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Evaluating the EU ETS impacts on profits, investments and prices of the Italian electricity market

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HIGHLIGHTS

- We evaluate the EU-ETS impacts on the Italian electricity market.
- We model different EU-ETS scenarios and energy market organizations.
- Generators can invest in new capacity.
- Investments in CCGT plants are preferable to those in clean technologies.
- Profits depend on market organization and on ETS allowance allocation policies.

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ABSTRACT

Climate change is a global issue, but actions to mitigate its development are regional. Europe has taken the leadership in the carbon emission policy by introducing the Emissions Trading Scheme (EU ETS), formerly regulated by Directive 2003/87/EC and since 2013 by Directive 2009/29/EC. This new Directive imposes a full auctioning system for allocating CO_2 allowances to the power sector and encourages the use of renewable energy sources.

We investigate the economic impacts of the EU ETS on the Italian electricity market using a power generation expansion model. We adopt a technological representation of the energy market that also accounts for power exchanges with foreign countries and we assume that generators operate in different zones connected by interconnections with limited capacity. We study both an oligopolistic and a perfectly competitive behavior of Italian generators and we compare the corresponding outcomes under different EU ETS scenarios. Our analysis shows that, in perfect competition, generators generally invest more than in an oligopolistic framework, but in both market configurations, investments in Italy are mainly concentrated in fossil-fired plants, especially in 2020. This happens also when incentives are given to renewables.

The developed models are implemented as complementarity problems and solved in GAMS using the PATH solver.

1. Introduction

In the last twenty years, the restructuring process of the electricity system has deeply changed the organization of this market around the world. In Europe, following the examples of United Kingdom and Norway, the European Commission issued the Directive 96/92/EC in order to liberalize the power sector and create an Internal Electricity Market (IEM). This Directive imposed the unbundling of generation, transmission and distribution that, since then, were vertically integrated and controlled by a sole entity (power company) operating in a monopolistic regime. The aim of this Directive was to improve efficiency and avoid abuses of dominant positions, especially in setting power prices.

In Italy, the disposals of the European Directive 96/92/EC were acknowledged by the Bersani decree in 1999, but only in 2004 the Power Exchange GME (Gestore del Mercato Elettrico) became operative on the Italian energy market (IPEX). With the Bersani decree, the old monopolist Enel had to disinvest 15 GW of its production capacity in order to reduce its market share. The current Enel's contribute to the Italian power production is of

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26.4%, significantly lower than its 2004 level of 43.9%.[4] However, the Italian market cannot be yet considered fully competitive as highlighted by Floro (2009).

Since 2005, the energy sector is involved in the European Emissions Trading Scheme (EU ETS).[5] The EU ETS is an environmental policy developed in the framework of the Kyoto Protocol that aims at reducing the European CO_2 emissions generated by carbon-intensive installations of the energy and industrial sectors. Such a goal is achieved through the implementation of a cap-and-trade system that imposes a CO_2 emission limit to all covered installations and creates a market that prices CO_2 where ETS participants can exchange their emission permits. The EU ETS was initially subdivided into two phases as indicated by Directive 2003/87/EC. The first phase (2005–2007), the so-called "learning by doing phase", was introduced to test the functioning of the EU ETS system. Its implementation led to some economic distortions mainly due to the grandfathering of the emission allowances (Neuhoff et al., 2006a, 2006b; Reinaud, 2003, 2005) and to the consequent raise of "windfall profits" for the power sector (Sijm et al., 2006). Compared to the energy-intensive industries involved in the EU ETS, generators are able to pass through a high proportion of their carbon costs in electricity prices. This happens because the current organization of electricity markets allows for pricing power at marginal production cost. The outcome is twofold: the EU ETS causes both an increase of electricity prices and an intended raise of generators' profits. These two issues have been extensively discussed in the literature and many studies confirm this outcome (see, for instance, Chen et al., 2008; Kara et al., 2008; Linares et al., 2008; Lise et al., 2010; Oggioni and Smeers, 2009).

In order to remedy to this situation, the Directive 2009/29/EC, regulating the third EU ETS phase (2013–2020), has imposed a full auctioning system for the allocation of emission permits destined to the energy sector. For the industrial sectors, it foresees a progressive adoption of the auctioning system starting from a proportion of the 20% in 2013 and reaching a 70% level in 2020.[6] Moreover, the revised EU ETS will cover more industries and types of greenhouse gases and will encourage the development of renewables.

In this paper, we investigate the economic impacts of the EU ETS on the Italian electricity market. To this aim, we develop equilibrium models that describe the interaction of different agents. A first group of agents is represented by generators which aim at maximizing their profits; Market Operator is the other agent which maximizes consumers' willingness to pay while guaranteeing both the satisfaction of the energy market balance and the respect of the transfer limits of the interconnections linking the different zones. The market equilibrium results from the simultaneous interaction of generators and the Market Operator.

In particular, taking into account the current organization of the Italian electricity market, we first formulate a model, where generators are Cournot players. Indeed, imperfect competition models are often used to study electricity markets (see, for instance, Chen and Hobbs, 2005; Chen et al., 2006; Hobbs, 2001; Hobbs and Helman, 2004; Vespucci et al., 2009). An oligopolistic market can be described either by a Nash–Cournot or a Bertrand or a Supply Function Equilibrium models. Supply Function Equilibrium (see Anderson and Hu, 2008; Willems et al., 2009) and Cournot Equilibrium (for overviews see Tirole, 1988; Vives, 1999 and for review see Ventosa et al., 2005) are the most applied models to electricity markets. Alternative model formulations, such as equilibrium problem with equilibrium constraints (EPEC) or mathematical program with equilibrium constraints (MPEC), could be also applied in order to analyze the strategic interactions among different agents (see, for instance, Limpaitoon et al., 2011; Ralph and Smeers, 2006; Yao et al., 2008 for application to energy markets).

However, since the aim of the restructuring process has been to make the electricity market fully competitive, we also analyze the case where power producers operate in a perfectly competitive market.

In all model formulations, we adopt a technological representation of the energy market and we assume that generators operate existing and new power plants in different zones that are linked by inter-connectors with limited transfer capacity. Generators are, in fact, allowed to invest in new capacity. The solution of the overall system is found by exploiting the mixed complementarity theoretical framework and solution algorithms.

The organization of this paper is as follows. In Section 2, we describe the market model where generators are Cournot competitors. Section 3 presents a perfectly competitive version of the model illustrated in Section 2. In Sections 4 and 5, we discuss the results of our analysis. In particular, the results presented in Section 4 are based on the assumption that the Italian power market is closed and has no exchanges with other countries, while in Section 5 we illustrate how these outcomes change when also imports/exports with foreign zones contribute to the equilibrium of the Italian electricity market. Finally, Section 6 is devoted to conclusions and final remarks.

2. The market model

We first describe the energy market by developing an equilibrium model where Italian generators compete à la Cournot. In this formulation, each generator f maximizes its profits taking into account the decision taken by his competitors. The Italian Market Operator maximizes consumers' willingness to pay taking into account the physical constraints of the transmission grid and ensuring the respect of the energy balance in each zone i and time segment t. The Market Operator can be considered as an additional player. We also model an emission market limited to the energy sector. We first list the notation used in this paper.

2.1. Notation

We here introduce all symbols of the model. They are classified on the basis of their means and use.

Sets:

- $i \in I$: Zones;
- $t \in T$: Time segment, we consider time horizon $t = 1, \ldots, 24$ h;
- $p \in P$: Set of technologies (note that we respectively indicate with $p = h$ and $p = sh$ the hydro plants based on reservoir and on the pumped-storage technologies);
- $f \in F$: Generators.

Parameters:

- $vc_{f,p,i}$: Hourly variable costs of new and existing plant of technology type p owned by generator f in zone i (€/MWh);
- $fc_{f,p,i}$: Hourly fixed costs of new plant of technology type p owned by generator f in zone i (€/MWh);

[4] See Autorità per l'Energia Elettrica e il Gas (AEEG), Relazione annuale sullo stato dei servizi e sull'attività svolta, 2012. Available at http://www.autorita.energia.it/it/relaz_ann/12/12.htm.

[5] http://ec.europa.eu/clima/policies/ets/index_en.htm.

[6] The Article 10 ter of the Directive 2009/29/EC states that all industrial sectors that are exposed to the risk of carbon leakage will continue to receive free permits. See http://ec.europa.eu/clima/policies/ets/leakage/index_en.htm.