# WP5 – Future electricity markets – design implications and trade-offs with RES-E

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# Objectives

- **Assessment of policy design of the 5 policy paths to derive prerequisites for and trade-offs with electricity markets**
  - Assessment of interactions between RES policies and electricity market/grid regulation design
- **Identification of opportunities and barriers of electricity market design and grid regulation for the integration of large RES-E shares**
  - To what extent does electricity market design affects RES-E penetration?
  - To what extent does grid regulation affects RES-E penetration?



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# Contents

- Major interactions between RES-E and electricity markets
- Major interactions between RES-E and grids
- Methods: From policy pathways to impacts on markets and grids
- First ideas to change market design and grid regulation



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# Interactions between RES-E and electricity markets

- Very long-term
  - Reduction in energy costs
- Long-Medium term
  - Re-adaptation generation technology mix
  - Increase back-up capacity, flexibility requirements
- Short term
  - Lower marginal costs: merit order effect
  - Increased cycling of thermal power plants
  - Amplification of market power
  - Increased volatility of wholesale prices
  - Negative prices
- Very short-term
  - Increased provision of reserves



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# Challenges for system adequacy

- Need to reformulate reliability assessments
- Geographical distribution increases wind capacity credit
- Larger penetration reduces wind capacity credit
- Lower predictability reduces system reliability
- Lower average and more volatile prices make a more reduced signal for long-term investment



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# Changes in plant operation

- Heavy cycling, low capacity factors for thermal power plants
- Incentive for flexible, low-capital cost technologies
- Change in load profiles for non-variable plants, reduction in operating hours
- Increased need and costs of balancing or intraday adjustments



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# Challenges for grid infrastructure & regulation

- Requirements for new infrastructure, including cross-national
- Changes in grid codes to adapt technical requirements (voltage, frequency regulation)
- Use-of-system and connection charges for distribution
- Nodal / Zonal pricing



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# Methodological approach: From policy pathways to impacts on markets and grids

Policy pathways — E.g.: Feed-in-premiums

↳ Design elements — E.g.: Market-linked income

↳ Technology / System characteristics — E.g.: Decreased dispatchability

↳ Impacts on markets & grids — E.g.: Lower requirements for reserves



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# First ideas for required changes in market design and grid regulation

*List should be explained and prioritized*

- Increased prevalence of complex auctions
- Larger use of discriminatory pricing to give sound long-term market signals
- Nodal pricing
- Rethinking priority of dispatch
- Redesign of flexibility mechanisms
  - Increased participation of demand response
  - Integration and coordination of balancing areas
  - Reduced scheduling intervals



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# Market simulations with PowerACE

- First assessment of market development in Germany
- Scenario is based on **preliminary assumptions** on future development:
  - RES generation increase from 30 % in 2020 to 70 % in 2030 and to 80 % in 2050
  - Fuel prices increases until 2025 and decreases slightly afterwards
  - CO2-price stays below 50 €/t until 2030 and increases above 100 €/t after 2040



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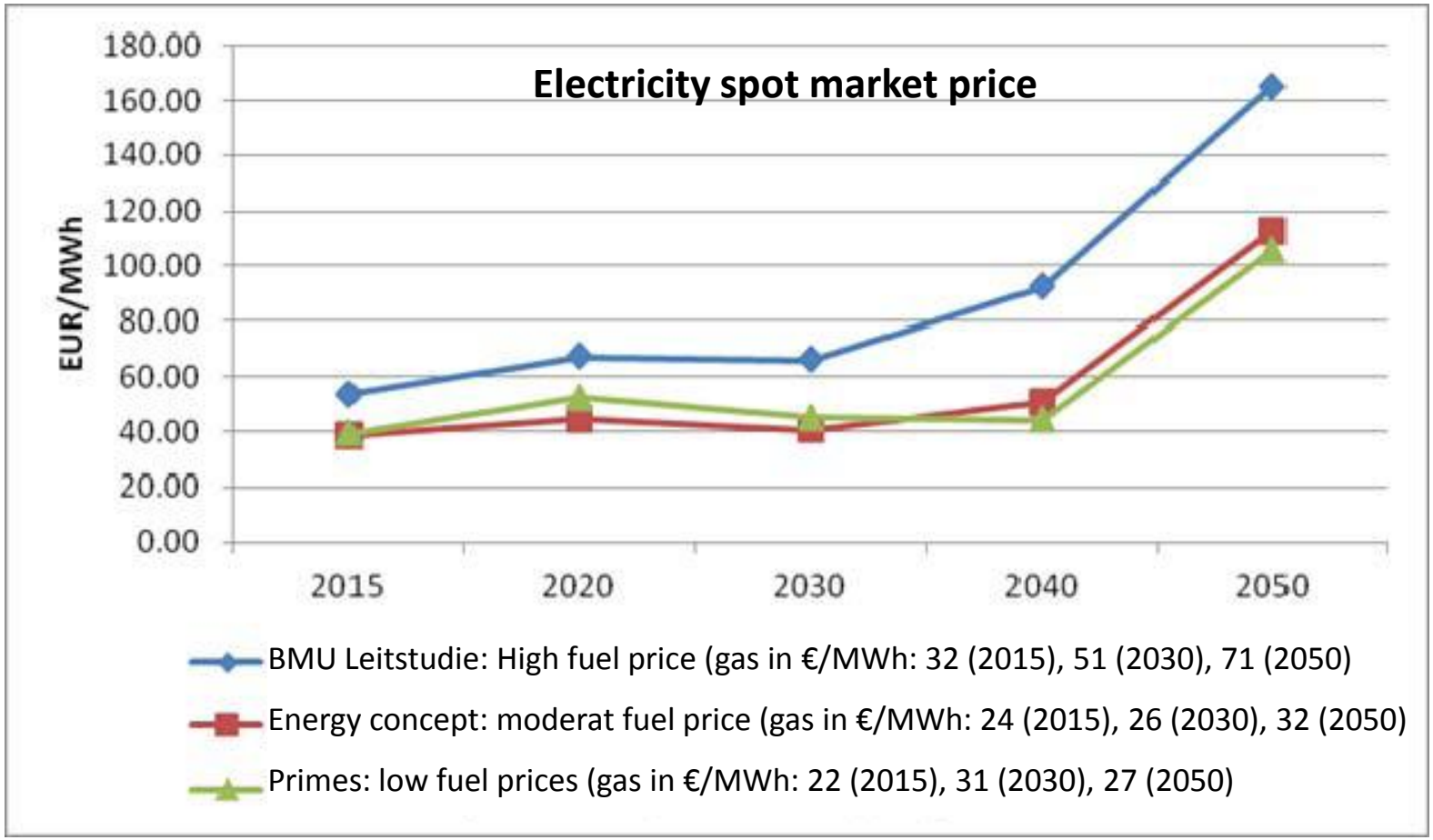
# Market simulations for Germany – Preliminary results




Source: PowerACE Simulation results



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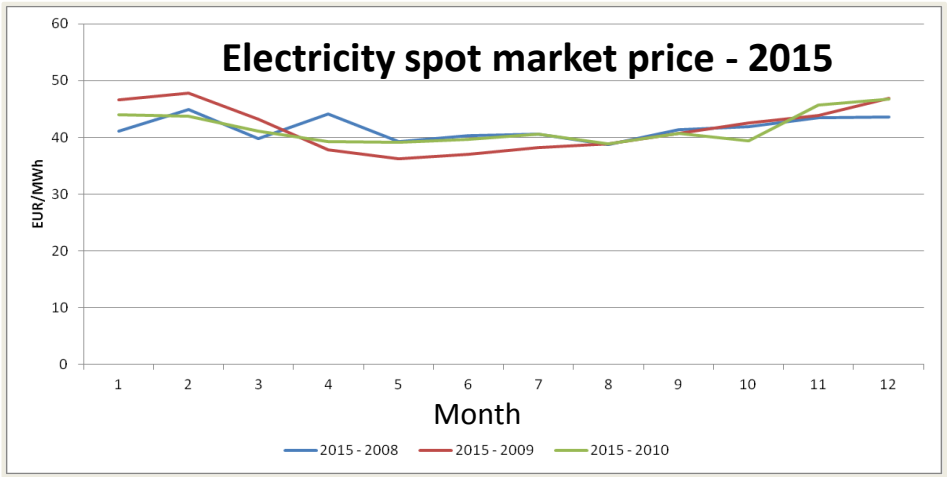
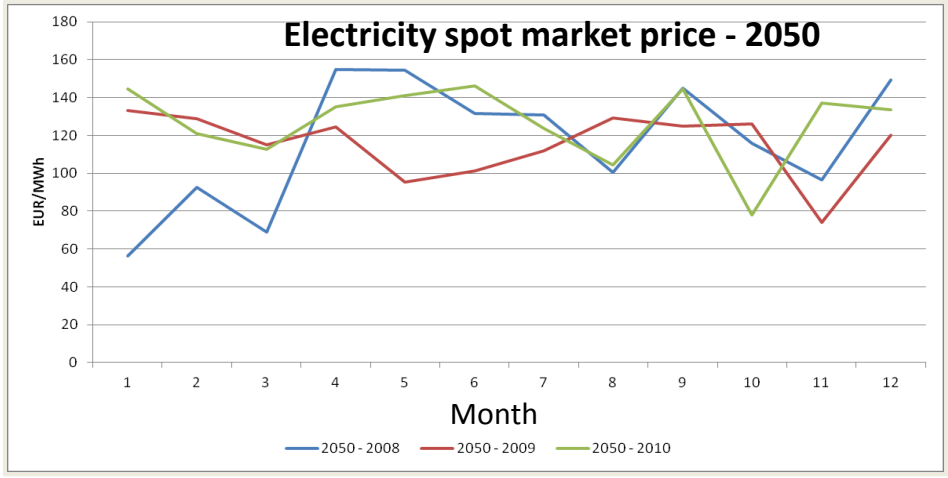
# Preliminary results on market simulations for Germany




Source: PowerACE Simulation results

- Monthly market price in 2015
- Yearly average:
  - 2015_08: 39 EUR/MWh
  - 2015_09: 39 EUR/MWh
  - 2015_10: 39 EUR/MWh

- Monthly market price in 2050
- Yearly average:
  - 2050_08: 108 EUR/MWh
  - 2050_09: 106 EUR/MWh
  - 2050_10: 116 EUR/MWh




Source: PowerACE Simulation results



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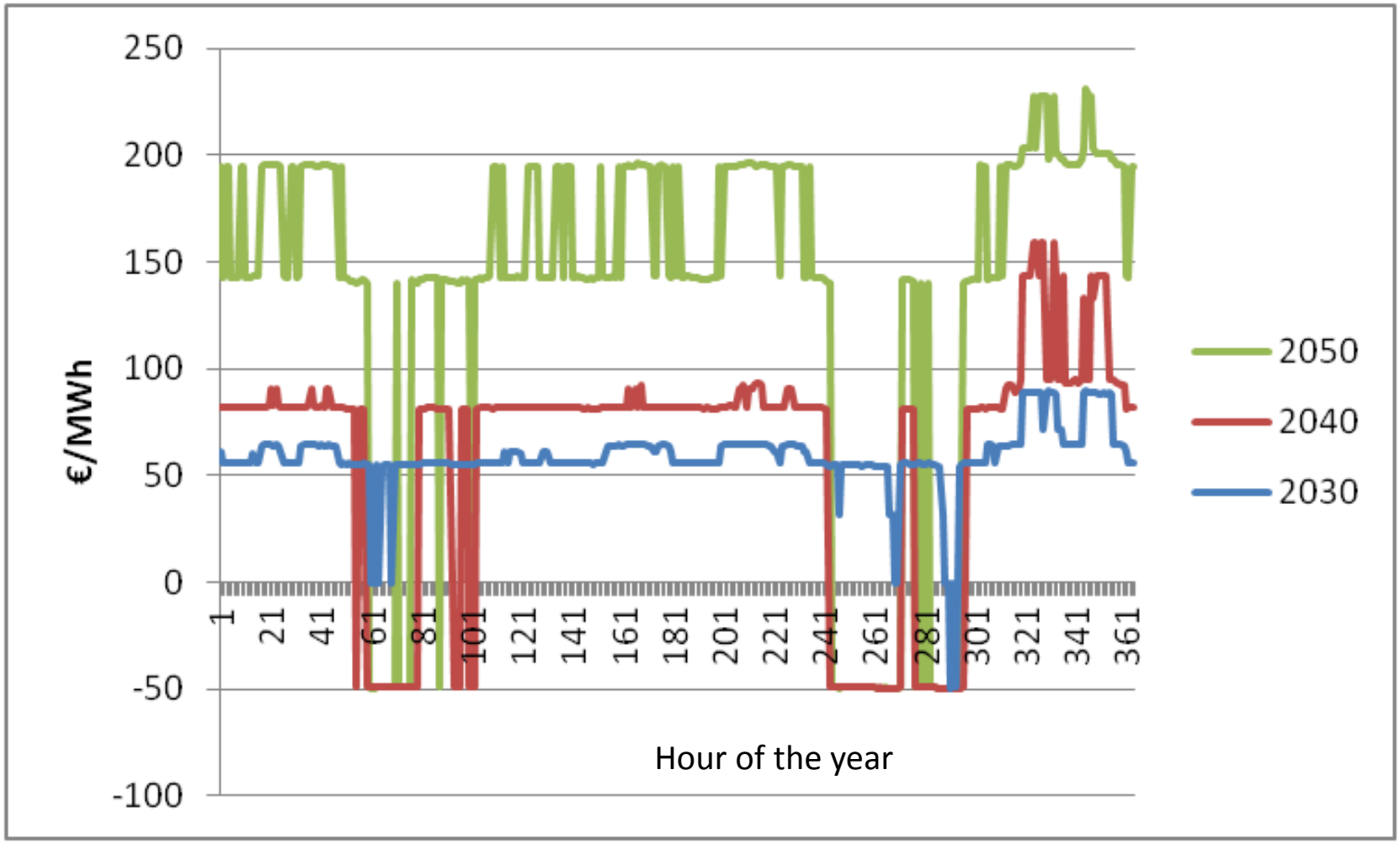
# Simulations of spot market price for Germany




Source: PowerACE Simulation results



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# Market simulations for Germany (preliminary results)

| | | 2015 | 2030 | 2040 | 2050 |
|---|---|---|---|---|---|
| Mean spot market price | €/MWh | 39,34 | 44,89 | 44,22 | 105,68 |
| Spot market price Standard deviation | €/MWh | 11,14 | 33,79 | 61,39 | 97,60 |
| Prices below zero | h | 0 | 865 | 2587 | 2376 |
| RES market value related to mean spot market price | % | 1,00 | 0,82 | 0,58 | 0,71 |

Source: PowerACE Simulation results



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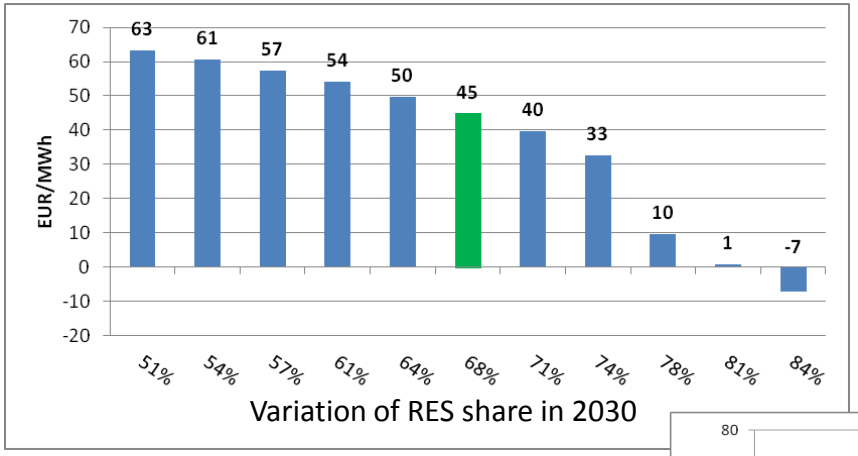
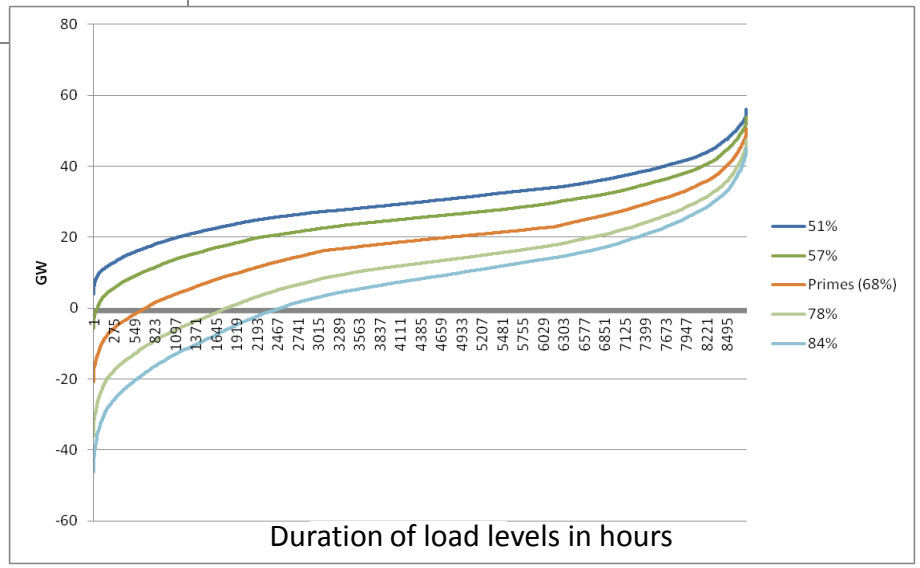
# Impact of RES share on market prices – Analysis for 2030




Source: PowerACE Simulation results

Variation of market prices in relation to RES shares in 2030
Remaining power plant capacity is not changed.

Variation of residual load in relation to RES share in 2030




Source: PowerACE Simulation results



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# Next steps: Quantifying the impacts

| Models | Possible Outputs |
|---|---|
| Power ACE (generation model, regional) | Development of electricity prices, price volatiliy, merit order effect, load profiles, balancing needs |
| LEEMA (generation model, local) | Development of electricity prices, price volatiliy, merit order effect, load profiles, balancing needs |
| Grid models | Congestion and interconnection effects |



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# Draft conclusions on market impacts

- Market impacts are mainly driven by RES shares and geographical distribution and less dependent on policy instruments
- Major driver for spot market prices next to RES deployment are the fuel price developments, $CO_2$-prices,the development of non-RES capacity and grid developments.



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# Thanks for your attention

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