Paper CC129

Creating a Hyperbolic Graph Using the SAS® Annotate Facility

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ABSTRACT

In order to optimize their rate design, electric utilities analyze their customers' bills and costs for electricity by looking at each hour's use of demand. These graphs of kWh energy usage versus hours of use are produced on a monthly basis (from 0 to 730 hours). The resulting graphs are typically curvilinear. To allow for an easier rate and cost comparison, we wanted the ability to plot hyperbolic hours, as well as cost curves, on the same graph. To do this, we applied a hyperbolic transformation to the hours use axis. This linearized the graph and made it easier to interpret. For our analysis, it is necessary to graph cost and price versus the hyperbolic axis, but at the same time show the original hours use axis. Proc GPLOT does not allow multiple X axes. Therefore, we solve the problem using the annotate facility. In this presentation, we will show you a step-by-step example of how we changed cost graphs for easier analysis and explain the code we used.

INTRODUCTION

Utilities use a number of graphs in their rate design analysis. GoodCents has worked with Mississippi Power Company (MPC) to develop a comprehensive rate design package called Rate Manager. This was presented at a previous SESUG 2006 Paper AP02 (See Reference 1). We were asked to improve the functionality of the graphics tasks of Rate Manager by adding hyperbolic bill and cost plots. General Service customers typically have rates that consist of a base charge, a demand charge, and an energy charge, as well as various riders for fuel and environmental cost. A typical bill and cost comparison graph is shown below.

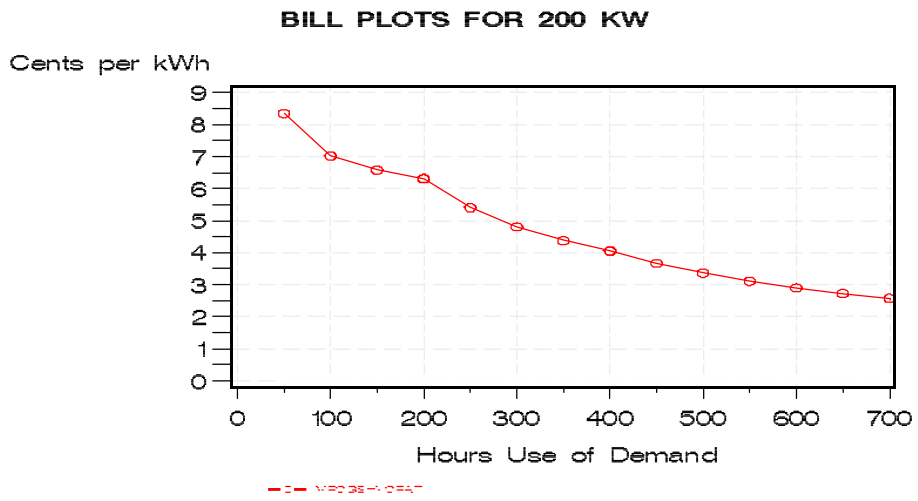

Figure 1: Typical Bill and Cost Comparison Graph

Graphs like the one above are usually shown for a specific level of demand. The cost and bill amounts are shown on the Y axis as cents per kWh and the X axis is hours use of demand. The utility must make a profit; therefore, the bill curve is typically above the cost curve. The graph above shows a bill curve for a rate at a level of 200 kW using a linear hours use scale for the X axis.

HYPERBOLIC BILL PLOTS

The linear scale can be converted to the hyperbolic scale using the following formula.

Xh = 10 / (10 - Xa)

Using the formula above, 5 on the arithmetic scale would be 2 on the hyperbolic scale. Another example: an arithmetic 9 would be 10 on the hyperbolic scale.

The graph below shows the bill curve for the same rate and level of demand using the hyperbolic scale for the hours use scale (X axis). The inflection points are clear in this graph and makes this type of graph more useful to the rate designer than the linear scale (See LJ Vogt Book Reference (2) for information).

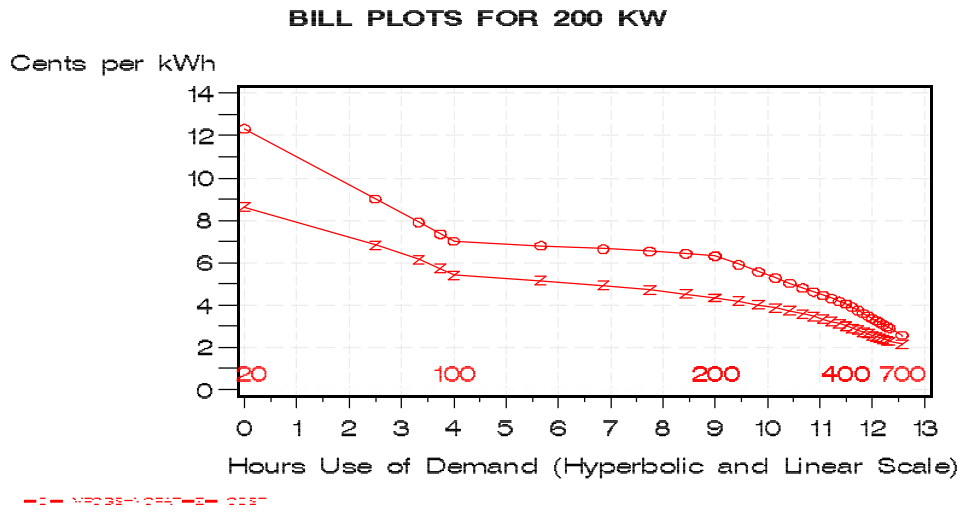

Figure 2: Hyperbolic Bill Curve

We have previously created macros to calculate bills and costs for all MPC rates at any level of demand and energy. We have a pre-existing graph routine to plot bills for a rate at a given demand and energy. These routines reside in the Rate Manager system of programs referenced earlier. Our challenge here was to graph bills and costs using the hyperbolic scale as the primary X axis and to show the corresponding linear scale as a secondary X axis to aid in interpretation of the results.

There are 3 input datasets. The hours use coordinate translation file data set contains the linear hours use and the associated hyperbolic scale value. The other 2 data sets contain the bill and cost at each hours use for the selected demand (The code and data sets will be provided on flash drive).

The hours use translation to hyperbolic coordinates data set is shown below. This file was provided by the MPC rate engineer. See reference 2 for a complete description of hyperbolic rate graphs and their use in utility rate design. The bill and cost file samples follow. The SAS® Code used to complete this task is shown following the tables.

Table 1: Hours Use Demand (HUD) to Hyperbolic (HUDHYP) Coordinate Translation File

HUD	HUDHYP		HUD	HUDHYP
20	0		200	9
21	0.24		210	9.24
22	0.45		220	9.45
23	0.65		230	9.65
24	0.83		240	9.83
25	1		250	10
26	1.15		260	10.15
27	1.3		270	10.3
28	1.43		280	10.43
29	1.55		290	10.55
30	1.67		300	10.67
31	1.77		310	10.77
32	1.88		320	10.88
33	1.97		330	10.97
34	2.06		340	11.06
35	2.14		350	11.14
36	2.22		360	11.22
37	2.3		370	11.3
38	2.37		380	11.37
39	2.44		390	11.44
40	2.5		400	11.5
42	2.62		420	11.62
44	2.73		440	11.73
46	2.83		460	11.83
48	2.92		480	11.92
50	3		500	12
52	3.08		520	12.08
54	3.15		540	12.15
56	3.21		560	12.21
58	3.28		580	12.28
60	3.33		600	12.33
65	3.46		650	12.46
70	3.57		700	12.57
80	3.75		730	12.63
90	3.89		800	12.75
100	4		900	12.89
110	4.91		1000	13
120	5.67			
130	6.31			
140	6.86			
150	7.33			
160	7.75			
170	8.12			
180	8.44			
190	8.74			

Table 2: Bill File

RATE	RATETYF	kw	kwh	houruse	bill
GS-HV-Current sum May-Oct	KW	200	4000	20	12.33675
GS-HV-Current sum May-Oct	KW	200	8000	40	9.017375
GS-HV-Current sum May-Oct	KW	200	12000	60	7.910917
GS-HV-Current sum May-Oct	KW	200	16000	80	7.357688
GS-HV-Current sum May-Oct	KW	200	20000	100	7.02575
GS-HV-Current sum May-Oct	KW	200	24000	120	6.804458
GS-HV-Current sum May-Oct	KW	200	28000	140	6.646393
GS-HV-Current sum May-Oct	KW	200	32000	160	6.527844
GS-HV-Current sum May-Oct	KW	200	36000	180	6.435639
GS-HV-Current sum May-Oct	KW	200	40000	200	6.315125
GS-HV-Current sum May-Oct	KW	200	40000	200	6.315125
GS-HV-Current sum May-Oct	KW	200	44000	220	5.904659
GS-HV-Current sum May-Oct	KW	200	48000	240	5.562604
GS-HV-Current sum May-Oct	KW	200	52000	260	5.273173
GS-HV-Current sum May-Oct	KW	200	56000	280	5.025089
GS-HV-Current sum May-Oct	KW	200	60000	300	4.810083
GS-HV-Current sum May-Oct	KW	200	64000	320	4.621953
GS-HV-Current sum May-Oct	KW	200	68000	340	4.455956
GS-HV-Current sum May-Oct	KW	200	72000	360	4.308403
GS-HV-Current sum May-Oct	KW	200	76000	380	4.176382
GS-HV-Current sum May-Oct	KW	200	80000	400	4.057563
GS-HV-Current sum May-Oct	KW	200	80000	400	4.057563
GS-HV-Current sum May-Oct	KW	200	84000	420	3.892917
GS-HV-Current sum May-Oct	KW	200	88000	440	3.743239
GS-HV-Current sum May-Oct	KW	200	92000	460	3.606576
GS-HV-Current sum May-Oct	KW	200	96000	480	3.481302
GS-HV-Current sum May-Oct	KW	200	100000	500	3.36605
GS-HV-Current sum May-Oct	KW	200	104000	520	3.259663
GS-HV-Current sum May-Oct	KW	200	108000	540	3.161157
GS-HV-Current sum May-Oct	KW	200	112000	560	3.069688
GS-HV-Current sum May-Oct	KW	200	116000	580	2.984526
GS-HV-Current sum May-Oct	KW	200	120000	600	2.905042
GS-HV-Current sum May-Oct	KW	200	124000	620	2.830685
GS-HV-Current sum May-Oct	KW	200	128000	640	2.760977
GS-HV-Current sum May-Oct	KW	200	132000	660	2.695492
GS-HV-Current sum May-Oct	KW	200	136000	680	2.63386
GS-HV-Current sum May-Oct	KW	200	140000	700	2.57575
GS-HV-Current sum May-Oct	KW	200	144000	720	2.520868

Table 3: Cost File (First 50 Hours Use)

kw	kwh	houruse	Cost
200	200	1	70.6497
200	400	2	38.09627
200	600	3	27.22153
200	800	4	21.78416
200	1000	5	18.51466
200	1200	6	16.32909
200	1400	7	14.77724
200	1600	8	13.5964
200	1800	9	12.6891
200	2000	10	11.95973
200	2200	11	11.35653
200	2400	12	10.85387
200	2600	13	10.43625
200	2800	14	10.06607
200	3000	15	9.749578
200	3200	16	9.472645
200	3400	17	9.226211
200	3600	18	9.005192
200	3800	19	8.805575
200	4000	20	8.625921
200	4200	21	8.460005
200	4400	22	8.31373
200	4600	23	8.174277
200	4800	24	8.050622
200	5000	25	7.934028
200	5200	26	7.826403
200	5400	27	7.72544
200	5600	28	7.630424
200	5800	29	7.545418
200	6000	30	7.461558
200	6200	31	7.381966
200	6400	32	7.309376
200	6600	33	7.241185
200	6800	34	7.174924
200	7000	35	7.11346
200	7200	36	7.053445
200	7400	37	6.996674
200	7600	38	6.941959
200	7800	39	6.889143
200	8000	40	6.840589
200	8200	41	6.791959
200	8400	42	6.747188
200	8600	43	6.7045
200	8800	44	6.66067
200	9000	45	6.620229
200	9200	46	6.580777
200	9400	47	6.543003
200	9600	48	6.506066
200	9800	49	6.470637
200	10000	50	6.437923

SAS Code

```
/* Get Bill and Cost files and subset for 200 kW only*/

data bill200kw;
set main.bill200kw;
run;

proc sort data=bill200kw;
by kw kwh;
run;

data cost200kw;
set main.cost200kw;
if kw=200;
cost=100*(cost/kwh);
run;

/****merge bill and cost calculations****/

data billcost200kw;
merge bill200kw cost200kw;
by kw kwh;
run;

proc sort data=billcost200kw;
by houruse;
run;

/*Bring in Hours Use to Hyperbolic Translation File*/

data hyp;
set main.hudhyp;
houruse=hud;
run;

proc sort; by houruse;
run;

data totalhyp;
merge billcost200kw hyp;
by houruse;
run;

proc sort;
by kw kwh houruse;
run;

/*Change houruse to hyperbolic*/
data total1;
set totalhyp;
houruse=hudhyp;
if bill= . then delete;
if houruse=. then delete;
if houruse=0 then x1=int(bill+1);
bform='Cents per kWh';
call symput('bformat',trim(bform));
run;

/*Annotate dataset needed to create 2nd linear X scale*/
/*Plots text at Y=1 and X=houruse +.125 or slightly above X axis and offset
from houruse 0 */
```

```
/* xsys ysys set to 2 - Use data ramge of values in creation of location for
annotate symbols*/
/*Use Label function and style to plot text on graph at X and Y values*/

data anno1;
set total1;
length function $8 text $200;
color='RED';
retain hsys xsys ysys '2';
if houruse=0 then do;
function='LABEL';
style='SWISS';
text='20';
x = houruse+.125;
y=1;
output;
end;

if houruse=4 then do;
function='LABEL';
style='SWISS';
text='100';
x = houruse;
y=1;
output;
end;

if houruse=9 then do;
function='LABEL';
style='SWISS';
text='200';
x = houruse;
y=1;
output;
end;

if houruse=11.5 then do;
function='LABEL';
style='SWISS';
text='400';
x = houruse;
y=1;
output;
end;

if houruse=12.57 then do;
function='LABEL';
style='SWISS';
text='700';
x = houruse;
y=1;
output;
end;
run;

/*End of Annotate Dataset Creation*/

data total2;
set total1;
%global ymax;
if _N_ =1;
call symput('ymax',x1);
run;
```

```
title "Rate Manager Cross Section Bill Plots";

goptions reset=global gunit=pct border cback=white
         colors=(black blue green red orange brown)
         ftitle=swissb ftext=swiss htitle=4 htext=4;

title1 "BILL PLOTS FOR 200 kW";

%let infna1='MPCGSHVCRAT';

%let c100=red;

  symbol1 color=&c100
        interpol=join
        value=circle
        height=3;

  symbol2 color=&c100
        value=Z
        interpol=join
        height=3;

  axis1
      order=(0 to &ymax by 1) minor=(number=1 height=1)
      label=('Hours Use of Demand (Hyperbolic and Linear Scale)')
      major=(height=2)
      width=3;

  axis2
      order= (0 to 15 by 1)
      label=("&bformat" justify=right height=1)
      major=(height=2) minor=(height=2)
      width=1;

/*Create False Legend Using Footnote Statements, Otherwise get seperate legend
for each segment*/

footnote1 height=2

Color=&c100
"-O- &infna1"
"-Z- COST"
;

footnote2 height=1
color=white
'This does not print';

/* plot cross sections*/

proc gplot data=total1 annotate=anno1;
plot bill*houruse cost*houruse / overlay nolegend autohref autovref frame
lvref=21 lhref=21
  haxis=axis1 hminor=1
  vaxis=axis2 vminor=1;

run;
quit;
footnote1;
footnote2;
```

Conclusions

It is possible to use an annotate dataset to create an additional X axis. This is especially useful where the original X axis has been transformed mathematically. The additional X axis helps the user to understand and interpret the graph data in its original form.

References

SESUG 2006, Paper AP02, Using Proc Pmenu to Develop a User Friendly Utility Rate Design System, Bill Bland, GoodCents, Loganville, GA, Perry Hilton, Mississippi Power Company, Gulfport, MS, Allen Dunn, Mississippi Power Company, Gulfport, MS

Lawrence J. Vogt, 'Electricity Pricing: Engineering Principles and Methodologies', CRC Press, December, 2009, pages 346,347.

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