Major Issues on Scarcity Pricing According to the Clean Energy Package and a Case Study on Implementing a Scarcity Pricing Mechanism

Anthony Papavasiliou, UCLouvain

CEER Online Specialised Training on Electricity Market Design and Implementation of the Clean Energy Package

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UCLouvain

Outline

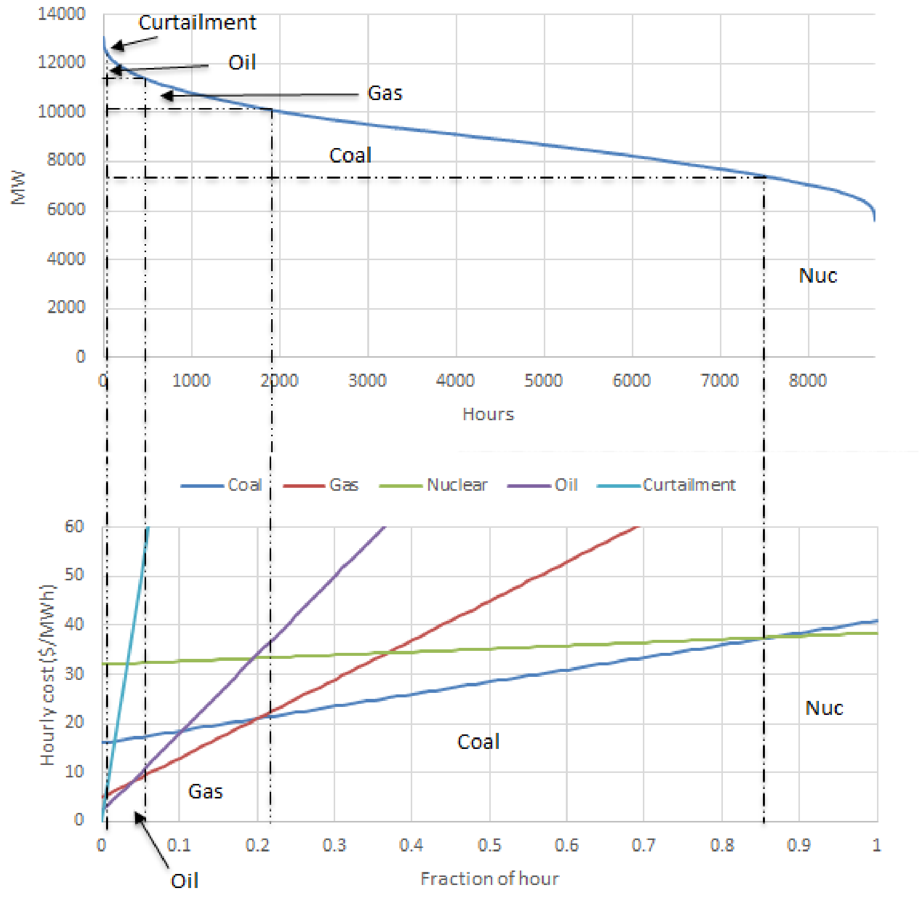
- Principles of Scarcity Pricing
- Implementing Scarcity Pricing in the European Balancing Market
- Scarcity Pricing Outside Europe
- Scarcity Pricing Developments in Europe

Principles of Scarcity Pricing

Anthony Papavasiliou
CEER online training, September 2020

The Missing Money Problem

- Electricity demand is extremely inelastic
- Even if demand is perfectly predictable, a competitive equilibrium entails some degree of load curtailment, at which time the price of electricity is very high
- Due to market power concerns, electricity price is capped => <u>missing money</u>

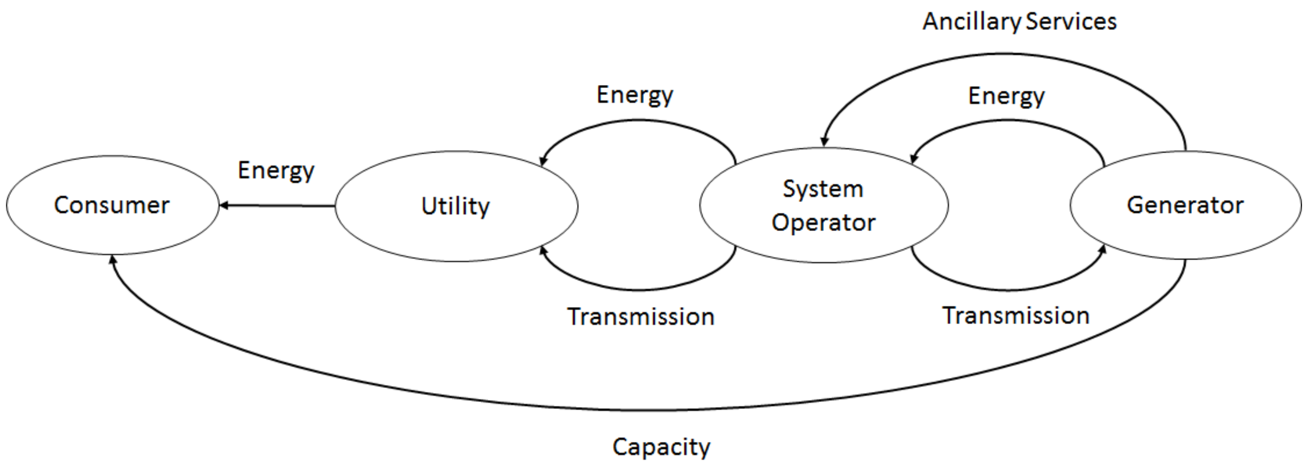


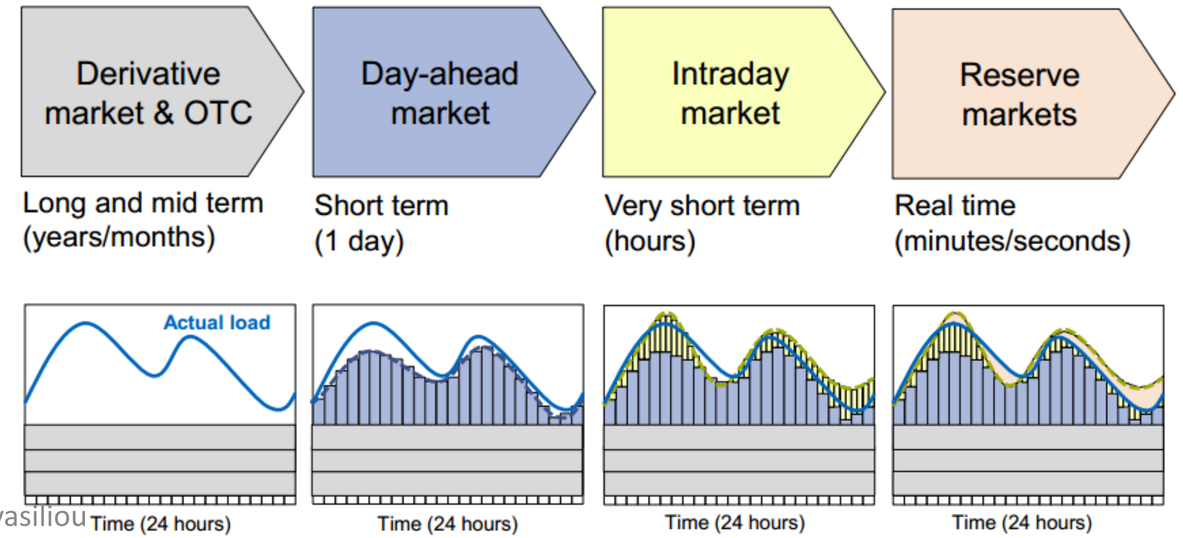
Mechanisms for Compensating Capacity

- Energy-only markets that rely only on VOLL pricing
  - The energy market without price caps is the only source of revenue
  - Risky for investors (-), politically contentious (-)
- Installed capacity requirements
  - Member States decide on a target capacity and TSO procures it through annual auctions
  - Safer for investors (+), capacity target is contestable/non-transparent (-), does not ensure flexibility (-), complex variations among member states (-)
- Capacity payments
  - Energy prices are uplifted by capacity payment
  - Installed capacity may err significantly (-)

Revenue Streams in Electricity Markets

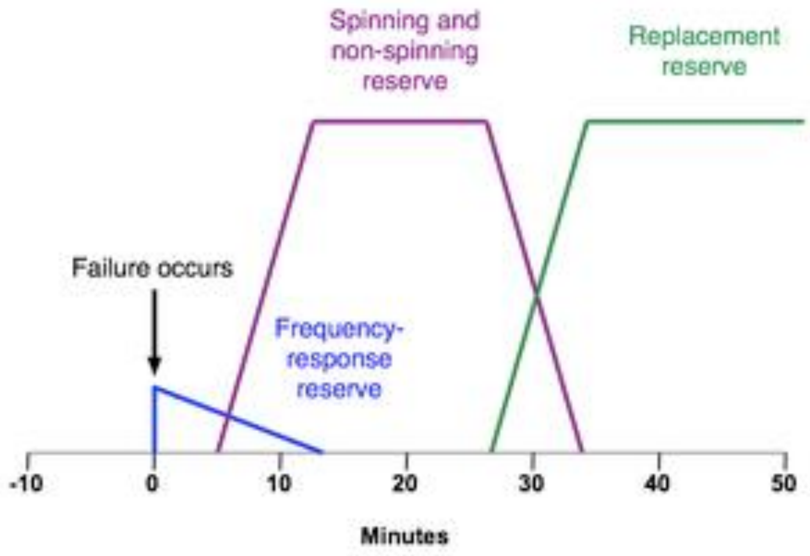
- Energy
  - Day-ahead ‘uniform price’ auction
  - Real-time uniform price auction for activated *energy*
- Reserve
  - Month/week/day-ahead auction for reserve *capacity*
- Capacity
  - Auctioned annually in <u>some</u> markets
- Recent migration of value away from energy markets and into flexibility (reserves)

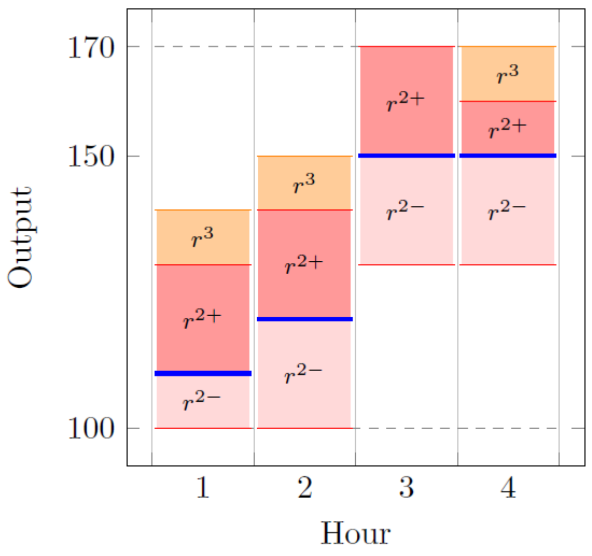




Reserves

- Frequency containment reserve (FCR): immediate response to change in frequency
- Automatic frequency restoration reserve (aFRR): reaction in a few seconds, full response in 7 minutes
- Manual frequency restoration reserve (mFRR): available within 15 minutes
- Replacement reserve
- Commitment of reserve induces opportunity cost because it displaces energy sales



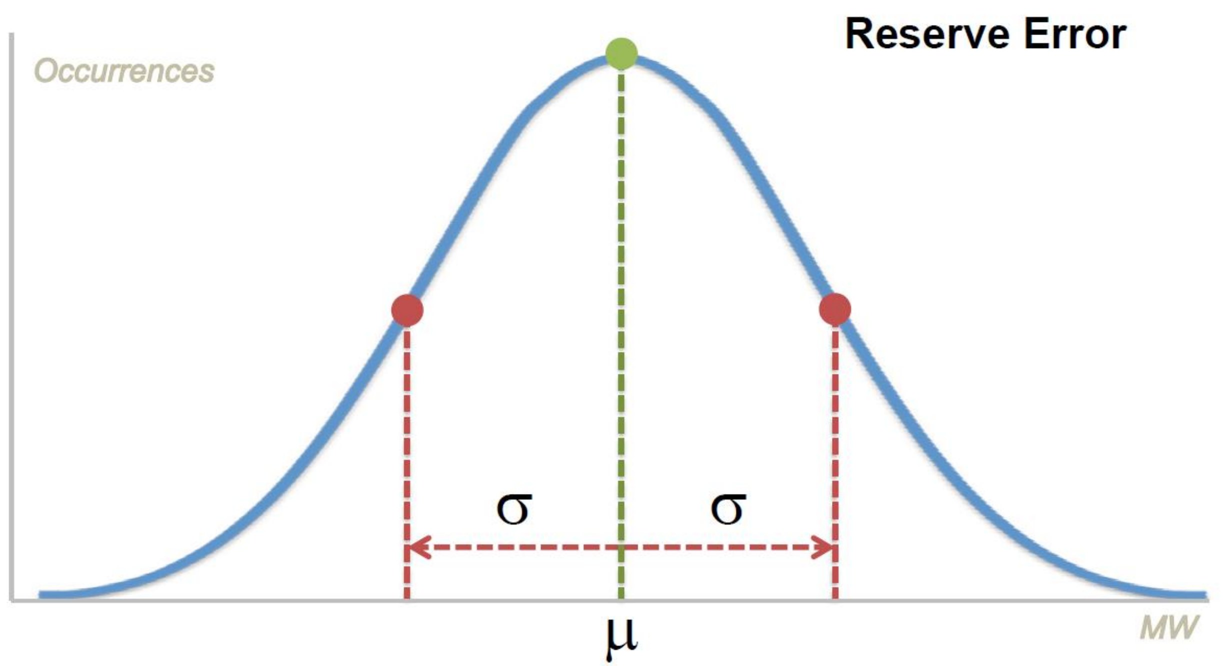


Operating Reserve Demand Curve (ORDC)

- Reserve is procured by the system operator from generators in order to ensure reliability, which is a public good
- Demand for reserve can be driven by its value for dealing with uncertainty, based on engineering principles:
  - Above a max threshold (Qmax), extra reserve offers no additional protection => (P, Q) = (0, Qmax)
  - Below a min threshold (Qmin), operator is willing to curtail demand involuntarily => (P, Q) = (VOLL, Qmin), where VOLL is value of lost load
  - At Qmin < Qi < Qmax , extra reserve increases probability of preventing load curtailment => (P, Q) = ($LOLP \cdot VOLL$, Qi), where LOLP is loss of load probability

Loss of Load Probability

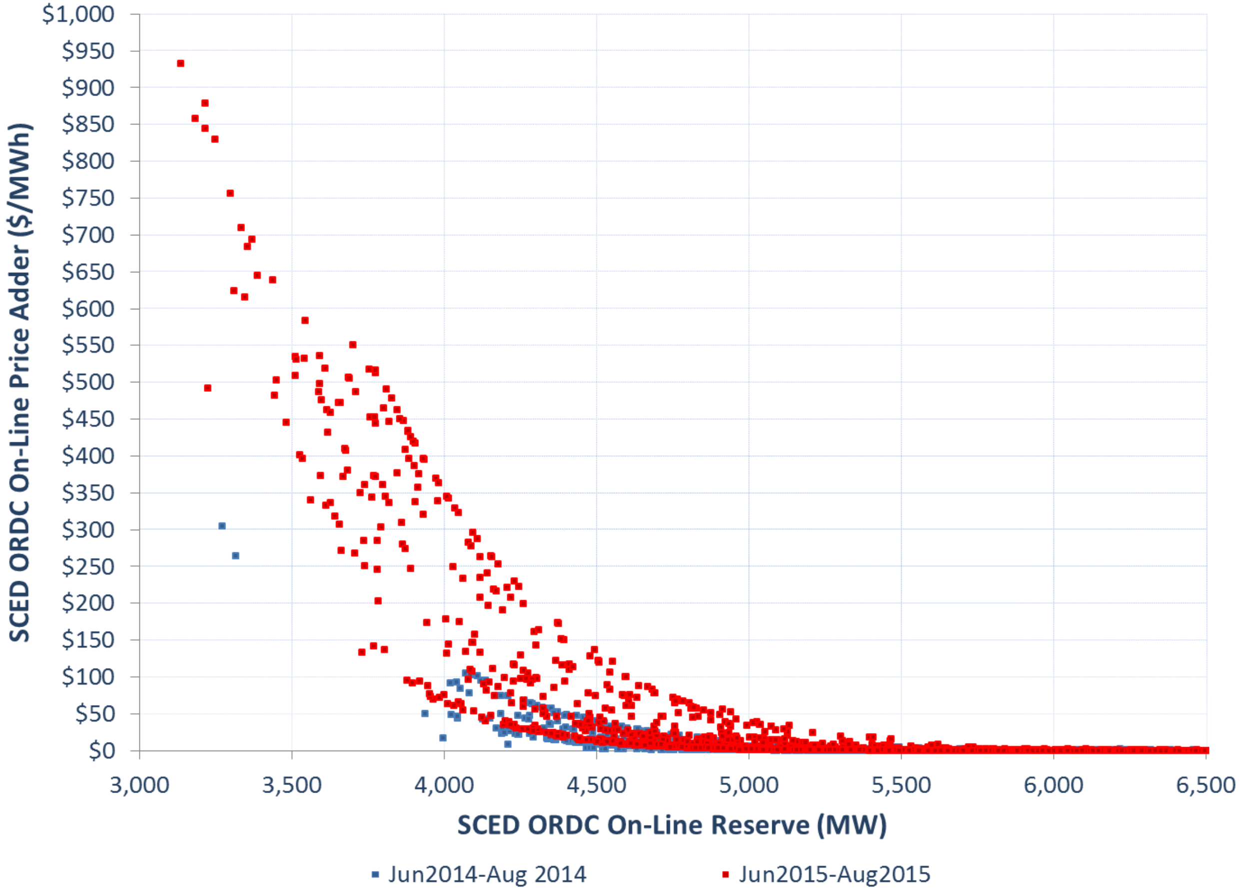
- Uncertainty Δ in real time due to:
  - demand forecast errors
  - import uncertainty
  - unscheduled outages of generators
- $LOLP(x) = Prob(\Delta \geq x)$ is the probability that real-time uncertainty exceeds reserve capacity x

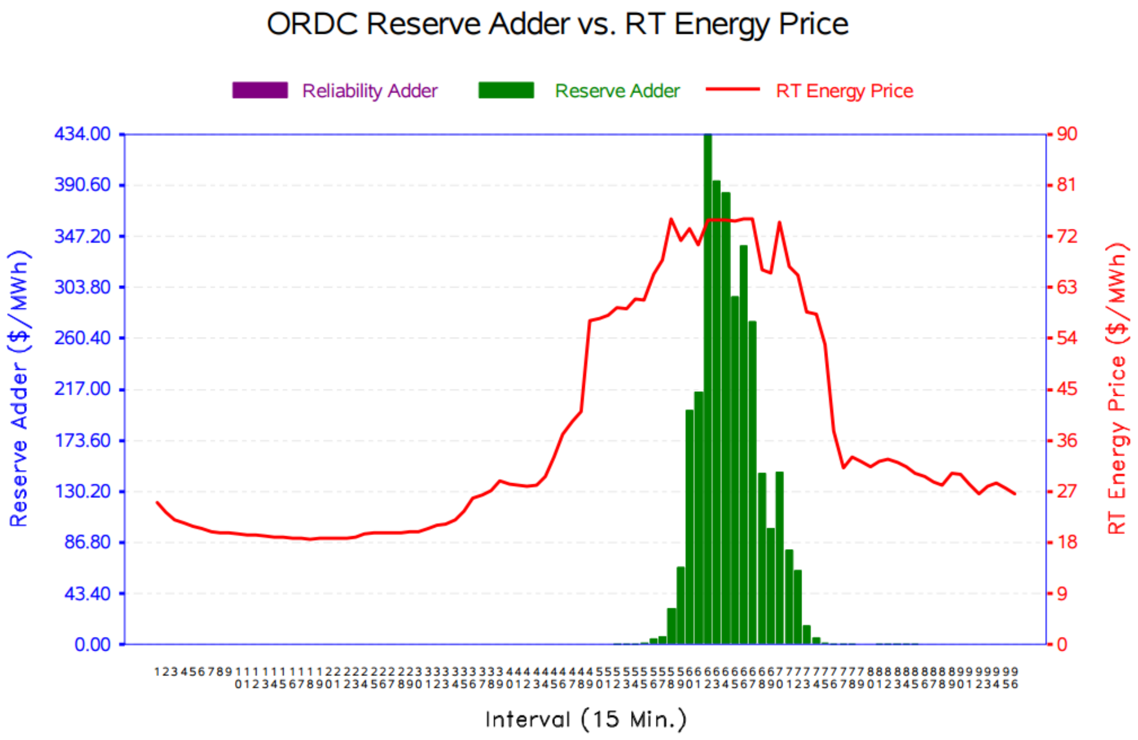


ORDC Price Adders

- Price adder: $\mu = (VOLL - \lambda) \cdot LOLP(R - X)$, where λ is the marginal cost of the marginal producer, R is the available reserve, and X is the minimum threshold of reserve
- More frequent, lower amplitude price spikes
- Price spikes can occur even if regulator mitigates bids of suppliers in order to mitigate market power
- Through arbitrage, reserve adders back-propagate to forward (day/week/month-ahead) reservation auctions
- Scarcity pricing can co-exist with capacity mechanisms, however precedence matters: important to give the energy-only market design a chance to function properly *first*

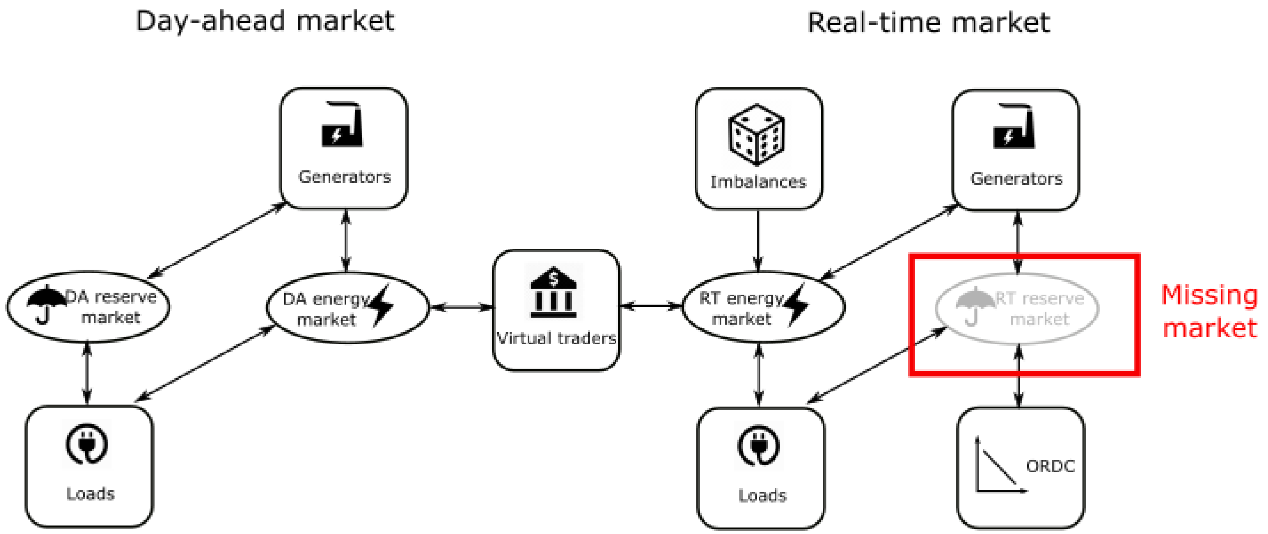
Illustration from Texas: July 30, 2015





A Missing Market for Reserve Imbalances / Real-Time Reserve

- One of the premises for back-propagation is that reserve imbalances are settled in real time (at the ORDC price)
- Reserve imbalances are *not* settled in the current EU design
- Plugging the adder to the balancing energy / imbalance price not enough for back-propagation



Example: Settlement without Adder

Settlement type	Formula	Price [€/MWh]	Quantity [MW]	Cash flow [€/h]
Day-ahead energy	$\lambda PF_t \cdot pF_{gt}$	λPF_t =20 €/MWh	pF_{gt} = 0 MW	0
Day-ahead reserve	$\tilde{\lambda} RF_t \cdot rF_{gt}$	rF_{gt} = 65 MW	rF_{gt} = 25 MW	1,625
Real-time energy	$\lambda PRT_t \cdot (pRT_{gt} - pF_{gt})$	λPRT_t = 300.0 €/MWh	$pRT_{gt} - pF_{gt}$ = 125 MW	37,500
Total				39,125

Example: Settlement with Adder

Settlement type	Formula	Price [€/MWh]	Quantity [MW]	Cash flow [€/h]
Day-ahead energy	$\lambda PF_t \cdot pF_{gt}$	λPF_t =20 €/MWh	pF_{gt} = 0 MW	0
Day-ahead reserve	$\tilde{\lambda} RF_t \cdot rF_{gt}$	rF_{gt} = 65 MW	rF_{gt} = 25 MW	1,625
Real-time energy	$\lambda PRT_t \cdot (pRT_{gt} - pF_{gt})$	λPRT_t = 1,529.2 €/MWh	$pRT_{gt} - pF_{gt}$ = 125 MW	191,150
Real-time reserve	$\tilde{\lambda} RRT_t \cdot (rRT_{gt} - rF_{gt})$	$\tilde{\lambda} RRT_t$ = 1,229.2 €/MWh	$rRT_{gt} - rF_{gt}$ = -25 MW	-30,730
Total				162,045

Implementing Scarcity Pricing in the European Balancing Market

Anthony Papavasiliou
CEER online training, September 2020

BRPs and BSPs

- **Balancing responsible parties**: own assets that may consume or produce power, but are not able to offer reserve services
- **Balancing service providers**: BSPs are essentially resources that can offer reserves
- The message of the next two slides is that it is worth considering
  - Alignment of balancing prices and imbalance prices (a real-time price for energy), see also slide European Commission response [6] to Belgian national implementation plan
  - A market for real-time reserve capacity (i.e. a market for reserve imbalances), which is presently absent in the EU design

Implementing Scarcity Pricing

- **Option 1**: Vanilla balancing market design:

$$\lambda^B \cdot qa - \lambda^B \cdot (Imb - ai) - C \cdot (qa + ai)$$

  - λ^B: The balancing price (system lambda)
  - C: The marginal cost of the reserve resource of the agent
  - qa: reserve capacity activated for balancing by the system operator
  - Imb: uncontrollable imbalance in the portfolio of an agent
  - ai: active imbalance
  - No incentive for agents to bid non-zero prices in day-ahead reserve market

- **Option 2**: Imbalance price adders

$$\lambda^I = \lambda^B + \alpha^U \cdot \mathbb{I}[Imb^s > UI] - \alpha^L \cdot \mathbb{I}[Imb^s < LI]$$

  - $\mathbb{I}[x]$: An indicator function that is equal to 1 when condition x is true, and zero otherwise
  - Imb^s: Total system imbalance
  - α^U, α^L: alpha component
  - UI, LI: The threshold beyond which the system is considered to be short (respectively long)
  - In the case of symmetric imbalance adders, no incentive for agents to bid non-zero prices in day-ahead reserve market

Implementing Scarcity Pricing

- **Option 3**: Scarcity adders limited to imbalance prices [9]:

$$\lambda^I = \lambda^B + \lambda^R$$

  - λ^R: The scarcity adder
  - Incentive to withdraw cheap resources from balancing market (-), which counteracts the effect of the adder (-)

- **Option 4**: Real-time market for reserve capacity

$$(\lambda^B + \lambda^R) \cdot qa - (\lambda^B + \lambda^R) \cdot (Imb - ai) - C \cdot (qa + ai)$$
$$+\lambda^R \cdot (P^+ - qa - ai) - \lambda^R \cdot qa^R$$

  - P^+: The capacity of the reserve
  - qa^R: The reserve traded in the day-ahead market

- An analytical model [12] concludes that option 4 is the only one that
  (i) gives BSPs an incentive to bid their reserve in the balancing market, while
  (ii) also giving them the incentive to value their reserve correctly in the day-ahead reserve market

Legal Framework

- European Commission regulation 2017 / 2195 (the Electricity Balancing Guideline – EBGL) provides certain legal bases that can be considered in the implementation of scarcity pricing
- Cornerstone regulations:
  - (i) the attribution of each BSP to at least one BRP (article 18.4(d)), and
  - (ii) the possibility of introducing an additional settlement mechanism separate from imbalance settlement (article 44.3)
- Article 18.4(d):

"The terms and conditions for balancing service providers shall require that **each balancing energy bid from a balancing service provider is assigned to one or more balance responsible parties** to enable the calculation of an imbalance adjustment pursuant to Article 49"

- Article 44.3:

"Each TSO may develop a proposal for an additional settlement mechanism separate from the imbalance settlement, to settle the procurement costs of balancing capacity pursuant to Chapter 5 of this Title, administrative costs and other costs related to balancing. The additional settlement mechanism **shall apply to balance responsible parties**. This should be preferably achieved with the **introduction of a shortage pricing function**. If TSOs choose another mechanism, they should justify this in the proposal."

Legal Framework (II)

Recall the formula:

$$(\lambda^B + \lambda^R) \cdot qa - (\lambda^B + \lambda^R) \cdot (Imb - ai) - C \cdot (qa + ai)$$
$$+\lambda^R \cdot (P^+ - qa - ai) - \lambda^R \cdot qa^R$$

A possible approach

i. introducing the scarcity adder to the imbalance settlement, payable by BRPs

ii. keeping the platform settlement price for activated energy

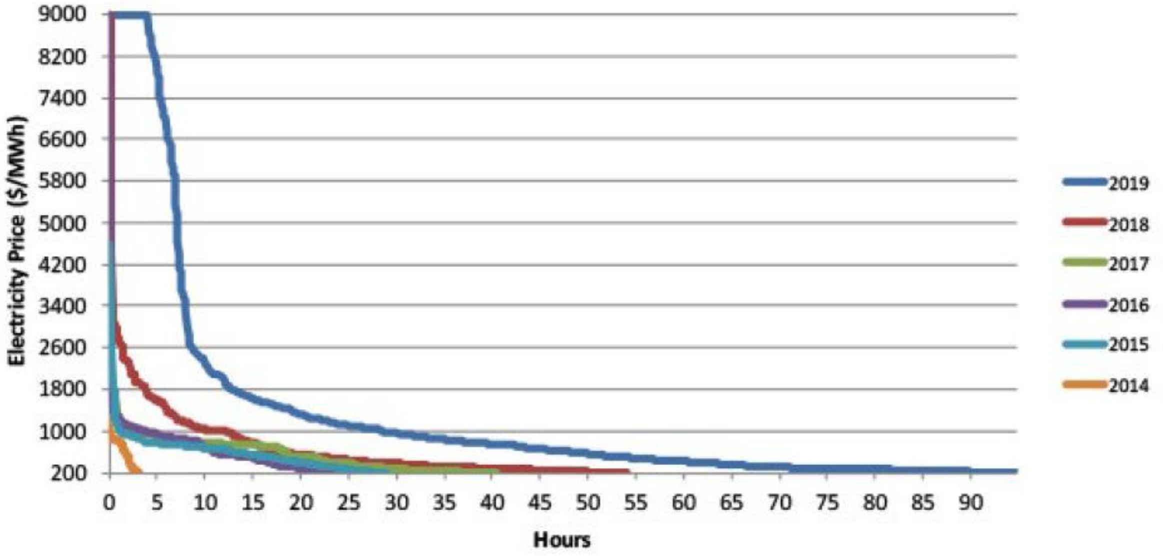
iii. introducing two terms, related to the real-time value of balancing energy and to reserve capacity imbalance, as foreseen by article 44.3 of the EBGL

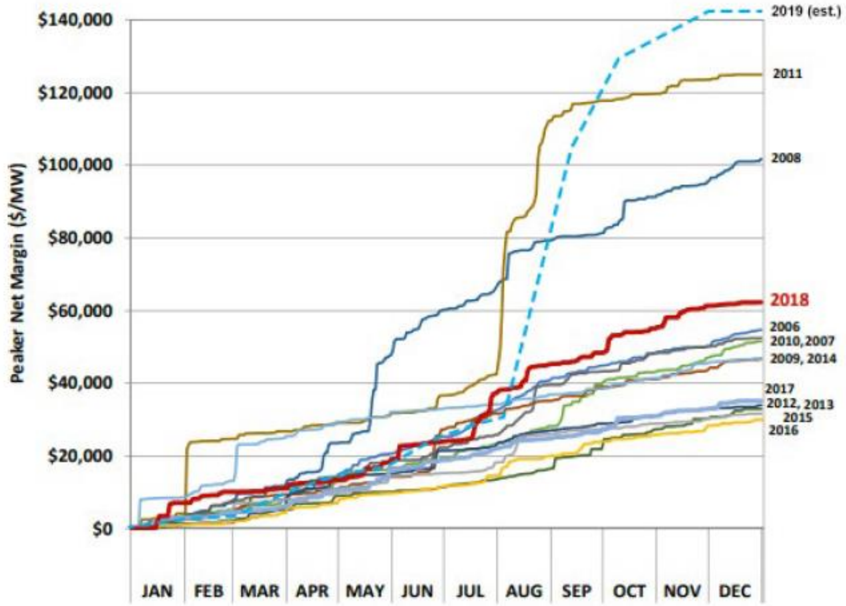
Cross-Border Interactions

- Neighboring resources pay the zonal balancing platform price, and therefore they are *not* directly affected by the adder settlements
- The adder may have an effect on the equilibrium outcome of the balancing platform, this is discussed further in [11]

Scarcity Pricing Outside Europe

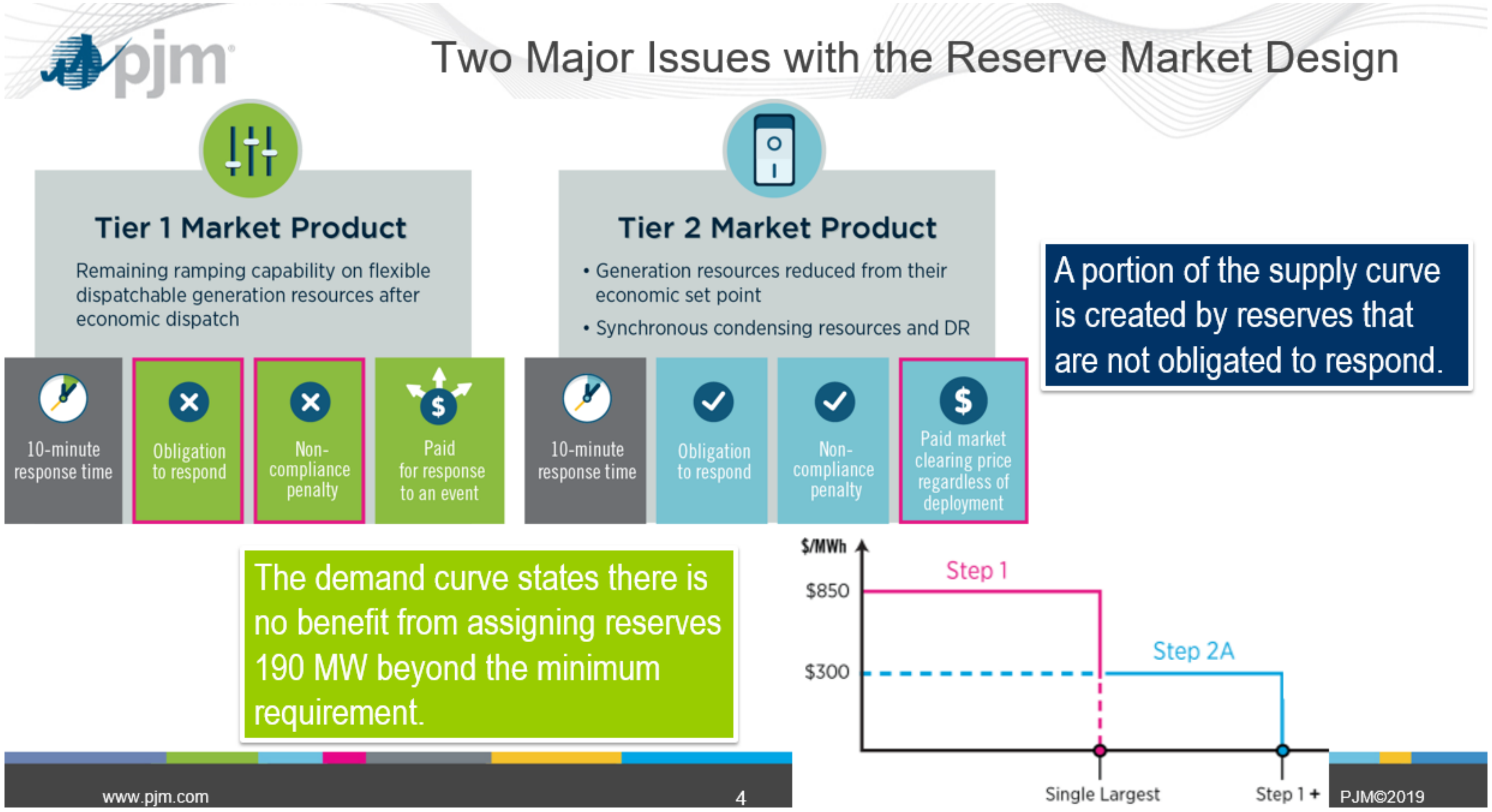
Texas in 2019





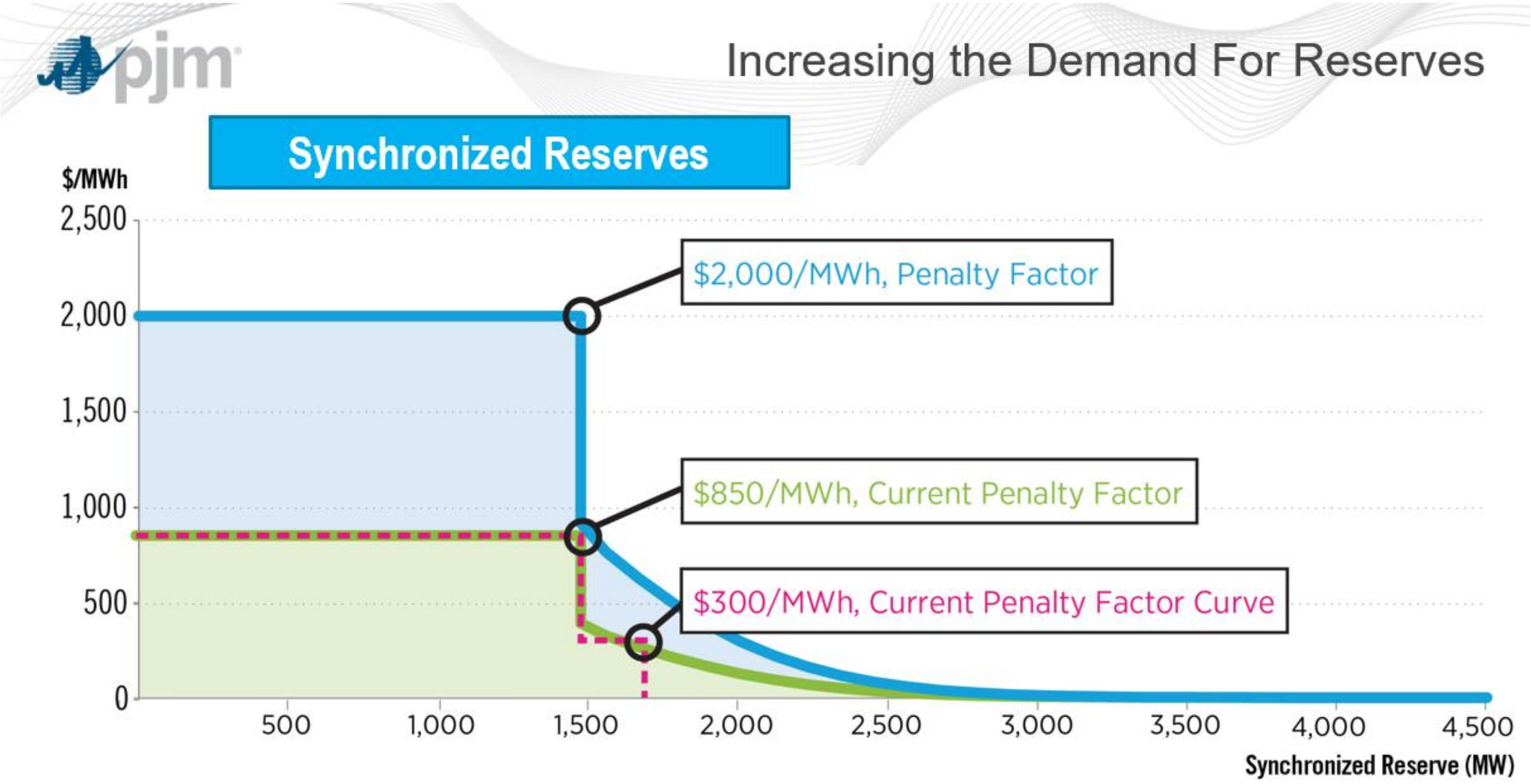
Source: RTO Insider, “ERCOT 2019: Final Proof of a Successful Market Design?”, by Rob Gramlich, October 15, 2019

Scarcity Pricing Developments in PJM



Source: HEPG, June 2019 (see [10])

Scarcity Pricing Developments in PJM



Source: HEPG, June 2019 (see [10])

FERC Approval of ORDC in PJM (May, 2020)

Commission determination

We adopt as part of the just and reasonable replacement rate PJM's proposal to modify its ORDCs to establish a downward-sloping portion to the right of the applicable MRR, and to construct that portion as a function of the Reserve Penalty Factor and the probability of experiencing a reserve shortage in real-time at varying reserve procurement quantities. We agree with PJM that it is just and reasonable for ORDCs to value reserves in excess of MRRs, and to determine the value of those reserves using the empirical probability formulas proposed.

171 FERC ¶ 61,153
UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Before Commissioners: Neil Chatterjee, Chairman;
Richard Glick, Bernard L. McNamee,
and James P. Danly.

PJM Interconnection, L.L.C. — Docket Nos. EL19-58-000, ER19-1486-000

ORDER ON PROPOSED TARIFF AND OPERATING AGREEMENT REVISIONS

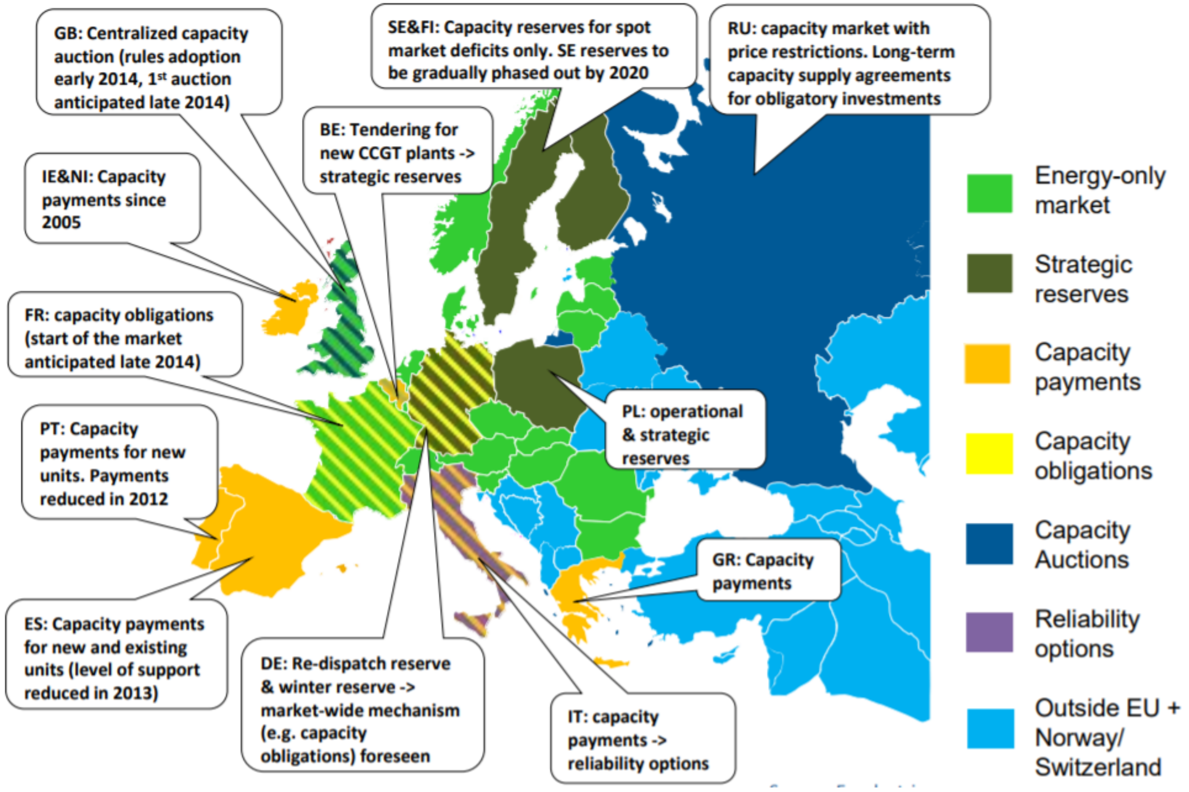
(Issued May 21, 2020)

Scarcity Pricing Developments in Europe

Anthony Papavasiliou
CEER online training, September 2020

Balkanization of European Electricity Market

- Diverse approaches towards remuneration of (flexible) capacity in Europe
- Some of these measures draw scrutiny as possibly constituting anti-competitive *state aid*
- European Commission not in favor of balkanization of member-state market rules
- Two *legal documents* of the European Commission indicate favorable view towards scarcity pricing:
  - Electricity balancing guideline
  - Clean energy package



Source: Eurelectric

European Commission Electricity Balancing Guideline, Article 44(3)

Each TSO may develop a proposal for an additional settlement mechanism separate from the imbalance settlement, to settle the procurement costs of balancing capacity pursuant to Chapter 5 of this Title, administrative costs and other costs related to balancing. The additional settlement mechanism shall apply to balance responsible parties. This should be preferably achieved with the introduction of a **shortage pricing function**. If TSOs choose another mechanism, they should justify this in the proposal. Such a proposal shall be subject to approval by the relevant regulatory authority.

Official Journal of the European Union

COMMISSION REGULATION (EU) 2017/2195

of 23 November 2017

establishing a guideline on electricity balancing

Clean Energy Package, Article 20(3)

Member States *with identified resource adequacy concerns* shall develop and publish *an implementation plan with* a timeline for adopting measures to eliminate any identified regulatory distortions *or market failures as a part of the State aid process*. When addressing resource adequacy concerns*, the* Member States shall in particular *take into account the principles set out in Article 3 and shall consider:*

...

(c) introducing a shortage pricing *function for balancing energy as referred to in Article 44(3) of Regulation 2017/2195;*

...

European Parliament

2014-2019

TEXTS ADOPTED

Provisional edition

P8_TA-PROV(2019)0227

Internal market for electricity ***I

European Parliament legislative resolution of 26 March 2019 on the proposal for a regulation of the European Parliament and of the Council on the internal market for electricity (recast) (COM(2016)0861 – C8-0492/2016 – 2016/0379(COD))

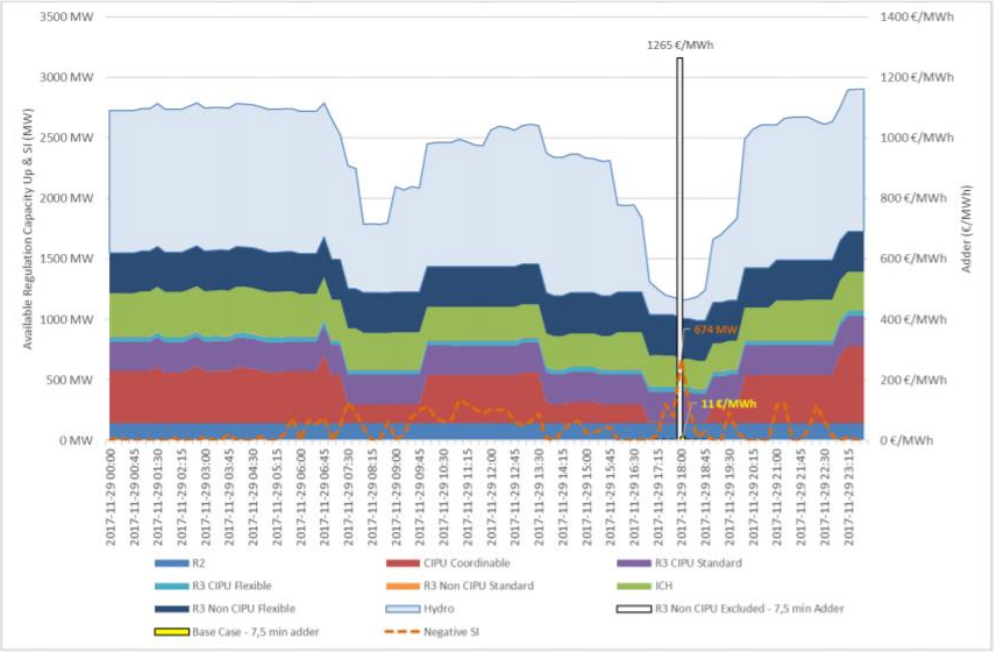
(Ordinary legislative procedure – recast)

The Belgian Scarcity Pricing Studies

- **First study (2015)** [1]: How would electricity prices change if we introduce ORDC in the Belgian market?
  - **Finding**: it could enable the majority of combined cycle gas turbines, which are currently operating at a loss, to *recover their investment costs*
- **Second study (2016)** [2]: How does scarcity pricing depend on
  - strategic reserve
  - value of lost load
  - restoration of nuclear capacity
  - day-ahead (instead of month-ahead) clearing of reserves
- **Third study (2017)** [3]: can we take a US-inspired design and plug it into the existing European market?
  - **Finding**: essential role of *real-time market for reserve capacity* for back-propagation of adders to forward reserve markets

Scarcity Pricing Developments in Belgium

- **ELIA ex-post simulation (2018)** [4]: ELIA (Belgian TSO) releases report on the simulation of scarcity prices in the Belgian market for 2017
  - **Finding**: comfortable year, infrequent occurrence of adders
- **Extension of third study** [7, 11, 12]: could Belgium implement ORDC unilaterally? How do the adders interact with the MARI and PICASSO platforms?
- **Ongoing work**: sensitivity of the design to the exact shape of the ORDC



Scarcity adder on November 29, 2017
Source: ELIA [4]

Publication of Scarcity Prices by ELIA

- **ELIA D+1 publication of adders (2019)**: Effective October 2019, ELIA is publishing adders in D+1

D+1 publication of the different scarcity price-adders

The scarcity price-adders shown here are calculated according to the model conceptualized in the CREG/UCL study (cf. chapter 7. Implementation) that - under specific assumptions - assesses the risk of scarcity and assigns a value to these moments that is linked to the loss of load probability and the value of lost load. The relevant concepts from the CREG/UCL study linked to this publication are described below. How such scarcity price-adders might link further to the prevailing market design and remuneration flows goes beyond this price-adder publication and is reflected upon in other parts of the CREG/UCL study.

Which scarcity price-adders are shown? (cf. section 7.1 The Three Adders in CREG/UCL study)

How are the scarcity price-adders calculated? (cf. section 7.3 Constructing the Price Adders in CREG/UCL study)

21/10/2019

Quarter	Adder 7.5 min. (€/MWh)	Adder 15 min. (€/MWh)	Adder Energy (€/MWh)
00:00 > 00:15	0,00	0,00	0,00
00:15 > 00:30	0,00	0,00	0,00
00:30 > 00:45	0,00	0,00	0,00
00:45 > 01:00	0,00	0,00	0,00
01:00 > 01:15	0,00	0,00	0,00
01:15 > 01:30	0,00	0,00	0,00
01:30 > 01:45	0,00	0,00	0,00
01:45 > 02:00	0,00	0,00	0,00

Source: ELIA https://www.elia.be/en/electricity-market-and-system/studies/scarcity-pricing-simulation

Belgian Electricity Market Implementation Plan [5]

- Argument of Belgian government:

"the existing alpha component in the imbalance price mechanism … already exhibits quite some characteristics of a scarcity pricing mechanism"

- Note: imbalance adders are related to level of imbalance in the system, not whether the system is short on reserves or not

European Commission Response to Belgian National Implementation Plan [6]

- "The Commission also considers that the scarcity pricing function should be triggered by the **scarcity of reserves** in the system and it should be calibrated to increase balancing energy prices to the Value of Lost Load when the system runs out of reserves. The Commission invites Belgium to consider **amending its scarcity pricing scheme** accordingly by **no later than 1 January 2022**."
- "The Commission, however, invites Belgium to consider whether the **scarcity pricing function should apply not only to BRPs but also to balancing service providers (BSPs)**. This may support security of supply by ensuring that **BRPs and BSPs face the same price for the energy produced / consumed**, as price differentiation may result in inefficient arbitrage from market players."

Thank You

For more information

anthony.papavasiliou@uclouvain.be

http://perso.uclouvain.be/anthony.papavasiliou/public_html/home.html

https://ap-rg.eu/

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[1] A. Papavasiliou, Y. Smeers. “Remuneration of Flexibility under Conditions of Scarcity: A Case Study of Belgium”, the *Energy Journal*, vol. 38, no. 6, pp. 105-135, 2017.

[2] A. Papavasiliou, Y. Smeers, G. Bertrand. “An Extended Analysis on the Remuneration of Capacity under Scarcity Conditions”, *Economics of Energy and Environmental Policy*, vol. 7, no. 2, 2018.

[3] A. Papavasiliou, Y. Smeers, G. de Maere d'Aertrycke, “Study on the general design of a mechanism for the remuneration of reserves in scarcity situations”, June 6, 2019.

[4] ELIA, “Study report on Scarcity Pricing in the context of the 2018 discretionary incentives”, December 20, 2018.

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[5] Federal Public Service Economy, 2019. Belgian electricity market: implementation plan, Brussels: Federal Public Service Economy.

[6] European Commission, 2020. *Commission opinion of 30/04/2020 pursuant to article 20(5) of Regulation (EC) No 2019/943 on the implementation plan of Belgium,* Brussels: European Commission.

[7] A. Papavasiliou, “Scarcity Pricing and the Missing European Market for Real-Time Reserve Capacity”, under review in the Electricity Journal.

[8] A. Papavasiliou, B. Gilles, “A Modeling Framework for Analyzing European Balancing Markets”.

[9] Paul Giesbertz, “The power market design column – The scarcity of scarcity pricing”, available online: https://www.linkedin.com/pulse/power-market-design-column-scarcity-pricing-paul-giesbertz/

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[10] Anthony Papavasiliou, 95th Session of the Harvard Electricity Policy Group, "Market Reforms for Stressed Conditions: the Case of Europe", Harvard University, Boston, MA, June 14, 2019

[11] A. Papavasiliou, "Modeling Cross-Border Interactions of EU Balancing Markets: a Focus on Scarcity Pricing", chapter in *Mathematical modelling of contemporary electricity markets: New challenges and methodologies*, Elsevier

- [12] A. Papavasiliou, G. Bertrand, "Market Design Options for Scarcity Pricing in European Balancing Markets", under review in *IEEE Transactions in Power Systems*