RESONANCE
ASSET MANAGEMENT

Heat Management: Industrial Cooling Solutions
January 2024

Executive Summary

Industrial Context

- Industrial producers must manage heat generated during core industrial processes to achieve continuous operations.
- Industrial cooling consumes large quantities of **water** and **energy**, releasing **carbon emissions** and waste heat. Efficient cooling solutions are essential for achieving carbon reduction targets and complying with tightening reporting requirements.
- Technology for sustainable cooling is available - energy-efficient solutions are typically water-intensive, which can cause water stress and pollute the local environment.
- Corporations should invest in retrofitting existing assets with sustainable heat management technology that achieves both energy and water consumption reduction to reduce their negative impact on the environment.

Cooling Data Centres – a growing global challenge to water and energy resources.

- Demand for data storage and processing, accelerated by COVID-19 and AI advancements, is driving the growth of the data centre industry.
- The rapid expansion of the IT sector is posing a challenge to local water and energy resources as cooling is essential to sustained operations.
- The scope for greening data centres is broad, examples include investing in renewable and low-carbon power, recycling waste heat through innovative co-location strategies, and using alternative liquids to potable water.
- Data centres are essential to society and national security. The global investment opportunity is significant and extends to retrofitting sites with co-located sustainable assets and building new, green data centres which incorporate sustainability into their operating model.

Resonance Asset Management specialises in financing sustainable solutions to reduce the impact of industry on the environment. Resonance possesses the technical expertise to collaborate with cooling solutions developers and operators to service industrial clients with reliable technology. We are experienced in financing and advising on water treatment and re-use solutions that can be essential to achieving more sustainable data centre cooling systems.

Industrial Context

Industrial processes generate a substantial amount of heat with approximately 20 to 50% of overall energy inputs being converted and wasted as heat.[1] If unchecked, this excess heat poses a serious risk from overheating and an increased likelihood of equipment damage or fires.[2] This makes industrial cooling indispensable across various sectors, playing a critical role in high-energy processes within oil and gas, chemicals, metallurgical plants, and the high-tech sector's data centres as well as other key process industries.

In general, cooling activities fall into two categories: process cooling, focusing on precision heat removal from industrial processes, and space cooling, providing basic climate control in industrial spaces through air conditioning/heat pumps to maintain a comfortable temperature level. The demand for both process and space cooling is anticipated to rise significantly due to the dual pressures of climate change and economic expansion.

Environmental Context

Globally, industrial cooling contributes to over 10% of greenhouse gas emissions as most systems are powered by fossil fuel-based sources.[3]

Water cooling approaches, while relatively efficient, can lead to significant water consumption from water-stressed regions. Industrial evaporative and direct cooling are reported to have been responsible for an average of 60% of water use at industrial sites in 2021, a figure that is unsustainable if sources are not replenished.[4]

Therefore, environmentally minded corporations who are striving to meet sustainability targets would make significant gains by investing in low-carbon, circular technologies.

Cooling Data Centres

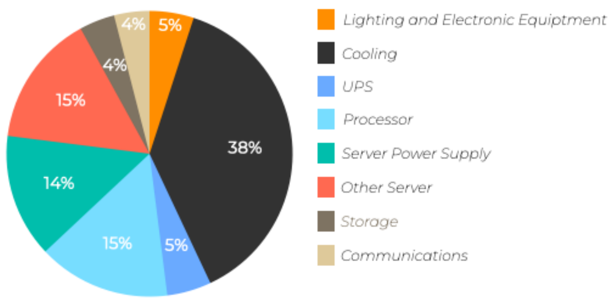
The high-tech industry has expanded rapidly in recent years - more processing capacity requires more cooling as existing sites increase their capacity and more data centres are coming online.[5]

Sector growth has been driven by the adoption of remote work models since COVID-19, the expansion of digital currencies, and the increasing online presence of mobile phones, which already account for 60% of today's internet traffic. Generative AI will demand even more processing power and process cooling as it is use cases increase; currently, for every 5 - 50 tasks the processing requires approx. half a litre of water for cooling, depending on complexity and data centre processing efficiency.[6]

Sustainability Challenges

The expansion of the data centre market will continue to increase strain energy and water resources if sustainable operations are not achieved.

Despite gains in efficiency, input demand has risen 20 – 40% annually with the combined electricity consumption from the largest providers, Amazon WS, Microsoft, Google, and Meta, doubling between 2017 and 2021.[7] Projections indicate that by 2030, global electricity consumption by data centres is anticipated to reach 4%.



Source: Engie, 2021

The chart illustrates cooling as being the most energy-intensive process. Reducing this wedge can accelerate progress toward corporations' net-zero goals and sustainability pledges.

To put the figures into perspective, a typical 20-50MW hyperscale facility has ten times the power consumption of a typical American home, consuming approximately 1,000kWh per square metre.[8]

[1] US Department of Energy, Waste Heat Recovery Basics, Website accessed Dec 2023
[2] Cordis, Horizon 2020, EU Commission 2020
[3] Annual Review of Environment and Resources, Uni of Michigan 2021
[4] Veolia, Industrial Cooling Circuits, 2023
[5] Data Centre Dynamics, April 2023
[6] Business Today quoting Shaloei Ren, Research from University of California 2023
[7] IEA, Energy Systems, Data Centres and Data Transmission Networks, 2022
[8] C&C Technology Group, Josh Mahan, 2023

US hyperscale facilities consume approximately 1,000kWh per square metre → 10 times the power consumption of a typical US household → and an equivalent daily quantity of water in a small US city of 50,000.

The tech sector is likely to become the third largest consumer of water after energy production and agriculture as its demand is forecasted to double from approx. 1bn litres per annum to 2bn by 2030.[9]

Currently, data centres in the US are the tenth largest consumer, with an average water usage effectiveness of 1.8l per kWh, consuming 11 - 20 million litres of water a day, equivalent to a small city of ~50,000 people.[10]

Policy Updates

At the moment, regulations restricting energy and water use have not been passed, but new guidance, standards, incentives and disclosure requirements are being announced.

The **EU's Energy Directive**, recast in October 2023, introduced minimum performance standards for new and refurbished data centres based on the best available technology, mandatory reporting obligations for data centres with a capacity of >500kW, and an obligation for operators to promote the use of renewable energy in their facilities.[11]

In the US, in January 2023, the **Department of Energy** issued efficiency requirements for Heating, Ventilation, and Air Conditioning (HVAC) equipment essential to data centres. In 2024, the **Securities and Exchange Commission** is expected to rule on standardising climate-related disclosures impacting data centre companies.[12]

Voluntary schemes are also on the rise. Europe's **Climate Neutral Data Centre Pact** (set up in 2021) has over 100 service providers committing to be climate-neutral by 2030. The UK's **Climate Change Agreement for Data Centres** (since 2014) offered discounts on the Climate Change Levy targeting PUE reductions of 15%. Failure to reach the targets results in penalties in the form of carbon offset purchases. In December 2021, 50% of enrolled data centre companies had to buy carbon offsets.[13] This Department of Energy Security and Net Zero (DESNZ) is likely to extend the scheme until March 2025.[14]

To achieve long-term sustainable growth, tech companies have to invest in efficiency and circular solutions to reduce their environmental footprint, protect their brand image, and comply with government standards on reporting and efficiency.

Solution: Sustainable Power

Case Example: Behind the Meter Wind Power Purchase Agreements[15]

After a successful pilot programme. Digital Power Optimisation, a US data centre developer, has agreed to a behind-the-meter PPA covering up to 100MW from a Texas wind farm. Decentralised power is likely to be a solution for many data centres located in isolated areas with limited grid infrastructure. Building on-site energy solutions requires less investment than building out central-grid infrastructure and can offer better control and efficiency improvements.

- This is the first of several expected agreements as DPO expects its data centre deployment to reach 100MW in size locally, extending across six of the seller's Texas wind assets.
- The data centre will draw power directly from the generating facility, curbing efficiency losses in grid transmission.
- The first data centre is expected to come online by 2024 with other sites being added over the next two years.

[9] Bluefield Research, taken from The Telegraph, December 2023
[10] Clifford Chance, Data Centre Trends, 2023
[11] **E**nergy efficiency directive, Tpics, European Commission December 2023
[12] Data Centre Dynamics, The path to data centre decarbonization starts now. July 2023
[13] Climate Change Agreement for Data Centres Jan 2020 – Dec 2021 Data
[14] TechUK News, Climate Change Agreements for Data Centres Insights, Nov 2023
[15] Inspiratia, 5th January 2024

Case Example: Data Centres inside Large Turbines

WestfalenWIND IT, an operator subsidiary of Westfalen Wind Group, has partnered with a carbon-neutral Swiss TV streaming platform and Green IT data centre developer to deliver data centres located inside large on-shore wind turbines in Germany.[16]

WindCORE Project

- The turbines are 13m wide, and 150m high - fit four fire-resistant IT safety cabinets housing 62U server racks.
- 92% of the required power came from the wind turbine above it, the facility is also connected to two independent electricity providers to ensure a constant flow.
- The WindCORE project has been operating for around for 10 years – WestfalenWIND estimates that unused electricity generated could power one-third of all German data centres.
- German data centres average 430g grams of CO2 released per KWh, for WindCORE it is around 10 grams.

Case Example: Geothermal Power for Google[17]

Geothermal energy is reliable with flexible energy generation capacity. In the US it currently provides a low percentage of carbon-free baseload energy to several power grids.

Google is supporting Fervo, a geothermal power developer, to build a pilot facility, Project Red, to support its data centres in Nevada.

Alastair Wiper / Courtesy of Fervo

- Fervo is a US start-up that uses oil and gas drilling technology to drill deep wells, water is pumped through a system of underground fissures absorbing heat before returning to the surface at temperatures sufficient to generate steam.
- The US government is supportive of geothermal energy production with IRA funding available and the DOE's Enhanced Geothermal Shot initiative to reduce costs by 90%.[18]
- Geothermal energy avoids intermittency issues. Harnessing this power reduces the risk of downtime, providing a stable, zero-carbon, supply to data centres.
- Google has signed a PPA with Fervo will provide power to the grid.

Case Example: Nuclear Powered Data Centres

Another solution that avoids the risk of intermittency and data centre downtime is nuclear power. Nuclear energy is a reliable source of high-density, carbon-free power that would remove the need for onsite, fossil fuel backup generators.

There are several data centres already co-located with large nuclear power plants in the US. However, small modular reactors are gaining prominence with the growing potential for SMR developers to supply data centres with infrastructure-as-a-service.[19]

Rolls Royce, Small Modular Nuclear Reactor Rendor, Website Jan 2024

- Despite being at the proof-of-concept stage, the market for SMRs is expected to reach $72.4bn by 2033 with 80 designs under development globally.[20]

[16] CNN, December 2023

[17] Climate Wire, Article December 2023

[18] Infrastructure Investor, 3rd January 2024

[1919] Doomberg, Fission Chips, Nov 2023

[20] Infrastructure Investor, 11th January 2024

- A recent job posting by Microsoft for the role of 'Principal Program Manager Nuclear Technology' suggests that big tech companies are taking nuclear energy seriously.[21]
- OpenAI's CEO Sam Altman recently announced a start-up, Oklo, specialising in modular nuclear microreactors that power the rapid expansion of the tech industry and AI capabilities sustainably.[22]

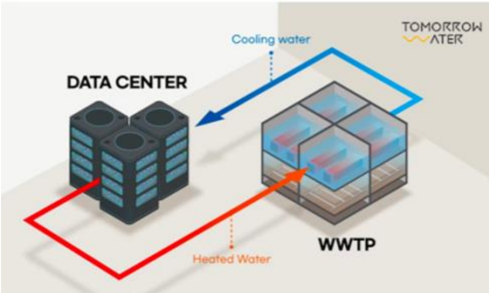
At the moment, renewable energy dominates policy marginalising nuclear which is marred by controversy around public safety and the environmental risks of toxic waste. However, these developments focus on nuclear as a viable carbon-free energy source with a more optimistic outlook on the development and deployment of SMRs as a net zero solution.

Solution: Cooling and Re-cycling Waste Heat

Case Example: Anaerobic Digesters Co-located with Data Centre Sites

A Korean water treatment company, Tomorrow Water, is proposing to build data centres at water treatment plant sites in cities:

- The project, currently in its pilot stage, aims to reduce the environmental impact of municipal water treatment and data centres by repurposing waste heat. •
- Sewage treatment plants near cities use anaerobic digestion to generate biogas and produce potable water.
- Co-locating AD plants with data centre assets would achieve efficiency through heat transfers. The transmitted heat enhances the biological process and dries the sludge at the reclamation site.
- Biogas can serve as an onsite energy source as biomethane can be compatible with natural gas backup generators.



Co-Flow Data Centre, designed by Arcadis and Tomorrow Water, in South Korea, pioneering BBF/Proteus bio filtration technology from BKT Co

This solution could be adopted on many sites to achieve reduced energy and water footprints and is in line with environmental initiatives such as the EU's Green New Deal and the UN's SDGs. Tomorrow water is currently securing funding to develop the pilot site WRRF-data centre system in Asia.[23]

Resonance Pipeline Project: Seawater Cooling in Singapore

Singapore is the world's most power-constrained data centre market due to rapid growth in demand for storage and processing power. The vacancy rate in its data centres is less than 2%, which means that each centre is working at near capacity requiring vast amounts of power and cooling 24/7.[24]

Resonance is developing a greenfield seawater cooling solution for an industrial district in Southeast Asia:

- Resonance is evaluating a project in Singapore to build a seawater cooling asset that uses ambient temperature water and circulates the waste heat from the data centres to an industrial park for heating purposes. The sea water does not require energy-intensive desalination treatment.
- This solution presents significant cost savings and reduces the environmental impact of the data centres on the natural environment as seawater is an abundant resource and waste heat is re-used, reducing the overall carbon footprint of the sites.
- The societal impact is also reduced - Singapore is densely populated and suffers stress on its potable water resources. This asset would avoid the consumption of potable water, a precious and limited resource.

[21] CNBC, September 2023
[22] Fortune, Environment, July 2023
[23] Datacentre Dynamics, 2021
[24] CBRE, Global Data Center Trends 2023

Investing in Co-located Sustainable Assets

Resonance Asset Management specialises in financing sustainable solutions to reduce the industry's impact on the environment. Resonance possesses the technical expertise to collaborate with cooling solutions developers and operators to service industrial clients with reliable technology. We are experienced in financing and advising on water treatment and re-use solutions that can be essential to achieving more sustainable data centre cooling systems.

Several existing pipeline deals achieve onsite wastewater treatment, heat reuse and efficiency gains from re-distributing heat from data centre to other industrial purposes. Our strategy achieves the following benefits for our stakeholders:

Benefits for Client Corporations:

A low-carbon solution for both energy and cooling allows industrial clients to:

- Outsource expertise for constructing and operating assets.
- Achieve emissions targets with access to the latest low-carbon solutions and expertise.
- Reduce costs through efficiency savings.
- Comply with current and upcoming regulations.
- Gain approval from end-consumers, thereby supporting brand reputation.

Benefits for Investors:

For Resonance's investors, sustainable solutions offer:

- Tangible and measurable impact by reducing emissions and limiting waste.
- A diversified portfolio of environmental investments.
- Predictable cash flows from long-term off-take contracts.
- Additional upside potential from various subsidies and tradable carbon offsets.

By adopting sustainable cooling solutions, industry can enhance operational resilience and contribute to internal and global environmental goals. Embracing circular and alternative technologies demonstrates a forward-thinking approach to balancing industrial growth with environmental responsibility.