Sabrina Caputi, Maria Dicorato, Giuseppe Forte, Anna Minoia and Michele Trovato

GENERATION COMPANIES' BEHAVIOUR IN PRESENCE OF AN EMISSION TRADING SCHEME

DEE – Politecnico di Bari, via Orabona 4, 70125 Bari, Italy
sabrinacaputi@libero.it, dicorato@poliba.it, forte@deemail.poliba.it, a.minoia@poliba.it, trovato@poliba.it

Overview

In order to comply with limits on greenhouse emissions imposed by Kyoto Protocol, in the outline of an Emission Trading Scheme (ETS), many countries have developed Emission Allocation Plans 0. Various industrial settlements are involved in the mechanism, and in particular electric power plants play the most significant role in the emission policy. The operation of electricity generation companies can be notably affected by the presence of such a mechanism.
In this work, an analytical method is carried out in order to analyse the mid-term behaviour of electricity generation companies when an Emission Trading Scheme is implemented, by means of an allocation plan. The proposed model is applied to the Italian electrical system.

Methods

The proposed methodology aims to maximise the sum of the profits of each generation company over the selected time horizon [2]. The profit is given by the difference between revenues coming from energy sold at the market price and production costs. Several generation technologies are taken into account in the procedure. Conventional plants are divided according to their installed power size and to the fuel they burn. Combined-cycle plants and co-generation plants are also considered. Hydroelectric generation capacity is accounted by means of four technologies: pumping units, run-of-the-river plants, open-air basin plants and reservoir units. Other renewable technologies are present: biomass-to-energy plants, wind farms, RDF-fuelled plants, geothermal units. Suitable fuel costs and heat rate curves are accounted for each technology, in order to evaluate production costs. Moreover, the presence of the emission allocation gives rise to another term in the profit, which is positive if the company plants globally produce smaller emissions than the allowed amount, otherwise it is negative. To this aim, a unitary emission rate is related to each technology, according to the exploited fuel and the efficiency level, evaluated as in [3]. The maximisation of the generation companies' profit reduces to a non-linear optimisation problem, subject to equality and inequality constraints. Equality constraints mainly concern electricity balance between energy generation and final demand. The duration curve of annual electricity demand is divided into five time steps, representing peak demand, high load, medium load, low load and very low load. Inequality constraints involve structural limits on energy production from each technology and limits on the total emissions, even exceeding the amount of allowances by a certain quota provided by the government.

Results

The proposed model is applied to the analysis of the Italian electrical system over a 8-year time horizon. The greatest generation companies present in Italy are Enel, Edison, Enipower, Edipower, Endesa. At the reference year 2005, the production capacity of each company, which respectively amounts to 40,941 MW, 6,556 MW, 5,524 MW, 8,786 MW and 6,838 MW, is divided among the considered generation technologies. The remaining

part of power plants, that is equal to 16,166 MW, pertaining to minor producers, is grouped into one company. The end-user electric energy demand amounts to 331,400 GWh at 2005, and it is supposed to yearly increase by the 2.3%. An average value of electricity price, based on 2005 data, is assumed for each time step of the duration curve. Moreover, for each time step, a power import up to 5,000 MW is supposed to be available. The price of emission allowances is considered to be 16 €/tCO2. The amount of allowances owned by each company is evaluated as in [3] for the first three years, whereas proper values able to guarantee feasible results are considered for the last years.

In Fig. 1, the companies' share of electricity production is reported. As Enel owns the most part of the production capacity, it covers the major quota of production, i.e. 45% in the first year. This amount decreases to 38% at the eight year, as a result of the allocation of CO2 permits, that requires a remarkable emission reduction for this company. Other companies can thus cover further production share, as in the case of Edison company, starting from 9% at the first year and reaching 14% in the eight year. In Fig. 2 the amount of emissions that each company experiences in the considered scenario is illustrated. It can be noted that Enel and Endesa, that mostly own conventional power plants, exceed their CO2 allowances, whereas other companies reveal to be more "virtuous" in environmental aspects. In particular, Edison and Enipower amounts of permits decrease (emissions increase) as their production rises (see Fig. 1).

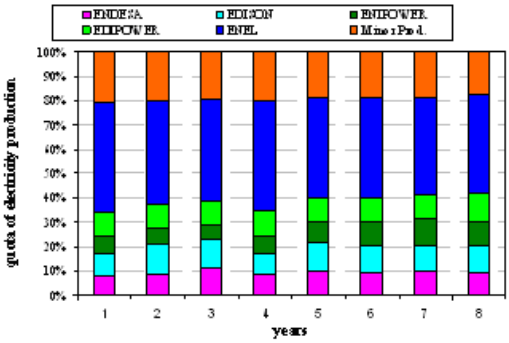

Fig. 1: Electricity demand covering

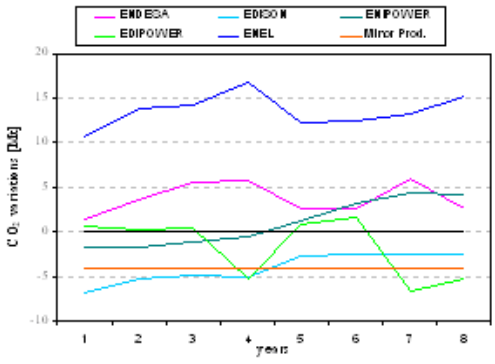

Fig. 2: Variation of CO_2 allowances

In Fig. 3, profit variation for each generation company are shown with regard to the reference year. They reflect the trend of electricity production and the costs to be sustained for purchasing CO2 emission permits. For example, Enipower and Endesa show a remarkable profit growth in periods when they need to buy, or at least are able to save, a lower amount of emission permits, although their profit is not very high. Other companies, such as Edison and Enel, do not display significant variations, even though they have the most significant profits.

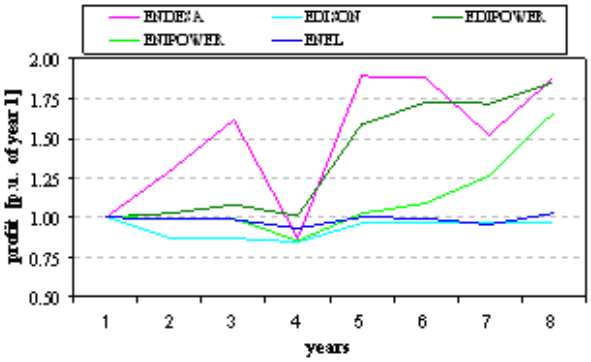

Fig.3: Profits of generation companies

Conclusions

In this paper, an optimisation methodology has been proposed to evaluate the behaviour of electric generation companies under a given ETS. This method has been applied to the Italian electric system. Simulation results show that companies owning clean technologies, such as combined-cycle plants and renewables, can save emission allowances and then get additional economic benefits compared to those obtained in absence of an ETS. On the other hand, companies that mainly have conventional plants can either reduce their production or purchase emission allowances in order to increase their profit.

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