

# WP 3 – Smart Monitoring of small flow rates: Algorithms for leakage detection

Online, 15.09.2021  
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Metrology for Real-World  
Domestic Water Metering

# Introduction: What is Leakage?

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- Leakage:
  - Outflow from pipes and installations
  - **Unaccounted**
  - **Continuously**
- The higher the flow rate of a leakage event, the faster it may be detected
- Problem is low flow rate leakage

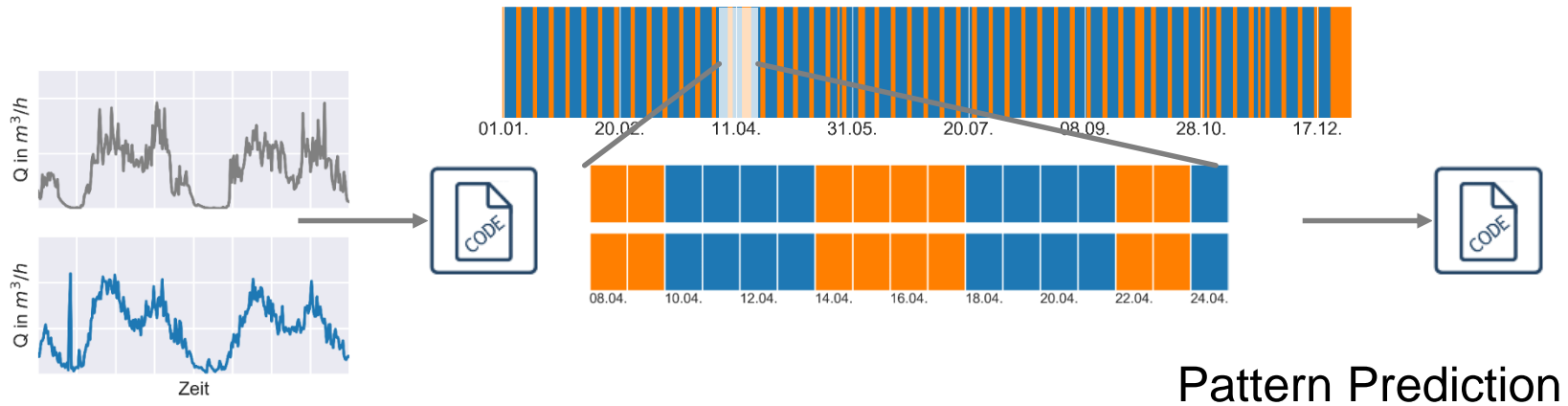
# Possible Algorithms

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- Minimum Night Flow
  - Based on assumption that during night, water consumption is reduced to a minimum (zero on a household level)
  - Additional water consumption could be accounted for as leakage
- Flow Pattern Analysis
  - Flow time series are disaggregated and classified into water consumption usage patterns
  - Events not matching the patterns can be classified as leakage
- Data Driven (Machine Learning) Approaches
  - Calculating/observing the deviation between a forecasted state of water consumption to the actual state, mostly in real time

# Developed Algorithm

- Algorithm derives from detection of water loss in water distribution systems (large scale, multivariate time series)
- Application „downscaled“ to univariate time series



Pattern Recognition

Pattern Prediction

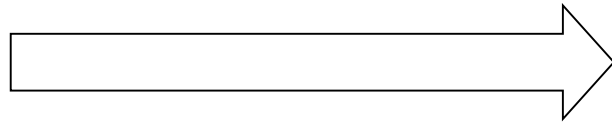
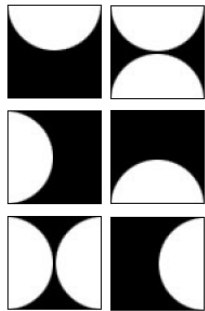
# Pattern Analysis

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- Identification of patterns (data structures) with non-negative matrix factorisation

## Example:

- Problem: find patterns
- Given: complex, component-based „picture“ (data)
- Wanted: identification of building blocks



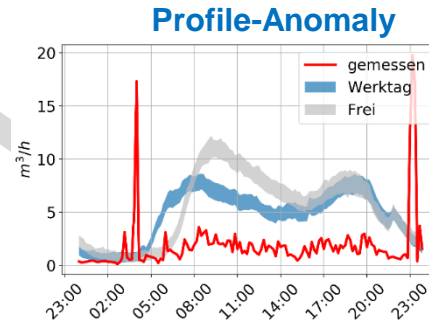
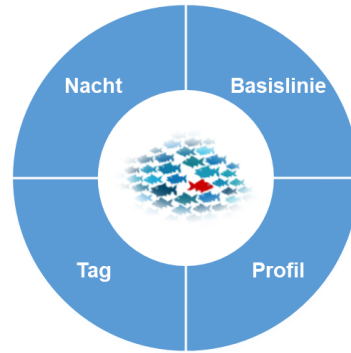
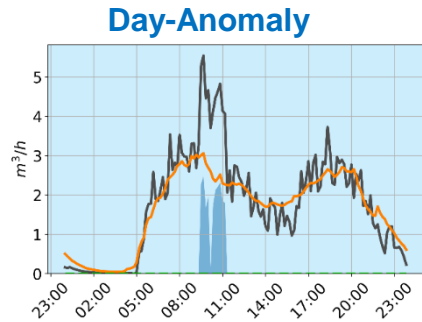
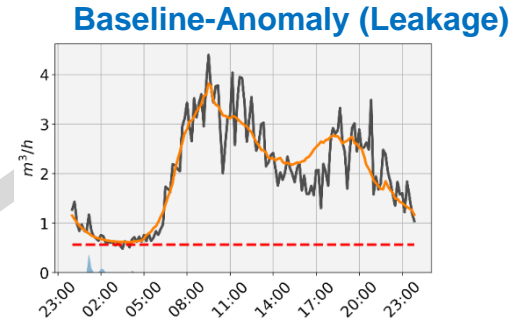
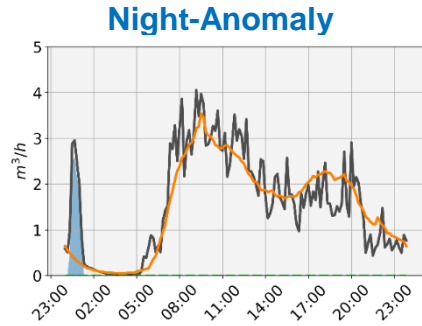
Advantage: mostly there is a “real”  
explanation for the patterns as identified  
patterns should not be negative

# Pattern Prediction

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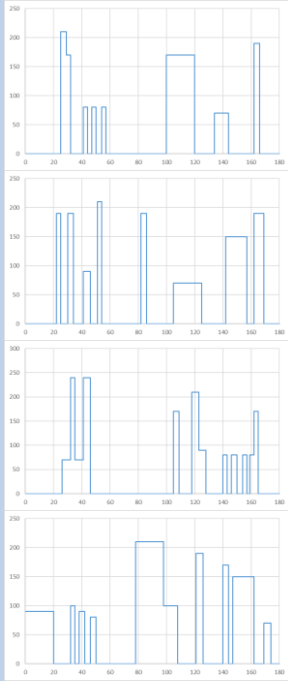
- Identified Patterns will be forecasted by forecasting the single building blocks (resulting from the NMF) and the reconstructing the timeseries
- Forecast is done by simple linear or non-linear regression models

# Leakage Detection



# Creating a database

Generate typical consumption profiles



Generate 365 daily profiles (~ 1 year data)

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Randomly slicing the consumption profiles (30/25/10/35)

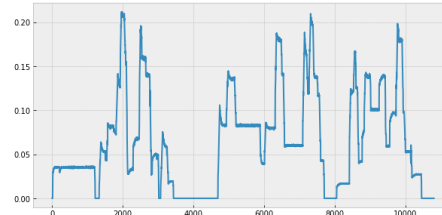
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some consumption peaks (spikes)

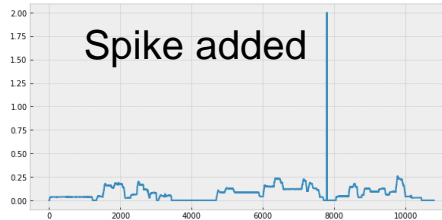
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a towards the end of the year slowly increasing leakage (max. 10 l/h)

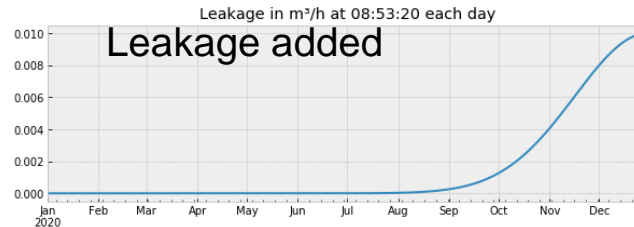
Daily consumption pattern



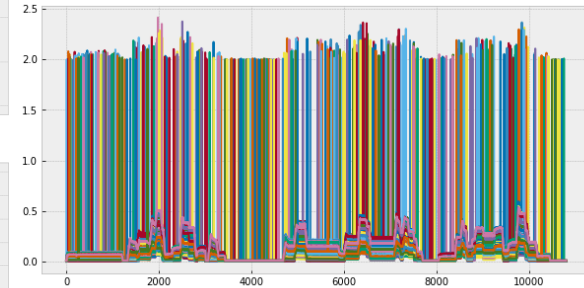
Spike added



Leakage added



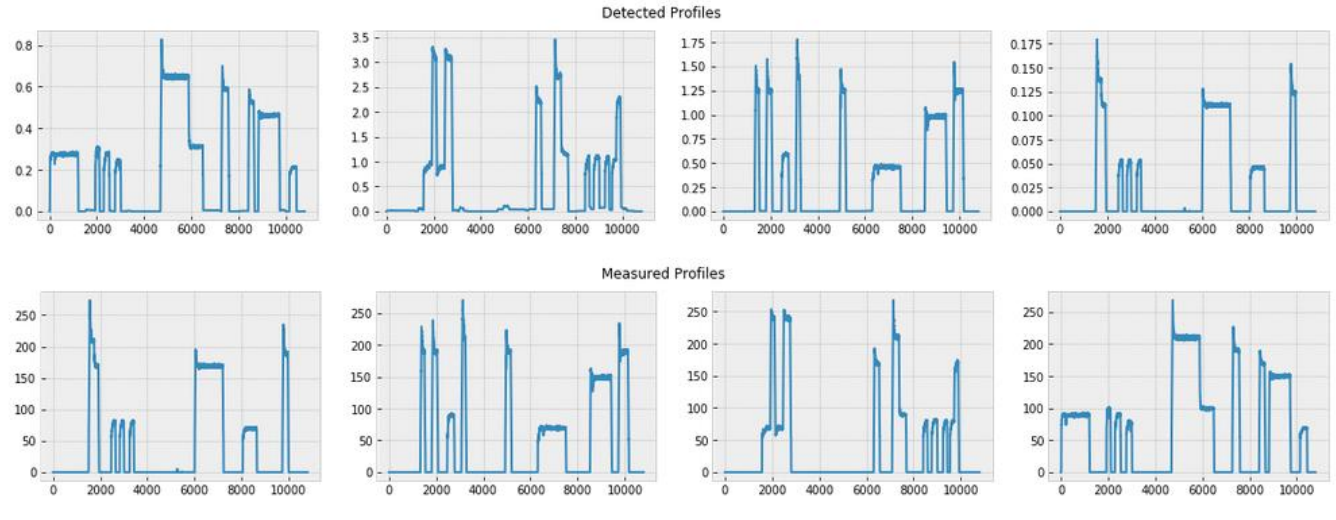
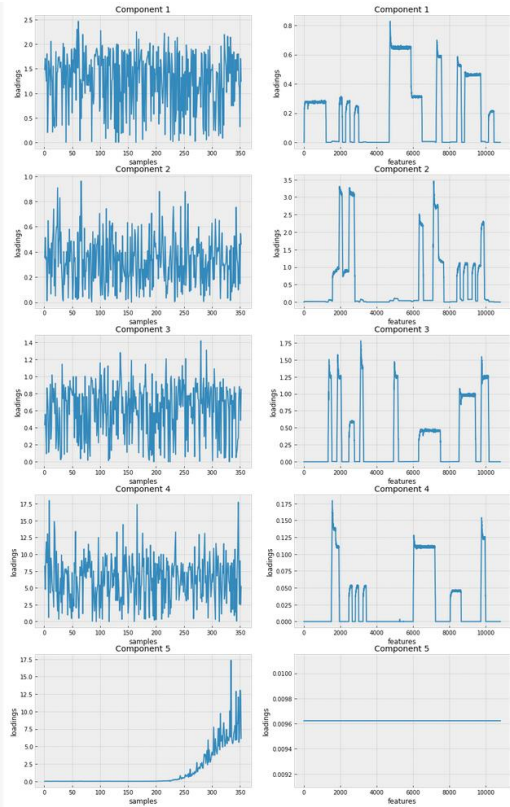
**Result:**  
**All daily patterns**





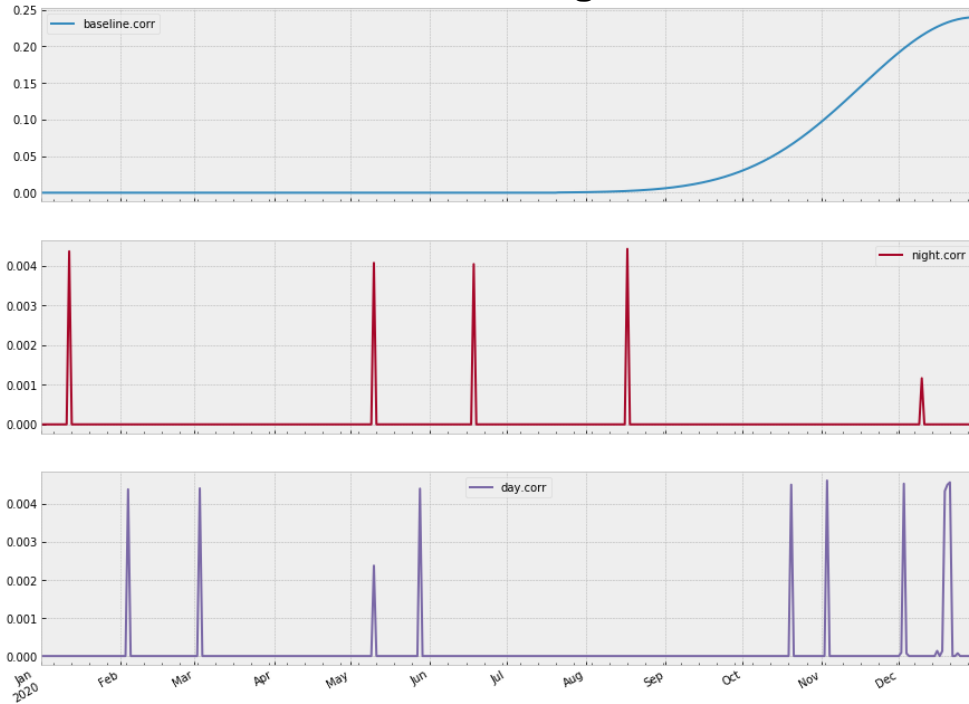
# Results (1)

- The Pattern Recognition detected 5 patterns from our data
- These 5 patterns are basically the 4 water use patterns plus 1 leakage pattern (as described earlier)
- Detected and actually measured profiles match perfectly!

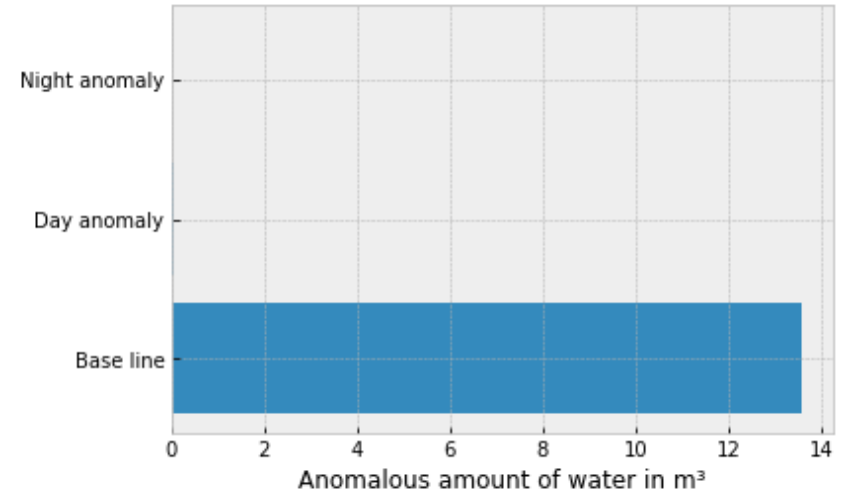


# Results (2)

## Outcome of Algorithm



## Quantification



# Acknowledgements

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The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

*“This project has received funding from the EMPIR programme co-financed by the Participating States and from the European Union’s Horizon 2020 research and innovation programme”*



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