMAX-YMIN);
   PUT FILE(DOUT)
      EDIT(YVALUE,'|',(GRID(J,I) DO J=1 TO JXMAX))
      (COL(1),F(8,2),A,130 A(1));
   END;

IXB=12/JXSTEP;
PUT FILE(DOUT) EDIT((DNAME1(I) DO I=KS TO KF BY IXB))
               (COL(1),X(5),8 A(12));

PUT FILE(DOUT) SKIP(2) EDIT('REFERENCE LIST') (COL(1),A);
   PUT FILE(DOUT)
      EDIT((PT(I),CASENAME(ISD.ICN(I)),DNAME2(ISD.ID2(I)),
            DNAME3(ISD.ID3(I)) DO I=1 TO NSEL))
           (COL(1),X(3),A(2),A,A(10),A(10),X(10),A(2),A,A(10),A(10));

DISPLAY('GRAPH COMPLETED');

IF DOUT=TOUT THEN DO;
   DISPLAY('PRINT THIS GRAPH?') REPLY(SRSP);
```

```
    IF SRSP='Y' THEN DO;
       DOUT=POUT;
       GO TO G50;
       END;
    END;

 RETURN;
 END GRAPS;


1/****** DATA TABLE CROSSECTION PROCEDURE **************************/
 CROSS: PROCEDURE;
 DCL SRSP CHAR(1);

 DISPLAY('DO YOU WISH TO PRODUCE CROSS-SECTIONAL TABLES?') REPLY(SRSP);
 IF SRSP¬='Y' THEN RETURN;

 /* TO SAVE CURRENT DATA */
 NSDATA=NSEL;
 DCL 1 ISV(10),
       3 ICN,
       3 ID2,
       3 ID3;
 DO  I=1 TO 10;
      ISV.ICN(I)=ISD.ICN(I);
      ISV.ID2(I)=ISD.ID2(I);
      ISV.ID3(I)=ISD.ID3(I);
      END;
 /* DATA SAVED */

 /* TABLE TIME SPANS */
 KS=6;  KF=MAXRANGE(1);

 DOUT=POUT; /* OUTPUT TO PRINTER */

 /* TABLES:  CASES OVER SELECTED DATA */
 DO IC=1 TO NCASE;  /* TABLES */
    DO JC=1 TO NSDATA;  /* COLUMNS */
       ISD.ICN(JC)=IC; /*CASE*/
       DO K=1 TO MAXRANGE(1);
          DISPDATA(JC,K)=DATA(IC,K,ISD.ID2(JC),ISD.ID3(JC));
          END;
       END; /* TABLE SETUP COMPLETED */
    CALL TAB2;
    END;
 /* 'CASE' TABLES COMPLETED */

 /* TABLES:  DATA OVER CASES */
 DO JC=1 TO NSDATA;
    NSEL=NCASE; /* COLUMNS=NO. OF CASES */
    DO IC=1 TO NCASE;
       ISD.ICN(IC)=IC; /*CASE NUMBER*/
       ISD.ID2(IC)=ISV.ID2(JC);
       ISD.ID3(IC)=ISV.ID3(JC);
       DO K=1 TO MAXRANGE(1);
```

```
          DISPDATA(IC,K)=DATA(IC,K,ISD.ID2(IC),ISD.ID3(IC));
          END;
       END;
    CALL TAB2;
    END;
/* 'DATA' TABLES COMPLETED */

/* RESTORING SELECTED DATA */
NSEL=NSDATA;
DO  I=1 TO 10;
    ISD.ICN(I)=ISV.ICN(I);
    ISD.ID2(I)=ISV.ID2(I);
    ISD.ID3(I)=ISV.ID3(I);
    DO K=1 TO MAXRANGE(1);
       DISPDATA(I,K)=DATA(ISD.ICN(I),K,ISD.ID2(I),ISD.ID3(I));
       END;
    END;
/* SELECTED DATA RESTORED */

DISPLAY('CROSS-SECTIONAL TABLES COMPLETED.');

RETURN;

END CROSS;


/******  TERMINATION PROCEDURE  ****************************************/
QUITS:  PROCEDURE;
DISPLAY('PROGRAM TERMINATED');
EXIT;
END QUITS;


END BJDISP;   /****************  END OF PROGRAM  *******************/
```

Appendix IV G
Fuel Price Changes

In BLKDATA:

```
      DATA CLPR/
C      0      1      2      3      4      5      6      7      8      9
     *                                                4.16,  4.99,  4.88,
     * 4.84,  4.92,  4.90,  4.92,  4.52,  4.50,  4.82,  5.08,  4.86,  4.77,
     * 4.69,  4.58,  4.48,  4.39,  4.45,  4.44,  4.54,  4.75,  5.00,  5.50,
     * 6.00,  6.50,  7.00,  7.50, 12.00, 24.82, 26.29, 27.76, 29.27, 31.18,
C  CHANGED HIGHER COAL PRICES TO MATCH MZ
     *33.31,35.76,38.59,41.29,44.93,48.30,51.22,54.17,57.31,60.64,
     *64.54,68.74,73.15,78.36,84.00,90.52,97.05,103.16/
      DATA CLPR/
C      0      1      2      3      4      5      6      7      8      9
     *                                                1.93,  2.60,  2.54,
     * 2.51,  2.53,  2.53,  2.68,  2.78,  2.77,  2.78,  3.09,  3.01,  2.90,
     * 2.88,  2.89,  2.90,  2.89,  2.88,  2.86,  2.88,  2.92,  2.94,  3.09,
     * 3.10,  3.15,  3.27,  4.00,  6.02,  8.18, 10.38, 12.22, 13.22, 14.33,
     *15.46,16.74,18.12,19.59,21.18,22.97,24.79,26.85,29.06,31.43,
     *33.97,36.82,39.75,43.03,46.55,50.48,54.54,59.06/
      DATA TNGPR/
C      0      1      2      3      4      5      6      7      8      9
     *                                                6.0,   6.5,   6.3,
     * 6.5,   7.3,   7.8,   9.2,   10.1,  10.4,  10.8,  11.3,  11.9,  12.9,
     * 14.0,  15.1,  15.5,  15.9,  15.4,  15.6,  15.7,  16.0,  16.4,  20.0,
     * 24.0,  28.0,  32.0,  60.0,150.0,155.0,160.0,165.0,170.0,175.0,
     *201.0,230.0,264.0,301.0,345.0,395.0,450.0,510.0,585.0,656.0,
     * 713.,  785.,  851.,  922.,  998.,1085.,1168.,1262./

C
C  COAL TRANSPORTATION COST (CENTS/MBTU)
C
     DATA FTRANC/
C YEAR  47  1952   1957   1962   1967   1972   1977   1982   1987   1992   1997
C REGION 1
     *16.00,16.00,16.00,15.00,14.00,21.00,45.09,87.0,107.3,131.7,143.0,
C REGION 2
     * 9.35,10.37,12.32,11.16, 9.98,20.00,34.8,65.1,94.4,119.5,123.5,
C REGION 3
     * 3.51,  3.53,  3.80,  3.67,  3.23,  3.20,17.2,14.9,5.9,-4.2,-34.9,
C REGION 4
     *9.36,  7.21,  6.08,  6.19,  7.14,  8.10,-13.6,-26.4,-48.5,-75.7,-129.0,
C REGION 5
     * 8.36,  8.56,  9.41,  8.46,  8.78,  8.80,37.6,73.6,94.7,114.8,122.8,
C REGION 6
     * 4.95,  2.03,  0.63,  2.43,  2.14,  2.20,11.8,47.6,56.1,67.9,54.5,
C REGION 7
     *20.00,20.00,20.00,20.00,20.00,20.00,0.00,0.00,0.00,0.00,0.00,
C REGION 8
     * 4.68,4.46,  3.17,  2.40,2.50,  2.50,-39.1,-58.1,-77.8,-101.3,-157.7,
C REGION 9
     *20.00,20.00,20.00,20.00,20.00,20.00,-3.1,-3.9,-16.4,-23.2,-57.4/
```

```
C                                                                           BJM14540
C  GAS TRANSPORTATION (TRANSMISSION) COSTS (CENTS/MBTU)                     BJM14550
C                                                                           BJM14560
      DATA FTRANG/                                                          BJM14570
C YEAR  47   1952   1957   1962   1967   1972   1977   1982   1987   1992   1997  BJM14580
C REGION 1                                                                  BJM14590
     *24.00,24.00,26.26,20.46,17.61,18.00,50.00,65.30,85.40,111.6,145.9,BJM14600
C REGION 2                                                                  BJM14610
     *24.95,19.88,20.86,20.78,19.42,19.50,35.00,45.70,59.80,78.10,102.1,BJM14620
C REGION 3                                                                  BJM14630
     * 9.90,10.81,12.12,10.72,12.04,12.10,35.00,45.70,59.80,78.10,102.1,BJM14640
C REGION 4                                                                  BJM14650
     * 7.83,11.45,11.16, 8.84, 8.78, 8.80,-25.0,-32.7,-42.7,-55.8,-72.9,BJM14660
C REGION 5                                                                  BJM14670
     * 9.25,11.51,15.62,17.58,16.22,16.50,-10.0,-13.1,-17.1,-22.3,-29.2,BJM14680
C REGION 6                                                                  BJM14690
     * 6.45, 7.26, 9.84,10.24, 8.04, 8.10,25.00,32.70,42.70,55.80,72.90,BJM14700
C REGION 7                                                                  BJM14710
     * 0.73, 1.21, 2.00, 4.14, 4.44, 4.50, -5.0, -6.5, -8.5,-11.2,-14.6,BJM14720
C REGION 8                                                                  BJM14730
```

ELEASE 2.0   BLK DATA   DATE = 78229   11/45/33

```
     * 9.00, 9.31,11.74,13.20,11.06,11.00, -5.0, -6.5, -8.5,-11.2,-14.6,BJM14740
C REGION 9                                                                  BJM14750
     *13.45,13.11,14.00,14.00,15.54,15.50,35.00,45.70,59.80,78.10,102.1/BJM14760
C                                                                           BJM14770
C OIL TRANSPORTATION (AND REFINING) COST (CENTS/MBTU)                       BJM14780
C                                                                           BJM14790
      DATA FTRANO/                                                          BJM14800
C YEAR  47   1952   1957   1962   1967   1972   1977   1982   1987   1992   1997  BJM14810
C REGION 1                                                                  BJM14820
     *-3.97,-10.8,-9.84,-13.9,-19.0, 0.00, -5.0, -6.5, -8.5,-11.2,-14.6,BJM14830
C REGION 2                                                                  BJM14840
     *-1.58,-11.6,-11.0,-15.9,-17.0, 0.00,00.00,00.00,00.00,00.00,00.00,BJM14850
C REGION 3                                                                  BJM14860
     *19.15,11.44,20.46,17.90,12.86,20.00,15.00,19.60,25.60,33.60,43.80,BJM14870
C REGION 4                                                                  BJM14880
     *16.70,-5.92,-6.12,-1.60, 1.10, 1.11,10.00,13.10,17.10,27.30,29.20,BJM14890
C REGION 5                                                                  BJM14900
     * 0.00, -7.3, -5.7,-10.0,-12.7, 0.00,-10.0,-13.1,-17.1,-22.3,-29.2,BJM14910
C REGION 6                                                                  BJM14920
     *27.52, -1.2, -6.7,-0.28, 4.64, 10.0, -5.0, -6.5, -8.5,-11.2,-14.6,BJM14930
C REGION 7                                                                  BJM14940
     * 5.95, 2.57,  3.3, 2.64, 1.28, 10.0, -5.0, -6.5, -8.5,-11.2,-14.6,BJM14950
C REGION 8                                                                  BJM14960
     * 8.70,-16.6,-20.0,-21.0,-21.0, 0.00,20.00,26.10,34.20,44.60,58.40,BJM14970
C REGION 9                                                                  BJM14980
     *-12.2,-12.7,-14.3,-17.3,-17.9, 0.00,30.00,39.20,51.20,67.00,87.50/BJM14990
```

In Fuels:

```
   63 CONTINUE
C
C  CORRECTED AND SIMPLIFIED STATE FUEL PRICES    D E WHITE  29 MAR 78
C
      IF (RTIME.LT.1975) GO TO 200
C
      DO 200 I=1, 9
C     DEFLATED REGIONAL FUEL PRICES  $/BTU
      RPC=(FOFUPR(1)+TIMTB5(9,FTRANC,TIME,11,I))/(WPI(M)*1.0E08)
      RPG=(FOFUPR(2)+TIMTB5(9,FTRANG,TIME,11,I))/(WPI(M)*1.0E08)
      RPO=(FOFUPR(3)+TIMTB5(9,FTRANC,TIME,11,I))/(WPI(M)*1.0E08)
C
      JS=NZ(I)+1
      JF=NZ(I+1)
      DO 210 J=JS, JF
C     STATE RC & IND PRICES, WITH MARKUP
      XRGPR(J)=RPG*1.0
      XROPR(J)=RPO*1.0
      XICPR(J)=RPC*1.0
      XIGPR(J)=RPG*1.0
      XIOPR(J)=RPO*1.0
  210 CONTINUE
  200 CONTINUE
C  END OF REVISED FUEL PRICES
C
      JJ=0
      DO 62 I=1,9
```