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# High-level design for the compliance of the Greek wholesale electricity market with the Target Model provisions in Europe

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ABSTRACT

The stated aim of the European Commission has been the unbounded flow of energy across Europe and the effective functioning of a single European power market so as to achieve secure, sustainable and affordable energy supplies, as well as to foster competition and increase the utilization of electricity networks and generation capacity. Most countries have already adapted or are gradually adapting their wholesale markets to the provisions of the so called *Target Model* for the internal electricity market in Europe, however Greece still lies behind in this binding target. In this paper, the basic design variables and respective options for the integration of the Greek wholesale electricity market with the other European markets under the *Target Model* paradigm are presented. The design variables refer to all market instances and mechanisms. The proposed choices are justified in terms of effectiveness and market power mitigation, considering the current market structure in Greece. A transitional phase for the full integration of the Greek *Intraday* and *Balancing Markets* is proposed, considering the relevant evolutions in the wholesale markets of Greece's neighboring countries. Finally, a simulation analysis is performed in order to highlight the implications on schedules of utilizing European-based order formats in the restructured Greek electricity market.



## 1. Introduction

The development of a single European electricity market is one of the major goals of the *Third Package* of European energy legislation, which came into force in September 2009 [1]. The rules for market integration are based on the so called *Target Model* for electricity in Europe, which is flanked by a series of *Network Codes (NCs)* [2] developed by *ENTSO-E* based on previous *ACER*'s framework guidelines [3]. The *Target Model* defines a number of market design elements to facilitate integration and cross-border trade (e.g. it directly refers to the transfer of electricity between zones), while leaving several other important market design issues to the discretion of *European Union (EU) Member States*. For example, in Poland a *US*-style nodal energy market has been designed under the *Target Model* provisions, which clears all market bids with full visibility of the transmission grid [4]. The market design allows the nodal-based energy market operated by the Polish *Transmission System Operator (TSO)* to be fully integrated with other bidding zones of *EU Member States* that have adopted a *Power Exchange (PX)* type of market architecture. However, the evolution of national market designs within Europe is expected to be influenced mainly by the existing markets in *North-West Europe (NWE)*, characterized by zonal network representation, portfolio-based market participation, and decentralized arrangements for scheduling and dispatch.

The current design of the Greek electricity market is substantially different from the above-mentioned market organization in

*Abbreviations:* aFRR, automatic Frequency Restoration Reserve; AGC, Automatic Generation Control; BASM, Balancing and Ancillary Services Market; BRE, Balance Responsible Entity; BRP, Balance Responsible Party; CACM NC, Network Code on Capacity Allocation and Congestion Management; CSE, Central South Europe; DAM, Day-Ahead Market; DR, Demand Response; EB NC, Network Code on Electricity Balancing; FCR, Frequency Containment Reserve; FM, Forward Market; IDM, Intraday Market; IPP, Independent Power Producer; ISP, Integrated Scheduling Process; mFRR, manual Frequency Restoration Reserve; MIC, Minimum Income Condition; MILP, Mixed Integer Linear Programming; MO, Market Operator; NDP, Net Delivery Position; NWE, North-West Europe; OTC, Over-the-Counter; PCR, Price Coupling of Regions; PPC, Public Power Corporation (former incumbent in Greece); PTR, Physical Transmission Right; PX, Power Exchange; RES, Renewable Energy Sources; RR, Replacement Reserve; RTBM, Real-Time Balancing Market; SMP, System Marginal Price; TSO, Transmission System Operator.

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*NWE*. In brief, the Greek market is currently organized as a centralized mandatory pool with two general processes: (a) *Day-Ahead Market (DAM)* with unit-based participation, where the *Market Operator (MO)* performs a co-optimization of energy and reserves, and (b) centralized scheduling and dispatch (balancing mechanism) operated by the *TSO*.[1] To a large extent, this model had been chosen in order to secure supply and bring efficiencies to short-term system operations, while mitigating market power by *Public Power Corporation (PPC)*, the former incumbent in Greece.[2] Under the current wholesale market structure, the participants cannot exploit trading opportunities in other market instances requiring harmonization across Europe, such as the *Forward Market (FM)* or the *Intraday Market (IDM)*. Also, unlike other market designs (e.g. France [7]), Greece lacks a "true" *Real-Time Balancing Market (RTBM)*, since the current 5-min real-time economic dispatch uses the bids of the *DAM*. The imbalance price is then derived by re-solving the same cost-minimization algorithm as in *DAM*, by inserting the actual values of the various inputs (demand, renewable output, plant availability) instead of day-ahead predictions. Thus, the resulting imbalance prices do not explicitly reflect the balancing cost of the *TSO* during real-time operation as mandated by the European *Network Code on Electricity Balancing (EB NC)* [8].

It is therefore undisputable that the Greek electricity market shall be subject to heavy restructuring in order to gradually achieve full integration with markets of other *EU Member States*. During the integration process, Greece shall primarily discover the possibilities for market coupling with its neighboring countries (Italy, Albania, FYROM, Bulgaria and Turkey). The compliance gaps of each neighboring country with regard to the *Target Model* provisions have been identified in [9], where it is concluded that the Italian electricity market is the most consistent with the European *Target Model*, having a *FM*, a *PX*-type *DAM*, an *IDM* and a *Balancing and Ancillary Services Market (BASM)*. Thus, Italy is expected to constitute the first neighboring country with which Greece shall couple in the following years. Therefore, the two markets should bear (at least) consistent and (preferably) harmonized market rules, facilitating their effective coupling. The rest neighboring countries exhibit huge deviations with regard to the *Target Model* provisions, so it is expected that they will delay their compliance with the European market design; consequently, the market coupling between Greece and these countries will be delayed as well for several years.

In this paper, the basic design variables and respective options for the integration of the Greek wholesale market with other European markets under the *Target Model* paradigm are presented. The design variables refer to all market instances and mechanisms. The proposed choices are justified in terms of effectiveness and market power mitigation, considering the current market structure in Greece. Additionally, a transitional phase for the full integration of the Greek *IDM* and *RTBM* is proposed, considering the relevant evolutions in the wholesale markets of Greece's neighboring countries. Finally, a simulation analysis is performed in order to highlight (a) the implications on schedules of utilizing European-based order formats in the restructured Greek day-ahead electricity market, and (b) the impact of potential strategies of the dominant player *PPC* when deploying forward contracts for physical delivery on the *Independent Power Producers (IPPs)*.

The structure of this paper is as follows: Section 2 provides a brief analysis of the design elements for the Greek wholesale electricity market, stating all high-level options and decisions that should be taken in each market timescale (forward, day-ahead, intraday, real-time, ex-post). Sections 3–7 provide a detailed analysis and justification of the proposed design choices for the *FM*, *DAM*, *IDM*, *BASM* and settlement processes, respectively; the pros and cons of each design option are presented in these *Sections*. Section 8 elaborates on the new capacity remuneration mechanism that is expected to be established in Greece. Section 9 *f*ocuses on *RES* and *Demand Response*, while Section 10 describes the key findings of the simulation analysis. Finally, the conclusions are drawn in Section 11.

## 2. High-level design variables and proposed choices

The proposed market architecture requires the analysis of several design variables and the selection of the best option for each variable that will result in the optimal design for the reformed wholesale electricity market in Greece. Figs. 1 and 2 summarize the various design variables and the associated choices (indicated with green circles) of the *NWE* markets and the Italian market, respectively, whereas Fig. 3 illustrates the proposed design choices for the Greek wholesale market. In each *Figure*, the horizontal frames denote the two fundamental options running through all market processes, namely the unit-based and the portfolio-based participation. The columns divide the decision process into the various market timeframes (forward, day-ahead, intraday, real-time and ex-post). Different decisions on the available options produce several "decision paths" (i.e. grey arrows in these *Figures*) that can be deployed by the decision makers to compare, evaluate and ultimately agree on. Detailed presentation and evaluation of the pros and cons regarding each option depicted in Fig. 3 (concerning the Greek wholesale market) is provided in the following *Sections* of this paper.

## 3. Proposed design of the Forward Market in Greece

Worldwide, the deregulating processes have been accompanied by the introduction of competitive spot wholesale and retail electricity markets along with forward contracts on electricity, both *Over-the-Counter (OTC)* and centrally-traded (organized *Forward Markets*), providing a variety of contract provisions to meet the needs of the participants. According to [10], the lack of bilateral contracts has been one of the main causes of the 2000–2001 California electricity crisis. The failure of the English pool to reduce prices and the collapse of the California electricity market led both countries to reform their systems, by opening them to the use of bilateral and financial contracts to hedge the risks [11].

The Greek electricity spot market has outlived its usefulness and, in its current format, is seriously flawed; clearly, it cannot fulfill the expectations of an open competitive market. Specifically, vulnerability to fuel price volatility and amenability to market power abuse has dominated the market. Several key issues that concern market efficiency and market power abuse have been put under scrutiny during public consultations conducted by the Greek *Ministry of Environment and Energy* [12] and the Greek *Regulatory Authority for Energy* (e.g. [13]), while a study has been recently tendered by the *Joint Research Centre* of the *European Commission* [14] aiming, among others, at investigating market power mitigation measures in Greece with a particular emphasis on the long-term contracts (*Forward* and *OTC* contracts). This is not surprising given

[1] For an analytical description of the current market design in Greece, the interested reader is referred to [5].

[2] Currently, most conventional (thermal and large hydro) generating units belong to the *PPC*, which retains its dominant position in the interconnected system (production capacity share of 79% in terms of conventional technologies, and 57% accounting also the *Renewable Energy Sources* – *RES*). Private producers own only seven gas-fired plants (combined and open cycle gas turbines) with a total installed capacity of approximately 2,580MW. The supply sector is even more heavily dominated by *PPC* (about 90% of total electricity supplied in July 2016); nevertheless, *PPC* is obliged to sell lignite and hydroelectric energy at low cost to third suppliers, in order the latter to be able to attract more customers, and to drop *PPC*'s market share in supply below 50% at the end of year 2019 [6].