The Optimal Design of a NOME-type Regulation in Greece[1]

Report prepared for the Greek Regulatory Authority for Energy[2]

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Final Report v.1 - July 2013

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[1] We are grateful to Claude Crampes and Patrick Rey for useful discussions concerning the analysis contained in this report. Of course, all errors, ambiguities and omissions remain solely our responsibility.

[2] We are grateful to Eleni Metsiou and Angeliki Anastopoulou for research assistance during the preparation of this report.

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Chapter 1: Introduction and Summary of Analysis and of Results

In the present report, our main objective is to examine the optimal design of a NOME-type regulation that will be introduced together with the other current reforms of the Greek wholesale market. To achieve this objective, it is imperative to specify how potential market equilibria (in terms of prices, sales and profits) *will* be affected by the NOME regulation and so we need to derive the potential market equilibria that we expect to emerge *following* the removal of regulatory controls on prices and the restructuring of the current pool.

Currently, substantial reforms are planned for the electricity market in Greece as we approach the implementation of the TARGET model. We expect that the wholesale market will, following the removal of regulatory controls on prices and the restructuring of the current pool:

- Rely at least in the short-run and perhaps the short-to-medium run, principally on a bid-based, centralized spot market with the design of the auction process being that of **uniform-price auctions,**
- while in the medium-to-long run the market in Greece will converge to the situation of the markets in by far most European countries[6] in which the great majority of transactions are based on **Over The Counter** (OTC) **bilateral contracts**.

Under uniform-price auctions, all suppliers receive the *same* market clearing price which is set at the offer price of the most expensive resource chosen to provide supply. Actually, though operating in a distorted way, this is the mechanism already in use in the mandatory pool of Greece. In contrast, in a pay (or earn)-as-bid auction, prices paid to winning suppliers are based on their *actual* bids, rather than the bid of the *highest* priced supplier selected to provide supply. For this reason, pay (or earn)-as-bid auctions are also known as **discriminatory auctions** – because they pay winners a different price tied to the specific prices offered in their bids. Uniform-price auctions have been used extensively in US while the best example of the application of discriminatory auctions is that of UK in the last 12 years or so. The advantages and disadvantages of these two alternative auction designs have been discussed extensively in the literature, both in general and specifically for the context of electricity markets. The main relevant works and arguments are overviewed in the Appendix of this report.

[6] See, for example, A. Pototschnig (2012) "Electricity Markets: the Wholesale Electricity Market", Florence School of Regulation, R Schuman Center for Advanced Studies.

Our approach is as follows.

We derive the potential market equilibria, *following* the removal of regulatory controls on prices and the restructuring of the current pool, *both* under the assumption that the market is organised as a bid-based, centralised spot market, with the design of the auction process being that of **uniform-price auctions** *and also* under the assumption that the market is dominated by transactions based on **Over The Counter** (OTC) **bilateral contracts**. In the latter case the implicit assumption is that there is no pool or centralized spot market and all electricity sales can be potentially made through contracting between producers and suppliers or final consumers. Our analysis of this case relies on the concept of **Bertrand – Edgeworth (B – E) equilibrium,** which is the main equilibrium concept proposed by economic theory for the analysis of oligopolistic markets that are characterised by capacity constraints[7].

It is very important to note at the outset that the B – E (OTC) equilibria examined here are the same with the equilibria that would emerge if instead the market was centralized and operated as a **Discriminatory (earn-as-you-bid) Auction**[8]. This implies that our report essentially contains an analysis of the potential market equilibria that we expect to emerge in the Greek electricity market under *both* the main types of trading mechanisms that could characterize a centralized wholesale market (a pool), those of uniform-price auction *and* of a discriminatory auction. Also, for a certain period of time, it is expected that both pool and OTC contracts will represent a significant portion of the traded energy. Of course, these two parts of the market will be interacting and interdependent. If the mechanism employed in the pool is that of a discriminatory auction, then the overall market (both auction and OTCs) is equivalent to a discriminatory auction covering the entire set of energy traded. In this sense, this case is also covered by our analysis based on the concept of Bertrand – Edgeworth (B – E) equilibrium. If the mechanism employed in the pool is that of a uniform price auction, then prices that are higher than in the previous case are expected to prevail.

We also need to emphasize that the market prices (under both auction setups) are the prices that the theoretical analysis predicts that will occur when the various players compete. These prices correspond to "equilibria" of the market and are *not* aligned necessarily with the underlying costs of the providers (which is the case in a regulated market). As we will show, the use of NOME affects these equilibria for various values of the demand compared to the case of a deregulated market without NOME. Our analysis compares these cases, with and without NOME, both for a

[7] For a seminal treatment of modern oligopoly theory and models and the B-E equilibria in particular, see X Vives (1999) "Oligopoly Pricing: Old Ideas and New Tools", MIT Press (especially Chapter 5). B – E models are thought of as the most appropriate models to use in the analysis of markets with a small number of players, homogeneous products and capacity constraints.

[8] See Fabra N., von der Fehr, and N.H. Harbord (2006) "Designing Electricity Auctions" Rand Journal of Economics, 37, 23 - 46. Also, for an analysis of uniform auctions in electricity markets, see M-A de Frutos and Fabra N.(2011) "How to allocate forward contracts: the case of electricity markets" European Economic Review, 1 - 19.

deregulated market, and analyzes the sensitivity of various aspects of the market with respect to key parameters defined by the NOME regulation.

It is worth mentioning here that the analyses of the wholesale market as a **uniform-price auction** (Chapter 2) and of the market dominated by transactions based on **Over The Counter** (OTC) **bilateral contracts** (Chapter 3), presented in this report, contain significant contributions to the academic analysis of electricity markets by extending existing analyses to the case where there are more than two competing firms that are asymmetric both in terms of capacities and in terms of marginal cost.

Our analysis of how the market will be affected by NOME also includes an examination of the **retail market** in Greece under the assumption that the NOME regulation is implemented with the wholesale market (the pool) operating to a large extent like it does today. Specifically, we examine the potential implications of price deregulation and the implementation of NOME under the assumptions that ADMIE and LAGIE are making concerning the operation of the wholesale market immediately after NOME is implemented. We consider that this analysis – which relies on two alternative scenaria (examined in section 6 of Chapter 2 and in Chapter 4, respectively) can reflect the very-short-term and short-term equilibria that will emerge in the aftermath of the NOME implementation. Further, we examine the implications of **forward contracts** on the wholesale market equilibria.

We conclude this introduction with a remark about the accuracy of economic analysis. We need to emphasize that any economic analysis at the level conducted in this document is *not* meant to accurately predict exactly how policy will affect market outcomes in terms of prices, profits, market shares etc. To be tractable and capable of generating useful predictions, the analysis uses models that abstract from certain practical parameters[9], for example, assuming no costs of turning off-and-on power plants and inelastic demand, as well as the exact description of the generation capabilities of the providers, the exact marginal costs of energy production, etc. Its goal is to capture most of the essential aspects of the electricity market and predict the important market trends in terms of prices and provider market share in the absence of cost-oriented price regulation and with a NOME-type regulation implemented. A more detailed analysis would not reveal important trends not captured by our more abstract and simpler market models.

The main **conclusions** that emerge from our analysis are the following:

The analysis of the uniform-price auction equilibria in Chapter 2 shows that there is clear gain using NOME for low and medium demand assuming that the α and φ parameters (respectively, the maximum fraction of total lignite capacity that is made available through NOME and the fraction of lignite energy in any one MWh sold by a firm using lignite allocated to it through NOME) are chosen appropriately by the regulator (see similar discussion for the results of the OTC auction for the choices of

[9] An additional problem is that the value of many of these parameters change over time.

φ and α). We observe that by using NOME the equilibrium prices drop from the marginal cost of gas (without NOME) to the marginal cost of the NOME mixture. The range of demand values for which we obtain this market price reduction is considerable and depends on the choice of α, φ. It also depends on the symmetry of the supply capabilities of the competitors of DEH (it is best if the competing providers have symmetric NOME allocations), and the price of NOME lignite (by increasing this price we increase the market prices when the equilibria are at the cost of the NOME mixture, but extend these equilibria over a broader demand range). We also analyze the impact of forward contracts and find that they have a considerable effect in reducing the high price equilibria and generating lower market prices. A detailed sensitivity analysis backs all these observations.

Regarding the providers using NOME we observe that for low demand these providers participate in the market in contrast to the case without NOME, for medium demand since the market price might drop their profits may be reduced, but for high demand their profits are by far larger than before and overall they make much higher profits by adopting NOME.

The analysis of the OTC/bilateral contracts market equilibria is undertaken in Chapter 3 and confirms to a large extent the findings of Chapter 2. It shows that the implications of the NOME regulation for the Greek electricity market depend crucially on the priorities of the regulator (RAE), which must determine, in conjunction with the findings of this report, the optimal values of the main regulatory NOME parameters α and φ. If RAE's prioritiy is to secure the lowest possible prices for consumers following the deregulation of market prices, then it will want to secure that low prices emerge for both low and medium market demand states and for this it will have to set α values reasonably high ($\alpha \geq 0,3$) and also set φ values reasonably low ($0,5 \leq \varphi \leq 0,588$) – and if φ exceeds 0,55, the value of α must also exceed 0,5.

If however it would like to secure that the firms that get NOME allocations increase their sales AND their profit following the implementation of the NOME regulation also in medium-demand equilibria, in an effort to incentivize new firms to participate in NOME and enter actively in the Greek retail market, then RAE must set values of φ that that are higher than the above. We derive the complete set of (α, φ) combinations that are necessary to satisfy the conditions necessary for low-price equilibria.

The analysis of the OTC equilibria also shows that **the prices in these OTC equilibria will be on average lower than when the market is run with a uniform auction type centralized exchange** (pool).

The analysis of the retail market in Chapter 4 is made under the assumption that the wholesale market continues to operate as a centralized exchange (a pool) AND under the assumptions that ADMIE and LAGIE are making concerning the operation of this market immediately after NOME is implemented. In contrast to the analysis of

section 6 of Chapter 2, here we assume that firms other than PPC can also purchase energy from the wholesale market (operated as a pool) in order to supply the retail market in competition with PPC. In this set-up NOME gives an important advantage to alternative providers by allowing them to make a part of their sales (that of their NOME-related OTC contracts) in the retail market at a cost lower than the wholesale price. With price competition, **this may allow alternative providers to capture a very large share of the retail market**.

In Chapter 5, we deal with the selection of a mechanism appropriate for the allocation of the lignite capacity of PPC to alternative providers under NOME, on the basis of the requirements of RAE as well as of the demand function of these players for lignite and the strategies stemming from this. In particular, regarding the incentives of the alternative providers, we establish that prefer to buy as much lignite capacity as possible, while keeping the price p_α as low as possible, in order to make higher profits. We then consider two main types of mechanisms, namely rationing rules and auctions, as well as some mechanisms combining features of both types. It follows from the assessment of these mechanisms, that one rationing rule (namely, allocation pro-rata to declared quantities demanded by the players at the reserve price) and one auction mechanism (namely, ascending clock auction with the option of rationing) are the most appropriate ones for allocating lignite capacity. The choice of reserve price is going to be very important for the incentives of the players under both mechanisms, since in the initial phase of the application of NOME alternative providers should be incentivized enough so as to participate in NOME, develop capability as retailers and look for OTC bilateral contracts.

The report is organized as follows. We start, in the following Chapter 2, with a full analysis of the Greek electricity market modeled as a **Uniform Auction** under alternative market conditions, in the presence of the main structural and regulatory characteristics of the Greek electricity market**.** This Chapter also includes an analysis of the implications of **forward contracts**. In Chapter 3, we examine potential market equilibria that will emerge in an **Over The Counter** (OTC) bilateral contracts electricity market again under alternative market conditions, in the presence of the main structural and regulatory characteristics of the Greek electricity market – in terms of capacity and technology features and the main parameters that are likely to characterize the NOME regulation when it is implemented. So Chapters 2 and 3 provide the fundamental steps in analyzing the optimal design of the NOME regulation, since they provide alternative frameworks for assessing the impact on a liberalized electricity market, that is free of price regulation[10], of alternative NOME designs. Chapter 4 includes an examination of the **retail market** in Greece under the assumption that the NOME regulation is implemented with the wholesale market (the pool) operating to a large extent like it does today but with full competition between

[10] Other than, perhaps, a maximum price cap – see for details below.

PPC (DEH) and other players in the retail market[11]. Finally, in Chapter 5, we examine **alternative mechanisms for implementing the NOME regulation** (including auction mechanisms), the outcome of which influences greatly the equilibria to prevail in the wholesale and retail markets. In the Appendix we provide a review of the basic applications of auction mechanisms to electricity markets, with emphasis on the comparison of uniform price auctions to discriminatory ones.

[11] Section 6 of Chapter 2 also examines the retail market in the very-short-run after the implementation of NOME under the assumption that only PPC purchases from the pool to supply the retail market while the E firms only supply the amount associated with their NOME-related OTC contracts.