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:*

- Targeted remuneration (~LCOE)
- Variable market premium
- Ø technology specific market value at spot market
- Return from sales
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           |
| Storage¹       | 20           |

¹Energy 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 \( \Rightarrow \) 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           |
| Storage¹         | 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            |

Energy to Power Ratio = 7

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**Chart 9**

- **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

Energy to Power Ratio = 7

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**Diagram:**

- **Simulation hour:**
  - Electricity price in €/MWh

- **Month:**
  - Monthly market value in €/MWh
  - Monthly market premium in €/MWh

- **Legend:**
  - Avg. Price
  - PV
  - WindOn
  - WindOff

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**Notes:**

- DLR.de • Chart 9 > IAEE 2021 > Nienhaus et al. • Self-reinforcing deflationary price dynamics under the variable market premium scheme
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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