PNNL-SA-41179

DSOM®—Decision Support for Operations and Maintenance—Application to a USMC Base Centralized Energy System

Richard J. Meador

Darrel D. Hatley

Pacific Northwest National Laboratory[1]
Richland, WA

ABSTRACT

PNNL DSOM technology coordinates efficient steam plant operation with EMCS and SCADA systems, providing electrical generation support and automated load shedding to meet peak demand limits saving over $1 M in 2 years.

KEY WORDS

Energy, co-generation, EMCS, peak demand, load shedding

[1] Operated for the U.S. Department of Energy by Battelle Memorial Institute under contract DE-AC06-76RL01830.

DSOM®—Decision Support for Operations and Maintenance—Application to a USMC Base Centralized Energy System

BACKGROUND

The United States Marine Corp's MCRD/ERR Parris Island facility had to deal with several different types of installed energy related control systems that could not 'talk' to each other. This situation was being exacerbated by the installation of new and/or unique types of control systems for every new building being constructed or older facility being upgraded. Their cogeneration capability was also not being utilized to its greatest potential during periods where peak power penalties existed for excessive demand. Over several years, Pacific Northwest National Laboratory (PNNL) worked with Parris Island staff to provide them with a cohesive energy conservation and reduction scheme, using PNNL-developed technology that had originally been developed and applied to the USMC's Twentynine Palms Base. The following topics address coordinated technologies applied to steam plants, buildings, and a wastewater treatment plant with a combined energy savings summary. PNNL's R&D 100 Award Winning DSOM software integrates data input from a network of sensors that constantly monitors the performance of a facility's numerous components. Driven by a customized facility database, it then diagnoses the data to let operators know in real-time if a system is malfunctioning or running below expectations. DSOM also identifies conditions that could lead to a problem, determines the root cause and suggests how to fix it.

CENTRAL ENERGY PLANT

Steam generation at the Central Energy Plant (CEP) at Parris Island utilizes four steam boilers rated at 50,000 lbm/hr. The CEP has three 400 psig boilers that can supply up to three 1-kW extraction steam turbine generators, plus 125 psig site steam loads via a reducer. A single use, 125 psig boiler is often used to supply site steam loads during periods of low steam demand, when no electricity generation is required.

DSOM is an upgraded version of the PNNL energy software system that was originally installed in the USMC's Twentynine Palms Base Central Heating Plant. The original DSOM software was upgraded to a Windows 2000 Professional platform and Rockwell Systems Studio Special Edition display software, and the capabilities were expanded to include monitoring of steam driven feed pumps and steam turbine generators. Algorithms were expanded to include an asset manager to indicate to the operator what boilers to operate, when to start and secure boilers, when to start electrical generation, when to bring on additional generators and pumps, and when to shut them down based on peak demand penalty periods and optimum efficiency combinations. It is the software's job to ensure the operator is aware of the most efficient combination of plant equipment. The software alerts the operator if equipment is operating at a less than optimum

Level, and tells the operator what the current condition is, what it should be, and what to do to restore it. DSOM provides approximately 40 specific diagnostics for various plant and component conditions plus a similar suite of information for all warning and alarm notifications.

From the early spring to late fall, Parris Island is under severe penalties for exceeding peak power demand during the day. Integration of the DSOM, EMCS and SCADA projects at Parris Island allows for automatic load shedding and finely controlled generation activities (the steam turbine generators can provide up to 3 kW of electrical power) to make the optimum decisions as to the most effective and energy efficient way to provide energy service to the Base. The software also has the capability to provide different information to different users. For example, depending on the mode selected (the options are: Operations, Maintenance, Engineering, Training and Administration), the user is presented with mode specific information. Through the selector icon in the lower left of the display (see Figure 1) the engineer can access engineering data, an administrator will be able to access fiscal data (a financial analysis module is under development), and the maintenance man will be able to access maintenance data through an interface to a system like Maximo (under development), the USMC's current computerized maintenance management system. Refer to Figures 1, 2, and 3 for typical interfaces provided.

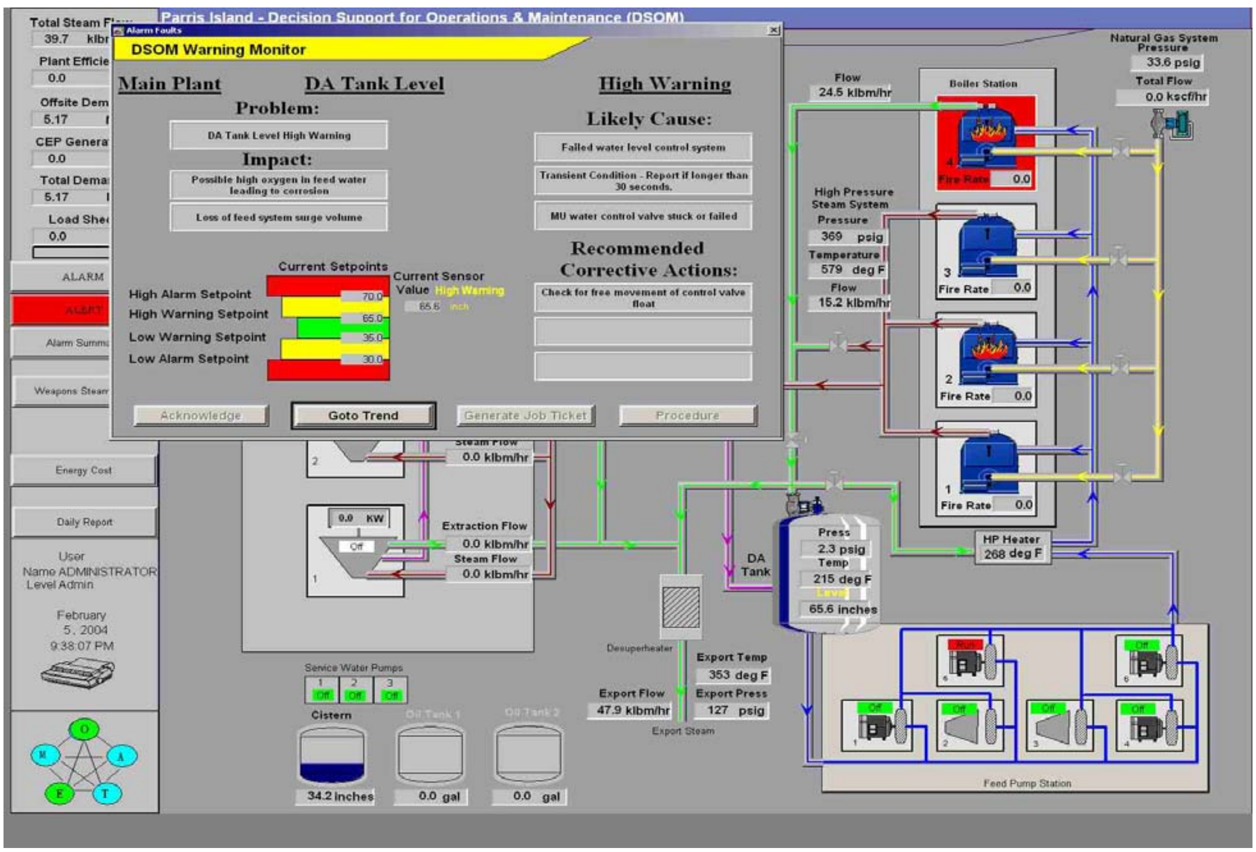

Figure 1: DSOM Diagnostic Display for DA Tank Level Alarm

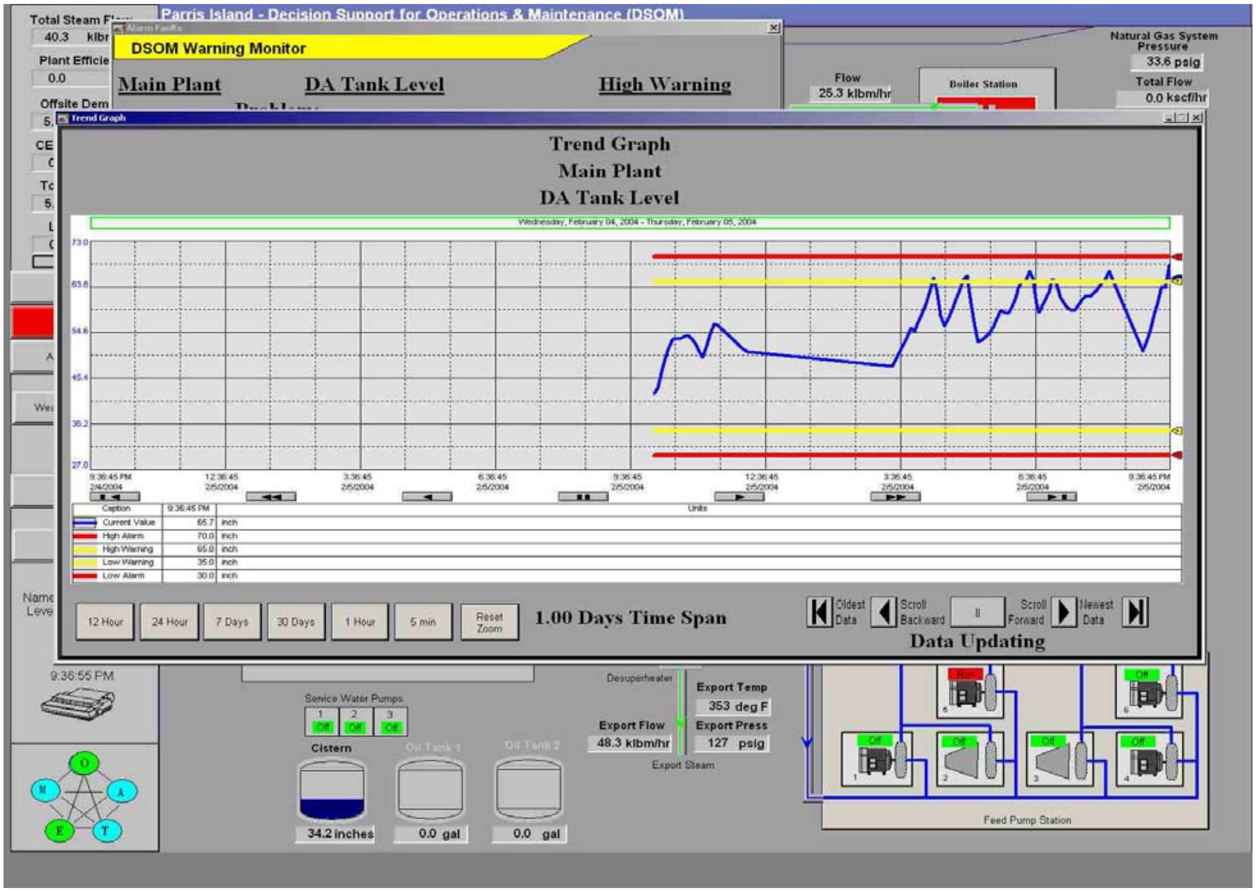

Figure 2: DA Tank Engineering Level Trend

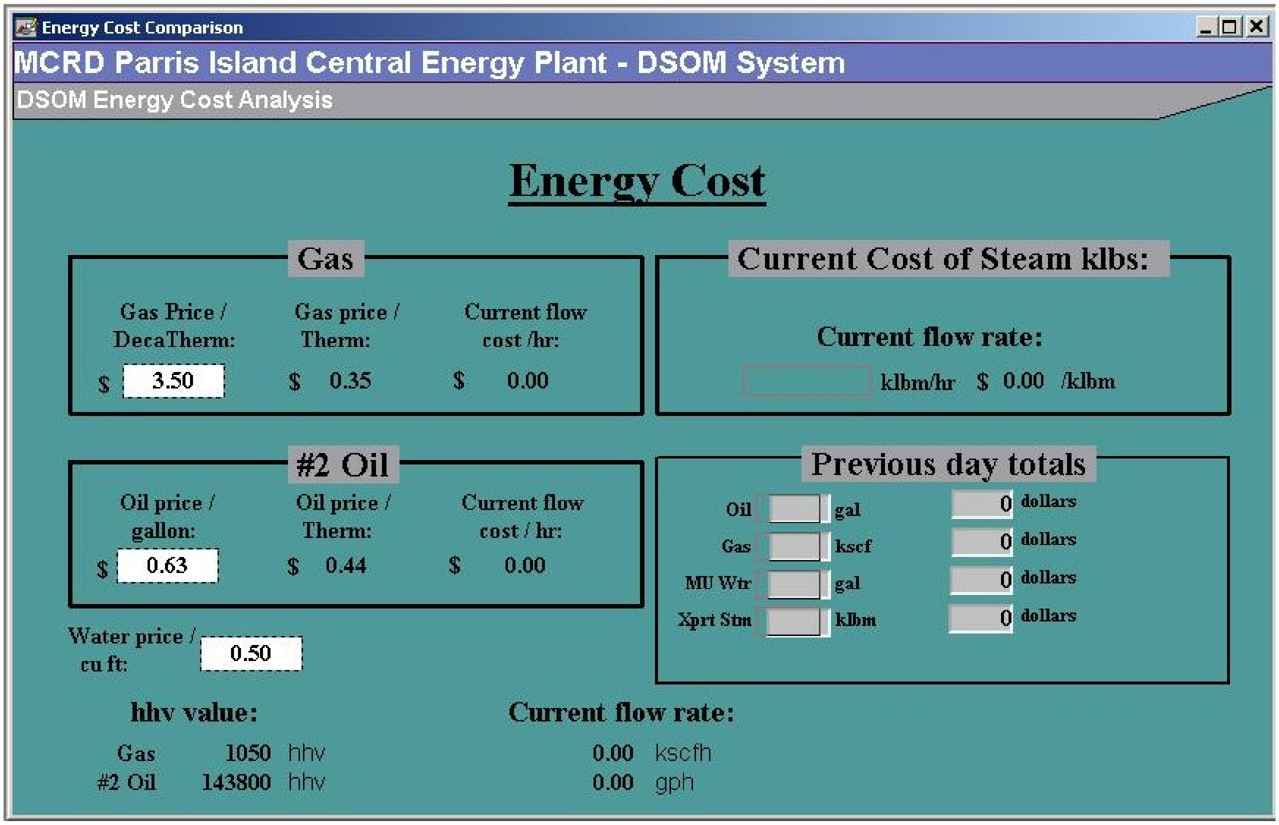

Figure 3: Administrative Energy Cost Oil vs Natural Gas

WEAPONS AREA PLANT

Parris Island boiler plant supervisors were faced with a common problem at many military installations today, a shortage of qualified plant staff to operate all their boiler plants. Part of the answer for Parris Island was to automate the Weapons Area Plant using the DSOM system and unman the plant. The Weapons Area Plant consists of three boilers that provide 125 psig steam for Weapons Area site loads. Prior to DSOM, this boiler plant was manned by one operator, 24-hours-a-day. The installation of DSOM allowed full remote monitoring from the CEP operator's office (see Figure 4) and provided remote shutdown control, allowing unmanning of the plant.

For this application, PNNL also utilized the same commercially available Windows 2000 Professional platform, Rockwell Systems Studio Special Edition, and DSOM software used at the CEP. In addition to the usual efficiency and parameter monitoring, the software can analyze and detect boiler tube leakage, boiler tube fouling, steam drum water level control malfunctions, excessive firebox heat loss, over-firing alarms and stack gas condensation alarms.

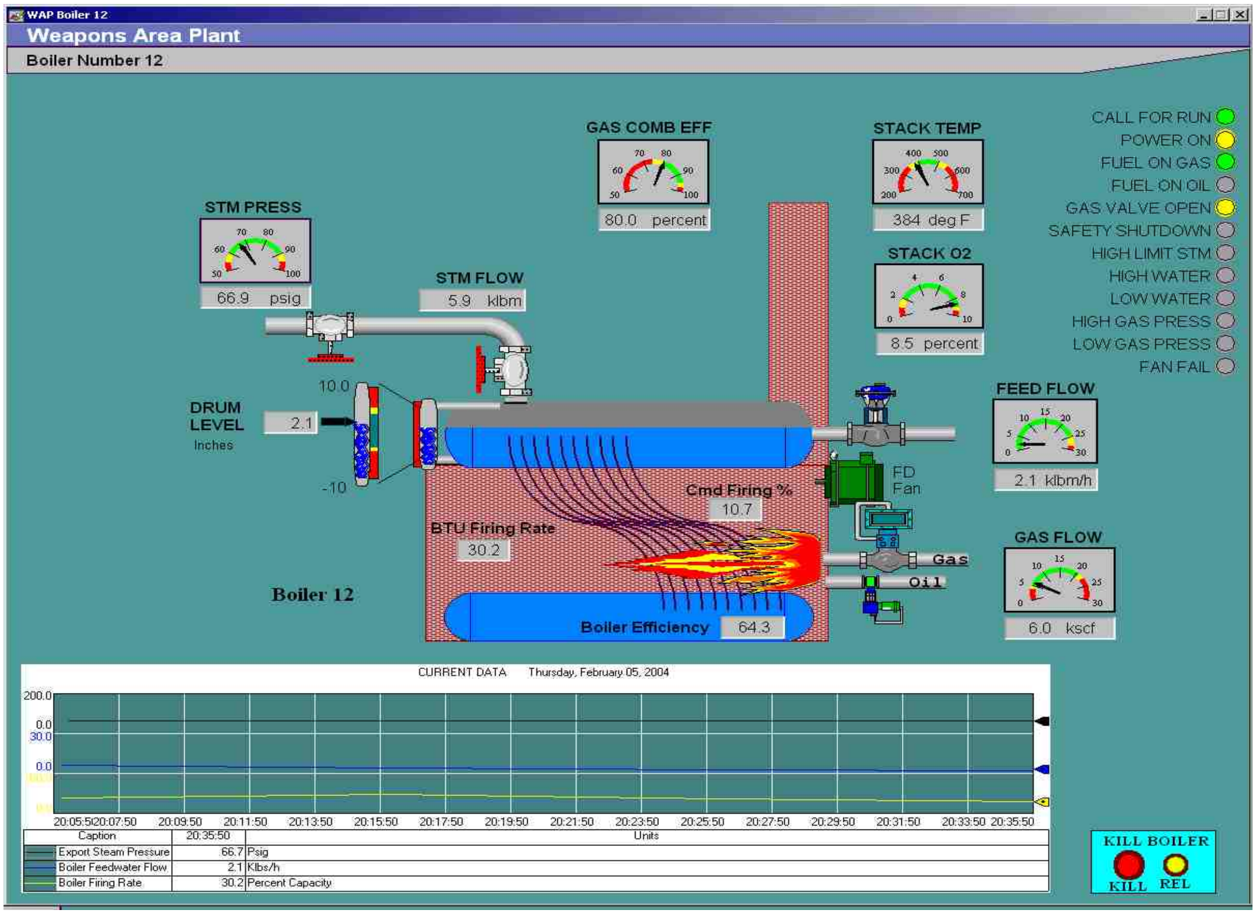

Figure 4: Weapons Area Plant Boiler 12 Display

ENERGY MANAGEMENT AND CONTROL SYSTEMS

In 2000, PNNL was commissioned to design, procure and install an energy management control system at Parris Island and at the nearby Marine Corp Air Station (MCAS) Beaufort. At Parris Island and Beaufort Air Station, like most commercial facilities over the past several years, new buildings and new or upgraded mechanical systems have been installed. These changes have been performed under several modest to large-scale projects. As each system was installed, a control system was installed independent of other control systems on the Base. Utilizing Automated Logic hardware and software, all the diverse EMCS systems were interfaced and upgraded to one supervisory system. These projects were completed in 2003.

At both Bases, energy management controls were engineered and developed to be interfaced to a site wide, open protocol system to control and manage loads from a central location. The new Parris Island Automated Logic EMCS is interfaced with DSOM and is set up to provide relief from excessive demand during peak power penalty periods. The system automatically load sheds demand by using a series of building heating, ventilation, and air conditioning control temperature setbacks. The first series of load shedding is shared equally among all the buildings programmed into the system prior to entering into the succeeding series, which overall has four stages of load shedding over 10 groups of buildings. For example, Group 1 Stage 1 will load shed first then up through Group 10 Stage 1. Then Group 1 Stage 2 will shed up through Group 10 Stage 2, and so on. The final, most severe, sequence does involve shutting down some air conditioning units completely. The load shed sequence starts when the target base load is exceeded as the central energy plant asset manager sequences generation of electricity to maintain the demand target in the most cost effective manner. The system also allows for building zone temperature set point control and utilization of occupied/unoccupied modes. Currently, demand control and the automated load shedding is applied only 8 hours a day, 5 days a week for the summer peak power demand penalty months of May through September and has been very effective in saving energy dollars.

The current Parris Island target peak set point is 8.0 MW. As can be seen in Table 1 below, the load shedding is spread out over 40 different set points over a demand range of approximately 400 kW. Building load shedding can be prioritized by assigning a building to its appropriate or desired demand group. This sequence will not allow demand load to go above 7907 kW. Figure 5 displays a typical summary screen of data available to the operator.

Table 1: Parris Island Load Shed Staging Sequence

Demand Group	Stage 1 (kW)	Stage 2 (kW)	Stage 3 (kW)	Stage 4 (kW)
1	7517	7617	7717	7817
2	7527	7627	7727	7827
3	7537	7637	7737	7837
4	7547	7647	7747	7847
5	7557	7657	7757	7857
6	7567	7667	7767	7867
7	7577	7677	7777	7877
8	7587	7687	7787	7887
9	7597	7697	7797	7897
10	7607	7707	7807	7907

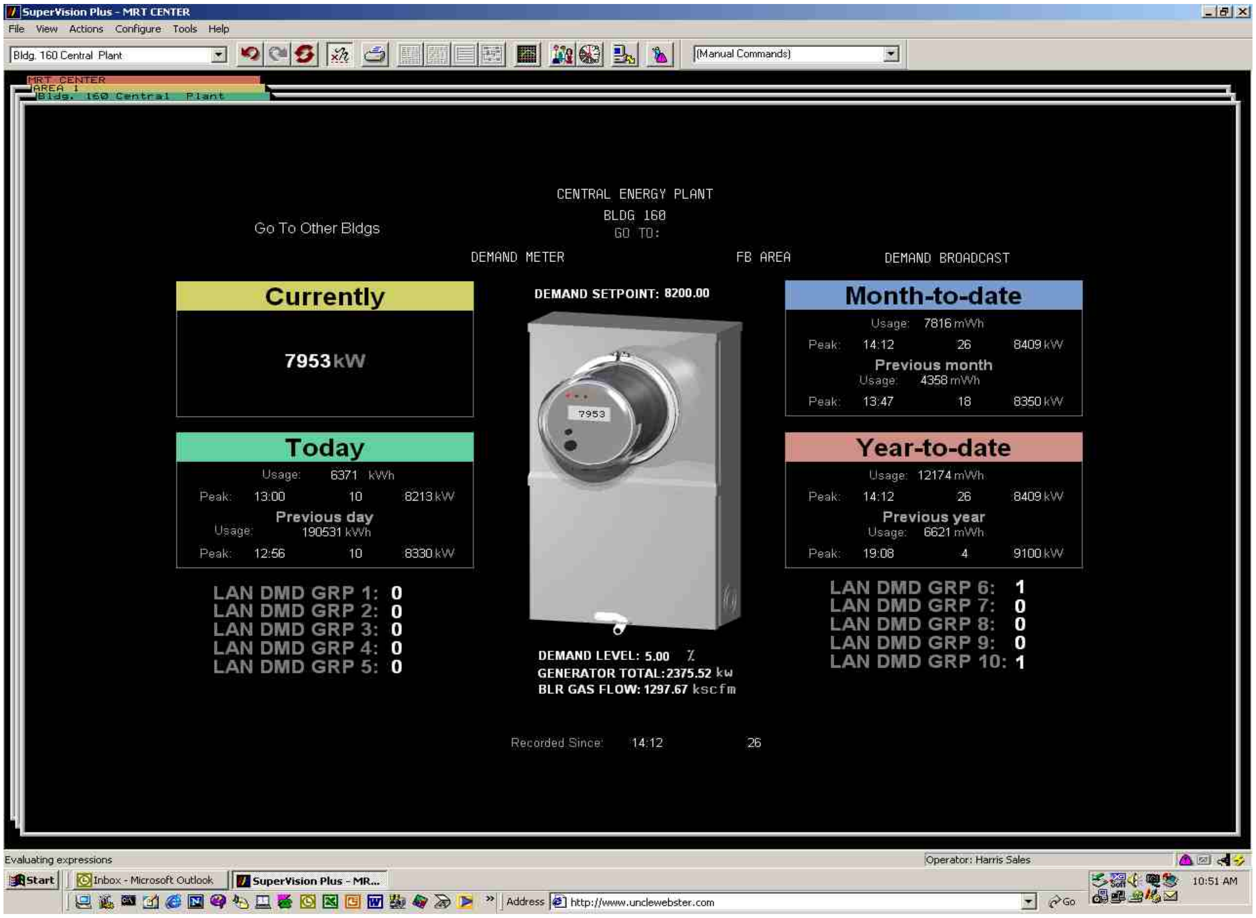

Figure 5: EMCS CEP Summary Screen of Current Load Shed Status

A load shedding scheme that would be typical of what was designed for Parris Island to actually reduce electricity consumption by setbacks is illustrated by the following actions, remembering that each one of the demand groups consists of assigned buildings. The four setback stages would be:

LAN DEMAND Stage # 1 : Resets thermostat set points out 1° F from set point and the chilled water valves stay at 100% capacity.

LAN DEMAND Stage # 2 : Resets thermostat set points out 2° F from set point and the chilled water valves close to 75% capacity.

LAN DEMAND Stage # 3 : Resets thermostat set points out 4° F from set point and the chilled water valves close to 25% capacity.

LAN DEMAND Stage # 4 : Turns main chiller off, and as a backup, closes all the chilled water valves.

The demand levels and building groups are all customer oriented and easily modified, making a very flexible system scheme that can easily be tailored to meet facility needs.

Current Parris Island Energy Conservation Depot Order 4101.C requires building cooling levels to be set at 78° F. As a result of high humidity conditions and personnel comfort for mission support, these temperature set points may be adjusted (varied) with the proper justification and permission. The Energy Controls Technician can program all load shedding groups and stages according to base load priorities. A total of 60 buildings have been brought on line as of 12/31/2003 and are controlled to reduce demand by nearly 2 MW over approximately 3.3 million square feet of building floor space.

WASTEWATER TREATMENT PLANT

The wastewater treatment facility (WWTF), with 38 associated lift stations, serves the whole military and training complex. The level of concern over the WWTF's potential for a major environmental discharge had been increasing for several years. The remote lift station control panels in the field had been failing at an increasing rate because of age, moisture penetration, and heat deterioration of the electronic packages. At any one time several of the alarm systems may have been off service. This left the waste collection and treatment facility at further risk for spills and environmental concerns. System age and resulting deterioration were reaching the point where the continuous repair costs were exceeding the replacement costs.

PNNL recommended and performed a thorough inspection of the complete system to clearly establish the baseline condition. The inspection included all wiring, sensor and monitoring devices, controllers, telemetry, and SCADA software. Assessment of this information was then used to develop a master plan for modification/ upgrade/ replacement of part or all of the control and physical system. PNNL staff designed SCADA control cabinets to be built and installed in each lift station. Instrumentation and control (I&C) systems specialists were contracted by PNNL to build, install and commission the I&C cabinets. New UL labeled weatherproof control panels were made up with Allen Bradley Micro 1000 programmable logic controllers (PLCs), power supplies, interface relays for pump monitoring, and override float operations in case of PLC failure. Communications were upgraded by including a radio communications system interface in each cabinet to establish data transmission with the main radio in the WWTF operator's office. Uninterruptible power supplies were provided in each of 33 cabinets for backup power of the control and radio links to continue monitoring during power outages.

An interface between the CEP DSOM system and the WWTF operator's office was established for alarm response and monitoring capabilities. The graphical user interface (GUI) was designed and set up by PNNL staff for simple point-and-click operation by the WWTF operators. An administrative level of security was established to allow supervisory personnel the ability to change pump automatic switchover set points and level alarm set points from the WWTF operator's console. All the lift stations and their associated alerts and alarms are accessible from one main screen display (see Figure 6).

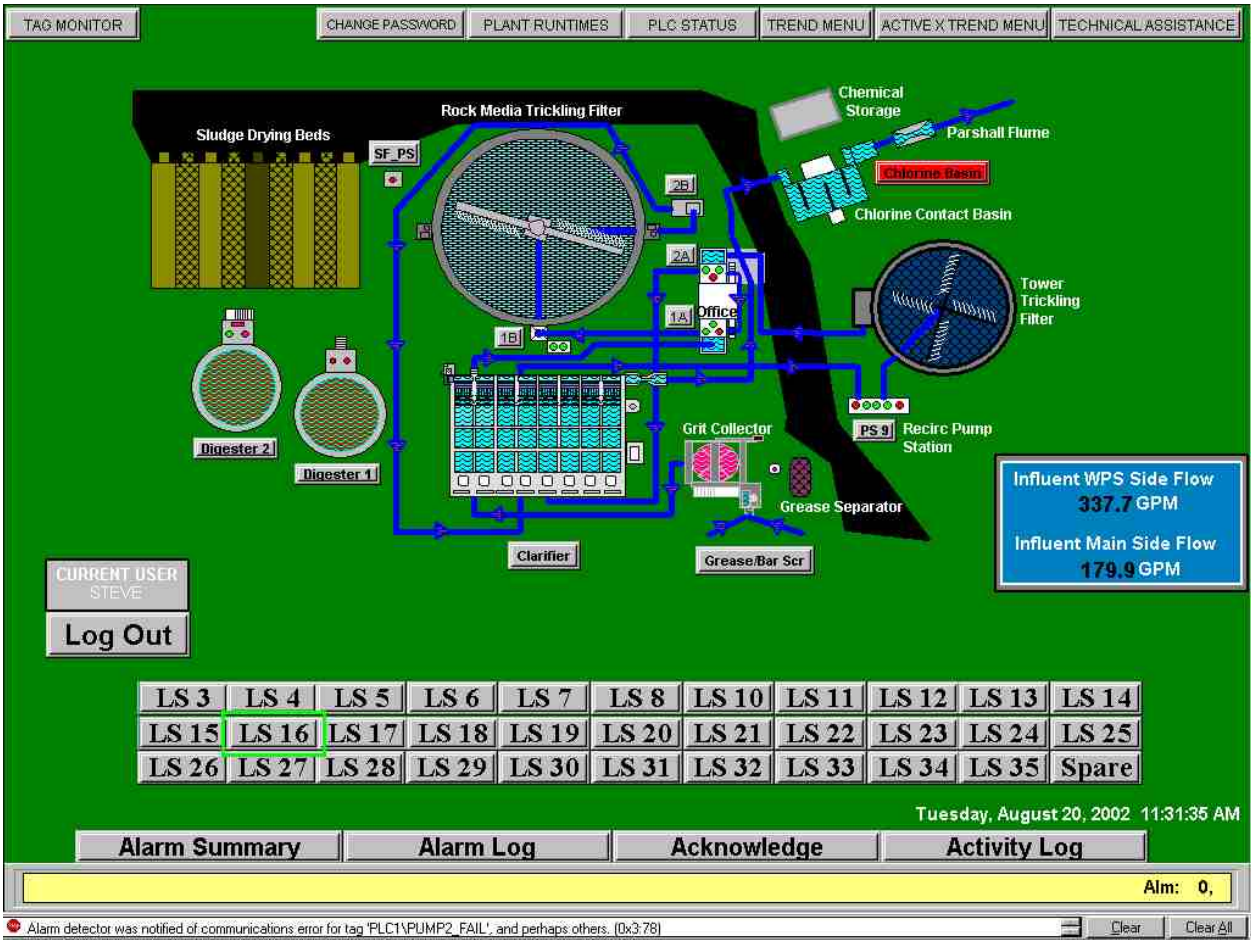

Figure 6: Wastewater Treatment Plant Main Screen Display

Each lift station is represented by a graphic depicting sump level, pump status, communications status, and remote generator status under loss of power conditions. The software provides the operators with the ability to trend data, manually start and stop pumps remotely, and change the auto mode sequence for automatic pump start and stop operations. With the supervisory access activated, supervisors can change alarm points, auto pump start and stop points, and level control set points through a simple-to-use set points interface screen (see Figure 7). Through active X trending capabilities, operators can easily examine trend data on all values monitored, such as run times, pump amperage, and pump capacity.

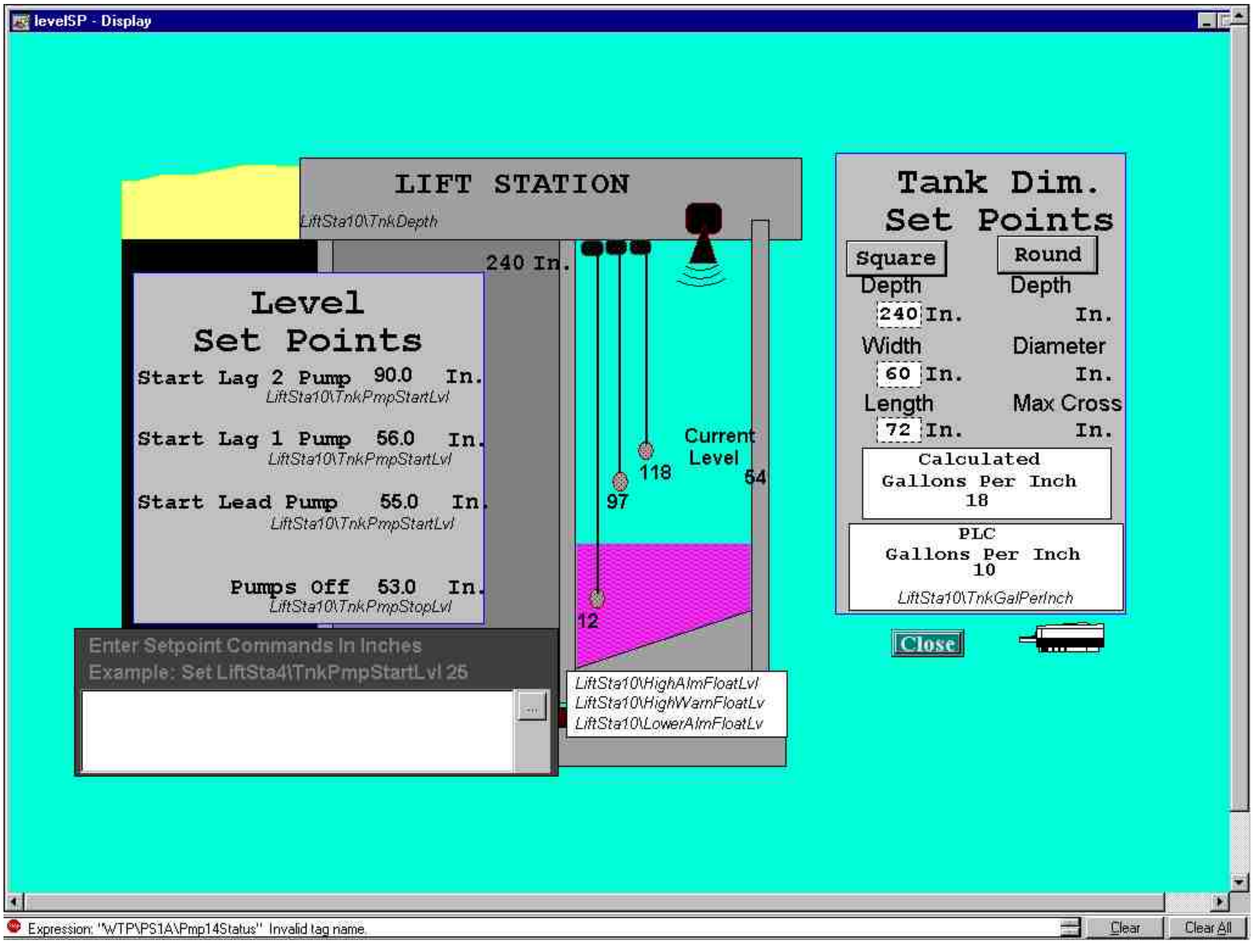

Figure 7: WWTF Lift Station Setpoints Screen

ENERGY SAVINGS SUMMARY

After extensive evaluation of the Defense Utility Energy Reporting System (DUERS), Utility Cost Analysis Reports (UCARs), energy bills, and other resources the following energy savings can be calculated from the data. DUERS data was used energy cost information, and housing data was not included.

The DSOM system went operational in March of 2000. For the preceding 3 years, various evaluations and characterizations, and instrument and equipment upgrades at the Central Energy Plant and Weapons Area Plant were in progress. To determine a baseline year in the physical sense, FY 1999 was the last full year in which no new energy conservation systems were on line. Therefore, for the purposes of energy savings calculations, FY 1999 has been determined to be the baseline year. The EMCS upgrades project has had an impact on FY 2001 and FY 2002 energy savings.

The best metric of energy usage is British Thermal Units (Btu) per square foot (sqft) per degree day (dd). This is because Parris Island is in constant flux on energy cost, demand charges and even changes in square footage.

Energy use per square foot went from 51.06 Btu/sqft/dd in the base year of FY 1999 down to 45.73 Btu/sqft/dd in FY 2002. This is a reduction of 5.33 Btu/sqft/dd or a 10.4% reduction from the base year. This can be attributed to DSOM and EMCS activities resulting in coordinated energy control at Parris Island. Assigning dollar values for avoided cost to this reduction is much more difficult to due because of price fluctuations from month to month. Using cost averaging from a monthly basis, the numbers are as indicated in Table 2 below.

Table 2: Btu/sqft/dd Reduction Chart – Energy Dollars

Fiscal Year		Btu/square foot/degree days		Reduction from Baseline		$ Saved
1999		**51.06**				
2000		**49.90**		1.16		$94,761
2001		**46.82**		4.24		$293,501
2002		**45.73**		5.33		$513,491

As of the end of FY 2002, savings total $901,753 dollars from the base year of avoided cost in energy only. When additional credit is taken for labor savings (Parris Island has had a net reduction of 8 FTEs because of the DSOM related work), a further reduction of $368K per year would apply starting in FY 2002 when the majority of the manpower reductions were realized. The jump in reduction the last 2 years can be attributed to EMCS load shedding and close coordination between the DSOM system and EMCS control capabilities. The avoided cost of $513K for FY 2002 corresponds to a 10.4% energy dollar savings for FY 2002 and a total labor and energy savings for FY 2002 of $881K (see Figure 8) for a 3 year total of $1.3 M.

In the similar EMCS only project at MCAS Beaufort, installation of the PNNL engineered EMCS system has saved them over $2 M over the last 3 years on a $2.6M investment.

These projects demonstrate that the integration of new technologies engineered to provide a facility-wide approach can have a significant impact on energy and personnel savings.

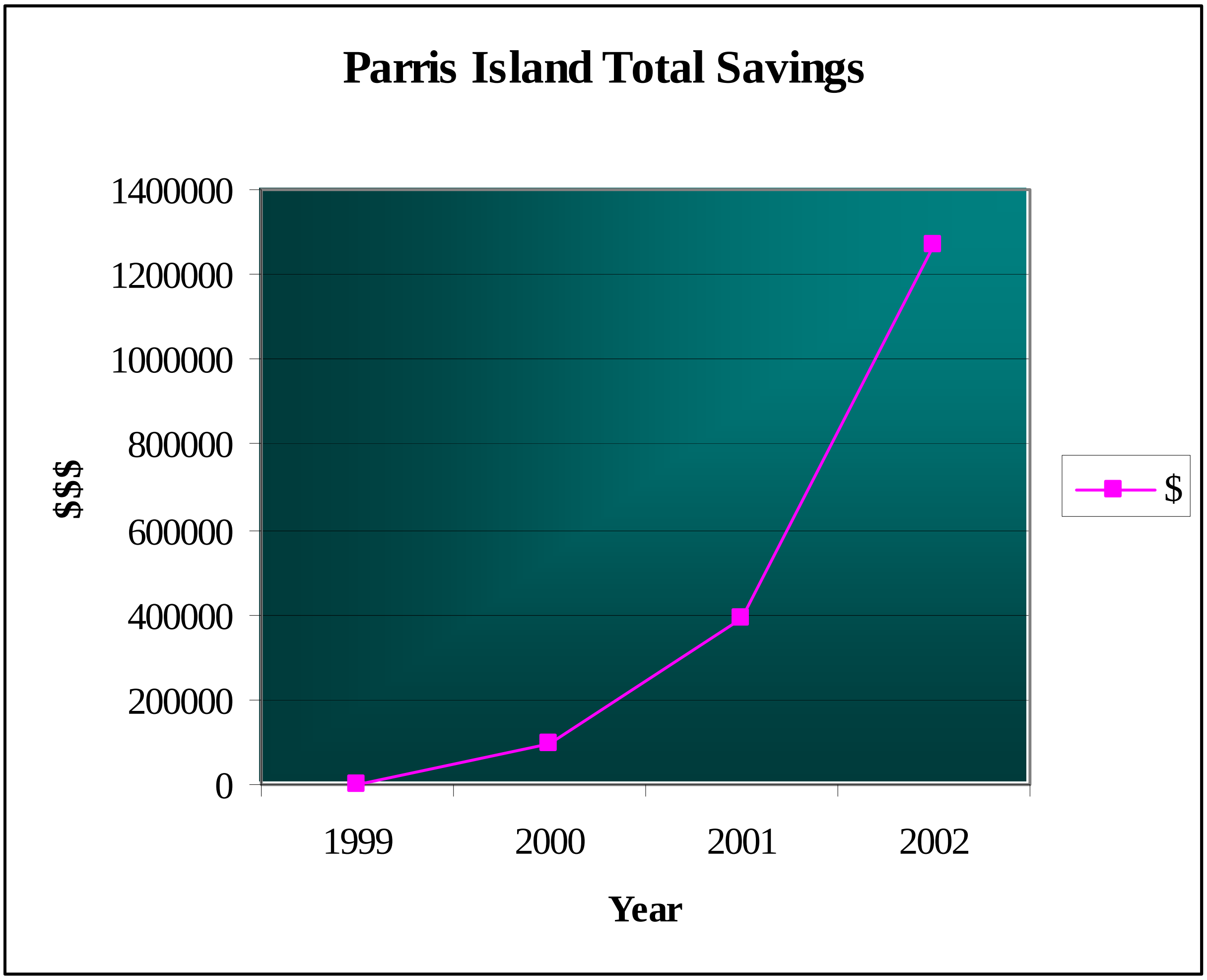

Figure 8: Energy and Labor Savings Graph at Parris Island