CHILLVENTA

Chillventa Specialist Forums 2022
Chillventa Fachforen 2022

CONNECTING EXPERTS.

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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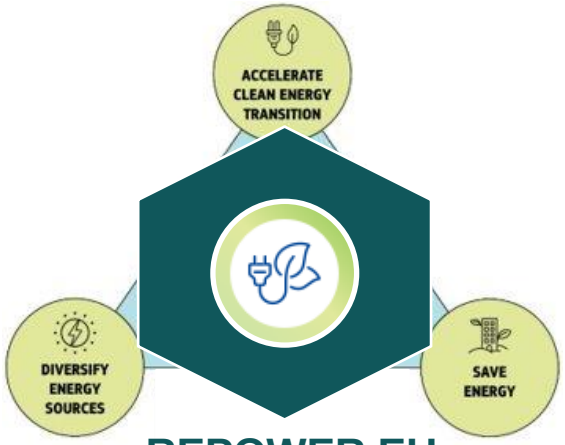
INTRODUCTION

EU GREEN DEAL

RENOVATION WAVE



REPOWER EU

HEAT PUMPS

- High Energy Efficiency → Reduce Energy Demand → Decrease CO2 emission
- Electricity Driven → Reduce Fossil Fuels → Increase Renewables

Heat Pumps are a key technology to achieve European objectives

SCOPE OF WORK

Kigali Amendment to the Montreal Protocol

F-Gas Regulation

Low GWP

Energy Efficiency

Energy Consumption

Cost

Emission

New Building

Building Renovation

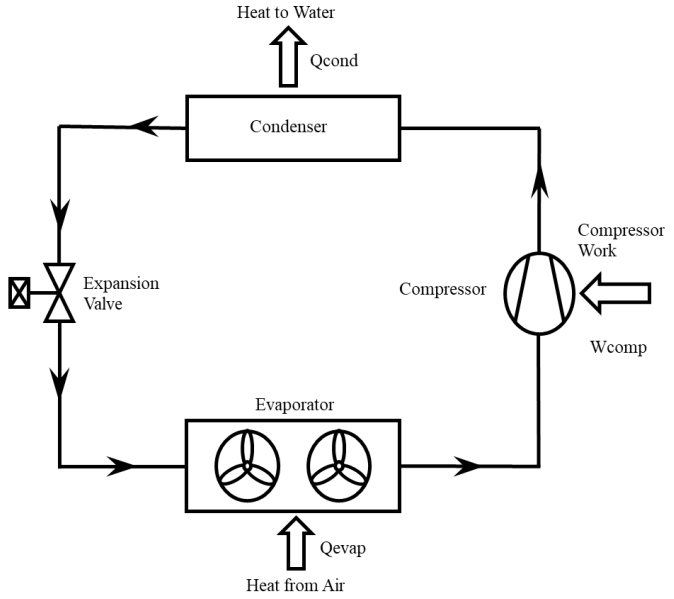
Confront refrigerants alternative to R-410A in residential Heat Pumps applications

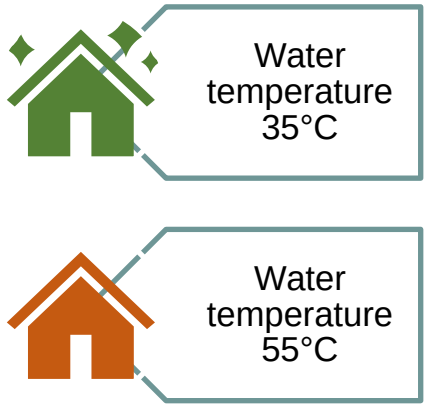
METHODOLOGY

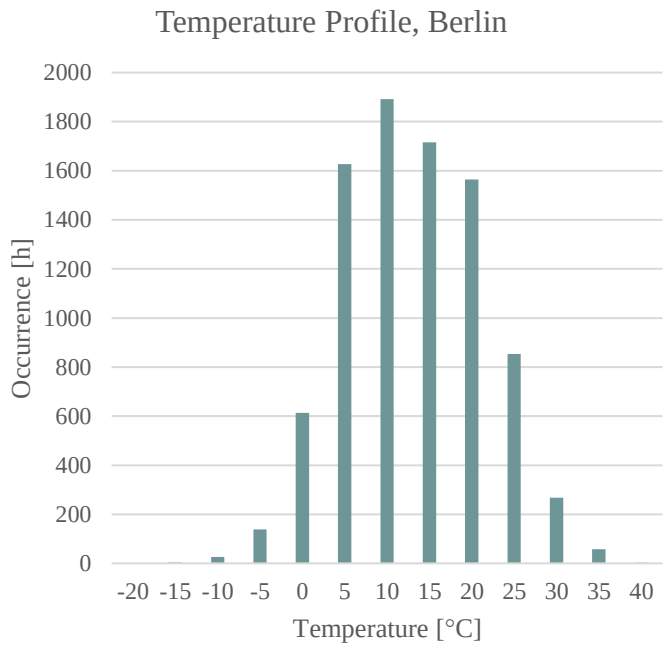
Develop a mathematical model of an air to water heat pump

Definition of residential demand

Definition of climatic condition







Simulation of Heat Pump operation in a typical German heating season

METHODOLOGY

Energy Efficiency

Seasonal Energy Efficiency for heating:

$$SCOP = \frac{\sum_{j=1}^{n} hj * Ph(Tj)}{\sum_{j=1}^{n} hj * \frac{Ph(Tj) - elbu(Tj)}{COPbin(Tj)} + elbu(Tj)}$$

$$COP(Tj) = \frac{Q_{cond}(Tj)}{W_{comp}(Tj)}$$

$$Ph(Tj) = P_{designh} * pl(Tj)$$

$$pl(Tj) = \frac{(Tj - 16)}{(T_{designh} - 16)}$$

hj = temperature Tj occurence
$P_{designh}$ = 10 kW
$T_{designh}$ = -2°C

Emission

Indirect Emissions:

$$\omega \left[\frac{\text{kgCO2}}{\text{year}}\right] = \text{Q}_{HE} \left[\frac{\text{kWh}}{\text{year}}\right] \cdot \text{f}\bar{\text{C}} \left[\frac{\text{kgCO2}}{\text{kWh}}\right]$$

$$\text{Q}_{HE} \left[\frac{\text{kWh}}{\text{year}}\right] = \frac{Q_H \left[\frac{\text{kWh}}{\text{year}}\right]}{\text{SCOP } [-]}$$

ω = CO2 emissions from electricity production needed to operate the system
Q_{HE} = Annual energy consumption for heating
Fc = CO2 emission factor for Germany 314 gCO2/kWh

Direct Emissions:

$$\theta \left[\frac{\text{kgCO2}}{\text{year}}\right] = \text{mn}[\text{kgn}] \cdot \text{GWPn} \left[\frac{\text{kgCO2}}{\text{kgn}}\right] \cdot \text{p}[\%]$$

θ = amount of fluid released in the atmosphere during operation, maintenance or fault.
mn = system charge
GWPn = refrigerant Global Warming Potential
p = annual leak rate 2%

Cost

Energy Cost:

$$\text{C} \left[\frac{€}{\text{year}}\right] = \text{Q}_{HE} \left[\frac{\text{kWh}}{\text{year}}\right] \cdot \text{p}_{el} \left[\frac{€}{\text{kWh}}\right]$$

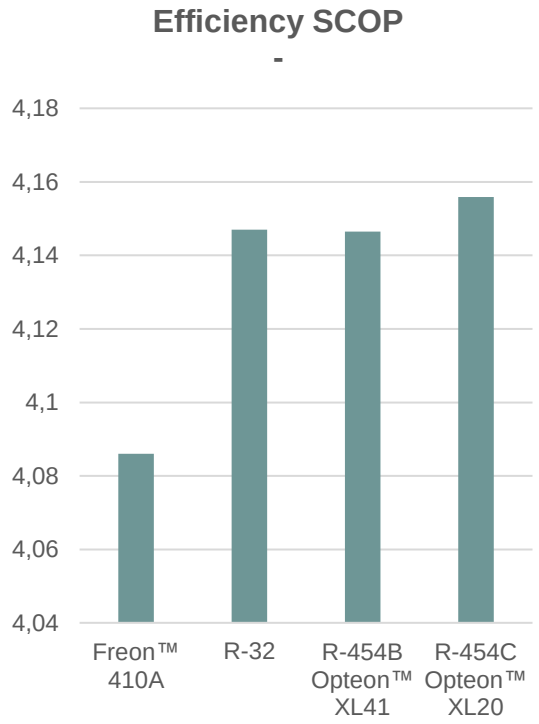
C = annual cost of used electricity
Q_{HE} = annual electrical energy used for heating
p_{el}= electricity price in Germany, second half 2021 equal to 0,3234 €/kWh

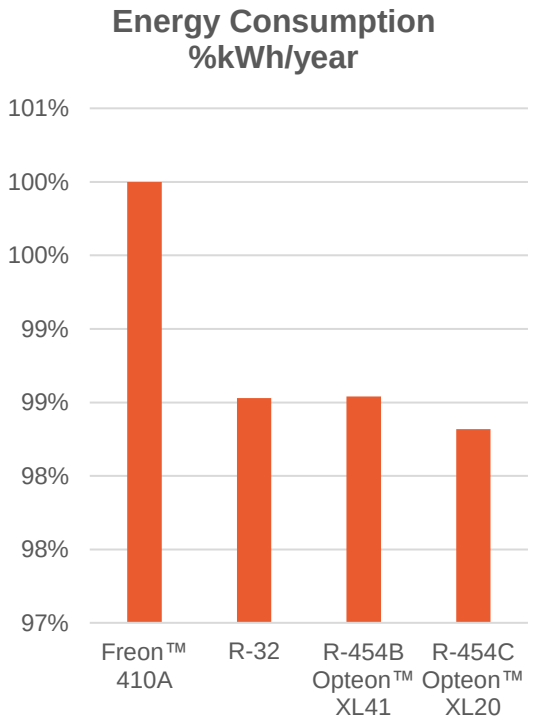
Energy price is considered to be constant. A price increase like the one seen in 2022, reinforces the favorable indication for the adoption of solutions characterized by higher efficiency and lower energy consumption.

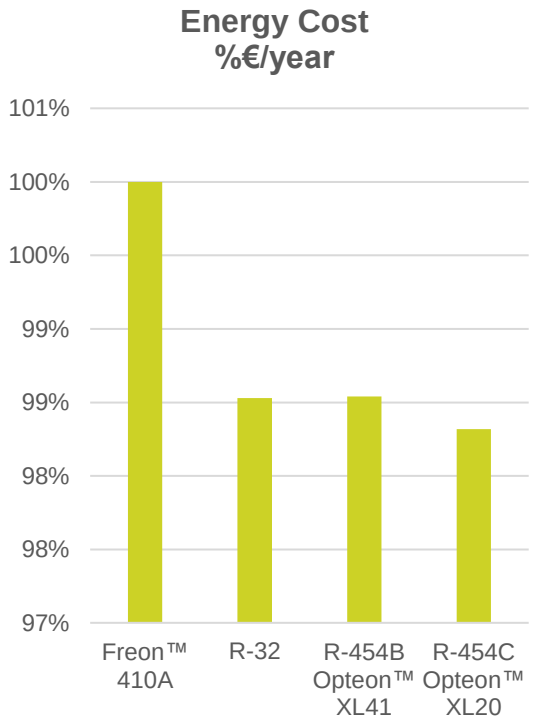
Calculation based on EcoDesign Directive

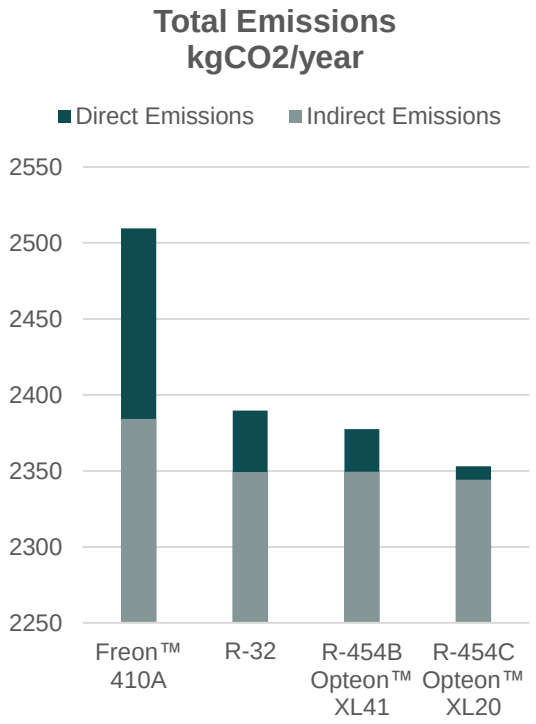
RESULTS

Water temperature 35°C





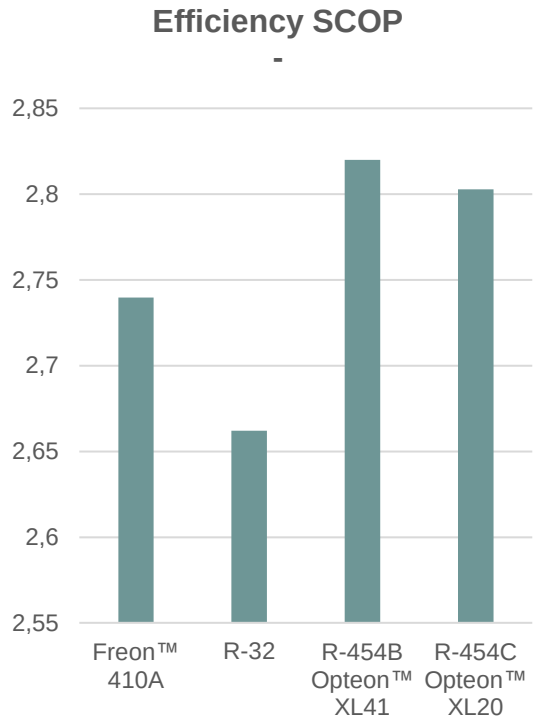


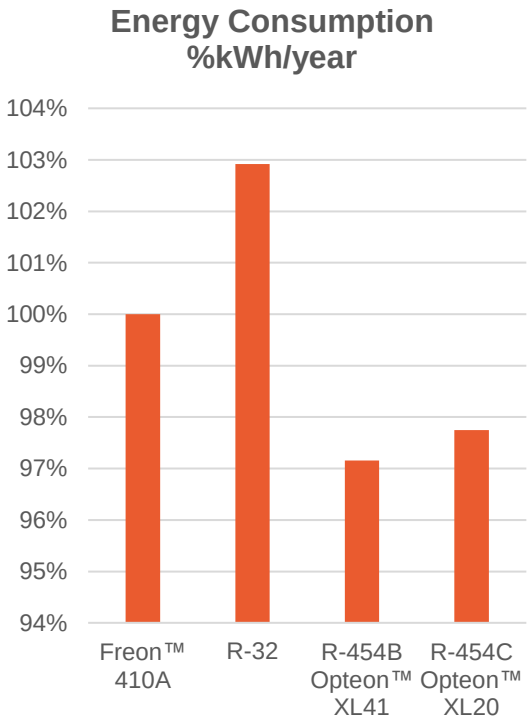


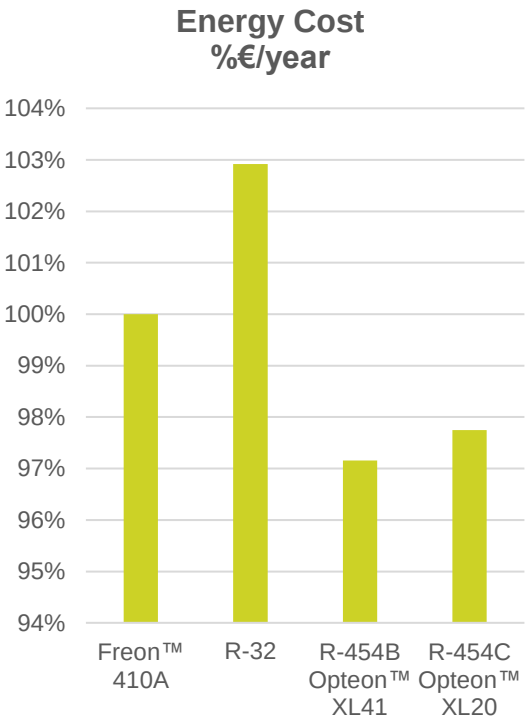
In new or recent buildings, R-454B e R-454C show better Efficiency, reduced Energy Consumption, Cost and Emission compared to R-410A and R-32

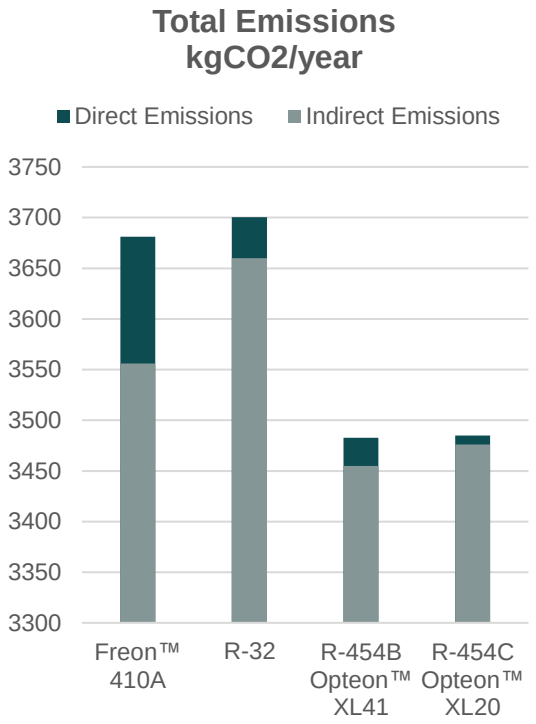
RESULTS

Water Temperature 55°C









In buildings renovation, R-454B e R-454C show better Efficiency, reduced Energy Consumption, Cost and Emission compared to R-410A and R-32

CONCLUSIONS

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 e R-454C show:

- Higher Energy Efficiency
- Lower Electrical Energy Consumption
- Lower Annual Cost
- Lower Direct Emission(-92,9%) end 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.

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

THANK YOU
FOR YOUR KIND ATTENTION

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