

ADVANCING SUSTAINABLE, HIGH-PERFORMANCE SERVER LIQUID COOLING—COMBINED WITH ENERGY- EFFICIENT HEAT REUSE



Figure 1: Proof of Concept (PoC) BiGreen-Modul at the MK Hotel Passau

THE INTEGRATION OF BITHEAT MODEL ONE WITH EVONIK'S DIELECTRIC IMMERSION COOLING FLUID

BitHeat is a German technology platform developed within the Lindner Group under the BiGreen¹ project (Building Integrated GREen Edge cloud Native) as part of the 8ra initiative². The platform integrates decentralized computing with building energy systems through immersion-cooled IT

infrastructure and heat recovery. This enables the reuse of server waste heat for applications such as space heating and hot water.

Its modular, plug-and-play systems can be installed directly in buildings, reducing the

need for conventional data center cooling. By decentralizing computing capacity and utilizing waste heat locally, BitHeat improves energy efficiency, reduces emissions, and supports more sustainable and sovereign digital infrastructure.

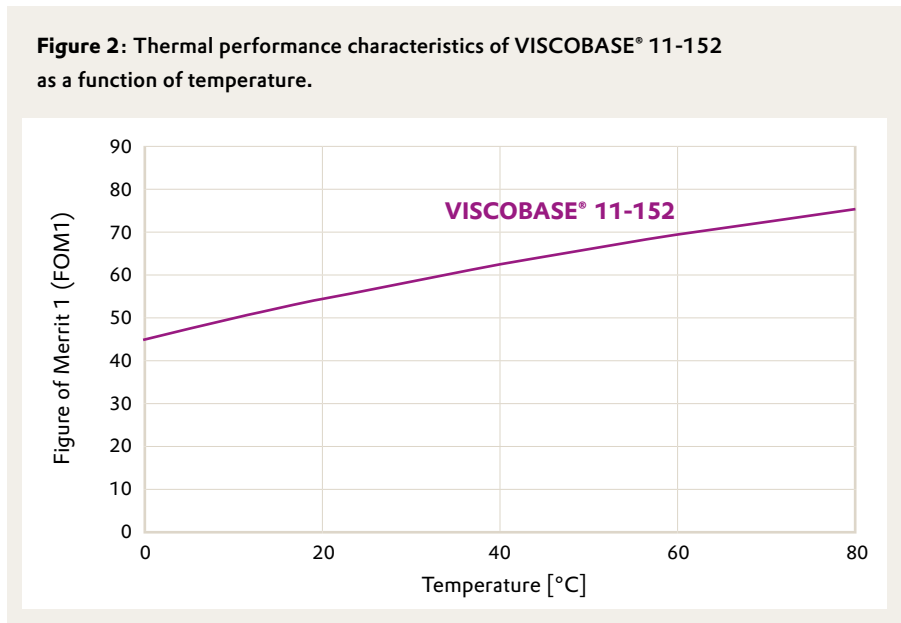
¹ BiGreen is funded by the Federal Ministry for Economic Affairs and Energy pursuant to a resolution of the German Bundestag. Funded by the European Union. www.8ra.com/projects/bigreen.

² The 8ra Initiative is a strategic European endeavor involving twelve EU member states and approximately 120 industrial as well as research partners dedicated to establishing a resilient, open, and future-proof digital infrastructure. www.8ra.com.

Evonik is a global specialty chemicals company focused on high-performance materials and solutions for advanced industrial applications. In the field of immersion cooling, Evonik develops ester-based dielectric fluids that combine strong thermal performance with improved safety and sustainability. Leveraging its expertise in molecular design and formulation, Evonik tailors fluid properties such as viscosity, stability, and material compatibility, enabling next-generation immersion cooling solutions for data centers and electronic systems.

BitHeat's Model One (www.bitheat.com) is a compact, immersion-cooled edge data center designed for building integration. The unit supports up to six servers (max. three rack units, 1U) and operates at a maximum load of ~3.2 kW. It uses single-phase immersion cooling in a closed loop, with a dielectric fluid circulating through a heat exchanger to deliver at least 55°C heat for direct use in building systems while ensuring efficient cooling of high-density electronics.

Under these highly integrated and demanding conditions, the cooling fluid becomes a key functional element of the system, directly determining thermal performance, reliability, and efficiency. It must operate continuously at elevated temperatures while simultaneously cooling sensitive electronic components and enabling heat reuse. As a result, the fluid must com-



bine robust thermal stability, electrical insulation, safety, good material compatibility and long-term durability, ensuring stable operation in a building environment with minimal maintenance.

Evonik's solution to these challenges is **VISCOBASE®11-152**, an innovative ester-based cooling fluid specifically designed for immersion applications. The fluid enables highly efficient cooling of immersed servers and heat transfer, driven by its tailored property profile, particularly its low viscosity, which supports effective circulation and reduces energy demand during operation.

In addition, VISCOBASE®11-152 is readily biodegradable, contributing to an improved environmental profile compared to conventional fluids. At the same time, it offers safe handling characteristics, including a high flash point, making it suitable for use in building-integrated systems.

VISCOBASE® 11-152 was selected for testing in BitHeat's Model One system due to its excellent thermal performance characteristics, which are particularly critical when operating with elevated cooling water temperatures supplied by the building's heating system.

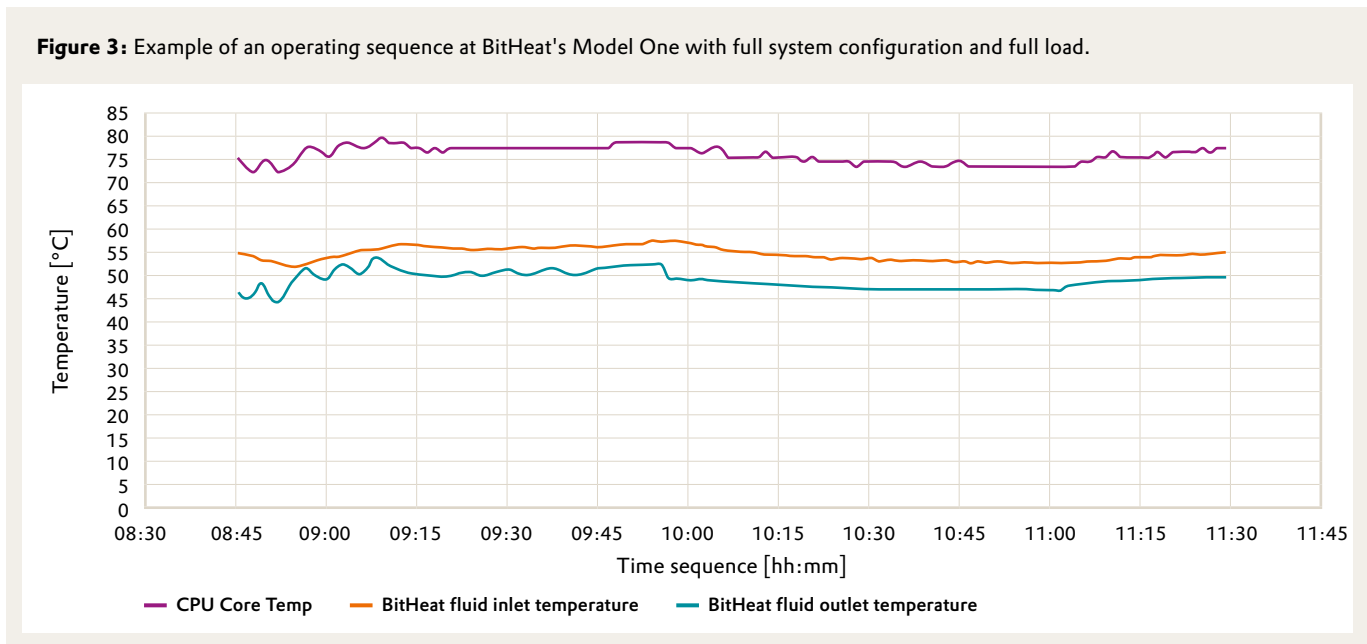


Table 1: The six-month laboratory testing demonstrated robust fluid performance and strong compatibility with hardware components, confirming long-term stability under representative operating conditions.

Requirement according to OCP Fluid Base Specification 1.0	Required performance for fresh fluids	After 6 months in service
Volume Resistivity	>1 GOhm*m	Pass
Dielectric Strength	>6 kV	Pass
Total acid number	≤0.03 mg KOH/g	Pass
Fluid performance properties (Viscosity, Density, Specific Heat, Thermal Conductivity)		No change
Server Hardware (Performance Characteristics, Optical Appearance)		No change

To enable a standardized comparison of different fluids, Intel introduced the Figure of Merit 1 (FOM1)³, based on the assumption of pure natural convection. This metric is also described in the Open Compute Project (OCP) Fluid Base Specification. The performance data for VISCOBASE® 11-152 are shown in Figure 2.

The thermal performance characteristics were subsequently used to model the behavior of BitHeat’s Model One system. Based on the favorable theoretical results, laboratory testing was initiated to validate the calculations and to evaluate the fluid under real operating conditions, including

compatibility with server hardware and long-term stability.

Figure 3 shows an operating sequence with full system configuration, full load, and a desired hot water outlet temperature of 55°C. The CPU core temperatures remained within a stable range, allowing the servers to operate at a level that was comfortable and stable for the hardware, even under application-specific high fluid temperatures.

Validation was conducted using a commercially available immersion-born server, sourced from an established vendor in the

immersion cooling ecosystem demonstrating reliable performance under realistic operating conditions (see table 1). The validated hardware included up to six dual-socket server configurations based on the Intel Xeon 5th generation series with a thermal design power (TDP) of up to approximately 250 W per processor.

Over an eight-month application period, continuous analytical monitoring revealed no evidence of fluid degradation or changes in performance. Parallel inspections confirmed no observable impact on server hardware.

Key indicators such as dielectric properties and Total Acid Number (TAN), used to assess fluid degradation, remained within the specified range of fresh fluid and well below the proposed threshold limits for aged or used fluids.

Following the successful outcome of the laboratory application tests, BitHeat, in partnership with Evonik, is advancing to the next phase of testing by evaluating the fluid in real-world applications.

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³ FOM1 (OCP): A dimensionless figure of merit that combines fluid thermal conductivity, heat capacity, density, expansion, and viscosity to quantify the effectiveness of a single-phase immersion fluid for heat removal under natural convection.