HSoG Energy Policy Exchange Forum

Integration of variable renewables: the role of storage and other flexibility options

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1. Characteristics of variable renewable energy sources
2. Different flexibility requirements
3. Options for providing flexibility
4. Power storage requirements for RES integration
5. Conclusions

Characteristics of variable renewable energy sources

- German and European energy transition implies increasing shares of variable renewable energy sources (RES)

- Wind and solar power have specific temporal and spatial characteristics:
  1. Variable feed-in patterns

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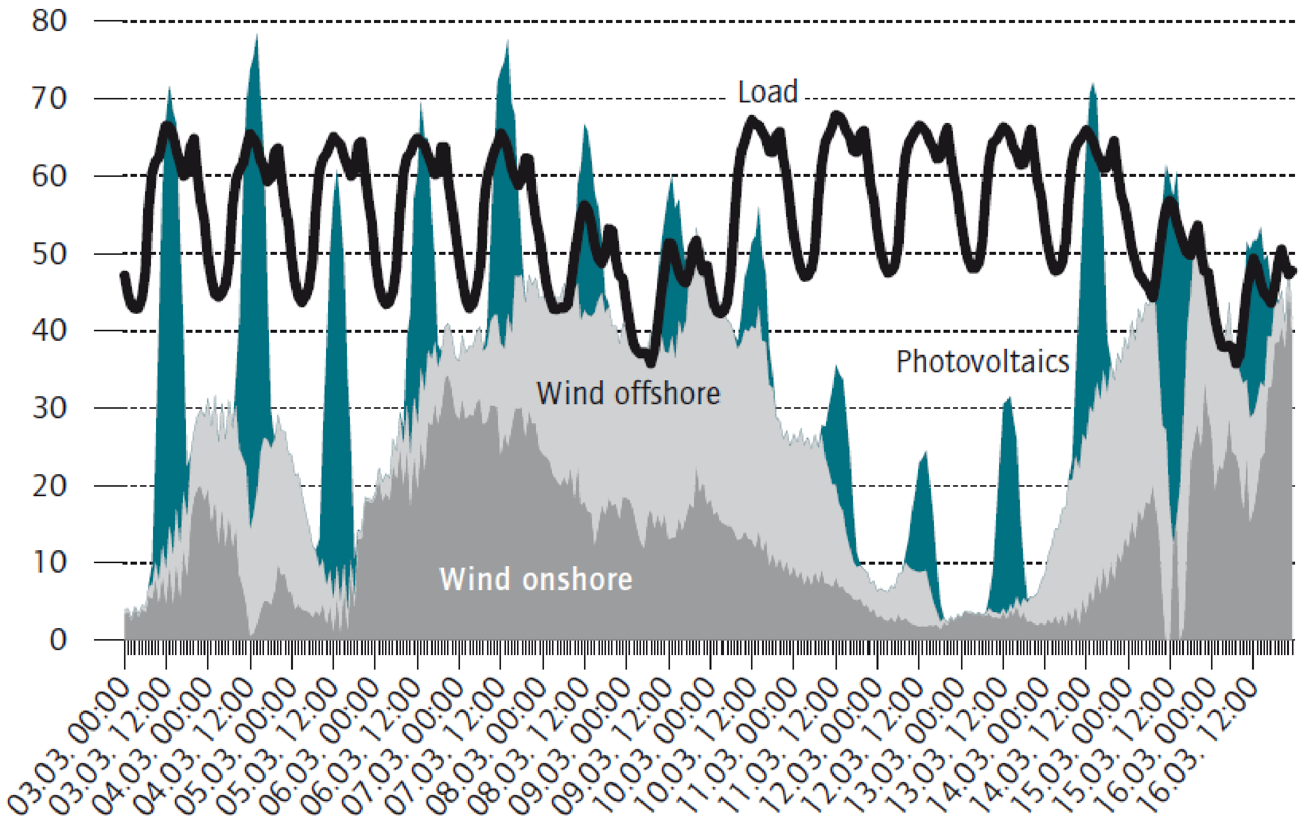
Electricity demand and supply from wind power and photovotaics for an overall renewable share of 80 percent

In gigawatts



Exemplary results of a simulation for two weeks, based on German load and feed-in data of 2013. The residual load ist the difference between load and the supply of fluctuating wind and solar power generators.

Schill et al. (2015): Power Storage: An Important Option for the German Energy Transition. *DIW Economic Bulletin* 10/2015

Characteristics of variable renewable energy sources

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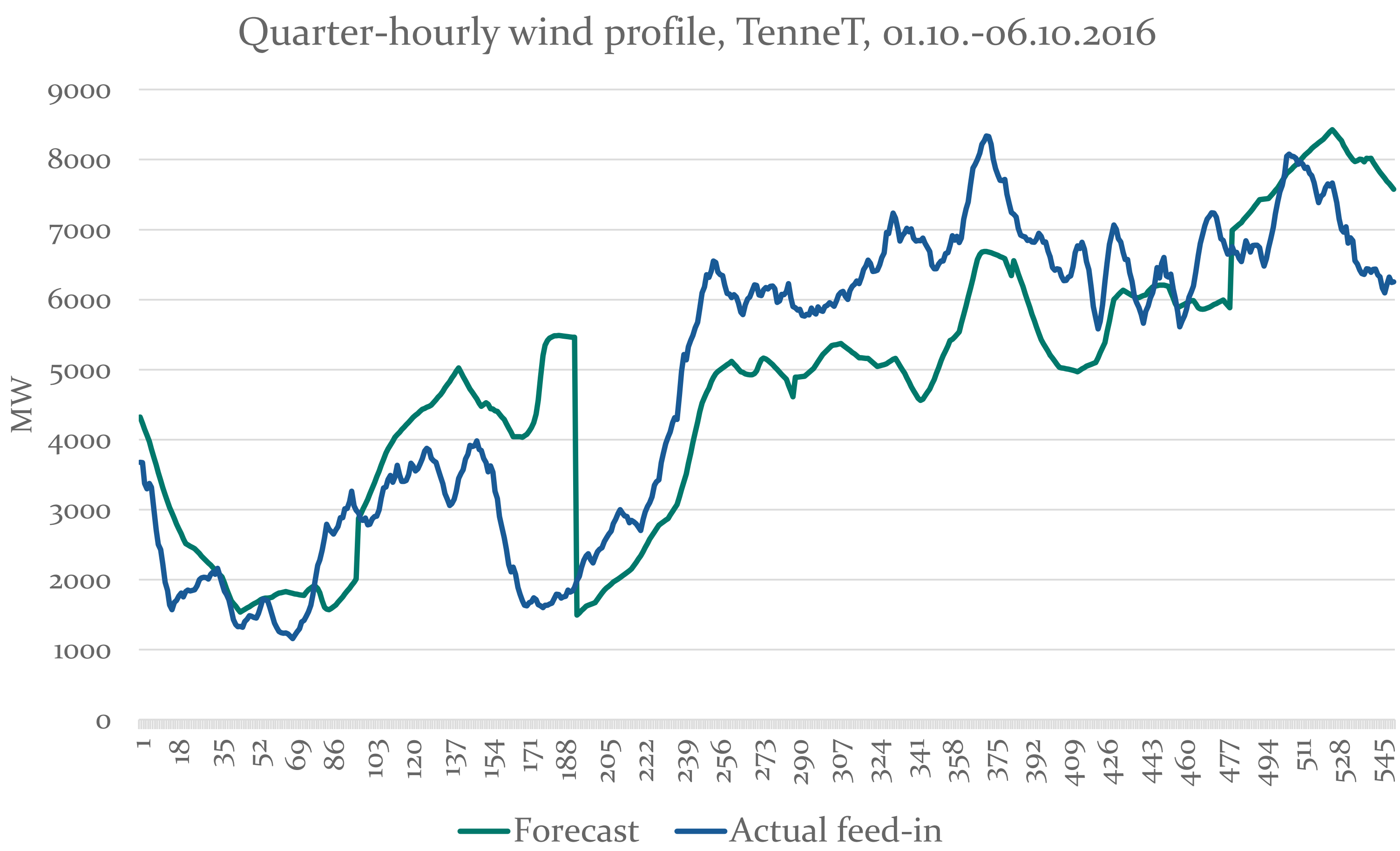
1 Characteristics of variable renewable energy sources



Characteristics of variable renewable energy sources

- German and European energy transition implies increasing shares of variable renewable energy sources (RES)

- Wind and solar power have specific temporal and spatial characteristics:
  1. Variable feed-in patterns
  2. Short-term deviations from forecasts
  3. Asynchronous grid connection, no inertia
  4. RES locations vs. current grid layout

→ Increasing temporal and spatial flexibility requirements

Different flexibility requirements

- Temporal flexibility:
  - Provision of (synthetic) inertia
  - Provision of balancing reserves
  - Residual load smoothing (daily, weekly, seasonal)
  - Handling of renewable surplus events
  - Provision of peak capacity

- Spatial flexibility:
  - Geographical balancing

→ System values related to the provision of such flexibility

3 Options for providing flexibility

Flexibility options	Examples
Power storage	• Mechanical, electrochemical, chemical storage
Supply-side options	• Adjusted use of hydro reservoirs • Flexible CHP and biomass • Flexible thermal generators • System-friendly renewables (dispatch)
Demand-side options	• Load shifting • Load shedding
New flexible load (sector coupling)	• Power-to-heat • Power-to-gas • Power-to-mobility
Grid-side options	• Grid extension and optimization • Power electronics

Functional power storage, „Power-to-power“

„X-to-power“

„Power-to-X“

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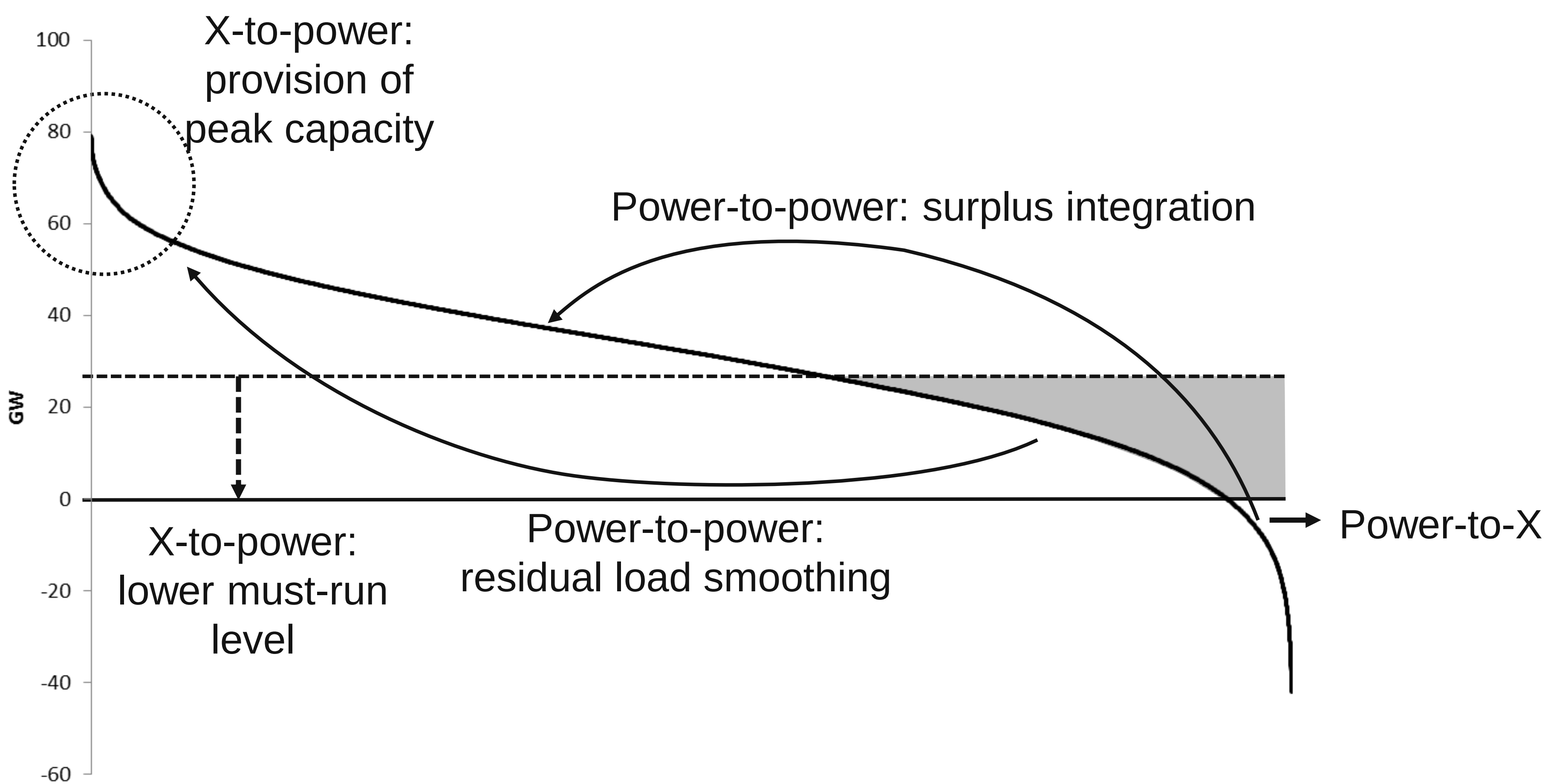
Options for providing flexibility – illustrated with a residual load curve



Based on Schill (2013): Systemintegration erneuerbarer Energien: Die Rolle von Speichern für die Energiewende. *Vierteljahrshefte zur Wirtschaftsforschung* (82) 61-88. http://dx.doi.org/10.3790/vjh.82.3.61

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Power storage requirements for RES integration: Literature survey

- International literature survey shows no clear picture
- Influential studies focusing on German storage needs:
  - „Roadmap Storage" (2014):
    - No additional storage up to 70% RES in Germany
    - 0-22 GW additional short-term storage in 88% RES scenario
  - Agora Energiewende (2014):
    - 7 GW short-term, 16 GW long-term in 90% RES scenario
- Findings driven by specific assumptions:
  - Demand-side flexibility
  - Large-scale geographical (European) balancing
- Most studies do not cover all "flexibility values" of storage

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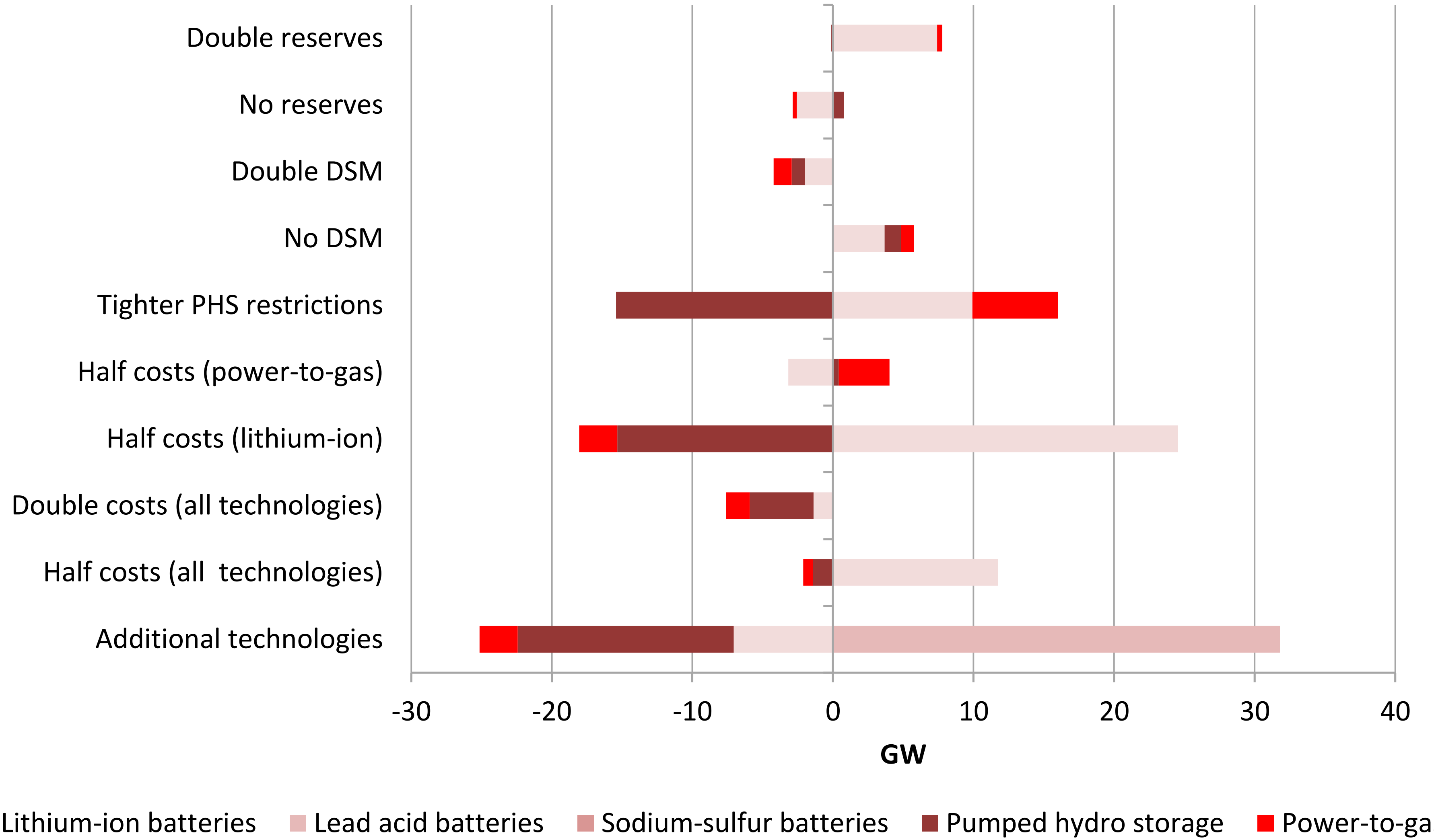
Power storage requirements for RES integration: Own analysis with DIETER

- A model to explore the role of different power storage technologies in a greenfield system with high RES shares
  - Code and input data under open-source licenses
  - Visit DIETER at www.diw.de/dieter
- Model captures different system values of storage
  - Arbitrage value
  - Balancing reserve value
  - Capacity value
- Baseline: ~34 GW power storage for 100% RES case
  - Largely pumped hydro

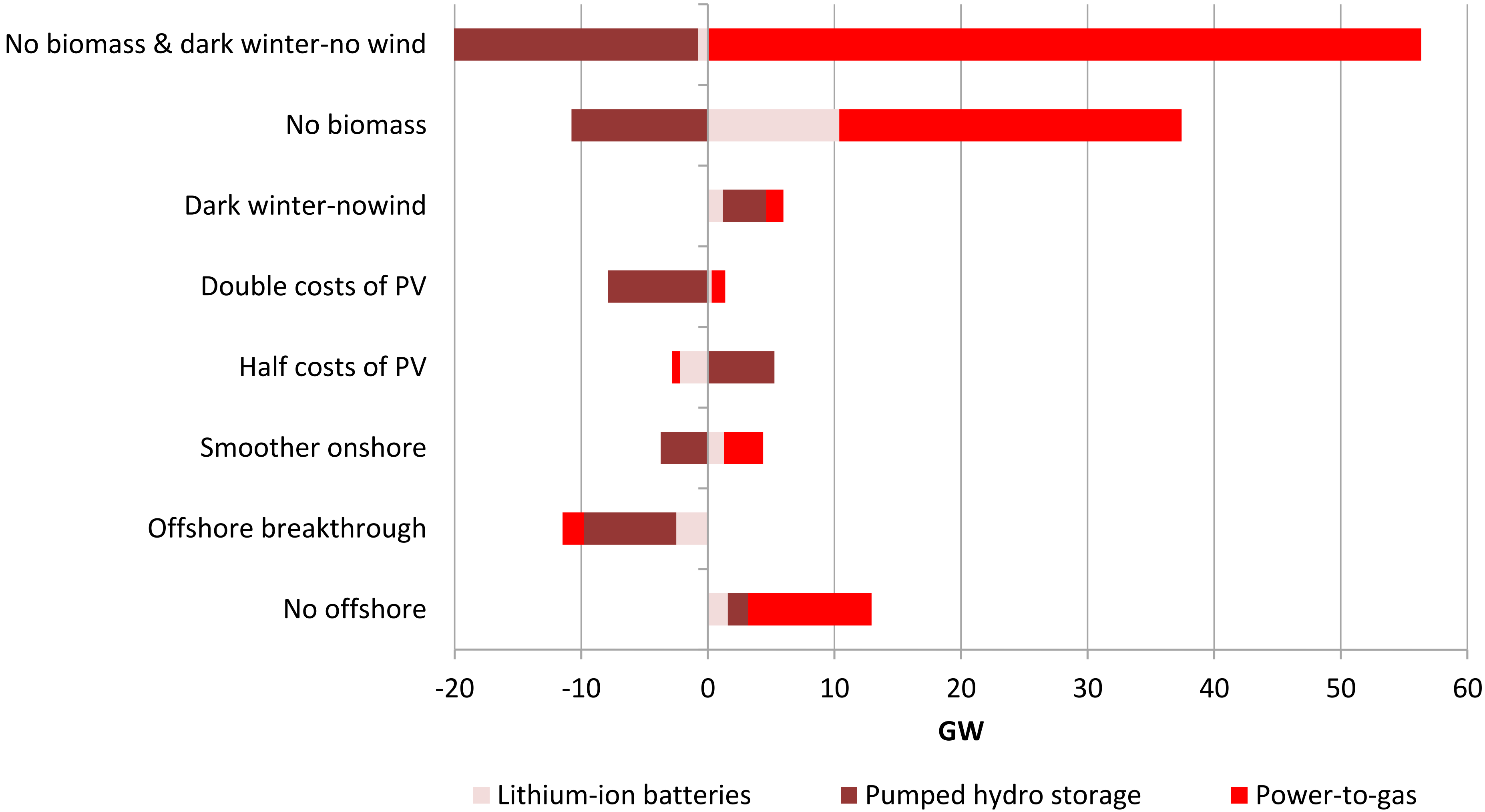
4 Sensitivities on storage, DSM, and reserves: changes in installed storage power for 100% renewables



Zerrahn, Schill (2015): A Greenfield Model to Evaluate Long-Run Power Storage Requirements for High Shares of Renewables. DIW Discussion Paper 1457

→ Storage deployment very sensitive to assumptions

4 Sensitivities on renewable costs and availabilities: changes in installed storage power for 100% renewables



→ Power-to-gas only under pessimistic assumptions

Zerrahn, Schill (2015): A Greenfield Model to Evaluate Long-Run Power Storage Requirements for High Shares of Renewables. DIW Discussion Paper 1457

5 Conclusions

- RES integration requires different types of flexibility
- Various flexibility options exist
- Model analyses:
  - Storage needs moderate up to 70-80% RES, grow towards 100%
  - Results heavily depend on costs and availability of other options
- Power storage probably not a bottleneck for RES integration in Germany / Europe in the medium run
- Policy:
  - Ensure level playing field for flexibility options
  - R&D&D support
- Long run: flexibility as a by-product of sector coupling?

Thank you for your attention.

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