IIR-IEA JOINT WORKSHOP:
IIR COMMISSION B1/B2 AND
IEA HPT TCP: ANNEX 54
HEAT PUMP SYSTEMS WITH LOW GWP REFRIGERANTS

2022-06-13
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www.heatpumpingtechnologies.org
INTRODUCTION

World Cooling Demands

World cooling demands will increase by 2.7 times for next 30 years.

Need Efficient Cooling Technologies

HFC Phase Down

The U.S. EPA needs to implement a phase down of HFCs by 85% by 2036.

Need Zero-to-Low GWP Working Fluids
EU F-GAS REGULATIONS

The EU Commission made a legislative proposal to update the F-gas Regulation on April 2022.

- Limiting the total amount of the most important F-gases (HFCs) that can be sold in the EU from 2015 onwards and phasing them down in steps to one-fifth of 2014 sales in 2030;
- Banning the use of F-gases in many new types of equipment where less harmful alternatives are widely available, such as fridges in homes or supermarkets, air conditioning, foams and asthma sprays;
- Preventing emissions of F-gases from existing equipment by requiring checks, proper servicing and recovery of the gases at the end of the equipment's life.


Need Zero-to-Low GWP Working Fluids

Move towards more climate-friendly technologies
DECARBONIZATION IMPACTS

US Actions needed for 50% Reduction by 2030 (Goal: Net Zero by 2050)

1. Increase solar and wind capacity 3.5 times, to 500 gigawatts
2. Eliminate most electricity generation from coal
3. Maintain current natural gas generating capacity for reliability
4. Increase zero-emission vehicle sales share to 50%
5. Increase sales share of building heat pumps to 50%
6. All new buildings and appliances meet strict energy efficiency goals
7. R&D for carbon capture, sequestration, and carbon-neutral fuels
8. Build electricity transmission and pipelines for carbon dioxide and hydrogen gas

Grid Emission Factor (GEF) and total emission will decrease. Direct emissions are equally important to indirect emissions.

Global Average 0.623
UK 0.277
Sweden (SE) 0.012
Switzerland (CH) 0.014
US FL 0.467
US AZ 0.425
US GA 0.457
JP 0.492
KR 0.517
CN 0.623

EFFECT OF GEF ON LCCP

LCCP Guideline link from the IIR Website:

Figure 60. Different refrigerant LCCP results for four selected cities
Next generation refrigerants should satisfy multidimensional requirements in a balanced manner.
Future systems should use low-GWP refrigerants and energy-efficient technologies.

Lower GWP refrigerants include R32, mixtures, and natural refrigerants (HCs, CO₂ & water).

Refrigerants have a wide range of thermophysical properties and heat transfer characteristics.

Need customized components and optimized systems.

IEA’S ANNEX54: LOW-GWP HEAT PUMPS MOTIVATION
IEA ANNEX 54: OBJECTIVES

• Promoting the application of low-GWP refrigerants to accelerate the phase-down of high-GWP HFCs
• Developing design guidelines for optimized components and systems for low-GWP refrigerants
• Current member countries are Austria, France, Germany, Italy, Japan, Korea, Sweden, and US.
ANNEX 54: TASKS

• Task 1: Review of state-of-the-art technologies (Year 1: 2019-2021)  
  (Latest low-GWP refrigerants; current components and system designs; Review of current standards and policies; thermophysical property and heat transfer characteristics; safety and flammability of refrigerants and safe use of flammable refrigerants)

• Task 2: Case studies and design guidelines for optimization of components and systems (Year 2-4: 2020-2022)

• Task 3: Review of design optimization and advancement impacts on LCCP reduction (Year 3-5: 2021-2023)

• Task 4: Outlook for 2030 (Year 5: 2023)

• Task 5: Report and information dissemination (Year 5: 2023)
COMPONENT OPTIMIZATION EXAMPLE

Table 3: Evaporator Optimization Results with Different Constraints

<table>
<thead>
<tr>
<th>Case</th>
<th>Baseline</th>
<th>(a)</th>
<th>(b)</th>
<th>(c)</th>
<th>(d)</th>
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<tbody>
<tr>
<td>Constraints</td>
<td>-</td>
<td>No constraints</td>
<td>Mfg. constraints</td>
<td>Refrigerant DP constraint</td>
<td>Mfg. constraints and DP constraint</td>
</tr>
<tr>
<td>Capacity [W]</td>
<td>5294</td>
<td>6065 (14.6%↑)</td>
<td>6027 (13.8%↑)</td>
<td>5497 (3.8%↑)</td>
<td>5421 (2.4%↑)</td>
</tr>
<tr>
<td>Ref. DP [kPa]</td>
<td>11.8</td>
<td>972.5 (51x↑)</td>
<td>160.5 (12x↑)</td>
<td>11.4 (1.0%↓)</td>
<td>11.7 (1.0%↓)</td>
</tr>
<tr>
<td>SHR</td>
<td>79.6%</td>
<td>67.6%</td>
<td>72.5%</td>
<td>79.8%</td>
<td>80.6%</td>
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<tr>
<td>U-bends L1</td>
<td>82</td>
<td>61</td>
<td>51</td>
<td>17</td>
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<td>U-bends L2</td>
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<td>35</td>
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<td>U-bends ≥ L3</td>
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<td>58</td>
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<tr>
<td>Collinear U-bends</td>
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<td>3</td>
<td>0</td>
<td>43</td>
<td>0</td>
</tr>
</tbody>
</table>

• Example case: Fin-tube heat exchanger, R-410A, 3-ton system

• Evaporator circuitry optimization alone can make a 14.6% capacity enhancement (Li et al., 2018)

Wan et al. (2021, Univ. of Maryland) developed A2L/A3 Refrigerant HPs architecture.

SUMMARY: FUTURE OF LOW GWP REFRIGERANTS

• Global zero emission efforts will reduce the indirect emission effects.

• The Montreal Protocol and EU F-gas regulation demand Zero-to-Low GWP Working Fluids.

• Next generation refrigerants should satisfy multidimensional requirements in a balanced manner.

• Design optimization of components and systems are equally important.
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