Analysis of Strategic Bidding Behaviours and Design of the UK Capacity Market

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Presentation Scope

Key Questions
- What can UK learn from US Capacity Mechanisms?
- Was bidding in UK Capacity Market rational?

Project Constraint
- Publicly available data
UK 2014 T-4 Capacity Auction

Brief Background

“The price went so low that the only those companies operating existing storage sites unburdened by construction debt.”

– Quarry Battery Company

“Natural Gas is the technology winner in this week’s UK Capacity Market auction with 45% of awards.”

- Mark Burnett
  Senior Advisor Energy & Climate
Lessons for UK from US Capacity Markets

Selected Markets

- New York Independent System Operator (NY-ISO)
- Pennsylvania New Jersey Maryland Interconnection (PJM)
Qualitative Analysis

- Main market design features
- Analysis of historical results
- Two principal design features significant to auction results
  - Penalty Mechanisms
  - Interconnectors
## Lessons for UK from US Capacity Markets

### High Level Comparison

<table>
<thead>
<tr>
<th>ISO-NE</th>
<th>PJM</th>
<th>NYISO</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward Capacity Auction. 3 year forward</td>
<td>Base Residual Auction. 3 year forward</td>
<td>Short-term Auctions held bi-annually and monthly</td>
<td>Forward Capacity Auctions 4 year forward</td>
</tr>
<tr>
<td>Volume-based, market wide Sloping demand curve</td>
<td>Volume-based, market wide Sloping demand curve</td>
<td>Volume-based, market wide Sloping demand curve (spot auction, locational)</td>
<td>Volume-based, market wide Sloping demand curve</td>
</tr>
<tr>
<td>4 External Interfaces</td>
<td>20 External Interfaces</td>
<td>4 External Interfaces</td>
<td>No external interfaces for 2014 T-4 (will be included for 2015 T-4 Auction)</td>
</tr>
</tbody>
</table>
Lessons for UK from US Capacity Markets
Key Clearing Price Movements

ISO-NE Forward Capacity Auction Results

PJM Base Residual Auction Results
BRA Clearing Prices in the RTO

NYISO Strip Auction Results
Lessons for UK from US Capacity Markets
Penalty Mechanisms – Analysis

<table>
<thead>
<tr>
<th>Region</th>
<th>Penalty Mechanism</th>
<th>Cap</th>
</tr>
</thead>
<tbody>
<tr>
<td>PJM (2007 – 2015)</td>
<td>Daily Deficiency Rate x Daily Commitment Shortage</td>
<td>No Cap but payment even for non-delivery</td>
</tr>
<tr>
<td>NYISO (1999 – 2003)</td>
<td>3 x Annualised Cost New Peaking Unit/MW</td>
<td>Fixed Charge</td>
</tr>
<tr>
<td>UK (From 2014)</td>
<td>1/24th Auction Clearing Price (£/MWh)</td>
<td>Monthly: 200% Annually: 100%</td>
</tr>
<tr>
<td>ISO-NE (From 2015)</td>
<td>Performance Payment Rate x [Dispatching MW – Capacity Supply Obligation] x Balancing Ratio</td>
<td>Monthly: [1.6 Net-CONE] x CSO Annual: 3 x Max Monthly Loss</td>
</tr>
<tr>
<td>PJM (Proposed)</td>
<td>Non-Shortage Hours: [Net CONE x 365] /350 Shortage Hours: $2,700 / MWh</td>
<td>Event: 0.5 x Net CONE Annual: 1.5 x Net CONE</td>
</tr>
<tr>
<td>NYISO (From 2003)</td>
<td>1.5 x Market Clearing Price x Monthly Shortfall in Capacity Obligation</td>
<td>Fixed Charge</td>
</tr>
</tbody>
</table>
Lessons for UK from US Capacity Markets
Penalty Mechanisms – Recommendations

- Two-Settlement Mechanism: Penalty Charge for Non-Delivery + Performance Payment
- Performance Payment Financed by Penalty Charge
- DO NOT Cap Penalty at 100% Annual Capacity Revenues
- Penalty Charge should be a Function of Net CONE
Lessons for UK from US Capacity Markets

Interconnectors – US vs. UK Analysis

US Markets
- ISO-NE: ~5% (~1600 MW); NYISO: 2.8% (1090 MW); PJM: 4% (7483 MW)

External Generators Participation
- Both face similar rules as local actors
- Interconnectors vs. External generators participation

Conditions to Demonstrate Availability
- Stricter in US to ensure reliability

Contracts
- Exclusively bound to the specific market
- Import limits to avoid speculative bidding.

- Clear investment signal
- Gaming risk decreased
- Administrative burden decreased
- Supply security reduced
- Problem of EU market coupling algorithm

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EU and UK Markets

- Implicit vs. Explicit participation

EU main challenges:
- Cooperation vs. National supply security
- Potential lucrative gains

FR/DE/IT main challenges:
- Control of foreign capacities
- Equivalence MS commitment
- Uncertain de-rated factors
- Foreign TSO Involvement
Lessons for UK from US Capacity Markets
Interconnectors – Recommendations

**BREXIT**
- Incentivise national investments
- Continue explicit participation (1-yr)
- CBA on generator participation
- Implement import limits

**UK Remains EU MS**
- Continue explicit participation (1-yr)
- Implement import limits
UK 2014 T-4 Strategic Bidding Behaviour
General Methodology

Micro-analysis - CMUs Profitability Model

Profitability

Revenues

Wholesale Market

Balancing Market

Costs

CAPEX

New build: Pre-development, construction costs

Refurbishing costs

Fixed O&M, transmission, decommissioning costs

OPEX

Variable O&M, fuel, carbon costs
**Micro-analysis**
- Discounted individual CMU profits over 2015-2018 (10% discount factor) vs. Discounted 2014 auction clearing price (£14.58/kW/year)
- Classification of bidding behaviours at CMUs level as:
  - Apparently Rational
  - Apparently Irrational

**Macro-analysis**
- Bidders’ portfolio analysis:
  - Technology mix impact on auction results
Monte-Carlo Simulation

Rationale
- Public data only: DECC, PB, ELEXON, NG, IPCC AR5, DUKES, UK ERC
- Bidders’ imperfect information

Variables
- Electricity price
- Fuel costs \( \text{Normal distribution with } +/- 0.5 \text{ s.d.} \)
- Load factors
- Balancing revenues \( \text{Uniform distribution with } +/- 25\% \).
UK 2014 T-4 Strategic Bidding Behaviour
Technology Specific Methodology

CCGT Methodology
- CMUs’ efficiencies differentiated by age
- Load factors calculated as a linear function of efficiency

Coal Methodology
- PLATTS’ dark spreads used to adjust DECC’s coal prices
- Sensitivity analyses show that:
  (i) more economical to refurbish in 2017 than in 2015
  (ii) more profitable to generate at high load factors until 2018/19 than at low load factor until 2023
# UK 2014 T-4 Strategic Bidding Behaviour
## Classification of CMUs based on Model

<table>
<thead>
<tr>
<th>Apparently Rational (AR) CMUs</th>
<th>“Profitable” CMUs</th>
<th></th>
<th>“Unprofitable” CMUs</th>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Breakeven Payment Required (£/kW/yr) &lt; Clearing Price</td>
<td>Secured agreement</td>
<td>Breakeven Payment Required (£/kW/yr) &gt; Clearing Price</td>
<td>Did not secure agreement</td>
<td></td>
</tr>
<tr>
<td>“Profitable” CMUs</td>
<td>120</td>
<td>(55.8%)</td>
<td>31</td>
<td>(14.4%)</td>
<td></td>
</tr>
<tr>
<td>“Unprofitable” CMUs</td>
<td>5</td>
<td>(2.3%)</td>
<td>59</td>
<td>(27.4%)</td>
<td></td>
</tr>
</tbody>
</table>
UK 2014 T-4 Strategic Bidding Behaviour
CCGT Discussion – Centrica

% chance to breakeven with CM price MCS
Centrica

Red = Not secured CM agreement
Green = Secured CM agreement

King's Lynn  0.0%
Brigg       17.8%
Killingholme 24.1%
Peterborough 24.0%
South Humber 1 41.3%
Barry       53.6%
South Humber 2 56.1%
Langage   86.1%
Thornhill, Sandbach, Connah’s Quay (E.On)

- MCS analysis
- CMUs exited at 13%
- Secured at 35.5%
- Potential optimistic view

Trafford (Wainstones)

- £590/kW/year
- Attributed to our methodology
- High levels of optimism
- GE’s latest 9HA tech
- Industry leading efficiency and flexibility
UK 2014 T-4 Strategic Bidding Behaviour
Coal/Biomass Discussion

- Hedging: West Burton A and SSE
- Opting out: Biomass and Longannet
UK 2014 T-4 Strategic Bidding Behaviour
Analysis of Bidder Portfolio of CMUs

<table>
<thead>
<tr>
<th>CCGT</th>
<th>Coal/Biomass</th>
<th>CHP</th>
<th>OCGT</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Centrica, Wainstones, Thorpe Marsh, Intergen, Seabank, ESB</td>
<td>• Eggborough, Drax</td>
<td>• VPI</td>
<td>• UKPR</td>
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</table>

<table>
<thead>
<tr>
<th>CCGT</th>
<th>Coal</th>
<th>CHP</th>
<th>OCGT</th>
<th>Nuclear</th>
<th>Hydro</th>
<th>Storage</th>
<th>Number of types</th>
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<tr>
<td>MPF</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
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<tr>
<td>RWE</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
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<td>3</td>
</tr>
<tr>
<td>EDF</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
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<tr>
<td>E.On</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>SSE</td>
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<td>x</td>
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<td>x</td>
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<td>SP Group</td>
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<tr>
<td>GDF</td>
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<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td>5</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Number of technology types</th>
<th>CMU</th>
<th>MW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average success</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>1</td>
<td>52.72%</td>
<td>44.84%</td>
</tr>
<tr>
<td>2</td>
<td>100.00%</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>100.00%</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>89.66%</td>
<td>9.75%</td>
</tr>
<tr>
<td>5</td>
<td>88.49%</td>
<td>2.28%</td>
</tr>
</tbody>
</table>

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UK 2014 T-4 Strategic Bidding Behaviour
Modelled Offer Curve

Breakeven Capacity Payment (£/kW/y)

Offer curve (red)

OCGT
CCGT
Coal/Biomass

Pumped Storage

Nuclear, hydro, CCGT, Coal/Biomass, OCGT

49,3 GW

Derated Capacity (MW)
Conclusion
Lessons for UK from US Capacity Market

- **Penalty Mechanisms**
  - Current UK mechanism only provides minimum incentive
  - Recommend two settlement mechanism and increased penalty cap

- **Interconnectors**
  - Recommendations depend on upcoming referendum
  - Explicit Interconnector participation to provide investment incentives while maintaining control with one-year agreements
  - Establishing import capacity limits to prevent speculative bidding
Conclusion
UK 2014 T-4 Strategic Bidding Behaviour

- Classified as Apparently Irrational and Apparently Rational
- Apparently Irrational behaviour due to future optimism and other revenues
- Portfolio analysis of bidding companies demonstrate advantages of having large range of technologies