Auctions for Renewable Energies
Model-based Analysis

Marijke Welisch
TU Wien

Vasilios Anatolitis
KIT

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AURES: Who we are

- A coordination and support action under the EU Horizon2020 programme
- Project runs from January 2015 to December 2017
- Eight partners from seven EU countries
- Cooperation with policy makers, market participants and other stakeholders.
AURES project at a glance

AURES combines

- **Target-oriented analysis**
  - empirical analysis
  - interviews with stakeholders
  - lessons from other industries
  - auction experiments
  - simulations in energy models

- **Capacity building activities**
  - workshops
  - webinars
  - case cooperations
  - bi- and multilateral meetings
  - interactive website

...find more information on: auresproject.eu
Research Question

- **How do different auction designs influence auction outcomes?**
  
  - Formally capture the incentive structures of RES investors from auctions and reveal the consequences on societal support costs.
  
  - Strategic behaviour by market participants will be investigated as well as options of the policy maker to modify structures in order to achieve desirable outcomes.
  
  - **Starting point is the analysis of wind power auctions in Germany**.
  
  - From this a modular system will be constructed for Member States to look into their specific auction design planned and potential modifications.
Modelling Framework

Potential auction participant (Agent)

Actor-specific characteristics
- Level of risk aversion (utility function) including the ability to bid strategically
- Budgetary constraints (interest rate, amount and limits)
- Available information about competitors

Auction-design specific characteristics
- Sunk costs (participation fees, contracting land owners, penalties, ...)
- Expected level of competition

Technology-specific characteristics
- Available potentials (location, size, technology) and corresponding costs (assuming risk free interest rate, etc...)
- Point in time of auction (Repetitive auctions)

Offered Bid
- Bid strategy according to theory and own elaborations
- Learn effects

Auction design
- Determines available strategies
- Prequalification criteria (minimum bid size, etc.)
- Diversity targets?
- Criteria based on location, access priority etc.,... ??
- Amount and type of auctioned goods (e.g. energy vs. capacity)
## Auction Specific Design Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Dynamic vs. Static</th>
<th>Multi-criteria vs. Price only</th>
<th>Multi vs. Single-Unit</th>
<th>National vs. European</th>
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</thead>
<tbody>
<tr>
<td>Theoretical implications</td>
<td>Important to model learning as a two step process in the dynamic auction</td>
<td>Start with a one-shot auction (rational agents) and build upon this</td>
<td>Focus on multi-unit (single unit as a special case (mostly wind offshore))</td>
<td>Design criteria change with a larger pool of competitors</td>
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<tr>
<td>Modelling</td>
<td>• There are two types of learning one has to consider:</td>
<td>• Use prequalification criteria or rather quantify different aspects of agents (small actors etc.) and give additional weight to desired criteria</td>
<td>• Auction wind/solar PV and make use of recent auction trials in different Member States</td>
<td>• Begin with national auctions</td>
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<td>o 1. Learning over time (from auction to auction)</td>
<td></td>
<td></td>
<td>• If possible test runs with country-cluster examples</td>
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<td>o 2. Learning in the course of the dynamic auction</td>
<td></td>
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<td>• In 1-2 years, exercise case studies with empirical data</td>
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<td>• Interdependent or Independent Value Model (in dynamic auctions)</td>
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Wind power auctions in Germany

Background Information

• Renewable Power Act (EEG) 2016, Germany implemented auctions in order to determine the future feed-in tariff for the support of renewable energies
• For onshore wind parks, tendering will start in 2017
• Tenders take place for projects that already have a concession via the Bundesimmissionsschutzgesetz (so-called „late tendering“)
• Only a small security deposit of 30 €/kW installed capacity is mandatory
• The project is to be built in the upcoming two years after winning the bid. In case of non-realisation, successive penalties come into place. After three years of non-compliance, the awarded bid is cancelled

Wind power auctions in Germany

Background Information

• Bid has to include amount of power in kW and bid price in ct/kW with two decimal figures
• 2,800 MW annual amount of capacity tendered, minimum size of 750 kW
• Sorting from the lowest price to the highest; equal price, the lower bid of power is preferred; until the cumulative amount matches the demand
• Accepted power amounts are published in detail, the lowest and highest accepted bid are published, together with a weighted average price
• Price limit: 7ct/kW for the first three auctions; from 01.01.2018: the average of the highest accepted bids of the last three auctions + 8%

Wind power auctions in Germany

Model Features

• The first round for wind power in Germany, taking into account the country-specific agent distribution:
  • Financial investors (10-50 MW), Community wind projects (3-18 MW), Project developers (15-50 MW)
  • Costs are assumed to be the same for both and randomly distributed between 5.9 and 6.7 ct/KWh

• If an agent’s bid wins, he does not participate in the next auction; new draws for every auction round

• Learning of agents over several rounds
  • 7 years as foreseen in the German EEG, 2,800 MW per year, three rounds per year
  • Agents adapt their bidding behavior according to the previous results
  • Uniform pricing and pay as bid has been implemented and compared
Wind power auctions in Germany

• The agent maximizes his expected utility taking into account the possibility to win in one of the following rounds

• $T = 0$:

$$E(u(b)) = (b_0 - c) \cdot (1 - F(b_0))$$

• $T > 0$:

$$E(u(b)) = (b_0 - c) \cdot (1 - F(b_0)) + \sum_{t=1}^{T} \delta^t \cdot (b_t - c) \cdot \prod_{x=1}^{t} F(b_{t-x})$$

$b_t = \text{bid}; c = \text{costs}; F(.) = \text{cumulative distribution function of the marginal bid}$
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Preliminary results

• The bid vector is calculated in every round by using the “Truncated Newton (TNC) algorithm”. So far, the algorithm and model generate realistic values:
  • Uniform:
    • Within each bid vector, the corresponding bids are decreasing in each round, i.e. the later an auction takes places, the more aggressive the bids become for each agent
    • The current bid ($b_0$) – which is solely important for the model – can be observed to decrease ceteris paribus in every round for each bidder
  • Pay as Bid:
    • In the first rounds, we observe an increase in the average price, as the “cheapest” bidders drop out
• A direct comparison is not yet possible, but policy conclusions are forthcoming
Wind power auctions in Germany

Preliminary results: Pay-as-Bid

Price development over six auction rounds; average prices in ct/kWh, upper left to lower right graph:

1. 6.37
2. 6.5
3. 6.57
4. 6.6
5. 6.59
6. 6.48
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Preliminary results: Uniform

Price development over six auction rounds; Prices in ct/kWh, upper left to lower right graph:

1. 6.19
2. 6.17
3. 6.09
4. 6.05
5. 6.0
6. 6.0
Next steps

- August 2016: Simulate PV Auction for Germany to verify results in comparison with test rounds executed in 2016
- December 2016: Implement modular stand-alone tool to model different designs and market situations (open source to trigger interest discussion on assumptions)
- Construct case studies and compare to actual data from auction results if available
Any Questions?
Thank you!

Contact

Marijke Welisch
Researcher
Gusshausstr. 25-29
1040 Wien
welisch@eeg.tuwien.ac.at
+43-1-58801 370365

Project coordination:

Lena Kitzing
Researcher
Frederiksborgvej 399
DK-4000 Roskilde
lkit@dtu.dk
+45 24 65 90 64

Communication and web:

Michael Minter
Head of Secretariat
Kattesundet 4, 3rd floor
DK-1458 København K
mm@concito.dk
+ 45 26 16 64 14

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