Proposed Agreement between California Energy Commission and Edison Materials Technology Center

Title: Development of Very Dense Liquid Cooled Computer Platform
Amount: $250,000.00
Term: 36 months
Contact: Paul Roggensack
Committee Meeting: 9/1/2010

Funding

FY	Program	Area	Initiative	Budget	This Project	Remaining Balance	
10	Electric	IAW	ARRA	$750,000	$250,000	$250,000	33%

Recommendation

Approve this agreement with Edison Materials Technology Center (EMTEC) for a 24 month, $250,000.00 cost share grant to supplement the contractor's American Recovery and Reinvestment Act of 2009 (ARRA) award. Under the Energy Efficient Information and Communication Technology DE-FOA-0000107, EMTEC was awarded $2,843,985 in U.S. Department of Energy (DOE) ARRA funds and is providing $468,876 in additional match funding to conduct research and development of a very dense liquid cooled compute platform. The total budget for the project is $3,562,861.

Issue

The electricity consumed in data centers and telecom systems is estimated to be 3 percent (8.6 billion kWhr/year) of the California total and growing rapidly. The energy used to provide cooling for data centers can be as much as 45 percent of the total facility power. Air and liquid are the options for data center cooling. Air has been perceived as the cheapest and simplest, while liquid as complex and expensive. However, because of increasing energy intensity of data centers, air is becoming more costly and less able to meet cooling demand.

With air, extreme measures are required to accommodate the ever increasing component power dissipation. To achieve this, there must be tremendous attention to detail in steering air, sealing gaps, optimizing multiple motors and balancing computer room air conditioners in an ongoing process. For dense systems, very powerful fans must drive high volumes of air through small spaces. An alternative is to decrease density by spreading out the data center. This would increase capital expense, energy consumption and green house gas (GHG) emissions for construction (cement manufacture is a major GHG producer). Even with oversized buildings, large amounts of energy are still required for cooling. Finally, users pay premium prices for custom design for every new or upgraded air cooled data center.

There have been significant efforts to reduce the energy for information technology (IT) cooling by making small improvements to the cooling equipment and the control of air movement. However, air circuits have high thermal resistance; hot and cold air mix in unpredictable ways; and air is simply incompatible with high density systems that are required for High Performance Computing (HPC). Technology improvements to date have been to push air through ever decreasing gap sizes, but the energy required is becoming unacceptably large.

Liquid cooling could address problems associated with air cooling. However, most liquid cooled systems require complex piping to bring fluids directly to individual components, spraying liquid on them or even immersing whole circuit boards in liquid. In these cases liquid is piped directly into the server. With large numbers of pipe connectors, as in a HPC system, some will eventually leak with potentially disastrous effects. Such systems are also expensive. Consequently liquid cooling has been an orphan technology for the last 20 years. The proposed project will provide the advantages of liquid with a much simpler technology than existing liquid cooling systems.

Background

EMTEC has obtained a $2.8 million grant from the American Reinvestment and Recovery Act (ARRA) to develop the Very Dense Liquid Cooled Compute Platform (Project). The Project redesigns a conventional air cooled server rack system to be 100% liquid cooled. Liquid cooling will provide significant energy savings because it has a much higher heat capacity and thermal conductivity compared to air.

Clustered Systems, a key partner, will conduct the research. Clustered Systems has established key business partners to ensure significant market penetration. The Stanford Linear Accelerator will provide a test location and will run applications on the system for up to one year. Intel Corporation will provide Central Processing Units (CPU) and support for server design. Emerson Network Power will provide the cooling infrastructure, power distribution units, racks and manpower for product development. Both of these companies have significant customer bases in the data center industry and will have a financial stake in the project.

The development of this technology has received prior PIER Program funding. Clustered Systems was awarded an Energy Innovation Small Grant to demonstrate the liquid-cooled, cold plate technology with the cold plate attached to a standard server. Clustered Systems then received funding through the California Institute for Energy and Environment to advance the technology by constructing a server rack using conventional servers adapted for liquid cooling. The current proposal will further develop the technology by customizing the servers and rack systems for liquid cooling.

Proposed Work

Clustered Systems will develop a prototype Very Dense Liquid Cooled Compute Platform. The prototype will consist of two server racks each with twelve shelves housing a minimum of 144 modules. The application of liquid cooling to this rack design is estimated to achieve a 17 to 45 percent reduction of energy used for cooling compared to air cooling.

The server racks will contain twelve shelves that can house a minimum of 144 modules. The racks will be four times as dense as a typical air cooled rack, and will have a cooling capacity of up to 200 kilowatts. A module is a server redesigned without cooling fans and consists mainly of 2 multi-core CPUs with memory storage and is stacked vertically on a shelf. The elimination of cooling fans could reduce the energy used by a typical server by 10 percent. Without needing to power the server fans, the server power source can be downsized. The energy to pump the coolant increases facility energy by about 2 percent, but it is outside the server. The modules will use heat risers to conduct heat from the CPUs, power source and other hot spots to flexible cold plates that have cooling liquid pumped through them fastened to the top. The cooling liquid is a common refrigerant connected to a heat exchanger connected to a chiller or cooling tower.

The energy savings were estimated using a modeling tool to compare the Very Dense Liquid Cooled Compute Platform with an optimally designed and operated air-cooled data center in San Mateo, California and showed a 17 percent reduction in cooling energy. Compared to more common, less efficiently run data centers, the liquid cooled racks could reduce cooling energy by up to 45 percent.

In addition to energy savings, the use of liquid cooling reduces floor space needed for servers. Removing large ducts and fans required to move large volumes of air will allow more freedom to place IT equipment closer together. Plus removing the 8 to 12 server fans will reduce the size of the server by 20 percent. These space savings combined with the reduction in energy use can reduce the annual cost of running a data center per server by 36 percent for new construction.

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)).

This will be accomplished by:

- Developing a rack design that will be 100% liquid cooled and is estimated to reduce the energy used for cooling data centers by 17 - 45 percent compared to conventional air cooling.