LONG-TERM MULTI(ANNUAL) MODULE

Long-term Modules

- Tools for integrated and modular energy management for distributed demand response provider and distribution grid operators
  - Annual and multiannual module calculates the available resources for flexibility, unit prices and the basis of the long term contract

LT module coordination

ID	Time (UTC)	Data exchange/ activity	D.5.3.1 (Annual and Multiannual) Nomenclature	module	Reads data	Puts data at disposal	Tri-gger
1	till December, before contract agreement	Calculation of flexibility needs, prices, penalty and quality of service by using “3Smart_LongTerm module_Flexibility calculation table.xls”	Result: DSO Flexibility table; Flexibility unit prices,penalty; Output for long term contract sheets	LT module	DSO (staff)	DSO (staff)	0
2	till December, before contract agreement	Importing results of “3Smart_LongTerm module_Flexibility calculation table.xls”	Result: DSO Flexibility table; Flexibility unit prices,penalty; Output for long term contract data base tables	LT module	DSO (LT)(script1)	DSO (staff)	0
3	After step 2	Building EMS Microgrid module is fetching data from LT database		Microgrid	Building	DSO (LT)	0
4	After step 3	Building calculate flexibility offer	Result: Building Flexibility database table, tbd by Microgrid database developer	Microgrid		Building	0

Long term module coordination 2

ID	Time (UTC)	Data exchange/ activity	D.5.3.1 (Annual and Multiannual) Nomenclature	module	Reads data	Puts data at disposal	Tri-gger
5	After step 4	DSO (LT) module is fetching data from Microgrid database		LT	DSO (LT) (script2)	Building	0
6	After step 5	Generating file from Building Flexibility table	Result: Building Flexibility table in CSV or Excel	LT	DSO (staff)	DSO (LT) (script3)	0
7	After step 6	Contract preparation by DSO, inserting Building Flexibility table into “3Smart_LongTerm module_Flexibility calculation table.xls”	Result: Output for long term contract sheet	LT		DSO (staff)	
8	After step 7	Acceptance/Rejection of Building offer	Result: Offer acceptance sheet (Yes/No)	LT		DSO (staff)	
9	After step 8	Importing Offer acceptance sheet of “3Smart_LongTerm module_Flexibility calculation table.xls”	Result: Offer acceptance database table (Yes/No)	LT	Building	DSO (LT) (script4)	

Long-term module coordination 3

3Smart LT   Home   Login

Long Term Workflow

Grid Choose...

Building Choose...

Contract New contract

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	

Communication model-description

1_Calculation of flexibility needs, prices, penalty and QoS

DSO staff is opening the excel file “3Smart_LongTerm module Flexibility calculation table.xls” and is filling preliminary data required by DSO flexibility and price calculations. Based on the input the excel is calculating automatically the results situating on the following tabs: “DSO Flexibility table”, “Flexibility unit prices, penalty” and “Output for long term contract”.

2_Importing results of “3Smart_LongTerm module_Flexibility calculation table.xls”

DSO staff is logging into the Long term module web application and is executing the import script by clicking on the corresponding menu item. After selecting “3Smart_LongTerm module_Flexibility calculation table.xls” from the user’s pc, the script is moving the result sheets content into the LT database. The following database tables will be written:

- contract
- dso_flexibility_table
- flexibility_unit_prices_and_penalty

At the same time the building_flexibility_table entries for that contract are removed. For the first import of that excel there is no such data anyway but it may happen that a reimport is necessary which invalidates the eventual building flexibility data belonging to the previous import.
Whenever an import activity is performed, the Microgrid staff needs to be notified that building flexibility calculations have to be (re)executed.

Communication model-description

3_Building EMS Microgrid module is fetching data from LT database

The general 3Smart concept in data exchange is to use Pull method for data transfers between the different modules. For that reason Microgrid side needs to implement a communication script which is going to read the above mentioned LT database tables and copy data to its own local communication tables. As the script is to be used once a year per building but at an undefined time, it wouldn't make much sense to schedule it for automatic processing. Our recommendation is to execute that script manually by Microgrid staff after receiving a notification from DSO staff that new result data is available

4_Building calculates flexibility offer

Based on the DSO flexibility data and prices the Microgrid is calculating a flexibility offer and stores the result in a communication table (Building Flexibility table) which is yet to be defined.
Microgrid staff is notifying DSO staff that new building flexibility data is available for reading.

5_DSO (LT) module is fetching data from Microgrid database

A py script is reading the building flexibility data from the Microgrid's communication table and copying it to the appropriate LT database table (building_flexibility_table). For the same reasons as mentioned in step 3 the DSO staff is going to execute that script manually by choosing the corresponding menu item instead of scheduling it for regular running. DSO staff will need to know that new data is available – by communication between DSO and Microgrid staff (step 4).

Communication model-description

6_Generating file from Building Flexibility table

DSO staff is exporting the content of the building_flexibility_table database table to a csv file on the local pc by executing a py script via the web application. That file will serve as an input for the Contract preparation activity performed by “3Smart_LongTerm module_Flexibility calculation table.xls”.

7_Contract preparation by DSO

DSO staff is copying the above csv content into the “3Smart_LongTerm module_Flexibility calculation table.xls” onto the “Building Flexibility table” sheet. Using that data the excel file is going to create the final result – the contract offer by filling automatically the “Output for long term contract” sheet.

8_Acceptance/Rejection of Building offer

DSO staff is accepting / rejecting the building offer by updating the “Offer acceptance” sheet in “3Smart_LongTerm module_Flexibility calculation table.xls”.

9_Importing Offer acceptance

DSO staff is executing a py script to import Offer acceptance information from “3Smart_LongTerm module_Flexibility calculation table.xls” to the LT database making it available for reading by other modules like Microgrid.

SHORT TERM DAY-AHEAD MODULE

Short-term Day-Ahead Module

- day – to – day operation module for determening building flexibility potential as the distribution network/system operator asset:
  - Interconnection with long term module and receiving flexibility requirements
  - Defined 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)

ST Day-Ahead Module Input

- From Grid.xlsx:
  - Grid information (grid topology, lines descriptions)
  - Active and reactive power profiles for every node defined for specific dates in year (3 characteristics profiles for every moth)

- From Long-term contract:
  - Building flexibility table

Module coordination

- Day before delivery of electricity
  - At **11.00 AM** (UTC) CROPEX publish (at 10:40 UTC) the Day-Ahead prices
  - „Retailer” gather the data, extend hourly prices to 15 min prices, convert prices to EUR/kWh and **store** into table „Retailer to building DA prices” in „Retailer” DB

Retailer database outlook

retailer on postgres@3s_grid

```
SELECT * FROM public.retailer_to_building_da_prices
```

Data Output | Explain | Messages | Notifications | Query History

	id [PK] integer	retailer_id integer	profile character varying (2000)	profile_created_at timestamp without time zone
1	7	1	{"DA prices": [0.0437, 0.0437,...	2019-02-03 11:48:50.887972

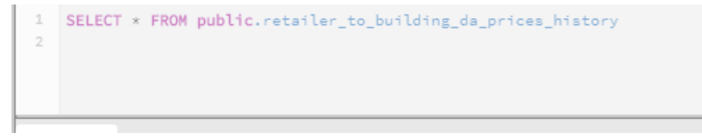
{"DA prices": [0.0437, 0.0437, 0.0437, 0.0437, 0.04137, 0.04137, 0.04137, 0.04137, 0.04048, 0.04048, 0.04048, 0.04048, 0.03921, 0.03921, 0.03921, 0.03921, 0.03855, 0.03855, 0.03855, 0.03855, 0.04072, 0.04072, 0.04072, 0.04072, 0.04923, 0.04923, 0.04923, 0.04923, 0.07315, 0.07315, 0.07315, 0.07315, 0.07963, 0.07963, 0.07963, 0.07963, 0.08009, 0.08009, 0.08009, 0.08009, 0.07233, 0.07233, 0.07233, 0.07233, 0.067, 0.067, 0.067, 0.067, 0.06178, 0.06178, 0.06178, 0.06178, 0.06104, 0.06104, 0.06104, 0.06104, 0.06481, 0.06481, 0.06481, 0.06481, 0.06495, 0.06495, 0.06495, 0.06495, 0.06815, 0.06815, 0.06815, 0.06815, 0.10107, 0.10107, 0.10107, 0.10107, 0.07727, 0.07727, 0.07727, 0.07727, 0.07066, 0.07066, 0.07066, 0.07066, 0.06623, 0.06623, 0.06623, 0.06623, 0.0441, 0.0441, 0.0441, 0.0441, 0.0431, 0.0431, 0.0431, 0.0431, 0.0361, 0.0361, 0.0361, 0.0361], "Measuring unit": "EUR/kWh", "Valid from": "2019-02-03 23:00:00"}

```
SELECT * FROM public.retailer_to_building_da_prices_history
```

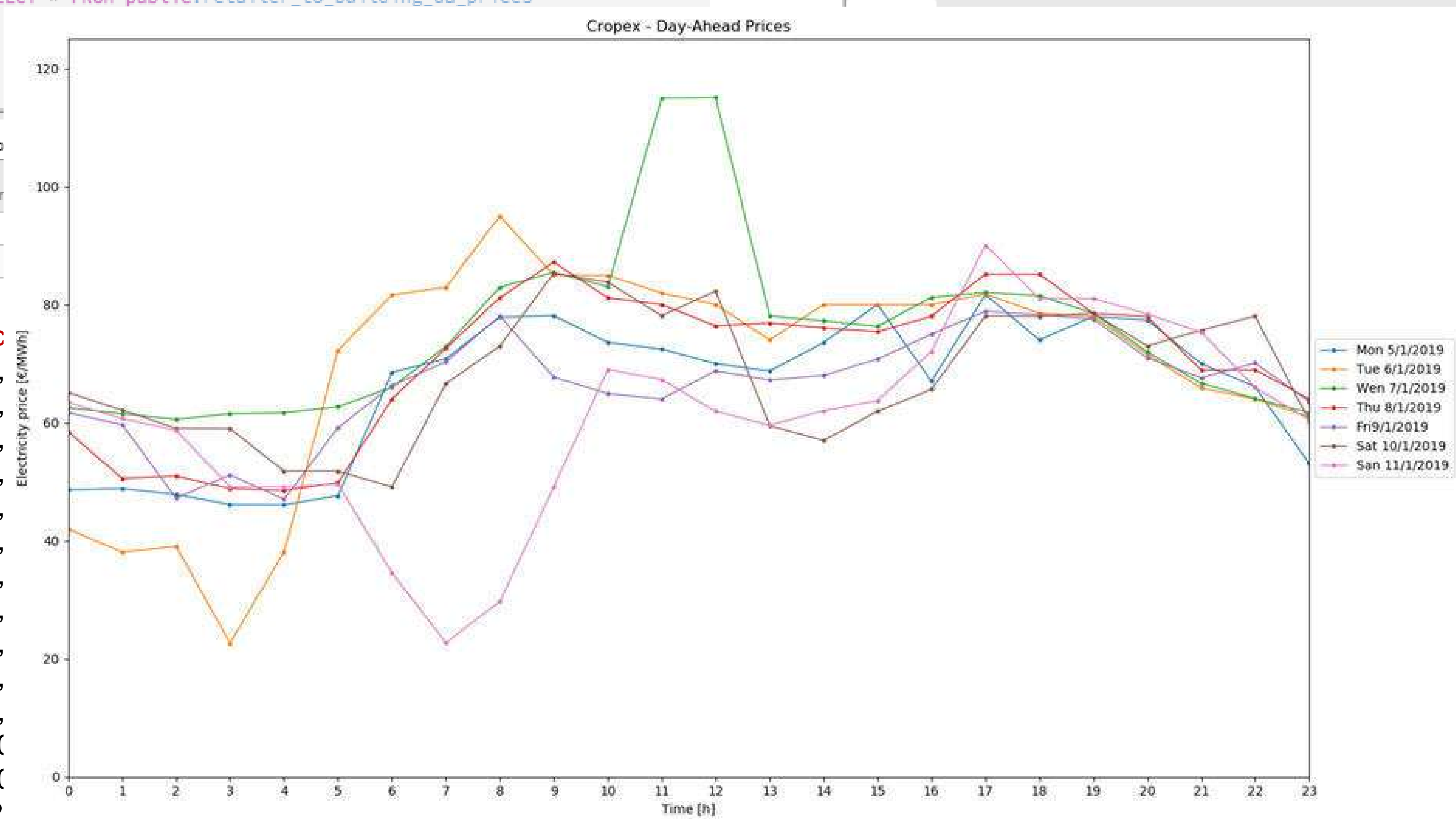
Data Output | Explain | Messages | Notifications | Query History

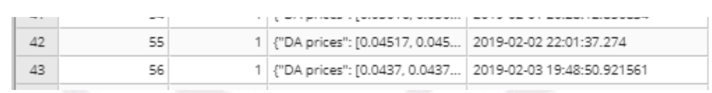
	id [PK] integer	retailer_id integer	profile character varying (2000)	profile_created_at timestamp without time zone
11	19	1	{"DA prices": [0.04202, 0.042...	2019-01-07 17:30:05.478255
12	20	1	{"DA prices": [0.06251, 0.062...	2019-01-08 17:30:05.478251
13	21	1	{"DA prices": [0.05846, 0.058...	2019-01-09 17:30:05.478278
14	22	1	{"DA prices": [0.06166, 0.061...	2019-01-10 17:30:05.4782
15	23	1	{"DA prices": [0.0651, 0.0651...	2019-01-11 17:30:05.51782
16	24	1	{"DA prices": [0.06344, 0.063...	2019-01-12 17:30:05.51782
17	25	1	{"DA prices": [0.05306, 0.053...	2019-01-13 17:30:05.51782
18	26	1	{"DA prices": [0.06214, 0.062...	2019-01-14 17:30:05.51782
19	27	1	{"DA prices": [0.06669, 0.066...	2019-01-15 17:30:05.51782
20	28	1	{"DA prices": [0.08001, 0.080...	2019-01-16 17:30:05.51782
21	29	1	{"DA prices": [0.06015, 0.060...	2019-01-17 17:30:05.51782
22	30	1	{"DA prices": [0.065, 0.065, 0....	2019-01-18 17:30:05.51782
23	31	1	{"DA prices": [0.06669, 0.066...	2019-01-19 17:30:05.51782
24	32	1	{"DA prices": [0.059, 0.059, 0...	2019-01-20 17:30:05.51782
25	33	1	{"DA prices": [0.07148, 0.071...	2019-01-21 17:30:05.51782
26	34	1	{"DA prices": [0.06157, 0.061...	2019-01-22 17:30:05.51782
27	35	1	{"DA prices": [0.06473, 0.064...	2019-01-23 17:30:05.51782
28	41	1	{"DA prices": [0.06463, 0.064...	2019-01-24 16:09:49.365266
29	42	1	{"DA prices": [0.06463, 0.064...	2019-01-24 16:10:04.599151
30	43	1	{"DA prices": [0.06463, 0.064...	2019-01-24 17:44:04.28671
31	44	1	{"DA prices": [0.06463, 0.064...	2019-01-24 20:27:32.337022
32	45	1	{"DA prices": [0.06463, 0.064...	2019-01-24 20:33:02.049466
33	46	1	{"DA prices": [0.06463, 0.064...	2019-01-24 20:33:22.226096
34	47	1	{"DA prices": [0.06463, 0.064...	2019-01-25 20:34:29.984231
35	48	1	{"DA prices": [0.04464, 0.044...	2019-01-26 18:43:02.694897
36	49	1	{"DA prices": [0.04706, 0.047...	2019-01-27 19:15:46.874447
37	50	1	{"DA prices": [0.04976, 0.049...	2019-01-28 11:19:05.883031
38	51	1	{"DA prices": [0.04701, 0.047...	2019-01-29 19:11:24.47434
39	52	1	{"DA prices": [0.05322, 0.053...	2019-01-31 19:10:06.929731
40	53	1	{"DA prices": [0.05322, 0.053...	2019-02-01 10:28:52.450285
41	54	1	{"DA prices": [0.05016, 0.050...	2019-02-01 20:28:12.850834
42	55	1	{"DA prices": [0.04517, 0.045...	2019-02-02 22:01:37.274
43	56	1	{"DA prices": [0.0437, 0.0437...	2019-02-03 19:48:50.921561

Retailer database outlook



{"DA pric
0.04137,
0.03921,
0.04072,
0.04923,
0.07963,
0.07233,
0.06178,
0.06481,
0.06495,
0.10107,
0.07066,
0.0441, (
0.0361, (
from": "2





Module coordination

- At **12.00 AM** (UTC) the building reads the DA price profile from „Retailer” DB table „Retailer to building DA prices” and runs MPC
  - At **13.00 AM** (UTC) **the building stores** the result „Declared DA profile” in communication table „building_to_dso_declared_da_profiles”
  - **the DSO reads** the profile and stores in its own communication table when AC OPF is started

Database outlook

dso on postgres@3s_grid

```sql
SELECT * FROM public.building_to_dso_declared_da_profiles
```

Data Output | Explain | Messages | Notifications | Query History

	id [PK] integer	building_id integer	profile character varying (3000)	profile_created_at timestamp without time zone
1	1	13	{"declared_da_profile": [51.6...	2019-02-04 13:30:19.713084

{"declared_da_profile": [51.622, 53.787000000000006, 54.728, 58.132, 56.885000000000005, 56.237, 56.932, 56.959, 56.596000000000004, 56.772000000000006, 56.534, 56.007999999999996, 56.077, 56.191, 55.366, 53.486000000000004, 53.236999999999995, 52.446, 52.844, 53.023999999999994, 52.607, 50.203, 50.539999999999999, 51.85, 61.81, 53.9, 51.726, 51.859, 46.728, 49.26, 49.483, 42.628, 42.387999999999999, 41.428, 41.141, 40.943, 40.899, 41.342, 41.481, 41.604, 41.799, 41.871, 41.931999999999995, 41.828999999999999, 41.973, 41.746, 41.933, 42.297, 42.455, 42.479, 42.7, 42.794, 42.647999999999996, 42.94, 42.772000000000006, 42.714, 42.843, 42.786, 42.863, 42.915, 42.968, 43.074, 42.943, 42.913, 42.979, 43.038, 43.254000000000005, 44.061, 43.275999999999996, 54.825, 58.078, 78.765999999999999, 74.7, 67.782000000000001, 69.033999999999999, 64.38, 59.166, 59.703999999999999, 60.242, 61.916000000000004, 63.428, 64.764000000000001, 62.852, 64.454000000000001, 61.600999999999999, 62.694, 63.524, 62.726000000000006, 60.739999999999995, 58.613, 58.803, 63.007999999999996, 60.995, 63.929, 70.607, 65.636], "measuring_unit": "kWh", "valid_from": "2018-02-04 23:00:00"}

dso on postgres@3s_grid

```sql
SELECT * FROM public.building_to_dso_declared_da_profiles_history
```

Data Output | Explain | Messages | Notifications | Query History

	id [PK] integer	building_id integer	profile character varying (3000)	profile_created_at timestamp without time zone
1	1	13	{"valid_from": "2018-12-13 0...	2018-12-11 23:44:47.509918
2	2	13	{"valid_from": "2018-12-13 0...	2018-12-11 23:47:49.023675
3	3	13	{"valid_from": "2018-12-13 0...	2018-12-11 23:50:06.826921
4	4	13	{"valid_from": "2018-12-13 0...	2018-12-11 23:55:11.779649
5	5	13	{"valid_from": "2018-12-13 0...	2018-12-11 23:55:22.83317
6	6	13	{"valid_from": "2018-12-13 0...	2018-12-11 23:57:14.576792
7	7	13	{"valid_from": "2018-12-13 0...	2018-12-12 00:00:57.386639
8	8	13	{"valid_from": "2018-12-13 0...	2018-12-12 00:02:05.532131
9	9	13	{"valid_from": "2018-12-13 0...	2018-12-12 00:02:43.999425
10	10	13	{"valid_from": "2018-12-13 0...	2018-12-12 00:04:34.190611
11	11	13	{"valid_from": "2018-12-14 0...	2018-12-12 07:58:38.982417
12	12	13	{"valid_from": "2018-12-14 0...	2018-12-12 07:59:01.930168
13	13	13	{"valid_from": "2018-12-14 0...	2018-12-12 07:59:53.970276
14	14	13	{"valid_from": "2018-12-14 0...	2018-12-12 08:00:50.930219
15	15	13	{"measuring_unit": "kWh", "v...	2018-12-12 08:49:54.18283
16	16	13	{"measuring_unit": "kWh", "v...	2018-12-12 08:50:35.589541
17	17	13	{"measuring_unit": "kWh", "v...	2018-12-12 08:52:49.261845
18	18	13	{"measuring_unit": "kWh", "v...	2018-12-12 08:53:39.052097
19	19	13	{"measuring_unit": "kWh", "v...	2018-12-12 08:54:01.973951
20	20	13	{"measuring_unit": "kWh", "v...	2018-12-12 08:55:39.557233
21	21	13	{"measuring_unit": "kWh", "v...	2018-12-12 08:55:59.647734
22	22	13	{"measuring_unit": "kWh", "v...	2018-12-12 08:57:00.642555
23	23	13	{"declared_da_profile": [[52....	2018-12-12 11:32:01.992102
24	24	13	{"declared_da_profile": [[52....	2018-12-12 11:41:21.440806
25	25	13	{"declared_da_profile": [[51....	2018-12-12 11:43:16.914286
26	26	13	{"declared_da_profile": [[51....	2018-12-12 11:43:59.42221
27	27	13	{"declared_da_profile": [[51....	2018-12-12 11:44:42.520898
28	28	13	{"declared_da_profile": [[51....	2018-12-12 11:48:12.730764
29	29	13	{"declared_da_profile": [[51....	2018-12-12 11:48:29.35575
30	30	13	{"declared_da_profile": [[51....	2018-12-12 11:52:39.251857
31	31	13	{"declared_da_profile": [[51....	2018-12-12 11:53:00.102413
32	32	13	{"declared_da_profile": [[50....	2018-12-12 13:06:46.425783
33	33	13	{"declared_da_profile": [[50....	2018-12-12 13:07:24.688093
34	34	13	{"valid_from": "2018-12-14 0...	2018-12-12 13:18:53.815162

AC OPF module

- Input:
  - Grid data ☑
  - Load profiles ☑
  - Long-term – building flexibility profiles ☑
  - Building „Declared DA profile” ☑

Defined for next day

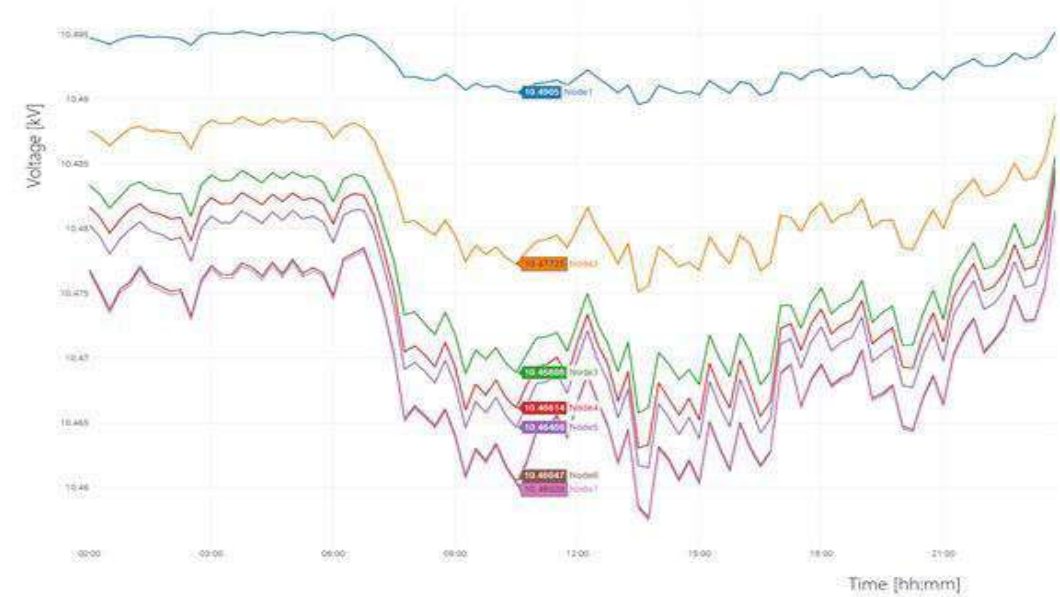
Day before delivery
at 3.00 PM (UTC)
ST DA module runs ACOPF

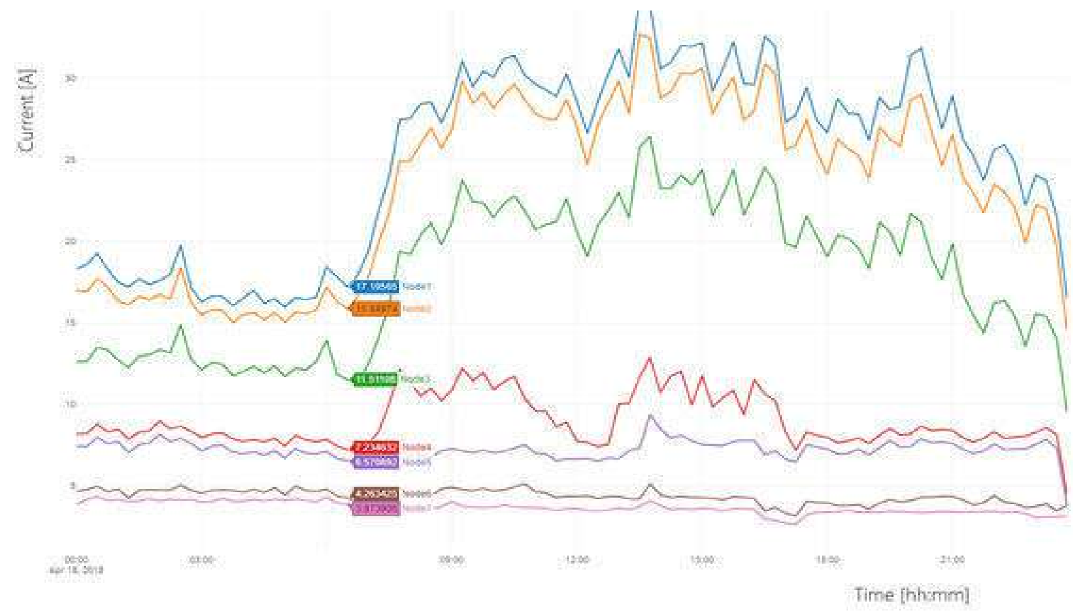
Gurobi solver
- Load-flow analysis
- Power loss minization

- Output:
  - Voltage and current state of network
  - Building flexibility activation profile

AC OPF results

- Results visualised:
  - Voltage
  - Current
  - Active power
  - Reactive power



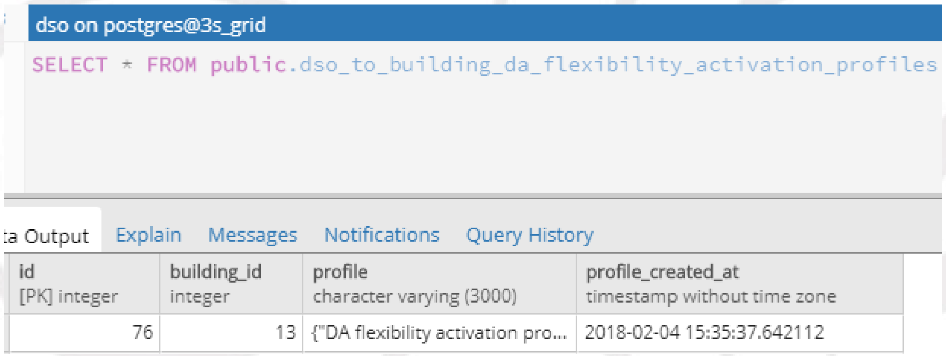


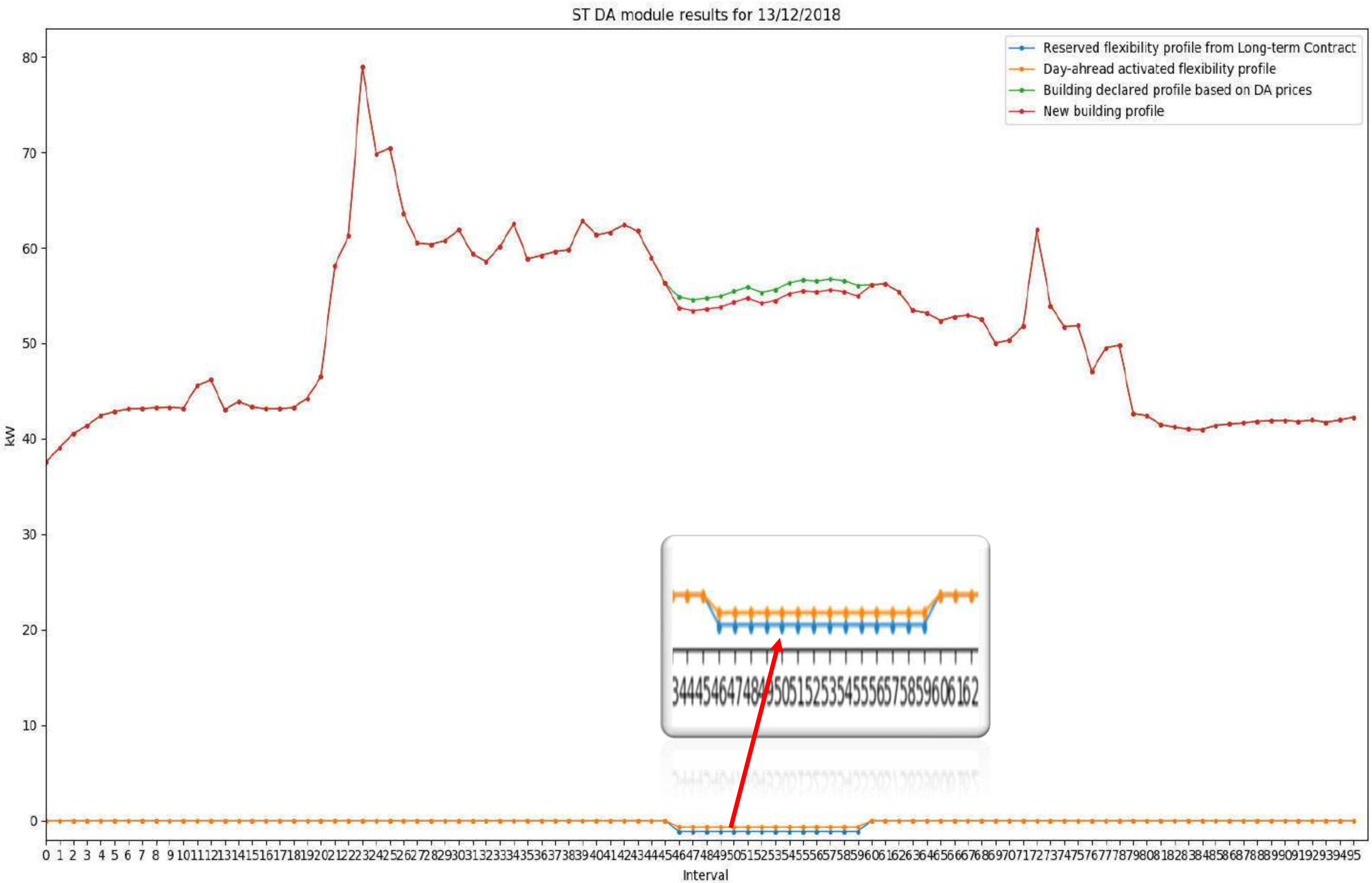
Interreg
Danube Transnational Programme
3Smart

AC OPF results (1)

- Day before delivery:
  - Building flexibility activation profile
    - At **3:15 AM** (UTC) **ST DA modules stores** the result in communication table „DSO to building flexibility activation profile”
    - At **4:00 AM (UTC) building reads** the profile and schedule assets to follow the request

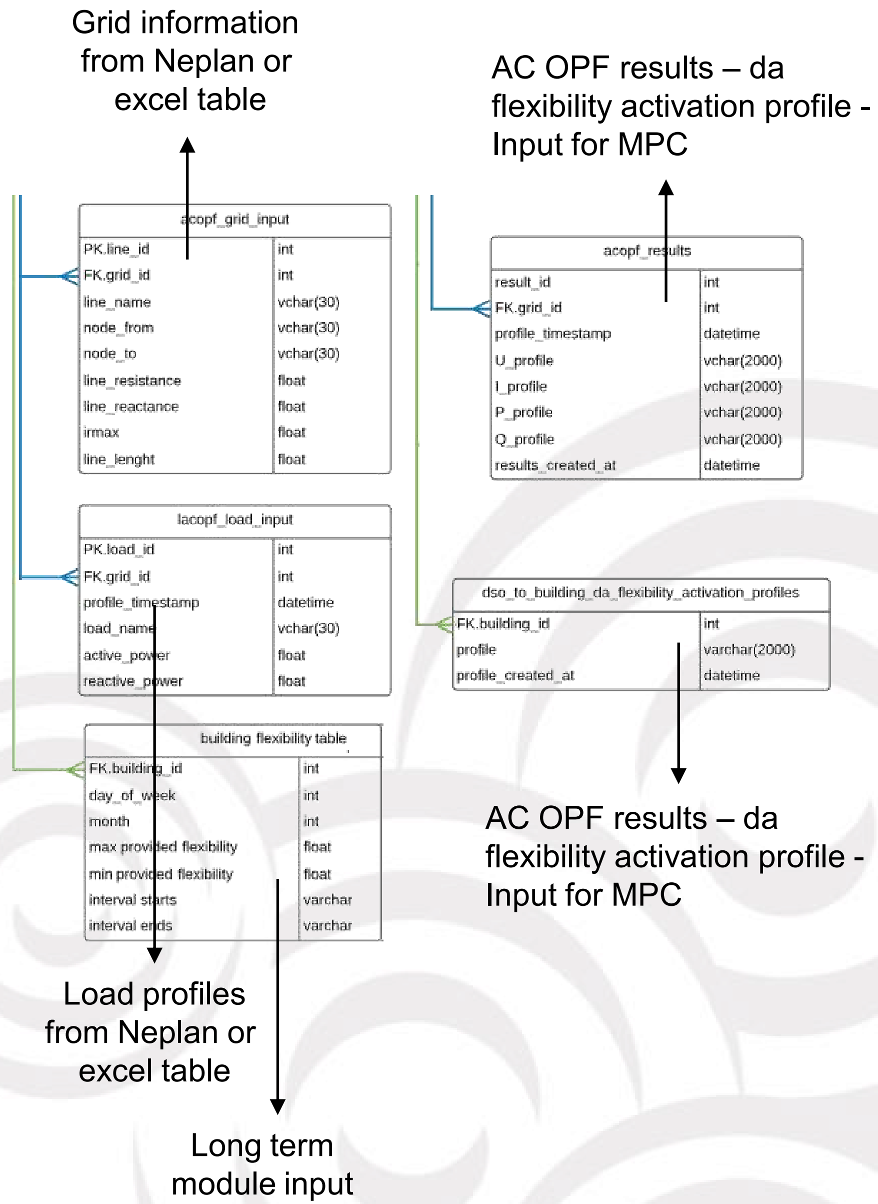
{"DA flexibility activation profile": [0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,, -1.137587, -1.13758, -1.13758, -1.1375877718386254, -1.1375893533847705, -1.1375895, -1.13758, -1.13758, -1.1375887786558803, -1.13758, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0], "Measuring unit": "kW", "Valid from": "2018-04-02 23:00:00"}

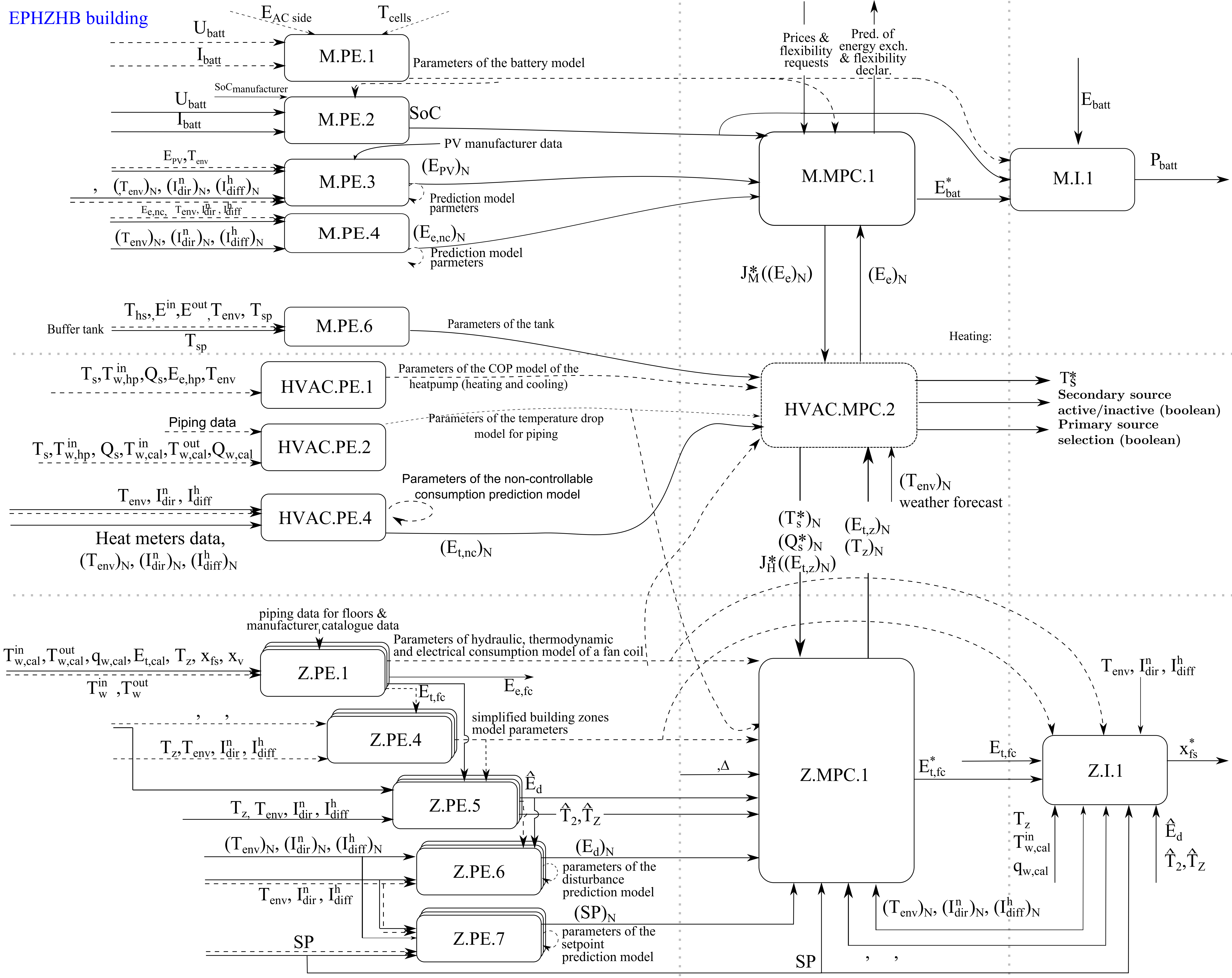



ST DA module results for 13/12/2018
Reserved flexibility profile from Long-term Contract
Day-ahread activated flexibility profile
Building declared profile based on DA prices
New building profile
kW
Interval

Database schema

- Input tables for AC OPF
  - From excel, Neplan, building and long term module
- Ouput tables – AC OPF results
  - For plotly and building
- Rest of communication tables
- Archive of communication tables





EPHZHB building
M.PE.1
Parameters of the battery model
M.PE.2
SoC
M.PE.3
PV manufacturer data
Prediction model parmeters
M.PE.4
Prediction model parmeters
M.PE.6
Buffer tank
Parameters of the tank
M.MPC.1
Prices & flexibility requests
Pred. of energy exch. & flexibility declar.
M.I.1
HVAC.PE.1
Parameters of the COP model of the heatpump (heating and cooling)
HVAC.PE.2
Piping data
Parameters of the temperature drop model for piping
HVAC.PE.4
Parameters of the non-controllable consumption prediction model
Heat meters data,
HVAC.MPC.2
Heating:
Secondary source active/inactive (boolean)
Primary source selection (boolean)
weather forecast
Z.PE.1
piping data for floors & manufacturer catalogue data
Parameters of hydraulic, thermodynamic and electrical consumption model of a fan coil
Z.PE.4
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
Z.I.1

3Smart First pilot study visit to the EPHZHB pilot: On-line demonstrations: 3Smart modules installed

Anita Martinčević, Nikola Hure, Danko Marušić, Hrvoje Novak

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3Smart pilot study visit to EPHZHB pilot No. 1 in Tomislavgrad

27 February 2019

UNIVERSITY OF ZAGREB
FACULTY OF ELECTRICAL ENGINEERING AND COMPUTING

Current EPHZHB modules status and upcoming plans

Current EPHZHB modules status

General prerequisites

1. Server connection (VPN SSTP)
2. Database connection (PgAdmin)
3. Python connection (PyCharm terminal, libraries etc.)
4. Historical data analysis

Current EPHZHB modules status

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Current EPHZHB modules status

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4. **Historical data analysis**

Current EPHZHB modules status

ZONE LEVEL MODULES

- Z.PE.6 – historical data accumulation (Z.PE.5)
- Z.PE.7 – in online operation, ‘local_switch’ needs to be changed

HVAC LEVEL MODULES

- HVAC.PE.4 – data and Python coding ready, waiting for Linux machine setup to finalize
  - HVAC non-controllable consumption submodule – in online operation

MICROGRID LEVEL MODULES

- M.PE.3 – location of pyranometers will be changed, Linux machine setup needs to be finalized
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Current EPHZHB modules status

ZONE LEVEL MODULES

- Z.PE.1
  - Calorimeter temperature resolution set to 0.1 °C → done
  - Experiments on individual* FCU required for identification of hydraulic model (*only on units with return medium sensor)
  - Sensor calibration
  - Identification of the hydraulic system model
  - Selection of fan coil units to perform longer experiments required to identify thermodynamic fan coil unit model
  - Performing experiments on few selected fan coil unit types
  - Identification of thermodynamic system model
  - Putting all identified models to database
  - Putting online part of Z.PE.1 into operation
- Z.PE.5
- Z.MPC.1
- Z.I.1

Current EPHZHB modules status

ZONE LEVEL MODULES

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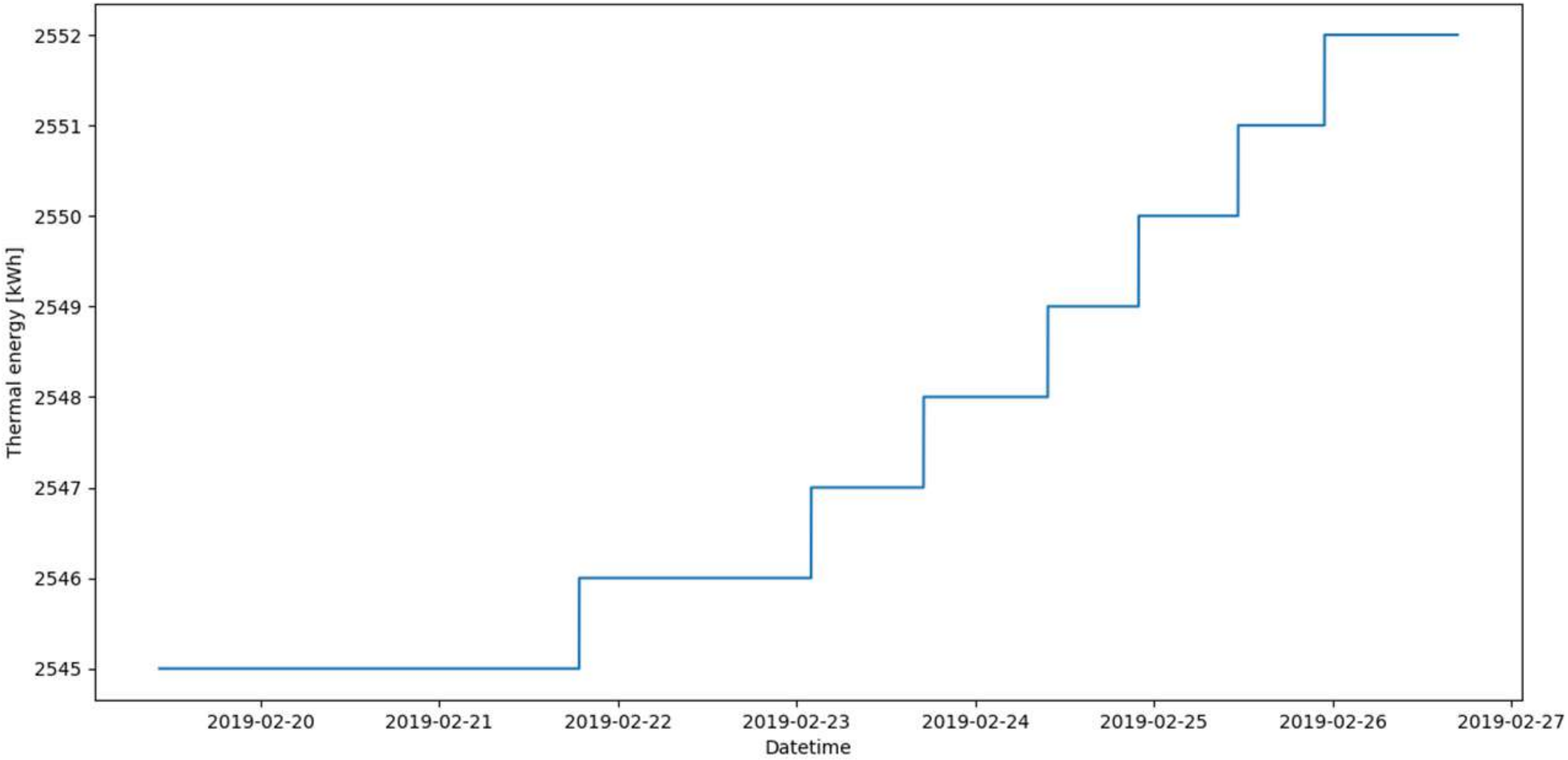
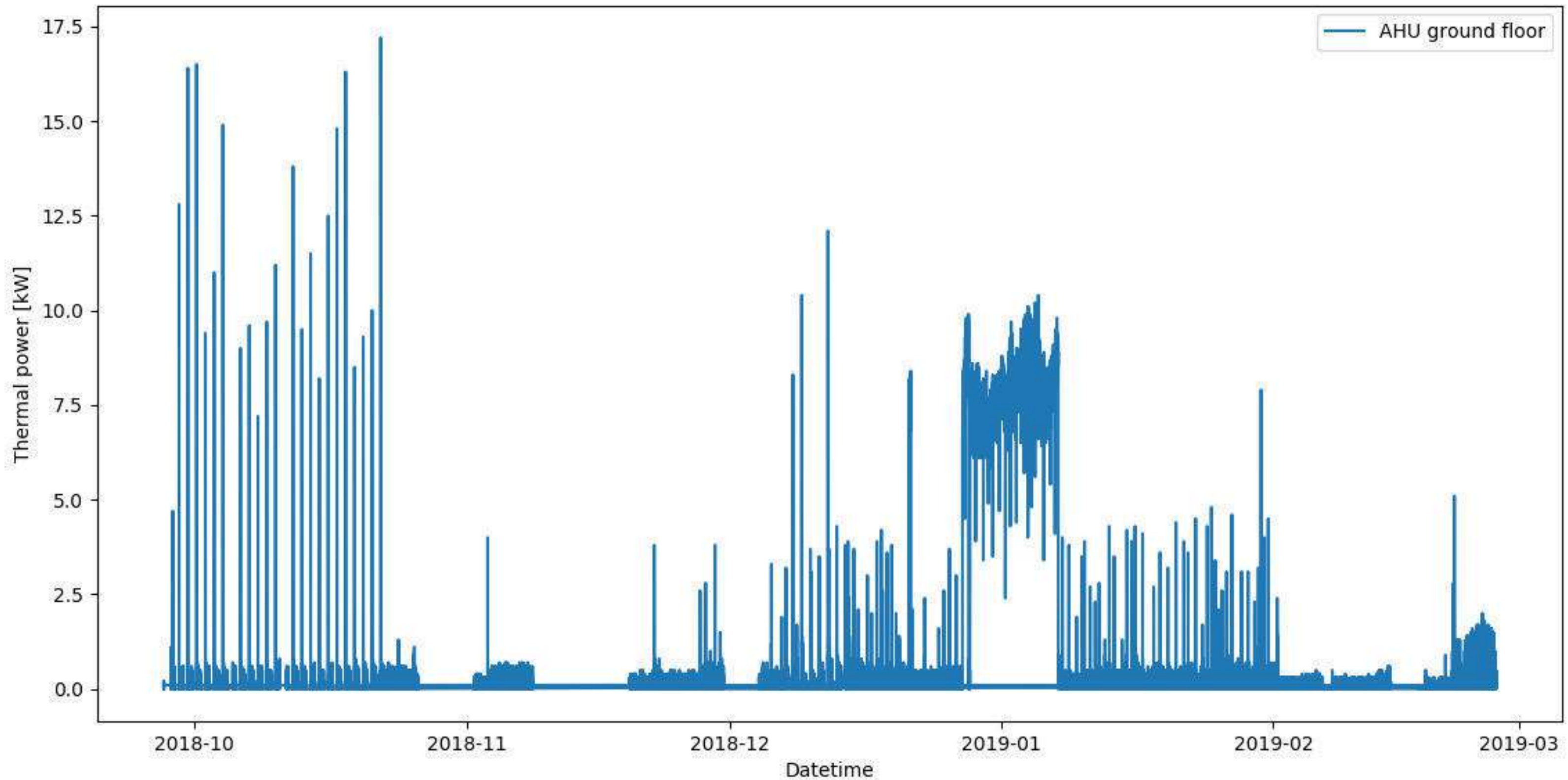
Current EPHZHB modules status

AHU ground floor thermal energy consumption



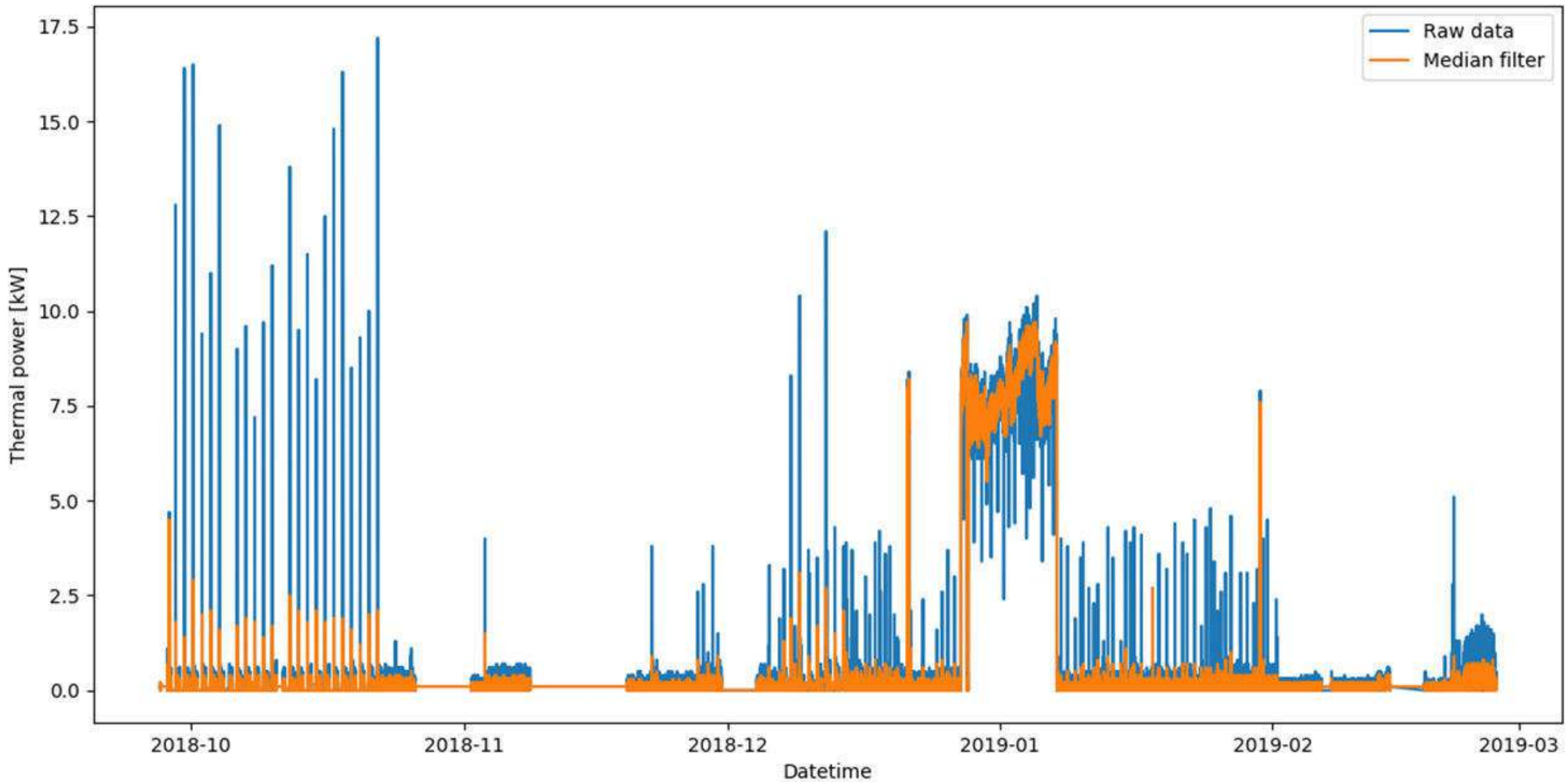
Current EPHZHB modules status

AHU ground floor thermal power



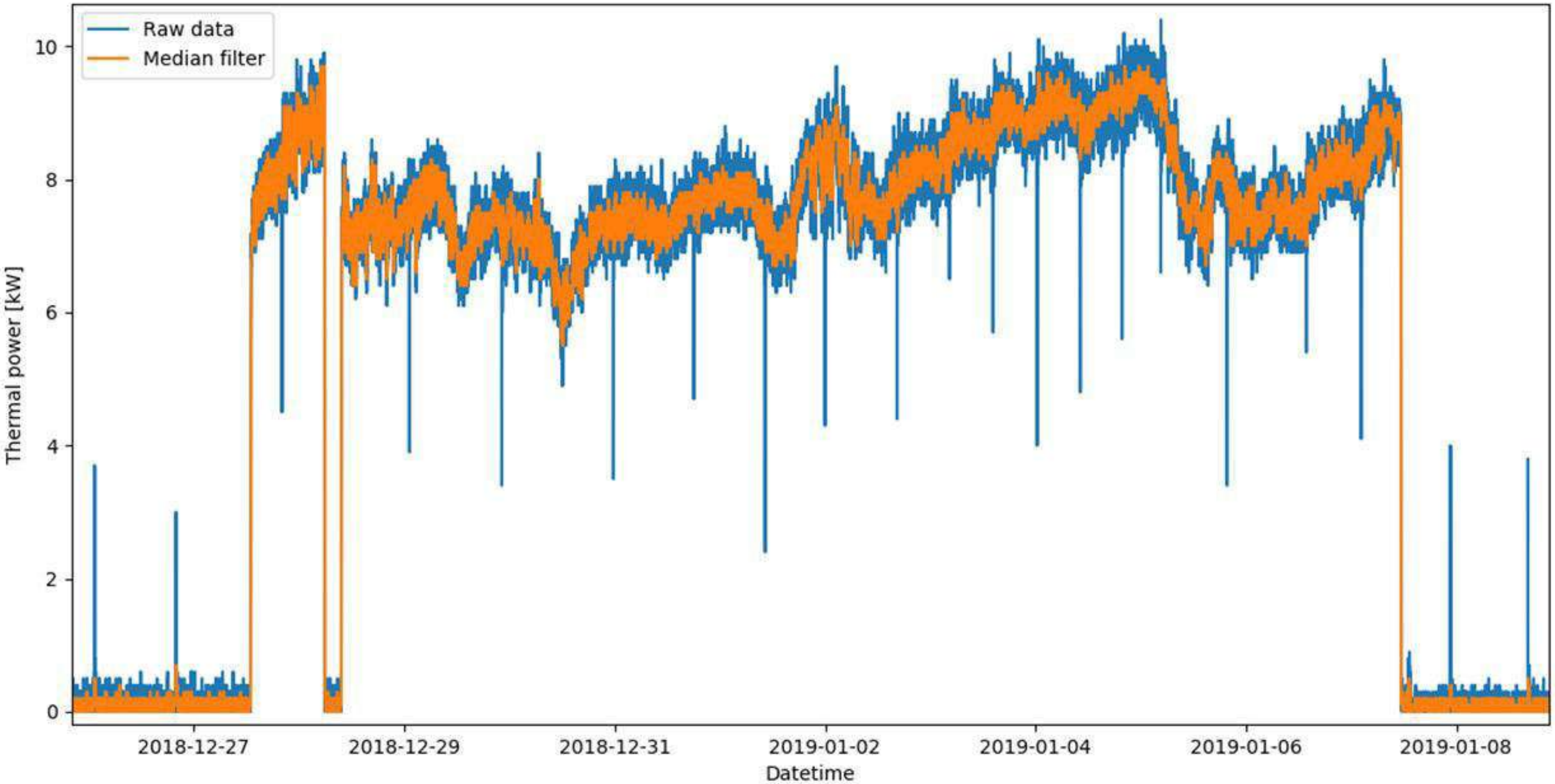
Current EPHZHB modules status

AHU ground floor thermal power - median



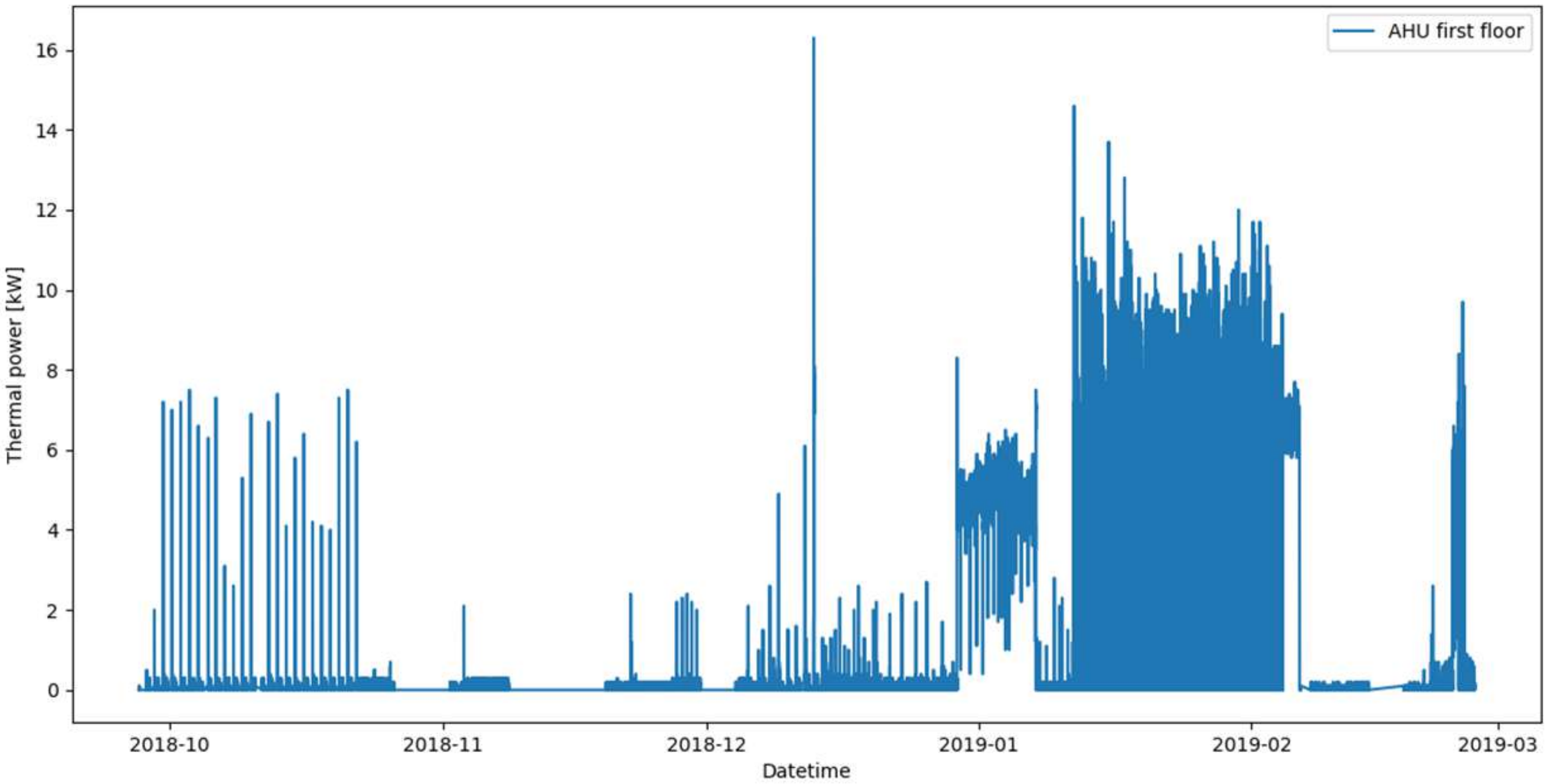
Current EPHZHB modules status

AHU ground floor thermal power - median



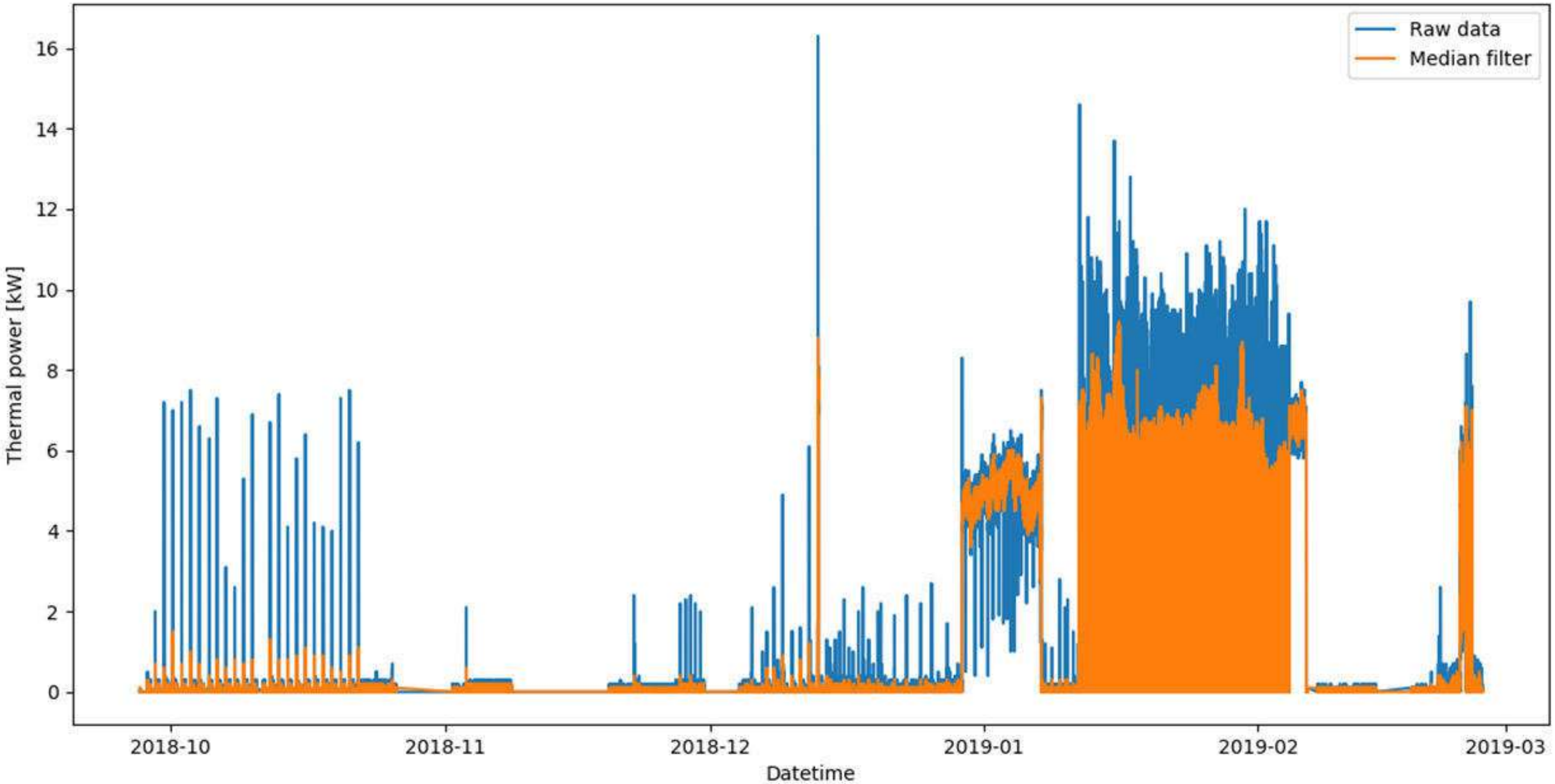
Current EPHZHB modules status

AHU ground floor thermal power



Current EPHZHB modules status

AHU ground floor thermal power - median



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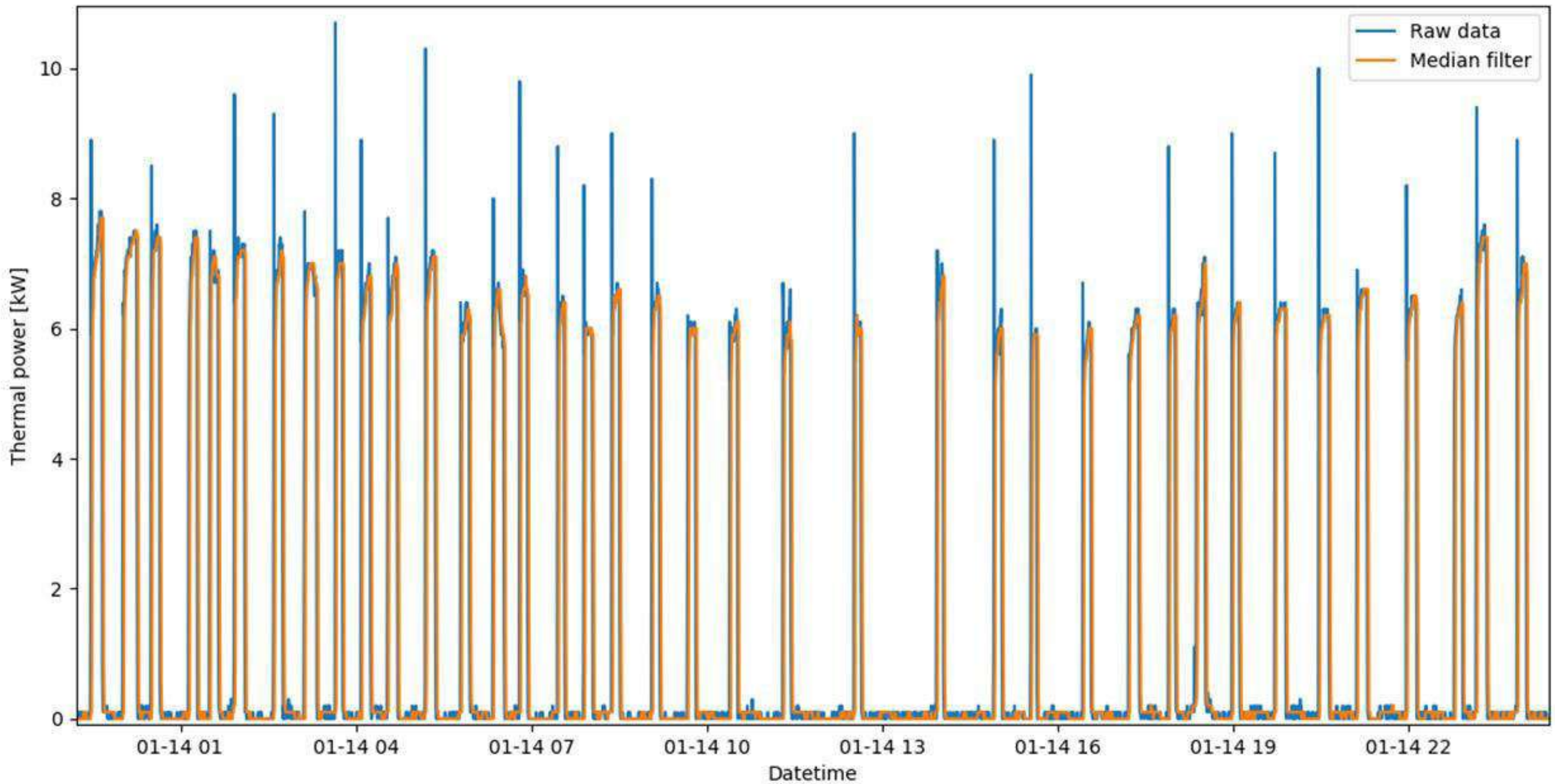
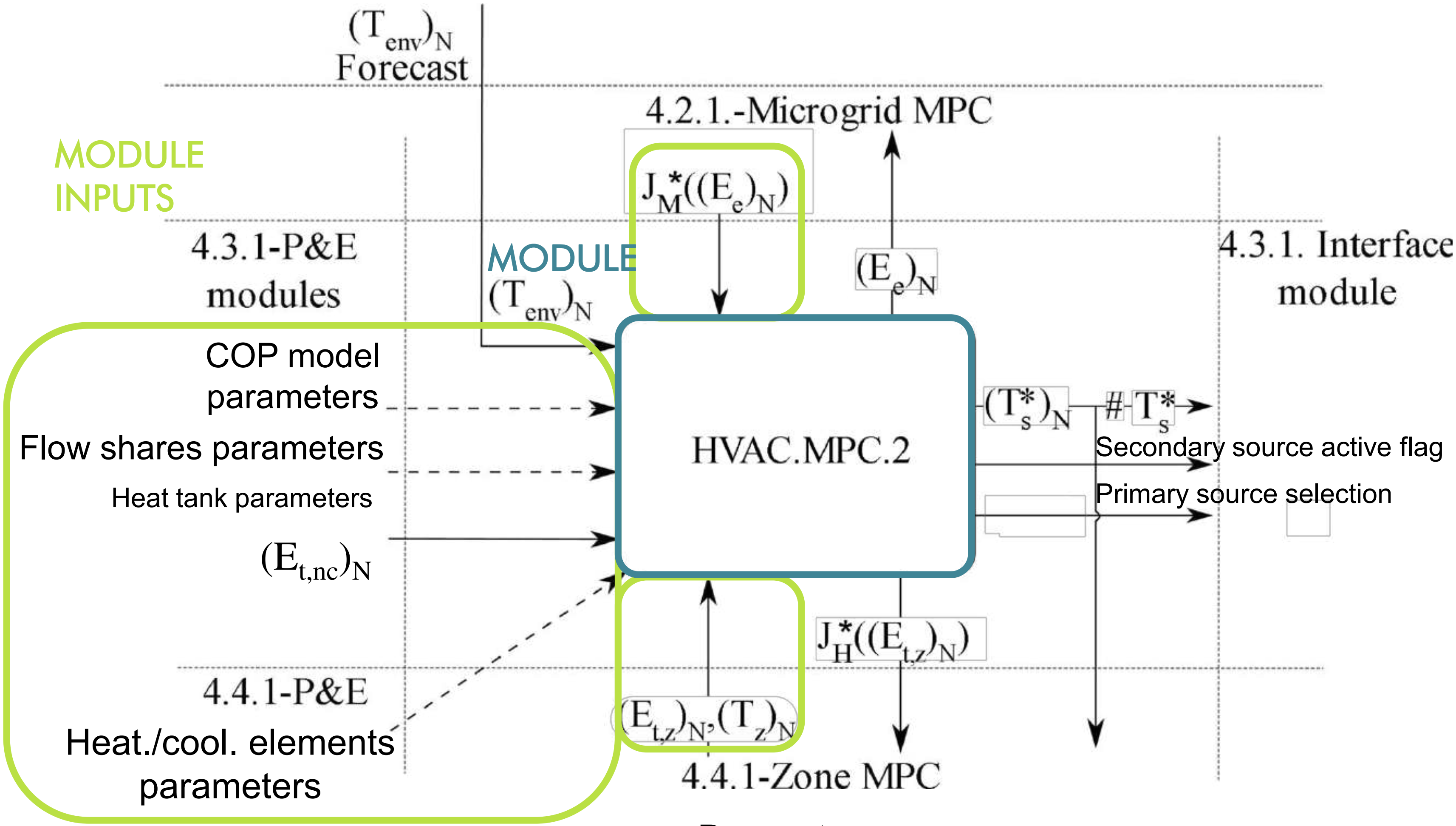


HVAC MPC 2a
Heat pump and heating block
3smart control

HVAC MPC 1 – module operation

- Description: medium temperature optimisation → costs and comfort
- Module interaction on HVAC level:
  - 4.2.1. – Microgrid MPC module
  - 4.3.1. – P&E modules
  - 4.4.1. – Zone MPC module
- Execution frequency: 15 minutes
- <15 min. coordination between the microgrid, HVAC and zone MPC

HVAC MPC 1 – information flow



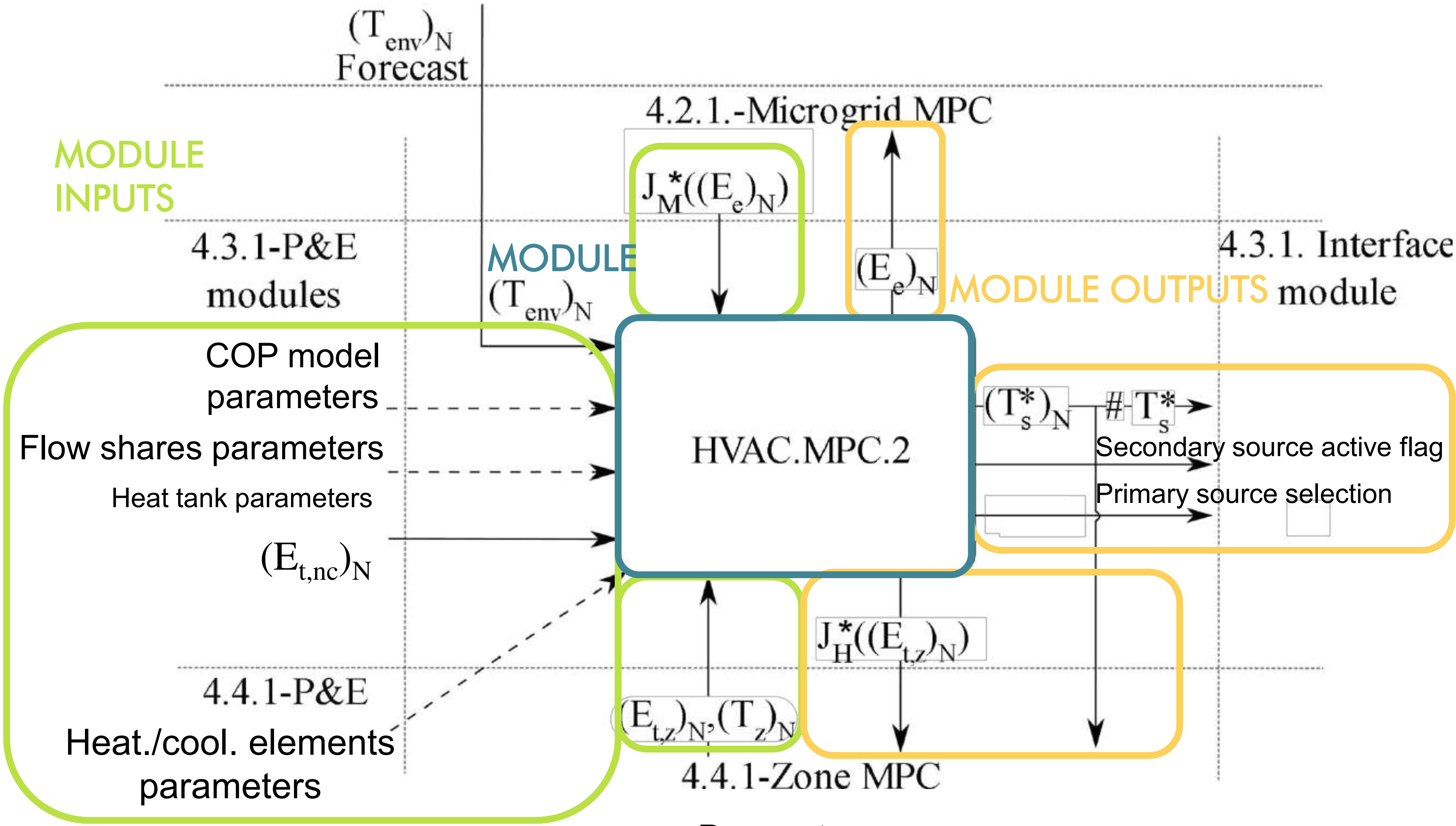
Parameters: - - - - - - - - - - →

Signals: ———————→

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

Index first element: #

HVAC MPC 1 – information flow



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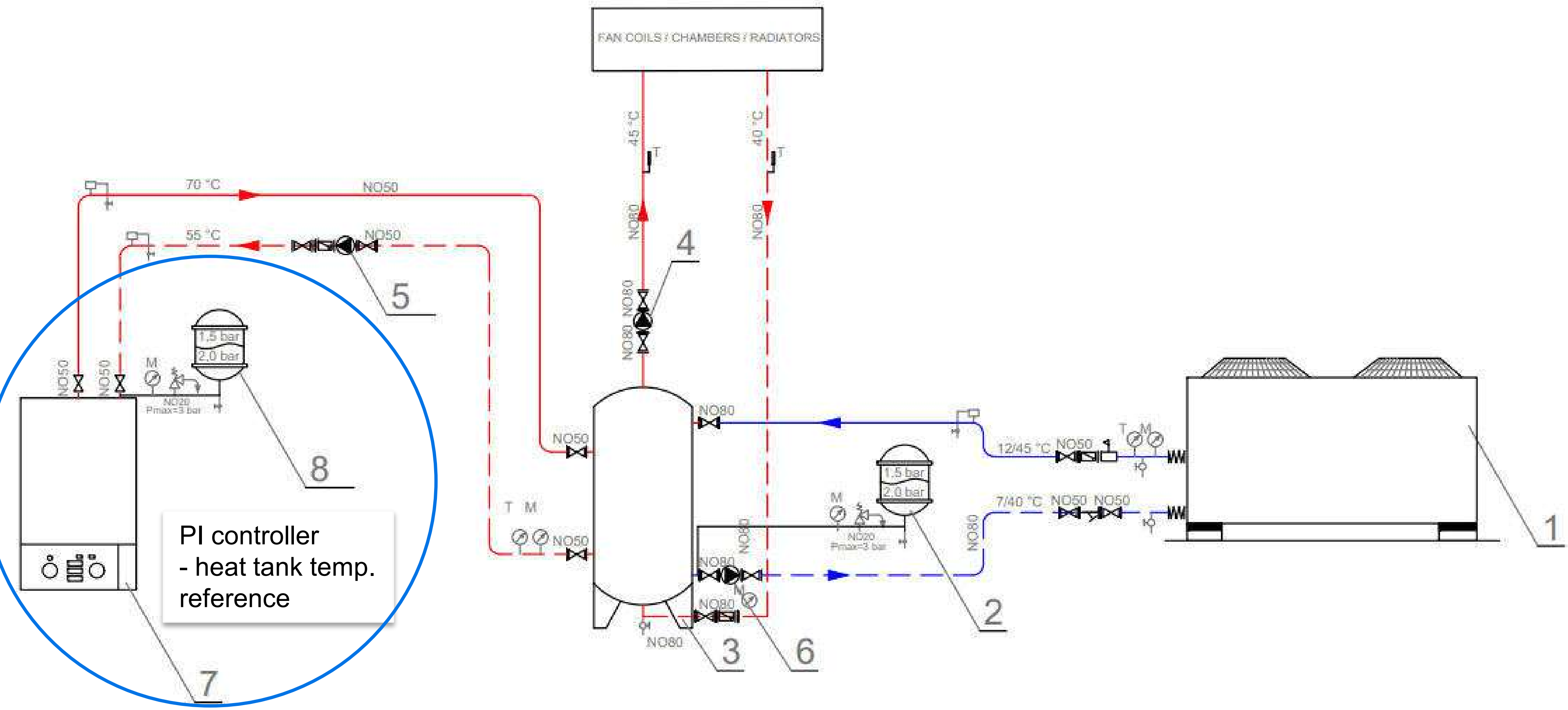
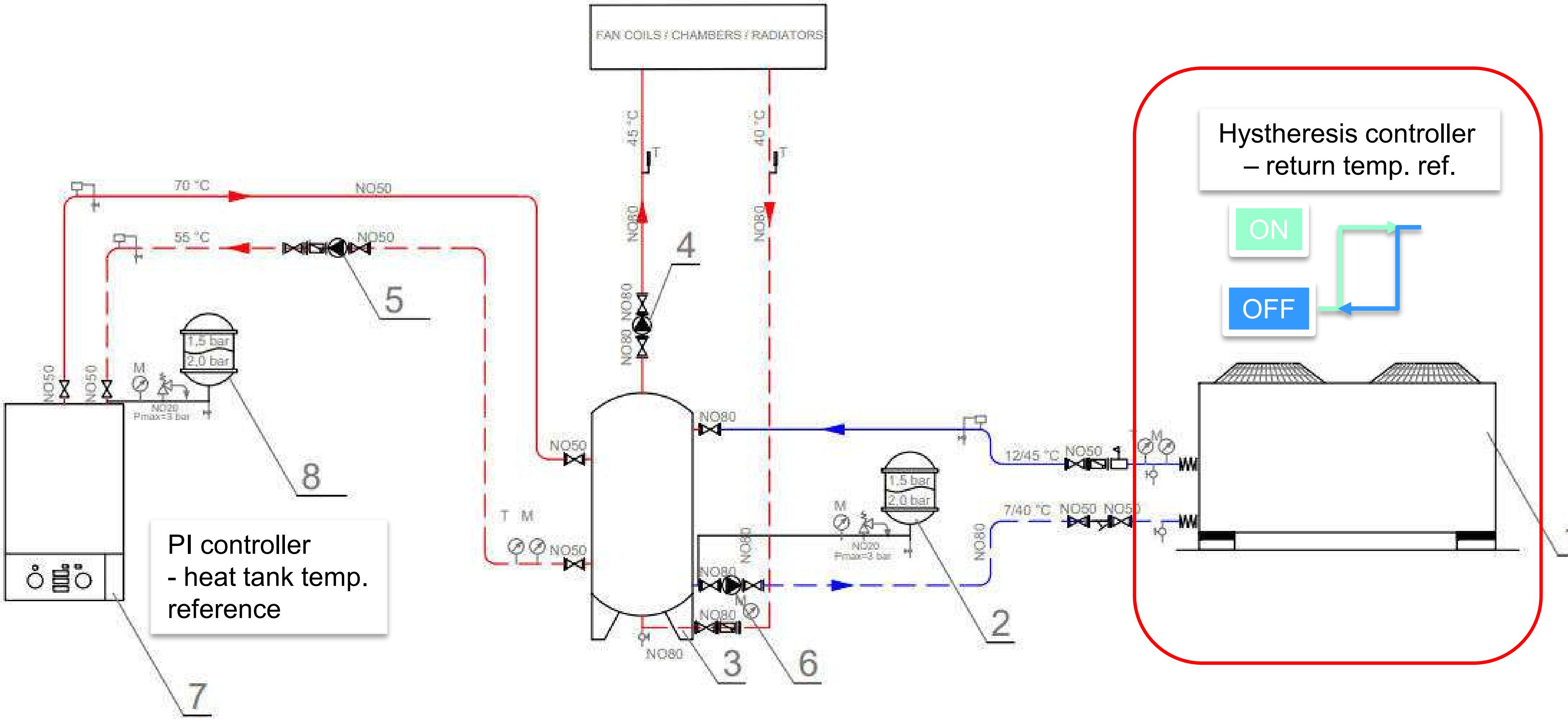
Medium conditioning functional scheme



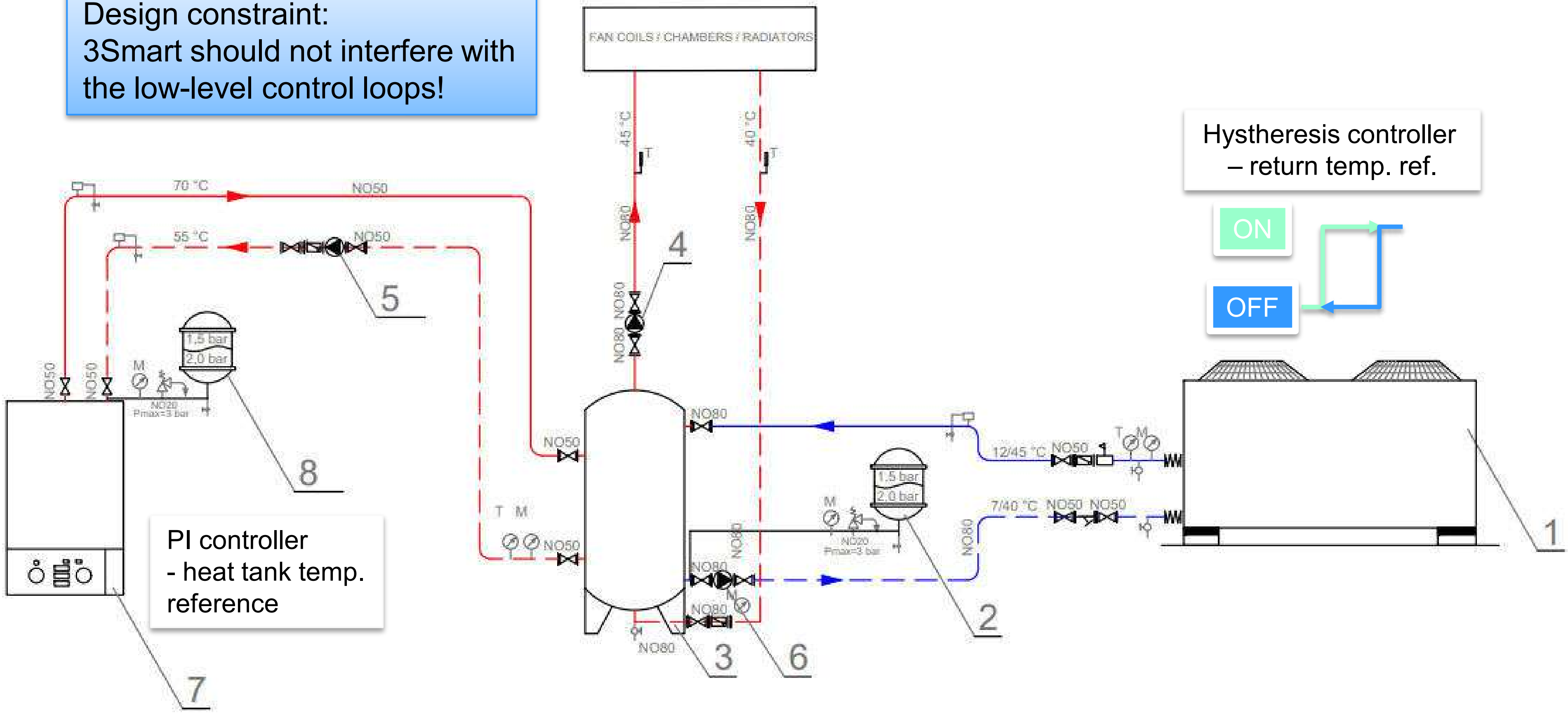
Medium conditioning functional scheme



Interreg
Danube Transnational Programme
3Smart

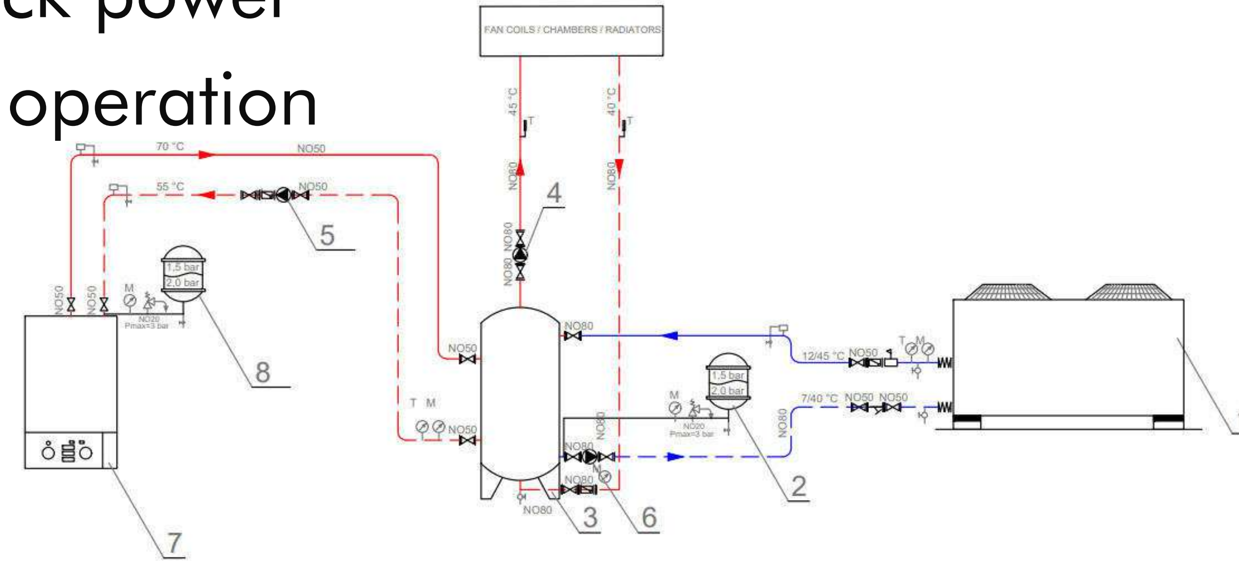
Medium conditioning functional scheme

Design constraint:
3Smart should not interfere with the low-level control loops!



Optimal control problem (1/3)

- Objective: minimise consumed (electrical) **energy cost** (volatility)
- DOF: Heat tank temperature
- Manipulated values:
  - Heating block power
  - Heat pump operation



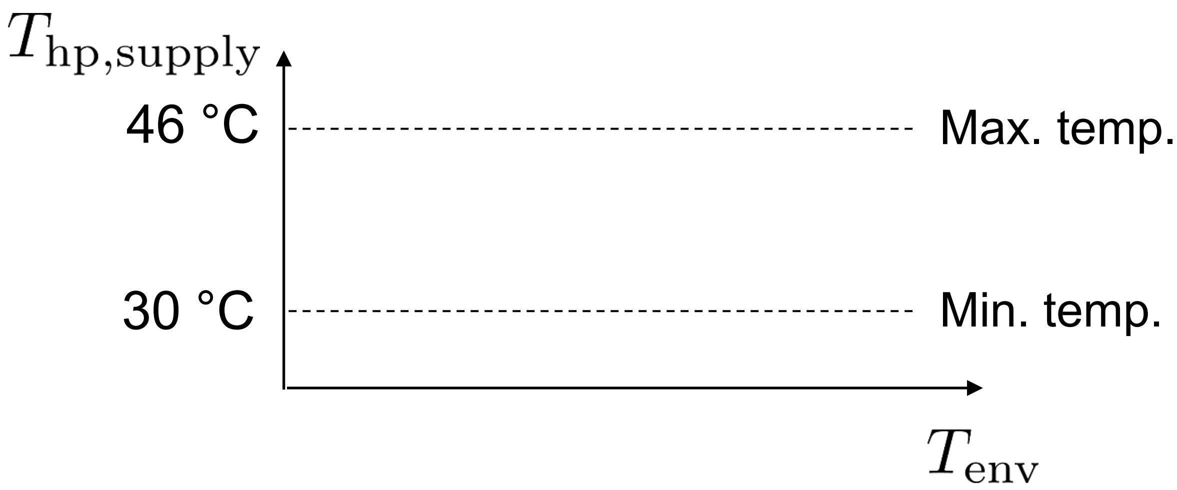
Optimal control problem (2/3)

- Constraints:
  - Delivered energy to the zones $(E_{\mathrm{t,z}})_N$
  - HVAC el. consumption
  - Heating block power: $0\ \mathrm{kW} \leq P_{\mathrm{el,hb}} \leq 88\ \mathrm{kW}$
  - Heat pump (heating) power:

    $0\ \mathrm{kW} \leq P_{\mathrm{t,hp}} \leq 74.7\ \mathrm{kW}$
  - *Heat pump supply temperature*

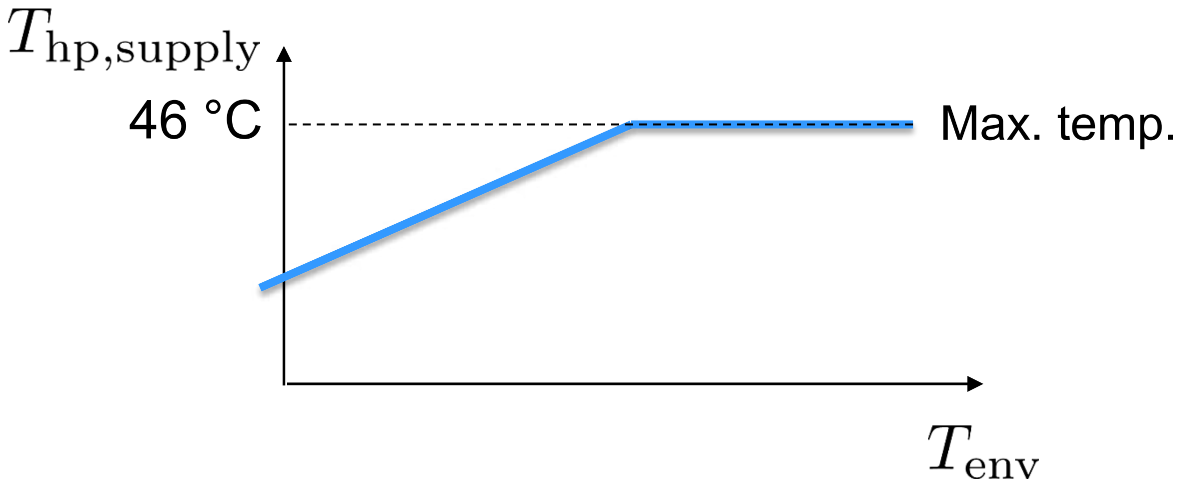
Optimal control problem (3/3)

- Heat pump supply temperature and environment temperature



Optimal control problem (3/3)

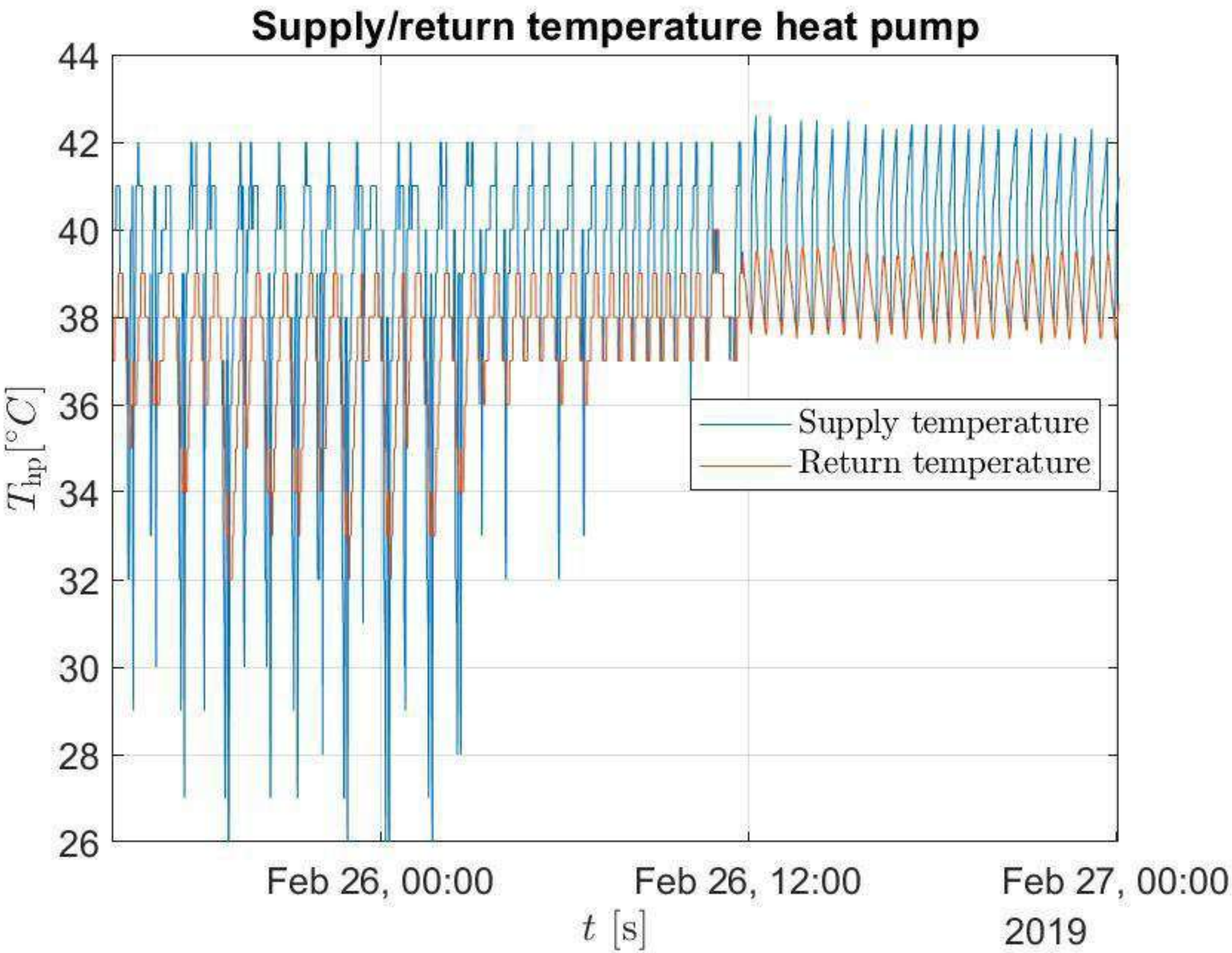
- Heat pump supply temperature, environment temperature



Required module inputs

Input	Notation	Unit	Source
Required thermal energy inputs prediction	$(E_{t,z})_N$	[kWh]	Z.MPC.1 module
Zone temperatures predictions	$(T_z)_N$	[°C]	
Environment temperature prediction	$(T_{\mathrm{env}})_N$	[°C]	Weather service/forecast
Noncontrollable thermal loads Heating energy price	$(E_{\mathrm{t,nc}})_N$	[€/kWh]	HVAC.PE.4 module
Electric energy consumption cost and constraints	$J_M((E_e)_N)$	[kWh]	M.MPC.1 module
COP model parameters	N/A	N/A	HVAC.PE.1 module
Flow shares model	N/A	N/A	HVAC.PE.2 module
Parameters of heat./cool. elements models	N/A	N/A	Z.PE.1 module

HVAC related measurements…



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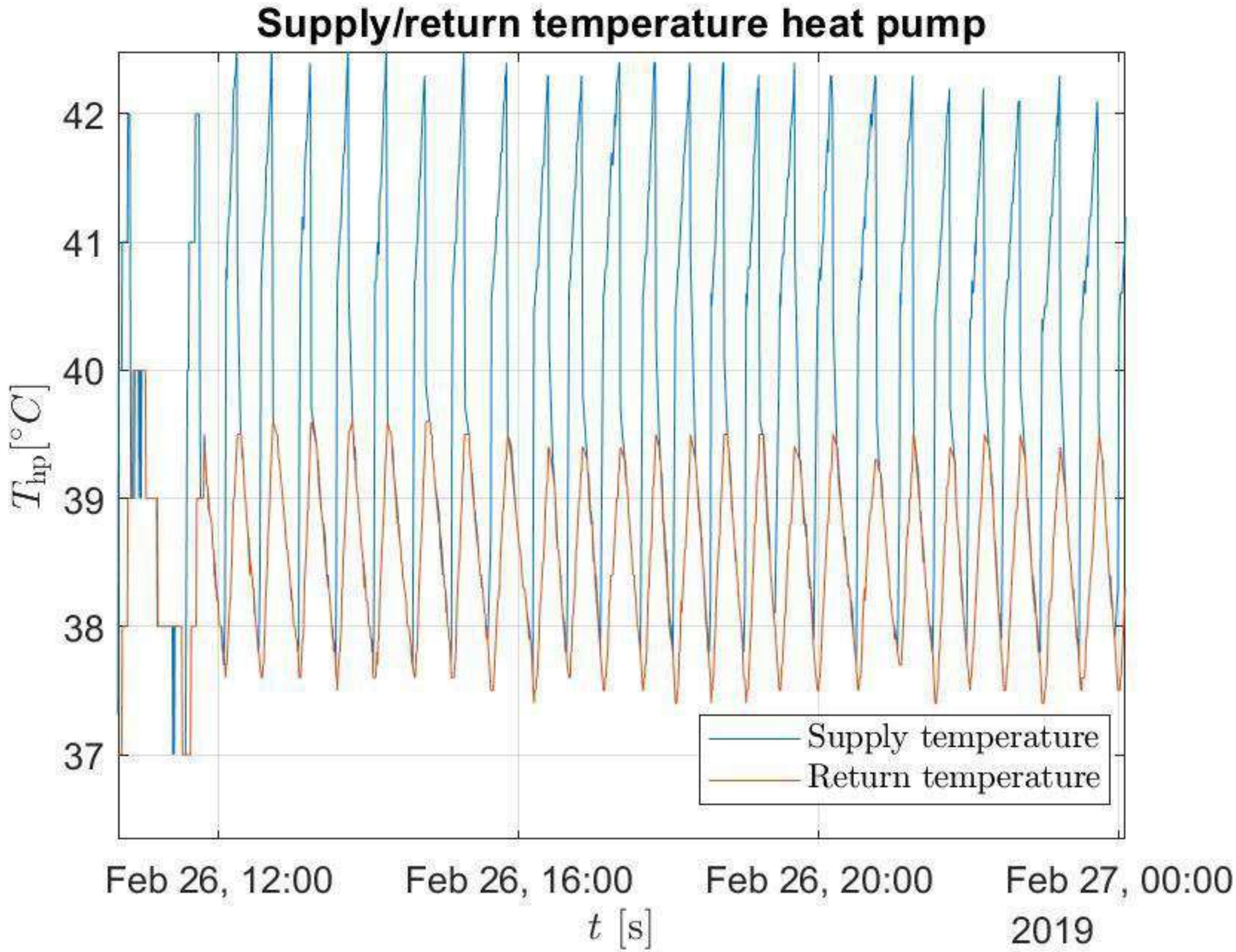

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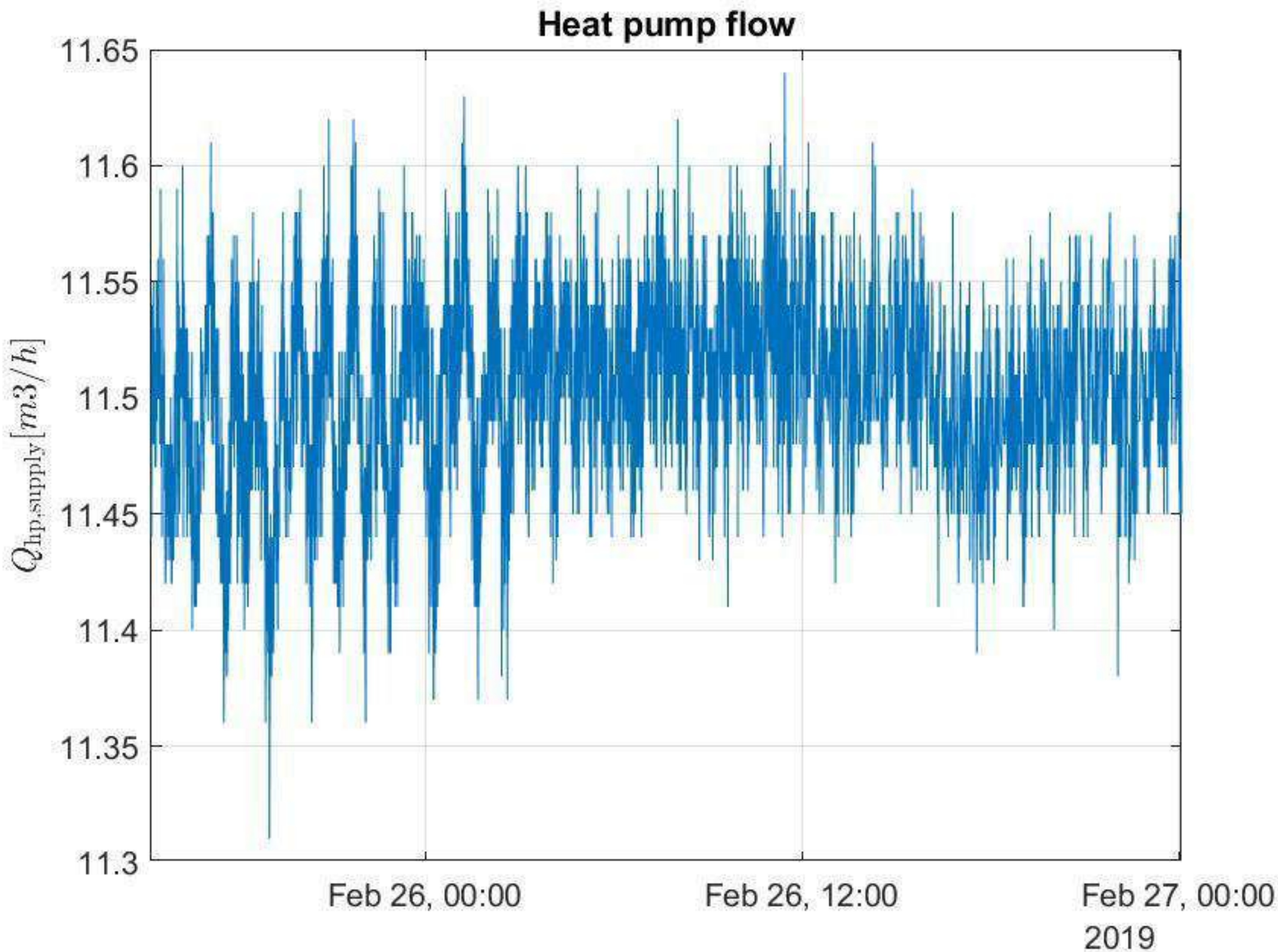

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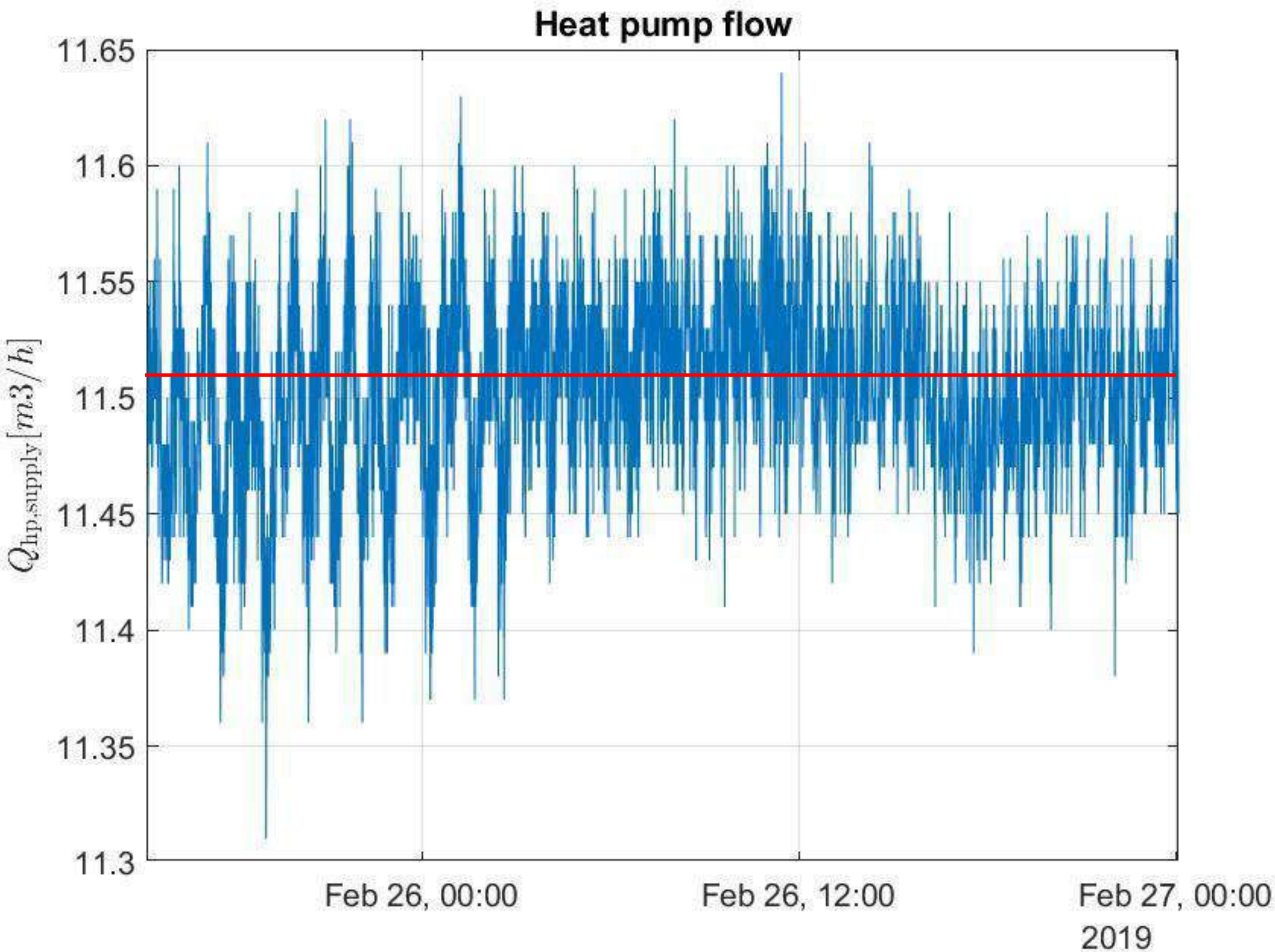

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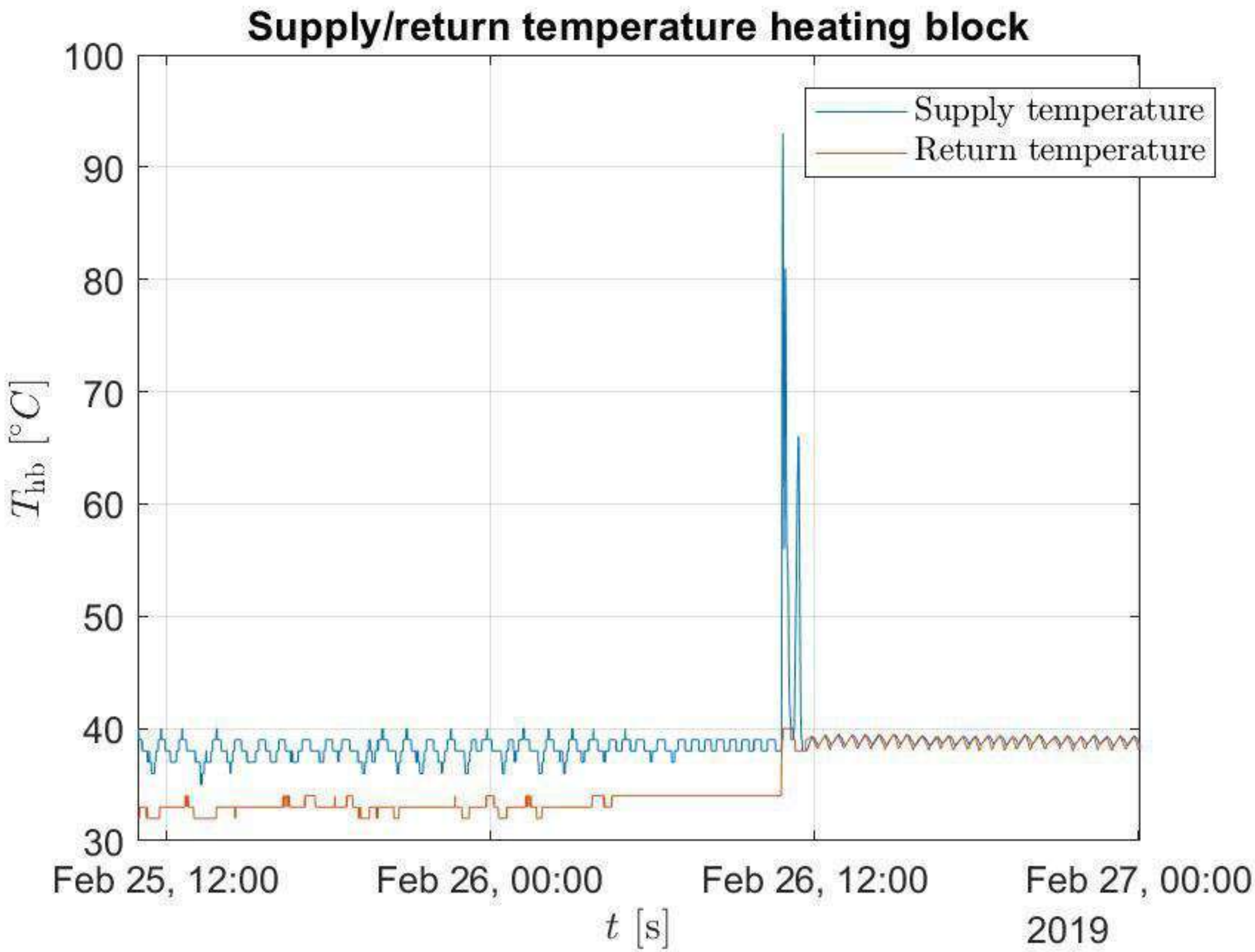

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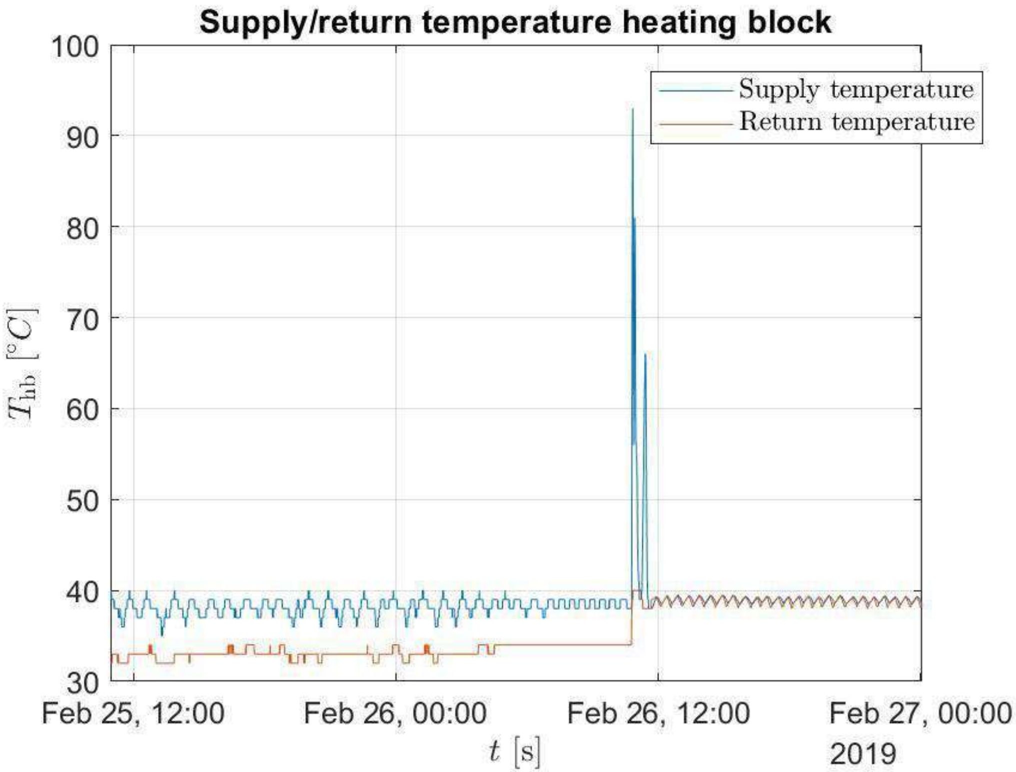

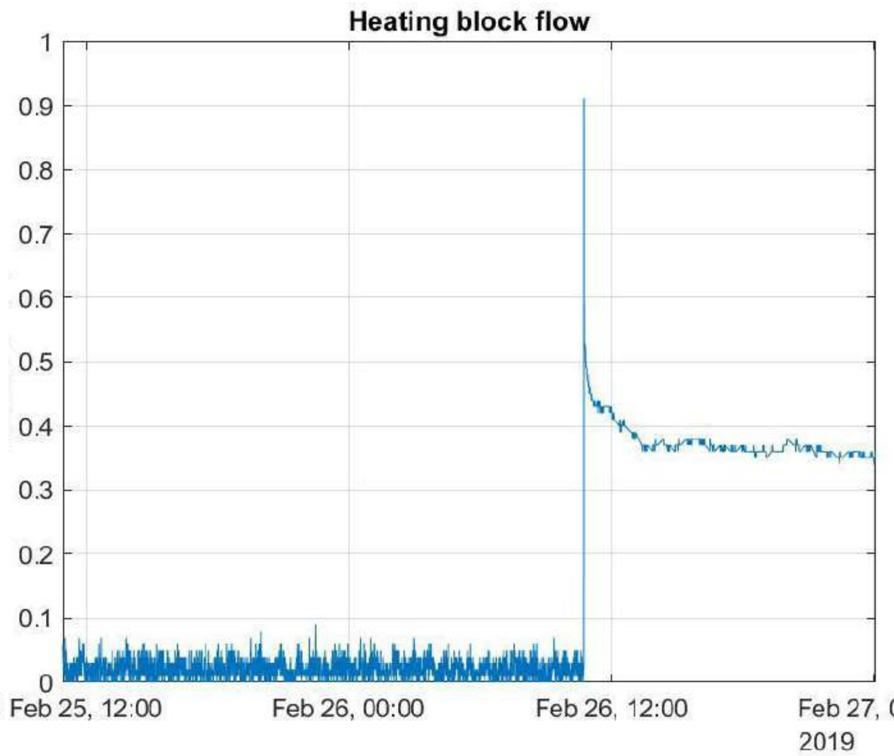

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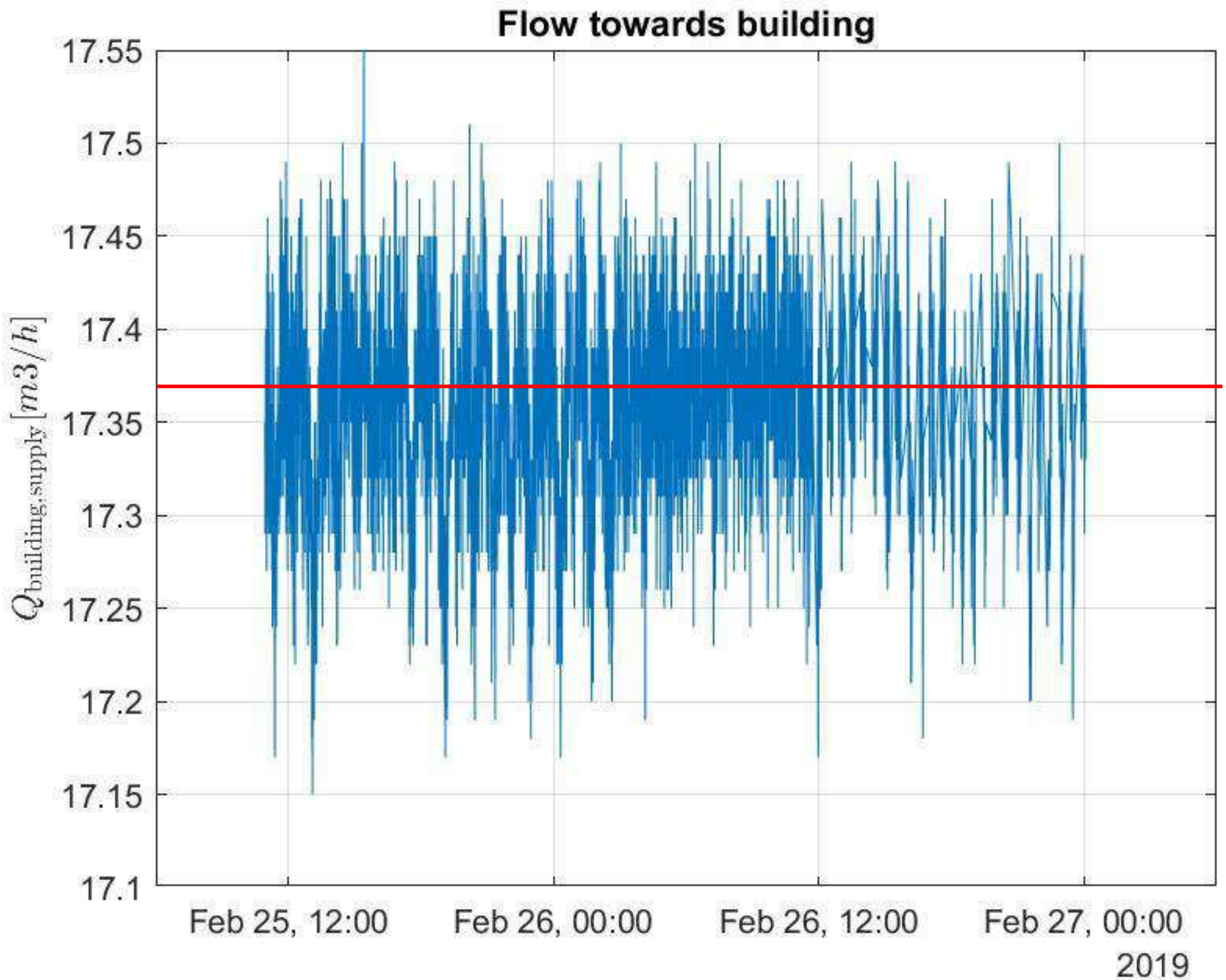

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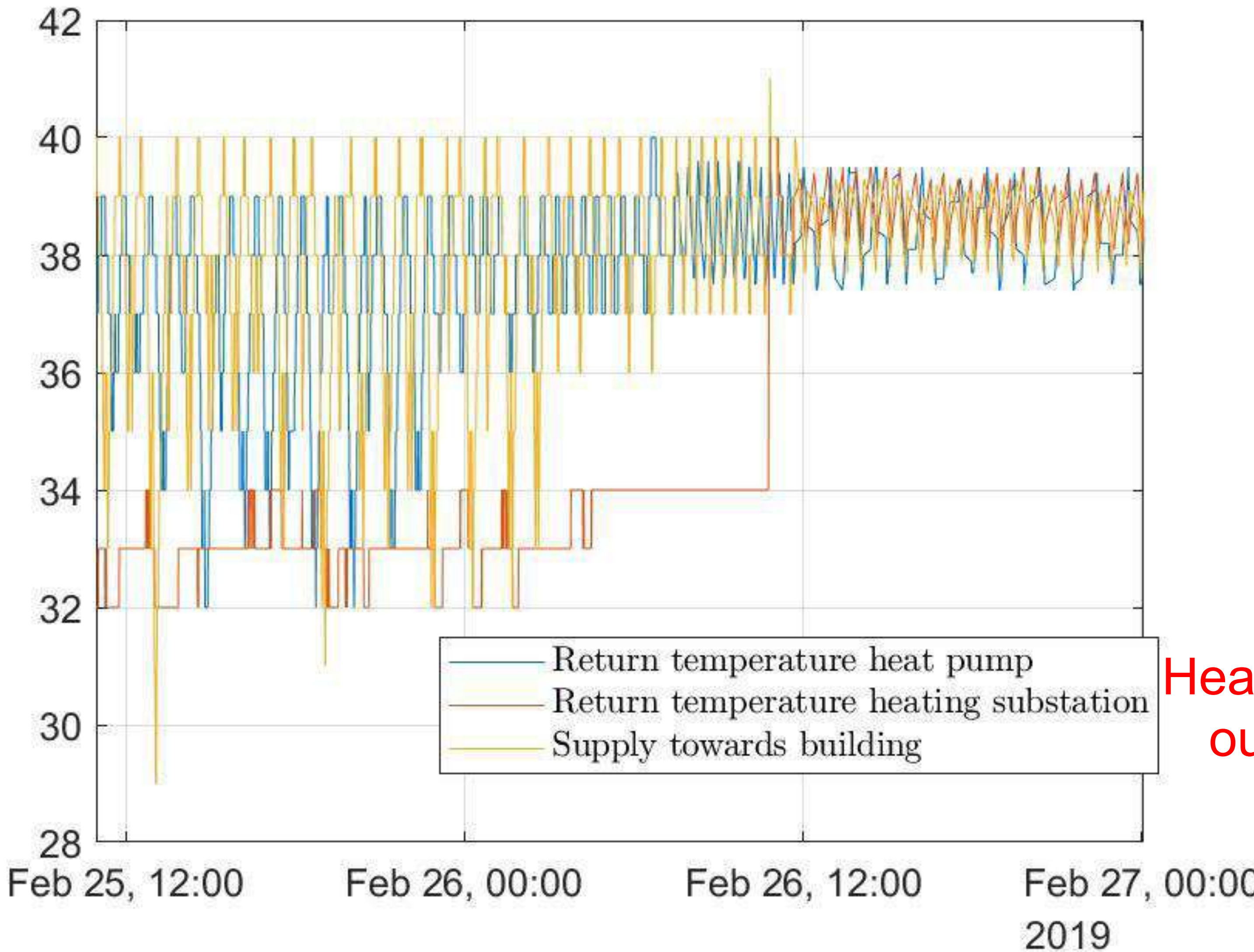
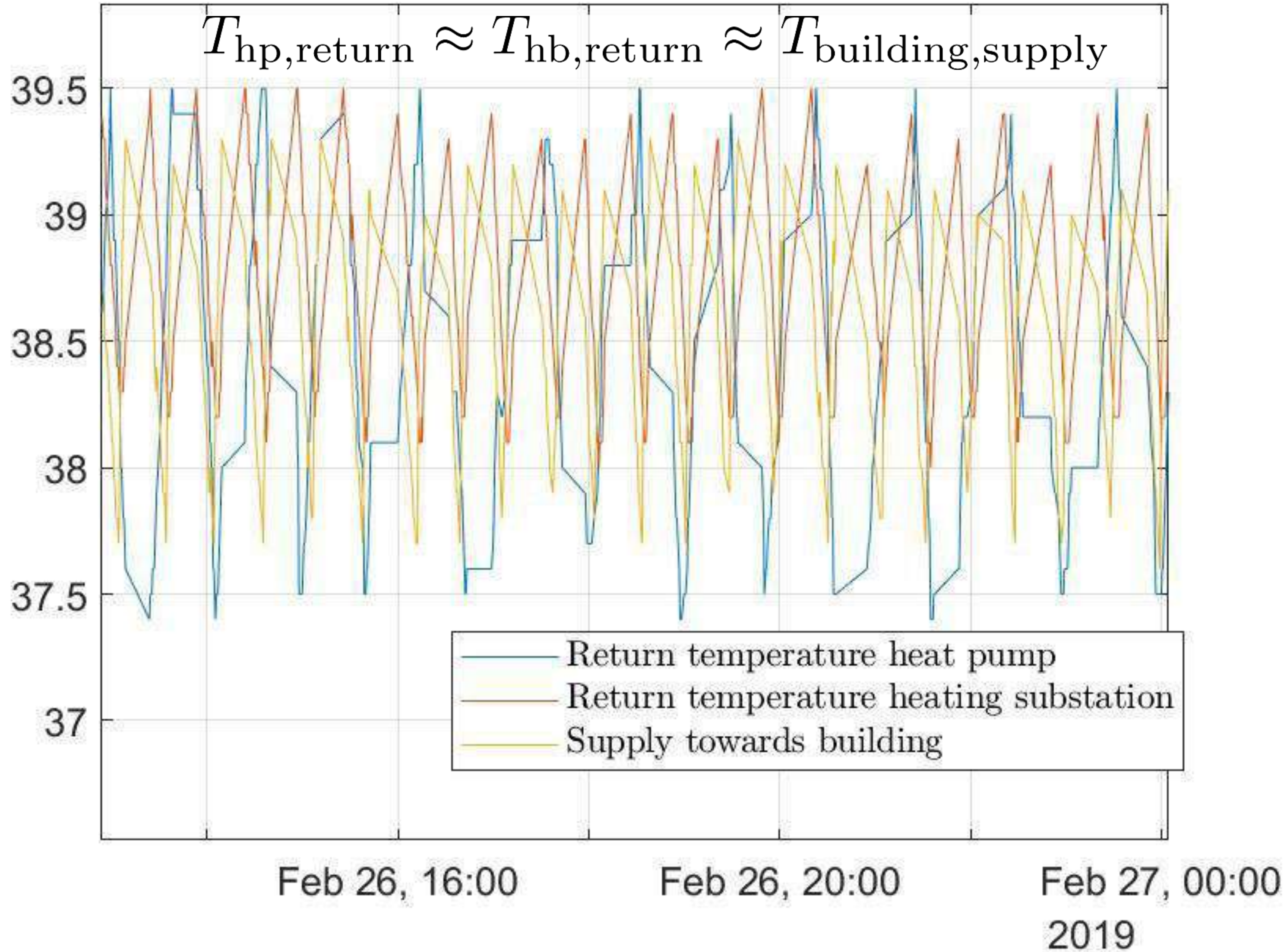


Heat tank outlet

HVAC related measurements…



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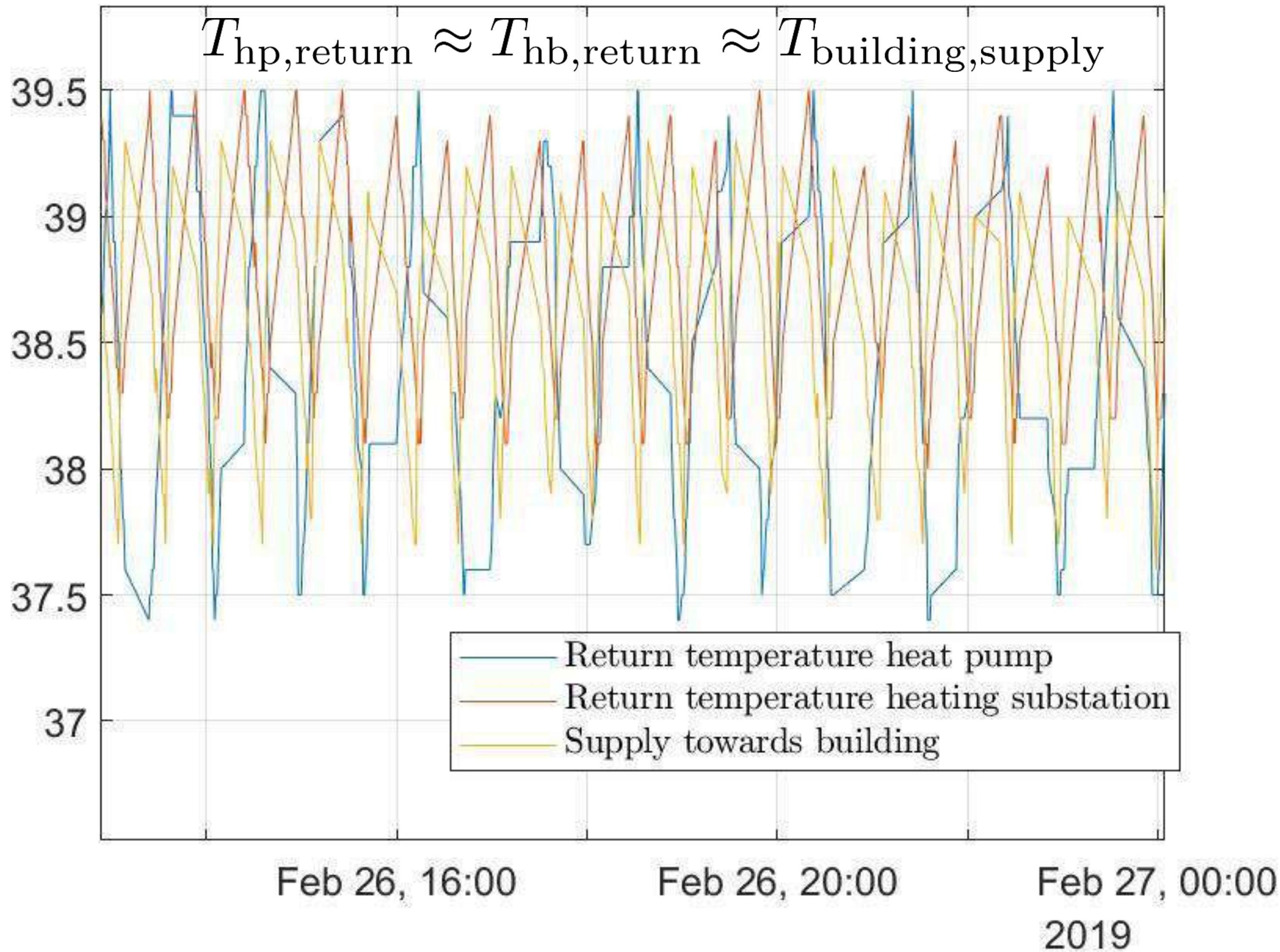

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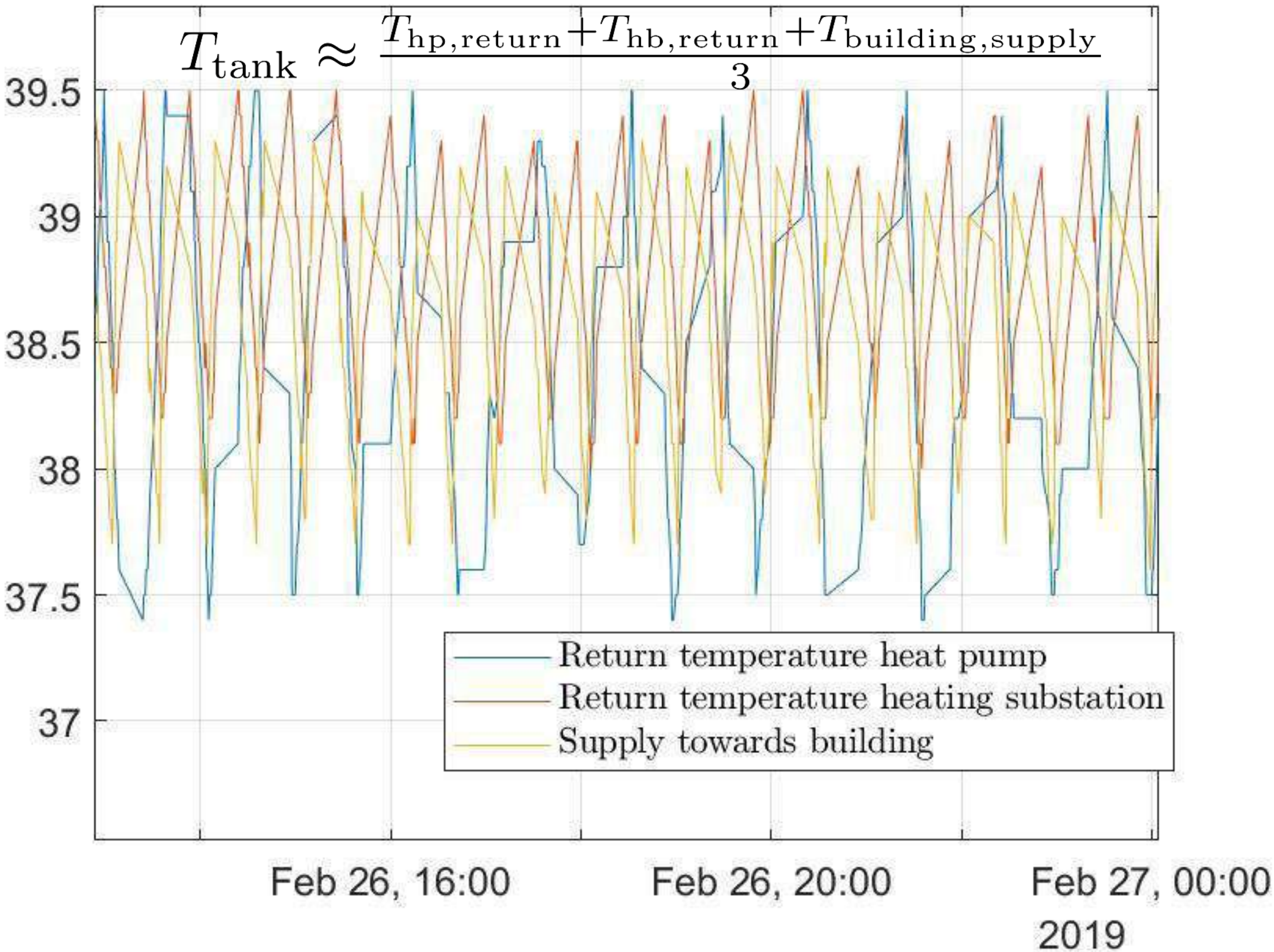
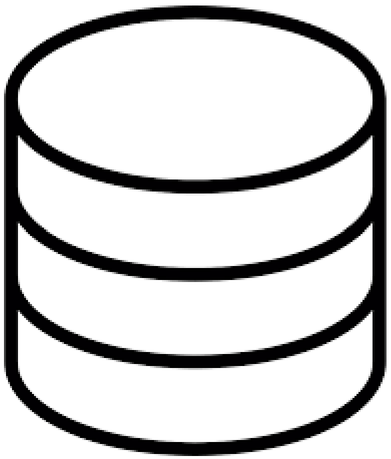


HVAC MPC 1 tables

hvac_mpc2_outputs
hvac_mpc2_outputs_history



Implementation timetable

- Technical requirements:
  - linear solver installed and recquired python packages
  - EMS references to BMS connection

Current EPHZHB modules status

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Additional prerequisites for Linux server environment

- Basic prerequisites published in WP7:
  3Smart_modules_installation_and_monitoring_v0.5_UNIZGFER.docx
- Some Python packages needed:
  – ipython
  – json, simplejson
  – apscheduler
  – numpy, scipy, pandas, sklearn
  – pysolar, pytz, threading
  – psycopg2/pymssql (depending on installed DB)
  – ...
- Full list and instructions to be published by tomorrow
- Either pre-install packages or give developers rights to do that
- If Linux is installed on a VM, 8GB RAM and 4-8 CPU cores minimum; DB must be directly accessible from VM

Grid-side modules installed on Bosnia and Herzegovina pilot

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University of Zagreb Faculty of Electrical Engineering and Computing

Tomislav.capuder@fer.hr; paula.mamic@fer.hr; mirna.grzanic@fer.hr

3Smart – Firtst BA pilot visit

26.02-27.02.2019.

Project co-funded by the European Union

Content

- BA pilot grid overview
- Long-term module
  - LT Multiannual & Annual contract
- Short-term module
  - ST Day-ahead modul

LONG TERM (MULTI)ANNUAL MODULE

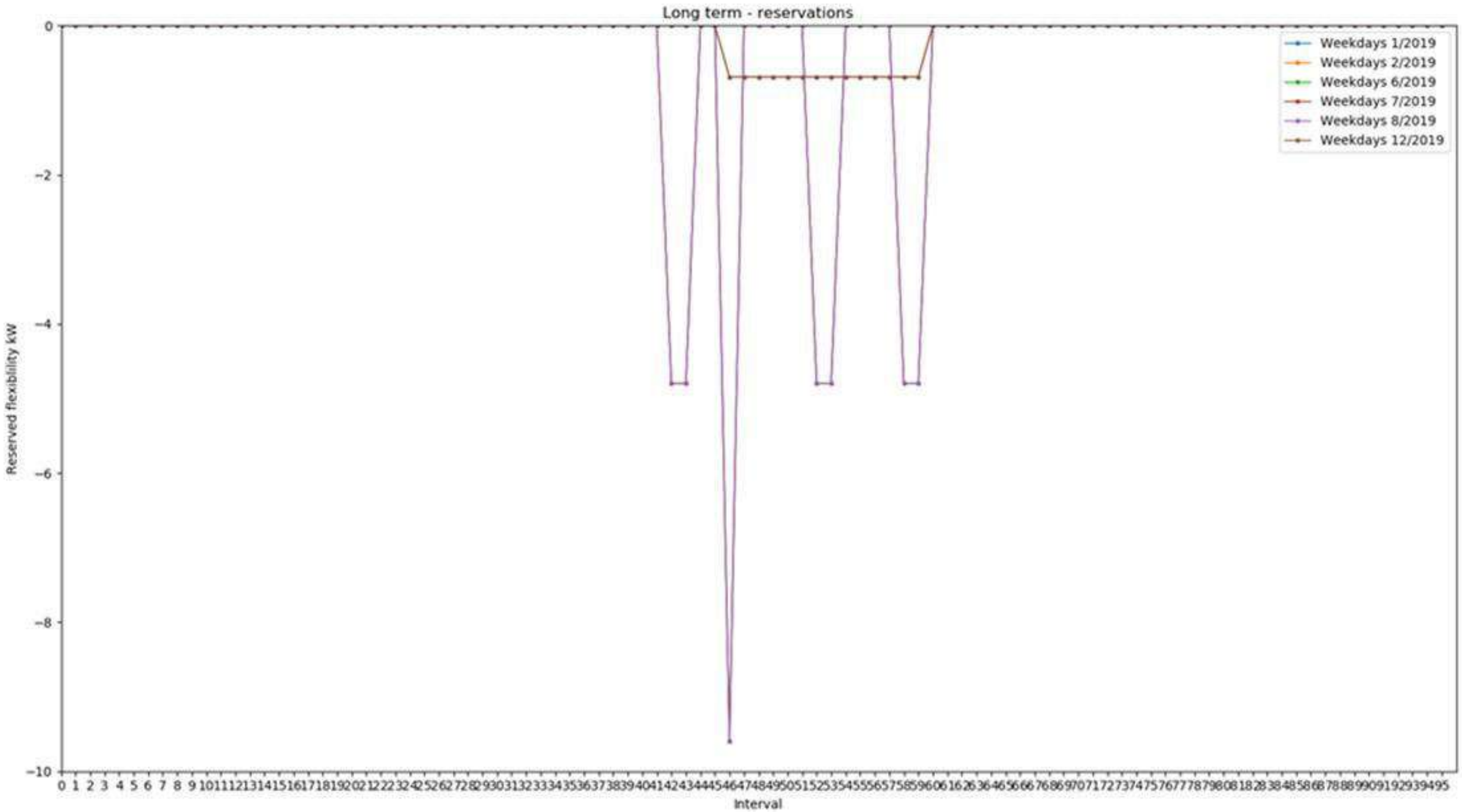
Long-term (Multi)Annual Module

- Tools for integrated and modular energy management for distributed demand rensponse provider and distribution grid operators
  - Annual and multiannual module calculates the available resources for flexibility, unit prices and the basis of the long term contract

LT Annual module

Month	Type of day	flexibility requirement [kW	Time interval (Start	Time interval length	flexibility requirement[kWh	Pcs of type of days	Time interval (End)
2017-01	WEEKDAYS	-11.38	11:30	3.50	-39.82	22	15:00
2017-02	WEEKDAYS	-11.38	11:30	3.50	-39.82	20	15:00
2017-06	WEEKDAYS	-23.22	10:30	0.50	-11.61	22	11:00
2017-06	WEEKDAYS	-23.22	11:30	0.25	-5.81	22	11:45
2017-06	WEEKDAYS	-73.63	13:00	0.50	-36.81	22	13:30
2017-06	WEEKDAYS	-73.63	14:30	0.50	-36.81	22	15:00
2017-07	WEEKDAYS	-23.22	10:30	0.50	-11.61	21	11:00
2017-07	WEEKDAYS	-23.22	11:30	0.25	-5.81	21	11:45
2017-07	WEEKDAYS	-73.63	13:00	0.50	-36.81	21	13:30
2017-07	WEEKDAYS	-73.63	14:30	0.50	-36.81	21	15:00
2017-08	WEEKDAYS	-23.22	10:30	0.50	-11.61	23	11:00
2017-08	WEEKDAYS	-23.22	11:30	0.25	-5.81	23	11:45
2017-08	WEEKDAYS	-73.63	13:00	0.50	-36.81	23	13:30
2017-08	WEEKDAYS	-73.63	14:30	0.50	-36.81	23	15:00
2017-12	WEEKDAYS	-11.38	11:30	3.50	-39.82	21	15:00

LT Annual module



LT Multiannual module

Service name		Flexibility service
1)	Contract valid from	1/1/2017
2)	Contract valid until	12/31/2017
3)	Est. no. of activations during period	327
4)	Maximum Size of service in power (kW)	9.60
5)	Max. duration of service per activation (h)	3.5
6)	On - Trigger	Signal from the DSO or according t calculator
7)	Off - Trigger	Maximum: see "Max.duration of activation" from "on"-signal, or by from the DSO
8)	Maximum allowed activation time	15 min (but it depends of the cap Customer process technology)
9)	Quality of Service	- Deviation in max. duration: +/- 15 min. - Deviation from, On - Trigger: +/- 15 min. Deviation in size of service: Max. - 10% deviation - Acceptable no. of unsuccessful activations: x
10)	Unit price of Reservation (EUR/kWh)	43.54
11)	Unit price of Activation (EUR/kWh)	0.38
12)	Reservation fee for the contractual period	418.01
13)	Activation fee for the whole contractual period	1,214.11
14)	Average activation price/activation	3.71
15)	Pricing	1,632.13
16)	Penalty if failed supply	121.41 3 times of failed delivery → termination of the contract

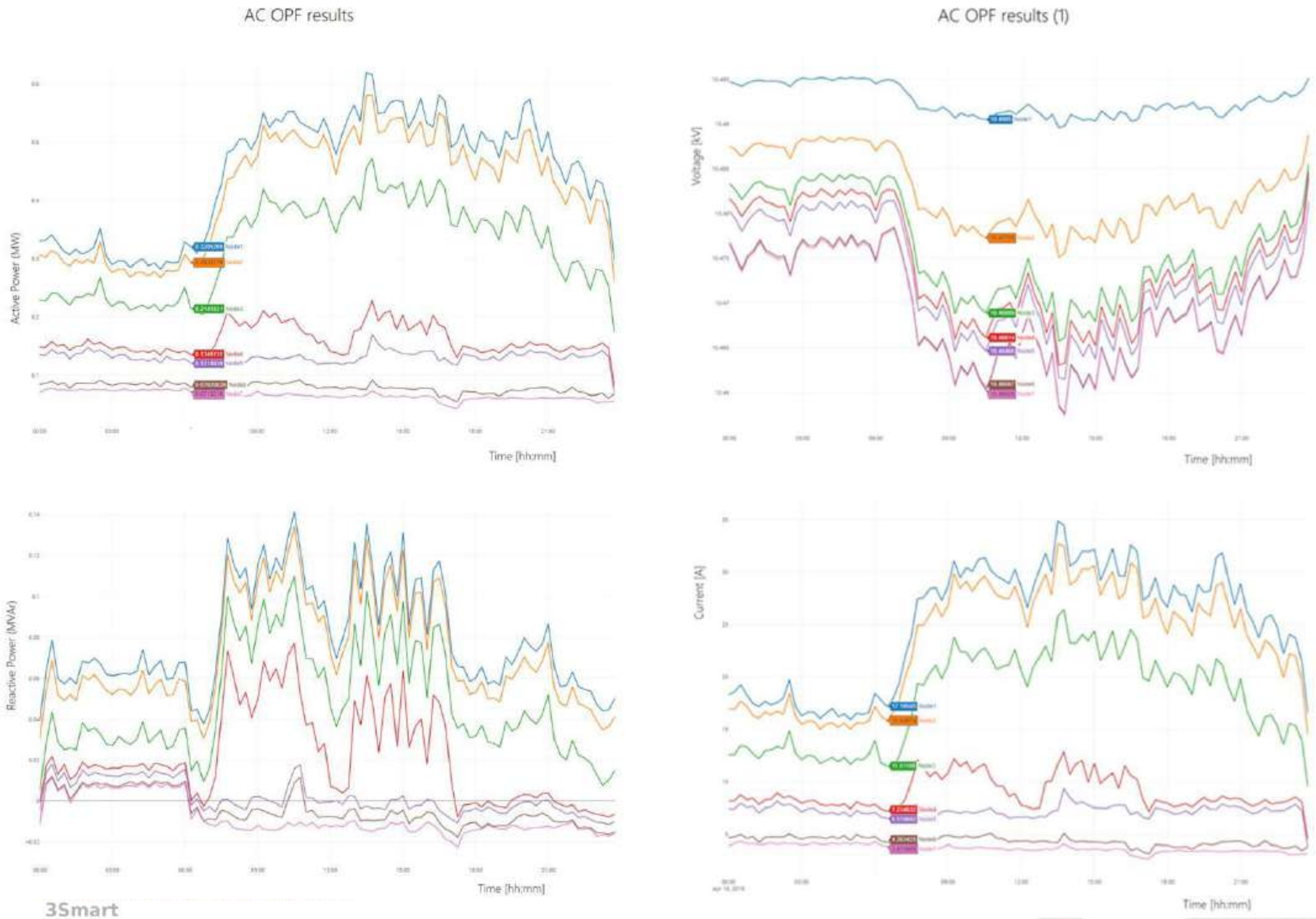
SHORT TERM DAY AHEAD MODULES

Short term Day-Ahead module

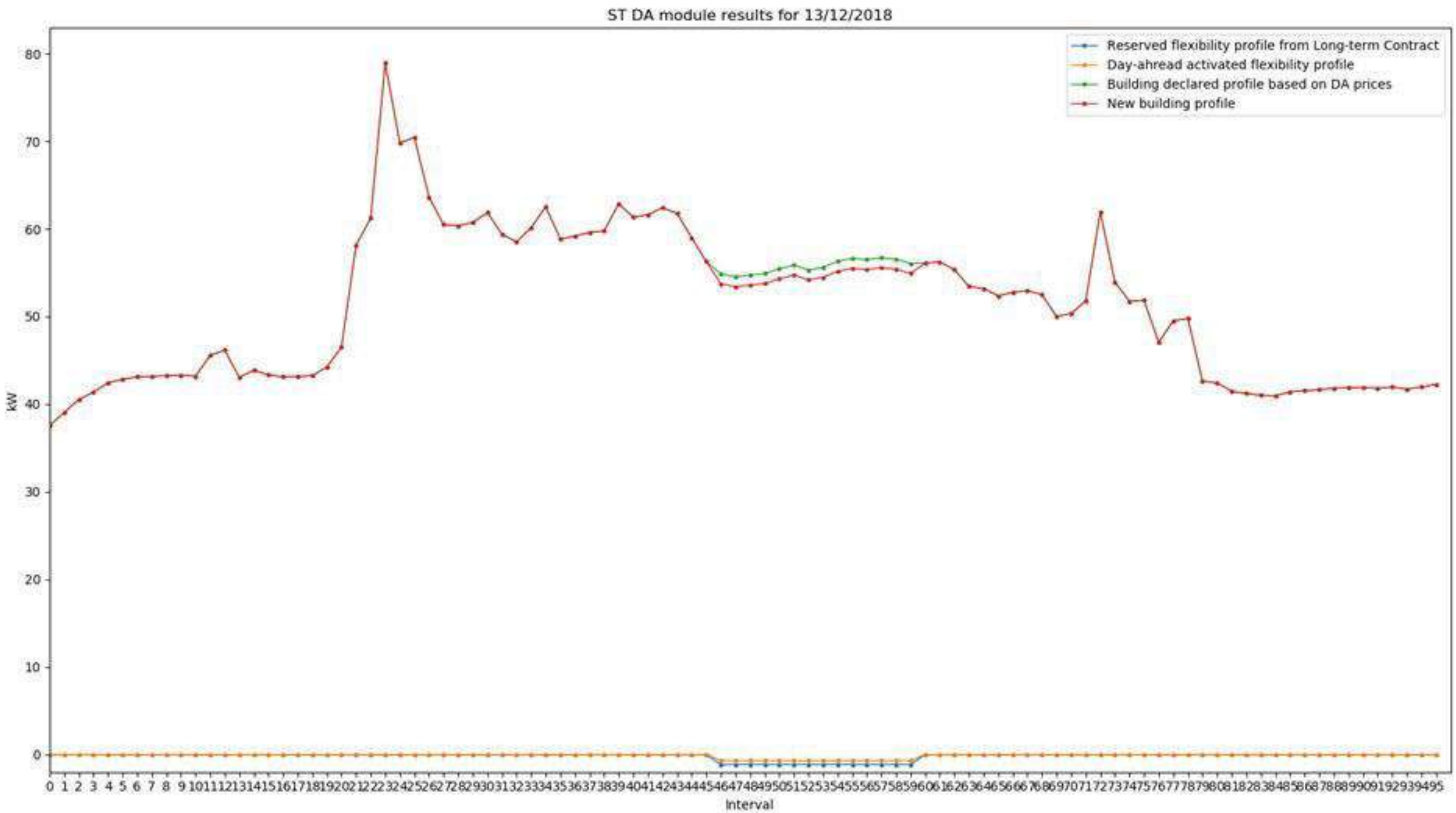
- day – to – day operation module for determining building flexibility potential as the distribution network/system operator asset:
  - Interconnection with long term module and receiving flexibility requirements
  - Defined flexibility requirements in long term module are set as maximum value bound 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)

The results for long term module (1)

- https://plot.ly/~3SMART/2/my-graph/#/



The results for long term module (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 Hungary – 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	36 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, UNIDEBTTK, EON, UNIBGFME
Authors (Partners)	Mario Vašak, Tomislav Capuder, Vinko Lešić, Anita Martinčević, Hrvoje Novak, Danko Marušić, Nikola Hure, Paula Mamić (UNIZGFER), Arpad Racz, Andras Mucsi (UNIDEBTTK), Gabor Peter, Kata Santa (EON), Vladimir Jovanović (UNIBGFME)
Contact person	Arpad Racz (UNIZGFER)
Abstract (for dissemination)	This document contains the minutes of the first study visit to the Hungarian pilot in 3Smart. It consists of a pilot building – EON headquarter building in Debrecen – 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	15 February 2019	Entered the minutes from the first Hungarian pilot study visit in the deliverable form	Mario Vašak (UNIZGFER)
v2.0	23 December 2019	Prepared the minutes 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 Hungary that consists of EON building in Debrecen and of the electricity distribution grid around this building. The visits were split in two parts for each pilot site – this first part of the deliverable for the Hungarian pilot site concerns the first pilot study visit.

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

Time: February 5-6, 2019

Venue: EON building, Kossuth utca 41, Debrecen, Hungary

February 5, 2019 (Tuesday)

Time	Place	Event
09:00-11:00	Lecture room, ground floor	Technical session (TS) 1: Presentation of the performed installations and realized IT infrastructure
11:00-11:15	In front of the room	Coffee break
11:15-13:00	Lecture room/ EON building	TS2: EON building visit
13:00-14:00	Cafeteria	Lunch
14:00-16:00	Lecture room/ EON building	TS3: On-line demonstration of basic IT infrastructure performance with the installed equipment
16:00-16:15	In front of the room	Coffee break
16:15-18:00	Lecture room, ground floor	TS4: 3Smart modules organization on the sides of EON building and the grid
20:00-22:00	Valentino Ristorante	Working dinner

February 6, 2019 (Wednesday)

Time	Place	Event
09:00-11:00	Lecture room, ground floor	TS5: On-line demonstrations: Zone-level modules EON, Central-HVAC-level modules EON
11:00-11:15	In front of the room	Coffee break
11:15-13:00	Lecture room/ EON building	TS6: On-line demonstrations: Microgrid-level EON
13:00-14:00	Cafeteria	Lunch
14:00-16:00	Lecture room/ EON building	TS7: On-line demonstrations: Short-term modules grid, Long-term modules grid
16:00-16:15	In front of the room	Coffee break
16:15-17:00	Lecture room, ground floor	TS8: Discussion, planning

Day 1:

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

Presentation of the performed installations on the building side was performed by Arpad Racz (UNIDEBTTK) and of the performed installations on the grid side by Gabor Peter (EON).

Details are provided in the appended presentation (Annex 1).

Technical session 2: Visit to EON building installations

Pilot visit encompassed all major points of installation in the building: the rooms where return medium sensors and integration through wireless transmitters were shown, the heating substation of one of the buildings, the heating center with central heat exchanger connected to the district heating system supply, the archives area where electric heaters actuators were integrated, and the roof with photovoltaic installation and the weather station.

Technical session 3: On-line demonstration of basic IT infrastructure performance with the installed equipment:

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

Data communication from the 3Smart database to the SCADA database and back was on-line demonstrated. Accessibility for different actions and monitoring via SCADA was shown, and also the possibilities of the analytics tool Qlik which provides different data visualization possibilities.

3Smart on-off switches were explained, and also the roll-back procedure in case of failure in the modules execution or lost connection to the server with the database. More technical details are provided in Annex 2.

Grid-building communication tables were discussed in more details, including the time resolution of day-ahead and intra-day prices. Although day-ahead prices change in hourly intervals, the prices will be presented in the database as 15-min values by repeating each hourly value 4 times in 4 consecutive 15-minute intervals of a particular hour.

Technical session 4: 3Smart modules organization on the sides of EON building and the grid

Organization and timing of execution of grid-side modules was presented by Paula Mamić (for the short-term modules) and Gabor Peter (for the long-term modules). The presentations related to this part are provided as Annex 3 and Annex 4.

Arpad Racz gave an overview of the building-side modules, and Mario Vašak explained the envisioned interaction between different building-side modules. The related presentation is given in Annex 5.

Day 2:

Technical session 5: On-line demonstrations: Zone-level modules EON, Central-HVAC-level modules EON

Operation of Z.PE.1 (fan coils identification), Z.PE.4 and Z.PE.5 modules was presented by Anita Martinčević. Z.PE.1 is on-line and running for buildings B+C and E, Z.PE.4 performed off-line to get the parameters for rooms with electric heaters in the archives. More details are given in Annex 6.

Operation of Z.PE.8 (fan coils heat consumption), Z.PE.9 (rooms temperature prediction) and HVAC.PE.4 (non-controllable heat consumption) was elaborated by Hrvoje Novak. Initial data checks revealed some problematic input data on the side of temperature measurements (outliers) for Z.PE.9 and on the side of calorimeters measurements for HVAC.PE.4. For calorimeter measurements a formula was shown to calculate the power consumption.

Also, formula for computation of the non-controllable heat consumption in HVAC.PE.4 was agreed, but through later discussion it was decided to hold on to the final decision how non-controllable consumption is to be formulated (related to the discussion of return pipe losses from below).

HVAC.PE.1 and HVAC.PE.2 modules were presented by Vladimir Jovanović. The presentation provided by Vladimir is given in Annex 7.

Nikola Hure has presented the functioning of HVAC.MPC.1 module which runs on the actual 3Smart database data in combination with generic profiles created by Nikola for testing, for those predictions that are still not operable (see Annex 6). Nikola has shown the module planning in terms of the supply temperature profile it predicts for the optimal operation of the central HVAC system.

Technical session 6: On-line demonstrations: Microgrid-level EON

On the microgrid level Hrvoje has shown the performance of M.PE.3 (prediction of maximum possible PV production) and M.PE.4 (prediction of electrical non-controllable loads).

M.PE.3 is installed and put in online operation. Hrvoje has strongly emphasized the need to have checked data in the database in order to facilitate the prediction modules operation both in tuning the prediction models and in providing predictions.

For M.PE.4 the formula for non-controllable electricity consumption was discussed and finally accepted.

Danko Marušić has presented the functioning of microgrid MPC module. It was demonstrated what behaviour from the building can be induced by coordination between different optimization levels.

Presentation of UNIZGFER modules on the microgrid level is provided as Annex 8.

Arpad and Andras have presented the current status and operation of building-side modules for which UNIDEBTTK is responsible. Modules M.I.4 (electric heaters control) and M.I.5 (PV inverter control) were discussed. The presentations for M.I.4 and M.I.5 are provided as Annex 9.

Technical session 7: On-line demonstrations: Short-term modules grid, Long-term modules grid

Gabor from EON presented the workflow for executing the long-term module, with all necessary steps explained in detail. The shown presentation is given as Annex 10.

Short-term modules operation was demonstrated by Paula. For day-ahead module different unclear issues were resolved such that EON development team can continue with finishing the database part for the short-term modules.

The intra-day module is discussed in more detail. The shown presentation is part of Annex 3.

Technical session 8: Discussion, next steps at the pilot site, schedule updating for installations, questions. Possibility for preparing the next pilot study visits, technical questions. Grid-side developers open hour.

The last session was used for various face-to-face interactions between pilot leaders / hosts and the developers.

List of annexes

Annex 1: Presentations of performed mechanical, electrical and IT installations

Annex 2: Presentation of on-line operation of the pilot IT infrastructure

Annex 3: Presentation of short-term grid-side modules operation

Annex 4: Presentation of long-term grid-side modules operation

Annex 5: Modules organization on the building side

Annex 6: Presentation of UNIZGFER building-side modules installation and operation on the zone and central HVAC levels

Annex 7: Presentation of UNIBGFME modules installation

Annex 8: Presentation of UNIZGFER building-side modules installation and operation on the microgrid level

Annex 9: Presentation of UNIDEBTTK modules installation and operation

Annex 10: Presentation of EON grid-side modules installation and operation

Performed installations and realized IT infrastructure

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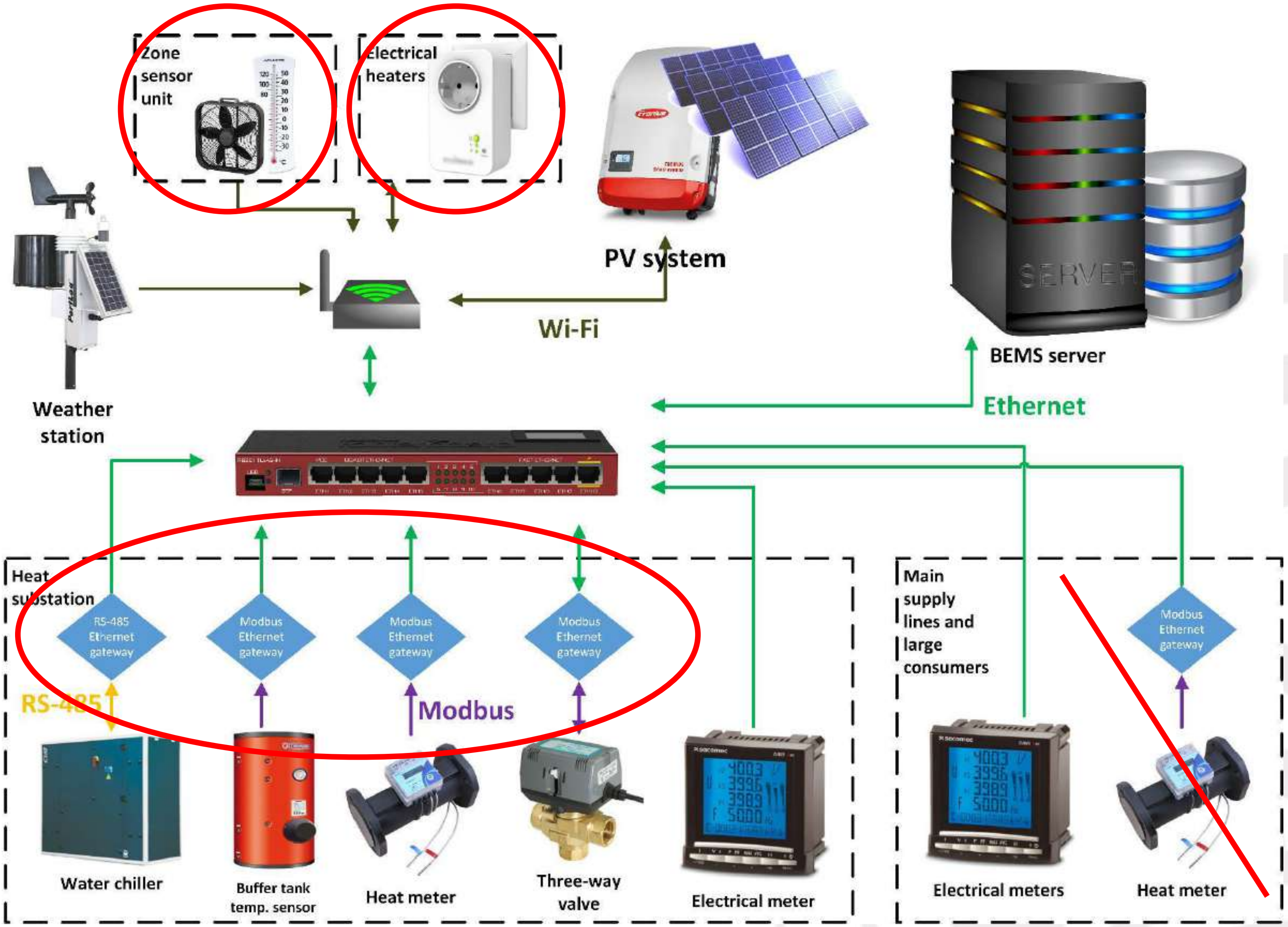
First pilot study visit to the Hungarian pilot

February 5-6, 2019.

Danube Transnational Programme
3Smart

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

System overview - Plan



Communication network

- Planning aspects:
  - As uniform as possible
  - Future-proof
  - Usage of current ModBus cabling
  - EON IT restrictions

Communication Network

Communication Network - Planning phase 2017 Q2-Q3

- Clarification of network requirements
- Survey of the existing structured cabling
- E.ON Corporate Network was not allowed to be used
- Wiring closets and legacy racks can be used
- WLAN access-points should be placed to corridors (instead of offices)
- WLAN coverage areas
- Min -64dBm RSSI value in the designated offices
- WLAN site surveys
- Endpoints positions on floor plans (with basement CIAT and power meter)
- Missing Fibre-optical cabling between building B and D

Communication network - Building phase 2017 Q4

- Building new structured cable system:
  - 114 endpoints (55 double)
  - 7600m Cat6 UTP cable
  - 7 pieces Cat6 UTP 24p patchpanel
  - 100m 8x OM3 fibre-optic cable between building B and D
- Mounting and installing network devices:
  - 1 pcs UniFi Security Gateway 4P
  - 7 pcs UniFi Switch
  - 34 pcs UniFi AP-AC-Mesh
  - 7 pcs UniFi AP-AC-Lite

Communication Network - Selecting the network products

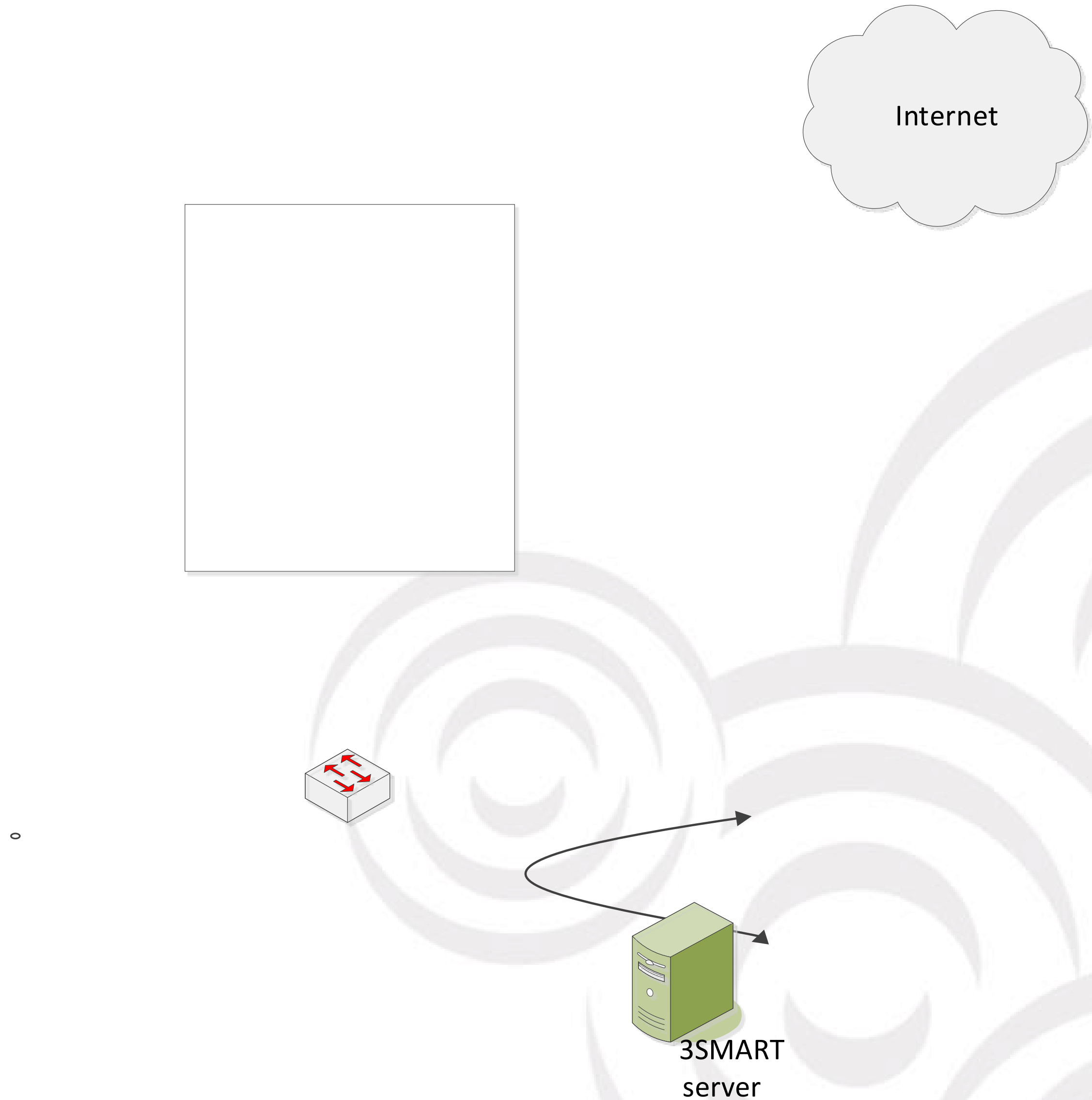
- Deciding factors:
  - cost effective and simple network management (Configuration, monitoring, SW upgrade, etc.)
  - All network devices from one vendor, one product line, if possible
- Switches:
  - Centralized management and statistics, SNMP,
  - 10/100/1000 Mbps RJ45 Ethernet Ports, SFP slots,
  - PoE (IEEE 802.3af/at), RSTP, VLAN, Port-mirroring, storm control, port aggregation
- Access-points:
  - Centralized management and statistics, multi SSID, guest WLAN
  - Wall or ceiling mounted, PoE powered, IEEE 802.11ac,
- Gateway
  - Centralized management and statistics, interVLAN-routing, dynamic routing
  - Site-to-Site and Site-to-Client(RAS) VPN
  - high packet forwarding and Firewall performance, SFP slot
  - Simple management of guest access
  - IDS/ IPS function if possible

Network services

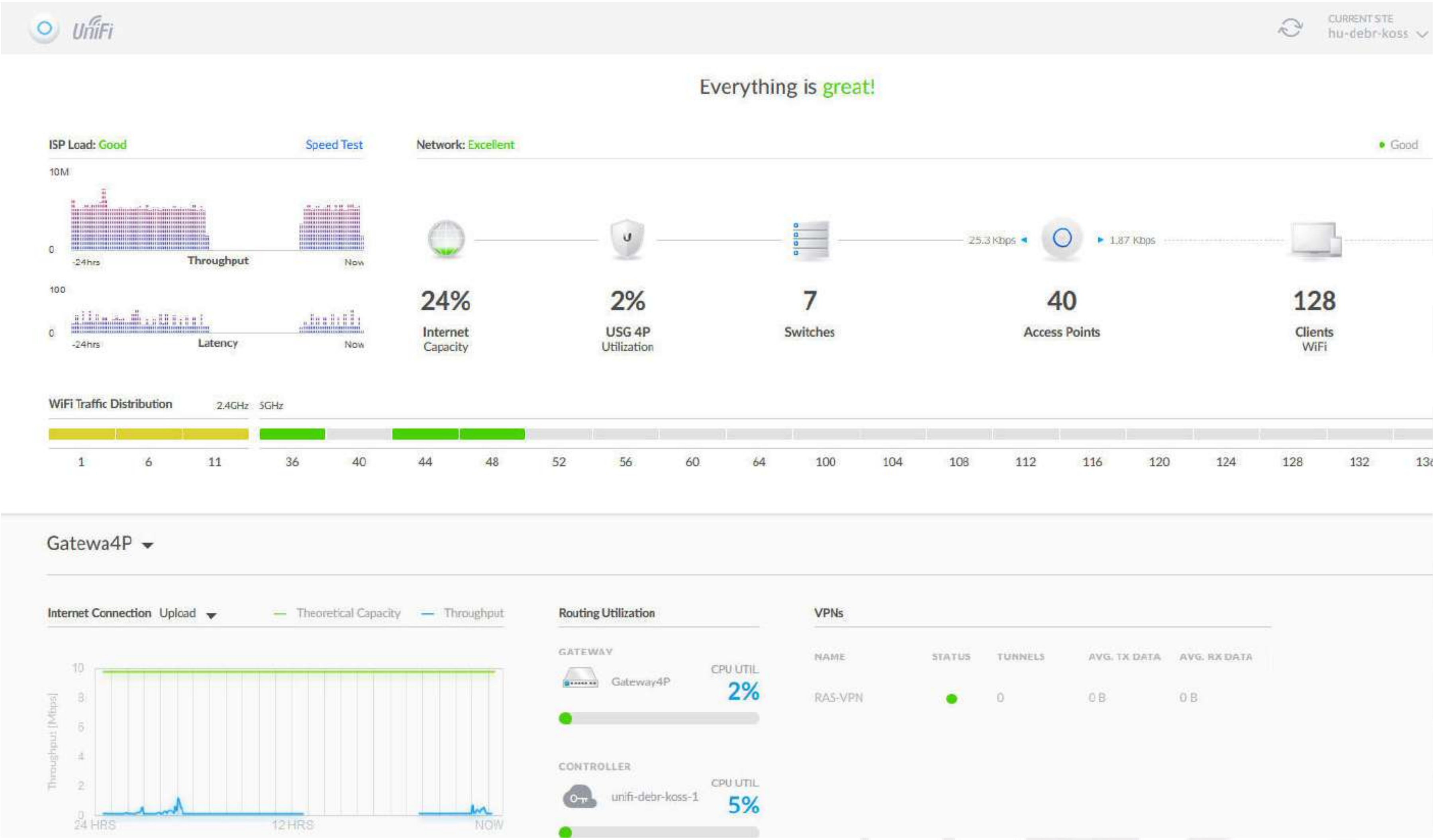
- Wireless access (multiple SSID)
  - 3SMART temperature sensors
  - 3SMART-service direct project participants
  - 3SMART-guest guests (Internet access only)
- Wired connectivity:
  - 3SMART server
  - Power meters
  - NAS-backup
- Site-to-Site VPN – University of Debrecen, Nextent and cloud server
- RAS VPN: L2TP/IPSec and SSTP VPN – built-in Windows client
- Firewall filter rules: WAN, LAN, Guest, E.ON Corporate Network
- Network Management: Unifi web surface, run on Unifi Cloud Key
- 10 /10 Mbps fibre-optic Internet connection with fix IP-subnet (/29)

3SMART Debrecen L2 network topology

3SMART Debrecen communication network



Network mgmt - Unifi Controller - Dashboard



Network mgmt - Unifi Controller - Maps

Network mgmt - Unifi Controller - Devices

ALL (48) | GATEWAY/SWITCHES (8) | APS (40)

Search or select tag

DEVICE NAME	IP ADDRESS	STATUS	MODEL	VERSION ↓	DOWN	UP	ACTIONS ↔
Gateway4P	192.168.3.1	CONNECTED	UniFi Security Gateway 4P	4.4.36.5146617	676 GB	40.3 GB	LOCATE RESTART
A-1EM-folyoso	192.168.3.61	CONNECTED	UniFi Switch 16 POE-150W	4.0.15.9872	0.98 GB	1.33 GB	LOCATE RESTART
E-FSZ-server	192.168.3.21	CONNECTED	UniFi Switch 16 POE-150W	4.0.15.9872	212 GB	112 GB	LOCATE RESTART
D-2EM-router1	192.168.3.25	CONNECTED	UniFi Switch 8 POE-150W	4.0.15.9872	25.7 GB	3.16 GB	LOCATE RESTART
E-3EM-folyoso	192.168.3.22	CONNECTED	UniFi Switch 8 POE-60W	4.0.15.9872	918 MB	1.74 GB	LOCATE RESTART
D-2EM-router2	192.168.3.19	CONNECTED	UniFi Switch 24 POE-250W	4.0.15.9872	2.48 GB	4.99 GB	LOCATE RESTART
B-3EM-folyoso	192.168.3.20	CONNECTED	UniFi Switch 8 POE-150W	4.0.15.9872	1.03 GB	1.94 GB	LOCATE RESTART
B-1EM-folyoso	192.168.3.26	CONNECTED	UniFi Switch 8 POE-150W	4.0.15.9872	895 MB	1.82 GB	LOCATE RESTART

Showing 1-8 of 8 records. Items per page: 50

Network mgmt - Unifi Controller - Clients

ALL (142) | WIRELESS (128) | WIRED (14) — ALL (128) | 2G (128) | 5G (0) — ALL (128) | USERS (128) | GUESTS (0) — ALL (128) | ACTIVE (62) — AP: All

+ ADD CLIENT | ALL CONFIGURED CLIENTS | Search

NAME	IP ADDRESS	WLAN	AP/PORT	CHANNEL	PHY MODE	SIGNAL	ACTIVITY ↔	ACTIVITY DOWN ↓	ACTIVITY UP	UPTIME
TRAFO-WLAN-bridge	192.168.0.57	3SMART-wired	D-ALA-D01	1	11ng (2.4 GHz)	74% (-61 dBm)		1.04 MB	1.57 MB	10d 1h 4
D-tető-inv	192.168.2.22	3SMART	E-4EM-E207	11	11ng (2.4 GHz)	99% (-47 dBm)		848 KB	3.98 MB	9h 37m 2
B-6EM-inv	192.168.2.21	3SMART	B-6EM-B603	11	11ng (2.4 GHz)	99% (-50 dBm)		767 KB	1.06 MB	9h 38m 5
ESP_24A9BD	192.168.2.97	3SMART	C-3EM-D33	6	11ng (2.4 GHz)	30% (-79 dBm)		183 KB	4.88 MB	10d 47m
ESP_24A9CA	192.168.2.56	3SMART	A-1EM-A19	1	11ng (2.4 GHz)	37% (-76 dBm)		181 KB	328 KB	5d 7h 59
ESP_24AA40	192.168.2.140	3SMART	A-FSZ-NAGYTARGYALO	6	11ng (2.4 GHz)	64% (-65 dBm)		181 KB	4.62 MB	5d 8h 42
ESP_24AACE	192.168.2.29	3SMART	D-1EM-D25	6	11ng (2.4 GHz)	77% (-60 dBm)		180 KB	4.59 MB	10d 26m
ESP_24A9FA	192.168.2.100	3SMART	E-2EM-KDSZ	1	11ng (2.4 GHz)	62% (-66 dBm)		179 KB	4.82 MB	5d 11h 5
ESP_305EA9	192.168.2.155	3SMART	A-FSZ-NAGYTARGYALO	6	11ng (2.4 GHz)	87% (-56 dBm)		179 KB	4.51 MB	10d 1h 4
ESP_24A9E7	192.168.2.69	3SMART	E-1EM-E014	6	11ng (2.4 GHz)	47% (-72 dBm)		179 KB	4.87 MB	7d 6h 55
ESP_24A9C9	192.168.2.106	3SMART	E-2EM-KDSZ	1	11ng (2.4 GHz)	59% (-67 dBm)		179 KB	4.81 MB	5d 11h 5
ESP_24AABF	192.168.2.40	3SMART	D-1EM-D23	11	11ng (2.4 GHz)	94% (-53 dBm)		179 KB	5.07 MB	7d 3h 51
ESP_24AA79	192.168.2.129	3SMART	D-FSZ-D19	6	11ng (2.4 GHz)	72% (-62 dBm)		179 KB	4.45 MB	7d 3h 40
ESP_24AA3F	192.168.2.152	3SMART	C-1EM-D21	6	11ng (2.4 GHz)	57% (-68 dBm)		179 KB	4.42 MB	6d 12h 21

Building energy management hardware

Building energy management hardware

- Planning aspects:
  - Maximize controllable load
  - Limited zone-level functionality

Installed equipment

- 114 pcs room temperature sensors in the pilot building
- 141 pcs fan coil outlet water temperature sensors in the pilot building
- 83 pcs 270 Wp solar panels on the roof of B and D building
- 2 pcs solar inverter
- 6 pcs electrical heating control units
- 4 pcs three-way valve control units
- 4 pcs calorimeters for main supply
- 4 pcs temperature measurement sensors for buffer tanks
- 11 pcs electrical meters for large consumers or consumer groups
- 1 pcs meteorological station on the roof of building B
- 1 pcs server in the pilot building
- 2 smart meter for middle voltage measurement in the pilot grid area
- 1 smart meter for low voltage measurement in the middle per low voltage transformer station (main supply of the building)

Installed control functions, abilities

- Electrical heaters – controllable temperature, electrical consumption
- Three-way valve units – controllable temperature of the forward heating/cooling medium
- CIAT water chillers – controllable temperature setpoint of the forward water, electrical consumption
- Solar inverters – controllable power output in percentages, electrical consumption

Room installation (Zone level)

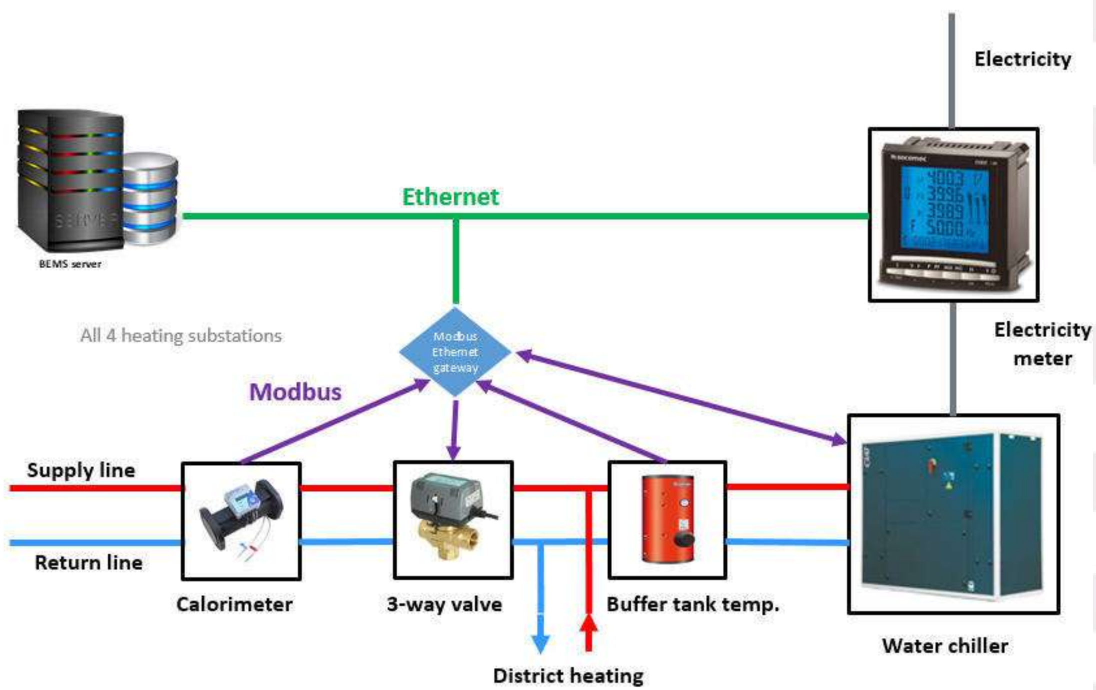
- Communication:
  - UDP packets (push with confirmation) via dedicated WiFi network
  - Internal clock synchronized in every hour

Room installation (Zone level)

- Measured:
  - room temperature
  - return medium temperature
- Sensor:
  - MCP9700 analog temperature sensor

Heat centers installation (HVAC level)

- DIRIS A40 electricity meter
- QALCOSONIC HEAT 2 calorimeter
- Lumel RE72 controller for the mixing valve



Heat centers installation (HVAC level)

Heat centers installation (HVAC level)

PV system (Microgrid level)

- 22.41 kWp photovoltaic plant
  - 83 PV panels (Solvis SV60-270)
  - 2 smart-grid-ready inverters (Fronius Symo 10.0-3-M with DataManager Card)

PV system (Microgrid level)

PV system (Microgrid level)

Electric heaters installation (Microgrid level)

- Components of the system:
  - 6 central control units (custom made)
  - 6 room temperature controls (custom made)
  - 1 electricity meter (Diris A40)
- Network connection: WiFi 2.4 GHz (IEEE 802.11 b/g/n)
- Communication protocol: custom over UDP (with message acknowledgment)

Electric heaters installation (Microgrid level)

Electric meters installation (Microgrid level)

- Each one has Modbus RS485 communication module
- One of them has an Ethernet communication module

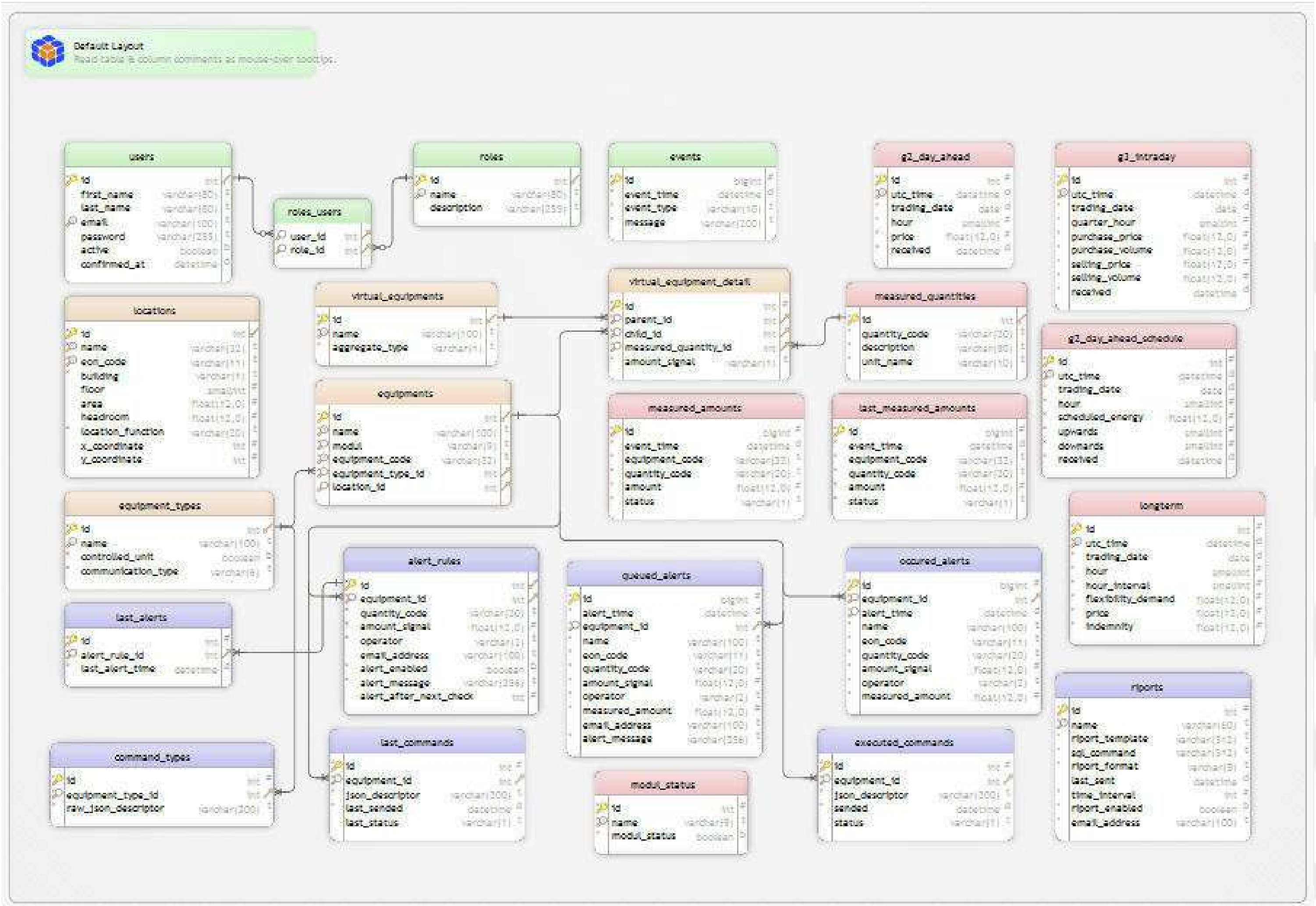
Location	Measured value
Heat center A	Water chiller (CIAT) A consumption
Heat center A	Fan coils' consumption for heat centre A
Heat center B+C	Water chiller (CIAT) B+C consumption
Heat center B+C	Fan coils' consumption for heat centre B+C
Heat center D	Water chiller (CIAT) D consumption
Heat center D	Fan coils' consumption for heat centre D
Basement of building B	Water chiller (CIAT) E consumption
Heat center E	Fan coils' consumption for heat centre E
Basement of building D	Electric heaters at basement D
Basement of building B	Building E consumption
Transformer station next to the building	Overall building consumption

Weather station installation

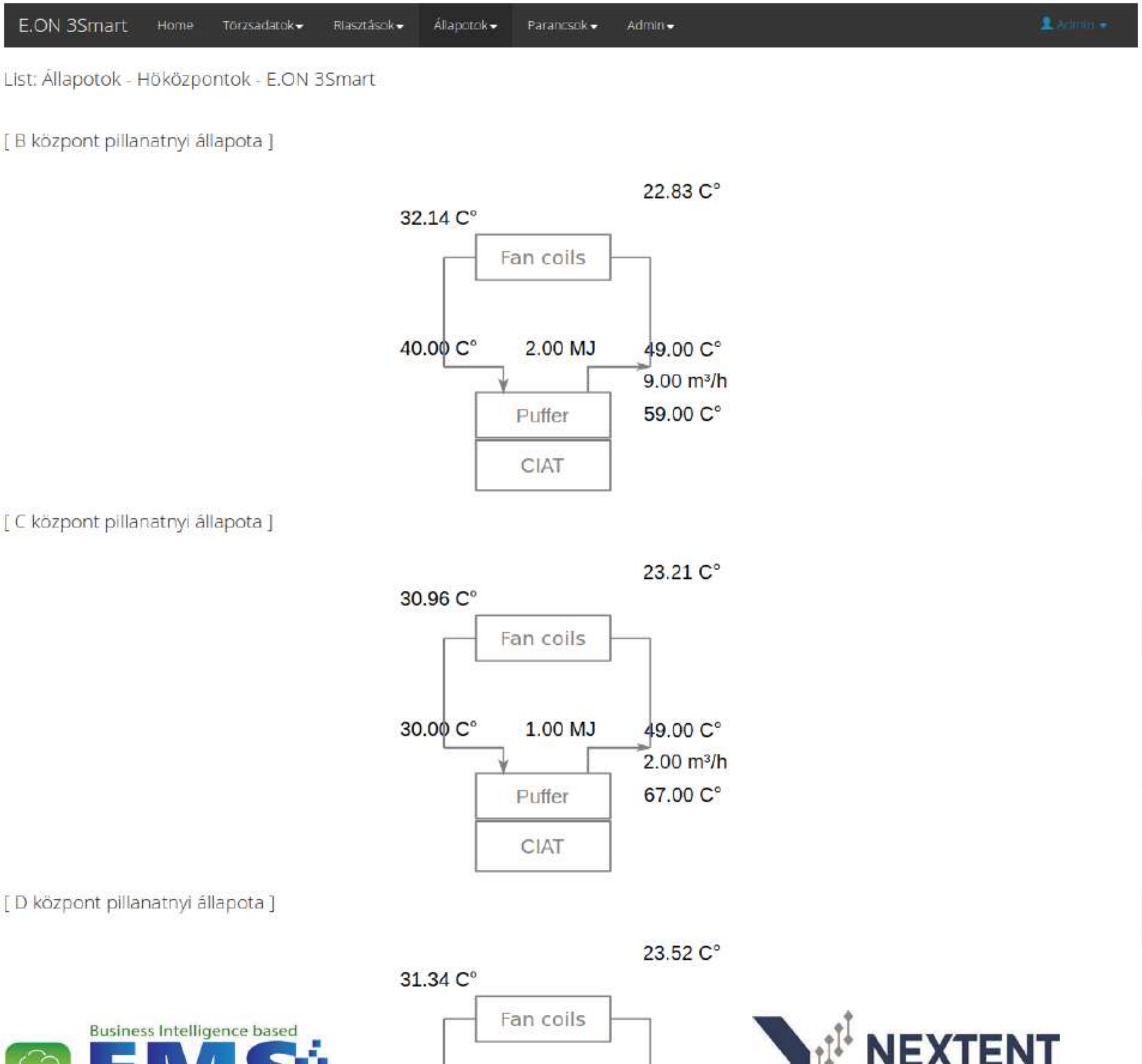
- The weather station consists of the following components:
  - RK900-01 Automatic Weather Station
  - RK110-02 Wind Direction Sensor
  - RK100-02 Wind Speed Sensor
  - RK330-01 Ambient Temperature Humidity & Pressure Sensor
  - RK200-04 Solar Radiation Sensor (2 pcs)
  - RK95-03 Solar Power Supply System
  - TAB 50P battery

Communication: ModBus

BEMS software



BEMS software

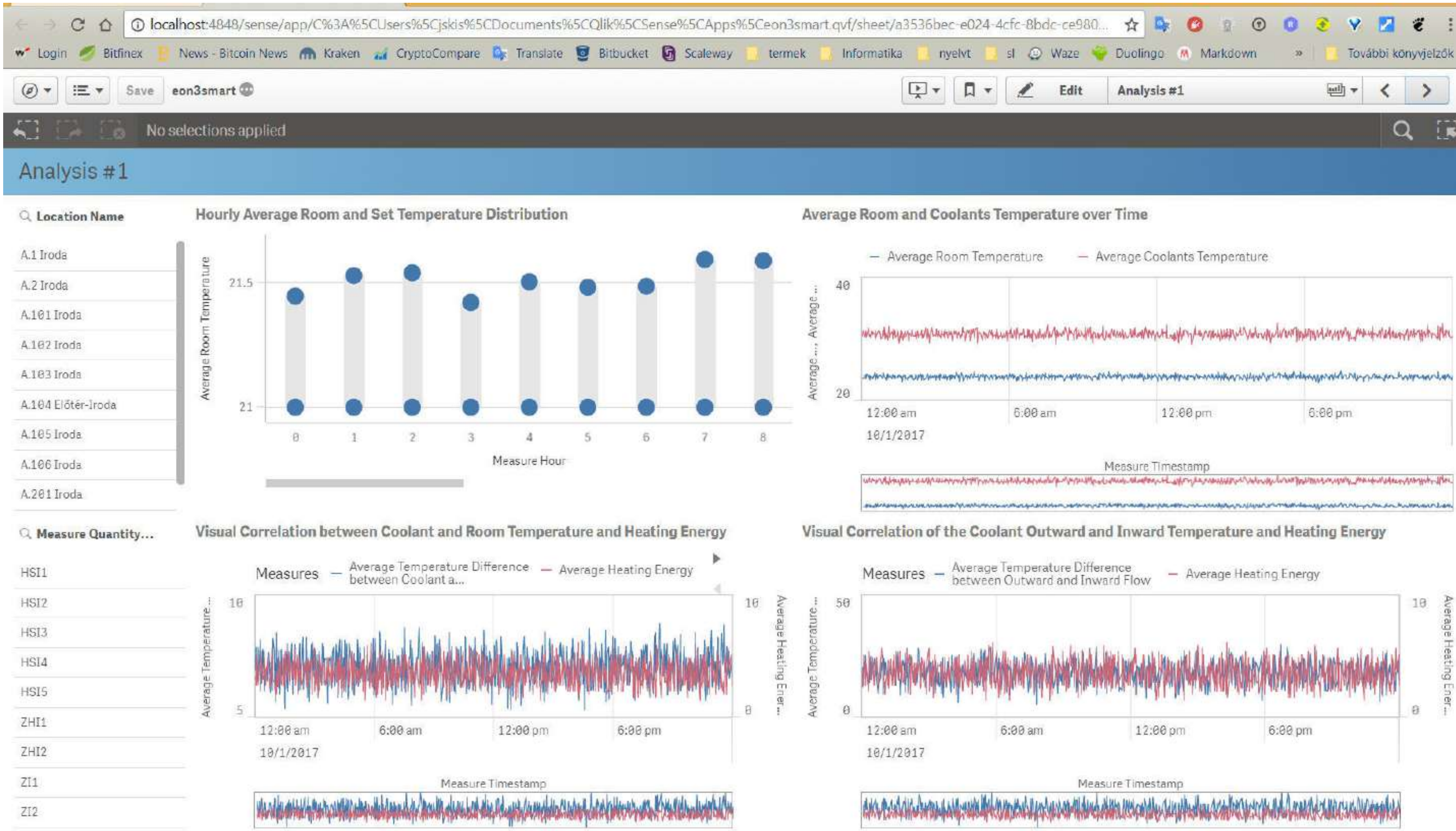


Business Intelligence based EMS Energy Management Solution

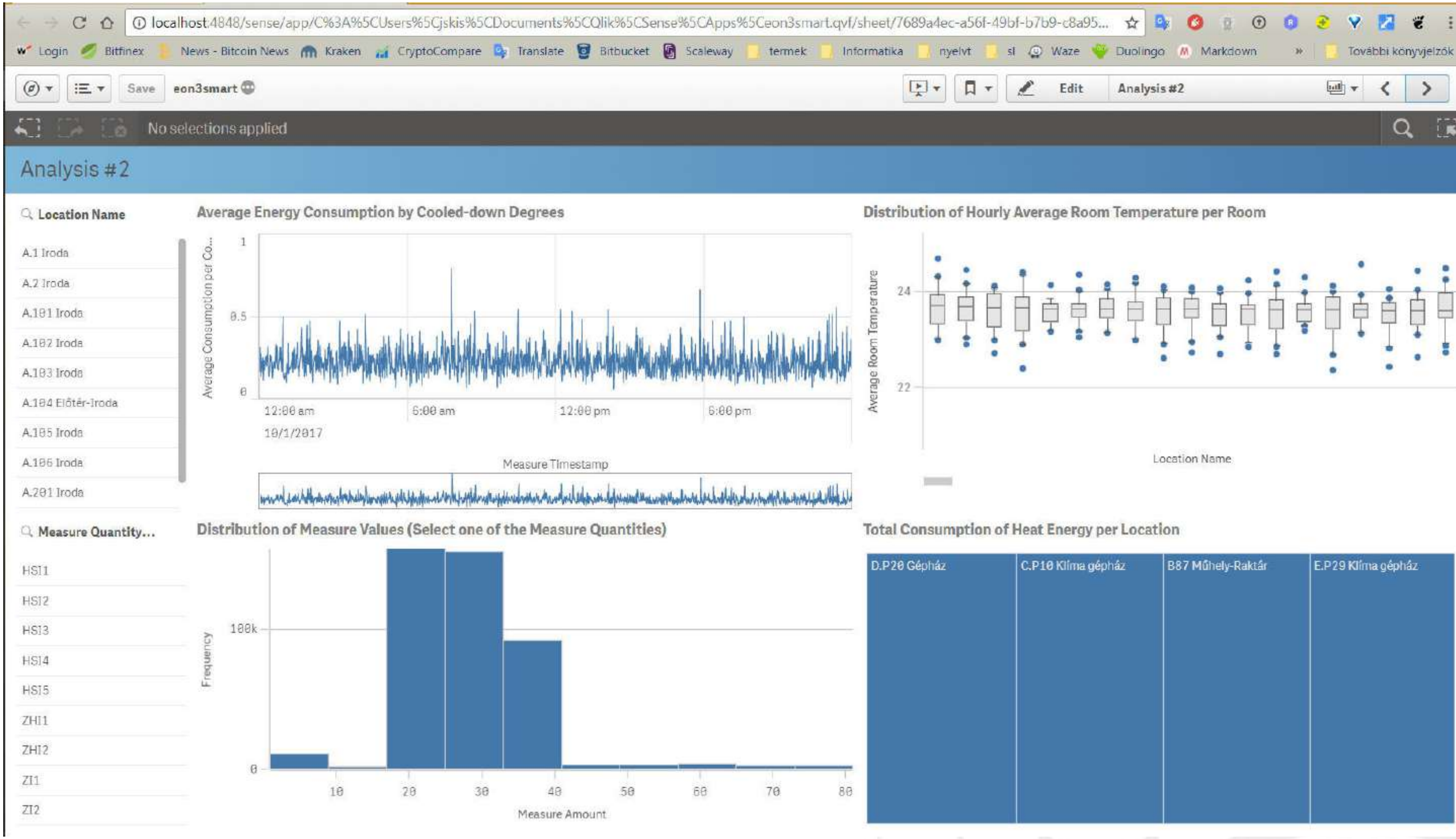
NEXTENT INFORMATICS

Interreg Danube Transnational Programme 3Smart

BEMS software



BEMS software



3SMART switch OFF scenario

- There are four groups of control signals:
  - Control signals for inverters output,
  - Control signals for water chillers return temperature,
  - Control signals for heating/cooling pipelines (per heat center) forward medium temperature (valve control),
  - Control signals for electric heaters.

3SMART switch OFF scenario

- All of these signal groups can be turned off separately by the software switch. After the signal is turned off the controlled units behave according to this:
  - Inverter: the output setpoint goes back to 100%. Value can be modified manually via the inverter’s web interface.
  - Water chiller: the setpoint for the return temperature goes to a predefined value. Value can be modified manually via the chiller’s control panel.
  - Valve: the original control system gets back the control possibility for the valve.
  - Electric heaters: the heaters will follow setpoint from the room controllers (user request).

3SMART ‚crash' scenario

- All of these signal groups can be turned off separately by the software switch. After the signal is turned off the controlled units behave according to this:
  - Inverter: the output setpoint stays at the last value. Value can be modified manually via the inverter's web interface.
  - Water chiller: the setpoint for the return temperature stays at the last value. Value can be modified manually via the chiller's control panel.
  - Valve: the original control system gets back the control possibility for the valve.
  - Electric heaters: the heaters will follow setpoint from the room controllers (user request).

Grid-side installation

Grid side installations - summary

Grid side developments were elaborated mainly on software side, so it wasn't needed to make major physical installations, except for the smart meters.

Content:

- DA and ID prices data collection
- Smart meters, measurement on the grid
- IT platform (SCADA)
- Qlik – Business Intelligence tool for analysis

Grid side investment-DA and ID prices

- Market prices are key elements in the pilot in order to have the cost function for optimization on building side, so automated data sending has been established between the electricity market and the 3Smart system. A script has been developed on the side of EON, for sending market prices in an automated way (scheduled e-mails). Two types of price tables are sent to the EMS system: day-ahead and intra-day price tables:

List: States and values - Day-Ahead - E.ON 3Smart

List (264) Create Export Add Filter With selected Search

ID	Send date	UTC Time	Trade day	Hour	Purchase price
1	2018-05-27 13:05:20	2018-05-27 23:00:00	2018-05-28	1	35.6
2	2018-05-27 13:05:20	2018-05-28 00:00:00	2018-05-28	2	32.62
3	2018-05-27 13:05:20	2018-05-28 01:00:00	2018-05-28	3	31.1
4	2018-05-27 13:05:20	2018-05-28 02:00:00	2018-05-28	4	30.4
5	2018-05-27 13:05:20	2018-05-28 03:00:00	2018-05-28	5	30.9
6	2018-05-27 13:05:20	2018-05-28 04:00:00	2018-05-28	6	34.35
7	2018-05-27 13:05:20	2018-05-28 05:00:00	2018-05-28	7	46.1
8	2018-05-27 13:05:20	2018-05-28 06:00:00	2018-05-28	8	54.3
9	2018-05-27 13:05:20	2018-05-28 07:00:00	2018-05-28	9	57.7
10	2018-05-27 13:05:20	2018-05-28 08:00:00	2018-05-28	10	53.0
11	2018-05-27 13:05:20	2018-05-28 09:00:00	2018-05-28	11	50.18
12	2018-05-27 13:05:20	2018-05-28 10:00:00	2018-05-28	12	49.5
13	2018-05-27 13:05:20	2018-05-28 11:00:00	2018-05-28	13	47.82
14	2018-05-27 13:05:20	2018-05-28 12:00:00	2018-05-28	14	46.6
15	2018-05-27 13:05:20	2018-05-28 13:00:00	2018-05-28	15	45.84
16	2018-05-27 13:05:20	2018-05-28 14:00:00	2018-05-28	16	47.21
17	2018-05-27 13:05:20	2018-05-28 15:00:00	2018-05-28	17	49.03
18	2018-05-27 13:05:20	2018-05-28 16:00:00	2018-05-28	18	52.5
19	2018-05-27 13:05:20	2018-05-28 17:00:00	2018-05-28	19	55.93

Day-ahead prices (DA)

List: States and values - Intraday - E.ON 3Smart

List (1072) Create Export Add Filter With selected Search

ID	Send date	UTC Time	Trade day	Quarter	Purchase price	Purchase volume	Selling price	Selling volume
125	2018-05-27 00:00:00	2018-05-27 05:15:00	2018-05-27	29	9.4	25.0	59.22	25.0
126	2018-05-27 00:00:00	2018-05-27 05:30:00	2018-05-27	30	9.4	25.0	59.22	25.0
127	2018-05-27 00:00:00	2018-05-27 05:45:00	2018-05-27	31	9.4	25.0	59.22	25.0
128	2018-05-27 00:00:00	2018-05-27 06:00:00	2018-05-27	32	9.4	25.0	59.22	25.0
129	2018-05-27 00:00:00	2018-05-27 06:15:00	2018-05-27	33	10.31	25.0	64.95	25.0
130	2018-05-27 00:00:00	2018-05-27 06:30:00	2018-05-27	34	10.31	25.0	64.95	25.0
131	2018-05-27 00:00:00	2018-05-27 06:45:00	2018-05-27	35	10.31	25.0	64.95	25.0
132	2018-05-27 00:00:00	2018-05-27 07:00:00	2018-05-27	36	10.31	25.0	64.95	25.0
133	2018-05-27 00:00:00	2018-05-27 07:15:00	2018-05-27	37	11.2	25.0	70.56	25.0
134	2018-05-27 00:00:00	2018-05-27 07:30:00	2018-05-27	38	11.2	25.0	70.56	25.0
135	2018-05-27 00:00:00	2018-05-27 07:45:00	2018-05-27	39	11.2	25.0	70.56	25.0
136	2018-05-27 00:00:00	2018-05-27 08:00:00	2018-05-27	40	11.2	25.0	70.56	25.0
137	2018-05-27 00:00:00	2018-05-27 08:15:00	2018-05-27	41	11.52	25.0	72.59	25.0
138	2018-05-27 00:00:00	2018-05-27 08:30:00	2018-05-27	42	11.52	25.0	72.59	25.0
139	2018-05-27 00:00:00	2018-05-27 08:45:00	2018-05-27	43	11.52	25.0	72.59	25.0
140	2018-05-27 00:00:00	2018-05-27 09:00:00	2018-05-27	44	11.52	25.0	72.59	25.0
141	2018-05-27 00:00:00	2018-05-27 09:15:00	2018-05-27	45	11.91	25.0	75.03	25.0
142	2018-05-27 00:00:00	2018-05-27 09:30:00	2018-05-27	46	11.91	25.0	75.03	25.0
143	2018-05-27 00:00:00	2018-05-27 09:45:00	2018-05-27	47	11.91	25.0	75.03	25.0

Intraday prices(ID)

Grid side investment-DA and ID prices

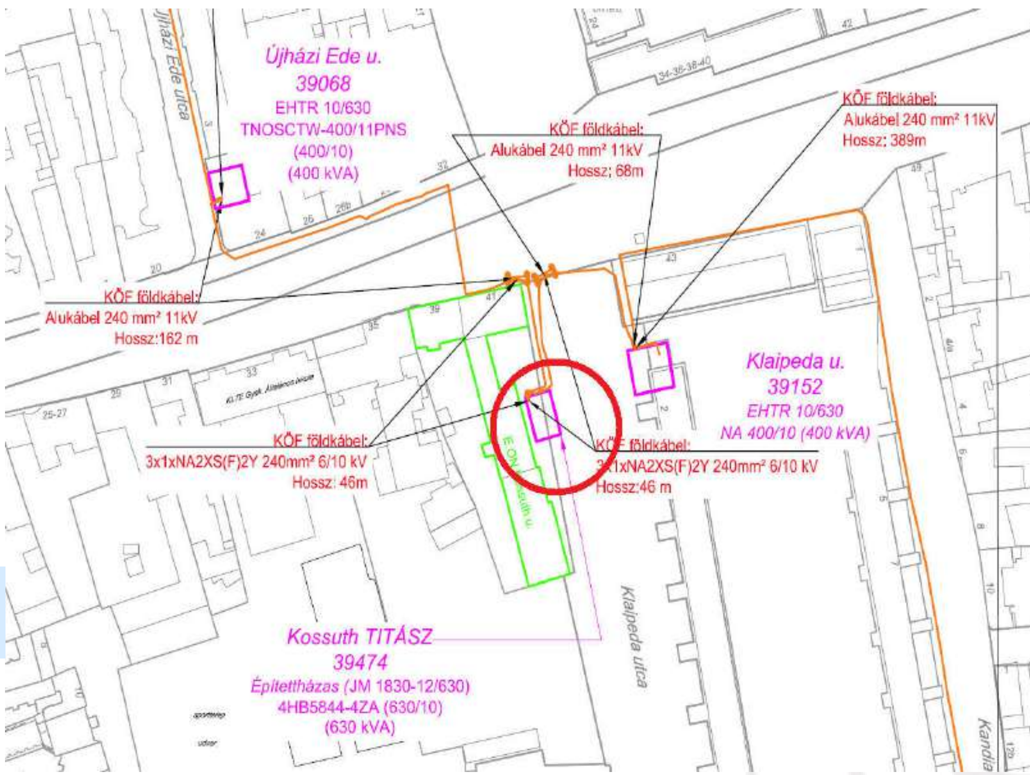
- Day-ahead table is sent once a day, at 13, with hourly prices for the next day, and intra-day tables are sent four times a day with quarter-hourly prices for the next hours. The tables arrive in csv format by mail, and integration to the database is automated

GUI displays both the day-ahead and intra-day information

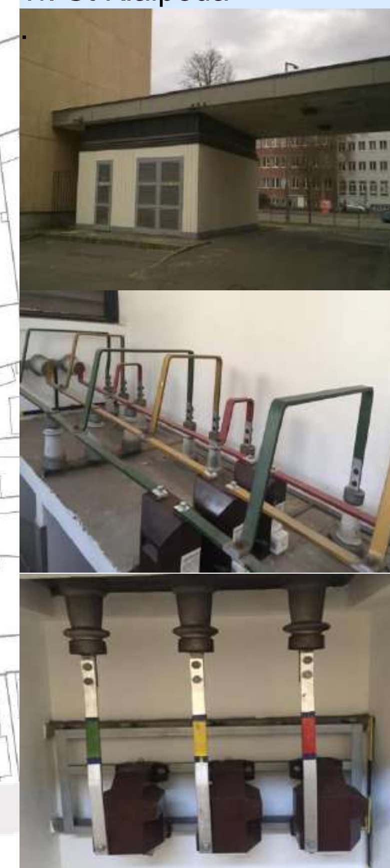
Grid side investment- Smart metering

- One meter has been installed on LV (Low Voltage) side of the Kossuth st. transformer station, which is measuring the total electrical consumption of the pilot building. Two meters, one main and one control meter, have been installed on the MV (Medium Voltage) side of the Klaipeda tr. station, and these are measuring the total load of the MV line.

LV measurement in MV/LV Tr. St.Kossuth u.

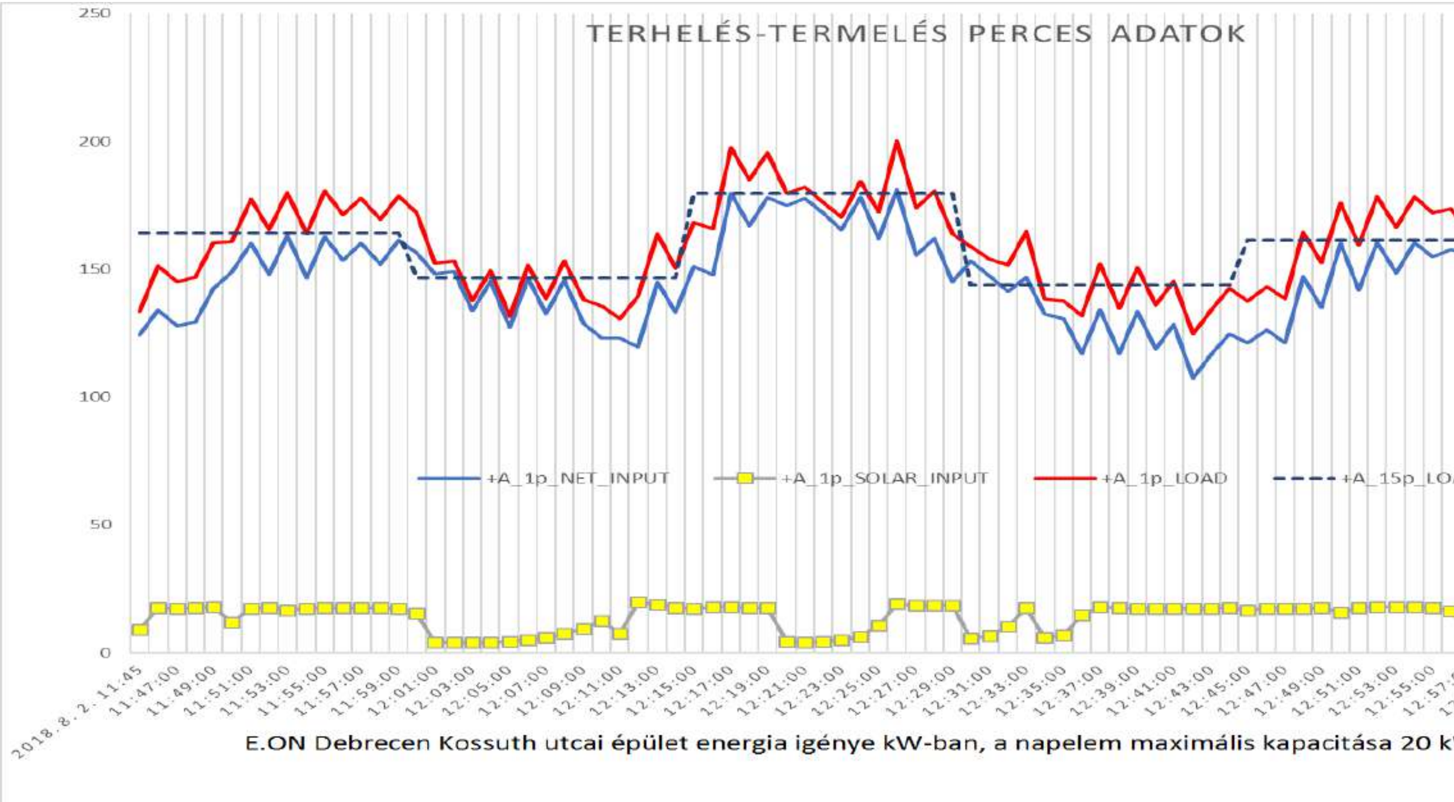


MV measurement in MV/LV Tr. St Klaipeda



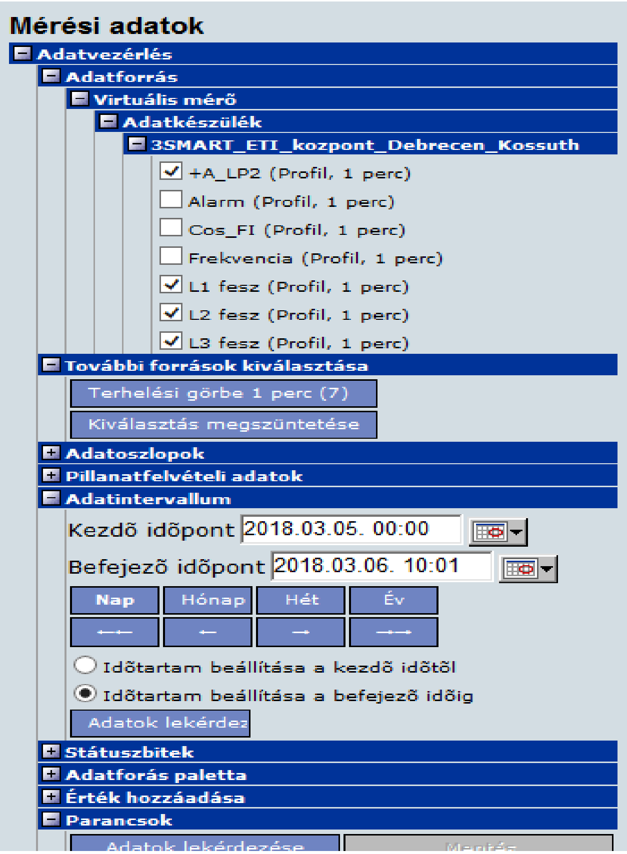
Grid side investment- Smart metering

- The smart meter is capable to collect one minute resolution data and communicates with the meter reading center. The biggest challange was of the communication since instead of the traditional 15 minutes resolution we had to handle the one minute data resolution. Instead of 96 data/day we need to handle 1440 data/day.



Grid side investment- Smart metering

- The smart meter was integrated into the E.ON Smart meter reading center. The main challange was the communication and data transfer between E.ON Smart meter reading center and 3Smart local server (IT platform for data acquisition).



Lokális Idő	Virtuális mérő							
	3SMART_ETI_kozpont_Debrecen_Kossuth							
	+A_LP2		L1 fesz		L2 fesz		L3 fesz	
	Aktuális adatok		Aktuális adatok		Aktuális adatok		Aktuális adatok	
	Normál érték	S.	Normál érték	S.	Normál érték	S.	Normál érték	S.
2018.03.05. 06:28:00	0,995		239,700		239,100		238,400	
2018.03.05. 06:29:00	1,002		239,700		239,000		238,500	
2018.03.05. 06:30:00	0,997		239,600		239,000		238,400	
2018.03.05. 06:31:00	1,078		239,900		239,300		238,700	
2018.03.05. 06:32:00	1,083		239,900		239,200		238,600	
2018.03.05. 06:33:00	1,120		239,700		238,900		238,400	
2018.03.05. 06:34:00	1,045		239,600		239,000		238,500	
2018.03.05. 06:35:00	1,147		239,600		238,900		238,500	
2018.03.05. 06:36:00	1,140		239,200		238,500		238,300	
2018.03.05. 06:37:00	1,190		239,500		238,600		238,200	
2018.03.05. 06:38:00	1,260		239,400		238,600		238,000	
2018.03.05. 06:39:00	1,153		239,200		238,500		237,900	
2018.03.05. 06:40:00	1,107		239,400		238,600		237,900	
2018.03.05. 06:41:00	1,055		239,100		238,400		237,700	
2018.03.05. 06:42:00	1,100		238,900		238,300		237,700	
2018.03.05. 06:43:00	1,133		239,200		238,500		237,900	
2018.03.05. 06:44:00	1,168		239,000		238,300		237,800	
2018.03.05. 06:45:00	1,163		239,100		238,300		237,900	
2018.03.05. 06:46:00	1,135		239,000		238,200		237,700	
2018.03.05. 06:47:00	1,223		238,900		238,100		237,700	
2018.03.05. 06:48:00	1,135		238,900		238,200		237,700	
2018.03.05. 06:49:00	1,232		238,900		238,100		237,700	
2018.03.05. 06:50:00	1,235		239,200		238,200		237,900	
2018.03.05. 06:51:00	1,247		241,600		240,700		240,200	
2018.03.05. 06:52:00	1,220		241,700		240,600		240,300	
2018.03.05. 06:53:00	1,250		241,500		240,500		240,000	

E.ON Smart meter reading center- Landis Converge system

IT platform for data acquisition/control

The IT platform covers a framework system which can be further developed. The main task of the platform is data collection from both the grid side and building side equipments and control of specific equipment in the building (modules developed by universities serve the basis of the control, but this platform will execute the command).

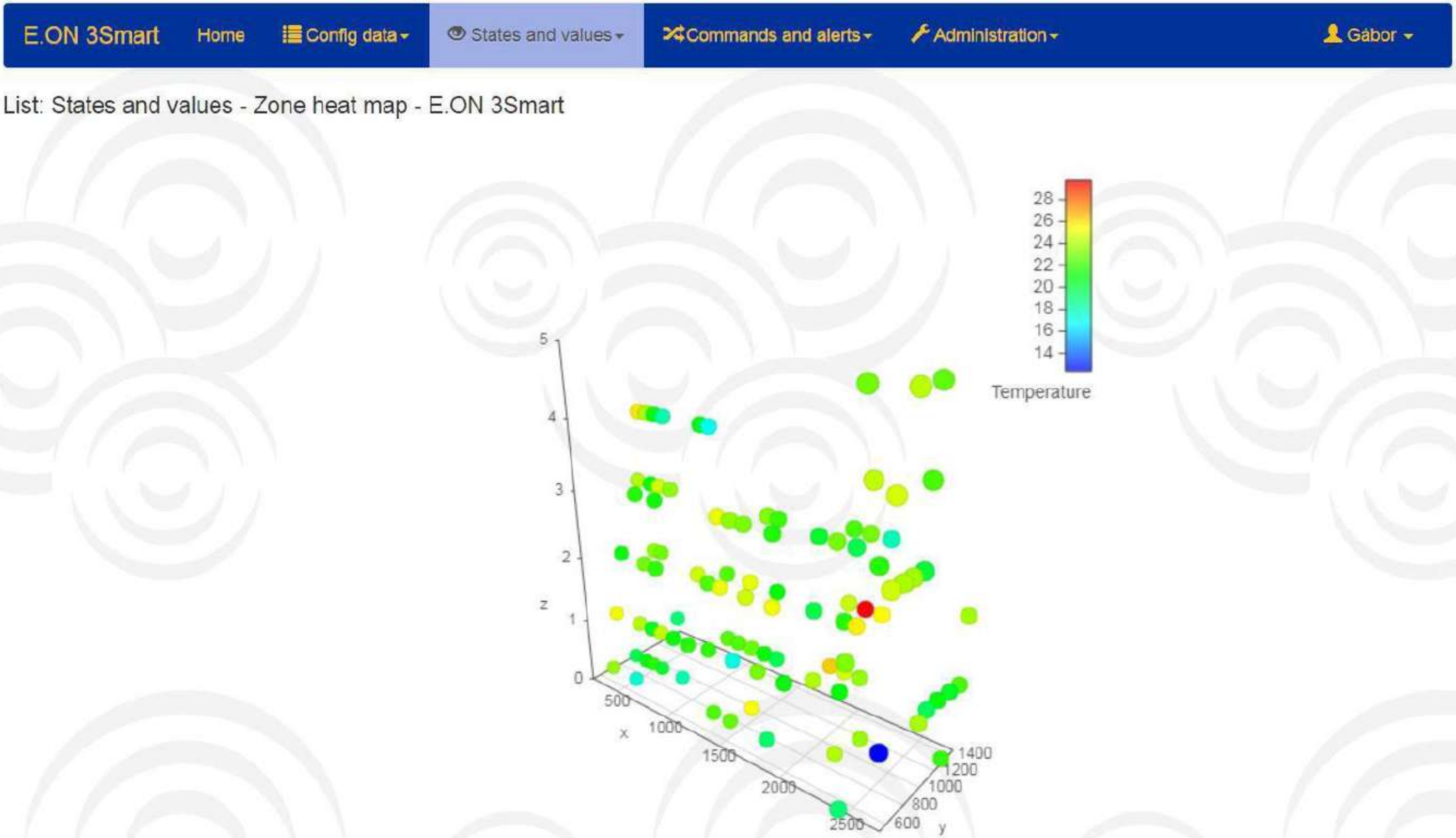
- Users can change temperature setpoint in the rooms where electrical heating is installed via the unit installed on the wall. The 3Smart system will take into consideration that setpoint while optimizing the building operation.

- In the rooms where fan coils are installed users can change the temperature setpoint via the original controllers. This information will not be collected by the 3Smart system.

- Internal web-based interface (system administrators): there are two separate systems which provides access to the test site. The first one is only available inside the 3Smart network and EON's network. This SCADA system provides supervision and control tool via intranet website. Through that site all current and historical data is available. It also provides all the required control possibilities including the software switches.

IT platform for data acquisition/control

IT platform for data acquisition/control



IT platform for data acquisition/control

E.ON 3Smart | Home | Config data | States and values | Commands and alerts | Administration | Gábor

List: States and values - RT measures - E.ON 3Smart

List (372) | Export | Add Filter | Search

Add Filter: Last time, Equipment code, Measured attr code, E.ON code, Building, Floor, Last value

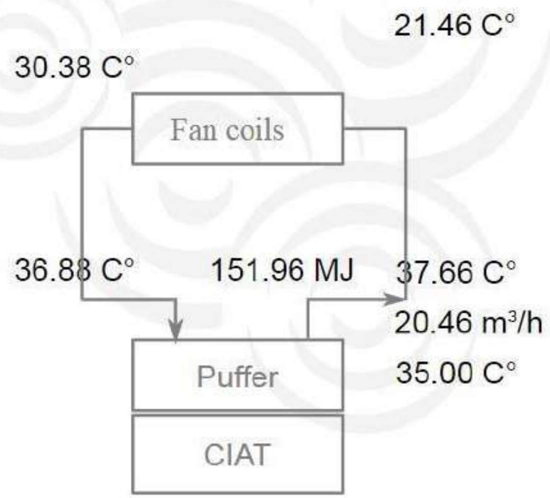
	Last time	ipment code	Measured attr code	E.ON code	Building	Floor	Last value
	2019-01-3	.168.2.114/1-1-96	ZI1	D VIRT	D	-1	25.45
	2019-01-3	.168.2.114/1-1-96/1	ZI2	D VIRT	D	-1	31.15
	2019-01-3	.168.2.123/1-1-123	ZI1	A38	A	2	19.75
	2019-01-3	.168.2.123/1-1-123/1	ZI2	A38	A	2	27.75
	2019-01-30 06:16:59	192.168.2.130/1-1-124	ZI1	D73	D	2	22.45
	2019-01-30 06:16:59	192.168.2.130/1-1-124/1	ZI2	D73	D	2	44.95
	2019-01-30 06:16:59	192.168.2.124/1-1-101	ZI1	A28	A	2	23.85
	2019-01-30 06:16:59	192.168.2.124/1-1-101/1	ZI2	A28	A	2	33.15
	2019-01-30 06:16:59	192.168.2.117/1-1-116	ZI1	B66	B	1	25.35
	2019-01-30 06:16:59	192.168.2.117/1-1-116/1	ZI2	B66	B	1	42.55
	2019-01-30 06:16:59	192.168.2.116/1-1-117	ZI1	C03	C	3	22.95
	2019-01-30 06:16:59	192.168.2.116/1-1-117/1	ZI2	C03	C	3	47.05
	2019-01-30 06:16:59	192.168.2.122/1-1-121	ZI1	A39	A	2	20.55
	2019-01-30 06:16:59	192.168.2.122/1-1-121/1	ZI2	A39	A	2	31.05

IT platform for data acquisition/control

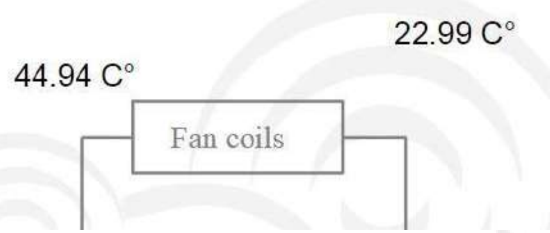
E.ON 3Smart | Home | Config data | States and values | Commands and alerts | Administration | Gábor

List: States and values - HVAC - E.ON 3Smart

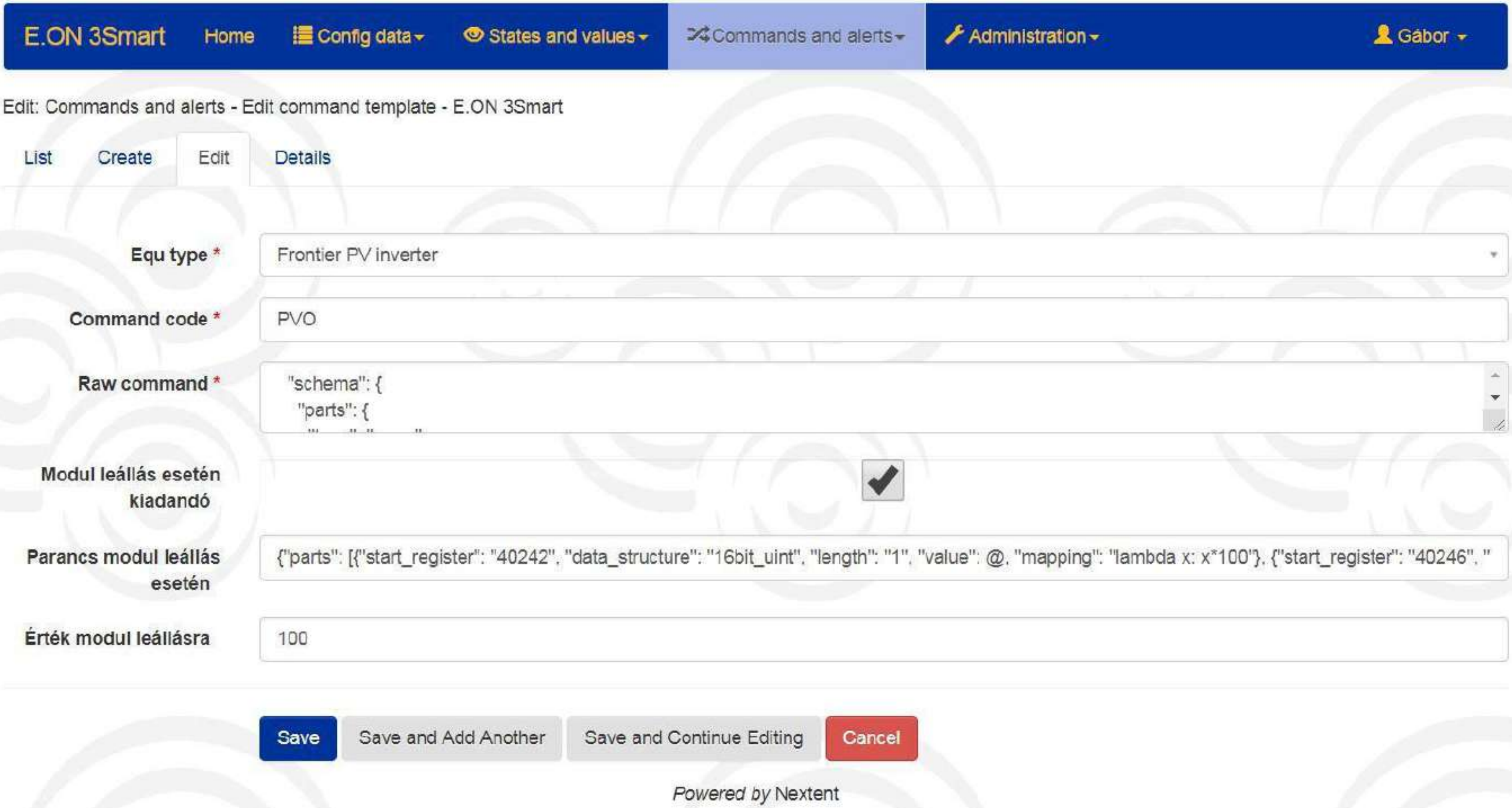
[A State now]



[B+C State now]



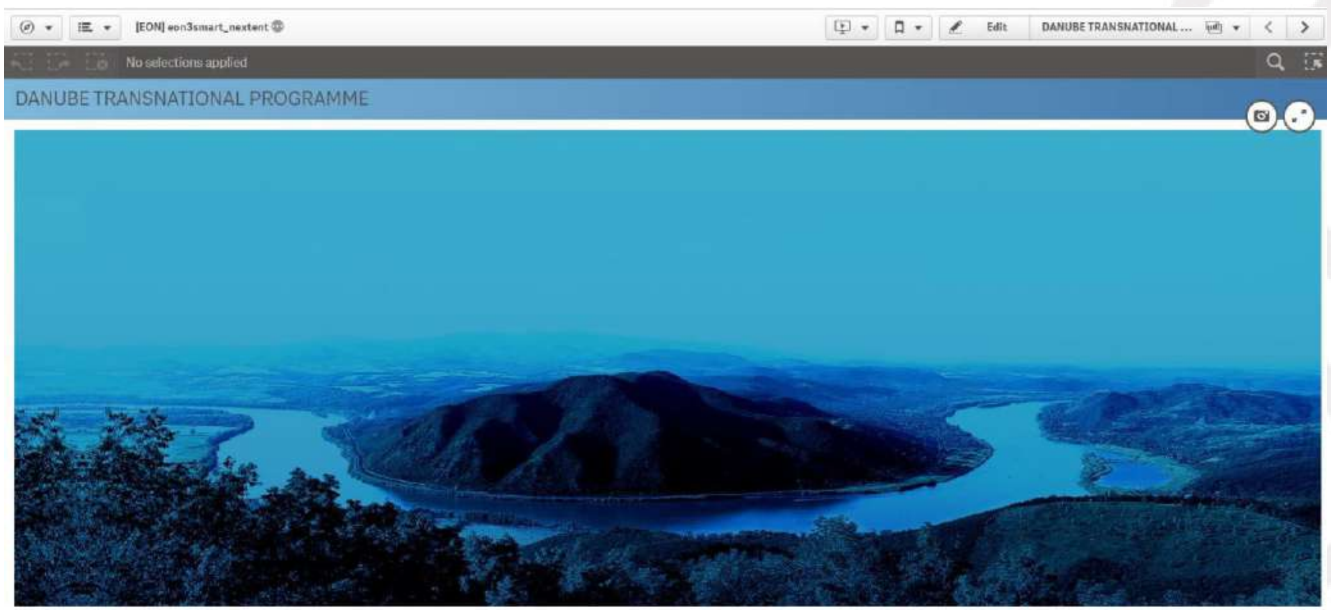
IT platform for data acquisition/control



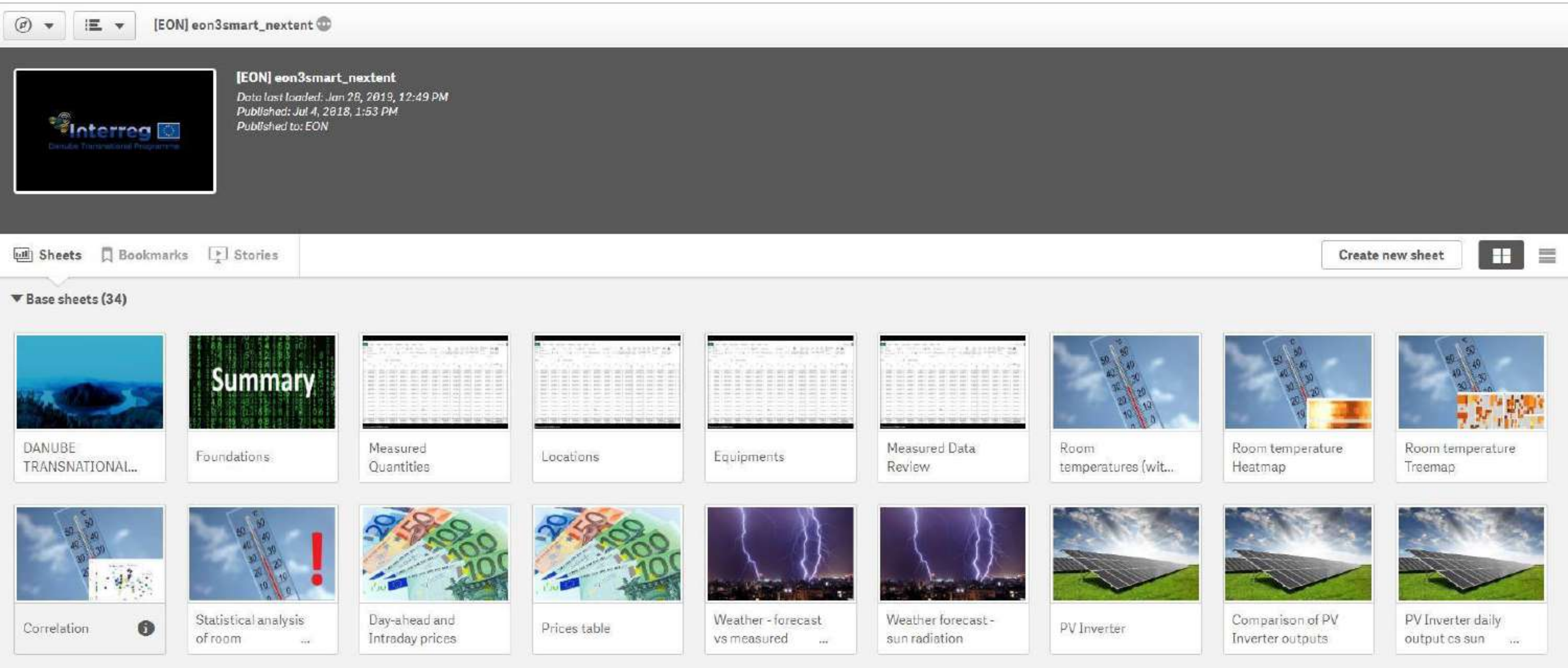
Data visualisation based on IT platform

Analytical and visualization tool for the 3Smart system – Qlik (system administrators)

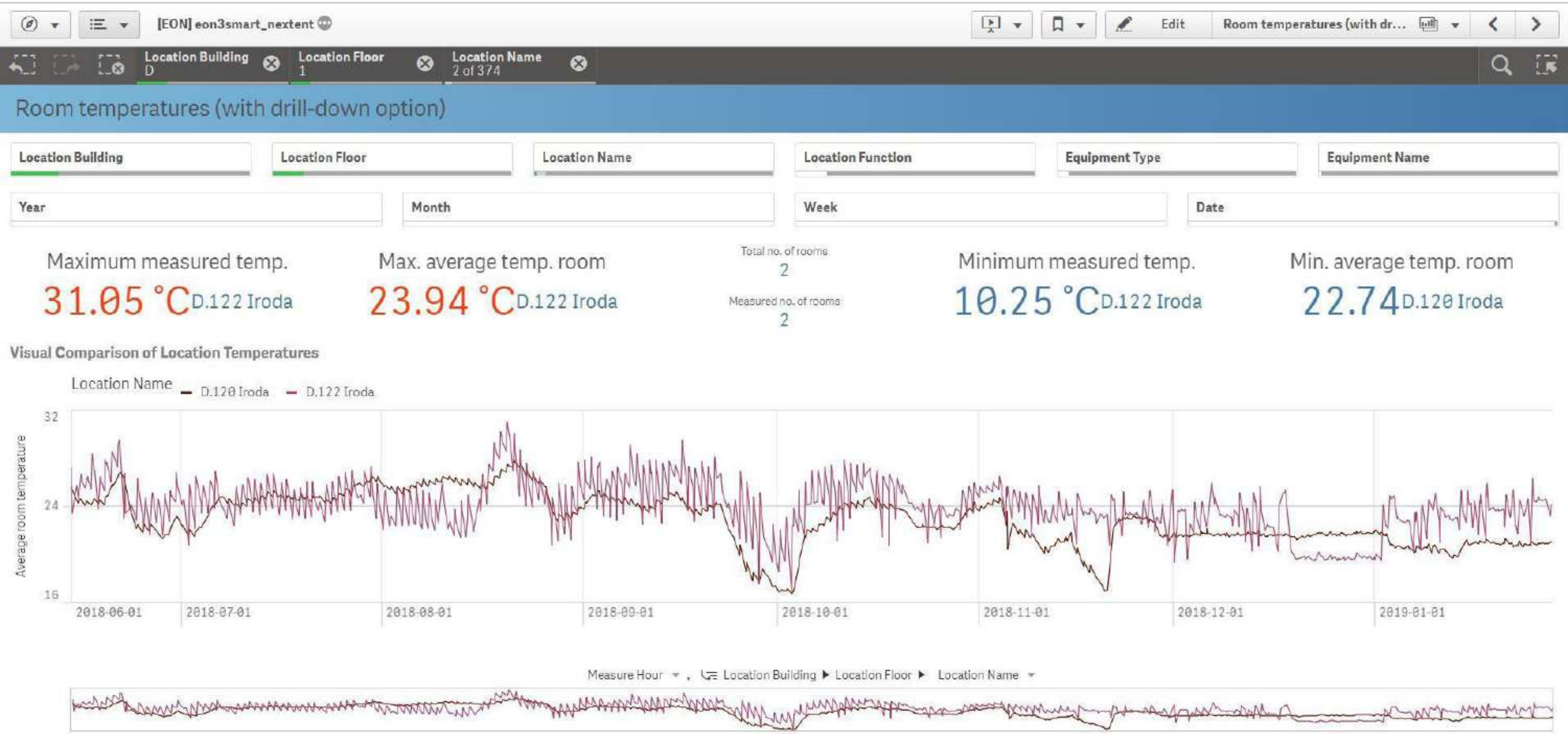
- This software is a second interface for the 3Smart system. This software is a business intelligence application for analysis and visualization based on historical data. The application uses the 3Smart database, reads the data once a day. The most recent data available is always from the previous day.
- This is a web-based application (thin client), no installation is needed and can be accessed by using a secure connection. Hungarian and English language is available.
- The Qlik software supports benchmarking and technical analysis.
- The user-friendly design allows many ways for the analyst to prepare relevant and detailed reports and analyses.



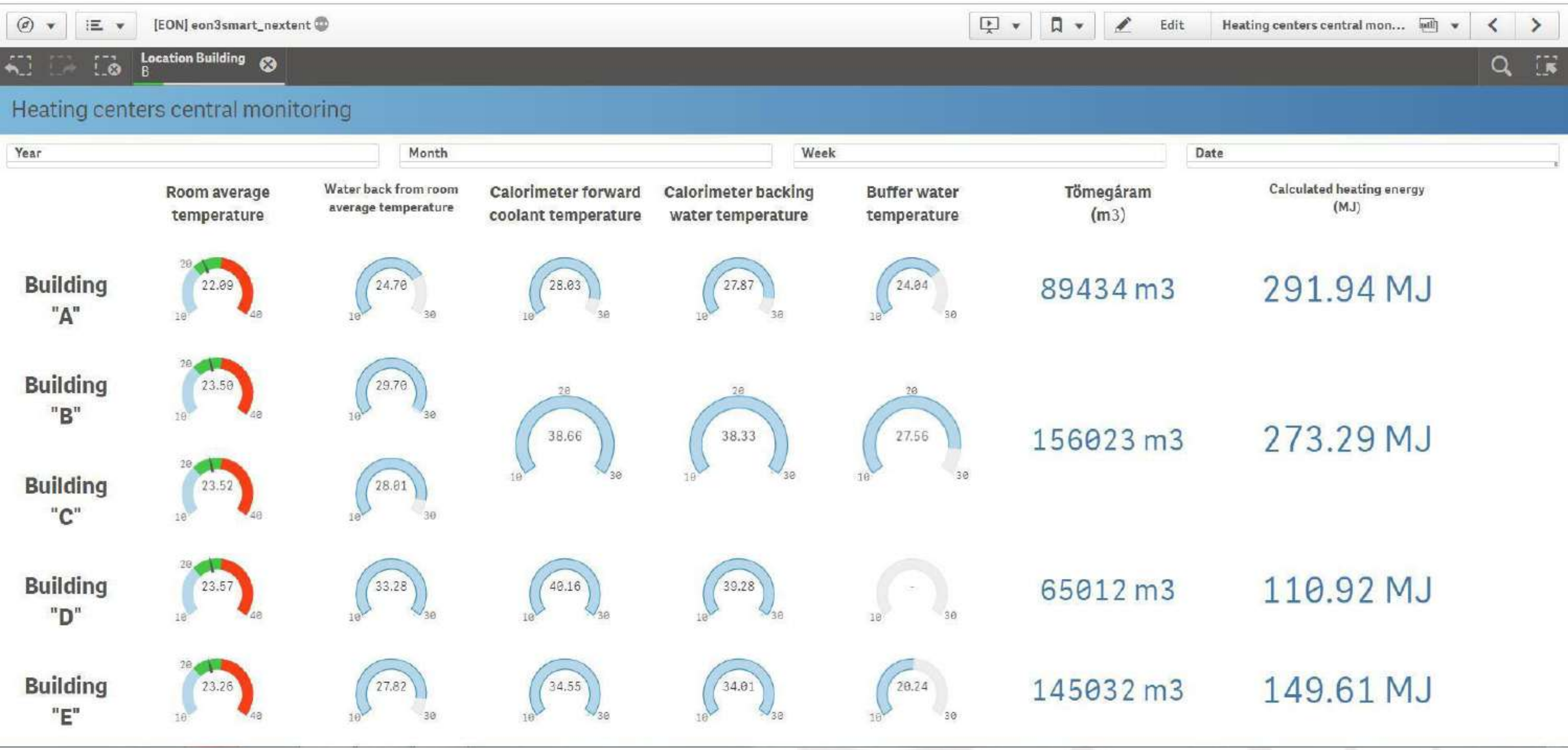
Data visualisation based on IT platform



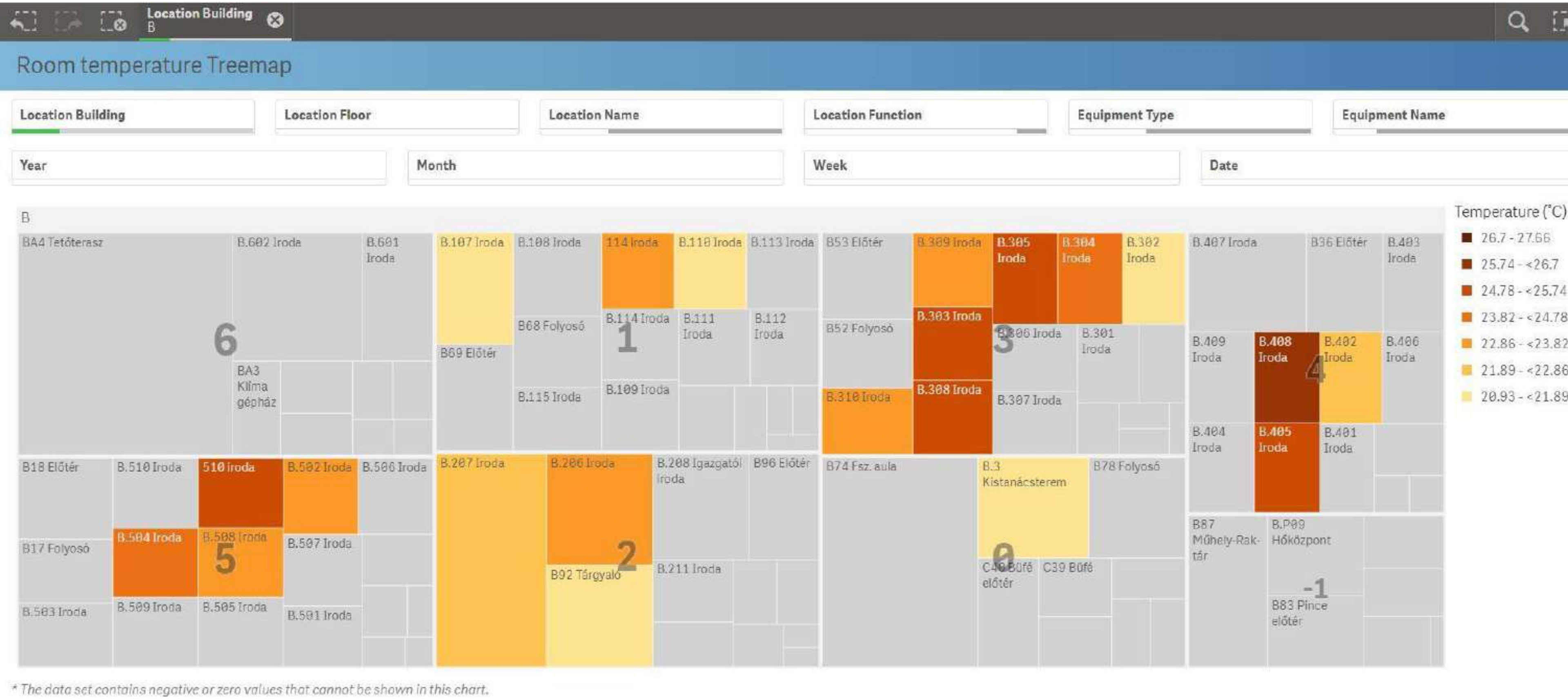
Data visualisation based on IT platform



Data visualisation based on IT platform



Data visualisation based on IT platform



Connection with grid side modules

Originally Short term and Long term grid side modules were planned to integrate into the IT platform, but finally both kind of grid side module were handled separatelly from development and application point of view.

- **Long term:** seperated application and workflow, in connection with 3Smart database

- **Short term:** seperated softwares (Neplan, Gurobi, Plotly) and codes in connection with 3Smart database

We can follow and monitor the behaviour of the building and see the context between the grid and building side operation through the IT paltform and Qlik.

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

Andras Mucsi/Gabor Papp

University of Debrecen/EON Tiszántúli Áramhálózati Zrt.

mucsi.andras@science.unideb.hu

First pilot study visit to the Hungarian pilot

February 5-6, 2019.

Interreg
EUROPEAN UNION
Danube Transnational Programme
3Smart

e·on

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

SCADA – Equipment list

E.ON 3Smart | Kezdőlap | Törzsadatok | Állapotok és értékek | Parancsok és riasztások | Adminisztráció | András

List: Törzsadatok - Eszközök - E.ON 3Smart

Lista (158) | Létrehozása | Exportálás | Szűrő hozzáadása | A kiválasztott | Keresés

		Azonosító	Név	Eszköz kód	IP cím	Alcím	Típus	Modul	Szoba
		1	ROOM_TEMP 5C:CF:7F:30:5C:E6 E85 D VIRT (0/2/0)	192.168.2.114/1-1-96	192.168.2.114	0	Szoba hőmérséklet mérő	ZONE	D VIRT
		2	ROOM_TEMP 5C:CF:7F:30:5C:C2 A38 (0/1/0)	192.168.2.123/1-1-123	192.168.2.123	0	Szoba hőmérséklet mérő	ZONE	A38
		3	ROOM_TEMP 5C:CF:7F:30:5C:C4 D73 (0/1/0)	192.168.2.130/1-1-124	192.168.2.130	0	Szoba hőmérséklet mérő	ZONE	D73
		4	ROOM_TEMP 5C:CF:7F:30:5C:C5 A28 (0/1/0)	192.168.2.124/1-1-101	192.168.2.124	0	Szoba hőmérséklet mérő	ZONE	A28
		5	ROOM_TEMP 5C:CF:7F:30:5C:C6 B91 (0/0/0)	192.168.2.143/1-1-97	192.168.2.143	0	Szoba hőmérséklet mérő	ZONE	B91
		8	ROOM_TEMP 5C:CF:7F:30:5E:A5 B66 (0/1/0)	192.168.2.117/1-1-116	192.168.2.117	0	Szoba hőmérséklet mérő	ZONE	B66
		9	ROOM_TEMP 5C:CF:7F:30:5E:A7 C03 (0/1/0)	192.168.2.116/1-1-117	192.168.2.116	0	Szoba hőmérséklet mérő	ZONE	C03
		10	ROOM_TEMP 5C:CF:7F:30:5E:A8 A39 (0/1/0)	192.168.2.122/1-1-121	192.168.2.122	0	Szoba hőmérséklet mérő	ZONE	A39
		11	ROOM_TEMP 5C:CF:7F:30:5E:AC E32 (0/0/0)	192.168.2.149/1-1-106	192.168.2.149	0	Szoba hőmérséklet mérő	ZONE	E32
		13	ROOM_TEMP 5C:CF:7F:30:60:A2 D29 (0/1/0)	192.168.2.150/1-1-107	192.168.2.150	0	Szoba hőmérséklet mérő	ZONE	D29

SCADA – Location list

E.ON 3Smart | Kezdőlap | Törzsadatok | Állapotok és értékek | Parancsok és riasztások | Adminisztráció | András

List: Törzsadatok - Helyszinek - E.ON 3Smart

Lista (374) | Létrehozása | Exportálás | Szűrő hozzáadása | A kiválasztott | Keresés

		Azonosító	Név	E.ON kód	Épület	Emelet	Alapterület	Belmagasság	Fukció	X koordináta	Y koordináta
		1	A01 Pinceklub	A01	A	-1	74.93	2.4	Szociális helyiség	2680	1220
		2	A02 Raktár	A02	A	-1	7.26	2.4	Raktár	2500	1370
		3	A04 Lépcső	A04	A	-1	6.39	2.4	Közlekedő terek	2570	1330
		4	A05/1 Bejárat - szélfogó	A05/1	B	0	5.6	3.8	Közlekedő terek	2620	525
		5	A.1 Iroda	A05	A	0	22.46	3.8	Iroda	2700	1330
		6	A.2 Iroda	A06	A	0	18.76	3.8	Iroda	2720	1445
		7	A07 Női Wc	A07	A	0	9.2	3.8	Iroda	2575	1450
		8	A08 Raktár	A08	A	0	3.46	3.8	Raktár	2625	1455
		9	A09 FF Wc	A09	A	0	9.54	3.8	Szociális helyiség	2480	1450
		10	A10 Folyosó	A10	A	0	25.33	3.8	Közlekedő terek	2570	1350
		11	A11 Nagytanácsterem	A11	C	0	166.69	3.3	Tárgyaló	2185	1175
		12	A12 Ruhatár	A12	A	0	17.61	3.8	Szociális helyiség	2700	1245
		13	A13 Lépcső	A13	A	1	19.17	3.75	Közlekedő terek	2430	1360
		14	A.101 Iroda	A14	A	1	12.82	3.75	Iroda	2510	1460
		15	A.102 Iroda	A15	A	1	21.27	3.75	Iroda	2710	1460

SCADA – Current measured values

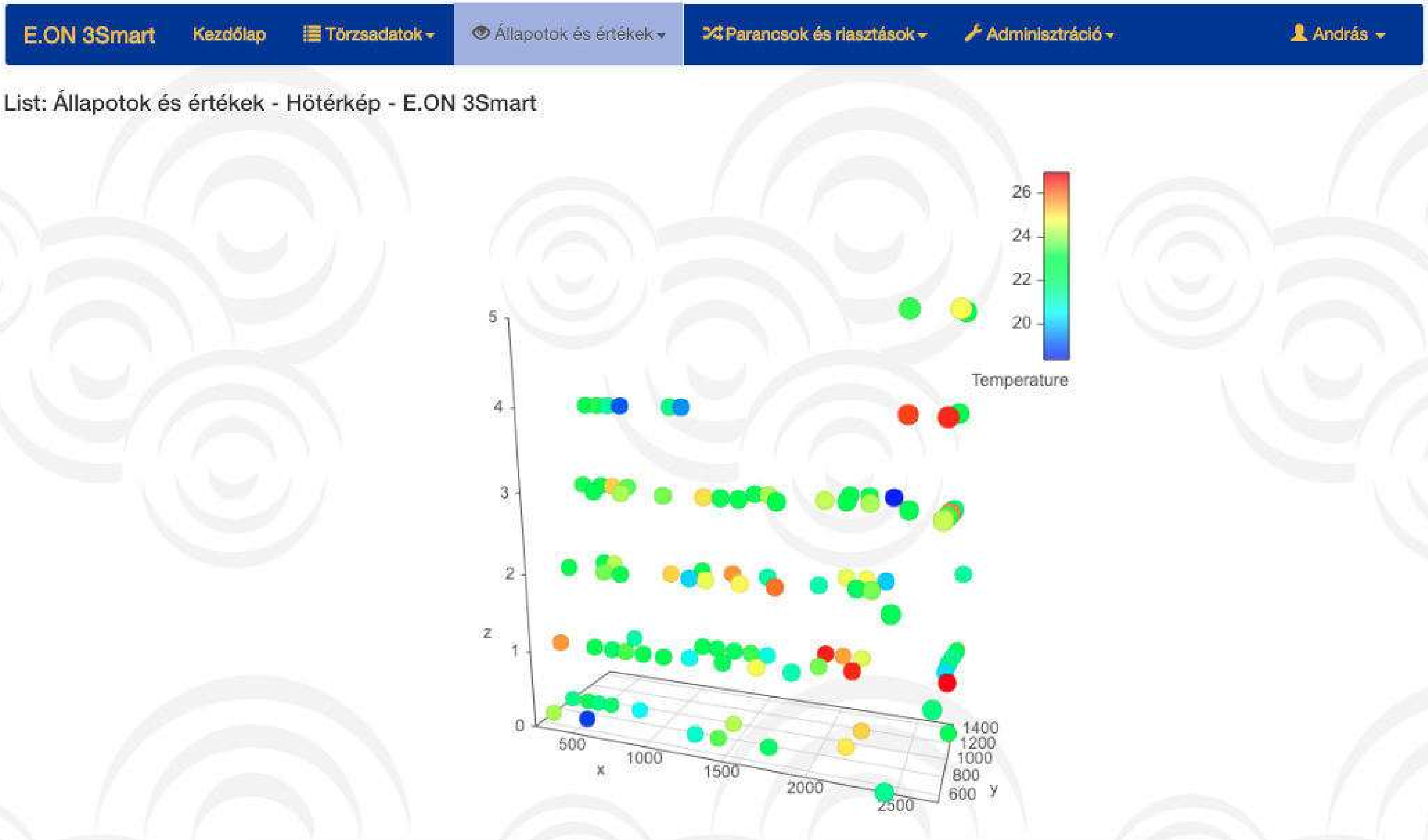
E.ON 3Smart | Kezdőlap | Törzsadatok | Állapotok és értékek | Parancsok és riasztások | Adminisztráció | András

List: Állapotok és értékek - Pillanatnyi adatok - E.ON 3Smart

Lista (372) | Exportálás | Szűrő hozzáadása | Keresés

	Utolsó mérés időpontja	Eszköz kód	Mért jellemző kódja	E.ON kód	Épület	Emelet	Utolsó mért érték
	2019-02-12 09:31:40	192.168.0.34:502/34	HSI4	E VIRT	E	-1	31.3696
	2019-02-12 09:31:40	192.168.0.34:502/31	HSI4	A VIRT	A	-1	20.6175
	2019-02-12 09:31:40	192.168.0.34:502/33	HSI4	D VIRT	D	-1	18.2831
	2019-02-12 09:31:41	192.168.0.34:502/64	HSI5	E VIRT	E	-1	25.0
	2019-02-12 09:31:41	192.168.0.34:502/62	HSI5	B+C VIRT	B	-1	41.0
	2019-02-12 09:31:41	192.168.0.34:502/63	HSI5	D VIRT	D	-1	27.0
	2019-02-12 09:31:42	192.168.0.36:502/101	WSI5				320.0
	2019-02-12 09:31:42	192.168.0.36:502/102	WSI4				4.0
	2019-02-12 09:31:43	192.168.0.36:502/104	WSI1				277.0
	2019-02-12 09:31:43	192.168.0.36:502/105	WSI2				220.0
	2019-02-12 09:31:43	192.168.0.36:502/103	WSI3				5.2
	2019-02-12 09:31:44	192.168.0.36:502/103	WSI6				999.9
	2019-02-12 09:31:44	192.168.0.36:502/103	WSI7				70.5
	2019-02-12 09:31:45	192.168.0.35:502/255	PMI1				161523.0
	2019-02-12 09:31:45	192.168.0.34:502/62	CHI1	B+C VIRT	B	-1	64.9525

SCADA – 3D map of values



SCADA – Heat center view

SCADA – Commands

E.ON 3Smart   Kezdőlap   Törzsadatok ▾   Állapotok és értékek ▾   Parancsok és riasztások ▾   Adminisztráció ▾   András ▾

List: Parancsok és riasztások - Parancs sablonok szerkesztése - E.ON 3Smart

Lista (8)   Létrehozása   Szűrő hozzáadása ▾   A kiválasztott ▾   Keresés

		Azonosító	Parancs kodja	Eszköz típus	Nyers parancs struktúra	Modul leállás esetén kiadandó	Érték modul leállásra	Parancs modul leállás esetén
		2	PVO	Frontier PV inverter	"schema": { "parts": { "type": "array", "items": { "type": "object", "properties": { "start_register": { "type": "hidden"}, "value": { "type": "integer", "title": "{{idx}}. Value"}, "length": { "type": "hidden"}, "data_structure": { "type": "hidden"}, "mapping": { "type": "hidden" } } } } }, "value": { "parts":[{"start_register":40242, "value": 100,"length": 1, "data_structure":"16bit_uint", "mapping": "lambda x: x*100"}, {"start_register":40246, "value": 0,"length": 1, "data_structure": "16bit_int", "mapping": "lambda x: x"}, {"start_register":40246, "value": 1,"length": 1, "data_structure": "16bit_int", "mapping": "lambda x: x"}] }	✓	100	{"parts": [{"start_register": "40242", "data_structure": "16bit_uint", "length": "1", "value": @, "mapping": "lamb x: x*100"}, {"start_register": "40246", "data_structure": "16bit_int", "lengtl "1", "value": 0, "mapping": "lamb x: x"}, {"start_register": "40246", "data_structure": "16bit_int", "lengtl "1", "value": 1, "mapping": "lamb x: x"}]}

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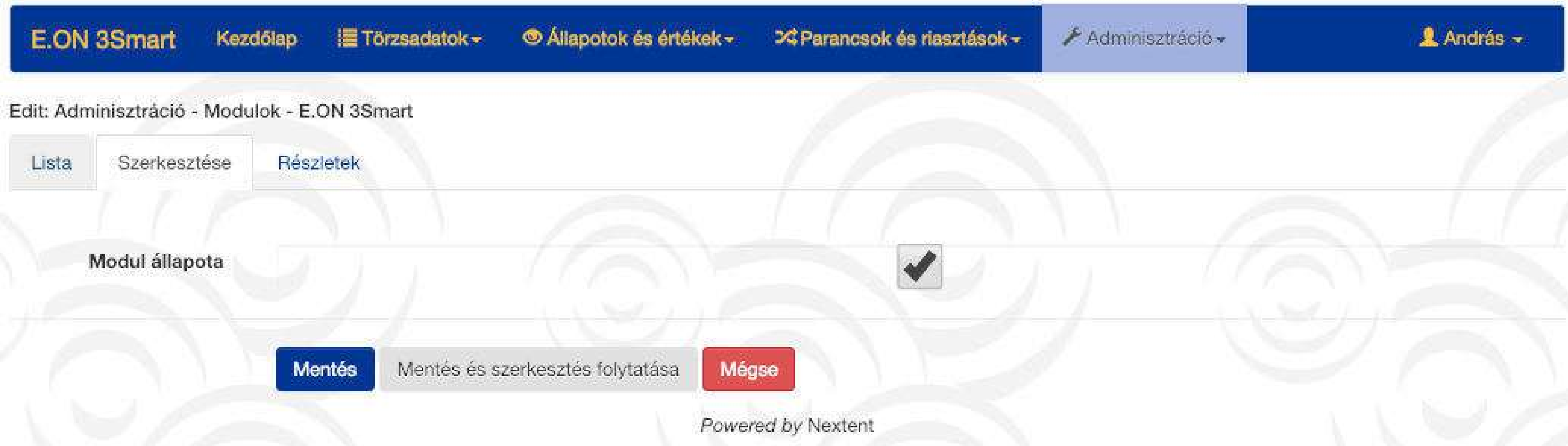
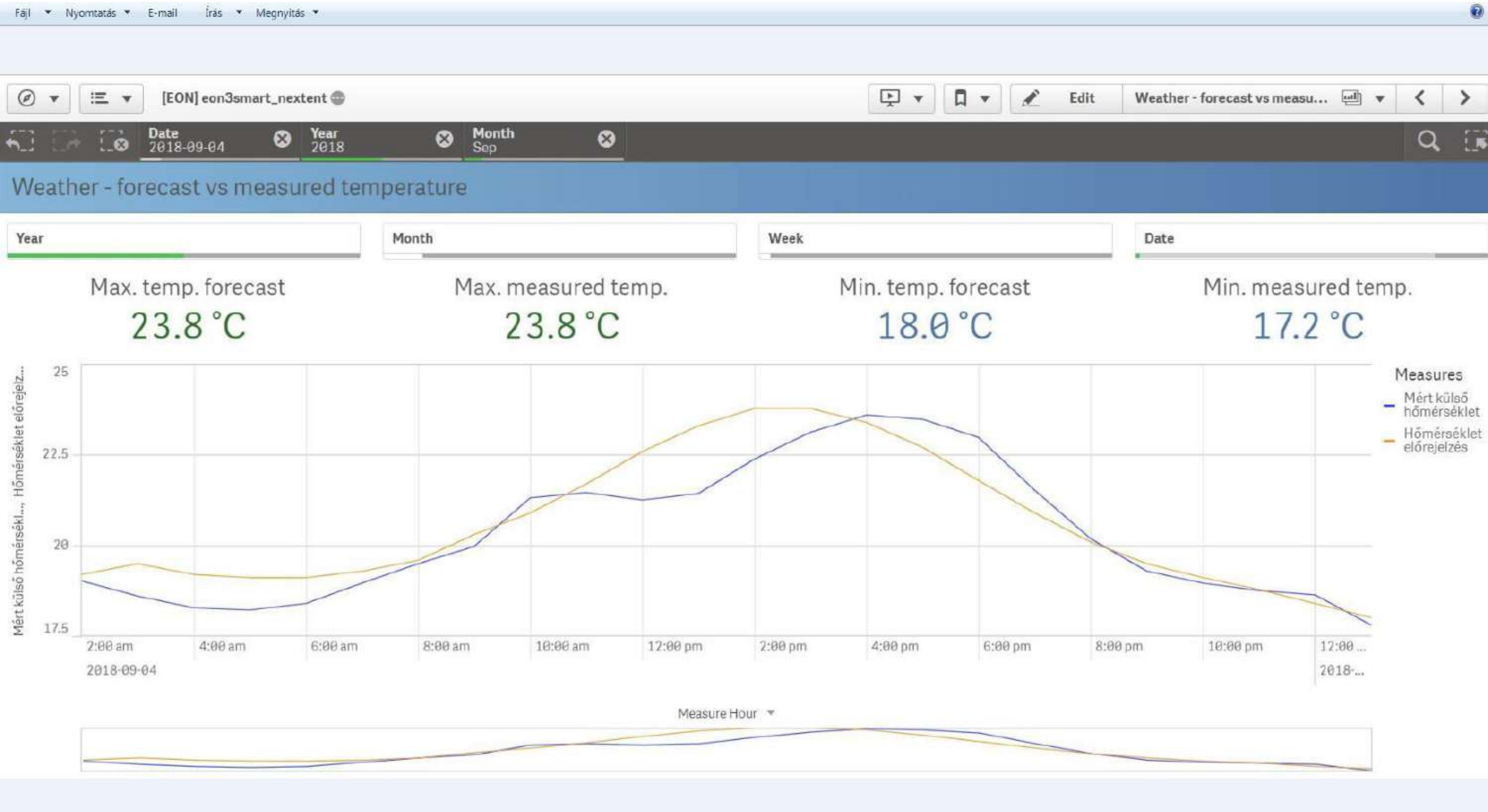
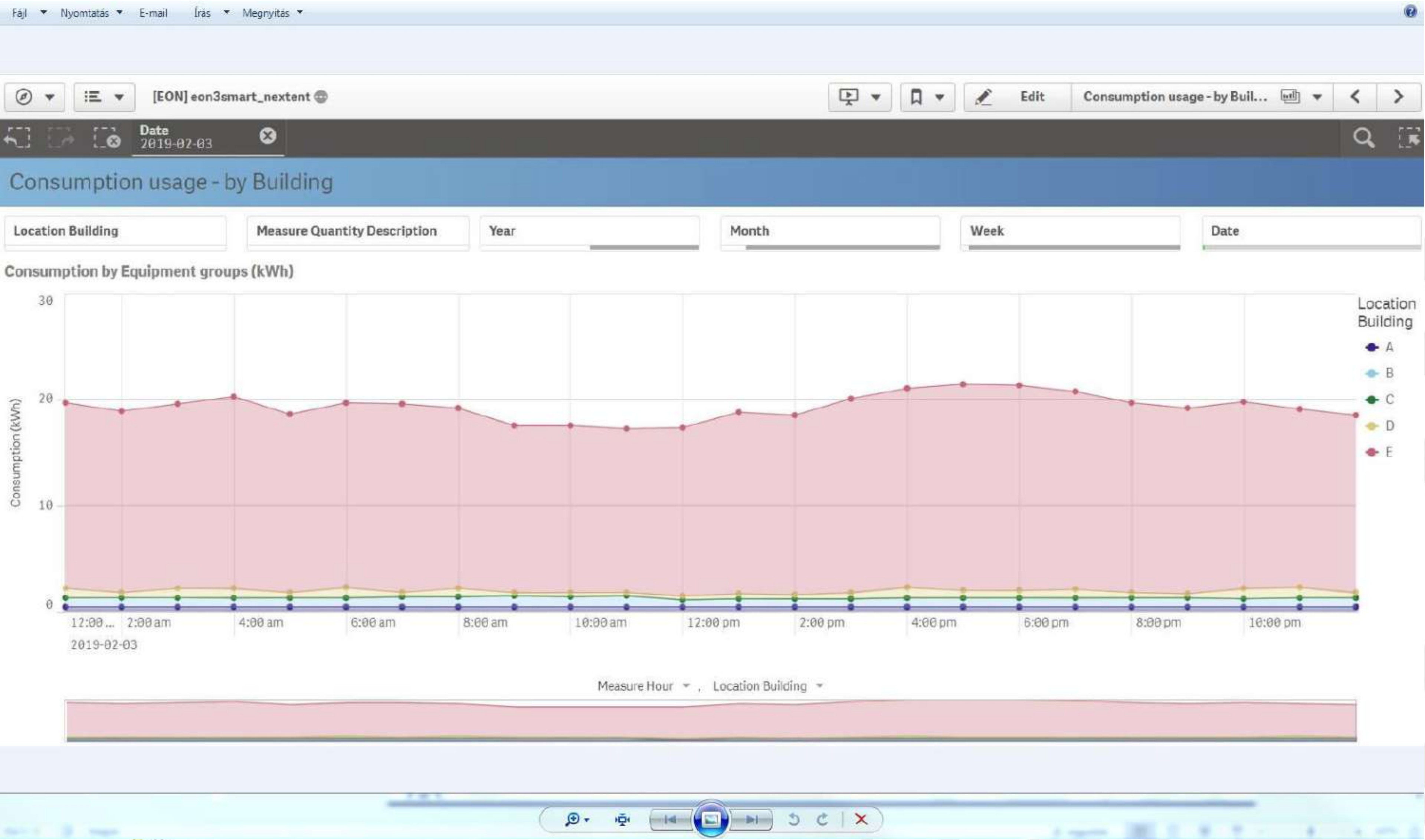
SCADA – Module state (Software switch)



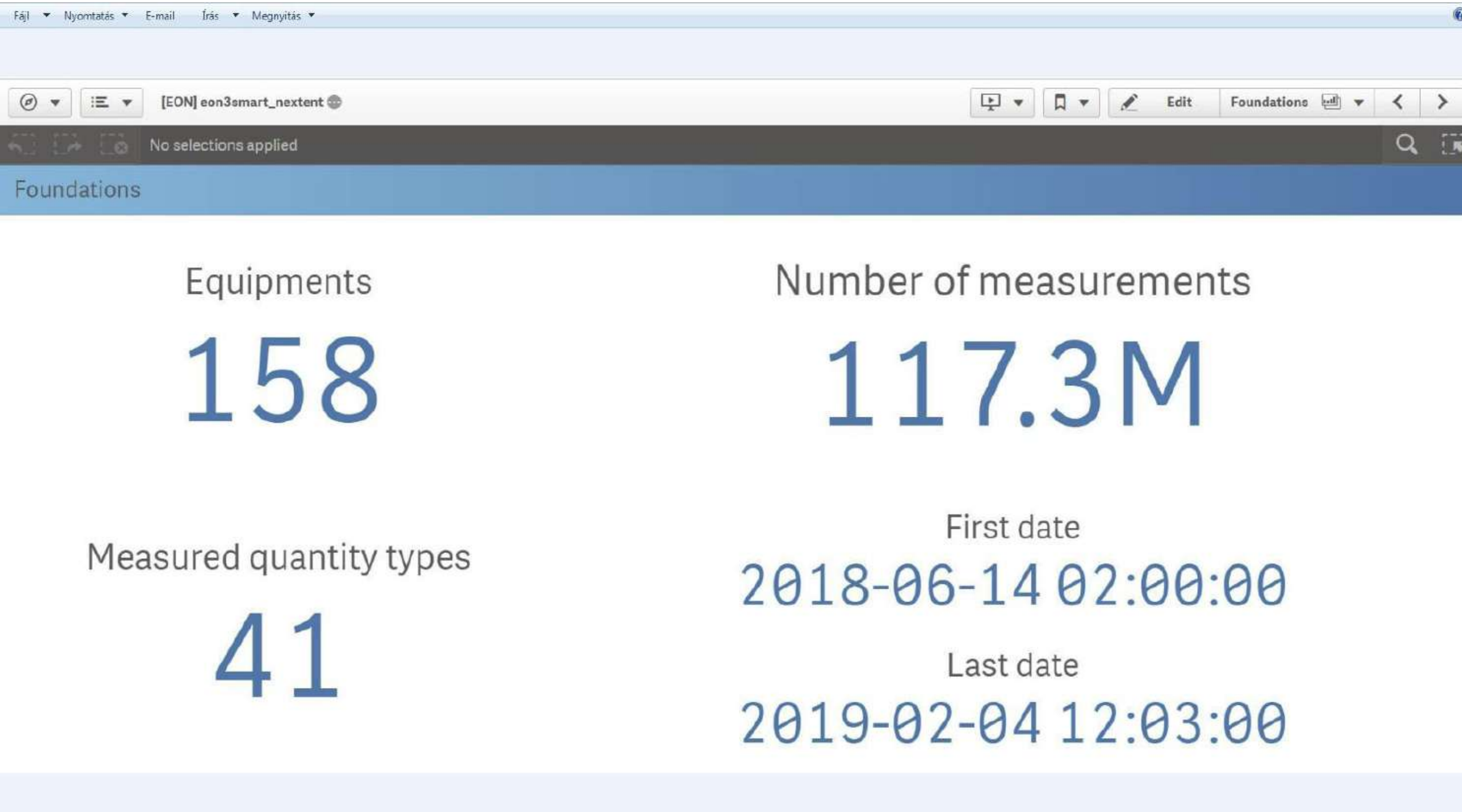
Qlik – BI tool for visualization and analitics



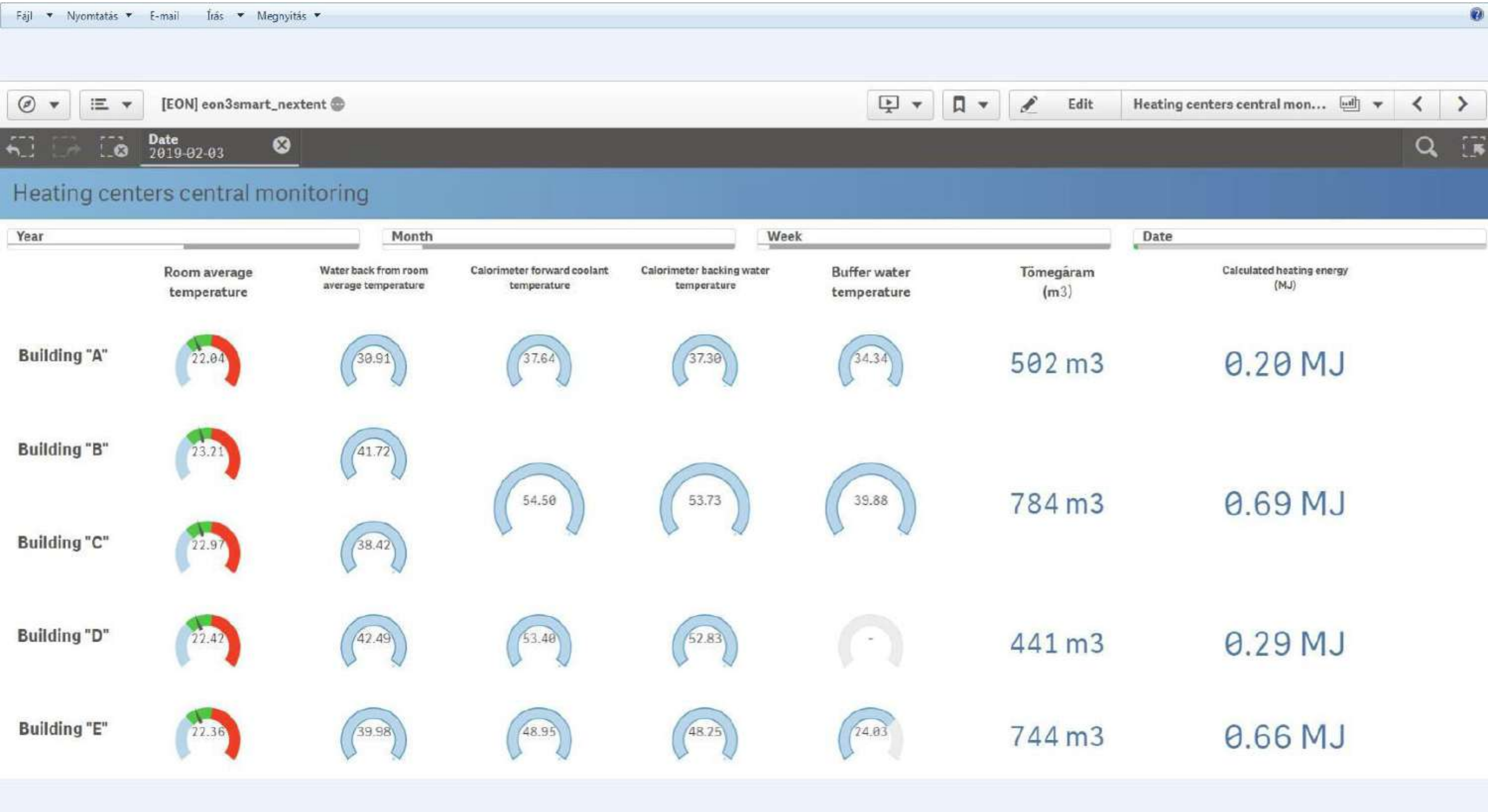
Qlik – BI tool for visualization and analitics



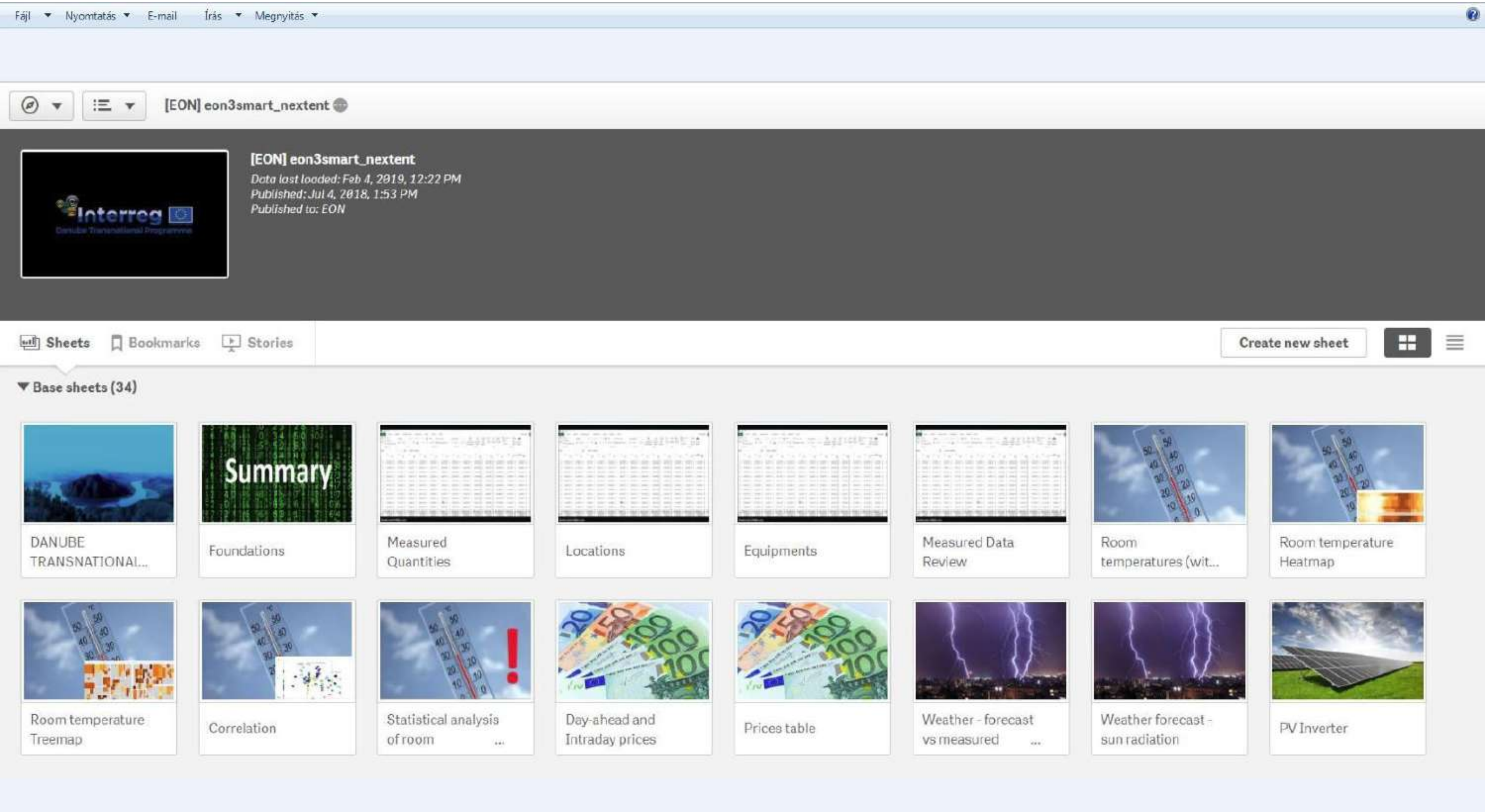
Qlik – BI tool for visualization and analitics



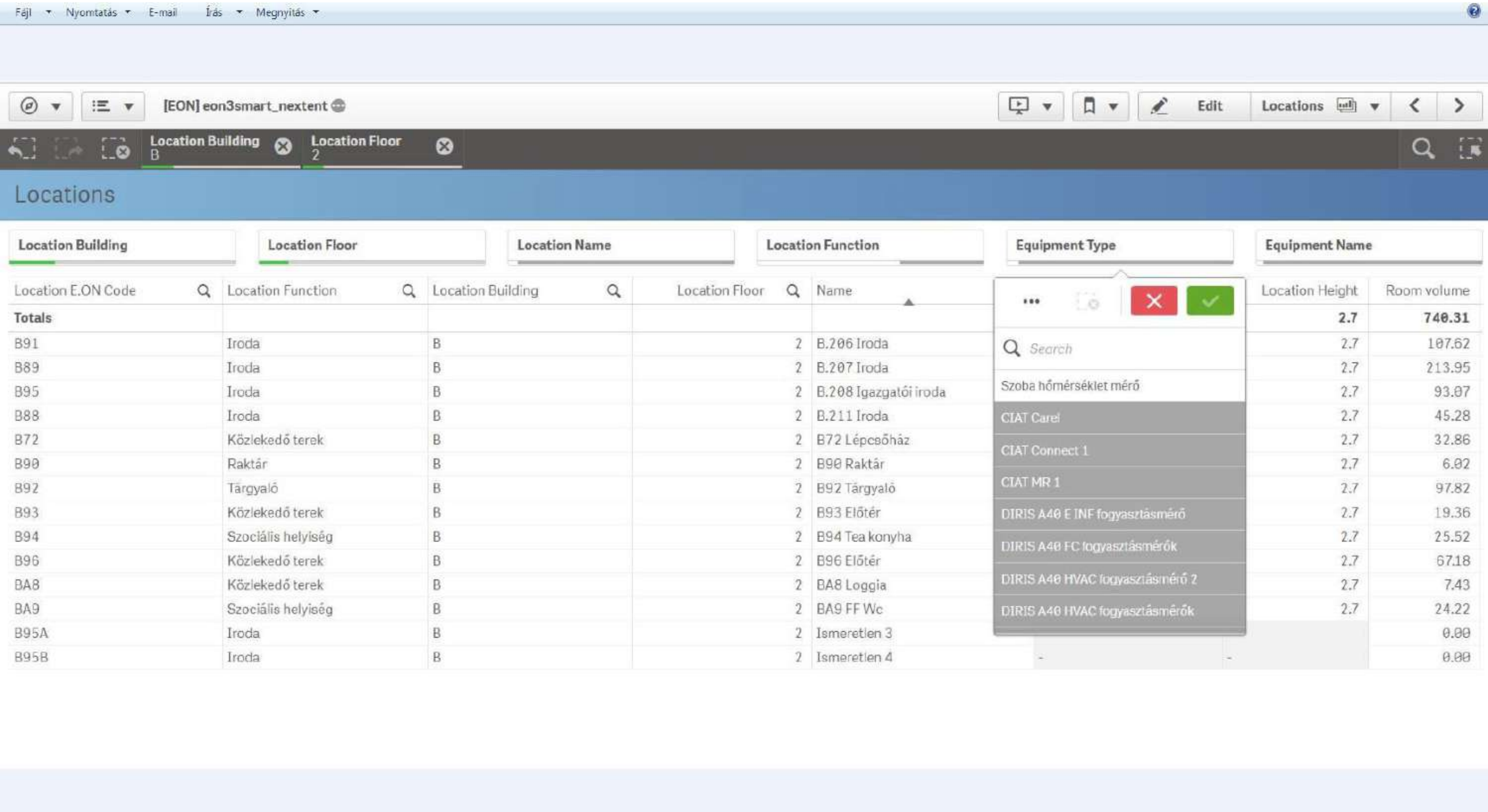
Qlik – BI tool for visualization and analitics



Qlik – BI tool for visualization and analitics

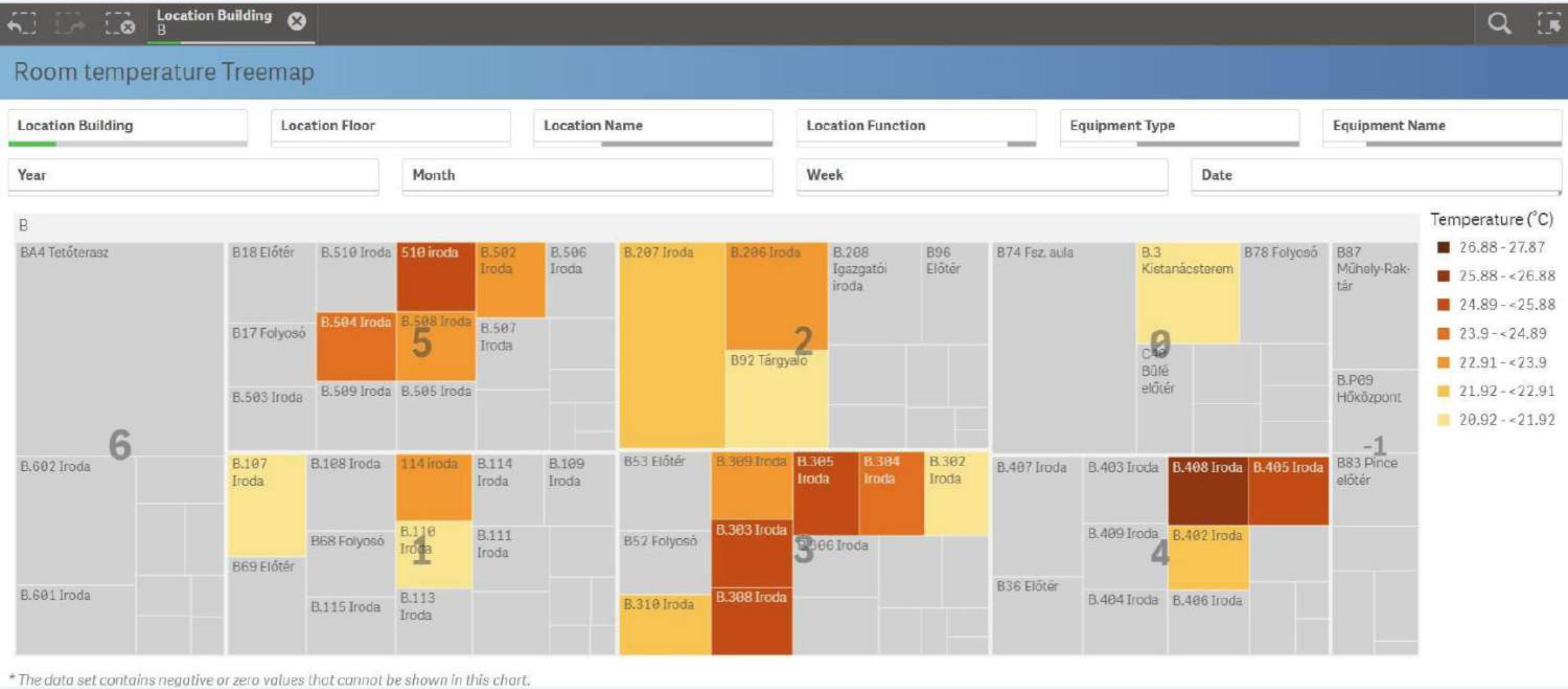


Qlik – BI tool for visualization and analitics

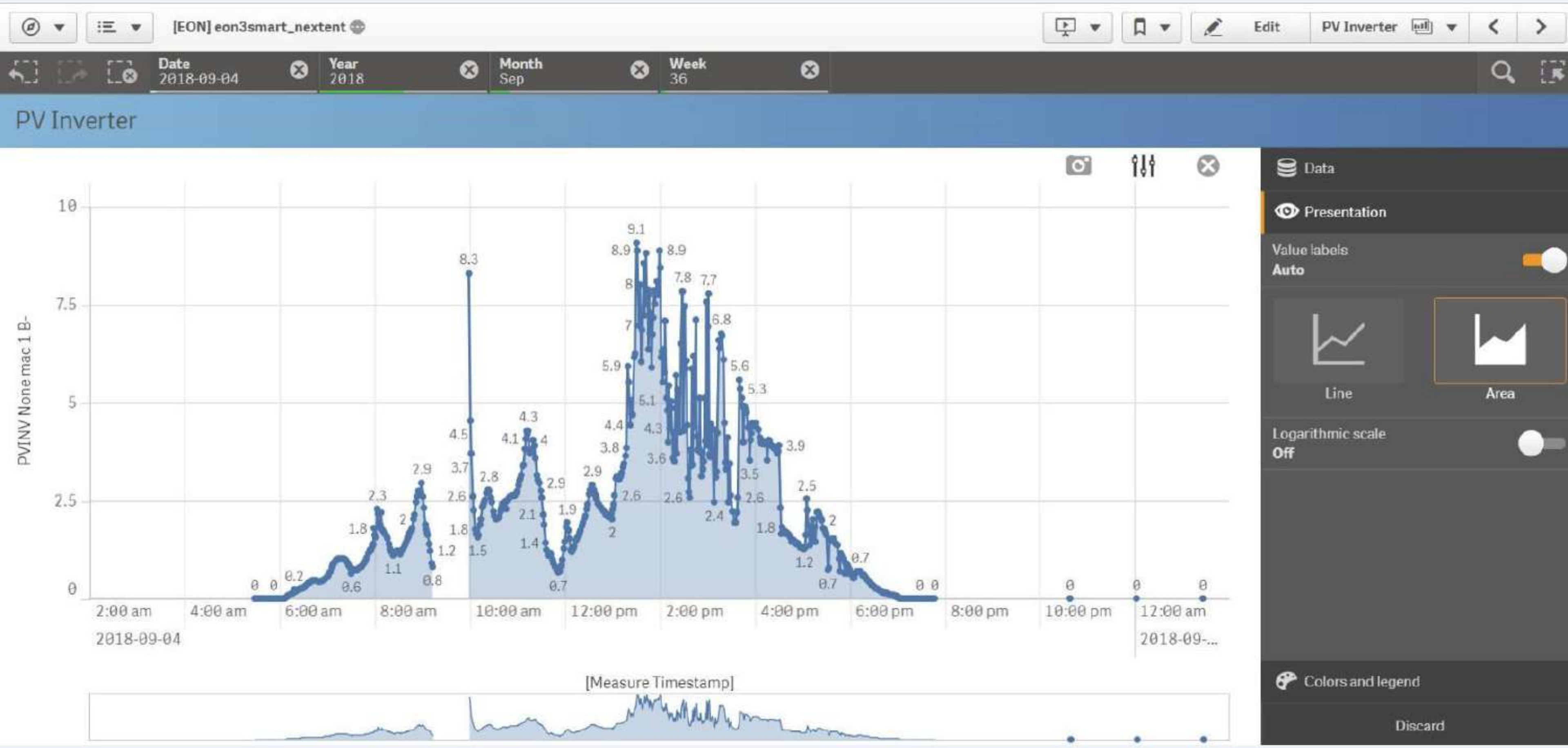


Location E.ON Code	Location Function	Location Building	Location Floor	Name	Location Height	Room volume
Totals					2.7	740.31
B91	Iroda	B	2	B.206 Iroda	2.7	107.62
B89	Iroda	B	2	B.207 Iroda	2.7	213.95
B95	Iroda	B	2	B.208 Igazgatói iroda	2.7	93.07
B88	Iroda	B	2	B.211 Iroda	2.7	45.28
B72	Közlekedő terek	B	2	B72 Lépcsőház	2.7	32.86
B90	Raktár	B	2	B90 Raktár	2.7	6.02
B92	Tárgyaló	B	2	B92 Tárgyaló	2.7	97.82
B93	Közlekedő terek	B	2	B93 Előtér	2.7	19.36
B94	Szociális helyiség	B	2	B94 Tea konyha	2.7	25.52
B96	Közlekedő terek	B	2	B96 Előtér	2.7	67.18
BA8	Közlekedő terek	B	2	BA8 Loggia	2.7	7.43
BA9	Szociális helyiség	B	2	BA9 FF Wc	2.7	24.22
B95A	Iroda	B	2	Ismeretlen 3		0.00
B95B	Iroda	B	2	Ismeretlen 4		0.00

Qlik – BI tool for visualization and analitics



Qlik – BI tool for visualization and analitics



Qlik – BI tool for visualization and analitics

Short term modules coordination on the sides of E.ON

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3Smart – First pilot visit Debrecen

05. – 06.02.2019

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UNIVERSITY OF ZAGREB FACULTY OF ELECTRICAL ENGINEERING AND COMPUTING

Interreg Danube Transnational Programme 3Smart

Project co-funded by the European Union

Content

- Short-term Day-ahead module
  - Model architecture
  - Database overview
  - Communication model

- Short-term Intra-day module
  - Model architecture
  - Database overview
  - Communication model

SHORT TERM DAY-AHEAD MODULE

Short-term Day-Ahead Module

- Day – to – day operation module for determining building flexibility potential as the distribution network/system operator asset:
  - Interconnection with long term module and receiving flexibility requirements
  - Defined 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 contract)

ST Day-Ahead Module Input

- Neplan project (.nepprj):
  - Neplan_extension.dll *runs load-flow analysis with profiles* and exports results and grid information in MySQL
    - Prepare data for ACOPF
  - Neplan conditions:
    - Radial network with one-feeder
    - Lines, nodes and substations named with short-label and index from 0 to n

ST Day-Ahead Module Input (1)

- From Neplan:
  - Grid information (grid topology, lines descriptions)
  - Active and reactive power profiles for every node defined for specific days during the year (3 characteristics profiles for each moth)
- From Long-term contract:
  - Building flexibility table

Module coordination

- Day before delivery of electricity
  - At **11.00 AM** (UTC) HUPX publish (at 10:40 UTC) the Day-Ahead prices
  - „Retailer” gather the data, extend hourly prices to 15 min prices, convert prices to EUR/kWh and **store** into table „Retailer to building DA prices” in „Retailer” DB

Retailer database outlook

retailer on postgres@3s_grid

```sql
SELECT * FROM public.retailer_to_building_da_prices
```

Data Output | Explain | Messages | Notifications | Query History

	id [PK] integer	retailer_id integer	profile character varying (2000)	profile_created_at timestamp without time zone
1	7	1	{"DA prices": [0.0437, 0.0437,...	2019-02-03 11:48:50.887972

{"DA prices": [0.0437, 0.0437, 0.0437, 0.0437, 0.04137, 0.04137, 0.04137, 0.04137, 0.04048, 0.04048, 0.04048, 0.04048, 0.03921, 0.03921, 0.03921, 0.03921, 0.03855, 0.03855, 0.03855, 0.03855, 0.04072, 0.04072, 0.04072, 0.04072, 0.04923, 0.04923, 0.04923, 0.04923, 0.07315, 0.07315, 0.07315, 0.07315, 0.07963, 0.07963, 0.07963, 0.07963, 0.08009, 0.08009, 0.08009, 0.08009, 0.07233, 0.07233, 0.07233, 0.07233, 0.067, 0.067, 0.067, 0.067, 0.06178, 0.06178, 0.06178, 0.06178, 0.06104, 0.06104, 0.06104, 0.06104, 0.06481, 0.06481, 0.06481, 0.06481, 0.06495, 0.06495, 0.06495, 0.06495, 0.06815, 0.06815, 0.06815, 0.06815, 0.10107, 0.10107, 0.10107, 0.10107, 0.07727, 0.07727, 0.07727, 0.07727, 0.07066, 0.07066, 0.07066, 0.07066, 0.06623, 0.06623, 0.06623, 0.06623, 0.0441, 0.0441, 0.0441, 0.0441, 0.0431, 0.0431, 0.0431, 0.0431, 0.0361, 0.0361, 0.0361, 0.0361], "Measuring unit": "EUR/kWh", "Valid from": "2019-02-03 23:00:00"}

```sql
SELECT * FROM public.retailer_to_building_da_prices_history
```

Data Output | Explain | Messages | Notifications | Query History

	id [PK] integer	retailer_id integer	profile character varying (2000)	profile_created_at timestamp without time zone
11	19	1	{"DA prices": [0.04202, 0.042...	2019-01-07 17:30:05.478255
12	20	1	{"DA prices": [0.06251, 0.062...	2019-01-08 17:30:05.478251
13	21	1	{"DA prices": [0.05846, 0.058...	2019-01-09 17:30:05.478278
14	22	1	{"DA prices": [0.06166, 0.061...	2019-01-10 17:30:05.4782
15	23	1	{"DA prices": [0.0651, 0.0651...	2019-01-11 17:30:05.51782
16	24	1	{"DA prices": [0.06344, 0.063...	2019-01-12 17:30:05.51782
17	25	1	{"DA prices": [0.05306, 0.053...	2019-01-13 17:30:05.51782
18	26	1	{"DA prices": [0.06214, 0.062...	2019-01-14 17:30:05.51782
19	27	1	{"DA prices": [0.06669, 0.066...	2019-01-15 17:30:05.51782
20	28	1	{"DA prices": [0.08001, 0.080...	2019-01-16 17:30:05.51782
21	29	1	{"DA prices": [0.06015, 0.060...	2019-01-17 17:30:05.51782
22	30	1	{"DA prices": [0.065, 0.065, 0....	2019-01-18 17:30:05.51782
23	31	1	{"DA prices": [0.06669, 0.066...	2019-01-19 17:30:05.51782
24	32	1	{"DA prices": [0.059, 0.059, 0...	2019-01-20 17:30:05.51782
25	33	1	{"DA prices": [0.07148, 0.071...	2019-01-21 17:30:05.51782
26	34	1	{"DA prices": [0.06157, 0.061...	2019-01-22 17:30:05.51782
27	35	1	{"DA prices": [0.06473, 0.064...	2019-01-23 17:30:05.51782
28	41	1	{"DA prices": [0.06463, 0.064...	2019-01-24 16:09:49.365266
29	42	1	{"DA prices": [0.06463, 0.064...	2019-01-24 16:10:04.599151
30	43	1	{"DA prices": [0.06463, 0.064...	2019-01-24 17:44:04.28671
31	44	1	{"DA prices": [0.06463, 0.064...	2019-01-24 20:27:32.337022
32	45	1	{"DA prices": [0.06463, 0.064...	2019-01-24 20:33:02.049466
33	46	1	{"DA prices": [0.06463, 0.064...	2019-01-24 20:33:22.226096
34	47	1	{"DA prices": [0.06463, 0.064...	2019-01-25 20:34:29.984231
35	48	1	{"DA prices": [0.04464, 0.044...	2019-01-26 18:43:02.694897
36	49	1	{"DA prices": [0.04706, 0.047...	2019-01-27 19:15:46.874447
37	50	1	{"DA prices": [0.04976, 0.049...	2019-01-28 11:19:05.883031
38	51	1	{"DA prices": [0.04701, 0.047...	2019-01-29 19:11:24.47434
39	52	1	{"DA prices": [0.05322, 0.053...	2019-01-31 19:10:06.929731
40	53	1	{"DA prices": [0.05322, 0.053...	2019-02-01 10:28:52.450285
41	54	1	{"DA prices": [0.05016, 0.050...	2019-02-01 20:28:12.850834
42	55	1	{"DA prices": [0.04517, 0.045...	2019-02-02 22:01:37.274
43	56	1	{"DA prices": [0.0437, 0.0437...	2019-02-03 19:48:50.921561

Retailer database outlook

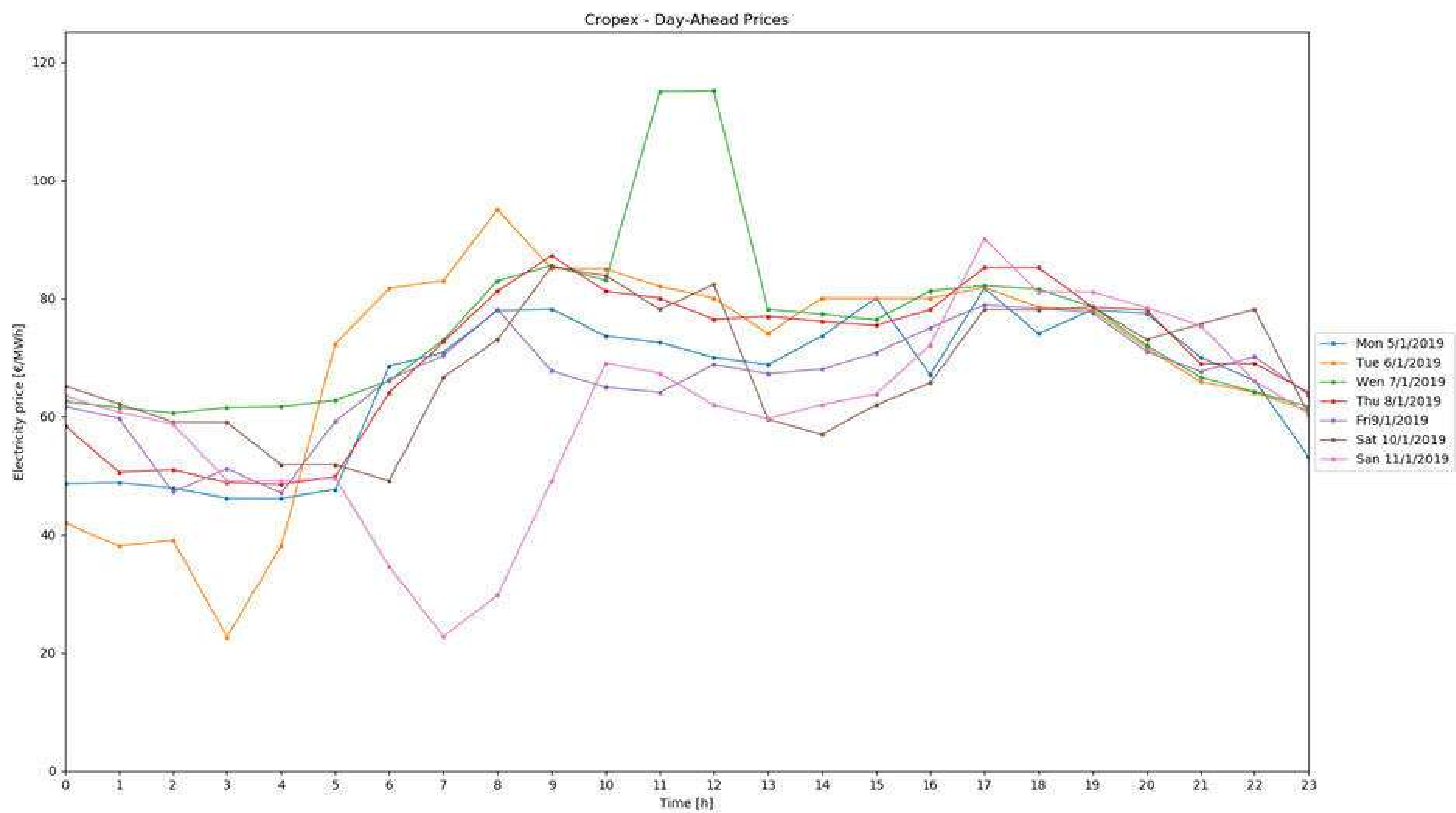
```
SELECT * FROM public.retailer_to_building_da_prices_history
```

retailer on postgres@3s_grid

```
SELECT * FROM public.retailer_to_building_da_prices
```

Data Outp

	id [PK] ir
1	



{"DA pric
0.04137,
0.03921,
0.04072,
0.04923,
0.07963,
0.07233,
0.06178,
0.06481,
0.06495,
0.10107,
0.07066,
0.0441, (
0.0361, (
from": "2

42	55	1	{"DA prices": [0.04517, 0.045...	2019-02-02 22:01:37.274
43	56	1	{"DA prices": [0.0437, 0.0437...	2019-02-03 19:48:50.921561

Module coordination

- At **12.00 AM** (UTC) the building reads the DA price profile from „Retailer” DB table „Retailer to building DA prices” and runs MPC
  - At **13.00 AM** (UTC) **the building stores** the result „Declared DA profile” in communication table „building_to_dso_declared_da_profiles”
  - **the DSO reads** the profile and stores in its own communication table when AC OPF is started

Database outlook

dso on postgres@3s_grid

```sql
SELECT * FROM public.building_to_dso_declared_da_profiles
```

Data Output | Explain | Messages | Notifications | Query History

	id [PK] integer	building_id integer	profile character varying (3000)	profile_created_at timestamp without time zone
1	1	13	{"declared_da_profile": [51.6...	2019-02-04 13:30:19.713084

{"declared_da_profile": [51.622, 53.787000000000006, 54.728, 58.132, 56.885000000000005, 56.237, 56.932, 56.959, 56.596000000000004, 56.772000000000006, 56.534, 56.007999999999996, 56.077, 56.191, 55.366, 53.486000000000004, 53.236999999999995, 52.446, 52.844, 53.023999999999994, 52.607, 50.203, 50.539999999999999, 51.85, 61.81, 53.9, 51.726, 51.859, 46.728, 49.26, 49.483, 42.628, 42.387999999999999, 41.428, 41.141, 40.943, 40.899, 41.342, 41.481, 41.604, 41.799, 41.871, 41.931999999999995, 41.828999999999999, 41.973, 41.746, 41.933, 42.297, 42.455, 42.479, 42.7, 42.794, 42.647999999999996, 42.94, 42.772000000000006, 42.714, 42.843, 42.786, 42.863, 42.915, 42.968, 43.074, 42.943, 42.913, 42.979, 43.038, 43.254000000000005, 44.061, 43.275999999999996, 54.825, 58.078, 78.765999999999999, 74.7, 67.782000000000001, 69.033999999999999, 64.38, 59.166, 59.703999999999999, 60.242, 61.916000000000004, 63.428, 64.764000000000001, 62.852, 64.454000000000001, 61.600999999999999, 62.694, 63.524, 62.726000000000006, 60.739999999999995, 58.613, 58.803, 63.007999999999996, 60.995, 63.929, 70.607, 65.636], "measuring_unit": "kWh", "valid_from": "2018-02-04 23:00:00"}

dso on postgres@3s_grid

```sql
SELECT * FROM public.building_to_dso_declared_da_profiles_history
```

Data Output | Explain | Messages | Notifications | Query History

	id [PK] integer	building_id integer	profile character varying (3000)	profile_created_at timestamp without time zone
1	1	13	{"valid_from": "2018-12-13 0...	2018-12-11 23:44:47.509918
2	2	13	{"valid_from": "2018-12-13 0...	2018-12-11 23:47:49.023675
3	3	13	{"valid_from": "2018-12-13 0...	2018-12-11 23:50:06.826921
4	4	13	{"valid_from": "2018-12-13 0...	2018-12-11 23:55:11.779649
5	5	13	{"valid_from": "2018-12-13 0...	2018-12-11 23:55:22.83317
6	6	13	{"valid_from": "2018-12-13 0...	2018-12-11 23:57:14.576792
7	7	13	{"valid_from": "2018-12-13 0...	2018-12-12 00:00:57.386639
8	8	13	{"valid_from": "2018-12-13 0...	2018-12-12 00:02:05.532131
9	9	13	{"valid_from": "2018-12-13 0...	2018-12-12 00:02:43.999425
10	10	13	{"valid_from": "2018-12-13 0...	2018-12-12 00:04:34.190611
11	11	13	{"valid_from": "2018-12-14 0...	2018-12-12 07:58:38.982417
12	12	13	{"valid_from": "2018-12-14 0...	2018-12-12 07:59:01.930168
13	13	13	{"valid_from": "2018-12-14 0...	2018-12-12 07:59:53.970276
14	14	13	{"valid_from": "2018-12-14 0...	2018-12-12 08:00:50.930219
15	15	13	{"measuring_unit": "kWh", "v...	2018-12-12 08:49:54.18283
16	16	13	{"measuring_unit": "kWh", "v...	2018-12-12 08:50:35.589541
17	17	13	{"measuring_unit": "kWh", "v...	2018-12-12 08:52:49.261845
18	18	13	{"measuring_unit": "kWh", "v...	2018-12-12 08:53:39.052097
19	19	13	{"measuring_unit": "kWh", "v...	2018-12-12 08:54:01.973951
20	20	13	{"measuring_unit": "kWh", "v...	2018-12-12 08:55:39.557233
21	21	13	{"measuring_unit": "kWh", "v...	2018-12-12 08:55:59.647734
22	22	13	{"measuring_unit": "kWh", "v...	2018-12-12 08:57:00.642555
23	23	13	{"declared_da_profile": [[52....	2018-12-12 11:32:01.992102
24	24	13	{"declared_da_profile": [[52....	2018-12-12 11:41:21.440806
25	25	13	{"declared_da_profile": [[51....	2018-12-12 11:43:16.914286
26	26	13	{"declared_da_profile": [[51....	2018-12-12 11:43:59.42221
27	27	13	{"declared_da_profile": [[51....	2018-12-12 11:44:42.520898
28	28	13	{"declared_da_profile": [[51....	2018-12-12 11:48:12.730764
29	29	13	{"declared_da_profile": [[51....	2018-12-12 11:48:29.35575
30	30	13	{"declared_da_profile": [[51....	2018-12-12 11:52:39.251857
31	31	13	{"declared_da_profile": [[51....	2018-12-12 11:53:00.102413
32	32	13	{"declared_da_profile": [[50....	2018-12-12 13:06:46.425783
33	33	13	{"declared_da_profile": [[50....	2018-12-12 13:07:24.688093
34	34	13	{"valid_from": "2018-12-14 0...	2018-12-12 13:18:53.815162

AC OPF module

- Input:
  - Grid data ☑
  - Load profiles ☑
  - Long-term – building flexibility profiles ☑
  - Building „Declared DA profile" ☑

Defined for the next day

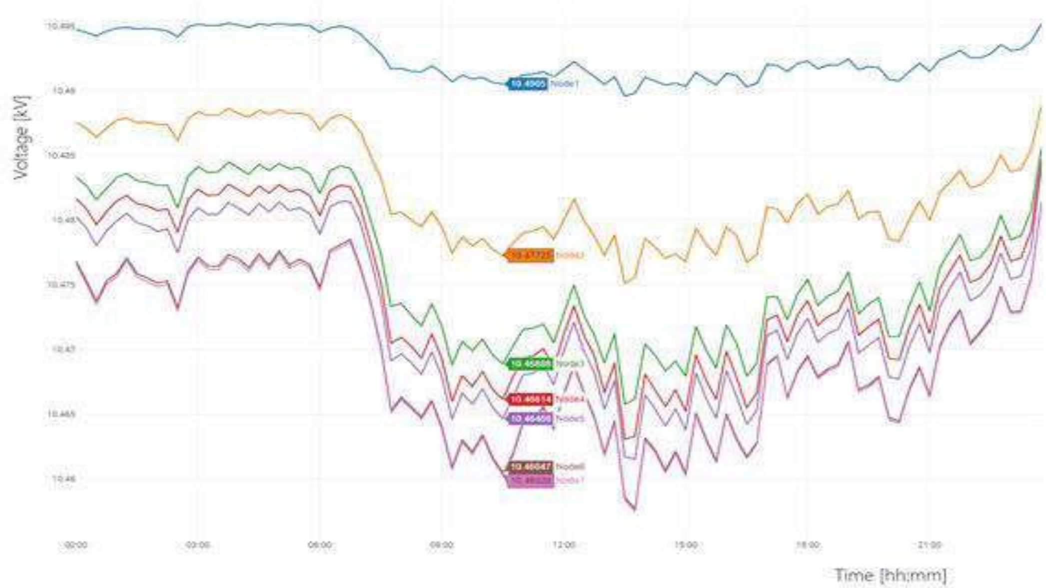
Day before delivery
at 3.00 PM (UTC)
ST DA module runs ACOPF

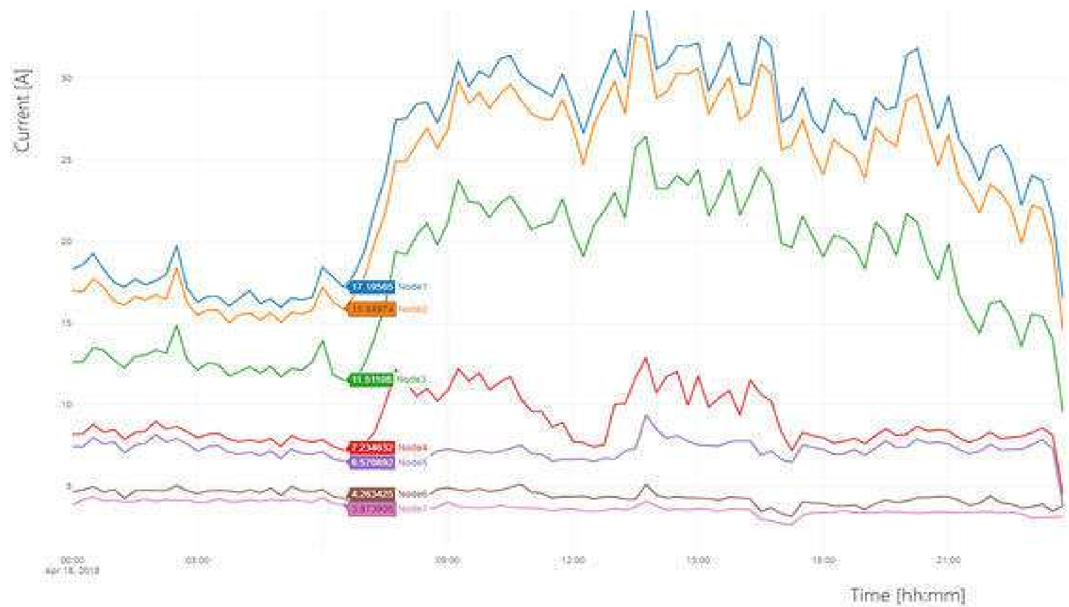
Gurobi solver
- Load-flow analysis
- Power loss minimization

- Output:
  - Voltage and current state of network
  - Building flexibility activation profile

AC OPF results

- Results visualised:
  - Voltage
  - Current
  - Active power
  - Reactive power

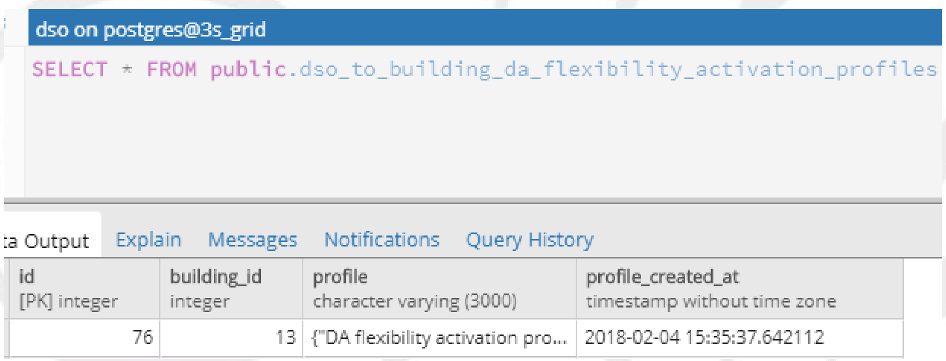


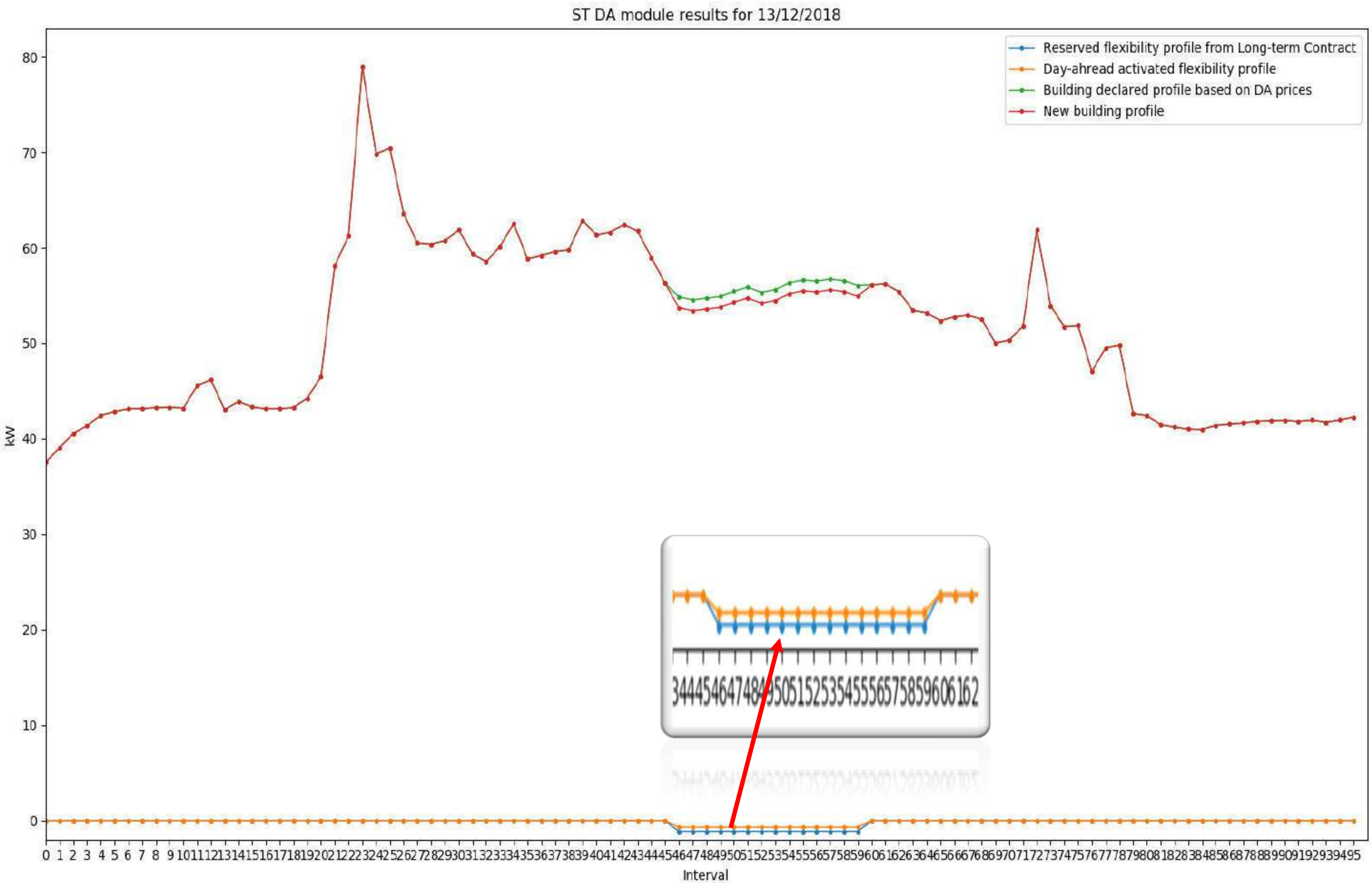


AC OPF results (1)

- Day before delivery:
  - Building flexibility activation profile
    - At **3:15 AM** (UTC) **ST DA modules stores** the result in communication table „DSO to building flexibility activation profile”
    - At **4:00 AM (UTC) building reads** the profile and schedule assets to follow the request

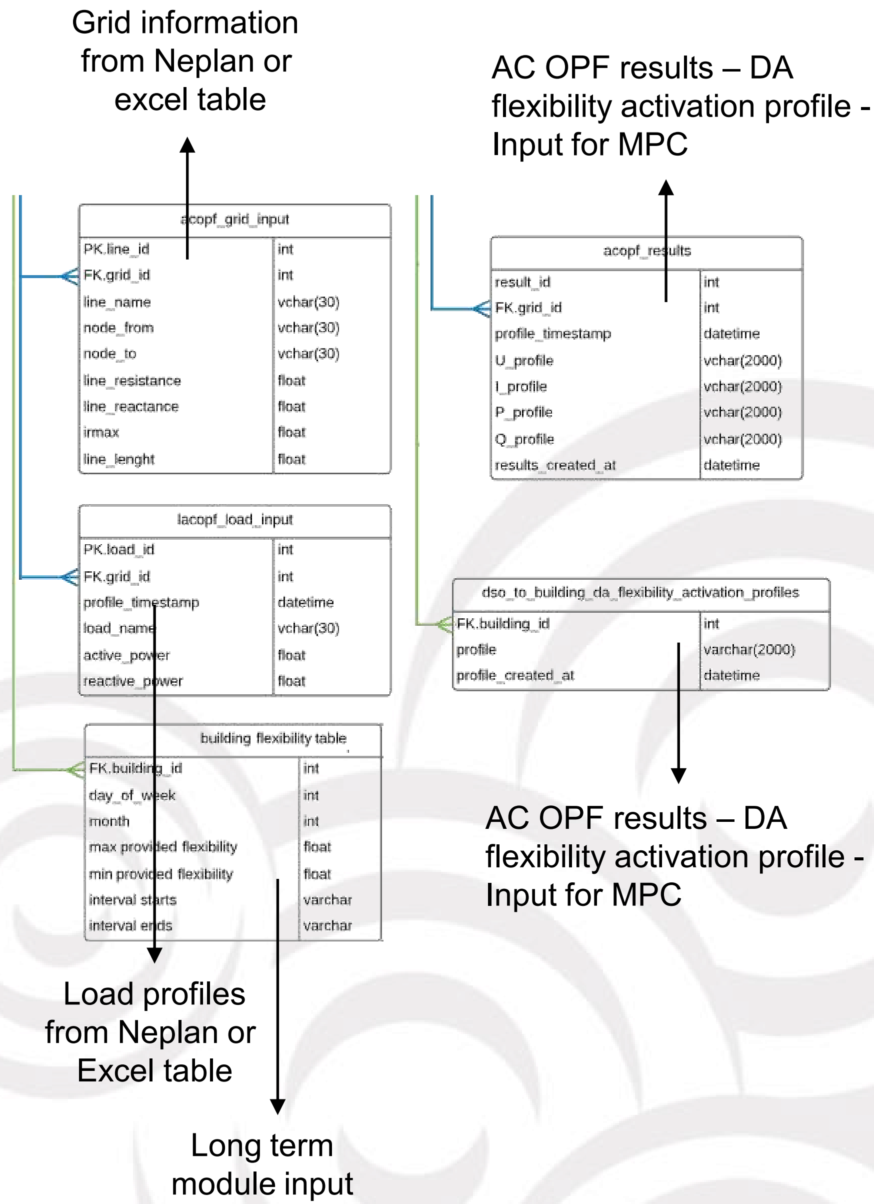
{"DA flexibility activation profile": [0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,, -1.137587, -1.13758, -1.13758, -1.1375877718386254, -1.1375893533847705, -1.1375895, -1.13758, -1.13758, -1.1375887786558803, -1.13758, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0], "Measuring unit": "kW", "Valid from": "2018-04-02 23:00:00"}




ST DA module results for 13/12/2018
Reserved flexibility profile from Long-term Contract
Day-ahread activated flexibility profile
Building declared profile based on DA prices
New building profile
kW
Interval

Database schema

- Input tables for AC OPF
  - From Excel, Neplan, building and long term module
- Ouput tables – AC OPF results
  - For plotly and building
- Rest of communication tables
- Archive of communication tables



SHORT TERM INTRA-DAY MODULE

Short-term Intra-Day Module

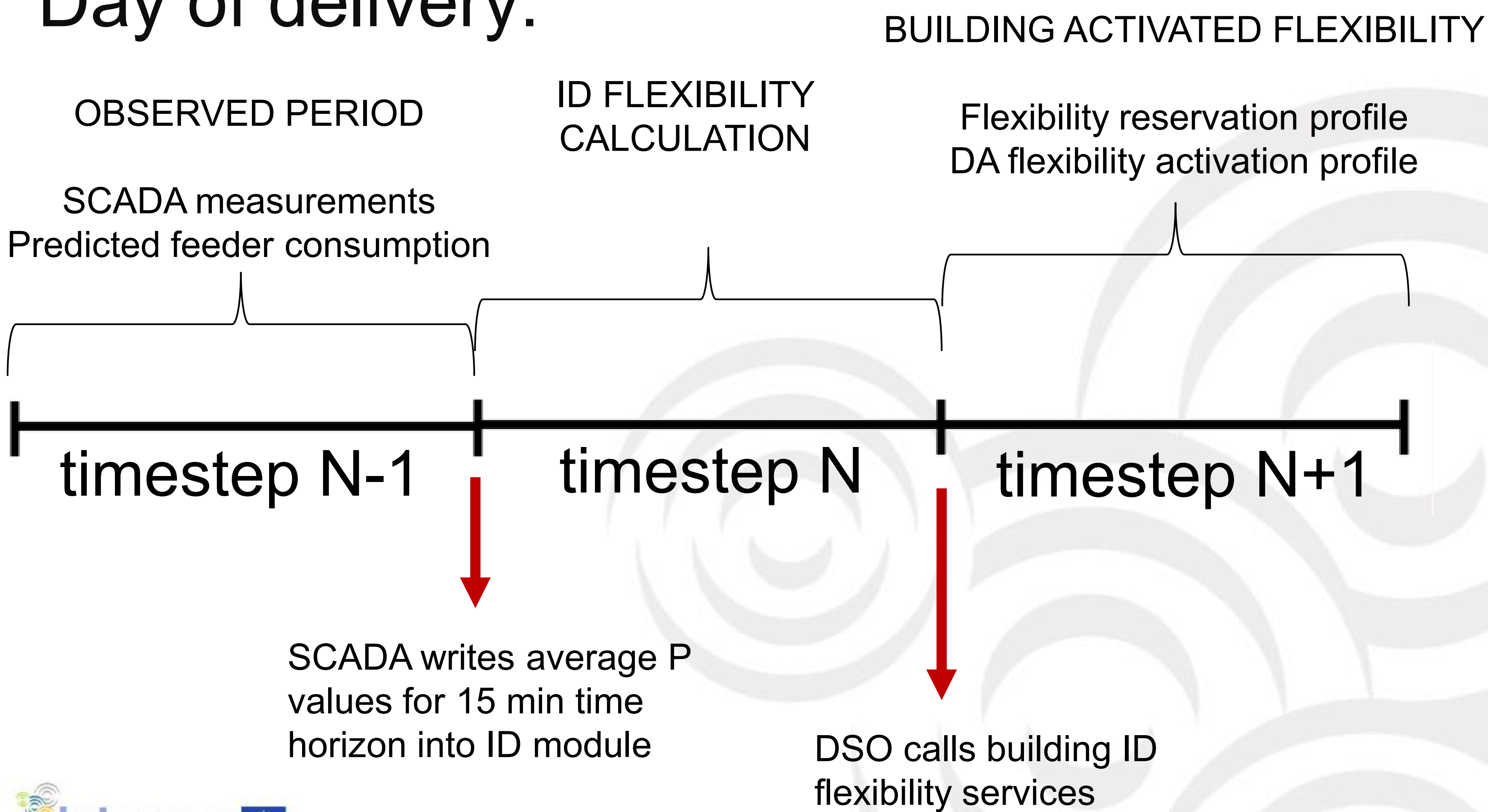
- Intra-day operations allow DSO to improve day-ahead schedule with real time measurements and prices
  - ST ID module is interconnected with the long term contract, ST DA module and with SCADA measurements
- Focus: triggering flexibility through real-time measurements in case DA forecasts deviate from actual events
- ID flexibility is triggered only in case of imbalances (if the measured value is higher than the triggering value):
  - If such event occurs before the scheduled utilization of the flexibility coming from the day-ahead module
  - In case of unforcasted events or „specific" network conditions.

ST Intra-Day Module Input

- SCADA
  - Real time measurement from feeder
- AC OPF:
  - Predicted feeder consumtion
  - DA flexibility activation profile
- Long term
  - Flexibility reservation profile

ST Intra-Day Module Coordination

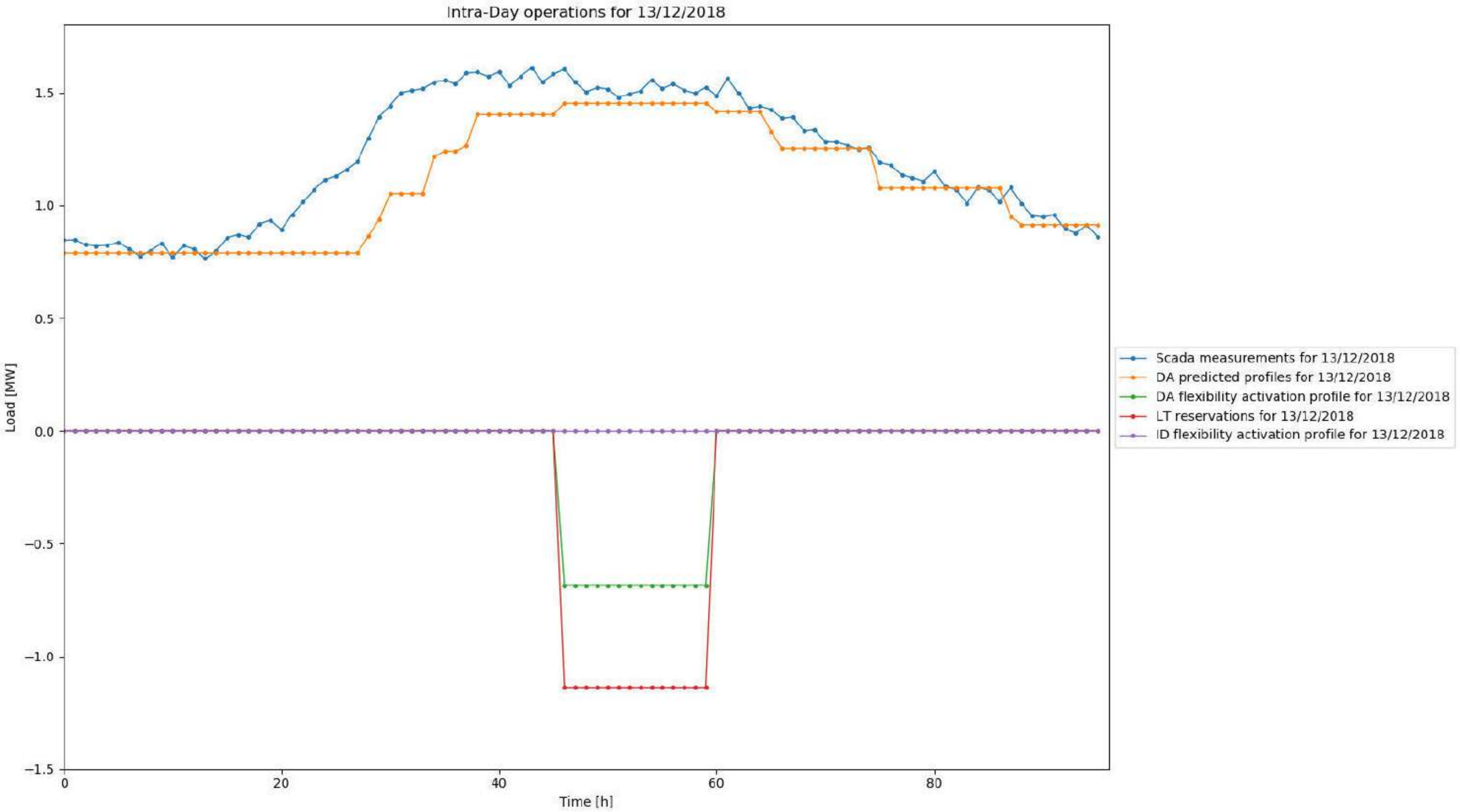
- Day of delivery:



ST Intra-Day Module Logic

- Conditions:
  - Measurements > predicted AND
  - Flexibility reservation (from LT) > 0 AND
  - DA flexibility activation profile < 0
    - Then it calculates ID triggering value

ST Intra-Day Module Results



3Smart modules organization on the grid side

Katalin Décseiné Giczi/
Gábor Péter

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3Smart – Pilot study visit- Debrecen
06. – 05.02.2019.

UNIVERSITY OF ZAGREB FACULTY OF ELECTRICAL ENGINEERING AND COMPUTING

Interreg Danube Transnational Programme 3Smart

Project co-funded by the European Union

Grid side modules to be installed in Debrecen

- Annual Long term module -> ready, installed
- Multiannual Long term module -> ready, installed
- DA Short term module -> in progress
- ID short term module -> under development

LONG TERM (MULTI)ANNUAL MODULE

Installation package of LT module

Installation package was provided via Basecamp at the end of 2018.

- 3Smart Long term module manual
- 3Smart_LT module_v1
- dso_lt_v1
- Grid side database - LT v1
- Long Term Module Installation_v1
- Long-term communication between DSO and building as flexibility service provider

Technical requirement

- Linux Ubuntu or Windows
- Database (PostgreSQL or MySQL, or any database supported by python's SQLAlchemy), Hungarian implementation is using MySQL.
- Python 3.6.5
- MS Office – Excel (for local DSO users who will work with the LT excel (data filling, initiation of calculations) on local PC
- Microgrid database has to be accessible by Grid side database

Database structure

dso_flexibility_table	
PK,id	int
FK.contract_id	int
yyyy_mm	char(7)
type_of_day	varchar(30)
flexibility_requirement_kw	float
time_interval_starts	char(5)
time_interval_length	float
flexibility_requirement_kwh	float
pcs_of_type_of_days	int
created_at	timestamp

building_flexibility_table	
PK.id	int
FK.contract_id	int
yyyy_mm	char(7)
type_of_day	varchar(30)
provided_flexibility_kw	float
minimum_flebilitiy	float
time_interval_starts	char(5)
time_interval_length	float
provided_flexibility_kwh	float
pcs_of_type_of_days	int
created_at	timestamp

contract	
PK.id	int
FK.building_Id	int
FK. grid_id	int
name	varchar(30)
valid_from	date
valid_to	date
estim_activations	int
max_size_of_service	float
max_duration_of_service	float
reservation_price	float
activation_price	float
reservation_fee	float
activation_fee	float
avg_activation_price	float
pricing	float
penalty	float
offer_accepted	boolean
created_at	timestamp

flexibility_unit_prices_and_penalty	
PK.id	int
FK.contract_id	int
reservation_part_of_fup	float
activation_part_of_fup	float
penalty_price	float
deviation_in_size_of_service	int
created_at	timestamp

Operation of web based LT module

3Smart LT   Home   Login

Long Term Workflow

Grid Choose...

Building Choose...

Contract New contract

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	

1. Initial screen – only download template is active
    a. LT staff is downloading the template and enters input data in the excel

Operation of web based LT module

3Smart LT   Home   Login

Long Term Workflow

Grid Grid 1

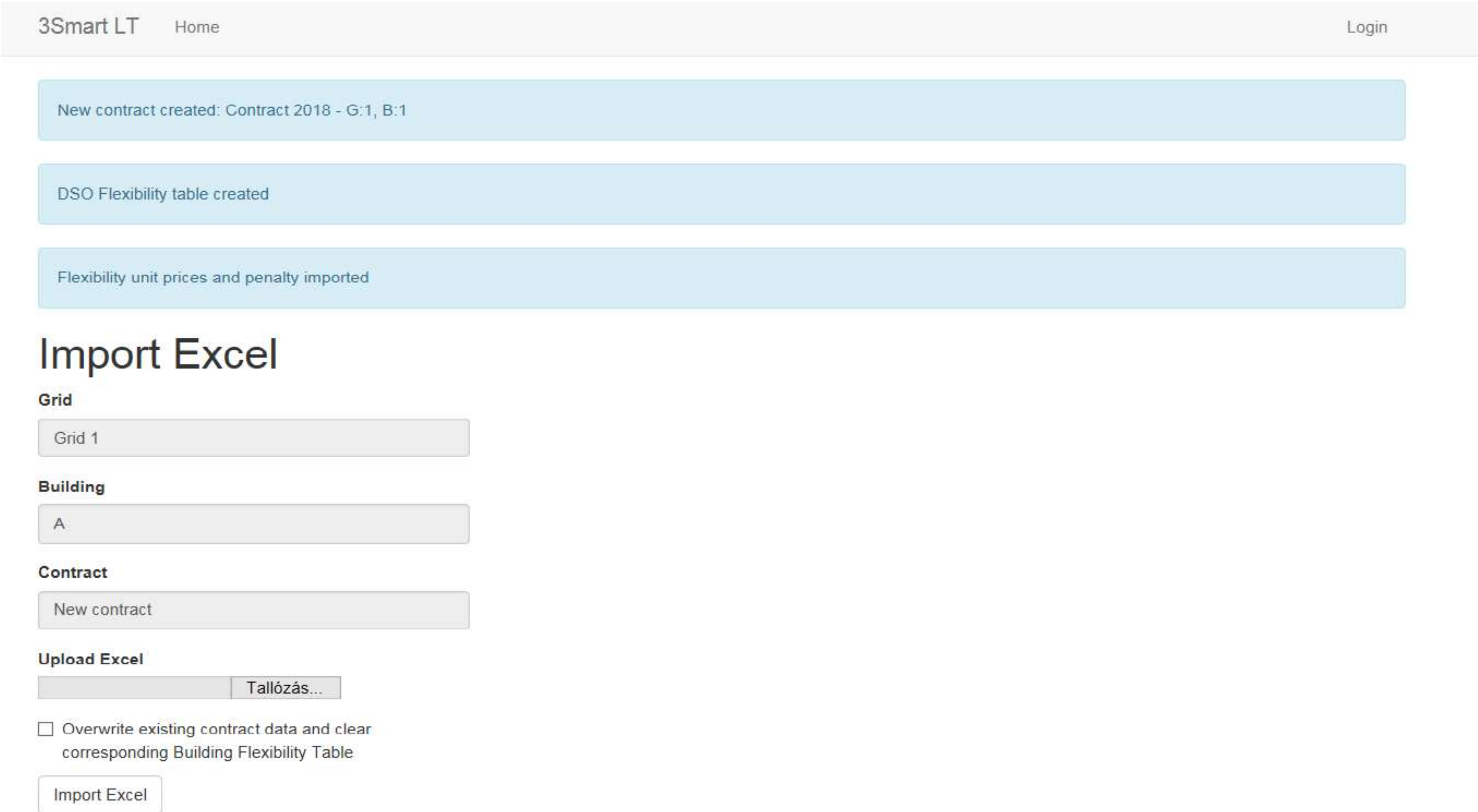
Building A

Contract New contract

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	?

2. Building selected – import Dso Flex Table is also active

Operation of web based LT module



3. Dso staff uploads the excel

Operation of web based LT module

3Smart LT   Home   Login

Long Term Workflow

Grid Grid 1

Building A

Contract Contract 2018 - G:1, B:1

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	?

4. Microgrid can take the data (Dso Flex table and Prices) and generate Building Flex Table for the given building

Operation of web based LT module

3Smart LT   Home   Login

Long Term Workflow

Grid Grid 1

Building A

Contract Contract 2018 - G:1, B:1

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	?

5. When Microgrid's Building Flex is available the Building Flex Transfer button becomes active. At this stage we are using a dummy Microgrid Building Flex tablet o emulate that functionality until Microgrid is delivering.

Operation of web based LT module

3Smart LT   Home   Login

Building Flexibility table imported

Long Term Workflow

Grid Grid 1

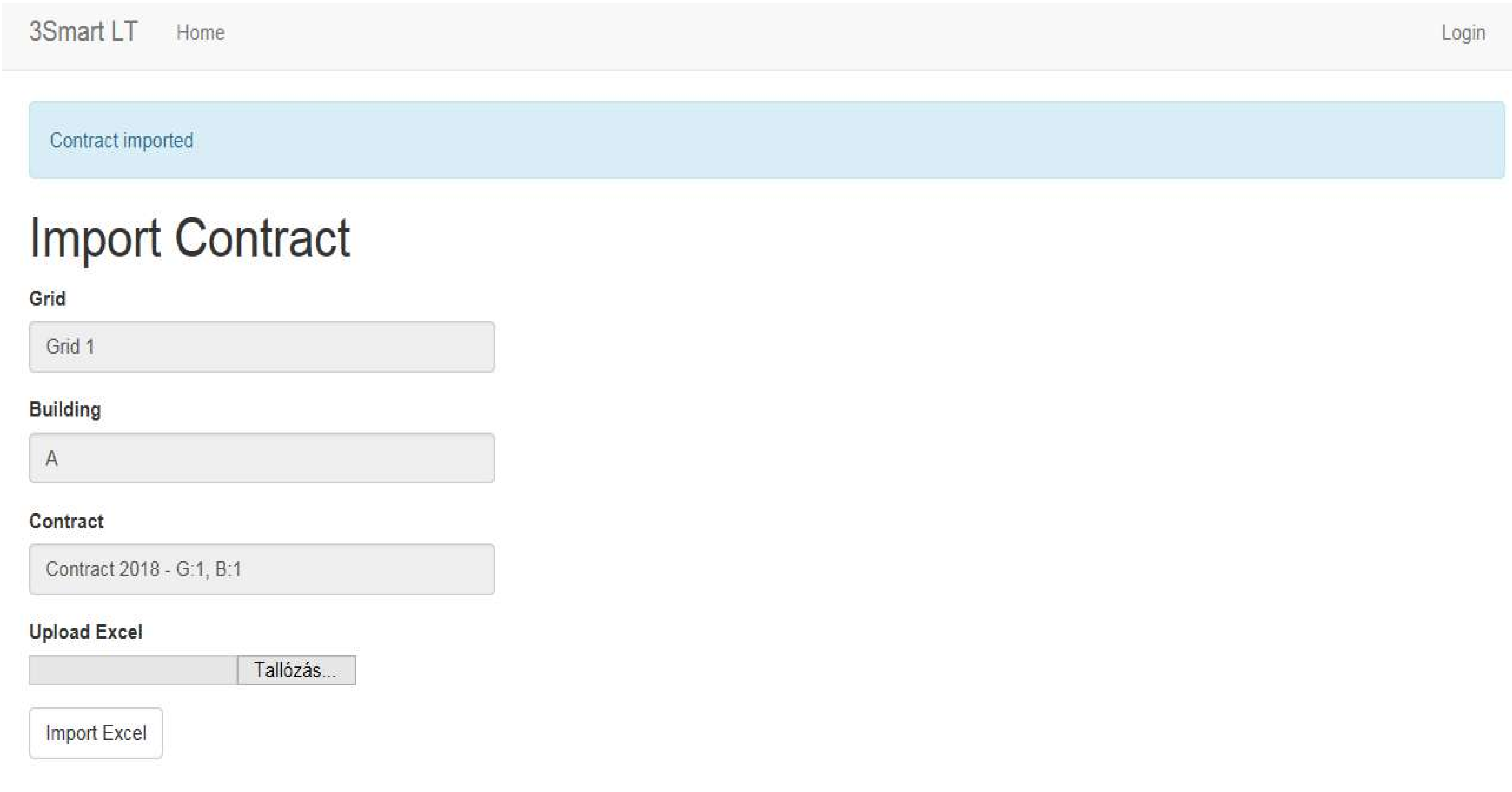
Building A

Contract Contract 2018 - G:1, B:1

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	?

6. After transfering Building Flex, the corresponding download button and Import Contract becomes available

Operation of web based LT module



7. The downloaded data (in excel file) goes into the original excel onto the Building Flexibility Table tab and excel is calculating the contract offer.

Operation of web based LT module

3Smart LT Home Login

Long Term Workflow

Grid Grid 1

Building A

Contract Contract 2018 - G:1, B:1

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	✖

8. The entered Offer acceptance value will decide the final status of the contract

17)	**Building offer accepted**	yes/no	Manual entry

Operation of web based LT module

- The web based LT module will be available for all Memebers.
- It is database type independent.
- Local database was developed and connected web LT module also.
- The web based LT module is a type of workflow, the DSO user interaction is necessary because the process is semi-automated (see steps in operation pages).

https://10.133.128.11/3smart_lt/index

First time deployment- LT flexibility needs test

Thermal limit of cable/ line	5000	kW
Operational limit (January)	970	kW
Operational limit (February)	970	kW
Operational limit (March)	730	kW
Operational limit (April)	730	kW
Operational limit (May)	730	kW
Operational limit (June)	690	kW
Operational limit (July)	690	kW
Operational limit (August)	690	kW
Operational limit (September)	830	kW
Operational limit (October)	830	kW
Operational limit (November)	830	kW
Operational limit (December)	970	kW

Calculate

Choose year:

2019

Choose column for calculation check:

January - Weekdays

Show calculation

Calendar | Calculation input | DS

A	B	C	D	E	F	G
Month	Type of day	Flexibility requirement [kW]	Time interval (Start)	Time interval (Length)	Flexibility requirement [kWh]	Pcs of type of days
2019-01	WEEKDAYS	-71,94	7:00	2,00	-143,89	23
2019-01	WEEKDAYS	-39,02	13:00	3,00	-117,06	23
2019-03	WEEKDAYS	-66,13	7:00	3,00	-198,39	21
2019-03	WEEKDAYS	-20,51	13:00	2,00	-41,03	21
2019-04	WEEKDAYS	-62,86	8:00	2,00	-125,72	22
2019-06	WEEKDAYS	-16,01	9:00	1,00	-16,01	20
2019-06	WEEKDAYS	-51,02	12:00	5,00	-255,08	20
2019-07	WEEKDAYS	-1,93	14:00	2,00	-3,86	23
2019-10	WEEKDAYS	-59,98	8:00	2,00	-119,96	23
2019-11	WEEKDAYS	-97,73	7:00	2,00	-195,46	21
2019-11	WEEKDAYS	-47,66	13:00	4,00	-190,63	21
				0,00	0,00	
				0,00	0,00	
				0,00	0,00	
				0,00	0,00	
				0,00	0,00	
				0,00	0,00	
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				0,00	0,00	
				0,00	0,00	

Calendar | Calculation input | DSO Flexibility table | Flexibility calculation | Price and penalty | Flexibility unit prices,

First time deployment- LT flexibility needs test

Month	Type of day	Flexibility requirement [kW]
2019-01	WEEKDAYS	-71,94
2019-01	WEEKDAYS	-39,02
2019-03	WEEKDAYS	-66,13
2019-03	WEEKDAYS	-20,51
2019-04	WEEKDAYS	-62,86
2019-06	WEEKDAYS	-16,01
2019-06	WEEKDAYS	-51,02
2019-07	WEEKDAYS	-1,93
2019-10	WEEKDAYS	-59,98
2019-11	WEEKDAYS	-97,73
2019-11	WEEKDAYS	-47,66

Calendar | Calculation input | DSO Flexibilit

And other inputs, such as investment cost, penalty multiplicator

Caclulation of flexibility resource		
WACC	4,69%	
Inflation	2,50%	
The cost of investment	195 000	EUR
Ratio of used flexibility price	90%	
Year	2018	2019
WACC	4,7%	4,7%
Inflation	2,5%	2,5%
FV (Future Value)	195 000	200 302
Cost of Investment (with consideration of inflation)	195 000	199 875
Minimum amount of money available to cover the future investment	190 921	195 694
Maximum price of flexibility	4 079	4 608
Used price of flexibility (maximum*ratio)	3 671	4 147
Free amount of money after flexibility price	191 329	196 155
Unused source	408	461
Calculation of unit prices		
Reservation ratio	50,0%	
Penalty price multiplicator	2	
Reservation part of Flexibility unit price	18,783	EUR/kW
Activation part of Flexibility unit price	0,061	EUR/kWh
Penalty	0,122	EUR/kWh
Quality threshold (max. devviation in size of service without penalty)	-10	%

First time deployment- LT flexibility needs test

Month	Type of day	Flexibility requirement [kW]
2019-01	WEEKDAYS	-71,94
2019-01	WEEKDAYS	-39,02
2019-03	WEEKDAYS	-66,13
2019-03	WEEKDAYS	-20,51
2019-04	WEEKDAYS	-62,86
2019-06	WEEKDAYS	-16,01
2019-06	WEEKDAYS	-51,02
2019-07	WEEKDAYS	-1,93
2019-10	WEEKDAYS	-59,98
2019-11	WEEKDAYS	-9
2019-11	WEEKDAYS	-4

Calendar | Calculation input | DSO Flex

This represents only a test data in order to be able to calculate the contractual outputs

Month	Type of day	Provided flexibility by Building [kW]	Minimum flexibility that can be called by the grid [kW]	Time interval (Start)	Time interval length	Provided Flexibility by Building in kWh	pcs of specific type of days in the given month	This table is the the Flexibility r
2019-01	WEEKDAYS	-20		7:00	2,00	-40,00	0:00	
2019-01	WEEKDAYS	-20		13:00	3,00	-60,00	0:00	
2019-03	WEEKDAYS	-20		7:00	3,00	-60,00	0:00	
2019-03	WEEKDAYS	-20,51252174		13:00	2,00	-41,03	0:00	
2019-04	WEEKDAYS	-62,85980952		8:00	2,00	-125,72	0:00	
2019-06	WEEKDAYS	-16,01481818		9:00	1,00	-16,01	0:00	
2019-06	WEEKDAYS	-51,01536364		12:00	5,00	-255,08	0:00	
2019-07	WEEKDAYS	-1,928095238		14:00	2,00	-3,86	0:00	
2019-10	WEEKDAYS	-20		8:00	2,00	-40,00	0:00	
2019-11	WEEKDAYS	-20		7:00	2,00	-40,00	0:00	
2019-11	WEEKDAYS	-20		13:00	4,00	-80,00	0:00	
						0,00		
						0,00		
						0,00		
						0,00		
						0,00		
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						0,00		

Calendar | Calculation input | DSO Flexibility table | Flexibility calculation | Price and penalty | Flexibility unit prices,penalty | Building Flexibility table

First time deployment- LT flexibility needs test

Service name		Flexibility service			
1)	Contract valid from	dd.mm.yyyy.			
2)	Contract valid until	dd.mm.yyyy.			
3)	Est. no. of activations during period	238	Practically here will the number of activation be calculated within the contractual periode, i.e. the number of activations from Provided flexibility table by the Building		
4)	Maximum Size of service in power (kW)	62,85980952	The algorithm seeks the maxumum power within the Flexibility table provided by the Building (i.e. the maxumim in the column "Provided flexibility by Building [kW]")		
5)	Max. duration of service per activation (h)	5,00	The algorithm seeks the maxumum duration within the Flexibility table provided by the Building (i.e. the maxumim time interval)		
6)	On - Trigger	Signal from the DSO or according to DA AC OPF calculator	Manual entry		
7)	Off - Trigger	Maximum: see "Max.duration of service per activation" from "on"-signal, or by earlier signal from the DSO	From "Max.duration of service per activation(h)" and partly Manual entry		
8)	Maximum allowed activation time	15 min (but it depends of the capability of the Customer process technology)	Manual entry		
9)	Quality of Service	Deviation in max. duration: +/-	min	Value	Manual entry
		Deviation from, On - Trigger: +/-	min	Value	Manual entry
		Deviation in size of service: +/-	% of kW	Value	Manual entry
		Acceptable no. of unsuccessful activations (aboe it terminate contract):	pcs	Value	Manual entry
10)	Unit price of Reservation (EUR/kWh)	18,78287115			
11)	Unit price of Activation (EUR/kWh)	0,060837835			
12)	Reservation fee for the contractual period	1180,687703			
13)	Activation fee for the whole contractual period	981,7938414			
14)	Average activation price/activation	4,125184208	Since during the whole contractual periode the duration and size of activation varies day by day, therfore the whole amount of Activation fee ("Activation fee for the whole contractual period")will be diveded by the number of activation from "Est. no. of activations during period "		
15)	Pricing	2162,481544	Reservation fee for the whole contractual periode (in EUR)+ number of activation*Average activation price (inEUR)=EUR		
16)	Penalty if failed supply	0,12167567	Calculation of penalty in case of failed delivery of one activation(zero activation): The fee of Sum of Activations* Percentage of the Activation fee for the whole contractual period. In case of partial service provision the slope of penalty curve can be found in "Input for longtermcontract_1" sheet of the Multiannual module		
		- Y times of failed delivery → termination of the contract	Manual entry		
17)	Building offer accepted	yes/no	Manual entry		

The contractual results which are based on calculations

3Smart modules organization on the EON pilot building

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First pilot study visit to the Hungarian pilot

February 5-6, 2019.

Interreg

EUROPEAN UNION

Danube Transnational Programme

3Smart

e·on

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

Modules on the zone level

- Zone level prediction and estimation
  - Z.PE.1, Z.PE.8, Z.PE.9

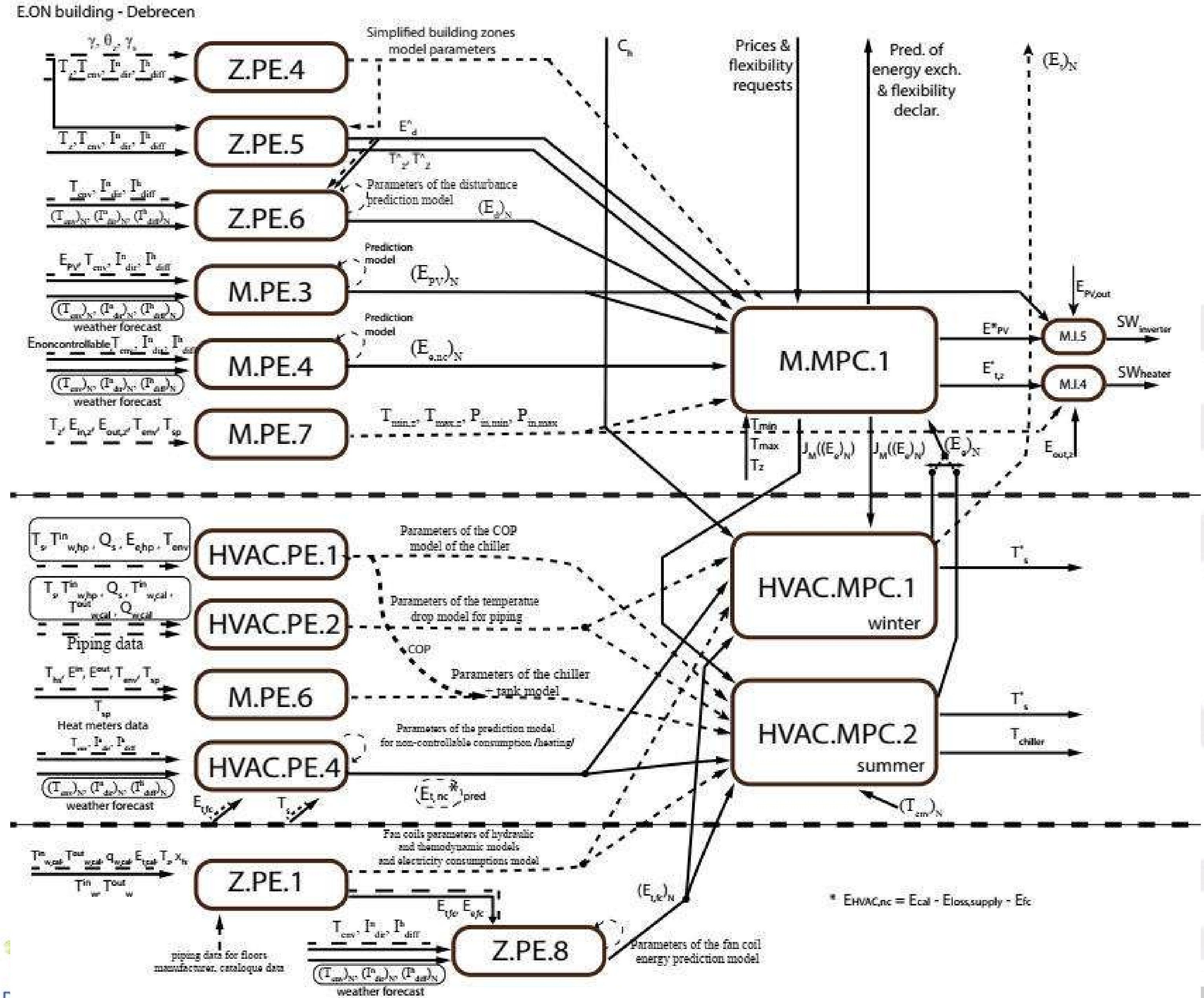
Modules on the central HVAC system level

- Central HVAC system level prediction and estimation
  - HVAC.PE.1, HVAC.PE.2, HVAC.PE.4, M.PE.6
- Central HVAC system level model predictive control
  - HVAC.MPC.1 (heating), HVAC.MPC.2 (cooling)

Modules on the microgrid level

- Microgrid level prediction and estimation
  - M.PE.3, M.PE.4, M.PE.7, Z.PE.4, Z.PE.5, Z.PE.6
- Microgrid level model predictive control
  - M.MPC.1
- Microgrid level interfacing
  - M.I.4, M.I.5

Information flow between modules



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

Anita Martinčević, Nikola Hure, Danko Marušić, Hrvoje Novak

UNIZGFER

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3Smart pilot study visit to HUN pilot No. 1 in Debrecen

6 February 2019

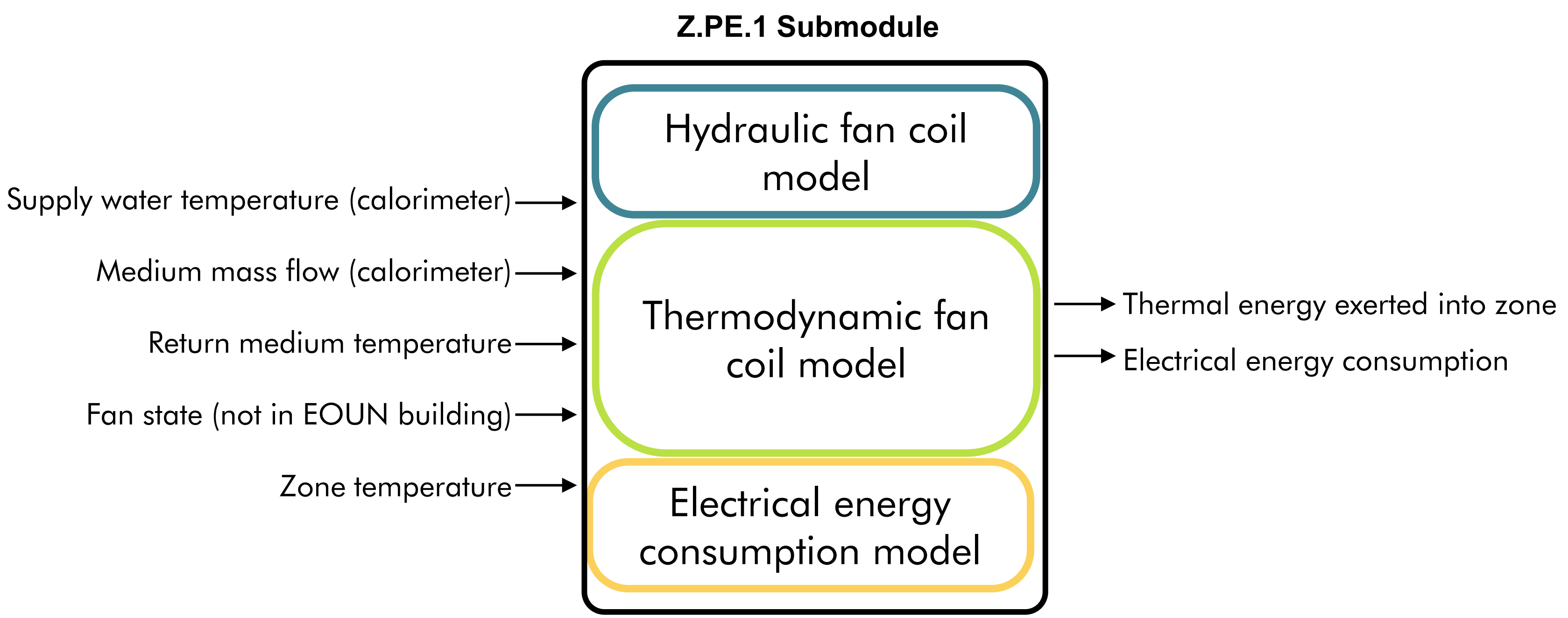
Project co-funded by the European Union

Zone-level modules
EON building

Z.PE.1 – offline
Fan coil unit identification submodule

Why is it needed?

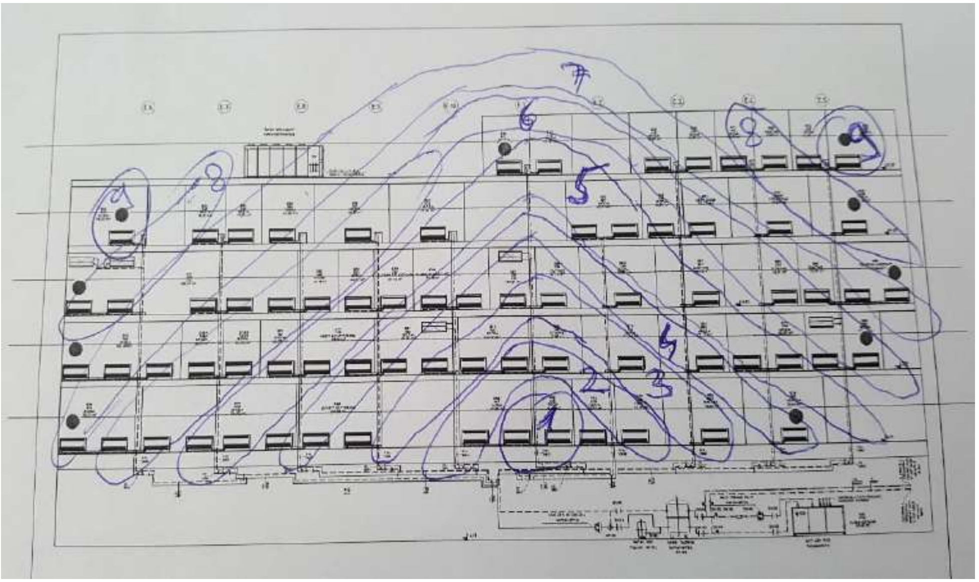
Calculation of current thermal energy consumed by every fan coil unit equipped with return medium temperature sensors



Z.PE.1 – offline
Fan coil unit identification submodule

Main prerequisites:

1. Identification of temperature drop along the pipes
   - fan coil units grouped into 9 groups based on the length of supply pipeline



Z.PE.1 – offline
Fan coil unit identification submodule

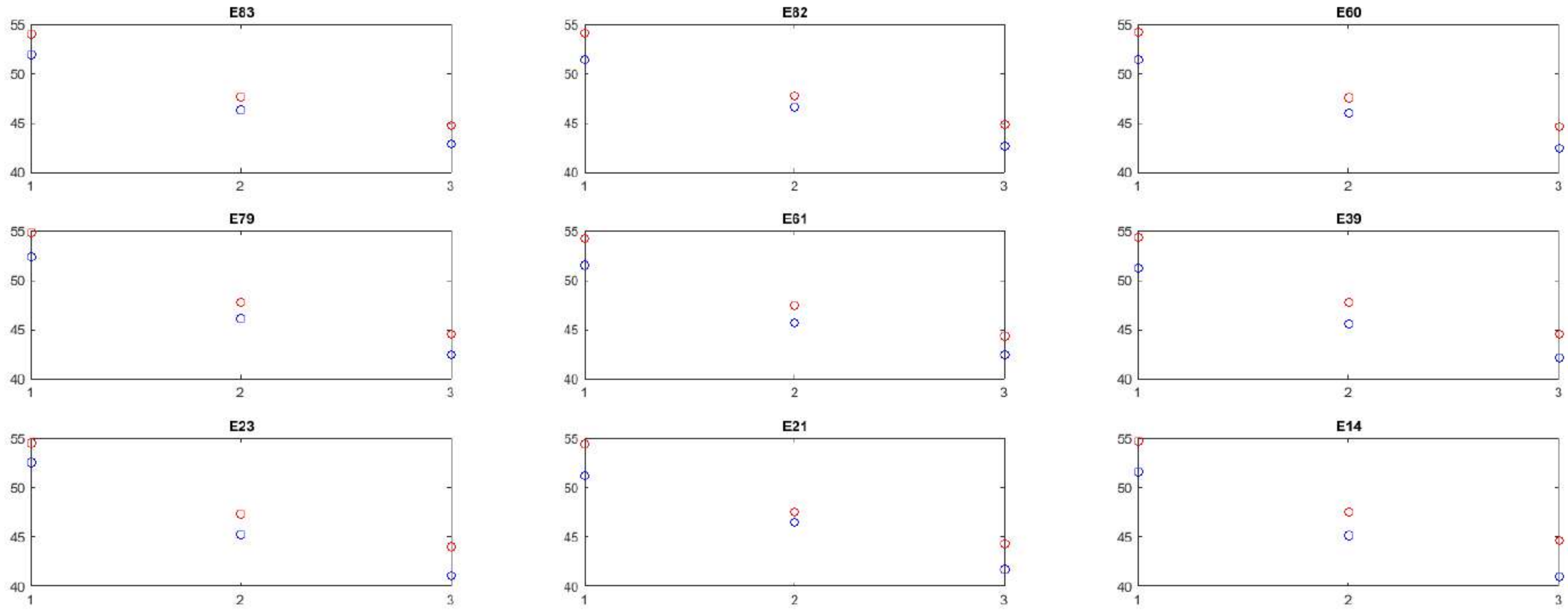
Main prerequisites:

1. Identification of temperature drop along the pipes
   - fan coil units grouped into 9 groups based on the length of supply pipeline
   - for every group at least three manual measurements are performed by using the calibrated portable temperature sensor (UNIDEBTTK)
   - temperature drop function is identified by comparing those measurements with supply temperature measurements

Z.PE.1 – offline
Fan coil unit identification submodule

Main prerequisites:

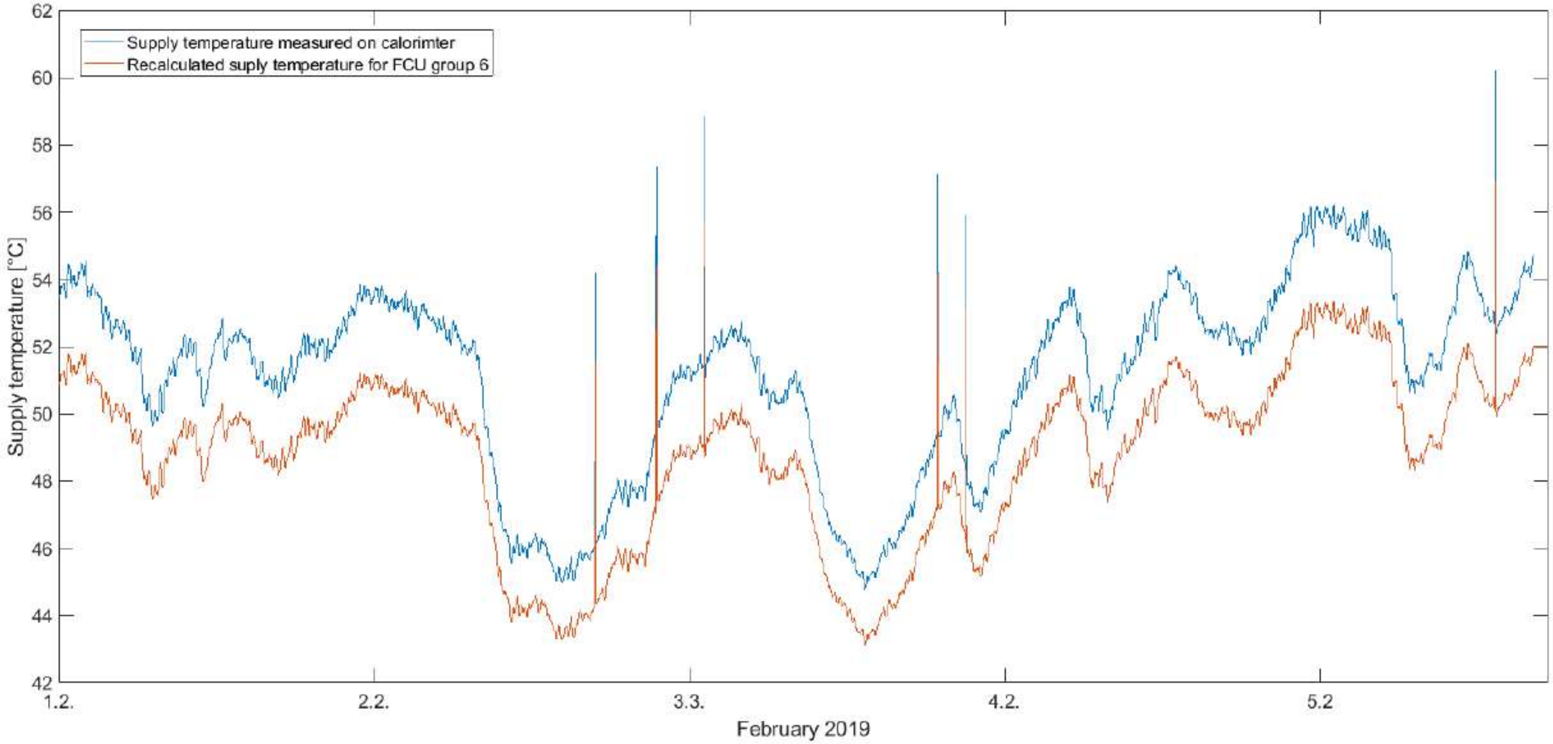
1. Identification of temperature drop along the pipes



Z.PE.1 – offline
Fan coil unit identification submodule

Main prerequisites:

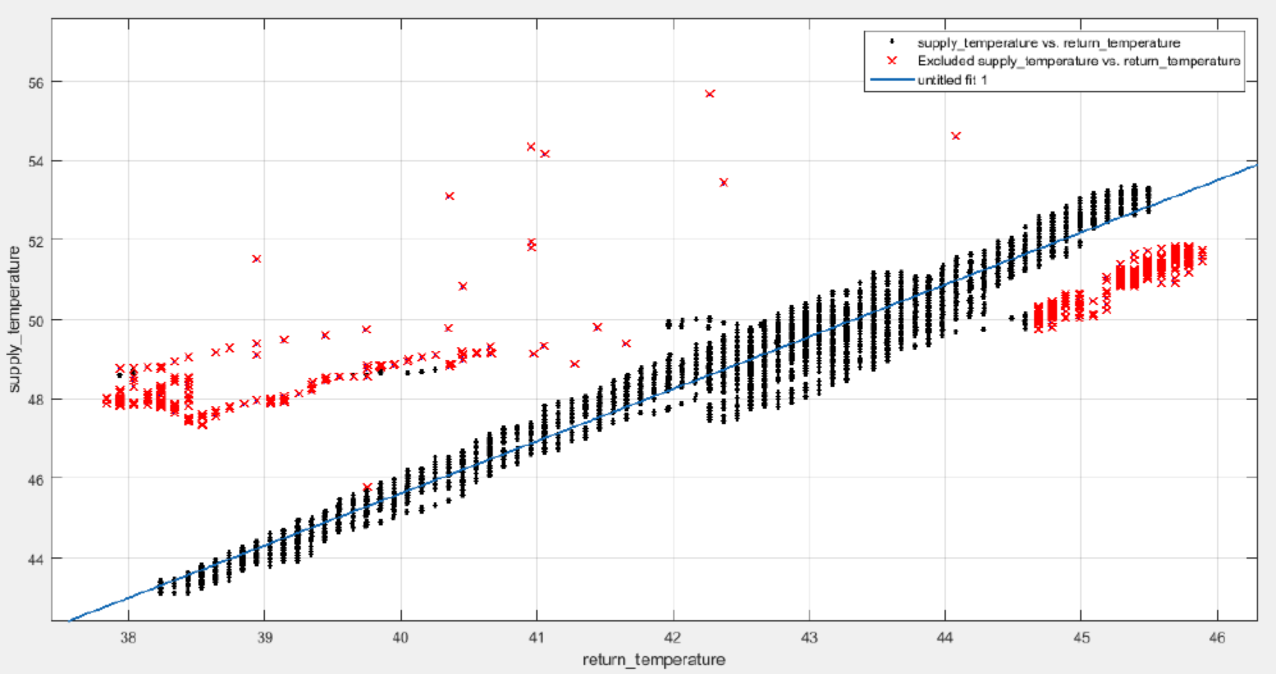
1. Identification of temperature drop along the pipes



Z.PE.1 – offline
Fan coil unit identification submodule

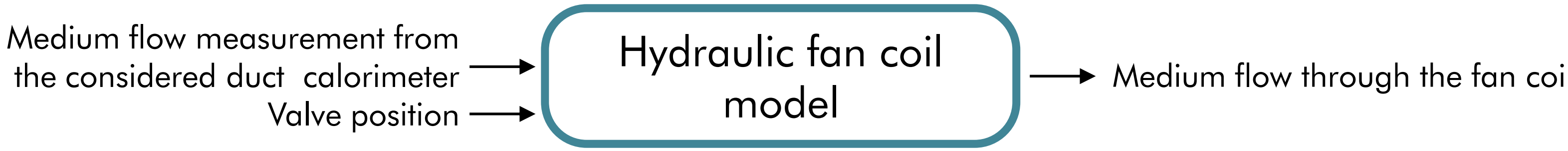
Main prerequisites:

1. Identification of temperature drop along the pipes
2. Calibration of return medium temperature sensors



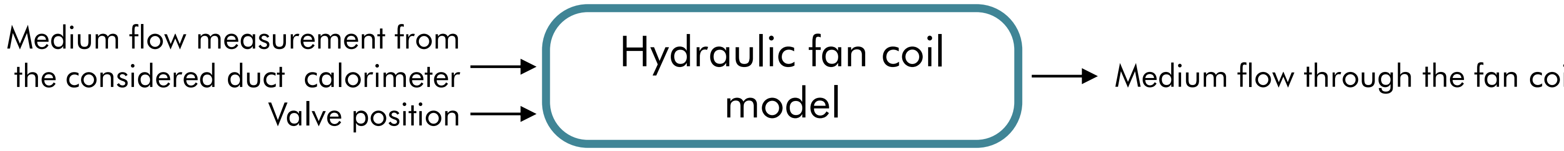
Z.PE.1 – offline
Fan coil unit identification submodule

- Hydraulic fan coil model - based on experimental data recorded under special conditions



Z.PE.1 – offline
Fan coil unit identification submodule

- Hydraulic fan coil model - based on experimental data recorded under special conditions

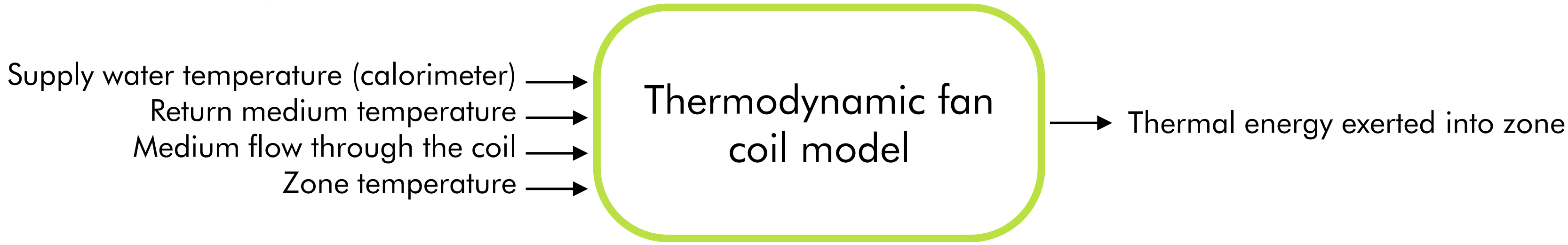


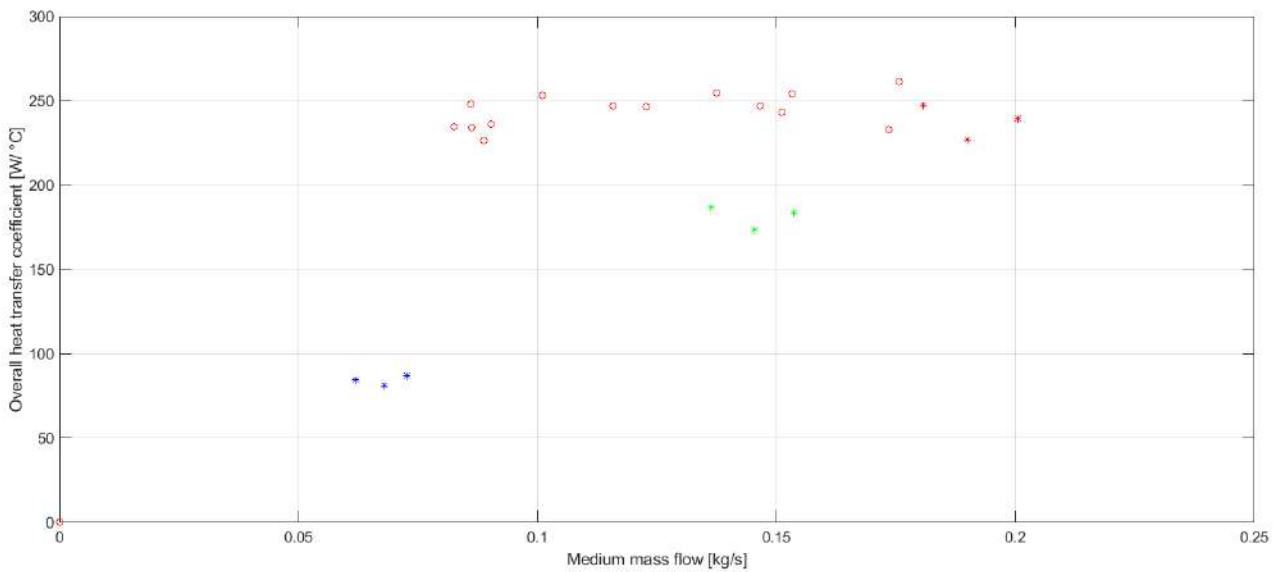
- Experiments and data analysis done by UNIDEBTTK
- Data validated and entered to *fcu_hydraulic_model* table in database for E building

fcu_id	timestamp	flow_share
66	2018-10-19 10:49:07	NULL
67	2019-02-01 11:32:27	0.011
68	2019-02-01 11:32:27	0.0138
69	2019-02-01 11:32:27	0.009
70	2019-02-01 11:32:27	0.012
71	2019-02-01 11:32:27	0.013
72	2019-02-01 11:32:27	0.016
73	2019-02-01 11:32:27	0.0138
74	2019-02-01 11:32:27	0.0138
75	2019-02-01 11:32:27	0.0138
76	2019-02-01 11:32:28	0.00805
77	2019-02-01 11:32:28	0.0138
78	2019-02-01 11:32:28	0.0138
79	2019-02-01 11:32:28	0.0138

Z.PE.1 – offline
Fan coil unit identification submodule

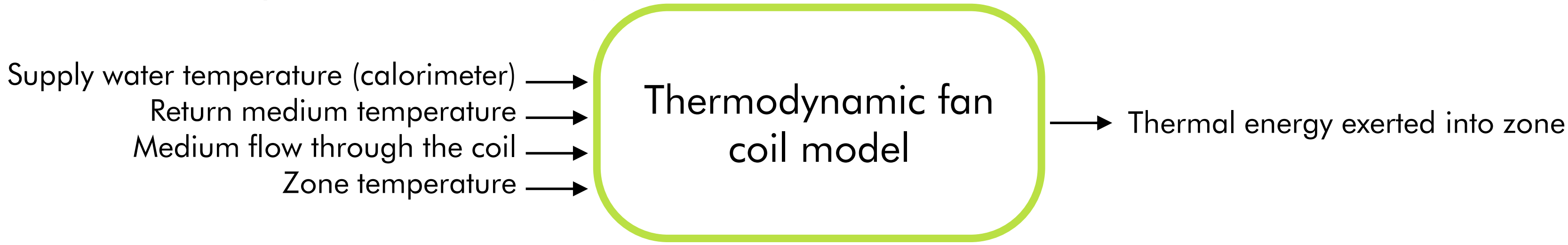
- Identification of thermodynamic fan coil model based on experimental data (data recorded in special conditions)





Z.PE.1 – offline
Fan coil unit identification submodule

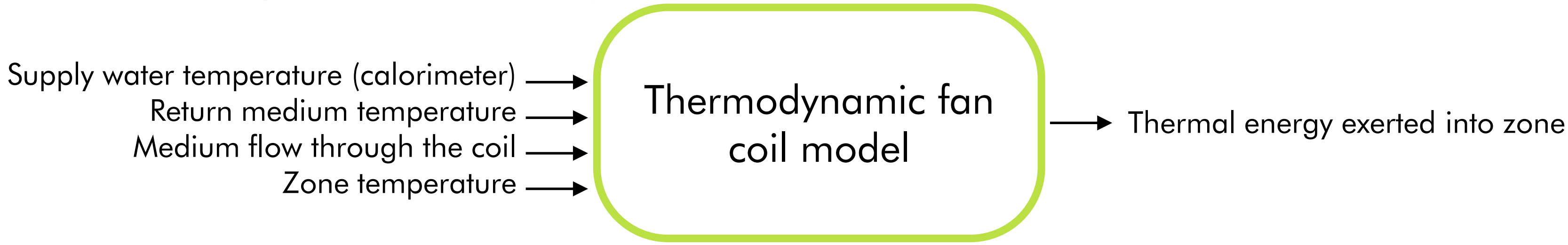
- Identification of thermodynamic fan coil model based on experimental data (data recorded in special conditions)



- Fan coil units operating in linear operation range
- Based on it we are able to estimate the fan state (low/medium/high)

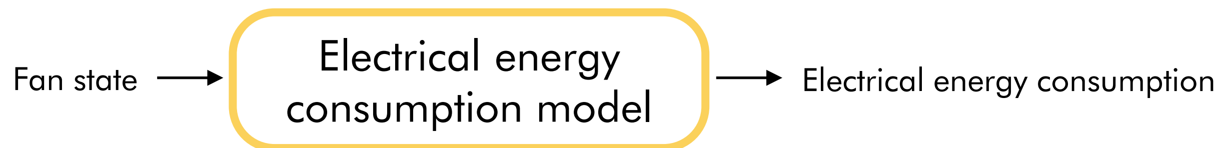
Z.PE.1 – offline
Fan coil unit identification submodule

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



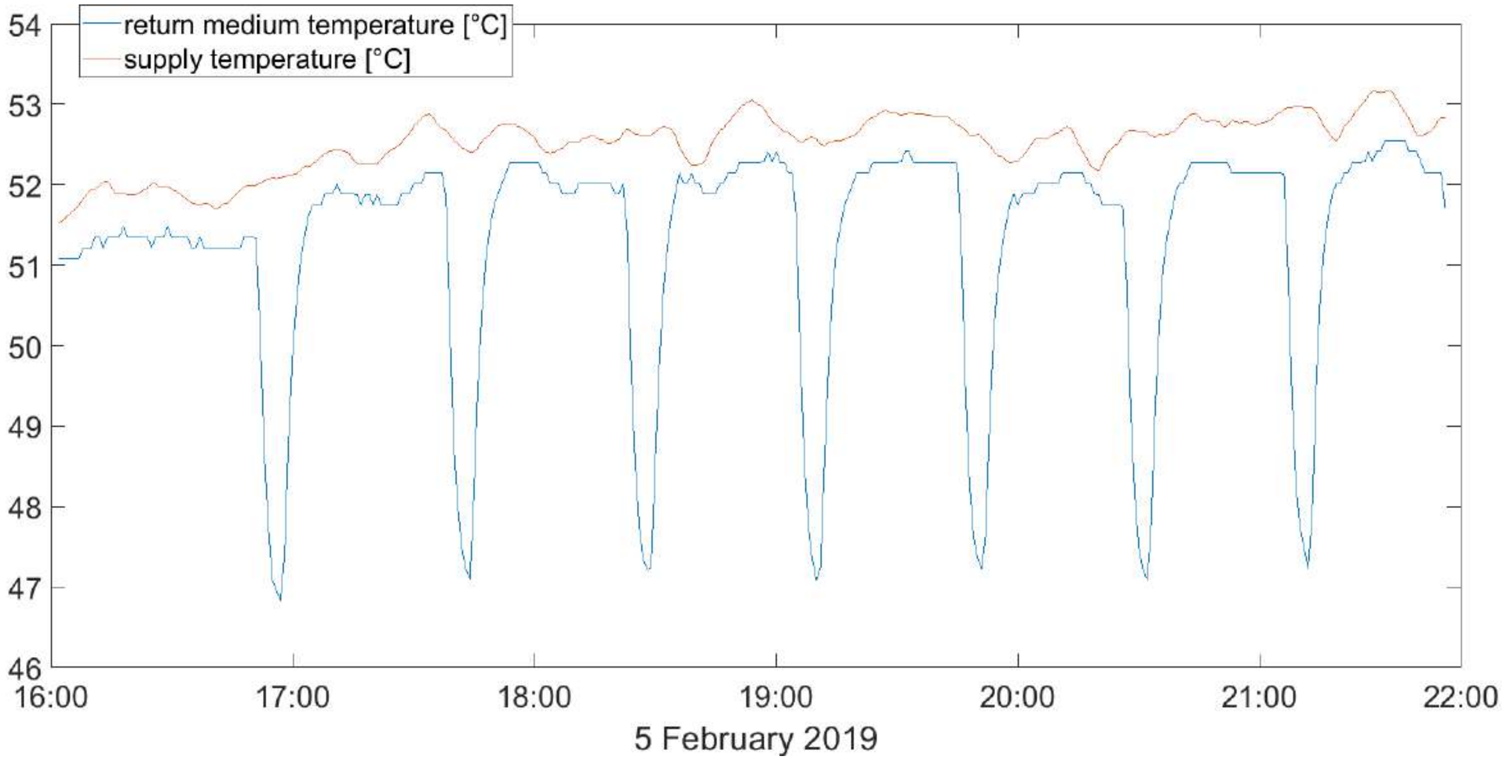
- Fan coil units operating in linear operation range
- Based on it we are able to estimate the fan state (low/medium/high)

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

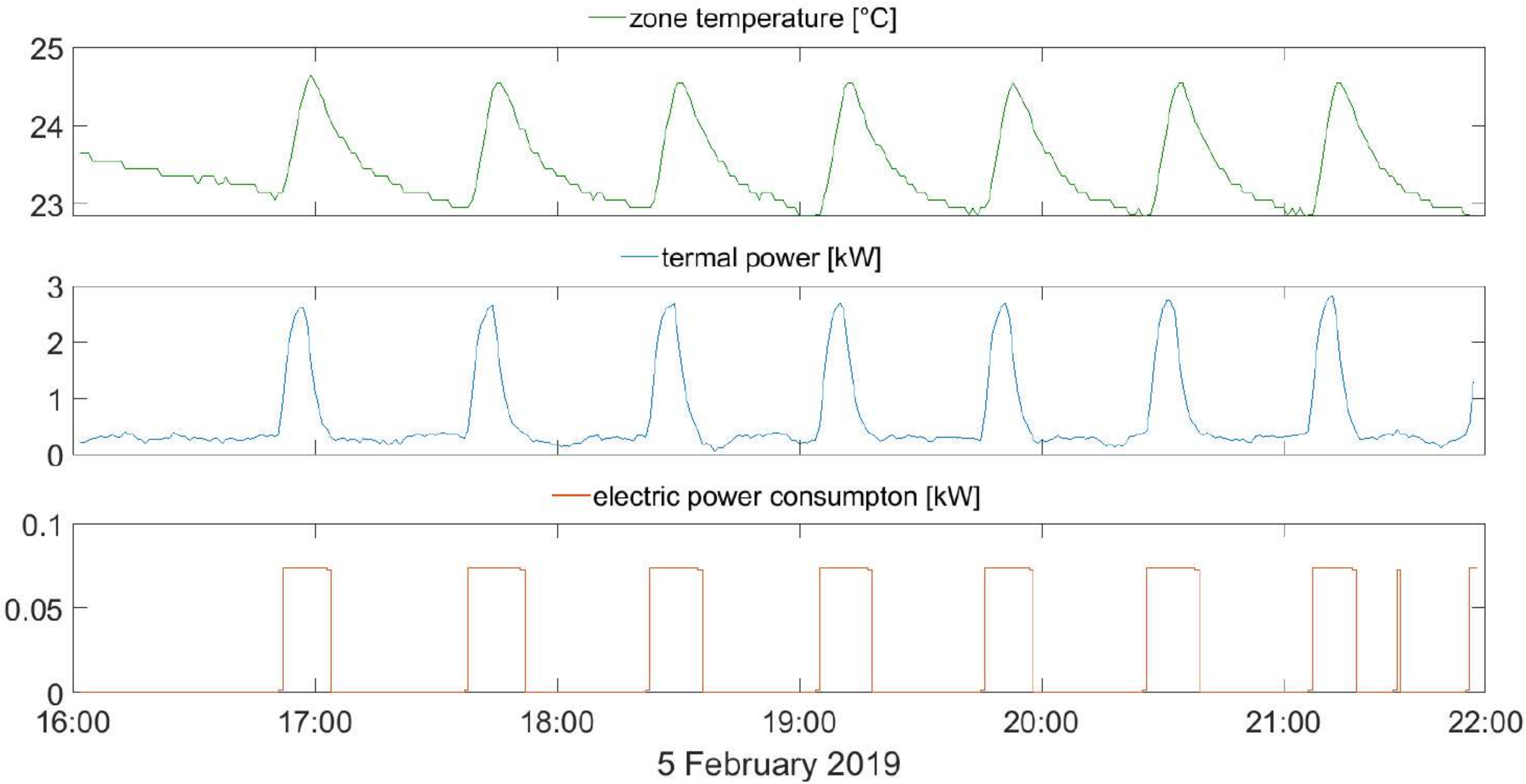


Z.PE.1 – online
Fan coil unit identification submodule

- 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 unit identification submodule



Zone PE 4
Identification of the simplified building thermodynamic model

- Identification of continuous models performed for 6 zones with controllable electric heaters (UNIDEBTTK)
- Models are discretized with sampling times of 60 s and entered to database

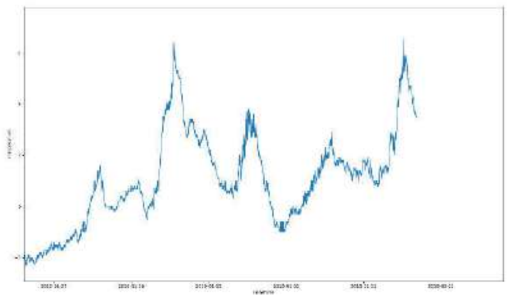
zone_id	timestamp	continous_zone_model	discrete_zone_model_60
108	2018-10-01 12:06:27	{ "A": [[-9.0039e-04, 8.3663e-04], [1.3954e-0...	{ "A": [[0.9474, 0.0488], [8.1471e-04, 0.999...
109	2018-10-01 12:08:34	{ "A": [[-2.1580e-04, 1.9639e-04], [2.7782e-0...	{ "A": [[0.9871, 0.0117], [0.0017, 0.9983]], ...
110	2018-10-01 12:09:33	{ "A": [[-9.4844e-04, 9.1056e-04], [1.3169e-0...	{ "A": [[0.9447, 0.0531], [7.6781e-04, 0.999...
111	2018-10-01 12:10:11	{ "A": [[-3.5740e-04, 3.1408e-04], [5.0749e-0...	{ "A": [[0.9788, 0.0186], [3.0126e-07, 1.000...
112	2018-10-01 12:10:59	{ "A": [[-3.5915e-04, 3.2687e-04], [5.9492e-0...	{ "A": [[0.9787, 0.0194], [3.5307e-04, 0.999...
113	2018-10-01 12:11:42	{ "A": [[-8.4422e-04, 7.5321e-04], [5.3252e-0...	{ "A": [[0.9506, 0.0441], [3.1155e-06, 1.000...

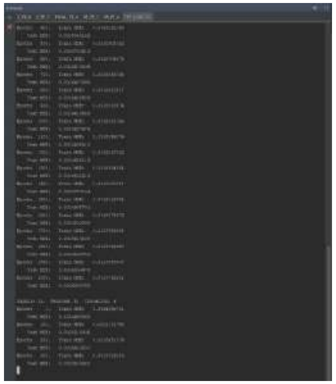
Zone PE 5

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

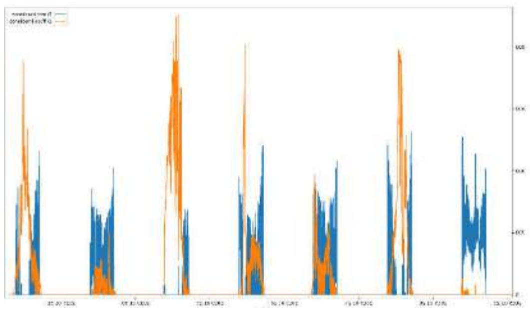
- Waiting for electric_heater and electric_heater_measurements tables in database
- Containing information on
  - nominal powers of electric heaters
  - placement
  - current state (on/off)

Zone PE 8 – off-line initialization (prediction of zone heating/cooling energy consumption)





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

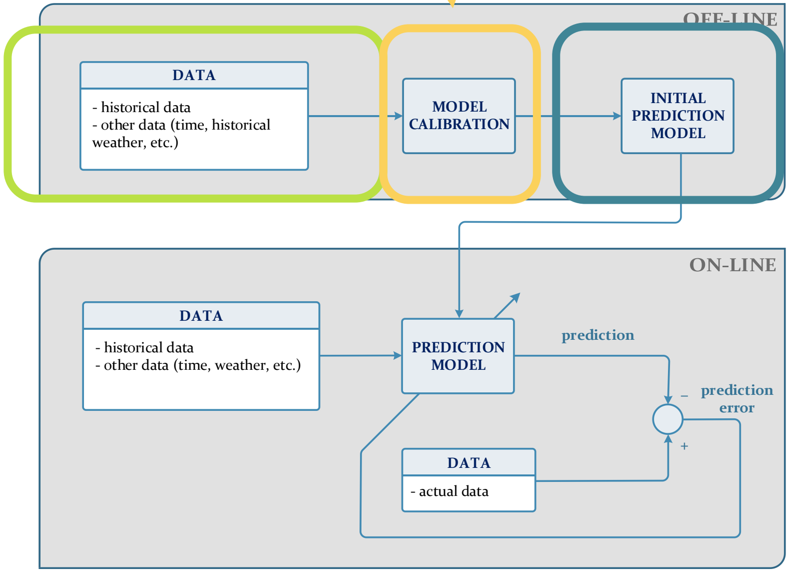


Historical **heating/cooling consumption**

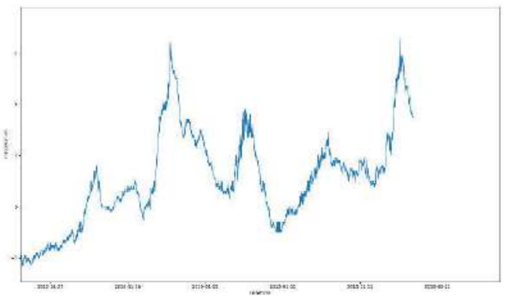
Locally stored:
inputsXY_neuronsZ.net

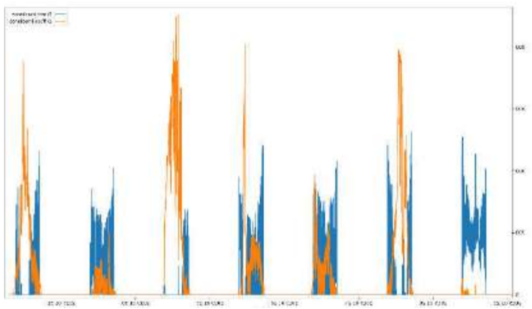
MODULE INPUTS

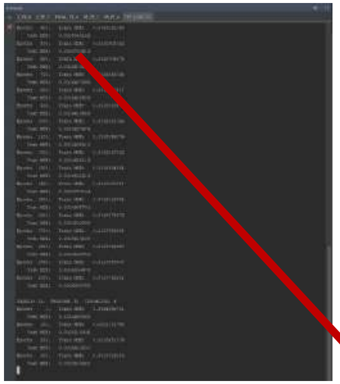
MODULE



Zone PE 8 – off-line initialization
(prediction of zone heating/cooling energy consumption)



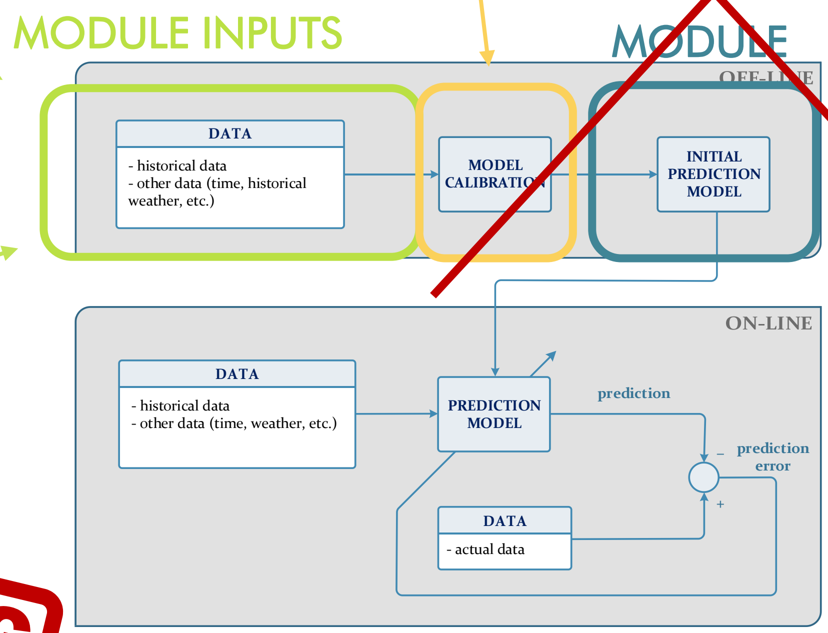




Historical **weather measurements**:
- Temperature
- Direct, diffuse solar irradiance

Historical **heating/cooling consumption**

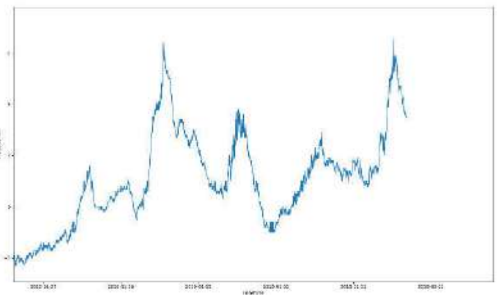
Locally stored:
inputsXY_neuronsZ.net

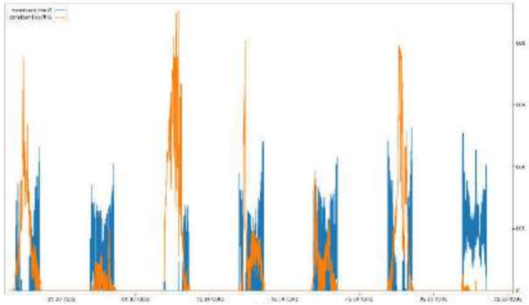


MISSING

Zone PE 9 – off-line initialization
(prediction of zone heating/cooling energy consumption)

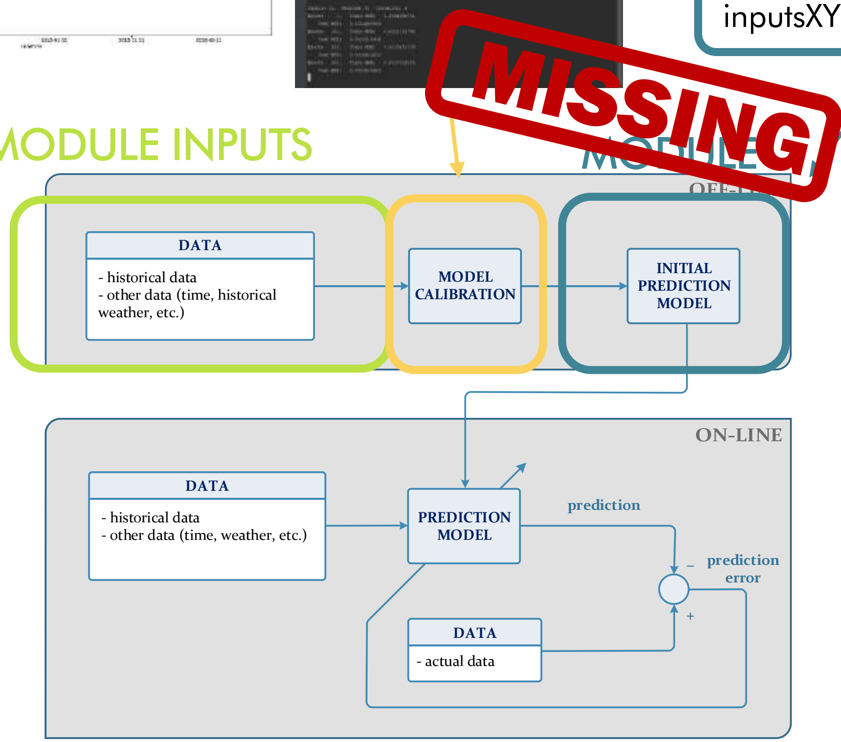
Historical **weather measurements**:
- Temperature
- Direct, diffuse solar irradiance



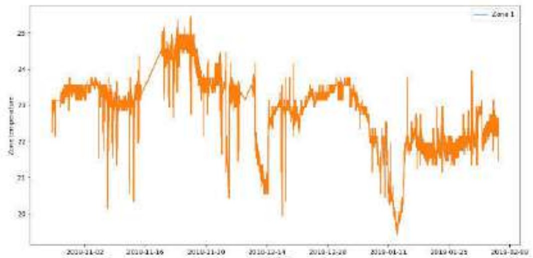


Locally stored:
inputsXY_neuronsZ.net

MODULE INPUTS

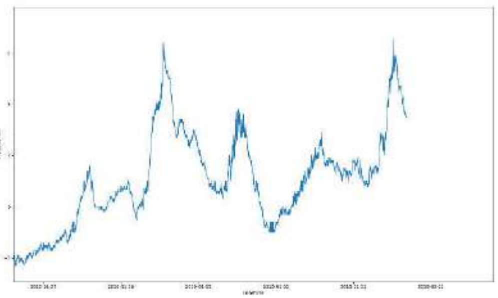


Historical **zones temperature**



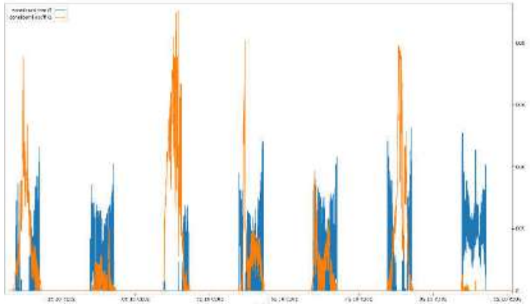
HVAC-level modules UNIZGFER

HVAC PE 4 – off-line initialization

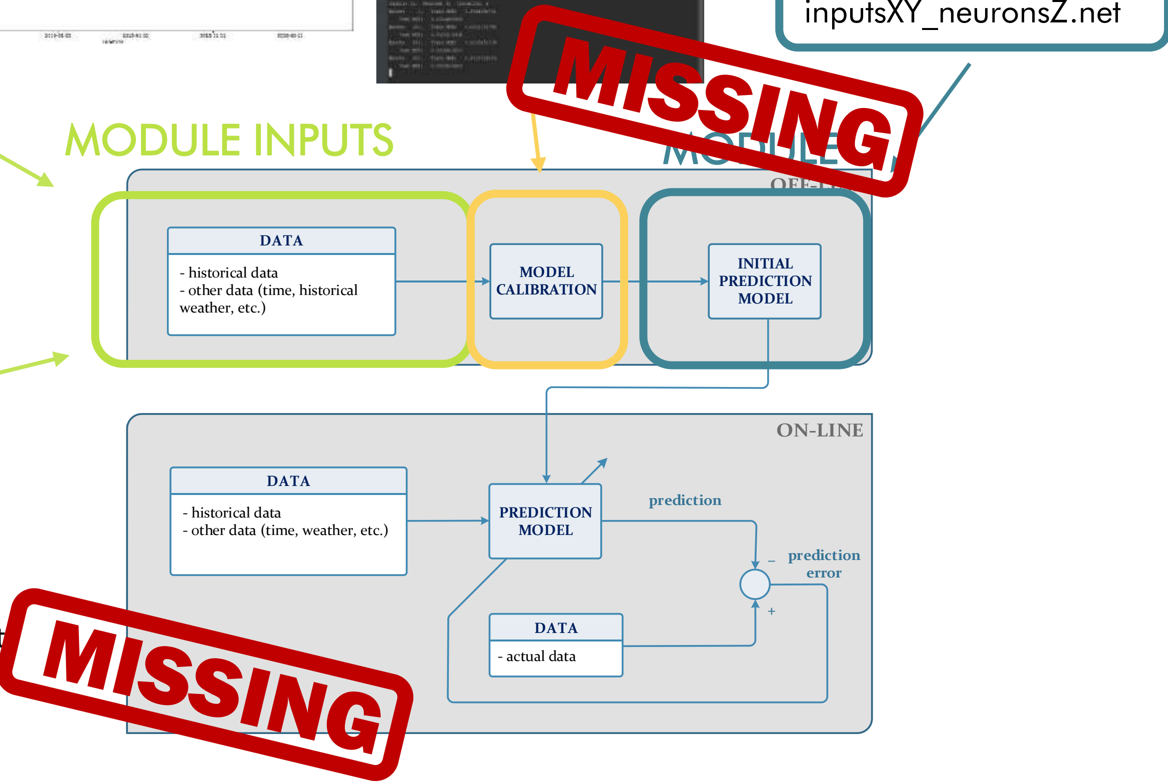


Historical **weather measurements**:

- Temperature
- Direct, diffuse solar irradiance



Historical **non-controllable consumption**



Consumed heat on the central calorimeter

-

(consumed heat in zones with fan coils measurement

+

calculated energy loss on the vertical supply lines)

HVAC PE 4 – non-controllable consumption

Consumed heat on the central calorimeter

-

(consumed heat in zones with fan coils measurements

+

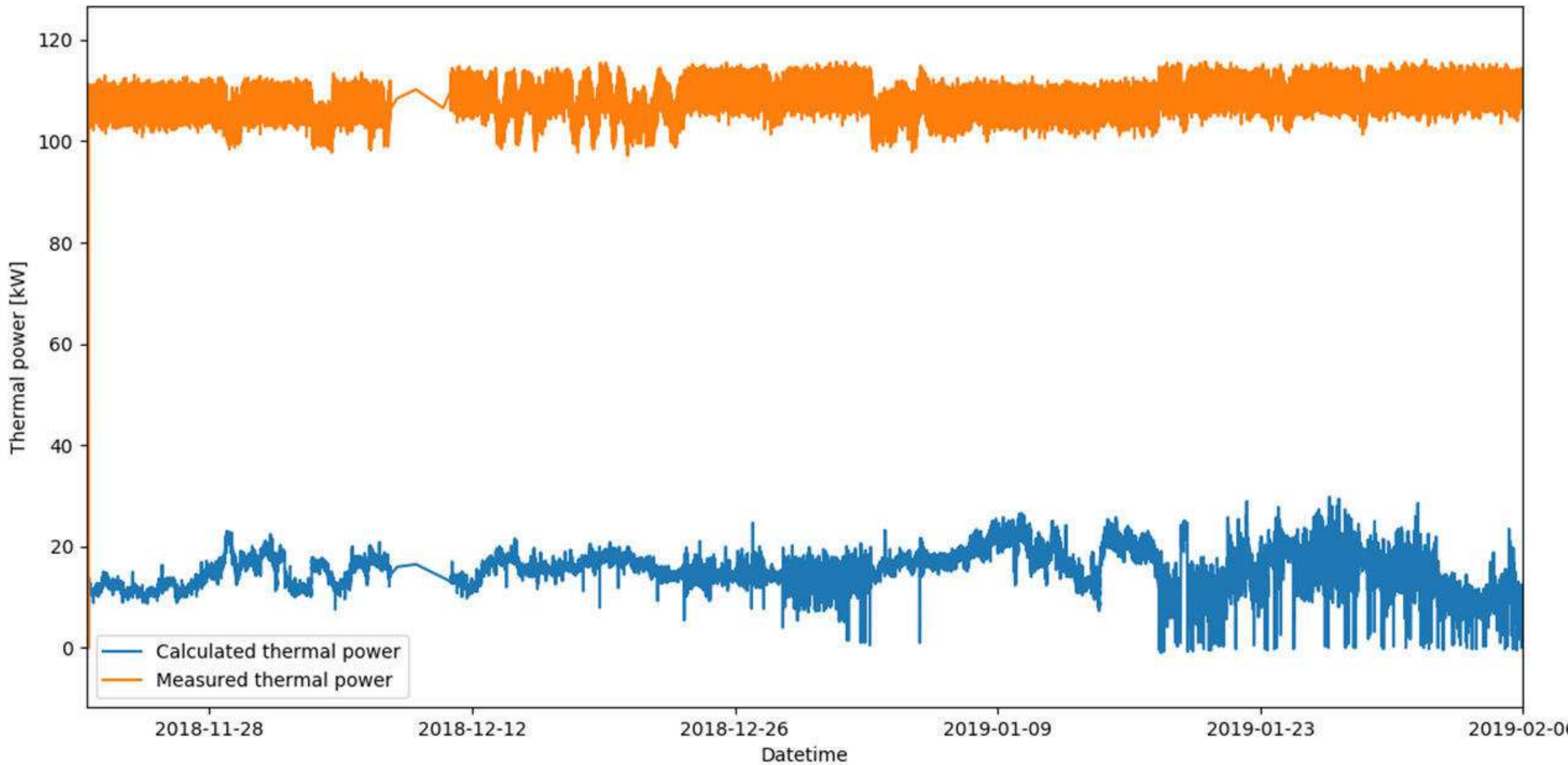
calculated energy loss on the vertical supply lines)

HVAC PE 4 – calorimeter power calculation/measurement

$$P = \frac{q}{3.6} \cdot 4186 \cdot (T_{supply} - T_{return}) \quad [W]$$

- 3.6: m^3/h to kg/s
- 4186: specific heat capacity of the medium

Calorimeter ID 1: A building

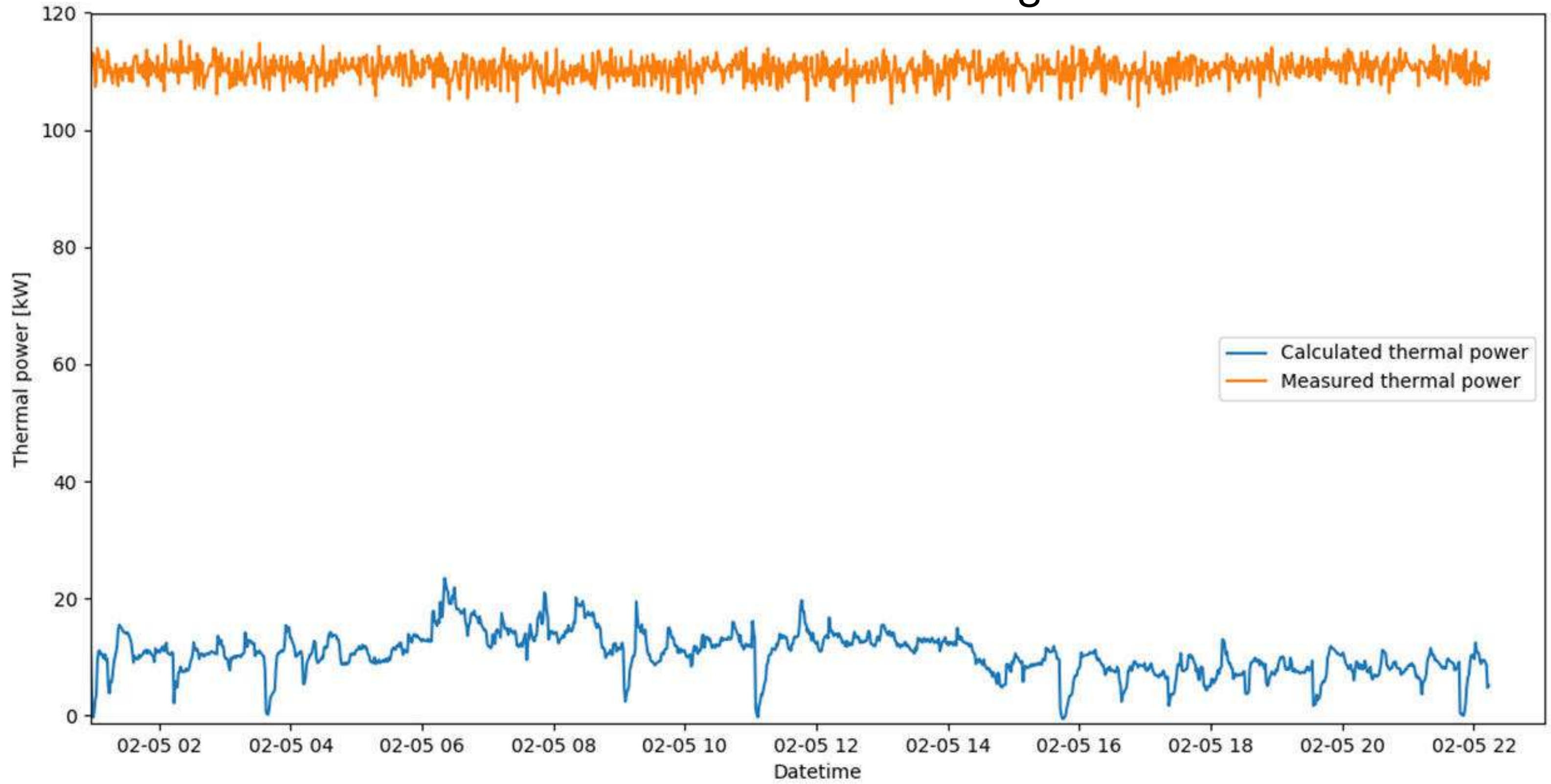


HVAC PE 4 – calorimeter power calculation/measurement

$$P = \frac{q}{3.6} \cdot 4186 \cdot (\mathrm{T}_{\mathrm{supply}} - \mathrm{T}_{\mathrm{return}}) \quad [\mathrm{W}]$$

- 3.6: m^3/h to kg/s
- 4186: specific heat capacity of the medium

Calorimeter ID 1: A building

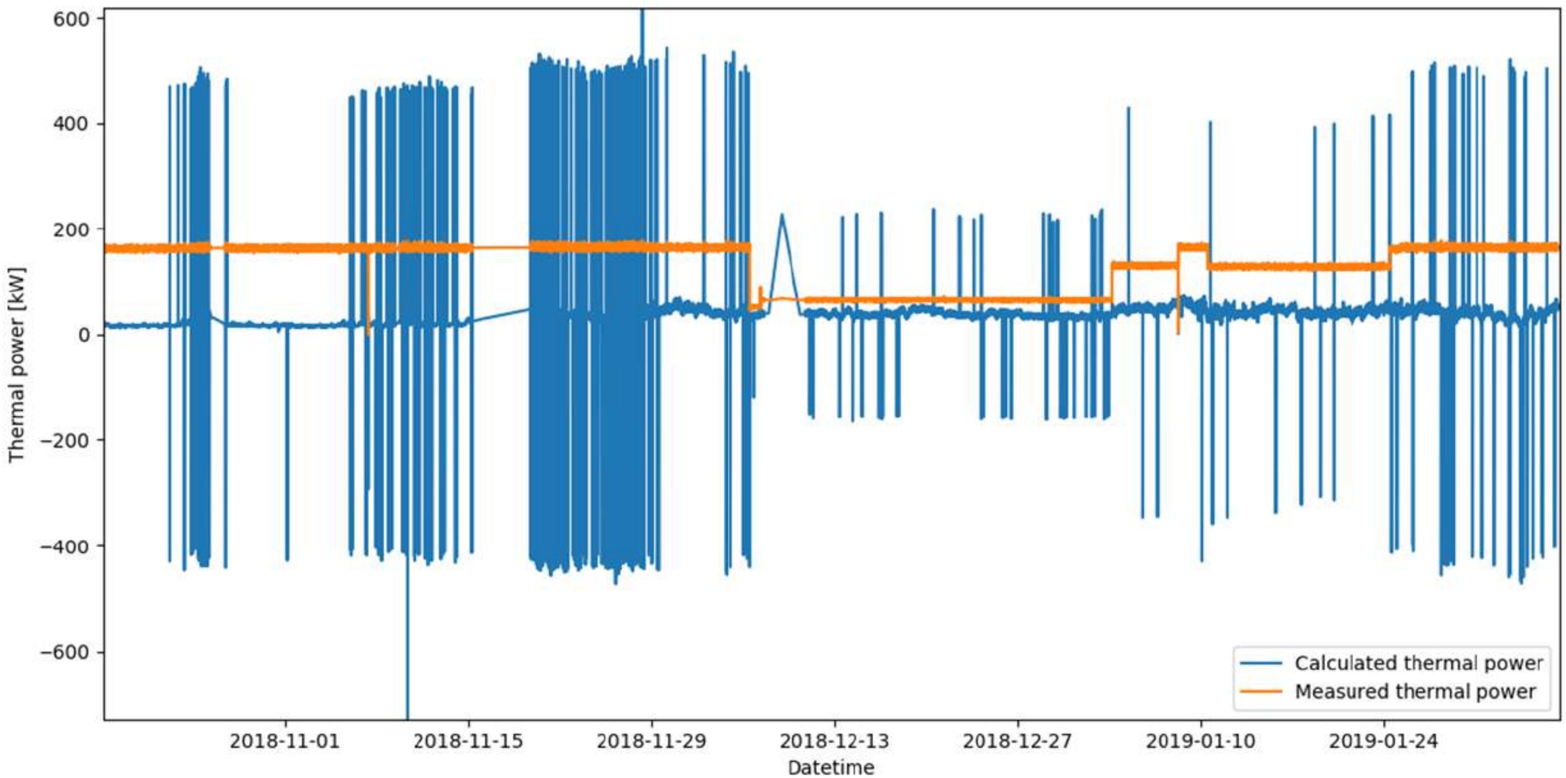


HVAC PE 4 – calorimeter power calculation/measurement

$$P = \frac{q}{3.6} \cdot 4186 \cdot (T_{supply} - T_{return}) \quad [W]$$

- 3.6: m^3/h to kg/s
- 4186: specific heat capacity of the medium

Calorimeter ID 4: E building

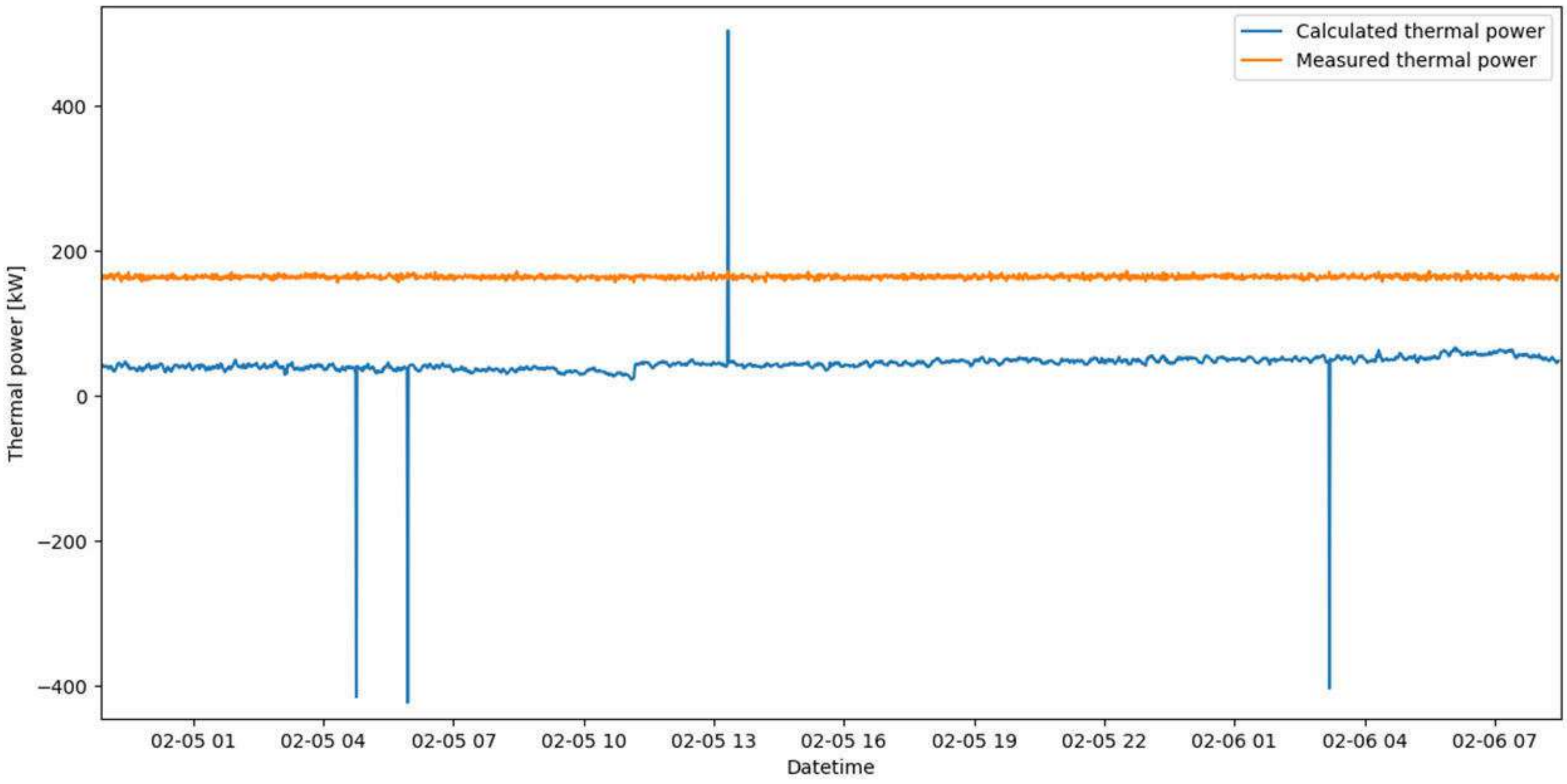


HVAC PE 4 – calorimeter power calculation/measurement

$$P = \frac{q}{3.6} \cdot 4186 \cdot (T_{supply} - T_{return}) \quad [W]$$

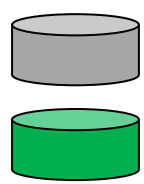
- 3.6: m^3/h to kg/s
- 4186: specific heat capacity of the medium

Calorimeter ID 4: E building



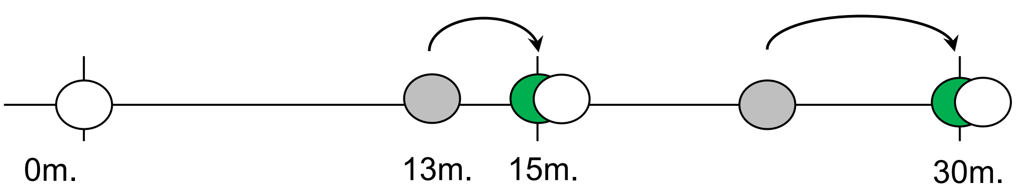
HVAC MPC 1
Heating substation
3smart control

3smart

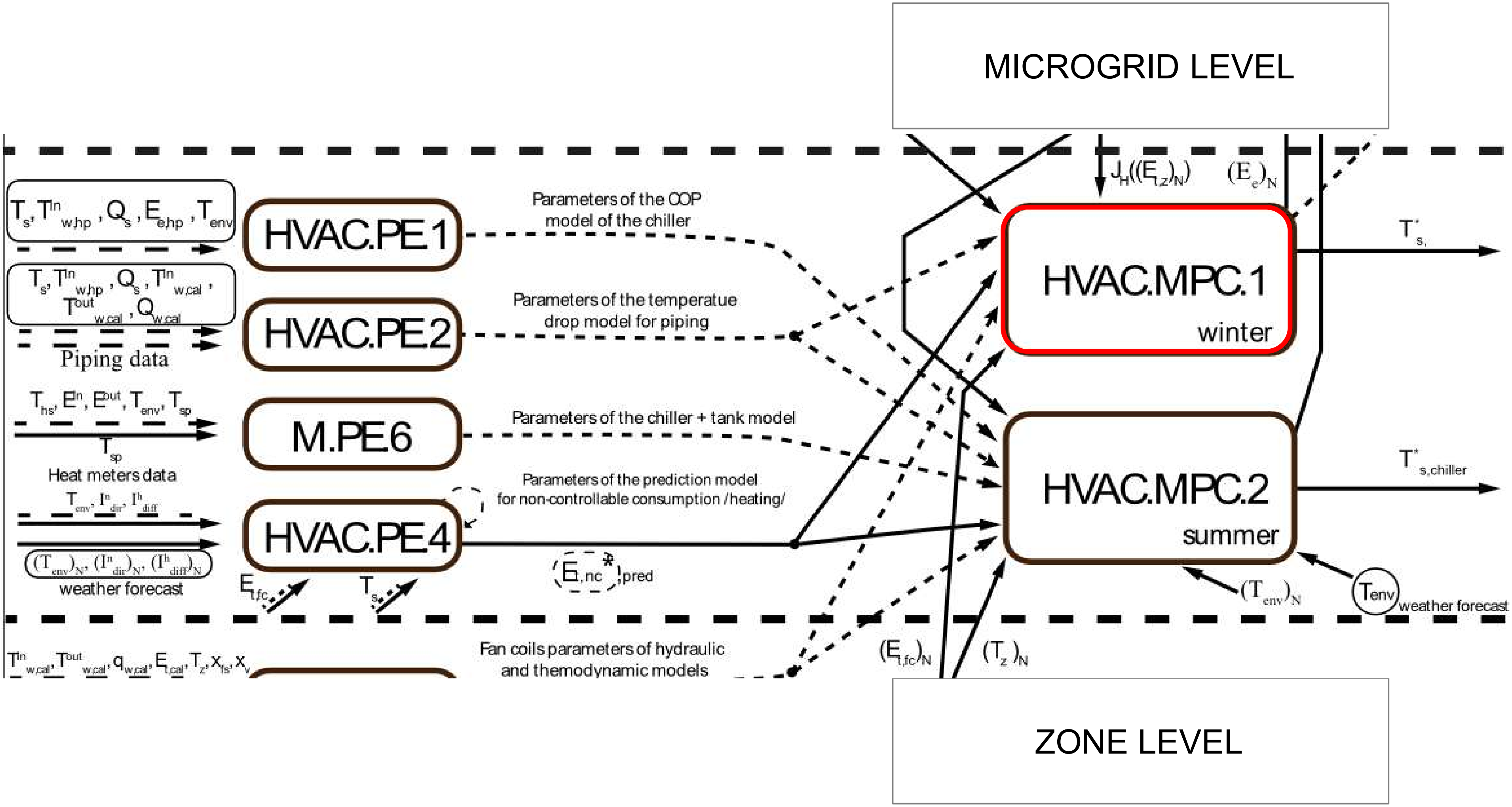


HVAC MPC 1 – module operation

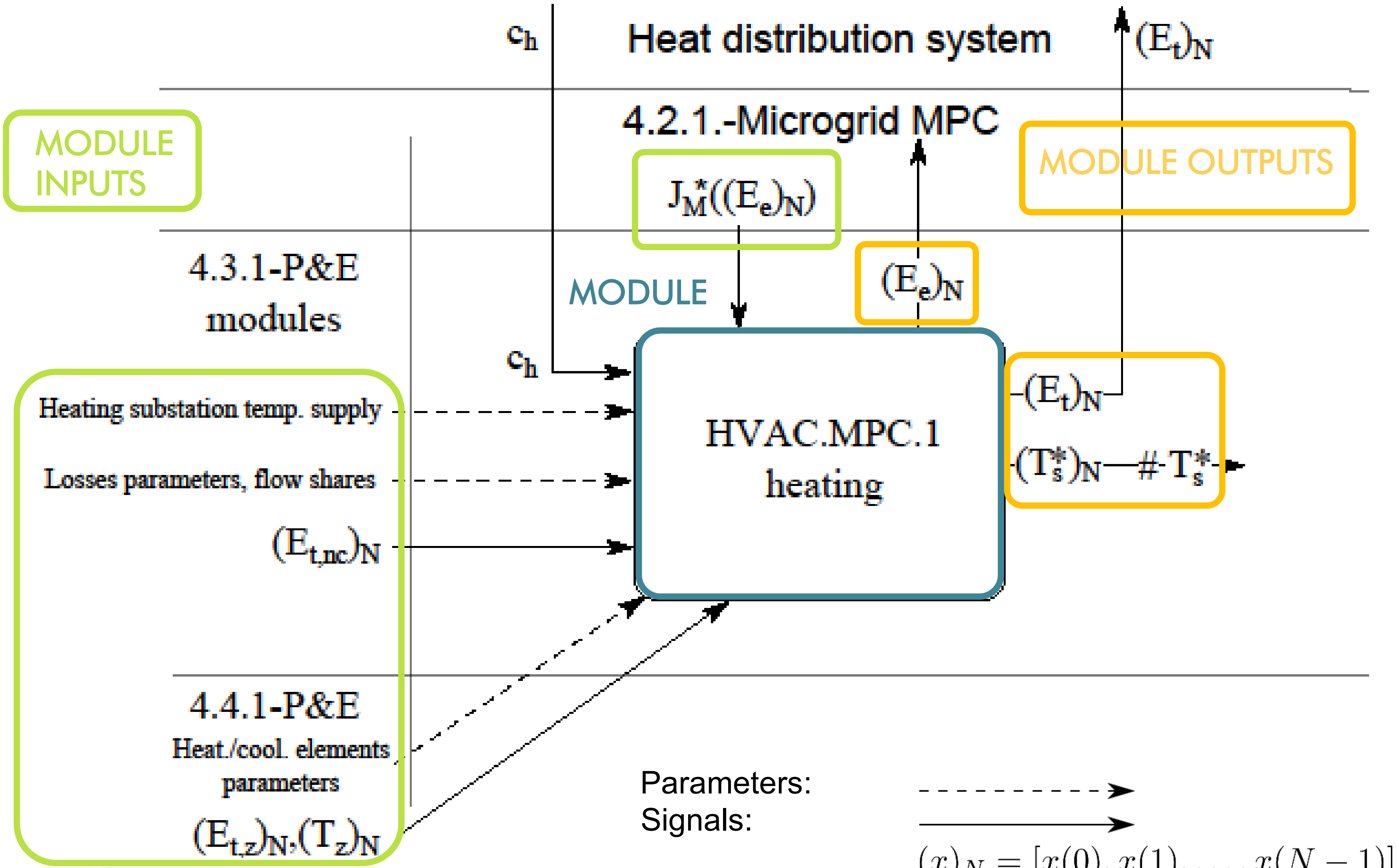
- Description: medium temperature optimisation → costs and comfort
- Module interaction on HVAC level:
  - 4.2.1. - Microgrid MPC module
  - 4.3.1. – P&E modules
- Execution frequency: 15 minutes
- <15 min. coordination between the microgrid and HVAC MPC



HVAC MPC 1 – information flow

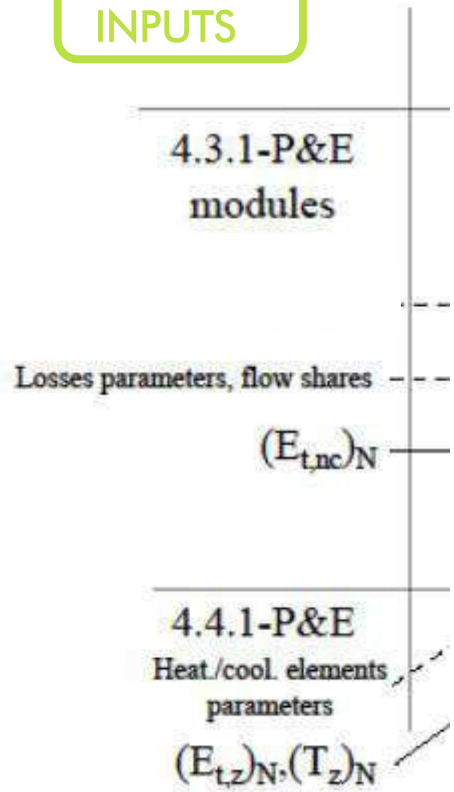


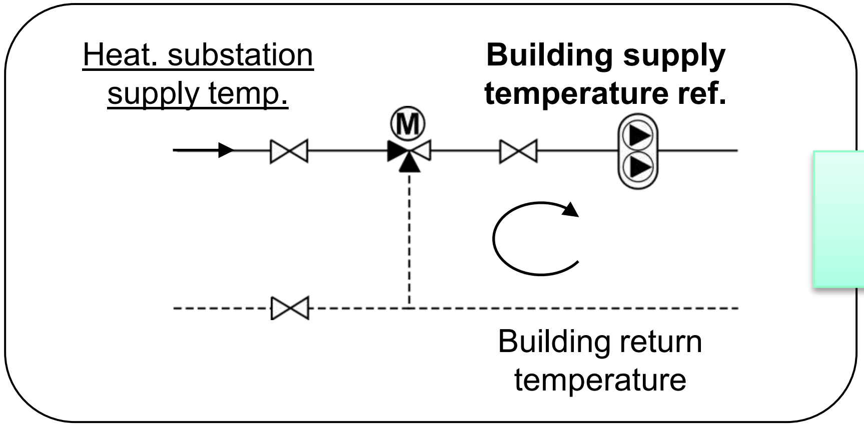
HVAC MPC 1 – information flow



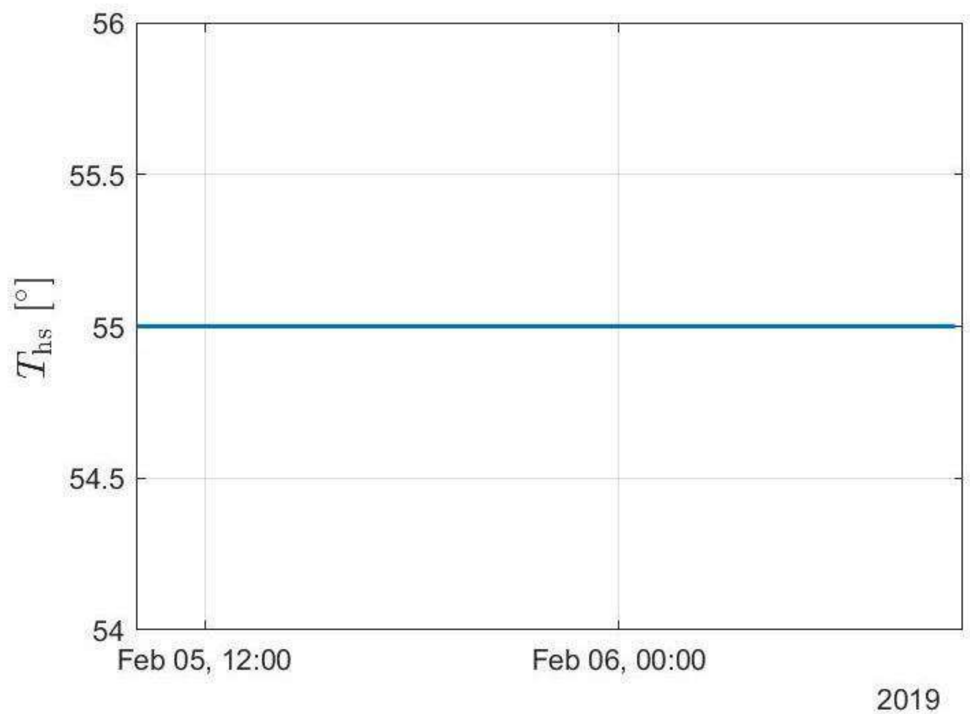
HVAC MPC 1 – information flow

MODULE INPUTS

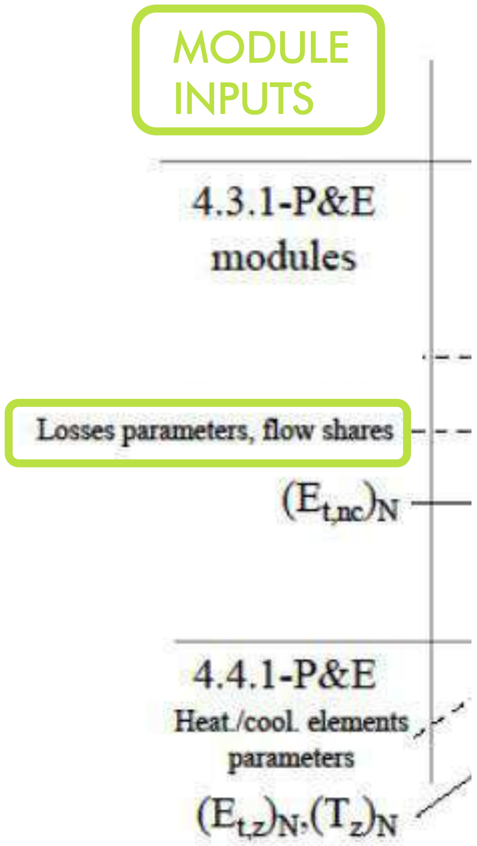




Does flow change?



HVAC MPC 1 – information flow



- Losses supply: flow shares & temperature drop (*partly defined, synthetic data*) -- hvac_pe2_fcu_outputs table

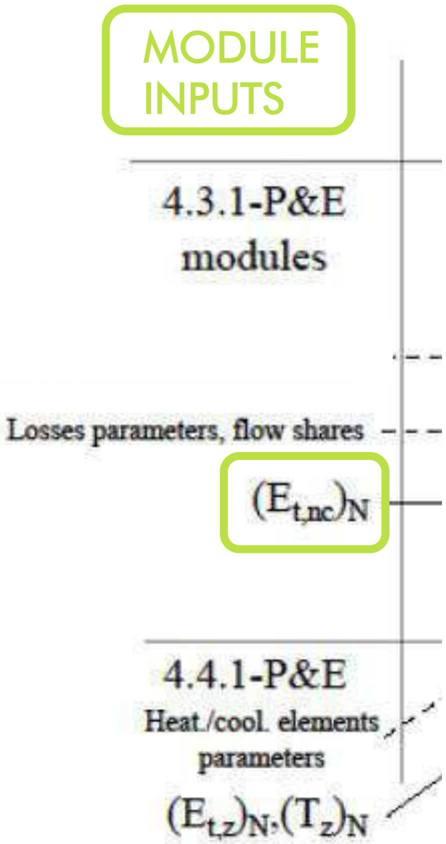
Model of pipework losses scale-up for entire building?

- Losses return: model parameters (*synthetic data*) – hvac_pe2_calorimeter_return

Parameters: - - - - - - - - - - ➤
Signals: ————————➤

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

HVAC MPC 1 – information flow



- Non-controllable thermal loads: together with controllable loads form cummulative thermal energy consumption

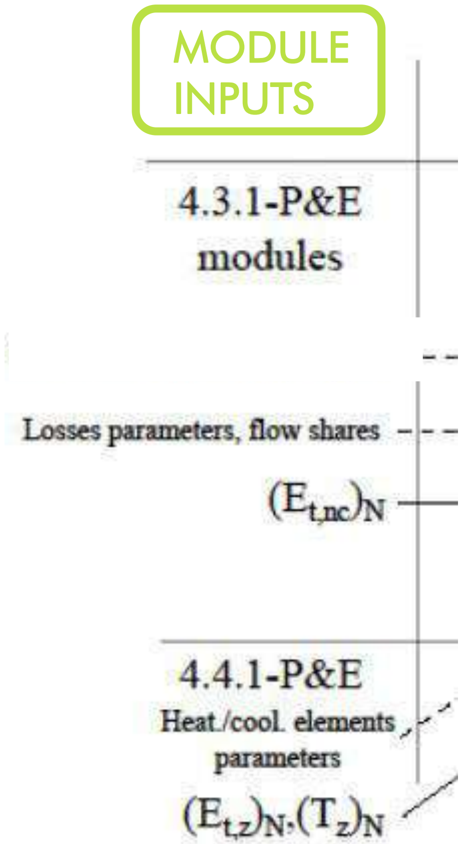
Et,nc considered constant in predictions

Parameters: - - - - - - - - - - ➤

Signals: ──────────➤

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

HVAC MPC 1 – information flow



- Volatile el. prices obtained from MGRID module

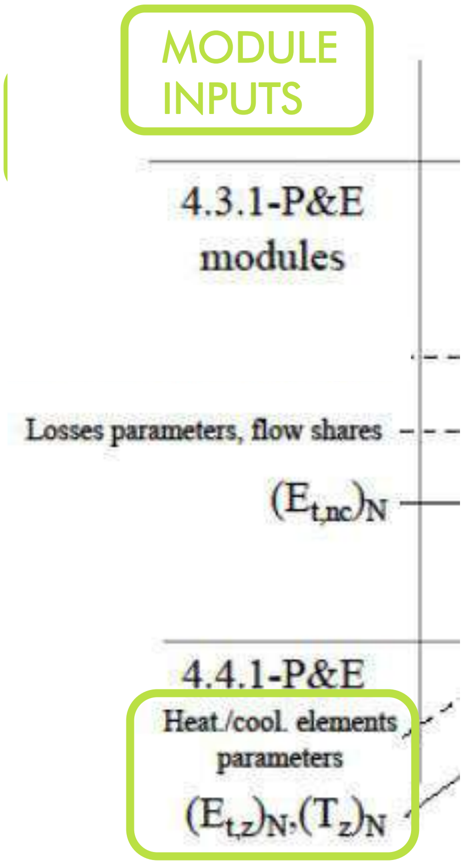
ce considered constant in predictions 0.12 [EUR/kWh]

- Heating energy price constant 0.08 [EUR/kWh] – possible volatility

Parameters: $- - - - - - - - - - \rightarrow$
Signals: $\longrightarrow$

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

HVAC MPC 1 – information flow



- FCU parameters: table fcu_thermodynamic_model (*partly defined*)
- Zone energy demand/zone temperature predictions

Synthetic data

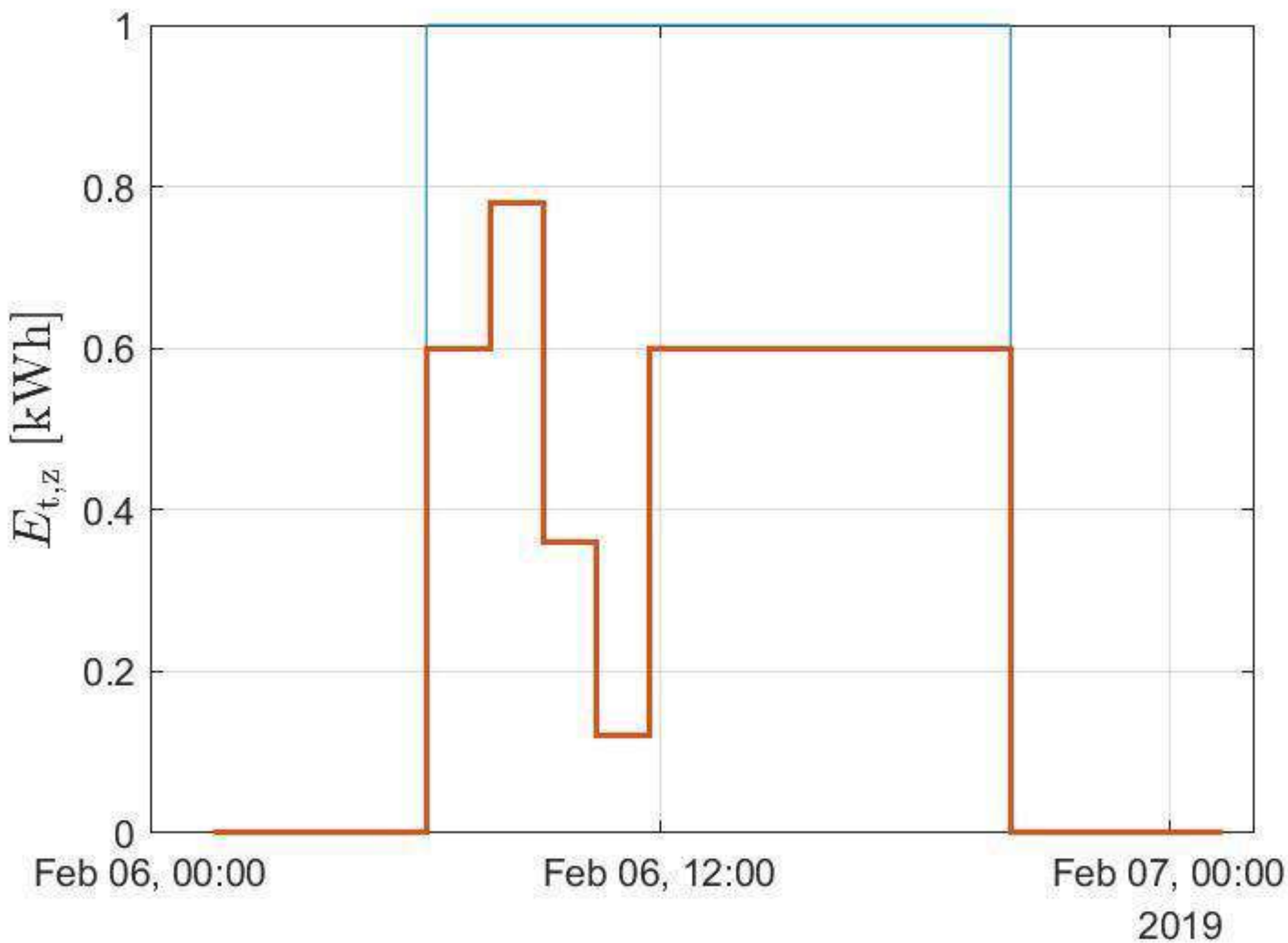
Parameters:
Signals:

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

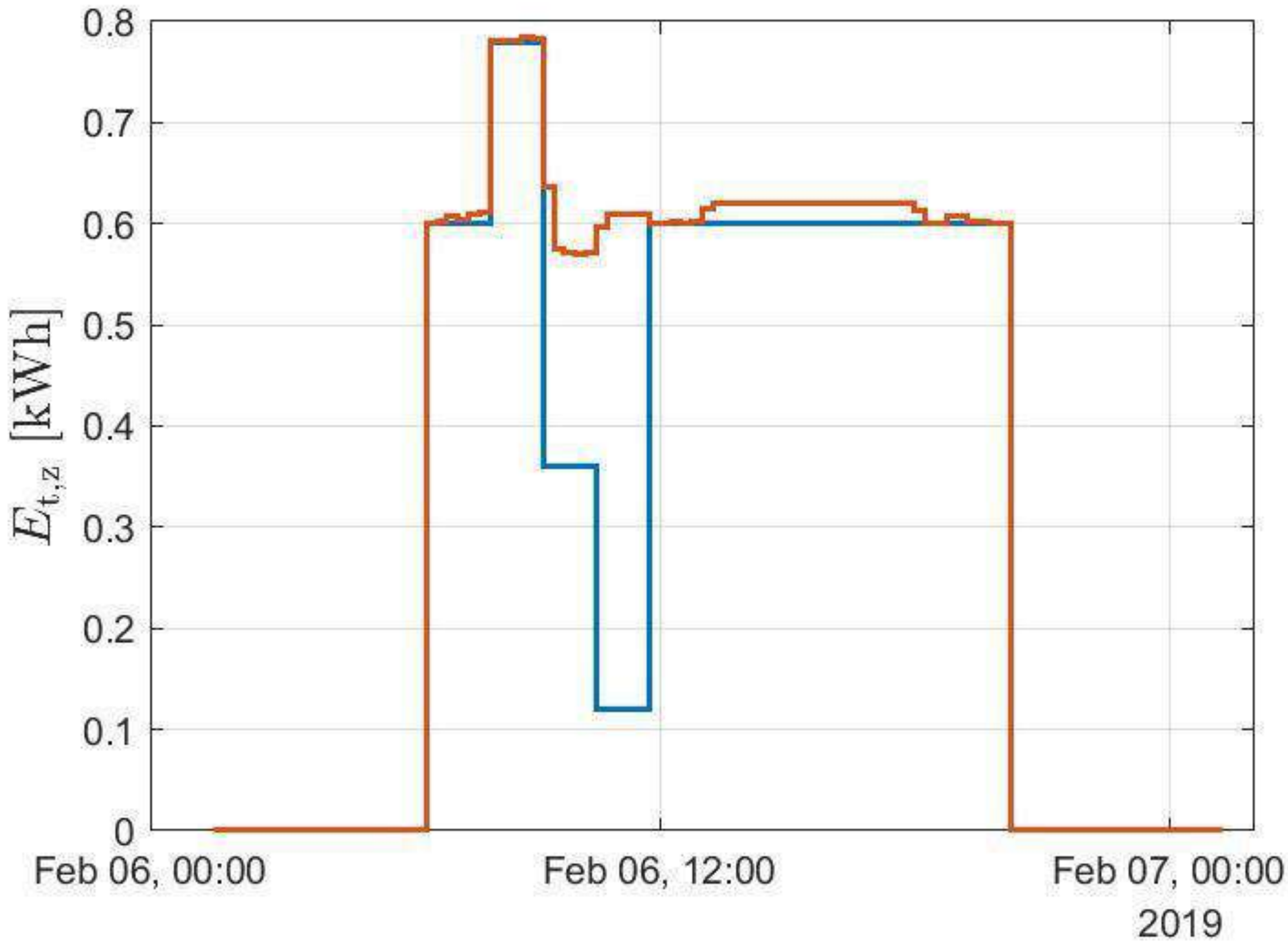
HVAC MPC 1 scenario

- **B+C** and **E** EON buildings -- 2 supply temp. ref.
- **24h** ahead predictions
- approx. 2.5 min. optimisation duration
- problem is initialised with control values in medium range
- HVAC not operating from 20:00 to 6:30 next day

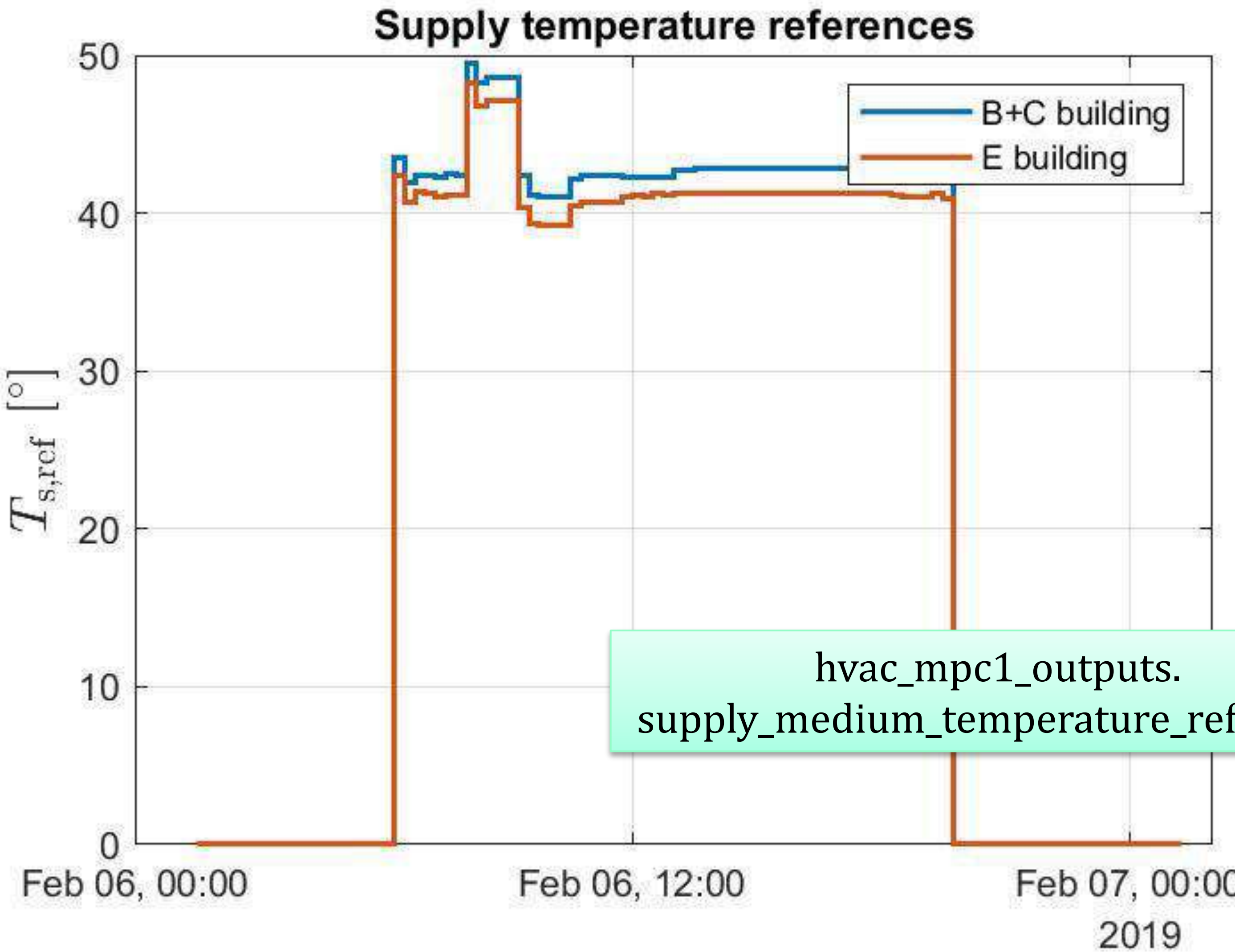
HVAC MPC 1 scenario – zone energy demands,



HVAC MPC 1 scenario – attainable zone energy

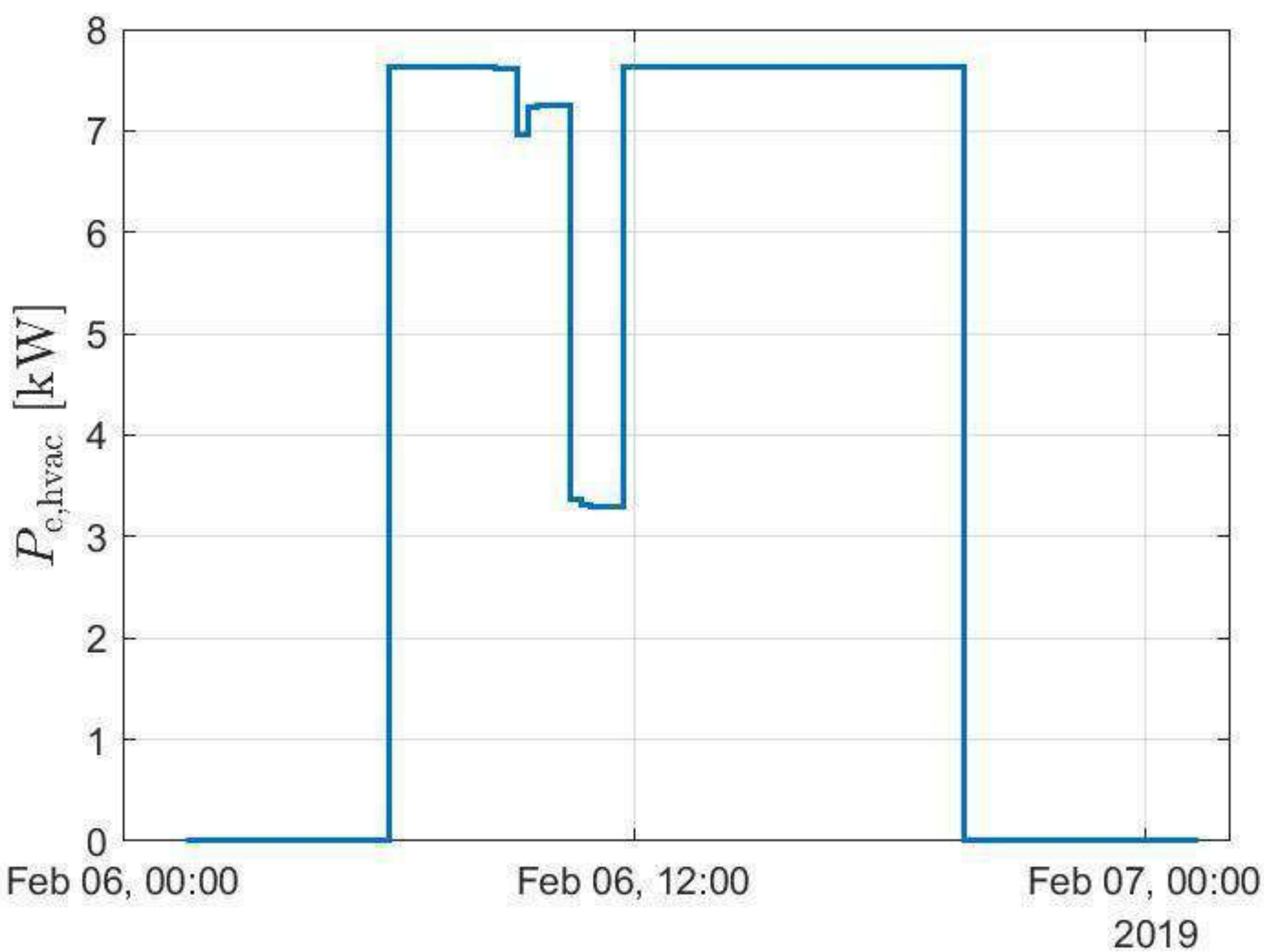


HVAC MPC 1 scenario – supply temperature ref.

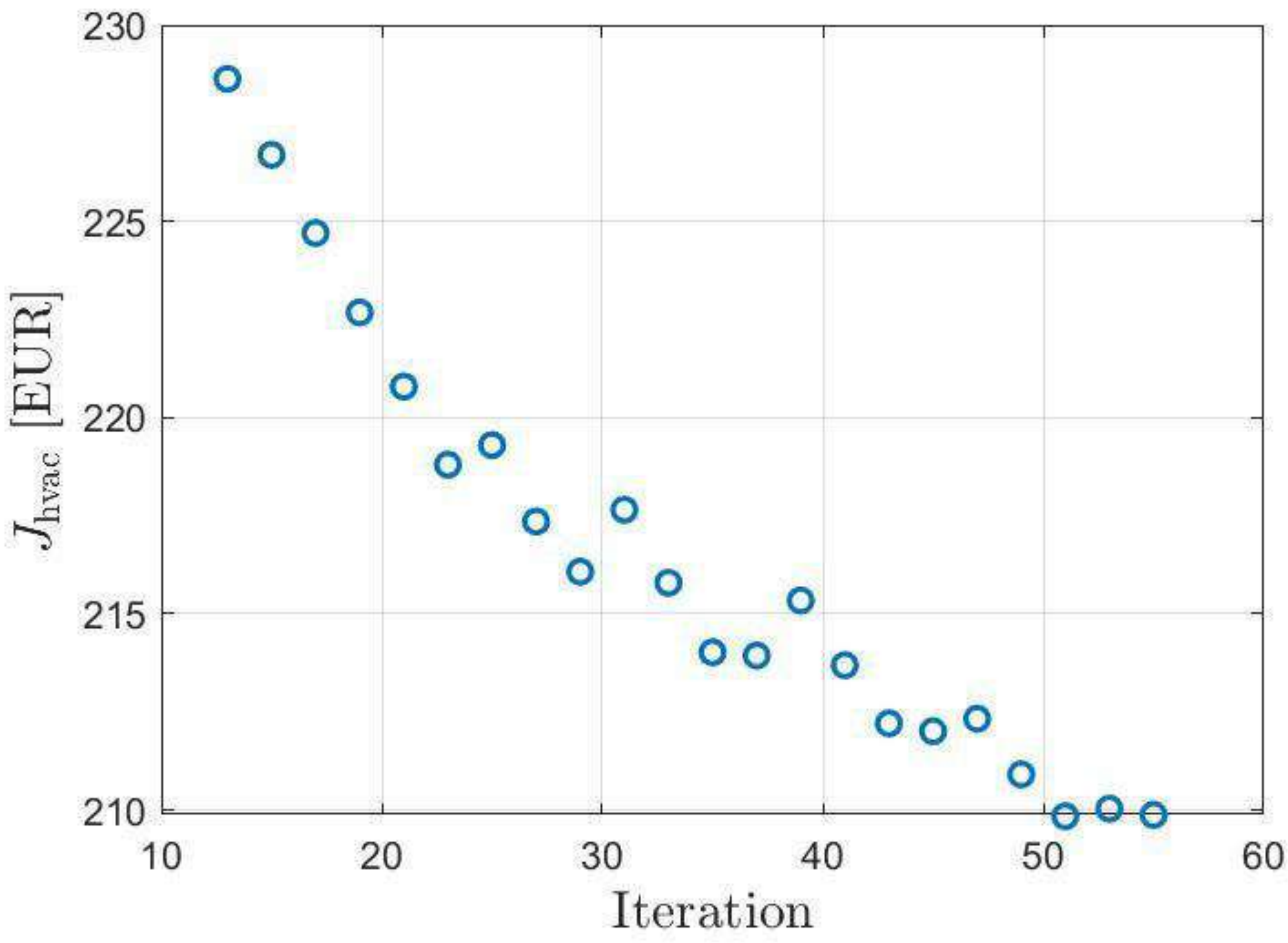


hvac_mpc1_outputs.
supply_medium_temperature_reference

HVAC MPC 1 scenario – electrical energy cons.

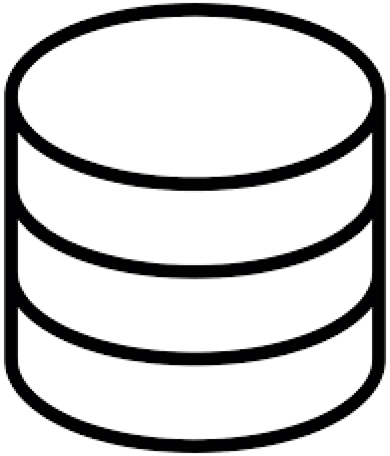


HVAC MPC 1 scenario – optim. cost 24h ahead…



HVAC MPC 1 tables

hvac_mpc1_outputs
hvac_mpc1_outputs_history



HVAC.PE.1 and HVAC.PE.2

Vladimir Jovanović, Mirko Komatina, Nebojša Manić
UNIBGFME
vjovanovic@mas.bg.ac.rs

First pilot study visit - Debrecen

February 5-6, 2019

Interreg
EUROPEAN UNION
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 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

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 – Results (Inputs tables)

- At the moment no results are available in the format of inputs tables.
- Calculations are made based on historical data supplied by EON.
- Module is developed and ready to be coded in Python for both off-line and on-line operation.

HVAC.PE.1 – Results (Outputs table)

- At the moment no results are available for the outputs tables.

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)

- Measurement results from all calorimeters in EON building were provided yesterday.
- Calculations of coefficients a, b and c in the equation for temperature drop determination will be calculated ASAP.
- Afterwards, Python coding will be possible.

HVAC.PE.2 – Results (Outputs table)

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

Anita Martinčević, Nikola Hure, Danko Marušić, Hrvoje Novak

UNIZGFER

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3Smart pilot study visit to HUN pilot No. 1 in Debrecen

6 February 2019

UNIVERSITY OF ZAGREB
FACULTY OF ELECTRICAL ENGINEERING AND COMPUTING

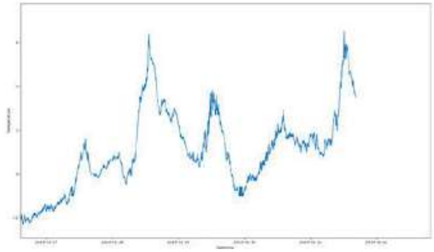
Project co-funded by the European Union

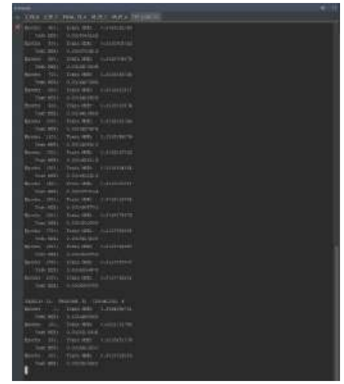
Microgrid-level modules UNIZGFER

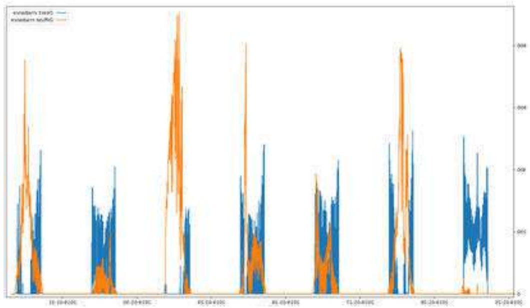
M PE 3 – off-line initialization

Historical **weather measurements**:

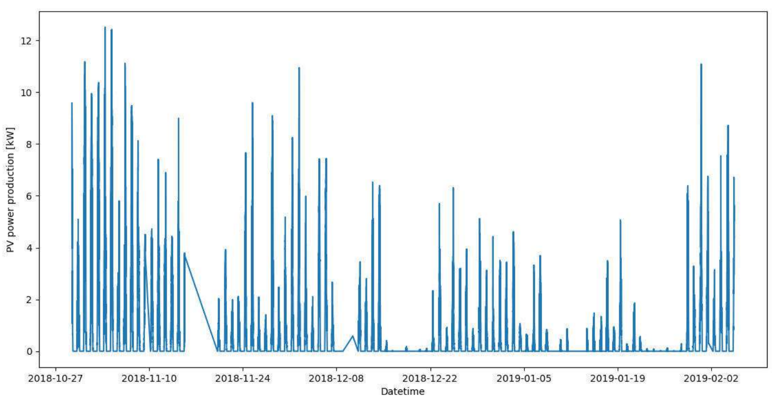
- Temperature
- Direct, diffuse solar irradiance
- Solar zenith and azimuth angles



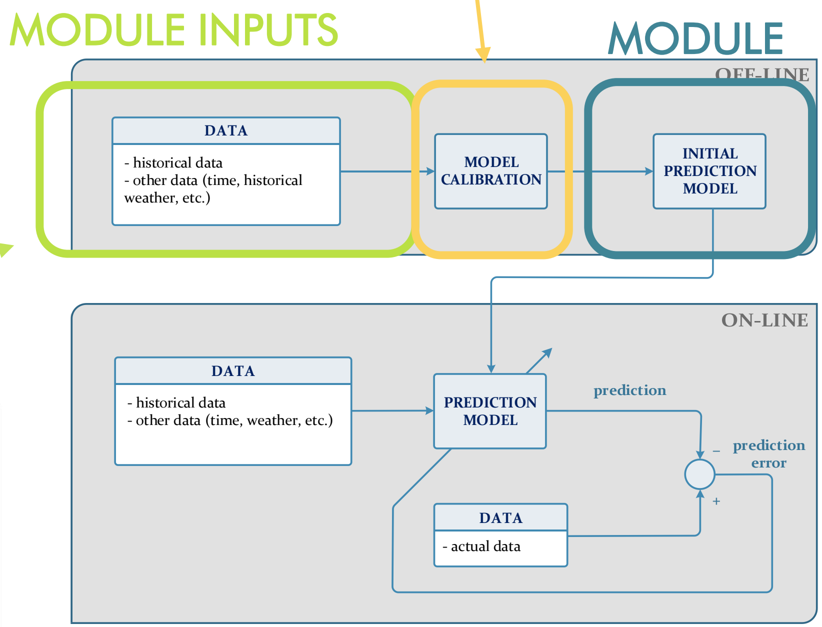




Historical **PV production data**



Locally stored:
inputsXY_neuronsZ.net



M PE 3 – off-line initialization

General prerequisites

1. Server connection (VPN SSTP)
2. Database connection (MySQL Workbench)
3. Python connection (PyCharm terminal, libraries etc.)
4. Virtualenv on the server side
5. Historical data analysis

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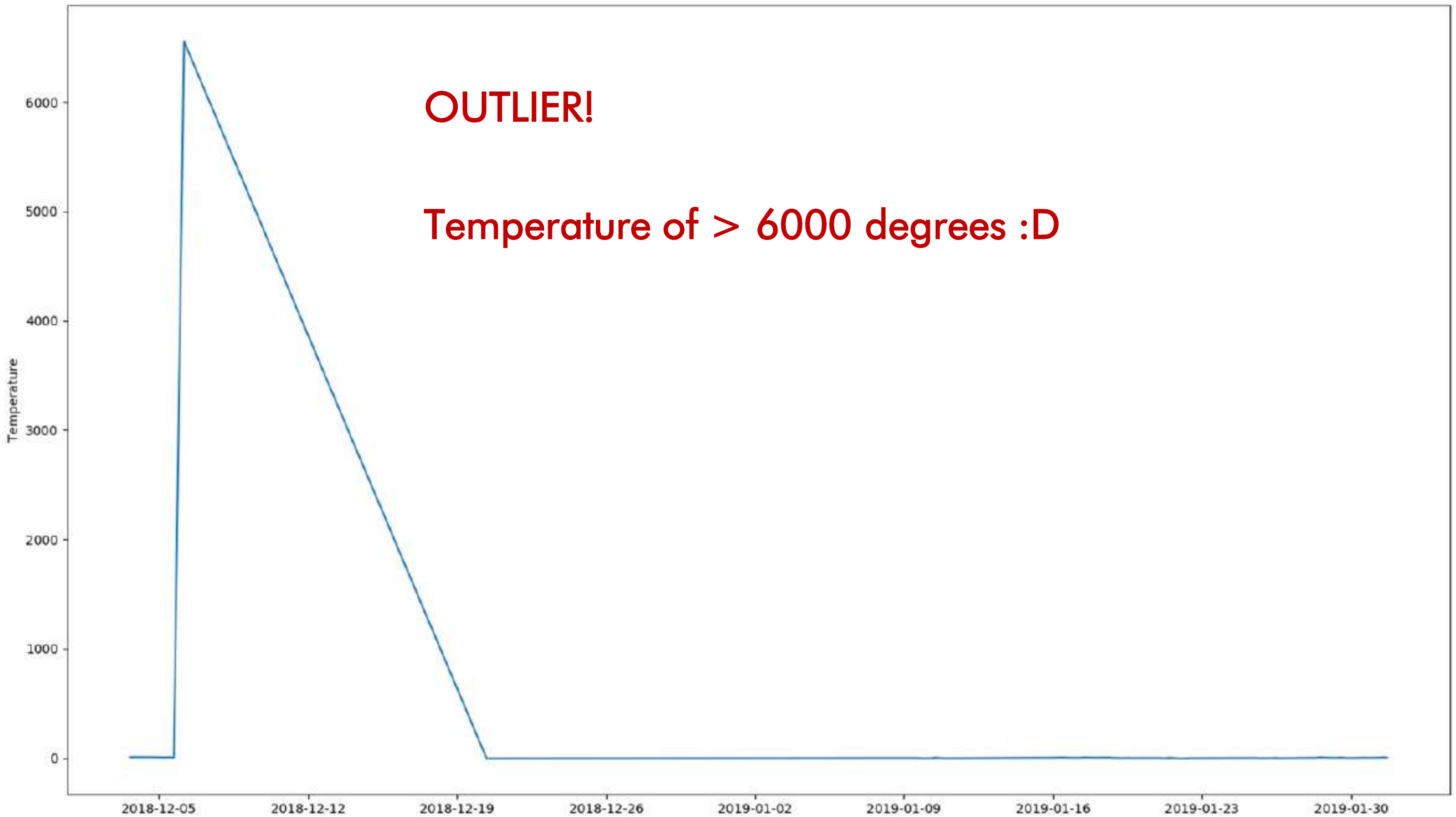
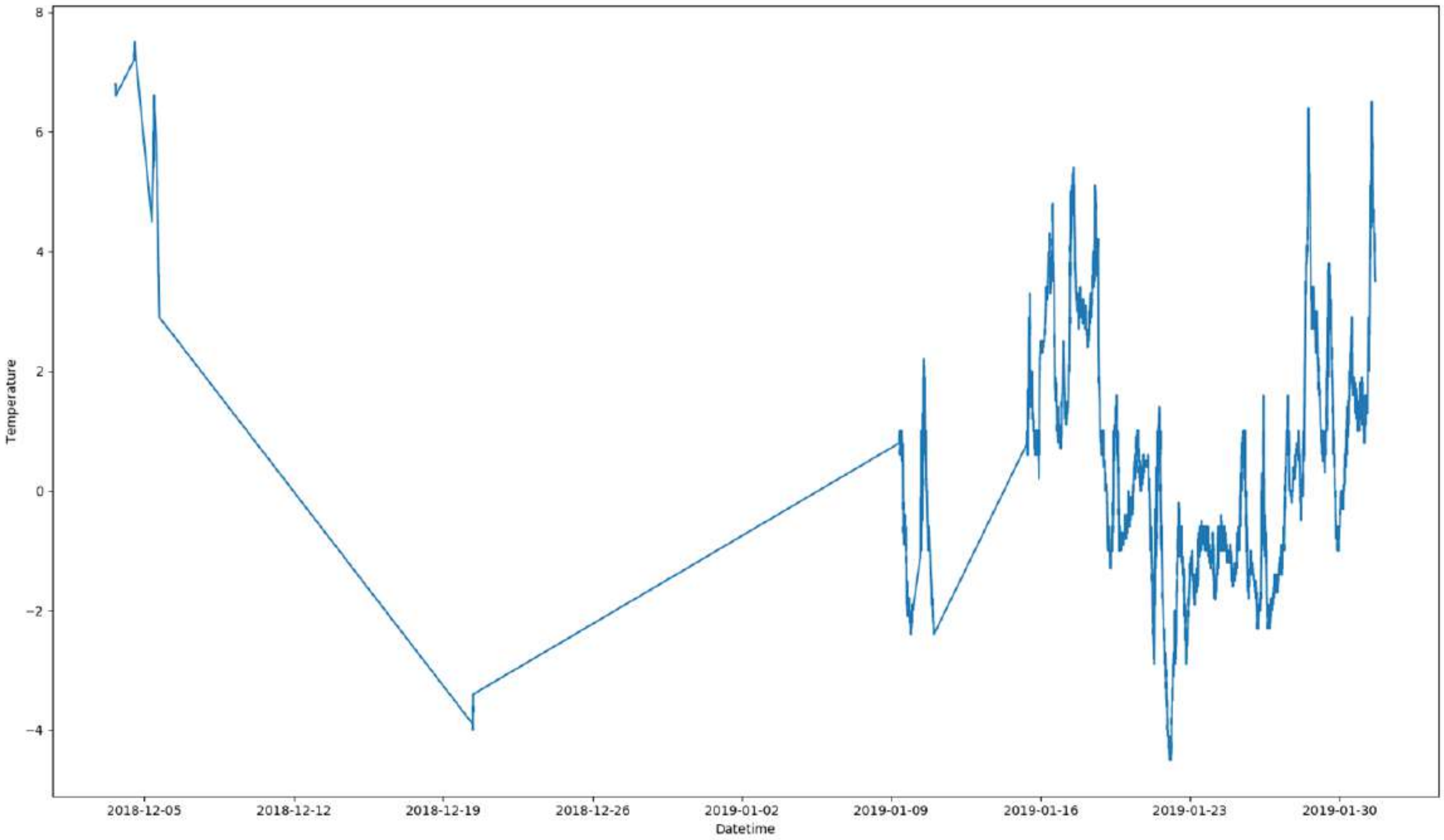
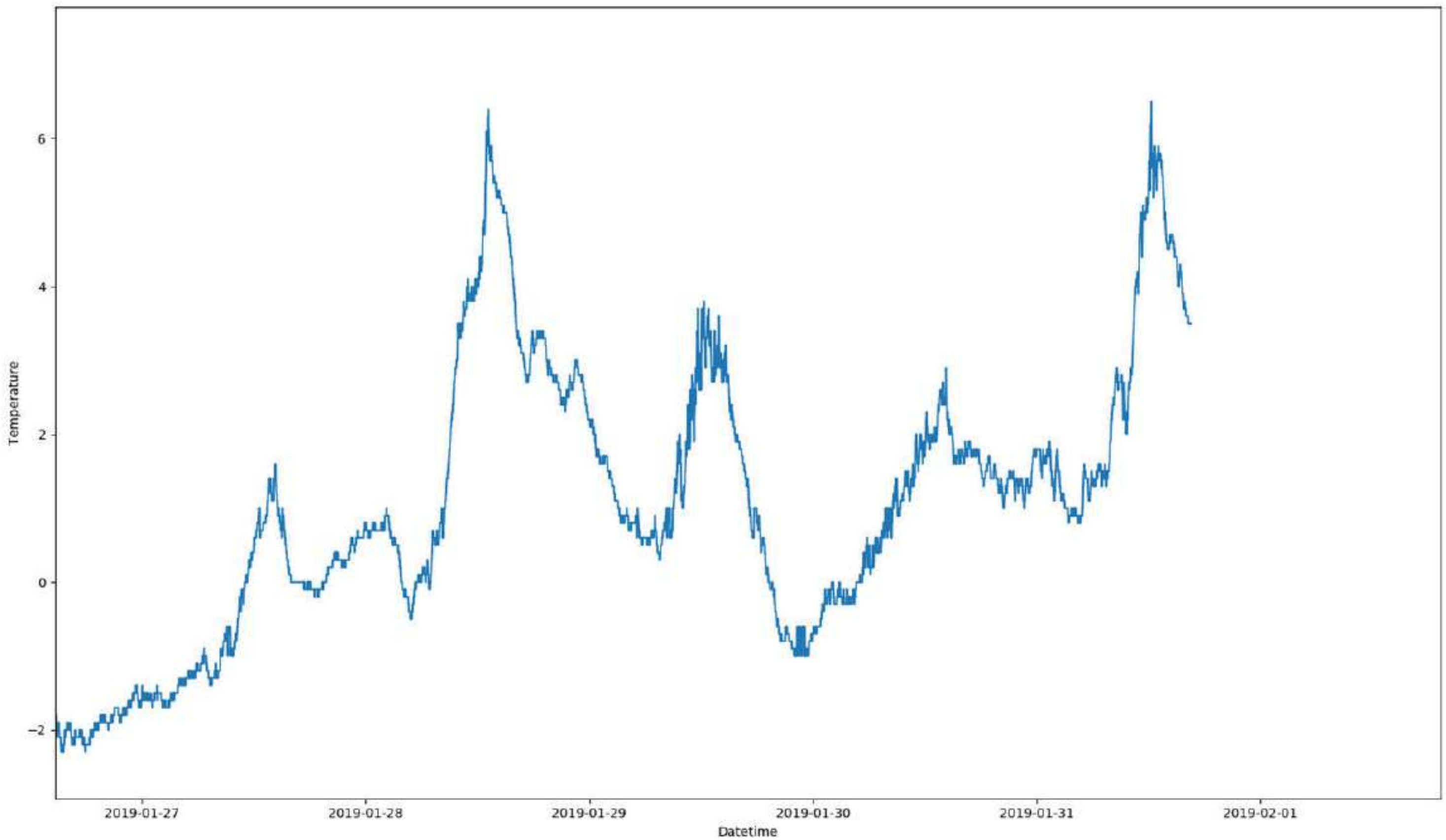
M PE 3 – temperature measurements (initial)



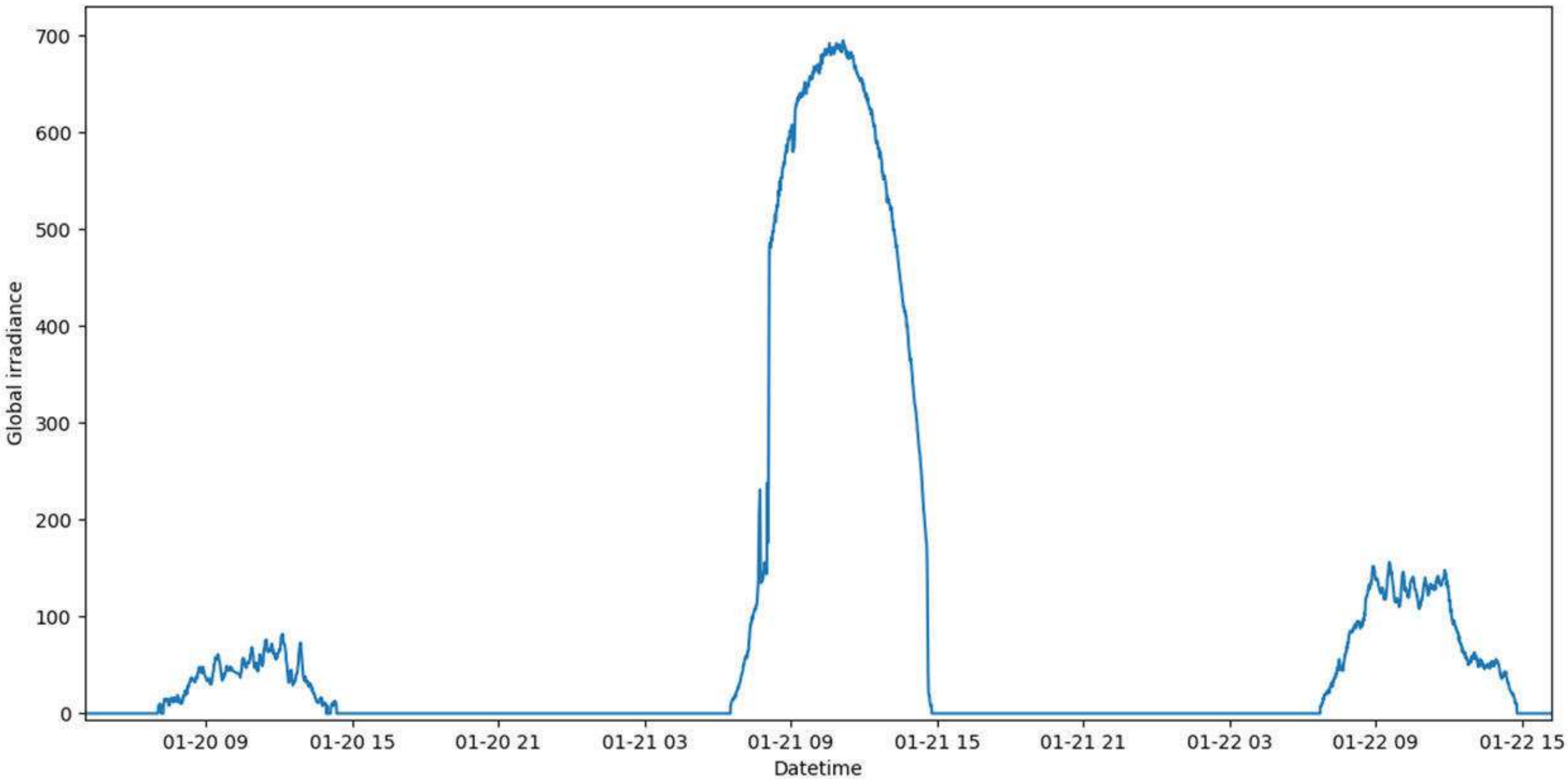
M PE 3 – temperature measurements (filtered)



M PE 3 – temperature measurements (recent data)



M PE 3 – irradiance measurement (global)



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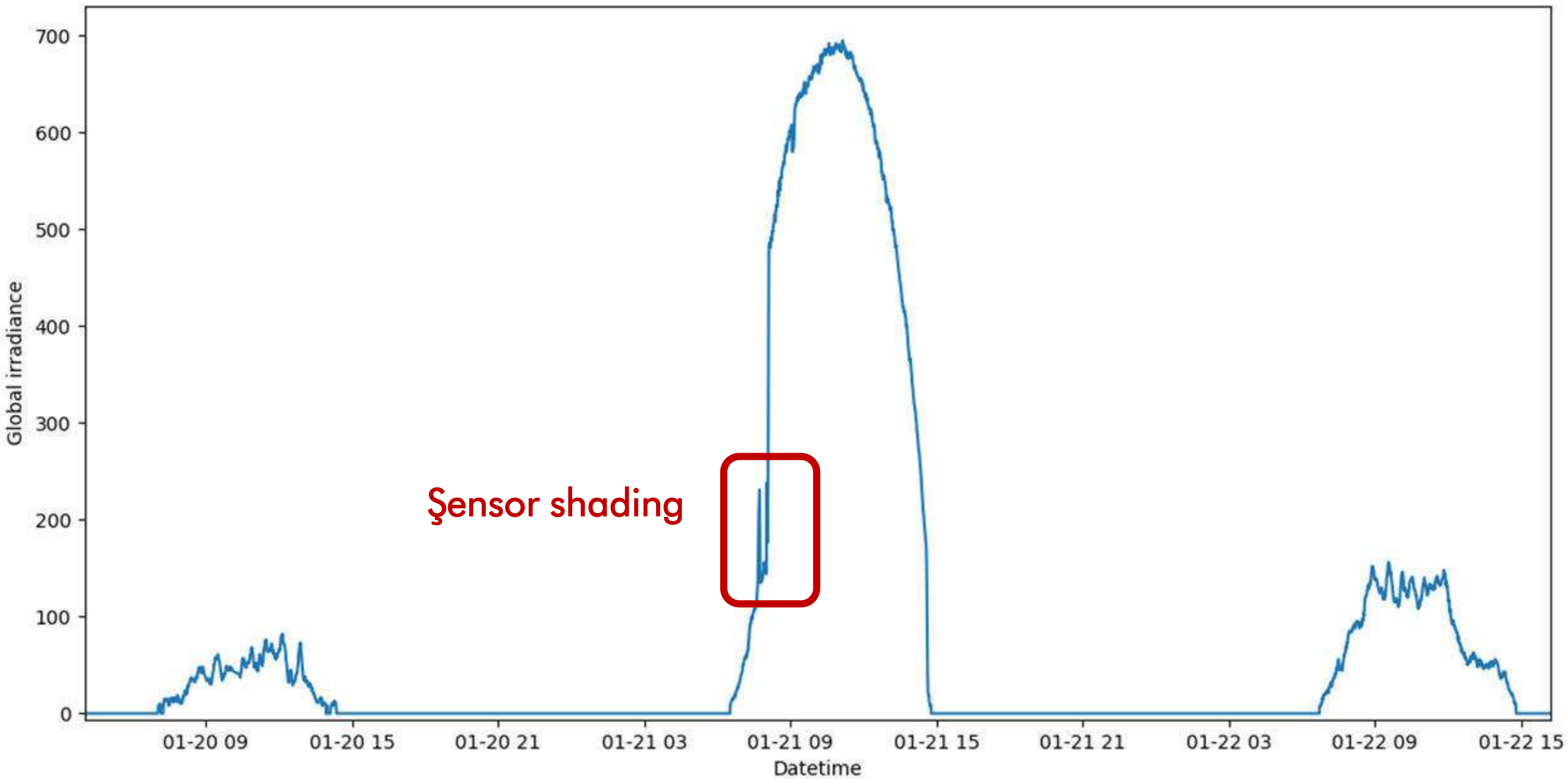
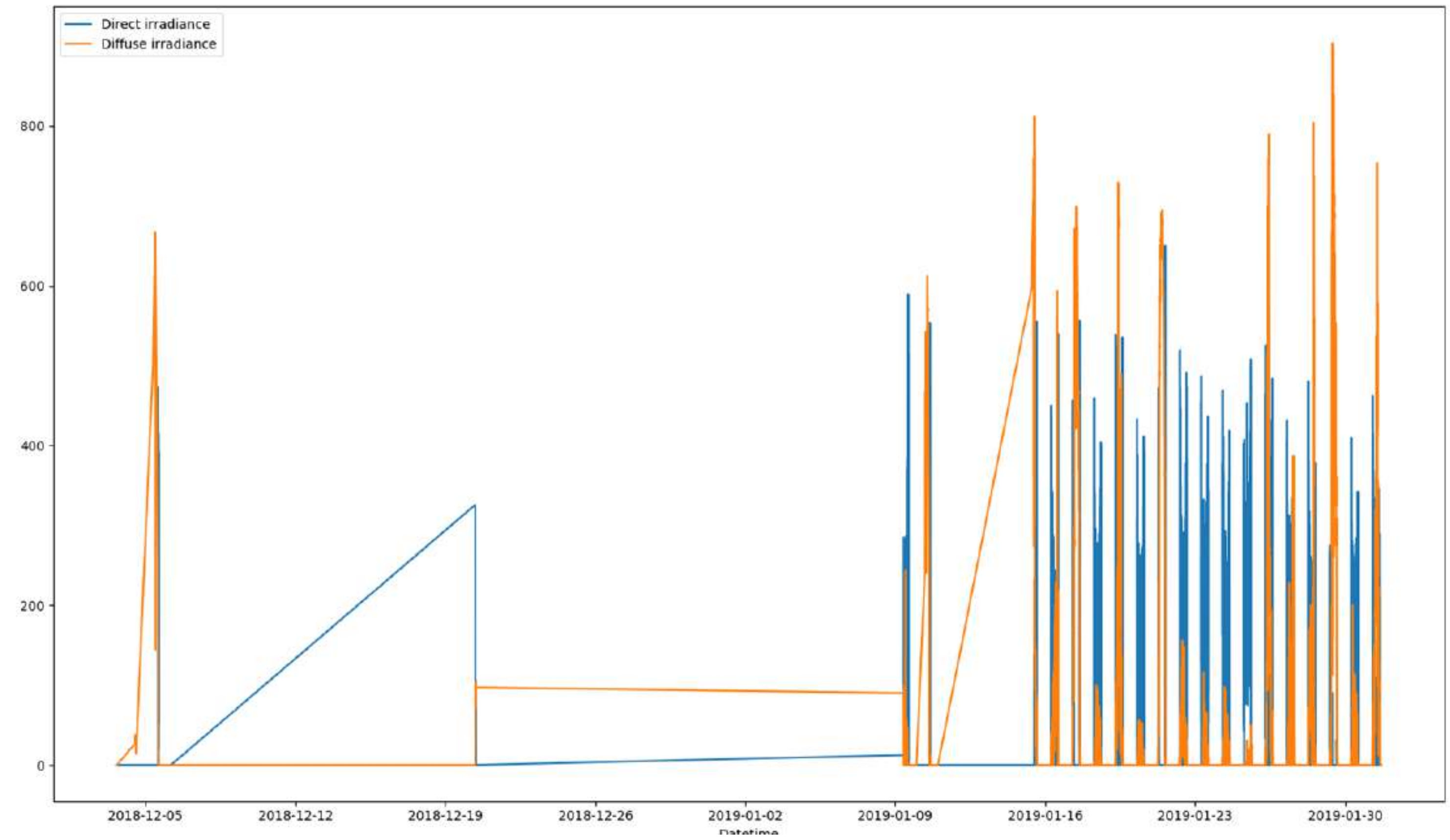
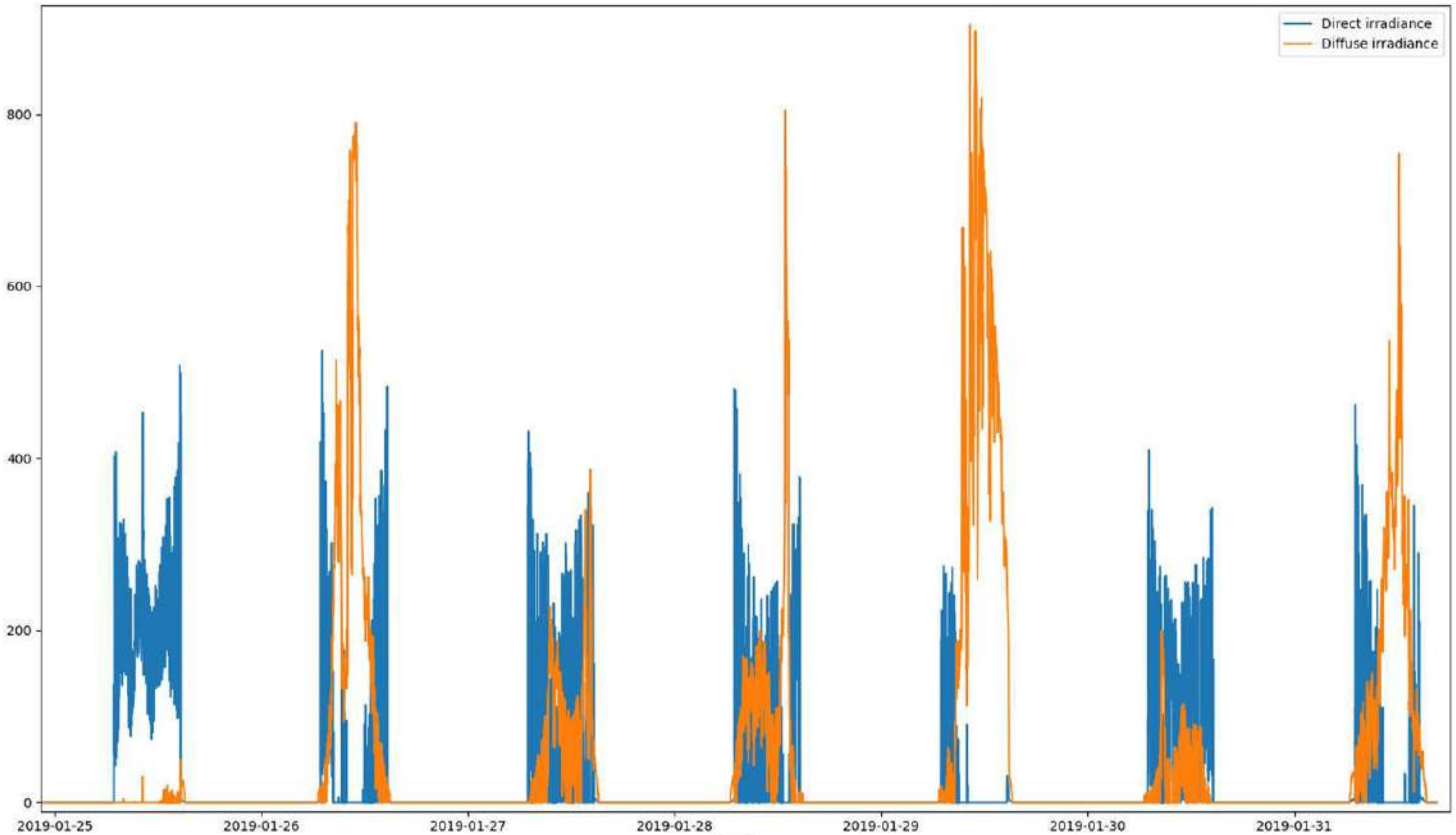


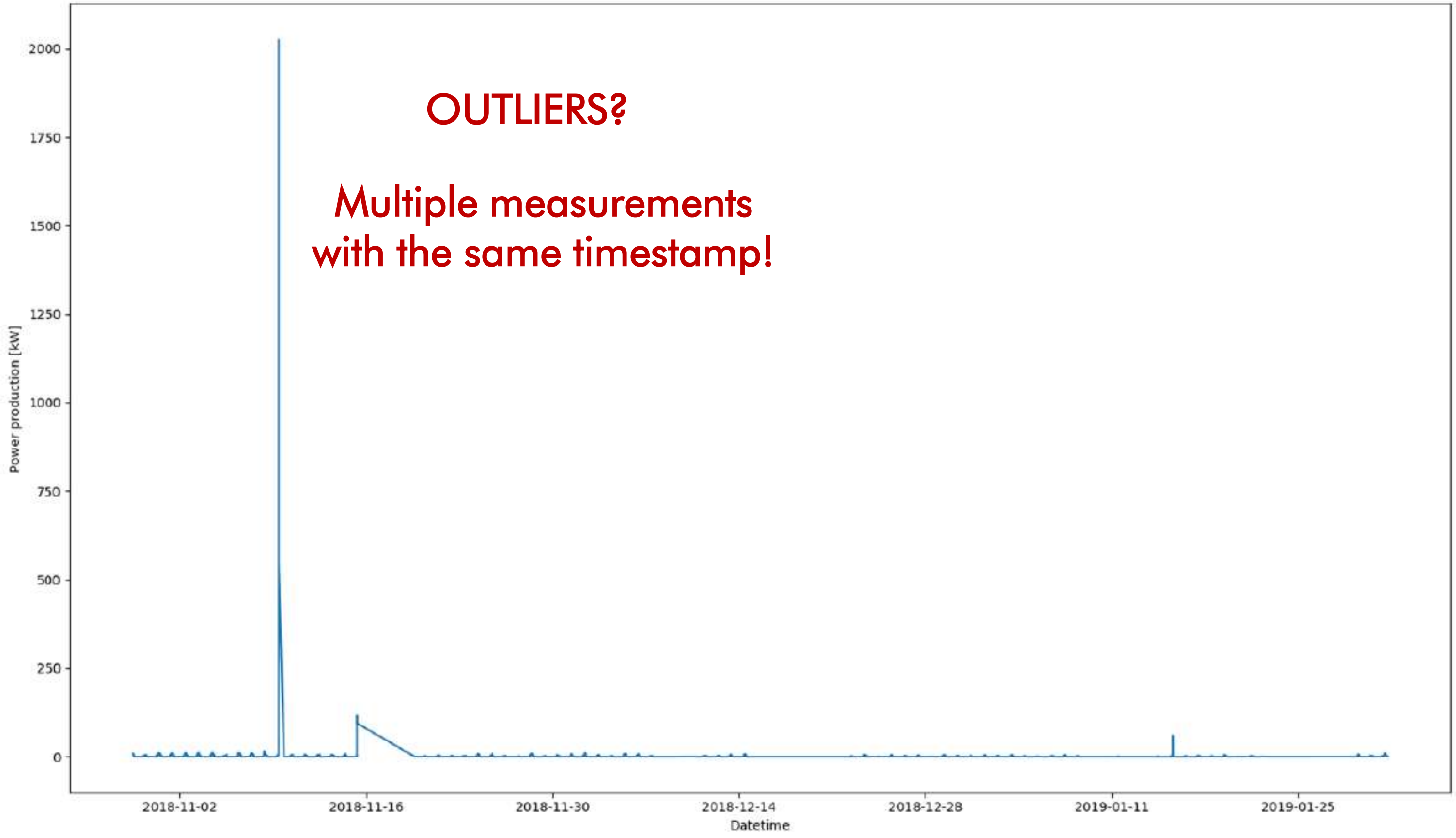
M PE 3 – irradiance calculations (all data)



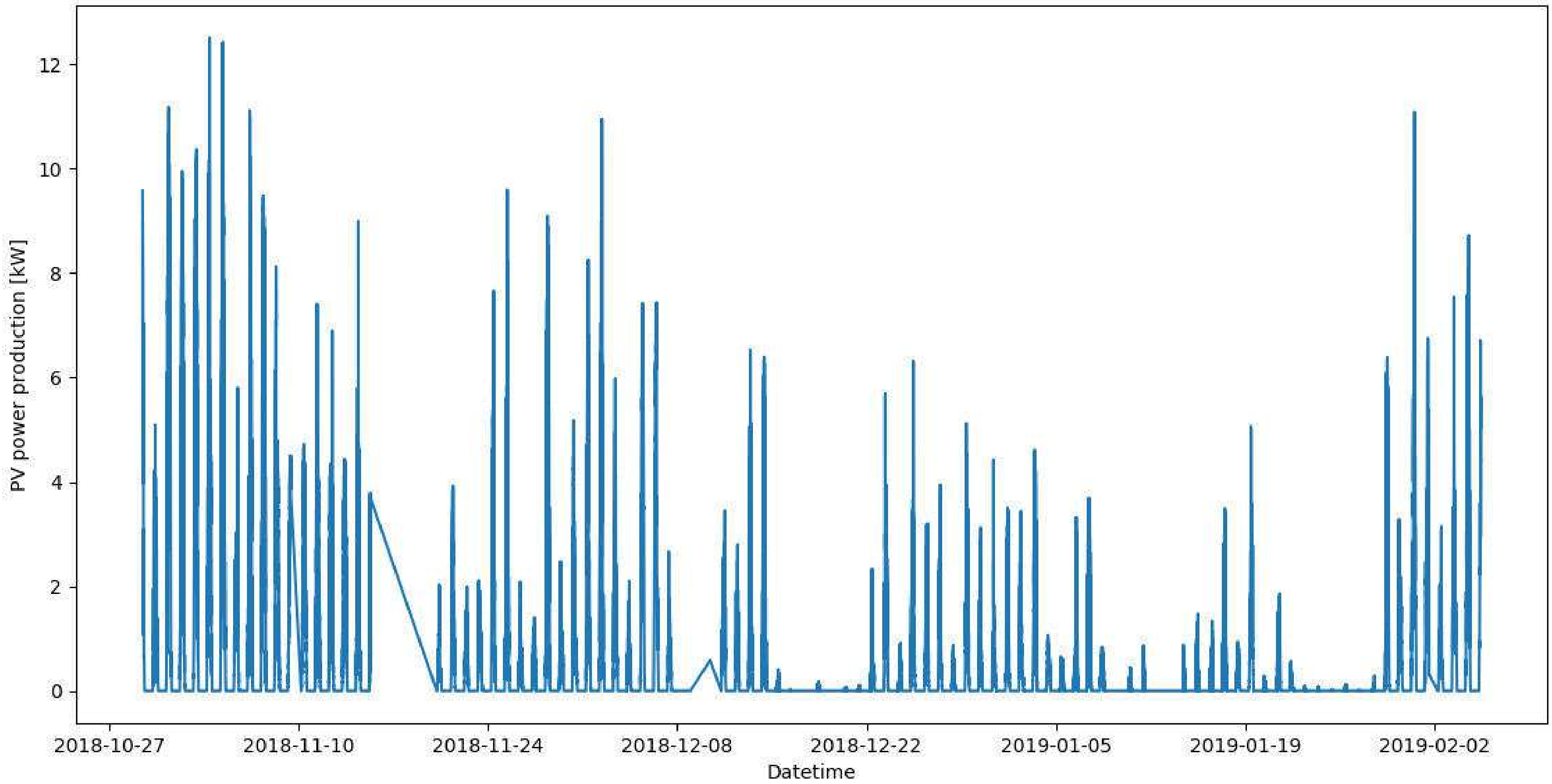
M PE 3 – irradiance calculations (recent)



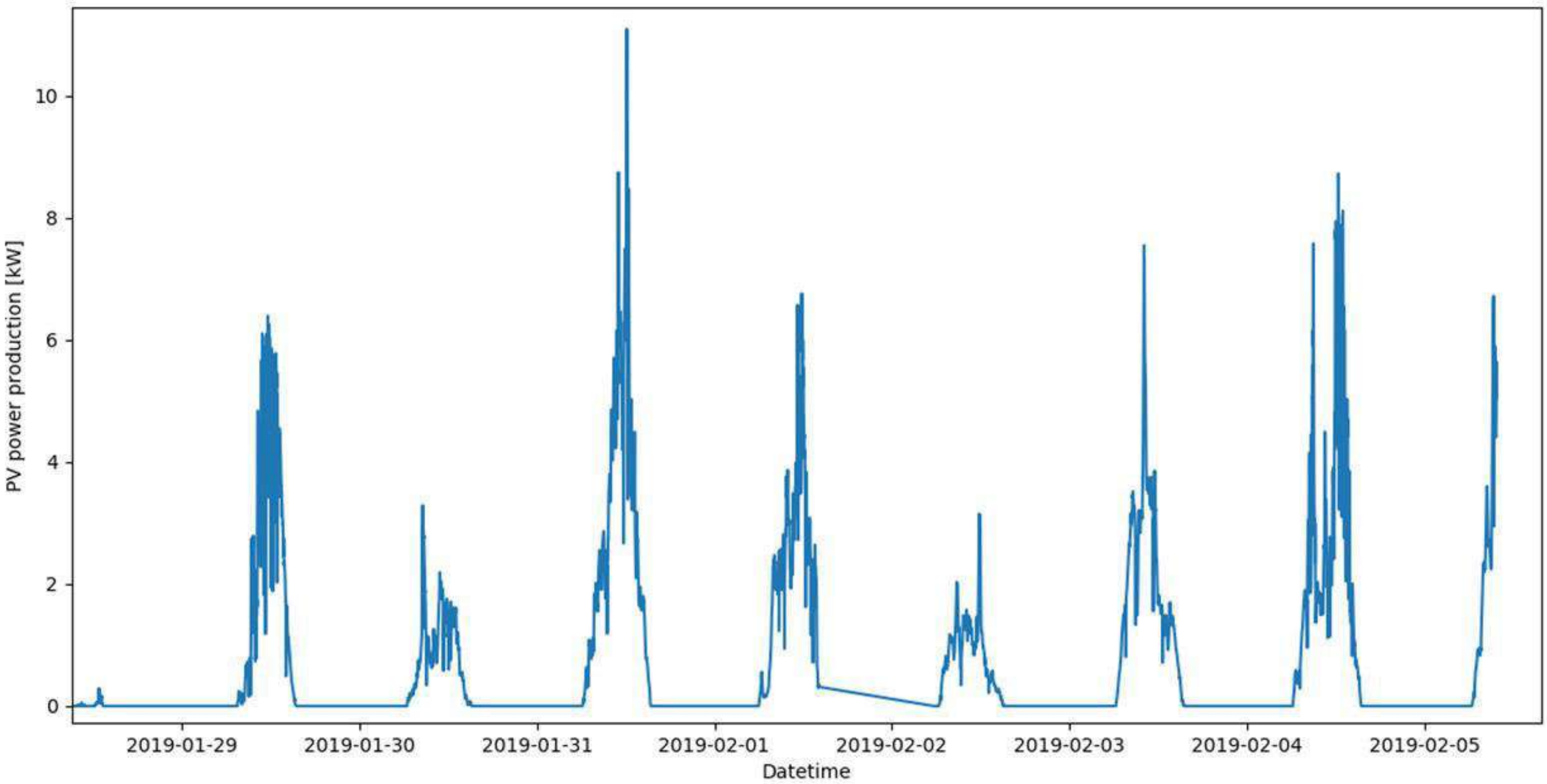
M PE 3 –PV production measurements (initial)



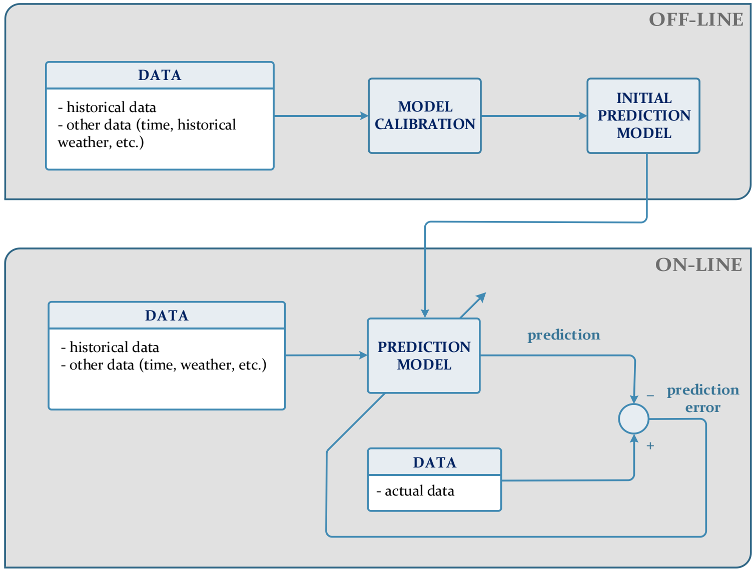
M PE 3 –PV production measurements (after filtering)



M PE 3 –PV production measurements (recent data)



M PE 3 – on-line operation

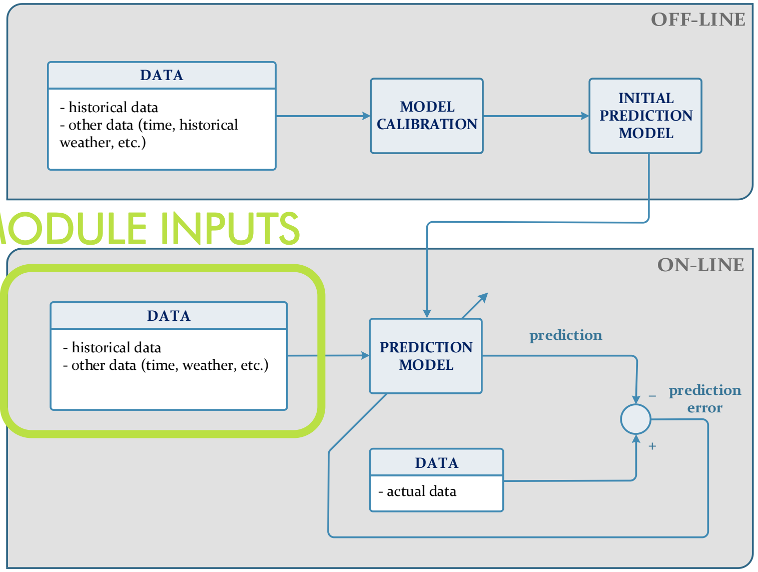


M PE 3 – on-line operation

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)

MODULE INPUTS



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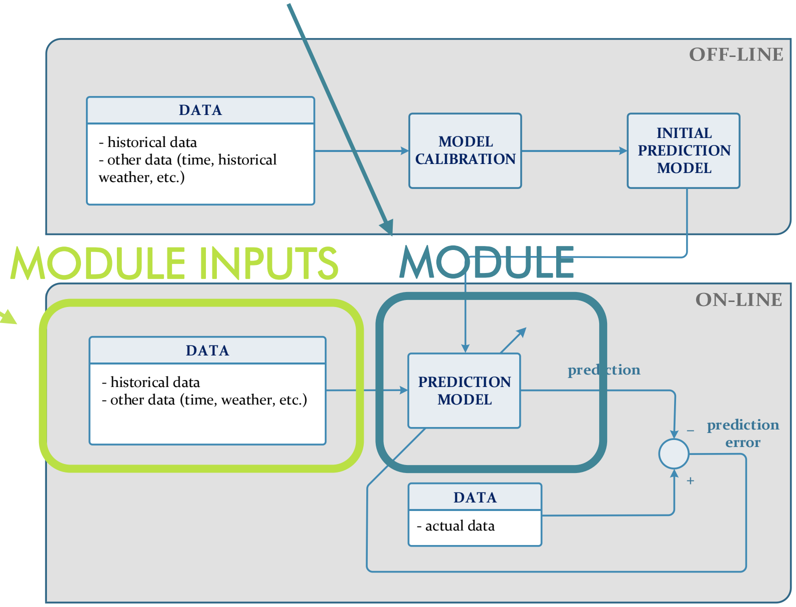
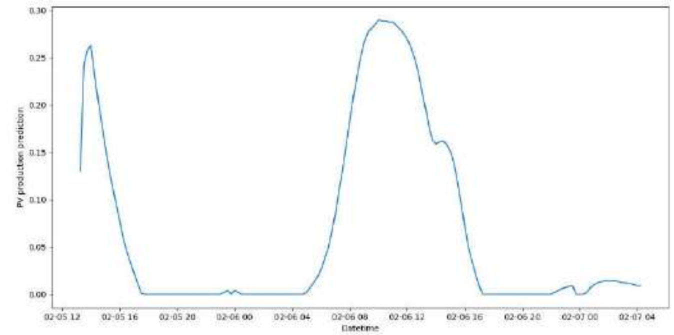


M PE 3 – on-line operation



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- solar_zenith(t-1,…,t-3)
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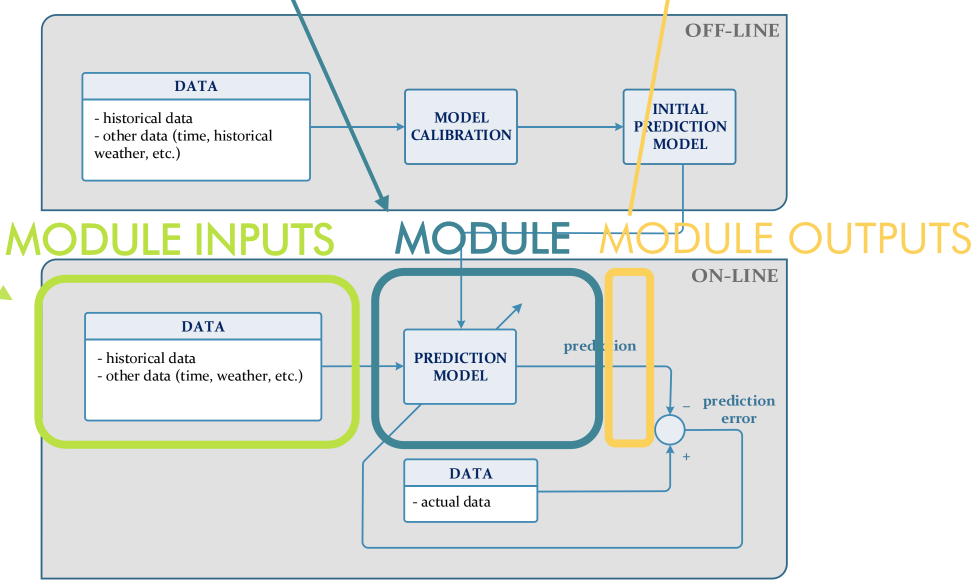
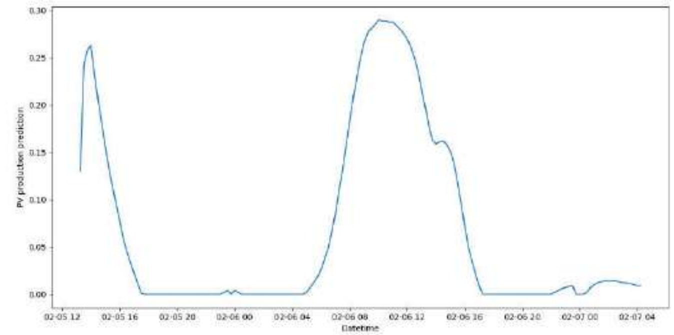


M PE 3 – on-line operation



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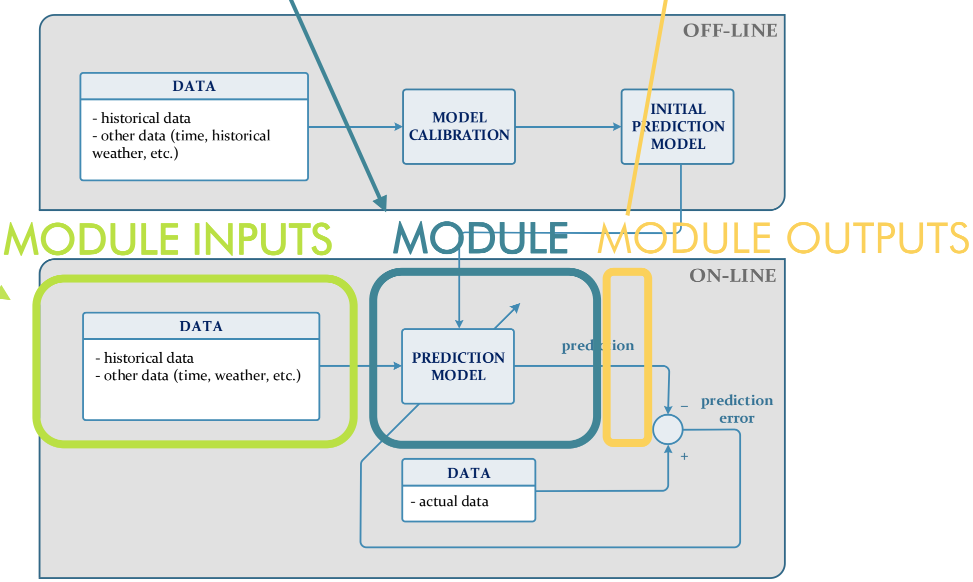
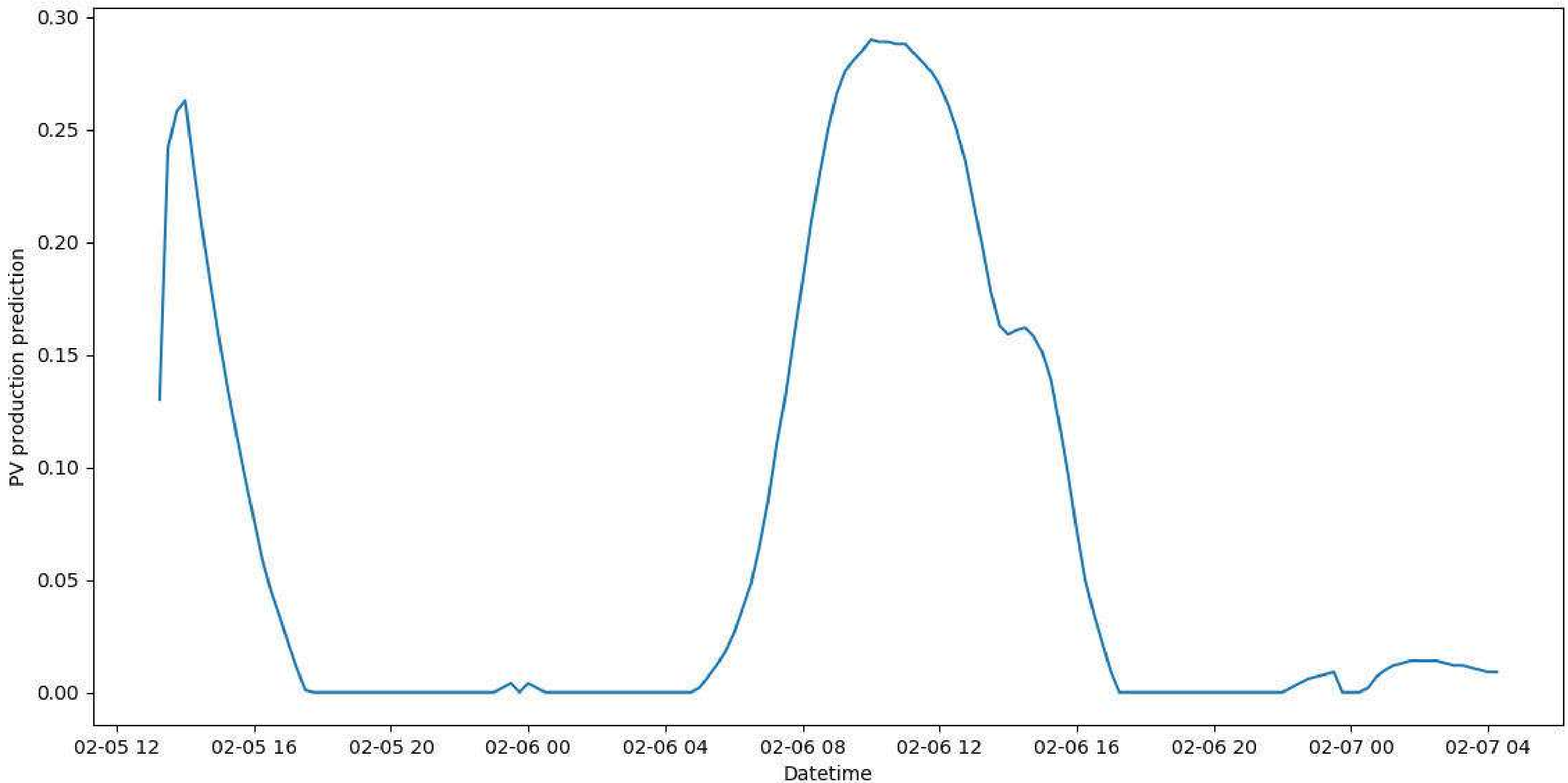


Initial predictions: **production spike around 1AM**

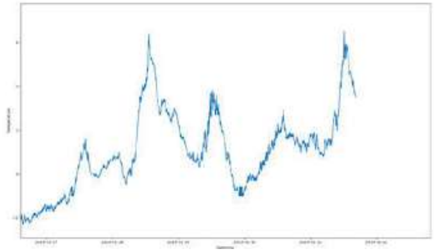
Weather forecast error

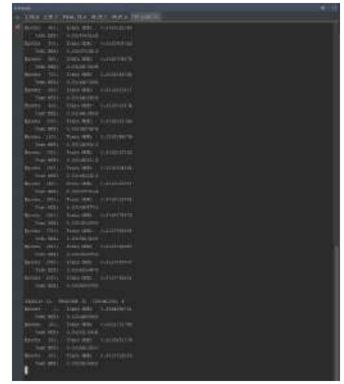
M PE 3 – on-line operation



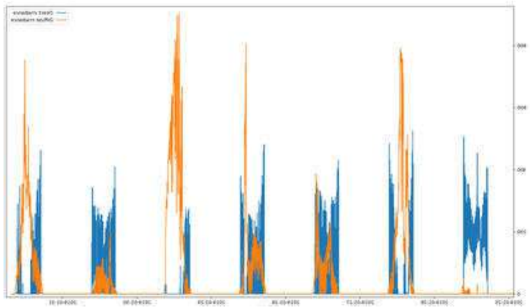
M PE 4 – off-line initialization

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





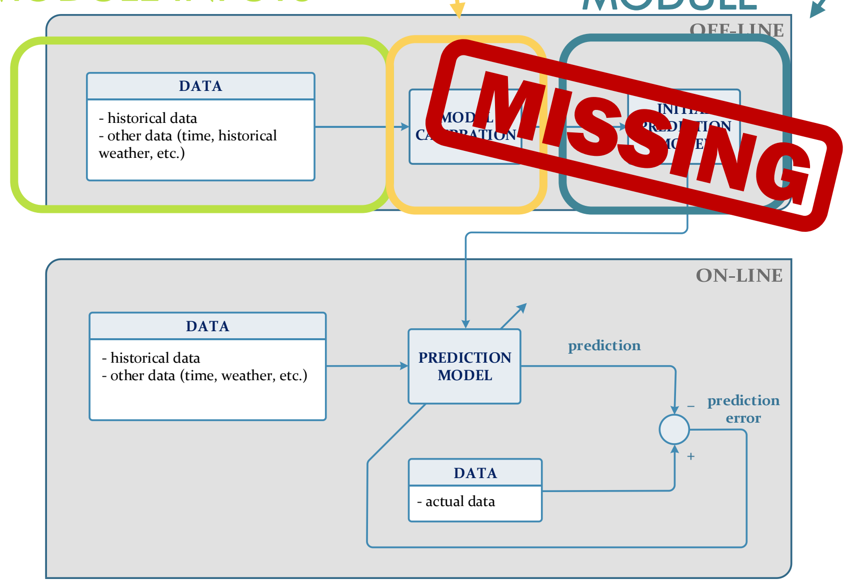
Locally stored:
inputsXY_neuronsZ.net



Historical **non-controllable consumption**

MODULE INPUTS

MODULE



Overall electrical energy consumption of the building

-

electrical energy consumption of heat pumps (4 water chillers)

-

electrical energy consumption of electric heaters

+

electrical energy production of the PV system

MISSING

M PE 4 – non-controllable consumption

Overall electrical energy consumption of the building

-

electrical energy consumption of heat pumps (4 water chillers)

-

electrical energy consumption of electric heaters

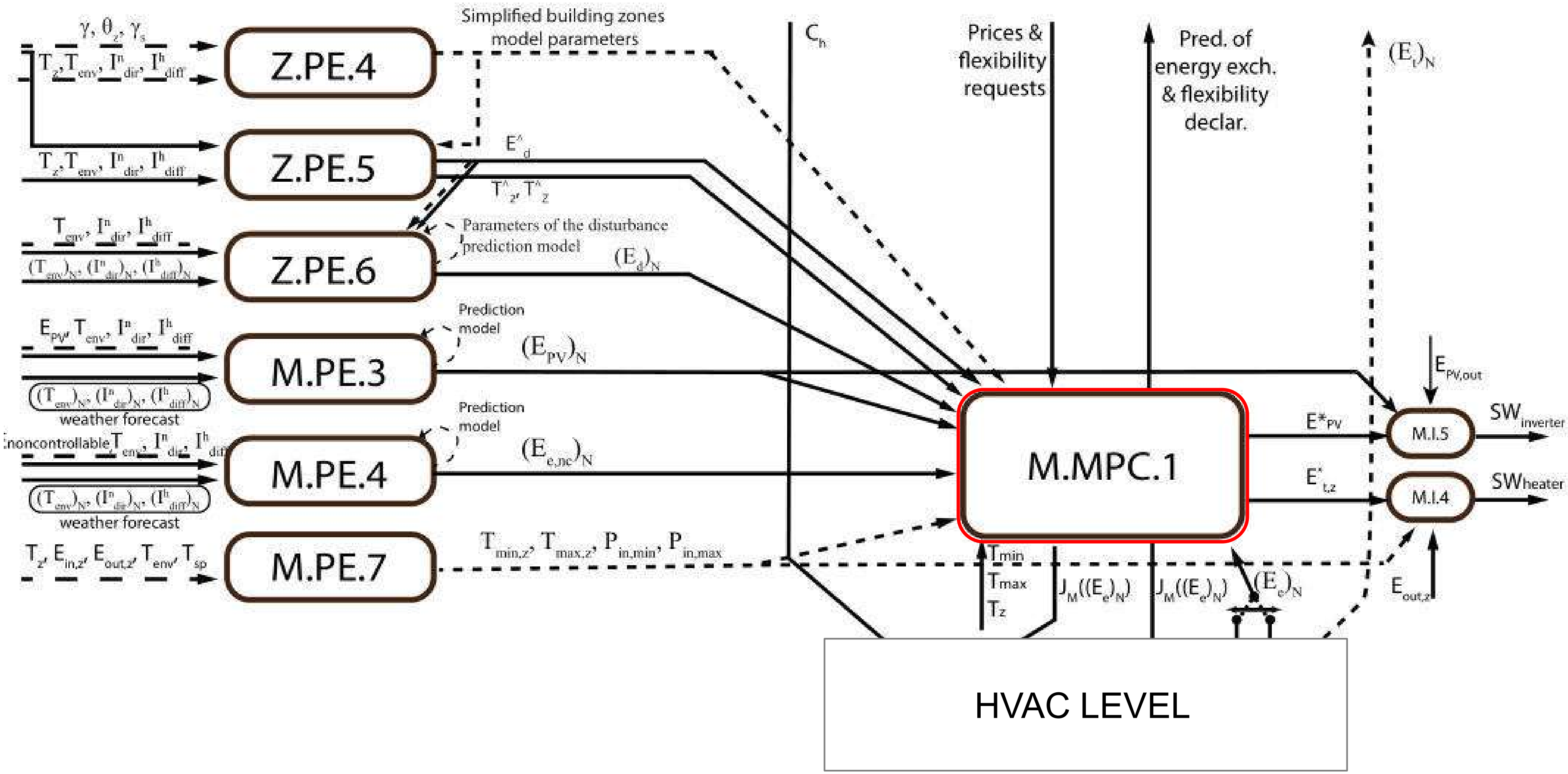
+

electrical energy production of the PV system

-

El. energy consumption of fan coils (4 heating/cooling circuits)

M MPC 1

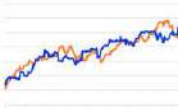

Simplified building zones model parameters
Z.PE.4
Z.PE.5
Z.PE.6
M.PE.3
M.PE.4
M.PE.7
Parameters of the disturbance prediction model
Prediction model
Prediction model
weather forecast
weather forecast
C_h
Prices & flexibility requests
Pred. of energy exch. & flexibility declar.
(E_t)_N
E_PV,out
SW_inverter
SW_heater
M.I.5
M.I.4
M.MPC.1
E*_PV
E*_t,z
T_min, z, T_max, z, P_in,min, P_in,max
Tmin
Tmax
Tz
E_out,z
HVAC LEVEL

M MPC 1 – short-term

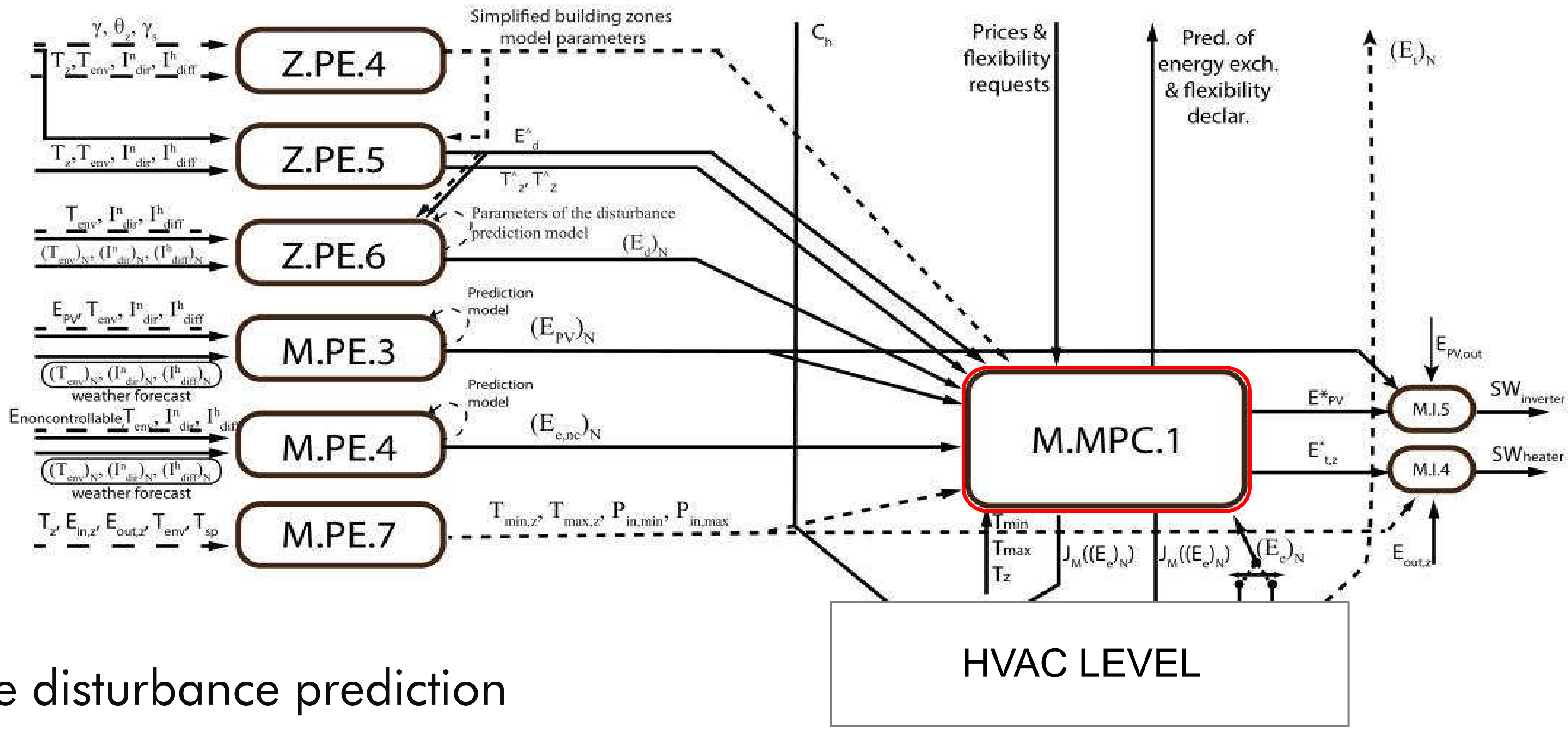
- The building provides the following services to the rid:
  - Prediction of day-ahead (DA) consumption
  - Following the declared DA consumption profile
  - Flexibility in consumption on grid's demand
- Control of electric heaters and PV plant
- Minimization of total building electricity cost:

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




M MPC 1



Inputs

- Zone disturbance prediction
- Non-controllables prediction
- Estimated model of zones
- Parameters of electric heaters and PV plant
- Prices and requests from grid

Outputs

- Commands for electric heaters
- Commands for PV plant
- Energy profiles for the grid

M MPC 1 – data exchange – points for discussion

- storing electric heater and PV plant parameters?

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

M MPC 1 – data exchange – points for discussion

- ctrl_load_command: JSON array of format {'room_id1':'energy', ...}
- pv_command: do we control the PV arrays separately?
- Measurement units?

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)

M MPC 1 – building-grid data exchange

- rule: have identical table structure as on the grid side

dso_flexibility_table	
PK,id	int
FK.contract_id	int
yyyy_mm	char(7)
type_of_day	varchar(30)
flexibility_requirement_kw	float
time_interval_starts	char(5)
time_interval_length	float
flexibility_requirement_kwh	float
pcs_of_type_of_days	int
created_at	timestamp

building_flexibility_table	
PK.id	int
FK.contract_id	int
yyyy_mm	char(7)
type_of_day	varchar(30)
provided_flexibility_kw	float
minimum_flebilitiy	float
time_interval_starts	char(5)
time_interval_length	float
provided_flexibility_kwh	float
pcs_of_type_of_days	int
created_at	timestamp

contract	
PK.id	int
FK.building_Id	int
FK. grid_id	int
name	varchar(30)
valid_from	date
valid_to	date
estim_activations	int
max_size_of_service	float
max_duration_of_service	float
reservation_price	float
activation_price	float
reservation_fee	float
activation_fee	float
avg_activation_price	float
pricing	float
penalty	float
offer_accepted	boolean
created_at	timestamp

flexibility_unit_prices_and_penalty	
PK.id	int
FK.contract_id	int
reservation_part_of_fup	float
activation_part_of_fup	float
penalty_price	float
deviation_in_size_of_service	int
created_at	timestamp

info_retailer	
PK.retailer_id	int
FK.market_id	int
retailer_name	vchar(30)
retailer_created_at	timestamp

info_markets	
PK.market_id	int
market_location	vchar(100)
market_name	vchar(100)
market_created_at	timestamp

info_buildings	
PK. building_id	int
FK. retailer_id	int
building_name	vchar(100)
building_location	vchar(100)
building_db_ipaddress	varchar(20)
building_db_name	varchar(20)
building_db_username	varchar(20)
building_db_password	varchar(20)
building_db_port	varchar(20)
building_created_at	timestamp

retailer_to_building_da_prices	
FK.retailer_id	int
profile	varchar(2000)
profile_created_at	timestamp

retailer_to_building_id_prices	
FK.retailer_id	int
profile	varchar(2000)
profile_created_at	timestamp

retailer_to_building_da_prices_history	
PK.id	int
FK.retailer_id	int
profile	varchar(2000)
profile_created_at	timestamp

retailer_to_building_id_prices_history	
PK.id	int
FK.retailer_id	int
profile	varchar(2000)
profile_created_at	timestamp

building_to_retailer_informative_da_profiles	
PK.id	int
FK.building_id	int
profile	varchar(2000)
profile_created_at	timestamp

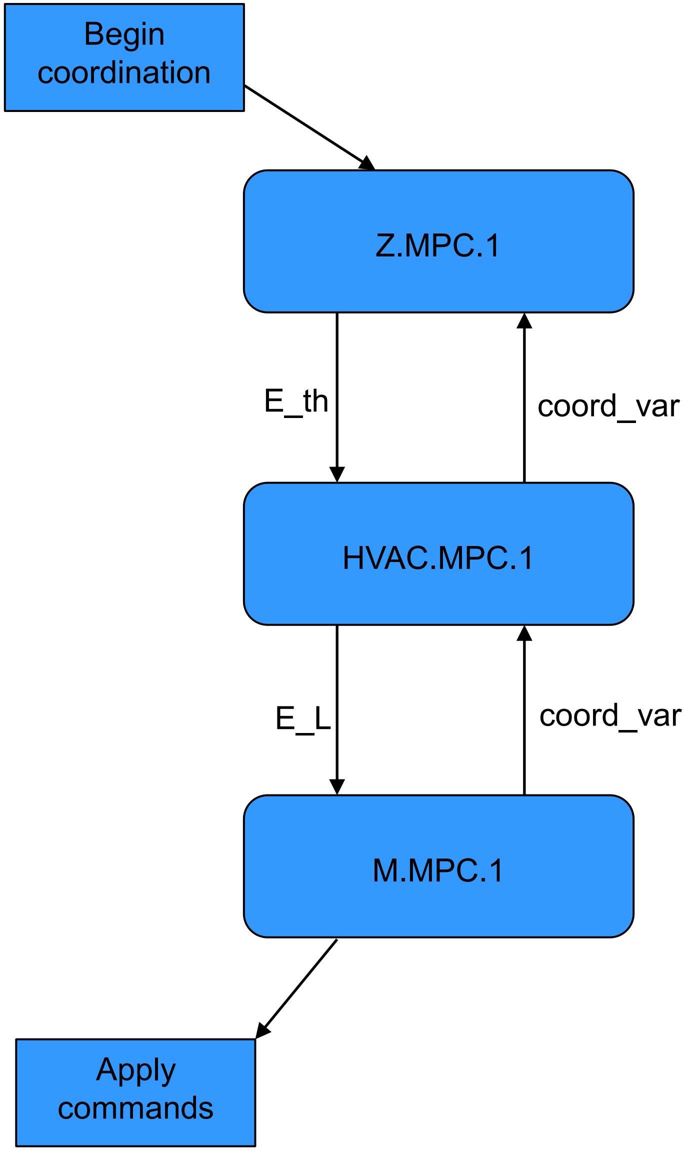
building_to_retailer_declared_da_profiles	
PK.id	int
FK.building_id	int
profile	varchar(2000)
profile_created_at	timestamp

building_to_retailer_predicted_id_profiles	
PK.id	int
FK.building_id	int
profile	varchar(2000)
profile_created_at	timestamp

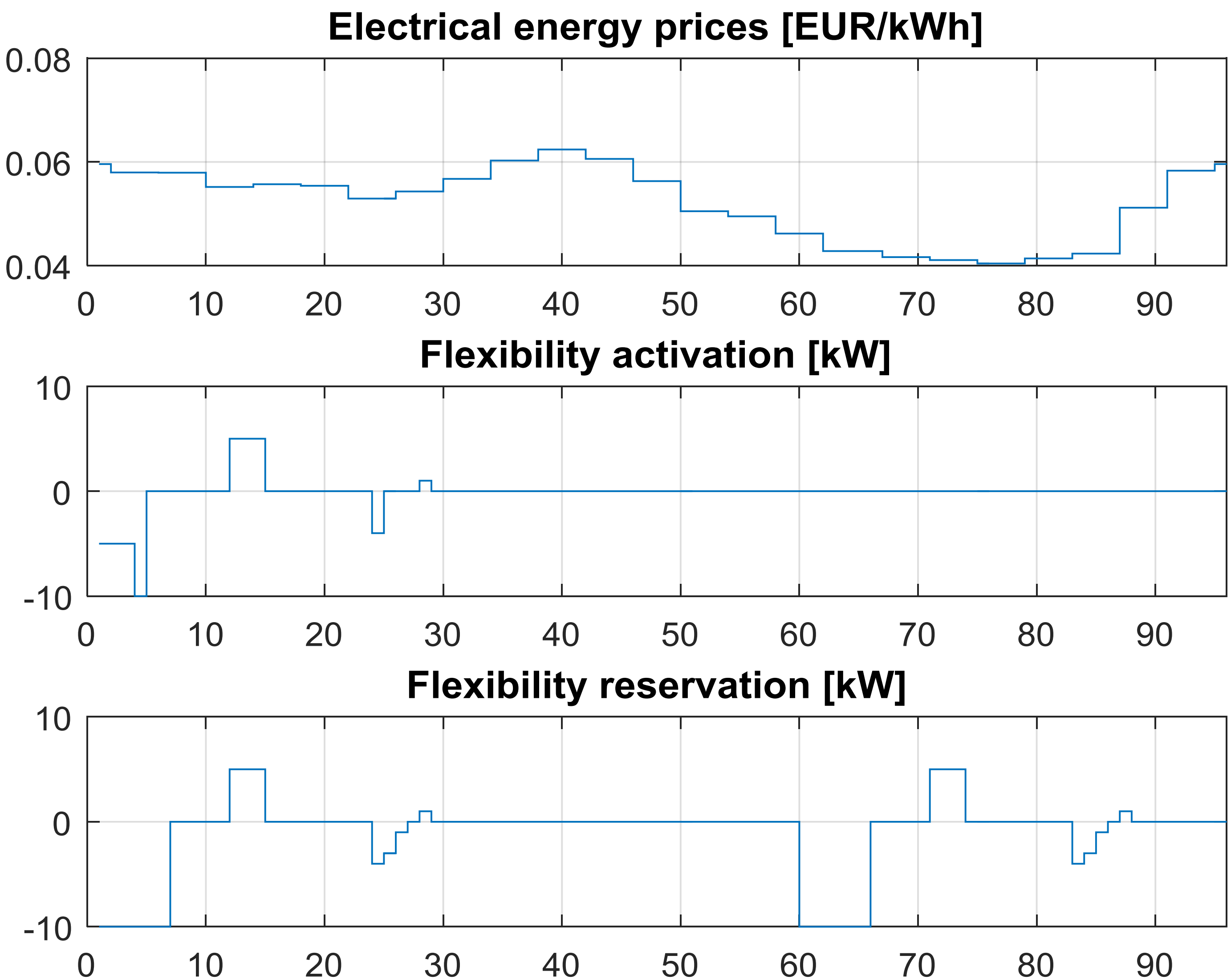
building_to_retailer_realized_profiles	
PK.id	int
FK.building_id	int
profile	varchar(2000)
profile_created_at	timestamp

MPC coordination

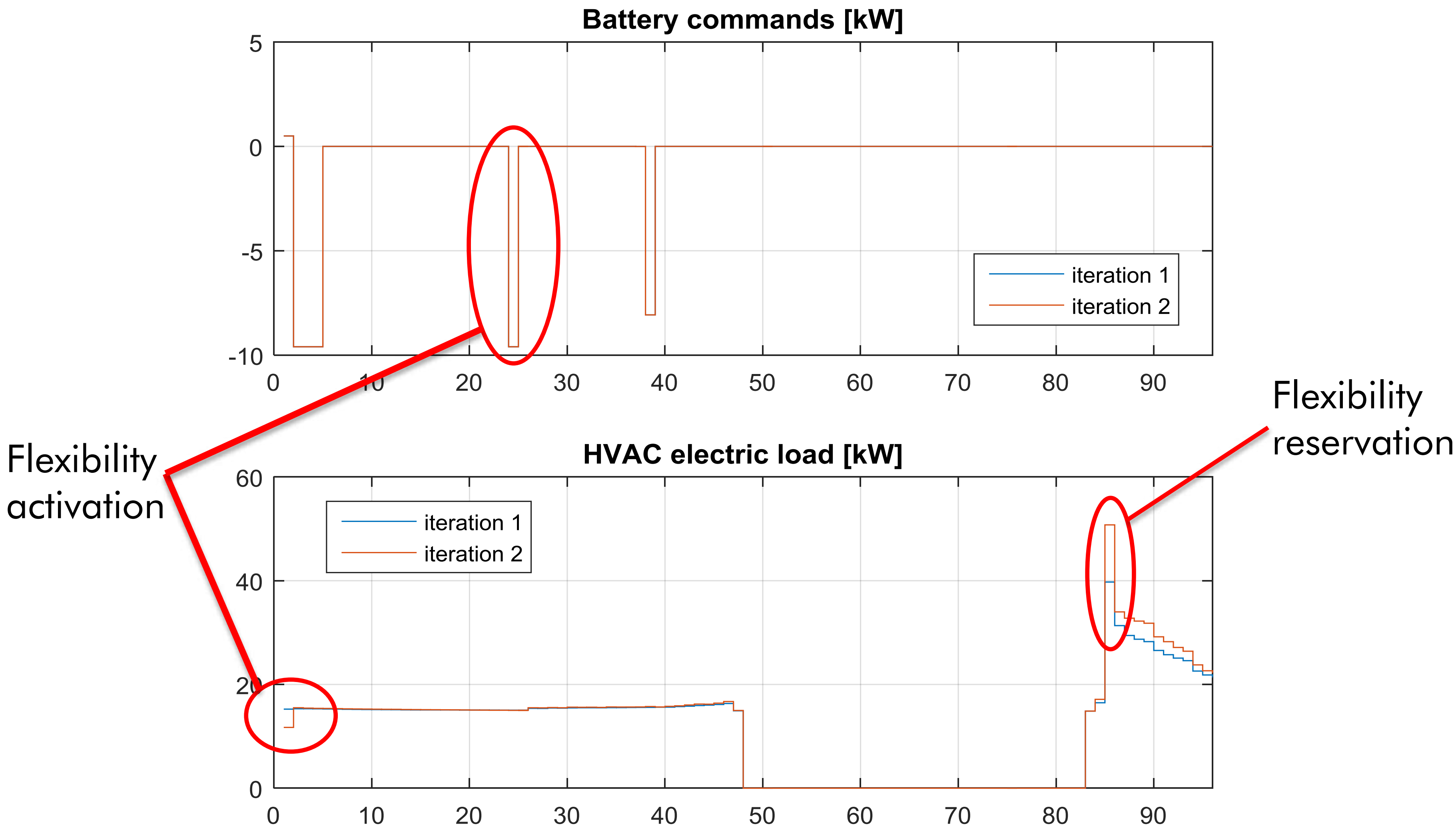
- Can we obtain flexibility by adjusting HVAC consumption?
- Is that cheaper than using the battery?
- Iterative process
- Simulation environment:
  - UNIZGFER building
  - Heating season
  - Actual data for 2019-02-06 ~09:00



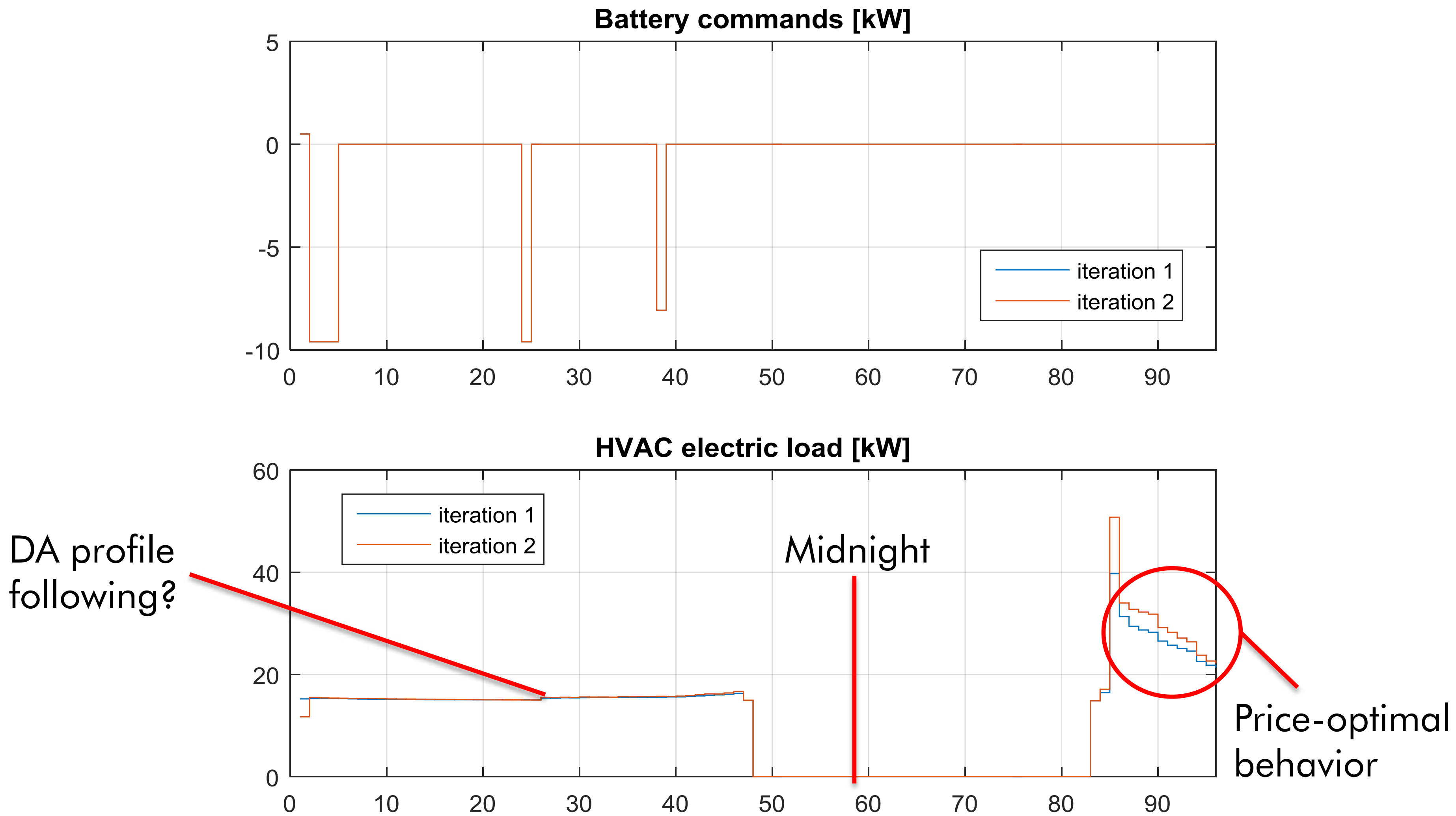
MPC coordination – simulation environment



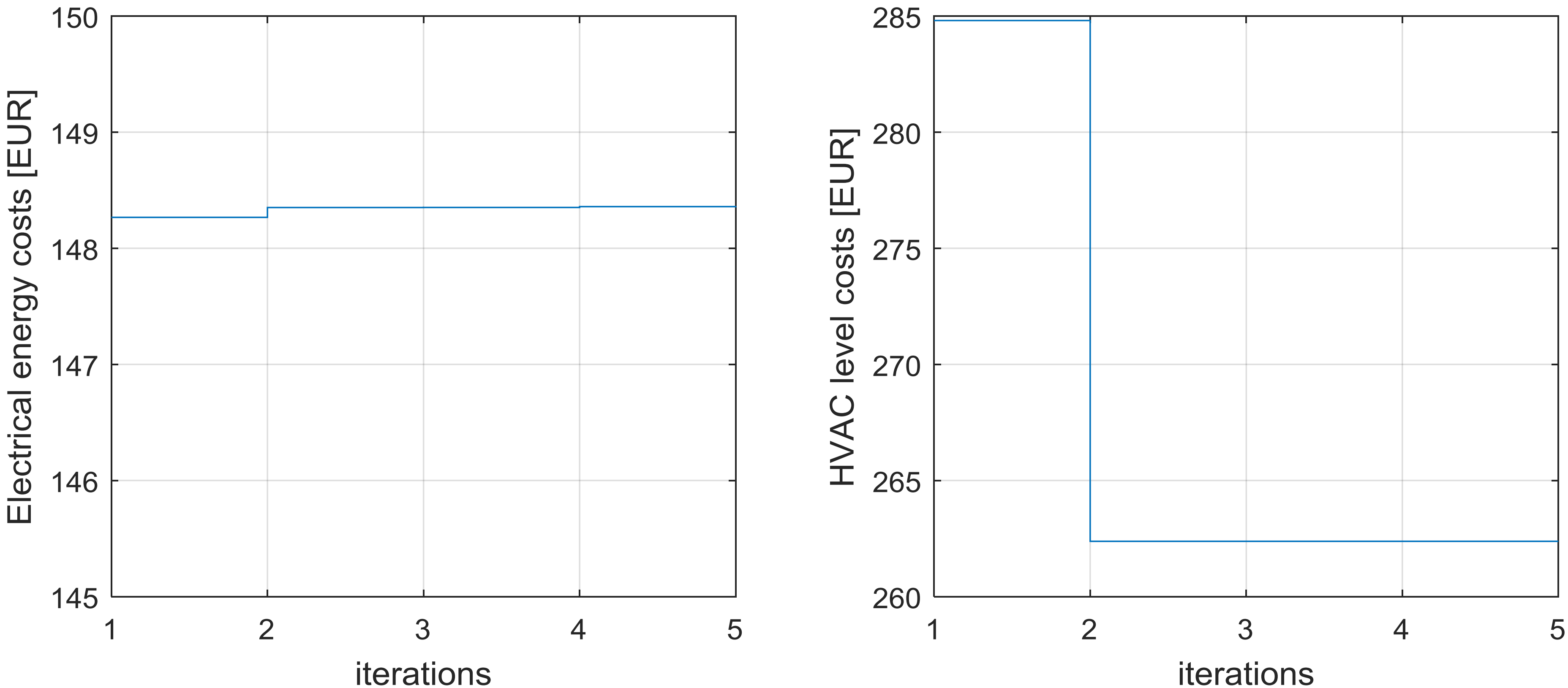
MPC coordination – results



MPC coordination – results

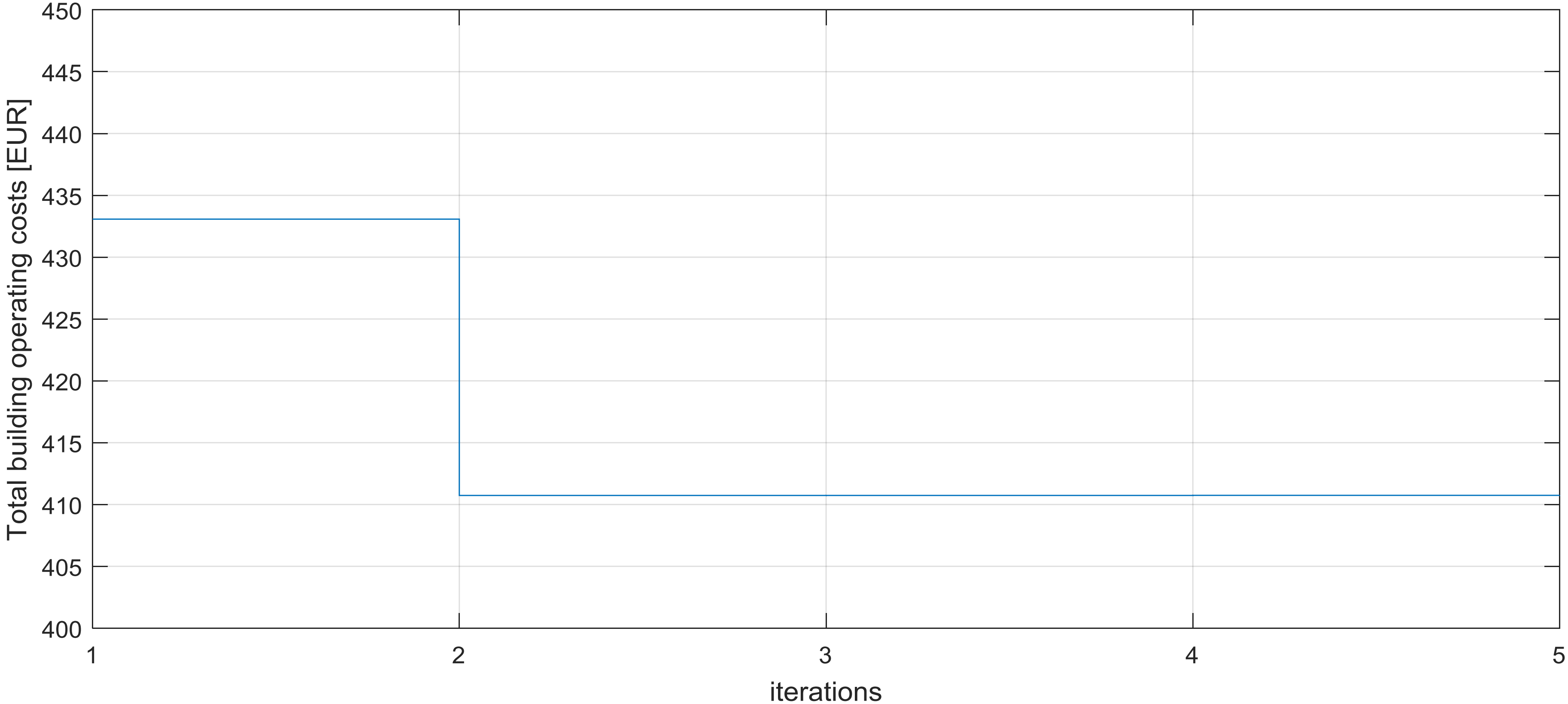


MPC coordination - results



- Thermal energy more expensive per kWh than electrical
- Decreased HVAC thermal consumption → increased HVAC electrical consumption
- Extra benefit: handling flexibility

MPC coordination - results



- Coordination: savings about 5% for given test case
- Two iterations enough

3Smart modules M.I.4-M.I.5-M.PE.7 on the EON pilot building

Árpád Rácz

University of Debrecen

racz.arpad@science.unideb.hu

First pilot study visit to the Hungarian pilot

February 5-6, 2019.

Interreg

EUROPEAN UNION

Danube Transnational Programme

3Smart

e·on

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

M.I.4


Interreg
Danube Transnational Programme
HeaterZ0ne
EIKI
NEXTENT
www.eiki.hu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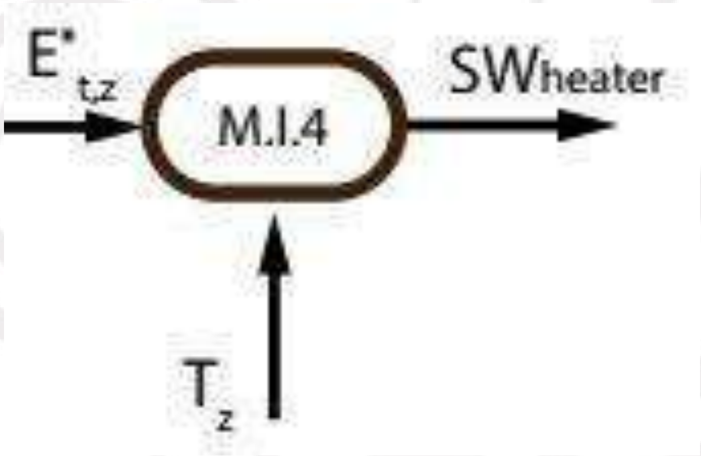
Therm0ffice

Module information flow

MODULE INPUTS	MODULE	MODULE OUTPUTS
Parameters of the heater Room model Energy command	**M.I.4**	Switching signals for each minute of the cycle

- EON building



Module operation

- Controllable load (room) has several power levels based on the number of heaters
- Commanded energy is distributed equally during the next MPC cycle
- Output power level is calculeted for each minute
- After each minute the energy consumption is measured
- The output power levels the remaining minutes are recalculated

- Frequency of module calls
  - Every minute

M.I.5

Module information flow

MODULE INPUTS

$(E_{PV})_N$
E_{PV}^*
$E_{PV,out}$

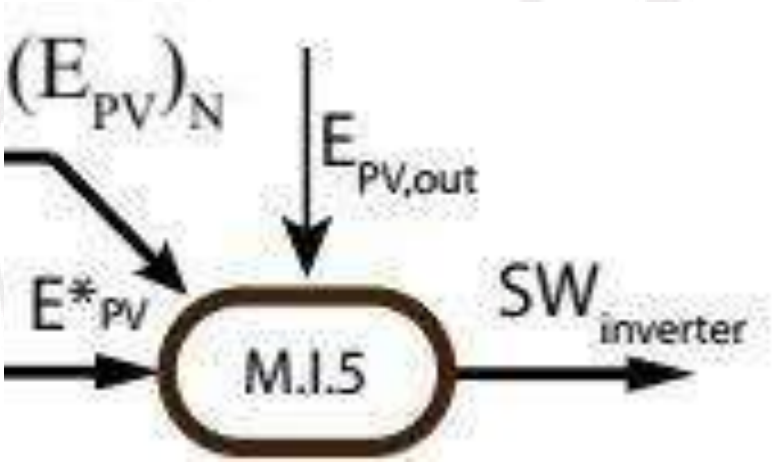
MODULE

M.I.5

MODULE OUTPUTS

$SW_{inverter}$

- EON building



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- Frequency of module calls
  - Every minute

On-line demonstrations – grid side

Gabor Hornyak

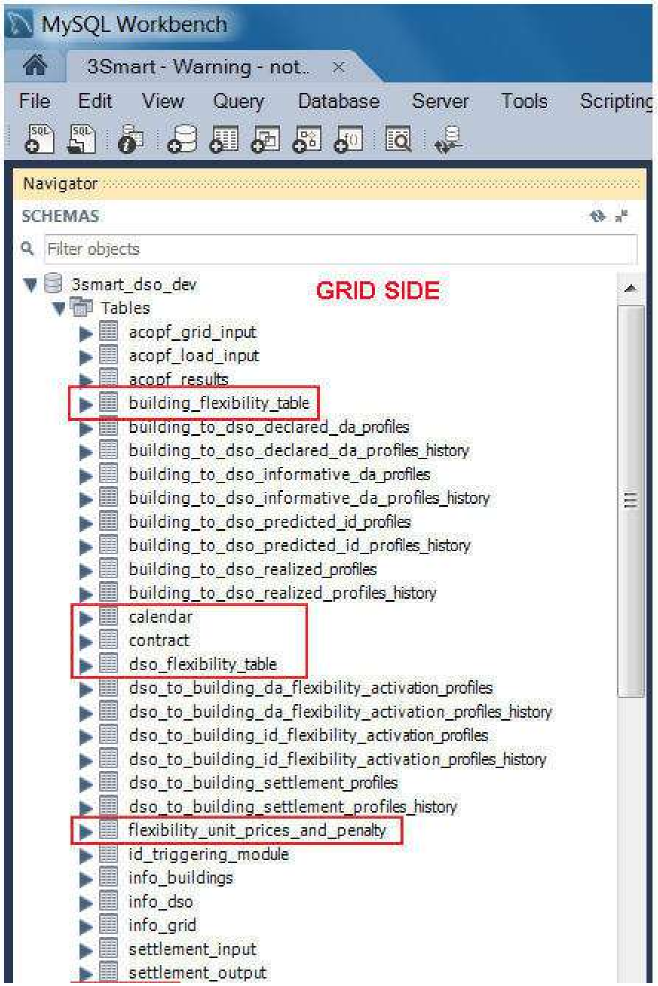
EON Tiszántúli Áramhálózati Zrt.

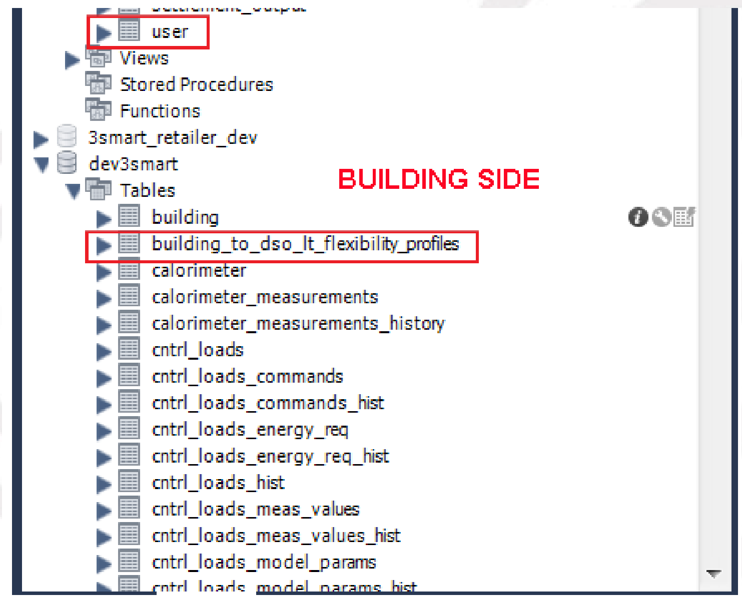
3Smart – Pilot study visit- Debrecen
06. – 05.02.2019.

Project co-funded by the European Union

LONG TERM MODULES

Database: LT relevant tables on the server in Debrecen





The most important packages/technologies

```
from flask import Flask
from config import Config
from app.reverse_proxied import ReverseProxied

from flask_sqlalchemy import SQLAlchemy
from flask_bootstrap import Bootstrap
from flask_login import LoginManager
import os

excel_template_dir = os.path.join(os.path.dirname(os.path.realpath(__file__)), 'excel_template')
app = Flask(__name__)
# add config
app.config.from_object(Config)
# add bootstrap
bootstrap = Bootstrap(app)
# handling nginx location subfolders added to the URL during reverse proxying
app.wsgi_app = ReverseProxied(app.wsgi_app)

# database
db = SQLAlchemy(app)

# login
login = LoginManager(app)
login.login_view = 'login'

# routes is imported at last to avoid circular imports because routes is importing the app variable
from app import routes, models, errors
```

Creating default user at the first running

```python

# user loader for login
@login.user_loader
def load_user(id):
    return db.session.query(User).get(int(id))


# if user table empty then create an admin user
usr = db.session.query(User).first()
if usr is None:
    usr = User()
    usr.email = 'admin@3smart_lt.com'
    usr.name = 'Default Admin'
    usr.set_password('Default1234')
    usr.active = True
    usr.is_admin = True

    db.session.add(usr)
    db.session.commit()

```

Operation of web based LT module

3Smart LT   Home   Login

Long Term Workflow

Grid Choose...

Building Choose...

Contract New contract

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	?

1. Initial screen – only download template is active
    a. LT staff is downloading the template and enters input data in the excel

Operation of web based LT module

3Smart LT Home Login

Long Term Workflow

Grid Grid 1

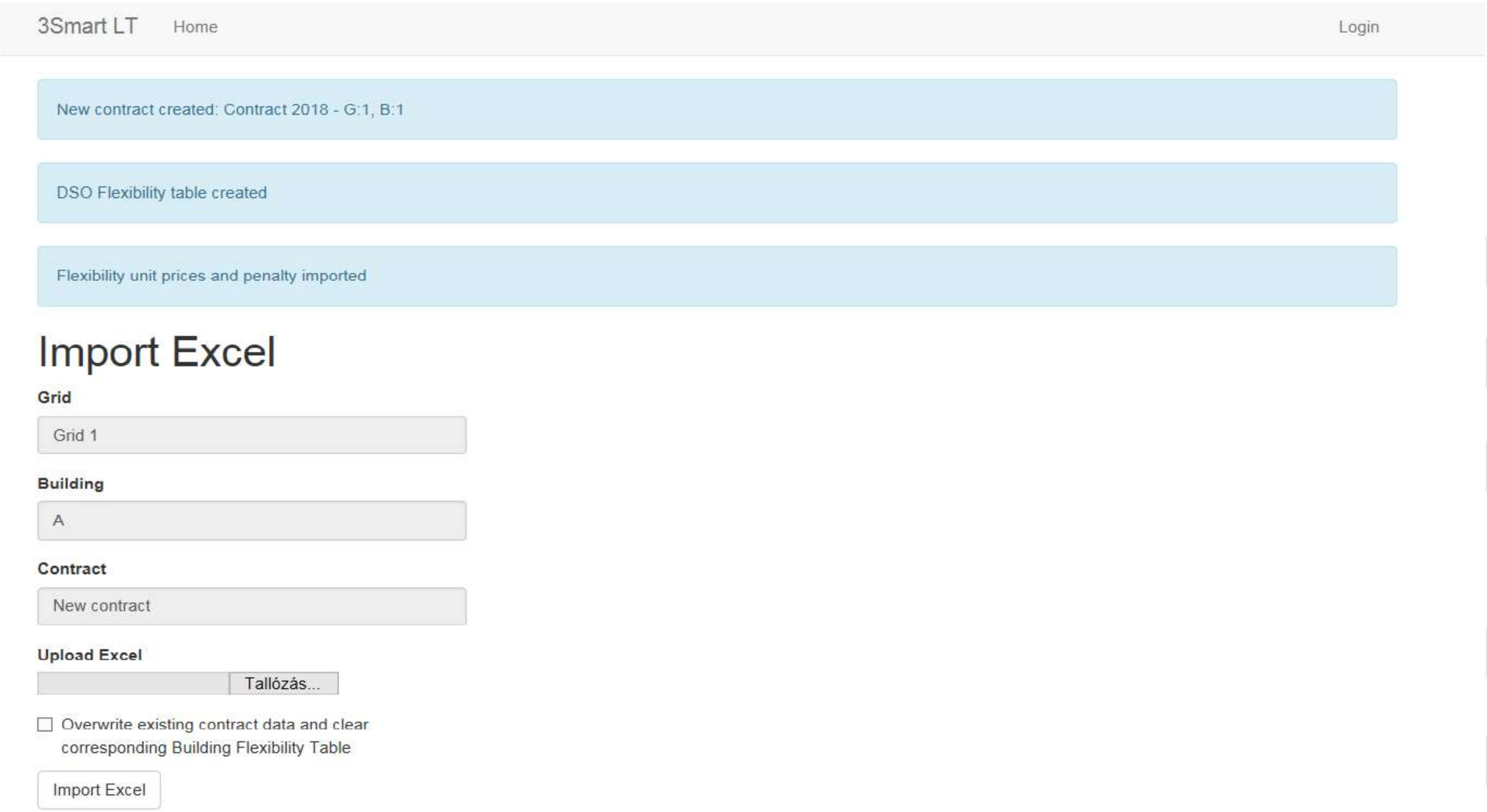
Building A

Contract New contract

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	?

2. Building selected – import Dso Flex Table is also active

Operation of web based LT module



3. Dso staff uploads the excel

Operation of web based LT module

3Smart LT Home Login

Long Term Workflow

Grid Grid 1

Building A

Contract Contract 2018 - G:1, B:1

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	?

4. Microgrid can take the data (Dso Flex table and Prices) and generate Building Flex Table for the given building

Operation of web based LT module

3Smart LT   Home   Login

Long Term Workflow

Grid Grid 1

Building A

Contract Contract 2018 - G:1, B:1

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	?

5. When Microgrid's Building Flex is available the Building Flex Transfer button becomes active. At this stage we are using a dummy Microgrid Building Flex tablet o emulate that functionality until Microgrid is delivering.

Operation of web based LT module

3Smart LT Home Login

Building Flexibility table imported

Long Term Workflow

Grid Grid 1

Building A

Contract Contract 2018 - G:1, B:1

Step	Activity	Link	Status
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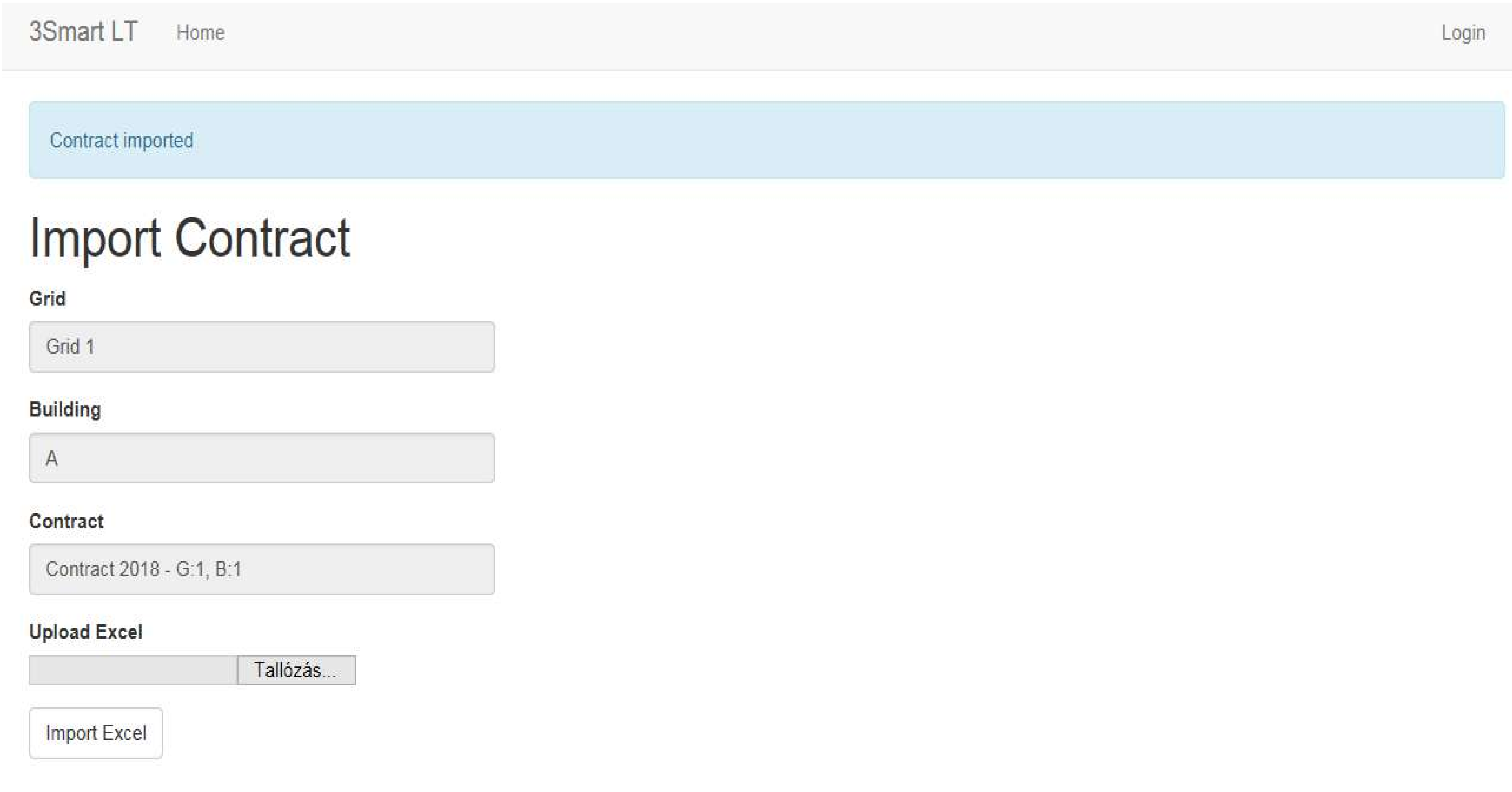
2	[DSO staff] is importing the results of "3Smart_LT module_v1.xlsm"	Import DSO Flex Table	✔
3	[Building EMS Microgrid module] is fetching data from LT database		✔
4	[Building EMS Microgrid module] is calculating flexibility offer		✔
5	[DSO LT module] is fetching data from Microgrid database	Building 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	?

6. After transfering Building Flex, the corresponding download button and Import Contract becomes available

Operation of web based LT module



7. The downloaded data (in excel file) goes into the original excel onto the Building Flexibility Table tab and excel is calculating the contract offer.

Operation of web based LT module

3Smart LT   Home   Login

Long Term Workflow

Grid Grid 1

Building A

Contract Contract 2018 - G:1, B:1

Step	Activity	Link	Status
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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	✖

8. The entered Offer acceptance value will decide the final status of the contract

17)	**Building offer accepted**	yes/no	Manual entry

Output Quality Report

Output title: T4.1 Transnational training activities	
Type of output:	☑ Documented learning interaction ☐ Strategy/ Action Plan ☐ Tool ☐ Pilot action
Contribution to PO indicator:	**P07 No. of documented learning interactions in finalised operations**

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 hosts explained the interventions performed while modules developers explained the needed steps for installation of the modules. In the second round the hosts explained the progress with modules installations 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 –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.

Added value	
The output provides the information on pilots initial state, preparation actions for putting in place the 3Smart platform on the site, the architecture of the modular 3Smart system for a particular site i.e. which modules it contains to exhibit smart operation of the building or grid, needed steps for installation of modules as well as modules performance in operation. The documentation provided was created by experts in particular fields to be understandable also to non-experts in that field. In this way, already within the consortium, which gathers versatile expertises, the information provided needed to be simple and easy to understand. The transnational context in which the materials arose ensures also its transnational relevance and can be used as a reference to interested stakeholders all across the Danube region and wider.	
Applicability and replicability	
The output can be used for a picturesque introduction to what was done on the project and to easily grasp the steps needed for replication of the 3Smart platform for energy management and demand response in a particular setup of a building or a grid. Different technologies in buildings were encompassed both on the level of zones (fan coils, radiators, floor heating/cooling), the central heating/cooling medium preparation (heat exchangers, heat pumps) and in shaping the overall energy flows between buildings and external grids (from nothing, which is also a viable option, to PV systems, batteries, CHPs, electric heaters, etc.). These varieties of implementation show the flexibility of the developed tool for adaptation at some new replication site, even in case it has some totally different configuration from any of the pilots.	
Suggestions for improvement, if applicable	
The output is useful to get an overview and impression how the 3Smart platform can be installed and what it can bring to a certain building or grid or even to a more complex setups. Especially useful are the estimations of gains which are also more concisely provided in other outputs, like Output T4.3 (presentations to stakeholders). This output can be considered as a useful interim material to get a gradual introduction into the 3Smart project developments. Considering the existence of more detailed written deliverables and outputs and that this is a material to get an overall impression on variety of implementation possibilities for 3Smart, I have no particular suggestions for improvement.	
Output Quality Level	☐ Low ☐ Average ☐ Good ☑ Excellent

Name of the Quality Manager

Prof. dr. Mato Baotić

Signature of the Quality Manager

Mato Baotić