Why liquid cooling?

" The future of computers lies in Liquid Cooling. "

< Jensen Huang, **CEO of NVIDIA** >

In the past, air-cooled internal combustion engine cars without liquid cooling radiators had to be parked with the hood open for about 2 hours after just 30 minutes of driving to cool the engine. However, with the development of liquid cooling radiators that cool the engine directly, it became possible to run the engine for 5 to 6 hours or even longer.

The same applies to computers. In the past, most high-performance servers rarely exceeded a total power consumption of 1kW per unit, and core cooling was possible with air cooling. However, today, for various purposes such as AI training, inference, computation, and rendering, each server requires 3kW to 6kW or more. As performance increases, heat generation continues to rise proportionally.

As a result, **installing multiple GPUs on a typical air-cooled server can cause a decline in GPU performance by over 10-20%.** This can lead to system instability and voluntary performance throttling of CPU, GPU, and NPU. Continuous high heat also affects product durability, resulting in a shortened lifespan.

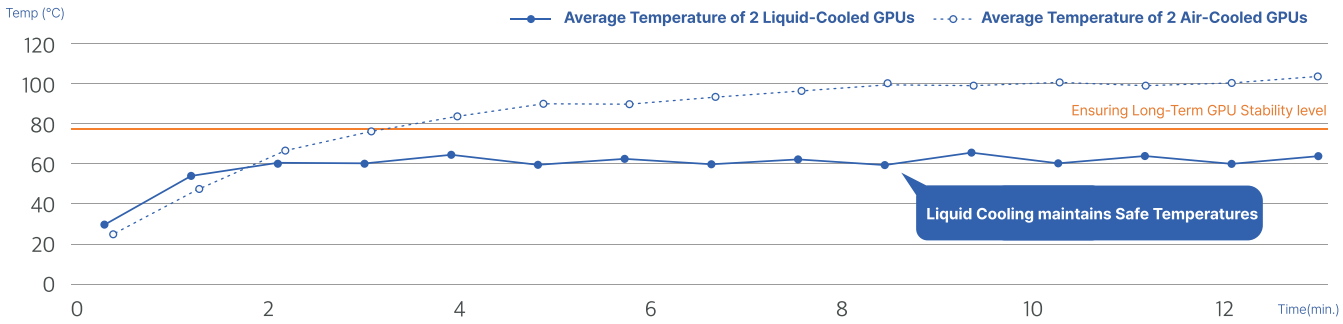
As a result, they face the challenge of purchasing high-cost server equipment that they cannot effectively utilize. This issue is reported not only among individual users but also in state-of-the-art IDCs (Internet Data Centers) operated by major corporations, where operational difficulties arise due to related issues.

	Air (20°C)	Water (20°C)
Thermal conductivity [J/(m*K*s)]	0.026	0.598
Volumetric heat capacity [J/(m^3*K*s)]	1213	4174472
Thermal inertia [J/(m^2*K*s)]	5.09	1579.98

The thermal conductivity of water exceeds that of air by over 300 times, allowing it to absorb and dissipate more heat effectively. Currently, the only solution to address this issue is Liquid Cooling using water.

Liquid Cooling vs. Air Cooling:

GPU Heat and Performance Degradation Rate



Degradation Rate relative to Maximum Performance

Air Cooling : Decline	97%	95%	94%	92%	90%	89%
Liquid Cooling : Maintain	98%	98%	98%	98%	98%	98%

With Liquid Cooling, you can..

- **Keep systems cool with minimal impact from indoor temperatures.**
- **Improve energy efficiency by reducing cooling power consumption.**
- **Install high-density computing devices with ease.**

Since 2022, infrastructure companies including NVIDIA have been actively adopting **Direct Liquid Cooling.**


NVIDIA To Release Liquid Cooled A100 and H100 PCIe Accelerators

by Ryan Smith on May 24, 2022 10:00 AM EDT

Among NVIDIA's slate of announcements tonight at Computex 2022, the company has revealed that it is preparing to launch liquid cooled versions of their high-end PCIe accelerator cards. Being offered as an alternative to the traditional dual-slot air cooled cards, the liquid cooled cards come in a more compact single-


Nvidia's CEO confirms upcoming system will be liquid cooled

As GPU TDPs look set to pass 1kW

Nvidia CEO Jensen Huang has confirmed that an upcoming iteration of the company's server family will be liquid cooled.

Huang let slip the detail during a presentation at the 2024 SIEPR Economic Summit at Stanford, but is likely to officially announce the new GPU server system at the company's GTC event from March 18.

"When you look at one of our computers, it's a magnificent thing. It weighs a lot, [has] hundreds of miles of cables," Huang said of the system, potentially a DGX or a different brand.

"The next one - soon coming - is liquid cooled. It's beautiful in lots of ways. And it computes at data center scales."

Earlier this month, Dell's CEO revealed in an earnings call that the upcoming Nvidia B100 GPU would have a thermal design point (TDP)

The Nvidia DGX H100

Exclusive dg® Liquid Cooling Technology

Supercomputer R&D Experts X Toyota Automotive Cooling Engineer

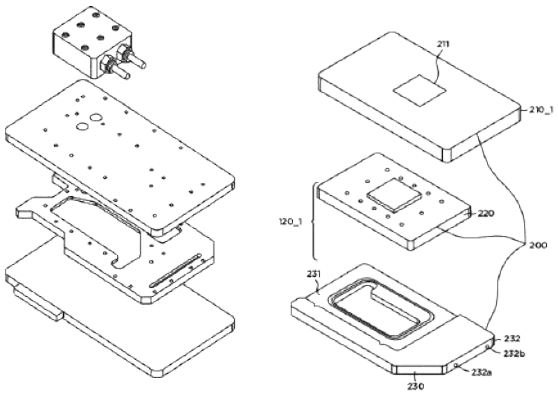
deep gadget® isn't just another custom liquid cooling system. It's a state-of-the-art, next-generation cooling solution that integrates the supercomputer expertise from Seoul National University's research lab, the design skills of a Toyota headquarters engineer with 20 years of experience, and a decade of intensive R&D.

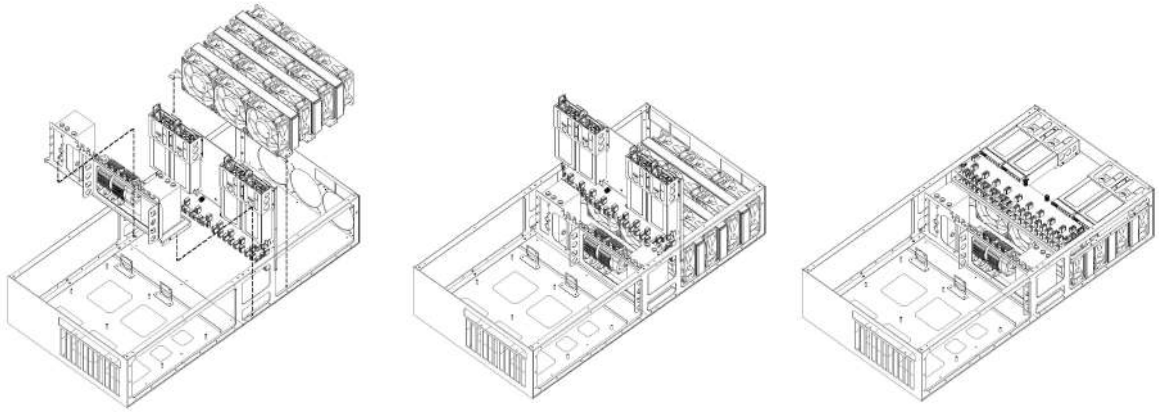
- Patented cooling technology and advanced hardware design expertise.
- Custom-designed cold plates for liquid cooling a wide range of AI accelerators, including NVIDIA AI GPUs, gaming GPUs, CPUs, NPUs, and Infiniband NICs.
- Fast integration of cutting-edge hardware components like CXL, NMC, and PIM for next-gen computing and memory/storage solutions.

Patents:

•COOLING DEVICE USING WATER FOR COMPUTER AND DRIVING METHOD THEREOF(컴퓨터용 수냉식 냉각장치 및 그 구동방법) Patent No : 10-2118786

•Cooling Plates for High-Density GPU Liquid Cooling(고밀도 GPU 액체 냉각을 위한 냉각판) Patent No: 20-0477833, 20-0479465





Built-in Liquid Cooling without the Need for Additional devices

Direct Liquid Cooling + Cutting-Edge Channel Design = Unrivaled Cooling Performance

With just one deep gadget®, up to 16 A100 GPUs can operate seamlessly.

- **Usable even at room temperature (30°C and above), no separate temperature or humidity control required**
- No need for external devices like chillers or piping
- Cost savings in infrastructure setup and management, high energy efficiency

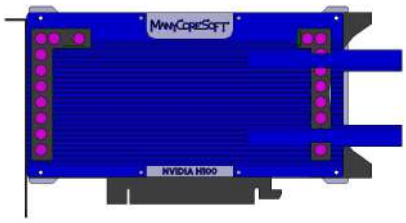
Direct Liquid Cooling System

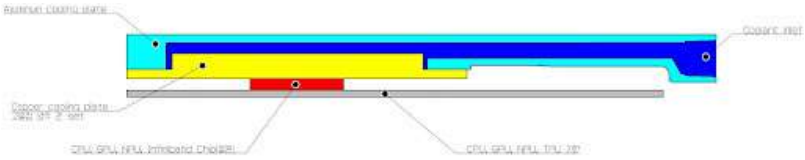
1. Directly attaches high thermal conductivity copper cooling plates to heat sources for rapid heat conduction

2. Simultaneously passes high-density fins of the copper cooling plates through a cooling liquid cooled by radiators and cooling fans

These two simultaneous processes maximize GPU cooling

※ Heat Conduction : Heat source(Chip) → Liquid → Radiator → Air

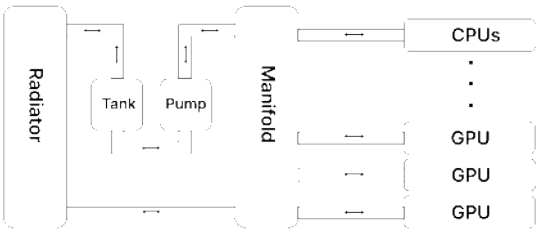




1:1 Parallel Channel Design

Independently cools each component to deliver optimal performance.

(Other liquid cooling systems: serially connect all components, leading to inefficient heat accumulation)

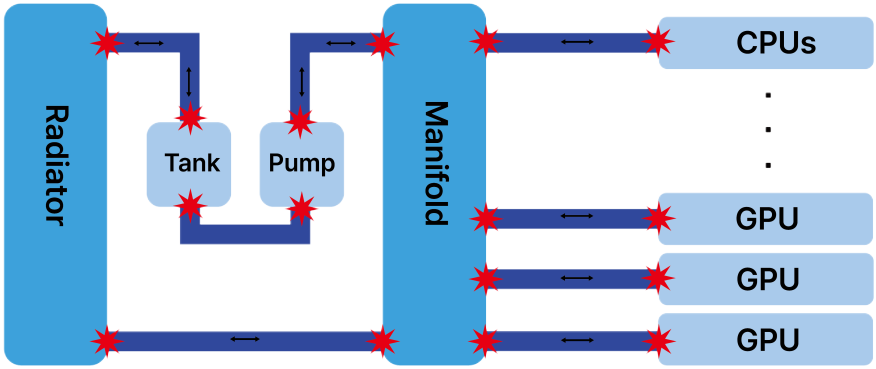


5 reasons to trust us with confidence

01. Zero Incidents of Leakage for 10 Consecutive Years

deep gadget® has a flawless sales history with zero incidents of product leakage.
With a decade of expertise and trust, we guarantee safety.

02. Design : Fully Sealed



① Special Adhesive — All leak points, connected by screws between components, are coated with special adhesive for a fully sealed structure ensuring stability even under impact.

② Hose, Fitting, Clip — Utilizing hose components selected through meticulous design, ensuring a seamless structure.

③ Quick Connector — The quick connectors guarantee sealing even with outputs exceeding 3 times the set values for hydraulic flow, preventing risks between CPU, GPU, and the manifold (safe detachment/attachment during server operation).

④ Rack Shelf Equipped — in the event of flooding or leaks, our system ensures complete prevention of secondary damage. The rack shelf, larger than the dg4F standard size, holds approximately double the cooling liquid capacity of the server (43cm x 89.5cm x 2.5cm). It undergoes testing during manufacturing and is finished with waterproof and corrosion-resistant coatings to prevent corrosion.

※ dg® Cooling's fully sealed structure ensures safety and preserves cooling liquid at a 99.99% rate, enabling virtually permanent use without the need for coolant management.

03. Manufacturing : 144 hours of testing over 4 cycles

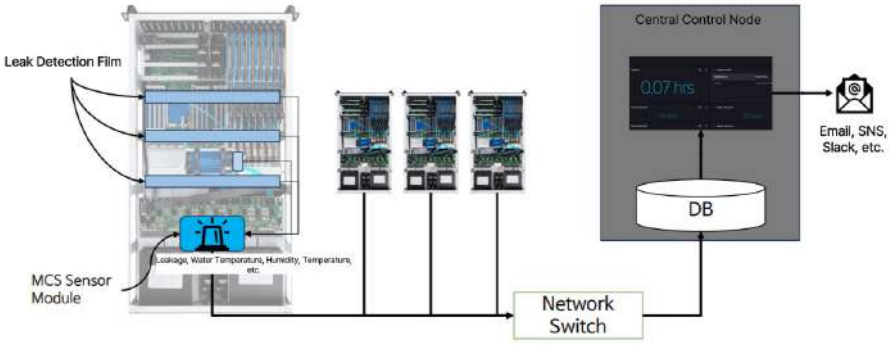
① Rigorous 24-hour test after attaching CPU/GPU cooling plates

② Comprehensive 24-hour test after applying special adhesive to leak points and completing hose connections

③ Thorough 24-hour secondary test of the cooling liquid

④ Extensive 72-hour burn-in test before delivery to ensure unmatched cooling performance and stability

04. Upon Shipment : Control System



05. Post-Shipment: Robust Quality Assurance

We offer an unparalleled 3-year quality guarantee with every purchase, setting the industry standard for reliability. (See page 28 for detailed coverage and terms.) Additionally, our expert guidance helps you safeguard against natural disasters like flooding and leaks, ensuring your investment remains secure.

Coolant information

Our product employs top-quality coolant, ensuring high cooling efficiency while safeguarding against corrosion, freezing, bacteria, algae, and other contaminants. Total capacity based on dg4F standards: 1.3 liters.

***Coolant Composition**

·Distilled Water: 70~75%

· Propylene Glycol: 25~30%

· Potassium Phosphate Dibasic: ≤ 1%

· Sodium molybdate: ≤ 1%

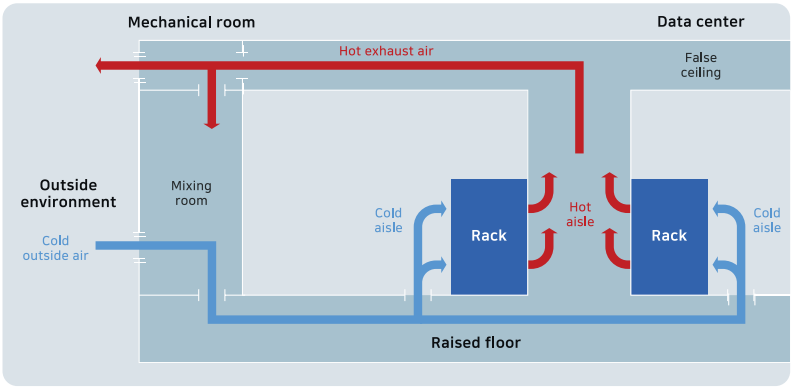
· Meta-toluic Acid: ≤ 1%

Electrical Conductivity	2500
Freezing Point	-15°C(5F)
Specific Gravity @20°C	1.03
UV Reactive	Blue
Viscosity @20°C (cP)	2.3

For Large-Scale AI Clusters, Save costs with dg®.

Built-in deep gadget® system offers Free-Cooling!

- Built-in liquid cooling boasts overwhelming performance, eliminating the need for additional devices.
- Capable of operating smoothly even in high-temperature environments exceeding 30°C.
- In domestic climates, Remarkable energy efficiency can be achieved with only deep gadget and outdoor air
- Easily lower PUE to 1.1 or below.



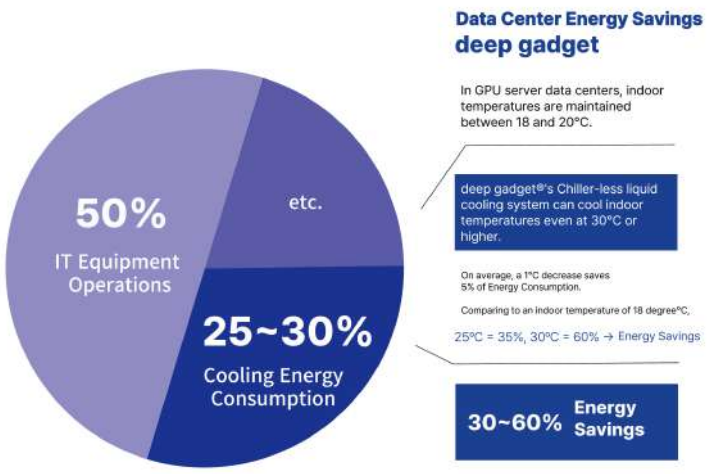
*PUE = Power usage effectiveness)

$$PUE = \frac{\text{Total Facility Power}}{\text{IT Equipment Power}}$$

Datacenter 268 locations average PUE = 1.8

*Avgerinou, Maria, Paolo Bertoldi, and Luca Castellazzi. "Trends in data centre energy consumption under the european code of conduct for data centre energy efficiency." Energies 10.10 (2017): 1470.

Data Center Energy Saving Scenario



*A study found that for every 1-degree temperature in the data center, energy consumption can be reduced by 4.3% to 9.8%.

Table 7
Energy consumption per unit area at the different temperature set points.

Month	Energy consumption per unit area at 24 °C (kWh/m²)	Energy consumption per unit area at 25 °C (kWh/m²)	Energy consumption per unit area at 26 °C (kWh/m²)
January	2.328	2.116	1.923
February	2.104	1.898	1.722
March	2.334	2.120	1.930
April	2.183	2.009	1.849
May	1.949	1.793	1.654
June	1.887	1.747	.625
July	1.869	1.781	1.705
August	1.863	1.723	1.601
September	1.834	1.705	1.594
October	1.930	1.783	1.667
November	2.003	1.847	1.715
December	2.314	2.127	1.974

* Iyengar, Madhusudan, et al. "Server liquid cooling with chiller-less data center design to enable significant energy savings." 2012 28th annual IEEE semiconductor thermal measurement and management symposium (SEMI-THERM). IEEE, 2012.

* The results shown that the percentage of energy saving was 4.3-9.8% for every 1°C rise in temperature set points.
Nan Wang, Jiangfeng Zhang, Xiaohua Xia, Energy consumption of air conditioners at different temperature set points, Energy and Buildings, Volume 65, 2013, Pages 412-418

Estimated Scenarios for Cost, Energy, and CO_2 Reduction

Environmental, Social and corporate Governance

▸ Energy Cost Savings - $0.28 million Annually - $1.42 million over 5 years ▸ CO_2 Reduction - 1,295t Annually - 6,478t over 5 years	▸ Energy Cost Savings - $0.47 million Annually - $2.38 million over 5 years ▸ CO_2 Reduction - 2,159t Annually - 10,797t over 5 years

항목	Conventional Air Cooling	dg liquid cooling[30°C]	dg liquid cooling + Free-Cooling
IT Power Consumption	1,000 kW	1,000 kW	1,000 kW
PUE	1.60	1.30	1.10
Total Power Consumption	1,600 kW	1,300 kW	1,100 kW
Annual Energy	14,016,000 kWh	11,388,000 kWh	9,636,000 kWh
Annual Cost	$1.59 million	$1.25 million	$1.05 million
Annual CO_2 Footprint	6,910 t	5,614 t	4,751 t
Cooling Power Consumption	500 kW	200 kW	≈0 kW

Comprehensive Comparison of Cooling Methods

Category	Air Cooling	Water Cooling with Chiller	Immersion	dg® Liquid Cooling + Free-Cooling
PUE	**Around 1.6**	**Around 1.2**	**Around 1.1**	**Around 1.05**
Equipment Costs	High Cost	High Cost	High Cost	Low Cost
Cooling Performance	Moderate	High	High	High
Server Management	Moderate	Difficult	Very Difficult	Moderate
Overhead Costs	Moderate	High	Very High	Very Low
Density	Moderate	Low	Very Low	High
Noise	High	Low	Low	Low