A New Monitoring System Cuts Costs Two Ways

- *Optimizes Compressed Air System Efficiency*
- *Same System Identifies, Tracks, and Allocates Peak Demand Costs*

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COMPRESSED AIR CASE HISTORY

Summary

In 1994, Thomson Consumer Electronics (RCA), an international manufacturer of electronics equipment, purchased a U*tili*TRACK® Monitoring System for a plant in Indianapolis, Indiana. The system monitored gas and electric meters, substations, main feeders, and major equipment and systems including compressed air. For the compressed air system, monitored data included compressor amps, electrical demand and consumption, pressure and airflow.

The resulting U*tili*TRACK® reports and graphs showed a significant variation in system efficiency depending upon the demand for air (day of week, time of day, production schedule) and which compressor or compressors were operating. By working with the boiler plant operators and making minor modifications to the existing compressor controls, the operating sequence was modified to maintain high system efficiency under all operating conditions. Monitored data after the changes were made showed a 20% reduction in compressed air system operating costs.

BACKGROUND

In 1993, the Corporate Offices of Thomson Consumer Electronics were moved from the Sherman Avenue Plant in Indianapolis, Indiana, to a new facility north of the city. The Sherman Avenue Plant was a large site with a central boiler plant providing chilled water, compressed air, heat and domestic hot water to several buildings spread out over more than 80 acres. With the possibility of leasing or selling the vacated space, Thomson purchased a *Utili*TRACK® Monitoring System to allow utility costs to be billed to individual departments and lessees.

MONITORING SYSTEM DESCRIPTION

The initial phase included 108 points monitoring gas and electric meters, substations, main feeders, and major equipment and systems. Monitoring for the compressed air system included two 500 Hp Centacs, one 350 Hp Worthington, system air pressure and total airflow. Figure 1 shows a one line diagram of the electric feed to the compressors.

Four *Utili*TRACK® panels and a dedicated PC and printer were included along with the sensors and interface devices required to connect to each monitoring point. The System included Real-Time screens showing the current status of each monitored point individually or grouped according to the owner's preference. It included Historical reports and

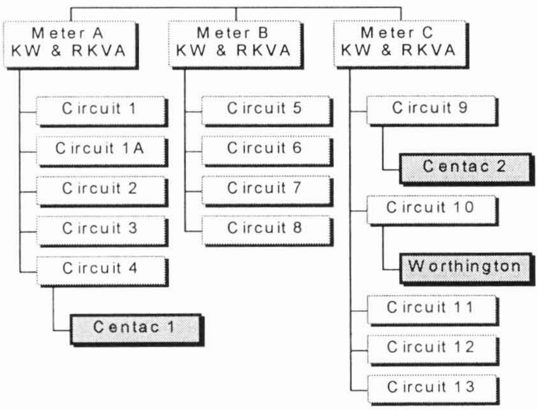

Figure 1. Main Meters and Feeders Monitored

graphs showing consumption and demand by 15-minute intervals, daily, monthly or annual totals. For compressed air, total system electrical demand and consumption, airflow and efficiency as well as individual compressor performance were available.

OPPORTUNITY

Although the system was initially purchased and used primarily to track and distribute utility costs, internal restructuring and changes in personnel at Thomson during 1996 resulted in an emphasis on utility cost reduction. In February 1997, as the plant engineers reviewed the compressed air system reports, they noticed a significant variation in compressed air system efficiency depending upon the demand for air (day of week & time of day) and which compressor or compressors were operating. On a daily basis, system efficiency varied from less than 155 to more than 191 CU FT/kWh, a 20% difference in efficiency and electrical consumption. The most obvious difference occurred when the Worthington, the smallest compressor, was run by itself during third shift and on weekends when the demand for compressed air was lower.

Using the main menu shown in Figure 2 to select the Monthly Compressed Air Report for February 1997, the Report shown as Figure 3 was reviewed on the screen and then printed. It showed the total kWh consumption, compressed air production and system efficiency in CU FT/kWh, which varied from a low of 148 on Saturday February 3rd to a high of 191 on Friday February 14th. Although the three compressors are fed from separate main electrical feeders, Centac 1 from Circuit No. 4, Centac 2 from Circuit No. 9 and the Worthington from Circuit No. 10, the *Utili*TRACK® software has the capability to group monitored data by system in order to produce Reports such as the one shown in Figure 3.

In order to determine the differences between compressors and find the optimum operation under all conditions, the engineers began to experiment with various compressor combinations and loading under different operating conditions. The compressed air system Real-Time screens shown in Figure 4 was used for instantaneous feedback and the historical reports and graphs for documenting results.

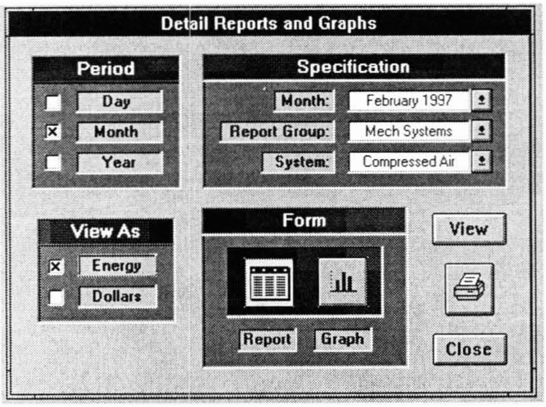

Figure 2. *Utili*TRACK® Historical Menu

Compressed Air System Performance - February 1997						
Date	Centac 1 KWH	Centac 2 KWH	Worth KWH	Total KWH	Total CU FT	CU FT/ KWH
Sat 01	9,137	0	0	9,137	1,489,472	163.02
Sun 02	9,138	0	0	9,138	1,501,384	164.31
Mon 03	9,764	2,176	8	11,948	2,086,201	174.61
Tue 04	9,219	0	3,360	12,579	2,272,159	180.64
Wed 05	9,172	0	3,551	12,724	2,226,339	174.98
Thu 06	9,156	0	3,539	12,695	2,185,692	172.17
Fri 07	9,149	0	3,530	12,679	2,162,727	170.57
Sat 08	9,138	0	91	9,229	1,366,614	148.08
Sun 09	9,139	0	0	9,139	1,412,168	154.51
Mon 10	9,290	266	2,678	12,234	2,092,729	171.06
Tue 11	4,558	5,945	1,002	11,505	2,189,517	190.31
Wed 12	2,434	8,924	0	11,358	2,142,391	188.62
Thu 13	560	8,379	0	8,938	1,649,571	184.55
Fri 14	1,303	8,887	0	10,190	1,950,471	191.42
Sat 15	0	8,185	0	8,185	1,324,151	161.78
Sun 16	0	8,199	0	8,199	1,332,030	162.47
Mon 17	2,849	8,889	0	11,738	2,086,521	177.76
Tue 18	4,988	8,647	0	13,635	2,285,534	167.62
Wed 19	5,176	8,885	0	14,061	2,334,612	166.03
Thu 20	6,236	8,057	0	14,294	2,358,234	164.98
Fri 21	9,851	4,929	0	14,779	2,452,214	165.92
Sat 22	9,178	0	0	9,178	1,627,944	177.38
Sun 23	5,636	3,279	0	8,914	1,649,091	184.99
Mon 24	5,273	8,783	0	14,056	2,308,992	164.27
Tue 25	5,479	9,067	0	14,546	2,422,776	166.56
Wed 26	5,075	9,113	0	14,188	2,391,736	168.58
Thu 27	1,482	8,753	2,446	12,680	2,360,016	186.12
Fri 28	1,158	8,842	3,545	13,545	2,494,519	184.17
Totals	163,535	138,203	23,751	325,490	56,155,806	172.53

Figure 3. February Compressed Air Report

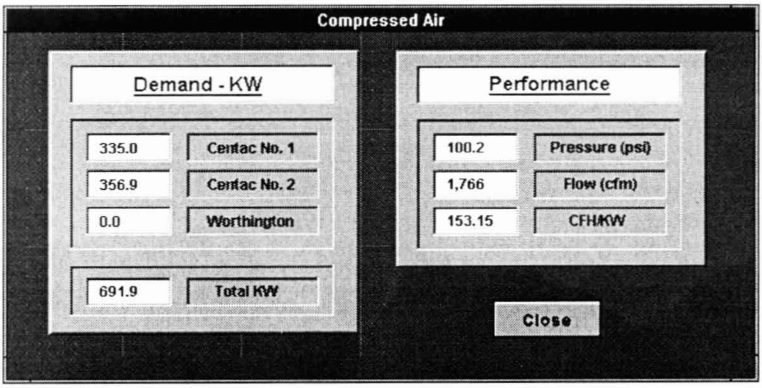

Figure 4. U*tili*TRACK® Real-Time Screen

MODIFICATIONS

Figures 5 & 6 show 3 weekend days each with a different compressor running by itself. For similar compressed air requirements averaging 1,000 CFM, Centac 1 required 380 kW, Centac 2 slightly under 350 and the Worthington less than 250 kW. Running the Worthington alone on weekends offered the most obvious opportunity for savings. However, the existing control system provided for each Centac to serve as automatic back up for the other, but not for the smaller Worthington. The existing controls were modified to allow the Worthington to be run as primary with the Centacs serving as automatic backups and the weekend boiler plant operators were instructed to run the Worthington in the lead position. Total cost was less than $1,000.

In addition to the advantage of the Worthington over the bigger Centacs during low demand periods, it was discovered that Centac 2 was more efficient than the "identical" Centac 1 under all conditions. Figure 7 shows the normal production day operation on February 20th when both Centacs were running.

By working with the boiler plant operators and utilizing U*tili*TRACK® data, the operating sequence for the three compressors during production days was modified to maintain high system efficiency under all operating conditions. Figure 8 shows the modified production day operation on June 17th when Centac 2 and the Worthington were running.

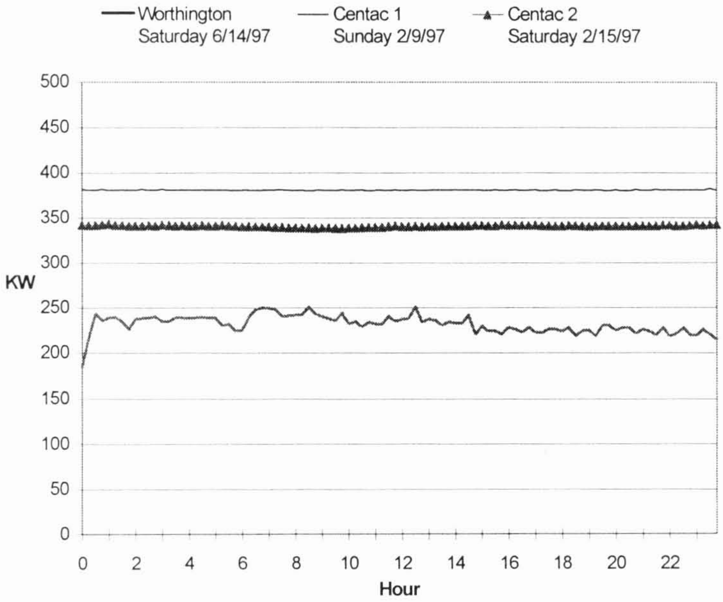

Figure 5. Weekend kW Demand

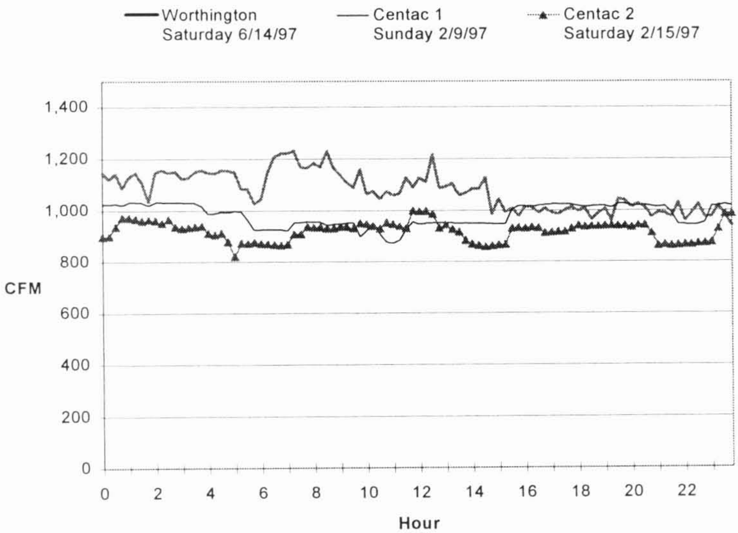

Figure 6. Weekend Total CFM Demand

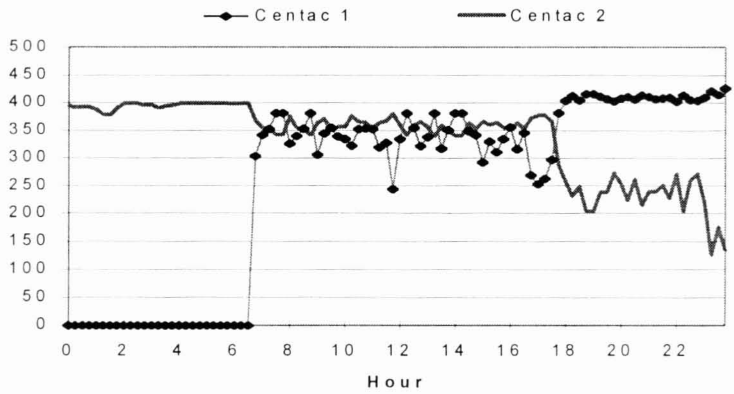

Figure 7. Initial Production Day kW

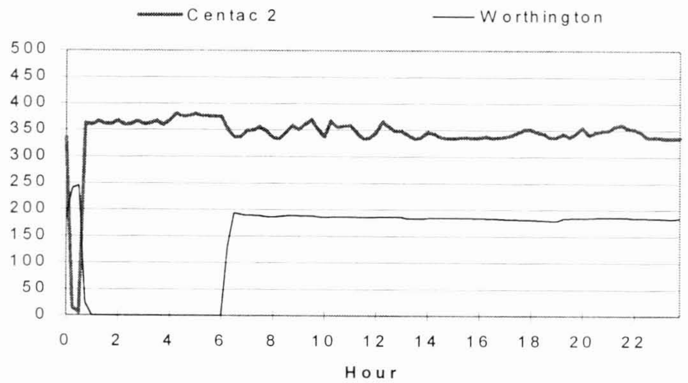

Figure 8. Modified Production Day kW

RESULTS

Figures 9 and 10 show comparisons of the total kW and CFM demand for the two production days. They show that the compressed air requirements can be satisfied with a demand reduction of approximately 175 kW through good compressor management.

Figure 11 shows the Compressed air report for June 1997 after new operating procedures had been implemented. With a Peak Demand reduction of 175 kW and a reduction in kWh consumption when compared with February of nearly 64,000, the total annual cost savings exceeded $35,000, a reduction in air compressor electrical costs of 20%.

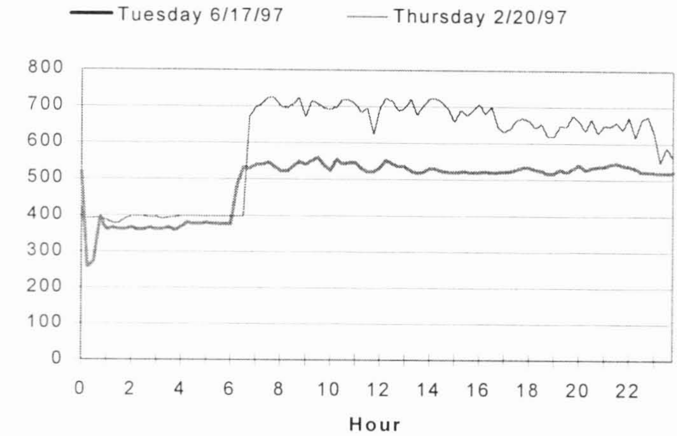

Figure 9. Production Day kW Demand

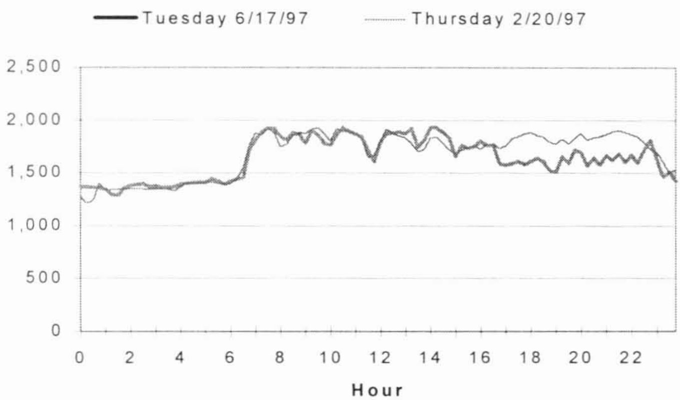

Figure 10. Production Day CFM Demand

PEAK DEMAND REDUCTION CASE HISTORY

Summary

The same U*tili*TRACK Monitoring System reviewed in Case History 1, above, was first used at Thomson Consumer Electronics to bill utility costs to individual departments within the company as well as to outside organizations on the site.

The most common way to distribute monthly electric costs within a facility when consumption by area or department is available through

Compressed Air System Performance - June 1997

Date	Centac 1 KWH	Centac 2 KWH	Worth KWH	Total KWH	Total CU FT	CU FT/ KWH
Sun 01	0	0	5,485	5,485	1,502,913	274.01
Mon 02	10	5,971	4,850	10,831	2,332,414	215.35
Tue 03	0	8,589	3,481	12,070	2,482,579	205.68
Wed 04	0	8,458	3,783	12,241	2,550,120	208.32
Thu 05	0	8,597	3,313	11,910	2,489,633	209.04
Fri 06	0	8,656	3,324	11,980	2,499,173	208.62
Sat 07	2,778	52	5,504	8,335	1,842,828	221.11
Sun 08	1,600	0	5,484	7,085	1,655,432	233.66
Mon 09	0	5,965	4,861	10,826	2,370,435	218.97
Tue 10	0	8,487	3,417	11,904	2,403,916	201.95
Wed 11	2,301	8,527	2,108	12,936	2,424,496	187.43
Thu 12	25	7,862	3,721	11,607	2,433,399	209.65
Fri 13	0	8,188	3,297	11,485	2,195,832	191.19
Sat 14	0	121	5,572	5,693	1,550,128	272.28
Sun 15	0	0	5,250	5,250	1,373,408	261.60
Mon 16	0	6,061	4,774	10,835	2,220,513	204.95
Tue 17	8	8,246	3,449	11,704	2,424,871	207.19
Wed 18	0	8,607	3,306	11,913	2,467,707	207.14
Thu 19	7	8,485	3,335	11,827	2,385,516	201.70
Fri 20	0	8,174	3,553	11,727	2,131,849	181.79
Sat 21	0	76	5,503	5,579	1,470,338	263.55
Sun 22	0	0	5,413	5,413	1,419,311	262.20
Mon 23	0	0	5,345	5,345	1,369,913	256.30
Tue 24	0	0	5,318	5,319	1,347,923	253.44
Wed 25	3,615	501	2,941	7,057	1,407,906	199.50
Thu 26	3,236	0	0	3,236	450,541	139.23
Fri 27	2,400	0	3,831	6,231	1,295,028	207.85
Sat 28	0	0	5,329	5,329	1,418,818	266.23
Sun 29	0	0	5,474	5,474	1,474,643	269.41
Mon 30	0	0	5,402	5,402	1,417,855	262.47
Totals	15,980	119,625	126,421	262,026	56,809,437	216.81

Figure 11. June Compressed Air Report

submetering or other means, is to apply the average cost per kWh from the utility bill to the individual consumption figures. Thompson initially used the data from the U*tili*TRACK System in this way.

As the plant engineer worked with system data on a daily basis and began to develop a much better understanding of the plant's electrical profile, it was clear that the percentage contribution by department or area to the plant's peak demand was not the same as that assigned based solely upon consumption.

With a monthly peak exceeding 8 MW and peak demand charges accounting for more than 60% of the monthly electric bill, he realized that to be accurate and fair, costs must be allocated based both on consumption and peak demand. He asked *Utili*TRACK to develop a method for tracking and allocating peak demand costs. The resulting software continuously tracks the total plant demand (the sum of 3 utility meters) and records the contribution of each monitored point at the time the peak occurs. The resulting reports and graphs not only enable the owner to accurately allocate peak demand costs but also provide a means for tracking and managing peaks on a continuous basis.

DISCUSSION

The approach to developing software to identify peak demand contributors included:

1. Tracking the total plant kW demand (sum of all three meters) on a Real Time basis.

2. Recording the time and the contribution of all major systems and equipment when the total reached the (15 minute) peak each day.

3. Storing the daily peak data for easy review by day and by billing period.

This approach would allow the peak for each billing period to be known at all times and targets to be set and achieved. It would also allow the accurate allocation of peak demand as well as electrical consumption costs to each area within the site.

RESULTS

Shortly after adding the peak tracking and reporting features, the peak demand for July 1996 spiked 800 kW higher than the next highest peak during the entire month. The following describes how the *Utili*TRACK® software was used to determine the cause.

Step 1

As the first step, the Monthly Peak Demand Report and Graph were selected from the main menu (Figure 1) and initially reviewed on the screen.

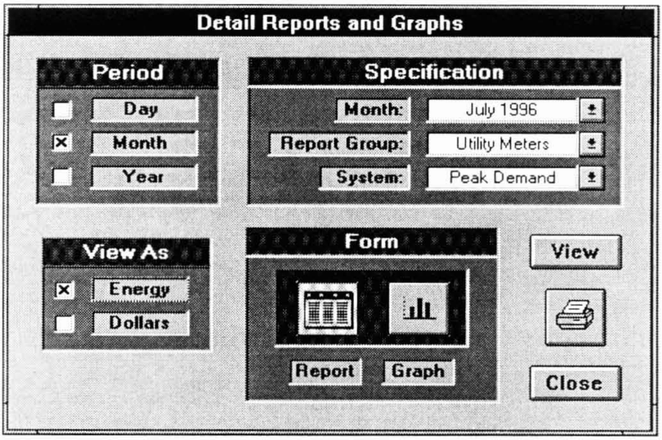

Figure 1. U*tili*TRACK® Menu

The Monthly Graph (Figure 2) clearly shows that the peak demand on Friday, July 19, 1996 was 800 kW higher than the next highest peak during the month.

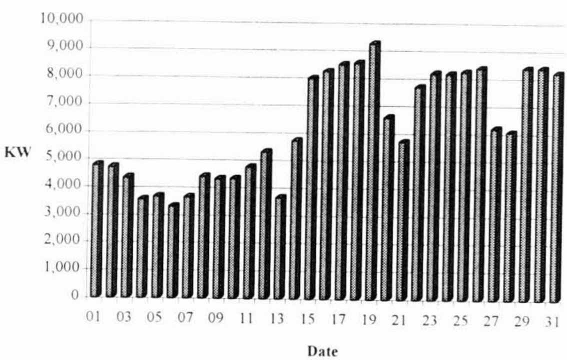

Figure 2. Peak Demand—July 1996

Step 2

In order to quickly determine where in the plant the additional load had come from, the peak contributors form was used as shown in Figures 3-5.

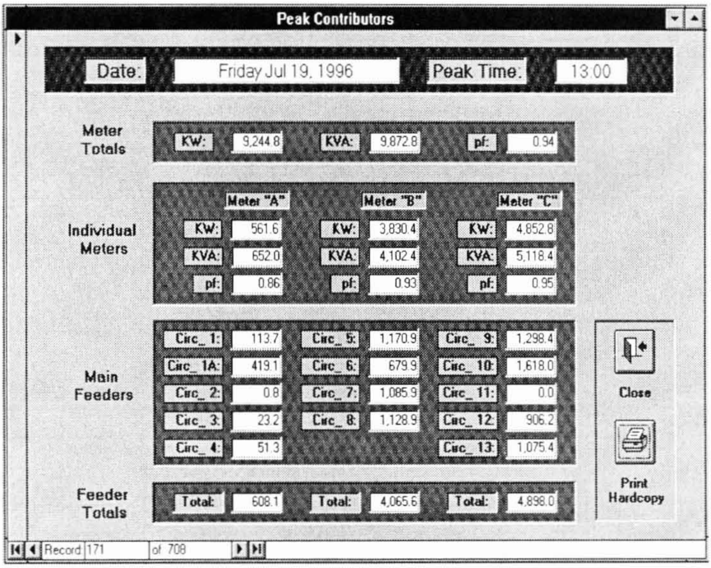

Figure 3. Peak Contributors Form for July 19, 1996

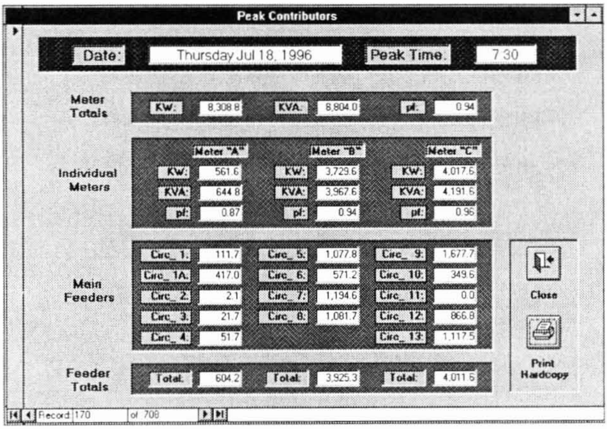

Figure 4. Peak Contributors Form for July 18, 1996

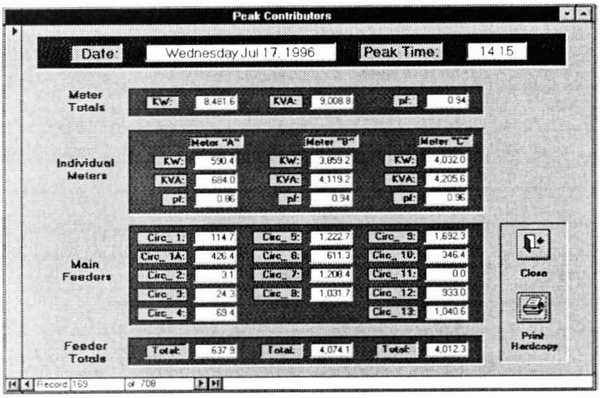

Figure 5. Peak Contributors Form for July 17, 1996

By using the record selector to step between July 17, 18 and 19, it could be seen that the plant peaked at 9,245 kW at 13:00 (1 PM) on July 19th as compared with 8,309 on the 18th and 8,482 kW on the July 17th. At the peak, the contributions from Meters A & B were similar all three days but Meter C on the 19th was more than 800 kW higher than on either of the other days. At peak, Circuit No. 10 was at 1,618 kW on the 19th, versus 350 and 346 on the 18th and 17th. It was obvious that the monthly peak came from an unusual load on Circuit 10 of Meter C.

Step 3

To learn more about the specific circumstances that had produced the 800 kW spike, the graph of the total plant daily electrical demand for July 19 was reviewed and compared with the previous day as shown in Figure 6. It showed that the additional 800 kW load was started at 9:00 AM and shut down at 7:00 PM.

Step 4

The graphs of the individual electrical meters (Figures 7 & 8) for July 17 & 18 show the normal daily profile with a 1,200-1,500 kW load on Meter C starting around 6:00 AM.

For July 19th the graph of the individual electrical meters (Figure 9) shows the normal 6:00 AM load but also shows an additional load exceeding 1,500 kW on Meter C starting at 9:00 AM and shutting down at 19:00 (7:00 PM).

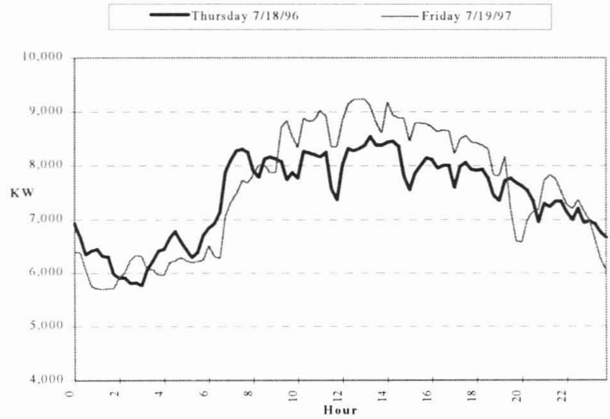

Figure 6. Plant Totals

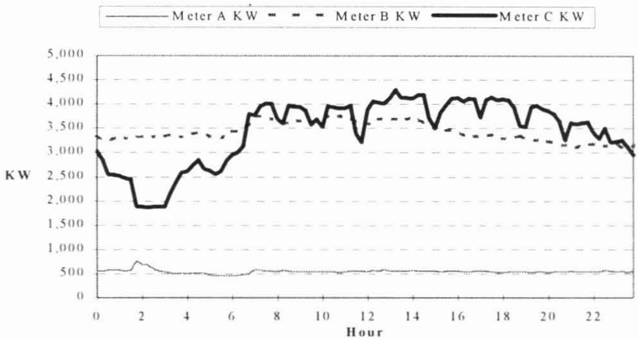

Figure 7. Electric Meters—Thursday 7/18/96

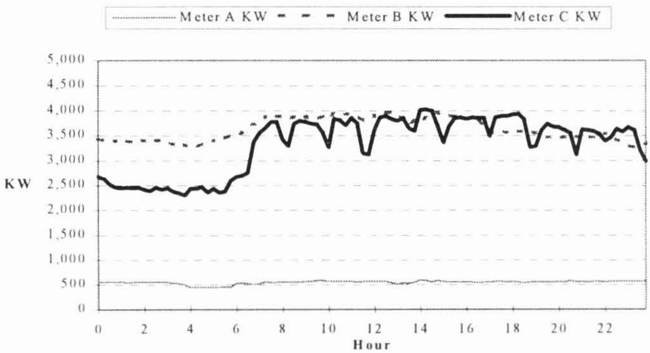

Figure 8. Electric Meters—Wednesday 7/17/96

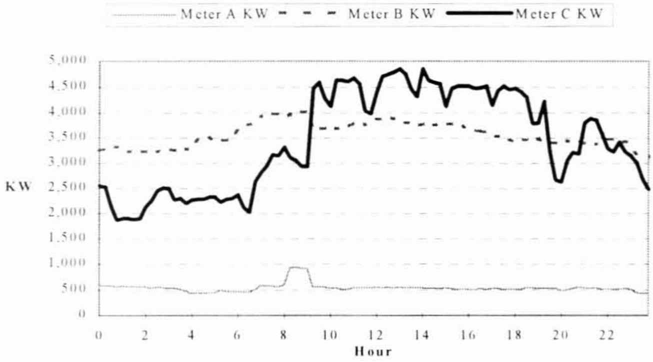

Figure 9. Electric Meters—Friday 7/19/96

Step 5

A Graph of Meter C alone (Figure 10) for July 18 and 19 shows the normal profile compared with the peak day and confirms the 1,500 kW load as well the net difference in the peak of over 800 kW.

Step 6

The next step was to find what load on Meter C was responsible for the peak. Continuing to the daily graphs of the Meter C main circuits for the 1 9th & 1 8th (Figures 11 & 12), it can be seen that the culprit was on Circuit No. 10.

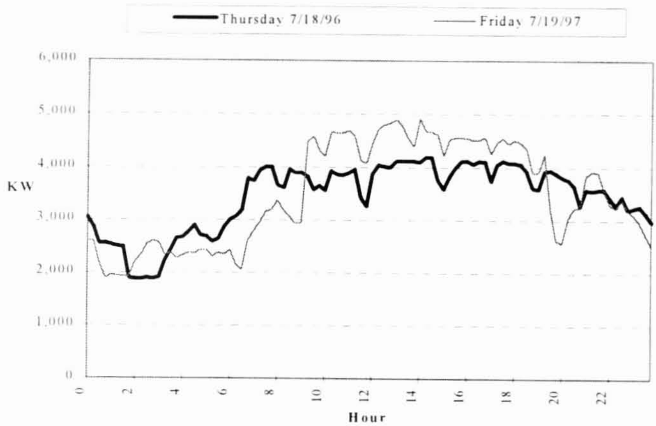

Figure 10. Meter C Totals

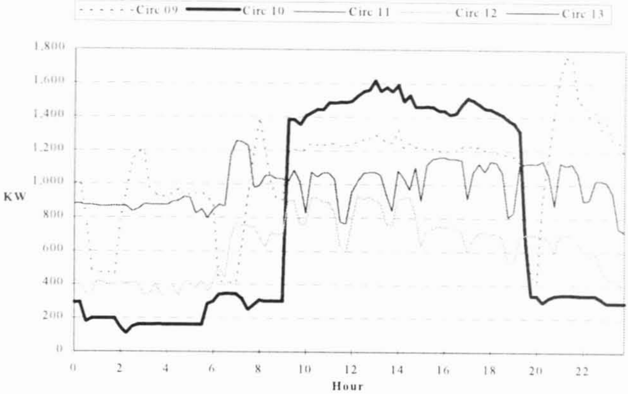

Figure 11. Meter C Feeders—Friday 7/19/96

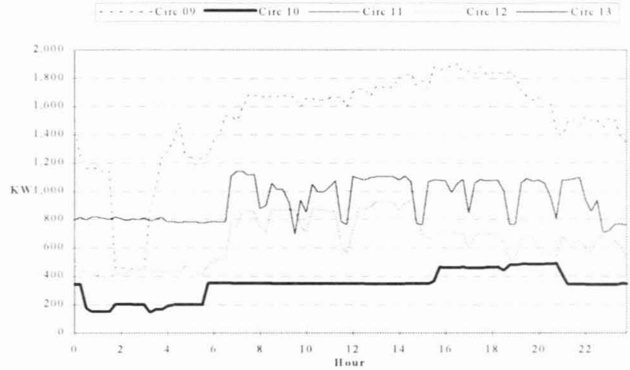

Figure 12. Meter C Feeders—Thursday 7/18/96

Step 7

Because Circuit No 10 serves the Main Utilities building which contains boilers, air compressors and chillers, and because the only single piece of equipment large enough to create such a spike would be a chiller, the next step was to call up the Main Chiller Plant Totals for those two days. Figure 13 confirms that the additional 800 kW did in fact come from the chiller plant.

Step 8

Although the two main chillers are fed from separate main electrical feeders, the West Chiller from Circuit No. 9 and the East Chiller from

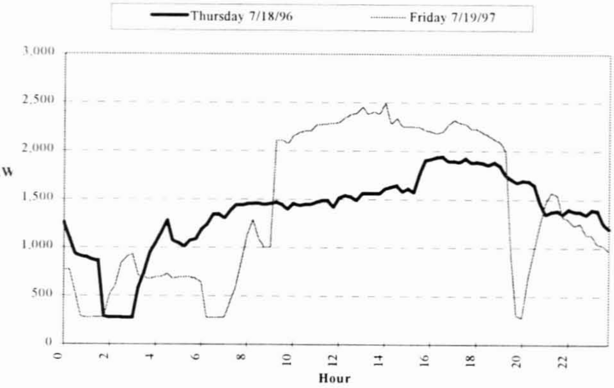

Figure 13. Chilled Water Plant Totals

Circuit No. 10, the U*tili*TRACK® software has the capability to group monitored data by system or process as well as according to the electrical distribution system.

Graphs showing all components of the Chilled Water system for the 19th and 18th are included as Figures 14 & 15.

The exact cause of the 800 kW additional peak was now obvious. On a normal basis, only one chiller is operated at a time with the load dropping off in the evening and increasing in the morning around 6:00 AM as air handlers are started and the first shift begins. On Friday morning the East Chiller was started and the West chiller left running. The

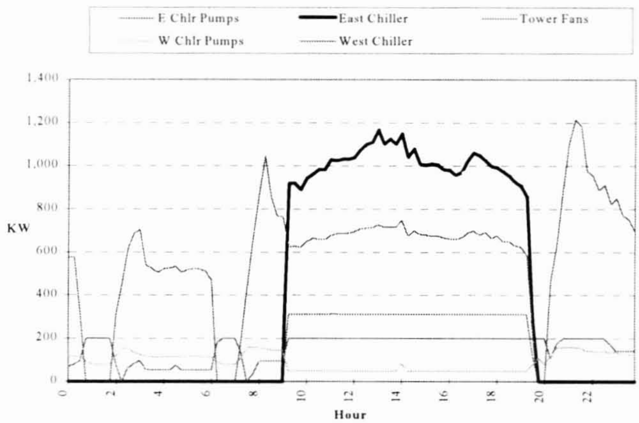

Figure 14. Chiller Plant Detail—Friday 7/19/96

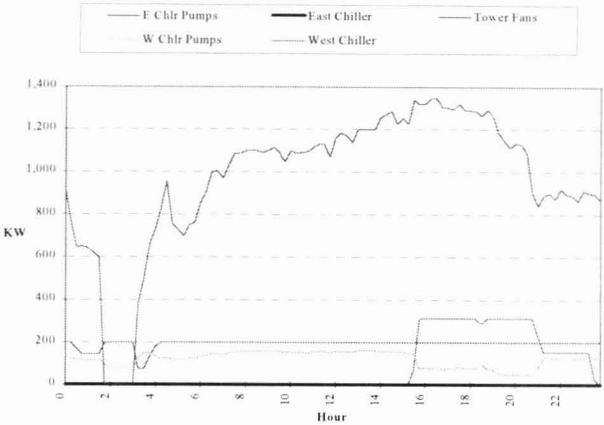

Figure 15. Chiller Plant Detail—Thursday 7/18/96

East Chiller varied between 1,400 and 1,600 kW while the West one unloaded and ran at about 1,200 kW throughout the day.

The total chiller load was about 2,700 kW versus 1,900 kW the previous day for a net increase of 800 kW. The 1,500 kW increase load detected on Circuit No. 10 was from the East Chiller but with the West Chiller unloaded, Circuit No. 9 decreased from 1,900 kW on the previous day to 1,200 kW. Thus all of the data was in agreement as to the cause of the additional 800 kW peak.

CONCLUSIONS

Production was shut down during the first 2 weeks in July for maintenance resulting in a reduced plant peak demand (see Figure 3) and consumption. On Friday during the first full production week following shutdown, the peak demand was more than 800 kW higher than any other day during the month. Investigation by the plant engineer determined that the chiller service contractor was on site on July 19th and from the historical data it was clear that the peak had resulted from a serviceman running both chillers simultaneously rather than one at a time as he was supposed to do. By using the *Utili*TRACK system and peak demand tracking capability, the owner was able to document the cause of the $10,000 in increased demand charges and assign the costs to the responsible individuals.

ABOUT THE AUTHOR

Bill Holmes is president of *Utili*TRACK Corporation, in Columbus, Indiana. After five years with a consulting firm doing energy audits and designing improvements, he taught for six years in Purdue's Mechanical Engineering Technology Program. In 1979 he founded *Utili*TRACK Corporation which designs and installs utility monitoring systems in large industrial facilities. *Utili*TRACK has received awards from the State of Indiana for achievement in energy efficiency as well as a U.S. Department of Energy Award for Energy Innovation. Bill holds B.S. and M.S. degrees in mechanical engineering, and is a registered Professional Engineer and a Certified Energy Manager. He is a regular lecturer in the Continuing Education Energy Management Program at the University of Wisconsin and has published and spoken extensively about his work.

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