The Sustainable Data Center Transformation:

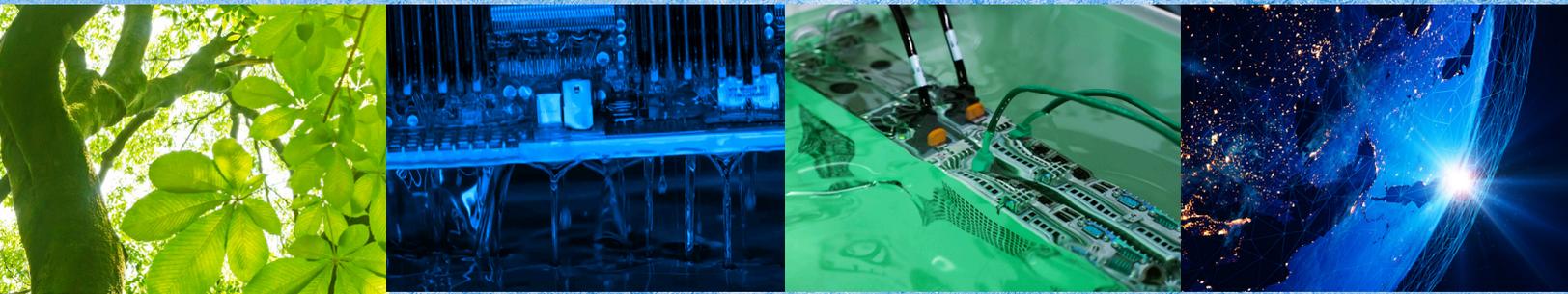Reducing Carbon Footprint with
Liquid Immersion Cooling

White Paper

The Sustainable Data Center Transformation:
Reducing Carbon Footprint with Liquid Immersion Cooling

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Introduction

Data centers leave a significant carbon footprint and, as the need for these mission critical facilities continues to surge, the current trajectory is toward increasing power use and greenhouse gas emissions. Greenhouse gas emissions can contribute to extreme weather and put the health of our planet at risk. There is growing demand from both the public and industry to reduce the environmental impact of all businesses — sustainability has moved into the corporate domain and, due to regulations and the cost implications of reducing a carbon footprint, it can be a hot button issue.

With these economic and political pressures driving data centers to seek alternative approaches to conventional facility design, owners and operators are turning to liquid immersion cooling to reduce power use and drive sustainability efforts.

Market Drivers

There are two key forces at work in the data center space that demand sustainable solutions: power use and the role of sustainability in the corporate agenda.

Power Use

Globally, data centers currently use approximately 1.5 - 2% of the world's electricity.[1] Several models suggest that data center energy use will only increase, accounting for up to 13% of global electricity use in the next decade.[2] Up to 40% of a data center's energy consumption goes into cooling,[3] since dozens of servers stacked on top of each other get very hot. And, as the power density of processors continues to increase, server platforms are pushing the limits of what you can cool with air.

This energy use is a dire concern, but could potentially be mitigated if that electricity was generated from wind or solar farms. The reality is, though, that over 60% of the world's electricity is still produced using fossil fuels,[4] with carbon emissions from tech infrastructure and the data servers that enable cloud computing already exceeding those of pre-Covid air travel.[5] This paints a grim picture for the environmental impact of data centers.
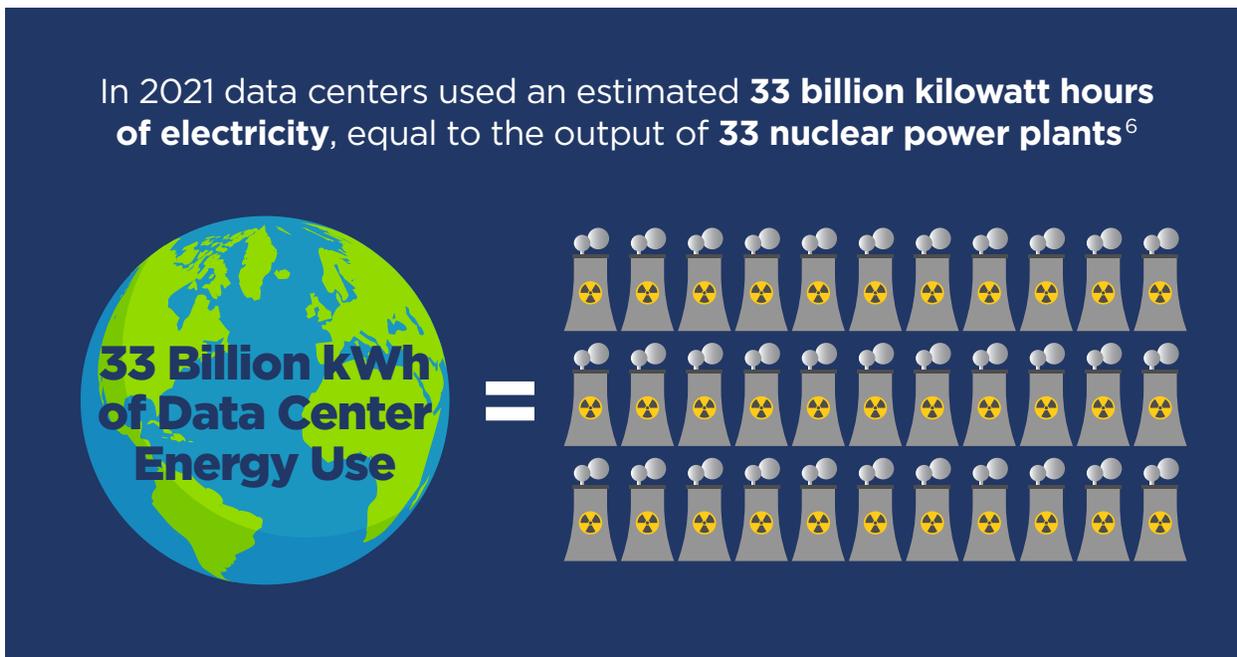
[1] https://davidmytton.blog/how-much-energy-do-data-centers-use/
[2] https://davidmytton.blog/how-much-energy-do-data-centers-use/
[3] https://www.energy.gov/eere/amo/energy-efficient-cooling-control-systems-data-centers
[4] https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions
[5] https://www.ft.com/content/c719f655-149c-4ce0-a7a5-18527c7776cf

In 2021 data centers used an estimated **33 billion kilowatt hours of electricity**, equal to the output of **33 nuclear power plants**[6]
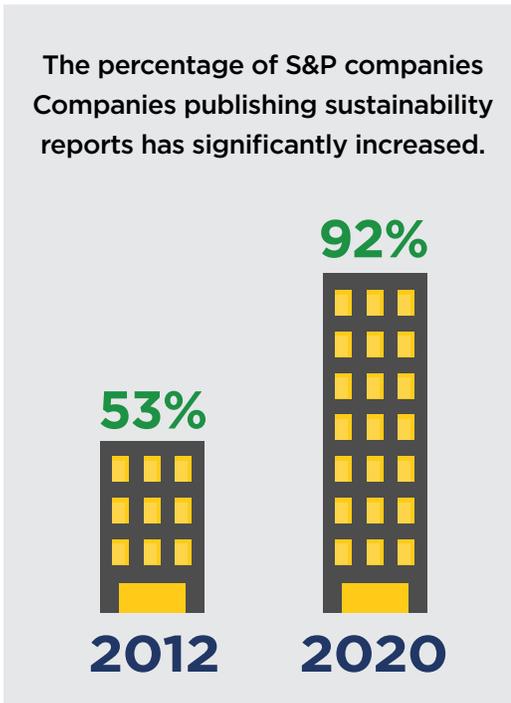
33 Billion kWh of Data Center Energy Use =

Sustainability on the Agenda

Recognizing the global trend in this direction, the value of environmentally responsible operations in their own right and increasing governmental regulations, sustainability is high on the agenda of many corporations. Some customers will not even consider working with a company that is not taking action to reduce their impact on the environment.

Sustainability is on the radar in the data center space, too. There is a growing awareness of how operations impact the environment — including the power brought into the data center, how much is actually used for compute work, and how much of that energy is wasted. And three-quarters of data centers are right now thinking about the importance of sustainability as a competitive differentiator.
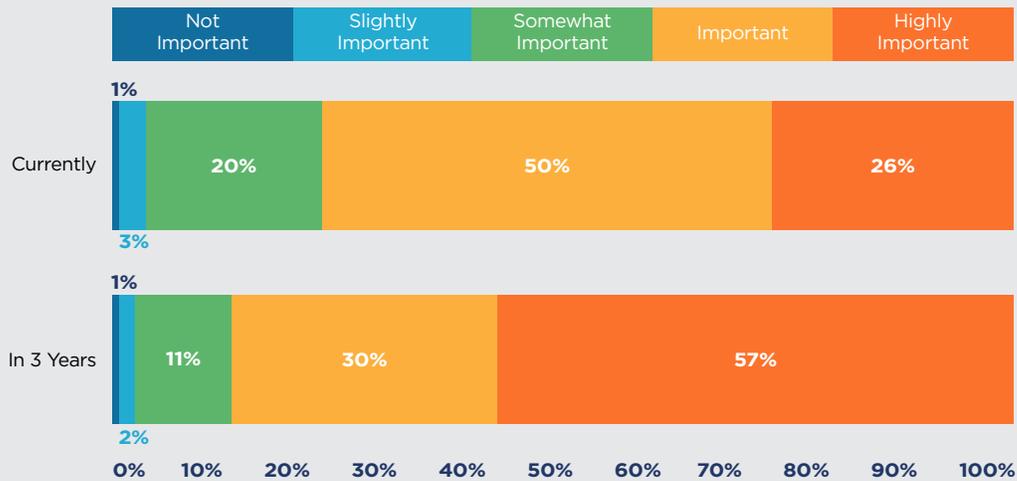
The percentage of S&P companies Companies publishing sustainability reports has significantly increased.

92%

53%

2012   **2020**

Source: Governance and Accountability Institute[7]

[6] https://www.statista.com/statistics/186992/global-derived-electricity-consumption-in-data-centers-and-telecoms/#statisticContainer

[7] https://www.ga-institute.com/research/ga-research-collection/sustainability-reporting-trends/2021-sustainability-reporting-in-focus.html

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Sustainability's Impact on Competitive Differentiation

Q: How would you rate importance of efficiency and sustainability to your organization's competitive differentiation, currently and in three years?

Not Important	Slightly Important	Somewhat Important	Important	Highly Important

Currently
1%
20%
50%
26%
3%

In 3 Years
1%
11%
30%
57%
2%

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Source: From 451, webinar: Immersion Cooling the Future is now

The Problem

To keep up with demand, data centers are implementing more powerful compute resources, which consume more energy and rapidly expand an organization's carbon footprint. The increasing dependency on internet-enabled devices is likely to drive increased electrical use, and a significant environmental impact, in data centers. IDC expects that by 2025, 152,000 new devices will be connecting to the internet every minute, bringing the total to 80 billion worldwide.[8] That's a lot of data flying and flowing through data centers.

Even data centers that are aware of this energy use challenge haven't been able to move the needle much. The average data center has hit a wall in power usage effectiveness (PUE), which has been hovering around 1.6 for almost a decade.[9]

Causes of increasing energy demand	• Power-hungry processors • Internet of Things (IoT) • Artificial intelligence (AI)	• Streaming entertainment • Edge deployments • 5G mobile networks

[8] https://www.forbes.com/sites/michaelkanellos/2016/03/03/152000-smart-devices-every-minute-in-2025-idc-outlines-the-future-of-smart-things/?sh=4de871574b63
[9] https://www.statista.com/statistics/1229367/data-center-average-annual-pue-worldwide/

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The Solution

Where power consumption is concerned, there are many steps operators can take, and are taking, to green up their data centers. Installing more energy efficient UPSs, servers, and power distribution units (PDU) are a good start. However, since upwards of 40% of a data center's energy consumption goes into cooling,[10] that is the most productive focus for improvement.

Liquid immersion cooling is much more efficient than air cooling and has emerged as one of the leading technologies to address these challenges. Air cooling only captures 30% of the heat generated by the servers. Because in an immersion cooling system the liquid circulates around all of the components, the fluid captures 100% of the server heat, making it more efficient and cost effective.

"There's a fair amount of consensus that the end game is using immersion cooling"

— Marc Bhuyan, Google Machine Learning Infrastructure Project Manager [11]

Benefits of Liquid Immersion Cooling

Liquid immersion cooling delivers an integrated cooling ecosystem in the data center, that enhances sustainability and reduces costs.
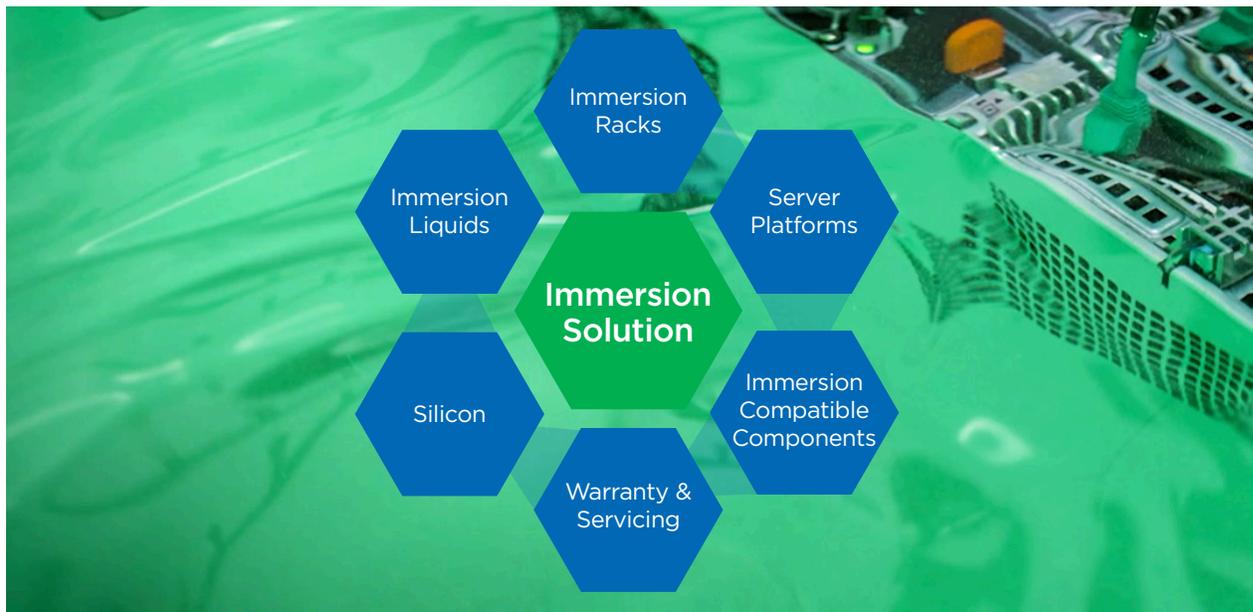
Source: (screenshot from) Intel Cloud Innovations PDF

[10] https://www.energy.gov/eere/amo/energy-efficient-cooling-control-systems-data-centers
[11] At the December 2018 BisNow Conference

• Sustainability

The first step to sustainability in data centers requires understanding where energy is consumed and how power is divided between infrastructure and server load. Then, reducing the environmental impact is a matter of finding ways to reduce power demand and reuse waste heat.

The removal of internal server fans reduces the energy load by 10-15%. Essentially, same amount of compute that required 1,000 kW of power can be performed with only 900 kW of power with immersion cooling, since immersion cooling consumes a fraction of a percent to operate. And, this doesn't include power savings realized from decommissioning the existing cooling infrastructure.
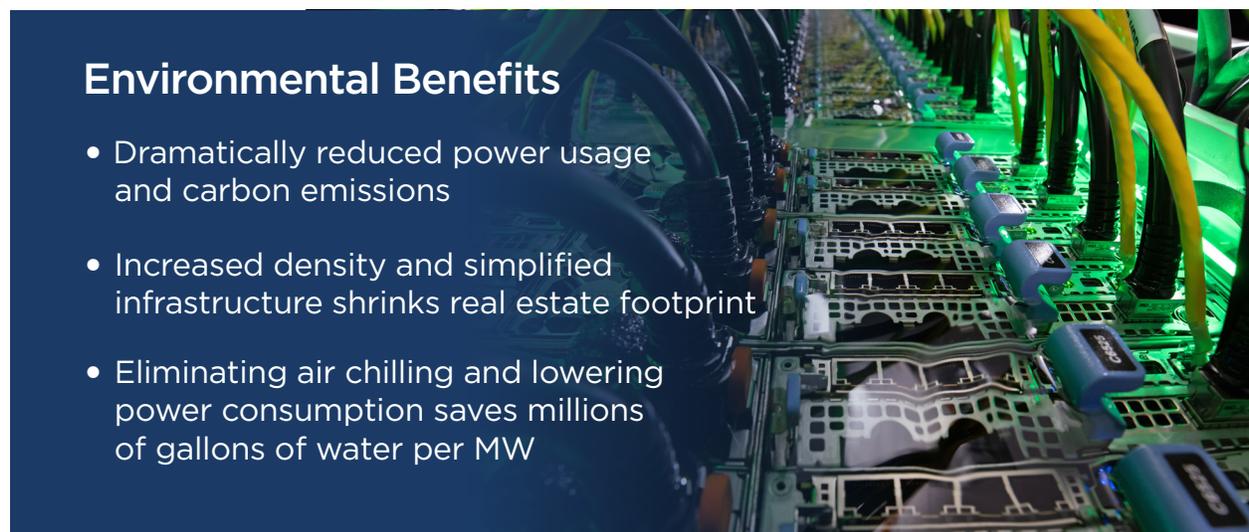
Environmental Benefits

- Dramatically reduced power usage and carbon emissions

- Increased density and simplified infrastructure shrinks real estate footprint

- Eliminating air chilling and lowering power consumption saves millions of gallons of water per MW

Water use is also a significant sustainability factor for traditional, air-cooled data centers and is primarily driven by two factors, power generation (indirect) and chilling water for cooling purposes (direct). In 2018, US data centers alone consumed 5.13×10^8 m³ of water.[12] Immersion-cooled data centers can significantly reduce the water consumption due to the minimal power requirements of the systems themselves, as well as their ability to cool high-density racks with chiller-free water.

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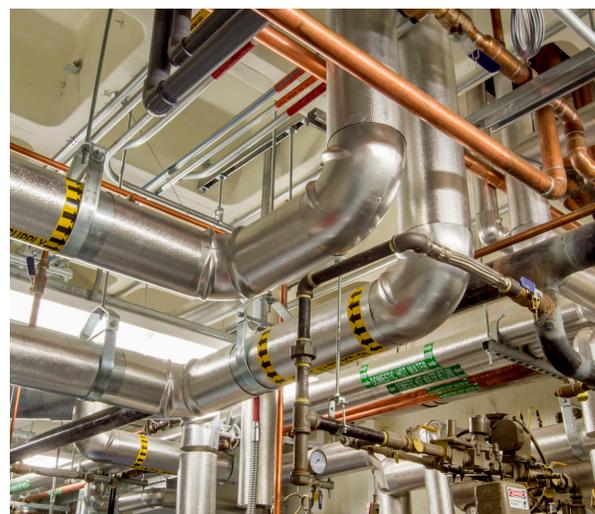
• Cost Reduction

Immersion cooling also reduces costs throughout the life of the data center — including the construction of the data center and its disposal at end of life. Because immersion cooling enables more servers to fit in a compact space, data centers can be smaller. This, in turn, reduces the amount of building materials used, and equipment that is not required or is reduced in size, such as switchgear, cabling, and smaller stand-by generators due to the decreased load. So, apart from the reduced power demand to the site there is also a reduced CapEx and OpEx.

Immersion Cooling Reduces Costs

- High capacity, immersion cooling systems reduce data center space requirements — and construction costs — without sacrificing compute

- Air cooling infrastructure and accompanying operation and maintenance expenses are eliminated

- Removing server fans and power-hungry refrigeration infrastructure results in up to 90% reduction in cooling energy consumption

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GRC + Intel: Liquid Immersion Cooling

One of the advantages to liquid immersion cooling is that it is scalable — you can start small with some servers in your data center or deploying an edge date center, for example. Single-phase liquid immersion cooling is the most energy efficient of all liquid cooling technologies. Its extraordinary energy efficiency also enables the downsizing and/or elimination of other data center infrastructure, and significantly reduces energy requirements.

Servers used in immersion cooling are the same as those used in air cooling with a few modifications, such as removing the fans. Providers in the ecosystem are working together to continuously improve the designs and enhance the technology for immersion cooling. Additionally, Intel and GRC have partnered to optimize compatibility and performance of immersion fluids for servers using Intel processors. This collaboration is designed to ensure that as new fluid formulations enter the market, data centers can be confident these fluids meet standards for safety, material compatibility, and thermal performance.

GRC and Intel are also looking at how to continue to improve the ecosystem. As leading industries, including those in the cloud and telecom spaces, are adopting liquid cooling solutions, Intel is designing silicon with immersion cooling in mind, rethinking elements like the heat sink. GRC continues to innovate tank design to refine components and serviceability to address the evolving needs of clients across industries.

Comparing Liquid Cooling Solutions

Key Considerations	Rear-Door Heat Exchanger	Liquid-to-Chip	2-Phase Immersion	Single-Phase Immersion
Improved Energy Efficiency	🟡	🟢	🟢	🟢
High-Density Cooling Performance	🟢	🟢	🟢	🟢
Low Acquisition Cost	🟡	🟡	🔴	🟢
Sustainability	🟡	🟢	🟡	🟢
Minimal Complexity	🟡	🔴	🔴	🟢
Server Reliability	🔴	🟢	🔴	🟢
Simplified O&M Practices	🟢	🟢	🔴	🟡
Location Flexibility	🔴	🟡	🟢	🟢

Poor 🔴 🔴 🟡 🟢 🟢 Excellent

Compute demand continues to increase, fueling the need for data center capacity and the consumption of increased power. Because the implementation of immersion cooling can materially reduce the environmental impact of data centers, data centers are looking to liquid cooling to improve sustainability and reduce carbon footprint.

By coming together to support the ecosystem, Intel and GRC are working to develop solutions for enabling greater compute while improving sustainability profiles. Contact us to learn more and get started on your journey to a greener data center.

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