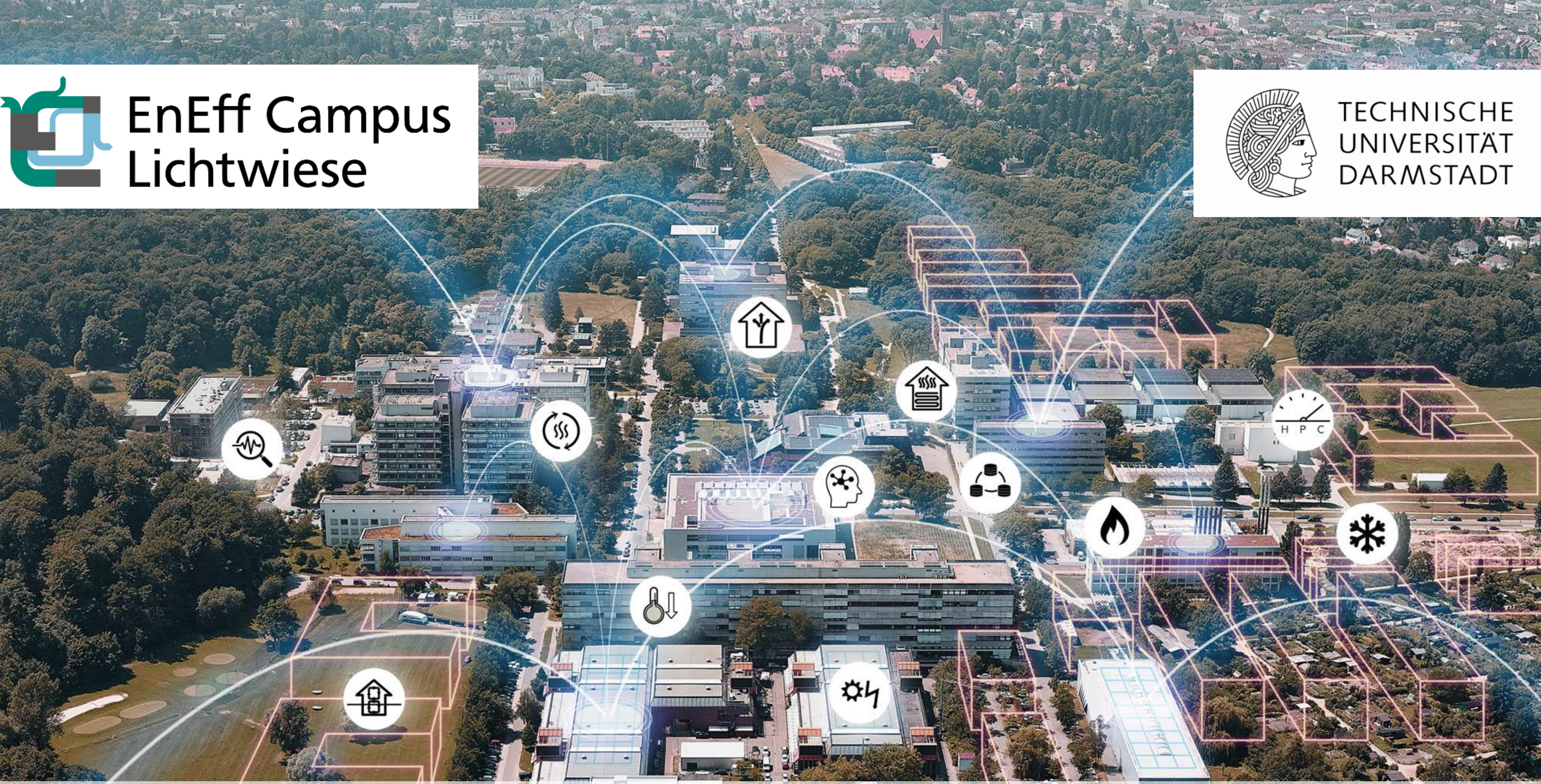
EnEff Campus Lichtwiese

TECHNISCHE UNIVERSITÄT DARMSTADT



Reducing the temperature of an existing district heating system

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TU Darmstadt

ENERGIE WENDE BAUEN

Forschung für energieoptimierte Gebäude und Quartiere

PtJ Projektträger Jülich Forschungszentrum Jülich

Gefördert durch:

Bundesministerium für Wirtschaft und Energie

aufgrund eines Beschlusses des Deutschen Bundestages

EnEff:Stadt
Campus Lichtwiese II

EnEff Campus Lichtwiese

TECHNISCHE UNIVERSITÄT DARMSTADT

How can CO_2 emissions at Campus Lichtwiese be reduced by 80% compared to 1990?

Project period:

2019 -2022

Supported by:

Gefördert durch:

Bundesministerium für Wirtschaft und Energie

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ENERGIE WENDE BAUEN Forschung für energieoptimierte Gebäude und Quartiere

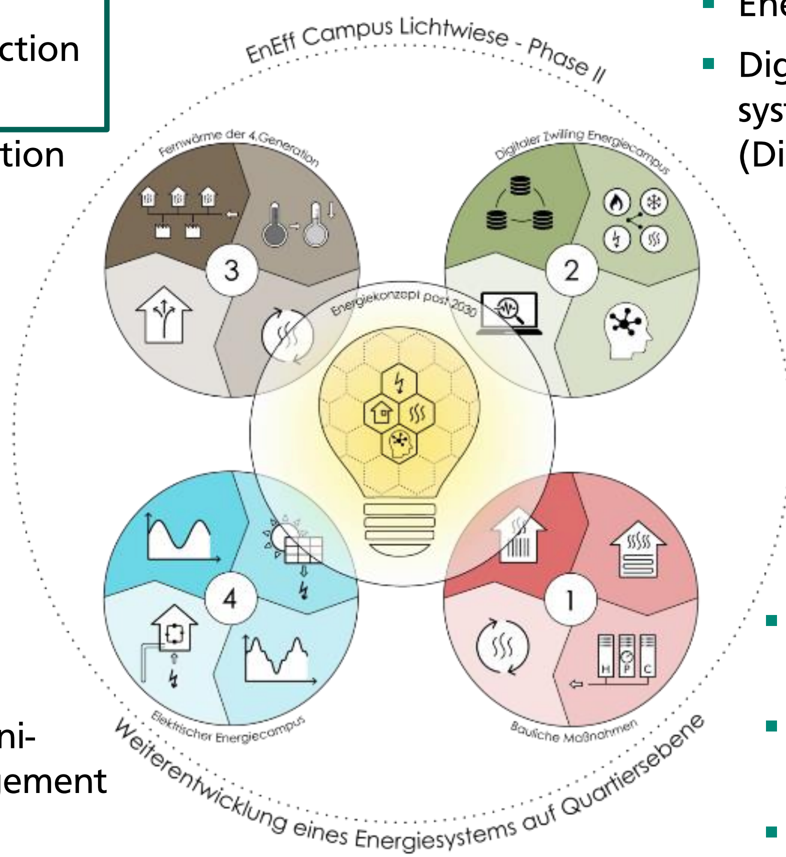
PtJ Projektträger Jülich Forschungszentrum Jülich

- District heating temperature reduction (4GDH)
- Waste heat utilization data center
- Renewable heat

TTD Technische Thermodynamik

EV

- Power quality monitoring and management



- Energy monitoring
- Digitalization & energy system optimization (Digital Twin)

EINS
Energy Information Networks and Systems

ENB

- Energetic building optimization
- Temperature reduction buildings
- Flexibilization of building heat supply

Quick facts on Campus Lichtwiese

The campus was first erected in the 1960s and expanded repeatedly.

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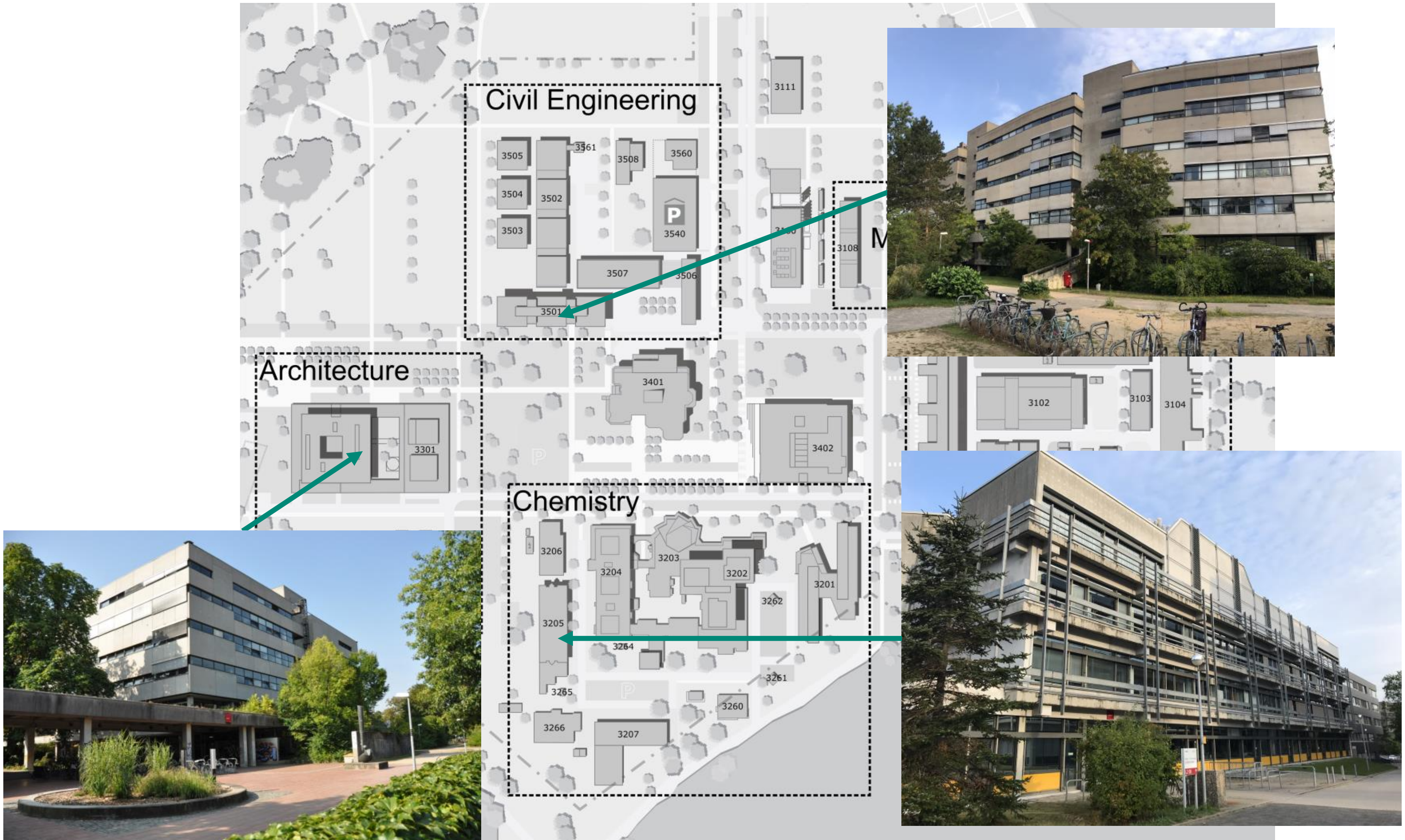
Category	Quantity	Unit
Land area for buildings served by heat distribution network	245000	m²
Total heated floor area in buildings connected	150000	m²
Number of buildings connected to district heating	34	-
Trench length for heat distribution network	4200	m
Heat annually supplied into the district heating network	27000	MWh
Heat annually delivered from the heat distribution network	23000	MWh
Average outer pipe diameter in the heat distribution network	240	mm
Annual average supply temperature in the heat distribution network	88	°C
Annual average return temperature in the heat distribution network	58	°C
Annual average outdoor temperature	10	°C

Building stock at TU Darmstadt Lichtwiese

Campus Lichtwiese was first developed in the late 1960s.



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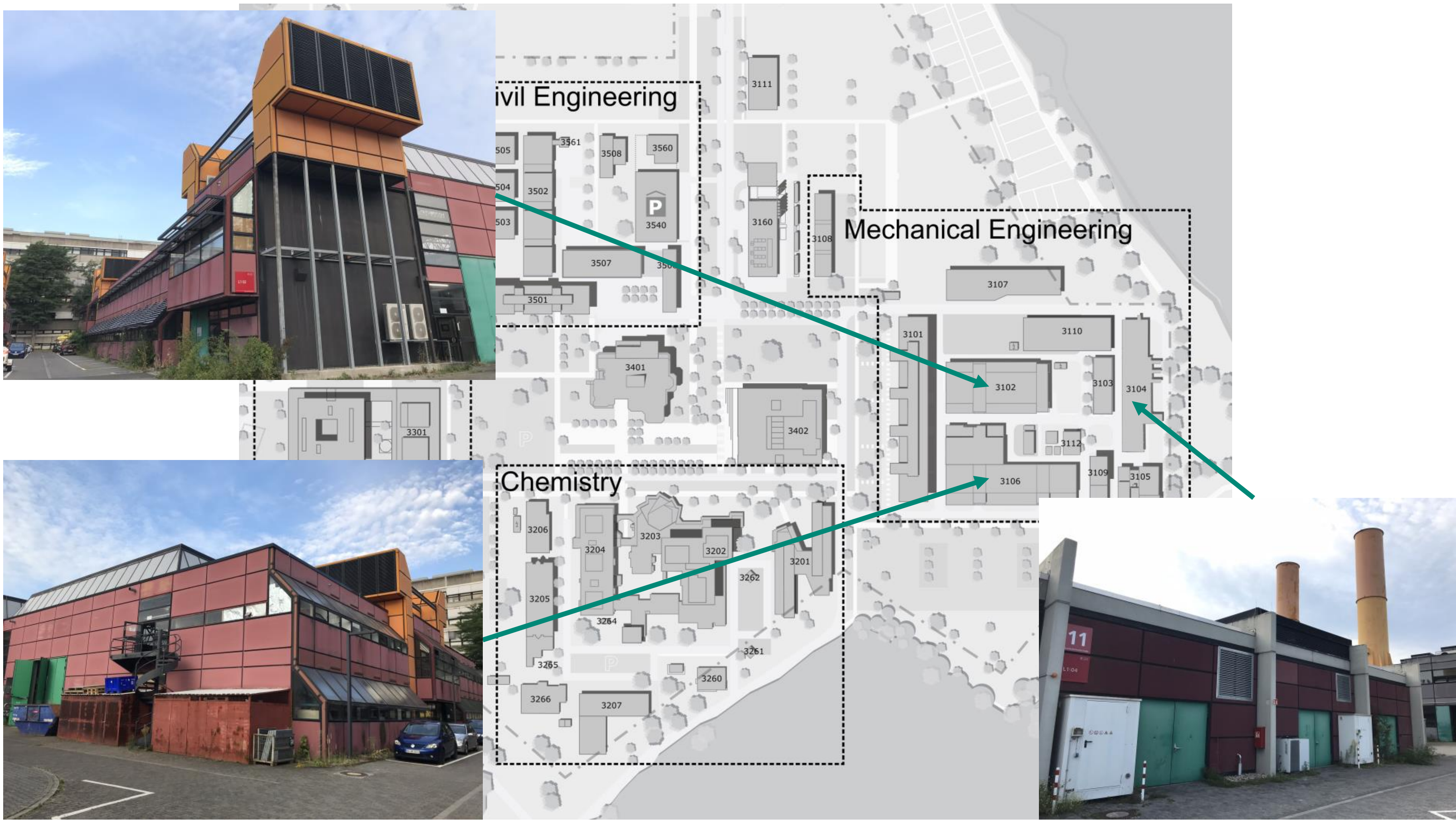
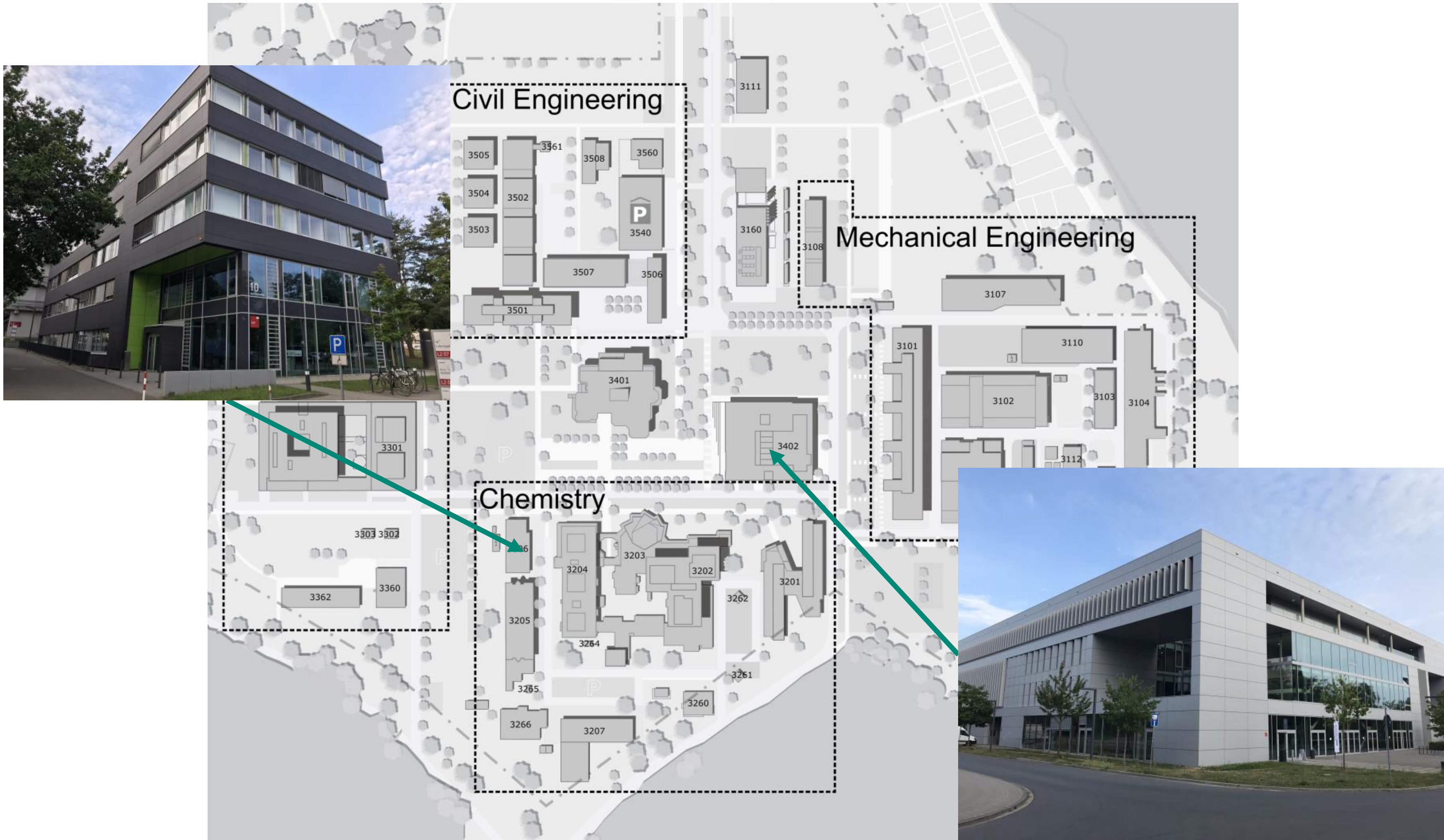


Building stock at TU Darmstadt Lichtwiese

In the last 10 years, several new buildings have been added.



Measures to decrease building temperatures

Depending on the current building performance, different measures have to be applied.

Measure	Key figure	Formula	
• Hydraulic balancing • Renovation of ventilation system	• Building Impact on $\overline{T}_{\mathrm{R,Campus}}$	$\overline{\Delta T}_{\mathrm{R,Campus}} = \frac{\sum_{\mathrm{i}} \frac{\left(T_{\mathrm{Build,R,I,i}} - T_{\mathrm{R,target}}\right) \cdot \dot{M}_{\mathrm{Build,i}}}{\dot{M}_{\mathrm{Campus,i}}}}{\sum \tau} \; [\mathrm{K}]$ $T_{\mathrm{R,target}} = 35°C$	
Installation of surface heating system	Logarithmic excess temperature	$\overline{\Delta T}_{\mathrm{m}} = \frac{\sum_{\mathrm{i}} \frac{T_{\mathrm{S,II,i}} - T_{\mathrm{R,II,i}}}{\ln\left(\frac{\overline{T}_{\mathrm{S,II,i}} - T_{\mathrm{room,i}}}{T_{\mathrm{R,II,i}} - T_{\mathrm{room,i}}}\right)}}{\sum \tau} \; [\mathrm{K}]$	
Building renovation	Share of overall heat demand compared to dimensionless heat demand of each building	$\frac{\sum Q_{\mathrm{Build}}}{\sum Q_{\mathrm{Campus}}}$	$\frac{\sum Q_{\mathrm{Build,real}}}{\sum Q_{\mathrm{Build,ref}}}$

Hydraulic balancing & ventilation systems

Comparison of building impact on campus return temperature and building return temperature.

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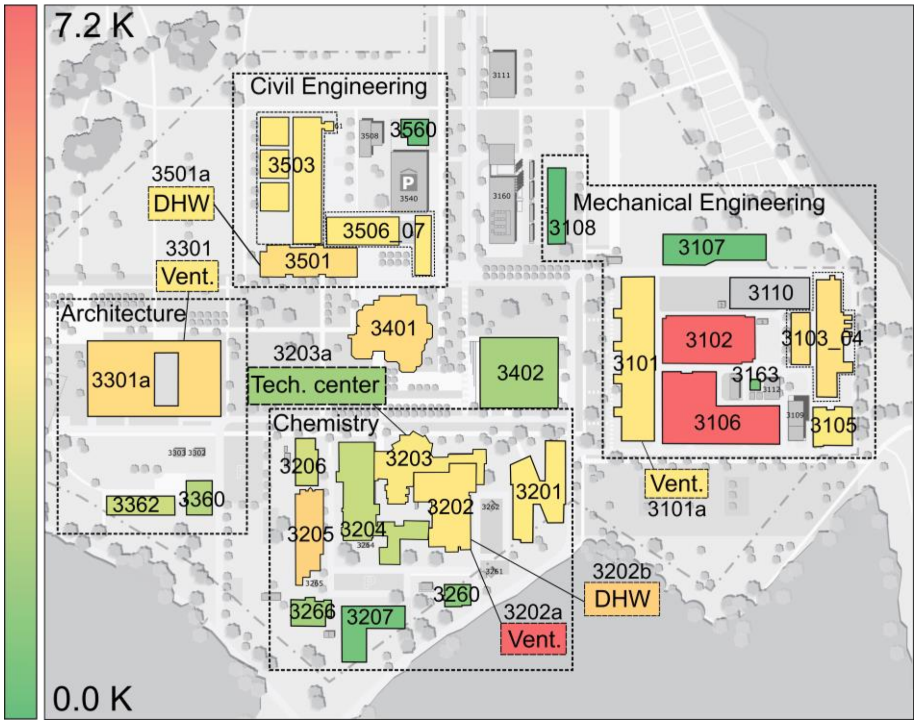
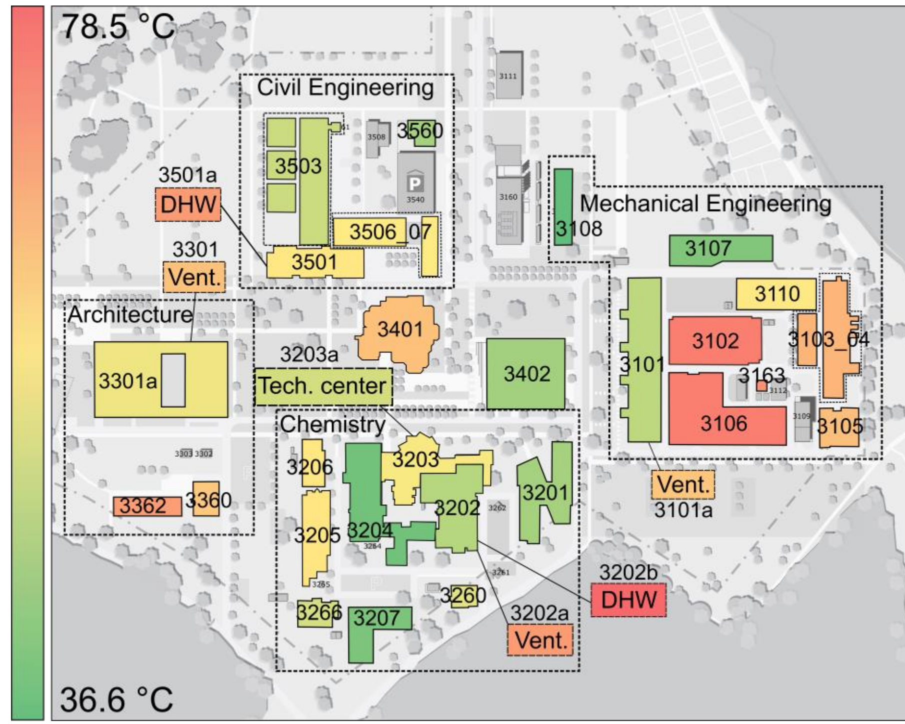
Individual building impact on campus return temperature ($\bar{T}_{\mathrm{R,target}} = 35°C$)



Building return temperature



Large buildings have a significant impact on the campus return temperature, even when their indivual return temperature is not exceptionally high.

Hydraulic balancing & ventilation systems

Poorly functioning ventilation systems are a major cause for high return temperatures.

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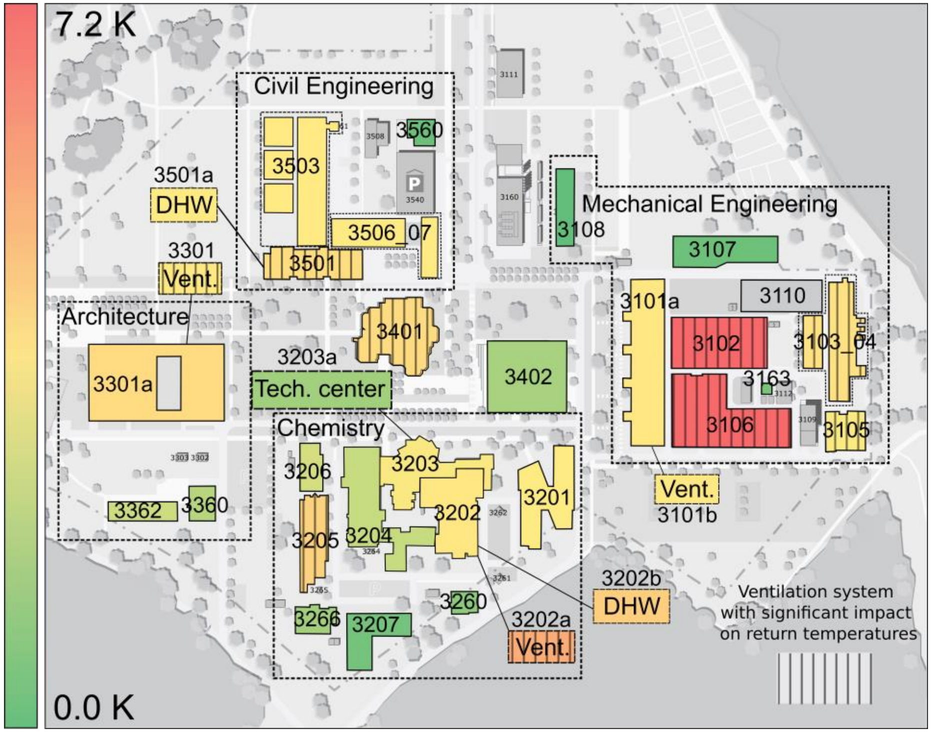
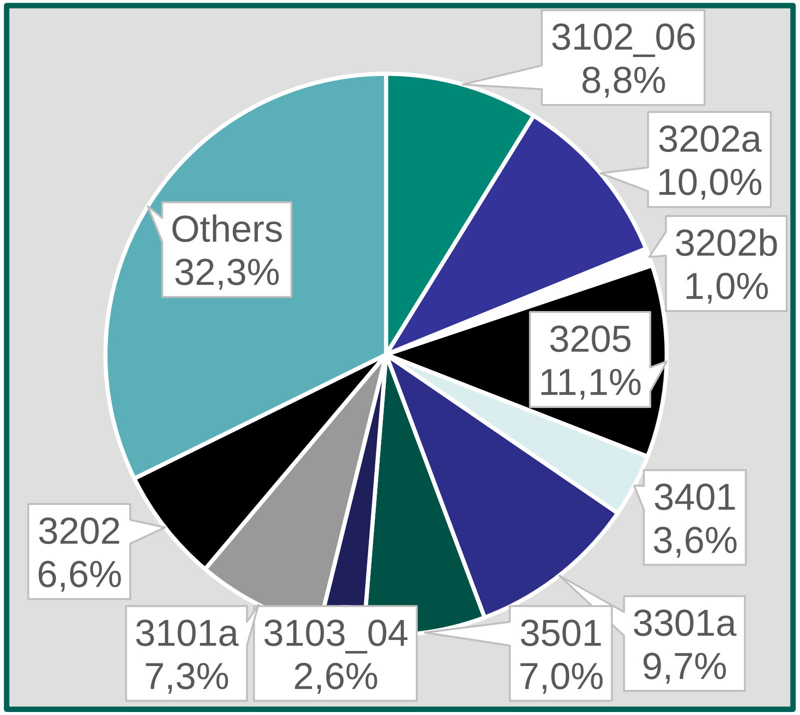
Individual Building Impact on Campus Return Temperature ($\bar{T}_{\mathrm{R,target}} = 35°C$)



Share of campus heat demand 04/2017 – 04/2019



Most buildings with high impact on the campus return temperature have high heat demands and a poorly functioning ventilation system.

Impact Mechanical Engineering laboratories 1&2

The Mechanical Engineering laboratories influence the return temperature significantly.

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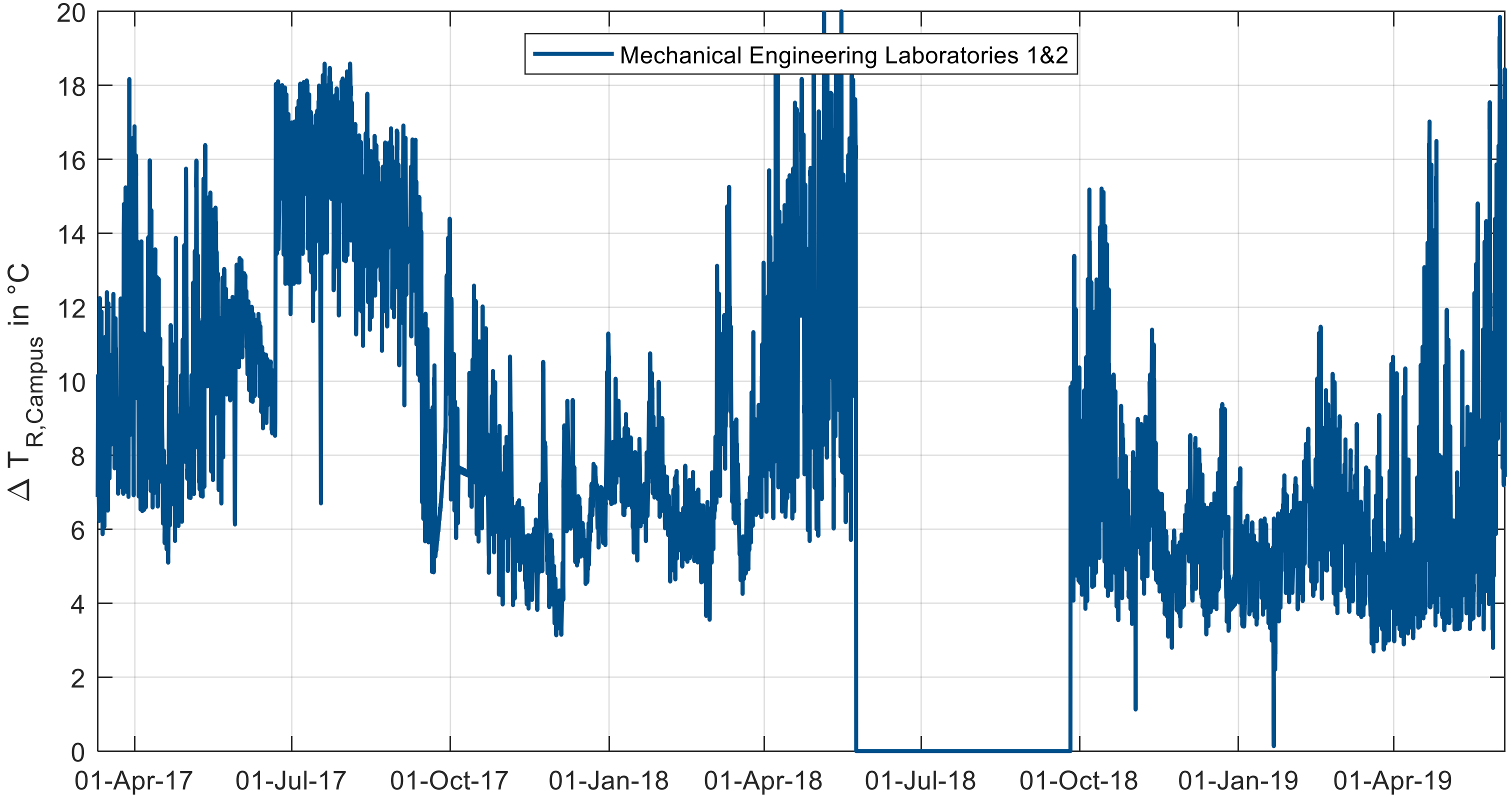
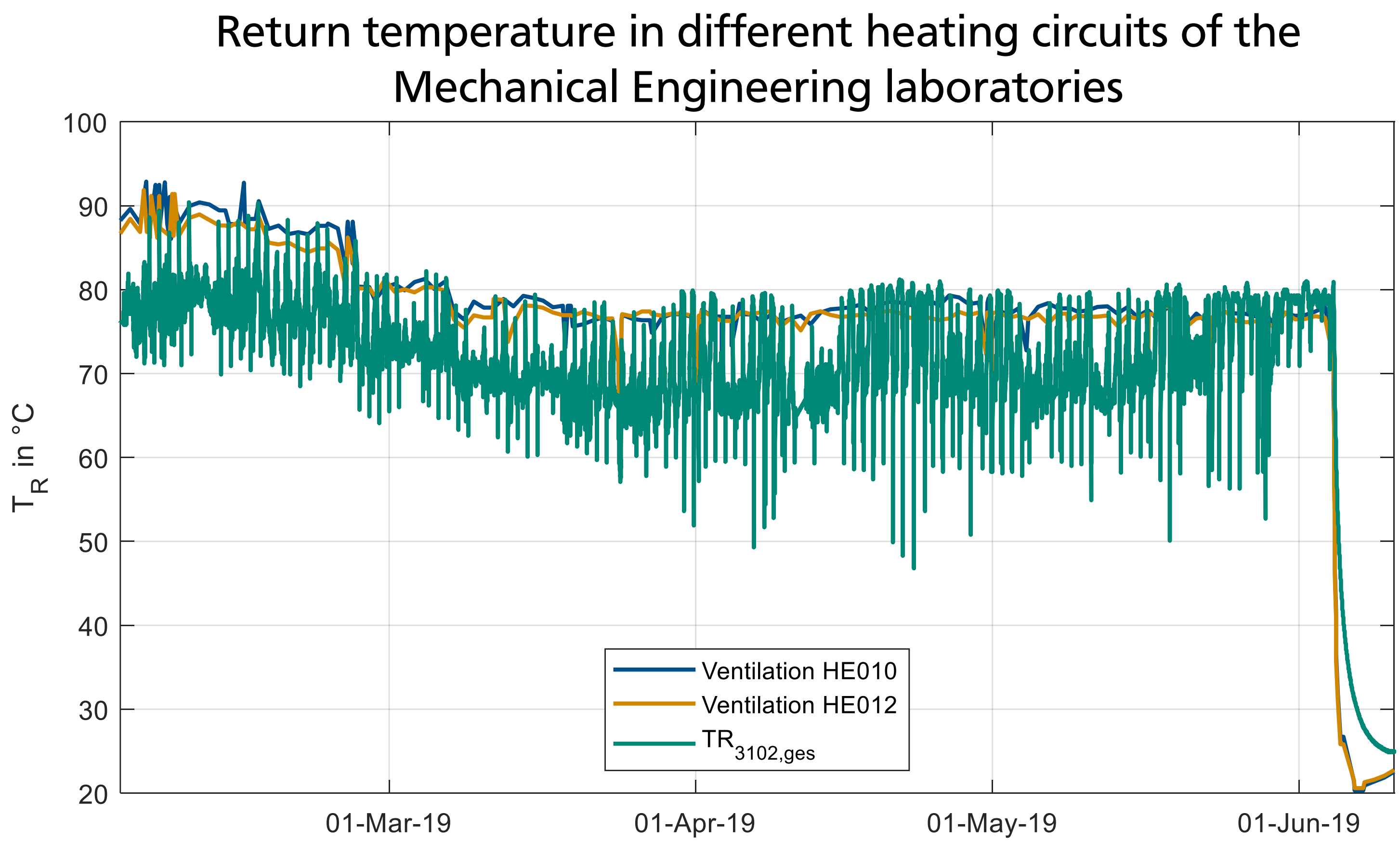
Impact of the Mechanical Engineering laboratories on campus return temperature ($T_{R,target} = 35°C$)



The Mechanical Engineering laboratories increase the campus return temperature by up to 20 K compared to the target temperature $T_{R,target} = 35°C$.

Return temperatures of ventilation systems

The ventilation systems show almost constant return temperatures of about 80°C.

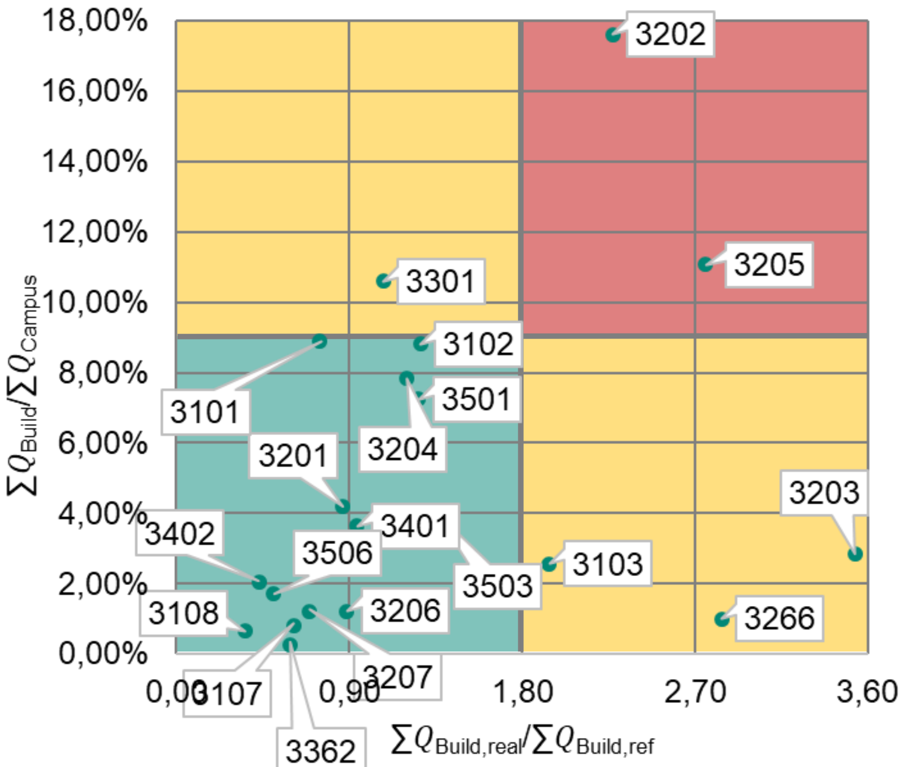


During the winter months, return temperatures from the ventilation systems are between 75°C and 90°C and supply temperatures are only 10-15 K higher.

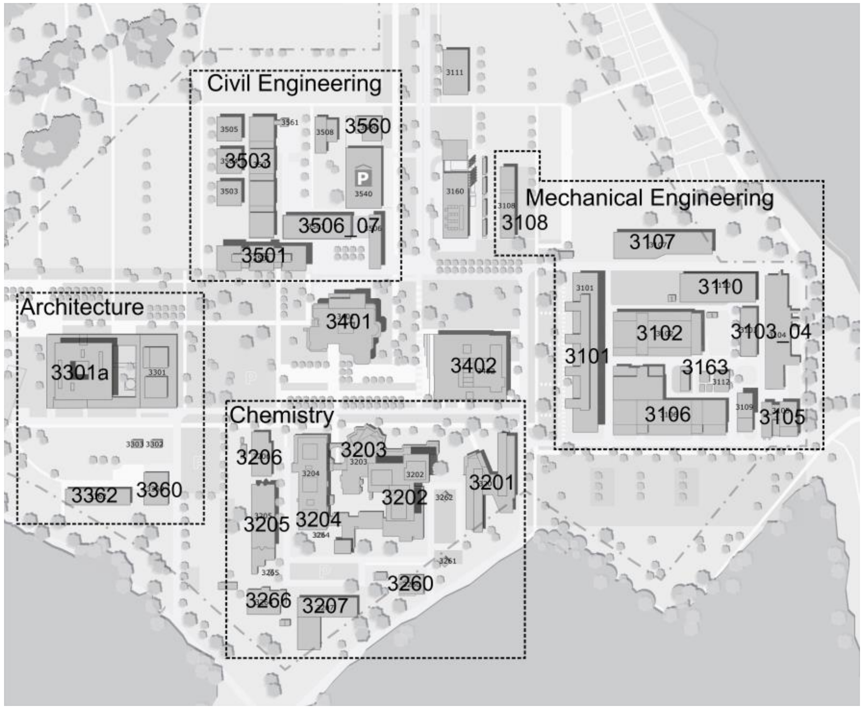
Building renovation

A comprehensive building renovation is most necessary in big old buildings.

Share of overall heat demand compared to dimensionless heat demand of each building



Lichtwiese campus map



Especially in the chemistry department, comprehensive building renovation of the institute buildings is an urgent need.

Conclusion

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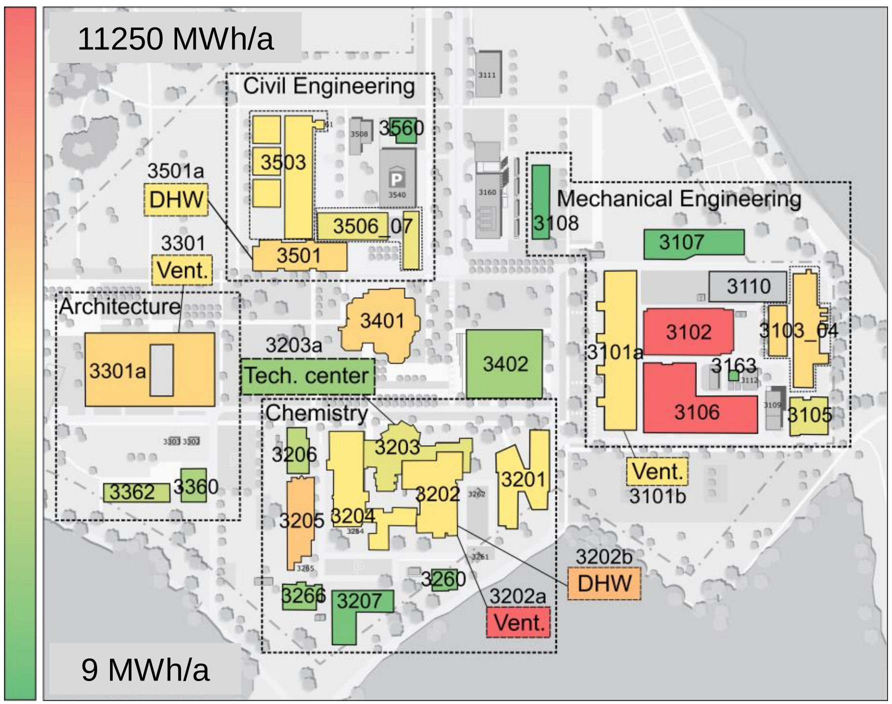
- The most pressing issue in terms of district heating return temperatures are malfunctioning ventilation systems.
  - Mechanical Engineering laboratories
  - Chemistry buildings
  - University restaurant
  - Institute buildings architecture & civil engineering
- Not all buildings have to be renovated in order to reduce network temperatures, an important impact can be achieved concentrating on the worst performing buildings.


H P C
Thank you for your interest!

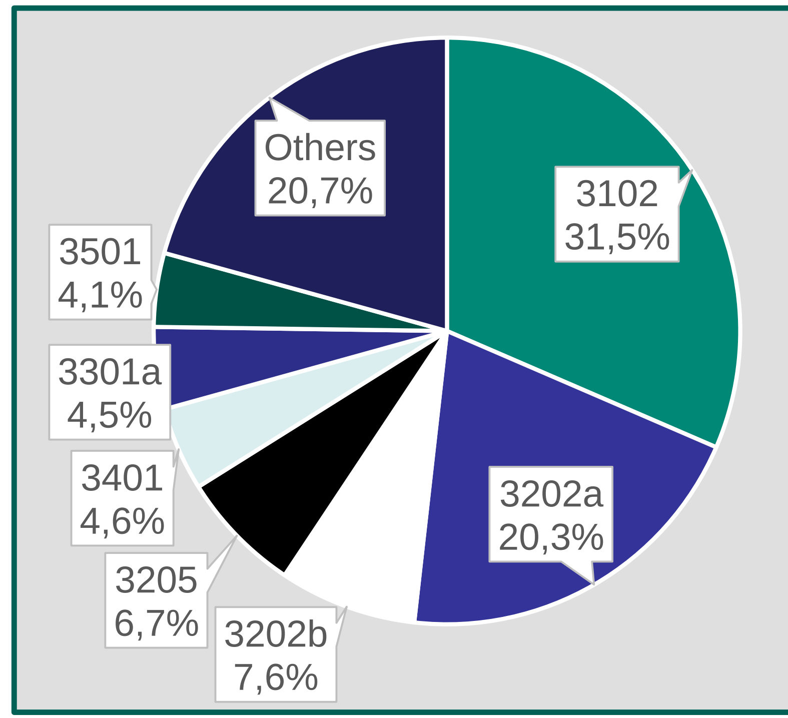
Energetic analysis of the buildings' return flow

80% of the return flow energy come from the 7 most important heating circuits.

Aggregated enthalpy difference between return temperature and $\bar{T}_{\mathrm{R,target}} = 35°C$



Share of aggregated enthalpy difference 04/2017 – 04/2019



$$U_{\mathrm{Build,R}} = \sum_i \dot{M}_\mathrm{i}\, \Delta\tau_\mathrm{i} \cdot c_W \left(T_{\mathrm{Build,R,i}} - T_{\mathrm{R,target}}\right)$$

Measures to decrease building temperatures

Depending on the current building performance, different measures have to be applied.

Impact / Cost

Measure	Key figure	Formula	
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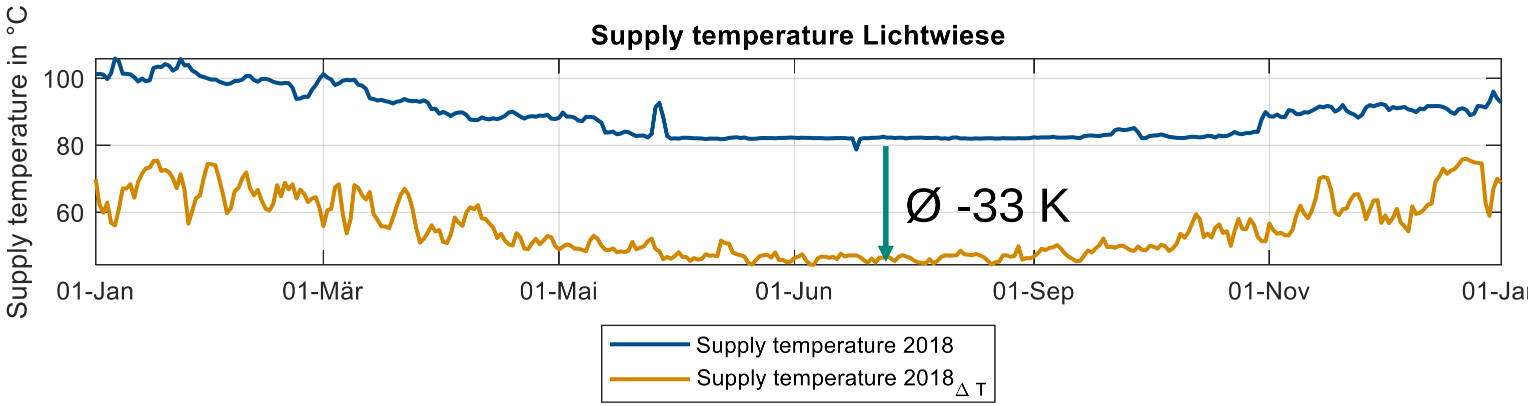
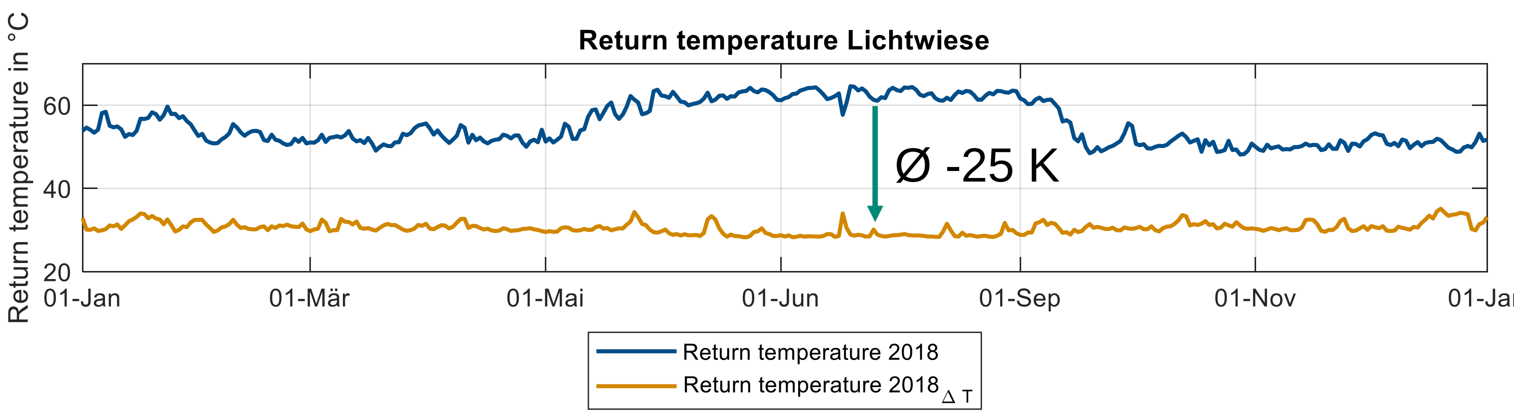
Building renovation	Share of overall heat demand compared to dimensionless heat demand of each building	$\frac{\sum Q_{\mathrm{Build}}}{\sum Q_{\mathrm{Campus}}}$	$\frac{\sum Q_{\mathrm{Build,real}}}{\sum Q_{\mathrm{Build,ref}}}$

Comparison of district heating temperatures

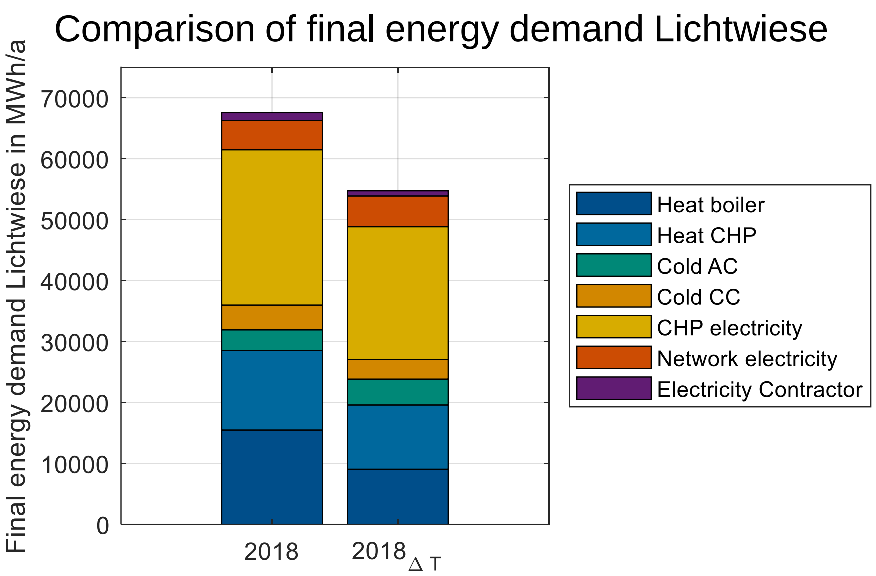
Surface heating makes major temperature reductions possible.

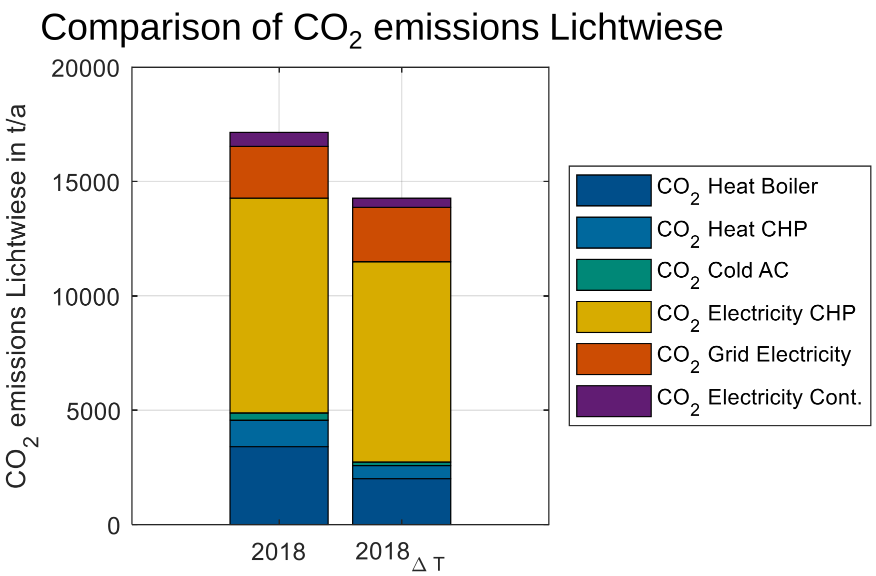




Final energy and CO_2 emissions savings

Decreasing network temperatures helps reduce final energy demand and CO_2 emissions.





- Final energy demand is decreased due to lower building heat demand and **reduced losses in district heating**.
- The temperature decrease has a high impact on the boiler heat generation.

- CO_2 emissions for heat generation is decreased considerably.
- The greatest share of CO_2 emissions is emitted by **CHP electric generation** and **grid electricity demand**.