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Study on the recent developments on the implementation of a scarcity pricing mechanism in Belgium

carried out pursuant to Article 23, §2, second paragraph, of the Law of 29 April 1999 on the organisation of the electricity market

Non confidential

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INTRODUCTION

1. Significant progress in the development of a scarcity pricing mechanism applied to Belgium has been made recently, with the finalisation of the studies made by the Consultant, Prof. Anthony Papavasiliou of the CORE Department of the Université Catholique de Louvain, in the scope of the Second addendum to the study on the general design of a scarcity pricing mechanism in Belgium.

2. This study covers the main conclusions of the 4 papers on the justification of the design of the proposed scarcity pricing mechanism, on the integration of the proposed design with the balancing platforms and on the interaction with neighbours in case of a unilateral implementation in Belgium. The study will also recall the relevant legal context and highlight some key features of the proposed design.

3. Concerning the papers, only draft versions are published here: indeed, as these papers are proposed for publication in prestigious journals, they may still be under a review process. Therefore, at this stage, these papers are published for information as an annex to this study.

This study is organised as follows:

1) Recall of the relevant legal framework

2) Main conclusions of the different papers

3) Discussion of some key elements of the design of a scarcity pricing mechanism applied to Belgium.

4. As an introduction, it is good to recall that with the energy transition, the system is undergoing fundamental changes linked to the introduction of renewables characterised by a lack of controllability, the inability (or the difficulty) to provide some ancillary services (reserves, inertia, voltage,..) and low variable costs.

5. Although these services came as by-product (at nearly no cost) in thermal system, this is not the case anymore in the new context where adequate remuneration schemes (technology neutral) compatible with the energy only market design have to be developed.

6. Solutions based on co-optimisation (energy, reserves, inertia,..) and in particular scarcity pricing mechanisms (co-optimisation of energy with the value of reserves on the basis of the "appetite" of consumers for reliability) will be more and more important for providing adequate price signals in short term markets. These price signals are key in the functioning of energy only markets and therefore the implementation of a scarcity pricing mechanism appears as a no regret measure.

7. This study and the EU legislation refer to balancing energy as the energy provided by Balancing Service Providers (BSPs) to balance the system and to imbalances as the energy in imbalance attributable to Balancing Responsible parties (BRPs). In addition, Balancing Capacity (BC) auctions corresponding to automatic Frequency restoration reserves (aFRR) are organised on a daily basis in D-2 and D-1 before 9 am and BC auctions corresponding to manual Frequency restoration reserves (mFRR) are organised in D-1 before 10 am.

8. Finally, opinions expressed in this study are of preliminary nature and may evolve in the future.

9. This study was approved at CREG's Board of the 19th of November 2020.

1. RELEVANT LEGAL FRAMEWORK

10. The most important legal requirements related to this study are recalled below.

1.1. DIRECTIVE (EU) 2019/944 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL OF 5 JUNE 2019 ON COMMON RULES FOR THE INTERNAL MARKET FOR ELECTRICITY ("DIRECTIVE 944" HEREAFTER)

11. CHAPTER II GENERAL RULES FOR THE ORGANISATION OF THE ELECTRICITY SECTOR

Article 3 Competitive, consumer-centred, flexible and non-discriminatory electricity markets

1.Member States shall ensure that their national law does not unduly hamper cross-border trade in electricity, consumer participation, including through demand response, investments into, in particular, variable and flexible energy generation, energy storage, or the deployment of electromobility or new interconnectors between Member States, and ***shall ensure that electricity prices reflect actual demand and supply.***

1.2. REGULATION (EU) 2019/943 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL OF 5 JUNE 2019 ON THE INTERNAL MARKET FOR ELECTRICITY ("REGULATION 943" HEREAFTER)

12. Article 3 Principles regarding the operation of electricity markets

(a) prices shall be formed ***based on demand and supply***

*(g****) market rules shall deliver appropriate investment incentives for generation, in particular for long-term investments in a decarbonised and sustainable electricity system****, energy storage, energy efficiency and demand response to meet market needs, and shall facilitate fair competition thus ensuring security of supply;*

Article 6 Balancing market

1. Balancing markets, including prequalification processes, shall be organised in such a way as to:

(a) ensure effective non-discrimination between market participants taking account of the different technical needs of the electricity system and the different technical capabilities of generation sources, energy storage and demand response;

(c) ensure non-discriminatory access to all market participants, individually or through aggregation, including for electricity generated from variable renewable energy sources, demand response and energy storage;

…

4. The settlement of ***balancing energy*** *for standard balancing products and specific balancing products shall be* ***based on marginal pricing*** *(pay-as-cleared)…*

5. The ***imbalances*** *shall be settled at a price* ***that reflects the real-time value of energy****.*

Article 20 on Resource adequacy in the internal market for electricity

1. …

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 (EU) 2017/2195;

1.3. COMMISSION REGULATION (EU) 2017/2195 OF 23 NOVEMBER 2017 ESTABLISHING A GUIDELINE ON ELECTRICITY BALANCING ("BALANCING GUIDELINE" HEREAFTER)

13. Article 18 Terms and conditions related to balancing

1. No later than six months after entry into force of this Regulation and for all scheduling areas of a Member State, the TSOs of this Member State shall develop a proposal regarding:

(a) the terms and conditions for balancing service providers;

(b) the terms and conditions for balance responsible parties.

…

3. When developing proposals for terms and conditions for balancing service providers and balance responsible parties, each TSO shall:

…

(b) respect the frameworks for the establishment of European platforms for the exchange of balancing energy and for the imbalance netting process pursuant to Articles 19, 20, 21 and 22;

…

4. The terms and conditions for balancing service providers shall:

…

(d) 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.

…

5. The terms and conditions for balancing service providers shall contain:

…

(i) the rules for the settlement of balancing service providers defined pursuant to Chapters 2 and 5 of Title V;

…

6. The terms and conditions for balance responsible parties shall contain:

…

(f) the rules for the settlement of balance responsible parties defined pursuant to Chapter 4 of Title V;

…

TITLE V SETTLEMENT CHAPTER 1 Settlement principles Article 44 General principles

***(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**.*

1.4. COMMISSION OPINION OF 30.4.2020 PURSUANT TO ARTICLE 20(5) OF REGULATION (EC) NO 2019/943 ON THE IMPLEMENTATION PLAN OF BELGIUM (COMMISSION OPINION HEREAFTER)

14. The view of the Commission on scarcity pricing mechanism related to the implementation of a capacity remuneration mechanism in Belgium can be found in the quote below:

*The Commission is of the view that the 'alpha component' already exhibits certain characteristics of a scarcity pricing function. **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. 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.*

1.5. DECISION NO 01/2020 OF THE EUROPEAN UNION AGENCY FOR THE COOPERATION OF ENERGY REGULATORS OF 24 JANUARY 2020 ("ACER DECISION ON BALANCING ENERGY" HEREAFTER) ON THE METHODOLOGY TO DETERMINE PRICES FOR THE BALANCING ENERGY THAT RESULTS FROM THE ACTIVATION OF BALANCING ENERGY BIDS

15. The approved methodology is described in the Annex 1 presented below:

*Annex I – **Methodology for pricing balancing energy and cross-zonal capacity used for the exchange of balancing energy** or operating the imbalance netting process in accordance with Article 30(1) of*

Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing

Article 1 Subject matter and scope

4. This pricing methodology is without ***prejudice to the introduction of a shortage pricing function for balancing energy as referred in Article 20(3) of the Regulation (EU) 2019/943****, within the national terms and conditions related to balancing pursuant to article 18 of the EB Regulation*.

1.6. DECISION NO 18/2020 OF THE EUROPEAN UNION AGENCY FOR THE COOPERATION OF ENERGY REGULATORS ("ACER DECISION ON IMBALANCE SETTLEMENT HARMONISATION" HEREAFTER) OF 15 JULY 2020 ON THE HARMONISATION OF THE MAIN FEATURES OF IMBALANCE SETTLEMENT

16. The details of the imbalance settlement harmonisation can be found in Annex 1 of that decision where Article 9 6 a allows a shortage pricing function for BRPs:

(6) The connecting TSO or connecting TSOs of an imbalance price area may propose in the Member State's terms and conditions for BRPs the conditions and a methodology to calculate additional components, to be included in the imbalance price calculation. In that case, this TSO or these TSOs shall propose one or more of the following additional components:

(a) a scarcity component to be used in nationally defined scarcity situations;

(b) an incentivising component to be used to fulfil nationally defined boundary conditions;

(c) a component related to the financial neutrality of the connecting TSO.

2. SECOND ADDENDUM TO THE STUDY ON THE GENERAL DESIGN OF A SCARCITY PRICING MECHANISM IN BELGIUM

17. The study on the general design of a scarcity pricing mechanism (third study) was to propose a general design for the implementation of a reserve scarcity pricing mechanism in Belgium based on the ORDC approach.

The second addendum to this study on the general design of a scarcity pricing mechanism comprises three tasks. Four papers were delivered by the Consultant as answers to the addendum requirements.

Task 1: Verification that the formulas proposed for the 3 adders accurately reflect system scarcity. This verification will be based on a three-stage stochastic program which represents the sequence of events in balancing.

Task 2: Definition of formulas for the settlement of BRPs and BSPs which depend on the outcomes of the MARI and PICASSO platforms, so as to reproduce the settlement outcomes of scarcity pricing adders. Proposed formulas will minimize as much as possible the eventual incompatibilities with the

Clean Energy Package (CEP) and the Balancing Guideline, and if not, to highlight what are the points of conflict.

Task 3: Clarification on how a unilateral implementation of scarcity pricing in Belgium would interact with the sharing of reserve with other systems via the MARI and PICASSO balancing platforms.

Issues related to Task 1 are covered in the first and the second papers: "Market Design Options for Scarcity Pricing in European Balancing Markets", of Anthony Papavasiliou and Gilles Bertrand and "Analytical Derivation of Optimal BSP / BRP Balancing Market Strategies" of Anthony Papavasiliou.

Issues related to Task 2 are covered in the third paper "Scarcity Pricing and the Missing European Market for Real-Time Reserve Capacity" of Anthony Papavasiliou.

Issues related to Task 3 are tackled in the fourth paper "Modeling Cross-Border Interactions of EU Balancing Markets: a Focus on Scarcity Pricing", of Anthony Papavasiliou

18. The determination of market design choices is based on models. One thing about models: these models are approximations of the reality and the fact that a given market design is able to meet its goal in theory, with some modelling assumptions does not provide a guarantee that this design will work as expected in practice. But at the same time, market designs options which are not able to meet their objectives when modelled have little chance to perform adequately in practice. With other words, market designs options identified as non-satisfactory in these studies should not be further considered for implementation as many issues may even worsen the situation in reality.

19. Finally, note that the text below describing the different papers is to a large extent "copy-pasted" from these papers.

2.1. FIRST PAPER MAIN ELEMENTS : "MARKET DESIGN OPTIONS FOR SCARCITY PRICING IN EUROPEAN BALANCING MARKETS"

20. This paper, and also the next one (see below) presents the works done to check if the proposed design is able to reflect scarcity conditions and whether it is able to back propagate the scarcity signal to market players.

21. This paper highlights the advantages and disadvantages of several market design options, some of them considered by ELIA. These conclusions are confirmed by a mathematical analysis of these market designs options, complemented by multi-agent simulations, presented in the following paper.

22. In previous analysis[1] , stochastic equilibrium has been used as quantitative method of choice for representing the back-propagation effect of scarcity pricing quantitatively.

23. However, the stochastic equilibrium framework encountered an immediate weakness from the outset during discussions with stakeholders: the model assumes a unique market for real-time energy, and therefore a unique price for balancing energy and for imbalance energy. This assumption contradicts the practice of using imbalance prices for BRP settlement that are different from balancing prices for BSP settlement. To put it differently: whereas stochastic equilibrium can be used for

[1] A. Papavasiliou, Y. Smeers, and G. de Maere d'Aertrycke, "Study on the general design of a mechanism for the remuneration of reserves in scarcity situations," UCLouvain Tech. Rep., 2019. [Online]. Available: https://www.creg.be/sites/default/files/assets/Publications/Notes/Z1986Annex.pdf

A. Papavasiliou, Y. Smeers, G. de Maere d'Aertrycke, Market Design Considerations for Scarcity Pricing: A Stochastic Equilibrium Framework, The Energy Journal, forthcoming
https://ap-rg.eu/wp-content/uploads/2020/10/J26.pdf

understanding the effect of certain market design choices on the back-propagation of reserve prices to forward markets, it cannot be used for assessing the validity of different mixtures of BSP and BRP settlement on this back-propagation. Therefore, an alternative model based on the representation of the balancing market as a Markov Decision Process (MDP) is used in this paper to compare the efficiency of different designs.

24. In this analysis, BRPs and BSPs are considered as agents that engage in trade in a balancing market, and develop trading strategies given different market design options.

25. The MDP simulation framework is then used for providing tangible evidence for the behaviour that the analytical mathematical framework predicts (see the next paper below).

26. Four designs have been studied and compared.

(D1): this design corresponds to the default European design where the balancing price equals the imbalance price

(D2): this design corresponds to the current Belgian design with an Alpha component. It is important to note that design relies on imbalance penalties which depend on the level of system imbalance, which is not to be confused with the level of scarcity in the system. To clarify: a system that is exhibiting a very large positive imbalance is not experiencing scarcity if it carries abundant reserve at the moment in time when the large imbalance occurs. So, in this design, the BRP price is different from the BSP price and is equal to the Alpha plus the BSP price

(D3): this design foresees an adder reflecting scarcity on the imbalance energy only. This design corresponds approximately to the design currently proposed by ELIA with the Omega, but without the Alpha and the BRP price is equal to the Omega component reflecting scarcity plus the BSP price. Again, in this design, BRP and BSP prices are different.

(D4): This is the design currently proposed for the implementation of a scarcity pricing mechanism which relies on a real-time market for reserve capacity, i.e. a Balancing Capacity market operated in the balancing time frame. In this design, BRPs and BSPs face the same price, and an additional settlement of reserve imbalances applies.

27. From the simulations performed, the following has been observed. For designs (D1) and (D2), the reserve price sample average converges to a small value. This is anticipated by the analytical results (see paper below), because the opportunity cost for each agent in the day-ahead balancing capacity auction is equal to 0. For design (D3), the reserve price sample average arrives slightly above the one resulting from (D1). As the analysis shows in the next paper (see below), under (D3) certain low-cost producers may face a positive opportunity cost when bidding into the day-ahead reserve market. Nevertheless, the resulting reserve price remains close to the one of (D1), because few producers are sufficiently cheap to fulfil this condition. Finally, under design (D4), **the day-ahead reserve price converges to a value which is close to the average real-time scarcity adder.**

28. In conclusion, the simulations performed here expose the inability of market design alternatives (D2) and (D3) in back-propagating the value of reserve capacity in day-ahead markets and validate the ability of a real-time market for reserve capacity - design (D4) - to back-propagate the value of the real time reserve capacity to the day ahead markets, while also preserving the incentive of agents to make their reserve resources available in the balancing market. With this real-time market for reserve capacity, agents will only sell reserve capacity in forward markets (i.e. day-ahead auctions) at the value that they would need to buy it back in real time. This is especially crucial, since it allows the value of reserve capacity to back-propagate into forward reserve auctions, and send the signal to investors that the market can support investments in reserve capacity.

29. To make it clear, when bidding in the DA market coupling, market players bid at a price that reflects fixed costs in day ahead, plus variable costs corresponding to the production of electricity and

finally opportunity costs related at least to the existence of several subsequent energy markets/mechanisms such as intraday, re-dispatching and balancing. When bidding balancing capacity in DA, before the DA market coupling, the situation is different: we have the fixed costs necessary to make this capacity available for the system, and in the absence of a real-time BC market, no opportunity cost that may back propagate the scarcity adder applied in the balancing time frame to forward markets (here just before the DA market), but only an opportunity cost related to selling energy in DA, for low-cost producers which may feel some impact of the balancing, real-time energy adder, if any.

30. With other words, when bidding in the day-ahead balancing capacity auction, successful bids are committing to make their balancing energy available in real time. Apart from fixed costs required for bringing reserve resources online, this commitment carries minimal opportunity costs in the absence of reserve imbalance settlements.

2.2. SECOND PAPER MAIN ELEMENTS "ANALYTICAL DERIVATION OF OPTIMAL BSP / BRP BALANCING MARKET STRATEGIES"

31. This paper provides an analytical comparison of the 4 designs already presented in the previous paper. The results of this analytical derivation of the properties of the 4 examined designs are presented below.

32. With the design (D1), it is always optimal for agents to bid their entire balancing capacity at the true marginal cost to the balancing auction. For agents with upward balancing capacity, the opportunity cost of bidding their capacity to the day-ahead reserve auction is zero. This is a pure strategy Nash equilibrium.

33. With the design (D2), in a system with independent and symmetric imbalances, it is optimal for agents to bid their entire balancing capacity at the true marginal cost to the balancing auction. For agents with upward balancing capacity, the opportunity cost[2] of bidding their capacity to the day-ahead reserve auction is zero. This is a pure strategy Nash equilibrium.

34. With the design (D3), it is optimal for a subset of agents to bid their entire balancing capacity at the true marginal cost to the balancing auction, whereas for a subset of the agents it is optimal to self-balance, and keep their flexible capacity out of the balancing auction. For agents with upward balancing capacity, the opportunity cost of bidding their capacity to the day-ahead reserve auction is less than or equal to the scarcity value. This design is depressing the scarcity price in two ways: (i) agents who find it optimal to self-balance face an opportunity cost which is less than the scarcity price, while the action itself of self-balancing is depressing balancing energy prices and (ii) agents who find it optimal to bid their entire capacity to the balancing auction face an opportunity cost of zero for bidding reserve in the day ahead market.

35. With design (D4), it is always optimal for agents to bid their entire balancing capacity at the true marginal cost to the balancing auction. Agents have an incentive to bid the average scarcity price in the day-ahead reserve auction. This is a pure strategy Nash equilibrium.

36. In conclusion, design (D4) is the only design that (i) maintains the incentive of agents to bid their entire flexible capacity to the balancing auction, while also (ii) giving an incentive to agents to back-propagate the average scarcity price to day-ahead reserve auctions. Therefore, **a proper**

[2] This opportunity cost refers to the fact that successful bids in the day-ahead reserve auctions are required to bid at least the amount of day-ahead reserved capacity as balancing energy in the balancing market

implementation of scarcity pricing requires a real-time market for reserve capacity. Equating the balancing price with the imbalance price has been shown to be part of the appropriate market design. No market design was found that did not settle real-time reserves and that is still capable of back-propagating reserve prices.

2.3. THIRD PAPER MAIN ELEMENTS "SCARCITY PRICING AND THE MISSING EUROPEAN MARKET FOR REAL-TIME RESERVE CAPACITY"

37. The paper highlights and justifies the interactions of the proposed formulas for the implementation of scarcity pricing with the CEP and the balancing platforms. The paper also explores other design alternatives and explains why these alternatives do not answer adequately to the objectives of a scarcity pricing mechanism and to the requirements of back propagation. Some key inputs provided by this paper are highlighted below.

38. Currently, in the European market design, the trading of energy and reserve is not co-optimized, and there is a weak consistency between day-ahead and real-time market design. Both of these elements complicate price formation. In some countries, reserves are auctioned before the day-ahead energy market (e.g. Belgium, Germany, the Netherlands), whereas in other countries reserves are auctioned after the day-ahead market (e.g. Spain, Italy). Therefore, the aforementioned equilibrium between day-ahead energy and reserve prices relies on the ability of asset owners to anticipate the opportunity cost of trading their generation capacity in one auction versus the other. The weak consistency between day-ahead and real-time markets implies a host of challenges. The one that is of interest in the paper is a fundamental difficulty for valuing reserve accurately, which undermines an effective implementation of scarcity pricing.

39. In future balancing platforms, BSPs will be paid a uniform clearing price. Each balancing platform will be run separately, and will produce a different balancing price, at a different time step. However, the functional separation of BSPs and BRPs does not negate the fact that the two are essentially trading energy in the balancing market. The functional distinction between BSPs and BRPs has unfortunately led to two notable distortions in European market design. On the one hand, BRPs and BSPs face a different real-time price for trading energy, with BSPs being settled at a co-called balancing price, and BRPs being settled at a so-called imbalance price. On the other hand, whereas Europe operates a real-time energy market (the so-called balancing market, which settles energy imbalances), there is no provision for a real-time reserve market (i.e. there is no settlement of reserve imbalances).

40. An inconsistent application of the principles of the scarcity pricing design would amount to adding the scarcity component to the energy price alone. The distinction between balancing and imbalance prices allows for further creative combinations: one may envision applying the adder to the imbalance price, but not the balancing price.

41. The proposed implementation of a scarcity pricing mechanism introduces a scarcity adder applied on the real-time price of reserve capacity of a real-time market created for that purpose ("the missing market"). This has two effects: (i) Due to the no-arbitrage relation between energy and reserve capacity, this adder uplifts the energy price (ii) Reserve imbalances need to be settled against the real-time price of reserve capacity.

42. An alternative that has been considered for the possible implementation of scarcity pricing is to limit the application of the scarcity adder to the imbalance price alone (this alternative corresponds to the current ELIA proposal called Omega without the Alpha component). An interpretation of this proposal it to replace the alpha component in the imbalance price with the ORDC adder. The effect of this proposal is notably different from the alpha component. In this case, and in contrast to the case

of the Belgian alpha component, BSPs face an opportunity cost for bidding reserve capacity in the day-ahead balancing capacity auction (see § below), however this opportunity cost is largely counteracted by the fact that they also face an incentive to be long in their portfolios, thereby exerting a downward pressure on balancing energy prices.

43. The trade-off of agents to use their balancing capacity in order to self-balance their portfolio in this design creates conditions for certain agents (those with the lowest marginal costs in the merit order stack for upward activation) to take their chances by activating their reserve upwards without being asked to do so by the system operator.

44. This effect is interesting, because it creates an opportunity cost for bidding these resources into the balancing market, and therefore produces a back-propagation of a day-ahead reserve price. However, the opportunity cost is lower than that of the average ORDC adder, and only applies to a subset of the balancing resources. Therefore, something is being back-propagated, but it is not the average ORDC scarcity adder. Moreover, it is worth noting that self-balancing results in economic inefficiencies on the balancing energy market, since the imbalances that are being resolved by the balancing energy market could have been balanced by potentially cheaper resources reserved for balancing within a balancing portfolio.

45. The paper also indicates that scarcity adders can be computed based on ARC data already computed by ELIA. In 2018, at the request of the Belgian regulatory authority, the Belgian transmission system operator undertook a counterfactual analysis that aimed at computing the ORDC scarcity prices that would have occurred in Belgium in 2017 based on historically telemetered data. For this purpose, ELIA used the so-called Available Reserve Capacity (ARC), which is the amount of reserve capacity that is recorded by ELIA telemetry. The ARC can be used as an input to the adder formula, thereby allowing scarcity adders to be computed ex post. The study found few occurrences of a non-zero scarcity price in the system, which is consistent with the fact that 2017 was a comfortable year for the Belgian system. Since October 2019, the Belgian system operator publishes scarcity prices one day after operations based on the ARC data that has transpired during the previous day.

2.4. FOURTH PAPER MAIN ELEMENTS “MODELLING CROSS-BORDER INTERACTIONS OF EU BALANCING MARKETS: A FOCUS ON SCARCITY PRICING”

46. This paper studies the cross-border effect of a “unilateral” implementation of a scarcity pricing mechanism in Belgium. Some key elements are presented below.

47. Even if Article 44.3 of the balancing Guideline allows for a unilateral, national implementation of scarcity pricing, as described by Article 18, CREG raised questions about the cross-border effects of scarcity pricing in case of a unilateral implementation.

48. Concretely, suppose that Belgium implements the mechanism, whereas neighbouring zones do not. How should the settlement exactly work out? And what could one expect in terms of balancing energy prices and day-ahead energy and reserve prices in neighbouring zones?

49. These questions are addressed using a stochastic equilibrium model. The stochastic equilibrium model used does not require risk averse agents in order to provide useful insights. It can also provide useful insights in the case were all agents are risk neutral, because it explains the mechanism by which agents arbitrage real-time prices against day-ahead prices. Thus, the stochastic equilibrium framework provides a quantitative approach to explaining the back-propagation of energy and reserve prices in

forward (e.g. day-ahead) markets when a change is introduced to the real-time market design (e.g. via the introduction of a scarcity adder).

50. A stylized two-zone example, i.e. Belgium and the Netherlands, is considered, with the two zones connected by a link of limited capacity. The market model considers features a missing market: the Dutch TSO does not trade reserve capacity in real time.

51. An underlying institutional concern of this analysis has been to understand how the proposed mechanism should interact with neighbouring BSPs and BRPs. According to the proposal analysed in the paper, the balancing platforms will produce a local zonal energy price for each BSP in the market. Zones which apply scarcity pricing settle their BRPs (and the associated BSPs of each BRP) according to the proposed scarcity pricing formulas, whereas zones which do not apply scarcity pricing are not affected.

52. Concretely, Dutch resources will pay the Dutch zonal price, and therefore they are not directly affected by the adder settlements (even if the adder may have an effect on the equilibrium outcome of the balancing platform). The fact that Dutch resources are being activated in order to address a Belgian scarcity incident is not at odds with the fact that these Dutch resources are supplying their balancing energy in the Dutch zone, and the balancing platforms produce a price for this balancing energy.

53. There is no need for violating the merit order of the balancing platform in order to arrive to the computed equilibrium outcome. If neighbouring Dutch BSPs are not exposed to real-time markets for reserve capacity in the Netherlands, they anyways would not internalize the cost of delivering this reserve in real time to their day-ahead reserve capacity auction bids.

54. This discussion underscores the importance of applying scarcity pricing for reserve imbalance settlements (equivalently, putting in place a real-time market for reserve capacity), and not limiting the application of the adder as an add-on to imbalance charges. Indeed, if scarcity adders would only be limited to add-ons on the imbalance price, then one could envision that Belgian BSPs might lower their marginal price so that they would be selected at the expense of imported bids from foreign BSPs. This would raise a concern among foreign NRAs as a violation of the (common) merit order: if the scarcity adder is applicable if the import potential is not fully used, then the perception is that Belgian BSPs push away foreign BSPs. **By contrast, the application of scarcity pricing**, as it is intended, for settling not only real-time energy **but also real-time reserve capacity, would eliminate the interest for Belgian BSPs to mark down their bids, since whatever Belgian BSPs gain on the margin from providing balancing energy is balanced off from using up reserve capacity during activation.** This explains why the implementation of the proposed scarcity pricing mechanism, with the creation of two BC capacity markets in real-time should not distort competition. What remains is the incentive for Belgian BSPs to internalize the real-time adders in their day-ahead reserve capacity bids, which would serve towards back-propagating real-time scarcity adders to day-ahead reserve prices in Belgium.

55. The following conclusions are drawn from the analysis of the simplified model:

- A unilateral implementation of ORDC in Belgium does not affect the day-ahead reserve price of the Netherlands.
- A unilateral implementation of ORDC in Belgium increases the day-ahead reserve price in Belgium.
- A unilateral implementation of ORDC in Belgium increases the real-time energy price in the Netherlands under conditions of scarcity.
- The merit order of the balancing platforms (e.g. MARI) is respected, opportunity costs can be incorporated by Belgian resources in their balancing offers.

3. FURTHER DISCUSSION OF SOME KEY ELEMENTS OF THE DESIGN OF A SCARCITY PRICING MECHANISM APPLIED TO BELGIUM.

56. As complement to the studies mentioned above, some key elements of the proposed design are further explained and discussed below.

3.1. ELECTRICITY AS A GOOD

57. The focus is set on energy only markets.

58. In theory, there should be one price for electricity at a given location and time. Indeed, when produced, it seems not possible to distinguish the exact source of the electricity produced. And in most designs, the price of electricity should correspond to the highest variable cost – or the marginal price - of the activated generators.

59. The prices determined by the different balancing platforms may lead to implementations that may depart from this theoretical rule.

60. At the same time, it seems natural that reserves of generation units that can be activated with different speed, or ramp rates, have different values: and the highest the ramp rate, the highest the value. So, if several real-time markets for reserves exist, it seems natural that these reserves markets have different prices and ensure that units providing fast reserve can be better remunerated.

61. In the EU design, we have day-ahead (and intraday) and real-time markets **for energy**. There are also day-ahead markets for the procurement of reserves, but no (corresponding) real-time markets for reserves: it is referred to here as missing markets.

62. The current (EU) design recourse to reserve acquired in DA through auctions, and failing to deliver leads to sanctions (as an example for Belgium[3]) which are not linked to the value of the missing service, i.e. to the additional costs related to a higher probability of resorting to a curtailment. There is also no possibility for market players to provide missing reserves if the volumes procured in the day-ahead by the TSO cannot be delivered. No specific product related to reserves exists in real-time. So the current design does not provide adequate incentives for providing reserves at the right price when needed.

63. Furthermore, the existence of real-time markets for reserves where the availability of these reserves can be checked in real-time makes market-players indifferent in their reaction inside the current 15' period to help the system in relation with the reactive balancing concept. Therefore, this existence of real-time BC markets for reserves reduces inefficient arbitrage possibilities[4].

[3] The availability of reserves is checked based on tests where the delivery of **energy** under specific conditions is verified.

[4] This issue has to be examined in the context of the possibility of a direct activation by the TSO of mFrr within the 15' versus self-balancing.

3.2. THE SAME PRICE AND ADDER FOR BRPS AND BSPS

64. An important element of the Consultant proposal is to apply the same price (with a different sign) for the energy supplied or withdrawn to BRPs and BSPs.

65. First, according to Article 18 of the Balancing Guideline, most of the requirements related to balancing are specified in national terms and conditions, provided that these terms and conditions are compatible with the development of the different balancing platforms currently implemented. These national Terms and Conditions (T&C) for BRPs and BSPs specify the actual settlement rules (prices, volumes, for BSPs and BRPs). This is the result of the chosen TSO-TSO model: every BSP/BRP always deals with his own TSO with respect to T&C and clearly allows the implementation of a design where imbalance and balancing energy prices are equal (with a different sign).

66. Different prices for balancing energy (applied to BSPs) and for imbalance energy (charged on BRPs), linked to the presence of an Alpha component, is rather exceptional in Europe. Concerning the link between these two entities/concepts, at the origin, only BRPs existed and BSPs were created to allow more flexibility for the procurement by the TSO of reserves necessary to the system. But the concept of the BRP remains unchanged, meaning that this party is kept accountable for the imbalances it causes in the system. All market participants shall be responsible for the imbalances they cause in the system ('balance responsibility') and shall strive to be balanced or shall help the electricity system to be balanced (see Article 5.1. Regulation 943). This responsibility cannot be imagined without a strong link to a BSP that balances the energy consumed/produced by the BRP (see Article 18(4) of the Balancing Guideline). There is no obvious reason for having a different price applying to the supply side (BSP) and to the consumption side (BRP), and any differentiation may lead to inefficient (for the system) arbitrage possibilities.

67. As an example, for the Netherlands, BRPs and BSPs face mostly[5] the same energy price[6].

68. Quick readings of the existing legislation may lead to the conclusion that a scarcity pricing adder can only be added to BRPs. But as it will be shown below, this interpretation leads to inconsistencies indicating that this interpretation may not be the right one.

69. Article 44(3) of the Balancing Guideline clearly allows the application of a scarcity adder (to settle the procurement costs of balancing capacity) on the imbalance price charged on BRPs. This is confirmed by the ACER Decision on imbalance settlement harmonisation where Article 9.6 (a) allows a scarcity component to be used in nationally defined scarcity situations. Note also that this article clearly envisages a **national implementation** of this mechanism.

[5] The BRP/BSP price is mostly the same with some exceptions**: a**. Currently the BSPs (all of them: so providing aFRR and mFRR directly activated) receive the same marginal balancing energy price for the energy delivered to the TSO in that single ISP. The revenue of each BSP is thus equal to the $Q_{BSP}xP_{ISP}$. Until the end of 2018 the pricing was slightly dfifferent because aFRR BSPs received the price equal to the marginally priced bid whereas mFRRda BSPs received a balancing energy price based on a specific pricing rule. These latter BSPs do not bid BE-bids but the price they received was set according to a price formula which lead to a BE-price roughly 200 EUR higher than the aFRR BE price in every ISP where mFRRda is activated (in Dutch this product is called 'Noodvermogen' and it is usually provided by large industries and only for a maximum of 20 ISPs per year). In the current regime the two pricing rules were merged into one: the first part (when aFRR is used) is based on the CMOL of aFRR (merit order price), the 2nd part is an mFRRda price adder on top of the aFRR price and now all the BSPs in NL receive this same price (so also aFRR BSPs receive the adder). This price rule is included in the Dutch gridcode **b.** Regarding the price that BRPs pay for their imbalances, this is in general a single imbalance price (same for long and short imbalance BRPs) and is equal to the (single) price for BSPs as outlined above. Nevertheless, in some ISPs there is a dual imbalance price system having different prices for long and short imbalance BRPs. This happens in case the TSO must activate balancing energy in different directions (both positive/negative or upward/downward balancing energy in the same ISP). In order to incentivise BRPs in those ISPs as much as possible to stay close to their position (and not help the system) TenneT applies dual pricing. This happens in around 10-15% of ISPs per year.

[6] https://www.tennet.eu/fileadmin/user_upload/SO_NL/Imbalance_pricing_system.pdf

70. Article 20 (c) of the Regulation 943 also makes a reference to a shortage pricing function in its section on resource adequacy (so targeting BSPs) as a measure to be considered when implementing a CRM: “introducing a shortage pricing function for balancing energy as referred to in Article 44(3)...”. But this article clearly targets **balancing energy** and so **BSPs**, where Article 44(3) refers to imbalances, and BRPs. So what is referred to in Article 44(3) is not the balancing energy, which leads to a contradiction, but the **shortage pricing function**. So this Article 20 (c) can more easily be red as “introducing a shortage pricing function (“**also**” for balancing energy) as referred to in Article 44(3)”.

71. ACER Decision on **balancing energy** (so applicable to **BSP**) confirms this reading when indicating in Article 1 (4) that this pricing methodology (for BSP) is without prejudice to the introduction of a shortage pricing function for balancing energy (so for BSPs) as referred in Article 20(3). Another interpretation should lead to a second inconsistency or contradiction.

72. The application of an energy adder to both BRPs and BSPs is considered in the Commission Opinion on the Belgian implementation plan when indicating that the scarcity pricing function should apply not only to **BRPs** but also to balancing service providers **(BSPs)** : “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)”.**

73. Finally, the ACER Decision on **imbalance** settlement harmonisation indicates that the TSO may propose in the Member State’s terms and conditions for BRPs the conditions and a methodology to calculate additional components, to be included in the imbalance price calculation, such as a scarcity component to be used in nationally defined scarcity situations.

74. The elements presented above indicate that scarcity pricing adders may be applied to the settlement of BRPs but also to the remuneration of BSPs.

75. Based on current developments, EU balancing platforms shall deliver for Belgium (where no Replacement reserves exist) balancing energy prices for each 15’ period on the basis:

- one price for the remuneration of BSP for the activation of aFRR which is equal to the weighted average of the marginal bid prices for each 4 seconds
- one or two prices for the remuneration of BSPs for the activation of mFRR

76. ELIA determines the local, zonal imbalance energy price applied to BRPs as the maximum of the aFRR and mFRR prices. An Alpha component is added to this imbalance energy price when the volume of imbalances on several consecutive periods remains high.

77. What is proposed here with the implementation of a scarcity pricing mechanism is that this imbalance price, with the energy scarcity adder, will be computed and will be given to all BSPs providing energy during that 15’ period.

78. The goal is to avoid here inefficient (for the system) arbitrage of market players between the different balancing platforms. This solution also facilitates the participation of small players to these mechanisms as they may not have the resources/skills to coordinate their bidding in the different platforms. Note that the remuneration linked to the different characteristics or “quality” of the reserves will be realised through the DA BC procurement auctions organised for aFRR and mFRR and through the proposed real-time BC market settlement.

3.3. DISCRIMINATION BETWEEN NATIONAL AND FOREIGN BIDS

79. This section complements the answer provided by the Consultant on the question related to a unilateral implementation of a scarcity pricing mechanism in one country, when neighbouring countries are not making the same move.

80. The current design of the scarcity pricing mechanism for Belgium foresees the application of an energy scarcity adder for the remuneration of thee activation of bids located in Belgium, and not to the remuneration of the activation of foreign BSPs coming from other bidding zones through the balancing platforms. This difference of treatment may raise some concerns about a possible discrimination of these foreign BSPs.

81. Concerning this difference of treatment, it is opportune to recall that in the balancing platforms, balancing energy bids are settled locally, and bids of different bidding zones with the same price may be settled at different prices depending of local conditions, and that it is impossible to attribute the activation of a bid in a bidding zone to a request for energy in another bidding zone. It is only in the rather theoretical case of a two-zone system where the link between the activation of a bid and a TSO request can be made.

82. In order to assess the issue of a potential discrimination, it is good to recall several examples of differences in treatment of the current EU design, and why some of them may be explained:

- 1. Pricing of mFRR
- 2. Day-ahead market coupling
- 3. Scarcity pricing

3.4. MFRR PRICING RULES

83. There are two main products related to mFRR: scheduled mFRR (activated based on a schedule at the beginning of a 15' period) and direct activated (DA) mFRR that may be activated during a 15' period.

84. Scheduled mFRR bids are cleared at marginal price (pay-as-cleared). All direct activated mFRR bids are also cleared at marginal price (pay-as-cleared). If, during any quarter hour, the Direct Activated (DA) mFRR bids are cleared at a lower marginal price than the schedule activated mFRR bids, the direct activated mFRR bids receive the marginal price of the schedule activated mFRR bids.

85. The next example shows how these two pricing rules interact, and only the upward direction is described.

86. In the first 15' period (QH) the Scheduled Activated (SA) mFRR process clears at 20 euro/MWh. In QH2, more is activated and the price rises to 40 euro/MWh. A set of DA mFRR bids is then activated at minute 5 at 30 euro/MWh marginal price. This set is activated during the 5-30' period because of the market design. A second set of DA mFRR bids is activated at 20', at price 50 euro/MWh.

87. In the first QH, the first DA mFRR set receives 30 euro/MWh as being the maximum of the DA mFRR price and the SA mFRR price. As the price SA mFRR rises in the second QH to 40 euro/MWh, the first DA mFRR bids receives 40 euro/MWh as well during the second QH. The second activated DAmFRR bid receives 50 euro/MWh from 20' onward. Note that the two DA mFRR sets do not influence each other in terms of price and so receive a different price for the same time period. As the scheduled

activation price drops to 10 euro/MWh in QH3, the second set of DA mFRR bids receives a price of 50 euro/MWh being equal to their marginal clearing price.

	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45
Scheduled activation	20	20	20	40	40	40	10	10	10
Direct activation 1	-	30	30	40	40	40	-	-	-
Direct activation 2	-	-	-	-	50	50	50	50	50

88. This shows that the same product, direct activated mFRR, that may be located in the same bidding zone (so no transportation considerations here – see below) may receive different prices for energy generated during the same 15' time period, depending of the exact activation moment. The question here is not to discuss this design option, even if it may appear surprising from a theoretical point of view, but to show a situation where a difference in treatment of energy bids (DA mFRR) seems to be accepted.

3.5. DIFFERENT PRICE DUE TO TRANSPORTATION COSTS : DA MARKET COUPLING AND BALANCING PLATFORMS

89. The day-ahead market coupling constitutes another example where energy bids activated at the same time in different bidding zones receive a different treatment.

90. This difference is due to the transportation costs, the cost necessary to make the energy available in the other bidding zone and there is no-discrimination here.

91. With a flow-based market coupling, in the presence of a congestion, **all zonal prices may be different** and bids accepted receive the local, i.e. zonal energy price, even if that energy is used abroad. In fact, we do not exactly know where the energy is generated/used in a market coupling: only the net export and import volumes are known.

92. So, in the presence of a congestion, a bid activated in an exporting bidding zone and used in another importing bidding zone **receives a different remuneration** than a bid activated at the same moment in the importing bidding zone. This difference in treatment directly results of transportation costs and has never been considered as discriminatory and a source of competition distortion. To the contrary, this property is linked to the transportation costs and is fundamental for the delivery of an **adequate zonal price signal.**

93. The same shall apply with the PICASSO and MARI balancing platforms, where, due to the global welfare optimisation and the limitations of the transmission system (NTC in a first stage), the remuneration of balancing energy bids (BSP) may differ in the different bidding zones. In addition, due to the approximation inherent to NTC model, congestions may appear between two BZ where an implementation of a FB mechanism may split the bidding zones differently.

3.6. APPLICATION TO SCARCITY PRICING MECHANISM

94. Scarcity pricing is a measure to be considered when resource adequacy issues have been identified, before the possible implementation of a capacity remuneration mechanism, as indicated by Article 20(3) c of Regulation 943, where a national implementation is foreseen. Similar to capacity

market mechanisms, scarcity pricing can be applied nationally as a complement of the existing EU markets in day-ahead, intraday and balancing. Scarcity pricing can also be implemented on the basis of the Balancing Guidelines (Article 44 (3) and Article 18). From this we can derive that scarcity pricing need not necessarily be applied within an EU-wide market design, but can be applied outside of it, as a complement of it.

95. Concerning a possible discrimination of foreign BSPs due to the application of a scarcity price adder to the balancing energy price, the following should be mentioned, in addition to what has already been indicated above on accepted difference in treatment already existing in balancing and in the day-ahead market coupling.

96. It is important to note that, to the contrary to what is sometimes argued, two BSP located in different bidding zones offering energy at the same price for the same time period do not correspond to the same product: the difference between the two is constituted by the transportation requirements and costs. This reasoning is well known for other goods where transportation is important.

97. In addition, it should be indicated that due to the existence of balancing platforms, foreign BSPs will be allowed to contribute in the reduction of the scarcity observed in Belgium through the delivery of energy bids up to the capacities of the transmission system, for which they will receive the local balancing price determined by the balancing platform[7].

98. If Belgium is in a scarcity situation, there is a high probability that import capacities in real time will be saturated. In this particular situation, by analogy with the market coupling organisation presented above, a different treatment, i.e. a different remuneration is natural given the transportation costs and if the goal is to provide an augmented zonal scarcity price signal.

99. If Belgian importing capacities are not congested in real-time, the following elements should be taken into account.

100. First, it is impossible to determine which market actor has exported what amount of energy abroad, in a coupled market. Any allocation rule is purely hypothetical and might be viewed as discriminatory for the ones that were considered delivering energy locally. So the only way to remunerate market actors abroad equally is to increase the price of the neighbouring market to the same price level, with the same adder for all market actors, and neglecting congestions and the local scarcity situation.

101. This is not even possible if scarcity pricing is included as a standard feature in the EU design and also applied in the neighbouring countries in a situation of scarcity. Indeed, scarcity situations may be encountered in some countries and not all at the same time: so scarcity adders will not be triggered at the same time in all countries.

102. In addition, it should be indicated that if scarcity pricing mechanisms are generalised across the whole Europe, BSP remunerations will still differ as scarcity adders reflect different VOLL levels of the different countries.

103. Finally, this request of equal treatment rule shall be jeopardised by the presence of congestions and transportation costs, as explained above, and this request shall also by definition annihilate any zonal price signal incentivising investment in the right bidding zone.

[7] See the fourth paper "MODELING CROSS-BORDER INTERACTIONS OF EU BALANCING MARKETS: A FOCUS ON SCARCITY PRICING" and in particular the section "4.2 The fact that Dutch resources are being activated in order to address a Belgian scarcity incident is not at odds with the fact that these Dutch resources are supplying their balancing energy in the Dutch zone, and the balancing platforms produce a price for this balancing energy."

104. It is only in the rather hypothetical case where two countries, applying both the same scarcity pricing mechanism, face the same scarcity situation, with the same VOLL, without congestions in real-time that the remuneration may be equal.

105. The implementation of the proposed scarcity pricing mechanism will not affect the functioning of the balancing platforms: bids transmitted to these platforms are unchanged and so the prices resulting from these platforms should not be modified. What the mechanism will well do in Belgium is the addition of a scarcity adder in situation of scarcity.

3.7. PRICING OF ENERGY BASED ON SUPPLY AND DEMAND

106. Even if this question has already been tackled in a previous publication of CREG[8], this section provides some technical/legal arguments supporting our views.

107. Article 3 of Directive 944 indicates that "1. Member States shall ensure … that electricity prices r**eflect actual** demand and supply " and Article 3 of Regulation 943 stipulates that "(a) prices shall be formed **on the basis of** demand and supply".

108. It is important to indicate that it is not written that the electricity price is set at the intersection of the offer and demand curve, as this leads to a situation where many features of the current EU design will be illegal.

109. Indeed, a strict or narrow interpretation of these provisions forbid the recourse to non-convex products reflecting technical limitations of generation units already implemented today, but also the implementation of co-optimisation where the price reflects also transport capacity (through an implicit market coupling) or reserve (the proposed scarcity pricing mechanism constitutes a particular case of co-optimisation).

110. With the implementation of the proposed mechanism for scarcity pricing, the "old", classical rule specifying that prices **shall be formed on the basis of demand and supply** always applies. But the rule must be adapted in order to cope with the massive introduction of renewables which may not provide reserves. In the past, the provision of reserves was a kind of side product always available in a system composed of thermal units. This is less and less the case today.

111. With the paradigm **of an energy only market**, and for systems with a large contribution of units with a low variable cost and not able to provide reserves, a price signal based on the intersection of the offer price curve and the demand only cannot anymore constitute an "all inclusive"(namely energy and reserves) price for energy.

112. In an electric system, reserves are needed for ensuring reliability. Therefore, in order to get the price right, the energy price should be determined by the intersection of the offer curve and of the demand curve augmented by the necessary volume of reserves. With the proposed scarcity pricing mechanism, the demand curve for reserve (price versus volume) is determined on the basis of the (implicit) valuation of demand for reliability through the Value of Loss of Load and the Loss of Load Probability.

113. In addition, Article 6 on balancing market of Regulation 943 stipulates that "5. The imbalances shall be settled at a price that **reflects the real-time value of energy**." This is the electricity price paid by BRPs. In an electric system, the fundamental components constituting **the value of energy** are the value of producing energy, the corresponding losses, the value of the transmission capacity and its associated reliability, the **value of reserves** and the value of inertia. This formulation indicates that all

[8] https://www.creg.be/sites/default/files/assets/Publications/Notes/Z2111EN.pdf

necessary components of the value of energy may/should be reflected in this imbalance price (in an energy only design, the price of energy is deemed to be “all inclusive”). A scarcity pricing mechanism providing a real time adder pricing adequately the value of reserves in real time fulfils these requirements.

114. The above elements indicate why valuing reserves in the electricity price is not only allowed but also requested if we want to comply with the provision referring to the **real time value of energy**.

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ANNEXE 1

Market Design Options for Scarcity Pricing in European Balancing Markets

IEEE, Anthony Papavasiliou

ANNEXE 2

Analytical Derivation of Optimal BSP/BRP

Anthony Papavasiliou

ANNEXE 3

Scarcity Pricing and the Missing European Market for Real-Time Reserve Capacity

CORE, Anthony Papavasiliou

ANNEXE 4

Modeling Cross-Border Interactions of EU Balancing Markets : a Focus on Scarcity Pricing

UCL, Anthony Papavasiliou