Agreement between California Energy Commission and DOE- Lawrence Berkeley National Laboratory

Title: Demonstration of Intelligent Control for an Enterprise Datacenter
Amount: $400,000.00
Term: 24 months
PIER Contact: Donald Kazama
RD&D Committee: 9/22/2010

Funding

FY	Program	Area	Initiative	Budget	This Project	Remaining Balance	
08	Electric	IAW	Energy Efficiency	$3,326,731	$99,956	$0	0%
08	Electric	IAW	Emerging Technologies	$1,000,000	$300,044	$0	0%

For the 2008 fiscal year, the total Electric budget was $62.5 million. Within the Electric program, the IAW program area budget was $5.5 million and, from this amount, $3.3 million was allocated to the Energy Efficiency budget initiative and $1 million for the Emerging Technologies initiative. After approval, the remaining balances will be $0.00 for the both initiatives.

Recommendation

Approve change in project demonstration site and participating utility for agreement number PIR-10-014 with DOE- Lawrence Berkeley National Laboratory (LBNL) for $400,000.00. Staff recommends placing this item on the discussion agenda of the Commission Business Meeting.

The Problem

The American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) recommends operating temperature ranges for inlet air to datacenter computing equipment of 64.4 - 80.6 ºF, and for humidity 42-59 ºF dew point (with a maximum 60% relative humidity). Although the cooling units in a datacenter may be networked for remote monitoring, they are normally controlled in a standalone, decentralized mode based on return air temperature to the cooling unit, rather than inlet air temperature to the servers which is the critical parameter. Without direct feedback of inlet air temperatures, data centers generally operate all their computer room air handling units and over-cool the conditioned space between 70 ºF -75 ºF, which wastes significant amounts of energy. Most cooling units in existing data centers have constant-speed fans. When variable-frequency drives (VFD) are added and controlled using a decentralized control scheme, they must be controlled so that low fan speed does not cause a hot spot in the data center. Adding VFD control to the cooling units adds to the problem of contending control because there is an additional degree of freedom for one cooling unit to disturb another.

Proposed Research

Recent developments in low-power, wireless mesh network temperature sensing have enabled low-cost, flexible monitoring of inlet air conditions in existing data centers. These sensors can be integrated with intelligent control software that can reliably solve the problems described above. In particular, Federspiel Controls has developed a supervisory control system for data center cooling that includes software than can learn the impact on server inlet air conditions from control actions such as shutting off or turning down computer room air handling units retrofitted with VFDs. These relationships can then be used to make control decisions that significantly reduce cooling energy consumption while ensuring that servers get the recommended inlet air conditions. This project will demonstrate that the intelligent, supervisory control and wireless mesh network sensing system demonstrated in an earlier PIER-sponsored pilot project at the Franchise Tax Board's Sacramento Data Center can scale to large enterprise scale data centers that are times larger with fifteen times the computing load. This project will also demonstrate that the savings calculation produced by the control software is sufficiently accurate to support a shared savings business model that could enable rapid market adoption.

Research Justification and Goals

This project "[will develop, and help bring to market] increased energy efficiency in buildings, appliances, lighting, and other applications beyond applicable standards, and that benefit electric utility customers" (Public Resources Code 25620.1.(b)(2)), (Chapter 512, Statues of 2006)); and supports California's goal to allocate and prioritize RD&D funding for energy efficiency and demand response, including new communication and control technologies, planning models, end-use technologies, and validation methodologies per the Energy Action Plan 2005 by:

- Installing and commissioning the Datacenter Automation Software and Hardware (DASH) solution in a data center that is five times larger and has fifteen times the computing load than the PIER funded pilot project conducted at the Franchise Tax Board's Sacramento data center.
- Compare the automated savings estimates of DASH with detailed energy savings from independent datalogging and metering equipment to validate the effectiveness of the technology.
- Demonstrating that the savings calculation produced by the control software is sufficiently accurate to support a shared savings business model that could enable rapid market adoption.

These proposed awards support the general goal of SB 1250 (Perata, Chapter 512, Statutes of 2006), which states, in part, "the Public Interest Research, Development, and Demonstration Program is to develop, and help bring to market, energy technologies that provide increased environmental benefits, greater system reliability, and lower system cost, and that provide tangible benefits to electric utility customers."

Background

LBNL originally competed for this funding in July 2009 through the Emerging Technology Demonstrations Grants Program (ETDG) Opportunity Notice 08-006 in the Data Center category. Their proposal ranked #2 out of the 7 submitted in this category. LBNL was subsequently awarded the grant in December 2009.

The goal of this project is to demonstrate the scalability of Federspiel Controls Datacenter Automation Software and Hardware (DASH) solution successfully applied at the State of California's Franchise Tax Board (FTB) facility, to a much larger enterprise data center facility. Under the proposal they

submitted, LBNL partnered with the Herakles Data Center in Sacramento, a facility five times larger and having more than fifteen times the computing load of FTB. The participating utility for conducting measurement and verification (M&V) of project energy savings and awarding energy efficiency incentives was the Sacramento Municipal Utility District. On August 17, 2010, Herakles notified LBNL that they were no longer interested in participating as the demonstration site. LBNL subsequently recruited Level 3, Inc. located in Sunnyvale, to replace Herakles. The Level 3 site is located in Pacific Gas and Electric's (PG&E) service territory and is even larger than Herakles in terms of facility square footage and computing load. However, a change in the participating utility is also required to support M&V and provide energy efficiency incentives for installing the technology. LBNL confirmed with PG&E that they would provide the same function as SMUD and would maintain the same M&V and energy efficiency incentive award schedule.

ASHRAE with agreement from manufacturers of IT equipment (servers, network equipment, and storage devices) have collectively recommended operating temperature ranges for inlet air to datacenter IT equipment. These server inlet recommendations for temperature are: 64.4 - 80.6 ºF (18 ºC – 27 ºC), and for humidity 42-59 ºF (5.5 ºC - 15 ºC) dew point (with a maximum 60% relative humidity). Although the cooling units in a data center may be networked for remote monitoring, they are normally controlled in a standalone, decentralized mode based on return air temperature to the cooling unit, rather than inlet air temperature to the servers which is the critical parameter. Since the cooling controls do not normally have direct feedback of inlet air temperatures operators often configure the cooling units so that they over-cool, which wastes energy and all units are typically operated even if the load only requires a fraction of the units to provide proper cooling.

Computer room air handling (CRAH) units are in close proximity to one another, and often deliver air into a common plenum or duct header. They are also deployed so as to provide redundancy, and may be configured for differing temperature and humidity settings. This decentralized control often results in contending (i.e., "fighting") control behavior, which wastes more energy. Finally, most cooling units in existing data centers have constant-speed fans. When variable-frequency drives are added and controlled using a decentralized control paradigm, they must be controlled so that low fan speed does not cause a hot spot in the data center. Additionally, adding variable speed control to the cooling units adds to the problem of contending control because there is an additional degree of freedom for one cooling unit to disturb another.

Recent developments in low-power, wireless mesh network sensing have enabled low-cost, flexible monitoring of inlet air conditions in existing data centers. These sensors can be integrated with intelligent control software that can reliably solve the problems described above. In particular, Federspiel Controls has developed a supervisory control system for data center cooling that includes software than can learn the impact on server inlet air conditions from control actions such as shutting off or turning down a CRAH. These relationships can then be used to make control decisions that significantly reduce cooling energy consumption while ensuring that servers get the recommended inlet air conditions.

This project will follow up on a pilot project recently completed by LBNL and Federspiel Controls. That project involved the deployment of Federspiel Controls Datacenter Automation Software and Hardware (DASH) solution at the Franchise Tax Board's Sacramento Data Center. The project showed that DASH eliminated 15.2% of the baseline energy consumption while keeping temperatures substantially within the limits recommended by ASHRAE. The project also demonstrated the reliability of the wireless mesh network sensing used by DASH, with a packet delivery reliability of 99.999% over a five-month period

of time. The Franchise Tax Board pilot project was funded by the California Energy Commission's PIER program, and was managed by LBNL.