



Data science and predictive analytics in virtual power plant environment

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Presented by Sebastian Dudzik, prof. CUT

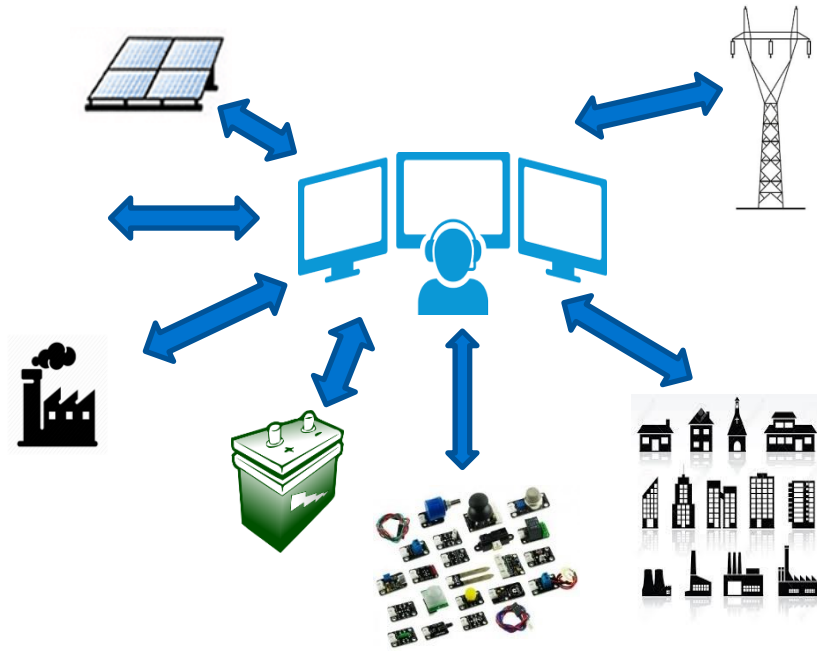
Częstochowa University of Technology



Presentation Agenda

- Virtual Power Plant at Faculty of Electrical Engineering
 - Idea
 - Assets
 - PI System in VPP
- Data science and predictive analytics
- Methodology of data analysis
- Results of data analysis
- Conclusion and next steps

Vitrual Power Plant - Idea



- A group of producers, consumers
- Control and monitoring system (PI System)
- Predicting demand/production of electric energy
- Balancing inside group
- Connecting with electric network

VPP in Czestochowa - assets



photovoltaic panels



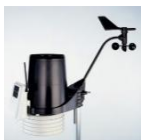
wind turbines



energy storages



smart meters

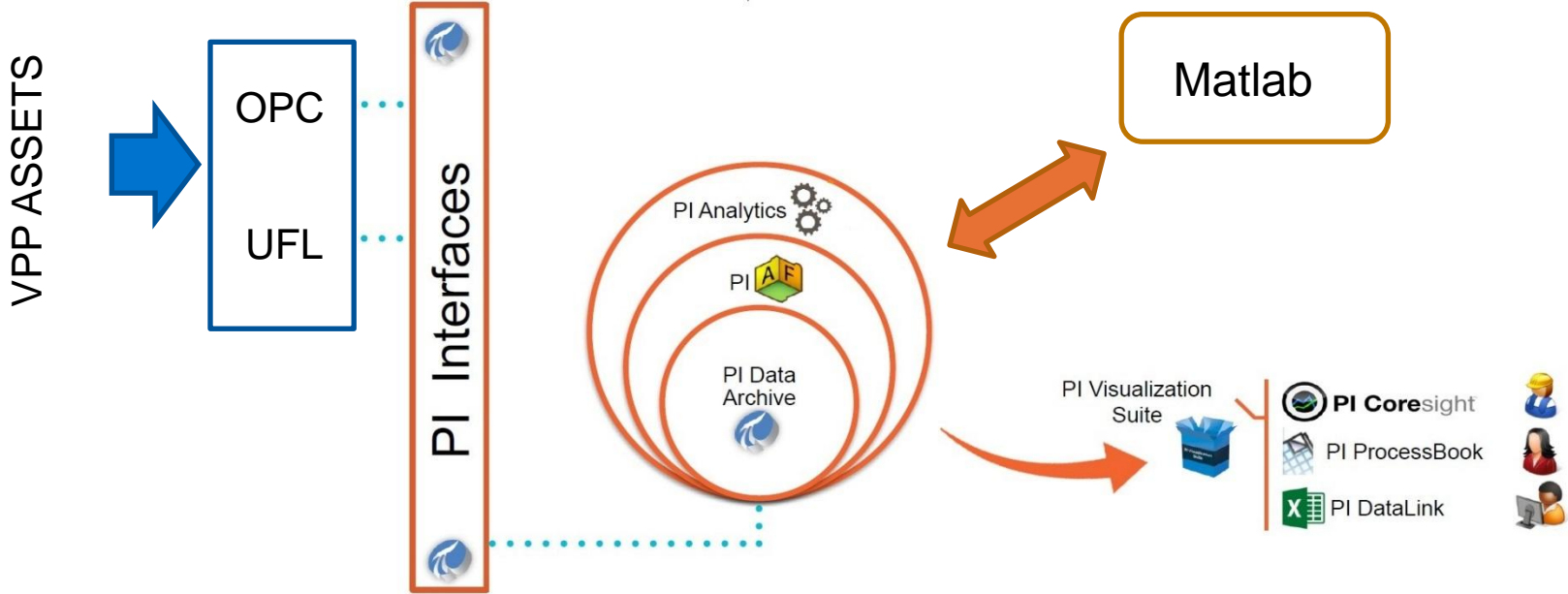


weather station

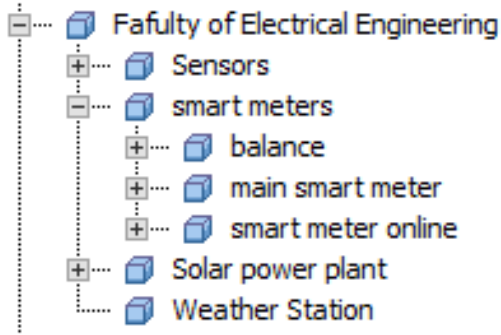
air quality sensors



VPP in Czestochowa – real time computer system



PI System in VPP



General	Child Elements	Attributes	Ports	Analyses	Notification Rules	Version
Filter						
Name	Value					
EP+	4688,05 kWh					
EP+ 1h Real	373,3333 Wh					
EP+ Real	Pt Created					
P+	112 W					
P+ 1h Real	8960 W					
P+ Real	8960 W					

PI System in VPP

Examples of analyses

The screenshot shows the 'Analyses' tab in the VPP interface. It displays a table with three rows, each representing an analysis for a different London location. The 'Backfilling' column shows green checkmarks, indicating successful backfilling.

Name	Backfilling
f00 For London	✓
f00 For London 2	✓
f00 For London 3	✓

Below the table, there is an 'Evaluate' button and a table for variable definitions:

Name	Expression	Value at Evaluation	Value at Last Trig	Output Attribute
Variable2	TagVal('EP+ 1h Real',')			P+ 1h Real

At the bottom, the 'Scheduling' section is set to 'Event-Triggered' with a 'Trigger on' dropdown set to 'Any Input'.

in

The screenshot shows the 'Analyses' tab in the VPP interface, similar to the first screenshot. It displays a table with three rows, each representing an analysis for a different London location. The 'Backfilling' column shows green checkmarks, indicating successful backfilling.

Name	Backfilling
f00 For London	✓
f00 For London 2	✓
f00 For London 3	✓

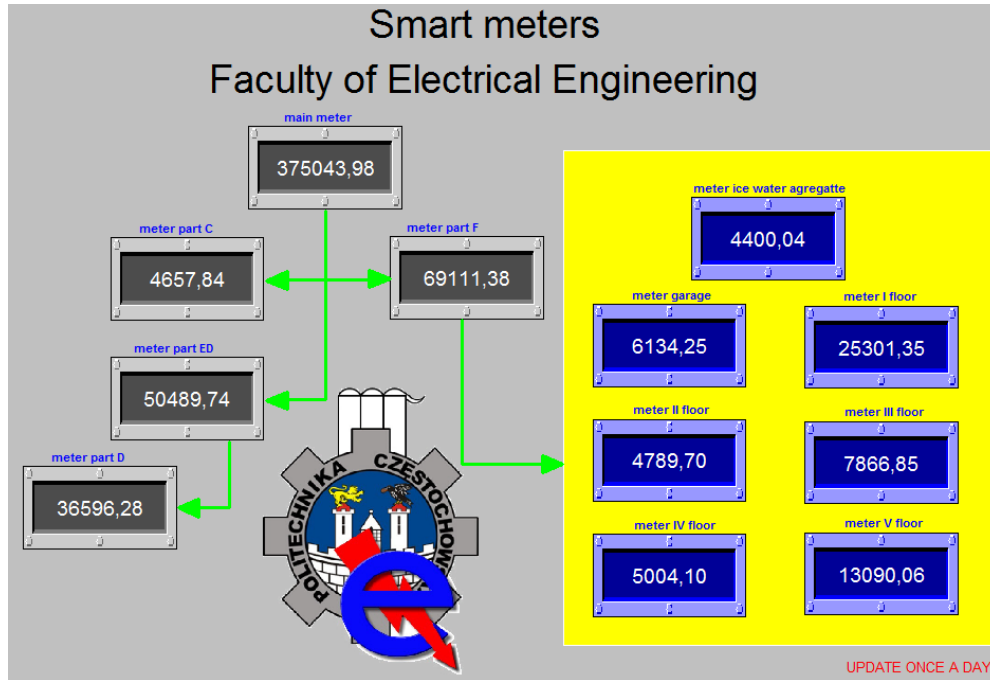
Below the table, there is an 'Evaluate' button and a table for variable definitions:

Name	Expression	Value at Evaluation	Value at Last Trig	Output Attribute
Variable1	TagTot('P+ Real',')			EP+ 1h Real
Variable3	TagAvg('P+ Real',')			P+ 1h Real

At the bottom, the 'Scheduling' section is set to 'Periodic' with a 'Period' of '01h 00m 00s'.

PI Asset Framework

Balancing/verification of electricity consumption



- Ability to balance logically coherent items:
 - Area
 - Building
- Localisation of illegal energy consumption sources
- Identification of abnormal behaviours
- Detecting change in the profile of electricity consumption

Energy balance of a building



Pavillion F [kWh]: 35837,26	
Cold water aggregate	[kWh]: 3126,22
Floor 5	[kWh]: 7923,01
Floor 4	[kWh]: 2119,40
Floor 3	[kWh]: 3259,22
Floor 2	[kWh]: 3086,72
Floor 1	[kWh]: 12177,88
Garage, floor 1 & 2	[kWh]: 3336,94

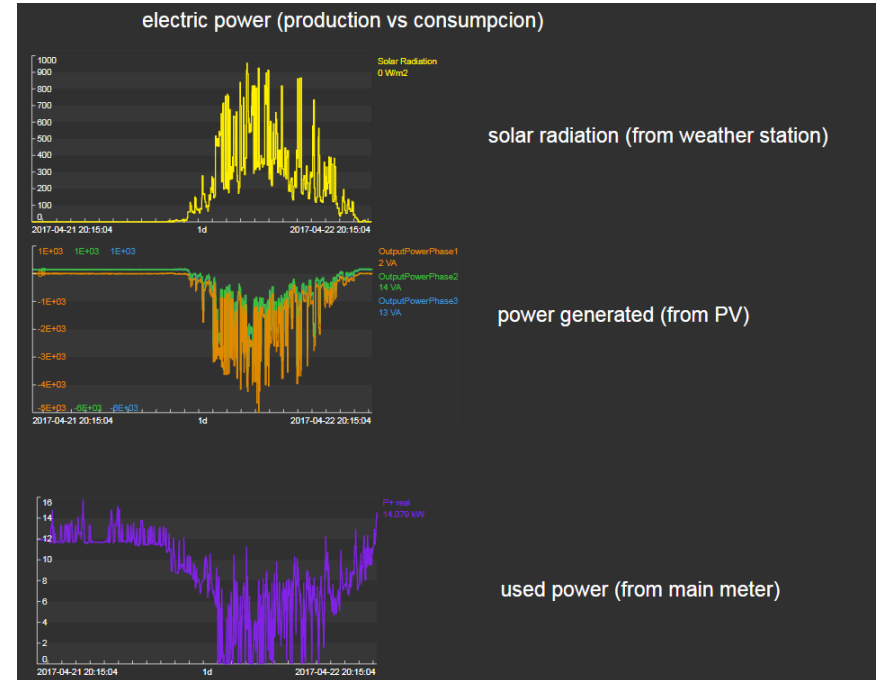
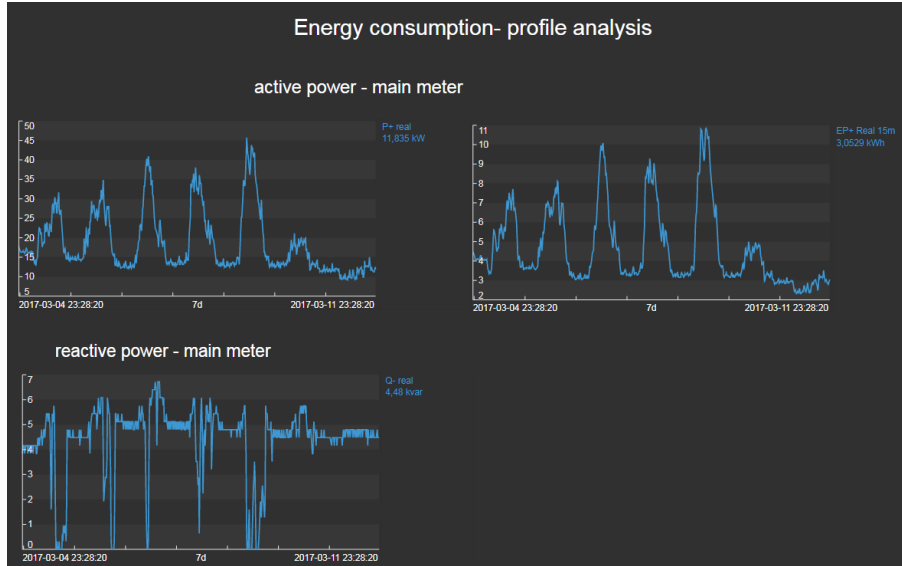
Balance [kWh]: 807,88

The total from the meters is smaller than the readings from pavillion's main meter

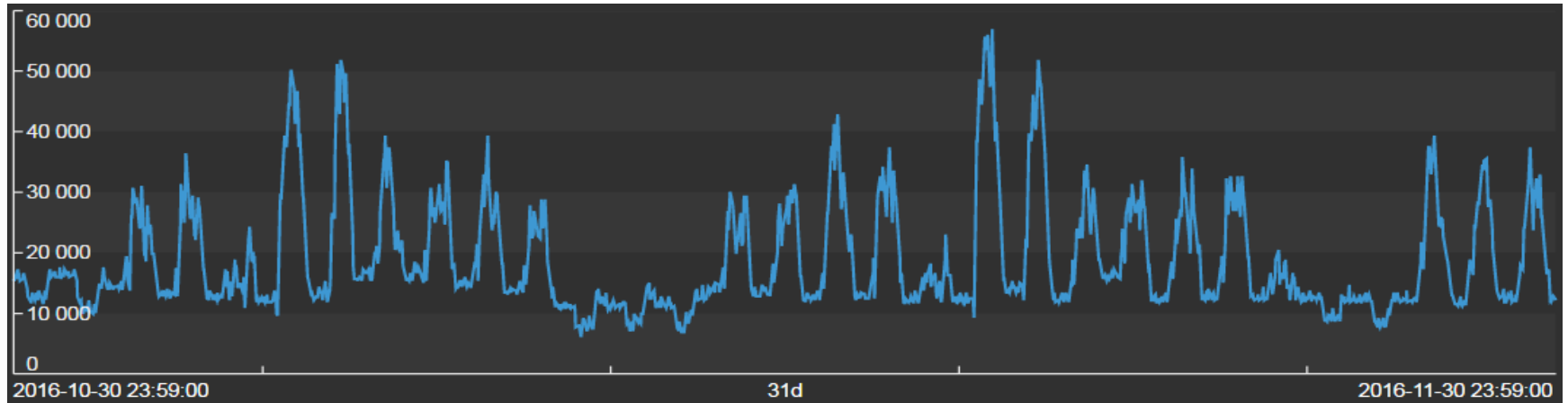
Illegal eletric energy consumption?

Consumption between the main meter and the other meters – the lift

Monitoring - PI Coresight



Optimum tariff choice (customer)

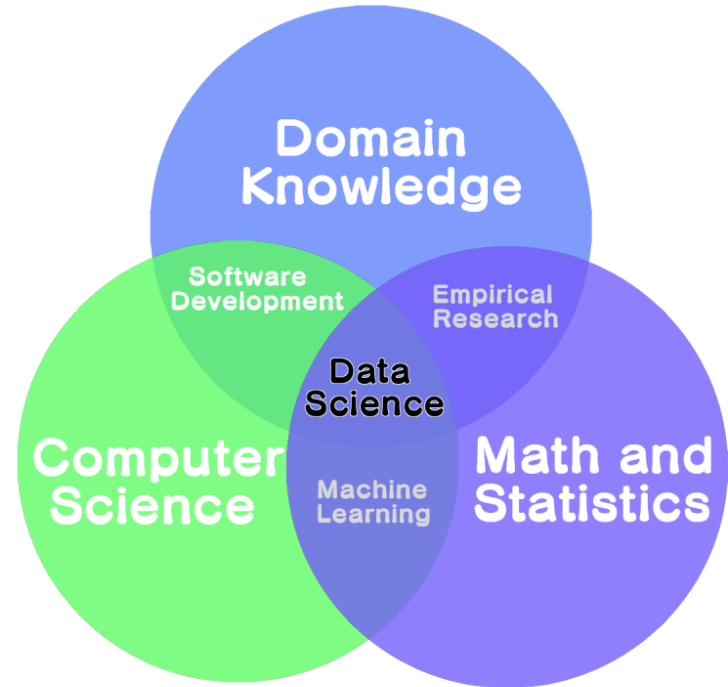


Customer's ability to:

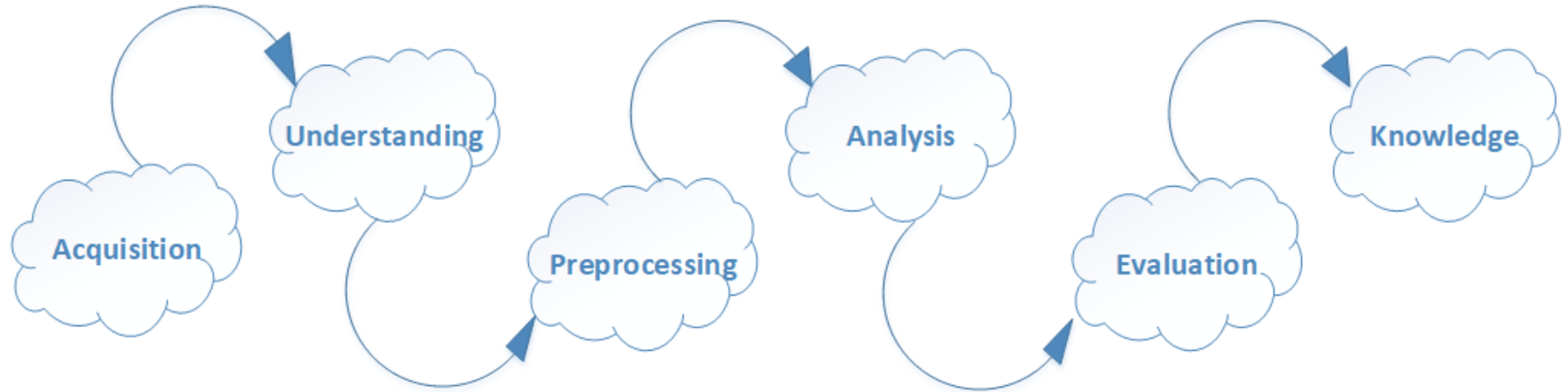
- Plan electricity consumption (e.g. during lectures)
- Choose an optimum tariff
- Use of stored energy
- Forecast production / consumption of electricity

Data science and predictive analytics

- Computer science
- Math & statistics
- Machine learning
- Domain knowledge
- **Predicting the future**

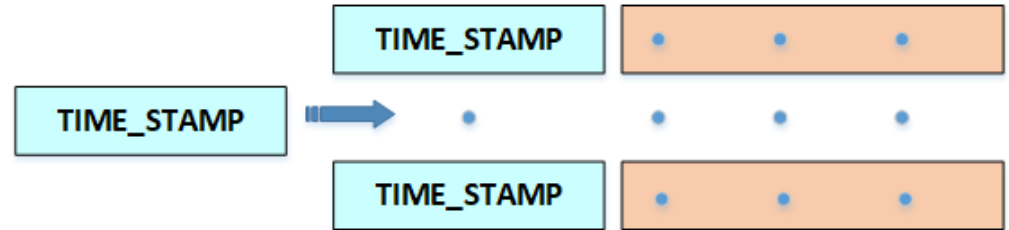


Typical data science workflow



Methodology of data analysis

- Cleaning data
 - Missed time rows
 - Missed values (imputation)
- Dividing data into the subsets
- Choice a time ranges meeting some selected criteria:
 - annual time range
 - semester time range
 - season time range

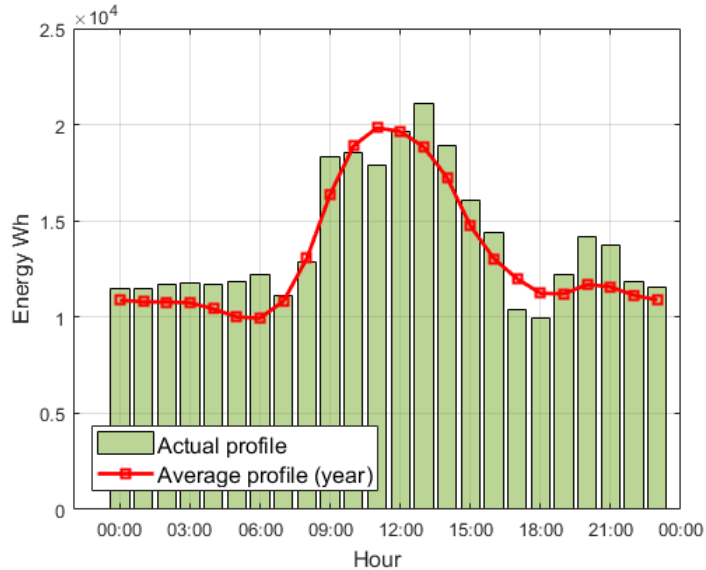


Methodology of data analysis (continued)

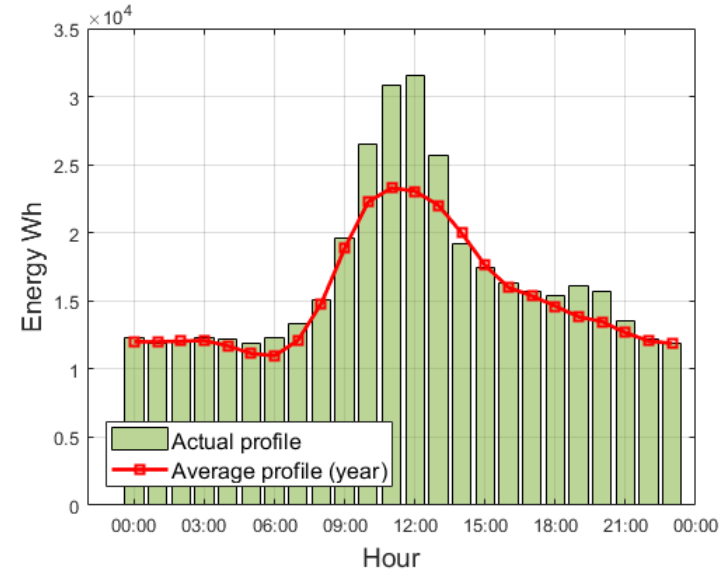
- Applying the 'mean profile' method ('naïve') for prediction of the power consumption profile for a selected day of the week
- Analysis of prediction accuracy

Results of data analysis

Exemplary day profile analysis (annual average: Wednesday 2015, 2016)



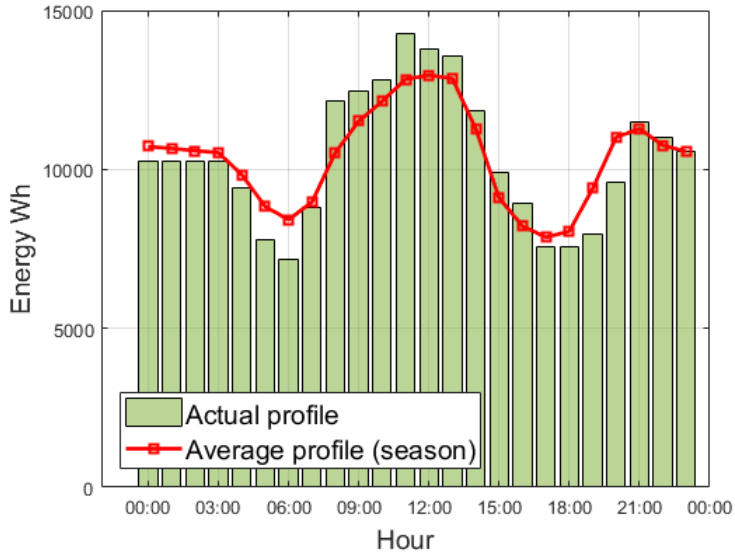
2015



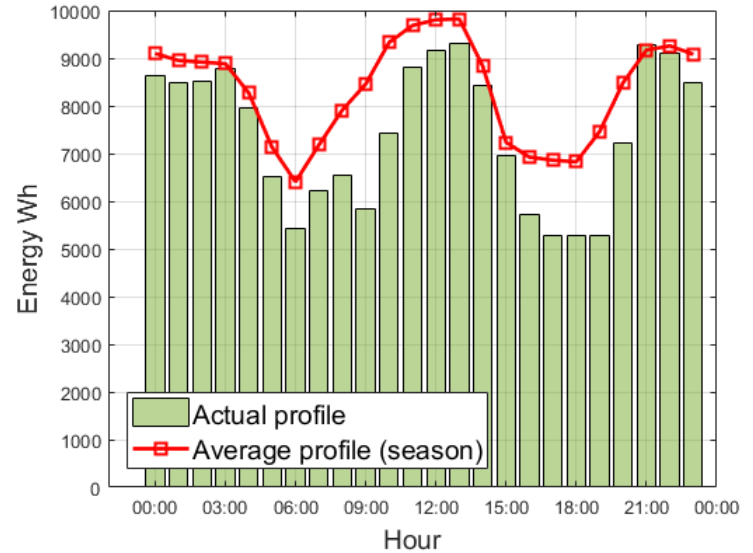
2016

Results of data analysis

Exemplary day profile analysis (season average: Friday)



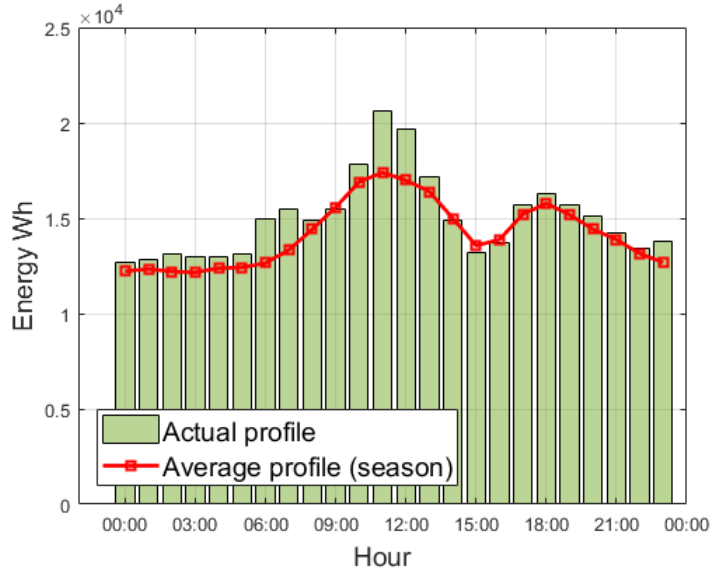
Spring



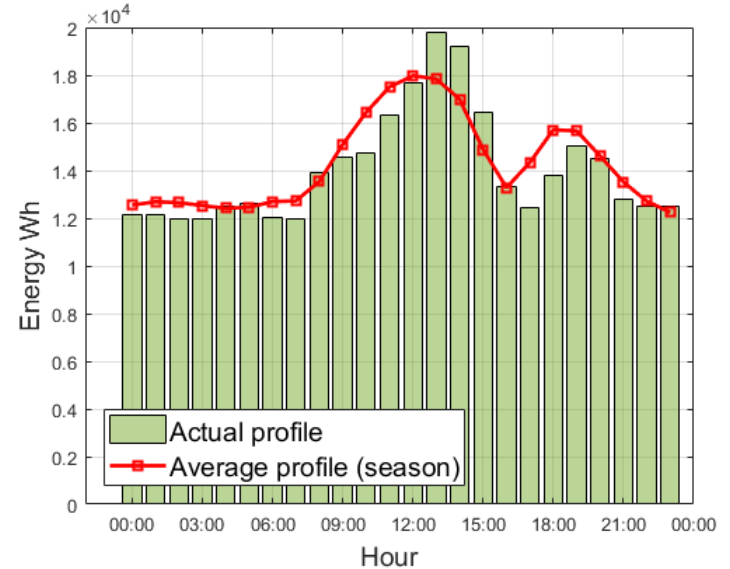
Summer

Results of data analysis

Exemplary day profile analysis (season average: Friday)



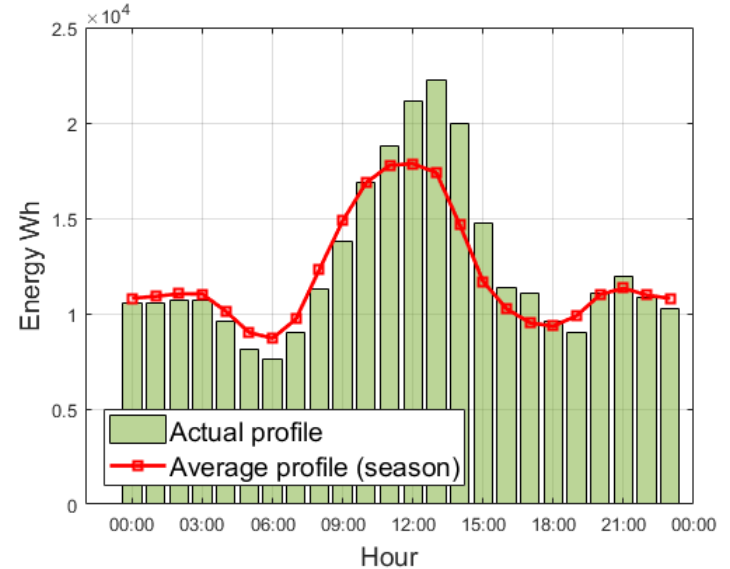
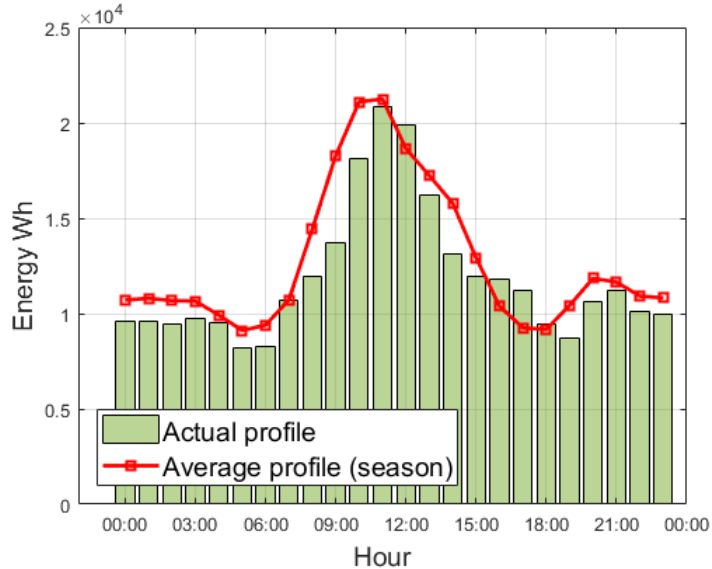
Fall



Winter

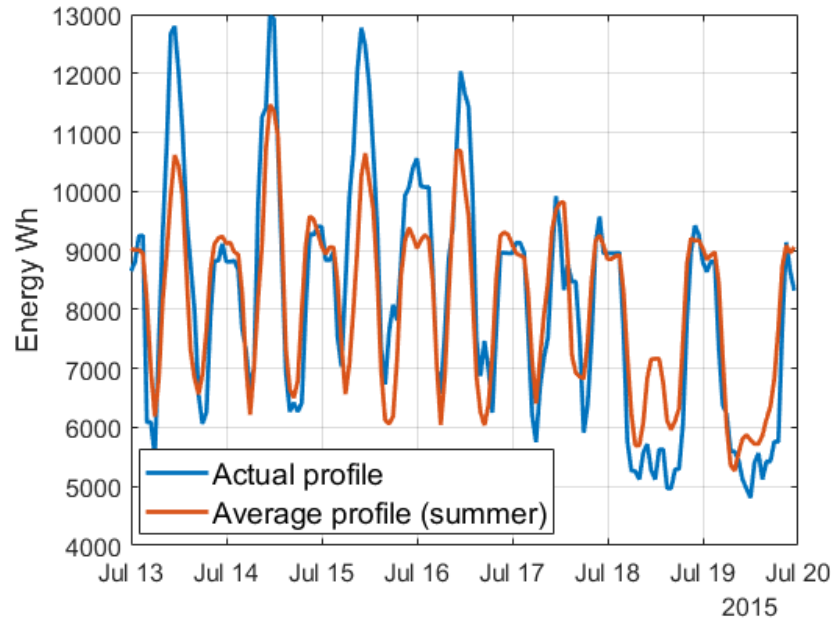
Results of data analysis

Exemplary day profile analysis (season average: spring 2015)



Results of data analysis

Exemplary week profile analysis (season average: 2015)



Conclusions

- Profile analysis has shown that even the naive method gives good results
- This is due to the stability of the electricity consumption of the analyzed object during the considered time periods
- Further research is needed including other prediction and validation models (cross validation, etc.).

Next steps

- Challenge: Incorporation of renewable energy sources and existing energy storage (the analysis covered years where renewables and storage were not included in VPP)
- Challenge: Transfer of analytical algorithms from Matlab to PI Analytics
- Implementation of anomaly detection algorithms (too big or too small consumption) - PI Analytics and PI Notifications

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Questions

Please wait for the **microphone** before asking your questions

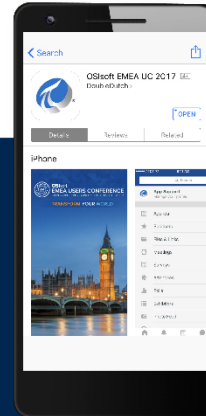


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Danke

谢谢

Merci

Gracias

Thank You

ありがとう

Спасибо

Obrigado

Dziękuję