SUPERMARKET WITH GROUND COUPLED CARBON DIOXIDE REFRIGERATION PLANT

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AGENDA

1. Background on supermarkets, energy and greenhouse gases
2. Energy efficient supermarket concept and goals
3. Results
4. Conclusion and outlook

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Why do we need energy efficient supermarkets?

- Supermarkets play a central role in our consumer society
- Today‘s food system is built upon refrigeration
- Supermarkets are massive energy consumers
- Supermarkets create greenhouse gases

In 2011, 72.4 % of the sales share of food retail industry realized in discounters and supermarkets in Germany [1]

Supermarket:
~ 600 – 2.000 kWh/m².a (PE) [3]

Normal building:
200 – 400 kWh/m².a (PE) [4]

About 65 % of the cooling needs in Germany for frozen and refrigerated food products
→ over 50.000 GWh/a [2]

“Supermarket refrigeration remains the last big subsector and the strongest emission source of the fluorinated hydrocarbons (HFC) in Germany” - Kauffeld [4]

[1] EHI retail institute 2012
[2] Franzke, U. Ki Luft- und Kältetechnik 2005
[3] Notvedt -Hafner – Sintef 2012 + own investigations
[4] EnOB
[5] Kauffeld 2009

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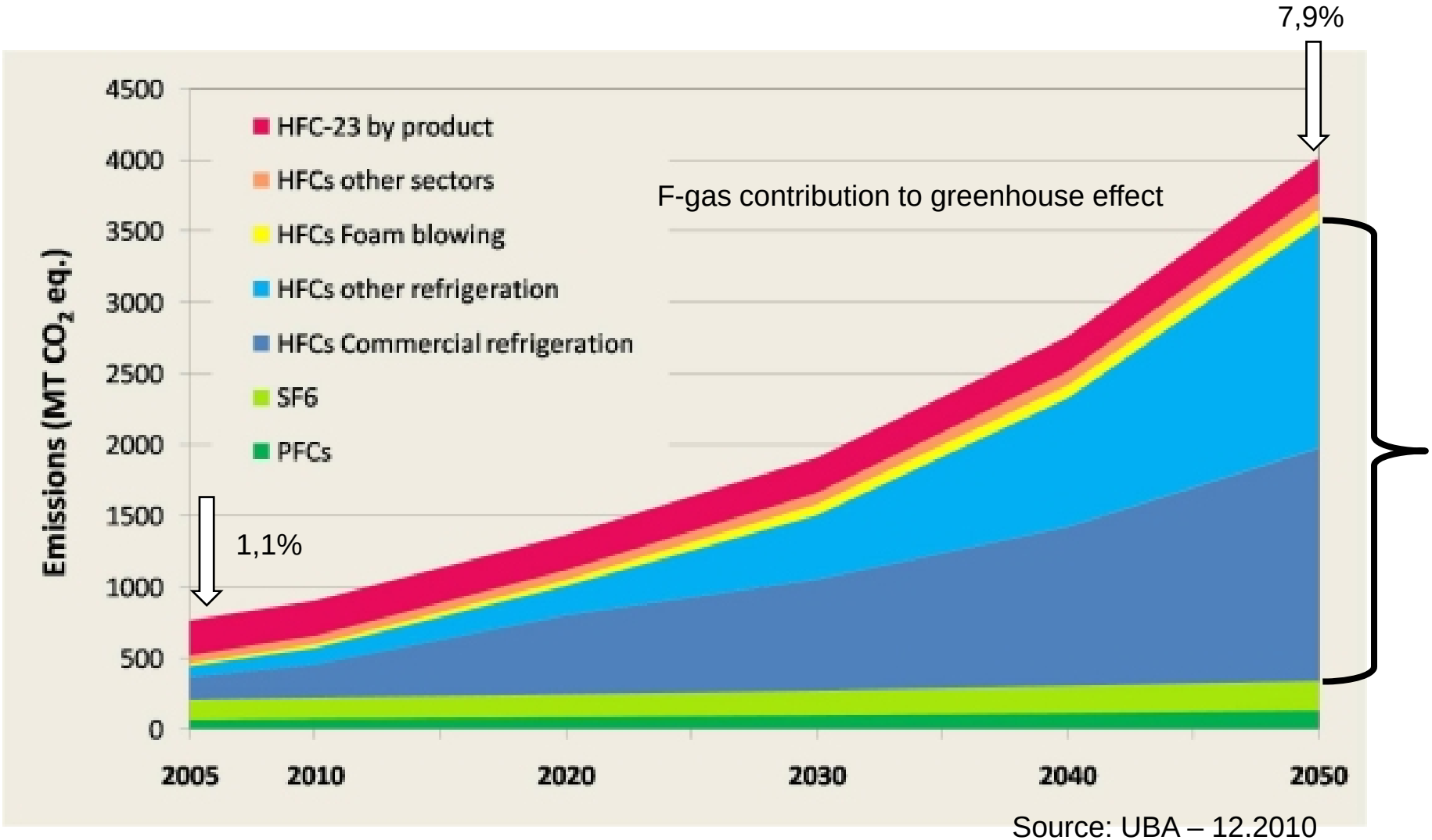
Global emissions of fluorinated greenhouse gases



Source: UBA – 12.2010

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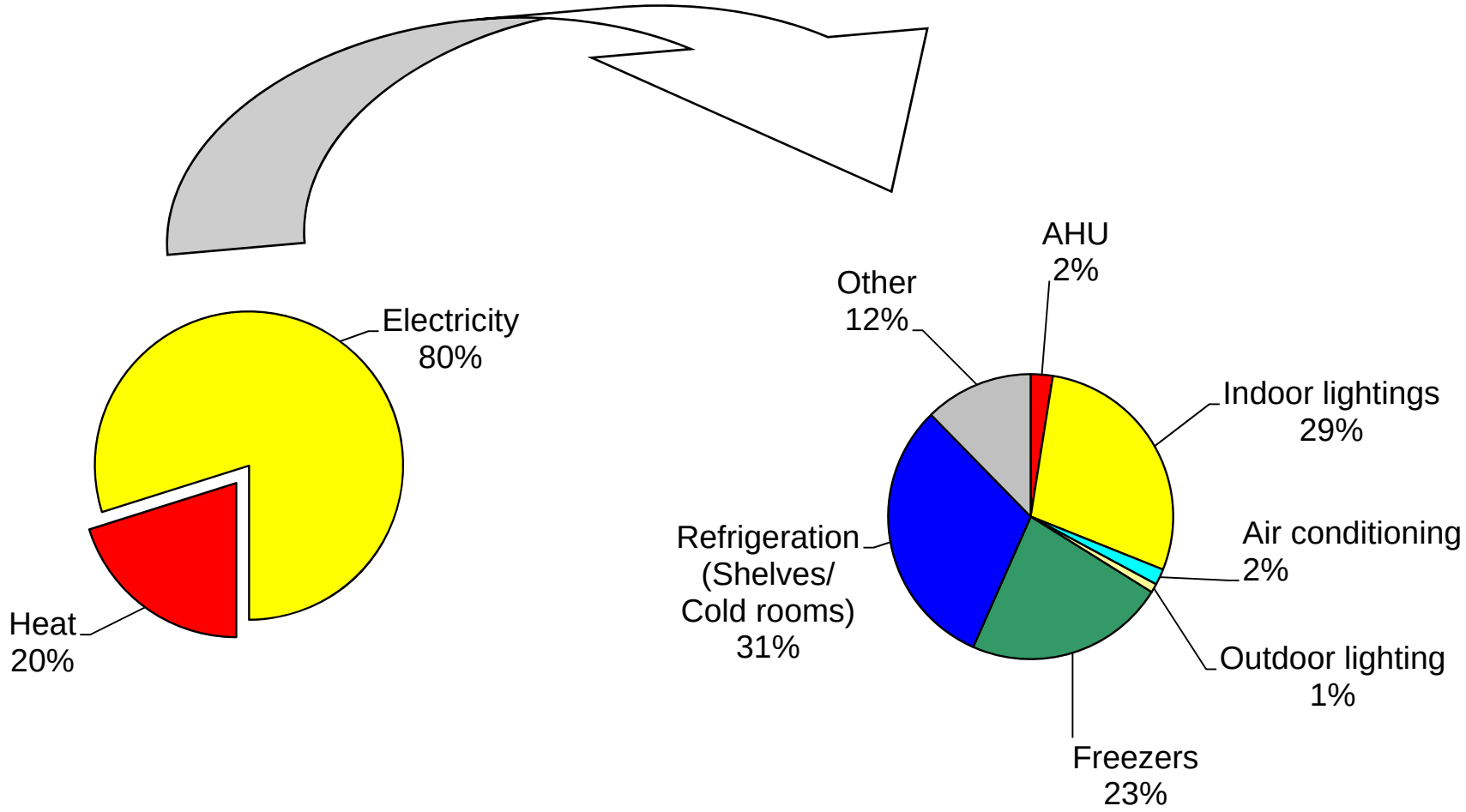
Energy breakdown in a standard supermarket



What are (some) answers?

- Highly insulated building envelope

- Energy efficient heating and ventilating

- Waste heat recovery

- Use of natural heat sinks and sources

- Covered refrigerated shelves

- Natural refrigerants

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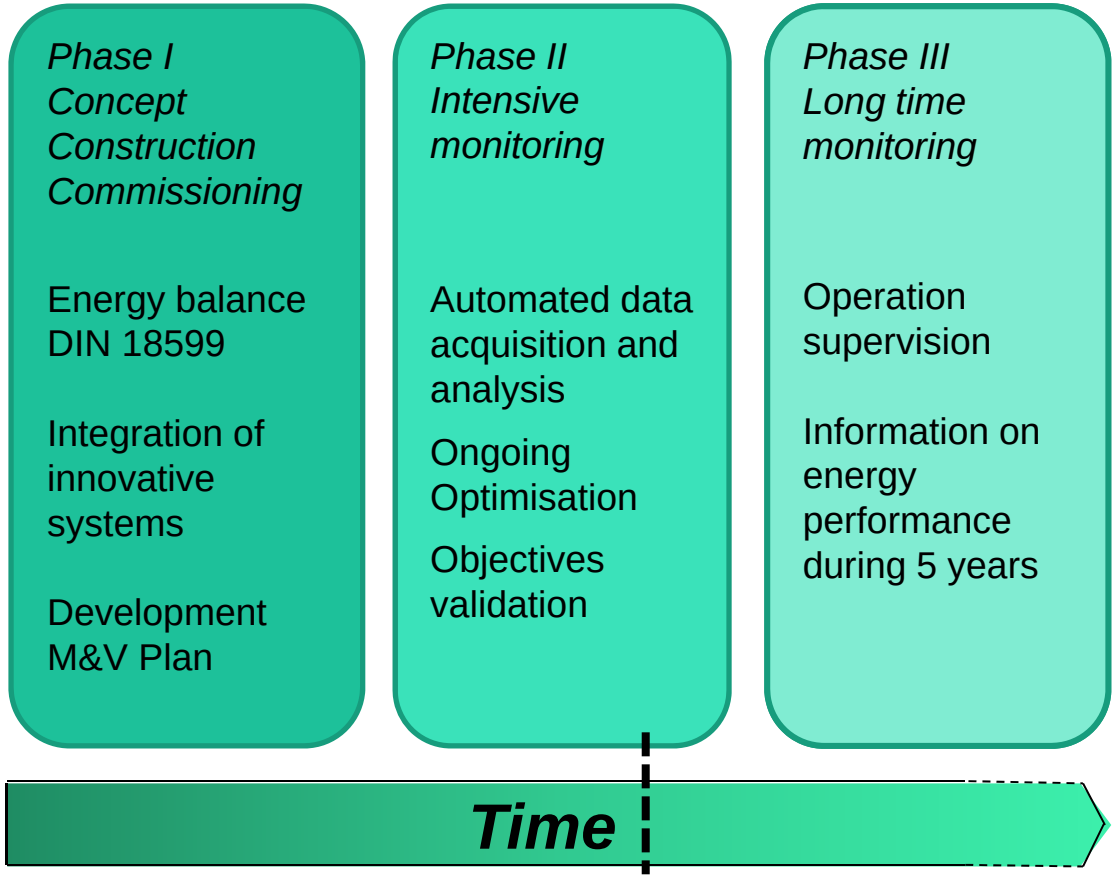
EnOB: Research for Energy Optimized Buildings

- German federal ministry of economics and technology
- Objectives:
  - drastically reduce energy demand of buildings
  - R&D of innovative technologies
  - test & demonstrate the validity of the technologies
- www.enob.info



ptJ Projektträger Jülich Forschungszentrum Jülich
Bundesministerium für Wirtschaft und Technologie
EnBau

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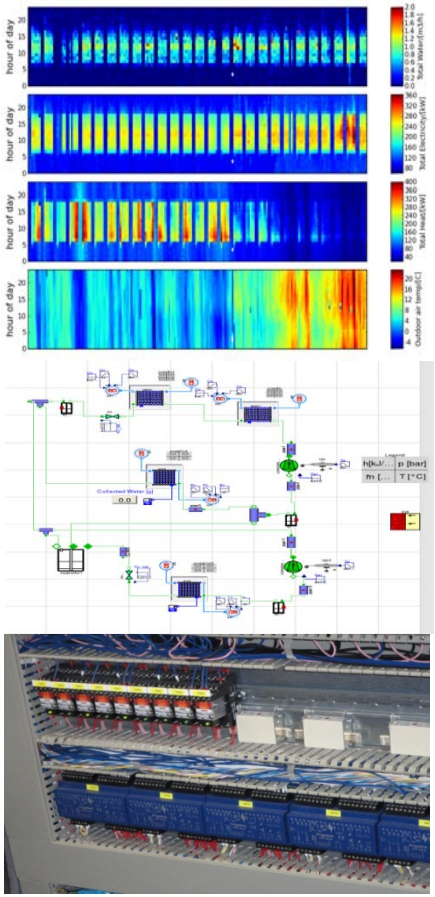
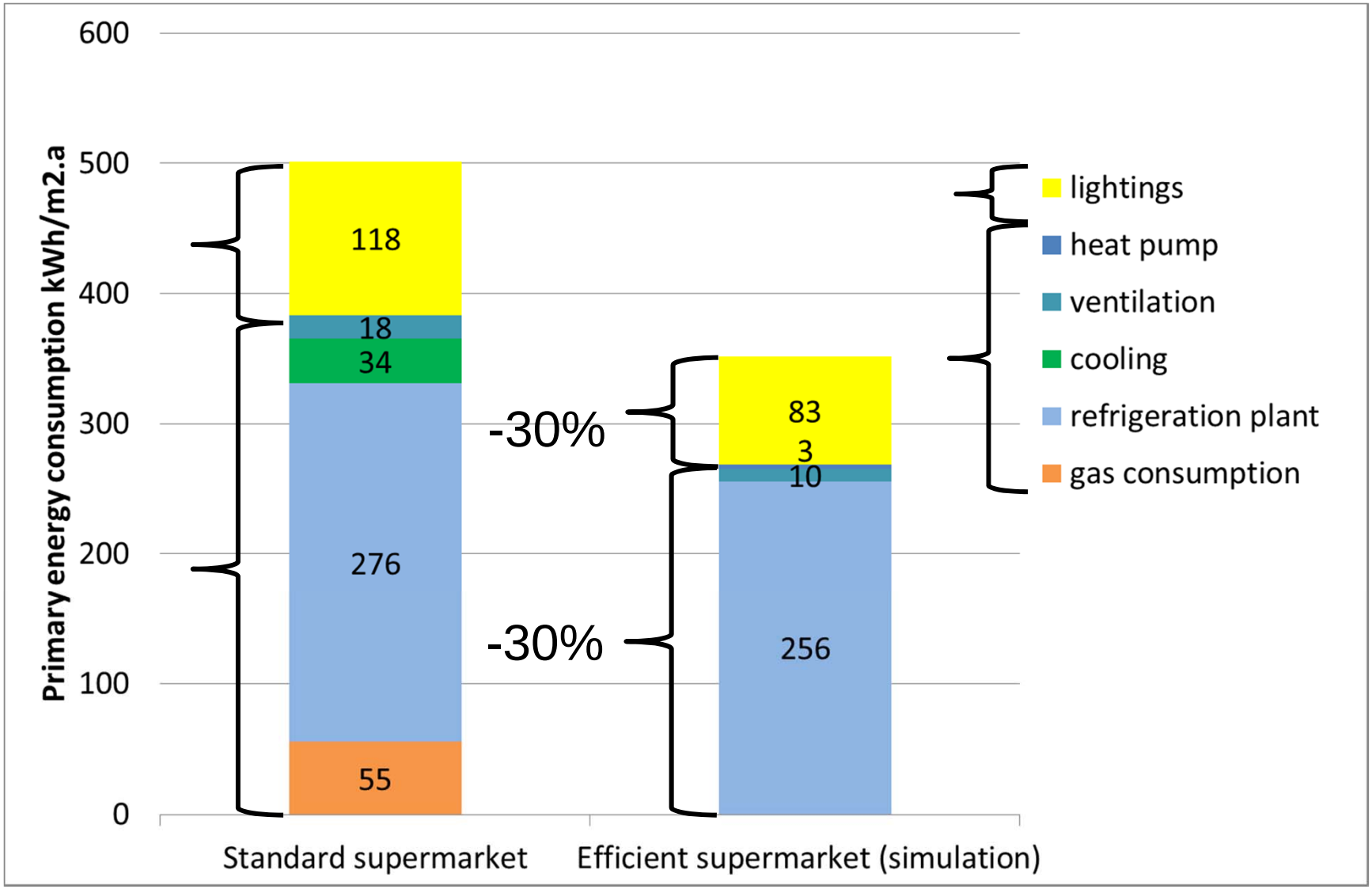
Monitoringprogramm



- Over 150 datapoints, high time resolution
  - Temperature, solar radiation
  - Power-, Heat and Cold meters, refrigerant mass flow meters
- Real time data transfer via secured internet connection to Fraunhofer ISE
- Data analysis and continuous operation and control optimization
- Smart visualization techniques

Energy reduction objectives for the new supermarket



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Concept overview – Key elements

- **Building Envelope:** Insulation and air tightness to Passivhaus Standard

- **Refrigeration:** CO_2 refrigeration plant as only energy supply

  No use of fossil fuels

  Use of ground to sub-cool refrigerant and as heat source for heat pump

- **Refrigerated shelves and freezers:** Use of covers and night curtains

  LED-Lighting

- **Ventilation Air-conditioning:** Activated Core Slab

  Air handling unit downsizing

  No air curtains

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Refrigerant choice: CO_2 (R744)

Benefits:

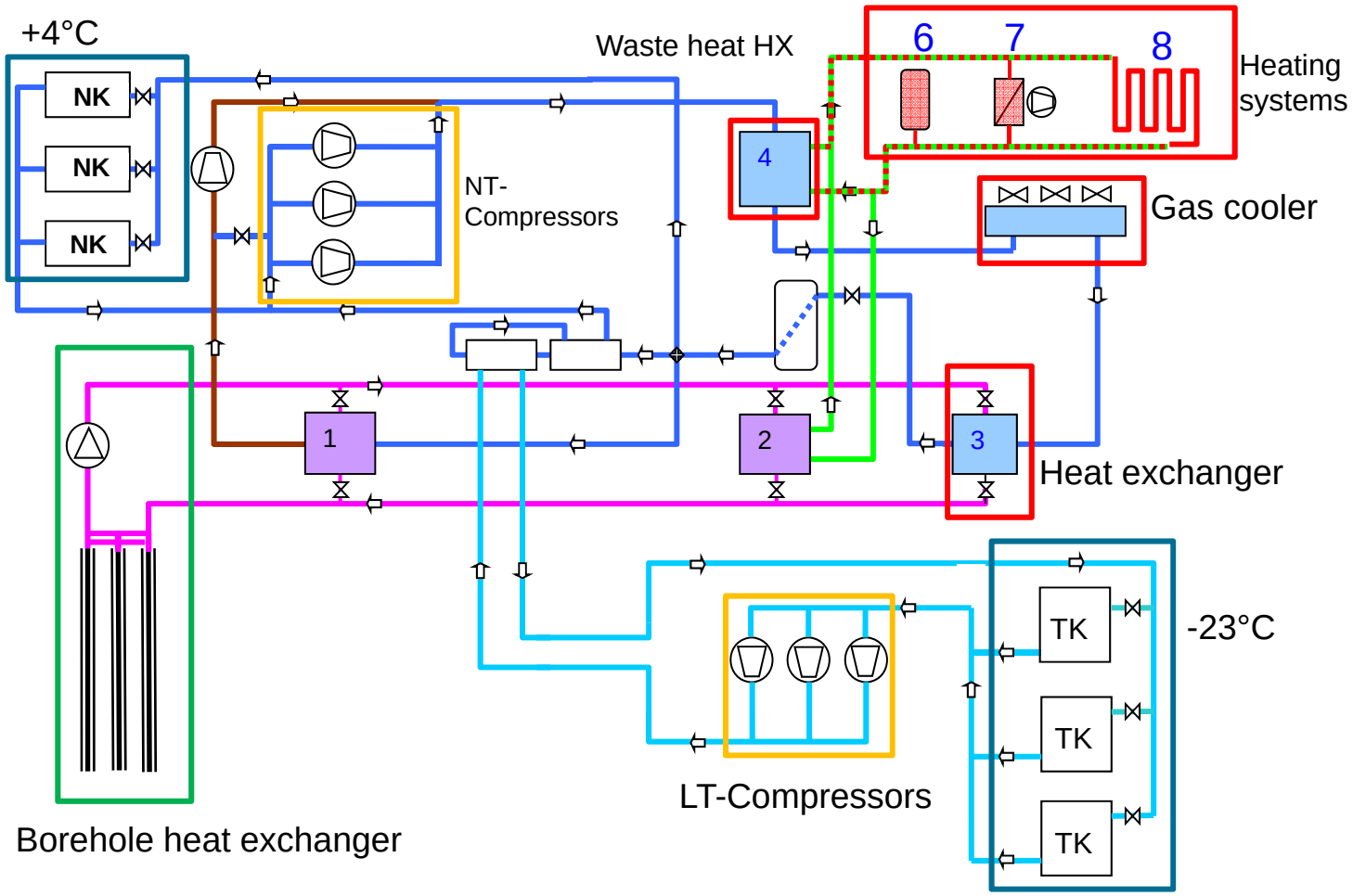
- High environmental compatibility:
  - very low Global Warming Potential = 1
    (R404A GWP=3700)
  - Ozone Depletion Potential = 0
- Non-inflammable, nontoxic
- High volumetric heat capacity
- Higher efficiency in comparison to plants running with R134a or R404 (at low condensation temperatures…)

Drawbacks:

- High operating pressures (40-100bar)
- Low critical point 31°C
- Efficiency is highly dependent of the condensation temperature
  - Transcritical operation with low energy efficiency when outdoor temp. > 20°C

↳ This effect can be reduced through additional cooling via borehole heat exchanger

Refrigeration plant and building systems



Legende

1 Heat pump HX

2 Free cooling HX

3 Borehole HX

4 Waste heat recovery

5 Gas cooler

6 Hot water Tank

7 Air handling unit

8 activated concrete slab

9 Heat pump comp.

10 Normal cooling Comp.

11 Low pressure comp.

Low temp. freezers

Normal temp. freezers

 Source: Hafner-Muschler

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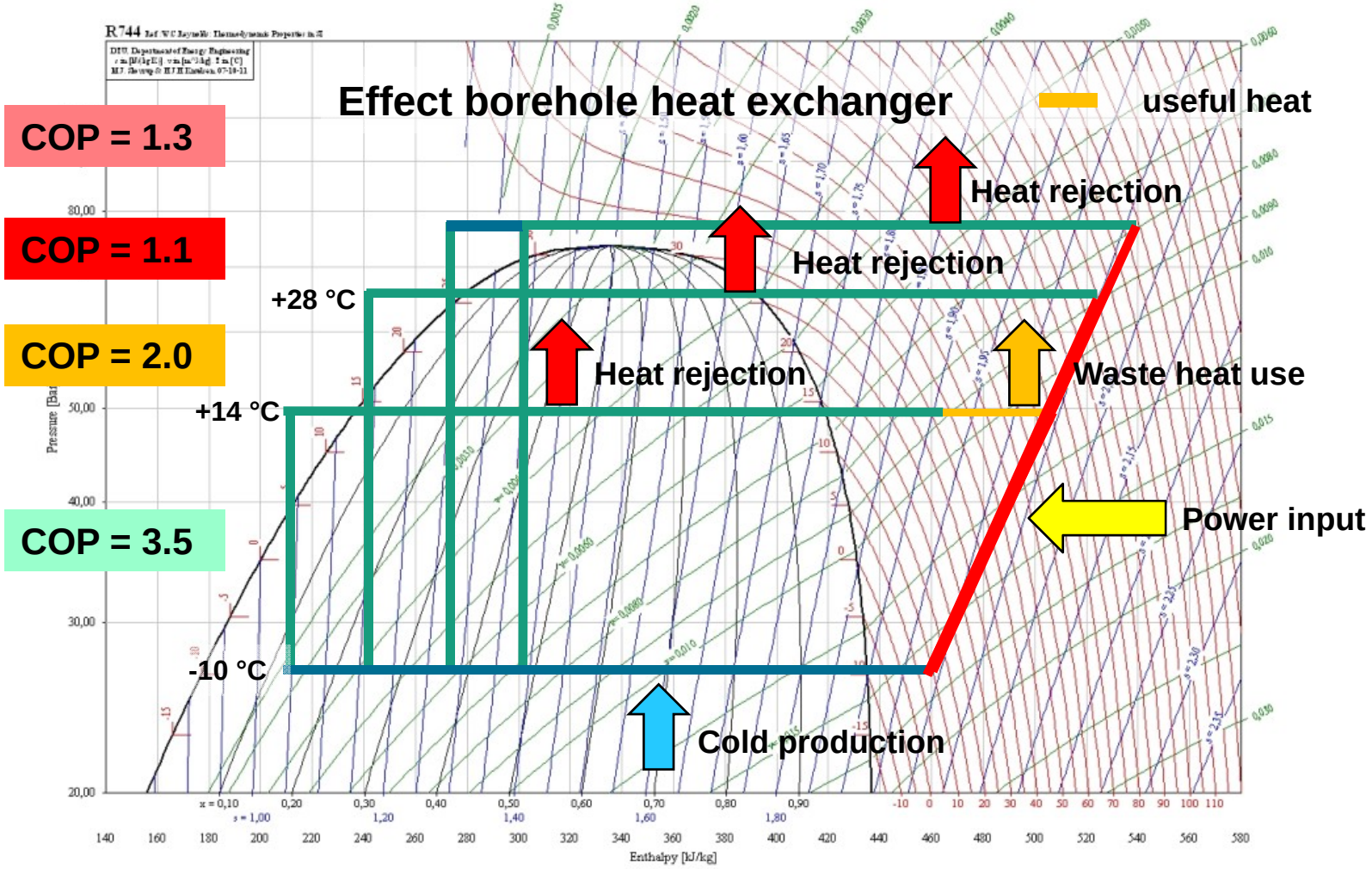
Heat recovery and sub-cooling with borehole heat exchanger



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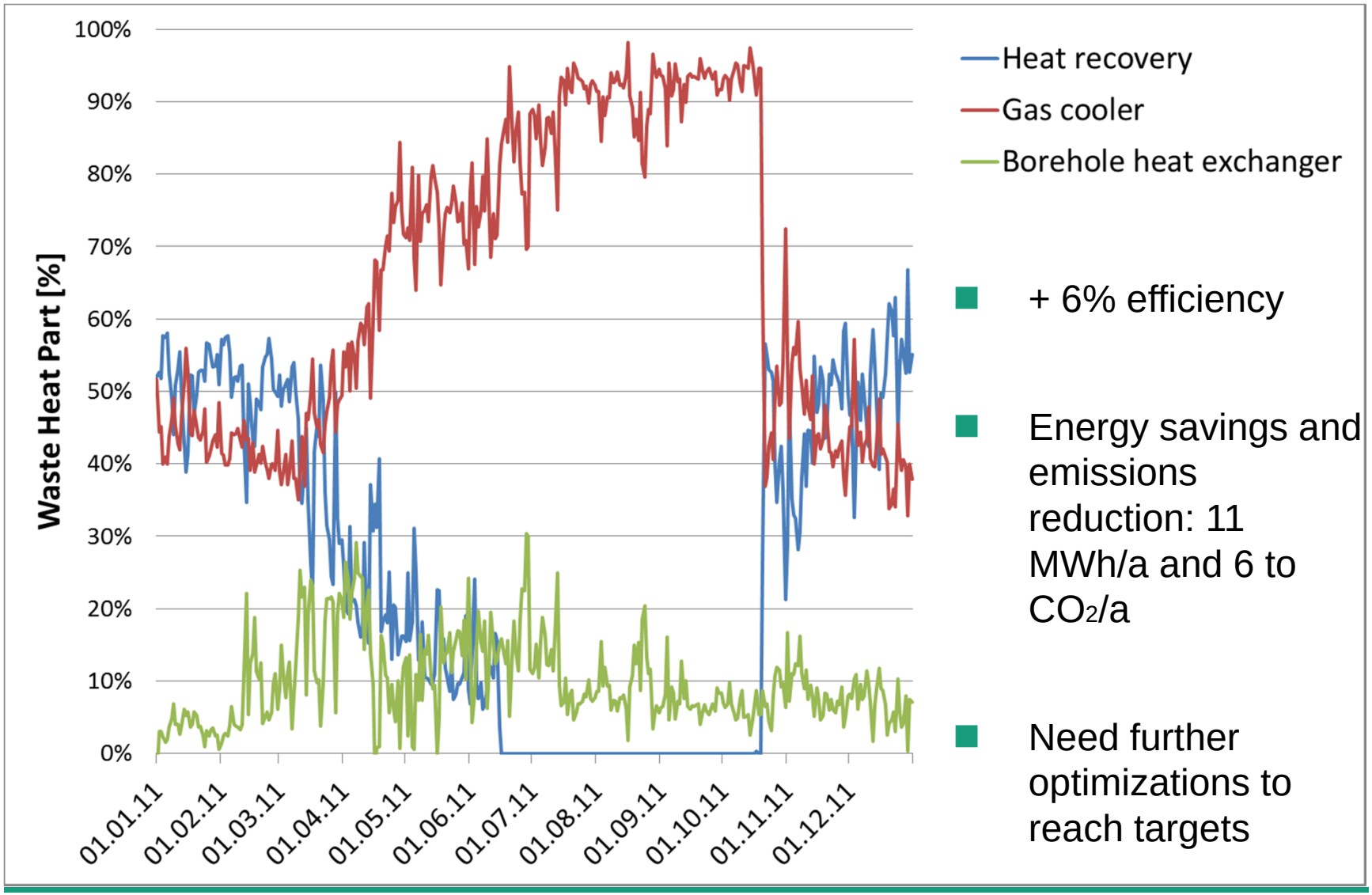
Measured effect of the borehole heat exchanger



- + 6% efficiency
- Energy savings and emissions reduction: 11 MWh/a and 6 to CO_2/a
- Need further optimizations to reach targets

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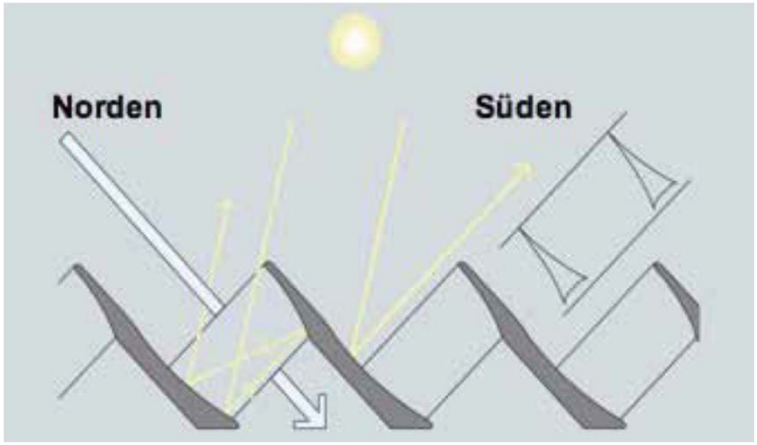
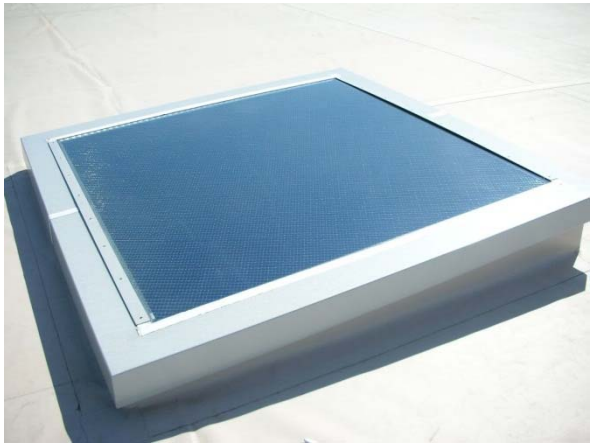
Solar Energy Use

- **Use of daylight**
  - 28 Skylights with microgrid integrated in triple-glazings in sales and warehouse space
  - Direct sun radiation is reflected to the outside





- **Daylight dependent artificial lighting control**
  - Energy consumption reduction of -25% in 2011
  - Energy input reduction up to 70% in summer for lighting system

Use of daylight

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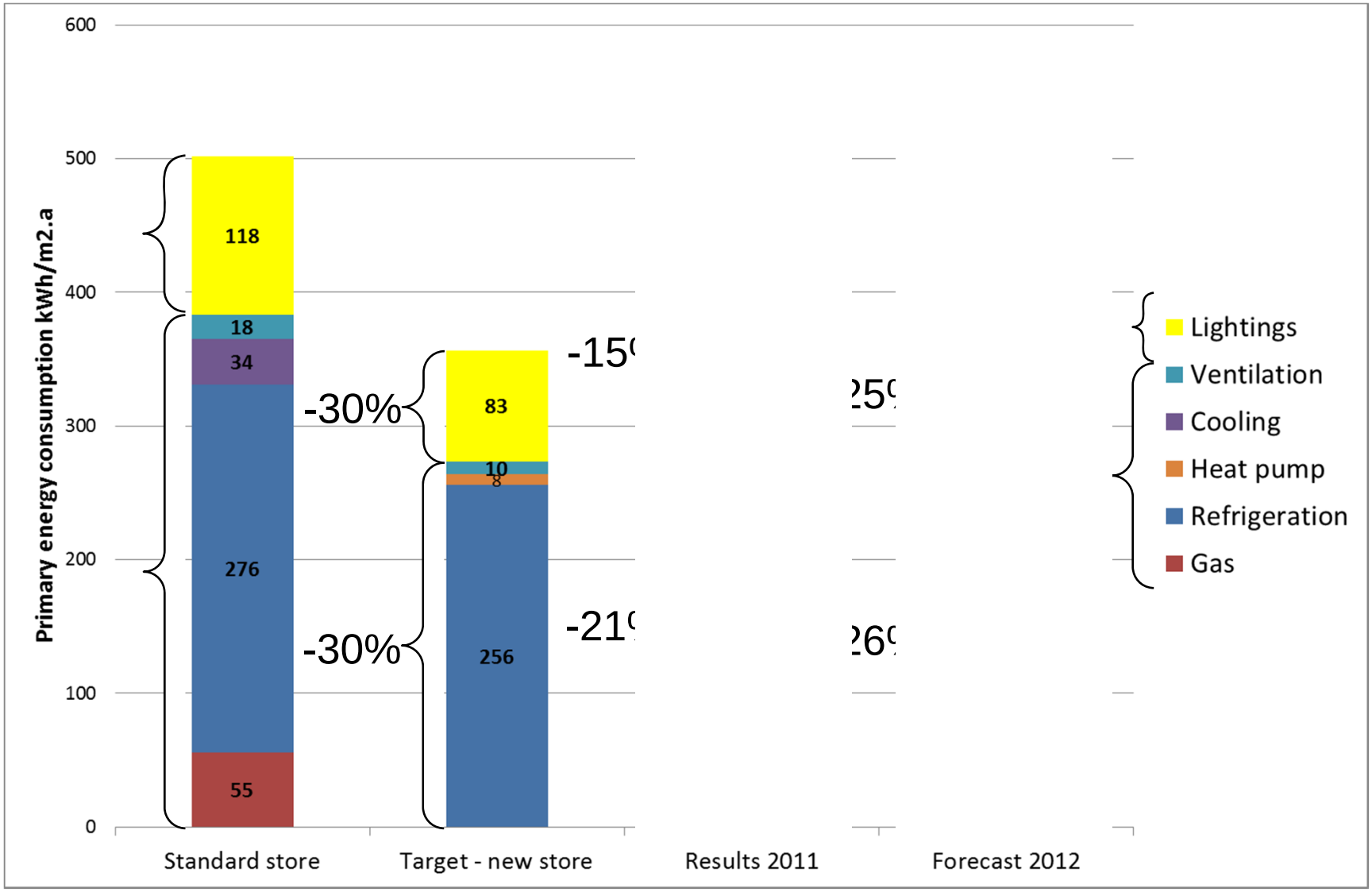
Energy: comparison with objectives and forecast



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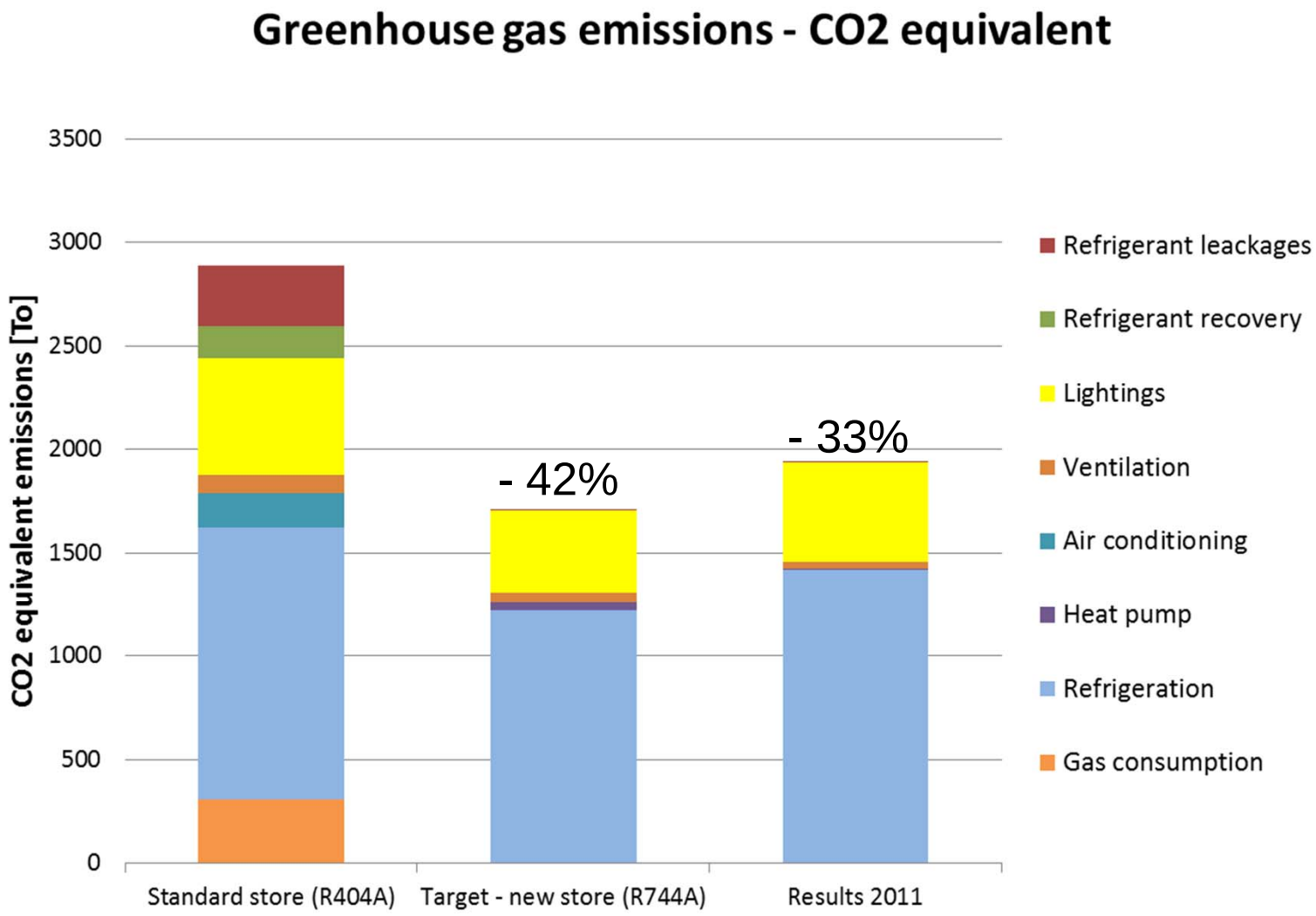
Greenhouse gas emissions: reduction of the new supermarket



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Lessons learned and outlook:

- New concept reached 20% energy savings after 1 year
- Greenhouse gas emissions cut by over 30% after 1 year through the use of CO_2 as refrigerant
- Integrated concepts have future: combining insulation + natural refrigerants + waste heat + innovative lightings
- Further gains are possible through an ongoing system operation optimization
- Outlook:
  - + energy supermarkets are possible
  - hybrid BIPV systems to be developed for PV and daylighting integration
  - Supermarket to grid: through PV power and waste heat usage

Thank you for your attention!

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