EnEff Campus Lichtwiese

TECHNISCHE UNIVERSITÄT DARMSTADT

Interdisciplinary Research Project

„EnEff:Stadt Campus Lichtwiese II“

IFast Annual Meeting WP11, 03.05.2020

Supported by:

Federal Ministry for Economic Affairs and Energy

on the basis of a decision by the German Bundestag

ptj Projektträger Jülich Forschungszentrum Jülich

ENERGIE WENDE BAUEN

Forschung für energieoptimierte Gebäude und Quartiere

EnEff:Stadt Campus Lichtwiese II –

Interdisciplinary energy system research project at the TU Darmstadt

EnEff Campus Lichtwiese

TECHNISCHE UNIVERSITÄT DARMSTADT

Project duration:

2019 -2021

Funding volume:

4,5 Mio. €

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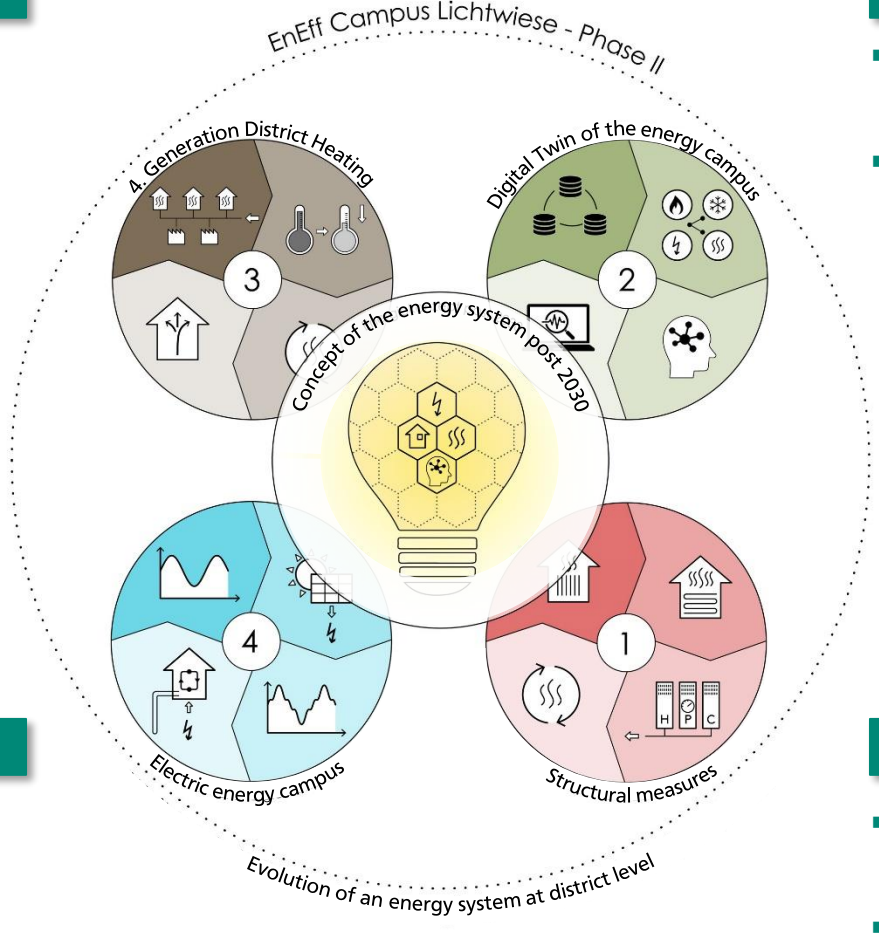
Mechanical Engineering

- Low temperature grid (4. Generation district heating)
- Waste heat utilization of high-performance computing

TTD Technische Thermodynamik

Electrical Engineering

- Power Quality Monitoring & Management



Electrical Engineering

- Implementation of the high resolution energy monitoring
- **Digitization of the energy system(„Digital Twin“)**

EINS Energy Information Networks and Systems

ENB

Architecture

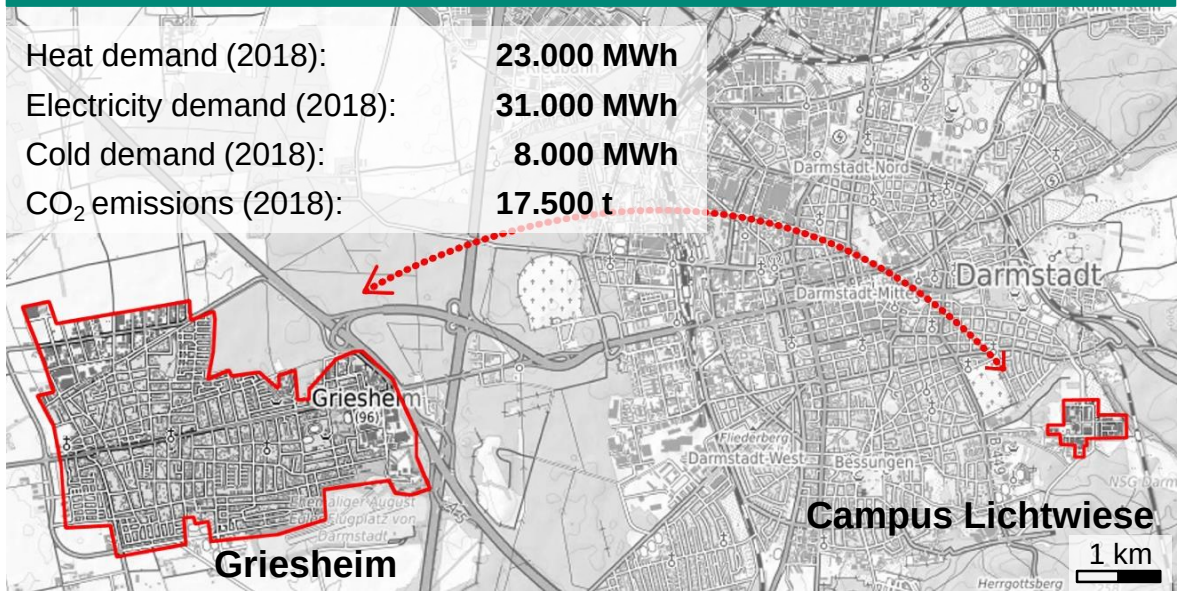
- Energetic modernization of the building stock
- Flexibilization of heat demand in existing buildings

The Campus Lichtwiese: A Multi Energy System

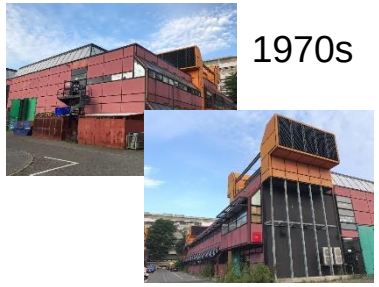
The campus self-supplies electricity, heat, and cold

The electricity demand corresponds to that of a small town

Heat demand (2018):	**23.000 MWh**
Electricity demand (2018):	**31.000 MWh**
Cold demand (2018):	**8.000 MWh**
CO_2 emissions (2018):	**17.500 t**

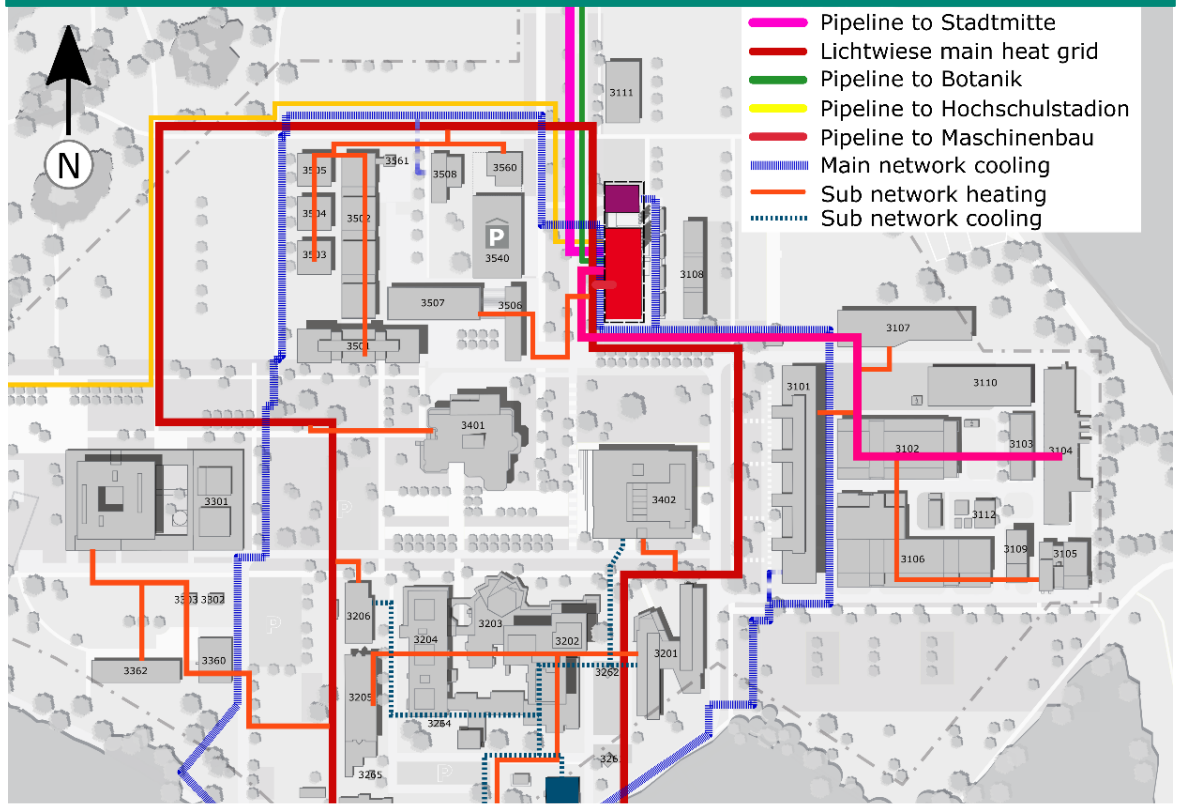


1960s


1970s

2010s

The campus has its own supply networks + generation

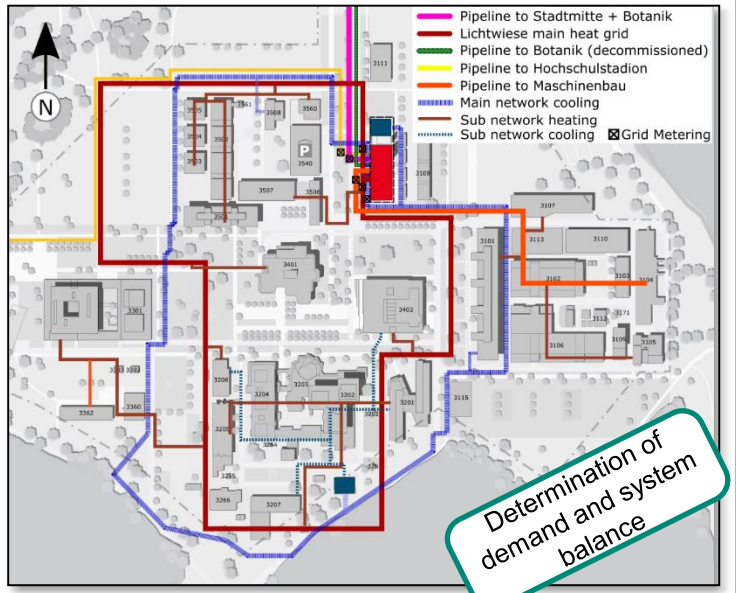


- CHPs (gas fueled):
  - 3x P = 2.0 MW_{th} / 2.0 MW_{el}
  - 1x P = 3.0 MW_{th} / 3.25 Mw_{el}
- 6 Gas boiler ∑ 9.3 MW_{th}
- 1 absorption chiller 1 MW_{th}
- 2 compression chiller ∑ 1.0 MW_{th}

Digital Twin: Energy Monitoring

Over 380 million data points are stored per day

Thermal | Status: Completed

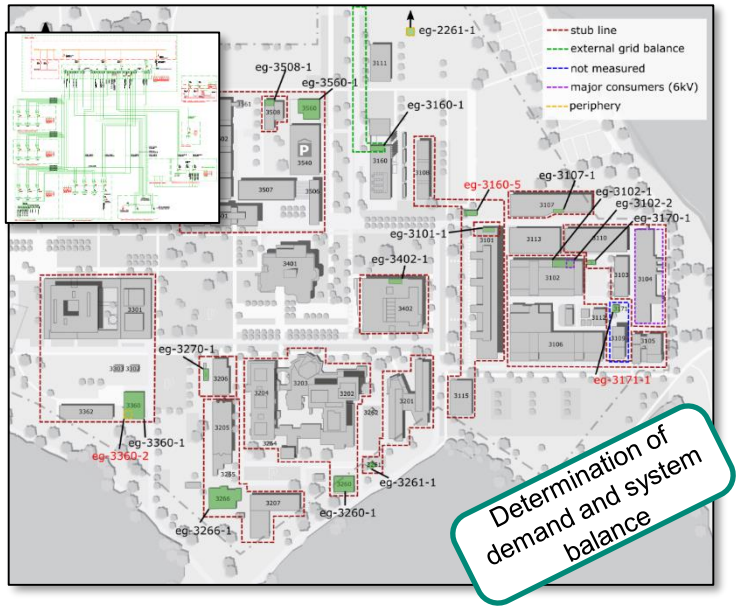


- 37 Heat meters
- 16 Cold meters

Integration of the billing meter devices

- Heat network measurements
  - Five within heating network
  - One within cooling network
- 47 heat meter devices inside buildings

Electricity | Status: Completed



- 17 Network analyzers (medium voltage: 6kV/ 20kV)
- 142 Active power meters (low voltage: 400V)

Supply | Status: Completed

- Power plant data from the energy contractor:
  - Absorption/compression chillers
  - Combined heat and power units
  - Boilers and storage tanks

➢ ~180 data points

Implementation of a Digital Twin of a Multi Energy System

Part of the EnEff campus Lichtwiese project at TU Darmstadt

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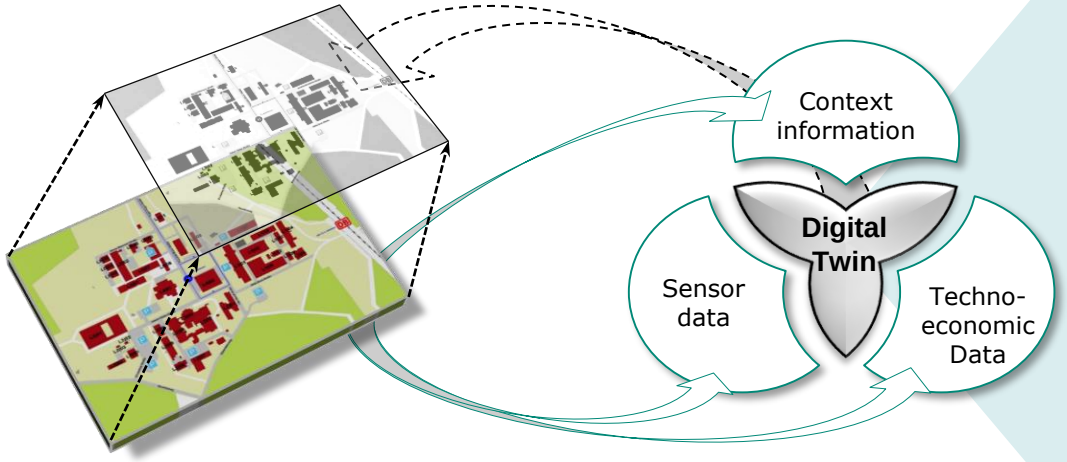
A Digital Twin is...

Digital twin provides target state



Real system provides actual state

...a virtual representation of a real world system.

Objective: Optimization of the Systems Performance (Cost and Emission minimal)

Operational Optimization: Two staged cost and emission optimization

Input

- Demand Time series D(t)
- Technology parameters $\eta, u_p, \bar{P}$
- Price Time series $c_{var}(t)$
- CO2 Intensity $CO_2I(c,t)$

Cost $min \sum_t c_{var}(t) u_{cp} P\ (c_{in}, cp, c_{out}, t)$

CO_2 $min \sum_t P\ (c_{in}, cp, c_{out}, t)\ CO_2I(c,t)$

s.t. $P(c_{in}, cp, c_{out}, t) \leq u_{cp}(t)\bar{P}(cp)$

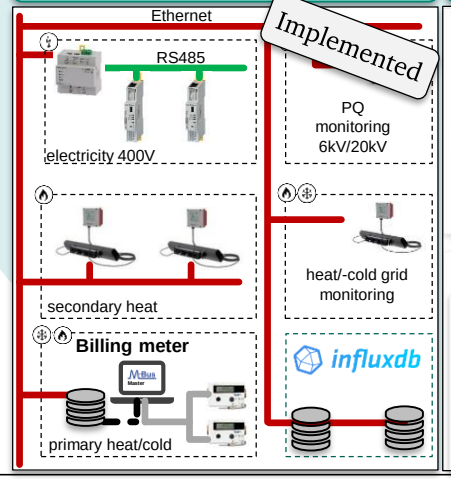
$u_{cp} \in \{0,1\}$

- Energy balance
- Consistent storage operation
- Co-generation efficiency
- ...

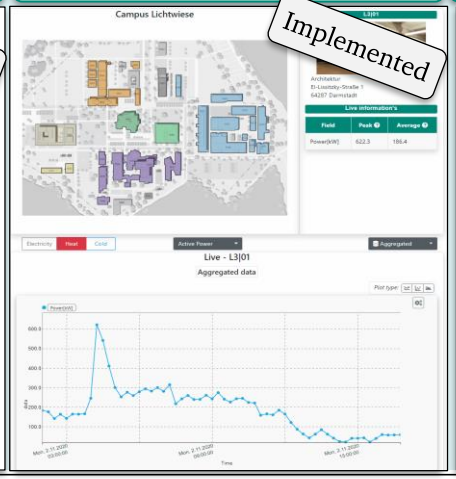
Output

- Dispatch P(j,t,y)
- Costs €
- Emissions CO2

High-Res Energy Monitoring — Implemented



Web-based energy platform — Implemented

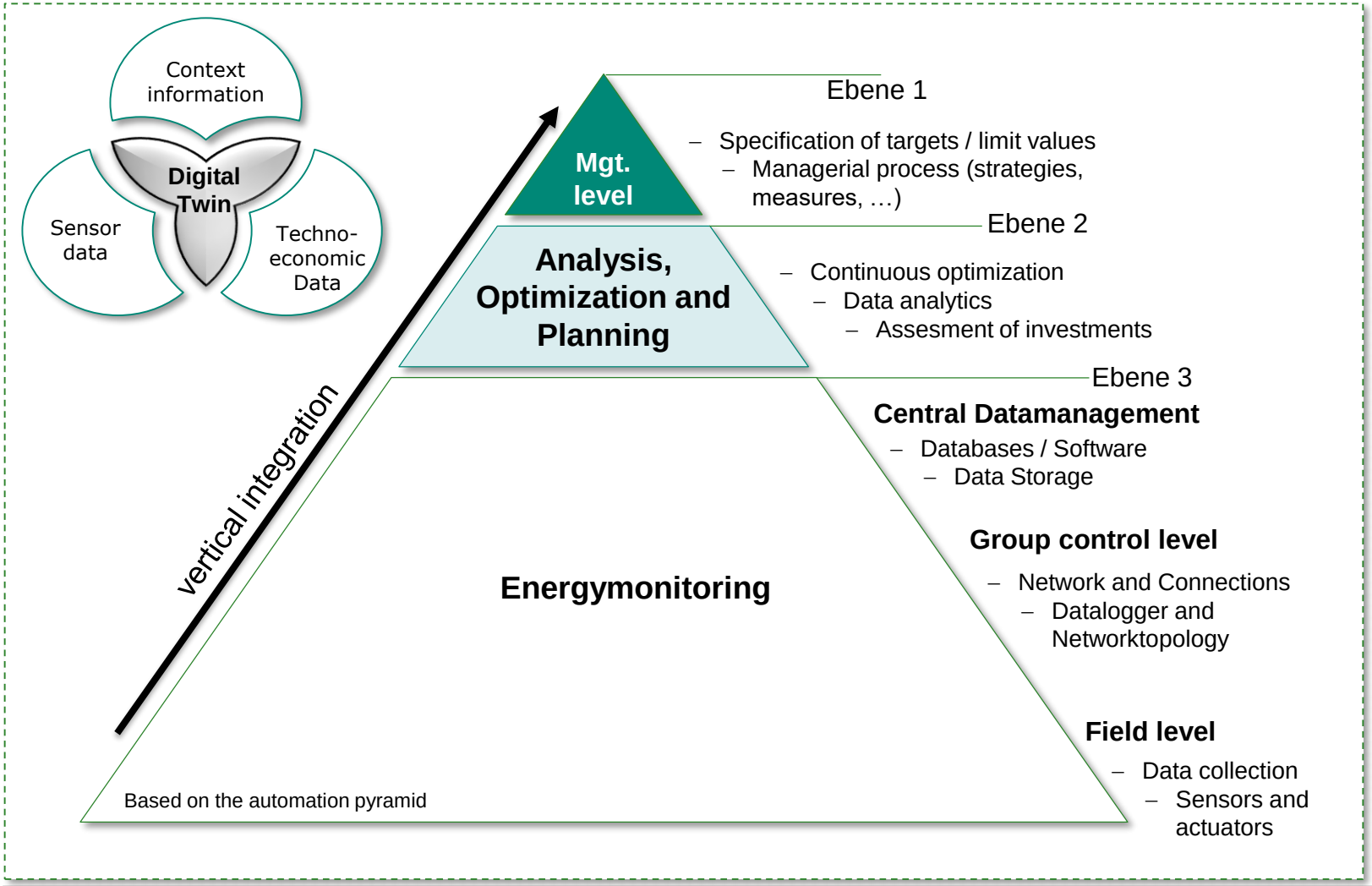


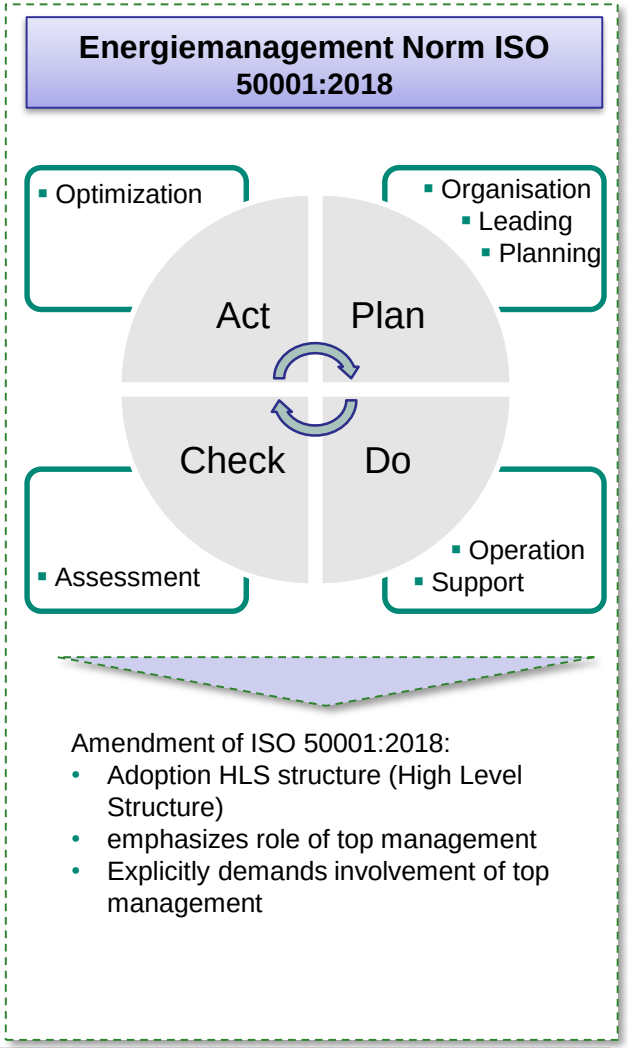
Machine Learning Forecasts — In progress

- Automatized data validation
- Probabilistic forecast for electricity, heat, and cold
- Operational parameter estimation, e.g., efficiency rates, power gradients

The Digital Twin and Energy Management Norm ISO 500001

Digital Twin and amendment of ISO 50001:2018





Amendment of ISO 50001:2018:

- Adoption HLS structure (High Level Structure)
- emphasizes role of top management
- Explicitly demands involvement of top management

Modern and Interactive Data Access

Web-based energy platform of the developed digital twin

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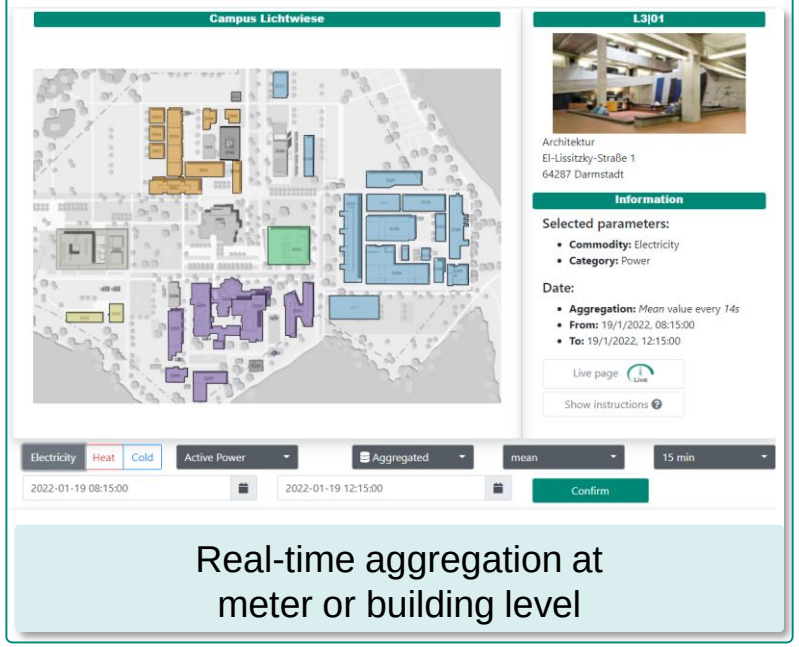
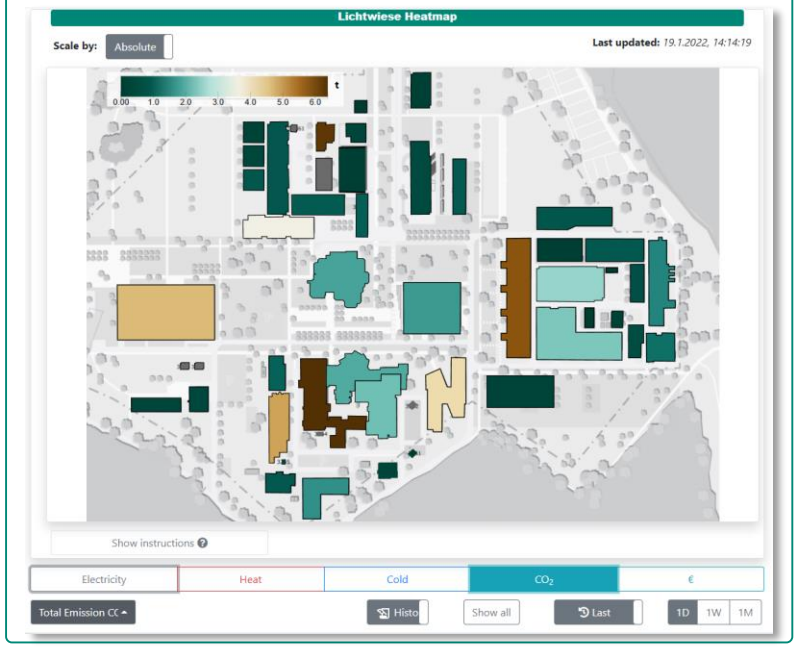
Access to monitoring data via bird's eye view

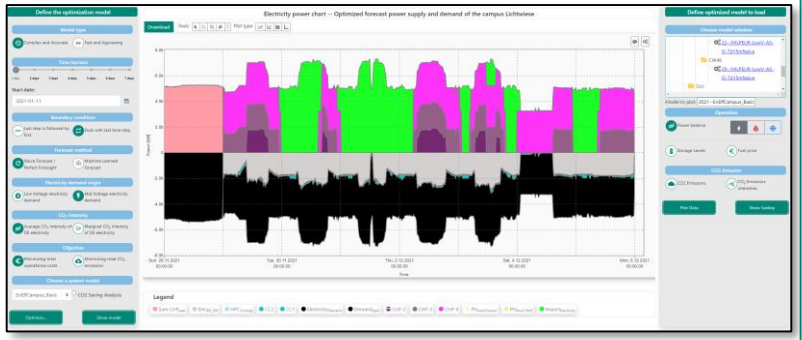


Real-time aggregation at meter or building level

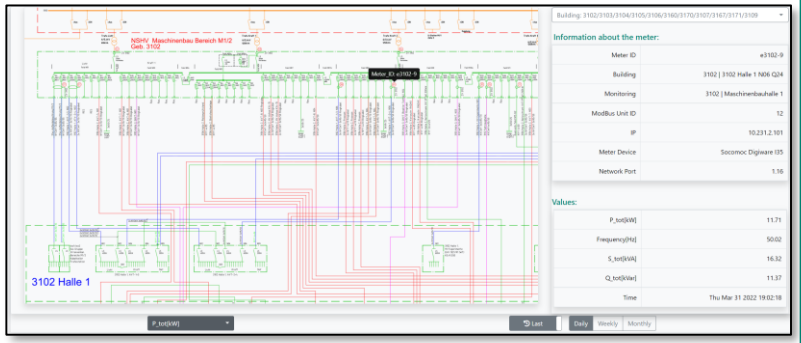
Energy heatmap: The energy system at a



Further applications



App: Optimization Control Panel



App: Interactive Circuit Diagrams

EnEff web platform is in operation - access exclusively via TU Darmstadt VPN

- Platform enables access to all measurands of all meters device, aggregated or raw data
- Presentation of variables derived from the data, such as CO2 emissions per building
- Final goal ⇨ Live optimization based on machine learning forecast (currently in development)

Live Demo

Thank you for your interest!

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Room for questions