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Dispatch Optimization of Solar Thermal Power Plants considering Forecast Uncertainties

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Motivation

- The high grid penetration of renewable energies brings imbalance on power prices and modify typical demand design curves(1).
- Due to their thermal storage, concentrated solar power plants (CSP) are dispatchable and therefore expected to balance electricity production and demand.
- In contrast to other renewables, CSP can compete with conventional energy sources in the wholesale energy market.

Objectives

- **Why to optimize the dispatch?**
  - To produce clean energy during electricity demand peaks
  - To reach higher selling prices of electricity produced from CSP
  - To adapt plant operation practices according to optimal production schedule
  - To allow CSP plants with storage to participate in the wholesale energy market
- **Why to consider forecast uncertainties?**
  - To improve the quality of electricity scheduling by actively considering associated uncertainties in weather and pricing forecasts
  - To reduce financial drawbacks related to modification of scheduled energy delivery

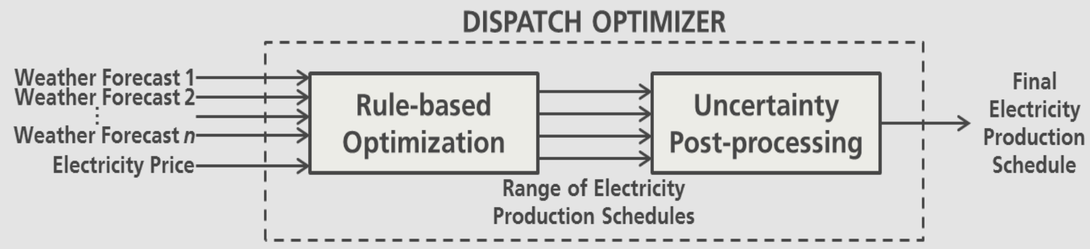
Approach & Methods

- **Developed tool:**

Dispatch Optimizer to derive CSP plant electricity production schedule for the next 2 days, considering weather and electricity pricing forecasts as input.

- **Methodology:**

Partitioned calculation between a problem-specific(2) rule-based optimization algorithm and the uncertainty processing, based in game theory calculations.

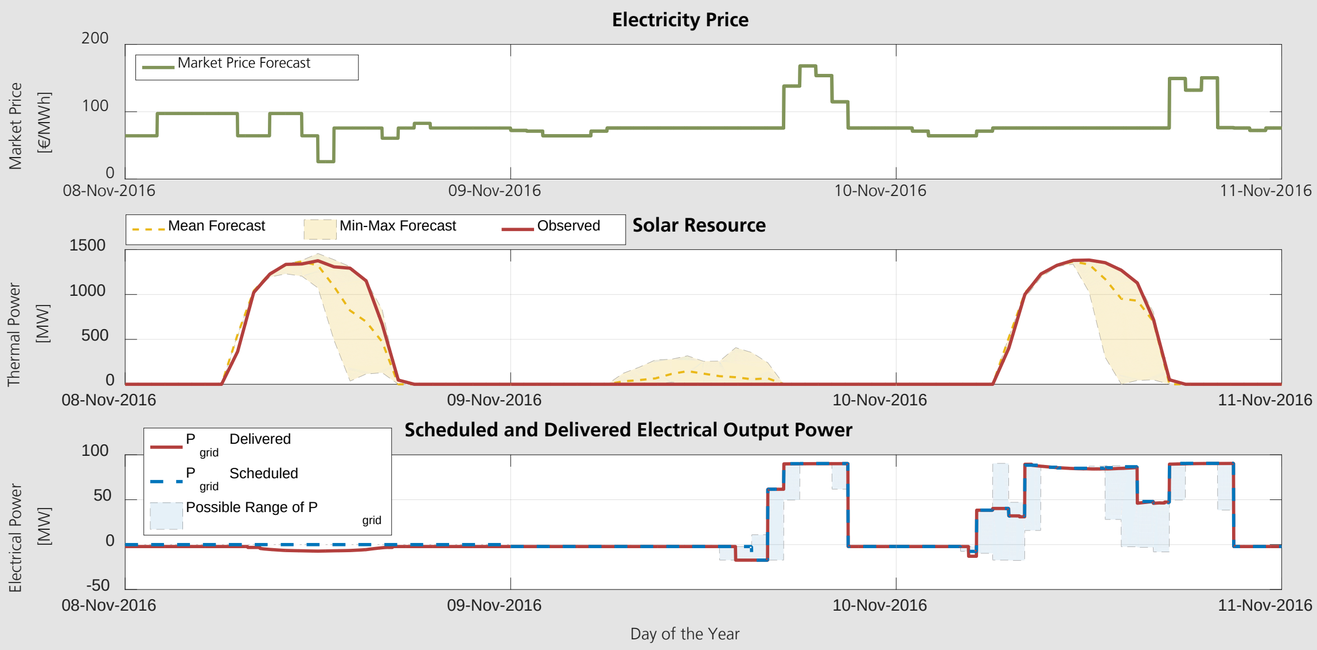


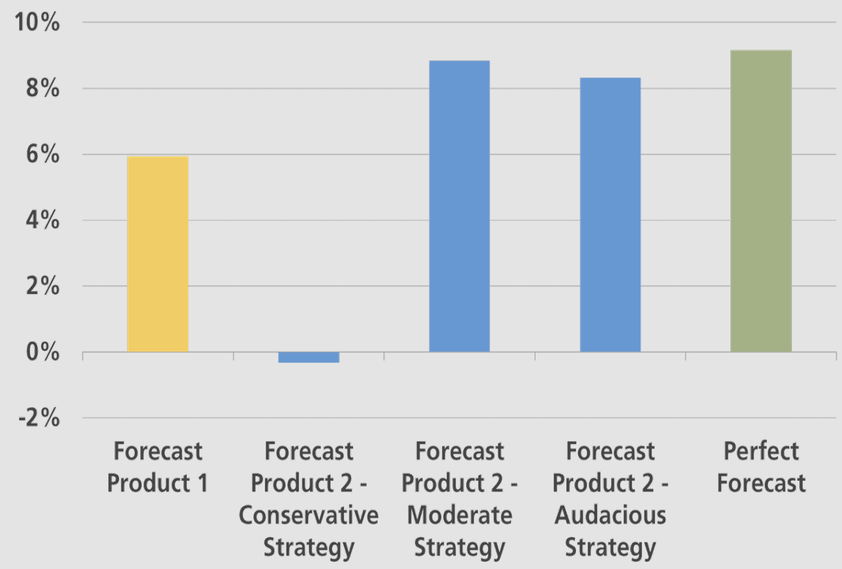
- **Innovations:**
  - Uncertainties incorporation
  - Several types of weather forecasts as possible input
  - Consideration of market penalties in optimization
- **Benefits:**
  - Schedule development according to market setup and decision making strategy
  - Flexible application for several electricity markets

Results

- **Annual Simulations:**
  - Considering the operation of a CSP plant following the dispatch optimizer strategy
  - Modelling a 100 MW solar thermal tower with 10 h of thermal storage to operate in a site in Badajoz, Spain, considering weather and electricity price data for the whole year of 2016
- **Improvement in Financial Income:**
  - Possible achievement of more accurate delivery
  - Related to the quality of weather forecast and enhanced with uncertainty post-processing
  - Related to electricity market characteristics, contemplated by different scheduling strategies

Illustrating Example: financial income comparison
- for different weather forecast products
- combined with different operation strategies
- compared with benchmark scheduling strategy





Summary & Outlook

- **Achieved goals:**
  - Uncertainties and market characteristics included optimization
  - More accurate delivery scheduling
  - CSP financial income improvement, leading to possible participation in wholesale energy market
- **Next steps:**
  - To perform annual simulations with more forecast products and more countries
  - To include intra-day market characteristics in optimization
  - To include price forecast uncertainties

References

(1) IRENA, "Adapting market design to high shares of variable renewable energy", Abu Dhabi (2017).

(2) D.H. Wolpert and W.G. Macready, "No free lunch theorems for optimization", in IEEE Transactions on Evolutionary Computation, Vol.1, No. 1 (1997).

Acknowledgements:

This work was conducted in cooperation with partners from the PreFlexMS project, under Grant Agreement no. 654984 of European Union's Horizon 2020 Programme.

PreFlexMS
PREDICTABLE&FLEXIBLE SOLAR POWER WITH MOLTEN SALT ENERGY STORAGE

DLR Deutsches Zentrum für Luft- und Raumfahrt

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