REDUCING ENVIRONMENT FOOTPRINT OF DATA CENTRE - ENVIRONMENT

NEWS: A new study by researchers from **Microsoft and WSP Global,** published in **Journal Nature,** reveals that **advanced cooling methods** can significantly cut the **environmental footprint of data centres.**

WHAT'S IN THE NEWS?

Understanding Data Centres and the Need for Cooling

- **Definition:**
  Data centres are large-scale facilities that house interconnected systems such as servers, storage units, networking equipment, and computing infrastructure used to store, manage, and process massive volumes of digital data.

- **Applications:**
  They serve as the backbone for essential digital services including cloud computing, AI processing, big data analytics, web hosting, online banking, e-commerce, and enterprise IT operations.

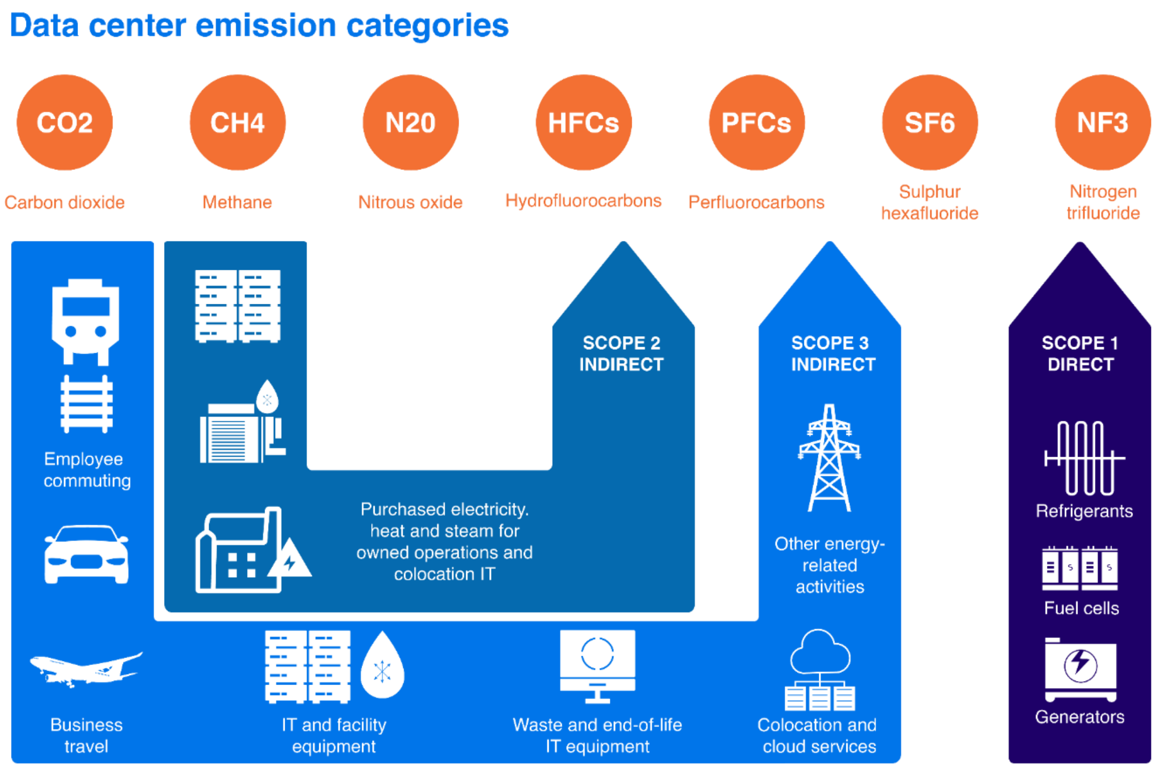
- **Heat Generation Issue:**
  Continuous high-speed computing operations generate intense heat due to the dense arrangement of electronic components such as CPUs, GPUs, and memory units.

- **Importance of Cooling:**
  Without proper cooling mechanisms, overheating can lead to hardware failures, performance degradation, reduced life expectancy of components, and unplanned service disruptions.

Modern Cooling Techniques in Data Centres

- **Cold Plate Cooling (Direct-to-Chip):**
  - Involves the direct attachment of microchannel heat exchangers (cold plates) to CPUs/GPUs.
  - Coolants like treated water or refrigerants absorb and carry away heat efficiently.
  - Offers a high-performance thermal solution akin to placing an ice pack on a fevered head.
- **Immersion Cooling:**
  - Hardware components are fully submerged in a dielectric liquid that absorbs and dissipates heat.
  - **Single-phase systems:** Fluid stays liquid and circulates heat without changing phase.
  - **Two-phase systems:** Fluid evaporates upon contact with hot components, then condenses and recycles.

- Common coolants include **synthetic esters, mineral oils, silicone-based fluids, fluorocarbon liquids**, and **fluorinated ketones**.



Comparison of Cooling Technologies

Aspect	**Air Cooling**	**Direct-to-Chip Cooling**	**Immersion Cooling**
Cooling Medium	Air via CRAC/CRAH, fan walls	Liquid via cold plates	Dielectric fluids (liquid/vapour)
Efficiency	Low (due to air's low thermal conductivity)	High (targets specific components)	Very high (fluid contacts all surfaces)
Component Coverage	Whole rack environment	CPUs, GPUs only	Entire system submersion
Power Density Support	~20 kW/rack (optimized)	50–100 kW/rack	Up to 500 kW/rack or more
Maintenance	Easy; widely supported	Moderate; limited support	Complex; needs specialised hardware
Deployment	Simple, widely used	Moderate; leak-prone	Complex infrastructure (tanks, handling units)
Sustainability Potential	Lower	Medium	High – better energy and water efficiency

Key Findings of the Study

- **Emission Reductions:**
    - Cold plates and immersion cooling can cut data centre **emissions by 15–21%** compared to conventional air-cooling systems.
- **Energy Savings:**
    - These advanced systems help reduce **energy consumption by 15–20%** by increasing heat removal efficiency and reducing fan usage.
- **Water Use Reduction:**
    - **Water consumption drops by 31–52%**, especially in immersion cooling systems that don't rely on evaporative cooling.
- **Life Cycle Assessment (LCA):**
    - The study employed a **cradle-to-grave life cycle assessment** to evaluate environmental impacts from manufacturing through end-of-life disposal for each cooling system.
- **Impact of Renewable Energy Integration:**
    - Using **100% renewable electricity** further reduced:
        - **Cooling-related emissions by 85–90%**,
        - **Water use by 55–85%**, and
        - **Energy use by 6–7%**, showcasing the multiplier effect of green energy on sustainability.

Challenges to Greener Cooling Technology

- **Regulatory and Design Complexity:**
    - Coolants such as fluorinated compounds are subject to different environmental regulations across regions.
    - Engineering complexity and lack of harmonised standards slow down adoption.
- **Sustainability Trade-offs:**
    - Although greener in operation, advanced cooling systems may raise other concerns like:
        - Mining and refining of coolants,

        - Disposal issues (hazardous waste), and
        - Potential lifecycle emissions – a reminder that replacing one pollutant may introduce another (e.g., plastic straws vs. paper straws).

- **Dependency on Electricity Source:**
    - Even efficient cooling technologies can have **high carbon footprints** if powered by **fossil-fuel-based grids**, just like electric cars running on coal-derived power.

Way Forward

- **Systemic Sustainability Thinking:**
    - Policymakers, industry, and researchers should move from **isolated solutions** to **integrated approaches**, using full life cycle analysis to assess long-term environmental impacts.
- **Pairing Cooling with Clean Power:**
    - Maximum benefits are realised when **advanced cooling systems are powered by renewable energy**, amplifying reductions in emissions and water consumption.
- **Policy Support and Standardisation:**
    - There is an urgent need for:
        - **Harmonised global standards** for coolants,
        - **Fast-tracked regulatory approvals**, and
        - **Government incentives** for adopting energy-efficient technologies.
- **Scalable Industry Adoption:**
    - The industry must **invest in cold plate and immersion cooling at scale**, integrating them in **new builds and retrofitting existing data centres** to achieve long-term gains.
- **Balancing Digital Growth with Climate Goals:**
    - As demand for **cloud computing and AI infrastructure** grows, it is crucial to adopt **climate-conscious cooling systems** to align technological expansion with **sustainability objectives**.

Source: https://www.weforum.org/stories/2025/06/how-ai-use-impacts-the-environment/