GRE – Autocascade Refrigerators – Cryousers 2024

GRE's test & development system cooling a cryotherapy chamber

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What is it??

A specialised refrigeration system designed to achieve extremely low temperatures

The GRE Range offers 2x model sizes : 2 kW and 4kW at -110°C, with an ultimate temperature range of -80 to -140°C for the 50Hz models.

Combines the principles of a **conventional vapor-compression cycle** with a **cascade refrigeration system**, utilizing a single compressor and multiple refrigerants with varying boiling points.

The refrigeration circuit is arranged in stages, where each refrigerant cools and condenses the next one in the sequence, allowing progressively lower temperatures to be reached with one compressor in one machine.

Autocascade cryochillers are widely used in applications requiring low temperatures **but not necessarily LN2 temperatures**, such as :

- Semiconductor manufacturing
- Medical cryopreservation
- Vapour-trapping in vacuum processes
- Cryosurgery & Cryotherapy
- Scientific research
- Environmental Testing
- Pharmaceutical Storage
- High-Performance Computing (HPC)
- Food Processing and Preservation (flash freezing)
- Moisture removal & moisture trapping

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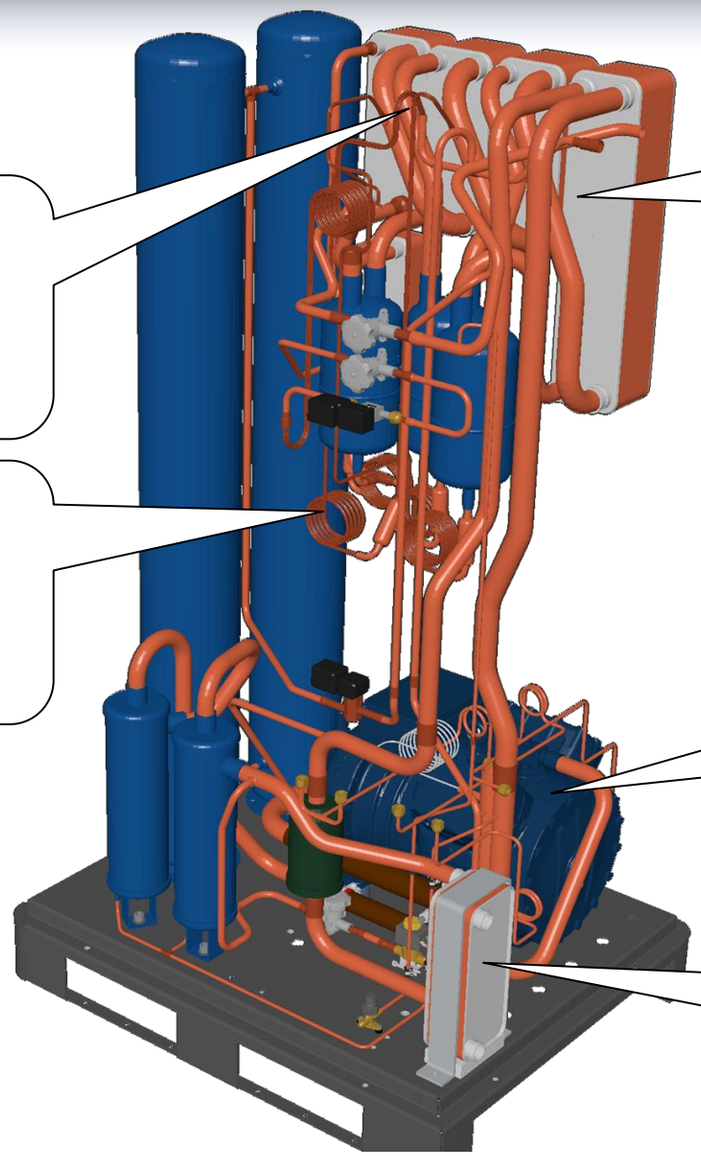
Key Features

Refrigeration quality copper tubing
Brazing according to the latest legislation and pressure tested to 1.5x the maximum working pressure

Capillary type expansion devices
Can be tuned to optimise temperature, No moving mechanical or electrical parts, so no maintenance required

Only one moving part
The compressor is the only moving part, making this a very reliable design



Brazed Plate Heat Exchangers
High quality heat exchangers with large surface area

Copeland semi-hermetic compressor
Reliable, industry-leading technology

Water Cooled Condenser
Secondary water cooling at up to 35°C from a chiller or an air-blast cooler

CONTROL WITH COMMUNICATION AND RELIABILITY

HMI and PLC controls by Siemens offer graphical and digital representation of processes ensuring operation within optimal parameters, as well as onboard diagnostic and data logging functions. The machine is fully equipped with a suite of communications options for IOT.

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Cost comparison Example – Autocascade vs Liquid Nitrogen

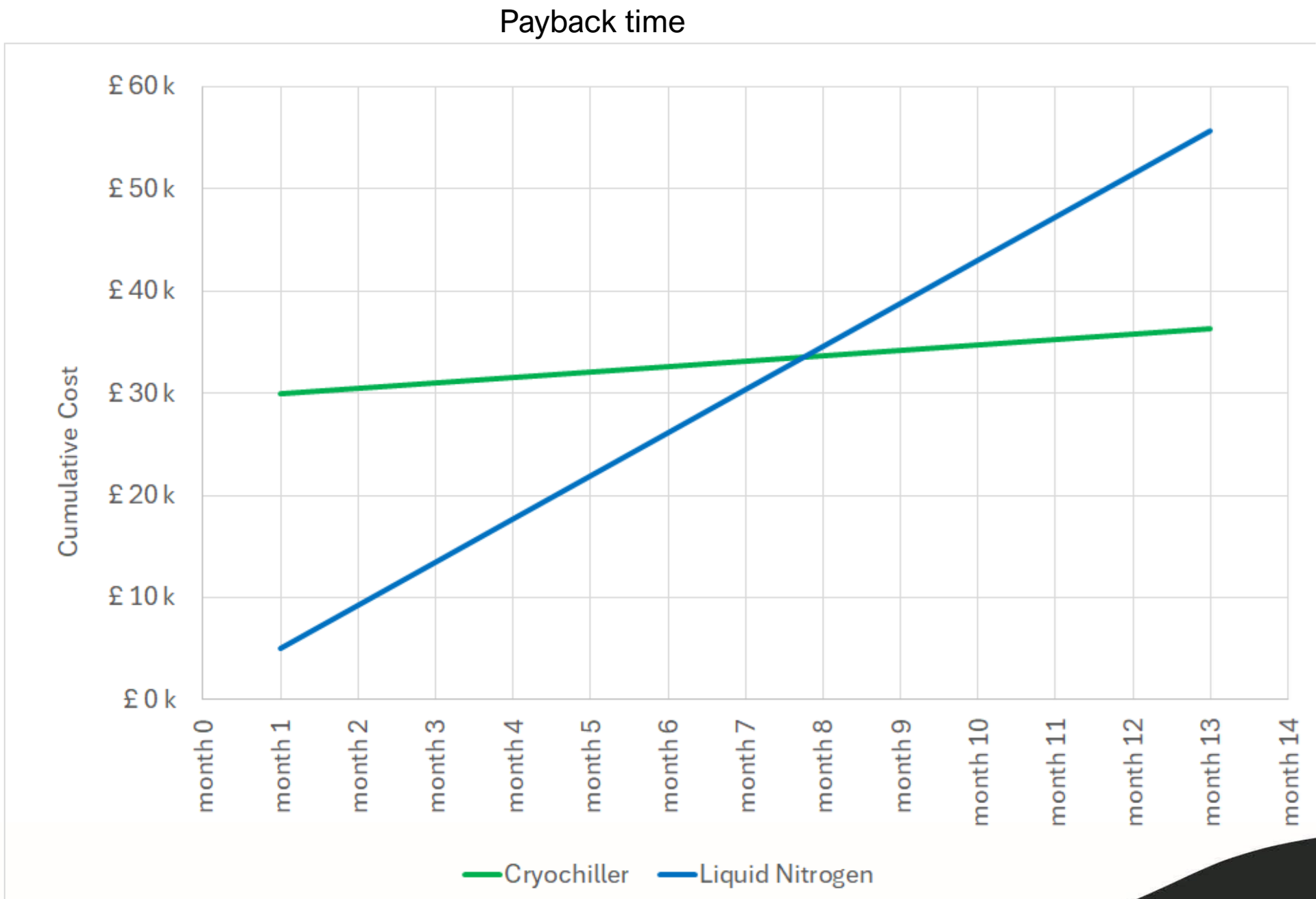
Example for an Autocascade refrigerator used on a cryotherapy suite

Taking cryotherapy as an example, this is a typical cost comparison of a cooling system of capacity 2.5kW nett average running for 8 hours a day / 5 days a week.

		Cryochiller	Liquid Nitrogen
Duty Cycle		8.0 Hrs/day 5.0 Days/wk 50.0 wks/Yr **2000.0 Hrs/Yr**	8.0 Hrs/day 5.0 Days/wk 50.0 wks/Yr **2000.0 Hrs/Yr**
Cooling & Power Consumption	Average Cooling Power	2.5 kW	2.5 kW
	Average Power Consumption	10.5 kW	-
	Power consumption of external cooling plant	3.0 kW	-
	LN2 Consumption	-	40.6 kg/h
	Inlet Condition	-	2.0 barg / Sat Liq.
	Outlet Condition	-	2.0 barg / 120K S'heated gas
Costing	Cost of Electricity	£0.235 / kWh	-
	Cost of LN2	-	£0.37 / Litre
	Cost of Delivery	-	£0.13 / Litre
	Overall cost of LN2		£0.63 / kg
	Cost of running per hour	£3.16 / hr	£25.34 / hr
	Cost of running per Month	£527 / month	£4,224 / month
	Cost of running per Year	£6,329 / yr	£50,689 / yr
	Installed Cost	£ 30 k	£ 5 k

Cost comparison Example – Autocascade vs Liquid Nitrogen

Autocascade refrigerator used on a cryotherapy suite



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Benefits

1. Cost Efficiency

NO CRYOGEN REFILL COSTS: Autocascade cryochillers use a closed-loop refrigeration cycle and do not require the continuous purchase and refilling of cryogens, which can be expensive over time. This leads to significant cost savings in operations where long-term or continuous cooling is required.

LOWER OPERATING COSTS: Operating an autocascade cryochiller typically involves only electrical power and water cooling, avoiding the costs associated with storing, handling, and replenishing cryogens.

IDLE TIME cryocoolers can be set to automatically shut down at the end of the day and restart each morning, and can be completely powered down for up to 2 hours once cool without any loss of cooling performance. In batch processing this can mean up to a 33% reduction in energy consumption.

Benefits

2. Safety

REDUCED RISK OF HAZARDS: Handling cryogens, especially in large quantities, involves risks such as frostbite, asphyxiation (due to oxygen displacement by gases like nitrogen), and potential cryogen leaks. Autocascade cryochillers mitigate these risks because they do not involve handling extremely cold, liquefied gases.

NO NEED FOR CRYOGEN STORAGE: Storing cryogens requires special insulated containers (dewars) and/or a fixed piping infrastructure, and safety protocols. Autocascade cryochillers provide instantaneous cooling without "consuming" any fluid, thus eliminate the need for these storage solutions, reducing the risk of leaks or accidents associated with cryogen storage.

Benefits

3. Convenience and Ease of Use

CONTINUOUS OPERATION: Autocascade cryochillers can operate continuously for extended periods, providing a stable temperature without the need to periodically refill cryogen reservoirs.

MINIMAL MAINTENANCE: Since there are no cryogens to handle, the maintenance associated with cryogen storage, transfer, and handling is eliminated.

SIMPLE OPERATION: The operation of an autocascade system is generally automated and straightforward, requiring less specialized knowledge compared to handling and operating with cryogens.

Benefits

4. Temperature Control and Stability

PRECISE TEMPERATURE REGULATION: can maintain very precise temperature control, which is important for applications where temperature stability is critical. This is harder to achieve with cryogens, as the temperature can fluctuate as the cryogen evaporates.

WIDE TEMPERATURE RANGE: can cover a broad range of temperatures by using mixed refrigerants, allowing for versatile applications without needing different cryogens for different temperature requirements.

Benefits

5. Environmental Impact

REDUCED CRYOGEN CONSUMPTION: By eliminating or reducing the need for cryogens, autocascade cryochillers can lower the environmental impact associated with cryogen production, transportation, and evaporation (particularly for helium, which is a non-renewable resource).

ENERGY EFFICIENCY: Modern autocascade cryochillers are designed to be energy-efficient, reducing the overall environmental footprint compared to systems that consume large amounts of cryogens.

Benefits

6. Scalability and Integration

FLEXIBLE DESIGN: Autocascade cryochillers can be integrated into a variety of systems, from laboratory-scale setups to industrial applications. This flexibility is harder to achieve with cryogens, which often require dedicated infrastructure.

PORTABLE SOLUTIONS: Autocascade systems can be more portable and easier to move than setups that depend on large cryogen tanks or supply systems. Suitable for mobile installation e.g. coach-built mobile cryotherapy unit

ADAPTABILITY: The GRE technology platform can be ‘tuned’ for specific applications by varying the gas ratios, recalculating capillary expansion etc. to be optimised for higher / lower temperatures or higher / lower heat loads

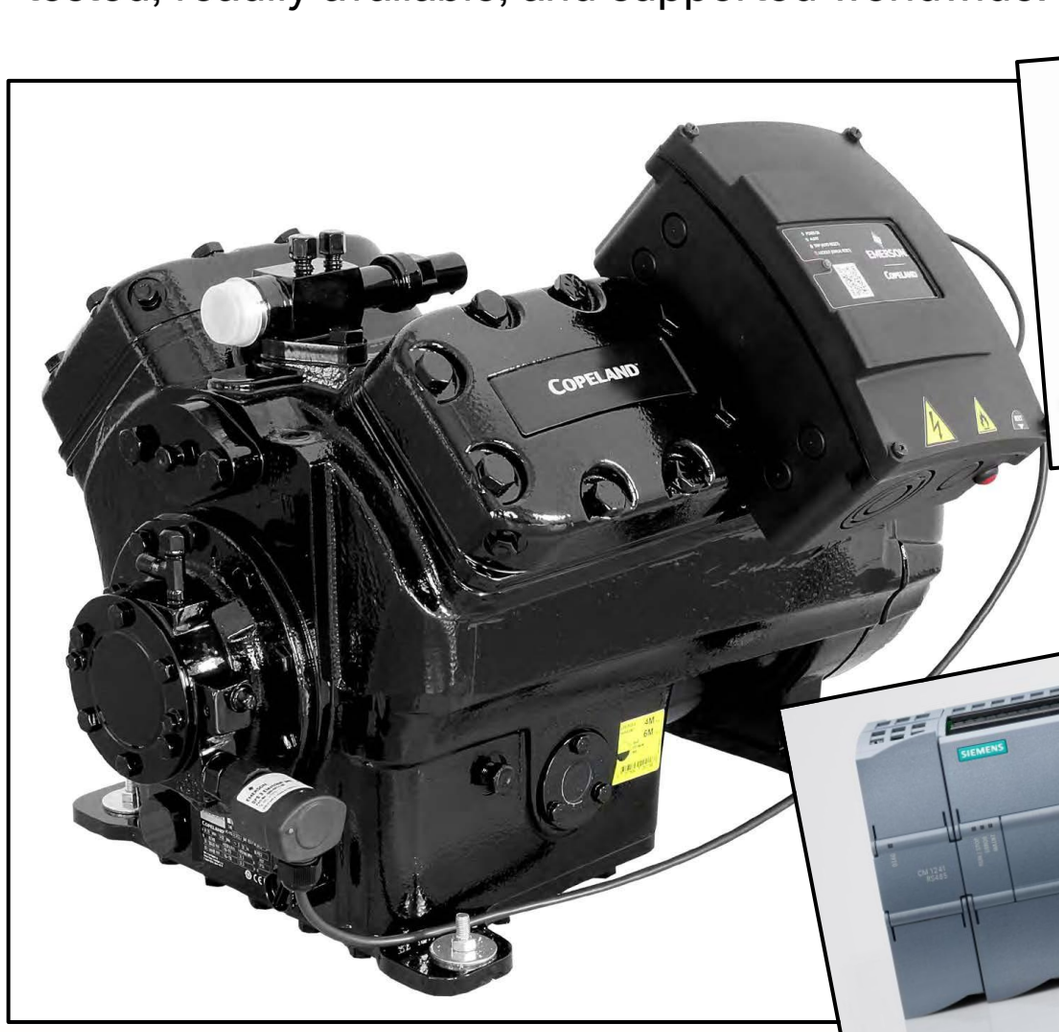
7. Regulatory Compliance

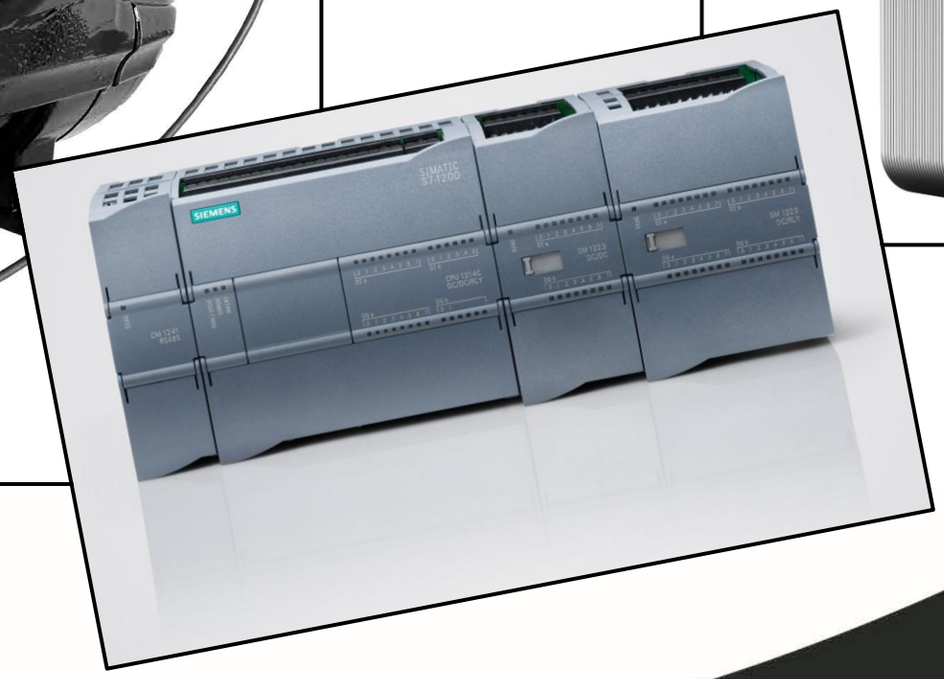
AVOIDANCE OF CRYOGEN REGULATIONS: In many locations, the handling and storage of cryogens are subject to strict regulations. Autocascade cryochillers can simplify compliance by avoiding the need for cryogen-specific safety measures and regulatory approvals.

Benefits

8. Uses entirely conventional refrigeration technology

Compressors, Heat Exchangers, Controls, pipework, valves etc. are all COTS items meaning they are tried and tested, readily available, and supported worldwide.





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....But there are a few caveats

- **Limited in low temperature range** : cannot go much below -145°C with current technology
  - Not a complete replacement for cryogens like LN2 and LHe
- **Uses fluorinated refrigerants** which can introduce handling implications for the equipment owner
- **More Complex Systems with more components.** : potential for higher maintenance demands and requirement for specialized knowledge for installation, operation, and troubleshooting.
- **Higher Initial Cost** of the equipment & installation can be more than a simple LN2 dewar set up. Although likely cheaper than a full hard-piped LN2 installation
- **Greater potential for downtime** If the system fails, repair can be more complicated and time-consuming compared to simpler cryogenic setups, potentially leading to longer downtimes
- **Energy Consumption & waste heat** Cryochillers can consume a significant amount of electrical power. Being a refrigeration system, heat is produced which must be dissipated (typically 20kW for a 4kW cryochiller running at -135°C)
- **Compressor Noise**: Although quiet, these machine are not silent which may not suit certain medical installations
- **Increased Cool-Down Time** Compared to using liquid cryogens, Autocascade refrigerators may take longer to reach their target low temperatures due to the staged cooling process.

....Next Steps

- Additional models in range – larger and smaller – from 0.5kW to 40.0kW cooling at -110°C
- Move away from fluorinated refrigerants towards natural refrigerants
  - Although this will likely involve hydrocarbons and as such must be handled correctly
- Enhanced control platform
  - Additional remote monitoring capabilities
  - Remote fleet management
  - Cloud-based data logging
- Further regulatory approval
  - CSA, UL

PLUS

Joint development with Sumitomo on a British designed-and-made desktop helium re-liquifier

- thanks for your time -