Market Implications of Emerging Air Quality Regulations

Impact of the NOx SIP Call on Electricity Markets

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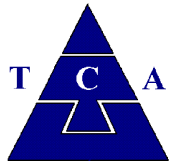


Introduction – NOx SIP Call

- In October 1998, EPA issues the NOx State Implementation Plan Call requiring 22 states and DC (Upwind states) to revise their SIPs to impose additional controls on NOx Emissions.
- EPA concluded that emissions from Upwind states "contribute significantly" to ozone nonattainment in downwind states.
- Thus, upwind states are required to reduce emissions to meet a specified NOx budgets.
- Those budgets were determined by forecasting NOx emissions to 2007 for all source categories and then applying the most cost effective technology to reduce these emissions (removing NOx at an average of $ 2000/ton or less).
- For generators, EPA determined that it was cost effective to achieve emission rates of 0.15 lb/mmbtu. (Total state budget equal to forecasted 2007 heat input multiplied by NOx emission rate 0.15 lb/mmbtu)
- These budgets can be met in part by implementing a cap and trade program (The total budget for the 22 states is 544,000 tons)

Introduction – NOx SIP Call

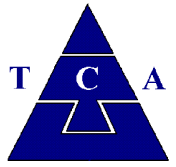
- On January 2000, EPA issued a final rule to control emissions of NOx under Section 126 of the CAA. In the rule, EPA made final its finding that stationary sources of NOx emissions in 12 upwind states and DC contribute to non attainment in the northeastern states.
- On May and June of 2001, the court ruled on a number of challenges to EPA's section 126 Rule, where it largely upheld the section 126 Rule
- The SIP Call followed the Memorandum of Understanding (MOU) in the 12-state Northeast Ozone Transport Region (OTR), where states volunteered to reduce emissions to a level almost as stringent as the SIP Call by 2003, through institution of a cap-and-trade program.
  - Phase II of the MOU allocates allowances based on the less stringent of a 75% reduction and a reduction to 0.15lb/MMBtu.

Introduction

- **The policy and legal debates on EPA's NOx SIP Call indicate that there is a strong need to quantify the costs and benefits of NOx regulations in the US.**
- **There has been serious speculation that deregulating the electricity markets will degrade the environment and cause major harm to the Northeast region by emissions from Midwestern generation.**
- **The effectiveness of a tradable-permits markets in achieving efficient outcomes for environmental emissions has not yet been fully modeled and analyzed.**

Insights from the Market

- Generators should bid their marginal production cost, fuel and VOM cost plus trading opportunity cost, plus any VOM associated with emission reduction technologies.
- The energy market-clearing price will be set by the marginal unit(s)' marginal production cost.
- Generators should invest in emission reduction technologies as long as their total cost of investment (capital and operating) is less than the tradable permits cost.
- The tradable permits market-clearing price will exceed, equal, or be below the incremental cost of emission reduction in the case of under, perfect or over compliance, respectively.
- The incremental cost of emission reduction is related to the incremental investment cost in reduction technology divided by the total energy generated plus the technology VOM.



General Market Simulation Methodology

- **We utilized GE-MAPS to model the electric power generation markets, in an iterative approach to solve for the Combined Energy and Tradable Allowances market clearing prices.**
  - **First solve for energy market clearing prices and cost of tradable permits, then invest in new control and generation technologies based on economics and recalculate market clearing prices and determine if any additional investments are economic.**
  - **GE-MAPS is a security-constrained least-cost chronological production cost model.**
  - **It is used to determine the locational energy market-clearing prices, the revenues, costs and profitability of generation units.**
  - **We used the most up to date data on load forecast, fuel price, thermal units availability (nuclear), thermal units heat rates and fixed and operating costs, transmission constraints, and market rules.**
- **Why an iterative approach?**
  - **Model capabilities to solve joint optimization of energy dispatch and investment decisions are not readily available.**
  - **The generation investment problem is solved separately in an iterative approach (new entry and retirements).**

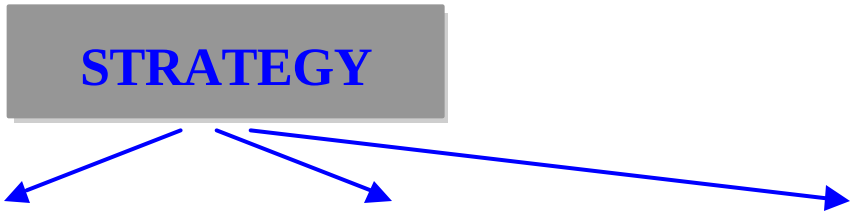
Emissions Modeling Assumptions

- Assume a perfect competitive market for tradable permits with no transaction cost.
- Assume a cap-and-trade emission reduction program with budget constraints only (no unit or time specific constraints).
- The cap-and-trade program is applied on a regional (including Northeast and Midwest) basis rather than on a state by state basis.

Investment in Emission Reduction - Algorithm

1. Start with least-cost dispatch ignoring environmental costs, determine units' generation, revenues and costs.
2. Select a projected equilibrium trading allowance price, and compare the cost of trading to the cost of investing (evaluate different technologies), given the performance level assumed in 1. Choose the option that results in lower costs for each evaluated unit.
3. For those units that opted to invest, add the variable O&M of the selected technology to their generation bid. For all units add the emission opportunity costs as the tradable allowance price times their emission rate (either original or post-investment).
4. Solve for least-cost dispatch with the new unit marginal costs, determine units' generation, revenues and costs, and total NO_x emissions.
5. Check to see if total emissions are within budget. If yes, stop iterations, if no, go back to 2 (increasing the projected equilibrium allowance price).

Investment in Emission Reduction - Algorithm

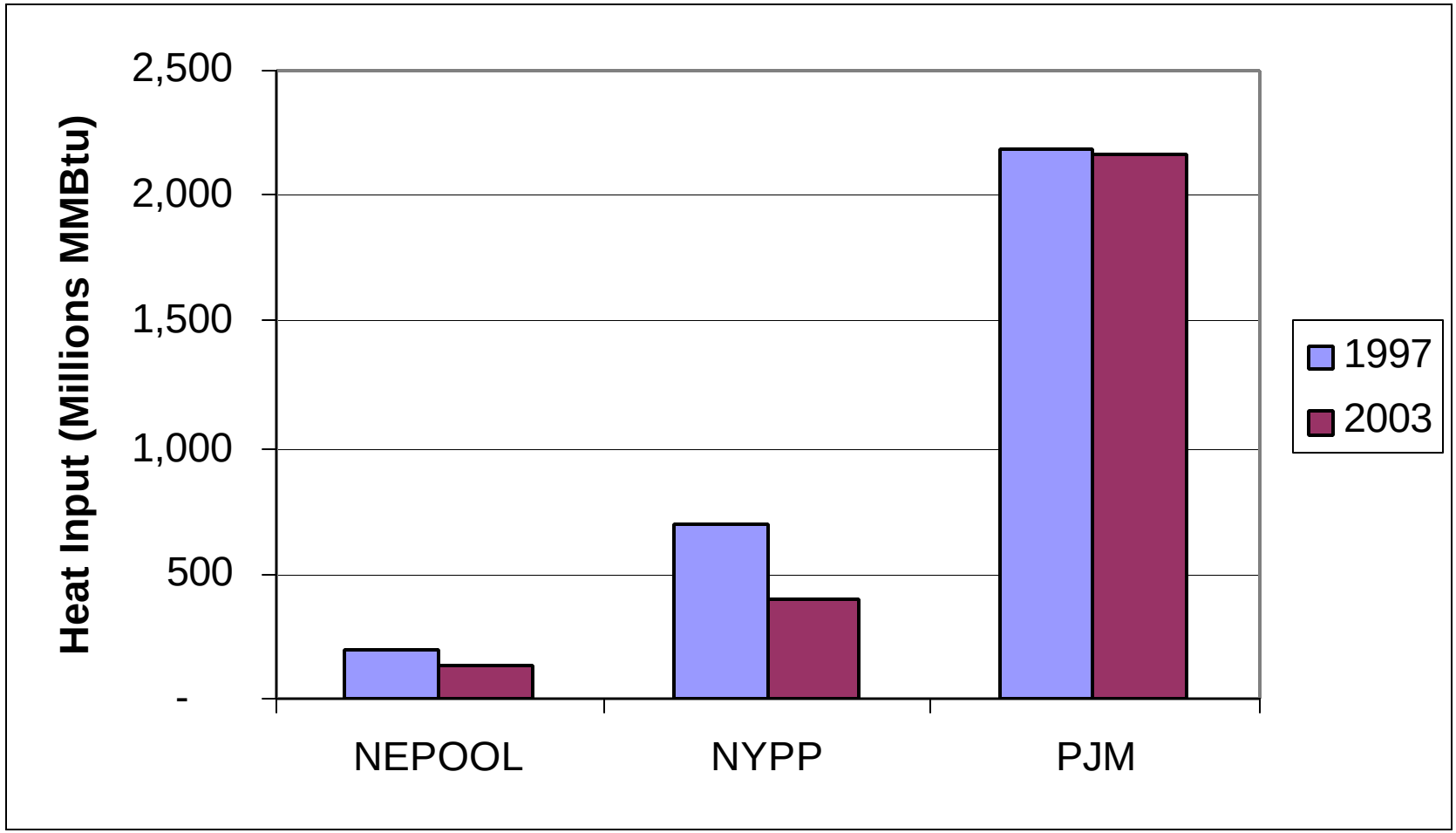


	Invest	Trade	Retire?
Fixed Cost	Annual carrying cost of NOx abatement technology	None	
Variable Cost (in energy bid)	• Operating cost of abatement technology + • Opportunity cost of used allowances	• Cost of purchased allowances + • Opportunity cost of used allowances + • Opportunity cost of lower dispatch	

Impact on Northeast Markets

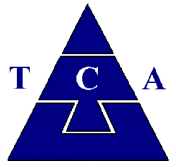
- **Market Prices: prices increase by up to 5% in PJM, 2-4% in NYPP and NEPOOL. However, the combined impact of environmental regulations and new entry is to reduce the prices.**
- **Investment cost: a very small incremental cost associated with the NOx SIP Call was estimated (around $40 Million/year), because several investments have been made as part of Phase I of MOU in the OTR.**
- **Capacity Profile: significant new entry helps in displacing dirtier units, and causes some retirements. The new entry significantly exceed the load growth and is more economic than many existing units.**

Impact on Coal-Fired Generation Units

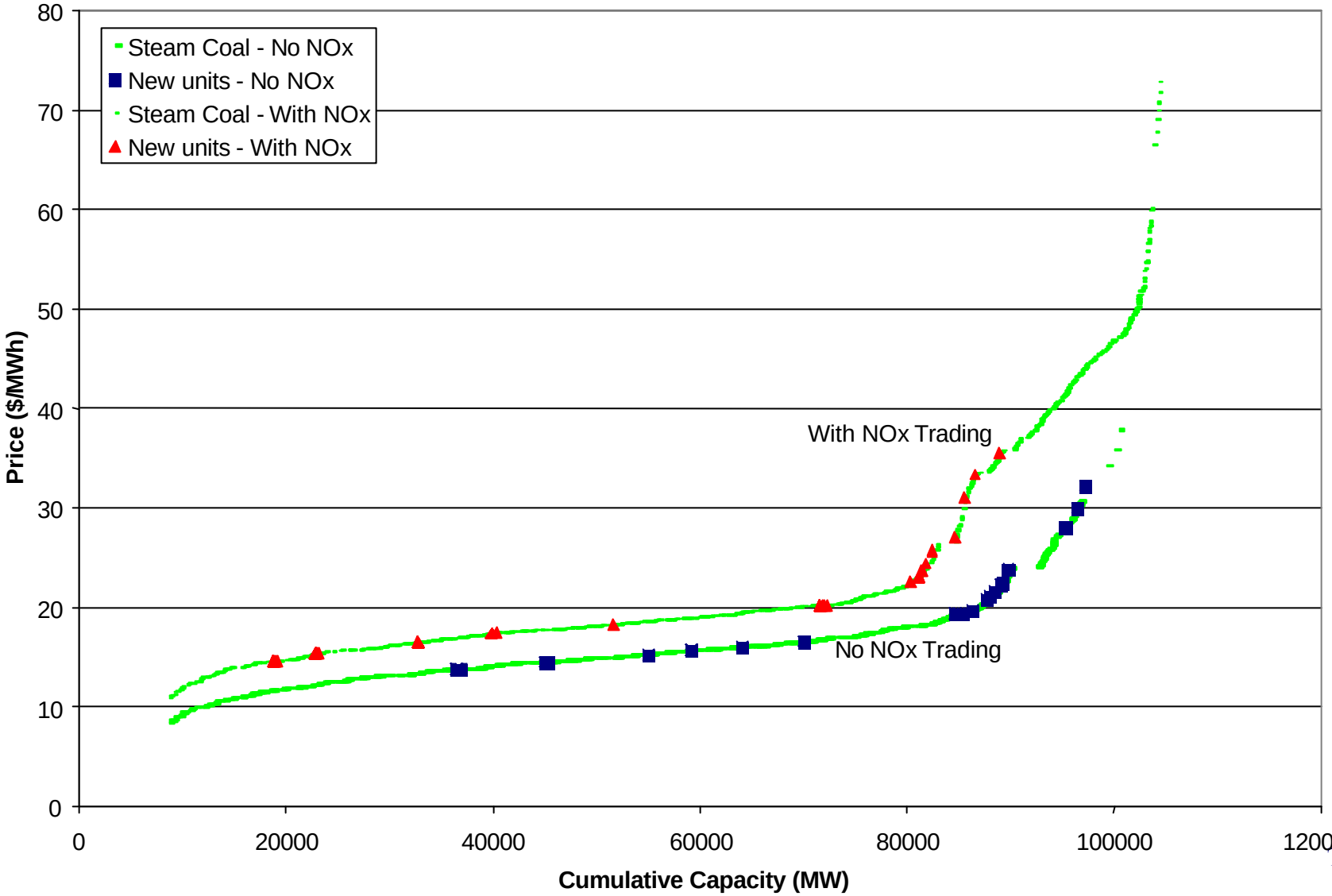


Impact on Midwest Electricity Markets

- **Market Prices: prices increase by up to 15% in ECAR. However, the combined impact of environmental regulations and new entry is to reduce the prices relative to today.**
- **Investment cost: the cost associated with abatement technology associated with the SIP Call is significantly higher than in the Northeast, and many more units will be impacted. The reason for this higher cost is the higher portion of coal in the generation mix in the Midwest.**
- **Capacity Profile: significant new entry helps in displacing dirtier units, and causes some retirements. The new entry significantly exceed the load growth and is more economic than many existing units.**



Impact of Nox Emissions Trading on ECAR Supply Curve



Conclusions

- The above approach can be used by the industry to make informed policy decisions, and to evaluate the impact of environmental regulations on market clearing prices of electricity and the costs of emission reduction for generators.
- The impact of EPA's NOx SIP Call on energy market-clearing prices in the Northeastern and Midwest US can be up to 5% in PJM and up to 15% in ECAR (but marginal cost of energy go down compared to historical cost).
- The competitive entry will reduce the stringency and the incremental cost associated with the NOx SIP Call.
- The analysis shows that the deregulation of the electric power markets and the environmental regulations can join hands in reducing emissions from power plants.