MELONET

Models for EV-charging Load Optimization

(using advanced networking and photovoltaic supply

Sandford Bessler, Jesper Groenbaeck**, FTW**

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Outline

- Motivation
- Project objectives
- System Architecture
- Scenarios and grid data quality
- Evaluation Results
- Concluding Remarks

Motivation

- Grid operators have **little to no knowledge** of the **real load patterns** in low voltage (LV) grids

  → **Now:** use **offline tools** and **standard profiles** (may fit, may not)

- The introduction of **decentralized production** and **new consumption services** challenges LV grids

- Can **smart meters** help gain a better **overview of LV grid events?**

- How **improved LV grid knowledge** can be applied to
  - estimate the availability of grid resources
  - control flexible EV charging loads and PV production

E-Mobility Project **MELONET**

Takes a LV Grid Perspective

Objectives

- Analyze the dynamic interaction between PV and e-mobility in LV grids
- Develop and evaluate solutions for grid-aware charging management
  - Planning of charging tasks
  - Limit PV output
  - Analyze impact of prediction accuracy
- Identify capabilities and limitations of using smart metering for monitoring

Project Partners:

Alcatel Lucent,
KELAG Netz,
FH-Technikum,
FTW Forschungszentrum Telekommunikation Wien

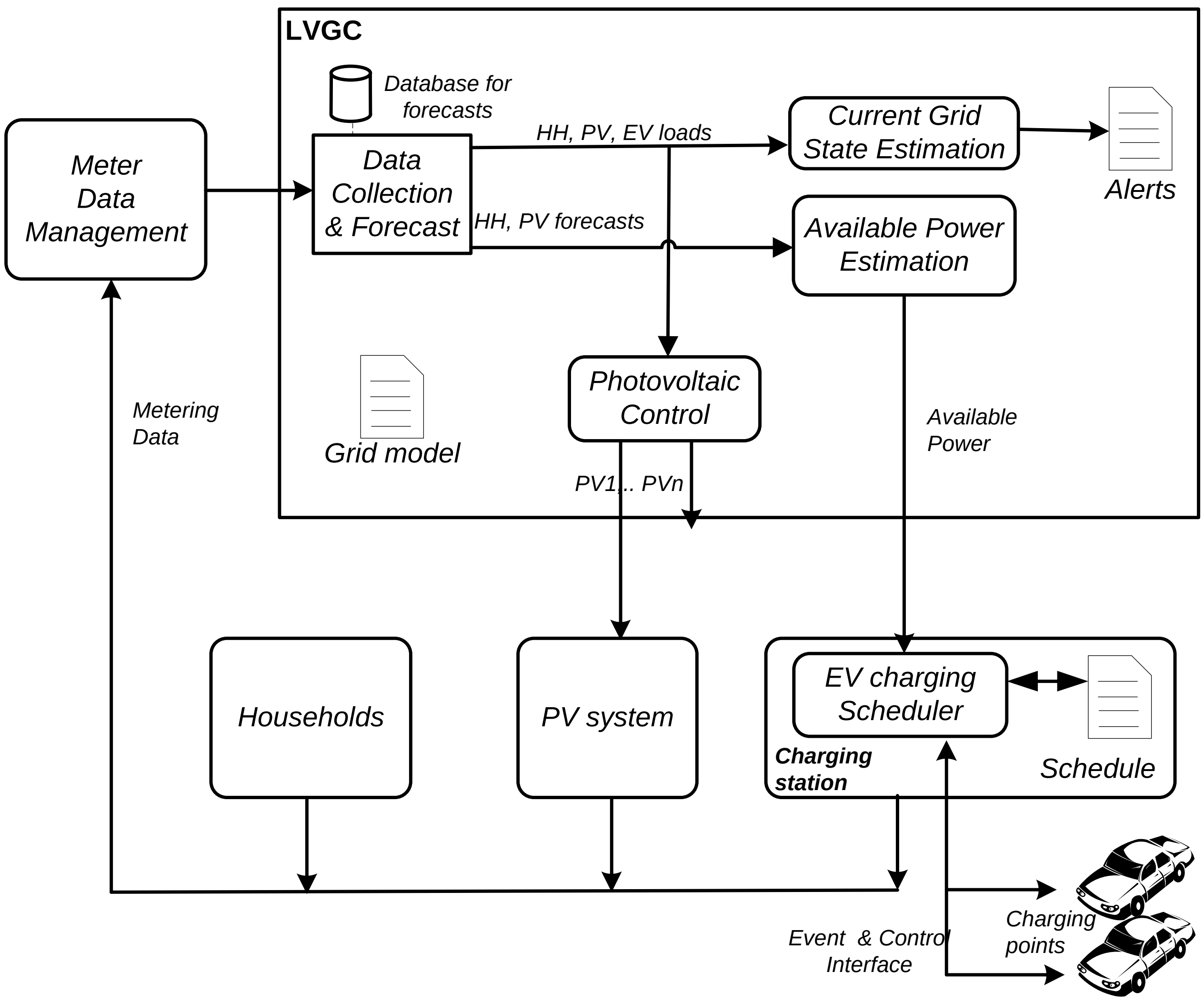
Duration: Jun. 2011- Nov.2012

Work Overview

- Define **data models** for managing PV output, grid system, E-mobility, metering data and control signals.
  - Evaluate differences between **smart meter data** and standard profiles
- Develop grid monitoring and **grid state estimation** in the low voltage grid (near-real time)
- Develop algorithms to **control** the EV charging load and PV output power

- **Evaluation**:
  - Park & Ride, Shopping and Residential Scenarios
  - Real Grid Topology, Meter Data
  - Closed Loop Emulation in MATLAB & Java

High level architecture

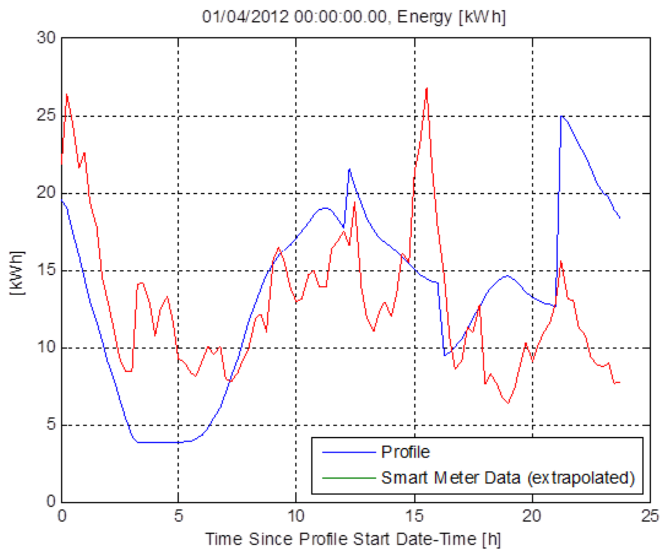


Meter Data Quality

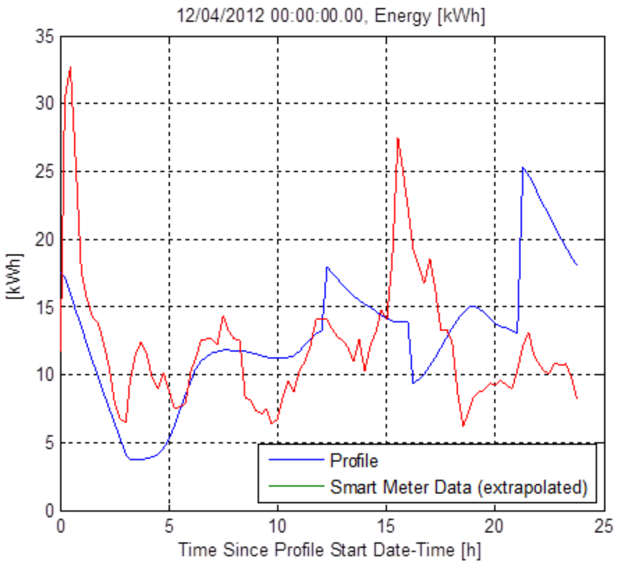
- Created from extrapolation of KELAG smart meter data
  - Extrapolate data from 70 Smart Meters to 253
  - Based on random day profiles sorted according to month and weekday
  - Total consumption adjusted to consumption factors

- **Comparison of std. Profiles & Smart Meter Data**

Sunday



Weekday



Evaluation Overview
Scenarios

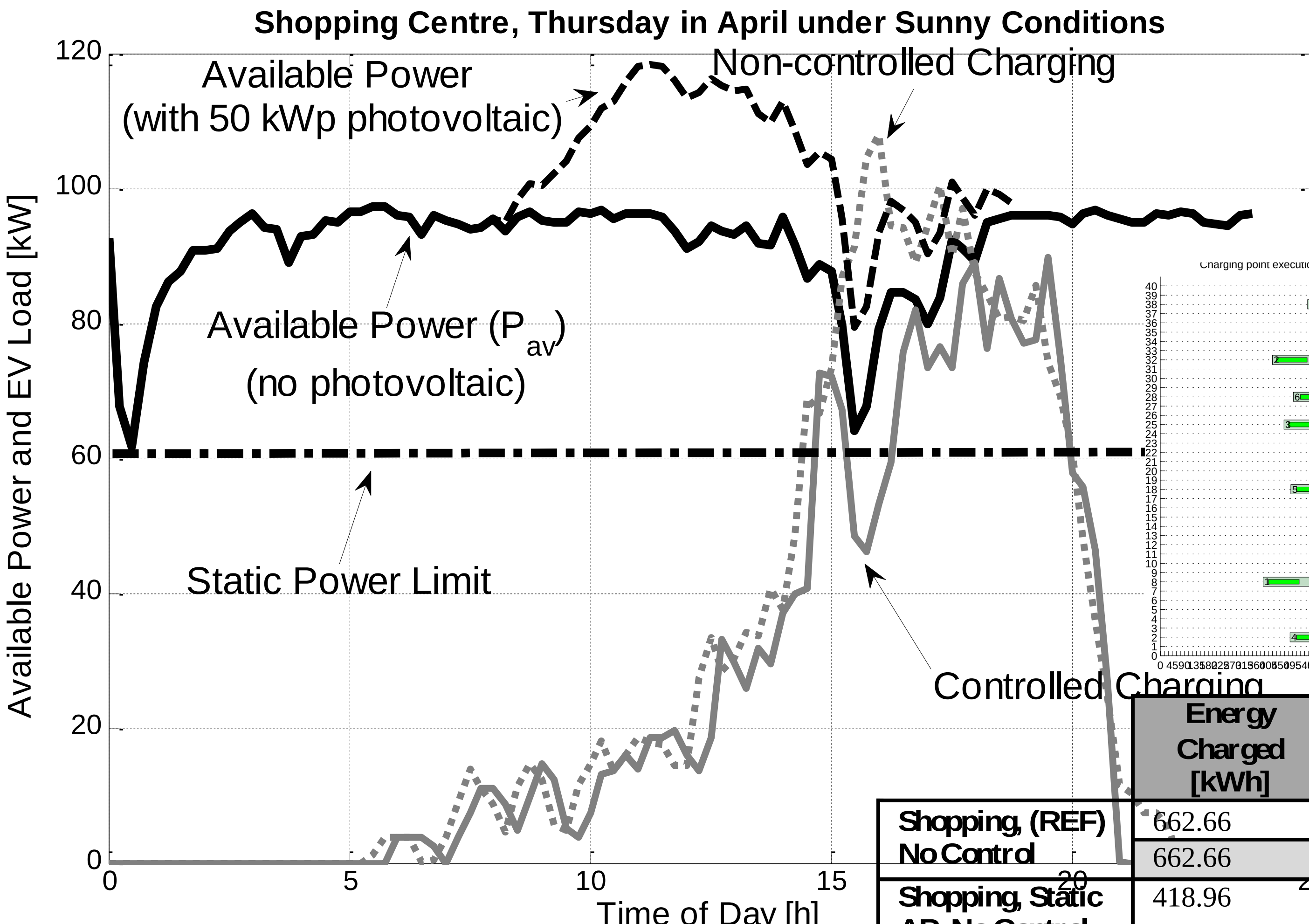
- **Park & Ride**
  - Long stay duration
  - Bursty arrival
  - Planned PV and EV charging deployment

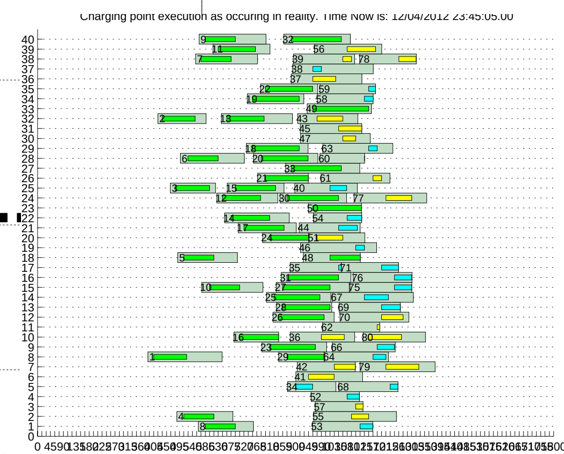
- **Supermarket**
  - Short stay duration
  - Arrivals all day but with busy period
  - Planned PV and EV charging deployment:

    110 EVs are served during the day at 35 charging spots in a Shopping Center, where a 50 kWp PV generation is installed.

- **Residential**
  - Long stay duration (overnight)
  - Arrivals all day but with busy period
  - Evolutionary rollout of PV and EV charging

Evaluation of LV grid control





	Energy Charged [kWh]	Grid Events [#]	Full Charge Fraction [%]
Shopping, (REF)	662.66	35 (UV+OC)	68.2
No Control	662.66	13 (OC)	68.2
Shopping, Static AP, No Control	418.96	0	48.00
Shopping, Dynamic Control	562.61±4.5	0.4±0.8 (OC)	51.00±1.2
	593.55±3.7	0	58.94±1.5

Evaluation results

- **Charging control** significantly **improves** the utilization of grid capacity
  - Maintain close to 0 alarms
  - P&R Scenario
    - 96% of demand while reducing alarms to 0 (44.5% for no control)
    - Dynamic available Power has limited effect due to long stay durations
    - Charging performance : ~1.9x increase in number of charged vehicles, ~2.1x charged energy
  - Shopping Scenario
    - 85% of demand while reducing alarms to 0 (70% for no control)
    - Performance: no. of charged cars (x1.06), more energy (x1.34)
- Effect of **PV generation:** more available power
  - reduces alarms (if on the same bus)
  - Highest improvement in shopping case (15% more cars get full, 5.5% improved capacity)
- **Errors** in the prediction of consumption and production up to 10-20% can be accomodated by robust scheduling.
- EV control can accomodate the increase of **meter sampling period** up to 2h

Concluding remarks

- **The Mellonet LV grid Controller** can provide the operator near real-time information about utilization of grid resources, or overload events, can control EV charging and PV generation .
- Smart metering with sampling rates in **minutes** range is required for control purpose
- Melonet solution **benefits** for Grid Operation & Energy Provisioning
  - Defers grid investments
  - Improves utilization of renewable energy generation with flexible EV prosumers
  - Better data management (comm. + control arch.)
  - Provides “what if” and optimization tools
- **Further work**:
  - Include fast changes in the PV generation in the control loop
  - evaluate and mitigate the impact of **imperfect networks** on distributed control decisions in the grid.

Thank you for your attention !

Contact:

Dr. Sandford Bessler,
Key Researcher, Project Manager

FTW Forschungszentrum
Telekommunikation Wien GmbH

bessler@ftw.at
Tel: +43 1 5052830-43

Dr. Jesper Groenbaek,
Senior Researcher

FTW Forschungszentrum
Telekommunikation Wien GmbH

groenbaek@ftw.at
Tel: +43 1 5052830-43