



12TH - 13TH JUNE 2025 | POLITECNICO DI MILANO

THE ROLE OF REFRIGERATION IN THE GLOBAL ECONOMY 3RD EDITION, 60TH IIR TECHNICAL BRIEF ON REFRIGERATION TECHNOLOGIES

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2024 was the warmest year on record, surpassing the record of 2023 with a streak of exceptionally high monthly global mean temperatures. With the growing frequency and duration of extreme heatwaves and the challenges of global warming, sustainable refrigeration is a global necessity when addressing climate adaptation and mitigation. The refrigeration sector, which includes the cold chain for food and health products, air conditioning, cryogenics and heat pumps, is recognised within the United Nations as a development priority for its benefits to human life. Over 1.12 billion people globally — primarily among the rural and urban poor — face immediate risks due to a lack of access to refrigeration, which is crucial for reducing food loss and ensuring food availability to combat hunger and malnutrition. In this regard, access to refrigeration is a more sustainable solution than investing in large-scale food production, which carries significant energy and environmental costs.

Improving access to sustainable refrigeration solutions is also essential to mitigate the effects of severe heatwaves. Driven by a rising population, increasing incomes, and increasing global temperatures, the use of refrigeration is expanding dramatically, especially in the world's emerging economies. As an essential component in countless sectors from food to healthcare, industry, information communication technology (ICT), and energy, refrigeration plays a key role in the economic and social development of every country. Refrigeration also contributes significantly to countries' economic growth and global trade through sales of refrigeration equipment and the substantial workforce employed in the manufacturing, installation, maintenance and servicing of the refrigeration equipment. This technical brief presents key figures illustrating the size and reach of the refrigeration sector and its importance to humankind, as refrigeration is intrinsically linked to the United Nations' Sustainable Development Goals (SDGs). The brief aims to raise policymakers' awareness of the growing importance of refrigeration to further encourage its development in a sustainable manner, particularly in developing countries and emerging economies.

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ITA (version for policymakers)





THE COLD CHAIN: A STRATEGIC INFRASTRUCTURE FOR SUSTAINABLE DEVELOPMENT IN AFRICA

Said El Harch,
Vice President U-3ARC

The cold chain is a strategic lever for sustainable development in Africa, yet remains critically underdeveloped across the continent. Nearly 39% of agricultural production is lost at the production stage, with an additional 37% lost during handling and storage phases. These figures reflect both physical and qualitative degradation of produce, highlighting a structural deficiency in agricultural value chains. Poor cold chain infrastructure leads to significant food spoilage, not only reducing the quantity available for market or consumption but also degrading nutritional quality.

While countries like South Africa, Morocco, and Tunisia have made advances in cold logistics, much of sub-Saharan Africa still lacks basic refrigeration facilities, technical training, and reliable energy. Investments focus predominantly on boosting production, with only 5% directed toward post-harvest systems. This imbalance leads to waste, not development.

However, the cold chain offers powerful opportunities for Africa socio-economic development by reducing agricultural losses. Building this infrastructure through renewable energy, digital innovation and human capacity development is essential for inclusive growth. Organizations like U-3ARC are leading the way by promoting technical training and sustainable cold technologies.

Developing the cold chain is not a luxury, but a necessity for Africa's sustainable future.

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EXPERIMENTAL INVESTIGATION OF A CARBON DIOXIDE REFRIGERATION UNIT DESIGNED FOR MEDIUM SIZE REFRIGERATED TRUCKS

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The EU project ENOUGH is focusing on strengthening the sustainability of EU's food supply chain by offering technological, financial, and political resources to lower greenhouse gas emissions by 2030 and attain carbon neutrality by 2050 within the food sector. As the project is approaching its conclusion in September 2025, several demonstrators across Europe are collecting results to demonstrate feasible solutions to decarbonize the EU food industry. In particular, to help reducing the carbon footprint of transport operations within the cold chain, a new CO₂ refrigerating unit for medium-sized refrigerated trucks has been developed and designed at CNR (Padova), and an experimental campaign to evaluate the performance of such system has been conducted on a stationary prototype installed in the lab.

The steady-state performance of the unit has been experimentally assessed for different values of the refrigerated space temperature (-5 °C ,0 °C and 5 °C) and ambient temperature (varying between 20 and 40 °C, with a step of 5 °C). Results demonstrate good energy performance of the developed CO₂ unit compared to baseline synthetic refrigerants-based solutions currently employed in the market.

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EXPLAINABLE AI (XAI) DRIVES THE CHANGE TO PREDICTIVE MAINTENANCE (PDM) IN AIR-CONDITIONING, REFRIGERATION AND HEAT PUMPS

Klas Berglöf,

Head of R&D and Founder at ClimaCheck Sweden AB

A paradigm shift is approaching the HVACR industry. Digitalisation has resulted in that sensors are often factory installed, and systems are connected to Building Management Systems and cloud platforms. IoT will change our industry. Commissioning and maintenance practices have not yet been upgraded to take advantage of the available data.

The HVACR industry use 20% of the global electrical consumption and there is a saving potential of 25% in existing equipment achievable at low cost. The poor operating efficiency is caused by a lack of commissioning at varying operating conditions and a wide range of "faults" not detected when they occur. Prevailing commissioning and maintenance practices do not ensure efficient and reliable systems.

"Business as usual" lack requirements on verification of operating performance and good control at normal operation. Inspection at hand-over and warranty focus on ticking boxes for delivered goods rather than good operation. Product standards are expected to deliver efficient operation but often fail to do so due to the lack of monitoring and understanding of and dynamic operation.

Awareness among equipment owners is increasing and regulations are focusing on efficiency and benchmarking. The increasing focus on sustainability drives a paradigm shift that is made possible through digitalisation and new analytical methods.

The article presents experiences and results of Explainable AI (XAI), and how it differs from "Black-box" AI and how Digital Twins, based on well-proven models for performance analytics, enhance Automated Fault Detection and Diagnosis (AFDD), and reduce the engineering hours required, and enhance the precision of early detection. Any performance deviation can be detected and root cause identified which is the foundation for predictive maintenance (PdM).

Keywords Predictive maintenance, Automated Fault Detection and Diagnosis, AFDD, Digital Twins, Energy Efficiency, Performance Analytics, Trouble shooting, air conditioning, refrigeration, heat pumps, optimisation, Machine learning, Explainable AI, XAI.

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