DataCentre Heat Reuse and Decarbonisation using a Single Loop with a Single Unit

Introducing a Heat Transfer System for Next-Gen Compliant DataCentres

Frigel
Intelligent Process Cooling

MOTUL

PrimientCovation™

Photo: Frigel

IMPLEON

Executive Summary

A revolutionary fluid is winning over the heart of DataCentres. 1,3-Propanediol (1,3-PDO) is the first bioglycol for Direct Liquid Cooling that enables a virtuous single-loop circuit.

The most demanding operations in the DataCentre require a new cooling architecture based on proven, economic and environment-friendly fluids.

Introducing 1,3-Propanediol (PDO), the first and foremost bioglycol for Direct Liquid Cooling.

Aligned with DDP design recommendations, it provides a game-changer to modern DataCentres designed for AI and compute intensive applications.

Reduced costs and complexity

Recent innovations enable a next-generation single-loop system eliminating intermediary chillers and CDUs, while traditional DataCentres use two or three loops.

The new approach leverages an ultra-pure circuit directly connecting cold plates to dry/adiabatic coolers or heat reuse heat exchangers, achieving up to 95% on-chip cooling share. This reduces embodied carbon, PUE (Power Usage Effectiveness), energy infrastructure, complexity, and costs.

A planet conscious single-loop

According to **Sean GAHAN**, **Primient Covation LLC** Global Technical Service Manager, working with Impleon is the first step in the right direction: « *Our partnership brings a redesign of the cooling architecture that has become necessary due to the higher density per powered rack. The design should be based on a bio-degradable fluid, now mandatory for economic and environmental reasons. We're building together a strong ecosystem promoting the single 1,3-PDO loop.* »

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Selecting the Optimal Liquid Cooling Fluid

Direct-on-chip cooling is an effective way to control energy consumption and increase server density. While selecting fluids, several criteria must be taken into consideration.

Water is a natural heat transfer fluid, but its freezing point (0°C, 32°F) is a limiting factor. The incorporation of glycol can reduce the freezing point for protection.

For decades, traditional heat transfer fluids have dominated the market, but an increasing emphasis on sustainability, performance, and safety is driving the search for innovative alternatives.

Environmentally responsible

Among these, 1,3-Propanediol (1,3-PDO) stands out as a remarkably promising candidate, offering a compelling blend of environmental responsibility and superior technical attributes that are poised to revolutionize the heat transfer landscape.

As 1,3-PDO demonstrates lower viscosity than propylene glycol at low temperatures, it offers significant energy efficiency advantages by reducing pump power consumption.

This translates into measurable cost savings for systems with continuous operation or high electricity costs, making it ideal in environments where energy penalties are a concern.

Maintaining optimal flow and heat transfer performance ensures that desired rates can be achieved even under challenging cold conditions.

Long-term efficiency

The reduced strain on pumps extends their lifespan and reduces maintenance expenses, supporting long-term operational efficiency.

Its non-toxic profile aligns with stringent safety regulations while providing the necessary performance benefits for critical industries like AI DataCentres.

As a result, 1,3-PDO can contribute to both performance and sustainability goals.

DataCentre Heat Transfer Fluids Overview

	Toxicity	Viscosity at 25 vol %@-5°C	GHG emissions, kg CO2-eq./kg	Foaming, Vol ASTM D1881 for final product
EG25	Yes	4.5 cps	2.00	<150 ml
PG25	No	7.9 cps	4.43	<150 ml
Bio PDO25	No	6.4 cps	0.71	<50 ml

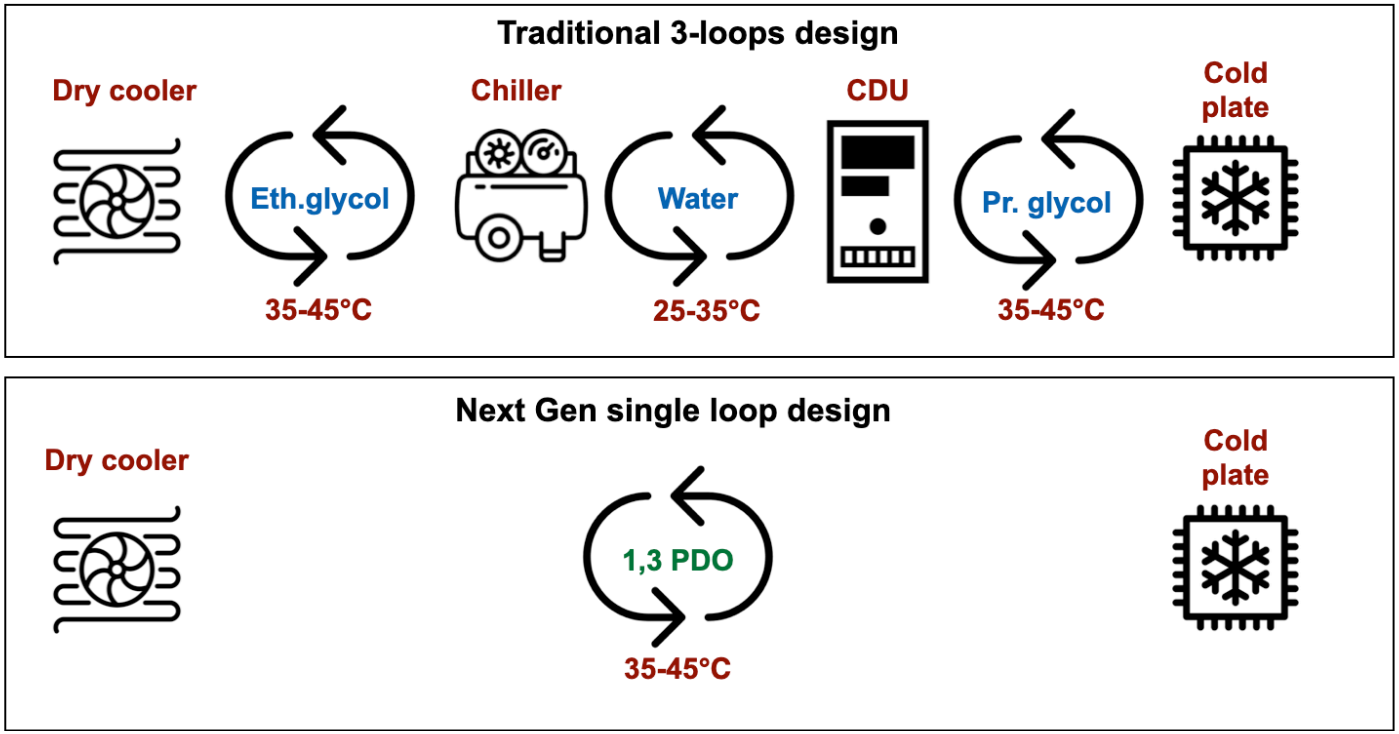
A Single Loop Smart Cooling Architecture

Next Gen DataCentres will host very high density racks. They'll need a new standard and effective cooling system. The 1,3 PDO single loop is suitable for operations within the desired temperature range.

Three cooling loops are a consequence of traditional DataCentre design. Rack-mounted liquid cooling targets stacked servers, networking and storage equipments (on the right). Upstream of the racks, another loop connects water chillers to the CDUs. Finally, a third loop removes hot air from the building using dry coolers.

Direct liquid cooling now targets high-energy-density hot spots (CPUs, GPUs), as rack density increases. The new architecture, based on a single 1,3-PDO loop, improves heat transfer performance and efficiency while reducing the cooling equipment required and maintenance operations.

Traditional and Next Gen Liquid Cooling Designs



The Seven Advantages of Bio-Based PDO

The key features of PDO fluids are their sustainability, decarbonisation, environmental compliance, biostability, biodegradability, thermal stability, and performance.

The first bioglycol for Direct Liquid Cooling is engineered for decarbonisation. Susterra® 1,3-PDO delivers an 84% lower embodied carbon footprint ("cradle to gate") compared to propylene glycol, drastically reducing the GHG emissions and non-renewable energy consumption associated with DataCentre operations—a major contributor to environmental goals and certification initiatives.

MOTUL EGEN DLC 100R25 complies with European REACH regulations and is classified as non-hazardous, non-PBT/vPvB, and non-endocrine disrupting, underscoring its safety and environmental compliance.

Unlike water, which requires the addition of biocides, PDO fluids offer intrinsic biostatic properties, preventing bacterial growth by default, even at a concentration of 25%, thereby eliminating chemical additives and simplifying maintenance.

A key differentiator is 100% biodegradability; biobased PDO fluids inherently minimize environmental impact and lower disposal costs. They offer robust performance at extreme temperatures, from high-power AI cold plate cooling (low temp) to heat reuse applications (high temp).

MOTUL EGEN DLC 100R25 maintains physical stability and corrosion protection across a wide range of temperatures and a lower freezing point of -10°C.

The viscosity of PDO based fluids is lower than PG25, directly improving flow rates across existing systems, and enabling easy retrofits for better thermal performance and energy savings. This translates to higher performance in both DataCentre and residential or commercial heating cooling loops.

Seven key benefits

1,3 PDO fluids offer significant sustainability and performance advantages over traditional petroleum-based ethylene and propylene glycol heat transfer fluids, including:

1. **Decarbonisation** & **Sustainability**
2. **Environmental Compliance**
3. **Biostability**, **hygiene**
4. **Biodegradability**
5. **Thermal stability**
6. **Flow Performance and Viscosity**
7. **Advanced DataCentre Loop Design**

FinOps: Achieving Better PUE and TCO Together

A single-loop circuit can now increase computing power by +43% within the same footprint. This significantly improves the Power Usage Effectiveness and the site's Total Cost of Ownership.

Recent DataCentres are leveraging a single PDO loop system, eliminating the need for intermediate equipments such as chillers and CDUs, reducing hardware production, maintenance costs, and lowering the energy bills.

The design connects cold plates directly to heat-exchange units, improving efficiency and reducing the carbon footprint.

The system relies on ultra-pure piping for clean flow and filters that support high flow rates with 50 microns of filtration. A PICV valve ensures reliable control at the rack-level without requiring relocation.

DataCentres that have adopted 1,3-PDO based fluids and are now recognized as the most environment friendly facilities in the industry.

Given the internal and external impacts resulting from DataCentre changes, a PDCA (plan-do-check-act/adapt) approach suggests implementing a continuous improvement cycle.

The introduction of a single 1,3-PDO loop fits in perfectly, to host new high-density racks without having to invest in building extensions.

DataCentre cooling options with TCO comparison

IMPLEON	Air (2 loops)	Direct-on-Chip with PG25% (3 loops)	Direct-on-Chip with PDO25% (1 loop)
DC Power Input	7,2 MW	6,8 MW	5,3 MW
Compute Cores	447 550	642 098	642 098
Rack Power	14 kW	61 kW	61 kW
CAPEX	50 M$	43 M$	36 M$
OPEX for 3 years	25 M$	22 M$	19 M$
TCO / Core for 3 years	168 $	102 $	87 $

Space and cost savings

Here are some quantified benefits from migrating a DataCentre to a single 1,3-PDO loop achieving up to 95% on-chip cooling share. Implementing such a system in an existing 1 MW data room provides a better PUE of 1,14, against 1,5 initially.

A 43% increase in computing capacity will become possible soon and coupled with the reduced carbon footprint. No more need to invest in traditional cooling equipment.

This will result in further energy savings of 72% compared to traditional DataCentre expansion, once the 5 MW IT installation is complete.

Moreover, it will reduce embodied carbon, infrastructure complexity, and maintenance costs.

FRIGEL SYNERGO : A FLEXIBLE UNIT FOR HEAT REUSE

Integrators and early adopters appreciate a seamless transition between the cooling options offered by the Synergo single unit, designed to provide resilience, scalability, and simple operations.

What inspired you to create the SYNERGO solution?

Our original idea was inspired by the challenges facing DataCentres. The single-unit design meets the needs of ultra-high-density racks for cloud computing, AI, and computationally intensive workloads, while enabling the reuse of waste heat, in accordance with the requirements of European regulatory authorities. The goal is to transform DataCentres into “energy providers” by reusing the heat generated by microprocessors and graphics processing units (GPUs) to reduce energy consumption and support decarbonization efforts.

How does it integrate with existing air-cooling systems and the new liquid heat transfer systems that are becoming increasingly common in the field of AI computing?

Combining the supply of chilled water for Data Centres with the ability to export heat, the SYNERGO unit can be integrated into both traditional air cooling systems and new fluid-based heat transfer systems, handling higher supply temperatures of up to 45°C, operating with an existing water circuit and/or a glycol loop. It is particularly suited to the hybrid configurations commonly used in Europe, where air cooling and heat transfer systems are combined in proportions from 30% to 70%.

Massimiliano Dall'Armellina
Frigel Global Sales Dev. Manager

What temperature range and main benefits should we consider?

The system can operate at temperatures ranging from -30°C to +50°C. SYNERGO's innovation lies in its flexibility and fault-tolerance capabilities, thanks to redundant modules.

What motivates your first clients to embrace this unit?

Our customers can see four key aspects in their environment: speed and simplified deployment, operational resilience, scalability, and economic benefits including sustainability factors.

Our customers note that the SYNERGO single unit reduces administrative burdens, and attracts financial investors, particularly in Europe where there are opportunities to convert office buildings into DataCentres and connect them to the district heating network.

The solution offers integrated modular features that simplify on-site commissioning, maintenance, and operation. This allows a faulty module to be bypassed without interrupting the operation of the heat transfer system.

Frigel
Intelligent Process Cooling

MOTUL SUPPORTS SUSTAINABLE COOLING SYSTEMS

Cold plate and immersion cooling promise sustainable solutions for DataCentres by reducing their environmental footprint while improving performance.

PDO has a lower viscosity compared to the traditional propylene glycol, which means that it makes it really relevant with thin cold plates. Besides this features, it has intrinsic bacteriostatic properties, avoiding the growth of bacteria which would be detrimental to the cooling efficiency. The fluid has been designed to resist against the corrosion according to ASTM norms recommended by DDP.

Liquid cooling options

The main obstacle to the adoption of bioglycol is undoubtedly resistance to change. There are two options: cold plate, which is now in vogue, and immersion, which is undoubtedly more effective but requires radical change.

I believe that both technologies will grow, no doubt in combination.

Christophe LACROIX, MOTUL
Chief Innovation & Sustainabilty Officer

Microprocessors using a cold plate don't enter into direct contact with a fluid. Only the plate is being cooled, which reassures those worried about immersing their equipment in a basin.

The integrity of the chipsets is guaranteed by a well-controlled temperature.

At MOTUL, our EGEN fluids range provides solutions for cold plates, cooling loops and immersion. We design innovations to help de-carbonize DataCentres.

Once combined, cooling performance and innovation can form a sustainable solution.
Well-designed for immersion, the DataCentre takes up less floor space. Therefore, its footprint is reduced.

Upcoming collaborations

The present offer - although not plethoric - will modify certain behaviors, in particular between the operational teams.

Air exchange is no longer enough to cool the latest CPUs and GPUs. As a result, cold plate and immersion cooling have become essential.

SUSTERRA® 1,3-PROPANEDIOL ALLOWS FOR 24/7 OPERATION

Stable, biodegradable, non-toxic Susterra® 1,3-PDO is optimizing the always-on DataCentre operations, explains Sean Gahan, Global Technology Service Manager at Primient Covation LLC.

What makes 1,3-PDO a good candidate for large DataCentres?

1,3-Propanediol, specifically the Susterra® brand, offers significant performance benefits. Its low viscosity at cold temperatures and stability at high temperatures make it an efficient heat transfer fluid. This reduces the resistance in pumps, cold plates, and piping, meaning less energy is required to circulate the coolant through the system. This directly improves the DataCentre's Power Usage Effectiveness (PUE), a key metric for efficiency. This is particularly beneficial for cooling CPU and GPU-intensive AI applications.

What about the environment ?

Susterra® 1,3-PDO is highlighted as a sustainable solution with several key advantages including a 100% bio-based production process, involving no petroleum.

A longer lifespan makes it last three to five times longer than conventional propylene glycol, reducing replacement frequency and costs. When it does need to be replaced, the waste fluid can be disposed of more easily without complex disposal procedures.

Sean GAHAN, **Primient Covation**
Global Technical Service Manager

These factors make it an economically and environmentally responsible choice, especially as regulations around biodegradable fluids become more common.

Can you provide a recent use case in a real DataCentre?

A large liquid cooled DataCentre in Oklahoma that will ultimately be a 640 MW site with a fluid containing Susterra® 1,3-PDO. This demonstrates its viability in demanding, always-on operations.

What is the usual fluid replacement cycle?

The fluid replace-ment cycle for Susterra® fluids would be estimated to be three to five times longer than conventional propylene glycol, reducing replacement frequency and costs.

How confident are you about the future of 1,3-PDO?

The future for 1,3-PDO in DataCentres appears promising due to the industry-wide shift from air cooling to liquid cooling.

This transition is driven by the increasing power density of server racks needed for AI and other heavy workloads. Using a single-loop 1,3-PDO system helps enable the deployment of waterless, energy-efficient DataCentres of the next generation.

susterra® 100% BioRenewable™

The DataCentre Decarbonisation Project Fosters Heat Reuse

Most efficient hosting solutions will be based on sustainable bio-based liquid cooling, confirms François Tournesac, DDP Leader, and Impleon co-founder and CEO.

« Increased density per powered rack in DataCentres requires a new cooling architecture. The unique 1,3-PDO loop is based on a biodegradable fluid, offering both economic and ecological benefits. No petroleum is involved in the fluid production process.

Impleon is delivering expertises in design, architecture, end-to-end TCO and implementation of liquid cooling and heat reuse solutions. David and I advise companies on improving their environmental performance and adapting to ongoing climate change in order to assess, understand, simplify and reduce greenhouse gas emissions, water and raw material consumption. We are transforming the DataCentre to meet fast-growing demands using an ecosystemic way. »

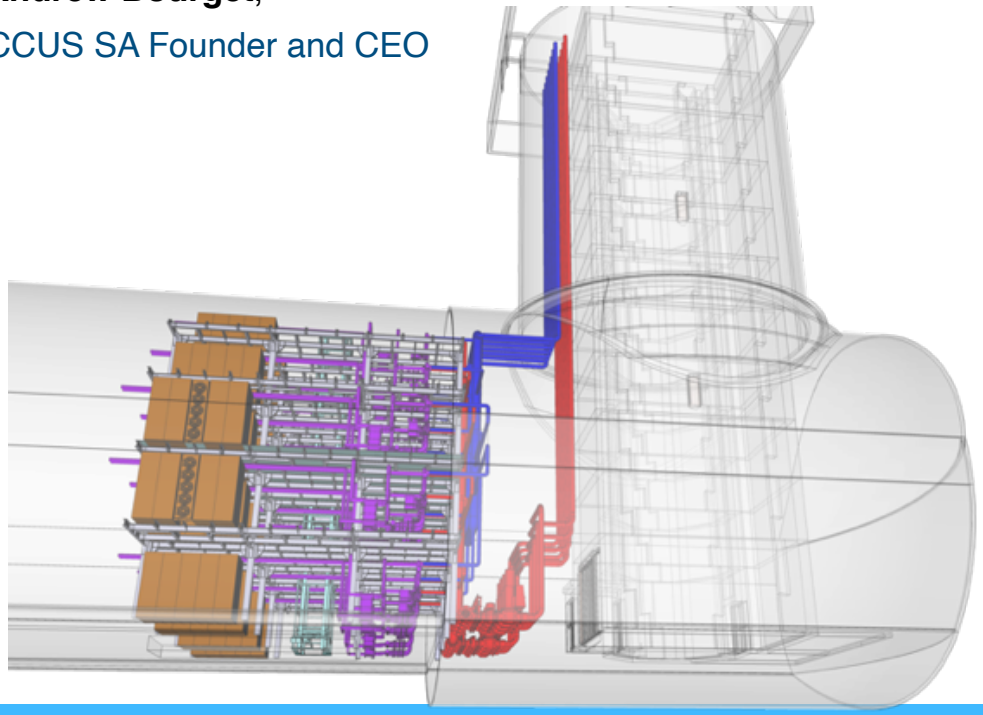
A DataCentre Ecosystem Builder

François Tournesac has over 25 years of experience in computing, storage, and networking. As co-founder of Impleon, he developed a methodology for specifying liquid-cooled solutions with heat reuse capabilities. He launched the DataCentre optimization program for waste heat reuse and decarbonization to initiate the transition to cooling infrastructures by building ecosystems.

Underground DataCentre Turns Sustainable Smart Cities

« Impleon transformed our underground modular DataCentre, boosting our power density from 4 MW to an impressive 160 MW using advanced liquid cooling technology. This innovative approach not only improved energy efficiency but also enabled us to reuse heat for district heating, supporting sustainability in smart cities. »

- **Andrew Bourget**,
ECCUS SA Founder and CEO



Improving DataCentre Environmental and Social Pillars

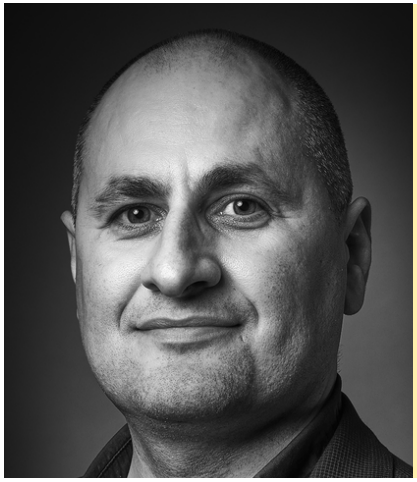
It's time to think inside and outside the DataCentre. David Gyulnazaryan demonstrates that combining a bio-based PDO with energy circularity is key to DataCentre sustainability.

What are the main challenges currently facing DataCentres?

DG: Historically, DataCentres were primarily driven by the financial considerations, focusing on reducing land and energy costs, and lowering the PUE. Nowadays, however, growth is limited by power and energy availability, as well as the need to address environmental and social concerns.

How can we address both issues?

DG: The environmental pillar can be achieved through the decarbonisation of DataCentres. Up to 99% of carbon is now concentrated in Scope 3 , which covers the upstream and downstream supply chains. We should focus on petroleum-based coolants (PG, EG), the chillers with high GWP refrigerants, energy infrastructure (UPS, batteries, generators), and electrical grid with power plants. The potential volume of glycol to be flushed by DataCentres will reach 1 million m^3, which will have a significant environmental impact. Reusing heat from DataCentres can replace the consumption of fossil fuels by neighbouring district heating systems, industries, greenhouses, and water desalination plants, and create the conditions for carbon-negative operations and water free operations. This provides cities with circular heat and reduces residents' heating bills, representing social value.



Liquid Heat Transfer has a global impact

By shifting to single loop, we'll reduce by 43% energy generation. By creating heat reuse, we can eliminate the need for fossil fuels for heating.
A 200 MW DataCentre in North America that uses a direct-on-chip, single loop approach has an extremely low PUE. It does not use chillers, which results in a 35% reduction in energy demand.

- **David Gyulnazaryan,** IMPLEON Consultant

What exactly is the role of bio-based PDO?

DG: Firstly, it is derived entirely from corn, and contains 84% less carbon than petroleum-based PG. It's biodegradable and does not have any harmful environmental effects. Its improved viscosity at low temperatures makes it beneficial for natural cooling, while its longer service life at high temperatures makes it suitable for heat reuse. It also protects cold plates from bacteria growth and corrosion in the system.

This enables intensive growth of DataCentres by 43%, within existing energy availability.

The heat transfer fluid in DataCentres can enable residential heating to benefit from renewable energy sources through a circular energy flow.

Glossary

Biocide: A substance that destroys living things, especially a pesticide, fungicide, or herbicide.

Biodegradable: The property of a substance that can be broken down by bacteria or other living organisms, thereby preventing pollution. (See Ready Biodegradability Test method, OECD 301B.).

Corrosion inhibitor: A substance that effectively reduces or prevents the corrosion of exposed metal in a corrosive environment. Inhibitors are added to cooling water, acid and steam in small concentrations to maintain an inhibiting surface film.

CDU: The Coolant Distribution Unit circulates and pumps coolant in a closed-loop system within the rack and server chassis. It uses water from the facility and air from outside the rack to cool the servers.

CPU: Central processing unit, the processor that performs arithmetic, logic, controlling, and I/O operations specified by the software.

DTC: Direct-to-chip cooling, also known as cold plate cooling, is a type of liquid cooling that replaces the traditional air-cooled heat sink with a liquid-cooled one. A heat sink is a component that absorbs and dissipates heat.

GPU: Graphics processing unit, a specialized processor designed to accelerate the creation of images and to process large blocks of data in parallel, making it suitable for AI and cryptographic applications.

GWP: Global Warming Potential. Index measuring the ozone depletion over 100 years due to the release of 1 kg of refrigerant.

1,3 PDO: An efficient bio glycol that improves the PUE of DataCentres hosting CPU- and GPU-intensive infrastructures.

PG: Propylene Glycol, an organic solvent with good heat transfer fluid properties. However, it has lower flow rates than 1,3-PDO.

PUE: Power Usage Effectiveness, a ratio - calculated by dividing the total facility power by the IT equipment power - describing how much extra energy a DataCentre requires to maintain IT equipment for every watt delivered to the equipment.

TCO: The total cost of ownership includes hardware and software costs, as well as those related to cooling, fire suppression, energy, monitoring, labour, waste disposal and recycling. It also includes any penalties incurred during downtime.

CONTACT

For more information:

IMPLEON

Impleon is DataCentre Decarbonisation Project Leader

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