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ADOPTION OF NATURAL REFRIGERANTS FOR DISTRICT COOLING SYSTEMS IN INDIA

CONTEXT AND RATIONALE

India's cooling demand is projected to increase nearly eightfold by 2037 due to rapid urbanisation and rising temperatures, with the India Cooling Action Plan estimating refrigerant production to rise from 24,300 metric tonnes in 2017–18 to 166,000–181,000 metric tonnes by 2037–38, highlighting the risk of long-term dependence on high-GWP synthetic refrigerants. In this context, District Cooling Systems (DCS) offer a climate-aligned urban infrastructure solution, delivering 40–50% energy savings, improved peak-load management, and efficient centralised cooling, while their long-term sustainability critically depends on adopting refrigerants that are efficient, safe, scalable, and future-ready in line with climate and regulatory goals.

As India phases down HFCs under the Kigali Amendment, natural refrigerants—including carbon dioxide (CO_2), hydrocarbons (such as propane and isobutane), and ammonia (NH_2)—have emerged as viable alternatives. These refrigerants occur naturally in the biosphere, avoid the high climate impact of conventional HFCs (R410A, R32) and HCFCs (R22), and align with global trends toward PFAS-free cooling.

Their applicability varies:

- **CO_2 (R744):** Non-flammable and compact, but efficiency decreases at high ambient temperatures.
- **Hydrocarbons (R290/R600a):** Highly efficient but limited by charge restrictions in large installations.
- **Ammonia (R717):** Superior thermodynamic performance, industrial maturity, and strong suitability for large, centralised cooling networks.

Given India's climate, scale, and long-term needs, ammonia is the most technically mature and commercially viable natural refrigerant for DCS.

WHY AMMONIA FOR DISTRICT COOLING?

Climate-Compatible and Future-Proof

- Zero ODP, Zero GWP, fully aligned with India's long-term climate and cooling objectives.
- Avoids the use of PFAS-linked HFO/HFC refrigerants, which are facing tightening global regulations because of documented health risks.

High Energy-Efficiency

- Consistently deliver high efficiency, including at high ambient temperatures.
- Lower electricity consumption reduces operating costs and indirect emissions.

Proven and Scalable Technology

Ammonia refrigeration, backed by over a century of global deployment, now supports advanced large-scale systems that deliver high efficiency, robust safety, and proven scalability for district cooling applications.

TECHNOLOGY CHARACTERISTICS RELEVANT FOR INDIA

Design & Operational Feature	Relevance for Indian DCS Applications
Low-charge configurations	Reduces total refrigerant volume, enhancing safety and suitability for urban plantrooms.
Semi-hermetic screw compressors	Eliminates shaft-seal leakage risks; improves reliability and minimises refrigerant emissions.
Compact chiller footprint	Enables installation in space-constrained buildings and reduces plantroom size requirements.
Stable performance across varying ambient conditions	Maintains cooling output during India's hot summer peaks.
High part-load efficiency (VFD optimisation)	Ensures energy savings under fluctuating load conditions typical in DCS networks.
Automated safety and remote monitoring systems	Improves operational uptime, reduces manual intervention needs, and supports predictive maintenance.

These characteristics suit the spatial, operational, and phasing needs of Indian DCS developments.

SAFETY FRAMEWORK AND COMPLIANCE

Modern ammonia-based district cooling systems comply with stringent international standards such as EN 378, ISO 5149, ASHRAE 15, and the Pressure Equipment Directive, ensuring robust regulatory adherence. They integrate multiple engineered safety measures including gas detection and alarms, explosion-proof ventilation, containment and scrubbing systems, and sealed compressor designs. While ammonia is toxic, advanced system design and continuous monitoring significantly minimise the risk of exposure. Its strong, easily detectable odour provides an inherent early warning well below harmful levels, further enhancing safety.

Priority Actions to Enable Adoption in India

- Implement a lighthouse ammonia-based DCS project (e.g., GIFT City) to validate performance, safety, and replicability.
- Facilitate structured cooperation among DC service providers, real estate developers, utilities, and technology suppliers to support adoption of natural-refrigerant-based district cooling.

CONCLUSION

Low-charge ammonia systems offer a climate-resilient, energy-efficient, and future-ready pathway for scaling district cooling in India. Targeted pilots, strengthened standards, and capacity building can accelerate adoption of sustainable cooling solutions aligned with the India Cooling Action Plan, Kigali commitments, and national energy-efficiency goals.

Can Ammonia be the Forever Refrigerant?

Zero ODP

Zero GWP

Natural Refrigerants

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