

THE BENEFIT/COST ANALYSIS
OF TIME-OF-DAY RATES (BENCOST) PROGRAM

USER'S MANUAL

by

J. Shih
Institute Researcher in Engineering

Y. M. Chen
Graduate Research Associate

S. Nakamura
Professor of Nuclear Engineering

THE NATIONAL REGULATORY RESEARCH INSTITUTE
2130 Neil Avenue
Columbus, Ohio 43210

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TABLE OF CONTENTS

	Page
INTRODUCTION	1
DESCRIPTION OF THE PROGRAM	2
Subroutine TOD1	2
Subroutine TOD2	3
Subroutine TOD3	4
INPUT DATA	6
REFERENCE	9
APPENDICES	
A Sample output	10
B Fortran listing	14

INTRODUCTION

The objectives of the BENCOST program are to calculate (1) the revenue excesses or deficiencies caused by the implementation of time-of-day rates [1], (2) additional customer charges or credits due to implementing time-of-day rates, and (3) net benefits of time-of-day rates. The user supplies the number of seasons, customer response coefficients, peak and off-peak prices, MWH sales, estimated metering costs, marginal capacity costs, and on/off peak energy cost differences as basic inputs. The BENCOST program produces three tables listing revenue excesses or deficiencies, monthly customer charges or credits, and net benefits of time-of-day rates accordingly for each season.

The users are referred to reference 1 for the theory behind this program and for the important discussions of the limitations of this theory.



DESCRIPTION OF THE PROGRAM

The BENCOST program is based on the assumption that peak electric users will respond to the implementation of the time-of-day rates by shifting their uses of electricity from peak periods to off-peak periods. It also assumes that the maximum generating capacity of the company remains the same after the shifting. Then the utility can benefit from the reductions in energy and capacity costs due to the implementation of the time-of-day rates.

The BENCOST program has a built-in constraint corresponding to the limitations discussed in reference 1. If the peak customer response causes new peak periods, the program execution will be terminated, and an error message of this peak chasing situation will be issued. In response to this message, the user can either lengthen the duration of the peak period or reduce the peak price differential and rerun the program.

The three objectives are achieved by separate subroutines presented below.

Subroutine TOD1

Subroutine TOD1 calculates the revenue excesses (or deficiencies) due to the time-of-day rates. The revenue excess or deficiency is defined by

$$\text{Excess or deficiency} = \text{(TOD revenue)} - \text{(revenue rate)}$$

where "TOD revenue" is the revenue based on the marginal or embedded cost time-of-day rates and "revenue rate" is the revenue based on the current company rates.

In order to calculate the TOD revenue, peak and off-peak customer responses must be obtained first by

$$\begin{aligned} &\text{Peak(off-peak) customer response} = \\ &\quad (\text{customer response coefficient}) \times (\text{peak(off-peak) price change}) \\ &\quad \quad \times (\text{estimated peak(off-peak) sales}) \end{aligned}$$

Then, the TOD revenue is calculated by

$$\begin{aligned} \text{TOD revenue} = & \\ & (\text{peak price}) \times (\text{estimated peak sales} + \text{peak customer response}) \\ & + (\text{off-peak price}) \times (\text{estimated off-peak sales} + \text{off-peak response}) \end{aligned}$$

A table of revenue excesses or deficiencies is printed by this subroutine as illustrated on page 11. The first column in the table shows voltage levels considered in the case study. The second column contains abbreviated names of rate schedules, and the third column lists the customer response coefficient. The average company price, the peak price, and off-peak price are shown in the next three columns, respectively. Percentage changes in price of peak and off-peak periods are presented in the seventh and eighth column, respectively. Columns nine and ten contain peak and off-peak customer responses calculated according to the second equation in this section. Estimated total sales, peak sales, and off-peak sales are calculated and listed in columns eleven to thirteen. Column fourteen shows the TOD revenue as calculated by the equation described above. The company revenue is reported in column fifteen as specified by the input. The last column presents revenue excesses or deficiencies obtained from the first equation in this section.

Subroutine TOD2

Subroutine TOD2 calculates monthly customer charges before adding the special TOD metering and is based on the revenue excesses or de-

iciencies obtained in subroutine TOD1. A monthly customer charge without metering is calculated by

$$\text{Monthly charge before metering} = \frac{\text{(revenue excess or deficiency)}}{\text{(average number of customers x Months)}}$$

where "Months" is the duration of the season.

The monthly customer charge with the TOD metering is the sum of the monthly customer charge without metering and the monthly customer charge for this metering.

The voltage level average of monthly customer charges with metering is derived by a weighted average of monthly customer charges with metering. The weight for a class is the ratio of the average number of customers in that class to the total number of customers in that voltage level.

A table of monthly customer charges is printed out at the end of this subroutine as illustrated on page 12. The first three columns show the voltage level, the rate schedule, and the average number of customers, respectively. The revenue excesses or deficiencies obtained from subroutine TOD1 are reported in the fourth column. In the fifth and sixth columns, the monthly customer charges or credits without and with special TOD metering are presented. The voltage level average of the monthly customer charges with metering is shown in the last column. The average value of the monthly customer charges with metering for all customer classes is shown in the last line of the table.

Subroutine TOD3

This subroutine performs a cost-benefit analysis for the time-of-day rates. Net benefit is calculated by

$$\begin{aligned} \text{Net benefit} = & \text{(capacity benefit)} + \text{(energy savings benefit)} \\ & - \text{(estimated metering costs)} \end{aligned}$$

where the capacity benefit and the energy savings benefit are both obtained from the peak customer response calculated in subroutine TOD1. The capacity benefit is calculated by

$$\text{Capacity benefit} = (\text{marginal capacity cost}) \\ \times (\text{peak customer response})$$

The energy savings benefit is calculated by

$$\text{Energy savings benefit} = (\text{on/off peak energy cost difference}) \\ \times (\text{peak customer response})$$

A table of net benefits is printed out by this subroutine as illustrated on page 13. The marginal capacity cost in \$/MWH (input) is shown in the third column. The peak customer response, which is obtained from subroutine TOD1, is shown in the fourth column. The capacity benefit, the energy savings benefit, and the net benefit are presented in the next three columns, respectively. The last column shows the benefit/cost ratio, which is obtained by dividing the sum of the capacity benefit and the energy savings benefit by the estimated metering cost shown in the eighth column.

INPUT DATA

The input variables to be supplied by the user are listed in table 1. Table 2 lists a set of sample inputs. The inputs consist of seven kinds of cards. Cards 1 through 3 respectively contain the name of the company analyzed, the case number, and the number of seasons. If there are seasonal rates, enter the number of seasons used for costing within the test year. If there are no seasonal rates, enter 1. Maximum number of seasons allowed in the BENCOST program is 3. Card 4 contains the duration of the season in months, the duration of the peak period in hours, and the duration of the off-peak period in hours. Card 5 contains the number of customer classes. Cards 6 and 7 are repeated NM (number of customer classes) times. In cards 4 through 7, the position and length of numbers are arbitrary, but the numbers must be separated by one or more blank spaces. In cards 4, 6, and 7, the data must follow the order in Table 1. Cards 4 through 7 are repeated NSEN (number of seasons) times to supply inputs for each season.

Table 1
List of Input Variables

Card	Variable	Definition	Format
1	INAME	Name of the company	14A1
2	NCASE	Case number	A6
3	NSEN	Number of seasons	I
4	MONTHS	Duration of seasons (months)	I
	NTPK	Duration of peak period (hours)	I
	NTOFPK	Duration of off-peak period (hours)	I
5	NM	Number of customer classes	I
6	IV	Voltage level	I
	IRSCHE	Rate schedule	A2
	ICAT	Voltage level aggregate identifier	I
	ACP	Average company price	F
	P1	Peak price	F
	P2	Off-peak price	F
	CMC	Marginal capacity costs	F
	ECD	On/off peak energy cost difference	F
	MET	Estimated metering cost	I
	COE	Customer response coefficient	F
	DELT	Monthly customer charges of metering	F
7	MSALE	Seasonal MWH sales	I
	PEAK	Estimated ratio of peak sales to total sales	F
	MREV	Revenue rate	I
	NCUST	Number of customers in each class	I

TABLE 2

LIST OF A SAMPLE INPUT SET

 POTOMAC EDISON

79-230

1

12 3132 5652

12

1	PP	1	2.925	3.979	1.480	16.86	8.13	160	-.2	3.4
2	C	2	4.727	4.522	1.684	8.31	10.07	40	-.2	3.4
2	DL	2	3.614	4.522	1.684	18.31	10.07	400	-.2	3.4
2	PH	2	3.261	4.522	1.684	18.31	10.07	120	-.2	3.4
3	R	3	5.530	4.664	1.736	18.73	10.56	810680	-.2	3.4
3	RW	3	4.827	4.664	1.736	18.73	10.56	835080	-.2	3.4
3	RA	3	4.049	4.664	1.736	18.73	10.56	540760	-.2	3.4
3	CW	4	5.395	4.664	1.736	18.73	10.56	259280	-.2	3.4
3	CA	4	4.265	4.664	1.736	18.73	10.56	22440	-.2	3.4
3	CA	4	3.541	4.664	1.736	18.73	10.56	7320	-.2	3.4
3	PL	4	4.115	4.664	1.736	18.73	10.56	4040	-.2	3.4
3	PH	4	3.551	4.664	1.736	18.73	10.56	4040	-.2	3.4
204430			.67000	5980291	4					
127			.66929	5998	1					
31017			.66999	1121042	10					
23987			.66999	782206	3					
96911			.67000	5358894	20267					
190202			.67000	9181313	20877					
255567			.67000	10347118	13519					
85311			.67000	4602271	6482					
46896			.67000	2000260	561					
40307			.67000	1427111	183					
75505			.67000	3107401	101					
110496			.67000	3923910	101					

REFERENCE

- (1) Czamanski, D. Z., and Biggs, G. T. "A Method for Computing the Main Benefits and Costs of Time-of-Use Rates for Colorado Electric Utilities", Section III of Electric Utility Time-of-Use and Interruptible Ratemaking and Power Pooling Issues in Colorado, NRRI 81-4, Columbus, Ohio: The National Regulatory Research Institute, August 1981.

APPENDIX A
SAMPLE OUTPUT

This appendix contains sample output of the BENCOST program. The sample output includes three tables. The first table is a table of revenue excesses or deficiencies. The second table is a table of monthly customer charges or credits. The third table is a table of net benefits of time-of-day rates.



POTOMAC EDISON COMPANY
CASE NO. 79-230
SEASON NO. 1

REVENUE EXCESS OR DEFICIENCY

V	SCHED	COE	ACP (C/KWH)	PRICE		PRICE CHANGE		RESPONSE		SALE (MWH)	ESTIMATED SALES		TOD REVENUE (\$)	COMPANY REVENUE (\$)	EXCESS (\$)
				PEAK (C/KWH)	OFF-P	PEAK (%)	OFF-P (%)	PEAK (MWH)	OFF-P (MWH)		PEAK (MWH)	OFF-P (MWH)			
1	PP	-0.2	2.925	3.979	1.480	36.03	-49.40	-9871	6665	204430	136968	67462	5980291	6154266	173975
2	C	-0.2	4.724	4.522	1.684	-4.28	-64.35	0	5	127	84	43	5998	4606	-1392
2	DL	-0.2	3.614	4.522	1.684	25.12	-53.40	-1044	1093	31017	20781	10236	1121042	1083286	-37756
2	PH	-0.2	3.261	4.522	1.684	38.67	-48.36	-1242	765	23987	16071	7916	782206	816754	34548
3	R	-0.2	5.530	4.664	1.736	-15.66	-68.61	2033	4388	96911	64930	31981	5358894	3754518	-1604376
3	RW	-0.2	4.827	4.664	1.736	-3.38	-64.04	860	8038	190202	127435	62767	9181313	7212851	-1968462
3	RA	-0.2	4.049	4.664	1.736	15.19	-57.13	-5201	9635	255567	171229	84338	10347118	9374915	-972203
3	CW	-0.2	5.395	4.664	1.736	-13.55	-67.82	1548	3818	85311	57158	28153	4602271	3293063	-1309208
3	CA	-0.2	4.265	4.664	1.736	9.36	-59.30	-587	1835	46896	31420	15476	2000260	1738569	-261691
3	CA	-0.2	3.541	4.664	1.736	31.71	-50.97	-1712	1356	40307	27006	13301	1427111	1434156	7045
3	PL	-0.2	4.115	4.664	1.736	13.34	-57.81	-1349	2881	75505	50588	24917	3107401	2779078	-328323
3	PH	-0.2	3.551	4.664	1.736	31.34	-51.11	-4640	3727	110496	74032	36464	3923910	3934157	10247

COE : CUSTOMER RESPONSE COEFFICIENT
TOD : REVENUE BASED ON MARGINAL OR EMBEDDED COST TIME-OF-DAY RATES
EXCESS : NEGATIVE EXCESS IS EQUAL TO DEFICIENCY

POTOMAC EDISON COMPANY
CASE NO. 79-230
SEASON NO. 1

CUSTOMER CHARGE/CREDIT

VOLTAGE LEVEL	RATE SCHEDULE	AVERAGE NUMBER OF CUSTOMERS (1)	EXCESS (DEFICIENCY) (2) (\$)	MONTHLY CUSTOMER CREDIT (OR CHARGE)		VOLTAGE LEVEL AVERAGE OF (4) (5) (\$)
				WITHOUT METERING (3) (\$)	WITH METERING (4) (\$)	
1	PP	4	173975	3624.00	3627.40	3627.40
2	C	1	-1392	-116.00	-112.60	
2	DL	10	-37756	-314.00	-310.60	
2	PH	3	34548	959.00	962.40	-23.67
3	R	20267	-1604376	-6.00	-2.60	
3	RW	20877	-1968462	-7.00	-3.60	
3	RA	13519	-972203	-5.00	-1.60	-2.73
3	CW	6482	-1309208	-16.00	-12.60	
3	CA	561	-261691	-38.00	-34.60	
3	CA	183	7045	3.00	6.40	
3	PL	101	-328323	-270.00	-266.60	
3	PH	101	10247	8.00	11.40	-16.92

AVERAGE OF MONTHLY CUSTOMER
CHARGE WITH METERING FOR
ALL CUSTOMER CLASSES : -4.20

EXCESS : NEGATIVE EXCESS IS EQUAL TO DEFICIENCY
CREDIT : NEGATIVE CREDIT IS EQUAL TO CHARGE

POTOMAC EDISON COMPANY
CASE NO. 79-230
SEASON NO. 1

NET BENEFITS OF TOD RATES

VOLTAGE LEVEL	RATE SCHEDULE	MARGINAL CAPACITY COSTS (\$/MWH)	PEAK CUSTOMER RESPONSE (MWH)	CAPACITY BENEFIT (COSTS) (\$)	ON/OFF PEAK ENERGY COST DIFFERENCE (\$/MWH)	ENERGY SAVINGS BENEFITS (\$)	ESTIMATED METERING COSTS (\$)	NET BENEFITS (\$)	BENEFIT/COST RATIO
1	PP	16.86	-9871	166425.	8.13	80251.	160	246516	1541.726
2	C	18.31	0	0.	10.07	0.	40	-40	0.0
2	DL	18.31	-1044	19116.	10.07	10513.	400	29228	74.072
2	PH	18.31	-1242	22741.	10.07	12507.	120	35127	293.733
3	R	18.73	2033	-38078.	10.56	-21468.	810680	-870226	-0.073
3	RW	18.73	860	-16108.	10.56	-9082.	835080	-860269	-0.030
3	RA	18.73	-5201	97415.	10.56	54923.	540760	-388422	0.282
3	CW	18.73	1548	-28994.	10.56	-16347.	259280	-304620	-0.175
3	CA	18.73	-587	10995.	10.56	6199.	22440	-5246	0.766
3	CA	18.73	-1712	32066.	10.56	18079.	7320	42824	6.850
3	PL	18.73	-1349	25267.	10.56	14245.	4040	35472	9.780
3	PH	18.73	-4640	86907.	10.56	48998.	4040	131865	33.640

BENEFIT : NEGATIVE BENEFIT IS EQUAL TO COST



APPENDIX B
FORTRAN LISTING

This appendix contains the Fortran listing of the BENCOST
source program.

C		00000690
C	LOOP FOR SEASON	00000700
C		00000710
C		00000720
	DO 100 N=1, NSEN	00000730
	NITE=N	00000740
	CALL GETI(MONTH)	00000750
	CALL GETI(NTPK)	00000760
	CALL GETI(NTOPFK)	00000770
	CALL GETI(NM)	00000780
	DO 60 I=1, NM	00000790
	CALL GETI(IV(I))	00000800
	IRSCHE(I,1) = IARRAY(3)	00000810
	IRSCHE(I,2) = IARRAY(4)	00000820
	IP = 5	00000830
	CALL GETI(ICAT(I))	00000840
	CALL GETX(ACP(I))	00000850
	CALL GETX(P1(I))	00000860
	CALL GETX(P2(I))	00000870
	CALL GETX(CMC(I))	00000880
	CALL GETX(ECD(I))	00000890
	CALL GETI(MET(I))	00000900
	CALL GETX(COE(I))	00000910
	CALL GETX(DELT)	00000920
60	CONTINUE	00000930
C		00000940
C		00000950
	DO 70 I=1, NM	00000960
	CALL GETI(MSALE(I))	00000970
	CALL GETX(PEAK(I))	00000980
	CALL GETI(MREV(I))	00000990
	CALL GETI(NCUST(I))	00010000
70	CONTINUE	00001010
C		00001020
	CALL TOD1	00001030
C		00001040
C		00001050
C	CHECK FOR PEAK CHASING CONSTRAINT	00001060
C		00001070
	IF(IFLAG.GT.0) GO TO 900	00001080
C		00001090
	CALL TOD2	00001100
	CALL TOD3	00001110
100	CONTINUE	00001120
C		00001130
C		00001140
900	STOP	00001150
	END	00001160
C	*****	00001170
	SUBROUTINE TOD1	00001180
	COMMON /ONE/ NM, IV(15), ICAT(15), IRSCHE(15,2), NCUST(15), INAME(14),	00001190
	+ COE(15), NCASE(6), IARRAY(80), IP, DELT	00001200
C		00001210
C		00001220
	COMMON /TWO/ ACP(15), P1(15), P2(15), MWRP(15), MWRO(15), MSALE(15),	00001230
	+ ECD(15), CMC(15), MET(15), PEAK(15), MSAL1(15),	00001240
	+ MSAL2(15), MREV(15), MTREV(15), MED(15)	00001250
C		00001260
C		00001270
	COMMON /THRE/ NSEN, MONTH, NTPK, NTOFPK, IFLAG, NITE	00001280
C		00001290
	DIMENSION PC1(15), PC2(15)	00001300
	WRITE(6,100) (INAME(I), I=1,14), (NCASE(I), I=1,6), NITE	00001310
100	FORMAT ('1', //, 42X, 14A1, ' COMPANY' /	00001320
	*46X, 'CASE NO. ', 6A1 /	00001330
	*46X, 'SEASON NO. ', I1 //	00001340
	*39X, 'REVENUE EXCESS OR DEFICIENCY' ///)	00001350
		00001360

	COMMON /THRE/ NSEN, MONTH, NTPK, NTOFPK, IFLAG, NITE	00004090
C	DIMENSION NUMB(10)	00004100
	DATA NUMB/'0','1','2','3','4','5','6','7','8','9'/	00004110
	DATA MBLNK/' ','/ ,MCOMA/' ','/ ,MDASH/'-'/' ,MPLUS/'+'/'	00004120
	DATA MC/'C'/	00004130
	IF(IP-80) 30, 30, 10	00004140
10	READ(5, 20) IARAY	00004150
20	FORMAT(80A1)	00004160
	IF(IARAY(1).EQ.MC) GO TO 10	00004170
	IP=1	00004180
30	NEGSW=+1	00004190
	IVALU=0	00004200
	DO 150 IPOS=IP, 80	00004210
	ICHAR= IARAY(IPOS)	00004220
	IF(ICHAR-MBLNK) 110, 150, 110	00004230
110	IF(ICHAR-MCOMA) 120, 150, 120	00004240
120	IF(ICHAR-MPLUS) 130, 150, 130	00004250
130	IF(ICHAR-MDASH) 175, 140, 175	00004260
140	NEGSW=-1	00004270
150	CONTINUE	00004280
	GO TO 10	00004290
175	DO 200 N=1, 10	00004300
	IF(ICHAR-NUMB(N)) 200, 250, 200	00004310
200	CONTINUE	00004320
	GO TO 300	00004330
250	IVALU= IVALU*10+N-1	00004340
	IPOS= IPOS+1	00004350
	IF(IPOS-80) 260, 260, 300	00004360
260	ICHAR= IARAY(IPOS)	00004370
	GO TO 175	00004380
300	IVALU=NEGSW*IVALU	00004390
	IP= IPOS	00004400
	RETURN	00004410
	END	00004420
		00004430
		00004440
		00004450
		00004460
	-----	00004470
	SUBROUTINE GETX(VALUE)	00004480
	-----	00004490
		00004500
		00004510
	COMMON /ONE/ NM, IV(15), ICAT(15), IRSCH(15, 2), NCUST(15), INAME(14),	00004520
+	COE(15), NCASE(6), IARAY(80), IP, DELT	00004530
COMMON /TWO/	ACP(15), P1(15), P2(15), MWRP(15), MWRO(15), MSAL(15),	00004540
+	ECD(15), CMC(15), MET(15), PEAK(15), MSAL1(15),	00004550
+	MSAL2(15), MREV(15), MTREV(15), MED(15)	00004560
C	COMMON /THRE/ NSEN, MONTH, NTPK, NTOFPK, IFLAG, NITE	00004570
		00004580
	DIMENSION NUMB(10)	00004590
	DATA NUMB/'0','1','2','3','4','5','6','7','8','9'/	00004600
	DATA MBLNK/' ','/ ,MCOMA/' ','/ ,MDASH/'-'/' ,MPLUS/'+'/'	00004610
	DATA MDECM/' ','/ ,ME/'E'/	00004620
	DATA MC/'C'/	00004630
	IF(IP-80) 30, 30, 10	00004640
10	READ(5, 20) IARAY	00004650
20	FORMAT(80A1)	00004660
	IF(IARAY(1).EQ.MC) GO TO 10	00004670
	IP=1	00004680
30	NEGSW=+1	00004690
	NEGEX=+1	00004700
	NDEC=0	00004710
	NEXP=0	00004720
	NPNT=0	00004730
	VALUE=0.	00004740
	DO 150 IPOS=IP, 80	00004750
	ICHAR= IARAY(IPOS)	00004760

	IF(ICHAR-MBLNK) 110, 150, 110	00004770
110	IF(ICHAR-MCOMA) 120, 150, 120	00004780
120	IF(ICHAR-MPLUS) 130, 150, 130	00004790
130	IF(ICHAR-MDASH) 175, 140, 175	00004800
140	NEGSW=-1	00004810
150	CONTINUE	00004820
	GO TO 10	00004830
C		00004840
175	IF(NPNT) 190, 190, 200	00004850
190	IF(ICHAR-MDECD) 200, 195, 200	00004860
195	NPNT=1	00004870
	GO TO 350	00004880
200	IF(ICHAR-ME) 300, 205, 300	00004890
C		00004900
205	IF(IARRAY(IPOS+1) -MDASH) 208, 206, 208	00004910
206	NEGEX=-1	00004920
	IPOS= IPOS+1	00004930
208	IPOS= IPOS+1	00004940
	IF(IPOS-80) 210, 210, 400	00004950
210	ICHAR= IARRAY(IPOS)	00004960
	DO 220 N=1, 10	00004970
	IF(ICHAR-NUMB(N)) 220, 230, 220	00004980
220	CONTINUE	00004990
	GO TO 400	00005000
230	NEXP=NEXP*10+(N-1)	00005010
	GO TO 208	00005020
C		00005030
300	DO 310 N=1, 10	00005040
	IF(ICHAR-NUMB(N)) 310, 320, 310	00005050
310	CONTINUE	00005060
	GO TO 400	00005070
320	VALUE=VALUE*10.+(N-1)	00005080
	IF(NPNT) 350, 350, 330	00005090
330	NDEC=NDEC+1	00005100
350	IPOS= IPOS+1	00005110
	IF(IPOS-80) 370, 370, 400	00005120
370	ICHAR= IARRAY(IPOS)	00005130
	GO TO 175	00005140
400	NEXP=NEXP*NEGEX	00005150
	VALUE=NEGSW*VALUE*(10.**NEXP)/(10.**NDEC)	00005160
	IP= IPOS	00005170
	RETURN	00005180
	END	00005190

