



Modular Integrated Sustainable Datacenter

Robust Immersion Cooling System, High Thermal Design Power (TDP) Immersion Cooling System

Deliverable 4.1, 4.2

Deliverable: Robust Immersion Cooling System, High Thermal Design Power (TDP)
Immersion Cooling System

Work-package: 4 (Advanced Thermal Management)

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**MODULAR INTEGRATED
SUSTAINABLE DATACENTER**

This
is



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8ra CLOUD-EDGE
CONTINUUM

conducted in the scope of Modular Integrated Sustainable Data Center (MISD) project which received funding from the Netherlands Enterprise Agency (RVO) under the 8ra initiative (IPCEI-CIS)

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Introduction

As part of Work Package 4 (WP4) within the MISD project, Asperitas has focused on the development of advanced immersion cooling solutions specifically designed for edge computing applications. These solutions are critical for meeting the growing demand for efficient, sustainable, and space-optimized cooling technologies in distributed IT environments, such as micro data centers and edge infrastructure. **Two key deliverables** have been defined in this work package to be delivered as part of Milestone 1:

- **Deliverable 4.1:** A robust immersion cooling system based on Perpetual Natural Convection (PNC) technology.
- **Deliverable 4.2:** A high Thermal Design Power (TDP) immersion cooling system based on the newly developed Direct Forced Convection (DFC) technology.

Both deliverables aim to enhance cooling efficiency, energy performance, and adaptability for modern edge computing scenarios while addressing the technical and economic challenges associated with deployment in real-world environments.

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Development

Deliverable 4.1: Robust Immersion Cooling System ("PNC Configurable")

For Deliverable 4.1, Asperitas developed a configurable immersion cooling system utilizing its established **Perpetual Natural Convection (PNC)** technology. The system is designed to provide reliable and maintenance-friendly cooling without the need for active fluid pumping, making it well-suited for edge applications where simplicity and operational stability are crucial.

The first version of the "**PNC Configurable**" system was developed, assembled, and extensively tested in Asperitas' in-house lab. Following the successful completion of these internal tests, the system was prepared for external validation and deployed to the **staging lab at Eurofiber** as part of WP1 activities.

Deliverable 4.2: High TDP Immersion Cooling System ("DFCX1")

For Deliverable 4.2, Asperitas introduced a more advanced technology called **Direct Forced Convection (DFC)**, designed to handle higher thermal loads (TDP) typical of highly dense and extremely powerful compute environments. The DFC approach incorporates active coolant circulation to enhance heat dissipation and performance scalability compared to our passive systems leveraging PNC technology.

A functional prototype of the first version **DFCX1 system** was completed and validated in Asperitas' lab. This prototype supports **12U of server capacity**, fitting the needs of micro data centers and on-site compute installations. Following the prototype's success, a **pre-production series (zero series)** is being prepared for delivery to the Eurofiber staging lab, expected around the end of Milestone 1 (anticipated July).



Illustration of the development cycle

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Results

- The **"PNC Configurable" system** (Deliverable 4.1) met its initial design and performance objectives during lab testing. Its completed installation at the Eurofiber staging site marks the transition to operational readiness in real-world alike conditions. The system satisfies fundamental edge and especially remote deployment requirements by going through a cost-down process and focusing on high configurability and ruggedness, yet it may benefit from further refinement to achieve optimized cost-efficiency and broader market competitiveness. Through its underlying Perpetual Natural Convection technology, the system demonstrates a power overhead of just 100W per 44kW of IT power, making it the most energy efficient IT cooling method on the market today.



PNC Configurable

- The **"DFCX1" prototype** (Deliverable 4.2) has also achieved its developmental milestones, proving its ability to cool high-TDP components effectively in a compact 12U form factor. This form factor aligns well with decentralized computing applications but poses limitations for larger, modular cloud or data center zones. The planned delivery of the zero series to Eurofiber will allow for further operational validation and performance assessment. Through its underlying newly developed Direct Forced Convection technology, the system demonstrates a cooling capacity potential of 5kW per U overall and over 2kW of cooling capacity per processor (i.e., per socket) by integration of precision cooling and targeted flow heatsinks, which ensures even the most power-hungry and heat-intensive CPUs and GPUs are efficiently cooled.



DFCX1

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Future Work

While both deliverables have successfully reached critical development and validation stages, several areas for further improvement and evolution have been identified:

1. **PNC Configurable System (Deliverable 4.1):**

Further development could focus on economic optimization to enhance production scalability and cost-effectiveness. Potential improvements include refining the system design for easier integration, manufacturing simplification, and greater adaptability to various edge use cases.

2. **DFCX1 System (Deliverable 4.2):**

To meet the demands of larger-scale data center zones, Asperitas plans to scale the system design to accommodate **24U server capacities**. The roadmap includes the development of configurations consisting of **one to four 24U units**, all connected to a single **external Coolant Distribution Unit (CDU)** that will be decoupled from the system for optimal energy efficiency, increased scalability and easy integration into more challenging data center layouts. This will allow for flexible deployment in modular data center architectures, improving system scalability and operational efficiency.

3. **Integration with Future WP4 Deliverables:**

Elements from subsequent WP4 deliverables are expected to contribute to the optimization and expansion of both systems, ensuring they remain aligned with evolving technological advancements. For instance, the integration of both systems into a to be developed modular immersion cooled data center that may leverage thermal storage and harvesting innovations to enable off-grid deployments.

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