INTEGRATED IMMERSION COOLING SOLUTIONS ENABLING GAME-CHANGING ENERGY USE REDUCTION AT DATA CENTERS

www.shell.us/immersion

Shell
Immersion Cooling Fluid

THE INTERNET IS A FUNDAMENTAL PART OF MODERN LIFE. THE CLOUD ENABLES US TO WORK ANYWHERE, WATCH ON-DEMAND MOVIES AND MUCH MORE. THE CLOUD MAY SOUND TRANSIENT, BUT IT HAS A PHYSICAL, ENERGY-HUNGRY HOME – A NETWORK OF DATA CENTERS.

These account for an estimated 1% of global electricity consumption,[1] more than a third of which is for cooling electronic components, and have half the carbon dioxide emissions of global air travel. To compound matters, data center infrastructure is expanding by more than 20% every year,[2] so, without game-changing action, data center emissions will increase exponentially. At the same time, society needs to cut carbon dioxide emissions by 50% to reduce the impact of global warming.[3]

Shell's Ambition Is to Be a Net-Zero Emissions Energy Business

In tackling climate change, the focus is increasingly on limiting the global temperature rise to 1.5°C. To achieve this, society needs to stop adding to atmospheric greenhouse gases – a state known as net-zero emissions – by around 2060. More advanced parts of the world need to reach that point sooner.

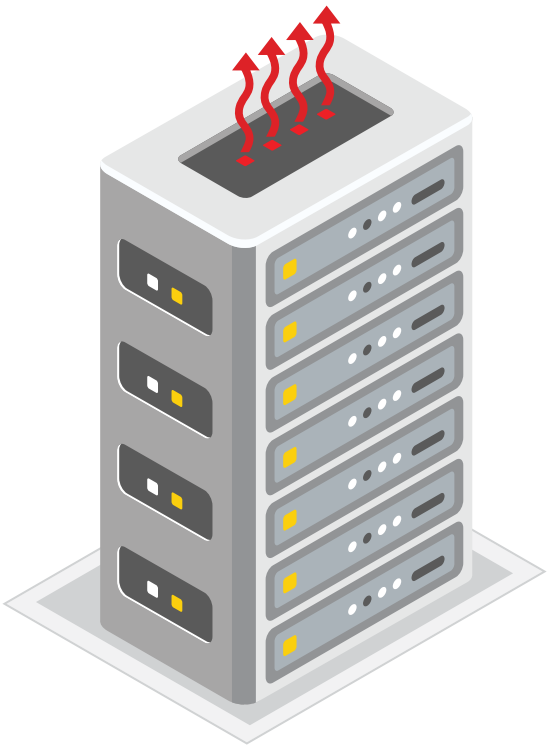
That is why Shell has set itself an ambition to become, by 2050 or sooner, a net-zero-emissions energy business.[4] We are working towards this in many ways, including our Shell Immersion Cooling Fluid to tackle data center energy use as part of a wider integrated offer to help center operators meet their climate action ambitions.

More Data and Higher Processing Power Are Creating a New Cooling Era

Air cooling equipment for electronic components accounts for 38% of the electricity use in data centers,[5] takes up considerable space and is being put under increasing demand.

Traditional air cooling, with its low cooling capacity and practical limitations (noise, footprint and build complexity), cannot meet these growing demands without higher energy and space requirements, but there are cost-effective alternatives.

Full immersion in a thermally conductive, electrically non-conductive (dielectric) coolant is a highly efficient way to keep data center hardware and computer components cool. It can cut energy consumption and reduce carbon dioxide emissions while reducing costs and increasing location flexibility. On a larger scale, immersion cooling offers standardized efficiency that is independent of location, facility and hardware requirements.



More data. Estimates show that there will be more than 50 billion connected devices.[4]

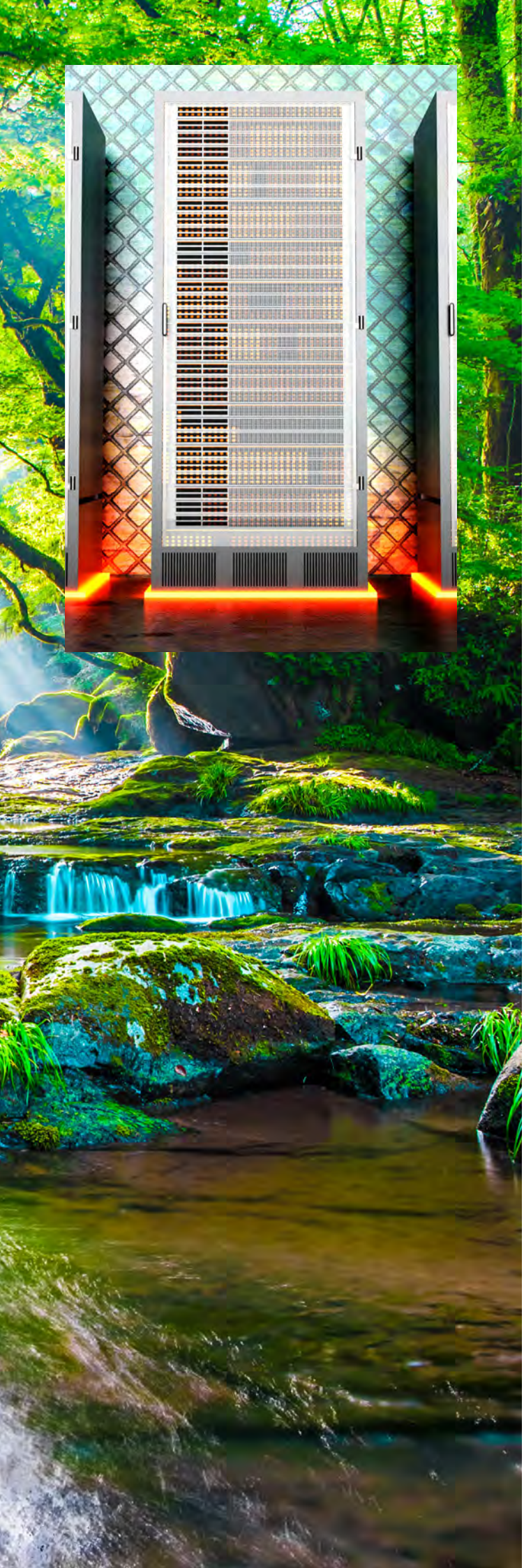
Extreme processing speeds that generate more heat. High-performance computing is required for machine learning, speech and facial recognition, cryptocurrency mining, blockchains, artificial intelligence, etc.

Increased demand for online services. Examples include near-real-time analysis for autonomous vehicle route finding, content distribution and fintech.

Edge computing. Data centers are being built on the network edge to reduce data transfer time and increase availability; these facilities often have space and energy infrastructure constraints.

What Is Immersion Cooling?

Immersion cooling is a way of cooling IT components, including whole servers, by submerging them in a dielectric (electrically non-conducting) fluid. The fluid has more than a thousand times the thermal capacity of air (by volume), which makes immersion cooling a highly efficient alternative to air cooling. The liquid circulates by natural convection or is pumped to remove heat from the components. An added benefit is that this heat can be recovered by water-cooled heat exchangers for reuse in district heating projects. In single-phase immersion cooling, the coolant stays as a liquid without phase changing, whereas the coolant boils to form a gas and then condenses back to a liquid in two-phase immersion cooling.



What Is the Best Energy-Saving Solution?

Using water-filled plates can upgrade the cooling capacity of some air-cooled facilities, but there is a high leakage potential with the risk of water damage to the system, and air cooling is still necessary. Plus, this method is inflexible and expensive.

Two-phase immersion cooling offers a high cooling capacity without needing circulation pumps and thus has a lower energy requirement. However, these systems have very high capital costs and use expensive fluids with high global warming potential. Although these systems are sealed, fluid may be lost through evaporation. The effect of coolant vapor on people's health is unclear and the fluid needs regular maintenance to replace losses. Access for maintenance is also more complicated with sealed systems.

Compared with two-phase systems, single-phase immersion cooling systems have a simple architecture for significantly lower capital costs. Since there is no evaporation of the dielectric coolant, open tanks can be used for easy maintenance. Compared with traditional air cooling, single-phase immersion cooling technology as an integrated solution offers[6,7]:

- Up to a **33%** lower total cost of ownership
- Up to a **48%** reduction in energy footprint
- Up to potentially **30%** less carbon dioxide emissions
- Up to **80%** less floor space
- Up to **40%** more CPU performance
- **30–40%** less operating and capital expenditure
- **High reliability** with no moving parts
- **Independence from climate.** It works in challenging environments, including high ambient temperatures (up to 45°C) (130°F), humid environments and industrial settings

SINGLE-PHASE IMMERSION COOLING TECHNOLOGY AS AN INTEGRATED SOLUTION OFFERS UP TO 48% REDUCTION IN ENERGY FOOTPRINT[7]

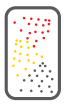
Which Type of Cooling System Is the Best Fit for Your Data Center?

	AIR COOLING	LIQUID COOLING		
	Air cooling (traditional data centers)[a]	Single-phase cooling: cold plate (water)[b]	Single-phase cooling: immersion[ab]	Two-phase cooling: (High heat range applications)[b]
Cooling capacity	+	+ +	+ + +	+ + + +
Harware integration (For example, space needed)	+	+ +	+ +	+ +
Hardware reliability	+	–	+ +	+
Hardware performance	+	+ +	+ + +	+ + +
Heat recovery	+	+ +	+ + +	+ + +
Initial capital expenditure	+	–	+ +	– – –
Operating expenditure	+	+ +	+ +	+ + +
		The liquid coolant never changes state (no boiling/freezing, etc.), for example, it is used in high-performance computing		Mainly for high heat range applications such as crypto mining

a. Infrastructure Services Group, reported in Global immersion cooling market in data centers – Growth, trends, forecast (2019–2024), Mordor Intelligence (2019)
b. Customer feedback and internal evaluation

Immersion Cooling – The Heart of an Integrated Energy Solution

Single-phase immersion cooling solutions are at the heart of our integrated energy solution for data centers.



Fluid Solutions. We have developed **Shell Immersion Cooling Fluid S5 X** to help you get the most from your natural convection or pumped/forced data server liquid cooling systems. This synthetic fluid made from natural gas is inherently stable to provide superior performance and material compatibility with server components. It is clear, odorless, non-toxic and so safe that it is approved for use in applications such as cosmetics.

Heat Reuse. Immersion cooling gives you the opportunity to reuse the heat generated by your servers. For example, a system can be optimized for heat reuse scenarios to recover up to 99% of the heat generated as 55°C water for use in district heating projects or directly by industrial users.[9]

Renewable Energy. Immersion cooling technology as an integrated energy solution can cut data center energy use by up to 48%.[7] We can help you reduce your carbon footprint further through on-site solar power and/or renewable energy supply.

Carbon Credits. Once you have reduced your energy needs, we can deliver environmental solutions that enable you to manage your local and regional carbon dioxide compliance obligations and gain access to global markets. If you have made a strategic decision to reduce or eliminate your net carbon footprint, we offer a variety of high-quality voluntary carbon credit solutions. Most of the projects in our global portfolio are nature-based and focused on protecting, transforming or restoring land.

The Shell Immersion Cooling Fluid solution is one of a handful of innovations featured in a World Economic Forum white paper showcasing disruptive innovations in the energy sector judged to be **NOVEL, BENEFICIAL TO SOCIETY AND ACCELERATING THE ENERGY TRANSITION.**[8]

Benefits by User

Cloud providers and hyperscale data centers can optimize their efficiency and achieve their sustainability goals while standardizing facilities for a variety of hardware requirements.

Enterprises can simplify their on-premise data centers for high efficiency and decreased dependency on the public cloud by adopting next-generation hardware.

Telecom providers can operate edge data centers anywhere. They can also use existing buildings within power and cooling availability constraints.

Research institutes can facilitate on-campus HPC environments without the need for advanced data centers with their associated energy and cost demands.

Colocation providers can facilitate high density and performance compute users in a simple and scalable manner.

IMMERSED COMPUTING TECHNOLOGY CAN CUT ENERGY USE BY 48%, BOOST CPU PERFORMANCE BY UP TO 40% AND REDUCE CAPITAL AND OPERATING EXPENDITURE BY 30-40%.[6,7]

Fluid Development

Shell Immersion Cooling Fluid S5 X, is a synthetic, single-phase immersion cooling fluid made from natural gas using Shell's gas-to-liquids technology.

It is designed to[9]:

- **Reduce energy costs and emissions** through its high cooling efficiency, flow behavior and excellent thermodynamic properties
- **Cost less to manufacture than** fluorocarbon and incisively engineered synthetic fluids
- **Improve product safety** through its high compatibility with computer components
- **Be safe** and easy to handle

Compared with the fluorocarbons typically used in two-phase systems, Shell Immersion Cooling Fluid S5 X has[9]:

- **Better** heat capacity
- **Higher** heat transfer efficiency
- **Improve product safety** through its high compatibility with computer components
- **Lower** volatility means that the tanks can be operated safely for the life of the data center without being sealed or having the fluid replaced
- **Lower** fluid density for less floor loading and possible reinforcement

SHELL IMMERSION COOLING FLUID S5 X IS A SYNTHETIC, SINGLE-PHASE IMMERSION COOLING FLUID MADE FROM NATURAL GAS USING SHELL'S GAS-TO-LIQUIDS TECHNOLOGY.

Shell Immersion Cooling Fluid S5 X has been developed to achieve high levels of safety, performance and reliability. It is optimized for natural convection-driven immersion cooling solutions but can also be used in pumped/forced circulation systems.

- **Safety and purity.** Being made from natural gas gives Shell Immersion Cooling Fluid S5 X outstanding safety and purity. It meets EU and US pharmaceutical purity requirements, is a non-halogenated, food-grade product that is free from allergens and has extremely low volatility.[10]

- **Performance.** Shell Immersion Cooling Fluid S5 X has excellent thermodynamic properties, a low density and a high flash-point. It is non-evaporating.[10]

- **Protection and reliability.** The fluid has high compositional consistency and very high oxidation and thermal stability. It contains virtually no sulphur, nitrogen or aromatics, and is non-corrosive.[10]

FOOTNOTES

[1] Kamiya, G., & Kvarnström, O. (2019, December 20). Data centres and energy – from global headlines to local headaches? Retrieved April 27, 2021, from https://www.iea.org/commentaries/data-centres-and-energy-from-global-headlines-to-local-headaches

[2] Data center infrastructure management Solutions market by application and geography - forecast and Analysis 2020-2024. (2020, August). Retrieved April 27, 2021, from https://www.technavio.com/report/data-center-infrastructure-management-solutions-market-industry-analysis

[3] Our climate target: Frequently asked questions. (n.d.). Retrieved April 27, 2021, from https://www.shell.com/energy-and-innovation/the-energy-future/what-is-shells-net-carbon-footprint-ambition/faq.html

[4] Behind the numbers: Growth in the Internet of things. (2015, March 20). Retrieved April 27, 2021, from https://www.ncta.com/whats-new/behind-the-numbers-growth-in-the-internet-of-things

[5] Centres using traditional air-based cooling technologies. 3M report referenced in Global Immersion Cooling Technology, Mordor Intelligence (2019).

[6] Immersion cooling market in data centers: Growth, forecast (2019-2024). (2020). Retrieved April 27, 2021, from https:/www.mordorintelligence.com/industry-reports/immersion-cooling-market-in-data-centers

[7] De Azevedo, E., Wang, L., Veeralinga Shivaprasad, P., &; Wei, T. A NEW IMMERSION COOLING FLUID to enable low-carbon data centres (No. 30 ed., Vol. 09, pp. 50-55, Tech.). Shell TechXplorer. These figures are based on Asperitas' test results. The benefits achieved will vary according to the actual site deployment.

[8] Global innovations from the energy sector: World Economic Forum white paper. (2020, May 27). Retrieved April 27, 2021, from https://www.weforum.org/whitepapers/global-innovations-from-the-energy-sector

[9] Asperitas' & Shell. Integrated Immersion Cooling Solutions - Enabling Game Changing Energy USE Reduction at Data Centers [Brochure]. Author. Retrieved May 03, 2021, from https://www.shell.us/businesscustomers/lubricants-for-business/process-oils/immersion-cooling-fluids

[10] Based on Shell's internal tests and evaluations. Technical Data Sheet: Immersion Cooling Fluid S5 X. (2020, September 27).