GENERATION CAPACITY EXPANSION UNDER LONG-TERM UNCERTAINTIES IN THE US ELECTRIC MARKET

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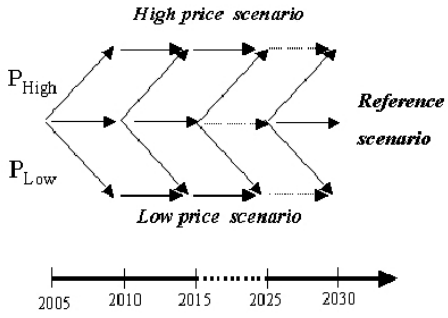
Overview

The recent high volatility in fuel markets, combined with environmental regulation policies, has introduced major uncertainties into the planning of generation capacity expansion. These uncertainties make generators' decisions to invest in new capacities more difficult. The literature has focused mainly on long-term demand uncertainties, but little has been done regarding fuel price and environmental policy uncertainties. This article discusses the optimal generation investment choices made in an electricity market with fuel price and regulatory uncertainties over the period 2010-2030. It focuses particularly on long-term uncertainties surrounding coal and gas prices, and on CO_2 emissions reduction policy. We have developed an optimization model for electric generation investments based on stochastic dynamic programming to tackle this issue.
To illustrate our discussion, we consider the case of the US long-term electricity market seen as perfectly competitive. The electricity market data and the fuel price scenarios are taken from the Annual Energy Outlook 2008 of the US Department of Energy (DOE).

The paper is organized as follows: in the next section, is summarized the related literature. Then, in section 3 is presented the generation investment model. Section 4 describes the general data and assumptions made regarding the long-term US electricity market and section 5 presents the results obtained for this market. Finally, section 6 concludes.

Methods

The model is based on Stochastic Dynamic Programming and consists in maximizing social welfare over a period.
We represent CO_2 regulation policy as a CO_2 market where CO_2 has a price per ton.
The uncertainties (fuel costs, CO_2 price) are modeled as a markovian event tree based on the DOE fuel price scenarios :



Results

The first, second and third sets of results assume risk-neutral generators.

First, the results suggest that CO_2 regulation policy can modify the technological mix: in the DOE “reference scenario”, a CO_2 price above 40$/ton over the period 2010-2030 will deter investments in coal plants and will lead the market to invest mainly in CCGTs. Conversely, for a lower CO_2 price, generators will invest in coal plants for baseload generation and in CCGTs for the mid-merit power plants.

Second, we consider a probability to switch every five years from the DOE Reference scenario to the High price or to the Low price scenarios. Generators can invest only in fossil thermal units (CCGTs, coal plants and peak units). We show that the

investment decisions for the Reference scenario are robust to the risk to switch to the High price scenario. But the decisions are not robust as far as uncertainties to switch to the Low price scenario are concerned (especially for high probabilities).

Third, if generators are allowed to invest in nuclear plants and if the Reference scenario occurs, we show that the investment decisions for the Reference scenario are robust to the risk to switch to another scenario.

Finally, we find that risk-averse generators (Minmax Regret criterion) will only focus on the DOE High price scenario to determine their investments: they will invest in coal plants for baseload generation in order to hedge against the risk of high gas prices.

Conclusions

We show that generation capacity expansion planning in the continuous US is sensitive to uncertainties regarding fuel and CO_2 costs as far as nuclear unit investments are not considered. Indeed, if only fossil thermal units are allowed, the DOE Reference scenario is not robust to these uncertainties. Conversely, allowing nuclear investments make the generation investment decisions robust. Finally, we show that generators react differently to uncertainties on fuel and CO_2 costs depending on risk-aversion.

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