Annex 54

Heat pump systems with low-GWP refrigerants

Executive Summary

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November 2024
Report no. HPT-AN54-1

Published by Heat Pump Centre
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ISBN XXX-XX-XXXXX-XX-X
Report No. HPT-AN54-1

Preface

This project was carried out within the Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP), which is a Technology Collaboration Programme within the International Energy Agency, IEA.

The IEA

The IEA was established in 1974 within the framework of the Organization for Economic Cooperation and Development (OECD) to implement an International Energy Programme. A basic aim of the IEA is to foster cooperation among the IEA participating countries to increase energy security through energy conservation, development of alternative energy sources, new energy technology and research and development (R&D). This is achieved, in part, through a programme of energy technology and R&D collaboration, currently within the framework of nearly 40 Technology Collaboration Programmes.

The Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP)

The Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP) forms the legal basis for the implementing agreement for a programme of research, development, demonstration and promotion of heat pumping technologies. Signatories of the TCP are either governments or organizations designated by their respective governments to conduct programmes in the field of energy conservation.

Under the TCP, collaborative tasks, or “Annexes”, in the field of heat pumps are undertaken. These tasks are conducted on a cost-sharing and/or task-sharing basis by the participating countries. An Annex is in general coordinated by one country which acts as the Operating Agent (manager). Annexes have specific topics and work plans and operate for a specified period, usually several years. The objectives vary from information exchange to the development and implementation of technology. This report presents the results of one Annex.
The Programme is governed by an Executive Committee, which monitors existing projects and identifies new areas where collaborative effort may be beneficial.

Disclaimer

The HPT TCP is part of a network of autonomous collaborative partnerships focused on a wide range of energy technologies known as Technology Collaboration Programmes or TCPs. The TCPs are organised under the auspices of the International Energy Agency (IEA), but the TCPs are functionally and legally autonomous. Views, findings and publications of the HPT TCP do not necessarily represent the views or policies of the IEA Secretariat or its individual member countries.

The Heat Pump Centre

A central role within the HPT TCP is played by the Heat Pump Centre (HPC).

Consistent with the overall objective of the HPT TCP, the HPC seeks to accelerate the implementation of heat pump technologies and thereby optimise the use of energy resources for the benefit of the environment. This is achieved by offering a worldwide information service to support all those who can play a part in the implementation of heat pumping technology including researchers, engineers, manufacturers, installers, equipment users, and energy policy makers in utilities, government offices and other organisations. Activities of the HPC include the production of a Magazine with an additional newsletter 3 times per year, the HPT TCP webpage, the organization of workshops, an inquiry service and a promotion programme. The HPC also publishes selected results from other Annexes, and this publication is one result of this activity.

For further information about the Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP) and for inquiries on heat pump issues in general contact the Heat Pump Centre at the following address:
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Foreword

The HVAC&R industry's shift to low-GWP refrigerants is driven by the need to mitigate global warming and adhere to international agreements such as the Kigali Amendment to the Montreal Protocol. Annex 54: Heat pump systems with low-GWP refrigerants started in 2019, aiming at promoting the application of low-GWP refrigerants to accelerate the phase-down of high-GWP HFCs and developing design guidelines for optimized components systems for low-GWP refrigerants. Member countries are Austria, France, Germany, Italy, Japan, Korea, Sweden, and the USA. Participating organizations are shown in Figure 1. This executive summary highlights work conducted, including reviews of the latest developments in low-GWP refrigerants, case studies for optimizing components and systems, and 2030 outlooks.

Figure 1: Annex 54 participants

1. Executive Summary

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Figure 1: Annex 54 participants

Key Findings:

- **State-of-the-Art Technologies**: While A1 refrigerants are limited, CO_2 is expanded in the commercial refrigeration application. A2L refrigerants, particularly R-32 and its mixtures, are widely researched. A3 refrigerants are widely investigated, especially in Europe, and considered for systems with low charges due to safety concerns.
- **Standards and Policies**: The Kigali Amendment, the EU F-gas regulations, and the USA AIM Act drive the regulatory landscape, promoting low-GWP refrigerants and updating safety standards.
- **Case Studies and Design Guidelines:** R-516A shows significant promise as a low-GWP alternative to R-134a, offering comparable performance with reduced direct emissions. Studies on refrigerants like R-290, R-32, R-454B, R-452B, and R-466A indicate their potential as replacements for R-410A. System design guidelines stress the importance of enhancing system efficiency, ensuring safety, and meeting regulatory standards through optimized component designs, which are crucial for achieving both environmental sustainability and operational excellence.
- **Design Optimization**: Optimization frameworks, such as Genetic Algorithms for heat exchangers, show significant improvements. Comprehensive Life Cycle Climate Performance (LCCP)assessments highlight the impact of system efficiency and refrigerant leakage on emissions. Among R-410A replacements, R-290 demonstrates the lowest LCCP.
- **Outlook for 2030**: Continued research into A1 refrigerants, in-depth safety studies on A2L and A3 refrigerants, and exploration of near zero-GWP refrigerants are crucial for future advancements.

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Report no. HPT-AN54-11