Single Phase **Immersion cooling**
Future **Data Center**

2CRSi research & learnings about immersion cooling
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Synopsys

1. STATEMENT

A datacenter (DC) is a facility composed of networked computers and storage, which requires a specific building, a dedicated space within a building, or a group of buildings concentrating a large quantity of computers, servers, storage racks, network and telecommunications equipment which produce heat.

The heat, called also “fatal heat” is energy from a production site whose primary purpose is not, in principle, to produce heat. IT (Information Technology) equipment produces heat following the Joule conversion of electrical energy into heat. In the case of our computer servers, almost the whole energy consumed by IT equipment in datacenter is converted into heat. This generated and uncontrolled heat is harmful to the equipment: its performance, its lifespan and can even lead to the outright decommissioning of the equipment.

To overcome this problem, datacenter are constantly cooled and kept at a stable temperature. This cooling is currently done mainly by cooling units that consume a lot of energy. Fortunately, new technologies have emerged to limit these losses.

In just a few figures, **datacenter account for around 4% of the world's energy consumption** and could represent nearly **10% in the coming years**. In Europe, according to the European Commission, the energy consumption of datacenter in 2013 alone represented 56 billion kilowatt hours. The same commission estimates that this figure will rise to **104 billion Kw/h in 2020**. However, the **use of air conditioning and cooling systems alone accounts for almost 40% of the energy consumption of data centres.**

Given this observation, the need to reduce the energy consumption of datacenter for its economic and ecological aspect was imposed to 2CRSi.
To achieve this, we worked on the development of the single-phase immersion cooling technology detailed in this report and the associated servers.

2. TRADITIONNAL DATACENTERS & MAIN CHALLENGES

The standard servers in datacenter are cooled by means of a permanent, tempered air flow. Without this cooling, they could not work properly.
In a datacenter, in a simplified way, the IT servers, stored in racks, are installed in a closed room with an air flow that is kept at a **constant temperature** by means of cooling units. These units operate thanks to gas compressors that cool a water network that provides air conditioning for the data centre rooms. In this way, they combat some of the heat emitted by the computer racks by producing cold. **But cold production also means heat production**, heat that is released into the air with the surplus heat produced by the servers themselves. (Diagram 1)

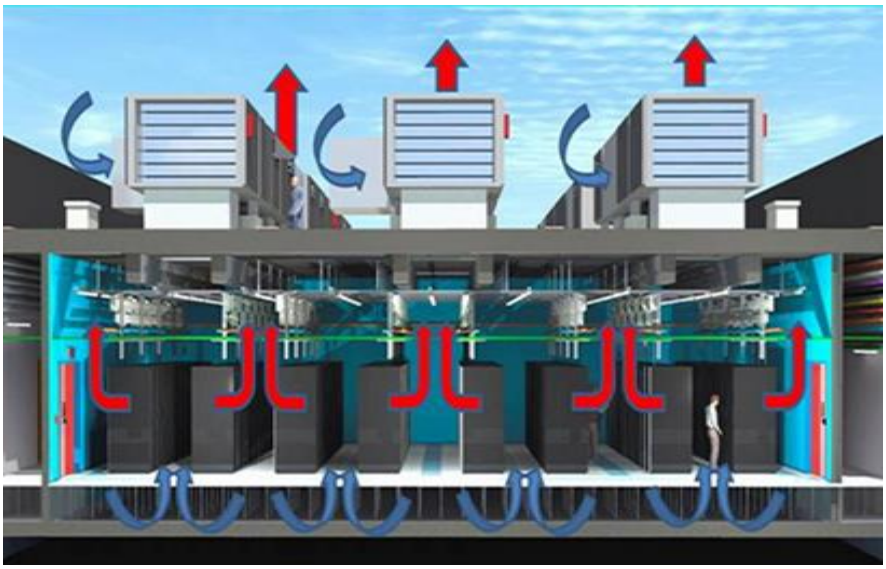


Diagram 1: Air cooling datacenter

In order to measure the energy efficiency of data centers, a criteria is used, called **PUE** (Power Usage Effectiveness). It represents **the power consumption of the entire data center** over the power consumption of the IT equipment alone. Thus, for a datacenter, **the closer the PUE is to 1, the better its energy efficiency**.
However, the chillers used to cool **conventional data centres represent between 35% and 40% of the data centre's electricity consumption.**

This is why, in a world that is finally becoming aware of the importance of energy savings and the ecological aspect, we have an obligation to rethink the infrastructure and the overall operation of datacenters.

Immersion cooling is the answer to this problem.

3. IMMERSION COOLING BY SINGLE-PHASE TECHNOLOGY PRINCIPLES

This technology basically consists of **completely immersing** a prepared computer server in a **dielectric liquid** (meaning it does not conduct electricity) such as vegetable, mineral or synthetic oil. The chosen liquid generally has a boiling temperature above 150°C and a high stability in order to prevent any risk of evaporation, overpressure or flammability (Picture 1).

Picture 1: Immersion tank

In single-phase immersion tanks, **the liquid recovers heat from the servers before transferring it via a heat exchanger to a secondary water system.** To do this, there are two types of movement of the liquid in contact with the server to cool it.

Either the so-called natural convection, the liquid in contact with the server heats up and rises to the surface before cooling down in contact with an exchanger through which the heat is released before going back down to the bottom of the tank.

In forced convection, the movement of the liquid is driven by a pump in order **to maximize the heat exchange between the server and the liquid and between the liquid and the heat exchanger** (Diagram 2).

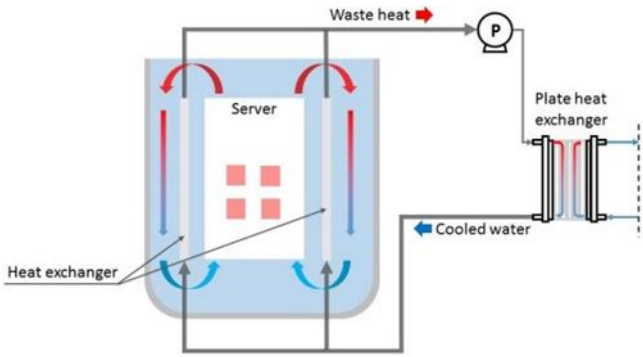


Diagram 2: Forced convection Immersion cooling concept

When convection is forced through a pump, there are two possibilities.

Either the dielectric liquid remains constantly in the tank. The heat exchanger is then also located in the tank and any leakage of the dielectric liquid outside the container is impossible.

Either the dielectric liquid circulates outside the tank to a cooling unit, which can supply several tanks, which will contain the heat exchanger.

Thus, when the computer servers are brought into conformity for immersion, the fans are removed or deactivated because they are useless with this type of cooling (which represent a first energy gain).
Then, all the energy consumed by the servers is transformed into heat which is directly absorbed by the dielectric liquid which will then rise in temperature. This heat power will then be transferred to an external water circuit (diagrams 2 and 3) via an exchanger.

The heat captured by the water network will then either be evacuated into the air by a drycooler (passive exchanger with second energy gain) **or reused for heating buildings or domestic water for example** (potential bonus by reusing the fatal heat).

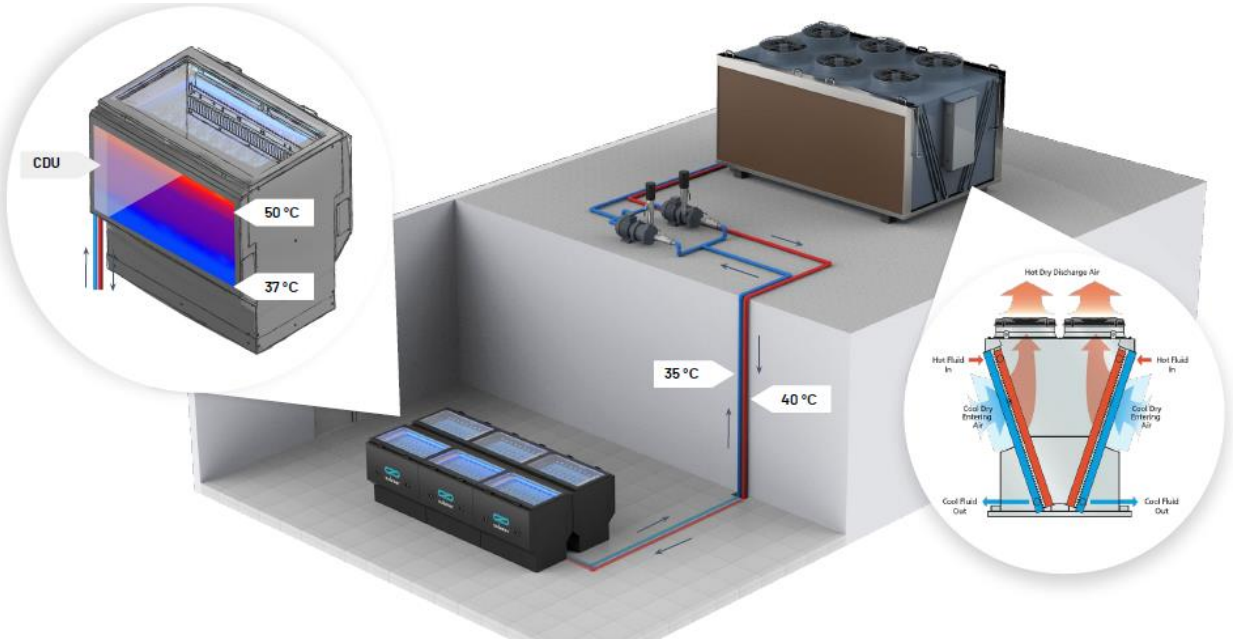


Diagram 3: Immersion tank het circuit

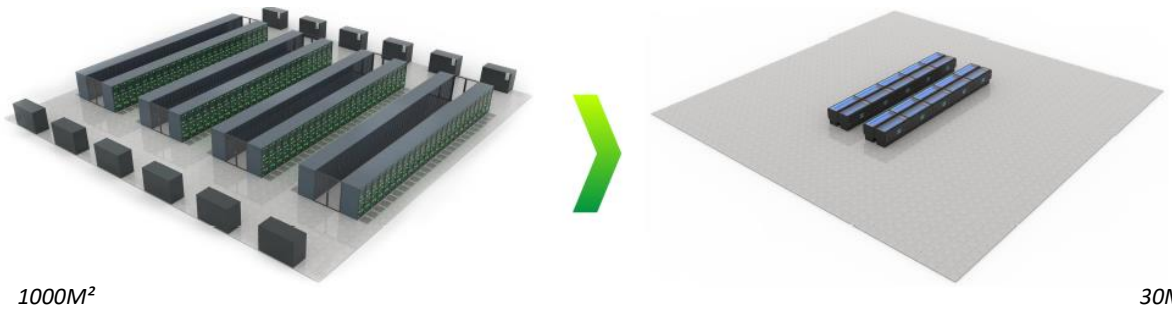
4. KEY BENEFITS OF IMMERSSION COOLING

Immersion cooling has many advantages:

- By replacing a standard cooling unit with a passive exchanger for the extraction of calories in immersion, it is estimated that a conventional datacenter can reduce its operating costs, in terms of power consumption and therefore the electricity bill, by about 40%. (**OPEX -40%**). Likewise, if a datacenter is limited in terms of the electrical power served in the building, it can allocate 99% of its electricity to its servers

- Furthermore, when installing a datacenter, since the extraction of calories is simply done through a closed water network, there is no need for all the standard equipment of an air datacentre : installation of refrigerated cabinets, false floors, corridor, etc... are therefore useless. In terms of installation and material costs, a cost reduction of about 25% is estimated. **(CAPEX -25%**)

- Due to the absence of all the various equipment essential for air datacenter, the **floor space of the datacenter can be optimized**. For example, immersion cooling technology makes it possible to densify the number of servers per m² (Diagram 4).



1000M²
Rack power : 5kW
Total 1MW

30M²
Tank power : 50kW
Total 1MW

Diagram 4: Floor space comparison between air-cooling and immersion

- As the dielectric liquid has a much higher specific heat than air, its cooling properties are far superior to those of air. These physical properties make it possible to **build much denser servers in terms of equipment (more CPUs or GPUs)** that would be impossible to cool with air. This immersion increases the computing power per server.

Picture 2 : Example of Immersion data center

- Following several customer feedbacks, we found that the life of the immersion cooled components was improved compared to using the same air cooled components. Also, the **failure rate is reduced, resulting in lower technician intervention costs**. This is due to the high heat capture capacity of the liquid and its temperature homogeneity. The immersed components are not subject to significant temperature differentials within the component and, under stress, the temperature rise of the components is less abrupt.

- In a conventional air-cooled datacenter, ambient noise can exceed 90 decibels. This is not only unpleasant, but can also damage the ears of the technicians working on site, forcing them to wear suitable hearing protection. **With this cooling solution, noise-causing fans are no longer needed**. The resulting silence provides a **high level of comfort during interventions** in datacenters.

- Overall, immersion cooling can reconcilite IT with the Planet.
Immersion cooling meets energy reduction which leads to **a reduction of nearly 45% of carbon emissions compared to a standard datacenter**.
In addition, the dielectric liquid used in the tanks is a biodegradable liquid.

Moreover, the ecological footprint can be further improved by **reusing the fatal heat** from the servers recovered by the water network. This hot water can be used, for example, as heating for buildings, heating for domestic water or heating for business processes.

Immersion cooling is a key components to design SmartCities (Diagram 5).

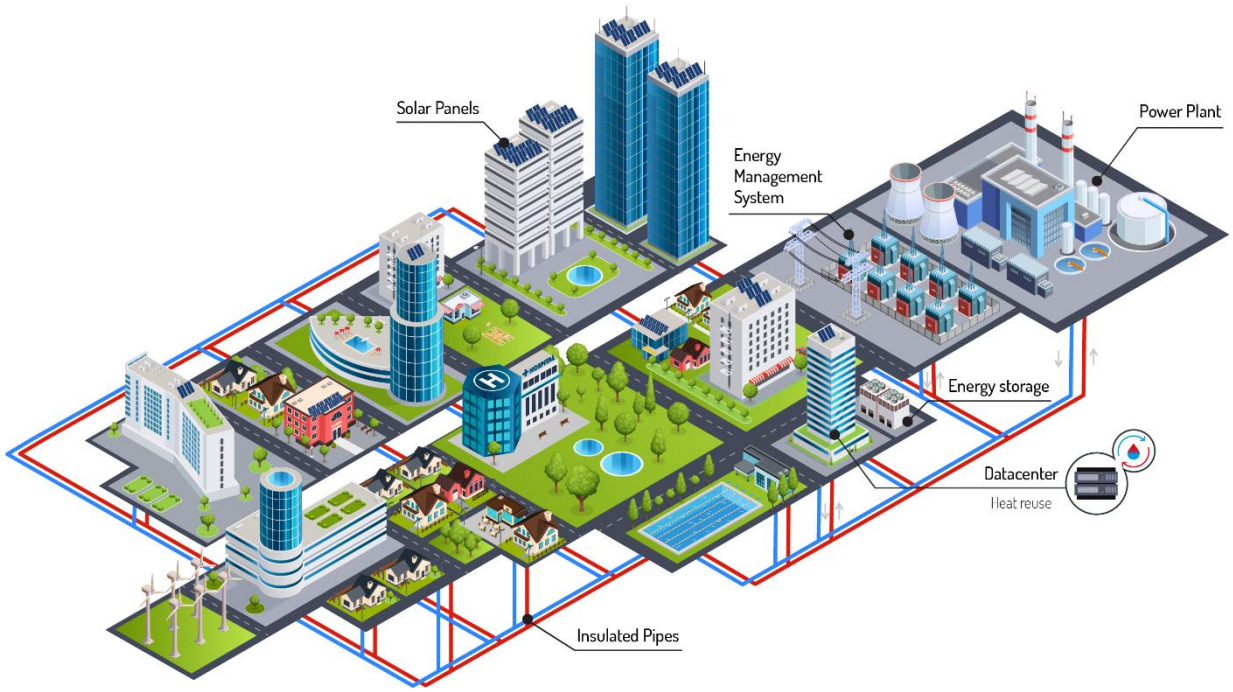


Diagram 5: Reuse of data center heat

5. CONCLUSION & TAKEAWAYS

In order to meet Europe's ecological demands as well as international pressure to reduce our CO2 emissions, today's data centers and their infrastructures must reinvent themselves and optimize their power consumption through new technologies.

We have demonstrated that with the many advantages of immersion cooling technology, not only does it save energy and money, but it is also a perfect fit with today's new environmental and global policies.

ACKNOWLEDGEMENT

We develop immersion solutions in close collaboration with 2 immersion tank manufacturers.

submer

Submer was founded in 2015 with the vision of building technologies to make data centers more sustainable. Headquarters are located in Spain

GRC

Green Revolution Cooling (GRC) is an American based company founded in 2009. Holder of 12 patents — with 9 pending, GRC has worldwide installations in 13 countries