Economizer-based Data Center Liquid Cooling with Advanced Metal Interfaces

Reduce cooling energy to 5% of total data center energy.

Introduction

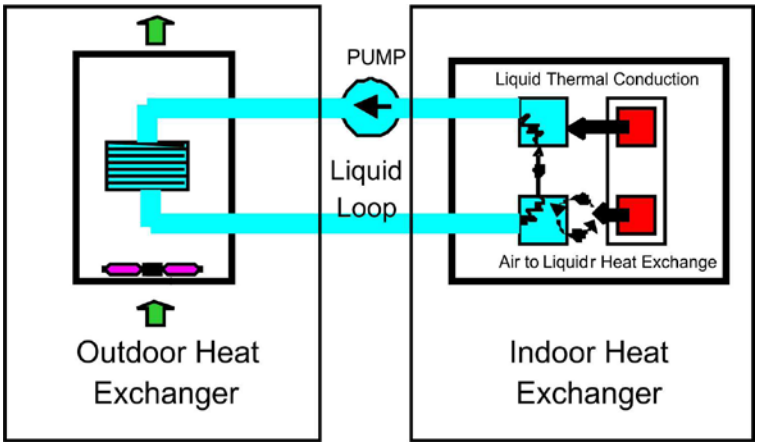
In 2005, server driven power usage amounted to more than 1% of total U.S. energy consumption. Information Technology (IT) equipment usually consumes about 45%–55% of the total electricity in a data center, and total cooling energy consumption is roughly 25% or more of the total data center energy use. Cooling infrastructure typically consists of three elements: the refrigeration chiller plant (including the cooling tower fans and condenser water pumps), the building chilled water pumps, and the data center floor computer room air conditioners.

This project aims to reduce the data center's cooling energy to 5% in a commercially viable path. Two complementary technologies are being developed. First, a liquid metal thermal interface (LMTI) to improve the thermal conduction paths of hot server components to the data center ambient cooling. Second, a Dual Enclosure Liquid Cooling (DELC) system that can use outdoor air heat exchange. Combined, these two technologies can eliminate the data center refrigeration chiller plant and other cooling components in order to minimize the use of cooling energy from refrigeration equipment.

Benefits for Our Industry and Our Nation

To maximize the energy impact, this project is focusing on volume and mid-range servers which comprise the largest segments of the server market. The integration of LMTI and DELC will eliminate the data center refrigeration chiller plant as well as several other cooling components, allowing for as much as an 85% reduction in the cooling energy cost. A paper study estimated a potential power usage effectiveness (PUE, total data center electricity use divided by IT equipment energy use) that was lower than 1.25 as compared to a typical average PUE of 1.7 or more.

These DELC and LMTI technologies will advance the state-of-the-art of liquid cooling by enabling the use of ambient-cooled liquid to provide a cost-effective solution for commercial data center systems.



Economizer-based data center liquid cooling.

Illustration courtesy of IBM.

Applications in Our Nation's Industry

Reducing the total energy consumption by data centers will save energy and reduce carbon dioxide (CO_2) emissions across our nation. Project developments will increase the energy efficiency of cooling infrastructure for volume servers, mid-range servers, and the medium data center market. This project will be of most interest to the following parties:

- Data center and telecommunication facility owners, operators, and construction and development companies
- Developers and distributors of buildings, data centers, and IT management software

Project Description

Two complementary technologies are being developed to enable the elimination of compressor-based refrigeration equipment.

First, developing a server-compatible LMTI will improve the thermal conduction path of hot server components to the data center ambient cooling. This liquid-metal thermal interface has a thermal conductivity an order of magnitude better than commonly used thermal paste materials. It will significantly improve thermal conduction and enable the server components to operate in a higher temperature environment.

Second, the development of a dual enclosure air/liquid cooling system, DELC, will use recirculated liquid, cooled only by heat exchange with the outside ambient air.

Integrating LMTI and DELC will eliminate the data center refrigeration chiller plant as well as several other cooling components, thus minimizing the use of cooling energy and equipment. The liquid, cooled only by heat exchange with the outside ambient environment, will enter the DELC at a

temperature above the outdoor air temperature and increase as it exchanges heat with the higher-temperature server components. In cases where the DELC outlet liquid temperature exceeds 40˚C, it provides an opportunity to recover the waste heat from the servers in the form of hot liquid that can be utilized for low-grade commercial or residential heating.

Barriers

The acceptance of energy-efficient data center cooling methods is one implementation barrier for this solution. This project will address several factors that have impeded efficient data center cooling designs, including the following:

- Heavy use of sub-ambient temperature air and liquid requires energy-intensive chillers
- Low thermal conductivity creates the need for large temperature drops
- Leakage of air to undesirable areas
- Pressure drop of the under-floor plenum, a separate space provided for air circulation
- Inability to efficiently utilize the economic method of cooling from the environment's external ambient air temperatures

Pathways

For a highly energy-efficient solution, IBM T.J. Watson Research Center's materials scientists will collaborate with server and data center thermal engineering specialists from the IBM System & Technology Group to develop a system that reduces data center energy consumption.

The focus of this project is to accomplish the following:

- Advance the reduction of thermal resistance in server components.
- Extend the application of liquid cooling to the volume server market space.

Milestones

- Construction of a data center test facility with an external heat exchanger to characterize system-cooling performance under varying operating conditions
- Design and development of the DELC and LMTI prototype
- Measurement, testing, and evaluation of the technology

Commercialization

This project will result in a prototype of DELC and LMTI technology. The prototype will be evaluated against its energy-efficiency goals, and IBM will evaluate how these developments may be incorporated into a portfolio of leading-edge, energy-efficient technologies.

Project Partners

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