Optimization of a Virtual Power Plant Portfolio in the German Electricity Market

Théobald Le Louarn
tll@kth.se
Degree Program in Electrical Engineering

- Master Thesis in collaboration with -

Supervisor
Dr. E. Moiseeva
moiseeva@kth.se

Examiner
Dr. M. R. Hesamzadeh
mrhesamzadeh@ee.kth.se
### Virtual Power Plant - the profitable solution for a safer power management?

#### How the future of the power industry will look like?

<table>
<thead>
<tr>
<th>Major changes in tomorrow’s electricity world ...</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Renewable assets</strong></td>
</tr>
<tr>
<td>➢ PV panels, Wind power, Biomass...</td>
</tr>
<tr>
<td><strong>Distributed generation</strong></td>
</tr>
<tr>
<td>➢ Small decentralized power plants</td>
</tr>
<tr>
<td><strong>Increasing demand</strong></td>
</tr>
<tr>
<td>➢ Electrical cars, growing population, batteries</td>
</tr>
</tbody>
</table>

#### ... that will lead to important technical challenges!

<table>
<thead>
<tr>
<th>Intermittent power supplies</th>
<th>Adapting the grid to new assets technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>➢ Stochastic production from wind and solar power plant can lead to lack/excess of power</td>
<td>➢ Smaller and distributed assets which can be remote-controlled</td>
</tr>
<tr>
<td><strong>Zero tolerance for black-outs</strong></td>
<td><strong>Increase of demand during peak hours</strong></td>
</tr>
<tr>
<td>➢ Ensuring a reliable frequency management with less large assets providing flexibility</td>
<td>➢ Constrained transmission lines, power shortage, high prices for consumers</td>
</tr>
</tbody>
</table>

#### What was at stake?

Optimize the profit of a VPP by bidding to multiple products in the power market

#### What solution did I provide?

AlocaBid: A tool developed from scratch to bid and allocate the portfolio resources

#### Solution: why a VPP?

<table>
<thead>
<tr>
<th>VPP definition: Flexible aggregation of decentralized assets (production/consumption) resulting in a behavior close to a large conventional power plant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reliability</strong></td>
</tr>
<tr>
<td>➢ Large portfolio manages any outages</td>
</tr>
<tr>
<td><strong>Optimality</strong></td>
</tr>
<tr>
<td>➢ Reduction of losses thanks to local optimization of the distributed generation</td>
</tr>
<tr>
<td><strong>Accessibility</strong></td>
</tr>
<tr>
<td>➢ Small actors (industry, services...) can access the market</td>
</tr>
</tbody>
</table>

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Optimization of a VPP portfolio in the German Electricity Market
AlocaBid – 3 steps to build a modeling & decision-making tool for allocating and bidding power

1. Portfolio & Products modeling
   - Creation of a realistic portfolio
     - 100 Assets
       - Gas turbines
       - Biomass
       - CHP
   - Analyze of the Power Market
     - Intraday
       - SRL ±
       - MRL ±
       - Spot market
       - Reserve market

2. VPP model: Characteristics
   - MILP
   - Stochastic (scenarios based)
   - Constraints
     - Assets
       - Installed capacity
       - Weekly schedule
       - Costs
     - Flexibility
       - TSO requirement
       - Prequalified flex
       - Assets available flex
   - Market
     - Minimal bid
     - Compatibility between products
     - Block bids
   - Stochastic
     - Expected activations
     - Linearization
     - Activation costs
   - Language: Gurobi (Solver) & Python (Tool)

3. Sequential bidding and allocation
   - Auctions
     - Daily
     - Weekly
   - VPP customers
     - Available flex schedule
   - Traders receive:
     - Volume
     - Price
   - Operators receive:
     - Planning for each asset
   - Bidding
   - Allocating

“Operational tool helping the company to make the most of its portfolio”

Contribution to the E-World
- Pricing strategy, VPP modeling, Asset’s & Products modeling, Automated tool
- Market Analysis, Power generation planning, Modeling, Programming

Skills used
- Market Analysis, Power generation planning, Modeling, Programming

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Optimization of a VPP portfolio in the German Electricity Market
AlocaBid – An automated tool bringing added-value to portfolio managers

Forecasting activations in the reserve market

- 3 Case studies -

3 Case studies to test the performance of AlocaBid

Base Case

High SRL prices Case

High MRL prices Case

Comparison between the profit a straightforward allocation (current process) and the profit generated with AlocaBid on an historical week +60 %

Profit

Optimal Dispatch

Straightforward allocation without AlocaBid

Allocation with AlocaBid

Activation curve: number of hours per week an asset is being activated regarding its rank in the merit order list of the considered product

Clustering into...

3 scenarios

Computing the weekly activations curves (2013-2016)

Impact: The model developed in the thesis has shown significant results (minimum +30% profit in all cases). It can be adapted to any other portfolio of assets. However, the real added-value of the Thesis, was to deliver a production-ready tool, which is currently being daily used to bid and efficiently plan the resources of the VPP portfolio.

Further steps: In the process of publishing an article to promote the model of AlocaBid and the outcome of the Thesis.