

Elspot: Nord Pool Spot Integration in MASCEM Electricity Market Simulator^{*}

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Abstract. The energy sector in industrialized countries has been restructured in the last years, with the purpose of decreasing electricity prices through the increase in competition, and facilitating the integration of distributed energy resources. However, the restructuring process increased the complexity in market players' interactions and generated emerging problems and new issues to be addressed. In order to provide players with competitive advantage in the market, decision support tools that facilitate the study and understanding of these markets become extremely useful. In this context arises MASCEM (Multi-Agent Simulator of Competitive Electricity Markets), a multi-agent based simulator that models real electricity markets. To reinforce MASCEM with the capability of recreating the electricity markets reality in the fullest possible extent, it is crucial to make it able to simulate as many market models and player types as possible. This paper presents a new negotiation model implemented in MASCEM based on the negotiation model used in day-ahead market (Elspot) of Nord Pool. This is a key module to study competitive electricity markets, as it presents well defined and distinct characteristics from the already implemented markets, and it is a reference electricity market in Europe (the one with the larger amount of traded power).

1 Introduction

Over the last few decades the electricity markets (EM) restructuring has been changing the EM paradigm. Some examples of the transformations that have been applied are the privatization, liberalization and international integration of previously nationally owned systems [1].

With this restructuring process several challenges were placed to governments and companies that are involved in the area of generation, transmission and distribution of

^{*} This work is supported by FEDER Funds through COMPETE program and by National Funds through FCT under the projects FCOMP-01-0124-FEDER: PEst-OE/EEI/UI0760/2011, PTDC/SEN-ENR/122174/2010 and SFRH/BD/80632/2011 (Tiago Pinto PhD).

electrical energy. To overcome these challenges, it became essential for the professionals to fully understand the principles of the markets, and how to evaluate their investments under such a competitive environment [2].

The need for understanding those mechanisms and how the involved players' interaction affects the outcomes of the markets, contributed to the growth of usage of simulation tools, with the purpose of taking the best possible results out of each market context for each participating entity.

To analyze dynamic and adaptive systems with complex interactions among its constituents, such as electricity markets, multi-agent based software is particularly well fitted. Some relevant modelling tools in the domain of restructured wholesale power markets have emerged, e.g. AMES (Agent-based Modeling of Electricity Systems) [3], EMCAS (Electricity Market Complex Adaptive System) [4], and MASCEM (Multi-Agent System for Competitive Electricity Markets) [5, 6].

The main goal of our research is to explore and study different approaches concerning the electricity markets environment, and power systems generally. For that we use the multi-agent system MASCEM [5, 6]. This system provides us with the realistic simulation of electricity markets, considering all the most relevant entities that take part in such operations, by representing reality in a controlled environment.

This paper presents the implementation and integration of Elspot (Nord Pool day-ahead market) [7] in MASCEM. The Nord Pool Spot is currently the largest energy market in the world, relative to the amount of electricity traded - in 2012 the volume of electricity transacted in this market reached 432 Terawatt-hours (TWh). This market operates in the Nordic and Baltic regions of Europe, accounting for about 70% of traded energy in these regions. "*Nord Pool Spot runs the leading power market in Europe, offering both day-ahead and intraday markets to its customers.*" [8]. The countries covered by Nord Pool Spot Market are: Norway, Denmark, Sweden, Finland, Estonia, Latvia and Lithuania. It includes the day-ahead market (Elspot), intraday market (Elbas) and a balancing market [8].

The implementation of Elspot market in MASCEM brings significant added value to the multi-agent platform. The European electricity market is evolving into a continental scale electricity market in day-ahead negotiation. Given the scale of the Elspot market, this market and its players will have great influence in the unified market operation [9]. The enhanced electricity markets simulator resulting from the integration of the Nord Pool in MASCEM provides a solid platform to study and explore the implications and consequences of new and existing approaches for both the scientific community and also for the electricity market involved players, whether market negotiating players, regulators, or operators. It also provides a good tool for power systems students to learn and understand how the market mechanisms work, and how the players' interactions affect the outcomes of the market.

After this introductory section, Section 2 features an overview of the MASCEM simulator. Section 3 presents the Elspot market from Nord Pool Spot, a discussion on its most important characteristics and particularities, and its implementation in MASCEM. A study case demonstrating and analyzing the simulation of Elspot market in MASCEM and its implications is adduced in Section 4. Finally, in Section 5 the most relevant conclusions of this article are exposed.