Output Factsheet

Output title: T4.1 Transnational training activities

Summary of the output

The output contains documented learning interactions performed during pilot study visits to the 3Smart locations for piloting of the developed modular tool for integrated grid-building energy management including demand response. Pilot study visits were attended by the members of the 3Smart consortium and for each pilot they were organized in two rounds. In the first round the pilot leaders/hosts explained the interventions performed while modules developers explained the needed steps for installation of the modules. In the second round the pilot leaders/hosts explained the progress with modules installations on the pilot of the study visit while the developers presented the results of modules operation on data from the building.

The documented learning interactions are organized as short explanation of how the learning interaction took place (minutes) which refer to presentation materials as annexes. For each round of pilot study visits a separate document is provided which contains the interactions from all five pilots of the 3Smart project –pilots in Croatia, Slovenia, Austria, Bosnia and Herzegovina and Hungary. The reader can by passing through this documentation get a basic insight into the pilots organization and 3Smart platform operation on them.

As the 3Smart pilots were very versatile in configuration, interested users can also estimate the effort and investment needed for some new planned sites. Of course, there are other outputs that detail the topics of platform organization in modules (T2.1), costs and benefits (T4.2) and 3Smart system performance on pilots (T5.1), but this output can be used to roughly get to know the platform and its possible very versatile usages.

Contribution to EUSDR actions and/or targets

The project in general contributes to Priority Area 2 "To encourage more sustainable energy" of the EUSDR within which the following actions are required: „To explore the possibility to have an increased energy production originating from local renewable energy sources to increase the energy autonomy", „To promote energy efficiency and use of renewable energy in buildings and heating systems", „To facilitate networking and cooperation between national authorities in order to promote awareness and increase the use of renewable energies".

As the developed output spreads the experiences in setting up and operation of energy management systems with demand response, which are of key importance to enable demand side flexibility and energy security, it also contributes to EUSDR implementation.

Performed testing, if applicable

The output has for now been used as a resource only among the 3Smart consortium members.

Integration and use of the output by the target group

The identified target groups for this output are: local public authorities, sectoral agencies, enterprise, excluding SME. It will support local public authorities and their counselling sectoral agencies in decisions on investments in smart energy communities on their territories. Software development enterprises can learn on business opportunities existing in energy management systems from the provided materials, while grids operators may also opt to consider in their future operations to use demand response based on procedures exposed. Of course, more detailed exposition for interested stakeholders should be found in other textual 3Smart outputs.

Geographical coverage and transferability

There are no geographical constraints in usage of the modular 3Smart platform for energy management. It can be used throughout the Danube region and beyond. The same also holds for this material which gives an overview how the 3Smart platform was applied in pilots of various countries and of various configurations.

Durability

The question of durability of this material is foremost the question of durability of the 3Smart platform. The 3Smart platform is a cutting-edge energy management platform since it uses a sequence of convex optimization procedures to exhibit an intelligent behaviour of the buildings and grids. Predictive control turns out to be the only viable option for inducing flexibility in buildings while maintaining comfort and safe supply.

Synergies with other projects/ initiatives and / or alignment with current EU policies/ directives/ regulations, if applicable

This output provides a case-based introduction to the usage of 3Smart platform in various environments of buildings and grids which were incurred in the 3Smart pilots. The 3Smart platform in general is in line with the major intention to make Europe an energy-neutral continent by 2050 (and numerous directives and national energy plans stemming out of it) as it unlocks the flexibility of energy demand. Synergy with some projects that are about to start can be mentioned – e.g. Horizon 2020 REWAISE project (Resilient water innovation for smart economy) where integration of energy management strategies with water management is envisioned and will be verified in several water cycles in different parts of Europe.

Output integration in the current political/ economic/ social/ technological/ environmental/ legal/ regulatory framework

The output can be foremost considered as a picturesque introduction into the 3Smart platform usage and energy management for savings and demand response in general, but more in-depth learning through other textual outputs of the 3Smart project is necessary for making an influence to different committees in charge for various formal frameworks like technical or regulatory frameworks.

Project Deliverable Report

Smart Building – Smart Grid – Smart City

http://www.interreg-danube.eu/3smart

DELIVERABLE D6.3.1

Transnational training materials – Pilot study visits to Croatia – Pilot study visit No. 1

Project Acronym	3Smart
Grant Agreement No.	DTP1-502-3.2-3Smart
Funding Scheme	Interreg Danube Transnational Programme
Project Start Date	1 January 2017
Project Duration	30 months
Work Package	6
Task	6.3
Date of delivery	**Contractual:** 31 December 2019 **Actual:** 23 December 2019
Code name	**Version:** 2.0 Final ☒ Final draft ☐ Draft ☐
Type of deliverable	Report
Security	Public
Deliverable participants	UNIZGFER, HEP, UNIDEBTTK, EON, UNIBGFME, SVEMOFSR
Authors (Partners)	Mario Vašak, Tomislav Capuder, Vinko Lešić, Anita Martinčević, Hrvoje Novak, Danko Marušić, Nikola Hure, Paula Perović (UNIZGFER), Leon Lepoša, Tomislav Stašić, Martin Bolfek (HEP), Arpad Racz (UNIDEBTTK), Gabor Peter (EON), Vladimir Jovanović, Nebojša Manić (UNIBGFME), Ivan Bevanda, Petar Marić (SVEMOFSR)
Contact person	Mario Vašak (UNIZGFER)
Abstract (for dissemination)	This document contains the minutes of the first study visit to the Croatian pilot in 3Smart. The pilot consists of two pilot buildings and the pilot electricity distribution grid around the buildings. On the pilot study visits the pilot leaders and hosts together with developers for different modules on the pilot site have performed demonstration to the consortium of functioning of different installations performed on the pilot and of the installed 3Smart modules.
Keyword List	building-side energy management system, grid-side management, pilot installations, 3Smart IT environment, 3Smart database

Revision history

Revision	Date	Description	Author (Organization)
v1.0	31 December 2018	Entered the minutes from the first Croatian pilot study visit in the deliverable form	Mario Vašak (UNIZGFER)
v1.1	28 June 2019	Small update	Mario Vašak (UNIZGFER)
v2.0	23 December 2019	Prepared for publication	Mario Vašak (UNIZGFER)

Table of Contents

Executive summary

The 3Smart project deals with transnational development of integrated energy management of buildings and energy distribution grids in real time. To substantiate knowledge transfer between partners, to synchronize developments and demonstrate the installation procedure to developers, pilots leaders and pilots hosts, a series of transnational trainings is organized, first for getting acquainted with the software modules for energy management, and then for getting acquainted with performed pilot installations and modules operation on the pilot site.

This deliverable provides minutes and materials from the pilot study visits to the 3Smart pilot in Croatia that consists of UNIZGFER and HEP buildings and of the electricity distribution grid around these two buildings. The visits were split in two parts for each pilot site – this first part of the deliverable for the Croatian pilot site concerns the first pilot study visit.

1. Minutes from the first pilot study visit to the 3Smart pilot in Croatia

Time: December 11-12, 2018

Venues: UNIZGFER and HEP building

December 11, 2018 (Tuesday)

Time	Place	Event
09:00-11:00	White hall UNIZGFER	Presentation of the performed installations and realized IT infrastructure
11:00-11:15	In front of White hall	Coffee break
11:15-13:00	UNIZGFER building	UNIZGFER building visit
13:00-14:00	Cassandra	Lunch
14:00-16:00	HEP building	HEP building visit
16:00-16:15	In front of White hall	Coffee break
16:15-18:00	White hall UNIZGFER	On-line demonstration of basic IT infrastructure performance with the installed equipment (belongs also to WP4/WP5 transnational training No. 7)
19:00-21:00	Mali medo, Tkalčićeva ulica	Working dinner

December 12, 2018 (Wednesday)

Time	Place	Event
09:00-11:00	Grey hall UNIZGFER	3Smart modules organization on the sides of UNIZGFER building, HEP building and the grid (belongs also to WP4/WP5 transnational training No. 7)
11:00-11:15	In front of Grey hall	Coffee break
11:15-13:00	Grey hall UNIZGFER	On-line demonstrations: Zone-level modules UNIZGFER, Central-HVAC-level modules UNIZGFER (belongs also to WP4/WP5 transnational training No. 7)
13:00-14:00	Cassandra	Lunch
14:00-16:00	Grey hall UNIZGFER	On-line demonstrations: Central-HVAC-level modules UNIZGFER, Microgrid-level UNIZGFER (belongs also to WP4/WP5 transnational training No. 7)
16:00-16:15	In front of Grey hall	Coffee break
16:15-18:00	Grey hall UNIZGFER	On-line demonstrations: Short-term modules grid, Long-term modules grid, Grid-buildings interaction (belongs also to WP4/WP5 transnational training No. 7)

All partners were present on the pilot study visit except for EnergyG. No one from the side of ASPs was present. Here are provided minutes for the first three technical sessions. For the other sessions the minutes are provided within the minutes of respective WP4 or WP5 transnational training No. 7.

Day 1:

Technical session 1: Presentation of the performed installations and realized IT infrastructure

Mario Vašak presented the installations performed on UNIZGFER building, including the realized IT infrastructure. The details are provided in the annexed ppt, see Annex 1.

Leon Lepoša presented the installations performed on HEP building, including the realized IT infrastructure. The details are provided in the annexed ppt, see Annex 2.

Martin Bolfek and Paula Mamić presented the installatons performed on the grid side, including the IT part. The details are provided in the annexed ppt, see Annex 3.

Technical session 2: Tour to visit the places of installations – UNIZGFER building

The tour was guided by Mario Vašak. The following places were visited:

- zone C9-01 as a representative of zones, where the following equipment was shown: the room controller, fan coil and return medium sensor;
- floor cabinet for climate control on the 9th floor which includes: (i) a concentrator controller for all room controllers on floors 9 and 10 – a Siemens PXC controller, and (ii) floor concentrators for one-wire sensors on floor 9 and 10;
- floor electricity smart meter location on the 9th floor;
- floor calorimeters on the 9th floor, in the restrooms area on the south building side and in the kitchen area on the north building side;
- heating substation area on the basement floor, including: (i) the heating substation controller and its control cabinet including the concentrating PXC controller, (ii) circulation pump and its control cabinet, and (iii) the three central calorimeters found in the basement – for the fan coil system, for air handling units of the lecture halls in the neigboring building of UNIZGFER and for billing on the primary side of the heating substation;
- room with the Li-ion batteries and their corresponding power converter, together with the fire alarming system;
- power converters for the photovoltaic system and the control cabinet for weather data acquisition on the first floor beneath the roof;
- photovoltaic system on the roof, including the weather station and equipment for measurement of the solar irradiance.

Technical session 3: Tour to visit the places of installations – HEP building

The tour was guided by Leon Lepoša and Tomislav Stašić. The following places were visited:

- room with the Li-ion battery set and its corresponding bidirectional power converter in the building garage area;
- heating substations area with control cabinets and central calorimeters in the building basement;

- water chillers and PV system area on the building roof;
- air handling unit area together with the controller for the air handling unit and for the chillers on the building 7th floor;
- climate control equipment in meeting halls on the building 7th floor;
- offices setup with the devices installed in zones (room controllers, fan coils and radiators with return medium temperature sensors, radiator valves) on the 2nd floor of the building;
- location of floor calorimeters installation on the 2nd floor.

Technical session 4: On-line demonstration of basic IT infrastructure performance with the installed equipment

For UNIZGFER building the on-line demonstration of basic IT infrastructure performance with the installed equipment was performed by Hrvoje Novak for weather data, weather forecast data and smart meters, Anita Martinčević for zones-related data, Nikola Hure for central-HVAC-level data and data from the calorimeters, and by Danko Marušić for microgrid level data including also the data for interaction with the grid.

Encompassed were:

- communication with field devices in the building (sensors, actuating units) and the 3Smart database;
- realization of on-off switches for 3Smart functionality on zone level, central HVAC level and microgrid level;
- securing comfort for end-users in case of EMS failure, ensuring safe operation of the battery system;
- building-grid communication and communication with the weather forecast service.

More details can be found in the annexed presentation that was held (Annex 4).

For HEP building the on-line demonstration of basic IT infrastructure performance with the installed equipment was performed by Leon Lepoša and the subcontractor for building data integration in the HEP building IT system.

The grid-side IT infrastructure is elaborated in technical session 8.

Day 2:

Technical session 5: 3Smart modules organization on the sides of FER building, HEP building and the grid

Mario Vašak presented the organization of 3Smart modules on UNIZGFER building and the information flow between them. More details can be found in the annexed presentation that was held (Annex 5).

Leon Leposa presented the organization of 3Smart modules on HEP building and the information flow between them. More details can be found in the annexed presentation that was held (Annex 6).

The grid-side modules organization for the Croatian pilot is elaborated in technical session 8.

Technical session 6: On-line demonstrations: Zone-level modules UNIZGFER, Central-HVAC-level modules UNIZGFER

The zone-level modules functioning on UNIZGFER building was demonstrated by Anita Martinčević (for Z.PE.1, Z.PE.4 and Z.PE.5) and Hrvoje Novak (for Z.PE.6 and Z.PE.7), and then again by Anita Martinčević (for Z.MPC.1 and Z.I.1). Anita and Hrvoje presented the modules operation on-line via overlooking the 3Smart database content and also gave insight into recent time responses which they explained. More details can be found in the annexed presentation (Annex 7).

The central HVAC level modules functioning on UNIZGFER building was demonstrated by Vladimir Jovanović (for HVAC.PE.1 and HVAC.PE.2) and Nebojša Manić (for HVAC.PE.3 and HVAC.I.1). More details on the presentation of Vladimir and Nebojša can be found in the annexed presentation documents (Annex 8 and Annex 9).

Technical session 7: On-line demonstrations: Central-HVAC-level modules UNIZGFER, Microgrid-level UNIZGFER

The central HVAC level modules functioning on UNIZGFER building were demonstrated by Hrvoje Novak (for HVAC.PE.4) and Nikola Hure (for HVAC.MPC.1). Hrvoje and Nikola also performed on-line demonstration of modules operation: they presented the modules operation on-line via overlooking the 3Smart database content and also gave insight into recent time responses which they explained. More details on their presentation can be found in the annexed presentation document (Annex 7).

Microgrid-level modules functioning on UNIZGFER building was explained by Arpad Racz (for M.PE.1, M.PE.2 and M.I.1).

Hrvoje Novak demonstrated the operation of M.PE.3 and M.PE.4 modules on UNIZGFER building, while Danko Marušić explained and demonstrated the operation of M.MPC.1 module on UNIZGFER building, including also the building-side part of grid-building interaction. More details on the presentation of Hrvoje and Danko can be found in the annexed presentation document (Annex 7).

Technical session 8: On-line demonstrations: Short-term modules grid, Long-term modules grid, Grid-buildings interaction.

During the technical session No. 8 Paula and Tomislav demonstrated how all developed grid-side modules work on Zagreb pilot site, showing:

- How to start and run each module,
- what is happening in real time when each module is started,

- how data is prepared, simulated, forecasted, collected from other sources,
- how the modules communicate (long and short term as well as grid side and building side),
- how the results are stored and used for later analyses,
- how the results (and benefits) are visualized graphically.

This was an online demonstration, opening simulation tool, long-term module, each submodule of the short-term module as well as different database tables to show how and where data is written or read.

After the demonstration, there was a discussion on potential upgrades which could be made especially in terms of more accurate forecasts on the side of the distribution network (also regarding introducing measurements from AMR in case they are collected more frequent).

The presentations given are in Annex 10 (grid-building communication) and in Annex 11 (grid-side modules organization and functioning).

Annexes:

Annex 1: UNIZGFER building performed installations with included IT installations

Annex 2: HEP building performed installations with included IT installations

Annex 3: Grid-side performed installations with included IT installations

Annex 4: On-line demonstration of basic IT infrastructure performance with the installed equipment

Annex 5: 3Smart modules organization on the UNIZGFER pilot building

Annex 6: 3Smart modules organization on the side of HEP building

Annex 7: On-line demonstrations: 3Smart modules installed on UNIZGFER building

Annex 8: HVAC.PE.1 and HVAC.PE.2

Annex 9: HVAC.PE.3 and HVAC.I.1

Annex 10: On-line demonstration of basic IT infrastructure performance with the installed equipment: Grid-building interaction

Annex 11: 3Smart modules organization on the sides of the grid

3Smart First pilot study visit to the Croatian pilot: Performed installations and realized IT infrastructure on the UNIZGFER pilot building

Mario Vašak, Anita Martinčević, Nikola Hure, Danko Marušić, Hrvoje Novak, Vinko Lešić, Juraj Havelka, Matija Zidar

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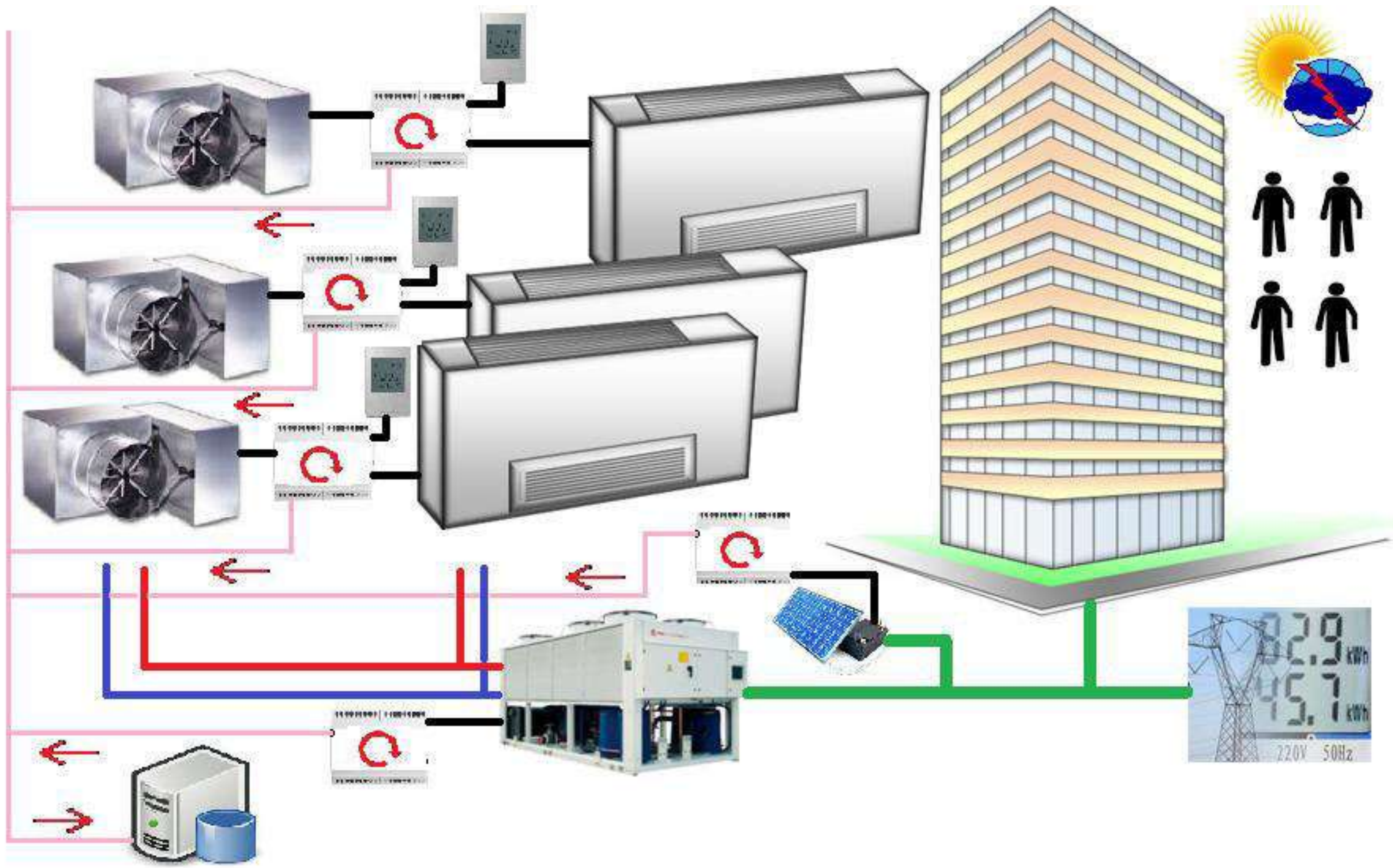
3Smart pilot study visit to HR pilot No. 1 in Zagreb

11 December 2018

UNIVERSITY OF ZAGREB FACULTY OF ELECTRICAL ENGINEERING AND COMPUTING

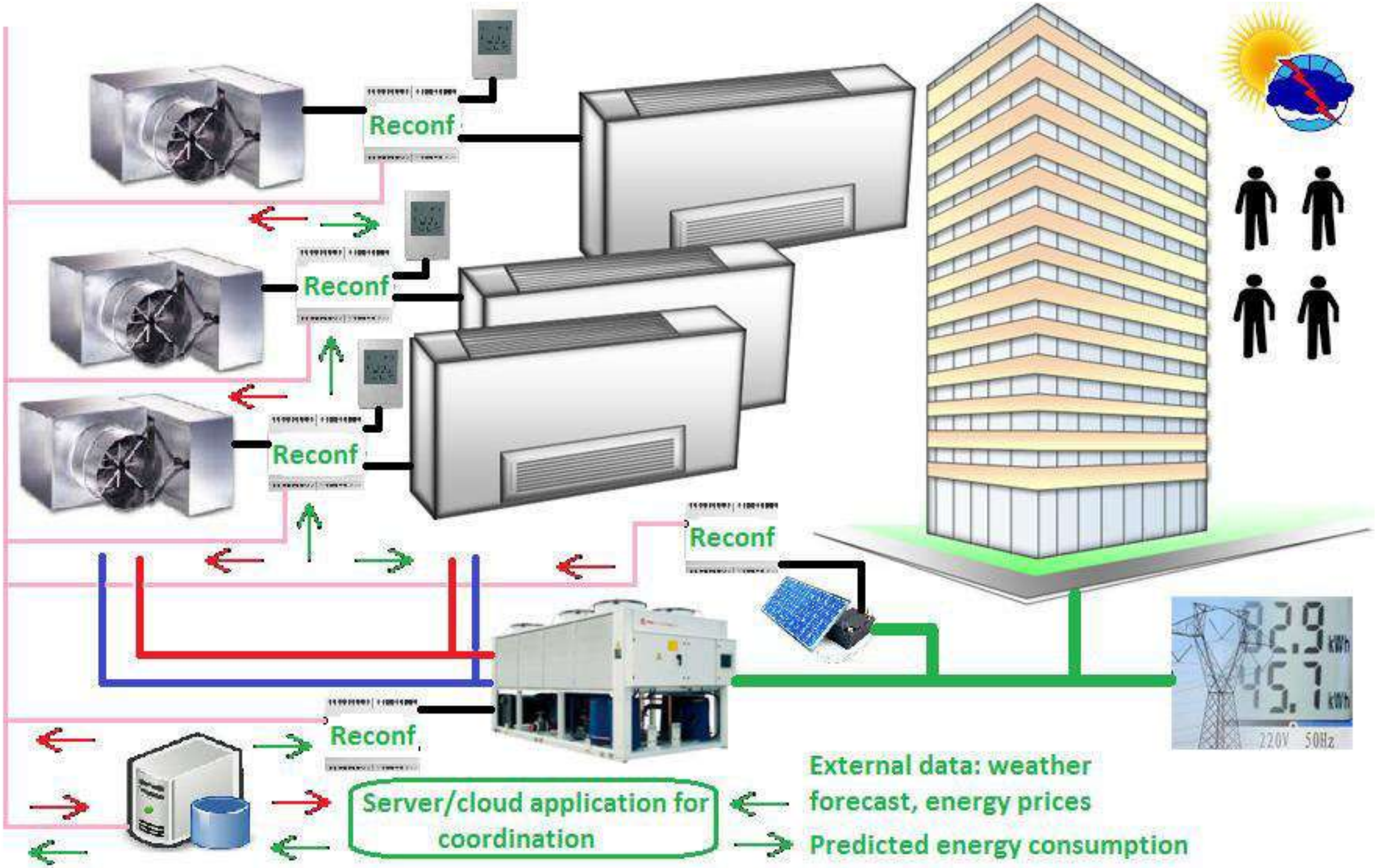
Project co-funded by the European Union

Situation before the 3Smart investment



None/weak coordination between controllers!
The building operation to maintain comfort costs higher than it should!

Targeted situation after the 3Smart investment



Requirements on the interventions in the building

- Gradual takeover of control by the 3Smart EMS
  – selectable up to the level of individual rooms
- Easy software-based roll-back to the decentralized control configuration if necessary
- Data sampling from different sources including existing SCADA with ~1 min refresh period
- Data from the database can propagate to the field level and be implemented as commands

Interventions on the UNIZGFER building

- Existing:
  - 248 rooms with Siemens RXC 21.1/21.5 (12 floors + ground floor)
  - 368 Trane fan coils
  - 1000 kW heating substation
  - 200 kW chiller
  - DESIGO SCADA (integrating RXCs and chiller)
  - 21,5 kWp photovoltaic plant
  - weather station including solar irradiance measurement equipment
  - prototype weather forecast for the UNIZGFER building location from DHMZ
  - power meters by floors

Interventions on the rooms level

- Existing:
  - 248 rooms; 360 fan coils; 1 RXC controller with a display unit per room
    - setting reference temperature in 6°C span
    - choosing the operation mode (standby-AUTO-fixed speed 1-2-3)
  - (RXCs) – LoN – (PXC) – BACNET/IP – (SCADA computer)
- Intervention:
  - upgraded RXC 21.1/21.5 software
    - enabled acceptance of external commands for fans without any noticeable difference in end-user interfacing
  - temperature sensor for return water of each fan coil (368)
    - 1-wire, non-used two twisted pairs from LoN cable exploited
    - (sensor) –1-wire – (floor concentrator) – MODBUS RTU – (building concentrator) – MODBUS TCP/IP

Interventions on the rooms level

- Existing:
  - 248 rooms; 360 fan coils; 1 RXC controller with a display

)-fixed speed 1-2-3)

:ADA computer)

ıt any

  - temperature sensor for return water of each fan coil (368)
    - 1-wire, non-used two twisted pairs from LoN cable exploited
    - (sensor) –1-wire – (floor concentrator) – MODBUS RTU – (building concentrator) – MODBUS TCP/IP

Data related to the rooms level

- Initial idea: all data from room controllers fetched to 3Smart databse through DESIGO SCADA – abandoned due to inherent delay expected, left for fetching historical data
- Data communication from RXC controllers:
  - (PXC controllers) – BACNET/IP – (Loytec LINX-153 controller) – MODBUS TCP/IP – (3Smart server)
- Data communication from fan coils return medium temperature 1-wire sensors:
  - (building concentrator) – MODBUS TCP/IP – (3Smart server)

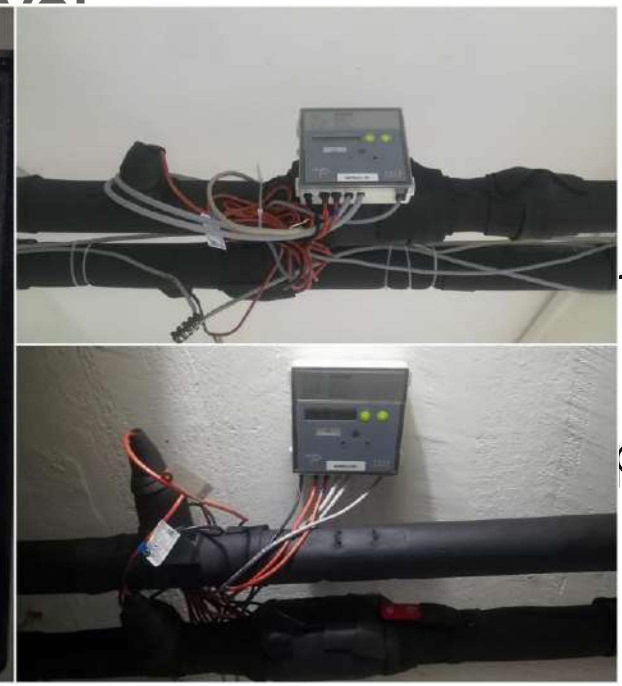
Data related to the rooms level (2)

- From RXC controllers (each room):
  - room temperature, reference temperature
  - operating mode selection
  - fan state, valve state
- From 1-wire sensors (each fan coil):
  - return medium temperature
- From the SCADA:
  - 3Smart on/off for each room
- To RXC controllers (each room):
  - fan command, valve command (not used)

Interventions on the floors level

- Existing:
  - northern and southern vertical for supplying heating/cooling medium to northern and southern half of each floor
  - calorimeters existing only on two floors (from the previous small-scale pilot project ENHEMS-Buildings)
- Intervention:
  - calorimeters installed on all transitions of vertical to horizontal distribution at the entry of the floor, 26 calorimeters present at the end, for 12 floors + ground floor
  - (calorimeter) – M-BUS– (PXC integration controller) – BACNET/IP – (SCADA computer)

Interventio



- Existing:
  - northe
    heatin   half of
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- Interven
  - calorimeters installed on all transitions of vertical to horizontal distribution at the entry of the floor, 26 calorimeters present at the end, for 12 floors + ground floor
  - (calorimeter) – M-BUS– (PXC integration controller) – BACNET/IP – (SCADA computer)

Data related to the floor level

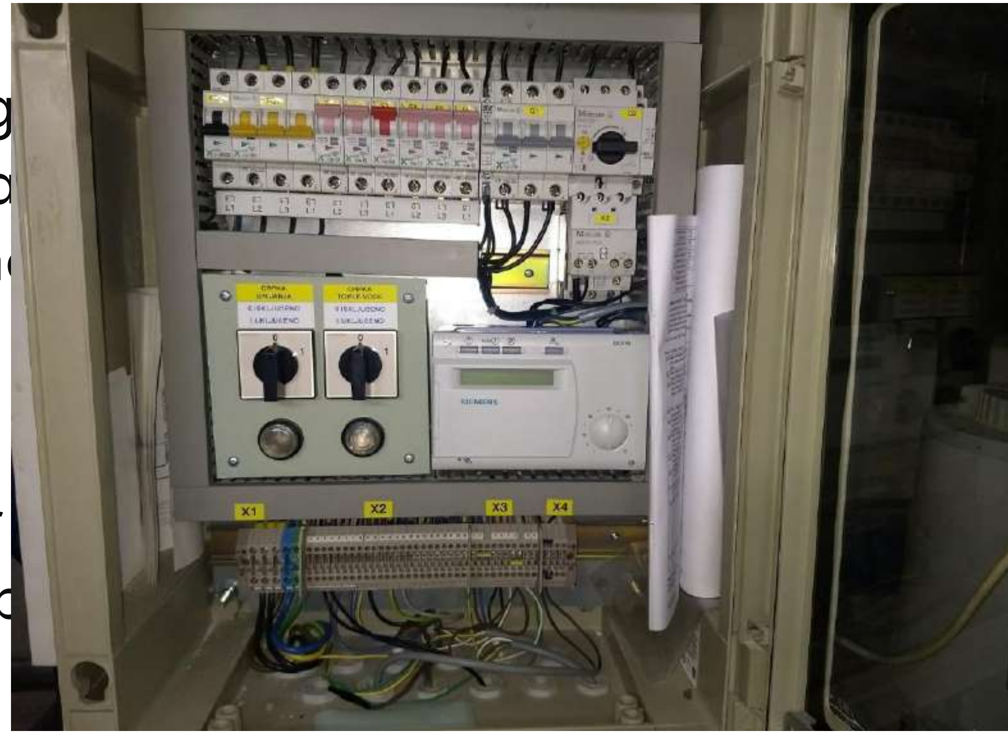
- Calorimeters data integrated in the DESIGO SCADA system
  - for building operators and data backup
- Data communication for 3Smart:
  - (PXC controllers) – BACNET/IP – (Loytec LINX-153 controller) – MODBUS TCP/IP – (3Smart server)
- Data from each calorimeter:
  - medium outgoing and return temperature, temperature difference
  - medium flow, cumulated energy and current power

Interventions on the central HVAC system level (1)

- Existing:
  - 1000 kW heating substation with outdoor-temperature-driven control for the starting medium temperature and the billing calorimeter on the primary side; not integrated in SCADA
  - circulation pump for the heating substation with possibility of manual pressure setting; not integrated in SCADA
  - 200 kW el chiller which supplies the skyscraper building and AHU of another building
- Interventions:
  - enable setting the heat. subst. temperature comm. from the 3Smart system and fetching data from it
  - enabling pressure difference command to the pump

Interventions on the central HVAC system level (1)

- Existing:
  - 1000 kW heating … e-driven control for the sta … illing calorimeter on th … ADA
  - circulation pump … bility of manual pressure
  - 200 kW el chiller … ng and AHU of another b



- Interventions:
  - enable setting the heat. subst. temperature comm. from the 3Smart system and fetching data from it
  - enabling pressure difference command to the pump

Interventions on the central HVAC system level (2)

- Interventions (continued):
  - enabled starting medium command issuing to the chiller and fetching data from the chiller
  - introduced central calorimeter for measurement of the entire heating or cooling energy towards the fan coils
  - introduced calorimeter for mesurement of cooling energy provided from the chiller to the AHU of another building
  - integrated exsting billing calorimeter

Inte… s on the central HVAC system level (2)

- Int… on
  - … st … n … e
    … nd … n
  - introduced central calorimeter for measurement of the entire heating or cooling energy towards the fan coils
  - introduced calorimeter for mesurement of cooling energy provided from the chiller to the AHU of another building
  - integrated exsting b… ime…

Data communication with the central HVAC system (1)

- Heating substation and circulation pump:
  - (heating substation controller) – MODBUS – (PXC integration controller) – BACNET/IP – (SCADA computer)
  - (heating substation controller) – MODBUS – (PXC integration controller) – BACNET/IP – (Loytec LINX-153 controller) – MODBUS TCP/IP – (3Smart server)
  - (pump on/off controller) – MBUS – (PXC integration controller)
  - (circulation pump drive) – Ethernet – (SCADA computer) – BACNET/IP – (Loytec LINX-153 controller) – MODBUS TCP/IP – (3Smart server)

Data communication with the central HVAC system (2)

- Chiller:
  - (chiller controller) – LON – (PXC controller) – BACNET/IP– (SCADA computer)
  - (chiller controller) – LON – (PXC controller) – BACNET/IP– (Loytec LINX-153 controller) – MODBUS TCP/IP – (3Smart server)
- Central calorimeters
  - Integrated in the DESIGO SCADA system for building operators and data backup
  - Data communication for 3Smart: (calorimeter) – MBUS– (PXC integration controller) – BACNET/IP – (Loytec LINX-153 controller) – MODBUS TCP/IP – (3Smart server)

Data related to the central HVAC system

- Heating substation:
  - reference temperature for the starting medium, measured temperature, 3Smart on/off
- Circulation pump:
  - differential pressure setting
- Chiller:
  - starting medium temperature, return medium temperature, electricity consumption data
  - reference starting medium temperature, 3Smart on/off
- Calorimeters (same as floor calorimeters):
  - starting and return medium temperature, temperature difference, flow, cumulated energy, current power

Interventions on the microgrid level

- Existing:
  - 21 kWp photovoltaic system on the skyscraper roof with power converters, with existing production data logging
  - smart electricity meters on each building floor
- Interventions:
  - introduction of a battery storage system based Li-ion batteries, 32 kWh with bidirectional 10 kW power converter
  - integration of PV production data into the 3Smart EMS
  - integration of smart meters data into the 3Smart system

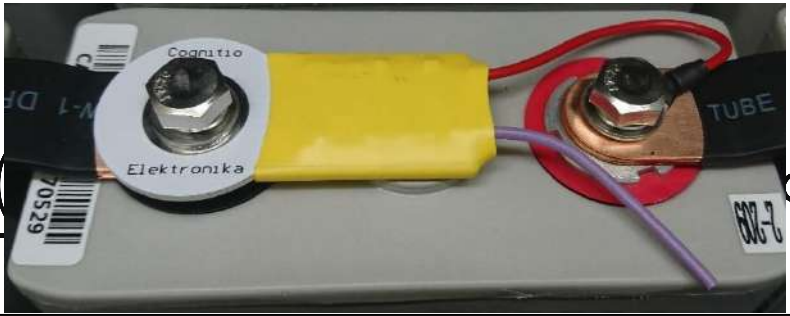
Data communication with the microgrid level

- Communication:
  - (battery system communication controller) – MODBUS TCP/IP – (3Smart server)
- Battery management system:
  - cells temperature and voltage monitoring
  - initiating safety procedures when limits in voltage, current or temperature are overstepped, including also room temperature and power cabinet temperature
- Data from the battery system:
  - averaged current measurement on the DC side, current SoC estimation
  - power command for the AC side or cu

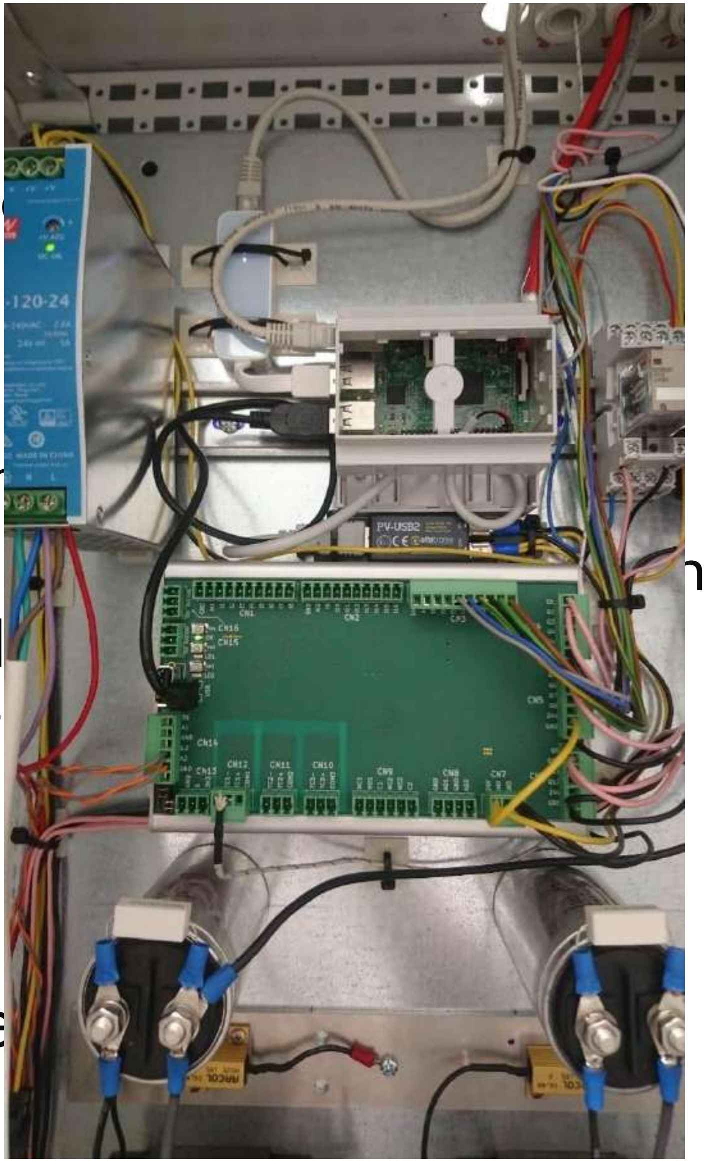
Battery system data communication and features

- Communication:
  - (battery system communication controller) – MODBUS TCP/IP – (3Smart server)
- Battery management system:
  - cells temperature and voltage monitoring
  - initiating safety procedures when limits in voltage, current or temperature are overstepped, including also room temperature and power cabinet temperature
- Alerts sending via e-mail and sms to designated contacts
- Implemented independent fire alarming system

Battery system data communication and features



- Co
  - (on
- Battery management system:
  - cells temperature and voltage m
  - initiating safety procedures whe nt or temperature are overstepped temperature and power cabinet
- Alerts sending via e-mail and contacts
- Implemented independent fire



Data related to the battery system

- Data from the battery system:
  - averaged current measurement on the DC side, current SoC estimation, cells temperatures and voltages measurements, power measurement on the AC side
- Data for the battery system:
  - power command for the AC side or current command for the DC side, with command selector

Weather data and weather forecast

- Measurements from the weather station and solar irradiance measurements
  - collected in the integration controller, fetched by the 3Smart server and stored in the 3Smart database
  - temperature, direct & diffuse & global solar irradiance, wind velocity and direction, pressure, relative humidity
- Weather forecasts
  - fetched from the server of Croatian Meteorological and Hydrological service
  - 4 times a day, hourly resolution, 72 hours ahead
  - temperature, direct and diffuse solar irradiance, wind velocity and direction, pressure, relative humidity

Weather data and weather forecast

- Measurements from the weather station and solar irradiance measurements
  - collected in the integration controller, fetc
    3Smart server and stored in the 3Smart d
  - temperature, direct & diffuse & global sol
    wind velocity and direction, pressure, rel

- Weather forecasts
  - fetched from the server of Croatian Meteorological and Hydrological service
  - 4 times a day, hourly resolution, 72 hours ahead
  - temperature, direct and diffuse solar irradiance, wind velocity and direction, pressure, relative humidity

PV production and electricity consumption data

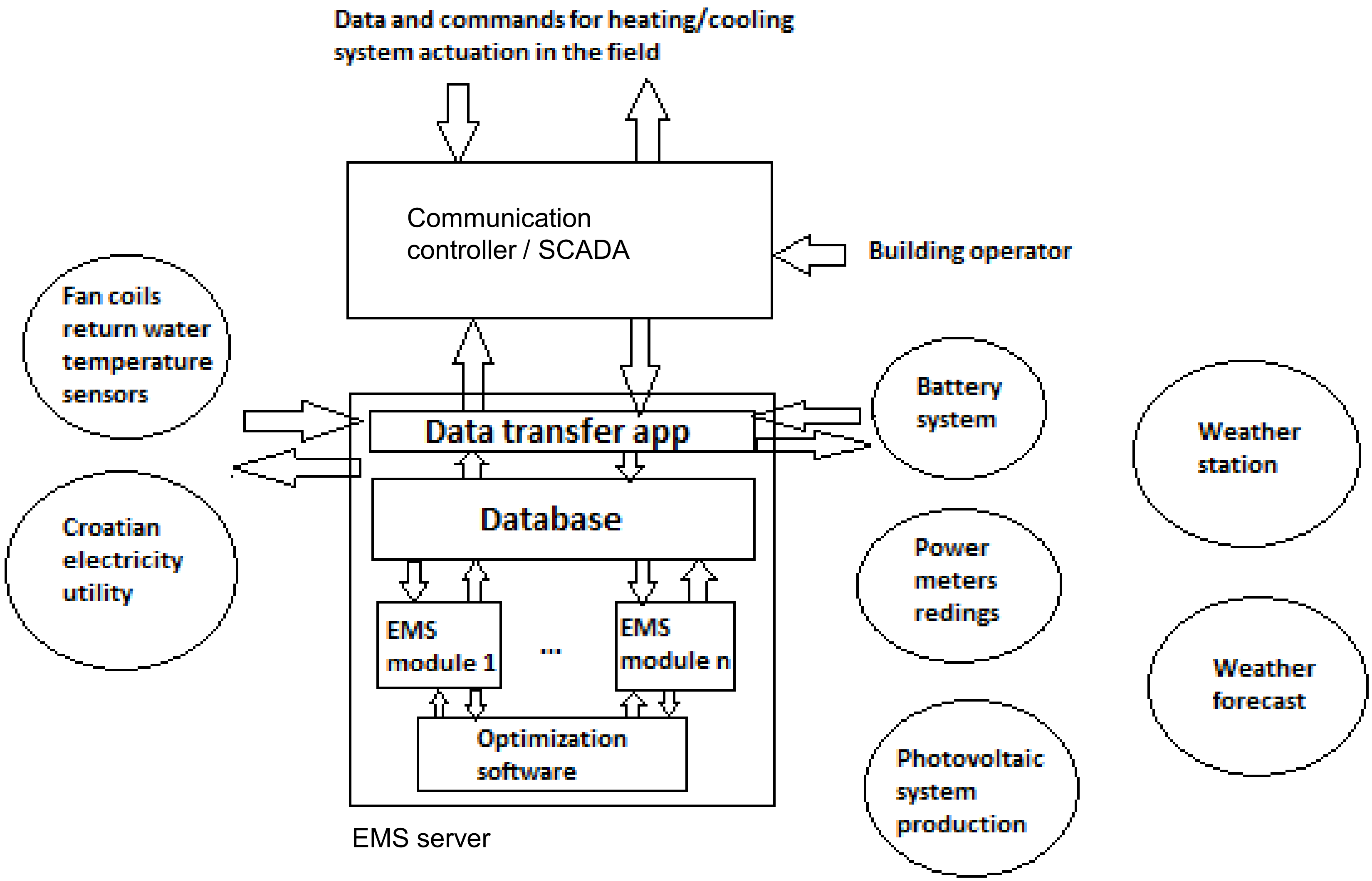
- PV production data from six 3,5 kWp groups
  - logged into the integration controller
  - fetched by the 3Smart server and entered into the 3Smart database
- Electricity consumption data from all building floors (14 meters)
  - logged into the integration controller
  - fetched by the 3Smart server and entered into the 3Smart database

PV production and electricity consumption data

- PV production data from six 3,5 kWp groups
  - logged i
  - fetched o the 3Sm

- Electricity consumption data from all building floors (14 meters)
  - logged into the integrat
  - fetched by the 3Smart s into the 3Smart database

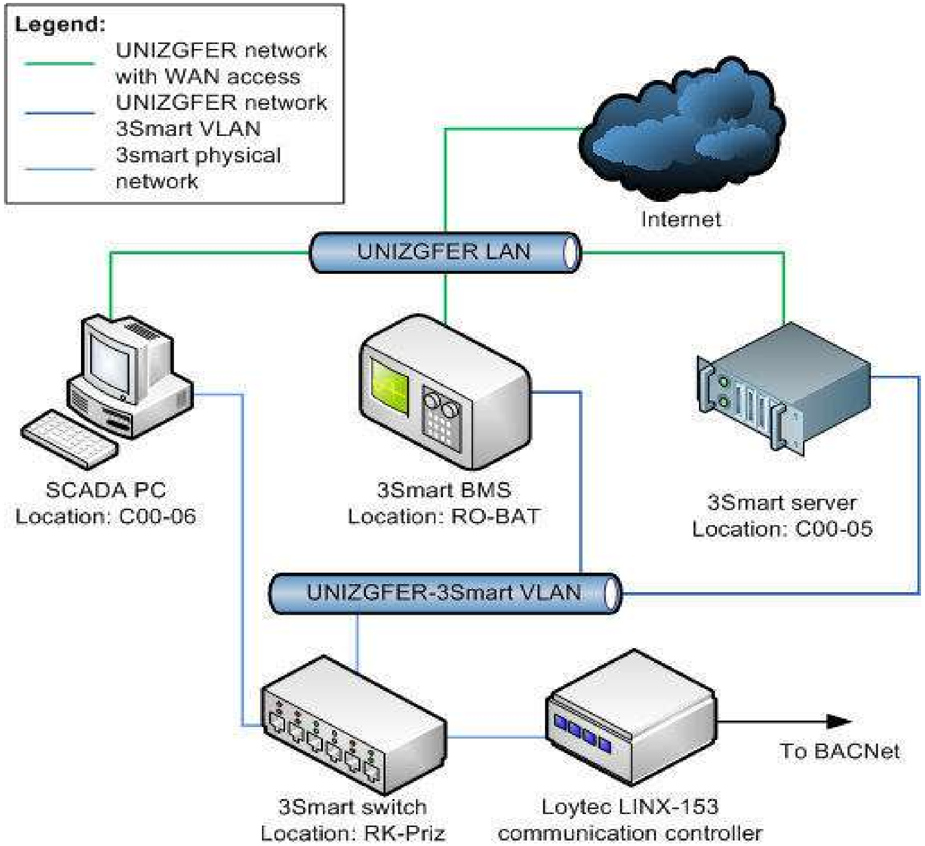
Structure of the information system for EMS



Installation steps on the 3Smart server side

- Installed necessary software on the 3Smart server

  - the server connected to the faculty network
  - carefully implemented access rights from the network

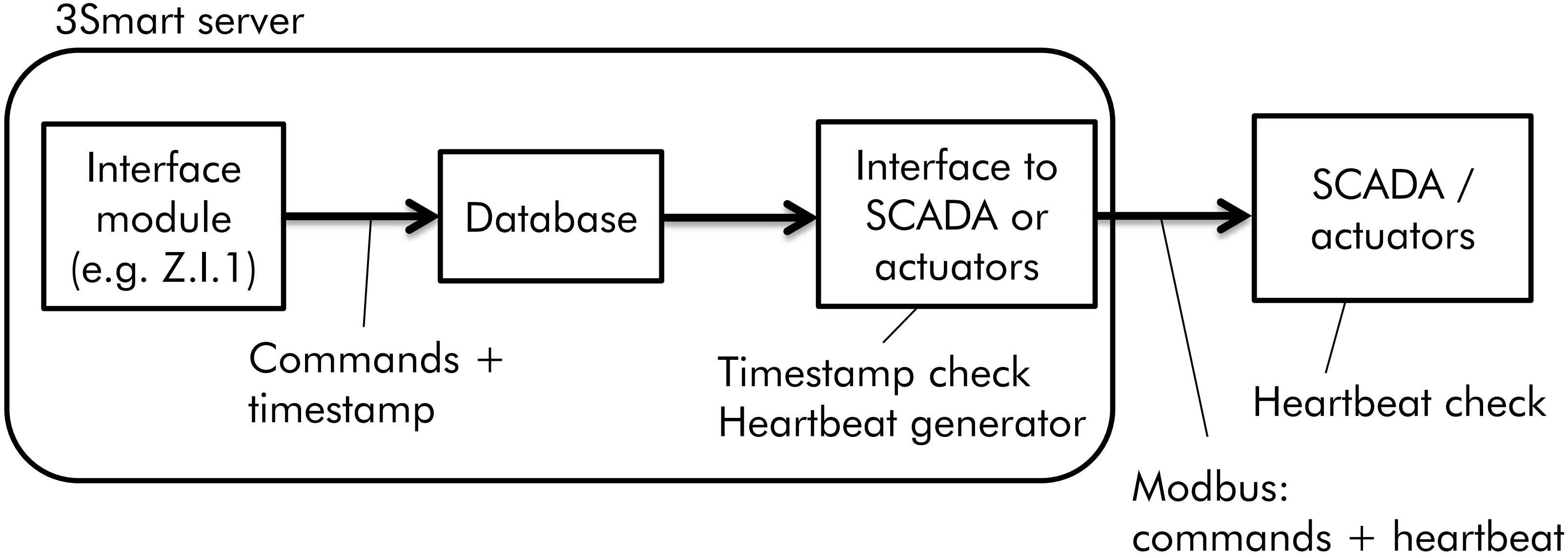


Installation steps on the 3Smart server side

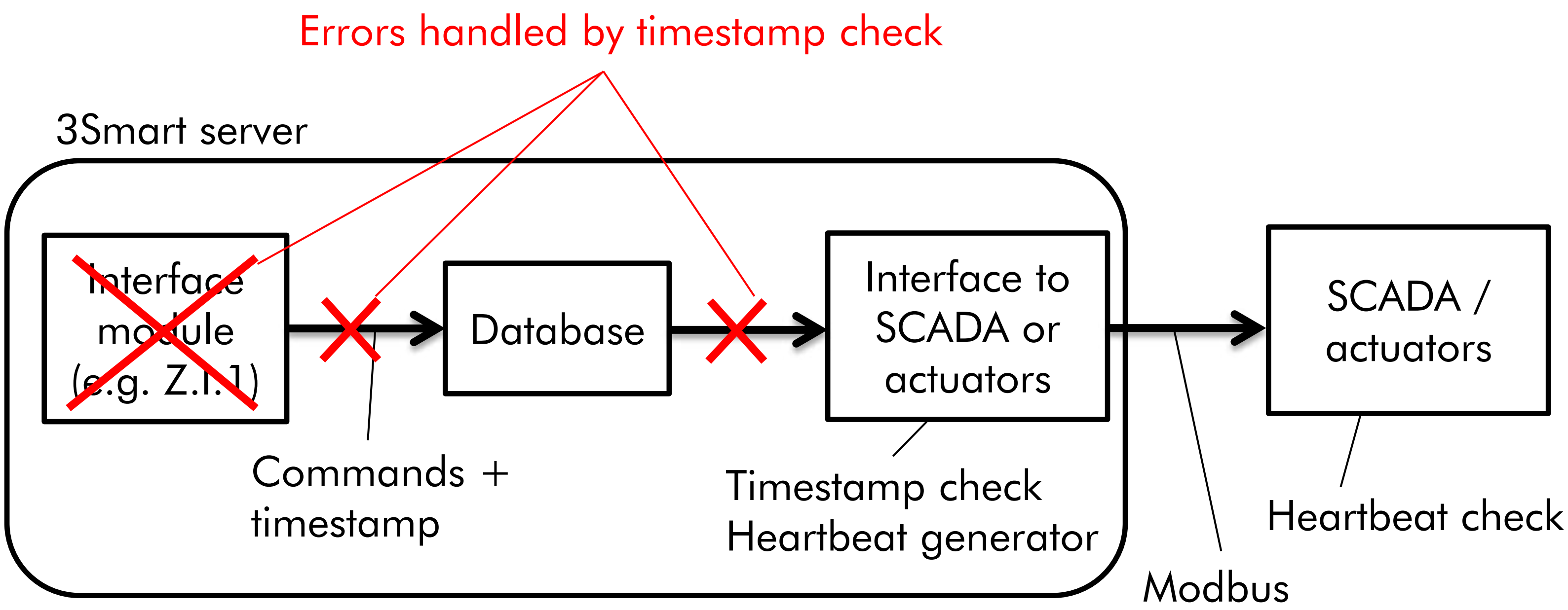
- Put up the database tables and data transfer application by encompassing different parts of the available data
  - from zones, floors, central HVAC, battery system, PV,...
- Implemented features for seamless transition to 3Smart way of operation in different building segments
  - implemented safety roll-back to the classical decentralized way of operation

Security options – global outline

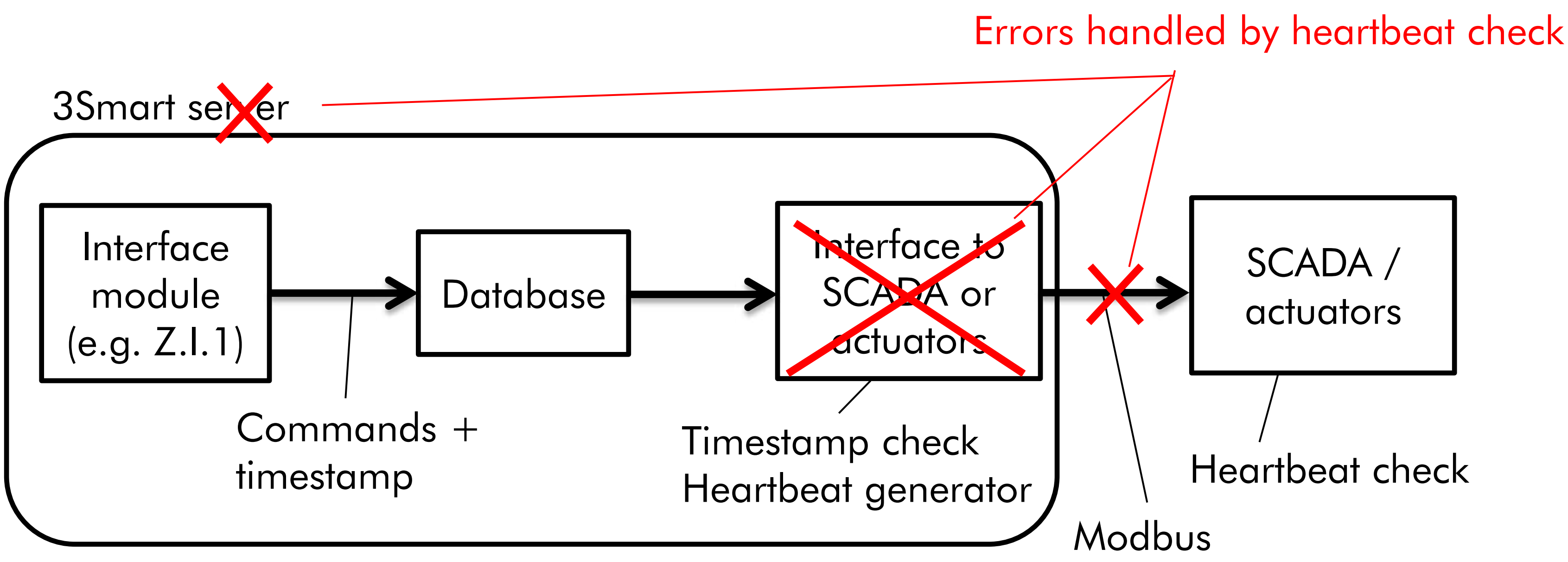
- The building actuators must return to classical operation (or neutral if classical does not exist!) if the 3Smart system fails!



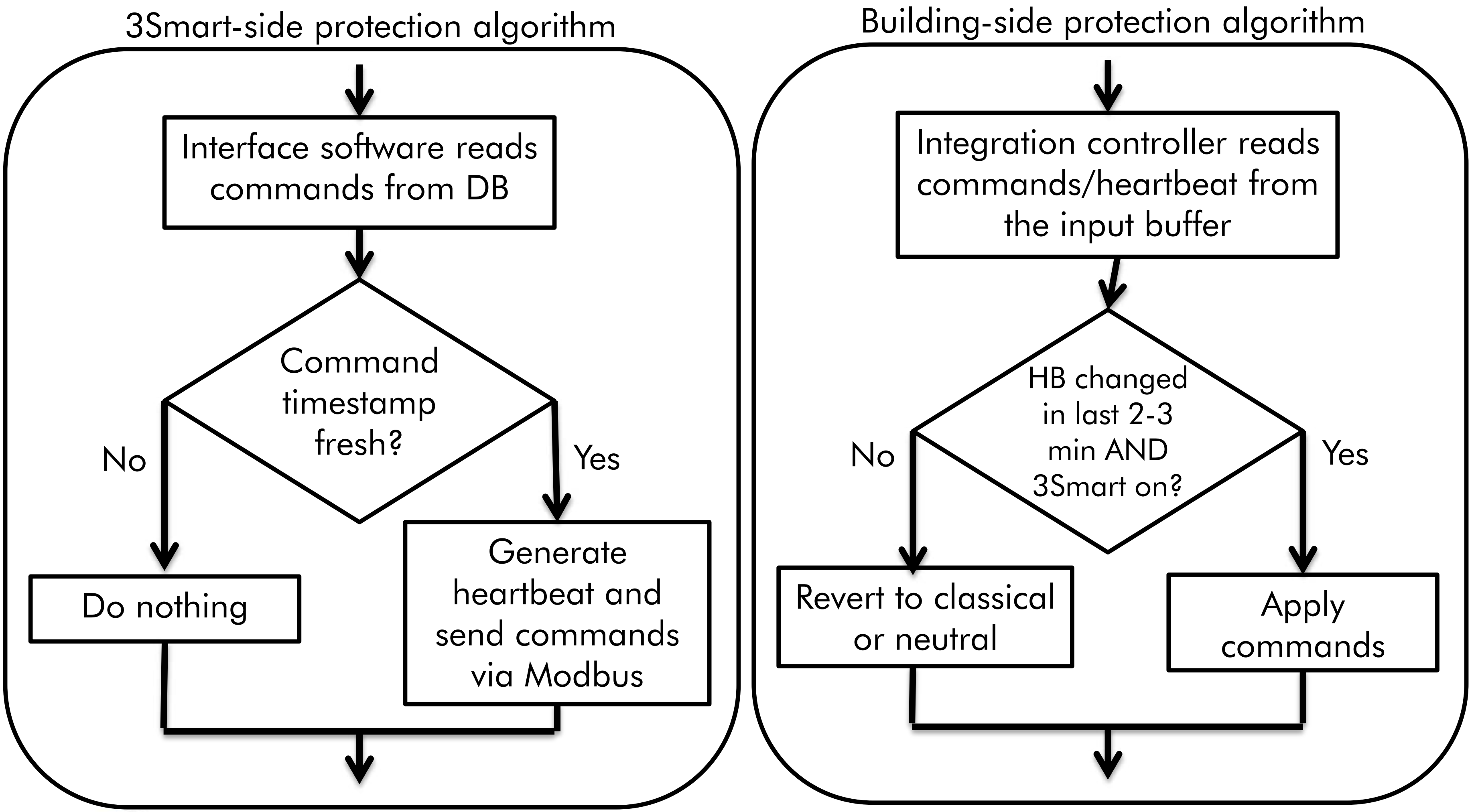
Security options – global outline



Security options – global outline



Security options – general algorithms



Security options on the zone level

1. **3Smart switch (True/False)**

- easy transition between 3smart control and local control for every zone individually

2. **Heartbeat signal for a zone level**

- switches zone control back to local control if 3smart interface module did not issue new commands in the last 2 min
- if there is no connection between database and the building either caused by programming errors or communication fallouts local controllers start to regulate the zone temperature regardless of the active 3Smart switch

3. **Shadow values**

- smooth transition to 3smart operating regime (when 3Smart switch False → True)
- during the intervals with 3smart inactive FCU interface module writes zeros to modbus register

Security options on the HVAC level (1/2)

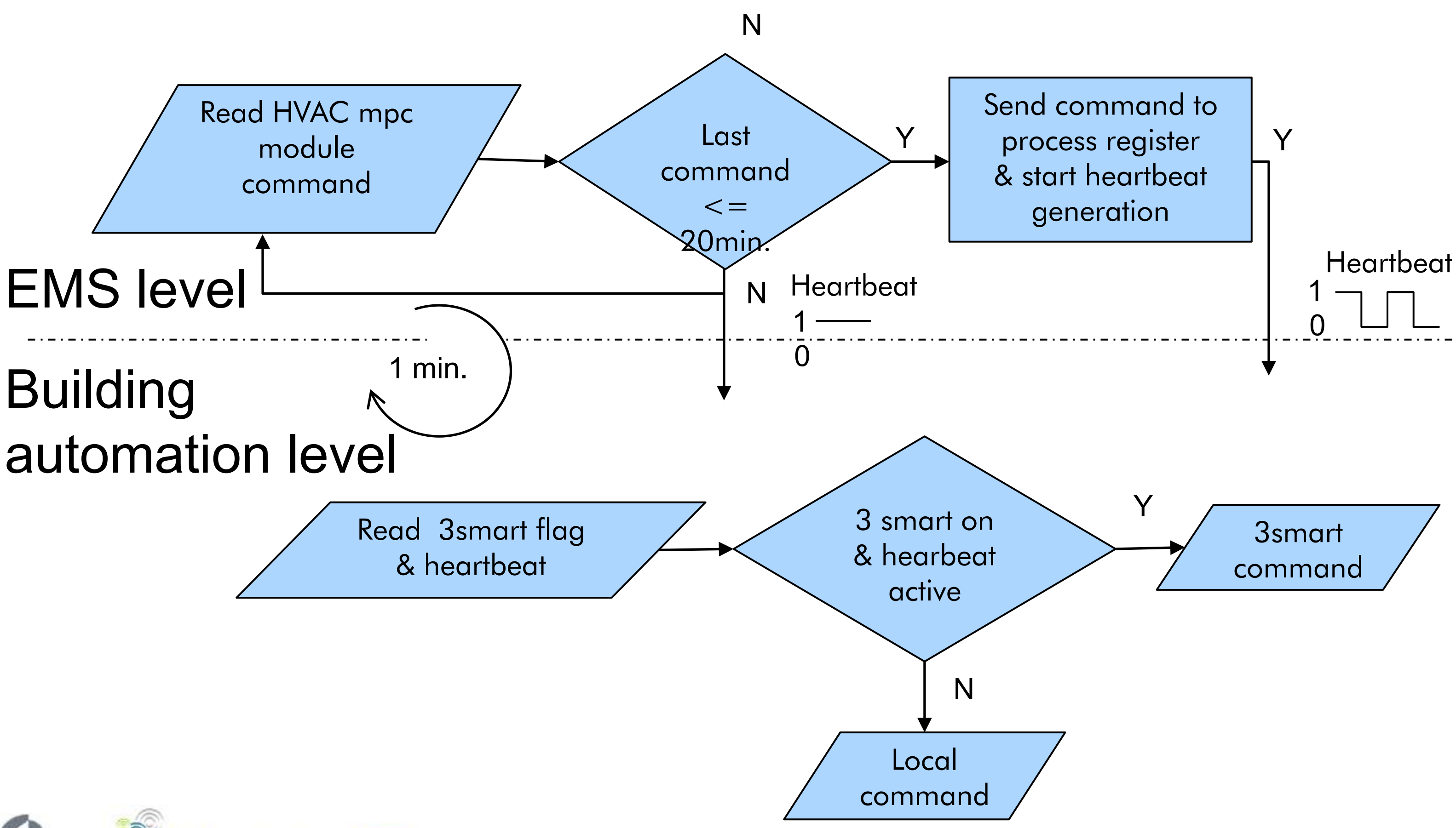
1. **3Smart switch (True/False)**

- 3smart control and local control for the heating substation/chiller individually

2. **Heartbeat signal for a heating substation/chiller**

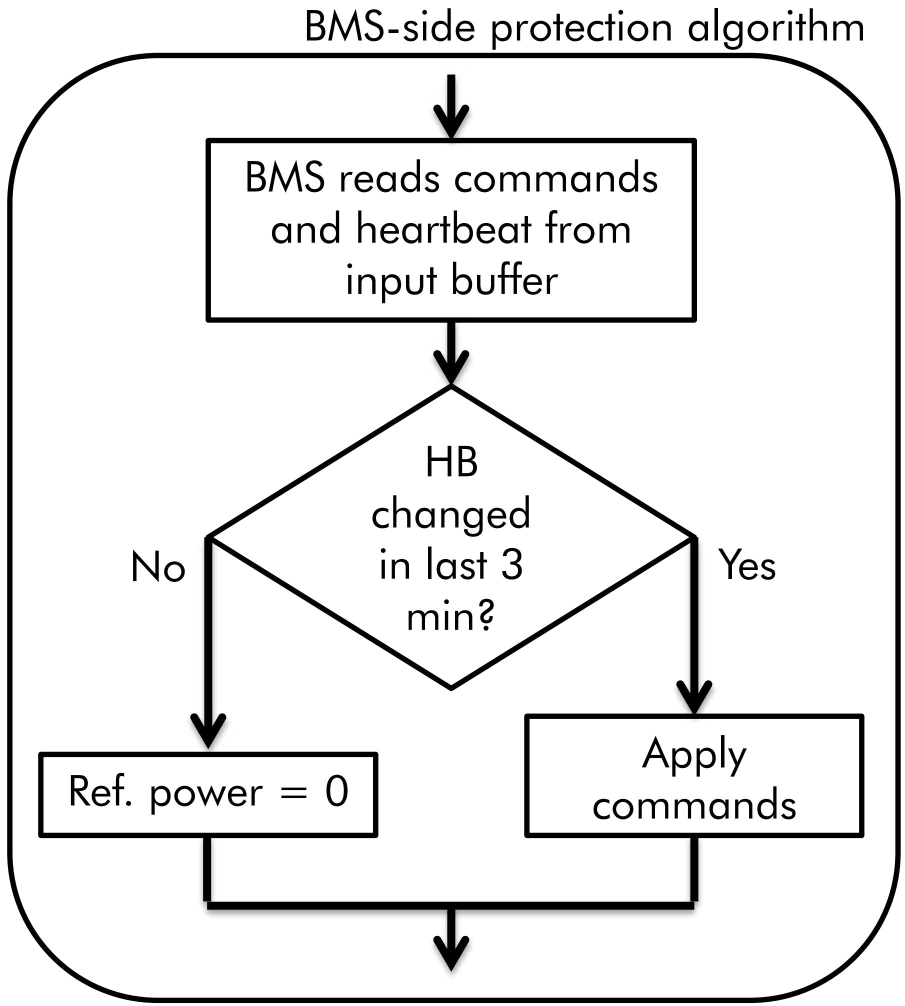
- Hearbeat conditions:
  - Updated commands within the last 20 min
  - 3smart ON
- Heartbeat enables **detection of connection blackout** and indicates **operation of 3Smart modules** – mandatory for safe operation
- 3smart commands if 3smart on and heartbeat is active, otherwise simple local controller

Security options on the HVAC level (2/2)



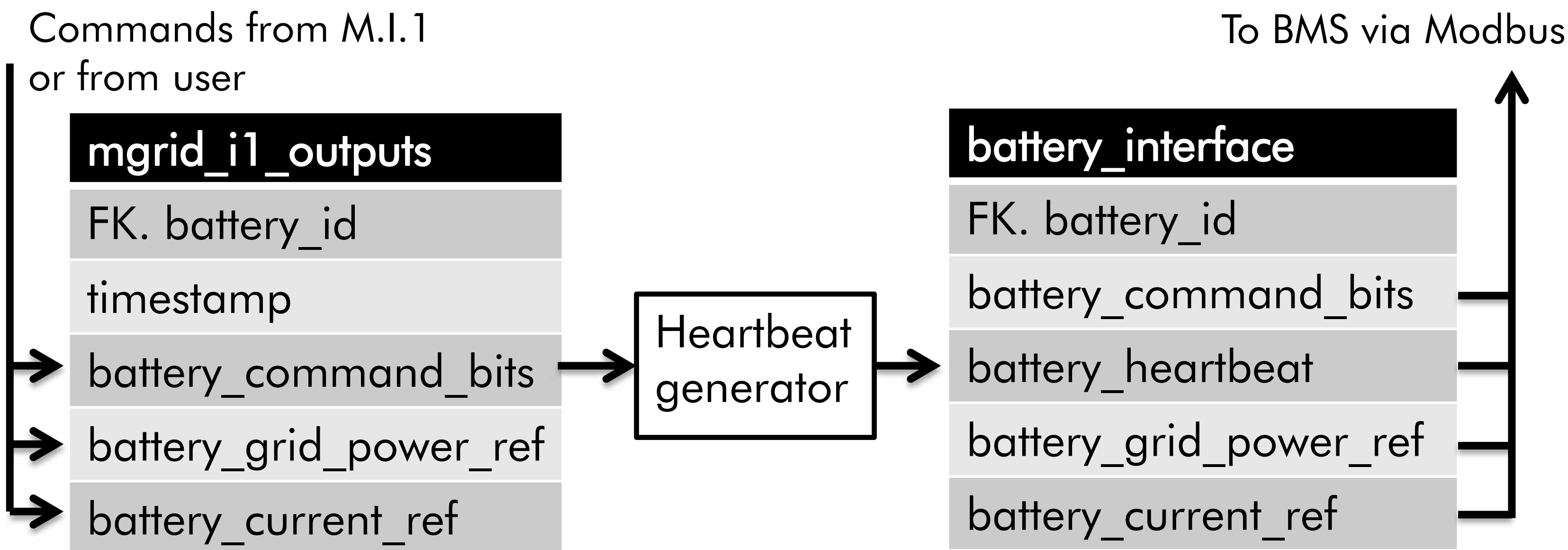
Security options on the microgrid level

- Heartbeat signal between the DB and BMS
- Heartbeat
  - integer value
  - shall be changed (easiest: incremented) every sampling interval (i.e. every minute)
  - Threshold: 3 sampling intervals = 3 min



Security options on the microgrid level

- Heartbeat is handled by the database



3Smart database

- Data are organized in the 3Smart database according to the provided template
- On-line demonstration in the afternoon

3Smart First pilot study visit to the Croatian pilot: Performed installations and realized IT infrastructure on the HEP pilot building

Leon Leposa, Tomislav Stašić

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3Smart pilot study visit to HR pilot No. 1 in Zagreb

11 December 2018

Project co-funded by the European Union

Existing system - Recap

- 2 Water Chillers – 1.063 $kW_{cooling}$
- Heating station (District Heating) with 3 substations:
  - Kompakt 1000 (1000 kW)
  - Kompakt 1000DHW (1000 kW)
  - Kompakt 120 (120 kW)
- Air Handling Unit – 5.000 m^3/h
- PV Plant – 29,64 kW_e

- Radiators – 288
- Fan Coils - 313

Existing system - Recap

- 3 Heat meters – one per Heating substation
- 2 Electricity meters
  - Building overall
  - PV Plant

- NO AUTOMATION AT ALL!

Current status – overview

- All installation works are finished
- There are some issues with FC on the 7th floor, will be resolved outside the project
- Few RDG controllers missing (malfunctioning when delivered), waiting for new to come
- All Heat meters installed and working
- Integration of Heating station and AHU to BMS completed
- Water chillers needs to be integrated to BMS
- Battery system installed and tested with factory software – needs to be integrated to BMS

Current status – overview

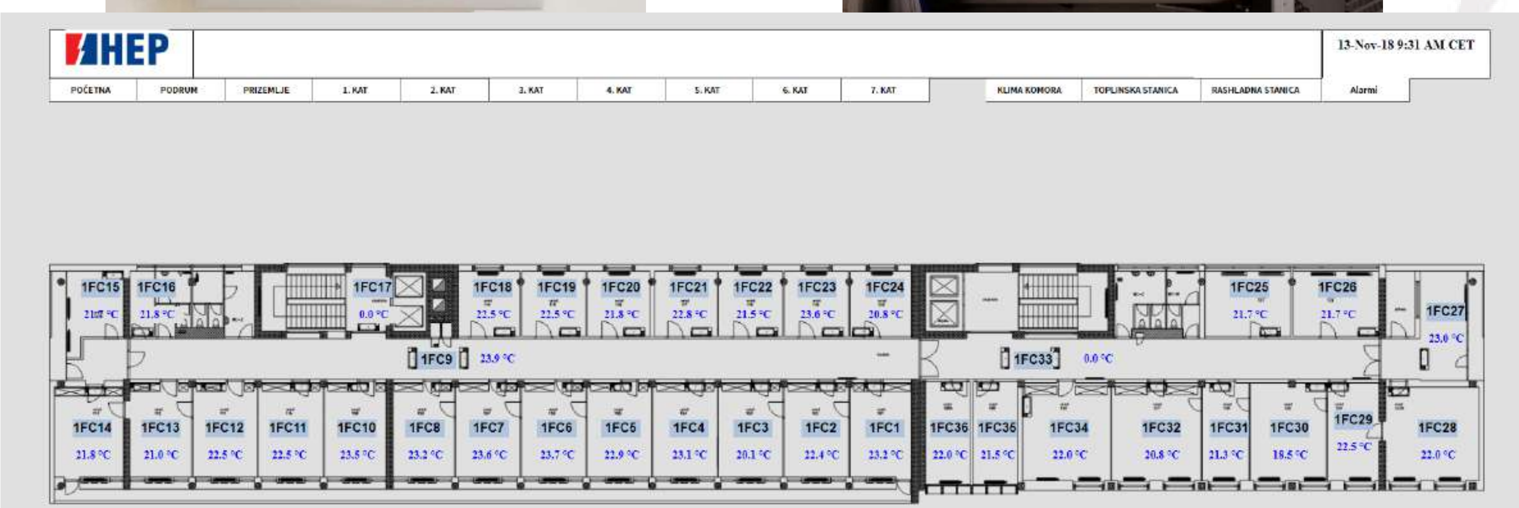
- Installation works paid
- Installation supervision paid
- Some extra works performed due to malfunctioning of the system:
  - New plenum installed in the East meeting hall on the 7^{th} floor
  - New automatic deaerators installed on heating system
  - Will be paid in following weeks (by the end of 2018)

Zones installations

- All offices equipped with:
  - RDG controller for controlling heating and cooling equipment in the room
  - Thermal actuators for radiators
  - 2 temperature sensors – one on heating return and one on cooling return
- Equipment installed:
  - RDG Controllers – 243
  - RXB Controllers (Hallways) – 30
  - Thermal actuators – 288
  - Temperature sensors – 486
  - Wiring – 14,5 km (14.714 m)

Zones installations

Zones installations



Dana related to rooms level

- Controllers (RDG and RXB) connected to SCADA via KNX communication through floor control cabinets
- From RDG controllers (each room):
  - Status: ON/OFF, Heating or Cooling
  - Room temperature
  - Reference temperature
  - Temperature from heating and cooling medium return
  - Fan speed and mode (auto or manual)
  - Radiator valve control possible only via temperature
- From RXB controler:
  - Reference temperature
- Hallway temperature sensor connected to RXB via KNX

Floor installations

- Existing:
  - eastern and western vertical for supplying heating and cooling medium to eastern and western half of each floor
  - Heat meters existing only for heating substations
- Intervention:
  - Heat meters installed on all transitions of vertical to horizontal distribution at the entry of the floor, 36 heat meters present at the end, for 7 floors + ground floor + basement
  - (heat meter) – M-BUS – (Integrator) – (SCADA computer)
  - Heat meter for each floor will be integrated in SCADA shortly

Data related to floor level

- Data from each heat meter:
  - Medium outgoing temperature
  - Medium return temperature
  - Temperature difference
  - Medium flow
  - Cumulated energy
  - Current power

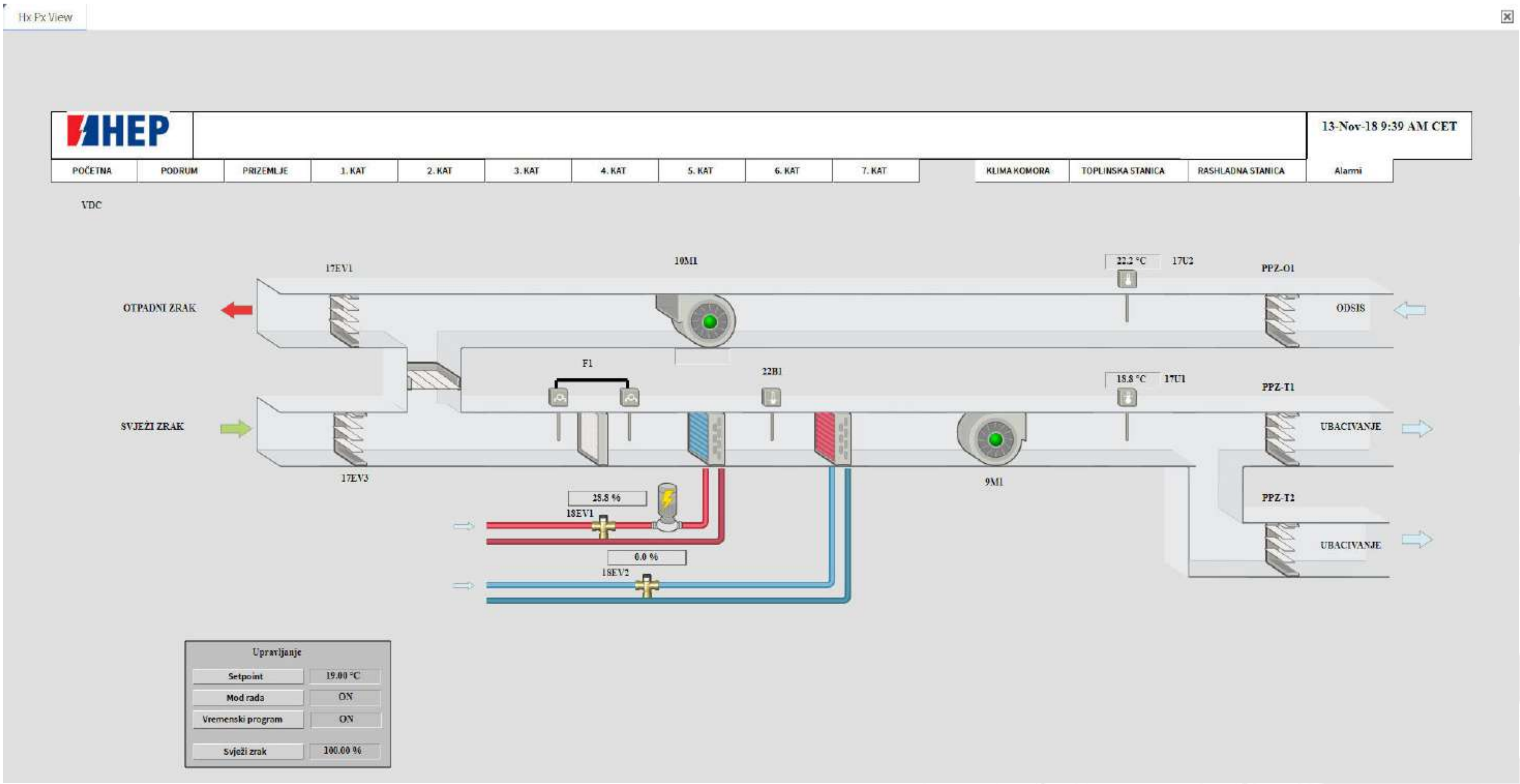
Central HVAC system installations

- Integration of heating station – completed
- Integration of AHU – completed
- Water chillers (with pumps) – needs to be integrated (some issues with ModBus registries on 1 Chiller)
- Circulation pumps for cooling – integrated to BMS

Central HVAC system installations

Control cabinet for AHU and Cooling Station (Water Chillers and pumps)

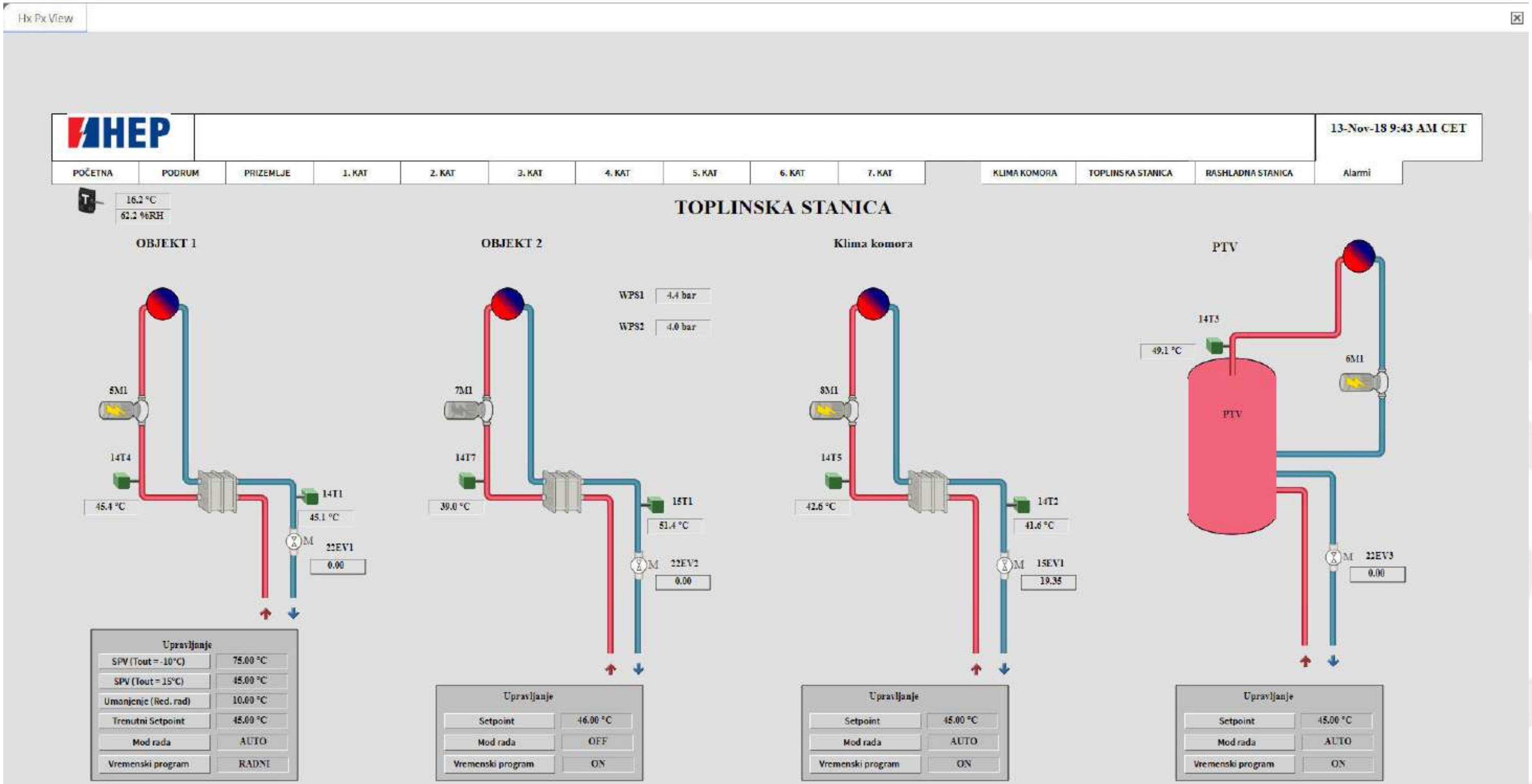
Central HVAC system installations



Central HVAC system installations

Control cabinet for Heating Station

Central HVAC system installations



Data related to HVAC system

- Heating substation:
  - Medium outgoing temperature to the building
  - Return temperature to the DH system
  - Temperature of DHW tank
  - Valve postion (0 -100%)
  - Pump status – ON/OFF
  - System status – ON/OFF
  - Pressure level in the heating system (only for Kompakt 1000)
- Water chiller:
  - Problem with Modbus registries
  - Still unkonwn what will be available
  - Electricity measurement via Mbus - working

Battery system

- Battery system is installed and tested with factory software
- Measurement available on “box” level
- Needs to be integrated to BMS
- Database for batteries already exist
- Few issues still needs to be resolved by our subcontractor

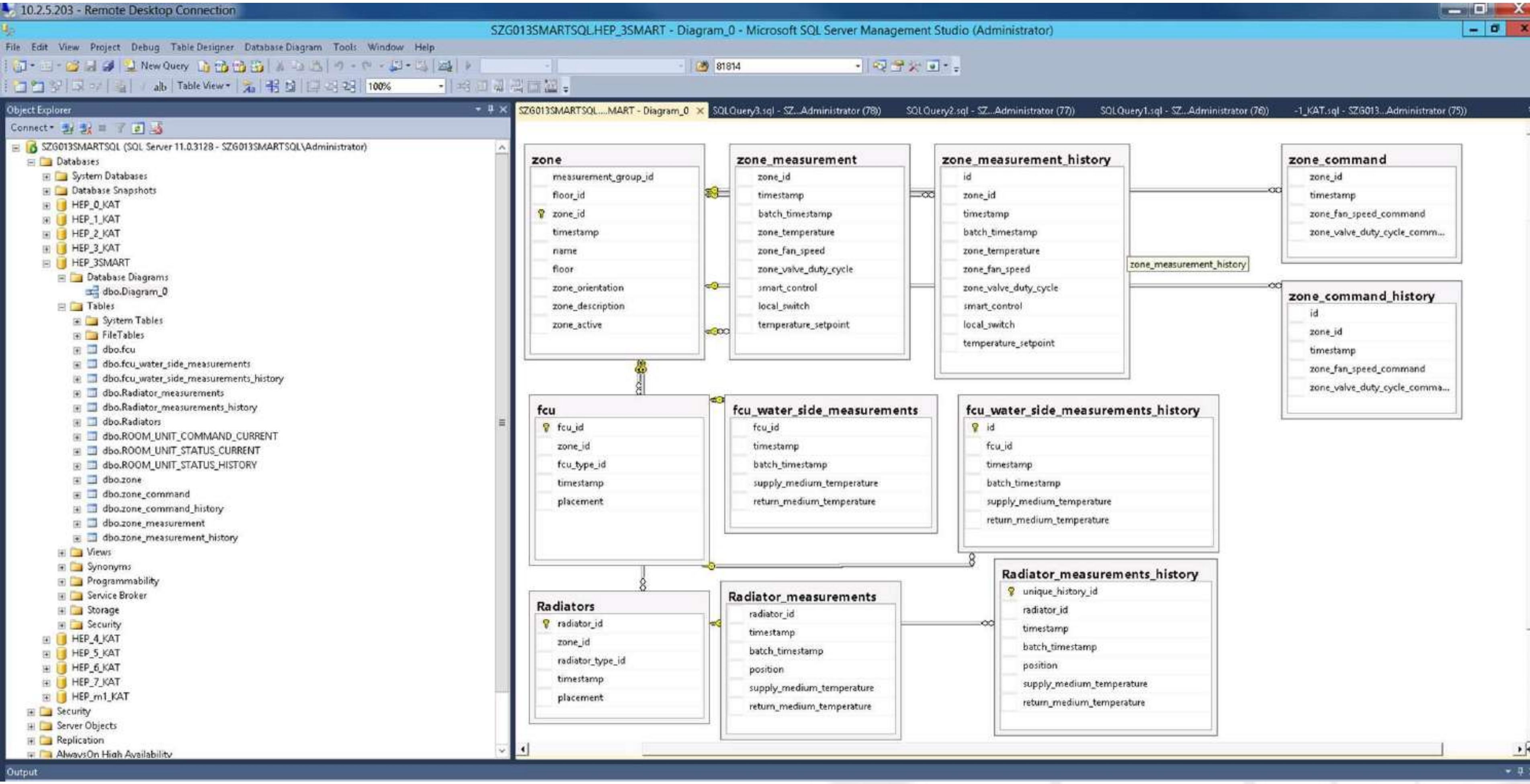
Data related to microgrid level

- Batteries:
  - (battery system communication controller) – MODBUS TCP/IP – (SCADA)
  - Measuring equipment on 8 boxes installed – integration to SCADA is still to come
- Data from batteries:
  - SOC Overall system
  - Temperature on box level
  - Current and voltage of the overall system
  - Current and voltage on the box level

Data related to microgrid level

- 3 electricity meters overall
  - 3 electricity meters in function and measurements are visible in ESCO Monitor® and will be integrated to BMS:
    - Pilot site – overall
    - PV plant
    - Water chillers

Outlook of the database



3Smart First pilot study visit to the Croatian pilot: Performed installations and realized IT infrastructure on the grid

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3Smart – First pilot study Zagreb
11. – 12.12.2018.

UNIVERSITY OF ZAGREB FACULTY OF ELECTRICAL ENGINEERING AND COMPUTING

HEP OPERATOR DISTRIBUCIJSKOG SUSTAVA d.o.o.

Interreg Danube Transnational Programme 3Smart

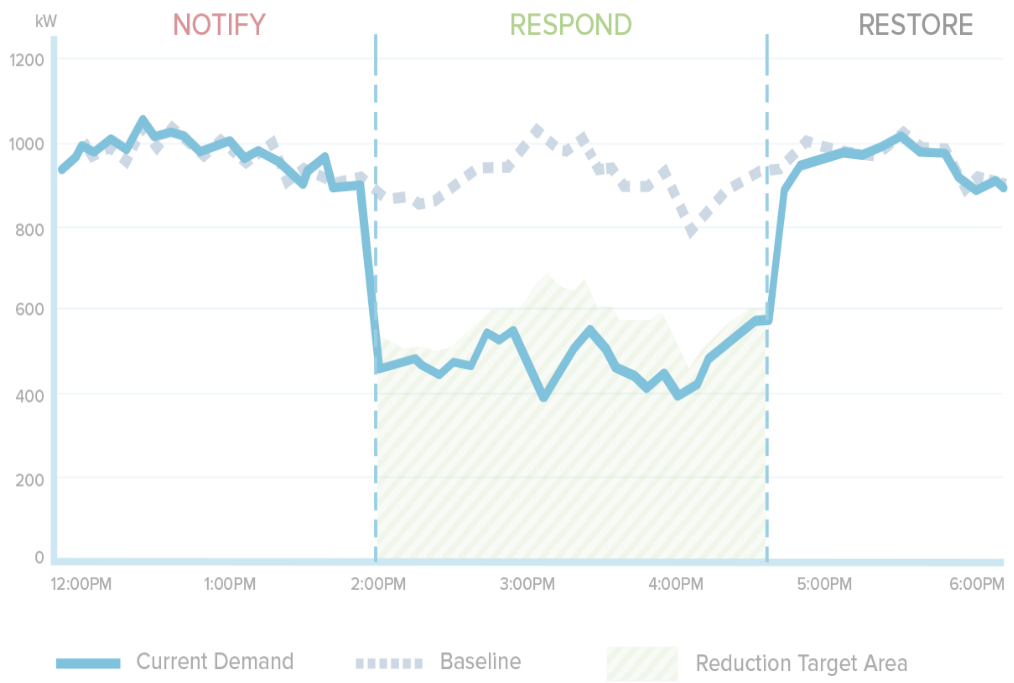
Project co-funded by the European Union

Content

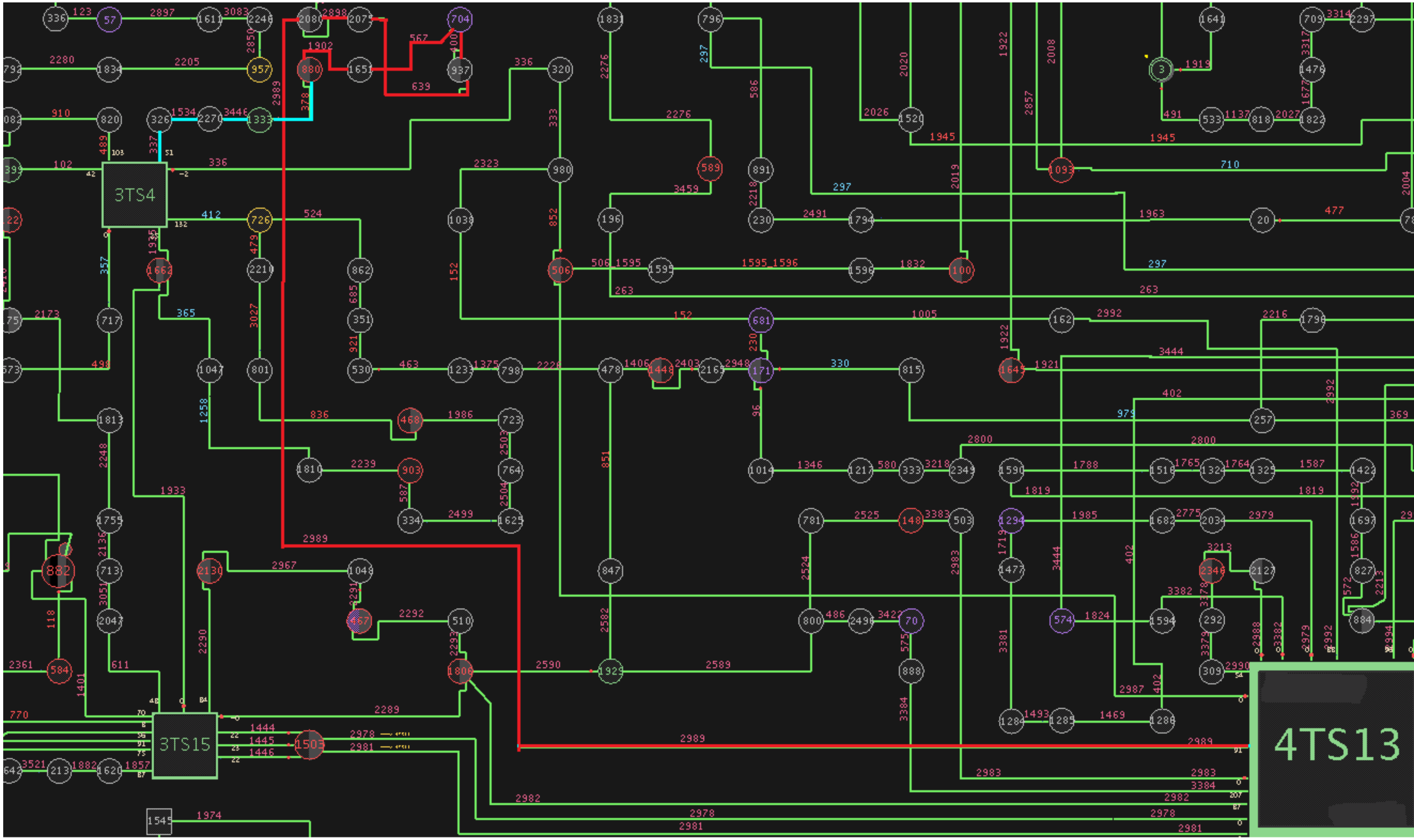
- SCADA
  - Demand response
  - Measurements
  - export
- Working station
  - Server configuration
  - Software requirements
  - Outlook of database

Demand response – general idea

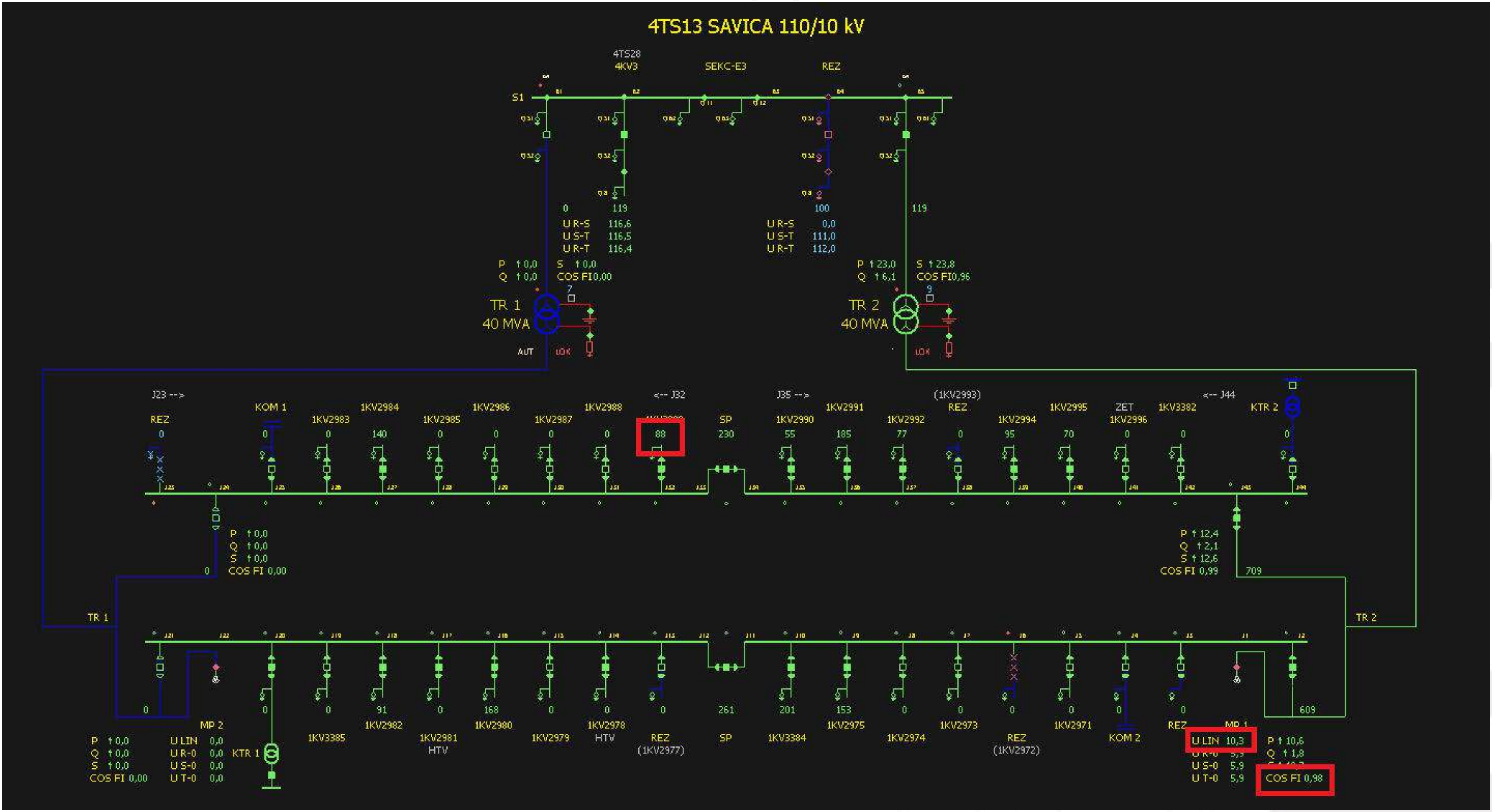
- Demand response as tool for DSO in case of unpredicted events
- Mitigate congestion or voltage fluctuations
- SCADA triggering implemented in Intra Day module



SCADA measurements (I)



SCADA measurements (II)



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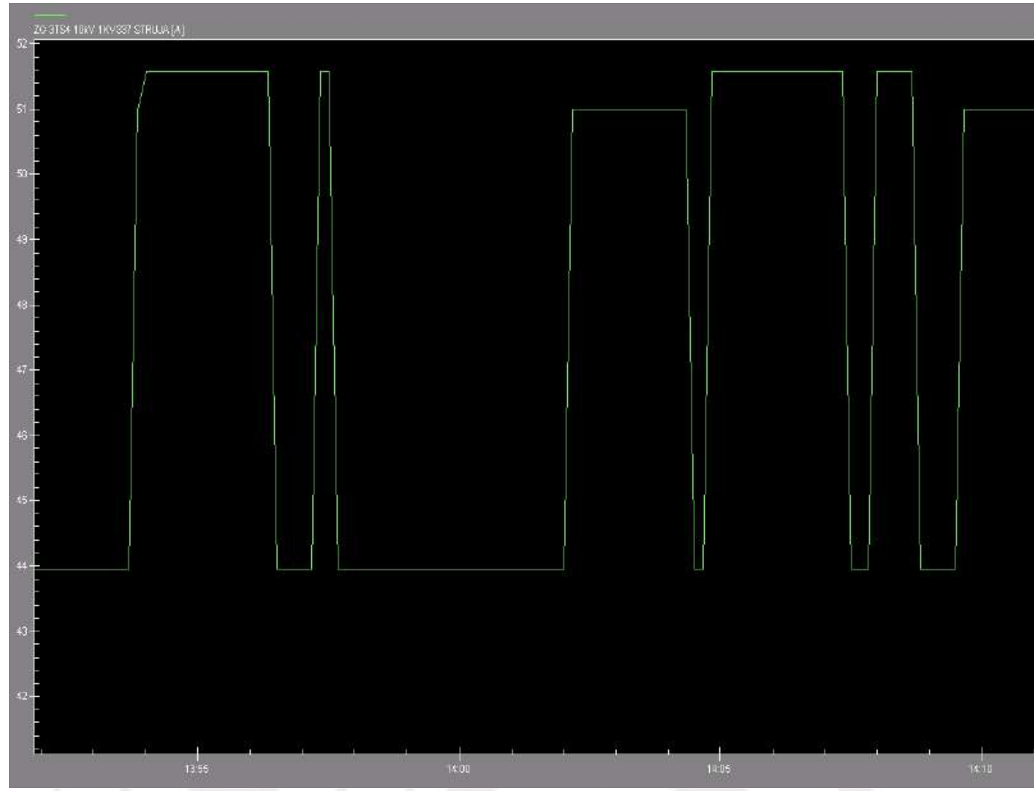
SCADA measurements (III)

- Measurement deadband problem in certain substations
- 4 A deadband = 70 kW
- Available time interval:
  - 10 seconds
  - 1 minute
  - 15 minutes



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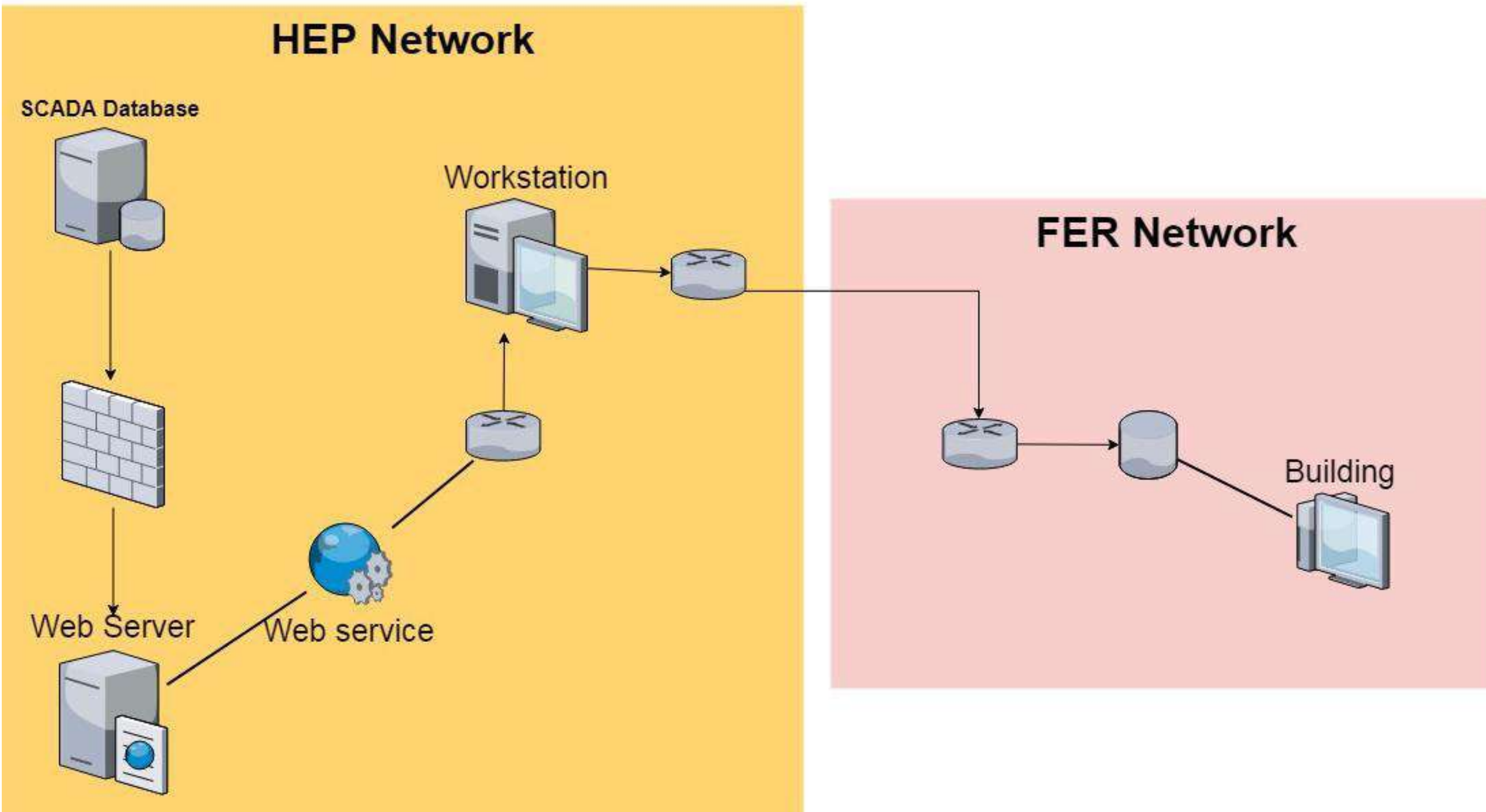
SCADA measurements export



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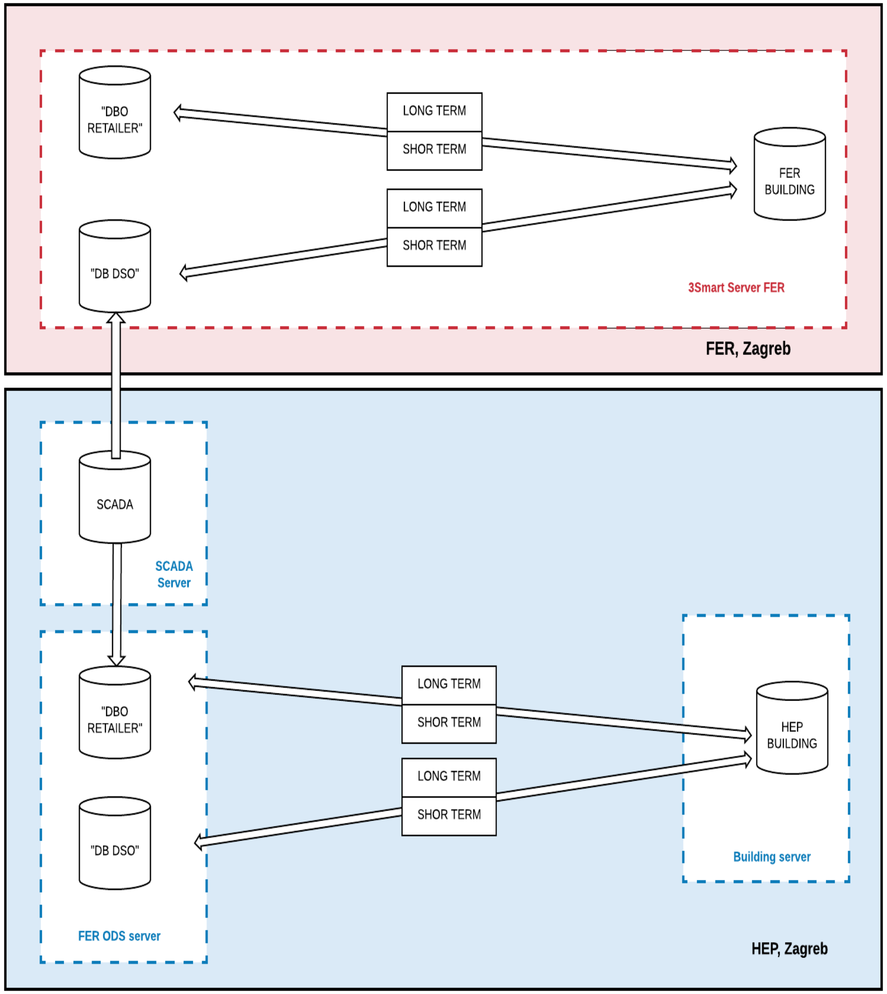
Working station

- 2 working station:
  - HEP ODS machine
  - 3Smart server in FER Building



FER Interreg Danube Transnational Programme 3Smart HEP

Working station – 3Smar server

- Technical specifications:
  - CPU: at least 8 cores
  - RAM: 16 – 32 GB
  - Data storage: 2x 1TB, RAID controller supporting at least RAID 1, 10 (RAID 5, 6 optional)
  - Power supply: redundant
  - Housing: 19“ rackmount, free space for at least four 3.5“ disks

Working station – 3Smart server

- Virtual Machine:
  - CPU v4 2.10 GHz
  - RAM 8,00 GB
  - 64-bit Operating system:
    - Windows Server 2012 R2 Standard

Working station – software requirement

- Python 3.6
  - PIP (package manager)
  - All necessary packages are available in requirements.txt
  - Command prompt or terminal posited in directory with python.exe:

pip install -r REQUIREMENTS.txt

REQUIREMENTS - Notepad

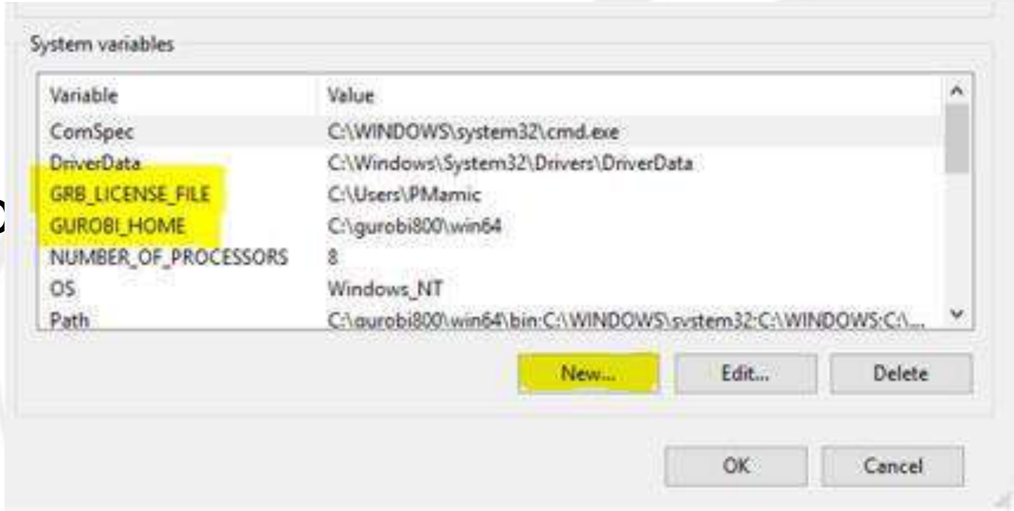
File Edit Format View Help

```
certifi==2018.4.16
chardet==3.0.4
decorator==4.3.0
idna==2.7
ipython-genutils==0.2.0
jsonschema==2.6.0
jupyter-core==4.4.0
nbformat==4.4.0
numpy==1.14.4
plotly==2.7.0
pyodbc==4.0.23
pytz==2018.4
requests==2.19.0
six==1.11.0
traitlets==4.3.2
urllib3==1.23
xlrd==1.1.0
XlsxWriter==1.0.5
```

Working station – software requirement

- Gurobi 8.0.0
  - Licence activation
  - Environment variables:
    - GRB_LICENCE_FILE
    - GUROBI_HOME
  - Positing with command prompt or terminal in Guro directory with setup.py:

    python setup.py install



Working station – software requirement

- PostgreSQL
  - pgAdmin 4
  - Network settings!
- MS Office
  - excel
  - LT, STDA
- Neplan
  - Grid modules with load profiles
  - Neplan.dll

DATA INPUT

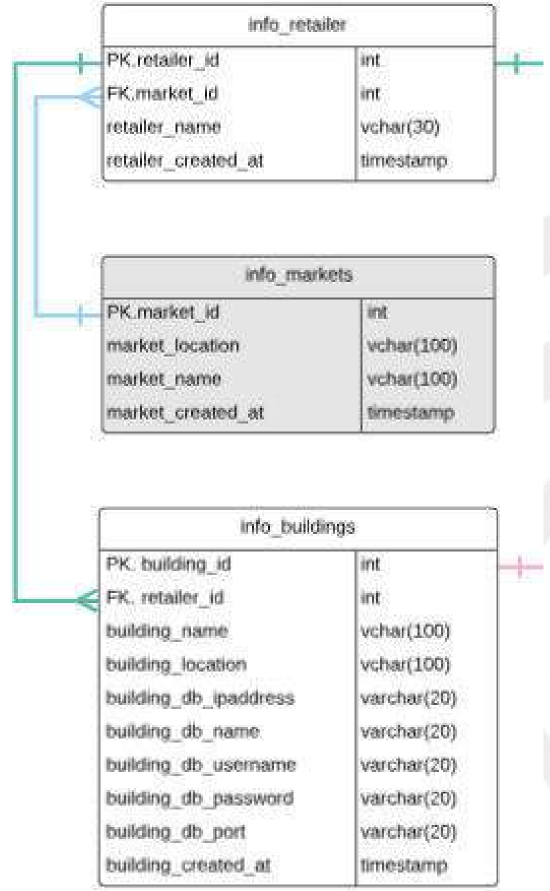
Developed modules

- C++: MFC console – Neplan.dll
- Python:
  - Market Price Scrawler
  - Retailer communication scripts
  - ACOPF
  - DSO communication scripts
  - ID module
  - Settlement module

TASK SCHEDULER

Outlook of database – Retailer I

- Retailer database:
  - Tables with general information
  - Tables with communication profiles

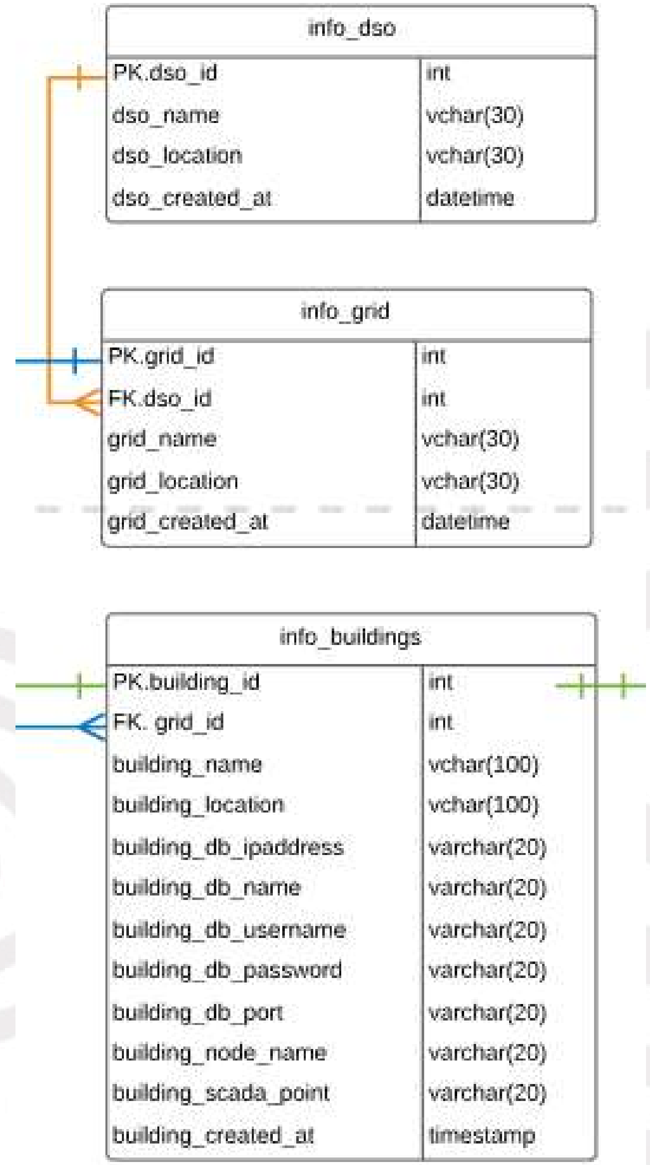


Outlook of database – Retailer II

- Retailer database
  - Tables with general information
  - Tables with communication profiles

Outlook of database – DSO

- Tables with general information



Outlook of database

- DA module tables
- ID module tables

acopf_grid_input	
PK.line_id	int
FK.grid_id	int
line_name	vchar(30)
node_from	vchar(30)
node_to	vchar(30)
line_resistance	float
line_reactance	float
irmax	float
line_lenght	float

lacopf_load_input	
PK.load_id	int
FK.grid_id	int
profile_timestamp	datetime
load_name	vchar(30)
active_power	float
reactive_power	float

acopf_results	
result_id	int
FK.grid_id	int
profile_timestamp	datetime
U_profile	vchar(2000)
I_profile	vchar(2000)
P_profile	vchar(2000)
Q_profile	vchar(2000)
results_created_at	datetime

id_triggering_module	
PK.end_of_measurement_period	datetime
FK.building_id	int
scada_measured_feeder_consumption	float
predicted_feeder_consumption	float
da_flexibility_activation_profile	varchar(2000)
flexibility_reservation_profile	varchar(2000)
total_flexibility_activation_profile	varchar(2000)
id_flexibility_activation_request_timestamp	datetime
id_flexibility_activation	float

Outlook of database - DSO

- Communication tables:
  - DA module
  - ID Module
  - Settlement module

Danube Transnational Programme
3Smart

3Smart First pilot study visit to the Croatian pilot: On-line demonstration of basic IT infrastructure performance with the installed equipment

Anita Martinčević, Nikola Hure, Danko Marušić, Hrvoje Novak

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3Smart pilot study visit to HR pilot No. 1 in Zagreb

11 December 2018

Interreg
EUROPEAN UNION
Danube Transnational Programme
3Smart

UNIVERSITY OF ZAGREB
FACULTY OF ELECTRICAL ENGINEERING AND COMPUTING

Order of presentation

- Weather data and weather forecast, PV panels production data, and smart electricity meters data – Hrvoje
- Battery system data – Danko
- Central HVAC system data (heating substation, circulation pump, chiller), central and floor calorimeters – Nikola
- Zone and FCU level – Anita
- Principle: showing now-operation in the database, and graphical representation of the recent historical data

Weather measurements - database

Weather data support

- Measurements from building

weather_station	
PK. weather_station_id	int
FK. building_id	int
weather_station_timestamp	datetime
weather_station_name	varchar(200)
weather_station_description	varchar(1000)

+ history tables

weather_station_measurements	
FK. weather_station_id	int
batch_timestamp	datetime
weather_station_measurement_timestamp	datetime
weather_station_measurement_sun_zenith_angle	real
weather_station_measurement_sun_azimuth	real
weather_station_measurement_outdoor_temperature_south	real
weather_station_measurement_outdoor_temperature_north	real
weather_station_measurement_global_irradiance	real
weather_station_measurement_global_irradiance_estimated	real
weather_station_measurement_irradiance_estimation_error	real
weather_station_measurement_direct_solar_irradiance	real
weather_station_measurement_diffuse_solar_irradiance	real
weather_station_measurement_reflected_solar_irradiance	real
weather_station_measurement_wind_speed	real
weather_station_measurement_wind_direction	real
weather_station_measurement_relative_humidity	real
weather_station_measurement_pressure_at_xy_meters	real

- for test sites with unavailable measurements of direct and diffuse solar irradiance python module on how to calculate those values is provided
- solar angles calculation - python package pysolar.solar (ready to use functions)

Weather measurements - database

Weather data support

- Measurements from building

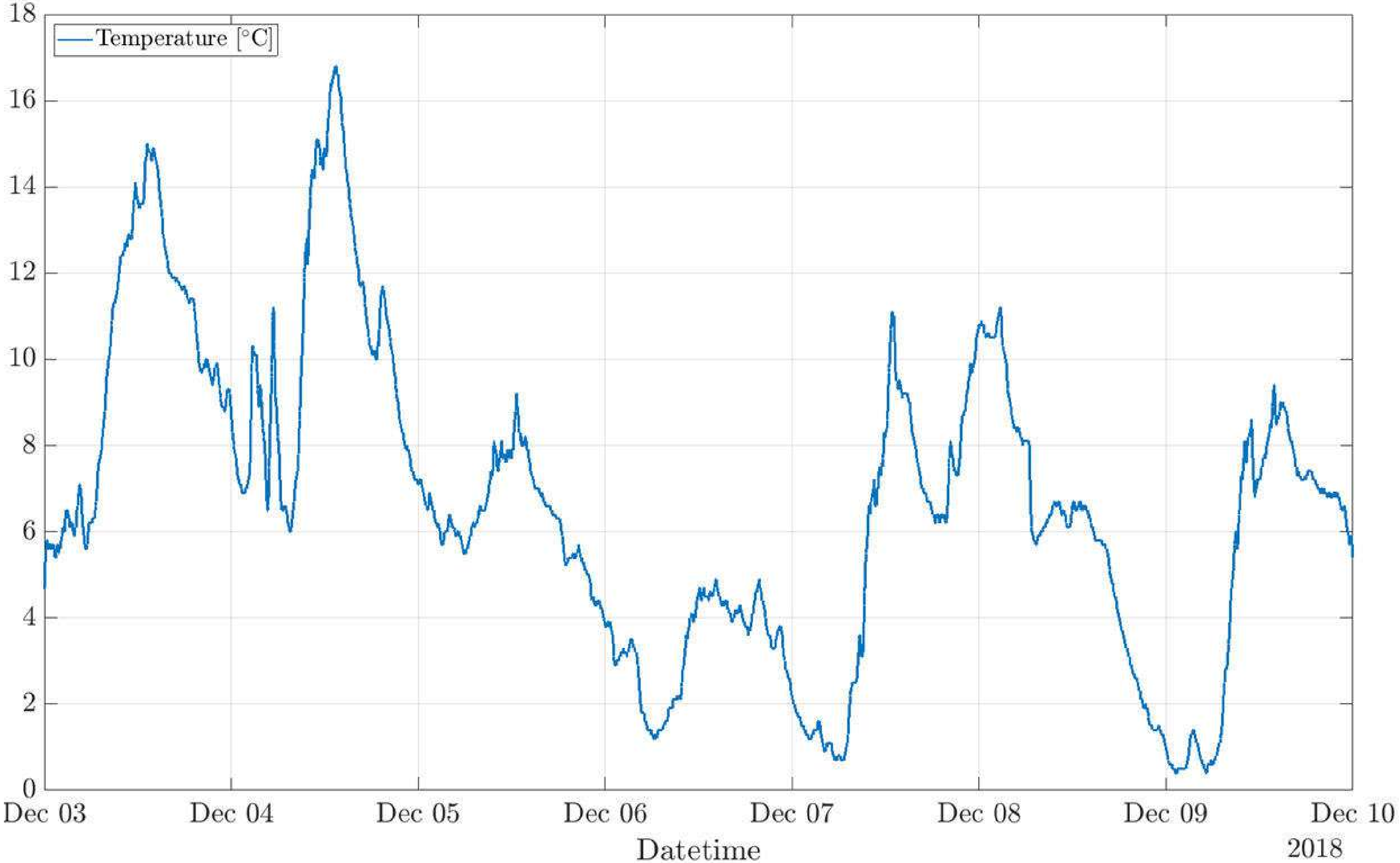
weather_station	
PK. weather_station_id	int
FK. building_id	int
weather_station_timestamp	datetime
weather_station_name	varchar(200)
weather_station_description	varchar(1000)

+ history tables

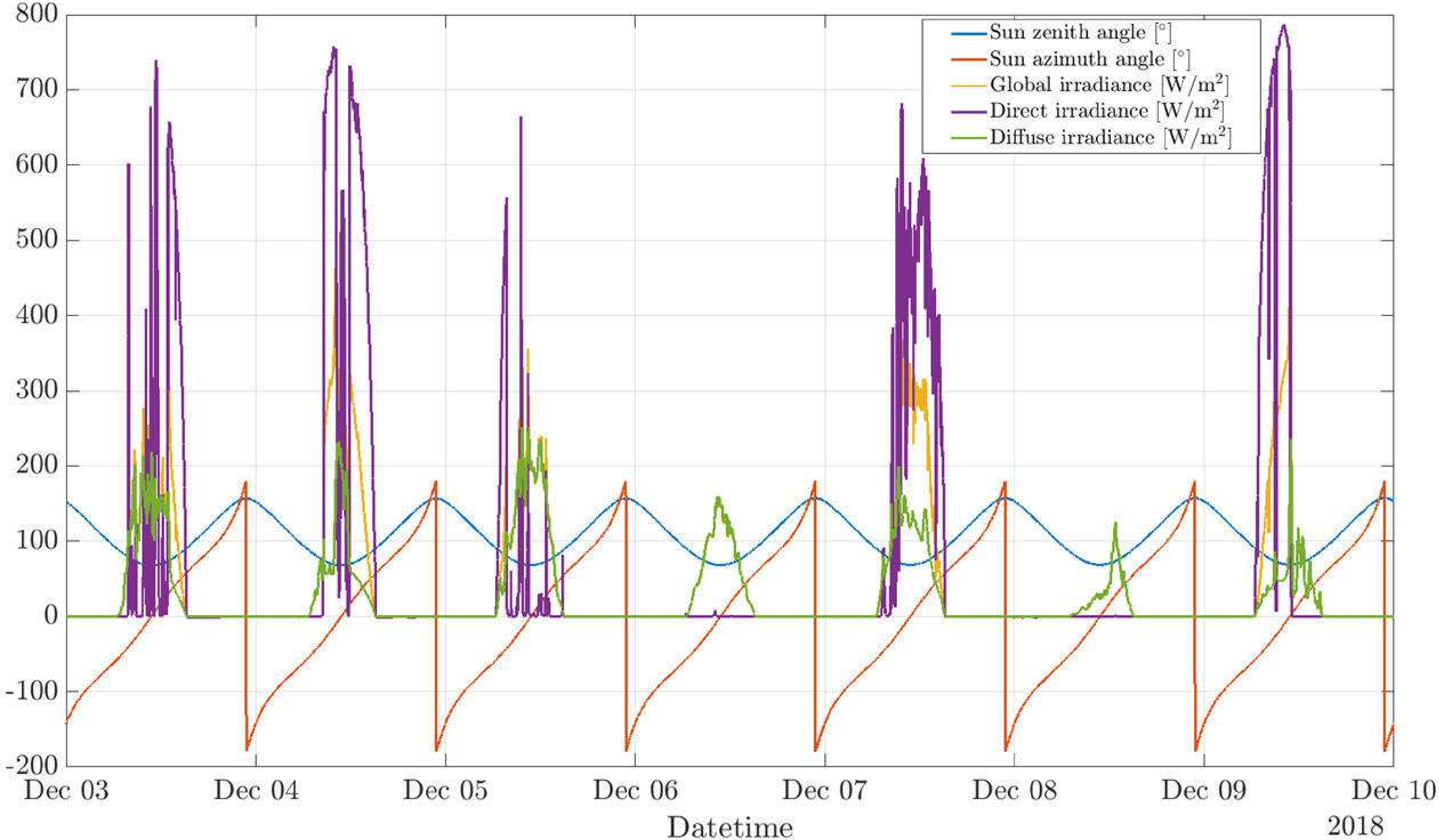
weather_station_measurements	
FK. weather_station_id	int
batch_timestamp	datetime
weather_station_measurement_timestamp	datetime
weather_station_measurement_sun_zenith_angle	real
weather_station_measurement_sun_azimuth	real
weather_station_measurement_outdoor_temperature_south	real
weather_station_measurement_outdoor_temperature_north	real
weather_station_measurement_global_irradiance	real
weather_station_measurement_global_irradiance_estimated	real
weather_station_measurement_irradiance_estimation_error	real
weather_station_measurement_direct_solar_irradiance	real
weather_station_measurement_diffuse_solar_irradiance	real
weather_station_measurement_reflected_solar_irradiance	real
weather_station_measurement_wind_speed	real
weather_station_measurement_wind_direction	real
weather_station_measurement_relative_humidity	real
weather_station_measurement_pressure_at_xy_meters	real

- for test sites with unavailable measurements of direct and diffuse solar irradiance python module on how to calculate those values is provided
- solar angles calculation - python package pysolar.solar (ready to use functions)

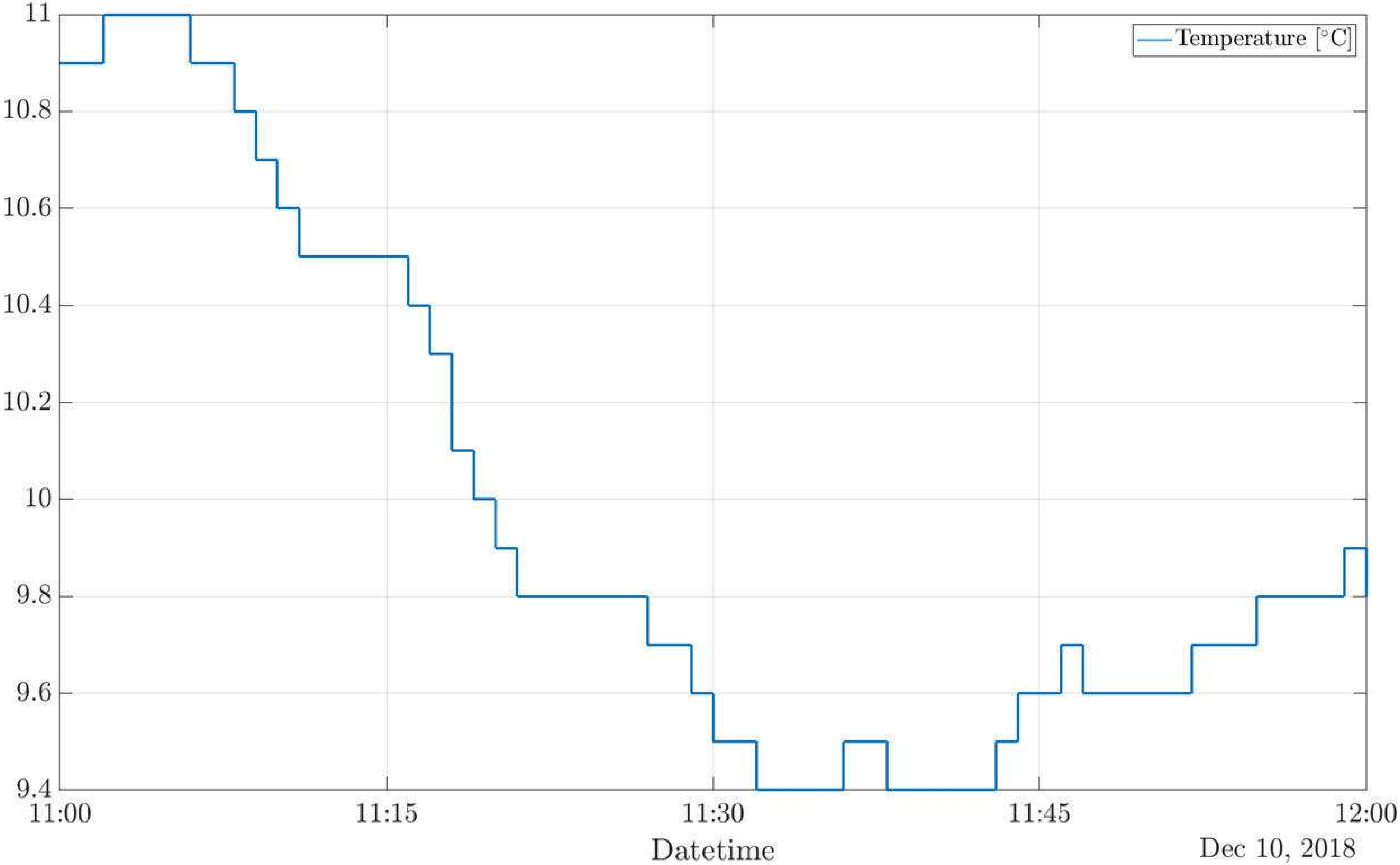
Weather measurements – history



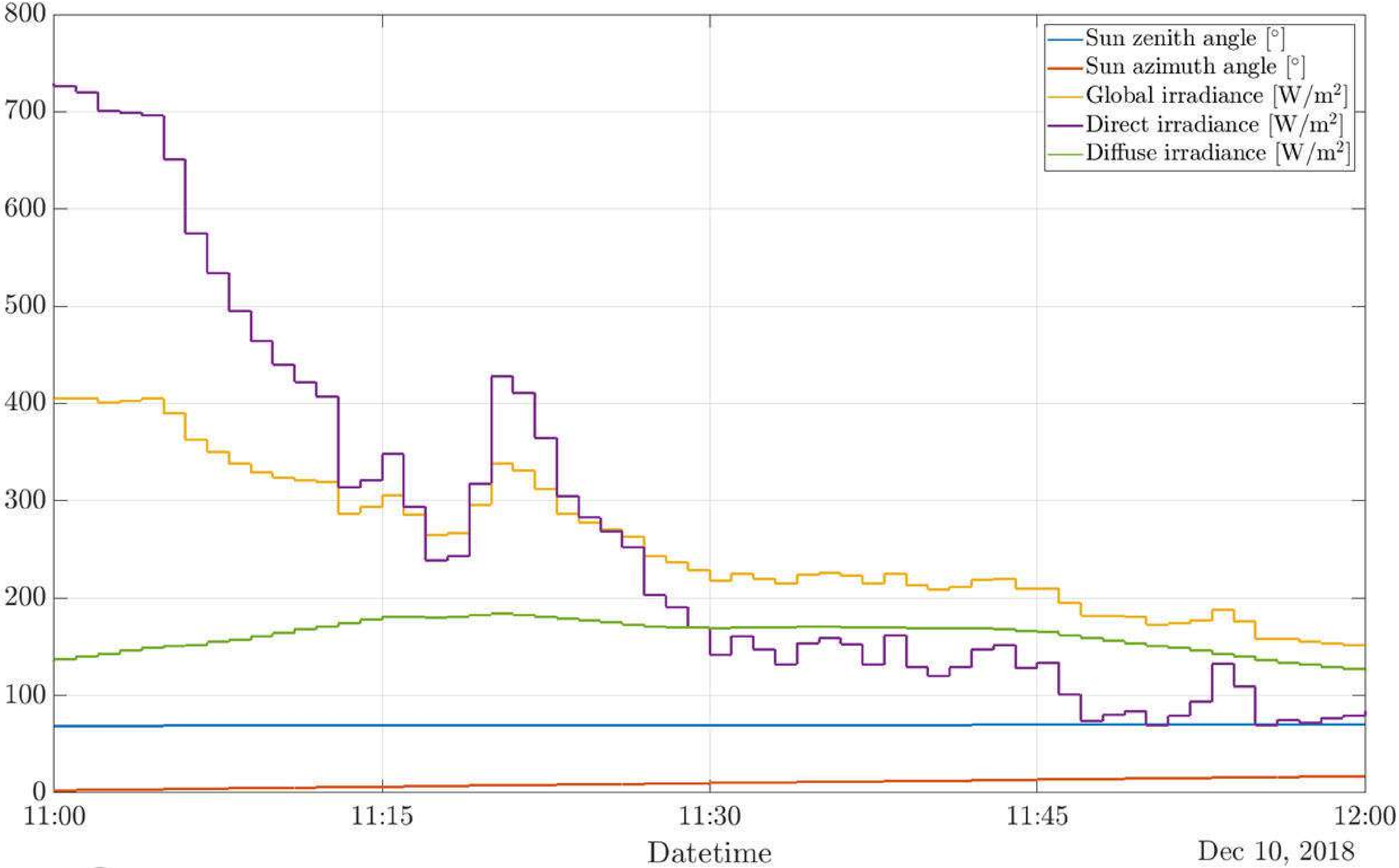
Weather measurements – history



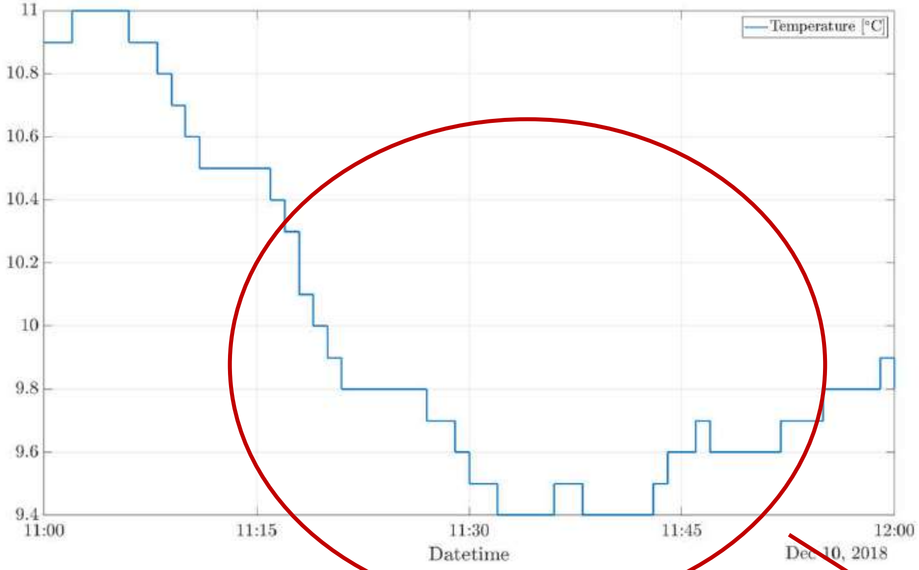
Weather measurements – recent



Weather measurements – recent



Weather measurements – recent



Measured temperature drop

Loss of irradiance
due to cloudiness

Weather forecasts - database

Weather data support

- Weather forecast support

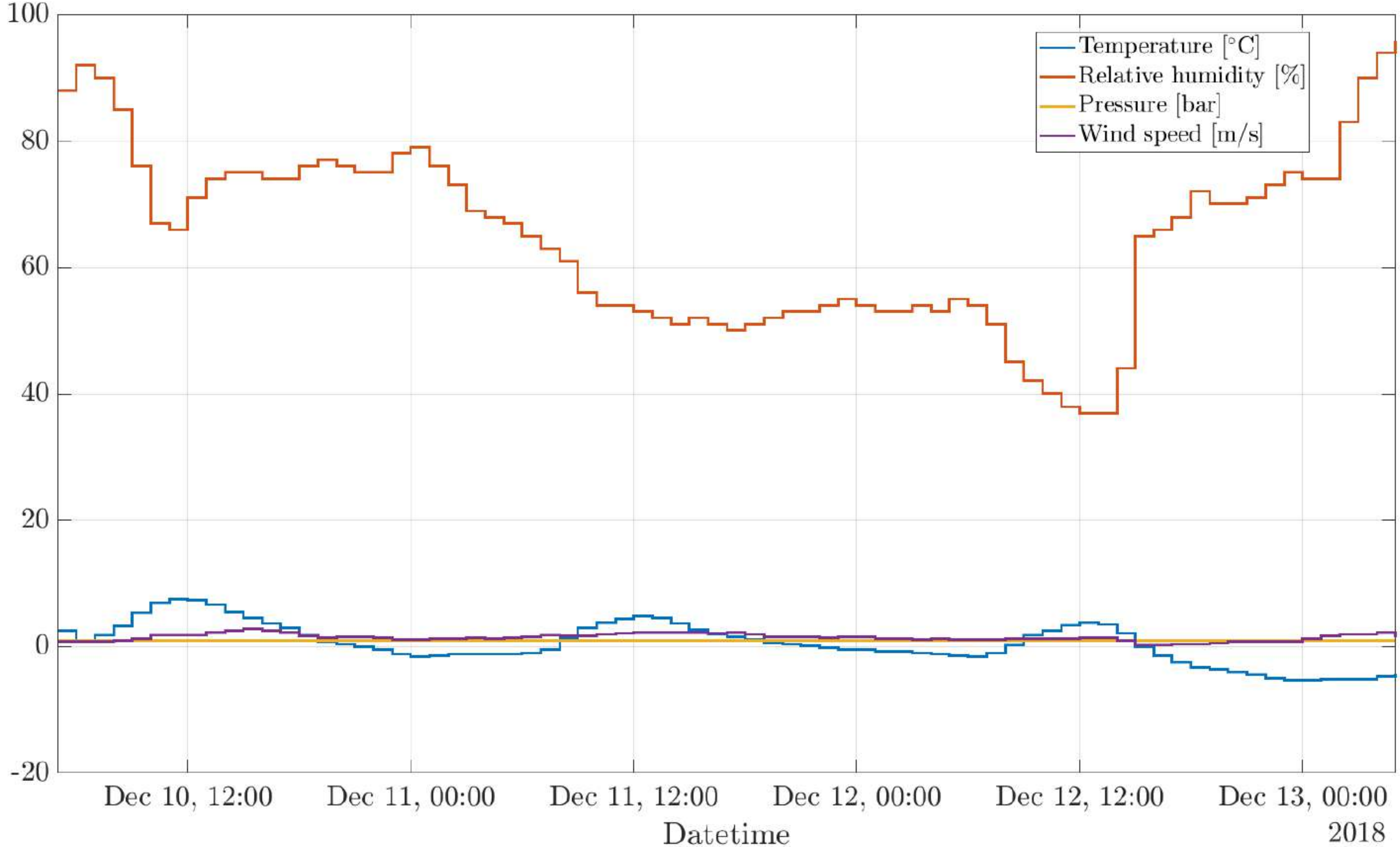
weather_predictor	
PK. weather_predictor_id	int
weather_predictor_timestamp	datetime
weather_predictor_name	varchar(100)
weather_predictor_description	varchar(100)
weather_predictor_sample_time	int

- Sampling time = 1 hour
- update 4 times per day

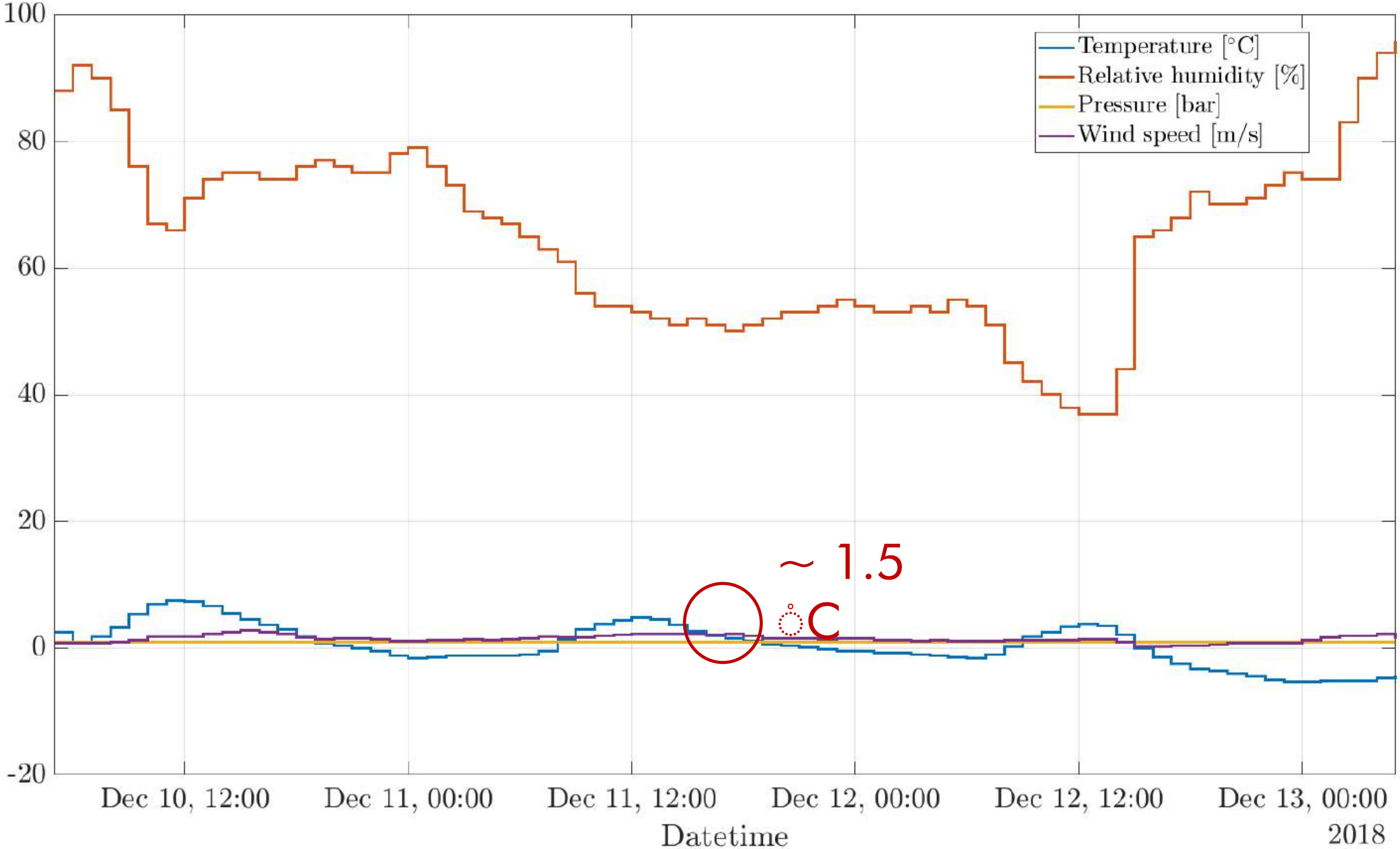
+ weather_prediction_history

weather_prediction	
FK. weather_predictor_id	int
weather_prediction_timestamp	datetime
weather_prediction_start_timestamp	datetime
weather_prediction_temperature_at_2m	varchar(1000)
weather_prediction_dew_point_at_2m	varchar(1000)
weather_prediction_relative_humidity_at_2m	varchar(1000)
weather_prediction_mean_wind_speed_at_10m	varchar(1000)
weather_prediction_wind_direction_at_10m	varchar(1000)
weather_prediction_wind_gust_at_10m	varchar(1000)
weather_prediction_mean_wind_speed_at_bldg_top	varchar(1000)
weather_prediction_wind_direction_at_bldg_top	varchar(1000)
weather_prediction_mean_sea_level_pressure	varchar(1000)
weather_prediction_total_cloud_coverage	varchar(1000)
weather_prediction_high_cloud_coverage	varchar(1000)
weather_prediction_low_cloud_coverage	varchar(1000)
weather_prediction_mean_cloud_coverage	varchar(1000)
weather_prediction_total_precipitation	varchar(1000)
weather_prediction_total_snow	varchar(1000)
weather_prediction_direct_solar_irradiance	varchar(1000)
weather_prediction_diffuse_solar_irradiance	varchar(1000)
weather_prediction_total_solar_irradiance	varchar(1000)
weather_prediction_variance_of_the_2m_temperature	varchar(1000)
weather_prediction_variance_of_direct_solar_irradiance	varchar(1000)
weather_prediction_variance_of_diffuse_solar_irradiance	varchar(1000)
weather_prediction_variance_of_total_irradiance	varchar(1000)

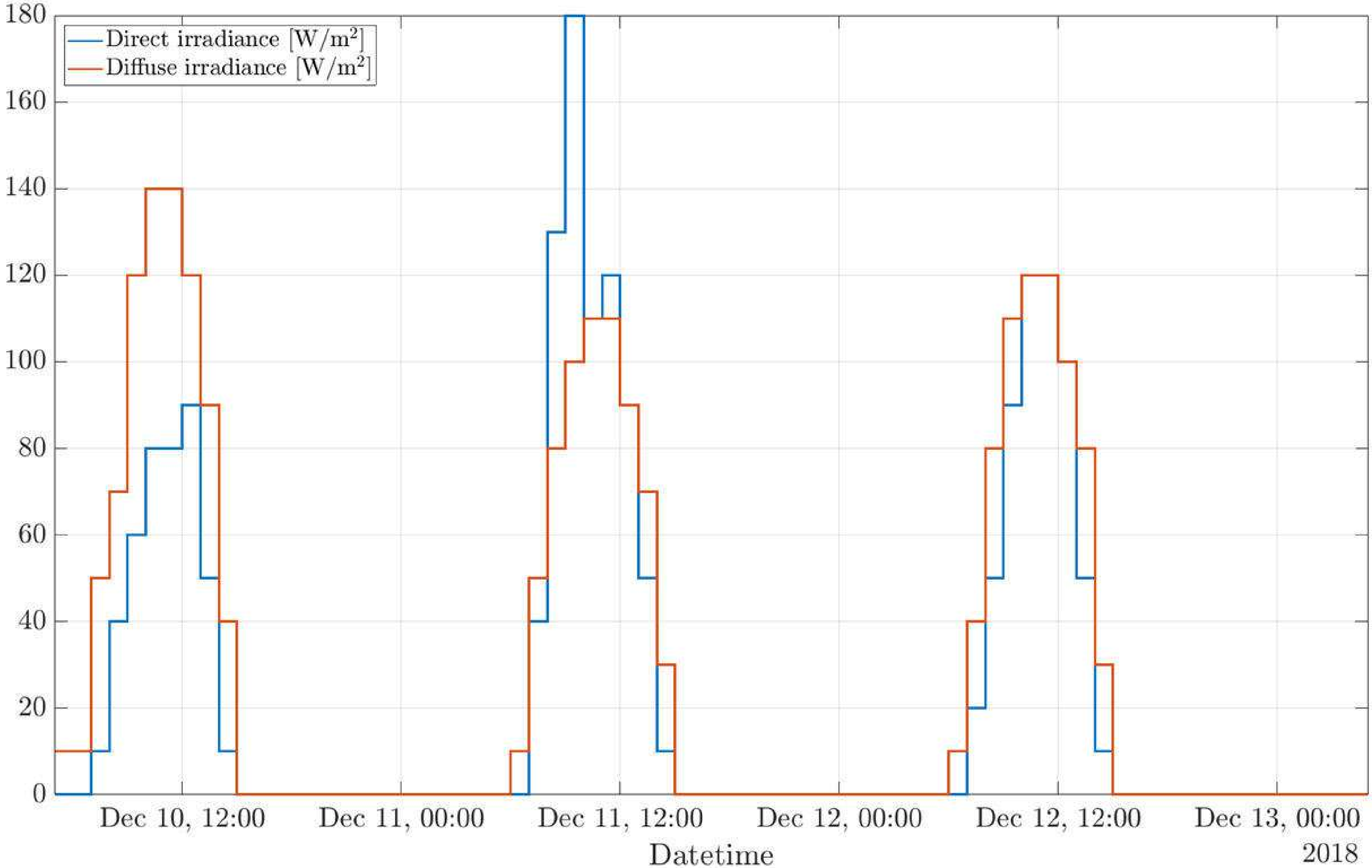
Weather forecast (generated yesterday at 05:00 AM)



Weather forecast (generated yesterday at 05:00 AM)



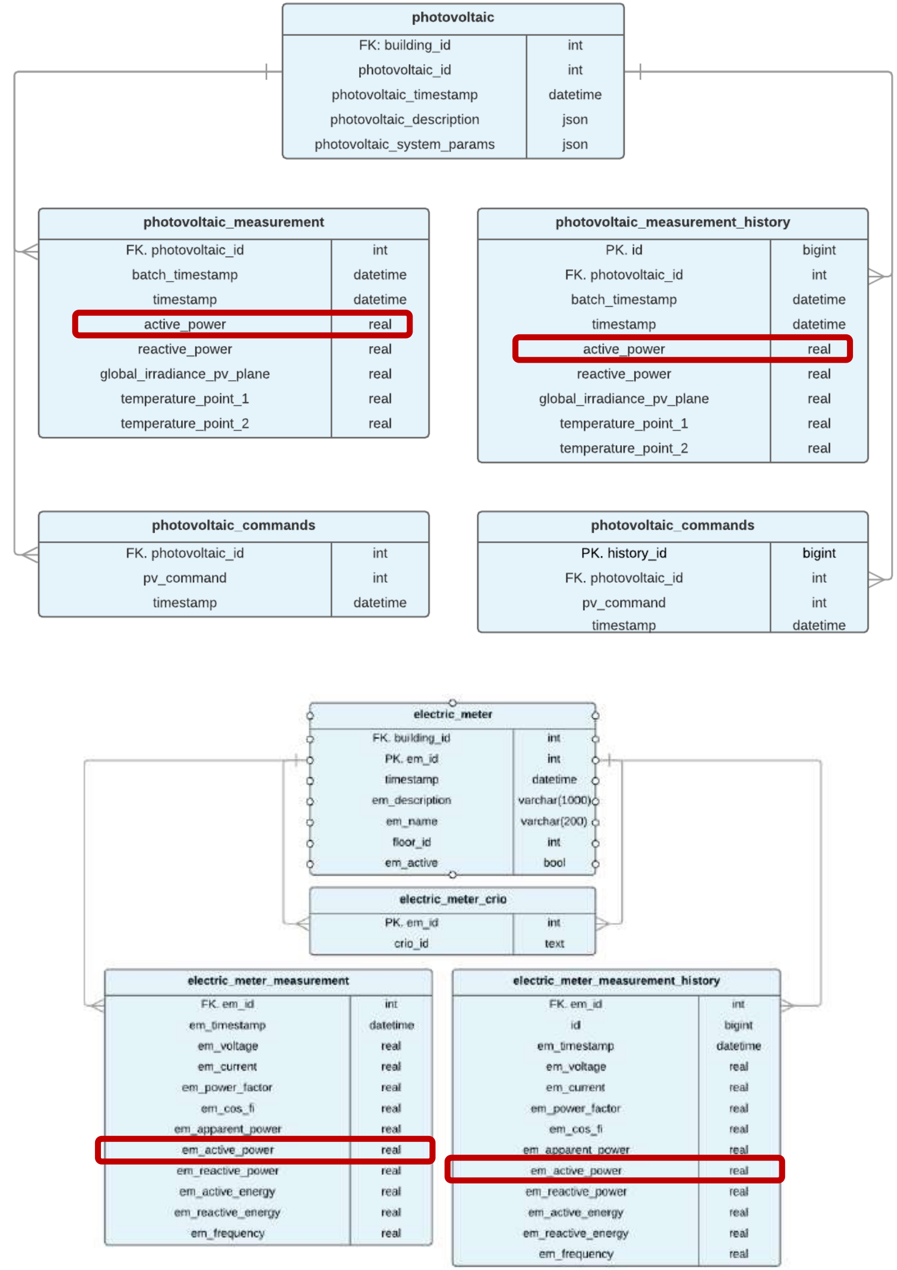
Weather forecast (generated yesterday at 05:00 AM)



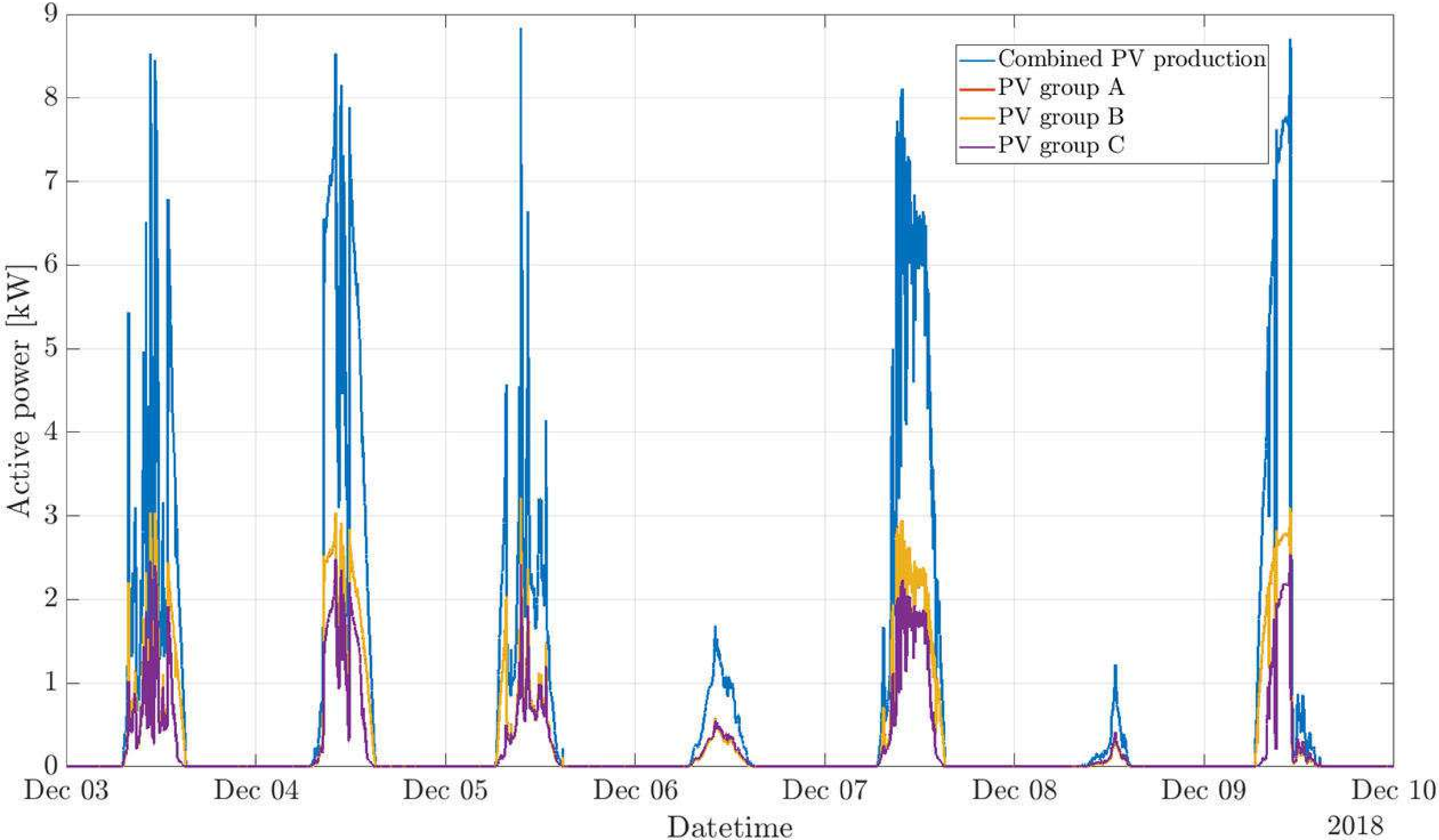
Microgrid measurements – database

Microgrid level

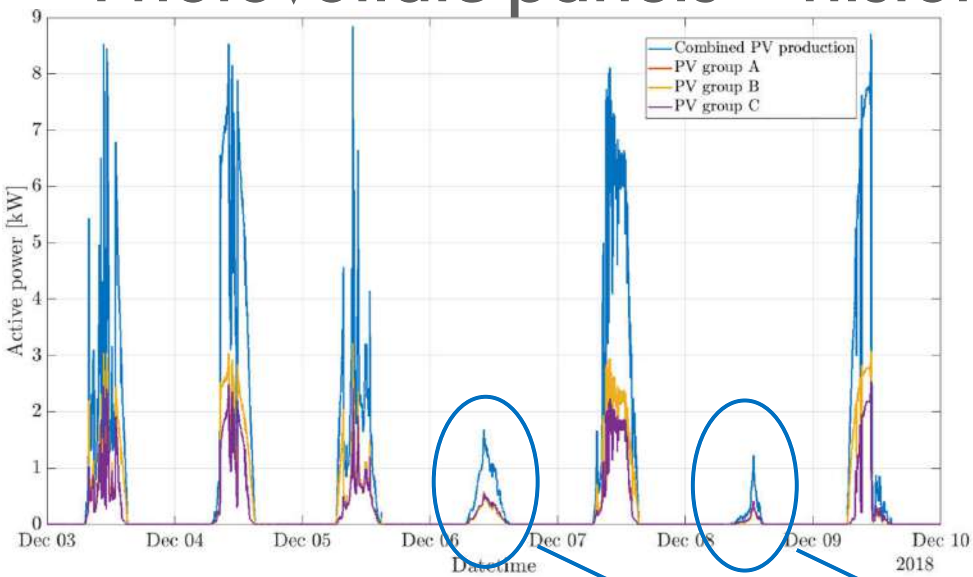
- PV panels measurements
- Electric energy measurements



Photovoltaic panels – history

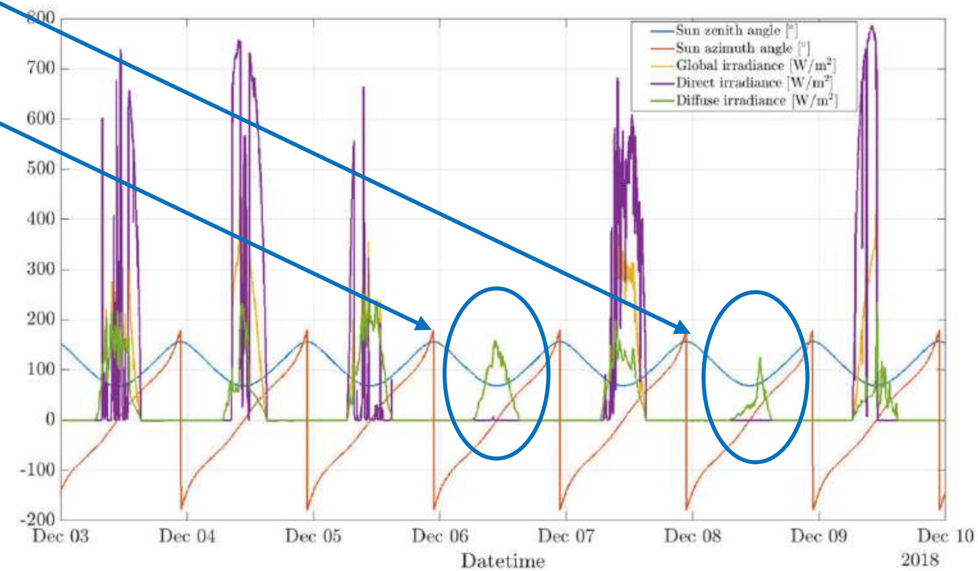


Photovoltaic panels – history

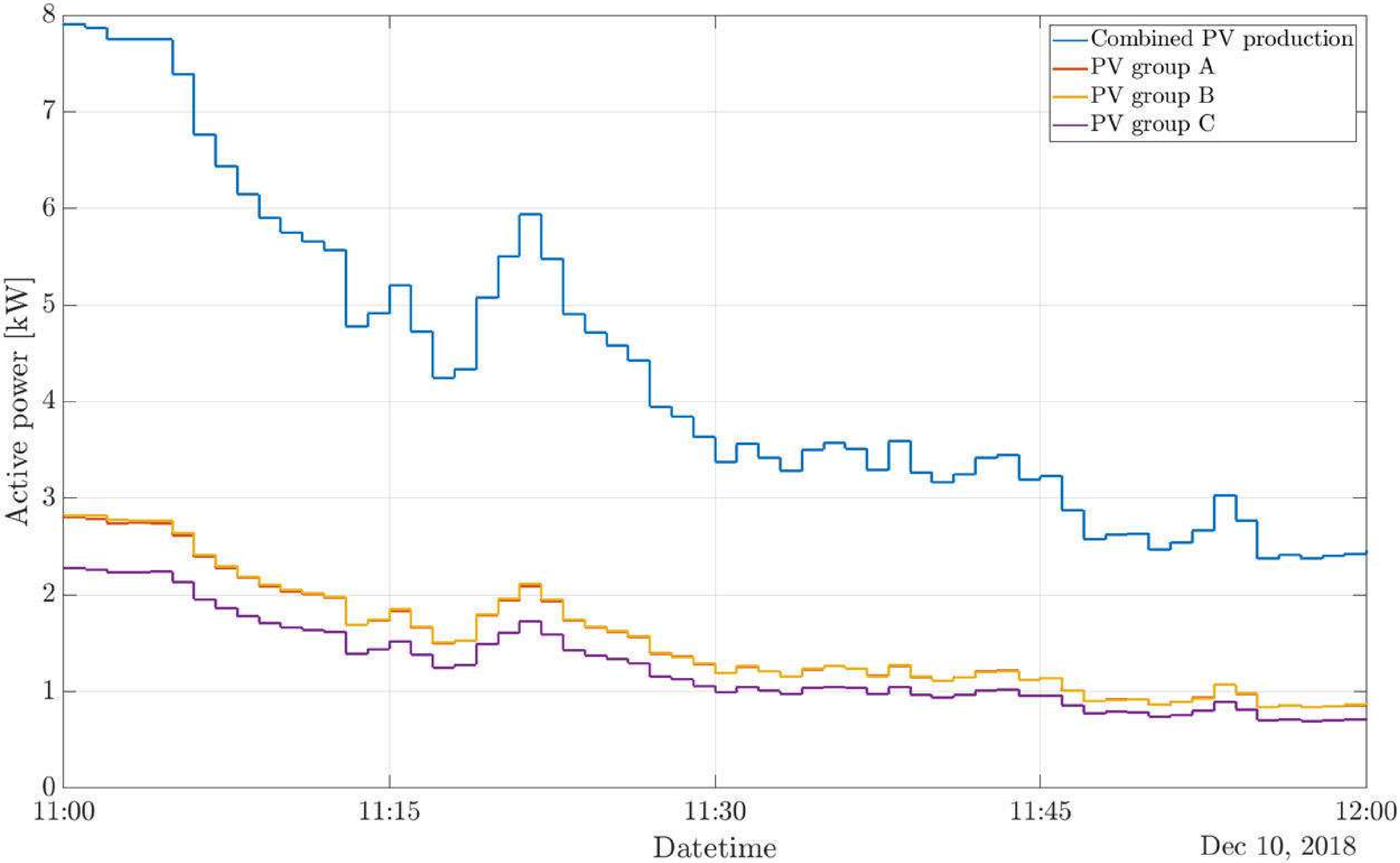


Measured solar irradiance

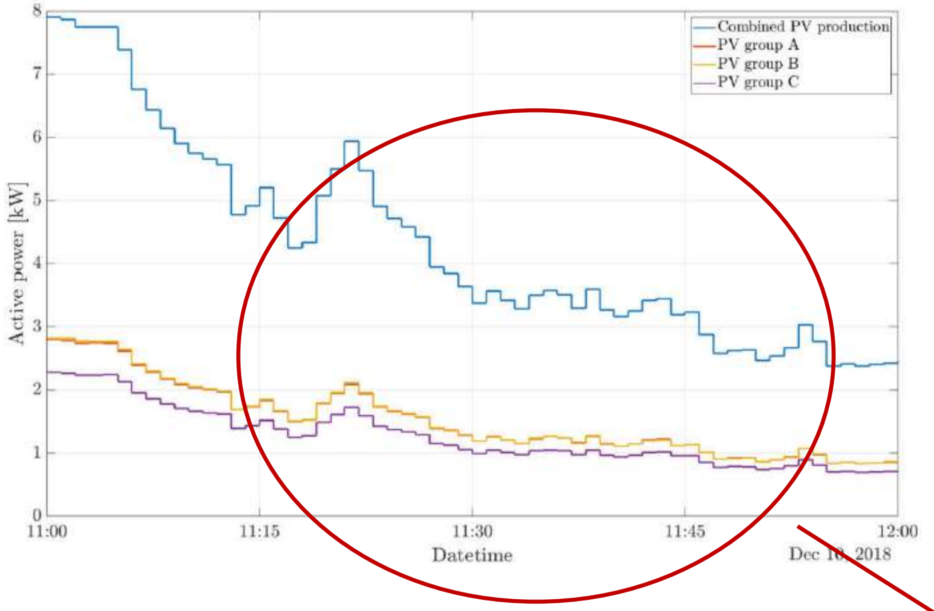
PV panels production



Photovoltaic panels – recent



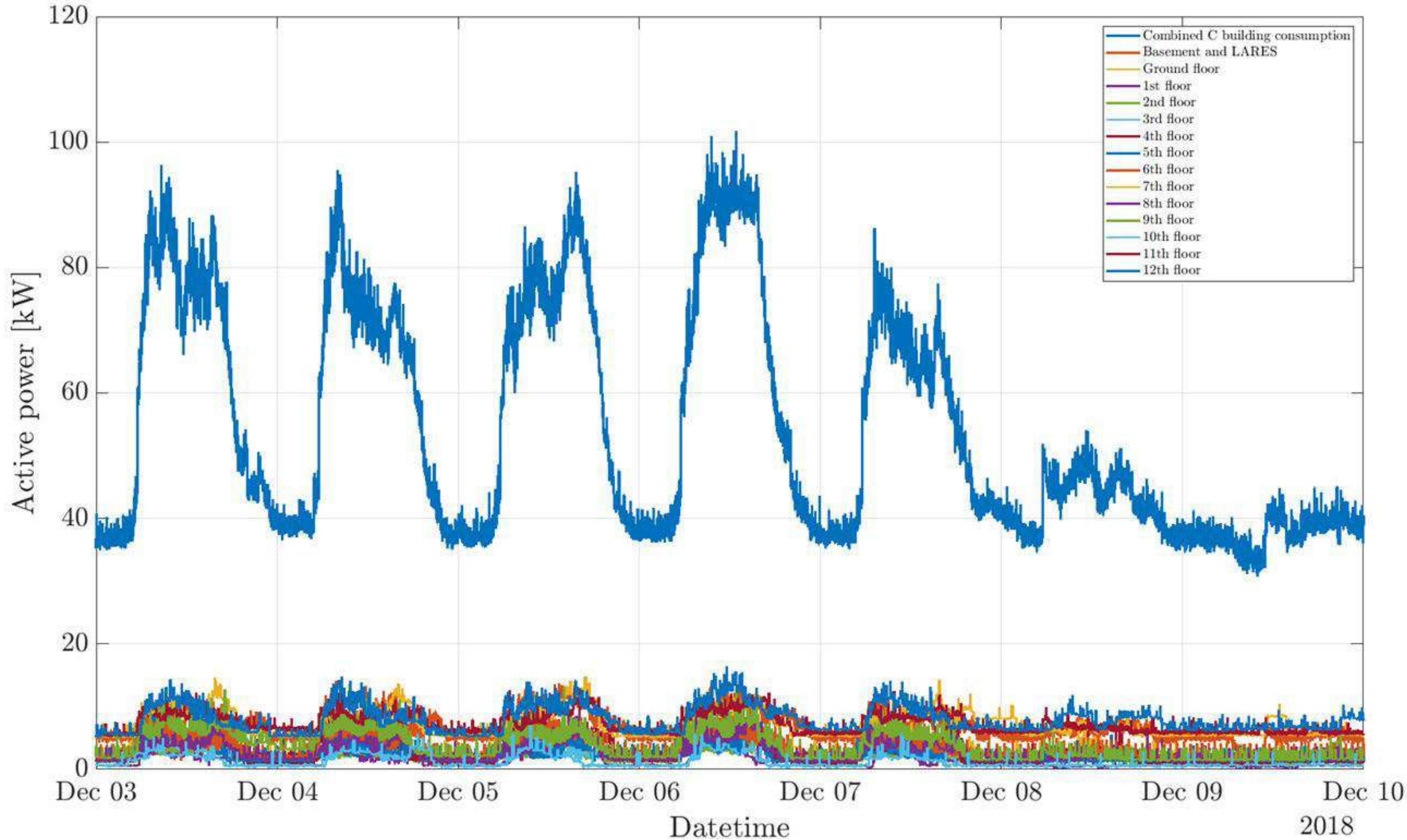
Weather measurements – recent



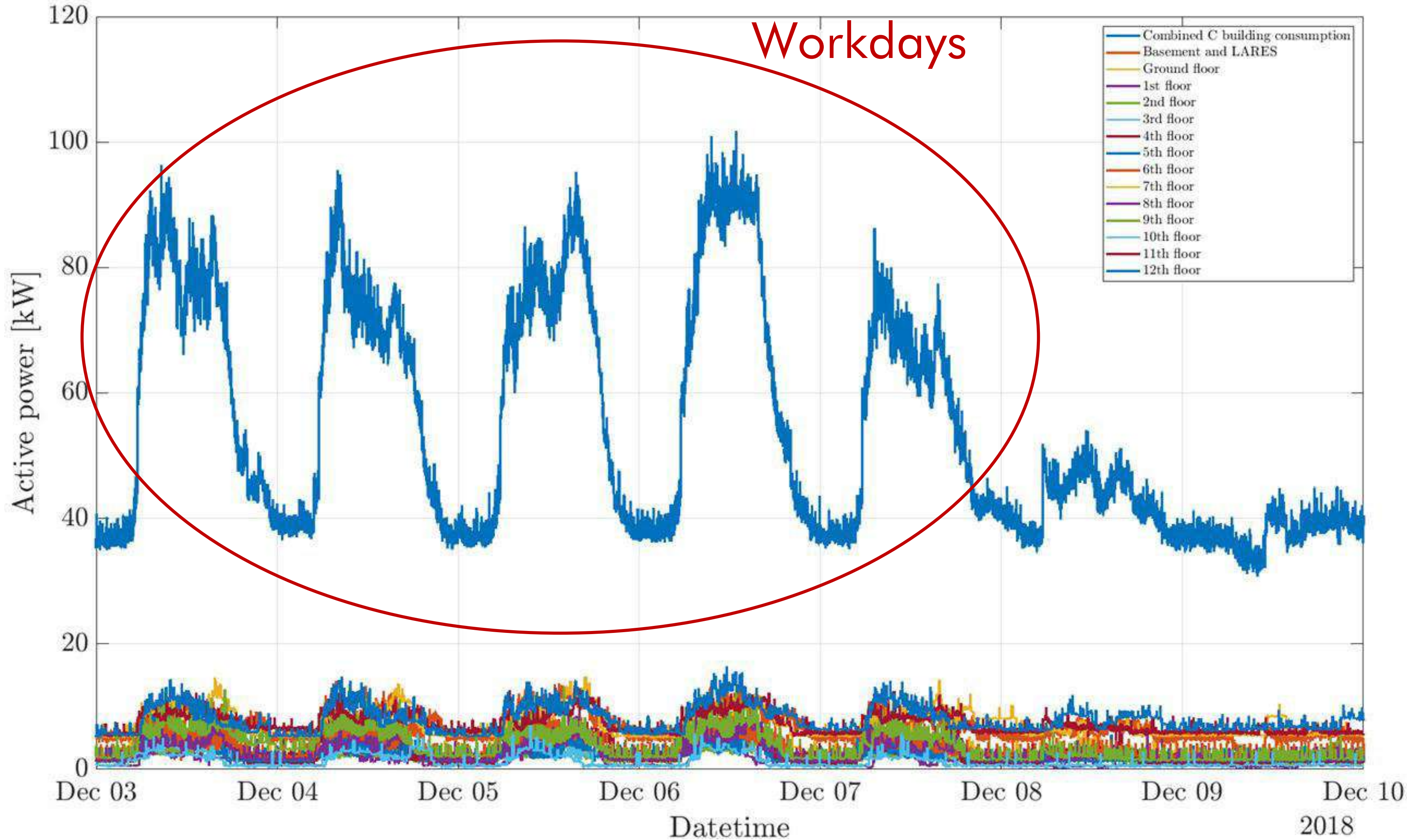
Measured PV production

Loss of irradiance due to cloudiness

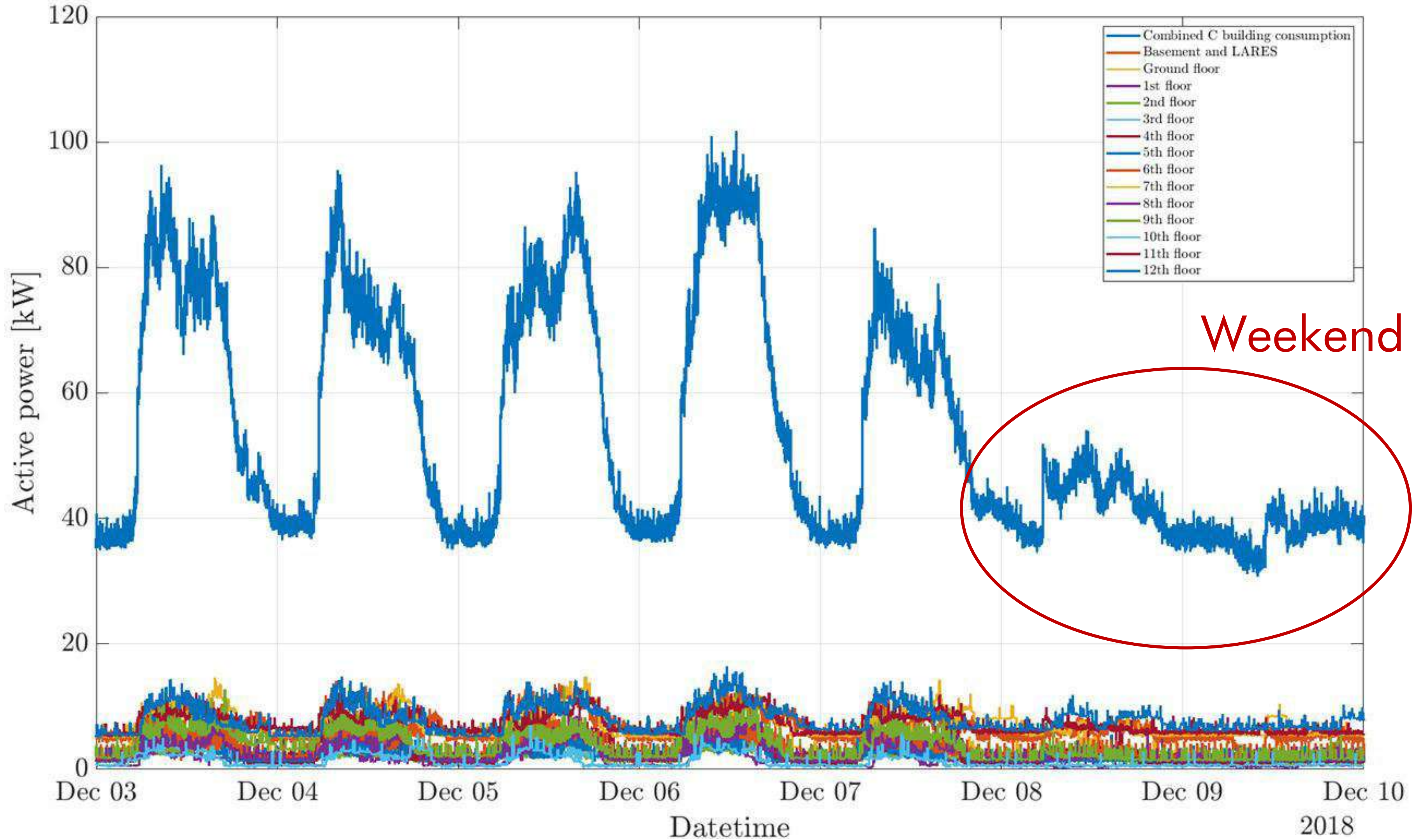
Electricity meters consumption data – history



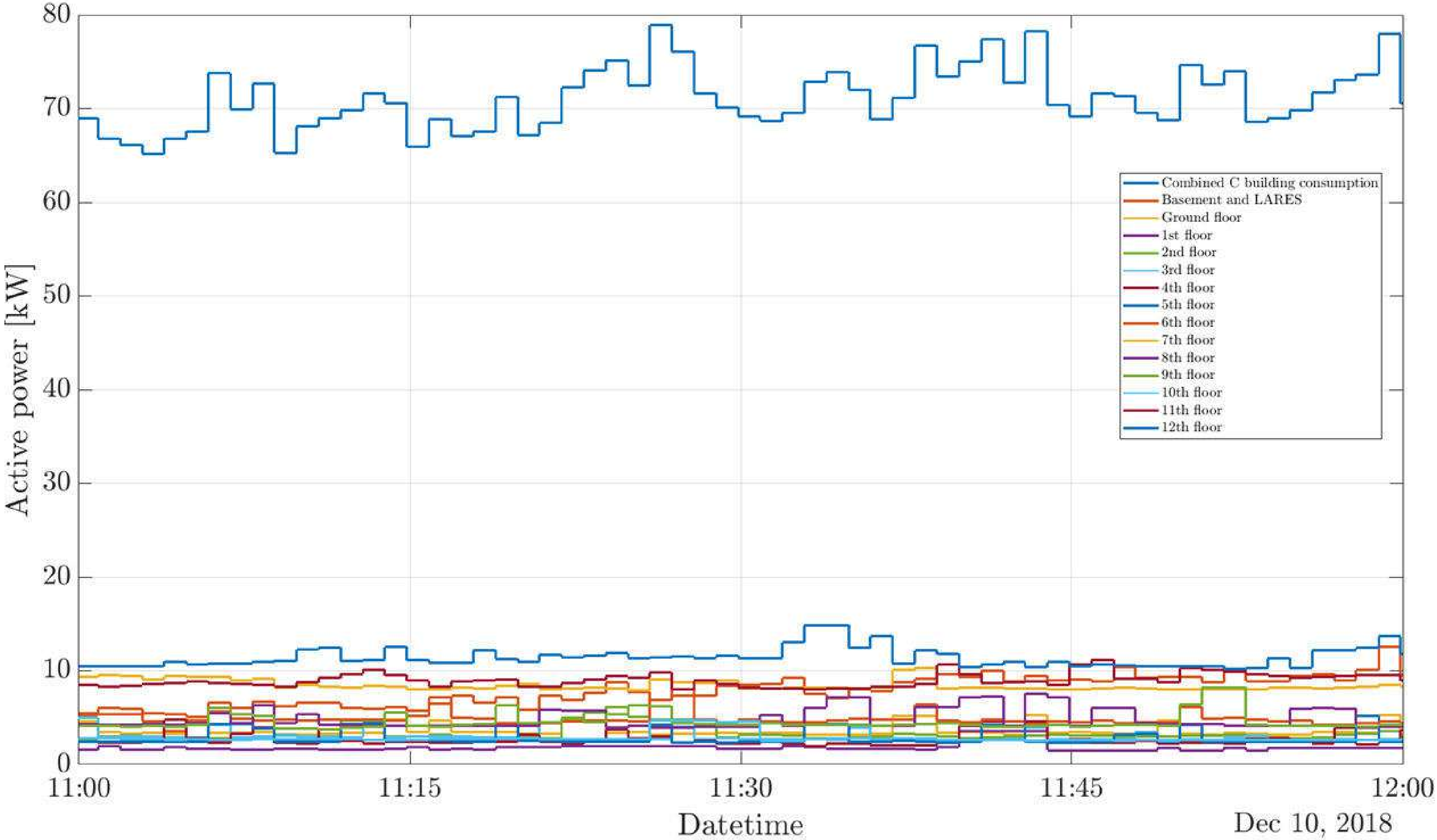
Electricity meters consumption data – history



Electricity meters consumption data – history



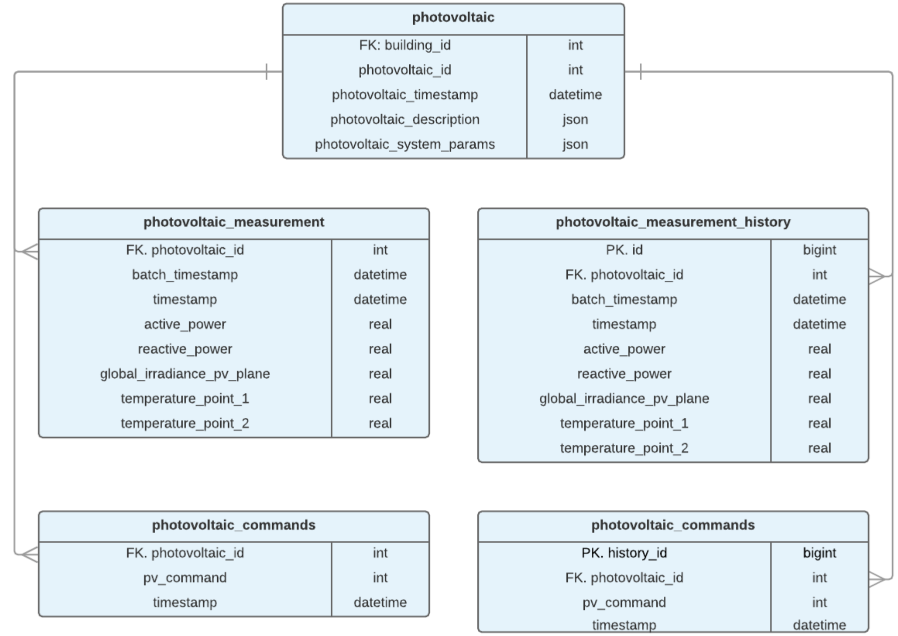
Electricity meters consumption data – recent

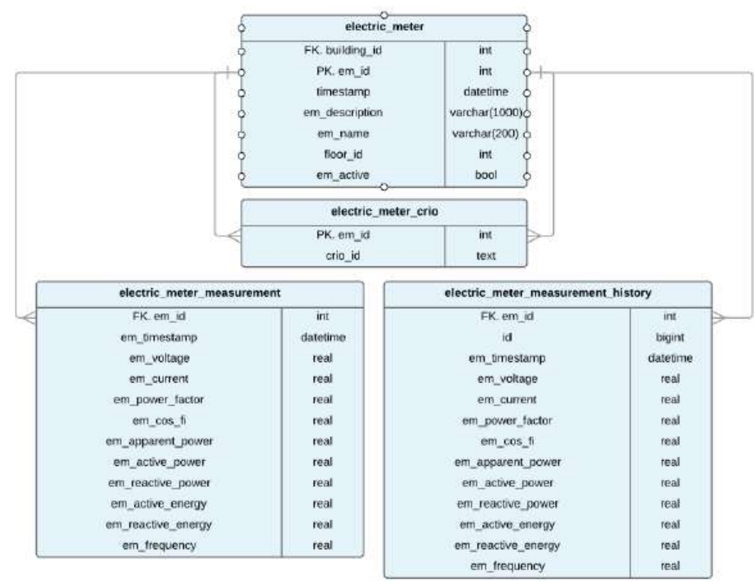


Microgrid measurements – database

Microgrid level

- PV panels measurements
- Electric energy measurements





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3Smart

Microgrid level - database

- MPC I/O tables

microgrids	
FK. building_id	int
PK. microgrid_id	int
timestamp	datetime
description	varchar(200)
model	json

mgrid_mpc1_inputs	
FK. microgrid_id	int
nctrl_elec_consumption_pred	varchar(2000)
nctrl_ther_consumption_pred	varchar(2000)
nctrl_gas_consumption_pred	varchar(2000)
pv_production_pred	varchar(2000)
batt_energy_exchange	varchar(2000)
batt_soc	real
batt_timestamp	datetime
rooms_temperatures	varchar(2000)
room_temperatures_timestamp	datetime
c_da	varchar(2000)
da_timestamp	datetime
c_pmax	real
c_pmax_timestamp	datetime
idf_penalty_factor	real
flex_reservation	varchar(2000)
flex_activation	varchar(2000)
flex_reservation_prices	varchar(2000)
flex_activation_prices	varchar(2000)
flex_penalty_prices	varchar(2000)
flex_penalty_threshold	real
lt_contract_timestamp	datetime

mgrid_mpc1_outputs	
FK. microgrid_id	int
timestamp	datetime
batt_command	real
batt_energy_profile	varchar(2000)
ctrl_load_command	varchar(2000)
ctrl_load_energy_profile	varchar(4000)
pv_command	real
pv_energy_profile	varchar(2000)
coordination_var	varchar(16000)
predicted_da_profile	varchar(2000)

mgrid_mpc1_outputs_history	
PK. id	bigint
FK. microgrid_id	int
timestamp	datetime
batt_command	real
batt_energy_profile	varchar(2000)
ctrl_load_command	varchar(2000)
ctrl_load_energy_profile	varchar(4000)
pv_command	real
pv_energy_profile	varchar(2000)
coordination_var	varchar(16000)
predicted_da_profile	varchar(2000)

Microgrid level - database

- Battery interface tables
  - Slight changes possible in cooperation with UNIDEBTTK

Microgrid Batteries	
FK. Pilot block ID	int
PK. Battery ID	int
Timestamp	datetime
Battery name	varchar(100)
Nr of cells	int
Max current in	real
Max current out	real
Max temp	real
Model	varchar(200)

Battery status - current	
FK. Battery ID	int
Cells voltage	varchar(1000)
Cells temperature	varchar(1000)
Charge/discharge current	real
Safety flags	varchar(1000)
Provided SOC	real
Energy in-out in 1min	real
Estimated SOC	real
Device update timestamp	datetime
SOC Estimation update timestamp	datetime

Battery status - history	
PK. Battery history ID	int
FK. Battery ID	int
Cells voltage	varchar(1000)
Cells temperature	varchar(1000)
Charge/discharge current	real
Safety flags	varchar(1000)
Provided SOC	real
Energy in-out in 1min	real
Estimated SOC	real
Device update timestamp	datetime
SOC Estimation update timestamp	datetime

Battery energy request - current	
FK. Battery ID	int
Energy request	real
Software switches	byte
Timestamp	datetime

Battery energy request - history	
PK. Battery energy request history ID	int
FK. Battery ID	int
Energy request	real
Software switches	byte
Timestamp	datetime

BMS command - current	
FK. Battery ID	int
Current reference	real
Software switches	byte
Timestamp	datetime
Heartbeat signal	int
PWM value for bypass resistor	int

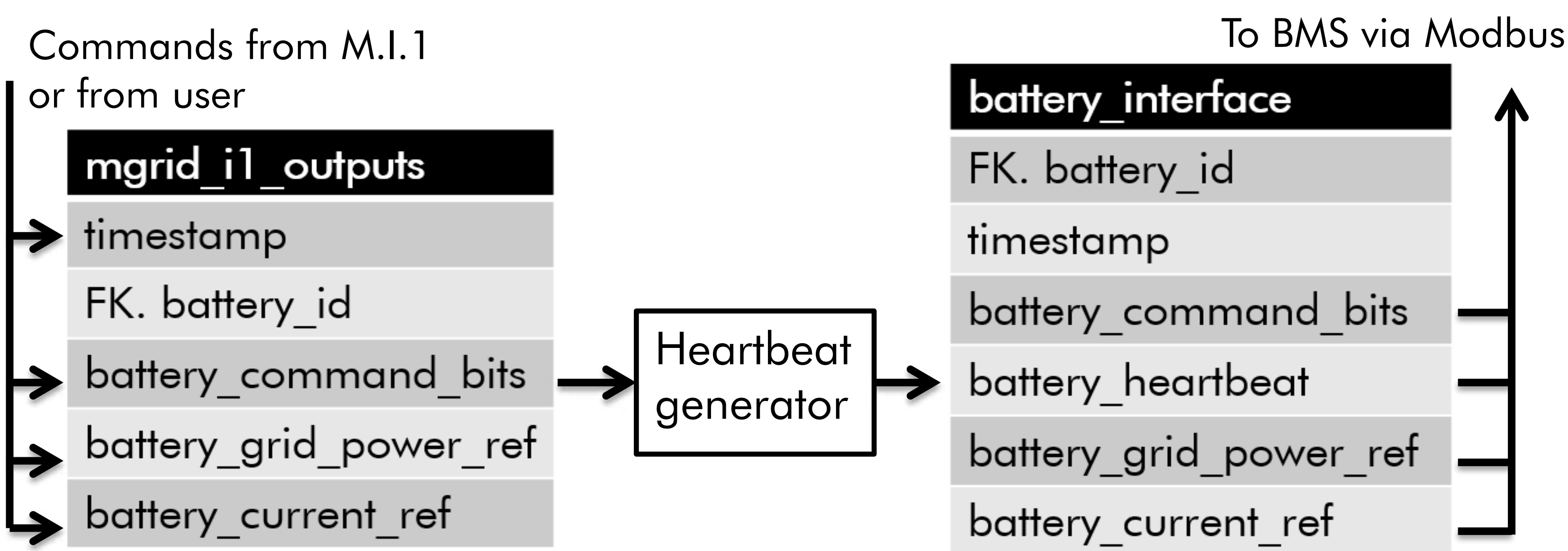
BMS command - history	
PK. Battery command history ID	int
FK. Battery ID	int
Current reference	real
Software switches	byte
Timestamp	datetime
Heartbeat signal	int
PWM value for bypass resistor	int

Battery model parameters - current	
FK. Battery ID	int
Battery model parameters	varchar(300)
Timestamp	datetime

Battery model parameters - history	
PK. Battery model parameters history ID	int
FK. Battery ID	int
Parameters	varchar(300)
Timestamp	datetime

Battery commands

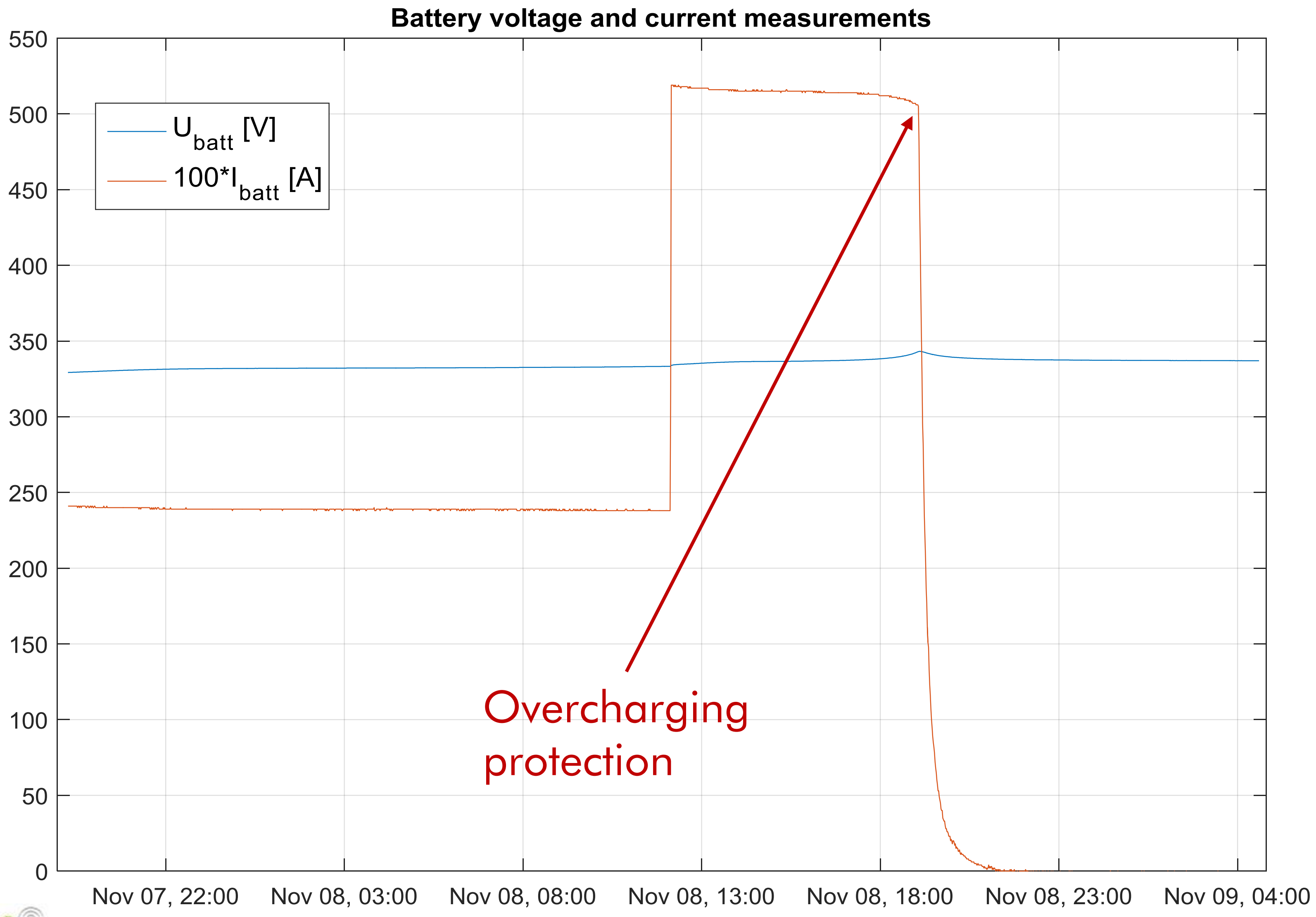
- Command bits
  - enable/disable BMS
  - enable/disable inverter
  - toggle AC power/DC current reference
- AC power reference [W]
- DC current reference [mA]



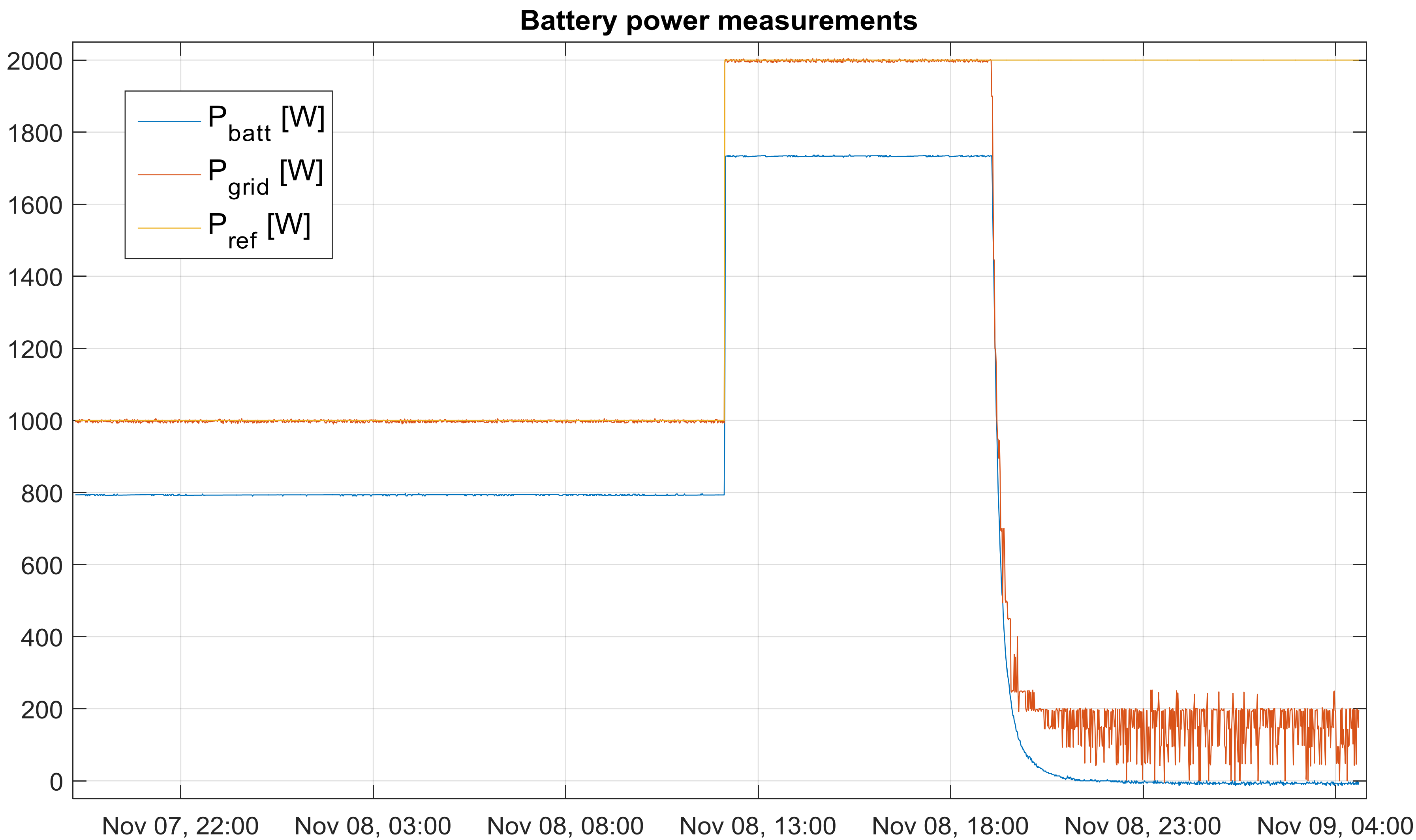
Battery measurements history

- AC voltage
- AC reference power
- AC measured power
- DC Link voltage
- Battery pack voltage
- Battery current
- Accumulated charge
- Cell voltages
- Inverter status bits
- BMS status bits
- Fire protection status
- Cell temperatures
- Inverter temperature
- Status of bypass resistors for balancing
- Safety limits
- Other diagnostic data

Battery measurements history



Battery measurements history

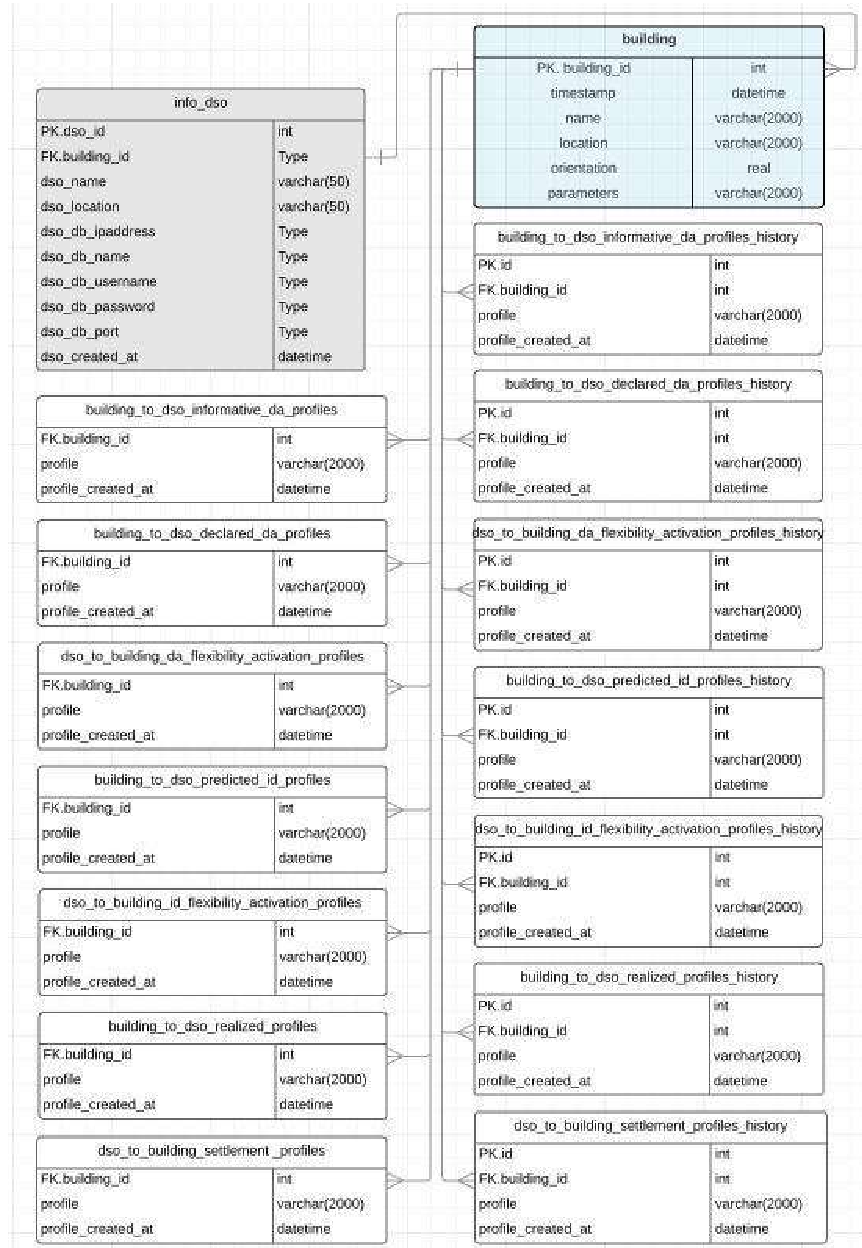


Battery measurements history

- AC voltage
- AC reference power
- AC measured power
- DC Link voltage
- Battery pack voltage
- Battery current
- Accumulated charge
- Cell voltages
- Inverter status bits
- BMS status bits
- Fire protection status
- Cell temperatures
- Inverter temperature
- Status of bypass resistors for balancing
- Safety limits
- Other diagnostic data

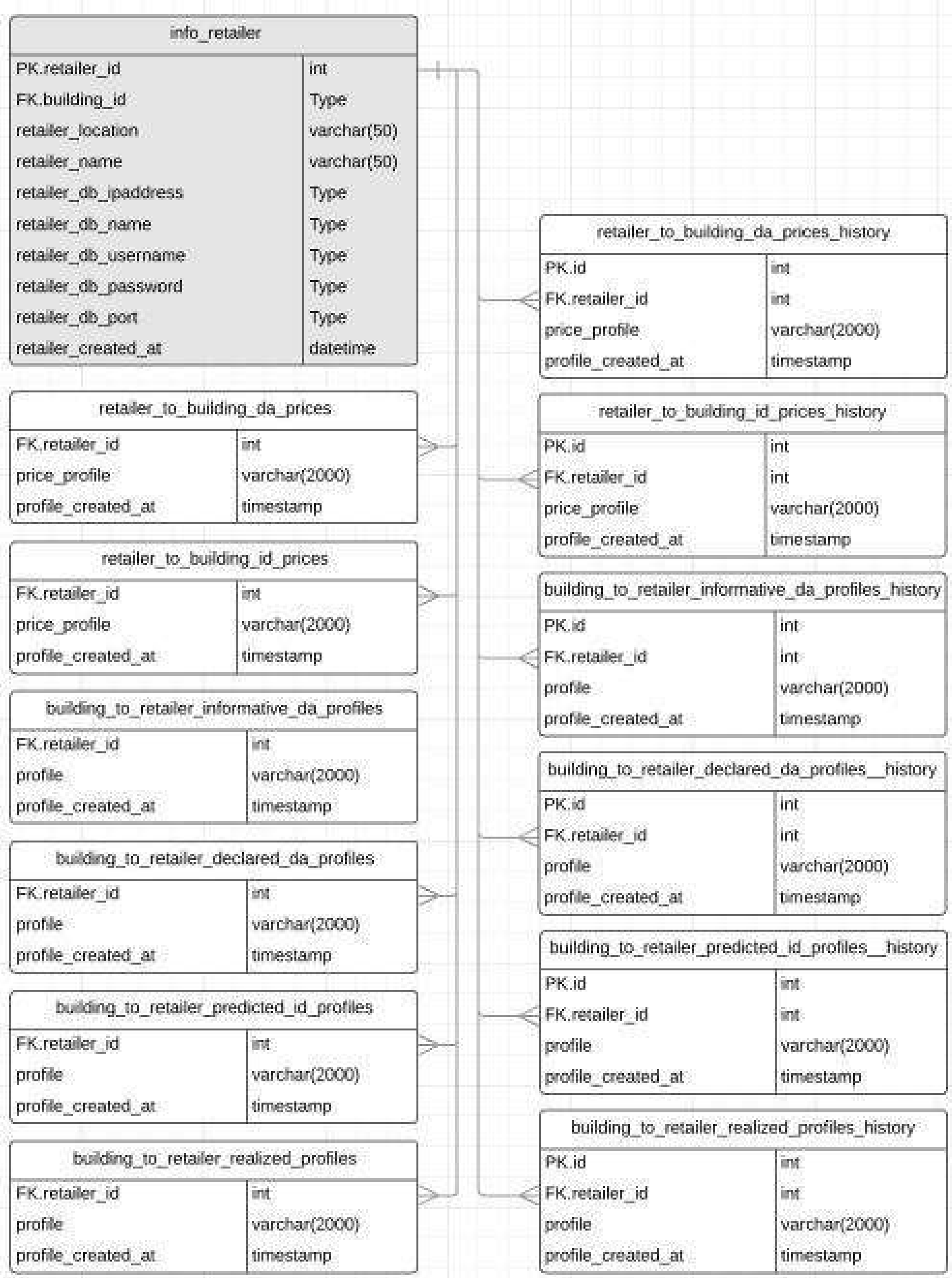
Microgrid level – database

- Communication with the DSO
  - Short-term
  - Long-term



Microgrid level – database

- Communication with the retailer



Calorimeters – database

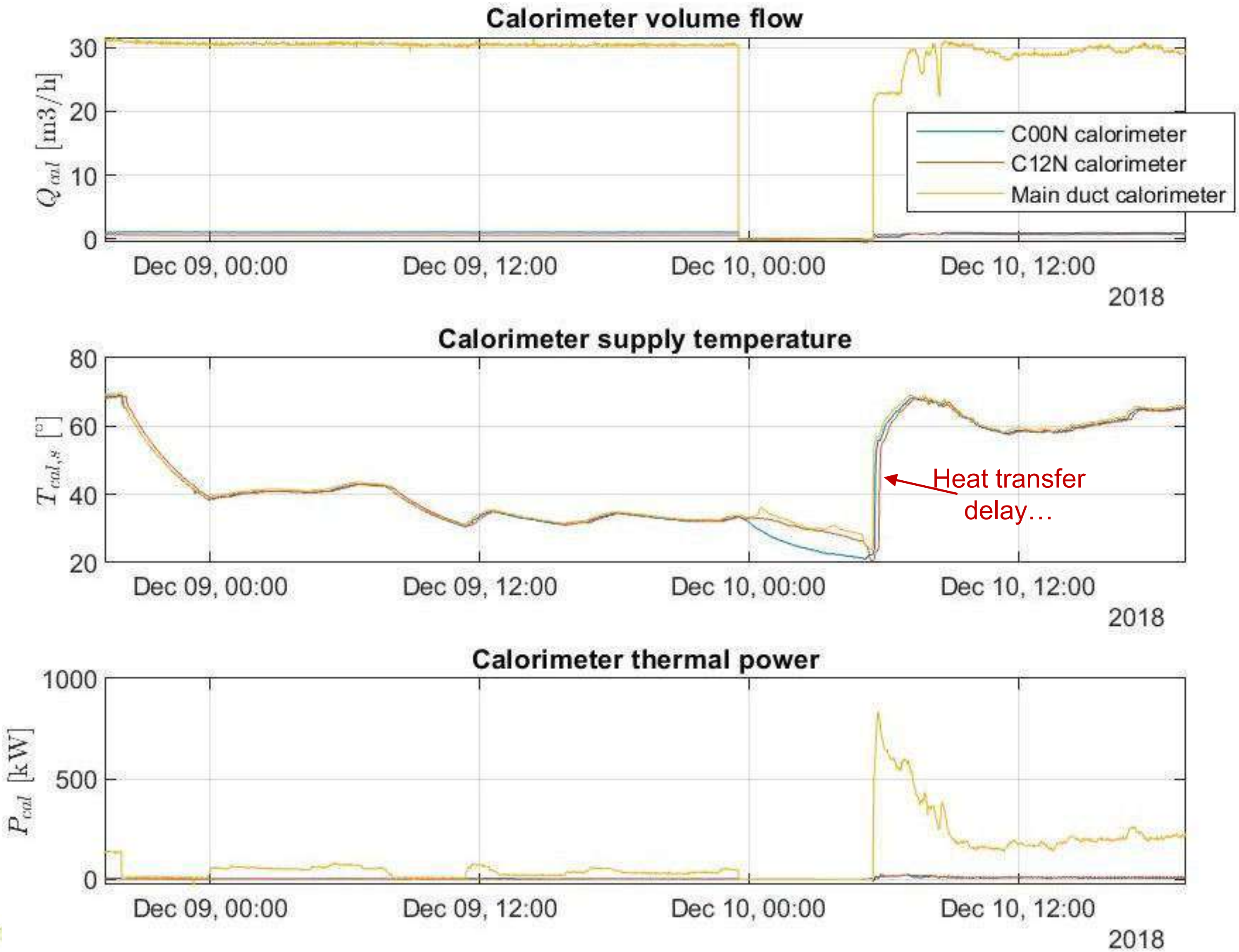
- Signals from building:
  - Central + floor calorimeters
  - Minutely sampled

calorimeter	
FK. measurement_group_id	int
FK. floor_id	int
PK. calorimeter_id	int
timestamp	datetime
name	varchar(30)
description	varchar(200)
orientation	int

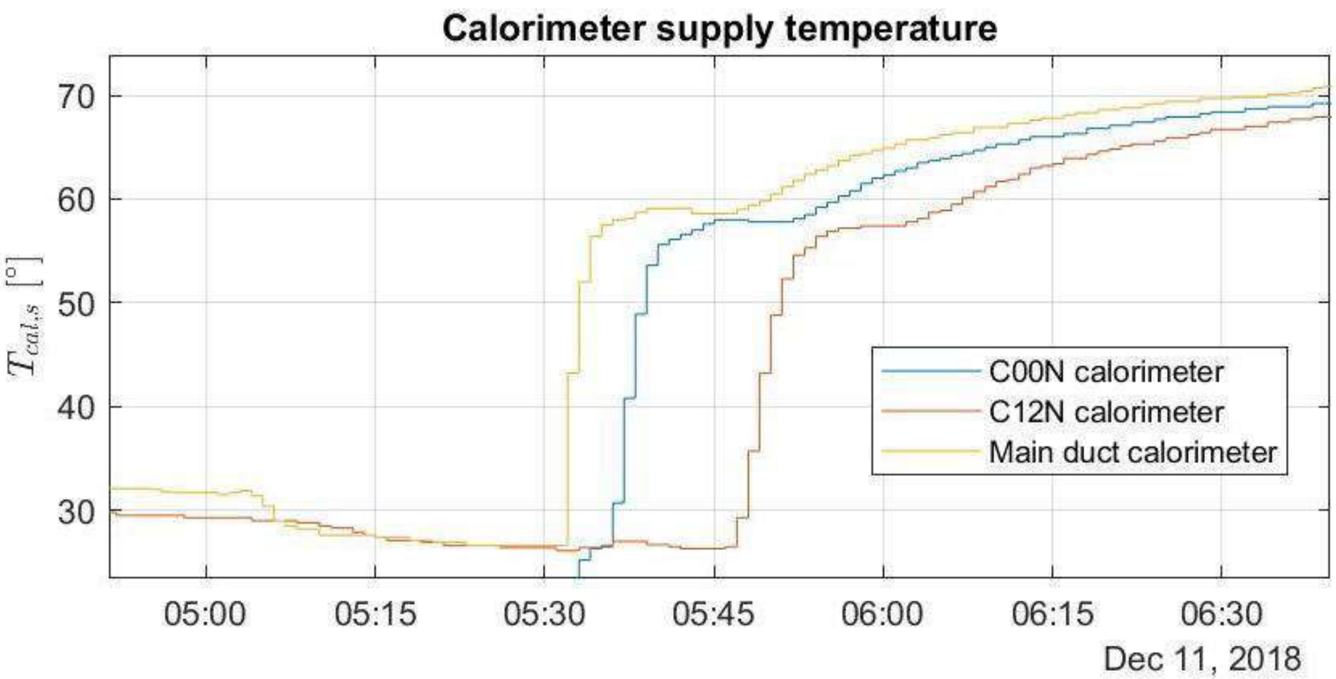
calorimeter_measurements	
FK. calorimeter_id	int
timestamp	datetime
batch_timestamp	datetime
supply_temperature	real
return_temperature	real
temperature_difference	real
mass_volume_flow	real
thermal_power	real
thermal_energy_heating	real
thermal_energy_cooling	real
error	real

calorimeter_measurements_history	
PK. id	bigint
FK. calorimeter_id	int
timestamp	datetime
batch_timestamp	datetime
supply_temperature	real
return_temperature	real
temperature_difference	real
mass_volume_flow	real
thermal_power	real
thermal_energy_heating	real
thermal_energy_cooling	real
error	real

Calorimeters – recent



Calorimeters – recent



HVAC, heating subst. + hydraulic pump – database

- Signals from/to building
- Minutely sampled
- 3smart flag => 3Smart module references

hydraulic_pump	
FK. building_id	int
FK. pipework_id	int
PK. hydraulic_pump_id	Int
measurement_group_id	int
hydraulic_pump_description	varchar(1000)
hydraulic_pump_name	varchar(30)

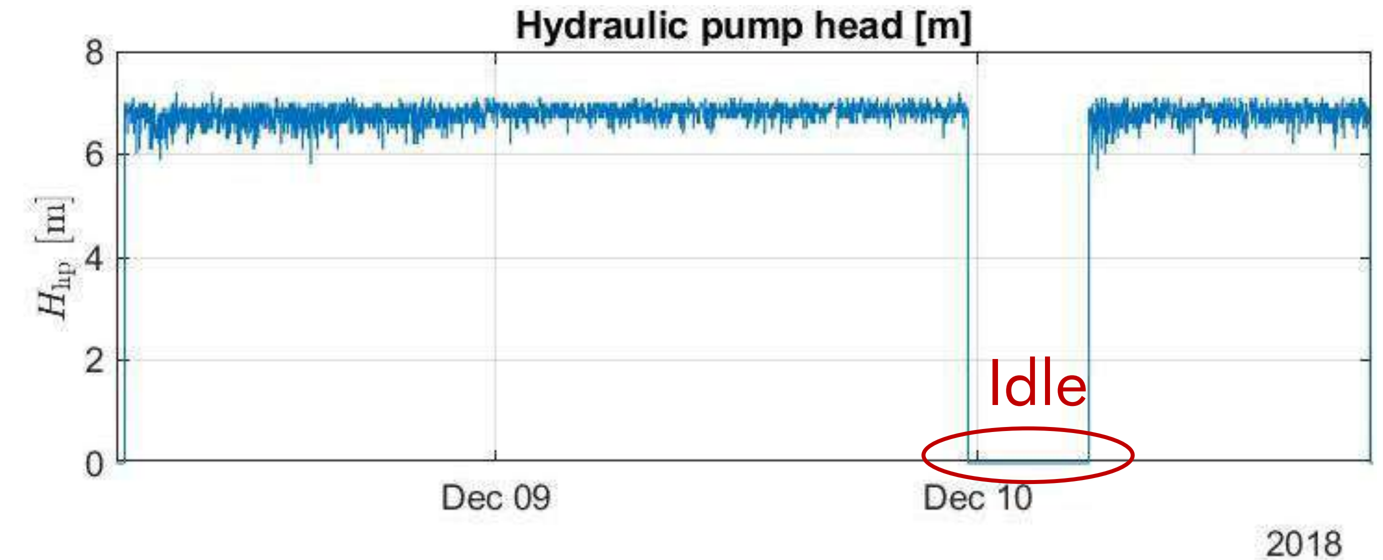
hydraulic_pump_measurement	
PK./FK hydraulic_pump_id	Int
batch_timestamp	timestamp without time zone
timestamp	timestamp without time zone
hydraulic_pump_head	real
hydraulic_pump_rpm	real
hydraulic_pump_power	real
hydraulic_pump_current	real
hydraulic_pump_flow	real
hydraulic_pump_efficiency	real

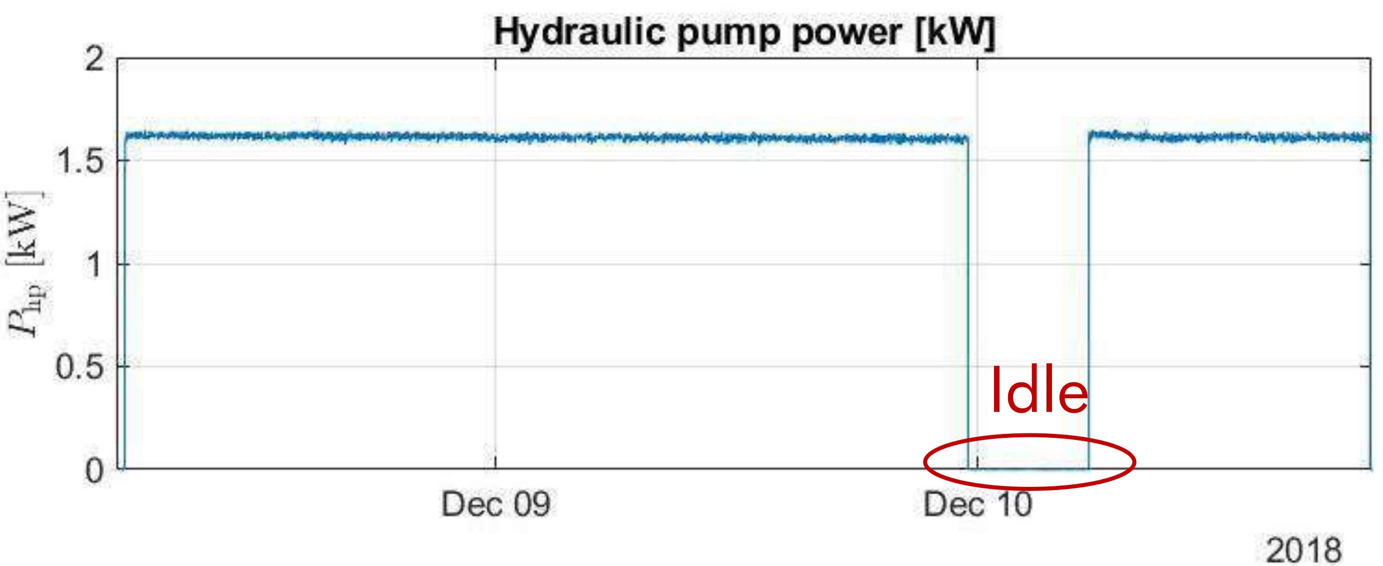
heating_substation_command	
PK./FK. heating_substation_id	Int

hydraulic_pump_command	
PK./FK hydraulic_pump_id	Int
timestamp	timestamp without time zone
hydraulic_pump_head_command	Real

+ coresponding history tables

HVAC, heating subst. + hydraulic pump – recent





HVAC, heat pump – database

- Signals from/to building
- Minutely sampled
- 3smart flag => 3Smart module references

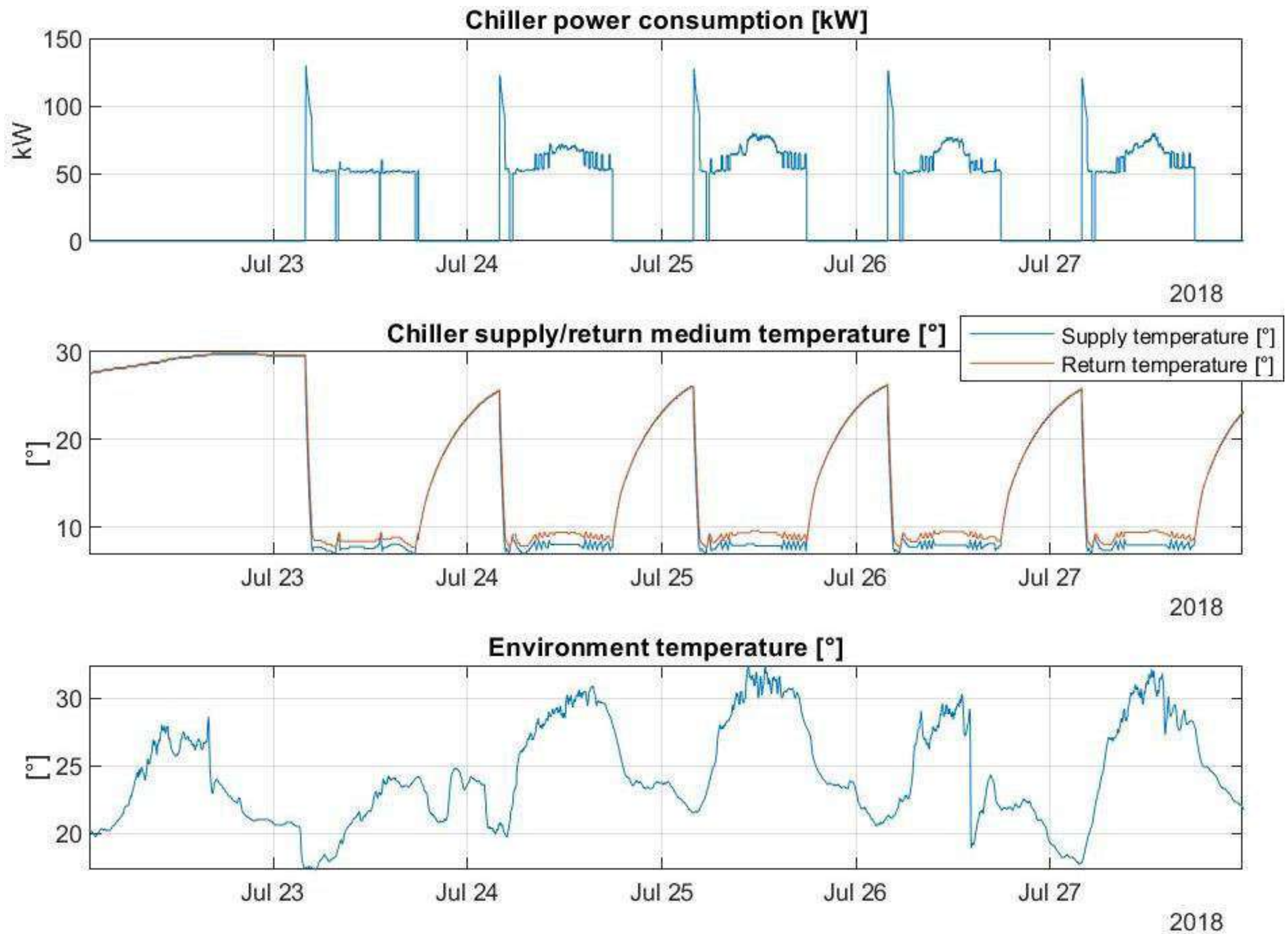
heat_pump	
PK. heat_pump_id	int
FK. measurement_group_id	Int
FK. building_id	int
heat_pump_name	varchar(30)
heat_pump_description	varchar(1000)
FK. pipework_id	int

heat_pump_compressor_measurement	
PK. heat_pump_compressor_id	Int
FK. heat_pump_id	Int
batch_timestamp	timestamp w/o time zone
timestamp	timestamp w/o time zone
heat_pump_compressor_load	varchar(100)
heat_pump_compressor_phase_current	varchar(100)
heat_pump_compressor_line_voltage	varchar(100)

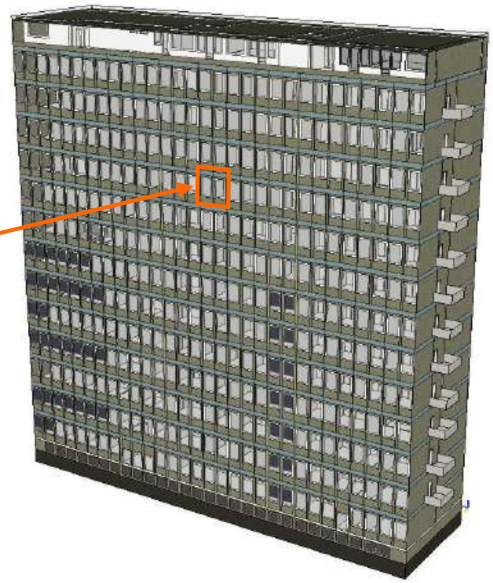
heat_pump_measurement	
PK./FK. heat_pump_id	Int
batch_timestamp	timestamp w/o time zone
timestamp	timestamp w/o time zone
heat_pump_return_medium_temperature	real
heat_pump_supply_medium_temperature	real
heat_pump_supply_medium_ temperature_reference	real
heat_pump_smart_control	boolean

heat_pump_command	
PK./FK. heat_pump_id	Int
timestamp	timestamp w/o time zone
heat_pump_supply_medium_temperature_ reference_command	real

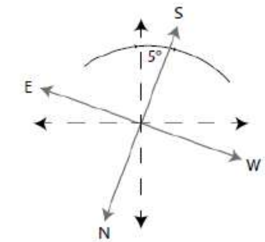
HVAC, heat pump – database



Zone and FCU level measurements



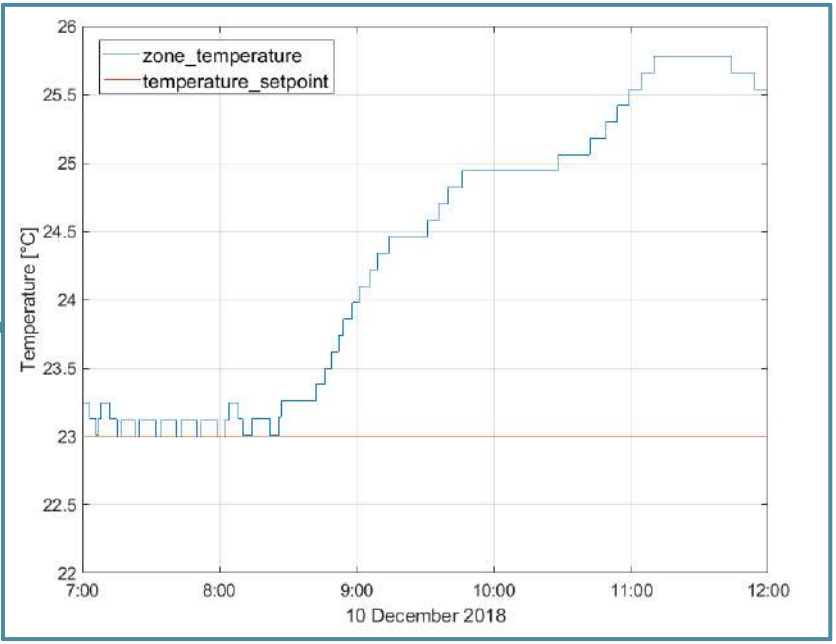
(9th floor – zone C09-10)



Zone level measurements

- zone_measurement(_history)

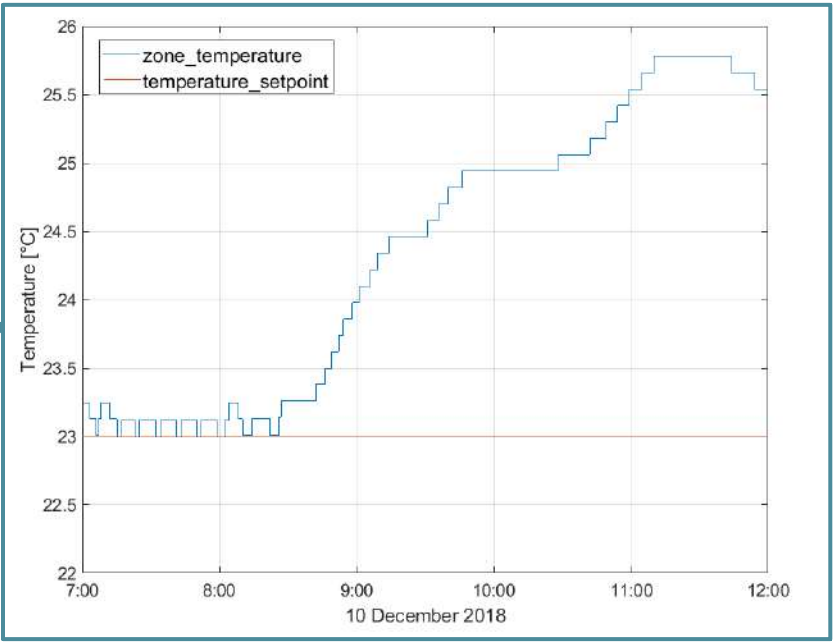
zone_measurement	
FK. zone_id	int
timestamp	datetime
batch_timestamp	datetime
zone_temperature	real
zone_fan_speed	real
zone_valve_duty_cycle	real
smart_control	bool
local_switch	real
temperature_setpoint	real

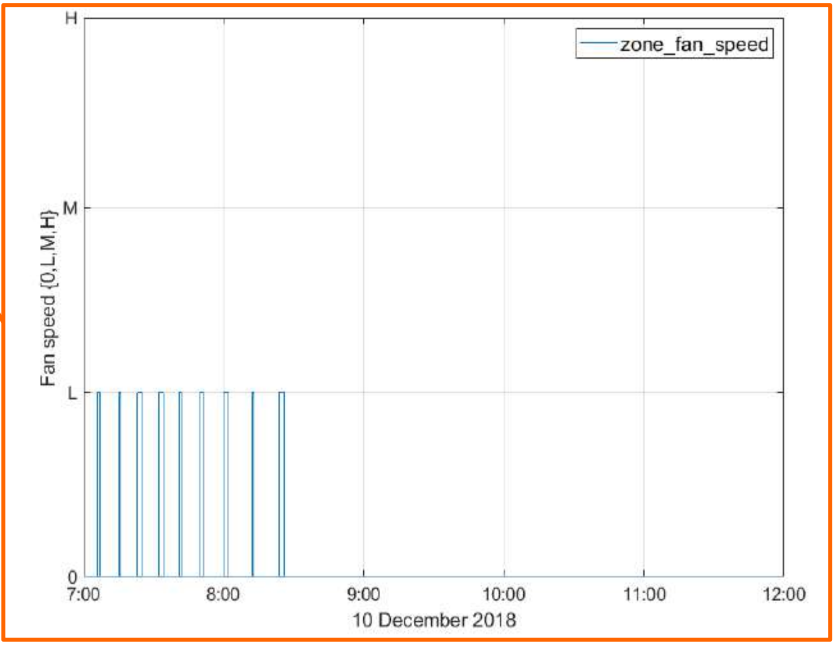


Zone level measurements

- zone_measurement(_history)

zone_measurement	
FK. zone_id	int
timestamp	datetime
batch_timestamp	datetime
zone_temperature	real
zone_fan_speed	real
zone_valve_duty_cycle	real
smart_control	bool
local_switch	real
temperature_setpoint	real

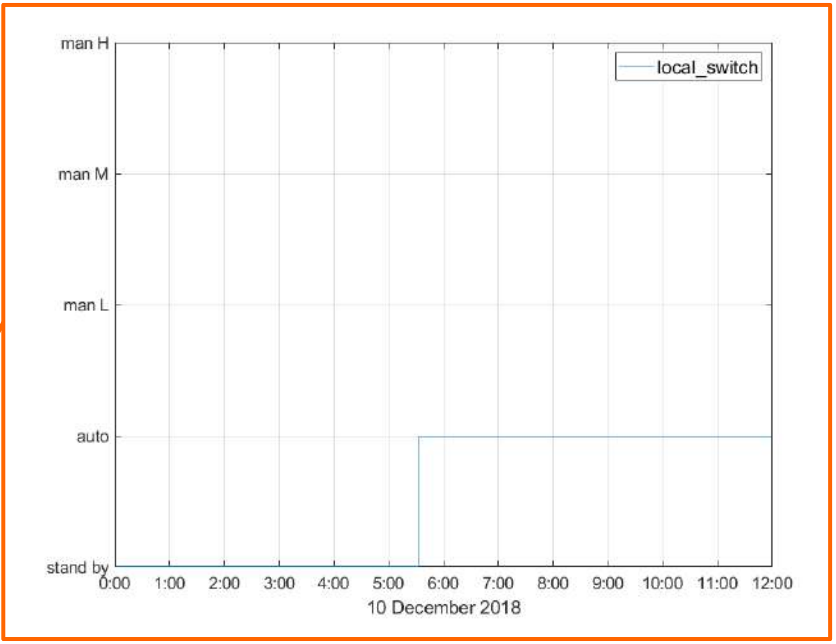




Zone level measurements

- zone_measurement(_history)

zone_measurement	
FK. zone_id	int
timestamp	datetime
batch_timestamp	datetime
zone_temperature	real
zone_fan_speed	real
zone_valve_duty_cycle	real
smart_control	bool
local_switch	real
temperature_setpoint	real

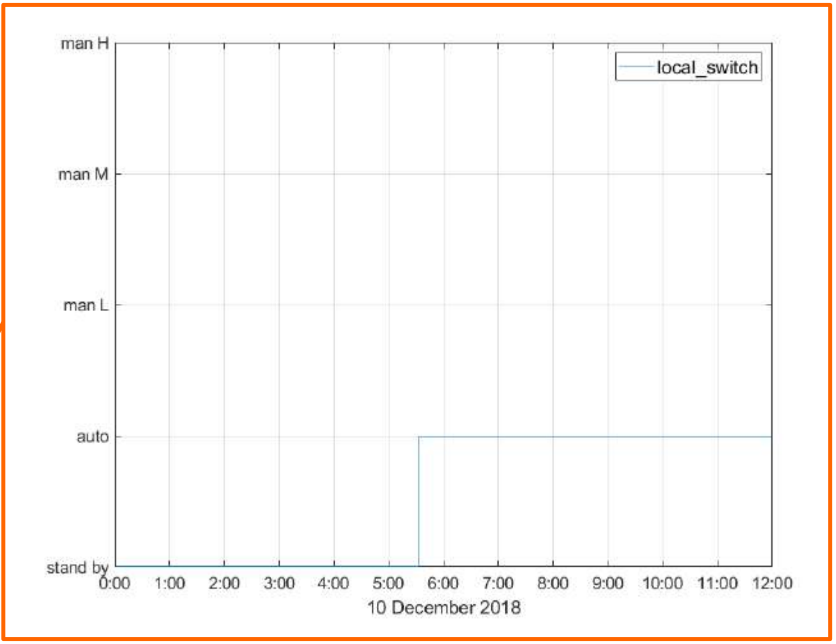


timestamp timestamp without tim	zone_temperature real	zone_fan_spe real	zone_valve_duty_cycl real	smart_control boolean	local_switch real	temperature_setpoint real
2018-12-10 12:24:05	25.66	0		TRUE	0.5	23
2018-12-10 12:23:05	25.66	0		TRUE	0.5	23
2018-12-10 12:22:05	25.54	0		TRUE	0.5	23
2018-12-10 12:21:04	25.54	0		TRUE	0.5	23
2018-12-10 12:20:05	25.54	0		TRUE	0.5	23
2018-12-10 12:19:04	25.54	0		TRUE	0.5	23
2018-12-10 12:18:05	25.42	0		TRUE	0.5	23
2018-12-10 12:17:05	25.42	0		TRUE	0.5	23
2018-12-10 12:16:05	25.42	0		TRUE	0.5	23
2018-12-10 12:15:05	25.42	0		TRUE	0.5	23
2018-12-10 12:14:05	25.42	0		TRUE	0.5	23
2018-12-10 12:13:05	25.42	0		TRUE	0.5	23
2018-12-10 12:12:05	25.42	0		TRUE	0.5	23
2018-12-10 12:11:05	25.42	0		TRUE	0.5	23

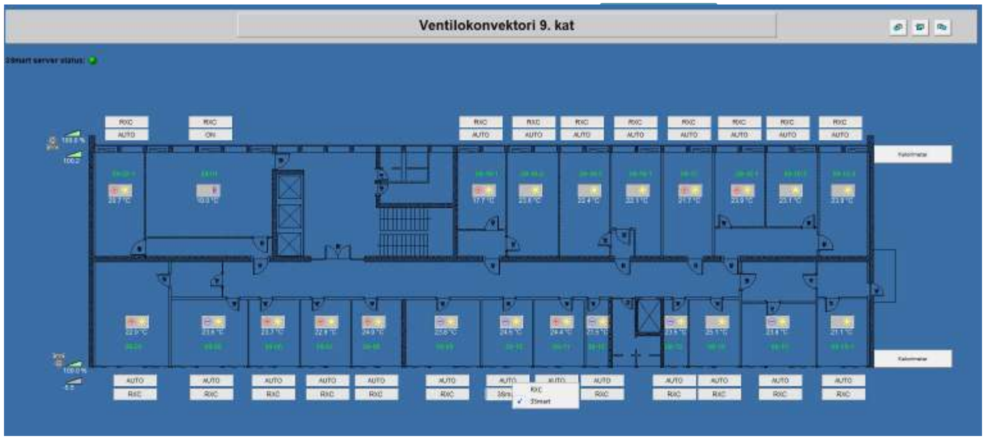
Zone level measurements

- zone_measurement(_history)

zone_measurement	
FK. zone_id	int
timestamp	datetime
batch_timestamp	datetime
zone_temperature	real
zone_fan_speed	real
zone_valve_duty_cycle	real
smart_control	bool
local_switch	real
temperature_setpoint	real



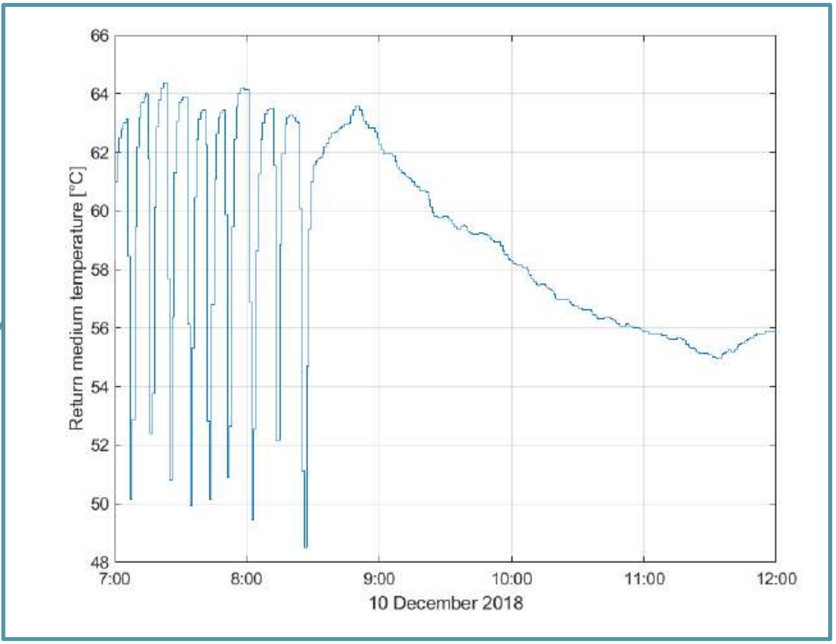
DESIGO



FCU level measurements

- fcu_water_side_measurements(_history)

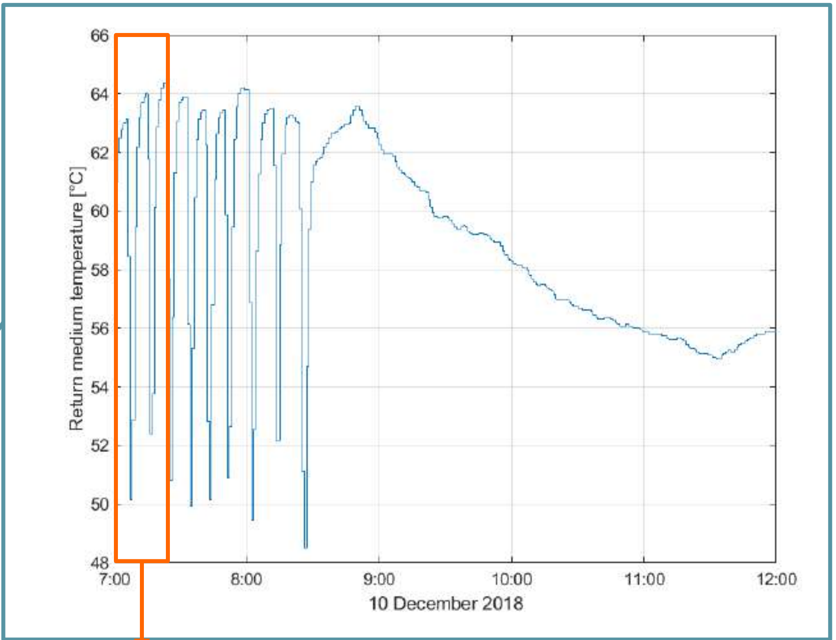
fcu_water_side_measurements	
K. fcu_id	int
timestamp	datetime
batch_timestamp	datetime
supply_medium_temperature	real
return_medium_temperature	real

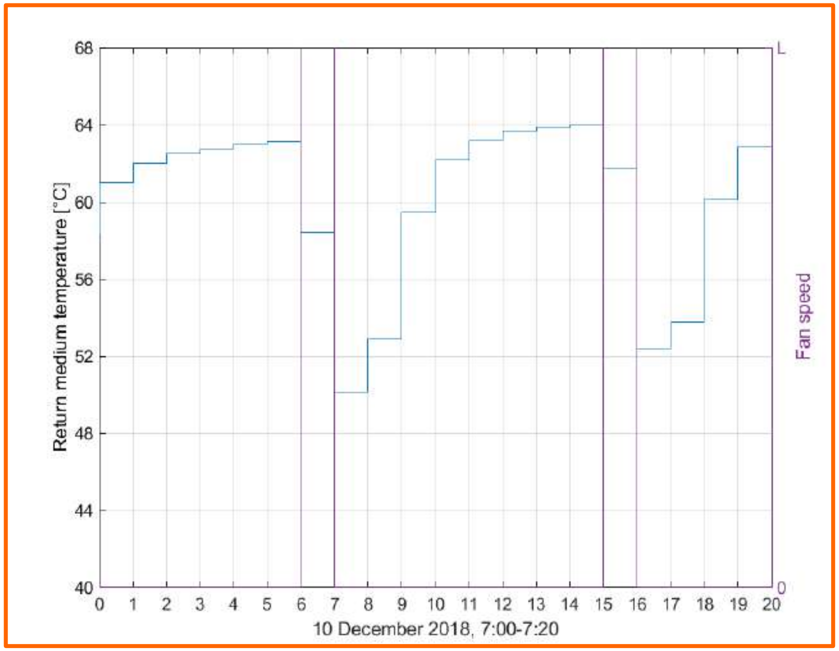


FCU level measurements

- fcu_water_side_measurements(_history)

fcu_water_side_measurements	
K. fcu_id	int
timestamp	datetime
batch_timestamp	datetime
supply_medium_temperature	real
return_medium_temperature	real

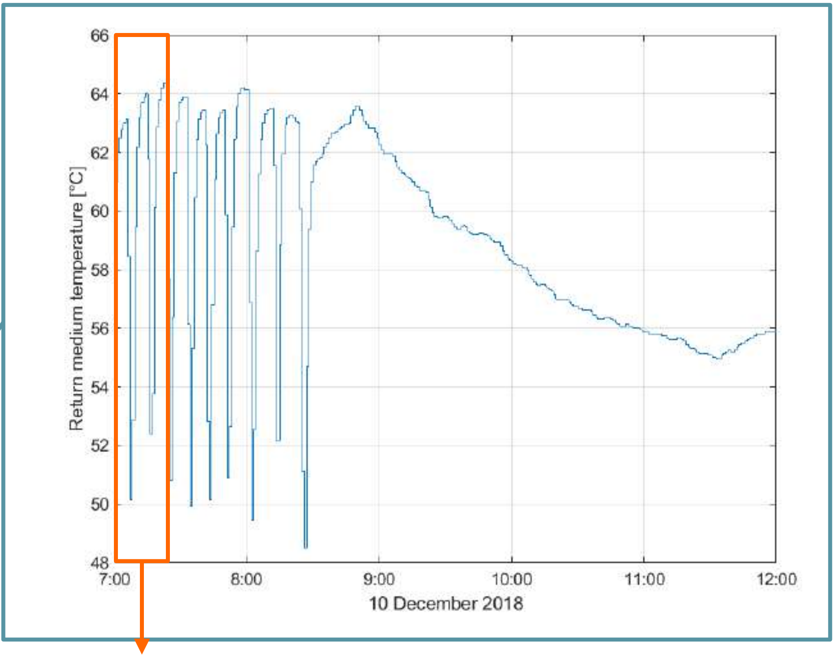


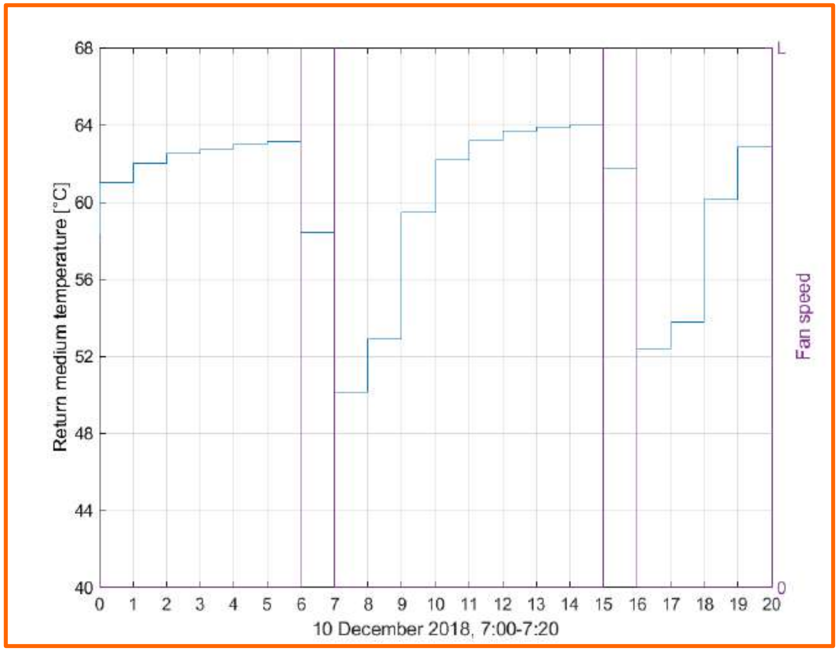


FCU level measurements

- fcu_water_side_measurements(_history)

fcu_water_side_measurements	
K. fcu_id	int
timestamp	datetime
batch_timestamp	datetime
supply_medium_temperature	real
return_medium_temperature	real



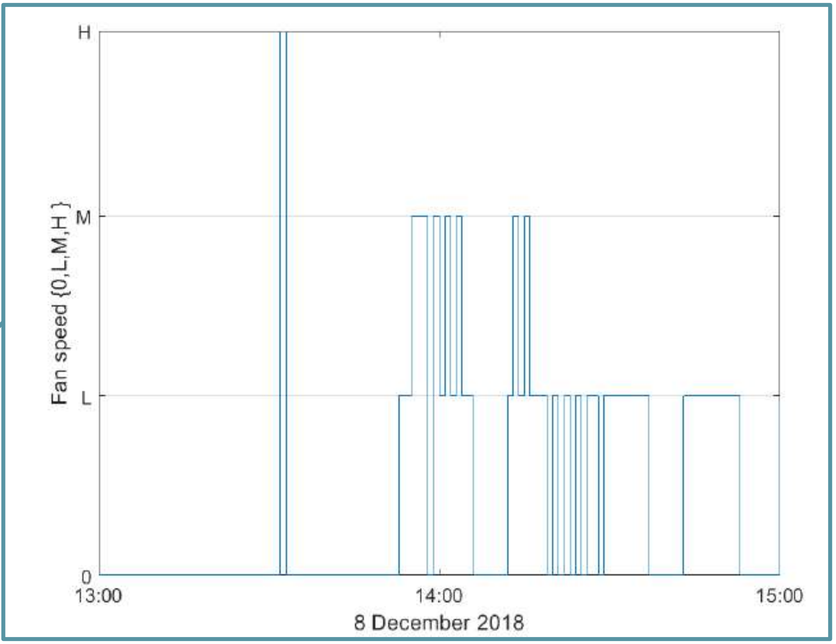


zone_command	
FK. zone_id	int
timestamp	datetime
zone_fan_speed_command	real

FCU level measurements

- zone_command(_history)

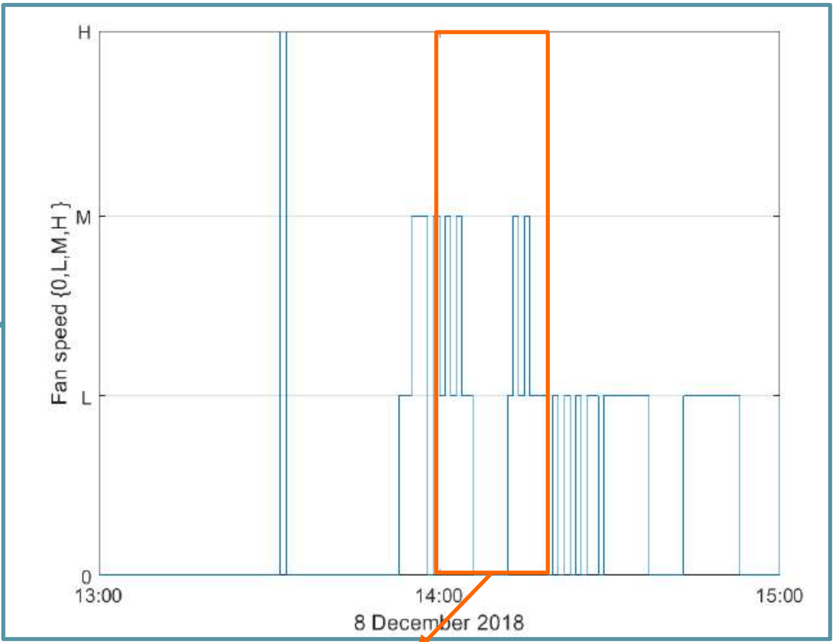
zone_command	
FK. zone_id	int
timestamp	datetime
zone_fan_speed_command	real

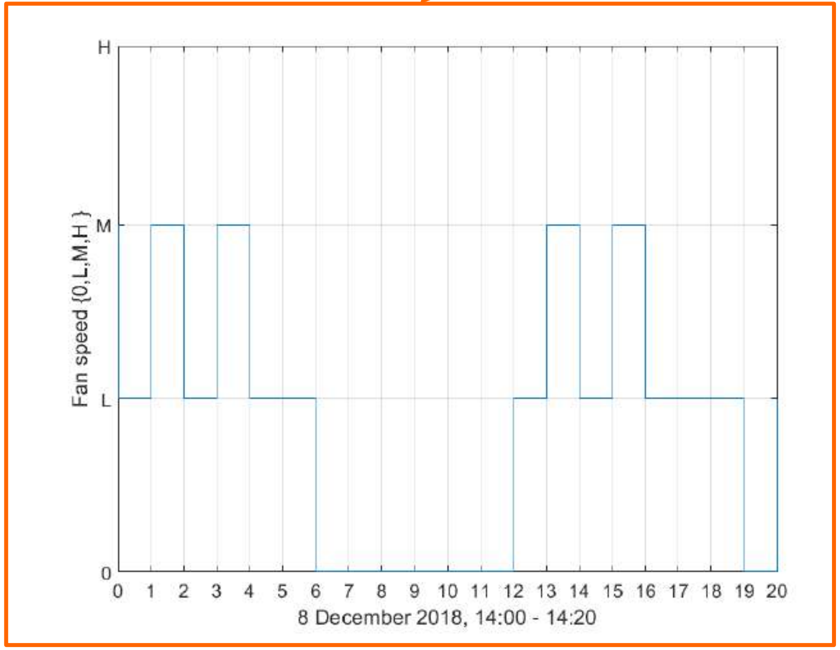


FCU level measurements

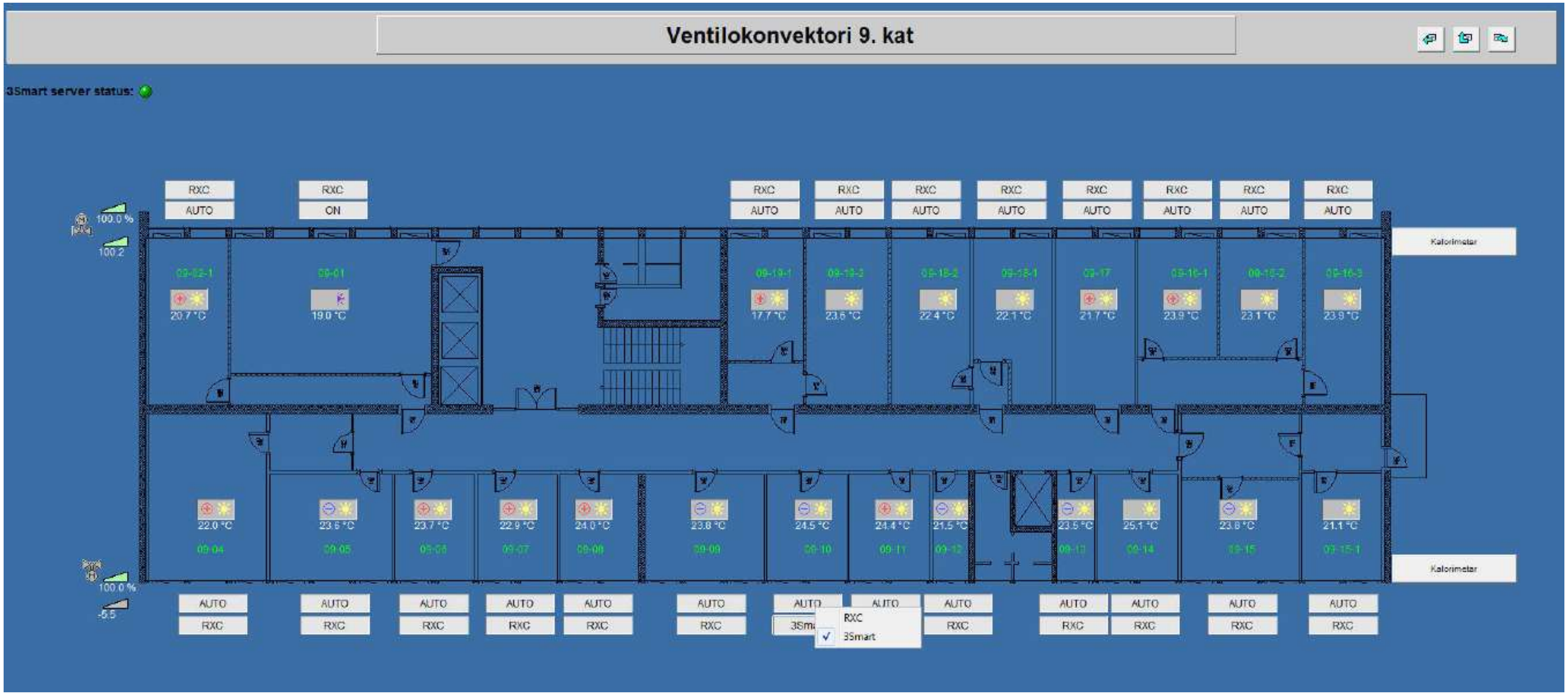
- zone_command(_history)

zone_command	
FK. zone_id	int
timestamp	datetime
zone_fan_speed_command	real





Online demonstration of FCU control



3Smart First pilot study visit to the Croatian pilot: 3Smart modules organization on the UNIZGFER pilot building

Mario Vašak, Anita Martinčević, Nikola Hure, Danko Marušić, Hrvoje Novak, Vinko Lešić

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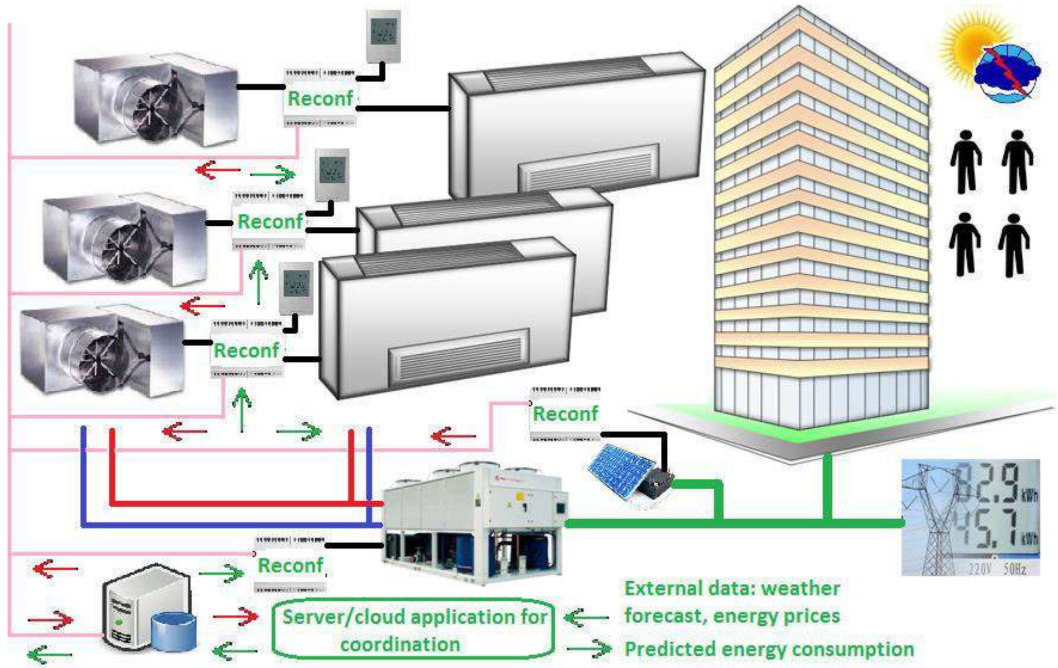
3Smart pilot study visit to HR pilot No. 1 in Zagreb

12 December 2018

Modular energy management in buildings

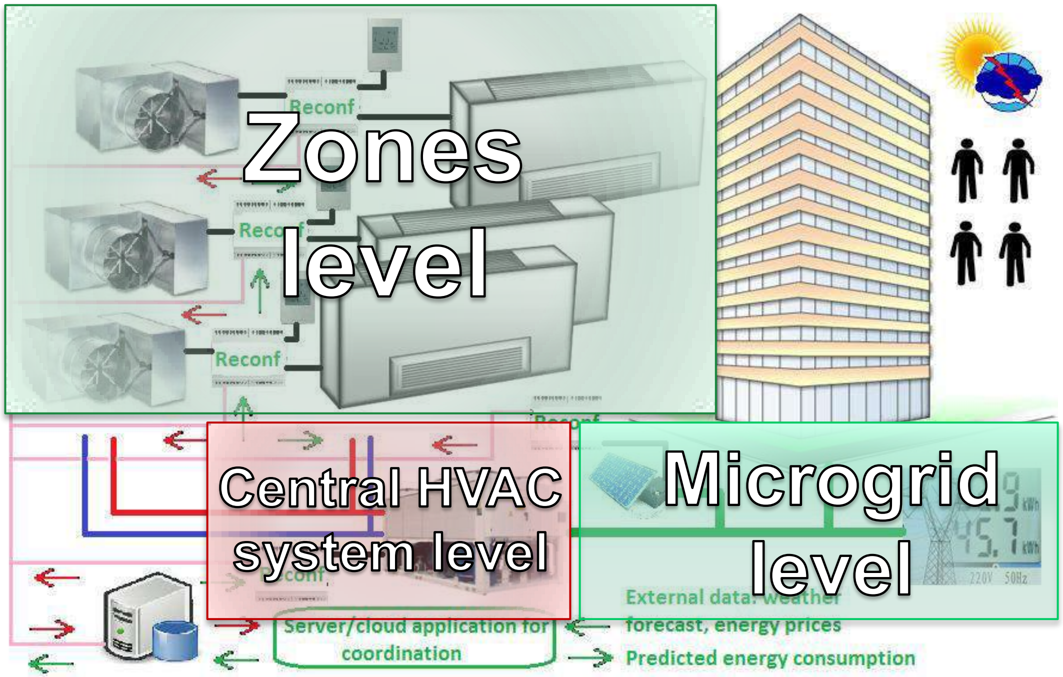
– Modularity of the coordination service
  • Separate modules for different building levels



  • Mutually coordinated in any configuration

Modular energy management in buildings

- Modularity of the coordination service
  - Separate modules for different building levels



  - Mutually coordinated in any configuration

Modules on the zone level

- Zone level prediction and estimation
  - Z.PE.1, Z.PE.4, Z.PE.5, Z.PE.6, Z.PE.7
- Zone level model predictive control
  - Z.MPC.1
- Zone level interfacing
  - Z.I.1

Modules on the central HVAC system level

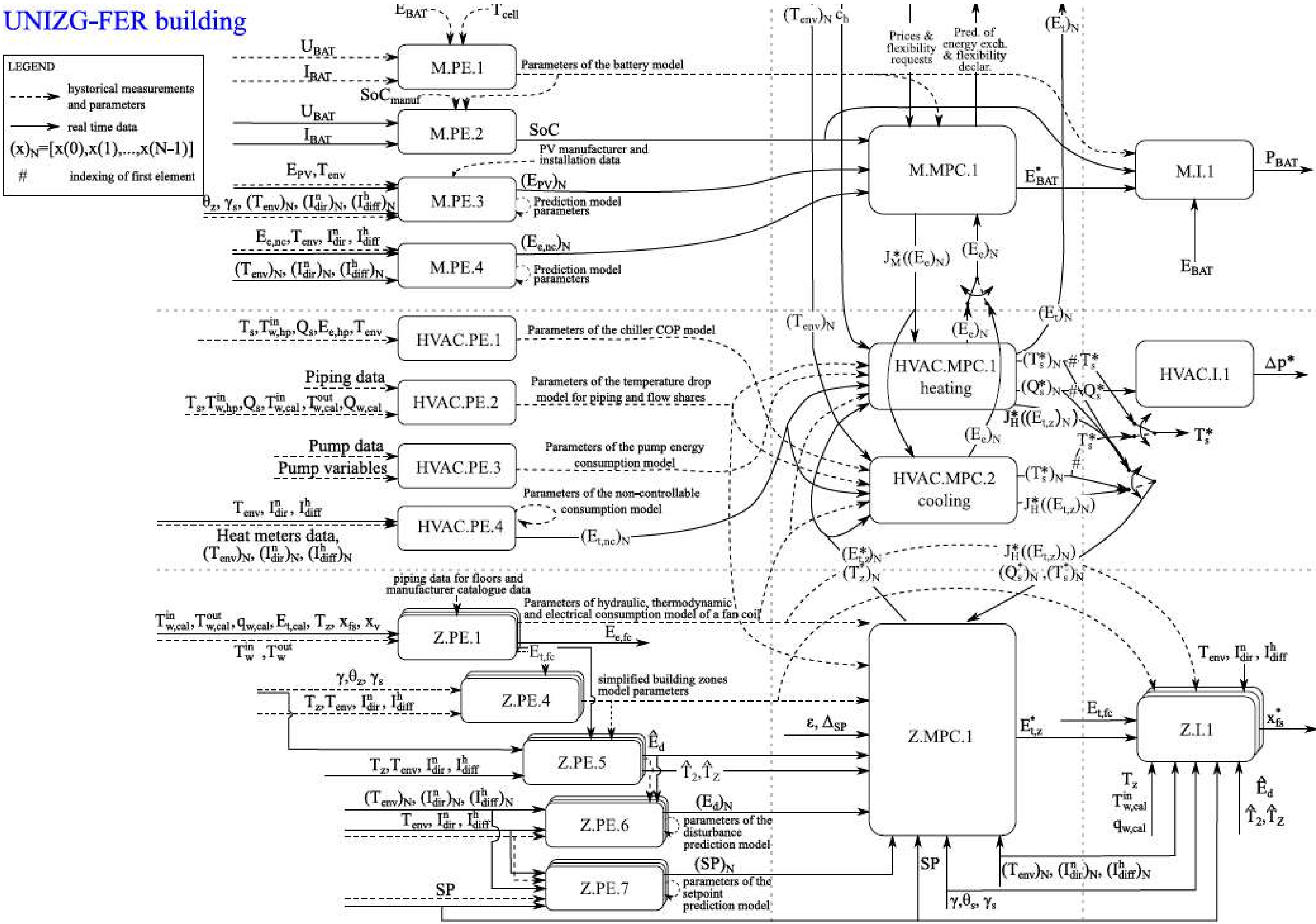
- Central HVAC system level prediction and estimation
  - HVAC.PE.1 (cooling), HVAC.PE.2, HVAC.PE.3 (heating), HVAC.PE.4
- Central HVAC system level model predictive control
  - HVAC.MPC.1 (heating), HVAC.MPC.2 (cooling)
- Central HVAC system level interfacing
  - HVAC.I.1 (heating)

Modules on the microgrid level

- Microgrid level prediction and estimation
  - M.PE.1, M.PE.2, M.PE.3, M.PE.4
- Microgrid level model predictive control
  - M.MPC.1
- Microgrid level interfacing
  - M.I.1

Information flow between modules

UNIZG-FER building



3Smart First pilot study visit to the Croatian pilot: 3Smart modules organization on the side of HEP building

Leon Leposa, Tomislav Stašić

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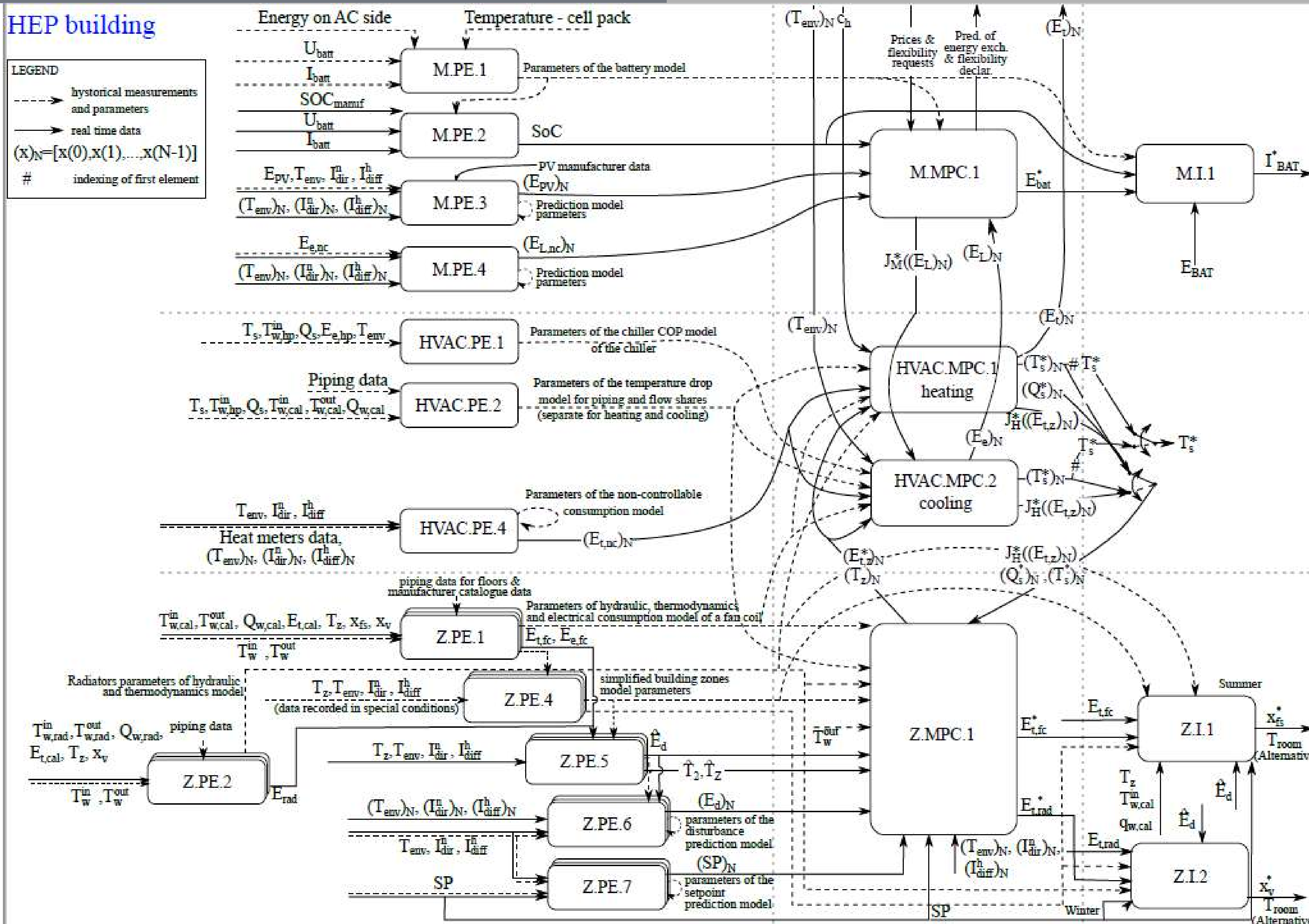
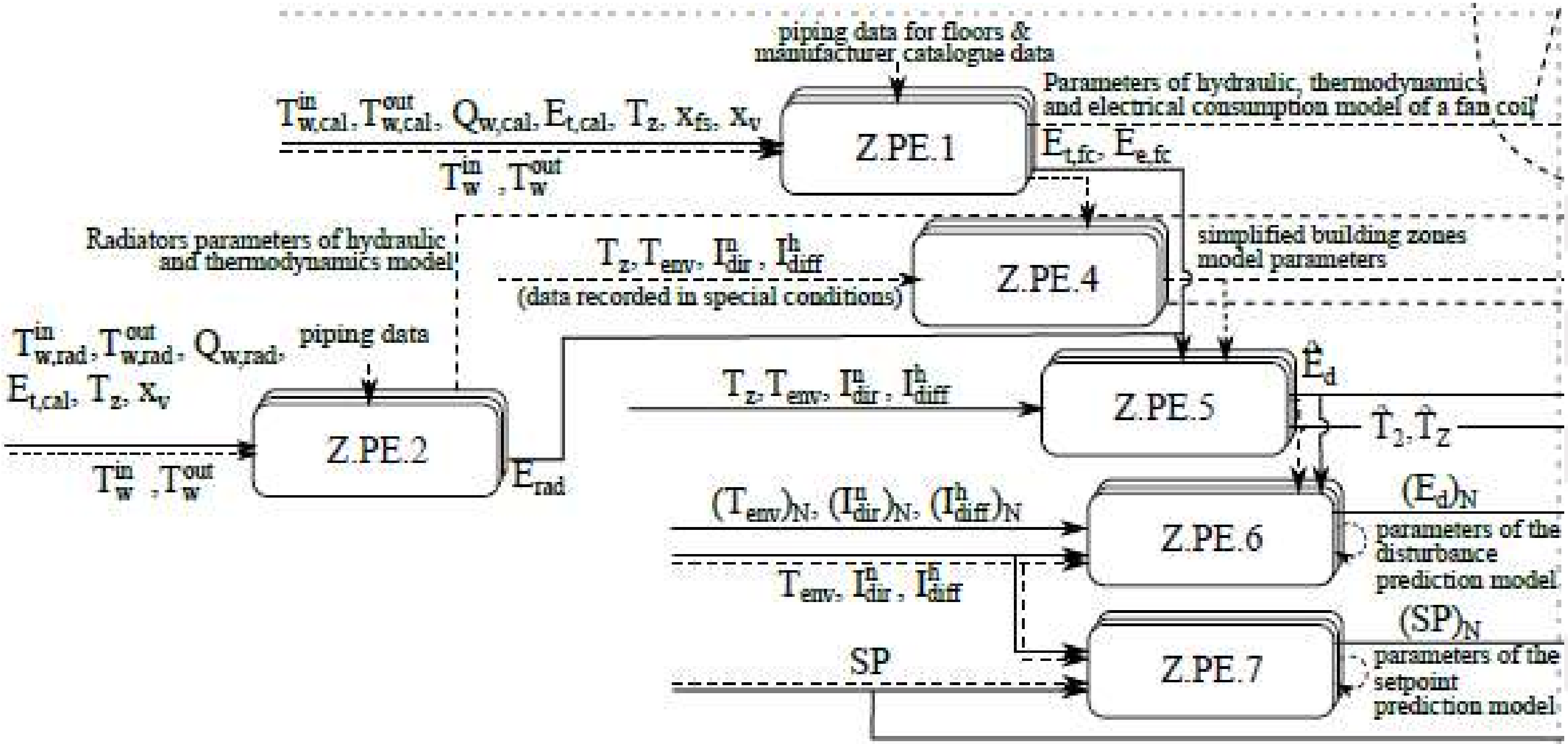
3Smart pilot study visit to HR pilot No. 1 in Zagreb

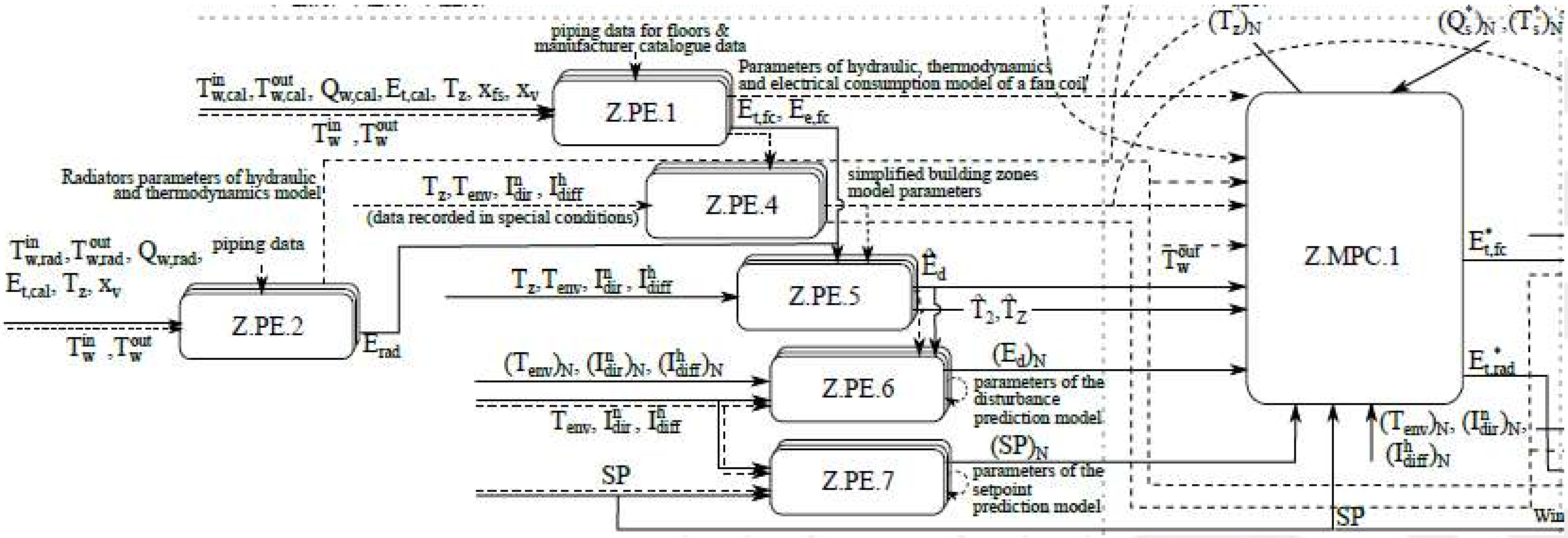
12 December 2018

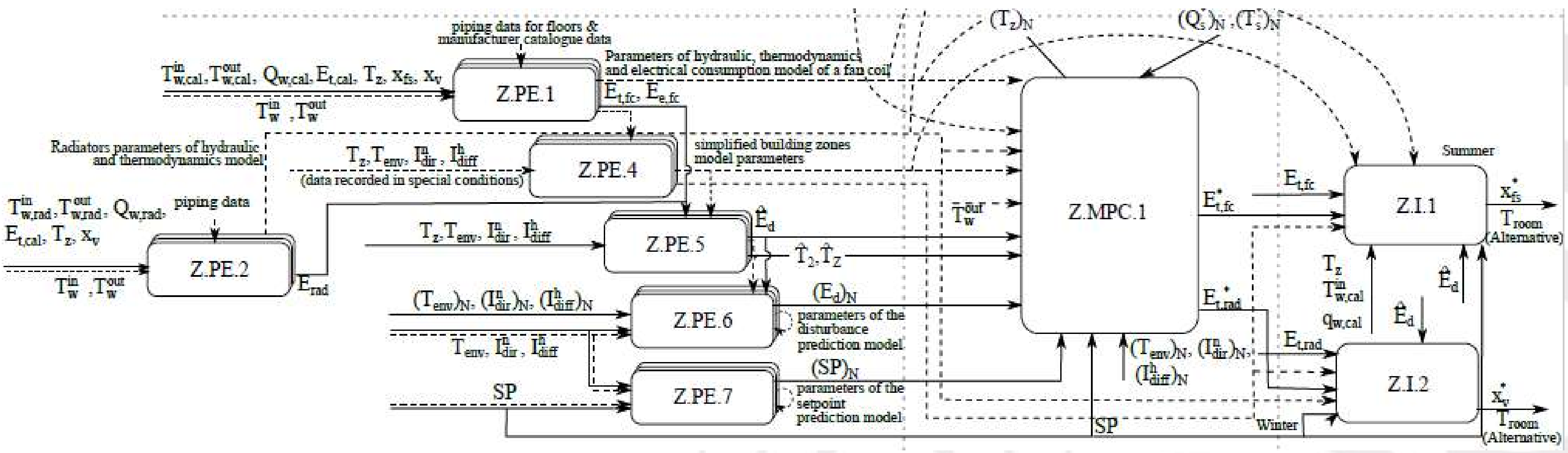
Project co-funded by the European Union

HEP building

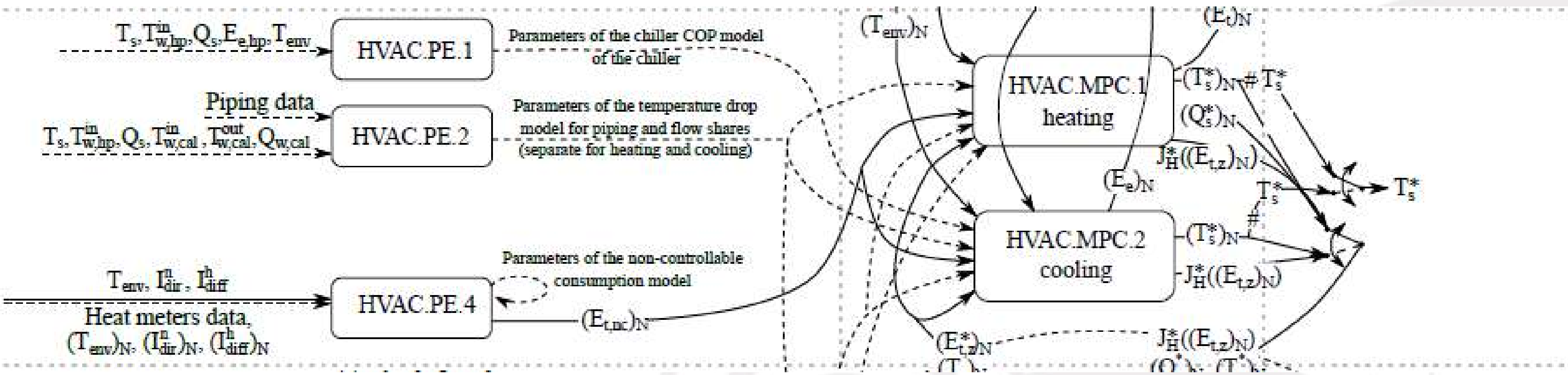



piping data for floors & manufacturer catalogue data
$T^{in}_{w,cal}, T^{out}_{w,cal}, Q_{w,cal}, E_{t,cal}, T_z, x_{fs}, x_v$
T^{in}_{w}, T^{out}_{w}
Z.PE.1
Parameters of hydraulic, thermodynamics and electrical consumption model of a fan coil
$E_{t,fc}, E_{e,fc}$
Radiators parameters of hydraulic and thermodynamics model
$T_z, T_{env}, I^n_{dir}, I^h_{diff}$
(data recorded in special conditions)
Z.PE.4
simplified building zones model parameters
$T^{in}_{w,rad}, T^{out}_{w,rad}, Q_{w,rad}, E_{t,cal}, T_z, x_v$
piping data
Z.PE.2
T^{in}_{w}, T^{out}_{w}
E_{rad}
$T_z, T_{env}, I^n_{dir}, I^h_{diff}$
Z.PE.5
$\hat{E}_d$
$\hat{T}_z, \hat{T}_Z$
$(T_{env})_N, (I^n_{dir})_N, (I^h_{diff})_N$
Z.PE.6
$(E_d)_N$
parameters of the disturbance prediction model
$T_{env}, I^n_{dir}, I^h_{diff}$
SP
Z.PE.7
$(SP)_N$
parameters of the setpoint prediction model


piping data for floors & manufacturer catalogue data
Z.PE.1
Parameters of hydraulic, thermodynamics and electrical consumption model of a fan coil
Radiators parameters of hydraulic and thermodynamics model
Z.PE.4
(data recorded in special conditions)
simplified building zones model parameters
piping data
Z.PE.2
Z.PE.5
Z.MPC.1
Z.PE.6
parameters of the disturbance prediction model
SP
Z.PE.7
parameters of the setpoint prediction model
SP



piping data for floors & manufacturer catalogue data
Z.PE.1
Parameters of hydraulic, thermodynamics and electrical consumption model of a fan coil
Radiators parameters of hydraulic and thermodynamics model
piping data
Z.PE.2
Z.PE.4
(data recorded in special conditions)
simplified building zones model parameters
Z.PE.5
Z.PE.6
parameters of the disturbance prediction model
Z.PE.7
parameters of the setpoint prediction model
SP
Z.MPC.1
Summer
Z.I.1
Z.I.2
Winter
(Alternative)



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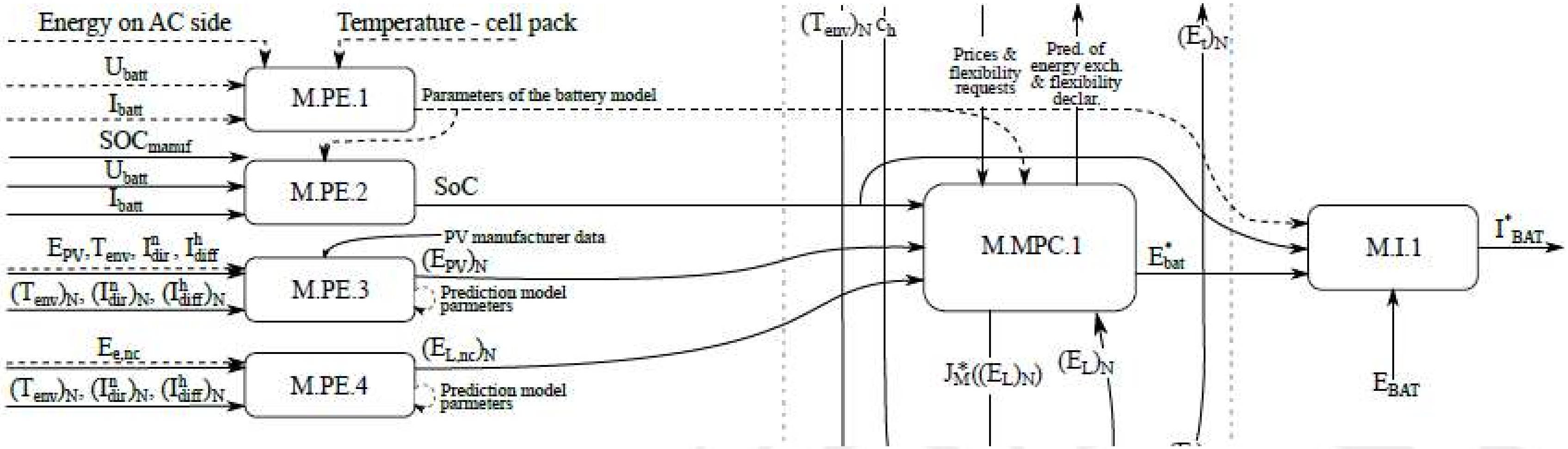
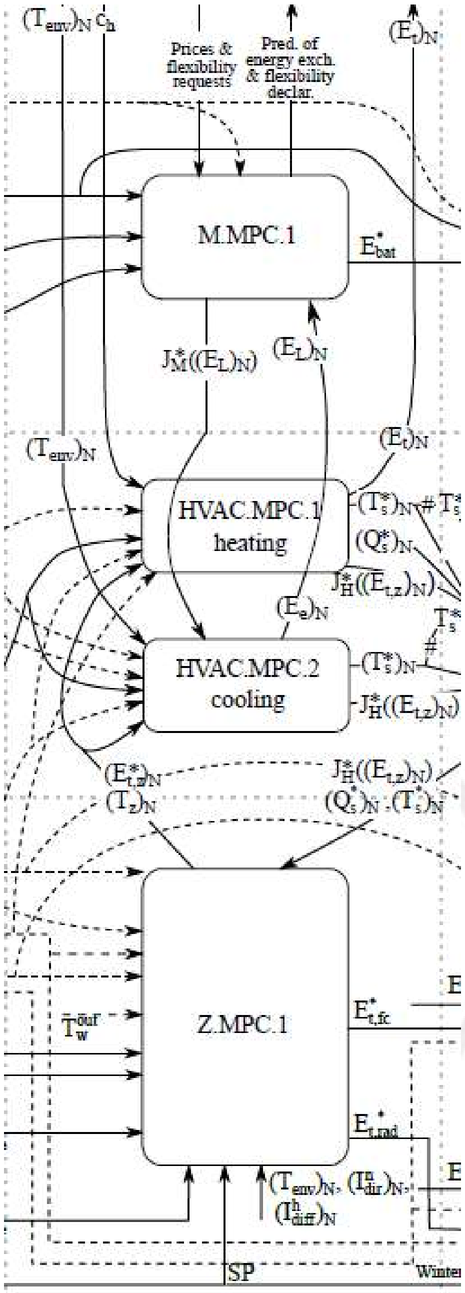

Energy on AC side
Temperature - cell pack
U_{batt}
I_{batt}
M.PE.1
Parameters of the battery model
SOC_{manuf}
U_{batt}
I_{batt}
M.PE.2
SoC
$E_{PV}, T_{env}, I^{n}_{dir}, I^{h}_{diff}$
$(T_{env})_N, (I^{n}_{dir})_N, (I^{h}_{diff})_N$
M.PE.3
PV manufacturer data
$(E_{PV})_N$
Prediction model parmeters
$E_{e,nc}$
$(T_{env})_N, (I^{n}_{dir})_N, (I^{h}_{diff})_N$
M.PE.4
$(E_{L,nc})_N$
Prediction model parmeters
$(T_{env})_N$ c_h
Prices & flexibility requests
Pred. of energy exch. & flexibility declar.
$(E_l)_N$
M.MPC.1
E^{*}_{bat}
$J^{*}_{M}((E_L)_N)$
$(E_L)_N$
M.I.1
I^{*}_{BAT}
E_{BAT}



HEP
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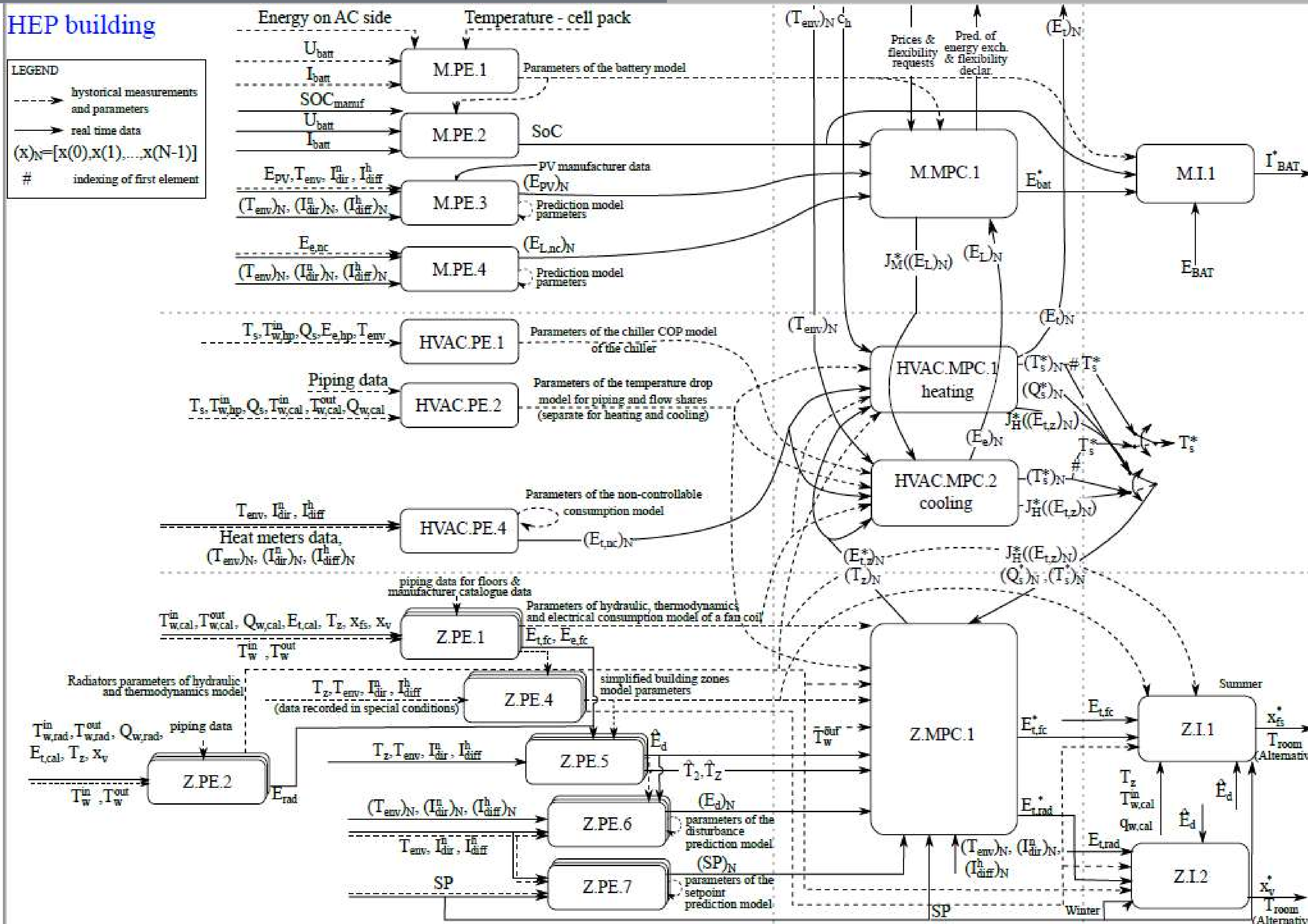
Danube Transnational Programme
3Smart


HEP building
LEGEND
hystorical measurements and parameters
real time data
$(x)_N=[x(0),x(1),\dots,x(N-1)]$
indexing of first element
Energy on AC side
Temperature - cell pack
U_{batt}
I_{batt}
M.PE.1
Parameters of the battery model
SOC_{manuf}
M.PE.2
SoC
$E_{PV}, T_{env}, I^n_{dir}, I^h_{diff}$
$(T_{env})_N, (I^n_{dir})_N, (I^h_{diff})_N$
M.PE.3
PV manufacturer data
$(E_{PV})_N$
Prediction model parmeters
$E_{e,nc}$
M.PE.4
$(E_{L,nc})_N$
Prediction model parmeters
M.MPC.1
E^*_{bat}
M.I.1
I^*_{BAT}
E_{BAT}
$(T_{env})_N$ c_h
Prices & flexibility requests
Pred. of energy exch. & flexibility declar.
$(E_t)_N$
$J^*_M((E_L)_N)$
$(E_L)_N$
$T_s, T^{in}_{w,hp}, Q_s, E_{e,hp}, T_{env}$
HVAC.PE.1
Parameters of the chiller COP model of the chiller
Piping data
$T_s, T^{in}_{w,hp}, Q_s, T^{in}_{w,cal}, T^{out}_{w,cal}, Q_{w,cal}$
HVAC.PE.2
Parameters of the temperature drop model for piping and flow shares (separate for heating and cooling)
HVAC.MPC.1 heating
$(T^*_s)_N$ # T^*_s
$(Q^*_s)_N$
$J^*_H((E_{t,z})_N)$
$(E_e)_N$
T^*_s
HVAC.MPC.2 cooling
$(T^*_s)_N$
$J^*_H((E_{t,z})_N)$
$T_{env}, I^n_{dir}, I^h_{diff}$
Heat meters data,
$(T_{env})_N, (I^n_{dir})_N, (I^h_{diff})_N$
HVAC.PE.4
Parameters of the non-controllable consumption model
$(E_{t,nc})_N$
$(E^*_{t,z})_N$
$(T_z)_N$
$J^*_H((E_{t,z})_N)$
$(Q^*_s)_N, (T^*_s)_N$
piping data for floors & manufacturer catalogue data
$T^{in}_{w,cal}, T^{out}_{w,cal}, Q_{w,cal}, E_{t,cal}, T_z, x_{fs}, x_v$
T^{in}_w, T^{out}_w
Z.PE.1
Parameters of hydraulic, thermodynamics and electrical consumption model of a fan coil
$E_{t,fc}, E_{e,fc}$
Radiators parameters of hydraulic and thermodynamics model
$T_z, T_{env}, I^n_{dir}, I^h_{diff}$
(data recorded in special conditions)
Z.PE.4
simplified building zones model parameters
$T^{in}_{w,rad}, T^{out}_{w,rad}, Q_{w,rad}$, piping data
$E_{t,cal}, T_z, x_v$
Z.PE.2
T^{in}_w, T^{out}_w
E_{rad}
$T_z, T_{env}, I^n_{dir}, I^h_{diff}$
Z.PE.5
$\hat{E}_d$
$\hat{T}_z, \hat{T}_z$
$(T_{env})_N, (I^n_{dir})_N, (I^h_{diff})_N$
Z.PE.6
$(E_d)_N$
parameters of the disturbance prediction model
$T_{env}, I^n_{dir}, I^h_{diff}$
SP
Z.PE.7
$(SP)_N$
parameters of the setpoint prediction model
T^{out}_w
Z.MPC.1
$E^*_{t,fc}$
$E^*_{t,rad}$
$(T_{env})_N, (I^n_{dir})_N, (I^h_{diff})_N$
SP
Summer
$E_{t,fc}$
Z.I.1
x^*_{fs}
T_{room} (Alternative)
T_z
$T^{in}_{w,cal}$
$q_{w,cal}$
$\hat{E}_d$
$E_{t,rad}$
Z.I.2
Winter
x^*_v
T_{room} (Alternative)

3Smart First pilot study visit to the Croatian pilot: On-line demonstrations: 3Smart modules installed on UNIZGFER

Anita Martinčević, Nikola Hure, Danko Marušić, Hrvoje Novak

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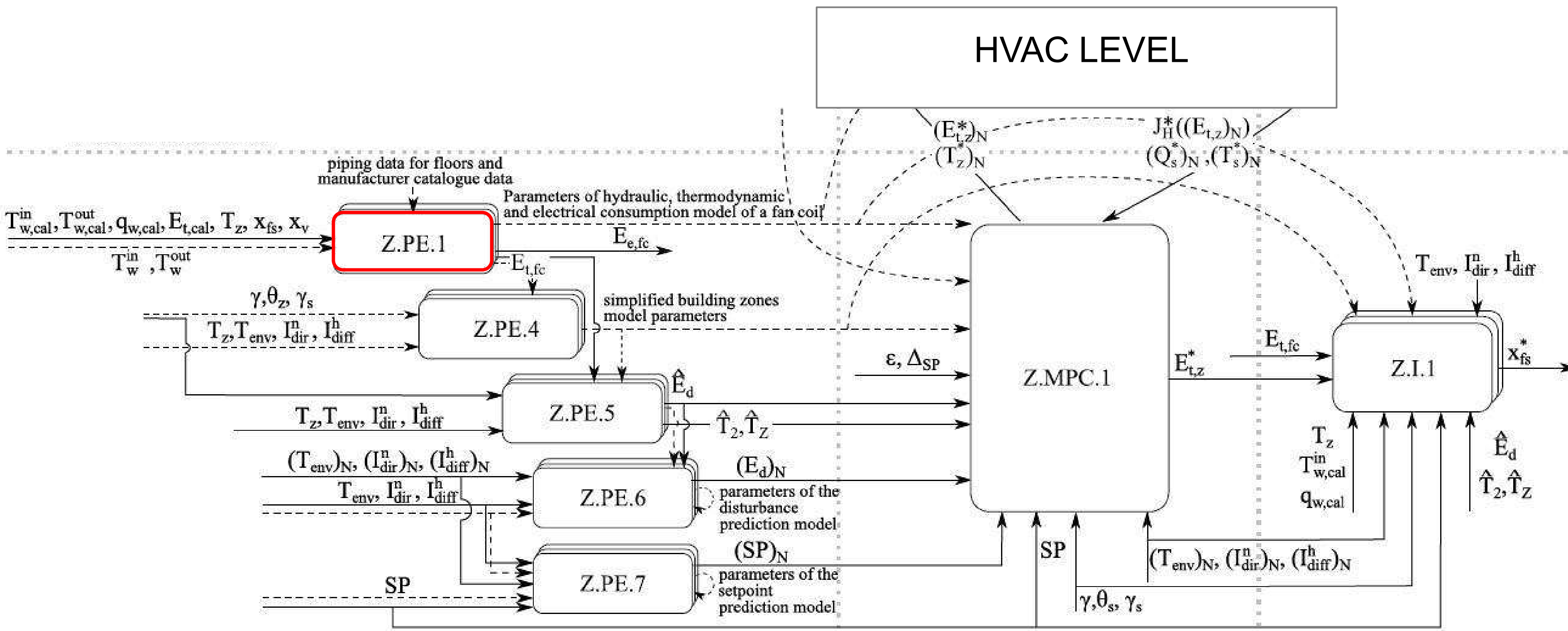
3Smart pilot study visit to HR pilot No. 1 in Zagreb

12 December 2018

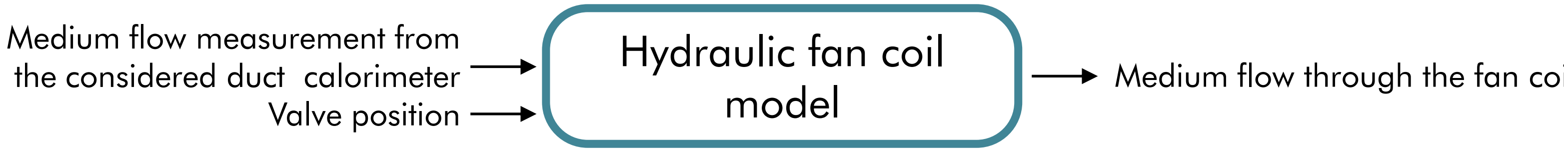
Zone-level modules UNIZGFER

Z.PE.1 – offline (fan coil identification submodule)

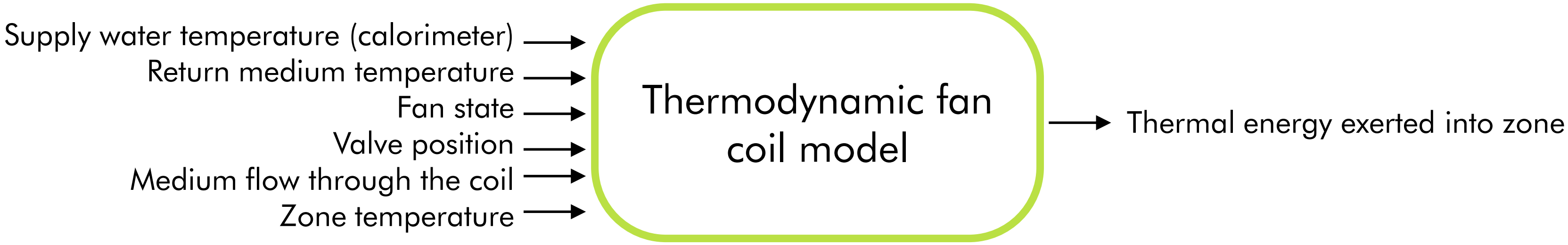


Z.PE.1 – offline (fan coil identification submodule)

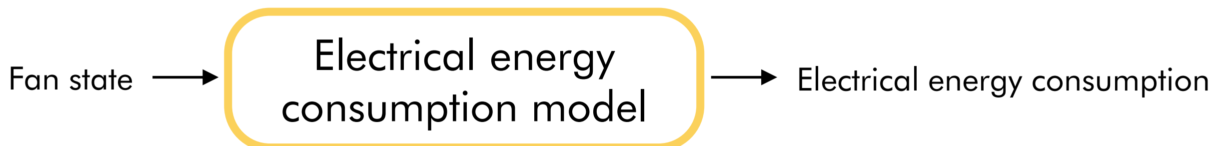
- Identification of hydraulic fan coil model - based on experimental data recorded under special conditions or piping data for floors and pressure drop data from manufacturer's catalogue



- Identification of thermodynamic fan coil model based on experimental data (data recorded in special conditions)

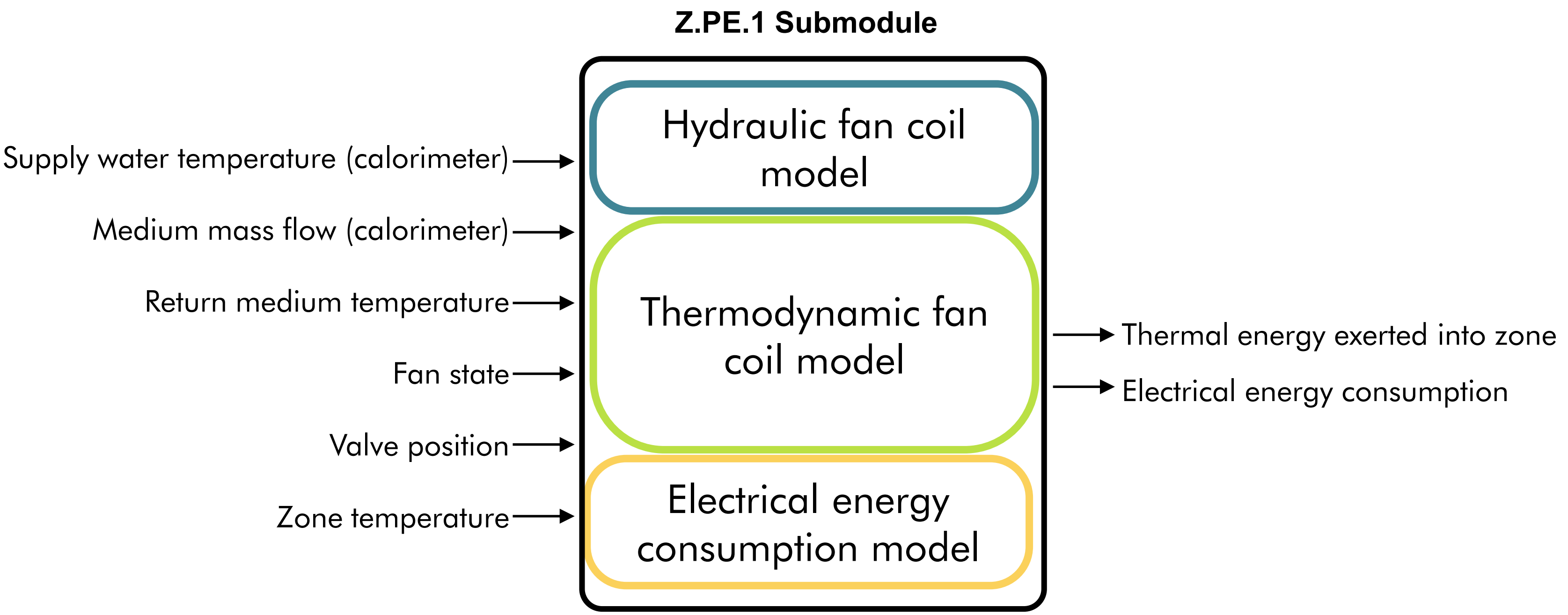


- Identification of electrical energy consumption model of fan coil unit based on the manufacturer's catalogue data



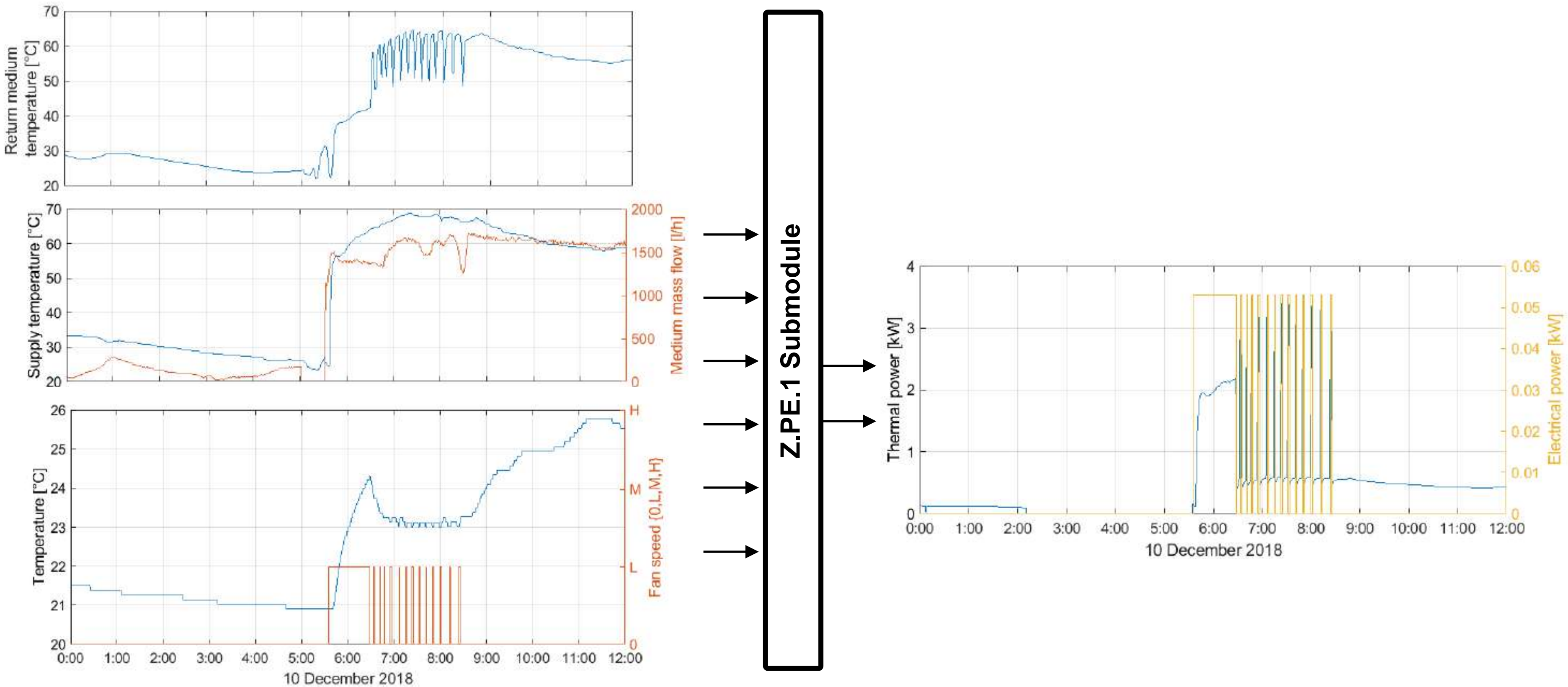
Z.PE.1 – online (fan coil identification submodule)

- Based on the identified hydraulic, thermodynamic and electrical energy consumption fan coil models and available measurements calculate the thermal and electrical consumption of every monitored fan coil unit

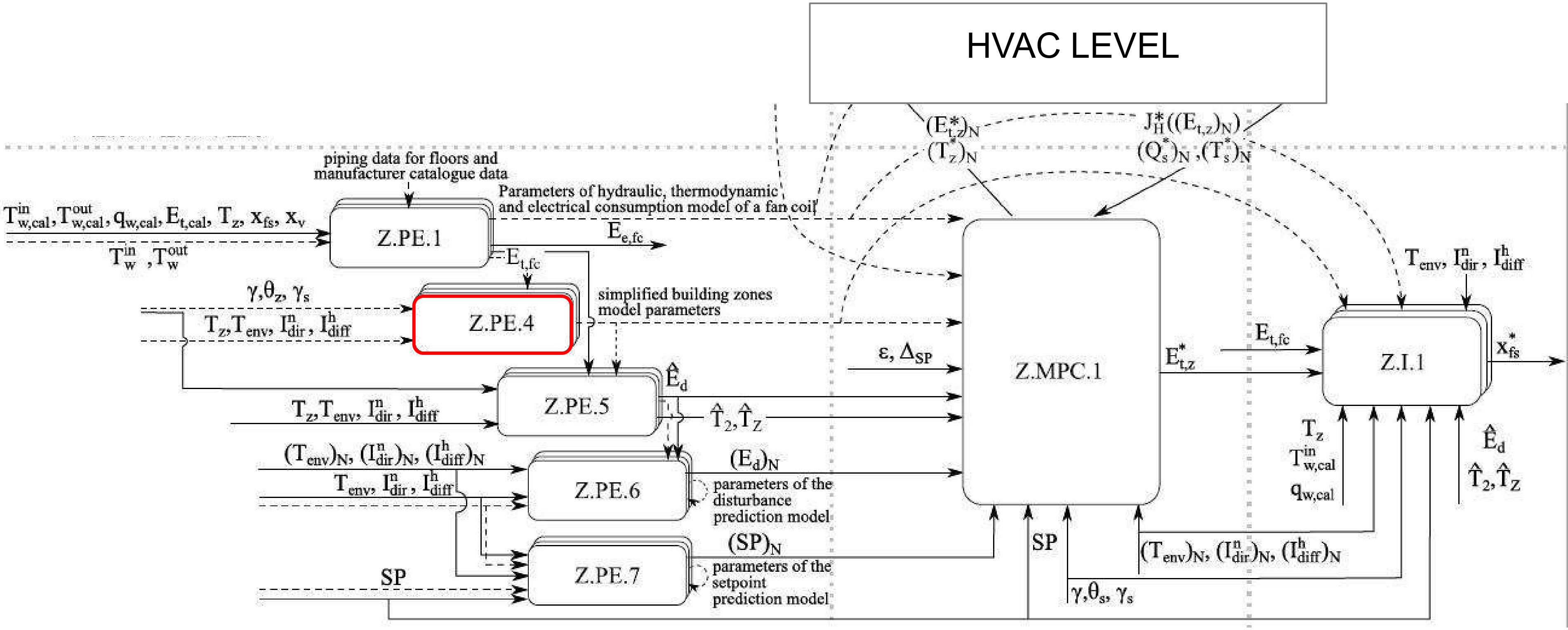


Z.PE.1 – online (fan coil identification submodule)

- Based on the identified hydraulic, thermodynamic and electrical energy consumption fan coil models and available measurements calculate the thermal and electrical consumption of every monitored fan coil unit



Zone PE 4 (identification of the simplified building thermodynamic model)



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Zone PE 4
(identification of the simplified building thermodynamic model)

Output	Notation
Parameters of the simplified building thermal dynamics model	$A_{room}, B_{room}, C_{room}, D_{room}$

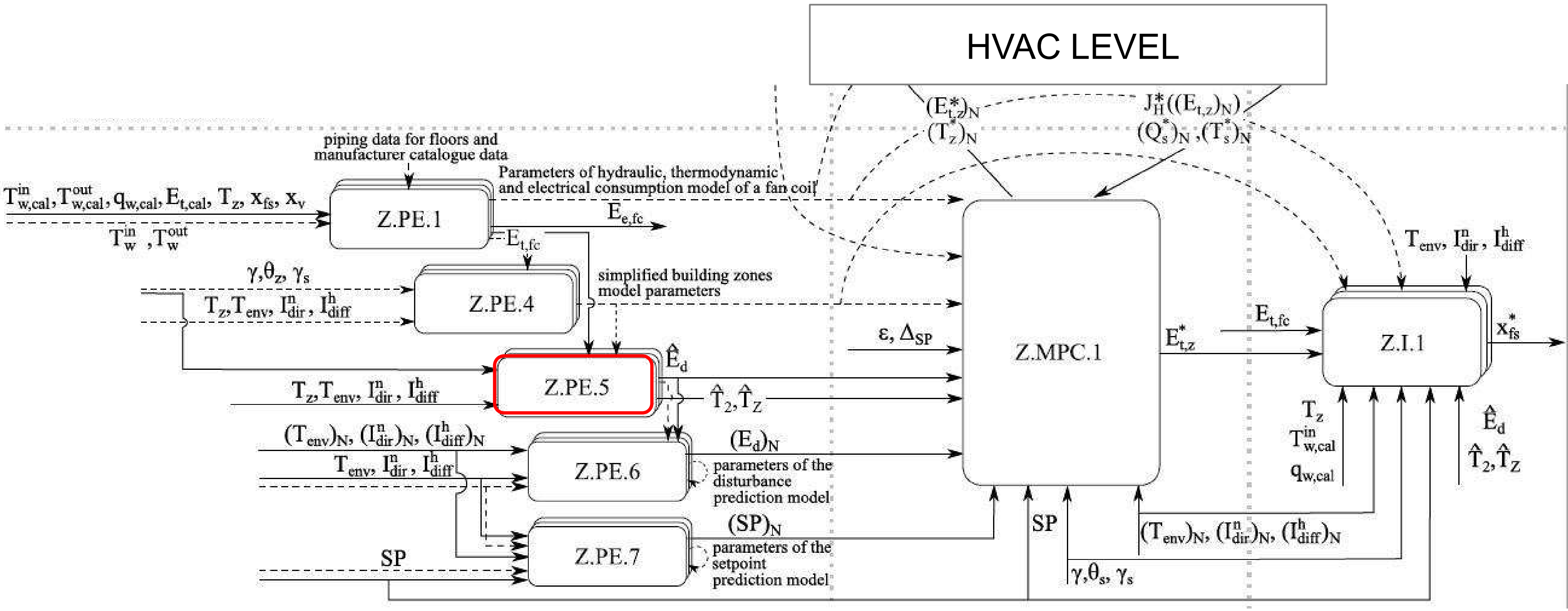
```
{
"A": [[a11, a12], [a21, a22]],
"B": [[b11, b12(N), b13(E), b14(S), b15(W), b16(N), b17(E), b18(S), b19(W), b20],
     [0, 0, 0, 0, 0, 0, 0, 0, 0, 0]],
"description": "zone_name",
"orientation": "orientation_of_external_walls"
}
```

CONTIONUS ZONE MODEL

{"A":[[-0.000879305204326003, 0.000844044113912501],
[6.20735302428606e-05, -6.20735302428606e-05]],
"B":[[3.52610904135020e-05,0,0,2.23001608550947e-06,0,0,0,4.51800104606322e-06,0,0.0014167773877100],
[0,0,0,0,0,0,0,0,0,0]],
"description":"C09-10",
"orientation":"S"}

Zone PE 5

(estimation of the states of the simplified building thermal dynamics model including also the estimation of heat disturbance in zone)



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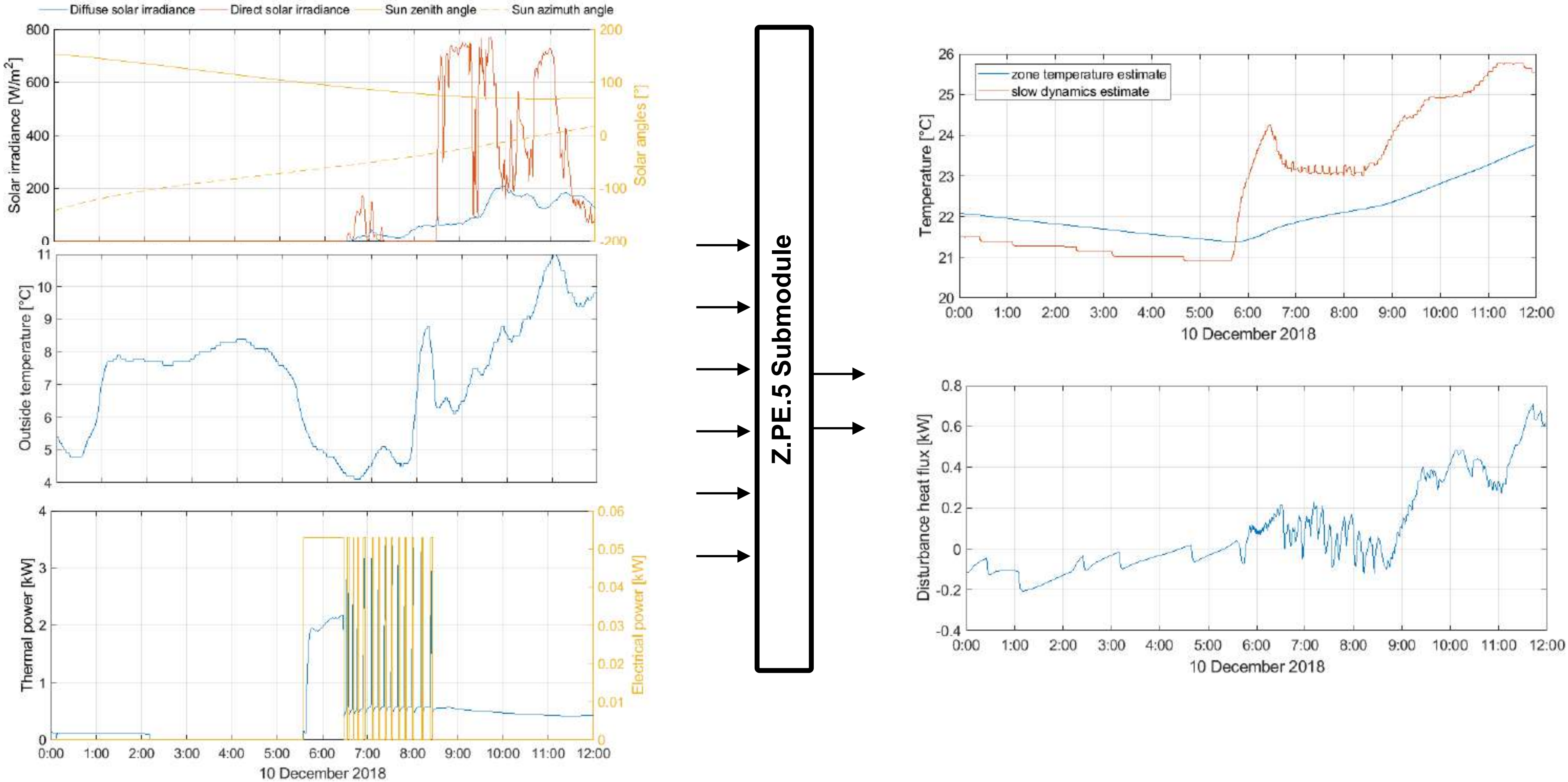
Zone PE 5

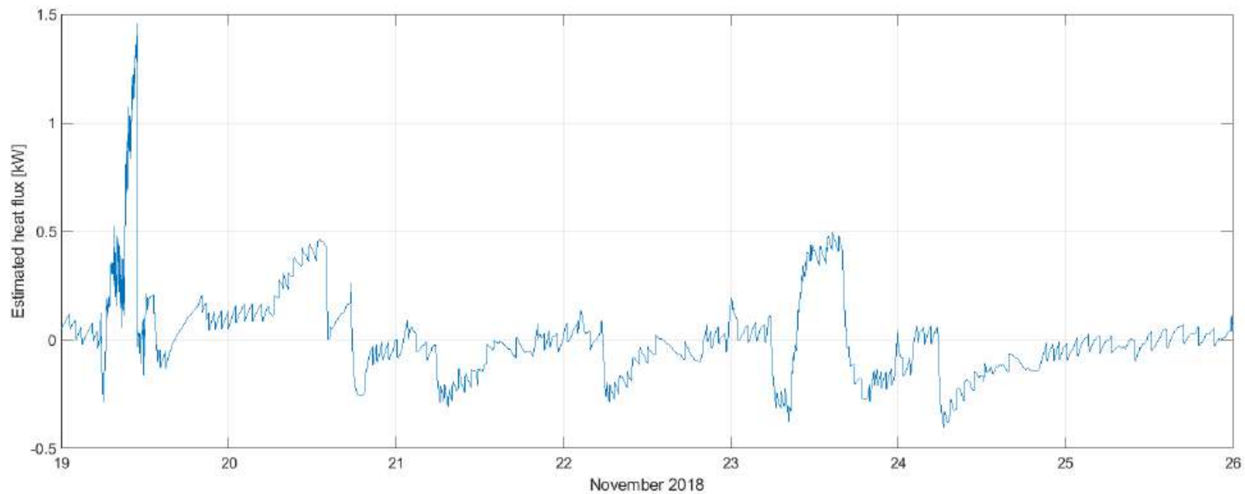
(estimation of the states of the simplified building thermal dynamics model including also the estimation of heat disturbance in zone)

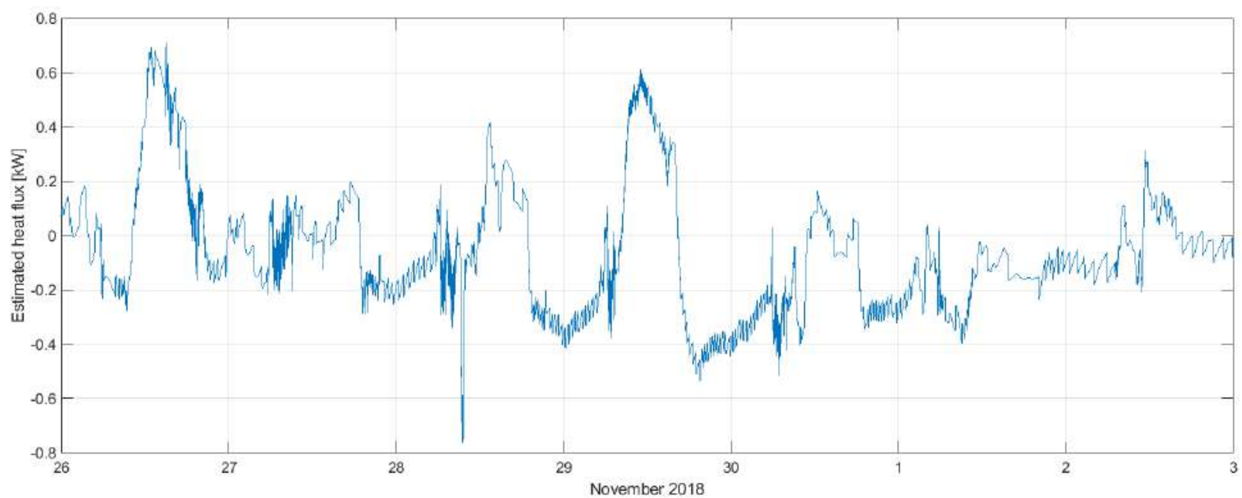


FER
Interreg
Danube Transnational Programme
3Smart

Zone PE 5

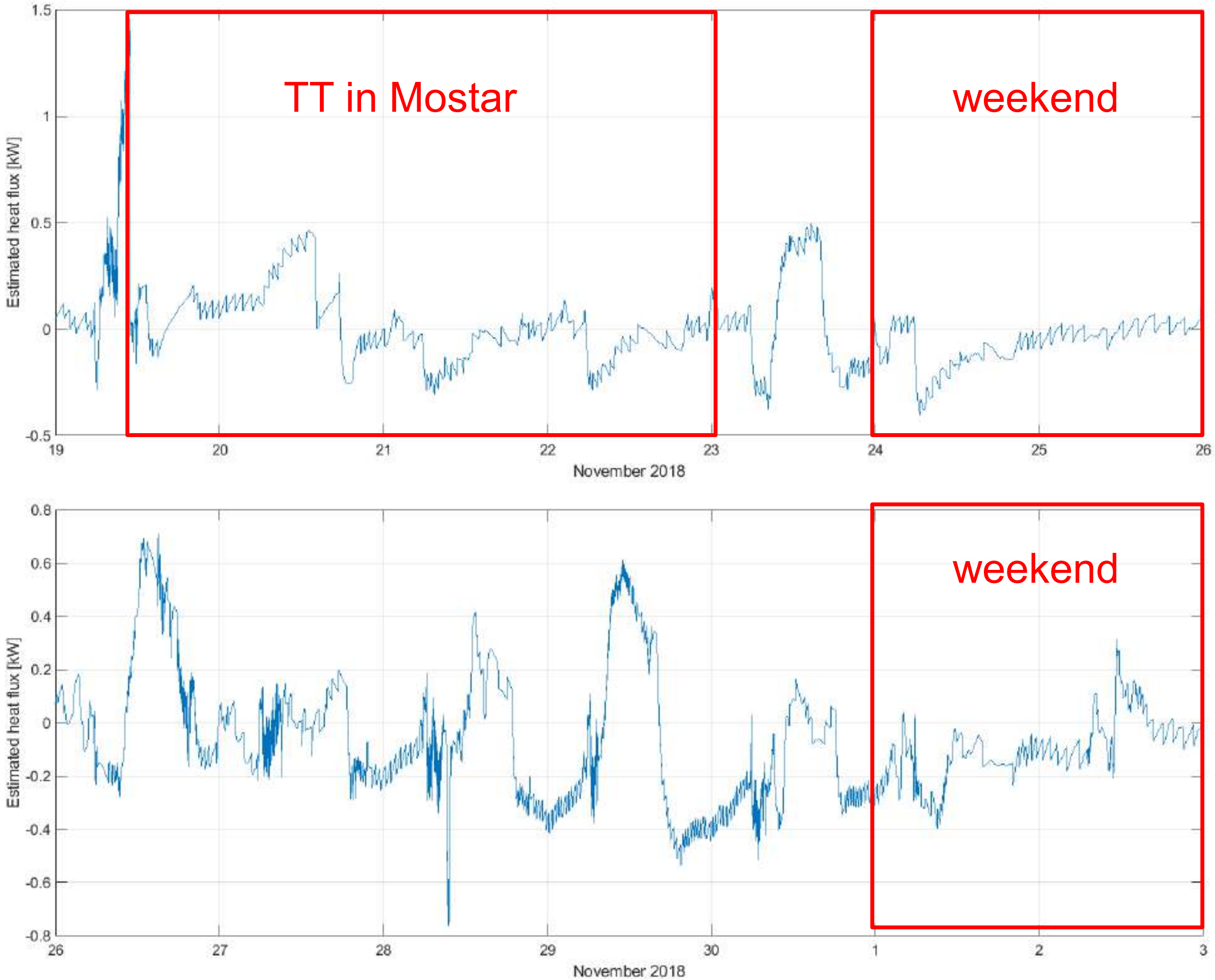
(estimation of the states of the simplified building thermal dynamics model including also the estimation of heat disturbance in zone)





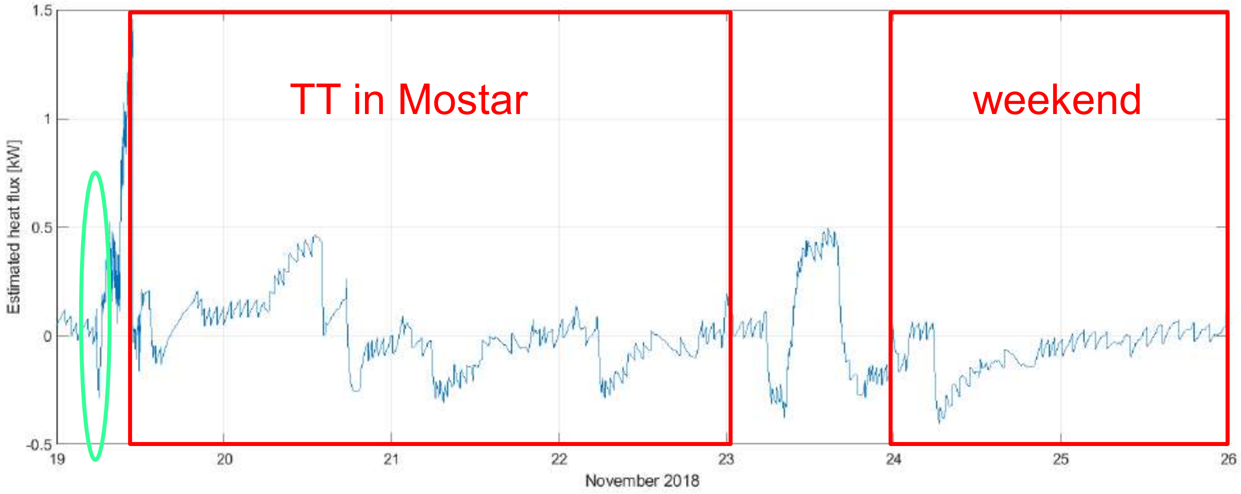
Zone PE 5

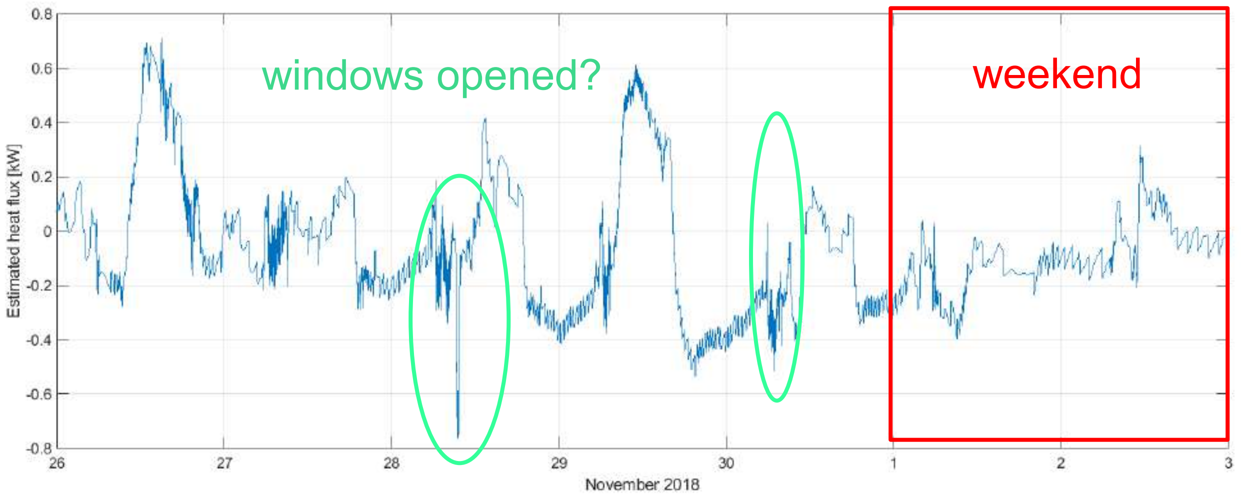
(estimation of the states of the simplified building thermal dynamics model including also the estimation of heat disturbance in zone)



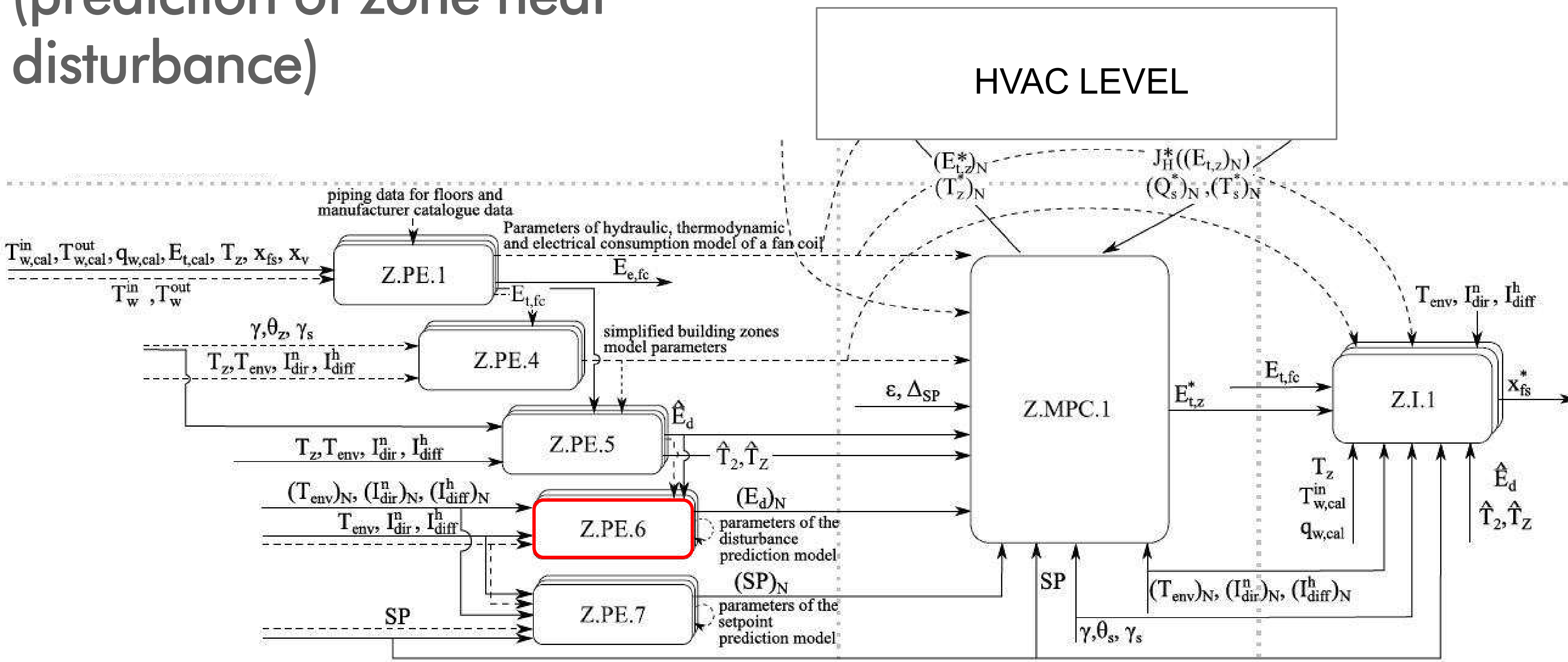
Zone PE 5

(estimation of the states of the simplified building thermal dynamics model including also the estimation of heat disturbance in zone)

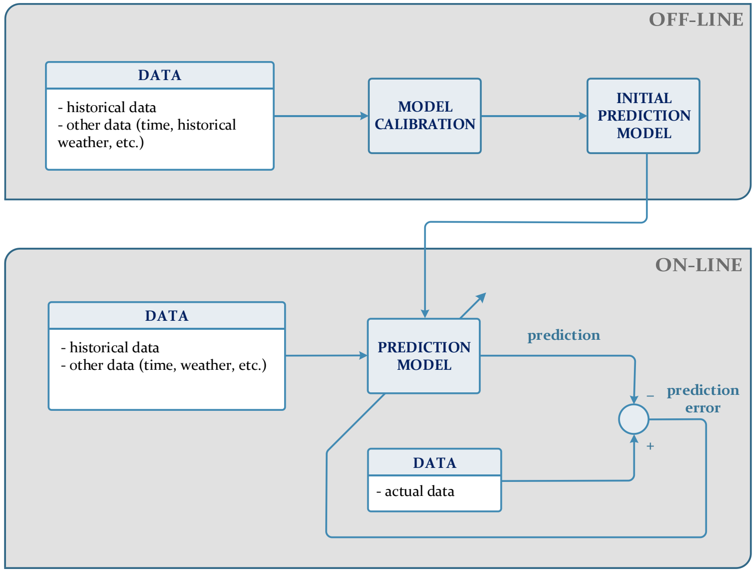




Zone PE 6 (prediction of zone heat disturbance)

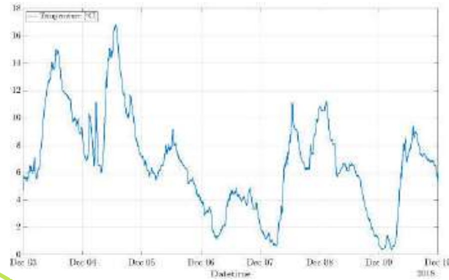


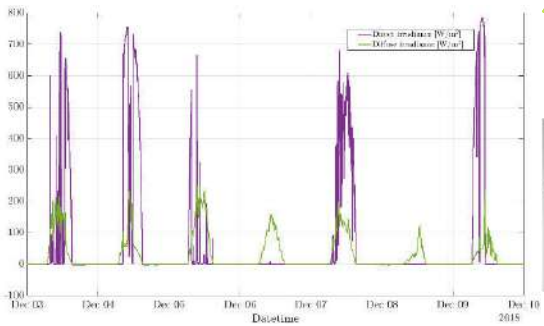
Zone PE 6 – off-line initialization



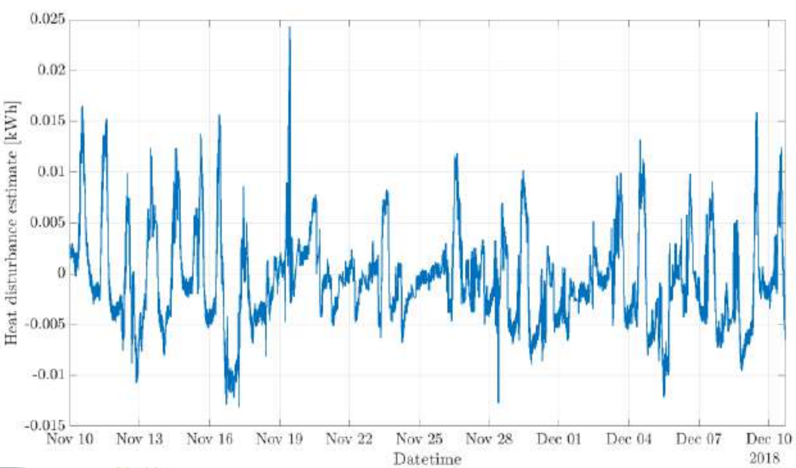
Zone PE 6 – off-line initialization

Historical **weather measurements**:
- Temperature
- Direct, diffuse solar irradiance

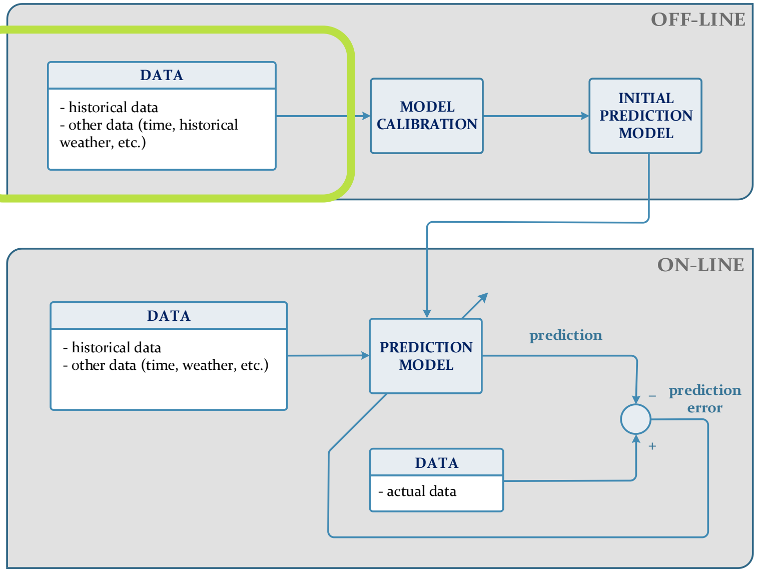


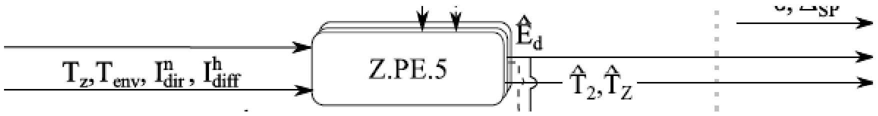


Historical **heat disturbance estimate**

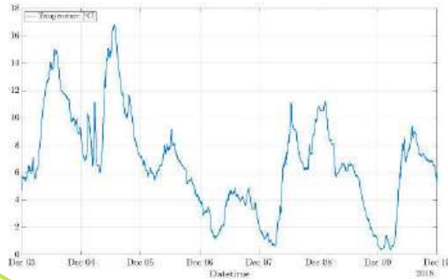


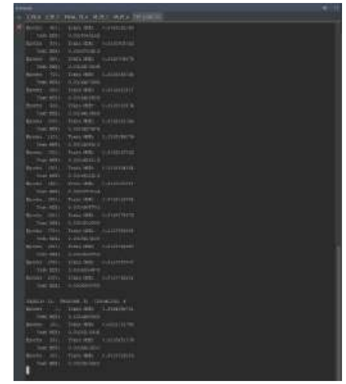
MODULE INPUTS



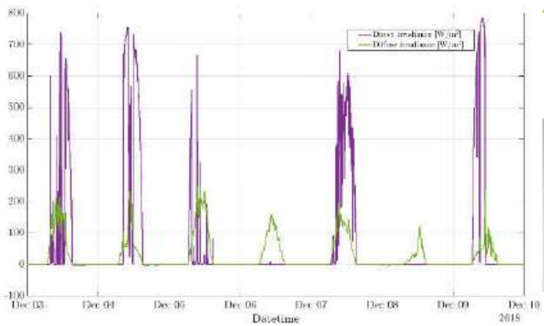


Zone PE 6 – off-line initialization

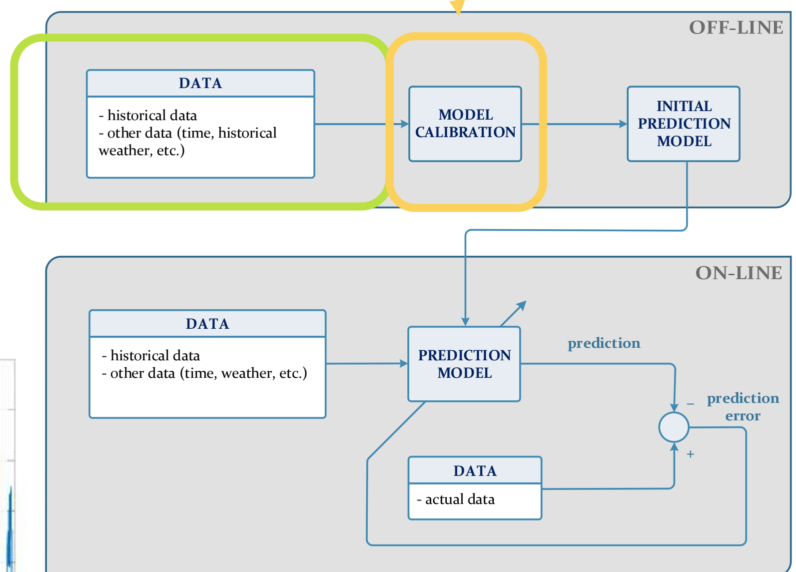




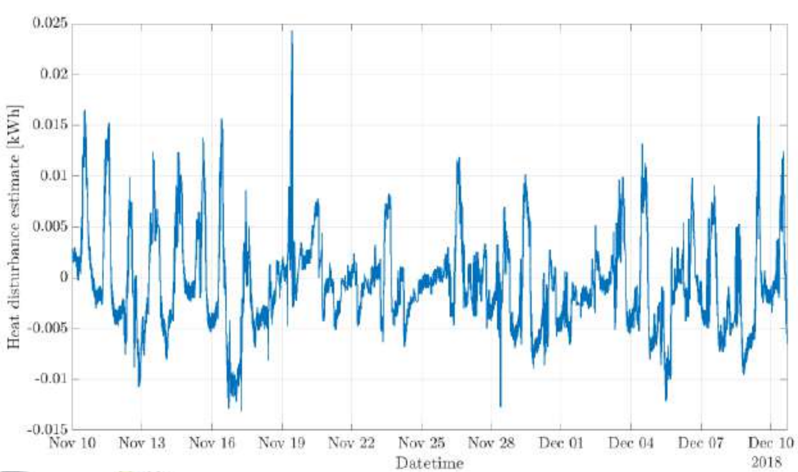
Historical **weather measurements**:
- Temperature
- Direct, diffuse solar irradiance

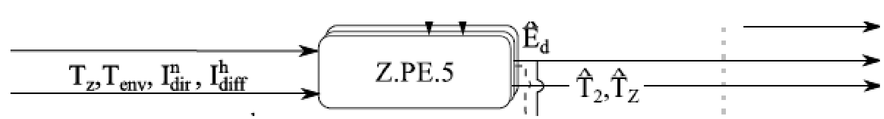


MODULE INPUTS

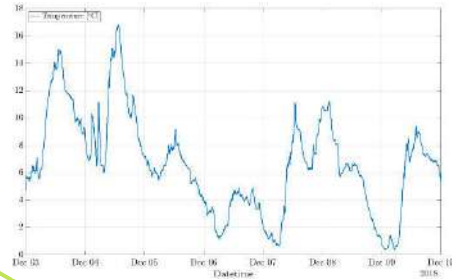


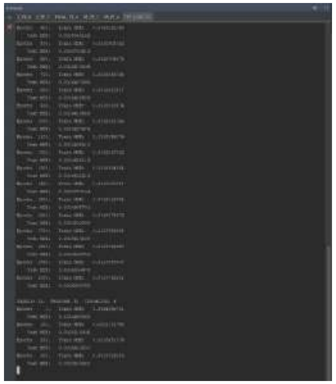
Historical **heat disturbance estimate**





Zone PE 6 – off-line initialization

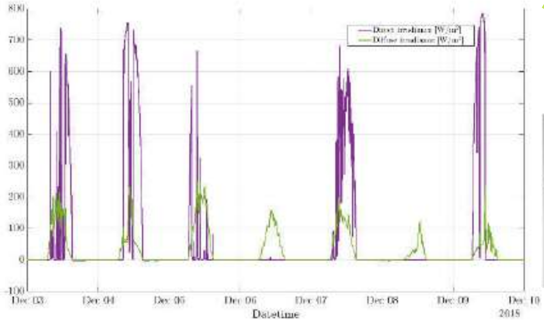




Locally stored:
inputsXY_neuronsZ.net

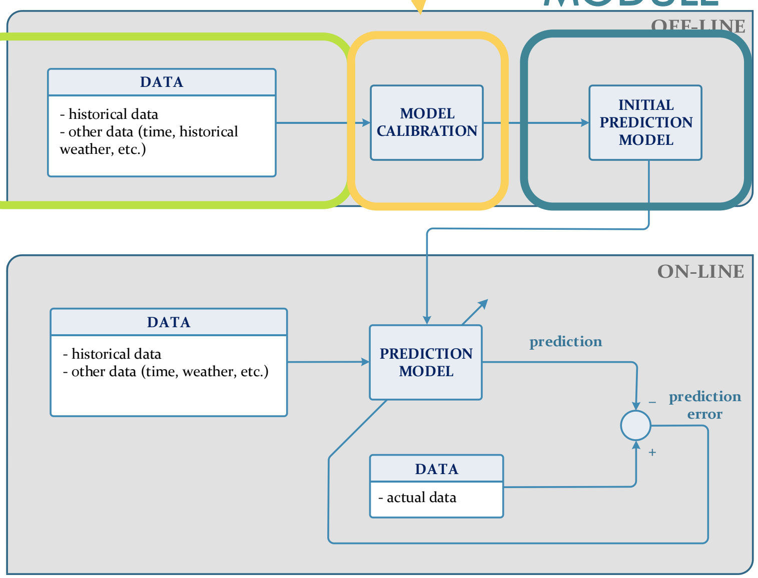
Historical **weather measurements**:

- Temperature
- Direct, diffuse solar irradiance

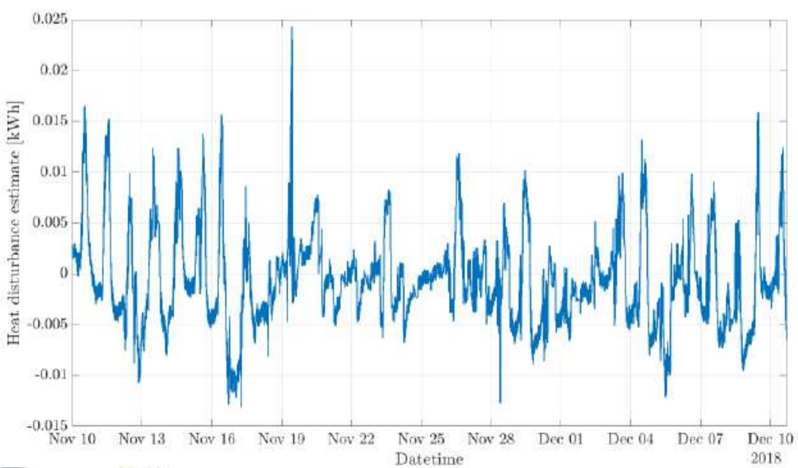


MODULE INPUTS

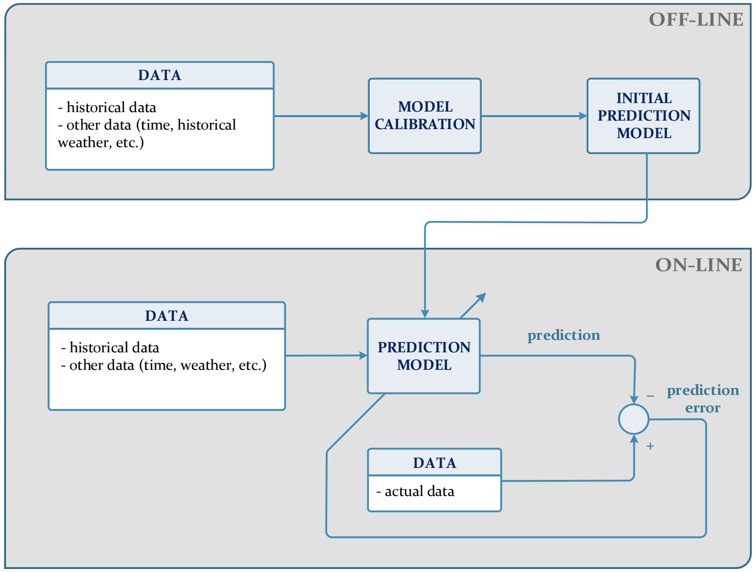
MODULE



Historical **heat disturbance estimate**



Zone PE 6 – on-line operation



Zone PE 6 – on-line operation

Regressor created from specific historical intervals of data:

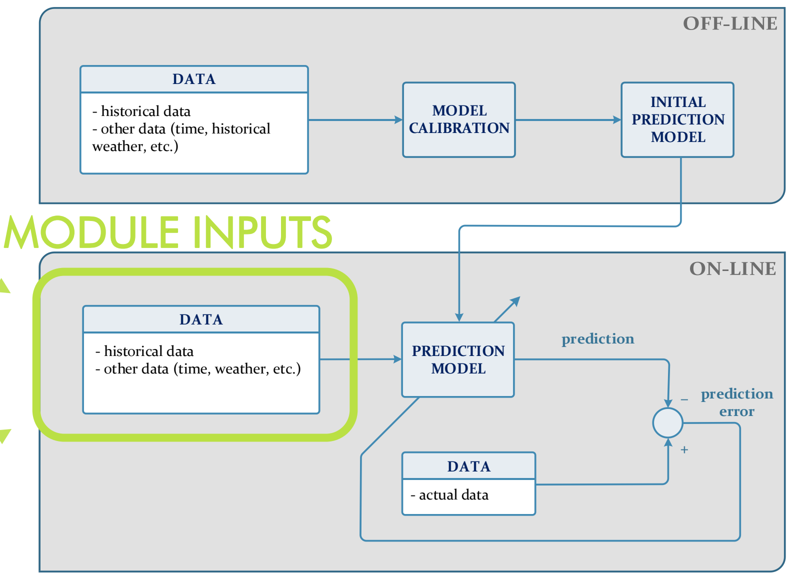
- heat disturbance(t-1,...,t-5)
- heat disturbance(t-46,...,t-50)
- heat disturbance(t-166,...,t-170)

- tau_s_d, tau_c_d
- tau_s_w, tau_c_w
- tau_s_y, tau_c_y

- temperature(t-1,...,t-3)
- temperature(t-47,...,t-49)
- temperature(t-167,...,t-169)

- direct irradiance(t-1,...,t-3)
- direct irradiance(t-47,...,t-49)
- direct irradiance(t-167,...,t-169)

- diffuse irradiance(t-1,...,t-3)
- diffuse irradiance(t-47,...,t-49)
- diffuse irradiance(t-167,...,t-169)



Zone PE 6 – on-line operation

Regressor created from specific historical intervals of data:

- heat disturbance(t-1,…,t-5)
- heat disturbance(t-46,…,t-50)
- heat disturbance(t-166,…,t-170)

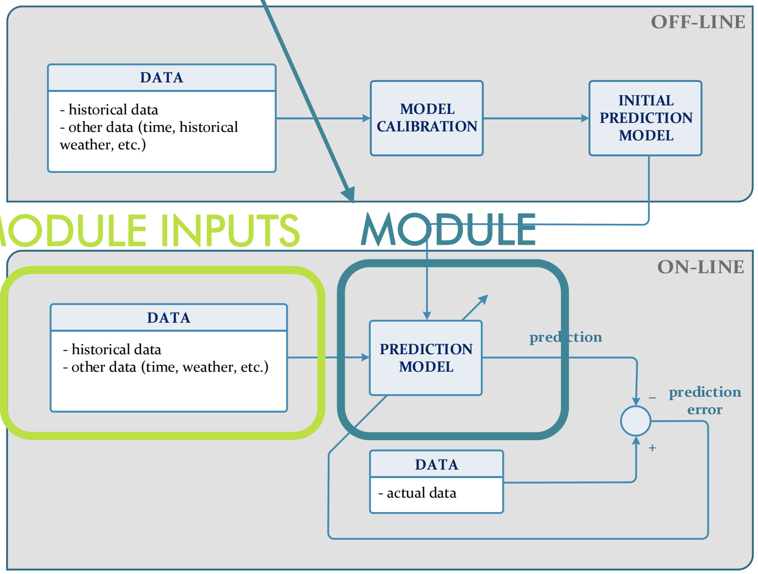
- tau_s_d, tau_c_d
- tau_s_w, tau_c_w
- tau_s_y, tau_c_y

- temperature(t-1,…,t-3)
- temperature(t-47,…,t-49)
- temperature(t-167,…,t-169)

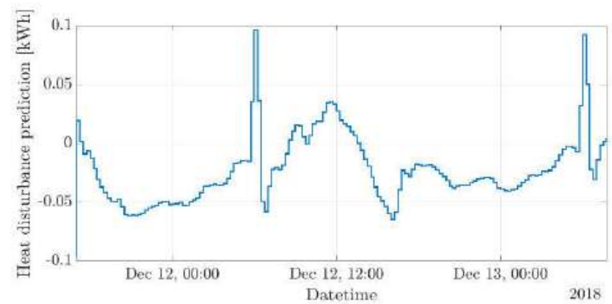
- direct irradiance(t-1,…,t-3)
- direct irradiance(t-47,…,t-49)
- direct irradiance(t-167,…,t-169)

- diffuse irradiance(t-1,…,t-3)
- diffuse irradiance(t-47,…,t-49)
- diffuse irradiance(t-167,…,t-169)

Locally stored:
inputsXY_neuronsZ.net



Zone PE 6 – on-line operation



Locally stored:
inputsXY_neuronsZ.net

Regressor created from specific historical intervals of data:

- heat disturbance(t-1,…,t-5)
- heat disturbance(t-46,…,t-50)
- heat disturbance(t-166,…,t-170)

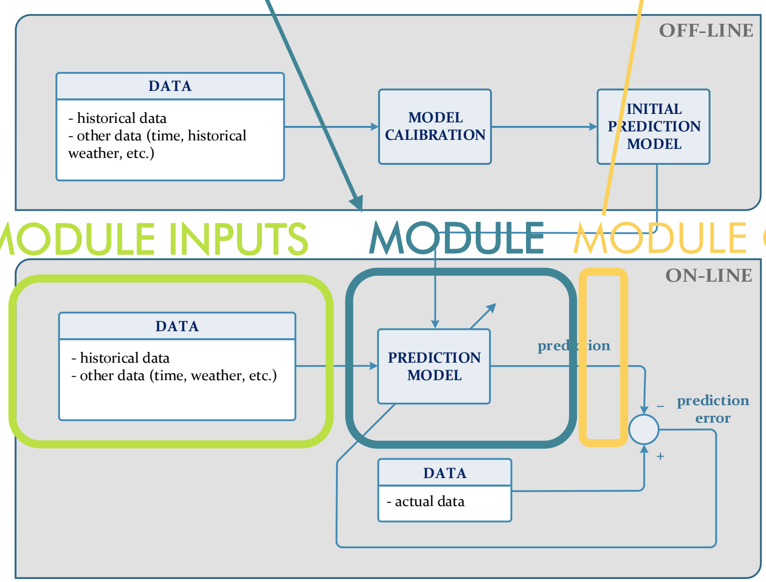
- tau_s_d, tau_c_d
- tau_s_w, tau_c_w
- tau_s_y, tau_c_y

- temperature(t-1,…,t-3)
- temperature(t-47,…,t-49)
- temperature(t-167,…,t-169)

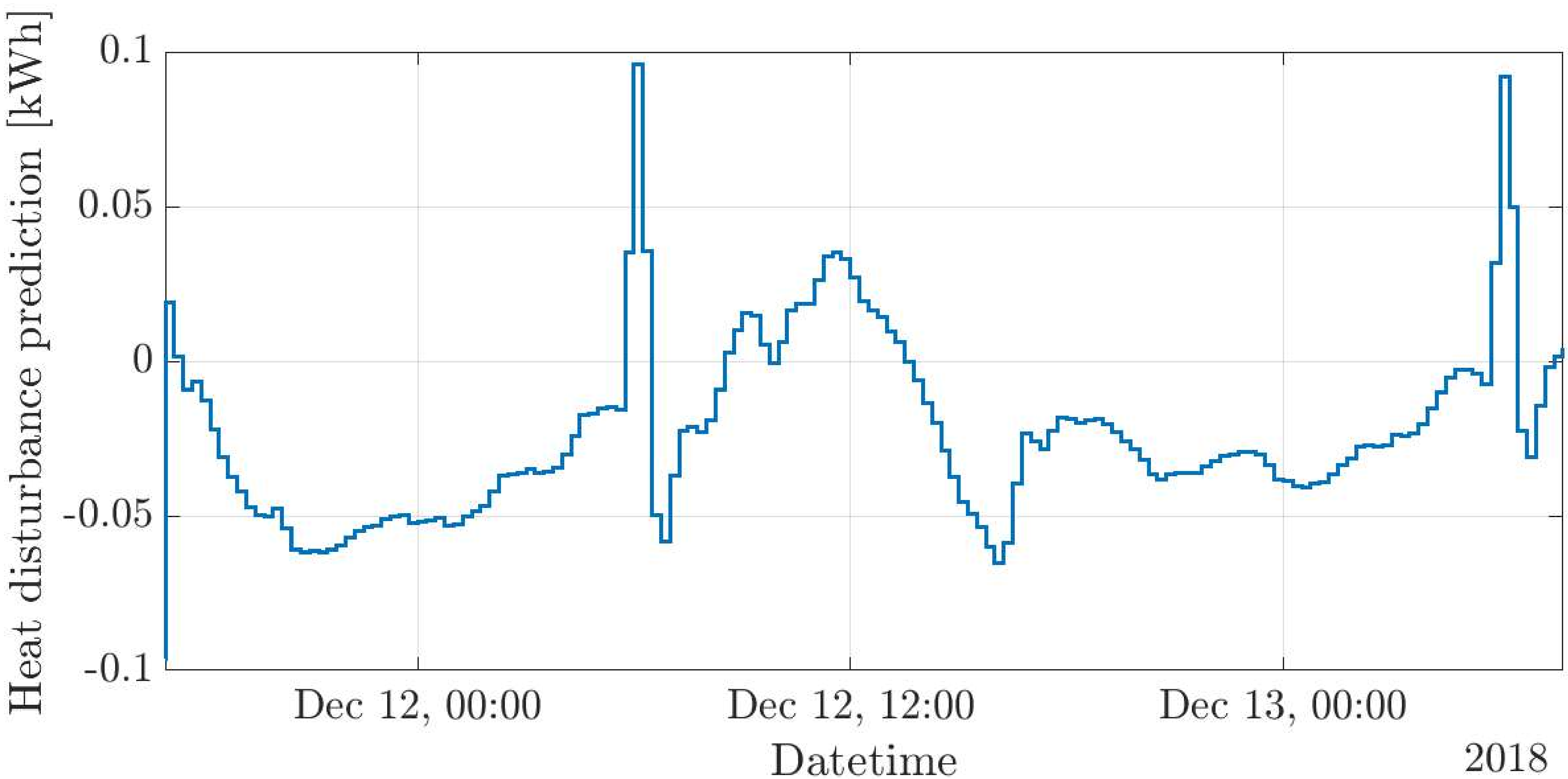
- direct irradiance(t-1,…,t-3)
- direct irradiance(t-47,…,t-49)
- direct irradiance(t-167,…,t-169)

- diffuse irradiance(t-1,…,t-3)
- diffuse irradiance(t-47,…,t-49)
- diffuse irradiance(t-167,…,t-169)

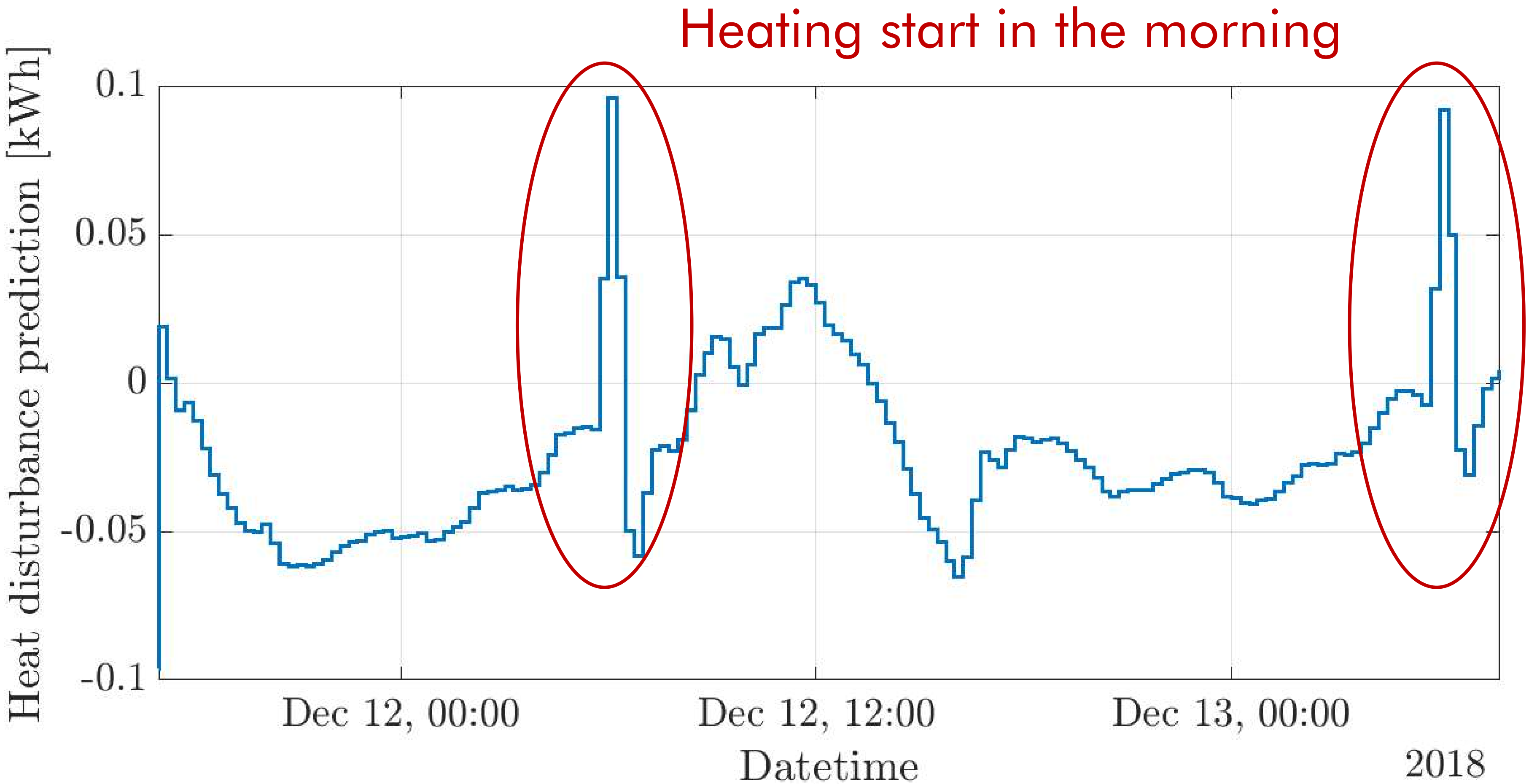
MODULE INPUTS MODULE MODULE OUTPUTS



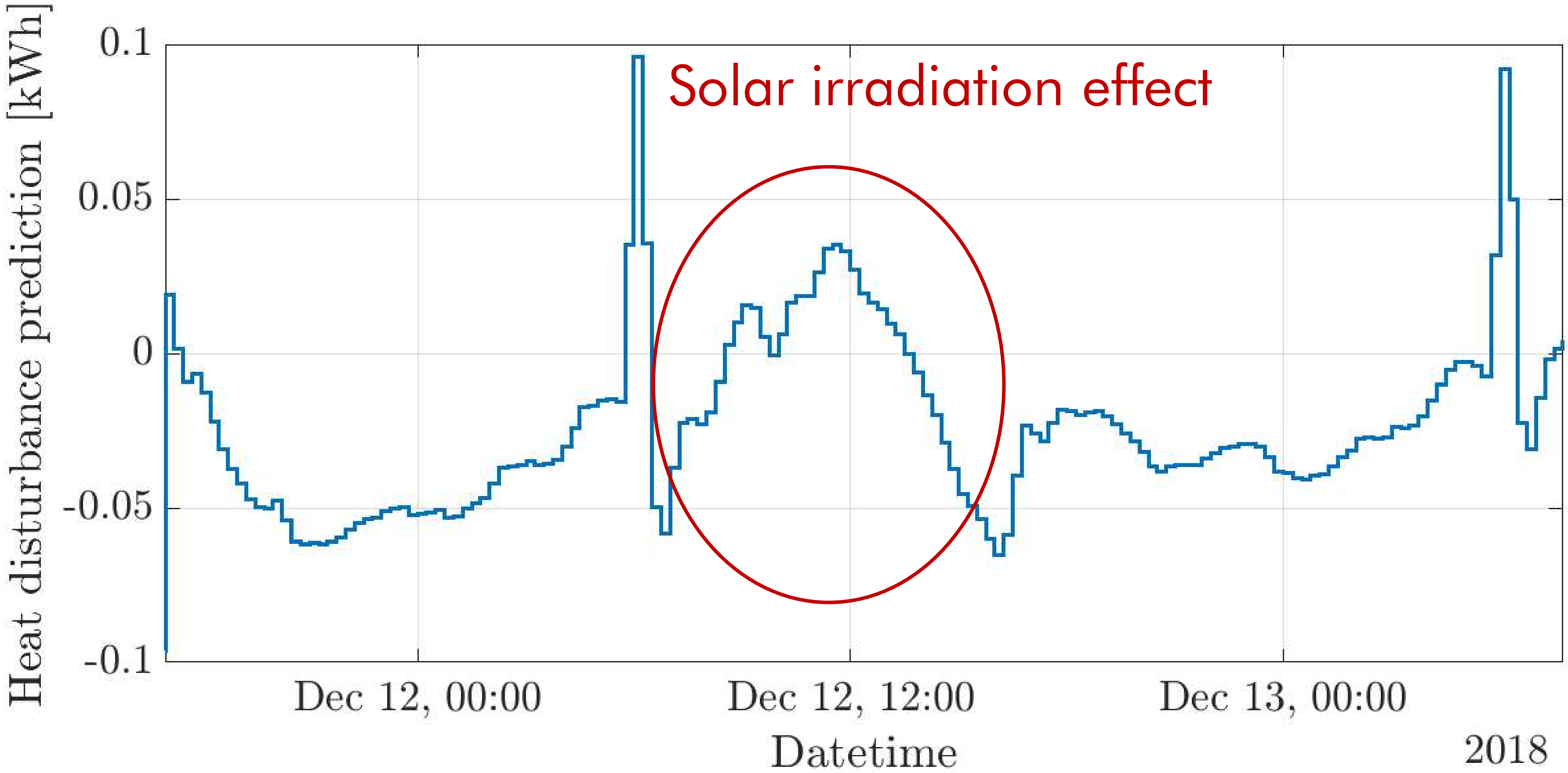
Zone PE 6 – on-line operation



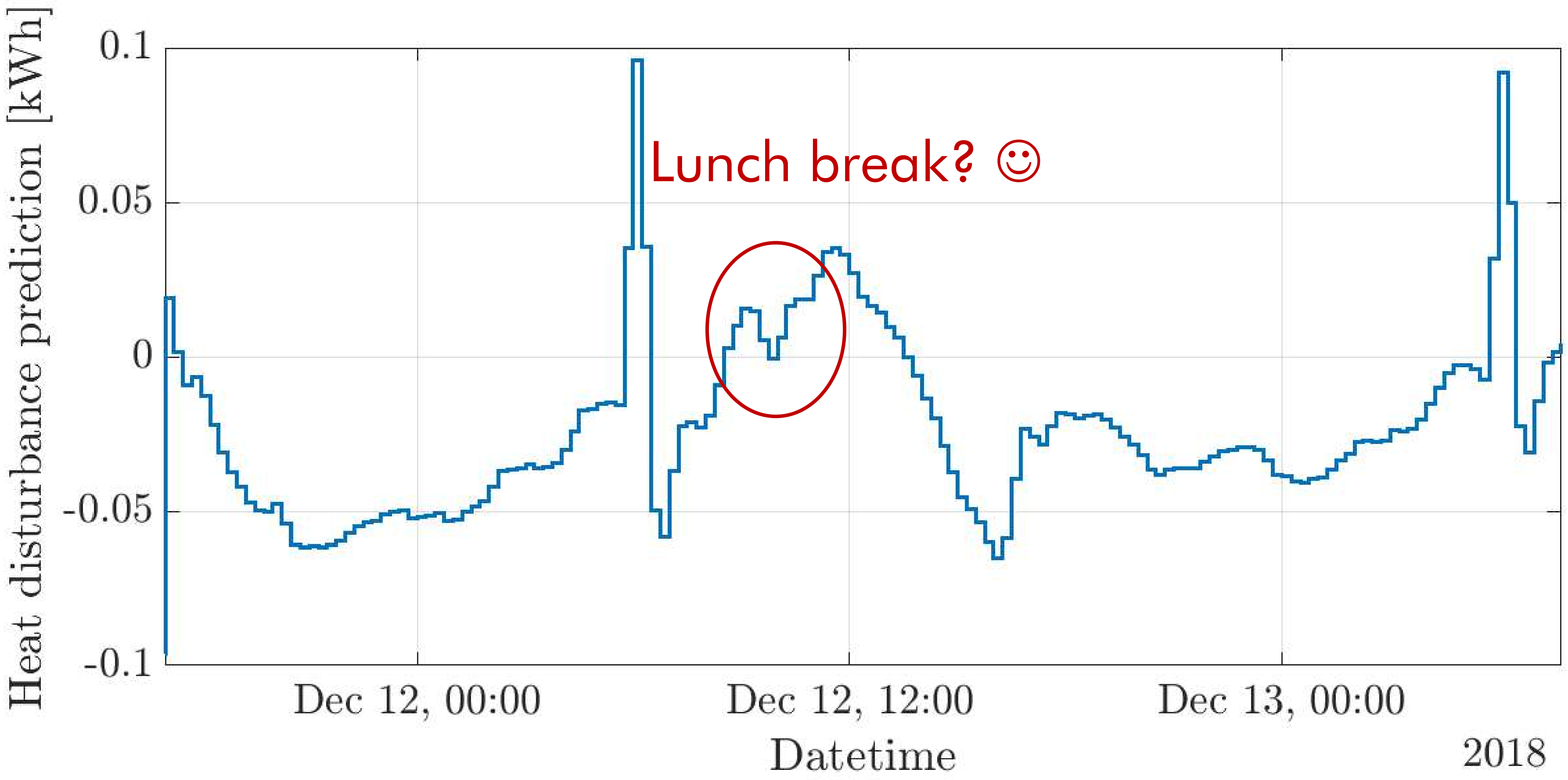
Zone PE 6 – on-line operation



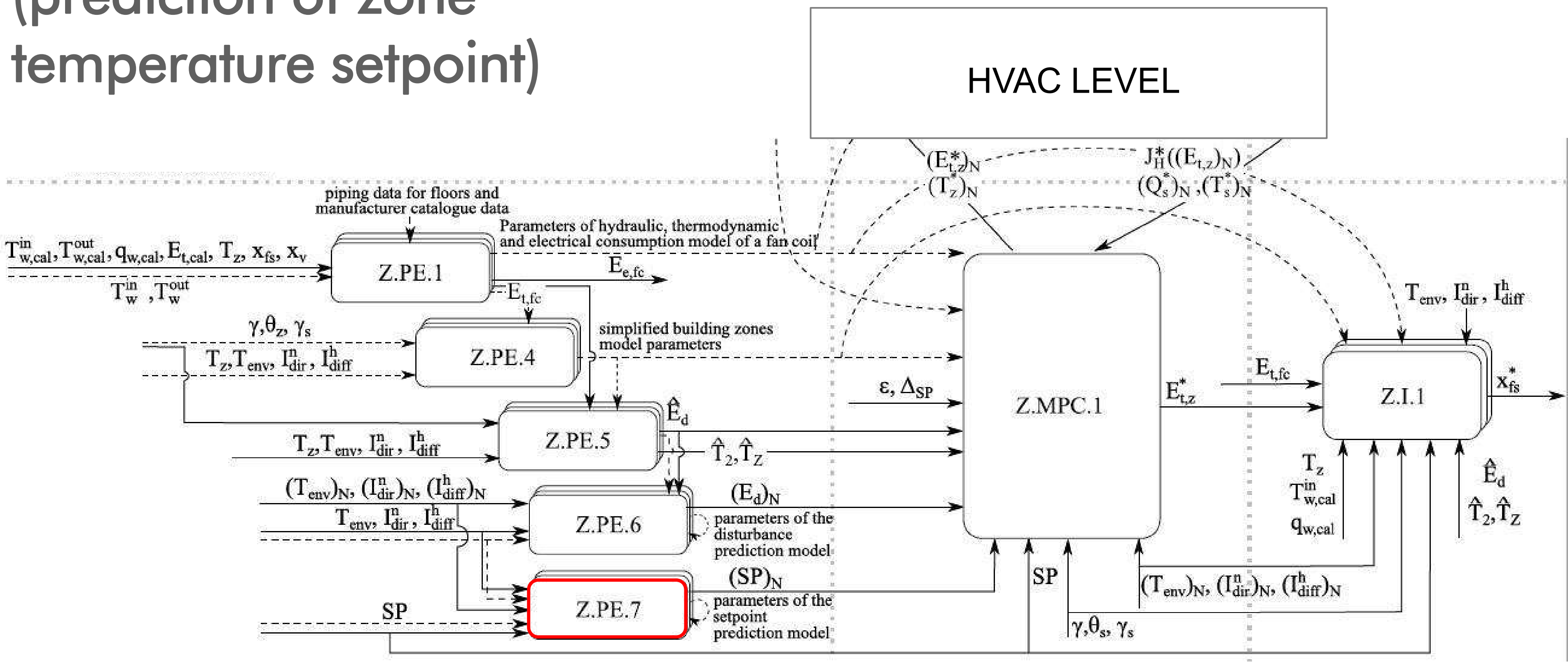
Zone PE 6 – on-line operation



Zone PE 6 – on-line operation



Zone PE 7 (prediction of zone temperature setpoint)



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Zone PE 7 – zone in auto mode

MODULE INPUTS

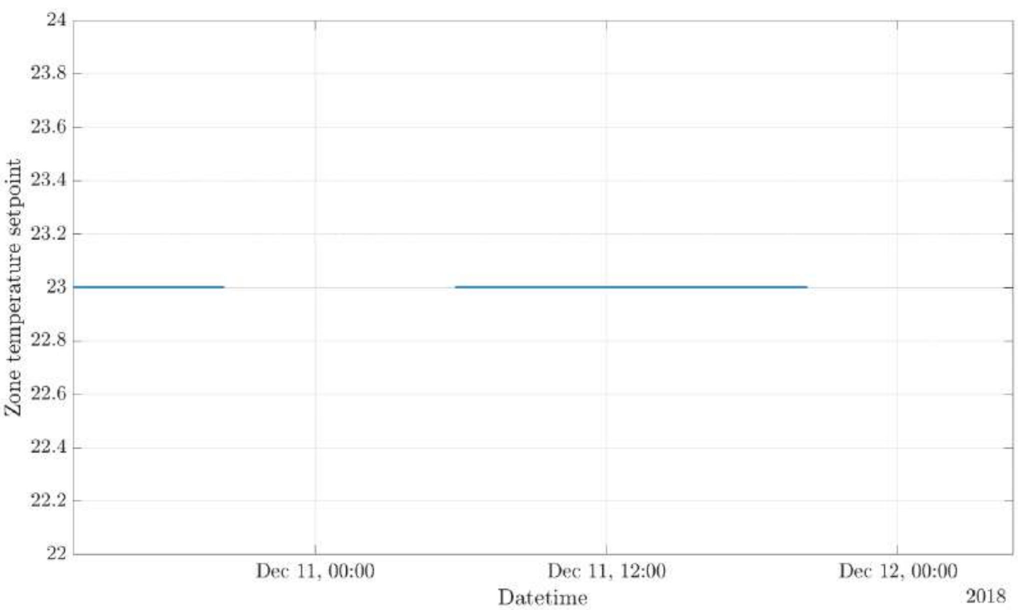
Current zone setpoint measurement

MODULE

Zone PE 7

MODULE OUTPUTS

Setpoint prolongated with the exception of night regime 21:00 – 6:30 (stand-by mode)



Zone PE 7 – zone in auto mode

MODULE INPUTS

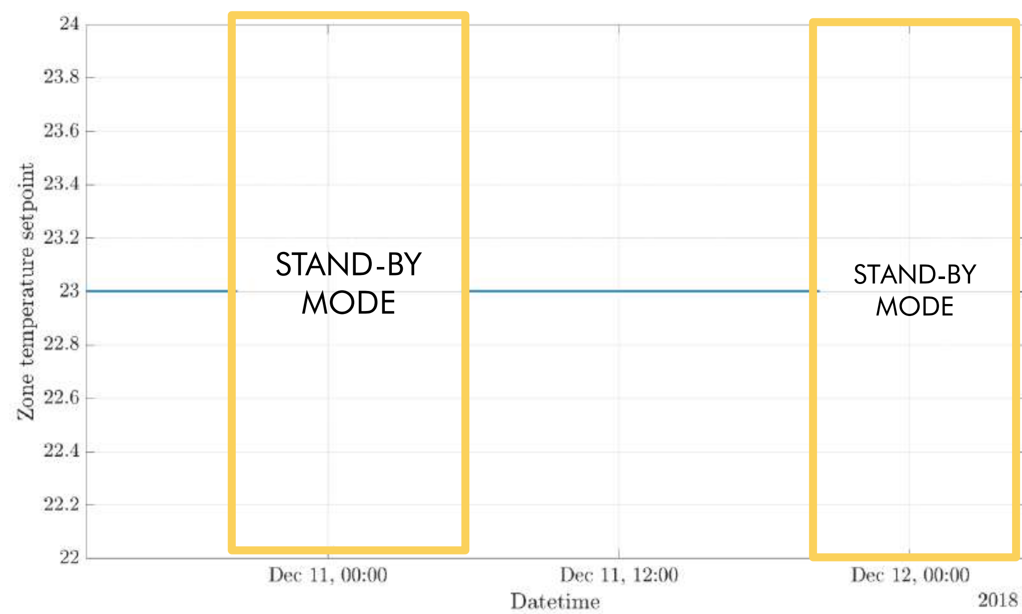
Current zone setpoint measurement

MODULE

Zone PE 7

MODULE OUTPUTS

Setpoint prolongated with the exception of night regime 21:00 – 6:30 (stand-by mode)



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Zone PE 7 – zone in off mode

MODULE INPUTS

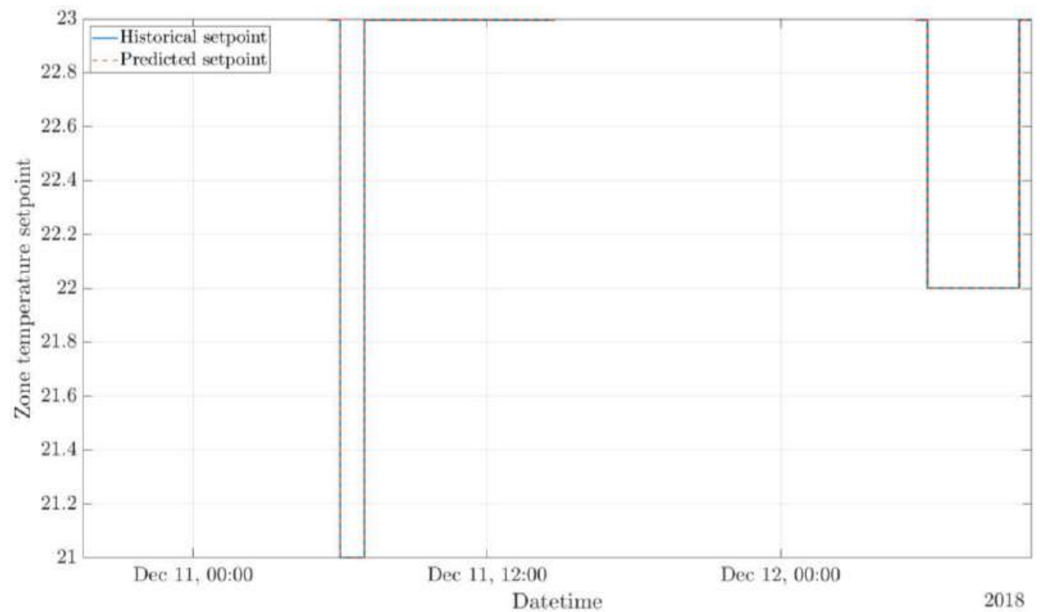
Historical zone setpoint measurement from the same interval of the week before

MODULE

Zone PE 7

MODULE OUTPUTS

Historical setpoint with the exception of night regime 21:00 – 6:30 (stand-by mode)



Zone PE 7 – zone in off mode

MODULE INPUTS

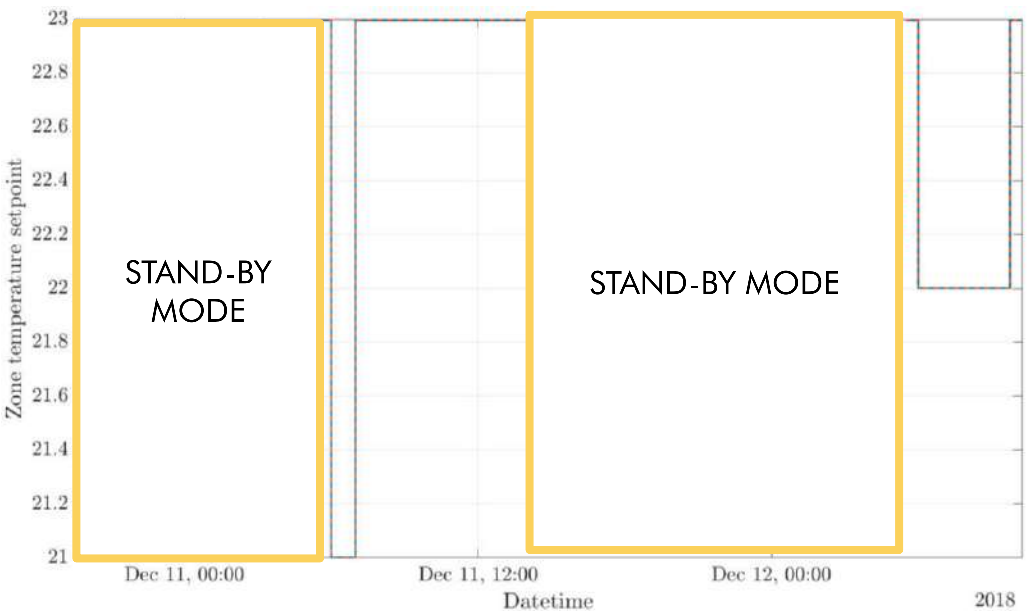
Historical zone setpoint measurement from the same interval of the week before

MODULE

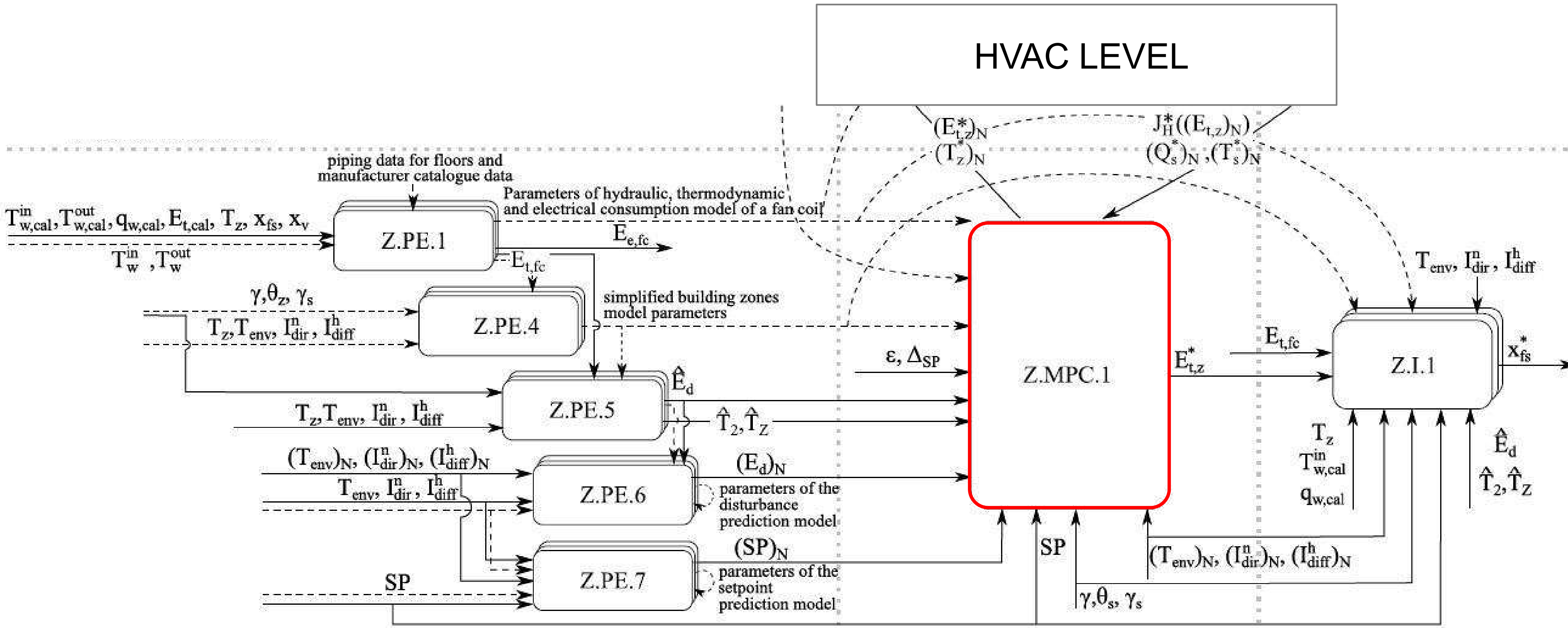
Zone PE 7

MODULE OUTPUTS

Historical setpoint with the exception of night regime 21:00 – 6:30 (stand-by mode)



Zone MPC 1
(model predictive control module for zones comfort control)



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Zone MPC 1
(model predictive control module for zones comfort control)

INPUTS

a) locally stored and outputs of other 3smart modules

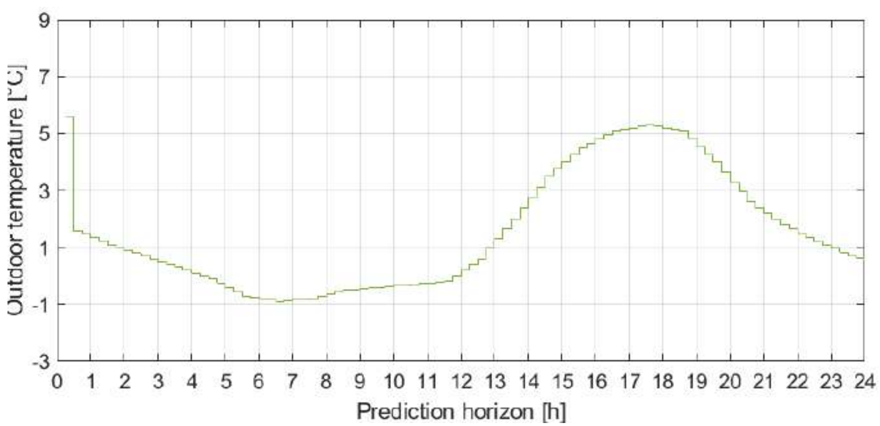
	Input	DB table
1	Parameters of hydraulic model of the HCE	fcu_hydraulic_model
2	Parameters of thermodynamic model of the HCE	fcu_thermodynamic_model
3	Parameters of temperature drop model for HCE	hvac_pe2_calorimeter_supply_outputs
2	Parameters of simplified building zones model	zone_pe4_outputs
3	External wall (window) azimuth angle	building
6	Control parameters	user_preferences
7	Estimated states of simplified building zones model	zone_pe5_outputs
8	Estimated disturbance	zone_pe5_outputs
9	Calorimeter measurements	calorimeter_measurement
10	HVAC MPC outputs	hvac_mpc1_outputs

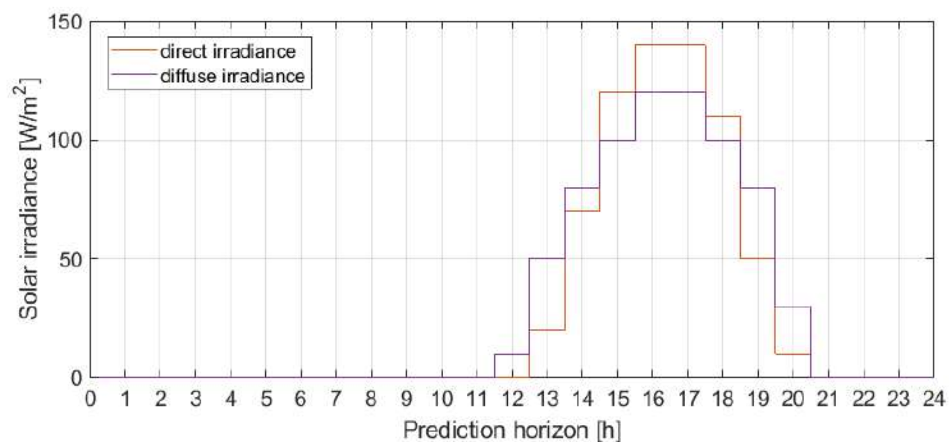
HCE = heating/cooling elements

Zone MPC 1
(model predictive control module for zones comfort control)

INPUTS
b) predictions

	Input	DB table
1	Prediction of solar elevation and azimuth angles	Locally computed
2	Weather prediction	weather_prediction
3	Predicted disturbance	zone_pe6_outputs
4	Predicted setpoint	zone_pe7_outputs



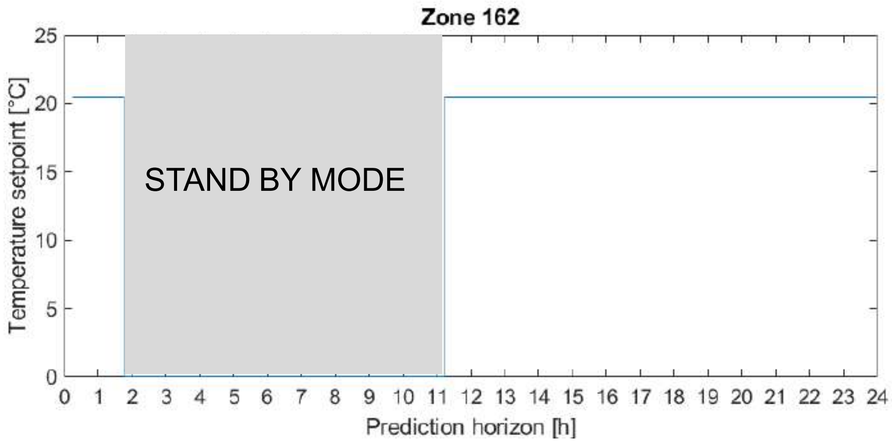


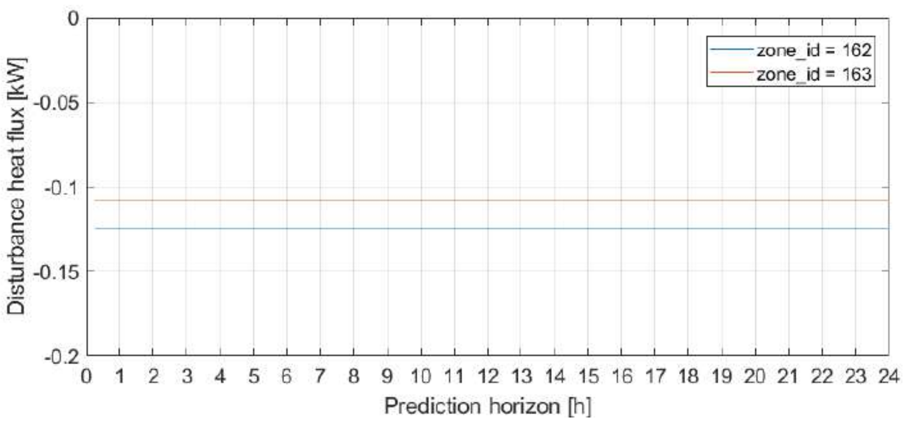
PREDICTION START : 10 December 2018 20:00

Zone MPC 1
(model predictive control module for zones comfort control)

INPUTS
b) predictions

	Input	DB table
1	Prediction of solar elevation and azimuth angles	Locally computed
2	Weather prediction	weather_prediction
3	Predicted disturbance	zone_pe6_outputs
4	Predicted setpoint	zone_pe7_outputs



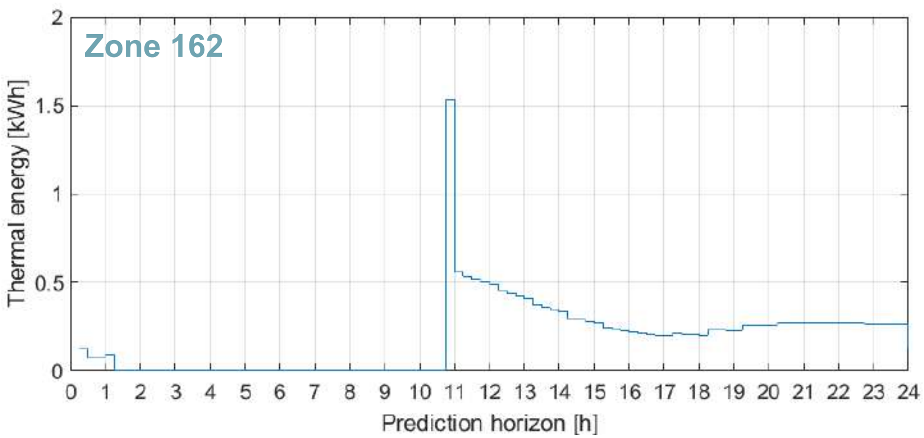


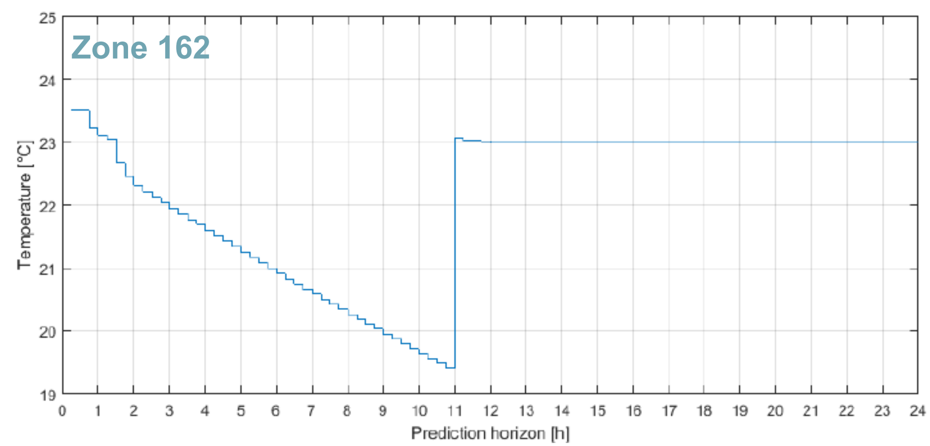
PREDICTION START : 10 December 2018 20:00

Zone MPC 1
(model predictive control module for zones comfort control)

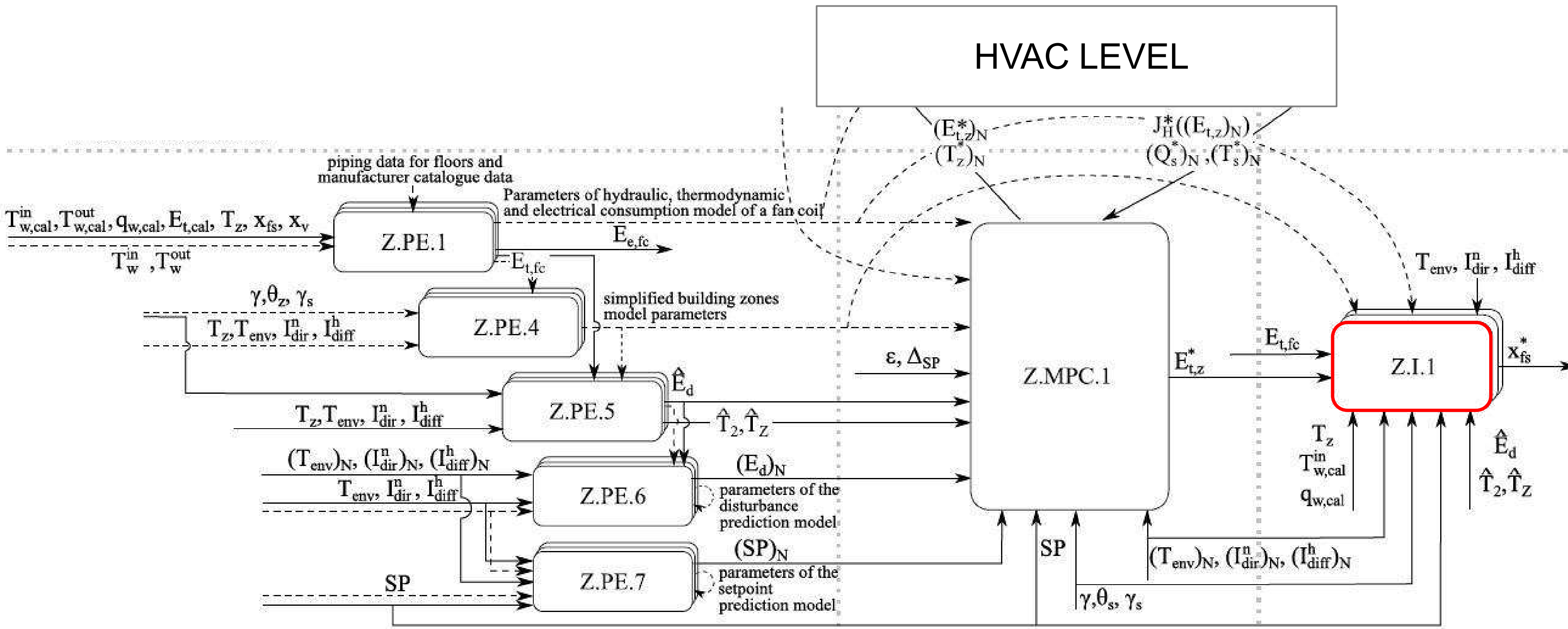
OUTPUTS

	OUTPUTS	DB table
1	Optimal profile of heating/cooling energy from actuators in zones	zone_mpc1_outputs
2	Optimized profile of temperatures in zones	zone_mpc1_outputs





Zone Interface 1
(Fan coils energy input control submodule)



Zone Interface 1
(Fan coils energy input control submodule)

CASE STUDY – fulfilling energy request between 17:00 – 17:15

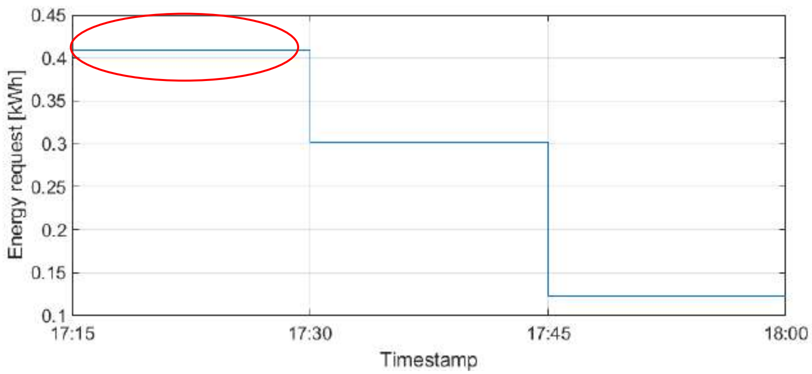
INPUTS
a) measurements/calculations

	Inputs measured/calculated at 17:00	DB table	Value
1	Energy input references for fan coils	zone_mpc1_outputs	
2	Temperature setpoint	zone_measurement	26.00 °C
3	Estimated states of simplified building zones model	zone_pe5_outputs	$[25.44°C, 24.89°C]^T$
4	Estimated disturbance	zone_pe5_outputs	0.120 kW
5	Measured flow on the corresponding floor calorimeter	calorimeter_measurement	1730 l/h
6	Measured supply temperature on the corresponding floor calorimeter	calorimeter_measurement	66 °C
7	Measured solar irradiances		
8	Measured outdoor temperature		

Zone Interface 1
(Fan coils energy input control submodule)

INPUTS

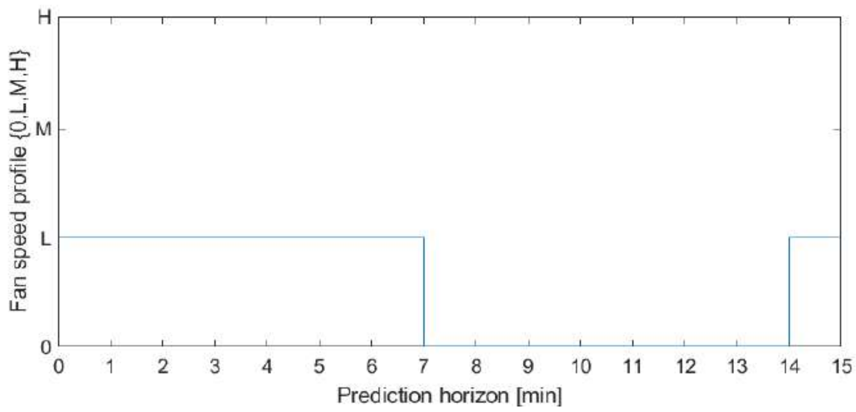
a) energy input request



Prediction calculated by zone_mpc1 module run at 17:00 for zone with zone_id=162

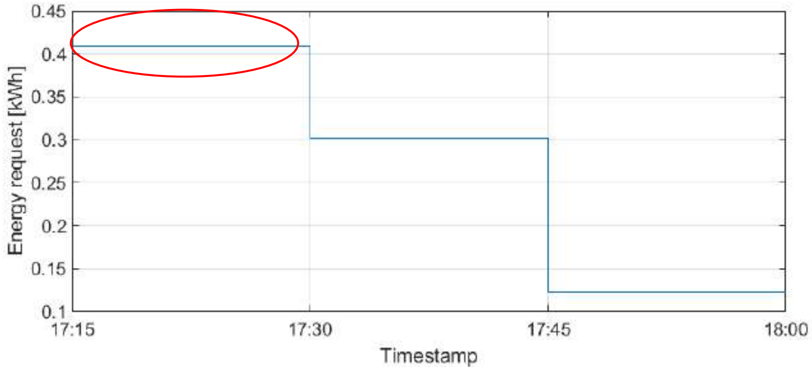
OUTPUT

a) fan spees profile within current 15 min interval



Zone Interface 1
(Fan coils energy input control submodule)

INPUTS
a) energy input request



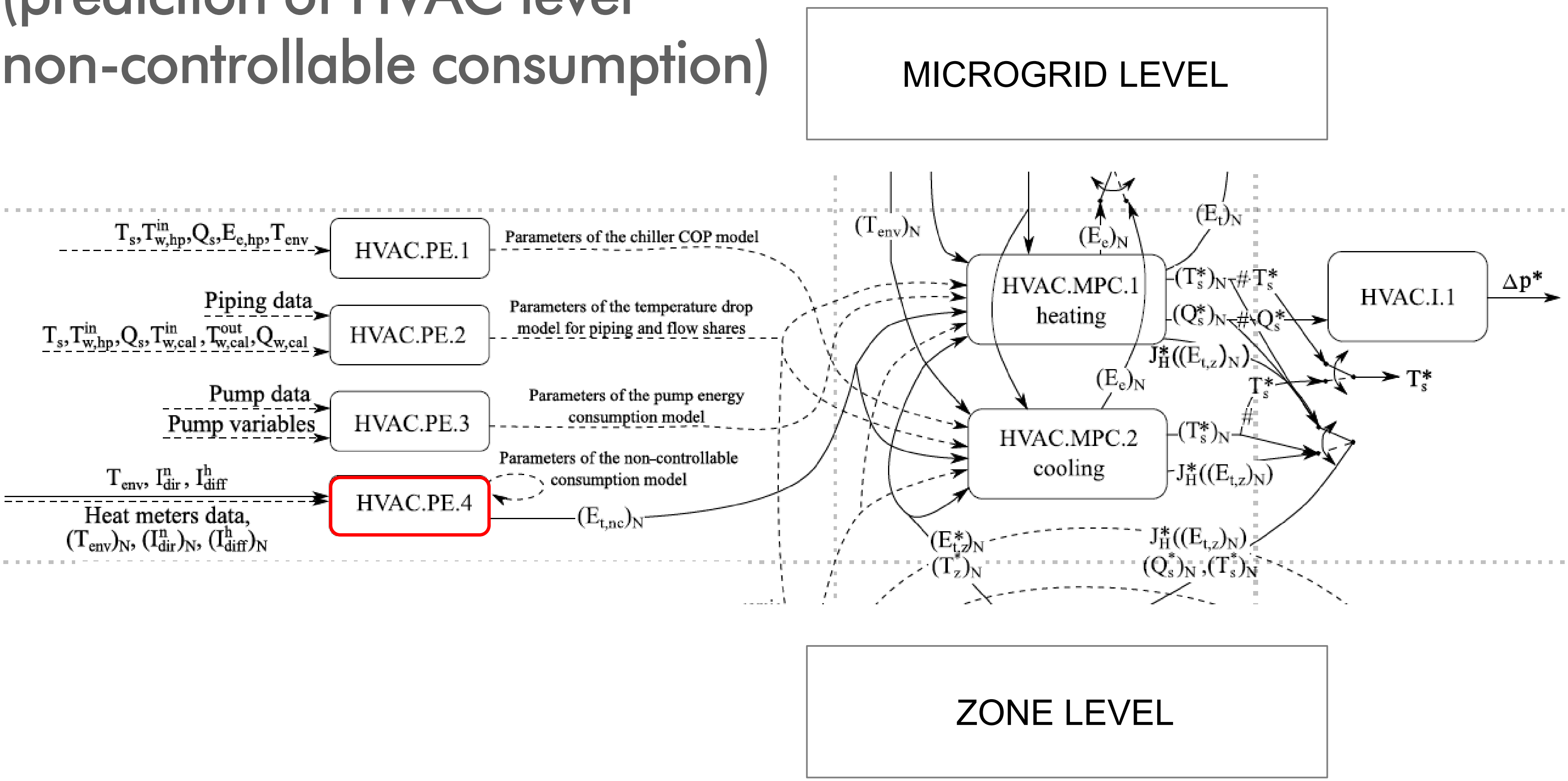
Prediction calculated by zone_mpc1 module run at 17:00 for zone with zone_id=162

OUTPUT
a) fan spees profile within current 15 min interval

2018-12-08 16:30:20.0	[33, 33, 33, 33, 33, 33, 33, 0, 0, 0, 0, 0, 0, 0, 33]
2018-12-08 16:31:20.0	[33, 33, 33, 33, 33, 0, 0, 0, 0, 0, 0, 33, 33]
2018-12-08 16:32:20.0	[33, 33, 33, 33, 33, 0, 0, 0, 0, 0, 33, 33]
2018-12-08 16:33:20.0	[33, 33, 33, 33, 0, 0, 0, 0, 0, 33, 33]
2018-12-08 16:34:20.0	[33, 33, 33, 33, 0, 0, 0, 0, 0, 33]
2018-12-08 16:35:20.0	[33, 33, 33, 0, 0, 0, 0, 0, 33]
2018-12-08 16:36:20.0	[0, 0, 0, 0, 0, 33, 33, 33]
2018-12-08 16:37:20.0	[0, 0, 0, 0, 0, 0, 66]
2018-12-08 16:38:20.0	[0, 0, 0, 0, 0, 33]
2018-12-08 16:39:20.0	[0, 0, 0, 0, 33]
2018-12-08 16:40:20.0	[0, 0, 0, 33]
2018-12-08 16:41:20.0	[0, 0, 33]
2018-12-08 16:42:20.0	[0, 33]
2018-12-08 16:43:20.0	[0, 33]
2018-12-08 16:44:20.0	[0]

HVAC-level modules UNIZGFER

HVAC PE 4 (prediction of HVAC level non-controllable consumption)



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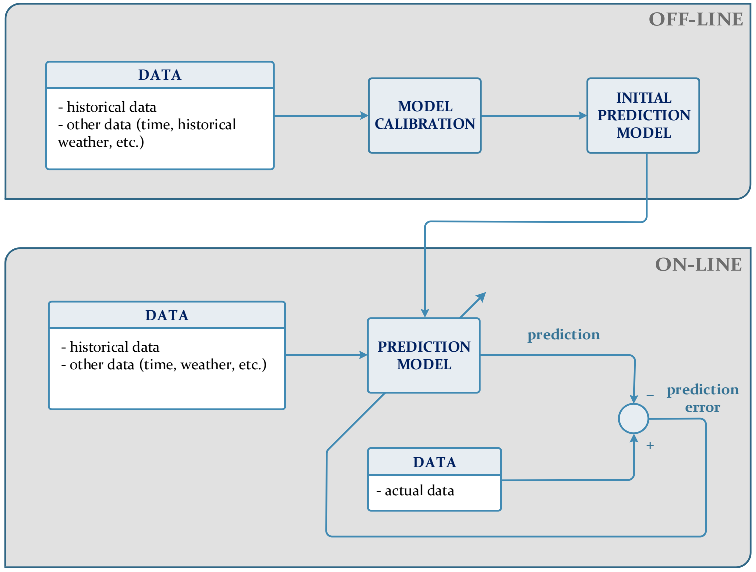
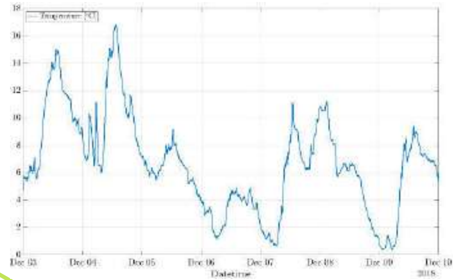
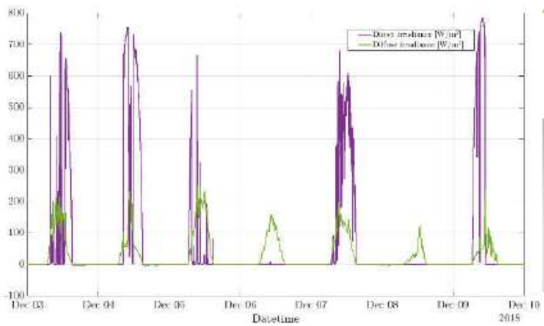
HVAC PE 4 – off-line initialization



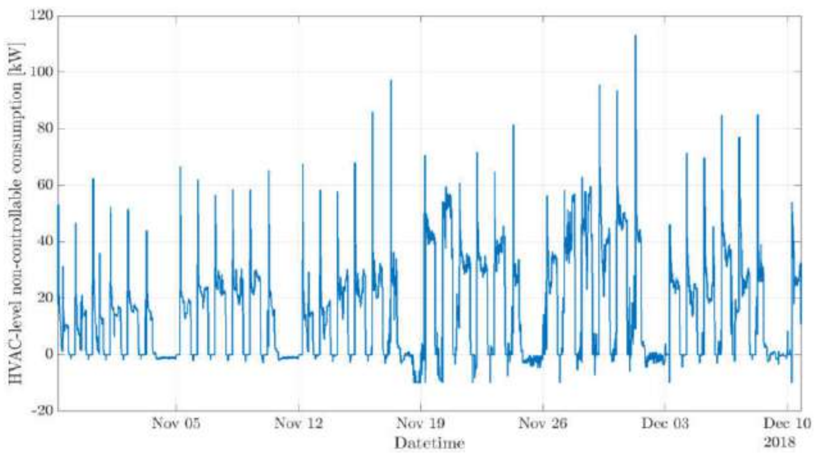
HVAC PE 4 – off-line initialization

Historical **weather measurements**:
- Temperature
- Direct, diffuse solar irradiance

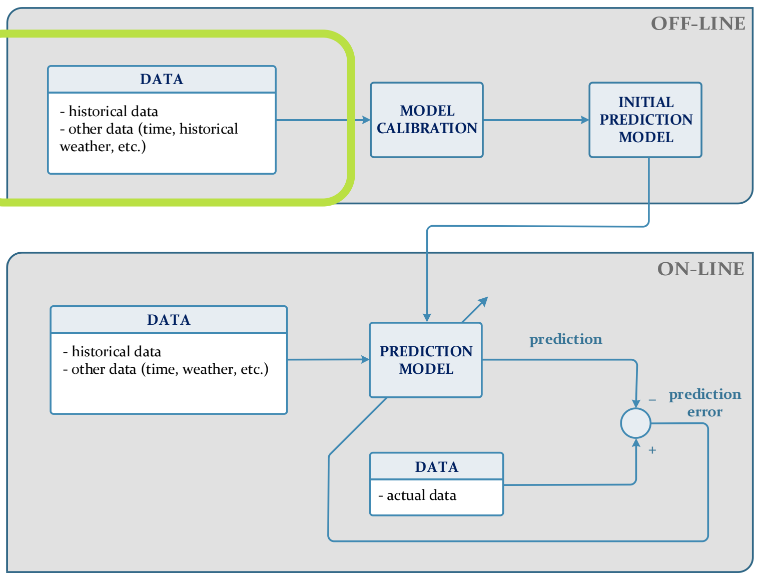




Historical **non-controllable consumption**



MODULE INPUTS



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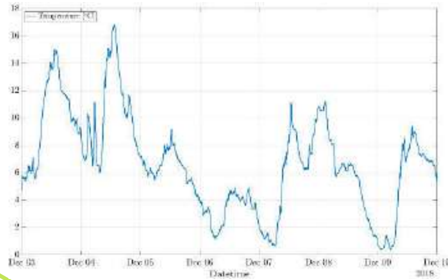
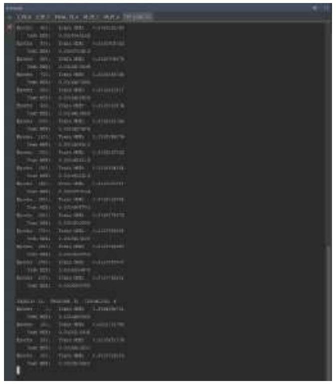
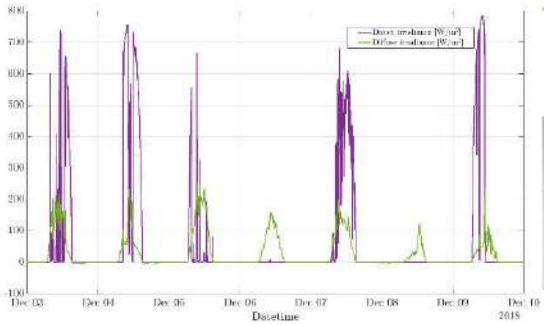
HVAC PE 4 – off-line initialization

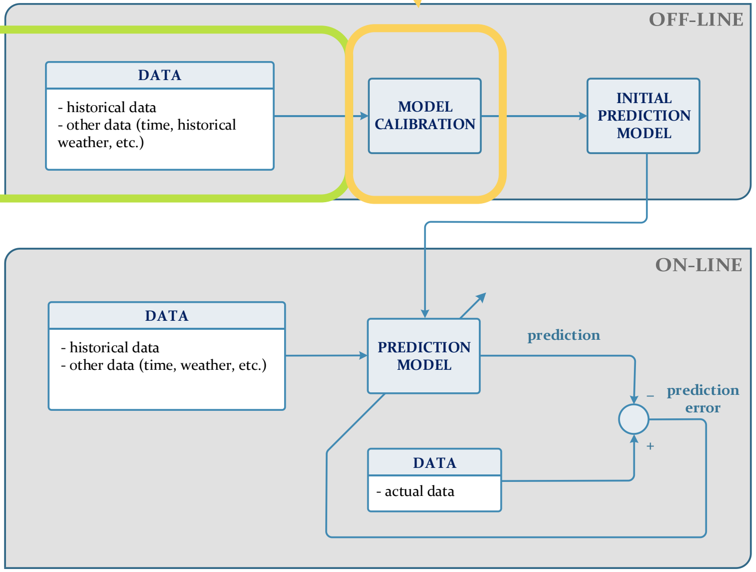




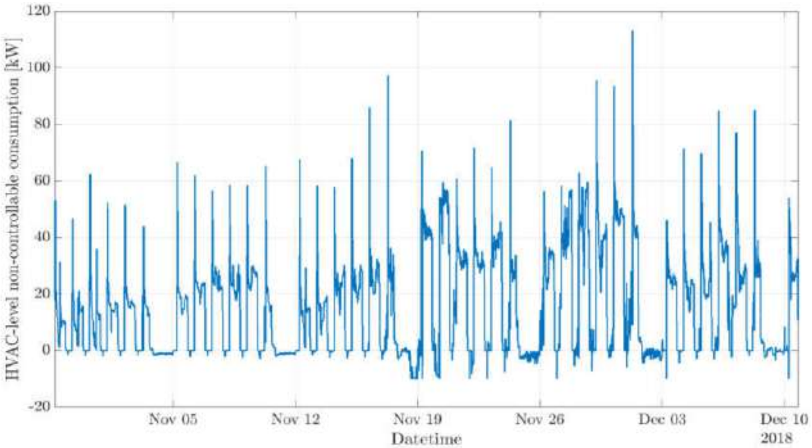
Historical **weather measurements**:
- Temperature
- Direct, diffuse solar irradiance



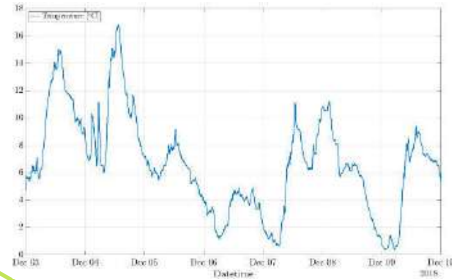
MODULE INPUTS

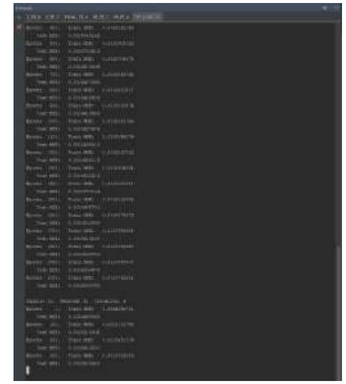


Historical **non-controllable consumption**



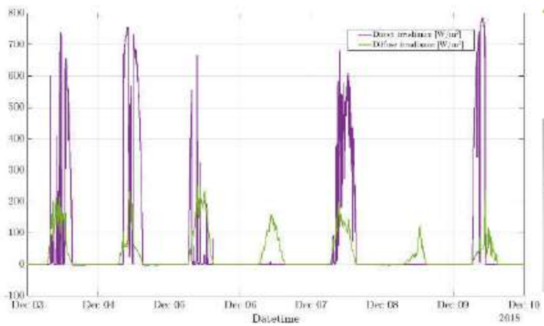
HVAC PE 4 – off-line initialization





Historical **weather measurements**:

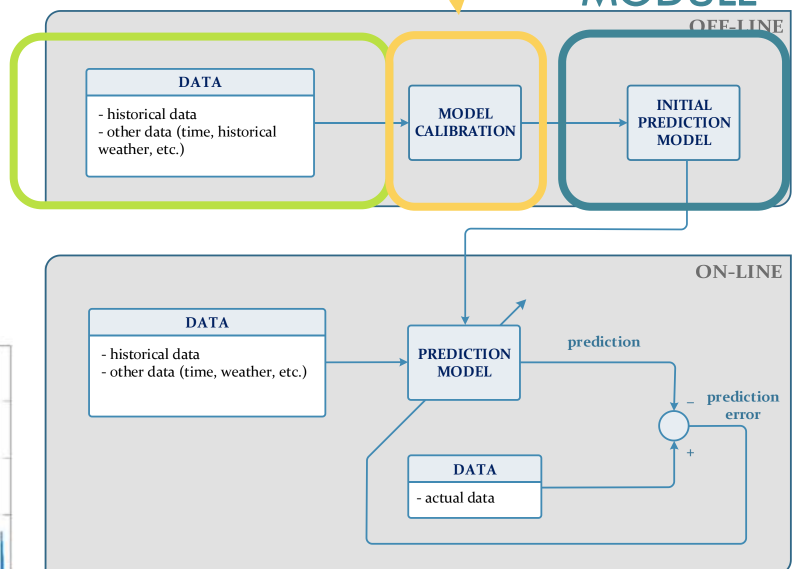
- Temperature
- Direct, diffuse solar irradiance



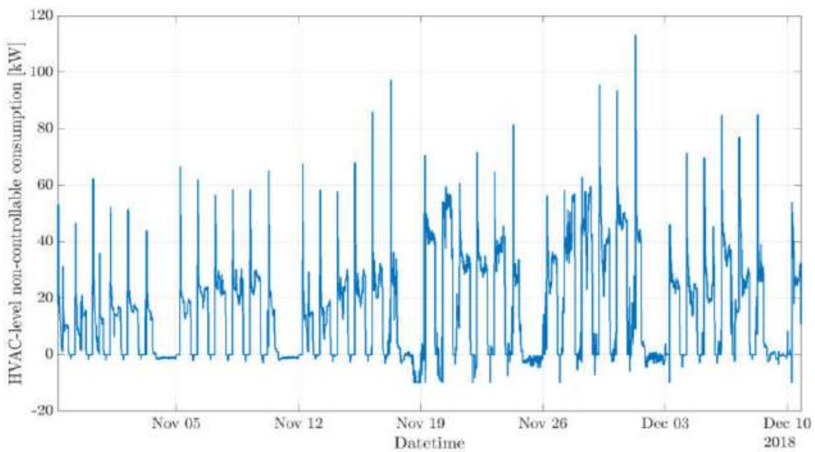
Locally stored:
inputsXY_neuronsZ.net

MODULE INPUTS

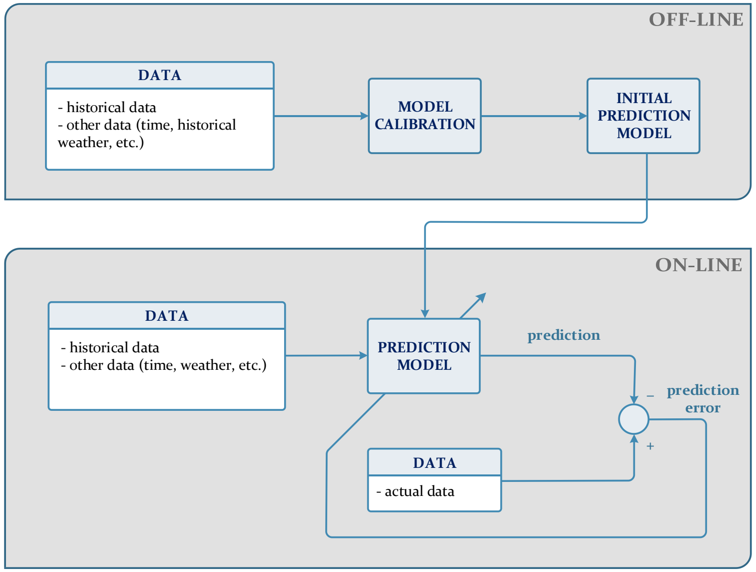
MODULE



Historical **non-controllable consumption**



HVAC PE 4 – on-line operation



HVAC PE 4 – on-line operation

Regressor created from specific historical intervals of data:

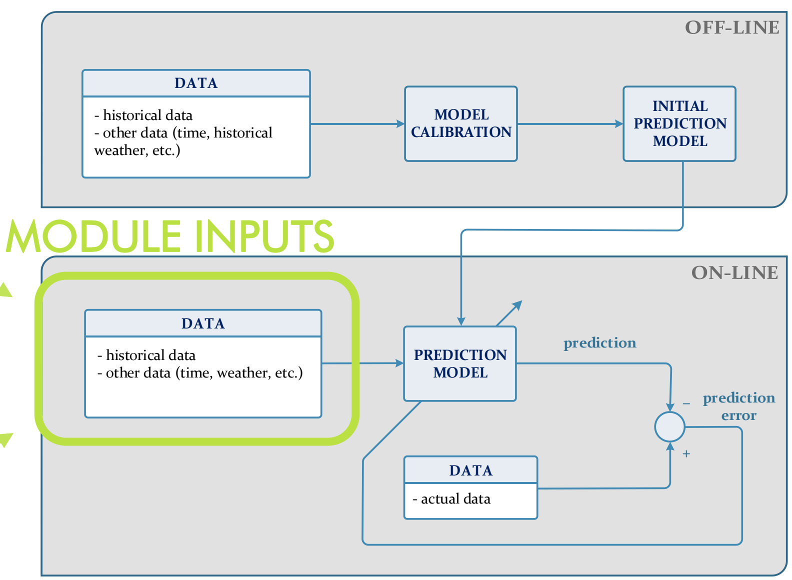
- nctrl consumption(t-1,…,t-5)
- nctrl consumption(t-46,…,t-50)
- nctrl consumption(t-166,…,t-170)

- tau_s_d, tau_c_d
- tau_s_w, tau_c_w
- tau_s_y, tau_c_y

- temperature(t-1,…,t-3)
- temperature(t-95,…,t-97)
- temperature(t-671,…,t-673)

- direct irradiance(t-1,…,t-3)
- direct irradiance (t-95,…,t-97)
- direct irradiance(t-671,…,t-673)

- diffuse irradiance(t-1,…,t-3)
- diffuse irradiance (t-95,…,t-97)
- diffuse irradiance(t-671,…,t-673)



HVAC PE 4 – on-line operation

Regressor created from specific historical intervals of data:

- nctrl consumption(t-1,…,t-5)
- nctrl consumption(t-46,…,t-50)
- nctrl consumption(t-166,…,t-170)

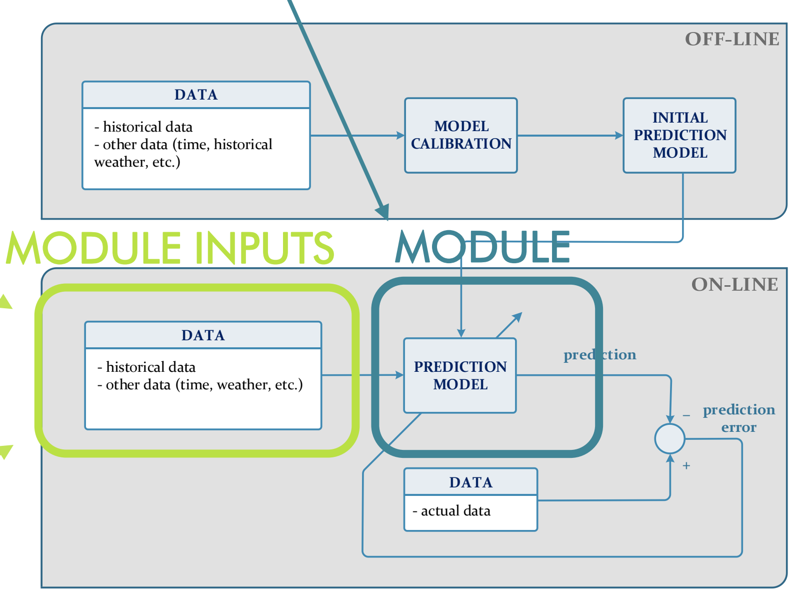
- tau_s_d, tau_c_d
- tau_s_w, tau_c_w
- tau_s_y, tau_c_y

- temperature(t-1,…,t-3)
- temperature(t-95,…,t-97)
- temperature(t-671,…,t-673)

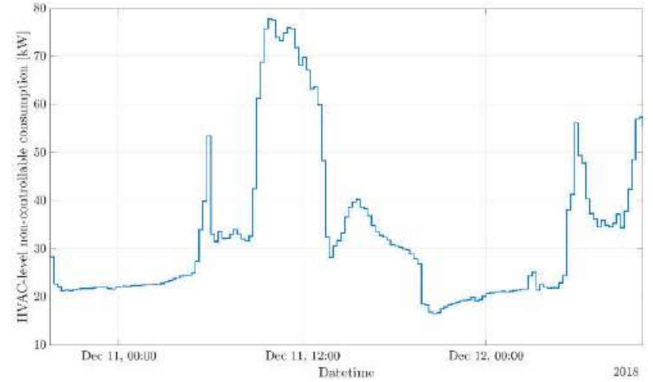
- direct irradiance(t-1,…,t-3)
- direct irradiance (t-95,…,t-97)
- direct irradiance(t-671,…,t-673)

- diffuse irradiance(t-1,…,t-3)
- diffuse irradiance (t-95,…,t-97)
- diffuse irradiance(t-671,…,t-673)

Locally stored:
inputsXY_neuronsZ.net



HVAC PE 4 – on-line operation



Locally stored:
inputsXY_neuronsZ.net

Regressor created from specific historical intervals of data:

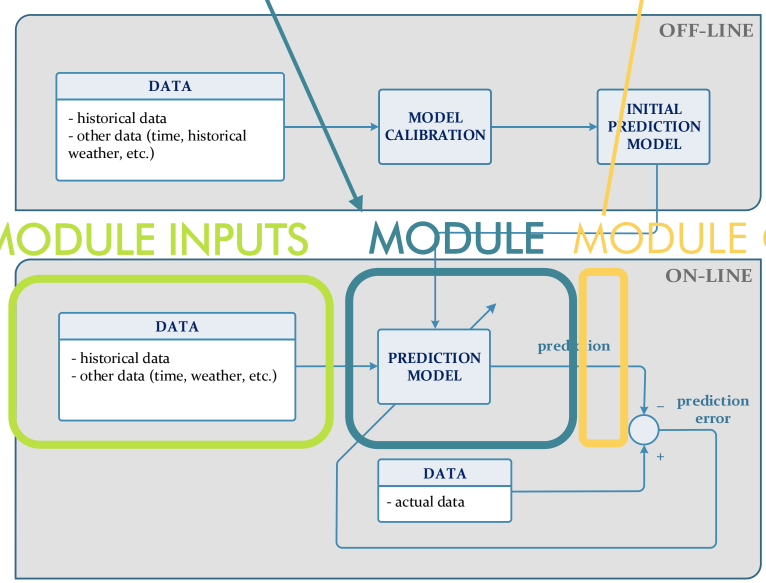
- nctrl consumption(t-1,…,t-5)
- nctrl consumption(t-46,…,t-50)
- nctrl consumption(t-166,…,t-170)

- tau_s_d, tau_c_d
- tau_s_w, tau_c_w
- tau_s_y, tau_c_y

- temperature(t-1,…,t-3)
- temperature(t-95,…,t-97)
- temperature(t-671,…,t-673)

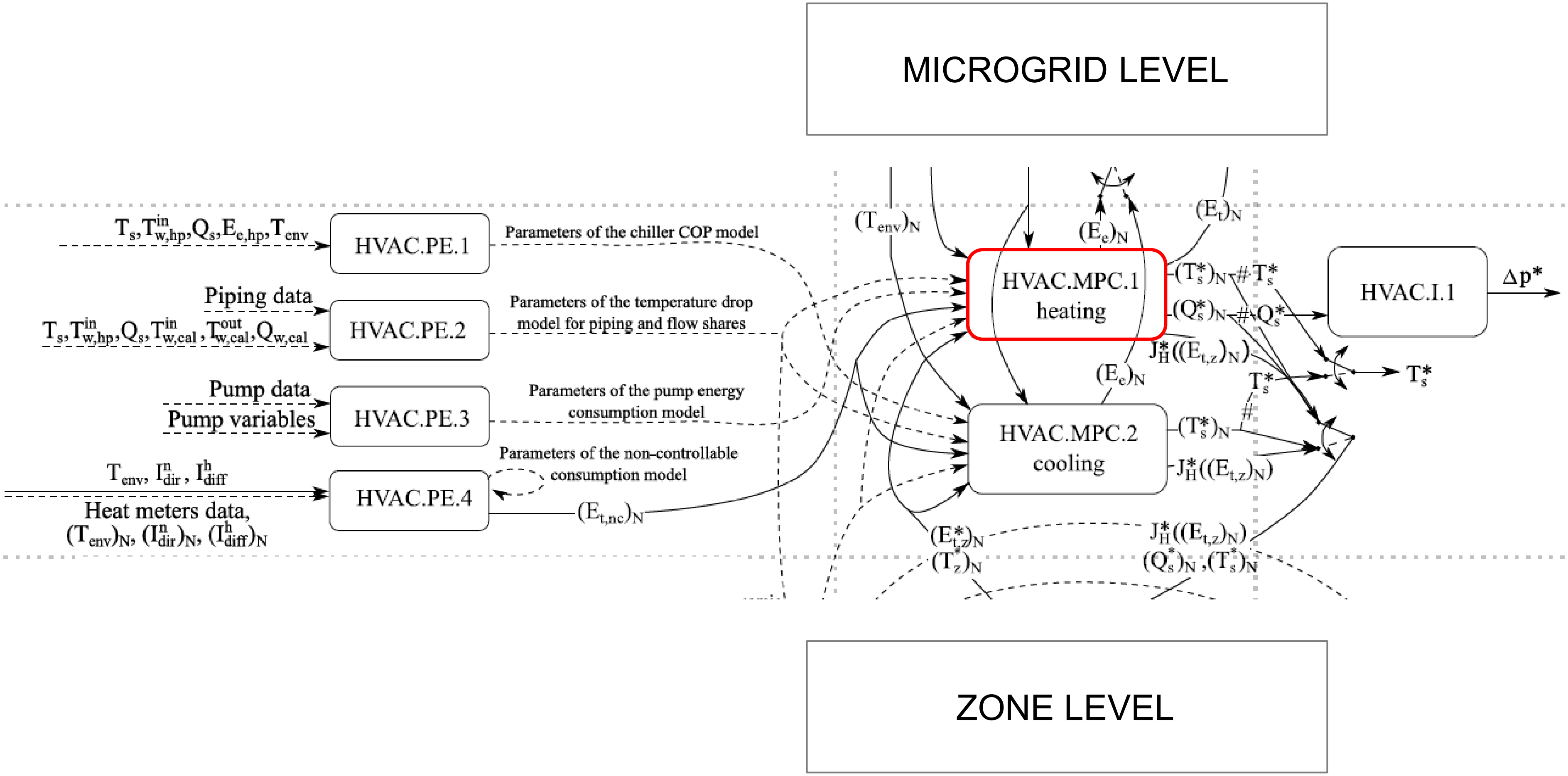
- direct irradiance(t-1,…,t-3)
- direct irradiance (t-95,…,t-97)
- direct irradiance(t-671,…,t-673)

- diffuse irradiance(t-1,…,t-3)
- diffuse irradiance (t-95,…,t-97)
- diffuse irradiance(t-671,…,t-673)



HVAC MPC 1
Heating substation

HVAC MPC 1 – information flow



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Danube Transnational Programme
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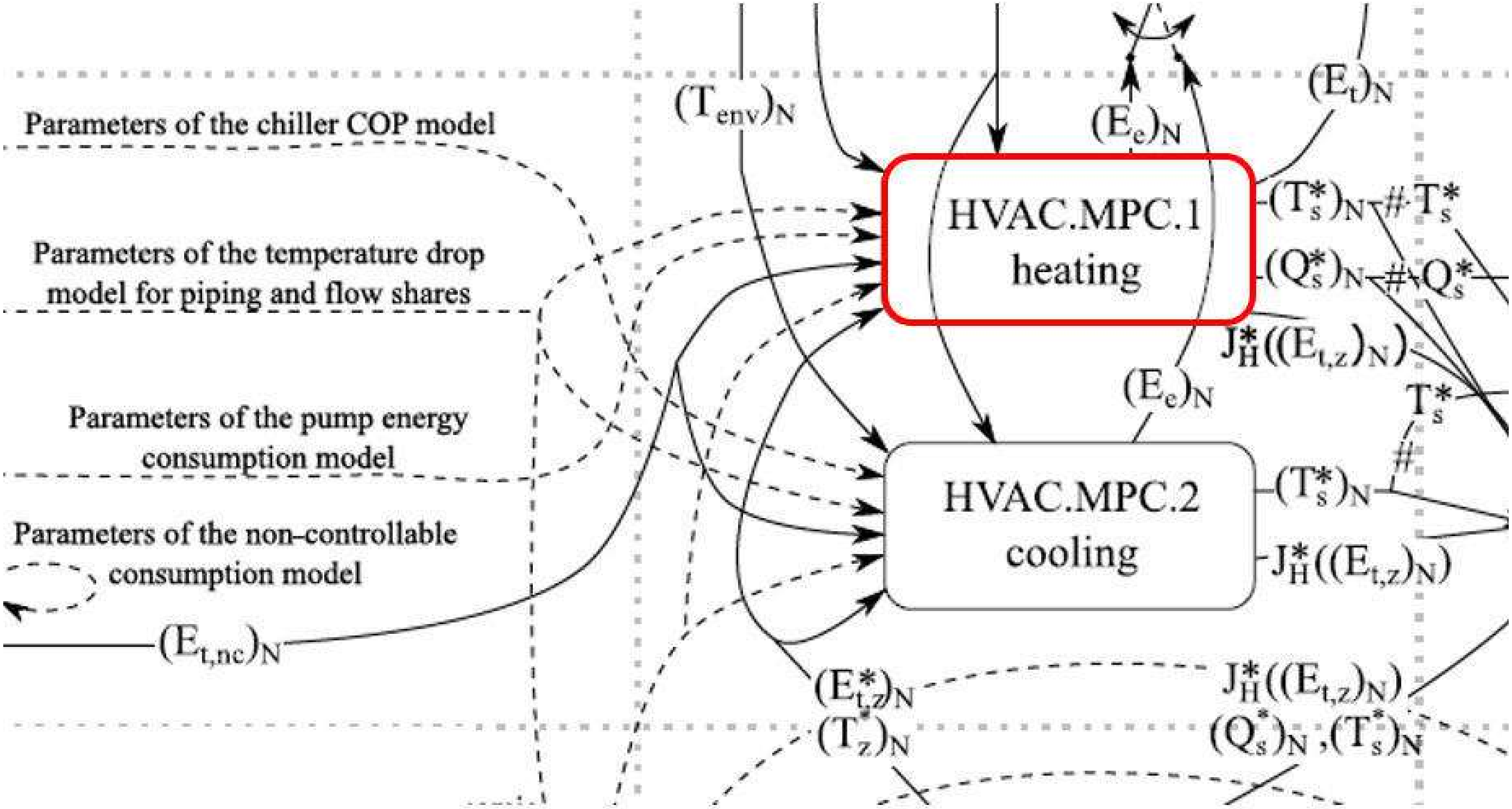
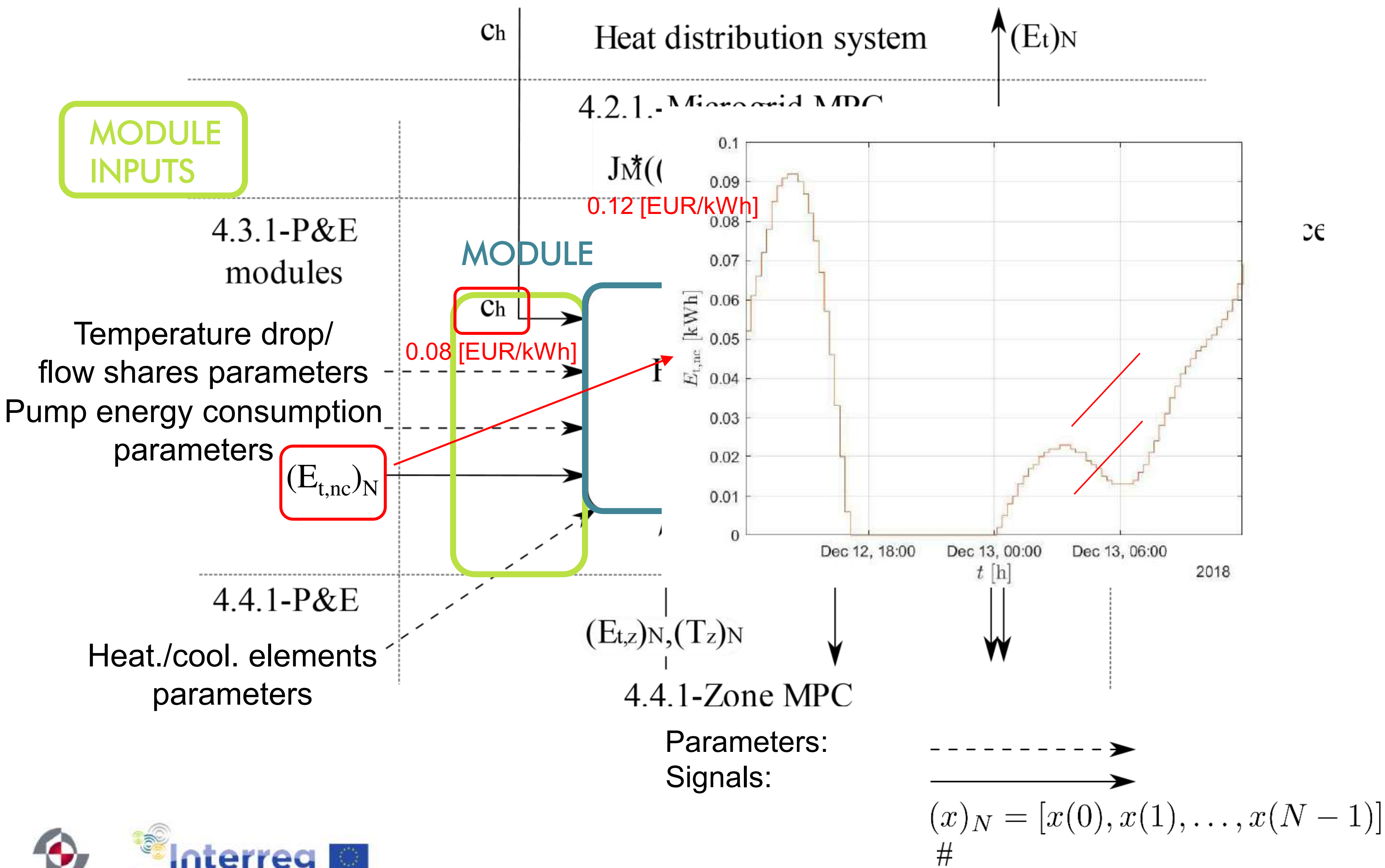
HVAC MPC 1 – information flow



HVAC MPC 1 – module operation

- Description: medium condition optimisation → costs and comfort
- Module interaction:
  - 4.2.1. - Microgrid MPC module
  - 4.4.1. – Zone MPC module
  - 4.3.1./4.4.1 – P&E modules, interface module
- Execution frequency: 15 minutes
- <15 min. coordination between the levels

HVAC MPC 1 – operation



HVAC MPC 1 – operation

MODULE
INPUTS

Temperatu
flow shares p
Pump energy c
parame

Heat./coo
para

PUTS

Interface
odule

Parameters:
Signals:

$(x)_N = [x(0), x(1), \ldots, x(N-1)]$
#

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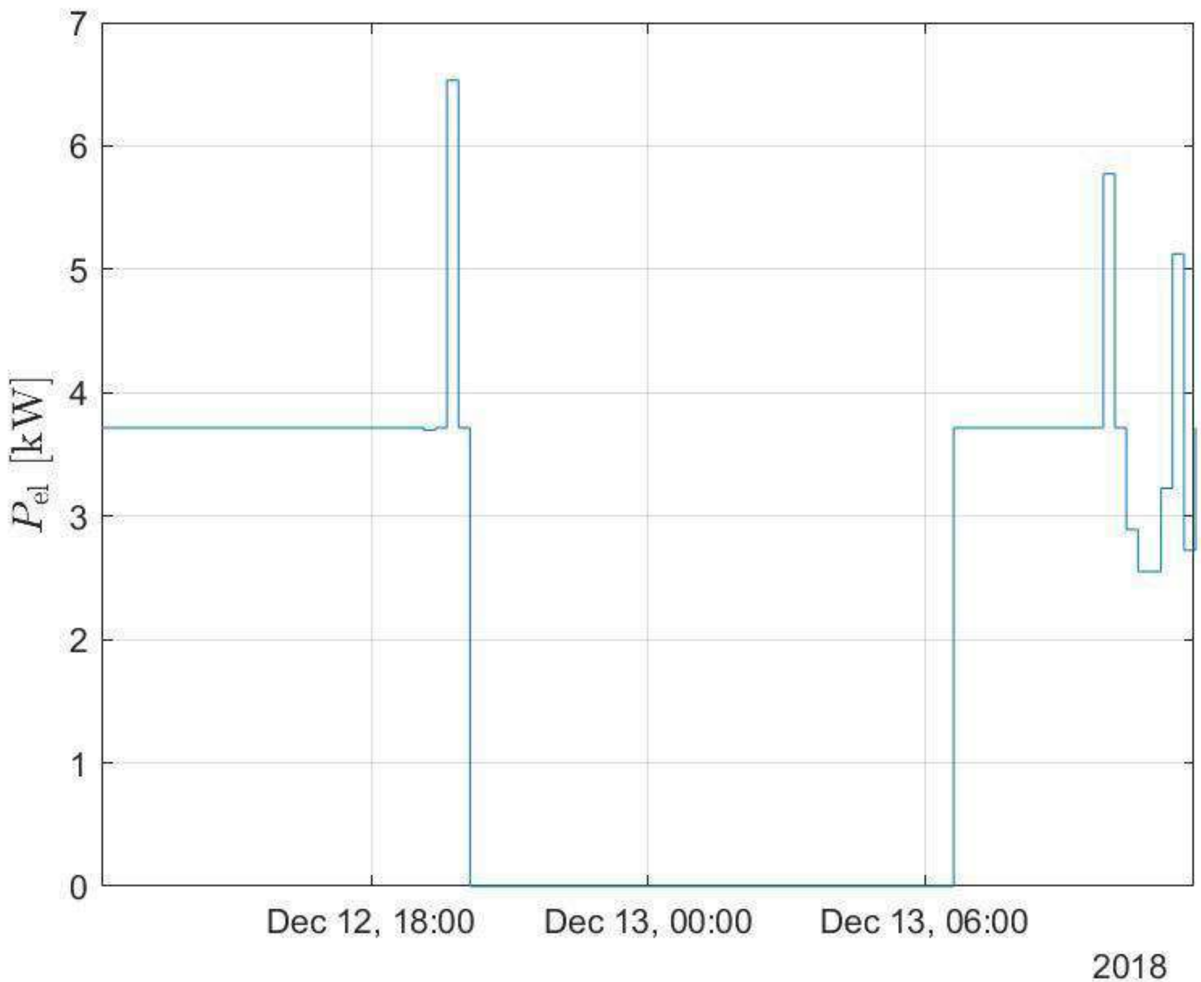
HVAC MPC 1 – operation

MODU
INPUT

Temper
flow share
Pump energ
para

Heat./c
pa



JTS

terface
ule

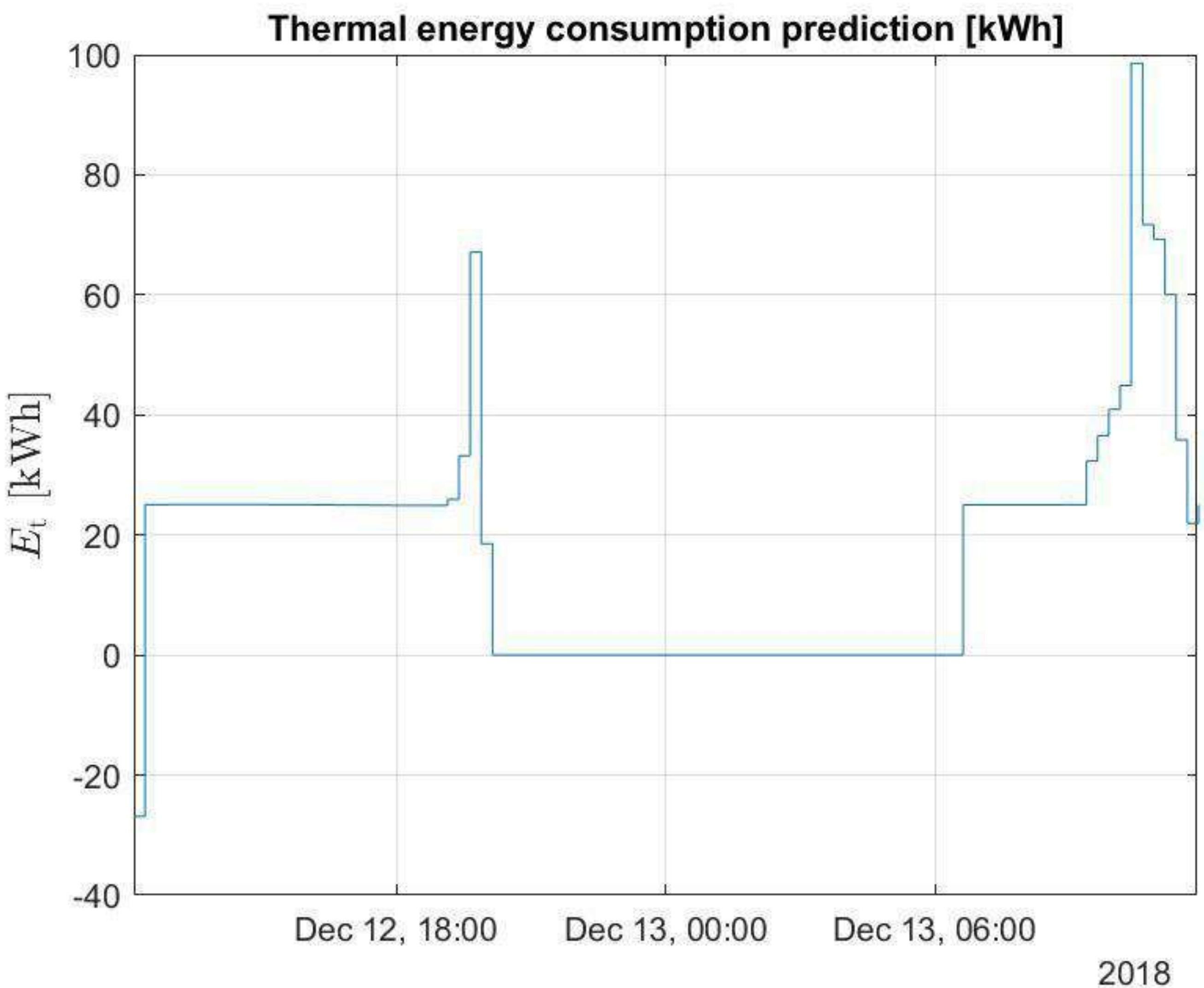
$$(x)_N = [x(0), x(1), \ldots, x(N-1)]$$
#

HVAC MPC 1 – operation

MOD
INPU

Tempe
flow sha
Pump ener
par

Heat



S

rface
e

$(x)_N = [x(0), x(1), \ldots, x(N-1)]$
#

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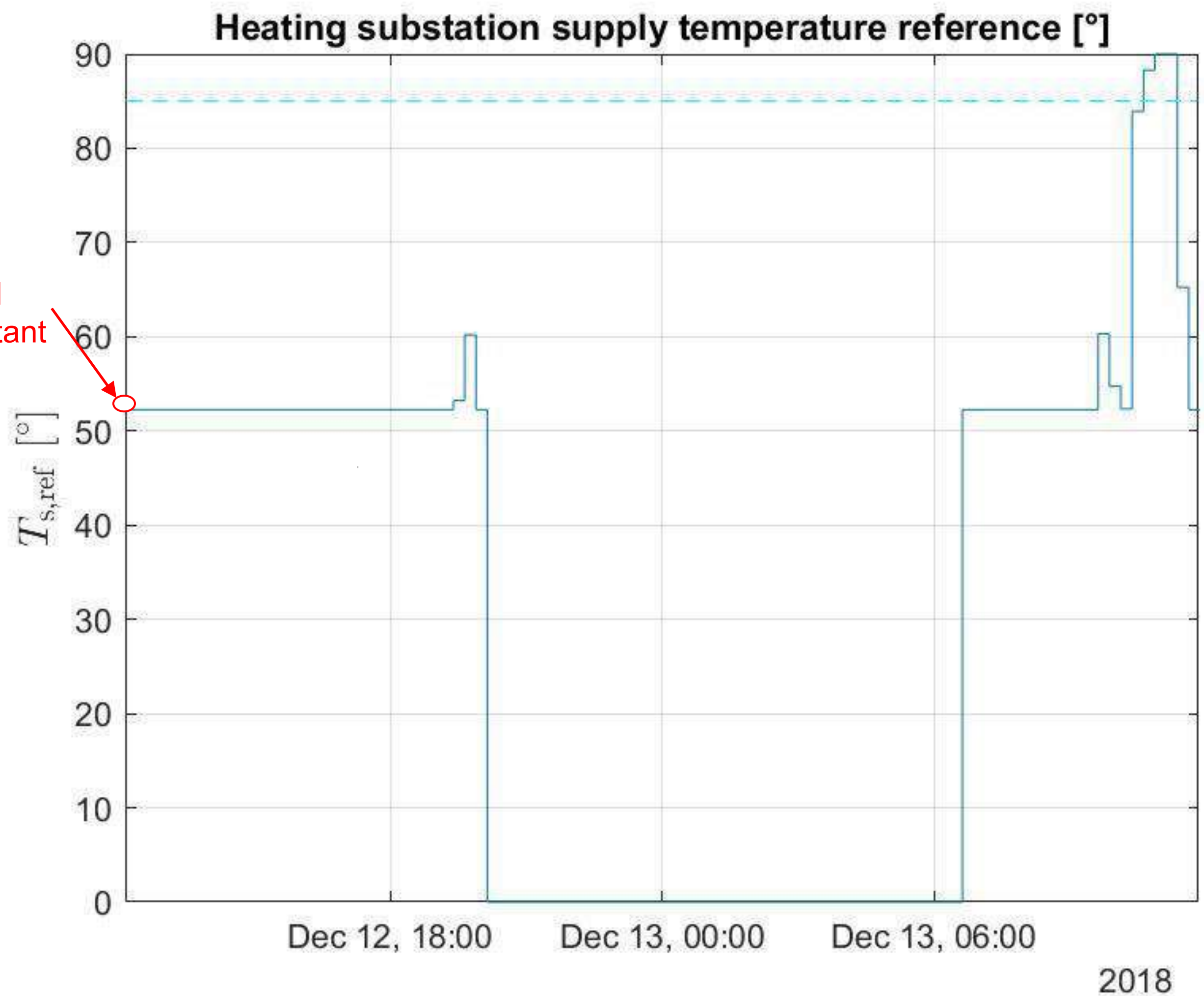
HVAC MPC 1 – operation

MODU
INPUT

Applied
in next instant



UTS

ıterface
lule

Temper
flow share
Pump energ
para

Heat./
pa

Signals:

$$(x)_N = [x(0), x(1), \ldots, x(N-1)]$$

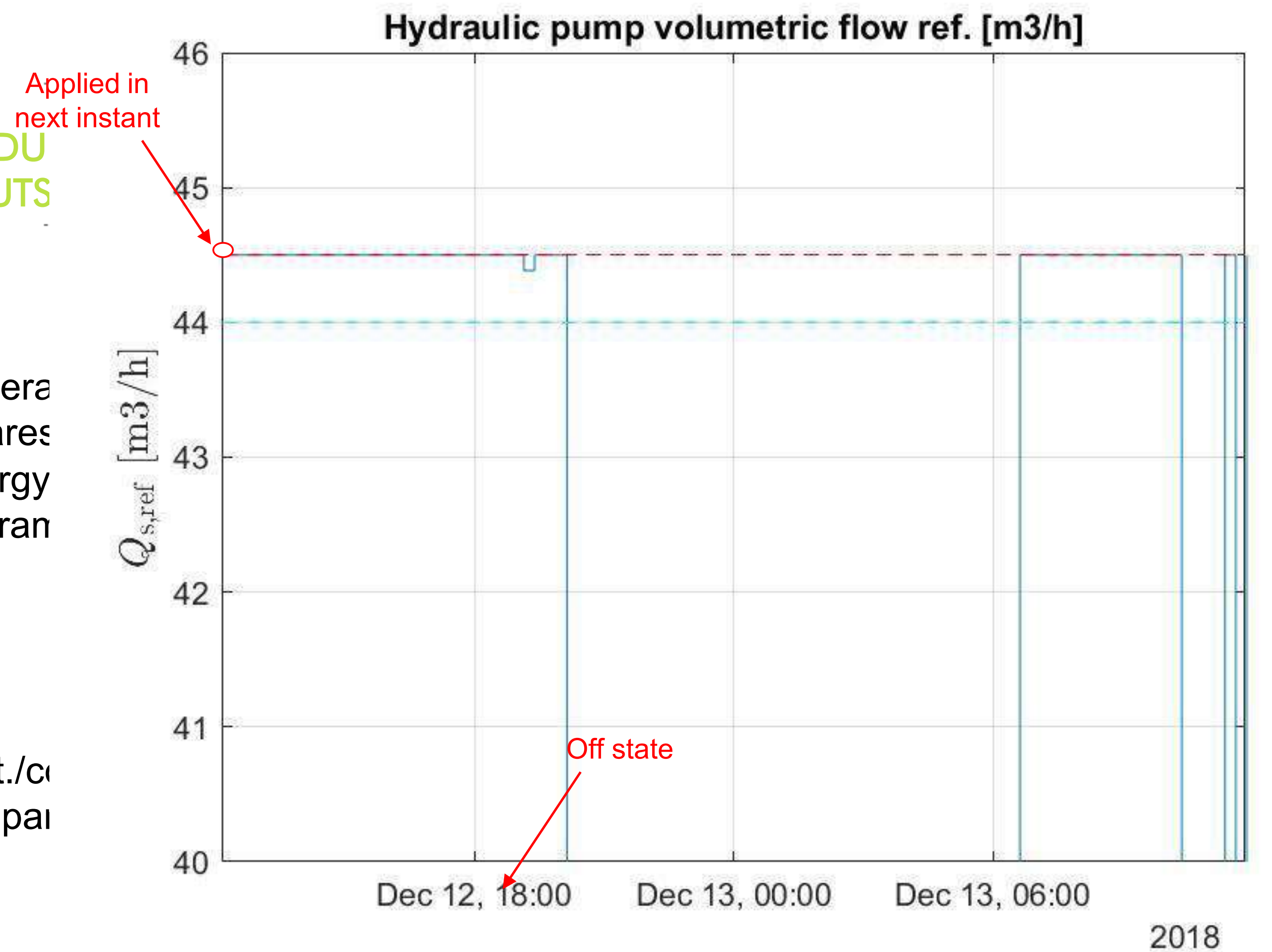
#

HVAC MPC 1 – operation

MODU
INPUTS

Tempera
flow shares
Pump energy
paran

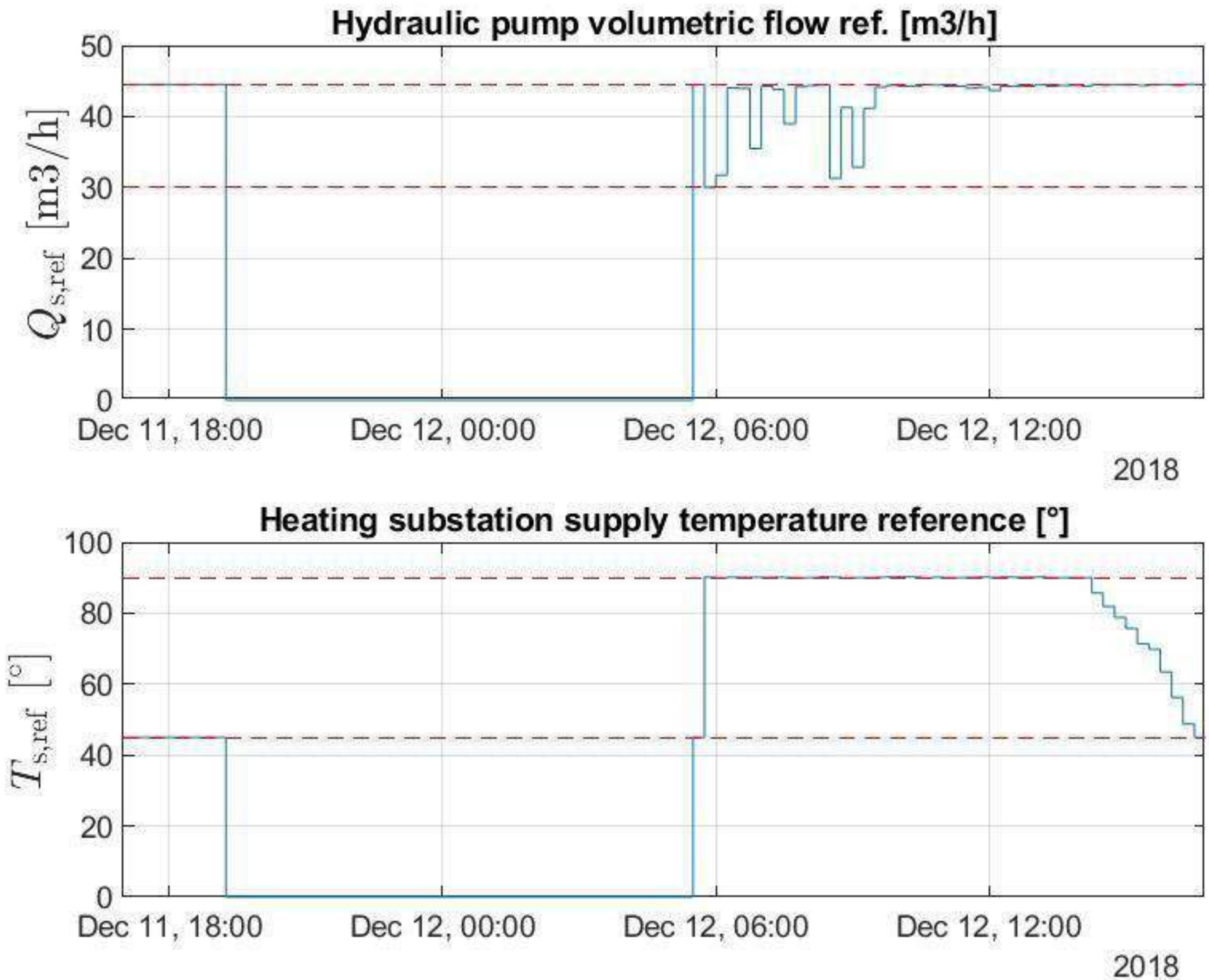
Heat./c
pa



ce

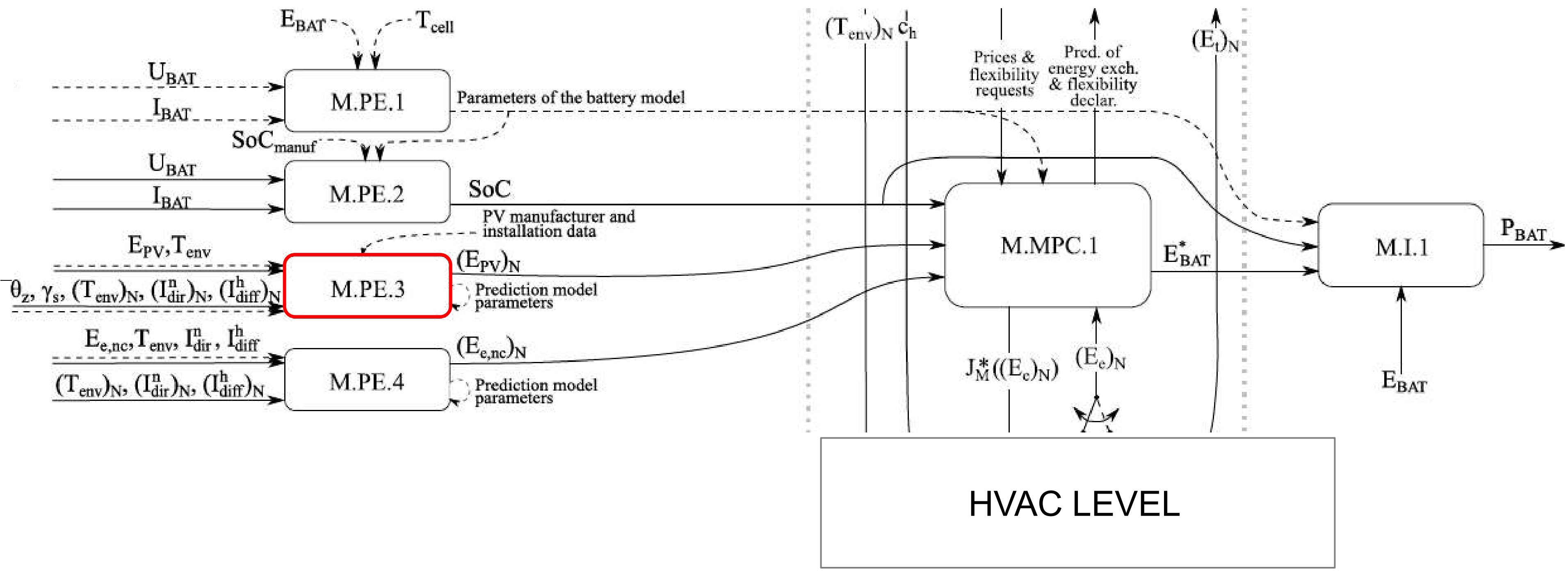
$- 1)]$

#

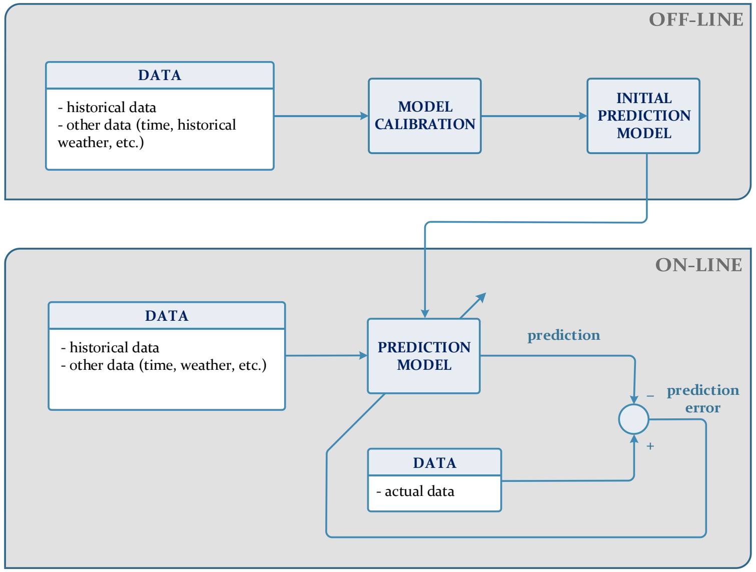

Hydraulic pump volumetric flow ref. [m3/h]
$Q_{\mathrm{s,ref}}$ [m3/h]
50
40
30
20
10
0
Dec 11, 18:00
Dec 12, 00:00
Dec 12, 06:00
Dec 12, 12:00
2018
Heating substation supply temperature reference [°]
$T_{\mathrm{s,ref}}$ [°]
100
80
60
40
20
0
Dec 11, 18:00
Dec 12, 00:00
Dec 12, 06:00
Dec 12, 12:00
2018

Microgrid-level modules UNIZGFER

M PE 3
(prediction of photovoltaic panels energy production)

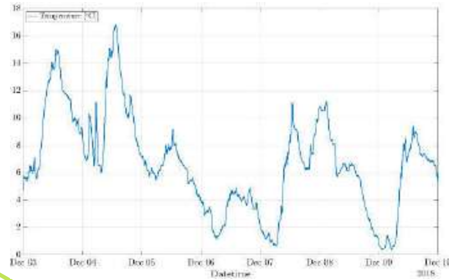


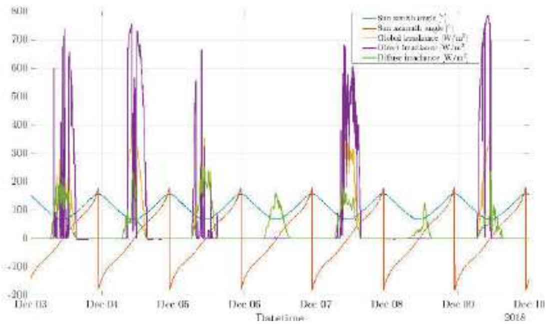
M PE 3 – off-line initialization



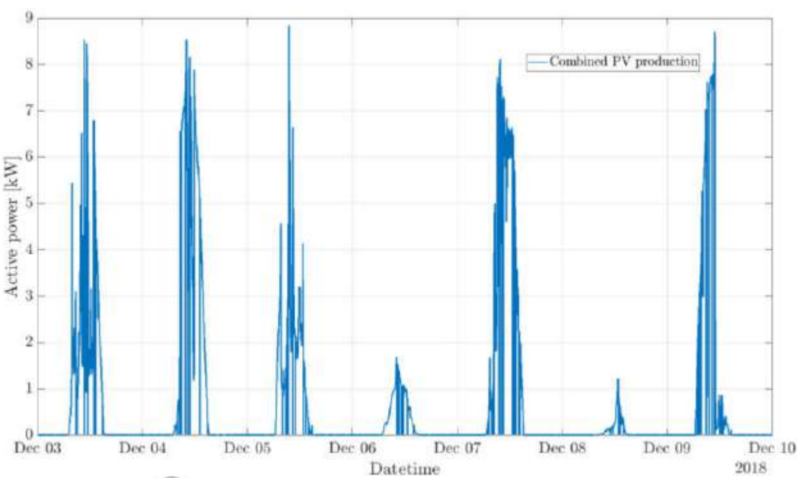
M PE 3 – off-line initialization

Historical **weather measurements**:
- Temperature
- Direct, diffuse solar irradiance
- Solar zenith and azimuth angles

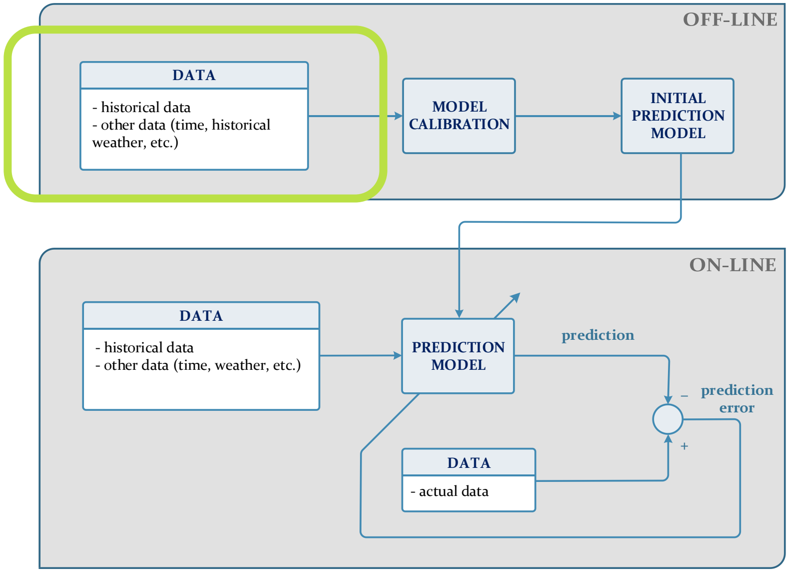




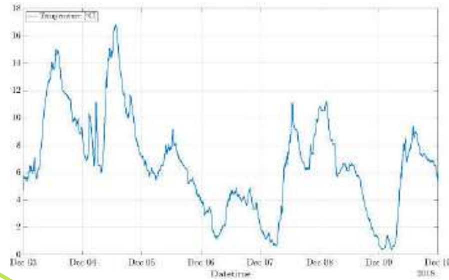
Historical **PV production data**

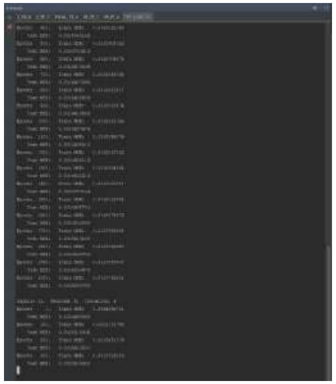


MODULE INPUTS



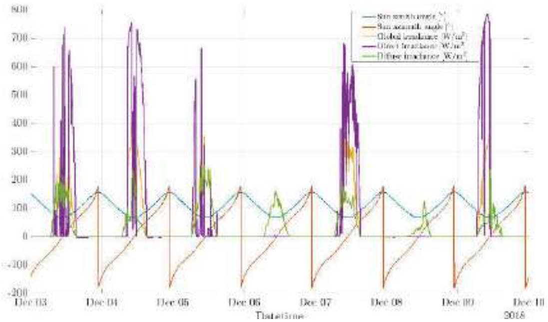
M PE 3 – off-line initialization



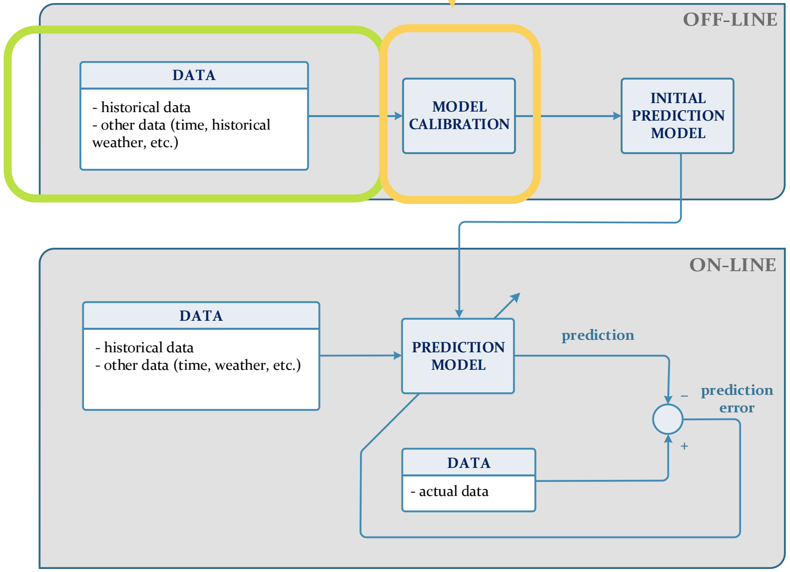


Historical **weather measurements**:

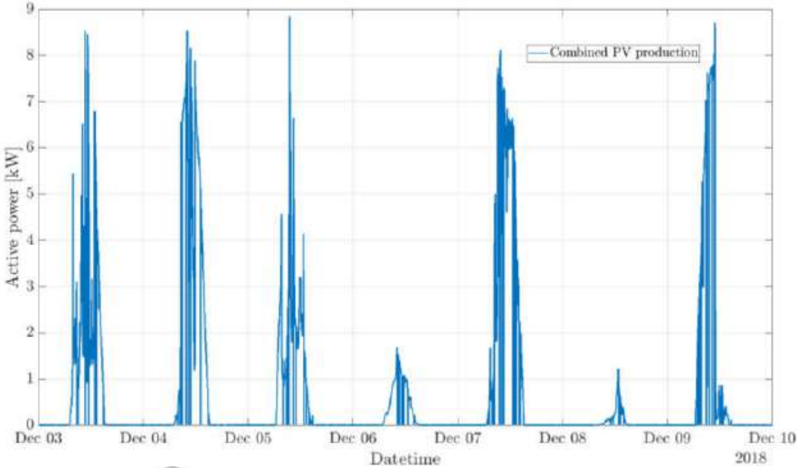
- Temperature
- Direct, diffuse solar irradiance
- Solar zenith and azimuth angles



MODULE INPUTS



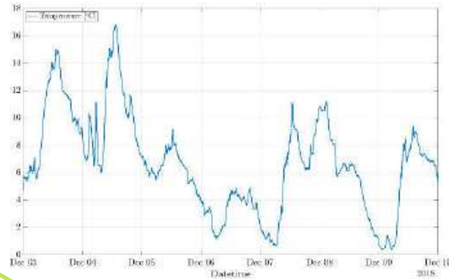
Historical **PV production data**

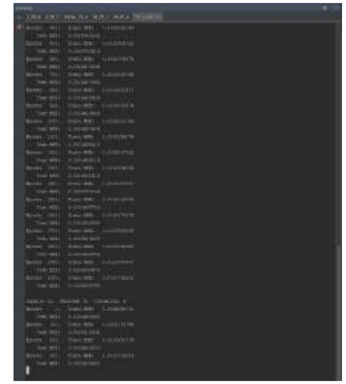


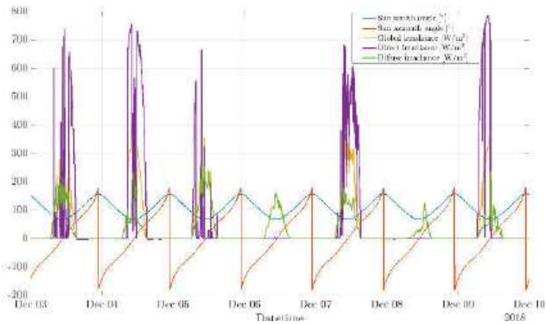
M PE 3 – off-line initialization

Historical **weather measurements**:

- Temperature
- Direct, diffuse solar irradiance
- Solar zenith and azimuth angles



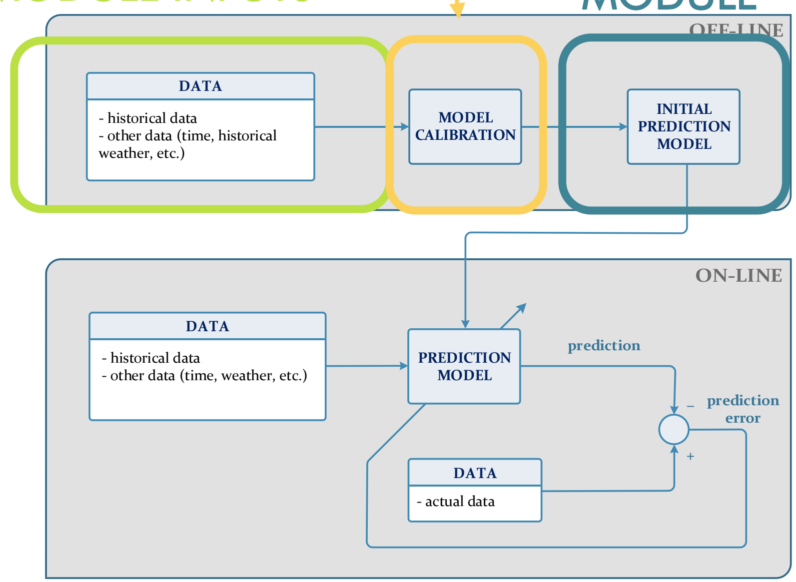




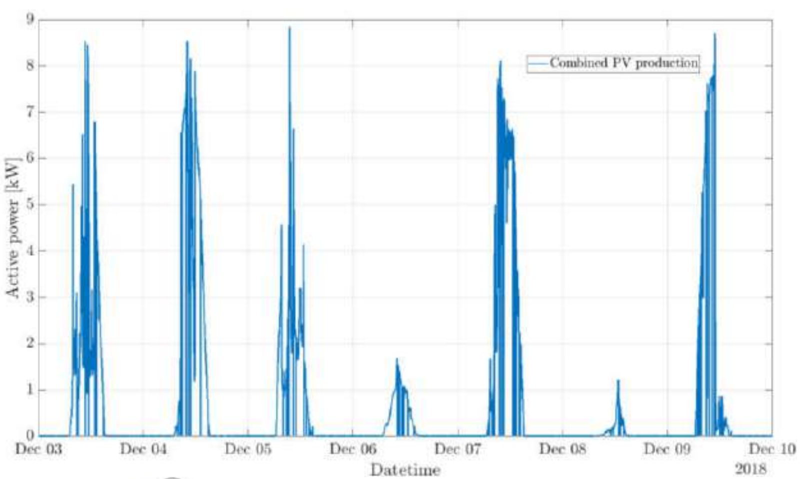
Locally stored:
inputsXY_neuronsZ.net

MODULE INPUTS

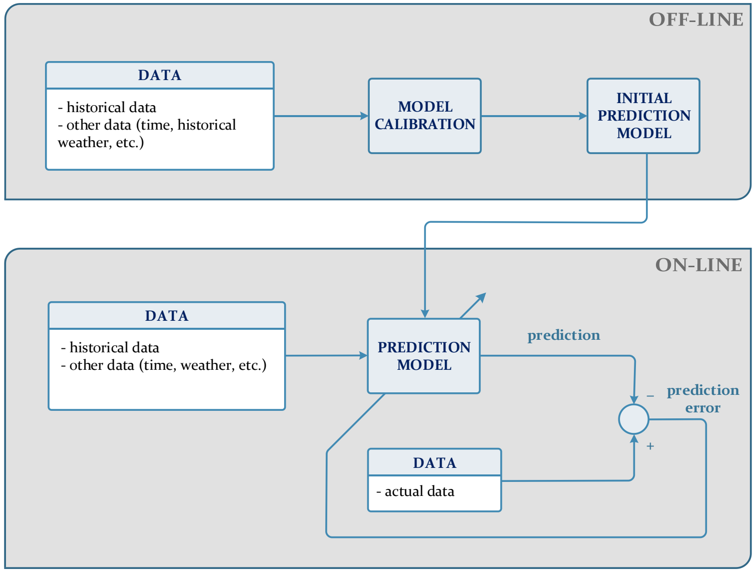
MODULE



Historical **PV production data**



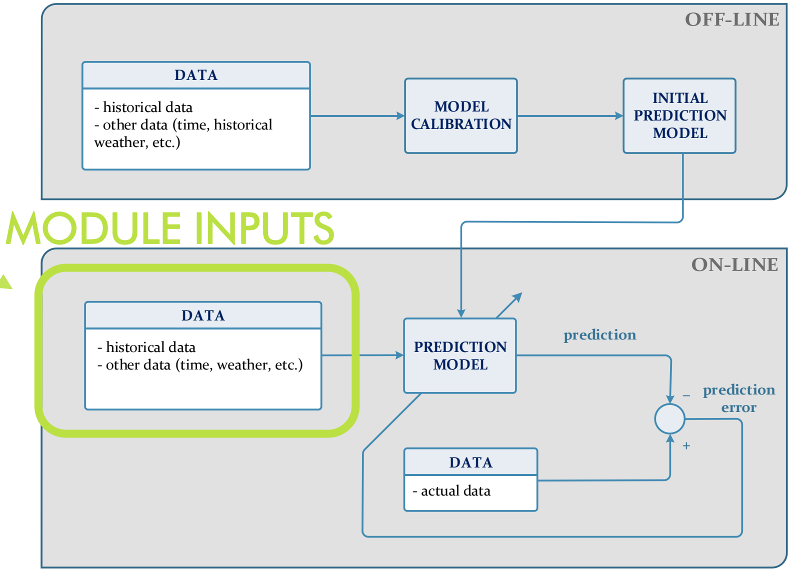
M PE 3 – on-line operation



M PE 3 – on-line operation

Regressor created from specific historical intervals of data:

- solar_zenith(t-1,…,t-3)
- solar_azimuth(t-1,…,t-3)
- temperature(t-1,…,t-3)
- direct irradiance(t-1,…,t-3)
- diffuse irradiance(t-1,…,t-3)

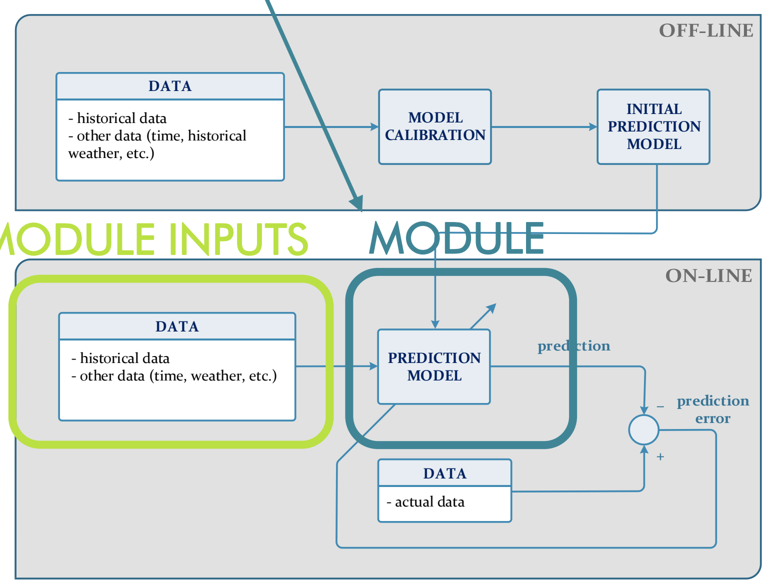


M PE 3 – on-line operation

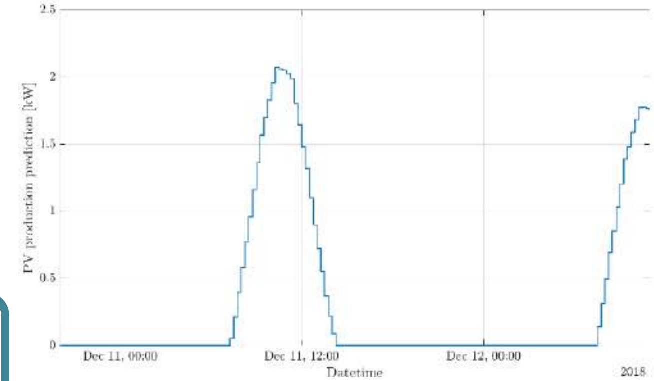
Regressor created from specific historical intervals of data:

- solar_zenith(t-1,…,t-3)
- solar_azimuth(t-1,…,t-3)
- temperature(t-1,…,t-3)
- direct irradiance(t-1,…,t-3)
- diffuse irradiance(t-1,…,t-3)

Locally stored:
inputsXY_neuronsZ.net



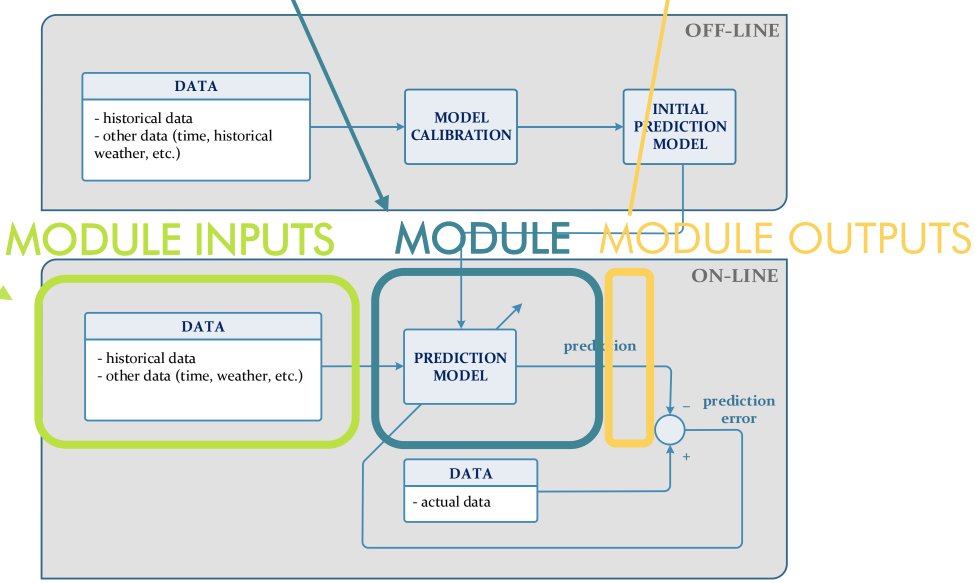
M PE 3 – on-line operation



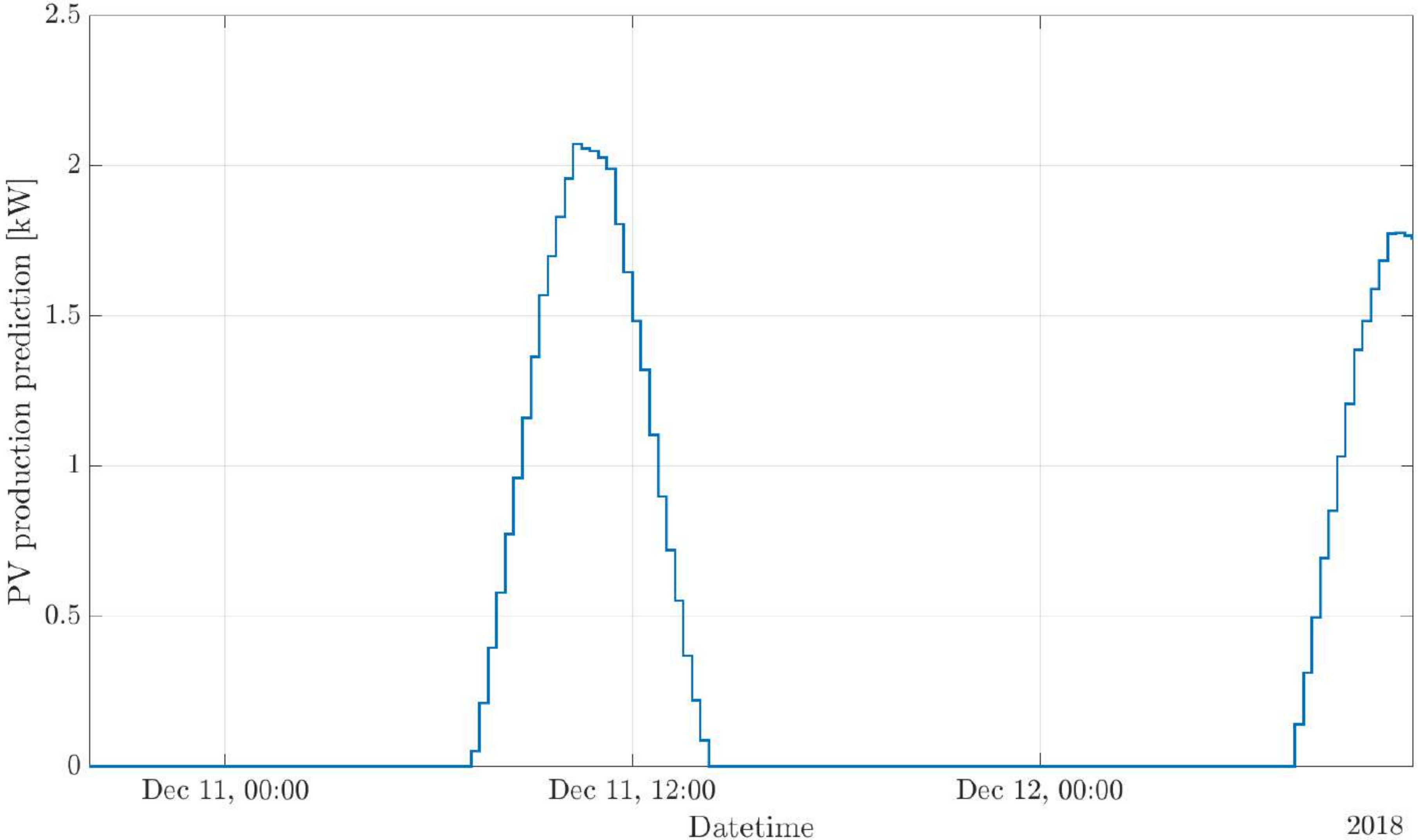
Locally stored:
inputsXY_neuronsZ.net

Regressor created from specific historical intervals of data:

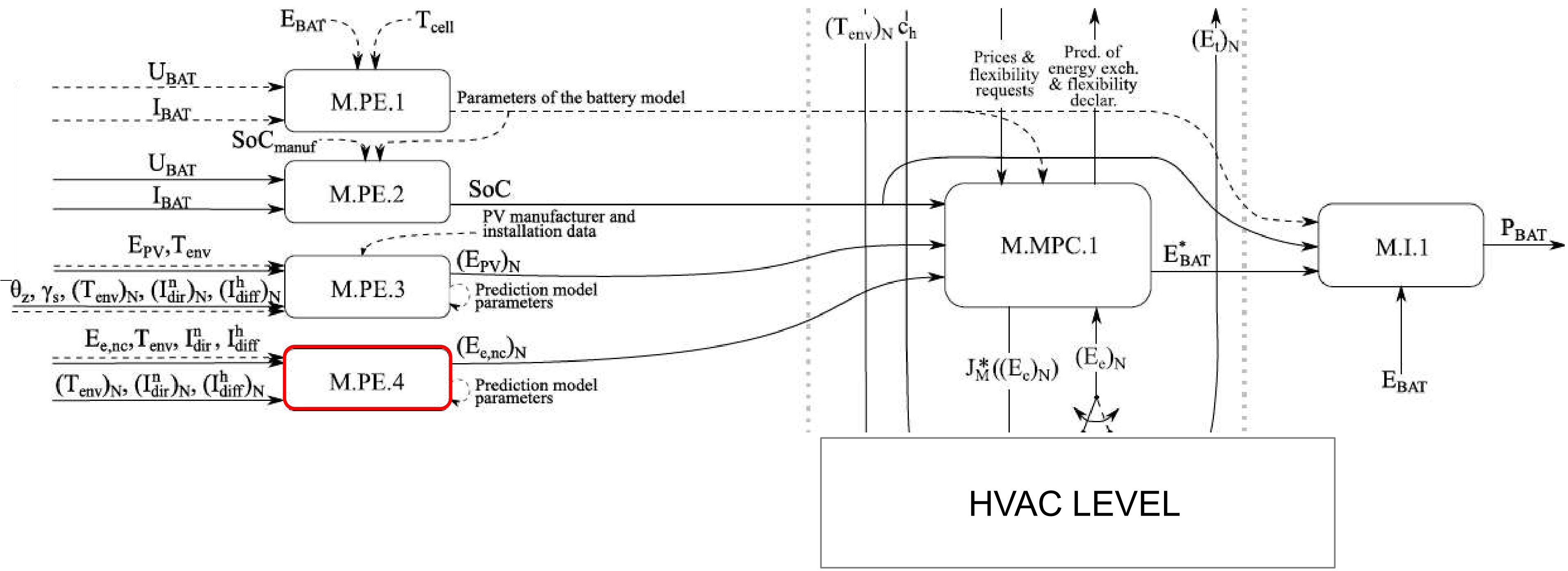
- solar_zenith(t-1,…,t-3)
- solar_azimuth(t-1,…,t-3)
- temperature(t-1,…,t-3)
- direct irradiance(t-1,…,t-3)
- diffuse irradiance(t-1,…,t-3)



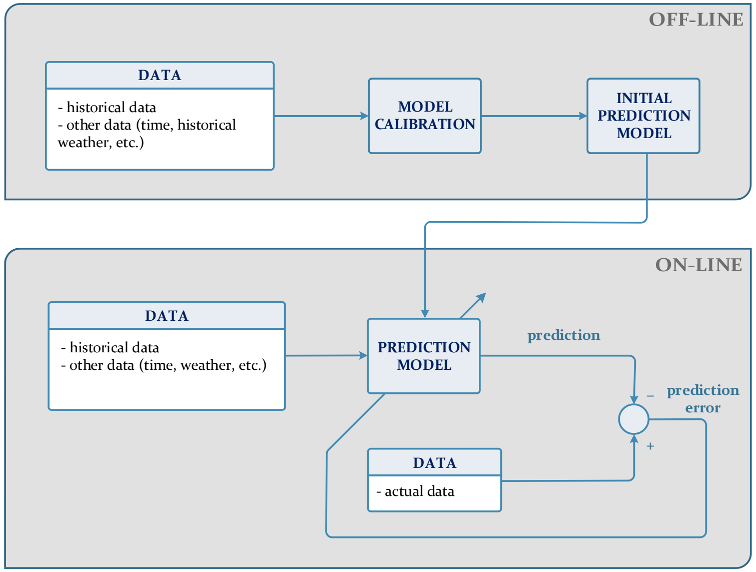
M PE 3 – on-line operation



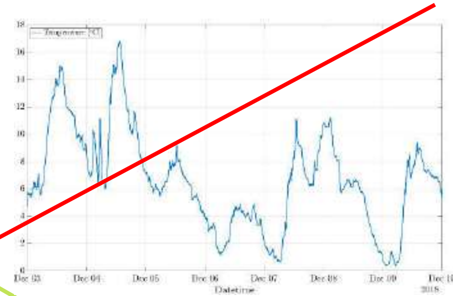
M PE 4 (prediction of microgrid level non-controllable consumption)



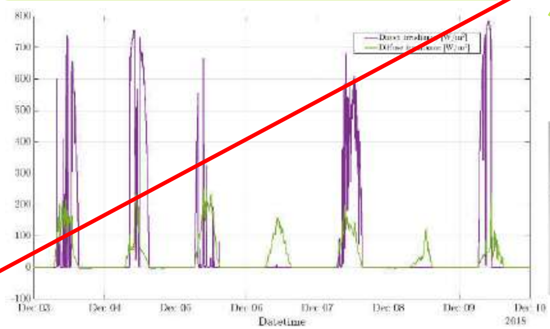
M PE 4 – off-line initialization



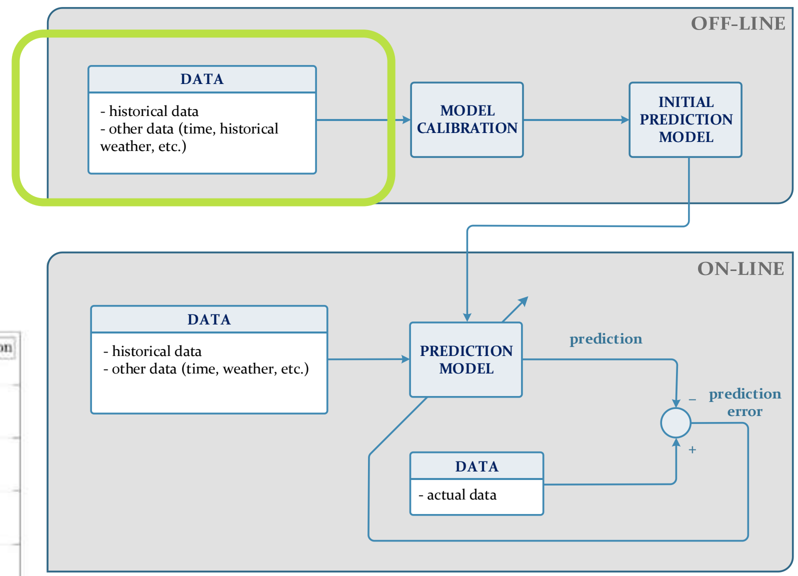
M PE 4 – off-line initialization



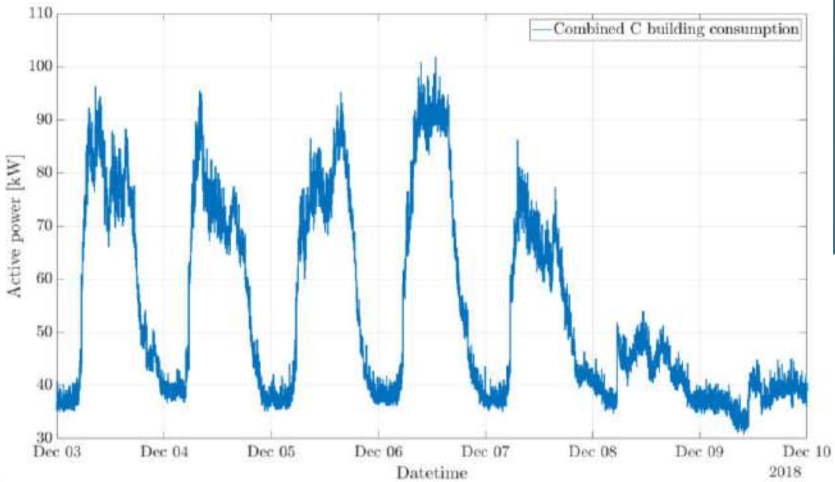
Historical **weather measurements**:
- Temperature
- Direct, diffuse solar irradiance



MODULE INPUTS



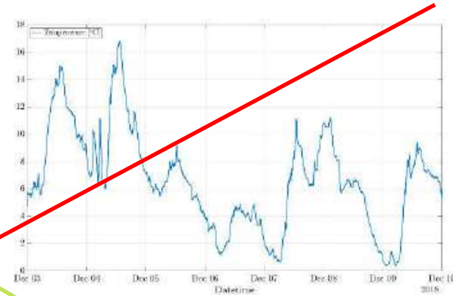
Historical **non-controllable consumption**

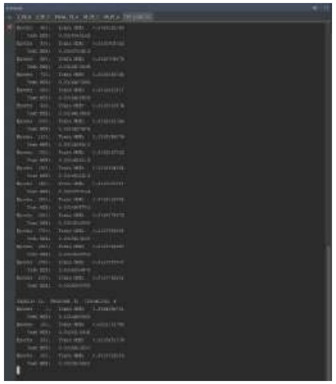


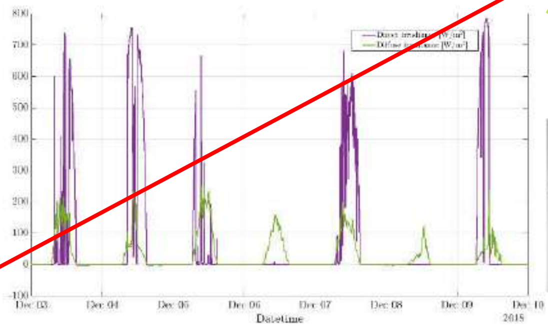
M PE 4 – off-line initialization

Historical **weather measurements**:

- Temperature
- Direct, diffuse solar irradiance

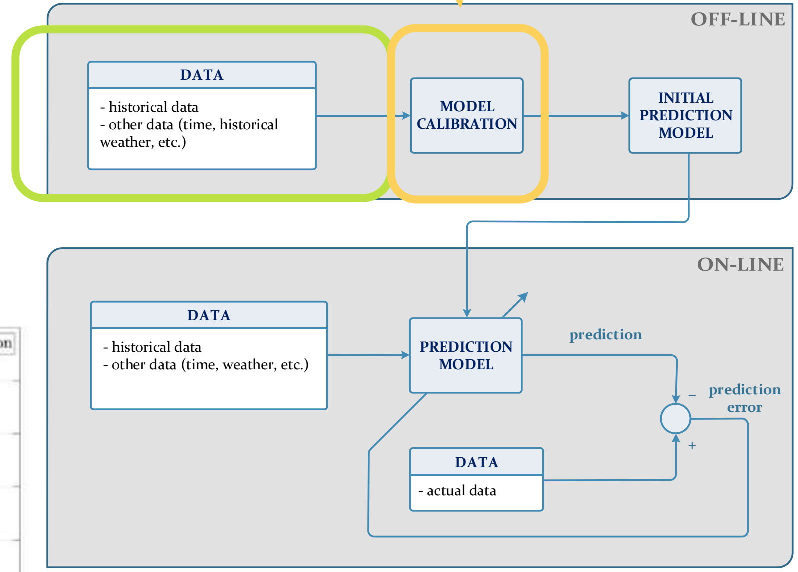


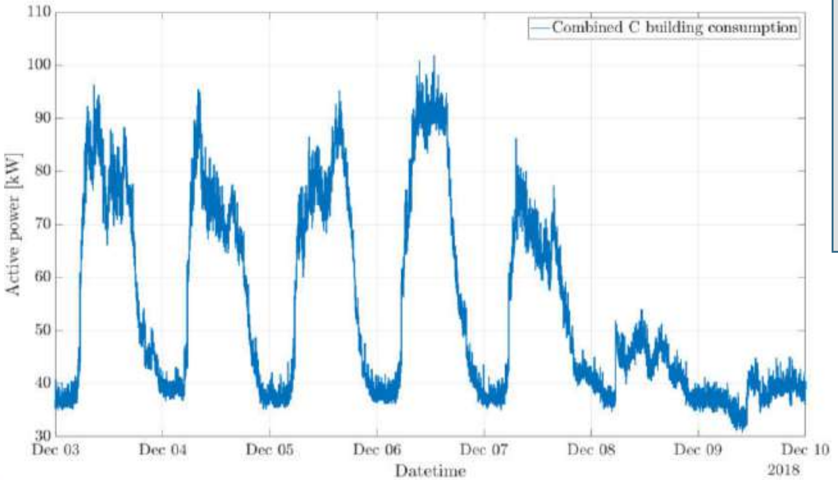




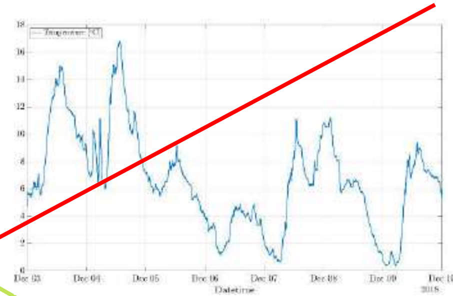
Historical **non-controllable consumption**

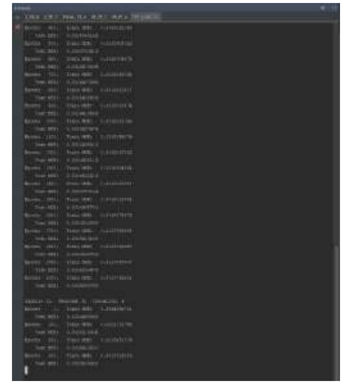
MODULE INPUTS



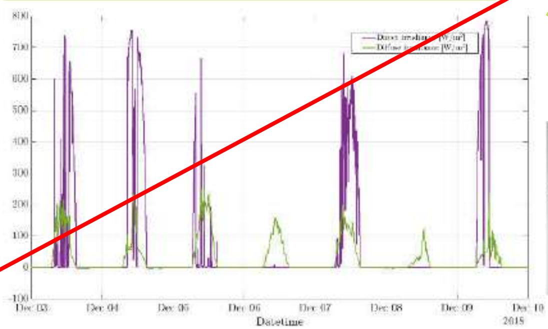


M PE 4 – off-line initialization





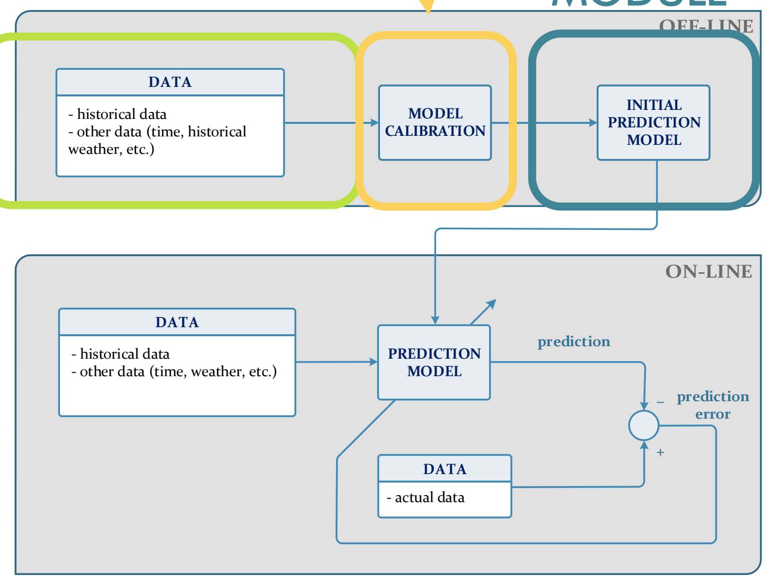
Historical **weather measurements**:
- Temperature
- Direct, diffuse solar irradiance



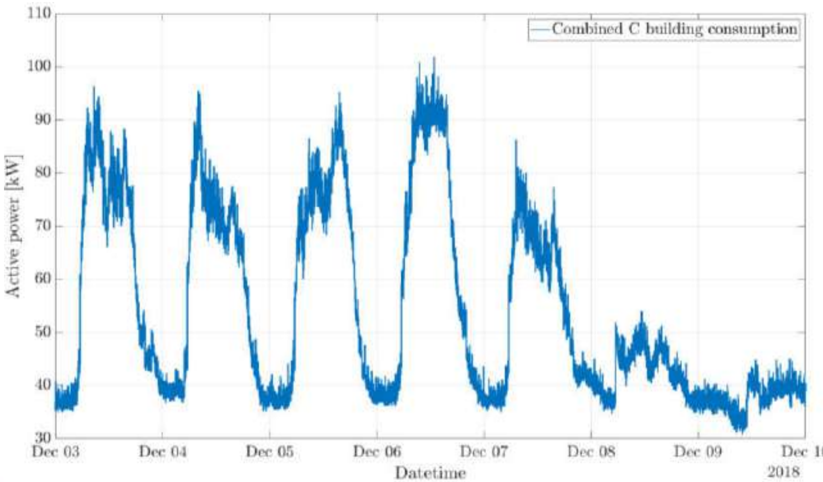
Locally stored:
inputsXY_neuronsZ.net

MODULE INPUTS

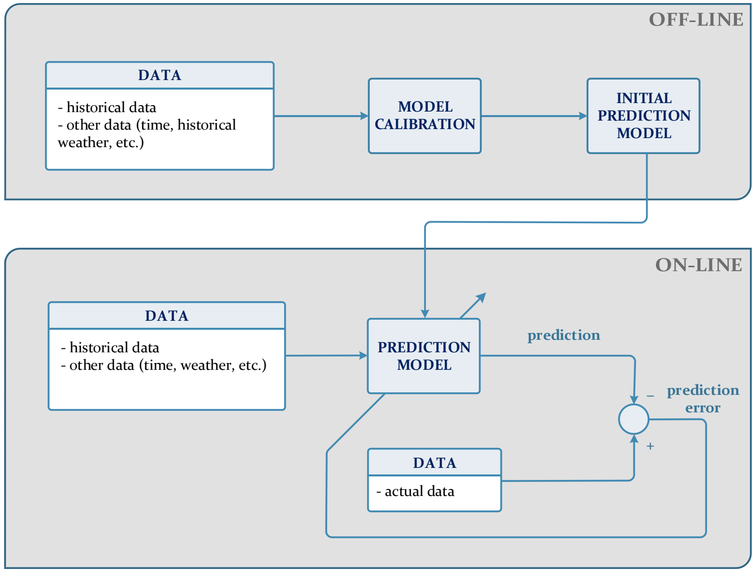
MODULE



Historical **non-controllable consumption**



M PE 4 – on-line operation



M PE 4 – on-line operation

Regressor created from specific historical intervals of data:

- nctrl consumption(t-1,…,t-5)
- nctrl consumption(t-46,…,t-50)
- nctrl consumption(t-166,…,t-170)

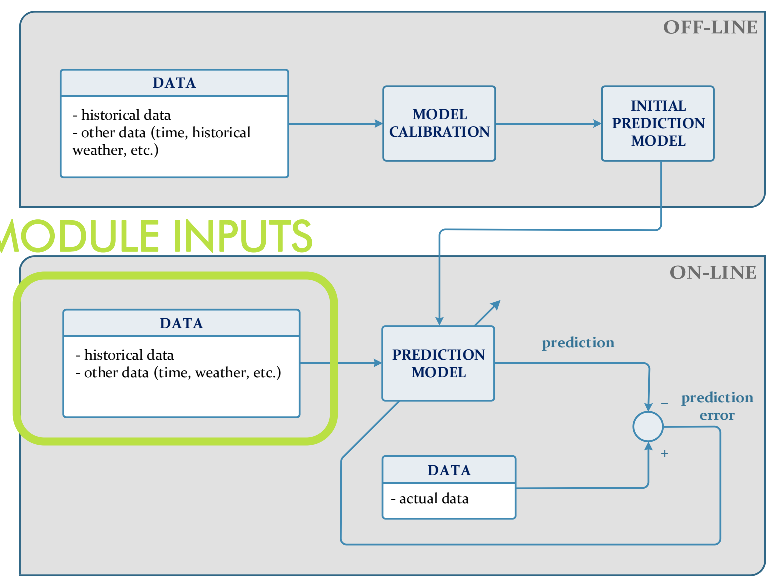
- tau_s_d, tau_c_d
- tau_s_w, tau_c_w
- tau_s_y, tau_c_y

- temperature(t-1,…,t-3)
- temperature(t-95,…,t-97)
- temperature(t-671,…,t-673)

- direct irradiance(t-1,…,t-3)
- direct irradiance (t-95,…,t-97)
- direct irradiance(t-671,…,t-673)

- diffuse irradiance(t-1,…,t-3)
- diffuse irradiance (t-95,…,t-97)
- diffuse irradiance(t-671,…,t-673)

MODULE INPUTS



M PE 4 – on-line operation

Regressor created from specific historical intervals of data:

- nctrl consumption(t-1,…,t-5)
- nctrl consumption(t-46,…,t-50)
- nctrl consumption(t-166,…,t-170)

- tau_s_d, tau_c_d
- tau_s_w, tau_c_w
- tau_s_y, tau_c_y

- temperature(t-1,…,t-3)
- temperature(t-95,…,t-97)
- temperature(t-671,…,t-673)

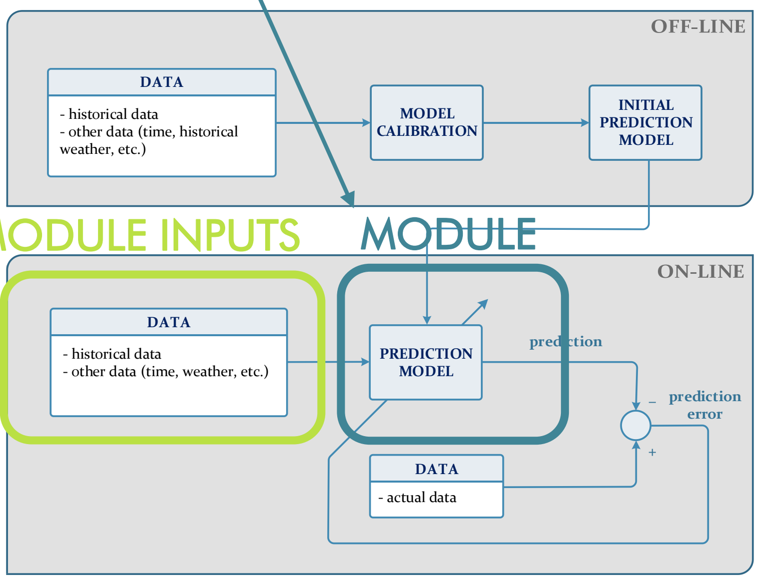
- direct irradiance(t-1,…,t-3)
- direct irradiance (t-95,…,t-97)
- direct irradiance(t-671,…,t-673)

- diffuse irradiance(t-1,…,t-3)
- diffuse irradiance (t-95,…,t-97)
- diffuse irradiance(t-671,…,t-673)

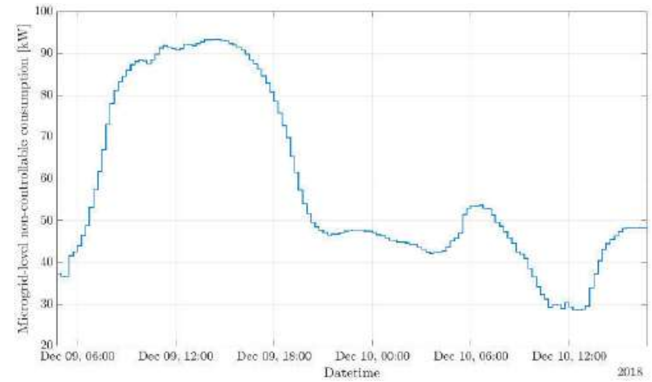
Locally stored:
inputsXY_neuronsZ.net

MODULE INPUTS

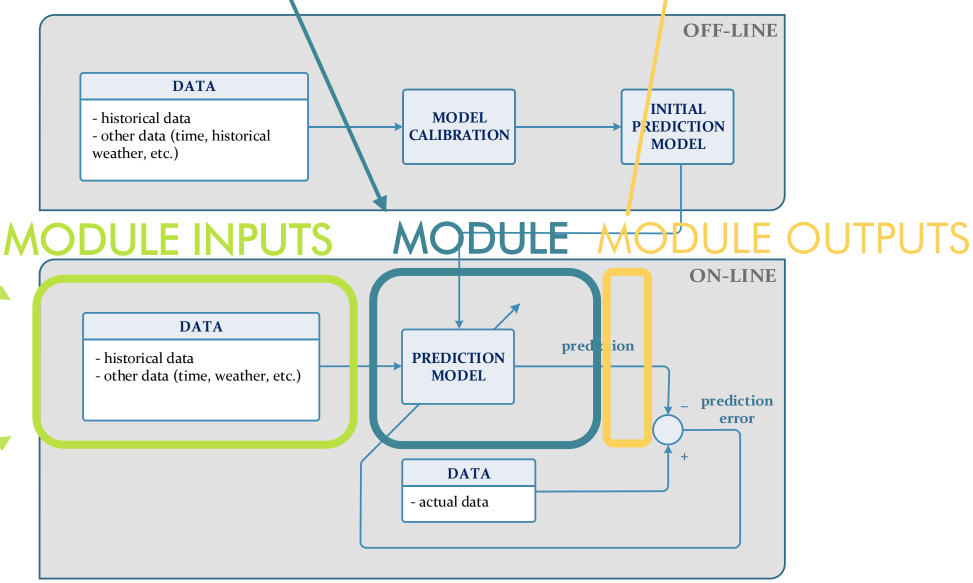
MODULE



M PE 4 – on-line operation



Locally stored:
inputsXY_neuronsZ.net



Regressor created from specific historical intervals of data:

- nctrl consumption(t-1,…,t-5)
- nctrl consumption(t-46,…,t-50)
- nctrl consumption(t-166,…,t-170)

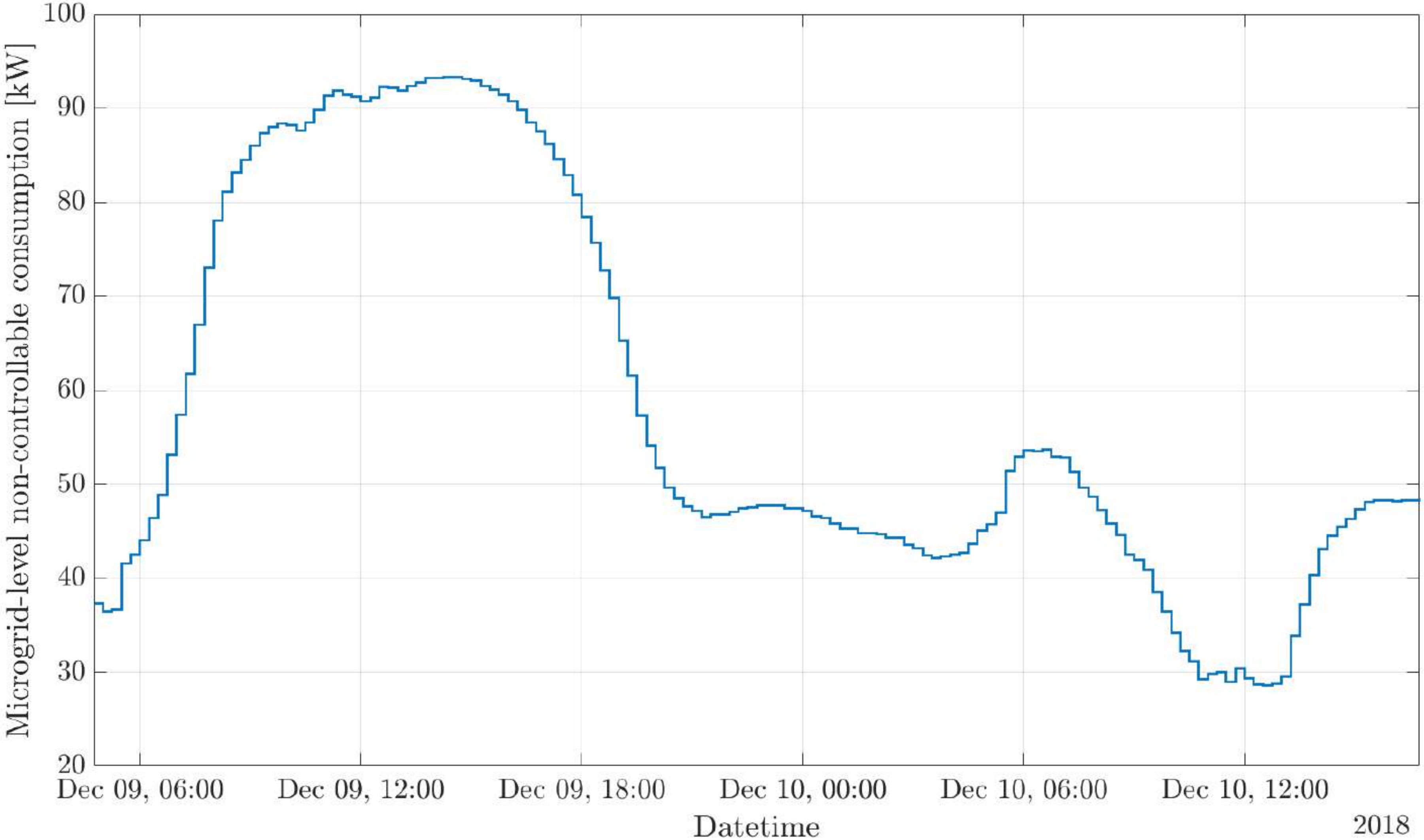
- tau_s_d, tau_c_d
- tau_s_w, tau_c_w
- tau_s_y, tau_c_y

- temperature(t-1,…,t-3)
- temperature(t-95,…,t-97)
- temperature(t-671,…,t-673)

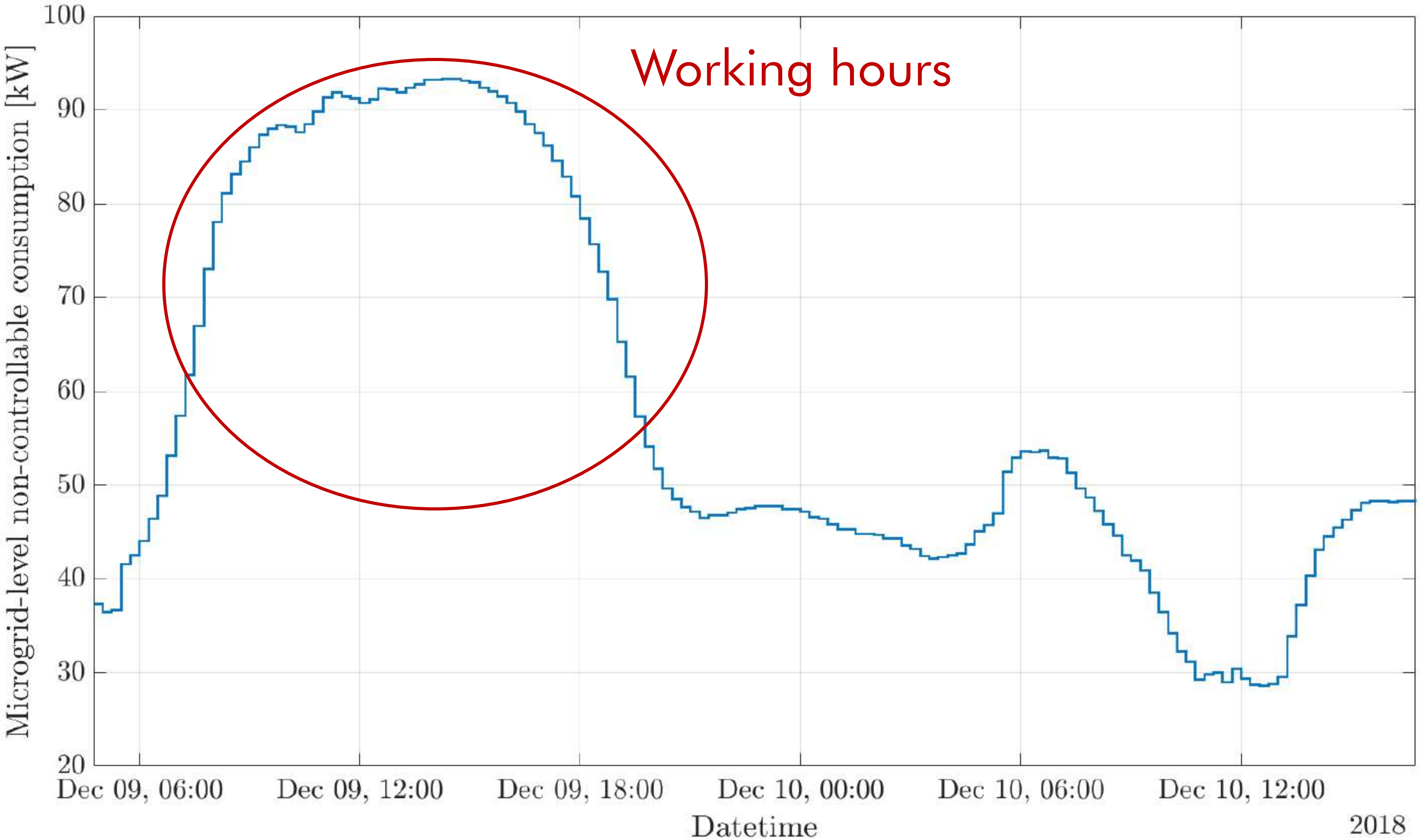
- direct irradiance(t-1,…,t-3)
- direct irradiance (t-95,…,t-97)
- direct irradiance(t-671,…,t-673)

- diffuse irradiance(t-1,…,t-3)
- diffuse irradiance (t-95,…,t-97)
- diffuse irradiance(t-671,…,t-673)

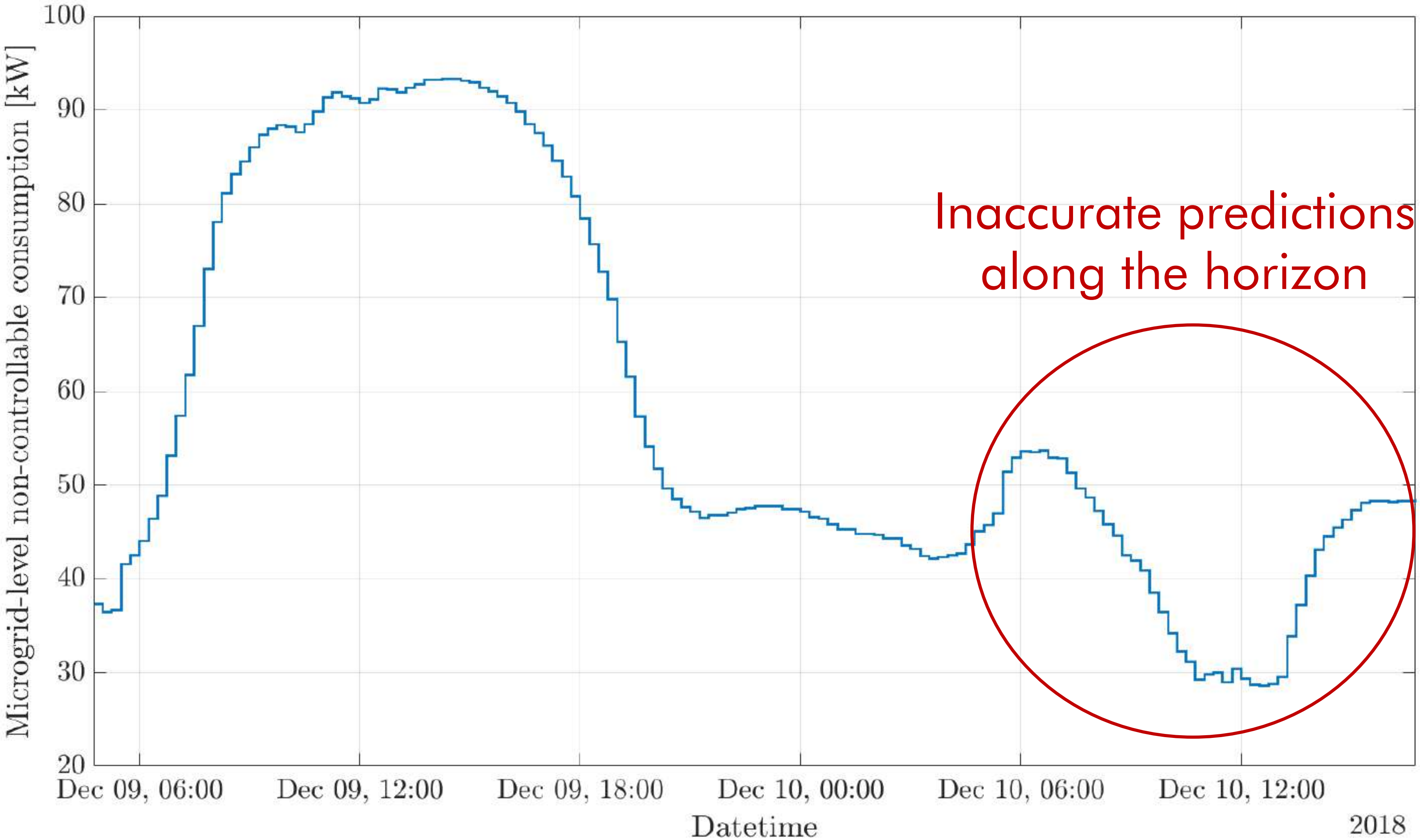
M PE 4 – on-line operation



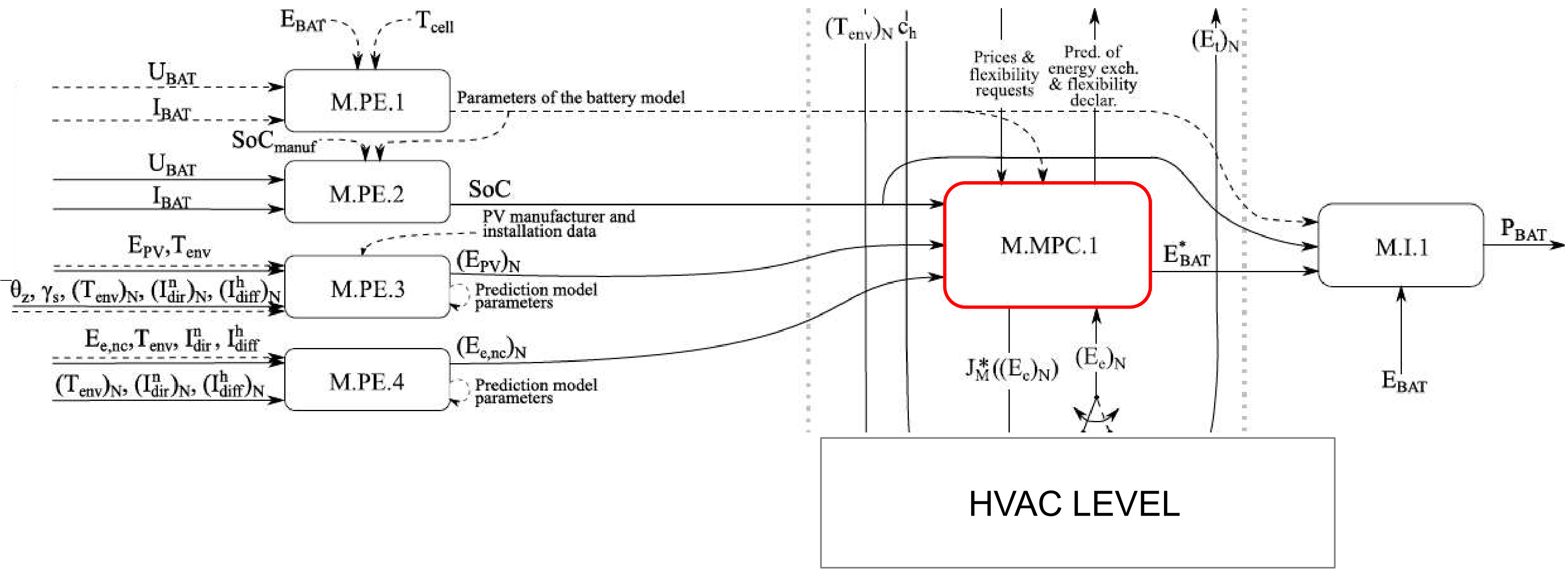
M PE 4 – on-line operation



M PE 4 – on-line operation



M MPC 1



Danube Transnational Programme
3Smart

M MPC 1 – short-term

- The building provides the following services to the rid:
  - Prediction of day-ahead (DA) consumption
  - Following the declared DA consumption profile
  - Flexibility in consumption on grid's demand
- Battery system control
- Minimization of total building operating cost:

$$J = J_{DA} + J_{BD} + J_{MP} + J_{IDf} + J_{flex,act,rew} + J_{flex,act,pen}$$





M MPC 1 – short-term

- Flexibility reservations done on the long term (LT)
- Flexibility activation requests must be in limits of the flexibility reserved in the LT!
  - DA flexibility activation – given in advance for the whole prediction horizon (i.e. next day)
  - ID flexibility activation – given only for the next sampling interval

M MPC 1 – short-term

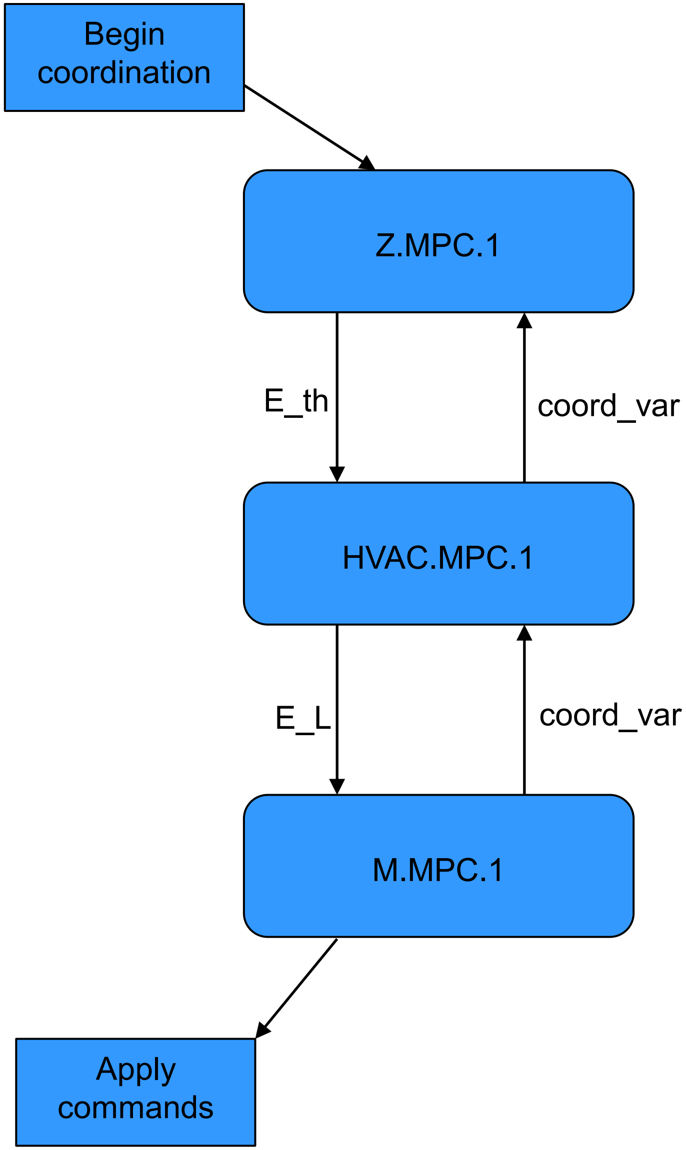
- Flexibility reservations done on the long term (LT)
- Flexibility activation requests limits:
  - activation must be in limits of the flexibility reserved in the LT
  - if flexibility is activated in a certain time period, no changes are possible
- Ensuring that reserved flexibility can be activated
  - worst-case: we presume all non-activated flexibility will be activated
  - activation after the DA profile end is rewarded/charged with lower prices

M MPC 1 – short-term

- Flexibility activation types:
  - DA flexibility activation – given in advance for the whole prediction horizon (i.e. next day)
  - ID flexibility activation – given only for the next sampling interval

M MPC 1 – short term

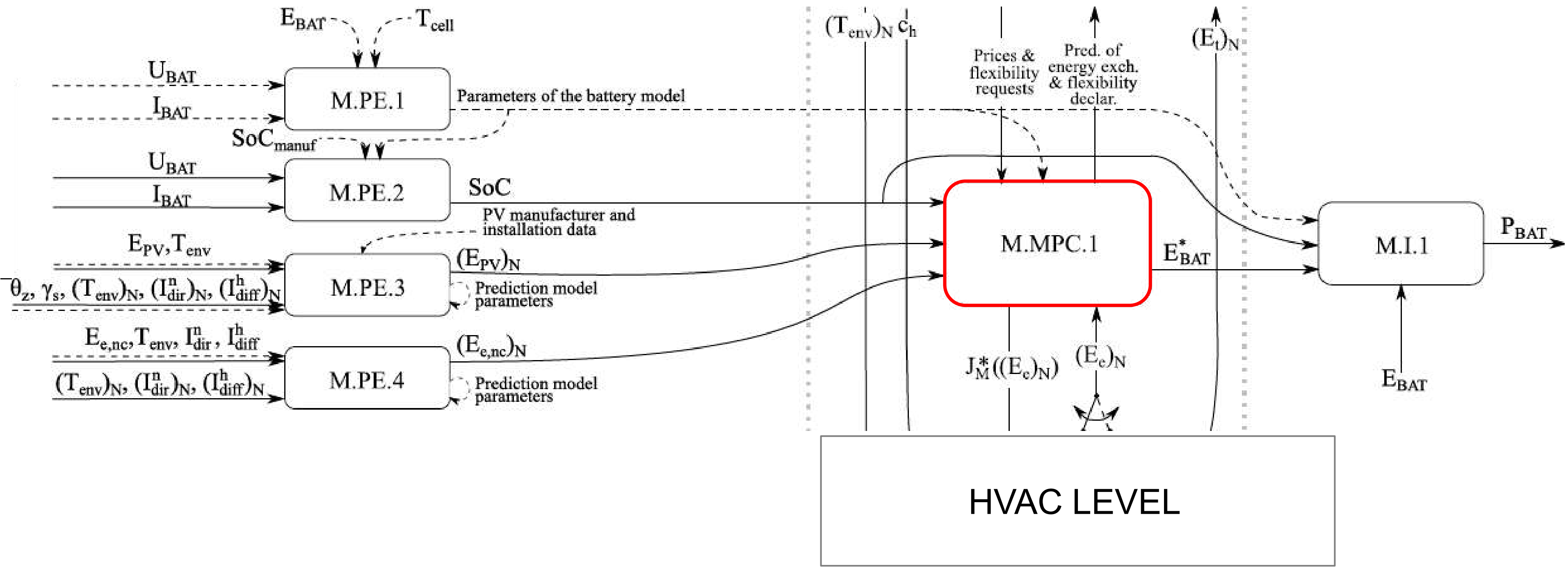
- Coordination with the lower level(s)
  - Can we obtain flexibility by adjusting HVAC consumption?
  - Is that cheaper than using the battery?
  - Iterative process
  - M.MPC.1 presumes all HVAC predicted loads from previous iterations are feasible



M MPC 1 – short-term operating schedule

- Before DA energy prices arrived:
  - computing the informative DA profile
- After DA energy prices and DA flexibility activations arrived:
  - computing the declared DA profile
- Every 15 minutes:
  - taking ID flexibility requests into account
  - price-optimal microgrid operation

M MPC 1 – data exchange



Inputs

- Non-controllables predictions
- Estimated battery model
- Measurements from the battery
- Prices and requests from the grid

Outputs

- Battery commands
- Coordination data → HVAC
- Consumption predictions → grid

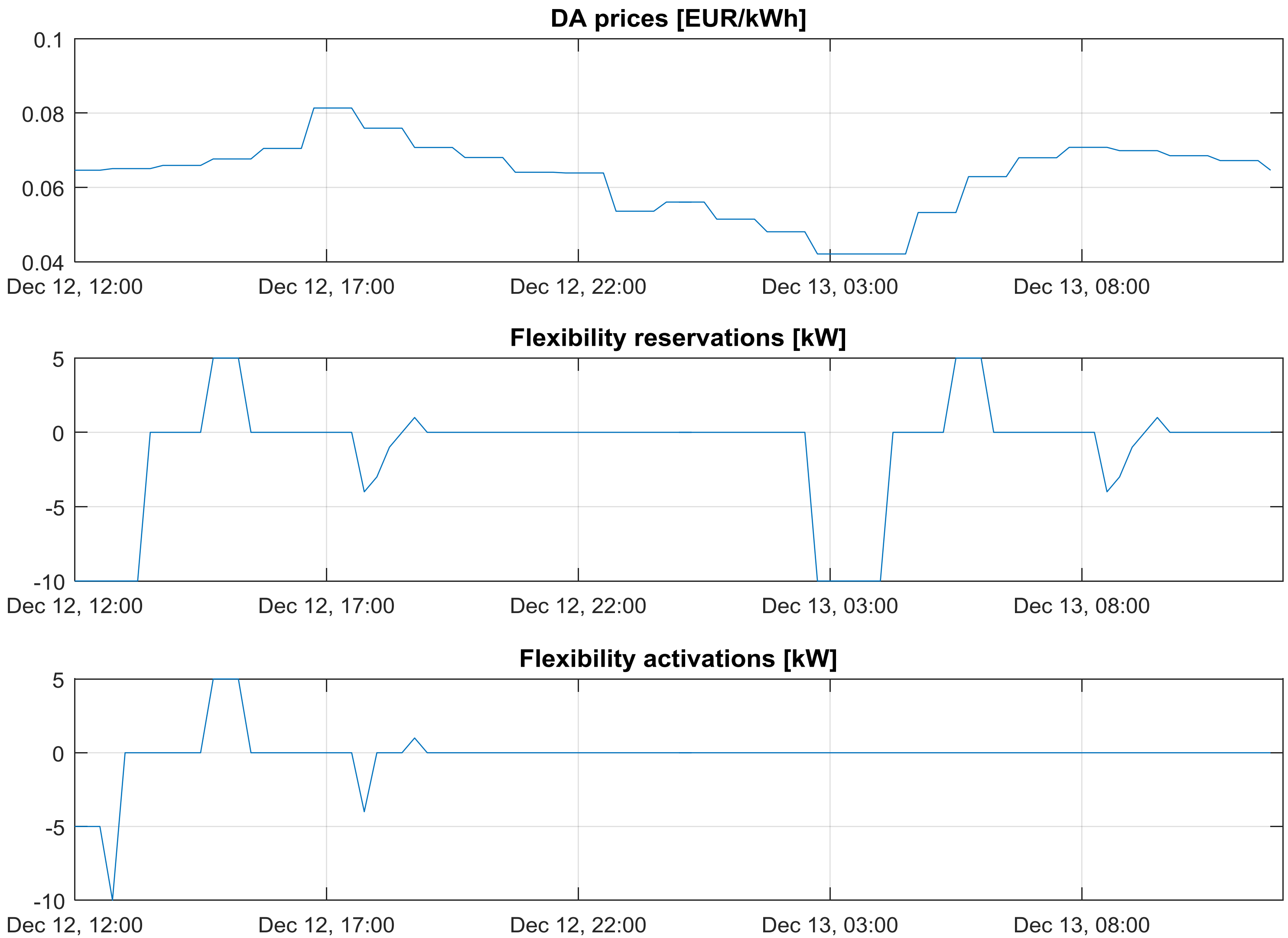
M MPC 1 – short-term operating schedule

- Before DA energy prices arrived:
  - computing the informative DA profile
- After DA energy prices and DA flexibility activations arrived:
  - computing the declared DA profile
- Every 15 minutes:
  - taking ID flexibility requests into account
  - price-optimal microgrid operation

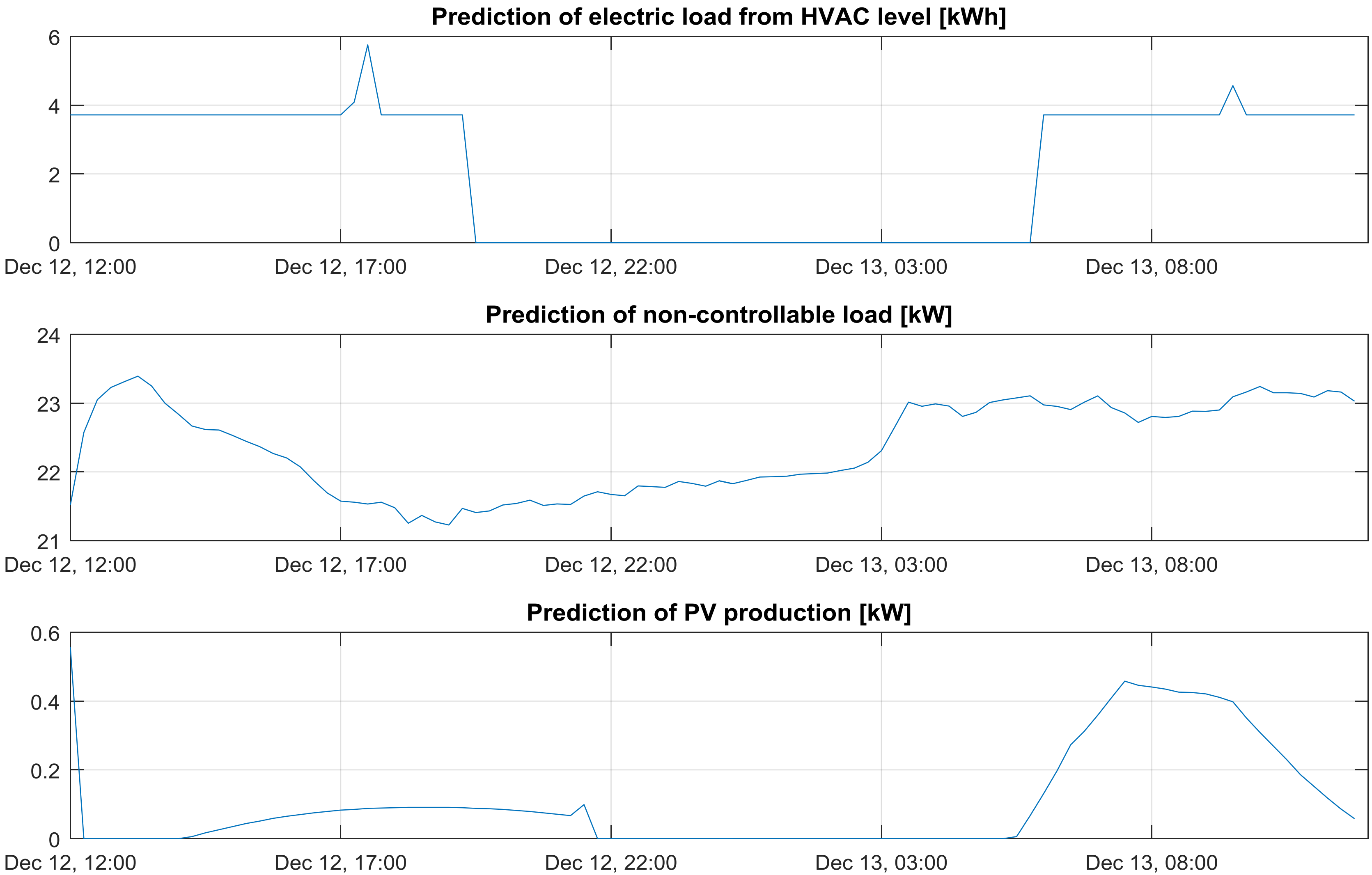
M MPC 1 – short-term operating schedule

- Before DA energy prices arrived:
  - computing the informative DA profile
- After DA energy prices and DA flexibility activations arrived:
  - computing the declared DA profile
- Every 15 minutes:
  - taking ID flexibility requests into account
  - price-optimal microgrid operation
- <u>Module not in online operation – displaying synthetic data!</u>

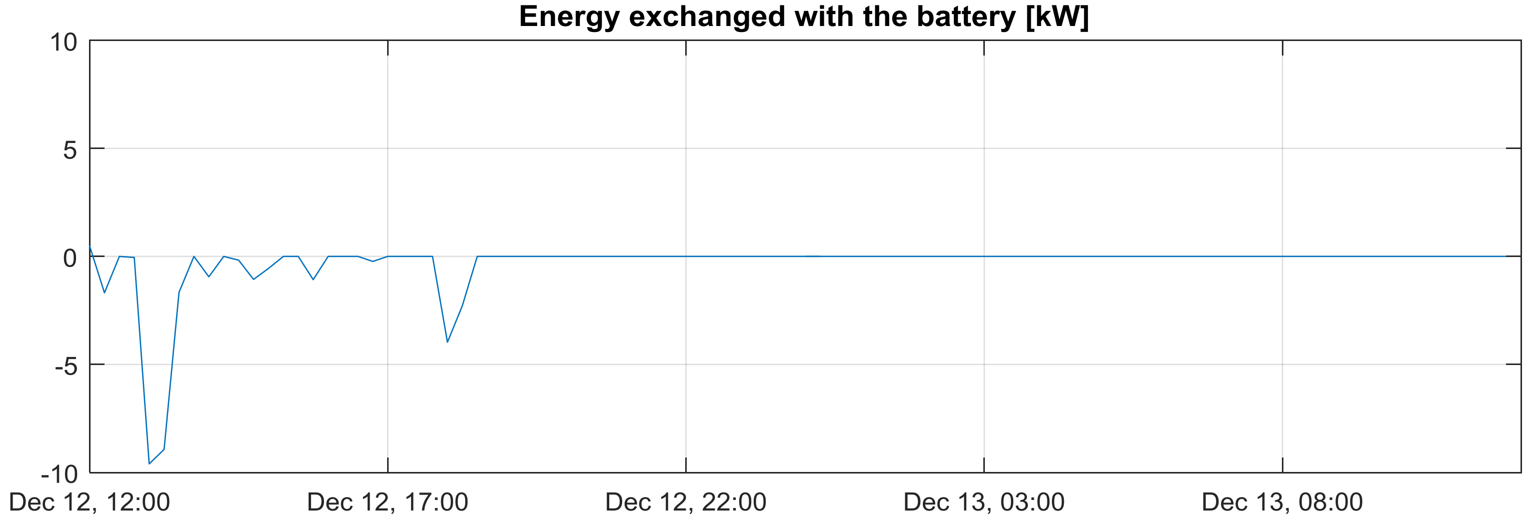
M MPC 1 - results

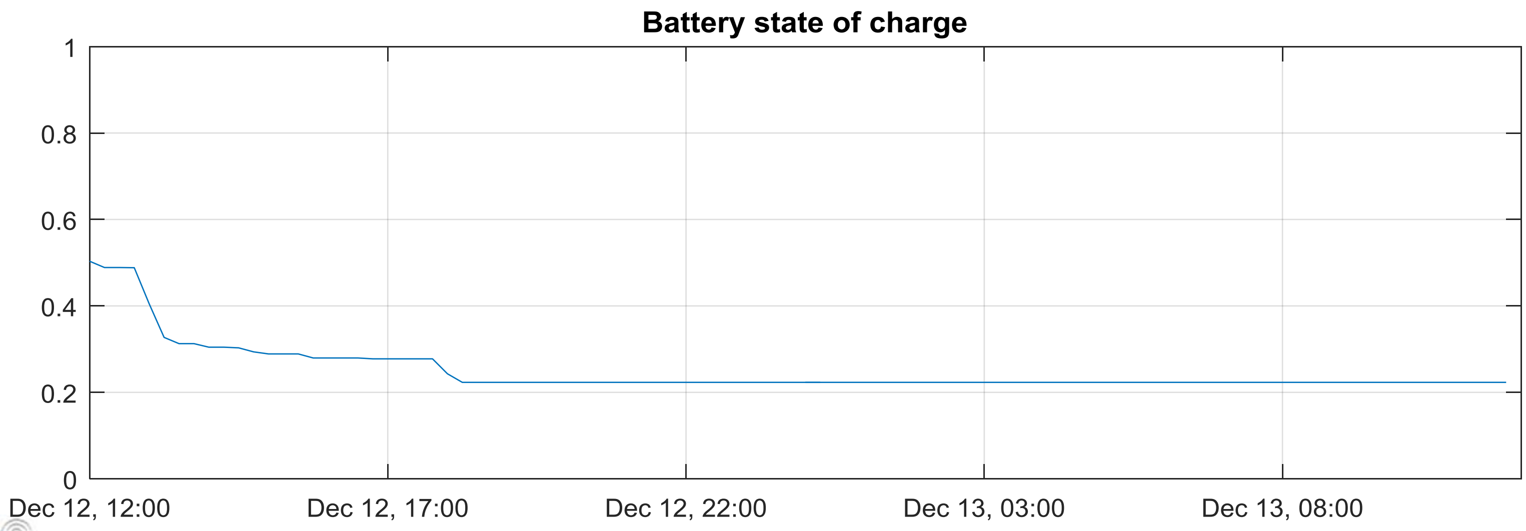


M MPC 1 - results

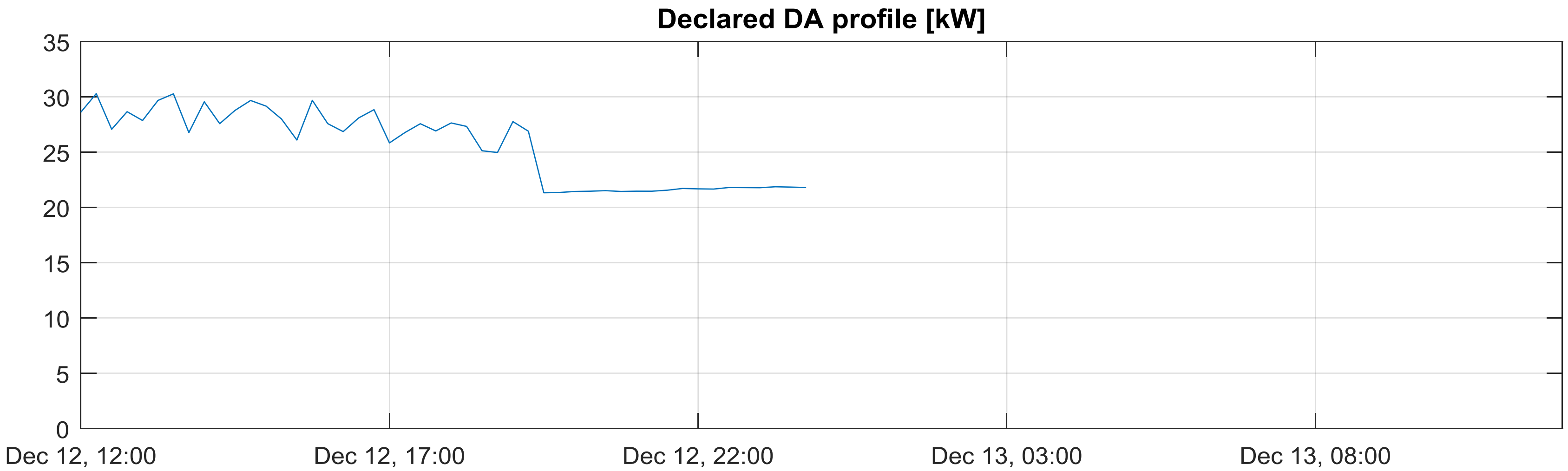


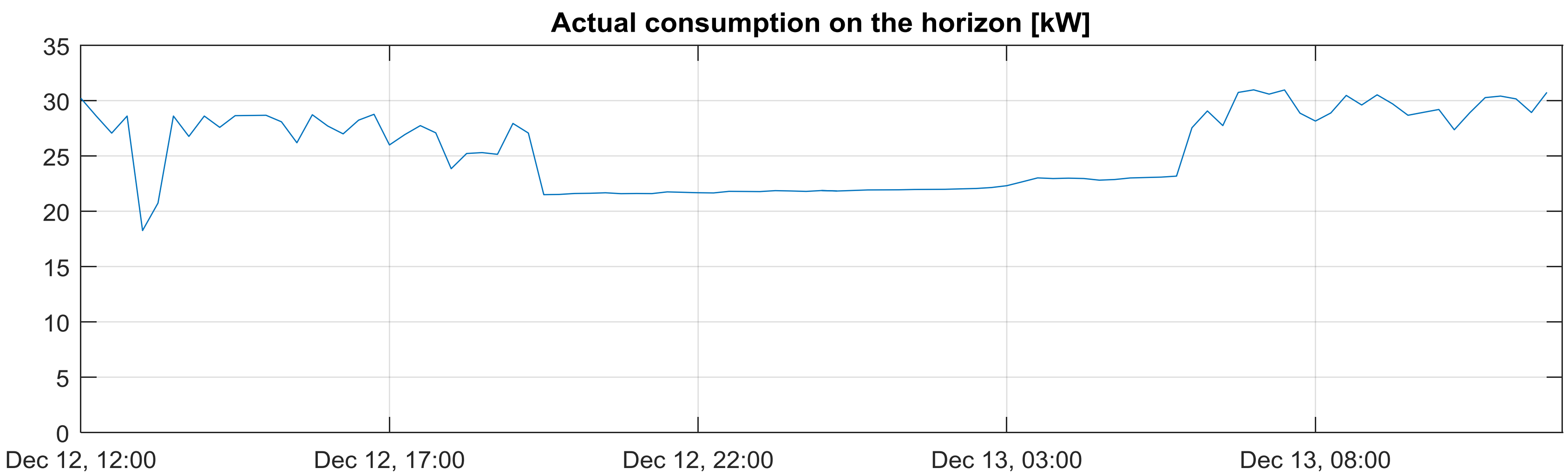
M MPC 1 - results





M MPC 1 - results





HVAC.PE.1 and HVAC.PE.2

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First pilot study visit - Zagreb

11-12 December 2018

Danube Transnational Programme

3Smart

Project co-funded by European Union funds (ERDF, IPA)

HVAC.PE.1

- HVAC.PE.1 – Estimation of the offline module parameters
- Heat pump COP

HVAC.PE.1

HVACPE1_inputs_online	
FK. HeatPumpID	Int
Timestamp	DateTime
Heat pump ambient temperature	Real
Heat pump medium flow	Real
Heat pump ingoing medium	Real
temperature Heat pump outgoing	Real
medium temp.	

HVACPE1_outputs_offline	
FK. HeatPumpID	Int
PK. HeatPumpModelID	Int
Timestamp	DateTime
Heat pump COP parameter	Real

HVAC.PE.1

HVACPE1_outputs_online	
FK. HeatPumpID	Int
Timestamp	DateTime
Estimated el. energy cons. of the heat pump.	Real

HVAC.PE.1

HVACPE1_inputs_online	
FK. HeatPumpID	Int
Timestamp	DateTime
Heat pump ambient temperature	Real
Heat pump medium flow	Real
Heat pump ingoing medium	Real
temperature Heat pump outgoing medium temp.	Real

HVACPE1_outputs_offline	
FK. HeatPumpID	Int
PK. HeatPumpModelID	Int
Timestamp	DateTime
Heat pump COP parameter	Real

HVAC.PE.1

HVACPE1_outputs_online	
FK. HeatPumpID	Int
Timestamp	DateTime
Estimated el. energy cons. of the heat pump.	Real

HVAC.PE.1 – Results (Inputs tables)

Edit Data - 3smart (localhost:5432) - smart_db - public.hvac_pe1_online_inputs

File Edit View Tools Help

No limit

	heat_pump_id integer	timestamp timestamp(6) without time zone	heat_pump_ambient_air_temperature real	heat_pump_supply_medium_flow real	heat_pump_return_medium_temperature real	heat_pump_supply_medium_temperature real	hvac_pe1_model_id [PK] integer
1	1	2018-11-15 22:15:00	20	42.8	40	42	1
*							

Edit Data - 3smart (localhost:5432) - smart_db - public.hvac_pe1_outputs

File Edit View Tools Help

No limit

	heat_pump_id integer	timestamp timestamp(6) without time zone	heat_pump_model_gamma real	hvac_pe1_model_id [PK] integer
1	1	2018-11-19 14:57:00	0.11	1
*				

HVAC.PE.1 – Results (Outputs table)

Edit Data - 3smart (localhost:5432) - smart_db - public.hvac_pe1_online_outputs_history

File Edit View Tools Help

No limit

	heat_pump_id integer	id [PK] bigserial	timestamp timestamp(6) without time zone	heat_pump_electrical_energy_consumption_est real	hvac_pe1_model_id integer
1	1	1	2018-11-19 15:20:00	0.3	1
2	1	2	2018-11-19 15:20:37	0.124525	1
3	1	3	2018-11-21 11:58:20	0.124525	1
4	1	4	2018-11-21 12:20:29	448291	1
5	1	5	2018-11-21 12:21:47	124.525	1
6	1	6	2018-11-21 12:24:31	65.1677	1
7	1	7	2018-11-21 18:36:10	65.1677	1
8	1	8	2018-11-21 18:39:27	65.1677	1
9	1	9	2018-11-22 09:37:21	72.7336	1
10	1	10	2018-11-26 22:52:16	72.7336	1
11	1	11	2018-11-26 23:03:37	72.7336	1
12	1	12	2018-11-26 23:04:16	66.1215	1
13	1	13	2018-11-28 12:26:41	60.3718	1
14	1	14	2018-12-08 07:59:12	0.0603718	1
15	1	15	2018-12-08 07:59:28	60.3718	1
16	1	16	2018-12-11 16:45:25	60.3718	1

HVAC.PE.2

- HVAC.PE.2 – Estimation of the offline module parameters

$$\Delta T = a + b \cdot T + c \cdot Q$$

- Coefficients (a, b and c)

HVAC.PE.2

HVACPE2_online_inputs	
FK. PipeworkID	**Int**
Timestamp	DateTime
Temperature of the medium coming out of the heat pump/heating substation	Real
Medium flow through the heat pump	Real

HVAC.PE.2

HVACPE2_calorimeter_supply_outputs_offline	
FK. PipeworkID	**Int**
FK. CalorimeterID	**Int**
PK. CalorimeterModelID Timestamp	**Int**
Parameters of the supply temp.	DateTime
model Flow share gain	varchar(250)
	Real

HVACPE2_calorimeter_supply_outputs_online	
FK. PipeworkID	**Int**
FK. CalorimeterID	Int
Timestamp	DateTime
Estimated (based on the model) supply temperature	Real
Estimated (based on the model) flow	Real

HVAC.PE.2

HVACPE2_online_inputs	
FK. PipeworkID	**Int**
Timestamp	DateTime
Temperature of the medium coming out of the heat pump/heating substation	Real
Medium flow through the heat pump	Real

HVAC.PE.2

HVACPE2_calorimeter_supply_outputs_offline	
FK. PipeworkID	**Int**
FK. CalorimeterID	**Int**
PK. CalorimeterModelID Timestamp	**Int**
Parameters of the supply temp.	DateTime
model Flow share gain	varchar(250)
	Real

HVACPE2_calorimeter_supply_outputs_online	
FK. PipeworkID	**Int**
FK. CalorimeterID	Int
Timestamp	DateTime
Estimated (based on the model) supply temperature	Real
Estimated (based on the model) flow	Real

HVAC.PE.2 – Results (Inputs tables)

Edit Data - 3smart (localhost:5432) - smart_db - public.hvac_pe2_online_inputs

File Edit View Tools Help

No limit

	hvac_pe2_model_id [PK] integer	pipework_id integer	timestamp timestamp(6) without time zone	supply_medium_temperature real	supply_medium_flow real
1	1	1	2018-12-08 08:41:04	42	1400
*					

Edit Data - 3smart (localhost:5432) - smart_db - public.hvac_pe2_calorimeter_supply_outputs

File Edit View Tools Help

No limit

	hvac_pe2_model_id [PK] integer	pipework_id integer	calorimeter_id integer	timestamp timestamp(6) without time zone	calorimeter_flow_share_gain real	calorimeter_supply_temperature_model character varying(500)
1	1	2	1	2018-09-06 13:00:00	0.1	[1.522, 0.002, -1.18E-03]
2	2	1	2	2018-12-08 08:41:04		[-0.035, 0.006, -3.86E-05]
3	3	3	3	2018-09-06 13:00:00		[0.751, 0.005, -9.28E-04]
4	4	4	4	2018-09-06 13:00:00		[0.409, 0.002, -2.67E-04]
5	5	5	5	2018-09-06 13:00:00		[1.457, 0.003, -1.55E-03]
6	6	1	6	2018-12-08 08:41:04		[-0.203, 0.006, 9.13E-05]
7	7	1	7	2018-12-08 08:41:04		[0.723, 0.005, -1.01E-03]
8	8	1	8	2018-12-08 08:41:04		[-0.304, 0.007, 9.96E-05]
9	9	1	9	2018-12-08 08:41:04		[1.007, 0.006, -1.16E-03]
10	10	1	10	2018-12-08 08:41:04		[-0.219, 0.009, 4.02E-05]
11	11	1	11	2018-12-08 08:41:04		[0.444, 0.008, -8.27E-04]
12	12	1	12	2018-12-08 08:41:04		[0.380, 0.008, -4.60E-04]
13	13	1	13	2018-12-08 08:41:04		[0.438, 0.010, -8.61E-04]
14	14	1	14	2018-12-08 08:41:04		[-0.109, 0.014, -1.57E-04]
15	15	1	15	2018-12-08 08:41:04		[0.478, 0.013, -7.61E-04]
16	16	1	16	2018-12-08 08:41:04		[0.420, 0.012, -4.07E-04]
17	17	1	17	2018-12-08 08:41:04		[0.315, 0.014, -5.90E-04]
18	18	1	18	2018-12-08 08:41:04		[-0.413, 0.012, 1.64E-04]
19	19	1	19	2018-12-08 08:41:04		[0.111, 0.016, -5.59E-04]
20	20	1	20	2018-12-08 08:41:04		[-0.412, 0.013, 1.31E-04]
21	21	1	21	2018-12-08 08:41:04		[0.803, 0.017, -1.51E-03]
22	22	1	22	2018-12-08 08:41:04		[-0.149, 0.015, -1.26E-04]
23	23	1	23	2018-12-08 08:41:04		[0.111, 0.024, -1.22E-03]
24	24	1	24	2018-12-08 08:41:04		[-0.596, 0.015, 1.34E-04]
25	25	1	25	2018-12-08 08:41:04		[-0.327, 0.031, -4.87E-04]
26	26	1	26	2018-12-08 08:41:04		[-0.409, 0.031, -4.87E-04]

HVAC.PE.2 – Results (Outputs table)

Edit Data - 3smart (localhost:5432) - smart_db - public.hvac_pe2_calorimeter_supply_online_outputs

File Edit View Tools Help

No limit

	hvac_pe2_model_id [PK] integer	pipework_id integer	calorimeter_id integer	timestamp timestamp(6) without time zone	calorimeter_supply_temperature_est real	calorimeter_flow_est real
1	1	2	1	2018-12-11 16:44:46	41.954	
2	2	1	2	2018-12-11 16:44:46	41.837	
3	4	4	4	2018-12-11 16:44:46	41.8808	
4	6	1	6	2018-12-11 16:44:46	41.8232	
5	8	1	8	2018-12-11 16:44:46	41.8706	
6	9	1	9	2018-12-11 16:44:46	41.635	
7	10	1	10	2018-12-11 16:44:46	41.7847	
8	11	1	11	2018-12-11 16:44:46	41.6222	
9	12	1	12	2018-12-11 16:44:46	41.928	
10	13	1	13	2018-12-11 16:44:46	41.6526	
11	14	1	14	2018-12-11 16:44:46	41.7408	
12	15	1	15	2018-12-11 16:44:46	41.9586	
13	16	1	16	2018-12-11 16:44:46	41.6458	
14	17	1	17	2018-12-11 16:44:46	41.923	
15	18	1	18	2018-12-11 16:44:46	41.6794	
16	19	1	19	2018-12-11 16:44:46	41.9996	
17	20	1	20	2018-12-11 16:44:46	41.6826	
18	21	1	21	2018-12-11 16:44:46	41.403	
19	22	1	22	2018-12-11 16:44:46	41.6954	
20	23	1	23	2018-12-11 16:44:46	41.411	
21	24	1	24	2018-12-11 16:44:46	41.7784	
22	25	1	25	2018-12-11 16:44:46	41.7068	
23	26	1	26	2018-12-11 16:44:46	41.7888	

HVAC.PE.3 and HVAC.I.1

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First pilot study visit - Zagreb

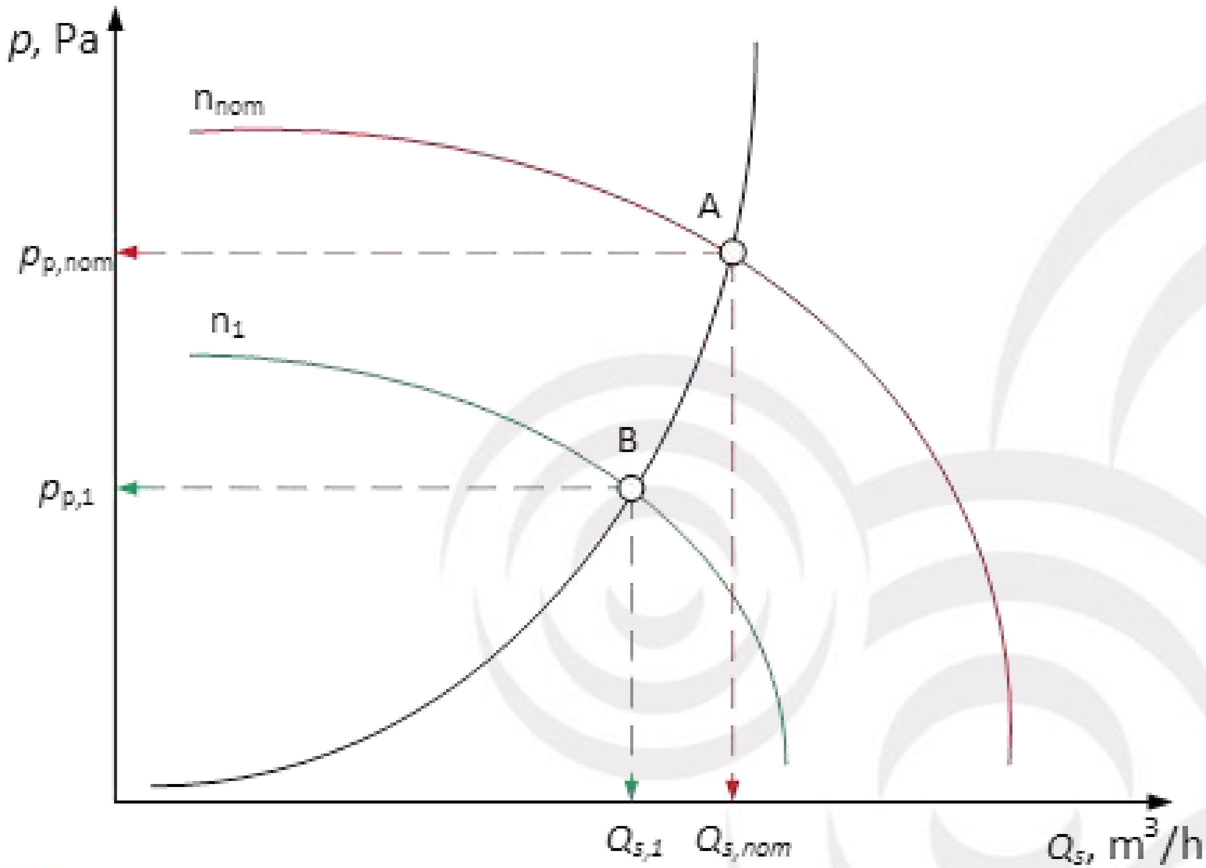
11-12 December 2018

Interreg
EUROPEAN UNION
Danube Transnational Programme
3Smart

Project co-funded by European Union funds (ERDF, IPA)

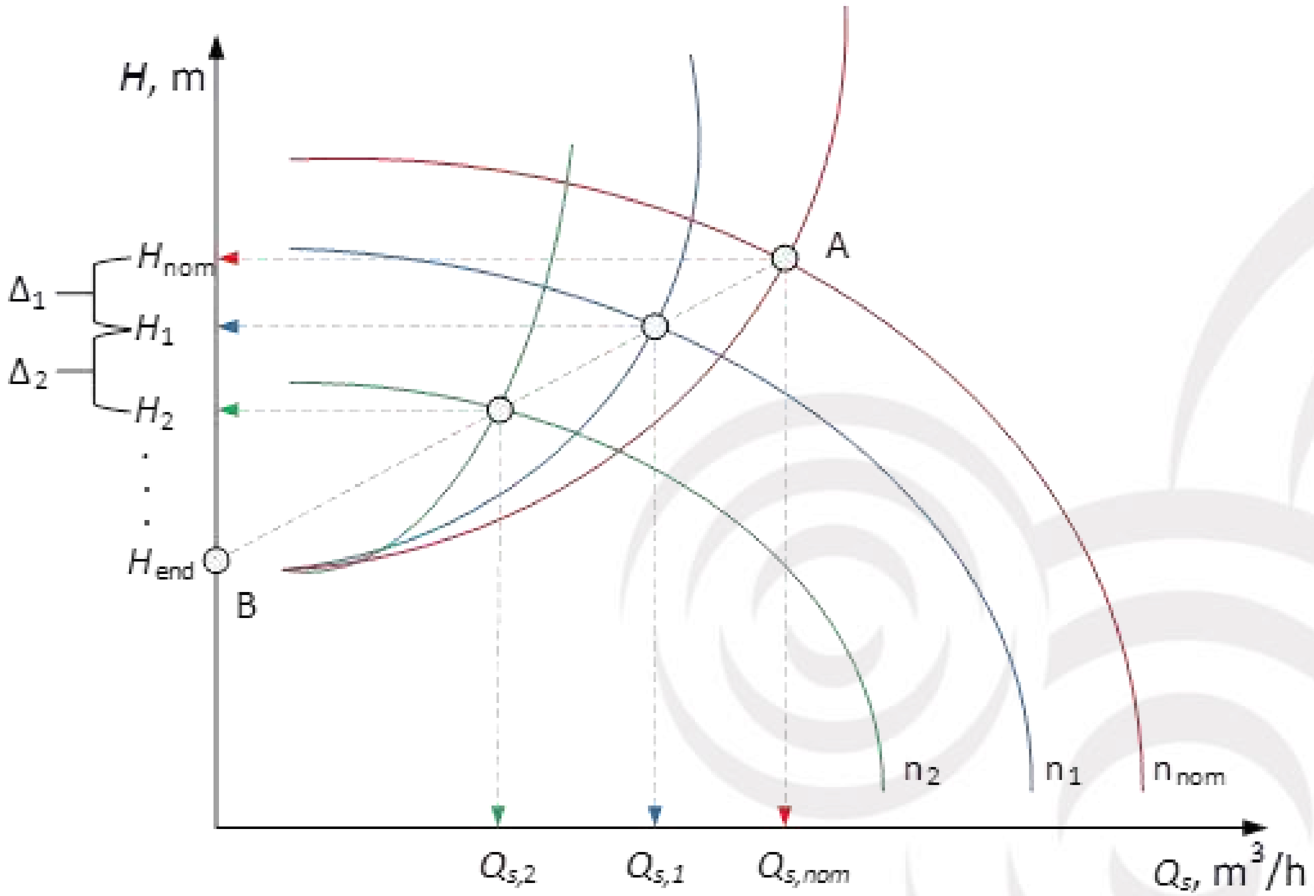
Module operation

CASE 1 - Fan coils as heating/cooling elements in the system



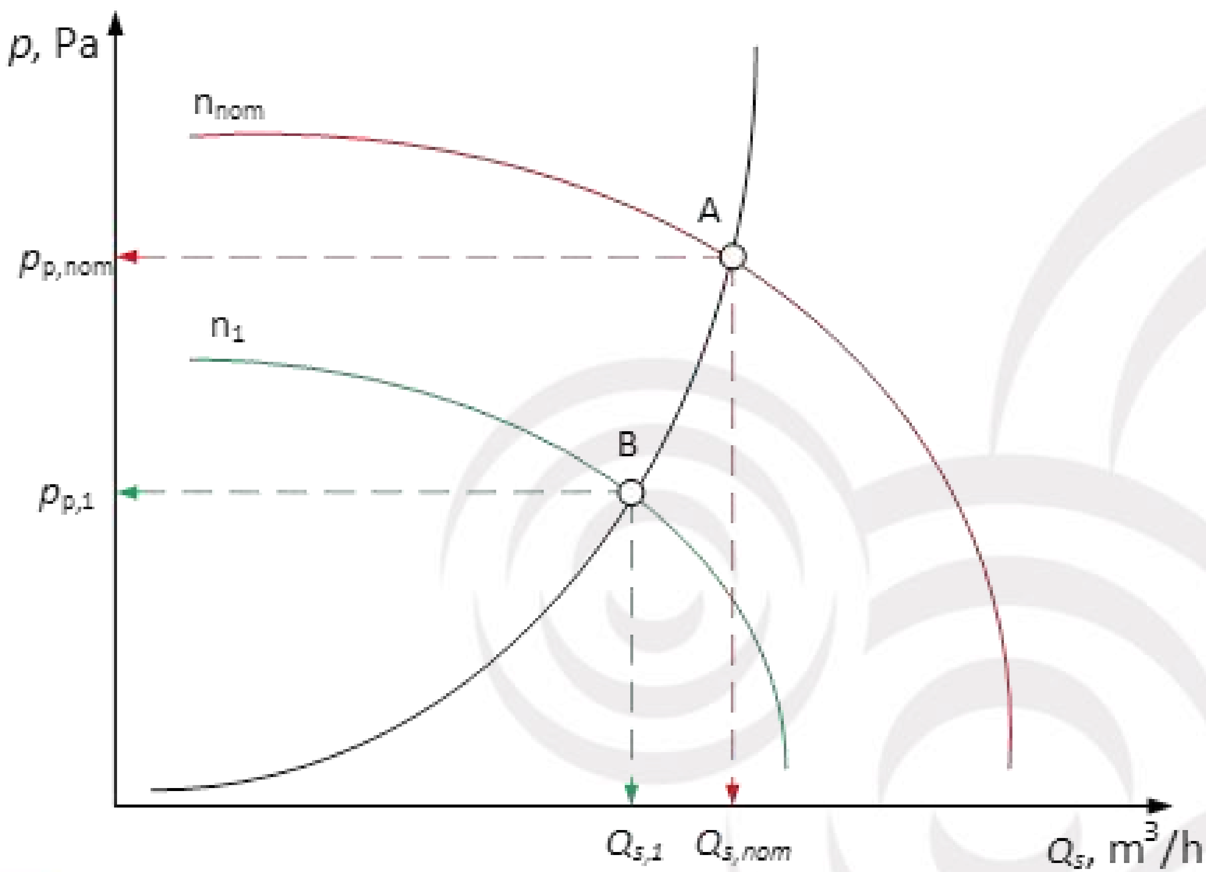
Module operation

CASE 2 - Radiators or floor heating elements in the system



Module operation for FER building

CASE 1 - Fan coils as heating/cooling elements in the system



HVAC.PE.3

HVACPE3_online_inputs	
FK. HydraulicPumpID	**Int**
Timestamp	DateTime
Total pump eff. polynome coeff.	varchar(100)
Measurement of flow Qs	Real
Qs_nom	Real

HVAC.PE.3

HVACPE3_outputs_online	
FK. HydraulicPumpID	**Int**
PK. HydraulicPumpModelID	**Int**
Timestamp	DateTime
Estimated energ. consumpt. for the pump	Real

HVAC.PE.3

HVACPE3_online_inputs	
FK. HydraulicPumpID	**Int**
Timestamp	DateTime
Total pump eff. polynome coeff.	varchar(100)
Measurement of flow Qs	Real
~~Qs_nom~~	Real

HVAC.PE.3

HVACPE3_outputs_online	
FK. HydraulicPumpID	**Int**
PK. HydraulicPumpModelID	**Int**
Timestamp	DateTime
Estimated energ. consumpt. for the pump	Real

HVAC.PE.3

HVACPE3_online_inputs	
FK. HydraulicPumpID	**Int**
Timestamp	DateTime
Total pump eff. polynome coeff.	varchar(100)
Measurement of flow Qs	Real
~~Qs_nom~~	Real

HVAC.PE.3

HVACPE3_outputs_online	
FK. HydraulicPumpID	**Int**
PK. HydraulicPumpModelID	**Int**
Timestamp	DateTime
Estimated energ. consumpt. for the pump	Real

HVAC.PE.3 – Results (Inputs tables)

Edit Data - 3smart (localhost:5432) - smart_db - public.hvac_pe3

File Edit View Tools Help

No limit

	hvac_pe3_model_id [PK] integer	hydraulic_pump_id integer	timestamp timestamp(6) without time zone	hvac_pe3_description character varying(1000)	hvac_pe3_name character varying(30)	hydraulic_pump_efficiency_curve character varying(500)
1	1	1	2018-11-09 20:54:22			[-0.03176, 2.483]

Edit Data - 3smart (localhost:5432) - smart_db - public.hvac_pe3_online_inputs

File Edit View Tools Help

No limit

	hvac_pe3_model_id [PK] integer	hydraulic_pump_id integer	timestamp timestamp(6) without time zone	supply_medium_flow real	nominal_supply_medium_flow real
1	1	1	2018-11-07 18:43:15	42.8	

HVAC.PE.3 – Results (Outputs table)

Edit Data - 3smart (localhost:5432) - smart_db - public.hvac_pe3_online_outputs_history

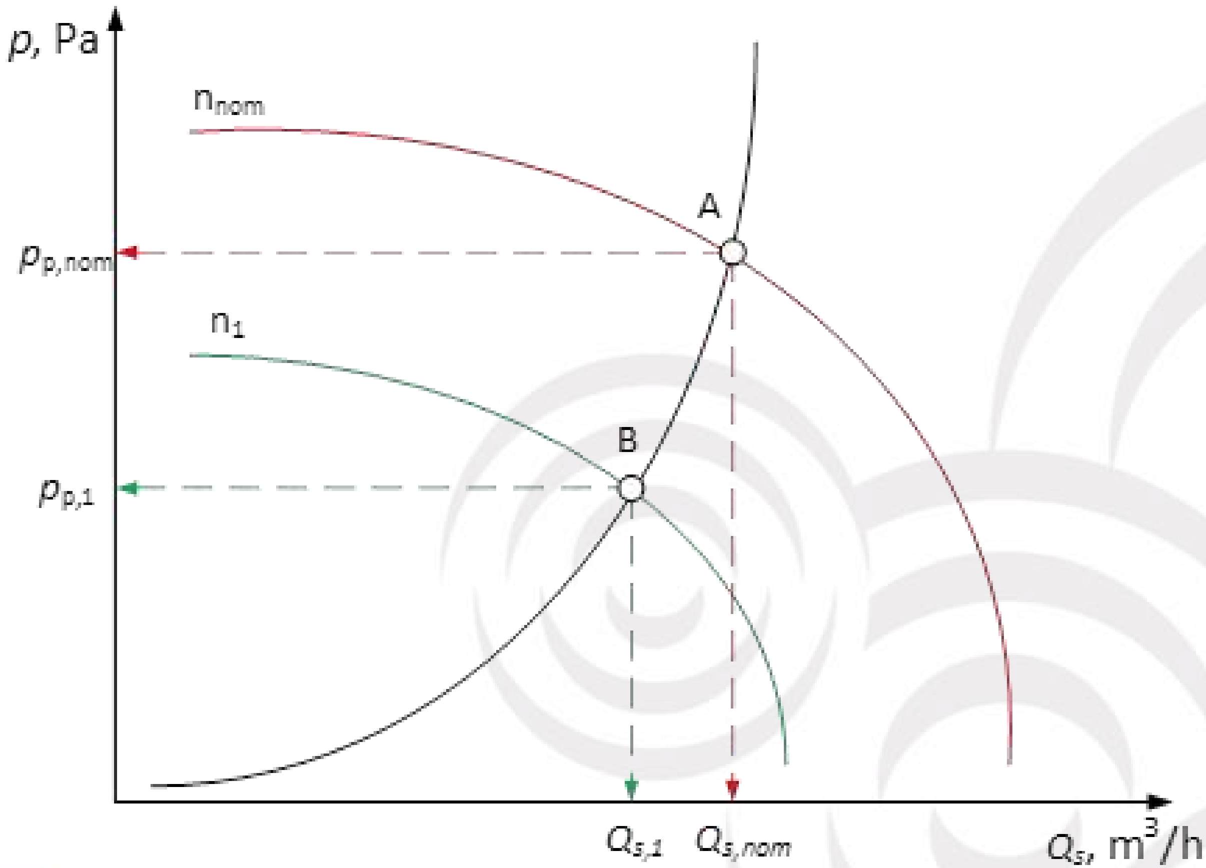
File Edit View Tools Help

No limit

	id [PK] bigserial	hvac_pe3_model_id integer	hydraulic_pump_id integer	timestamp timestamp(6) without time zone	hydraulic_pump_electrical_energy_consumption_est real
6	6	1	1	2018-11-09 13:47:08	1.52264
7	7	1	1	2018-11-10 00:03:13	1.52264
8	8	1	1	2018-11-10 00:09:38	1.52264
9	22	1	1	2018-11-10 08:41:31	1.11904
10	23	1	1	2018-11-10 08:41:31	1.11904
11	24	1	1	2018-11-10 08:49:30	1.52264
12	25	1	1	2018-11-10 08:51:45	1.52264
13	26	1	1	2018-11-10 08:55:06	1.81715
14	27	1	1	2018-11-10 08:55:25	1.52264
15	28	1	1	2018-11-12 13:03:13	1.52264
16	29	1	1	2018-11-12 13:04:38	1.52264
17	30	1	1	2018-11-12 13:09:50	1.52264
18	31	1	1	2018-11-12 13:10:34	1.52264
19	32	1	1	2018-11-12 13:13:14	1.52264
20	33	1	1	2018-11-12 13:46:13	1.52264
21	34	1	1	2018-11-12 14:07:18	1.52264
22	35	1	1	2018-11-13 00:29:42	1.52264
23	36	1	1	2018-11-13 00:31:52	1.52264
24	37	1	1	2018-11-13 10:51:40	1.52264
25	38	1	1	2018-11-13 10:52:52	1.52264
26	39	1	1	2018-11-13 20:31:43	1.52264
27	40	1	1	2018-11-13 20:31:52	1.52264
28	41	1	1	2018-11-16 07:56:09	1.52264
29	42	1	1	2018-11-16 08:51:20	1.52264
30	43	1	1	2018-11-16 08:52:31	1.52264
31	44	1	1	2018-11-16 08:53:12	1.52264

Module operation for FER building

HVAC.I.1



HVAC.I.1

HVACI1_online_inputs	
FK. HydraulicPumpID	**Int**
Timestamp	DateTime
Qs_nom	Real
Measurement of flow Qs	Real
p_end	Real

HVAC.I.1

HVACI1_online_outputs	
FK. HydraulicPumpID	**Int**
Timestamp	DateTime
Pump head	Real

HVAC.I.1

HVACI1_online_inputs	
FK. HydraulicPumpID	**Int**
Timestamp	DateTime
~~Qs_nom~~	Real
Measurement of flow Qs	Real
~~p_end~~	Real

HVAC.I.1

HVACI1_online_outputs	
FK. HydraulicPumpID	**Int**
Timestamp	DateTime
Pump head	Real

HVAC.I.1

HVACI1_online_inputs	
FK. HydraulicPumpID	**Int**
Timestamp	DateTime
~~Qs_nom~~	Real
Measurement of flow Qs	Real
~~p_end~~	Real

HVAC.I.1

HVACI1_online_outputs	
FK. HydraulicPumpID	**Int**
Timestamp	DateTime
Pump head	Real

HVAC.I.1 – Results (Inputs table)

Edit Data - 3smart (localhost:5432) - smart_db - public.hvac_i1_inputs

File Edit View Tools Help

No limit

	hydraulic_pump_id [PK] integer	p_end real	supply_medium_nominal_flow_ref real	supply_medium_flow real
1	1			42.8

HVAC.I.1 – Results (Outputs table)

Edit Data - 3smart (localhost:5432) - smart_db - public.hvac_i1_outputs_history

File Edit View Tools Help

No limit

	id [PK] bigserial	hydraulic_pump_id integer	hydraulic_pump_head_ref real	timestamp timestamp without time zone
24	24	1	6.29068	2018-11-11 23:09:17
25	25	1	6.29068	2018-11-11 23:10:29
26	26	1	6.29068	2018-11-12 00:27:03
27	27	1	6.29068	2018-11-12 00:28:13
28	28	1	6.29068	2018-11-12 00:29:54
29	29	1	6.29068	2018-11-12 00:29:59
30	30	1	6.29068	2018-11-12 00:32:28
31	31	1	6.29068	2018-11-12 00:32:37
32	32	1	6.29068	2018-11-12 00:50:47
33	33	1	6.29068	2018-11-12 13:44:41
34	34	1	6.29068	2018-11-13 00:16:42
35	35	1	6.29068	2018-11-13 00:31:23
36	36	1	6.29068	2018-11-13 10:50:52
37	37	1	6.29068	2018-11-13 20:32:03
38	38	1	6.29068	2018-11-16 23:49:59
39	39	1	6.29068	2018-11-21 18:39:38
40	40	1	6.29068	2018-11-21 18:39:53
41	41	1	6.29068	2018-11-21 18:40:04
42	42	1	6.29068	2018-11-22 09:29:00
43	43	1	6.29068	2018-11-22 09:29:38
44	44	1	6.29068	2018-11-22 09:30:50
45	45	1	6.29068	2018-11-22 09:32:11
46	46	1	6.29068	2018-11-22 09:34:29
47	47	1	6.29068	2018-11-22 09:35:20
48	48	1	6.29068	2018-12-11 16:45:13

Discussion

On-line demonstration of basic IT infrastructure performance with the installed equipment: Grid-building interaction

Danko Marušić / Paula Mamić

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3Smart – First Pilot Study Zagreb

11. – 12.12.2018.

UNIVERSITY OF ZAGREB FACULTY OF ELECTRICAL ENGINEERING AND COMPUTING

Interreg Danube Transnational Programme 3Smart

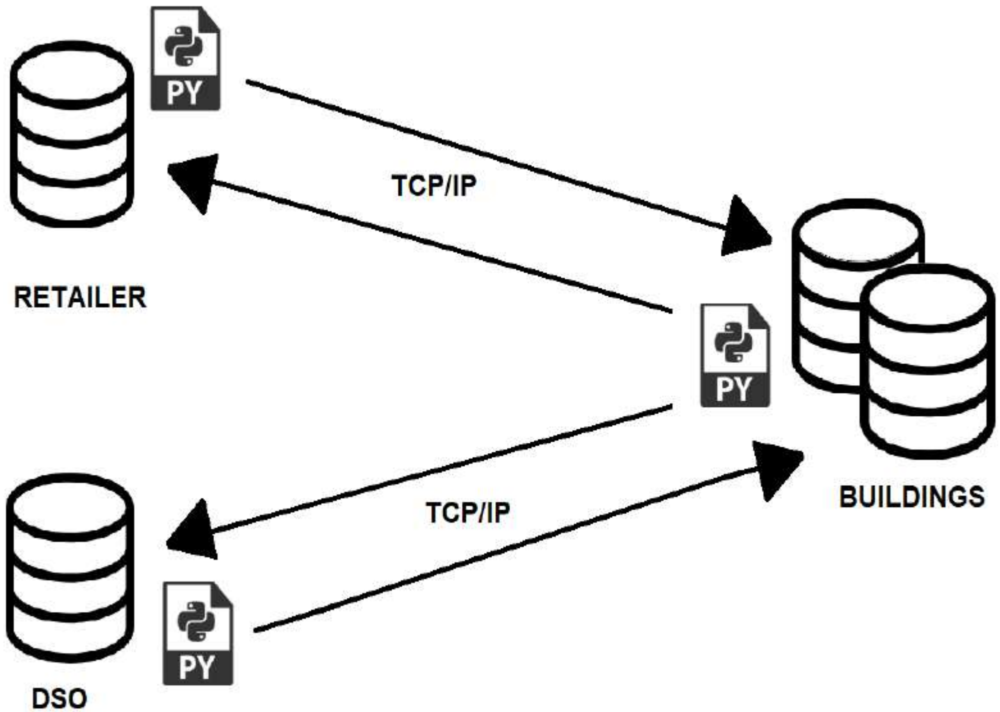
Project co-funded by the European Union

Content

- Communication model
  - Rules of communication
  - Database architecture
- Examples of communication profiles
  - Retailer to DSO
  - DSO to Building
  - Building to DSO

Communication model

- Communication rule (1/3):
  - Read-only access to databases of other entities
    - Sending data to other entity = putting data at disposal in the local database
    - Reading data from other entity = copying data into the local database



Communication model

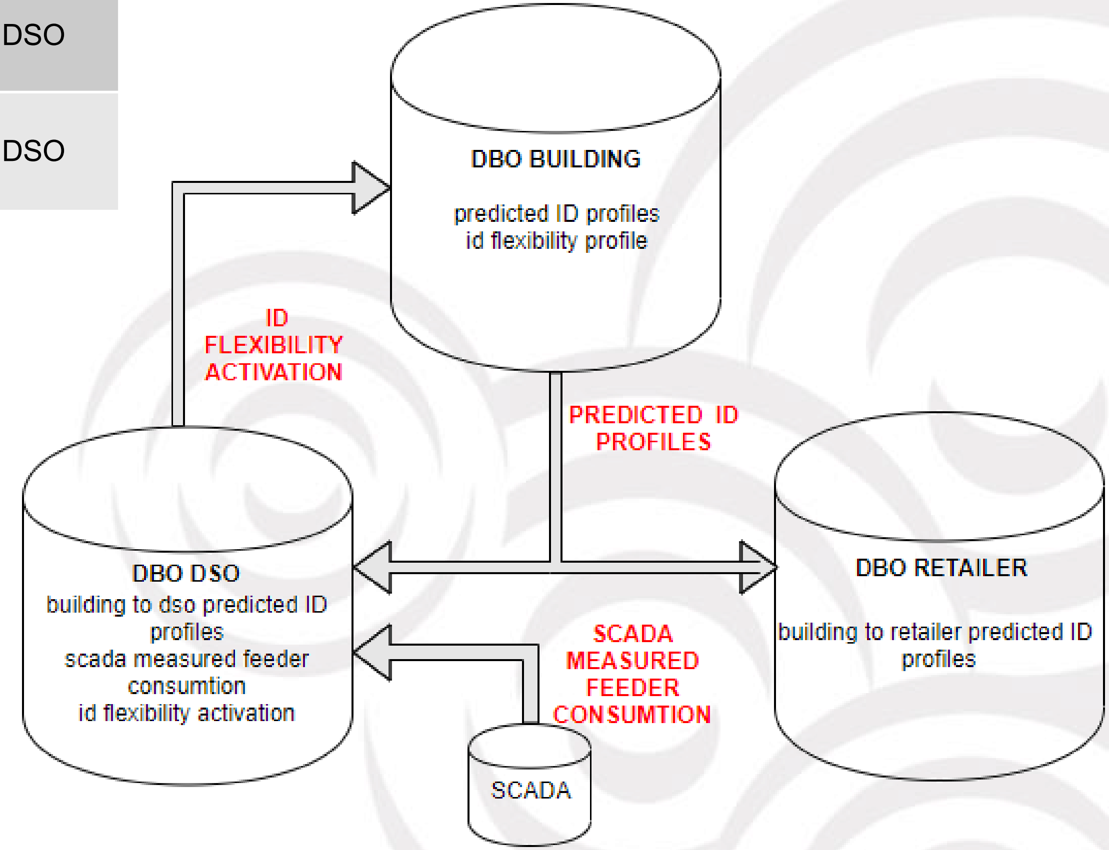
- Communication rule (2/3):
  - All communication scripts are called automatically at certain times-of-day

ID	Time (UTC)	Data exchange	Reads data	Puts data at disposal
1	DBD, 10:00	Informative DA profiles (json)	Retailer	Building
2	DBD, 13:15	DA prices (json)	Building	Retailer
4	DBD, 14:00	Declared DA profile (json)	DSO	Building
6	DBD, 14:15	DA flexibility activation profile (json)	Building	DSO

Grid-side communication module

- Designed according to aforementioned rules

ID	Time	Data exchange	Reads data	Puts data at disposal
0	DOD, every 15 minutes	SCADA measurements (float)	DSO	DSO
7	DOD, every 15 minutes	ID flexibility activation (float)	Building	DSO



Communication model

- Communication rule (3/3):
  - Communication tables contain only one row, older dana is archived to history tables
  - Only current data is exchanged, every entity generates historic data table locally

building_to_dso_informative_da_profiles	
FK.building_id	int
profile	varchar(2000)
profile_created_at	datetime

building_to_dso_informative_da_profiles_history	
PK.id	int
FK.building_id	int
profile	varchar(2000)
profile_created_at	datetime

building_to_dso_declared_da_profiles	
FK.building_id	int
profile	varchar(2000)
profile_created_at	datetime

building_to_dso_declared_da_profiles_history	
PK.id	int
FK.building_id	int
profile	varchar(2000)
profile_created_at	datetime

dso_to_building_da_flexibility_activation_profiles	
FK.building_id	int
profile	varchar(2000)
profile_created_at	datetime

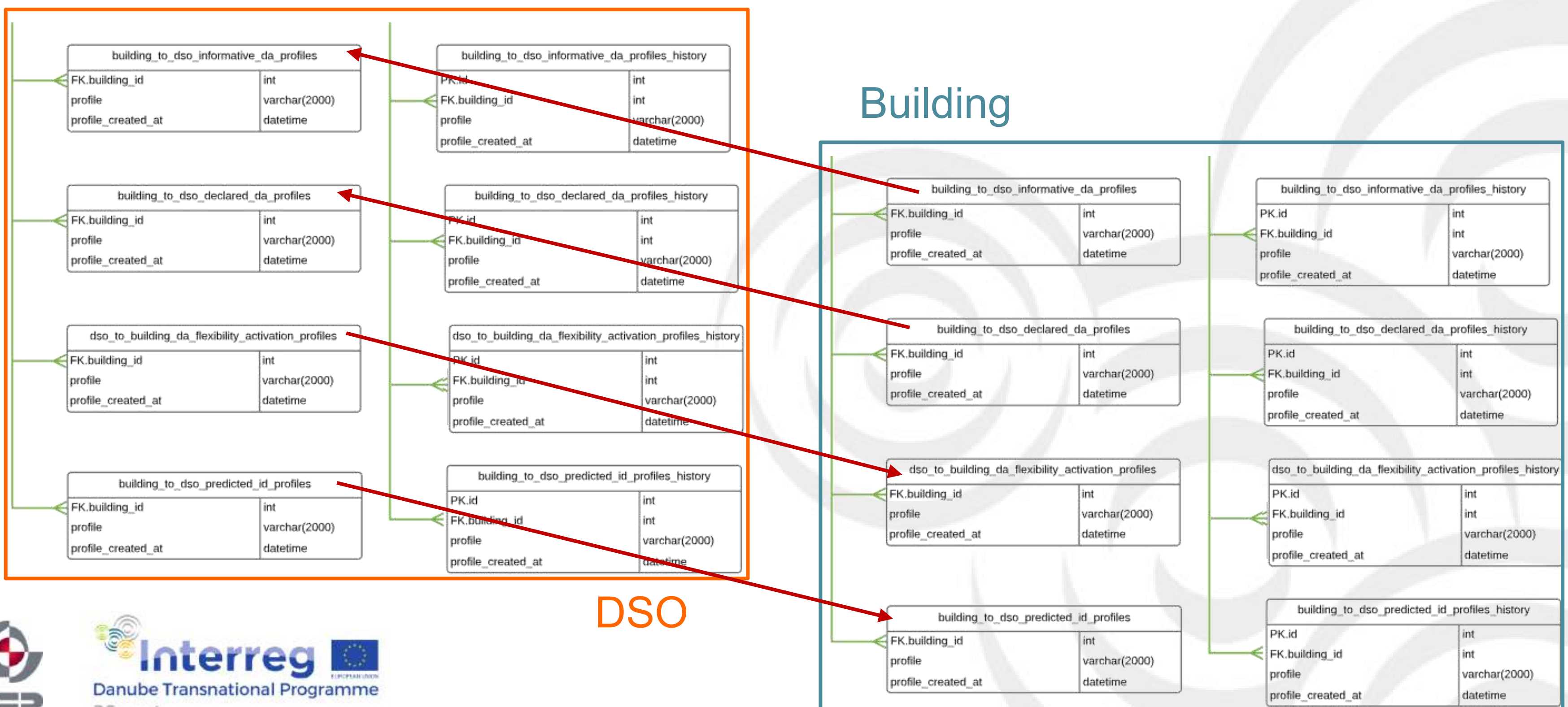
dso_to_building_da_flexibility_activation_profiles_history	
PK.id	int
FK.building_id	int
profile	varchar(2000)
profile_created_at	datetime

building_to_dso_predicted_id_profiles	
FK.building_id	int
profile	varchar(2000)
profile_created_at	datetime

building_to_dso_predicted_id_profiles_history	
PK.id	int
FK.building_id	int
profile	varchar(2000)
profile_created_at	datetime

Database architecture

- Rule: identically designed tables on both building-side and grid-side DBs
- Consequence: no data processing needed for data exchange



Interreg
Danube Transnational Programme
3Smart

Database architecture

- Database rules (2/2)
  - tables names:
    - real information flows between entities
    - profiles or information name

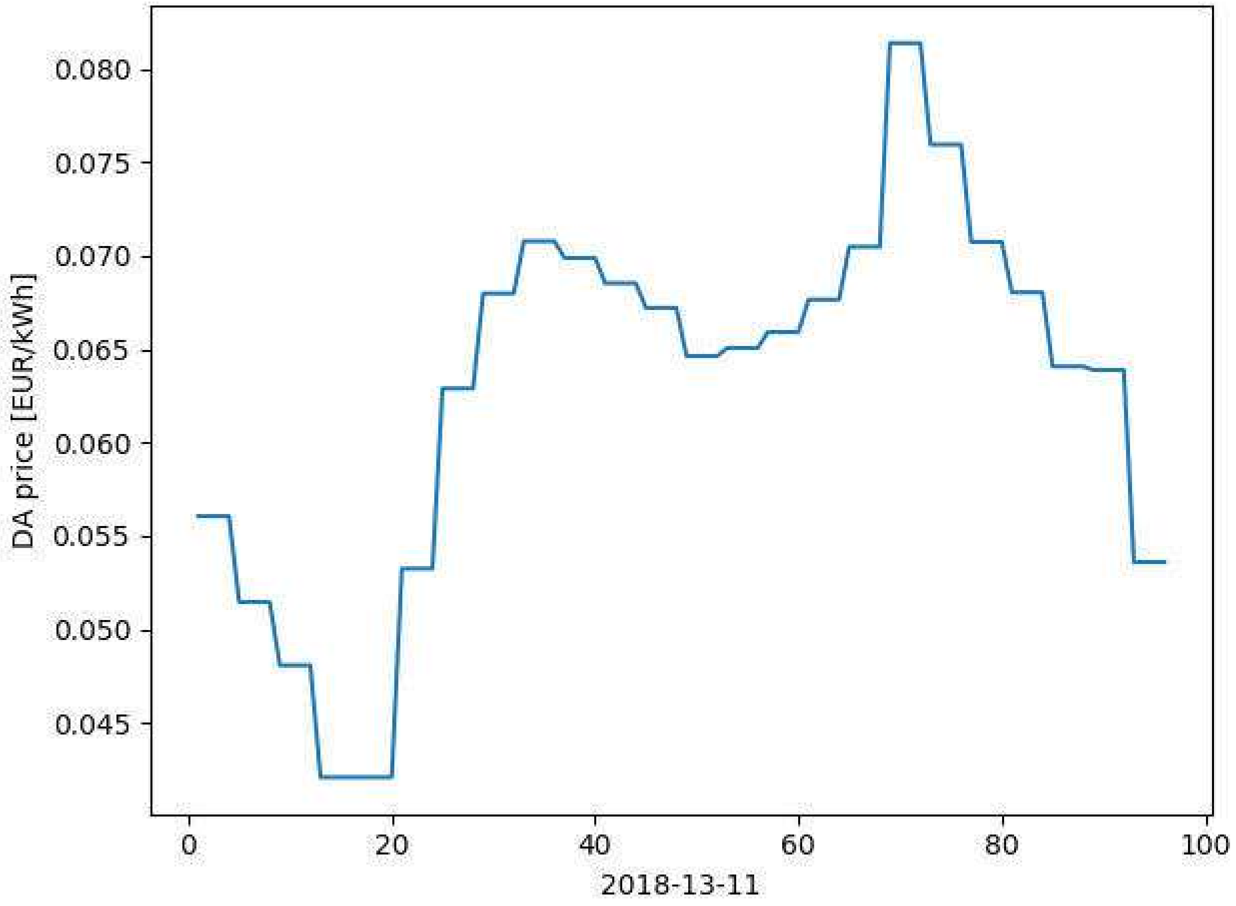
Json structure

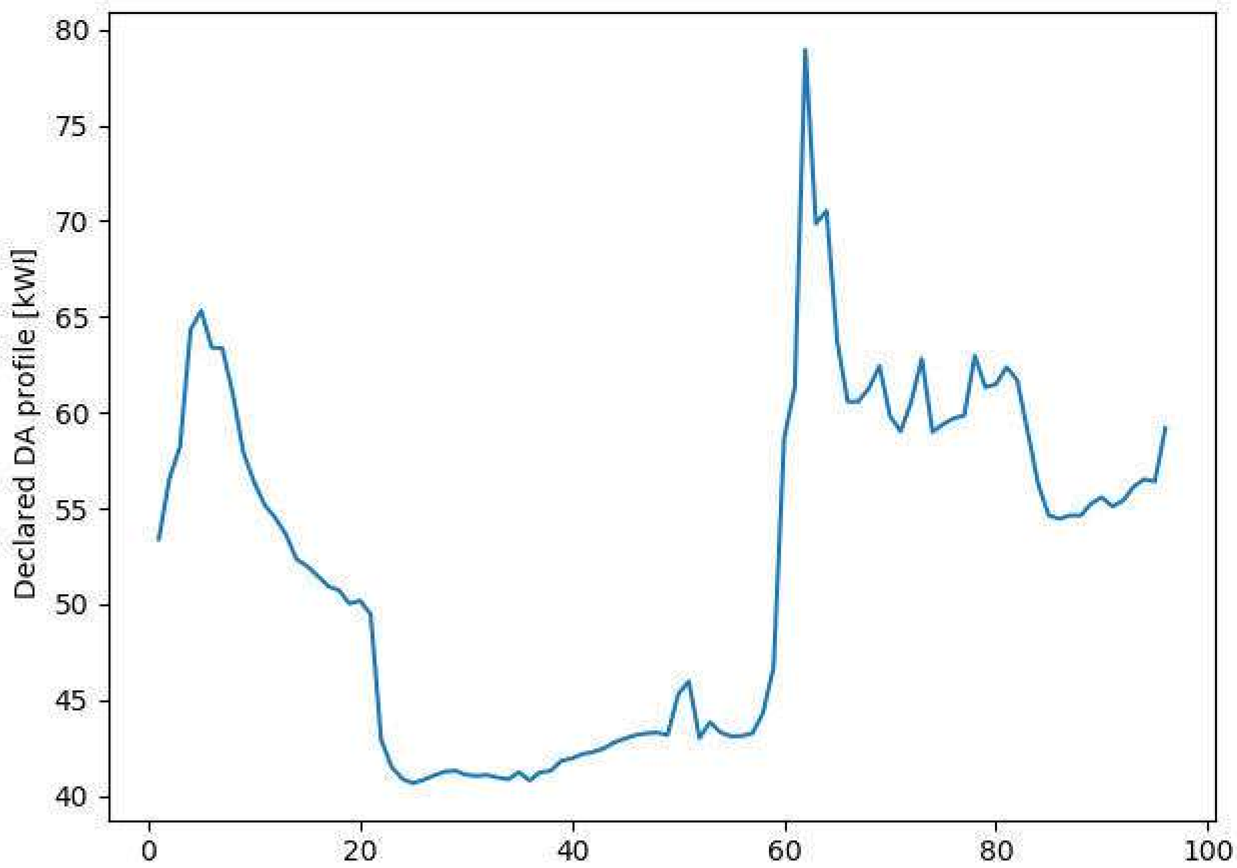
Profile = {
"**DA_flexibility_activation_profile**":
[0,0.606574912975372,1.02600697833224,0.901944678545856,0,-2.27583404120944,-
4.78750458145718,-6.86169525355939,-7.89602137707201,-6.88349111270873,-4.82005198123357,-
2.30099744070119,0,0.963681997196315,1.12643135531563,0.692489748106569,0,-
0.246250131913775,-0.311559428811153,-
0.203594181209020,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0.0392156399009166,0.0582947845934666,0.044
5349730406702,0,-0.221776913727023,-0.339384397697267,-
0.268242412118061,0,0.754335110221086,1.22703148009311,1.04974718768153,0,-
2.51646497247400,-5.26534283912386,-7.50956736614412,-8.60120481504233,-7.41812971373539,-
5.12880048916783,-
2.41089986671777,0,0.790747739909002,0.805732681406043,0.393906517906737,0,0.59115774376
0178,1.46158826336528,2.35136785391709,2.95320642919753,2.61767974068478,1.8592674456560
2,0,0,-0.360428592314349,-0.421298798687064,-
0.258999447772524,0,0.0921004944173757,0.116526952537633,0.0761466587007446,0,-
0.0185005333725646,-0.0247864383567575,-
0.0171095030911426,0,0.0181509673970601,0.0277763588380361,0.0219538598271621,0,-
0.0617373186504593,-0.100424376983395,-
0.0859148351311970,0,0.240854438581268,0.482810606928905,0.654240448357125,0.70395148687
7629,0.409762564606634,0.117735784028214,-0.0413961767103 3],
"**Measuring_unit**": " kW",
"**Valid_from**": "2018-10-22 22:00:00"}

Building-side communication module

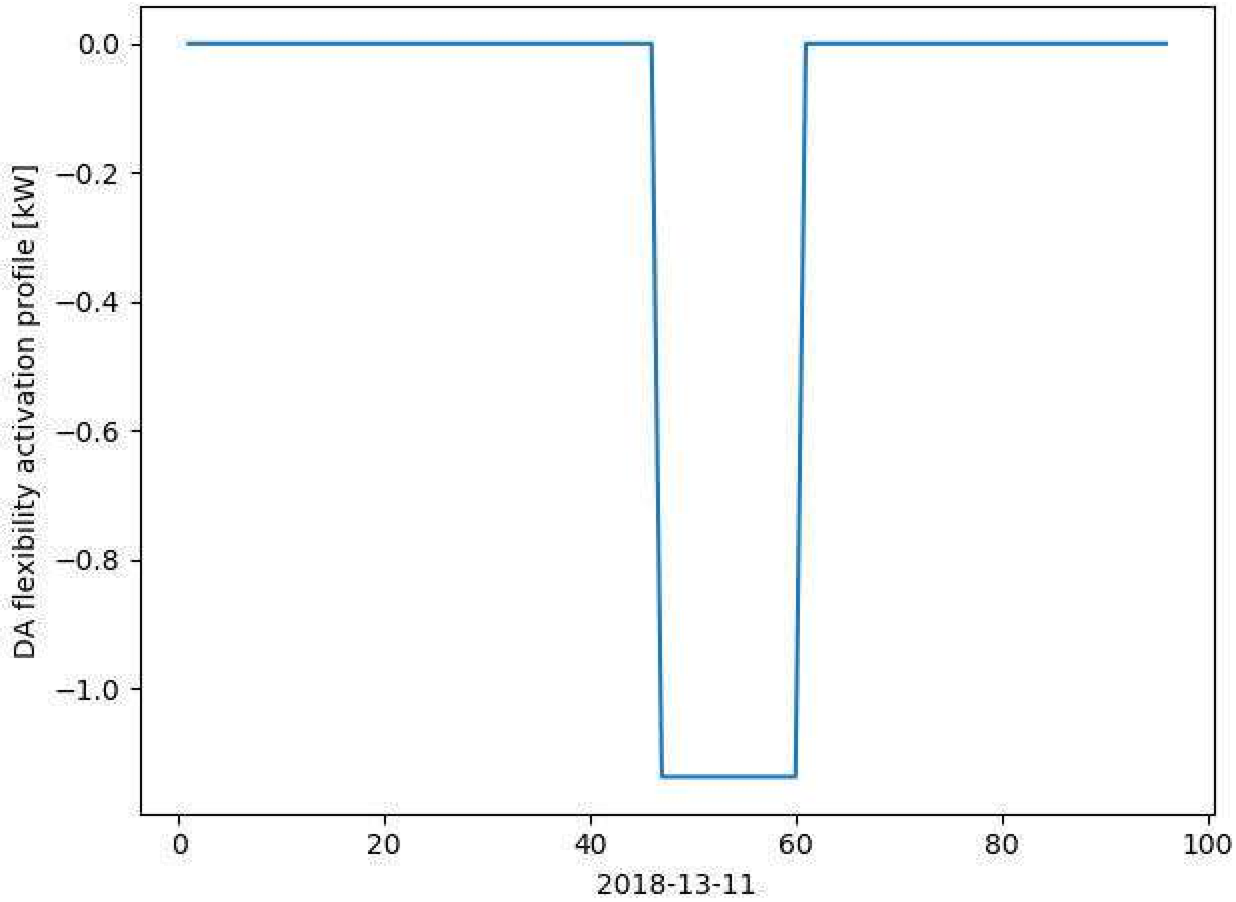
- Currently implemented on ST:
  - fetching prices
  - putting DA profiles at disposal
- Module running online every 15 min for demonstration purposes

Here go plots:





Declared DA profile [kW]
80
75
70
65
60
55
50
45
40
0
20
40
60
80
100


0.0
−0.2
−0.4
−0.6
−0.8
−1.0
DA flexibility activation profile [kW]
0
20
40
60
80
100
2018-13-11

3Smart modules organization on the side of the grid

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3Smart – First Pilot Study Zagreb

11 – 12.12.2018.

UNIVERSITY OF ZAGREB FACULTY OF ELECTRICAL ENGINEERING AND COMPUTING

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LONG TERM MODULE

Long term modules

- Two modules:
  - Multiannual: defines the costs (reservation and activation/utilization) based on avoided/postponed investment – excel tool for calculations
  - Annual: defines the flexibility windows for flexibility reservation. Combines simulation tools (PowerFactory, NEPLAN, GREDOS, Phyton LF) and excel.

Long term modules - goals

- Long term contract:
  - Coordination/execution of modules: end of November
  - Signing middle of December, valid from 1st January
  - Contract defines:
    - 1 year after signing: Building flexibility reservation windows
    - 1 (or N) year of signing: Reservation cost, activation cost
  - Teoretically: can be updates within a year
    - New consumers/producers who change conditions in the grid

Long term coordination

- Coordination between DSO and building

Step	Activity	Link	Status
1	[DSO staff] is calculating flexibility needs, prices, penalty and quality of service by using "3Smart_LT module_v1.xlsm"	Template	
2	[DSO staff] is importing the results of "3Smart_LT module_v1.xlsm"	Import DSO Flex Table	
3	[Building EMS Microgrid module] is fetching data from LT database		
4	[Building EMS Microgrid module] is calculating flexibility offer		
5	[DSO LT module] is fetching data from Microgrid database	Building Flexibility	
6	[DSO LT module] is generating file from Building Flexibility table	Building Flexibility	
7	[DSO staff] is preparing contract in "3Smart_LT module_v1.xlsm"		
8	[DSO staff] is importing the prepared contract from "3Smart_LT module_v1.xlsm"	Import Contract	

Long term coordination

1. DSO task:
   - Calculate flexibility needs, price, penalty and requested quality of service
   - INPUT:
     - operational and network limits
     - Investment costs
     - Loads profiles
     - Penalty price multiplicator
   - Publish table on long term web services

Step	Activity	Link	Status
1	[DSO staff] is calculating flexibility needs, prices, penalty and quality of service by using "3Smart_LT module_v1.xlsm"	Template	
2	[DSO staff] is importing the results of "3Smart_LT module_v1.xlsm"	Import DSO Flex Table	

Long term coordination

2. Building task:
   - Fetch DSO proposed long term (contract) tables
   - Run MPC to calculate building flexibility table – capability to make requested flexibility time windows available.
   - Publish offers to the DSO by LT web service tool

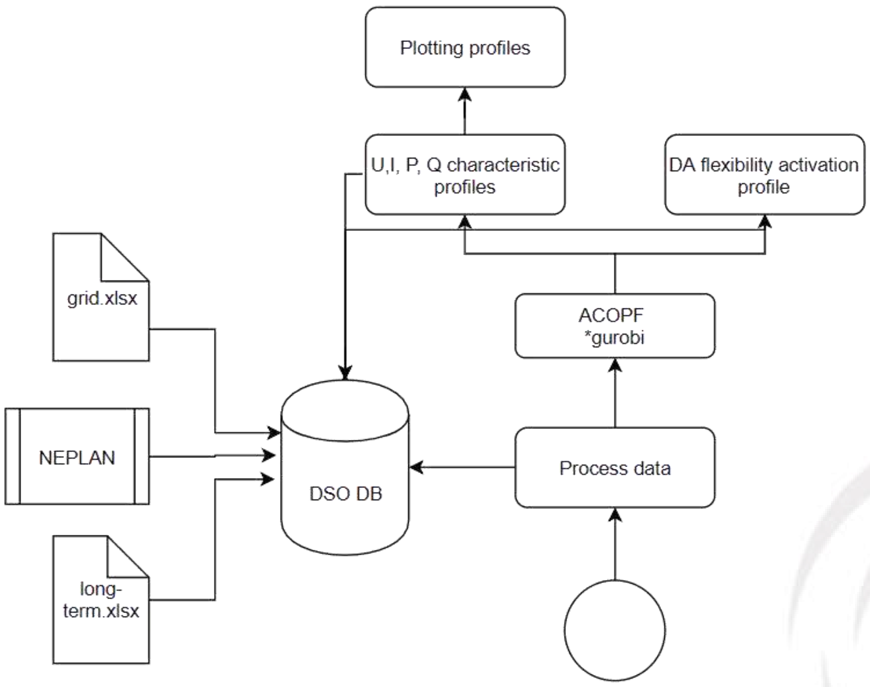
5	[DSO LT module] is fetching data from Microgrid database	Building Flexibility	?
6	[DSO LT module] is generating file from Building Flexibility table	Building Flexibility	?
7	[DSO staff] is preparing contract in "3Smart_LT module_v1.xlsm"		?
8	[DSO staff] is importing the prepared contract from "3Smart_LT module_v1.xlsm"	Import Contract	?

SHORT TERM DAY AHEAD MODULES

Short term Day-Ahead module

- day – to – day operation module for determining building flexibility potential as the distribution network/system operator asset:
  - Interconnected with long term module and receiving flexibility requirements
  - Predefined flexibility requirements in long term module are set as maximum value bound in short term DA module
  - AC OPF in Python (Gurobi solver) is run daily to define HOW MUCH (from 0 to max reserved capacity) of the reserved flexibility capacity will be activated the next day (bound by long term contact)

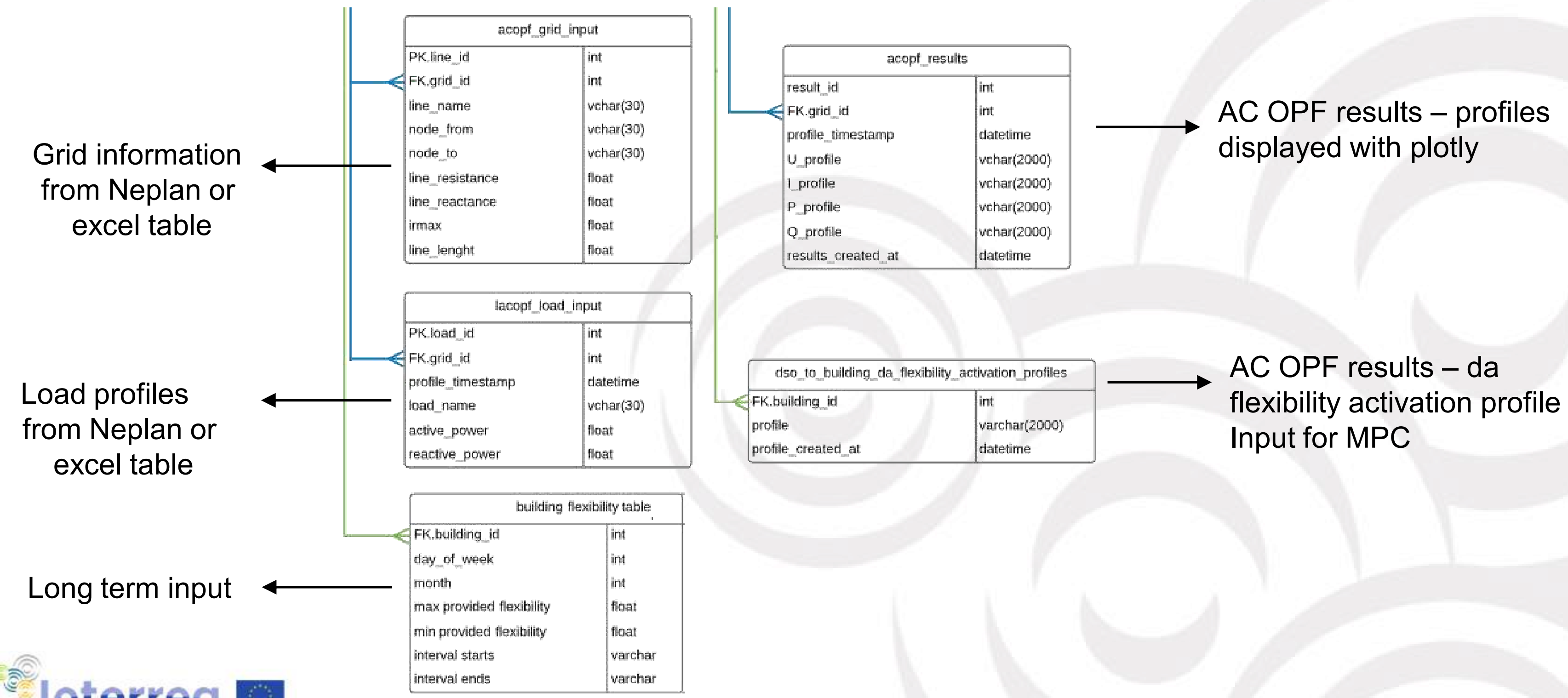
Model architecture



- ST DA structure in short:
  - inputs must be stored in the database (LT tables, grid information and load profile)
  - ST DA processes data and runs optimizations supported by Gurobi solver
- Outcomes are:
  - P, Q, I, U profile for every node present with charts
  - DA flexibility activation profile which is stored directly in communication tables „dso to building da flexibility activation profile"

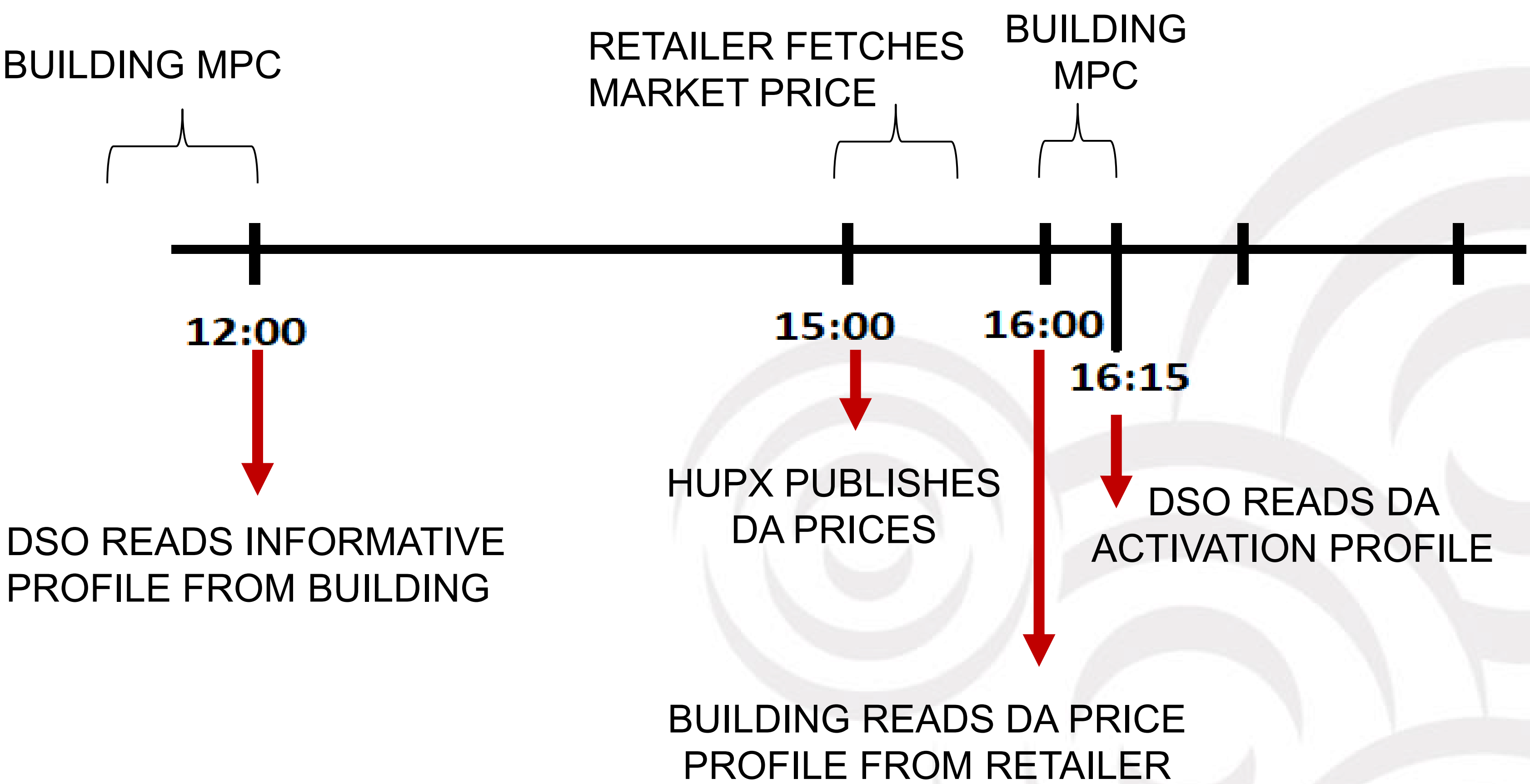
Database structure

- Database structure:
  - Input tables with grid information and load profile (acopf_grid_input, acopf_load_input) and long term tables for provided building flexibility
  - Tables with results (acopf_results) and output with building da flexibility activation profile
  - Communication tables (on next slide) and it's archive



Communication protocol

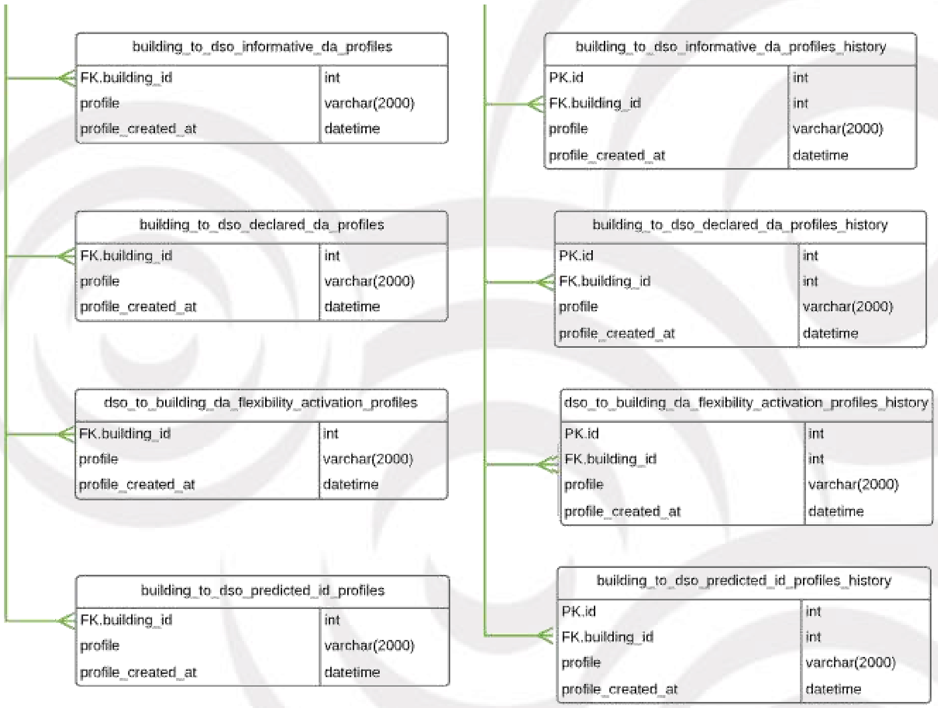
- Day before delivery:



Communication model

- Communication rules:
  - Entities (DSO, building, retailer) can approach to database tables of other entities with python scripts
  - These scripts enable: 1) reading the data which other entites put at disposal in communication tables; 2) writing the data in it’s own communication tables
  - Communication tables contain only current data, the rest is archived into history tables

ID	Time (UTC)	Data exchange	Reads data	Puts data at disposal
1	DBD, 10:00	Informative DA profiles (json)	Retailer	Building
2	DBD, 13:15	DA prices (json)	Building	Retailer
3	DBD, 14:00	Declared DA profile (json)	Retailer	Building
4	DBD, 14:00	Declared DA profile (json)	DSO	Building
6	DBD, 14:15	DA flexibility activation profile (json)	Building	DSO



SHORT TERM INTRA DAY MODULES

Short term intra-day module

- Intra-day operations allow DSO to improve day-ahead schedule with real time measurements and prices
  - ST ID module is interconnected with the long term contract, ST DA module and with SCADA measurements

- Focus: triggering flexibility through real-time measurements in case DA forecasts deviate from actual events

- ID flexibility is triggered only in case of flexibility need (events) occuring before predicted on a DA horizon (if the measured value is higher than the triggering value):

Database architecture

- Outcomes:

- Inputs:

id_triggering_module	
PK.end_of_measurement_period	datetime
FK.building_id	int
scada_measured_feeder_consumption	float
predicted_feeder_consumption	float
da_flexibility_activation_profile	varchar(2000)
flexibility_reservation_profile	varchar(2000)
total_flexibility_activation_profile	varchar(2000)
id_flexibility_activation_request_timestamp	datetime
id_flexibility_activation	float

SCADA

DA module (ACOPF)

DA module (ACOPF)

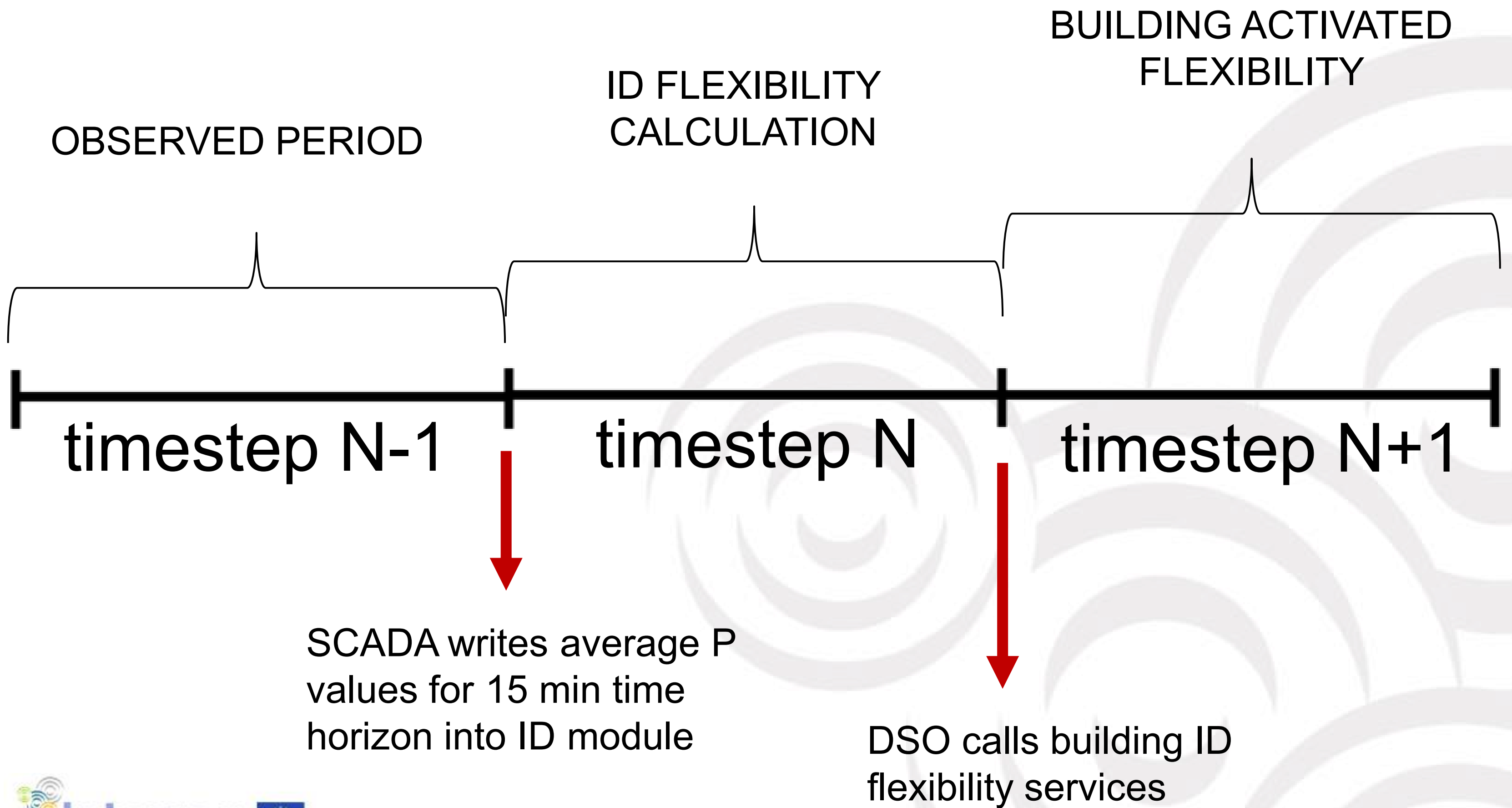
LT module

New flexibility activation profile

ID FLEXIBILITY ACTIVATION

Intra-day module

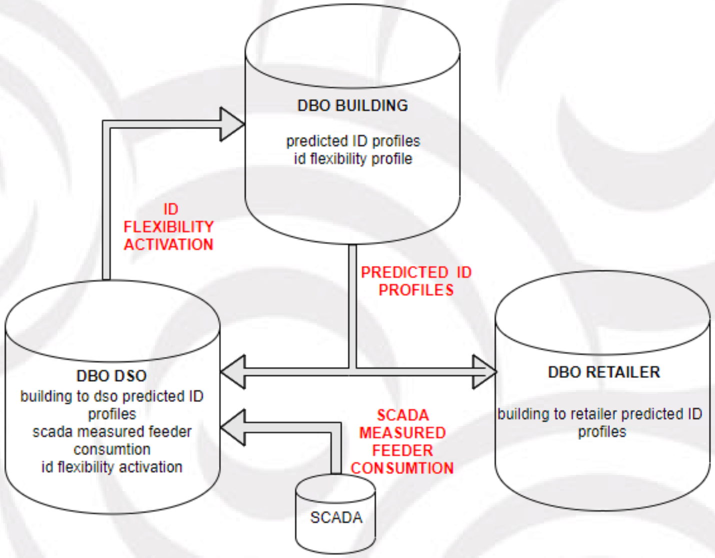
- Day of delivery:



Communication module

- Python scripts are time scheduled:
  - Python script that reads predicted ID profile from building database and writes data into the dso and retailer database. These events occur at 14:00 UTC (day before delivery). Scripts are ran on retailer and dso server.
  - python script that reads average 15 minutes values from measurements table at the beginning of the feeder (or from smart meters) from scada database and writes it to the dso database.
  - This event occurs every 15 minutes and it is ran on dso server
  - Python script that reads ID flexibility activaton value from the dso database and writes it to the building database. It is ran by the building server, and it is ran every 15 minutes

ID	Time	Data exchange	Reads data	Puts data at disposal	Trigger
1	DBD, 14:00	Predicted ID profile (json), profile created at (timestamp)	Retailer	Building	0
2	DBD, 14:00	Predicted ID profiles (json), profile created at (timestamp)	DSO	Building	0
3	DOD, every 15 minutes	SCADA measurements (float)	DSO	DSO	0
3	DOD, every 15 minutes	ID flexibility activation (float)	Building	DSO	1



Project Deliverable Report

Smart Building – Smart Grid – Smart City

http://www.interreg-danube.eu/3smart

DELIVERABLE D6.3.1

Transnational training materials – Pilot study visits to Slovenia – Pilot study visit No. 1

Project Acronym	3Smart
Grant Agreement No.	DTP1-502-3.2-3Smart
Funding Scheme	Interreg Danube Transnational Programme
Project Start Date	1 January 2017
Project Duration	30 months
Work Package	6
Task	6.3
Date of delivery	**Contractual:** 31 December 2019 **Actual:** 23 December 2019
Code name	**Version:** 2.0 Final ☒ Final draft ☐ Draft ☐
Type of deliverable	Report
Security	Restricted
Deliverable participants	UNIZGFER, E3, IDRIJA, ElektroP, EON, UNIBGFME, SVEMOFSR
Authors (Partners)	Mario Vašak, Tomislav Capuder, Vinko Lešić, Anita Martinčević, Hrvoje Novak, Danko Marušić, Nikola Hure, Paula Perović (UNIZGFER), Marko Baša, Alan Križaj (E3), Tadej Rupnik (IDRIJA), Nina Carli (ElektroP), Gabor Peter (EON), Vladimir Jovanović, Nebojša Manić (UNIBGFME), Ivan Bevanda, Petar Marić (SVEMOFSR)
Contact person	Tadej Rupnik (IDRIJA)
Abstract (for dissemination)	This document contains the minutes of the first study visit to the Slovenian pilot in 3Smart. The pilot consists of a pilot building which is primary school and sports centre in Idrija and the pilot electricity distribution grid around the building. On the pilot study visits the pilot leaders and hosts together with developers for different modules on the pilot site have performed demonstration to the consortium of functioning of different installations performed on the pilot and of the installed 3Smart modules.
Keyword List	building-side energy management system, grid-side management, pilot installations, 3Smart IT environment, 3Smart database

Revision history

Revision	Date	Description	Author (Organization)
v1.0	03 April 2019	Entered the minutes from the first study visit to the Slovenian pilot in the deliverable form	Mario Vašak (UNIZGFER)
v2.0	23 December 2019	Deliverable brought in publishable form	Mario Vašak (UNIZGFER)

Table of Contents

Executive summary

The 3Smart project deals with transnational development of integrated energy management of buildings and energy distribution grids in real time. To substantiate knowledge transfer between partners, to synchronize developments and demonstrate the installation procedure to developers, pilots leaders and pilots hosts, a series of transnational trainings is organized, first for getting acquainted with the software modules for energy management, and then for getting acquainted with performed pilot installations and modules operation on the pilot site.

This deliverable provides minutes and materials from the pilot study visits to the 3Smart pilot in Slovenia that consists of the primary school and sports centre building in Idrija and of the electricity distribution grid around the building. The visits were split in two parts for each pilot site – this first part of the deliverable for the Slovenian pilot site concerns the first pilot study visit.

1. Minutes from the first pilot study visit to the 3Smart pilot in Slovenia

Date: March 12-13, 2019

Address: Municipality building, meeting room, 1st floor, Mestni trg 1, Idrija, Slovenija

March 12, 2019 (Tuesday)

Time	Event	Place	Description
09:00-11:00	Technical session 1 (TS1)	Municipality meeting room	Presentation of the performed installations and realized IT infrastructure
11:00-11:15	Coffee break		
11:15-13:00	Technical session 2 (TS2)	Lapajnetova 48, Idrija	Site visit: sports center, boiler room
13:00-14:00	Lunch	Ulica sv. Barbare 9, 5280 Idrija	Restaurant Gostilna pri Škafarju
14:00-16:00	Technical session 3 (TS3)	Municipality meeting room	On-line demonstration of basic IT infrastructure performance with the installed equipment
16:00-16:15	Coffee break		
16:15-18:00	Technical session 4 (TS4)	Municipality meeting room	3Smart modules organization on the building and the grid
20:00-22:00	Working dinner	Ulica sv. Barbare 9, 5280 Idrija	Restaurant Gostilna pri Škafarju

March 13, 2019 (Wednesday)

Time	Event	Place	Description
09:00-10:30	Technical session 5 (TS5)	Municipality meeting room	On-line demonstrations: Short-term modules grid, Long-term modules grid
10:30-10:45	Coffee break		
10:45-12:15	Technical session 6 (TS6)	Municipality meeting room	On-line demonstrations: Zone-level modules, Central-HVAC-level modules, Microgrid-level
12:15-13:30	Lunch	Restaurant	Gostilna pri Škafarju ,Ulica sv. Barbare 9, 5280 Idrija
13:30-16:00	Technical session 7 (TS7)	Lapajnetova 50 , Idrija	Site visit: Primary school and mine pump system

Day 1:

Technical session 1: Presentation of the performed installations and realized IT infrastructure.

The performed installations were presented in detail by Tadej Rupnik (Idrija). The presentation held is attached as Annex 1 to these minutes.

A special attention was given to the installations performed on the zone level where wireless connectivity solutions were used, that rise concerns regarding batteries lifetime, constraints on the amount of data allowed to be transmitted and obstacles between emitting and receiving points. Finally agreed were the following time resolutions for data acquisition in the 3Smart database:

- return medium sensors data will be received **each 5 minutes**,
- calorimeters data will be received **each 5 minutes**,
- room temperature data will be received **each 10 minutes**.

The latter (10 minutes) is the most problematic, but currently this can be assessed as a hardware constraint. The developers will do their best to make the zone-level modules work properly with these time resolutions although the modules were developed with a clear request set to 1 minute for data acquisition. Here such a compromise needs to be done due to the constraints of the equipment procured – it will be interesting to see how the modules can function with such data sampling which is also very motivating for sustainable functioning of the system beyond the project timeline.

It was further agreed that global horizontal irradiance measurement should be repositioned near to the roof top on the school to prevent shading of one sky part by the roof, it will be done during the summer period. Lightning protection conductor spanned just about the roof top should stand on the north from the sensor.

Technical session 2: Site visit: sports center, boiler room, school.

Tadej Rupnik has led the pilot site visit. First the hill next to the school was visited from which the photovoltaic installation on the school is visible. Then the boiler room was visited where the CHP installation was explained and its operation demonstrated, and then different heating circuits of the boiler room were checked. Cabinets with smart meters and calorimeters were shown.

Sports centre was then visited where the installation of rooms temperature sensors and return medium temperature sensors were examined.

School dining room was also shortly visited. Most probably the calibration of the return medium temperature sensors will be needed.

Technical session 3: On-line demonstration of basic IT infrastructure performance with the installed equipment, zone level management system.

Tadej has first presented the outlook of a user interface that enables to define setpoints for day and night regime and the timings when these are applied.

Marko Baša has then presented the organization of IT system on the site and the database outlook. The presentation held is provided as Annex 2. The structure of the 3Smart database in Mysql is inherited from EON pilot site, but still the data are not filled in it. The data is expected to be in the 3Smart database by middle of April 2019. Also in it the historical data from the beginning of 2019 will be included.

Technical session 4: 3Smart modules organization on the building side. State, problems and plans.

Mario Vašak has explained the modules organization on the building side. Discussion was performed regarding modules functioning on individual levels – zone, central HVAC and microgrid and different details addressed like:

- day and night schedule, including the pump operation schedule,
- schedule for CHP operation,
- schedule for DHW tank operation regarding legionella protection behaviour.

The information flow diagram is provided as Annex 3. Different technical details regarding the database organization for different specifics were left to be agreed during the technical discussion the next day.

Presentation of grid-side modules organization is postponed for the next day, and is incorporated in TS5.

Day 2:

Technical session 5: Grid-side modules organization on the pilot. On-line demonstrations: Grid short-term modules, Grid long-term modules.

Paula Perović presented the modules organization on the grid side. Presentation covered Long-term module and Short-term module architecture and database structure and communication module overview.

After presentation, Paula Mamić and Nina Carli showed on-line demonstrations for Long-term module and Short-term module. The discussions performed and conclusions for further actions are summarized for different modules.

The presentation held is given as Annex 4.

Short-term day ahead module: Retailer and DSO roles are developed and installed on Elektro Primorska server. Paula showed where and when the data are stored in database, task-scheduler settings and the proofs that the scripts are run. Paula showed user-interface with network states (AC OPF results: voltage level, current, active and reactive power)

Long-term annual and multi-annual modules: Nina demonstrated long-term module. The module is installed on flask app server. She demonstrated the long-term planning. She indicated (and corrected) a few errors in Long-term table developed by DSO and is going to report it to EON.

We discussed a problem with the server in the network of Elektro Primorska, namely the access to the server is still not active from the outside network, as the IT department has some issues to resolve with the network architecture to satisfy major safety measures based on company's policy and outside company Infromatika d.d., that monitors the network. The issue is planned to be resolved as soon as possible.

Technical session 6: On-line demonstrations: Zone-level modules, Central-HVAC-level modules, Microgrid-level modules

The presentations, discussions performed and conclusions for further action are summarized by different modules.

Zones in general (comments from Anita):

- The necessity of putting additional insulation around return medium temperature sensors mounted on radiator water outlet should be tested by conducting an experiment in which measurements of the return medium sensor will be compared with a measurements of a trusted portable temperature sensor (ideally contact thermocouple or something similar)
- Medium mass flow information should also be saved to database (the measurement unit should be communicated to all or be included in the description columns)

For identifications in Z.PE.2 and HVAC.PE.2 detailed instructions and schedule were agreed by all parties. The consolidated document about this and the schedule can be found as Annex 5.

Z.PE.2 & Z.PE.4 (Ivo):

- Presentation of modules Z.PE.2 and Z.PE.4 is given as Annex 6.

Z.PE.5 (Anita):

- The standard one-minute operation od Z.PE.5 will be adjusted to the available measurement sampling time, 10 minutes for room temperature and 5 minutes for return medium sensor were agreed.

Z.PE.6 (Hrvoje):

- No problem on sight for now, the module operation must wait until data of Z.PE.5 are in the database;

Z.PE.7 (Hrvoje):

- The 'local_switch' variable is always ON for all zones since the setpoints are set directly in the user interface and stored in the database, there is no fixed fan speed or in radiators case, fixed valve openness position. Exception are the night hours where we can switch to the building protect mode (the predictions for these hours will be set to NaN). Occupancy sensors data will not be used to further correct the setpoint predictions.

Z.MPC.1:

- The allowed temperature deviation from the setpoint is defined for every zone individually. Z.MPC1 module reads the values from the user_preferences table. Typical values are in range from 0.2 to 1.5°C
- The building always operates in auto mode, however there are day and night regime (during night regime only building protection is active – we should agree on building protect specification – are we going to fix the start and end time and temperature limits or the module will read this data from database enabling thus the pilot leader to influence the data)

Z.I.2:

- It was not discussed in more technical details compared to before, just assessed that we have a possible considerable delay from the time of issuing command to application on the of the valve, which may be up to 5 minutes

HVAC.PE.2:

- Measurements to be performed on the input pipe for radiators, as to provide data for calculation of the temperature drop from calorimeter to the radiator.
- Marko and Tadej will perform those measurement for one radiator (representative) for each group of radiators, as agreed with Anita, Nikola and Ivo, and send the results to Vlada.
- Based on those results, Vlada will determine the formula for temperature drop for each group of radiators.

Presentation is given in Annex 7.

HVAC.PE.4 (Hrvoje):

- Non-controllable consumption is represented by the consumption of all radiators that are not under 3Smart control and the corresponding energy losses;
- The formula for the non-controllable thermal energy consumption is as follows: calorimeter measurements on the start of the two lines (school and sports center) - consumption of the controlled radiators (obtained from Z.PE.2) - thermal energy losses (how this data will be obtained needs to be agreed with Nikola)

HVAC.MPC.1 (Nikola):

- The maximum supply temperature of the medium towards the buildings is 80°C.
- The selected hydraulic pump schedules should be inserted into the 3Smart database. Table should be named hydraulic_pump_schedule and the format of the schedule is to be determined and reported by Marko.
- The heat losses of the pipework will not be included in the non-controllable thermal loads. Details about the computation and storing of the heat losses for the HVAC.PE.4 module are to be discussed between the module developers.
- Only relevant obstacle for the HVAC MPC model development is the identification of the radiator model. The development can be conducted after the building tables are integrated into the database and the radiator model is identified. Implementation and testing of the HVAC MPC 1 module should follow the zone MPC module development.

M.PE.3 (Hrvoje):

- Global horizontal irradiance sensor needs to be moved to the top of the roof for better measurements;
- The PV plant will not be controlled (i.e. production reduced) so all the measurements are considered as maximum power production measurements

M.PE.4 (Hrvoje):

- Two separate prediction models will be created, one for electrical and one for thermal energy;
- Non-controllable electrical consumption will be calculated as: main meter - heater – CHP
- Non-controllable thermal energy is represented by the thermal energy consumed by other buildings (there are separate calorimeters measuring these consumption whose measurements will be used as non-controllable thermal energy consumption)

M.PE.5 (Marko):

- Discussion about required parameters that need to be passed from Prediction and estimation modules for Domestic hot water tank to the M.MPC.1 module. The format and units were also proposed.
- The state variable of DHW tank will be representative tank temperature.
- We will have minimum and maximum allowed temperature values.
- Data from flow meters, temperatures in tank are not yet incorporated by subcontractor.
- Pump control for heat exchanger is to be performed by subcontractor.
- Legionella protection will be done as a temporary rise of DHW setpoint temperature according to schedule. Proposed format:

```
{
  "legionela_prot_schedule":[
    {
      "active":true,
      "name":"workday",
      "wdays":[1,1,1,1,1,0,0],
      "triger_date":null,
      "triger_time":"3:00:00:00",
      "setpoint":70
    },
    {
      "active":true,
      "name":"workday",
      "wdays":[1,0,0,0,0,0,0],
      "triger_date":null,
      "triger_time":"6:00:00:00",
      "setpoint":50
    }
  ]
}
```


M.MPC.1 (Danko):

- There are min and max power constraints on the CHP: 60%--100% of designed power.
- We shall minimize turning the CHP on and off. We agreed that the MPC will try to follow the CHP working schedule, and if this is infeasible, CHP will not be used on the whole horizon.
- Marko Baša proposed a format for storing CHP schedule, it is fine.
- Thermal efficiencies (or in other words - specific gas consumption) is not the same for boilers and CHP - we will get these data in order to incorporate it into the MPC problem. We will also get measurement data that enables us to check whether factory-supplied data is correct.
- The state variable of DHW tank will be tank temperature. We will have minimum and maximum allowed temperature values. Legionella protection will be done as a temporary rise of DHW setpoint temperature. This shall be done weekly according to provided schedule.
- DHW tank model is linear and incorporates heat losses of the tank.
- A small module will calculate maximum energy exchanged using the heat exchanger. There are some minor issues to discuss here.
- There is a calorimeter measuring non-controllable (district) heat consumption. It is integrated into the database, so predictions of non-controllable heat consumption may be done. The latest UNIZGFER database dump is ready for that - no changes in the database are needed.
- All of the above mentioned data will be stored in the database. We have agreed on the draft structure of pilot-specific tables and data structures - some slight alterations possible.
- As this module is different from other sites and has not been discussed in that level of detail before, also the presentation regarding it is included as Annex 8

M.I.6 (Marko):

- Danko proposed database table format for gas prices.
- Data table for schedule and chp needs to be created.
- Marko will send data for thermal and electrical efficiencies to Danko.

M.I.2.1 (Marko):

- Energy profiles in m.mpc.1 output table contain profiles on the whole prediction horizon.
- Electric heater has three power stages. The physical control is not done yet.

M.I.2.2 (Marko):

- Maximum heat exchange for heat exchanger at any conditions will be calculated by M.MPC.1. It is linear problem and formula and coefficients should be provided. Coefficient and representative temperature of tank will be provided as output from M.PE.5. Supply temperature is measured.

Technical session 7: Site visit: Primary school, mine and mine pump system

Tadej has led the school site visit and the visit to the mine pump system which is a part of A3.3 Idrija case study.

List of annexes:

Annex 1: TS1 presentation of the performed installations

Annex 2: TS3 presentation of the on-line demonstration of developed IT functioning

Annex 3: TS4 organization of the building-side modules on the Idrija pilot

Annex 4: TS4-5 grid-side presentation

Annex 5: Schedule for performing the identification

Annex 6: Presentation of Z.PE.2 and Z.PE.4 modules

Annex 7: Presentation about HVAC.PE.2 module.

Annex 8: Presentation about the M.MPC.1 module for Idrija pilot site

Performed installations and realized IT infrastructure

Tadej Rupnik, Marko Baša, Miran Podobnik, Alan Križaj

Municipality of Idrija

tadej.rupnik@idrija.si

First pilot study visit of the Slovenian pilot in Idrija

Idrija, 12-13.3.2019

Interreg
Danube Transnational Programme
3Smart

Project co-funded by European Union funds (ERDF, IPA)

Buildings in Slovenian pilot

Primary School

Sports Centre

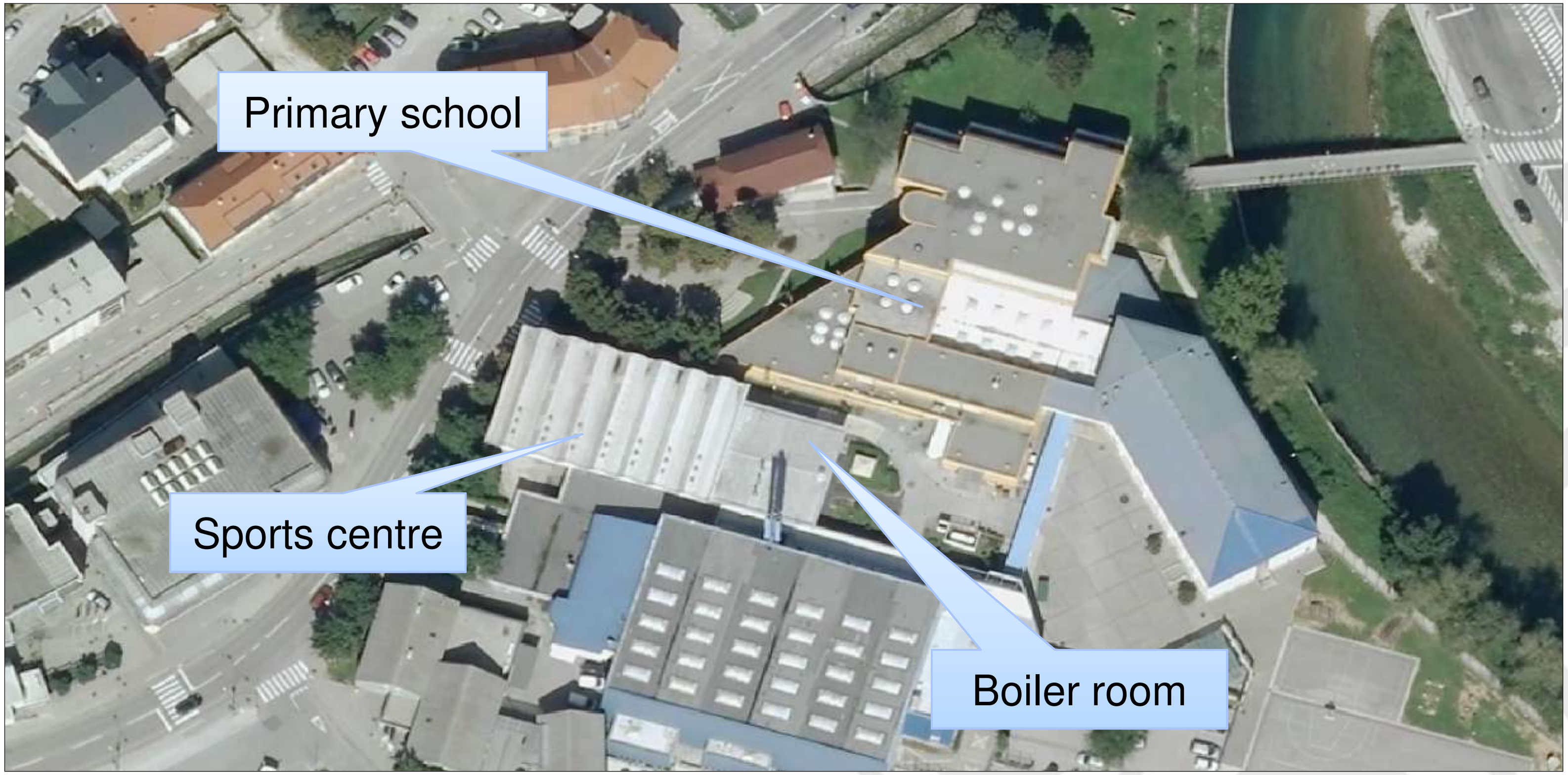
Installations to be performed

Pilot‘s main segments

- Zone level regulation
- Photo voltaic power plant
- Solar irrradiance and outside temperature information
- CHP unit
- DHW tank electrical heaters
- Connections to power grid
- Database server and software
- Communication connections between units

Zone level heating regulation

Joining two buildings into one unit to zone control



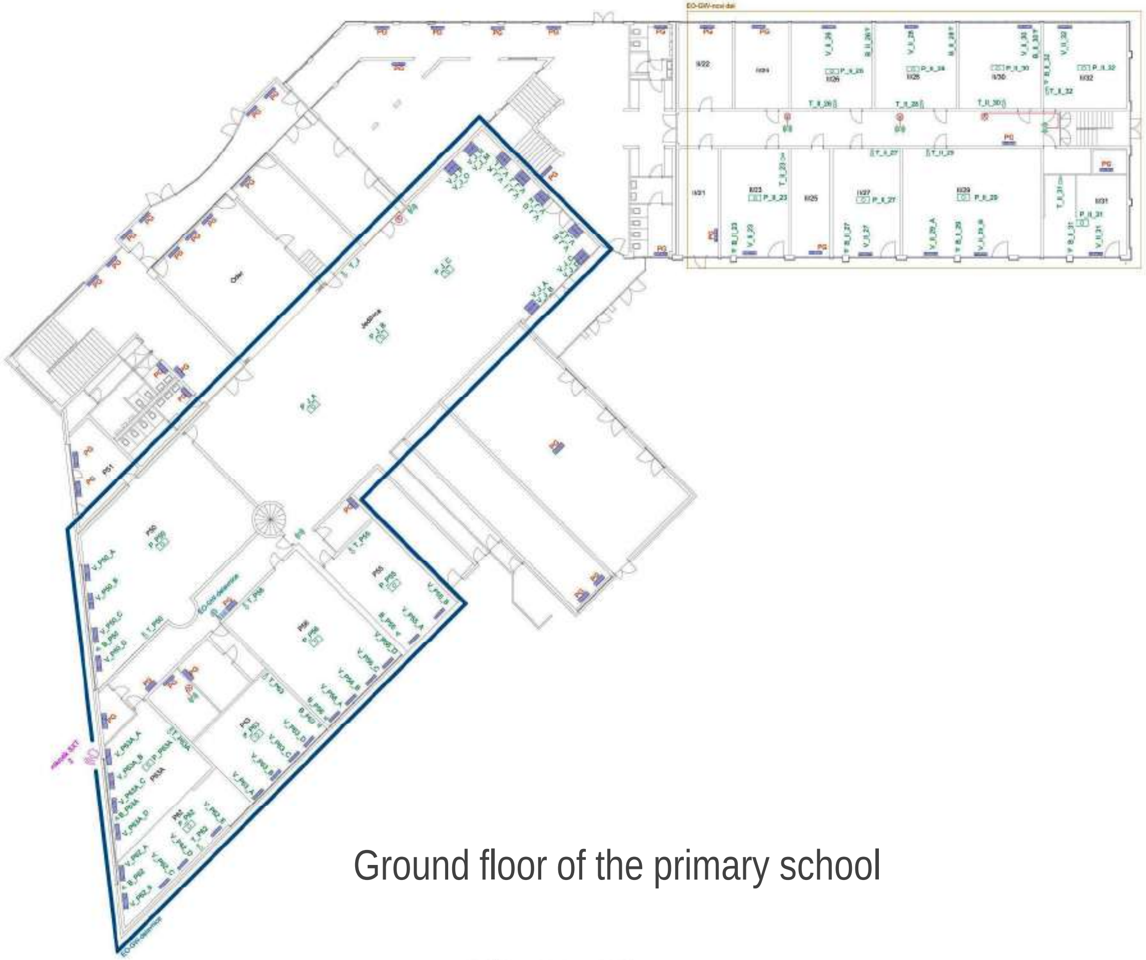
Proximity of the buildings = both are treated as one unit, Boiler room is a part of a Sports centre building

Zone level heating control

Conceptual projects

(Delivery 6.2.1)

- Diverse building plans
- Selecting rooms to became controlled zones
- Defining final state and technical interventions

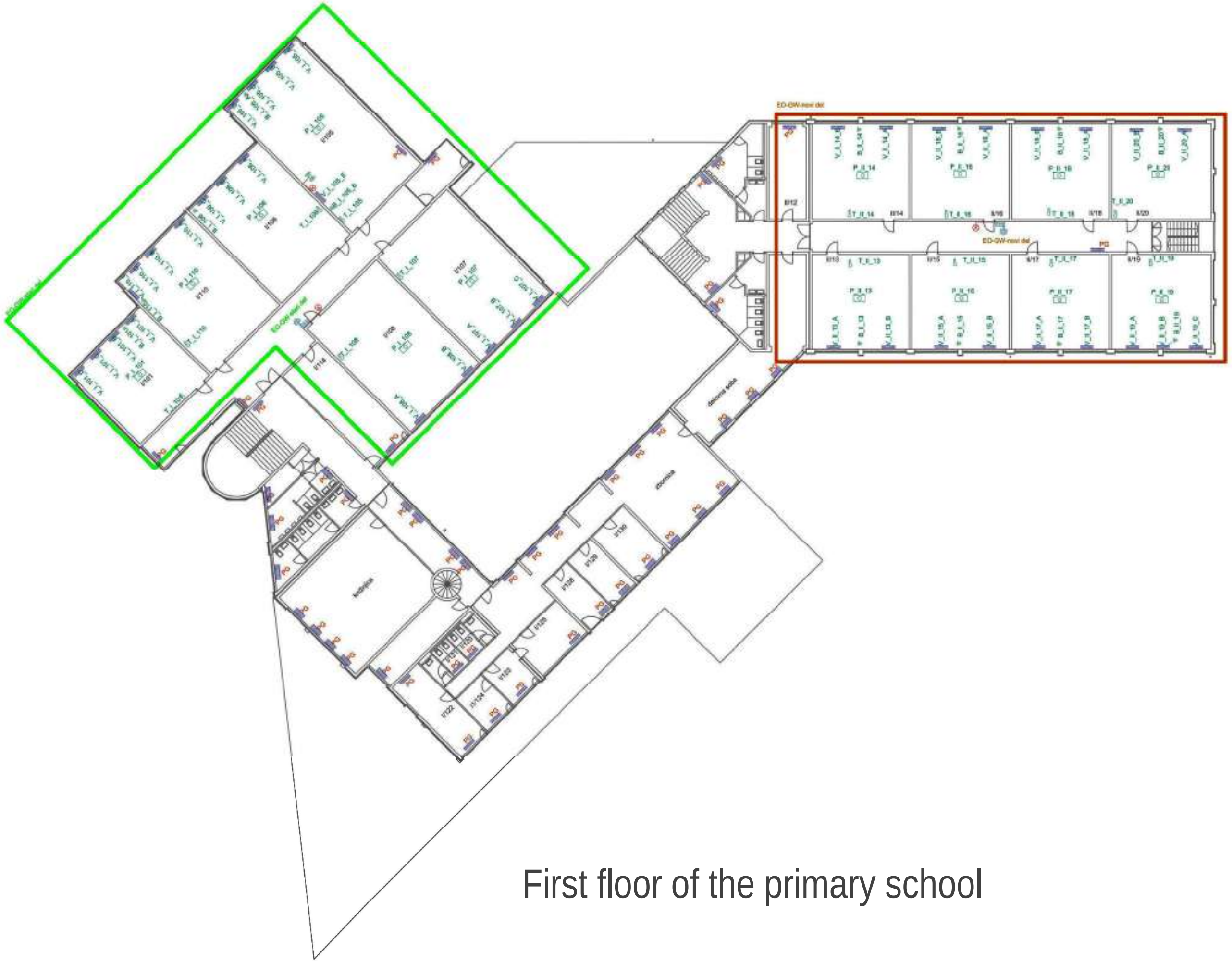


Ground floor of the primary school

Zone level heating control

Conceptual projects
(Delivery 6.2.1)

- Diverse building plans
- Selecting rooms to became controlled zones
- Defining final state and technical interventions



First floor of the primary school

Interreg
Danube Transnational Programme
3Smart

Zone level heating control

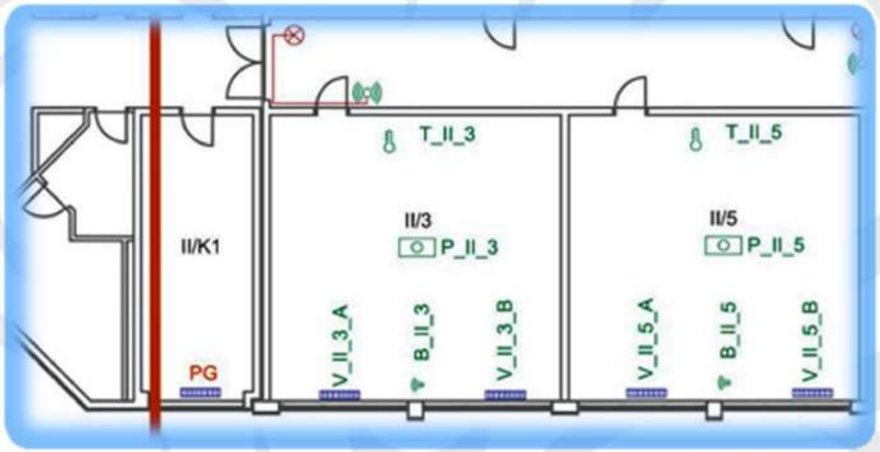
Conceptual projects

(Delivery 6.2.1)

- Diverse building plans
- Selecting rooms to became controlled zones
- Defining final state and technical interventions

New installations in zones:

- motorized valve actuators on the radiators,
- return temperature sensor for each of the radiators,
- room temperature sensor,
- presence sensor.



Detail from the building plan

Zone level heating control

Conceptual projects

(Delivery 6.2.1)

- Diverse building plans
- Selecting rooms to became controlled zones
- Defining final state and technical interventions

Outside the zones:

- hallways, toilets, cabinets, utility rooms and teachers offices are not 3smart controlled
- temperature in those regions are regulated with thermostatic valves

Thermostatic valve in the toilets

Zone level heating control

Permanently too cold classrooms

- Pipelines spread to and from many different directions
- Over the time almost all thermostatic valves finished in max open position
- Distant classrooms were undersupplied with heating medium
- In order to solve this problem, additional radiators were installed
- Of course, with the same supply pipelines, heating energy remained the same

Some classrooms are very exposed

Attempt to resolve underfed radiators in distant locations with adding more radiators

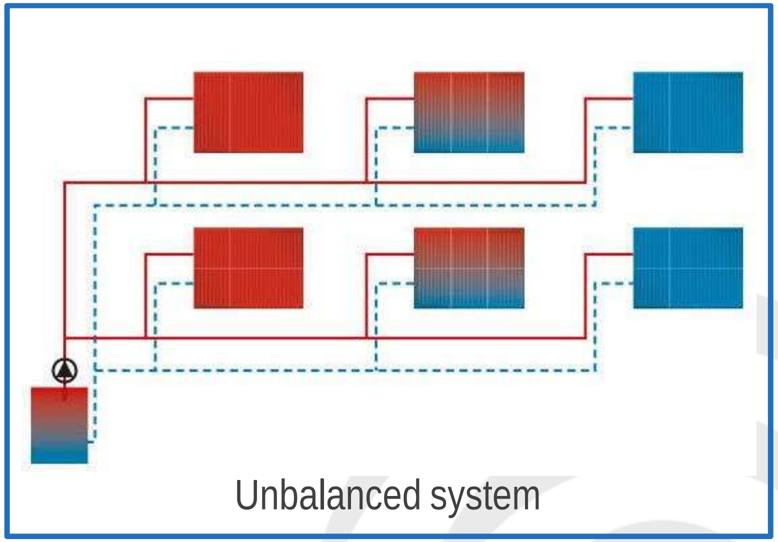
Zone level heating control

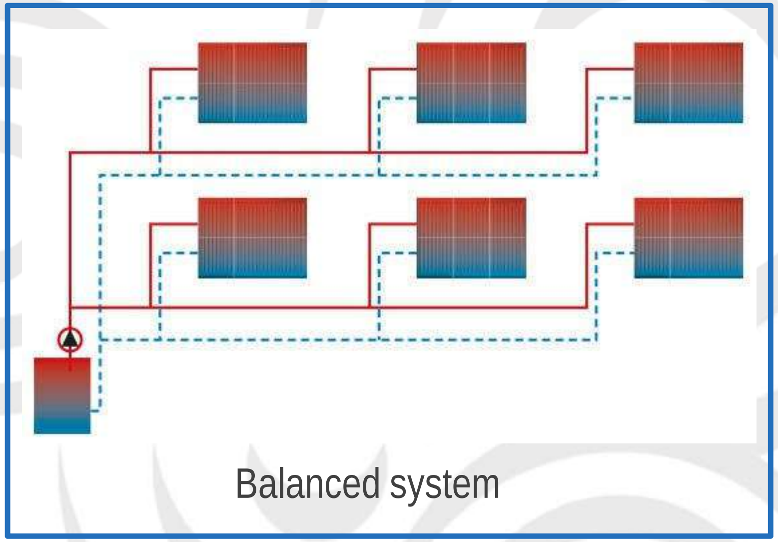
Unconventional pipelining installation – Four radiators in the room are supplied from three different sources

Zone level heating control

Hirdraulic balancing

- Different radiator valves installed
- Set the media flow in each radiator
- Valves installed: VarioQ (Afrisso)
- Quantity: 293 pcs





Zone level heating control

Hirdraulic balancing

VarioQCalc®

Einstellübersicht zum Hydraulischen Abgleich

Supply temperature 80,0 C° | Return temperature 52,6 C° | Sytemflow 4771,3 C°

						for standard radiator capacity			at 2C° Range								
						80	60	20	------------------------ Pressure drop across the Thermostatic Valve ------------------------								
									50 mbar			100 mbar			150 mbar		
Room Nr.	Radiator Nr.	Room name	t capacity Radi	Heat lost	room Temperatur	Water Temp.diff.	water flow rate	Valve recomondation selection	preset	preset	preset	preset	preset	preset	preset	preset	preset
			Qhk	Qn	Ti	dt	l/h		**VarioQ S**	**VarioQ M**	**VarioQ L**	**VarioQ S**	**VarioQ M**	**VarioQ L**	**VarioQ S**	**VarioQ M**	**VarioQ L**
0	1	Vetrolov	1090	1100	18	22,90	41	VarioQ S	7	4	3	6	3	2	5	3	1
0	2	Vetrolov	1090	1100	18	22,90	41	VarioQ S	7	4	3	6	3	2	5	3	1
0	3	Vetrolov	1090	1100	20	19,39	49	VarioQ S	7	4	3	6	3	2	5	3	2
0	4	Vetrolov	1090	1100	20	19,39	49	VarioQ S	7	4	3	6	3	2	5	3	2
0	20	Hodnik	2312	1120	20	49,66	19	VarioQ S	4	2	1	4	2	1	3	2	1
0	21	Hodnik	2312	1120	20	49,66	19	VarioQ S	4	2	1	4	2	1	3	2	1
0	22	Hodnik	2189	1120	20	48,39	20	VarioQ S	4	2	1	4	2	1	3	2	1
0	23	WC dečki -pritličje	437	420	20	22,55	16	VarioQ S	4	2	1	3	2	1	3	1	1
0	24	WC deklice -pritličje	437	420	20	22,55	16	VarioQ S	4	2	1	3	2	1	3	1	1
0	25	Hodnik	817	950	20	8,97	91	VarioQ S	***	7	6	***	5	4	8	4	3
0	26	Hodnik	817	950	20	8,97	91	VarioQ S	***	7	6	***	5	4	8	4	3
0	27	Temnica	817	300	20	54,49	5	VarioQ S	2	1	1	1	1	1	1	1	1
0	41	P55	1442	1470	20	18,71	68	VarioQ S	***	5	4	7	4	3	6	4	3
0	42	P55	1442	1470	20	18,71	68	VarioQ S	***	5	4	7	4	3	6	4	3
0	43	P56	1220	1050	20	28,95	31	VarioQ S	6	3	2	4	3	1	4	2	1
0	44	P56	1997	1470	20	36,46	35	VarioQ S	6	3	2	6	3	1	4	3	1
0	45	P56	1887	1470	20	33,93	37	VarioQ S	6	3	2	6	3	1	4	3	1

Example of data output sheet

Zone level heating control

Remotely controlled valve heads installed

- Wireless
- EnOcean technology
- Low-noise, energy saving operation
- Particularly suitable for use in schools and public buildings

- Model: AVD 10 by Afrisso
- Quantity: 154 pcs

Zone level heating control

Room temperature sensor

- Wireless, EnOcean technology
- Self powered with solar cell

- Installed also outside zones (in hallways and some officess)
- Also measuring humidity – this data is not used by 3smart, will be included in future User Interface upgrades

- Model: FTM T by Afrisso
- Quantity: 108 pcs

Zone level heating control

Occupancy Sensor

- Wireless, EnOcean technology
- Self powered with two solar cells
- PIR motion sensor 360 degree angle

- Model: EOSC by EnOcean
- Quantity: 48 pcs

Zone level heating control

Return medium temperature sensor

- DS18D20 OneWire from each radiator in zone to EO_bridge
- EO-Bridge: Wireless, EnOcean technology

- Model: customized by Inovatika d.o.o.
- Quantity: 154 pcs

Zone level heating control

Gateways

- Bridge between enocean devices and 3smart database
- sqLite local data base

- Model: SBC Raspberry Pi 3 B+
- Quantity: 4 pcs

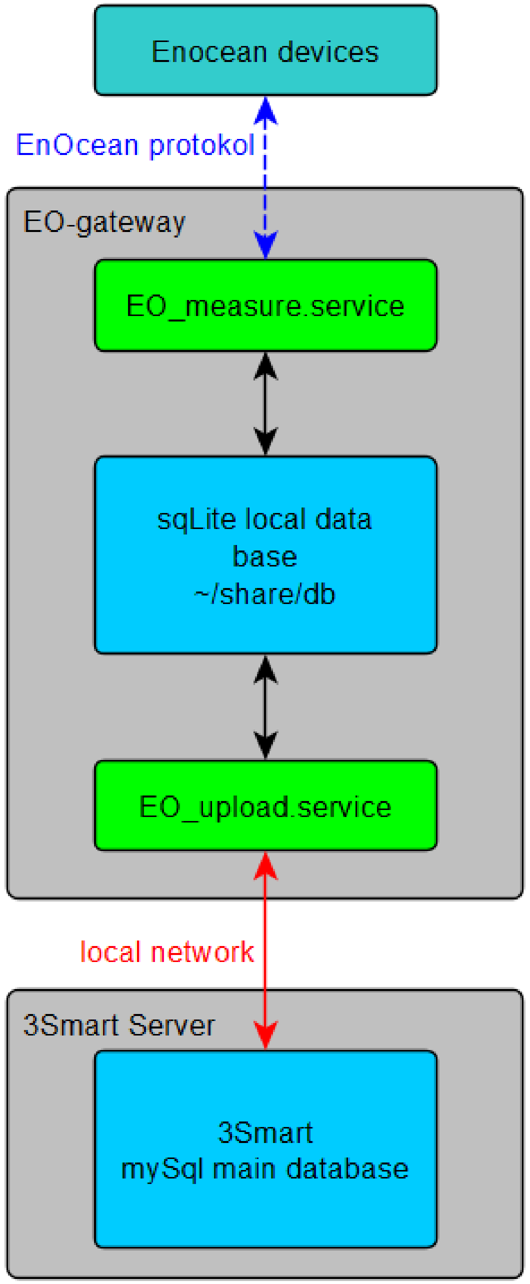
Gateway in sports centre

Gateway in the first floor hallway

Zone level heating control

Function of the gateway

- Sending and receiving telegrams to sensors and valve heads
- Read and write data to 3smart database
- Keep recent data in local database in case of communicaton failure with database server
- Keep room temperature setpoints in case of 3smart-OFF operation



Zone level heating control

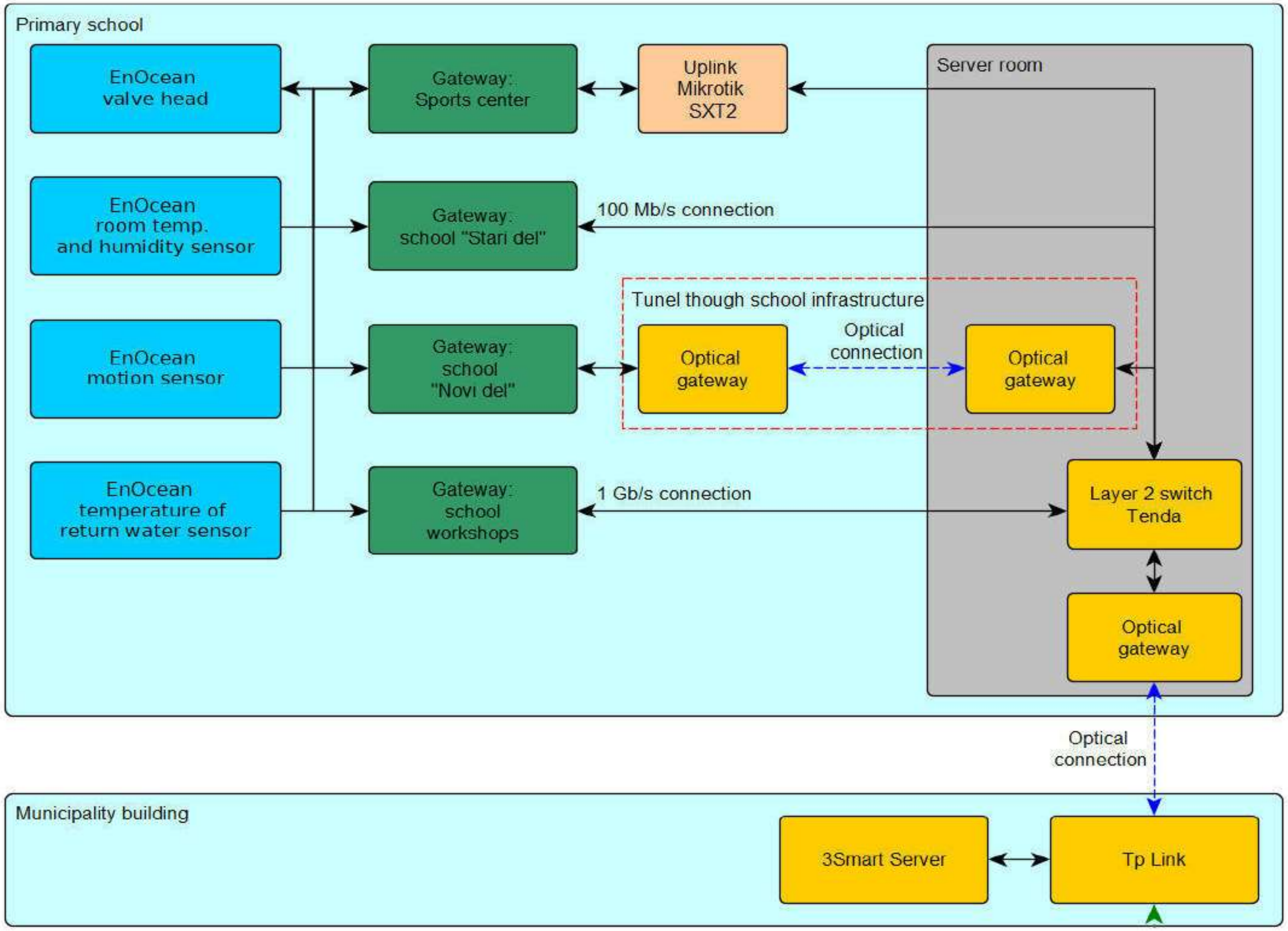
EnOcean signal repeaters

Funcion:

- Transmit signal between Enocean devices and gateways where distance or other obstacles prevent direct communication

- Model: Custom made by Inovatika d.o.o.
- Quantity: 14 pcs

Zone level heating control - Communication schematic



Photovoltaic power plant

Photovoltaic power plant

Installed equipment

- Panels: Luxor LX-270p, 112 pieces
- Inverter: SolarEdge SE27,6k
- Electric power: 30,24 kWp
- Manufacturer: LUXOR
- Optimizer: Solare Edge, double, P600
- Communicator: Solar Edge SE1000-CCG, 2 pieces
- Power Supply: SolarEdge SE1000-SEN-PSU-S1, 2 pieces

Electrical installations cabinet and inverter box

Weather and forecasting

Installed equipment

- Solar irradiance sensor SE1000-SEN-IRR-S1, 2 pieces
- Temperature sensor SE1000-SEN-TAMB-S1

Temperature sensor

Forecasting service

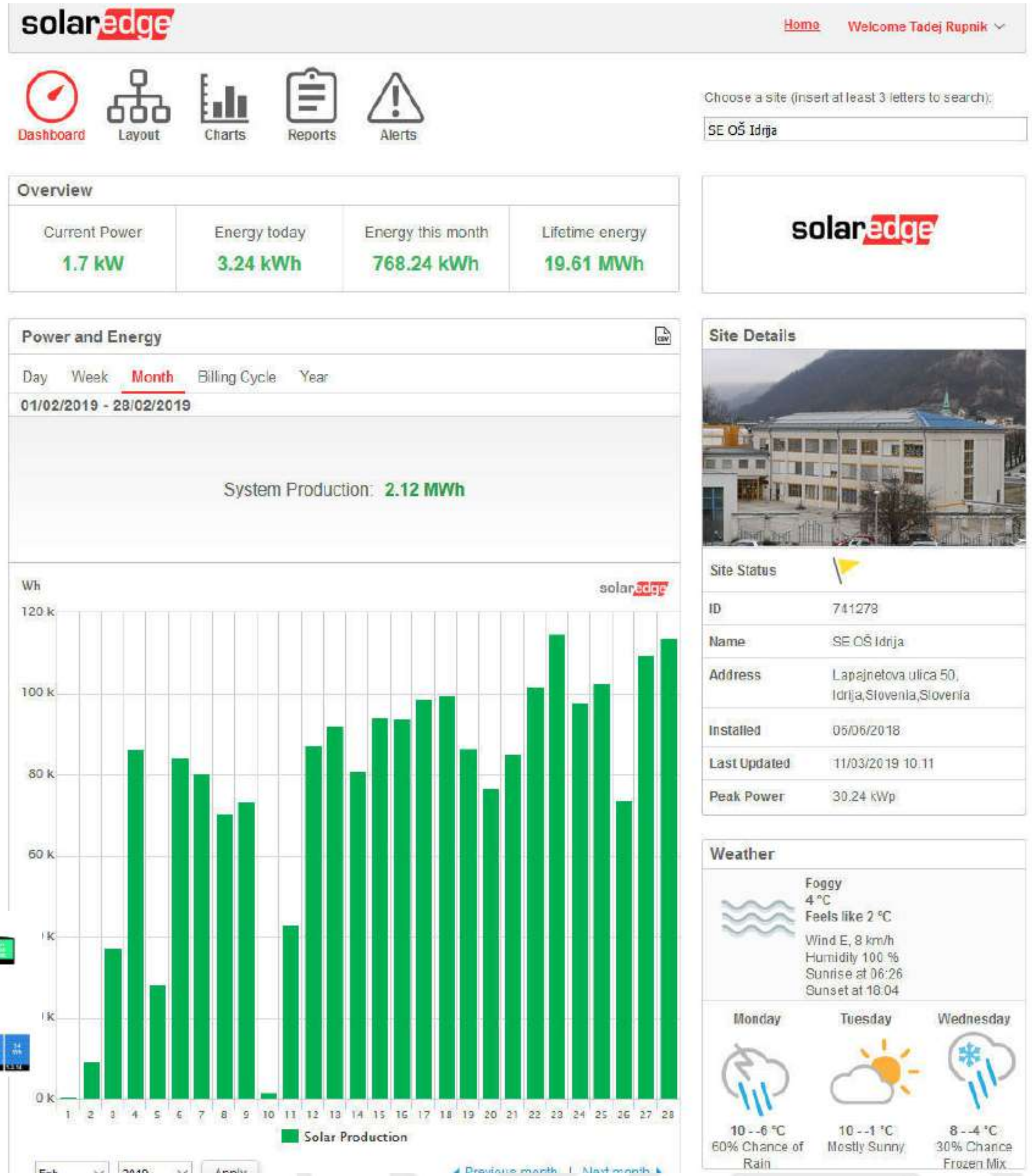
- Contract with LRC Servizi (www.datameteo.it)
- API access, 120 hours forecast, 1 hour increments
- Global, diffused and direct horizontal solar radiation, temperature

Solar irradiance sensor

Photovoltaic power plant

Data acquisition and control

- PV plantis connected to Solar Edge Cloud
- API is used to fill data into 3smart database
- GUI for monitoring – admin and public version
- https://monitoringpublic.solaredge.com/solaredge-web/p/site/public?name=se_idrija#/dashboard



CHP unit

CHP unit in boiler room

CHP unit

Installed equipment

- unit type: Indop50
- powered by: gas
- electric power: 50kW
- heating power: 90kW
- manufacturer: Gorenje Indop d.o.o

Connection to 3smart database is Modbus TCP/IP

Heated water is transmitted into the main boiler room heating system – through calorimeter

LCD on the command panel of the CHP with all basic informations and enable manual management of the CHP (start, stop, power output, scheduling, error descriptions...)

CHP unit

Measurement equipment installed

- Gas counter
- Calorimeter
- Synchroscope Sentron PAC3200

Synchroscope for synchronize electrical network and unit generator before it switch unit to the network

Gas counter and calorimeter

Gas counter and calorimeter are connected and sending data to the PLC on the CHP control board

DHW tank electrical heaters

DHW tank characteristics

- 4000 Lit
- Supply for three buildings:
    a) School,
    b) Blue hall (nearby sports facilities)
    c) sports centre

DHW tank electrical heaters

Installed equipment

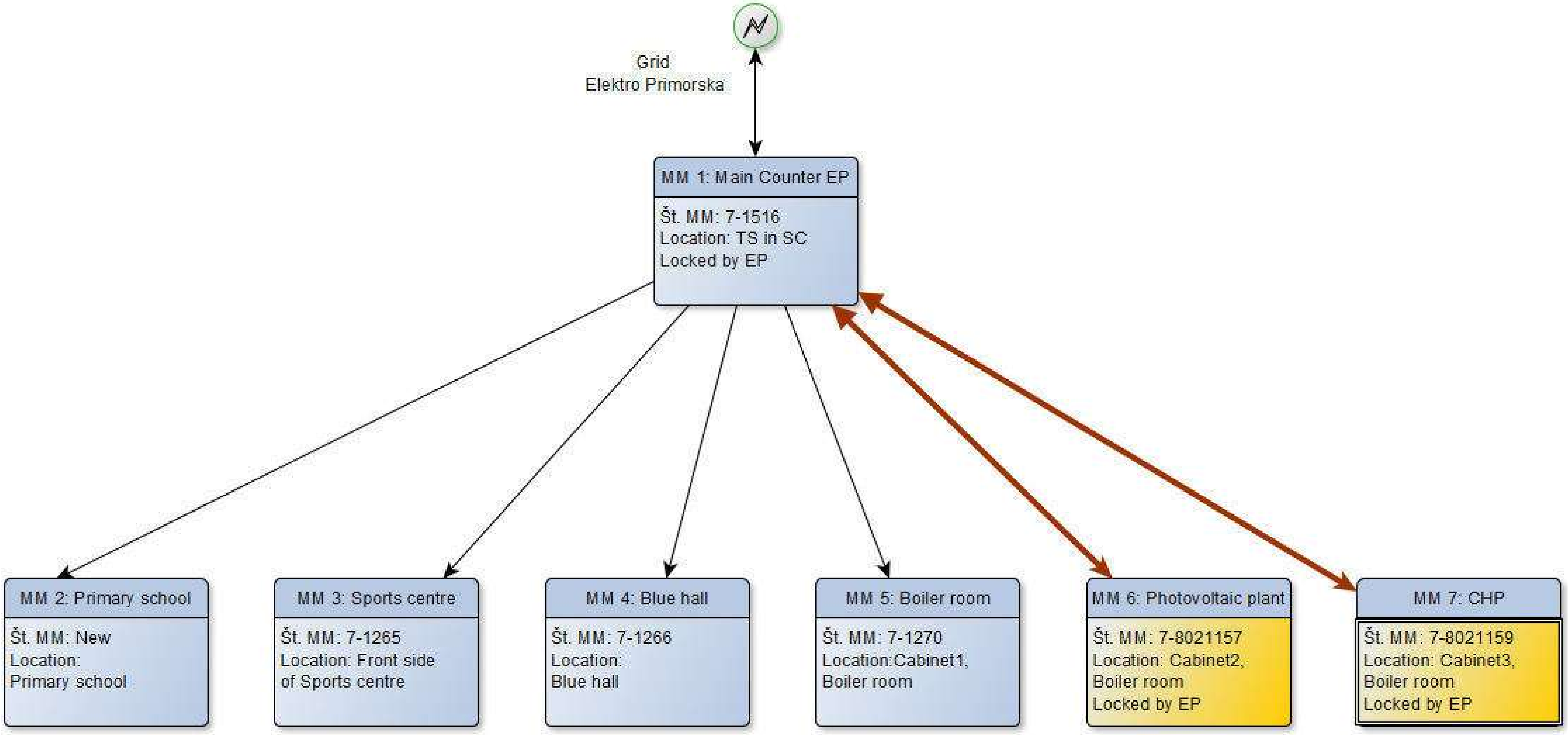
- Electrical heaters, 3pieces (2x14kW, 1x7kW)
- Flow meters, 3pieces

Flow meters

Electrical heaters, 35 kW

Connections to power grid

Four buildings were united under one main electrical counter



Connections to power grid

CHP & Photovoltaic plant connection cabinets

Main cabinet for boiler room and DHW heaters

Connections to power grid

Connecting electrical counters to the database

- LoRa wan electric pulse counters (Main counter, Blue hall, Primary school)
- Wired connection to the PLC (Boiler room, PV, CHP)

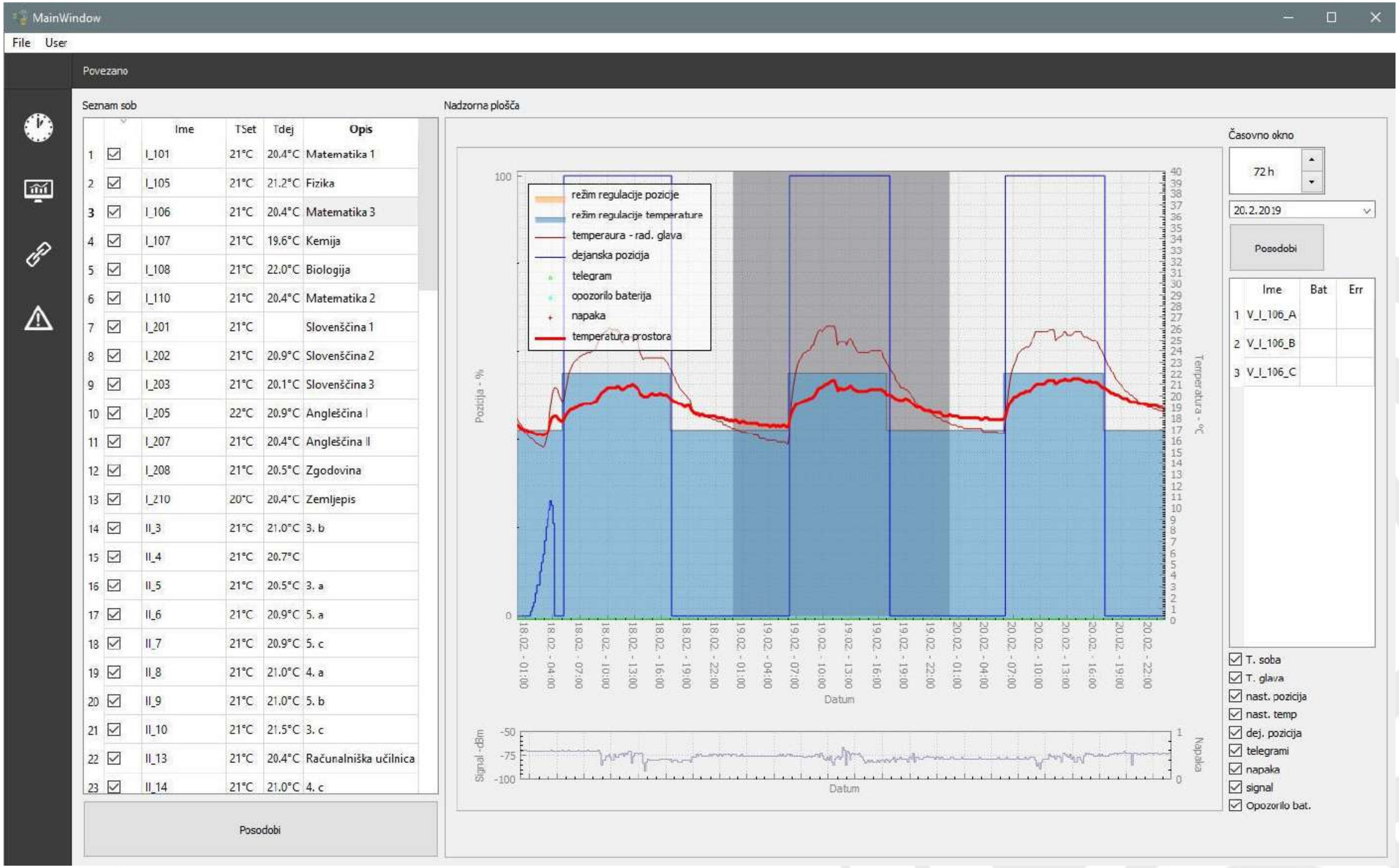
LoRa wan pulse counter/transmitter

LoRa wan gateway

- Located in electro cabinet of the PV on the roof of the Primary school
- Is cnnected to the 3smart database

LoRa wan gateway

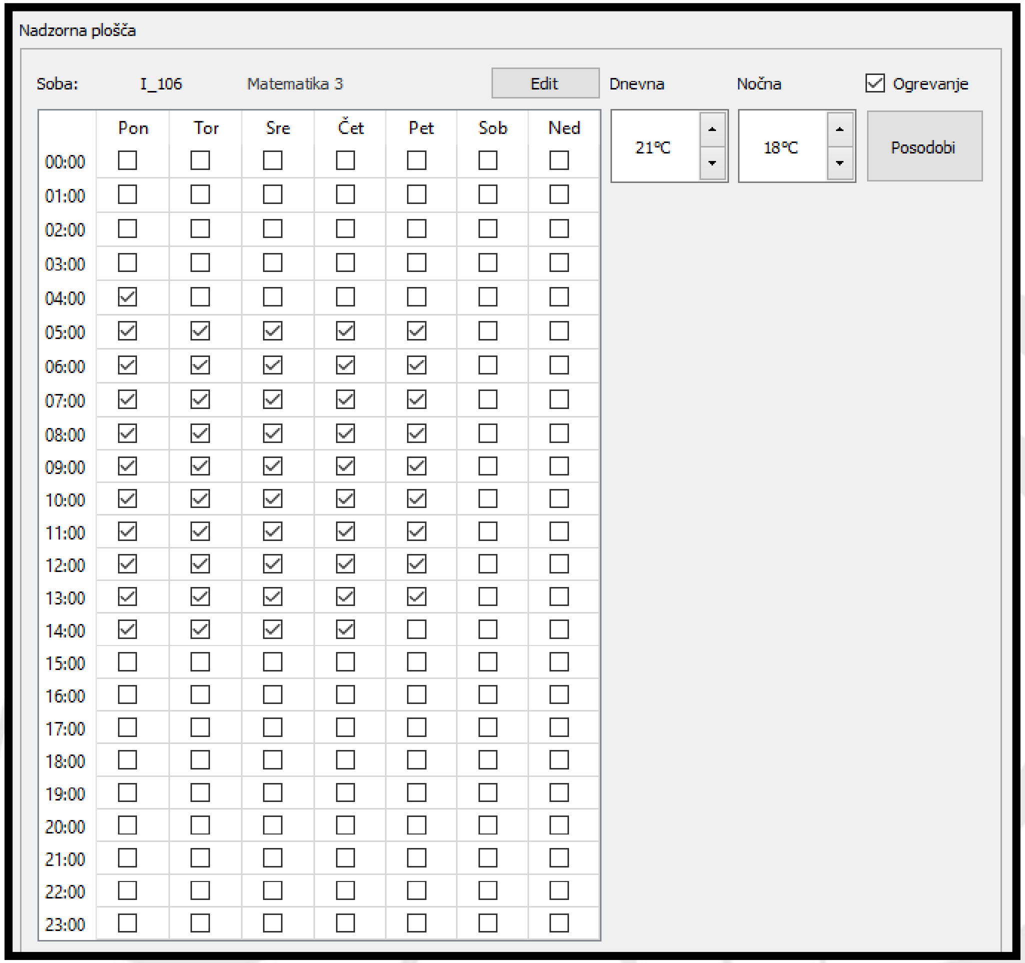
Regulating heating in the zones - User interface



Regulating heating in the zones - User interface

Settings for each zone

- Hourly schedule, 7/24
- Day / night temperature set point
- In case zone is not going to be occupied scheduling can be deactivated – night regime will be obtained in that case



Regulating heating in the zones - User interface

Quick overview over all zones

- Active state
- Day regime temperature set point
- Actual temperature in the zone

Seznam sob

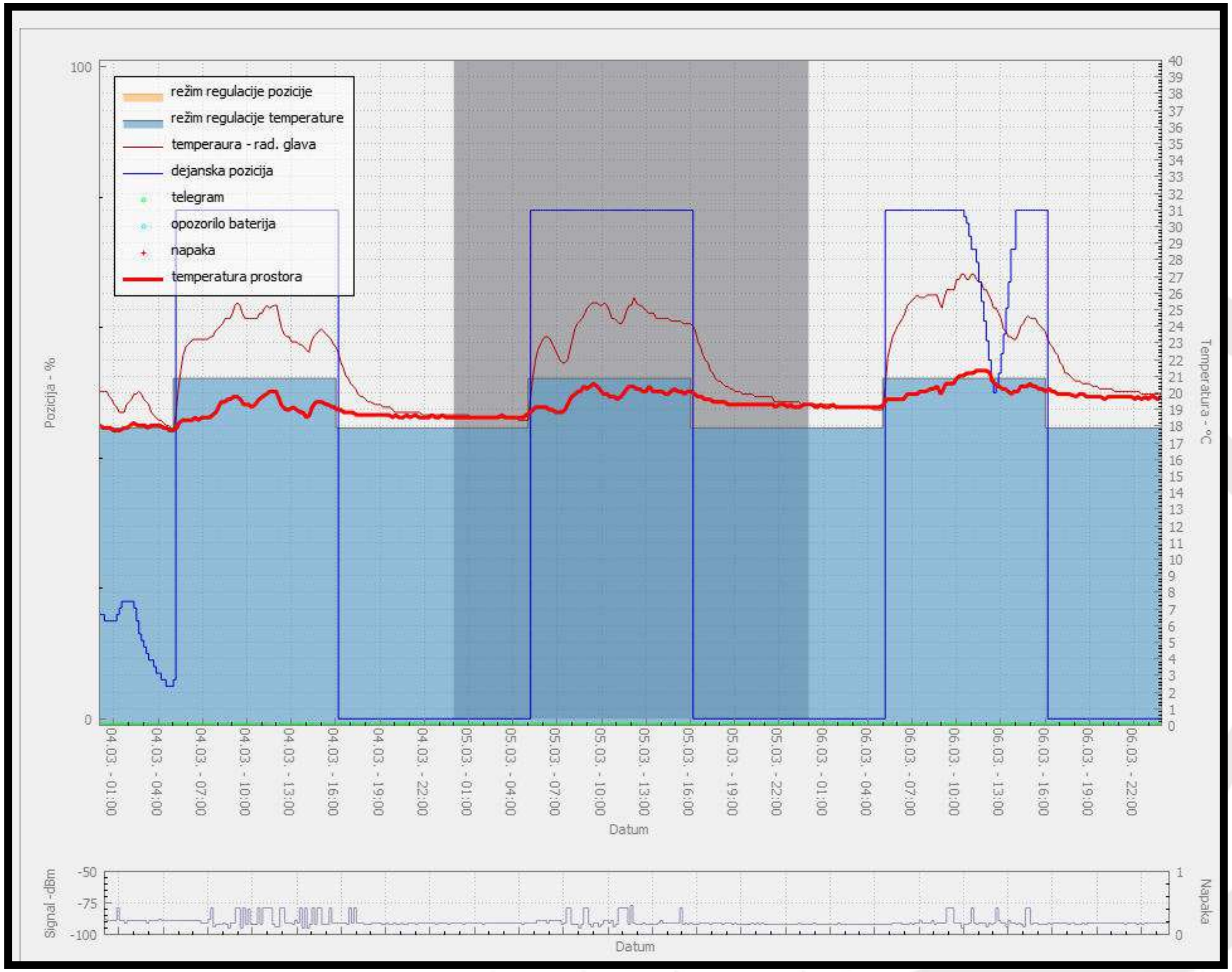
		Ime	TSet	Tdej	Opis
1	☑	I_101	21°C	20.4°C	Matematika 1
2	☑	I_105	21°C	21.2°C	Fizika
3	☑	I_106	21°C	20.4°C	Matematika 3
4	☑	I_107	21°C	19.6°C	Kemija
5	☑	I_108	21°C	22.0°C	Biologija
6	☑	I_110	21°C	20.4°C	Matematika 2
7	☑	I_201	21°C		Slovenščina 1
8	☑	I_202	21°C	20.9°C	Slovenščina 2
9	☑	I_203	21°C	20.1°C	Slovenščina 3
10	☑	I_205	22°C	20.9°C	Angleščina I
11	☑	I_207	21°C	20.4°C	Angleščina II
12	☑	I_208	21°C	20.5°C	Zgodovina
13	☑	I_210	20°C	20.4°C	Zemljepis
14	☑	II_3	21°C	21.0°C	3. b
15	☑	II_4	21°C	20.7°C	
16	☑	II_5	21°C	20.5°C	3. a
17	☑	II_6	21°C	20.9°C	5. a

Posodobi

Regulating heating in the zones - User interface

Graph view

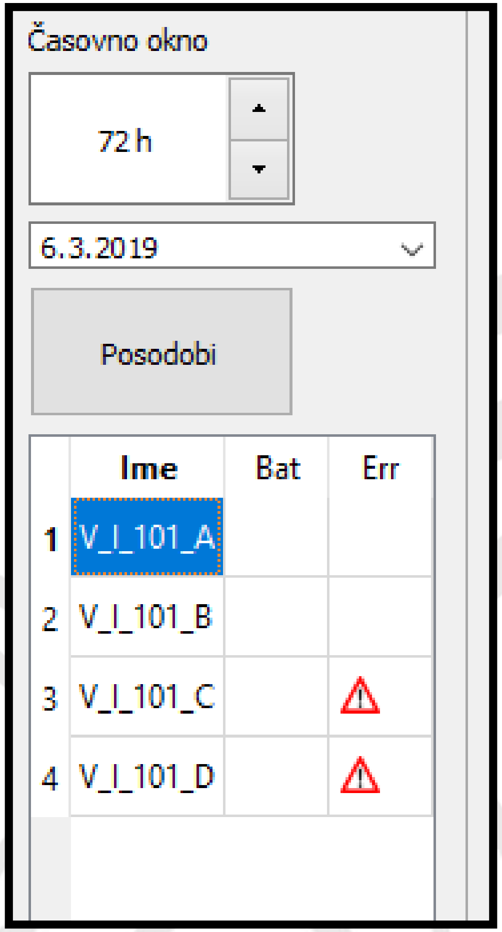
- Main valve regime (position/temp. regulation)
- Temperature on the valve head
- Temperature on the sensor
- Position of the head
- Battery state



Regulating heating in the zones - User interface

Graph view settings

- Time window
- Starting date
- Status of all valve heads in the zone
  - a) Battery almost empty error when battery will soon have to be replaced
  - b) Err = no communication with the head



Regulating heating in the zones - User interface

Error listing

- List all devices with issues
- Show timestamp of the last telegram successfully exchanged with the gateway
- Show type of the

Nadzorna plošča

Osveži | Save

	Ime	Datum zadnjega oglašanja	Baterija	Napaka	Signal
26	V_J_B	11.1.2019 10:53	1	0	92
27	V_J_C	7.3.2019 15:25	0	1	94
28	V_J_E	16.1.2019 12:08	1	0	91
29	V_J_F	7.3.2019 11:38	1	0	92
30	V_J_G	7.1.2019 16:22	1	0	94
31	V_J_H	7.3.2019 15:28	0	1	92
32	V_J_I	8.3.2019 15:12	0	1	91
33	V_J_J	9.1.2019 16:37	1	0	88
34	V_J_K	7.3.2019 15:36	0	1	89
35	V_J_L	19.1.2019 01:49	1	0	89
36	V_J_M	30.10.2018 14:24	0	1	91
37	V_J_N	7.3.2019 15:28	0	1	88
38	V_J_O	4.10.2018 21:39	0	0	83
39	V_J_P	8.3.2019 15:14	0	1	94
40	V_M_D	9.11.2018 18:04	0	0	74
41	V_M_E	18.10.2018 09:27	0	1	91
42	V_P50_C	10.10.2018 01:08	0	0	67
43	V_P50_D	4.2.2019 17:59	0	0	64

Regulating heating in the zones - User interface

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Thank you for your attention

Online demonstration of basic IT infrastructure performance with the installed equipment for building side

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3Smart 1st pilot study visit to the Slovenian pilot

Idrija, 12th – 13th March 2019

energetika
ekologija
ekonomija

Interreg
EUROPEAN UNION
Danube Transnational Programme
3Smart

Project co-funded by European Union funds (ERDF, IPA)

Overview

1. Server hardware and software environment
2. Network and connectivity
3. Database
4. Services monitoring – 3 layers

Overview

4. Access to 3Smart technology subsystems

   – PV plant

   – CHP

   – Zone heating control

   – Central heating station

Overview

5. Measurements presentation and evaulation.

Server hardware and software environment

Server hardware

- 3Smart server:
  - 8GB RAM
  - 4 CPU cores
  - HDD: 1 TB + 2 TB
  - UPS

Server software

- Server OS:
  - Windows 7 host
    - Virtualbox guest: Linux Mint (Ubuntu)
      - MySQL
      - Python 3.5
      - SSH server
      - SFTP server
      - Apache WEB server for UI.

Network and connectivity

Server connectivity

- VNC connection to windows host:

  Program TightVNC viewer for GUI access

- OpenVPN
  - Developers received instructions and data for access.

- Some services are accesible trough open ports. Some will be closed in future.

Server connectivity

- SFTP to transfer files.

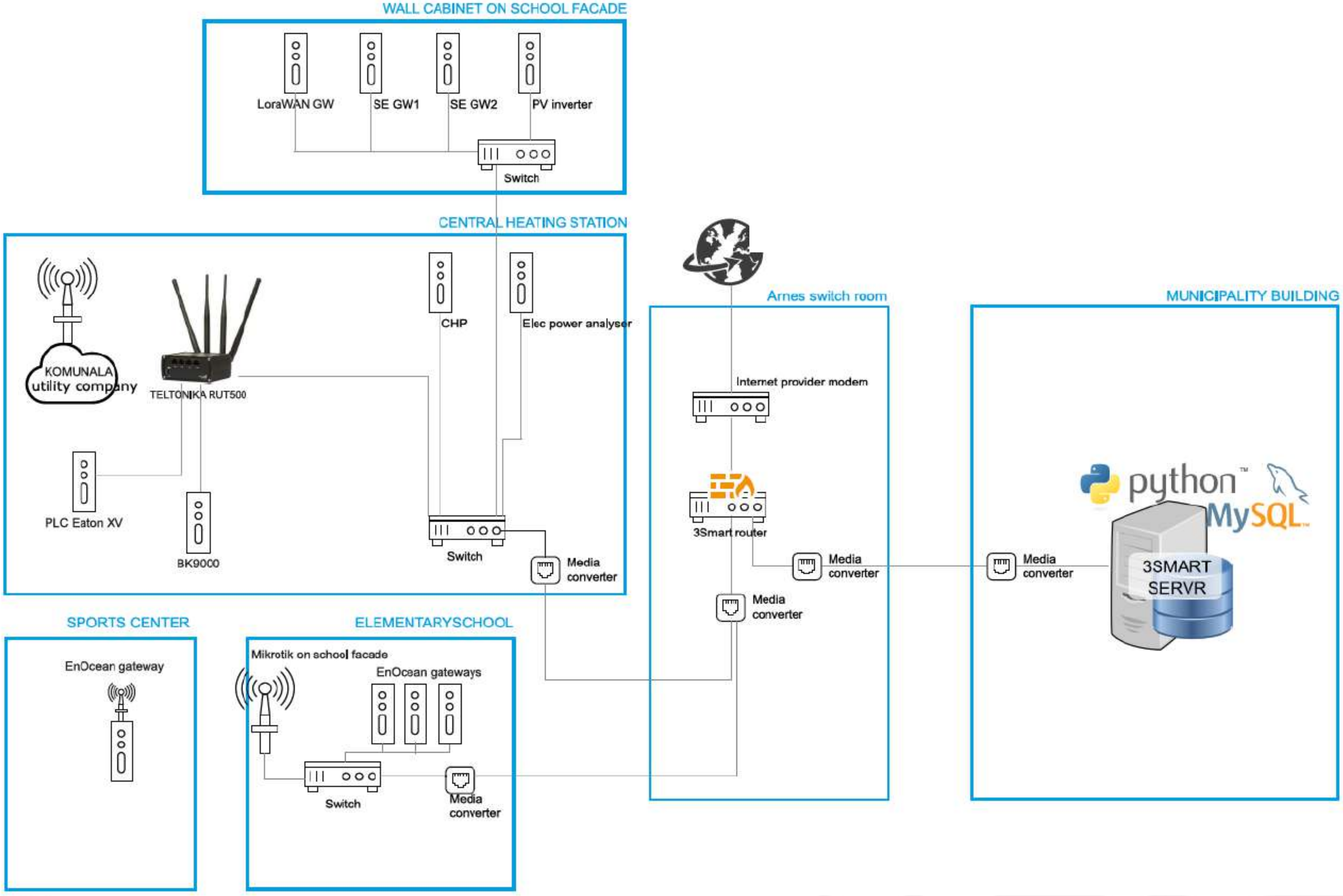
  On your machines you can use client for example yberduck, Filezilla, TotalCMD, WinSCP

- 3Smart files in one of appropriate subfolders (hvac, zone, mgrid) in: /home/smart/

- Terminal over SSH

  Client application: Putty

Network



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