M&M CARNOT

BETCO LTD.

REFRIGERANT RESTRICTIONS:

Is Your Data Center Ready for the Transition?

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Introduction

Data centers are the lifeblood of an enterprise and the world economy, and almost all of the world's IP traffic flows through data centers. With the continued increase in data creation, and the need to process and store that data safely and securely, comes the need to keep critical IT equipment cool to ensure efficient and always-on services.

Unfortunately, refrigerants used in traditional data center HVAC systems have high global warming potential. Because they are detrimental to the environment, Canada has phased out use of these harmful substances and the U.S. is phasing out their use over the next decade. How can data center owners, operators, and managers comply with these new directives and be responsible stewards of the environment while maintaining critical uptime and services?

Fortunately, there are options for air cooling systems that use new, acceptable refrigerants. Data centers that want equipment that can be used for its full lifespan of 25 years need to find a sustainable and cost-effective system now. Waiting until the end of the phase-out period in 2036 is too late and has costly implications. Regulatory compliance for the future is a motivating factor to update cooling solutions now.

This white paper will review the challenges facing data center owners, operators, and managers today in using traditional refrigerants for cooling, and examine the benefits of using CO_2 in keeping data centers cool, complying with upcoming regulations, and protecting the planet.

The state of data

- **Approximately 59 zettabytes of data created in 2020[1]**
- **Estimated 1.7 MB of data created every second for every person on earth[2]**
- **Almost all of the world's IP traffic flows through data centers.[3]**

Market drivers

Underlying the regulatory changes to refrigerant use, there are two major issues driving data centers to seek alternatives to their current hydrofluorocarbon-based cooling systems: energy use and the global climate emergency.

Energy use

Energy use has always been a motivator for data center owners and operators as they make decisions about cooling their IT equipment, since roughly 40% of the power in a data center is used for cooling[4]. And, data centers are responsible for consuming 1% of the world's electricity[5], 1.8% in the U.S.[6]

1. https://www.usitc.gov/publications/332/executive_briefings/ebot_data_centers_around_the_world.pdf
2. https://www.domo.com/assets/downloads/18_domo_data-never-sleeps-6+verticals.pdf
3. https://www.iea.org/reports/data-centres-and-data-transmission-networks
4. https://www.sciencedirect.com/science/article/pii/S1876610215009467
5. https://www.iea.org/reports/data-centres-and-data-transmission-networks
6. https://iopscience.iop.org/article/10.1088/1748-9326/abfba1

40% of the power in a data center is used for cooling[7]

Efficiency improvements for data center infrastructure has offset growth in energy demands[8] in many data center applications. Yet, as improved efficiencies and high-capacity computing have helped reduced power demands, there is a delicate dance to keep energy use in check across the sector. In 2020, for example, bitcoin miners alone used 0.3% of the world's electricity.[9]

This dynamic changes the equation of energy consumption and power usage effectiveness (PUE), beyond simply a question of costs or resources for the data centers themselves—to include considerations of how and where the power is generated, and the enterprise's responsibility for environmental sustainability.

Global climate emergency

The concentration of greenhouse gases in the earth's atmosphere has been rising due to human caused factors; and that increased concentration of gases has raised the average temperatures on the planet.

Data centers effectively have the same impact on the increase in concentration of greenhouse gases in the atmosphere as the aviation industry. And these numbers are expected to only increase without significant action.

The refrigerants used in computer room air conditioner (CRAC) units in data centers play a part in this damage to the climate. Emissions of hydrofluorocarbons (HFC) from HVAC units occur during the manufacturing process, leakage and service over the equipment's lifetime, and disposal at the end of a unit's useful life. In the environment, HFCs absorb and trap heat in the lower atmosphere and have a high global warming potential (GWP). HFCs typically have a GWP more than 1,000 times that of CO_2.[12]

2019: Global average temperature was 1.1°C above the pre-industrial period.[10]

2021 Global fossil CO_2 emissions expected to rebound 4.9% to 36.4 Gt CO_2,[11] after a record 5.4% drop in 2020

7. https://www.sciencedirect.com/science/article/pii/S1876610215009467
8. https://www.iea.org/reports/data-centres-and-data-transmission-networks
9. https://www.iea.org/reports/data-centres-and-data-transmission-networks
10. https://www.unep.org/resources/emissions-gap-report-2019
11. https://www.globalcarbonproject.org/carbonbudget/21/infographics.htm
12. https://www.epa.gov/sites/default/files/2015-07/documents/fugitiveemissions.pdf

Global warming potential of refrigerants widely used in data centers.	
Refrigerant	**GWP**
R-22	1,810
R-134a	1,430
R-407c	1,774
R-410a	2,088

Source: EPA[13]

Alternative refrigerants to replace HFCs in data center cooling systems have the potential to reduce emissions equivalent to 43.5–50.5 gigatons of carbon dioxide from 2020 to 2050.[15]

There are many types of refrigerants. Ozone-depleting substances including chlorofluorocarbons (CFCs) were phased out under the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer; hydrochlorofluorocarbons (HCFCs) were a temporary solution and are also being phased out. HFCs, which do not deplete ozone, became the go-to alternative to HCFCs, yet they also have significant global warming potential, and with the 2016 Kigali Amendment to the Montreal Protocal are being phased out.

Challenges

The basics of cooling technology has not significantly changed since the invention of air conditioning by Willis Carrier in 1902, when he used ice to chill coils that pulled the heat and moisture from the air. There are three challenges associated with the refrigerants used in air conditioning applications in today's world: the burden on the planet, how refrigerant impacts the environment, and operational costs for the data center.

Global warming potential:

Total contribution to global warming resulting from the emission of one unit of a gas relative to one unit of the reference gas: carbon dioxide, which is assigned a value of 1.[14]

Kigali Amendment

Signed in 2016 to phase down consumption and production of HFCs by more than 80 percent over the next 30 years.

13. https://www.epa.gov/sites/default/files/2015-07/documents/fugitiveemissions.pdf
14. https://www.greenfacts.org/glossary/ghi/global-warming-potential.htm
15. https://drawdown.org/solutions/alternative-refrigerants

Burden on the planet

Air conditioners double the burden on the planet.[16] The use of HFCs as a refrigerant contributes to global warming, and HVAC systems require significant energy to run. The UN estimates that there are 3.6 billion cooling devices used globally today, growing by ten new devices every second. Without intervention, direct and indirect emissions from air conditioning and refrigeration are expected to rise 90% above 2017 levels by 2050.[17]

Environmental emissions

The use of HFCs is a problem because the refrigerant is emitted to the environment—during production, due to leakage, and at the end of a unit's life. It is estimated that 99% of gas refrigerants complete their life cycle in the atmosphere. And in North America, 30% of refrigerants leak into the atmosphere. Completely banning HFCs would trim global warming by up to 0.4°C.[18]

Because these emissions are so dangerous to the health of the planet, synthetic refrigerants are being phased out. Canada is on course to reduce HFCs by 85% by 2036. And the United States has banned HFCs, including common refrigerants such as R134a, R410A, and R407C, from use in new chillers starting Jan 1, 2024.

In the U.S., the Environmental Protection Agency's Significant New Alternatives Policy (SNAP) has identified acceptable substitutes for air conditioning use that pose less overall risk to human health and the environment.[21]

Solution: CO_2 as a refrigerant

To overcome the challenges of the burden on the planet and the higher operational costs, data centers are turning to a new refrigerant in their CRAC system: Carbon dioxide (CO_2), a natural, safe, and non-flammable gas, that has negligible GWP when used as a refrigerant. This innovative technology is also a proven technology, and has been used in Canada to cool data centers since 2012. With the regulatory environment in the U.S. changing, preparing for the future is a motivating factor to update cooling solutions now.

> **To prevent warming beyond 1.5°C, we need to reduce emissions by 7.6% every year between 2019 and 2030[19]**

HFC phasedown Canada and United States[20] % Reduction

2019	2024	2030	2036
10	35	70	85

16. UN, IEA, Cooling Emissions and Policy Synthesis Report
17. https://wedocs.unep.org/bitstream/handle/20.500.11822/33094/CoolRep.pdf
18. https://www.ecowatch.com/air-conditioning-2646444619.html
19. https://www.unep.org/resources/emissions-gap-report-2019
20. https://www.epa.gov/climate-hfcs-reduction/final-rule-phasedown-hydrofluorocarbons-establishing-allowance-allocation
21. https://www.epa.gov/snap/overview-snap

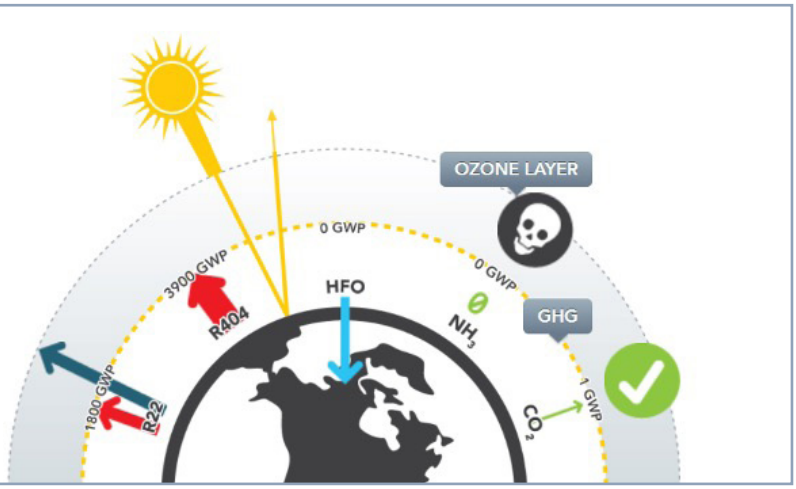
HVAC equipment using CO_2 improves the process, reduces costs, and reduces the use of equipment with high GWP, thus contributing significantly to a robust corporate environmental, social, and governance (ESG) program and demonstrating a commitment to the environment.

Important benefits

When data centers adopt a CO_2 cooling system, they see the following benefits:

- **COST SAVINGS:** A CO_2 HVAC system is 12x more economical than a system using traditional HFCs.
- **IMPROVED SYSTEM EFFICIENCY:** The heat transfer characteristics of CO_2 are more attractive then synthetic refrigerants.
- **MORE COMPACT SYSTEM:** Because CO_2 operates at high pressure, this reduces the size of the components and the entire system. And there is no water tower required, freeing up space.
- **ENERGY EFFICIENT:** A CO_2 cooling system with a heat recovery reduces energy consumption.
- **ENVIRONMENTALLY FRIENDLY:** A system using CO_2 as a refrigerant is 1,500 to 4,000 times less than that of synthetic refrigerants.
- **SAFE:** Uses non-reactive CO_2 instead of traditional refrigerant fluids.

Environmental Benefits



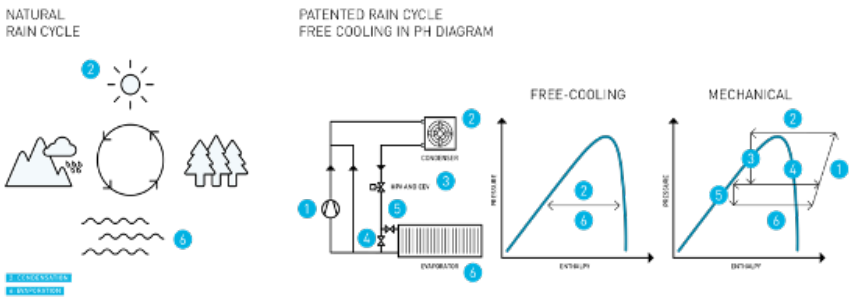
What to look for in a CO_2 CRAC system

When looking for a company to provide a CRAC that uses CO_2 as the refrigerant, consider the following requirements:

- **Designed for data center use.** Look for a solution that is designed with the unique always-on, mission critical nature of data centers in mind.

- **Compact system.** The right solution is one that improves your use of the data center facility, using less space.
- **Transcritical system.** Seek a solution that uses a fluid whose critical temperature is close to the ambient temperature, enabling the heat to dissipate through a gas cooler instead of a condenser, compressors only turn on when the environment reaches certain minimum temperatures.
- **Safety.** Look for a CO_2 CRAC system with pressure release valves and CO_2 sensor to detect leakage and alert technicians; that does not require an additional risk management plan to ensure safe operations.
- **Easy installation.** Find a vendor that offers a system pre-wired for controls and power, to minimize installation time and disruption to data center operations.
- **At least 10 years proven experience.** Seek a company that has a proven track record working with CO_2 cooling systems and extensive market knowledge in the U.S. and Canada.

Carnot's Rain Cycle™ Cooling System



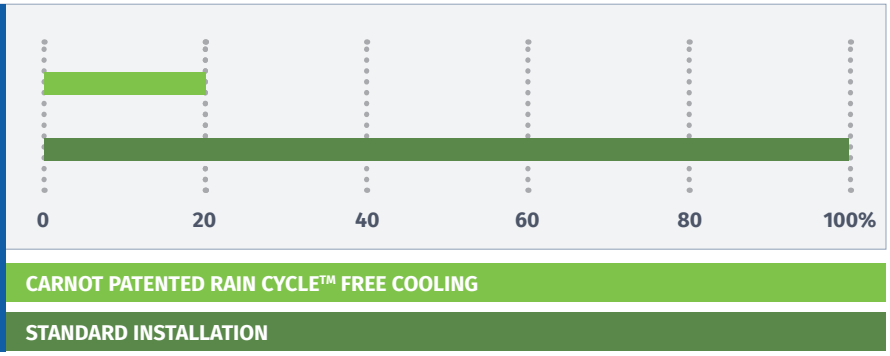
How it works

A CO_2 cooling system operates in 2 modes: mechanical and free cooling.

- Mechanical mode operates with a compressor and uses the natural properties of CO_2 in a direct expansion (DX) process. At partial loads the variable frequency drive modulates the compressor speed to match the heat load gaining efficiency.
- Free cooling mode is activated based on outdoor air temperatures and eliminates the use of compressors when outdoor air temperatures allow.

Similar to the natural rain cycle, the CO_2 refrigerant in the closed system absorbs the heat from the data center and flows up to the condenser. As the heat is rejected the CO_2 vapor cools and turns back to liquid and falls back down to the to the indoor evaporator where the process starts again.

Average Energy Consumption Using Rain Cycle™ System



The Aquilon™ Advantage

Carnot has been providing high quality CO^2 transcritical refrigeration systems across North American and Europe since 2008. CO^2 refrigeration technology by Carnot has set standards with its efficiency, profitability, sustained performance in the most extreme conditions, simplicity and operational reliability.

As many countries in the world are phasing out HCFCs and HFCs, data centers need to find sustainable and cost-effective systems to replace their existing cooling units. Direct replacement of R-22 units and extra energy savings with Carnot's Rain Cycle™ cooling system is the answer.

Carnot Aquilon™ provides the following unique advantages for data center cooling:

- Significant reduction in greenhouse gases, with a solution eligible for current LEED programs.
- Elimination of any future phase-outs of synthetic refrigerants, by using R-744, a natural refrigerant; and mitigating the risks of facing environmental or health and safety restrictions in the future.
- Decrease in energy consumption, up to 90% compared to conventional systems.
- Daily cost savings throughout equipment life. The cost of CO_2 is lower than average cost of refrigerants; and custom heat recovery enables re-use energy created by the process.
- Safe and reliable, with a remote alarm system, to detect CO_2 PPM level and sound an alarm if a leak causes pre-specified levels; pressure alarms for oil and refrigerant temperatures.
- Highly qualified engineering team constantly working to set higher standards for CO_2 refrigeration technology.

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- Awards and recognition form ASHRAE and EPA
- ASHRAE Best Technology Award — Institutional Existing Building 2015
- ASHRAE Best Technology Award — Industrial Facility 2010
- EPA Best of the Best Prize — First CO_2 transcritical design in USA 2013
- BGIS Global Supplier Innovation Award - 2022.

A decade of experience in data center cooling: Carnot understands data center cooling and has designed cooling units for server rooms.

CASE STUDY

Problem	Solution	Results
TELUS needed to replace the existing CRAC system in their 465 m^2 (5000 ft^2) data center in Quebec – to meet their own ambitious energy and greenhouse gas reduction objectives and to align with upcoming phasing out of the ozone depleting refrigerant their systems used, and to future proof their operations.	Replace old R22 refrigeration system with Carnot Aquilon™ CO_2 Computer Room Air Conditioning unit, using R-744 (CO_2) natural refrigerant, with "Rain Cycle Free Cooling", when outside temperatures permit, this allows the refrigerant to flow between the outside condenser and inside evaporator, without the use of a pump or a compressor.	The Aquilon™ CO_2 system: • Maintains the room at 23C / 73.4F year-round • Delivered energy savings of 60% in first year of operations, 14% decrease in energy consumption of entire building • Will provide payback of investment in approximately two years.

To take the first step toward future proofing your data center's CRAC system and protecting the environment, contact Betco today.

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