EUROPEAN CONVENTION CENTER LUXEMBOURG 24 SEPTEMBER 2024

PRELUDE DATA MONITORING FOR BUILDING ENERGY OPTIMIZATION

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement N° **958345**

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PRELUDE

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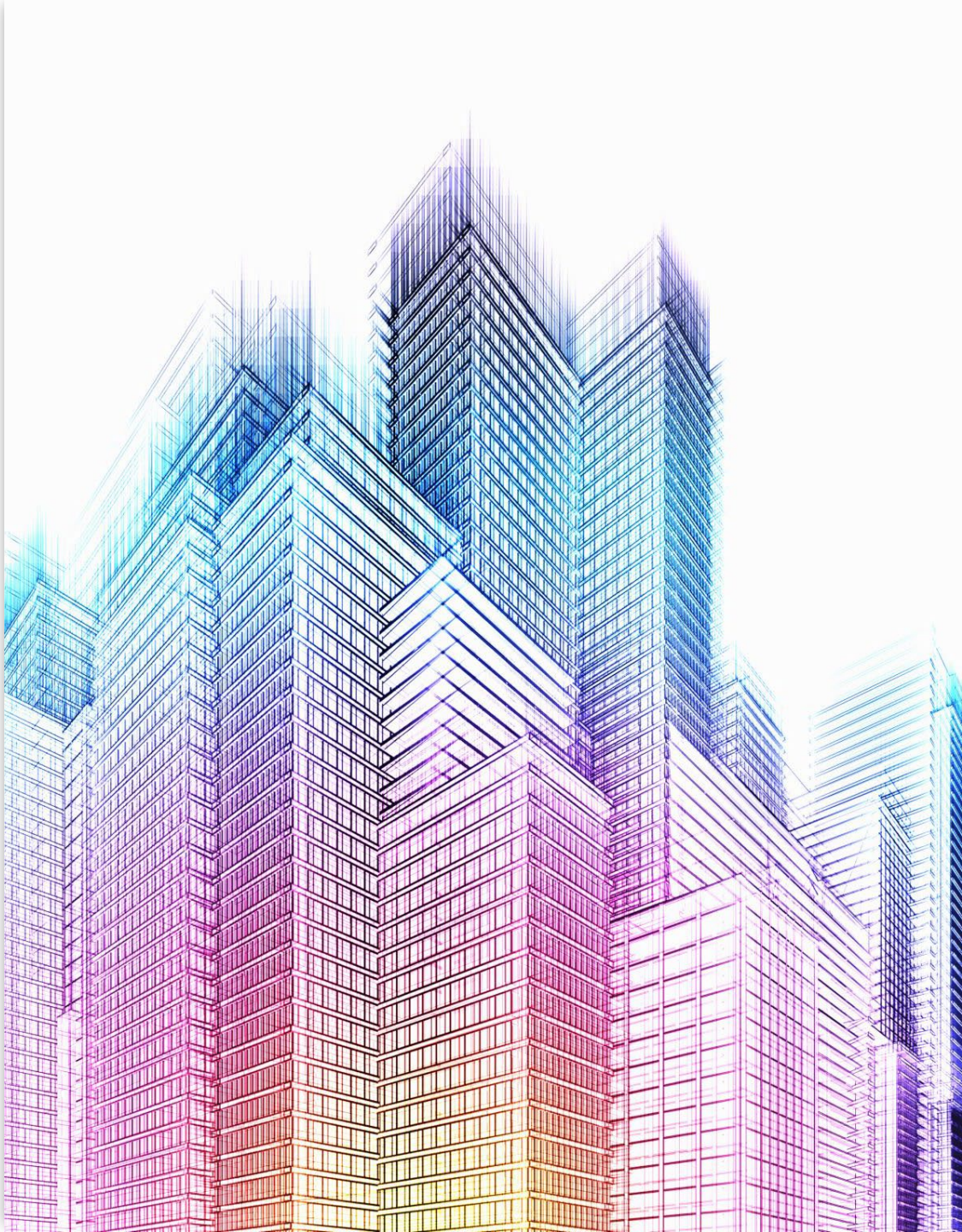
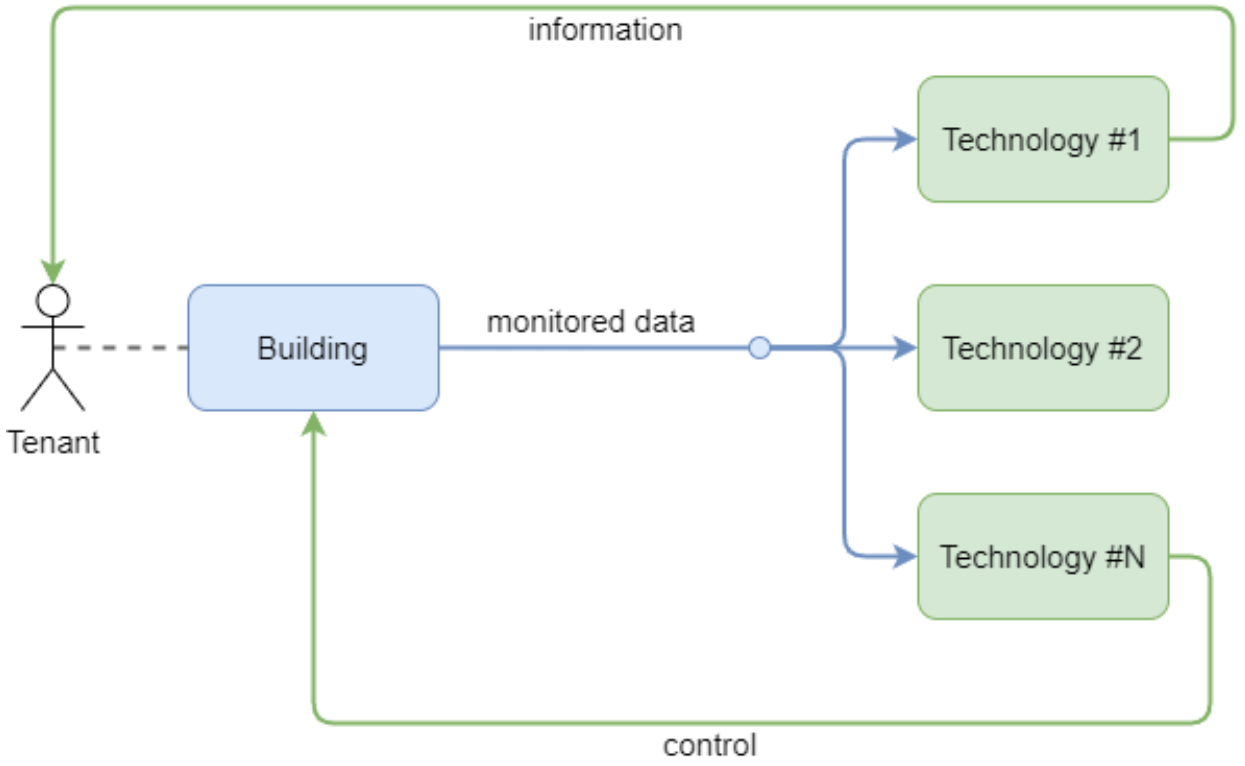
THE PRELUDE PROJECT

- PRELUDE project integrates innovative, low-cost solutions for optimizing energy use in households, based on user needs.
- Key Innovations and targets:
  - Data Predictive Control (DPC): Enables proactive building optimization.
  - Predictive Maintenance: Applied in residential buildings to reduce costs.
  - Smart Renovation: Custom assessments for sustainable improvements.
  - Free Running Model: Optimizes buildings with passive cooling and ventilation.
  - Neighborhood Focus: Buildings optimized within districts.
  - MFOS Sensors: Versatile Multirole Fiber Optic Sensors with high potential.



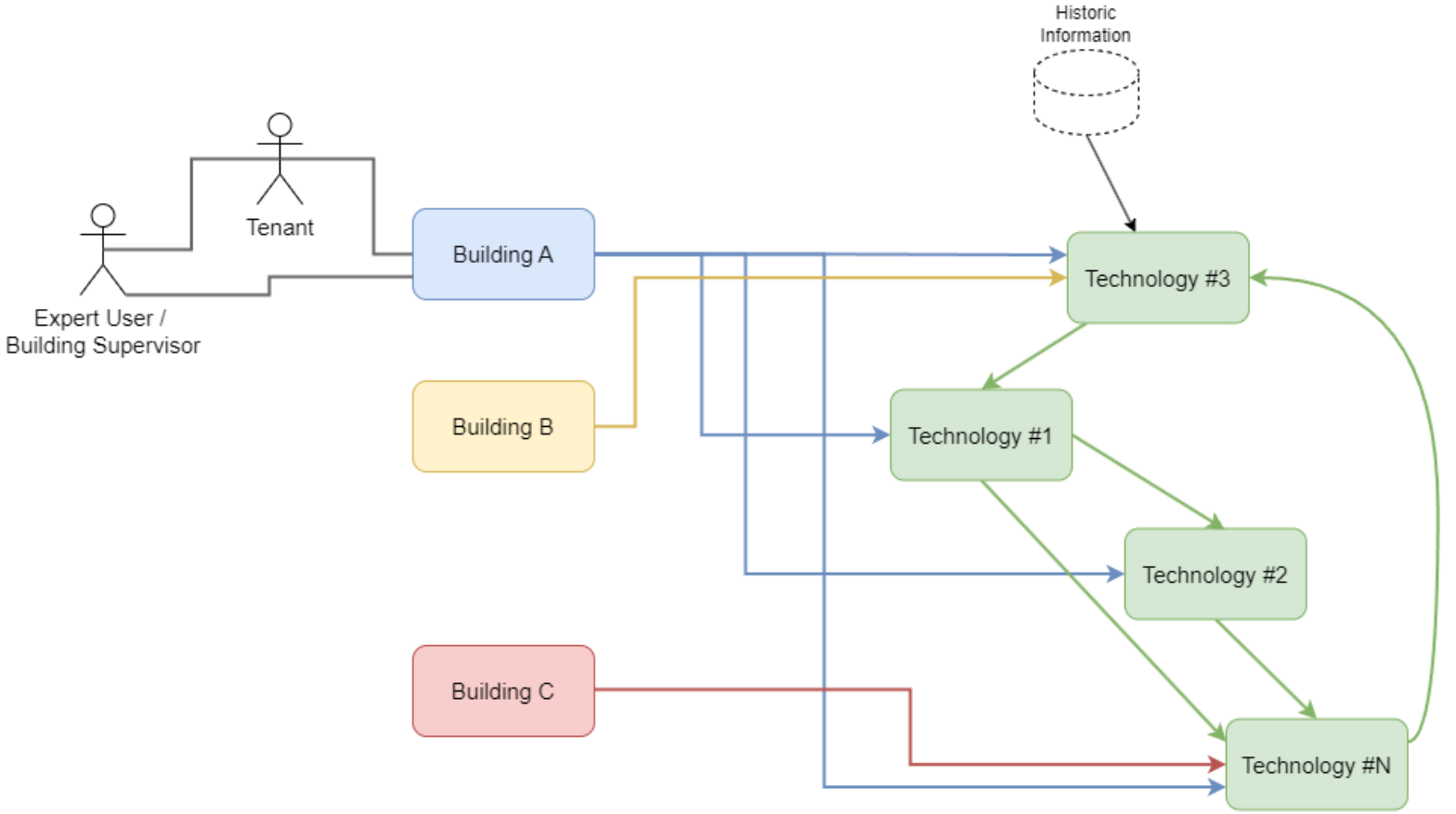
The PRELUDE Project from a software perspective

- Demo Buildings provide monitoring data
- Technology providers use monitored data (and other sources) for various high-level services such as: predictions, automated control, occupancy modelling, action recommendations and more.
- Results from the technology providers need to be provided back to the building targeting its improvement.



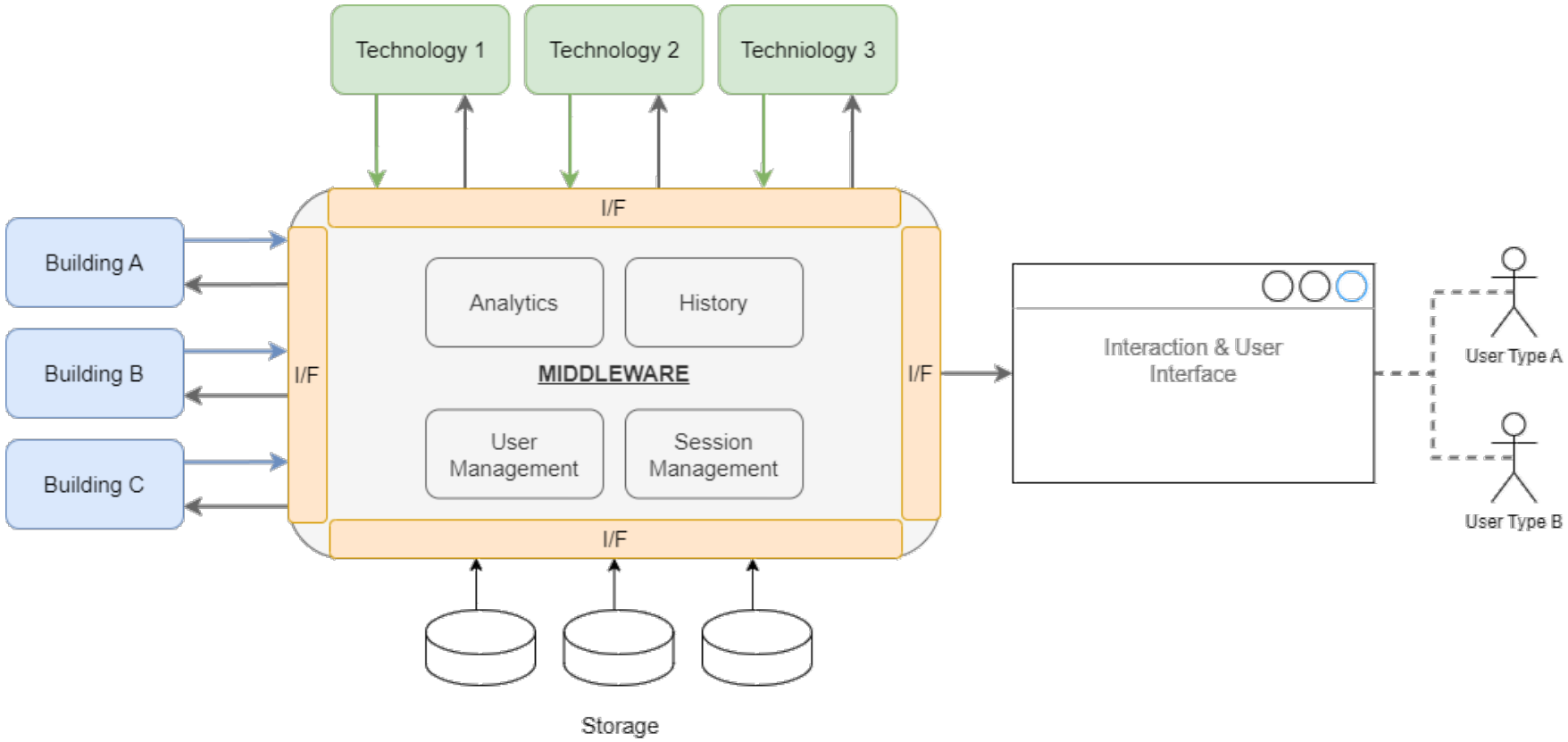
The actual case

- Technology providers interact
- There are multiple buildings. Each with its own monitoring scheme.
- There are different types of users. Different needs
- Technology providers need to consider additional “software” issues. For example, historic data retention.



Middleware Solution

- Consolidate all I/O
- Handle Storage, Security, Confidentiality, etc. Centrally
- Homogenize interaction among actors
- Provide any additional features needed at a central location



The FusiX Framework

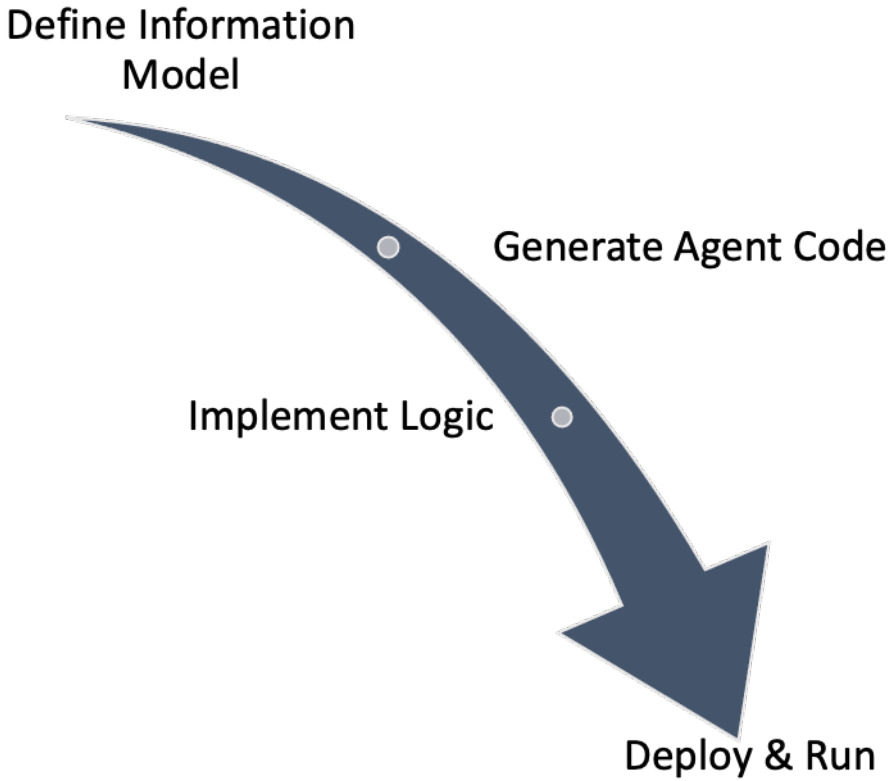
- We are developing FusiX to be a **generic** framework for the development of DSS applications
- As a **framework**, FusiX provides:
  - Abstraction and Virtualization of data resources to enable interoperability
  - Cloud architecture to enable scalability
  - Simulation support with the help of external tools.
  - Platform-independent dynamic GUI.
  - Set of common Services.
- FusiX **applications** use the framework to:
  - Collect data from heterogeneous sources
  - Abstract said data to a common data space
  - Process abstracted data to produce higher level and valuable information
  - Report findings to end-users
  - Control in a semi/automatic manner

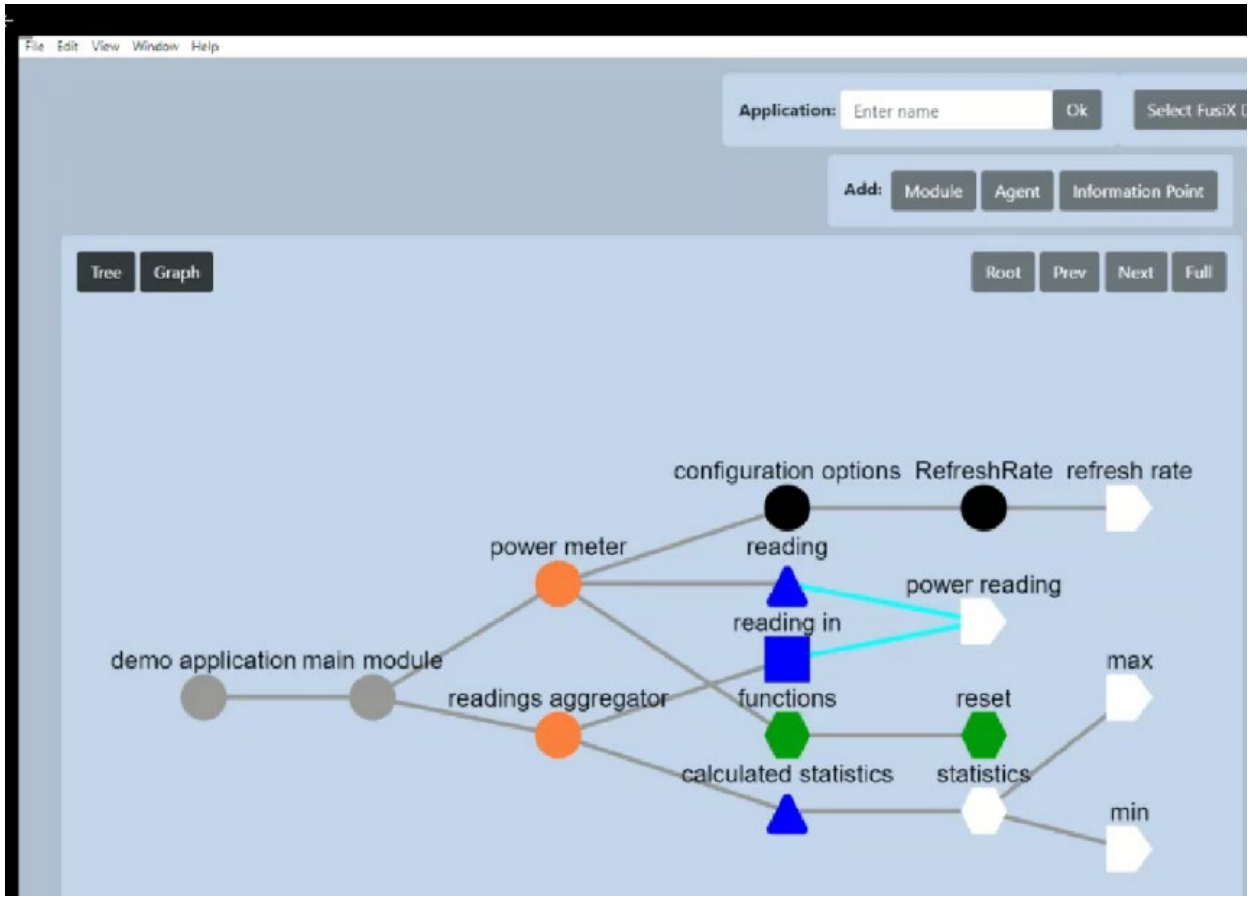
FusiX Application Structure

FusiX applications are defined by the following elements:

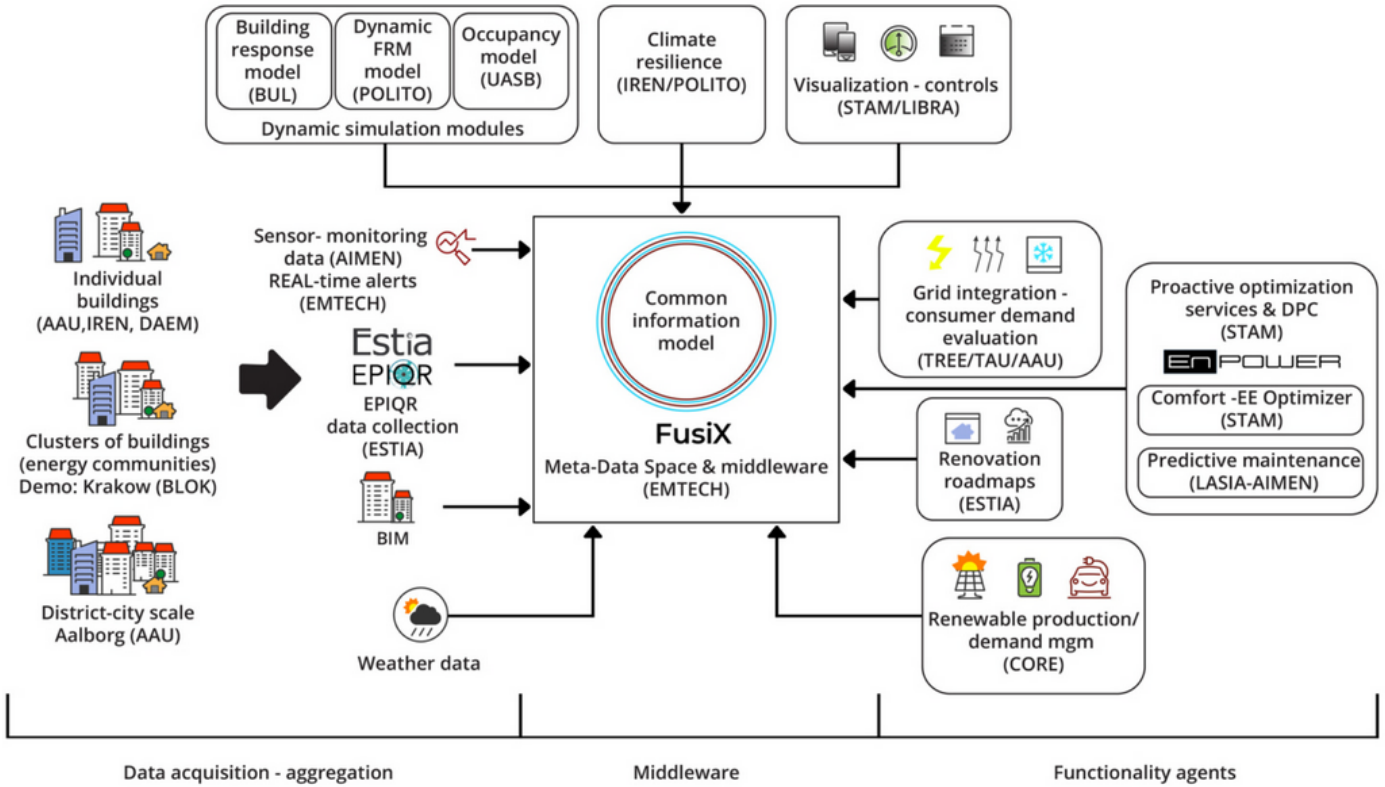
- Agents
  - Each agent implements a system functionality in a modular manner.
- Information Model
  - Defines all I/O of the application. This is how agents interact
- Nodes
  - Collections of agents on a single instance / container.
  - Location Transparency is guaranteed
- Services
  - Common features provided by the Framework by default

FusiX Application Creation

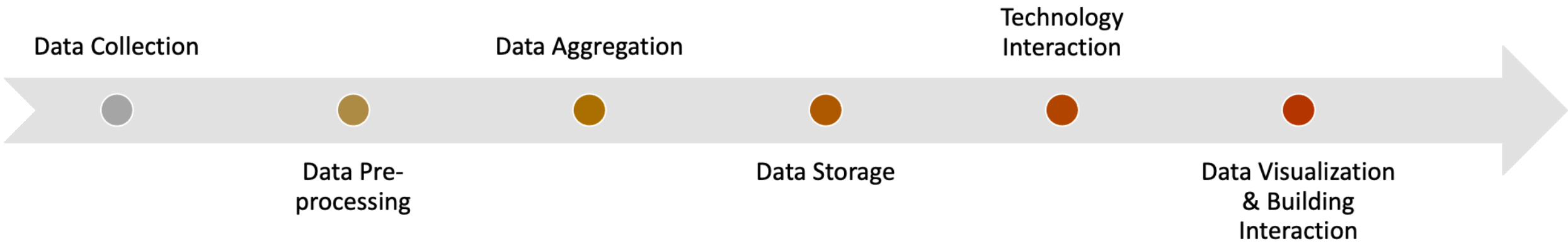




Middleware positioning in the PRELUDE project



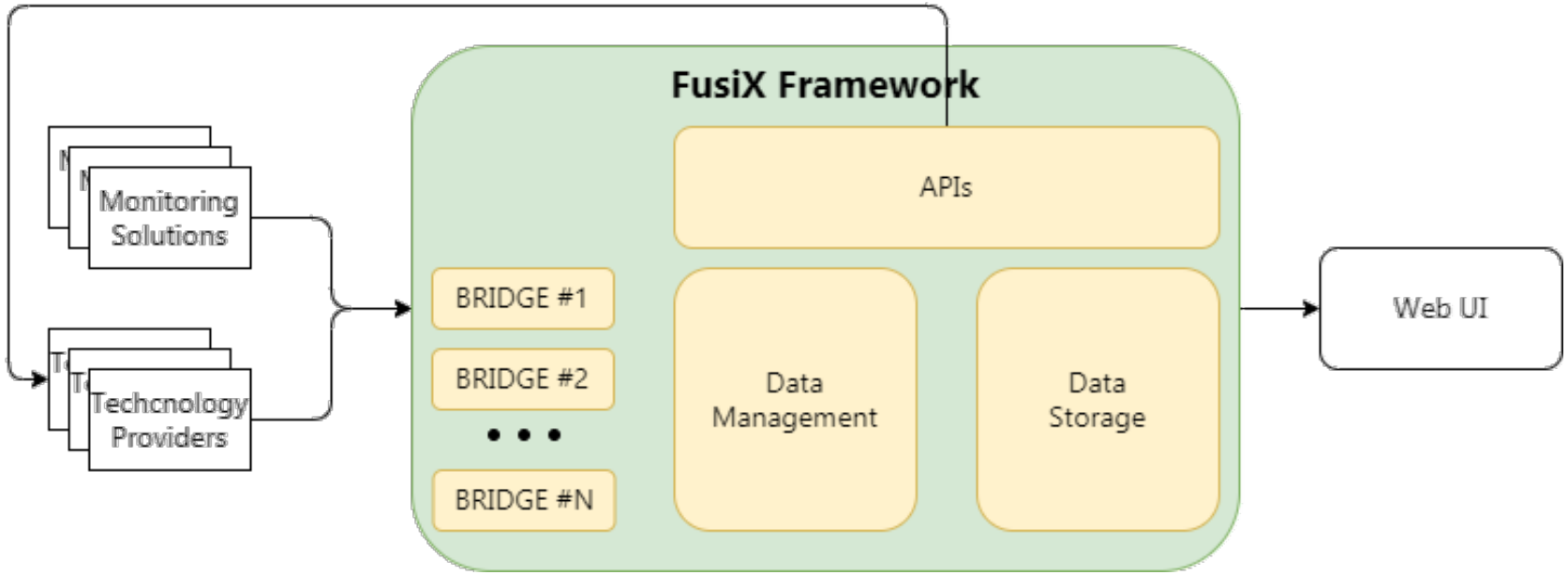
Middleware Processing and Data handling



Middleware Application Structure

- The Application has the following high- level blocks:

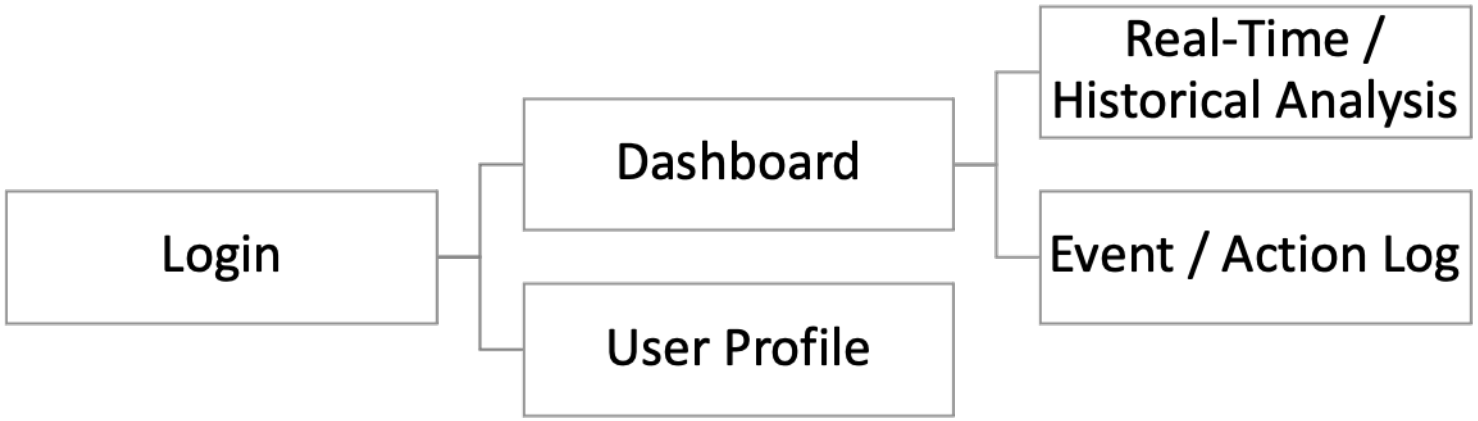
- **Bridges**: to interact with external elements
- **Data Management**: to perform filtering, aggregation and other operations on raw data
- **Data storage**: to handle database access
- **APIs**: To allow external elements to interact with FusiX



PRELUDE Portal

- Visualization of FusiX Data
- Support for different types of users
  - Tenant
  - Expert (building manager, engineers, etc.)
- Support for all demo buildings and all technology providers.

- The portal is WIP

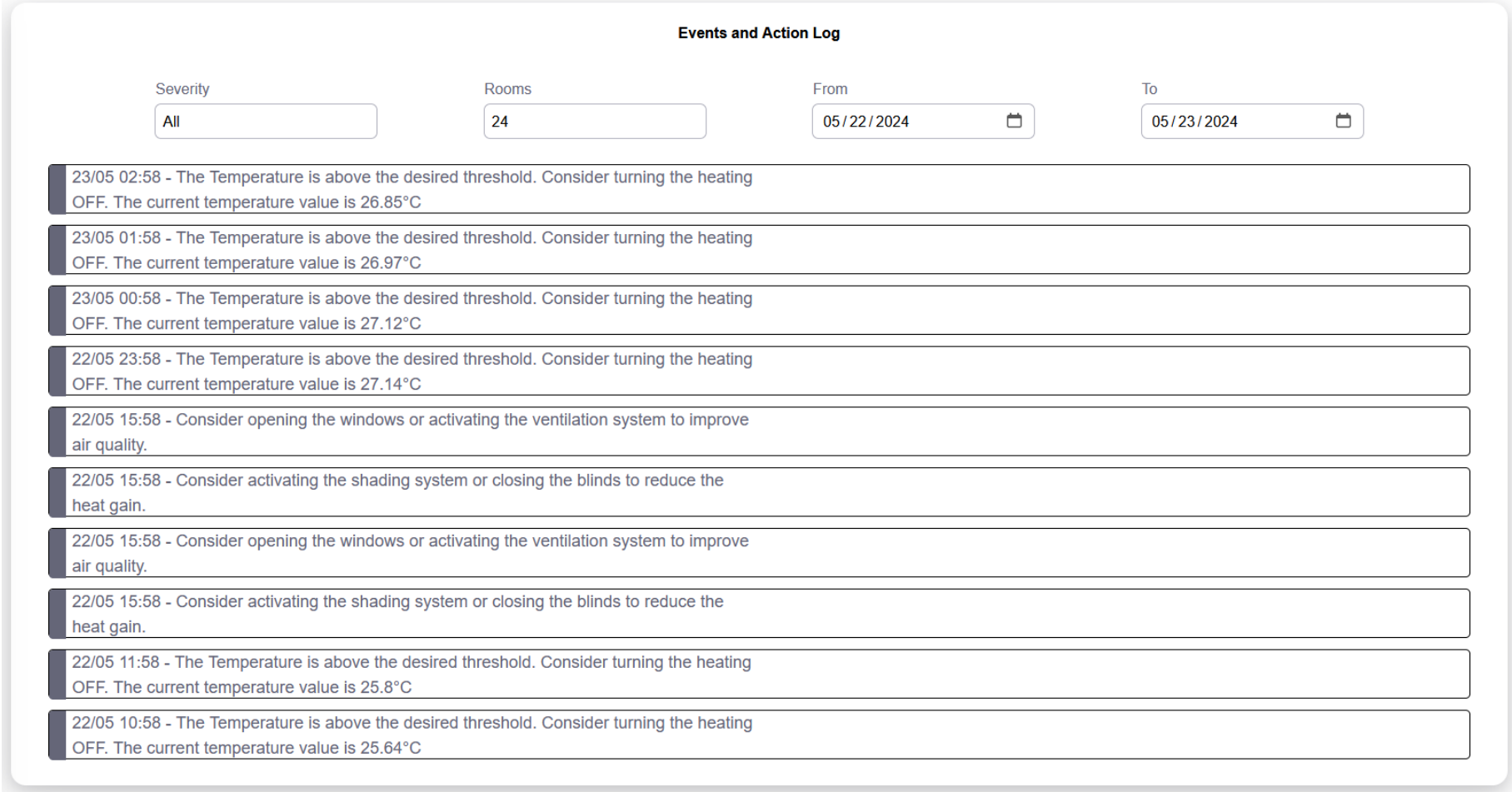


Dashboard

- Understand what's happening at a glance.

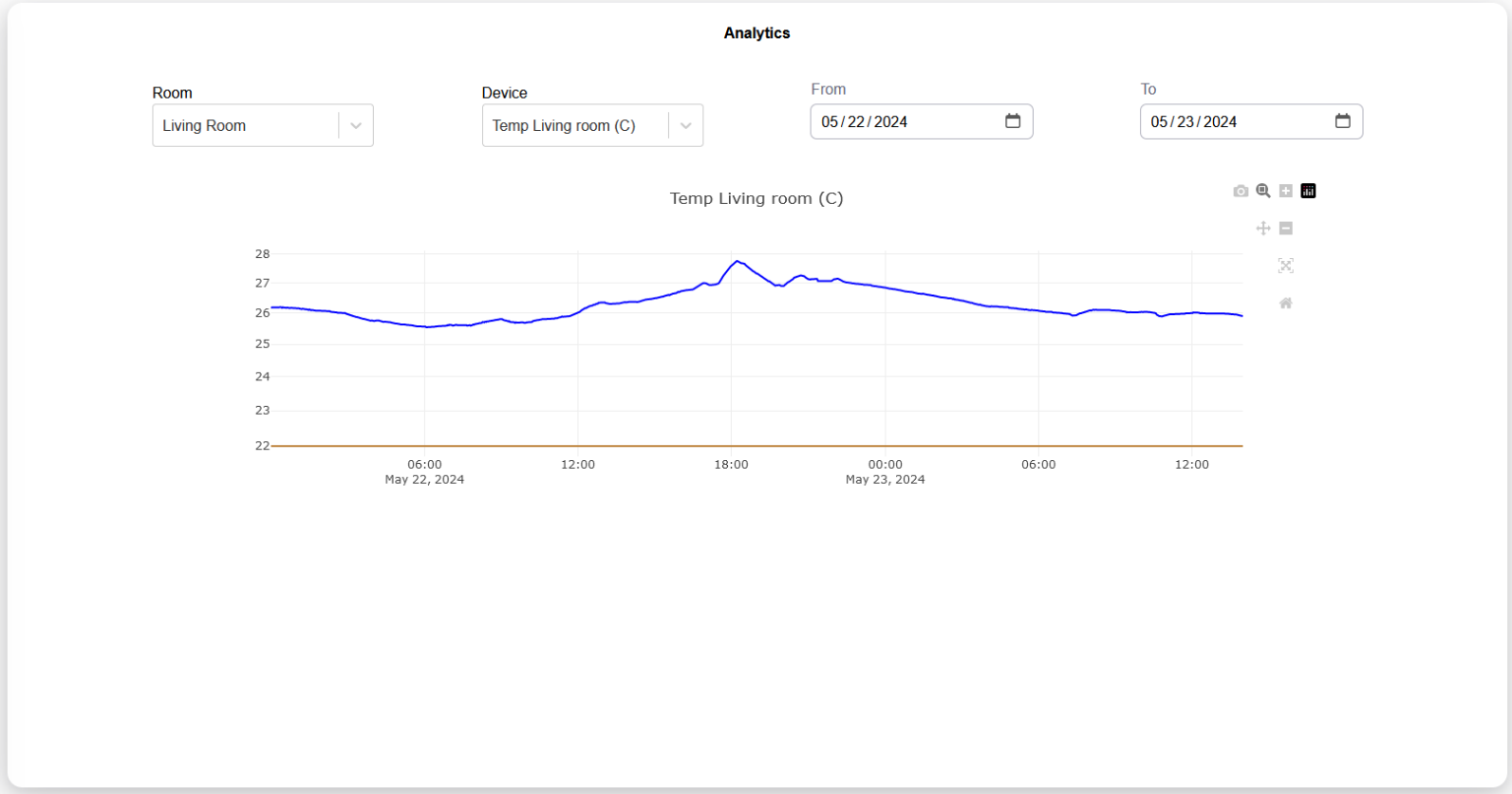
Events

- Understand what is happening in the building.
- Threshold violations.
- Triggered actions based on PRELUDE partner's and intelligent services.



Historic Data

- Selectable time ranges
- Raw data
- Appropriate Filters
- Threshold indicators



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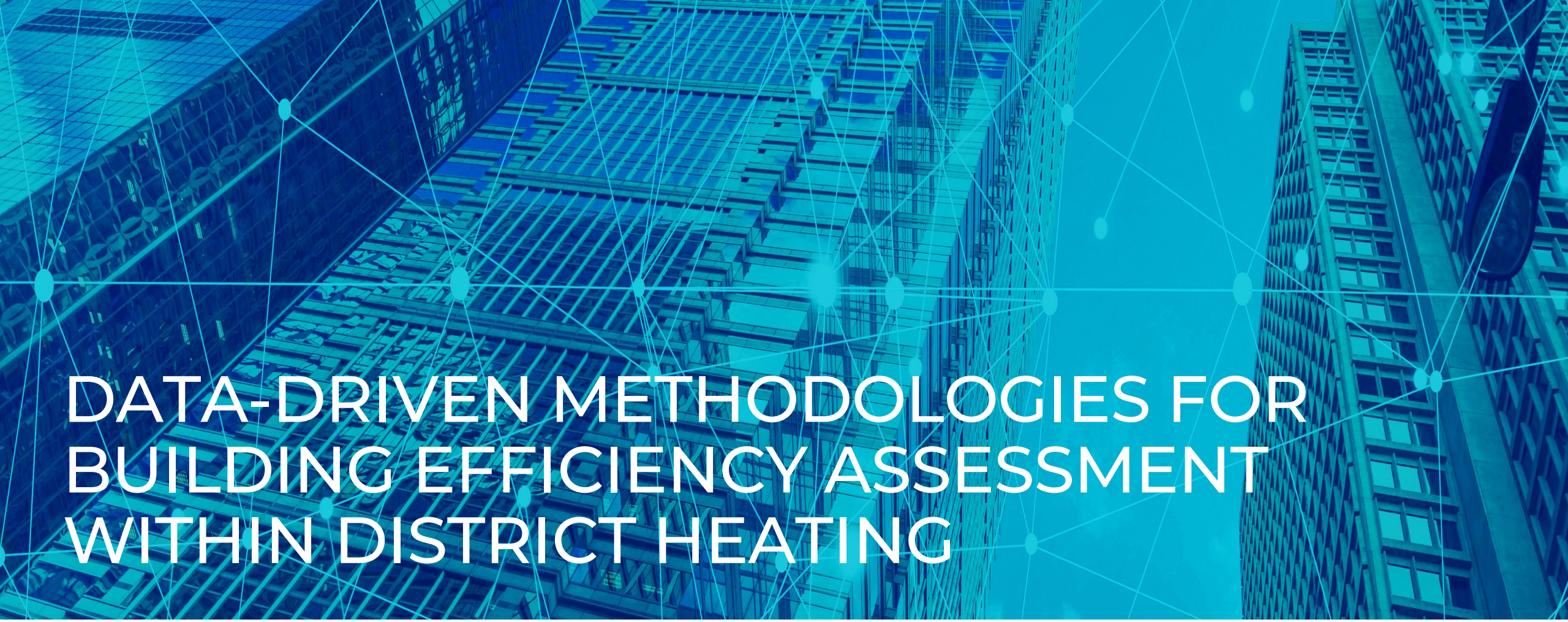

DATA-DRIVEN METHODOLOGIES FOR BUILDING EFFICIENCY ASSESSMENT WITHIN DISTRICT HEATING

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Aalborg University

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PRELUDE project and DH connected building

Focus on:

- realizing energy efficiency
- data-driven building assessment
- data- transferability
- different building smartness inclusion
  (no automation, low automation, high automation)
- adaptable solution (modularity)

Motivation and potentials for the presented work

- The fact: Smart heat meter roll-out supported by Energy Efficiency Directive (EED)

2020	2022	24 Sept 2024	2027
25.10.2020	**01.01.2022**	**Today**	**01.01.2022**
...possible to remotely read all heat and hot-water meters installed after this date. **They must be read every 3 months**	...possible to remotely read all heat and hot-water meters installed after this date **They must be read every month**		**Every home must have remotely readable heat and hot-water meters installed – with a monthly reading**

Meters deliver the data and open for new possibilities but also challenges…

*inspired from Kamstrup

New possibilites driven by smart heat meter data

- Data itself
- Fair billing

And more…

- Bring awareness to tenants
- User's behavior change
- Fault detection (building systems and users)
- Data-driven decisions
- Mapping critical customers
- Machine learning

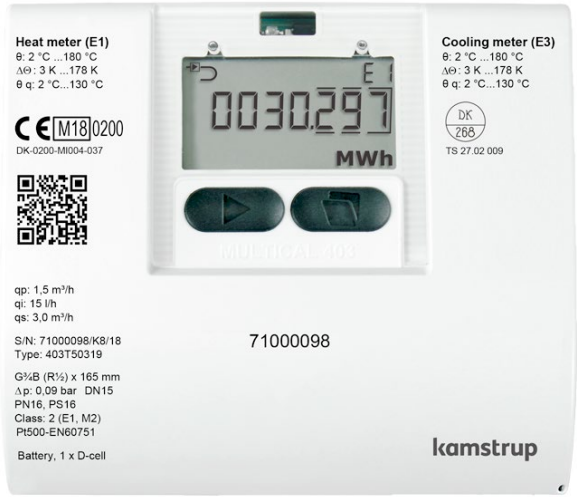
New challenges to make use of smart heat meter data

- Store data
- Preprocess data
- Split total measured heat energy to

  space heat (SH) and domestic hot water (DHW)
- Change data to knowledge =

  enable higher level analysis:
  - Identify suitable clustering
  - Data series analysis by suitable algorithms
  - Link SHM data with other data for further analysis

Data cases - PRELUDE

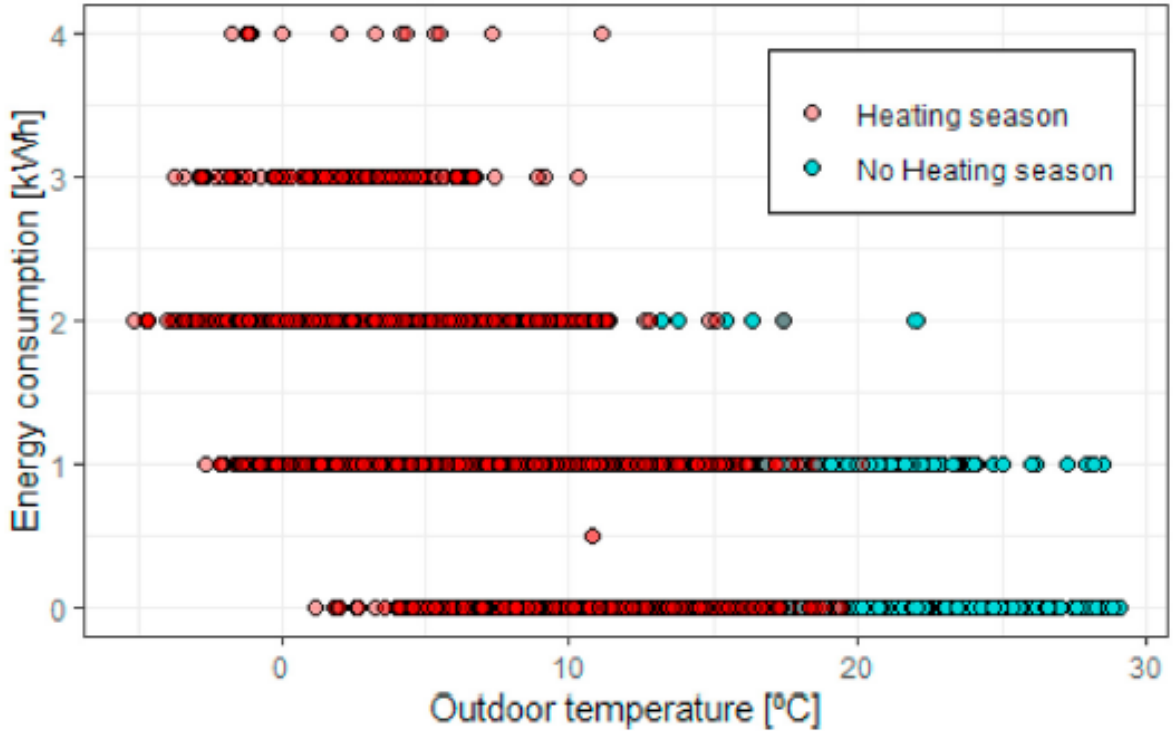


- **Aalborg District Heating connected buildings**
  - Large data sample of approx. **20.000 smart meters**

    from which data-subsets were made depending on purpose
  - Approximately **2 year** of data (2020, 2021)
  - Hourly data, rounded down to integer kWh (and also temperatures and flows)
- **28 apartments with detailed data (for validation purpose)**
  - Split space heat and domestic hot water
  - Data used to validate method for splitting total heat into SH and DHW
  - Hourly data with decimal on kWh data
- **Fault reports from inspection of substation in the DH connected buildings (> 500 reports)**

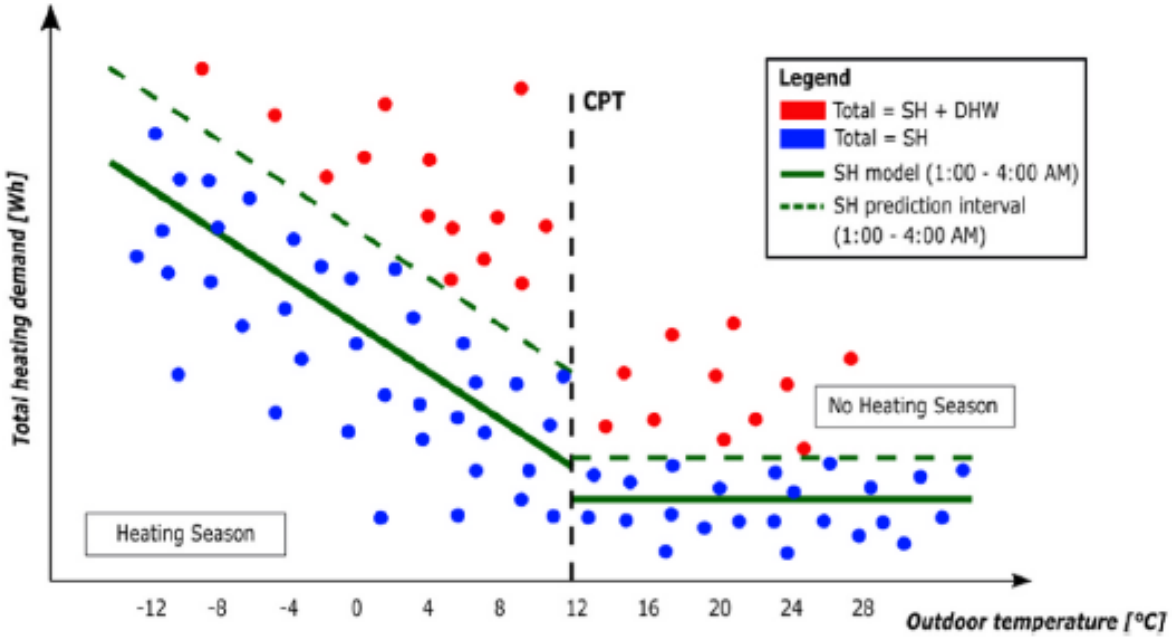
Initial work and detected challenges
(before PRELUDE project)

Challenge 1: Data truncation



Scatterplot between energy usage and outdoor temperature for a particular building.

Challenge 2: Total heat disaggregation (SH+DHW)



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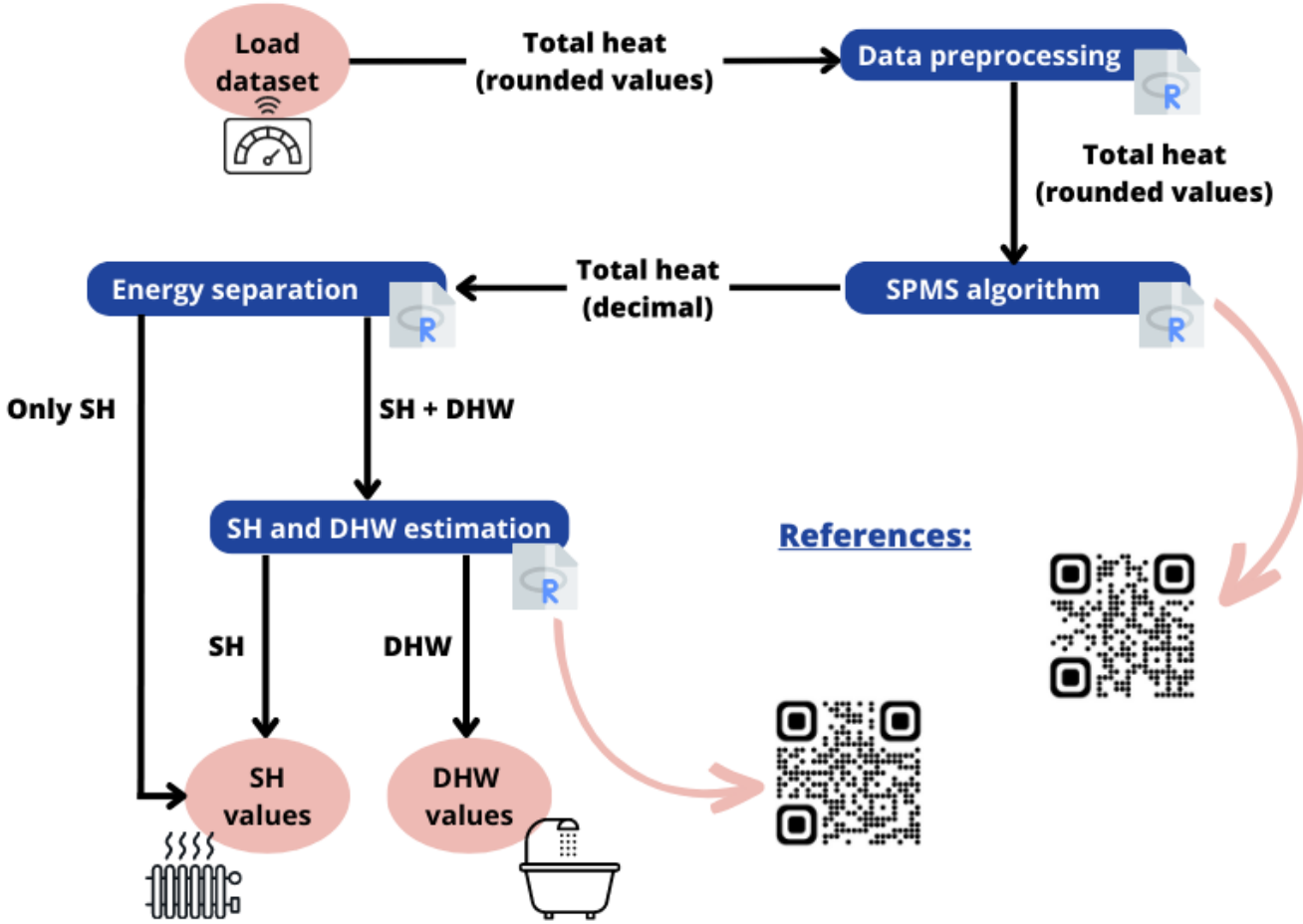
Total heat disaggregation to
space heating (SH) and domestic hot water (DHW)

The problem: While smart heat meters in Danish district heating grids do help us with billing, they have limitations. They record energy use in rounded integer values, which isn't sufficient for detailed modeling and analysis. Past efforts tried to estimate space heating and domestic hot water energy from this data, but with reduced accuracy.

The solution: We've integrated the SPMS, or Smooth-Pointwise Move-Scale algorithm, which extracts decimal values from these truncated measurements. And implemented in our methodology to disaggregate the total energy measurements into space heating and domestic hot water demands.



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Total heat disaggregation to
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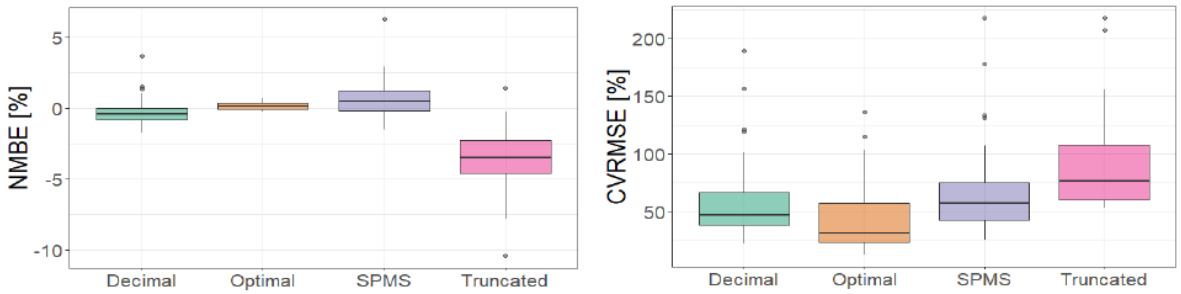
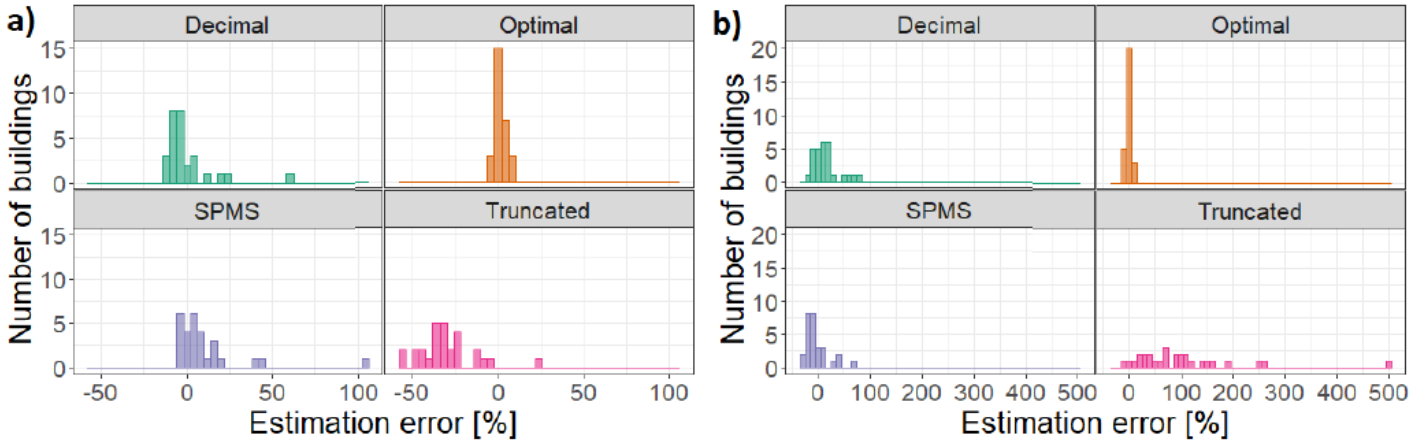


The NMBE and CVRMSE of the SH estimation of the different tested cases.



Estimation error for a) SH usage and b) DHW production.

- **28 apartments** with separately measured SH and DHW were used to validate method
- **SPMS methods significantly improved truncated data** (by evaluating NMBE and CVRMSE).
- Still original decimal dataset gives better results than applying the SPMS method
- DH companies could address this problem by **recording heat with a higher resolution and with decimal.**

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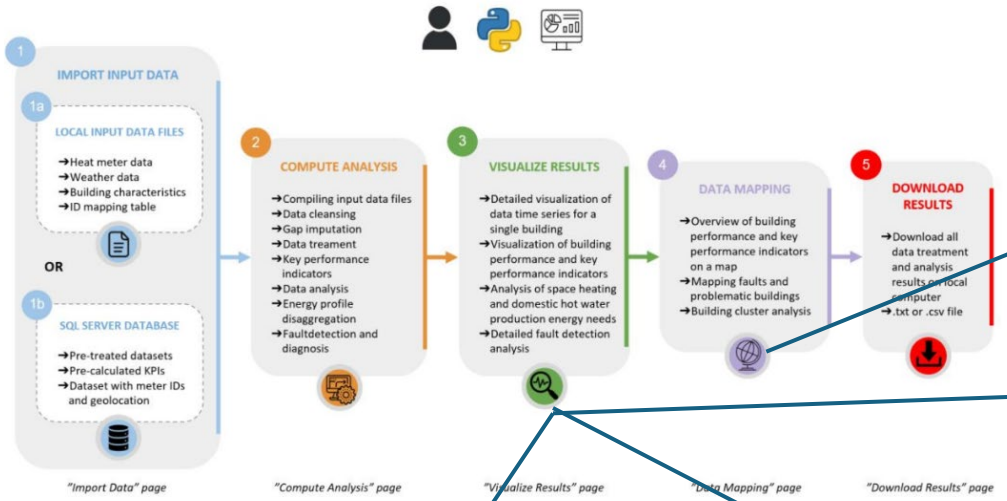
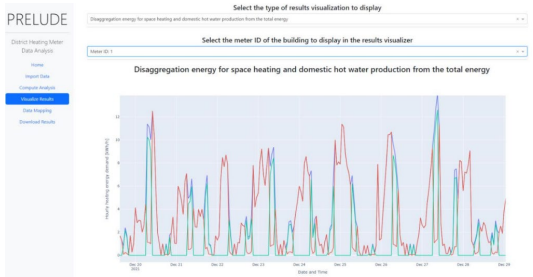
Web tool to facilitate SHM data analysis
(KPI examples)

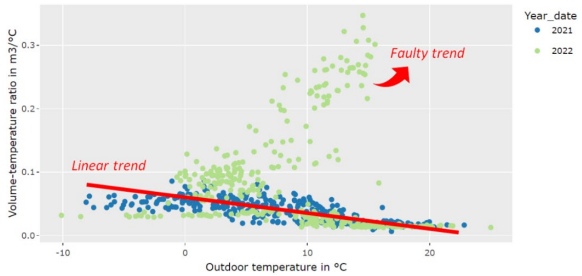


Data mapping

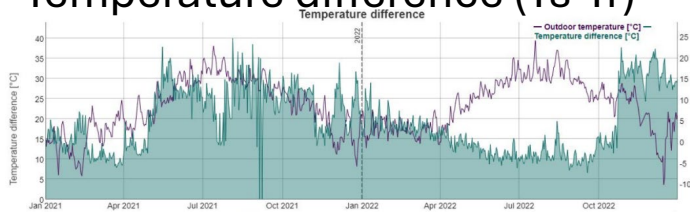
Total heat disaggregated to SH and DHW



Volume temperature ratio



Temperature difference (Ts-Tr)



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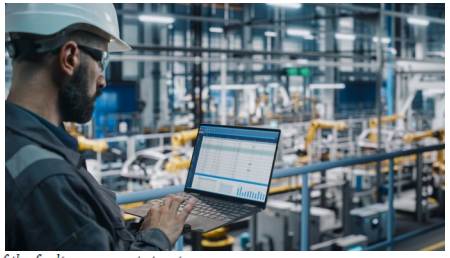
Fault detection and diagnosis
Labelled data



Development of FDD methodology

- Labeled data (ground truth) on the various faults **(>500 reports)**
- Fault Patterns - identification from SHM data series
- Fault classification and study of different patterns(SHM data)
  - Return temperature
  - Volume
  - Energy

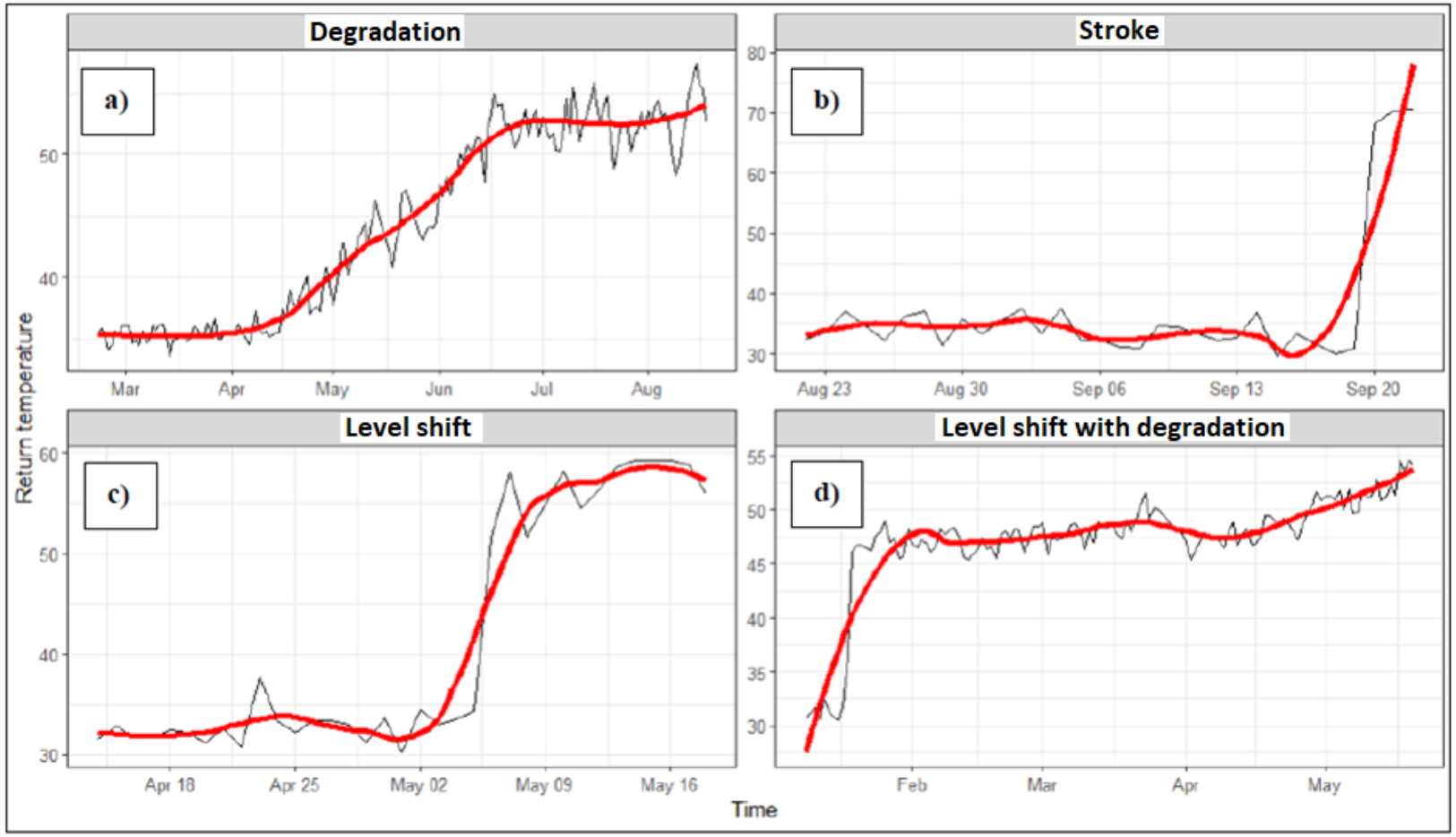
Table 2: Second iteration of the fault assessment structure.

Parameters	Type of input	Definition
Meter ID	Individual single number	A unique identifier of the SHM installed in the building
Assessment date	Date	The date of the technicians' visit, formatted as day/month/year
Contact type	Predefined multiple-choice answer	The method used to contact customers, with the given options: • Telephone/E-mail • Physical visit
Hydraulic connection type	Predefined multiple-choice answer	The existing type of DH connection to the heating systems in the building, with the given options: • Direct • Indirect
SH system	Predefined multiple-choice answer	The existing type of SH systems in the building, with the given options: • Radiators • UFH • Combined (both radiators and UFH)
DHW system	Predefined multiple-choice answer	The existing type of DHW system for heat production in the building, with the given options: • Heat exchanger • Storage tank

Faulty component	Predefined multiple-choice answer	The component where the fault was identified by the technician, is categorized into specific labels, with the given options:
		• In SH system:
		  ○ Pressure differential regulator
		  ○ Radiator thermostat
		  ○ UFH shunt
		  ○ Etc.
		• In DHW system:
		  ○ Temperature regulation valve
		  ○ Incorrect settings in the temperature regulation valve
		  ○ Incorrect pump settings
		  ○ Etc.

Fault description	Open text answer	Open-ended comments for the personnel to describe in detail the fault.
Fault identification status	Predefined multiple-choice answer	The status of fault analysis, with the given options: • Proven (fault identified and confirmed by the technician) • Suspicion (unverified assumption of a fault by the technician)
Technician action	Predefined multiple-choice answer	Actions undertaken to rectify the fault, with the given options: • Error is resolved (fault fixed) • The customer must contact VVS (customer advised to contact a plumber to resolve the fault) • No action (no measures taken)

Results – detected fault patterns



Representation of the different patterns (free scales).

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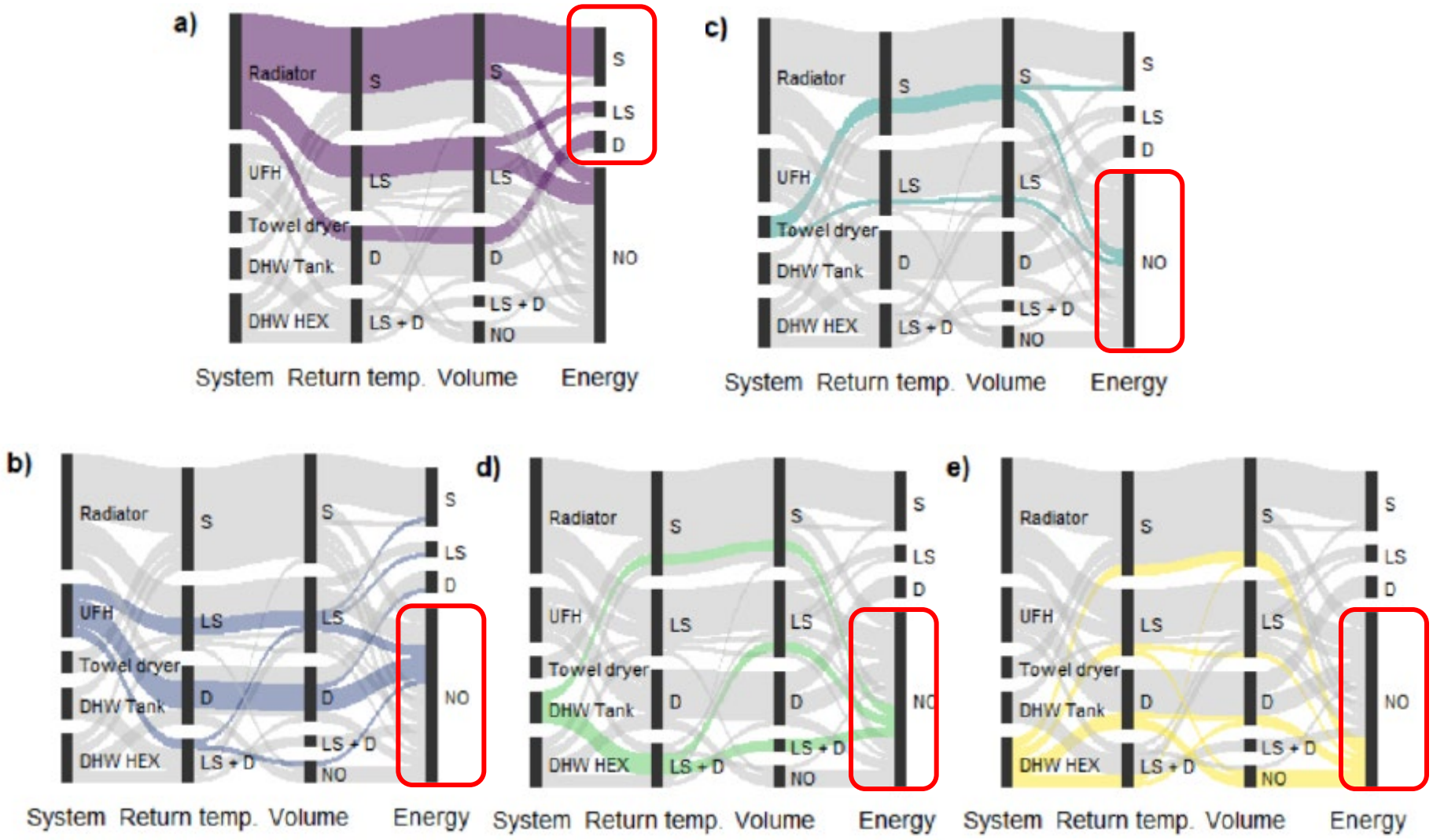
Results – fault patterns assigned to installation



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Conclusions

We have:

- identified methods to preprocess data series
- developed methods to split total heat to SH and DHW
- identified KPIs and graphical methods to facilitate the analysis of long SHM data series
- identified a standardized method to collect faults from the DH-connected buildings
- carried out the classification of fault patterns
- assigned fault patterns to the fault location

Thanks

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ENHANCING BUILDING ENERGY EFFICIENCY

Exploring challenges, opportunities and future pathways in a sustainable market

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CORE Group

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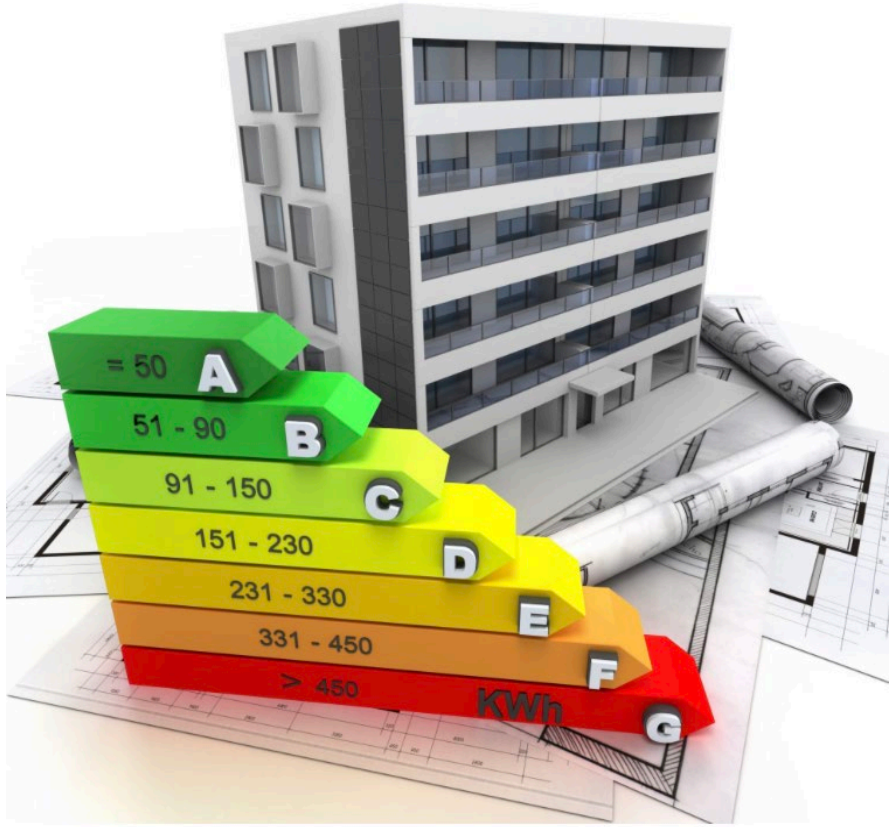
Energy Efficiency in buildings

- Reducing energy consumption
- Optimizing energy use

While maintaining or improving overall performance



Buildings: **> 40%** of energy consumption,

> 35% of greenhouse gas emissions in EU

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EU targets: reduce energy use of residential buildings by
16% (2030) and **22%** (2035)

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EU's Renovation Wave strategy (2020):

- **55%** of the energy savings in the residential sector will be delivered through renovations of buildings with the lowest energy performance
- Improvements in energy performance of the **16%** worst-performing non-residential buildings by 2030 and the **26%** worst-performing buildings by 2033

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EU's Renovation Wave strategy (2020):

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- Improvements in energy performance of the **16%** worst-performing non-residential buildings by 2030 and the **26%** worst-performing buildings by 2033

All new residential and non-residential buildings must have **zero on-site emissions** from fossil fuels (1/1/2028 for publicly owned buildings, 1/1/2030 for all other new buildings)

EU targets: reduce energy use of residential buildings by

16% (2030) and **22%** (2035)

The challenge is NOT one-dimensional

It is a very complex multidimensional question

How to navigate such a landscape?

Industry 4.0

For energy efficiency, flexibility and inclusivity

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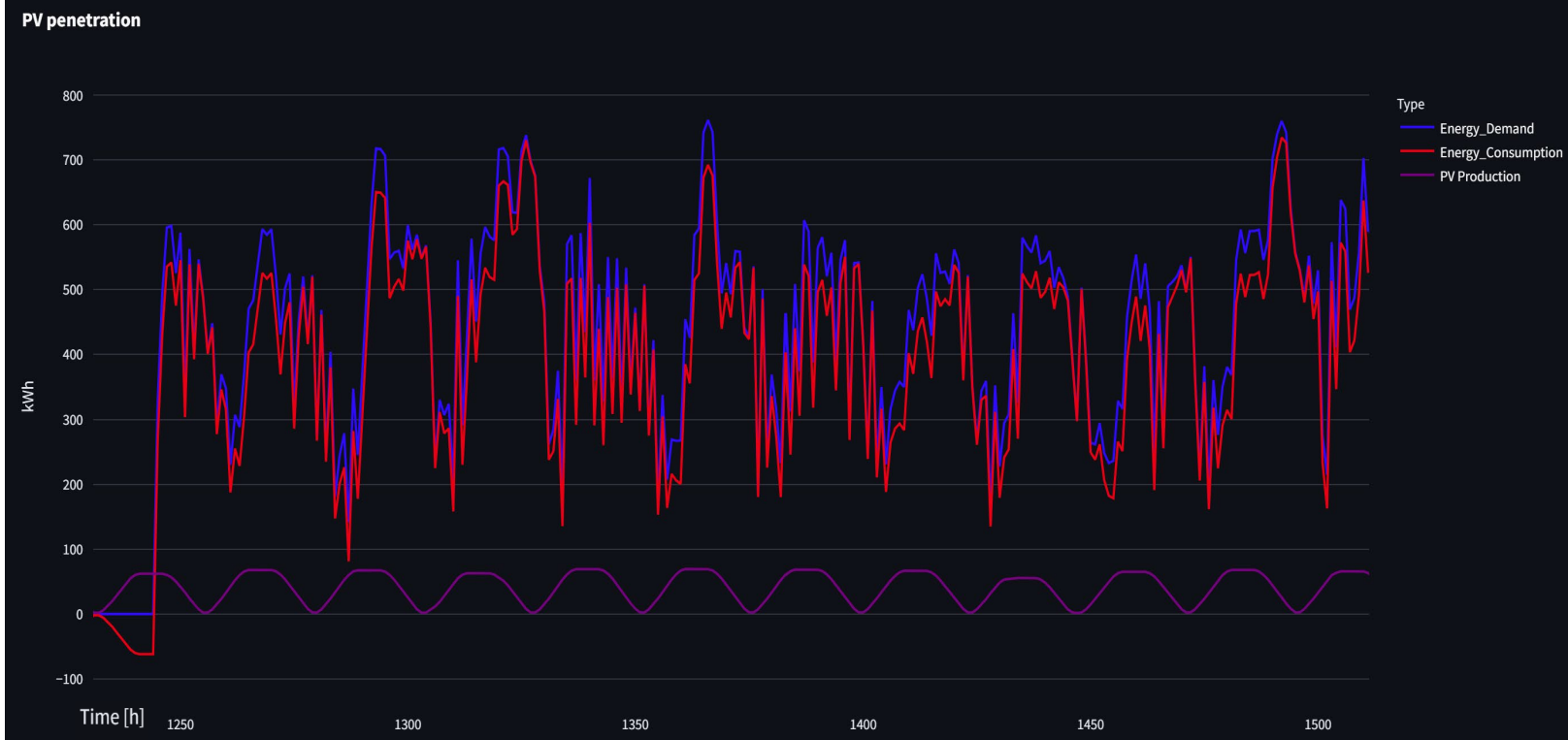
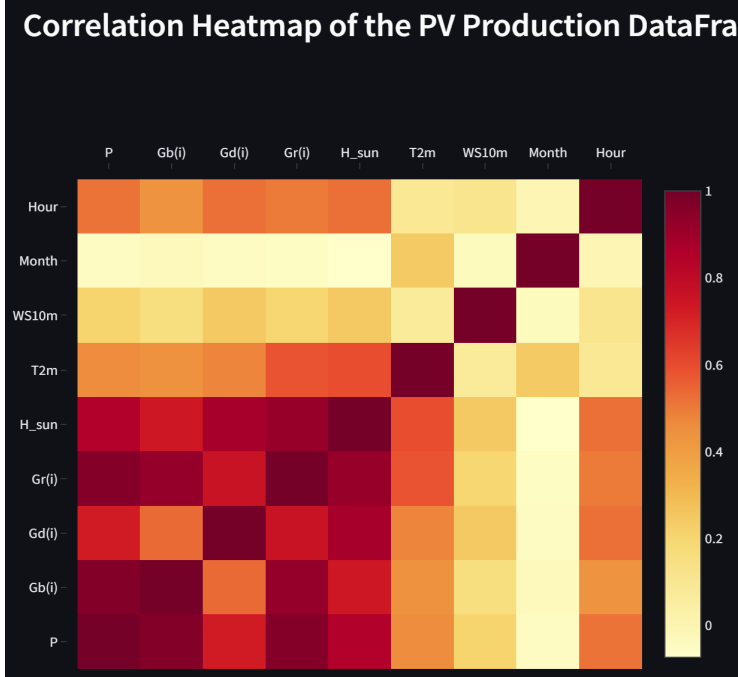
Step 1

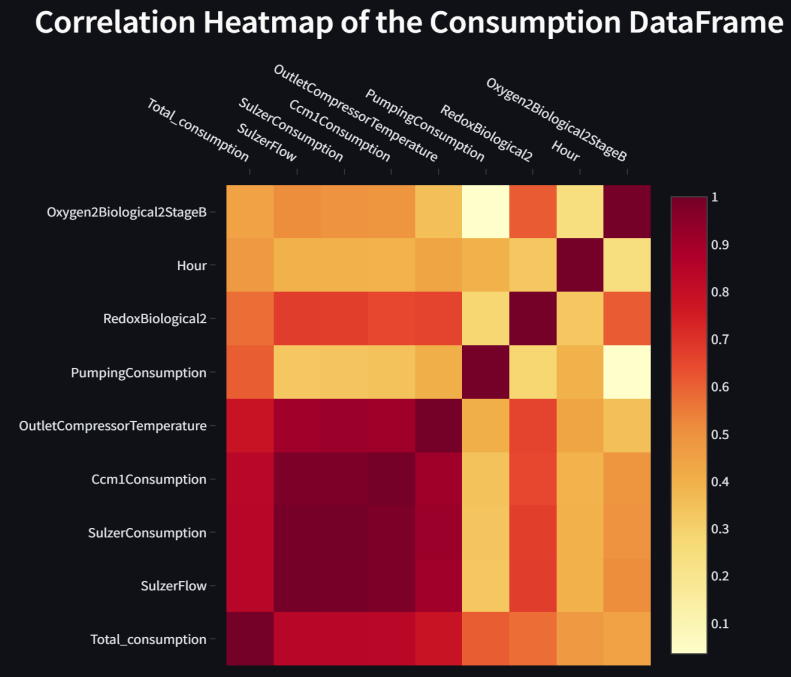
Assess the needs in terms of energy efficiency targets

&

Identify worst-performing assets

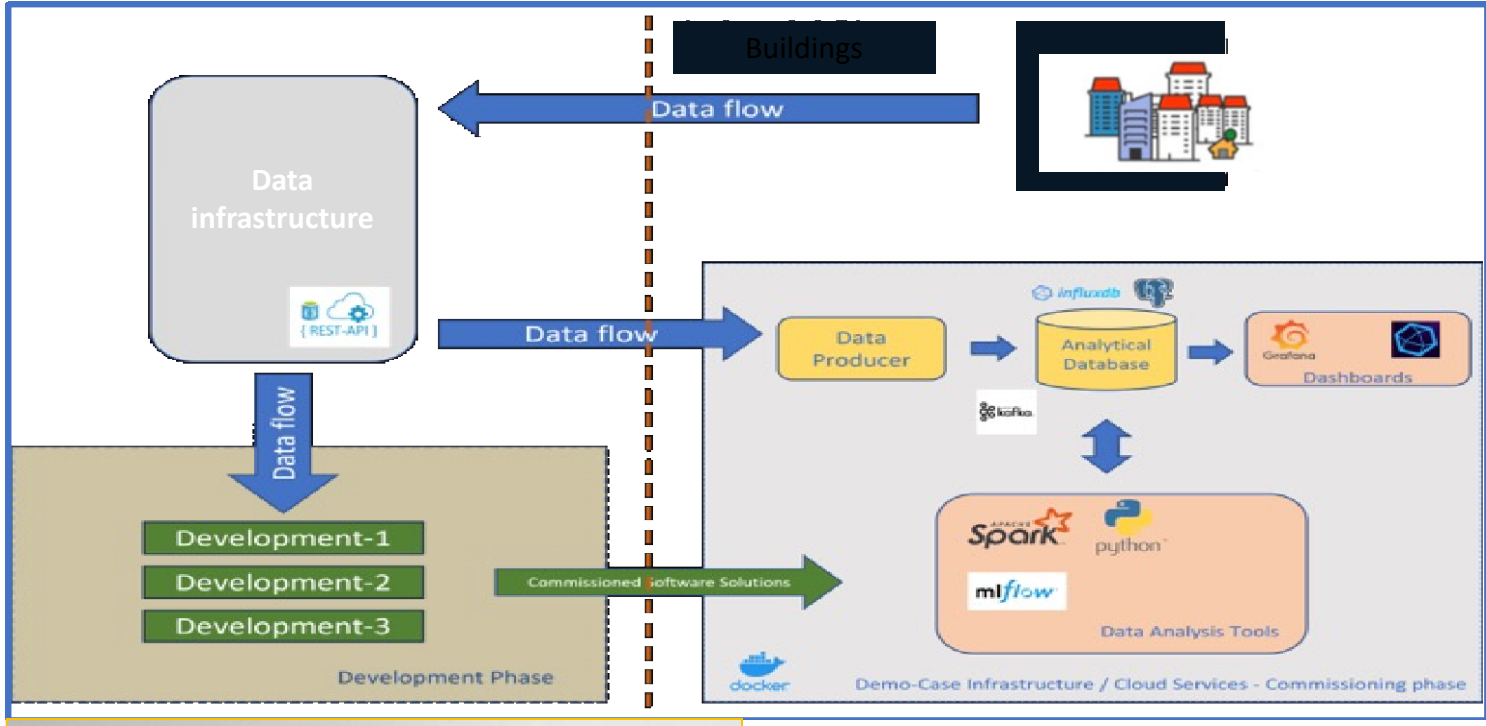


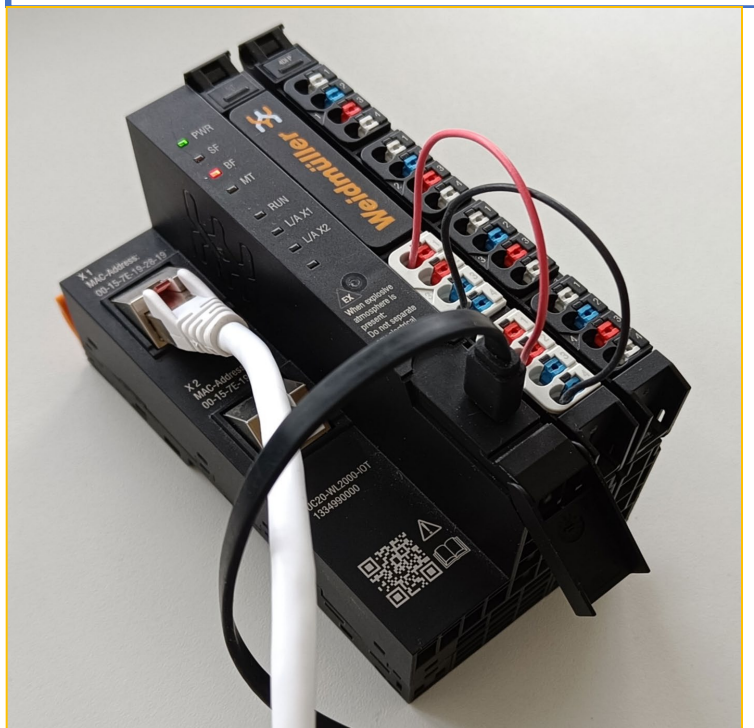




Step 2

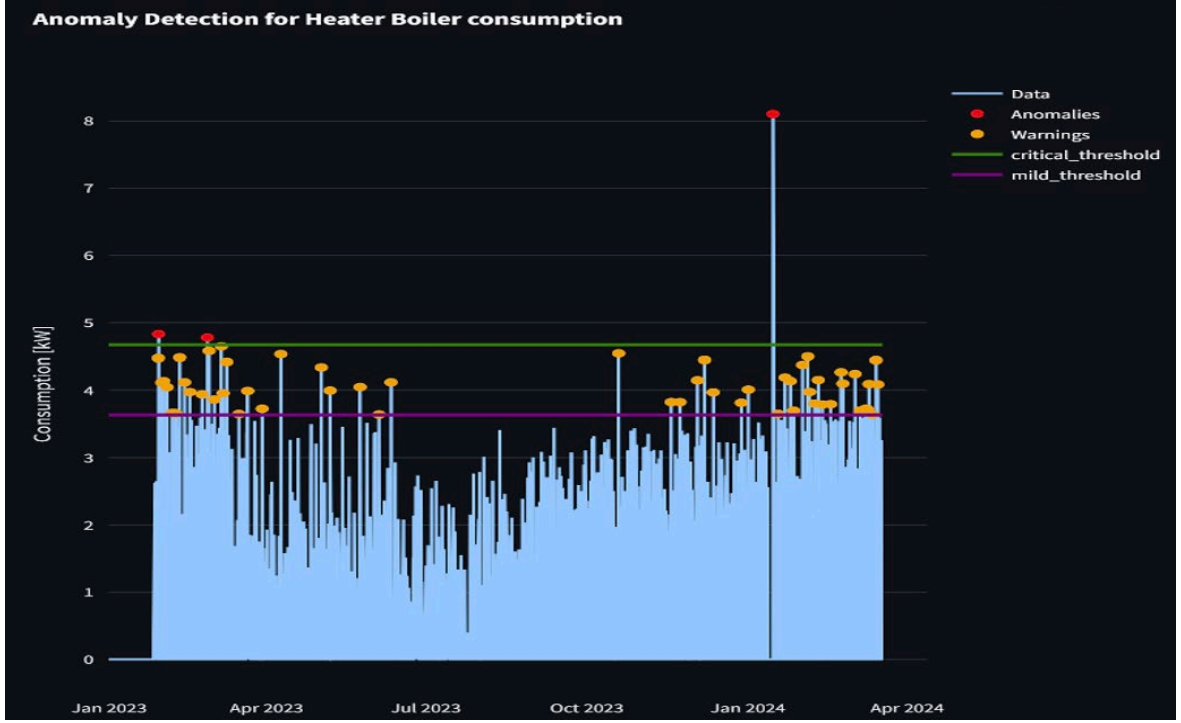
Install required smart energy meters and other sensors if necessary at identified assets to **collect all required data** for energy management

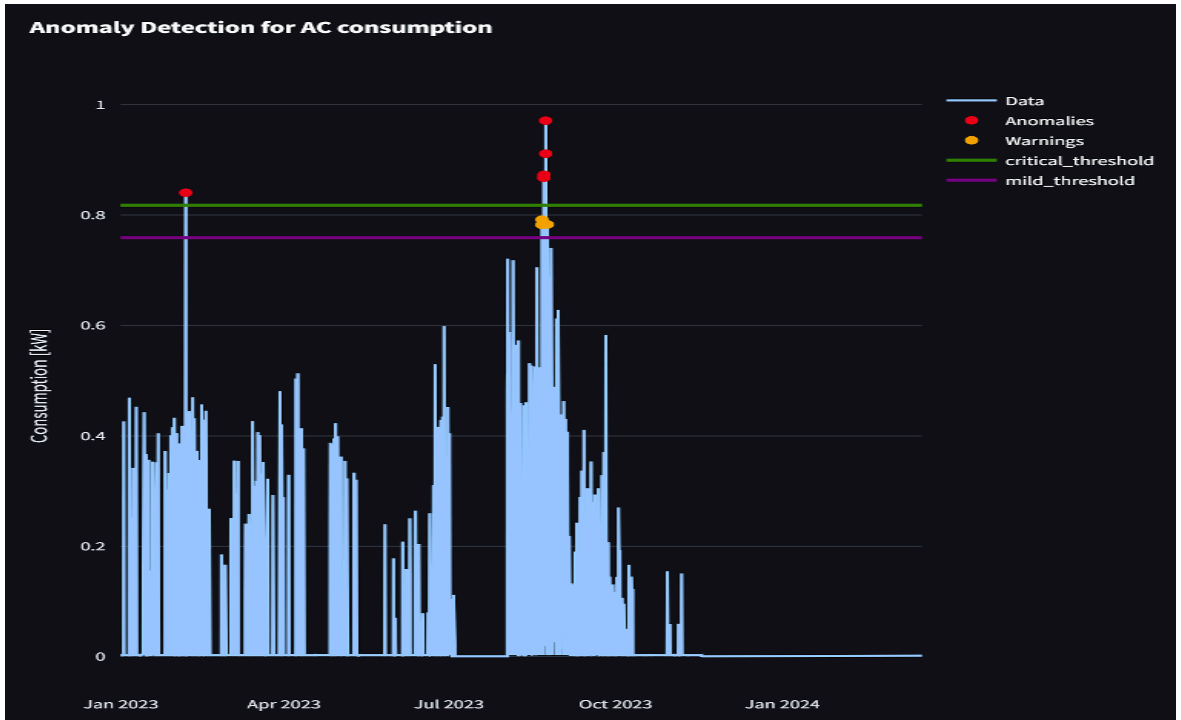




Step 3

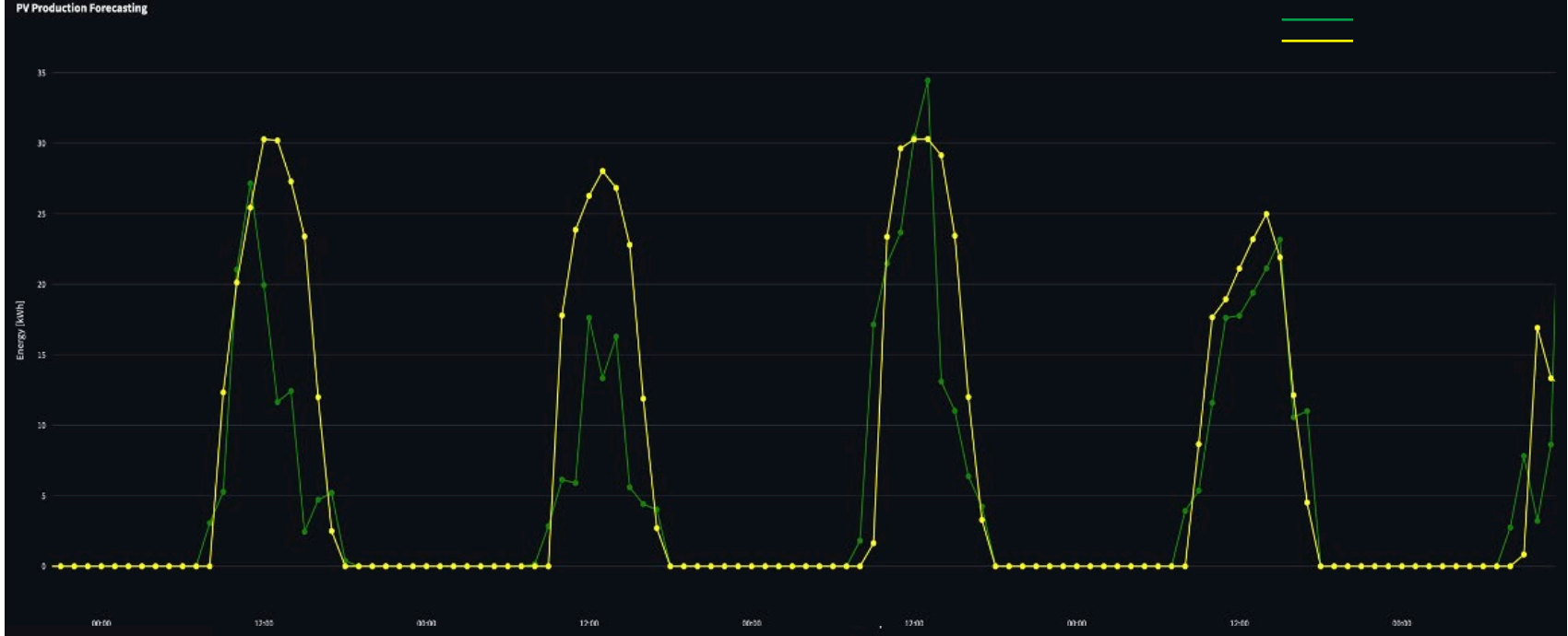
Deploy advanced data analytics tools to identify trends, patterns and anomalies

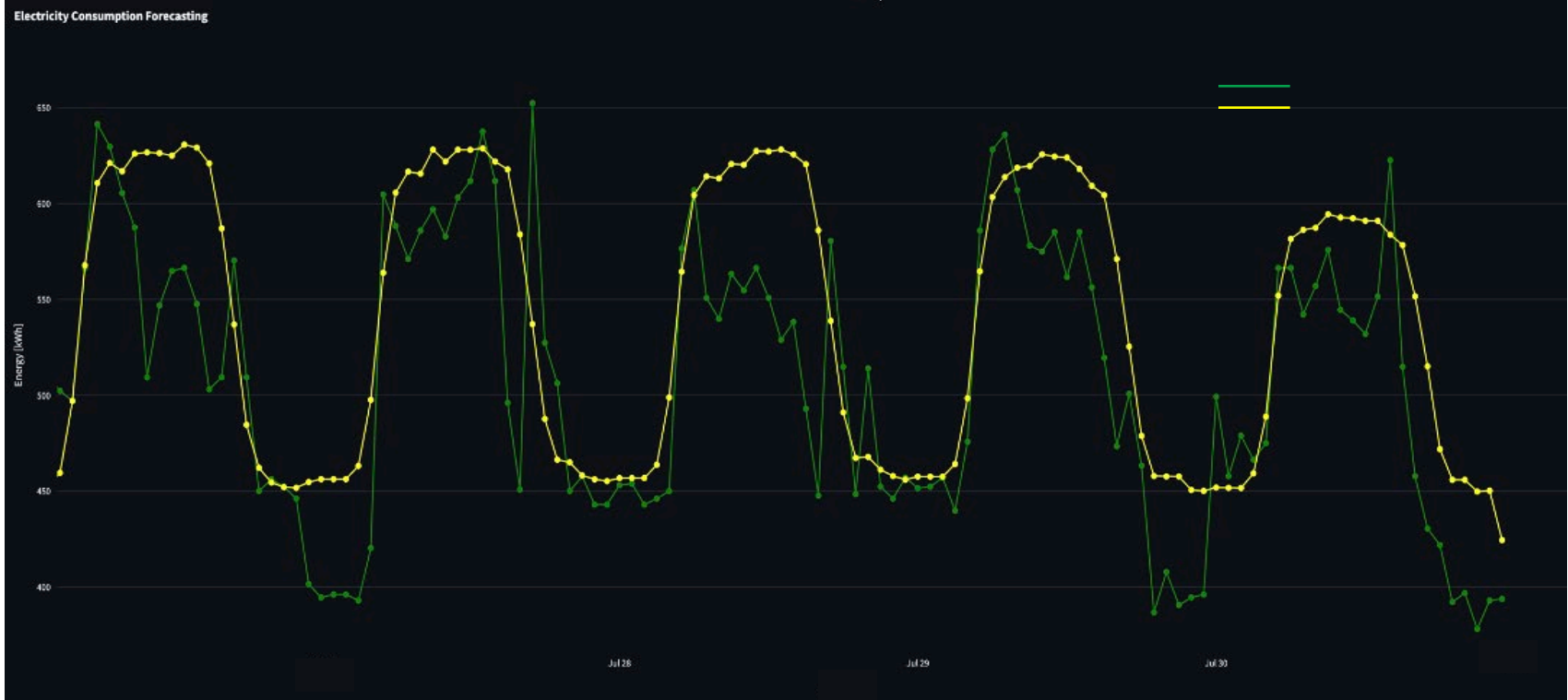




Step 4

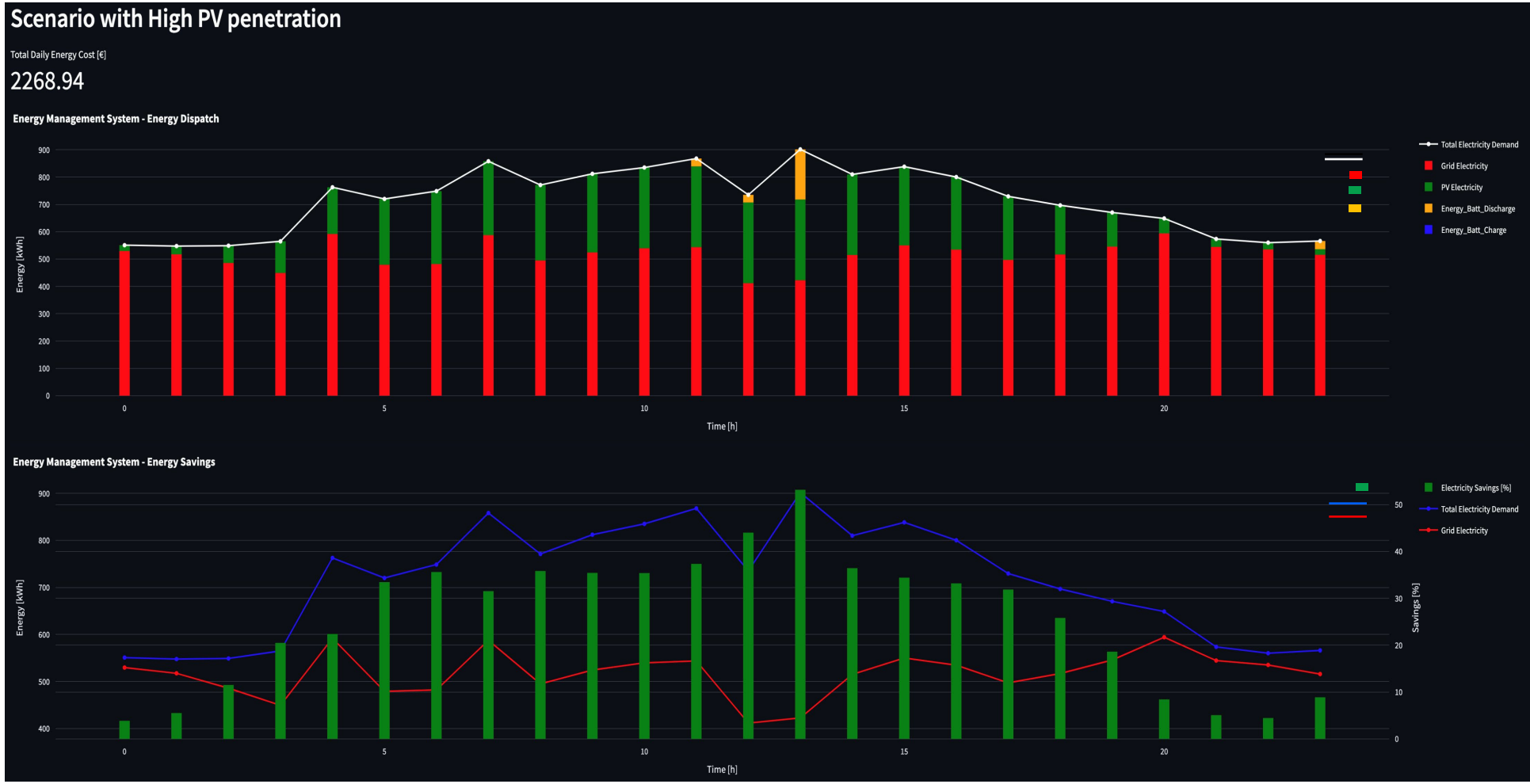
Develop AI models to forecast future energy consumption and generation





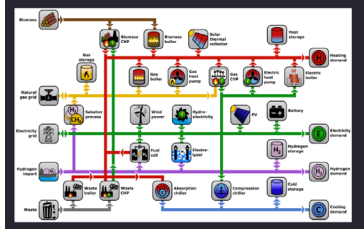
Step 5

Design advanced optimization algorithms to reduce peak energy consumption



Step 6

Provide suggestions for the optimal mix of renewable energy and storage investments by analysing feasibility and financial viability of various RES technologies



Select RES Devices

Renewable Energy Sources

- [x] Photovoltaics - PV
- [ ] Wind Turbine - WT
- [ ] Hydropower - WAT
- [x] Solar Thermal Collector - STC

Natural Gas

- [x] Combined Heat and Power - CHP
- [x] Gas Boiler - BOI
- [x] Gas Heat Pump - GHP

Heating and Cooling

- [x] Electric Heat Pump - HP
- [ ] Electric Boiler - EB
- [ ] Compression Chiller - CC
- [ ] Absorption Chiller - AC

Biomass and Waste

- [ ] Biomass CHP - BCHP
- [ ] Biomass Boiler - BBOI
- [ ] Waste CHP - WCHP
- [ ] Waste Boiler - WBOI

Hydrogen

- [ ] Electrolyzer - ELYZ
- [ ] Fuel Cell - FC
- [ ] Hydrogen Storage - H2S
- [ ] Sabatier reactor - SAB

Storages

- [ ] Thermal Energy Storage - TES
- [ ] Cold Thermal Energy Storage - CTES
- [x] Battery - BAT
- [x] Gas Storage - GS

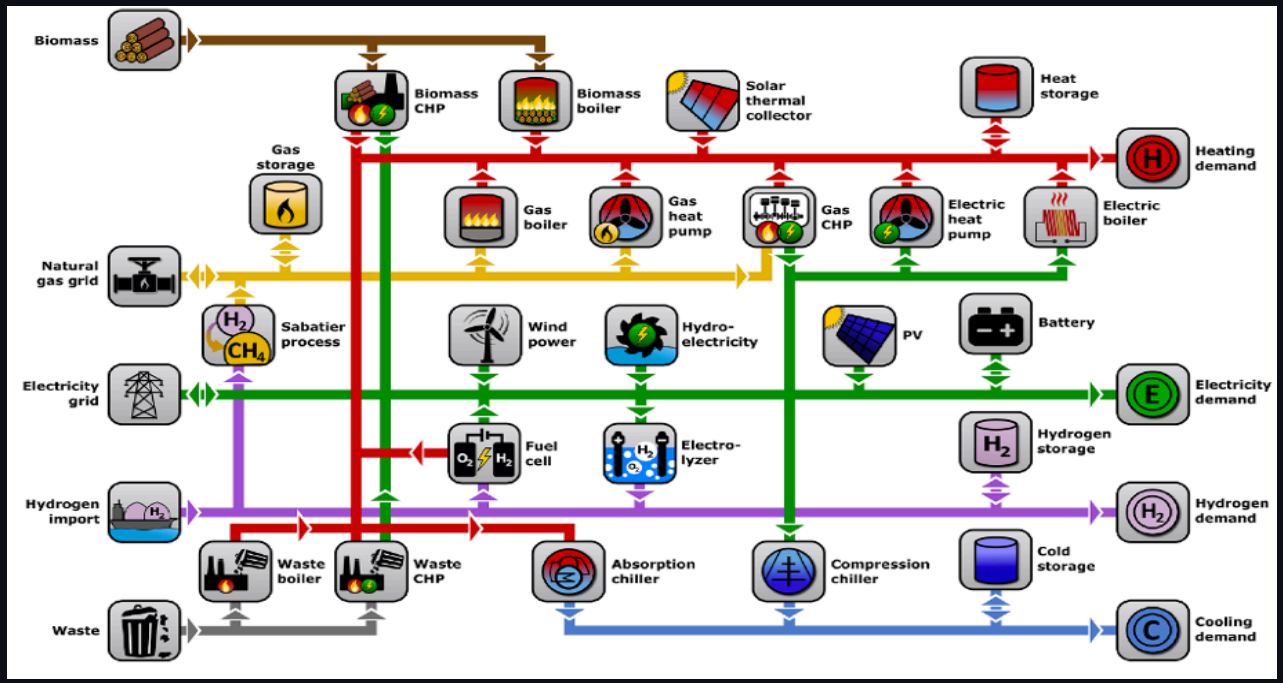
Prices

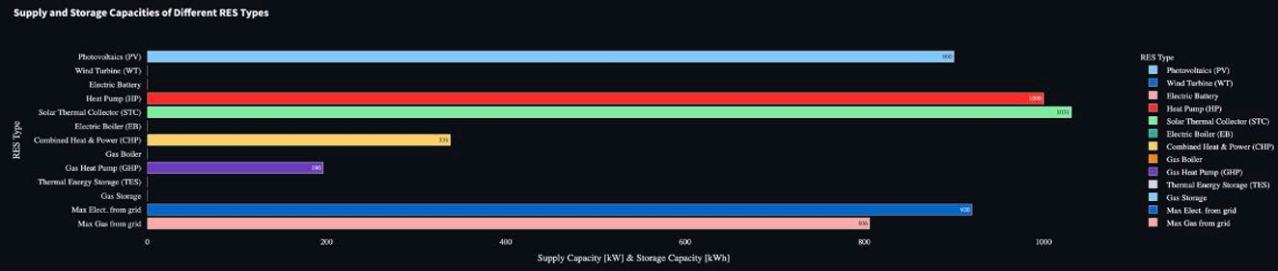
Electricity price [€/kWh]

0,15

RES Selector - Energy System Optimization

Run Optimization





Applied Industry 4.0

core group | SUSTAINABLE PLACES 2024 | PRELUDE

PRELUDE project

€ 9.5 million, 4 years

21 partners, 8 pilots in 5 countries

Transform EU residential buildings:

- optimize building operation
- minimize energy consumption
- maximize self-consumption and RES utilization

while maintaining comfortable and healthy conditions


Switzerland


Denmark


Italy


Greece


Poland

Other projects about buildings we are working on...

How it all begun…E-DYCE project

€ 2.8 million, 3 years (completed)

10 partners, several pilots in 4 countries

Real time optimization of building performance and comfort by capturing the building's dynamic behaviour

Increasing reliability of energy performance assessment process and supporting communication between labelling professionals and building owners


Switzerland


Denmark


Italy


Cyprus

SATO project

€ 6.8 million, 4 years (on-going)

17 partners, several pilots (mixed use buildings) in 5 countries

Building energy consuming equipment self-assessment and optimization platform

Develop and demonstrate solutions that, independently of the building type, can provide IoT capabilities to new and legacy energy devices for self- assessment and optimization


Spain


Denmark


Italy


Austria


Portugal

INPERSO project

€ 9.5 million, 4 years (on-going)

18 partners, several pilots (residential, heritage) in 3 countries

Deep renovation programme focusing on the building's entire lifecycle
Catering for individual needs of key stakeholders involved in the retrofit process

Addressing the challenges of digitalisation, fragmentation, quality, efficiency and rapidity from project design to the end-of-life


Spain


Netherlands


Greece

INBLANC project

€ 5 million, 3.5 years (start 2025)

22 partners, several pilots (residential, non-residential) in 6 countries

Goal to create an open ecosystem structured on the data economy of building lifecycle

Five types of indicators and models (Energy, Human, Environment, Economy, and Resilience) will be calculated, modelled, and operational-ised


Spain


Netherlands


Switzerland


Denmark


Greece


Cyprus

About CORE

core group

Leading the digital and green transition

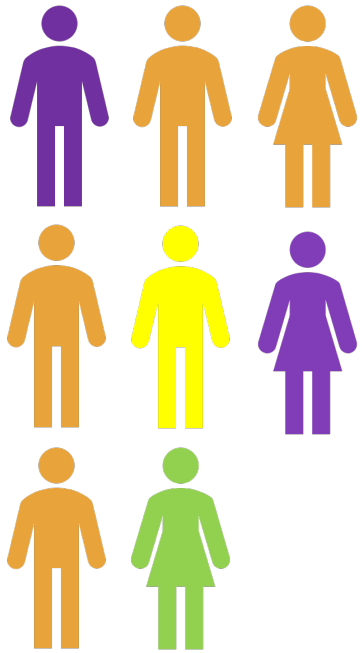
50+
EU-funded projects

20M €
EU funding

68
Team Members

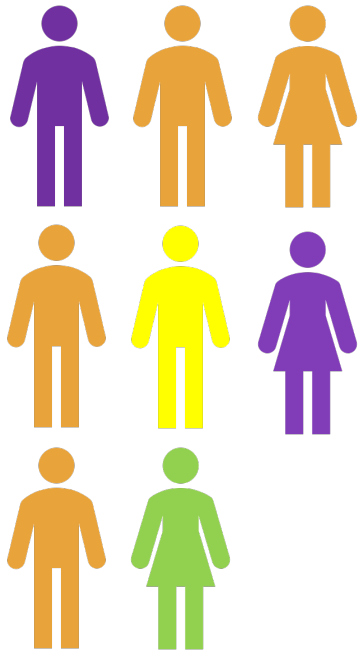
300+
Partners

Energy and Resource Efficiency Unit



Data scientists
Project Managers
Technical Project Manager

Energy and Resource Efficiency Unit



Data scientists
Project Managers
Technical Project Manager

- Team spirit and communication
- Access to data from various industries
- AI/ML models for interpretation and decision making
- Scalable, expandable, versatile solution
- Transfer solutions from one industry to another with domain expertise

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Thanks

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement N° **958345**

core group | SUSTAINABLE PLACES 2024 | PRELUDE

DEMONSTRATION RESULTS OF A LOW-TECH PREDICTIVE CONTROL SCHEME FOR DEMAND SIDE FLEXIBLE HEAT PUMP OPERATION IN THE RESIDENTIAL SECTOR

Florian Wenig

FH Burgenland GmbH, University of Applied Sciences Burgenland GmbH

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement N° **958345**

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SUSTAINABLE PLACES 2024

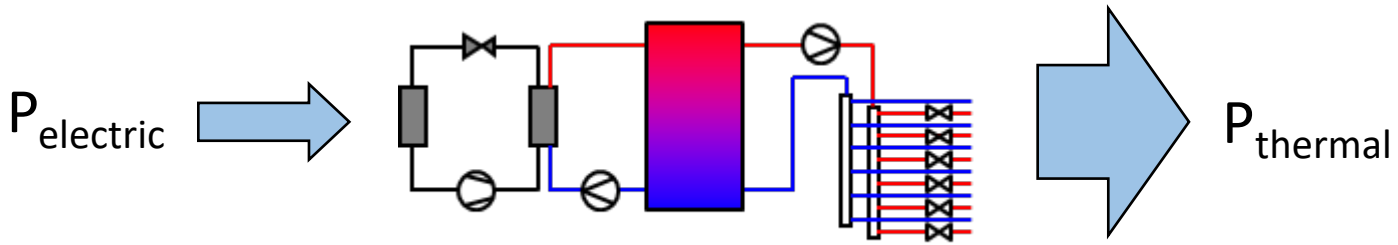
PRELUDE

Overview

- Introduction
- Building model
- Predictive control scheme
- Setpoint translation
- Results of a one-month test operation

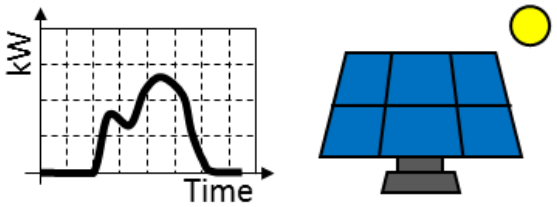
Demand side flexibility of heat supply

Electrification of building heat supply through heat pumps

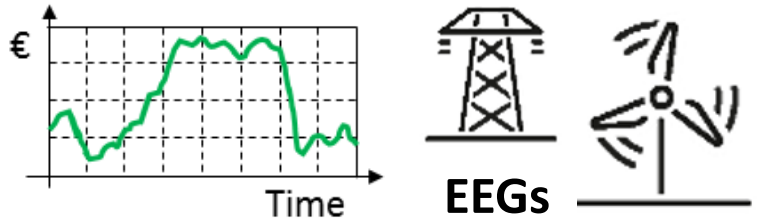


Adaptation of the load profile to volatile renewable generation

„Local generation“



„Regional generation“



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SUSTAINABLE PLACES 2024

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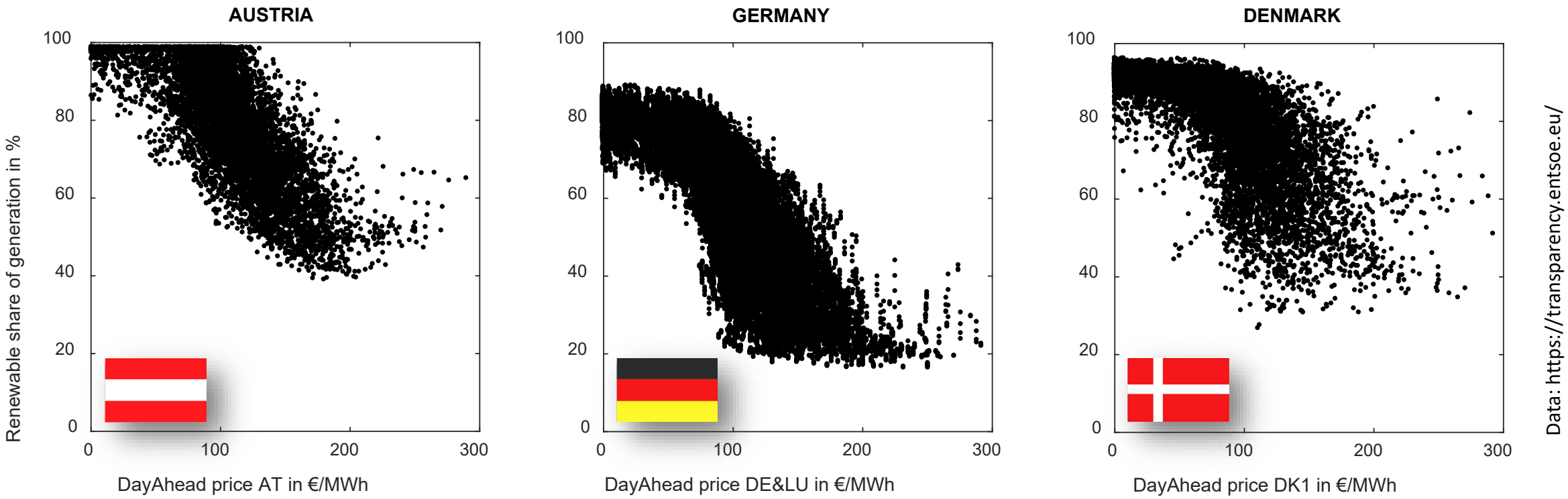
National electricity generation – renewable share



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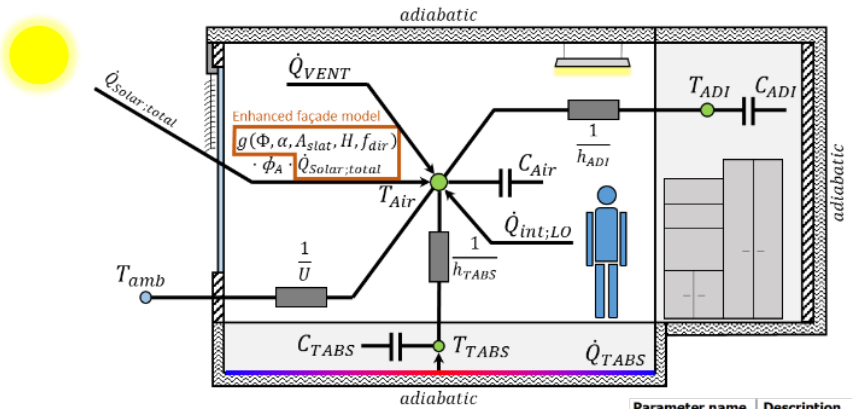
Predictive Control Schemes – PRELUDE

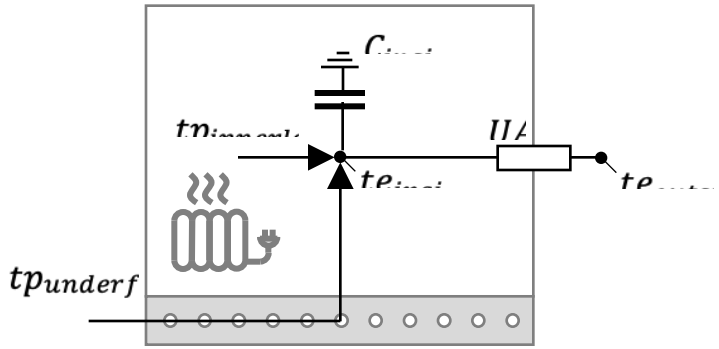
Pinkafeld, Austria

Multiple thermal zones with complex structure

Egernsund, Denmark

Single thermal zone with simple structure





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SUSTAINABLE PLACES 2024

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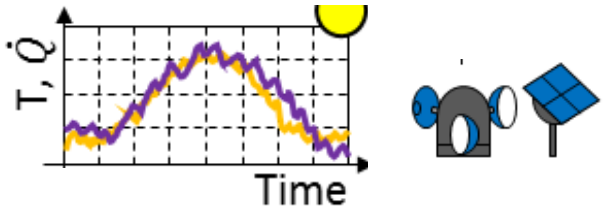
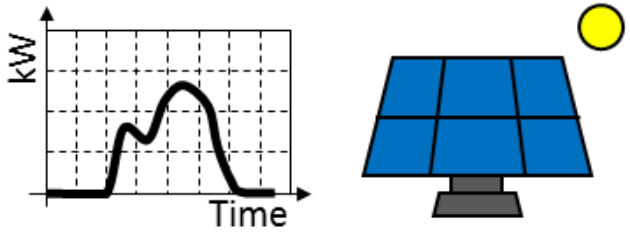
Predictive feed-forward control scheme

Weather prediction



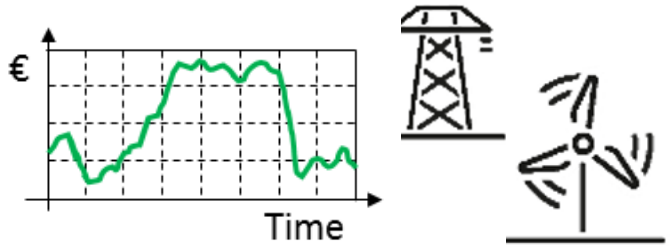
- Sufficient availability of Web APIs
- Sufficient accuracy
- Freely available from national weather services

Local generation



- Specific web APIs available
- Alternative: Simple models from radiation predictions

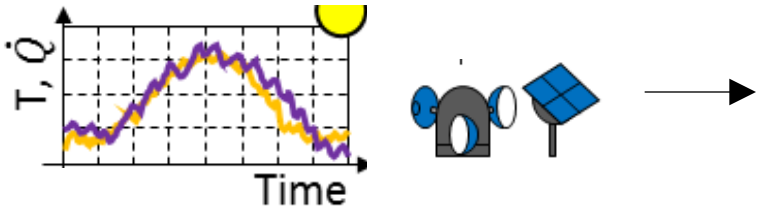
Regional generation



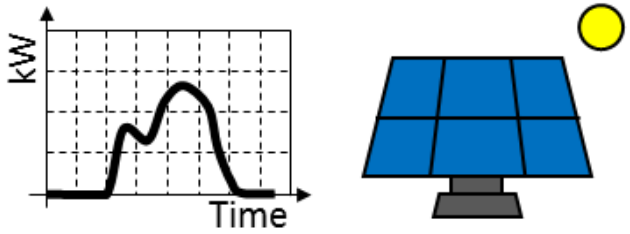
- Web APIs available
- Challenge: Estimation for electricity prices >DayAhead
  Simple models from historical data
- Integration of variable grid tariffs

Predictive feed-forward control scheme

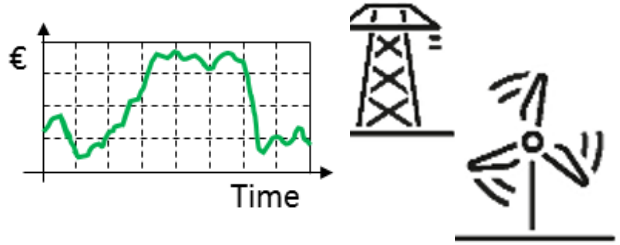
Weather prediction

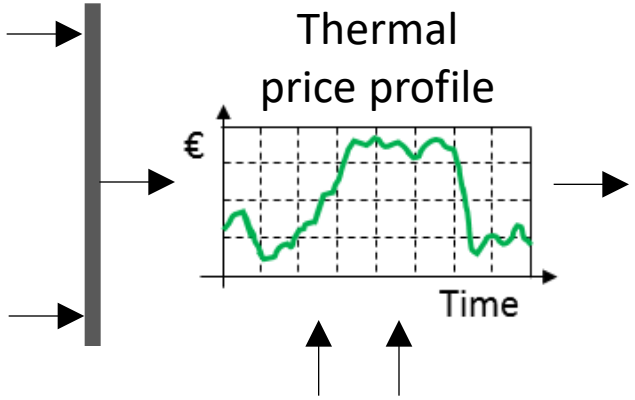


Local generation



Regional generation





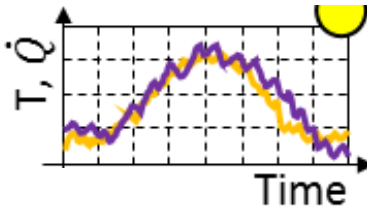
Efficiency of heat pump (COP)

Domestic electricity consumption

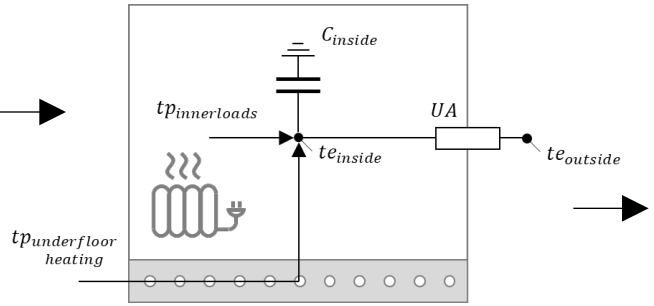
- Derivation of thermal price profile for integer control variables (on/off) possible
- Combination of local and regional generation in one signal
- Optional consideration of system efficiency (COP) and household electricity consumption

Predictive feed-forward control scheme

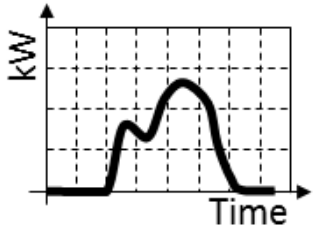
Weather prediction

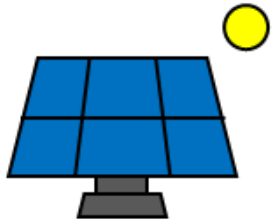


Heating demand from
Building model (steady state)

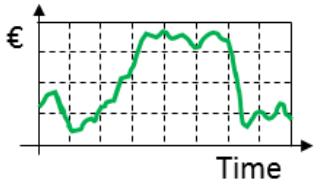


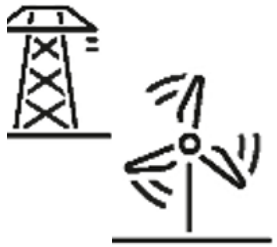
Local generation



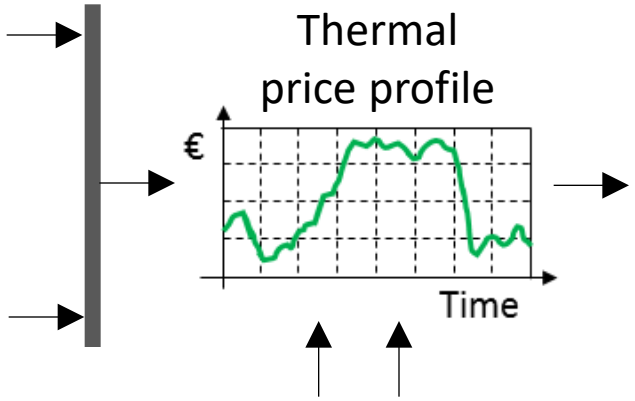


Regional generation





Thermal
price profile



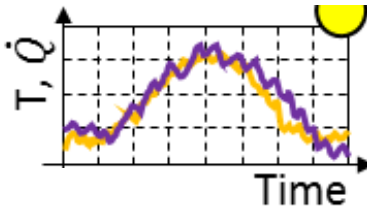
Efficiency of heat pump (COP)

Domestic electricity consumption

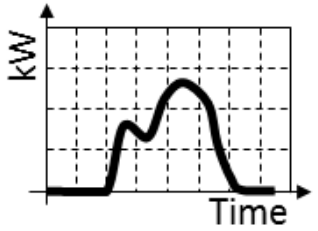
- Estimation of heating energy requirement from the steady state part of the building model (very simple approach!)

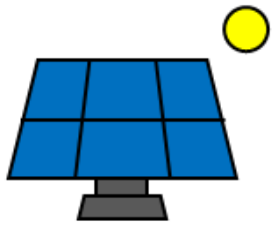
Predictive feed-forward control scheme

Weather prediction

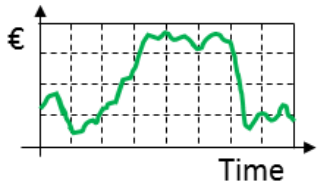


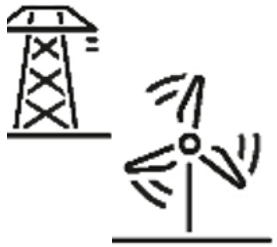
Local generation



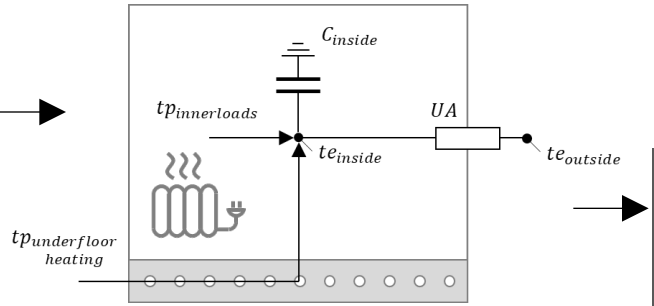


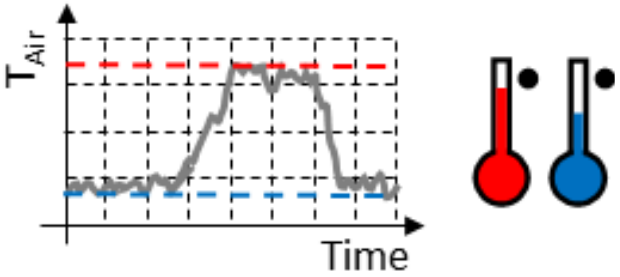
Regional generation





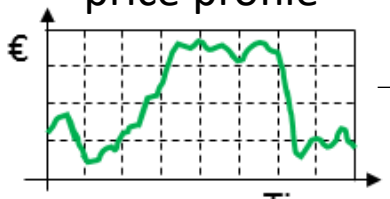
Heating demand from
Building model (steady state)





Thermal comfort constraints
for optimization problem

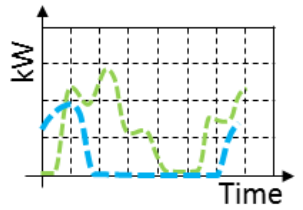
Thermal
price profile



Numerical
optimization

minimize $R^{\mathrm{T}}U_k$
subject to $AU_k \leq b$ (linear constraints)
$\mathrm{B_L} \leq U_k \leq B_U$ (bound constraints)

Operation plan

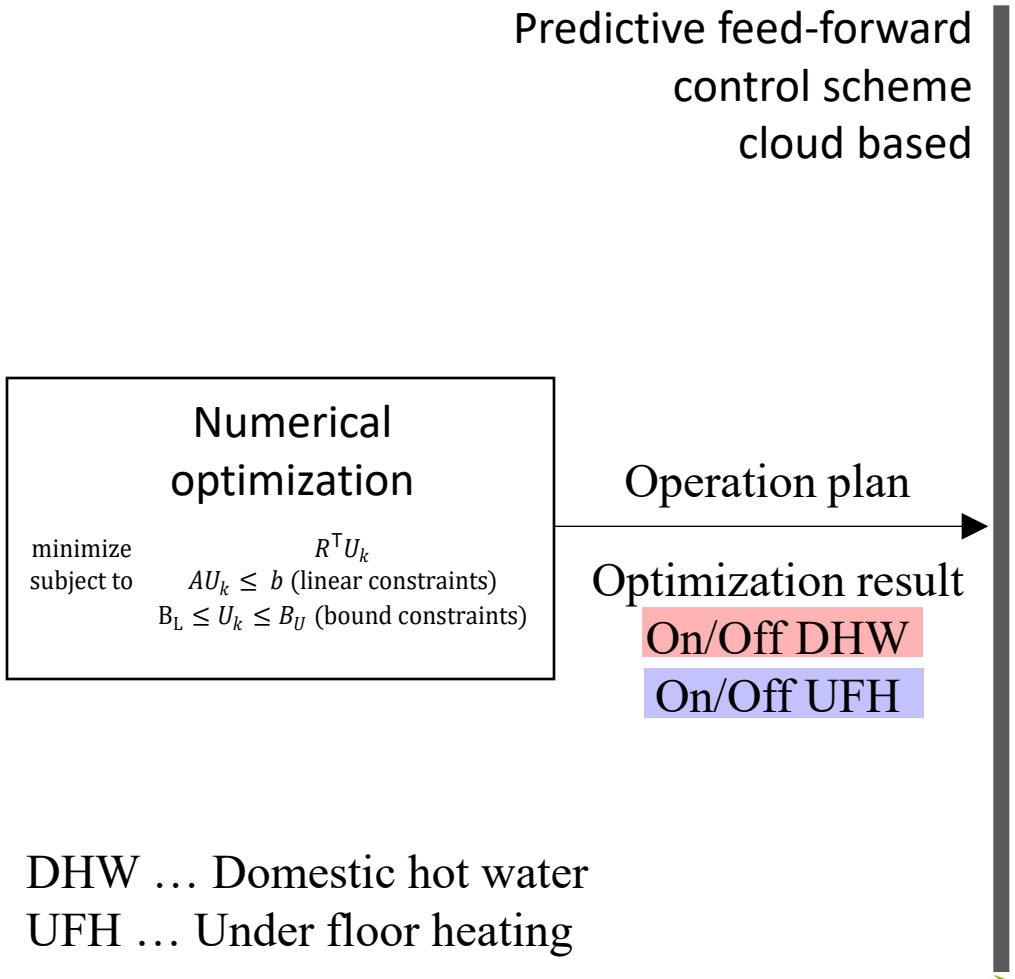


Building dynamics from
Building model (dynamic)

Efficiency of heat pump (COP)

Domestic electricity consumption

Optimization results combined with local controller (set point translation)



DHW … Domestic hot water
UFH … Under floor heating

Optimization results combined with local controller (set point translation)

Predictive feed-forward control scheme cloud based

Local setpoint controller at building level

Numerical optimization

minimize $R^{\mathrm{T}}U_k$

subject to $AU_k \leq b$ (linear constraints)

$\mathrm{B_L} \leq U_k \leq B_U$ (bound constraints)

Operation plan

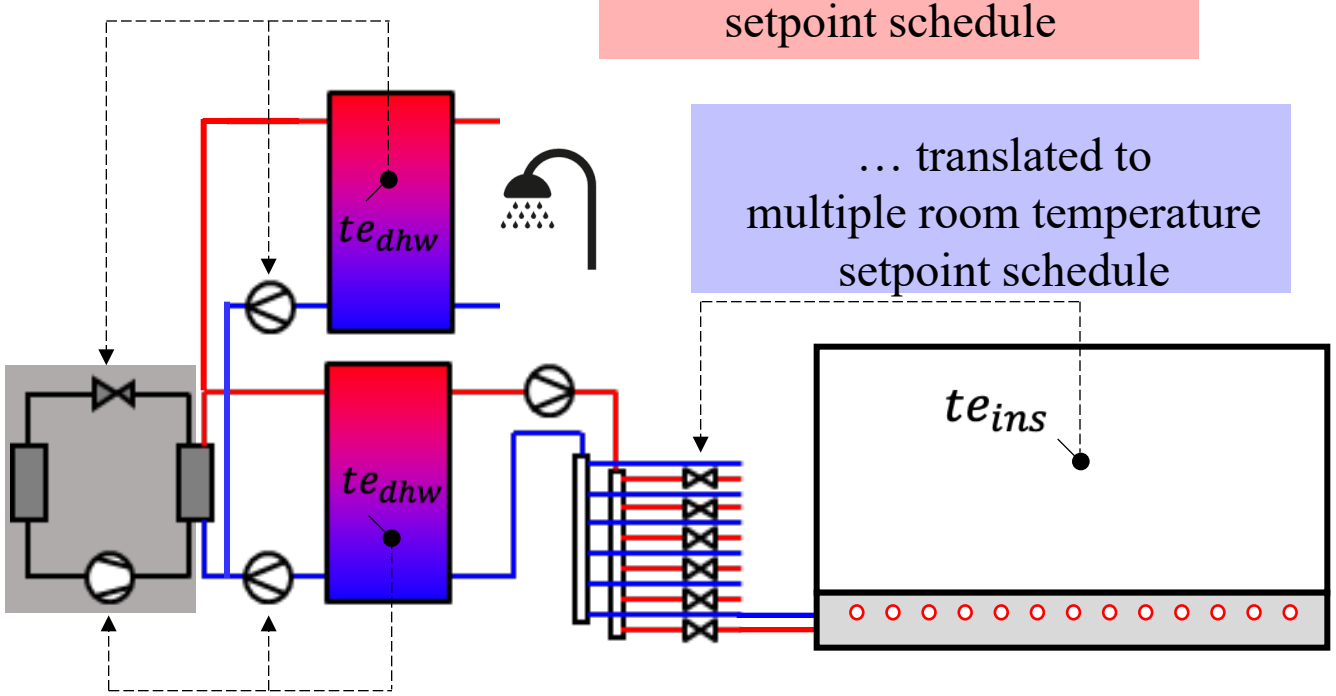
Optimization result

On/Off DHW

On/Off UFH

… translated to dhw buffertank temperature setpoint schedule

… translated to multiple room temperature setpoint schedule



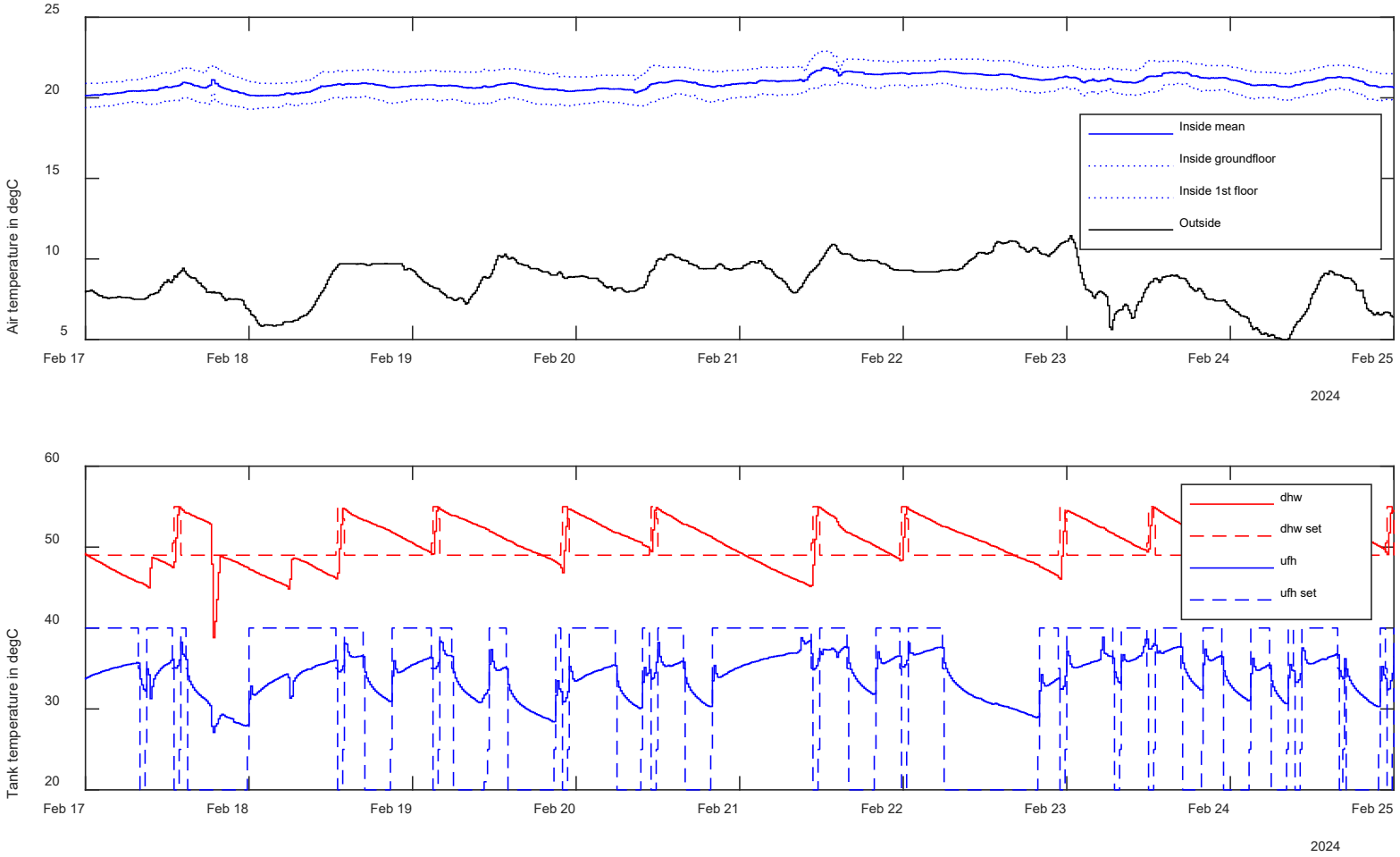
… translated to ufh buffertank temperature setpoint schedule

DHW … Domestic hot water

UFH … Under floor heating

Simplified hydraulic scheme!

Test building results February 2024



Exemplary 8 days

Stable mean inside air temperature

Total February 2024:

20.3 +/- 0.8 °C (mean +/- std)

17. February

DHW event

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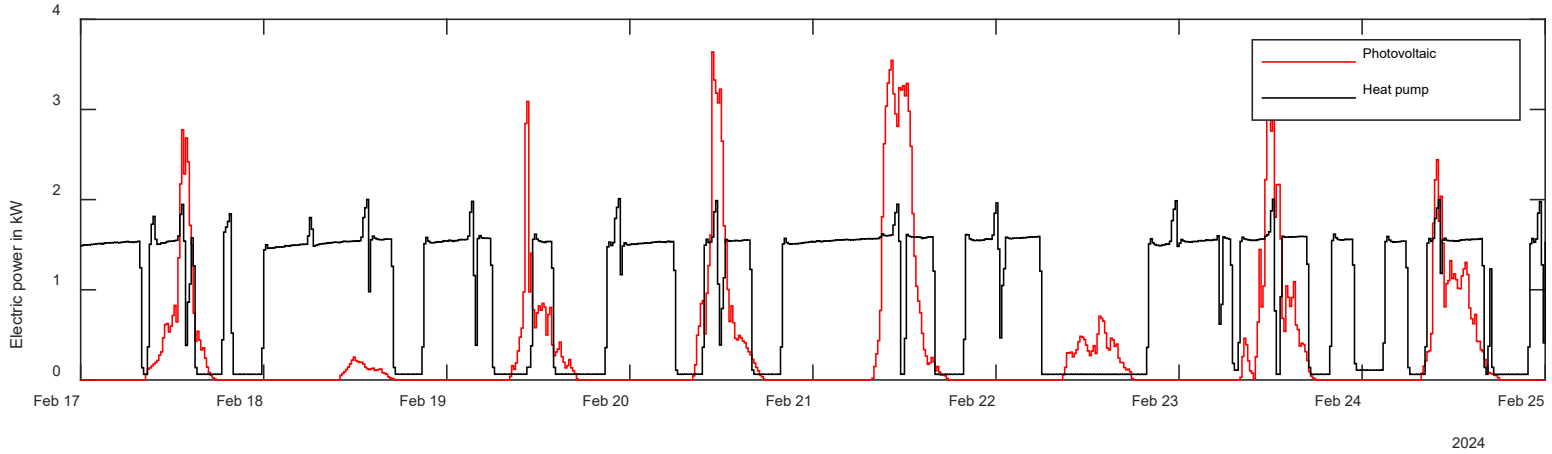
SUSTAINABLE PLACES 2024

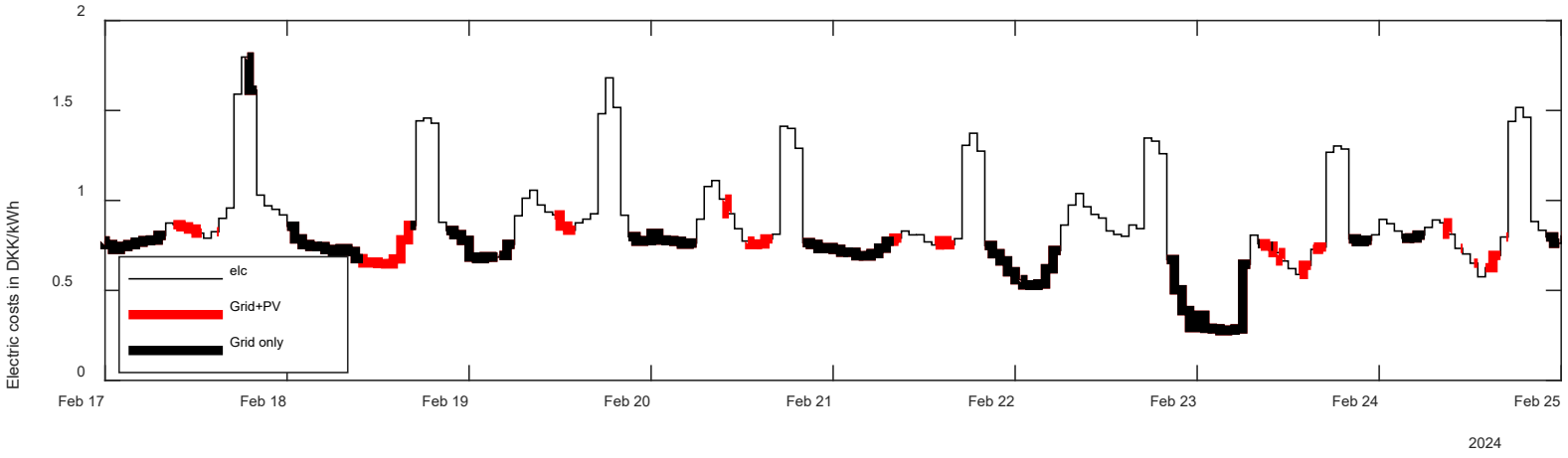
PRELUDE

Results February 2024

Network tariff in Egernsund

Time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Winter																								
Summer																								





Exemplary 8 days

17. February
    Fail due to DHW event
19. & 20. February
    Use of PV energy
22. February
    Avoidance of PV energy,
    followed by low cost period
24. February
    Use of small cost valleys

February 2024

Heat pump consumption	683 kWh	(100 %)
From grid	586 kWh	(86 %)
From PV	97 kWh	(14 %)
Photovoltaic production	138 kWh	(100 %)
To heat pump	97 kWh	(71 %)

Electricity import costs

Mean	0.88 DKK/kWh	(100 %)
Realized	0.75 DKK/kWh	(85 %)

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Thanks

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement N° **958345**

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PRELUDE

INVESTIGATION OF THE LONG-TERM PERFORMANCE OF A DATA-DRIVEN MODEL PREDICTIVE CONTROL (DMPC) SYSTEM IN A REAL OFFICE BUILDING

Peter Klanatsky
F. Veynandt, C. Heschl

FH Burgenland GmbH, University of Applied Sciences Burgenland GmbH

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement N° **958345**

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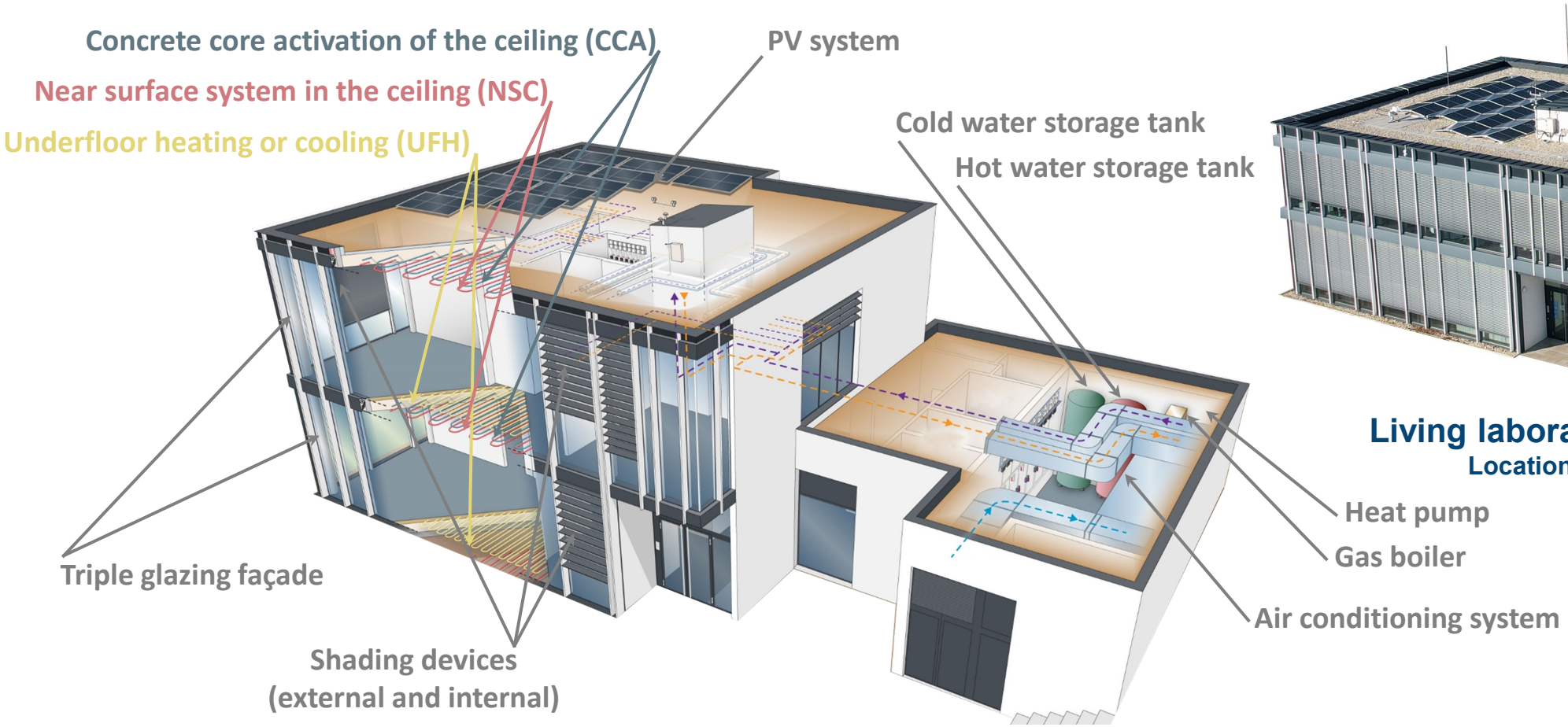
PRELUDE

Overview

- Main features of the real office building
- Hydraulic concept for heat and cold supply
- Developed Data-driven Model Predictive Control (DMPC) approach
- Results of the one-year long-term test

Main features of the real office building



Living laboratory ENERGETIKUM
Location: Pinkafeld, Austria

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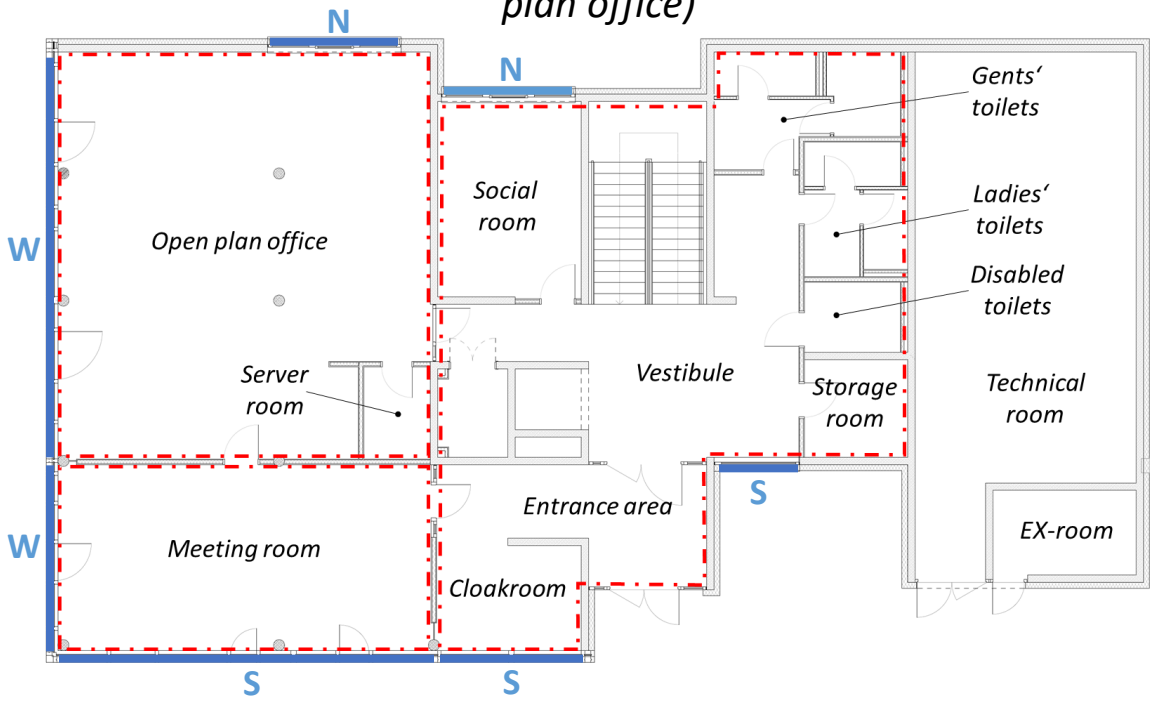
Main features of the real office building

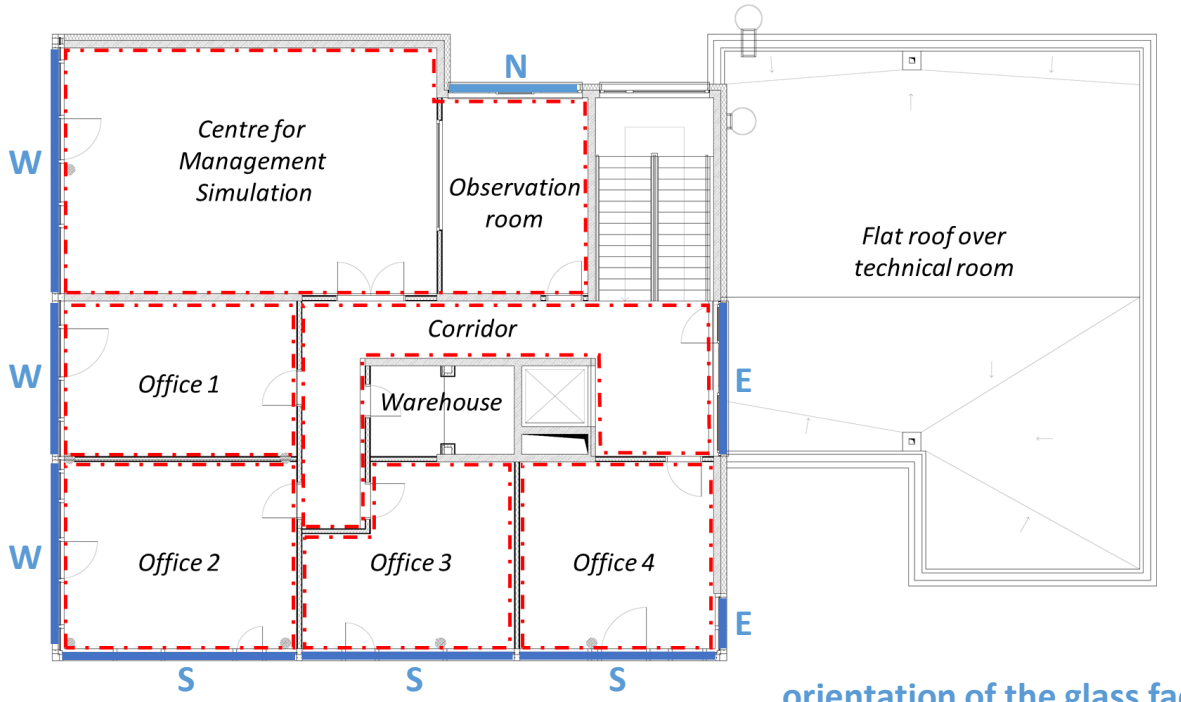
Ground floor

three thermal zones
- but only one UFH- and one NSC-system (controlled by Open plan office)



First floor

six thermal zones
- with totally six UFH- and five NSC-systems



... orientation of the glass façade

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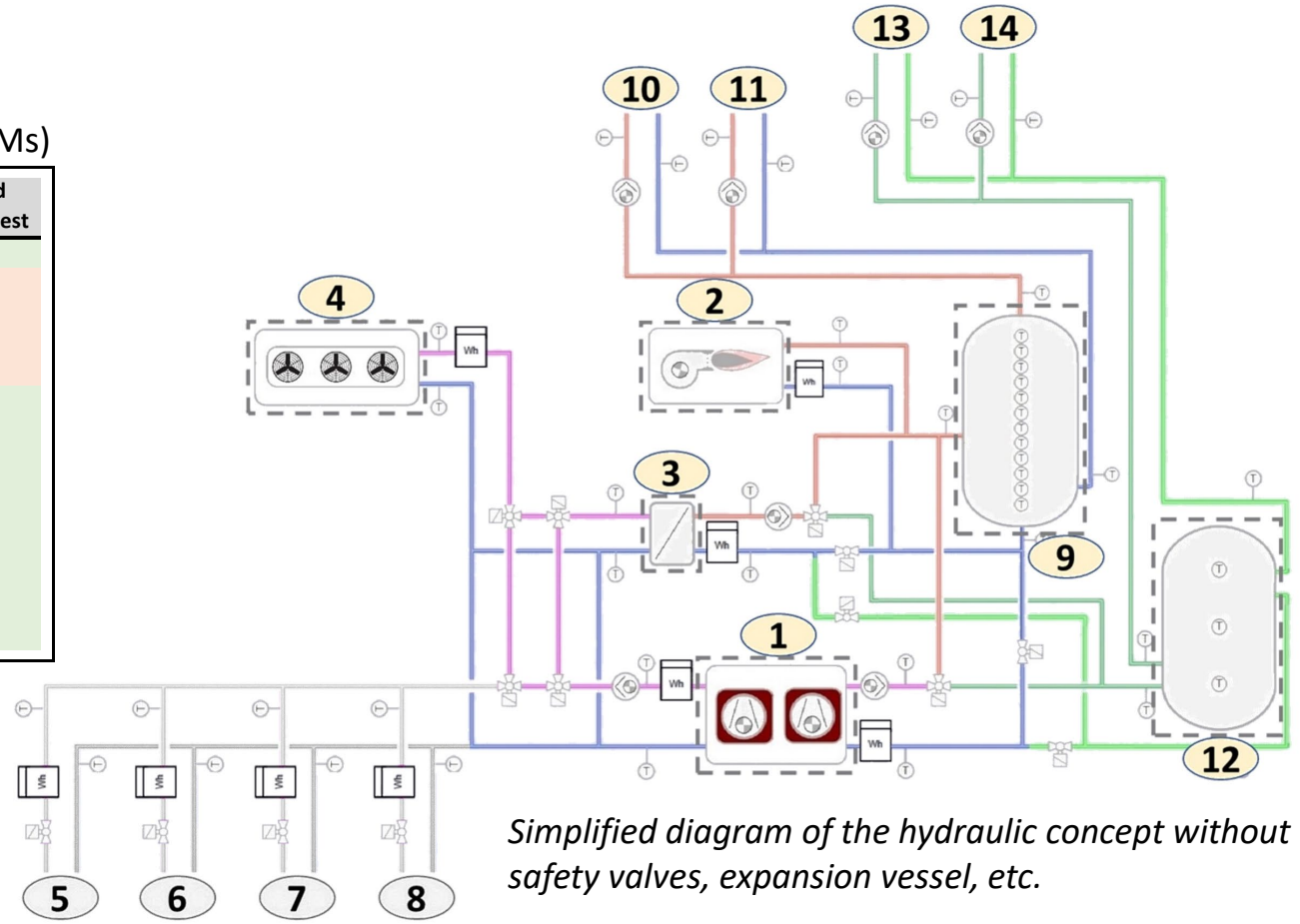
Hydraulic concept for heat and cold supply *baseline VS. longterm test*

*) Complementary Energy Conservation Measures (ECMs)

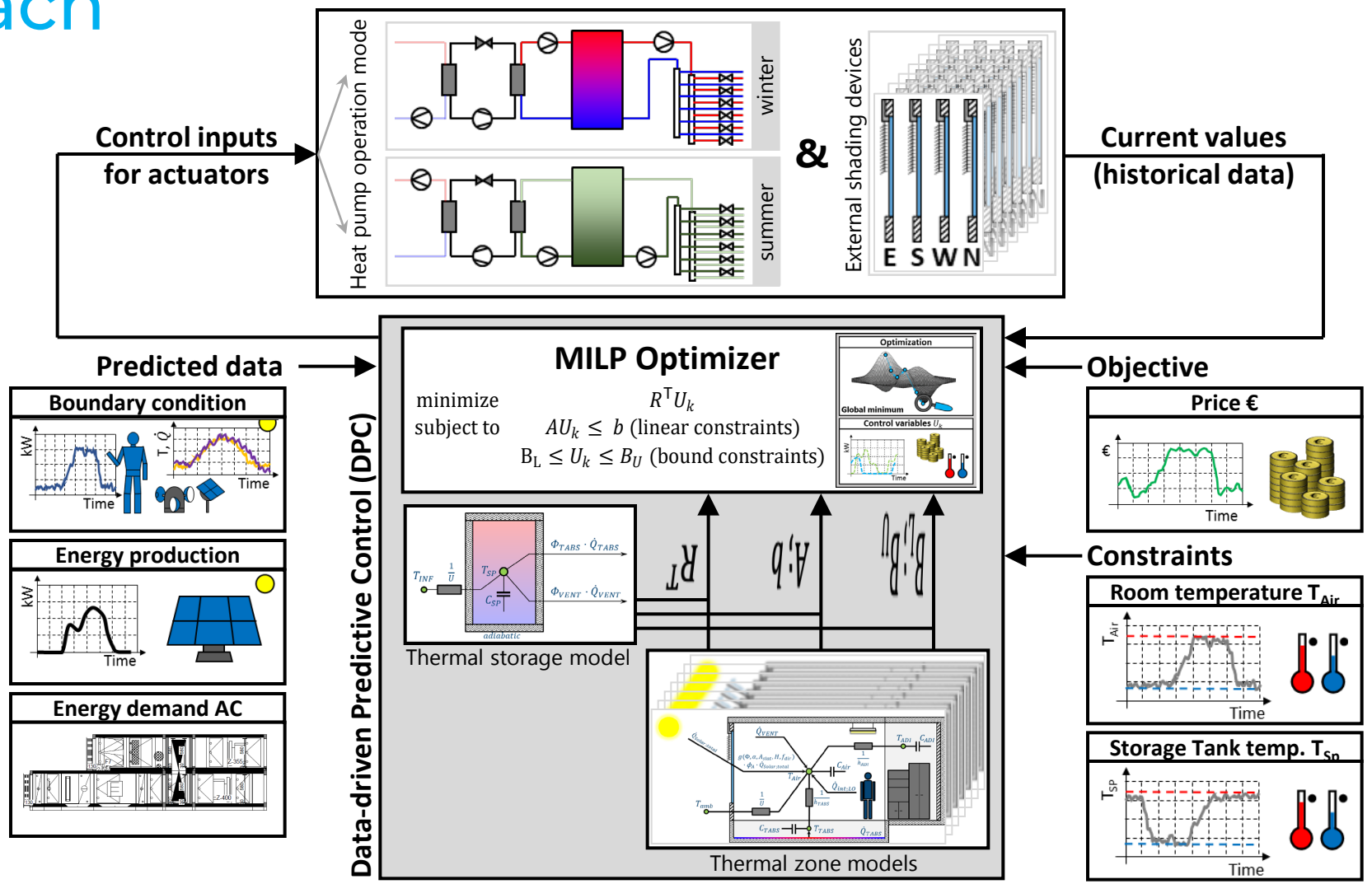
No.	Description	Activated Baseline	Activated Longterm Test
1	Reversible Heat Pump	yes	yes
2	Gas Boiler	yes	no
3	Heat Exchanger for Heat Recovery	yes	no
4	Re-Cooler	yes	no
5	Ground-coupled Heat Exchanger	no	no
6	Helical Ground Heat Exchanger	no	yes
7	Energy Basket Ground Heat Exchanger 1	no	yes
8	Energy Basket Ground Heat Exchanger 2	no	yes
9	Hot Water Storage Tank (Heating mode)	yes	yes
10	Connection to the Heat Distributor: Ground Floor (TABS) and Pre-Heater (AHU)	yes	yes
11	Connection to the Heat Distributor: First Floor (TABS)	yes	yes
12	Cold Water Storage Tank (Cooling mode)	yes	yes
13	Connection to the Cold Distribution system: Ground Floor (TABS) and Cooling Coil (AHU)	yes	yes
14	Connection to the Cold Distribution system: First Floor (TABS)	yes	yes



Simplified diagram of the hydraulic concept without safety valves, expansion vessel, etc.

DMPC approach

The DMPC algorithm with a timestep size Δt=15min. and 24h forecast horizon considers at minimum 13152 control variables with at least 12576 constraints!



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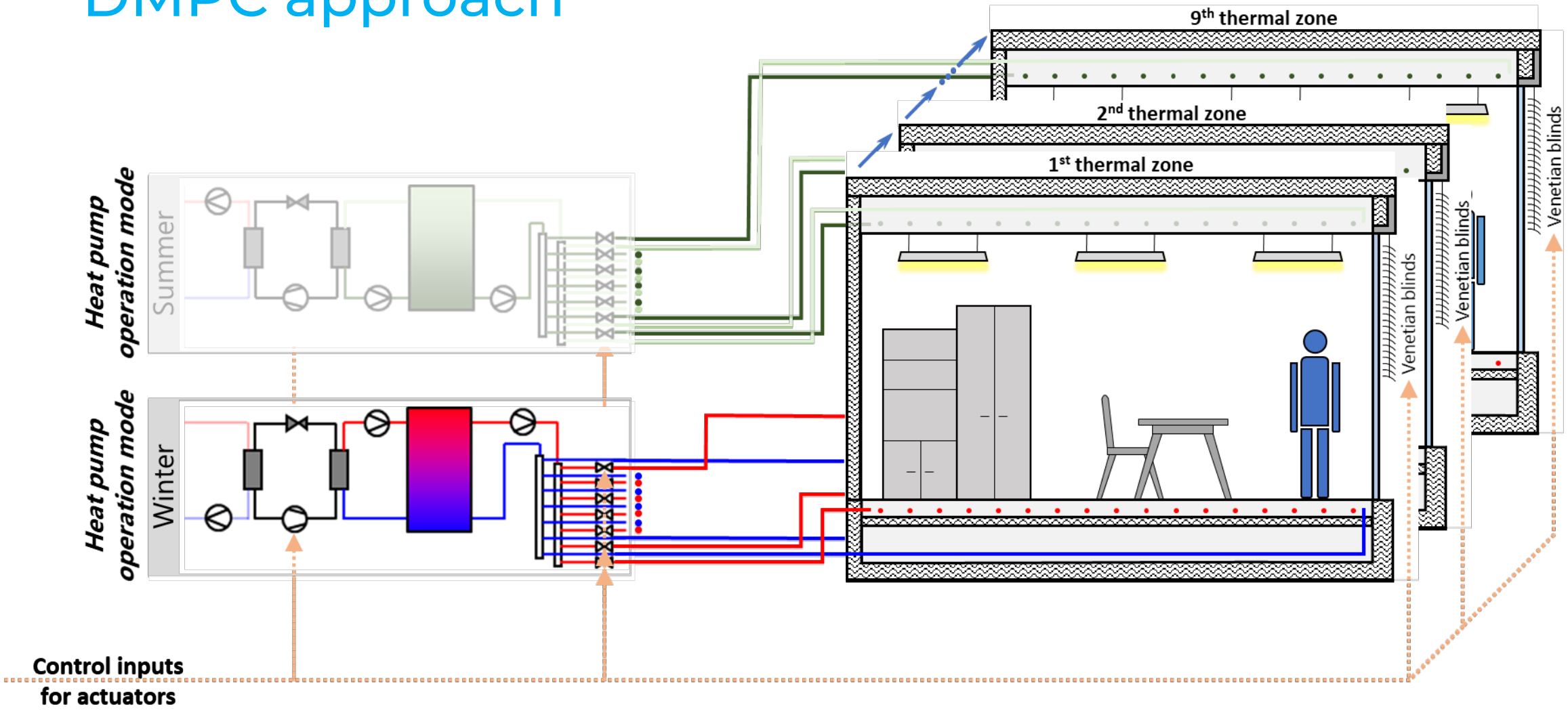
DMPC approach



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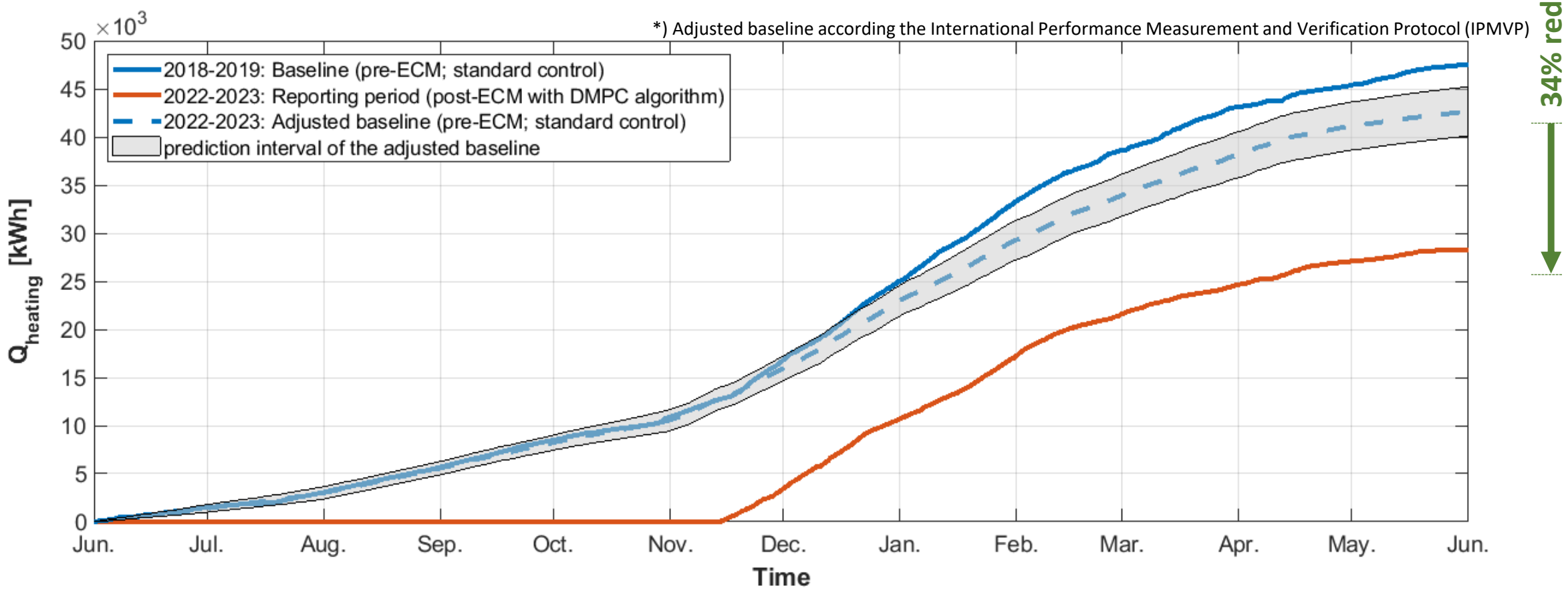
PRELUDE

Results of the one-year long-term test DMPC in combined with complementary ECMs

*) Adjusted baseline according the International Performance Measurement and Verification Protocol (IPMVP)



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Results of the one-year long-term test DMPC in combined with complementary ECMs

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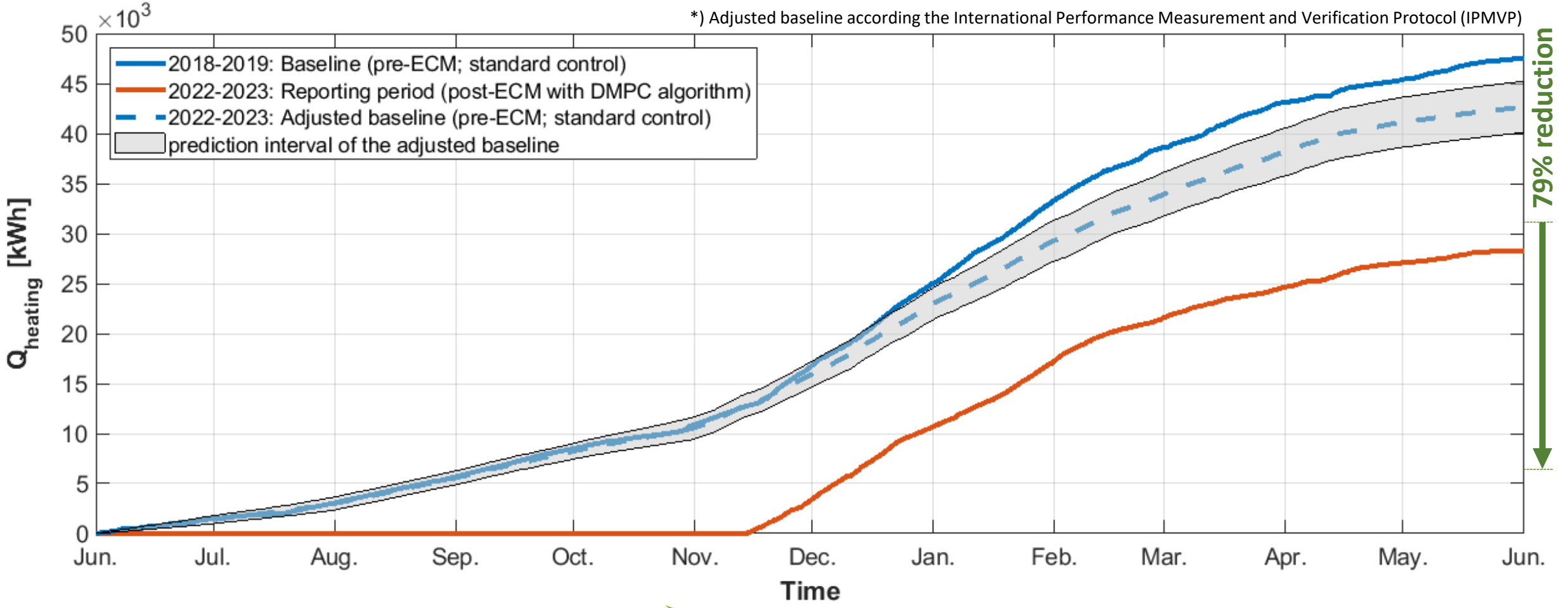

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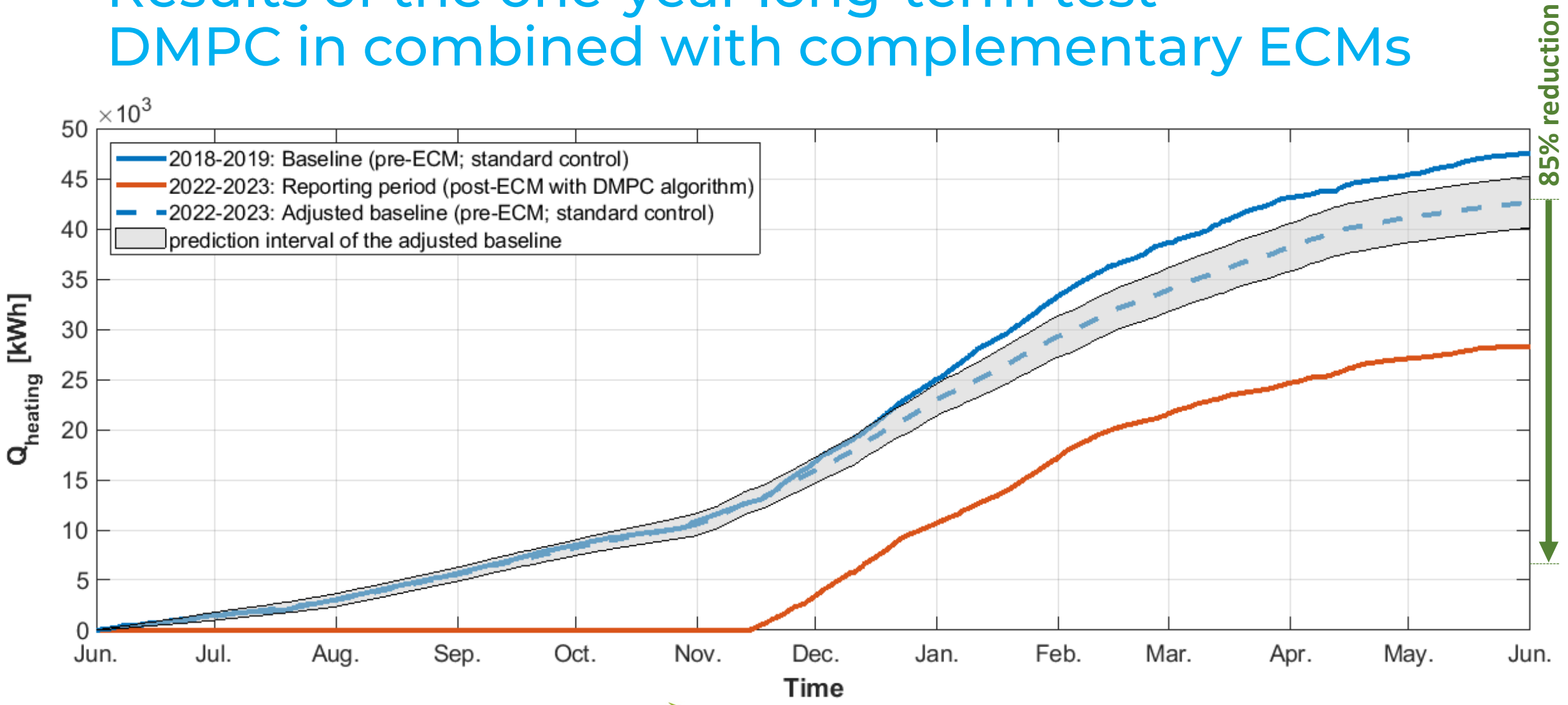
Results of the one-year long-term test DMPC in combined with complementary ECMs



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SUSTAINABLE PLACES 2024

PRELUDE

Results of the one-year long-term test DMPC in combined with complementary ECMs

	Adjusted baseline (pre-ECM, standard control)	**Reporting period** (post-ECM, with DMPC)	**Savings** thanks to ECMs with DMPC	
	kWh/a	kWh/a	kWh/a	%
Useful heating energy	42621	28234	14387	34
Useful cooling energy	24759	5145	19614	79
Total useful thermal energy	**67380**	**33379**	**34001**	**50**
Total final energy (gas + electricity)		10585	58066	85

Detailed documentation on the investigations

[1] F. Veynandt, C. Heschl, P. Klanatsky, M. Ringhofer, Y. Kopsinis, A. Balomenos, G. Siokas, G. Chiesa, P. Grasso, R. Ruiz, L. Farina, R. Aversa, M. Kolokotroni, T. Paing Tun, M. Zune, N. Sofias, D. Lokas, V. Alifragkis, Deliverable 6.3: PRELUDE validation and Living Lab demonstration report, Forschung Burgenland GmbH, 2023. https://prelude-project.eu/results/deliverables/

[2] P. Klanatsky, F. Veynandt, C. Heschl, Grey-box model for model predictive control of buildings, Energy and Buildings 300 (2023) 113624. https://doi.org/10.1016/j.enbuild.2023.113624.

[3] P. Klanatsky, F. Veynandt, C. Heschl, Data-driven model predictive control for buildings with large glass façade and thermally activated building structure, Energy and Buildings (2024), "under review"

[4] P. Klanatsky, F. Veynandt, G. Siokas, A. Balomenos, P. Zogas, C. Heschl, Long-term Performance Evaluation of Data-driven Model Predictive Control in a Real Office Building, Energy and Buildings (2024), "under review"

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PRELUDE

SMART DISTRICT HEATING: SCALABLE AND TRUSTWORTHY FORECASTING WITH ADVANCED AI

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Tree Technology SA

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement N° **958345**

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R&D – EU Projects

PRELUDE

EeB-07-2020 (ID: 958345)

Prescient building Operations utilizing Real Time data for ENergy Dynamic Optimization

(+info)

SHAPES
Smart and Healthy Ageing Promoting Empowering Systems

DT-TDS-01-2019 (ID: 857159)

Smart and Healthy Ageing through People Engaging in Supportive Systems

(+info)

PRIMAL

NGI Trust ICT-2019 (ID: 825618)

A Privacy pReservIng federated MAchine Learning implementation

(+info)

MUSKETEER

ICT-13-2018 (ID: 824988)

Machine learning to augment shared knowledge in federated privacy-preserving scenarios

(+info)

DECODER

ICT-16-2018 (ID: 824231)

DEveloper COmpanion for Documented and annotatEd code Reference

(+info)

SAFETY4RAILS

SU-INFRA-01-2019 (ID: 883532)

Data-based analysis for safety and security protection for detection, prevention, mitigation and response in trans-modal metro and railway networks

(+info)

4SECURail

S2R-OC-IP2-01-2019 (ID: 881775)

Formal Methods and CSIRT for the Railway Sector

(+info)

DEEPHEALTH

ICT-11-2018 (ID: 825111)

Deep-Learning and HPC to boost biomedical applications for Health

(+info)

LAY2FORM

ProACT

PHC-25-2015 (ID: 689996)

Integrated Technology Systems for ProACTive Patient Centred Care

(+info)

iTRACK
Protection and safety of humanitarian missions

BES-10-2015 (ID: 700510)

Integrated system for real-time TRACKing and collective intelligence in civilian humanitarian missions

(+info)

RAMSES

FCT-04-2015 (ID: 700326)

Internet forensic platform for tracking the money flow of financially-motivated malware

(+info)

R&D – EU Projects

AMIGOS

MISS-2022-CIT-01-01 (ID: 101104268)

Active Mobility Innovations for Green and safe city sOlutionS

TRUST aWARE

SU-DS-03-2020 (ID: 101021377)

Enhancing Digital Security, Privacy and TRUST in software

(+info)

Impulse

DT-TRANSFORMATIONS-02-2020 (ID: 101004459)

Identity Management in PUbLic SErvices A multidimensional analysis of disruptive technology approaches

(+info)

STRATIF-AI

HLTH-2022-TOOL-12-01-two-stage (ID: 101080875)

Continuous stratification for improved prevention, treatment, and rehabilitation of stroke patients using digital twins and AI

NIGHTINGALE

SU-DRS-02-2020 (ID: 101021957)

Novel InteGrated toolkit for enhanced pre-Hospital life support and Triage IN challenGing And Large Emergencies

(+info)

TeamaWare

SU-DRS-02-2020 (ID: 101019808)

Team Awareness Enhanced with Artificial Intelligence and Augmented Reality

(+info)

HEIDI

CL5-2021-D6-01 (ID: 101069538)

Holistic and adaptivE Interface Design for human-technology Interactions

(+info)

GLOMICAVE

BIOTEC-07-2020 (ID: 952908)

Global Omic Data Integration on Animal, Vegetal and Environment Sectors

(+info)

APRIL

FoF-12-2019 (ID: 870142)

multipurpose robotics for mAniPulation of defoRmable materIaLs in manufacturing processes

(+info)

AI-ARC

SU-BES-02-2020 (ID: 101021271)

Artificial Intelligence based Virtual Control Room for the Arctic

(+info)

INTERLINK

DT-GOVERNANCE-05-2020 (ID: 959201)

Innovating goverNment and ciTizen co-dEliveRy for the digitaL sINgle market

(+info)

VOJEXT

DT-ICT-03-2020 (ID: 870142)

Value Of Joint EXperimentation in digital Technologies for manufacturing and construction

(+info)

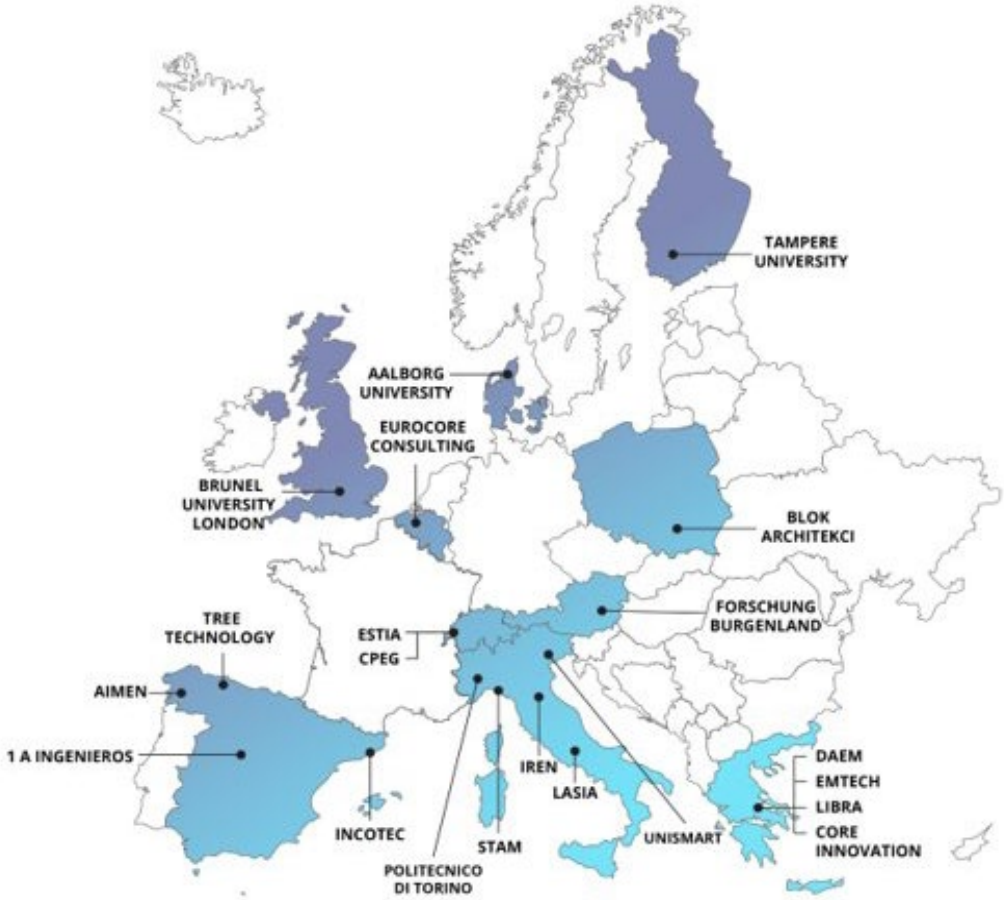
Commercial brand

treelogic
A TREE TECHNOLOGY S.A. BRAND

Treelogic (www.treelogic.com) the commercial brand of Tree Technology helps organizations in key sectors to improve their information systems with Big Data and Artificial Intelligence technology.

TREE TECHNOLOGY | SUSTAINABLE PLACES 2024 | PRELUDE

PRELUDE: Prescient building Operation utilizing Real Time data for Energy Dynamic Optimization



This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement N° **958345**

Objective

District heating demand forecasting model with a 24-hour prediction horizon, adaptable to different scales depending on data availability.

Monolithic Model

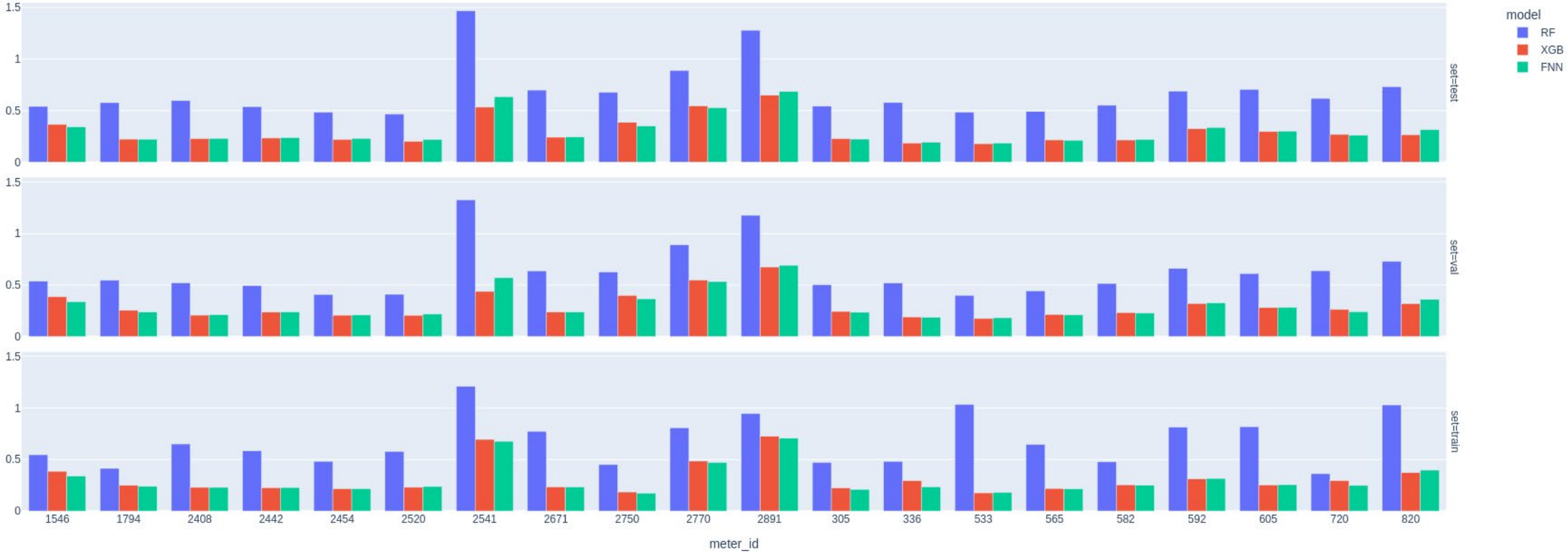
Inputs:

Date (DOW, MOY)
Hourly heating energy consumption per building
Hourly water volume per building
Building characteristics: area, number of rooms.
Weather information

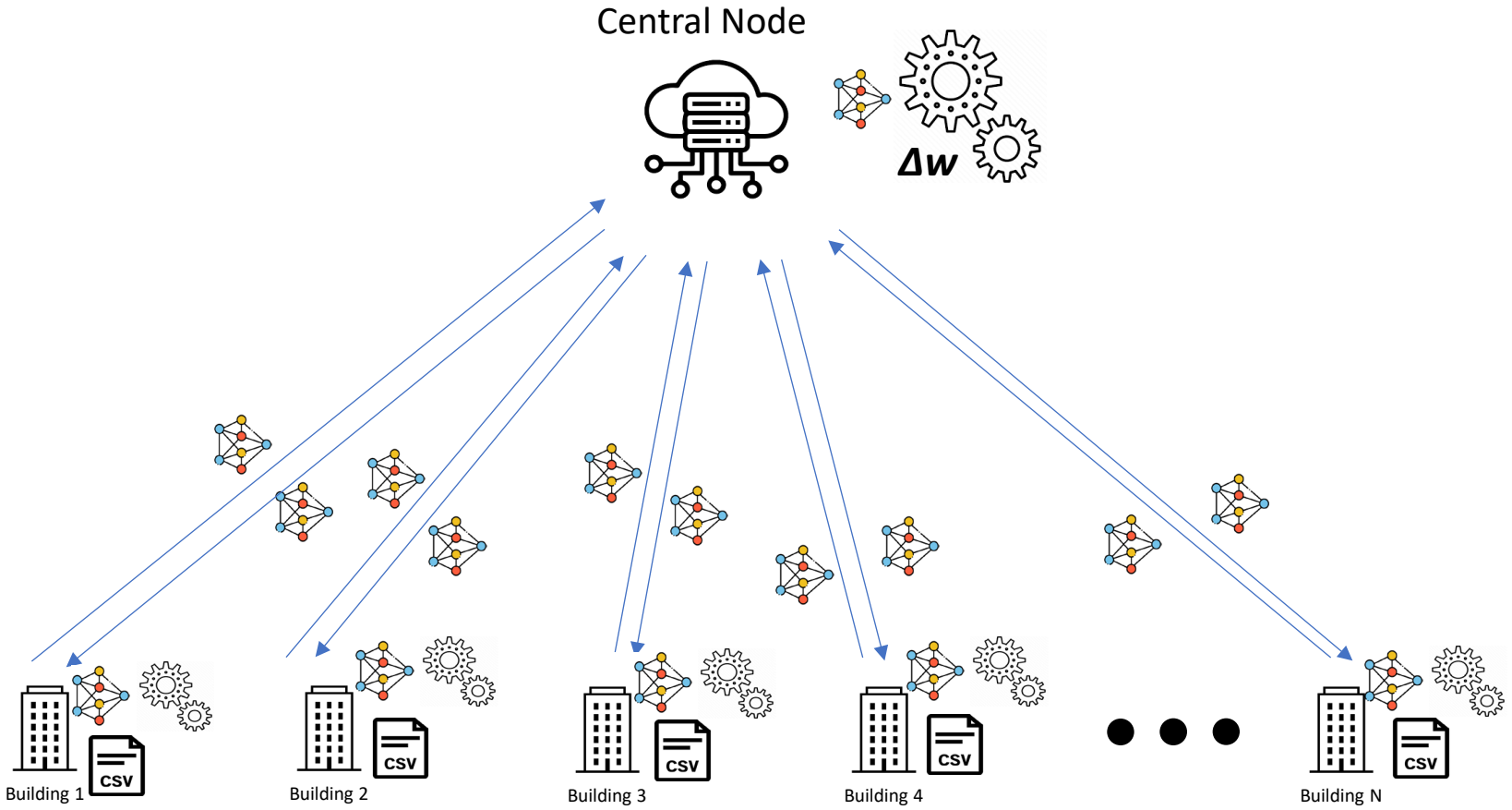
Output:

24h ahead (hourly) forecast of the district heating energy consumption.

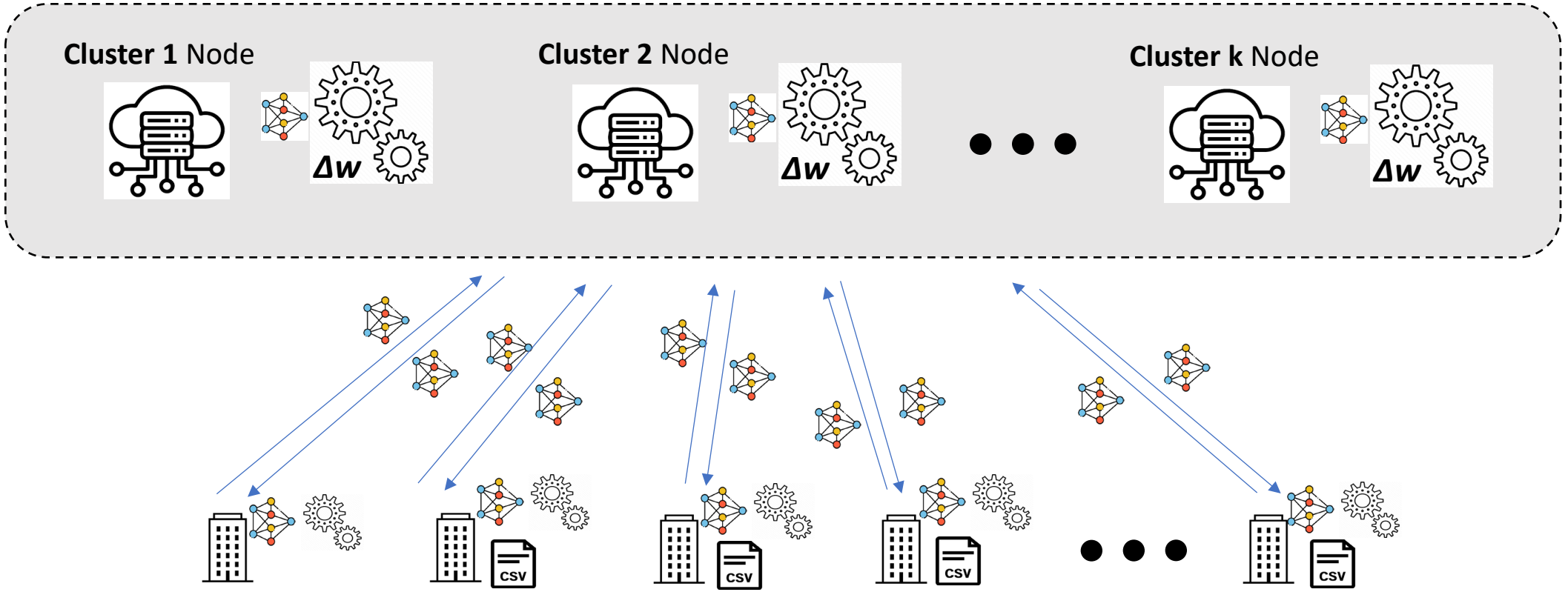
Monolithic Models



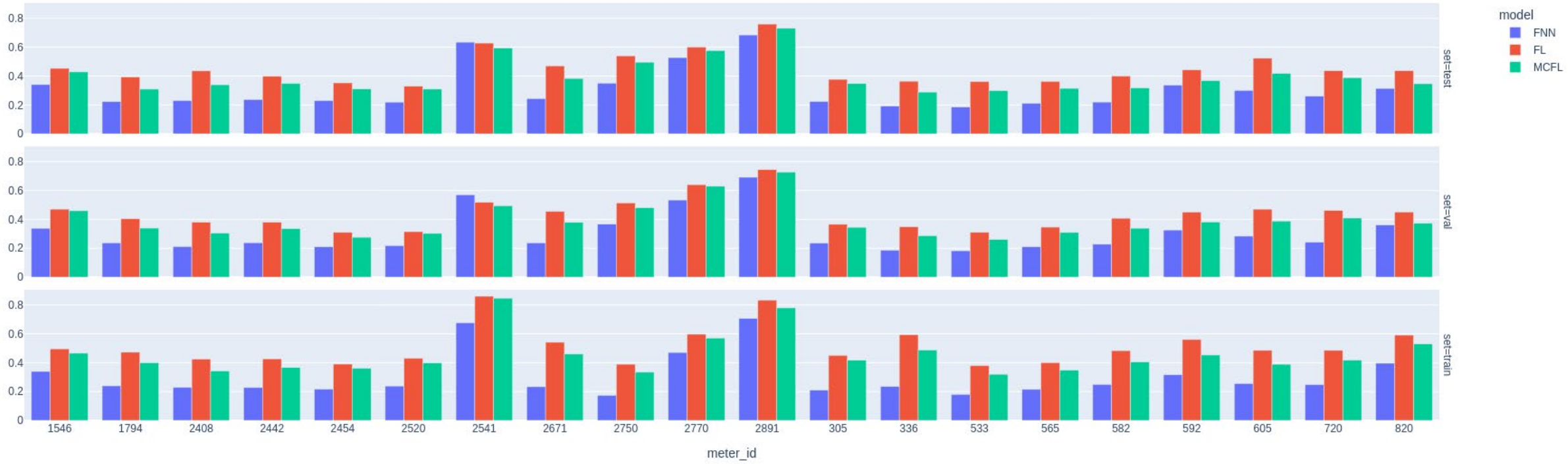
Federated learning



Multi-center Federated learning (MCFL)



Monolithic Vs FL Vs MCFL



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Conclusions

- The monolithic model achieves the highest accuracy.
- Federated Learning (FL) ensures GDPR-compliant data privacy and scalability.
- MCFL addresses data heterogeneity, delivering higher accuracy than standard FL models.
- The approach can be generalized to other energy forecasting tasks.

Thanks

ASTURIAS, Calle San Francisco 2, 4ª planta
33003 Oviedo.

MADRID, Camino de las Huertas 18, 1ª planta
28223 Pozuelo de Alarcón.

902 286 386

www.treelogic.com

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BUILDING RENOVATION ROADMAP

Bernard Paule

Estia SA

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WP 8 - Holistic sustainability strategy

Building Renovation Roadmap

Renovation Rules

Estia

Bernard Paule
Tristan de Kerchove d'Exaerde
Julien Boutillier
Flourentzos Flourentzou

\+

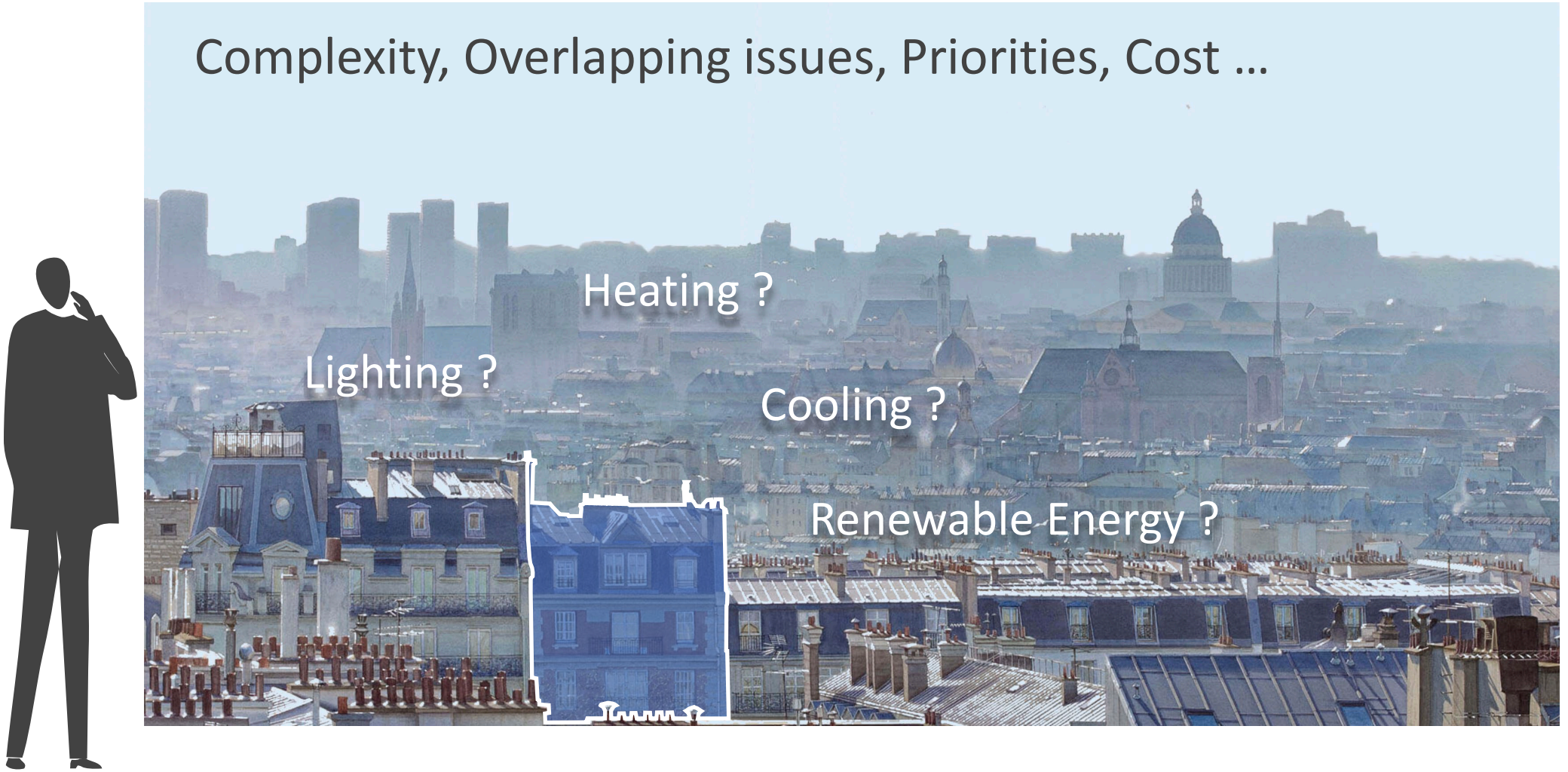
API Development

CORE | IC

Dimitris Lokas
Foteini Ypsilanti
Evangelos Foufikos
Aleksandros Rezkalla
Zoi Levesanou

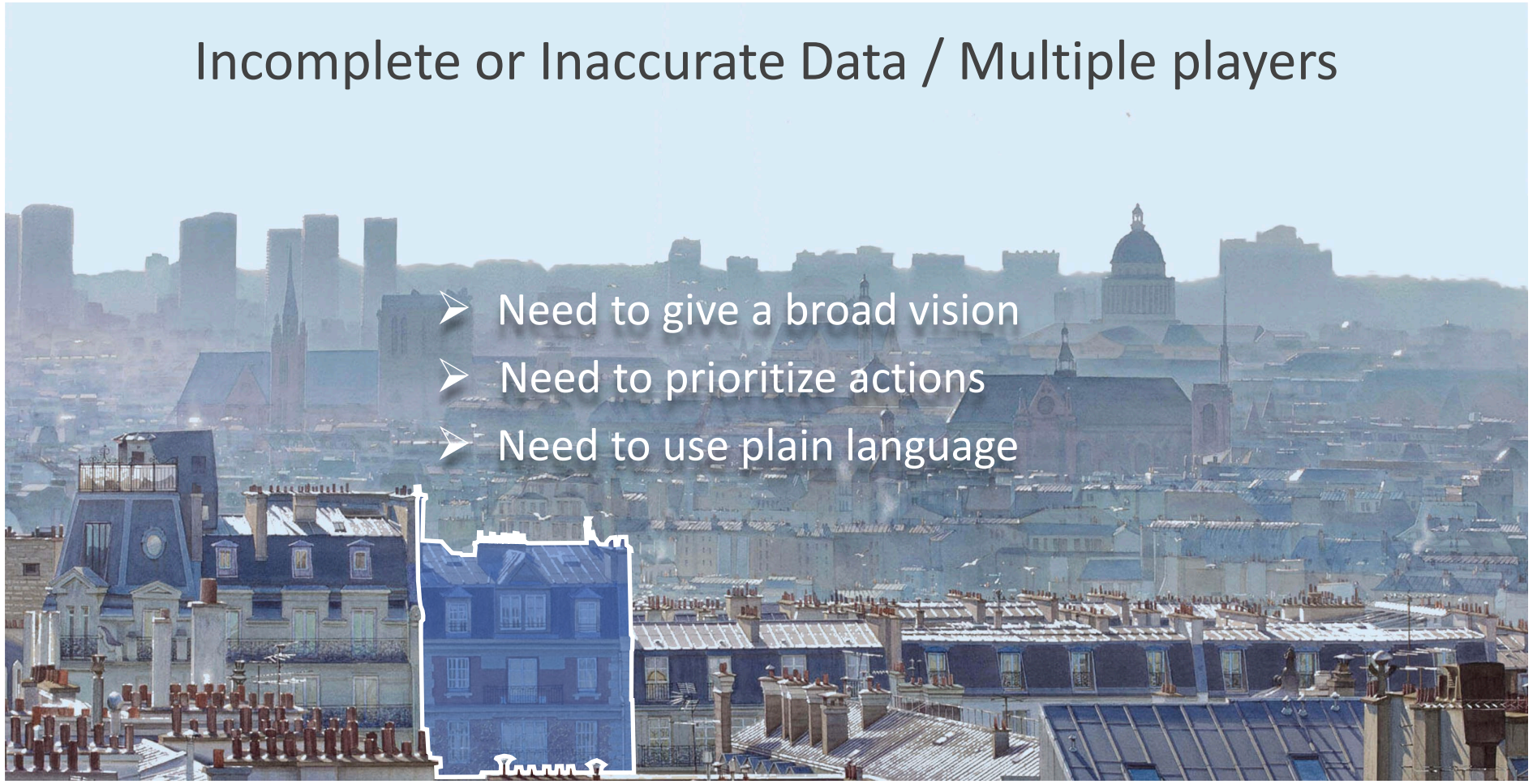
Estia | CORE | IC | SUSTAINABLE PLACES 2024 | PRELUDE

Context

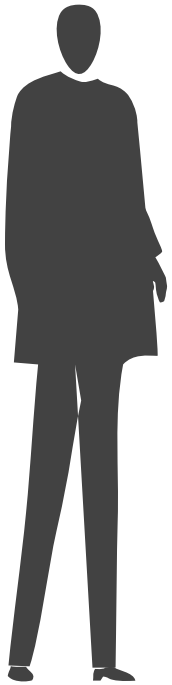

Complexity, Overlapping issues, Priorities, Cost …
Heating ?
Lighting ?
Cooling ?
Renewable Energy ?

Context

Incomplete or Inaccurate Data / Multiple players



- Need to give a broad vision
- Need to prioritize actions
- Need to use plain language



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Method

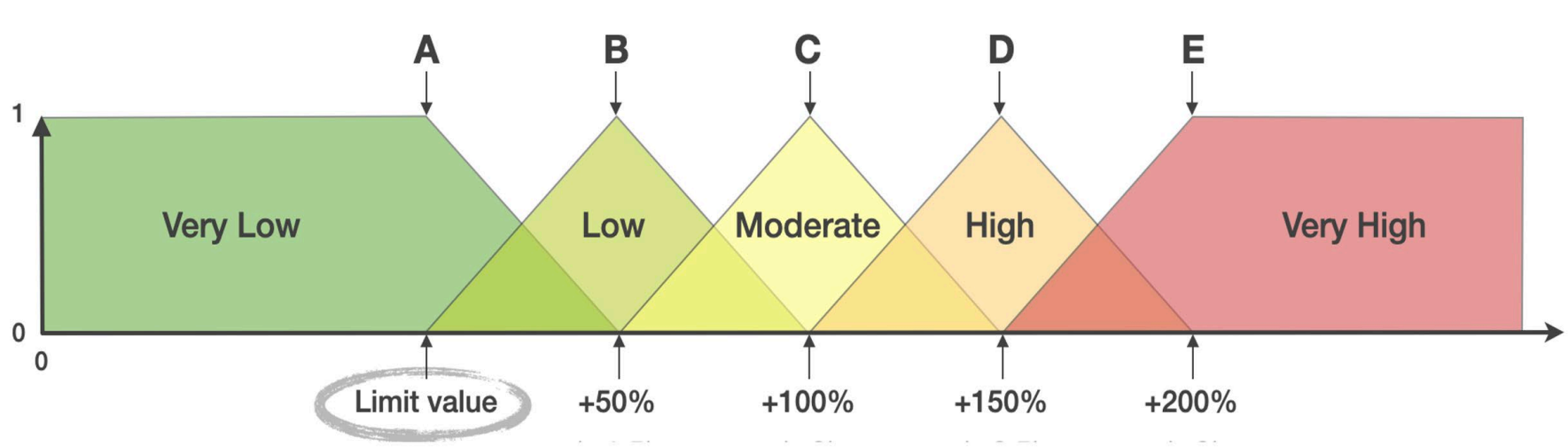
Fuzzy logic was chosen for its ability to :

- Manipulate imprecise values,
- Generate and deliver linguistic messages.

Method

Fuzzy Logic : Key Parameters

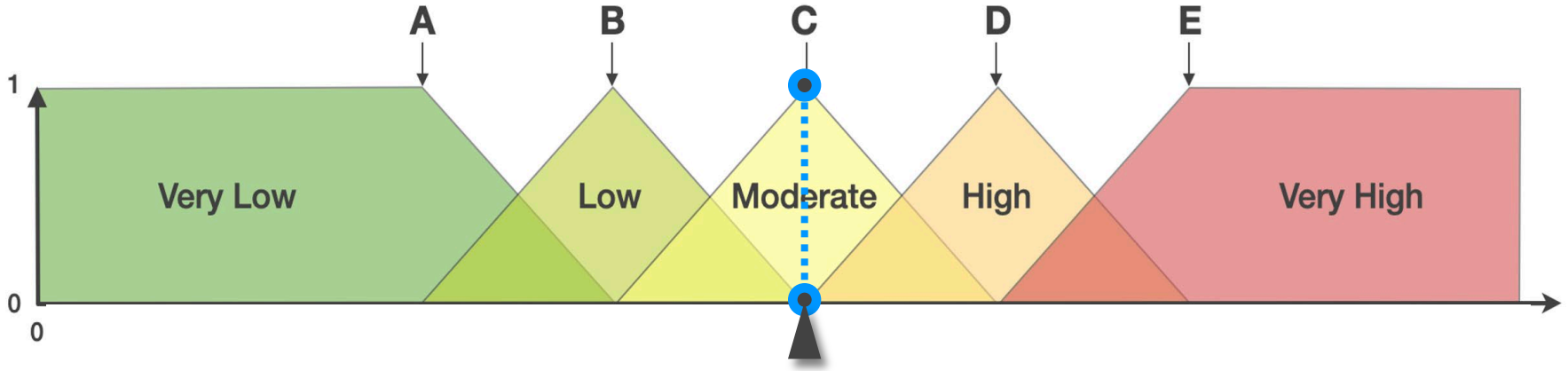
Example: Heating Loads



Method

Fuzzy Logic : Key Parameters

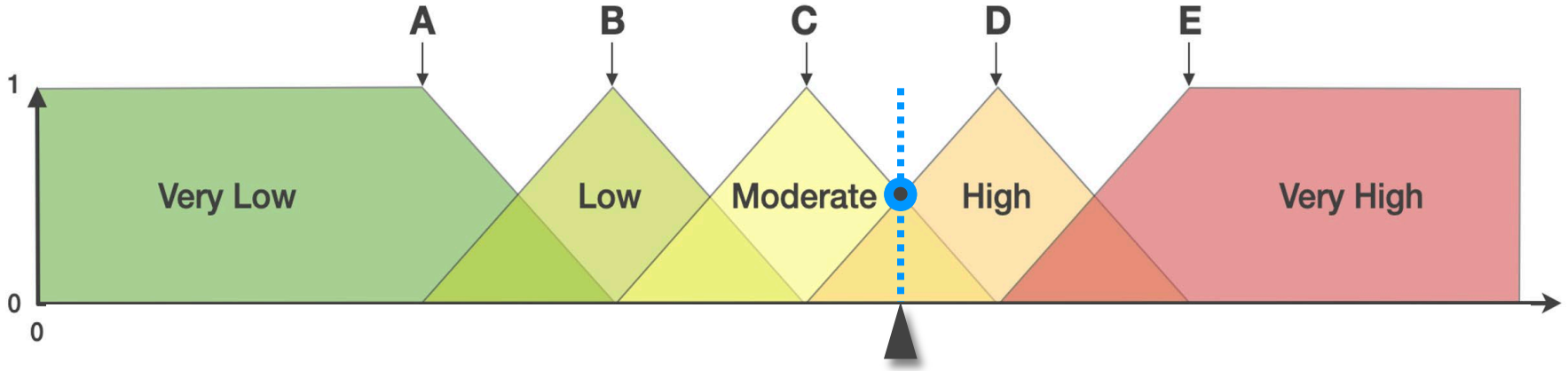
Example: Heating Loads



Method

Fuzzy Logic : Key Parameters

Example: Heating Loads



Method

Fuzzy Logic : Key Parameters

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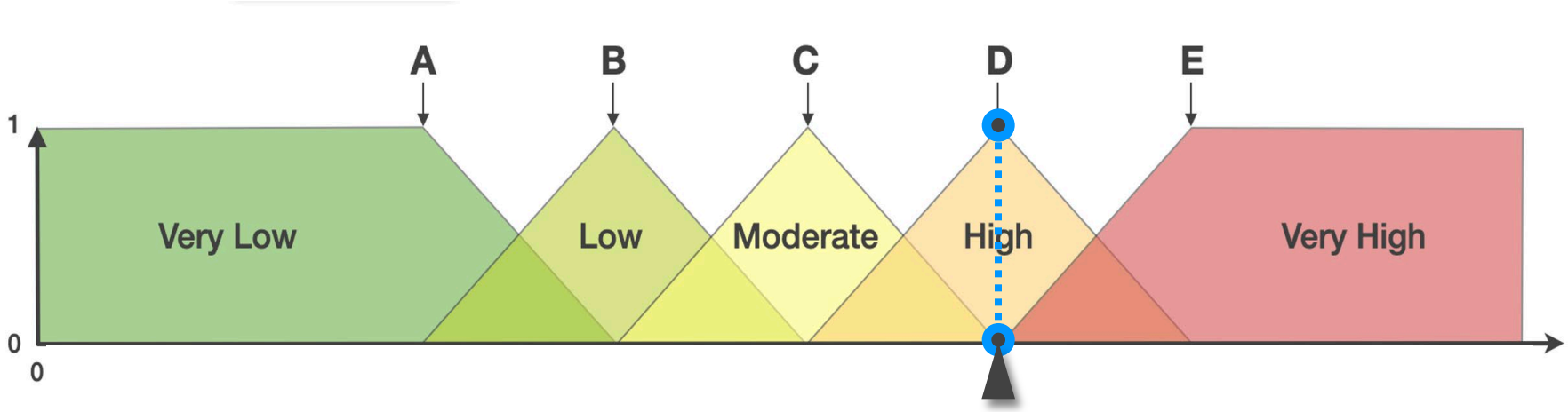

Method

Fuzzy Logic : Key Parameters

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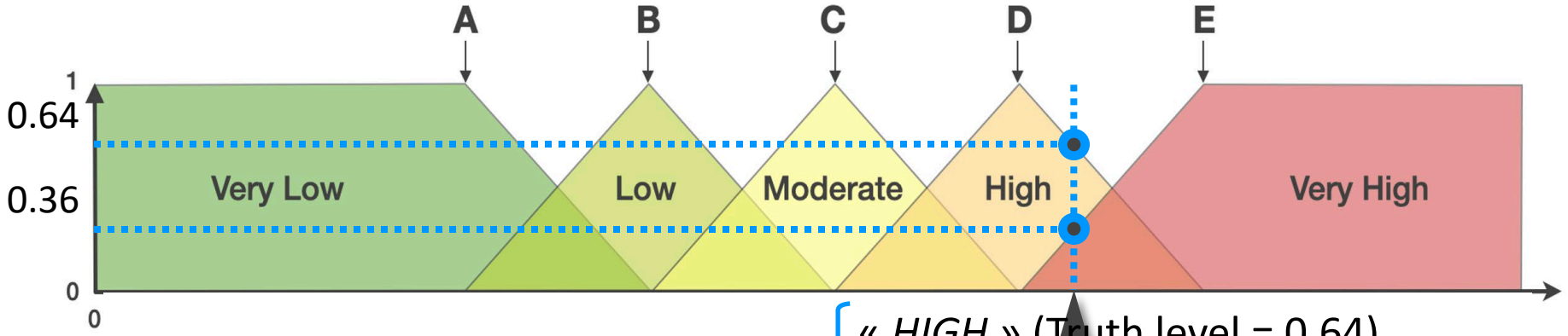


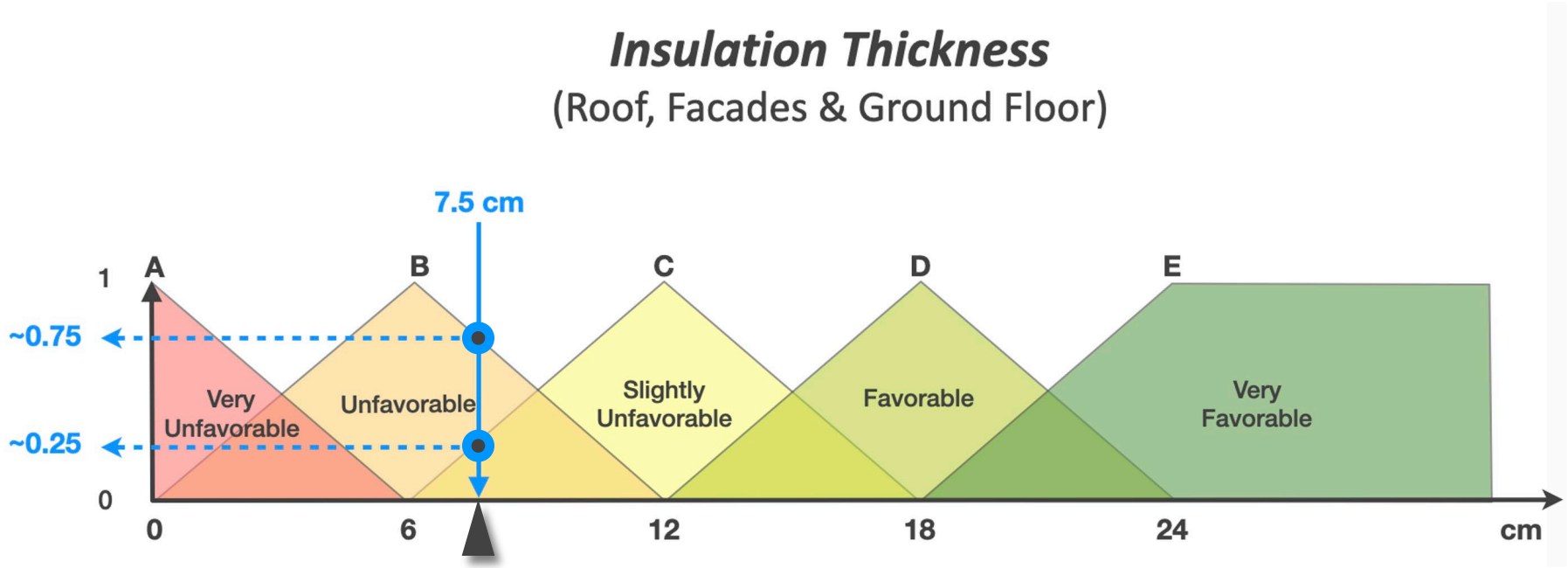
The Heating energy consumption is :

« *HIGH* » (Truth level = 0.64)

« *VERY HIGH* » (Truth level = 0.36)

Method

Fuzzy Logic : Associated parameters



The Heating Insulation Thickness is :

- « *Slightly Unfavorable* » (Truth level = 0.75)
- « *Unfavorable* » (Truth level = 0.25)

Method

Fuzzy Logic : Inference Rules

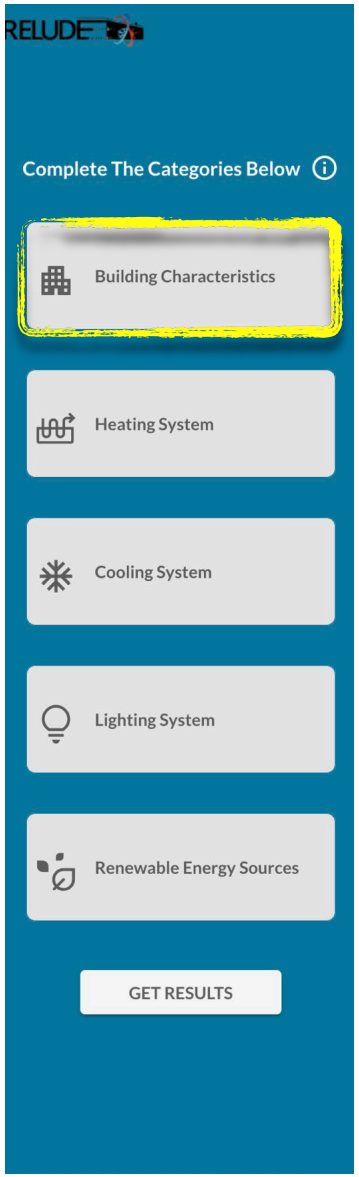
		Associated parameter status		
		Very Unfavorable	Unfavourable	Slightly unfavorable
Key parameter status	Moderate	Slight Incentive	-	-
	High	Strong Incentive	Slight Incentive	-
	Very High	Imperative Incentive	Strong Incentive	Slight Incentive

Method

Fuzzy Logic : Linguistic items

Key parameter status	Associated parameter status: Very Unfavorable	Unfavourable	Slightly unfavorable
Moderate	*COULD*	-	-
High	*SHOULD*	*COULD*	-
Very High	*MUST*	*SHOULD*	*COULD*

The Heating energy consumption is « Very HIGH »



BUILDING

Location Properties · Building Dimensions · Facade Properties · Roof Properties · Floor Properties · Windows Characteristics · Shading Devices

- Function
- Location
- Dimensions
- Composition
- Windows & shading

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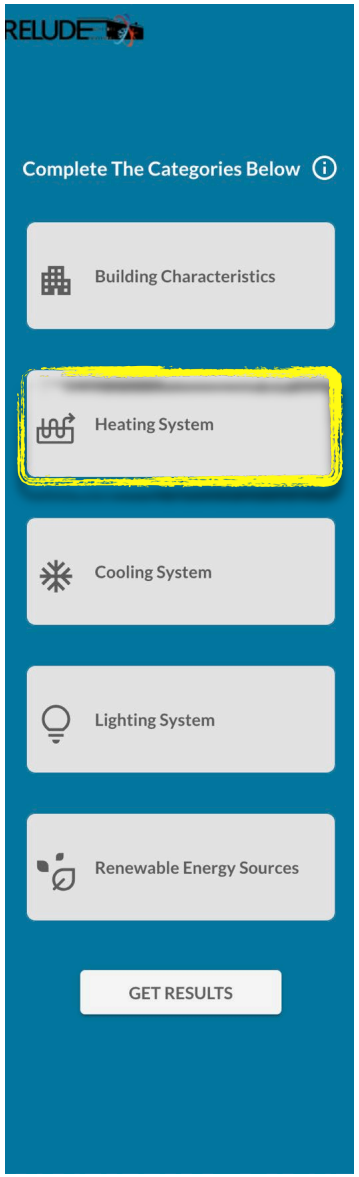

HEATING TOPIC

Energy Consumption — System Characteristics

- Key parameter : *Effective Energy Consumption*
  - Based on Swiss requirements
  - Climatic adaptation
- Associated factors
  - Facades & Windows composition
  - Technical parameters

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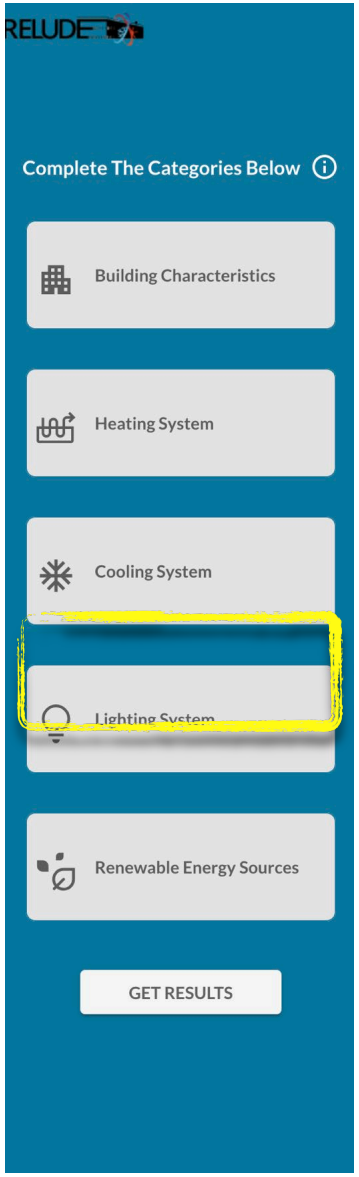

COOLING TOPIC

Cooling

- Key parameter : *Intrinsic Overheating Risk*
  - Location / Environment / Function
  - Glazed area / Thermal mass
- Associated factors
  - Shading device
  - Openable area
  - Technical Settings

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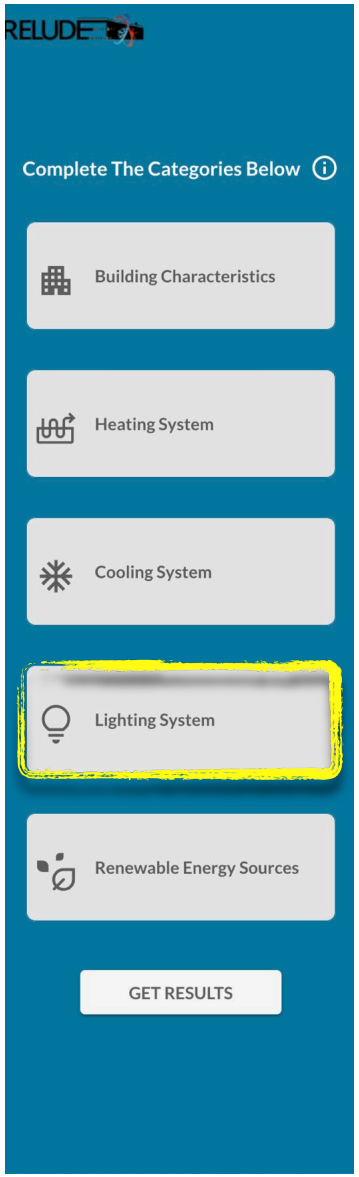

LIGHTING TOPIC

Lamps — Regulation — Zone Lightning

- Key parameter : *Obsolescence*
  - Lamps / Luminaires
  - Switching / Regulation / Zone lighting
- Adaptation
  - Room function

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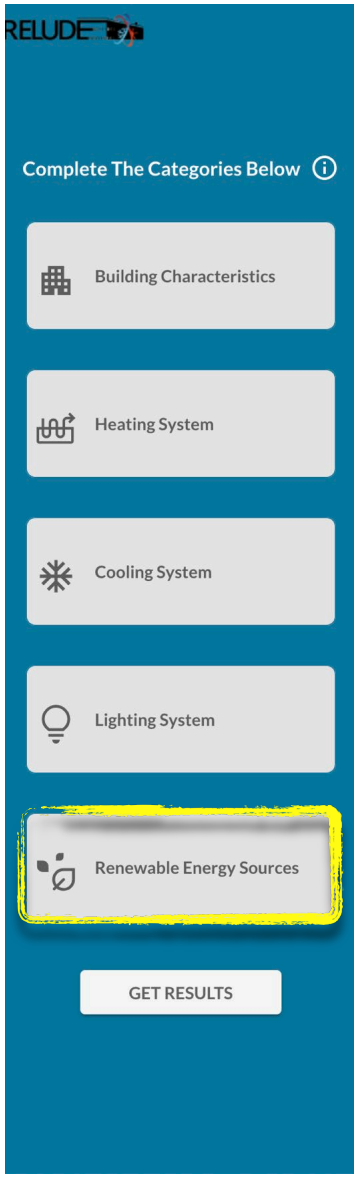

RENEWABLE ENERGY SOURCES

- RES Selector

- Developed by CORE as a stand-alone tool

PRELUDE

Complete The Categories Below

- Building Characteristics
- Heating System
- Cooling System
- Lighting System
- Renewable Energy Sources

GET RESULTS

Results And Suggestions

API Development | coreIC | EPIQR Ruleset | Estia

Heating

EPIQR Costs database

The Heating energy consumption is VERY HIGH

Must	Reduce Heating curve slope	
	Implement Nightshift	
	Increase Roof insulation thickness	82 000 €
	Increase Ground Floor insulation	66 000 €
	Replace the glazings	122 500 €
Should	Complete pipes insulation	108 000 €
	Increase Facades insulation thickness	108 000 €
Could	Replace the boiler base on the type of boiler	

The Overheating Risk is HIGH

Should	Implement outdoor movable shading device	108 000 €
	Activate night ventilation	
	Increase Facades insulation thickness	

Flats

COSTS

- EPIQR Database
  - 30 years' experience in Switzerland
  - thousands of renovation and/or maintenance works listed
  - Costs in relation to the building’s dimensional coefficients
  - Adaptation to European construction cost indexes

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