Matching Building Energy Use to Requirements and Occupancy

NAS Whidbey Island Ensures Energy Use Correlates with Energy Demands

PERSONNEL FROM NAVAL Air Station Whidbey Island (NASWI) in Washington State, led by Chris Taylor, Installation Energy Manager, saved over $500,000 (10.5 percent) in 2013 in energy costs, largely due to matching heating and cooling loads to actual building occupancy.

The Air Station, home to over 9,000 sailors, civilians and contractors occupying more than 280 buildings and 3.9 million square feet, was tasked with reducing utility bills by 10 percent base wide to meet Sequestration budget constraints during the period April through September 2013. They exceeded this goal by employing the following methodology:

- Identifying prospective users and matching claimed occupancy to actual occupancy.
- Using advanced metering infrastructure (smart meters) to construct building and base load profiles and measure progress.

Background

In March of 2013, naval leadership directed that due to Sequestration's significant budget cuts, utility costs would have to be reduced significantly. NASWI has the primary mission of supporting 21 aviation squadrons as well as an aviation intermediate maintenance depot and an ocean processing facility. The ocean processing facility operates much like a data center providing maritime surveillance.

NASWI has a strong energy and water conservation program in place, having won five Secretary of the Navy Platinum and four Gold awards for Energy and Water Conservation. Having achieved Energy Independence and Security Act (EISA) of 2007 goals early, NASWI sits at 37.6 percent below the energy baseline and 51.0 percent below the water baseline. A small city itself, it also supports training facilities, data centers, bachelor housing, dining, shopping, recreation, facility maintenance, a steam plant and a small hospital. Annual energy usage for the Air Station is about 460,000 million British Thermal Units (MBTU) and 88 million gallons of water. This does not include family housing—a privatized venture located about three miles away. Annual energy costs are approximately $4.9 million.

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Navy Culture

As a military installation, all active duty squadrons and many facilities work on the assumption that 24 hour operations may occur at any time. With all support services provided by a single large contractor, many tenants believe that once heating, ventilation, and air conditioning (HVAC) controls or temperatures are changed, they can never be reset (actual response time is two hours). This builds a culture with a common belief that one should keep a building warm/cool/ready with the lights on "just in case." In actuality, 24/7 operations are rare or sporadic. The first lesson was discerning the difference between "24/7 Operations" versus "24/7 Capable." A building that is occupied only during a normal "work week" of 40 hours is actually empty 77 percent of the time.

Facilities that do run actual 24/7 operations are comparable to data centers. Working from the old paradigm that computers need to be really cold to prevent failure, these facility managers keep their buildings as cold as allowable. Again, with no bill, and an evaluation that is based on the productivity of electronics, the mindset is to run the HVAC as cold as they can. One flight simulator building was kept at 59 degrees Fahrenheit (°F), when specifications called for an operating range of 65 to 75°F.

The Navy uses an internal working capital fund, charging a burdened rate to tenant command customers, utilizing the differential cost to fund utility sustainment, restoration and modernization efforts. While tenants are charged for utilities consumed, almost no one in the command sees "the bill;" perhaps only a financial management person at a separate location. NASWI's total annual utility budget is approximately $9.2 million; from this NASWI's share in the reduction effort was $570,000. With six months of the fiscal year in the rear view mirror, finding another 10 percent reduction in consumption would prove to be a formidable task.

Top 10 Facilities with Highest Raw Consumption

Facility ID	No.	Name	MBTU Usage
NFA100000840192	2547	FRC Facility	1,897.2
NFA100000837259	382	Admiral Nimitz Hall	1,237.8
NFA100000847943	2700	Naval Ocean Processing Facility	1,093.5
NFA100000839854	993	Hospital—Oak Harbor	940.0
NFA100000839630	976	Aircrew Systems Training Building	925.0
NFA100000837945	410	Maintenance Hangar 6	901.6
NFA100000846864	2593	Electronic Attack Simulator	791.2
NFA100000847952	2701	BRKS 13 (Mt. Rainier Building)	777.6
NFA100000848381	2738	Flight Simulator Building	701.6
NFA100000848452	2742	Commissary Store	636.0

The Methodology

In 2012, NASWI installed 493 Advanced Metering Infrastructure (AMI) smart meters allowing program managers to profile a building's utility consumption. These meters in turn aggregate data in the working capital fund's billing program called CIRCUITS (for Centralized and Integrated reporting for the Comprehensive Utilities Information Tracking System) as the central database for utility information. CIRCUITS also feeds a component of the Navy Geospatial Portal called NSGEM (for Navy Shore Geospatial Energy Module). These three tools allow Navy energy managers to examine consumption characteristics from a macro to micro level. Both NSGEM and CIRCUITS allow users to rank facilities by total energy consumption, and CIRCUITS allows users to rank individual commodities such as steam or electricity. A portion of this report is shown above. NSGEM produces a "Heat Map" based upon the facility's energy intensity measured in MBTU per thousand square feet (KSF). (See figures on the following page.)

Given that only the late spring and summer months remained to realize the utility reduction, NASWI personnel knew that only minimal savings could be had from steam heating cutbacks or efficiencies. Changing to a summer heating schedule four weeks early and setting building thermostats to a maximum heating temperature of 66°F saved $175,000 in the first month; after that, the steam was effectively off except for minimal domestic hot water production.

Since the majority of natural gas for the base was used for steam production and hangar bay heating and both of these uses were severely curtailed for the remaining portion of the fiscal year, NASWI personnel shifted their focus to electricity consumption.

Based upon examination of NSGEM and CIRCUITS ranking data, NASWI personnel discovered that the top 10 facilities at NASWI consumed 45 percent of the total electricity for the base. Although the examination of AMI meter data is both tedious and time consuming, it provides excellent resolution about a facility's energy use patterns and nearly immediate feedback on the impact of energy conservation measures.

Using CIRCUITS rankings to isolate the top 10 electrical users allowed NASWI personnel to avoid wasting time on AMI meter data for facilities that could not significantly contribute to the $500,000 goal.

NSGEM "Heat Map."

Building 2547—The Number One Consumer

The Fleet Readiness Center (FRC) is an aviation intermediate maintenance depot that provides spare parts for NASWI based aircraft. This industrial center works on such things as:

- Avionics and armament (the "600 Division")
- Open bays, tires, jet engines (the "400 Division")
- Ovens, welding, and paint booths (the "500 Division")

At 187,000 square feet, the FRC consumes 10 percent of the base's electricity.

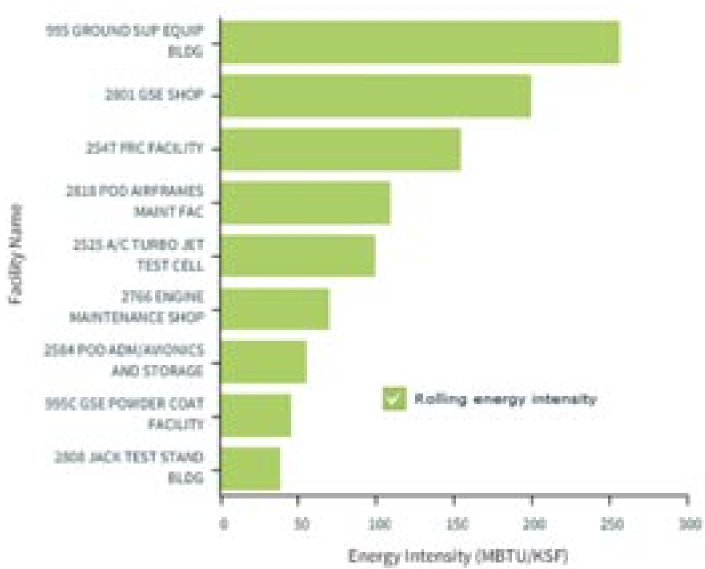
NASWI personnel examined the AMI data from four meters placed on the building; two on the 600 Division and one each for the 400 and the 500 Divisions. Large HVAC loads drive consumption for the 600 Division, keeping avionics test benches cool. The avionics test benches repair aircraft electronics that are normally (in an operational environment) cooled by the very cold air of the upper atmosphere flowing through the aircraft. To test repairs on these equipment on the ground, large amounts of cold air are forced over them. These four AMI meters provided 15 minute interval data on electrical usage for each of the divisions.

The next step was to interview building tenants and facility managers to determine actual occupancy and shift times, as well as any special needs. Questions about cooling needs and operating times were met with fear and sometimes anger. "I'm not changing anything that would affect production," said one warrant officer. Others cautioned, "Don't touch the cooling system. We need this eight-degree buffer or the machines will shut themselves down!"

Any potential changes to cooling temperatures or schedules were initially met as a threat to production levels and equipment reliability, even when they weren't there. A night time audit of the 400 Division showed temperatures of 72°F on Sunday morning at 1:00 am. Interviews with 600 Division workers determined that circulation fans and pumps ran all weekend to no useful end.

Once the actual work schedule for different parts of the building were mapped out, these schedules were programmed into the control systems by the HVAC technicians. Changes were also introduced slowly over a course of weeks. Building loads were monitored using the AMI smart meters to determine building use at 15 minute intervals.

Energy Intensity by Building Type

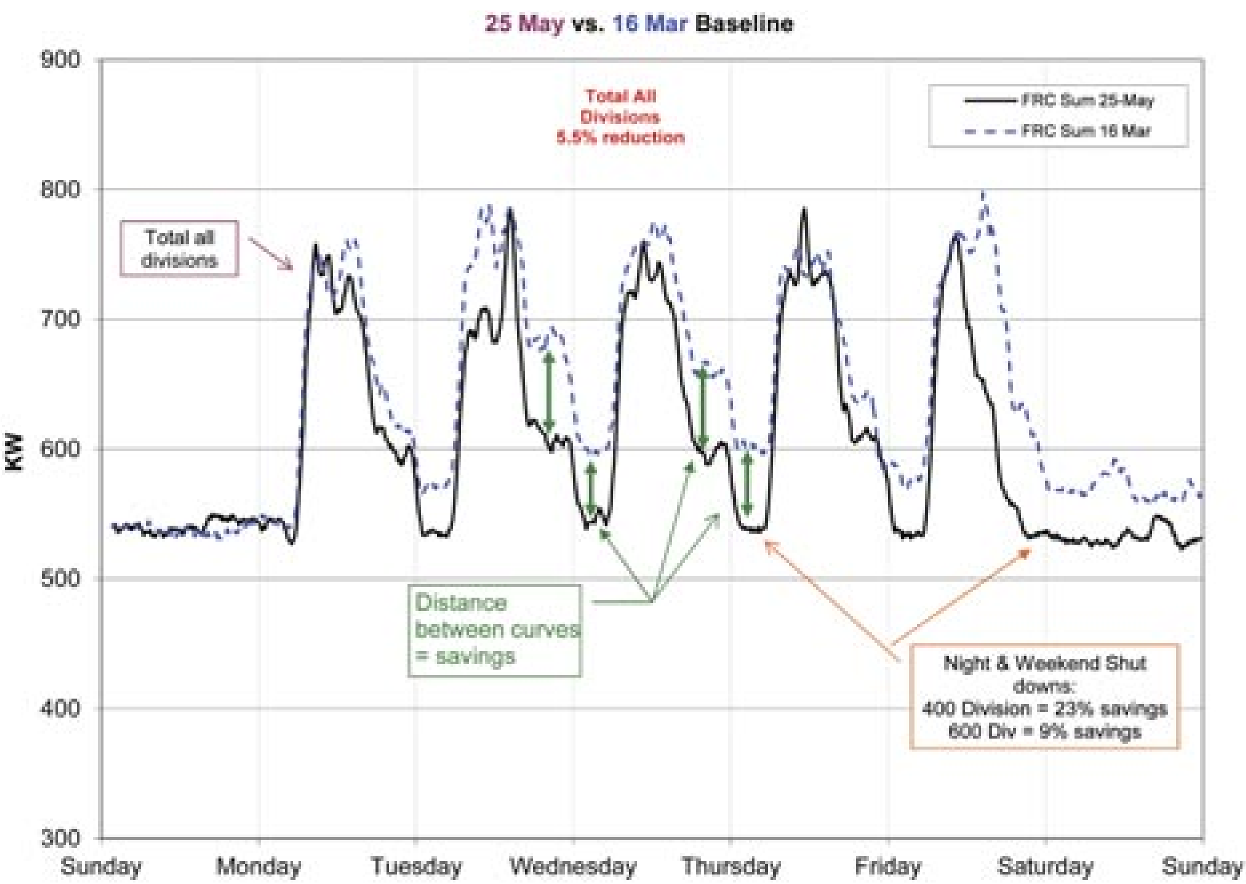


The effect of matching actual building occupancy to HVAC scheduling can be seen in the graph below. Building load in kilowatts is shown on the vertical axis while time of day for one week is shown on the horizontal axis, beginning with midnight on Sunday. Vertical grey bars depict midnight. A baseline week of 16–22 March 2013 is shown in blue, and the comparison week of 25–31 May 2013 is shown in purple. Monday 27 May 2013 was Memorial Day, but HVAC schedules were not changed.

FRC building and divisions.

The heating degree days for both weeks were approximately the same. Reduced energy usage can be seen nearly each night beginning at midnight and lasting about six hours. This was the result of staff interviews which determined that circulation fans and pumps were running needlessly. Previously, building tenants reported shift work that ran each night until midnight for the entire building. Interviews determined that this was actually only occurring in the 600 Division, in a few rooms, Monday through Thursday. Tailoring the HVAC system to meet just the needs of those rooms on those nights further reduced energy usage. This can be seen in the differential between the blue and purple lines just before midnight. Substantial savings were found when it was determined that there was no Saturday shift. Again, the mindset was to report the shift work occurring every weekend to the support contractors who schedule the HVAC systems on the chance they may need space conditioning in the future.

FRC Hourly Energy Usage—Total Progress



Lastly, follow-up with building tenants is critical to ensure that any future changes are met with acceptance. Here, changes were well timed. When meeting with one manager after several weeks of the implemented efficiency measures, he asked "When will you start making changes to the cooling system?"

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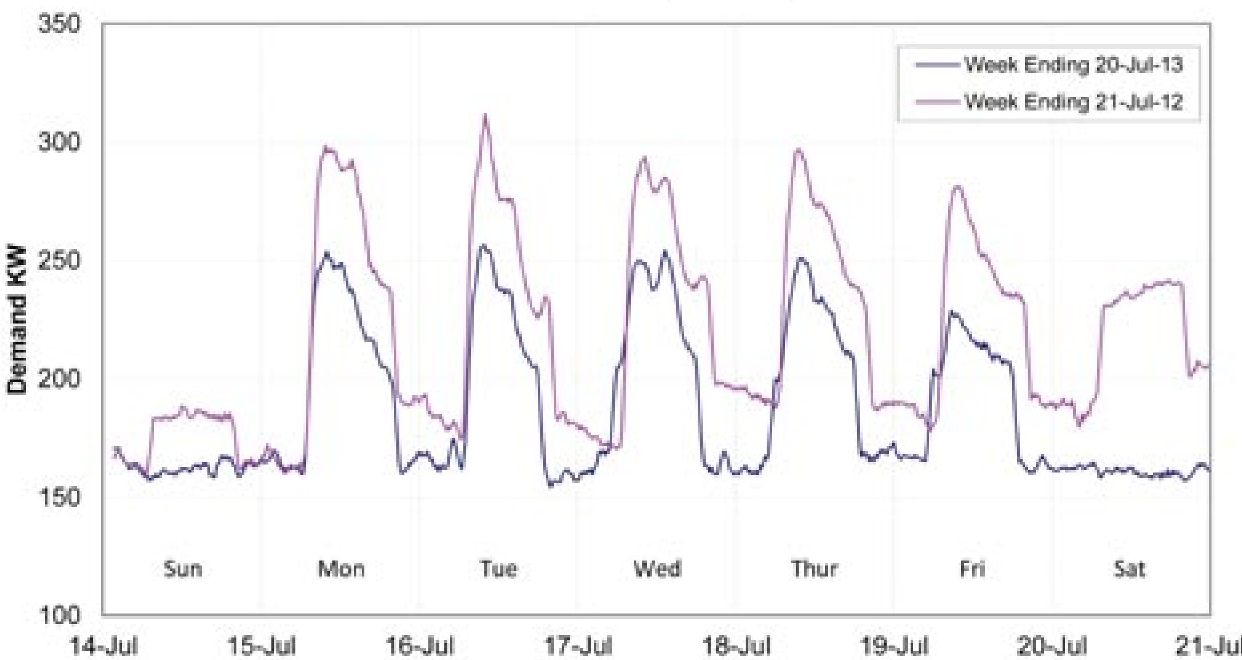
Aircrew Maintenance Training Facility, Building 976

Similarly, building 976, a 97,000 square foot maintenance training facility, has mixed aircraft maintenance training classrooms and conventional classrooms.

This building was identified as a top ten energy consumer through the CIRCUITS program. NASWI personnel researched the existing load profile through the AMI smart meters. Knowing the building had a complex HVAC system with loads that varied throughout the building, NASWI personnel toured the spaces with the facility manager. Again, interviews indicated that building occupancy was reported on the expectation that in the future, there would be a need for heating/cooling in the evenings or weekends. Occupants were asked when they held classes, which rooms and wings were occupied and where classes were held. Immediate answers were that they held classes until 2300 every night and on Saturdays. Additional questions revealed that this really meant they sometimes held classes after hours and sometimes on Saturdays, but that the next one might be scheduled in November, four months later. It was also discovered that one of the rooms with avionics test benches that had a high cooling load was rarely being used and that the room was about 20 degrees colder than the temperature control requirement for automatic shutdown. The information gathered from these interviews was used to adjust the HVAC systems to match the needs of the facility more precisely, tailoring the time schedule to meet class needs and cooling the test bench rooms only when classes were using them.

The graph below shows the effects of these adjustments. Building load

Effect of Occupancy Matching at Building 976



Building 976 aircrew systems training.

If you're doing it right, nobody notices.

–Chris Taylor

in kilowatts is shown on the vertical axis and days of the week are shown on the horizontal axis. Load profile data from 2012 are shown in blue and 2013 data are shown in purple.

HVAC technicians also reduced the night time fan loads. Note the reductions for the weekends. These had previously been scheduled because (in effect) the tenants might have classes. Daytime peaks are reduced due to temperature changes and shutting off areas not occupied. Note also the night time reductions on the graph.

While the daily temperature was on average two degrees warmer in 2012, additional analysis indicates that the HVAC cooling loads are relatively independent of small temperature changes of this scale. On Monday 15 July 2013 the high temperature was 64, while two days later on Wednesday the high was 75 and yet the maximum demand remains within one to two kilowatts (kw). Additionally, between 2012 and 2013, NASWI personnel implemented a lighting retrofit that would account for about 18 kw in the daytime.

Follow-up with building tenants again showed no adverse effects from the adjustments to the heating and cooling schedules. Similar savings continued on subsequent weeks and months.

Conclusions & Lessons Learned

Matching building heating and cooling to actual building occupancy was shown to significantly increase energy savings. With today's tight budget constraints, gone are the days of "leaving the lights on." While the analogy to lighting is there, the impact of HVAC systems running silently in the background when no one is there is much more significant and costly. Here NASWI personnel developed a methodology to more closely match the needs of the user to the capacity of the system—methodologies that are applicable to other military installations, university and corporate campuses.

Summarizing the methodology employed at NASWI:

1. Use campus wide utility applications to determine the most significant energy users. Heat maps and energy rankings provide direction.
2. Profile the significant facilities to determine existing use patterns, equipment inventory, tenant operational use requirements and special needs. Smart meter data should be used to develop a baseline energy use profile.
3. Meet with facility managers and HVAC system technicians to match up existi77ng needs on a zone-by-zone basis to HVAC system programming.
4. Implement setback schedules according to the needs of the facility users, matching system utilization as closely as possible to the current schedule.
5. Verify that system changes are making an impact via smart meter data comparison to the baseline data, being careful to account for additional variables such as weather and significant building use patterns.
6. Follow up with tenants to ensure system changes are not impacting mission operations or production levels.

And, according to Chris Taylor, "If you're doing it right, nobody notices." ⚓

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