How do capacity markets affect demand flexibility: Welfare effects of dynamic capacity pricing

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MOTIVATION
Motivation

Research Questions

• How to ensure both resource adequacy and dynamically efficient deployment of flexibility options?

• **Capacity Market Design:** How should consumers pay for adequate generation capacity? What is the welfare effect of time-variable capacity pricing?

• Are welfare effects of dynamic pricing pronounced in a system with large capacities of fluctuating renewables?
Method: Model Basic Framework
Borenstein & Holland (2005), Hunt Alcott (2012)

- **Two-Stage-Entry** model of a perfectly competitive
  1. Electricity wholesale market
  2. Retail market
  3. Forward capacity market
     - Exogenous reliability constraint = exogenous capacity reserve margin (RM);
     - Discriminatory (only dispatchable generation technologies)

- **Total electricity demand** = Price-elastic + Price-inelastic demand

- **First Stage**: Capacity investment decisions
  - Atomistic generators maximize annual revenues from energy (and capacity) sales under perfect foresight

- **Second Stage**: Output, Pricing and consumption decisions
Method: Model Setting Alcott (2012)
Two capacity pricing regimes

1. **Time varying cost-pass-through** (DICAP):
   - In addition to their electricity bill, customers pay a dynamic tariff for capacity according to the time varying scarcity of capacity (Bindingness of RM-Constraint);

2. **Constant cost-pass-through** (CICAP): Customers face a flat tariff for capacity on top of each unit of electricity consumed.
Method: Main Mechanism
“Excess” capacity entry under CICAP
Method: Main Mechanism

Effect of different capacity pricing regimes on retail prices

<table>
<thead>
<tr>
<th>Price [€/MWh]</th>
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<tbody>
<tr>
<td>0.00</td>
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<td>20.00</td>
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<td>120.00</td>
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- Energy & Capacity Price DICAP
- Energy & Capacity Price CICAP
- Energy Price
- Constant Capacity Adder
- Dynamic Capacity Adder
Method: Numerical Analysis

- Mixed Complementary Problem (**MCP**) in GAMS [NLP, work in progress];
- Model calibrated to **German**
  - clearing **price and load data (2010)**,
  - **RES infeeds/availability factors (2010)**;
- Time resolution: **6000 hours** [one full year, work in progress];
- **Scenarios (preliminary):**

<table>
<thead>
<tr>
<th>Comparative Statics (Welfare)</th>
<th>High RES share</th>
<th>No Res</th>
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</thead>
<tbody>
<tr>
<td>DICAP</td>
<td>High Cost DR</td>
<td>Low Cost DR</td>
</tr>
<tr>
<td>RTP Share</td>
<td></td>
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<tr>
<td>CICAP</td>
<td>RTP share</td>
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PRELIMINARY RESULTS
INCREASING RTP UNDER DICAP
Preliminary Results: Increasing RTP Share under DICAP
Total Capacity Entry and Technology Portfolio
Preliminary Results: Increasing RTP Share under DICAP
Total Capacity Entry and Technology Portfolio
Preliminary Results: Increasing RTP Share under DICAP
Decreasing Reduction of Total Capacity Entry
Preliminary Results: Increasing RTP Share under DICAP
Increasing Total Welfare (decreasingly)
PRELIMINARY RESULTS
CHANGING FROM CICAP TO DICAP
Preliminary Results: (Alcott 2012)
Capacity Entry
Preliminary Results: Change from CICAP to DICAP
Change in Total Capacity Entry/Differed by Technology
Preliminary Results: (Alcott 2012)

Welfare Change

Energy Only for Different RTP Shares

Max Price (log($/MWh)), Entry (GW)

Share of Consumers on RTP ($/year)

- log(Energy Only Max Price)
- Change in Entry from EO
- Change in Welfare from EO
- Change in Welfare from RTP
Preliminary Results: Change from CICAP to DICAP
Change in Total Welfare
CONCLUSION
Conclusion

- **Replication** of previous model results (Alcott 2012):
  1. Increasing RTP share decreases total (peaker) capacity entry;
  2. Increasing RTP share increases total welfare;
  3. *Welfare gains from changing to DICAP much higher than from increasing RTP share (not shown here!)*;

- **New Results** w.r.t. Low/High RES-System Comparison for DICAP:
  1. *Higher decrease in total capacity entry* from increasing RTP shares in low RES-Market;
  2. **But**, (dispatchable) **peaker-capacity-exit** is almost the same; RES entry partially compensates exit more than coal entry in low RES-market;
  3. **Welfare/Welfare gains from RTP** much higher in High RES-market;
  4. Changing from CICAP to DICAP reduces total & peaker capacity entry approximately by the same amount for each RTP share;
  5. **But**, Welfare gains from changing from CICAP to DICAP much higher in High RES-market; *Higher surplus change for RTP consumers???

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References

**Alcott, H., 2012.** *Real-Time Pricing and Electricity Market Design*. Working Paper, NYU (March). Available at:
