



Elektro Celje, d.d.

Leveraging smart meter data to provide insights into grid operation, maintenance and planning

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24. 2. 2021



Who are we?



- One of the 5 DSOs in Slovenia
- Electric energy distribution
- Since 1913
- Mid-size DSO
- We supply:
 - 3 regions
 - 40 municipalities
 - 383.000 people (19 % of population)
 - 4.345 km² (22 % of Slovenia)



Who are we?



- Grid assets:
 - **20** primary stations
 - **3.500** secondary stations
 - HV lines (110 kV): **89 km**
 - MV lines (10, 20 kV): **3.603 km**
 - LV lines (1, 0.4 kV): **12.774 km**
- End users:
 - **3.400** DERs (PV, water, wind...)
 - **174.000** metering points
- Smart metering:
 - **94 %** smart meter coverage
 - **100 %** coverage by end of **2021**



R&D, H2020 projects



Uporablaj
pametno



Compile

Strategic R&D partner





Smart meters... more than it looks like

Data services... leverage that data

Upgrade with machine learning & AI

What to do with that data?

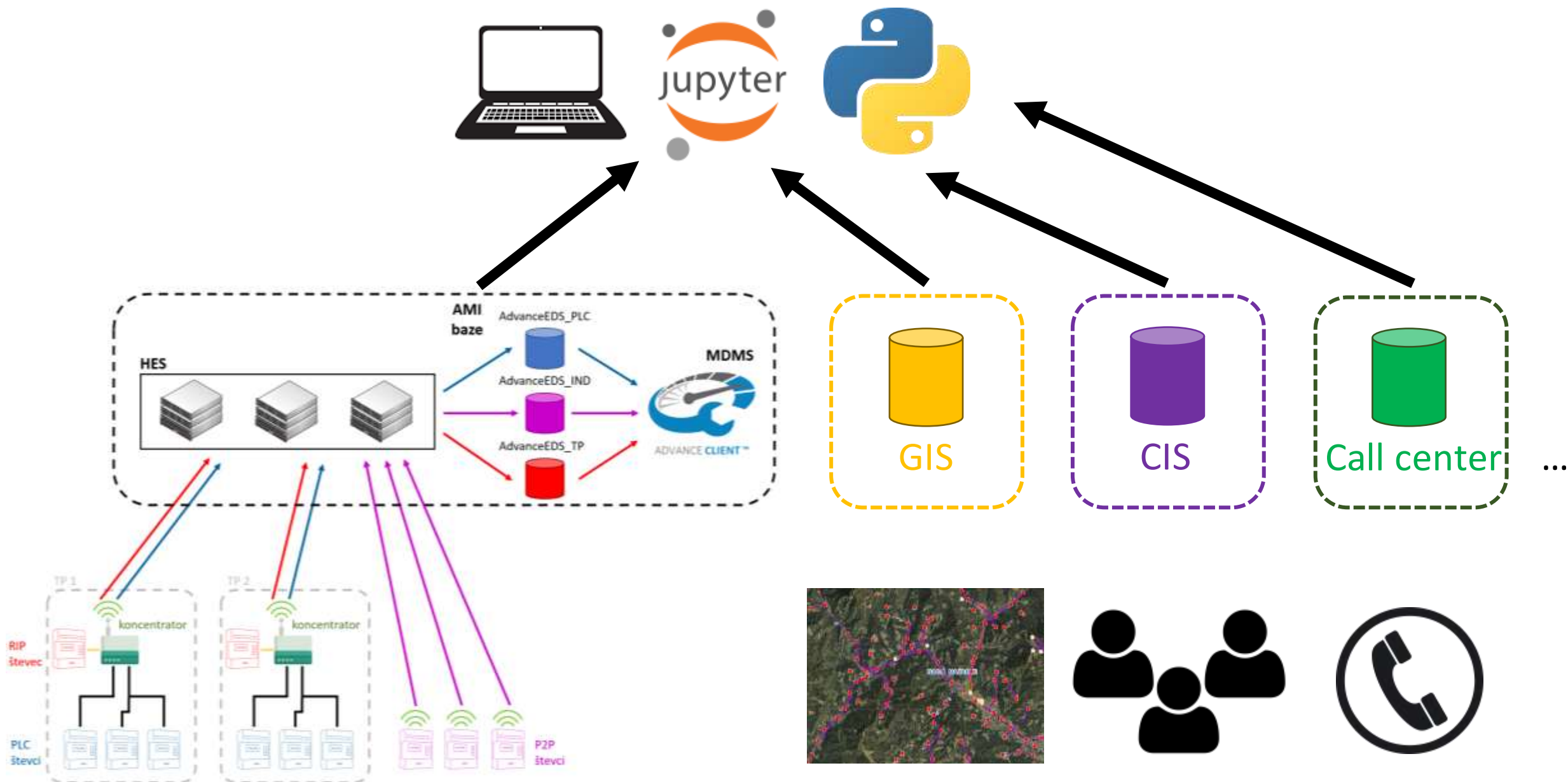


- What is the added value for the company?
- Develop use cases
- Check the data (integrity, accessibility, validity...)
- Develop data services
- Get insights
- Automate flow – CD/CI
- Visualize & share
- Integrate
- Scale

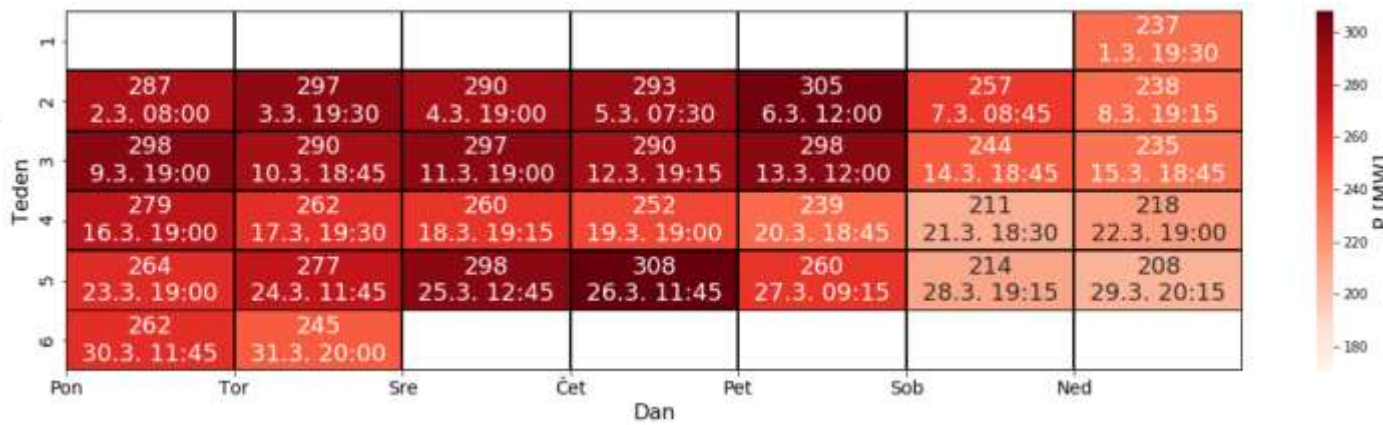
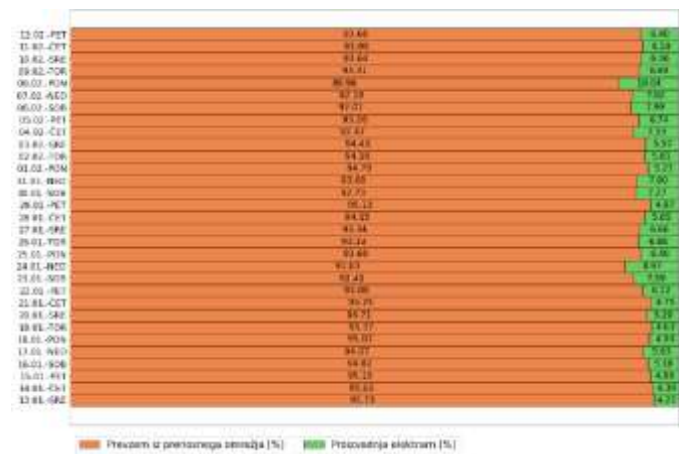
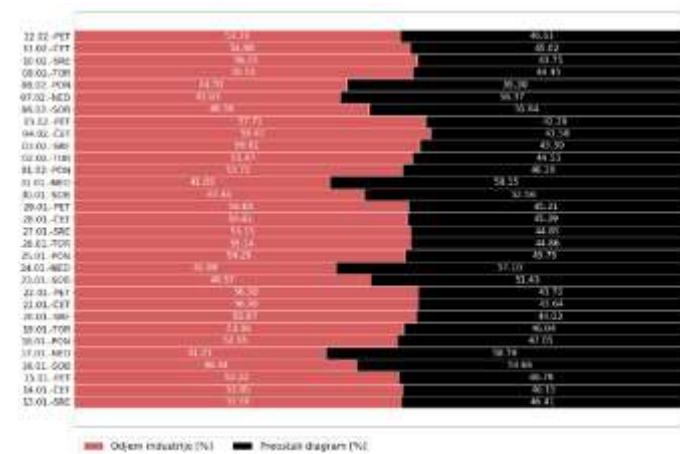
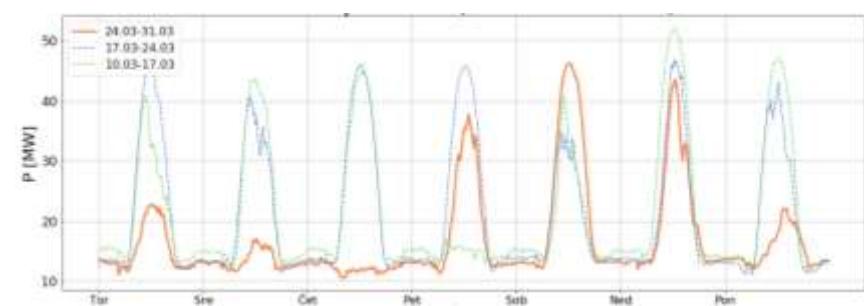
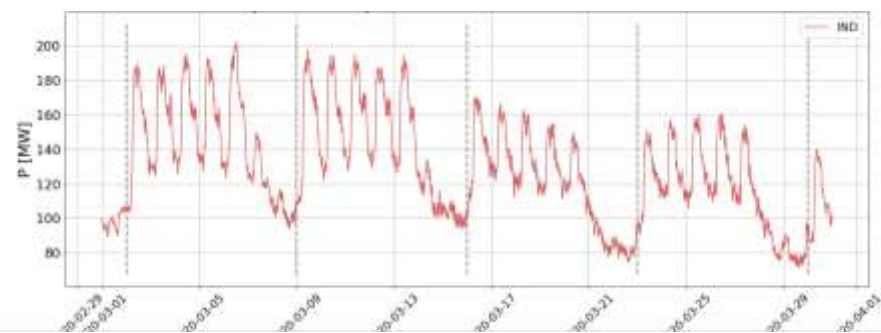
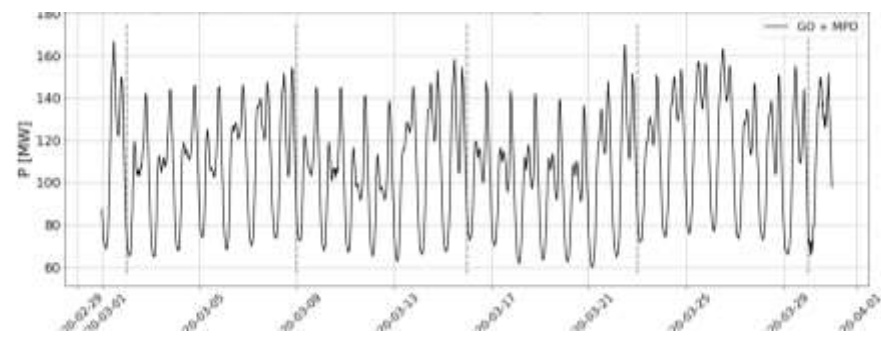
Everything you're about to see was developed in Python and SQL.



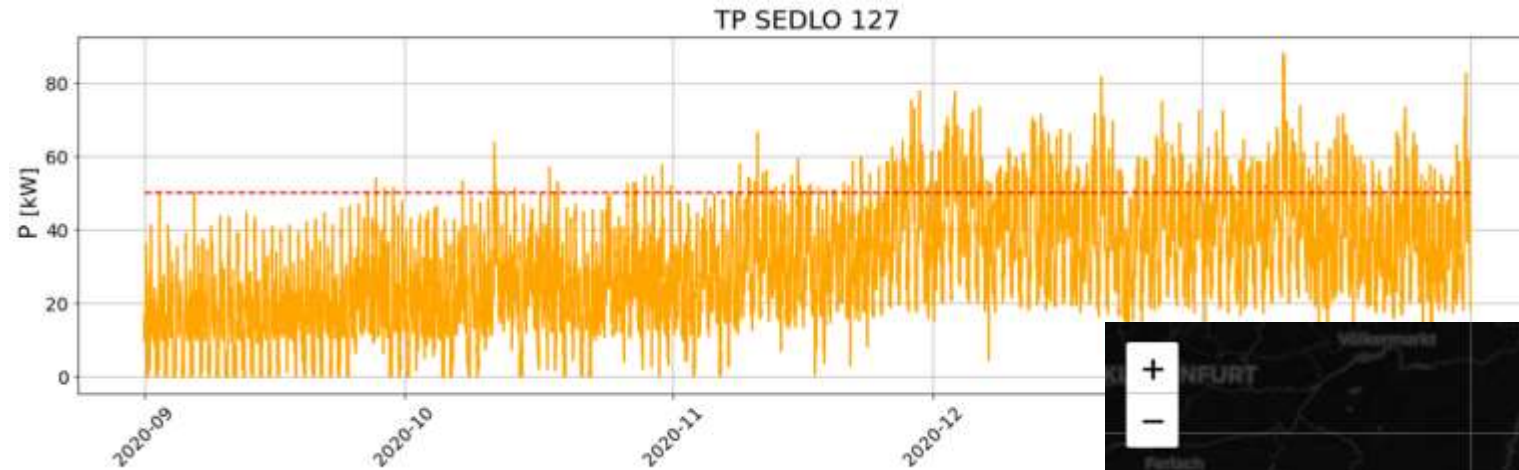
Step by step...



Basic services – reports & customer segmentation

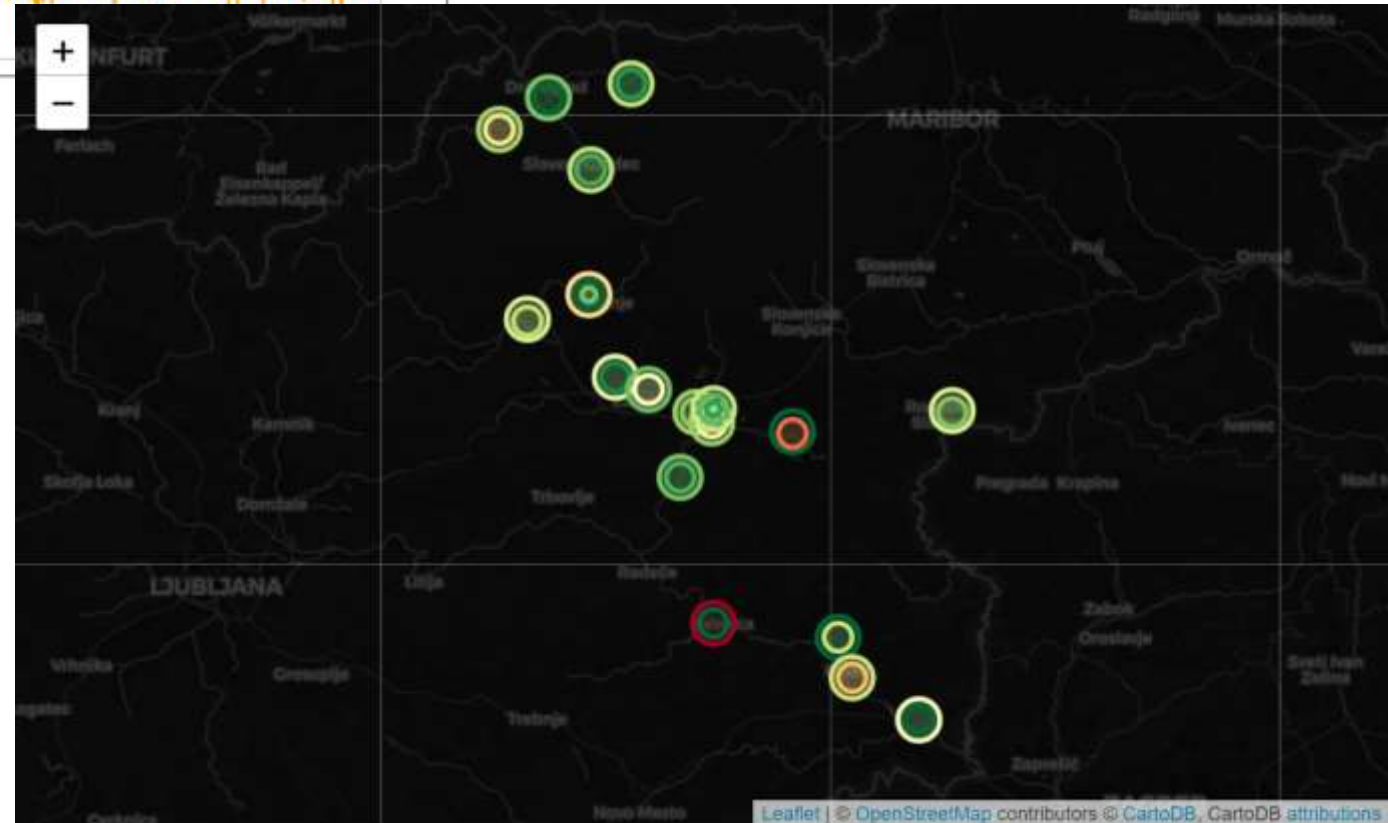


Data services – MV/LV station level (overloading)

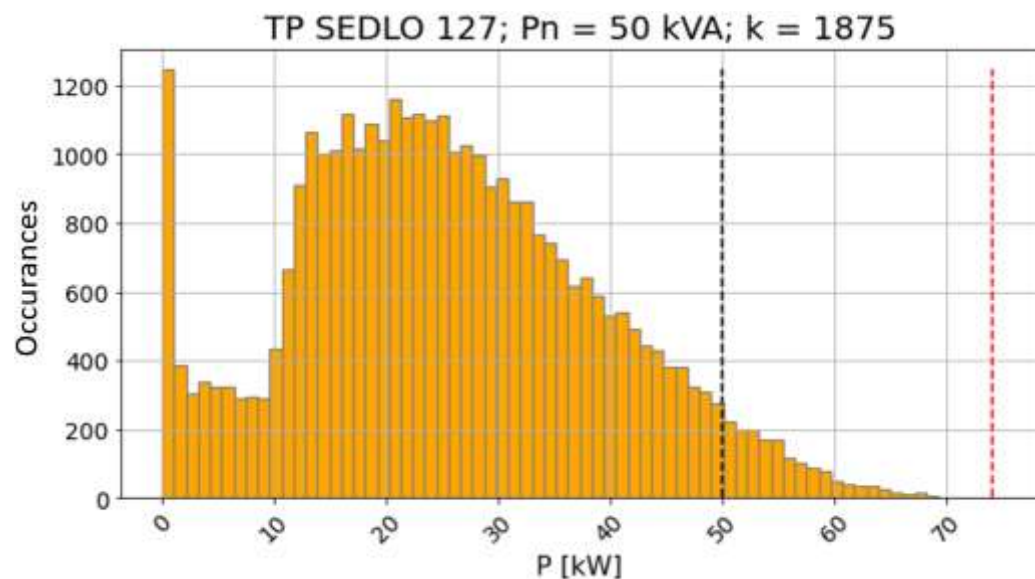
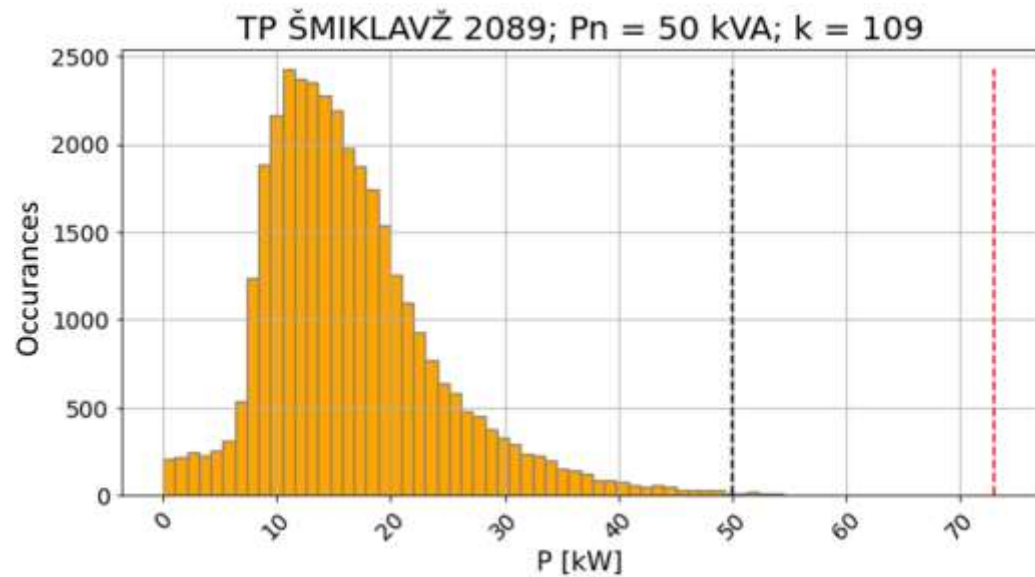


Secondary station load profile

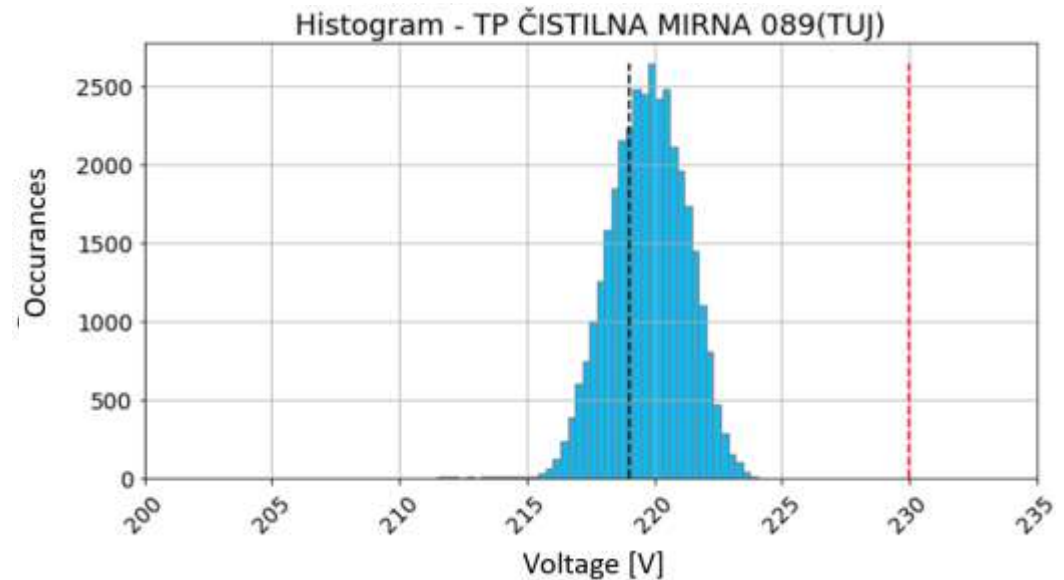
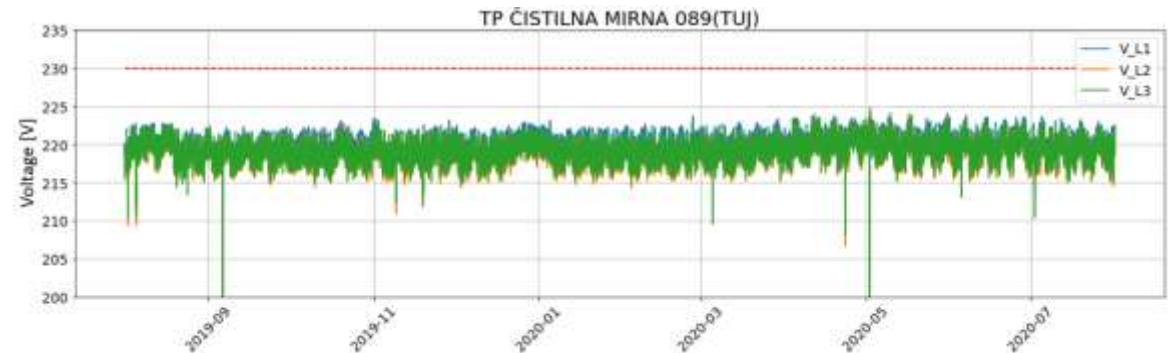
- Line plot visualization
- Geographic visualization
- How can we gain more insight?



Data services – MV/LV station level (overloading)



Histograms of overloading
and of voltage profiles



Data services – MV/LV station level (power down)



▲ MV/LV station
— LV feeder
● Consumer that called
● Consumers with no outage events
● Consumers with outage events

This consumer called at: 5.4.2020 13:00

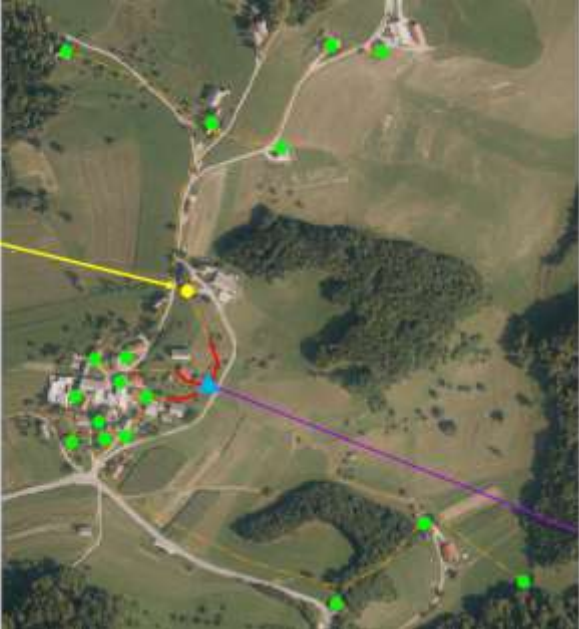
Check if it has smart meter?
YES

Pull this consumer's events for last 24h and filter only outage related events

4.4.2020 23:37	Missing V_L1
5.4.2020 04:25	Missing V_L3
5.4.2020 11:16	Power Down

For these timestamps +/- 5min pull events from other smart meters on this MV/LV station

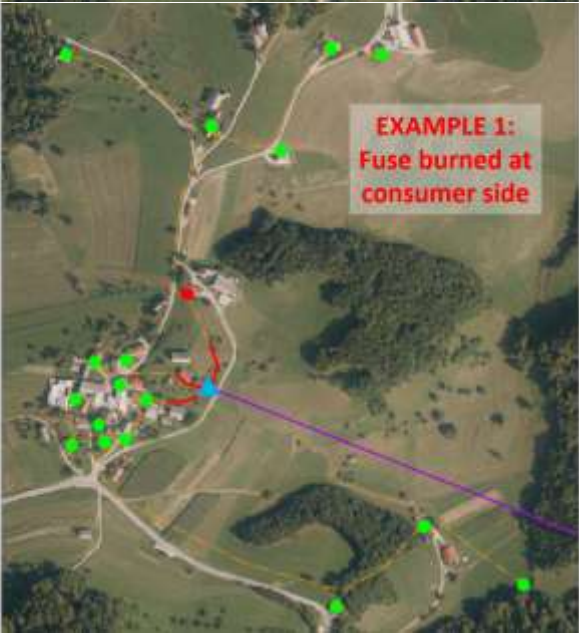
Filter only those that are outage related



Affected smart meters on each LV feeder

Asset	Affected SM	Affected SM [%]	Installed SM
Feed 1	1	16.6	6
Feed 2	0	0	3
Feed 3	0	0	9
TR station	1	5.5	18

- ▲ MV/LV station
— LV feeder
● Consumers with no outage events
● Consumers with outage events

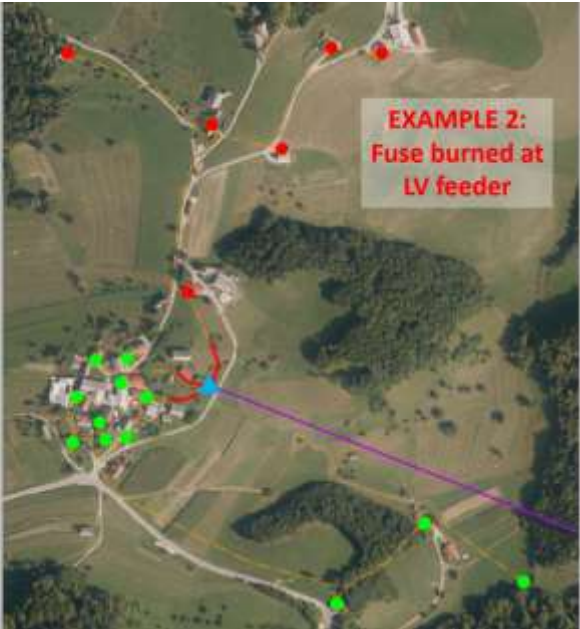


EXAMPLE 1:
Fuse burned at consumer side

Affected smart meters on each LV feeder

Asset	Affected SM	Affected SM [%]	Installed SM
Feed 1	6	100	6
Feed 2	0	0	3
Feed 3	0	0	9
TR station	6	33.3	18

- ▲ MV/LV station
— LV feeder
● Consumers with no outage events
● Consumers with outage events

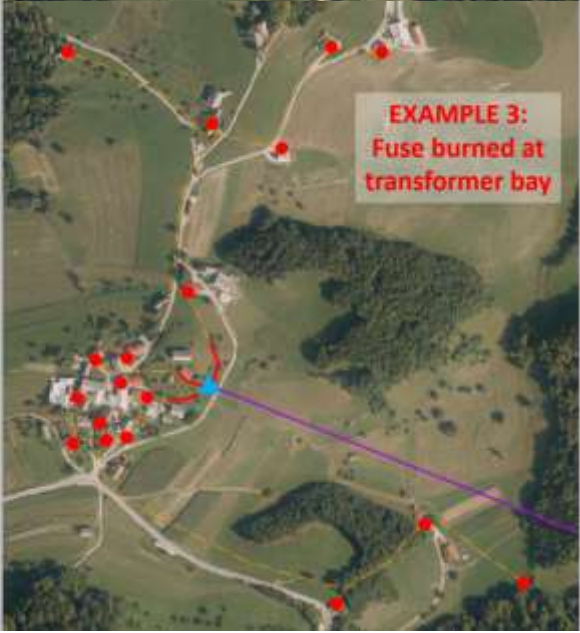


EXAMPLE 2:
Fuse burned at LV feeder

Affected smart meters on each LV feeder

Asset	Affected SM	Affected SM [%]	Installed SM
Feed 1	6	100	6
Feed 2	3	100	3
Feed 3	9	100	9
TR station	18	100	18

- ▲ MV/LV station
— LV feeder
● Consumers with no outage events
● Consumers with outage events

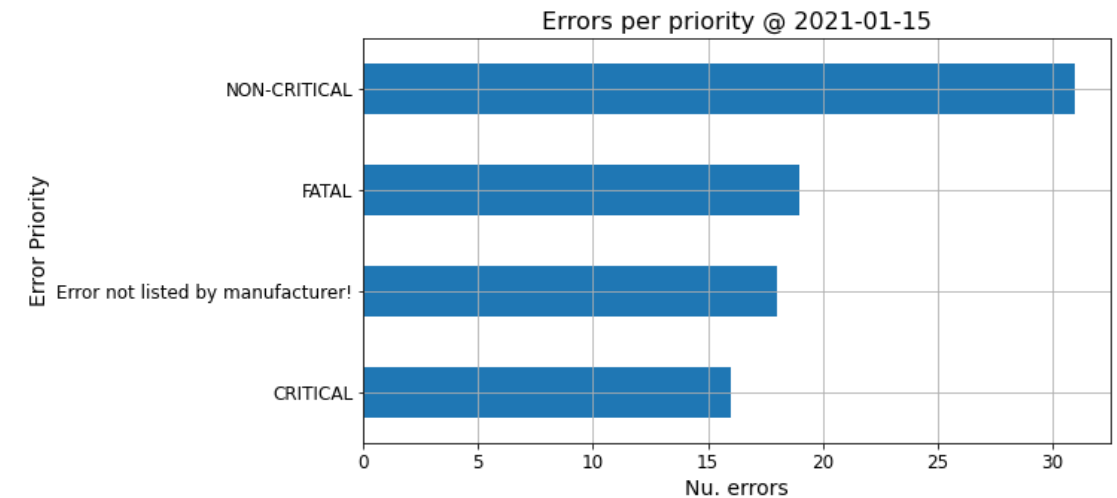
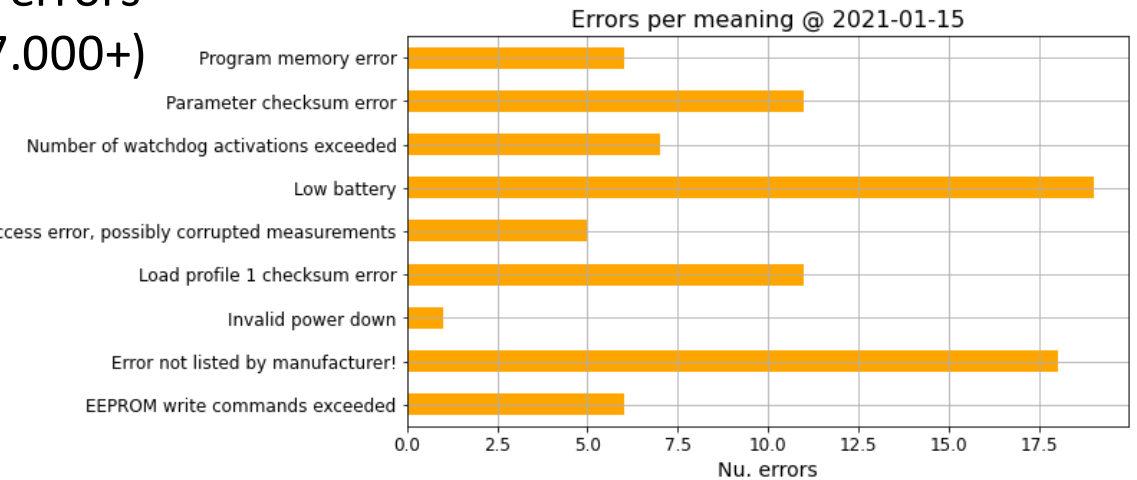
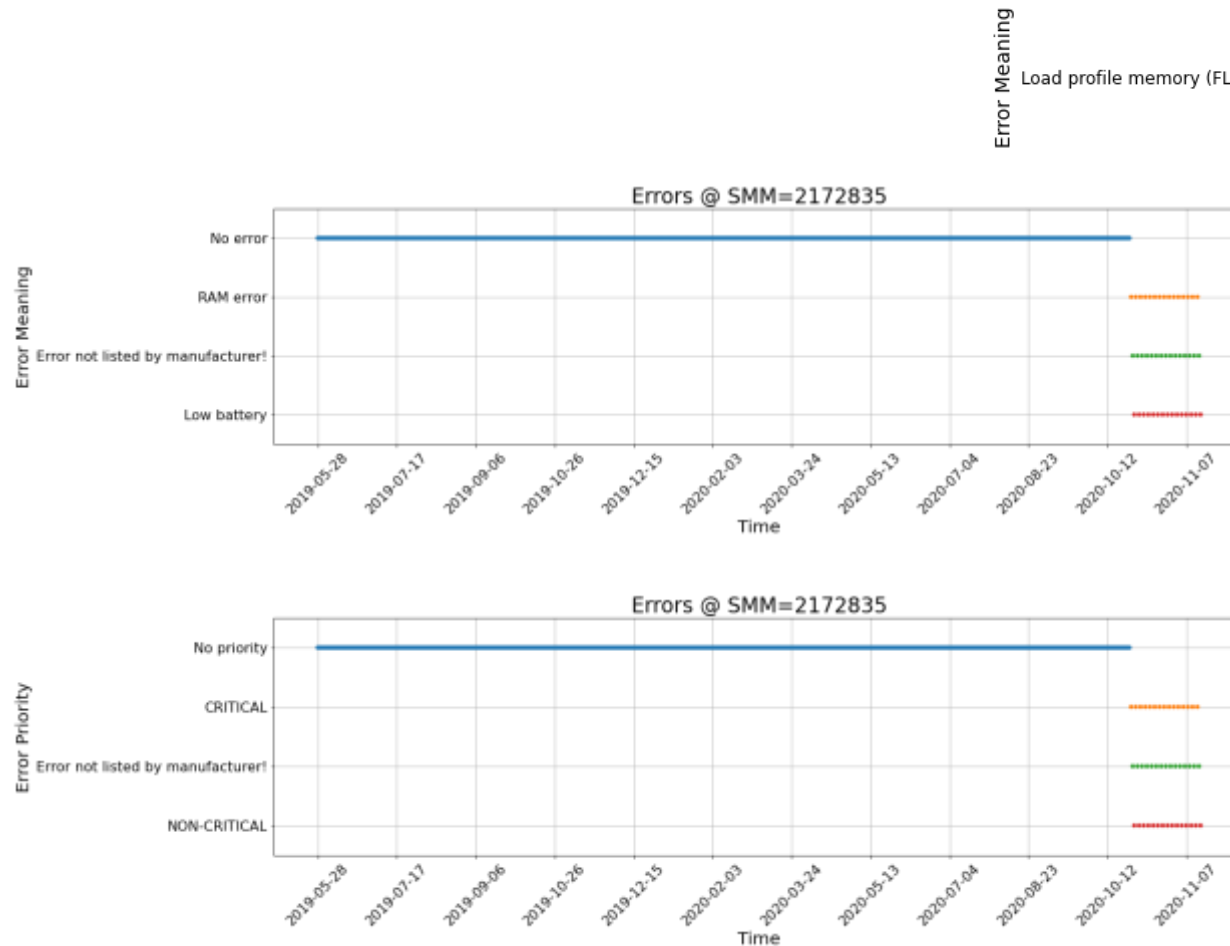


EXAMPLE 3:
Fuse burned at transformer bay

Data services – MV/LV station & customer level (FF regs)



- Smart meter **FF registers** – contain smart meter internal errors
- Collected at industrial and station transformer meters (7.000+)
- Plans for meter prescriptive maintenance





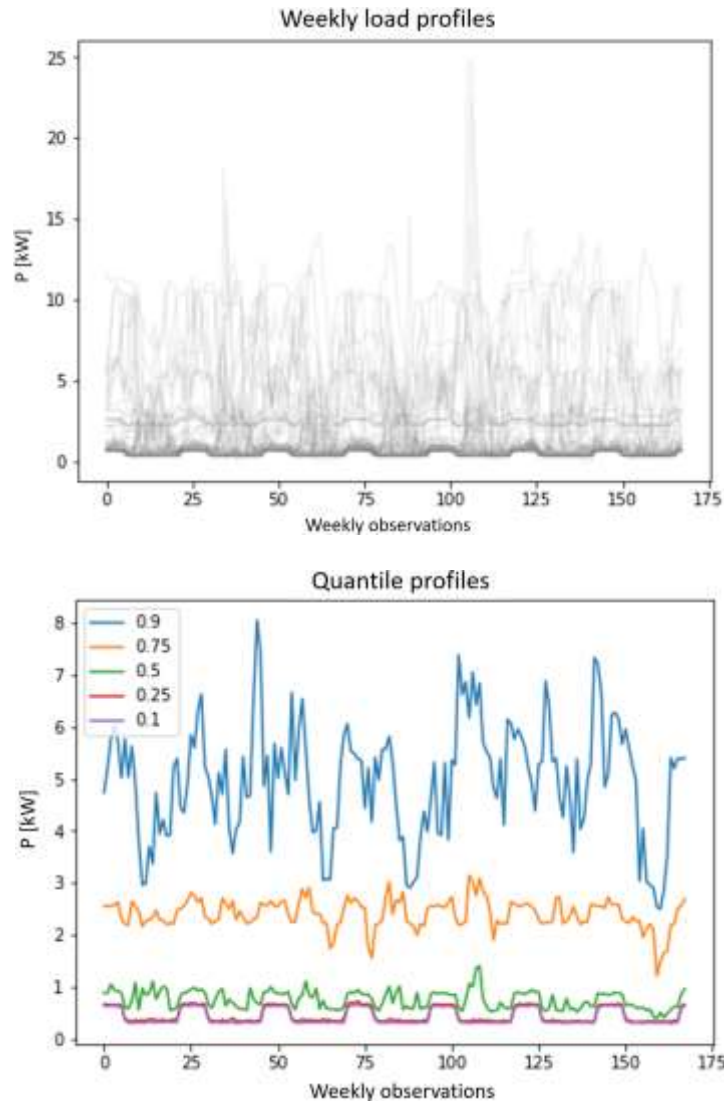
Recognizing consumer load trend



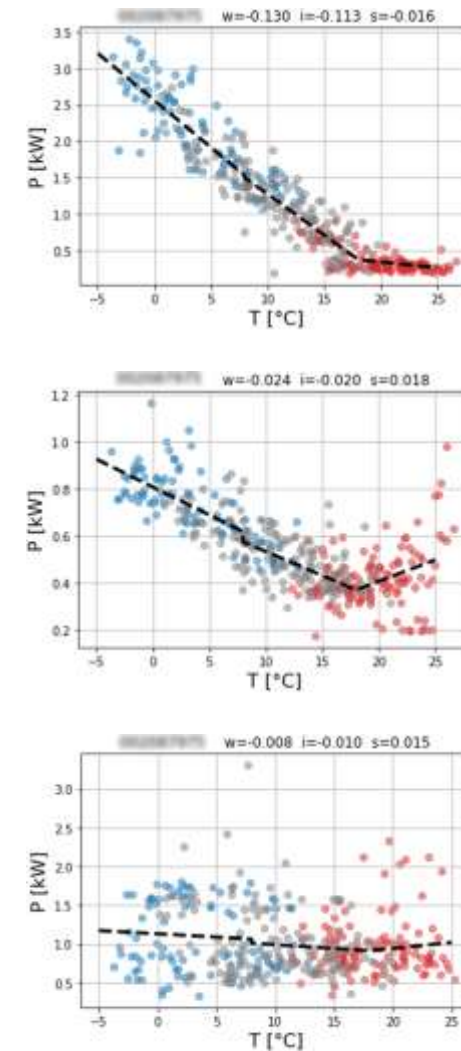
Data services – consumer level (segmentation)



Simple segmenting of consumer profiles



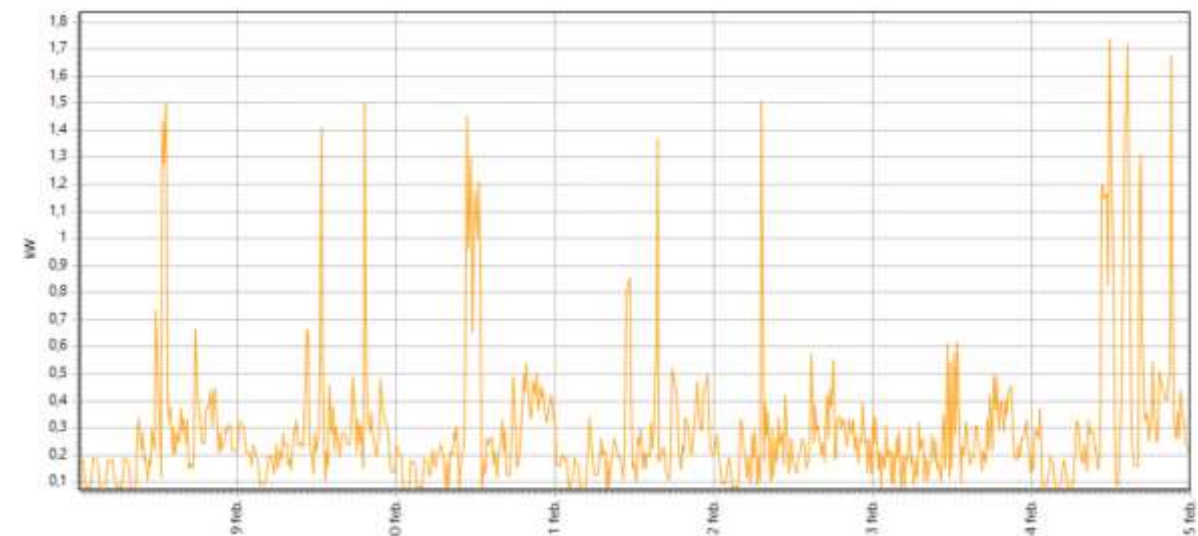
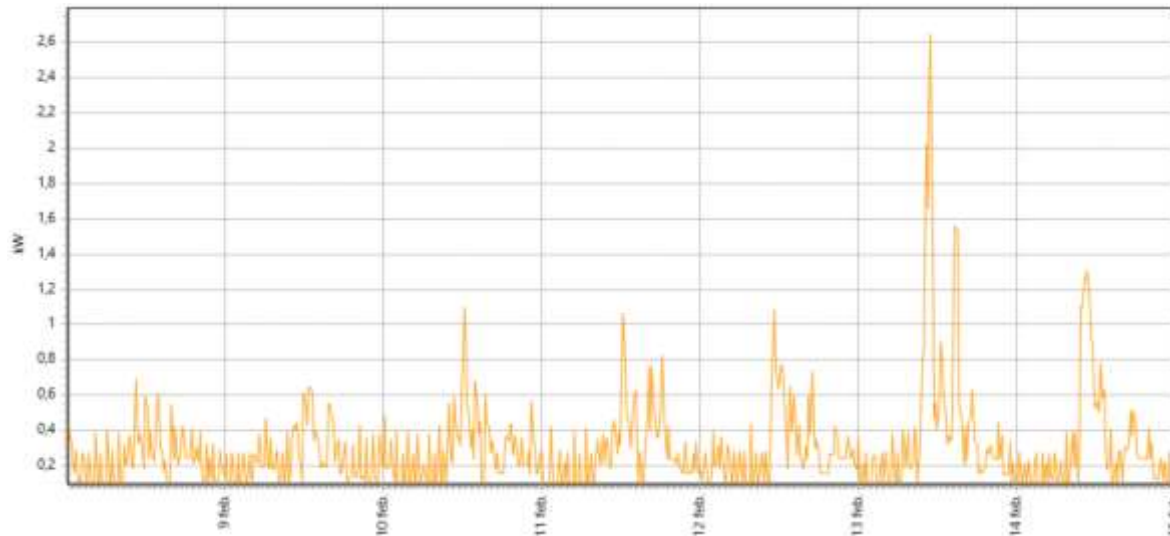
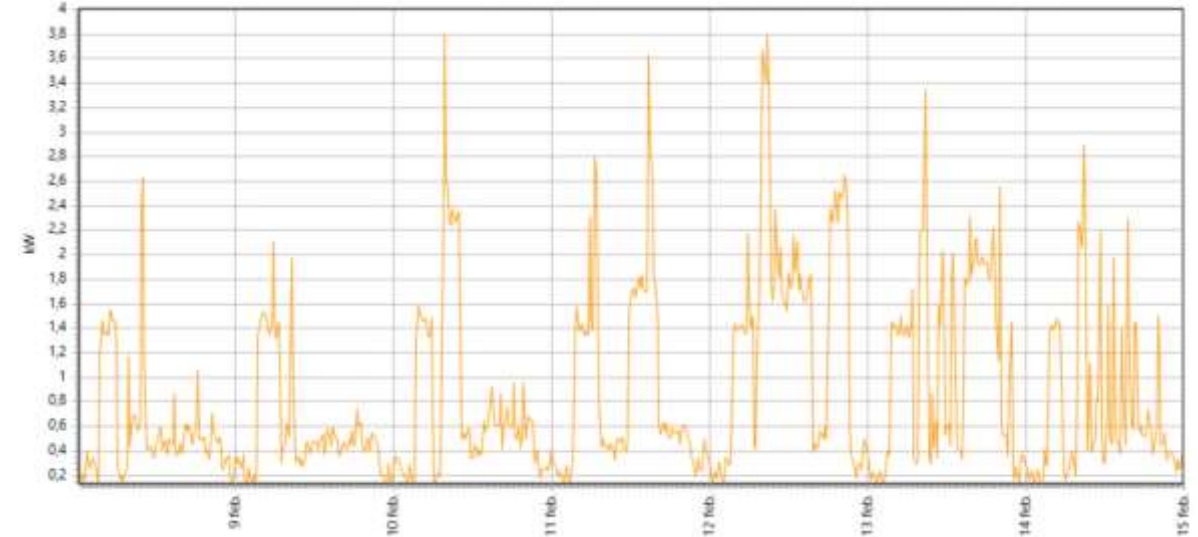
Detecting heat pumps



Clustering – load profiles



- Profiles recorded by smart meters
- Each consumer has its own load profile
- **Different but yet similar**
- Clustering to „subsidiary“ profile curves.
- Use cases:
 - Customers with no smart meter
 - LV load flow, state estimation
 - Other ADMS operations
 - Non-technical losses

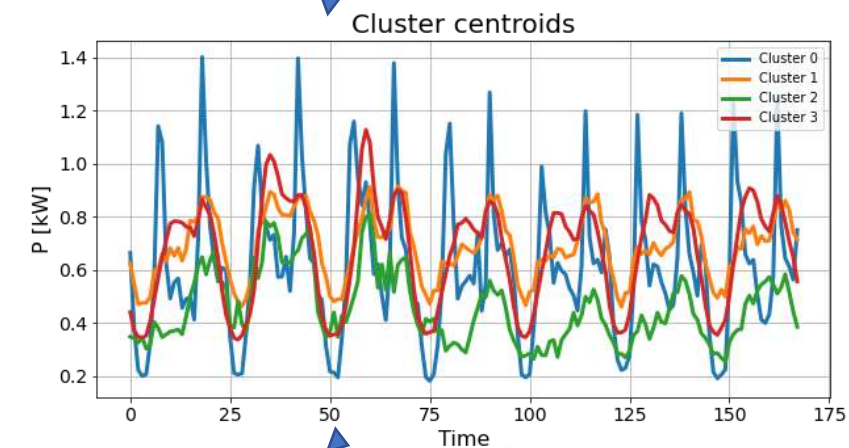
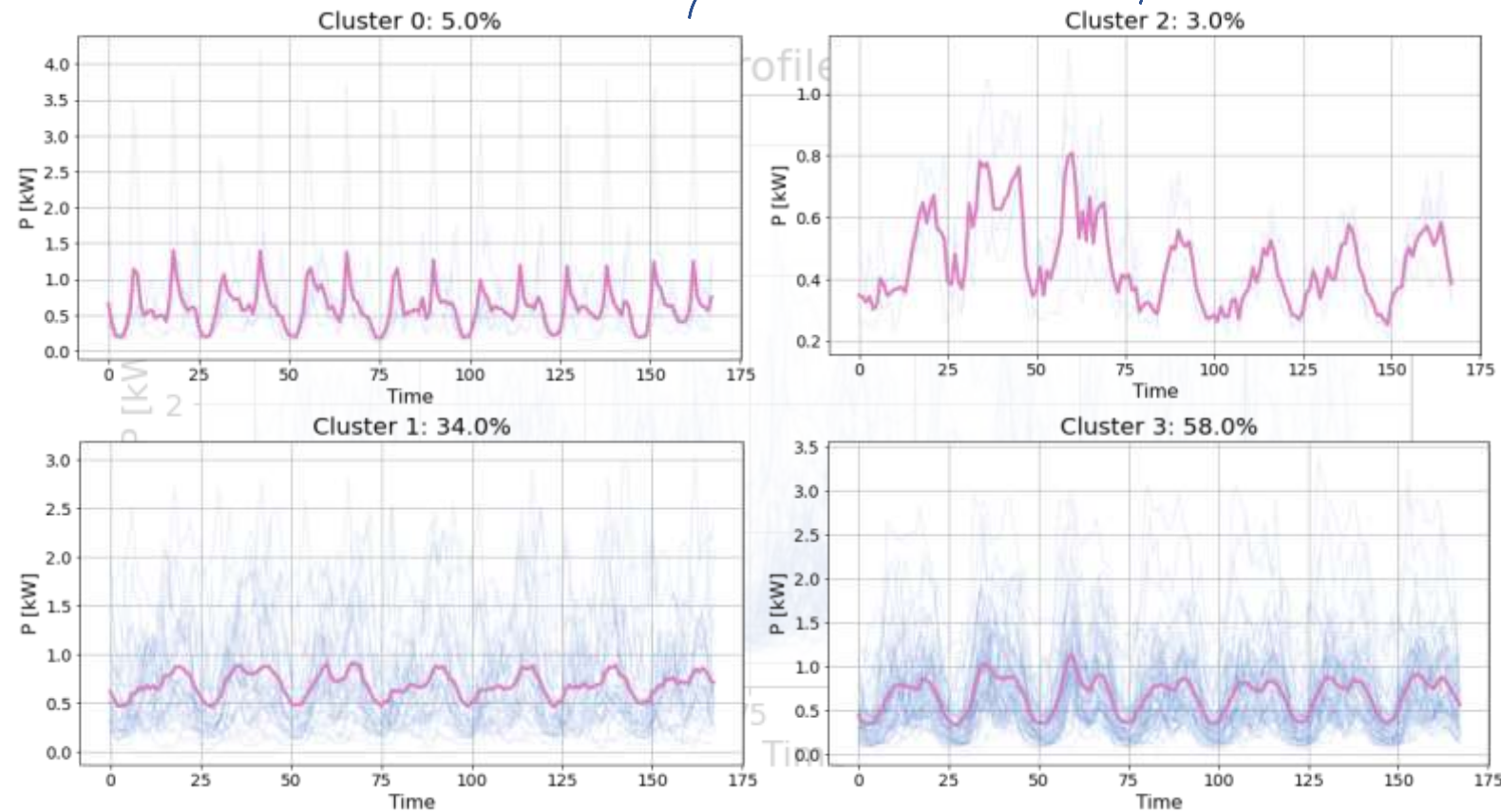


Clustering – load profiles



Example 1 of simple k-shape clustering

Important **TEMPORAL COMPONENT**
AMPLITUDE COMPONENT

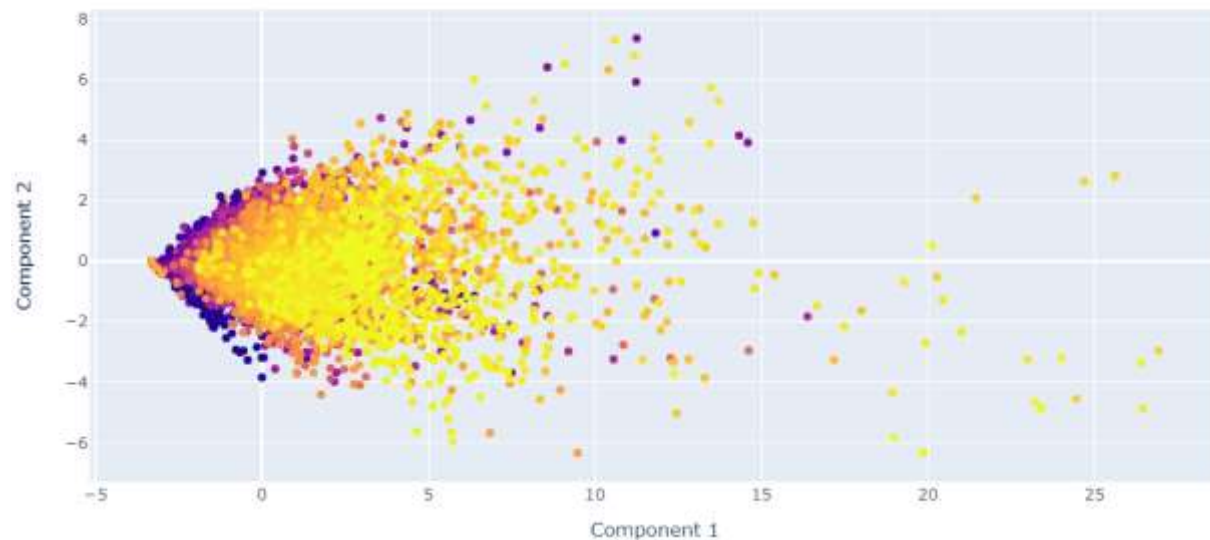
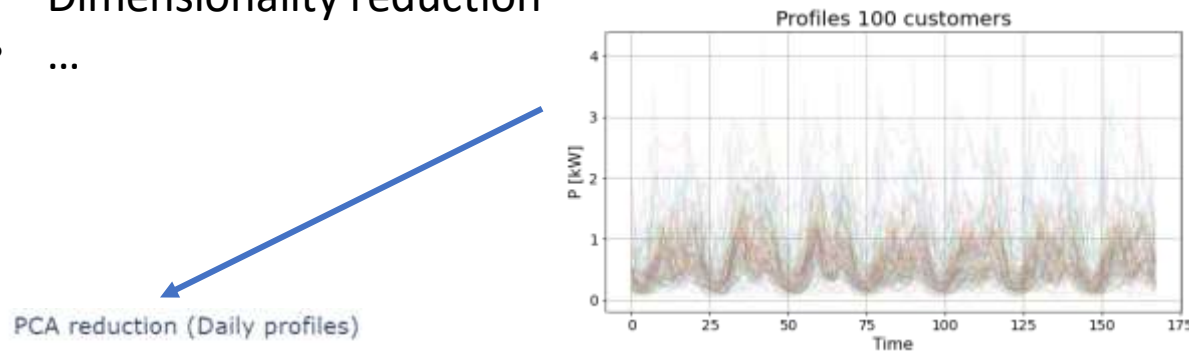




Clustering – load profiles (examples)

- Normalized profiles
- Segmentation (season, days)
- Clustering with appropriate parameters, metric
- Dimensionality reduction
- ...

**It all comes down to plying with different combinatinos!
And there are many of them.**

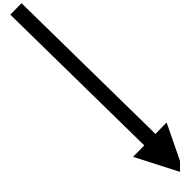




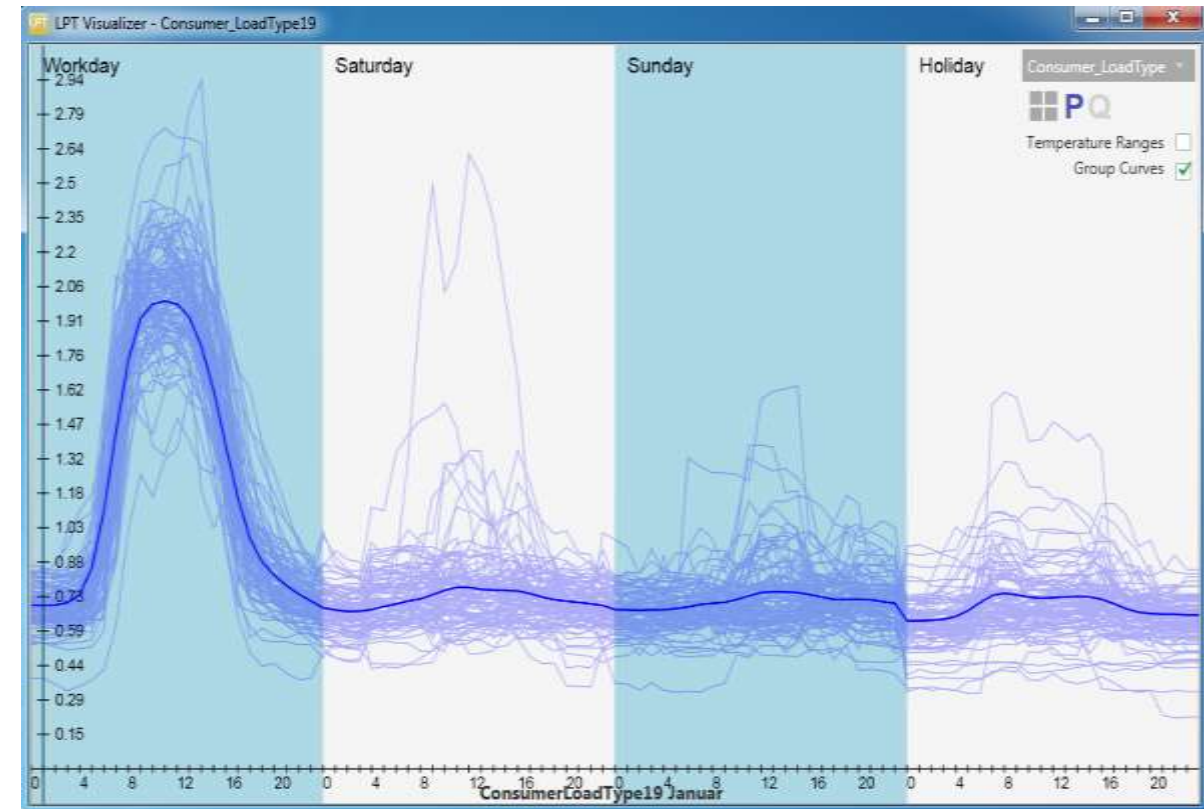
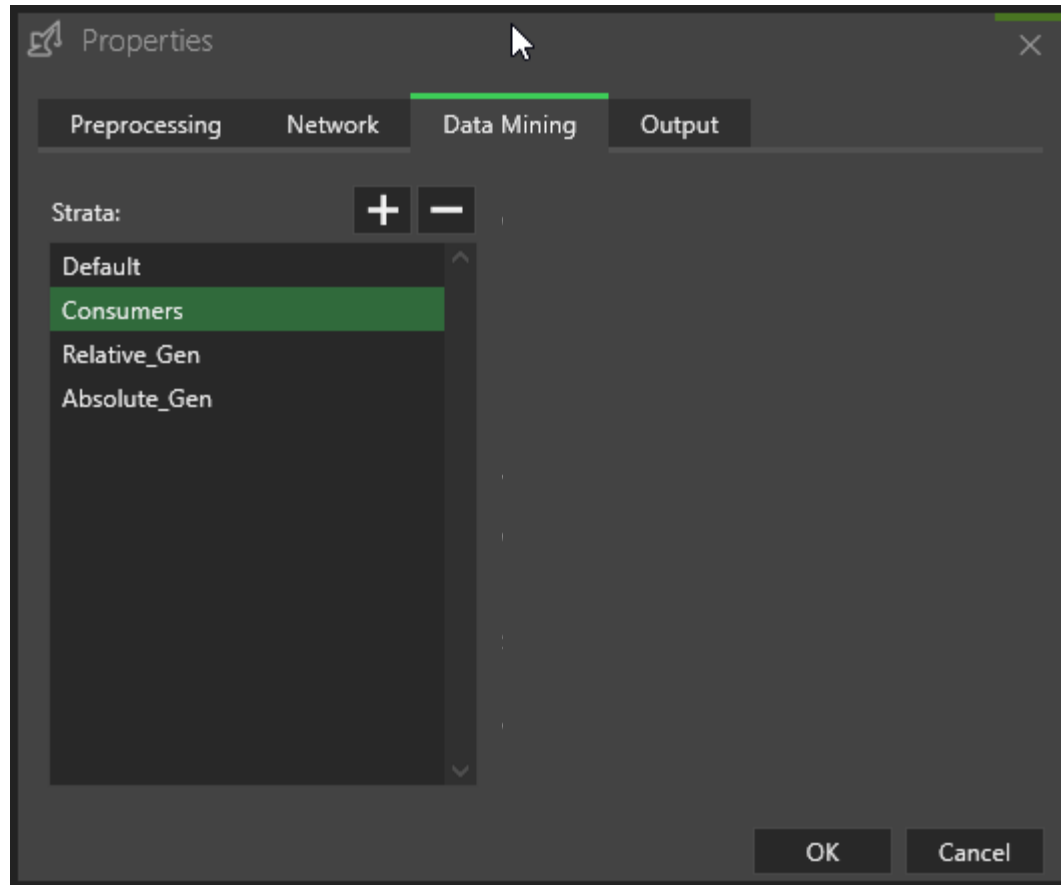
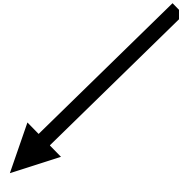
Clustering – load profiles (ADMS)



AMI



CIS



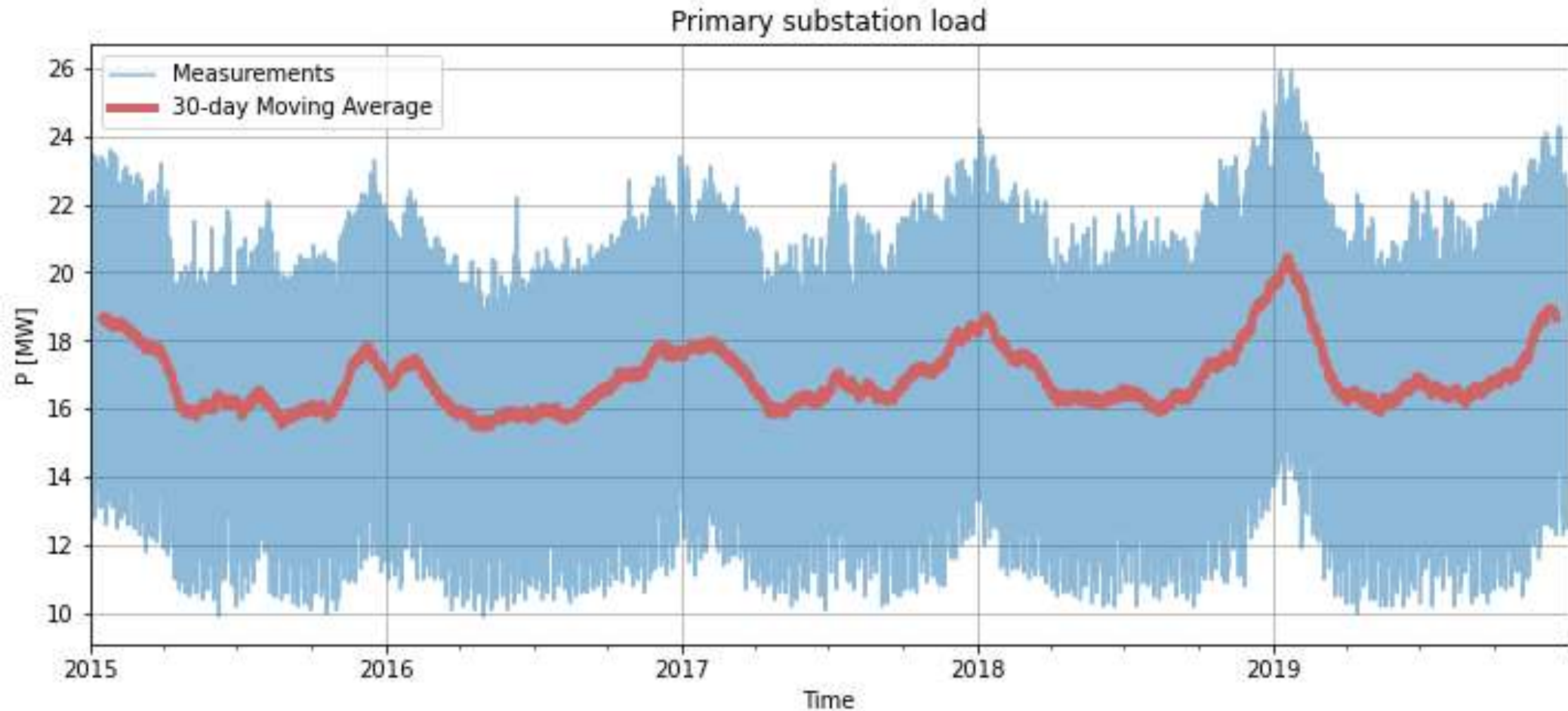
Forecasting – example primary station load forecasting



Original dataset

Duration: 4 years

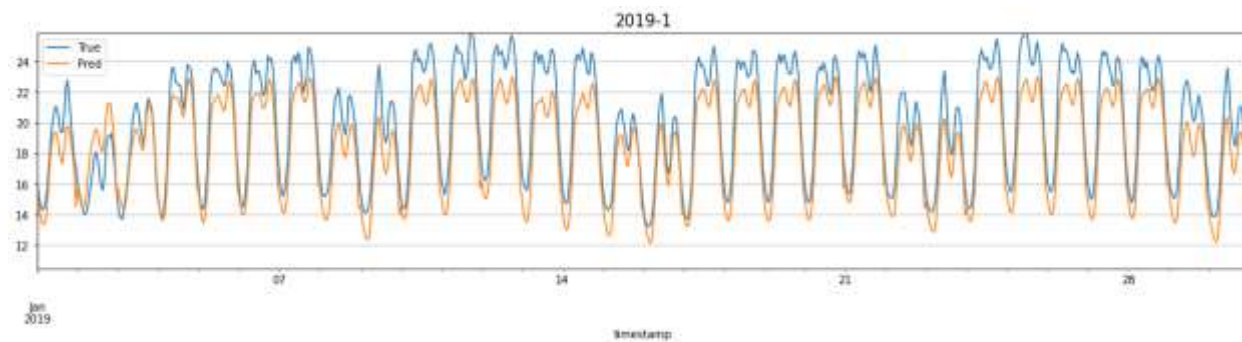
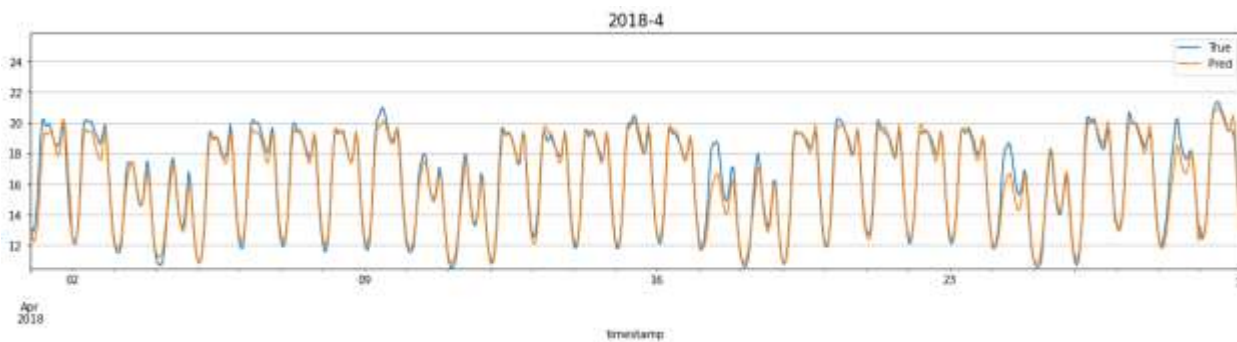
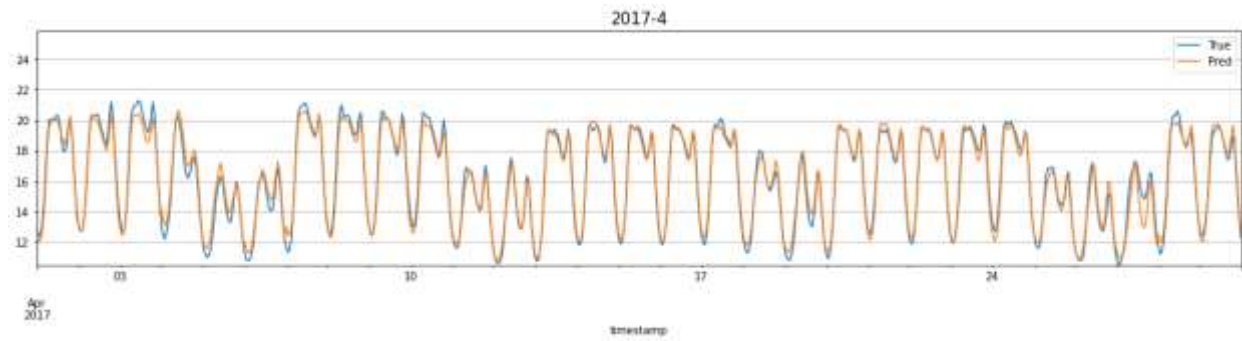
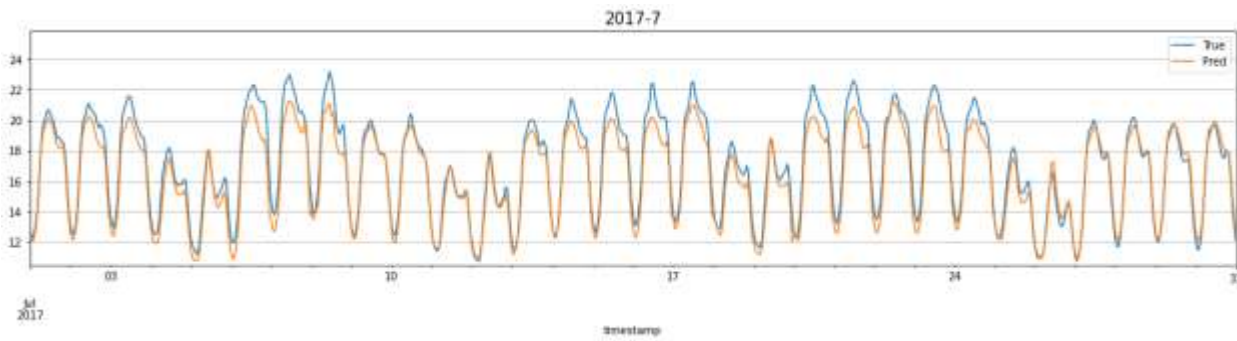
Resolution: 1h



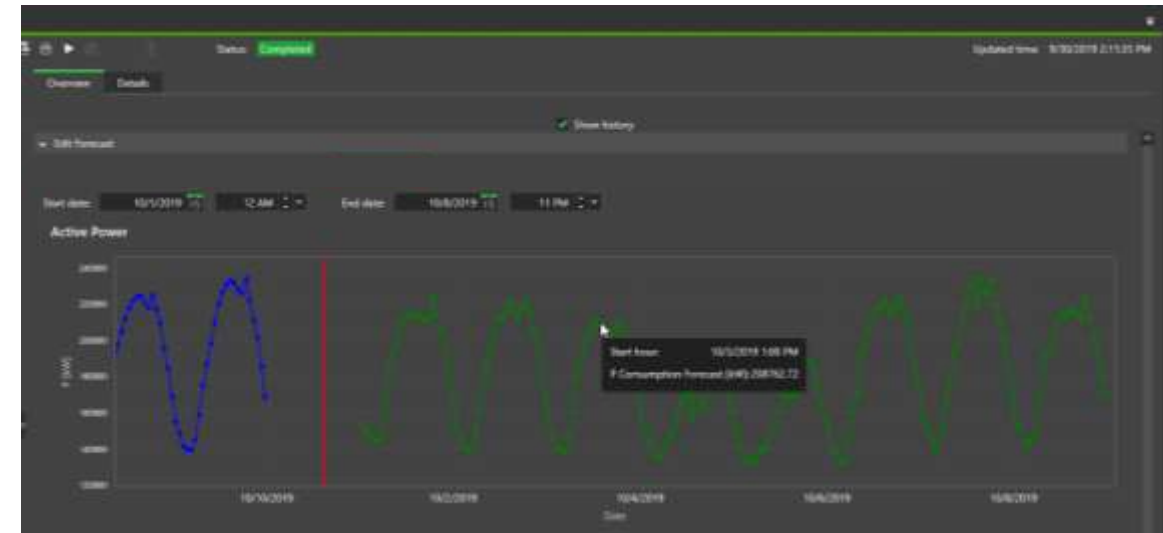
Forecasting – example EVALUATION



Asses the solution validity



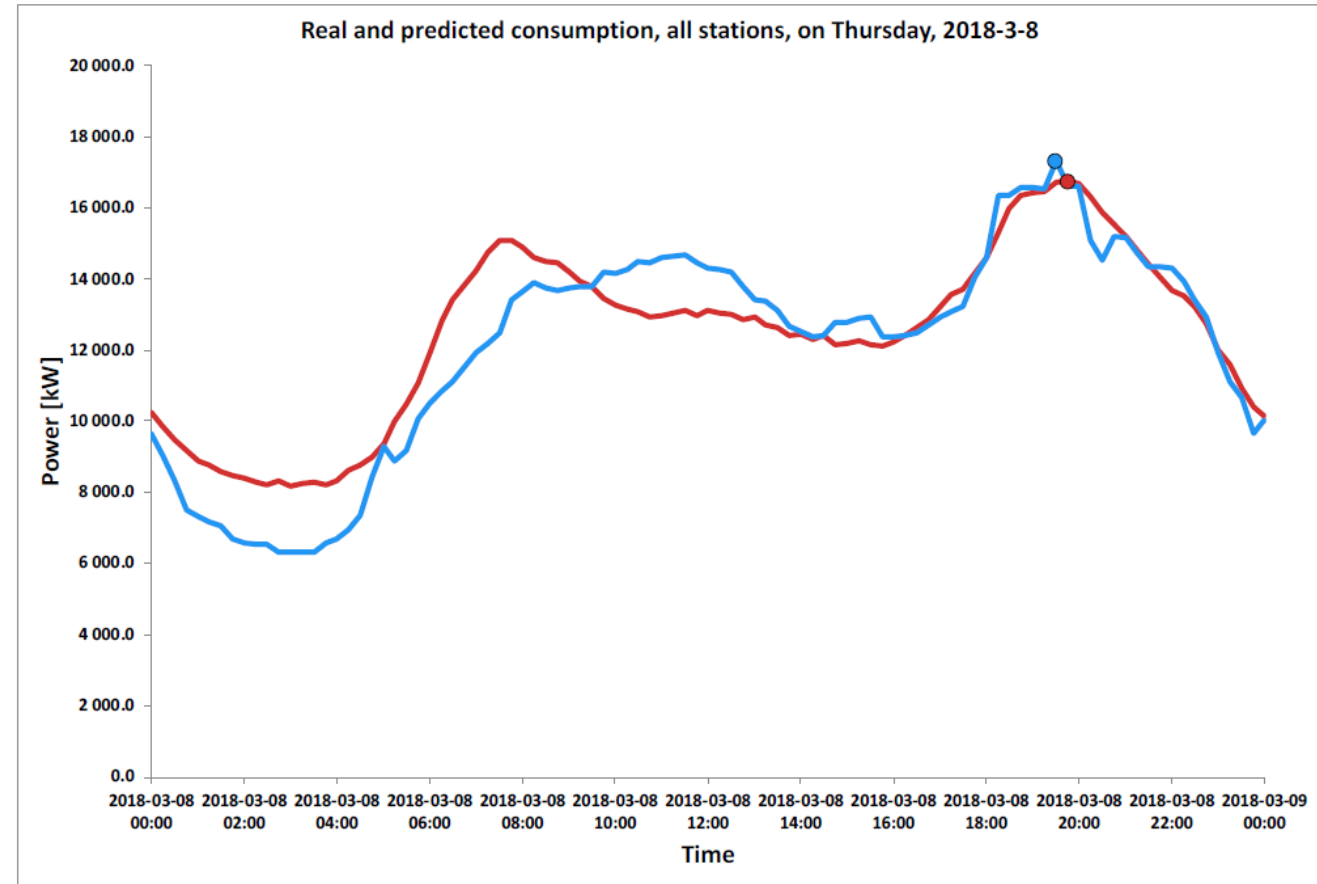
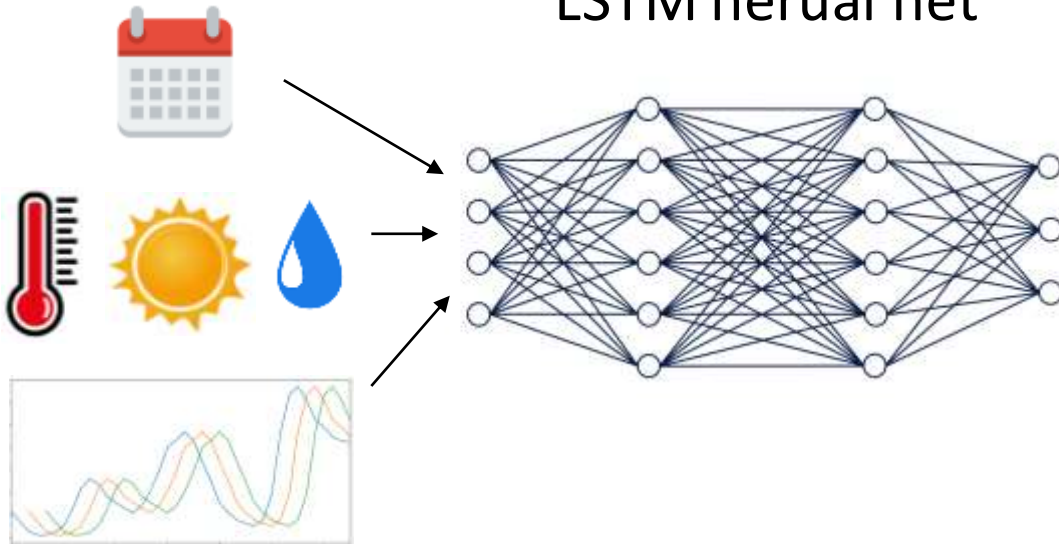
Forecasting – ADMS



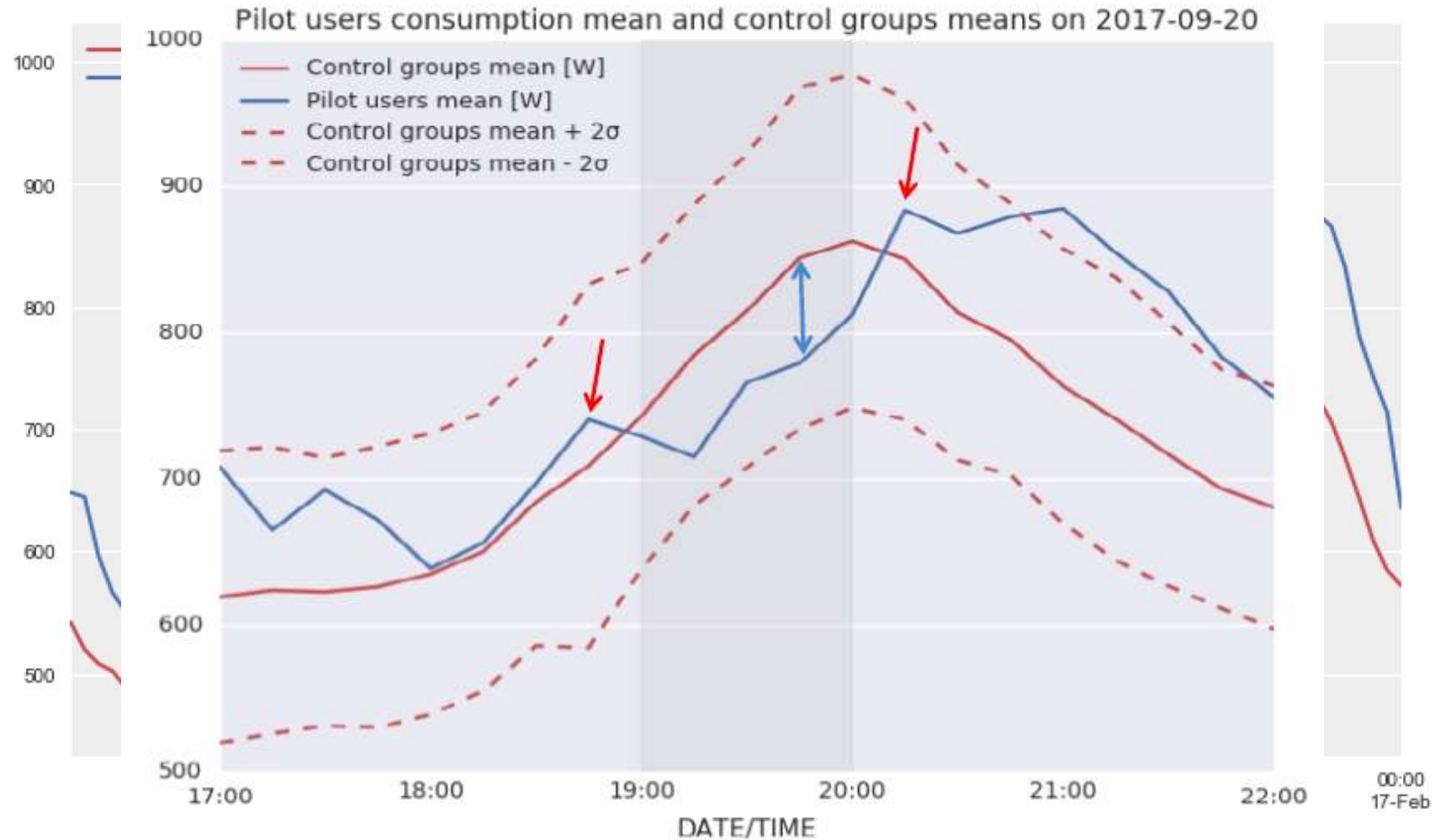
Forecasting– Load in flexibility area



LSTM neural net

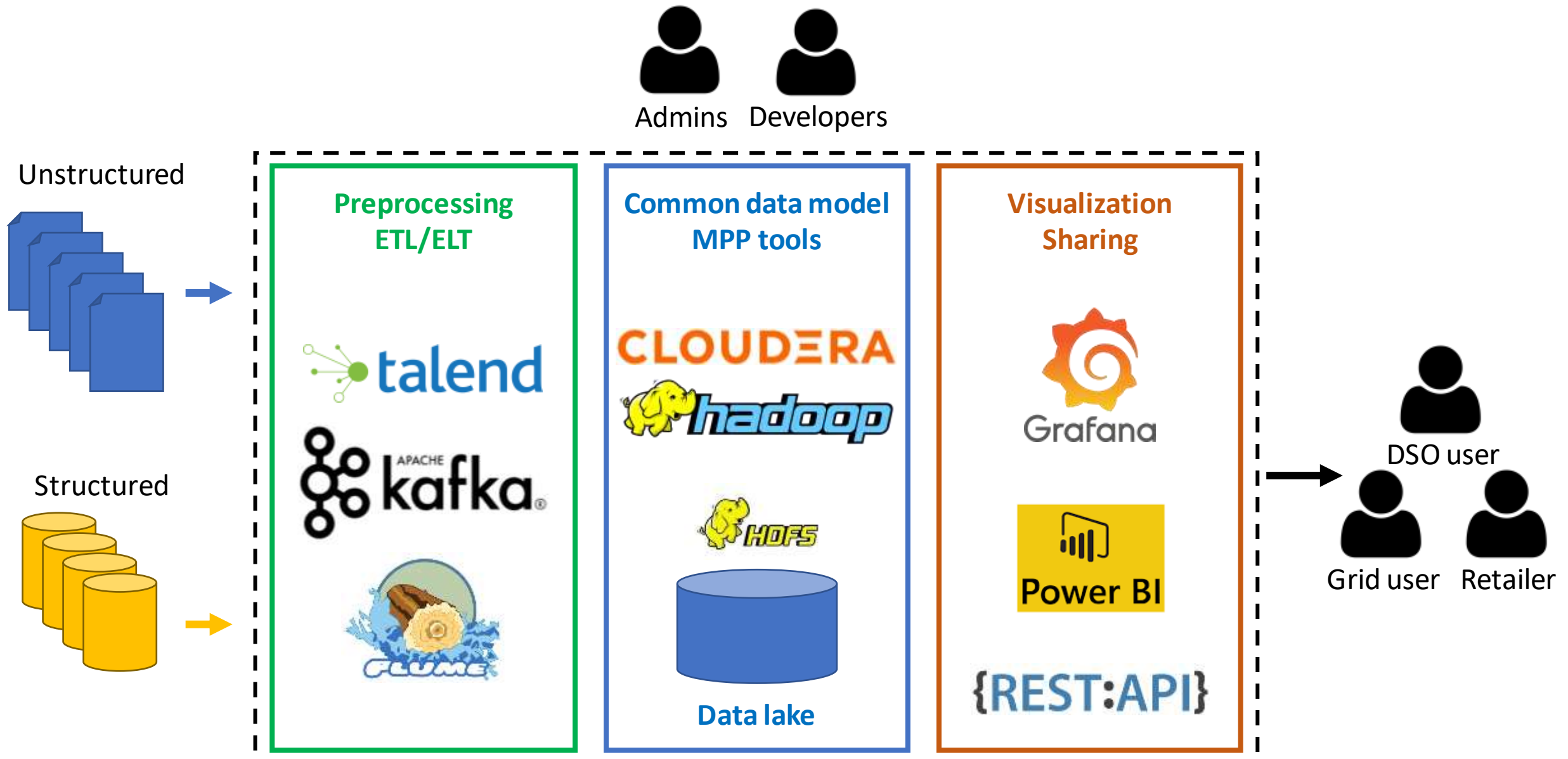


Forecasting – Flexibility response





BigData & DevOps – LAMBDA environment



Questions ?



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<https://www.linkedin.com/groups/13621702/>