Natural refrigerants in building design

A case study for the Witteveen+Bos main office renovation

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The challenge for HVAC engineers (1)

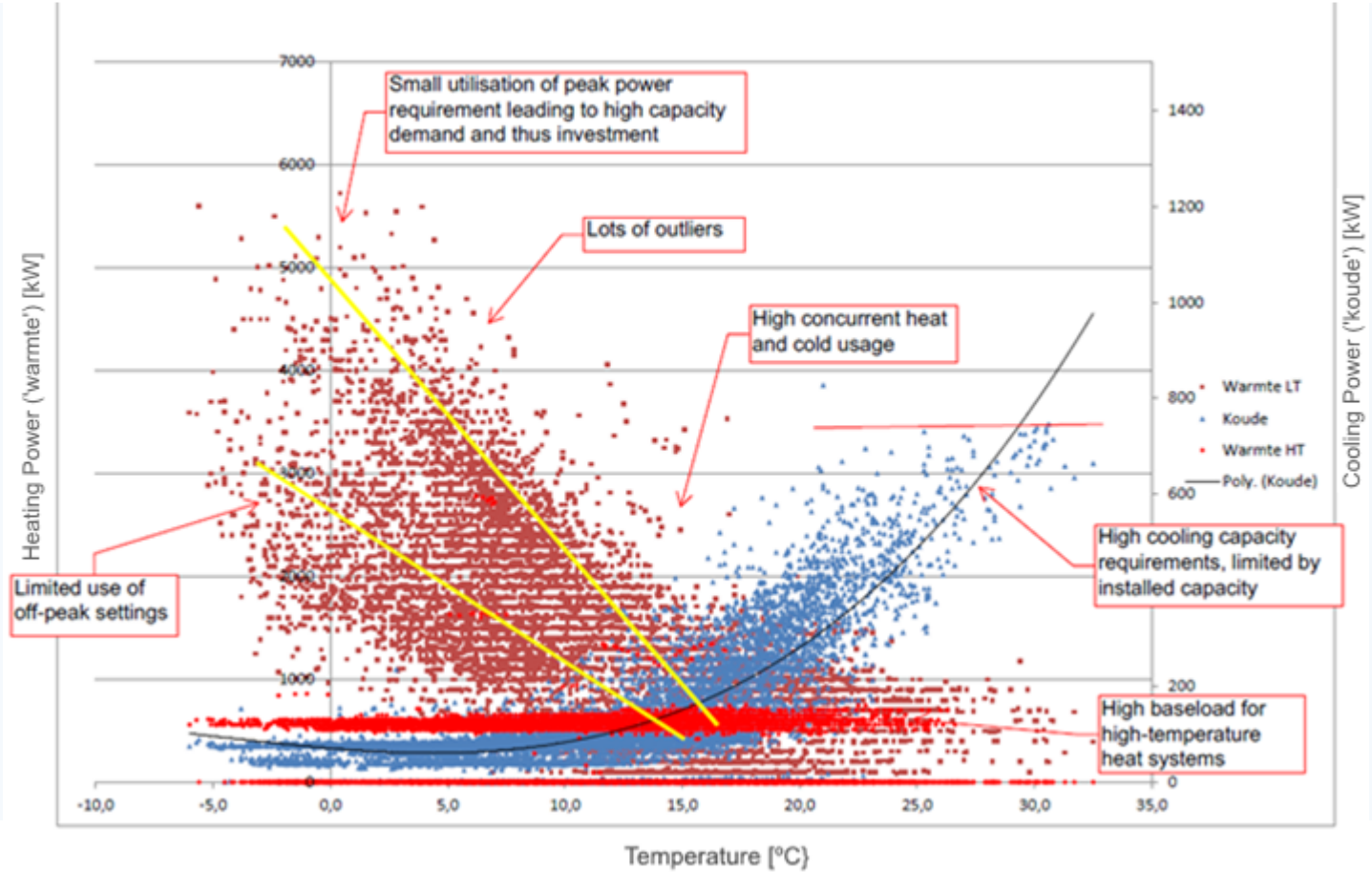
Challenges on HVAC systems

1. Netherlands: buildings responsible for ~13% of CO2 emmissions
2. Limited RES potential
3. Paris Climate Agreement & Montreal Protocol
4. Carbon-neutral by 2050 -> with large existing building stock
5. Material circularity by 2050

Mission

1. Renovate existing real estate
2. Do without natural gas
3. High ambitions: near Zero Energy Buildings (nZEB)
4. Work on energy savings first (building facade, isolation, LED-lighting, smart building, etc.)
5. Climate-proof technologies

The challenge for HVAC engineers (2)



The challenge for HVAC engineers (2) -> what do we learn?

- Much room for improvement on Building Management Systems (~10-20%)
- Heating and cooling often DOES occur simultanuously

- Thus, exchanging of heating ↔ cooling is logical to do
- One HVAC system creating heating and the cooling is able to meet this demand
- Storage of surplus heat or cold energy can be applied almost the whole year
- By this, TCOPs in the 8 – 10 range are now achievable

Introducing Witteveen+Bos

- Dutch consulting engineering agency
- Operates Water sector, Infrastructure, Dikes and Ports, Environment, Buildings
- Employees ± 1000 (worldwide)

  Ownership Shares are fully owned by the employees.
- Customers Government, industry, other cooperations
- Turnover € 137 mio (2016)
- Profit € 16 mio (2016)

Case Study: Witteveen+Bos office at Deventer (NL)

- High comfort and energy performance requirements
- High CO_2-reduction ambition (stemming from CSR-commitments)
- Limited potential for geothermal energy storage
- Ambition: **showcase for energy storage**: expertimental electrical HBr flow-battery, solar PV and heat and cold storage

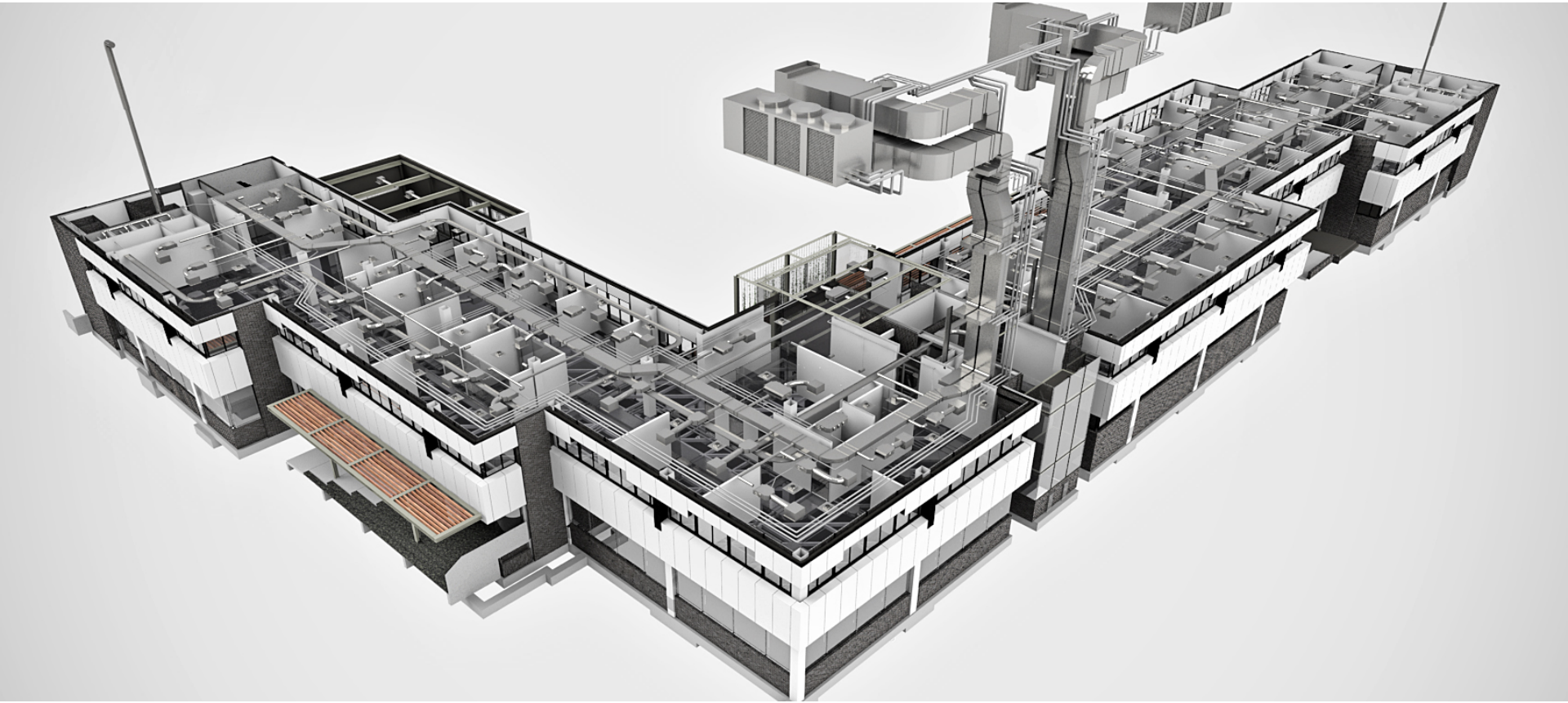
- Key findings:
  - **TripleAqua** outperformes AES (CapEx, OpEx)
  - Non-toxic refrigerant Propæne to avoid risk
  - PCM storage for heat & cold is cost effective

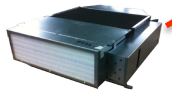
Key data of the project (BEFORE renovation)

Year of Construction	1975
Building area	8.000 m2
Installed heating capacity	700 kW
Installed cooling capacity	450 kW
Energy usage natural gas fired boiler	60.000 m^3/yr (= 500.000 kWh/yr)
Energy usage for HVAC vents +chiller	118.000 kWh/yr
Building facade isolation (average)	Rc ~ 1.5 m^2 K / W
Energy label	**E**

Key data of the project (AFTER renovation)

Installed heating capacity	300 kW
Installed cooling capacity	400 kW
Installed thermal storage capacity	99 kWh
Energy usage natural gas fired boiler	ZERO
Energy usage for HVAC vents and chiller	161.000 kWh/yr
Building facade isolation (average)	Rc = 3.5 m^2 K / W
Energy label	**A**
Savings in CO_2 carbon footprint	85 Tons/yr
Energy for HVAC	**~25-30 kWh/m^2 yr**
Energy Savings	**~68 %**





TRIPLEAQUA
Heat, cool and store in one go

STUDIO GROEN+SCHILD
PROGRAMMATEAM WITTEVEEN+BOS
RENOVATIE LEEUWENBRUG & DEVENTER

Why choose a natural heat pump with energy storage?

- Natural refrigerant instead of high GWP chemical refrigerants
- Heating and cooling with one integral system creates a high energy performance
- Thermal storage for cold and warm water allows for passive energy capacity
- An electrical heat pump can operate on renewable energy (solar/wind)
- TCO/LCC: lowest operational costs, comparable investments
- Added value for the real-estate property
- Avoid business risks on chemical refrigerants

-> We have the responsibility to aim for Carbon Neutral Building technology

Challenges for a wider uptake of NatRef and heat pumps

1. **Entrepreneurial behaviour and innovation**

   The construction Industry is characterized by low earning potential and slow productivity rise (innovation).

   Entrepreneurial companies (and people) need to step in, and take on the risks for front-runners

2. **Faster implementation of legislation from Paris and the Energy Performance of Buildings Directive**

   It's a strategic problem: on average, utility buildings are only being renovated on a 30-40 year timescale

3. **Refrigerants (often) not part of the decision-making process for utility buildings**

   For renovations and new-built utility buildings, the refrigerant is not being considered in selecting equipment

4. **Education and training needed (also for the consultants!)**

   As a consequence of risk-averseness, designers work with old, inefficient and strategically unfit technology

5. **Focus on a TCO/LCC-approach**

   By focusing on a Total Cost of Ownership or Life Cycle Costing approach, a (strategic) better trade-off in CapEx and OpEx for HVAC installations, building physics and the building processes can be made