Agreement between California Energy Commission
and
Electric Power Research Institute, Inc.

Title:	Variable Airflow Management with Direct Expansion (DX) Computer Room A/C
Amount:	$400,000.00
Term:	36 months
PIER Contact:	Anish Gautam
RD&D Committee:	12/3/2009

Funding

FY	Program	Area	Initiative	Budget	This Project	Remaining Balance	
08	Electric	IAW	Emerging Technologies	$1,000,000	$4,981	$0	0%
09	Electric	IAW	Energy Efficiency	$2,000,000	$395,019	$233,012	11%

For the 2008 fiscal year, the total Electric budget is $62.5 million. Within the Electric program, the IAW program area budget is $5.5 million and, from this amount, $1 million was allocated to the Emerging Technologies budget initiative. If approved, the remaining initiative balance will be $0.00.

For the 2009 fiscal year, the total Electric budget is $62.5 million. Within the Electric program, the IAW program area budget is $2.75 million and, from this amount, $2 million was allocated to the Energy Efficiency budget initiative. If approved, the remaining initiative balance will be $233,012.

Recommendation

Approve this agreement with Electric Power Research Institute, Inc. for $400,000.00, with $100,000 in match funding. Staff recommends placing this item on the discussion agenda of the Commission Business Meeting.

The Problem

A large fraction of the data center cooling equipment in existing data centers are Direct Exchange refrigerated based Computer Room Air Conditions (DX CRAC) units. These DX units currently do not use variable speed drive (VSD) control technology on their fans. The often-cited argument is that the cooling loads in data centers remain relatively unchanged and variable frequency drives are not economically justified. This argument was debunked in a 2004 large-scale data center for Oracle in Austin, TX. In the Oracle demonstration, VSDs on chilled-water CRAC units were implemented with a payback period of 6 months. Use of VSDs in chilled-water CRAC units is now accepted in the industry. In order to extend use of VSDs on DX CRAC units, a demonstration similar to Oracle for chilled water CRAC units is needed to provide the performance, reliability and economic data for market acceptance.

Proposed Research

This project will demonstrate the effectiveness of airflow management with retrofit of VSD to existing DX CRAC units along with a distributed wireless mesh temperature sensor network in data centers to control VSD operation. The demonstration will be at EPRI's own data center and at NetApp's data center in Sunnyvale. Successful demonstrations at these two locations will provide the necessary performance, reliability, and economic data necessary to overcome information barriers for adoption by the industry. It is estimated that use of VSDs with the wireless sensor network can reduce data center electricity consumption by 15%, with a potential total savings of approximately 854 million kWh and save data center operators $102 million in electricity cost each year.

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:

- Demonstrating the reliability, performance and economics of variable speed retrofits on DX CRAC units.
- Demonstrating, monitoring and verifying the savings achievable with distributed wireless network of temperature sensors for airflow management and effective control of the VSD in DX CRAC units,

The research areas promise to meet energy efficiency and environmental attributes and goals as set out in the Integrated Energy Policy Report (IEPR), the Warren-Alquist Act., Executive Order S-3-05 and AB 32. This solicitation also supports California's goals to expand efforts to improve public awareness and adoption of energy efficiency measures per the Energy Action Plan by early adoption of efficient technologies that will benefit California industry and providing a competitive advantage due to lower energy costs. 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

The proposal was submitted through competitive solicitation, Emerging Technology Demonstrations Grants Program (ETDG) Opportunity Notice 08-006. This opportunity notice was structured to solicit proposals under four categories 1) Data Center, 2) Energy Storage, 3)Industrial Energy Efficiency and 4) Water and Wastewater. This proposal was ranked 3 out of 7 proposals received through the solicitation under the data center category.

A large fraction of the data center cooling equipment in existing data centers are DX CRAC units. In DX units, compressors are located within CRAC units and provide cooling through expansion of refrigerant, from liquid to vapor in cooling coils, as opposed to chilled water CRAC units where compressors are located in a central chiller plant that circulates chilled water to cooling coils in CRAC units. DX units are common in smaller data centers and computer rooms where chilled water systems are not cost effective. Data centers with power demand of less than 500 kW and cooling capacity of less than 150 tons predominantly use DX systems. These are also common in larger data centers that have grown or expanded over a period of time. Some large data centers also use DX units to avoid concerns about potential water leaks.

The current CRAC equipment, especially DX units, does not use variable speed fan control. The often-cited argument is that the cooling loads in data centers remain relatively unchanged and variable frequency drives are not economically justified. This argument, however, was debunked in 2004 in a large-scale enterprise data center for Oracle in Austin, TX. In this installation, VFDs on the chilled-water CRAC units were implemented; the actual payback period was observed to be less than 6 months as compared to an estimated payback period of 19 months.

It is true that the data center loads remain relatively unchanged from hour to hour, but can change over a period when new equipment are installed or old equipment are retired. The data centers are also provisioned with extra cooling capacity for future growth. The data center design requires redundancy in cooling so that the failure of a unit will not bring down the entire data center. Large data centers are designed with typical redundancy of ~15%; generally one extra CRAC unit is provisioned for each 5 or 6 units. If the airflow could be reduced just by the redundant capacity of 15%, the fan law dictates that 38.6% of the direct fan energy would be saved. In addition, the avoided heat from the fan running at 85% instead of 100% would also reduce cooling energy. Further, the data center is gradually populated with the IT equipment over time; during this period a fan would run at much lower than 85% speed providing even more savings. These factors contributed to much better payback periods than estimated in the 2004 demonstration. Since the demonstration, the industry has quickly adapted with some CA utilities offering pilot programs in 2007 with incentives to retrofit existing data centers with VFDs and airflow management. The equipment manufacturers are also now offering ‘retrofit kits’ to install VFDs and controls. Though some control schemes are not as efficient as others, these still provide significant savings.

Proper airflow management also requires separation of the hot and cold airflows within a data center to prevent recirculation of hot air back to the IT equipment. The physical barrier for separation of the hot and cold air is expensive and often impractical. The use of distributed network of temperature sensors at the inlet of the IT equipment can identify where hot spots are and the information could be used to provide selective and localized barriers to prevent mixing as well as control the speed of fan for management of airflow. In a recent retrofit installation of VFDs by Federspiel Controls in Redwood City, CA, distributed temperature sensors at the inlet of the IT equipment with wireless network is used to adjust the speed of the fans to maintain the air temperatures within acceptable ASHRAE conditions. This installation with six chilled water CRAC units demonstrated that the fan speed could be effectively controlled without the need and considerable expense of barriers for elaborate separation of hot and cold air; the fan speed automatically adjusted to account for some mixing. In this installation, the fan speed reduced to about half, with over 80% fan power savings (just .95 to 1.05 kW versus ~5.5 kW at full speed) to provide cost effective solution with a payback periods of less than a year after utility incentives; the payback period would have been more than 4 years with the cost of elaborate separation of hot/cold air and would not have met cost effective criteria.

The use of VFDs in with chilled-water CRAC units is now accepted in the industry. This project will extend the use of VFD on DX CRAC units as the next logical step. Its use on DX units does pose some additional challenges. In particular, when airflow rate is reduced, the cooling coil temperature in a DX unit is also reduced, and reduced coil temperature condenses more moisture. Since cooling load in data centers is sensible only, any dehumidification causes extra energy consumption. But this argument is more theoretical than practical. After initial removal of more moisture with lower cooling coil temperature, there will be no more moisture to condense after some time since there is no continuous latent heat gain in a data center. The second often-cited concern is that if the airflow is reduced too much, the cooling coil temperature can fall below to cause condensate on the coil to freeze. First, the airflow can be controlled in a manner that will avoid such low temperatures. Second, should condensate freeze on the coil, it is freezing outside of the coil and will defrost when the compressor stops. It does not harm the unit in any way; for example, the refrigerators at home routinely form frost on the cooling coils! The compressor controls can also be reset to cut off compressor on low temperature and low pressure.

The proposed solution with wireless sensors network greatly reduces the cost of retrofitting expensive barriers between hot and cold air. It also provides actual measurement of air temperatures entering the IT equipment and will allow the users to adjust room set point temperatures; currently the IT managers overcool data centers and run the CRAC units at low temperature set points, generally 68-72 F at the return air to the CRAC units. With better knowledge of the temperature distribution, the space does not need to be overcooled providing additional energy savings.

The project team will demonstrate the airflow management, VFDs on DX CRAC units, and distributed sensor with intelligent fan speed control in an EPRI data center in Palo Alto, CA, and another NetApp data center in Sunnyvale, CA. The data center is a 1300 ft^2 raised-floor with two 30 tons nominal capacity Liebert DX CRAC units with a UPS /PDU load of just 67 kW. Each 30-ton unit should provide cooling 105 kW of the IT equipment load at nominal conditions. The system is running at less than 50% capacity, but as a common practice in the industry both units are operating simultaneously to provide redundancy. This is typical of many data centers in the industry. NetApp datacenter also has two CRAC units and is lightly loaded. The NetApp site is also included to get a well-known end user in the IT industry that will create pathway to wider use and commercialization of the technology.