Öko-Institut e.V.
Institut für angewandte Ökologie
Institute for Applied Ecology

Comparison of Centralized Market-Based Dispatch of Flexibility Options at Distribution Network Level with Regional Balancing Strategies in the German Power System

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Agenda

- Introduction
- Dispatch model „PowerFlex-Grid“
- BMBF project „Transparency of Transmission Grid Planning“ (case study 1)
- BMWi project „D-Flex“ (case study 2)
- Conclusions

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Introduction

The Öko-Institut e.V. – Our Profile

- Oeko-Institut is a leading European research and consultancy institute working for a sustainable future.
- Founded in 1977, non-profit association
- Offices in Freiburg, Darmstadt and Berlin
- Clients: European Union, national and state-level ministries, companies, foundations and non-governmental organizations
- 165 staff members, 400 projects/a, turnover 14 Mio. €/a
- Energy and climate division: e.g. energy scenarios, emissions trading, renewable energies, grid integration

Topic of the paper / presentation (I)

- Increasing share of RES-E to battle climate change
- Concentration of
  - wind turbines in the North of Germany in contrast with load centres in the western and southern part
  - photovoltaics at decentralized grid level
- More flexibility is needed (e.g. transmission grid, DSM, CHP engines with gas or thermal storages,…)
- Trade-off between decentralized coordination (larger capacities of local resources and dispatch them in a less efficient way) and centralized coordination (larger grid infrastructure).

Topic of the paper / presentation (II)

- Focus on the dimension of system coordination, which is currently mainly located on the transmission grid level.
- Increased share of decentralized generation may also entail the development of coordination mechanisms on lower grid levels (e.g. decentralized markets).
- Show differences between a decentralized and a centralized electricity system regarding the dispatch of generation, storage and flexibility options.
- Scenario analysis supported by the dispatch model PowerFlex-Grid within 2 research projects.

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Dispatch model „PowerFlex-Grid“

Dispatch model „PowerFlex-Grid“

- Linear optimization problem in hourly resolution.
- Implemented in GAMS and solved by CPLEX.
- Various generation and supply side technologies like thermal power plants and RES as well as different flexibility and storage options.
- The German transmission grid is implemented using the DC-approach on the underlying grid.
- <u>Case study 1:</u> 500 German nodes, all ENTSO-E countries, LP, perfect foresight of 72 h
- <u>Case study 2:</u> 5 German nodes, no import/export, MIP, perfect foresight of 120 h

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BMBF project „Transparency of Transmission Grid Planning“ in cooperation with e-fect (Berlin)

Scenario definition, methodology and results from case study 1

GEFÖRDERT VOM

Bundesministerium
für Bildung
und Forschung

The aim of the project "Transparency of Transmission Grid Planning“ (case study 1)

- Support stakeholders in understanding and evaluating the calculations of the TSOs and the BNetzA which lead to the definition of the need of grid extension.
- Stakeholders involved represent non-governmental organizations (e.g. WWF, DUH, BUND) or members from action groups of local projects on transmission grid extension.
- 5 Workshops: discussing results from the reference scenario B2024 and B2034 of the GDP as well as own scenario definitions.
- Highly requested: scenario with a decentralized electricity market

Scenario definition with a decentralized electricity market in contrast to the reference scenario B2024

- Multi parameter variation to define a decentralized world.
- Electricity demand decreases from 550 to 480 TWh/a.
- Increasing RES-E supply (+80 TWh) according to the federal targets (scenario C2024).
- Decrease of the installed capacity from lignite (-9.1 GW) and hard coal (-11.7 GW) fired power plants, increase from natural gas (+8 GW).
- The price of CO_2 certificates rises from 29 to 40 €/t.
- Potential for demand shifting of up to 4.7 GW.
- Transmission grid as scenario B2024, NTCs as present.

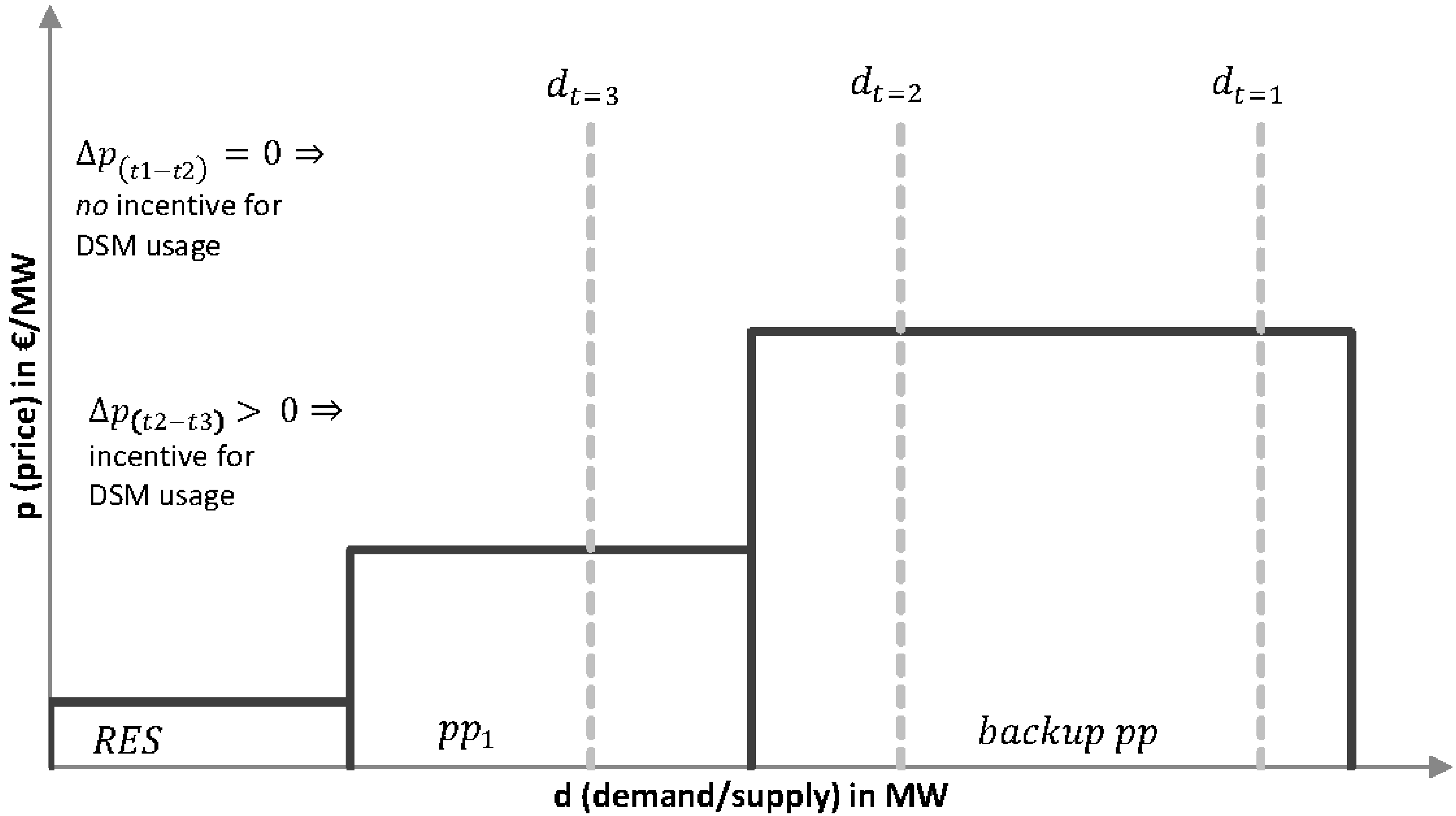
Methodology of the decentralized scenario using a two-step approach

- Step 1: each node has to supply its own demand.
  - The maximum transfer capacity of each power line is set to 0, and cross-border electricity exchange is disabled.
  - In case of deficit a generic backup power plant will produce shortfalls at very high costs.
  - In case of nodal electricity surpluses due to RE, must-run or heat production, there is the possibility to curtail production.
- Step 2: enabling internodal electricity exchange
  - All existing power plants have to produce the resulting supply of step 1 as a minimum (lower bounds).
  - The nodal production of backup power plants should be substituted with excess energy from other nodes.

Results from **Step 1** of the decentralized scenario (case study 1)

- Curtailement of 188 TWh from RES-E (mainly produced by wind energy turbines) and of 43 TWh from must-run and CHP units.
- Shortage of electricity reaches 158 TWh, corresponding to a capacity shortage of 38 GW distributed over 380 nodes.
- The flexibility option of DSM is used at most of the nodes, but only 2 TWh are shifted from one time step to another.
- Load shifting needs the impulse of a price gap between two time steps, which is rarely in many cases.

Price gaps between to time steps needed as incentive for load shifting



Results from **Step 2** of the decentralized scenario (case study 1)

- Electricity supply provided by backup power plants is completely substituted.
- RES-E curtailment drops to the amount of 38 TWh.
- Production from must-run and CHP facilities is completely used.
- There was a huge lack of flexibility in step 1 having the characteristics of the transmission grid.
- Less expensive generation units not needed for covering German demand start producing for export (+72 TWh).
- This increases the so far reduced CO_2 emissions and transmission grid load.

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BMWi project „D-Flex“ in cooperation with OFFIS e.V. (Oldenburg)

Scenario definition, methodology and results from case study 2

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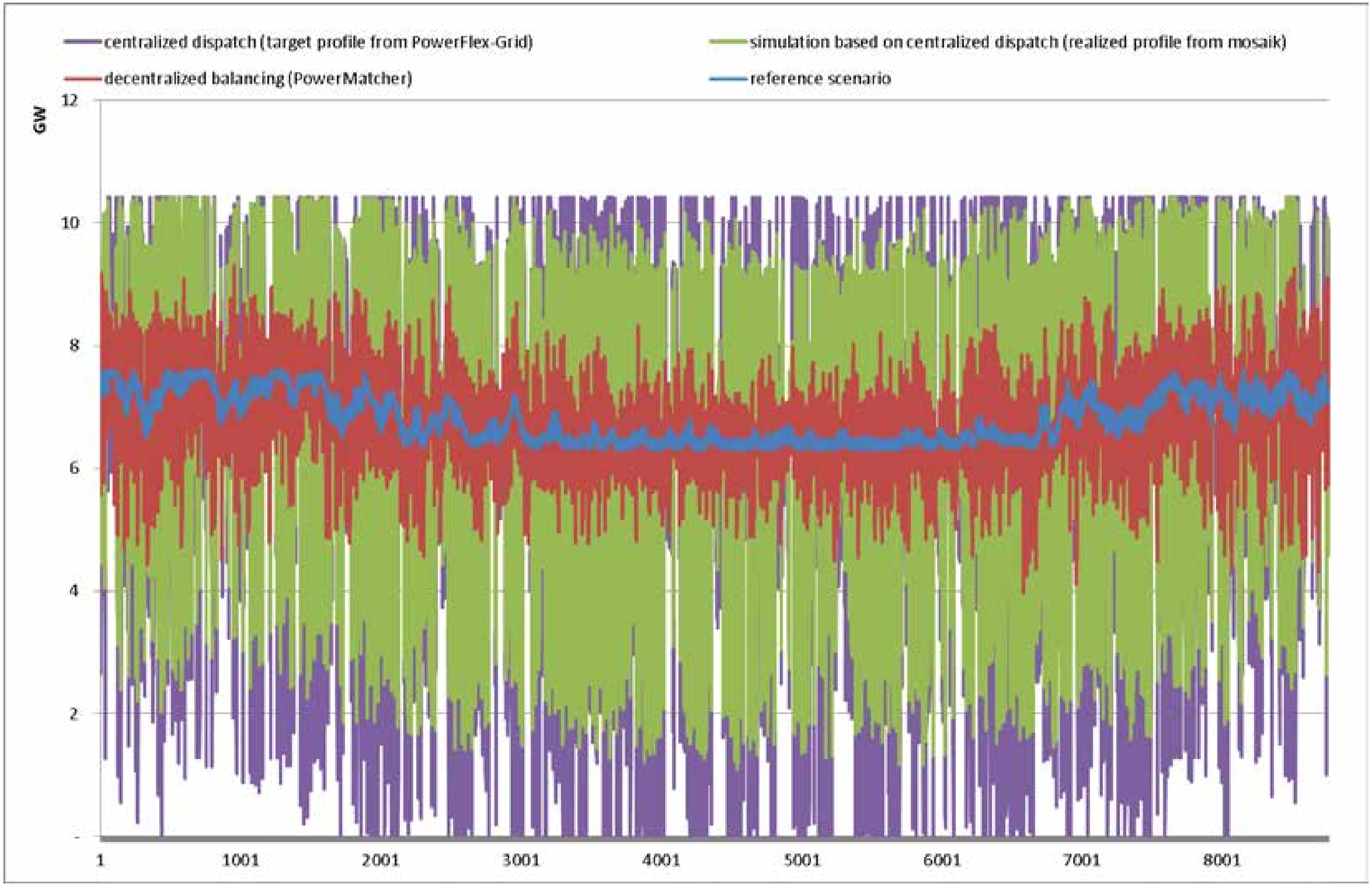
The aim and methodology of the project “D-Flex“ (case study 2)

- Should supply and demand be centrally balanced or better be dispatched within regional balancing areas?
- Allocation of demand and supply to centralized and decentralized grid level.
  - Decentralized level 2020: 60% demand, 70% RES-E, 10% conventional capacity
  - Flexibilized generation: 52 TWh (2020), 60 TWh (2030)
  - Flexibilized demand: 12 TWh (2020), 35 TWh (2030)
- Combination of the co-simulation platform mosaik from OFFIS for the decentralized sector with the dispatch model PowerFlex-Grid.

Subscenarios representing the balancing and dispatch strategy (case study 2)

- Reference scenario: decentralized flexibility is not available at all.
- Scenario with decentralized balancing strategy: flexibility options are coordinated on the distribution grid level to smooth the local residual loads (PowerMatcher, OFFIS)
- Scenario with a national, market-oriented dispatch strategy: committment of the flexibility options is optimized under consideration of minimizing overall dispatch costs.
  - Target profile calculated with PowerFex-Grid
  - Realized profile simulated with mosaik

Dispatch of decentralized CHP engines in different balancing strategies



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Conclusions

Conclusions

- The majority of demand and supply needs a transmission grid for balancing.
- Decentralization as control strategy leads to higher variable generation costs: more expensive generation and less efficient flexibility options come into the market.
- The less expensive generation capacities not needed for covering demand any more start producing for export.
- Decentralized flexibility options need additional incentives due to the reduced local merit order.
- Centralized dispatch including perfect foresight and neglecting unit specific restrictions overestimate flexibility.

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Vielen Dank für Ihre Aufmerksamkeit!
Thank you for your attention!

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Haben Sie noch Fragen?
Do you have any questions?