Database

Database

- MySQL DB
  - Client application: DBeaver, HeidiSQL, MySQL Workbench
- access to two databases.
  - Dev3smart. It is still empty.
  - Database smart_db contains data for exchanging data with installed hardware.

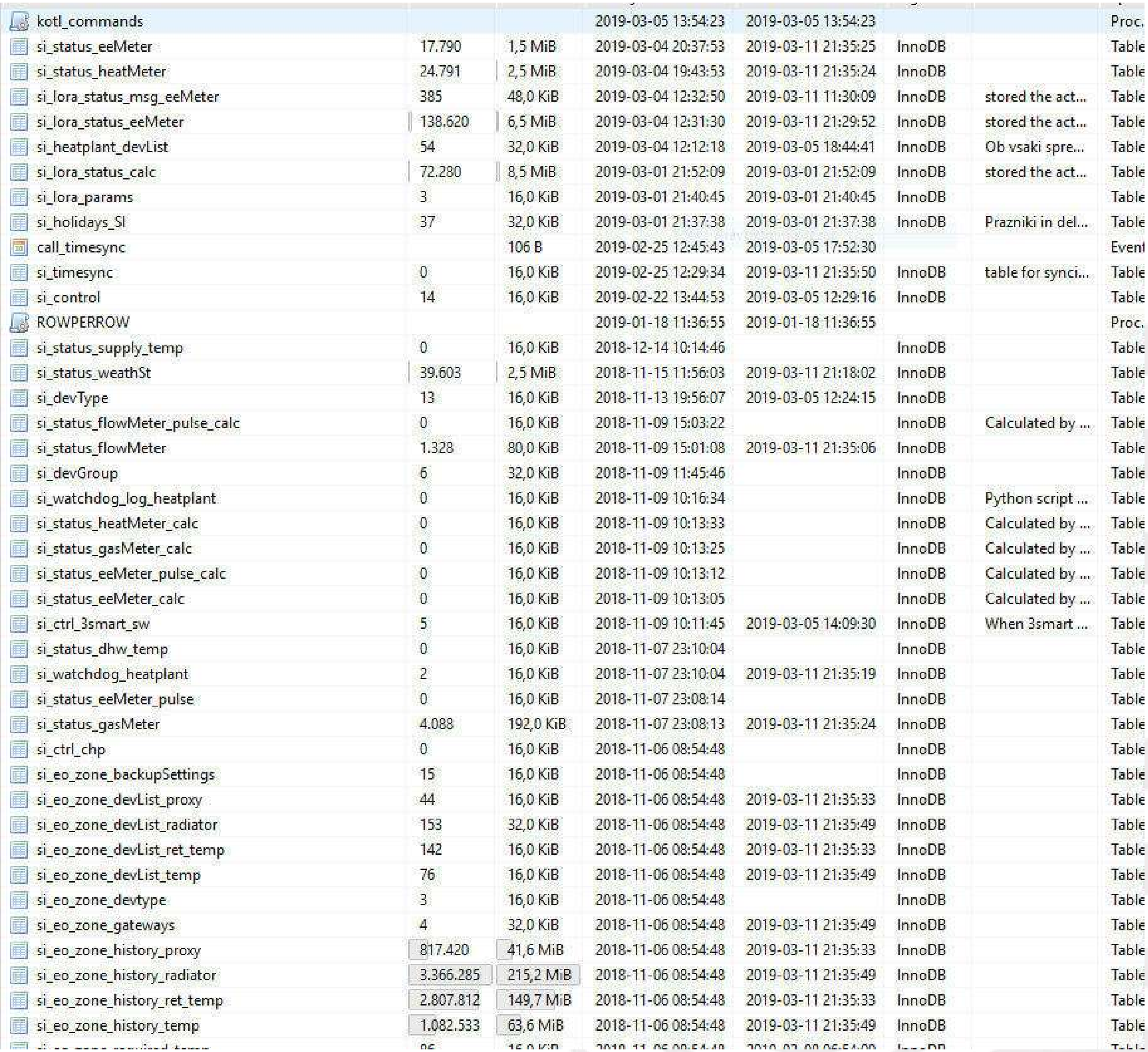
Database

- The tables that contains measurements:
  - 'si_eo_zone_history_temp' contains measurements of zone temperatures and humidity.
  - 'si_eo_zone_history_ret_temp' contains measurements of radiators return pipe temperature in zones.
  - 'si_eo_zone_history_radiator' contains data of radiators valve position, setpoint and mode of operation.
  - …

Database

- The tables that contains measurements:
  - …
  - 'si_eo_zone_history_proxy' contains data of presence sensors in zones.
  - 'si_status_heatMeter' – some records are value of total accumulated energy, some devices store energy produced/consumed in last interval. This will be unified in future.
  - 'si_status_eeMeter'
  - 'si_status_weathSt'

Database



kotl_commands			2019-03-05 13:54:23	2019-03-05 13:54:23			Proc.
si_status_eeMeter	17.790	1,5 MiB	2019-03-04 20:37:53	2019-03-11 21:35:25	InnoDB		Table
si_status_heatMeter	24.791	2,5 MiB	2019-03-04 19:43:53	2019-03-11 21:35:24	InnoDB		Table
si_lora_status_msg_eeMeter	385	48,0 KiB	2019-03-04 12:32:50	2019-03-11 11:30:09	InnoDB	stored the act...	Table
si_lora_status_eeMeter	138.620	6,5 MiB	2019-03-04 12:31:30	2019-03-11 21:29:52	InnoDB	stored the act...	Table
si_heatplant_devList	54	32,0 KiB	2019-03-04 12:12:18	2019-03-05 18:44:41	InnoDB	Ob vsaki spre...	Table
si_lora_status_calc	72.280	8,5 MiB	2019-03-01 21:52:09	2019-03-01 21:52:09	InnoDB	stored the act...	Table
si_lora_params	3	16,0 KiB	2019-03-01 21:40:45	2019-03-01 21:40:45	InnoDB		Table
si_holidays_SI	37	32,0 KiB	2019-03-01 21:37:38	2019-03-01 21:37:38	InnoDB	Prazniki in del...	Table
call_timesync		106 B	2019-02-25 12:45:43	2019-03-05 17:52:30			Event
si_timesync	0	16,0 KiB	2019-02-25 12:29:34	2019-03-11 21:35:50	InnoDB	table for synci...	Table
si_control	14	16,0 KiB	2019-02-22 13:44:53	2019-03-05 12:29:16	InnoDB		Table
ROWPERROW			2019-01-18 11:36:55	2019-01-18 11:36:55			Proc.
si_status_supply_temp	0	16,0 KiB	2018-12-14 10:14:46		InnoDB		Table
si_status_weathSt	39.603	2,5 MiB	2018-11-15 11:56:03	2019-03-11 21:18:02	InnoDB		Table
si_devType	13	16,0 KiB	2018-11-13 19:56:07	2019-03-05 12:24:15	InnoDB		Table
si_status_flowMeter_pulse_calc	0	16,0 KiB	2018-11-09 15:03:22		InnoDB	Calculated by ...	Table
si_status_flowMeter	1.328	80,0 KiB	2018-11-09 15:01:08	2019-03-11 21:35:06	InnoDB		Table
si_devGroup	6	32,0 KiB	2018-11-09 11:45:46		InnoDB		Table
si_watchdog_log_heatplant	0	16,0 KiB	2018-11-09 10:16:34		InnoDB	Python script ...	Table
si_status_heatMeter_calc	0	16,0 KiB	2018-11-09 10:13:33		InnoDB	Calculated by ...	Table
si_status_gasMeter_calc	0	16,0 KiB	2018-11-09 10:13:25		InnoDB	Calculated by ...	Table
si_status_eeMeter_pulse_calc	0	16,0 KiB	2018-11-09 10:13:12		InnoDB	Calculated by ...	Table
si_status_eeMeter_calc	0	16,0 KiB	2018-11-09 10:13:05		InnoDB	Calculated by ...	Table
si_ctrl_3smart_sw	5	16,0 KiB	2018-11-09 10:11:45	2019-03-05 14:09:30	InnoDB	When 3smart ...	Table
si_status_dhw_temp	0	16,0 KiB	2018-11-07 23:10:04		InnoDB		Table
si_watchdog_heatplant	2	16,0 KiB	2018-11-07 23:10:04	2019-03-11 21:35:19	InnoDB		Table
si_status_eeMeter_pulse	0	16,0 KiB	2018-11-07 23:08:14		InnoDB		Table
si_status_gasMeter	4.088	192,0 KiB	2018-11-07 23:08:13	2019-03-11 21:35:24	InnoDB		Table
si_ctrl_chp	0	16,0 KiB	2018-11-06 08:54:48		InnoDB		Table
si_eo_zone_backupSettings	15	16,0 KiB	2018-11-06 08:54:48		InnoDB		Table
si_eo_zone_devList_proxy	44	16,0 KiB	2018-11-06 08:54:48	2019-03-11 21:35:33	InnoDB		Table
si_eo_zone_devList_radiator	153	32,0 KiB	2018-11-06 08:54:48	2019-03-11 21:35:49	InnoDB		Table
si_eo_zone_devList_ret_temp	142	16,0 KiB	2018-11-06 08:54:48	2019-03-11 21:35:33	InnoDB		Table
si_eo_zone_devList_temp	76	16,0 KiB	2018-11-06 08:54:48	2019-03-11 21:35:49	InnoDB		Table
si_eo_zone_devtype	3	16,0 KiB	2018-11-06 08:54:48		InnoDB		Table
si_eo_zone_gateways	4	32,0 KiB	2018-11-06 08:54:48	2019-03-11 21:35:49	InnoDB		Table
si_eo_zone_history_proxy	817.420	41,6 MiB	2018-11-06 08:54:48	2019-03-11 21:35:33	InnoDB		Table
si_eo_zone_history_radiator	3.366.285	215,2 MiB	2018-11-06 08:54:48	2019-03-11 21:35:49	InnoDB		Table
si_eo_zone_history_ret_temp	2.807.812	149,7 MiB	2018-11-06 08:54:48	2019-03-11 21:35:33	InnoDB		Table
si_eo_zone_history_temp	1.082.533	63,6 MiB	2018-11-06 08:54:48	2019-03-11 21:35:49	InnoDB		Table

Server packages

- Solver GLPK
- packages on Linux:
  - python3
  - python3-dev
  - cmake
  - g++
  - ipython3
  - unzip
  - Octave
  - FANN

Server python libraries

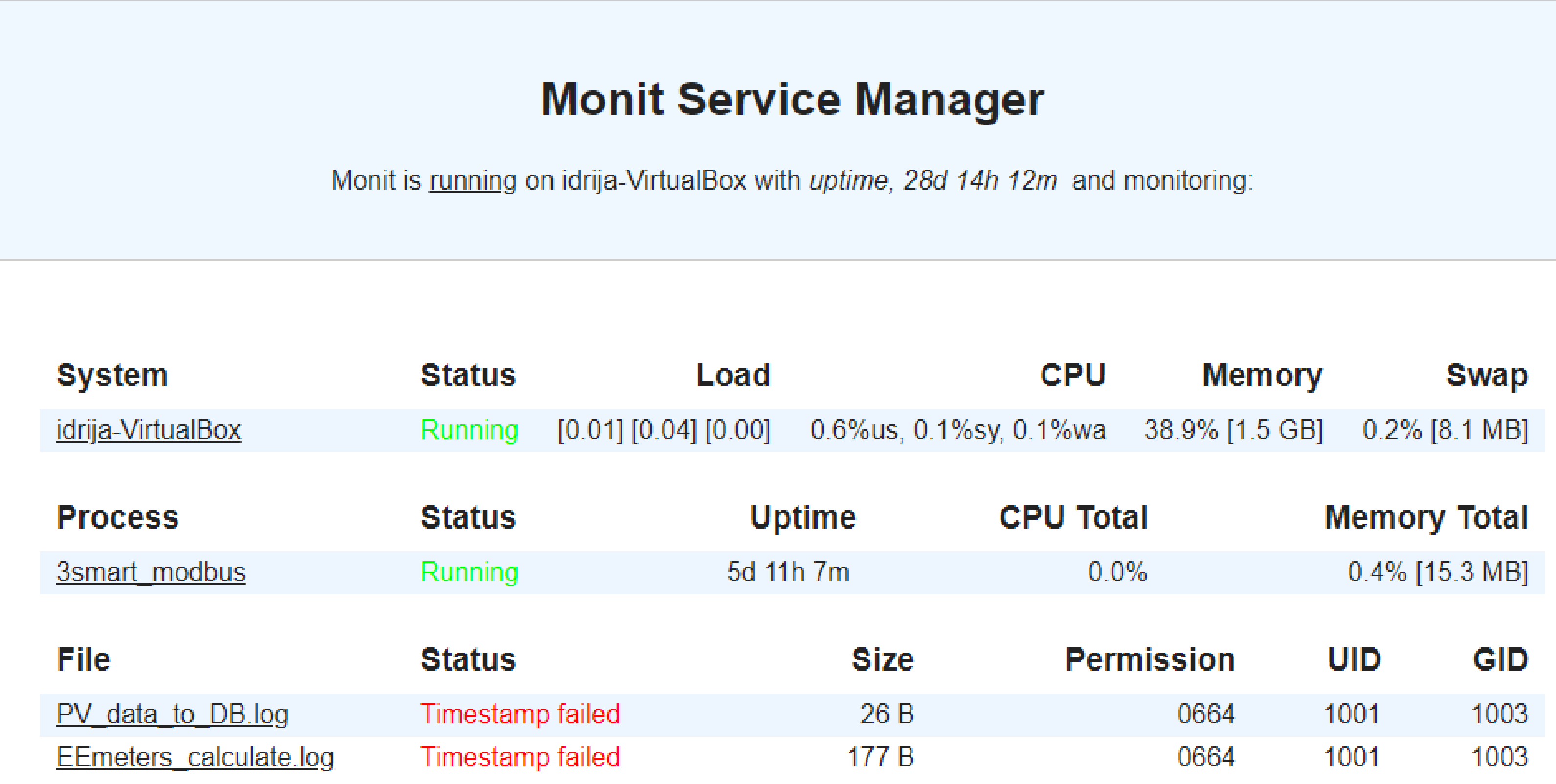
- Required by 3Smart:
  - ipython
  - json
  - simplejson
  - apscheduler
  - numpy
  - scipy
  - pandas
  - sklearn
  - pysolar
  - pytz
  - threading
  - Psycopg
  - fann2

Services monitoring

Services monitoring – 3 layers

- 1. heartbeat function that checks if device is alive. *Not applied jet.*
- 2. email notification:
  - system checks if new data is stored in database within last one hour. If no, then notifocation is send to e-mail. Email account was created for this purpose.
- 3. monitoring runniong processes on 3Smart server. (Monit)
  - check services at 2-minute intervals.

Services monitoring – 3 layers



Monit Service Manager

Monit is running on idrija-VirtualBox with *uptime, 28d 14h 12m* and monitoring:

System	Status	Load	CPU	Memory	Swap
idrija-VirtualBox	Running	[0.01] [0.04] [0.00]	0.6%us, 0.1%sy, 0.1%wa	38.9% [1.5 GB]	0.2% [8.1 MB]

Process	Status	Uptime	CPU Total	Memory Total
3smart_modbus	Running	5d 11h 7m	0.0%	0.4% [15.3 MB]

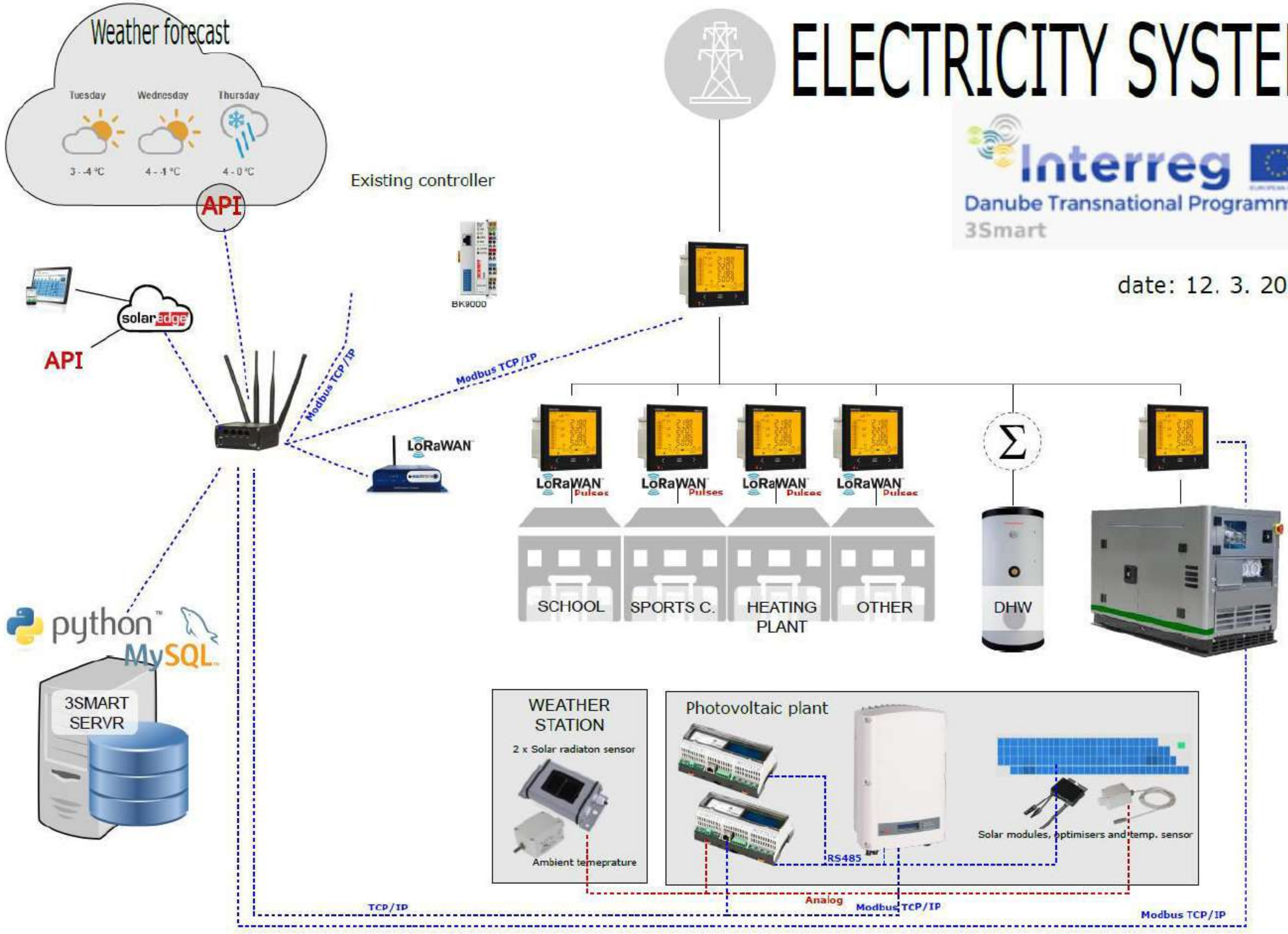
File	Status	Size	Permission	UID	GID
PV_data_to_DB.log	Timestamp failed	26 B	0664	1001	1003
EEmeters_calculate.log	Timestamp failed	177 B	0664	1001	1003

Access to 3Smart technology subsystems

ELECTRICITY SYSTEM

Interreg
Danube Transnational Programme
3Smart

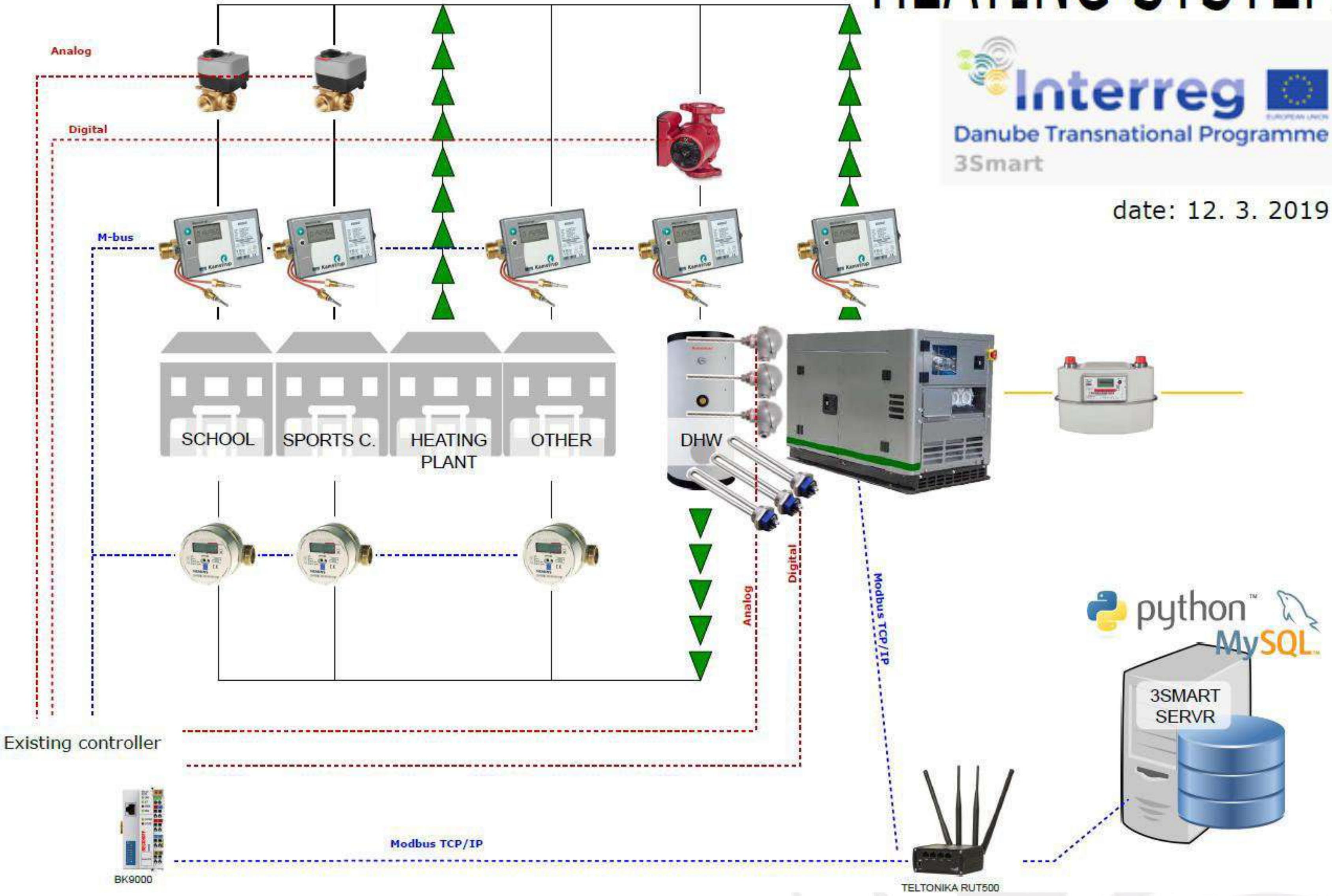
date: 12. 3. 2019



HEATING SYSTEM

Interreg
Danube Transnational Programme
3Smart

date: 12. 3. 2019



Data exchange intervals

- Zone (writing to device after read)
  - radiator valve: 5 min
  - Room temperature: 10 min
  - return temperature: 5 min
  - presence sensor: 5 min

- PV plant energy and power: 5 min
- Weather station: 15 min
- CHP: 5 min

Data exchange intervals

- EE Meters of non controllable load: 15 min
  - (sc, school …)
- EE Meter of heating substation and main meter: 5 min
- Heat and flow meters: 5 min

PV plant

- The inverter can be connected over PRI (power reduction interface) in order to dynamically limit the output power of the inverter from remote device.
- Inverter measurements over Mod-bus
- Environmental sensors data over web API.

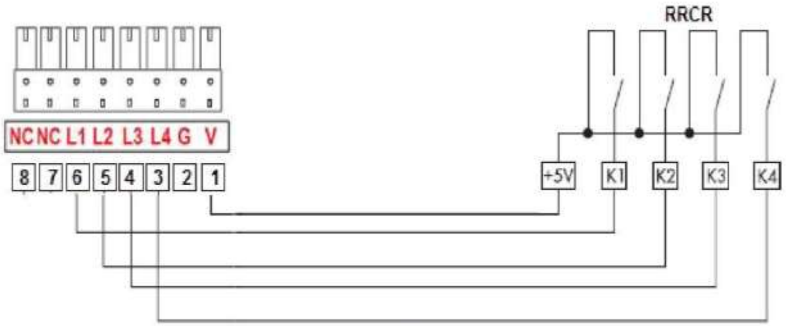
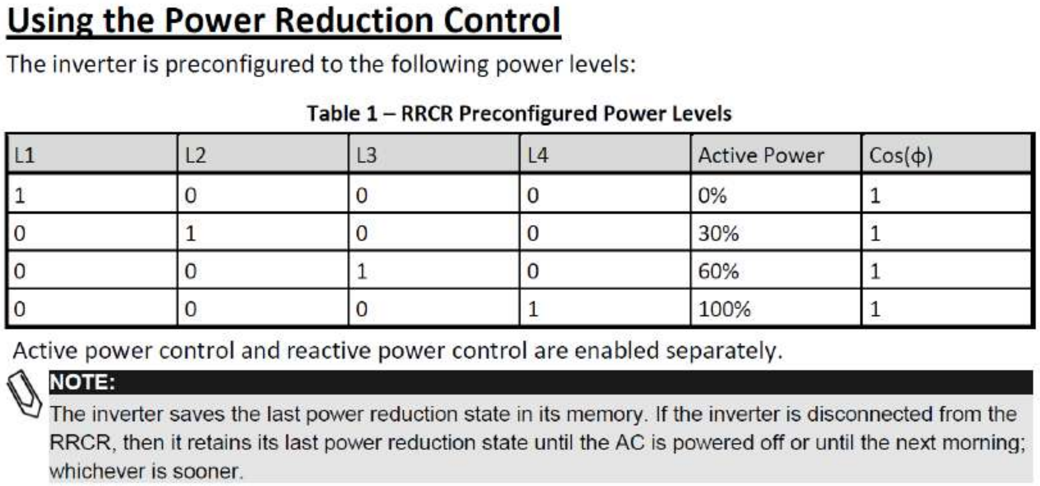


Figure 2 – Inverter – RRCR Connection



Using the Power Reduction Control

The inverter is preconfigured to the following power levels:

Table 1 – RRCR Preconfigured Power Levels

L1	L2	L3	L4	Active Power	Cos(ϕ)
1	0	0	0	0%	1
0	1	0	0	30%	1
0	0	1	0	60%	1
0	0	0	1	100%	1

Active power control and reactive power control are enabled separately.

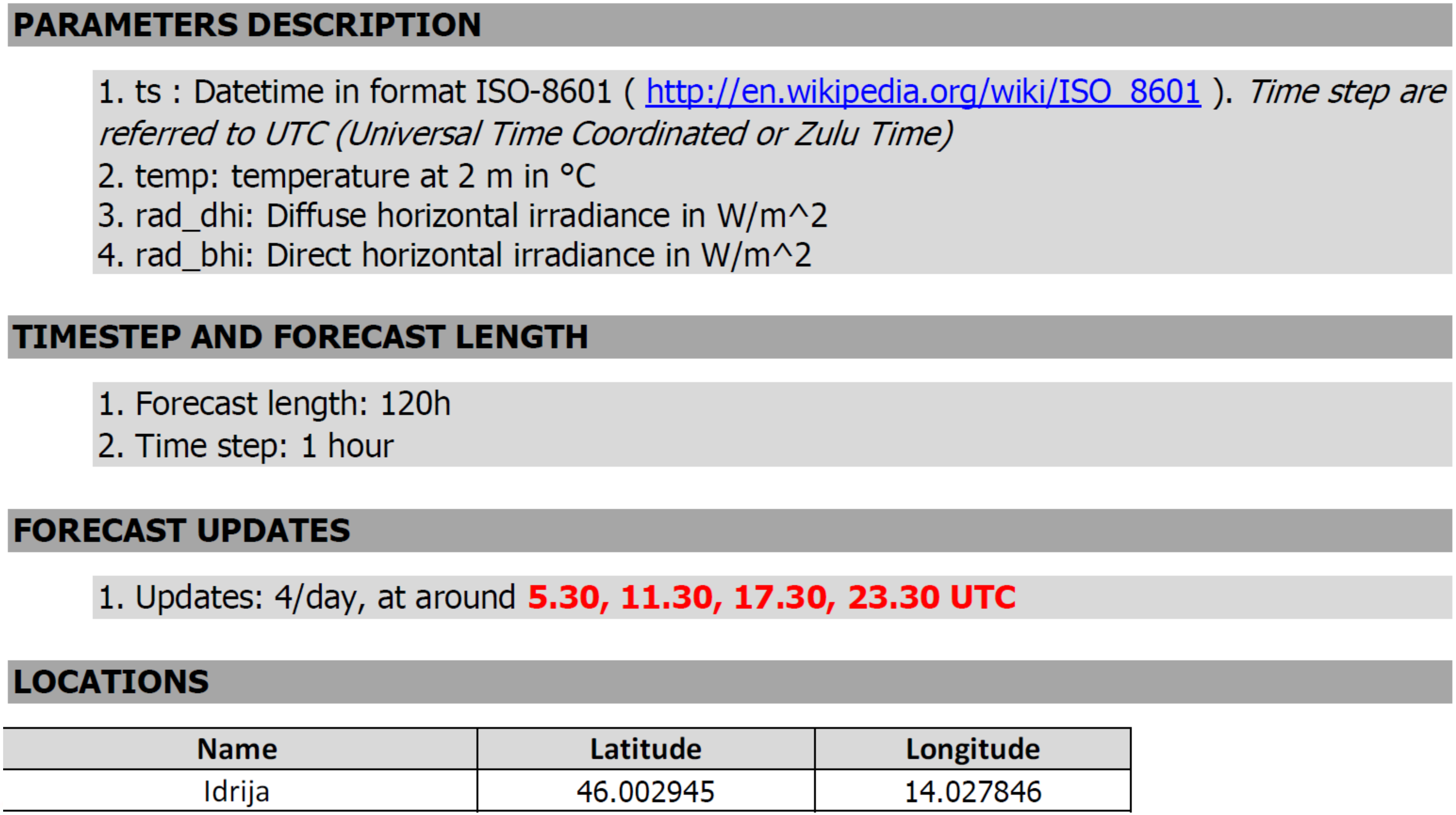
NOTE:

The inverter saves the last power reduction state in its memory. If the inverter is disconnected from the RRCR, then it retains its last power reduction state until the AC is powered off or until the next morning; whichever is sooner.

Zone control and measurements

- radiator valves
- Return temperature sensors
- Room temperature sensor
- Occupation sensor

weather forecast service



PARAMETERS DESCRIPTION

1. ts : Datetime in format ISO-8601 (http://en.wikipedia.org/wiki/ISO_8601). *Time step are referred to UTC (Universal Time Coordinated or Zulu Time)*
2. temp: temperature at 2 m in °C
3. rad_dhi: Diffuse horizontal irradiance in W/m^2
4. rad_bhi: Direct horizontal irradiance in W/m^2

TIMESTEP AND FORECAST LENGTH

1. Forecast length: 120h
2. Time step: 1 hour

FORECAST UPDATES

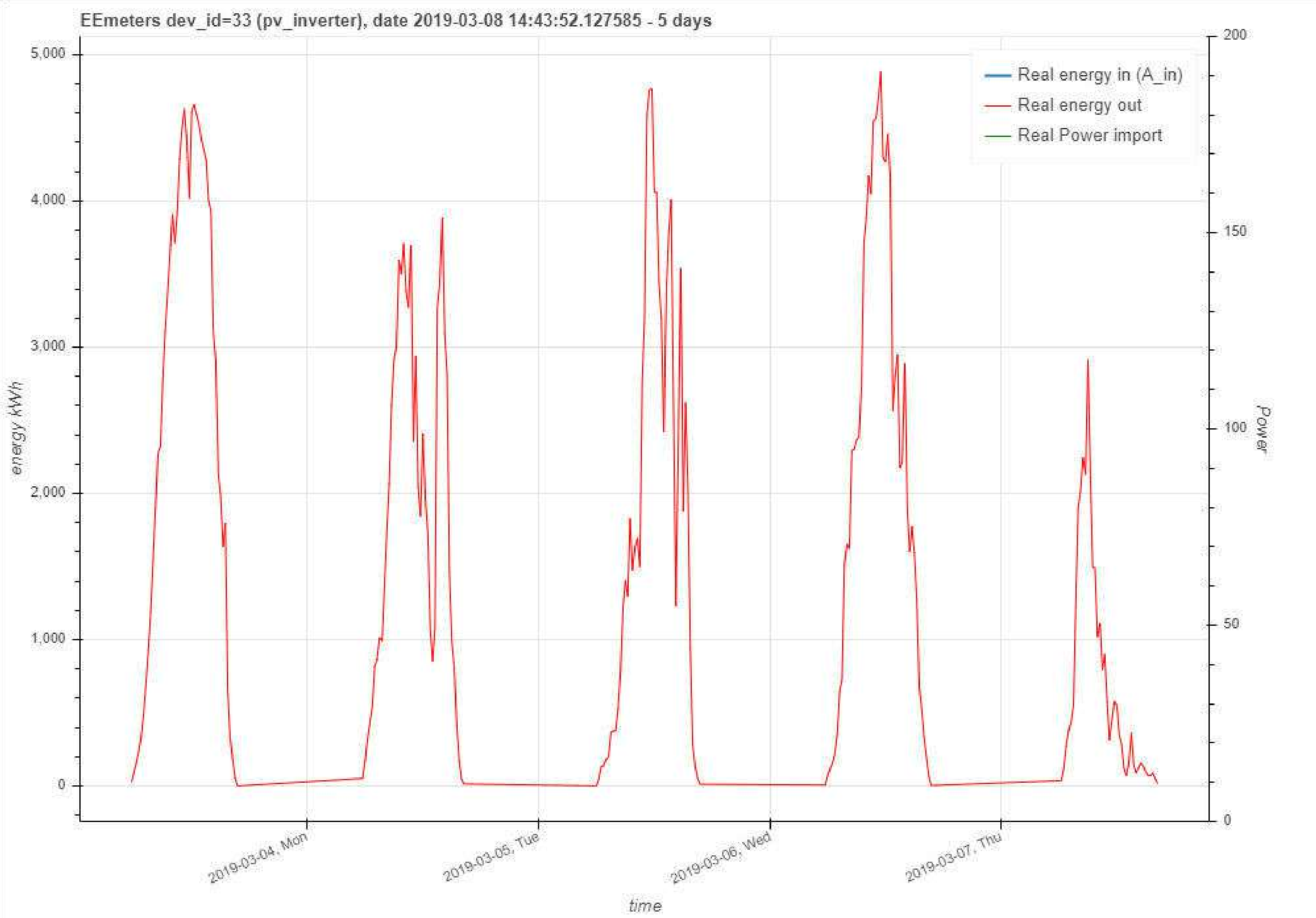
1. Updates: 4/day, at around **5.30, 11.30, 17.30, 23.30 UTC**

LOCATIONS

Name	Latitude	Longitude
Idrija	46.002945	14.027846

Measurements presentation and evaulation

Microgrid level – Electrical energy meters measurements



energetika
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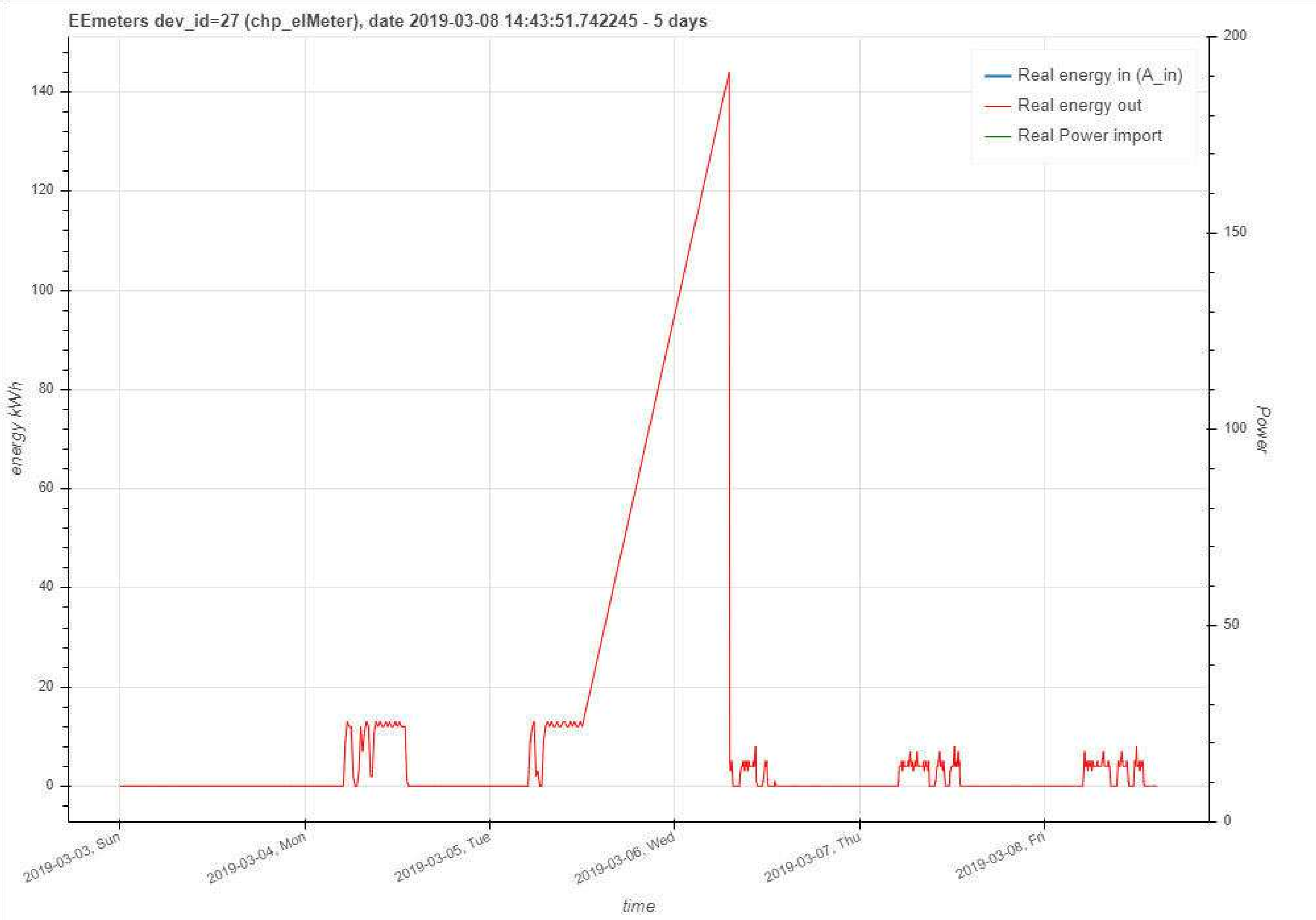
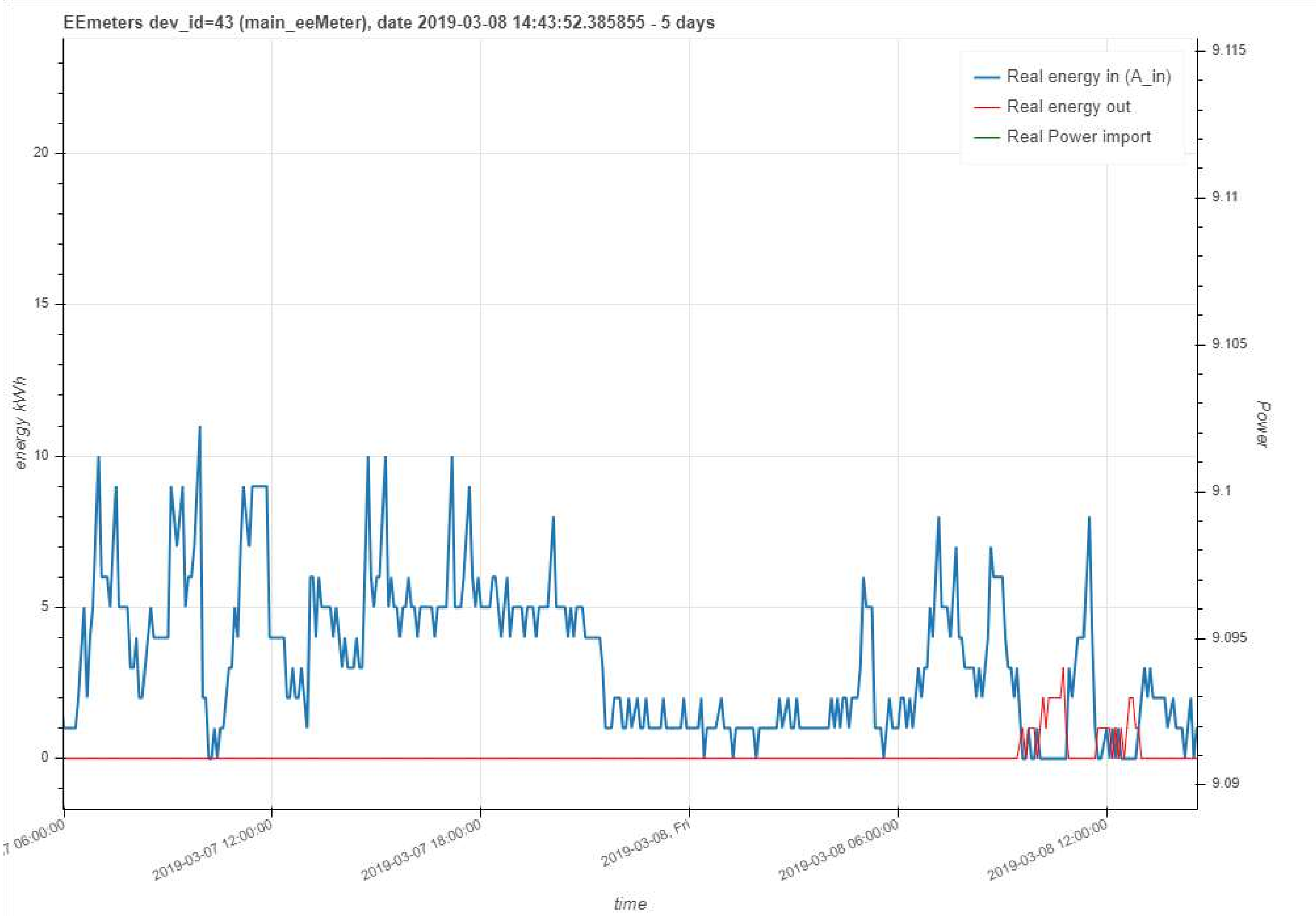
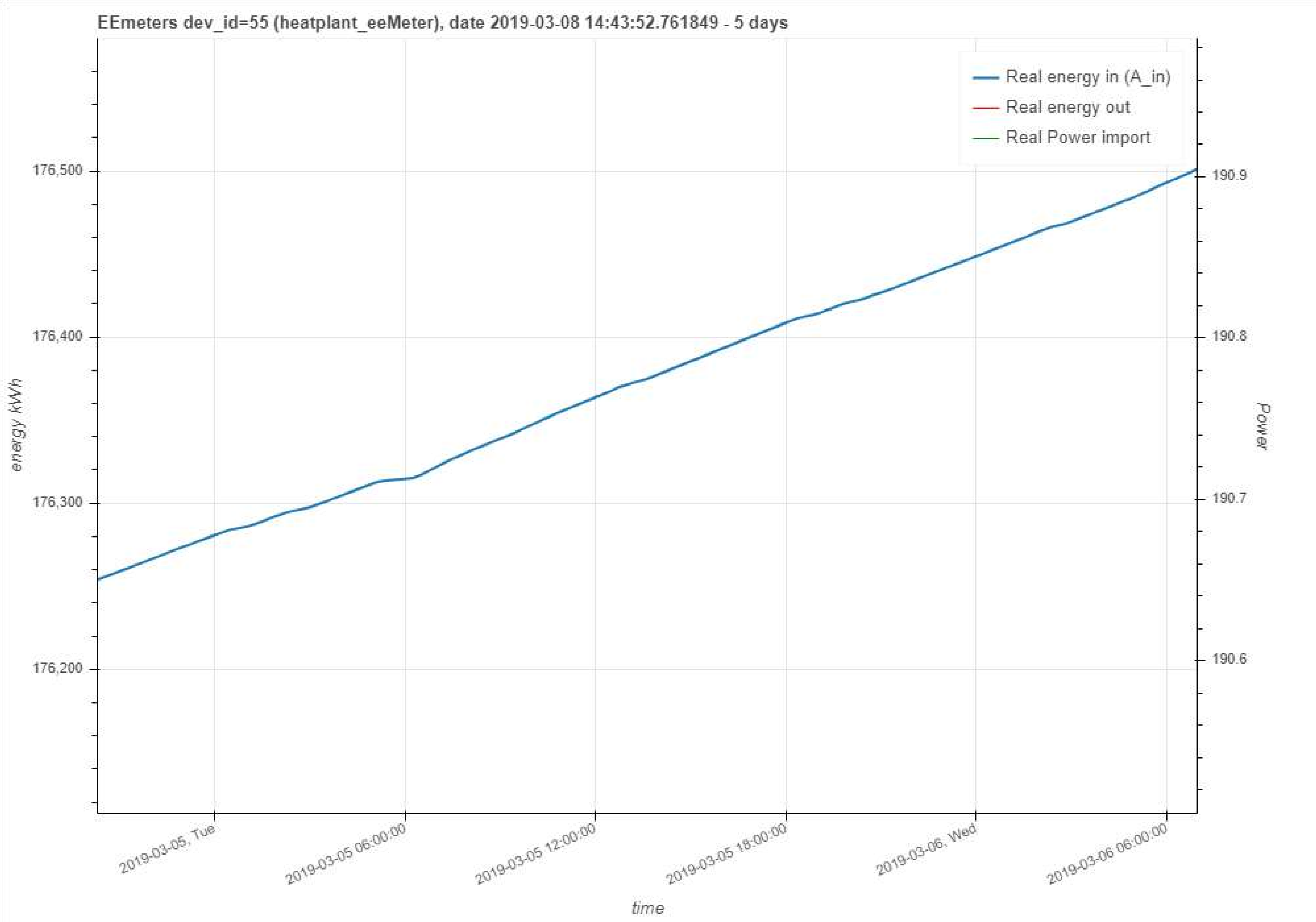
Microgrid level – Electrical energy meters measurements



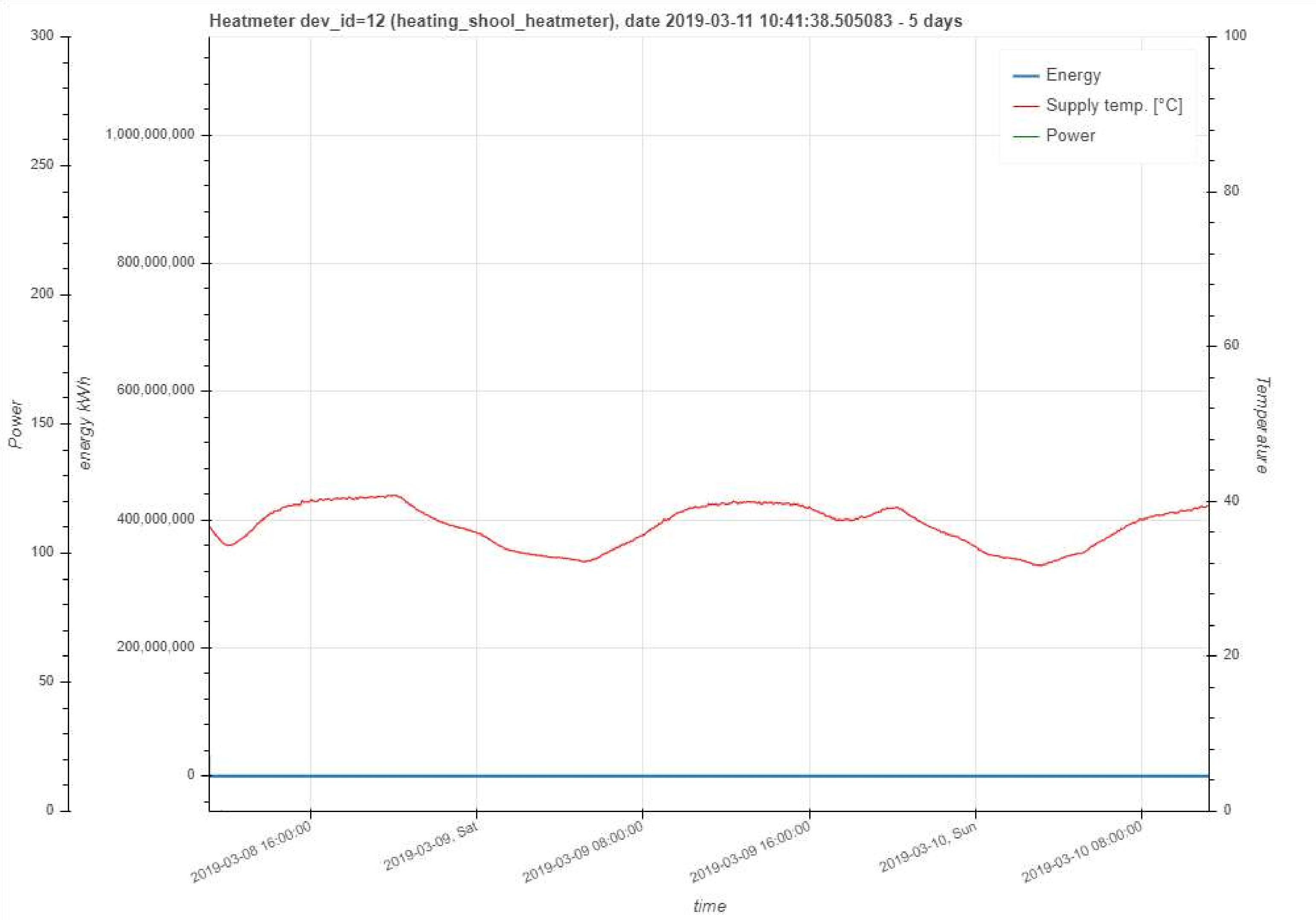
Microgrid level – Electrical energy meters measurements



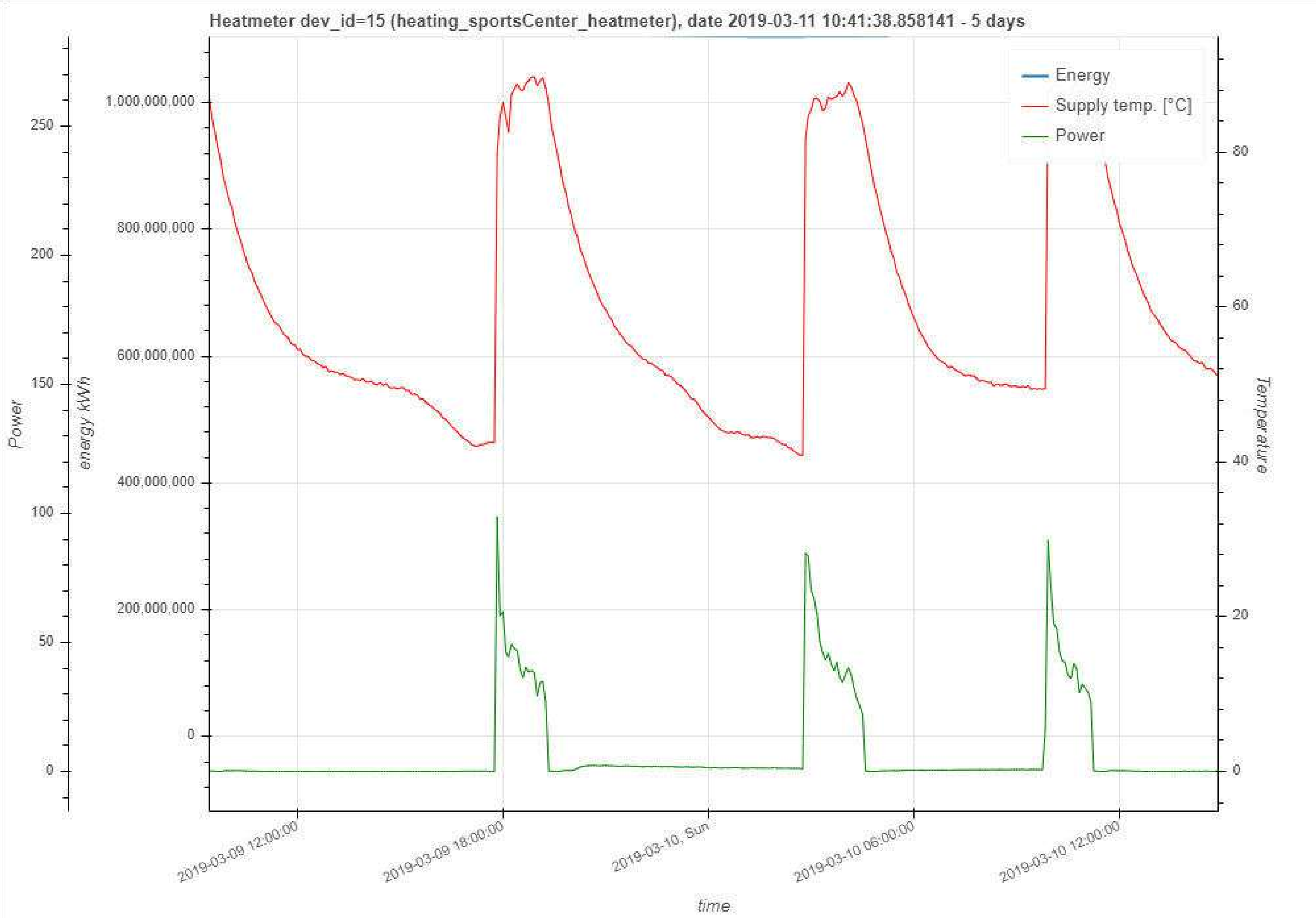
Microgrid level – Electrical energy meters measurements



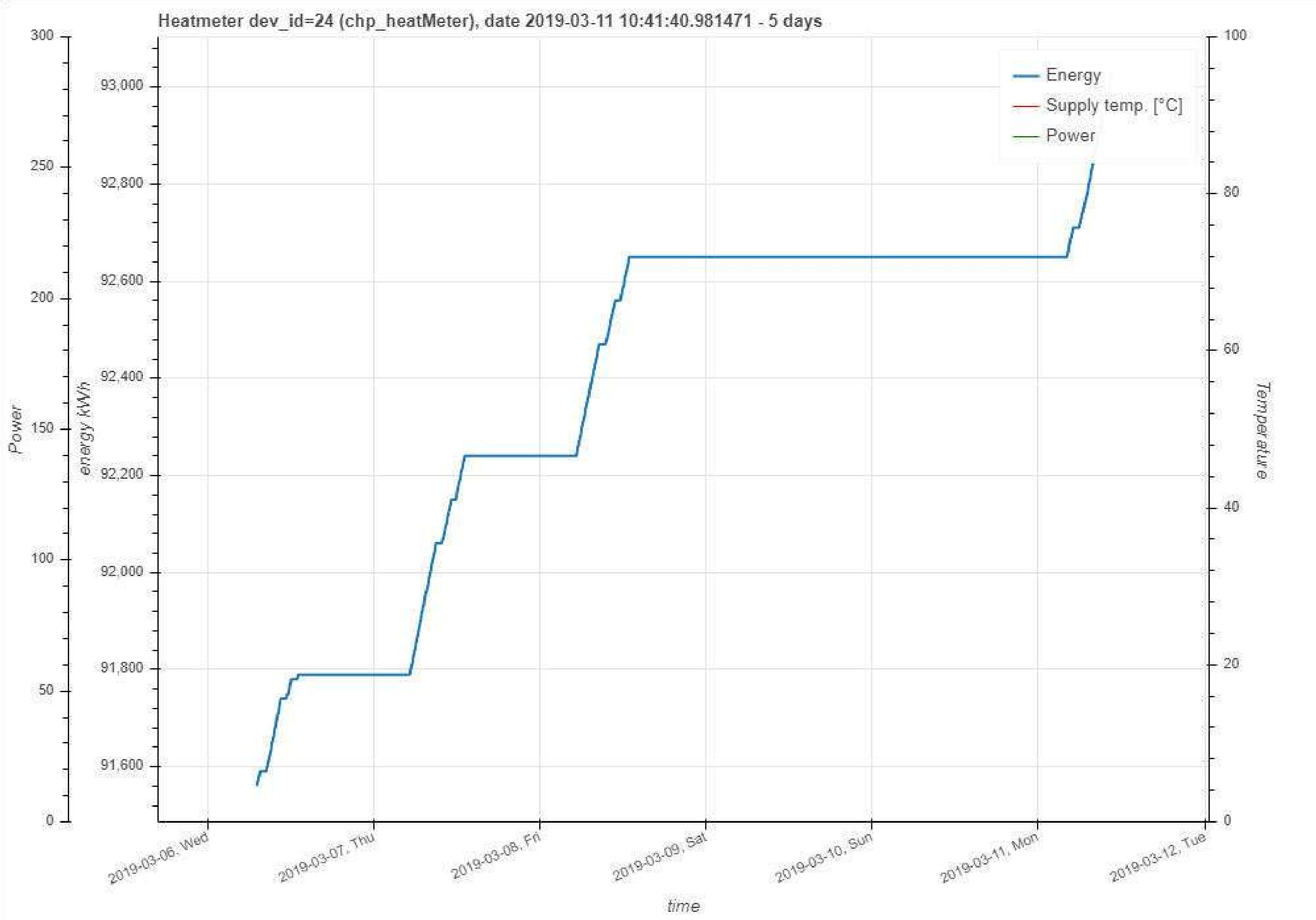
Microgrid level – Heat energy meters measurements



Microgrid level – Heat energy meters measurements



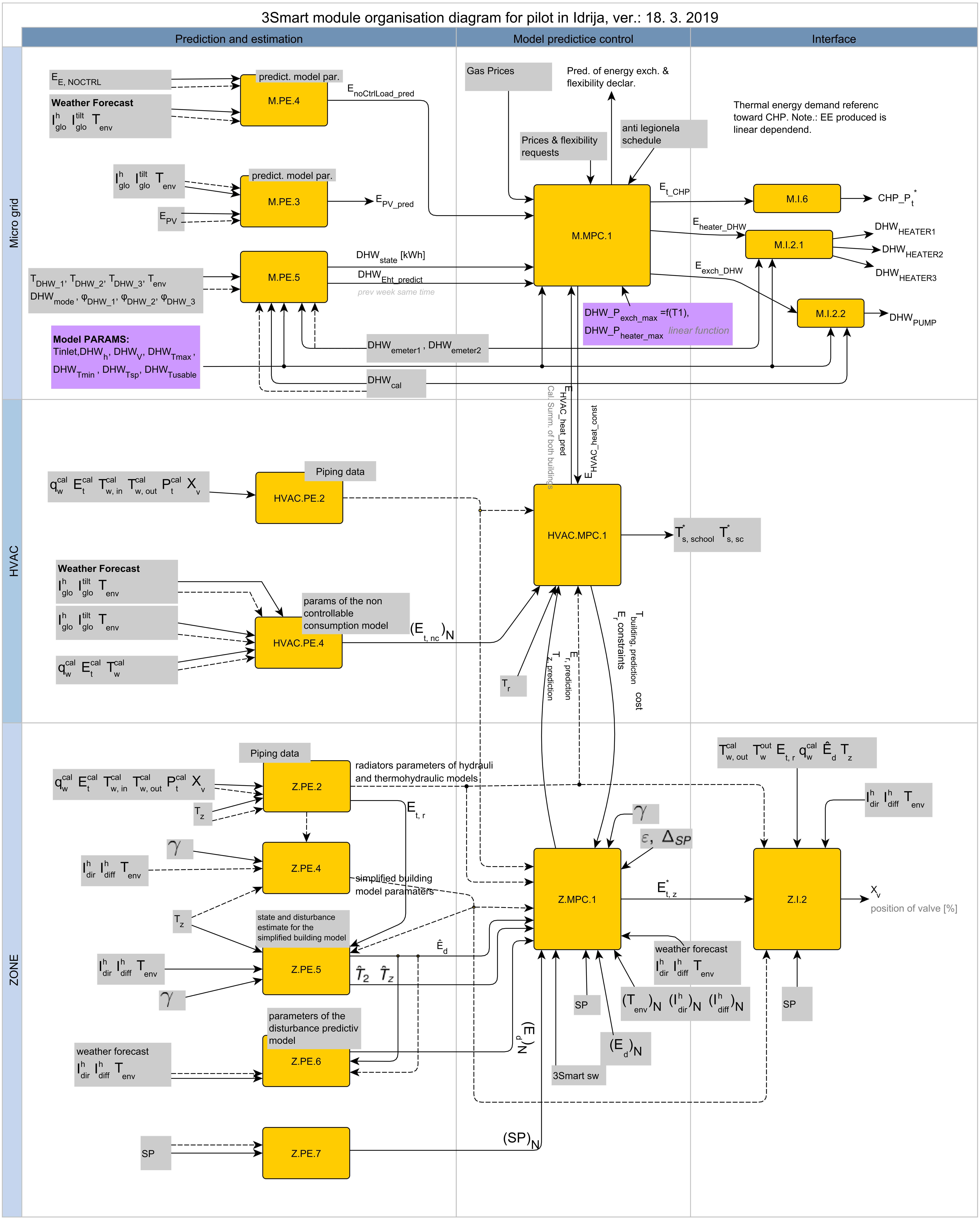
Microgrid level – Heat energy meters measurements



Thank you for your attention.

LEGEND:

- - - - - - - - HISTORICAL DATA
-------------- MEASURED ADATA


3Smart module organisation diagram for pilot in Idrija, ver.: 18. 3. 2019

Grid side modules coordination on the side of Elektroprimorska

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3Smart – First pilot study visit Idrija study
12. – 13.03.2019.

Project co-funded by the European Union

Content

- Long-term Multi(Annual) module
  - Model architecture
  - Database overview
  - Communication model

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

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

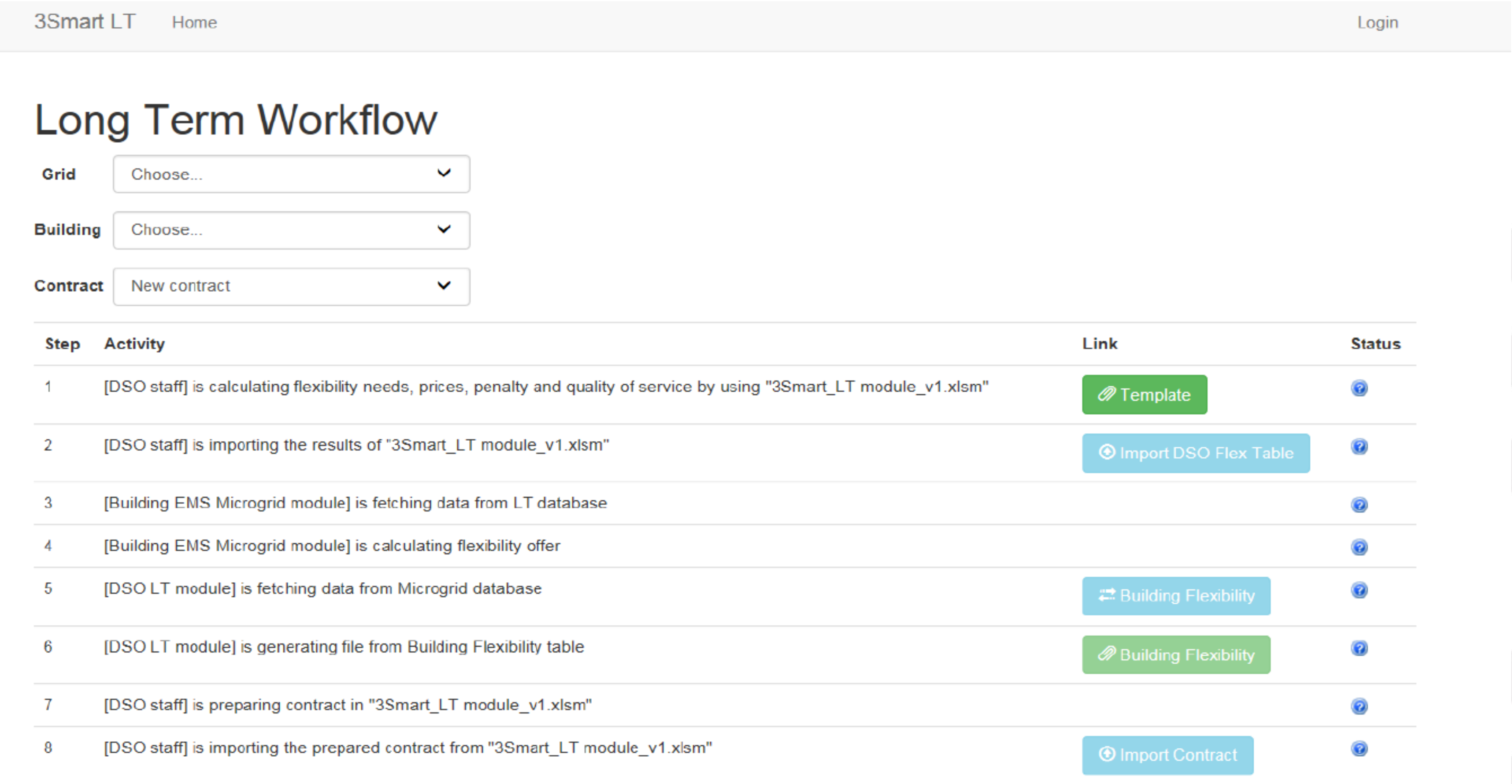
LT module coordination

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



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)

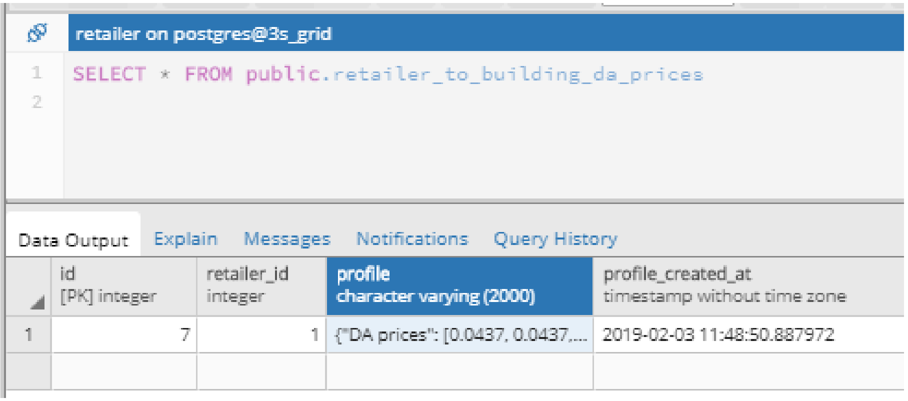
ST Day-Ahead Module Input

- 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

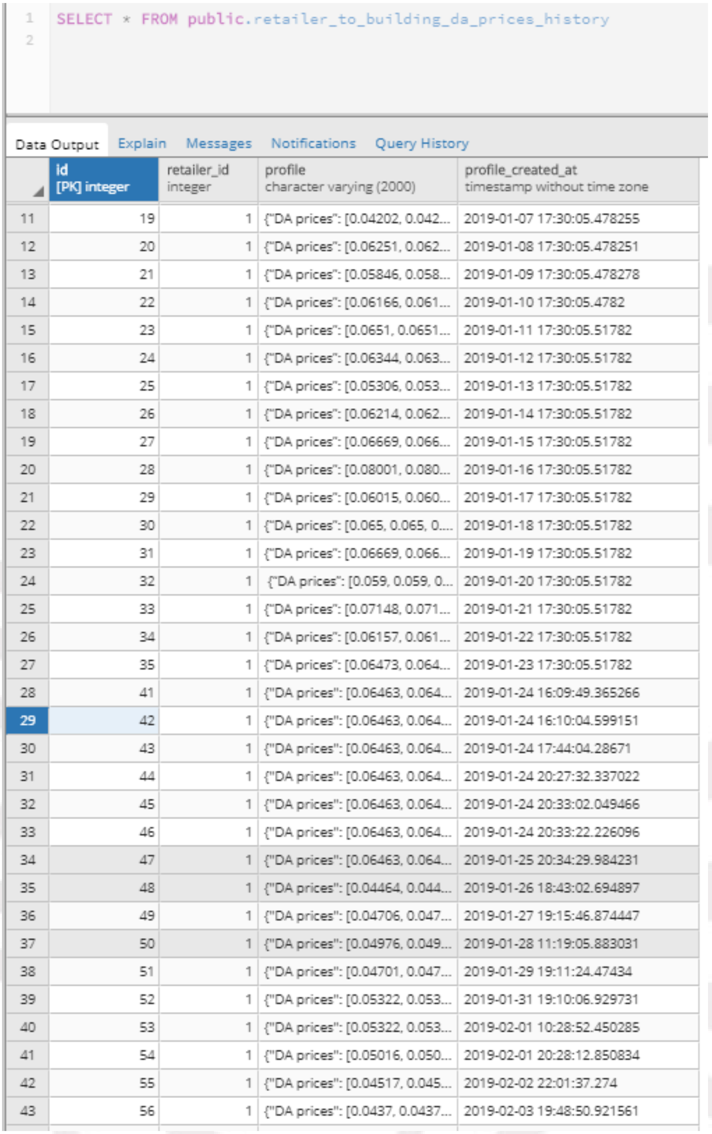
Retailer database outlook



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

	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"}

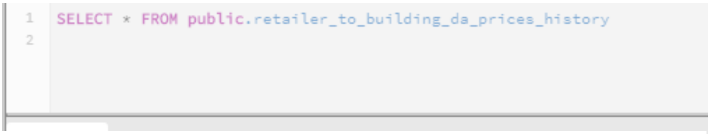


```
SELECT * FROM public.retailer_to_building_da_prices_history
```

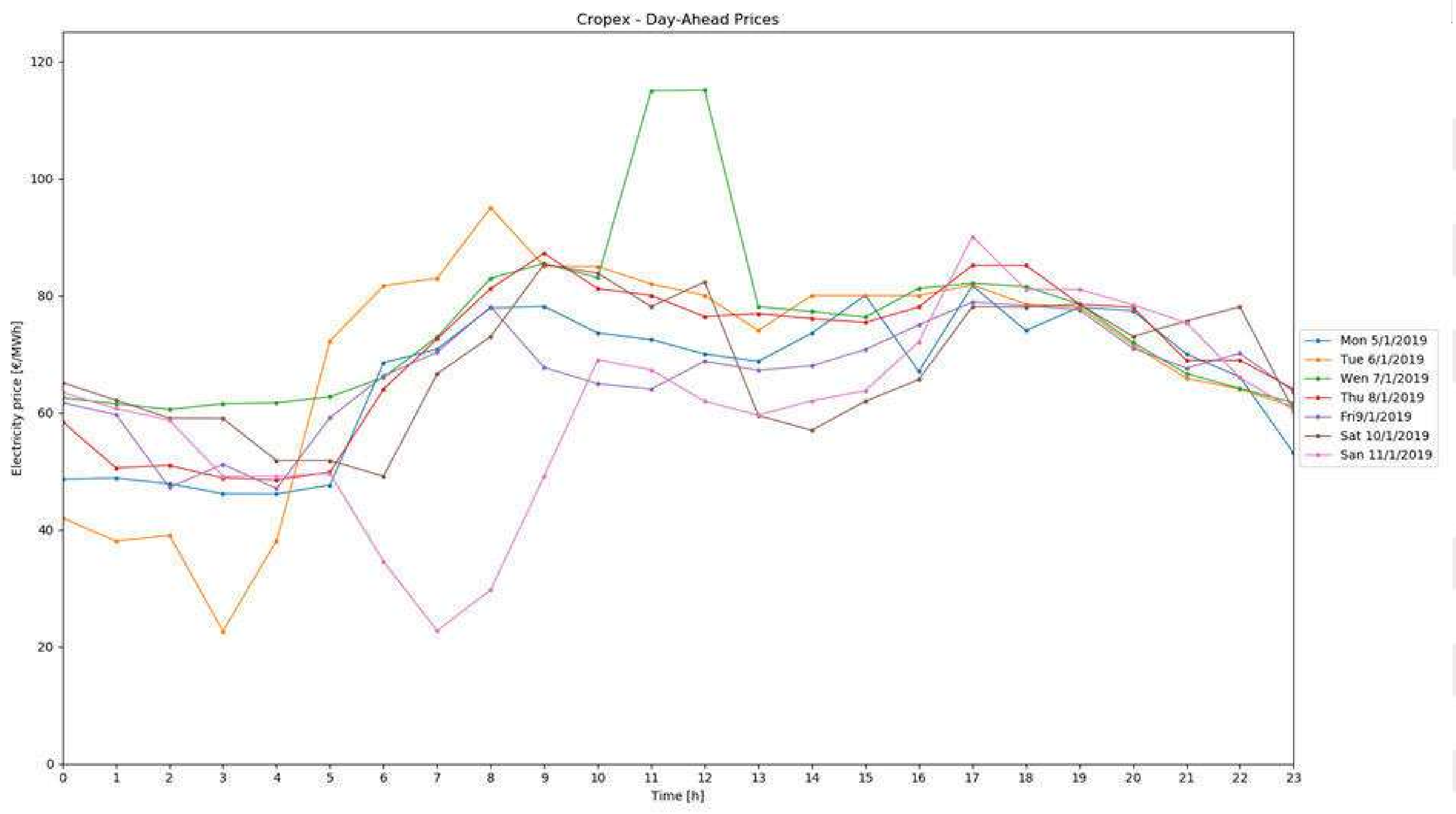
	id [PK] integer	retailer_id integer	profile character varying (2000)	profile_created_at timestamp without time zone
11	19	1	{"DA prices": [0.04202, 0.042...	2019-01-07 17:30:05.478255
12	20	1	{"DA prices": [0.06251, 0.062...	2019-01-08 17:30:05.478251
13	21	1	{"DA prices": [0.05846, 0.058...	2019-01-09 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

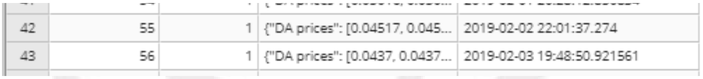
```
SELECT * FROM public.retailer_to_building_da_prices
```



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


Cropex - Day-Ahead Prices

{"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

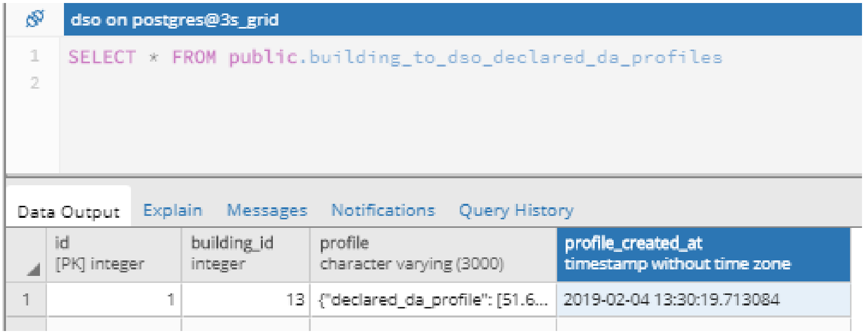


42	55	1	{"DA prices": [0.04517, 0.045...	2019-02-02 22:01:37.274
43	56	1	{"DA prices": [0.0437, 0.0437...	2019-02-03 19:48:50.921561

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

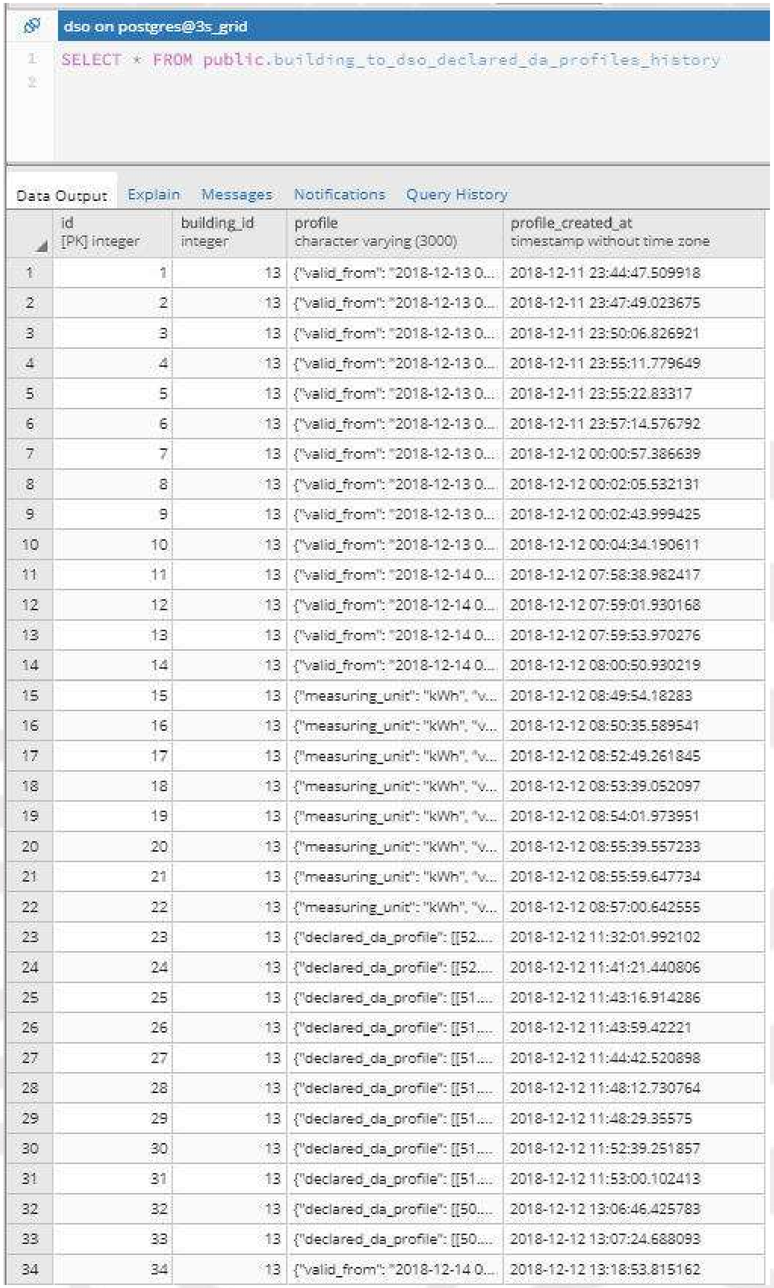


dso on postgres@3s_grid

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

	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

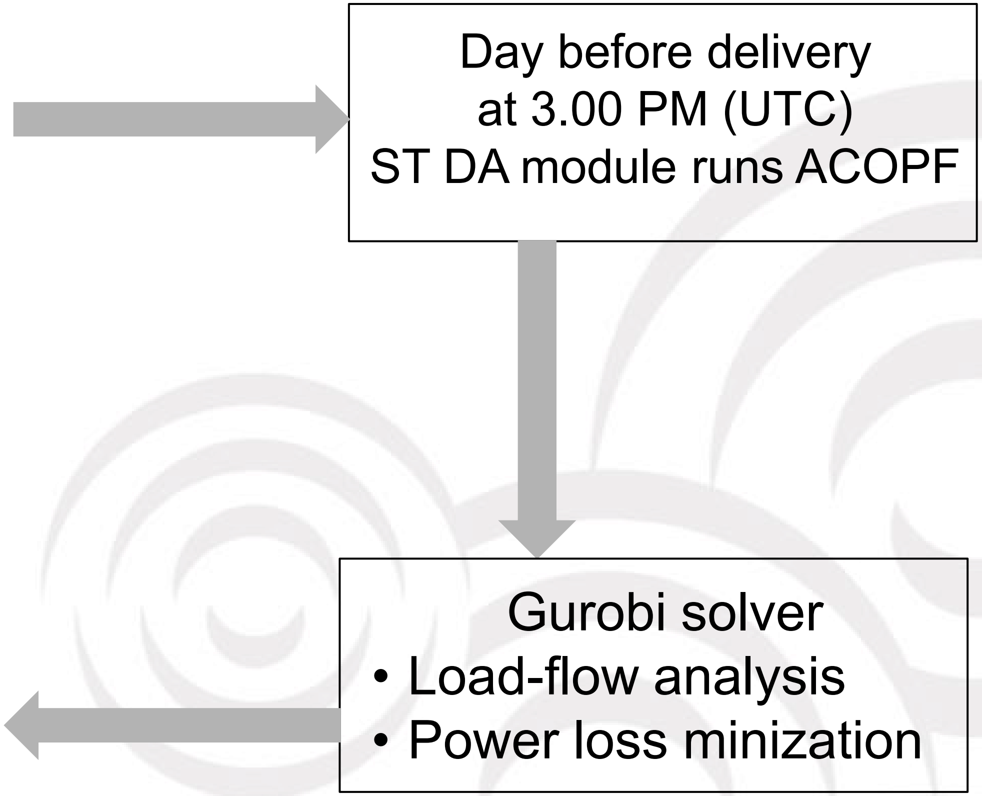
```
SELECT * FROM public.building_to_dso_declared_da_profiles_history
```

	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



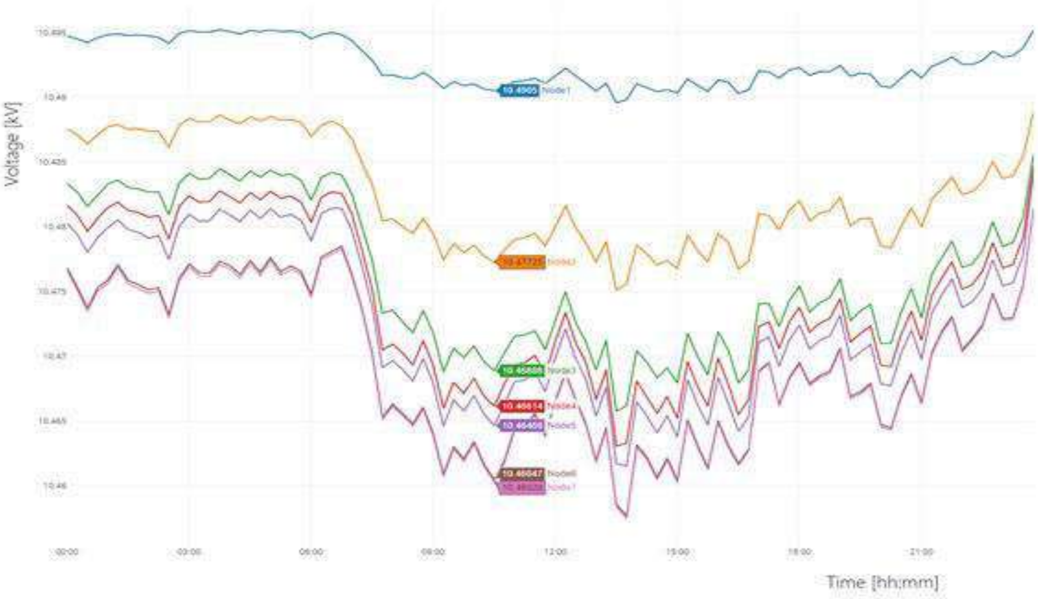
Day before delivery
at 3.00 PM (UTC)
ST DA module runs ACOPF

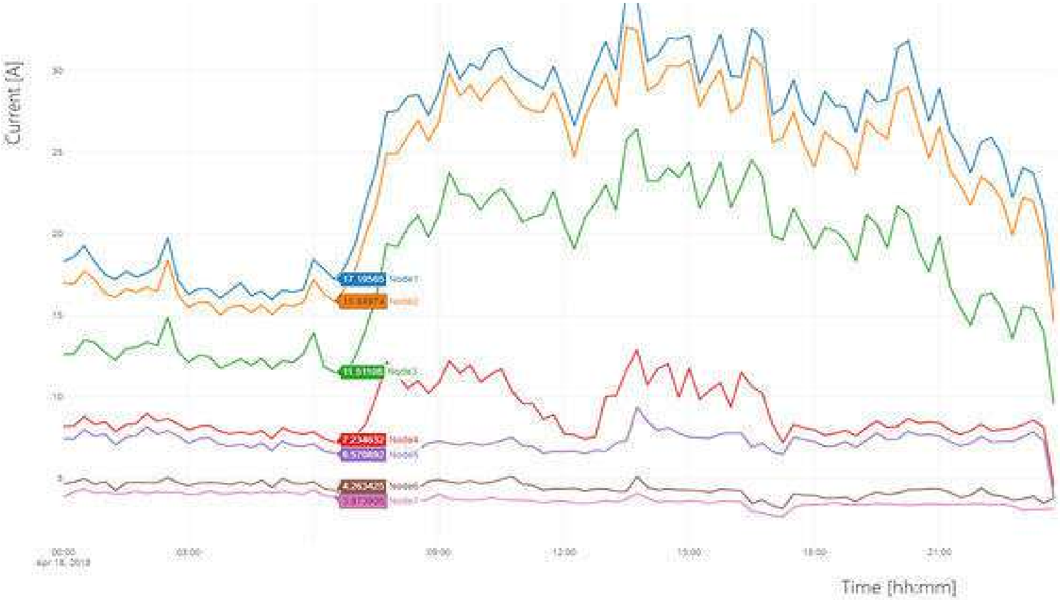
Gurobi solver
- Load-flow analysis
- Power loss minization

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

AC OPF results

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



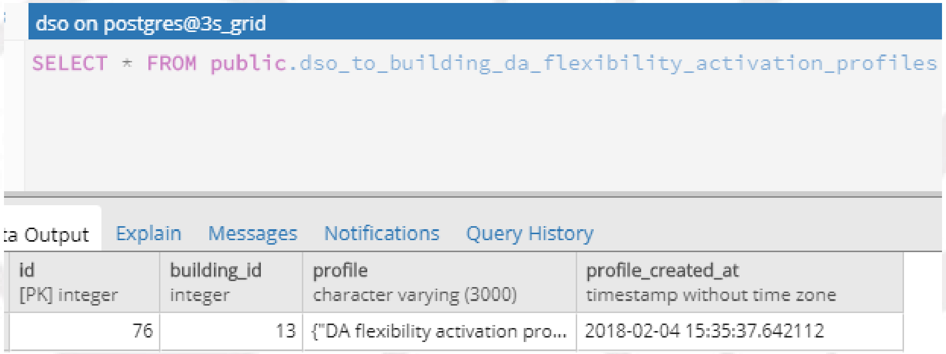


Interreg
Danube Transnational Programme
3Smart

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

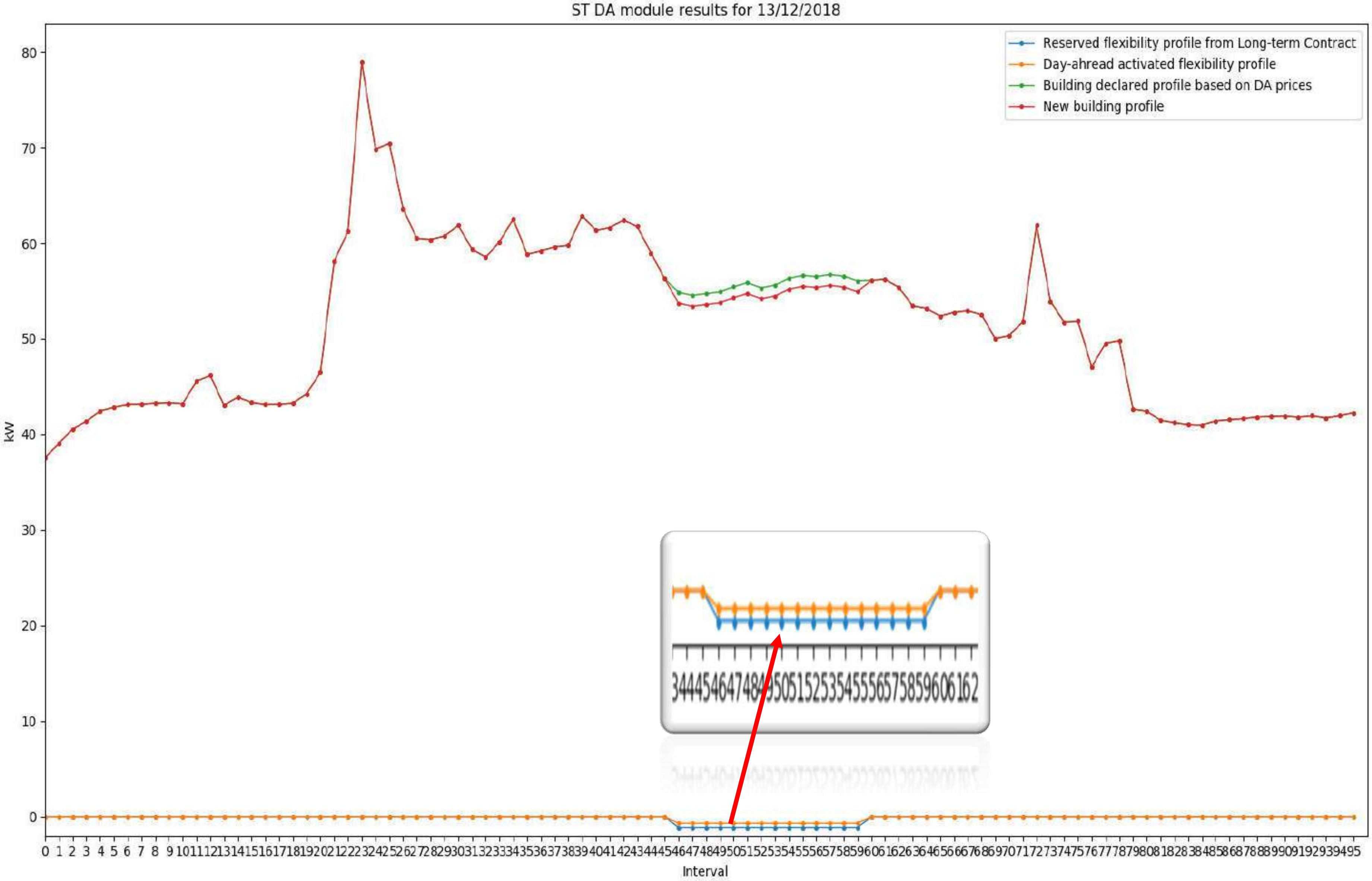
{"DA flexibility activation profile": [0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,, -1.137587, -1.13758, -1.13758, -1.1375877718386254, -1.1375893533847705,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



dso on postgres@3s_grid

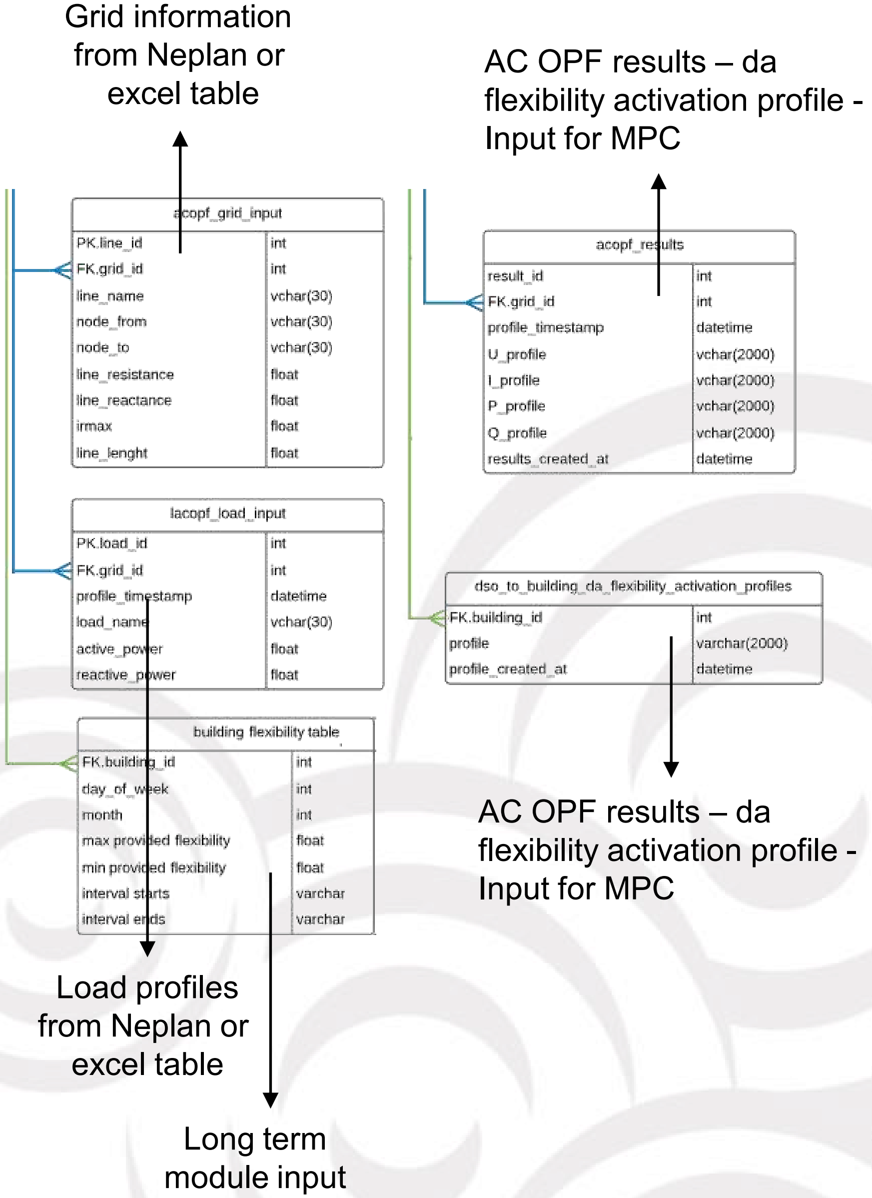
```
SELECT * FROM public.dso_to_building_da_flexibility_activation_profiles
```

id [PK] integer	building_id integer	profile character varying (3000)	profile_created_at timestamp without time zone
76	13	{"DA flexibility activation pro...	2018-02-04 15:35:37.642112


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
80
70
60
50
40
30
20
10
0
Interval
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95
3 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62

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



Grid information from Neplan or excel table

AC OPF results – da flexibility activation profile - Input for MPC

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

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

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

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

building flexibility table	
FK.building_id	int
day_of_week	int
month	int
max provided flexibility	float
min provided flexibility	float
interval starts	varchar
interval ends	varchar

AC OPF results – da flexibility activation profile - Input for MPC

Load profiles from Neplan or excel table

Long term module input

Identification procedure and execution schedule on Idrija site

The identification process comprises of the (i) temperature drop and calibration model estimation, (ii) flow share model estimation and the (iii) radiator model parameters estimation. All the radiators in the system are balanced which means that the valve position of a certain radiator does not affect the flow through the other ones.

Two specific radiators of a different kind are to be selected in the set of controllable radiators for the radiator model identification. Respective radiators are in the sequel noted as the identification radiators. The identification radiators should be positioned in the zones which allow the identification procedure to be conducted during the working hours (no one in the room).

Involved parties (partners) in this activity are: Mario Vašak, Anita Martinčević and Nikola Hure(UNIZGFER); Tadej Rupnik and Marko Baša (Idrija); Vladimir Jovanović and Mirko Komatina (UNIBGFME); Ivo Bevanda (UNIMOSFSR).

All the involved parties should be kept in the communication of the procedure progress and the related discussion. The responsible partners should keep the status of the finished tasks updated by checking the specified checkmark boxes of this document and by informing all the involved partners by e-mail.

(i) Temperature drop/sensor calibration measurements

Description:

For the model estimation purpose the temperatures at the radiator inlets and outlets should be collected. Temperature drop model estimation will be carried out for the neighbouring groups of radiators on the same duct. With this aim, the measurements at the radiator supply side are collected for a single selected radiator within a group. The measurements for the sensor calibration purpose should be collected at each one of the controllable radiators.

All the measurements are to be taken for at least two distinct supply temperatures on the school and sport centre calorimeters, e.g. 40°C and 70°C. Before taking any measurements from the radiators, the hand-held temperature sensor device should be calibrated with respect to the calorimeter supply temperature – the device should provide the same supply temperature measurement as the calorimeter readings.

Execution schedule:

Responsible	Description	Due to	Finished
Tadej, Marko, Vladimir	Groups are to be determined.	22nd of March 2019	
	Selected identification radiator ids are to be determined.	22nd of March 2019	
	Temperature measurements are to be collected on the supply and return of the selected identification radiators.	22nd of March 2019	
	The collected measurement data logged into excel file.	25th of March	
	Measurements on all the other radiators is to be conducted in the following period of the heating season. All the measurements should be recorded in the excel file.	Middle of April 2019	

(ii) Flow share model identification

Description:

The estimation will be carried out by closing the valves of all the non-controllable radiators and by setting all the controllable ones in the fully open position, conducted by Tadej. Flow shares will be determined from the database measurements by Vlada and Ivo, by using the stationary measurements on the calorimeters and by dividing the full flow with the number of the fully open radiators.

Execution schedule:

Responsible	Description	Due to	Finished
Tadej, Marko, Ivo, Vlada	The identification procedure for the flow share estimation (valve positioning) is to be performed. Ivo is synchronized with Tadej, such that the necessary amount of data is collected in the stationary flow conditions of the heating system.	22nd of March 2019	
Vlada, Ivo	Estimation of the flow share coefficients for the controllable radiators	27th of March 2019	

(iii) Radiator model parameters estimation

Description:

Ivo will perform the estimation of model parameters for the selected identification radiators (only two different models are on the site). Ivo should agree with Tadej about the hours when the identification is to be conducted as well as about the **necessary requirements** such that the identification data collection is successful.

Measurement procedure on radiators in Idrija:

- turn off all non-controllable radiators in the building,
- turn on all controllable radiators in the building,
- turn off radiator on which the measurements will be performed,
- turn off other radiators that are eventually located in that zone so that they do not affect the room temperature,
- after approx. 2 hours turn on the radiator and start collecting data,
- collect at least 12 hours of data.

Execution schedule:

Responsible	Description	Due to	Finished
Ivo	Estimation of the selected radiators models	29th of March, 2019	

(iv) Temperature drop/calibration model estimation

Description:

Vladimir should perform the estimation of the temperature drop models for each one of the selected groups of radiators as well as the calibration models for each controllable radiator. The model parameters are to be inserted into the corresponding tables (hvac_pe2_radiator_offline_outputs) of 3smart database.

Execution schedule:

Responsible	Description	Due to	Finished
Vlada, Ivo	Estimation of the temperature drop model parameters and the calibration model parameters for the identification radiators.	27th of March 2019	
Vlada	Estimation of the temperature drop model parameters and the calibration model parameters for all the controllable radiators excluding the identification radiators.	Middle of April 2019	

Online demonstration: Zone level modules (Radiators and simplified building model)

Ivan Bevanda, Petar Marić

Faculty of Mechanical Engineering, Computing and Electrical Engineering

ivan.bevanda@fsre.sum.ba

3Smart 1st pilot study visit to the Slovenian pilot

Idrija, 12th – 13th March 2019

FAKULTET STROJARSTVA, RAČUNARSTVA I ELEKTROTEHNIKE
SVEUČILIŠTE U MOSTARU

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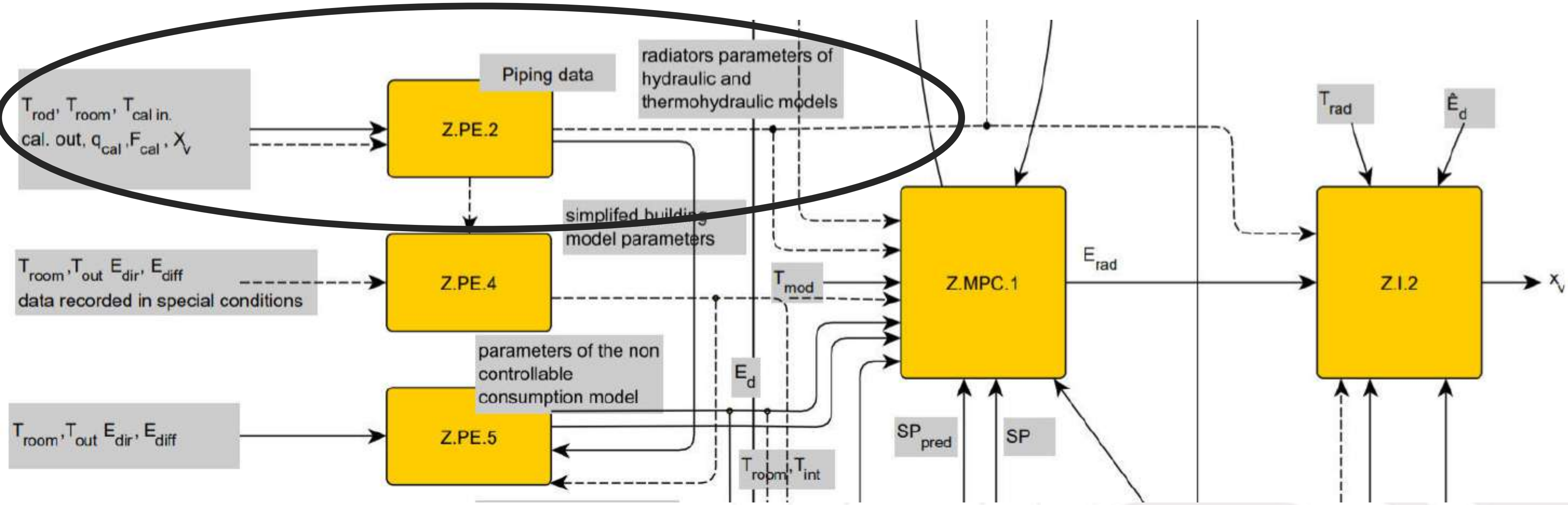
Danube Transnational Programme
3Smart

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

Radiator module



T_{rod}, T_{room}, $T_{cal\ in.}$ cal. out, q_{cal}, F_{cal}, X_v

Piping data

Z.PE.2

radiators parameters of hydraulic and thermohydraulic models

simplifed building model parameters

T_{room}, T_{out} E_{dir}, E_{diff} data recorded in special conditions

Z.PE.4

parameters of the non controllable consumption model

T_{room}, T_{out} E_{dir}, E_{diff}

Z.PE.5

E_d

T_{mod}

T_{room}, T_{int}

Z.MPC.1

E_{rad}

SP_{pred}

SP

T_{rad}

$\hat{E}_d$

Z.I.2

x_v

Data exchange intervals

- Zone (writing to device after read)
  - radiator valve: 5 min
  - Room temperature: 10 min
  - return temperature: 5 min
  - presence sensor: 5 min

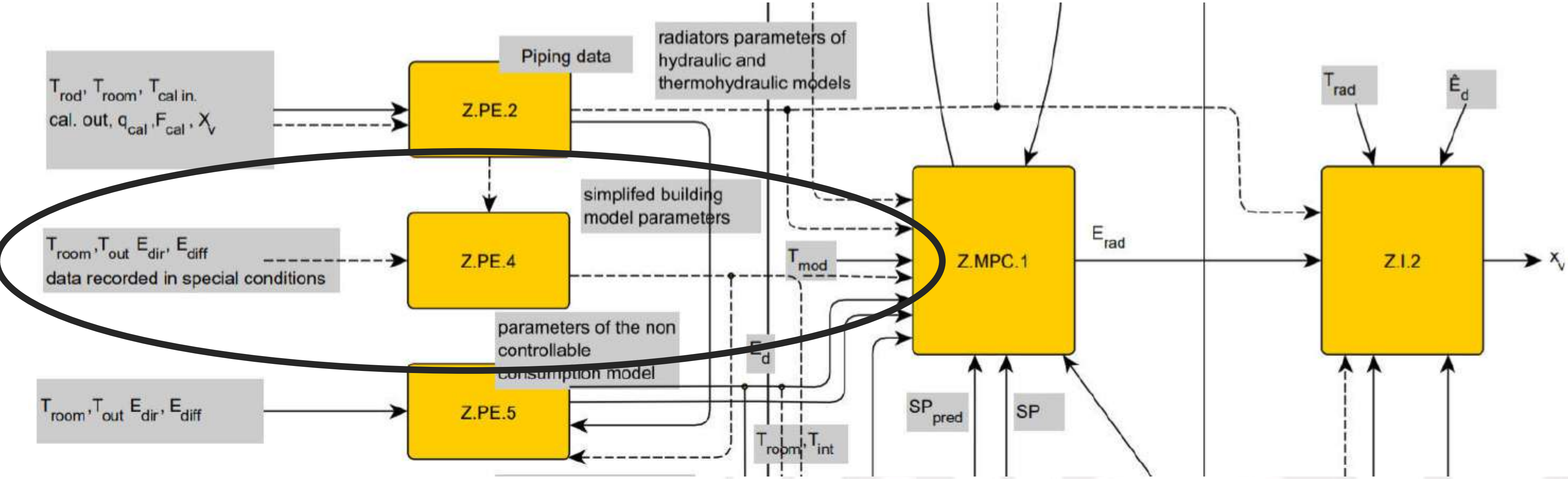
- PV plant energy and power: 5 min
- EE Meter of heating substation and main meter: 5 min
- Heat and flow meters: 5 min

- Energy calculation by using z.pe.2 will have larger errors in transient periods

Zone control and measurements

- radiator valves
- Return temperature sensors
- Room temperature sensor
- Occupation sensor

Simplified building model
Z.PE.4


T_{rod}, T_{room}, $T_{cal\ in.}$
cal. out, q_{cal}, F_{cal}, X_v
Piping data
Z.PE.2
radiators parameters of hydraulic and thermohydraulic models
T_{rad}
$\hat{E}_d$
simplifed building model parameters
T_{room}, T_{out} E_{dir}, E_{diff}
data recorded in special conditions
Z.PE.4
T_{mod}
Z.MPC.1
E_{rad}
Z.I.2
x_v
parameters of the non controllable consumption model
E_d
T_{room}, T_{out} E_{dir}, E_{diff}
Z.PE.5
SP_{pred}
SP
T_{room}, T_{int}

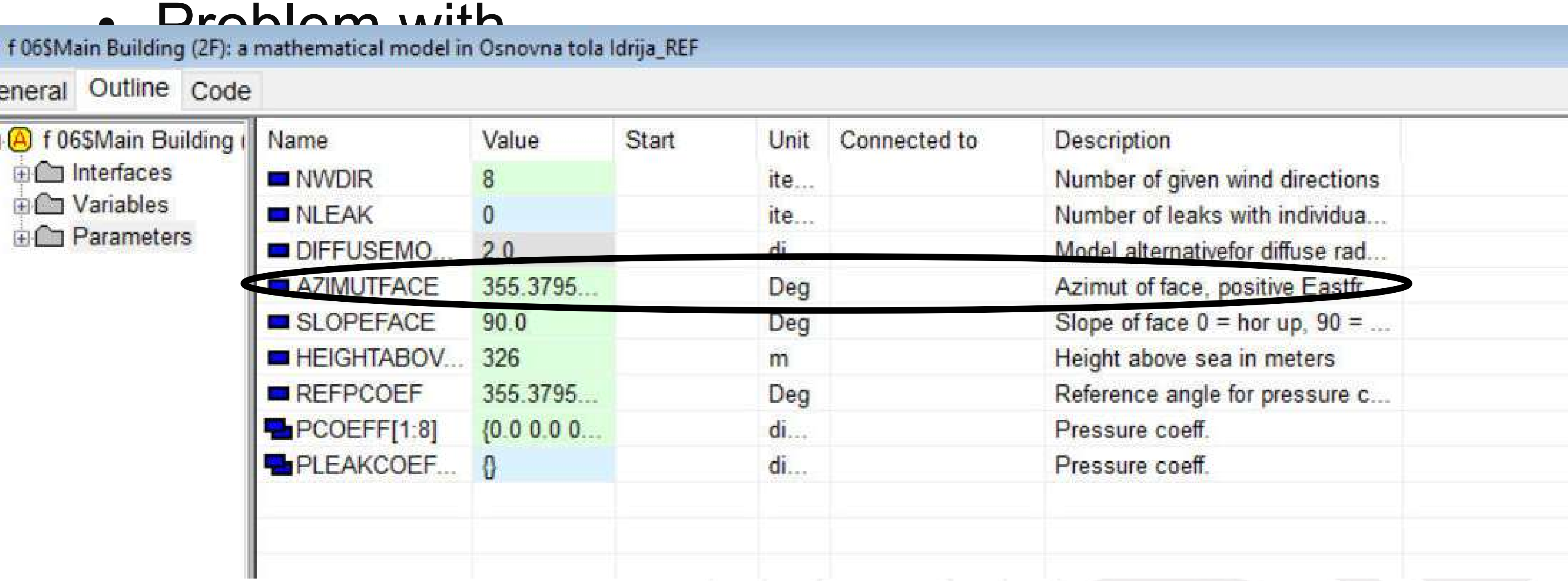
- 14 days simulation in IDA-ICE software
- Thermal behaviour of the building without internal heat disturbances (light, equipment, people, window opening...)
- Varibles taken from IDA-ICE: T_{room}, T_{out}, E_{dir}, E_{dif} (one minute interval)
- Parameters obtained in Matlab environment

Problems:

- Direct and diffuse solar radiation values

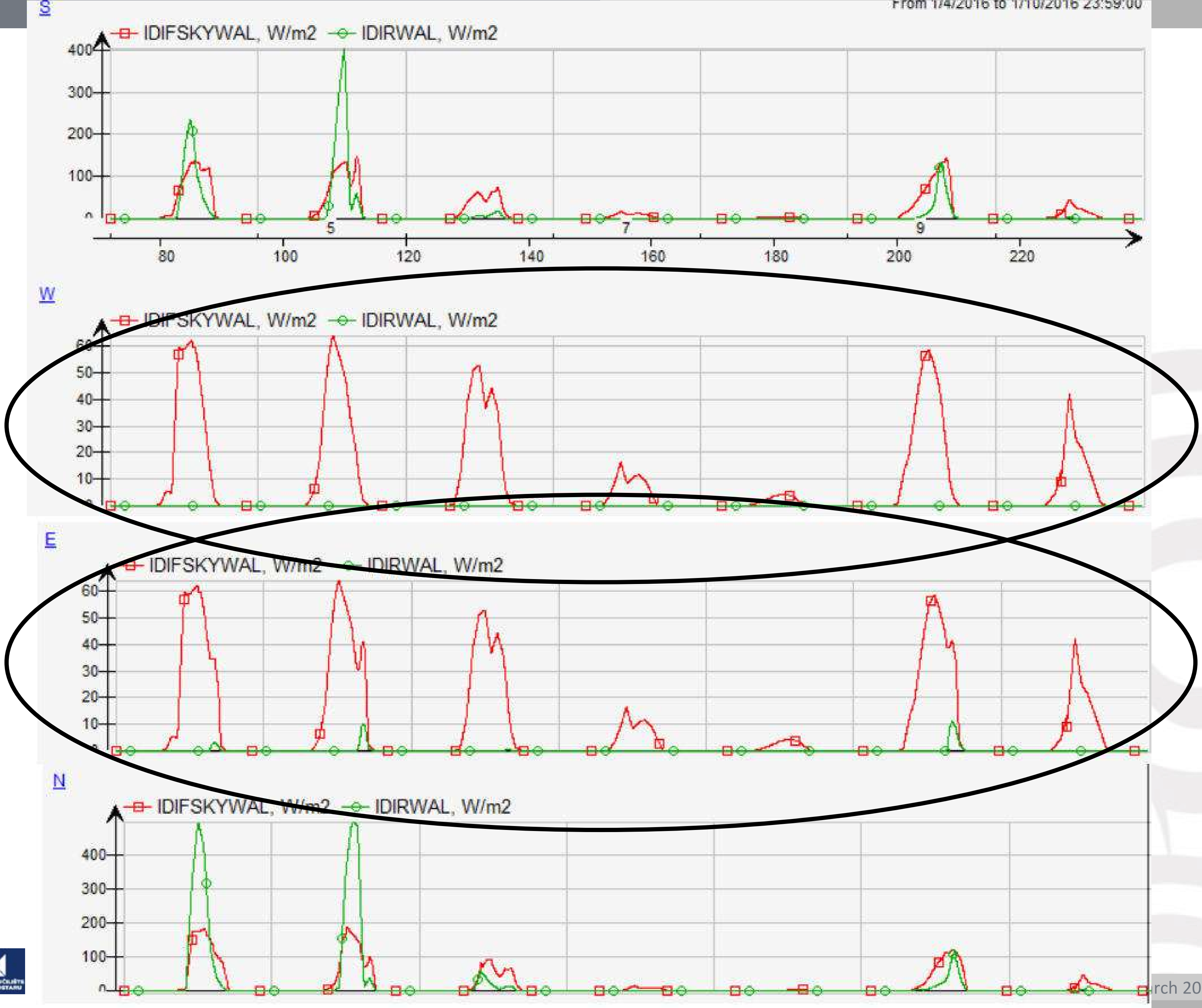
Contacted IDA-ICE support and Faculty of Mechanical engineering from Ljubljana

- Problem with



f 06$Main Building (2F): a mathematical model in Osnovna tola Idrija_REF

Name	Value	Start	Unit	Connected to	Description
NWDIR	8		ite...		Number of given wind directions
NLEAK	0		ite...		Number of leaks with individua...
DIFFUSEMO...	2.0		di...		Model alternativefor diffuse rad...
AZIMUTFACE	355.3795...		Deg		Azimut of face, positive Eastfr
SLOPEFACE	90.0		Deg		Slope of face 0 = hor up, 90 = ...
HEIGHTABOV...	326		m		Height above sea in meters
REFPCOEF	355.3795...		Deg		Reference angle for pressure c...
PCOEFF[1:8]	{0.0 0.0 0...		di...		Pressure coeff.
PLEAKCOEF...	{}		di...		Pressure coeff.


S
From 1/4/2016 to 1/10/2016 23:59:00
IDIFSKYWAL, W/m2
IDIRWAL, W/m2
400
300
200
100
0
5
7
9
80
100
120
140
160
180
200
220
W
IDIFSKYWAL, W/m2
IDIRWAL, W/m2
60
50
40
30
20
10
0
E
IDIFSKYWAL, W/m2
IDIRWAL, W/m2
60
50
40
30
20
10
0
N
IDIFSKYWAL, W/m2
IDIRWAL, W/m2
400
300
200
100
0

Thank you for your attention!

HVAC.PE.2

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

First pilot study visit - Idrija

March 12-13, 2019

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

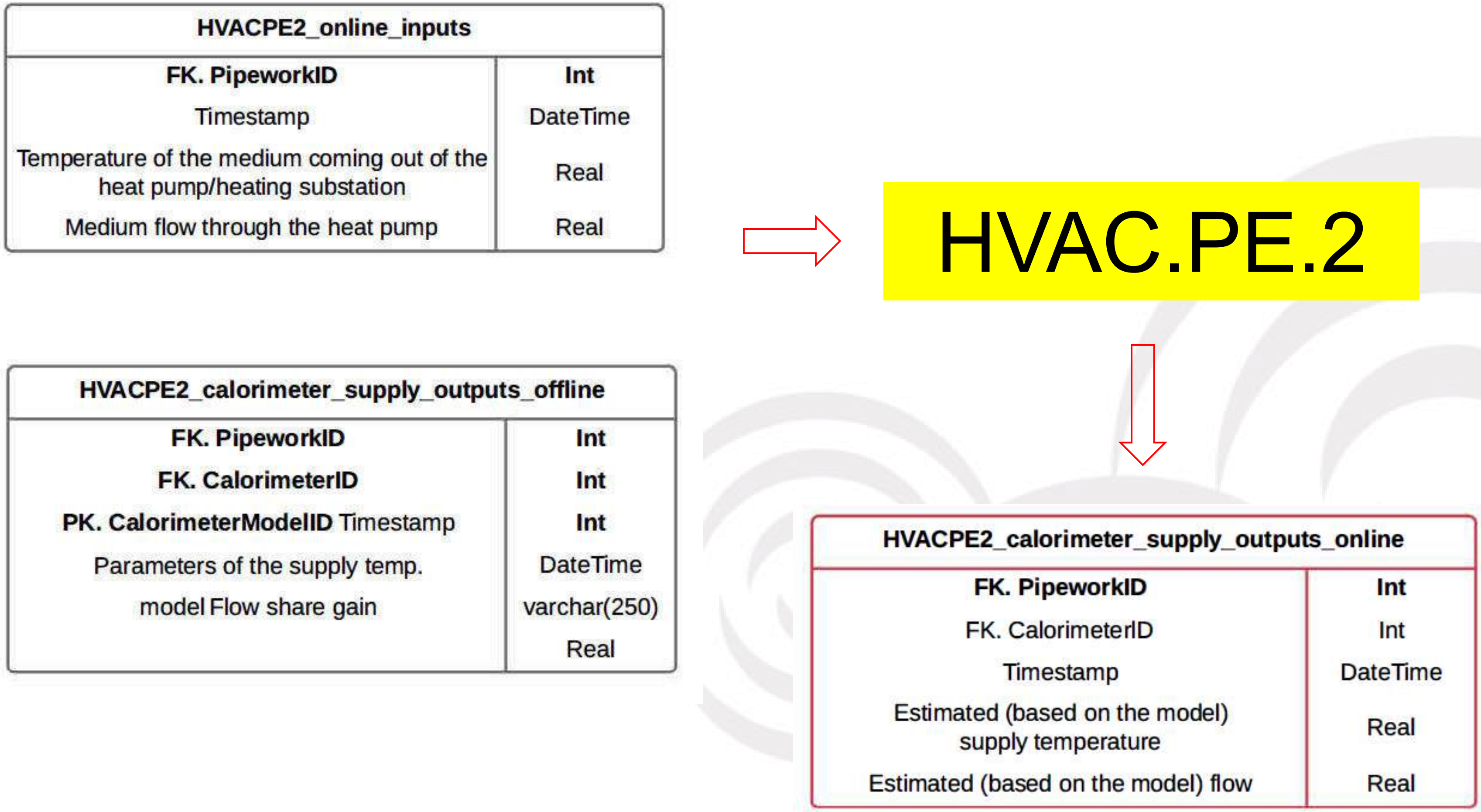
HVAC.PE.2

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

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

- Coefficients (a and b)

HVAC.PE.2



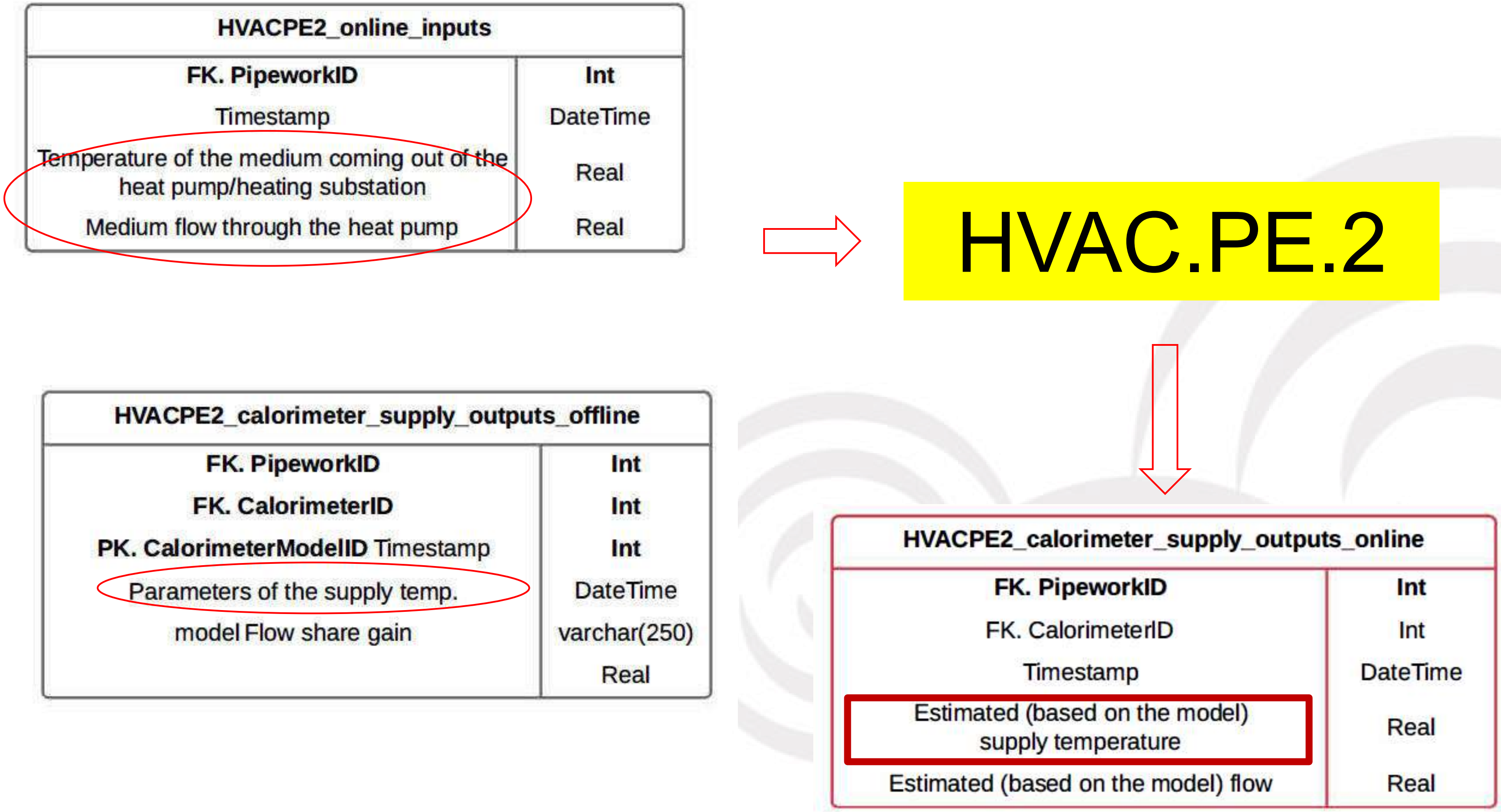
HVACPE2_online_inputs	
FK. PipeworkID	**Int**
Timestamp	DateTime
Temperature of the medium coming out of the heat pump/heating substation	Real
Medium flow through the heat pump	Real

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 Idrija buildings will be provided ASAP.
- Calculations of coefficients a and b in equation for temperature drop determination will be calculated after collection of real time data.
- Afterwards, Python coding will be possible.

HVAC.PE.2 – Results (Outputs table)

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

3Smart First pilot study visit to the Slovenian pilot: M.MPC.1

Danko Marušić

UNIZGFER

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3Smart pilot study visit to SLO pilot No. 1 in Idrija

12-13 March 2019

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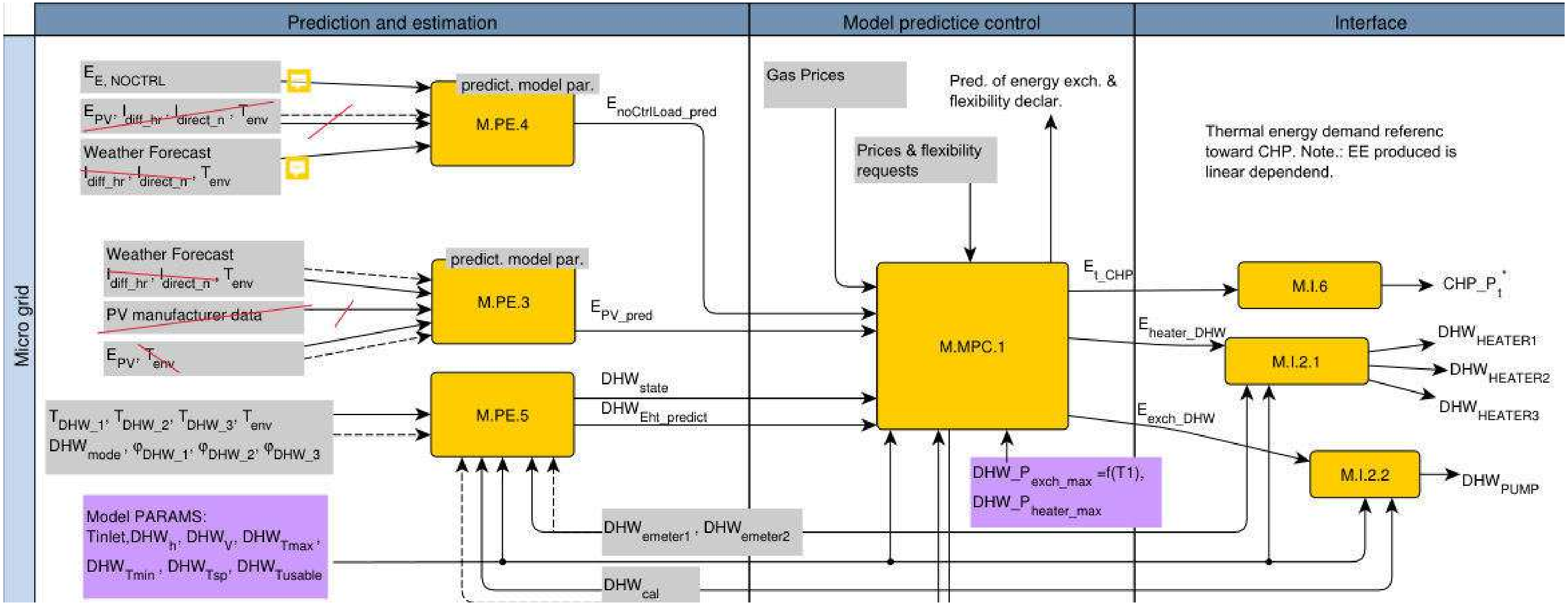
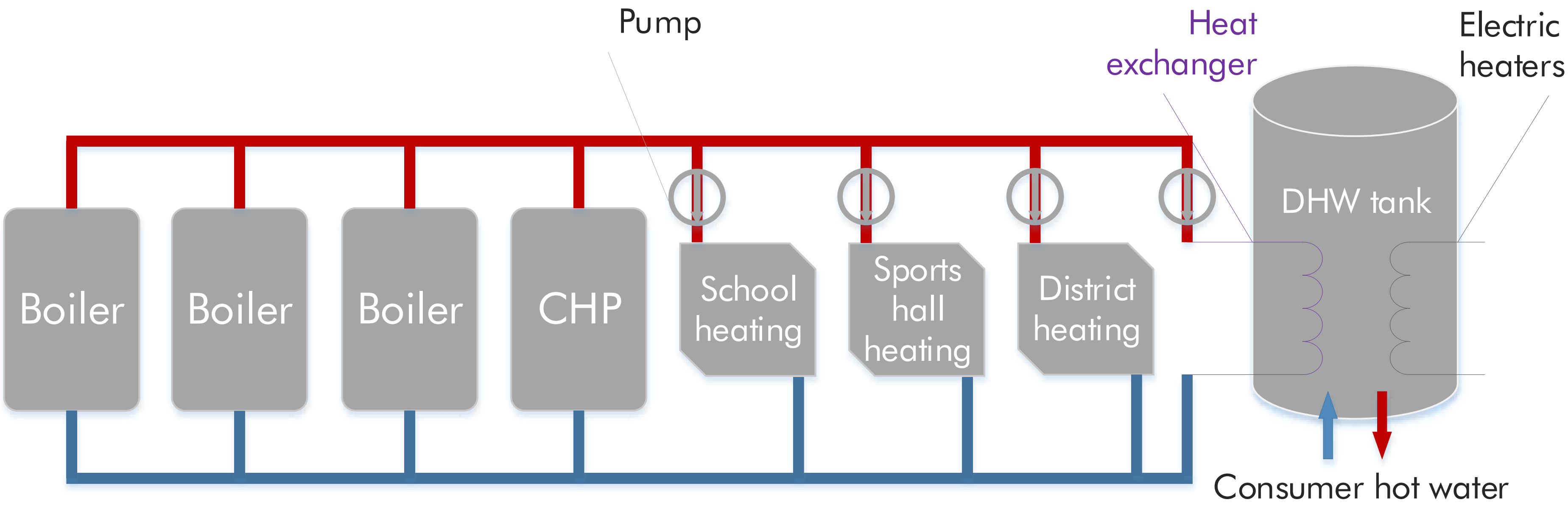
UNIVERSITY OF ZAGREB
FACULTY OF ELECTRICAL ENGINEERING AND COMPUTING

M MPC 1

- Pilot-specific: electrical and gas energy on microgrid level



M MPC 1 – thermal system



M MPC 1 – thermal system

- Thermal energy conservation law:

$$\underbrace{E_{HVAC} + E_{DHW} + E_{district}}_{\text{consumption}} = \underbrace{E_{boiler} + E_{CHP,th} + E_{heater\_DHW}}_{\text{production}}$$

- Gas energy cost for optimization:

$$J_{gas} = c_{gas}\,(E_{district} + E_{HVAC} + E_{exch,DHW} + \alpha\, E_{CHP,th})$$

parameter from LHL

optimization variables

s.t. $E_{CHP,th} \leq E_{HVAC} + E_{DHW} + E_{district}$

- We optimize CHP power, boilers will cover the rest

M MPC 1 – electrical system

- Electrical energy conservation law:

$$E_G = \underbrace{E_{heater\_DHW} + E_{nc}}_{\text{consumption}} - \underbrace{(E_{PV} + \alpha \cdot E_{CHP,th})}_{\text{production}}$$

- Total electrical energy cost:

$$J_{el} = c_{grid} \, (E_{heater\_DHW} + E_{nc} - E_{PV} - \alpha \cdot E_{CHP,th})$$

all grid-side costs

optimization variable

M MPC 1 – grid-side costs

- 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
- Minimization of total building electricity cost:

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

M MPC 1 – thermal system constraints

- CHP min and max power
  - 60-100% of maximum power?
- CHP availability schedule
  - fixed? Stored into the database?
- CHP switch on/off constraints
- Temperature constraints for DHW tank
  - Legionella protection? Contained in DHW energy requests?
- Heat exchanger energy constraints
  - $E_{exch,max} \leq kQ(T_{supp} - T_{DHW})$?

M MPC 1 – thermal system mathematical model and predictions

- DHW tank model?
  - $T_{DHW}(k+1) = T_{DHW}(k) + \frac{1}{mc}(E_{exch} + E_{heater} - E_{cons})$
- Prediction of neighborhood (block) heat demand?
  - It is preferable to use CHP over gas boilers
  - In spring or autumn, thermal request from school and sports center may be too low for CHP?
- Gas-thermal efficiencies of boiler and CHP?

M MPC 1 – inputs and outputs

Inputs

- Non-controllable load prediction
- PV production prediction
- DHW thermal energy request pred.
- DHW state (temperature or energy?)
- DHW model
- DHW and heat exchanger constraints
- CHP operating schedule
- CHP parameters and constraints
- Prices and requests from grid
- Gas prices
- District heating thermal energy request prediction?

Outputs

- Commands for CHP
- Commands for heat exchanger
- Energy profiles for the grid
- Coordination variables for LHL

Store everything into the database!

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 Austria – Pilot study visit No. 1

Project Acronym	3Smart
Grant Agreement No.	DTP1-502-3.2-3Smart
Funding Scheme	Interreg Danube Transnational Programme
Project Start Date	1 January 2017
Project Duration	30 months
Work Package	6
Task	6.3
Date of delivery	**Contractual:** 31 December 2019 **Actual:** 23 Decmber 2019
Code name	**Version:** 2.0 Final ☒ Final draft ☐ Draft ☐
Type of deliverable	Report
Security	Public
Deliverable participants	UNIZGFER, EEE, STREM, EnergyG, UNIDEBTTK, EON, UNIBGFME, SVEMOFSR
Authors (Partners)	Mario Vašak, Tomislav Capuder, Vinko Lešić, Anita Martinčević, Hrvoje Novak, Danko Marušić, Nikola Hure, Paula Perović (UNIZGFER), Andre Moser (EEE), Bernhard Deutsch (STREM), Markus Resch, Martin Zloklikovits (EnergyG), Arpad Racz (UNIDEBTTK), Gabor Peter (EON), Vladimir Jovanović (UNIBGFME), Ivan Bevanda, Petar Marić (SVEMOFSR)
Contact person	Andrea Moser (EEE)
Abstract (for dissemination)	This document contains the minutes of the study visits to the Austrian pilot in 3Smart. The pilot consists of two pilot buildings – primary school and retirement and care centre in Strem – and of the pilot electricity distribution grid around the buildings. On the pilot study visits the pilot leaders and hosts together with developers for different modules on the pilot site have discussed the necessary steps for the modules installations on the pilot and the 3Smart modules functioning on the pilot sites.
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	10 April 2019	Entered the minutes from the first study visit to the Austrian pilot in the deliverable form	Mario Vašak (UNIZGFER)
v2.0	23 December 2019	Pilot study visit material prepared 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 Austria that consists of the primary school and retirement and care centre in Strem and of the electricity distribution grid around the buildings. The visits were split in two parts for each pilot site – this first part of the deliverable for the Austrian pilot site concerns the first pilot study visit.

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

Time: March 27-28, 2019

Location of the Meeting: Technology Center Güssing, Europastraße 1, 7540 Güssing

Location of the site Visits: Primary school Strem, Hauptstraße 1, 7522 Strem
Retirement & care center, Kapellenstraße 24, 7522 Strem

March 27, 2019 (Wednesday)

Time	Place	Event
09:00-11:00	Large seminar room, ground floor	Presentation of the performed installations and realized IT infrastructure on pilot buildings
11:00 – 11:15	*In front of the room*	*Coffee break*
11:15 - 12:00	Large seminar room, ground floor	Presentation of the performed installations and realized IT infrastructure on pilot grid
12:00	Güssing, in front of the Technology center	Departure to Strem
12:15 – 13:00	*Restaurant in Strem*	*Lunch*
13:00 – 16:00	Strem	Visit of the pilot buildings in Strem
16:00	Strem	Departure to the Technology center Güssing
16:15 – 16:30	*In front of the room*	*Coffee break*
16:30 - 17:30	Large seminar room, ground floor	On-line demonstration of basic IT infrastructure performance with the installed equipment (buildings + grid)
18:30 – 20:30	*Castle of Güssing*	*Working dinner*

March 28, 2019 (Thursday)

Time	Place	Event
09:00-10:30	Large seminar room, ground floor	3Smart modules organization on the sides of the building and the grid
10:30-10:45	*In front of the room*	*Coffee break*
10:45-12:00	Large seminar room, ground floor	On-line demonstrations: Zone-level modules, Central-HVAC-level and Microgrid-level modules
12:00 – 13:30	*Restaurant in front of the room*	*Lunch*
13:30 – 14:30	Large seminar room, ground floor	Implementation of short-term modules grid, Long-term modules grid

Day 1:

Technical session 1:

Andrea Moser has presented the performed installations and IT infrastructure on the pilot buildings – primary school building and retirement and care centre building. The presentation is given here as Annex 1.

Markus Resch and Martin Zloklikovits have presented the performed installations and IT infrastructure on the grid side. The presentation is given as Annex 2.

Technical session 2: Tour to pilot buildings in Strem

In the school necessary work regarding the return medium temperature sensors on radiators was assessed: repositioning as far as possible on the radiator end pipe from the junction with the main pipe in the floor, using thermal paste for lowering thermal resistance in contact senor-pipe, using isolation to reduce the influence of air, measurement with portable instrument (calibrated on the calorimeter starting pipe) of the starting medium temperature on the pipe, in the first radiator in row in each room and on the outgoing pipe from the last radiator in the row, in each of the rooms, performing it for two distinct supply temperatures to get data for assessment of heat losses and for calibration of the return medium sensor. During both measurements, the valve should be open, for measurement of the temperature drop on the entering pipe into the radiators sequence in a certain room, radiators in all other rooms on the same heating circuit should be with closed valves. Martin will perform these operations within two weeks time.

In the retirement and care centre the calibration procedure of the return medium temperature sensors should be done by following the similar procedure.

Technical session 3:

Martin Gombotz has shown the operation of local controllers in the buildings and the data they log, as well as the control interface for the operators in buildings.

Martin has also shown the web API for reaching the data from energy valves and from the battery system.

3Smart database is still not installed, and different technical questions were discussed between the potential database developers and the developers of modules. All issues were cleared out.

Day 2:

Technical session 5: 3Smart modules organization on the sides building and the grid

Mario has presented the information flow diagram for the two pilot buildings and discussions were performed through the information flow diagrams.

First the school building was discussed. The information flow diagram is provided as Annex 3. Individual modules were discussed and especially the needed data for each of the modules. On-line weather measurements will be received from UBIMET with 15 minutes delay (e.g. at 12:00 will arrive the minute-level measurements from period 11:30-11:45). The modules will rely on these measurements – for tuning on historical data there will be no problems, for real-time operation we hope that the influence of lag will not be pronounced due to usually slowly varying weather conditions.

For zone-level MPC we agreed that allowed temperature deviation Delta should be 0.7°C and weighing parameter between comfort and cost should be set to equilibrium (at value 1).

It was explained why also microgrid MPC module is inserted in the flow diagram and will be used although it has no direct actuation elements leaned to it like in other pilot buildings – it will be used to compute the prices for the controllable electricity consumption of the HVAC system (the fan coil), to bid the flexibility with the grid and operate on-line in interaction with the grid. Otherwise this interaction and grid consideration would have to be moved to central HVAC MPC and would require significant additional development work on the module, while microgrid MPC module has it already developed and is ready.

All needed data were analyzed module-by-module and it was concluded that all of them are taken into account by now and will be available. Same is for the actuation points.

Then the retirement and care building was discussed. Its corresponding information flow diagram is provided as Annex 4.

Interactions between modules were explained. For Z.MPC.1 module it was agreed to have allowed temperature deviation Delta set on 0.5°C and weighing parameter between comfort and cost should be set to equilibrium (at value 1).

All needed data were analyzed module-by-module and it was concluded that all of them are taken into account by now and will be available. Same is for the actuation points.

Necessary steps for return medium sensors calibration were agreed. Meanwhile Petar will conduct the measurements for Z.PE.3 based on the agreed procedure. If the correction induced with the calibration curve will be significant, then the procedure of identification should be re-run on the collected data. Sensors calibration is to be performed by Martin via analogous procedure as in the school.

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

The presentation of operations of Z.PE.2 module (radiators identification module) was done by Ivo; also Z.PE.4 work (building zones simplified models identification) that was already performed was presented. The presentation is given as Annex 5.

The presentation of Z.PE.3 module is provided by Petar. The presentation is given as Annex 6.

The presentation of UNIZGFER modules operation was performed by Anita (Z.PE.1, Z.PE.5, Z.MPC.1, Z.I.1), Nikola (HVAC.MPC.1 and HVAC.MPC.2), Danko (M.MPC.1) and Hrvoje (Z.PE.6, Z.PE.7, HVAC.PE.4, M.PE.3, M.PE.4) – the presentation is given in Annex 7.

Also in more detail it was discussed what results are obtained with long-term MPC calculations for bidding the flexibility towards the distribution grid. There was a considerable amount of discussion regarding that, and the presentation can be found in Annex 8.

Arpad has presented the steps needed for installation of the battery modules (M.PE.1, M.PE.2 and M.I.1). The presentation is given as Annex 9.

Technical session 7: Implementation of short-term modules grid, Long-term modules grid

The operation of grid-side modules and the steps done so far were presented by Paula and Markus (EnergyG). The presentation can be found as Annex 10.

List of annexes:

Annex 1: Presentation of the performed installations and IT interventions on the buildings side of the AT pilot

Annex 2: Presentation of the performed installations and IT interventions on the grid side of the AT pilot

Annex 3: 3Smart information flow diagram for the school

Annex 4: 3Smart information flow diagram for the retirement and care centre

Annex 5: Presentation of operation of Z.PE.2 and Z.PE.4 modules

Annex 6: Presentation of operation of Z.PE.3 module

Annex 7: Presentation of operation of UNIZGFER modules

Annex 8: MPC calculations on a building and strategy for smart city upscale

Annex 9: Presentation of M.PE.1, M.PE.2 and M.I.1 modules operation

Annex 10: Presentation of grid-side modules operation

3Smart First pilot study visit to the Austrian Pilot

Performed installations and realized IT infrastructure on pilot buildings

Andrea Moser, European Center for Renewable Energy Güssing Ltd.

a.moser@eee-info.net

3Smart pilot study visit to AT pilot No. 1
27. – 28. March 2019

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EUROPEAN UNION
Danube Transnational Programme
3Smart

EUROPÄISCHES ZENTRUM
FÜR ERNEUERBARE ENERGIE
GÜSSING

Energie GÜSSING

Project co-funded by the European Union

3Smart pilot buildings Strem – basic data

Pilot 1

Primary School

- **Year of construction:** 1974
- **Building size:** 500m² (1 floor)
- **Energy consumption:**
  - -105.000 kWh/a heat
  - - 3.800 kWh/a electricity
- **Own RES production:** not existing
- **Electricity supply:** local DSO
- **Heat supply:** local biomass plants

Pilot 2

Retirement and care building

- **Year of construction:** 2004
- **Building size:** 3.000 m² (1 floor)
- **Energy demand:**
  - - 500.000 kWh/a heat
  - - 170.000 kWh/a electricity
- **Own RES production:** pv-plant
- **Electricity supply:** local DSO
- **Heat supply:** local biomass plants

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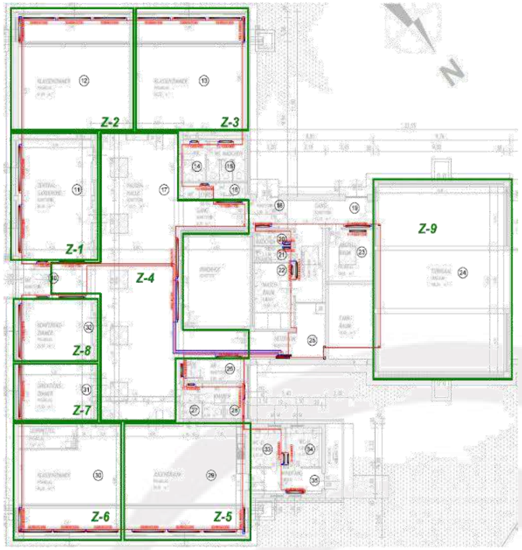
3Smart pilots in Strem - location

Pilot building 1 – Primary School

Pilot building 1 – Primary School

- **Situation before the 3Smart investment**
  - non-controllable system / no building management system implemented
  - 16 rooms equipped with 42 radiators with manual valves
  - 4 heating circuits (north, south, fan coil + sanitary area)
  - no room controllers / no electronic thermostatic valves
  - 1 manual controlled fan coil (activation with ON/OFF switch)
  - smart meters for electricity – no data access or recording

Pilot building 1 – Primary School



- **Interventions on the primary school:**

  ZONE LEVEL installations:

  – 9 controllable zones have been established + 1 non-controllable zone (sanitary area)

  - zone 1 – 8: rooms
  - zone 9: fan coil (gym hall)
    - room gets conditioned based on a schedule (timer)
    - room temperature can be varied with a switch for a predefined time-period

  – zone 10: sanitary area
    - no control – only energy monitoring via energy valves

Pilot building 1 – Primary School

- **Interventions on the primary school:**

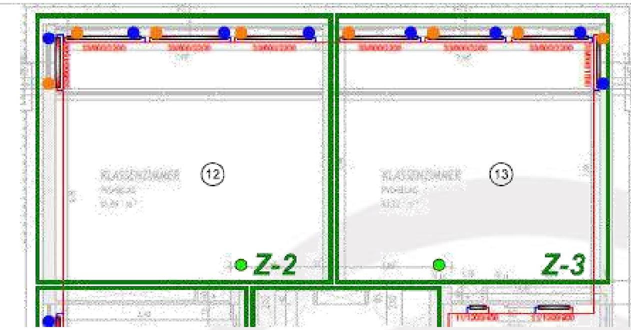
  ZONE LEVEL installations:

  – all 9 zones (Z1 – Z9) were equipped with room temperature sensors

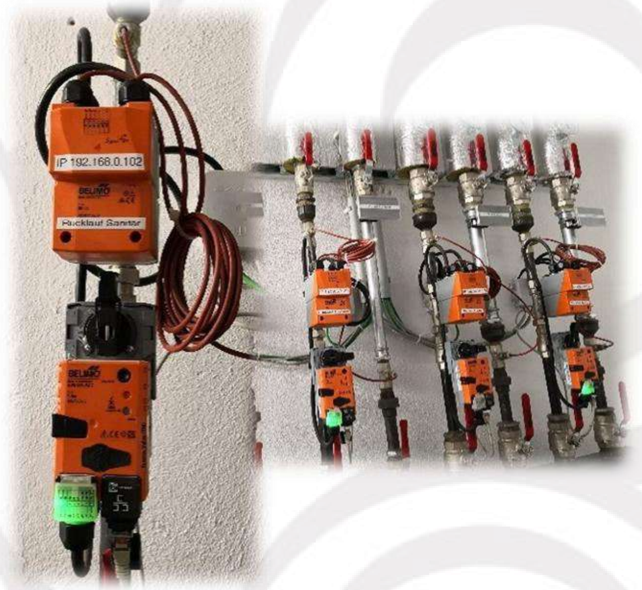
  - all radiators were equipped with thermoelectric actuators & return medium sensors

  – energy valves were installed (heating circuits north, south, fan coil + sanitary area)

    - securing a hydraulic balanced system
    - data collection of supply & return medium temperature, mass flow, power and energy demand



● Raumthermostat - room temperature sensors
● Thermoelektischer Antrieb - thermoelectric drives / valves
● Rücklauffühler - return medium sensor



Pilot building 1 – Primary School

- **Interventions on the primary school:**

ZONE LEVEL installations:

- 26 valves with actuators, 17 valves with thermostatic heads
  - HERZ 7711
  - manufacturer: HERZ
- 12 room temperature sensors
  - RTF RS485
  - manufacturer: EAP electric Ltd.
- 32 return medium sensors
  - ALTF 1-Wire DS18B20
  - manufacturer: EAP electric Ltd.

RTF RS485 P
Standard

Pilot building 1 – Primary School

- **Interventions on the primary school:**

HVAC LEVEL installations

- central elements of the HVAC are:
  - the district heating transfer station
  - district heating meter
- to enable a controllability of the HVAC level, a new controller for the heating substation was installed

MicroGrid LEVEL

- is not existent at the school building
- electricity consumption is measured – but considered as non-controllable load

Pilot building 1 – Primary School

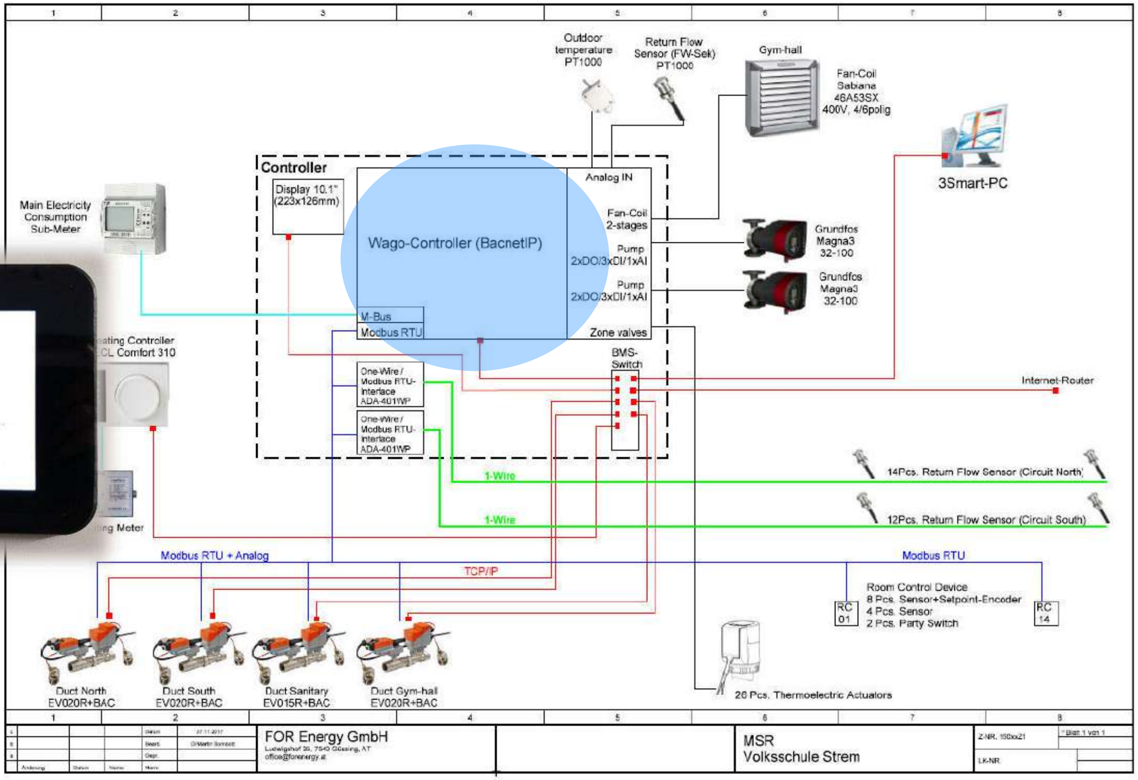
- **Interventions on the primary school:**

  MicroGrid LEVEL installations

  - changings in the electricity metering
    - 2 existing Smart Meters were combined to 1 single meter from DSO side
    - plus one additional meter for capturing the electricity consumption for 3Smart
    - this meter is connected via M-Bus with the measurement & control unit

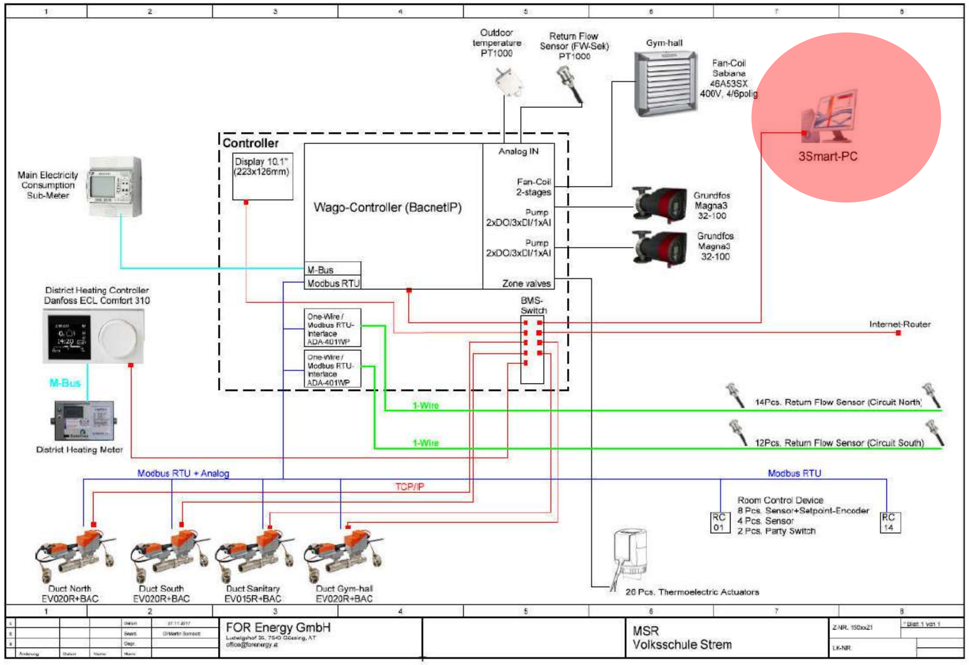
Pilot building 1 – Primary School

- **Interventions to enable controllability**
  - a central controller was installed
    - this central controller, manages the new implemented system and represents the basic unit for the operation of the 3Smart system



Pilot building 1 – Primary School

- **Interventions to enable 3Smart operation**
  - a master computer was installed – 3Smart computer
    - serves for data collection (database) and the operation of the 3Smart EMS system

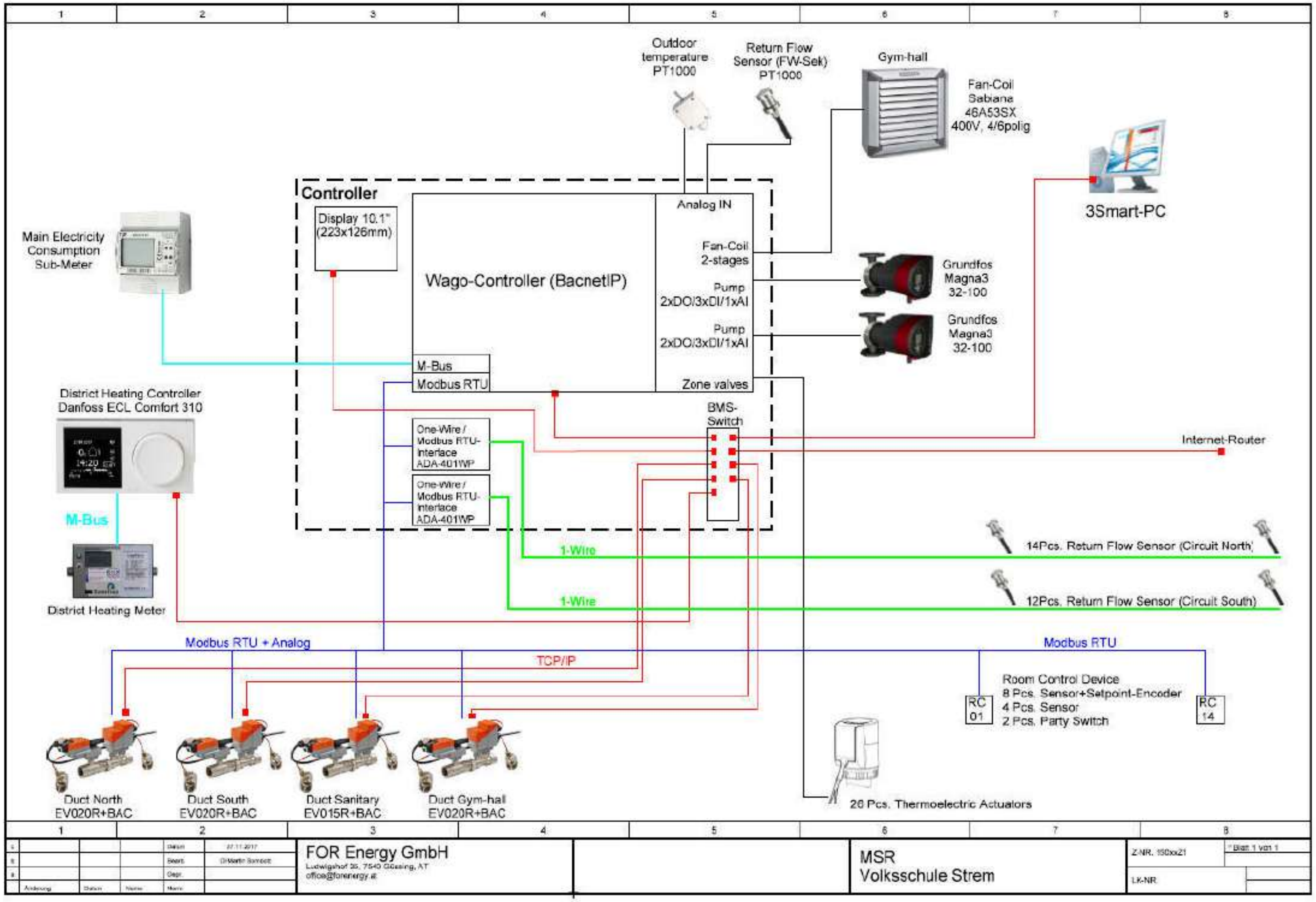


Pilot building 1 – Primary School

- **Interventions on the primary school:**
  - heating room was totally reconstructed and consists of:
    - district heating substation (including heating controller and heat meter)
    - heat distributor including energy valves and main heating pumps
    - control unit (WAGO controller)
    - 3Smart computer (for database and 3Smart EMS)

Pilot building 1 – Primary School

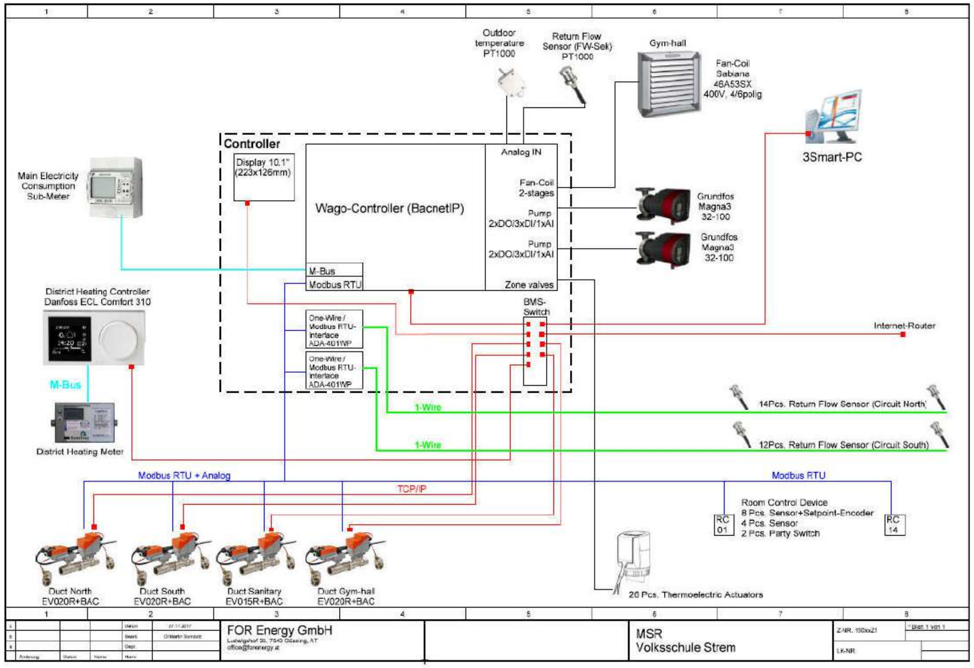
- **Data communication**



Pilot building 1 – Primary School

Data communication to the WAGO contoller

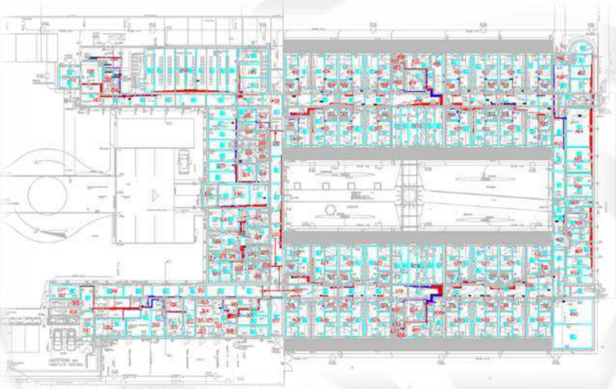
- smart meter → M-Bus
- district heat meter → M-Bus → district heating substation
- heating substation → Modbus TCP
- energy valves (for the 4 heating circuits) → Modbus-RTU
- energy valves also have an integrated web-server
- room controller → Modbus-RTU
- return medium sensors are connected over a bus line → One-Wire/Modbus RTU Interface
- the zone control valves (sum of thermoelectric actuators of one control zone) are activated analog

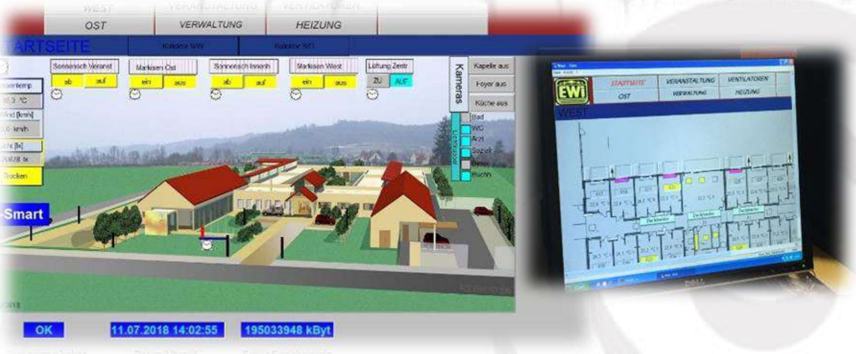


Pilot building 2 – Retirement and Care Center

Pilot building 2 – Retirement and Care Center

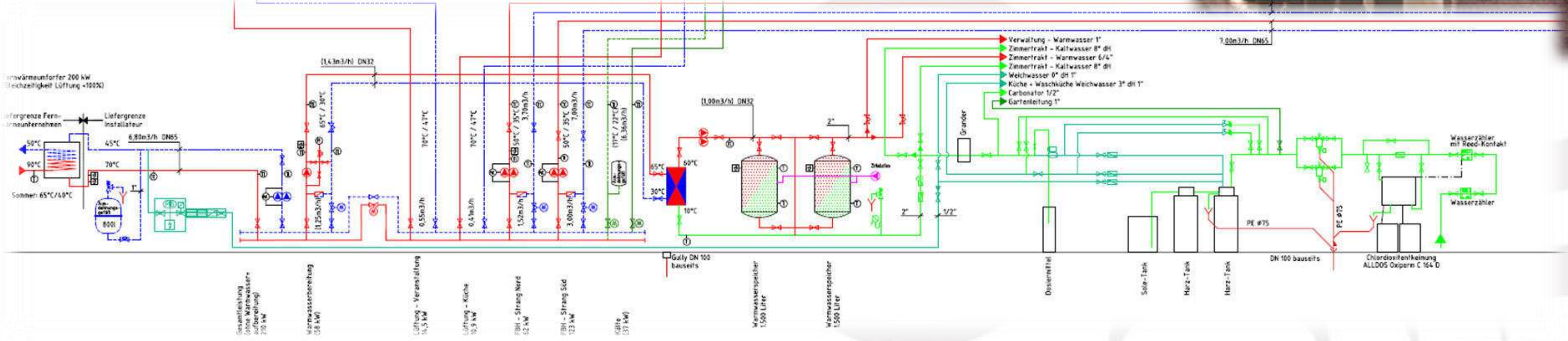
- **Situation before the 3Smart investment**
  - more complex system
  - 6 controllable heating/cooling areas
    - area 100: administration area
    - area 200: event area
    - area 300 (heating only): maintenance area
    - area 400: rooms east (including bath rooms east: area 500 – heating only)
    - area 600: rooms west (including bath rooms west: area 700 – heating only)
  - two control systems were already installed (Honeywell Excel 5000 – without visualization, EIB/KNX- bus system – including visualization)





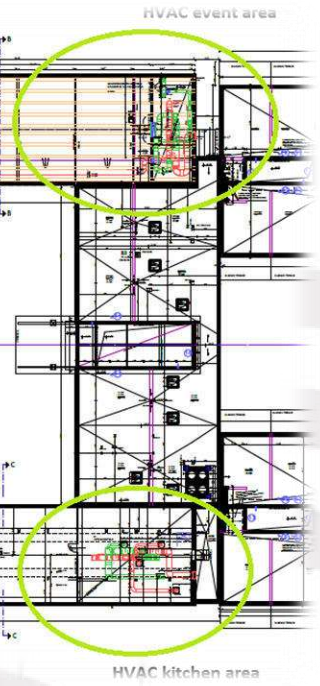
Pilot building 2 – Retirement and Care Center

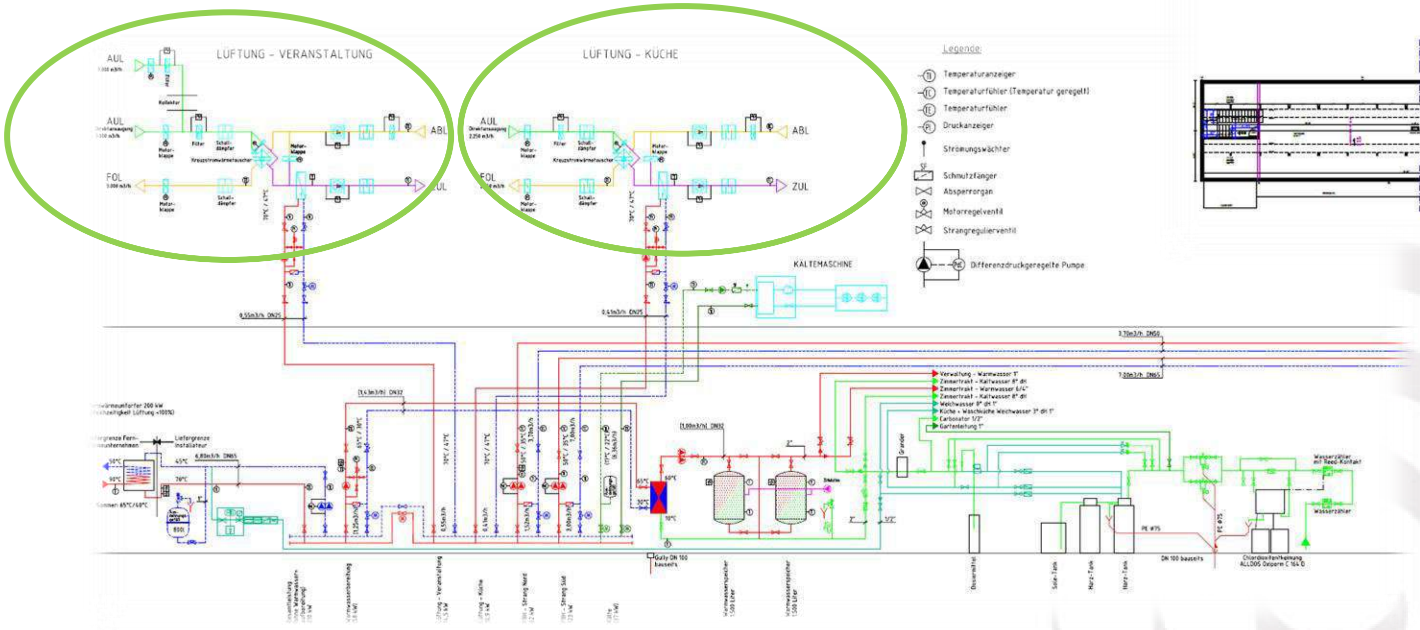
- **Situation before the 3Smart investment**
  - 4 heating circuits (floor heating & cooling):
    1. HVAC event area
    2. HVAC kitchen area
    3. heating duct north (control areas 100 + 200 + 300)
    4. heating duct south (control areas 400 + 500 + 600 + 700)



Pilot building 2 – Retirement and Care Center

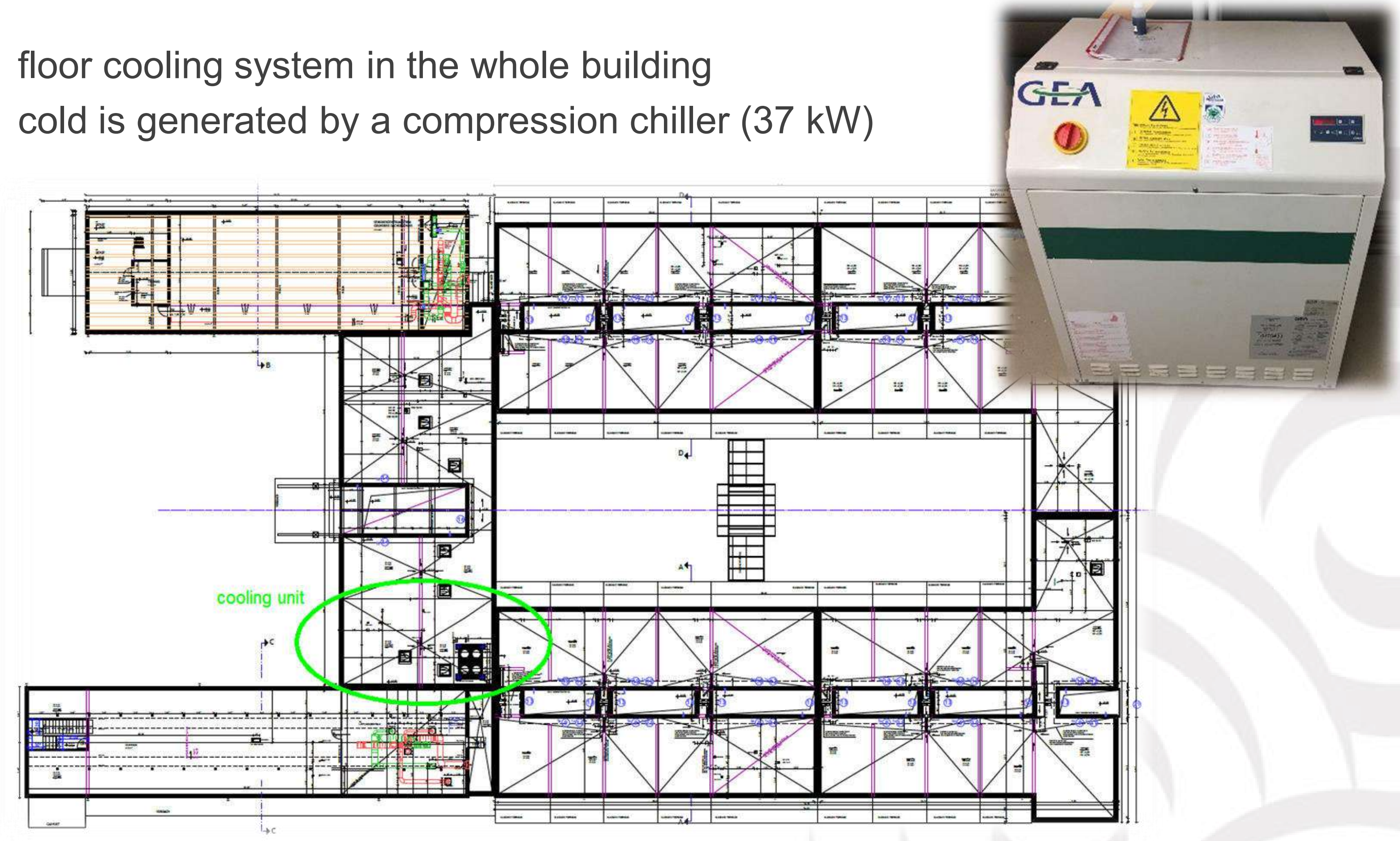
- **Situation before the 3Smart investment**
  - no central ventilation system installed
  - 2 separate ventilation systems for heating and cooling of kitchen & event area
  - ventilation system includes heat & cold recovery





Pilot building 2 – Retirement and Care Center

- **Situation before the 3Smart investment**
  - floor cooling system in the whole building
  - cold is generated by a compression chiller (37 kW)



Pilot building 2 – Retirement and Care Center

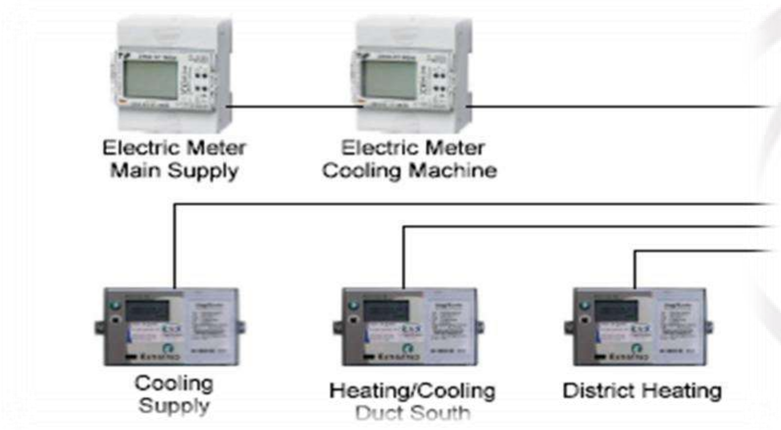
- **Interventions on the retirement and care center:**
  - Challenge: to build upon the existing complex system
    - floor heating & cooling system with 53 floor heating circuit distributors → 32 distributors for the rooms and 21 distributors for the general areas
  - Decision: focusing on the most suitable part of the building
    - focusing on the floor heating / cooling duct “south”
    - heating/cooling duct “south supplies the control area of the rooms (area 400 + 600) (including bath rooms / area 500 + 700))

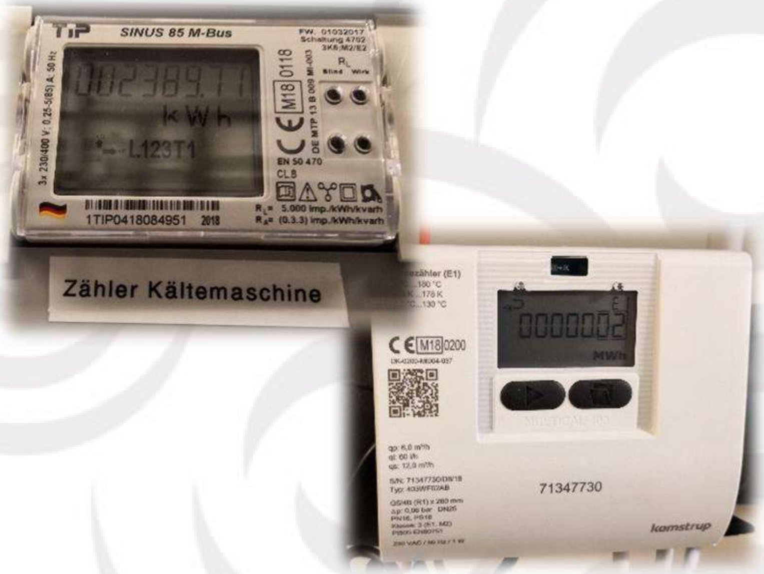
Pilot building 2 – Retirement and Care Center

- **Interventions on the retirement and care center:**
  - analysis of the existing system
  - ensuring the functionality of the installed equipment (thermoelectric actuators, sensors, communication elements, etc.)
  - replacement of defect sensors and KNX actuators
  - reconfiguration of those elements
  - installation of return medium sensors (37 sensors)


Pilot building 2 – Retirement and Care Center

- **Interventions on the retirement and care center:**
  - implementation of additional metering infrastructure:
    - electric meter main supply (with converter 400:5A)
    - electric meter cooling machine (direct measurement)
    - meter for the cooling supply (calorimeter)
    - heating / cooling meter for duct south / rooms
    - district heating meter

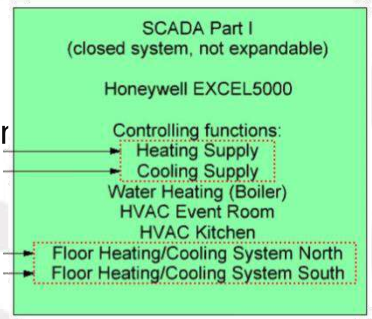


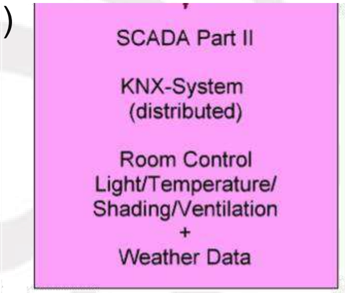


Pilot building 2 – Retirement and Care Center

- **Interventions on the retirement and care center:**
  - re-activation of the existing system to enable:
    - building management - zone control - room control - load management - control of electric equipment (shading elements, windows, light, etc.)

  - for zone control 2 different SCADA are installed - different & limited control functions
    - <u>SCADA part 1:</u>
      - Honeywell EXCEL 500, closed system, not expandable, no visualizatio
      - controlling functions like: heating/cooling supply, water heating (boiler), HVAC kitchen and event area, floor heating/cooling areas north/south
    - <u>SCADA part 2:</u>
      - KNX-system, distributed system with visualization
      - allows single-room control (light, temperature, shading, ventilation)
      - included weather data



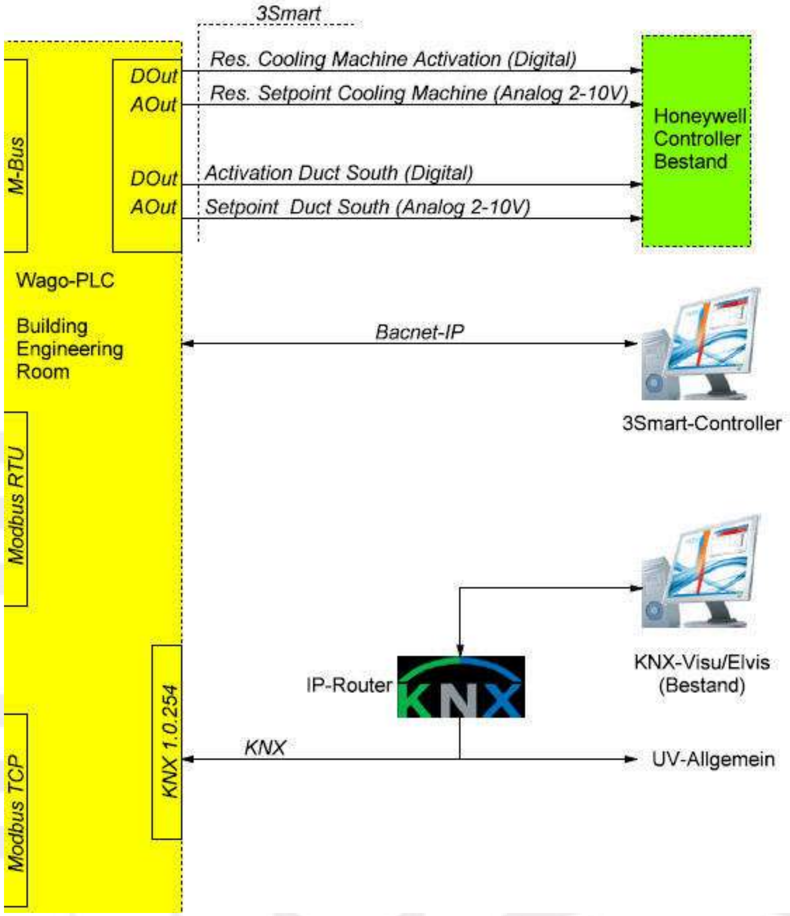


Pilot building 2 – Retirement and Care Center

- **Interventions on the retirement and care center:**

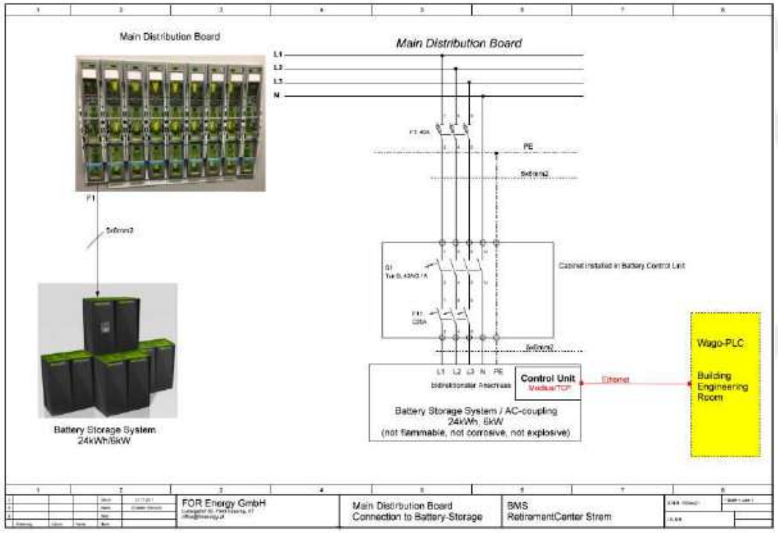
– integration of a new controller/CPU

- to combine all necessary functions for the 3Smart EMS of both existing systems
- connection to Honeywell system via digital and analog outputs
- connection to the single-room control part of the KNX system – KNX bus
- installation of a new computer for the visualization of the existing control system
- installation of a 3Smart computer



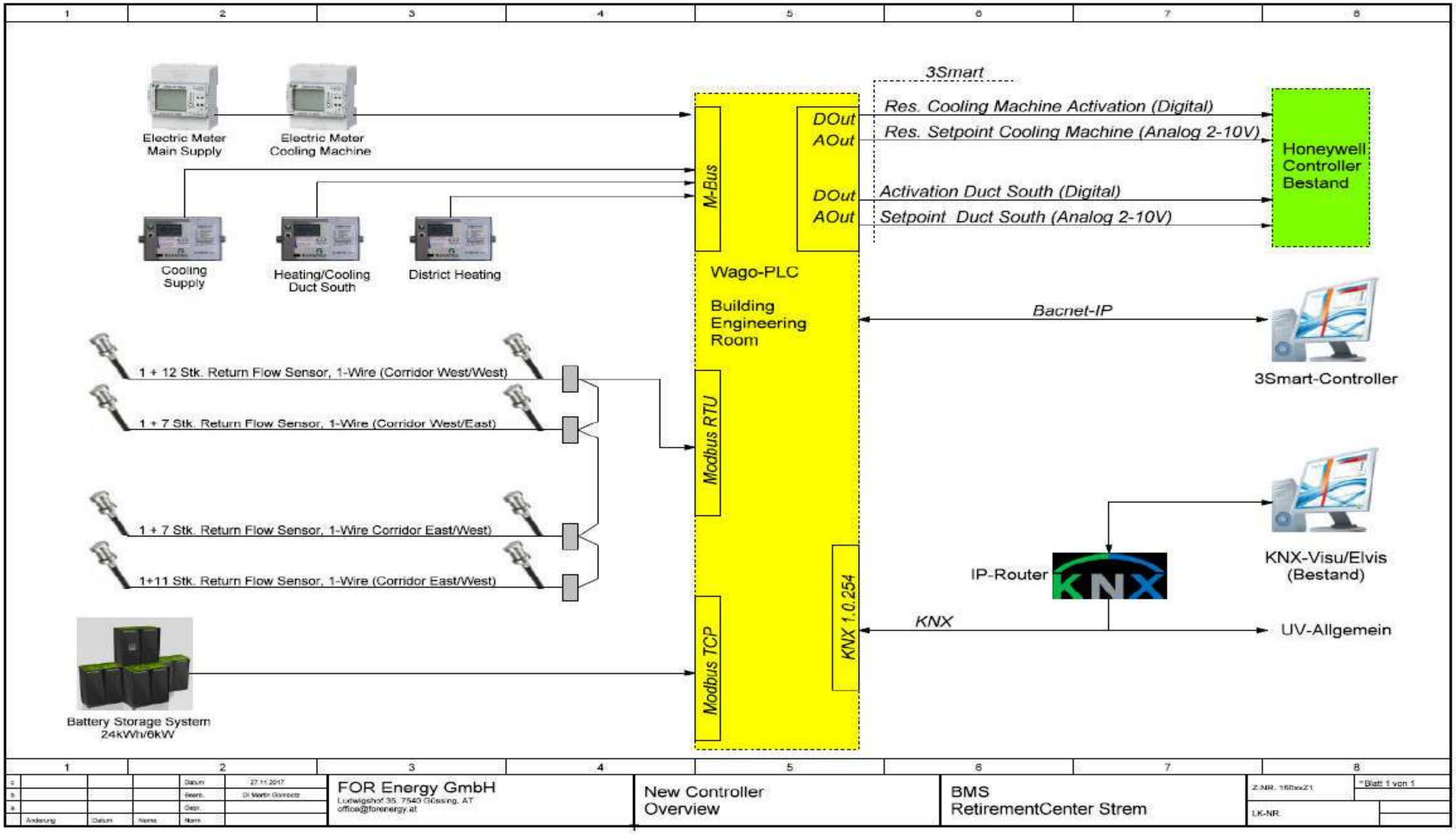
Pilot building 2 – Retirement and Care Center

- **Interventions on the retirement and care center:**
  - Installation of a battery storage system
    - saltwater battery storage system was intergrated due to legal issues
      - no toxic or poisonous materials
      - secure in transport and operation
      - maintenance free and economic friendly
    - 24 kWh, 12 battery stacks, 3 battery inverters
    - communication via LAN / Modbus TCP



Pilot building 2 – Retirement and Care Center

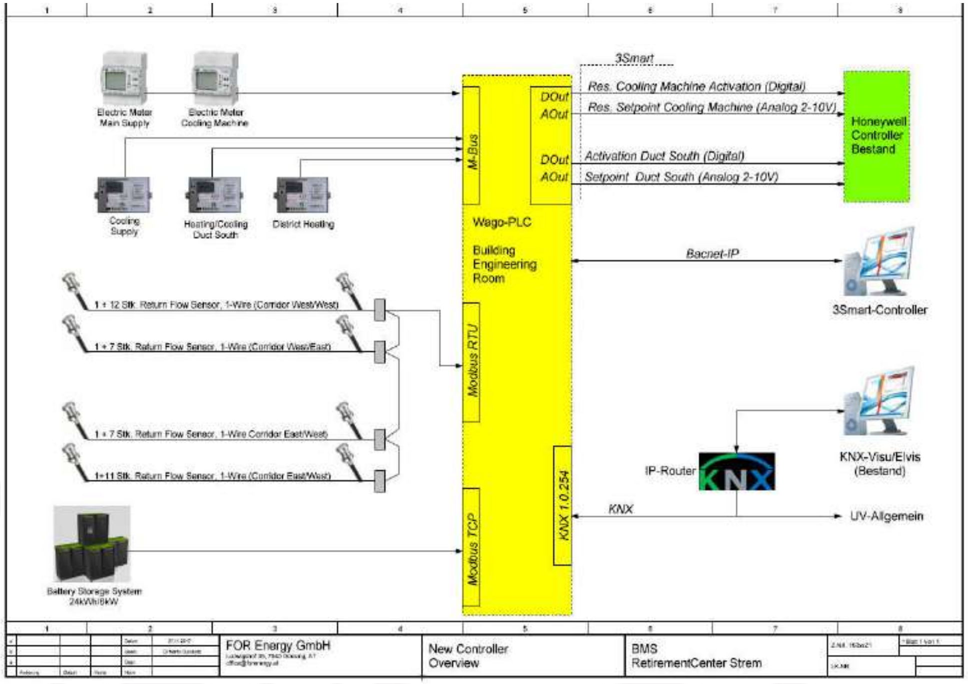
- **Data communication**



Pilot building 2 – Retirement and Care Center

Data communication with the WAGO controller

- Electric Meter (supply side) → M-Bus
- Electric meter for cooling machine → M-Bus
- Heating / cooling meter for duct south → M-Bus
- Cooling meter for cooling supply → M-Bus
- District heating meter → M-Bus
- 1-wire return medium sensors → Modbus RTU
- Battery storage → Modbus TCP
- Communication with the Honeywell system via digital and analog outputs
- Communication with the KNX System over the KNX bus
- Communication visualization computer → WAGO – KNX Gateway
- Communication 3Smart computer → WAGO → Bacnet IP (Modbus TCP)



Thank you for your attention!

Presentation of the performed installations and realized IT infrastructure in the pilot grid

Martin Zloklikovits / Markus Resch

Energie Güssing

martin.zloklikovits@htg.at / markus.resch@e-guessing.at

3Smart – First Pilot Study Strem

27-28.03.2019

Danube Transnational Programme

3Smart

Project co-funded by the European Union

Content

- 3 Smart Server – Güssing
- Long Term Module
- Short Term Day Ahead Module
- Grid Measurements

Danube Transnational Programme
3Smart

3 smart Server - Güssing

3 smart Server - Güssing

- Windows Server 2016
- 4 GB RAM

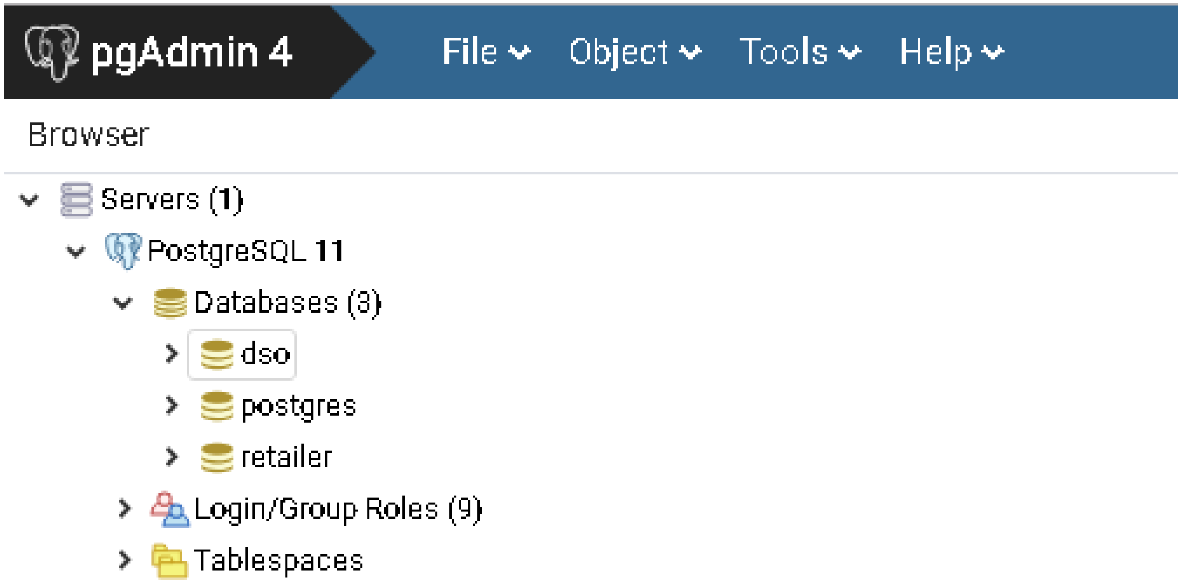
- Gurobi 8.0.1 (64 bit)
- Python 3.6.5 (64 bit)
- PostgreSQL
- pgAdmin 4
- Google Chrome

3 smart Server - Güssing

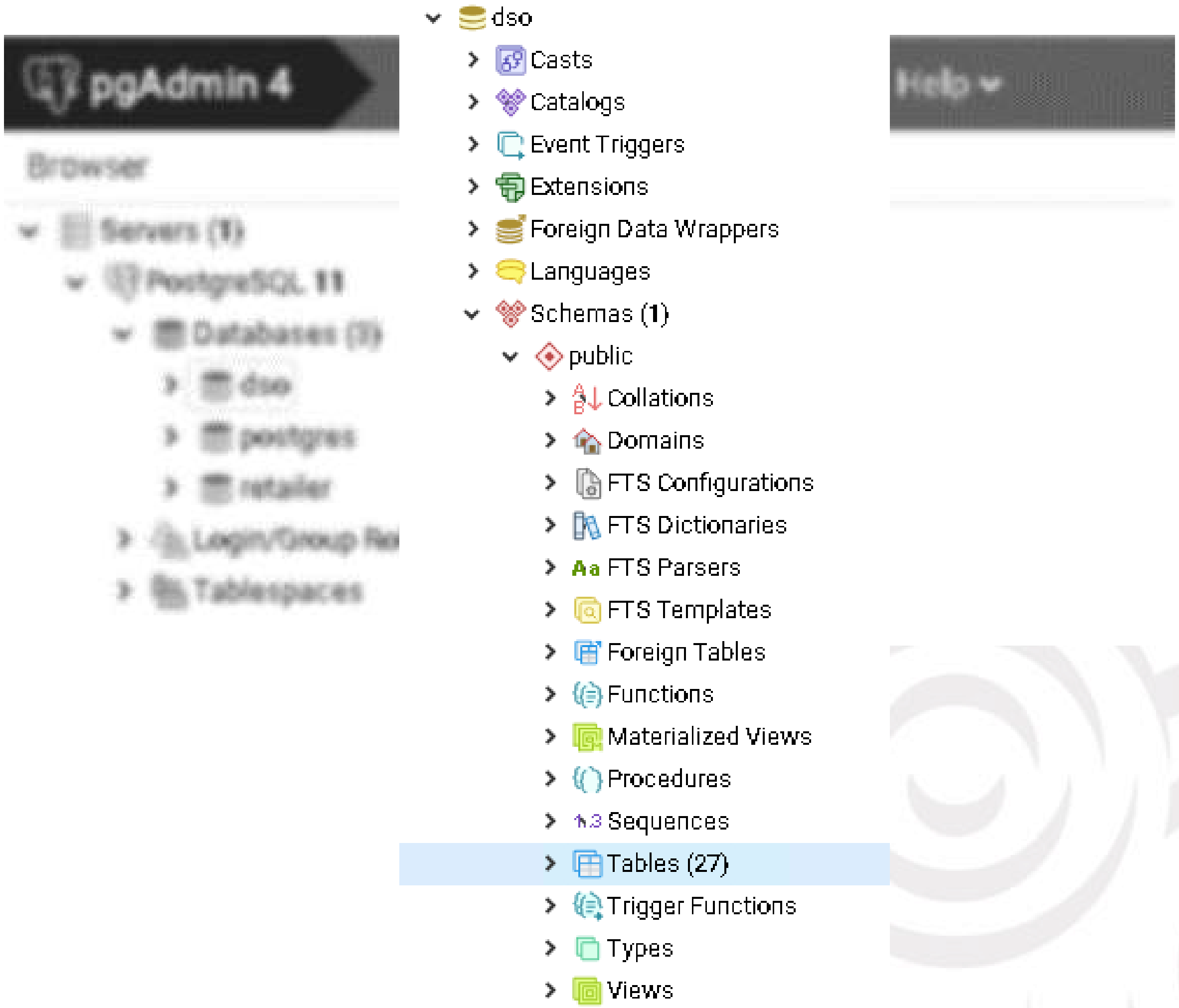
- accessible via remote desktop connection in the Energie Güssing network

- Access to the PostgreSQL database via pgAdmin 4
- Access to the Long Term Platform
- Implemented Short Term Module

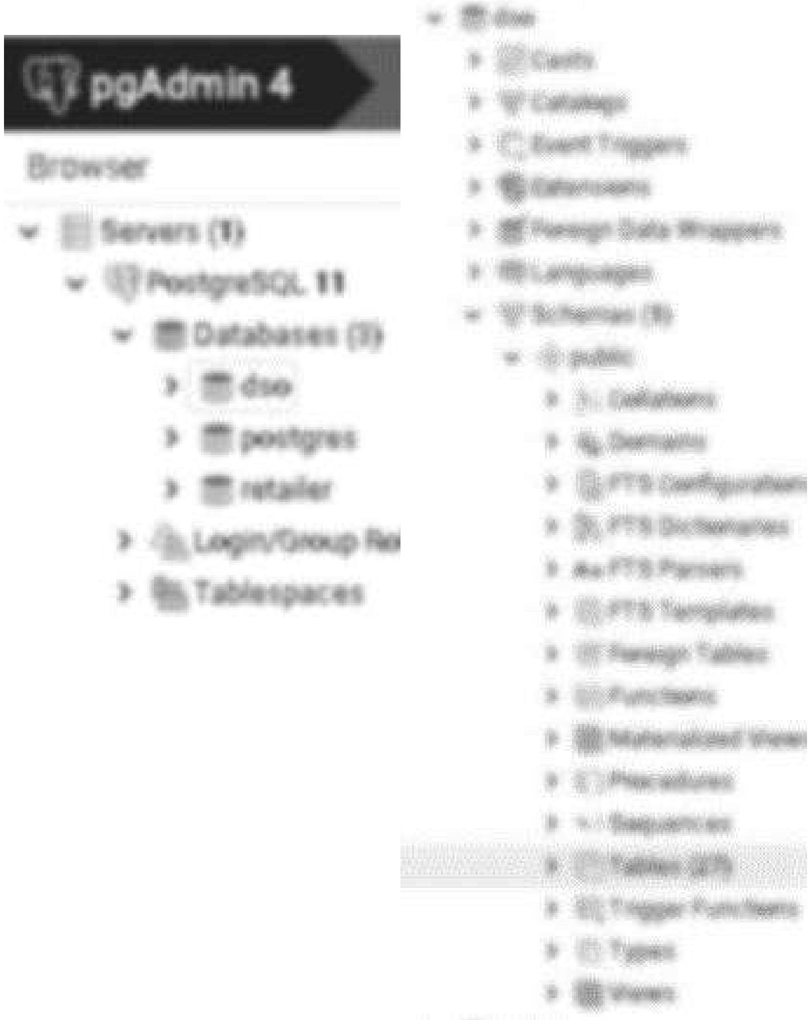
PostreSQL Database



PostreSQL Database



PostreSQL Database



Tables (27)

- ac_opf_module_grid_input
- ac_opf_module_load_input
- ac_opf_module_results
- building_flexibility_table
- building_to_dso_declared_da_profiles
- building_to_dso_declared_da_profiles_history
- building_to_dso_predicted_id_profiles
- building_to_dso_predicted_id_profiles_history
- building_to_dso_realized_profiles
- building_to_dso_realized_profiles_history
- calendar
- contract
- dso_flexibility_table
- dso_to_building_da_flexibility_activation_profiles
- dso_to_building_da_flexibility_activation_profiles_history
- dso_to_building_id_flexibility_activation_profiles
- dso_to_building_id_flexibility_activation_profiles_history
- dso_to_building_settlement_profiles
- dso_to_building_settlement_profiles_history
- flexibility_unit_prices_and_penalty
- id_triggering_module
- info_buildings
- info_dso
- info_grid
- settlement_module_input
- settlement_module_output
- user

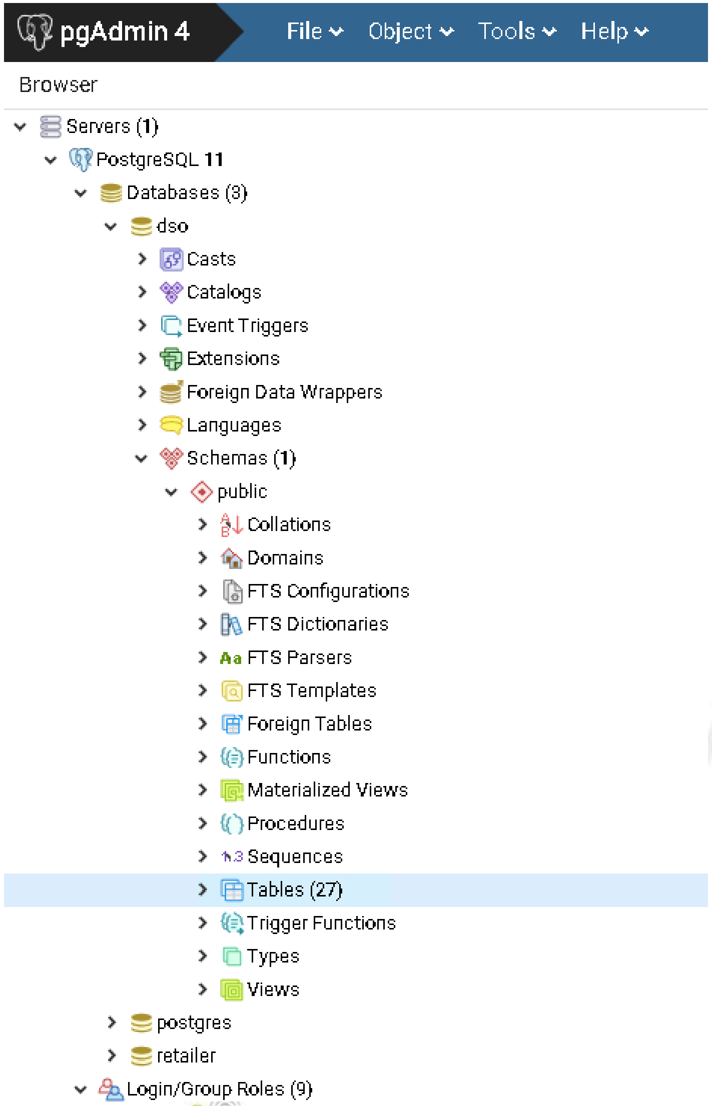
LONG TERM MODULE

Long Term Module

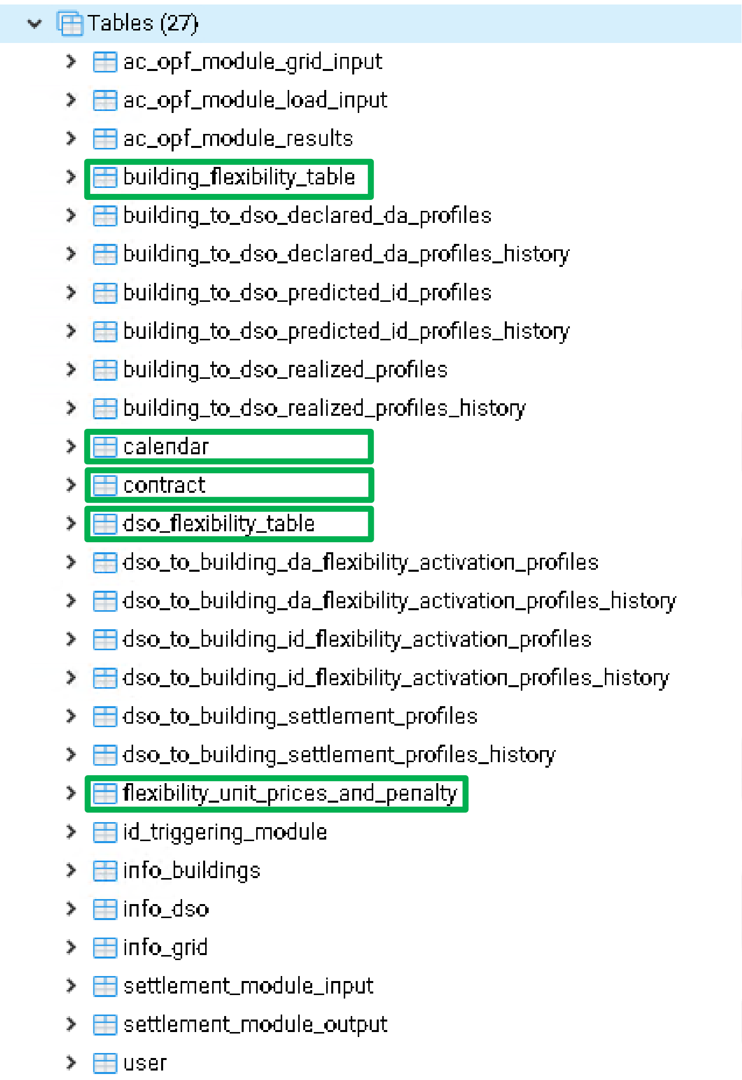
- Flexibility needs of the DSO for the upcoming year are defined
- Buildings can provide flexibility by offering available flexibility time windows

- Defining contracts between DSO and Buildings regarding flexibility reservation

PostreSQL Database



- Servers (1)
  - PostgreSQL 11
    - Databases (3)
      - dso
        - Casts
        - Catalogs
        - Event Triggers
        - Extensions
        - Foreign Data Wrappers
        - Languages
        - Schemas (1)
          - public
            - Collations
            - Domains
            - FTS Configurations
            - FTS Dictionaries
            - FTS Parsers
            - FTS Templates
            - Foreign Tables
            - Functions
            - Materialized Views
            - Procedures
            - Sequences
            - Tables (27)
            - Trigger Functions
            - Types
            - Views
      - postgres
      - retailer
    - Login/Group Roles (9)



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  - dso_to_building_id_flexibility_activation_profiles
  - dso_to_building_id_flexibility_activation_profiles_history
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  - settlement_module_output
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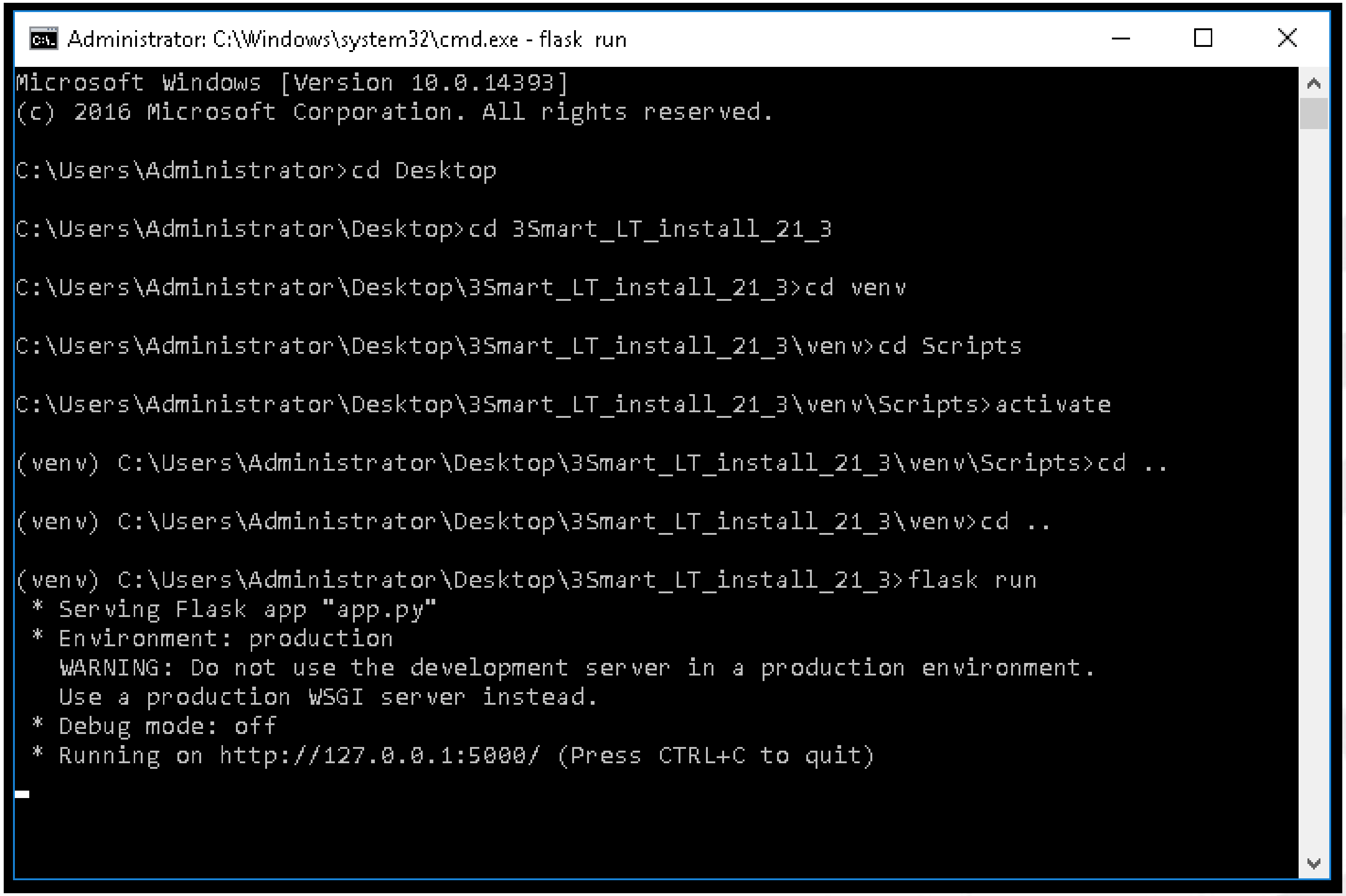
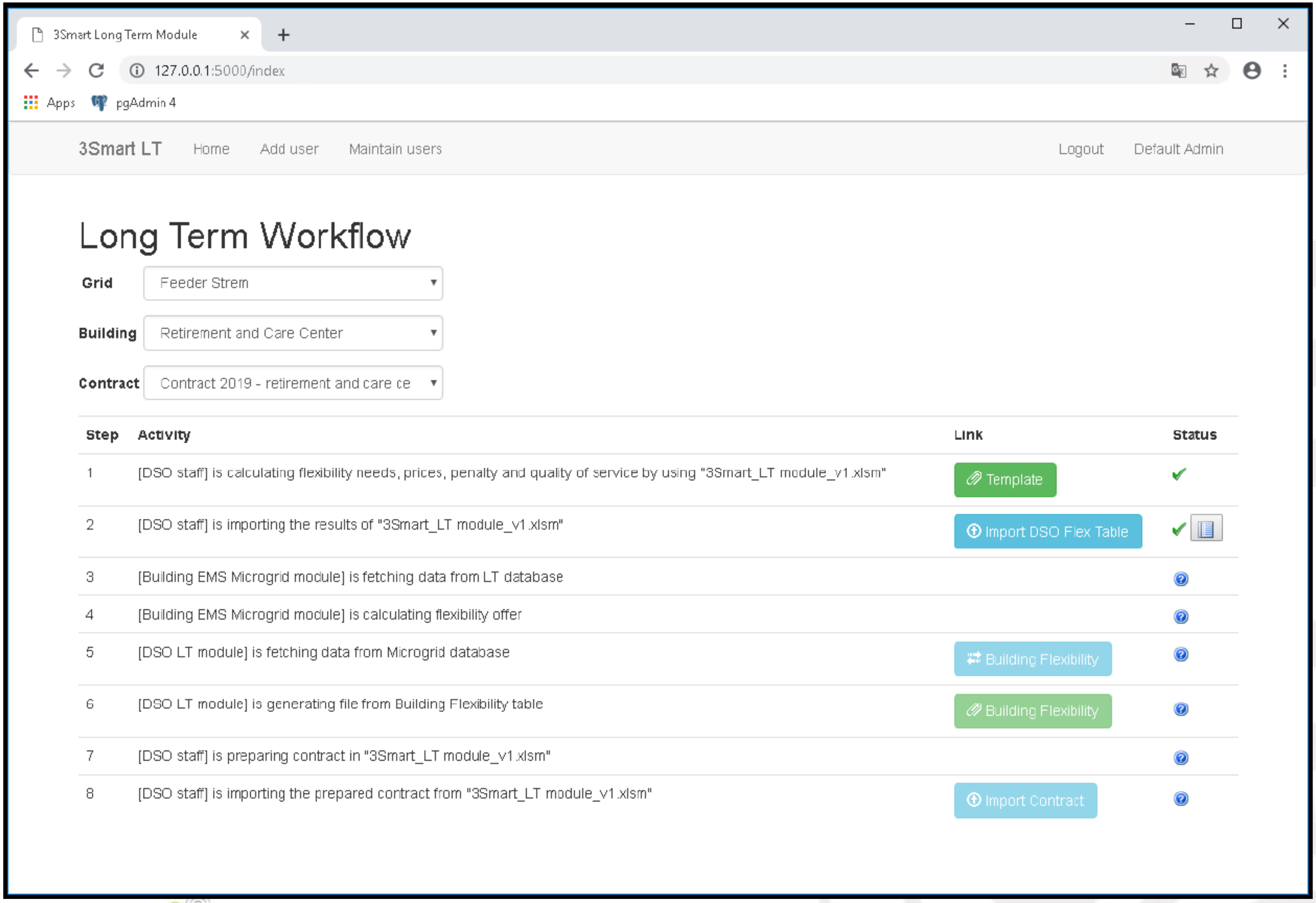
Access to Long Term platform



```
Microsoft Windows [Version 10.0.14393]
(c) 2016 Microsoft Corporation. All rights reserved.

C:\Users\Administrator>cd Desktop

C:\Users\Administrator\Desktop>cd 3Smart_LT_install_21_3

C:\Users\Administrator\Desktop\3Smart_LT_install_21_3>cd venv

C:\Users\Administrator\Desktop\3Smart_LT_install_21_3\venv>cd Scripts

C:\Users\Administrator\Desktop\3Smart_LT_install_21_3\venv\Scripts>activate

(venv) C:\Users\Administrator\Desktop\3Smart_LT_install_21_3\venv\Scripts>cd ..

(venv) C:\Users\Administrator\Desktop\3Smart_LT_install_21_3\venv>cd ..

(venv) C:\Users\Administrator\Desktop\3Smart_LT_install_21_3>flask run
 * Serving Flask app "app.py"
 * Environment: production
   WARNING: Do not use the development server in a production environment.
   Use a production WSGI server instead.
 * Debug mode: off
 * Running on http://127.0.0.1:5000/ (Press CTRL+C to quit)
```

Access to Long Term platform



Long Term Workflow

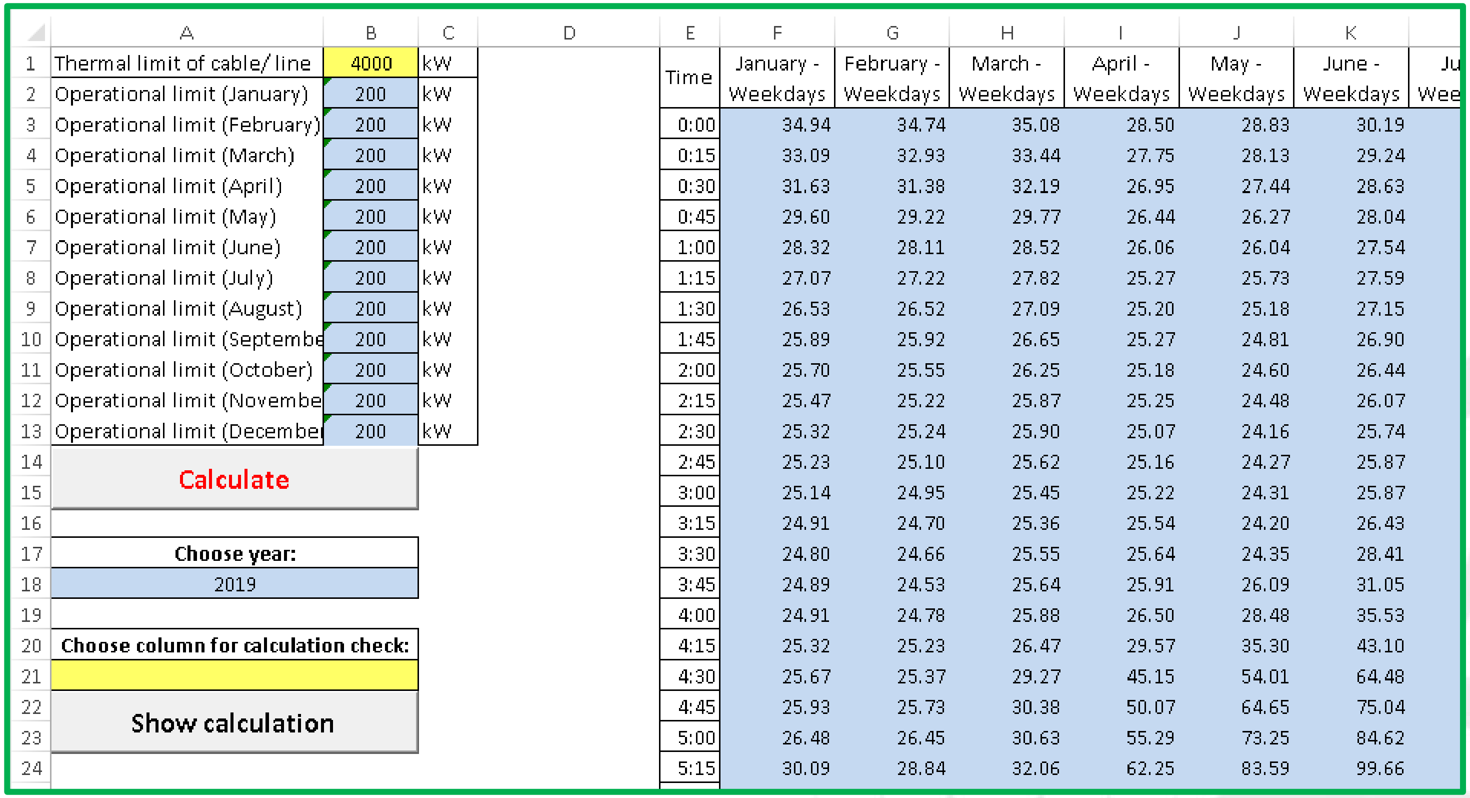
Grid Feeder Strem

Building Retirement and Care Center

Contract Contract 2019 - retirement and care ce

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	?

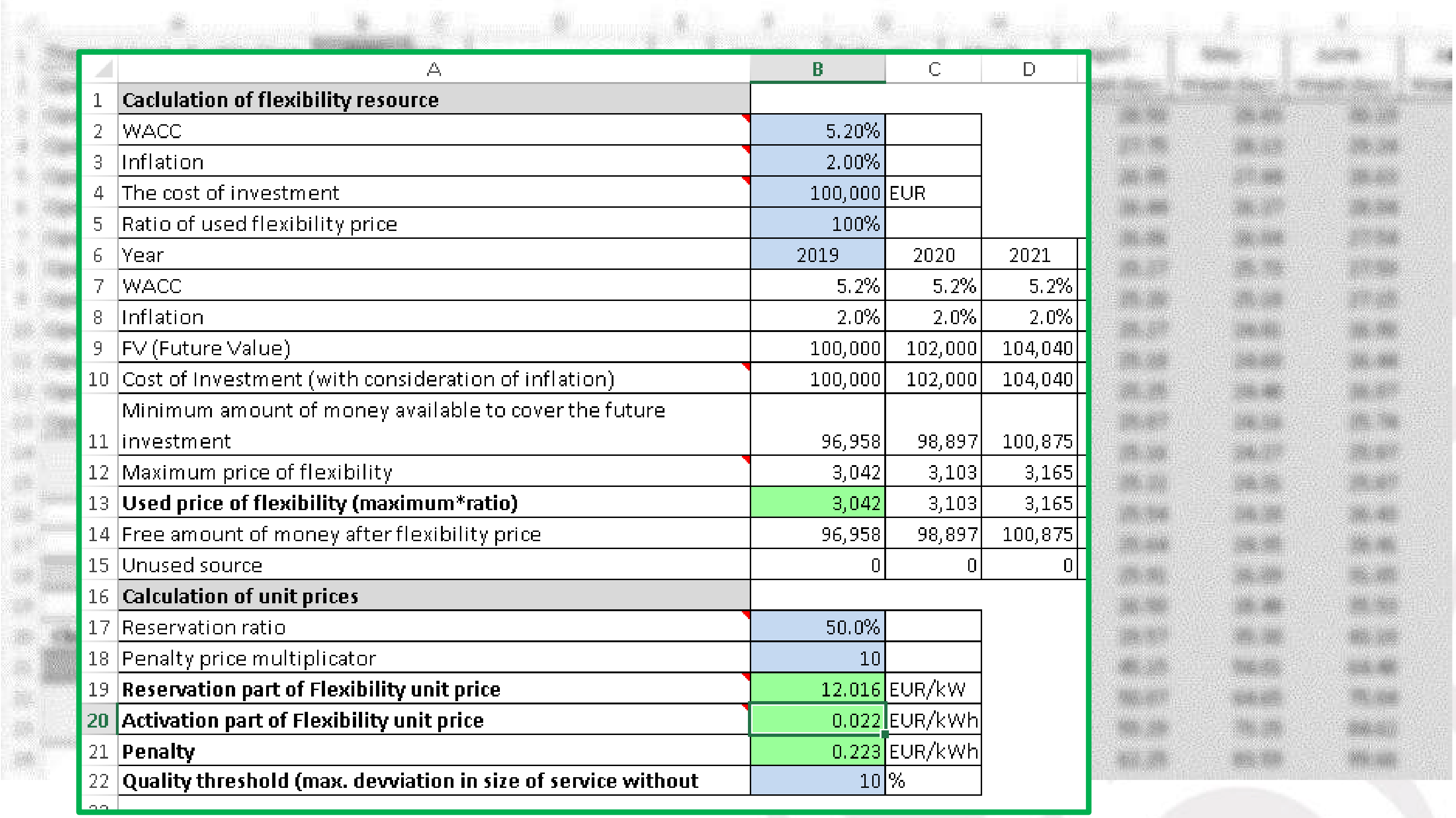
3Smart_LT module_v1.xlsm



	A	B	C	D	E	F	G	H	I	J	K	
1	Thermal limit of cable/ line	4000	kW		Time	January - Weekdays	February - Weekdays	March - Weekdays	April - Weekdays	May - Weekdays	June - Weekdays	Ju Wee
2	Operational limit (January)	200	kW									
3	Operational limit (February)	200	kW		0:00	34.94	34.74	35.08	28.50	28.83	30.19	
4	Operational limit (March)	200	kW		0:15	33.09	32.93	33.44	27.75	28.13	29.24	
5	Operational limit (April)	200	kW		0:30	31.63	31.38	32.19	26.95	27.44	28.63	
6	Operational limit (May)	200	kW		0:45	29.60	29.22	29.77	26.44	26.27	28.04	
7	Operational limit (June)	200	kW		1:00	28.32	28.11	28.52	26.06	26.04	27.54	
8	Operational limit (July)	200	kW		1:15	27.07	27.22	27.82	25.27	25.73	27.59	
9	Operational limit (August)	200	kW		1:30	26.53	26.52	27.09	25.20	25.18	27.15	
10	Operational limit (Septembe	200	kW		1:45	25.89	25.92	26.65	25.27	24.81	26.90	
11	Operational limit (October)	200	kW		2:00	25.70	25.55	26.25	25.18	24.60	26.44	
12	Operational limit (Novembe	200	kW		2:15	25.47	25.22	25.87	25.25	24.48	26.07	
13	Operational limit (Decembe	200	kW		2:30	25.32	25.24	25.90	25.07	24.16	25.74	
14	Calculate				2:45	25.23	25.10	25.62	25.16	24.27	25.87	
15					3:00	25.14	24.95	25.45	25.22	24.31	25.87	
16					3:15	24.91	24.70	25.36	25.54	24.20	26.43	
17	Choose year:				3:30	24.80	24.66	25.55	25.64	24.35	28.41	
18	2019				3:45	24.89	24.53	25.64	25.91	26.09	31.05	
19					4:00	24.91	24.78	25.88	26.50	28.48	35.53	
20	Choose column for calculation check:				4:15	25.32	25.23	26.47	29.57	35.30	43.10	
21					4:30	25.67	25.37	29.27	45.15	54.01	64.48	
22	Show calculation				4:45	25.93	25.73	30.38	50.07	64.65	75.04	
23					5:00	26.48	26.45	30.63	55.29	73.25	84.62	
24					5:15	30.09	28.84	32.06	62.25	83.59	99.66	

Calculation input

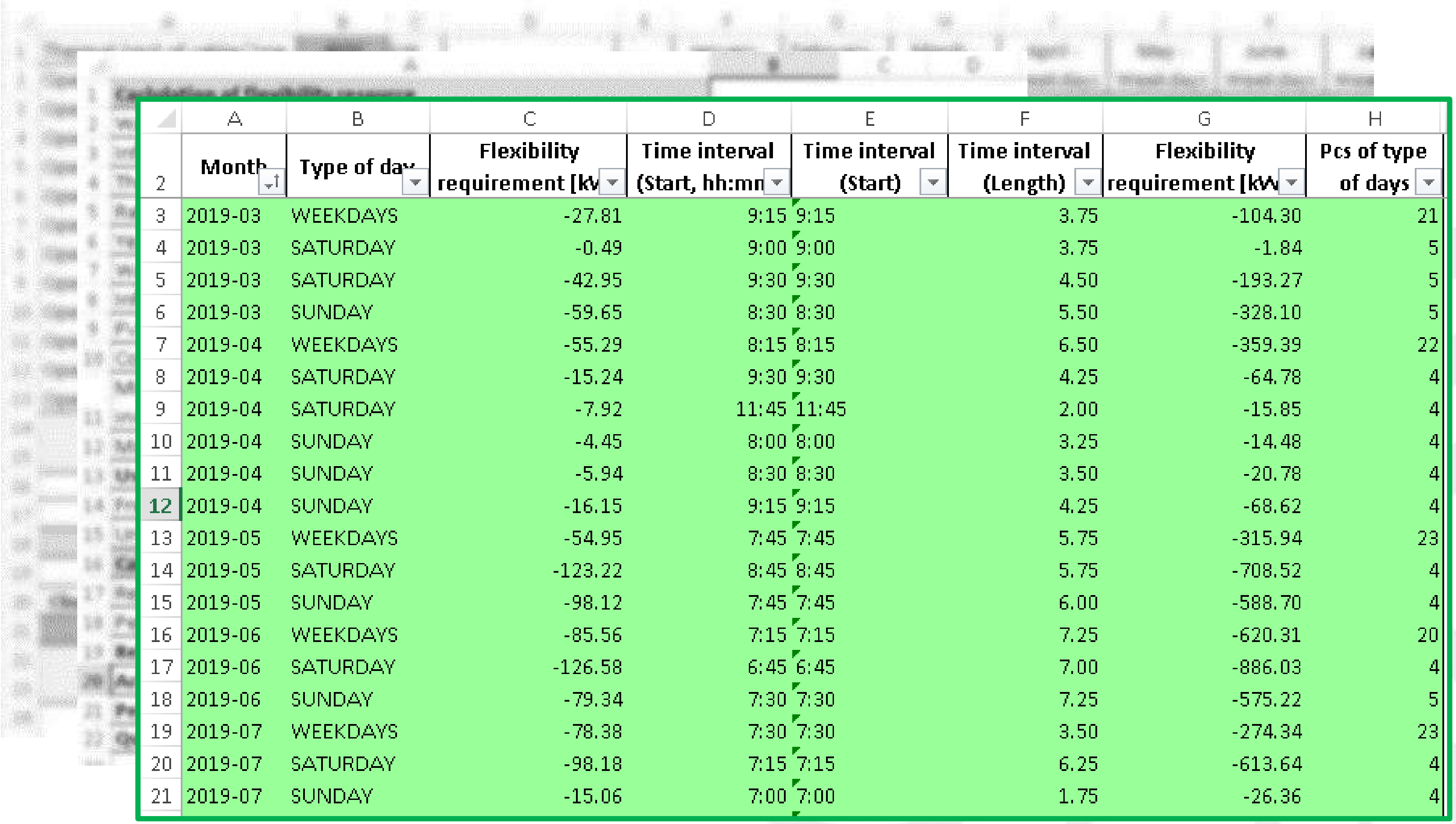
3Smart_LT module_v1.xlsm



	A	B	C	D
1	**Caclulation of flexibility resource**			
2	WACC	5.20%		
3	Inflation	2.00%		
4	The cost of investment	100,000	EUR	
5	Ratio of used flexibility price	100%		
6	Year	2019	2020	2021
7	WACC	5.2%	5.2%	5.2%
8	Inflation	2.0%	2.0%	2.0%
9	FV (Future Value)	100,000	102,000	104,040
10	Cost of Investment (with consideration of inflation)	100,000	102,000	104,040
11	Minimum amount of money available to cover the future investment	96,958	98,897	100,875
12	Maximum price of flexibility	3,042	3,103	3,165
13	**Used price of flexibility (maximum*ratio)**	3,042	3,103	3,165
14	Free amount of money after flexibility price	96,958	98,897	100,875
15	Unused source	0	0	0
16	**Calculation of unit prices**			
17	Reservation ratio	50.0%		
18	Penalty price multiplicator	10		
19	**Reservation part of Flexibility unit price**	12.016	EUR/kW	
20	**Activation part of Flexibility unit price**	0.022	EUR/kWh	
21	**Penalty**	0.223	EUR/kWh	
22	**Quality threshold (max. devviation in size of service without**	10	%	

Price and penalty

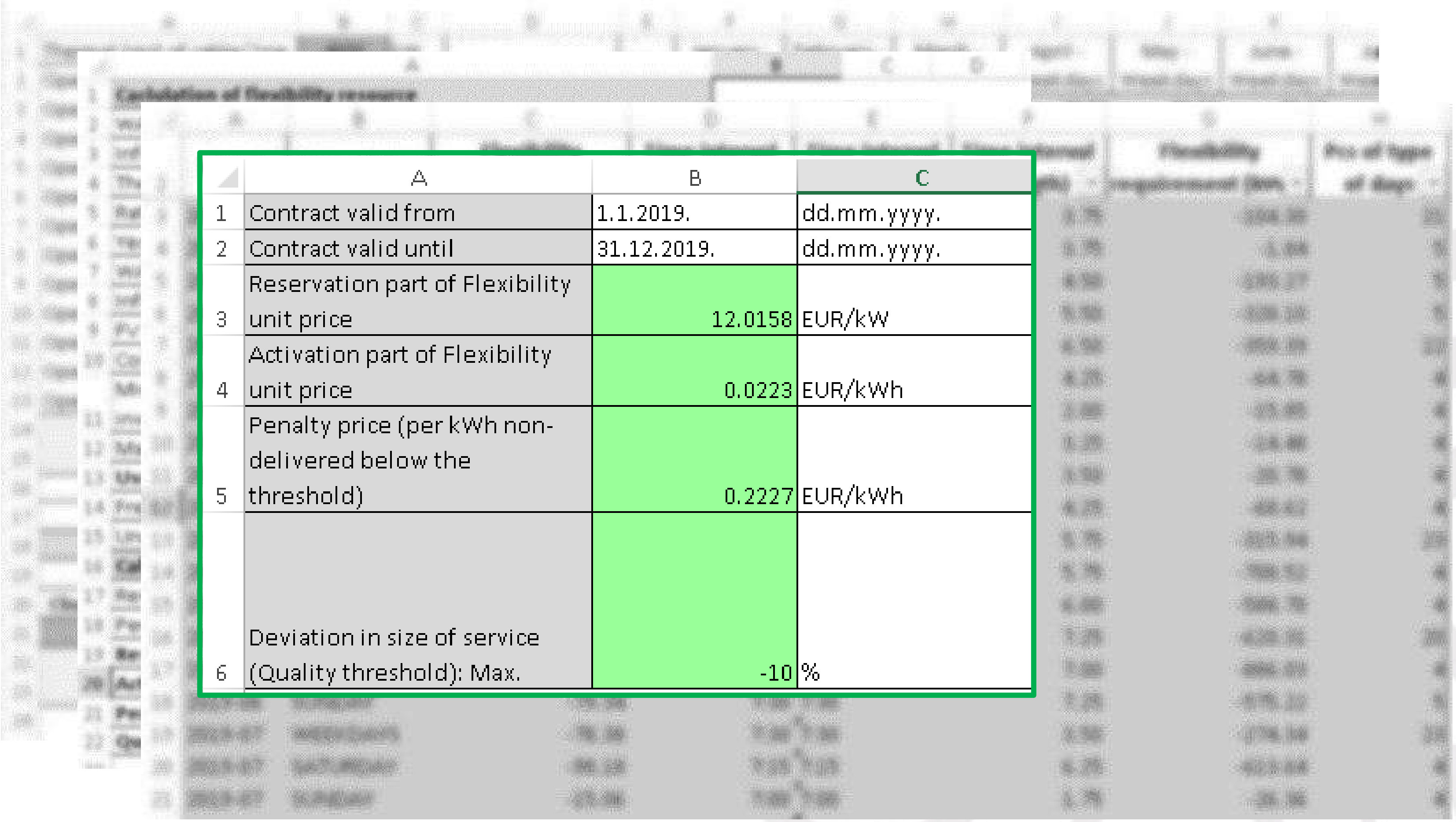
3Smart_LT module_v1.xlsm



	A	B	C	D	E	F	G	H
2	Month	Type of da	Flexibility requirement [kV	Time interval (Start, hh:mn	Time interval (Start)	Time interval (Length)	Flexibility requirement [kW	Pcs of type of days
3	2019-03	WEEKDAYS	-27.81	9:15	9:15	3.75	-104.30	21
4	2019-03	SATURDAY	-0.49	9:00	9:00	3.75	-1.84	5
5	2019-03	SATURDAY	-42.95	9:30	9:30	4.50	-193.27	5
6	2019-03	SUNDAY	-59.65	8:30	8:30	5.50	-328.10	5
7	2019-04	WEEKDAYS	-55.29	8:15	8:15	6.50	-359.39	22
8	2019-04	SATURDAY	-15.24	9:30	9:30	4.25	-64.78	4
9	2019-04	SATURDAY	-7.92	11:45	11:45	2.00	-15.85	4
10	2019-04	SUNDAY	-4.45	8:00	8:00	3.25	-14.48	4
11	2019-04	SUNDAY	-5.94	8:30	8:30	3.50	-20.78	4
12	2019-04	SUNDAY	-16.15	9:15	9:15	4.25	-68.62	4
13	2019-05	WEEKDAYS	-54.95	7:45	7:45	5.75	-315.94	23
14	2019-05	SATURDAY	-123.22	8:45	8:45	5.75	-708.52	4
15	2019-05	SUNDAY	-98.12	7:45	7:45	6.00	-588.70	4
16	2019-06	WEEKDAYS	-85.56	7:15	7:15	7.25	-620.31	20
17	2019-06	SATURDAY	-126.58	6:45	6:45	7.00	-886.03	4
18	2019-06	SUNDAY	-79.34	7:30	7:30	7.25	-575.22	5
19	2019-07	WEEKDAYS	-78.38	7:30	7:30	3.50	-274.34	23
20	2019-07	SATURDAY	-98.18	7:15	7:15	6.25	-613.64	4
21	2019-07	SUNDAY	-15.06	7:00	7:00	1.75	-26.36	4

DSO Flexibility table

3Smart_LT module_v1.xlsm



	A	B	C
1	Contract valid from	1.1.2019.	dd.mm.yyyy.
2	Contract valid until	31.12.2019.	dd.mm.yyyy.
3	Reservation part of Flexibility unit price	12.0158	EUR/kW
4	Activation part of Flexibility unit price	0.0223	EUR/kWh
5	Penalty price (per kWh non-delivered below the threshold)	0.2227	EUR/kWh
6	Deviation in size of service (Quality threshold): Max.	-10	%

Flexibility unit prices,penalty

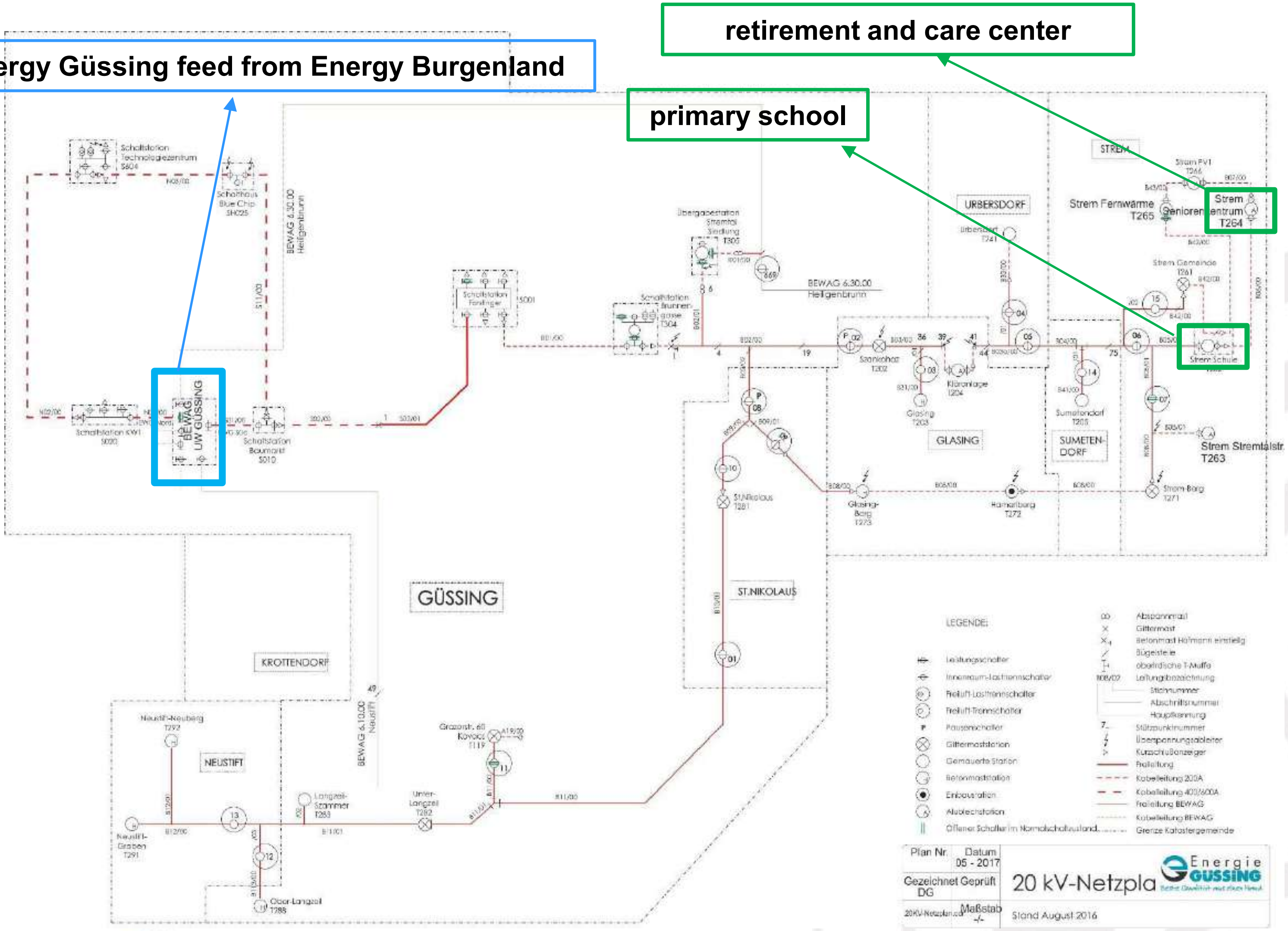
SHORT TERM DAY AHEAD MODULE

Short Term Module

- Day Ahead calculation to define the amount of the reserved flexibility capacity that is required by the DSO

- Daily calculation with ACOPF.py
- Use of Database information as well as the Grid.xlsx data file
- Connected with the LT Module

Modelling of the grid



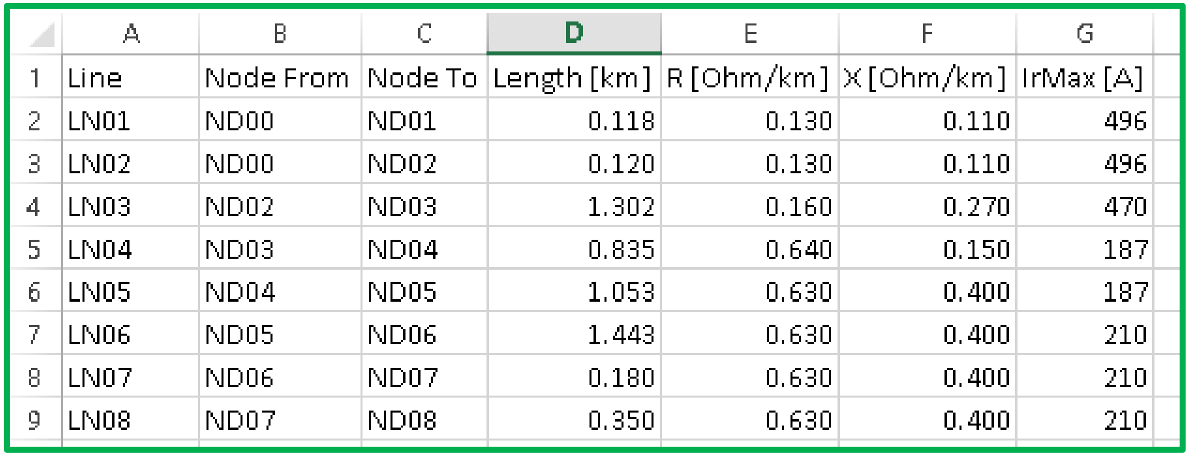
Energy Güssing feed from Energy Burgenland

retirement and care center

primary school

Energie GÜSSING
Interreg Danube Transnational Programme
3Smart

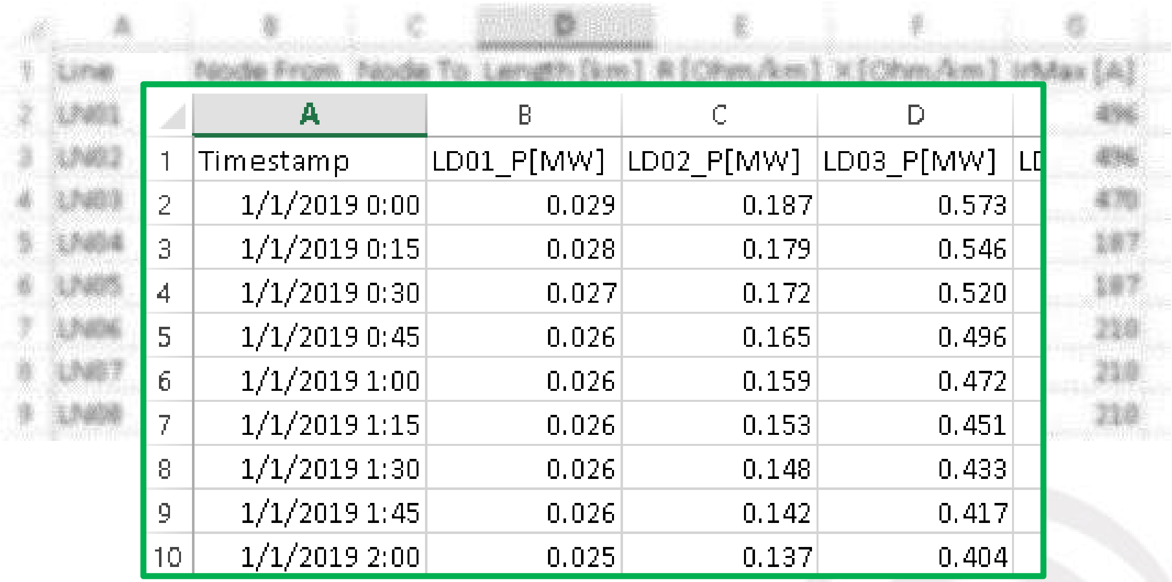
Grid.xlsx



	A	B	C	D	E	F	G
1	Line	Node From	Node To	Length [km]	R [Ohm/km]	X [Ohm/km]	IrMax [A]
2	LN01	ND00	ND01	0.118	0.130	0.110	496
3	LN02	ND00	ND02	0.120	0.130	0.110	496
4	LN03	ND02	ND03	1.302	0.160	0.270	470
5	LN04	ND03	ND04	0.835	0.640	0.150	187
6	LN05	ND04	ND05	1.053	0.630	0.400	187
7	LN06	ND05	ND06	1.443	0.630	0.400	210
8	LN07	ND06	ND07	0.180	0.630	0.400	210
9	LN08	ND07	ND08	0.350	0.630	0.400	210

Sheet1

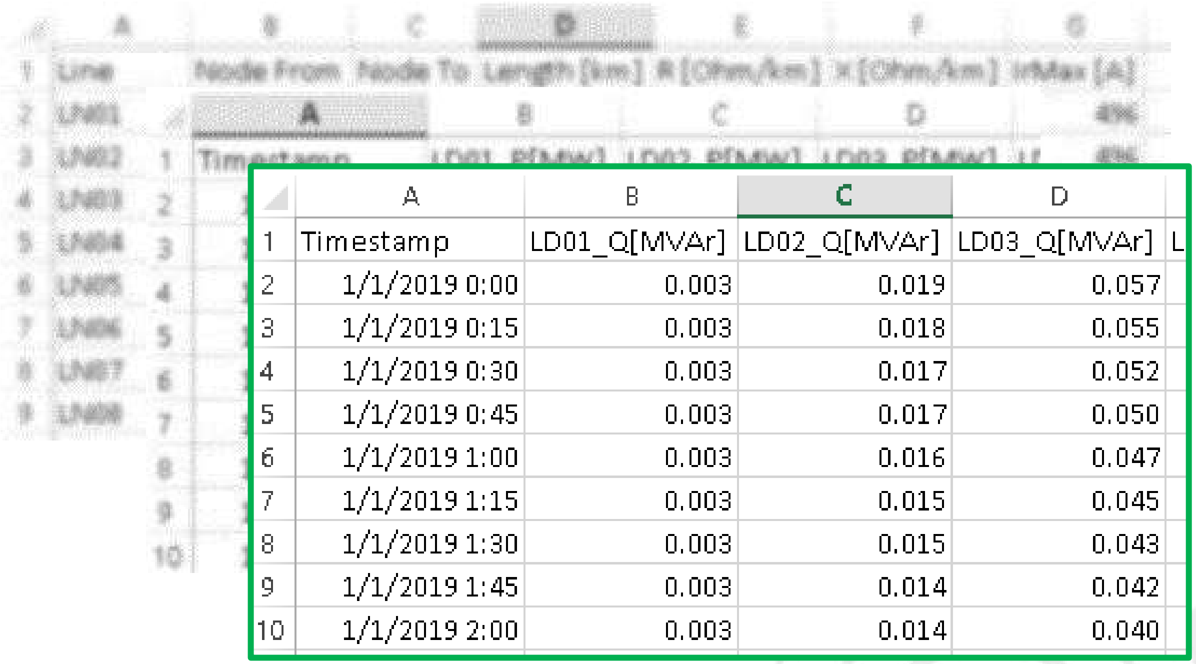
Grid.xlsx



	A	B	C	D
1	Timestamp	LD01_P[MW]	LD02_P[MW]	LD03_P[MW]
2	1/1/2019 0:00	0.029	0.187	0.573
3	1/1/2019 0:15	0.028	0.179	0.546
4	1/1/2019 0:30	0.027	0.172	0.520
5	1/1/2019 0:45	0.026	0.165	0.496
6	1/1/2019 1:00	0.026	0.159	0.472
7	1/1/2019 1:15	0.026	0.153	0.451
8	1/1/2019 1:30	0.026	0.148	0.433
9	1/1/2019 1:45	0.026	0.142	0.417
10	1/1/2019 2:00	0.025	0.137	0.404

Sheet2

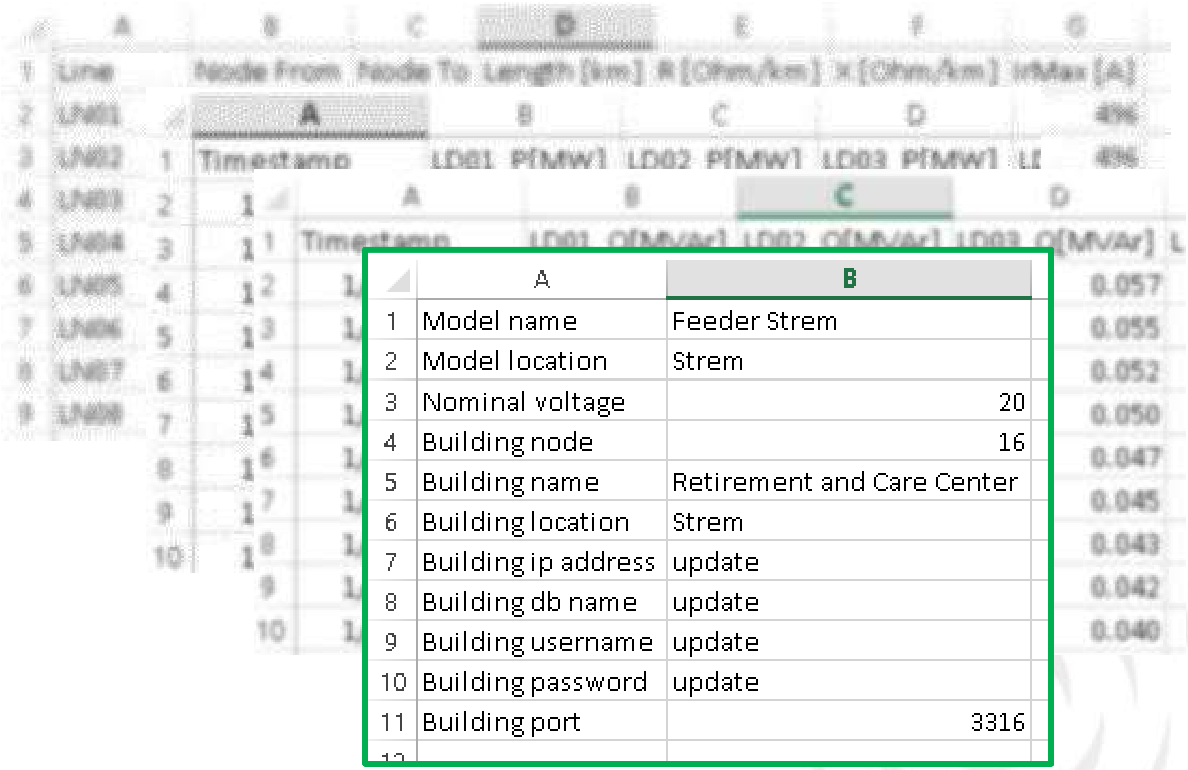
Grid.xlsx



Timestamp	LD01_Q[MVAr]	LD02_Q[MVAr]	LD03_Q[MVAr]
1/1/2019 0:00	0.003	0.019	0.057
1/1/2019 0:15	0.003	0.018	0.055
1/1/2019 0:30	0.003	0.017	0.052
1/1/2019 0:45	0.003	0.017	0.050
1/1/2019 1:00	0.003	0.016	0.047
1/1/2019 1:15	0.003	0.015	0.045
1/1/2019 1:30	0.003	0.015	0.043
1/1/2019 1:45	0.003	0.014	0.042
1/1/2019 2:00	0.003	0.014	0.040

Sheet3

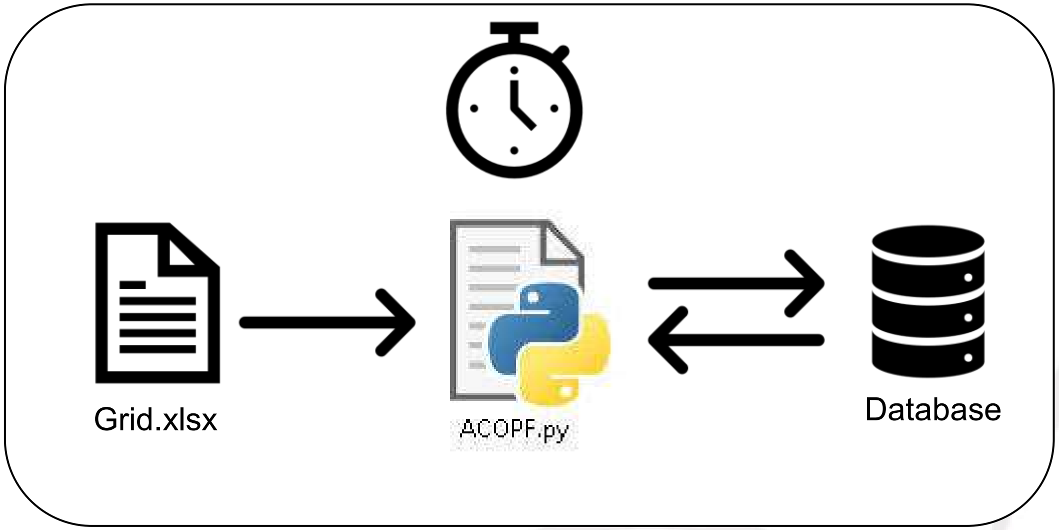
Grid.xlsx



	A	B
1	Model name	Feeder Strem
2	Model location	Strem
3	Nominal voltage	20
4	Building node	16
5	Building name	Retirement and Care Center
6	Building location	Strem
7	Building ip address	update
8	Building db name	update
9	Building username	update
10	Building password	update
11	Building port	3316

Sheet4

Short Term Day Ahead Module



- Daily determininating how much of the reserved flexibility capacity (predefiened in the long term contract) will be activated the next day

Grid Measurements

Grid Measurements

- Smart Meter rollout in the Güssing grid was not possible due to supply difficulties
  (+1 year)

- Rollout of new electricity meters in the upcomming week
- Start of measurements for first selected transformer stations in week 14

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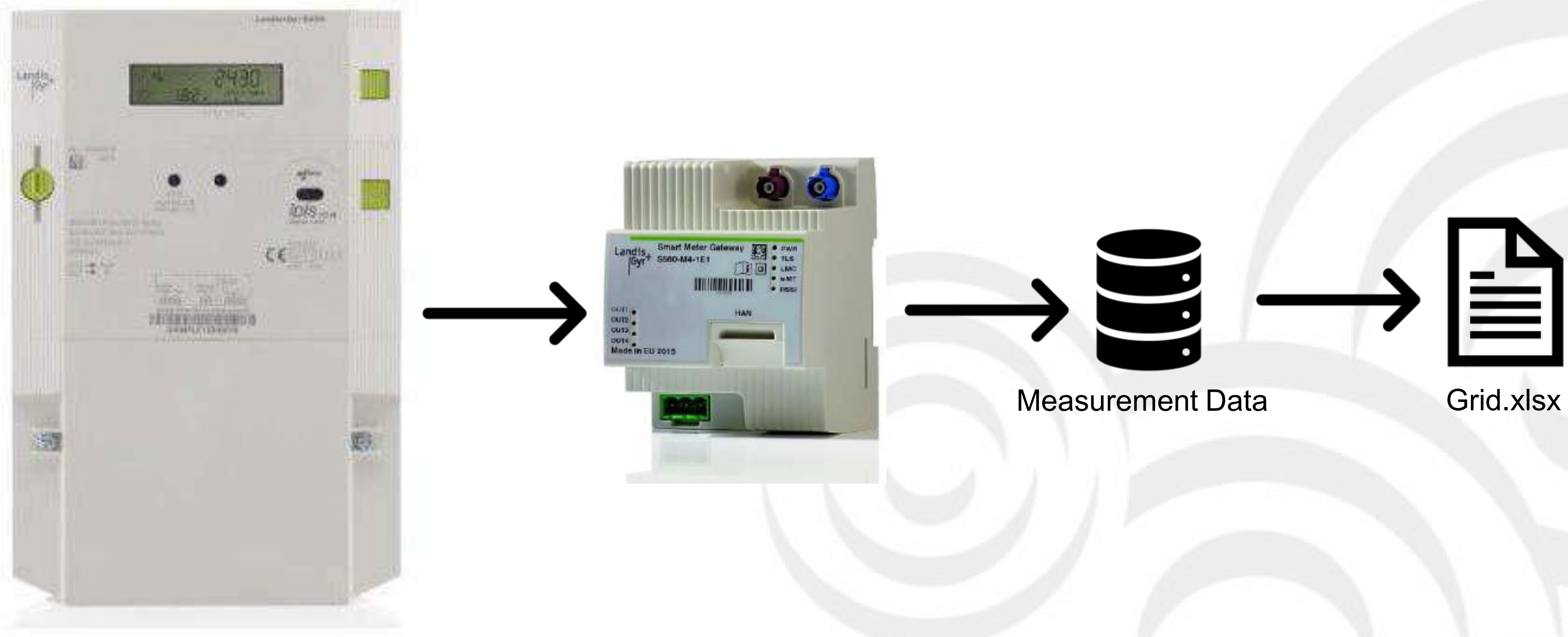
Grid Measurements

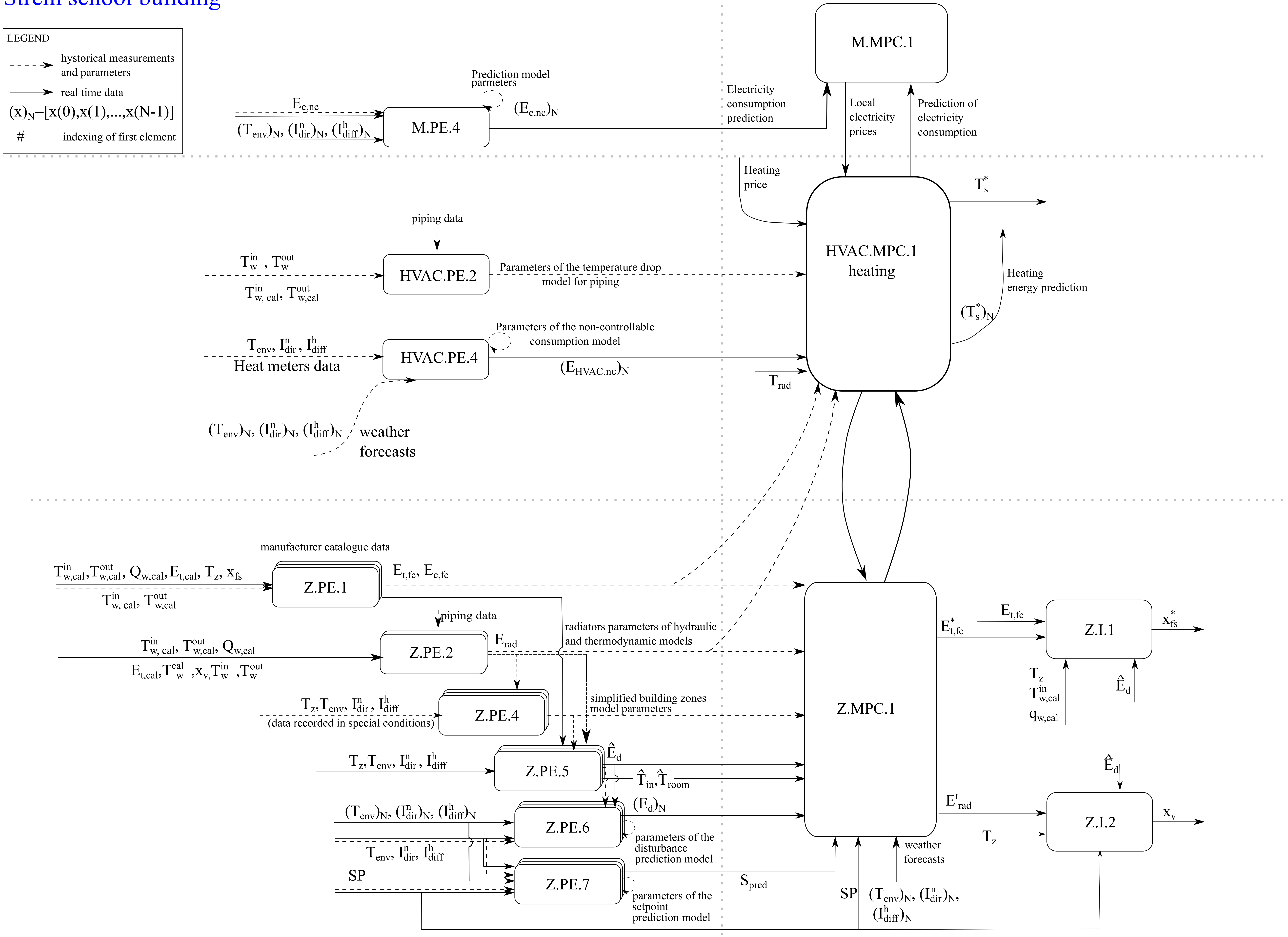
- Replacement of the synthetic load profiles with real measurement data

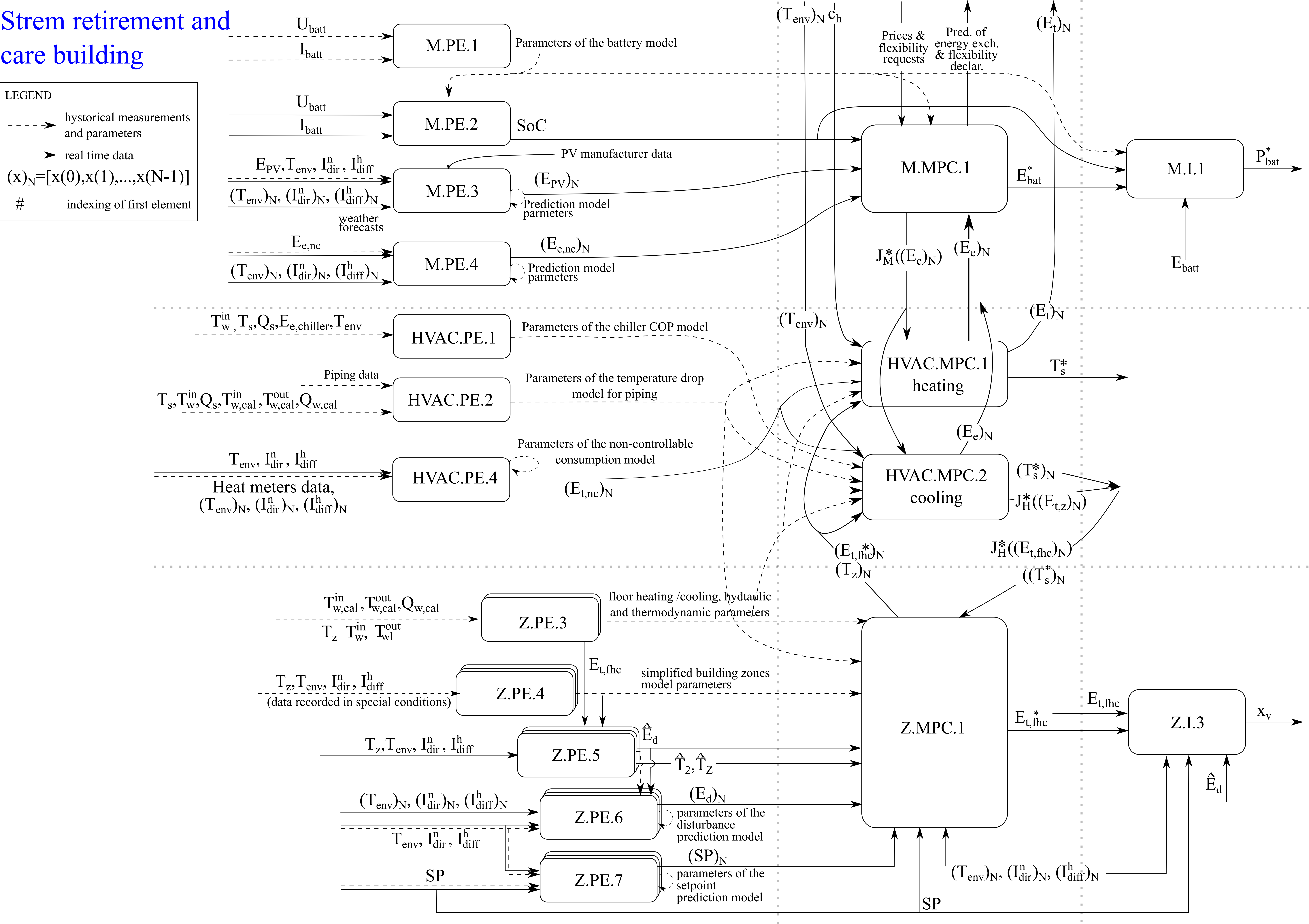


Measurement Data

Grid.xlsx

Strem school building




Strem retirement and care building
LEGEND
hystorical measurements and parameters
real time data
$(x)_N=[x(0),x(1),...,x(N-1)]$
indexing of first element
U_{batt}
I_{batt}
M.PE.1
Parameters of the battery model
M.PE.2
SoC
$E_{PV}, T_{env}, I^n_{dir}, I^h_{diff}$
$(T_{env})_N, (I^n_{dir})_N, (I^h_{diff})_N$
weather forecasts
M.PE.3
PV manufacturer data
$(E_{PV})_N$
Prediction model parmeters
$E_{e,nc}$
M.PE.4
$(E_{e,nc})_N$
Prediction model parmeters
$(T_{env})_N$ c_h
Prices & flexibility requests
Pred. of energy exch. & flexibility declar.
$(E_t)_N$
M.MPC.1
E^*_{bat}
M.I.1
P^*_{bat}
E_{batt}
$J^*_M((E_e)_N)$
$(E_e)_N$
$(E_t)_N$
$T^{in}_w, T_s, Q_s, E_{e,chiller}, T_{env}$
HVAC.PE.1
Parameters of the chiller COP model
Piping data
$T_s, T^{in}_w, Q_s, T^{in}_{w,cal}, T^{out}_{w,cal}, Q_{w,cal}$
HVAC.PE.2
Parameters of the temperature drop model for piping
$T_{env}, I^n_{dir}, I^h_{diff}$
HVAC.PE.4
Parameters of the non-controllable consumption model
Heat meters data, $(T_{env})_N, (I^n_{dir})_N, (I^h_{diff})_N$
$(E_{t,nc})_N$
$(T_{env})_N$
HVAC.MPC.1 heating
T^*_s
$(E_e)_N$
HVAC.MPC.2 cooling
$(T^*_s)_N$
$J^*_H((E_{t,z})_N)$
$(E^*_{t,fhc})_N$
$(T_z)_N$
$J^*_H((E_{t,fhc})_N)$
$((T^*_s)_N$
$T^{in}_{w,cal}, T^{out}_{w,cal}, Q_{w,cal}$
T_z T^{in}_w, T^{out}_{wl}
Z.PE.3
floor heating /cooling, hydtaulic and thermodynamic parameters
$E_{t,fhc}$
$T_z, T_{env}, I^n_{dir}, I^h_{diff}$
(data recorded in special conditions)
Z.PE.4
simplified building zones model parameters
$T_z, T_{env}, I^n_{dir}, I^h_{diff}$
Z.PE.5
$\hat{E}_d$
$\hat{T}_2, \hat{T}_Z$
Z.MPC.1
$E^*_{t,fhc}$
$E_{t,fhc}$
Z.I.3
x_v
$\hat{E}_d$
$(T_{env})_N, (I^n_{dir})_N, (I^h_{diff})_N$
$T_{env}, I^n_{dir}, I^h_{diff}$
Z.PE.6
$(E_d)_N$
parameters of the disturbance prediction model
SP
Z.PE.7
$(SP)_N$
parameters of the setpoint prediction model
$(T_{env})_N, (I^n_{dir})_N, (I^h_{diff})_N$
SP

Online demonstration: Zone level modules (Radiators and simplified building model)

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3Smart 1st pilot study visit to the Austrian pilot

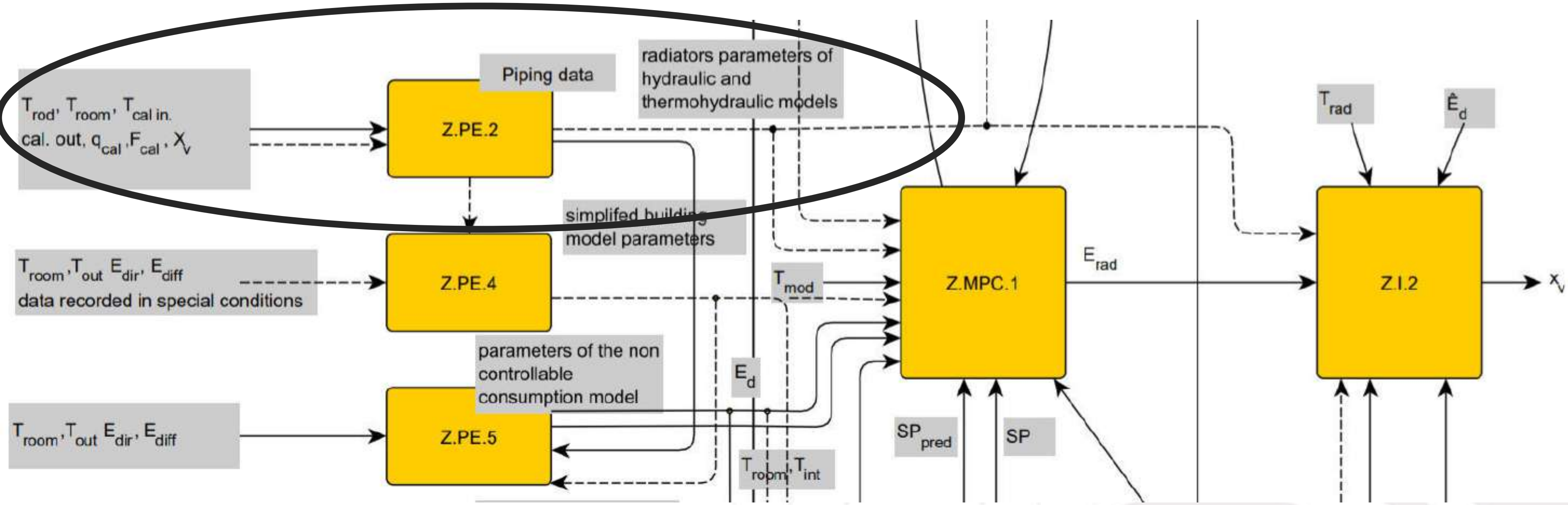
Strem, 27th – 28th March 2019

FAKULTET STROJARSTVA, RAČUNARSTVA I ELEKTROTEHNIKE
SVEUČILIŠTE U MOSTARU

Interreg
EUROPEAN UNION
Danube Transnational Programme
3Smart

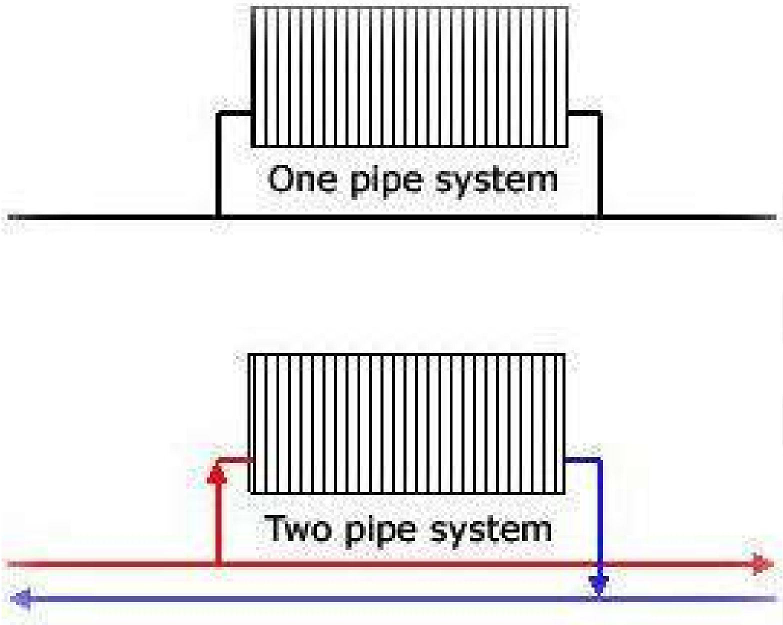
Project co-funded by European Union funds (ERDF, IPA)

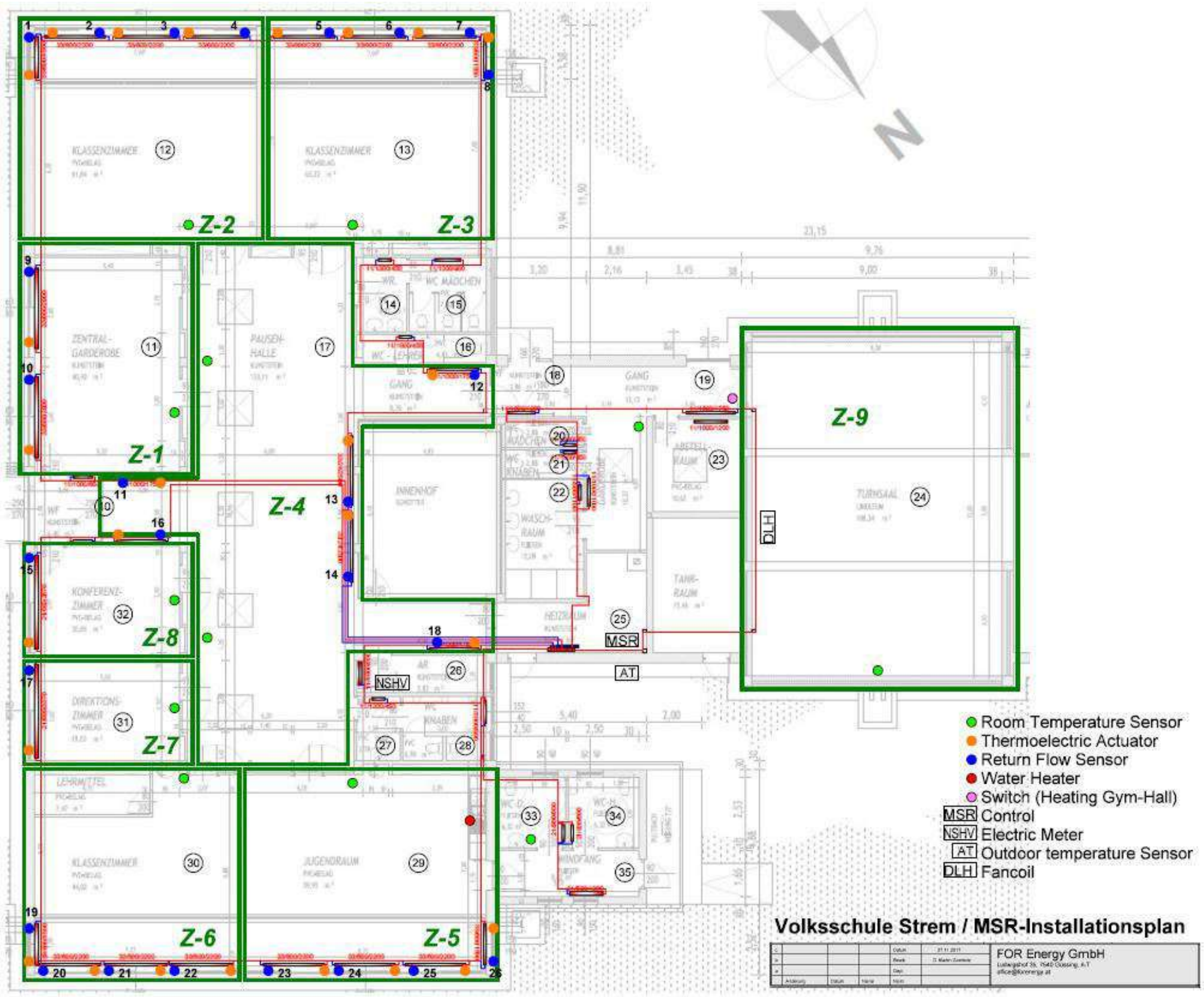
Radiator module


T_{rod}, T_{room}, $T_{cal\ in.}$
cal. out, q_{cal}, F_{cal}, X_v
Piping data
Z.PE.2
radiators parameters of hydraulic and thermohydraulic models
simplifed building model parameters
T_{room}, T_{out} E_{dir}, E_{diff}
data recorded in special conditions
Z.PE.4
T_{mod}
Z.MPC.1
E_{rad}
T_{rad}
$\hat{E}_d$
Z.I.2
x_v
parameters of the non controllable consumption model
E_d
T_{room}, T_{out} E_{dir}, E_{diff}
Z.PE.5
T_{room}, T_{int}
SP_{pred}
SP

Overview

- One-pipe system
- All the radiators in one zone are controled at the same time
- Data collected for all zones (constant flow and temperature)
- 10-12 hours of data for each zone




Z-1
Z-2
Z-3
Z-4
Z-5
Z-6
Z-7
Z-8
Z-9
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
N
KLASSENZIMMER
KLASSENZIMMER
ZENTRAL-GARDEROBE
PAUSEN-HALLE
WC MÄDCHEN
GANG
GANG
INNENHOF
WASCH-RAUM
HEIZRAUM
TURNSAAL
TANK-RAUM
KONFERENZ-ZIMMER
DIREKTIONS-ZIMMER
LEHRMITTEL
KLASSENZIMMER
JUGENDRAUM
WINDFANG
MSR
NSHV
AT
DLH
● Room Temperature Sensor
● Thermoelectric Actuator
● Return Flow Sensor
● Water Heater
○ Switch (Heating Gym-Hall)
MSR Control
NSHV Electric Meter
AT Outdoor temperature Sensor
DLH Fancoil
Volksschule Strem / MSR-Installationsplan
FOR Energy GmbH
Datum
Bearb.
Gepr.
Norm
Änderung
Datum
Name

Current problems

- Sensor position
- Heat losses from calorimeter to each radiator
- Possibility to control temperature at the duct inlet
- Calibration of the return medium temperature sensors
- Value of the medium mass flow

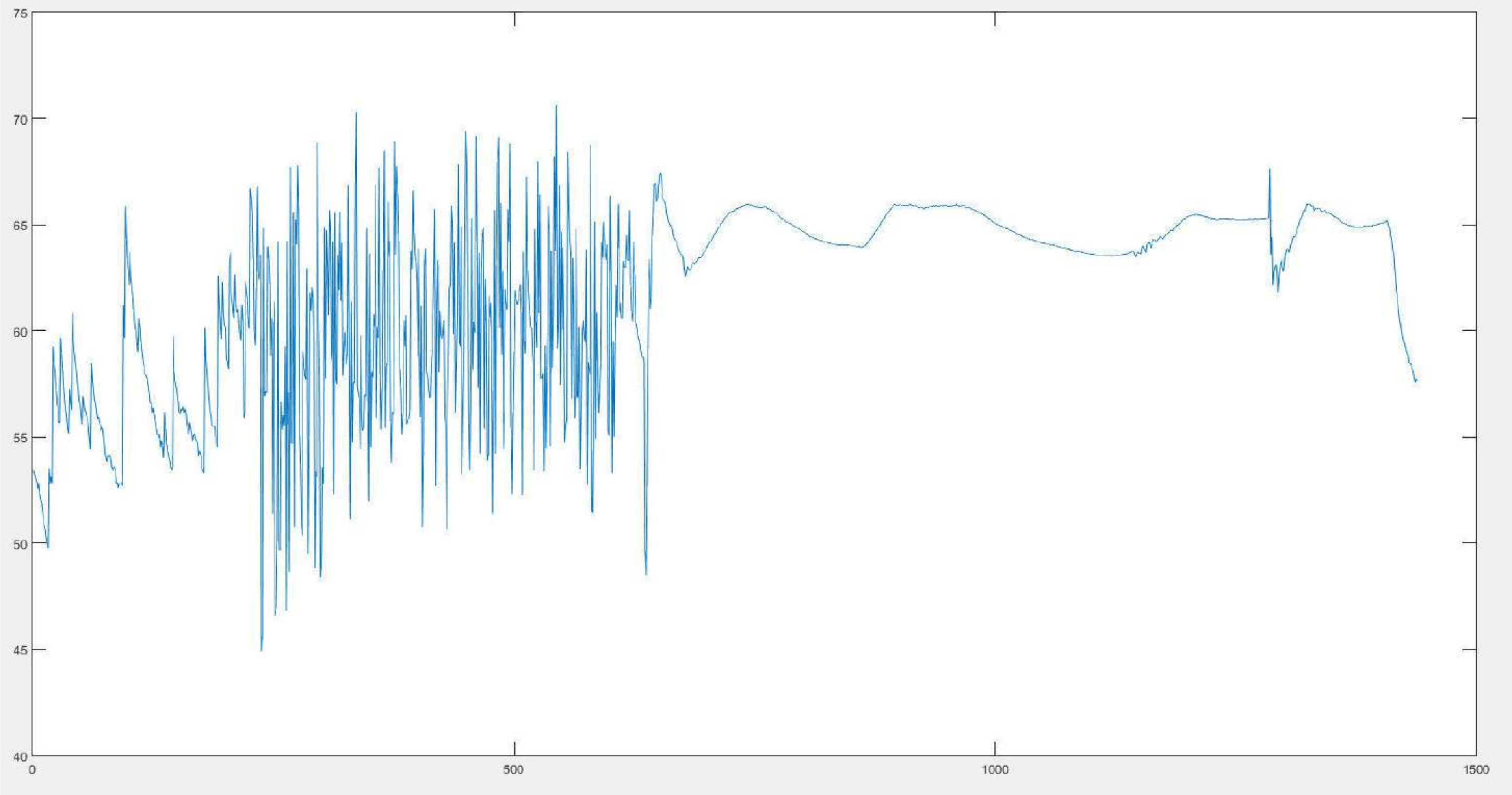
Sensor position

Sensor position

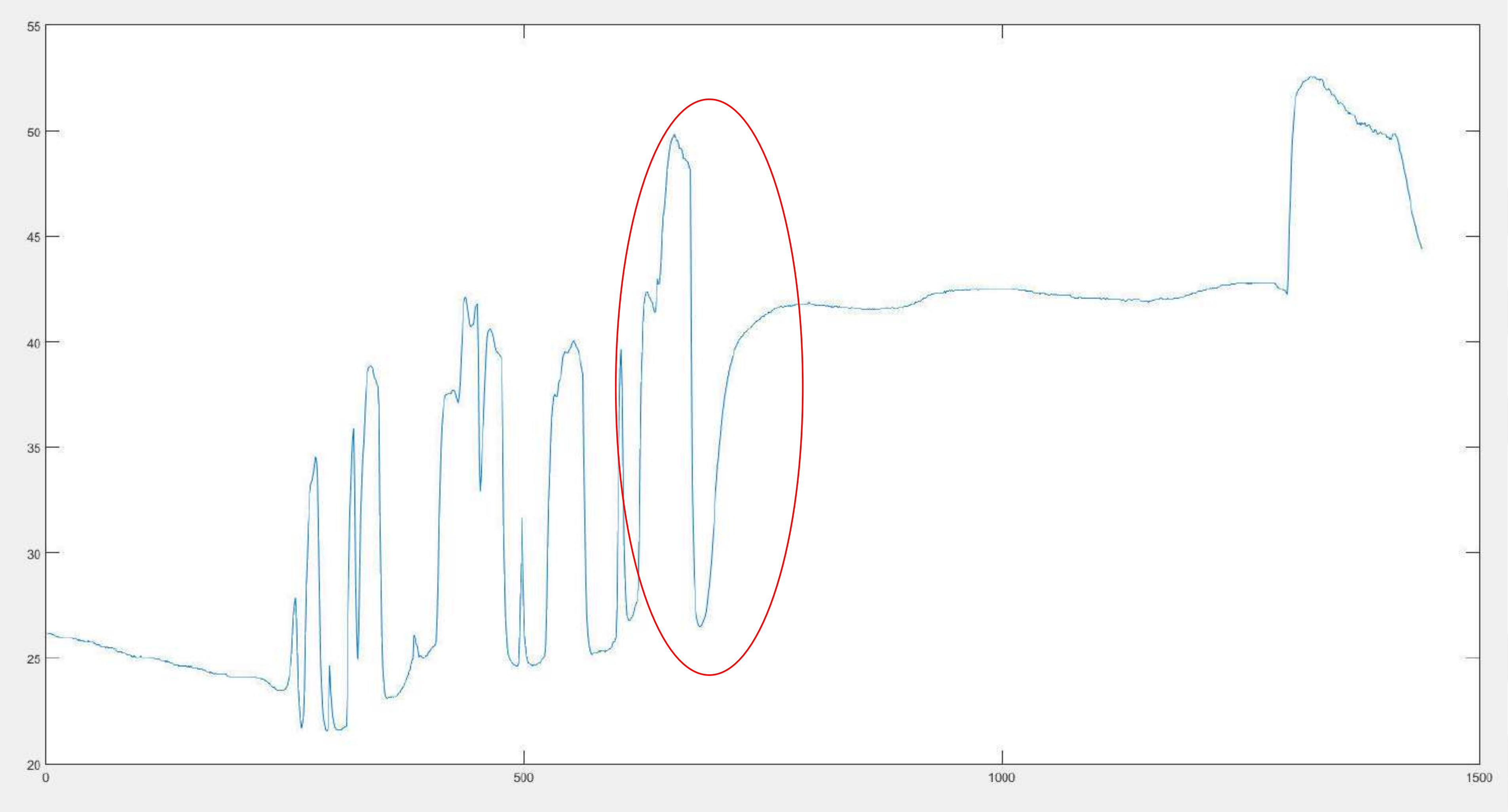

E
1

Results for one zone

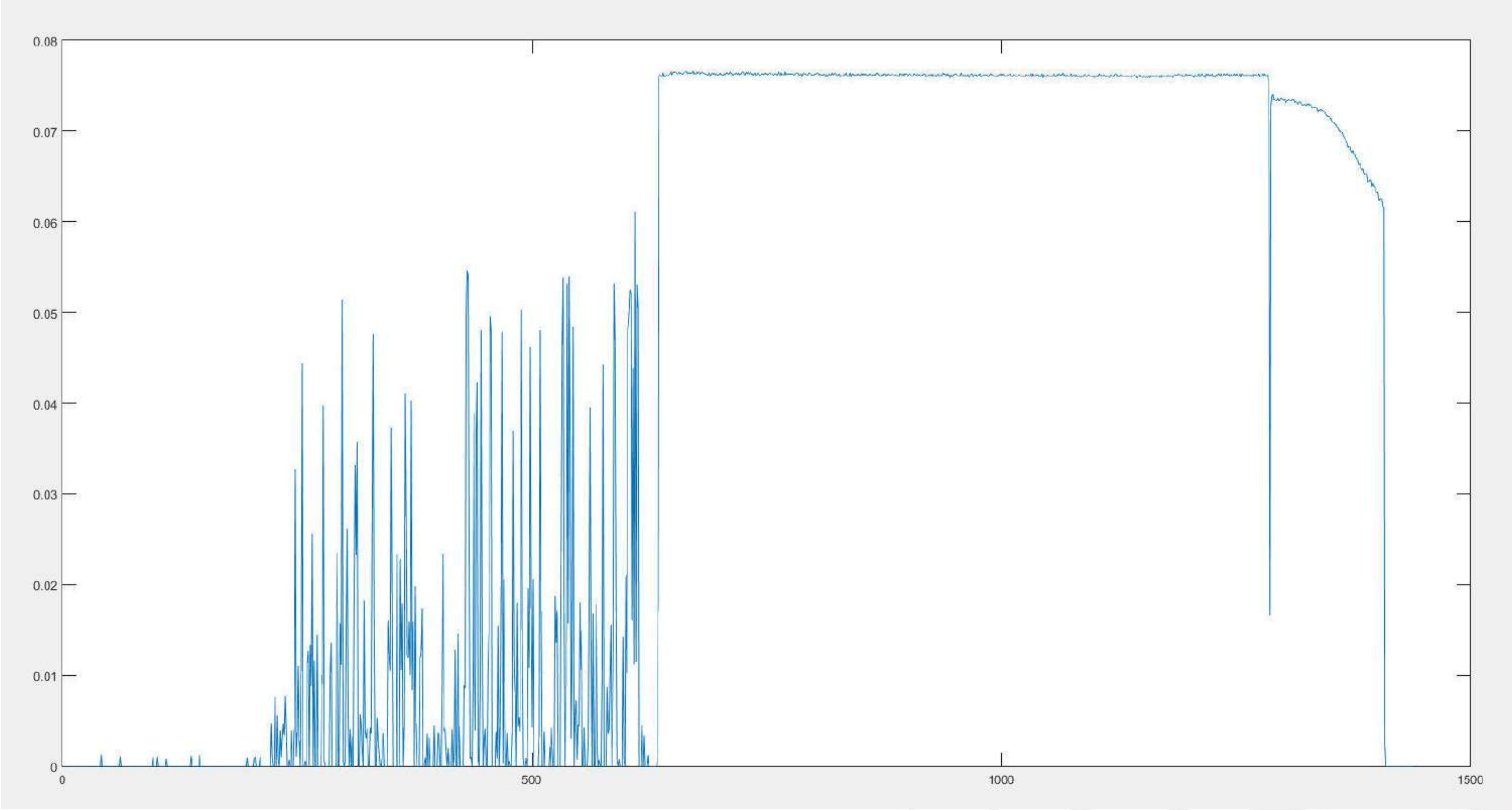
Inlet temperature at the calorimeter



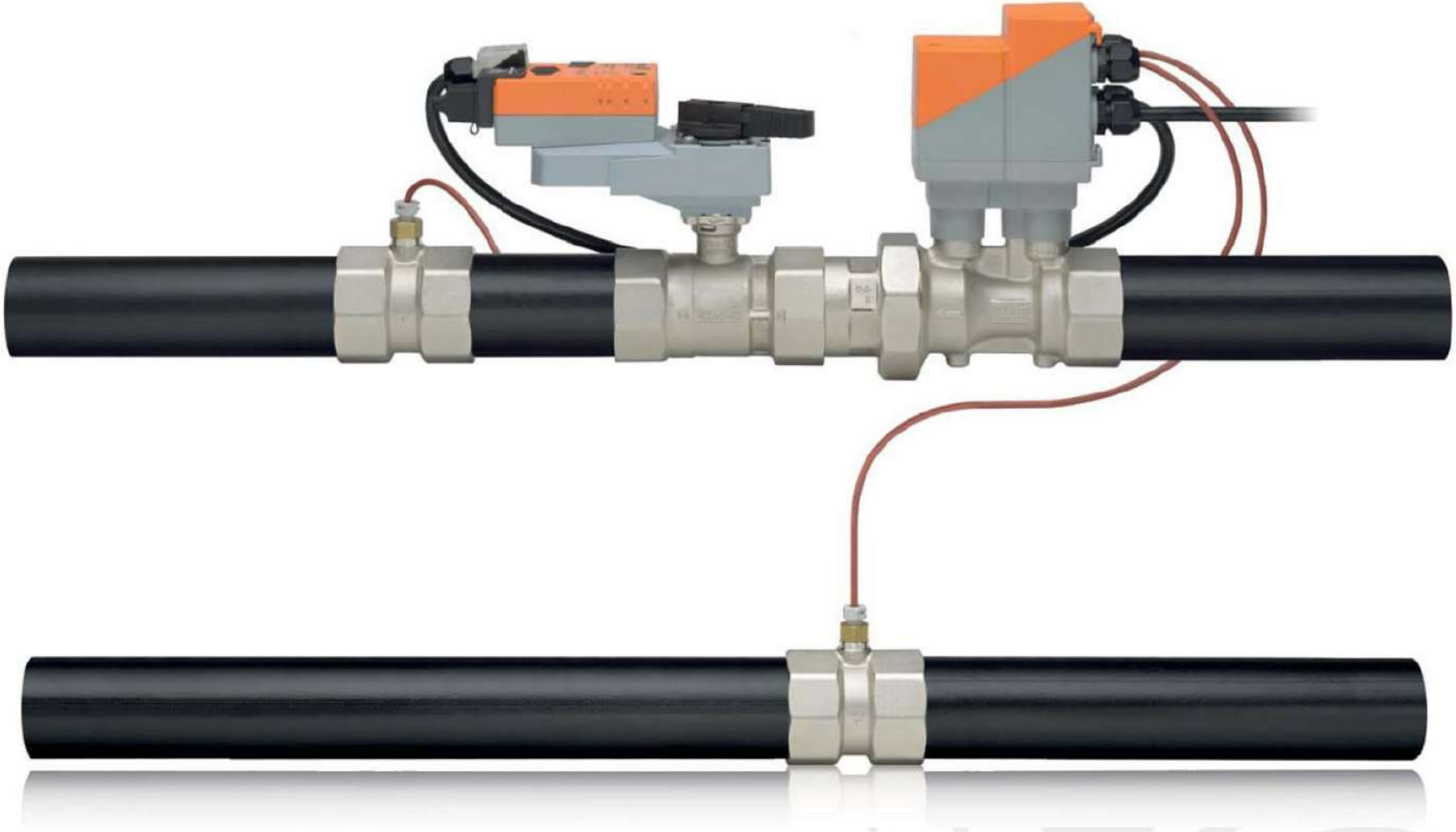
Outgoing radiator temperature



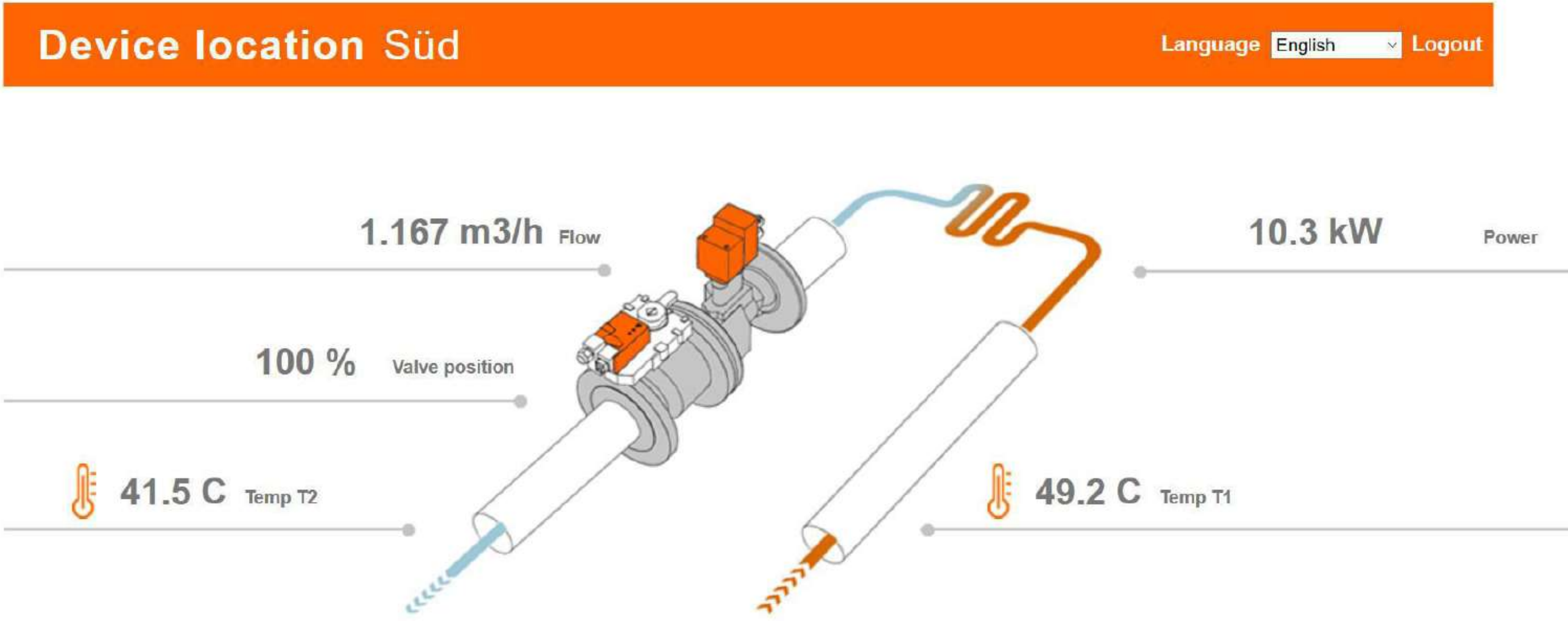
Medium mass flow



Energy valve



Energy valve



Device location Süd

1.167 m3/h Flow

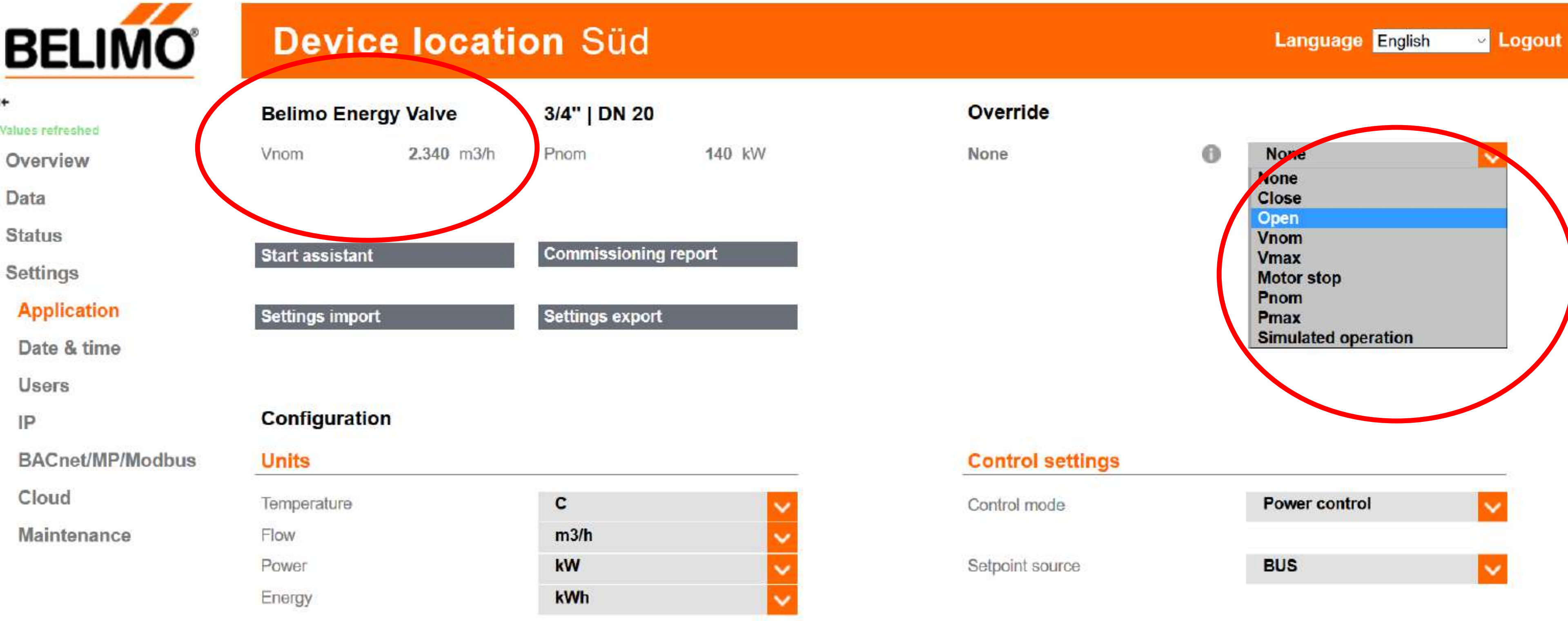
100 % Valve position

41.5 C Temp T2

10.3 kW Power

49.2 C Temp T1

Energy valve



Belimo Energy Valve **3/4" | DN 20**

Vnom 2.340 m3/h

Pnom 140 kW

Override

None: None

Configuration

Units

Temperature	C
Flow	m3/h
Power	kW
Energy	kWh

Control settings

Control mode	Power control
Setpoint source	BUS

Pale Moon

CoDeSys WebVisualization - Pale Moon

http://193.171.248.42:18102/plc/webvisu.htm

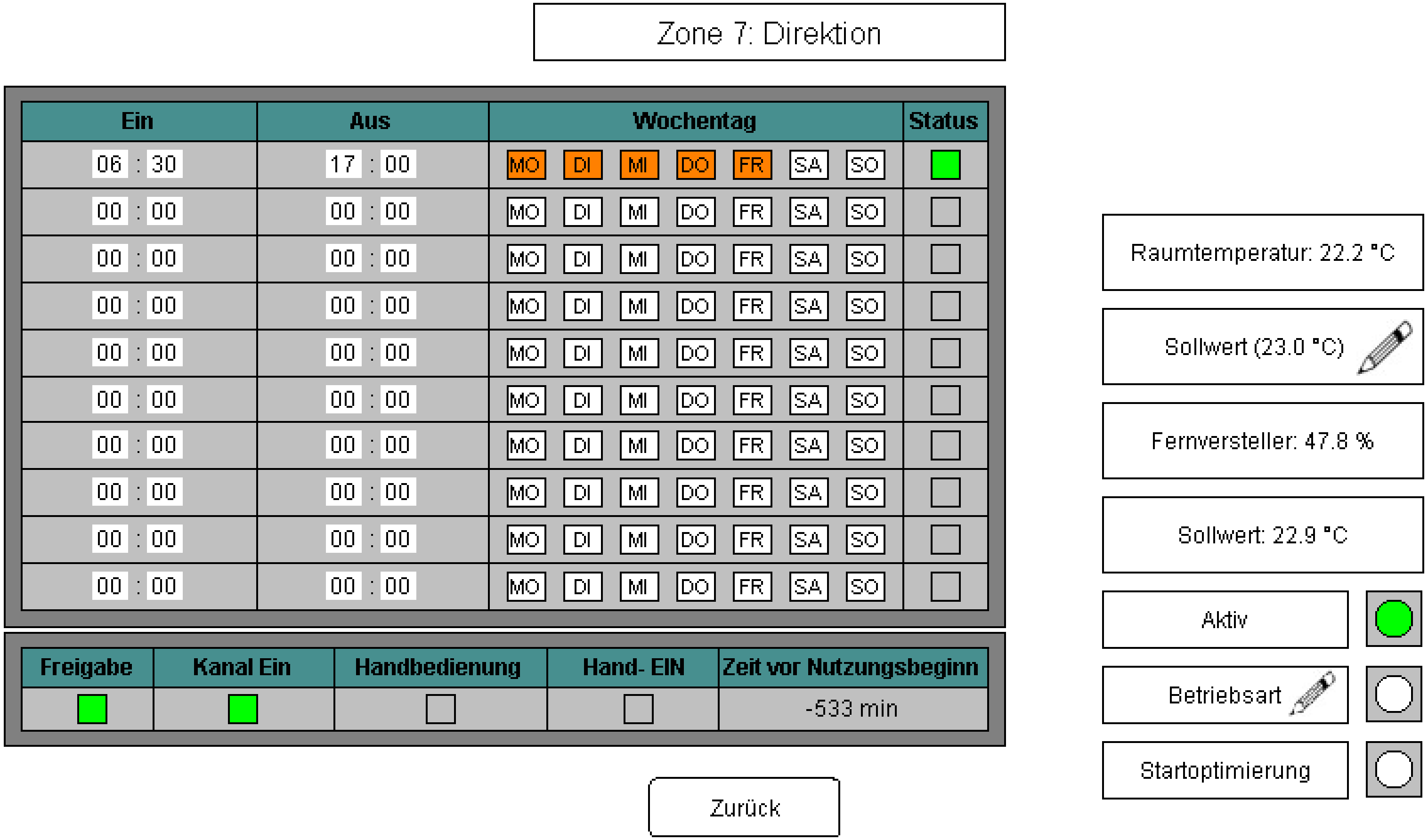
Most Visited · Pale Moon · Pale Moon forum · F.A.Q. · Release notes

CoDeSys WebVisualization

FISCHER

ELEKTROTECHNIK

Zone 1: Zentralgarderobe	Zone 6: Handarbeitsraum	Heizkreis Nord
Zone 2: Klassenzimmer 1	Zone 7: Direktion	Heizkreis Süd
Zone 3: Klassenzimmer 2	Zone 8: Konferenzzimmer	Heizkreis Sanitär
Zone 4: Pausenhalle	Zone 9: Turnsaal	Ferien
Zone 5: Jugendraum	Rücklauffühler	Versorgung
Es ist 08:10	Ausloggen	Zeit Taster 120 min



Zone 7: Direktion

Ein	Aus	Wochentag	Status
06 : 30	17 : 00	MO DI MI DO FR SA SO	🟩
00 : 00	00 : 00	MO DI MI DO FR SA SO	☐
00 : 00	00 : 00	MO DI MI DO FR SA SO	☐
00 : 00	00 : 00	MO DI MI DO FR SA SO	☐
00 : 00	00 : 00	MO DI MI DO FR SA SO	☐
00 : 00	00 : 00	MO DI MI DO FR SA SO	☐
00 : 00	00 : 00	MO DI MI DO FR SA SO	☐
00 : 00	00 : 00	MO DI MI DO FR SA SO	☐
00 : 00	00 : 00	MO DI MI DO FR SA SO	☐
00 : 00	00 : 00	MO DI MI DO FR SA SO	☐

Freigabe	Kanal Ein	Handbedienung	Hand- EIN	Zeit vor Nutzungsbeginn
🟩	🟩	☐	☐	-533 min

Raumtemperatur: 22.2 °C

Sollwert (23.0 °C)

Fernversteller: 47.8 %

Sollwert: 22.9 °C

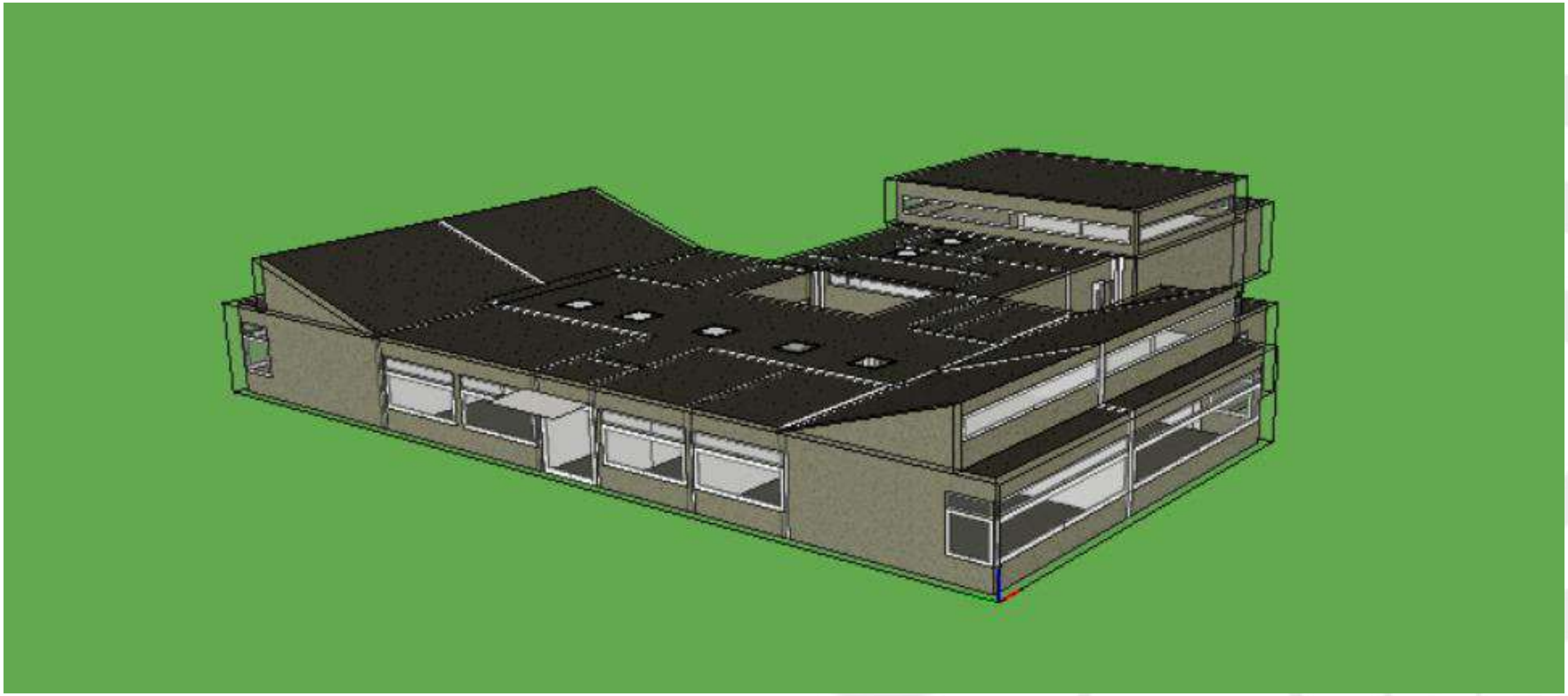
Aktiv ●

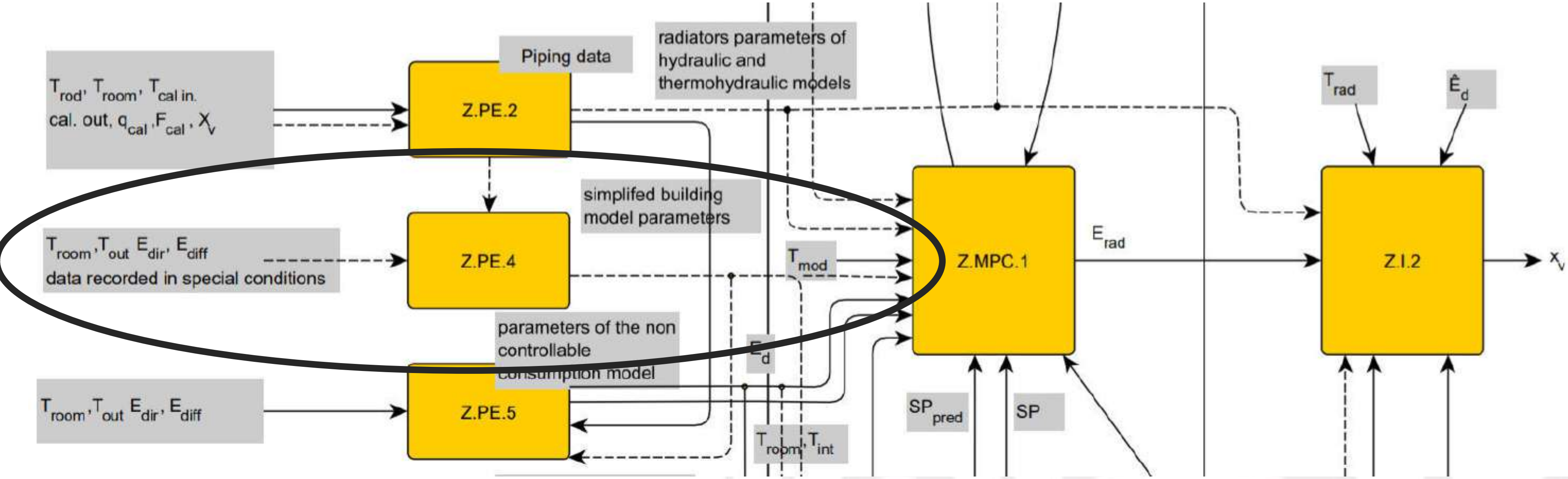
Betriebsart ○

Startoptimierung ○

Simplified building model
(Strem school and Retirement care center)
Z.PE.4

IDA-ICE model of school




T_{rod}, T_{room}, $T_{cal\ in.}$
cal. out, q_{cal}, F_{cal}, X_v
Piping data
Z.PE.2
radiators parameters of hydraulic and thermohydraulic models
T_{rad}
$\hat{E}_d$
simplifed building model parameters
T_{room}, T_{out} E_{dir}, E_{diff}
data recorded in special conditions
Z.PE.4
T_{mod}
Z.MPC.1
E_{rad}
Z.I.2
x_v
parameters of the non controllable consumption model
E_d
T_{room}, T_{out} E_{dir}, E_{diff}
Z.PE.5
T_{room}, T_{int}
SP_{pred}
SP

- 14 days simulation in IDA-ICE software
- Thermal behaviour of the building without internal heat disturbances (light, equipment, people, window opening...)
- Varibles taken from IDA-ICE: T_{room}, T_{out}, E_{dir}, E_{dif} (one minute interval)
- Parameters obtained in Matlab environment

Thank you for your attention!

Online demonstration: Zone level modules (Floor heating/cooling system)

Petar Marić, Ivan Bevanda

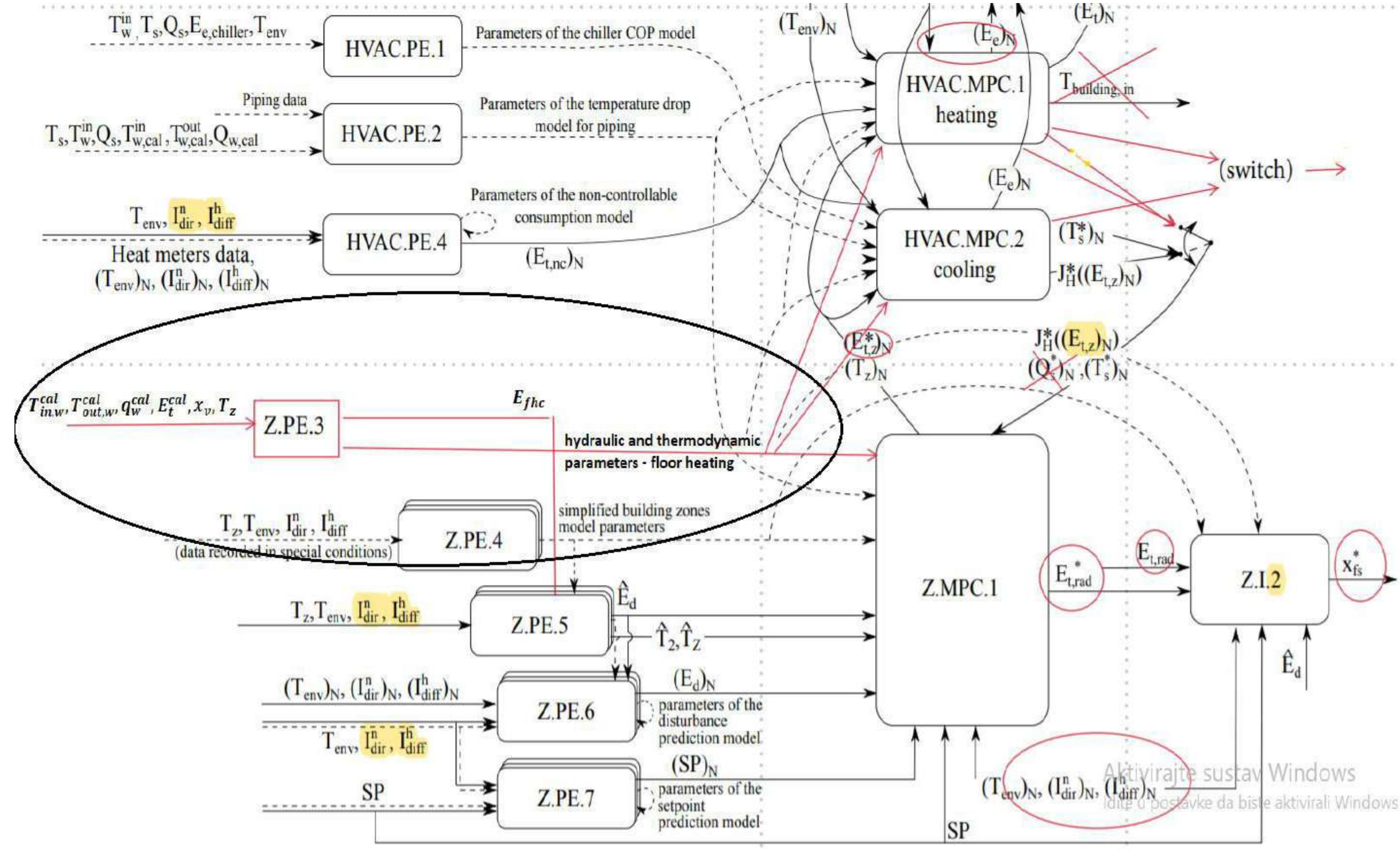
Faculty of Mechanical Engineering, Computing and Electrical Engineering

petar.maric@fsre.sum.ba

3Smart 1st pilot study visit to the Slovenian pilot

Strem, 27th – 28th March 2019

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


$T_w^{in}, T_s, Q_s, E_{e,chiller}, T_{env}$
HVAC.PE.1
Parameters of the chiller COP model
Piping data
$T_s, T_w^{in}, Q_s, T_{w,cal}^{in}, T_{w,cal}^{out}, Q_{w,cal}$
HVAC.PE.2
Parameters of the temperature drop model for piping
$T_{env}, I_{dir}^n, I_{diff}^h$
Heat meters data, $(T_{env})_N, (I_{dir}^n)_N, (I_{diff}^h)_N$
HVAC.PE.4
Parameters of the non-controllable consumption model
$(E_{t,nc})_N$
$(T_{env})_N$
$(E_e)_N$
$(E_t)_N$
HVAC.MPC.1 heating
~~$T_{building, in}$~~
(switch)
$(E_e)_N$
HVAC.MPC.2 cooling
$(T_s^*)_N$
$J_H^*((E_{t,z})_N)$
$(E_{t,z}^*)_N$
$(T_z)_N$
$J_H^*((E_{t,z})_N)$
$(Q_s^*)_N, (T_s^*)_N$
$T_{in,w}^{cal}, T_{out,w}^{cal}, q_w^{cal}, E_t^{cal}, x_v, T_z$
Z.PE.3
E_{fhc}
hydraulic and thermodynamic parameters - floor heating
$T_z, T_{env}, I_{dir}^n, I_{diff}^h$
(data recorded in special conditions)
Z.PE.4
simplified building zones model parameters
$T_z, T_{env}, I_{dir}^n, I_{diff}^h$
Z.PE.5
$\hat{E}_d$
$\hat{T}_2, \hat{T}_Z$
$(T_{env})_N, (I_{dir}^n)_N, (I_{diff}^h)_N$
$T_{env}, I_{dir}^n, I_{diff}^h$
Z.PE.6
$(E_d)_N$
parameters of the disturbance prediction model
SP
Z.PE.7
$(SP)_N$
parameters of the setpoint prediction model
Z.MPC.1
$E_{t,rad}^*$
$E_{t,rad}$
Z.I.2
x_{fs}^*
$\hat{E}_d$
$(T_{env})_N, (I_{dir}^n)_N, (I_{diff}^h)_N$
SP

Module inputs

- Measured inlet water temperature $\boldsymbol{T_{in,w}^{cal}}$ collected from the „duct south"
- Measured outgoing water temperature $\boldsymbol{T_{out,w}^{cal}}$ collected from the installed sensors
- Medium mass flow $\boldsymbol{q_{w}^{cal}}$ collected from the „duct south"
- Measured zone temperature $\boldsymbol{T_{z}}$ collected from the zone sensor
- Valve current position $\boldsymbol{x_{v}}$

Measurement and identification problems

- Initial measurements are going to be done with the zone 661 since this zone is most of the time unoccupied
- Measurement procedure is going to be adjusted since of the existing problem with the outgoing water mixing pipes
- Outgoing water pipe from the zone „661” is connected with the outgoing pipe of the zone „Friseur” before the temperature of water is measured
- Similar problem existing in other zones where the outgoing water pipe from the bathroom is connected to the 2 outgoing water pipes in the room

Measurement procedure

- First step would be to mechanically close all valves in the zone „661“ and the zone „Friseur“
- This state should be kept for at least 5 days in order to lower the temperature of the concrete and the zone temperature
- Then the 3 valves connected to the zone „661“ should be opened for at least 7 days in in order to capture the transition state of the temperature

Thanks for the attention

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

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3Smart pilot study visit to AUT pilot No. 1 in Strem

28 March 2019

Project co-funded by the European Union

Current modules status

General prerequisites

1. Server connection (OpenVPN)
2. Database connection (PgAdmin)
3. Python connection (SSH access, libraries etc.)
4. Database data analysis

Current modules status

General prerequisites

1. Server connection (OpenVPN) ✓
2. Database connection (PgAdmin)
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Current modules status

General prerequisites

1. Server connection (OpenVPN)
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Current modules status

General prerequisites

1. Server connection (OpenVPN)
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Current modules status

General prerequisites

1. Server connection (OpenVPN)
2. Database connection (PgAdmin)
3. Python connection (SSH access, libraries etc.)
4. Database data analysis

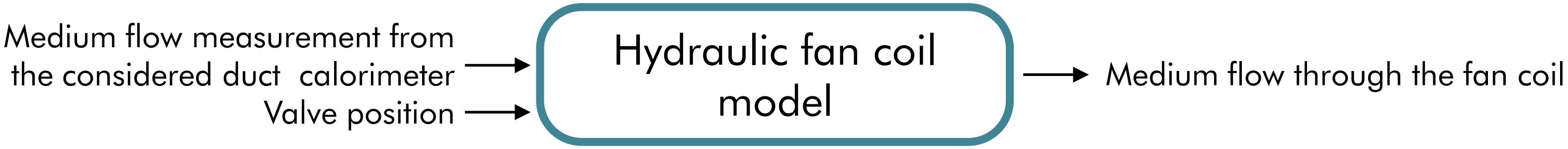
Additional prerequisites for Linux server environment

- Basic prerequisites published in WP7: 3Smart_modules_installation_and_monitoring_v0.6_UNIZGFER.docx
- Some Python packages needed:
  - ipython
  - json, simplejson
  - apscheduler
  - numpy, scipy, pandas, sklearn
  - pysolar, pytz, threading
  - psycopg2/pymssql (depending on installed DB)
- Either pre-install packages or give developers rights to do that
- If Linux is installed on a VM, 4GB RAM and 2-4 CPU cores minimum; DB must be directly accessible from VM
- Established two-way connection between Linux VM and grid-side server

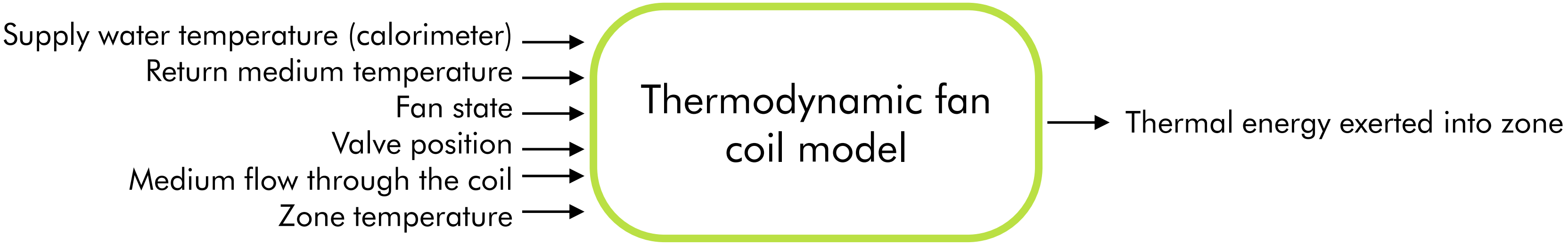
Zone-level modules
Strem pilots

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

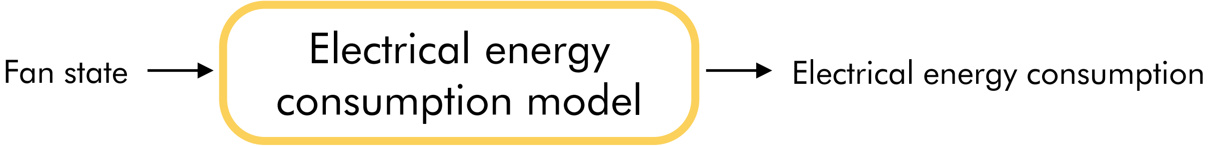
- Identification of hydraulic fan coil model - based on experimental data recorded under special conditions or piping data for floors and pressure drop data from manufacturer's catalogue



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

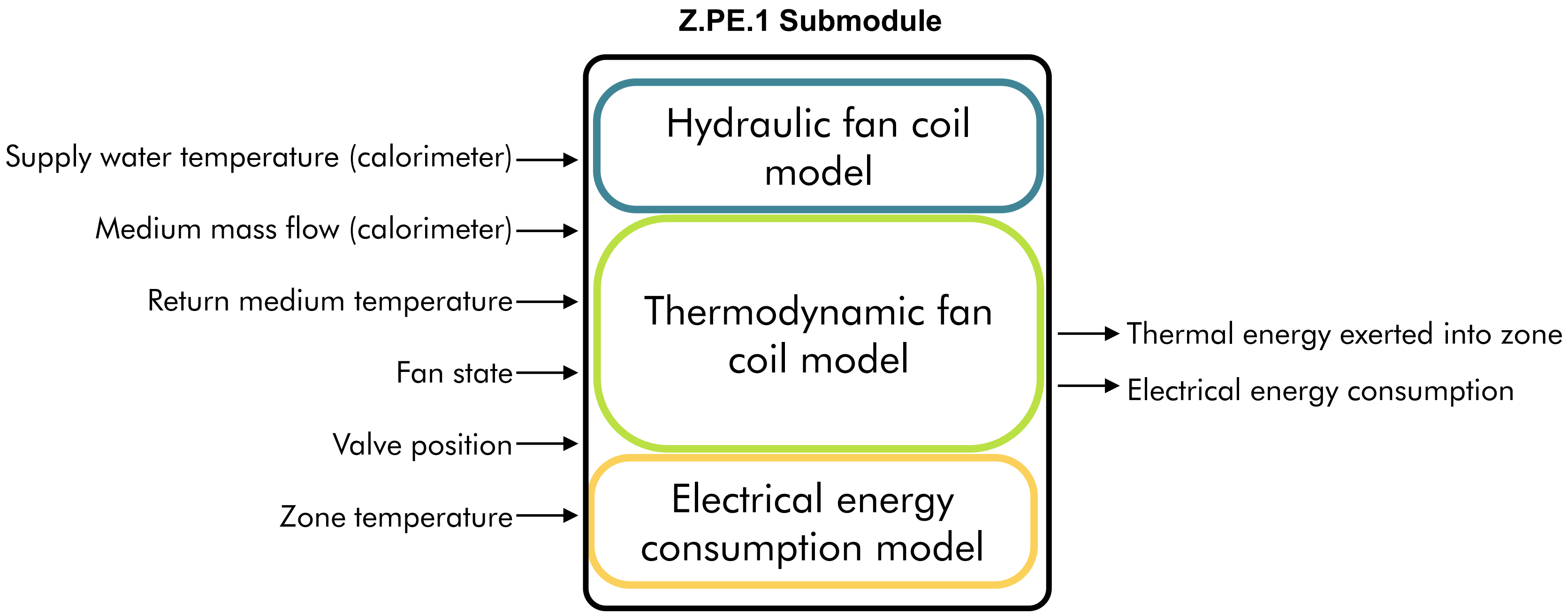


- Identification of electrical energy consumption model of fan coil unit based on the manufacturer's catalogue data



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

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



Z.PE.1 Submodule

Supply water temperature (calorimeter) →
Medium mass flow (calorimeter) →
Return medium temperature →
Fan state →
Valve position →
Zone temperature →

Hydraulic fan coil model

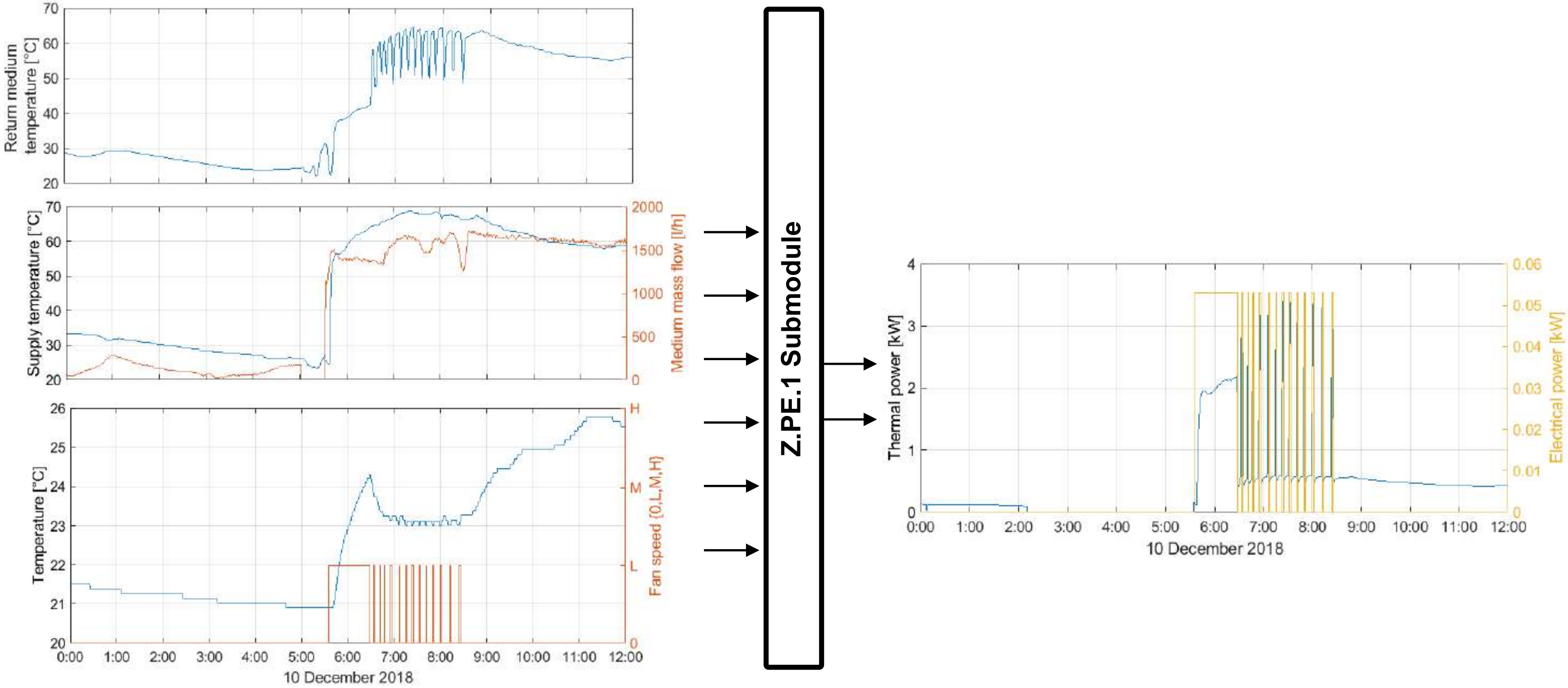
Thermodynamic fan coil model

Electrical energy consumption model

→ Thermal energy exerted into zone
→ Electrical energy consumption

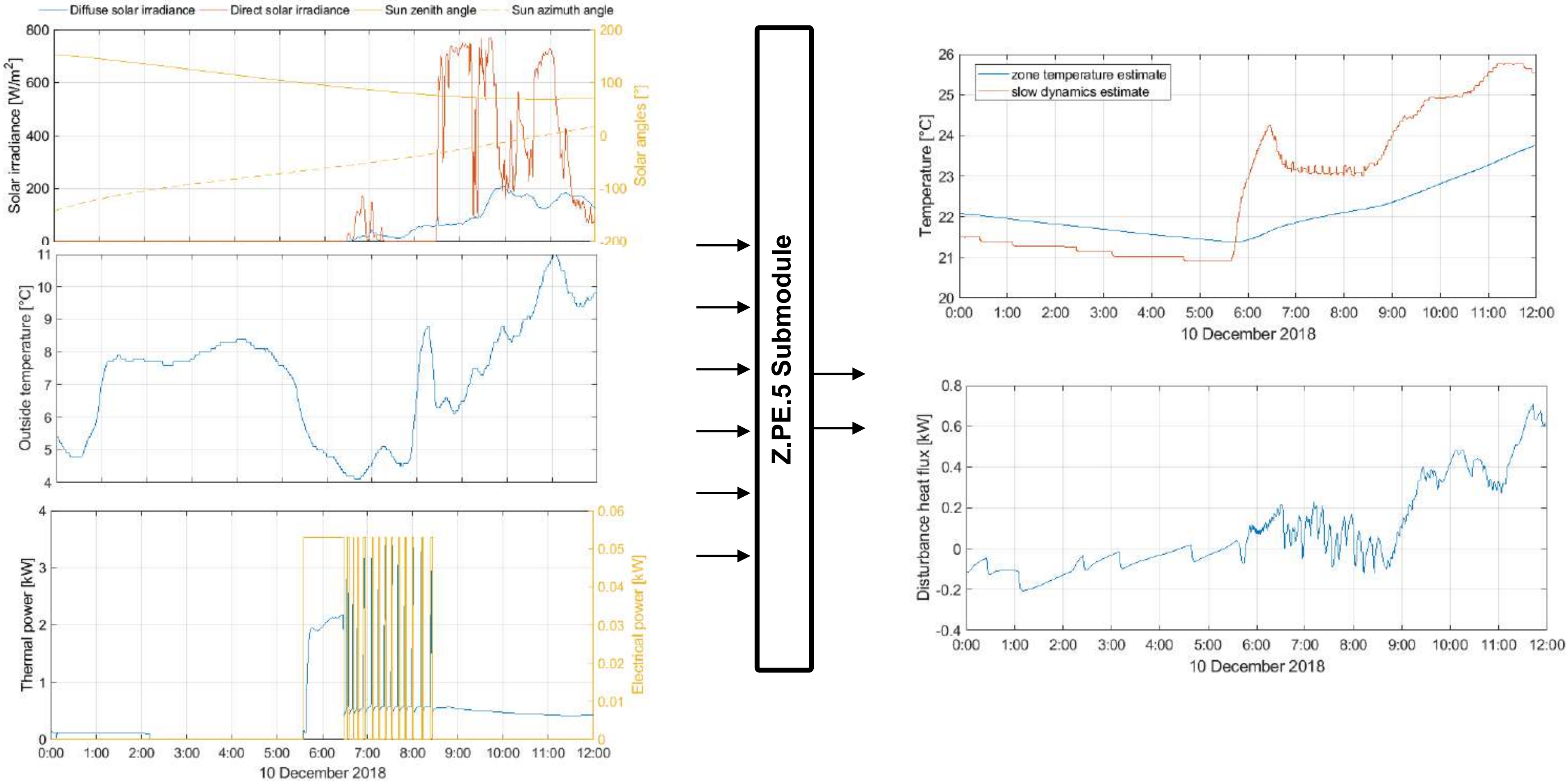
Z.PE.1 – online (fan coil identification submodule)

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



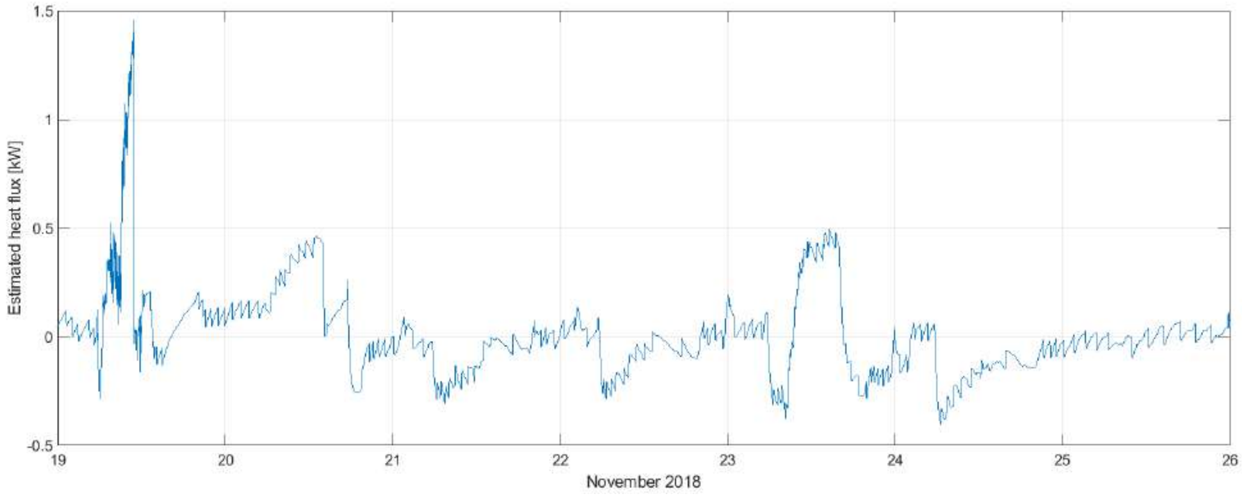
Zone PE 5

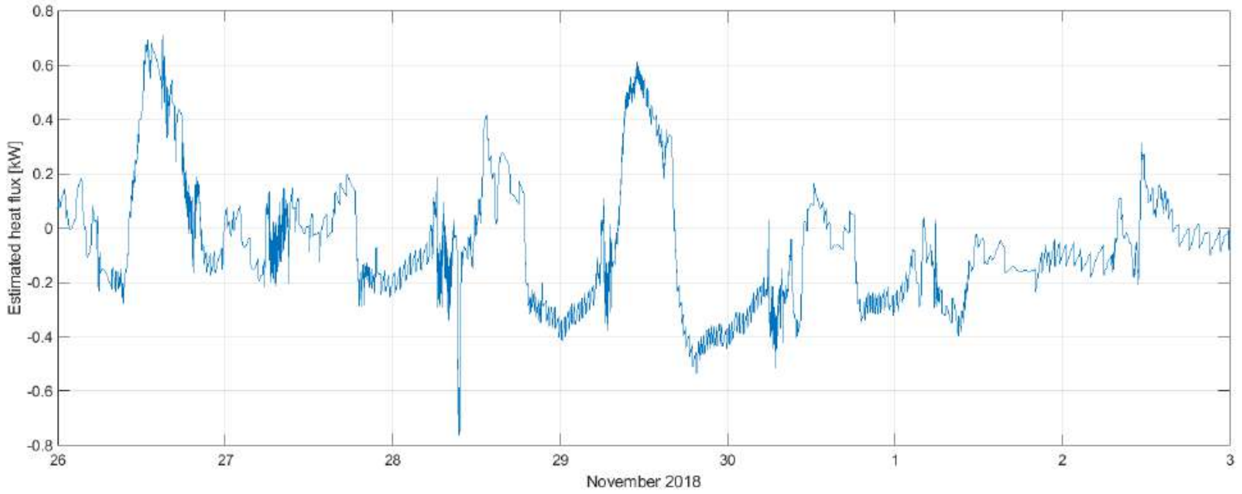
(estimation of the states of the simplified building thermal dynamics model including also the estimation of heat disturbance in zone)



Zone PE 5

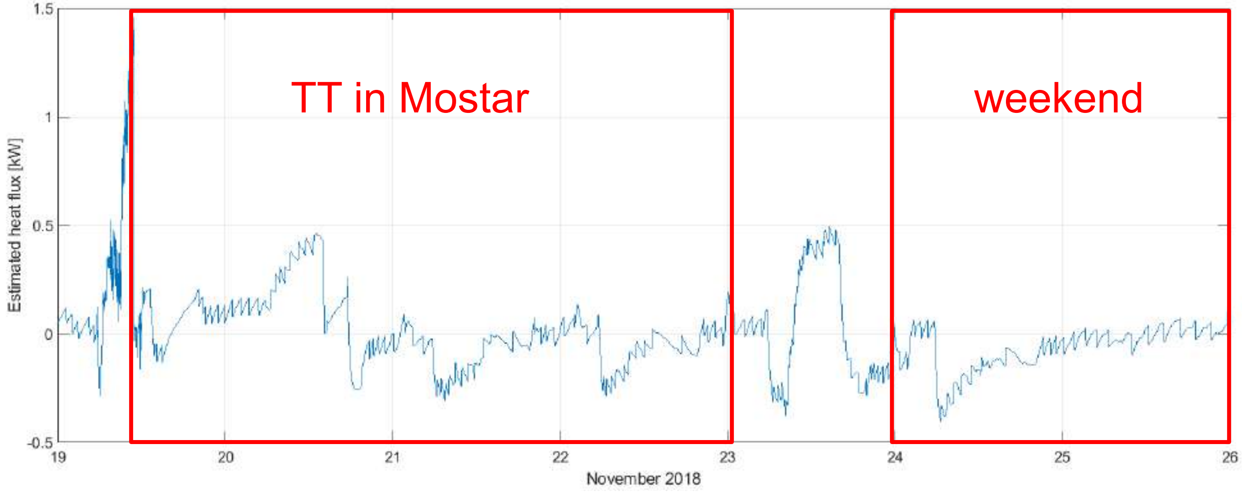
(estimation of the states of the simplified building thermal dynamics model including also the estimation of heat disturbance in zone)

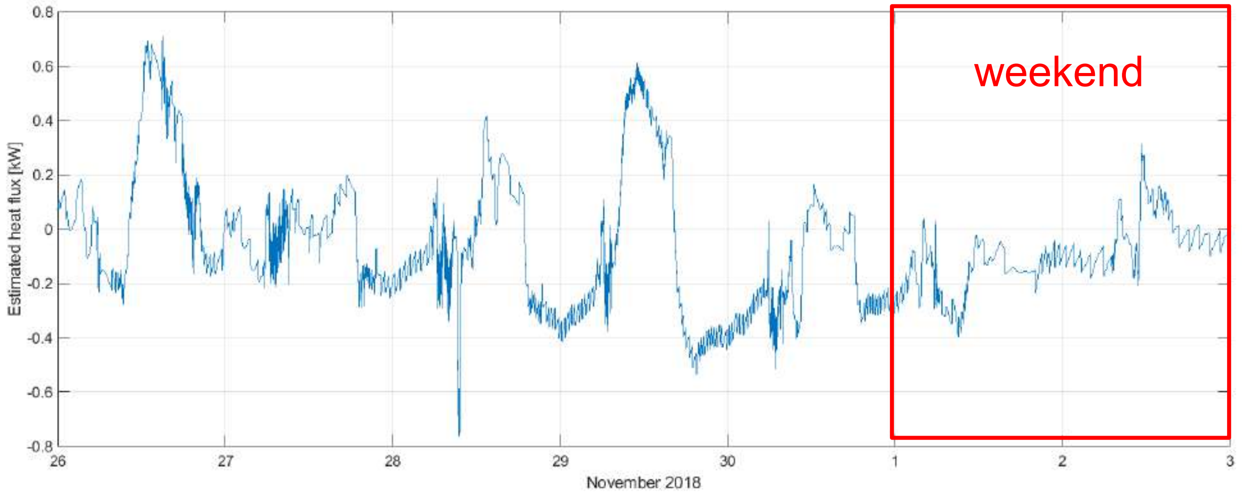




Zone PE 5

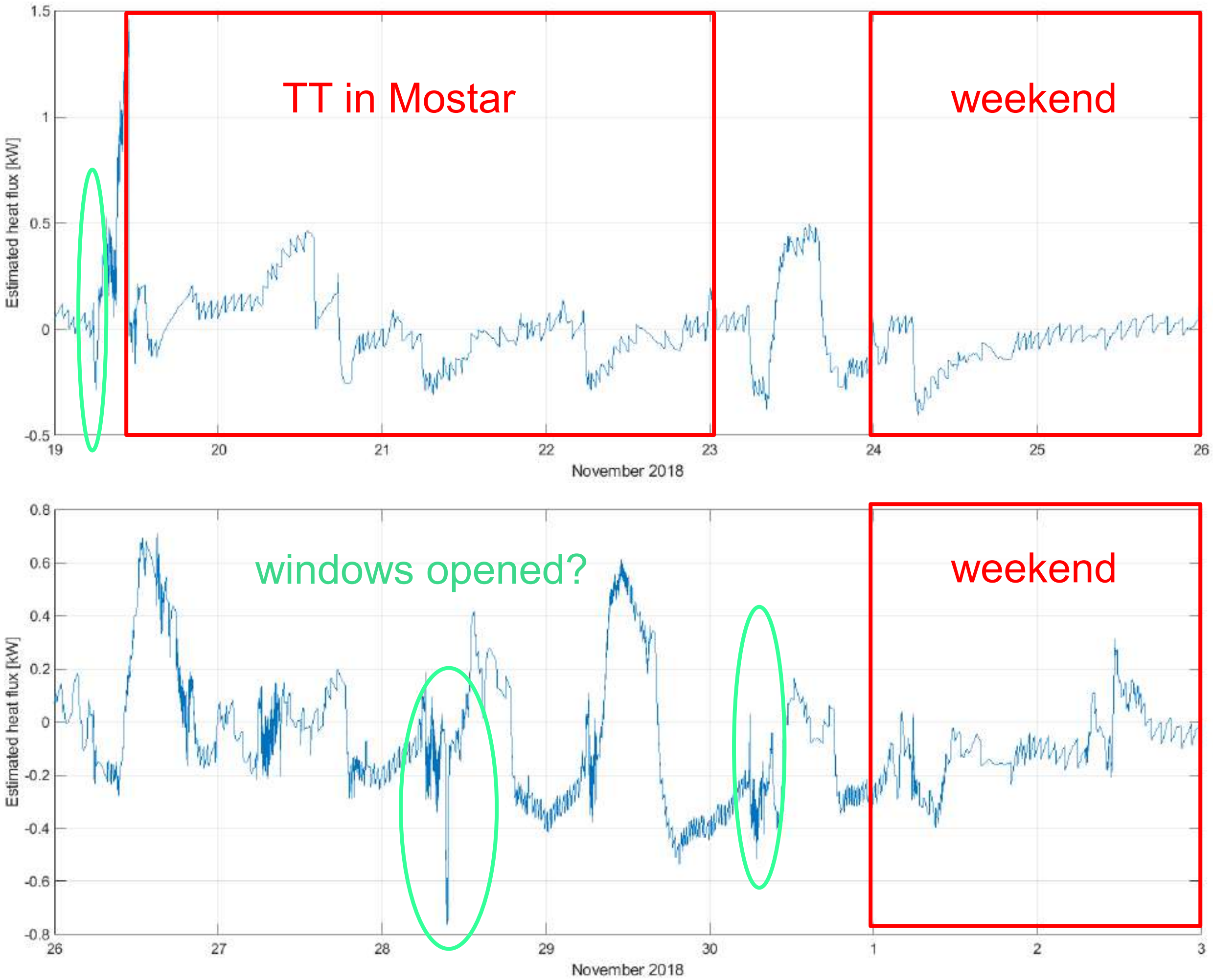
(estimation of the states of the simplified building thermal dynamics model including also the estimation of heat disturbance in zone)



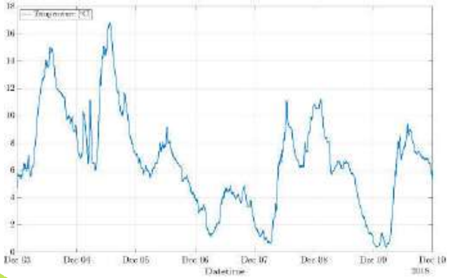


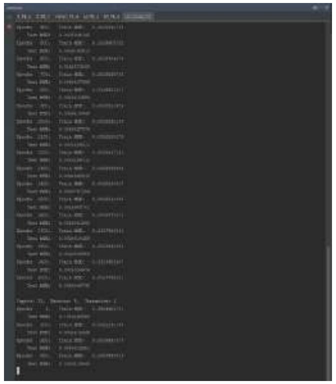
Zone PE 5

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



Zone PE 6 – off-line initialization

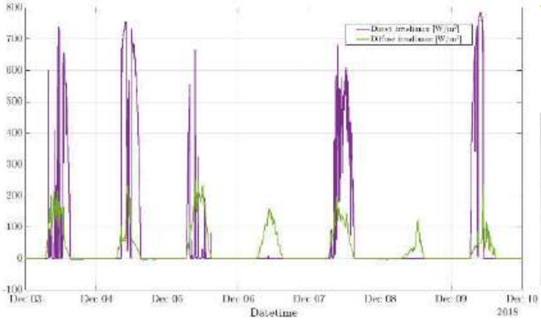




Historical **weather measurements**:

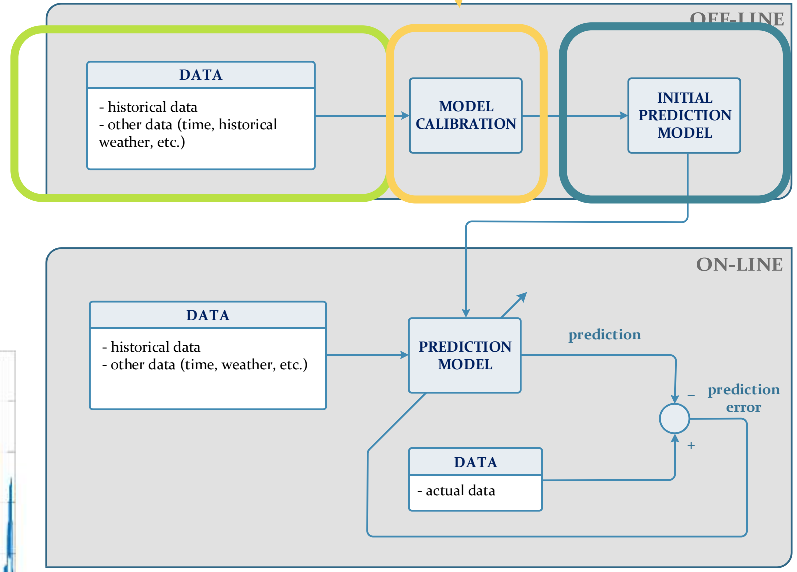
- Temperature
- Direct, diffuse solar irradiance

Locally stored:
inputsXY_neuronsZ.net

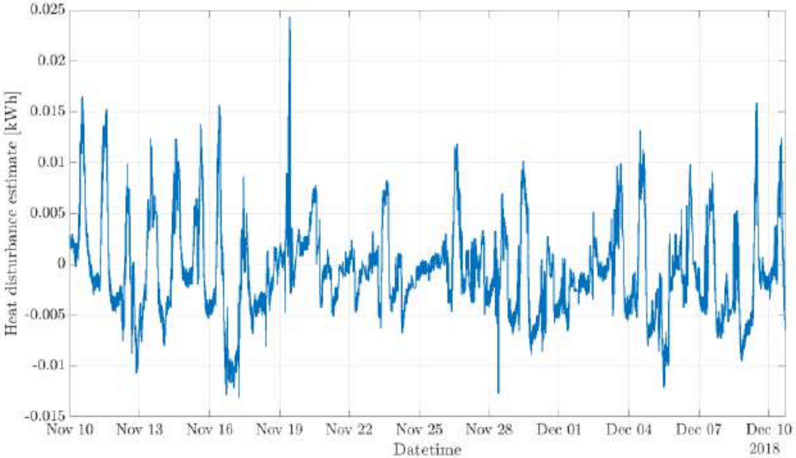


MODULE INPUTS

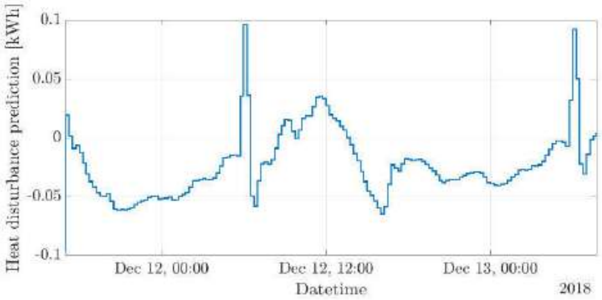
MODULE



Historical **heat disturbance estimate**



Zone PE 6 – on-line operation



Regressor created from specific historical intervals of data:

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

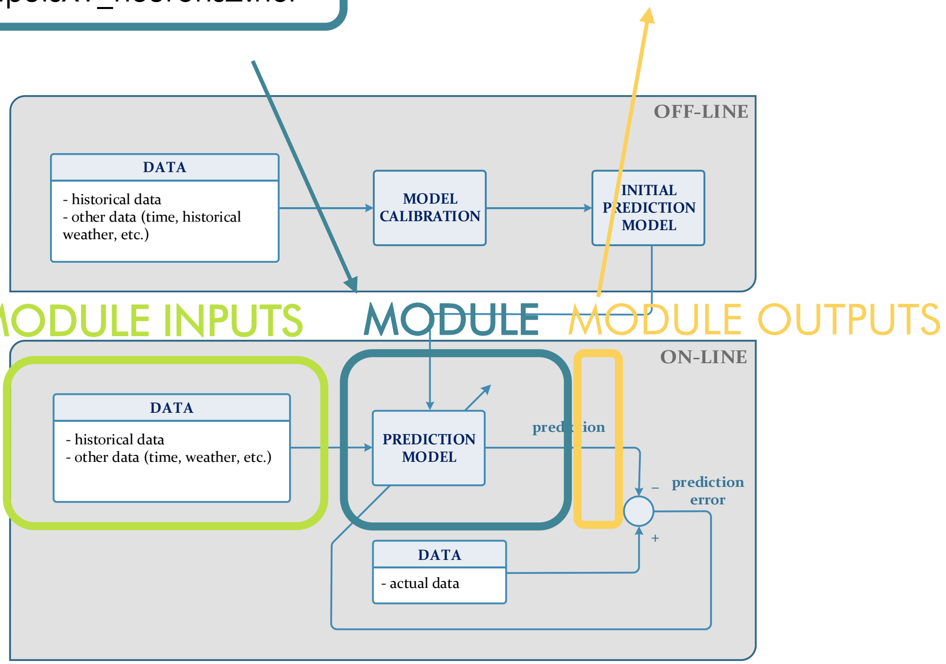
- tau_s_d, tau_c_d
- tau_s_w, tau_c_w
- tau_s_y, tau_c_y

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

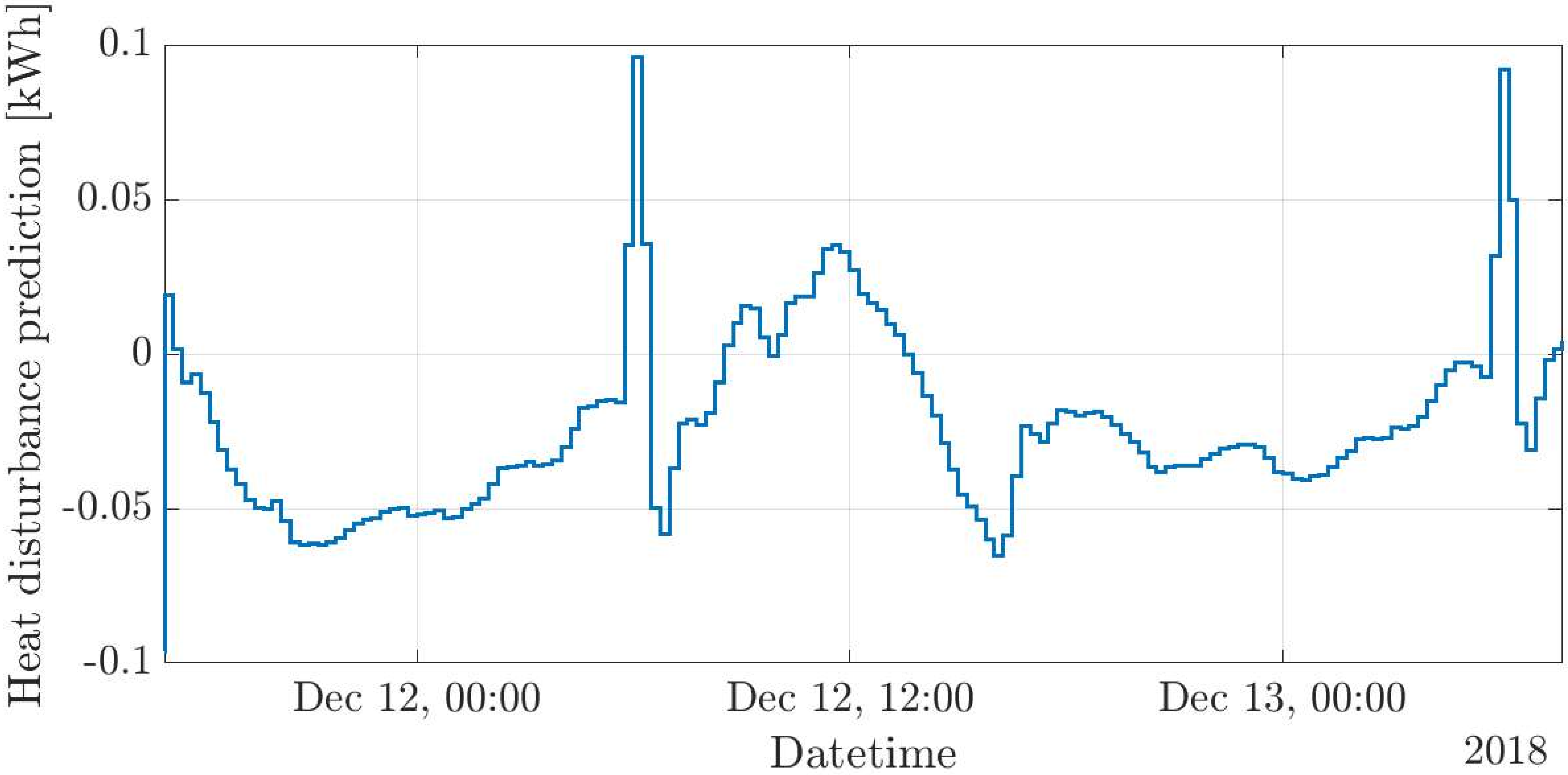
- direct irradiance(t-1,…,t-3)
- direct irradiance(t-47,…,t-49)
- direct irradiance(t-167,…,t-169)

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

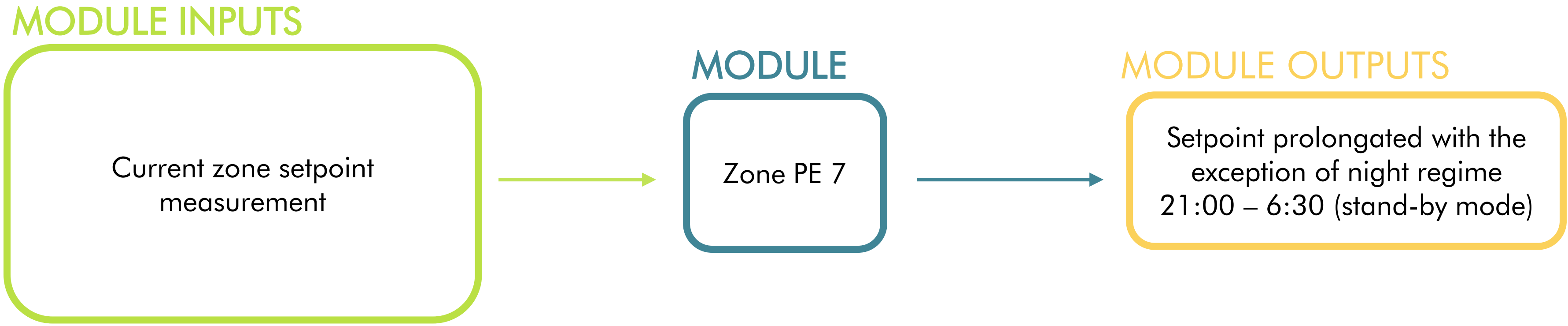
Locally stored:
inputsXY_neuronsZ.net



Zone PE 6 – on-line operation



Zone PE 7 – zone in auto mode



MODULE INPUTS

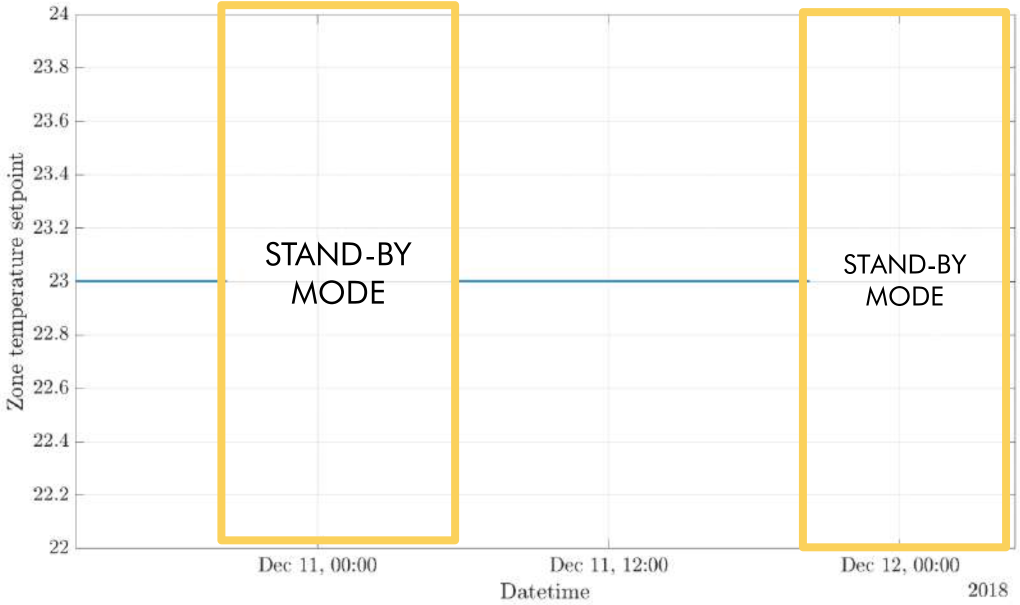
Current zone setpoint measurement

MODULE

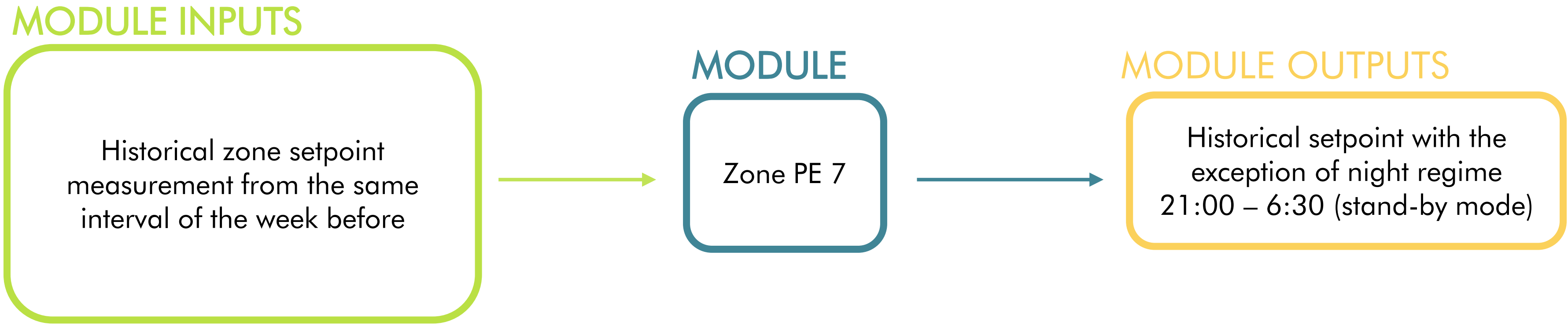
Zone PE 7

MODULE OUTPUTS

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



Zone PE 7 – zone in off mode



MODULE INPUTS

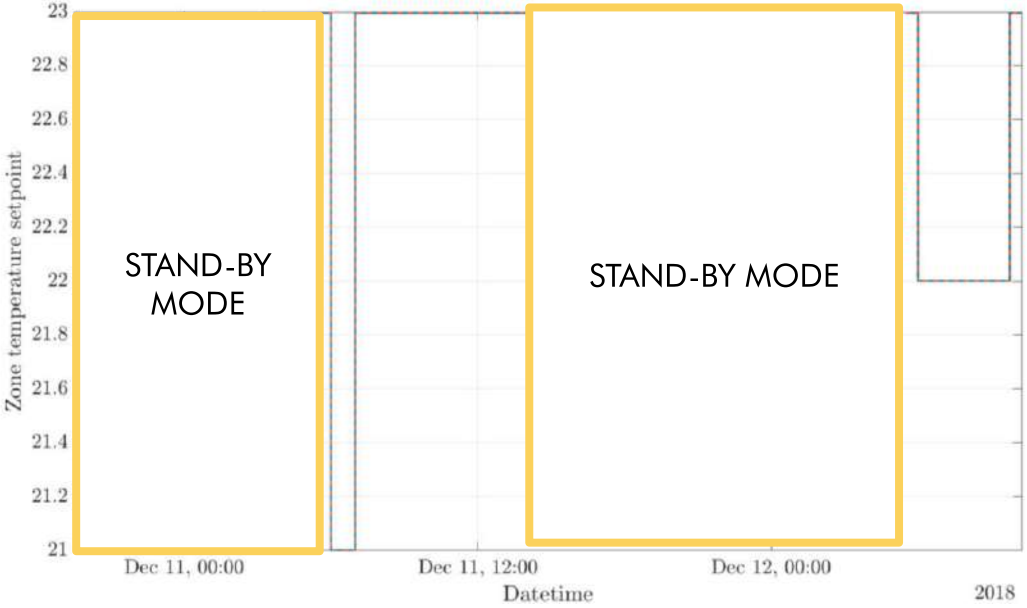
Historical zone setpoint measurement from the same interval of the week before

MODULE

Zone PE 7

MODULE OUTPUTS

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



Zone PE 7 – school building and retirement care centre

- School building:
  - Fixed schedule
  - Schedule fetched from the database and prolongated along the prediction horizon

- Retirement care centre:
  - All zones always in AUTO mode
  - Current setpoint fetched for all zones and prolongated along the prediction horizon
  - Check historical data and see if there is a need for ANN

Zone PE 7 – school building and retirement care centre

- **School building:**
  - Fixed schedule
  - Schedule fetched from the database and prolongated along the prediction horizon
- Retirement care centre:
  - All zones always in AUTO mode
  - Current setpoint fetched for all zones and prolongated along the prediction horizon
  - Check historical data and see if there is a need for ANN

Zone PE 7 – school building and retirement care centre

- School building:
  - Fixed schedule
  - Schedule fetched from the database and prolongated along the prediction horizon
- Retirement care centre:
  - All zones always in AUTO mode
  - Current setpoint fetched for all zones and prolongated along the prediction horizon
  - Check historical data and see if there is a need for ANN

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

INPUTS

a) locally stored and outputs of other 3smart modules

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

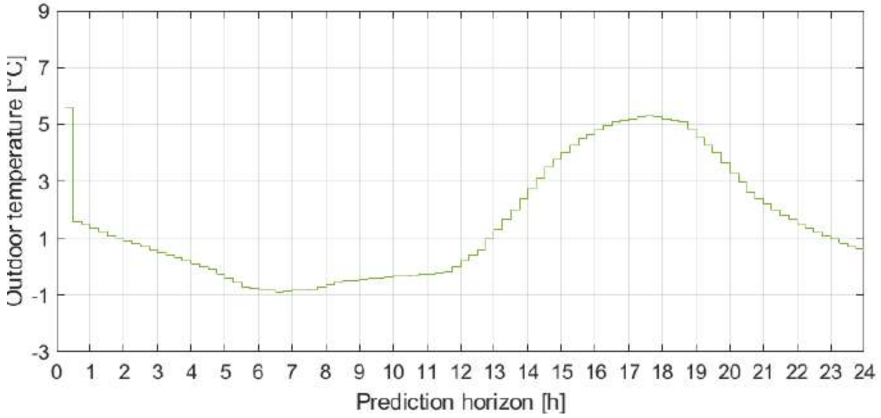
HCE = heating/cooling elements

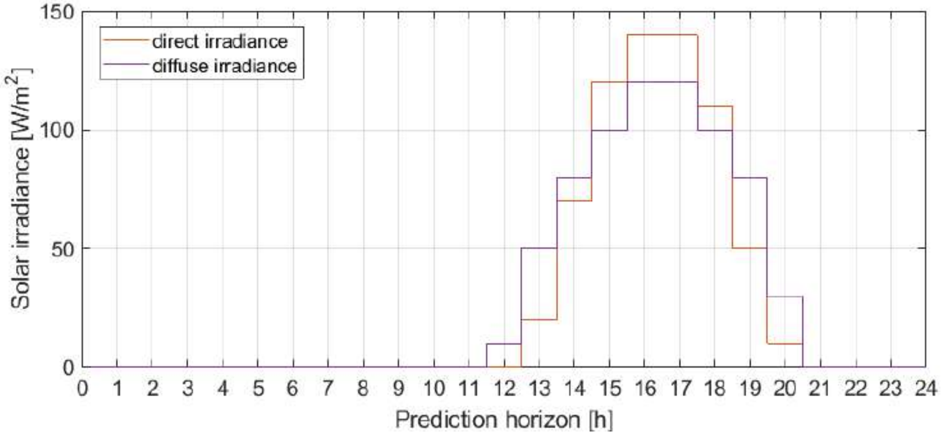
Zone MPC 1
(model predictive control module for zones comfort control)

INPUTS

b) predictions

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



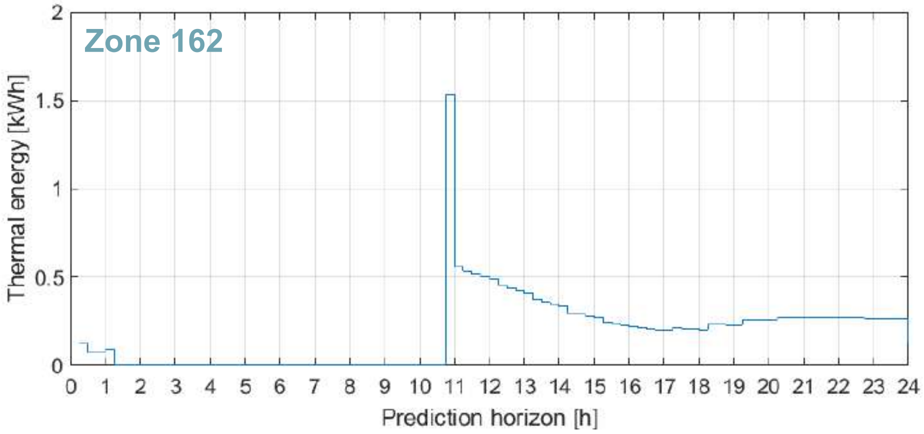


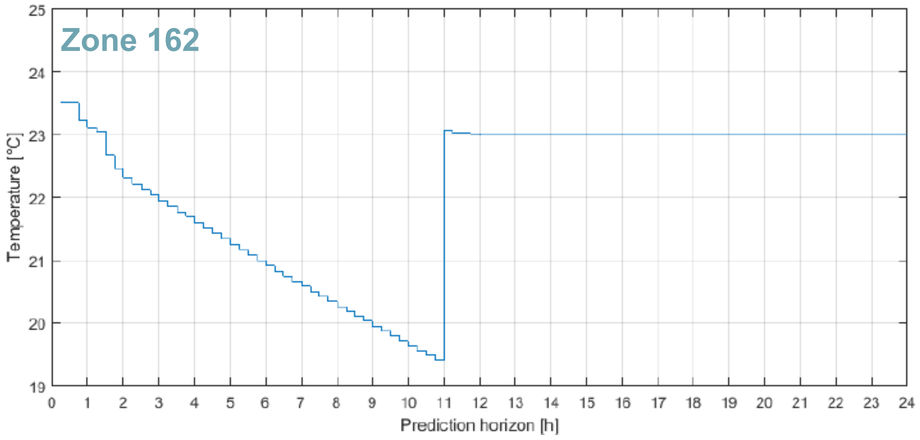
PREDICTION START : 10 December 2018 20:00

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

OUTPUTS

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





Zone Interface 1
(Fan coils energy input control submodule)

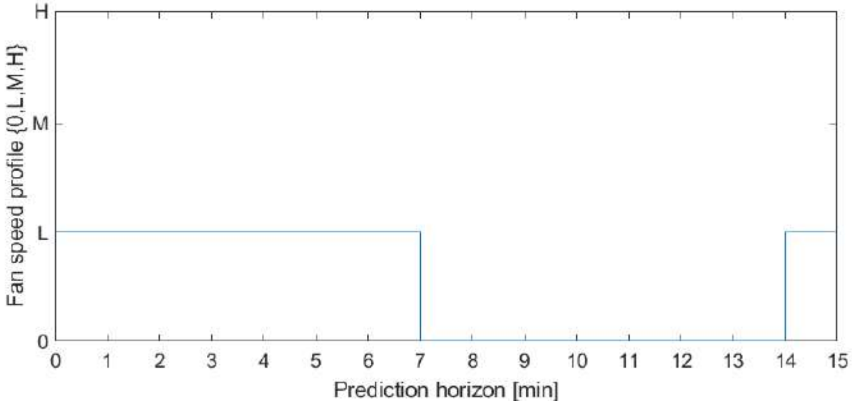
INPUTS

a) energy input request

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

OUTPUT

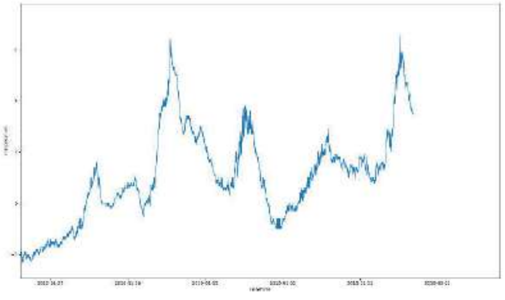
a) fan spees profile within current 15 min interval

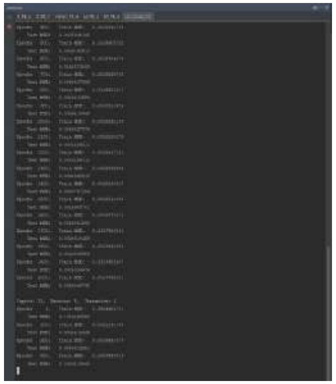


HVAC-level modules
Strem pilots

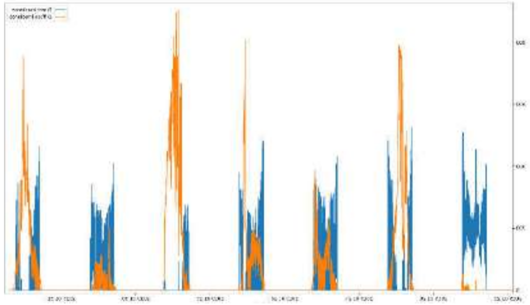
HVAC PE 4 – off-line initialization

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

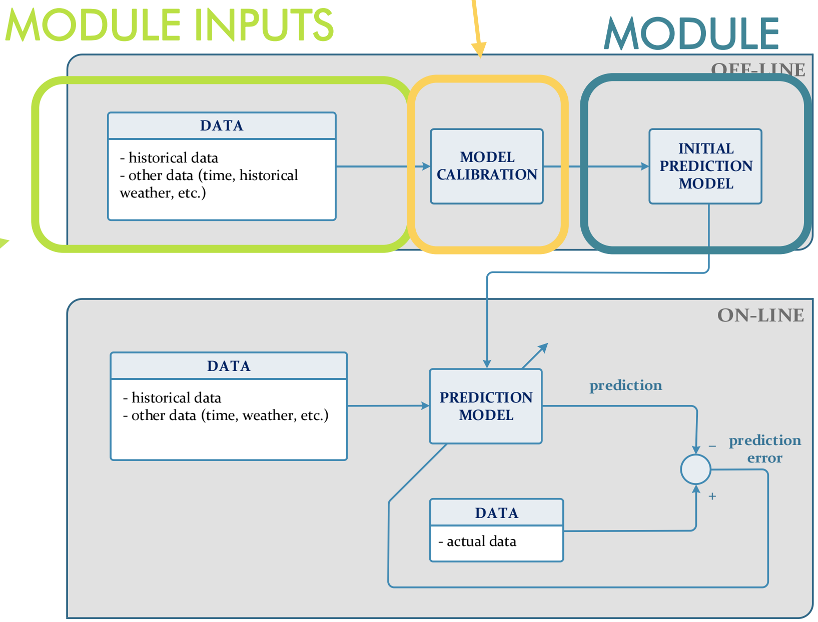




Locally stored:
inputsXY_neuronsZ.net



Historical **non-controllable consumption**



MODULE INPUTS

MODULE

OFF-LINE

DATA

- historical data
- other data (time, historical weather, etc.)

MODEL CALIBRATION

INITIAL PREDICTION MODEL

ON-LINE

DATA

- historical data
- other data (time, weather, etc.)

PREDICTION MODEL

prediction

prediction error

DATA

- actual data

HVAC PE 4 – non-controllable consumption – school building

Consumed heat on the non-controllable thermal circuit calorimeter

👍

HVAC PE 4 – non-controllable consumption – retirement care centre

COOLING PERIOD

Output of the cooling machine

-

calorimeter measurement from the controlled supply line

HEATING PERIOD

Consumed heat on the central calorimeter

-

calorimeter measurement from the controlled supply line

HVAC MPC -level modules Strem

HVAC MPC – module operation

- Description: medium condition optimisation → costs and comfort

HVAC MPC 1 – module operation

- Description: medium condition optimisation → costs and comfort
- Module interaction:
    - 4.2.1. - Microgrid MPC module
    - 4.4.1. – Zone MPC module
    - 4.3.1./4.4.1 – P&E modules, interface module

HVAC MPC 1 – module operation

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

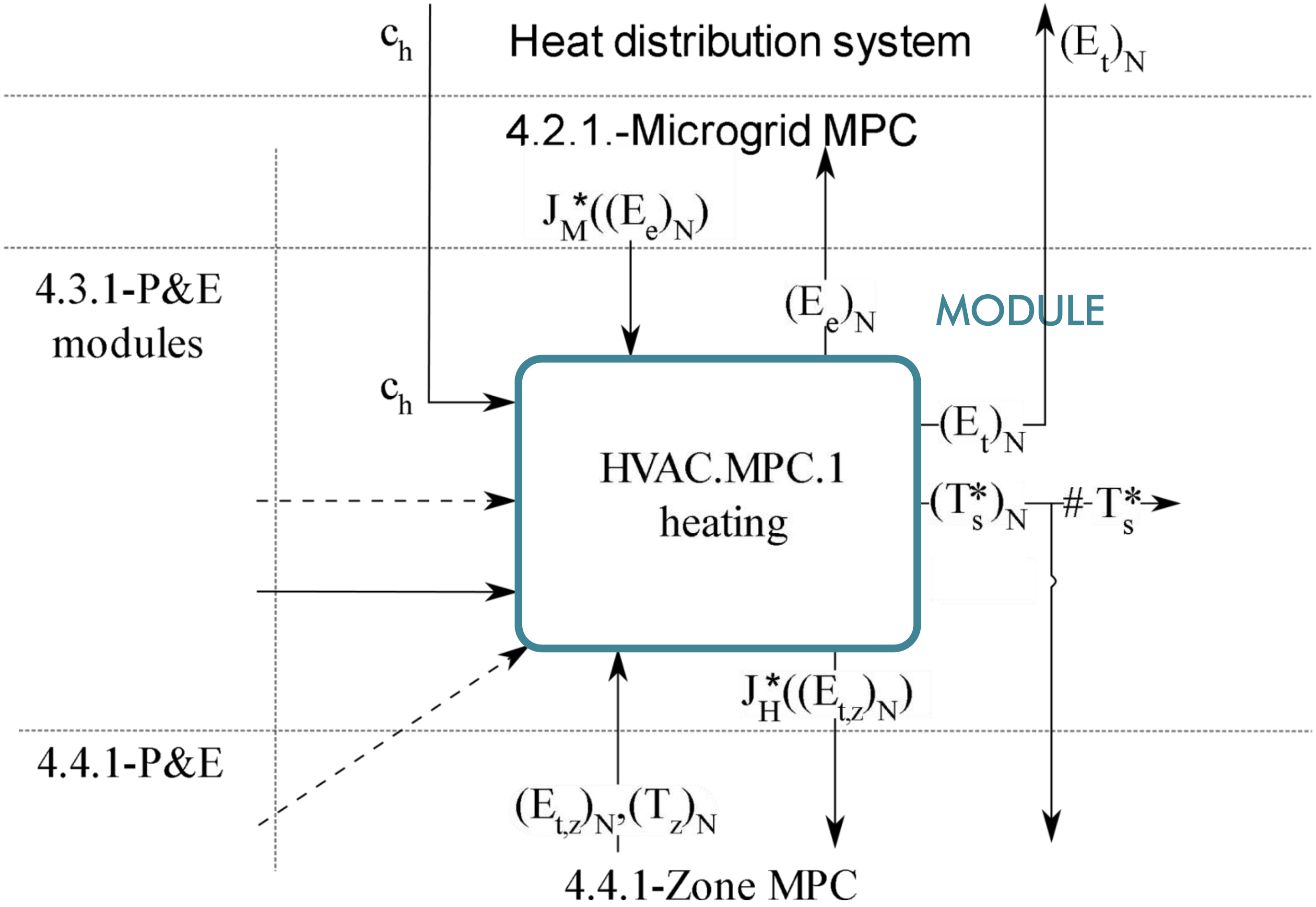
HVAC MPC 1 – module operation

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

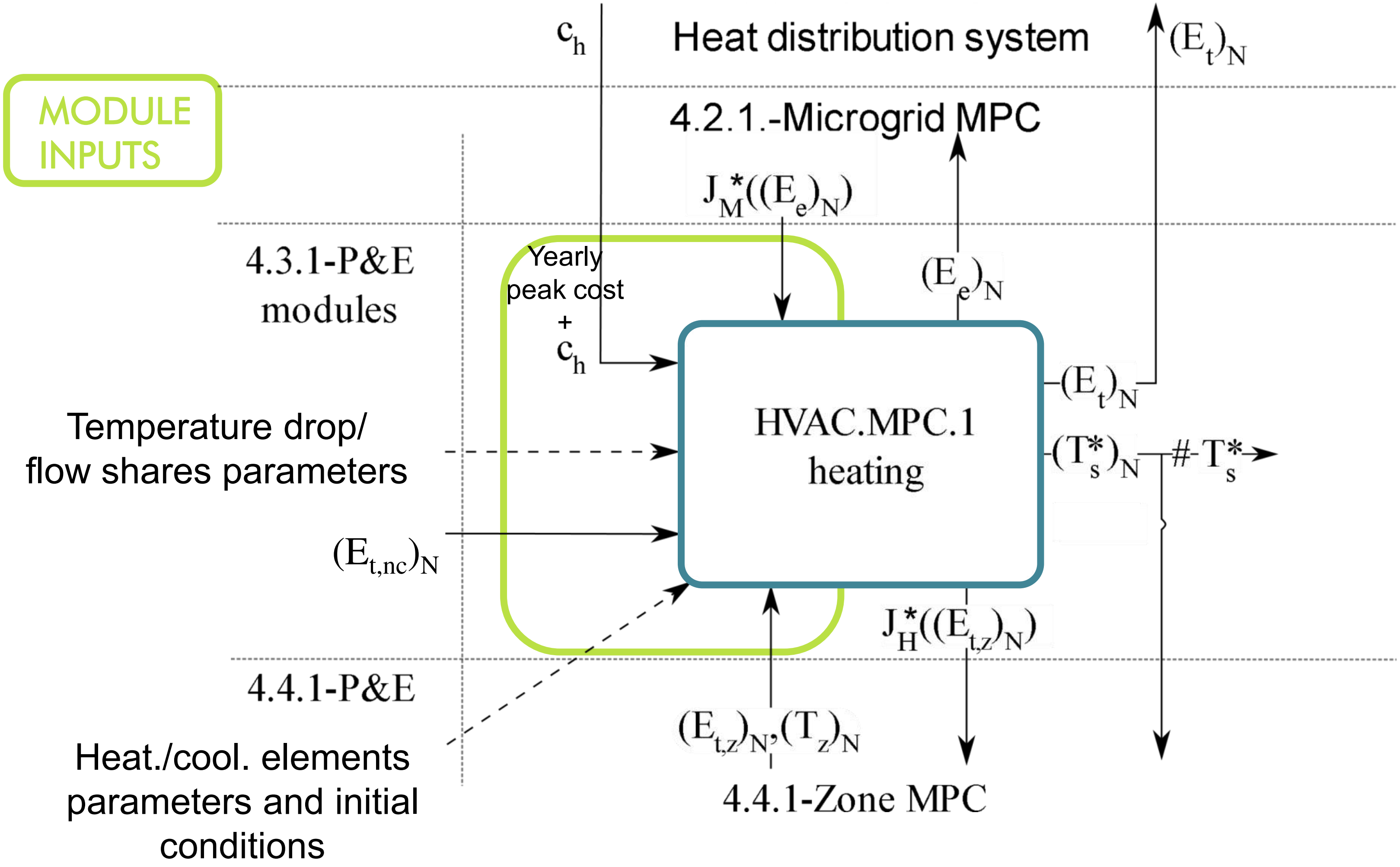
HVAC MPC 1- Heating substation

School

HVAC MPC 1 – information flow



HVAC MPC 1 – information flow



MODULE INPUTS

c_h

Heat distribution system

$(E_t)_N$

4.2.1.-Microgrid MPC

$J_M^*((E_e)_N)$

4.3.1-P&E modules

Yearly peak cost + c_h

$(E_e)_N$

$(E_t)_N$

HVAC.MPC.1 heating

Temperature drop/ flow shares parameters

$(T_s^*)_N$ #-T_s^*

$(E_{t,nc})_N$

$J_H^*((E_{t,z})_N)$

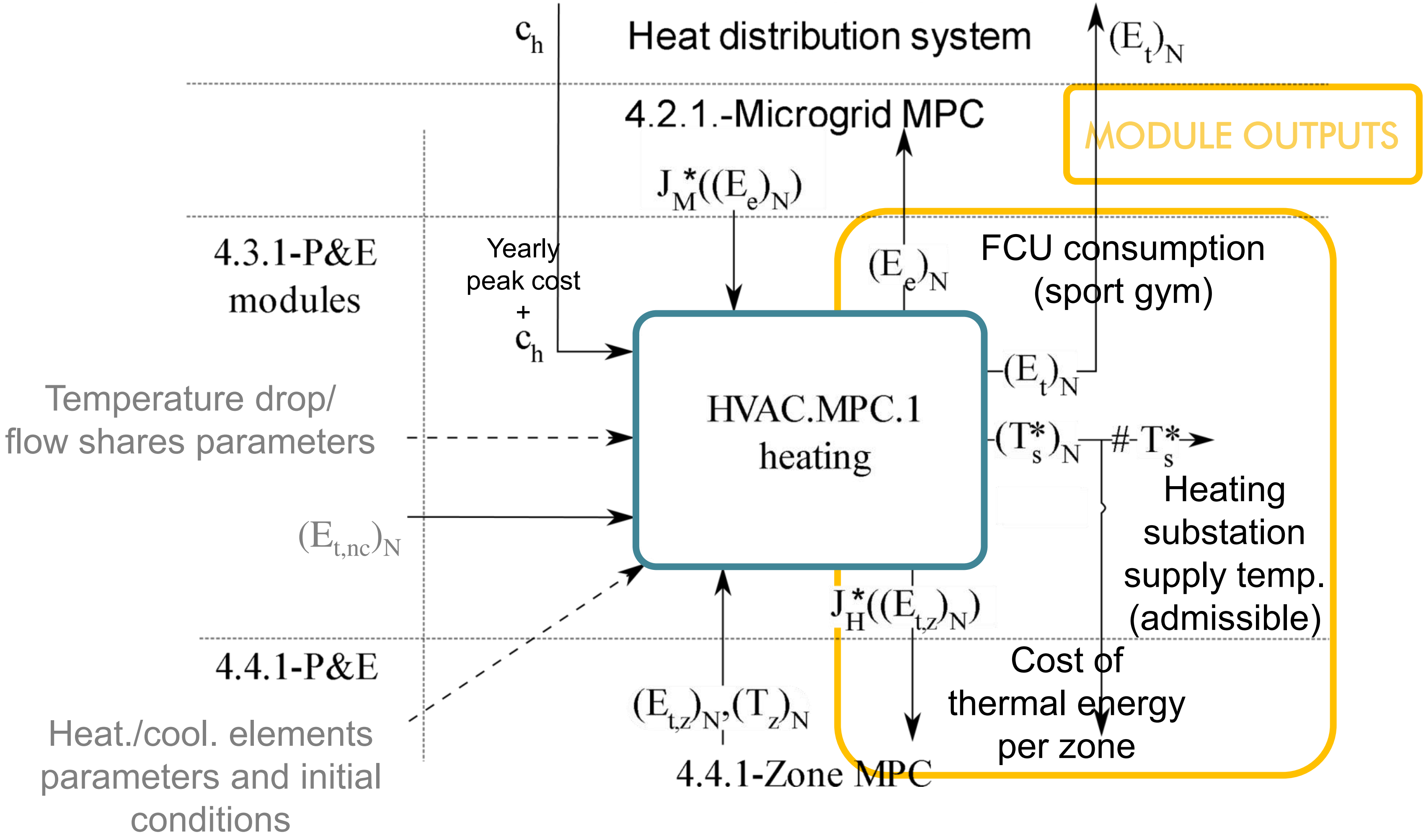
4.4.1-P&E

$(E_{t,z})_N,(T_z)_N$

Heat./cool. elements parameters and initial conditions

4.4.1-Zone MPC

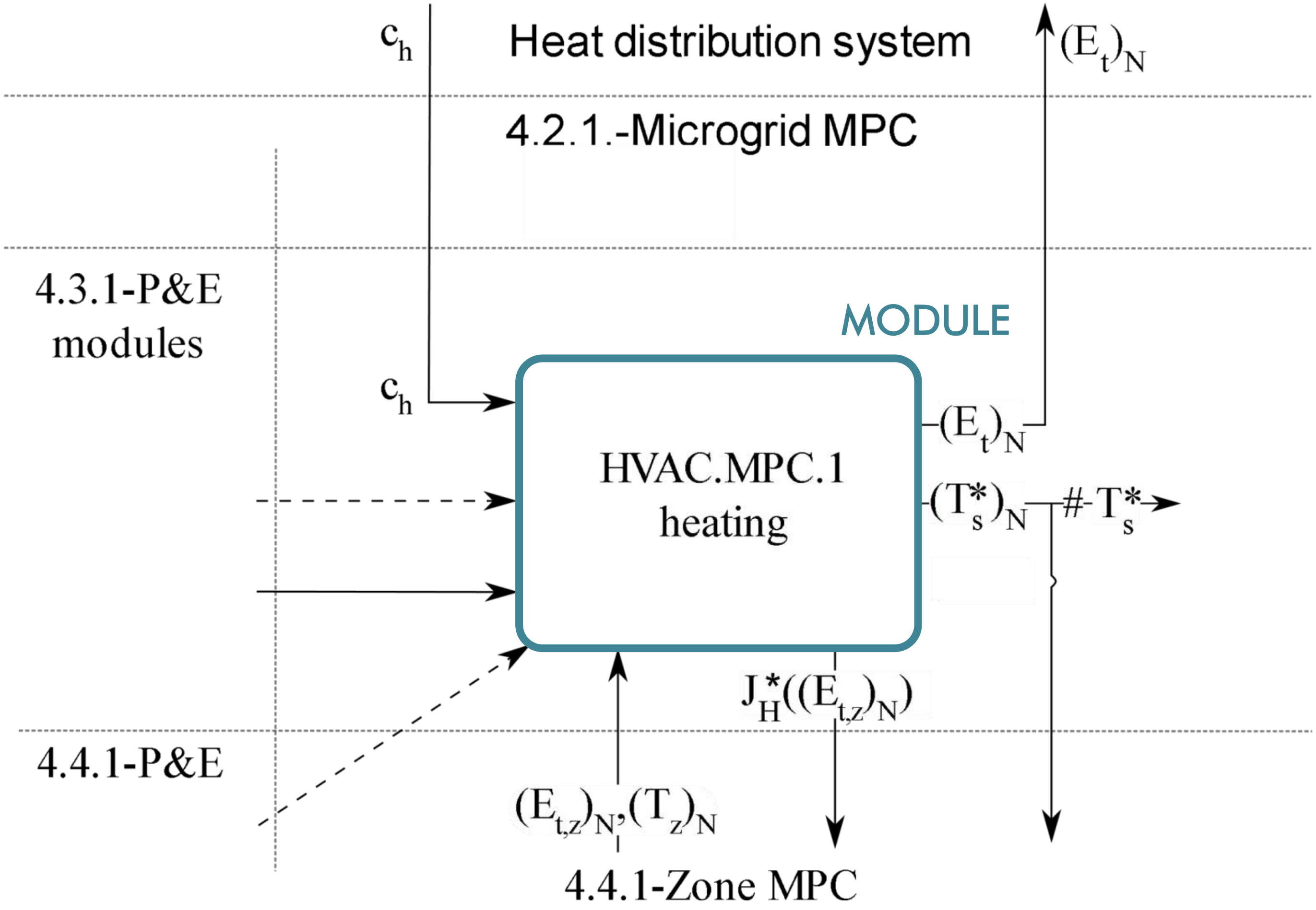
HVAC MPC 1 – information flow



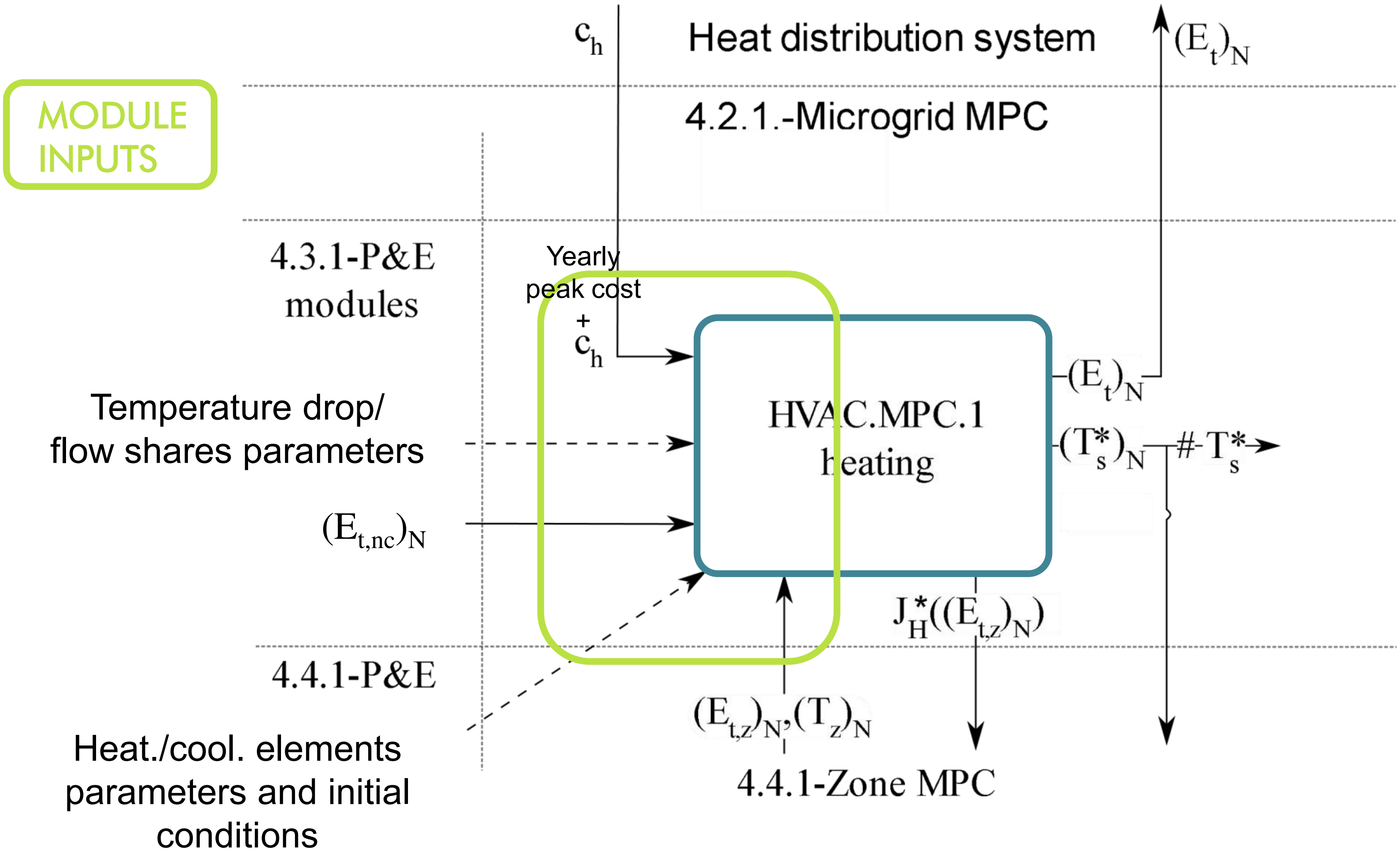
HVAC MPC 1- Heating substation

Retirement and care center

HVAC MPC 1 – information flow



HVAC MPC 1 – information flow



MODULE INPUTS

c_h

Heat distribution system

$(E_t)_N$

4.2.1.-Microgrid MPC

4.3.1-P&E modules

Yearly peak cost + c_h

Temperature drop/ flow shares parameters

$(E_{t,nc})_N$

HVAC.MPC.1 heating

$(E_t)_N$

$(T^*_s)_N$ — # T^*_s

$J^*_H((E_{t,z})_N)$

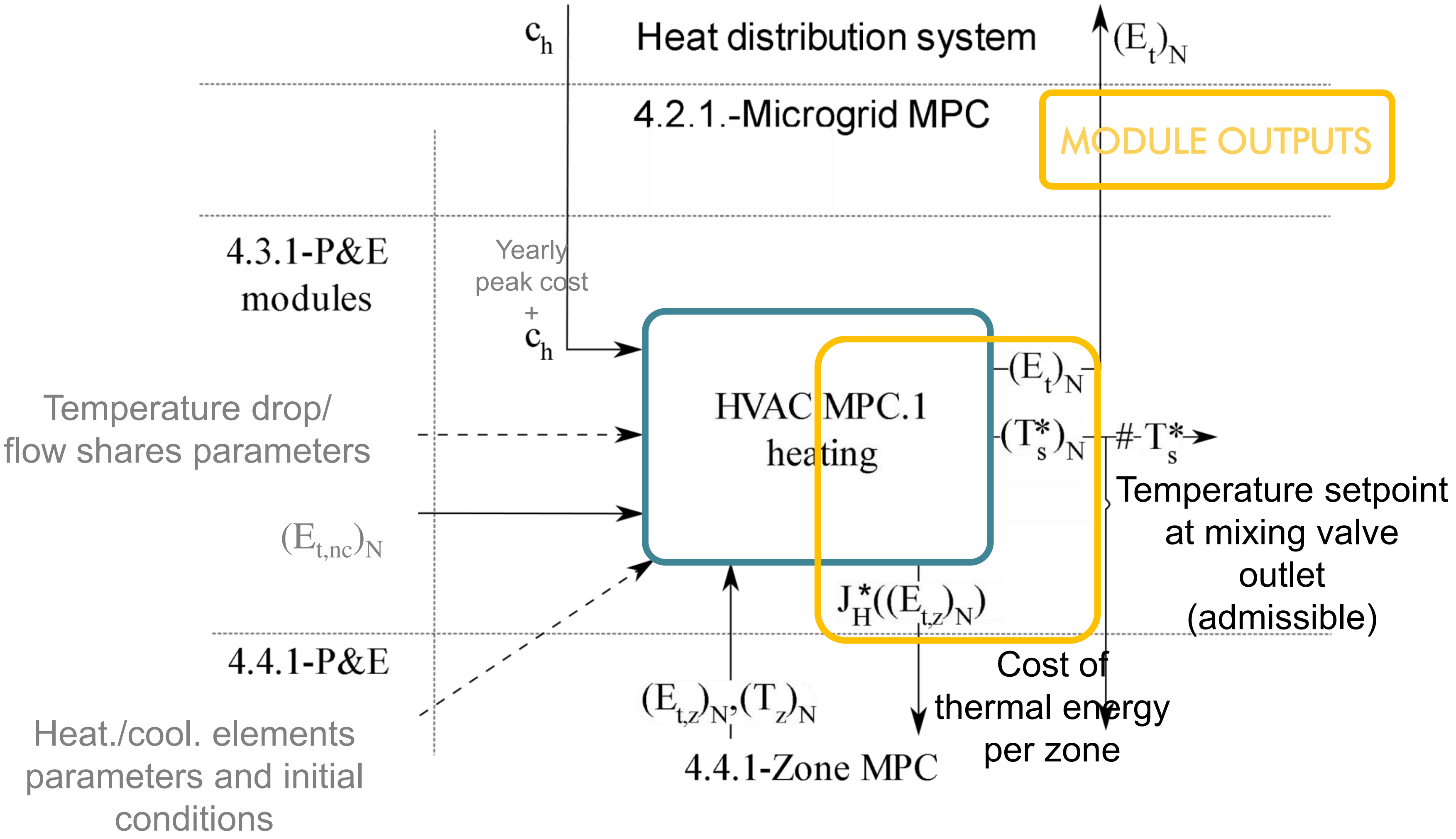
4.4.1-P&E

Heat./cool. elements parameters and initial conditions

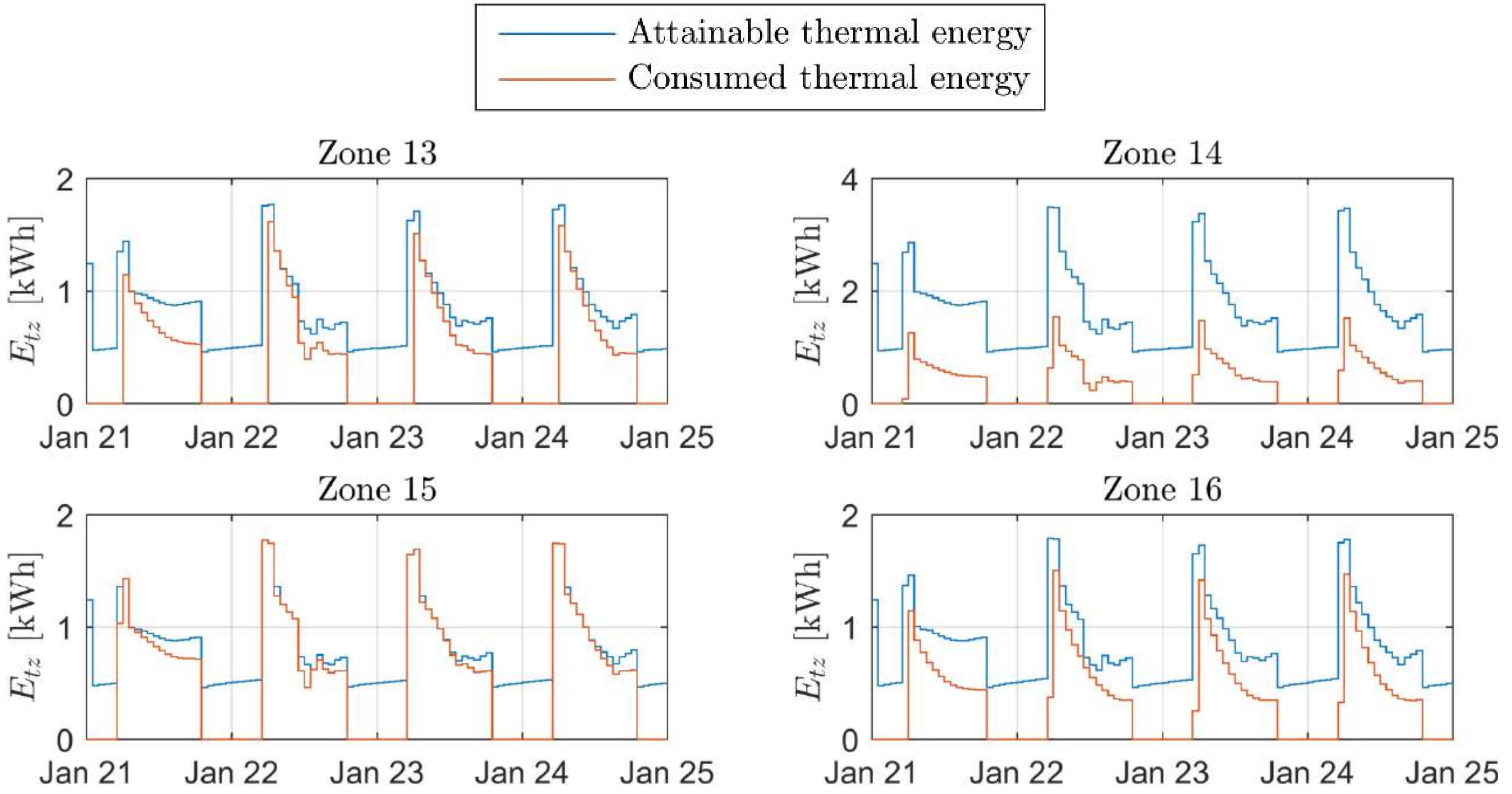
$(E_{t,z})_N, (T_z)_N$

4.4.1-Zone MPC

HVAC MPC 1 – information flow



HVAC MPC 1 – operation (1/2)



Parameters: $\dashrightarrow$

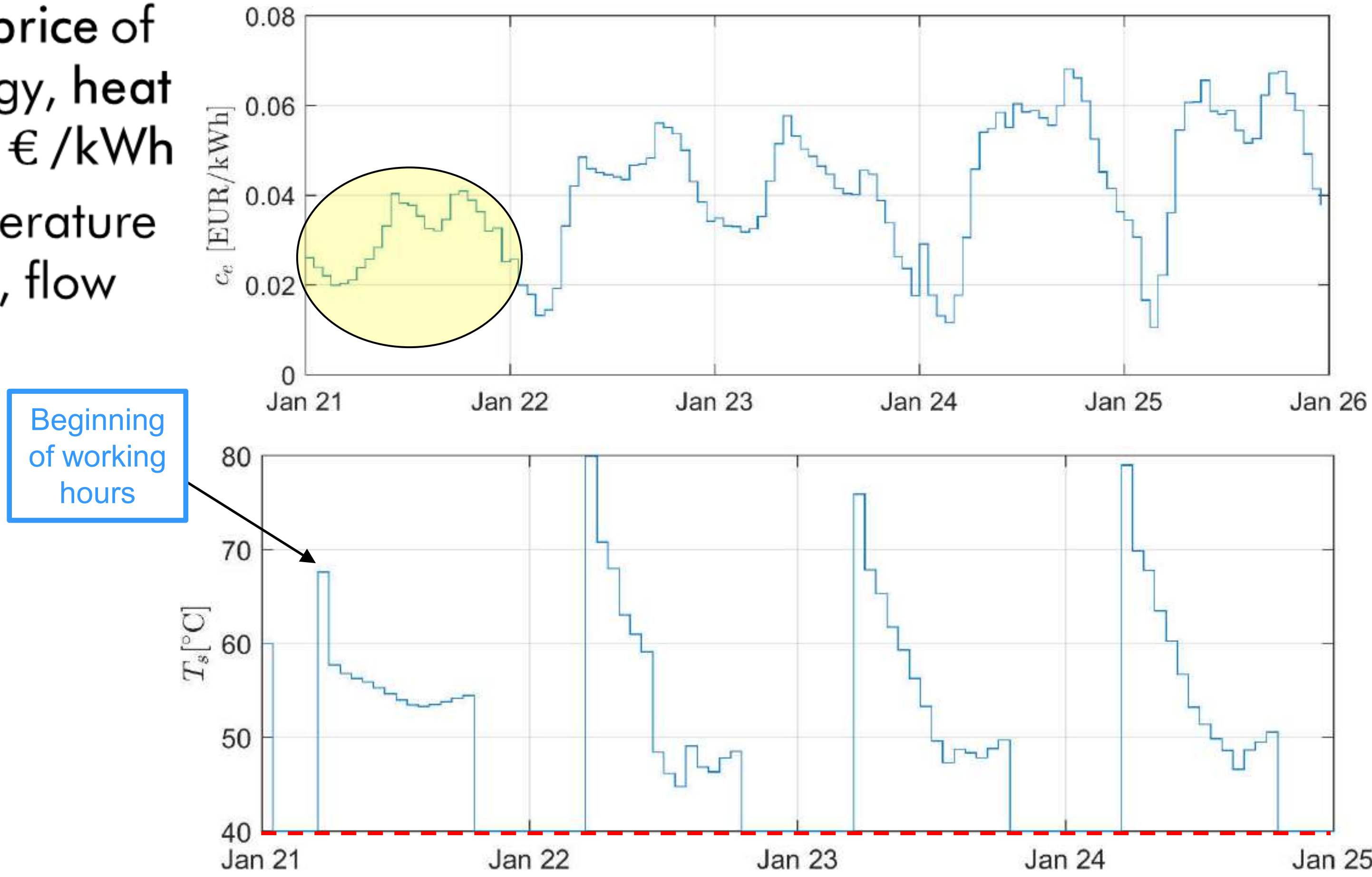
Signals: $\longrightarrow$

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

#

HVAC MPC 1 – operation (2/2)

- **Day-ahead price of electric** energy, **heat** energy **0.07 € /kWh**
- Supply temperature optimisation, flow constant



*Electricity prices: European electricity index, https://www.epexspot.com/en/market-data/elix

HVAC MPC 2 - Heat pump

Retirement and care center

Control configuration

- heat pump is regulated ON/OFF

Control configuration

- heat pump is regulated ON/OFF
- ON state:
  - supply medium temperature reference: 17 °C

Control configuration

- heat pump is regulated ON/OFF
- ON state:
  - supply medium temperature reference: 17 °C
- ON/OFF control on BMS level

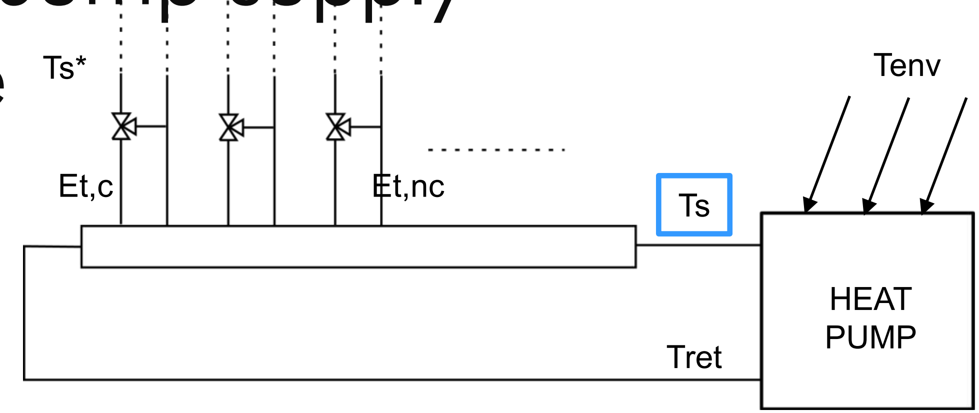
Control configuration

- heat pump is regulated ON/OFF
- ON state:
  - supply medium temperature reference: 17 °C
- ON/OFF control on BMS level
- HVAC 3Smart:
  - point of actuation: mixing valve on supply duct
  - control value: temperature setpoint for the south duct

Control configuration

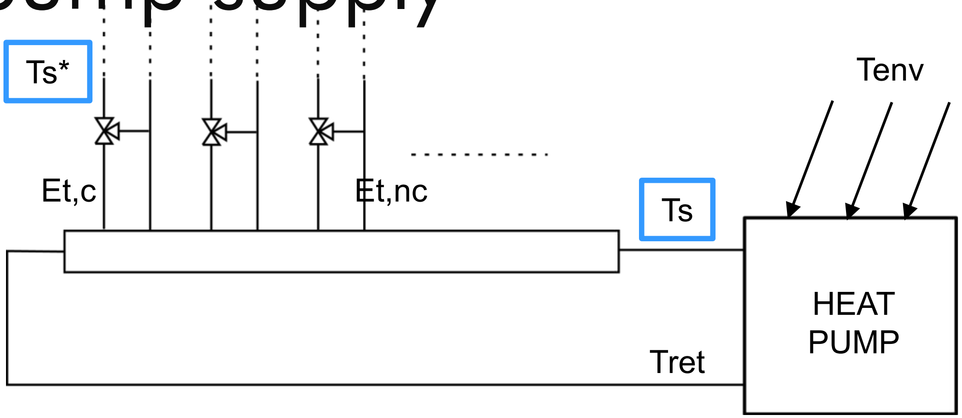
- heat pump is regulated ON/OFF
- ON state:
  - supply medium temperature reference: 17 °C
- ON/OFF control on BMS level
- HVAC 3Smart:
  - point of actuation: mixing valve on supply duct
  - control value: temperature setpoint for the south duct

- Assumption: heat pump supply temperature profile



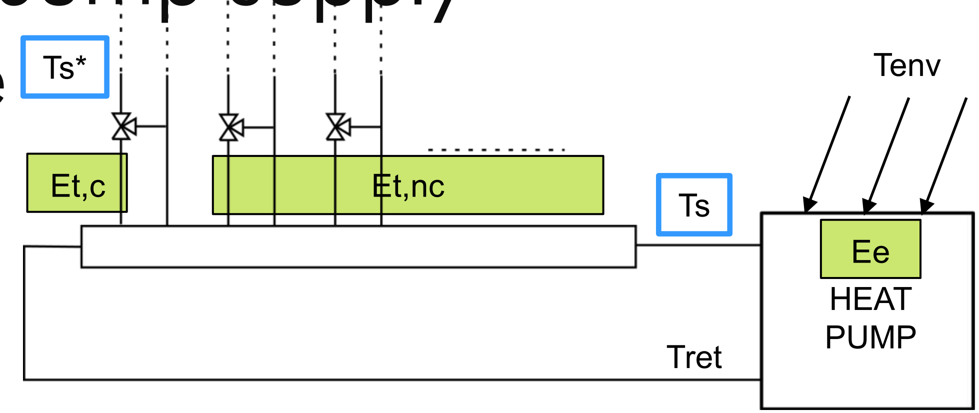
Control configuration

- heat pump is regulated ON/OFF
- ON state:
  - supply medium temperature reference: 17 °C
- ON/OFF control on BMS level
- HVAC 3Smart:
  - point of actuation: mixing valve on supply duct
  - control value: temperature setpoint for the south duct
- Assumption: heat pump supply temperature profile

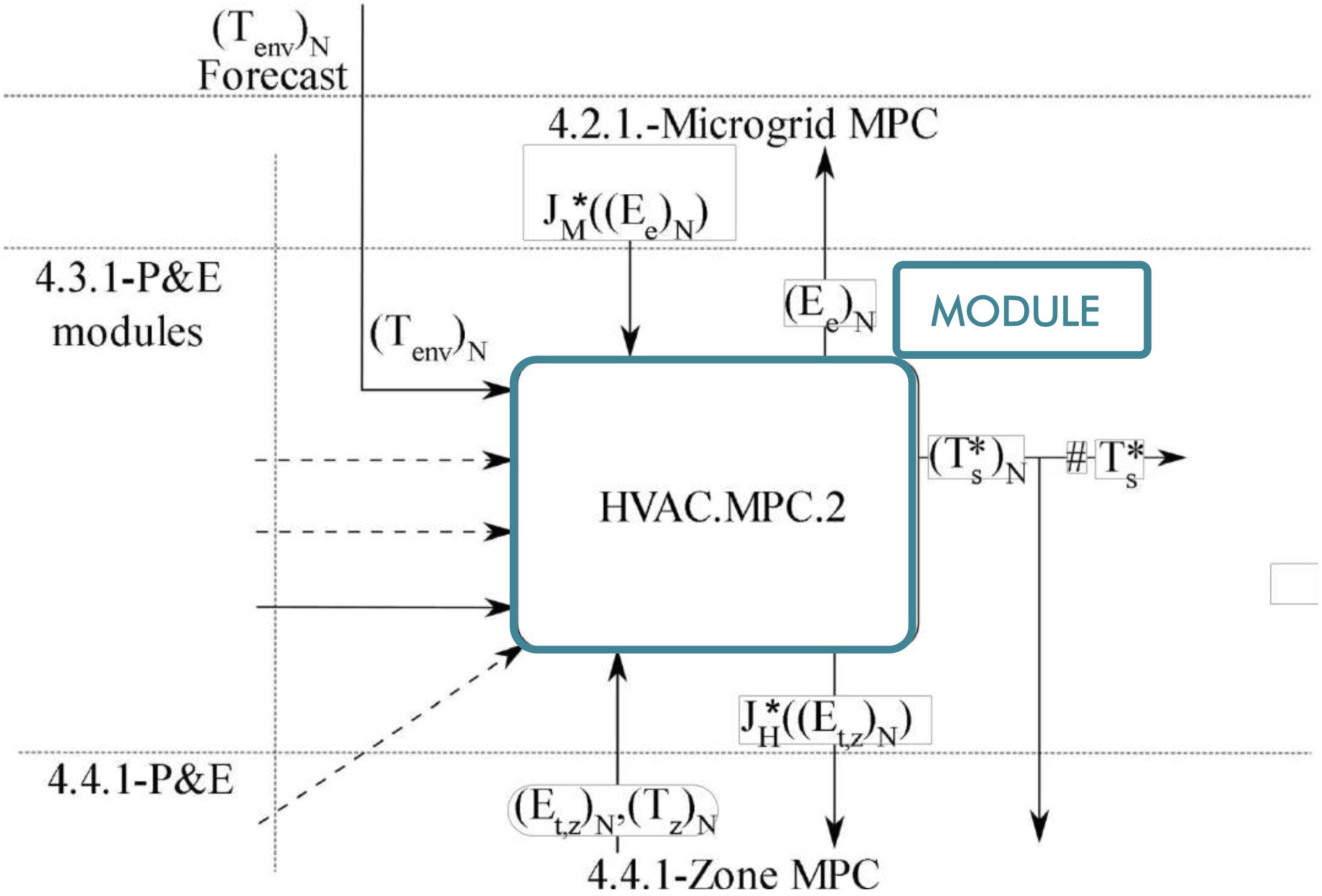


Control configuration

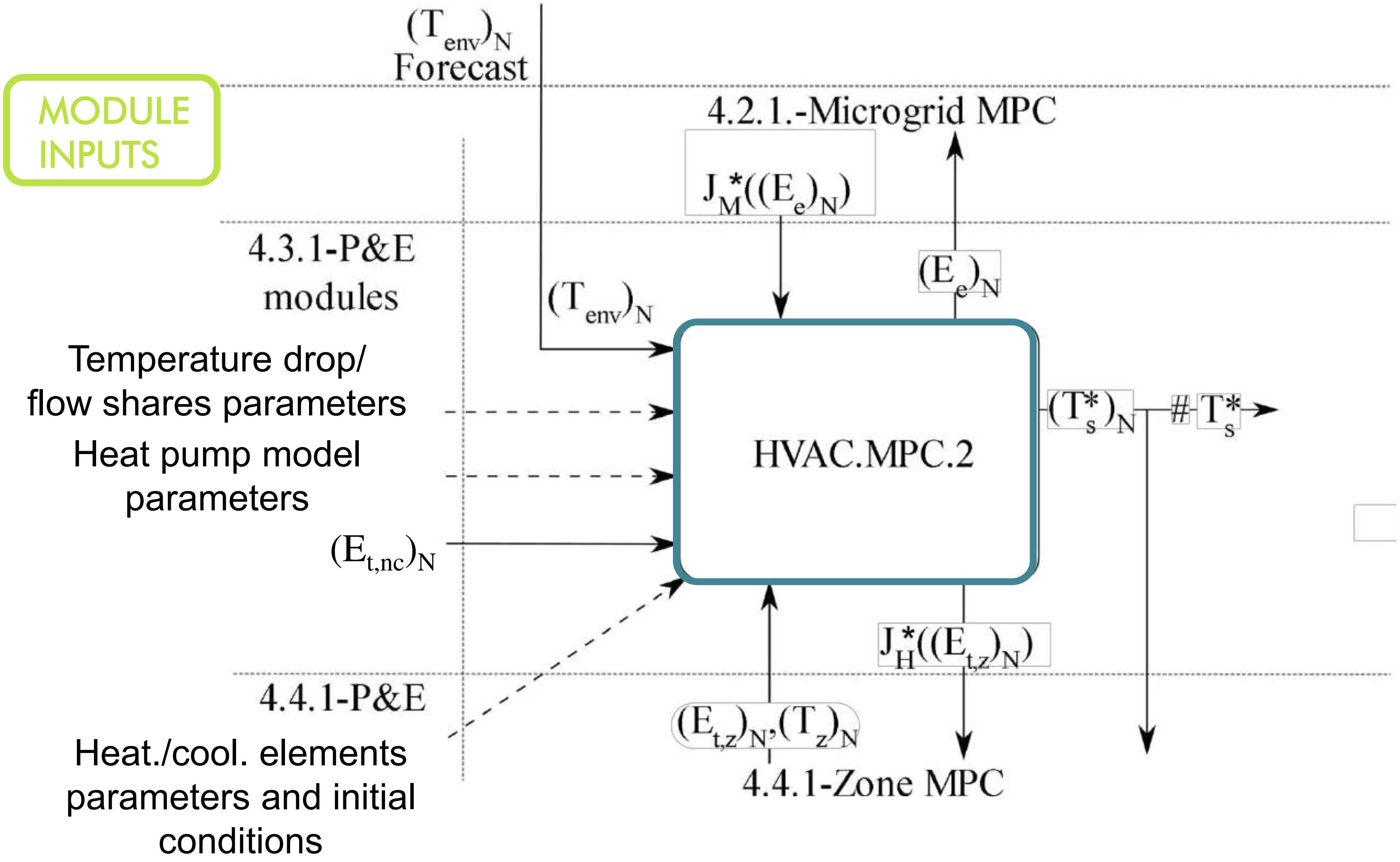
- heat pump is regulated ON/OFF
- ON state:
  - supply medium temperature reference: 17 °C
- ON/OFF control on BMS level
- HVAC 3Smart:
  - point of actuation: mixing valve on supply duct
  - control value: temperature setpoint for the south duct
- Assumption: heat pump supply temperature profile
  - COP model + heat pump el. power cons. constraints



HVAC MPC 2 – information flow



HVAC MPC 2 – information flow



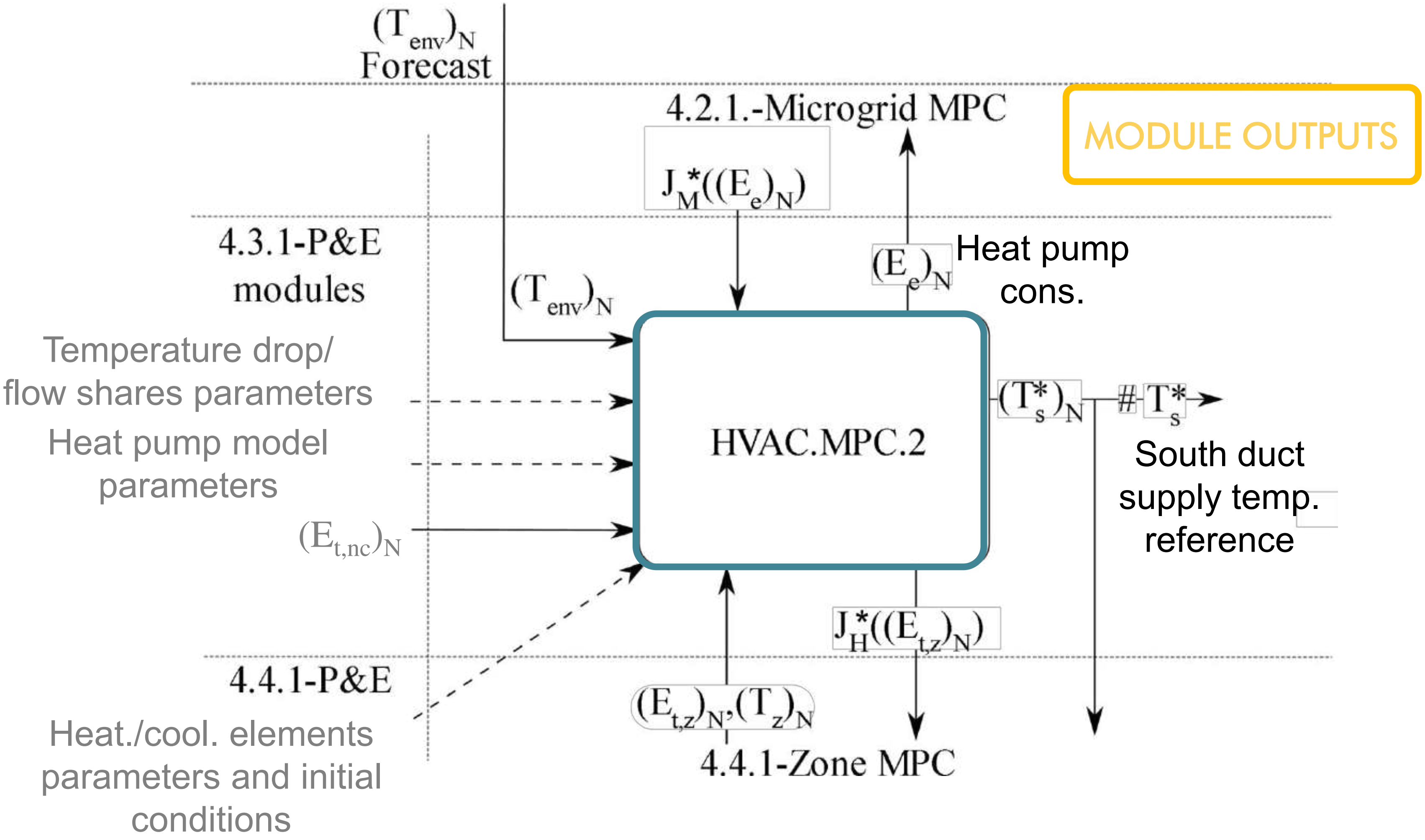
MODULE INPUTS

Temperature drop/ flow shares parameters

Heat pump model parameters

Heat./cool. elements parameters and initial conditions

HVAC MPC 2 – information flow



MODULE OUTPUTS

Heat pump cons.

Temperature drop/ flow shares parameters

Heat pump model parameters

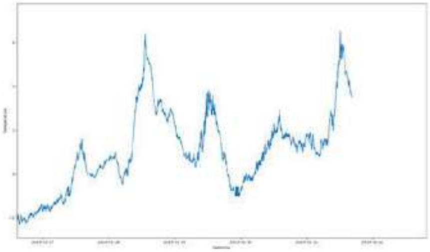
South duct supply temp. reference

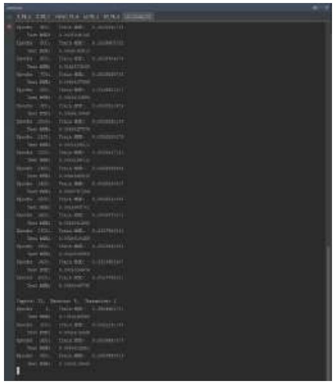
Heat./cool. elements parameters and initial conditions

Microgrid-level modules
Strem pilots

M PE 3 – off-line initialization

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

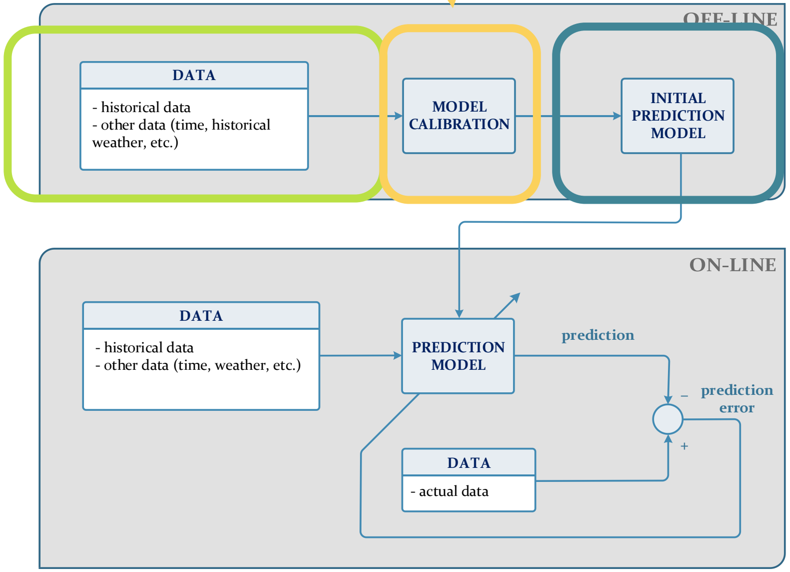




Locally stored:
inputsXY_neuronsZ.net

MODULE INPUTS

MODULE



OFF-LINE

DATA
- historical data
- other data (time, historical weather, etc.)

MODEL CALIBRATION

INITIAL PREDICTION MODEL

ON-LINE

DATA
- historical data
- other data (time, weather, etc.)

PREDICTION MODEL

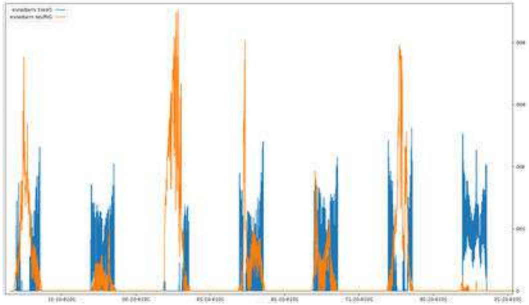
prediction

prediction error

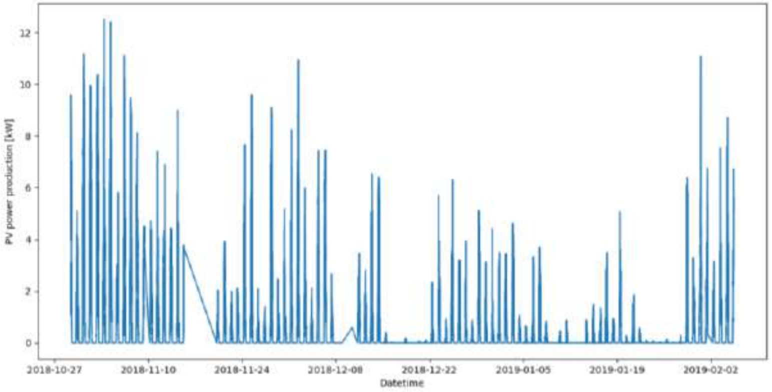
−

+

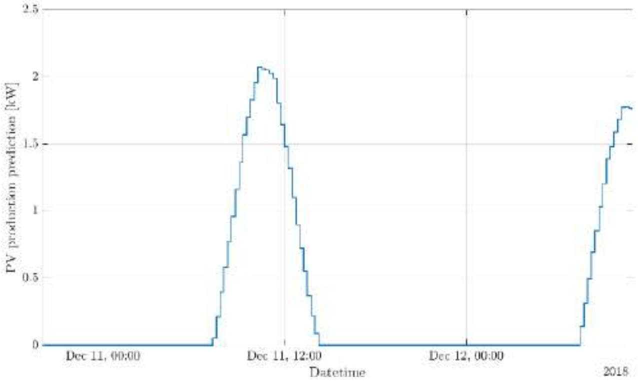
DATA
- actual data



Historical **PV production data**



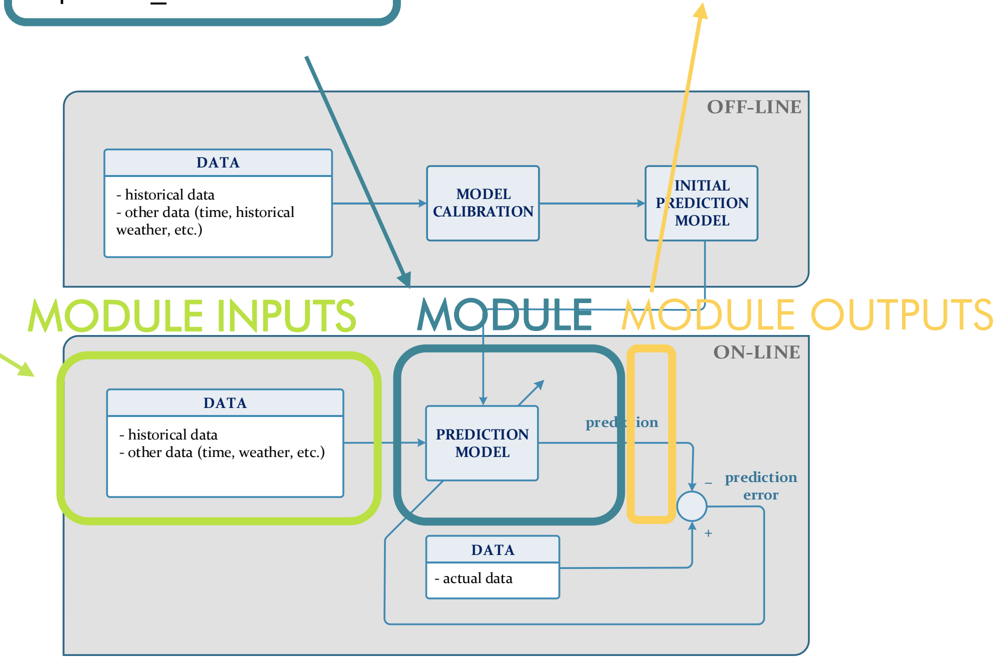
M PE 3 – on-line operation



Regressor created from specific historical intervals of data:

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

Locally stored:
inputsXY_neuronsZ.net

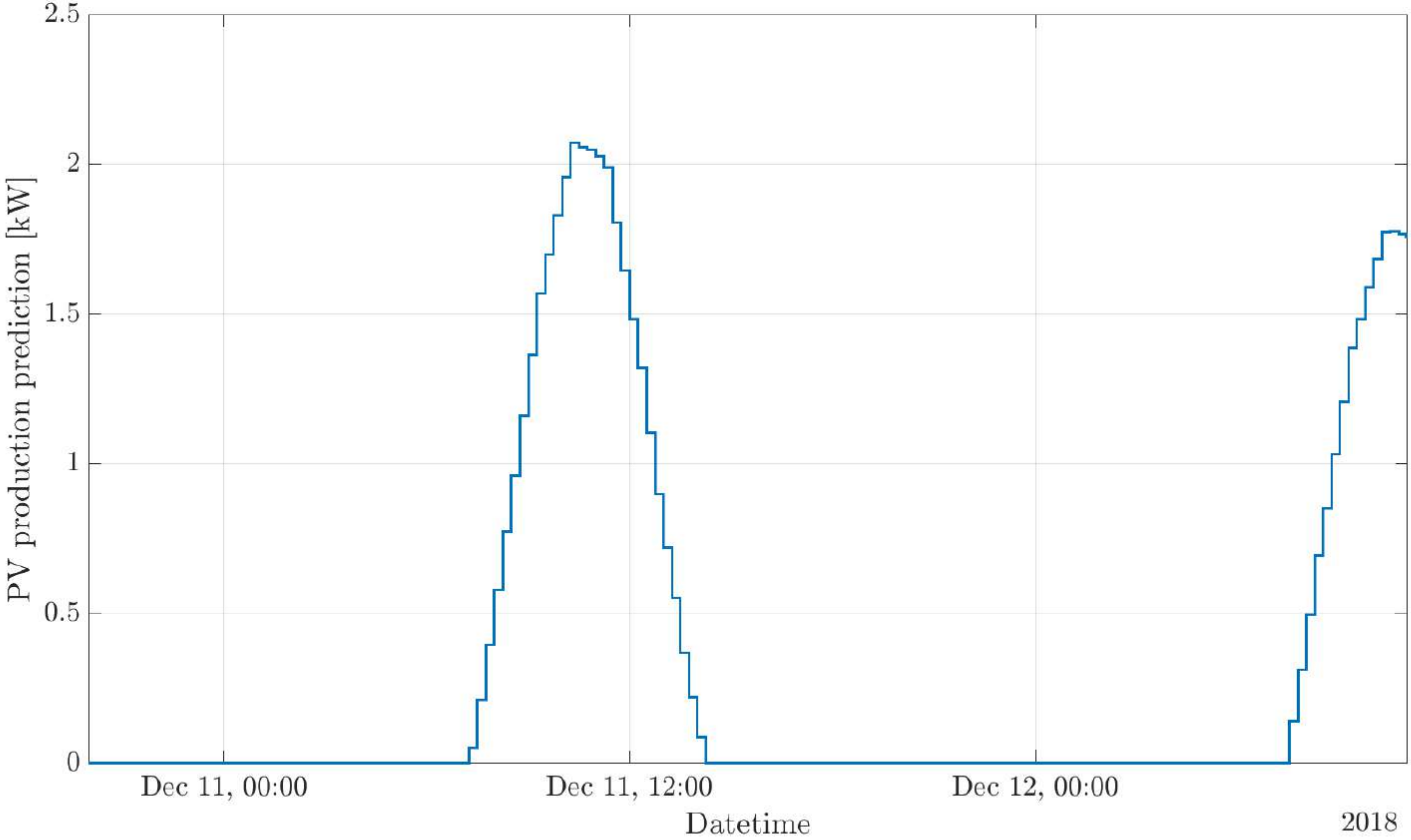


MODULE INPUTS

MODULE

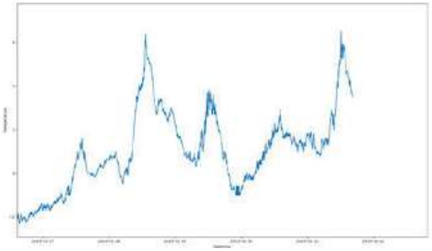
MODULE OUTPUTS

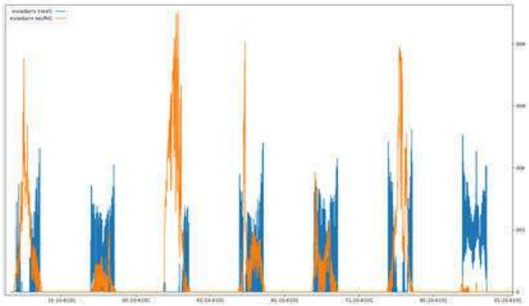
M PE 3 – on-line operation



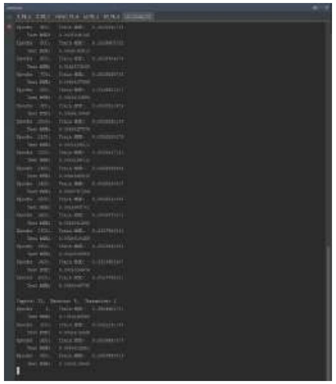
M PE 4 – off-line initialization

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





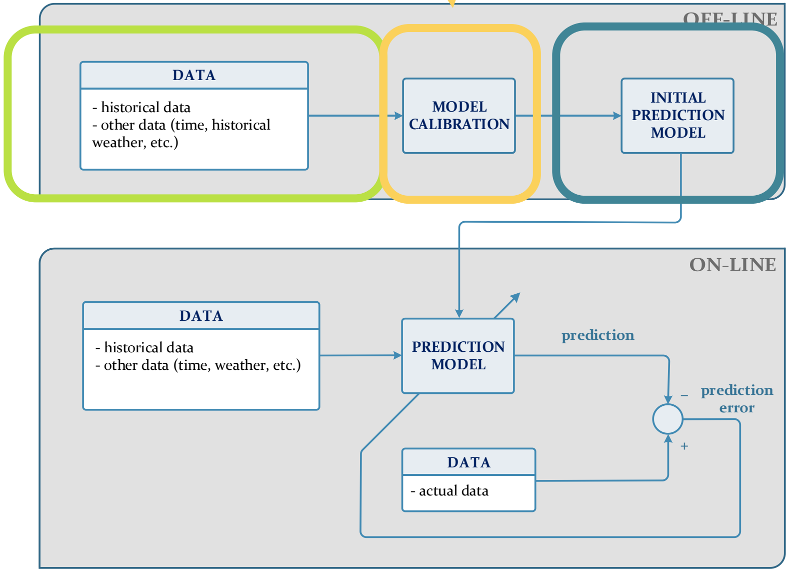
Historical **non-controllable consumption**



Locally stored:
inputsXY_neuronsZ.net

MODULE INPUTS

MODULE



M PE 4 – non-controllable consumption – school building

Consumption on the central electric meter

-

single fan coil consumption (z.pe.1 output)

M PE 4 – non-controllable consumption – retirement care centre

Consumption on the central meter

-

load of the cooling machine (HVAC.MPC.2 cooling)

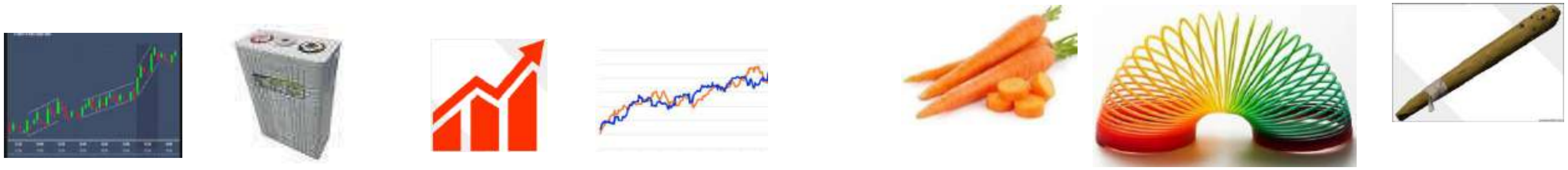
-

battery power (to be checked)

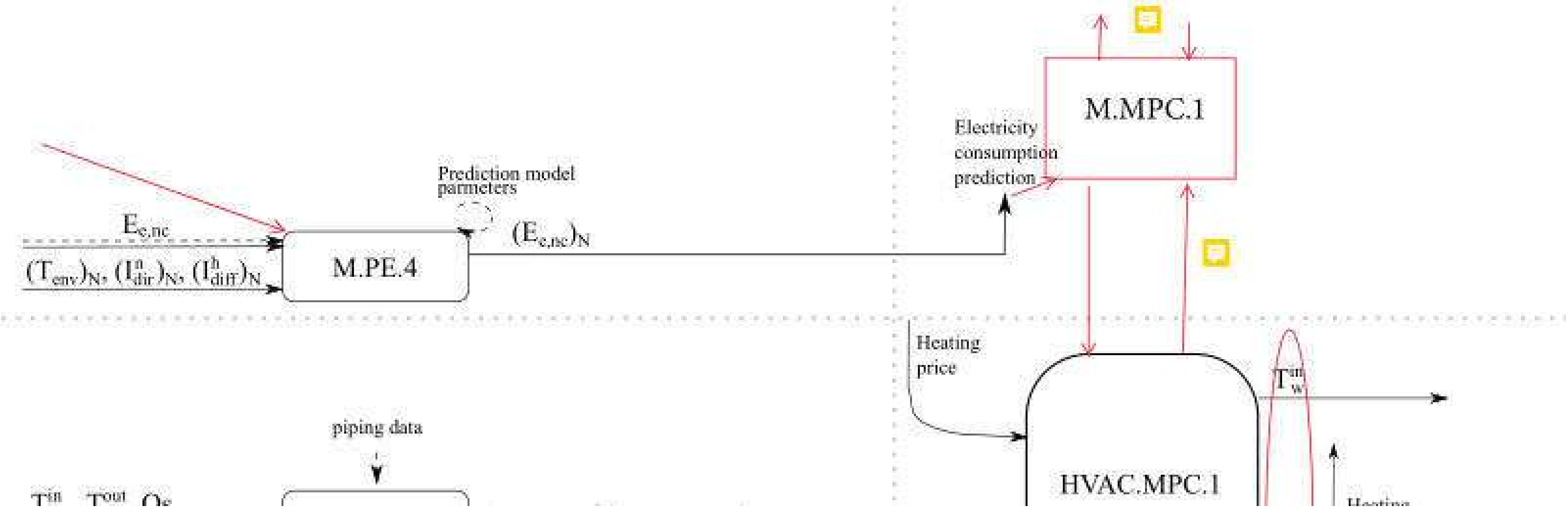
M MPC 1 – short-term

- 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 batteries in ret.care center
- 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 - school



Inputs

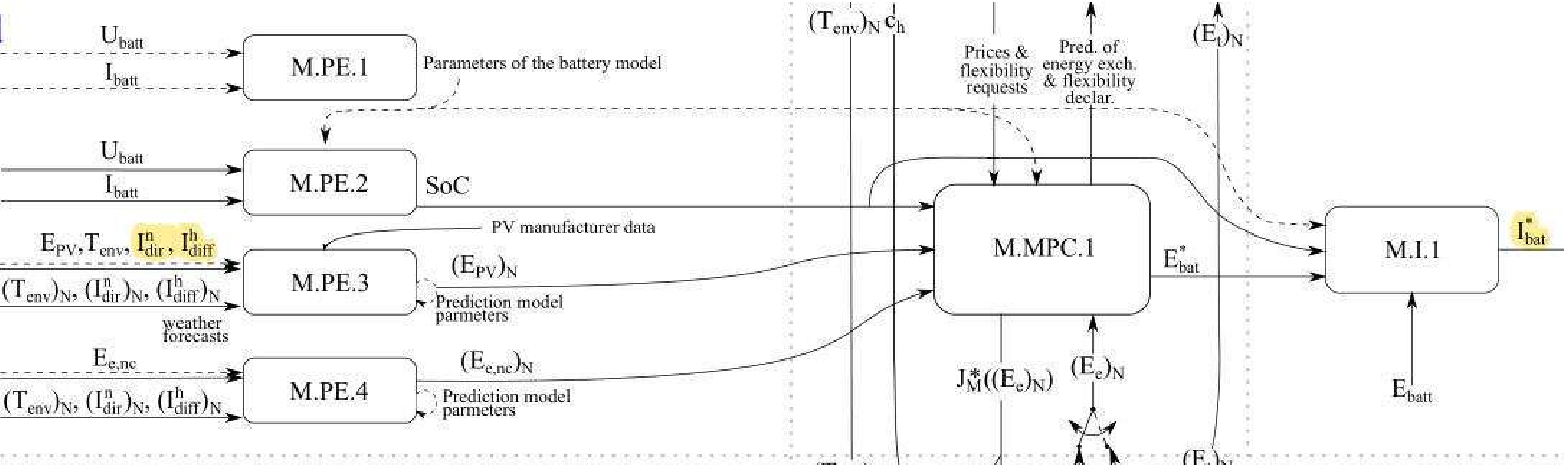
- Non-controllables prediction
- Prices and requests from grid

Outputs

- Energy profiles for the grid

- MPC coordination used only for adjusting consumption of sport hall fancoil!

M MPC 1 – ret.care center



Inputs

- Non-controllables prediction
- Estimated battery model and SoC
- Prices and requests from grid

Outputs

- Battery commands
- Energy profiles for the grid

- MPC coordination possible only in cooling season!

MPC calculations on a building and strategy for smart city upscale

Mario Vašak, Anita Martinčević, Nikola Hure, Danko Marušić, Hrvoje Novak,
Vinko Lešić, Paula Perović, Tomislav Capuder

UNIZGFER
mario.vasak@fer.hr

Study visit No.1 to the 3Smart pilot in Austria

Guessing, 28 March 2019

Interreg
EUROPEAN UNION
Danube Transnational Programme
3Smart

UNIVERSITY OF ZAGREB
FACULTY OF ELECTRICAL ENGINEERING AND COMPUTING

Project co-funded by the European Union

Zagreb case study – 1

- Optimized daily operation of UNIZGFER building with flexibility bid
  - application of off-line MPC tools
    - based on flexibility requests and pricing conditions coming from the long-term grid-side modules
- Optimized daily operation of a water distribution system
  - prepared scripts in Matlab for optimization of daily operations based on pricing conditions
    - pricing conditions come from the same microgrid module as for the building

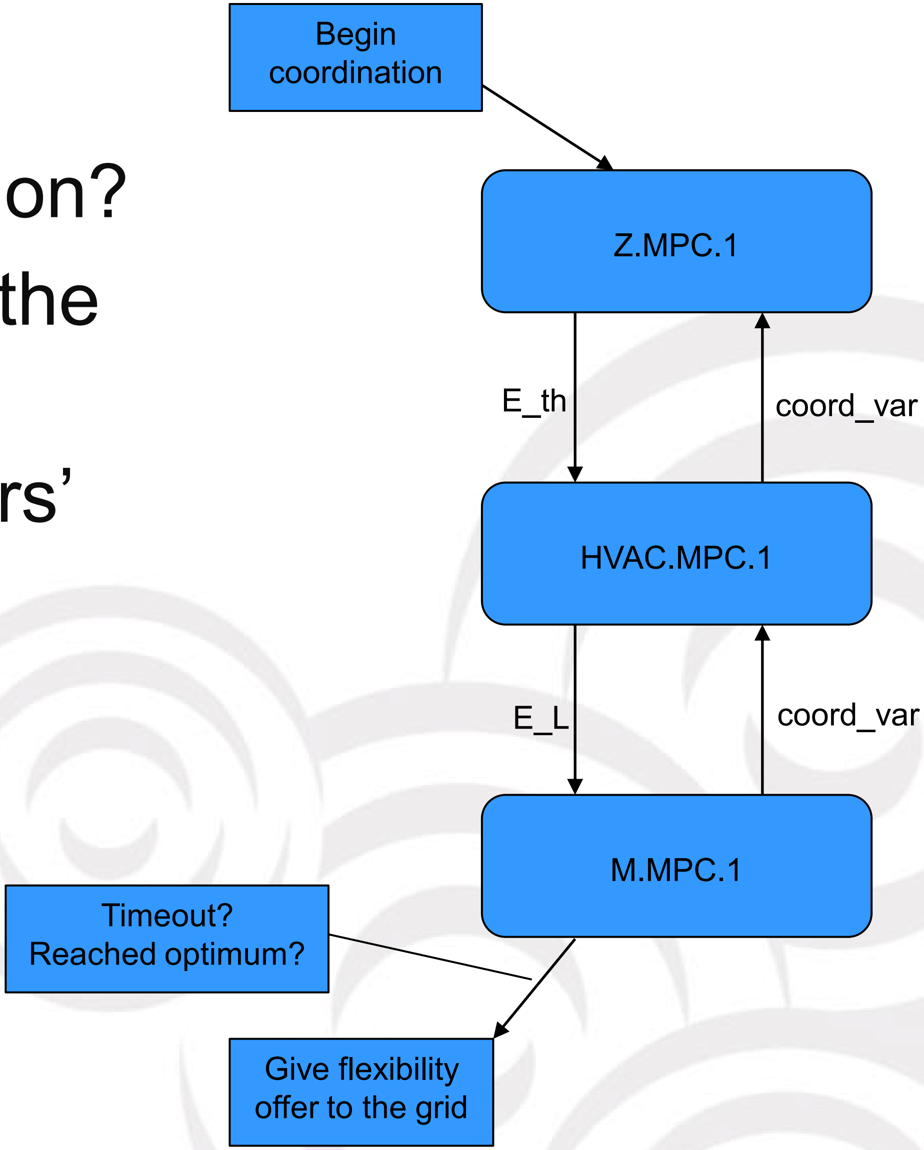
Zageb case study – 2

- Optimized daily operation of electric vehicles parking with chargers
- Optimized operation of electrified light rail with a single traction substation
  - still to do
- Analysis of joint effects of all flexible consumers on the local grid (artificially replicated building)
  - grid-side analysis
- Analysis of the demand shift for heat distribution network

UNIZGFER building optimized off-line

MPC coordination

- Can we obtain flexibility by adjusting HVAC consumption?
- Is that cheaper than using the battery?
- Is it possible to assure users' comfort while providing flexibility?
- Iterative process

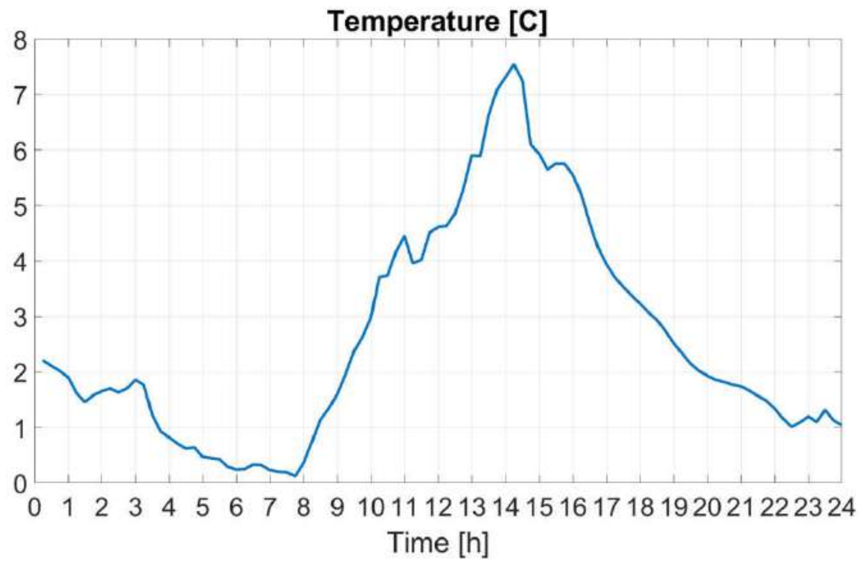


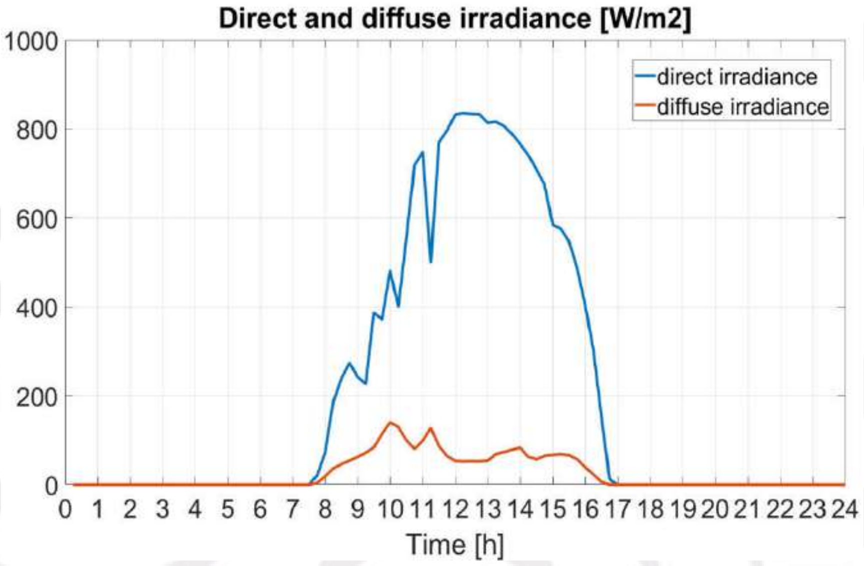
Long-term contracting – simulation environment

- LT calculation is performed for typical days in a month
- Typical weather conditions; non-controllable consumption deduced or extracted from historical data
- Accounted flexibility request from the grid
- Must be repeatable: building should be planned to be in the same state at the beginning and at the end of the day
- Computations given next are for UNIZGFER building for heating season (January, sunny workday)

Long-term contracting – meteorological data

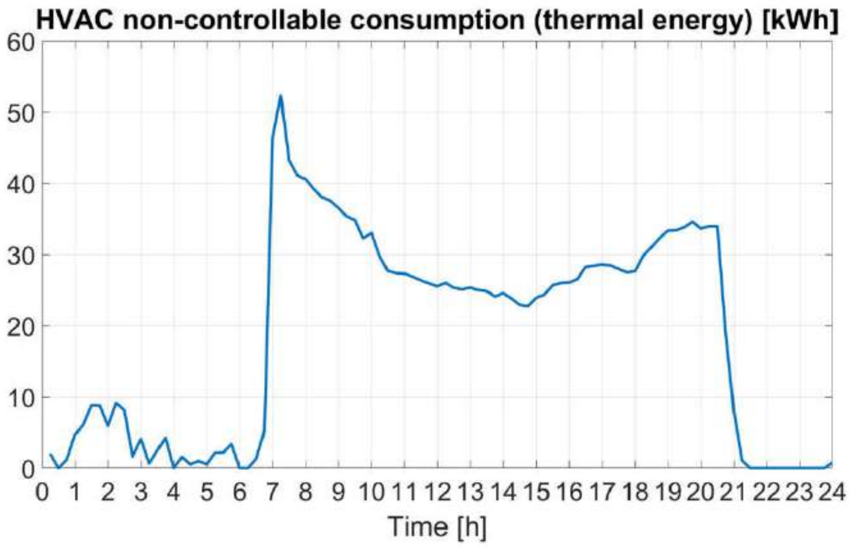
- Environment temperature, direct and diffuse irradiance profile for an average **sunny workday in January**

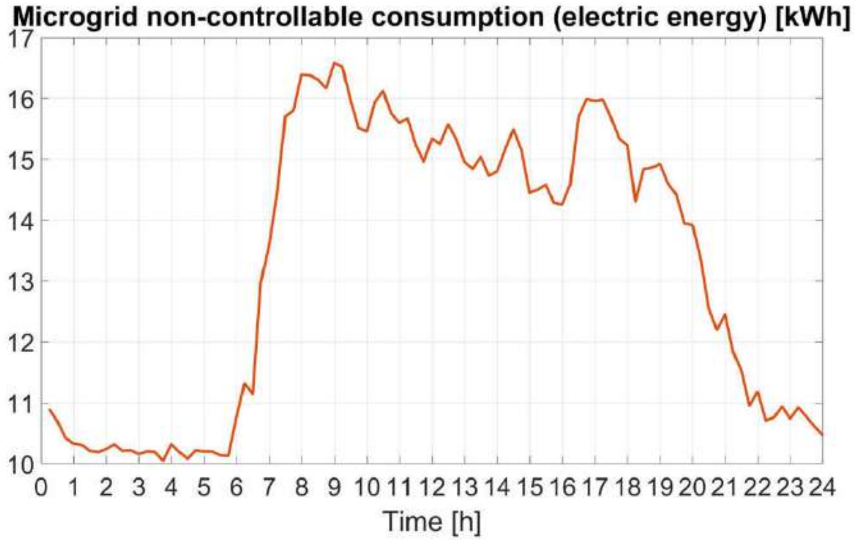




Long-term contracting – non-controllable consumptions data

- HVAC (thermal) and microgrid (electrical) level for an average sunny workday in January



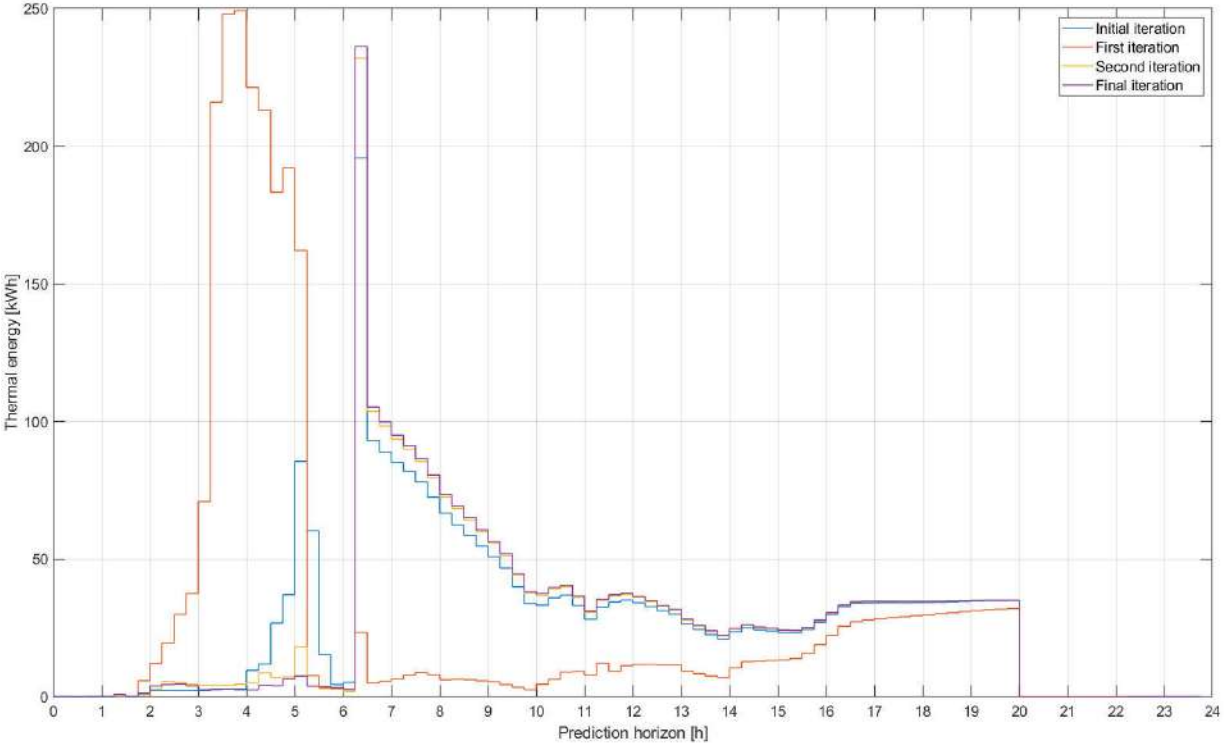


Computation procedure

- Start: Zones (energy-optimal, “Initial”) → HVAC (imposed high electricity prices in flexibility) → Zones (“First iteration”) → HVAC (“First iteration”) → Microgrid (“First iteration”) → HVAC → Zones (“Second iteration”) → HVAC (“Second iteration”) → Microgrid (“Second iteration”) → ...

Long-term MPC coordination – Z.MPC.1 results

- Thermal energy in zones re-shifted to enable activation of flexibility (flexibility time: 11:30 – 15:00)
  - In “First iteration” high prices are imposed in flexibility interval to motivate energy consumption shift from that interval



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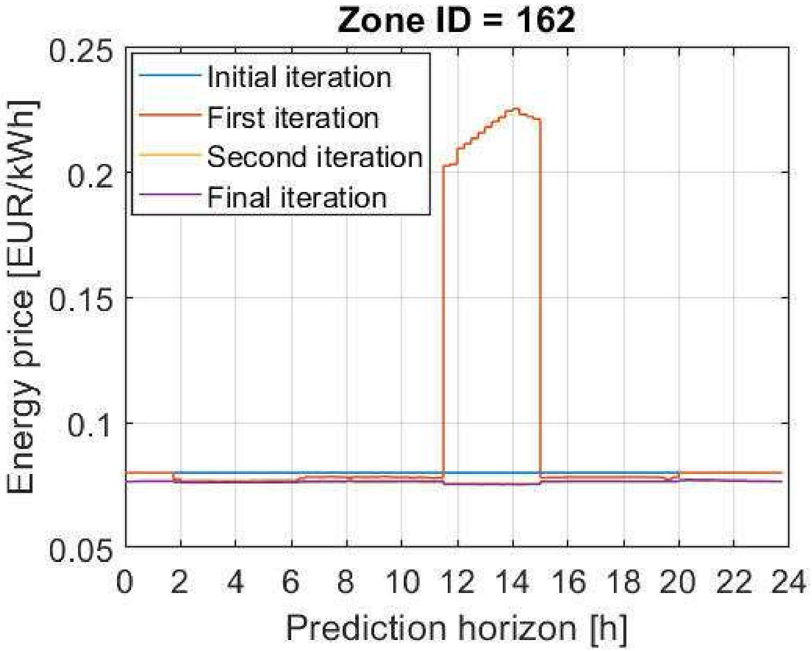
Danube Transnational Programme
3Smart

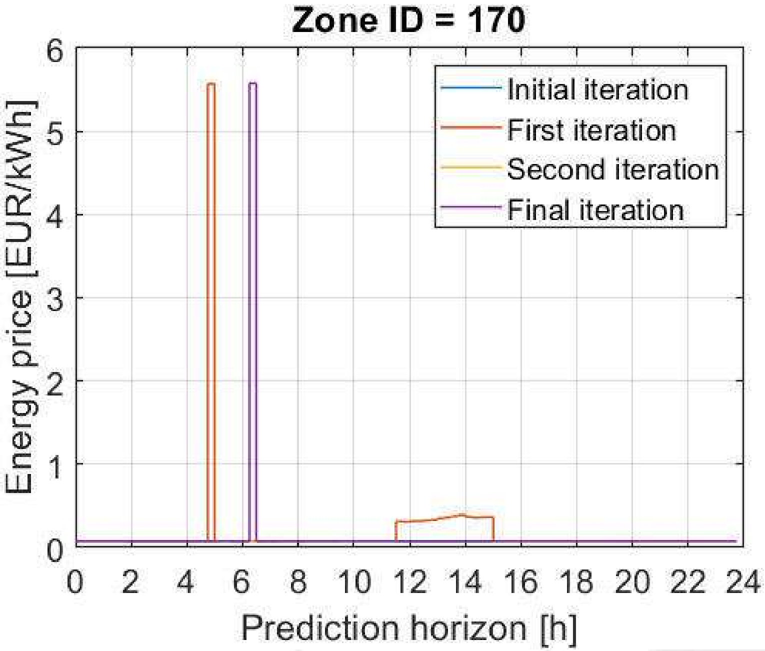
Long-term MPC coordination – Z.MPC.1 results

- HVAC issues thermal energy prices based on the prices of electricity issued by the microgrid

South-oriented zone



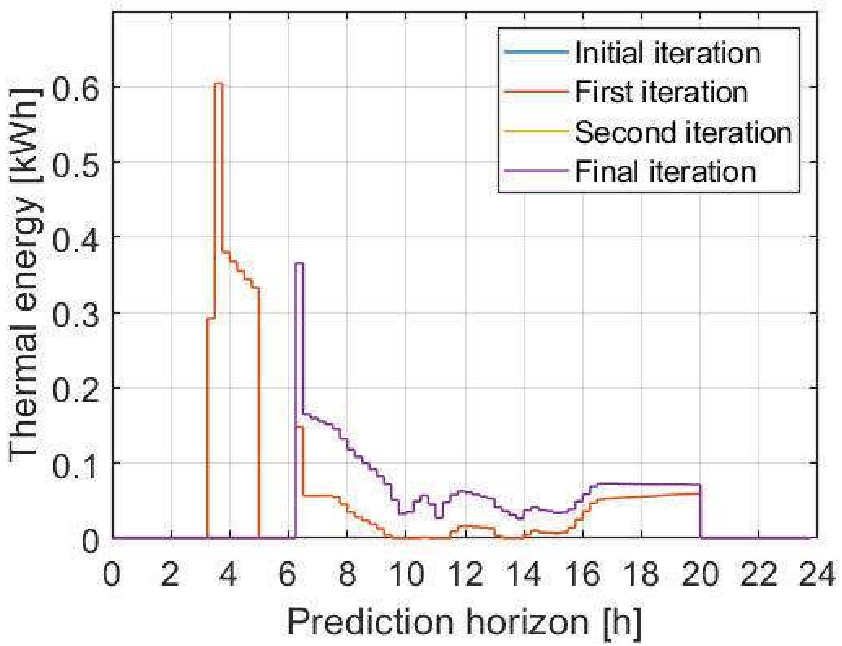
North-oriented zone



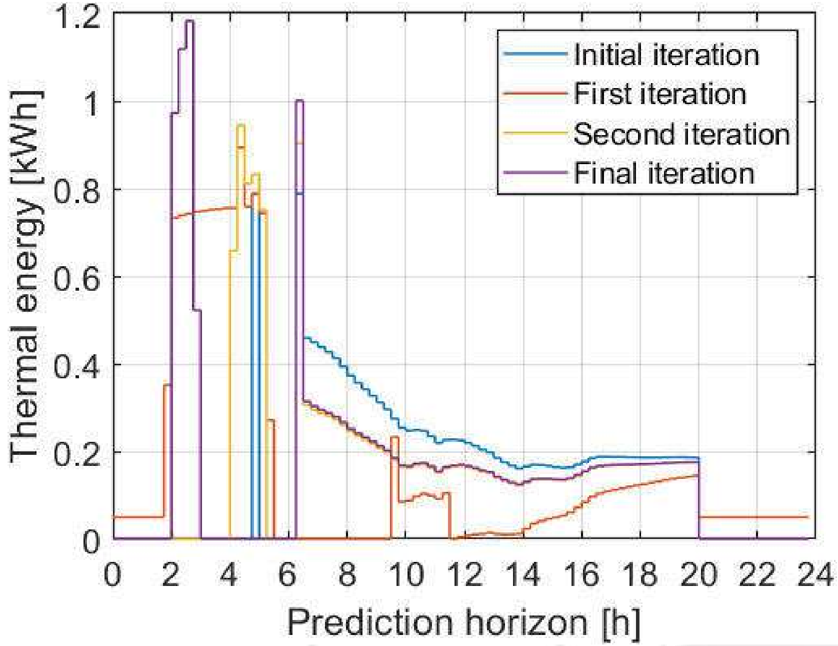
Long-term MPC coordination – Z.MPC.1 results

- Energy consumption per zones is re-shifted to follow the prices

South-oriented zone

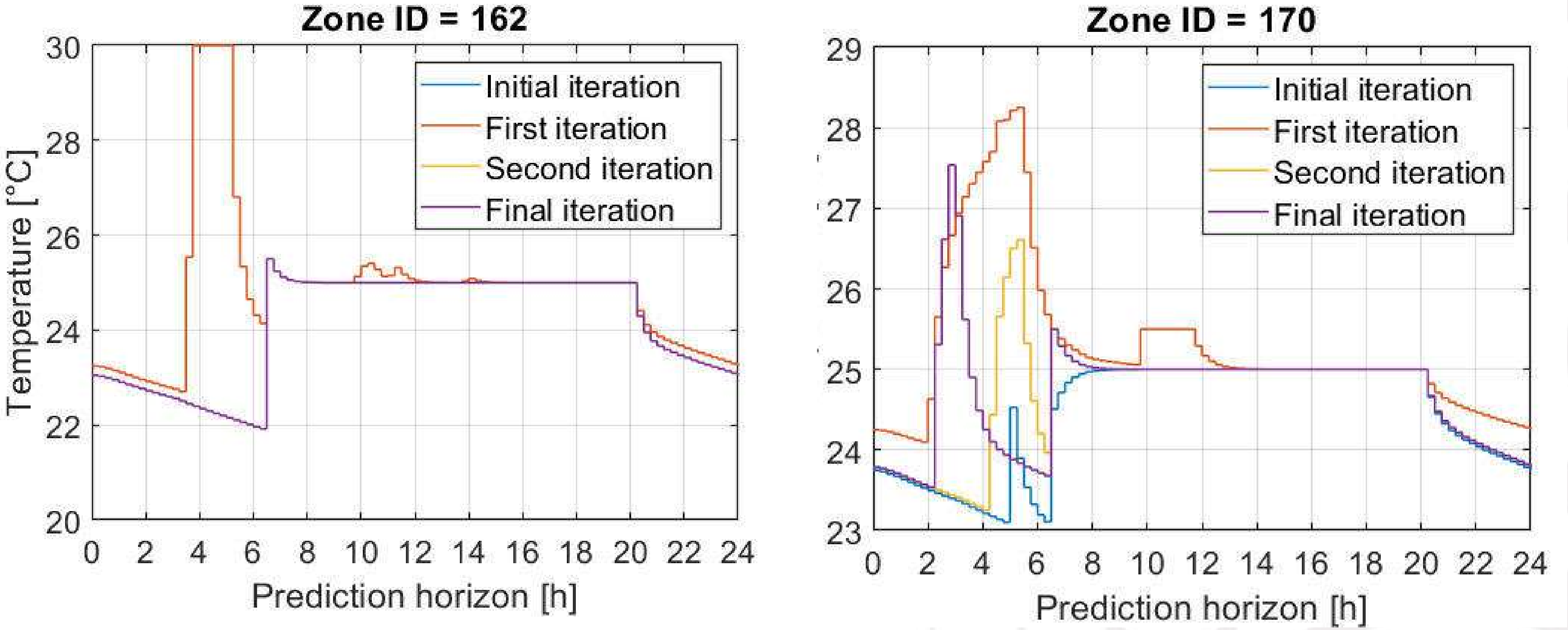


North-oriented zone



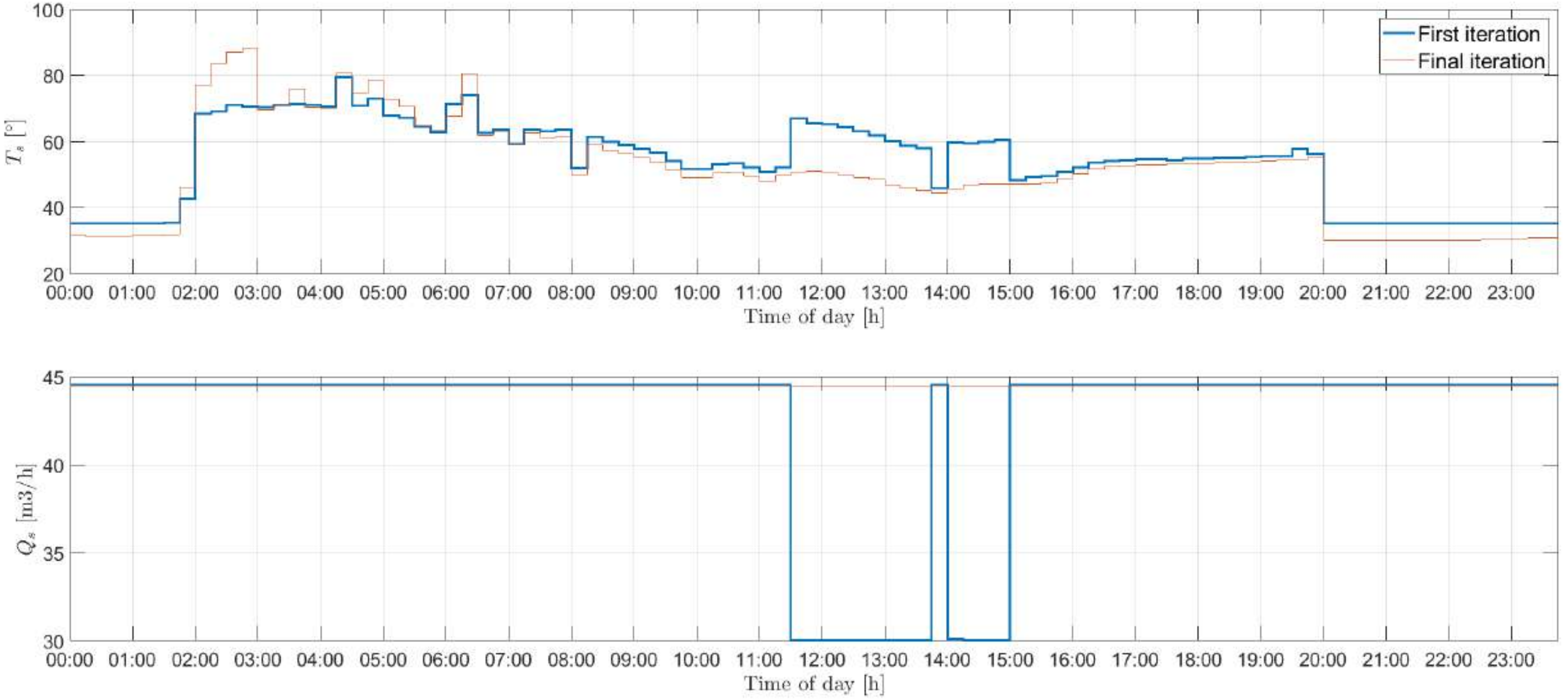
Long-term MPC coordination – Z.MPC.1 results

- Comfort in the zones during occupied hours (6:30 – 20:00) stays preserved
- Temperature within the [24.5, 25.5]



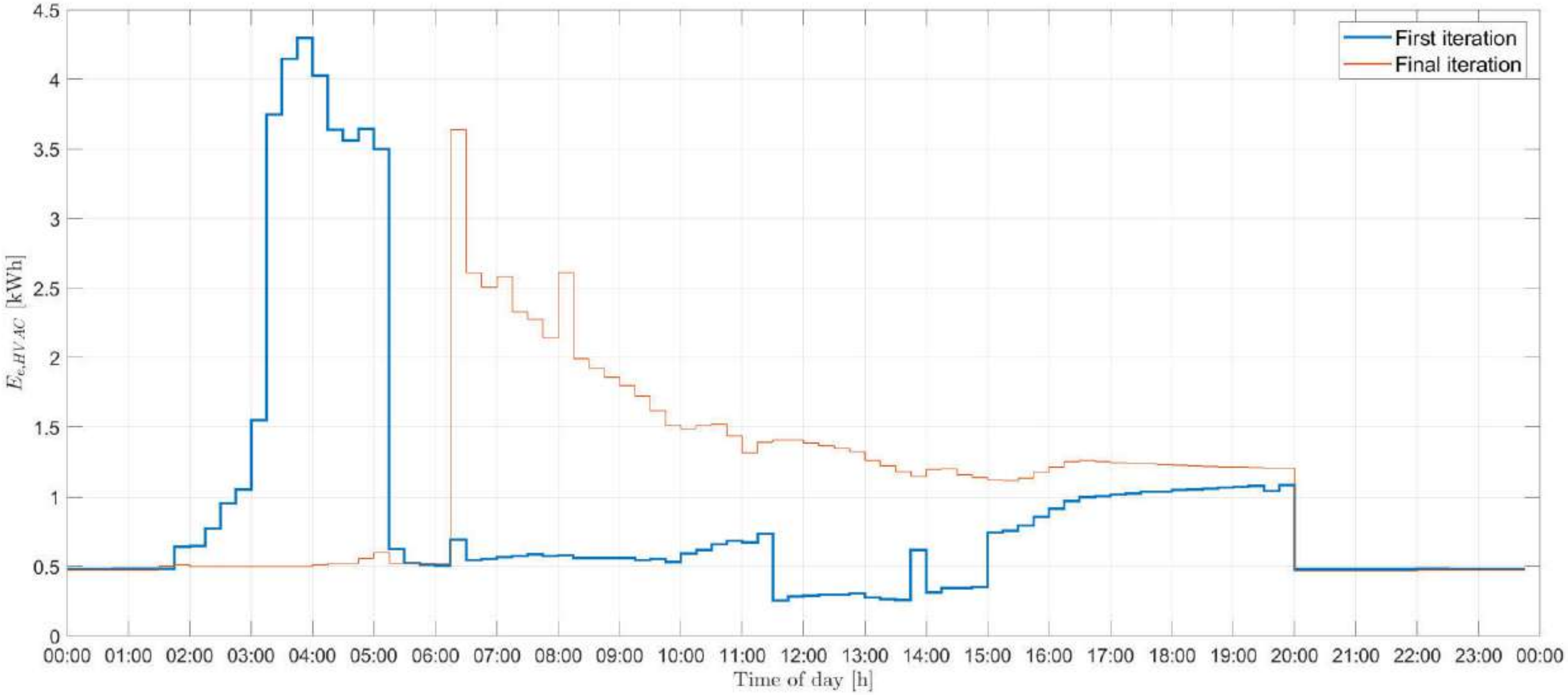
Long-term MPC coordination – HVAC.MPC.1 results

- HVAC MPC supply flow at the maximum level – reduced thermal losses
- Supply temperature ensures required zone thermal energies



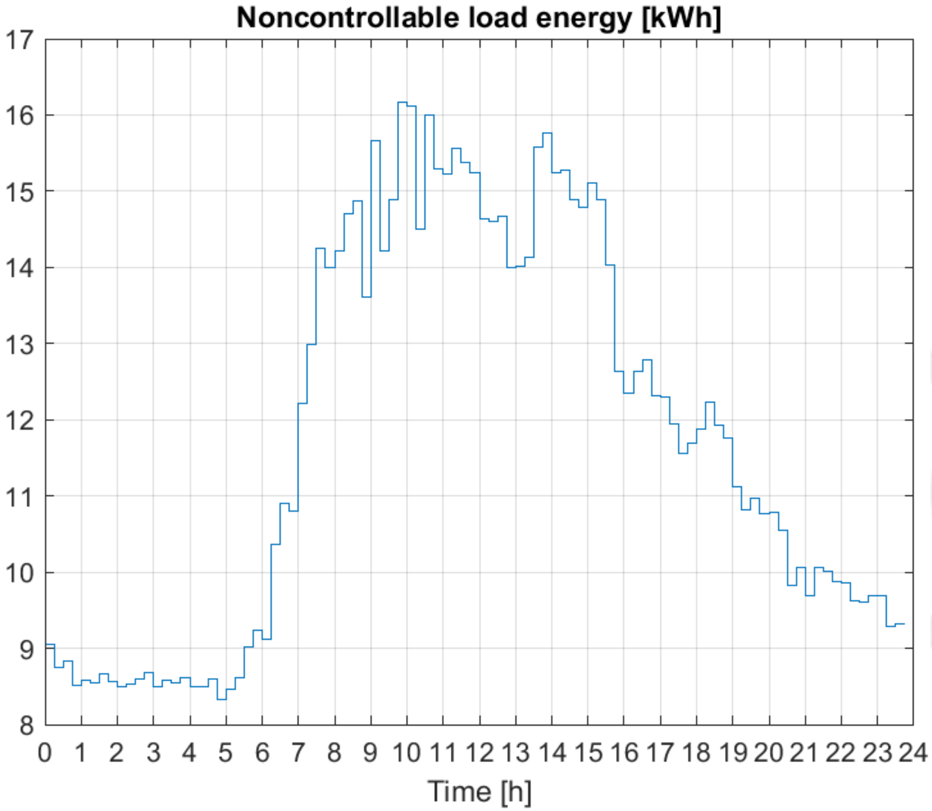
Long-term MPC coordination – HVAC.MPC.1 results

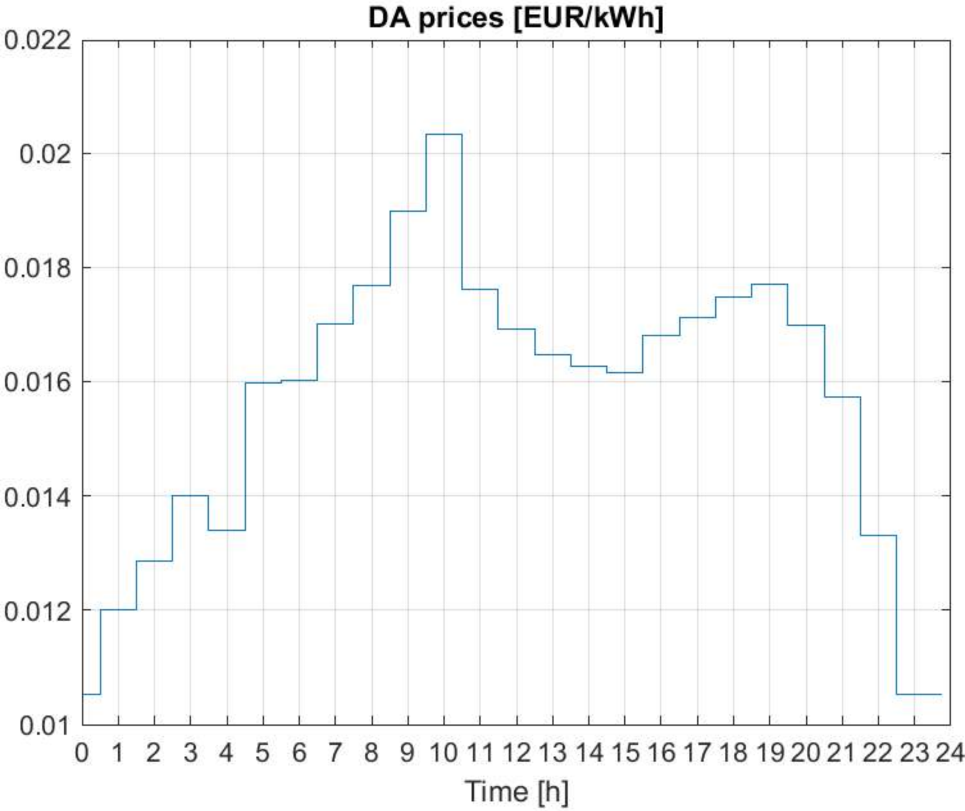
- Electrical energy consumption on FCUs + hydraulic pump
- Consumption on FCUs reflects the thermal consumption in zones



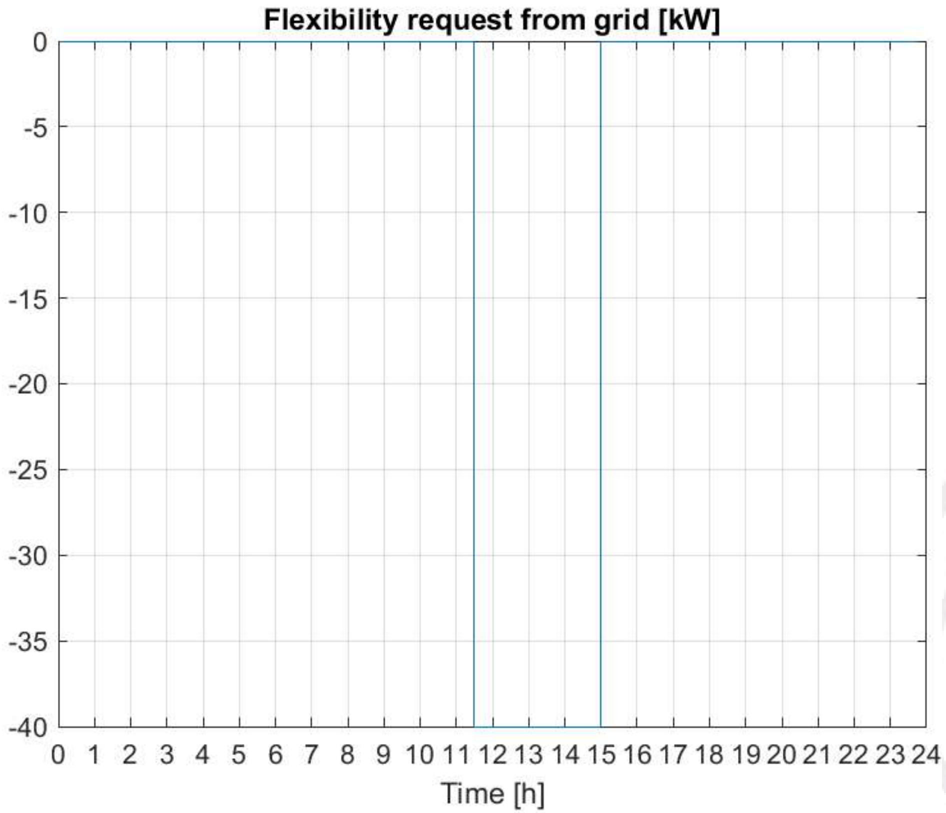
Long-term MPC coordination – M.MPC.1 results

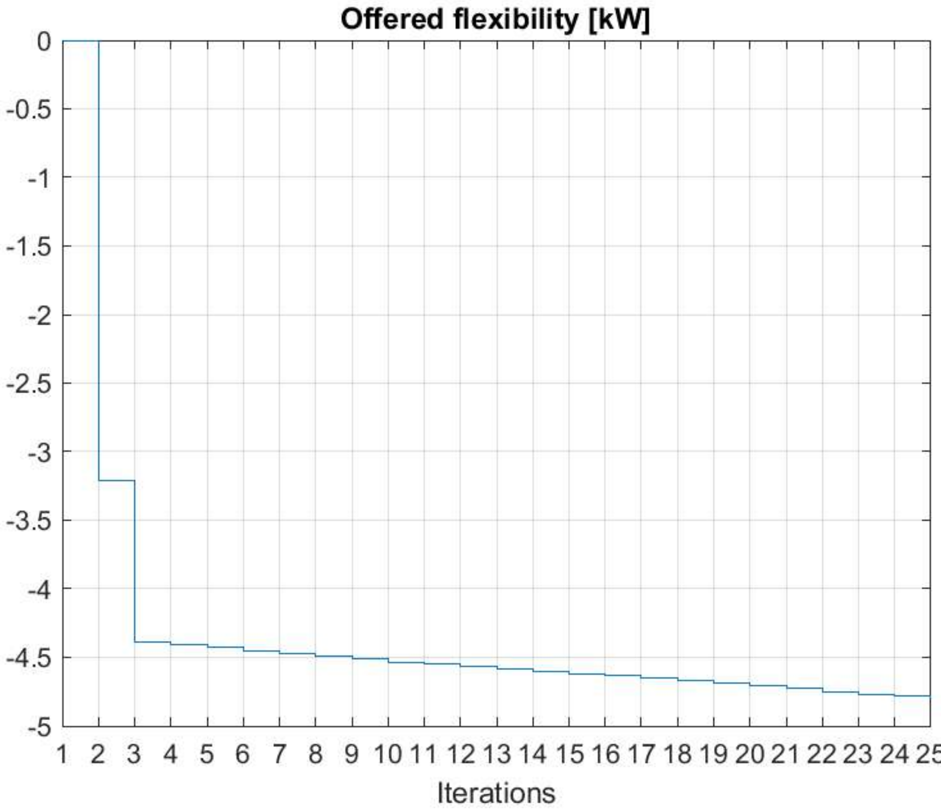
- Prices:
  - Unit price of reservation: 0.0162 EUR/kW/15min
  - Unit price of activation: 0.065 EUR/kWh
  - Penalty for nondelivered flexibility: 0.13 EUR/kWh





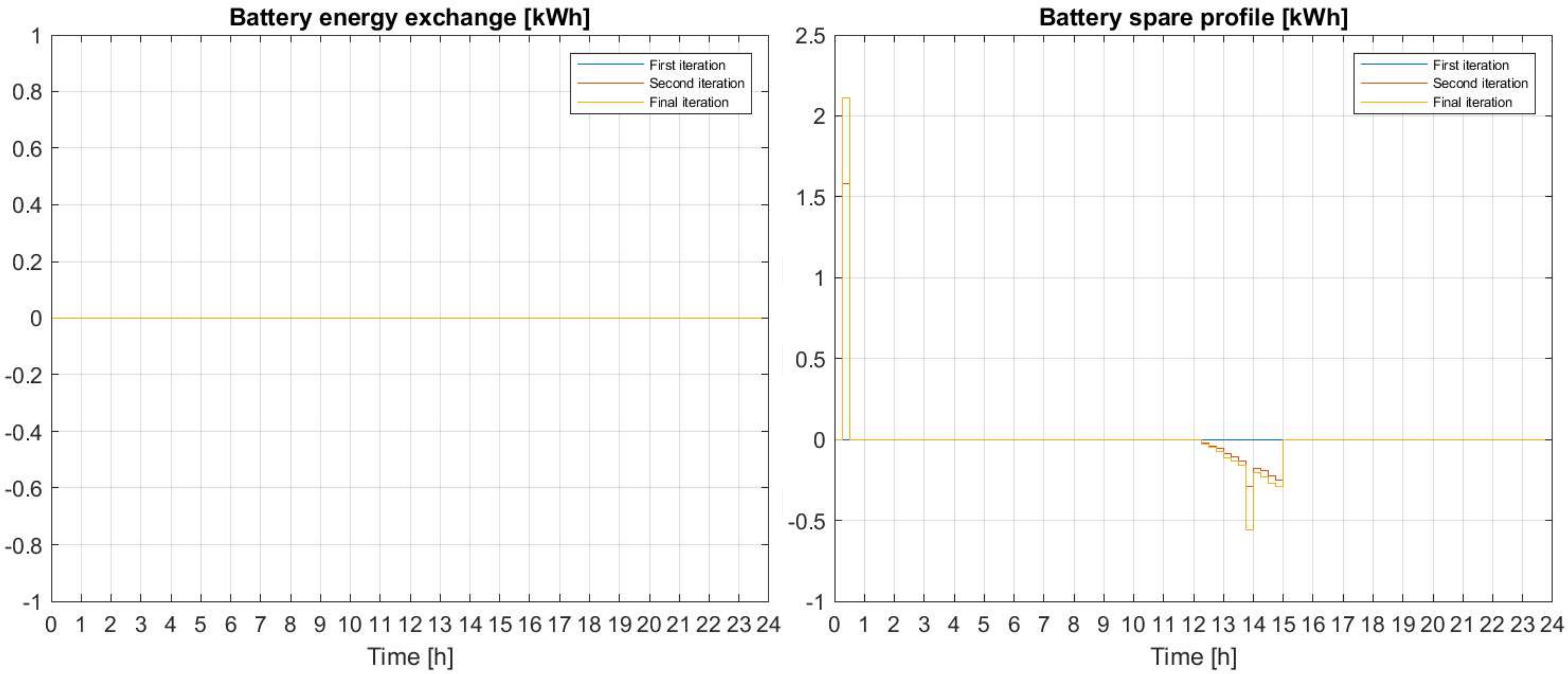
Long-term MPC coordination – M.MPC.1 results



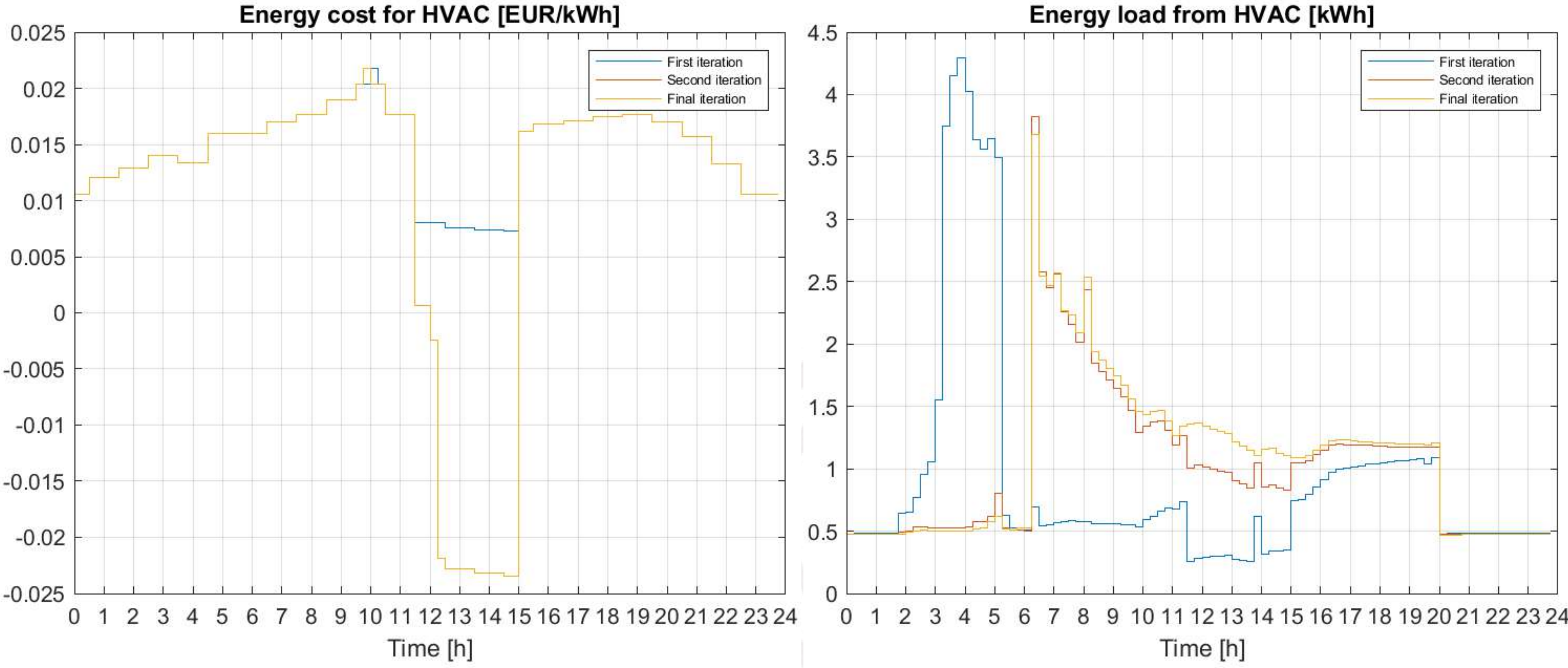


Long-term MPC coordination – M.MPC.1 results

- Battery used to straighten the flexibility possibility in the flexibility interval (when HVAC can no longer push)

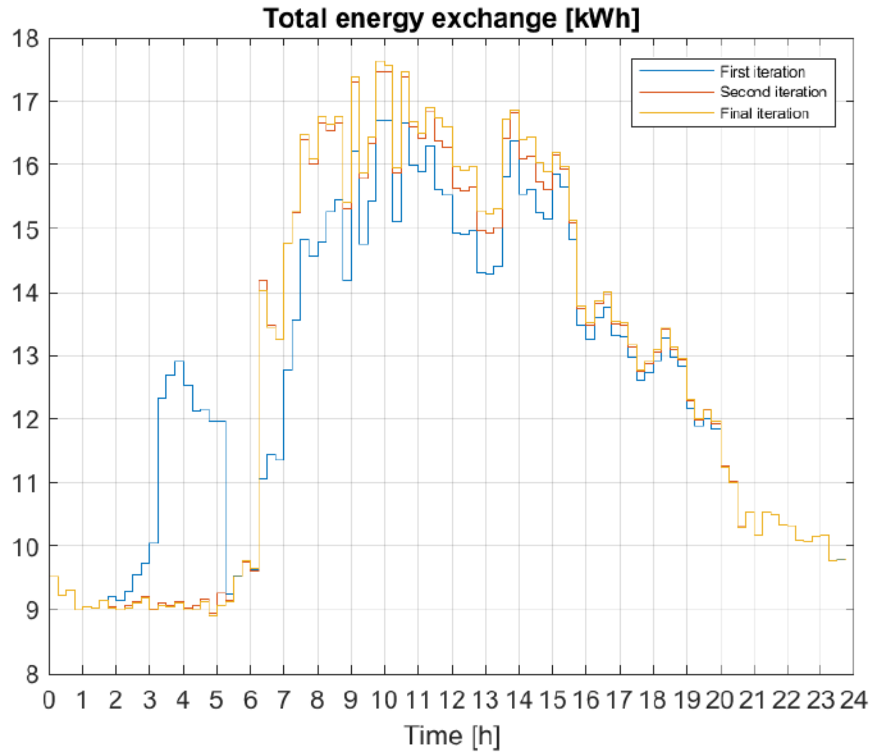


Long-term MPC coordination – M.MPC.1 results



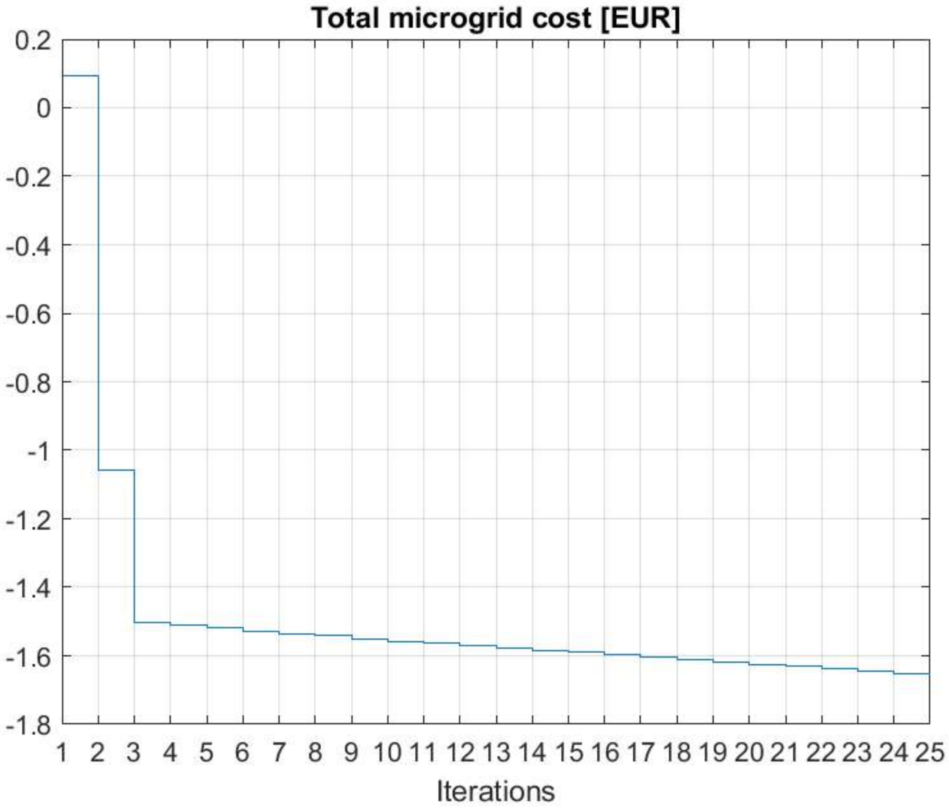
Long-term MPC coordination – M.MPC.1 results

- The enabled flexibility is observable between “First iteration” – to be followed if flexibility is called and “Final iteration” – to be declared to the grid and followed if flexibility is not called



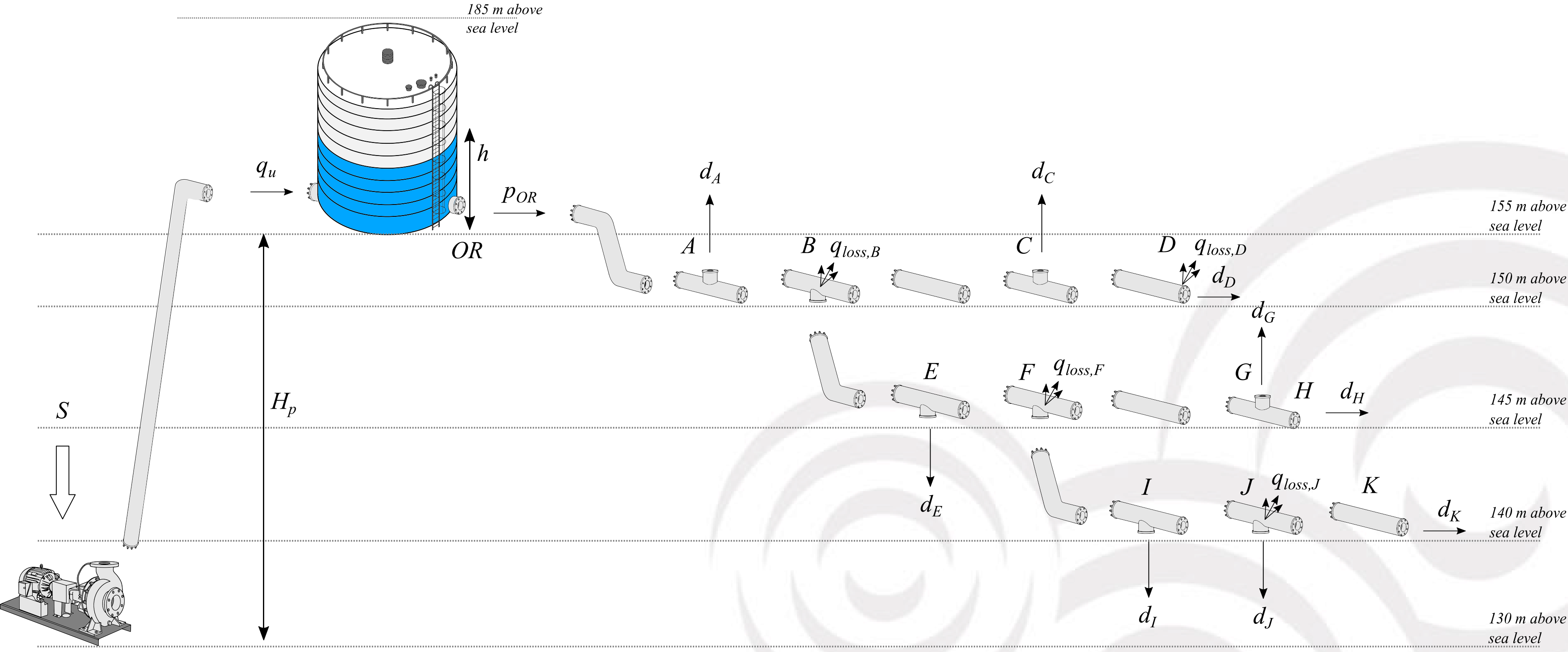
Long-term MPC coordination – M.MPC.1 results

- Assumption: all reserved flexibility was also activated. Consequence: negative total cost (just electricity).



Water distribution system case study

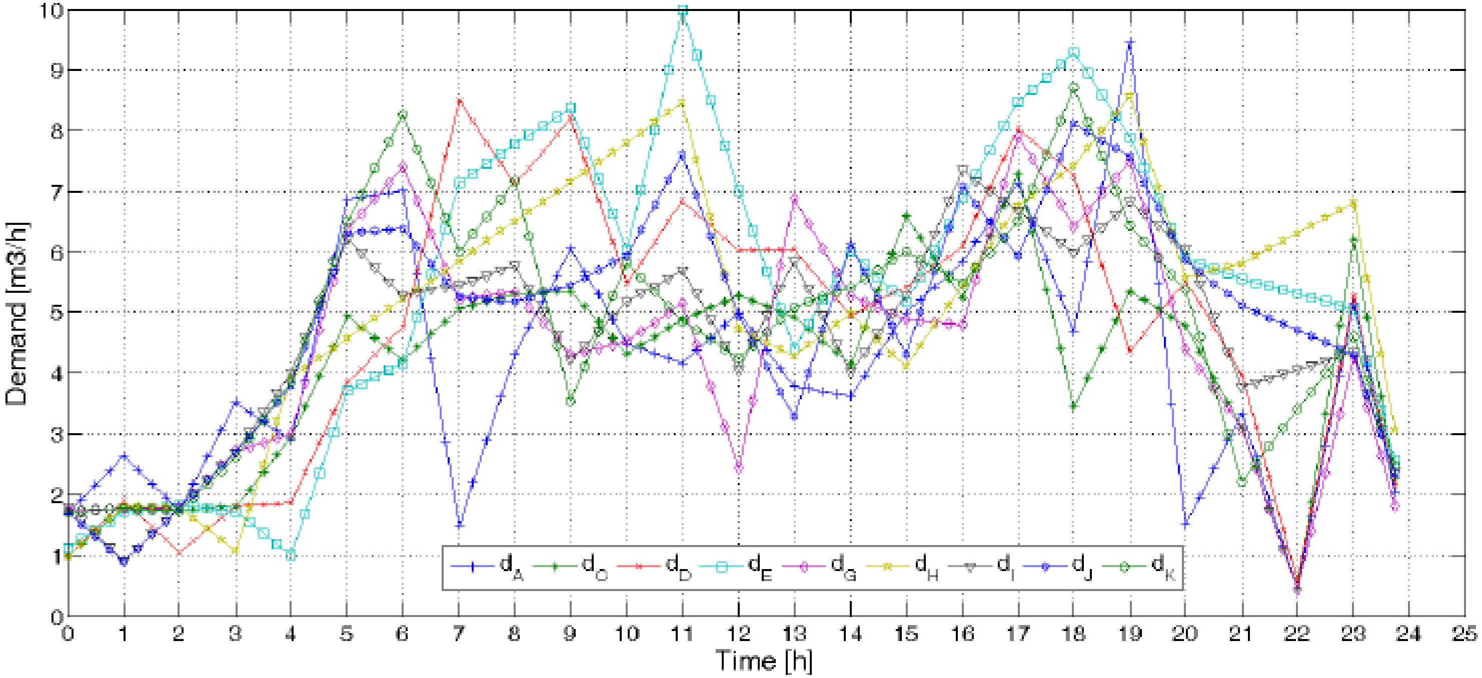
Water distribution system – computation of optimal daily behaviour



- *Ensure correct pressure in all end-points in the network, spend least possible on energy and leaks*

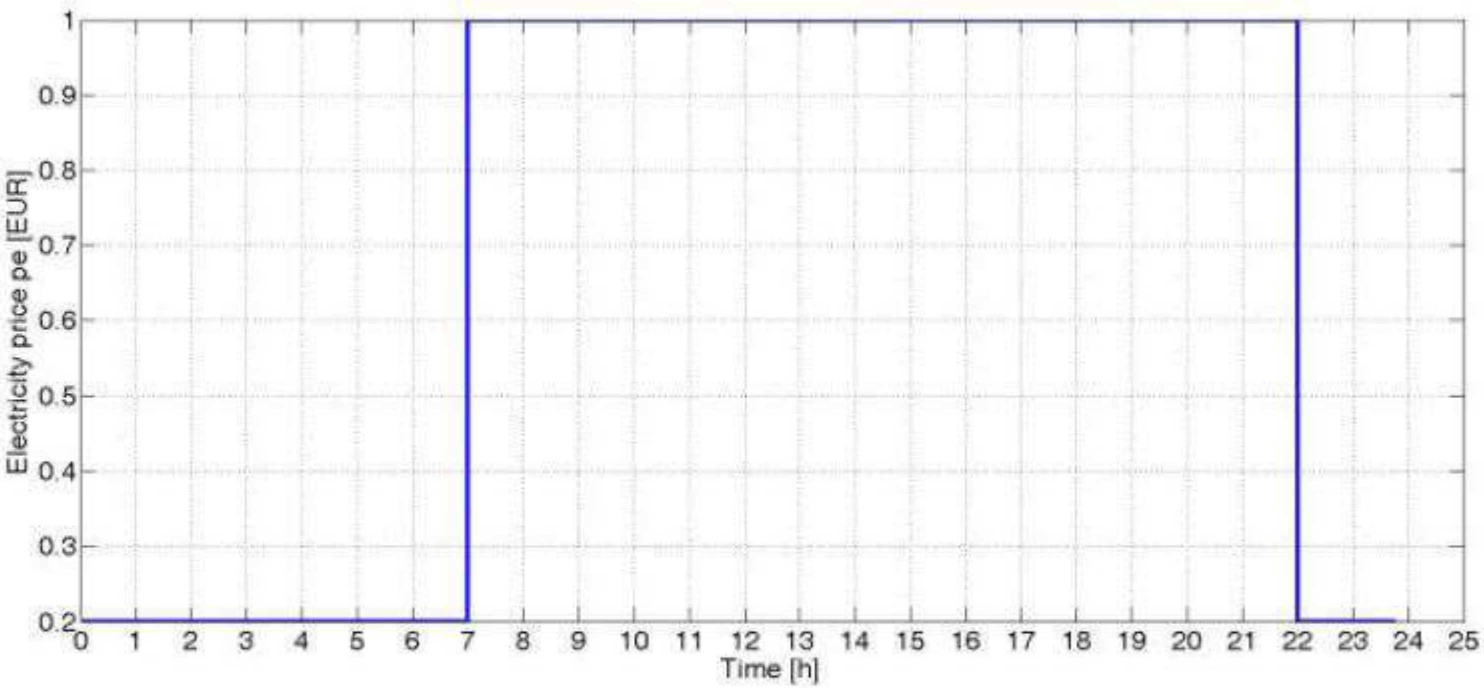
Water distribution system – Operation example

- Predicted demand profile in end-points



Water distribution system – Operation example

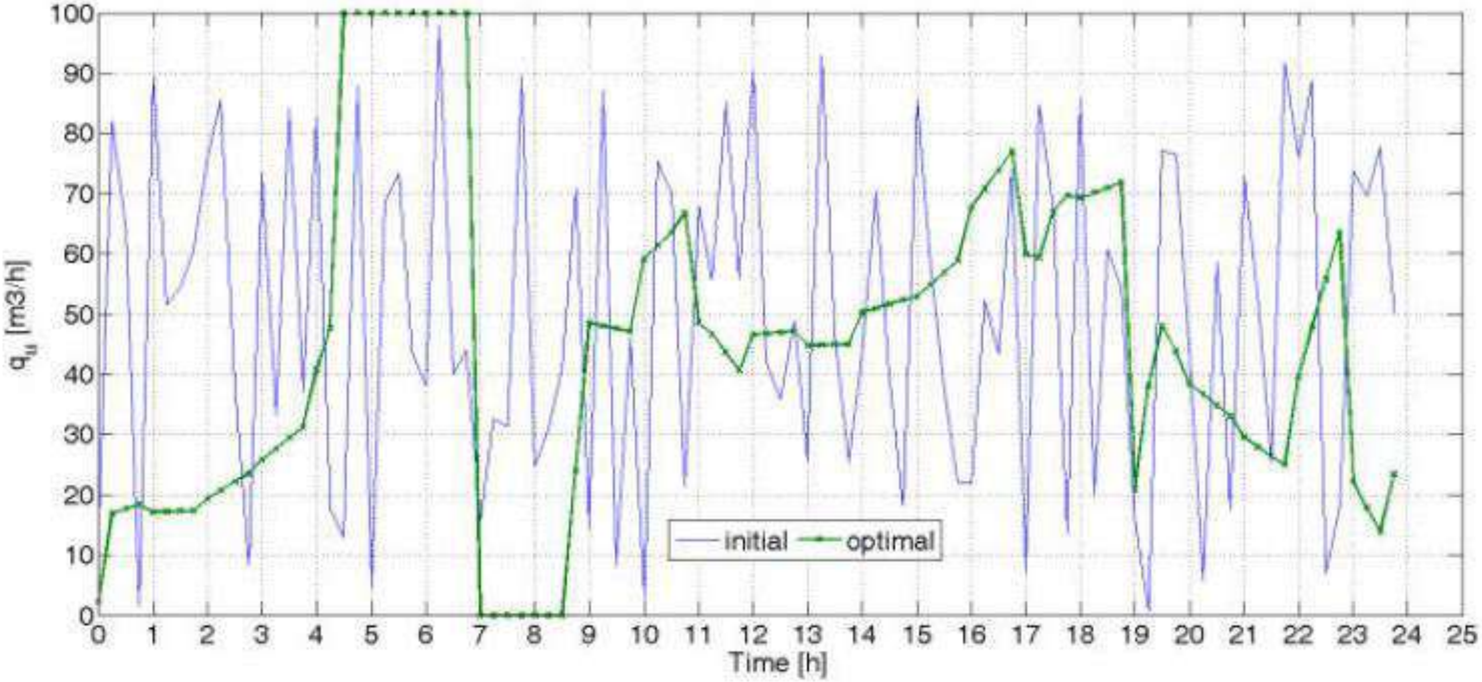
- Two-tariff electricity system:



- Price for lost water: 2 EUR/m3

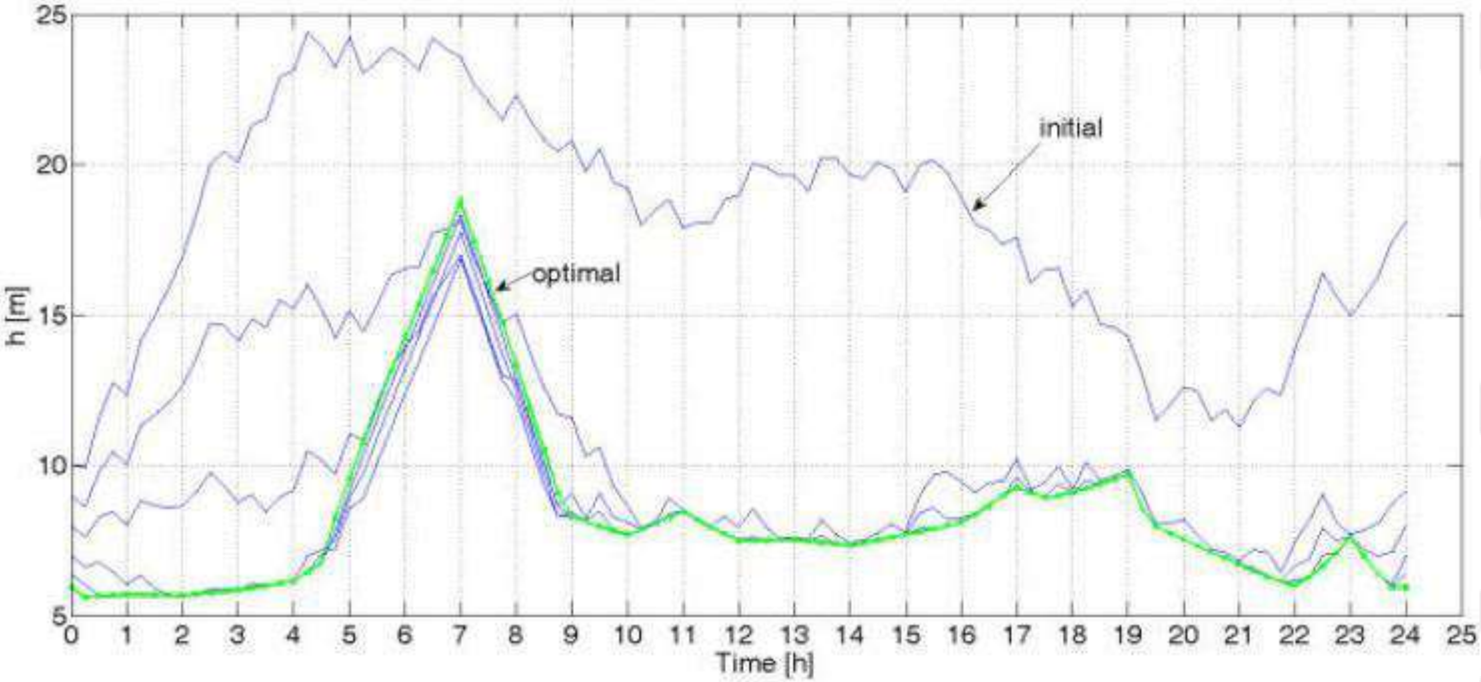
Water distribution system – Operation example

- Initial and optimal pumping profile



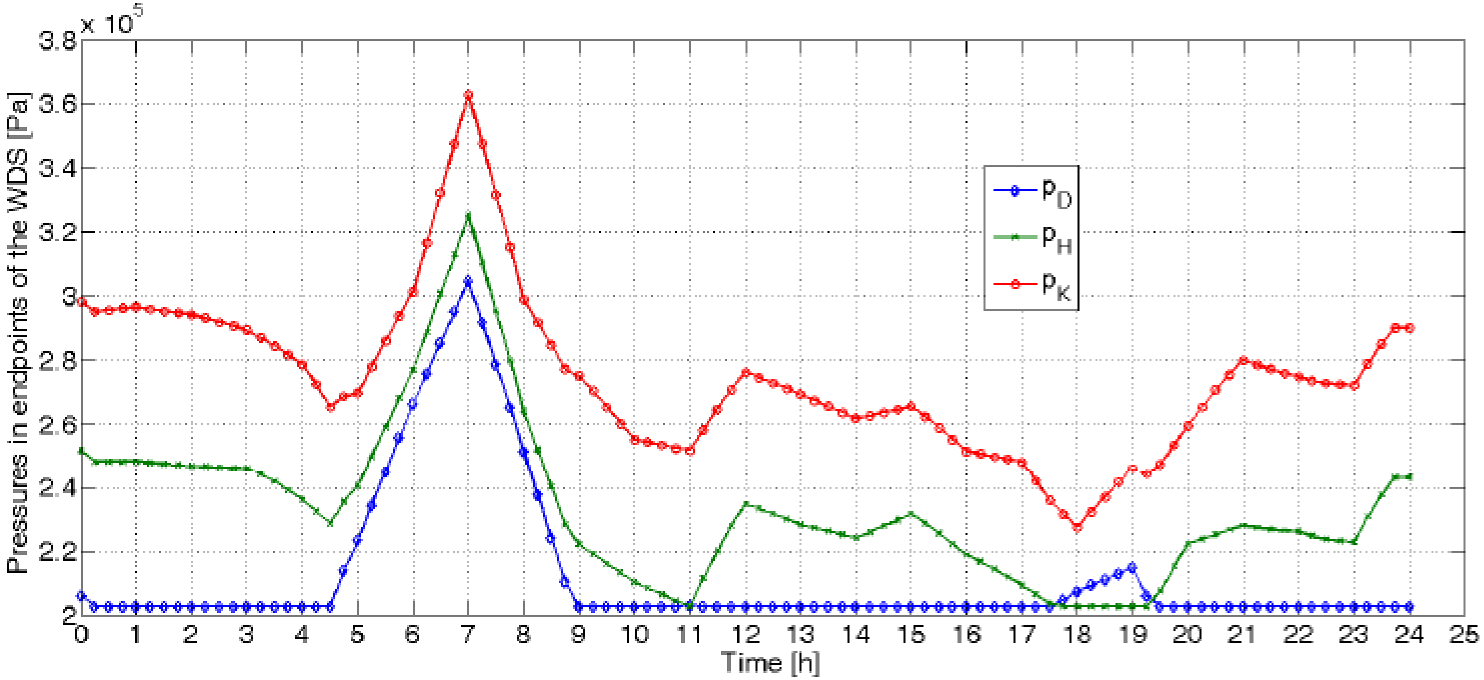
Water distribution system – Operation example

- Initial, profile through iterations, and the final, optimal profile of the water height in the tank



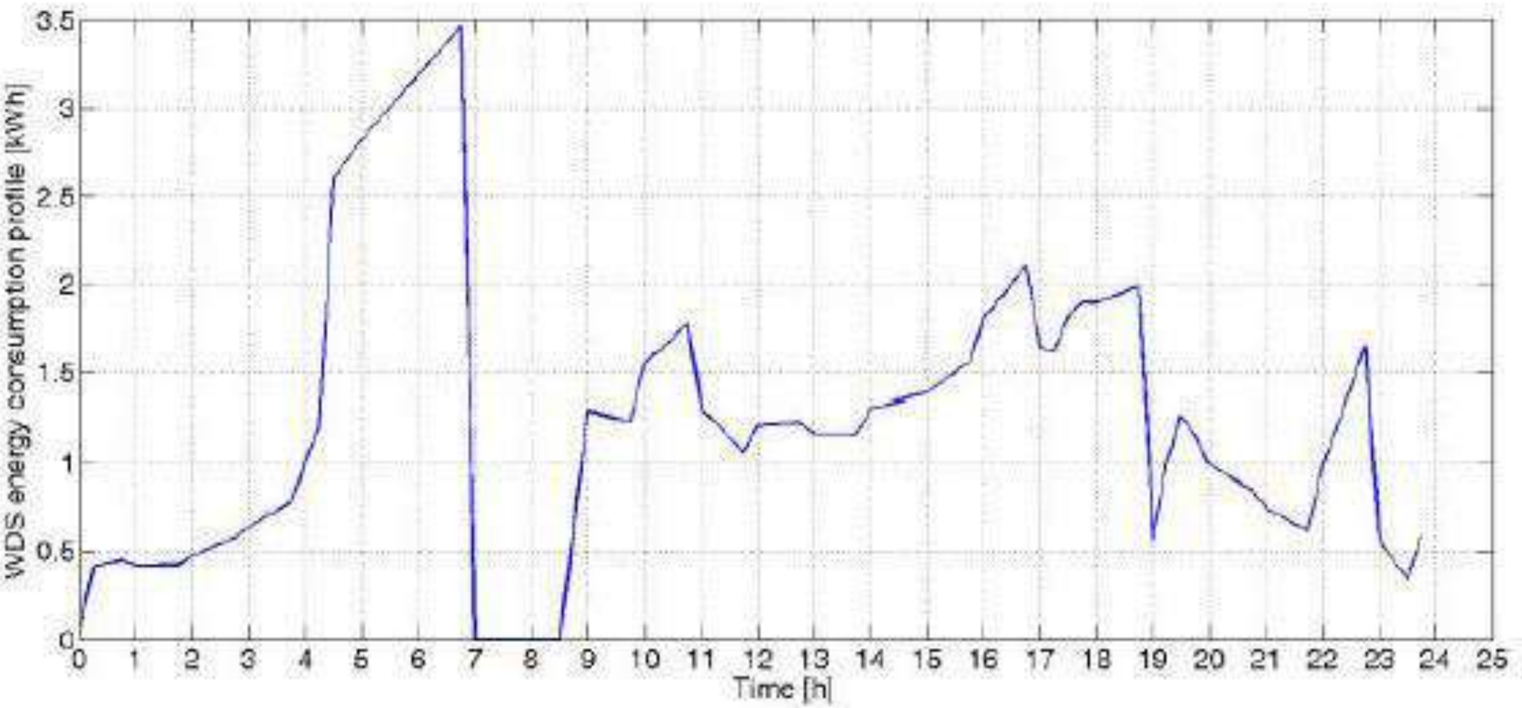
Water distribution system – Operation example

- Pressure profiles at the end-points of the water distribution network



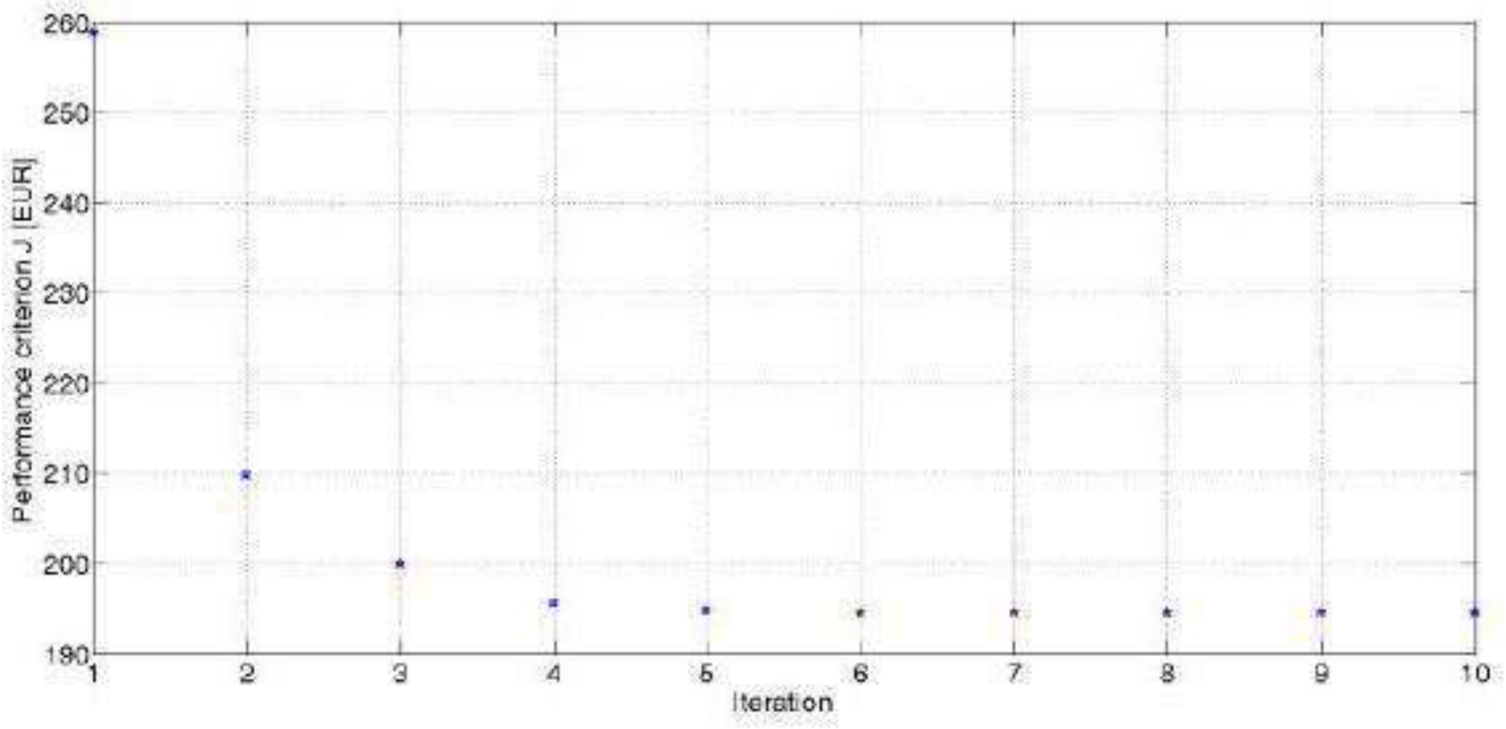
Water distribution system – Operation example

- Electricity consumption profile



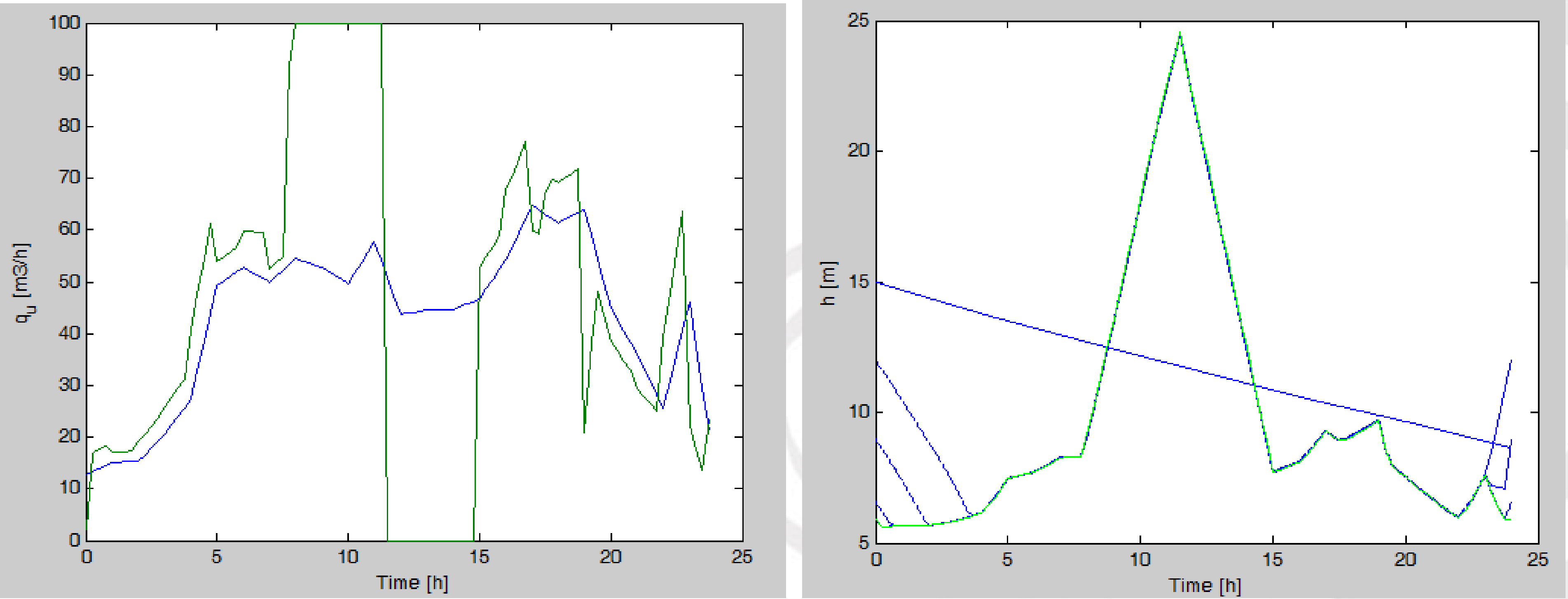
Water distribution system – Operation example

- Cost of the daily operation of the water distribution system through iterations



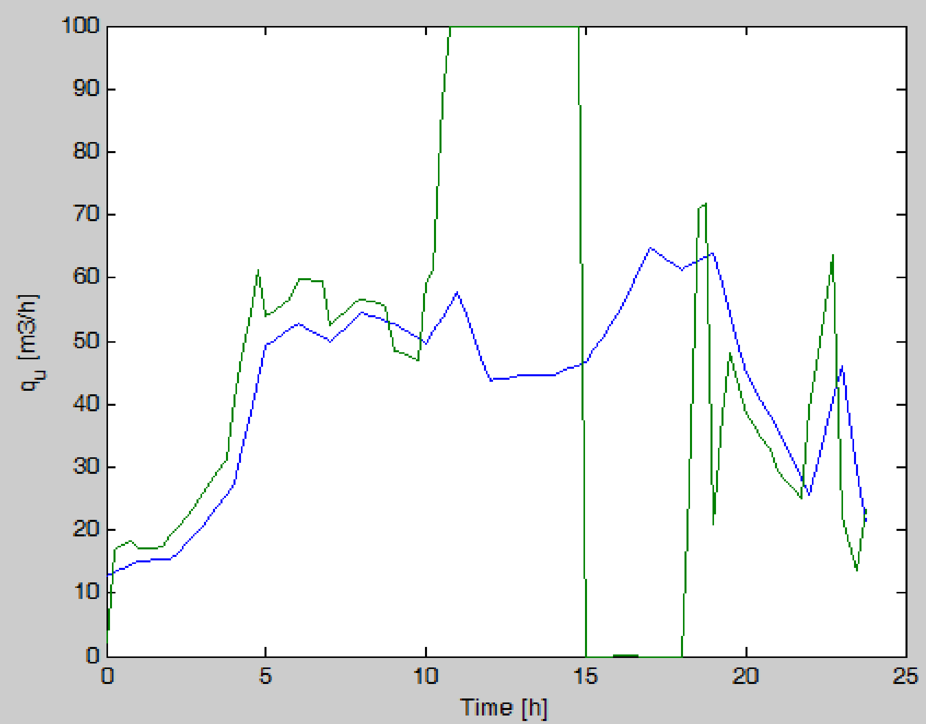
Water distribution system – Flexibility provision

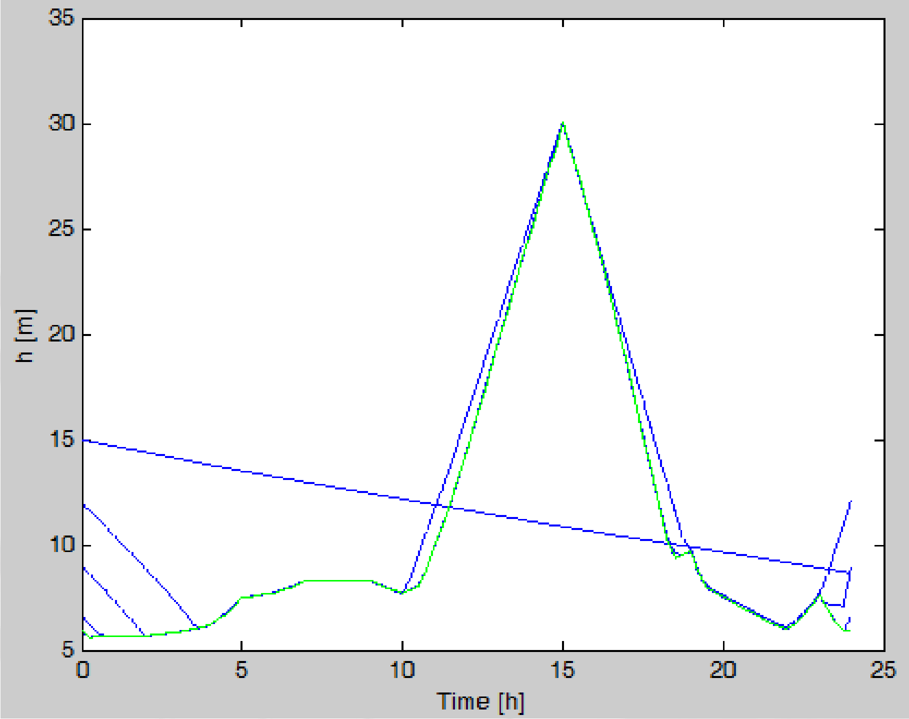
- Avoiding consumption between 11:30 and 15:00 (behaviour if called):



Water distribution system – Flexibility provision

- Enforcing consumption between 11:30 and 15:00 (behaviour if not called):





Minimal 15-min consuption in period: 2.8 kWh → Possibility of flexibility provision of 11.2 kW

EVs parking with chargers

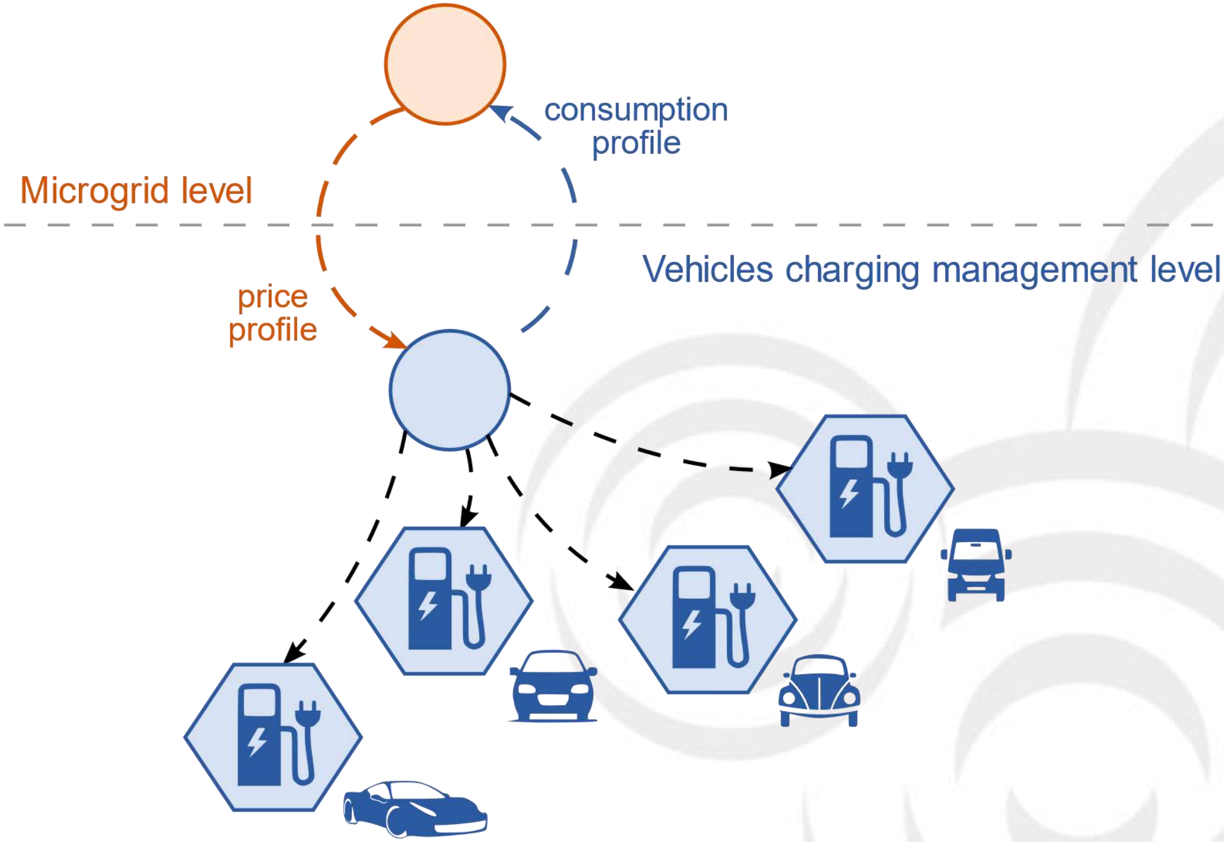
Building energy management → electrical vehicles

- **Extension of microgrid level**

⬡ hierarchy subunit

○ hierarchy coordinator

- - - - optimal control action



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Charging optimisation constraints

- Vehicle battery model

$$x_{k+1}^{i} = x_{k}^{i} + \frac{1}{C^{i}} \left(\frac{1}{\eta_{dch}^{i}} E_{dch,k}^{i} + \eta_{ch}^{i} E_{ch,k}^{i}\right)$$

- Aggregate energy flow
- Individual charger limit
- SoC limit

Charging optimisation constraints

- Vehicle battery model
- Aggregate energy flow
- Individual charger limit
- SoC limit

discharging charging

$$x_{k+1}^{i} = x_{k}^{i} + \frac{1}{C^{i}} \left(\frac{1}{\eta_{dch}^{i}} E_{dch,k}^{i} + \eta_{ch}^{i} E_{ch,k}^{i} \right)$$

$$x_{k+1}^{i} = A^{i}\, x_{k}^{i} + B^{i}\, u_{k}^{i} \quad (1)$$

$$E_{dch,k}^{i} \le 0$$
$$E_{ch,k}^{i} \ge 0$$

Charging optimisation constraints

- Vehicle battery model
- Aggregate energy flow
- Individual charger limit
- SoC limit

$$\boldsymbol{G}^F \boldsymbol{u}_k^F \leq \boldsymbol{w}^F \qquad (2)$$

Charging optimisation constraints

- Vehicle battery model
- Aggregate energy flow
- Individual charger limit
- SoC limit

$$P_{min}\, T_s \leq u_k^F \leq P_{max}\, T_s \quad (2)$$

$$u_k^F = \sum_{i=1}^{N} [1 \;\; 1]\, u_k^i$$

N number of vehicles

Charging optimisation constraints

- Vehicle battery model
- Aggregate energy flow
- Individual charger limit
- SoC limit

$$u^i_{min} \leq u^i_k \leq u^i_{max} \quad (3)$$

Charging optimisation constraints

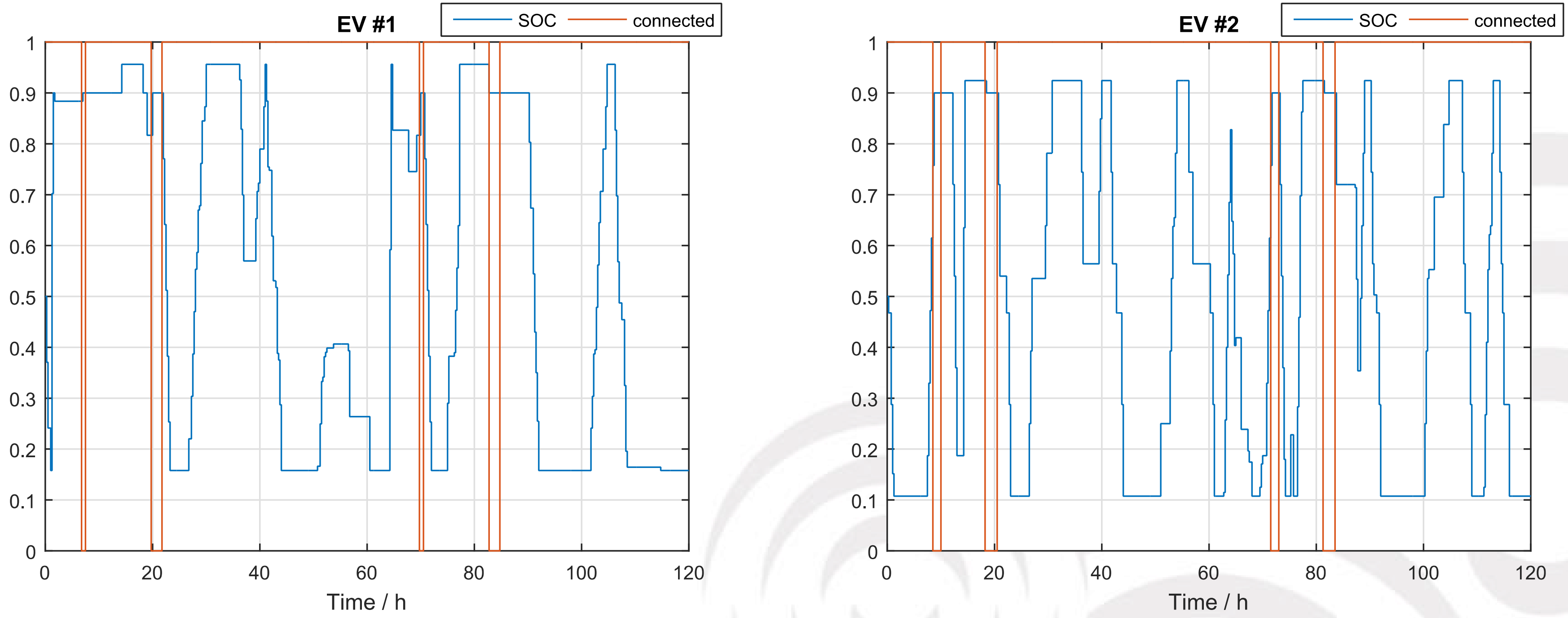
- Vehicle battery model
- Aggregate energy flow
- Individual charger limit
- SoC limit

$$x^i_{min} \leq x^i_k \leq x^i_{max} \quad (4)$$

Illustrative Case study

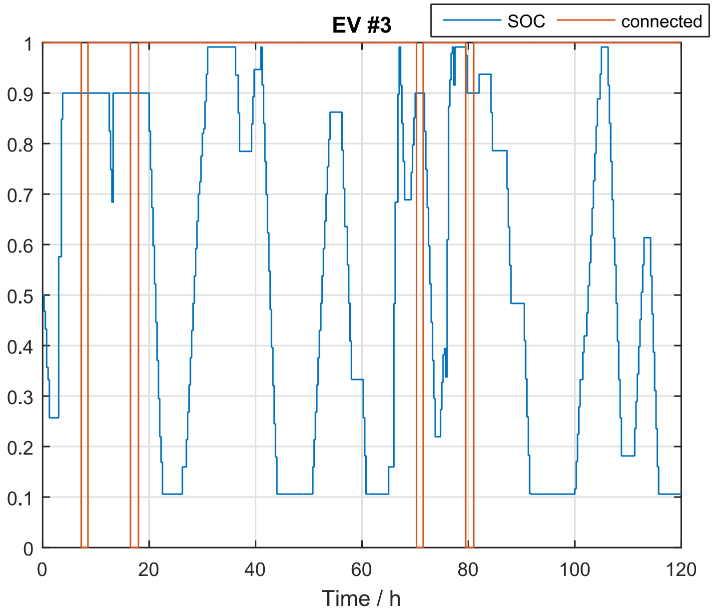
- Arbitrary number of vehicles – 5 chosen for illustrative purpose
- Arbitrary sample time – chosen 15 minutes
- Arbitrary prediction horizon – chosen 6 hours
- Heterogeneous vehicles (random)
  - Battery capacity varying from 5 to 20 kWh
  - Charging/discharging efficiency varying from 80% to 90%
  - Minimum allowed SoC varying from 0.1 to 0.2
  - Maximum allowed SoC varying from 0.9 to 1.0
  - Maximum allowed charging power varying from 3 kW to 5 kW
  - Maximum allowed discharging power varying from 3 kW to 5 kW
- Limited connection to the grid, 50% of capacity

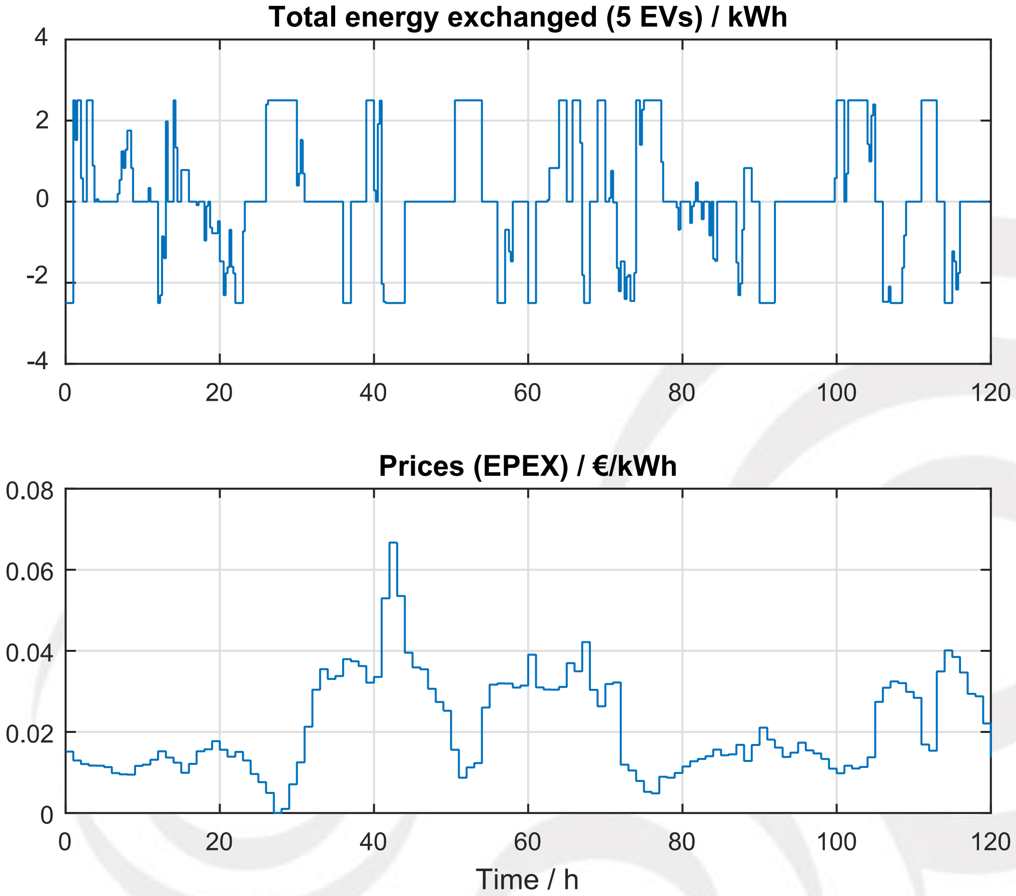
Charging before disconnect



- Battery charged to SOC = 0.9 before disconnecting

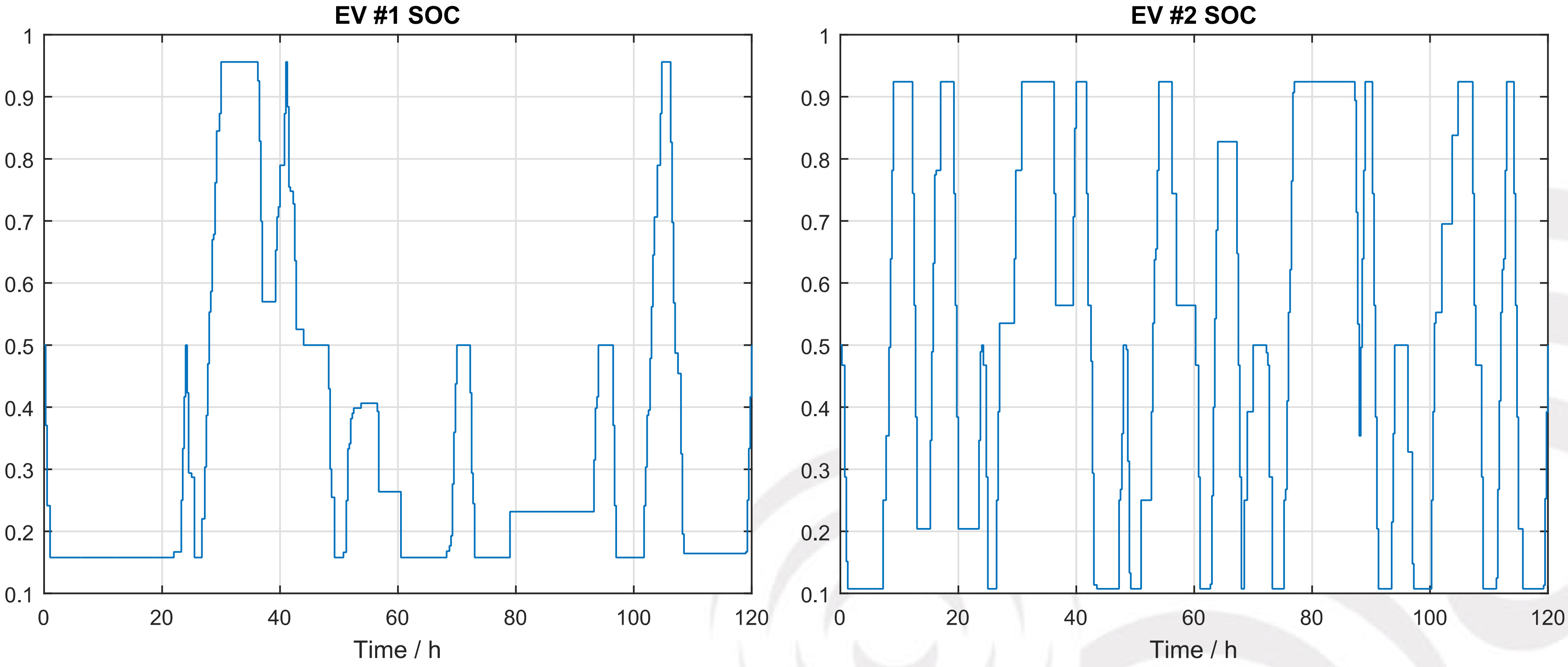
Charging before disconnect



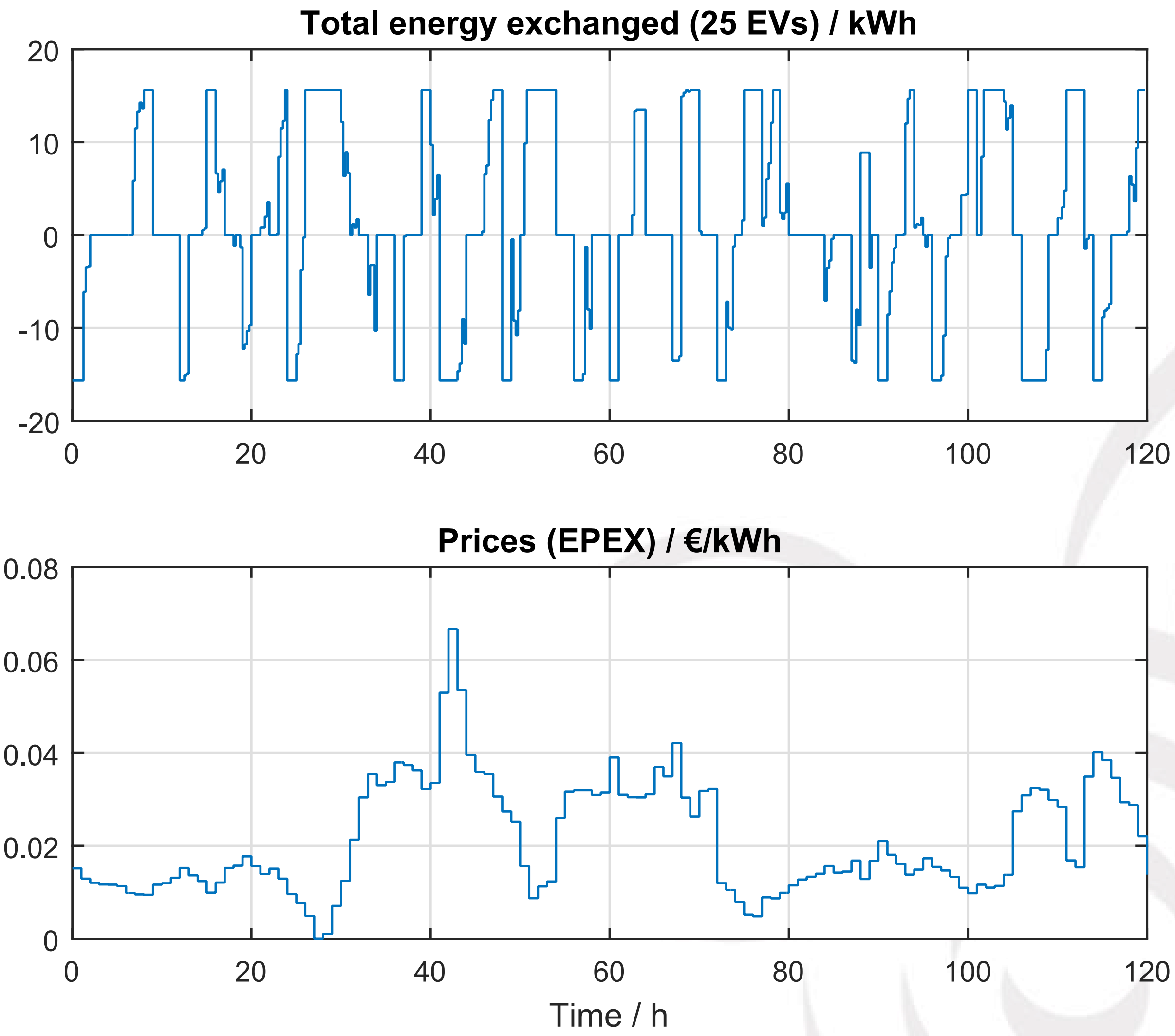


- Energy exchanged when favourable (15-min intervals)

Ending day at SOC = 0.5



25 vehicles (SOC = 0.5 at the end of day)



Conclusion

- 3Smart control strategy can be extended to utilize batteries of electrical vehicles connected to the grid
- Multicriteria optimisation: charged batteries, preserved batteries, energy-efficient building operation etc.
- Problem favourable for distributed control (information privacy, replication)
- Suitable for hierarchical MPC coordination (cost reduction, flexibility)

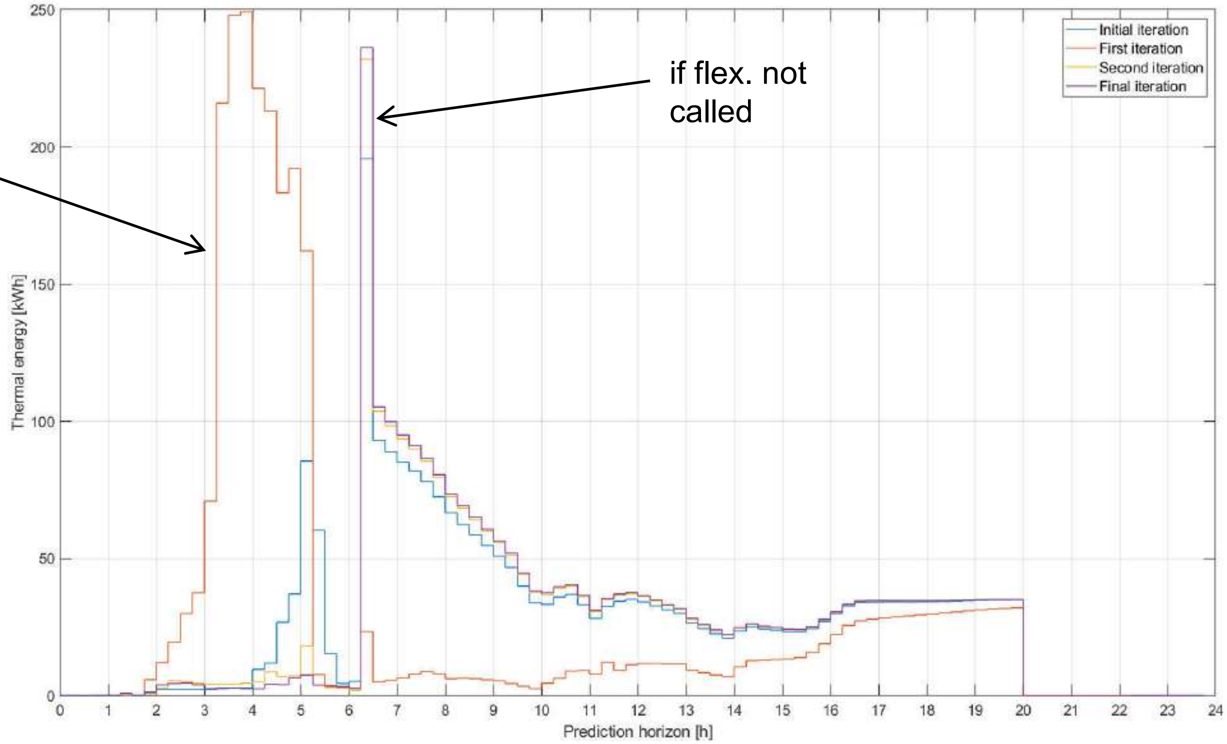
Smart city upscale strategy

Main points (1)

- Microgrid-level modules developed for buildings can be used for bidding flexibility of the infrastructure
  - Need to interconnect with the optimization software adapted for the infrastructure
- For a considerable number of players who provide flexibility autonomous trading can be established to further increase chances of economic gains and reduce penalty risk
- Infrastructure systems often have SCADA through which operators control the system
  - from the IT side it should be feasible to incorporate a server computer above most likely already existing database, initially as decision support and later on for autonomous operation

Main points (2)

- Favourable interplay between demand shift in heat distribution network and demand response in electricity can be spotted



Battery modules

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Strem pilot study visit

28. March 2019.

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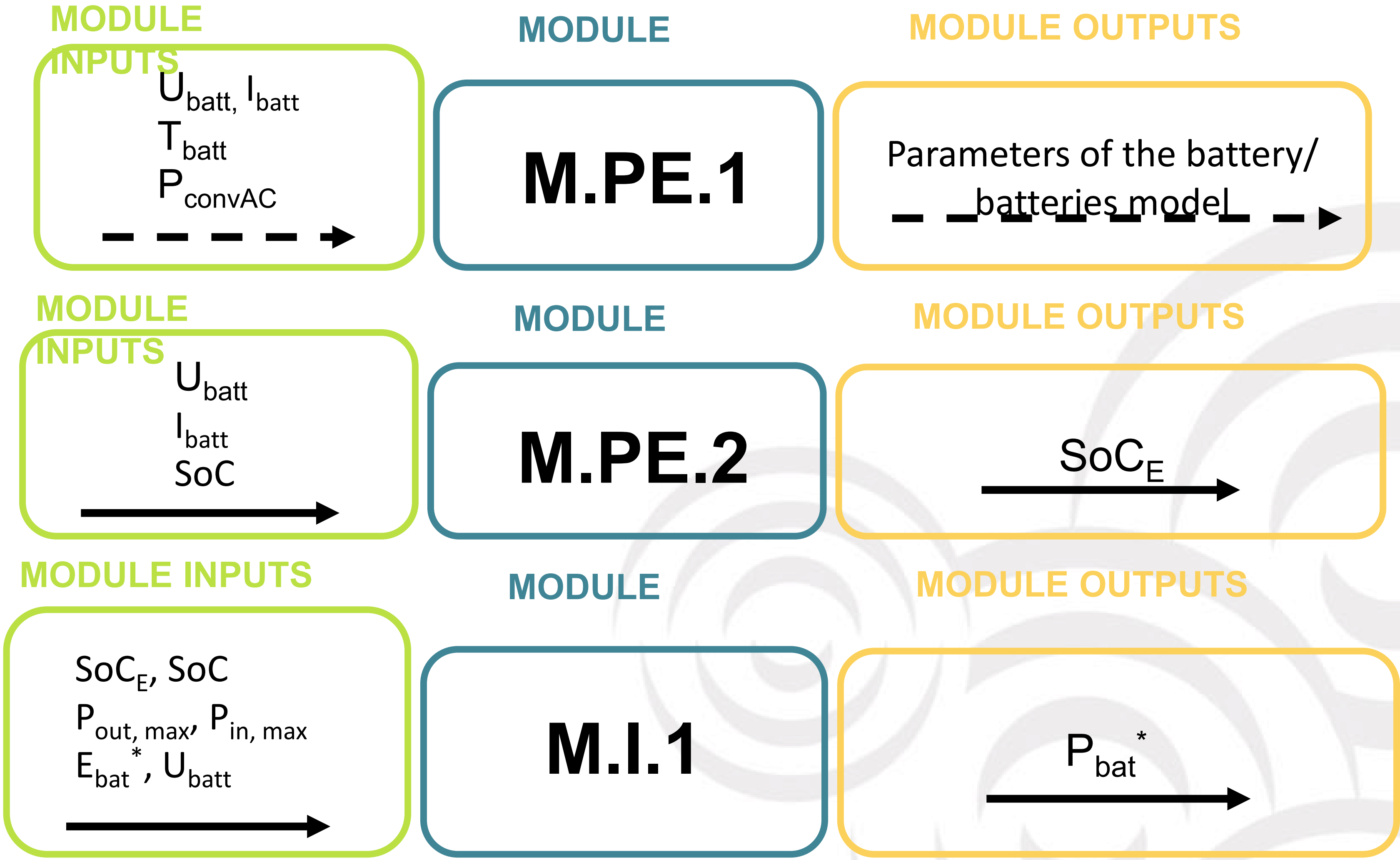
Project co-funded by European Union funds (ERDF, IPA)

Battery modules



MODULE INPUTS

U_{batt}, I_{batt}

T_{batt}

P_{convAC}

MODULE

M.PE.1

MODULE OUTPUTS

Parameters of the battery/ batteries model

MODULE INPUTS

U_{batt}

I_{batt}

SoC

MODULE

M.PE.2

MODULE OUTPUTS

SoC_E

MODULE INPUTS

SoC_E, SoC

$P_{out, max}$, $P_{in, max}$

E_{bat}^*, U_{batt}

MODULE

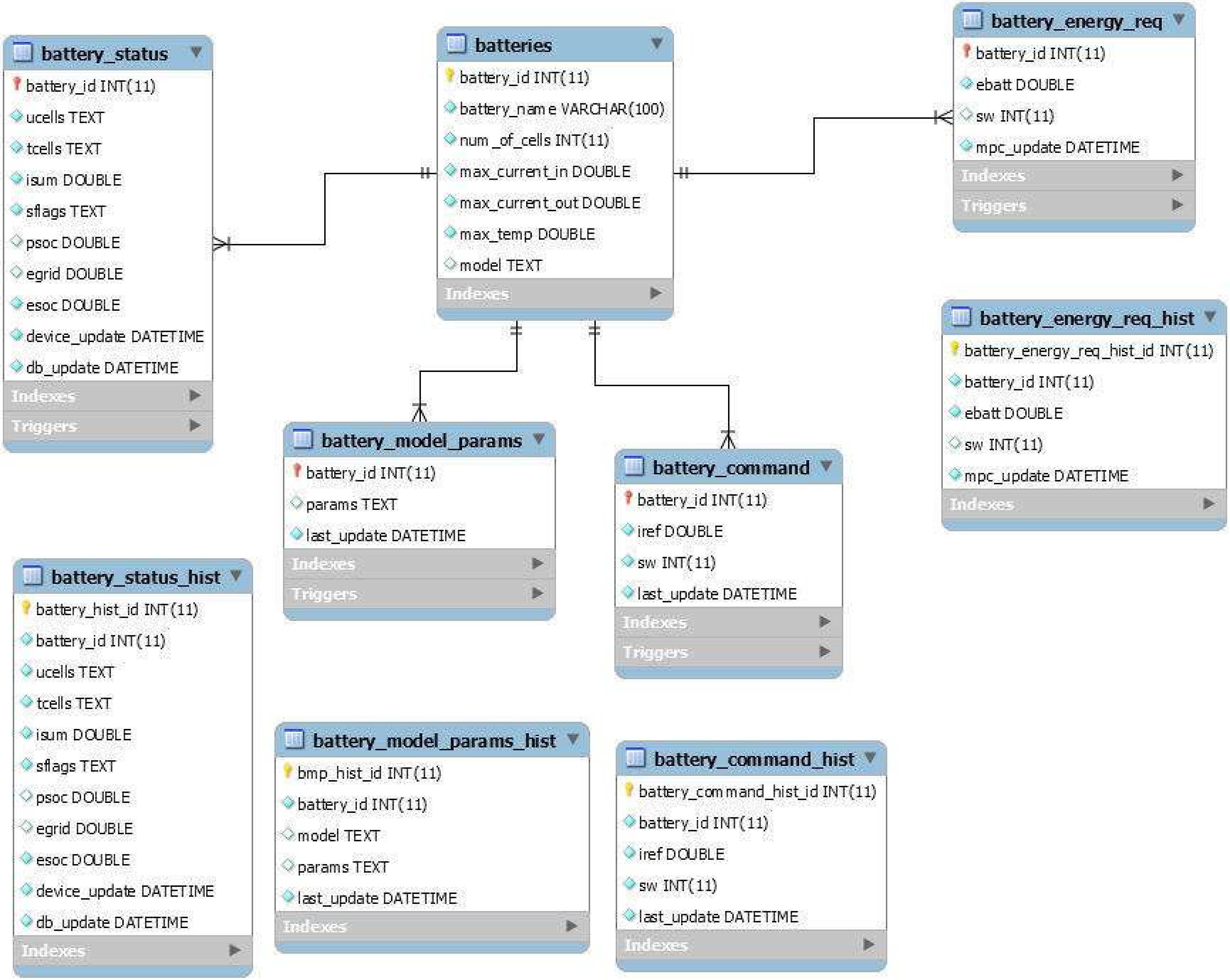
M.I.1

MODULE OUTPUTS

P_{bat}^*

Input values

- U_{batt}, T_{batt} – can be current value
- I_{bat}, P_{convAC} – has to be average for 1 min



battery_status
battery_id INT(11)
ucells TEXT
tcells TEXT
isum DOUBLE
sflags TEXT
psoc DOUBLE
egrid DOUBLE
esoc DOUBLE
device_update DATETIME
db_update DATETIME
Indexes
Triggers

batteries
battery_id INT(11)
battery_name VARCHAR(100)
num_of_cells INT(11)
max_current_in DOUBLE
max_current_out DOUBLE
max_temp DOUBLE
model TEXT
Indexes

battery_energy_req
battery_id INT(11)
ebatt DOUBLE
sw INT(11)
mpc_update DATETIME
Indexes
Triggers

battery_energy_req_hist
battery_energy_req_hist_id INT(11)
battery_id INT(11)
ebatt DOUBLE
sw INT(11)
mpc_update DATETIME
Indexes

battery_model_params
battery_id INT(11)
params TEXT
last_update DATETIME
Indexes
Triggers

battery_command
battery_id INT(11)
iref DOUBLE
sw INT(11)
last_update DATETIME
Indexes
Triggers

battery_status_hist
battery_hist_id INT(11)
battery_id INT(11)
ucells TEXT
tcells TEXT
isum DOUBLE
sflags TEXT
psoc DOUBLE
egrid DOUBLE
esoc DOUBLE
device_update DATETIME
db_update DATETIME
Indexes

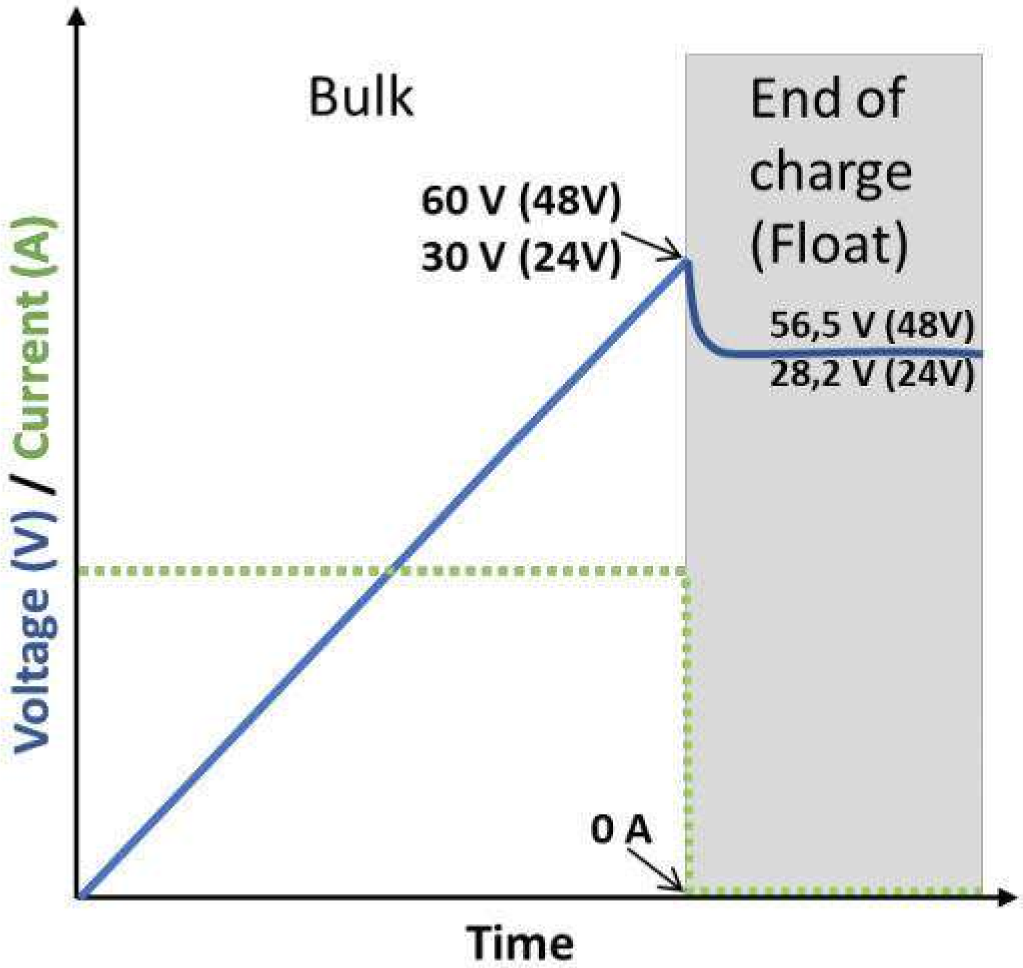
battery_model_params_hist
bmp_hist_id INT(11)
battery_id INT(11)
model TEXT
params TEXT
last_update DATETIME
Indexes

battery_command_hist
battery_command_hist_id INT(11)
battery_id INT(11)
iref DOUBLE
sw INT(11)
last_update DATETIME
Indexes

Battery parameters

- 24 kWh nominal capacity
- 3 x 3 kW inverter – is it fully available?

Battery parameters



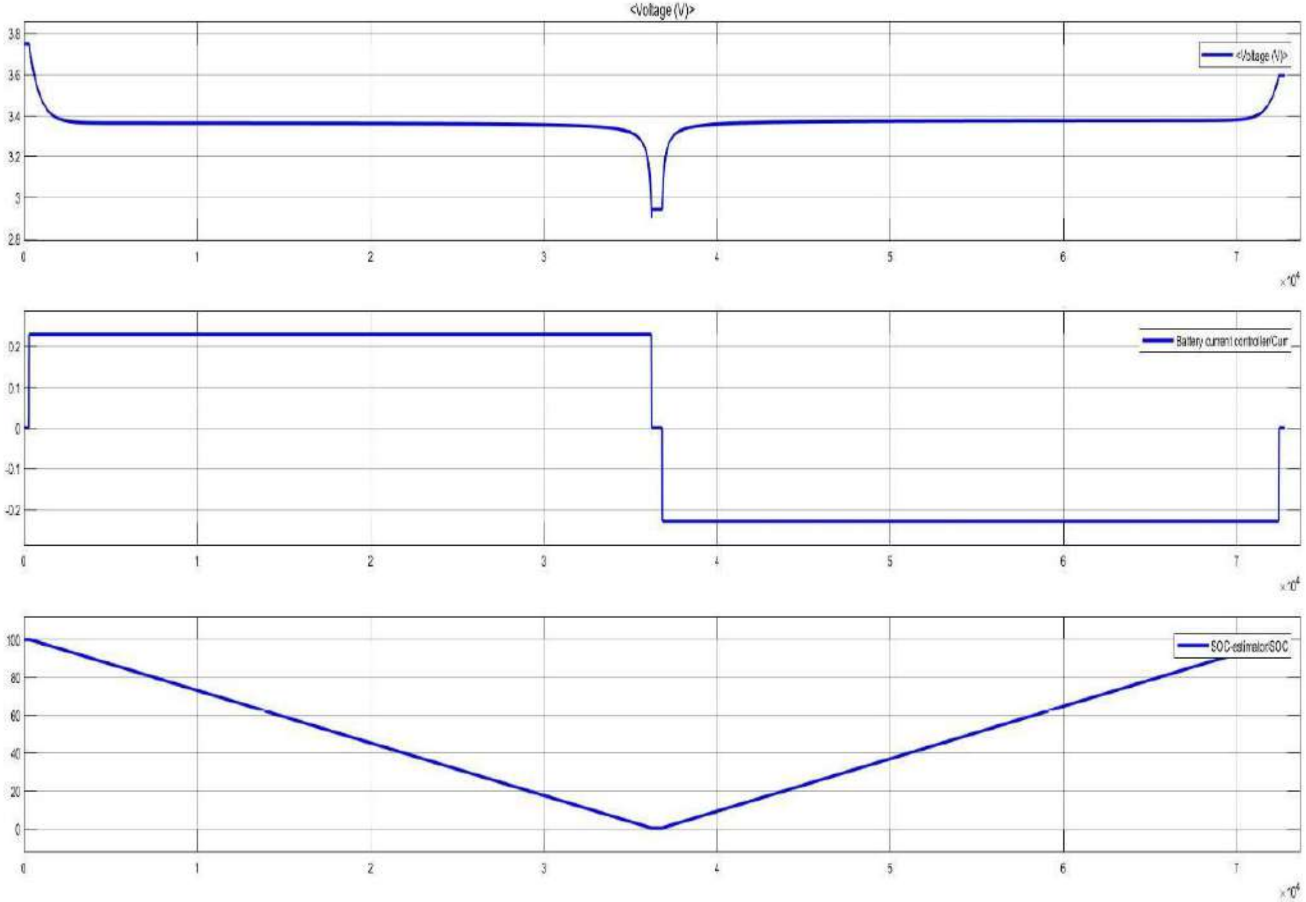
Installation

- Pre-installation tasks
  - datasheets of the systems (pilot host)
  - installation battery module tables (pilot host + UNIDEBTTK)
  - calculation and uploading battery initial parameters (UNIDEBTTK)
  - connecting data collection to tables (pilot host + UNIDEBTTK)

Installation

- Calibration cycle (to be done manually)
  1. Full charge of battery
  2. Full discharge of the battery with 0.05C
     (≈20 hours)
  1. Full charge of the battery with 0.05C
     (≈20 hours)

Calibration cycle



Installation

- First time installation with gradual introduction of features:
  1. Manual entering of battery parameters M.PE.1
  2. M.I.1 installation without feedback
  3. M.PE.2 installation and comparison with values from the system
  4. Checking of timings for M.I.1 feedback
  5. M.PE.1 installation based on collected data

Grid side modules coordination on the sides of Energy G

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3Smart – First pilot study visit Strem study

27. – 28.03.2019.

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FACULTY OF
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Content

- Long-term Multi(Annual) module
  - Model architecture
  - Database overview
  - Communication model

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

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

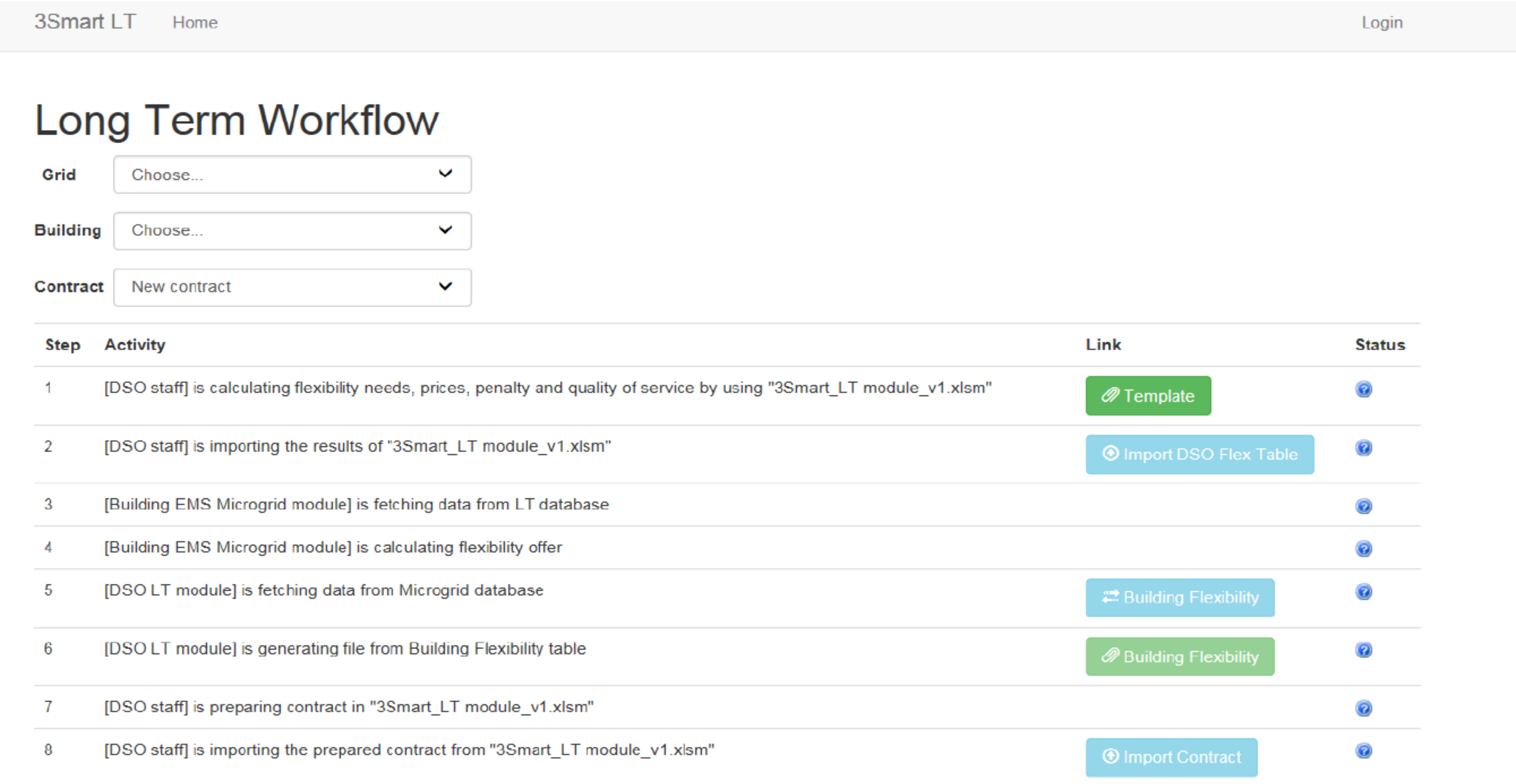
LT module coordination

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



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

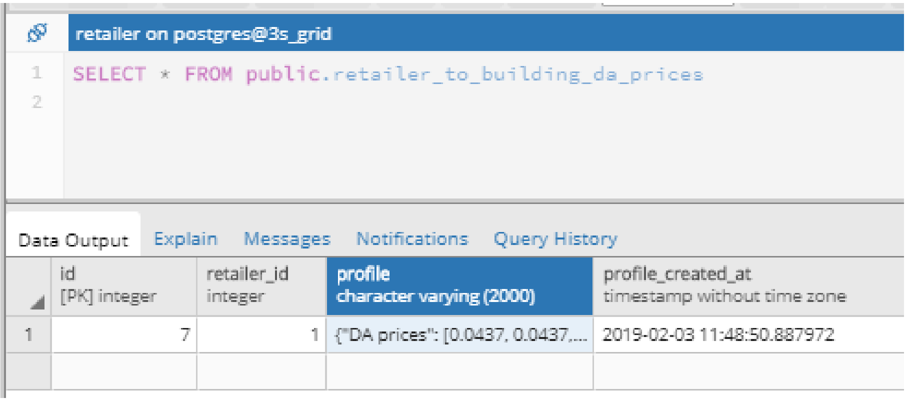
- From Grid.xlsx:
  - Grid information (grid topology, lines descriptions)
  - Active and reactive power profiles for every node defined for specific dates in year (3 characteristics profiles for every moth)

- From Long-term contract:
  - Building flexibility table

Module coordination

- Day before delivery of electricity
  - At **11.00 AM** (UTC) EPEX SPOT 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

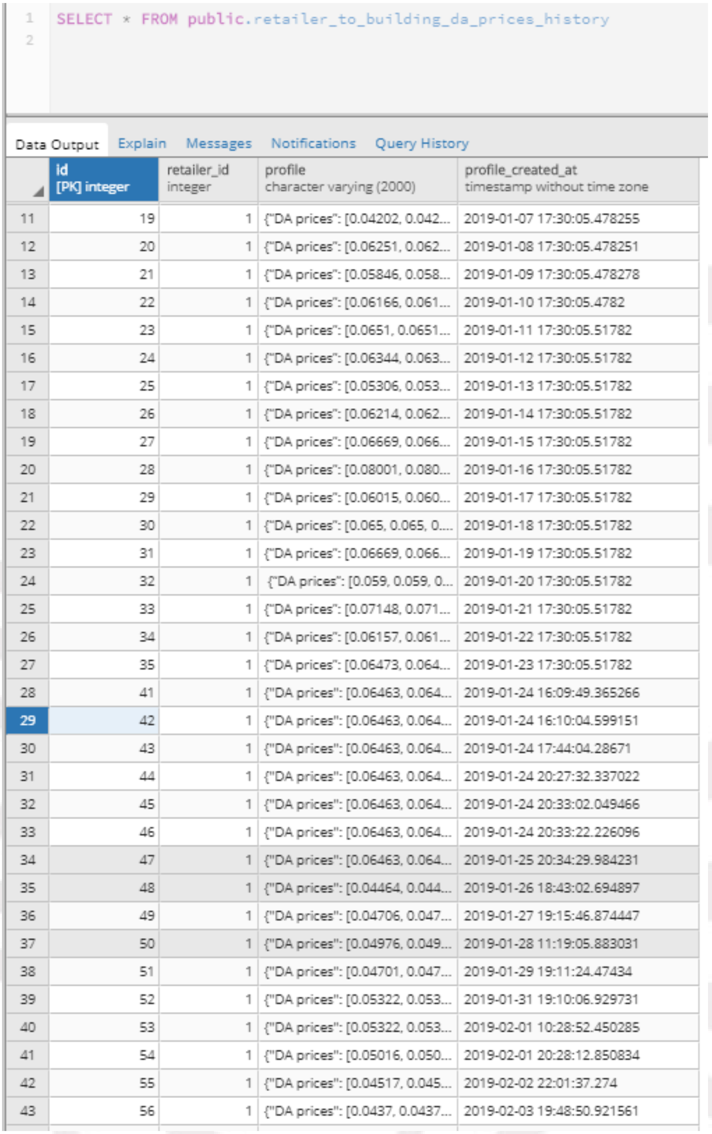
Retailer database outlook



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

	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
```

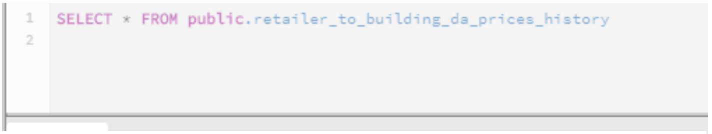
	id [PK] integer	retailer_id integer	profile character varying (2000)	profile_created_at timestamp without time zone
11	19	1	{"DA prices": [0.04202, 0.042...	2019-01-07 17:30:05.478255
12	20	1	{"DA prices": [0.06251, 0.062...	2019-01-08 17:30:05.478251
13	21	1	{"DA prices": [0.05846, 0.058...	2019-01-09 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

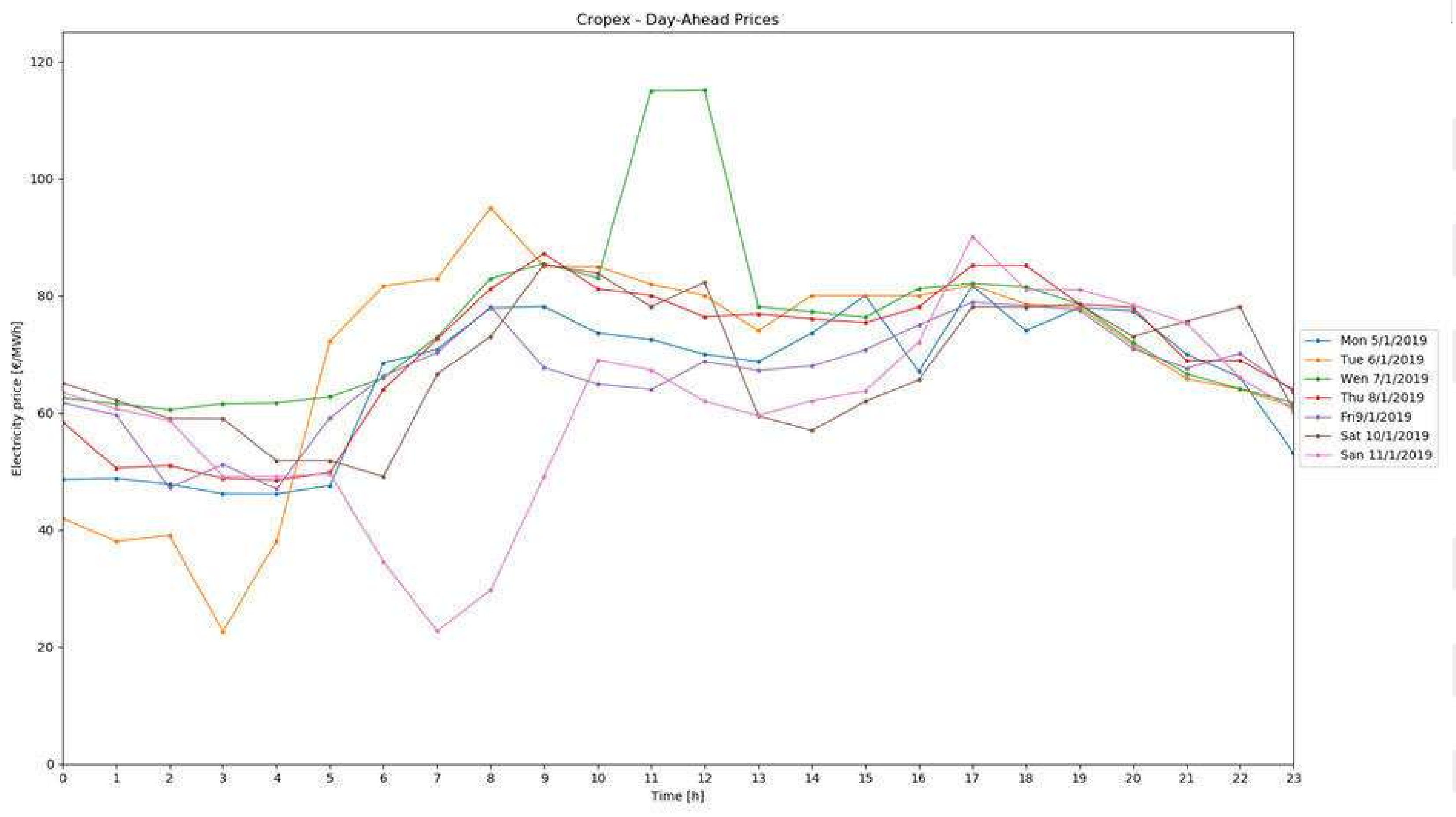
```
SELECT * FROM public.retailer_to_building_da_prices
```

Data Outp

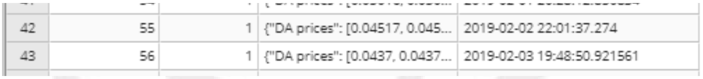
	id [PK] ir
1	



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



{"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

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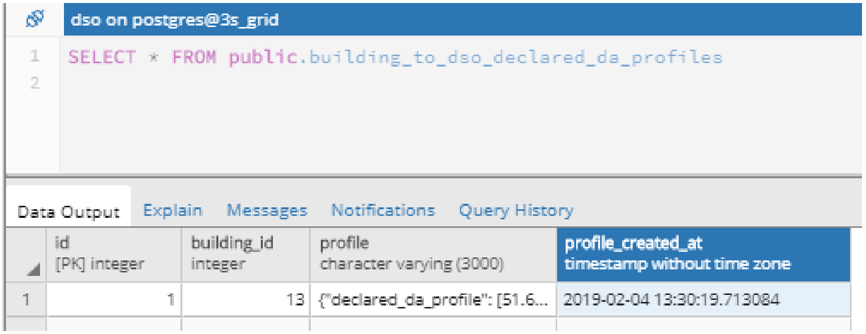
Module coordination

- 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

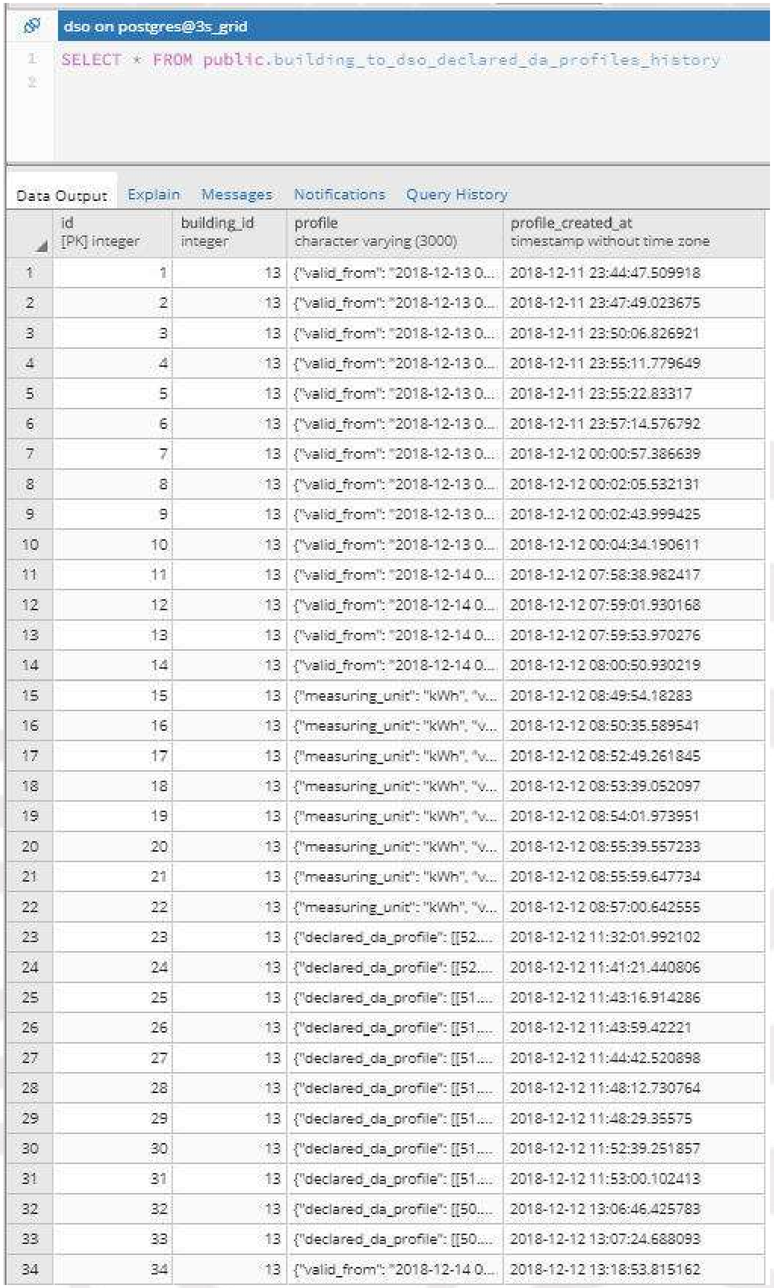
Database outlook



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

	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, 67.78200000000001, 69.033999999999999, 64.38, 59.166, 59.703999999999999, 60.242, 61.916000000000004, 63.428, 64.76400000000001, 62.852, 64.45400000000001, 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"}



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

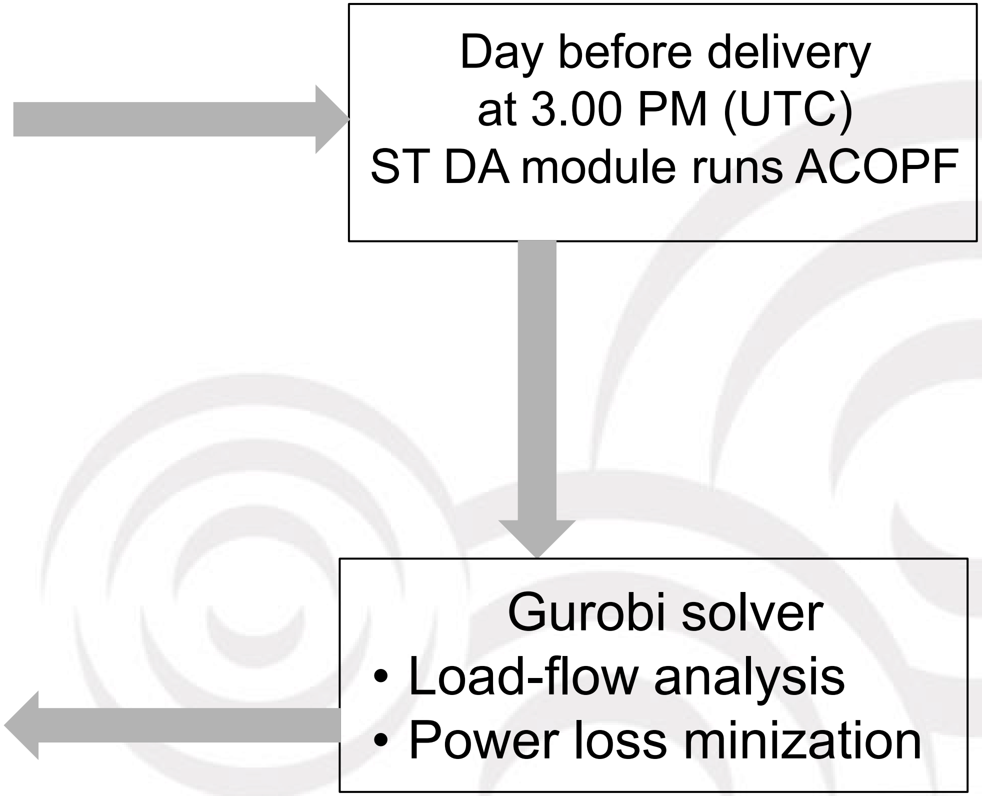
	id [PK] integer	building_id integer	profile character varying (3000)	profile_created_at timestamp without time zone
1	1	13	{"valid_from": "2018-12-13 0...	2018-12-11 23:44:47.509918
2	2	13	{"valid_from": "2018-12-13 0...	2018-12-11 23:47:49.023675
3	3	13	{"valid_from": "2018-12-13 0...	2018-12-11 23:50:06.826921
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

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

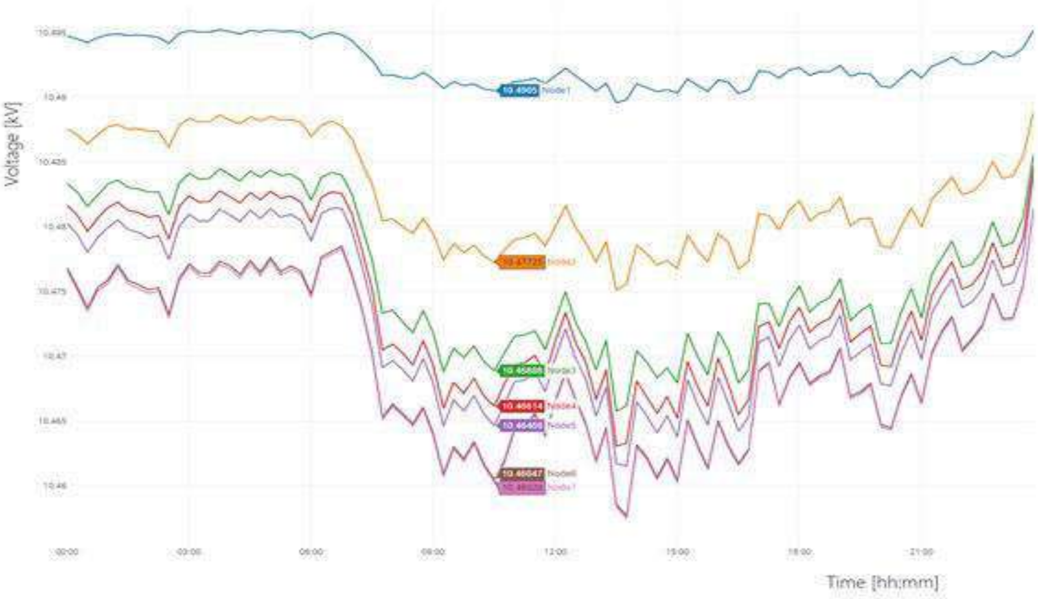


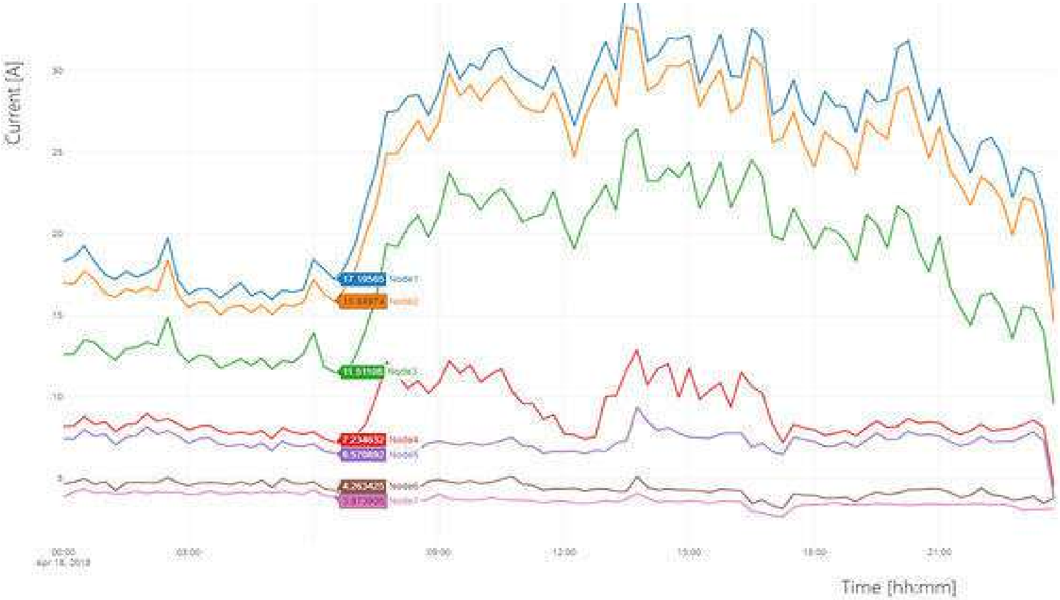
Day before delivery
at 3.00 PM (UTC)
ST DA module runs ACOPF

Gurobi solver
- Load-flow analysis
- Power loss minization

AC OPF results

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

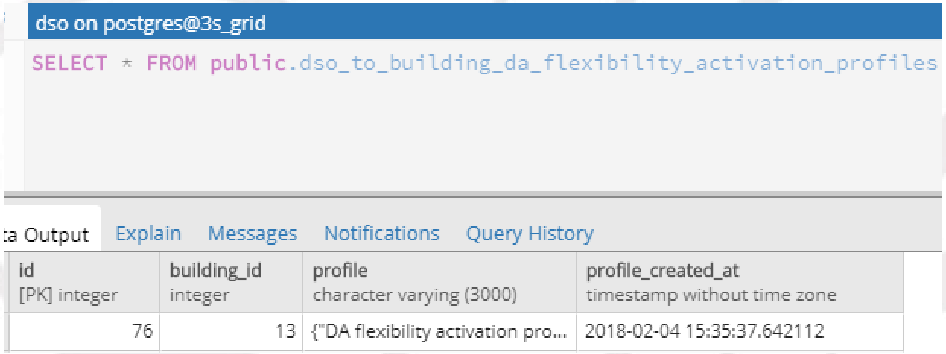




AC OPF results (1)

- 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

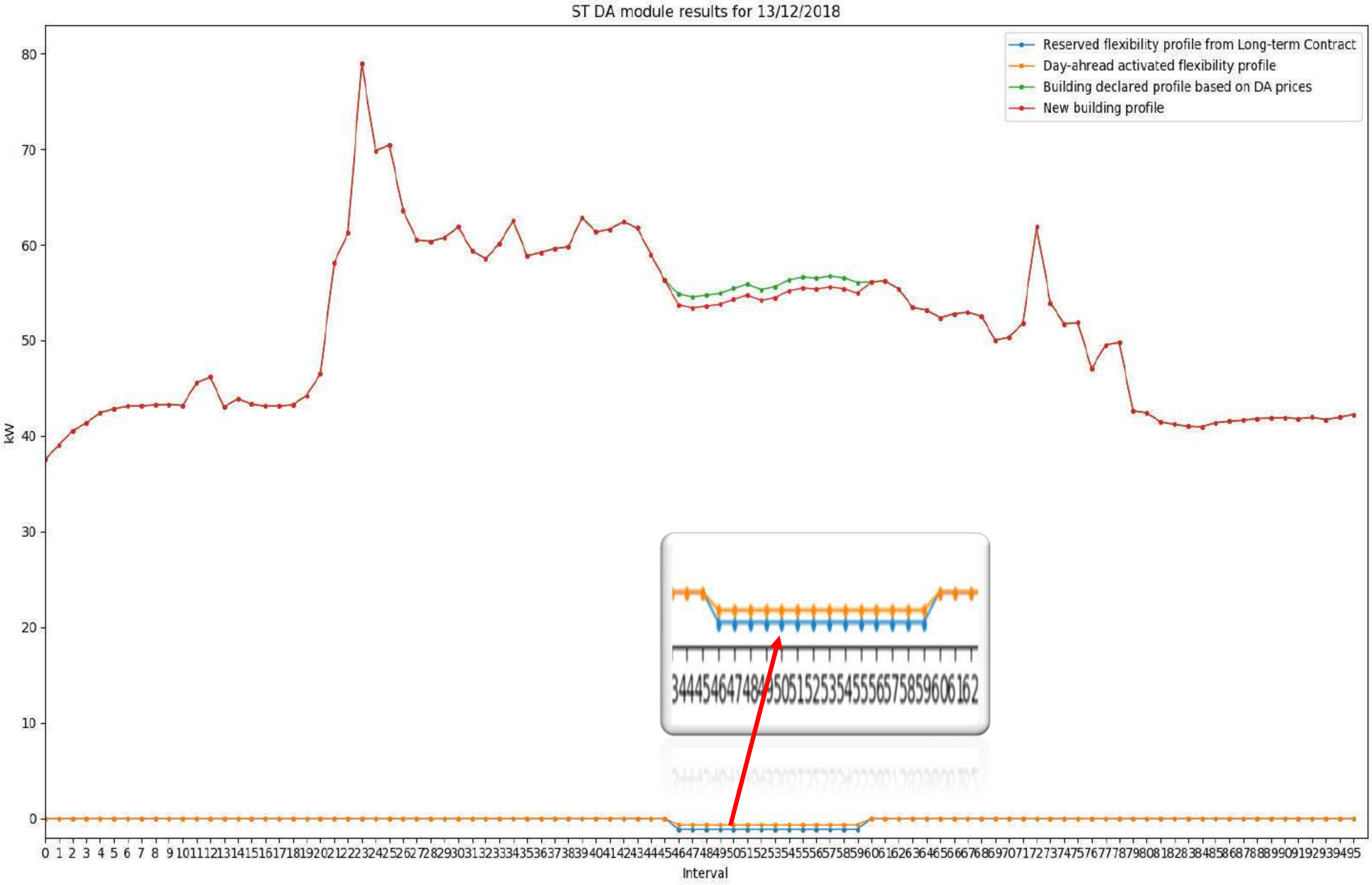
{"DA flexibility activation profile": [0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,, -1.137587, -1.13758, -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"}



dso on postgres@3s_grid

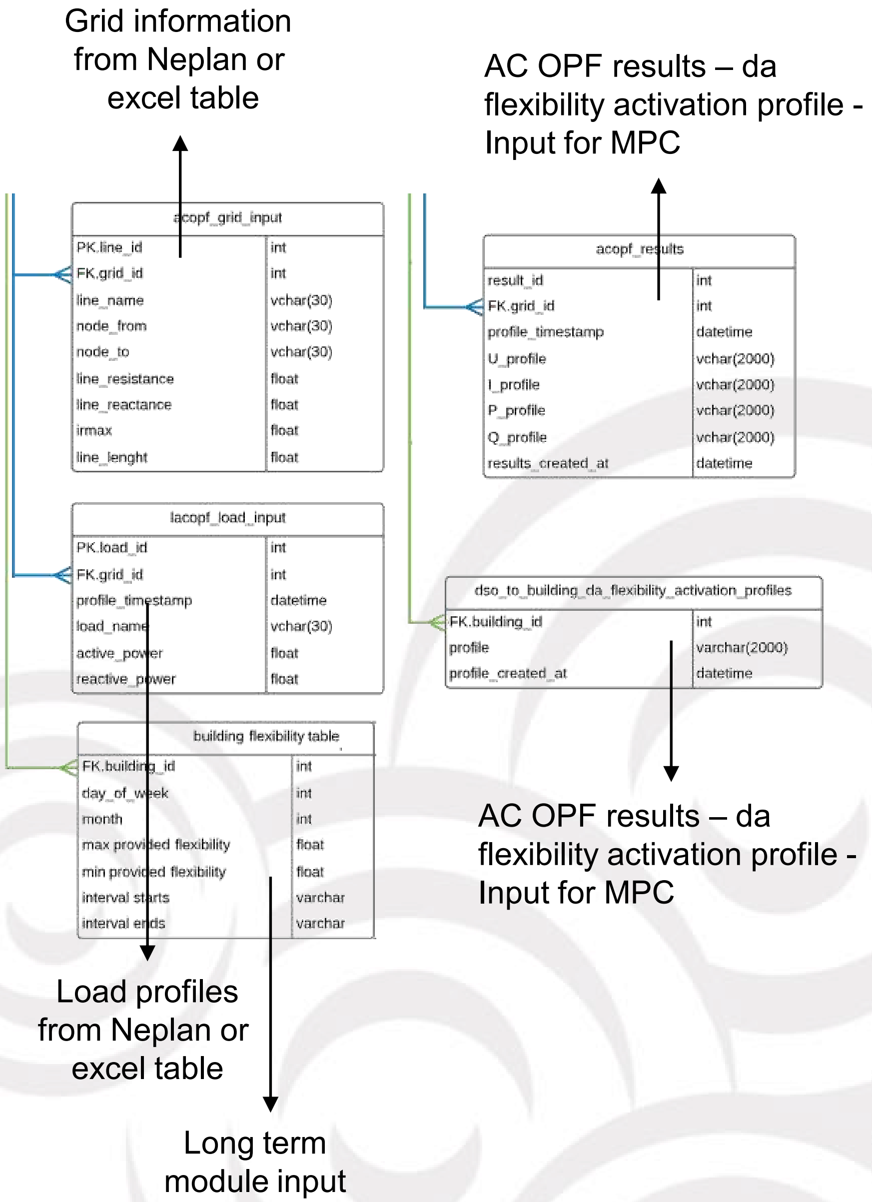
```
SELECT * FROM public.dso_to_building_da_flexibility_activation_profiles
```

id [PK] integer	building_id integer	profile character varying (3000)	profile_created_at timestamp without time zone
76	13	{"DA flexibility activation pro...	2018-02-04 15:35:37.642112


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
80
70
60
50
40
30
20
10
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95
Interval
34 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62

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



Grid information from Neplan or excel table

AC OPF results – da flexibility activation profile - Input for MPC

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

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

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

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

building flexibility table	
FK.building_id	int
day_of_week	int
month	int
max provided flexibility	float
min provided flexibility	float
interval starts	varchar
interval ends	varchar

AC OPF results – da flexibility activation profile - Input for MPC

Load profiles from Neplan or excel table

Long term module input

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 Bosnia and Herzegovina – Pilot study visit No. 1

Project Acronym	3Smart
Grant Agreement No.	DTP1-502-3.2-3Smart
Funding Scheme	Interreg Danube Transnational Programme
Project Start Date	1 January 2017
Project Duration	30 months
Work Package	6
Task	6.3
Date of delivery	**Contractual:** 31 December 2019 **Actual:** 23 December 2019
Code name	**Version:** 2.0 Final ☒ Final draft ☐ Draft ☐
Type of deliverable	Report
Security	Public
Deliverable participants	UNIZGFER, UNIDEBTTK, EON, UNIBGFME, EPHZHB, SVEMOFSR
Authors (Partners)	Mario Vašak, Tomislav Capuder, Vinko Lešić, Anita Martinčević, Hrvoje Novak, Danko Marušić, Nikola Hure, Paula Mamić (UNIZGFER), Arpad Racz (UNIDEBTTK), Gabor Peter (EON), Vladimir Jovanović (UNIBGFME), Mile Međugorac, Marin Bakula, Nikolina Ćorluka (EPHZHB), Ivan Bevanda, Petar Marić (SVEMOFSR)
Contact person	Mile Međugorac (EPHZHB)
Abstract (for dissemination)	This document contains the minutes of the first study visit to the Bosnia and Herzegovina pilot in 3Smart. It consists of a pilot building – the EPHZHB building in Tomislavgrad – and of 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 March 2019	Entered the minutes from the first Bosnia and Herzegovina 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 Bosnia and Herzegovina that consists of EPHZHB building in Tomislavgrad 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 Bosnia and Herzegovinian pilot site concerns the first pilot study visit.

1. Minutes from the first pilot study visit to the 3Smart pilot in Bosnia and Herzegovina

Time: February 26-27, 2019

Venues: HOTEL „B&M LIVNO“- GOSPODARSKA ZONA Jug b.b. Livno and EPHZHB pilot building in Tomislavgrad, Vučiji brig b.b. Tomislavgrad

February 26, 2019 (Tuesday)

Time	Place	Event
09:00-10:00	Hotel B&M conference room	**Technical session 1** - Presentation of the performed installations and realized IT infrastructure
10:00-10:15	In front of conference room	Coffee break
10:15-13:30	EPHZHB building	**Technical session 2** - EPHZHB building visit in Tomislavgrad
13:30-15:30	Restaurant in Tomislavgrad	Lunch in Tomislavgrad and return to the meeting place in Livno
15:30-17:00	Hotel B&M conference room	**Technical session 3** - On-line demonstration of basic IT infrastructure performance with the installed equipment
18:00-21:00	Restaurant in B&M hotel	Working dinner

February 27, 2019 (Wednesday)

Time	Place	Event
09:00-10:30	Hotel B&M conference room	**Technical session 4** - 3Smart modules organization on the sides of EPHZHB building and the grid
10:30-10:45	In front conference room	Coffee break
10:45-12:00	Hotel B&M conference room	**Technical session 5** - On-line demonstrations: Zone-level modules EPHZHB, Central-HVAC-level modules EPHZHB
12:00-13:30	Restaurant in B&M hotel	Lunch
13:30-15:00	Hotel B&M conference room	**Technical session 6** - On-line demonstrations: Central-HVAC-level modules EPHZHB, Microgrid-level EPHZHB
15:00-15:15	In front of conference room	Coffee break
15:15-16:30	Hotel B&M conference room	**Technical session 7** - On-line demonstrations: Short-term modules grid, Long-term modules grid, Grid-buildings interaction

Day 1:

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

Mile Međugorac has presented the performed installations on the building and the IT infrastructure. More details are provided in the presentation provided as Annex 1.

Since also the subcontractor Alpha Term was present, different issues were discussed:

- repositioning of the tilted irradiance pyranometer,
- interfacing between 3Smart and central HVAC system automation was agreed.

The battery system requires subcontractor's intervention which was engaged during the pilot study visit and finally the battery system is brought into the operational state.

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

During the tour to the pilot building and grid in Tomislavgrad all key installation places were visited and explained:

- the PV system including power converters, electricity meters and pyranometers;
- the battery system and its power converter;
- the heat pump and central HVAC system room with the mixing tank, heating block, calorimeters and piping;
- main electrical installations cabinet with smart meters;
- SCADA control room;
- zones installations including the room controllers and fan coils.

The data in the database were checked on site for consistency. Update is required for room controllers local switch variable which needs to indicate whether the controller is in the automatic control mode or not. Subcontractors will perform it during this week. Subcontractors have also during the tour increased the resolution of temperature measurements on calorimeters to 0.1 °C.

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

Mile Međugorac has shown first several responses taken as typical from the database showing the operation of the system on different levels – zone, central HVAC, microgrid. Mile pointed out that currently the disaggregation of solar irradiance on direct and diffuse component has some problems, but it was agreed that this issue will be checked if persists once the pyranometer for tilted irradiance is re-positioned. This presentation is given as Annex 2.

Then the representative of subcontractor Daniel Blažević has shown different tables in the database which are filled with data from the building. Except for the mentioned controller local switch variable in the tables, no other issues with the presented database tables were spotted.

The battery system integration still needs to be performed once the existing issues on the battery system are resolved by the subcontractor for the battery system, which is required to happen during this week.

Day 2:

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

Grid-side modules organization was presented by Paula Mamić. The presentation is provided as Annex 3.

Building-side modules organization is presented by Mario Vašak. The modules organization scheme is given as Annex 4.

Technical session 5 and Technical session 6: On-line demonstrations: Zone-level modules, Central-HVAC-level modules, Microgrid-level modules

Hrvoje Novak has discussed the prediction modules which are already installed (M.PE.7 and HVAC.PE.4) and the ones that still need to be installed (Z.PE.6, M.PE.3, M.PE.4), the details can be found in Annex 5 including the agreed timing for the remaining modules installation.

Danko Marušić has shortly addressed the M.MPC.1 module which is completely the same as for UNIZGFER site which facilitates replication. Danko also discussed the prerequisites for the modules to run and different software that needs to be installed to support all the modules (full list to be provided to all by February 28 end of day). For installation of the optimization solver GLPK it was agreed that the approach will be that Mile asks the IT support in EPHZHB to give Danko administrator rights to perform this installation (this is a preferred option). This is also provided within Annex 5.

Anita Martinčević has explained the procedure needed to be performed for putting Z.PE.1 module into operation – certain identification experiments are needed which can be performed now when the calorimeters are put on the right temperature measurement resolution by the subcontractors. Timing for this experimentation is agreed – will be done during the next week in a way that one experiment is performed by the hosts and then Anita will be consulted for correctness of data. Then Anita has shortly discussed the procedure and schedule with the remaining modules on the zone level – Z.PE.5, Z.I.1 and Z.MPC.1. The materials presented are also in Annex 5.

Nikola Hure has explained the operation of HVAC.MPC.2. Nikola has shown the data from the database regarding the central HVAC system. Discussion was performed on the thermal and electrical power constraining and also on interfacing towards the building automation system. Two points Nikola additionally has to address in direct communication with the subcontractors representatives Ammar Krhan and Daniel Blažević:

- constraining of electrical power on the heat pump – is it a fixed constraint (which would induce that maximum thermal power varies at the end with varying COP in different conditions);
- 3Smart EMS commands (reference temperature computed, auxiliary signals) communication towards the building automation system.

The timing suggested by Nikola for HVAC.MPC.2 installation is March 22 for module operation with generic data and end of March for on-line operation given all the needed data and data sequences are at the disposal. More details are provided in Annex 5.

HVAC.PE.1 was not discussed as UNIBGFME was not present. HVAC.PE.2 in parts of losses will not be used since the pipes are rather short and even 0.1°C precision of the calorimeters would not suffice.

Andras Mucsi has presented the modules for the battery system – M.PE.1, M.PE.2 and M.I.1. He has explained the procedure of battery system identification. Installation of these modules resides on correct functioning of the battery system. As the battery system is the same as the one installed on UNIZGFER building, this will facilitate the modules installation on EPHZHB site. Andras has also shown the M.PE.6 module which is needed for identification of the buffer tank model.

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

Paula Mamić has presented in detail through the grid-side database the operation of the short-term day-ahead module (Annex 6). It runs on-line each day and computes the required flexibility according to a generic long-term contract. The real long-term contract will be created after off-line computations of coordinated MPC modules on the building-side are done.

On the side of the long-term module (also in Annex 6), the web service procedure needs still to be put in place on EPHZHB site and this will be done by Paula in the coming days.

List of annexes:

Annex 1. Presentation from the technical session 1 regarding performed installations and IT organization on the EPHZHB site

Annex 2. Presentation from the technical session 3 related to demonstration of correct operation of data gathering within the 3Smart database

Annex 3. Presentation from the technical session 4 regarding the grid-side modules organization

Annex 4. Document showing the building-side modules organization presented in technical session 4

Annex 5. Presentation of UNIZGFER modules operation – prediction modules, microgrid-level, HVAC level and zone-level modules

Annex 6. Presentation of grid-side modules operation

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

Marin Bakula, Mile Međugorac, Nikolina Ćorluka, Miroslav Nikolić

EPHZHB

marin.bakula@ephzhb.ba

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

26 February 2019

Interreg
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Danube Transnational Programme
3Smart

JP ELEKTROPRIVREDA
HRVATSKE ZAJEDNICE HERCEG BOSNE d.d. Mostar

Project co-funded by European Union

EPHZHB building in Tomislavgrad

EPHZHB building technical data

- Two floors
- 13 zones on first floor
- 15 zones on second floor
- Total 28 zones

- 27 parapet fan-coils: York YFCN 340 VC, YFCN 440 VC and YFCN 540 VC
- 1 cassette fan coil – first floor : York YHK

- Heating pump – YORK YLHA 80T

  (≈75 kW – heating, ≈ 72 kW cooling)
- Thermoblock for additional heating – TERMOExtra 88 kW
- HVAC system regulated manualy

Interventions on the rooms level

- Intervention:
- room units Siemens DXR2.E09-101A in combination with fan coil controllers QMX3.P34 – 27 pcs
- room units Siemens DXR2.E18-101A + QMX3.P74 – 2 pcs
- Cable temperature sensors (2sensors/per fan coil), type Siemens QAP1030.200 – 58

Room operator unit
SIEMENS QMX3.P34

Fan coil controller SIEMENS
DXR2.E09-101A

Temperature sensor QAP1030.200
for return medium temperature
measurement

Temperature sensor
QAP1030.200 for outgoing air
temperature measurement

Data related to the rooms level

- From QAX (each room):
  - room temperature measurement,
  - room temperature setpoint,
  - room temperature setpoint offset,
  - selected room operating mode (OFF, AUTO, 1, 2, 3)
- From DXR controllers (each room):
  - Fan coil's fan speed
  - Fan coil's fan speed control variable
  - Changeover mode
- From temperature sensors (each fan coil):
  - Fan coil's return medium temperature
  - Fan coil's outgoing air temperature
- From the SCADA:
  - Server status
- To DXR controllers (each room):
  - Fan command

Heat meters at floor level and central HVAC

- Heat meters at floor level
  - 2 calorimeters installed per floor (2 pcs ground floor + 2 pcs first floor) + 2 calorimeters for AHUs
  - 6 calorimeters in total

calorimeters on ground floor

calorimeter for AHU

- Heat meters at central HVAC level

  - 3 calorimeters are installed in the boiler room for measuring the consumption of heat produced by the electric boiler and heat pump and central calorimeter for measurement of the entire heating or cooling energy towards the fan coils

Calorimeter for electric boiler
Siemens UH50-A45C-BA06-E

Central calorimeter for measurement of
entire heating/cooling energy twords
FCU, Siemens UH50-C60-BA06-E

Calorimeter for heat pump
Siemens UH50-C60-BA06-E

Data related to the floor level

- Calorimeters data integrated in the DESIGO SCADA system
  - for building operators and data backup
- Data from each calorimeter:
  - medium outgoing and return temperature, temperature difference
  - medium flow, cumulated energy and current power

Interventions on the central HVAC system level

- New SCADA system – Siemens Desigo CC
- Replacements of compressors for heat pump:
  - New compressors Copeland ZP182
- Regulation of current for electrical boiler (bigest electrical load in building):
  - Siemens SEA45.1 current valves

Interventions on the central HVAC system level

New compressors Copeland ZP182 for heat pump

Electrical cabinet RO-EOTB for electrical boiler automation with SEA45.1 current valves and SEM62.2 transformer

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Electric meters

- New electrical meters for measuring electrical energy, **Siemens Sentron PAC3200 and PAC2200**:
  - total electrical energy consumption of building (PM1),
  - PV system energy production (PM2)
  - battery storage system consumption and production (PM3),
  - heat pump energy consumption (PM4),
  - electric boiler energy consumption (PM5),
  - air handling unit 1, ground floor, energy consumption (PM6)
  - air handling unit 2, 1st floor, energy consumption (PM7)
- New electric meters and existing meter (PM8) integrated into Desigo CC SCADA and to 3Smart EMS database

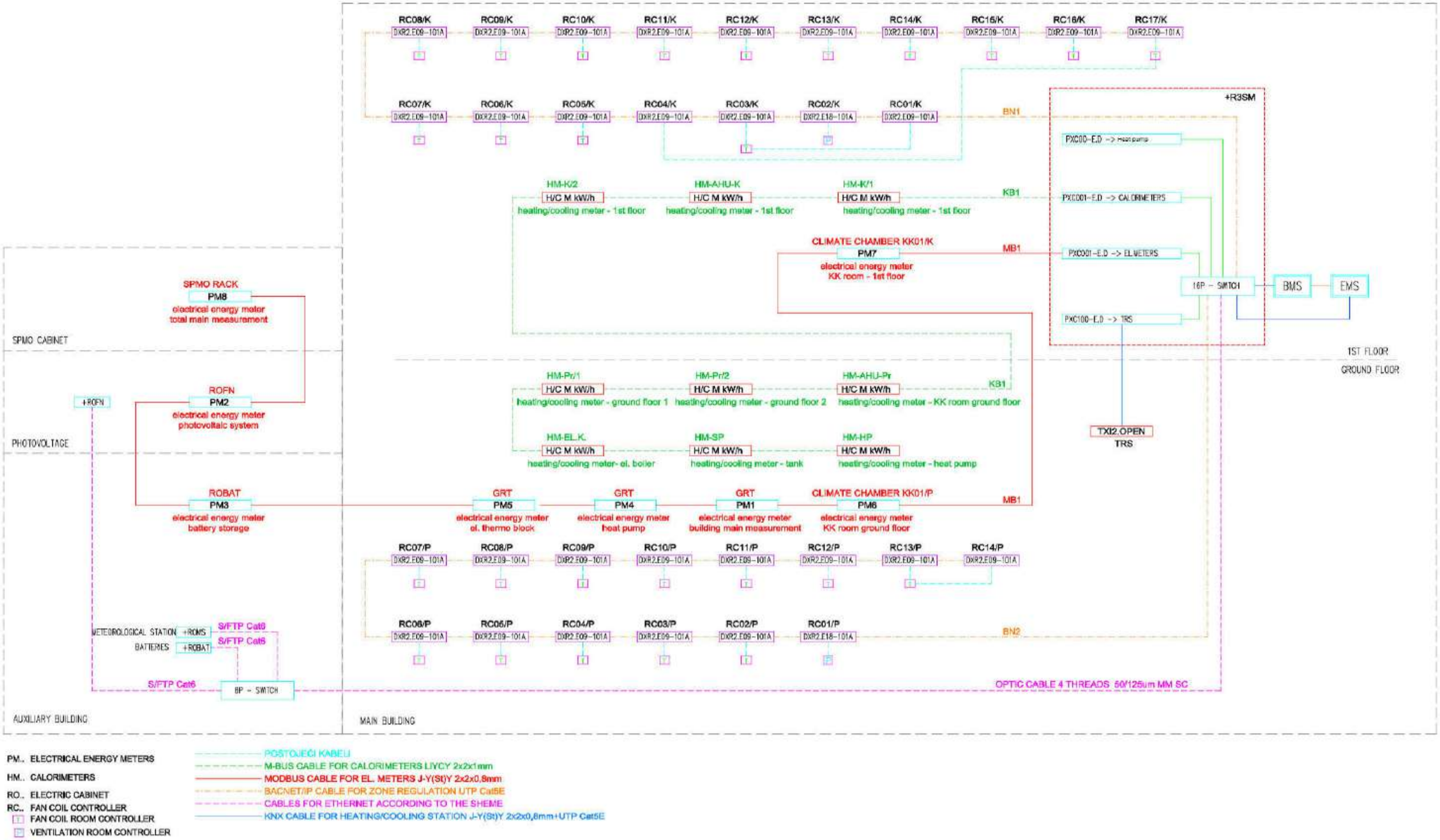
Electric meter at the building's main electrical cabinet Siemens SENTRON PAC3200 and Siemens SENTRON PAC2200

Electric meter Sentron PAC 2200
for battery system

Electric meter Sentron PAC 2200
for battery system

Electric meter Sentron PAC 3200
for PV plant

Communication system



Communication system

- Data communication from DXR controllers:

  (PXC controllers) – BACNET/IP – (16 Port Ethernet switch) – TCP/IP –

  (SCADA computer / 3Smart server)
- Data communication from caloriemeters:

  (calorimeter) – M-BUS– (PXC integration controller) – BACNET/IP –

  (SCADA computer / 3Smart server)
- Data communication from electric meters:

  (electric meter) – M-BUS– (PXC integration controller) – BACNET/IP –

  (SCADA computer /3Smart server)
- Data communication from heat pump:

  (heat pump) – M-BUS– (PXC integration controller) – BACNET/IP –

  (SCADA computer /3Smart server)

Interventions on the microgrid level

- Installed PV system:
  - 48,9 kWp PV system on the two parking constructions near the main building, as well as on the roof of auxiliary object
  - Panels: Eurener MVEP 300 (300 W), 166 pcs in total
  - DC/AC inverters:
    - Fronius Symo 20.0.-3M (20 kW): 2 pcs
    - Fronius Symo 10.0.-3M (10 kW): 1 pc

- Data that are integrated into 3Smart EMS (electric meter PM2):
  - Electrical power,
  - Electrical energy production.

PV system EPHZHB

PV panels, 166 pcs

DC/AC inverters, AC and DC electrical cabinet

Battery system

- Introduction of a battery storage system 32 kWh based Li-ion batteries with power converter:
    - Battery cell LiFePO4, 100 Ah, 3,2 V, 320 V voltage: GWL/Power, Type CALB CA100FI: **100 pcs**,
    - Battery Management System, Cognitio,type BMS Connectorless : **100 pcs**
    - Two-way AC/DC converter, 10 kW, Cognitio, Type Open4La: **1 pc**

- Implemented independent fire alarming system

- Air conditioning device type RX50/FTX50 Daikin installed for maintenance of constant temperature

Battery system

- Battery management system:
  - cells temperature and voltage monitoring
  - initiating safety procedures when limits in voltage, current or temperature are overstepped, including also room temperature and power cabinet temperature
- Alerts sending via e-mail and sms to designated contacts

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

- Data for the battery system:
  - power command for the AC side or current command for the DC side, with command selector

Battery system

Battery cells LiFePO4, 100 pcs

Battery cells with battery management system

Power converter rack, two-way AC / DC converter Cognitio type Open4Lab

Two way DC/AC power converter

Communication rack, autonomous fire alarm device

Air conditioning unit: Daikin RX50/FTX50

Weather data and weather forecast

- Measurements of solar irradiance:
  - Installed 2 pyranometers KIPP & ZONEN type SMP6-V for measurement of direct & diffuse solar irradiance
  - Mesurements collected in the integration controller, stored in Desigo CC SCADA system and in the 3Smart EMS database

- Measurements of outside temperature:
  - Collected and stored in Desigo CC / 3Smart EMS database

Weather data and weather forecast

- Weather forecasts:
  1. Forecast for direct and diffuse solar irradiance – provided by Ubimet Gmbh via FTP server:
     - weather forecast for the next three days with one-hour segments, delivery two times per day, text/csv file
  2. Forecast for temperature, wind speed and air pressure- fetched from web page of Federal meteorological institute (FHMZ):
     - resolution of one hour
     - Forecast fetched in the 3Smart EMS database, for fetching this data responsible FHMZ Communicator

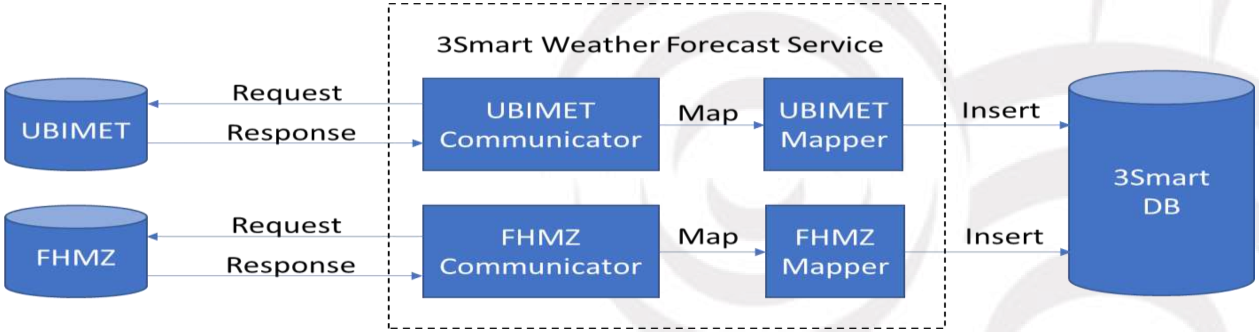


Diagram of integration of different data from UBIMET and FHMZ to 3Smart DB

3Smart EMS server - hardware

- New server for 3Smart EMS:
  - Manufacturer: Dell
  - Model: PowerEdge R730
  - RAM: 16 GB
  - Processor: Intel Xeon CPU E5-2620 v4 @2,1 GHz
  - Disk: Intel SSD 2x224 GB
  - Operating system: Microsoft Windows 10 Pro, 64-bit

3Smart EMS server

3Smart EMS server - software

- 3smart server has powered up by Windows 10 operation system + Linux in virtual machine.
- The list of installed software:
  - PostgreSQL database
  - Python 3.5
  - Remote control services and TeamViewer

3Smart database

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

3Smart 1st pilot study visit to the BA pilot – Online demonstration of basic IT infrastructure performance with the installed equipment for building side

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3Smart 1st pilot study visit to the BA pilot

Livno, 26th – 27th February 2019

JP ELEKTROPRIVREDA
HRVATSKE ZAJEDNICE HERCEG BOSNE d.d. Mostar

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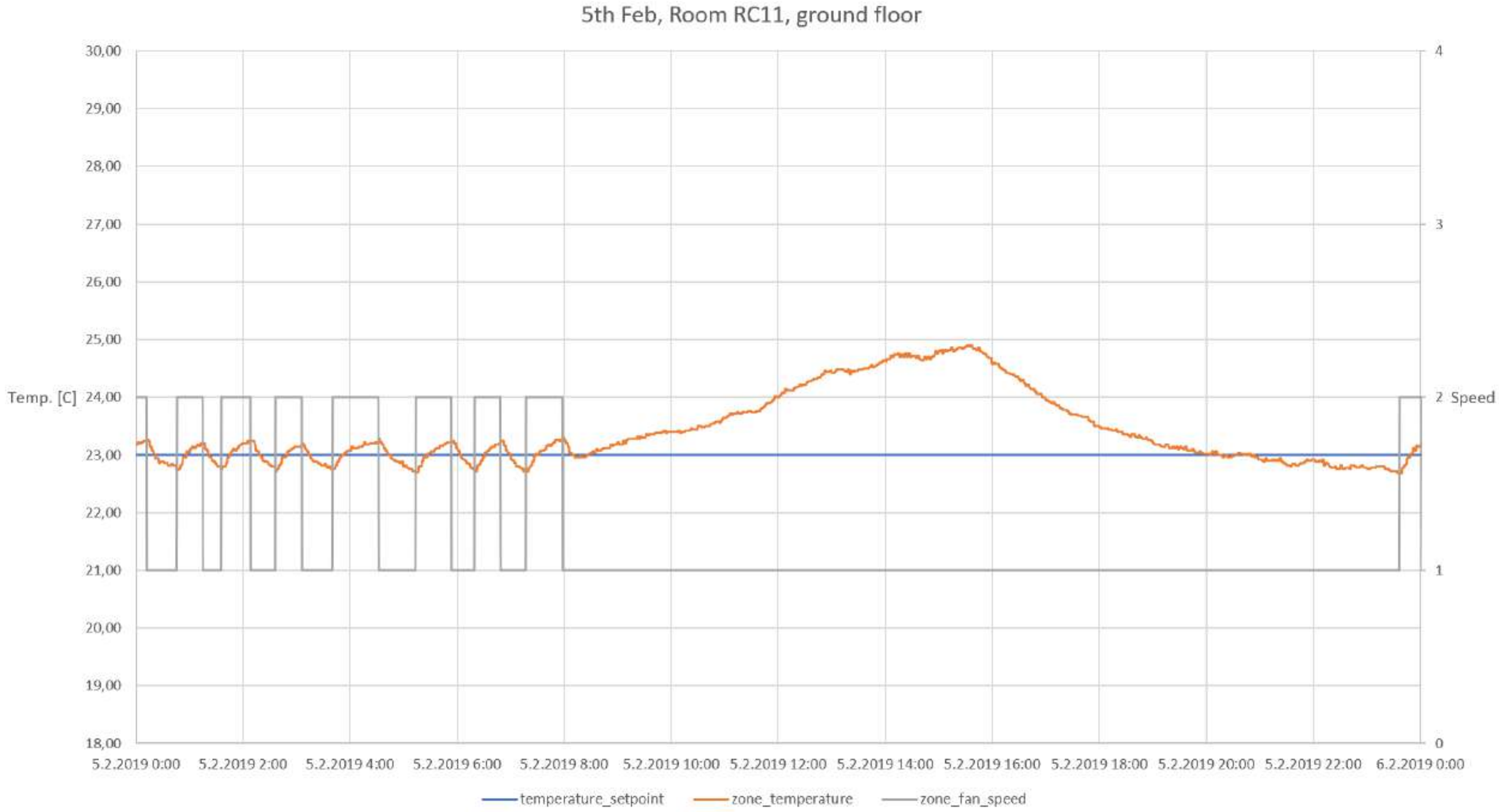
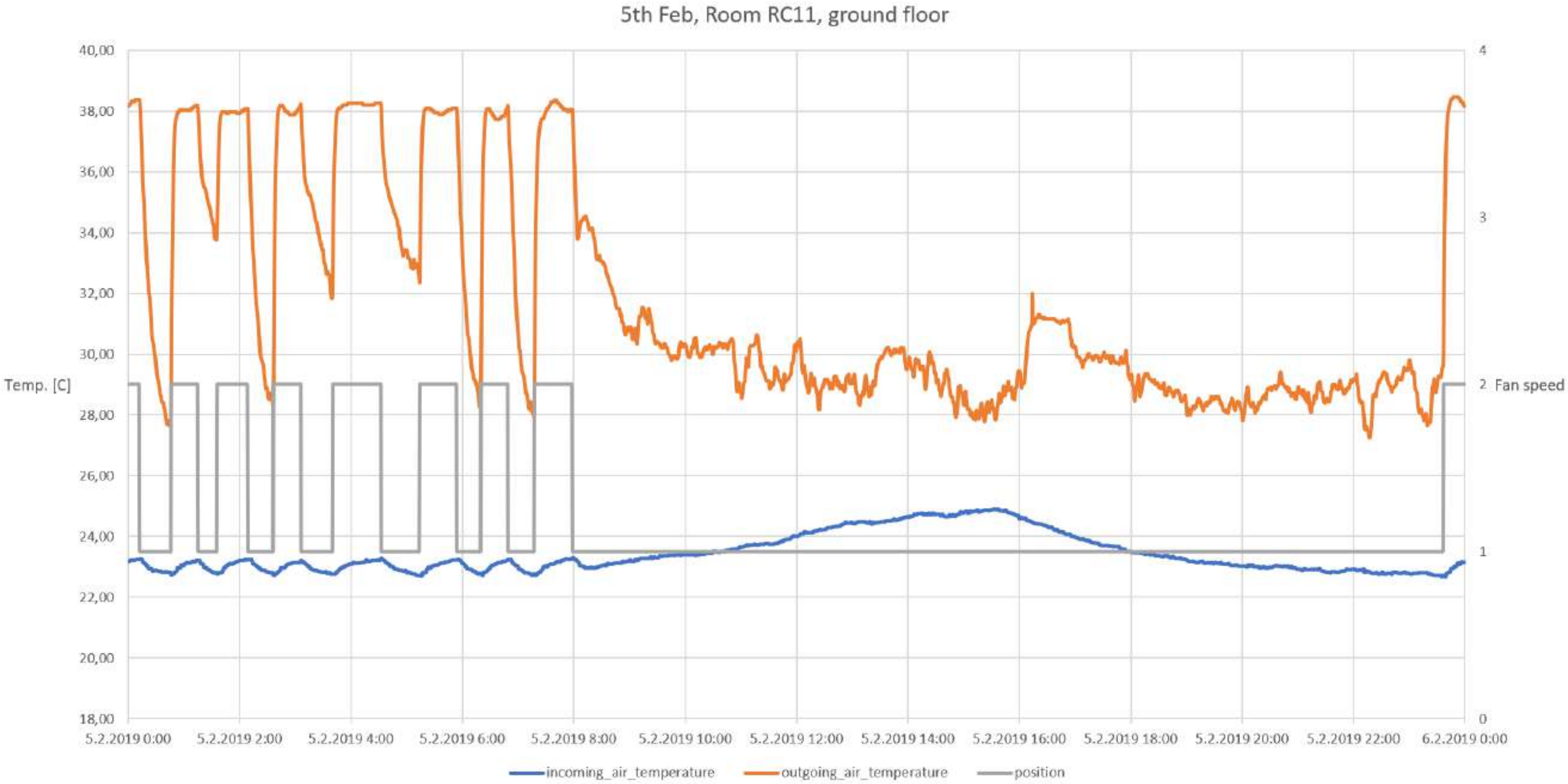
Zone level – zone temperature, zone setpoint and zone fan-speed



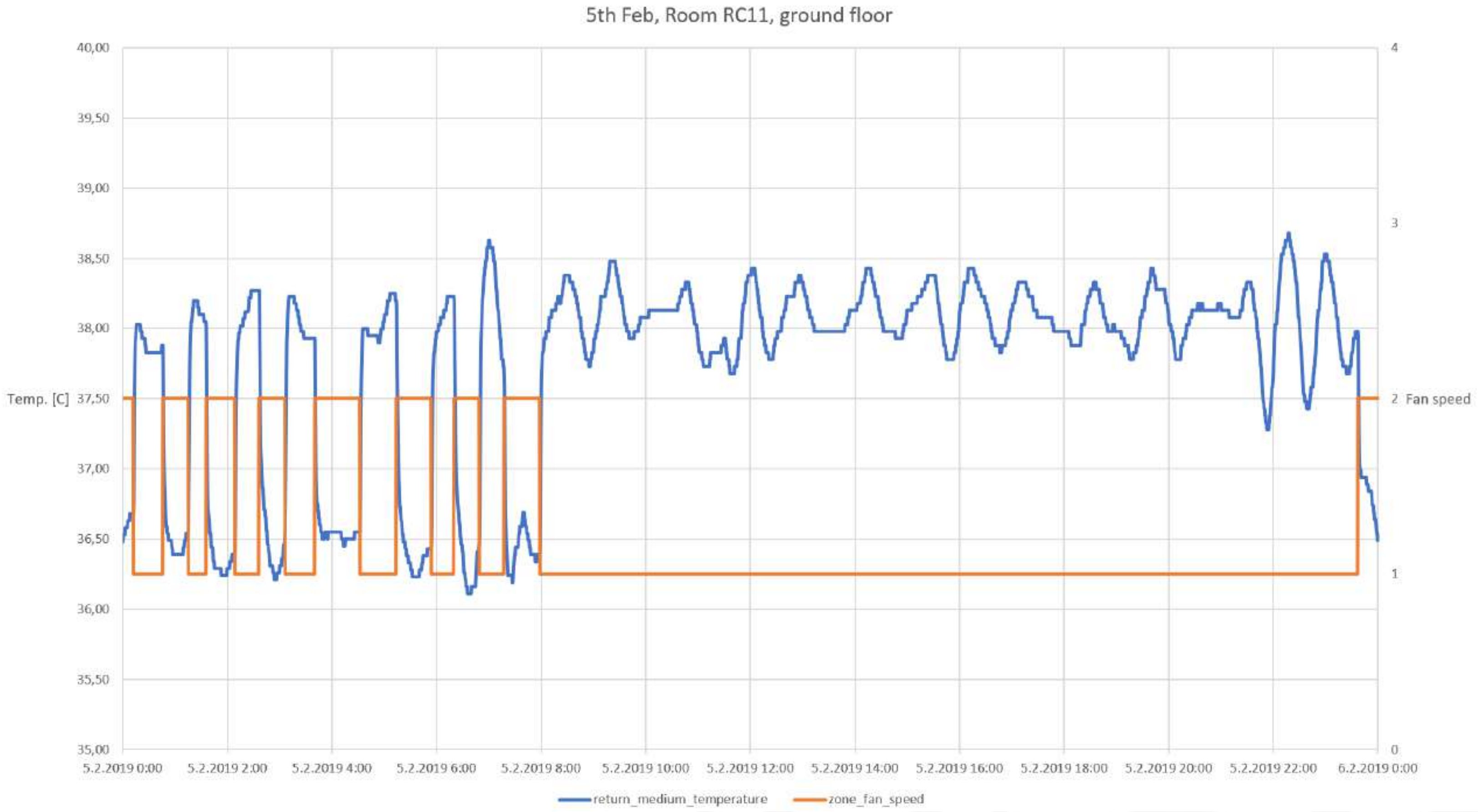
Zone temperature, temperature setpoint, fan speed position (1 – off, 2 – 1st speed, 3 – 2nd speed, 4 – 3rd speed)

Zone level – FCU air side measurements



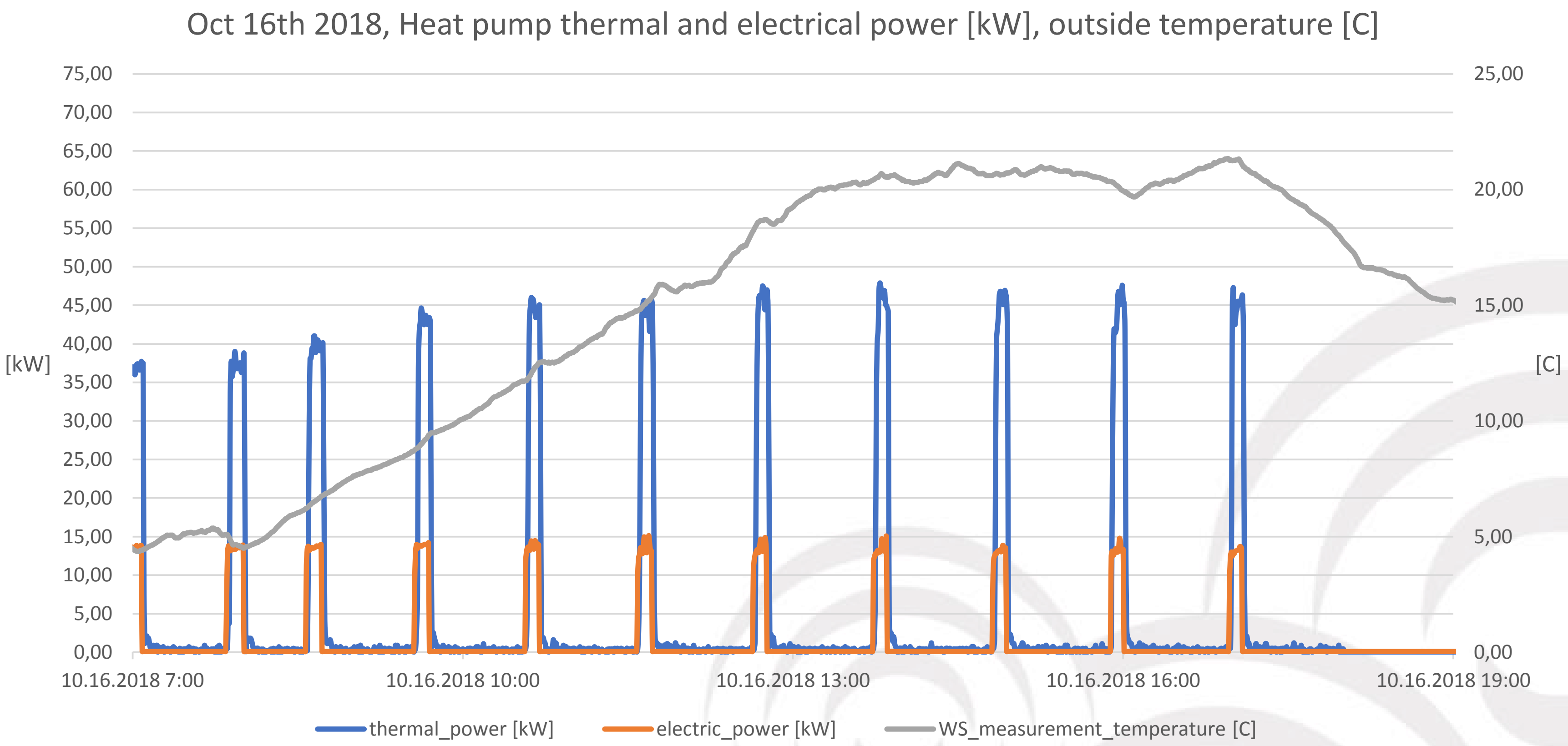
Zone incoming air temperature, outgoing air temperature, fan speed position

Zone level – FCU water side measurements



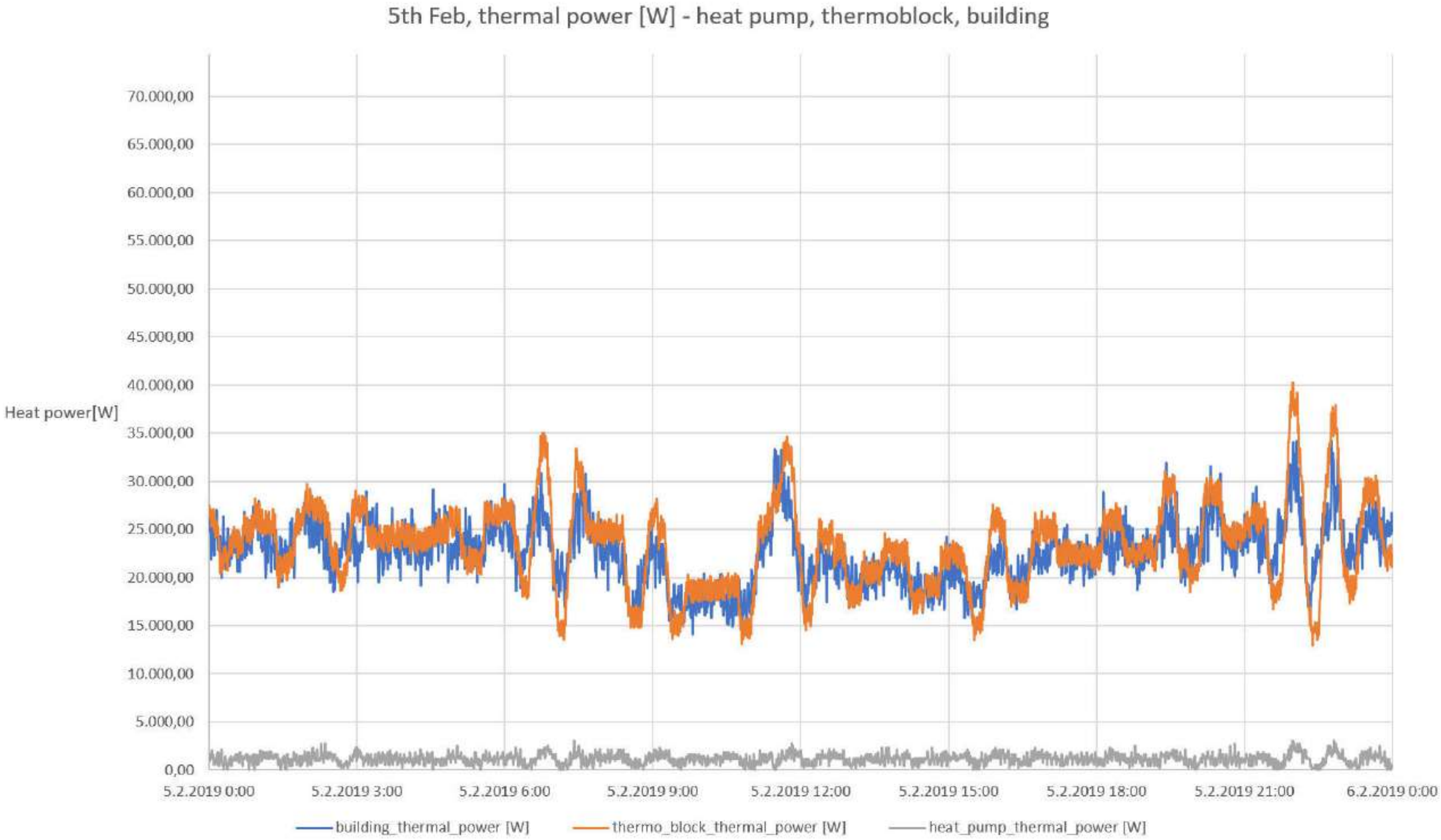
Zone return medium temperature, fan speed position

Central HVAC level – heat pump



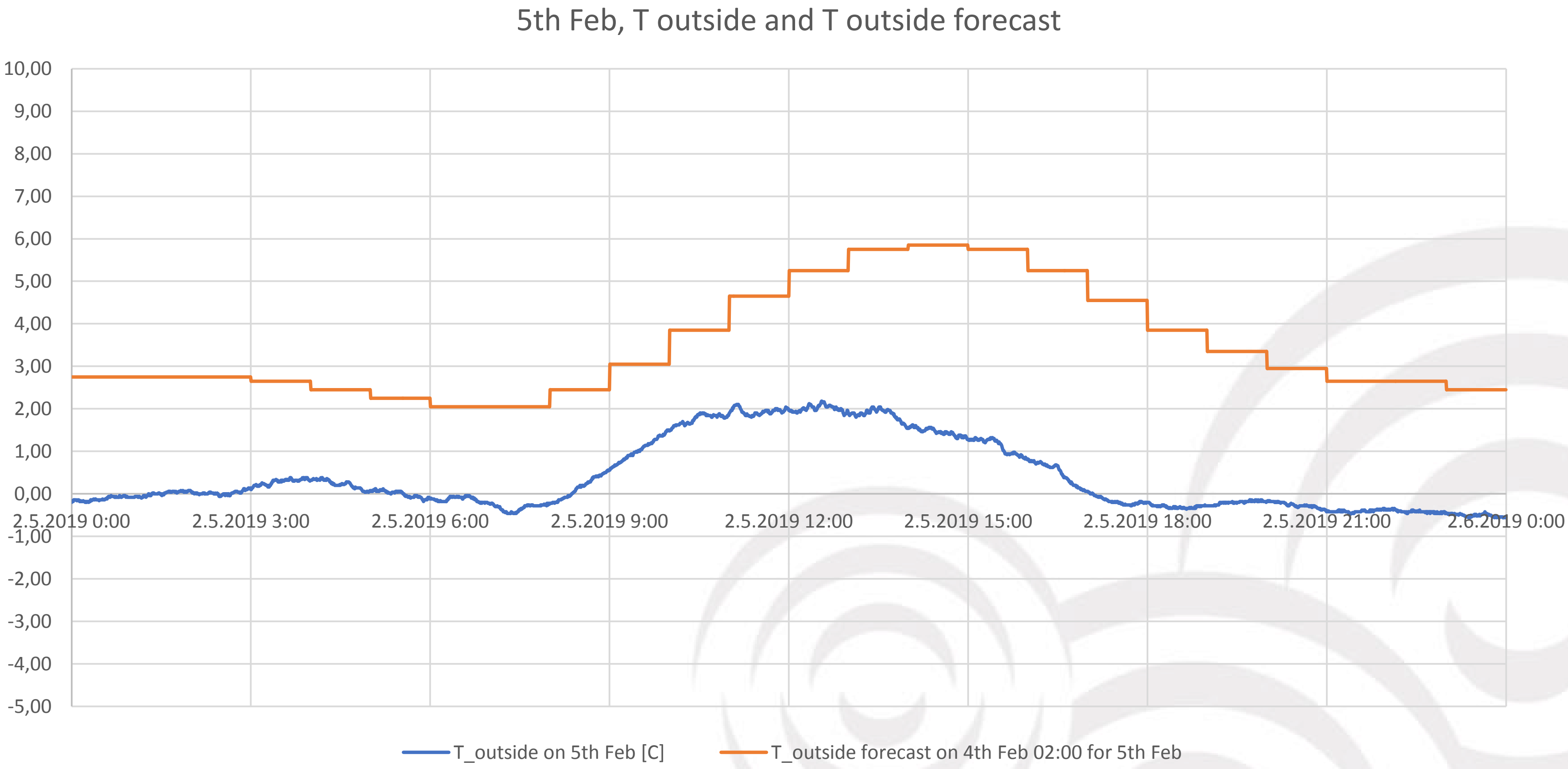
2018 Oct 16th, heat pump thermal power [kW], electrical power [kW], outside temperature [C]

Central HVAC level – heat meters



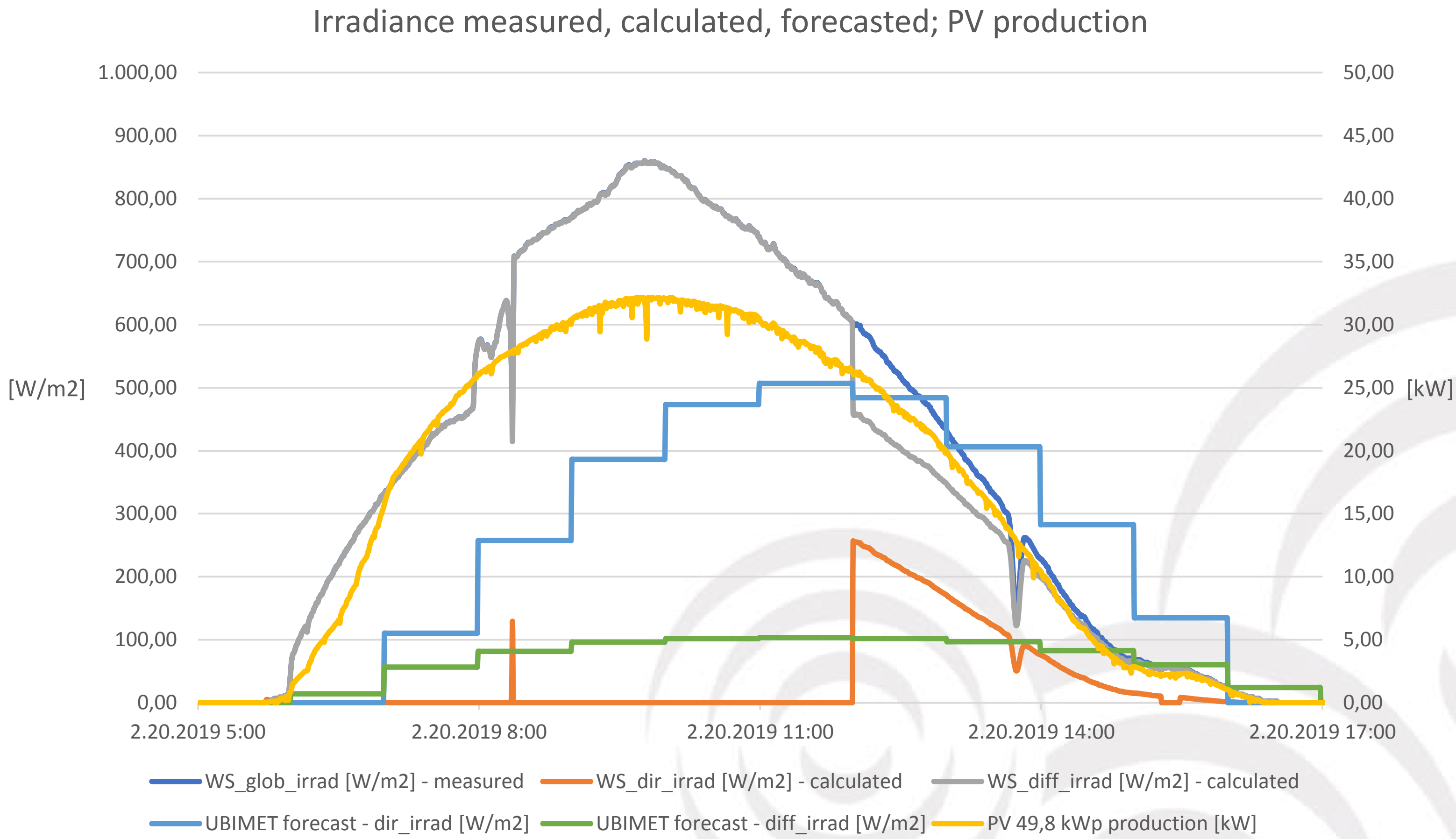
Heat power from heat meters – heat pump, thermo block, building

Microgrid level – weather data - pyranometers



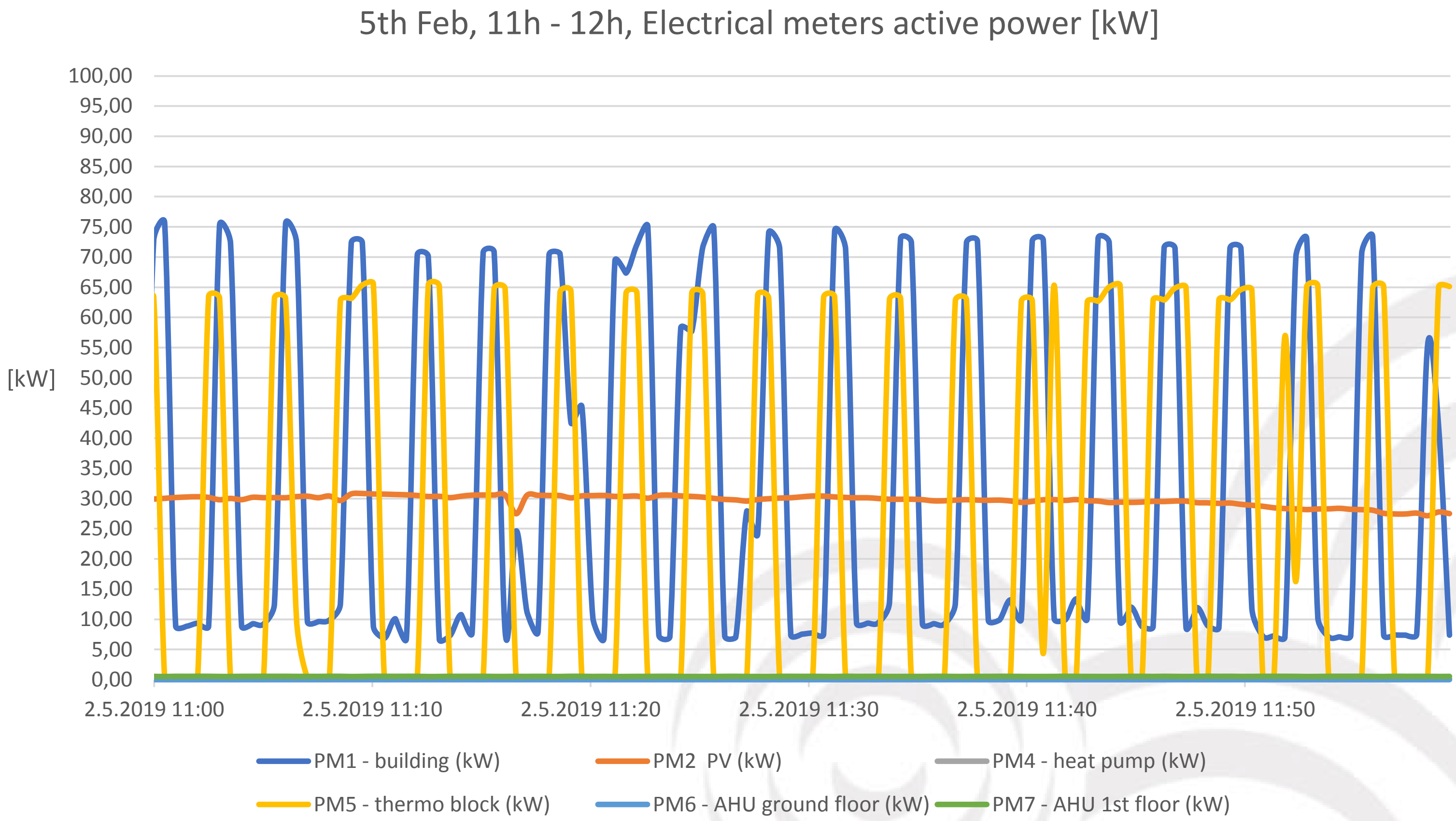
Outside temperature from pyranometers and temperature forecast from UBIMET [C]

Microgrid level – weather data, weather forecast



- Glob. irrad. measured(W/m^2), dir. and diff. irrad. calculated (W/m^2), dir. and diff. irrad. forecasted (W/m^2), PV production (kW)

Microgrid level – Electrical energy meters measurements



Electrical energy meters measurements

Grid side modules coordination on the sides of EPHZHB

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3Smart – First pilot study visit BA study
26. – 17.02.2019.

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Content

- Long-term Multi(Annual) module
  - Model architecture
  - Database overview
  - Communication model

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