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An
Bundesministerium für Digitales
und Staatsmodernisierung

Konsultationsprozess zur nationalen Rechenzentrumsstrategie

Sehr geehrte Damen und Herren,

In der Studie „Stand und Entwicklung des Rechenzentrumstandorts Deutschland“ des Bundesministeriums für Wirtschaft und Klimaschutz vom 17.01.2025 (BMWK-Projekt-Nr.: 115/21-45) wird festgestellt, dass die Kapazität der in Deutschland betriebenen Rechenzentren sich bis 2030 auf voraussichtlich 4.850 MW erhöht. Zudem wird ein weiterer starker Anstieg in den Folgejahren auf 10.000 – 12.000 MW DZ-Kapazität in 2045 erwartet. Allein die Tatsache, dass die Kapazität eines Rechenzentrums in Megawatt, also dem Stromverbrauch des entsprechenden RZ, angegeben wird zeigt, dass eine Herausforderung der kommenden Jahre die Steigerung der Stromeffizienz von RZ sein wird. Je nach Quelle (z.B. McKinsey & Company, 2023) werden dabei bis zu 40% des zum Betrieb eines RZ benötigten Stroms für die Kühlung benötigt. Effizientere Kühlsysteme können helfen, den Stromverbrauch von Rechenzentren zu senken und dabei neben einer höheren Kosteneffizienz einen positiven Beitrag zur Reduzierung des damit verbundenen CO2- Ausstoß zu erzielen.

Eine Reduzierung des Stromverbrauchs von Rechenzentren bei gleichzeitigem Erhalt bzw. einer Steigerung der Leistungsfähigkeit ist aus volkswirtschaftlicher Sicht wünschenswert. Neben einer Entlastung der Kraftwerke und notwendigen Stromnetze kann ein Beitrag zur Erreichung der national und international vereinbarten Klimaziele erzielt werden. Bei Einsatz eines aus nachwachsenden Rohstoffen hergestellten Kühlmittels kann der CO2-Ausstoß weiter reduziert werden. Zudem erlangen die Betreiber der Rechenzentren eine größere Wettbewerbsfähigkeit im internationalen Vergleich, wodurch die angebotenen Leistungen günstiger werden und eine überlegene Technologie neue Exportmärkte erschließen kann.

Die Kühlung moderner Rechenzentren erfolgt vermehrt durch Flüssigkeitskühlung. Neben den oben genannten Gründen ist insbesondere ein geringerer Platzbedarf im Vergleich zur Luftkühlung sowie die größere Wärmeleitfähigkeit und Wärmekapazität von flüssigen Wärmeträgern vorteilhaft beim Betrieb großer Rechenzentren. Als Industrie-Standard hat sich aktuell PG25 etabliert, eine Kühlflüssigkeit, die zu 25% aus fossil hergestelltem Propylenglykol

besteht. Eine weitere Verbesserung der Energieeffizienz kann hier durch den Ersatz des Propylenglykols durch zu 100% aus nachwachsenden Rohstoffen hergestelltes 1,3-Propandiol erzielt werden. Dies liegt am günstigeren Viskositätsprofil des 1,3-Propandiols im Vergleich zum Propylenglykol. Berechnungen unabhängiger Experten belegen, das bei Einsatz von 1,3-Propandiol Energieeinsparungen für den Betrieb von Rechenzentren von 30% und mehr bei gleicher Kühlleistung erzielt werden können. Es kann zudem eine Reduzierung der Investitionskosten bei passender Auslegung des Kühlsystems erzielt werden.

SUSTERRA 1,3-Propandiol wird zu 100% aus nachwachsenden Rohstoffen hergestellt. Im direkten Vergleich zu fossil hergestelltem Propylenglykol entstehen bei der Herstellung von SUSTERRA 86% weniger schädliche Treibhausgase als bei der Herstellung von aus fossilen Rohstoffen hergestelltem Propylenglykol. Hierdurch kann eine weitere Reduzierung der durch den Betrieb eines Rechenzentrums verursachten CO2-Emmissionen erreicht werden. Da für diesen sog. embedded carbon im Scope 3 des GHG protocol ab 2030 ebenfalls CO2-Zertifikate vorgehalten werden müssen, kann durch Einsatz von SUSTERRA ein weiterer Wettbewerbsvorteil im Vergleich zu fossil hergestellten Kühlmitteln erzielt werden.

Im Anhang zu diesem Schreiben sende ich Ihnen ein White Paper, das aktuell von meinen Kollegen zur Diskussion im Open Compute Project (OCP) vorbereitet wird. Eine Empfehlung seitens der Bundesregierung zur Verwendung von Kühlmitteln, die aus nachwachsenden Rohstoffen hergestellt werden, kann dabei helfen, den Transformationsprozess hin zu energieeffizienteren und klimaschonenden Rechenzentren zu Beschleunigen. Hierdurch kann sich Deutschland als Standort für hocheffiziente und klimaschonende Rechenzentren positionieren und Betreibern von Rechenzentren einen Wettbewerbsvorteil im Vergleich zur internationalen Konkurrenz bieten.

Gerne können Sie mich zu Fragen oder weiteren Konsultationen unter folgenden Kontaktdaten erreichen:

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Mit freundlichen Grüßen

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Anlagen

White Paper: Moving Past Traditional Glycols: A Modern Approach to Thermal Management for Reducing Costs and Carbon while Enhancing Performance and Safety

Moving Past Traditional Glycols: A Modern Approach to Thermal Management for Reducing Costs and Carbon while Enhancing Performance and Safety.

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Abstract

Traditional heat transfer fluids, such as ethylene glycol (EG) and propylene glycol (PG), present challenges related to toxicity and performance, particularly at low temperatures. This paper introduces bio-based 1,3-propanediol (PDO) as a revolutionary alternative that offers a compelling combination of sustainability, enhanced safety, and superior technical performance. Produced via the fermentation of renewable corn sugar, bio-based PDO has a significantly smaller carbon footprint, generating 84% fewer greenhouse gas emissions than petroleum-based propylene glycol.

Key performance advantages include a more favorable viscosity profile, especially at low temperatures when compared to propylene glycol, which reduces pumping power requirements and lowers operational costs. PDO also demonstrates excellent thermal stability, high heat capacity, and low corrosivity when properly inhibited. From a safety perspective, its non-toxic classification and ready biodegradability make it a superior choice over ethylene glycol, particularly in sensitive applications like HVAC, food processing, and data centers. Focusing on the data center market, the use o1,3-propanediol can lead to reduced infrastructural costs (CAPX), significant energy savings, and enhanced system longevity, aligning with industry goals for sustainability and efficiency. As industries increasingly seek greener and more efficient solutions, 1,3-propanediol is positioned to become a new standard in thermal management.

Introduction

The efficient and reliable transfer of heat is a cornerstone of modern industry, from the climate control systems in our homes and offices to the complex processes within manufacturing plants and renewable energy facilities. 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. Among these, 1,3-propanediol (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.

The Landscape of Heat Transfer Fluids: A Need for Evolution

Heat transfer fluids are the lifeblood of countless thermal management systems. Their primary role is to absorb heat from one location and release it in another, facilitating the controlled movement of thermal energy. Historically, glycols such as ethylene glycol (EG) and propylene glycol (PG) have been the industry stalwarts. While effective, they come with certain limitations. Ethylene glycol, for instance, is known for its toxicity, posing environmental and safety concerns in the event of leaks or spills. Propylene glycol, while less toxic, often falls short in terms of thermal performance and viscosity at lower temperatures compared to its counterpart.

Beyond glycols, other options like brines, mineral oils, and synthetic hydrocarbons each present their own set of advantages and disadvantages, often revolving around factors like freeze protection, boiling point, corrosivity, and environmental impact. The ideal heat transfer fluid is a complex equation, balancing performance, safety, longevity, and cost.

In Steps 1,3-Propanediol: A Bio-Based Alternative

1,3-Propanediol, a diol with a unique molecular structure, has emerged as a game-changer due to its distinct properties and, crucially, its bio-based origin. Unlike most conventional glycols derived from petrochemicals, bio-based 1,3-propanediol is produced through the fermentation of renewable sourced corn sugar from industrial corn cultivated in the Midwest of the United States. This bio-based production pathway significantly reduces its carbon footprint, aligning perfectly with global sustainability goals and the growing demand for eco-friendly industrial solutions, generating 84% less greenhouse gases (GHG) than petroleum- based propylene glycol. This inherent "green" advantage is a powerful differentiator, but it's the technical benefits that truly seal its position as a superior heat transfer fluid.

Unpacking the Performance Benefits of 1,3-Propanediol

The advantages of 1,3-propanediol in heat transfer fluids are multifaceted, extending across critical performance metrics:

1. **Superior Thermal Stability and Heat Capacity:** 1,3-Propanediol exhibits excellent thermal stability across a broad temperature range. This means it can withstand high operating temperatures without significant degradation, ensuring consistent performance and extending the fluid's lifespan. Furthermore, its heat capacity, a measure of how much heat a substance can absorb for a given temperature change, is comparable to or even surpasses that of traditional glycols. This translates to more efficient heat absorption and transfer, leading to improved system efficiency and potentially lower energy consumption.
2. **Optimized Viscosity Profile:** Enhancing Flow and Reducing Pumping Costs: One of the most significant advantages of 1,3-propanediol, particularly when compared to propylene glycol, is its favorable viscosity profile. At lower temperatures, 1,3-propanediol maintains a lower viscosity than propylene glycol, meaning it flows more easily through piping and heat exchangers. This reduced viscosity translates directly into lower pumping power requirements, leading to energy savings and reduced operational costs. In cold climates or systems operating at sub-zero temperatures, this can be a critical factor in maintaining efficient fluid circulation.
3. **Exceptional Freeze Protection:** Like other glycols, 1,3-propanediol offers excellent freeze protection, depressing the freezing point of water to very low temperatures. This makes it an ideal choice for systems exposed to freezing conditions, preventing damage to equipment and ensuring continuous operation. Its ability to form stable aqueous solutions further enhances its utility in diverse applications.
4. **Low Toxicity and Enhanced Safety Profile:** Perhaps one of the most compelling benefits of 1,3-propanediol is its significantly lower toxicity compared to ethylene glycol. It is classified as non-toxic, making it a much safer option for applications where human exposure or environmental release is a concern. This is particularly crucial in food processing, pharmaceutical manufacturing, and HVAC systems in public buildings, where the risk of accidental or incidental contact must be minimized. The reduced environmental impact in case of leaks or spills also aligns with stricter environmental regulations and

corporate responsibility initiatives.

5. **Reduced Corrosivity: Protecting System Integrity:** Corrosion is a persistent enemy of heat transfer systems, leading to costly downtime, repairs, and reduced efficiency. 1,3-Propanediol demonstrates excellent compatibility with a wide range of materials commonly used in heat transfer systems, including various metals and plastics. When properly formulated with appropriate corrosion inhibitors, 1,3-propanediol-based fluids can significantly extend the longevity of system components, reduce maintenance costs, and ensure long-term operational reliability.
6. **Biodegradability:** A Sustainable Choice: Beyond its bio-based origin, 1,3-propanediol is also readily biodegradable. In the event of an accidental release, it breaks down naturally in the environment, minimizing its ecological footprint. This biodegradability, coupled with its low toxicity, positions 1,3-propanediol as an environmentally responsible choice, contributing to a circular economy and reducing reliance on fossil fuel-derived chemicals.

The Critical Advantage: Reduced Viscosity at Low Temperatures and Pump Power Savings

While several of the benefits of 1,3-propanediol contribute to overall system efficiency and safety, its superior viscosity profile, especially at low temperature, warrants a more detailed examination, especially when considering applications where toxicity is a key concern.

In many heat transfer applications, particularly those in colder climates or those requiring sub-ambient cooling, the viscosity of the fluid at low temperatures becomes a critical performance determinant. Higher viscosity translates directly into increased resistance to flow within the piping and heat exchangers. This resistance, known as friction loss, necessitates greater energy input from the circulation pumps to maintain the desired flow rate.

Propylene glycol, while a safer alternative to ethylene glycol, tends to become significantly more viscous as temperatures drop. This characteristic can lead to several challenges:

- **Increased Pump Power Consumption:** To overcome the higher frictional losses, pumps must work harder, consuming more electricity. This directly translates to higher operating costs over the lifespan of the system. In large-scale industrial or commercial applications, these energy savings can be substantial.

- **Reduced Flow Rates:** If pump power is fixed, increased viscosity can lead to a reduction in flow rate, which in turn diminishes the system's ability to transfer heat efficiently. This can compromise performance and even lead to operational issues in critical processes.
- **Potential for Cavitation:** In extreme cases of high viscosity and demanding pump operation, there's an increased risk of cavitation, a phenomenon that can damage pump components and reduce their lifespan.
- **Larger Pump Sizing:** To compensate for the higher viscosity of propylene glycol at low temperatures, engineers might need to specify larger, more powerful, and therefore more expensive pumps at the initial design stage.

1,3-Propanediol, in contrast, consistently demonstrates lower viscosity than propylene glycol at comparable concentrations, especially in the crucial low-temperature ranges. This inherent fluid dynamic advantage translates directly into tangible benefits:

- **Significant Pump Power Savings:** By requiring less energy to circulate, 1,3-propanediol reduces electricity consumption, leading to measurable cost savings for operators. This is particularly impactful in systems with continuous operation or in regions with high energy costs.
- **Maintained Flow and Efficient Heat Transfer:** The lower viscosity ensures that desired flow rates can be achieved with less effort, maintaining optimal heat transfer performance even in challenging cold conditions.
- **Reduced Wear and Tear on Pumps:** Less strain on pumps due to lower resistance to flow can extend the lifespan of pumping equipment, reducing maintenance frequency and replacement costs.
- **Potentially Smaller Pump Footprint:** In some designs, the favorable viscosity profile of 1,3-propanediol might allow for the selection of smaller, more efficient pumps, reducing capital expenditure and occupying less valuable space.

This advantage is particularly salient in applications where the non-toxic nature of the fluid is paramount. Consider a pharmaceutical manufacturing facility, a food processing plant, or a data center with strict environmental controls. In such environments, the use of toxic fluids like ethylene glycol is often prohibited or heavily restricted due to the potential for catastrophic consequences from a leak. Propylene glycol, while safer, might impose significant energy penalties due to its viscosity profile at the required operating temperatures. 1,3-Propanediol offers the best of both worlds: a non-toxic profile that meets stringent safety regulations, combined with a superior low-temperature viscosity that drives energy efficiency and reduces operational costs, without compromising on thermal performance. This makes it an ideal solution where safety, performance, and sustainability must all be simultaneously optimized.

Applications Beyond the Horizon

The benefits of 1,3-propanediol are driving its adoption across a diverse range of applications:

- **HVAC and Refrigeration:** Ist low toxicity and efficient heat transfer properties make it ideal for residential, commercial, and industrial HVAC systems, as well as refrigeration units.
- **Geothermal Systems:** The long-term stability and freezing protection of 1,3-propanediol make it well-suited for ground-source heat pump systems.
- **Solar Thermal Systems:** Ist thermal stability at higher temperatures is advantageous for concentrating solar power and solar water heating applications.
- **Food and Beverage Processing:** The low toxicity is paramount in this sector, where direct or indirect contact with the fluid is a possibility.
- **Pharmaceutical and Biotech:** Like food processing, the safety profile of 1,3-propanediol is highly valued in these sensitive industries.
- **Industrial Process Cooling:** Ist overall performance and environmental benefits make it a strong contender for a wide array of industrial cooling applications.
- **Data Centers:** Efficient and reliable cooling is critical for data centers, and 1,3-propanediol can contribute to both performance and sustainability goals.

Susterra® Propanediol (1.3-Propanediol): A Superior Cooling Solution 9ort he Modern Data Center

The exponential growth of data and the increasing reliance on cloud computing and artificial intelligence are placing unprecedented demands on data centers. As a result, effective and efficient cooling has become a critical operational challenge. In this landscape, Susterra® propanediol, a bio-based 1,3-propanediol, emerges as a highly beneficial heat transfer fluid for the data center market, addressing key concerns around performance, sustainability, and operational costs.

Enhancing Energy Efficiency and Reducing Operational Costs

One of the most significant advantages of Susterra® propanediol in a data center environment is its favorable viscosity profile, particularly at lower temperatures. Compared to the traditionally used propylene glycol (PG), Susterra® (1,3-propanediol) maintains a lower viscosity, meaning it flows more easily through cooling systems. This characteristic directly translates to reduced CAPX infrastructural costs and pumping power requirements, leading to substantial energy savings and lower operational expenditures over the lifespan of the cooling infrastructure. In large-scale data centers where cooling can account for a significant portion of energy consumption, these savings can be substantial. The lower viscosity also ensures maintained flow rates, which is crucial for efficient and consistent heat transfer, a critical factor in preventing equipment failure from overheating.

A Commitment to Sustainability and Safety

Susterra® propanediol is produced through the fermentation of renewable corn sugar, making it a bio-based and more sustainable alternative to petroleum-derived glycols. This production process generates significantly fewer greenhouse gas emissions than that of petroleum-based propylene glycol. For data center operators increasingly focused on corporate sustainability goals and reducing their carbon footprint, Susterra® offers a compelling "green" advantage. Furthermore, Susterra® propanediol has a significantly lower toxicity profile compared to ethylene glycol (EG), another common heat transfer fluid. Classified as non-toxic, it presents a much safer option for environments where the risk of leaks or spills could have significant

consequences. In the event of an accidental release, Susterra® is also “Readily Biodegradable” (OECD 301B), minimizing its ecological impact. This enhanced safety and environmental profile is particularly valuable in meeting stringent environmental regulations and corporate responsibility initiatives.

Superior Performance and System Longevity

Beyond its efficiency and sustainability benefits, Susterra® propanediol offers excellent thermal stability across a wide range of operating temperatures. This stability ensures consistent performance and extends the fluid's lifespan, reducing the need for frequent and costly fluid change-outs. Its high heat capacity allows for efficient heat absorption and transfer, contributing to the overall efficiency of the cooling system. Corrosion is a persistent threat to the integrity and efficiency of cooling systems. Susterra® propanediol, when formulated with appropriate inhibitors, demonstrates excellent compatibility with a wide range of materials commonly used in heat transfer systems, including various metals and plastics. This helps to protect system components, extend their longevity, and reduce maintenance costs and downtime. Furthermore, Susterra® propanediol is biostatic at concentrations of 25% or greater, inhibiting the growth of bacteria and fungi that can lead to system fouling and reduced efficiency

In summary, the adoption of Susterra® propanediol in data center cooling systems offers a multifaceted solution that aligns with the industry's pressing needs for improved energy efficiency, enhanced sustainability, and reliable performance. Its unique combination of a bio-based origin, superior viscosity profile, low toxicity, and excellent thermal properties makes it an ideal choice for the forward-thinking data center operator.

The Future of Heat Transfer is Bright-Green and Efficient

The advent of 1,3-propanediol in heat transfer fluids represents more than just an incremental improvement; it signifies a paradigm shift towards more sustainable, safer, and ultimately more efficient thermal management solutions. Its bio-based origin addresses the growing imperative for renewable resources, while its superior performance characteristics – including optimized

viscosity, excellent thermal stability, and robust freeze protection – meet the rigorous demands of modern industrial processes. Coupled with its low toxicity and biodegradability, 1,3-propanediol offers a compelling value proposition that extends beyond immediate performance gains to encompass long-term environmental stewardship and operational cost savings. As industries worldwide continue to prioritize sustainability and efficiency, 1,3-propanediol is poised to become the heat transfer fluid of choice, ushering in a greener and more effective era of thermal management.

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