VERTIV WHITE PAPER

Charting a Course for Compliance, Carbon Emission Reductions, and Efficiency with Low GWP Refrigerants

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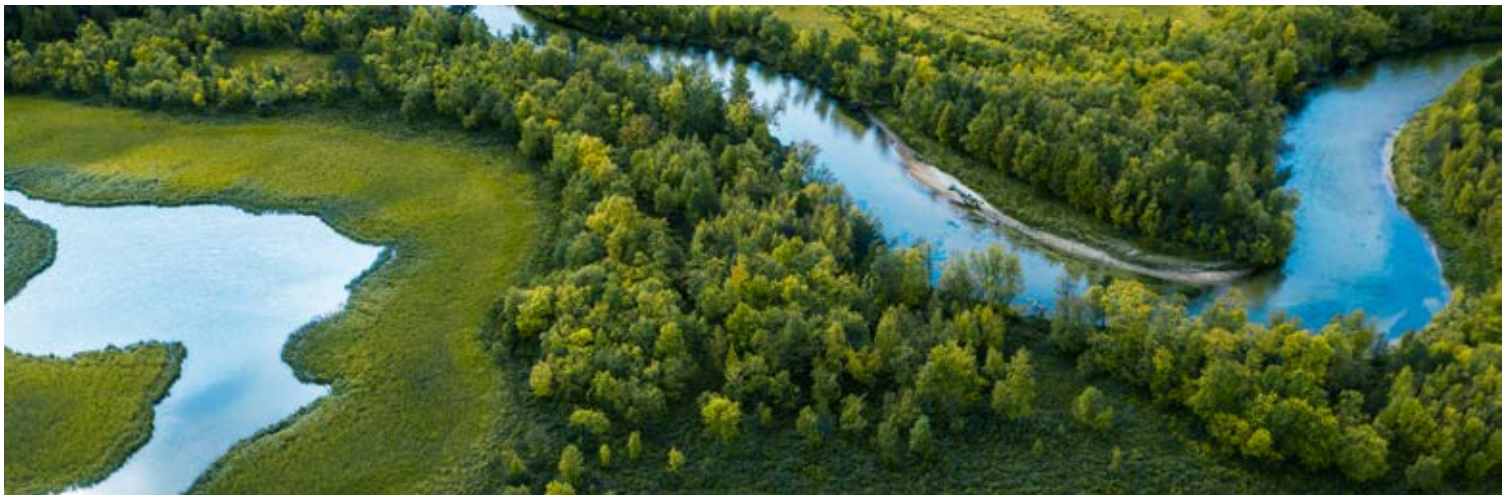

Executive Summary

Enterprises are on the front lines of transforming data centers to accomplish responsible business goals. By 2027, 75% of companies will have a data center infrastructure environmental development program, up from just 5% in 2022.[1] Data center operators and collaborators can make their businesses future-ready and reduce environmental impacts by considering infrastructure and operational emissions from the outset of the planning and design process. In addition, leaders increasingly see environmental responsibility as an opportunity to create business value. By innovating different ways to reduce carbon emissions, enterprises can win and keep new customers, drive revenues and profitability, and reduce costs.

However, it's also important to remember that environmental innovation is just one pillar of a company's responsible business platform. By considering environmental strategies in the broader responsible business context, data center operators can make the best decisions for their companies, facilities, customers, and society.

An additional two percentage points annual excess total shareholder return (TSR): A McKinsey study found that "triple outperformers" – companies that deliver strong growth and profitability while improving sustainable development and ESG scores – produced higher TSR than those who focused on financials alone.[2]

At data centers worldwide, leaders, operators, and facility managers collaborate with mechanical and cooling manufacturers and consultants to deploy the latest power and thermal management technologies and continuously optimize processes. In addition, they're developing new metrics to assess their ability to reduce environmental impacts and achieve strategic business goals.

One meaningful way to reduce carbon emissions is to adopt new refrigerants. Over the past few decades, scientists and academic researchers have demonstrated the harmful impacts of traditional commercial refrigerants on the Earth's stratosphere. Many high global warming potential (GWP) refrigerants, spanning different chemical compounds, have already been phased out due to international protocols and regional and national regulations.[3]

This paper provides a framework that data center stakeholders can use to consider low GWP refrigerants within the broader context of responsible business, emissions scopes, total equivalent warming impact (TEWI), and refrigerant GWP values and emissions. By using this paper, teams can make critical decisions about the refrigerants they use to cool and protect vital data center technology while complying with all relevant regulations and meeting their companies' responsible business goals.

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Top five takeaways

This paper is intended to provide data center operators with the insights they need to consider the transition to low GWP refrigerants within the broader context of responsible business initiatives. The top five takeaways from this paper are:

1. Responsible business involves more than setting and achieving environmental goals. For businesses to be environmentally responsible, they must also ensure social equity and be economically viable.
2. Responsible business is becoming a lever companies can use to differentiate themselves in the marketplace, driving revenues and profitability while meeting compliance requirements.
3. Data centers can improve their operations' environmental footprint multiple ways. One key strategy is to adopt low GWP refrigerants and more energy-efficient systems, reducing consumption and carbon emissions while protecting the earth's stratosphere.[4]
4. Adopting low GWP refrigerants and systems impacts Scope 2 and Scope 3 emissions. Data center operators and other stakeholders should know how refrigerants, systems, and operations create direct and indirect emissions.
5. Our paper offers strategies for reducing direct and indirect emissions. These changes reduce the total warming impact (TEWI) of cooling devices used in data centers.

How the modern responsible business movement evolved

While environmental stewardship has existed for centuries, corporate social responsibility and sustainable development have taken shape over the last few decades.[5] These three imperatives are now combined under the responsible business movement, which enterprises worldwide have widely embraced.

As prolific consumers of technology, power, and cooling, data centers have been scrutinized by shareholders, activists, and regulators for decades. The publication of a seminal research paper in 1974 drove global collaboration to phase out commercial refrigerants harming the earth's stratosphere and find new alternatives.[6]

Other key developments influencing this movement include:

- The passage of the United Nations (UN) Conference on the Human Environment (1972) and the subsequent creation of the UN Environment Programme.
- The UN's publication of Our Common Future (1987).
- The Montreal Protocol (1987).
- The Intergovernmental Panel on Climate Change report (1990 and 1992).
- The UN Sustainable Development Goals (2015).

As a result of these developments and others, high GWP refrigerants, including hydrofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs), have been — or are being — phased out in favor of low GWP refrigerants, including low GWP HFCs, hydrochlorofluoro-olefins (HCFOs) and hydrofluoric-olefins (HFOs). Chlorofluorocarbons (CFCs) are also being phased out because they have a higher-than-zero ozone depletion potential (ODP).

Defining responsible business and its aims

Enterprises are increasingly committed to sustainable development, which Our Common Future defines as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." [7] At 39% of organizations today, management drives sustainable development with board input; at 38%, these responsibilities are shared equally; and at 16%, these imperatives are managed solely by the board.[8]

Today, enterprise teams view environmental imperatives through the broader lens of building a responsible business. Over time, the concept of "three pillars" of sustainable development has arisen due to the work of many scientists and academic researchers.[9]

There is no single definition for each pillar. Using the UN Sustainable Development Goals as inspiration, [10] Vertiv defines each pillar as:

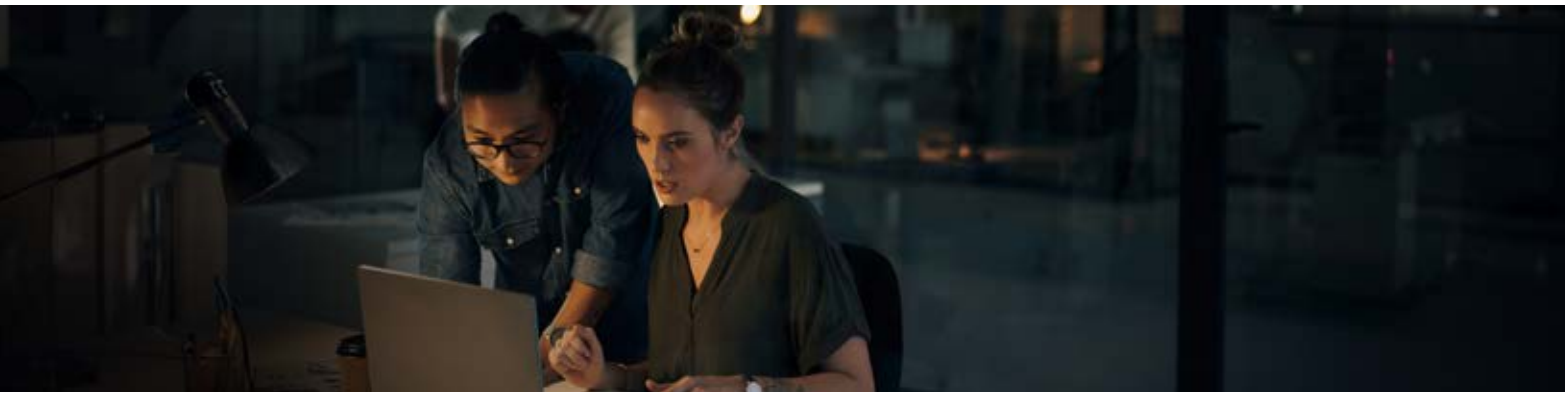
- **Environmental responsibility:** Minimizing the negative impact of human activities on the environment, including reducing pollution, conserving natural resources, and protecting biodiversity.
- **Social equity:** Promoting social well-being and equity by addressing issues like social justice, access to basic needs, and the fair distribution of resources and opportunities among all people, regardless of their background or circumstances.
- **Economic viability:** Responsible business practices should be economically viable, ensuring that they are financially feasible and do not compromise the stability and prosperity of current and future economies.

The global transition to low GWP refrigerants addresses all three pillars. It will deliver environmental benefits by reducing atmospheric impacts, leaving the world in better shape for future generations, and unlocking new opportunities for data centers to create business value by becoming more energy-efficient.

Challenges pursuing responsible business goals

The three pillars of responsible business have noble aims that few would argue with but require sustained commitment. Challenges data center companies face in realizing these ambitions include:

- **The goalposts are moving:** Companies typically develop ambitious responsible business strategies, benchmark their current state, implement various initiatives, use multiple metrics to chart progress, and publish yearly reports. While change is difficult, teams gain insights into – and experience using – new technologies and processes they can use to update their approach and improve results with each passing year.
- **Regulatory requirements are tightening:** Regulations are evolving, requiring that data center companies adopt a long-term business and compliance strategy and update systems and processes to address the latest changes. For example, regulators have proposed GWP values of 700[11] or even as low as 150[12] as new limits for refrigerant GWP values, down from original targets of 750 or less,[13] due to vendors' innovation of new refrigerants.
- **Investing in creating a responsible business:** Data centers adopting new solutions and processes that reduce carbon emissions often face a sizable upfront capital expense (CapEx) investment. However, they can work with manufacturing partners to adopt innovative technology that helps them accomplish other goals, such as increasing operational efficiency, as they meet new regulatory targets.
- **Adopting new processes:** Data center operators use new technologies, processes, and metrics, increasing change management challenges. In addition to training on new systems, teams must monitor them to ensure they are in good working order. For example, some low GWP refrigerants have mild flammability risks if three different operational conditions co-occur,[14] which is unlikely. As a result, operators must understand the chemical makeup of the new refrigerants they choose for their respective facilities and the corresponding steps for safe handling, usage, and storage conditions.



Five ways low GWP refrigerants further responsible business gains

Enterprises have a wide array of strategies they can use to accelerate progress toward achieving data center responsible business strategies and goals. Here are some reasons why using low GWP refrigerants in data center operations is essential:

1. **Transitioning to low GWP refrigerants is a social responsibility:** Significant scientific, academic, and nongovernmental research demonstrates the harmful impact of high GWP refrigerants.[15] As a result, the U.S., European Union, and other countries have passed legislation requiring covered entities to meet or exceed protocol agreements.

   While enterprises are required to meet new compliance requirements, transitioning to low GWP refrigerants is also a social responsibility. As part of their responsible business strategies and commitments, enterprises seek to serve their communities and protect the earth and atmosphere for future generations.

2. **Using new refrigerants prepares business models for the future:** Harming the earth's atmosphere is unsustainable over the long term. Enterprise leaders are thus highly motivated to adopt low GWP refrigerants to keep the earth habitable for human life and fit for industry operations while accomplishing their environmental goals as part of their responsible business strategies.

3. **The move to low GWP refrigerants is increasing innovation:** Vertiv and other manufacturers are using the global transition to low GWP refrigerants to optimize cooling system design for energy efficiency and lower emissions. Design team decisions determine up to 80% of product emissions.[16]

   As a result, companies like Vertiv can make design, material, and manufacturing choices that reduce embodied emissions and decrease operational emissions.

   Enterprises will see the most significant efficiency gains when implementing new systems with cutting-edge designs to drive operational performance. Simply implementing low GWP refrigerants alone doesn't always improve cooling efficiency compared to their high GWP equivalents.

4. **The need for low GWP refrigerants will continue with liquid cooling:** As enterprises adopt highly efficient direct-to-chip or immersion liquid cooling to power high-performance computing (HPC) workloads, they will still need to use refrigerants subject to fluorinated gas regulations. For example, the use of fluorinated gas is covered by laws such as the F-gas regulation.[17]

5. **Companies stand to reap financial gains:** Becoming a responsible business leader enables enterprises to win new customers, expand their businesses, reduce operational expense (OpEx) costs, and avoid financial penalties due to regulatory non-compliance. Many companies increasingly use environmental criteria to source new suppliers, enabling those that implement innovative strategies to reduce carbon emissions to increase market share.

   Using energy-efficient systems also reduces power costs, representing a large portion of data centers' operating budgets. Companies that sell low GWP refrigerants in the European Union can also avoid carbon taxes assessed on those firms that sell refrigerants with higher GWP values.[18]

Navigating emissions scopes and how they relate to refrigerant use

Enterprises chart progress against responsible business strategies by setting goals to reduce carbon emissions against three scopes. The Greenhouse Gas Protocol (GHG Protocol) created these definitions, which provide global standardized frameworks organizations use to measure, manage, and reduce carbon emissions. Considered the gold standard for GHG accounting standards, the GHG Protocol is used by more than 92% of Fortune 500 companies.[19] Carbon emissions related to enterprises' cooling equipment operational emissions span:[20]

- **Scope 1:** Emissions owned or controlled by an organization. These emissions include leaks from cooling equipment, power generation, and fuel used by fleet vehicles to service equipment.
- **Scope 2:** Emissions that an organization owns or controls directly, such as electricity used to power equipment, including losses.
- **Scope 3:** Emissions created by the organization's value chain, such as embodied emissions in producing refrigerants and equipment, waste management, and upstream emissions from purchased fuel.

The global transition to low GWP refrigerants impacts Scope 2 and 3 emissions. Data center teams should consider the following:

- **Usage emissions:** New systems and refrigerants will create emissions as they are powered, used, and maintained.
- **Refrigerant loss emissions:** Refrigerant leaks during initial installation or recharging create emissions that must be accounted for.
- **Transportation emissions:** Transporting products and personnel to data centers to install and service equipment creates emissions.
- **End-of-life emissions:** Teams will create emissions as they decommission legacy systems, which may involve recycling technology and safely disposing of high GWP refrigerants and system components.

How data center teams can calculate Scope 3 emissions

Calculating Scope 3 emissions has always been challenging for data centers, facilities, and responsible business teams. By definition, these emissions occur outside their organizations' purview and have limited consistency, even among companies in the same industry. Here's how these teams can measure these critical values:

- **Consult relevant standards:** ANSI/ASHRAE 90.4, Energy Standard for Data Centers, provides minimum energy efficiency requirements that enterprises must meet as they design, construct, operate, and maintain data centers. The standard, published in 2016, was last updated in 2022. [21]

Another relevant standard is TM65: Embodied carbon in building services: A calculation methodology, published in 2021. The standard guides the calculation of the embodied carbon of goods if environmental product declarations are available or estimates if not.[22]

- **Develop a template:** Most enterprises provide manufacturers with a template to collect information on Scope 3 emissions. Vertiv consults relevant standards when providing this guidance to customers.
- **Ask partners for documentation:** Vertiv provides a carbon certificate for its solutions, which includes embodied and operational emissions. Other manufacturers do likewise.

Calculating total equivalent warming impact (TEWI) scores to evaluate cooling's impact on emissions

As they calculate carbon emissions, data center teams want to understand how refrigerant-enabled cooling contributes to their operational footprint. The total equivalent warming impact (TEWI) is a standard formula considering direct and indirect emissions caused by refrigerants in cooling systems.[23] It was published by the International Institute for Refrigeration in 1996 and is widely used by data centers, facilities, and responsible business teams to calculate the impact of cooling devices on global warming, as measured in tons of CO2 emissions.

Calculating a Data Center's TEWI Score

Operators can use the following formula to calculate the TEWI score for their data center. [24]

TEWI = GWP (**direct**; refrigerant leaks incl. EOL) + GWP (**indirect**; operation)

= $(GWP \times m \times L_{annual} \times n) + (E_{annual} \times \beta \times n)$

Where:

GWP	=	Global Warming Potential of refrigerant, relative to CO_2 (GWP CO_2 = 1)
L_{annual}	=	Leakage rate p.a. (Units: percentage per year)
n	=	System operating life (Units: years)
m	=	Refrigerant charge (Units: kg)
E_{annual}	=	Energy consumption per year (Units: kWh p.a.)
β	=	Indirect emission factor (Units: kg CO_2 per kWh)

Since data centers use power and cooling 24 hours a day, 365 days a year, their TEWI scores are much higher than other commercial and residential facilities, which provide comfort cooling and heating that peaks when occupied or as outdoor temperatures rise or fall.

Source: "What Exactly Is TEWI, Anyway?," article, North American Sustainable Refrigeration Council, January 23, 2017, https://nasrc.org/articles1/2017/1/23/what-exactly-is-tewi-anyway.

There are multiple ways to impact TEWI scores. Those related to refrigerant use include:

- **Using low GWP refrigerants:** Current commercially available refrigerants have a wide range of GWP values considered in TEWI calculations. Commonly used refrigerants for IT and comfort cooling are R410A, which has a GWP value of 2,088; R407C, 1,774; and R134a, 1,430, measured over 100 years. Low GWP refrigerants R454B and R32 have values of 466 and 675, respectively, over the same period.[25] Thus, implementing low GWP refrigerants across systems can significantly reduce TEWI scores.
- **Minimizing direct emissions:** Refrigerant leakage, whether accidental or purposeful, can create direct emissions, as can losses when refrigerants are recovered from systems, such as when legacy systems are decommissioned, and high GWP refrigerants are collected. Avoiding these emissions positively impacts TEWI scores.
- **Reducing indirect emissions:** These emissions include all energy consumed to power cooling systems that use refrigerants. Implementing more energy-efficient cooling systems, whether liquid or otherwise, reduces energy consumption and emissions, decreasing TEWI values.

Data center teams can use their TEWI scores to baseline the potential GWP impact their refrigerant-cooled systems can have on the environment, benchmark themselves against industry averages and leaders, and create mitigation strategies. These scores can also be used to gain support and investment from stakeholders to make changes, such as transitioning to low GWP refrigerants ahead of regulatory mandates.

Data centers that embrace responsible business principles and practices are valuable assets. They use new technology and processes to reduce carbon emissions and operate more efficiently, improving return on investment.

How to reduce TEWI scores by using low GWP refrigerants

Data center and facilities teams can reduce their TEWI scores using a variety of strategies, including:

- **Using natural refrigerants:** Data centers leverage water and air to cool equipment. Other natural refrigerants, such as ammonia, carbon dioxide, and hydrocarbons, may become usable in the future and replace the existing ones that are chemical compounds.
- **Adopting new systems that use low GWP or natural refrigerants:** Adopting low GWP or natural refrigerants reduces direct emissions. In addition, data center operators and facility teams are deploying redesigned cooling systems, designed to operate more efficiently with these new refrigerants and decrease energy consumption. Thus, enterprises that move ahead of regulatory mandates can also reap business and environmental benefits they can share with customers and other stakeholders.
- **Preventing refrigerant leakage:** Vertiv prevents and reduces refrigerant leakages in two ways: by designing cooling systems that meet our high-quality standards and working with service partners to provide regular monitoring and maintenance, proactively identifying and addressing potential issues. If leaks occur, their direct emissions will be determined by the refrigerant released in a single circuit and its GWP value. All these activities are aimed at reducing the direct factor of the TEWI.
- **Using the right amount of refrigerant to charge systems and enabling energy-efficient cooling systems:** TEWI scores can be reduced by limiting the amount of refrigerant subject to potential leaks and by enhancing the energy efficiency of cooling systems. Unintended and accidental leaks with technical solutions that are aimed at reducing the refrigerant charge, such as microchannel coils, are available with the comprehensive product portfolio of Vertiv. The latter is directly related to reducing any useless power input: free cooling, modulating compressors, EC fans, and accurate fluid dynamics are some examples of the high standards of Vertiv's design philosophy.
- **Meeting refrigerant recovery and recycling mandates:** Data center operators and facilities teams must work with contractors to recover refrigerants during regular maintenance duties and when cooling systems reach end-of-life. By using prescribed recovery practices, contractors ensure that no refrigerant releases could cause direct emissions and negatively impact TEWI scores.
- **Improving overall energy efficiency:** Adopting specially engineered energy-efficient systems enables operators to reduce overall energy consumption, positively impacting their data center's TEWI scores.

Use low GWP refrigerants to help achieve responsible business goals

Adopting low GWP refrigerants and new systems and calculating TEWI scores is no easy matter. However, using these new refrigerants and more efficient cooling systems can help your company progress toward achieving responsible business goals faster. You can report decreased Scope 3 emissions and TEWI values to regulators, customers, partners, and shareholders. You can leverage these accomplishments to win customers, boost revenues, and reduce costs by becoming more energy-efficient and avoiding regulatory fines and carbon taxes.

Vertiv can help you set the strategy and scope for this journey. We work with enterprise customers to evaluate their refrigerant options against regulatory mandates, responsible business strategies and goals, timeframes for the transition, and budgets. We help customers select the best refrigerants for critical use cases, considering chemical compounds, GWP values, and safety levels.

Moving ahead of mandates helps your teams gain experience with new refrigerants and processes so that you can scale processes across data centers, networks, and regions. It also avoids situations where teams cannot source legacy refrigerants due to quota limits, which decrease yearly.

Contact Vertiv to learn more about deploying low GWP refrigerants and more energy-efficient systems at your data centers worldwide.

Glossary

- **Chlorofluorocarbons (CFCs):** Inert, nontoxic, and nonflammable chemical compounds. Legal sales of these refrigerants were phased out worldwide by 2010 due to chlorine's negative impact on the ozone layer. [26]
- **Global warming potential (GWP):** A metric used to measure the potential warming impact on the earth's surface and troposphere created by gas emissions in a specific timespan (usually 100 years) compared to the same quantity (1kg) of carbon dioxide (CO2).
- **Hydrocarbons (HCs):** Most HC refrigerants have low toxicity, good thermodynamic properties, and low GWP values. However, some of them are explosive or operate at very high pressure.
- **Hydrochlorofluorocarbons (HCFCs):** These nontoxic and nonflammable compounds are being phased out due to their high GWP values and environmental impact. Developed nations phased them out in 2020, and developing countries will follow suit by 2030. [27]
- **Hydrochlorofluoro–olefins (HCFOs):** Identified as non-flammable and having low toxicity, HCFOs also have low GWP values.
- **Hydrofluorocarbons (HFCs):** These chemical compounds have low toxicity and low to no flammability, but many have high GWP values. Those HFCs with high GWP values are being phased out globally via different regulations. In the US, the phaseout will take place between 2025 and 2036.[28] In Europe, the phaseout began in 2019 and will be completed by 2030.[29]
- **Hydrofluoro-olefins (HFOs):** These chemical compounds, comprised of hydrogen, fluorine, and carbon, have low toxicity and GWP values but are mildly flammable.
- **Total equivalent warming impact (TEWI):** A widely used index that measures the global warming impact of operating and disposing of equipment based on their greenhouse gas emissions. This includes direct refrigerant emissions from leaks, servicing losses, disposal, and the warming impact of CO2 emissions created by burning fossil fuels to generate electricity to run equipment.[30]

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[3] In line with regulatory standards worldwide, Vertiv defines high GWP refrigerants as having values of 750 or above, low GWP refrigerants as having values of less than 750, and very low GWP refrigerants as having values of 150 or lower.

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