A Primer on Capacity Mechanisms

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Electricity markets at a cross-road:

- Deployment of renewables needed for the low-carbon transition
- Renewables depress market prices
- Reduce profitability and increase risk of conventional technologies

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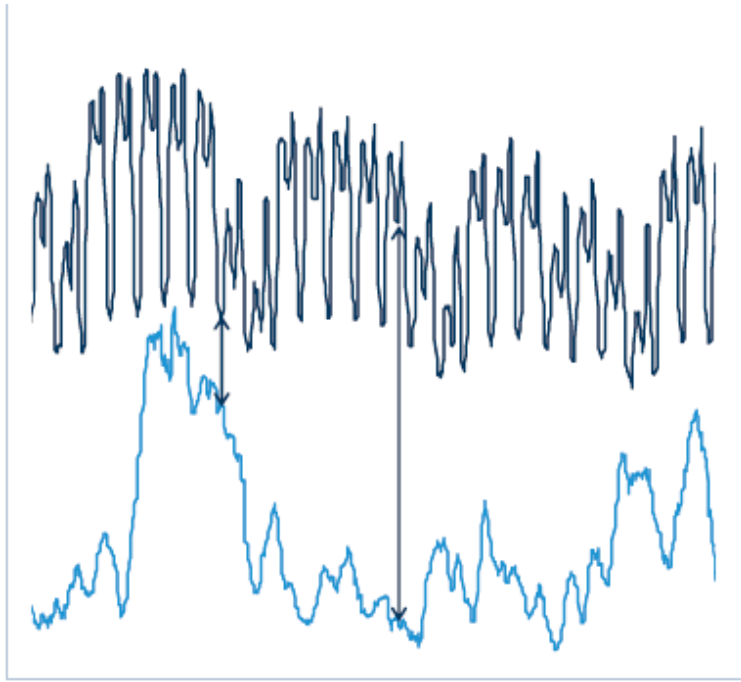

Figure 1: electricity demand (dark blue) and renewables (light blue)

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Introduction

Are the current arrangements well suited to induce adequate investments?

February 2010, **Ofgem**:

"There is a need for unprecedented levels of investment to be sustained over many years in difficult financial conditions and against a background of increased risk and uncertainty...Ofgem does not consider that leaving the current arrangements unaltered is in the interests of consumers."

The UK capacity market: demand

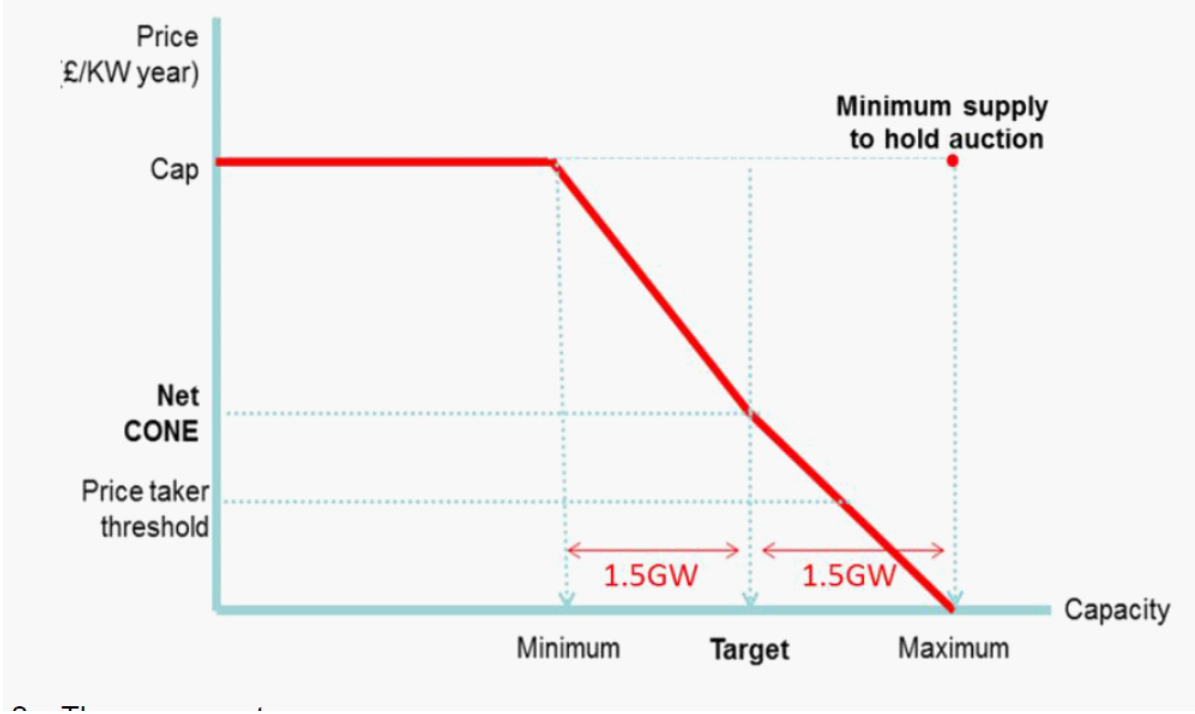

Figure 2: Demand in the UK capacity market

The UK capacity market: results of first auction

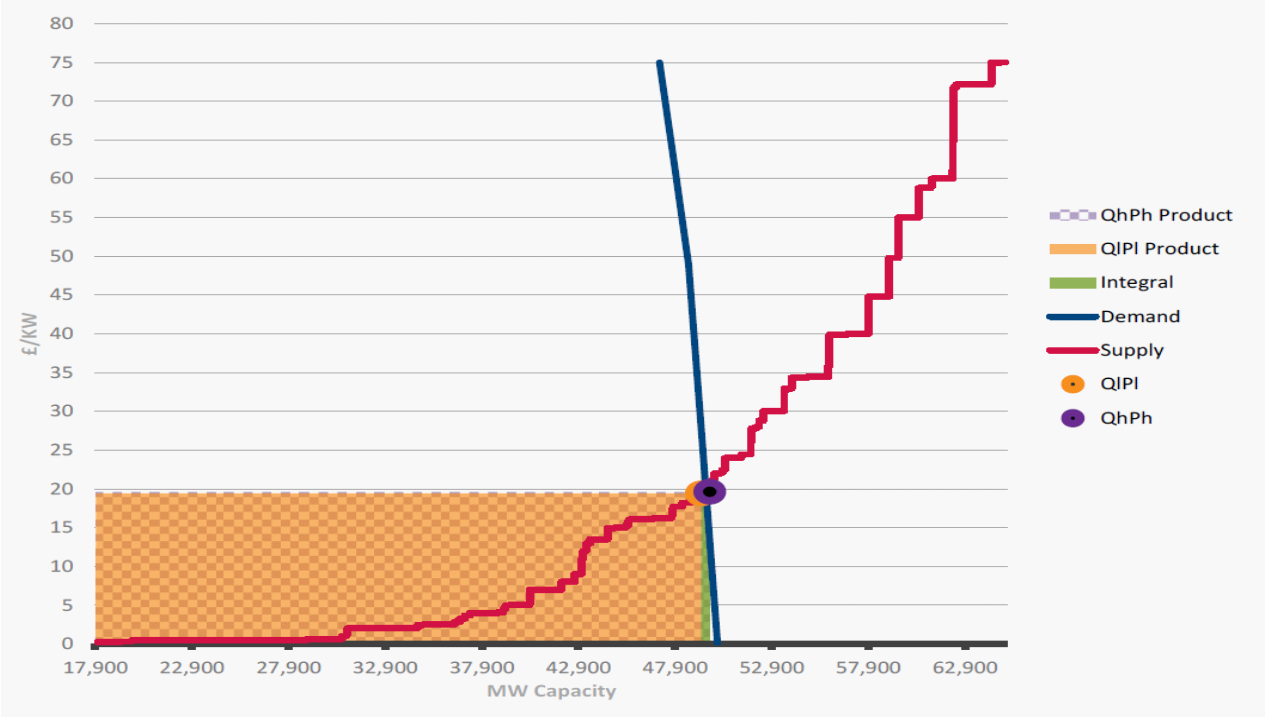

Figure 3: Result of 1st capacity auction in the UK (Dec. 2014)

A patchwork of solutions

- **UK:** centralized capacity market
- **France**: decentralized capacity market
- **Germany**: strategic reserves
- **Spain**: capacity payments
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2016 EC Sector Inquiry on Capacity Mechanisms

This Paper

Main Objective: Simple framework to assess

need, effect and design of capacity mechanisms

Issues:

- How to ensure security of supply at least cost?
- How do capacity payments affect energy markets?
- What is the optimal capacity target?
- And the optimal policy to achieve it?
- Should all plants receive capacity payments, or only the new ones?
- What if there is market power in the capacity market?
- Capacity payments plus financial commitments?

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Scarcity pricing leaves free-way to **market power**

Capacity payments needed to **restore missing money without reintroducing market power**

Roadmap

- Model description
- Benchmarks:
  - welfare maximizing capacity
  - the energy-only market paradigm
- Equilibrium investment
- Capacity mechanisms
- Further issues:
  - payments for new capacity only?
  - market power in the capacity market
  - reliability options
- Conclusions

Model Description

Firms, costs and demand

- n firm compete to generate electricity
- Zero production costs up to the firm's capacity, k_i, $i = 1, ..., n$
- Unit cost of capacity, $c > 0$
- Demand θ is uniformly distributed on $[0, 1]$
- Demand is price- inelastic; prices capped at P

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Timing

1. Simultaneous capacity choices $(k_1, ..., k_n)$
2. Capacity choices are publicly observed
3. Demand θ is revealed
4. Simultaneous price offers (bids for entire capacity)
5. Market cleared and payoffs realized

First-Best Capacity

- Consumers receive gross utility $v \geq P$ per unit consumed
- Expected welfare as a function of aggregate capacity K,

$$W = v \int_0^K \theta d\theta + v \int_K^1 K d\theta - cK$$

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- Trade-off: value of extra consumption (v) versus investment cost (c)
- Some rationing is optimal $K^{FB} < 1$

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- Price caps create under-investment
- Removing price caps allows for efficient investment and max. *CS*

Equilibrium investment under market power

Dominant firm-fringe model: [*robust;* Fabra *et al.* (2006)]

- firms $i = 2, .., n$ bid at marginal cost (up to fringe's capacity k_F)
- firm 1 maximizes profits over residual demand

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- Energy market profits:

$$\pi_1 = P \int_{k_F}^{k_F+k_1} [\theta - k_F]\, d\theta + P \int_{k_F+k_1}^{1} k_1\, d\theta - ck_1$$

$$\pi_f = P \int_{k_F}^{1} k_f\, d\theta - ck_f, \text{ for } f = 2, ., n$$

Equilibrium investment

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- **Fringe firms**: $k_f \uparrow$ has additional effects
  - $(+)$ produces at capacity more often
  - $(-)$ greater incidence of MC pricing
    - In equilibrium, both effects cancel out: symmetric capacities

Profits, Consumer Surplus and Welfare

- Profits = market power rents (scarcity rents = investment costs)

$$\pi_1^* = P \int_{(n-1)k^*}^{nk^*} \left[\theta - (n-1)\, k^*\right] d\theta > 0$$

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- CS maximized at some $P^* \in (0, v)$
  - trade-off greater consumption- higher prices
- Welfare maximized at $P^* = v$ [*$caveats$]

Removing price caps does not always maximize welfare

Involuntary rationing:

- Probability of a system blackouts: γ

$$W = v \int_0^K \theta d\theta + (1-\gamma)\, v \int_K^1 K d\theta - cK.$$

- Optimal capacity

$$K^{FB} = \begin{cases} 1 & \text{if} \quad \gamma \geq 1 - \frac{c}{v} \\ 1 - \frac{1}{1-\gamma}\frac{c}{v} & \text{if} \quad \gamma < 1 - \frac{c}{v} \end{cases}$$

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- Full insure against blackouts ($K^{FB} = 1$) if γ very high

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Downward sloping demand:

- Removing price caps reduces efficient consumption

Capacity Mechanisms

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  - **price regulation:** regulator sets s and investors choose K
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- To induce K^*, pay firms investment costs net of scarcity rents
- To induce first-best capacity

$$K^{FB} = 1 - \frac{c}{v} \Rightarrow s = c - \frac{c}{v} P$$

- $s = 0$ when $P = v$ (i.e., no price cap)
- $s = c$ when $P = 0$ (prices capped at MC)

The optimal policy: price-caps and capacity payments

- For given P, consumer surplus is maximized at

$$s^* = c - \frac{cn^2 + (2n-1)P}{vn^2 + (2n-1)P} P.$$

- s^* is lower if market power: decreasing P and increasing in v
- s^* is higher if K^{FB} higher: increasing in v

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- **Optimal policy:** $s^* = c$ and $P = 0$ [**caveat: asymmetric info*]
  - But too much capacity $K^* = 1 > K^{FB}$: pay s^* only up to K^{FB}

Support for new capacity only?

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- Support to new and old capacity
  - examples: capacity markets, decentralized obligation schemes

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  - investment depends on marginal profits, not on profit levels
- *CS* higher when only new capacity receives support
  - Regulator chooses higher $s \Rightarrow$ capacity closer K^{FB}
  - Old capacity loses profits but profit loss $<$ capacity payments

Market power in the capacity market

- Fringe takes s as given, but the dominant firm does not
- Market clearing for capacity target K :

$$s = c - (1 - K) P + P \frac{n}{n-1} \left(\frac{K}{n} - k_1 \right)$$

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- in equilibrium, capacity withholding $k_1^* = K / (n+1) < K / n$
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- Consumers worse off (price increase + capacity reduction)

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Impact of market power on regulator's choices:

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- Consumers worse off (price increase + capacity reduction)
- Downward sloping demand for capacity would mitigate market power

Reliability options

- Option price (s) and strike price (f)
  - Regulator chooses f and s is determined through an auction
- Consumers pay s in exchange of option to buy electricity at f

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- Firms' profits:

$$\pi = \begin{cases} pq - (c - s)\, k & \text{if} \quad p \leq f \\ fk - (c - s)\, k - p\,(k - q) & \text{if} \quad p \geq f \end{cases}$$

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- Market power is mitigated:
  - f acts as a plant-specific price-cap
  - optimal to set $f = 0$ at marginal cost
- Availability incentivized:
  - $-p\,(k - q)$ acts as endogenous penalty for not being available

Conclusions

- Scarcity pricing optimal *only if* free entry and no market power
  - removing price caps gives free-way to market power
  - Plus unpriced externality: less involuntary rationing
- Maximization of CS: price caps + capacity payments

Further issues:

- Targeted to new capacity: welfare-enhancing potential
- Concerns about market power in capacity markets
- Reliability options mitigate market power: strike prices close to MC
- Demand response reduces need of capacity support?...yet to be seen!

Thank You!

questions? comments?

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