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Heat Recovery Ventilation Heat Pump Water Heaters with Propane: Development & Challenges

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#GoNatRefs

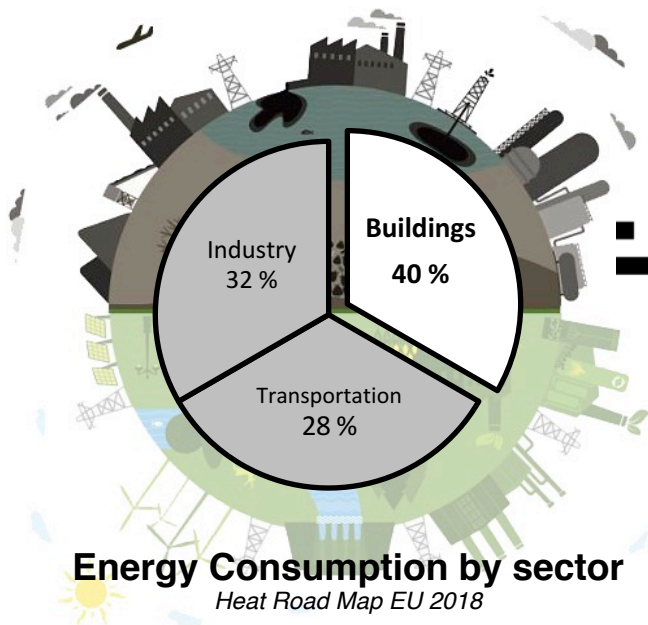


Outline

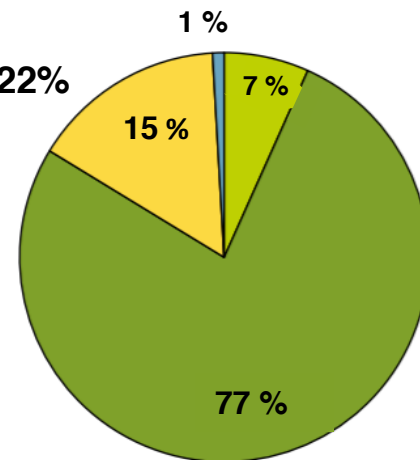
- Motivation and Background
- Overall Project Objective
- Research Methodology Flow Chart
- R290 : Challenges
- Conclusion

Motivation and Background

Building Sector Scenario



Residential 22%
Commercial 18%



Other Heating
Space Heating
Hot Water
Space Cooling



Motivation and Background

Building Sector Scenario



Improvements of
the **envelope**

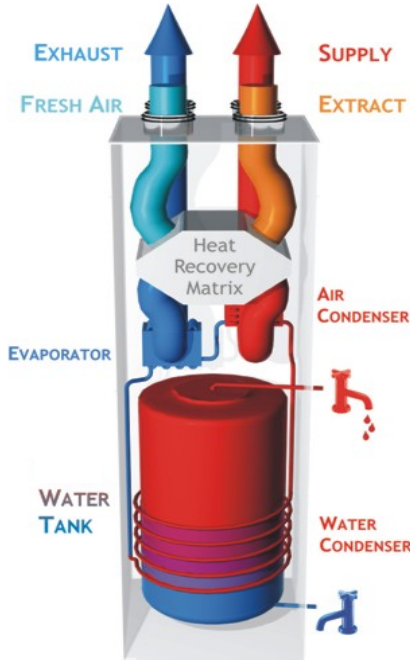


More efficient
building equipment

Motivation and Background

Compact Service Unit

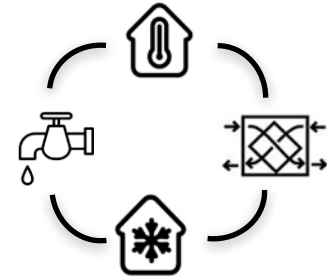
located in the
exhaust air flow
from the building



located in the
supply air flow
to the building

Passive and Active Heat Recovery

Heat Pump Water Heater

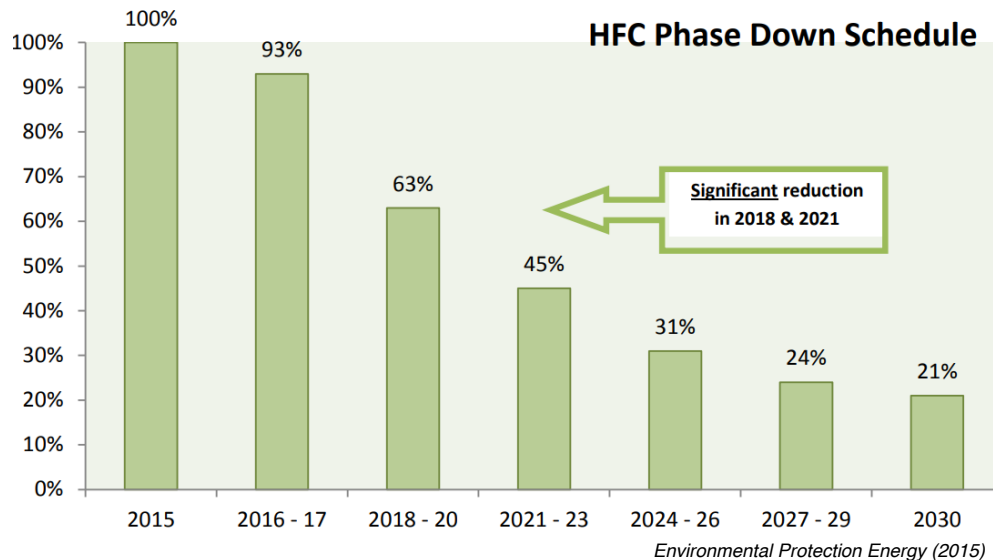




Motivation and Background

European F-Gas Regulation

The **phase down** means that **by 2030** the annual quantity of HFCs placed on the market and available to operators of equipment containing **HFC will be reduced by 79%** when compared to 2015.

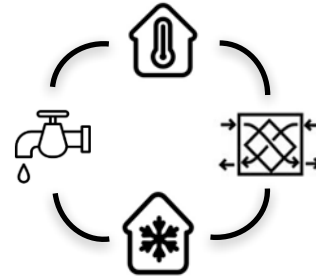


Overall Project Objective



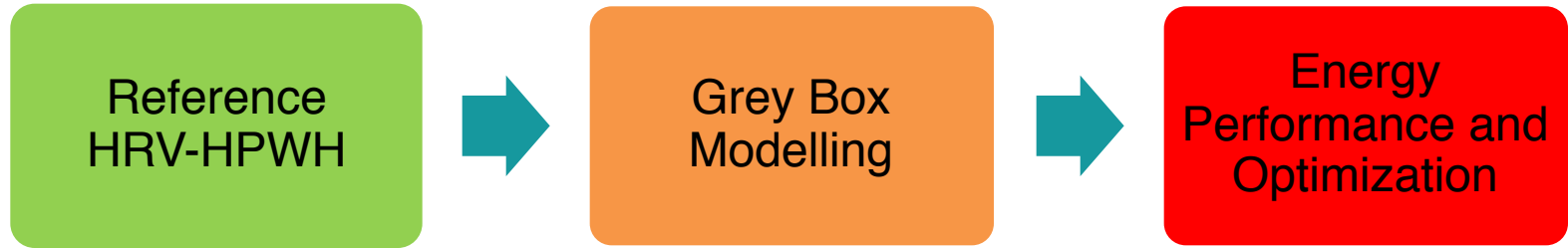
Heat Recovery Ventilation *Heat Pump* Water Heater

- Natural refrigerant based (**R290**)
- High energy efficiency
- Robust operation





Research Methodology Flow Chart



Reference
HRV-HPWH

Grey Box
Modelling

Energy Performance and
Optimization

Heat Pump

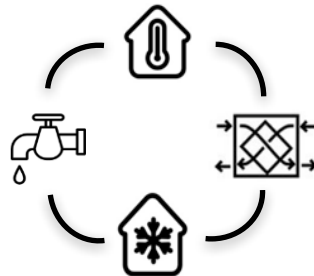
Heat Output DHW	1,6 kW
Maximum Electric Power (without heating element)	2,2 kW
Ambient temperature	- 20 / + 40 °C
Refrigerant type	R 134a (2.0 kg)

Tank

Capacity DHW tank	180 L
Supplementary electrical heating (DHW)	1,5 kW

Ventilation Heat Recovery Unit

Counter-current heat exchanger efficiency (2 °C / 20 °C – 220 /h)	88 %
Max Air Flow Rate	300 / h

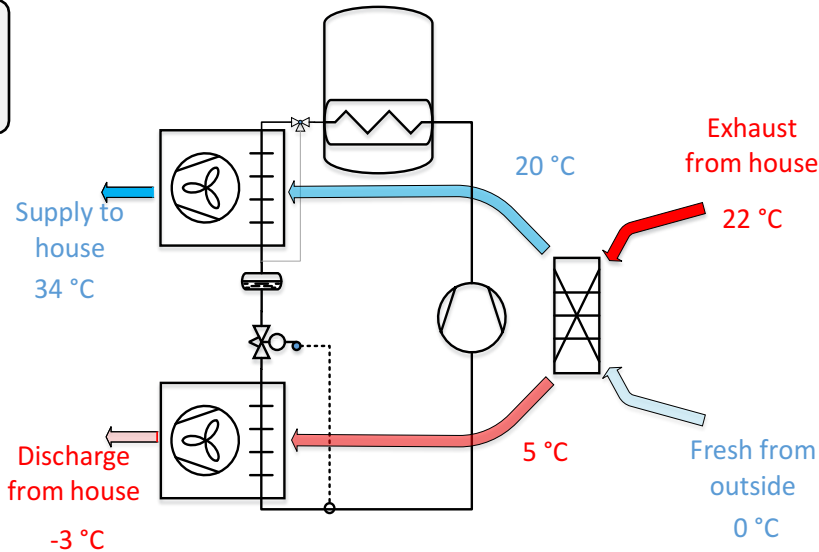
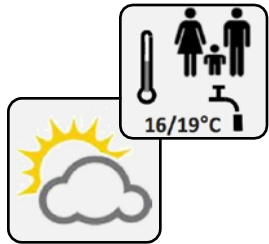


Reference
HRV-HPWH

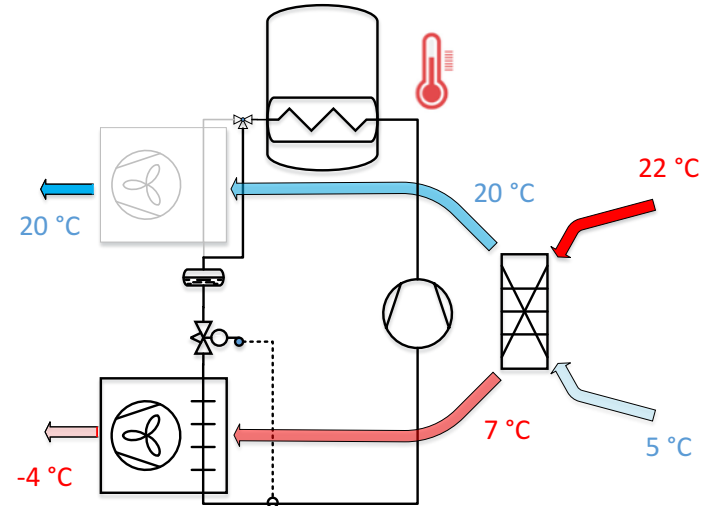
Grey Box
Modelling

Energy Performance and
Optimization

- Operating Modes (1)
- Testing procedure



Passive & Active Heat Recovery



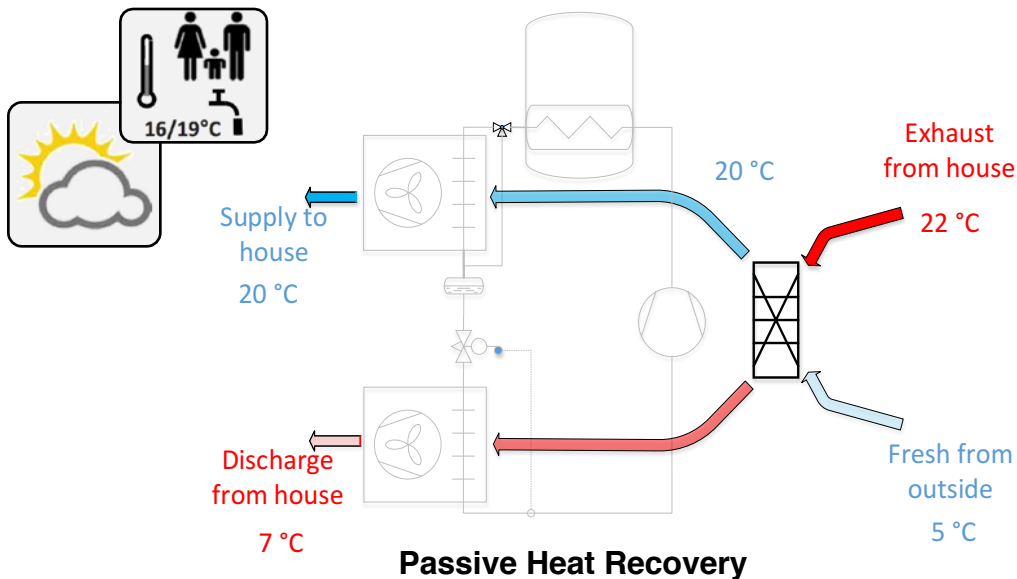
Domestic Hot Water Production
(heating up)

Reference
HRV-HPWH

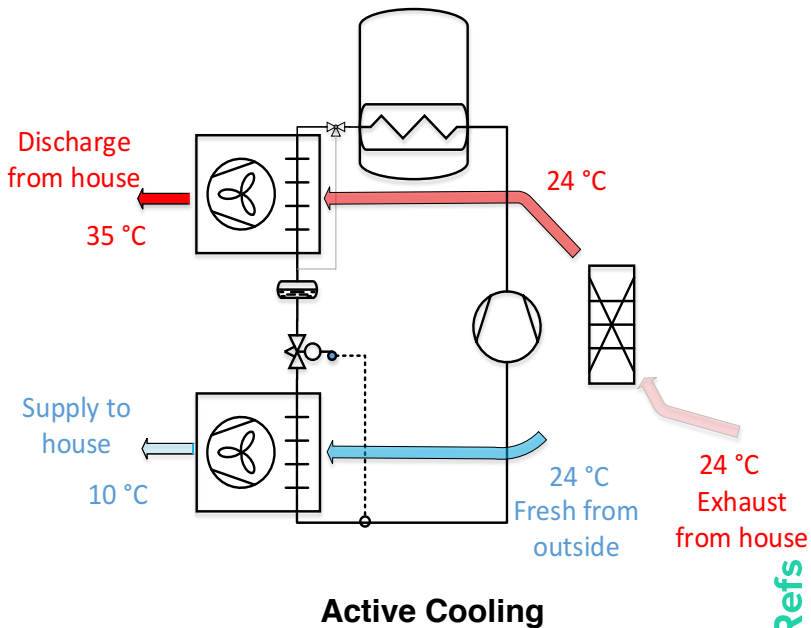
Grey Box
Modelling

Energy Performance and
Optimization

- Operating Modes (2)
- Testing procedure



Passive Heat Recovery



Active Cooling

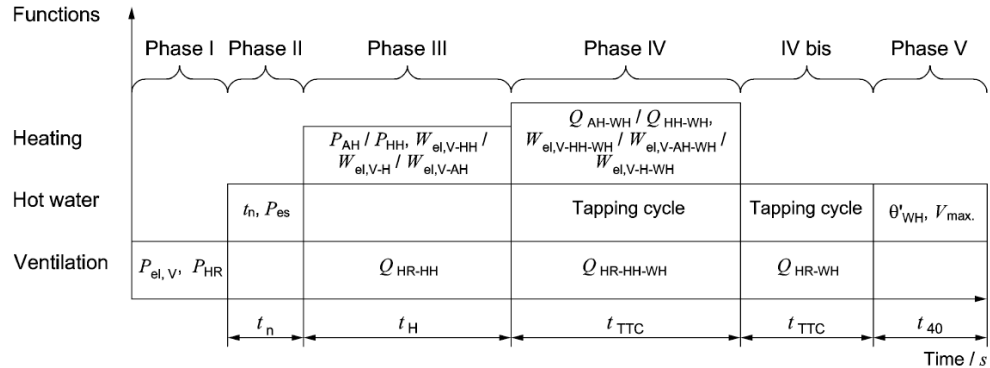
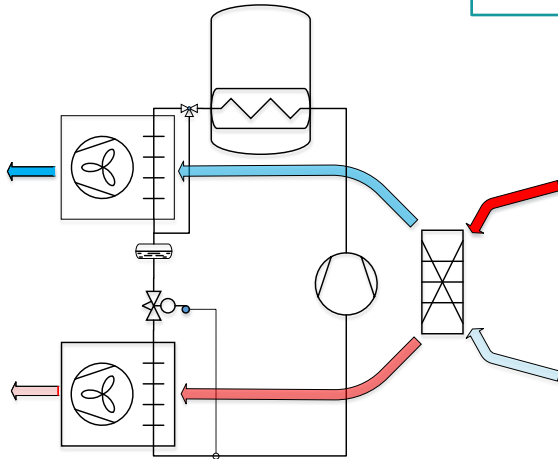
Reference
HRV-HPWH

Grey Box
Modelling

Energy Performance and
Optimization

- Operating Modes
- Testing procedure

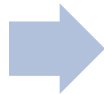
EN 16573 : 2017 performance testing of a multifunctional balanced ventilation units for single family dwellings, including heat pumps



Measuring the performance of the
heat recovery ventilation heat pump water heater for:

- hot water production (normative experiment: [EN 16147](#))
- passive and active heat recovery (normative experiment: [EN 13141-7 :2010](#))
- electrically driven heat pump (normative experiment: [EN 16573 : 2017](#))

Reference
HRV-HPWH

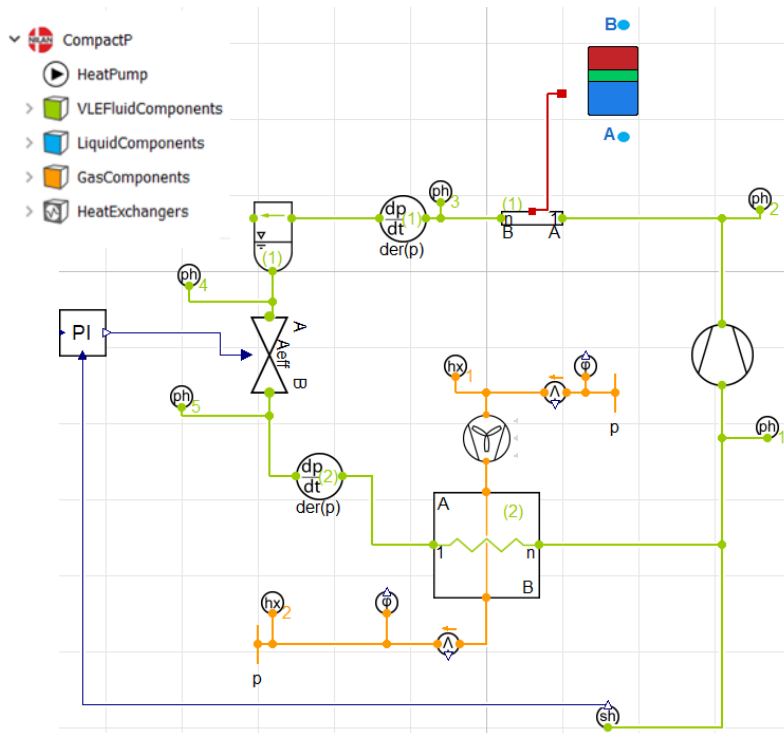


Grey Box
Modelling



Energy Performance and
Optimization

“easy” link
heat pump and water tank



Model Specifications

Precision

Physical phenomena influencing
refrigerant and water

Simulation speed

Perform simulations over longer
period of time

Extensiveness

Extend to different
configurations

Reference
HRV-HPWH



Grey Box
Modelling



Energy Performance
and Optimization

❑ Carry out performance studies (**long - term simulations**)



❑ **Control strategies** for meeting user's needs

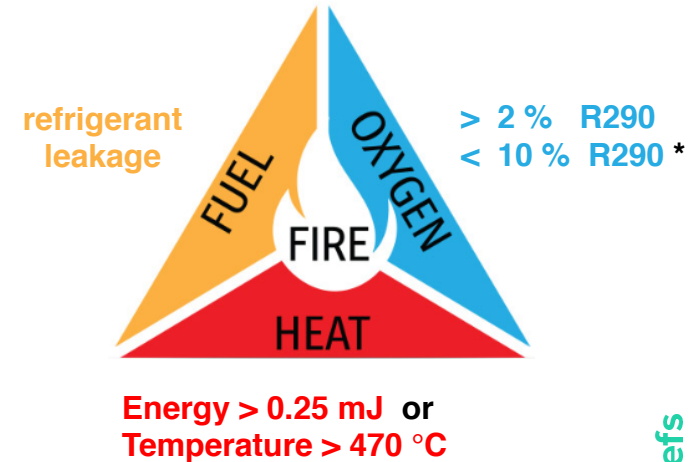
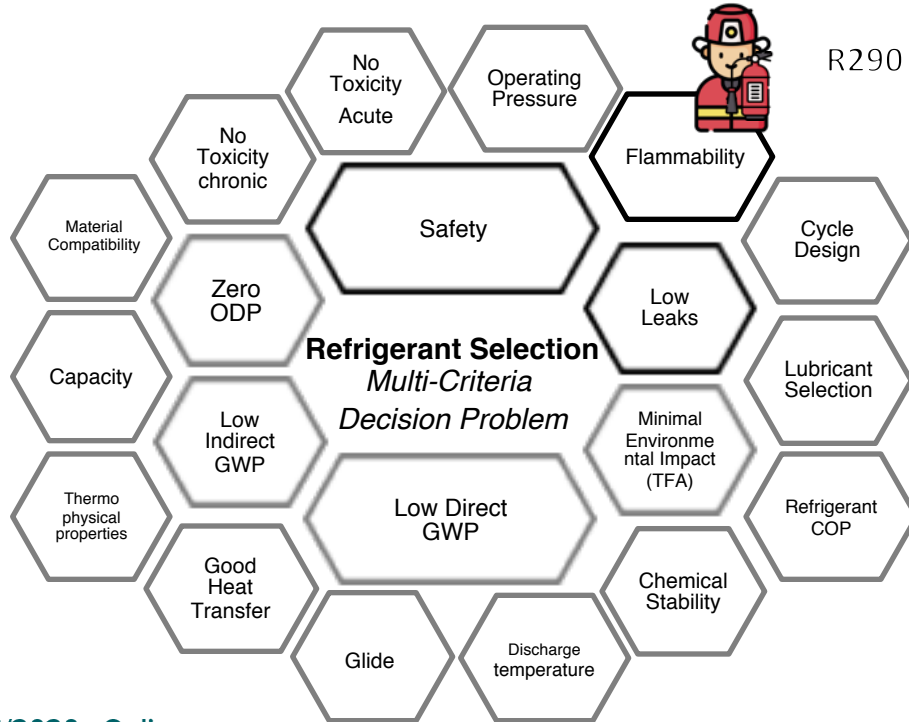
- *Climates* scenarios
- *Occupancy* scenarios

❑ **Re - use** the model with

- Different *configuration*
- Different *components sizes*
- Different *refrigerant* (**R290**)



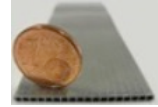
R290 : Challenges



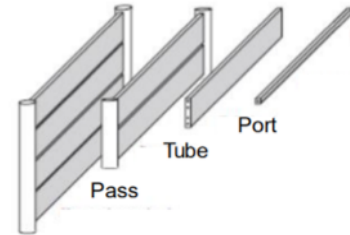
R290 : Challenges

Most reliable controllable
mitigation factor: **Charge Limit**

Mini channel heat exchanger



“Roll Bond” heat exchanger



Liquid pipes size

Reduce joints

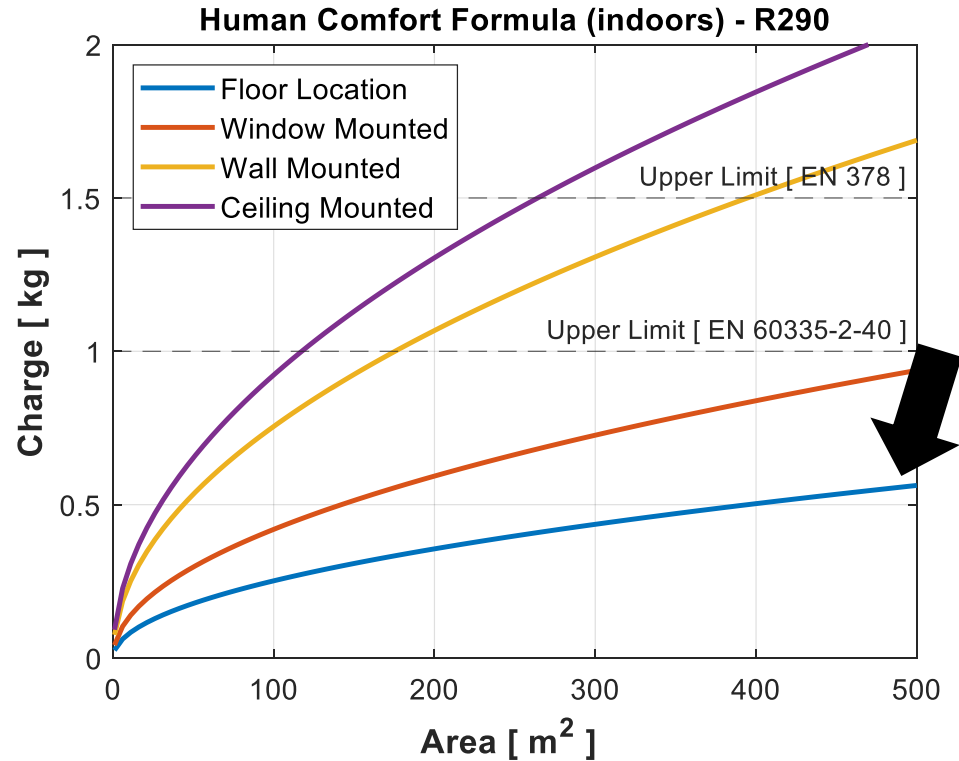
Smaller receiver

R290 : Challenges

Most reliable controllable mitigation factor: *Charge Limit*

❌ Conform with safety standards **EN 378** and **EN 60335-2-40** "human comfort formula"

- ✅ Risk assessment (on minimized charge system)
- ✅ Leak detection
- ✅ Ventilating leaks outdoors



$$m = 2.5 * LFL^{5/4} * h * A^{1/2}$$

upper limit : 1.5 kg R290 **EN 378**

upper limit : 26 x LFL = 0.988 kg R290 **EN 60335-2-40**

Conclusions

- ❑ An option for increasing the energy efficiency of buildings equipment is combining the supply of different services (“ **compact service unit** ”)
- ❑ Numerical model as **tool** for optimizing such systems and helping their transition to natural refrigerant
- ❑ **R290 : excellent fluid for heat pump applications**
It's natural, has a GWP of 3, requires half the charge for the system and is out of the HFC phase down quotas
- ❑ **R290 : safety requirements challenging**
Small charge system, risk-assessment, leak detection and ventilation to outdoor



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Thank you
for listening!



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