Low GWP HFO Refrigerants for residential Heat Pumps to enable a safe and sustainable European building renovation

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Special thanks
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Heat Pumps are a key technology to achieve European objectives.
SCOPE OF WORK

Confront refrigerants alternative to R-410A in residential Heat Pumps applications

- Kigali Amendment to the Montreal Protocol
- F-Gas Regulation

R-410A
- 2088 GWP

R-32
- 675 GWP

R-454B
- 466 GWP

R-454C
- 148 GWP

Energy Efficiency
Energy Consumption
Cost
Emission

Low GWP

New Building
Building Renovation

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METHODOLOGY

Develop a mathematical model of an air to water heat pump

Definition of residential demand

Definition of climatic condition

Simulation of Heat Pump operation in a typical German heating season
Calculation based on EcoDesign Directive

### Energy Efficiency

#### Seasonal Energy Efficiency for heating:

\[
SCOP = \frac{\sum_{j=1}^{n} h_j \cdot Ph(T_j)}{\sum_{j=1}^{n} h_j \cdot \frac{Ph(T_j) - elbu(T_j)}{COPbin(T_j)} + elbu(T_j)}
\]

\[
COP(T_j) = \frac{Q_{\text{cond}}(T_j)}{W_{\text{comp}}(T_j)}
\]

\[
Ph(T_j) = P_{\text{designh}} \cdot p(T_j)
\]

\[
p(T_j) = \frac{(T_j - 16)}{(T_{\text{designh}} - 16)}
\]

- \( h_j \) = temperature \( T_j \) occurrence
- \( P_{\text{designh}} \) = 10 kW
- \( T_{\text{designh}} \) = -2°C

### Emission

#### Indirect Emissions:

\[
\omega = CO_2 \text{ emissions from electricity production needed to}
\text{operate the system}
\]

\[
Q_{HE} [\text{kWh/year}] = \frac{Q_H [\text{kWh/year}]}{\text{SCOP [-]}}
\]

\[
C = annual \text{ cost of used electricity}
\]

\[
Q_{\text{he}} = \text{annual electrical energy used for heating}
\]

\[
P_{\text{el}} = \text{electricity price in Germany, second half 2021 equal to 0,3234 €/kWh}
\]

#### Direct Emissions:

\[
\theta = \text{amount of fluid released in the atmosphere during}
\text{operation, maintenance or fault.}
\]

\[
\omega = mn \text{ [kg/m] \cdot GWPn [kgCO2/kgn] \cdot p [%]}
\]

- \( mn \) = system charge
- \( GWPn \) = refrigerant Global Warming Potential
- \( p \) = annual leak rate 2%

Energy price is considered to be constant. A
price increase like the one seen in 2022,
reinforces the favorable indication for the
adoption of solutions characterized by higher
efficiency and lower energy consumption.
In new or recent buildings, R-454B and R-454C show better Efficiency, reduced Energy Consumption, Cost and Emission compared to R-410A and R-32.
In buildings renovation, R-454B e R-454C show better Efficiency, reduced Energy Consumption, Cost and Emission compared to R-410A and R-32.
Alternative refrigerants to R-410A have been compared for residential Heat Pump applications

- Climatic conditions of a typical German heating season
- Two water temperature levels (Recent buildings, Renovation buildings)

Results for HFO refrigerants R-454B and R-454C show:

- Higher Energy Efficiency
- Lower Electrical Energy Consumption
- Lower Annual Cost
- Lower Direct Emission (-92.9%) and Indirect Emission (-15.3%) than R-410A

The European electrification of heating can benefit from the adoption of Low and Very-Low GWP HFO refrigerants to replace R-410A.
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THANK YOU FOR YOUR KIND ATTENTION

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