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SDU OU44 – Big Data Living Lab

Occupancy Team at SDU Center for Energy Informatics

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Vision: *Sustainable Software-Defined Buildings in Symbiosis with their Occupants*

Post Doc **Aslak Johansen**, PhD Student **Fisayo Caleb Sangogboye**, PhD Student **Jakob Hviid**, PhD Student **Anooshmita Das** and Software Developers **Jens Hjort Schwee**, **Kennet Vangsgaard**, **Antonio Lascari**, **Daniel Åside, Emil Stubbe Kolvig-Raun**

25 people in the Center for Energy Informatics.
Head of Center is Bo Nørregaard Jørgensen

Why is Occupant Behavior Relevant?

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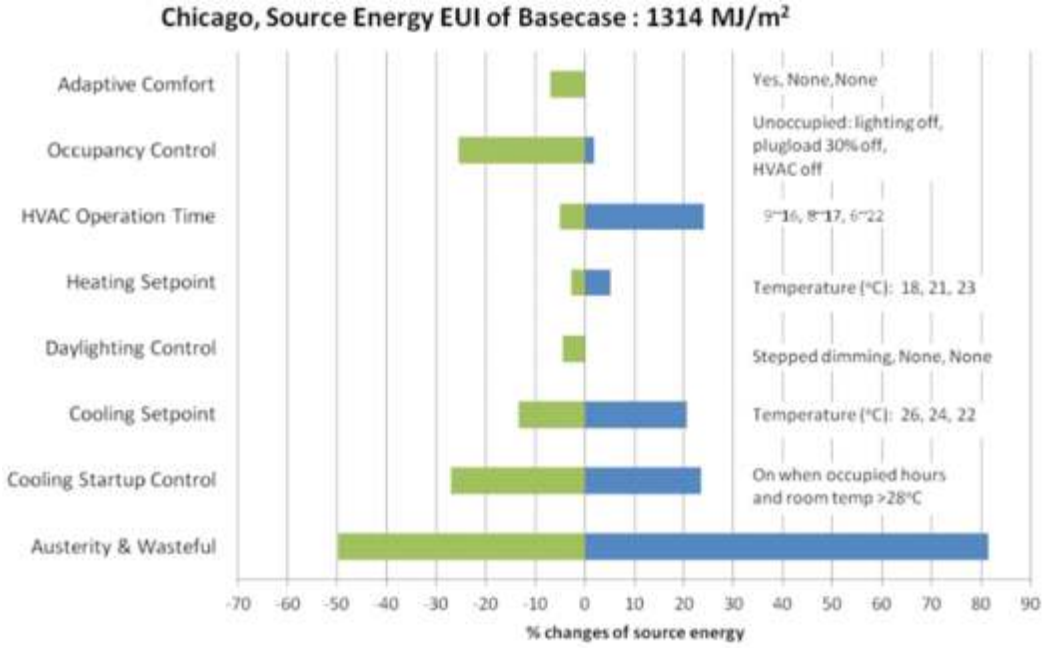
- Technologies alone not necessarily guarantee low energy use in buildings.
- Human behavior plays an essential role in buildings, but it is not well understood and usually over-simplified.

New book out as result of IEA EBC Annex 66



Relative impact on energy of occupant-related behaviors and building operational parameters (https://www.osti.gov/biblio/1172115)

Sensing Occupant Behavior

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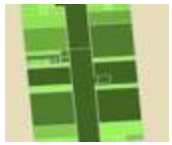
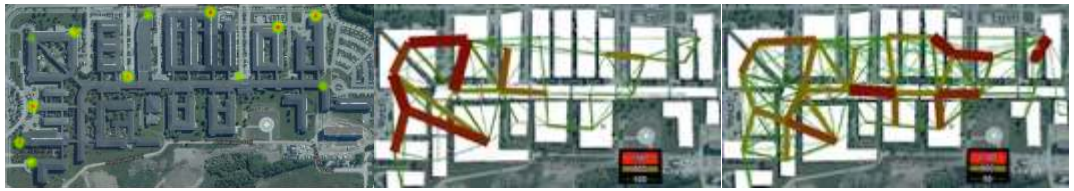
- Augment the environment

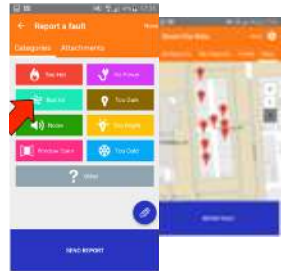



- Repurpose infrastructure



Antonio Jesus Ruiz Ruiz, Henrik Blunck, Thor S. Prentow, Allan Stisen, Mikkel Baun Kjærgaard: Analysis methods for extracting knowledge from large-scale WiFi monitoring to inform building facility planning. PerCom 2014: 130-138

- Occupant Interactions

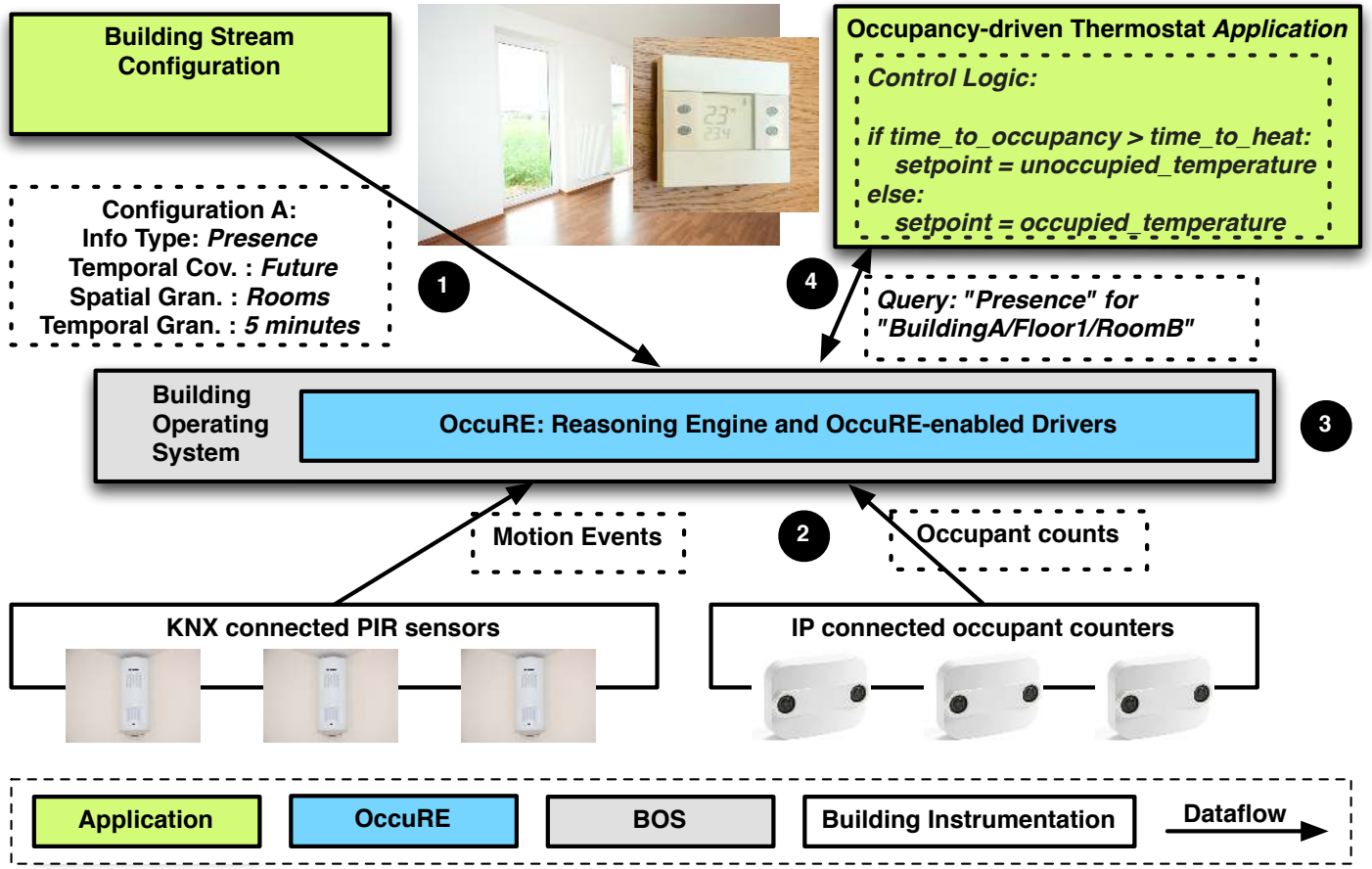



Sanja Lazarova-Molnar, Halldór Þór Logason, Peter Grønbæk Andersen, Mikkel Baun Kjærgaard: Mobile Crowdsourcing of Data for Fault Detection and Diagnosis in Smart Buildings. RACS 2016: 12-17

- Augment Persons

- Augment Objects

Software Support for Processing Building Data



- *Kjærgaard et. al.: OccuRE: An Occupancy REasoning Platform for Occupancy-Driven Applications. CBSE 2016: 39-48, ACM.*

Building Data and Web of Things

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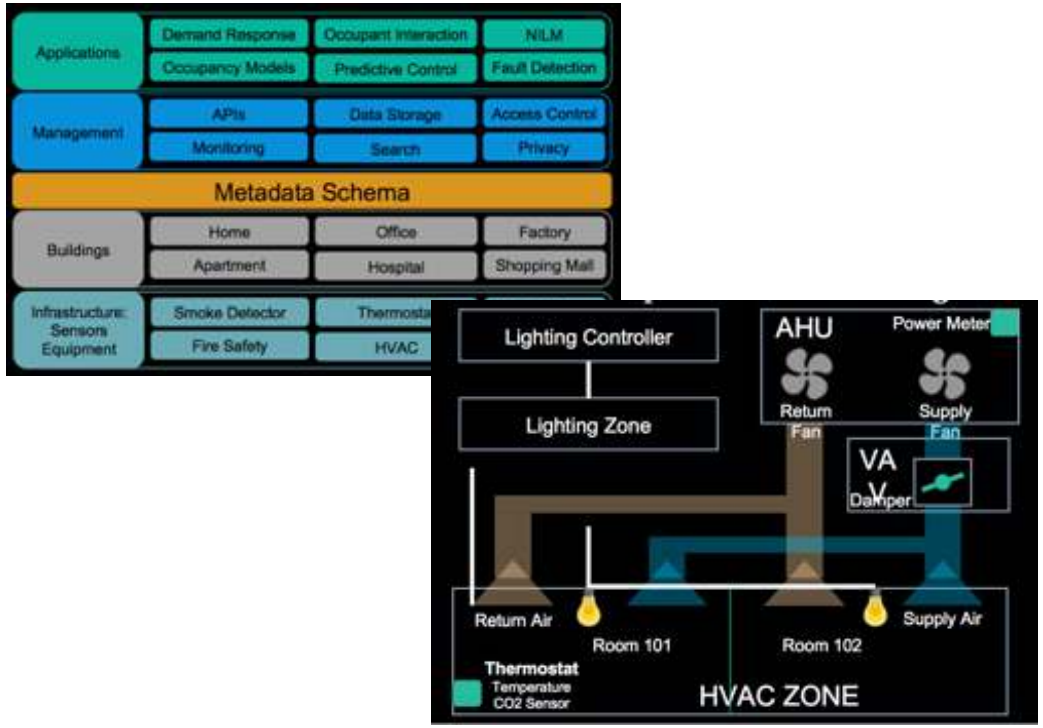
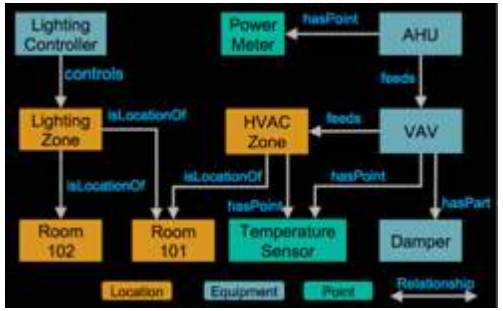
Challenges

- Semantic interpretation of data from buildings
- Increasing problem due to increase in digital building components (e.g. Internet of Things)



We have proposed a metadata scheme named **Brick**. The scheme has been created in an international collaboration with UC Berkeley, IBM Research and CMU among others.

Full details available at **brickschema.org**



Balaji et al., Brick: Towards a Unified Metadata Schema For Buildings. BuildSys 2016: 41-50, ACM.

Press Release: ASHRAE BACnet committee, Project Haystack and the Brick initiative partner to integrate tagging and data modeling into ASHRAE Standard 223P

Privacy Handling for Building Data

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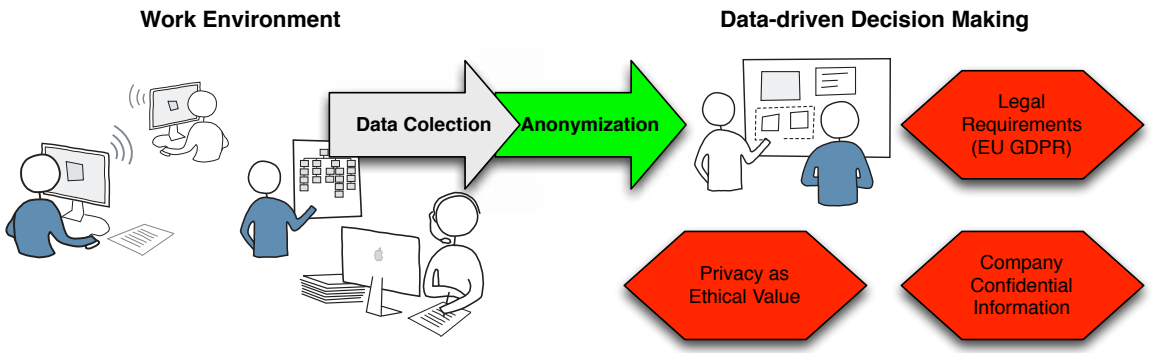
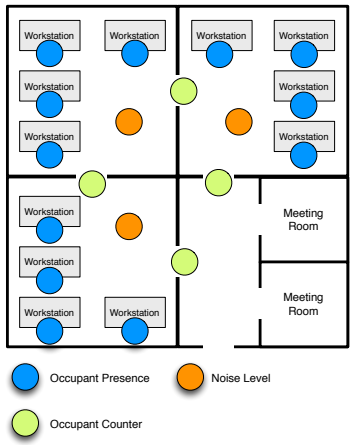
Challenges

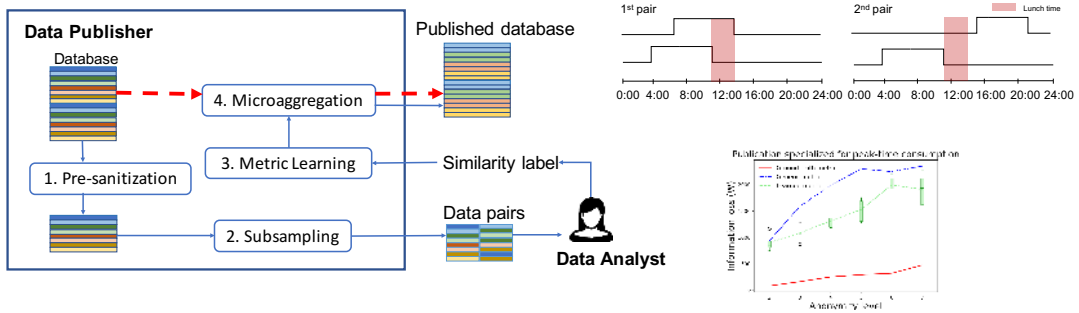
- Responsible data handling and privacy by design





Tools and methods for publishing open and real-time data that handle privacy concerns.

Developed the system PAD for protecting anonymity in publishing building related datasets.



Ruoxi Jia, Fisayo Caleb Sangogboye, Tianzhen Hong, Costas Spanos, and Mikkel Baun Kjærgaard: PAD: Protecting Anonymity in Publishing Building Related Datasets. BuildSys 2017, ACM

University of Southern Denmark

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OU44 Building Living Lab

Basic Information:

- Construction 2014-2015
- Price: 120 MDKK
- Number of Floors: 4
- Area: Blueprints: 8519 m² / Official: 9600 m²

Objectives:

- Automated performance testing
- Continuous performance tests and benchmarking
- FDD
- Automated zone model generation
- Occupancy modeling
- Multiobjective Optimal MPC

OU44 Building Living Lab

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Ventilation: 4 ventilation systems, each with a rotary heat exchanger for reclaiming heat from exhaust air and heating capacity from district heating

Heating: Radiators and ventilation

Light: Dimmable via setpoints

Blinds: Controllable on a per-room basis

Meters:

- Electrical: Building-level, floor-level and half-floor level
- District heating: In / out
- Heated Water: Electric and flow meters

BMS:

- Room-level: Logic distributed on Schneider Electric Automation Servers
- Ventilation: Schneider Electric StruxureWare

Models:

- Revit and Google Schetch-Up
- BE10 and Energy+
- BRICK metadata model

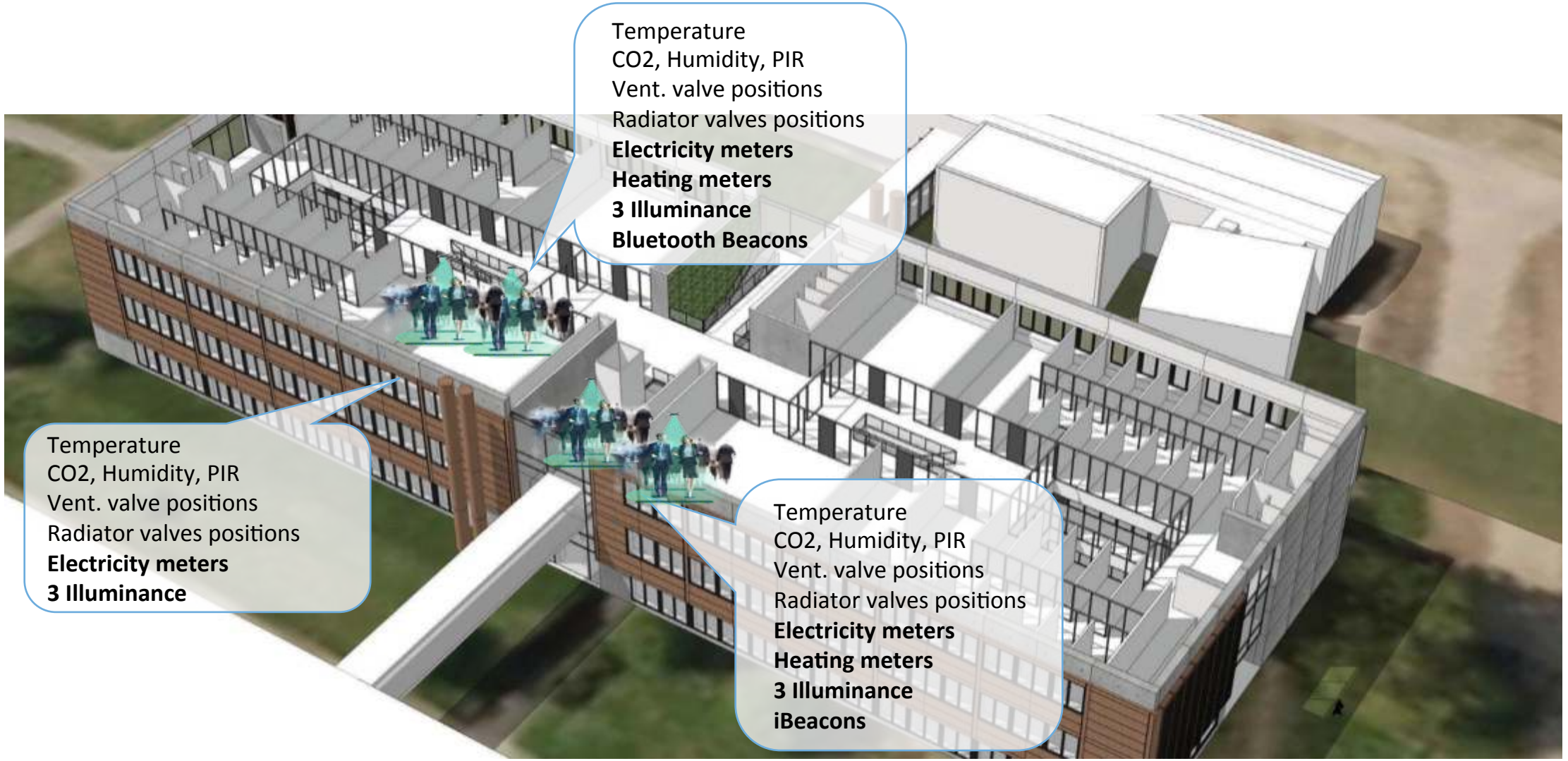
OU44 Parterre level

Standard sensor all rooms:
Temperature, CO2
Relative humidity, PIR
Vent. valve positions
Radiator valve positions
Illuminance
Curtain
Windows sensors - ground floor

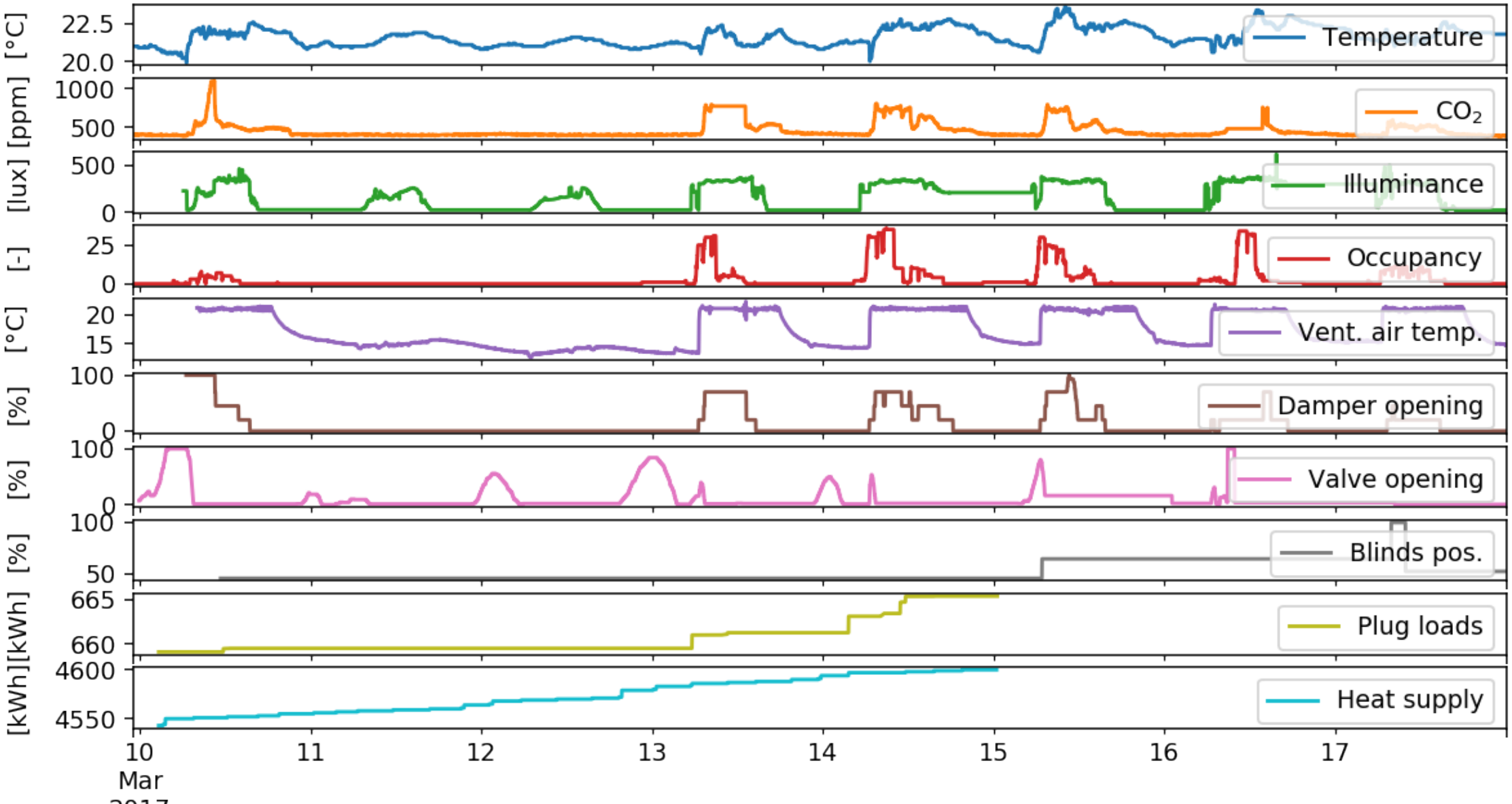
17 Person counters

OU44 Ground level

OU44 1st Floor



OU44 Common Sensors



Living Lab Data for Research and Teaching

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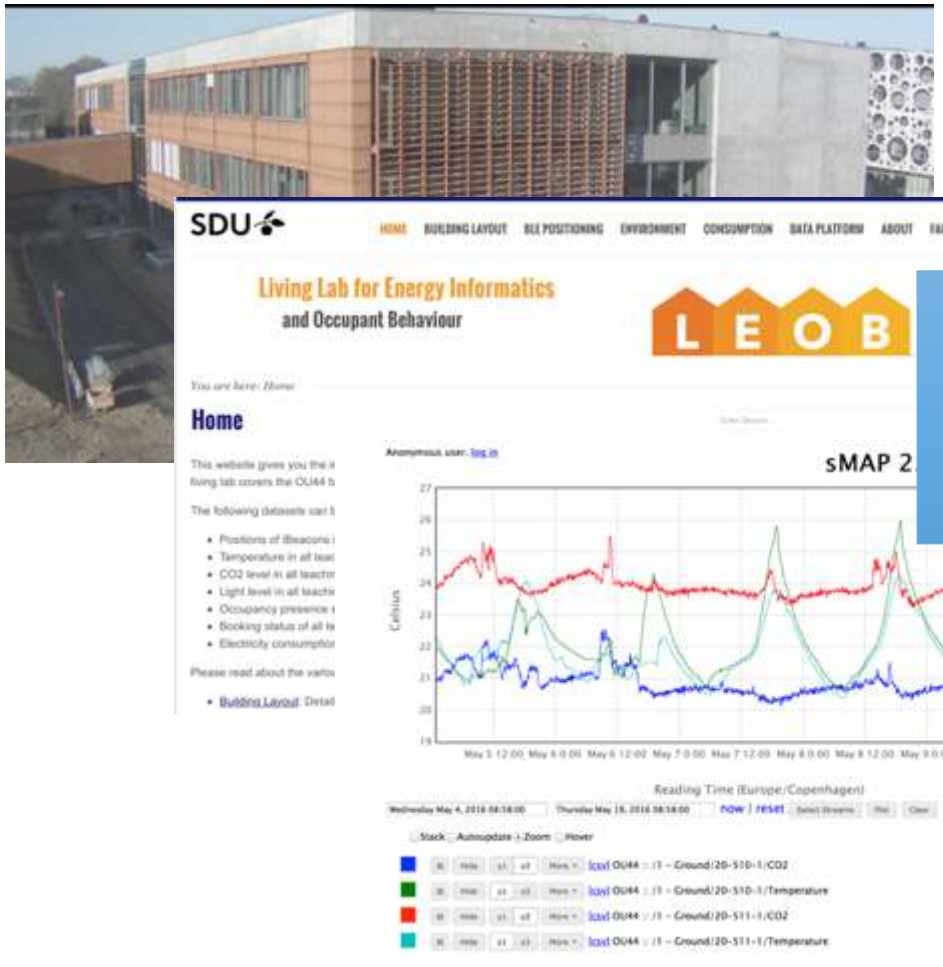
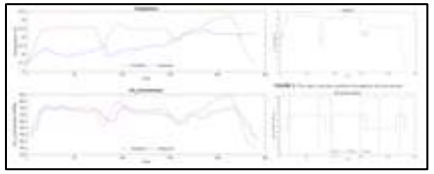
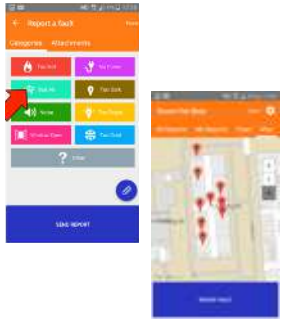


Data to SDU Students and Researchers

Jens & Dan
Software Engineering
Big data analytics of occupancy and building environmental data



Daniel & Alexander
Energy Technology
Study of ventilation system via simulations



Peter & Halldór
Software Engineering
Smartphone app for reporting building flaws

ICT-driven Coordination for Reaching 2020 Energy Efficiency Goals in Public and Commercial Buildings

Innovation Fund Denmark
RESEARCH, TECHNOLOGY & GROWTH

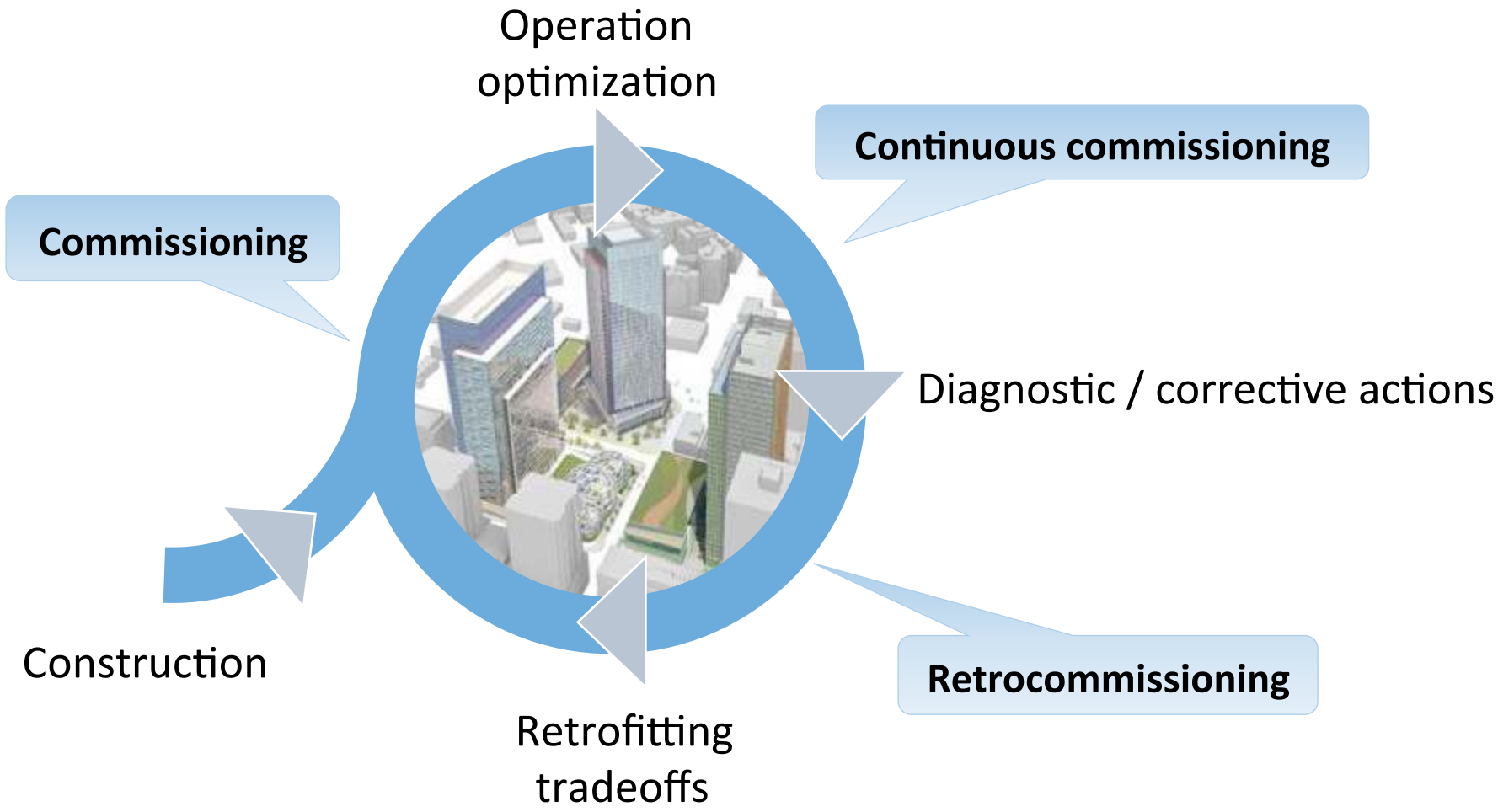
COORDICY - Objectives

- Closing the energy performance gap in energy-efficient public and commercial buildings
- Achieving cost-effective energy savings by balancing energy-retrofits and building intelligence
- Improving building energy performance by increasing building intelligence

COORDICY - Partners

Danish					
SDU ENERGY INFORMATICS	SDU Center for Energy Informatics	Green Tech Center - the living energy lab	Green Tech Center	Schneider Electric	Schneider Electric A/S
TEKNOLOGISK INSTITUT	Danish Technological Institute	RAMBØLL	Rambøll	**International**	
BYGNINGSSTYRELSEN	Danish Building & Property Agency	SIEMENS	Siemens		UC Berkeley, i4Energy
AARHUS KOMMUNE	Municipality of Aarhus	ReMoni	ReMoni	BERKELEY LAB	Lawrence Berkeley National Laboratory
ODENSE KOMMUNE	Municipality of Odense	DEVELCO PRODUCTS	Develco Products	NASA	NASA Ames Sustainability Base
Region of Southern Denmark OUH Odense University Hospital	Odense University Hospital - OUH	vemco group	Vemco Group A/S	DANISH CLEANTECH HUB	Danish Cleantech Hub in NY

COORDICY - Approach



Closing Energy Performance Gap

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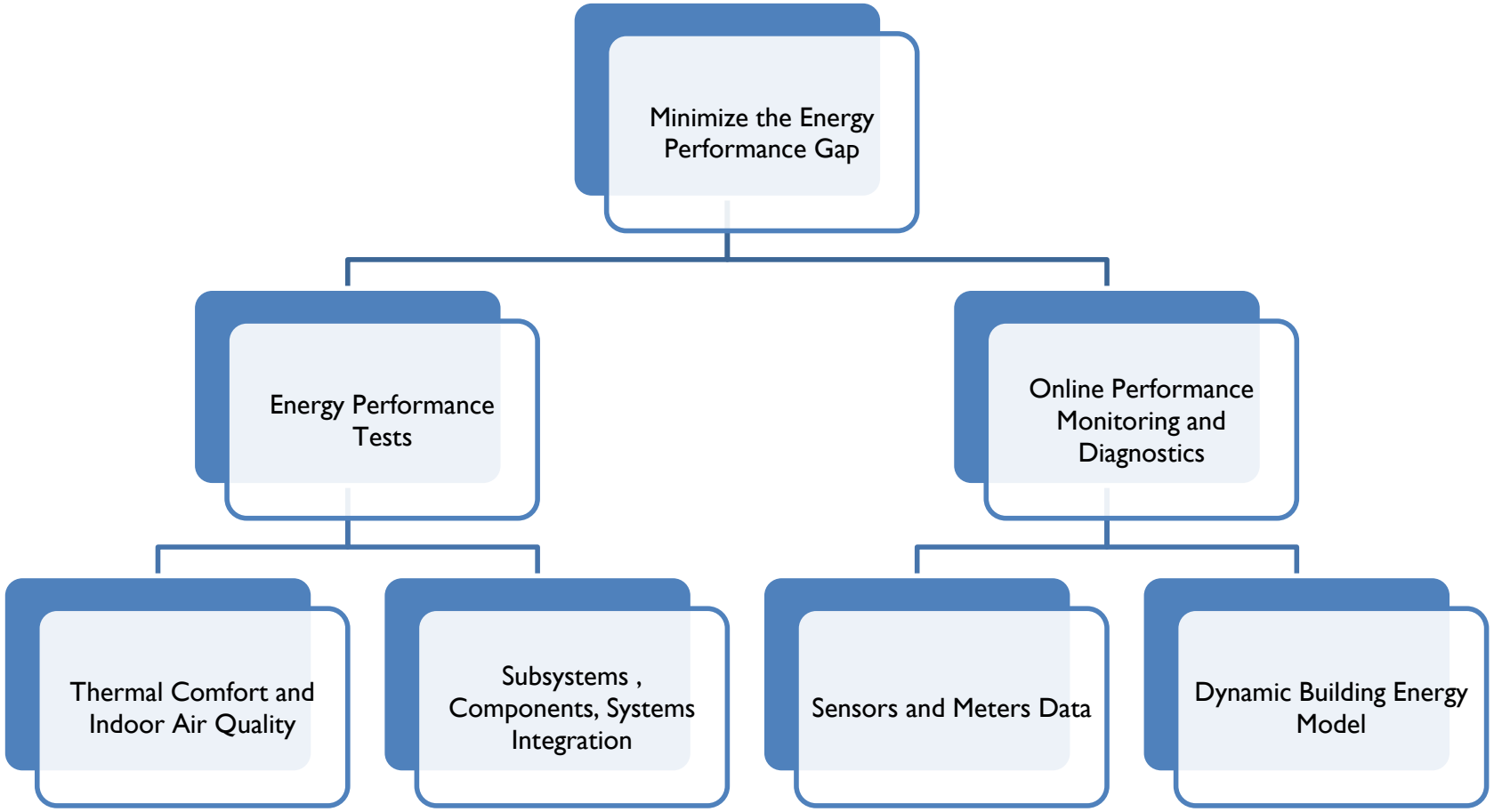
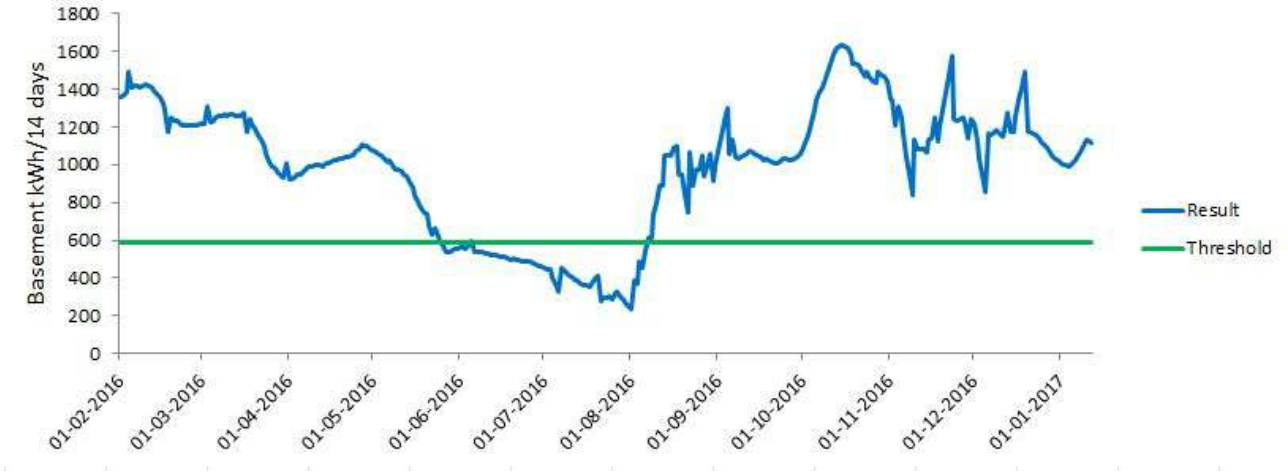


Energy Performance Test

Performance testing (PT) is a mean by which a building can be continuously commissioned, and verified for its expected performance and functionality, through the execution of various tests on a continuous basis.

- Benefits:
  - Continuous monitoring
  - Potential for FDD
  - Potential improved performance
  - Smarter decisions
  - Fewer faults



Online Performance Monitoring and Diagnostics

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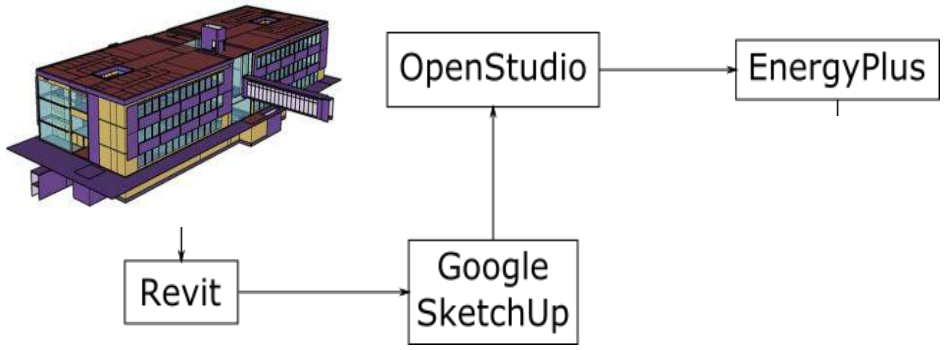
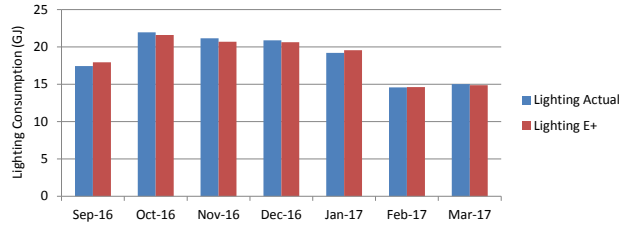
- Develop an overall dynamic energy model in EnergyPlus to predict the energy performance of the building aided by the Revit BIM model.
- Simulate the building's expected behavior for the previous day, given
  - Data from weather station
  - Occupancy data from camera counts
  - Set Points and building operation data



- Compare predictions with the actual performance data from meters.



Increasing Building Intelligence

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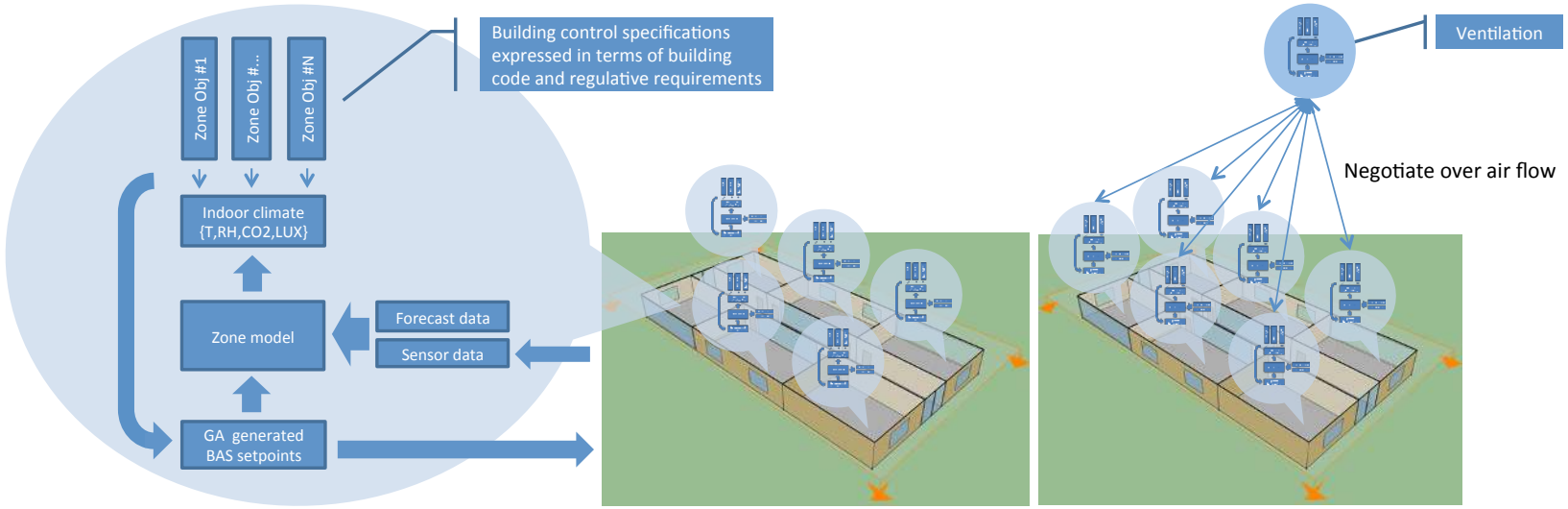
Objective name	Objective goal
TemperatureComfort	Keep temperature 20-22c
TemperatureDiff	Prevent Tdiff from exceeding 8
Temperature 18	Prevent more than x h/y at 18
Temperature 27	Prevent more than x h/y at 27
TemperatureOver27	Prevent more than y h/y > 27
TemperatureUnder18	Prevent more than y h/y < 18
CO2 Comfort	Keep CO2 under 450
CO2 Danger	Keep CO2 under 1200



E+ Virtual Building

Objective name	Objective goal
ElectricityMinimize	Minimize electricity use
AirVolumeMinimize	Minimize needed air volume
ElectricityCostMinimize	Minimize price of electricity
DRComply	Ensure DR event compliance

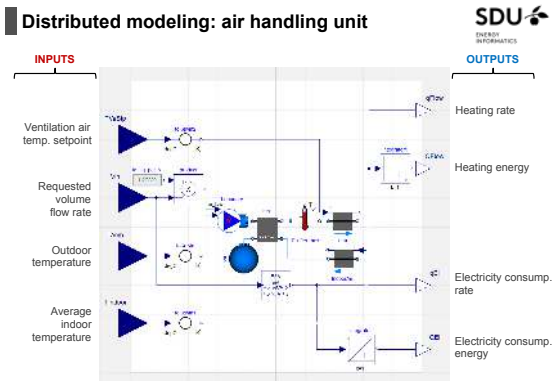
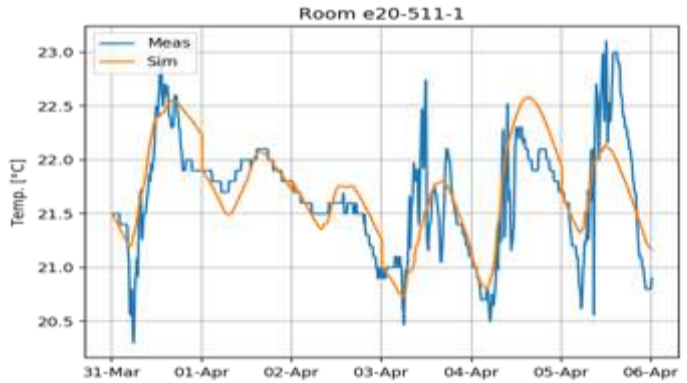


Fig: Ventilation system model (Modelica/Dymola)



Predicting Occupant Counts for Building Control

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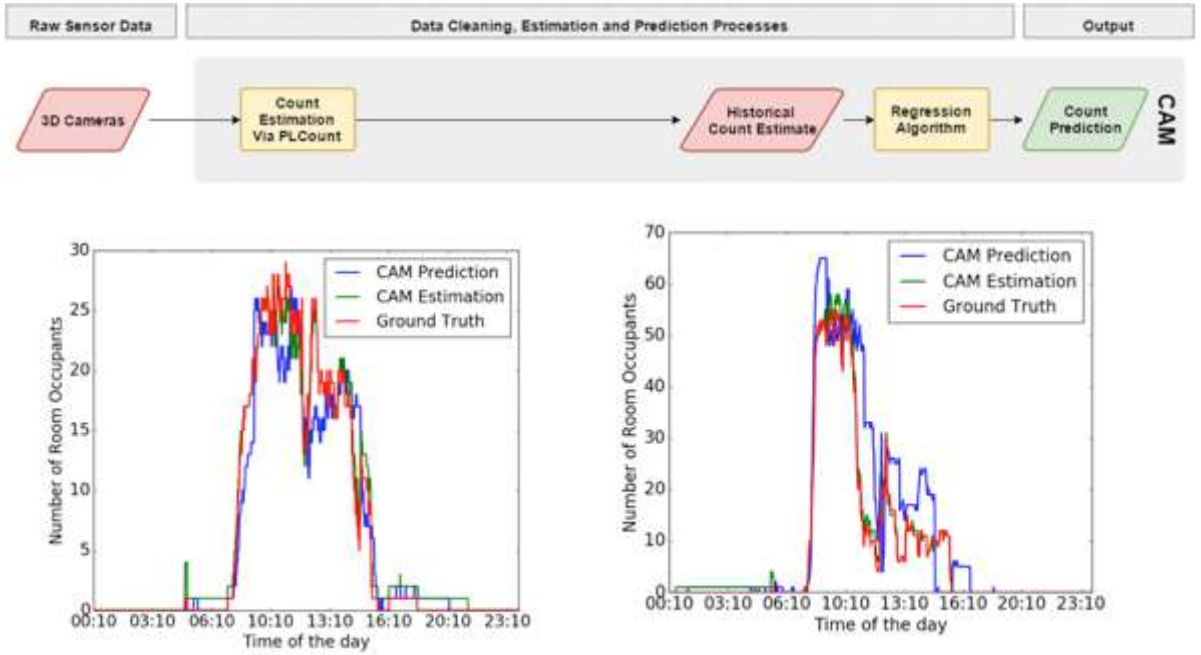

Sangogboye, Fisayo Caleb ; Arendt, Krzysztof ; Singh, Ashok Kumar ; Veje, Christian ; Kjærgaard, Mikkel Baun ; Jørgensen, Bo Nørregaard, Performance comparison of occupancy count estimation and prediction with common versus dedicated sensors for building model predictive control, Building Simulation, 2017

Occupancy Team at SDU Center for Energy Informatics

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Vision: *Sustainable Software-Defined Buildings in Symbiosis with their Occupants*

Please get in contact if you see future collaboration potentials…

email: mbkj@mmmi.sdu.dk