Self-reinforcing electricity price dynamics under the variable market premium scheme

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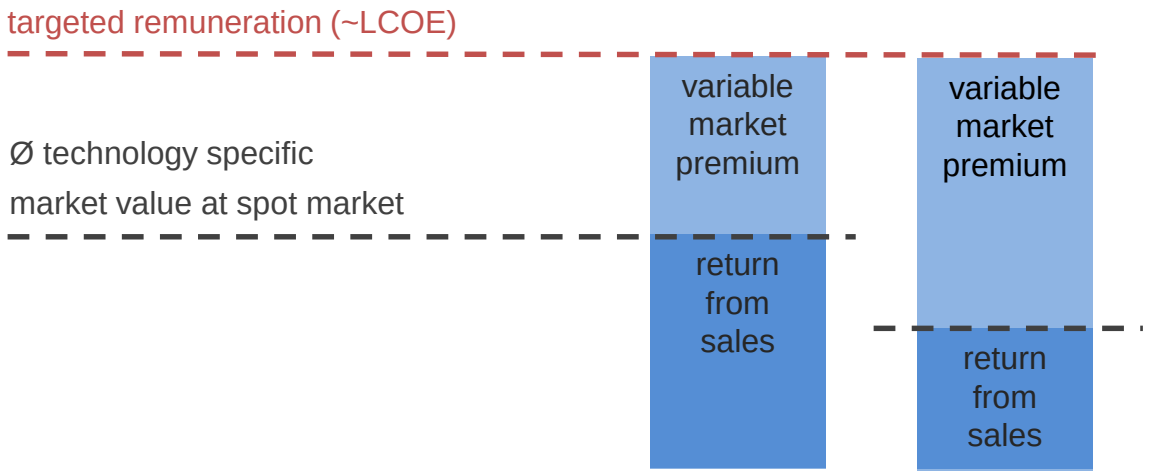
Motivation

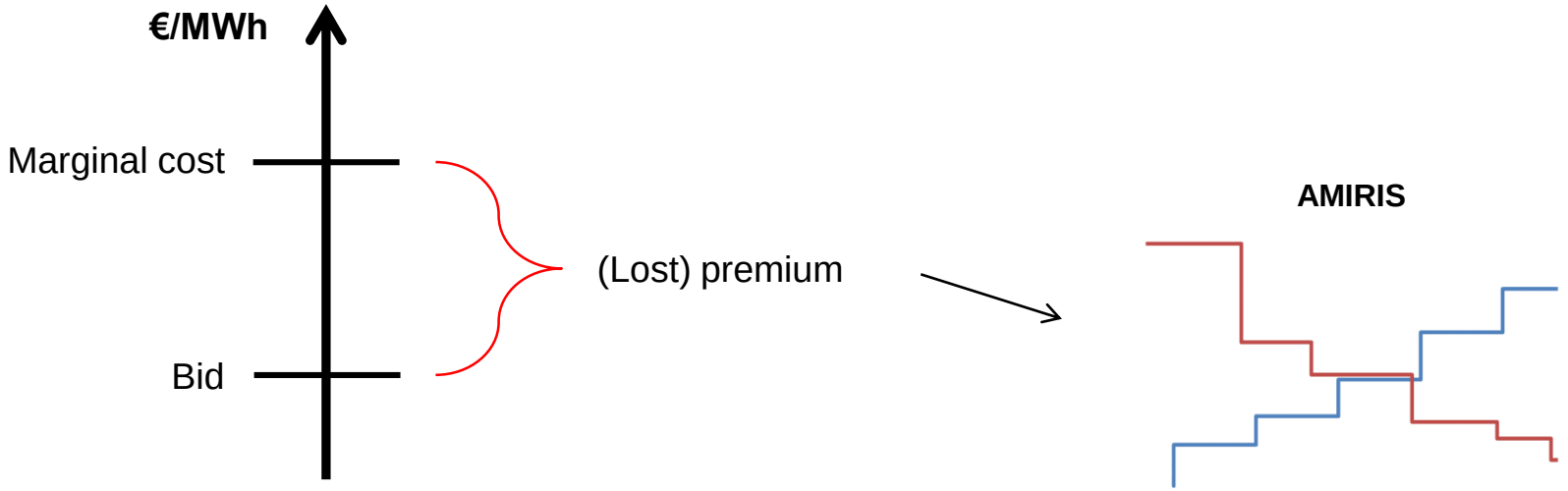
- In a lot of European countries current transition goals comprise very high shares of renewables
- Widely applied instrument: Variable market premium
- **Pre-studies show: Growing shares of variable renewables that receive a market premium put downward spiral of prices and accordingly increasing premia in motion**
- These effects might counteract an effective and efficient further integration of renewables
- Simple and extended scenario analyses with the agent-based electricity market model AMIRIS

Simplified sketch of the variable market premium:



AMIRIS - Agent-based electricity market model
Bidding considers premia

- No higher-level objective function
- Simulation results are generated from the interplay of the actions of the actors depicted as agents
- Hourly resolution, endogenous calculation of wholesale electricity prices
- Strategic bidding behavior of prototyped market actors



‘Simple scenario’: Scenario setup & electricity prices

Scenario setup:

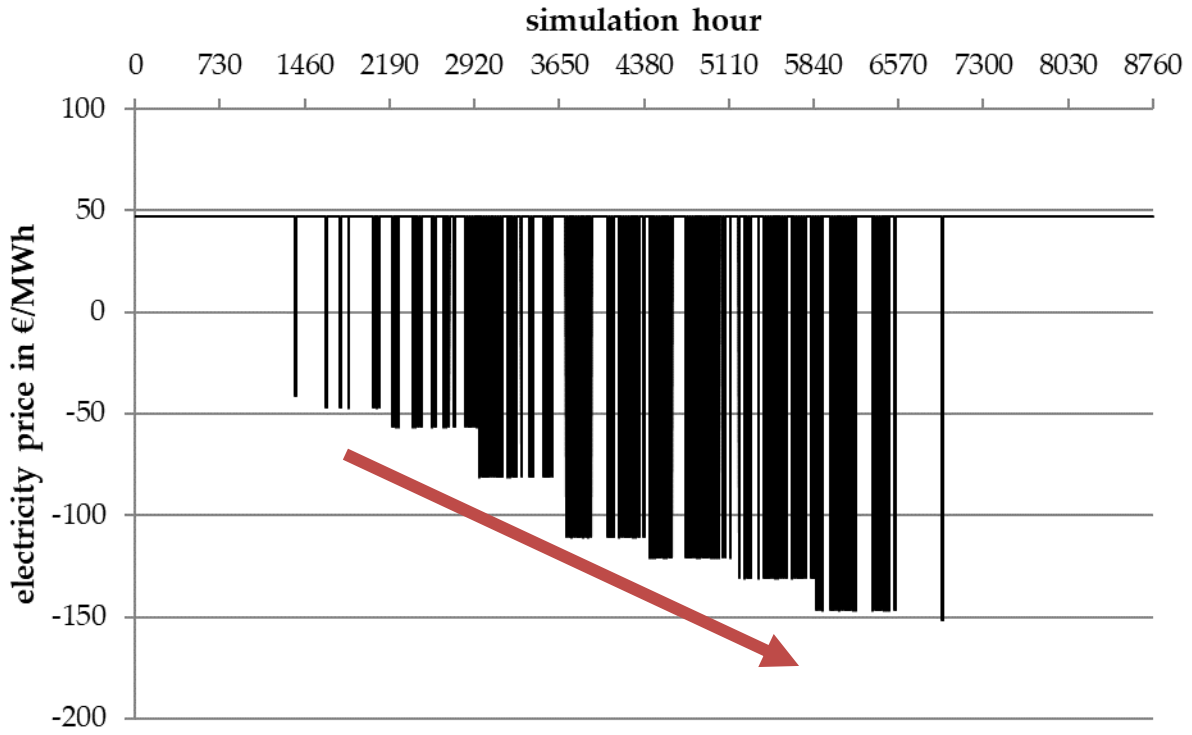
Technology	Capacity in GW
Photovoltaics	200
Gas Power Plant	120

– carbon price: 0 Euro/t

– constant fuel prices

Results at the spot market:

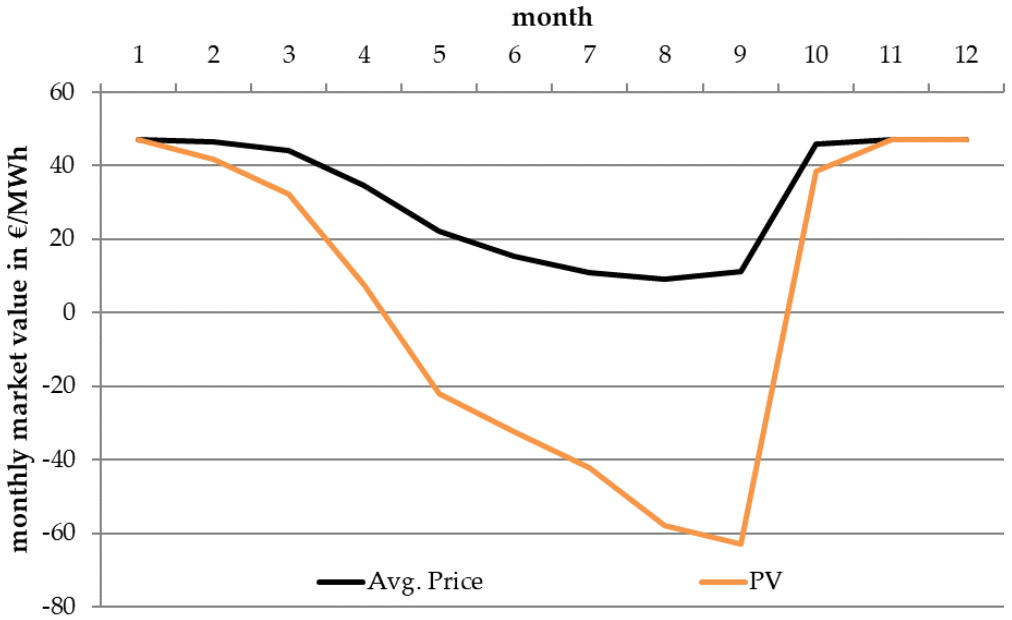
- In hours with a negative residual load, PV becomes price setting
- PV is able to bid at marginal cost minus the variable market premium (of the last month)
- Negative prices occur and continue to decline (as long as PV is able to cover the demand)

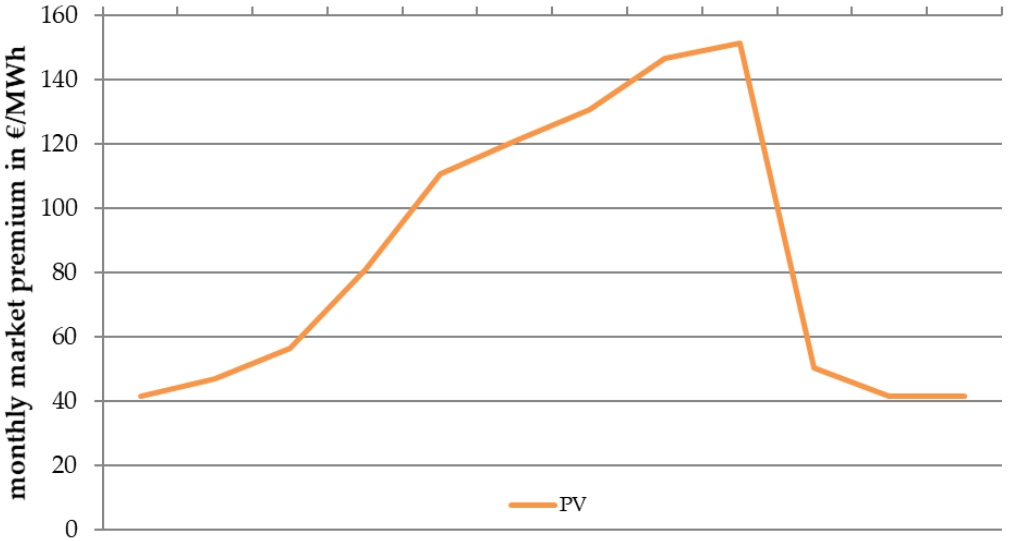


‘Simple scenario’: Results

What happens?

- With decreasing prices, PV’s average monthly market value starts to decline
- To ensure refinancing, the variable market premium needs to be increased to cover the LCOE
- PV bids will include this increased premium and prices become even more negative as long as PV is still price-setting
- This requires another increase of the premium, etc.





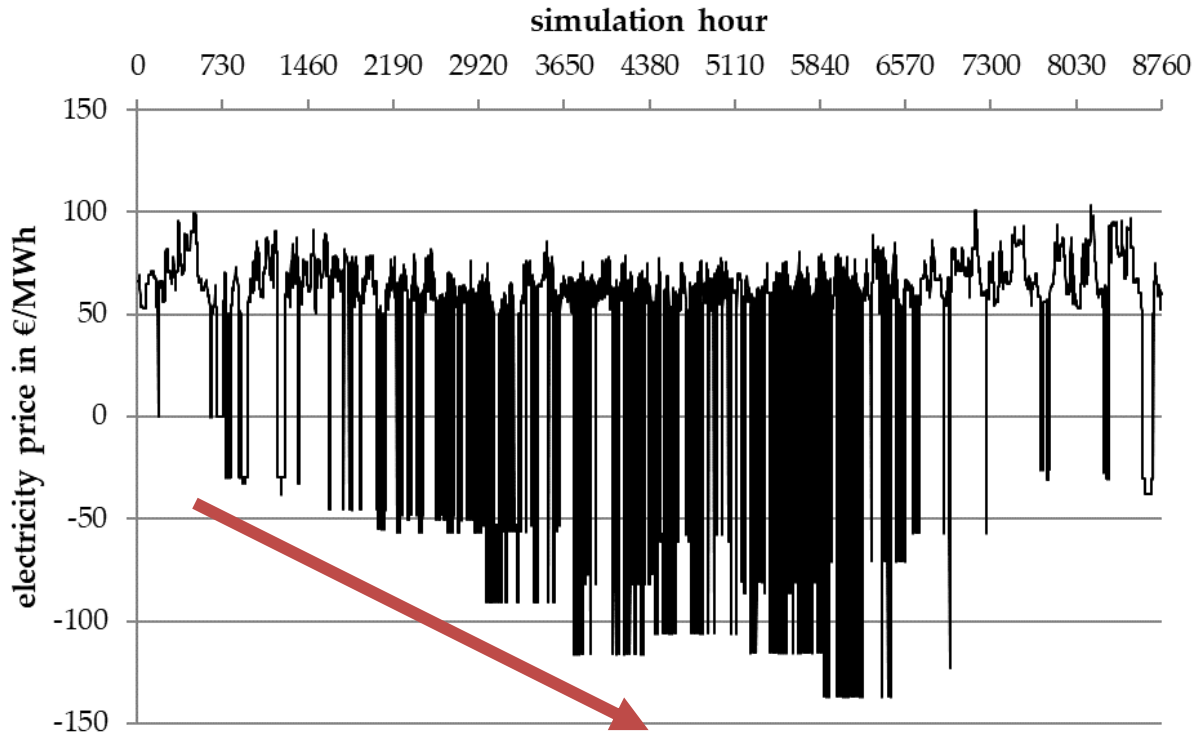
‘Extended scenario’: Scenario setup & electricity prices

Scenario setup

Technology	Capacity /GW
Photovoltaics	200
Wind Onshore	80
Wind Offshore	20
Gas CC	35
Gas Turbine	20
Hard Coal	15
Lignite	10
Storage [1]	20

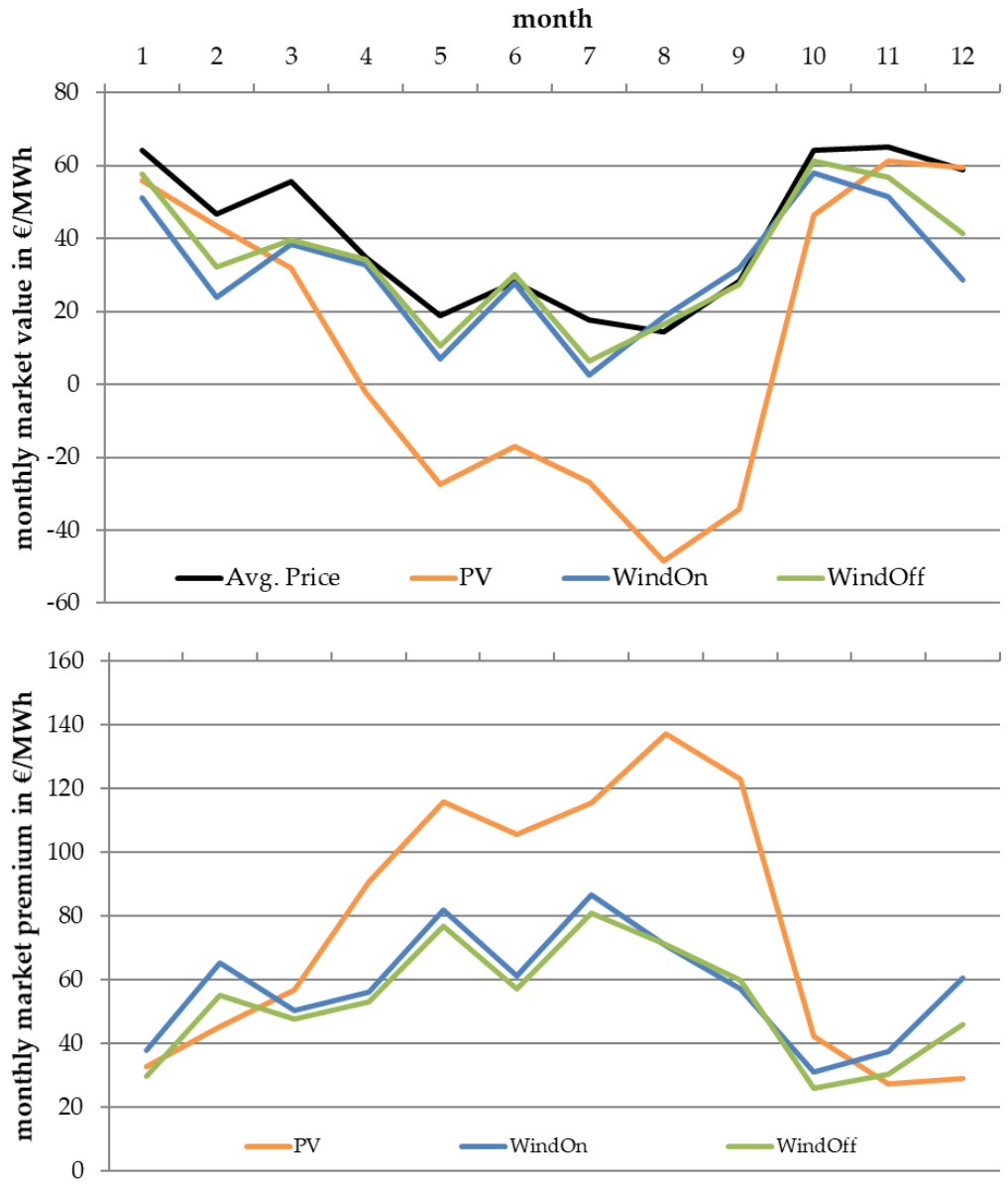
[1] Energy to Power Ratio = 7.

– carbon price: 50 Euro/t
– constant fuel prices



‘Extended scenario’: Results

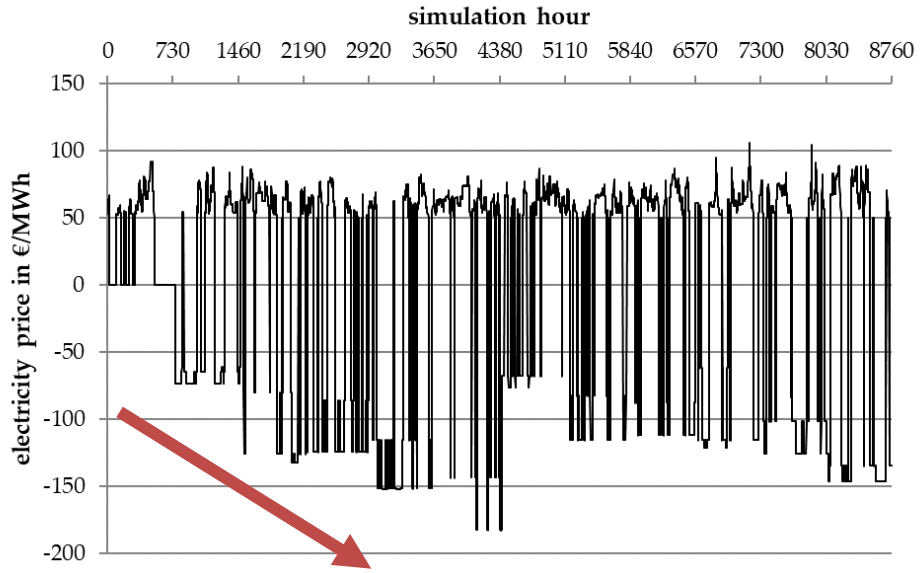
- Results for PV very similar to those of the simple scenario
- Price dynamic gains momentum in month 4, where PV and wind technologies together cover the load for 143 h
- As PV feed-in is more synchronous than wind, market values of PV decrease faster ⇒ position changes to the left end of the merit order
- **Cross effects**: Market value is even further decreased by complementary renewable energy technologies

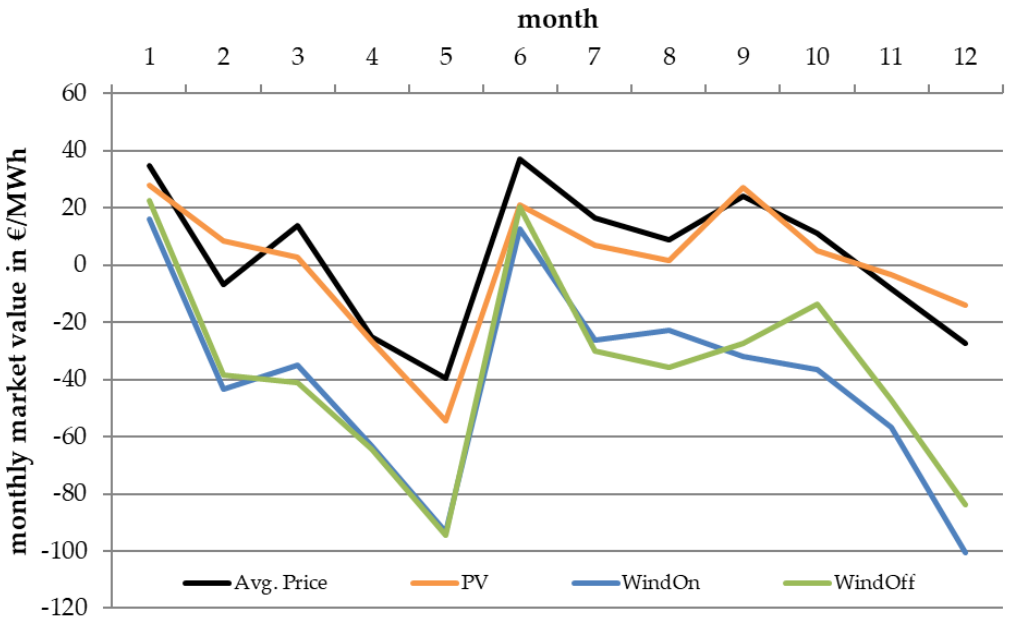


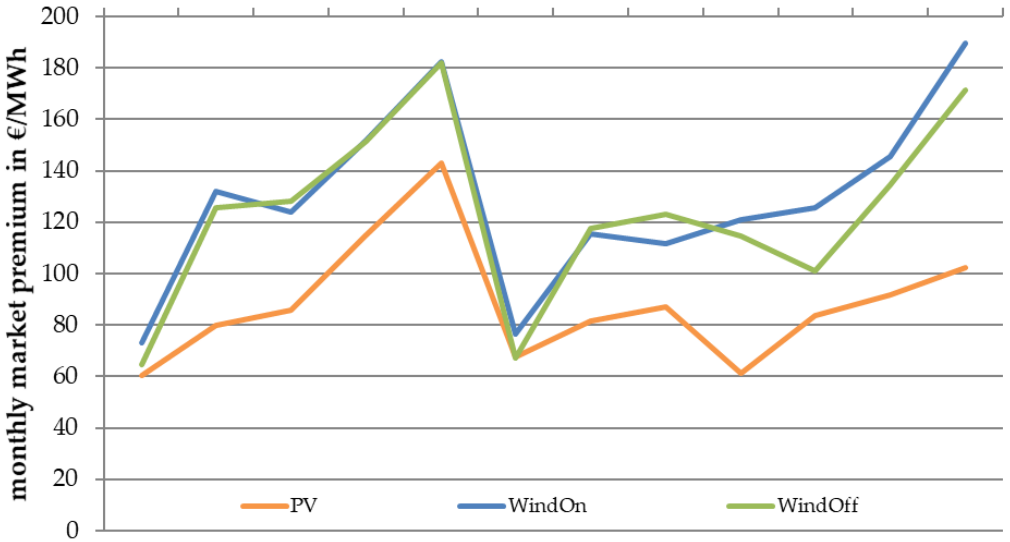
‘High wind scenario’

Technology	Capacity /GW
Photovoltaics	100
Wind Onshore	180
Wind Offshore	40
Gas CC	35
Gas Turbine	20
Hard Coal	15
Lignite	10
Storage[1]	20

[1] Energy to Power Ratio = 7



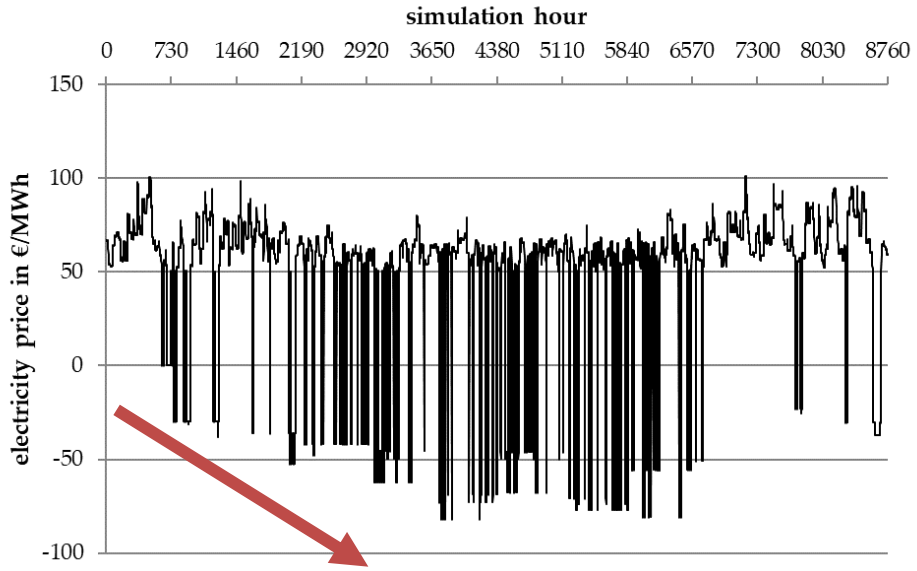


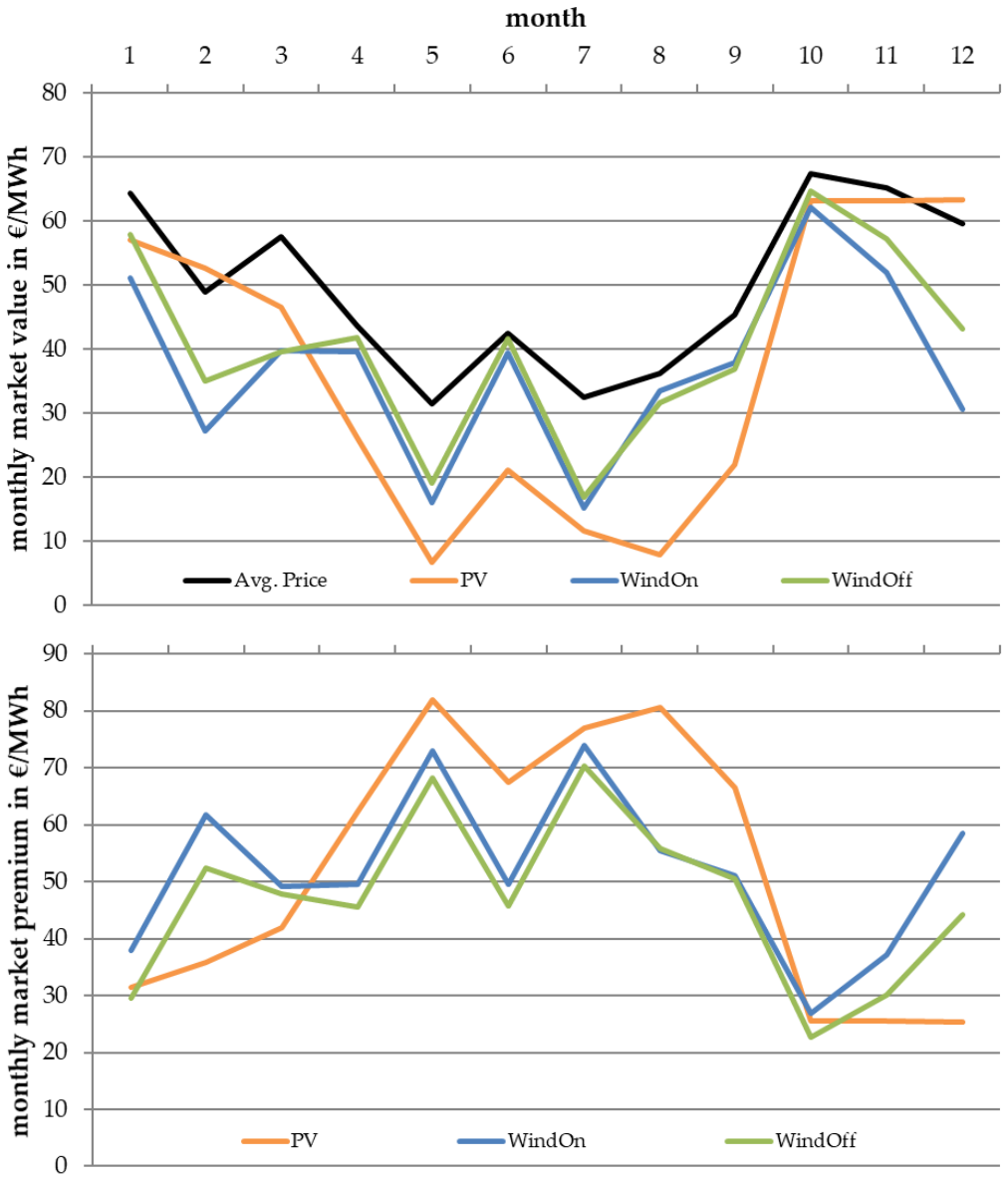


‘High storage scenario’

Technology	Capacity /GW
Photovoltaics	200
Wind Onshore	80
Wind Offshore	20
Gas CC	35
Gas Turbine	20
Hard Coal	15
Lignite	10
Storage[1]	40

[1] Energy to Power Ratio = 7





Discussion

- Model Artefact?
  - Setting bids to equal the marginal cost minus the anticipated market premium increases the probability of being awarded
  - Subsequent balancing of market revenues to the LCOE → negative bidding is virtually risk-free
- Other Influences?
  - Result is robust against different proportions of technologies (see e.g. “High wind scenario’ and ‘High storage scenario’)
  - Growing demand from P2X technologies delays the effect (share of VRE is essential)
- Regulations?
  - Suspension rules, e. g. 4h-rule* in Germany, cap premia at a maximum value, fixed market premia etc. prevent the effect, but have side-effects, esp. for refinancing renewables

* Market premium is set to zero if prices at the day-ahead auction are below zero in 4 and more consecutive hours

Conclusion & Outlook

- Variable market premium seems not to be designed for markets with high shares of variable renewable energies (VRE) due to self-reinforcing feedback loop of electricity prices once VRE become price-setting
- The described dilemma is not trivial to avert in the current market setting:
  - "Voluntary" change in bidding behavior not to be expected
  - Upper and lower limits would jeopardize refinancing
  - Fixed market premium would also entail immense investment risks
- **Is the premium's steering effect at very high VRE-shares still efficient and effective?**
- **How can refinancing be ensured in future?**

Frey, U.; Klein, M.; *Nienhaus, K.*; Schimeczek, C. (2020) Self-Reinforcing Electricity Price Dynamics under the Variable Market Premium Scheme. Energies. doi: 10.3390/en13205350.

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