

Optimized charging of electrical vehicles based on the Day-Ahead Auction and continuous Intraday market

2nd E-Mobility Power System Integration Symposium

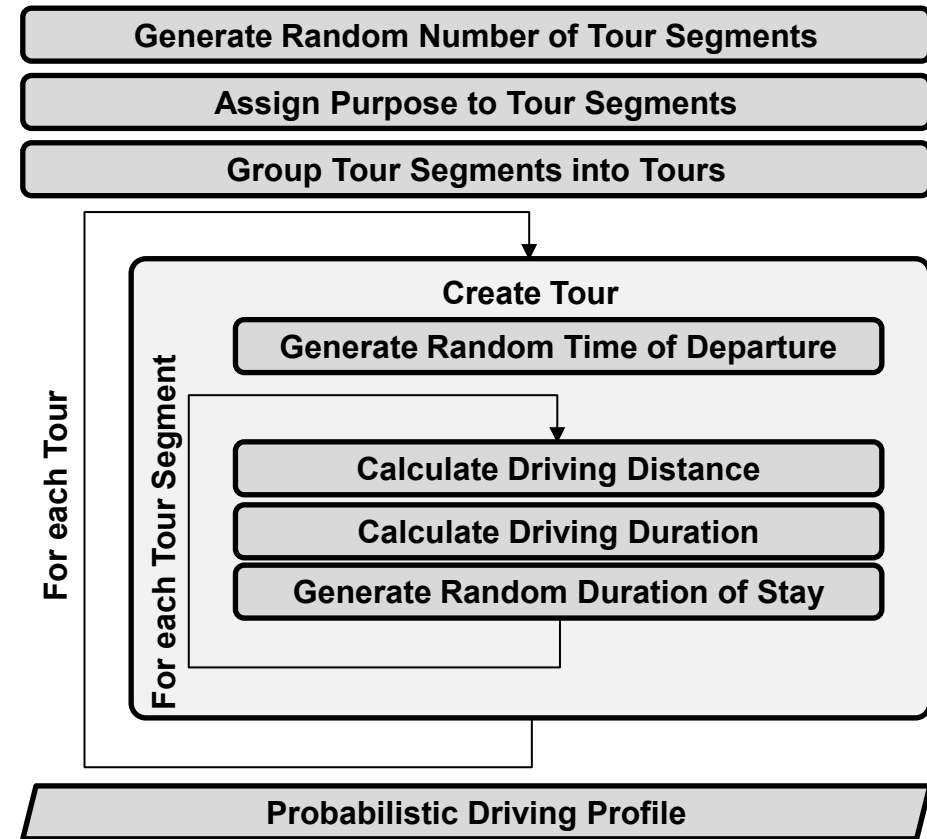
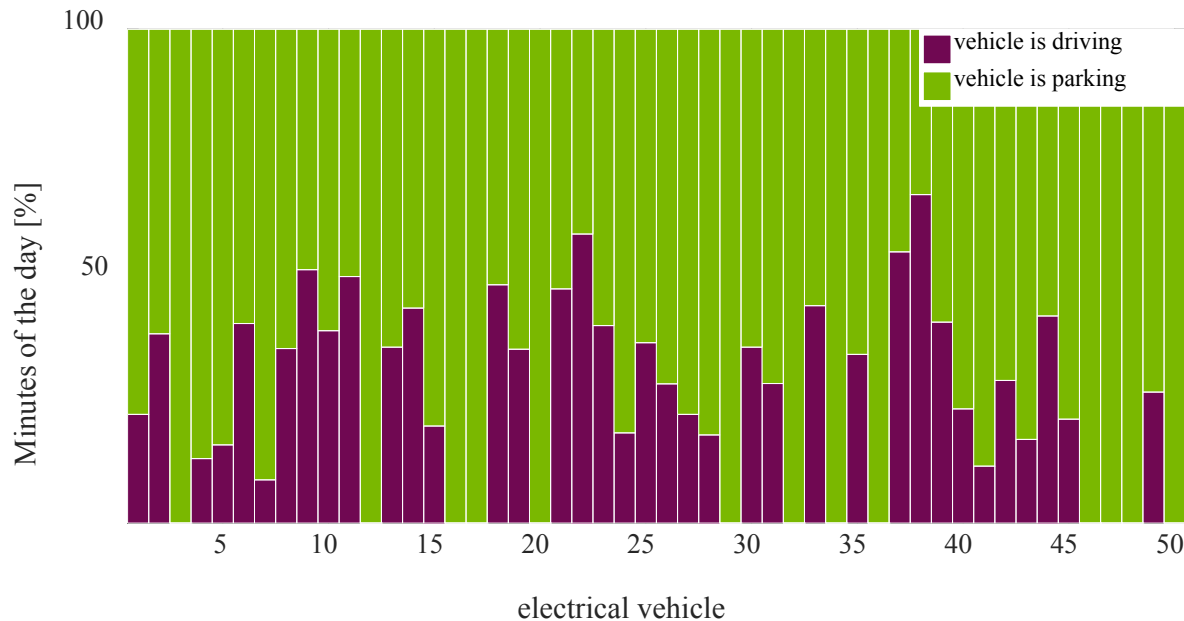
15 October 2018

Agenda

- Charging Flexibility
- Day-Ahead Auction & Continuous Intraday market
- Optimization model
- Case Study

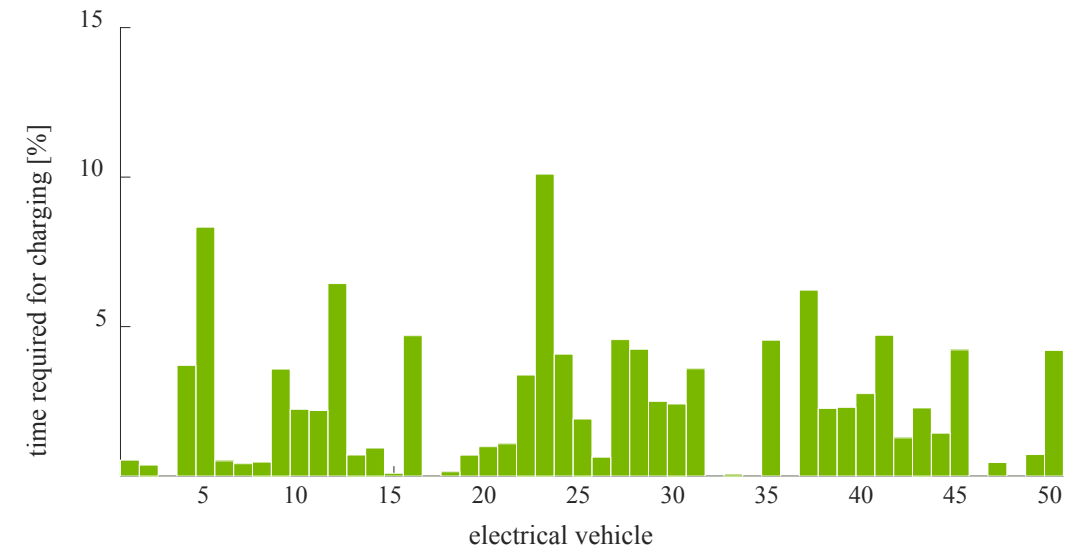
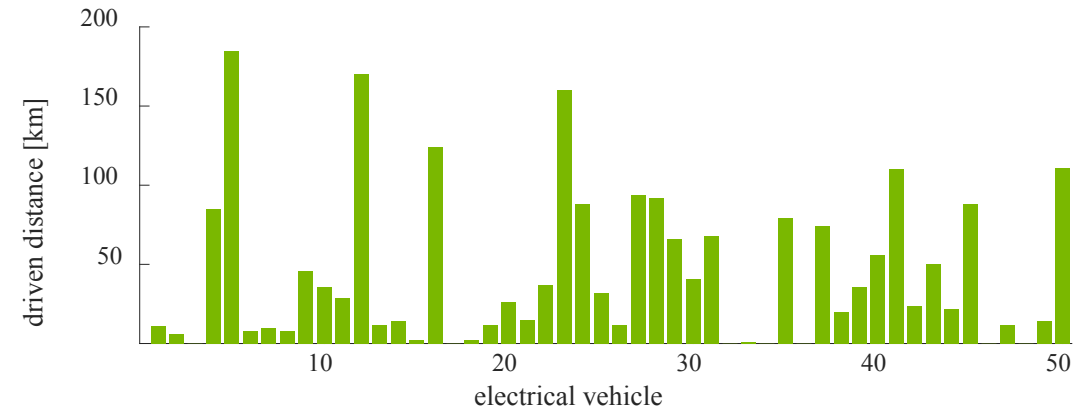
Charging Flexibility

- Simulation framework generates probabilistic driving profiles based on real mobility data



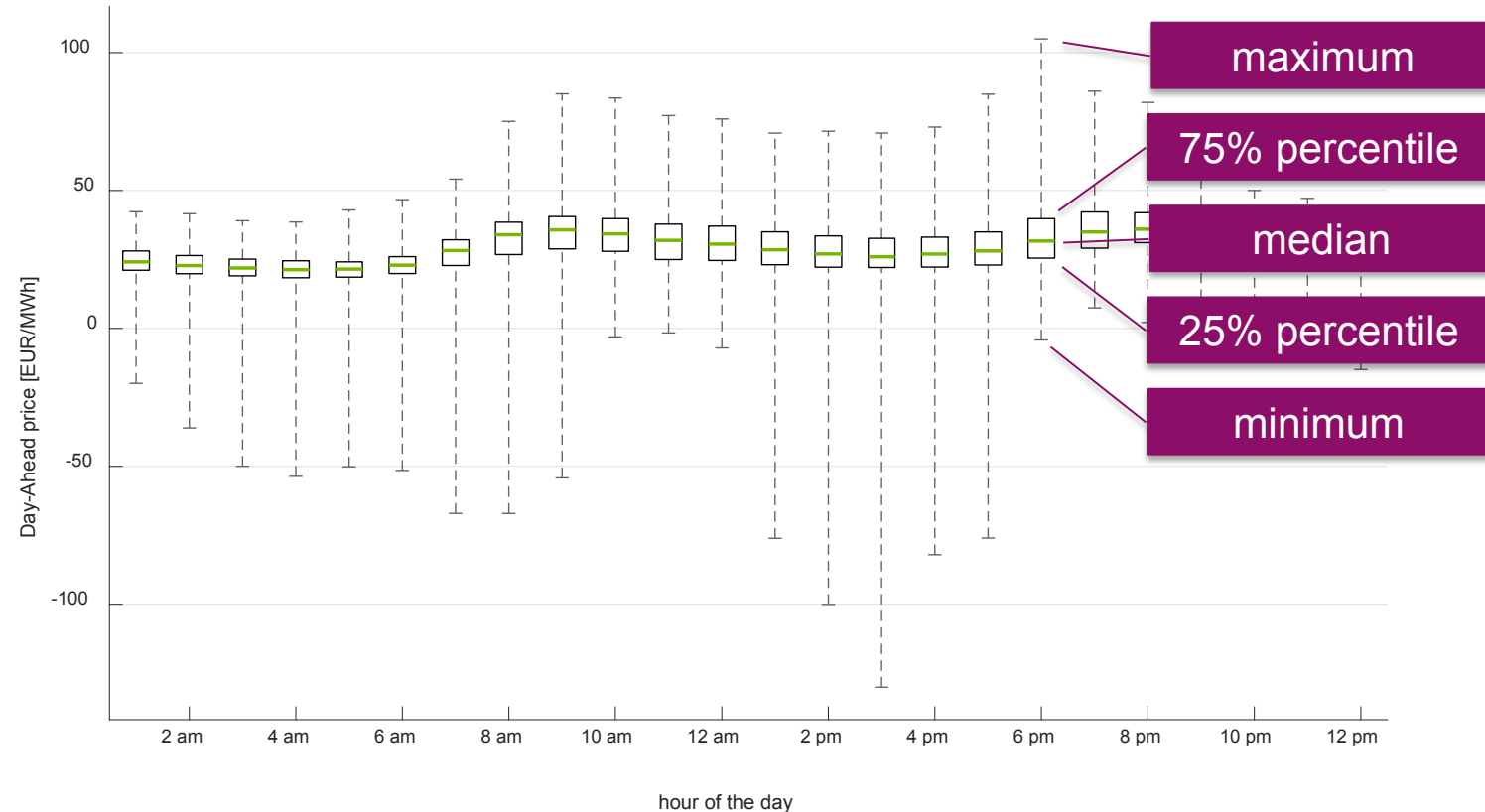
Charging Flexibility – Simulation results

- Yearly driving profiles of 50 cars
- Mean driving distance: 43.76 km/day
- Charging power: 22 kW
- Mean 2.25% (10.1% max.) of the parking time is required for charging
- Huge charging flexibility enables shifting the charging process in time



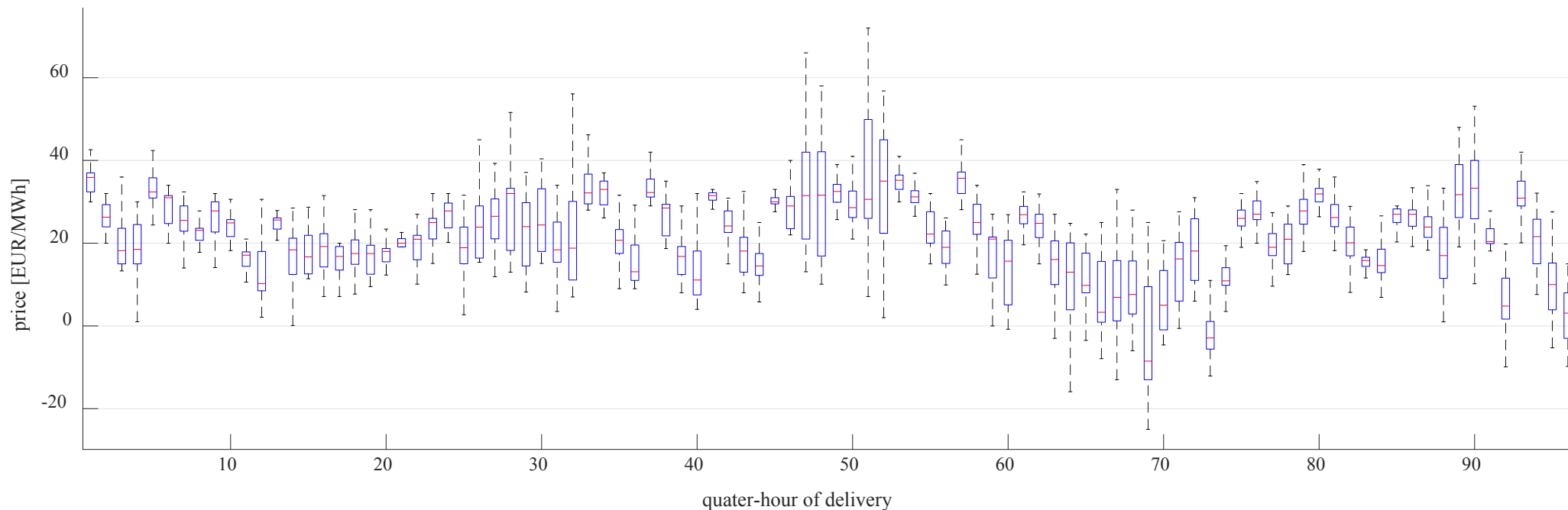
Day-Ahead Auction

- Daily auction at 12 pm
- Max: 104.96 €/MWh
Min: -130.09 €/MWh
- Great liquidity
but no big spreads



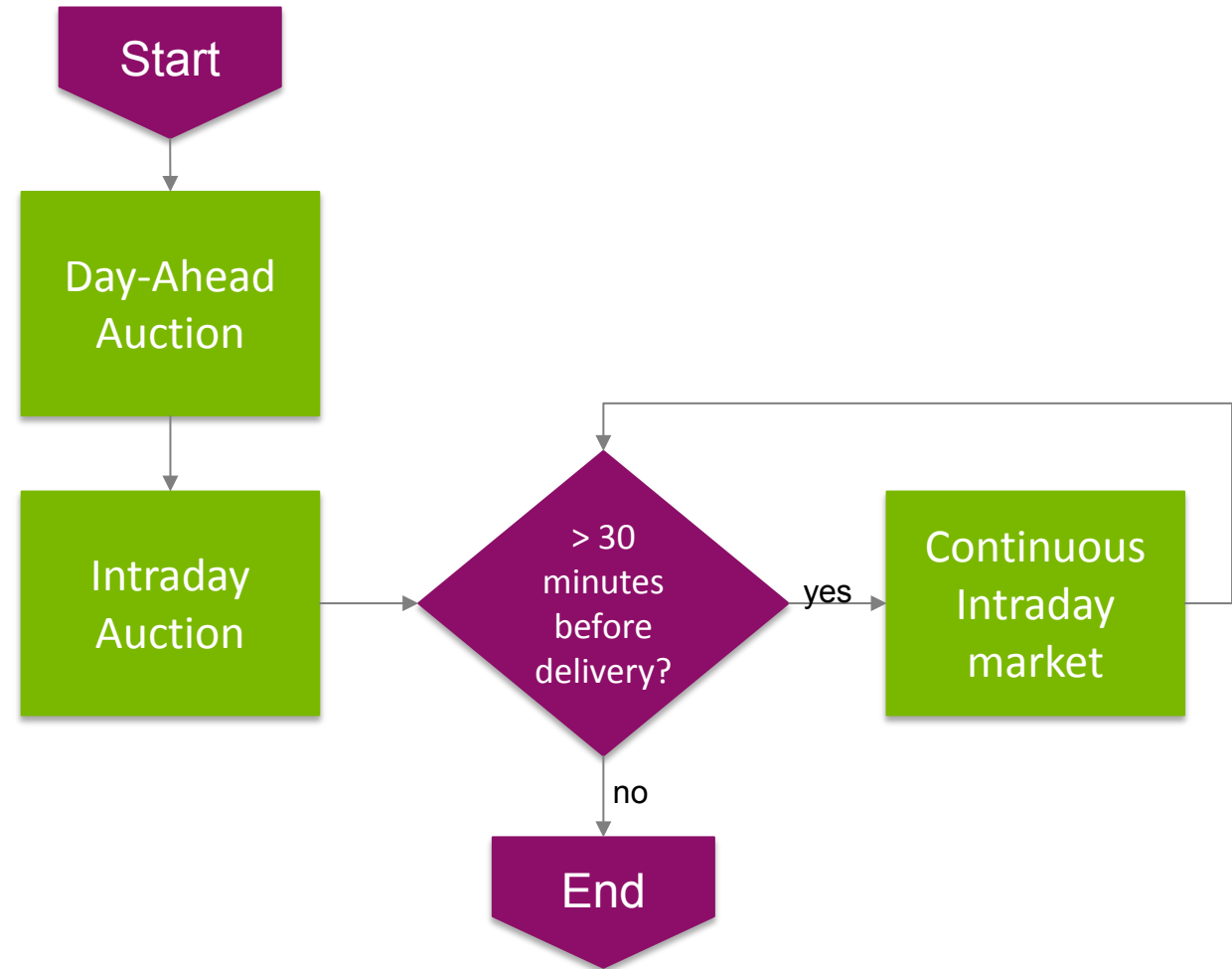
Continuous Intraday market

- Trading is possible from 4 pm at the day before until 30 minutes before delivery
- 60 minute and 15 minute-products
- Bigger spreads as the Day-Ahead Auction



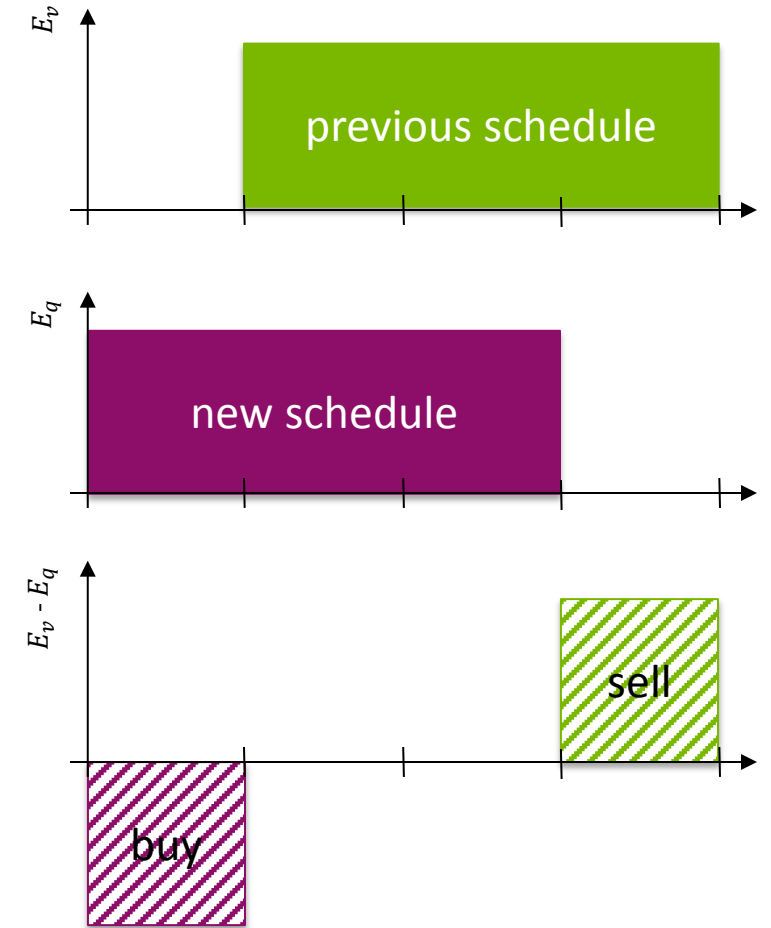
Combination of Day-Ahead and Continuous Intraday

- Whole energy will be purchased at the Day-Ahead Auction
- First savings and structuring to 15-minutes interval at the Intraday Auction
- Redispatch at continuous Intraday market is carried out periodically



Intraday Redispatch

- Optimization Objective Day Ahead:
Minimize the total costs regarding all constraints
- New prices of the Intraday Auction or Continuous Intraday market may lead to a new schedule
- Optimization Objective Intraday:
Maximize the difference between buy and sell

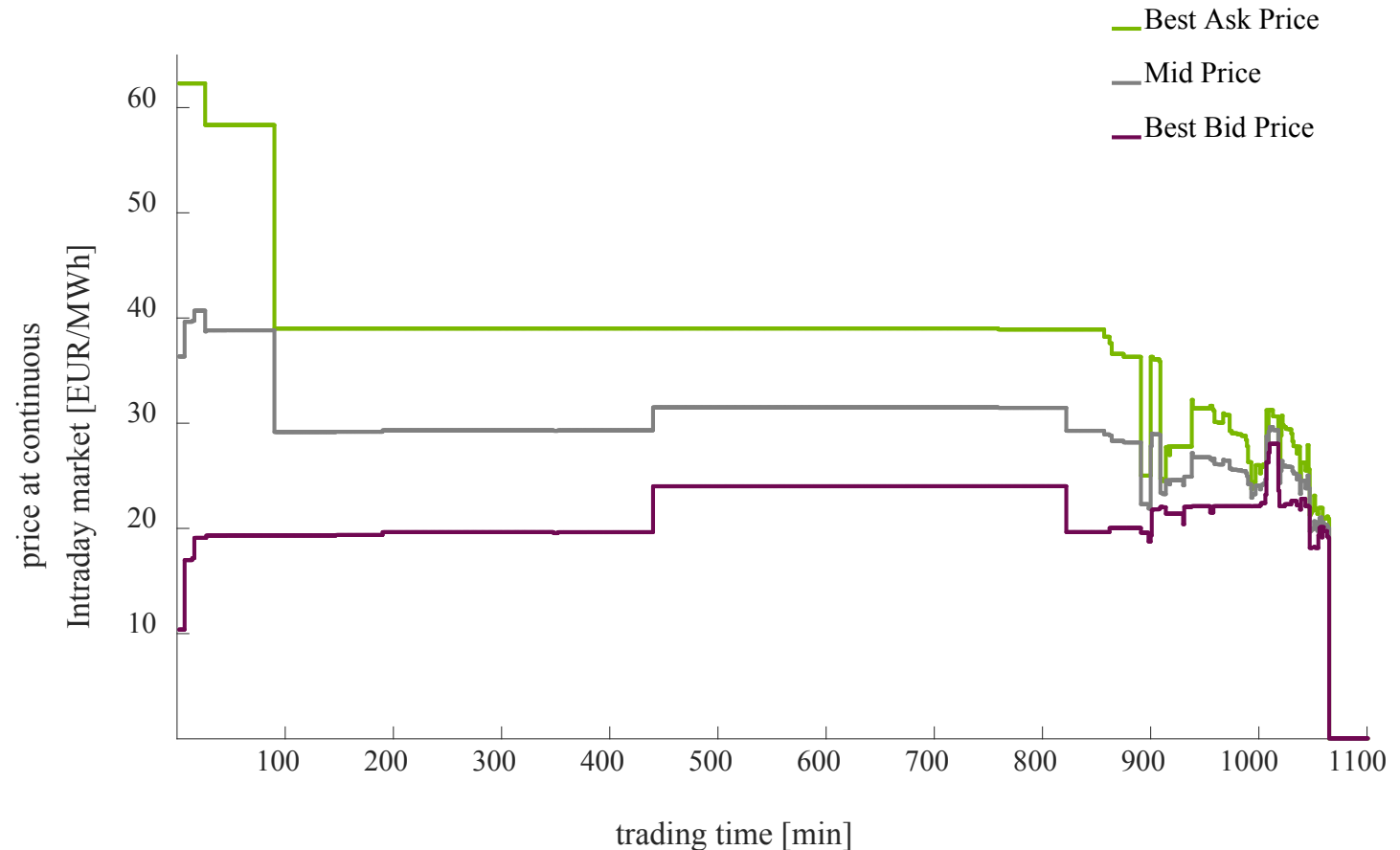


Optimization model

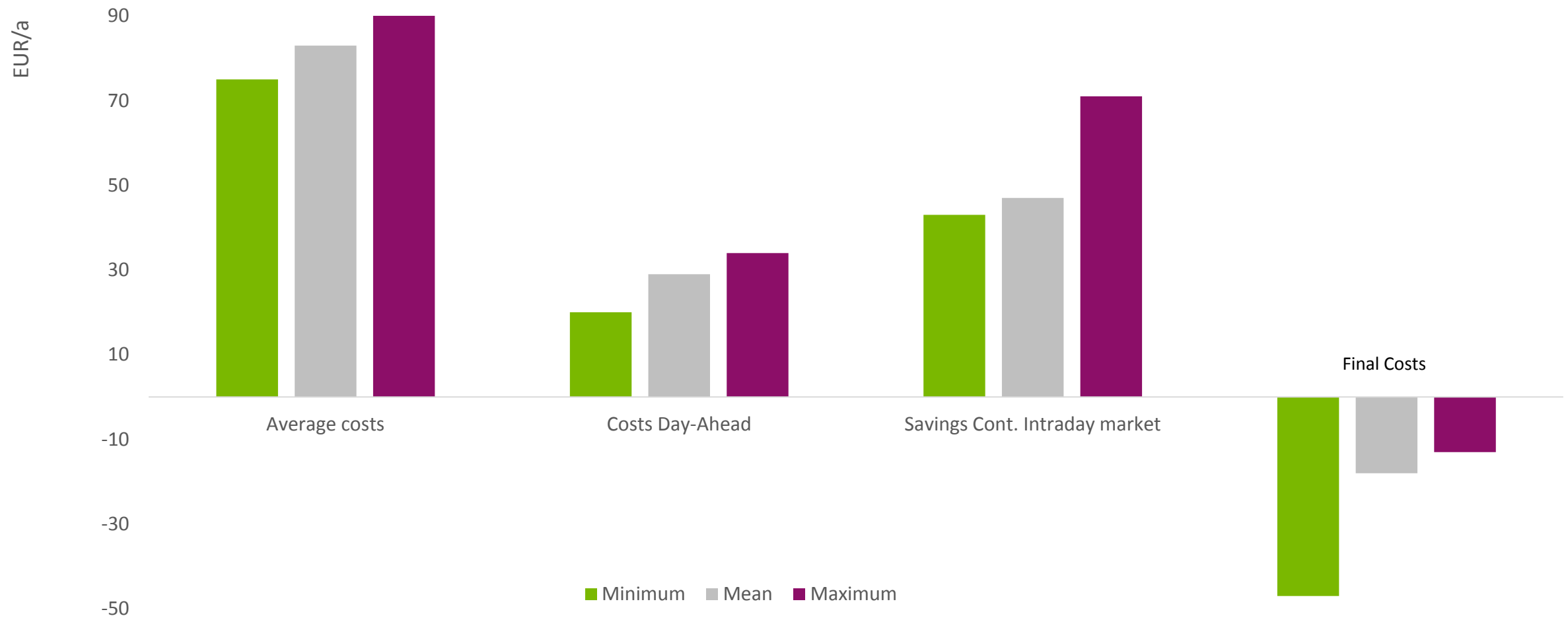
- Mixed-Integer Linear Optimization Problem based on a model of every single vehicle (with individual mobility requirements)
- 1-Minute Resolution for the Simulation offers:
 - Precise simulation of the charging process
 - Possibility to regard effects on the distribution grid (including power limits)
- Trades aggregated to 15-Minutes resolution
- Modeled in Matlab with YALMIP, solved by Gurobi

Case Study – General conditions

- 50 electrical vehicles
- Perfect foresight assumption for mobility requirements
- Vehicle is plugged in after each journey
- One year simulation with 2016 prices
- Continuous Intraday market with 15-minute average prices for each trading interval



Case Study - Results



Summary and Conclusion

- The charging process of electrical vehicles offers huge flexibility
- Charging can be shifted in time without restrictions for the user
- Combination of Day-Ahead Auction and Intraday Market yields to great savings
- Dynamic Charging Tariffs animate vehicle's users to offer their flexibility



This work was supported by the European Union under the grant EU-1-1-007A within the EFRE program "European Regional Development Fund – an investment in our future".



Bergische Universität Wuppertal
Lehrstuhl für Elektrische Energieversorgungstechnik

Jan Meese, M. Sc.

Rainer Gruenter-Str. 21
42119 Wuppertal / Germany
meese@uni-wuppertel.de
www.evt.uni-wuppertal.de