ESTEP Project Studies Data Center Smart Metering Technology

Effort Targets Large Energy Users for Greatest Efficiency Returns

WITH FUNDING PROVIDED by the Office of Naval Research's (ONR) Energy Systems Technology and Evaluation Program (ESTEP), researchers from the Space and Naval Warfare Systems Center, Pacific (SSC Pacific) are evaluating the effectiveness of a number of energy-saving measures, including smart metering technologies, to minimize the energy consumption of some the Navy's biggest single energy users—data centers.

Data Center Energy Usage

Data centers, or facilities that house computer systems and associated electronics, use a disproportionate amount of energy to run and cool the equipment. Today's commodity servers can handle staggering loads using the same power that a run-of-the-mill desktop computer would have used ten years ago. But a side effect of this increasing efficiency in computation is increasing power density—a server today generates substantially more heat per unit volume than a typical server from ten years ago. In fact, data centers often use 100 times more power than typical office buildings.

Of the roughly 1,000 buildings at Naval Base Coronado, three buildings (a data center and two industrial buildings), account for more than 20 percent of the entire base's total power. This means that data centers are particularly good targets for energy efficiency technologies, because making a small improvement in one or two locations can have a significant effect on a base's overall energy bill.

Evaluation of Smart Metering Technology

To tackle this issue, the SSC Pacific project team tested and evaluated a type of data center smart metering technology. Currently, data centers in the Navy have minimal metering of their consumption, individual component usage, and growth trends. In terms of cooling, little information is readily available regarding the effectiveness and efficiency of the cooling systems currently in use. A smart metering system would automatically monitor these variables.

The SSC Pacific project team, initially led by Dr. Daniel Grady and now led by Christine In, evaluated a type of smart metering called Data Center Infrastructure Management (DCIM). This technology tracks and monitors all of the physical assets in a data center, including the power consumption of servers, the room temperature—even the locations of network cables are recorded and logged in DCIM software. This software allows operators to get detailed measurements of how well the data center is performing and make changes to improve that performance. One of the most important functions of DCIM is to gather real-time measurements and asset data into consolidated metrics that provides a high-level picture of how the data center is doing energy-wise.

A 2013 survey by Uptime Institute reported that 83 percent of surveyed commercial data centers had already adopted DCIM. Prior to the SSC Pacific team's evaluation of DCIM, there were no Department of the Navy data centers using this technology. The project team's investigation turned up two primary reasons for this:

1. Navy data center operators and managers don't have visibility of

individual contributions into centralized energy bills and so they don't have a strong incentive to reduce energy consumption.

2. DCIM technology introduces several new security risks. These security risks were evaluated by the SSC Pacific team during the two-year project.

Date Center Infrastructure

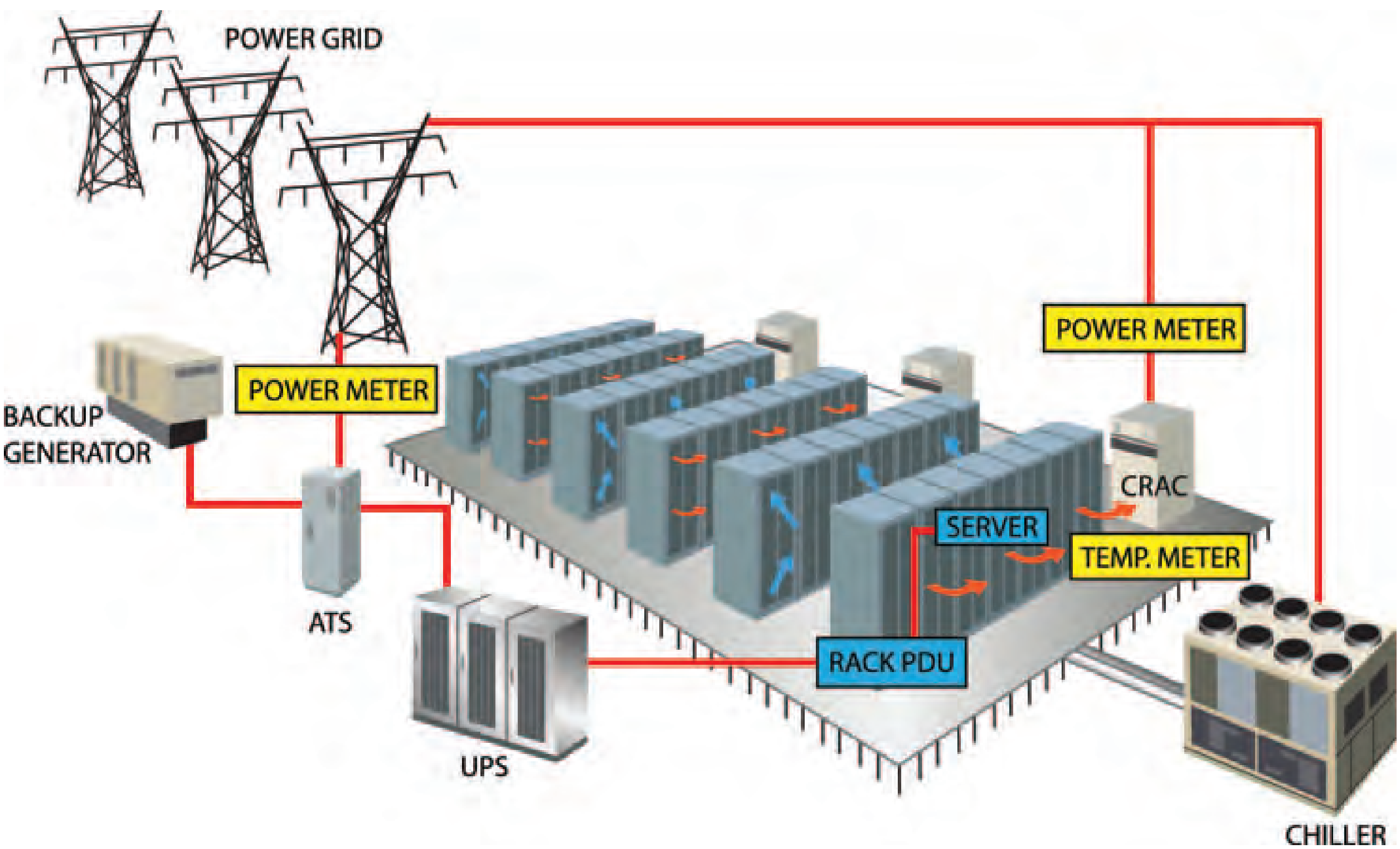
To understand how DCIM works, it is first necessary to understand data center infrastructure and systems. The data center consists of three primary systems:

1. Information Technology (IT) systems
2. Cooling systems
3. Power distribution systems

IT hardware consists of servers, Storage Area Networks (SAN) that store data, and network equipment that communicates between the systems and the internet or intranet. Because systems are moving toward cloud computing, an individual data center often does not have complete control over the software applications they support (such as the ability to put equipment in sleep mode).

Data center cooling systems are traditionally based on distributing cool air to the computing equipment so that hot air circulates away from the server. The power distribution system provides power to both IT equipment and cooling systems.

DCIM technology includes hardware sensors to monitor performance data, and software to collect this data, track physical assets, compile performance reports, and help plan capacity expansions. The SSC Pacific team evaluated different hardware meters and energy management software in a laboratory environment and demonstrated different options and configurations to stakeholders at the San Diego Data Center. The San Diego Data Center



Data center configuration with DCIM monitoring points. The Automatic Transfer Switch (ATS) is for transferring the system to battery power, the Uninterruptible Power Supply (UPS) ensures continuous power during switchover, and the Power Distribution Unit (PDU) distributes power from the building to system components.

provides web-based business and operational application services to the Navy and Department of Defense.

One major issue is that energy management software often assumes that it will be able to use temperature and power meters that are built into most modern servers, meaning that the energy management software has to reside on the same network as the server. In an operational military data center, this is a major security risk. Another concern was that modern servers and the power distribution units that they plug into usually provide a means to cut server power via software commands sent over the network—another big risk. After these and other similar issues were identified in laboratory testing, the team developed a mitigation strategy to ensure that the DCIM software would be isolated to a non-operational network (meaning that it would not directly access power and temperature meters built into servers), and the new power distribution units would not be capable of switching off power.

The project team chose a vendor to install new, metered power distribution units for a portion of the San Diego Data Center. The DCIM software solution (developed by Datacenter Clarity) resides on SSC Pacific's research and development network. This has allowed the project team to work with the vendor to identify and patch information assurance issues and take the first steps towards achieving a full accreditation, which involves several additional months of rigorous security screenings and adjustments.

The San Diego Data Center now has, for the first time at a Navy data center, an operational DCIM pilot program that is logging performance data from server racks, room temperature and humidity sensors, air conditioning equipment, and the power distribution infrastructure. This allowed the SSC Pacific team to measure the data center's Power Utilization Effectiveness (PUE) in real time. PUE is a measurement of what

The Basics About the Energy Systems Technology and Evaluation Program

ESTEP FOCUSES ON energy technologies that reduce costs, increase energy security, and ultimately increase the reach and persistence of the warfighter. ESTEP seeks to identify viable emerging energy technologies, obtained for the most part from open-market sources and in-house government demonstrations. Technologies identified as promising by ESTEP will be demonstrated, and data will be collected to evaluate the performance and reliability of selected technologies under various environmental and operating conditions. The entire program encompasses the following investment areas:

- Cyber and Energy Management for Information Systems
- Power and Energy Components
- Power and Energy Production/Efficiency

Established in fiscal year 2013, ESTEP casts a wide net across the Department of the Navy, academia, and private industry to investigate and test emerging energy technologies at Navy and Marine Corps installations. At present, ESTEP conducts nearly two dozen in-house government energy projects, ranging from energy management to alternative energy and storage technologies. Additionally, an ESTEP Broad Agency Announcement has awarded several contracts to industry in those same energy areas.

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In addition to testing and evaluating performance and reliability of energy technologies, the ESTEP program provides mentoring (via on-the-job training and education of interns) and other workforce development opportunities by partnering with the Troops-to-Engineers program for veterans at San Diego State University and other universities. Workforce and professional development are key components of ESTEP and integral to the success of executing and transitioning energy technology projects at naval facilities.

ONR provides funding and oversight for ESTEP, and program management is being handled by SSC Pacific. The Naval Facilities Engineering and Expeditionary Warfare Center and the Naval Postgraduate School are executing selected research projects, and every project plans to involve at least one veteran intern utilizing an ESTEP grant to academic institutions.

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This software allows operators to get detailed measurements of how well the data center is performing and make changes to improve that performance.

percentage of a data center's power consumption is being used to run the servers—lower numbers equate to higher energy efficiency. The DCIM program revealed that the San Diego Data Center has an above average PUE of 1.5. Federally managed data centers can have ratios ranging from 1.2 to 5.

The goal of this ESTEP project was to evaluate the software's efficacy as an energy management and decision-making tool. Although Clarity records energy data and reports some instantaneous aggregate measurements (such as PUE), these are not sufficient to enable a manager or engineer to assess what features of a data center could be made more energy efficient. This would require statistical tools to help determine whether apparent changes are actually explained by random variation or other factors in the environment.

A concurrent sister project, funded by the Navy Shore Energy Technology Transition and Integration program, is evaluating methods of improving data center cooling efficiency through such techniques as cold-aisle containment and improving the airflow throughout the IT room. This project team made two significant changes to the data center's cooling systems during this project, and the ESTEP team sought to determine if either of these changes resulted in a statistically significant difference in the daily energy use of the chiller plant that could not be accounted for by variations in the outside temperature.

The Cooling Factor

At the San Diego Data Center, an outside chilled water plant provides cold water in a closed loop that's circulated to an array of Computer Room Air Conditioners (CRAC). Each CRAC is effectively a large box with a fan that blows air over the cold water pipes. The CRACs in the San Diego Data Center are all fixed speed units, meaning that the fan is always on, and thus each CRAC is effectively a constant power load no matter what the temperature in the IT room may be. However, each CRAC has a feedback sensor that measures the incoming air temperature and an automatically controlled water diverter valve, so as the intake air temperature measured by the CRAC goes down, it will lower or shut off the flow of cold water. The chiller plant, in turn, measures the return water temperature and flow rate, and its power load varies significantly based on these measurements.

The first change enacted by the team was the installation of an under-floor cold air containment system to reduce the total volume of air that the CRACs would need to cool, and, approximately five weeks later, to raise the set point of two CRACs in the center. Both of these measures reduced the energy and chilled water usage. These actions resulted in an approximately 150 kilowatt hours per day drop in chiller plant energy consumption. This confirms the results seen by other individual data centers that have made significant improvements by adopting cold-aisle containment and various types of liquid cooling technology.

Conclusions

The goal of this project was to evaluate whether the adoption of DCIM can improve energy efficiency at Navy facilities. While the project team was able to remove the first roadblock to its adoption—security issues—the costs of installation and accreditation of a DCIM program outweigh the potential energy savings, at least in the short run.

In the long run, DCIM can save labor by providing reliable and timely information, without imposing the burden of additional data calls on data center managers and technicians. These benefits are potentially the most important impact of DCIM technology and the strongest argument for its adoption. However, estimating the monetary impact of these changes is difficult. More work needs to be done with vendors to reduce implementation costs.

For more information about data center smart metering and cooling efficiency, contact Christine In at the information provided below. ⚓

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