INNOVATIUM

PRISMA LAES for Compressed Air Users

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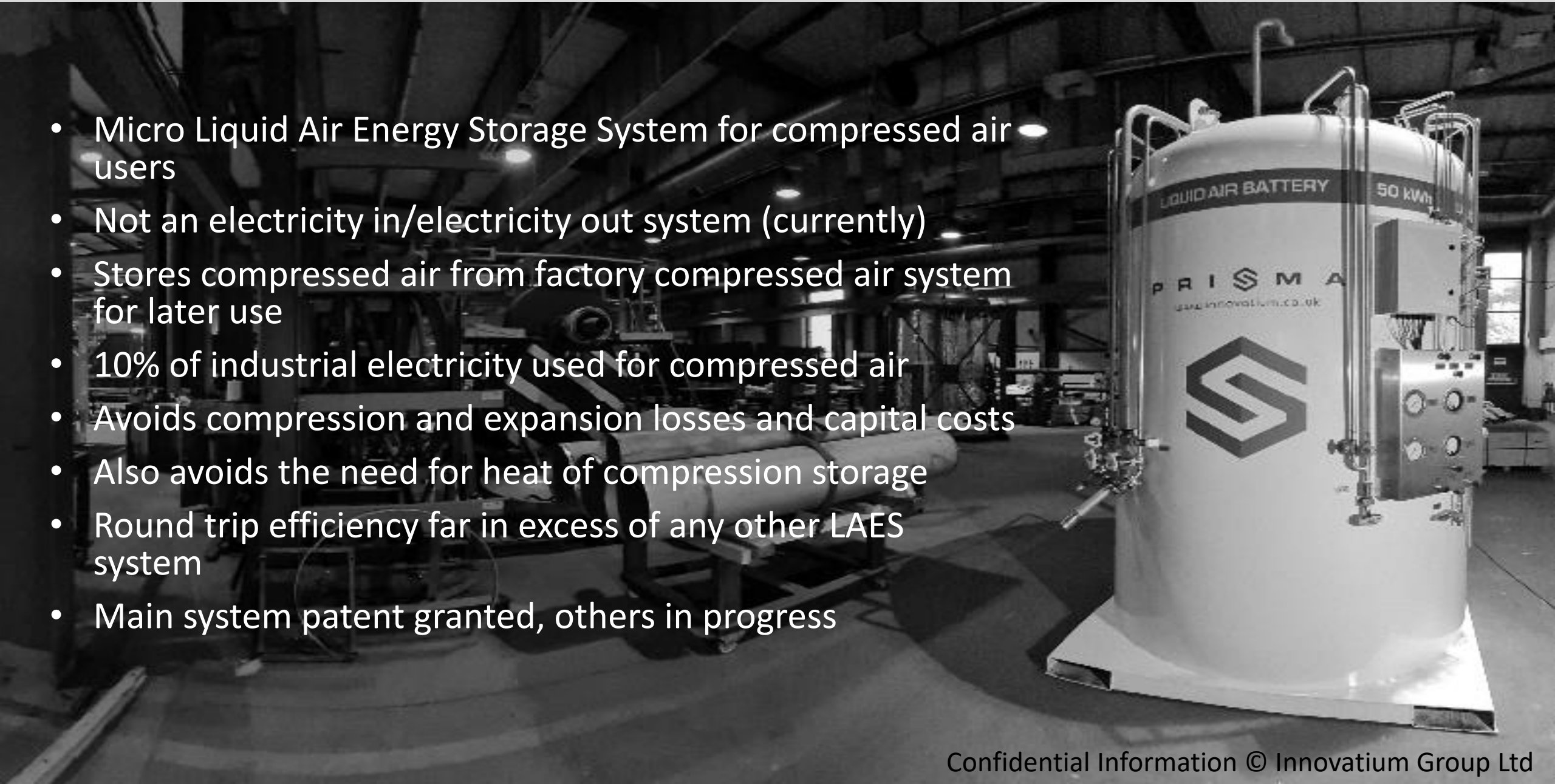
PRISMA LAES for Compressed Air Users

- Micro Liquid Air Energy Storage System for compressed air users
- Not an electricity in/electricity out system (currently)
- Stores compressed air from factory compressed air system for later use
- 10% of industrial electricity used for compressed air
- Avoids compression and expansion losses and capital costs
- Also avoids the need for heat of compression storage
- Round trip efficiency far in excess of any other LAES system
- Main system patent granted, others in progress



PRISMA Simplified Diagram

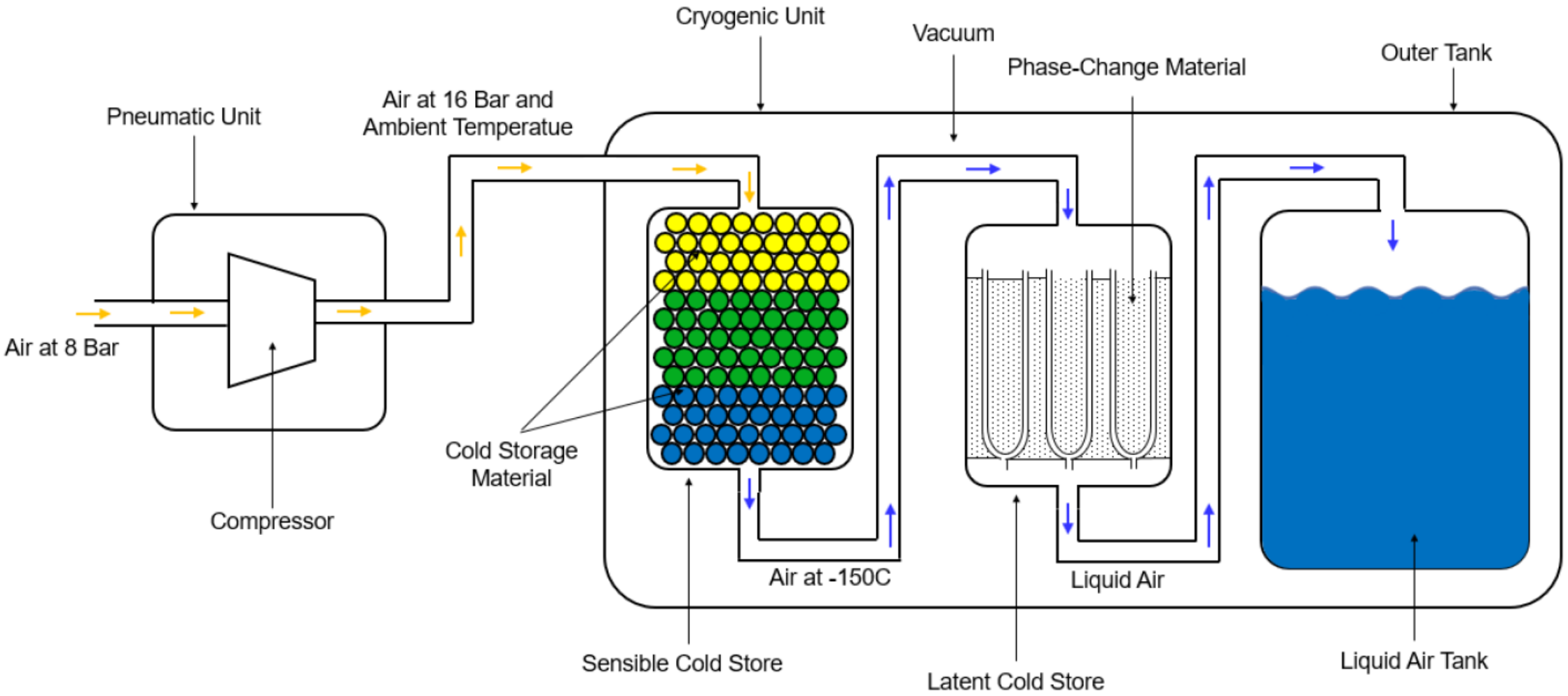


Figure 1. Simplified diagram of PRISMA system

PRISMA 2 Development Issues

Sensible Coolth Storage

- Packed bed internal heat soak degrades very valuable stored coolth

Latent Coolth Storage

- Large volume changes in PCM between ambient and operating temperature
- Significant volume change during freezing/thawing - damage and thermal contact issues
- Low thermal conductivity requires very large heat exchange surfaces

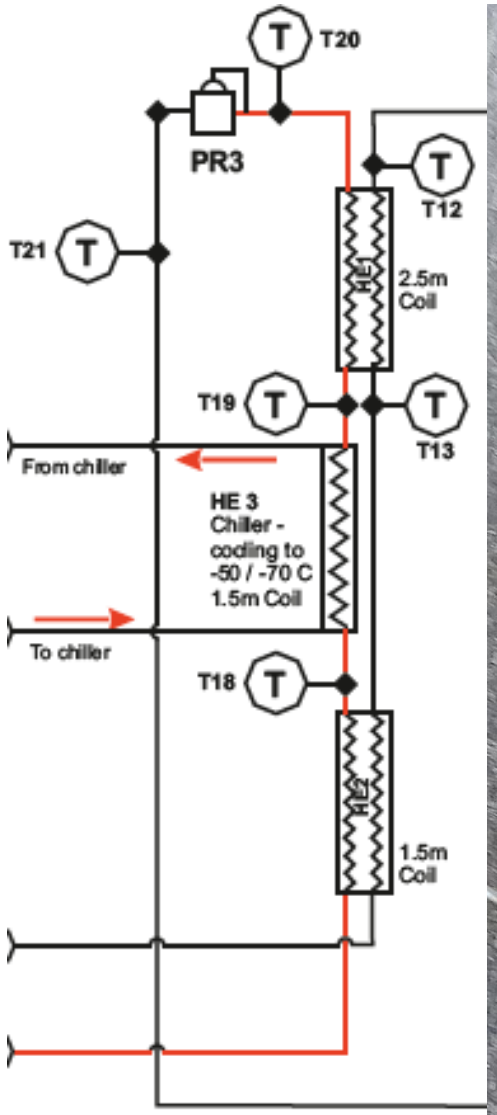
Air Quality

- Extremely dry air required to prevent frost blocking
- CO2 removal not required due to solubility in pressurized liquid air

Liquid and Saturated Air Management

- Liquid air tank similar to CAES air tank with liquid pressure balance but in reverse
- Pressure energy and coolth of headspace gas too valuable to discard
- Oxygen concentration avoided by system design

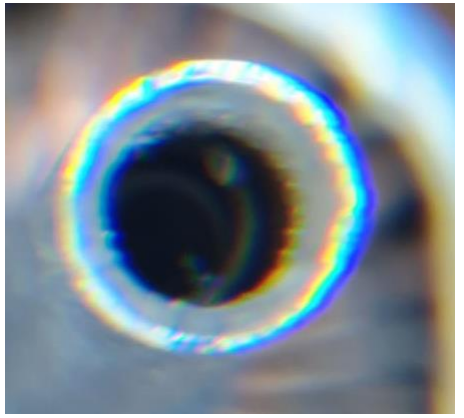
Micro Linde Cycle Cryocooler



Positions in photo correspond to P&ID

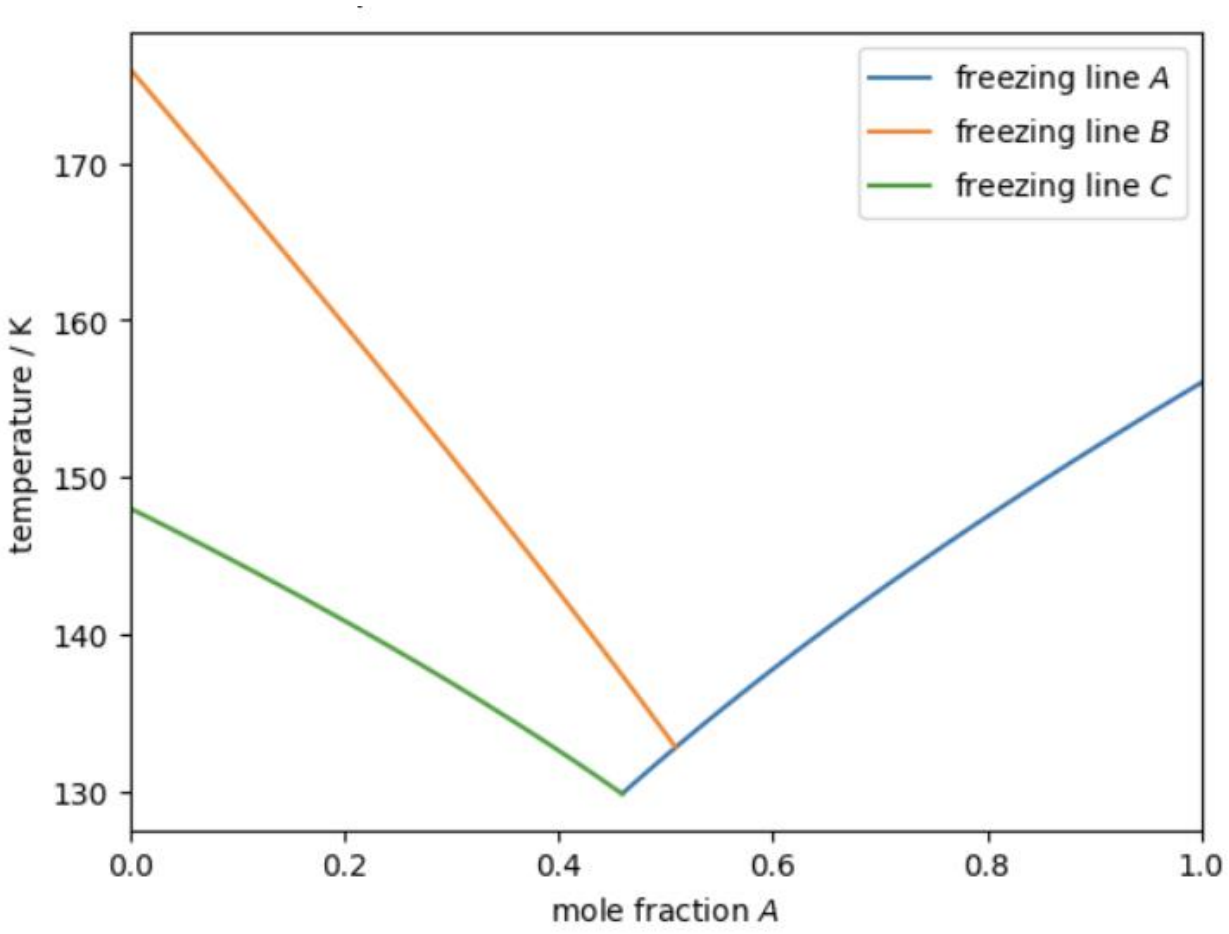
High surface area and turbulence creation

Turbulator surface area increase in central tube



PRISMA PCM Development

Binary Eutectic Phase Diagram



Ternary Eutectic (no Phase Diagram, would need to be 3d)

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eutectic temperature: 119.12 K
eutectic composition: 0.303  0.352  0.345
latent heat: 4.50 kJ mol^{-1}
878.28 kg mol^{-1}
energy density: 86.2 MJ m^{-1}
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- Further developments with dissolved substances underway
- F gases ruled out due to high GWP, toxicity and “forever chemical” status
- Alcohols with high boiling points far safer than isopentane etc, dissolved substances will reduce or prevent flammability

PRISMA Systems Integration

- Standard productionized equipment used where possible
- Temporal nature of cycle allows unusual modes of operation eg Linde cycle COP around 1.5 times that of steady state operation
- Integration of cryocooler, air and liquid pressure management and air quality management subsystems allows significantly reduced parts count and cost reduction

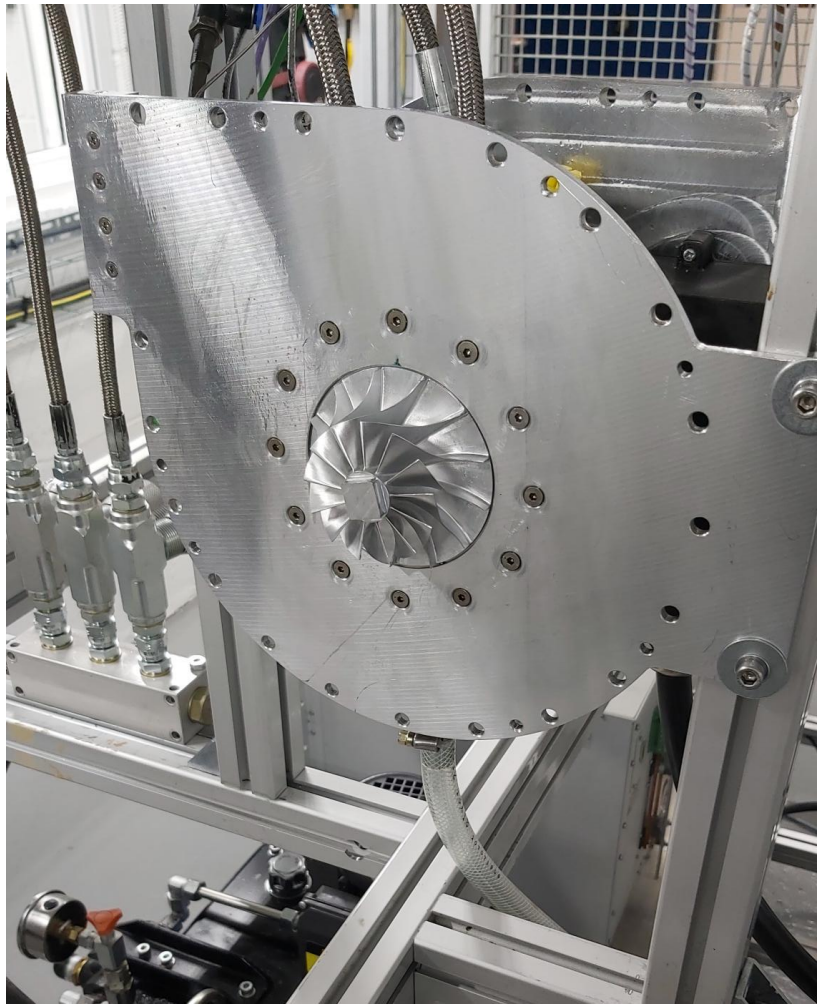
PRISMA Equipment

PRISMA 1 (0.25 tons liquid air)
Tested on industrial site

PRISMA 1.5 (0.5 tons liquid air) In build, modified PRISMA 1 incorporating PRISMA 2 cycle improvements

PRISMA 2 (1.5 tons liquid air)
Design ready for manufacture

Bi-Directional Turbo Machine



- Unusual flow dynamics found while designing a novel turbine pointed to potential for bi-directional operation
- 22kW test machine designed, CFD analysis carried out
- 2:1 PR as compressor, 87% t/t isentropic efficiency
- 3:1 PR as turbine, 93% t/t isentropic efficiency
- Compander test machine constructed, testing this month (will be less than the CFD!)
- Concept scales to multi-MW sizes, multiple series stages possible
- Use for CAES, LAES or pumped heat vapour or single-phase cycles