How effective are the capacity mechanism designs in enhancing the security of the electricity supplies in Europe and the USA?

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Scope

1. Motivation
2. Literature
3. Methodology
4. Data, analysis, results and discussions
5. Conclusions and limitations

Motivation

1. Concerns about the reliability of supplies[1]
   - 1996 & 2003: North America blackout
   - 2003 & 2006: Italy & Europe blackout
2. Policy priorities
   - 1990: Efficiency and Economics
     - 1990: Unbundling, 2000: Pool
     - 2001: NETA, 2005: BETTA
   - 2000: Sustainability
     - 2001: 20% New and RE
     - 2008: Climate Change Act – 80% emission reduction by 2050
     - 2019: Net Zero by 2050
   - 2010: Reliability
3. Thus, policies for capacity mechanisms face energy trilemma[2]

1. YAMASHITA, JOO, LI, ZHANG, & LIU, 2008
2. GUNNINGHAM, 2013; HEFFRON, MCCAULEY, & SOVACOOL, 2015; CARRICK, 2017; SONG, FU, ZHOU, & LAI, 2017; WEC, 2017

Relevant Literature

LITERATURE	OBJECTIVE OF CAPACITY MECHANISM
1. Missing money: Inefficient price signals (Simshauser, 2014)	1. Dispatchable resources efficiently
2. Exist of dispatchable resources: LCPD of EC: 2001/80/EC	2. Demand side resources (DSR) to aid in elastic consumption
3. Problems associated with their scheduling of RES (Siahkali and Vakilian, 2009).	3. Recognises capacity contributions from intermittent generation (based on time series analysis)
4. Demand: Peak demand growth rate higher in OECD (Lee and Lee, 2010)	4. Effective governance to meet 1, 2 & 3

Research gaps and method

RESEARCH GAPS

1. Limited studies that address all the ‘four’ objectives
2. Limited studies to compare the learning from the Europe and USA
3. Updates the information till 2019

METHOD: COMPARATIVE ANALYSIS

1. The 18 System Operator (SO) regions
2. Six in the USA: CAISO, ISO-NE, MISO, NYISO, PJM and SPP
3. 12 European: Belgium, Finland, France, Germany, Greece, Ireland and Northern Ireland, Italy, Poland, Spain, Sweden, and United Kingdom

Capacity mechanisms

Capacity mechanisms	SO Regions
Central capacity auction (CA)	United Kingdom, Poland, NYISO, PJM, MISO, and ISO-NE
Capacity obligation (CO)	France, SPP and CAISO
Capacity payments (CP)	Spain
Reliability Option (RO)	Italy and Ireland and Northern Ireland
Strategic reserves (SR)	Sweden, Finland, Germany, Belgium, Greece

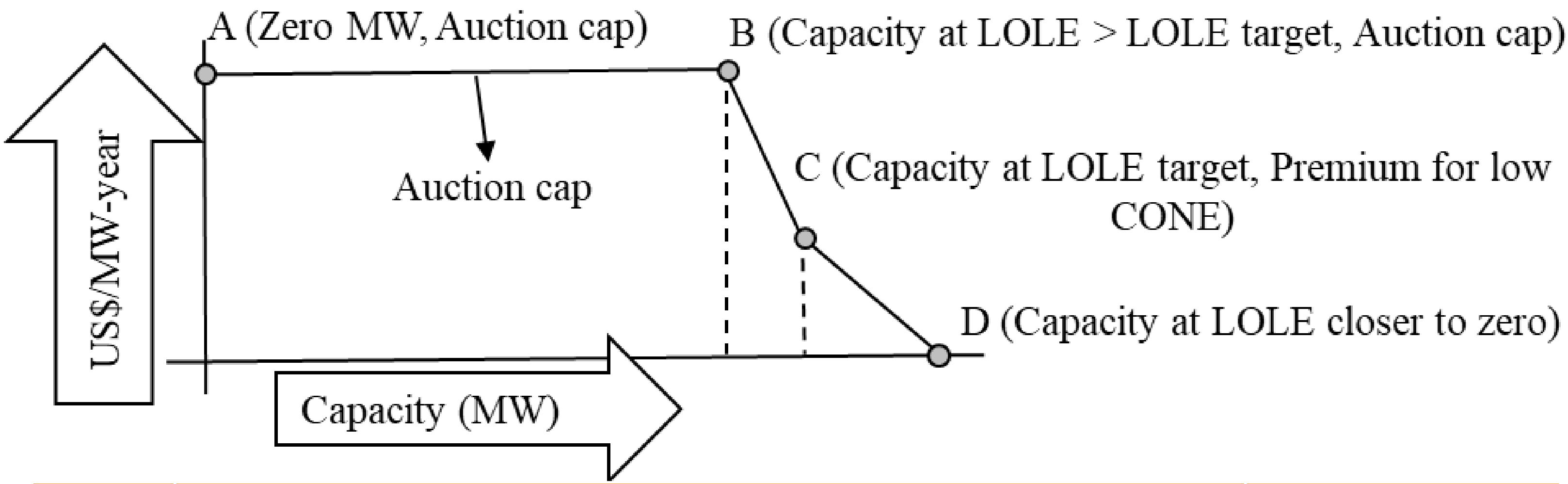
Five point

1. Principles of design
2. Generating resources
3. Demand side resources
4. Intermittent resources
5. Reliability option vs capacity auction

1. Principles of design

1. DEMAND CURVE
2. CAPACITY PRICE DISCOVERY
3. MINIMUM BID SIZE
4. FORWARD AUCTION AND LENGTH OF CONTRACT

1.1 Demand curve



Point	Capacity (x-axis)	Price (y-axis)
A	Zero capacity above 100% target derated capacity	Price cap
B	Capacity with LOLE (hours/year) higher than target LOLE	Price cap
C	Capacity at target LOLE	~ CONE
D	Capacity with LOLE less than target LOLE	~Zero

1.1 Demand curve….cont…

PRINCIPLES: ELASTICITY OF DEMAND CURVE	
Downward kinked sloping (1)	Italy, Ireland and N. Ireland, PJM, the UK
Downward linearly sloping (2)	NYISO and Poland
Downward variable sloping (3)	ISO-NE
Vertical (4)	Belgium, CAISO, Finland, France, Germany, Greece, MISO, Spain (DSR), SPP, Sweden
Horizontal (5)	Spain (regulated)

ANALYSIS AND DISCUSSION

Slope	**Price B/ Price C**	**CV = σ/μ (5 years)**
Downward kinked sloping	1.5 (PJM)	0.15-0.29 (PJM)
Downward linearly sloping	1.5 (NYISO)	0.15-0.33 (NYISO)
Downward variable sloping	2.65 (ISO-NE)	0.39 (ISO-NE)
Vertical	Very high (MISO)	1.18-1.43 (MISO)
Horizontal	~1.00 (Spain)	~0.00 (Spain)

1.2 Price discovery mechanism

PRINCIPLES: ECONOMICALLY EFFICIENT PRICES	
Sealed bid (1)	Belgium, Germany (Capacity res), Greece, Ireland and N. Ireland, MISO, NYISO, PJM
Descending clock (2)	ISO-NE, Italy, Poland, Spain, the UK
Bilateral trades followed by admin prices or auctions (3)	CAISO, Germany (Network res), France, SPP
Ancillary(4)	Finland (DSR), Sweden (DSR)
Regulated (5)	Spain

ANALYSIS AND DISCUSSION	
Sealed bid	Flexibility to pay-as-clear or pay-as-bid
Descending clock	No clear benefit over sealed bid. AESO rejected this for sealed-bid
Bilateral trades followed by admin prices or auctions	FERC rejected CAISO and SPP admin prices.
Regulated	Averch and Johnson effect ~ Installed capacity is 2.5 times of demand in 2017.

1.3 Minimum bid size

PRINCIPLES: COMPETITION AND NON-DISCRIMINATION

SO region	Min MW
The USA	0.1 or less
France	0.1
The UK	0.5
Belgium, Greece, Italy	1.0
Poland	2.0
Germany, Spain, Sweden	5.0
Finland, Ireland and N. Ireland	10.0

ANALYSIS AND DISCUSSION

1. DSR and Storage can participate in capacity, ancillary and operating reserve: FERC Order 719

2. Competition provides for resources for RTO/ISO market clearance software: FERC Order 841

3. ECJ: Tempus energy vs the UK, less barrier to DSR participation

1.4 Forward auction and contract length

	SO region	Forward main Auction	Maximum contract length (in years)	Maximum contract length for Demand Side Response (in years)
1	Belgium	Y-1 year	3	3
2	CAISO	Y-3 months	1	1
3	Finland	Y-1 year	4	4
4	France	Y-4 years	1	1
5	Germany	Y-1 years	2	2
6	Greece	Y-1 years	1	1
7,8	Ireland and Northern Ireland	Y-4 years	10	Participation in energy and ancillary services
9	ISO-NE	Y-3 years	1	1
10	Italy	Y-4 years	15	Participation in energy and ancillary services
11	MISO	M-14 months to M-2 months	1	1
12	NYISO	M-6 months to M-1 month	1	1
13	PJM	Y-3 years	1	1
14	Poland	Y-5 years	15	5: Participation in energy and ancillary services
15	Spain	DSR: M-1 month	1	1
16	SPP	DSR: M-4 months	1	1
17	Sweden	Y-1 year	1	1
18	The UK	Y-4 years	15	1

1.4 Forward auction and contract length…cont…

PRINCIPLES: LESS RISK, VOLATILITY AND LESS INCENTIVE TO COLLUDE

Forward auction	
Reduces cost to consumers	Kaye et al. (1990)
Reduced price volatility	Kaye et al. (1990), Ausubel and Cramton (2010)
Reduction of risk to suppliers	Cramton and Stoft (2008) and Ausubel and Cramton (2010)
Length of contract	
Less incentive to collude	Green and Le Coq (2010).
Market power reduced	Soledad Arellano and Serra (2010)

ANALYSIS AND DISCUSSION

1. Longer contract are preferred
2. Different length of contract for DSR and CCGT: *ECJ: Tempus energy vs the UK is discriminatory*
3. DSR may be offered a similar term as CCGT; else be allowed to participate in ancillary services market

2. Generating resources

1. CONTRACT TERM
2. FLOOR PRICE

2.1 New vs refurbished plants

PRINCIPLES: REGULATORY APPROVAL

SO region	New plants term (in years)	Refurbished plants term (in years)
Ireland and Northern Ireland	10	1
Italy	15	3
Poland	15	1-5
The UK	15	1-3

ANALYSIS AND DISCUSSION

1. Distorts market outcome (Pfeifenberger et al., 2012)
2. Short term contracts can not discourage collusions (Green and Le Coq, 2010)
3. Price Taker Threshold (PTTR)
4. Regulatory scrutiny

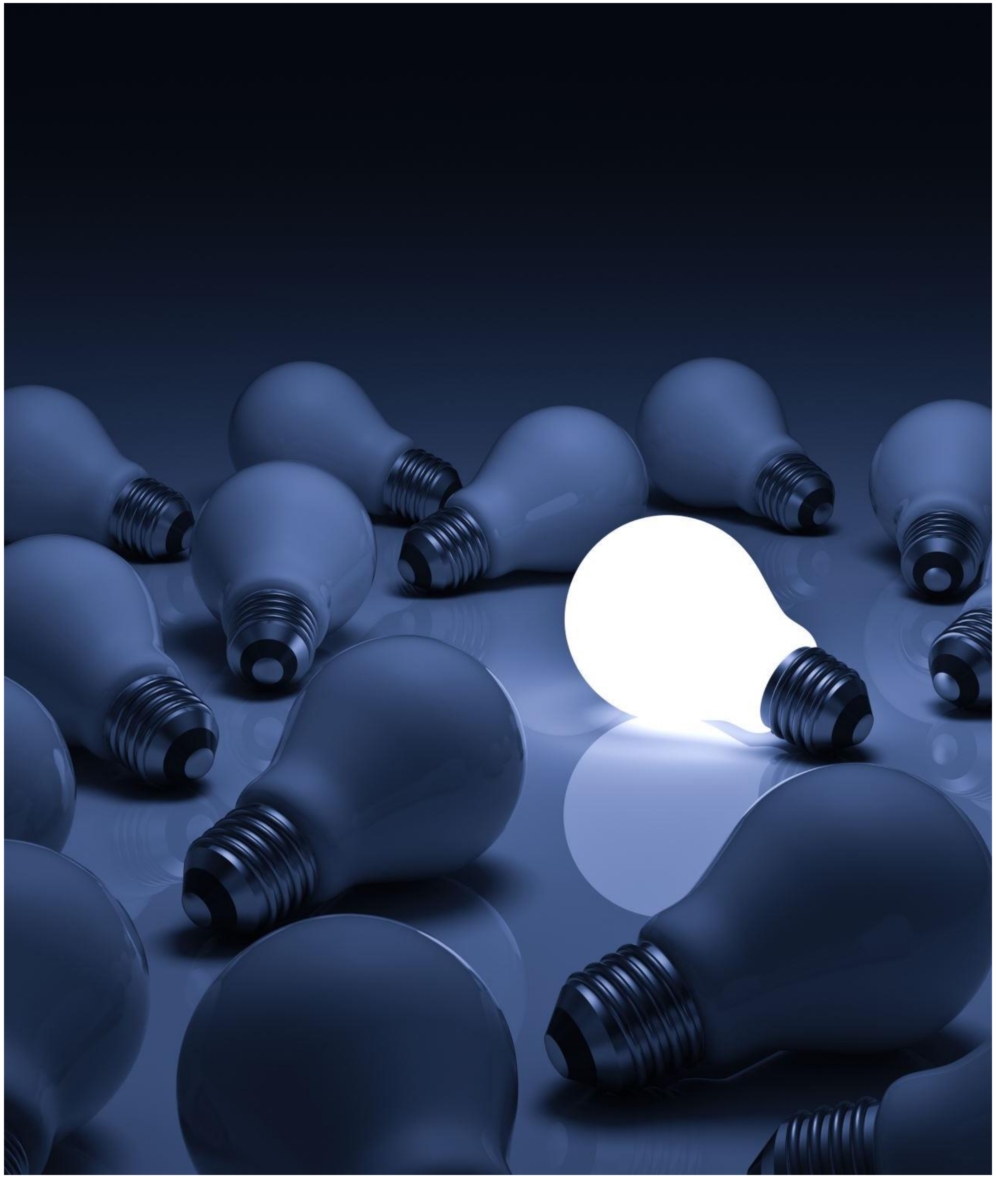
2.2 Price caps and floors

PRINCIPLES: REGULATORY APPROVAL

SO region	Price cap	Price floor
Ireland and Northern Ireland	0.5 Net-CONE	
ISO-NE		Minimum offer price rule (MOPR)
Italy	EUR 25,000/MW-year to EUR 45,000/MW-year	
NYISO	PTTR	MOPR
PJM		MOPR
Poland	EUR 45,000/MW-year	
The UK	0.5 Net-CONE ~ £25,000/MW-year	

ANALYSIS AND DISCUSSION

1. Price floor to discourage low bid from participants that have secured revenue or capital subsidies
2. PJM, ISO-NE and NYISO were engaged in ligations (Seeps, Newell et al. ,2013)
3. PTTR distorts the market outcome in favour of the suppliers (Pfeifenberger et al., 2012)



3. DSR

1. CENTRALISED AND DECENTRALISED MARKETS
2. RESIDENTIAL DSR AND DYNAMIC PRICING

3.1 Centralised vs decentralised

CENTRALISED	DECENTRALISED
1. All SO regions allow participation 2. The effective demonstrations to the LSEs by the DSR providers may be difficult (Spees et al., 2013) 3. Nord Pool: Ancillary Prices 4. Belgium, Germany, SPP: Admin prices	1. All SO regions are open for DSR 2. In the USA • In MISO Only 14 and 39% of all emergency resources, including LMR, on April 04, 2017 and January 17, 2018 respectively by ISO. 3. Belgium is not geared for DSR BTMG (CREG, 2017) 4. LMP for dispatch and availability irrespective of notification

3.2 Residential DSR and RTP

RESIDENTIAL CONSUMERS AS DSR	DYANAMIC PRICING
1. Peak load saving of 43 MW with 1 million residents (Silva and Mohammed, 2013) 2. Consumer initiated communication with SO: Telemetry and metering 3. 100% smart meter: Finland, Italy, Spain and Sweden have nearly 100% 4. Significant: CAISO, ISO-NE, MISO, PJM, SPP, France, Greece, Poland and the UK 5. Insignificant: NYISO, Germany, Ireland and Northern Island	1. Enrolled consumer are statistically significantly price elastic (Allcott, 2011). Consumer surplus increased by $10/household/year 2. DSR providers reduce prices and improve system reliability with Real Time Pricing (Albadi and El-Saadany, 2008) 3. 100% Dynamic: Italy and Spain (2) 4. 10% or more residential/retail: PJM, SPP and Sweden (3)

4. Intermittent resources

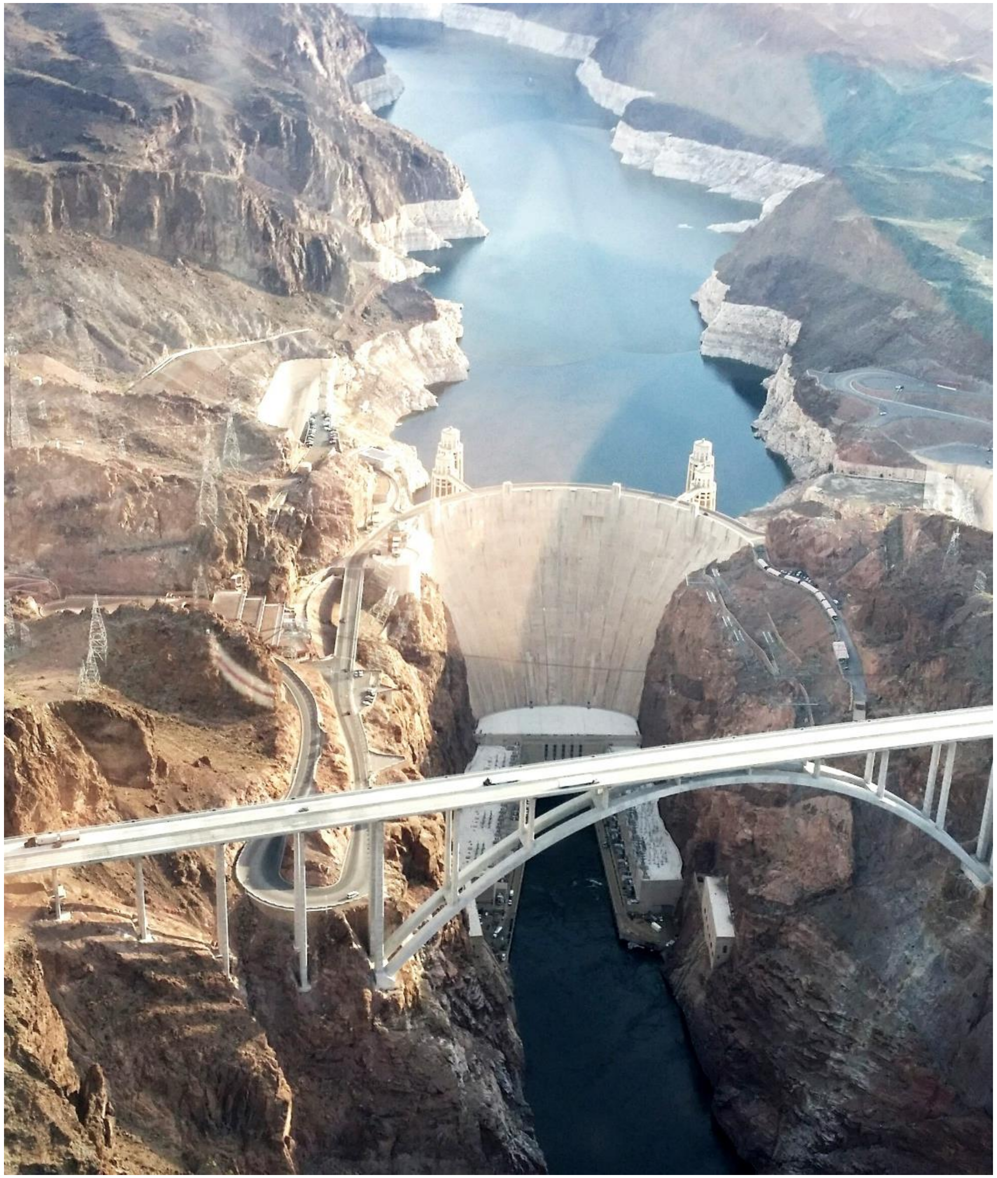
Impact of wind integration

BALANCING SERVICES

1. London School of Economics & Political Science and University of Leeds funded by the UK ESRC, among others (Bassi et al., 2012): Additional balancing services and reliable capacities in long run.
2. Gross et al. (2006) concludes that with 20% penetration of intermittent resources would lead to requirement of additional 15.2% - 22.1% non-intermittent capacities on the system.

MONTHLY TIME SERIES ANALYSIS

1. 1 TWh of wind results in increase in price of electricity by £1/MWh in short run and £0.70/MWh in long run due to procurement of constraint services
2. Constraint services granger cause the wind in UK
3. Cost increase due to balancing and cost decrease due to merit order effect currently seem to favour wind but not as a dispatchable resource.



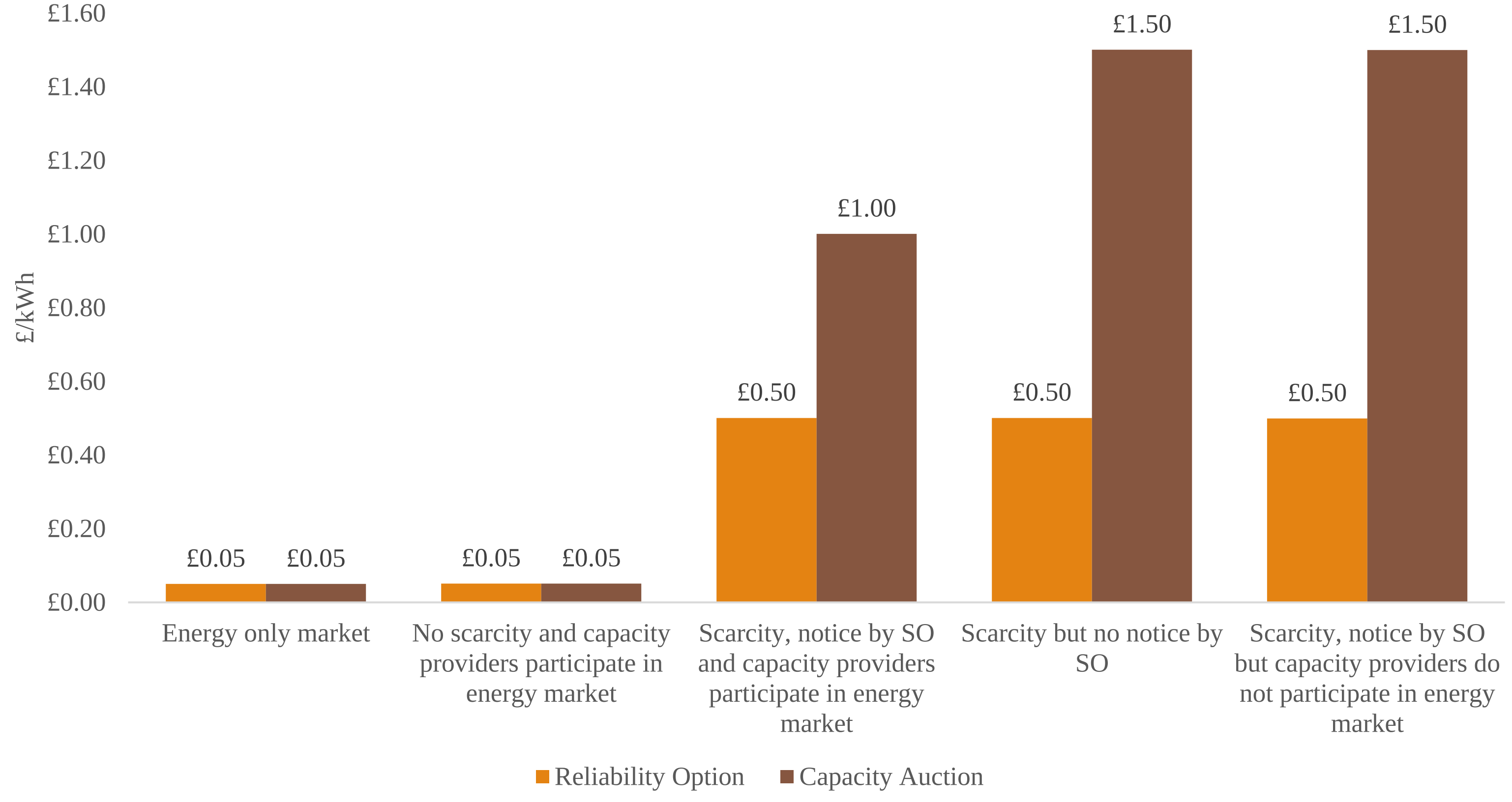
5. Back of envelope calculations

RELIABILITY OPTION VS CAPACITY AUCTION

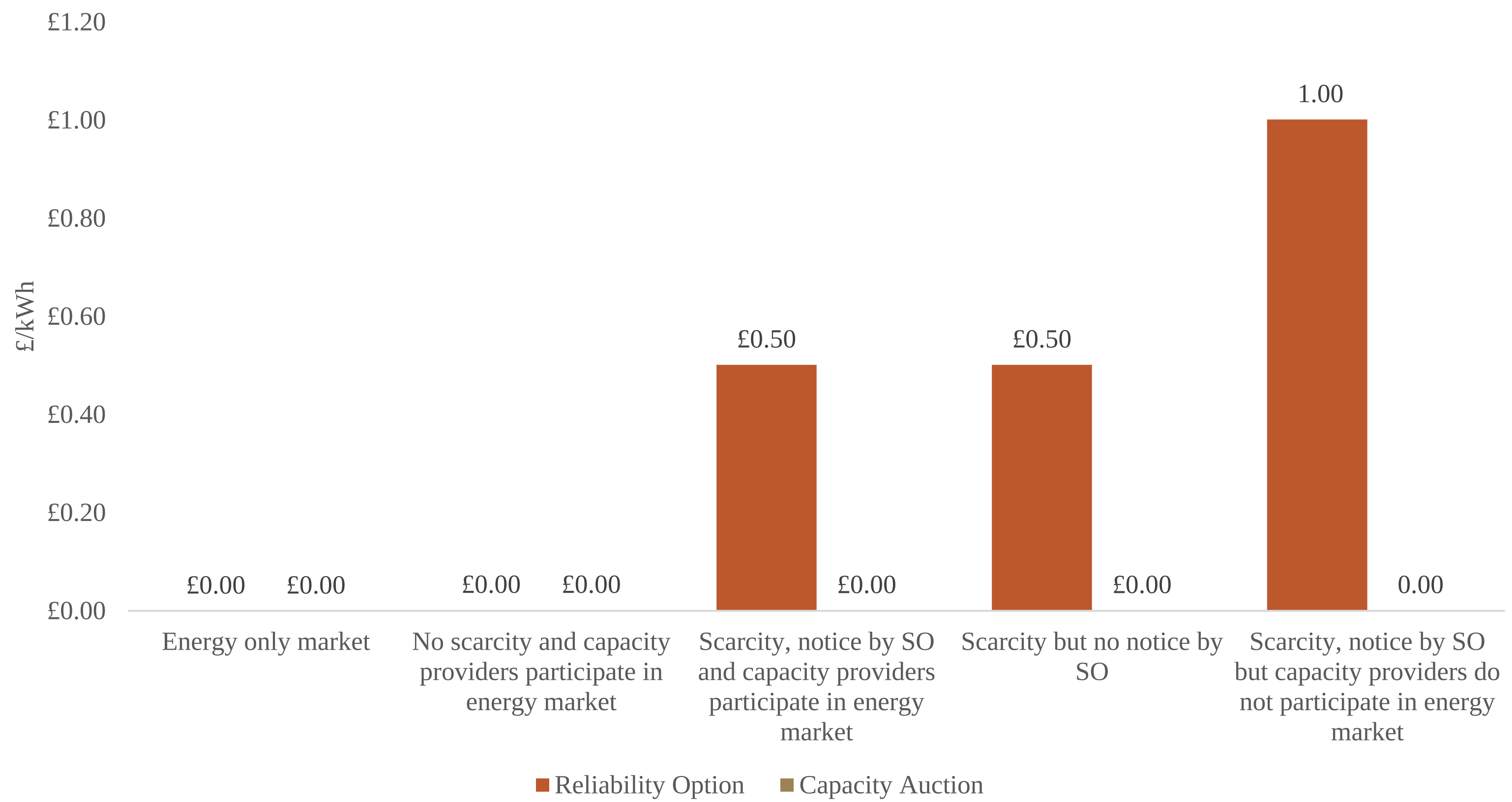
5. Back of envelops: Assumptions

1. The capacity payment is considered to be £8.4/kW/year (2017 T-4 auction in UK)
2. The retail price of electricity is assumed to be £1000/MWh during the stress event
3. Further the retail price from the alternative source is assumed to be £1500/MWh if the supplier makes an alternative arrangement.
4. The strike price is assumed to be £500/MWh (experience in Ireland and Northern Ireland)
5. Also, the penalty is capped at 150% and 100% of the capacity payment for reliability options (based on the rules in SEM-O) and capacity auction (based on the rules in UK)

5. Back of envelope marginal cost to consumers



5. Back of envelope marginal cost to a capacity provider



Conclusions and limitations

1. The question is answered using following analysis:
   - Principles of design
   - Generation resources
   - Demand side resources
   - Intermittent resources
   - RO vs Capacity auction
2. Limitations
   - This research is limited by publicly available data.
   - Effectiveness of mechanisms may be assessed through econometrics when sufficient data is available

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Thank you!

Capacity curve design: Kinked

SO region	Capacity basis	Approximate target margin	CONE or Net-CONE	A	B	C
Italy	LOLE of 3 hours/ year		CONE (EUR MW-year)	75,000 to 95,000 ≈1.5* CONE	75,000 to 95,000	50,000 to 70,000
Ireland and Northern Ireland	LOLE of 8 hours/ year	15% (of maximum de-rated capacity at D)	Net-CONE (EUR MW-year)	1. 5 *Net-CONE	1. 5 *Net-CONE	CONE of Best New Entrant Peaking plant
PJM	LOLE of 1 day in 10 years	16.6% (of unforced de-rated capacity at C, IRM)+8.8% at D	Net-CONE ($MW-day)	1. 5 *Net-CONE	1. 5 *Net-CONE	0.75*Net-CONE (at IRM+2.9%)
The UK	LOLE of 3 hours/ year		Net-CONE (£MW-year)	1. 5 *Net-CONE	1. 5 *Net-CONE	50000

Capacity curve design: Linear and variable slope

SO region	Capacity basis	Approximate target margin	CONE or Net-CONE	A	B	C
NYISO	LOLE of 1 day in 10 years	12% to 18% (of minimum de-rated capacity at D)	Net-CONE ($MW-month)	1.5*Net-CONE (monthly, seasonally not adjusted)	1.5*Net-CONE (monthly, seasonally not adjusted)	Three year historic Net-CONE (monthly, seasonally adjusted)
Poland	LOLE of 3 hours/ year		CONE ($MW-year)	1. 5 *CONE	1. 5 *CONE	65,000-70,000

SO region	Capacity basis	Approximate target margin	CONE or Net-CONE	A	B	C	D
ISO-NE	LOLE of 1 day in 10 years	6.5% to 8% (of maximum de-rated capacity at D	Net-CONE	18.62 ($/ kW-month)	18.62 ($/kW-month) LOLE: 1 day in 5 years	$7.03 ($/kW-month) LOLE: 1 day in 10 years	0 LOLE: 1 day in 87 years

Capacity curve design: Linear

SO region	Capacity basis	Approximate target margin	Market Price
Belgium	LOLE target of 3 hours/year		Competitive auction
CAISO	LOLE of 1 day in 10 years	15% (of minimum de-rated capacity)	Administrative caps with competitive auctions and then filing for approval by electricity regulator; and also through bilateral negotiations
Finland	Determined by Energy Authority	Administratively determined	DSR: Greater of EUR 3000/MWh or Balancing Market Price
France	LOLE of 3 hours/year		Administrative caps with competitive auctions and then filing for approval by electricity regulator; and through bilateral negotiations
Germany	German energy regulator	Administratively determined by regulator	Administrative caps with competitive auctions and then filing for approval by electricity regulator; and through bilateral negotiations
Greece	LOLE 2.4 hours/year		Competitive auctions
MISO	LOLE of 1 day in 10 years	15.8% (unforced de-rated capacity)	Administrative caps with competitive auctions and then filing for approval by electricity regulator
Spain	LOLE of 1 day in 10 years		Administrative caps with competitive auctions
SPP	LOLE of 1 day in 10 years	9.89% (of maximum de-rated capacity, if Hydro more than 75% of generation mix) or 12% (of minimum de-rated capacity)	Administrative caps with competitive auctions and then filing for approval by electricity regulator
Sweden	Determined by System Operator	Administratively determined	DSR: If activated, balancing market price; If not activated, administrative payment, and if activated for less than 30 mins, bid amount; Generating resources: Fixed and Variable Fees; and approval by electricity regulator

Reliability standards

Sl. No.	SO	LOLE
1	Belgium	3 hours/year
2	France	3 hours/year
3,4	Ireland and Northern Ireland	8 hours/year
5	Italy	3 hours/year
6	Poland	3 hours/year
7	Spain	1 day/10 years ≈ 0.2/month
8	United Kingdom	3 hours/year
9-14	The USA (six SO regions)	1 day/10 years

Sl. No.	SO	Derated capacity margin
15-18	Finland, Germany, Greece, Sweden	Variable