IIR-IEA JOINT WORKSHOP:

IEA HPT TCP: ANNEX 54
HEAT PUMP SYSTEMS WITH LOW GWP REFRIGERANTS
2021-09-01
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www.heatpumpingtechnologies.org
INTRODUCTION

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

Need Efficient Cooling Technologies

World Cooling Demands

Source: IEA, The Future of Cooling, 2018

Need Zero ~ Low GWP Working Fluids

HFC Phase Down

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

Air-to-water Heat Pump Demand in 2017 (JARN, 2018)

<table>
<thead>
<tr>
<th>Region</th>
<th>Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global</td>
<td>2.66 million</td>
</tr>
<tr>
<td>China</td>
<td>1.83 million</td>
</tr>
<tr>
<td>Japan</td>
<td>0.44 million</td>
</tr>
<tr>
<td>Europe</td>
<td>0.29 million</td>
</tr>
</tbody>
</table>

Share of Residential Heat Pumps for Heating and Hot Water (2010 – 2030)

IEA, https://www.iea.org/reports/heat-pumps
HEAT PUMP CHALLENGES

HPC 2020: Saikee Oh (2021), LG Electronic Inc.
TRADE-OFFS FOR CHOOSING ALTERNATIVES

- HX Impact
- Heat Transfer Pressure Drop
- No Glide
- Compressor & System Cost
- Compressor Capacity
- System Impact
- Non-Flammable
- Low GWP (<150)
- Non Toxic
- Compressor Efficiency
- Compressor Impact

Environmental Impact

- HC (R-290)
- HFC (R-410A)
- CO₂
- HFO (R-1234yf)
SEVERAL US COMPANIES SELECTED LOW-GWP REFRIGERANTS

- In 2018, Carrier announced to use R-454B for ducted residential and package unitary commercial systems sold in North America.
- On April 22, 2020, Carrier announced to use R-32 for commercial chillers.
- On May 27, 2021, Johnson Controls announced to use R-454B for ducted residential and commercial unitary systems, and air-cooled chillers sold in North America.

<table>
<thead>
<tr>
<th>Refrigerant</th>
<th>GWP</th>
<th>Safety Class</th>
<th>Temperature glide [K]</th>
<th>Critical T [°C]</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-410A</td>
<td>2088</td>
<td>A1</td>
<td>0.1</td>
<td>71.34</td>
</tr>
<tr>
<td>R-32</td>
<td>675</td>
<td>A2L</td>
<td>0.0</td>
<td>78.12</td>
</tr>
<tr>
<td>R-452B</td>
<td>698</td>
<td>A2L</td>
<td>1.3</td>
<td>79.68</td>
</tr>
<tr>
<td>R-454B</td>
<td>466</td>
<td>A2L</td>
<td>1.5</td>
<td>77.0</td>
</tr>
<tr>
<td>R-466A</td>
<td>733</td>
<td>A1</td>
<td>1.5</td>
<td>83.8</td>
</tr>
</tbody>
</table>

R-452B (R-32/R-125/R-1234yf by 67/7/26%)  
R-454B (R-32/R-1234yf by 68.9/31.1%)  
R-466A (R-32/R-125/CF3I by 49/11.5/39.5%)
NEW UL SAFETY REQUIREMENTS FOR SAFE APPLICATION OF A2L REFRIGERANTS

UL60335-2-40 3rd Edition Summary for a Residential Ducted Unit (direct system) A2L Refrigerant Requirements

Minimum Area Check ($A_{min}$)
- Safety factor of 4
- Or safety factor of 2 with additional measures
- Per Annex GG

Service Training and Education Annex DD, Annex HH

Active mitigation for leaks
- detect, circulate an dilute
- Annex GG

Residential Down Flow Air Conditioners with Gas Heat

Factory Installed Refrigerant Detector
- UL60335-2-40, IEC60079-29-1 and Annex LL, Annex MM
- UL qualification testing
- UL approved
- Safety Circuit approved
- Factory Calibrated
- Self Test Routine (one time/hr.)
- Fail safe mode with fan on
- Field inspection enable feature

Ignition Source Isolation
- Per UL 60335-2-40 Annex FF

Condensing Unit

No Competent Ignition
- Sources in unit and ducts
- Per 22.116, Annex KK, 22.117

Refrigerant Charge Limits (UL60335-2-40)

1. R-32 m1 = 4.1 lbs, m2 = 26.8 lbs, m3 = 134.1 lbs
2. R-454B m1 = 4.0 lbs, m2 = 26.0, m3 = 130.2 lbs

Labeling and Literature
- Per UL60335-2-40 Per 101, Annex DD

Refrigerant Piping (UL60335-2-40)
- Per 22.116, 101.DVG
  - Protected lines
  - Qualified joints (ISO 14903)
  - Field pressure test
  - Additional requirements for VRF

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LCCP COMPARISON FOR LOW-GWP REFRIGERANTS

<table>
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<tr>
<th>Refrigerant</th>
<th>Safety Category</th>
<th>GWP</th>
</tr>
</thead>
<tbody>
<tr>
<td>R-410A</td>
<td>A1</td>
<td>2,088</td>
</tr>
<tr>
<td>R-466A</td>
<td>A1</td>
<td>730</td>
</tr>
<tr>
<td>R-32</td>
<td>A2</td>
<td>675</td>
</tr>
<tr>
<td>R-452B</td>
<td>A2</td>
<td>676</td>
</tr>
<tr>
<td>R-290</td>
<td>A3</td>
<td>3</td>
</tr>
</tbody>
</table>

Refrigerant Safety Category GWP

![Graph showing LCCP comparison for different refrigerants](image-url)
Future refrigeration systems should use low-GWP refrigerants and energy-efficient technologies.

Lower GWP refrigerants (GWP<750) include R32, mixtures, and natural refrigerants (HCs, CO\textsubscript{2} and water).

Energy efficiency is equally important.

Candidate refrigerants have a wide range of thermophysical properties, and thermodynamic and heat transfer characteristics.

Therefore, customized component designs, and system optimization are very important.
IEA HPT’S ANNEX 54 (2019-2023): OBJECTIVES

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

• Task 1: Review of state-of-the-art technologies (Year 1)
  (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)

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

• Task 4: Outlook for 2030 (Year 5)

• Task 5: Report and information dissemination (Year 5)
ANNEX 54 WEBSITE

All presentation materials, meeting agenda, minute and attendee list are available from ANNEX54 website.

https://heatpumpingtechnologies.org/annex54/

www.heatpumpingtechnologies.org
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