Project C: Data-driven monitoring, prediction and real-time control for the smart grid and its users

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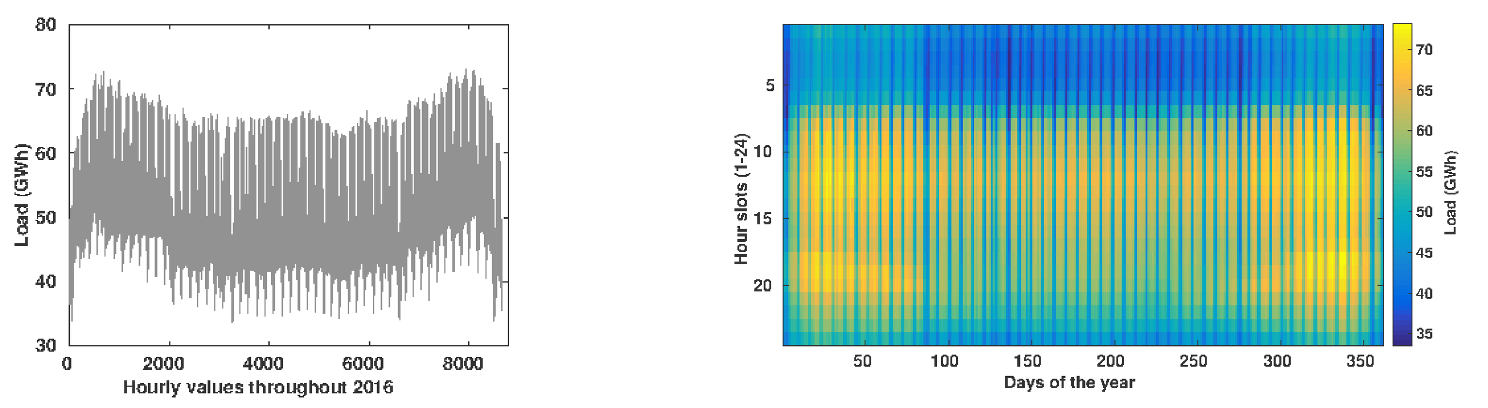
Description of the project

The objective of research project C is to enhance the monitoring and prediction of both prosumer behaviour and the state evolution of the underlying grid within the built environment. It will investigate methods of active computational learning to search large volumes of streaming sensor data for operator-defined events or automatic detection of statistically significant anomalies and develop new mathematical tools and algorithmic techniques for real-time monitoring and control of the smart grid infrastructure.

Outline of the project

WP3.1 User-Centric Sensor Data Mining for Smart Energy Systems:

- Goals
  - Data mining (bottom-up): what patterns and corresponding anomalies can be identified?
  - Searching (top-down): do specific user-defined events occur in data?
- Approaches
  - Recast time series as matrices and use image enhancement and decomposition techniques
  - Investigate the potential of deep learning to identify and extract patterns or events



(a) Time series *(b) The shift in daily patterns*

Figure 1: Total load data for Germany in 2016

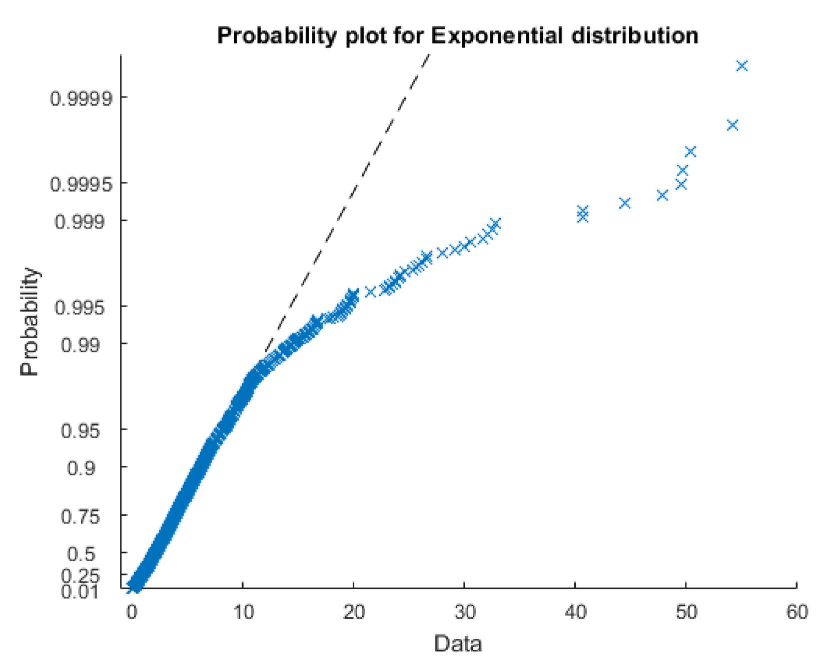


Figure 2: Fitting a exponential distribution to residuals of time series highlights outliers

WP3.2 Algorithms for Distributed Monitoring, Prediction and Control of Smart Grids:

1. Develop advanced mathematical models of the smart grid

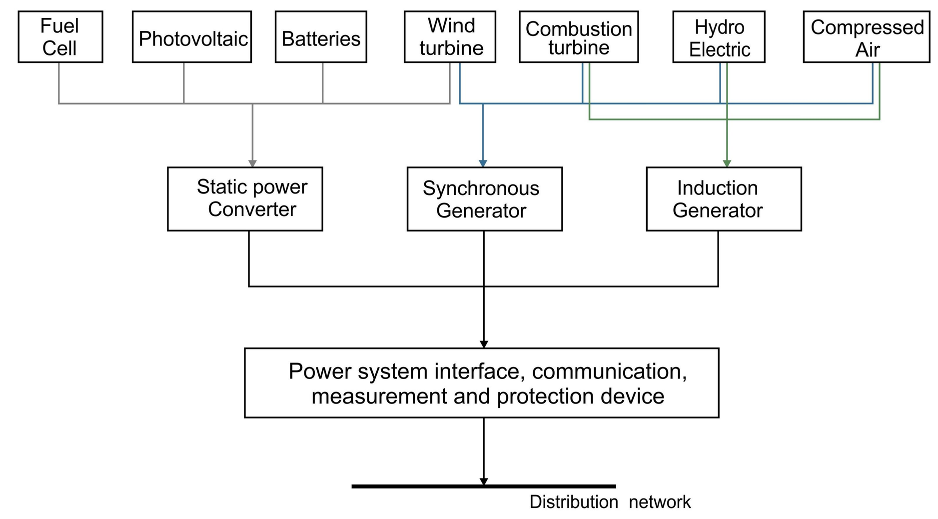
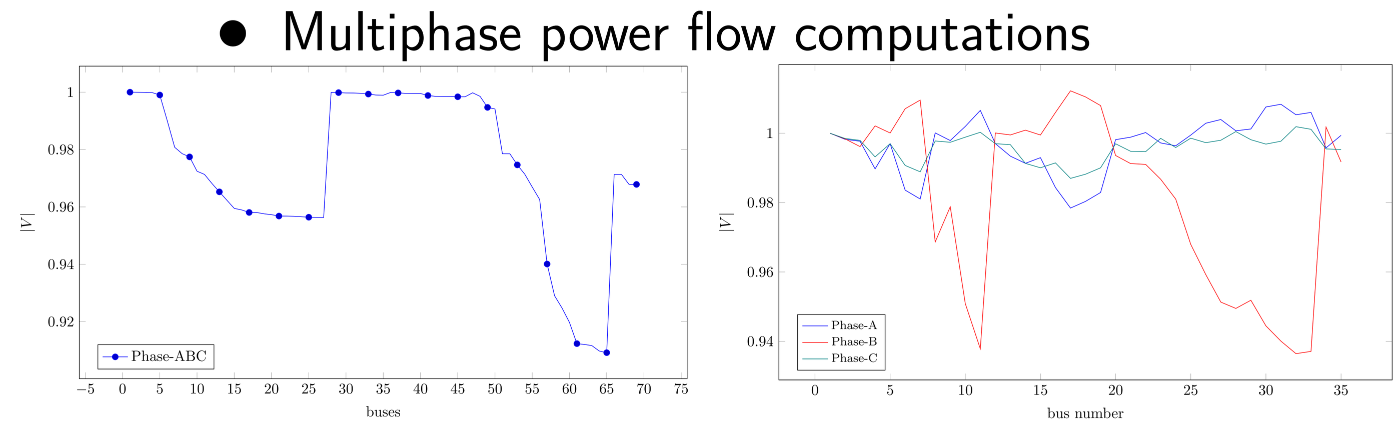


Figure 3: Combination of power converters and energy sources

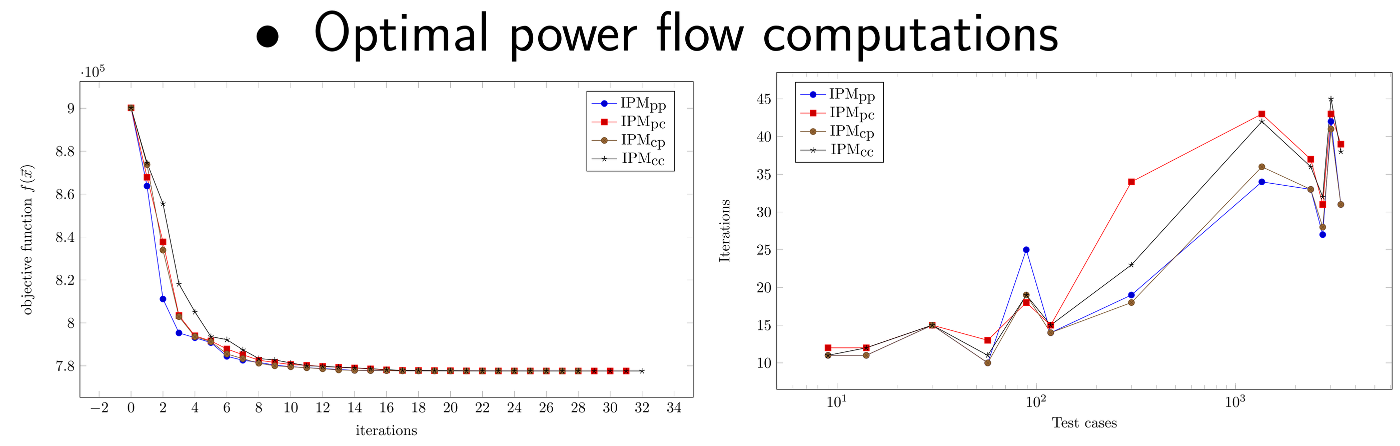
2. Develop real-time, fast and robust solution methods
   - Multiphase power flow computations



(a) Balanced distribution network *(b) Unbalanced distribution network*

Figure 4: Numerical result of the Newton power flow methods

   - Optimal power flow computations



(a) Objective functions vs iterations *(b) Iterations vs different cases*

Figure 5: Numerical result of the Interior Point Methods

3. Implement all solution methods on the modern accelerators like GPU and FPGA

Link between researchers and industry

- Solution methods can be applied by system operators (TSO or DSO) in power system operation, control and planning.
  - Algorithms can optimize the use of Distributed Generations (DGs) and the power supply due to predicted power demand and generation in the future that is obtained by analyzing the measurement data
- Collaboration on data mining, event detection and prediction (a.o VSL, Kropman)