Understanding Industrial Customers: *The Process Model*

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Abstract. The industrial class of customers can be segmented by Major Group (two-digit SIC code), by Industry Group (three-digit SIC code), and by Industry (four-digit SIC code). For example, SIC 26 represents the Major Group, Paper and Allied Products. Within this Major Group, there are five Industry Groups and seventeen Industries.

Increasingly, utilities are trying to obtain a better understanding the dynamics within an industry---both at the industry level and the customer level. The better understanding of the industry/customer dynamics the better the utility is able to provide energy services rather than strictly energy to its customers. This paper will describe method being employed by ACME Utility Corp, a fictitious utility, to begin developing an understanding of the industrial class.

The process model begins with development of key information by Major Group within the utility. This includes accessing and summarizing readily available customer information from existing utility sources, e.g., the customer billing system, the strategic market information system, the load research data system, etc. The next step is to develop 8,760 hourly representations of the load associated with the Major Groups and Industry Groups. The next logical step is to go inside the 8,760 total facility profiles to develop a series of *Process Models* for selected Industry Groups. The final objective is to develop a better understanding of the underlying processes that constitute the 8,760 hourly total facility demand profiles for selected Industry Groups. The focus of the paper will be to describe the analytical framework and the steps taken along the way.

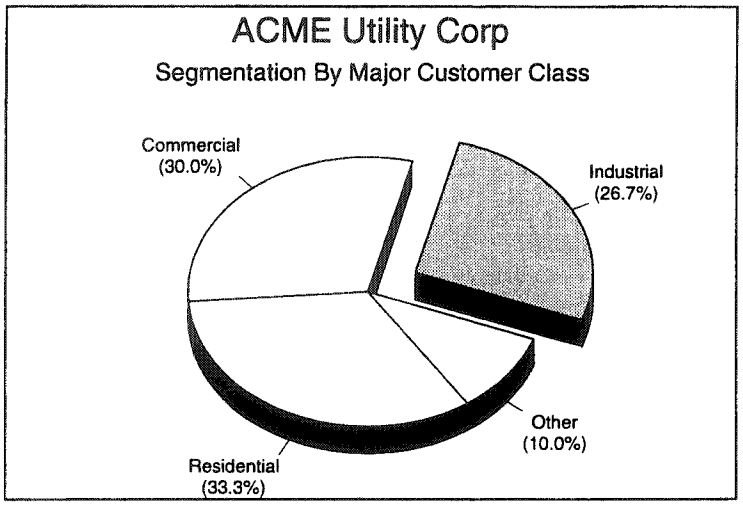

Figure 1 - Segmentation By Customer Class

A Starting Point. To begin the segmentation process, like our fictitious ACME Utility Corp, must start by developing a basic understanding of the industrial class. Figure 1 presents the simplest breakdown possible. This figure displays the proportion of total annual energy use by major customer segment and is readily developed from the Company's customer billing system. As is evidenced by Figure 1, the ACME Utility Corp is nearly proportionally allocated between the residential, commercial and industrial customer classes.

The residential class is dominate accounting for one-third of the total annual energy use but is of low interest. The Company has a substantial amount of information regarding this class as a result of years of residential load and market research. In addition, this class is considered to be more captive and at the lowest risk of loss in the increasingly competitive utility market.

The next major group is the commercial class which accounts for 30% of the annual energy use. While of interest, ACME has recently completed a detailed market segmentation study disaggregating the commercial class into twelve mutually exclusive segments. The Company initiated a end-use data development project that utilizes total load research data and DOE 2.1E modeling to develop an estimate of the end-use loads within the Office and Grocery segments. Furthermore, ACME has established a five year research agenda that addresses each of the remaining commercial market segments, i.e., two segments per year.

In recent months, ACME senior management has developed a keen interest in the make-up and risk associated with the industrial class. This class accounts for 27% of the annual energy sales but is feared to be at the greatest risk of leaving the system with the advent of open access. With competition looming just around the corner, senior management has requested an industrial market profile be developed to better understand this very important market segment. In addition, they have requested you to develop a research agenda that provides a specific understanding of the industrial class.

Segment	Population	
	N	Energy Use
20-Food Processing	331	575,595,153
21-Tobacco	1	17,607
22-Textile	18	4,330,735
23-Apparel	20	68,717,250
24-Lumber	314	103,782,605
25-Furniture	70	172,568,122
26-Paper	84	599,379,028
27-Printing	275	74,451,880
28-Chemical	153	573,285,556
29-Petroleum	21	110,162,533
30-Plastics	117	324,294,827
31-Leather	18	21,308,099
32-Stone, Clay	182	261,388,008
33-Primary Metals	182	1,216,785,421
34-Fabricated Metals	964	815,739,274
35-C&I Machinery	1,154	549,550,693
36-Electronics	109	598,528,222
37-Transportation	183	1,848,003,781
38-Intstruments	48	28,360,835
39-Miscellaneous	373	53,604,054
Totals	4,616	7,999,853,684

Table 1 - Industrial Segmentation By Major Group

Estimates By Major Group. Having been given this challenge, you immediately turn to all of the available data resources at your disposal. Unfortunately, you quickly learn that these information resources have been primarily designed in an environment where the specific intent of system was to bill the customer. What does this mean? Well, this means that for the

industrial class it may be impossible to find the simplest form of information, e.g., how many customers and what was the annual energy use of the industrial class by Major Group[1]. Instead of the number of customers, we are primarily able to obtain an estimate of the number of associated accounts. Furthermore, asking the Marketing or Billing people about the reliability of the SIC classification provides answers like, "Use them at your own risk", "I haven't the foggiest" and "Why do I care". Unfortunately, this is the starting point for our industrial customer segmentation. Table 1 presents an initial pass at segmenting the industrial by Major Group. The table indicates that a total of 4,616 accounts were identified by Major Group accounting for nearly 8,000 GWh.

Figures 2 and 3 present this same tabular information in graphical form. As is evidenced by the table, SIC 35-C&I Machinery and SIC 34-Fabricated Metals dominate with over 2,100 accounts combined---note the use of the term account and not customer. On an annual energy basis SIC 37-Transportation industries account for nearly one-quarter of the total annual energy use followed by SIC 34-Fabricated Metals with 10% of total annual industrial use. These two primary segments are followed by a cluster of five industrial segments accounting for 7-8% of the total annual energy consumption of the industrial class. These five segments include:

1. SIC 26-Pulp and Paper Products,
2. SIC 36-Electronics,
3. SIC 20-Food Processing,
4. SIC 28-Chemical and
5. SIC 35-C&I Machinery.

The seven primary segments comprise over 65% of the sales associated with the industrial class.

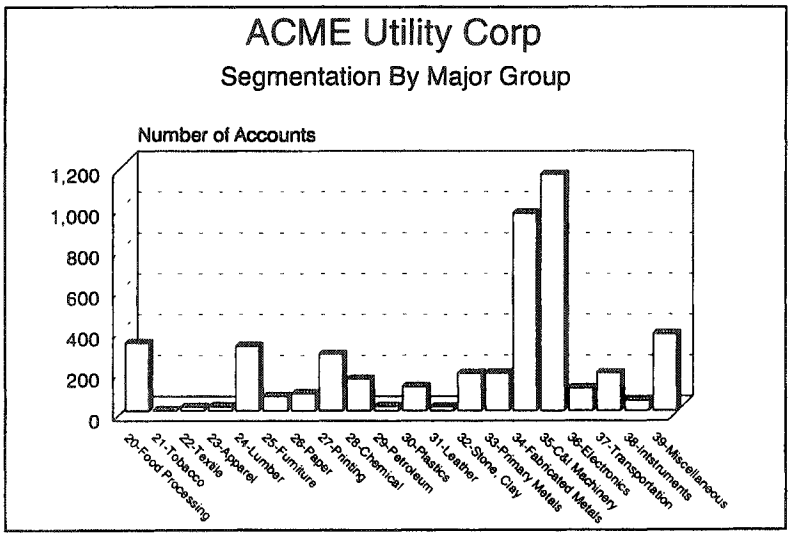

Figure 2 - Number of Customers by Major Group

[1] Major Groups are defined by the two-digit standard industrial classification, i.e., two-digit SIC code.

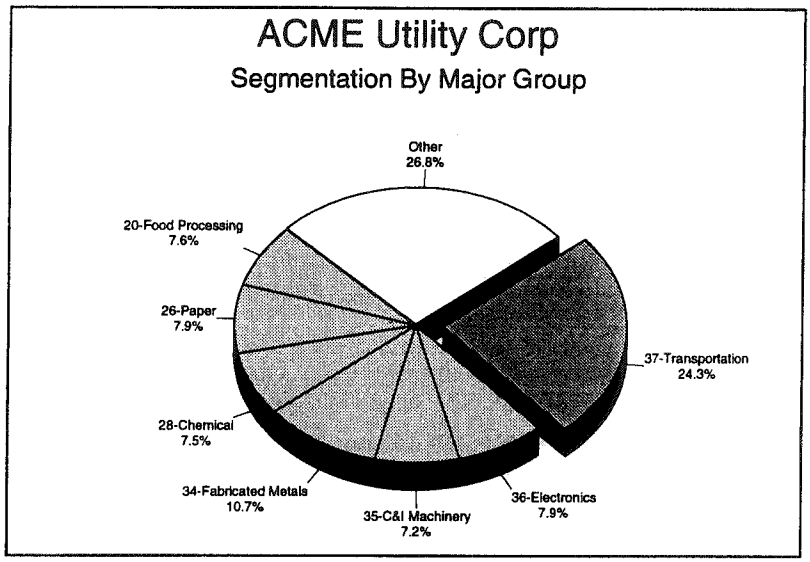

Figure 3 - Percentage of Annual Energy Use By Major Group

Table 2 displays the importance of large accounts in characterizing the industrial customer class. Table 2 is similar to Table 1 but displays four additional columns. These columns remove all accounts with an annual energy use of less than 100 MWh and presents the number of large accounts required to represent 90% of the annual energy use of the various market segments. For example, SIC 20-Food Processing has 126 accounts greater than 100,000 kWh with a total annual energy use of 569 MWh or nearly 99% of the segment's total annual energy use. For SIC 26-Paper and Allied Products, the 26 largest accounts represent 90% of the segment's total annual energy savings.

Segment	Population		Energy >100,000 kWh		90% of Energy	
	N	Energy Use	N	Energy Use	N	Energy Use
20-Food Processing	331	575,595,153	126	569,116,407	42	519,957,378
21-Tobacco	1	17,607	0	0	1	17,607
22-Textile	18	4,330,735	5	4,018,967	5	3,915,882
23-Apparel	20	68,717,250	8	68,580,846	6	62,029,903
24-Lumber	314	103,782,605	86	98,941,655	52	93,483,003
25-Furniture	70	172,568,122	32	171,529,565	9	156,059,275
26-Paper	84	599,379,028	51	548,331,693	26	539,441,125
27-Printing	275	74,451,880	75	70,206,808	52	67,055,464
28-Chemical	153	573,285,556	62	570,896,561	34	517,400,730
29-Petroleum	21	110,162,533	10	109,876,408	7	105,327,758
30-Plastics	117	324,294,827	78	322,931,342	33	292,313,286
31-Leather	18	21,308,099	8	21,054,735	5	20,221,581
32-Stone, Clay	182	261,388,008	56	258,103,571	9	236,978,047
33-Primary Metals	182	1,216,785,421	123	1,215,261,940	34	1,096,392,235
34-Fabricated Metals	964	815,739,274	446	802,216,945	187	734,523,860
35-C&I Machinery	1,154	549,550,693	455	528,566,817	254	494,636,374
36-Electronics	109	598,528,222	54	597,150,873	8	542,508,551
37-Transportation	183	1,848,003,781	122	1,846,436,828	26	1,669,360,098
38-Intstruments	48	28,360,835	21	27,714,714	12	25,834,811
39-Miscellaneous	373	53,604,054	84	46,804,256	101	48,291,289
Totals	4,616	7,999,853,684	1,904	7,877,740,930	901	7,225,748,257
Percentage of Total Energy Use				98.47%		90.32%

Table 2 - Large Industrial Accounts as a Percentage of Total Industrial

These data are effective in providing a glimpse of the number of accounts and the total annual energy of each industrial segment, however, they do not provide any detail on the segment's characteristics of use. Therefore, the next step in the segmentation analysis is to examine the availability of hourly load research type information. This information is generally maintained by the Company in support of the cost of service function. In addition, a number of utilities maintain hourly billing information on their largest customers, e.g., customers with a monthly demand greater than 100 kW. Turning to the load research and billing information systems provides an abundance of hourly load data on the largest industrial accounts.

Table 3 displays the total number of accounts in the segment, the total annual energy use of the segment and the availability of load research data or hourly billing load data. ACME utility has an abundance of hourly data available for the industrial class. The number of customers with hourly data range from a low of missing for SIC-21 Tobacco, an unimportant segment, to 133 of the 964 accounts representing SIC 34-Fabricated Metals.

Segment	N	Energy Use	n
20-Food Processing	331	575,595,153	37
21-Tobacco	1	17,607	0
22-Textile	18	4,330,735	2
23-Apparel	20	68,717,250	8
24-Lumber	314	103,782,605	13
25-Furniture	70	172,568,122	29
26-Paper	84	599,379,028	34
27-Printing	275	74,451,880	36
28-Chemical	153	573,285,556	45
29-Petroleum	21	110,162,533	7
30-Plastics	117	324,294,827	78
31-Leather	18	21,308,099	5
32-Stone, Clay	182	261,388,008	19
33-Primary Metals	182	1,216,785,421	55
34-Fabricated Metals	964	815,739,274	133
35-C&I Machinery	1,154	549,550,693	106
36-Electronics	109	598,528,222	24
37-Transportation	183	1,848,003,781	82
38-Intstruments	48	28,360,835	14
39-Miscellaneous	373	53,604,054	13
Totals	4,616	7,999,853,684	740

Table 3 - Availability of Load Data

Developing Hourly Load Representations. The next step in the segmentation analysis is to develop hourly load representations for each market segment. This is accomplished by post stratifying the available hourly load data for each market segment into the desired population of interest. The stratification variable can be annual energy use. The purpose of the post stratification is to develop weights to apply to each of the quasi load research sample points in an effort to create the best representation of the market segment at the system level.

Strata	Maximum Value (MWh)	Number in Population	Total Use (MWh)	Available Sample	Weight
1	3,614	62	40,666	16	3.875
2	39,458	14	102,012	12	1.167
3	69,395	4	159,978	4	1.000
4	>69,395	4	296,723	2	2.000
Totals		84	599,379	34	

Table 4 - Post Stratification of SIC 26-Paper and Allied Products

Table 4 presents the post stratification developed for SIC 26-Paper and Allied Products market segment. The first column identifies the stratum number, the second column displays the stratum cut points. Here again, annual energy use is being used to post stratify the hourly load data into the various market segments. In general, 3 to 5 strata should provide a good distribution of population and sample points. Column 3 presents the number in the population, column 4 presents the total annual use represented by the customers in the population. Column 5 presents the number of quasi sample points available for use in the extrapolation and column 6 presents the weight, i.e., the number of accounts in the population represented by the sample. For SIC 26-Paper and Allied Products, a total of 84 accounts comprised the population with a total annual use of nearly 600 GWh. For stratum 1, there were 62 accounts with less than 3,614 MMh of annual use representing 40,666 MWh of total use. Sixteen load research sample points were available for analysis yielding a weight of 3.875, i.e., each sample point represented 3.875 accounts in the population.

Hour	Estimated Demand (kW)	Error Bound (kW)	Lower Bound (kW)	Upper Bound (kW)	Relative Precision (%)
1	67,780	3,142	64,638	70,922	4.6
2	67,301	3,197	64,104	70,498	4.7
3	66,492	3,304	63,188	69,797	5.0
4	67,101	3,414	63,687	70,515	5.1
5	68,743	2,933	65,809	71,677	4.3
6	69,803	2,601	67,202	72,403	3.7
7	70,645	2,817	67,828	73,462	4.0
8	73,812	2,840	70,972	76,651	3.8
9	76,527	2,431	74,095	78,959	3.2
10	78,445	2,269	76,176	80,716	2.9
11	75,846	2,479	73,367	78,324	3.3
12	68,571	2,246	66,326	70,818	3.3
13	68,192	2,444	65,749	70,636	3.6
14	67,985	2,470	65,515	70,456	3.6
15	67,147	2,586	64,562	69,733	3.9
16	66,727	2,440	64,287	69,168	3.7
17	65,532	2,681	62,852	68,213	4.1
18	68,742	2,879	65,863	71,620	4.2
19	69,357	2,932	66,425	72,289	4.2
20	73,128	2,403	70,725	75,532	3.3
21	74,645	2,680	71,964	77,324	3.6
22	75,522	2,078	73,444	77,599	2.8
23	74,892	2,061	72,832	76,953	2.8
24	74,488	1,796	72,691	76,285	2.4

Table 5 - Table of Expansions Monday, January 5: SIC 26-Paper and Allied Products

Ratio estimation is used to expand the hourly load data to total system representation. It is important to check the annual use expansion to ensure that the weights provide a reasonable estimate of the total known consumption of the segment. Table 5 presents a tabular summary of the expanded market segment data for Monday, January 5, 199X. The data presents the total segment demand, the error bound, the lower confidence bound, the upper confidence bound, and the associated relative precision. The relative precision provides information on how good the quasi sample represented the population. As is evidenced by the very good relative precision estimates, i.e., less than ±10%,, the sample of 34 provided a very good estimate of the total demand associated with the population of 84 accounts.

These data are analyzed for each day providing a data file of 8,760 hourly load expansions for each market segment of interest. The hourly analysis is conducted using the batch processing features of *RLW Analytics*' Model-Based Statistical Sampling, MBSS, software.

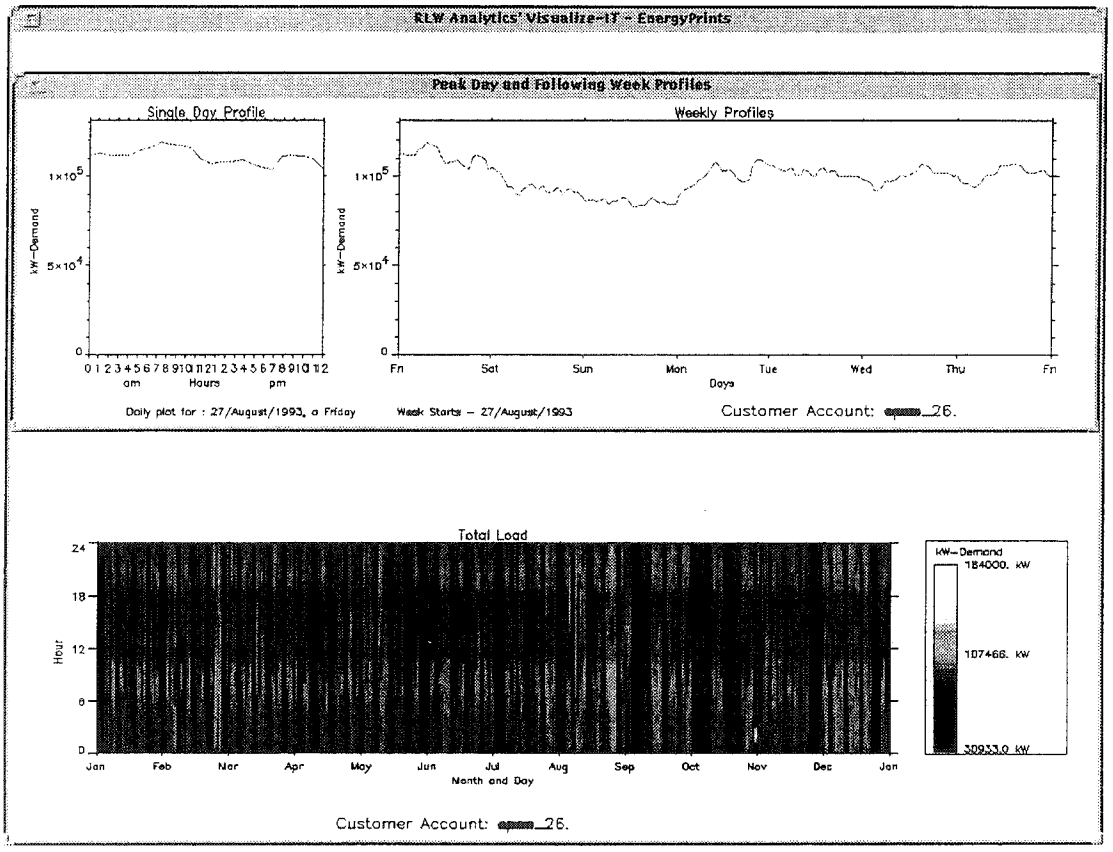

Figure 4 - System Representation for SIC 26-Paper and Allied Products

Figure 4 presents a graphical depiction of the full 8,760 load profile. The figures are displayed using *RLW*'s Visualize-IT data analysis software. The bottom of Figure 4 presents an EnergyPrint. The EnergyPrint provides a means of examining the general characteristics of an 8,760 hourly profile. Hours are displayed along the y-axis, days are displayed along the x-axis and the energy intensity is color coded according to the scale located at the right side of the EnergyPrint. The lighter the color the higher the level of demand. The EnergyPrint provides an effective mechanism for understanding the general usage patterns of the market segment of interest. For example, the SIC 26-Paper and Allied Products segment displays a relatively flat

load shape throughout the year. The dark troughs represent lower demand on the weekends. The wider troughs represent holiday shutdown. These are evident at the fourth of July, Labor Day, Thanksgiving, and Christmas.

Two figures are presented at the top of the figure presents a single day profile and a weekly profile. For SIC 26-Paper and Allied Products these profiles display a very high load factor segment. The Visualize-IT screens can be customized based on the specific desires of the analyst. For example, constant hour profiles can be provided or tabular information can be displayed including monthly energy, maximum demand, peak demand, or various load factors.

Do all segments look alike? Figures 5 and 6 present two additional EnergyPrints. Figure 5 presents SIC 20-Food Processing and Figure 6 presents SIC 37-Transportation. SIC 20 displays a substantial amount of seasonality with the greatest energy intensity during the summer periods. For SIC 37-Transportation, energy use is very predictable.

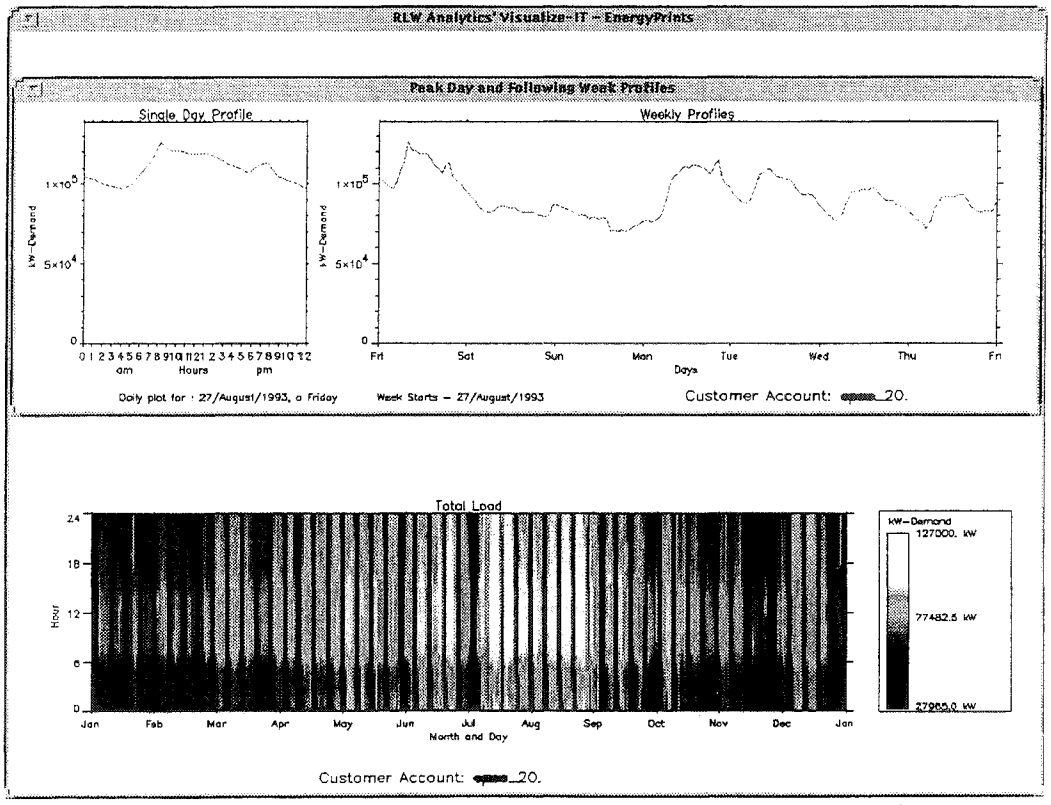

Figure 5 - System Representation for SIC 20-Food Processing

Not only can we use this tool to examine differences among the various industrial segments, but we can also use the tool to examine an individual customer's load. Under the process model scenario, the tool will be used to calibrate the various process loads comprising the selected sample customers. A similar application has been developed for the commercial class using DOE 2.1E modeling as a means of developing the "process" load profiles. The commercial processes comprise heating, cooling, water heating, lighting, etc. The industrial processes are expected to be more complex.

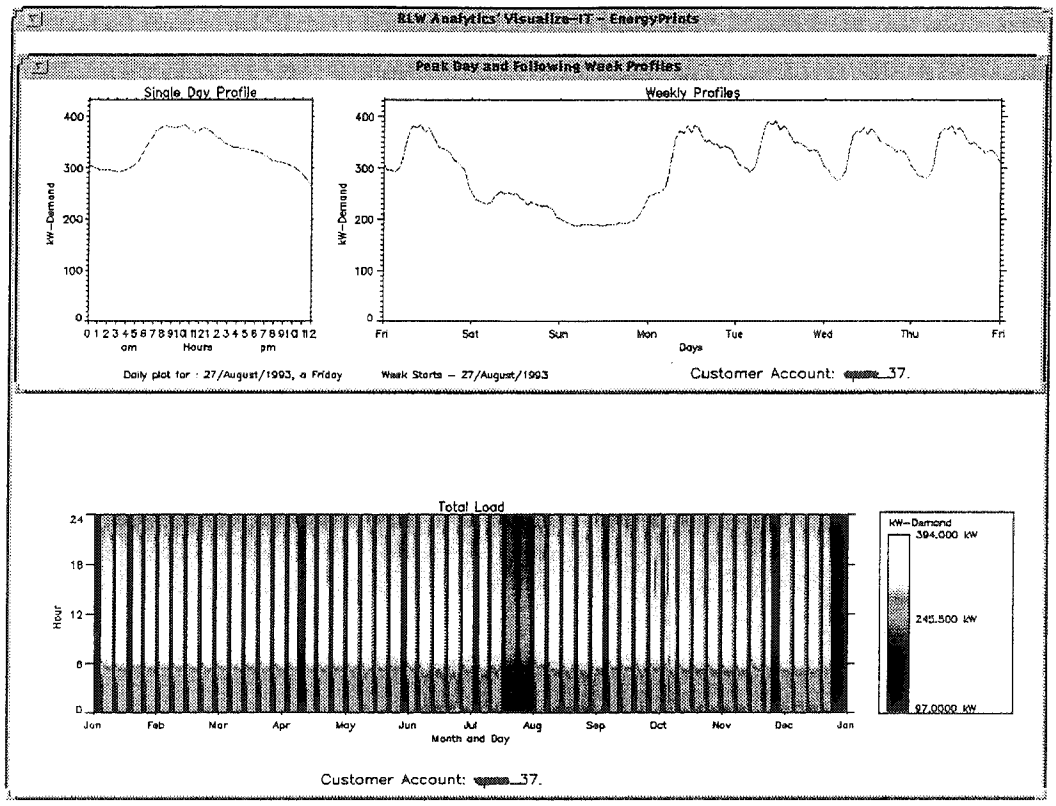

Figure 6 -System Representation for SIC 37-Transportation

Figure 7 presents an example of the Visualize-IT calibration tool using the commercial class as an example. Here, the customers actual and predicted total loads are presented in the first two EnergyPrints. The third EnergyPrint displays the residual load allowing the modeler to tweak the modeled process loads. The next four EnergyPrints display the modeled end-use processes for the customer. The last EnergyPrint displays the associated weather data.

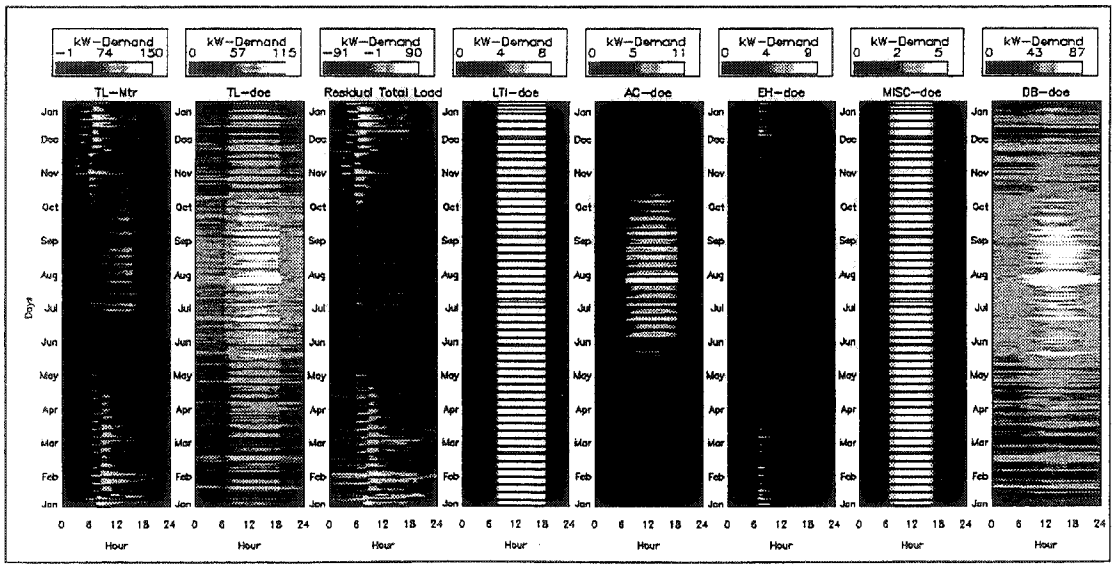

Figure 7 - Visualize-IT Calibration Tool

In addition to displaying the demand associated with the various processes, we are working on ways to display the profitability of various processes. Imagine being able to plot revenue versus cost of service data to yield a profitability profile of various segment or process loads.

Next Steps. The next steps in the development of the *process model* is to select a specific market segment of interest. For our purposes a risk matrix is being developed for each segment. Those segments at greatest risk are being characterized based on a number of qualitative and quantitative factors.

The first segment selected for study was SIC 26-Paper and Allied Products. We have characterized this segment's annual energy use and hourly demand characteristics but we still do not have answers to our key questions. These questions include:

- What individual processes are characteristic of the overall production process?
- What are the technologies, regardless of fuel, used to optimize the individual processes?
- What is the fuel(s) and energy consumption associated with each process? With each technology?
- What empirical data are necessary to populate the process model? How much of this information exists from industry sources? What kind of primary data collection is necessary to supplement the existing data?
- How does a firm in the selected industry make decisions about the fuel to use and/or the technologies to use?

To help answer these questions, we utilize the sample design conducted for the market segment extrapolation and select a random sample of two, or more, accounts per strata for engineering study. The statistical framework provides a mechanism to extrapolate the on-site engineering results to the segment population. Having selected the sample accounts for study the next steps include:

- Conducting literature review of available industry information to identify key processes,
- Developing data collection instruments for use in the on-site engineering studies,
- Recruiting the sample participants,
- Conducting the on-site engineering studies,
- Developing annual energy profiles by key process,
- Monitoring key processes for a 2 to 4 week period to provide a mechanism to develop hourly profiles,
- Developing annualized profiles based on monitored/modeled data,
- Calibrating the annualized profile at the customer level to the known total load, and
- Extrapolating the annualized profiles to the total segment load.