NEWS RELEASE

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NTU Singapore scientists invent spray cooling to lower carbon footprint of data centres

Scientists from **Nanyang Technological University, Singapore (NTU Singapore)** have invented a more sustainable and green method for cooling down servers in data centres, potentially reducing up to 26 per cent in both energy costs and carbon footprint.

Currently, data centres in Singapore accounts for 7 per cent of the nation's total electricity consumption. With demand for cloud computing increasing, it is critical to find a sustainable solution that reduces energy consumption and carbon footprint of data centres.

In a data centre, the hottest component in a server is the CPU – central processing unit – which requires a dedicated air-cooled heatsink for heat dissipation.

When servers are stacked together in a rack vertically, they produce a substantial amount of heat, so cold air is required to be drawn in to cool the server, after which, the hot air is expelled to the surroundings. This air-cooling method is the reason why data centres have to run on energy-intensive air-conditioning systems to lower the air temperatures.

In comparison, this new method developed by NTU scientists uses a special spray of non-conductive fluids to cool the CPU directly without a heatsink, utilising a combination of highly efficient heat removal mechanisms such as evaporation and boiling.

The gases and excess fluids are then collected in an enclosed system, condensed into liquid at tropical ambient temperatures (around 30 degrees Celsius) and recirculated back into the system to be reused.

More importantly, spray cooling has the potential to carry away more heat than air cooling, which will allow for CPUs to run faster and perform better than today's speeds which are limited by air cooling, since faster speeds will lead to higher temperatures.

Based on the power consumed by the servers in a rack (known as rack density), the resulting waste heat generated is estimated to be around 7kW per cubic metre in conventional air-cooled racks[1]. In comparison, the spray-cooling prototype has shown to be able to dissipate significantly more heat, capable of handling rack densities as high as 23kW per cubic metre.

If spray cooling is adopted industrially, it can allow for higher computing power servers to be packed into a smaller space than current data centres. The team estimates that it could translate into space savings of 30 per cent when compared to conventional data centres that use air-cooling systems, a significant advantage for land scarce countries like Singapore.

Leader of the project, **Associate Professor Wong Teck Neng** from **NTU's School of Mechanical and Aerospace Engineering**, says the main benefits of their new method are its high energy efficiency and targeted approach.

"Instead of cooling the entire data centre conventionally, we designed special sprays to aim directly at the CPU, the critical component which is the key source of heat in a data centre," says Assoc Prof Wong, who is also the Assistant Chair (Faculty) at the school.

"The inspiration for our innovation is simple. If there is a fire breaking out on a piece of wood, we are taught to point the fire extinguisher at the base of the fire to put it out, not spray at the flames or around the fire to cool it down, since the fire will continue to burn at the source. Similarly, why are we spending an immense amount of energy cooling down the air around the heat source, when we should be cooling it directly?"

Assoc Prof Wong explained that their targeted approach is a smarter approach, especially in tropical environments, where the high humidity and heat can put a significant strain on traditional air-cooling systems. For instance, a conventional data centre has to be cooled down to about 18 degrees Celsius, which accounts for about 40 per cent of its total energy usage.

In contrast, using spray cooling, CPUs can maintain their optimal temperature at about 55 degrees Celsius without the need for energy-intensive air-conditioning units. Power usage effectiveness (PUE) – ratio of total amount of power used by the data centre versus the actual power delivered to the servers – of the new prototype can go as low as 1.08. This can result in significant savings in cooling energy when compared to traditional air-cooled data centres which are usually at 1.8 PUE.

[1] Gowen, L. (2022, January 17). *The future is liquid*. Data Center Dynamics. Retrieved April 4, 2023, from https://www.datacenterdynamics.com/en/opinions/the-future-is-liquid/

Studies by the team also showed that based on a data centre IT load of 1 megawatt, their spray cooled system can save up to 1550 tons of CO_2 emission annually when compared to conventional air-cooling systems.

This will be a significant reduction in carbon footprint, given that most data centres consume 1000 kWh per metre square[2]. Energy efficient operation of spray cooled data centre can also lead to 26 per cent savings in annual energy costs.

It can also pave the way for faster and more efficient data centres in future, as demand for cloud computing continue to raise annually by some 15 per cent[3].

A spokesperson from **AFTERSHOCK PC**, which is Singapore's largest high performance custom personal computer builder and is collaborating with Assoc Prof Wong on another sustainability project, said that "spray cooling technology offers superior cooling capability, and this certainly helps to unlock full potential of computing chips and graphics card currently in market by overclocking beyond its normal operating range. This directly leads to the future and potential of seamless computing and video rendering performance for our high-performance computers".

The prototype system consists of an enclosed spray-cooled server rack capable of operating near atmospheric pressure, a water pump, sprays with multiple nozzles over each CPU, a collection system to collect the vapourised liquid, and an energy-efficient room-temperature condenser to convert the gases back into liquid again. Unlike conventional air-conditioning systems, no chiller system is required.

It was developed by a multi-disciplinary team, which involved former **Assoc Prof Toh Kok Chuan**, **Asst Prof Ho Jin Yao** from NTU's School of Mechanical and Aerospace Engineering, and research fellows **Ranjith Kandasamy** and **Liu Pengfei**.

This project is supported by the **National Research Foundation, Singapore**, under its Green Data Centre Programme**.** The NTU team took three years to design, build, test and commission their working prototype.

Patents for the technology has been filed through NTUitive, NTU's innovation and enterprise company, of which one has already been granted in the United States (patent no. 11,399,449 B2) in July last year.

Sustainability and innovation are two key pillars of **NTU's 2025 Strategic Plan**, where it aims to tackle some of humanity's greatest challenges, such as climate change and to support Singapore's ambition of achieving long-term net zero emissions by 2050.

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[2] Mahan, J. (2023, January 27). Understanding Data Center Energy Consumption. C&C Technology Group.
[3] Factors, F. &. (2022, June 22). Demand for Global Cloud Computing Market Size & Share to Surpass USD 1025.7 Bn by 2028, Exhibit a CAGR of 15.80% | Cloud Computing Industry Trends, Dynamics, Growth, Value, Analysis & Forecast Report by Facts & Factors. GlobeNewswire News Room.

Accelerating the translation of research breakthroughs into prototypes ready for commercialisation or adoption by industry is also one of the University's objectives under its new **NTU Innovation and Entrepreneurship initiative**.

Moving forward, Prof Wong and his team will seek to work with industry partners to develop a larger pilot plant system, which can demonstrate the potential of spray cooling in an industrial setting.

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About Nanyang Technological University, Singapore

A research-intensive public university, Nanyang Technological University, Singapore (NTU Singapore) has 33,000 undergraduate and postgraduate students in the Engineering, Business, Science, Medicine, Humanities, Arts, & Social Sciences, and Graduate colleges.

NTU is also home to world-renowned autonomous institutes – the National Institute of Education, S Rajaratnam School of International Studies, Earth Observatory of Singapore, and Singapore Centre for Environmental Life Sciences Engineering – and various leading research centres such as the Nanyang Environment & Water Research Institute (NEWRI) and Energy Research Institute @ NTU (ERI@N).

Under the NTU Smart Campus vision, the University harnesses the power of digital technology and tech-enabled solutions to support better learning and living experiences, the discovery of new knowledge, and the sustainability of resources.

Ranked amongst the world's top universities, the University's main campus is also frequently listed among the world's most beautiful. Known for its sustainability, over 95% of its building projects are certified Green Mark Platinum. Apart from its main campus, NTU also has a medical campus in Novena, Singapore's healthcare district.

For more information, visit www.ntu.edu.sg