ETIP SNET
South-Eastern Region Workshop

Hrvoje Pandžić
Faculty of Electrical Engineering and Computing
University of Zagreb (FER)

FER, Zagreb, September 20, 2018

About uGRIP

- H2020 ERA Net Smart Grids + project
- Project budget 1.117 M Eur, funding 776 k Eur
- Project partners:
  - FER
  - DTU
  - OFFIS
- Associate partners:
  - Končar KET
  - HEP

Smart Grids Plus ERA-Net

FER University of Zagreb Faculty of Electrical Engineering and Computing

DTU Technical University of Denmark

OFFIS Institute for Information Technology

KONČAR Končar - Power Plant and Electric Traction Engineering Inc.

HEP d.d.

About uGRIP

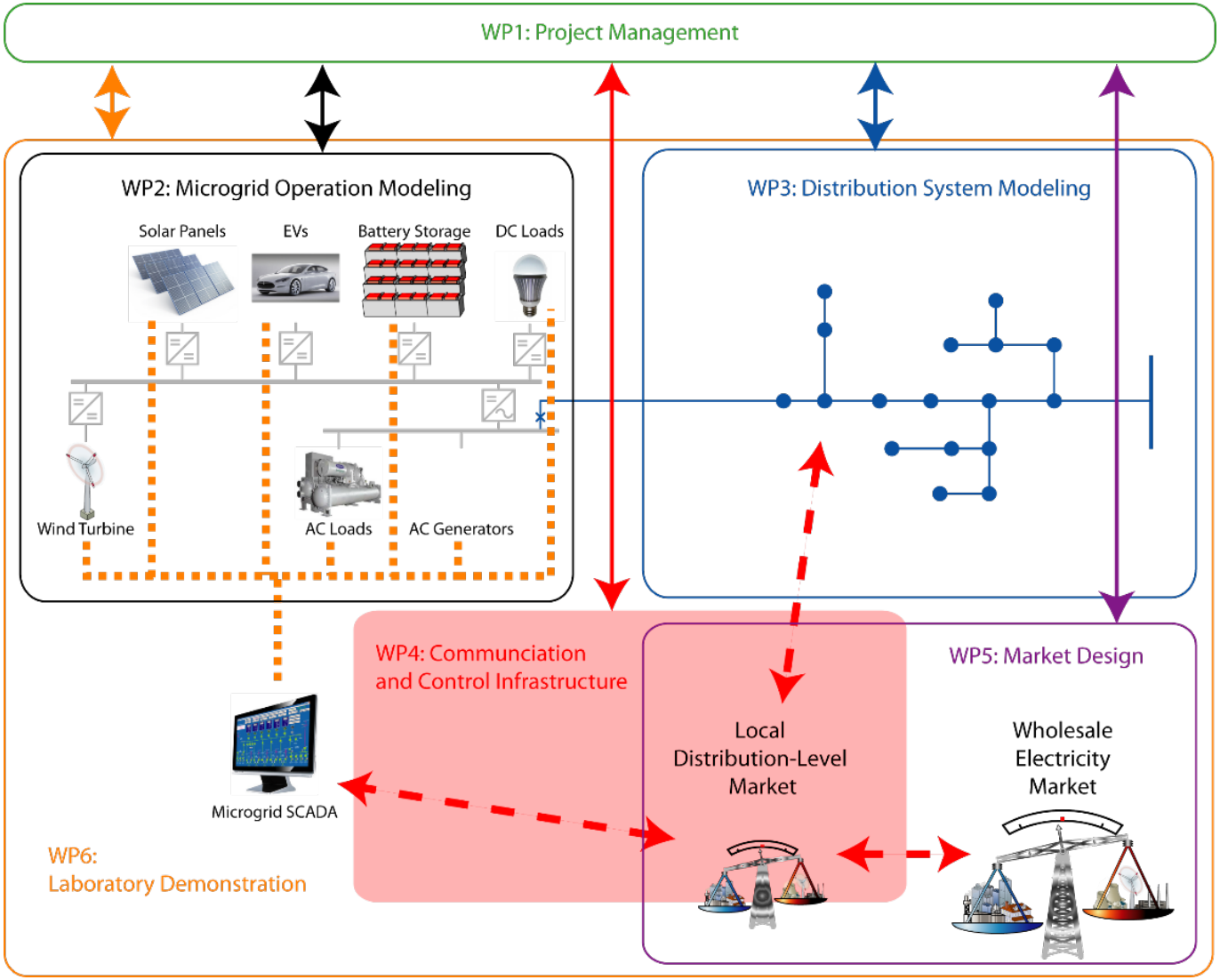
- Funded by:
  - FER
  - Croatian Environmental Protection and Energy Efficiency
  - Končar KET
  - HEP
- April 2016 – March 2019

FER UNIVERSITY OF ZAGREB FACULTY OF ELECTRICAL ENGINEERING AND COMPUTING
KONČAR Končar - Power Plant and Electric Traction Engineering Inc.
HEP d.d.
FOND ZA ZAŠTITU OKOLIŠA I ENERGETSKU UČINKOVITOST

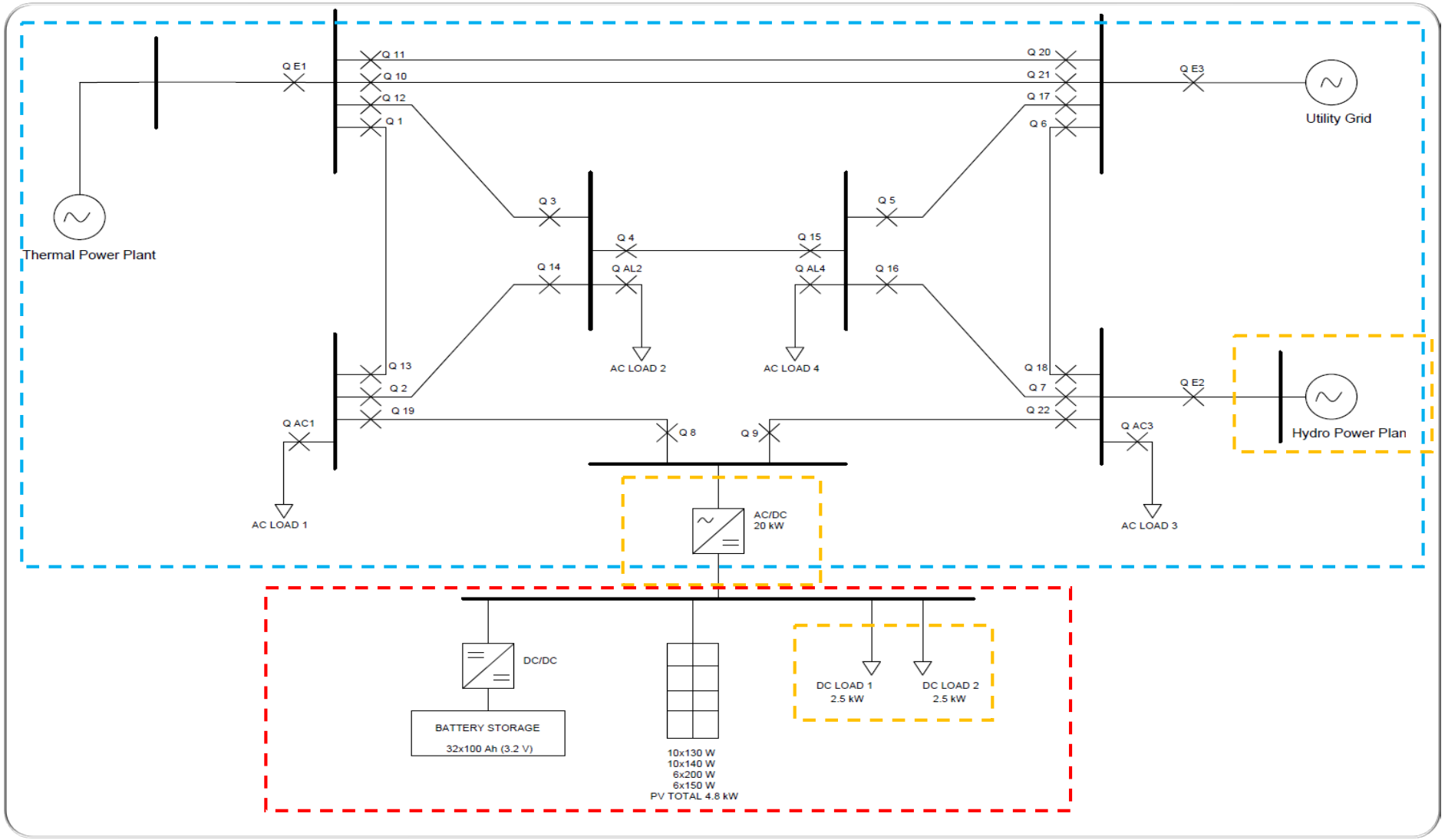
Objectives of uGRIP

- Assessment of the role of storage and the price responsiveness on the consumer side
- Assessment of microgrid business cases for different countries, i.e. Croatia, Denmark and Germany, based on their respective grid codes and incentive policies
- Development and definition of standardized communication protocols between the microgrid elements and the central computer in charge of the microgrid operation, as well as the microgrid and local (distribution level) electricity markets
- Design and development of a local market to manage the microgrid at the FER-UNIZG laboratory

Structure of uGRIP



Structure of Smart Grid Lab



Hydro Power Plant Model

AC/DC Converter

- Professional controllable bidirectional converter made by Swiss company Regatron
- Specifications:
  - Rated lineside AC voltage:
    400 V, 50 Hz, three-phase
  - Power span on the DC side:
    0-20 kW
  - Voltage span on the DC side:
    0-400 V
  - Current span on the DC side:
    0-63 A

DC Loads

- Professional controllable DC electronic load made by German company Elektro-Automatik
- Specifications:
  - AC mains supply voltage:
    90-264 V, 45-65 Hz, single-phase
  - Power span on the DC side:
    0-2.4 kW
  - Voltage span on the DC side:
    0-400 V
  - Current span on the DC side:
    0-50 A

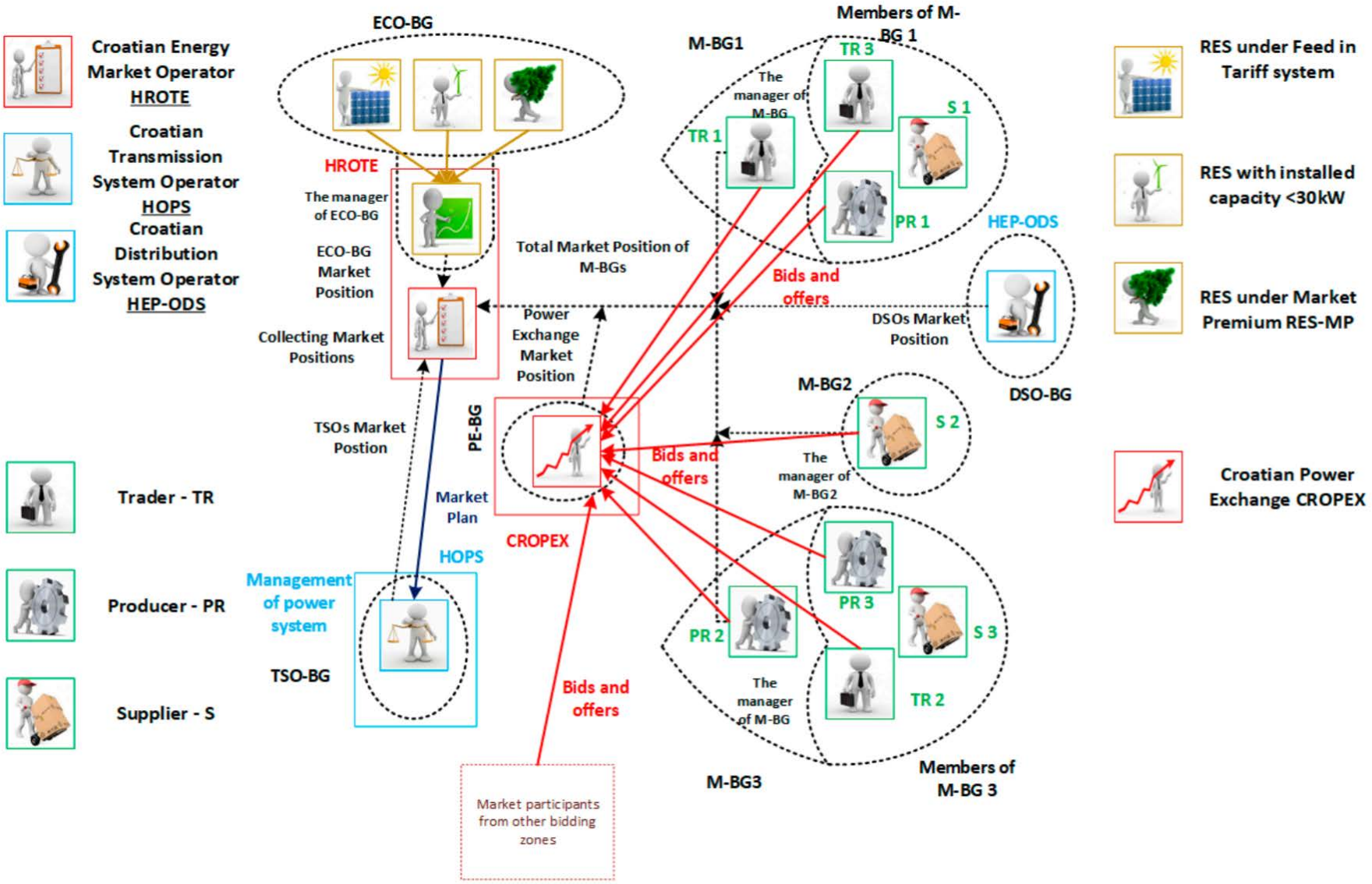
Research Focus

- Removing regulatory barriers
- Guidelines for improving competition and cost-effectiveness in the market
- Optimal microgrid operation and investment models
- Improving the existing models of microgrid elements
- Optimal control of microgrid elements
- Position of an aggregator

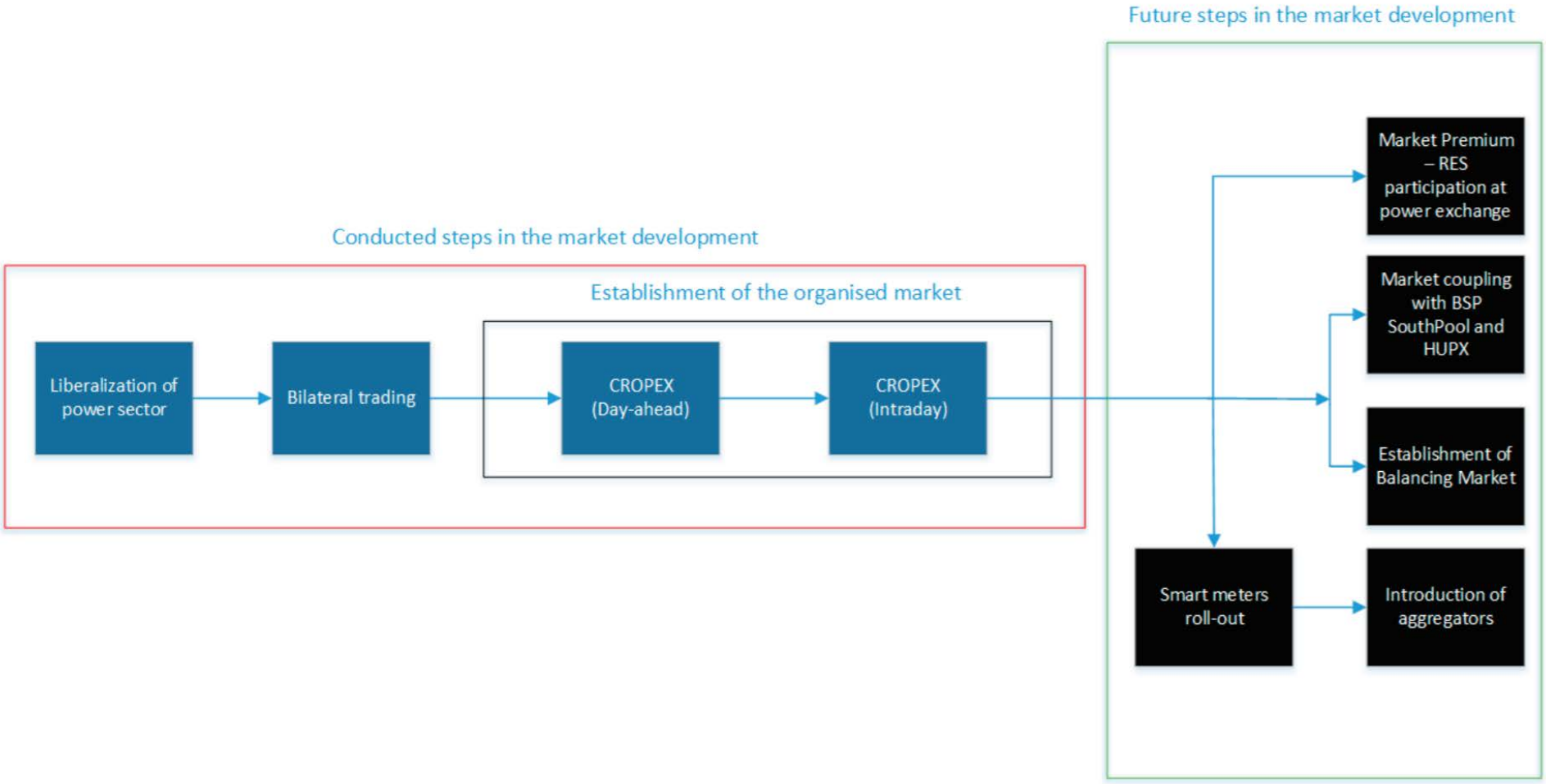
Removing Regulatory Barriers

- Assessment of Croatian energy market and recommendations for further development
- Most of electricity in Croatia is still traded on bilateral basis
- Low liquidity of CROPEX (2-3%)
- Day-ahead market coupling with MRC via Slovenia
- Intraday market coupling with Hungary

Market Organization in Croatia

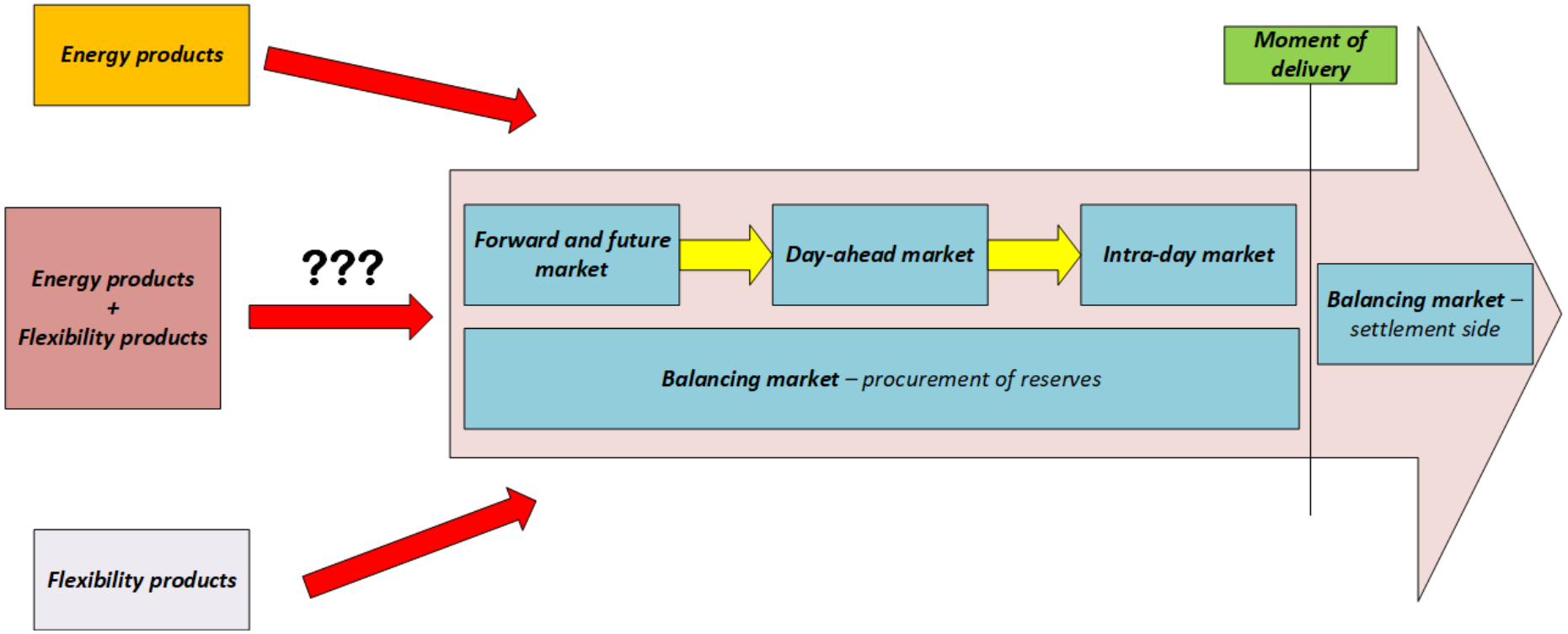


Future Steps

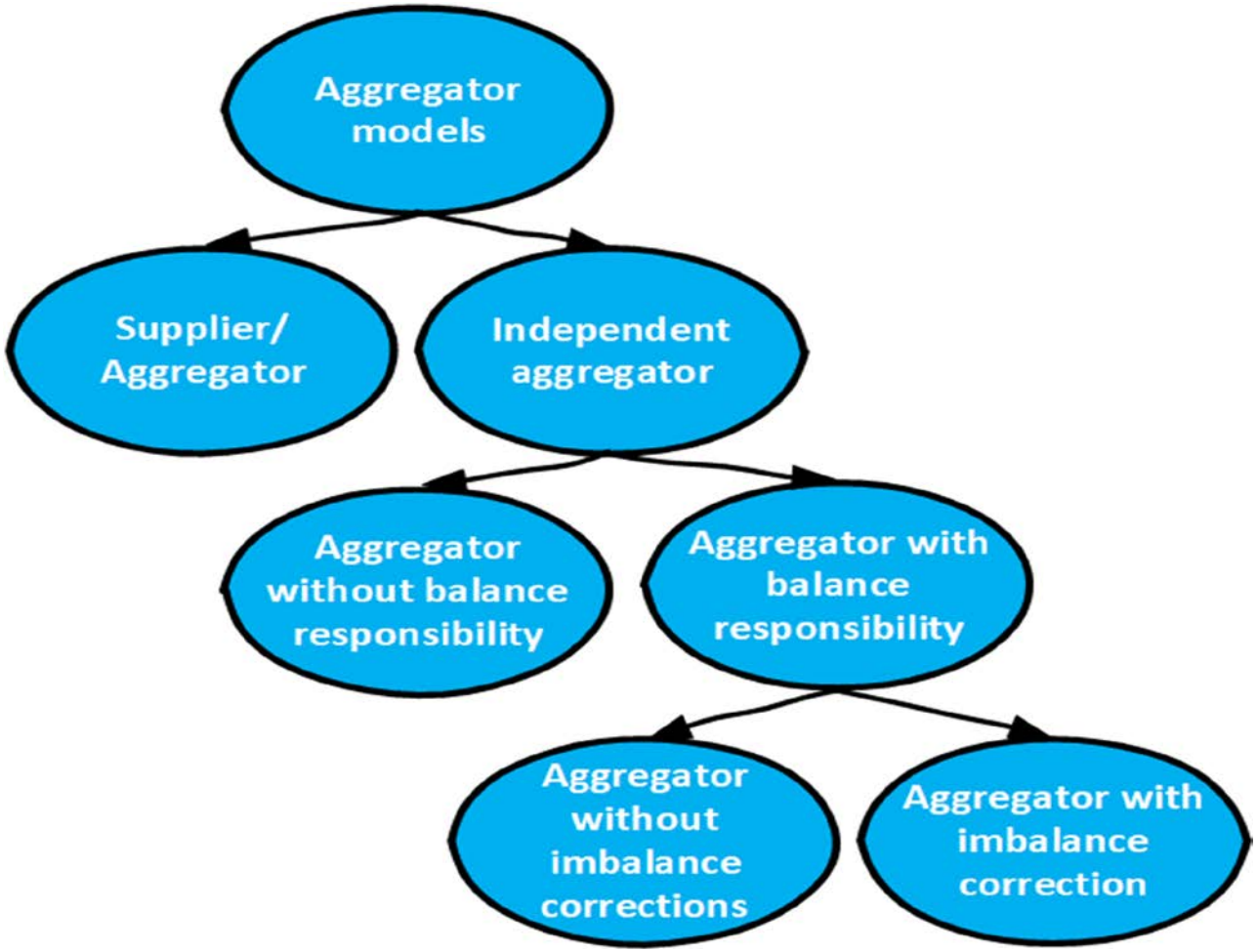


Energy and Flexibility

- Are “energy” and “flexibility” two different products that should be traded separately?



Position of an Aggregator



Optimal Investment Models

- Optimal battery storage investment in a hotel

$$\text{Minimize } P_1 + P_2 + P_3,$$

where

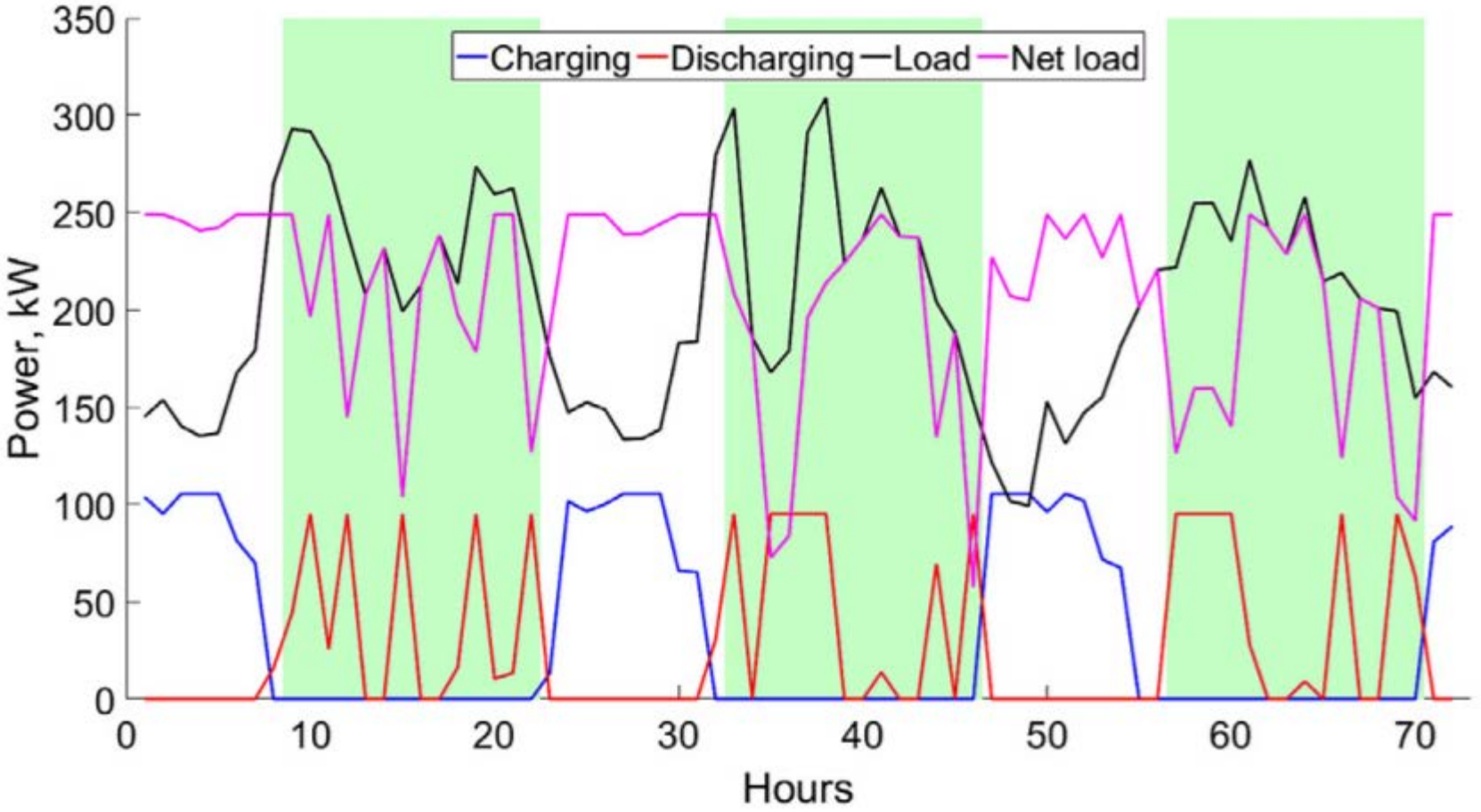
$$P_1 = \left(p^{\text{bat}} \cdot K^{\text{p}} + e^{\text{bat}} \cdot K^{\text{e}}\right) \cdot \frac{(1+R)^L}{L},$$

$$P_2 = \sum_t \sum_m C^{\text{e}}_{t,m} \cdot \Delta^{\text{T}} \cdot \left(D_{t,m} + p^{\text{ch}}_{t,m}/\eta^{\text{ch}} - p^{\text{dis}}_{t,m} \cdot \eta^{\text{dis}}\right),$$

$$P_3 = \sum_m C^{\text{p}} \cdot p^{\text{peak}}_m,$$

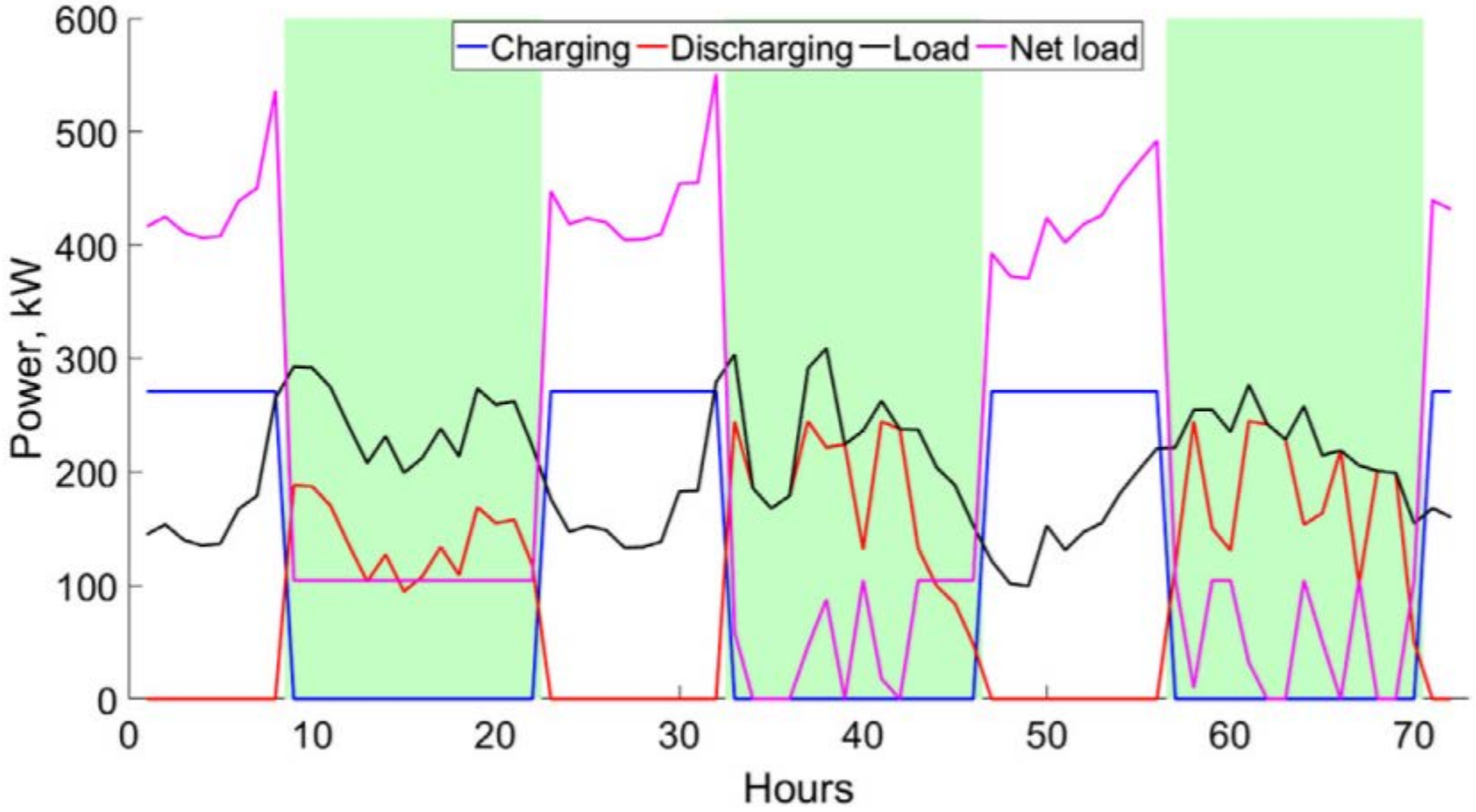
Optimal Investment Models

- Results for different peak payment policies



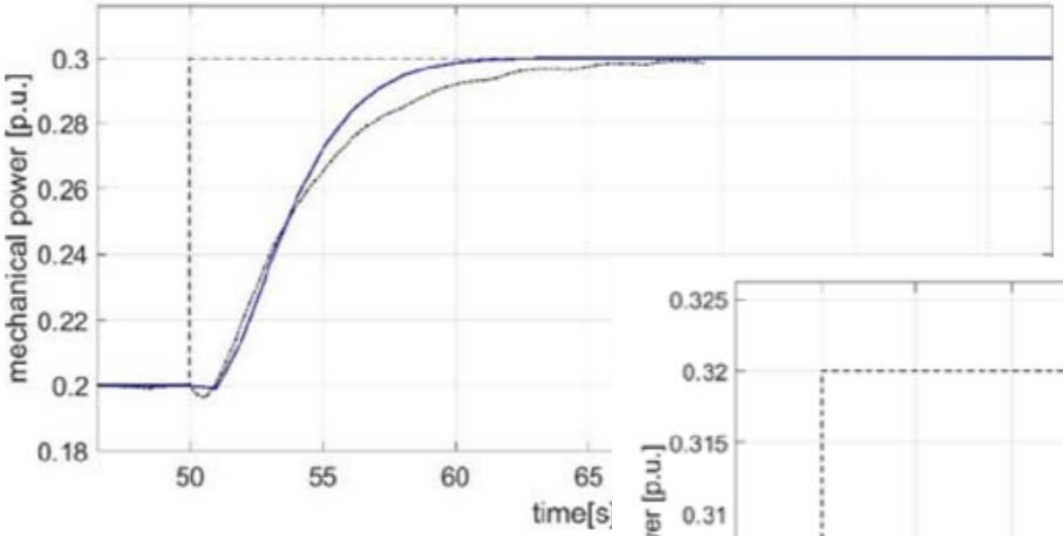
Optimal Investment Models

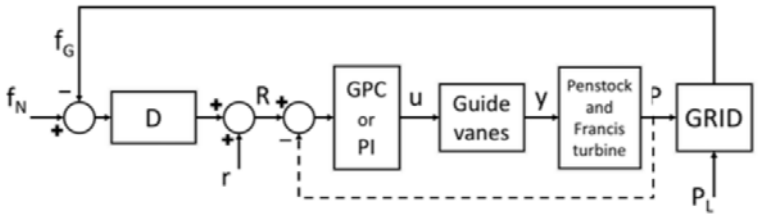
- Results for different peak payment policies

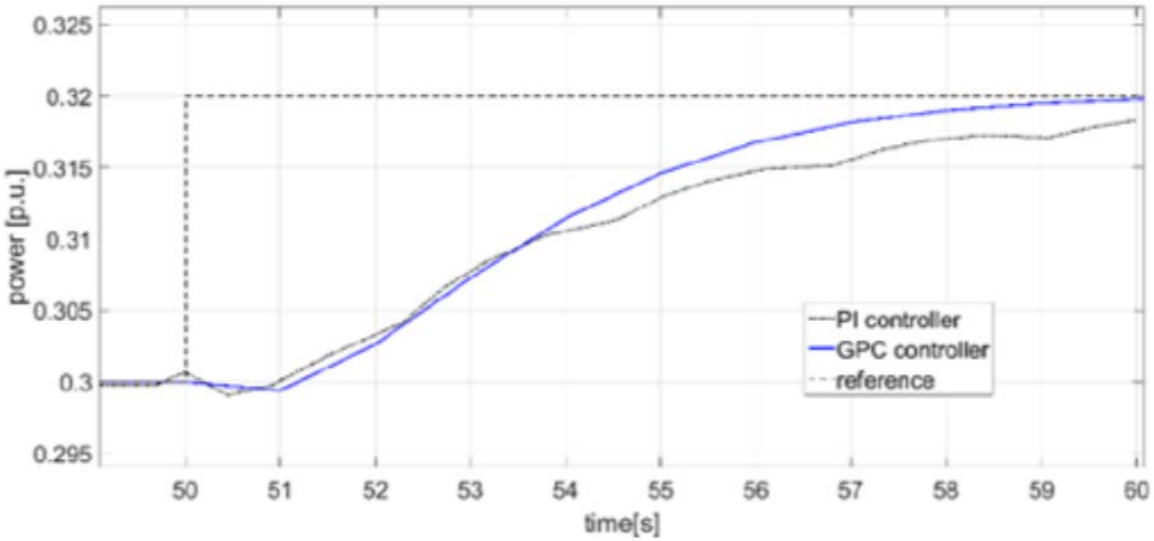


Optimal Control of Microgrid Elements

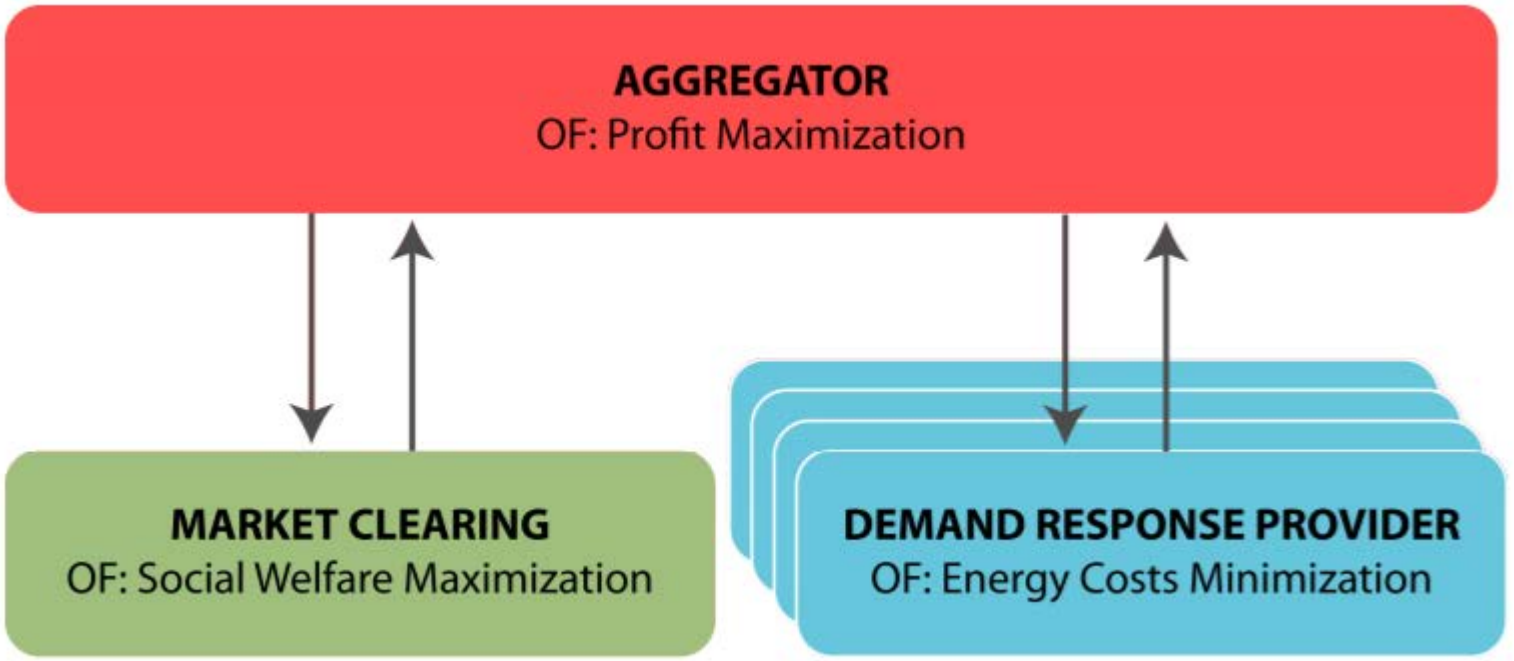
- Application of Model Predictive Control Algorithm on a Hydro Turbine Governor Control



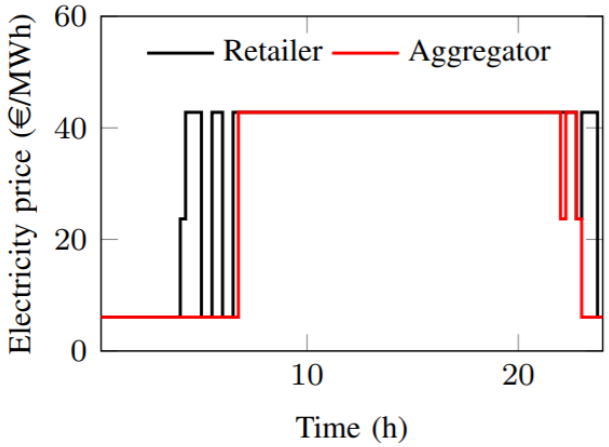




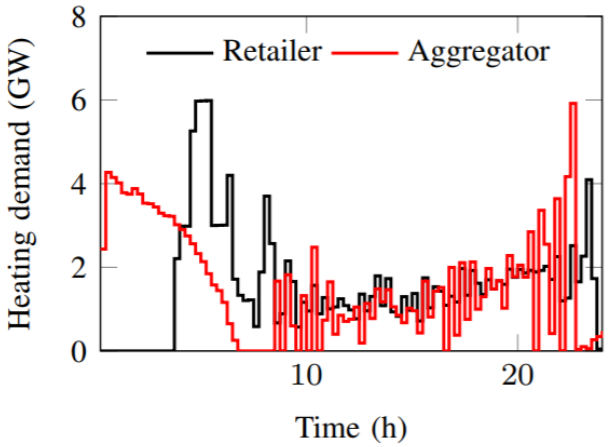
Position of an Aggregator



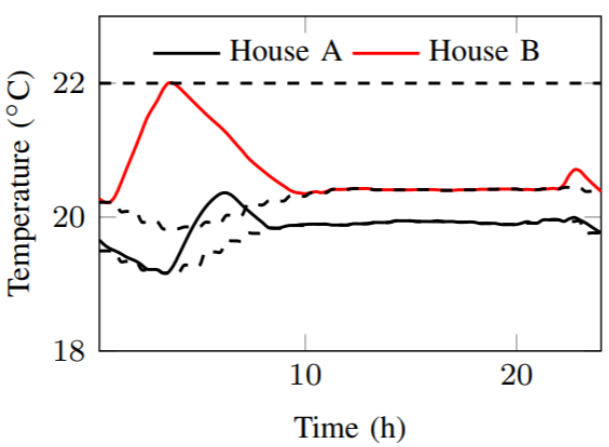
Position of an Aggregator



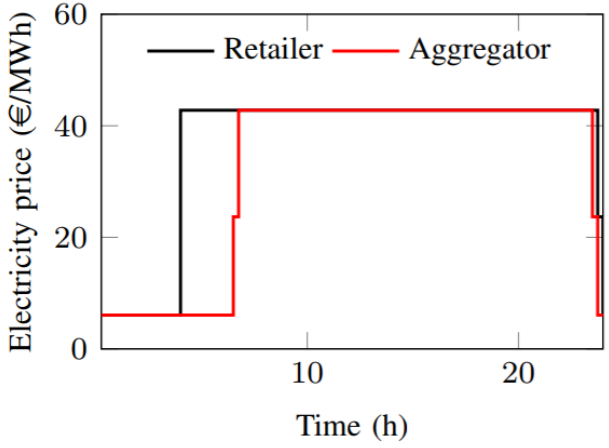
(a) Electricity prices



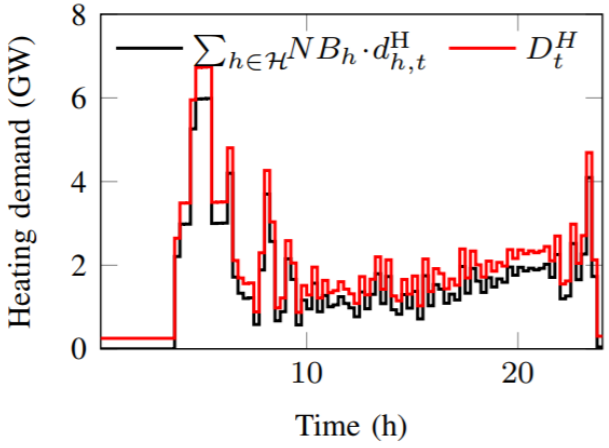
(b) Heating demand



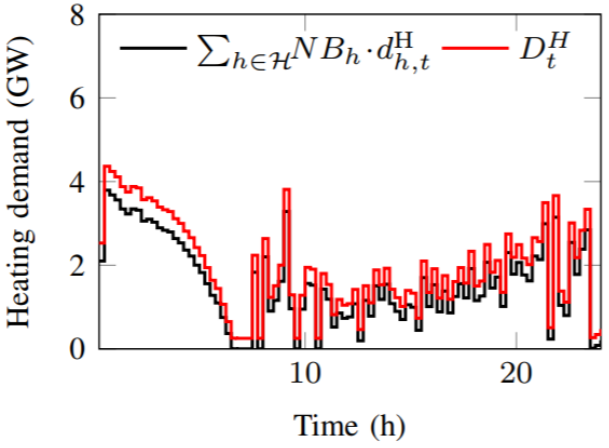
(c) Day-zone temperatures (aggregator)



(d) Electricity prices



(e) Heating demand (retailer)



(f) Heating demand (aggregator)

Key Results and Future Needs

- Aggregator can provide higher benefits to the consumers than a regular supplier
- Investments in renewables and storage can reduce cost of electricity for large consumers

- Better define market position of an aggregator, especially with respect ot balance responsibility
- Microgrid control models need to be improved based on laboratory or real-life measurements

Publications

- Hrvoje Pandzic, Optimal battery energy storage investment in buildings, Energy & Buildings, Volume 175, July 2018, Pages 189-198
- Mateo Beus, Ivan Pavic, Ivona Stritof, Tomislav Capuder, Hrvoje Pandzic, Electricity Market Design in Croatia within the European Electricity Market - Recommendations for Further Development, Energies, Volume 11, Issue 2, February 2018, Pages 1-20
- Luka Punda, Tomislav Capuder, Hrvoje Pandzic, Marko Delimar, Integration of renewable energy sources in southeast Europe: A review of incentive mechanisms and feasibility of investments, Renewable and Sustainable Energy Reviews, Volume 71, May 2017, Pages 77-88
- Mateo Beus, Hrvoje Pandzic, Application of Model Predictive Control Algorithm on a Hydro Turbine Governor Control, in PSCC 2018, Dublin, Ireland, June 11-15, 2018, pp. 1-6.
- Kenneth Bruninx, Hrvoje Pandzic, Helene Le Cadre and Erik Delarue, On Controllability of Demand Response Resources & Aggregators' Bidding Strategies, in PSCC 2018, Dublin, Ireland, June 11-15, 2018, pp. 1-6.
- Ivan Pavic, Mateo Beus, Hrvoje Pandzic, Tomislav Capuder, Ivona Stritof and Ivan Androcec, Impact of an Aggregator of Distributed Energy Resources on Traditional Power System Participants , CIRED Workshop, Ljubljana, Slovenia, June 7-8, 2018, pp. 1-4.
- Ivan Pavic, Mateo Beus, Hrvoje Pandzic, Tomislav Capuder and Ivona Stritof, Eletricity markets overview - market participation possibilities for renewable and distributed energy resources, in EEM 2018, Dresden, Germany, June 6-9, 2017, pp. 1-5.
- Ivan Pavic, Matea Filipovic, Igor Kuzle and Yong-qian Liu, Operating Reserve Allocation Methods Relative to Energy Unit Commitment, ICEPEE 2017, Schanghai, China, April 23-24, 2017, pp. 243-249.

Thank you for Your Attention

- Ugrip.eu
- Hrvoje.pandzic@fer.hr

- This project is supported in part by the Croatian Environmental Protection and Energy Efficiency Fund, Croatian Power Utility and Končar KET

UNIVERSITY OF ZAGREB FACULTY OF ELECTRICAL ENGINEERING AND COMPUTING

FOND ZA ZAŠTITU OKOLIŠA I ENERGETSKU UČINKOVITOST

HEP d.d.

KONČAR

Končar - Inženjering za energetiku i transport d.d.