

# Optimizing Compliance Cost for Coal-Fired Electric Generating Facilities in a Multipollutant Control Environment

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Coal, when gas was at \$2.00/MMBtu



# Coal, at today's gas prices



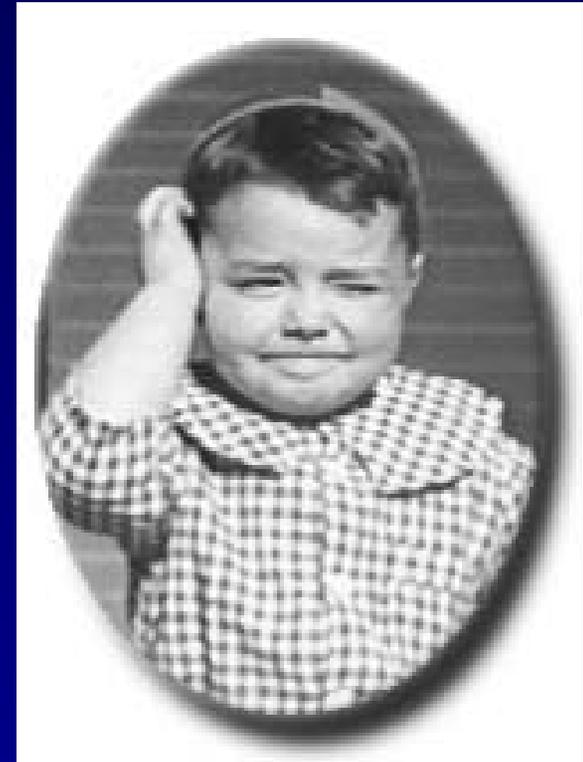
Ray Gray

# Coal Challenges

- Environmental Regulations
  - Regulatory Uncertainty
  - Investments likely necessary for many existing units
- Investments required at time of financial stress for the industry
  - Highest percentage of power companies with debt rated “junk” since the Great Depression

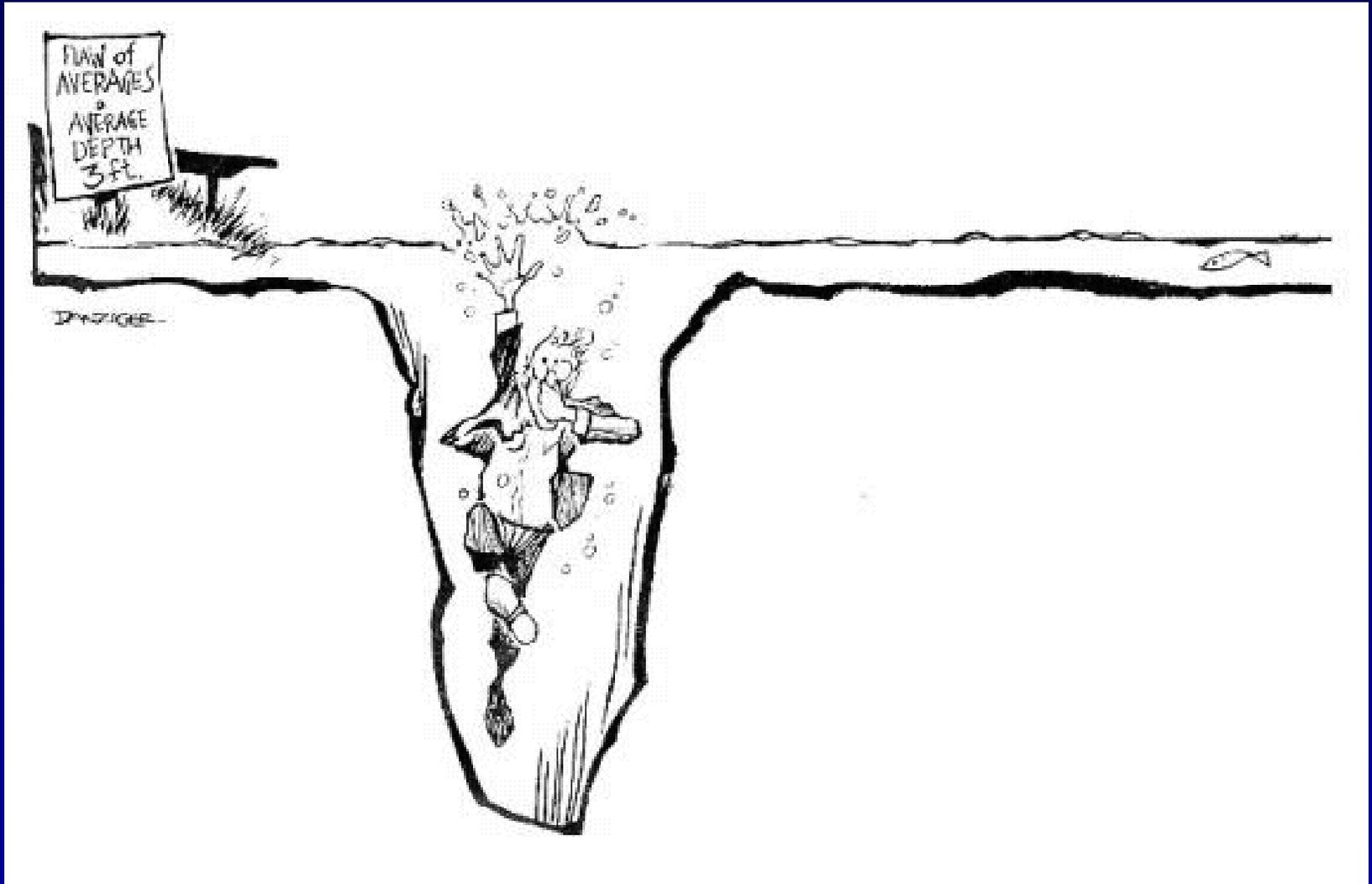
# Challenges to Developing a Strategy

- Complex interrelationships
  - Control of multiple pollutants
  - Business concerns
  - Hard to predict outcomes (or allowance prices!)
  - Preferable to delay commitments
- “Average” or “Likely” solutions entail significant risk



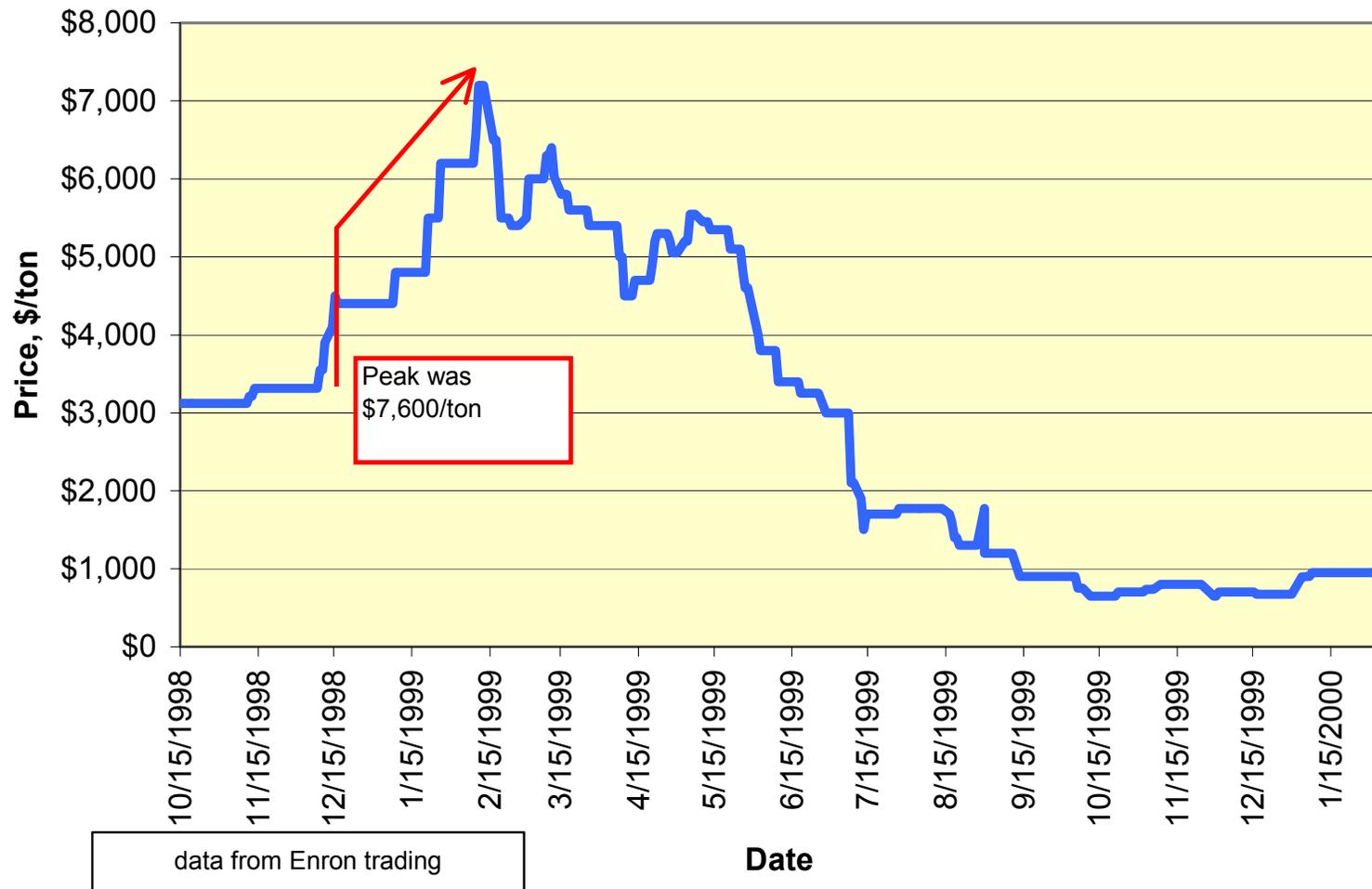
# The Flaw of Averages

Sam Savage



# Remember 1999 Allowance Prices?

## 1999 NOx Allowance Prices

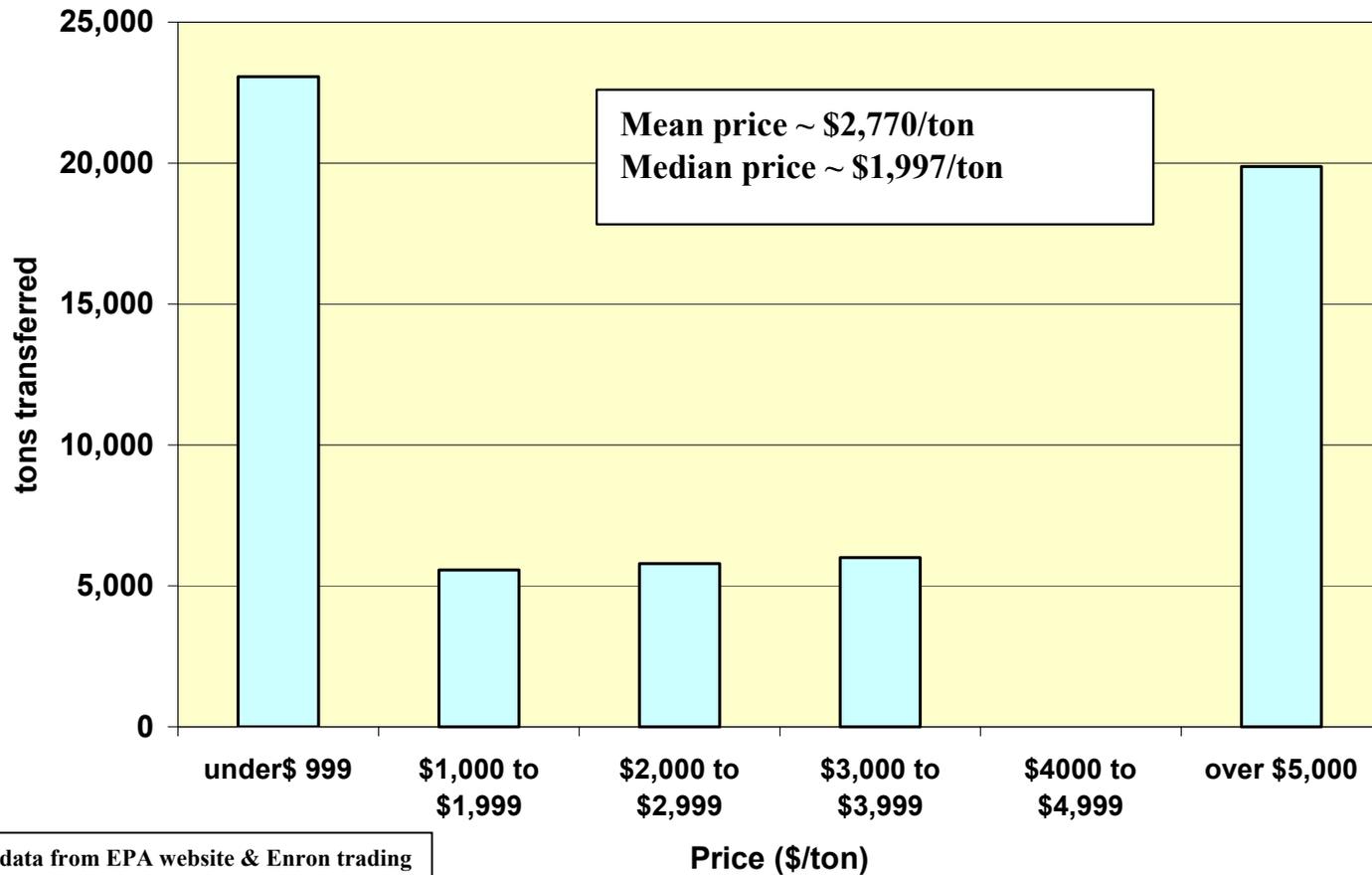


Me, when I heard of the \$7,600 trade.



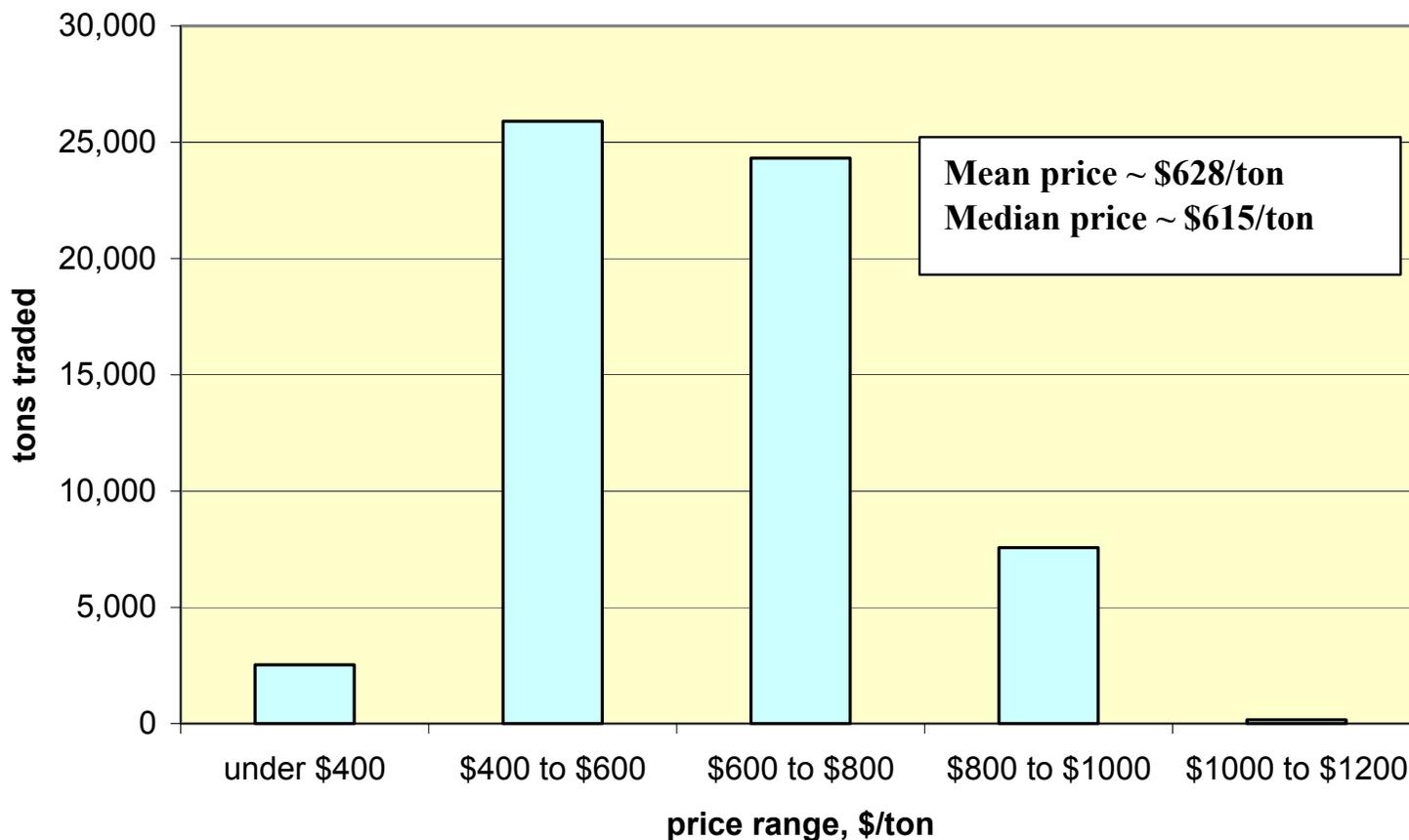
# 1999 OTR NOx Price and Volume

Frequency Histogram of Allowance Prices (1999 Vintage) for "Economically Significant" trades through Dec 1999



# 2000 OTR NOx Price and Volume

**Frequency Histogram of Allowance Prices (2000 Vintage) for  
"Economically Significant" trades through Dec 2000**



Data from EPA

# 2003 Prices (1999 déjà vu?)

from Evolution Markets

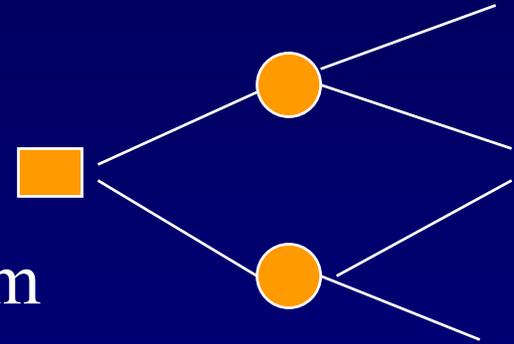
SIP NOx 2003 (08/09/01...10/03/03) [454dp]



evomarkets.com

# Decision-Making Tools

- Decision Trees
  - Identify key decision points
- Real Options
  - Estimate value of flexibility from delaying a commitment
- Simulation
  - Enables testing of scenarios for complex and highly uncertain systems



# Compliance Purely by Technology versus Compliance Purely by Market (the two extremes)

	<b>Technology</b>	<b>Allowance Market</b>
Capital Commitment	<b>High</b>	<b>None</b>
Market Risk	<b>Low/None</b>	<b>High</b>
Option Value/ Flexibility	<b>Low/None</b>	<b>High</b>

# Compliance at Risk<sup>SM</sup>

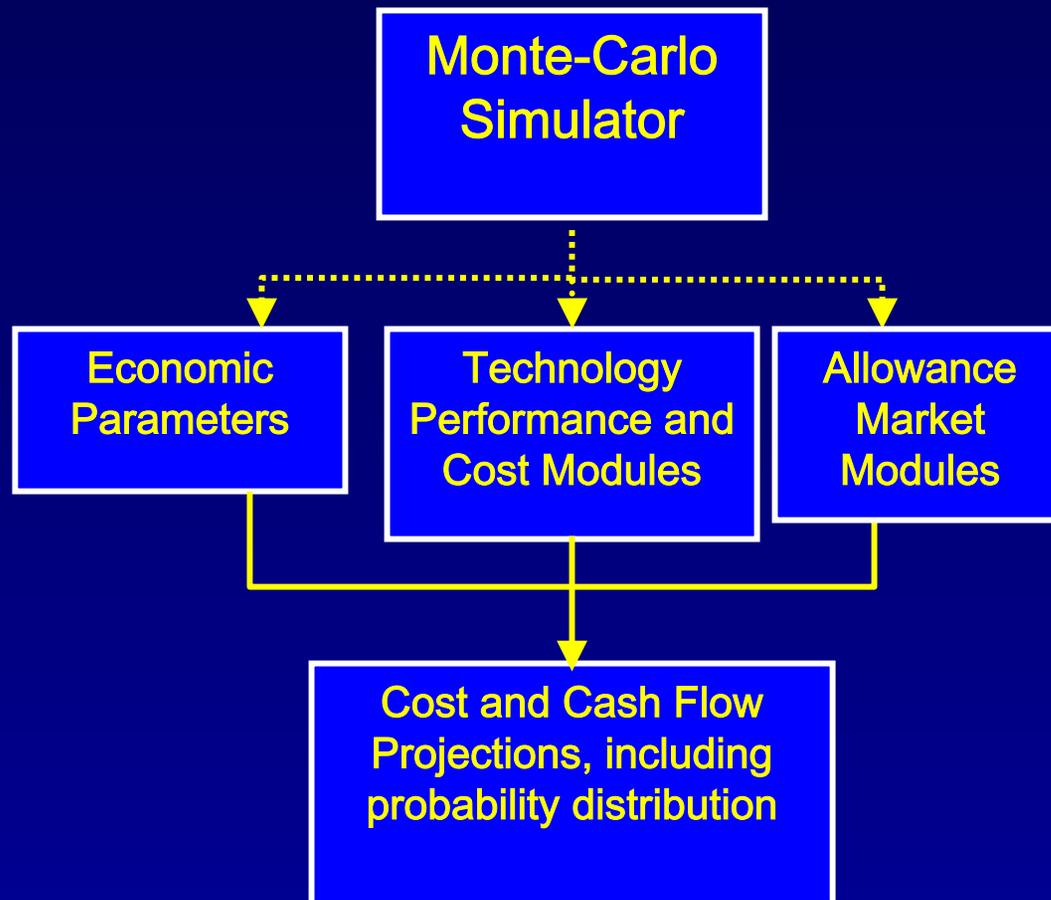
– A Method for Managing Compliance Cost Risk

- An approach for finding the right balance between reliance on technology versus reliance on the market.
- Manage cost and uncertainty.
- Will enable you to estimate risk of exceeding a threshold compliance cost
  - X% of exceeding \$Y in compliance cost over a specified time window

# Compliance at Risk<sup>SM</sup>

- A Method for Managing Compliance Cost Risk
- Annual compliance cost, comprised of
  - Amortization of capital cost of technology
  - Plus annual fixed and variable operating costs
  - Plus cost to purchase allowances, if needed
  - Minus net proceeds from selling allowances, if available
- Minimize compliance cost
- Minimize compliance cost risk (uncertainty)

# Compliance at Risk<sup>SM</sup>



# Control Technology Performance and Cost Modules

<b>Pollutant</b>	<b>Control Technologies</b>
<b>NO<sub>x</sub></b>	<ul style="list-style-type: none"><li>•Combustion Controls</li><li>•SNCR</li><li>•SCR</li></ul>
<b>SO<sub>2</sub></b>	<ul style="list-style-type: none"><li>•Limestone Forced Oxidation Wet FGD</li><li>•Spray Dryer Absorber</li><li>•Advanced Dry FGD (CFB Scrubber)</li></ul>
<b>Hg</b>	<ul style="list-style-type: none"><li>•Powdered Activated Carbon Injection</li><li>•Multipollutant control technologies</li><li>•Cobenefit approaches with other control technologies</li></ul>
<b>PM</b>	<ul style="list-style-type: none"><li>•Dry Electrostatic Precipitator</li><li>•Reverse Gas Fabric Filter</li><li>•Pulse Jet Fabric Filter</li><li>•Wet Electrostatic Precipitator</li></ul>
<b>Multipollutant</b>	<ul style="list-style-type: none"><li>•Electro-Catalytic Oxidation (ECO)</li></ul>

# Emissions Market Modules

- Allowance market trading for NO<sub>x</sub>, SO<sub>2</sub>, and mercury
- Incorporates pricing uncertainty for allowances
- Incorporates market derivatives trading
  - Futures, Options, Swaptions, etc.
  - Liquidity of these contracts is improving due to indexed pricing rules that are now being established

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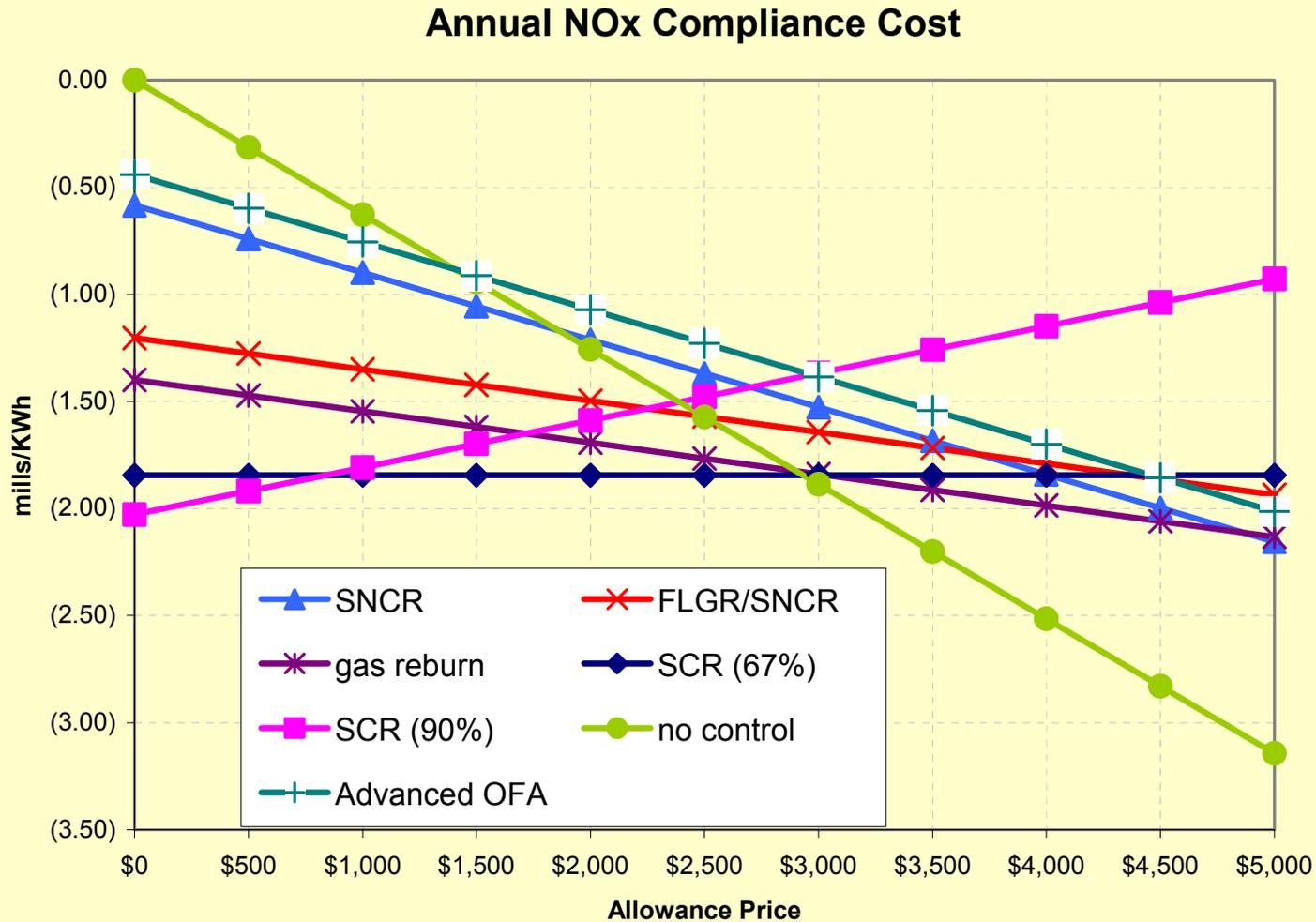
# Two Examples

- Example 1
  - Single Pollutant (NO<sub>x</sub>) and seasonal control
    - to demonstrate some basic concepts
- Example 2
  - Multiple Pollutant (NO<sub>x</sub>, SO<sub>2</sub>, mercury) and annual control
    - to demonstrate more comprehensive approach

# Example 1

- 500 MW coal-fired boiler
  - Current ozone season emissions 3305 tons
  - Budget of 1100 tons (67% reduction)
  - Seasonal Control
  - Assorted economic and technical assumptions
  - Compare various control choices: SCR, SNCR, gas reburn, FLGR+SNCR, advanced OFA, and no additional control
- Analysis is possible with spreadsheets

# Projected Costs



# Projected Costs

Figure 4. Annual NOx Compliance Cost

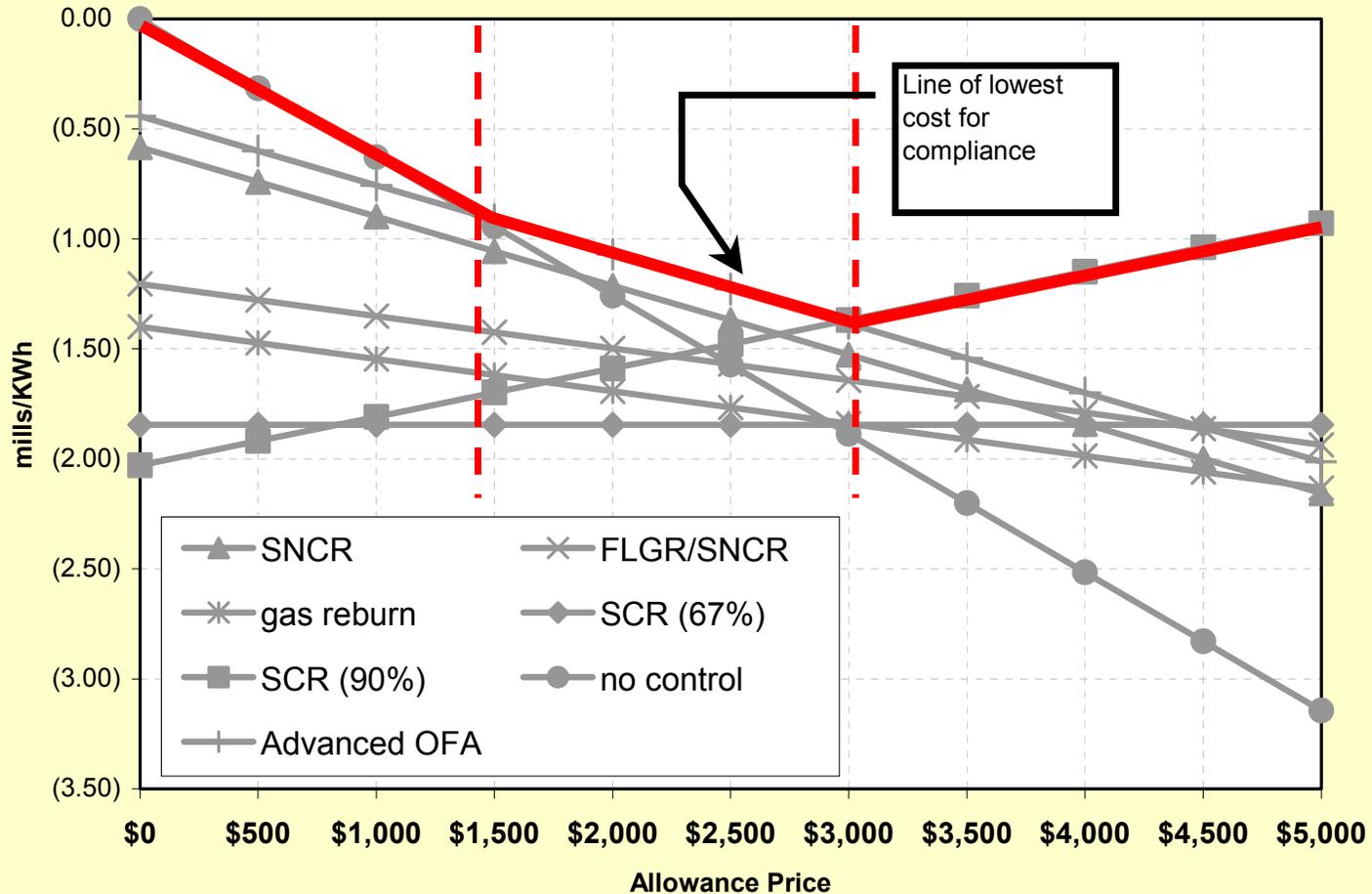


Figure 5. Probability Density

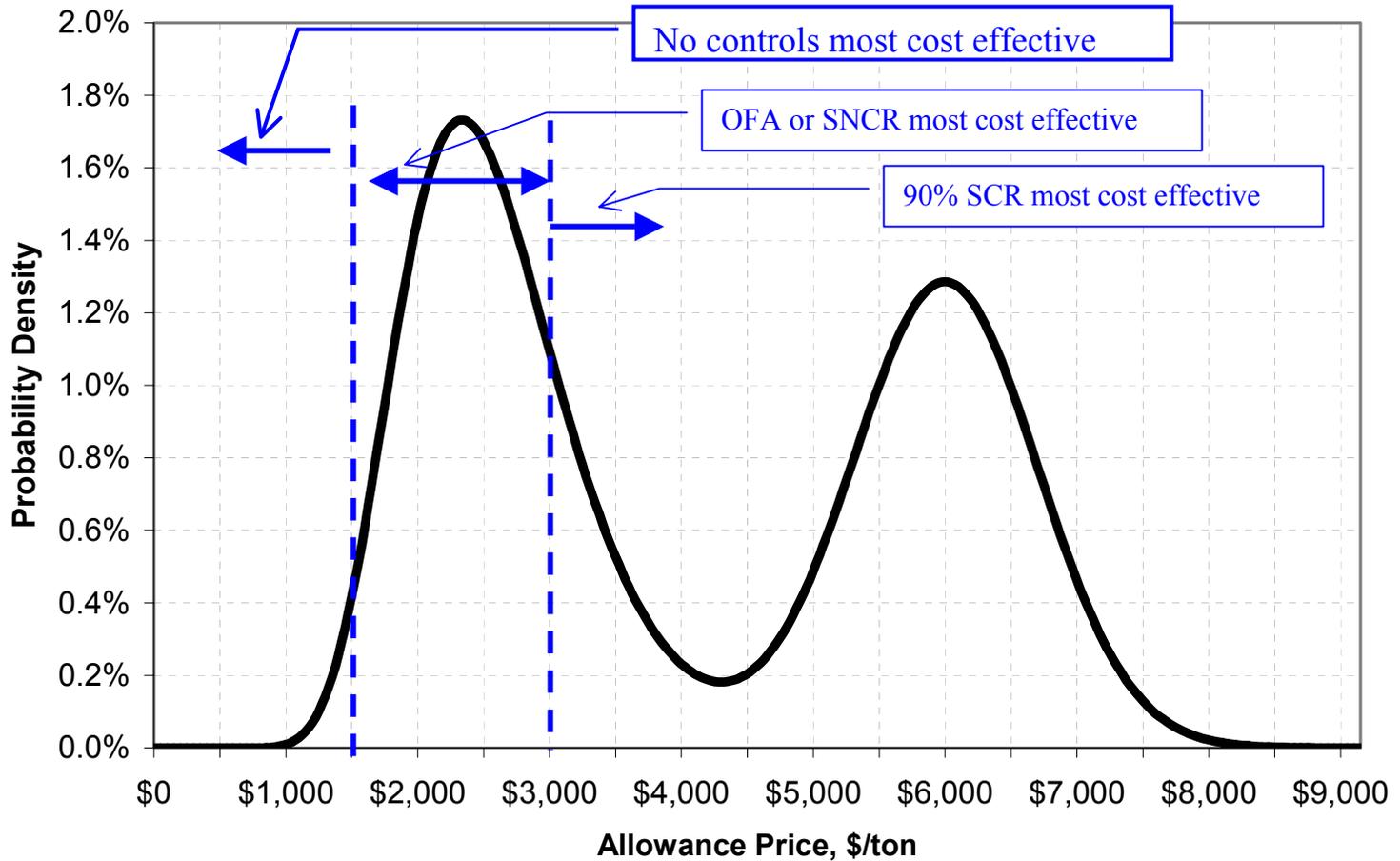
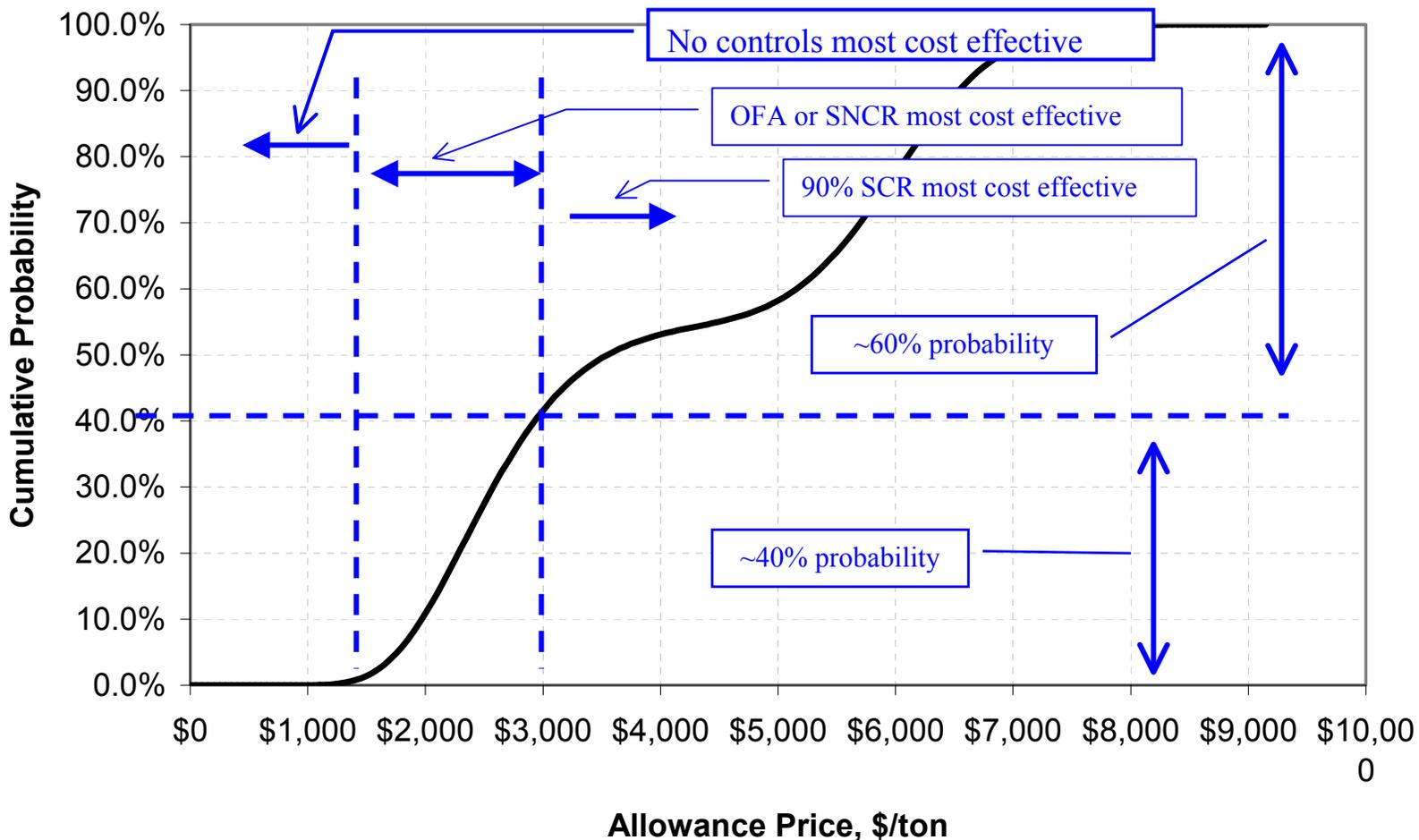
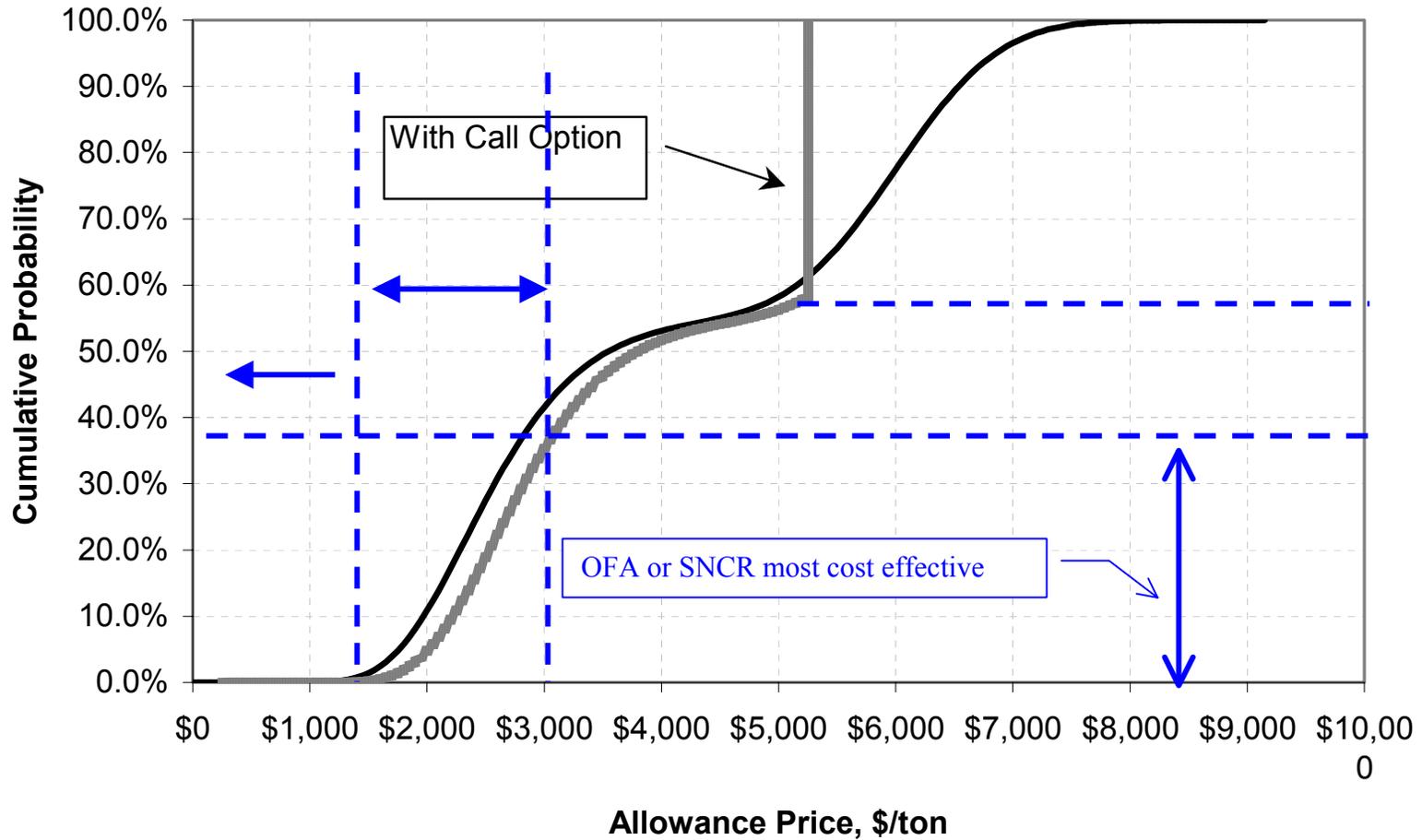


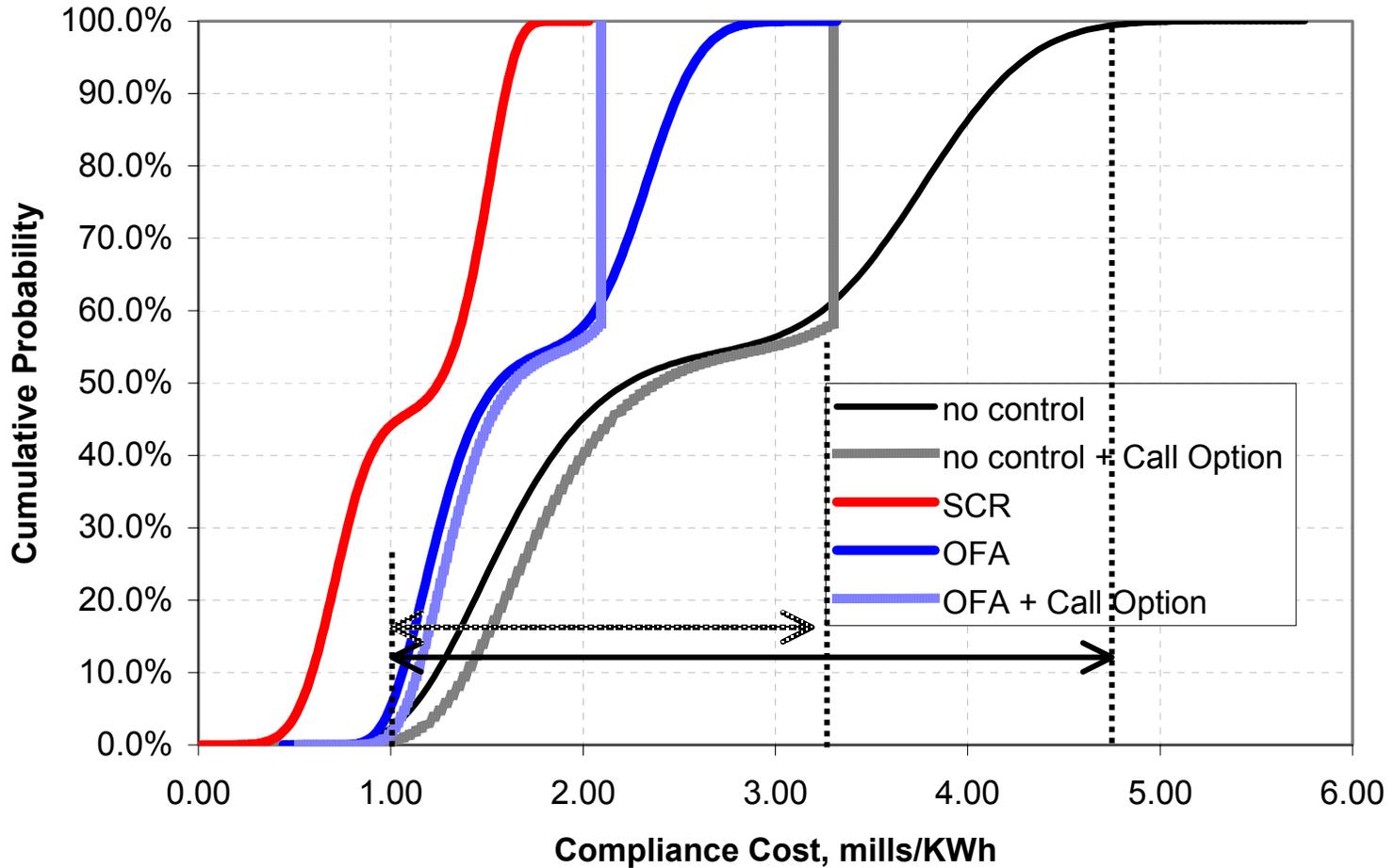
Figure 6. Cumulative Probability



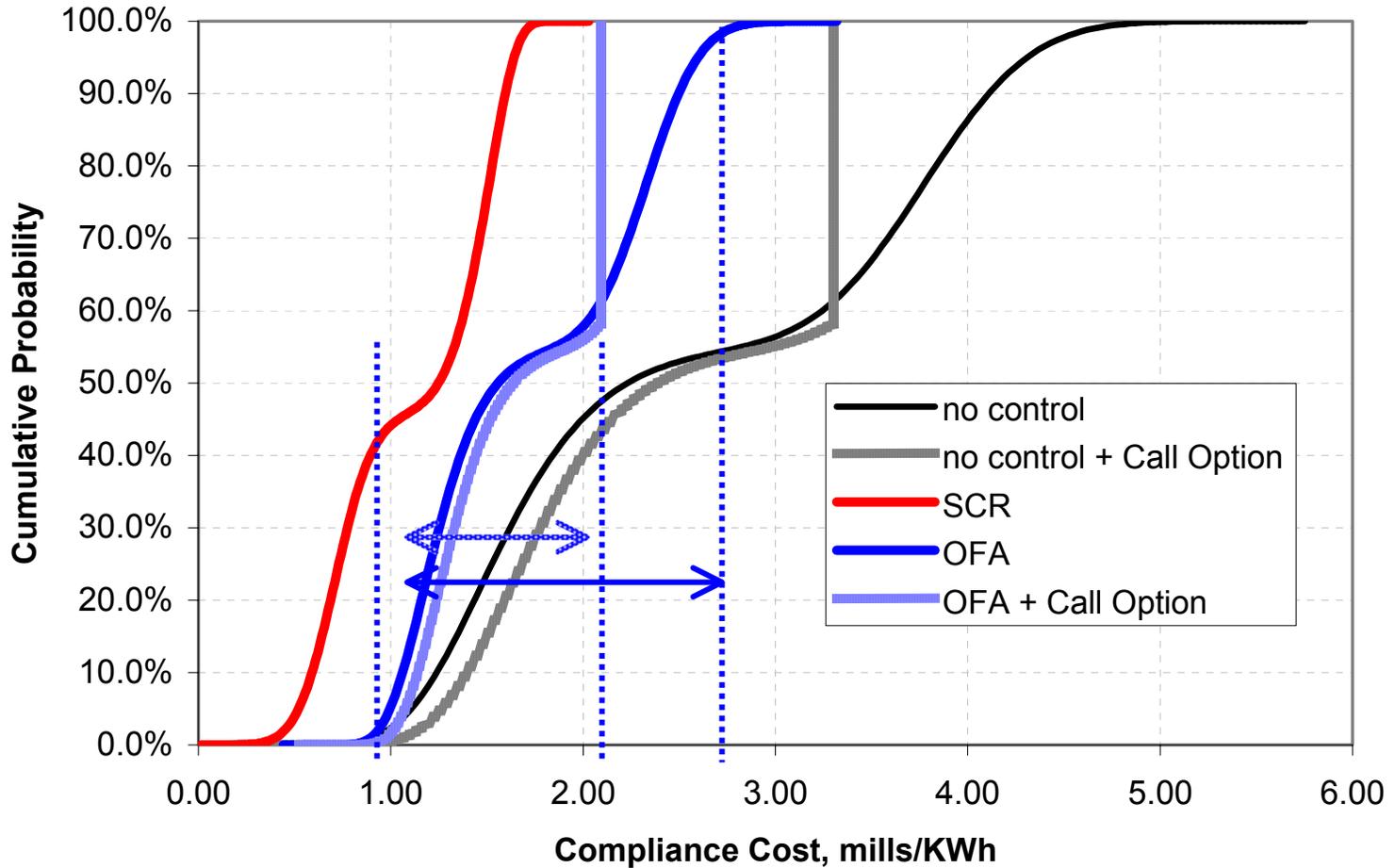
**Figure 7. Cumulative Probability With Call Option or "Cap"**



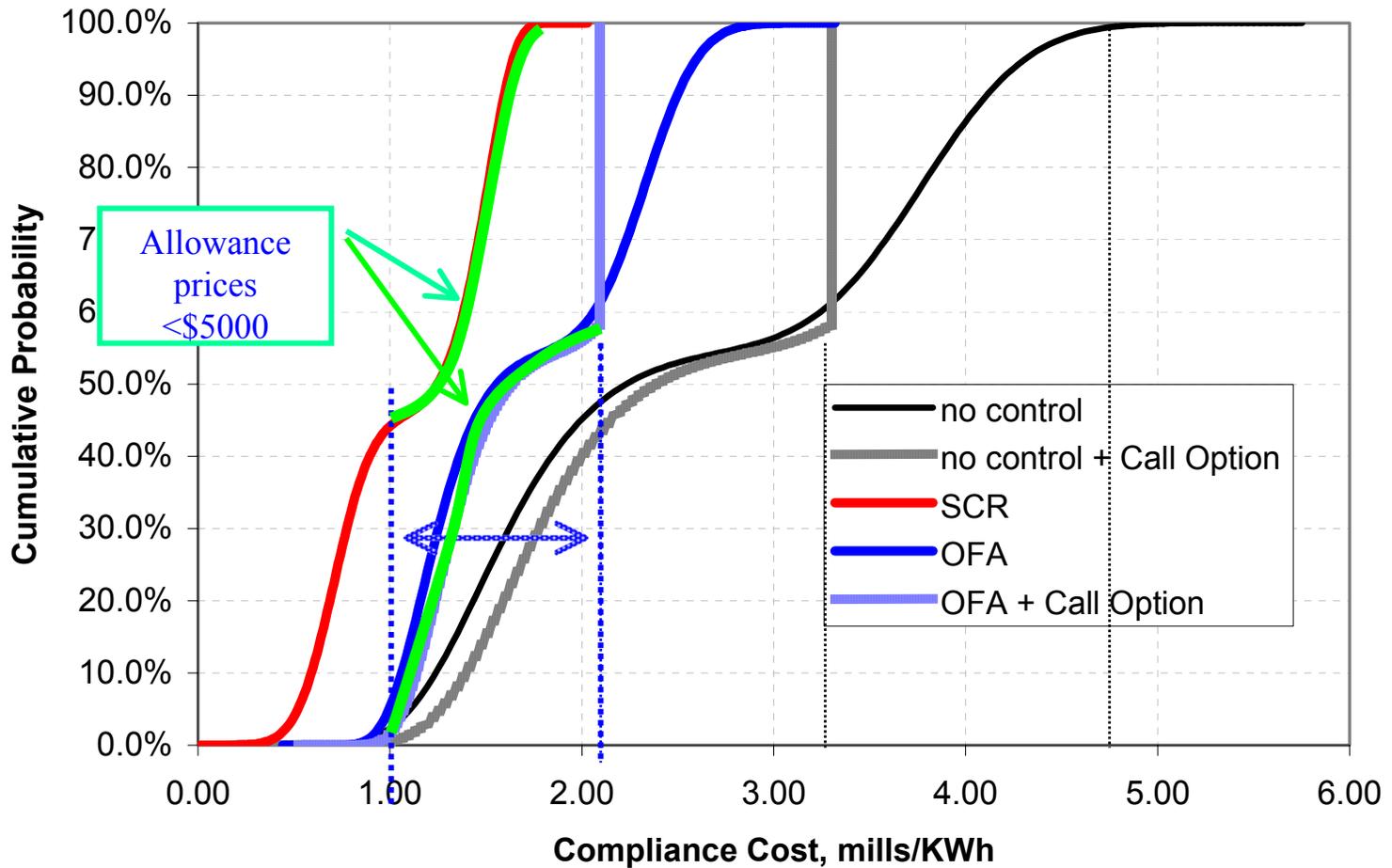
## Cumulative Probability of NOx Control Options 500 MW seasonally controlled



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# For this Example . . .

- Buying in the Cash Market
  - ~40 % probability that Advanced OFA or SNCR plus purchasing allowances is the lowest cost
  - ~60 % probability that 90% SCR plus selling allowances is lowest cost
  - Very low probability that no additional controls plus purchase of allowances is lowest cost
- Use of Market Derivatives (in this case, Call Options)
  - Can address the risk of having to purchase allowances at high prices, making less capital intensive approaches less risky
  - Lower capital cost options are now potentially more attractive

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# Example 2

- 500 MW plant needs to control
  - NO<sub>x</sub> annual limit of 2000 tons (currently emitting 5,230 tons)
  - SO<sub>2</sub> annual limit 1500 tons (currently emitting 12,645 tons)
  - Mercury limit 50 lbs (mercury in coal 210 lbs)
- Assumed distributions for allowance prices.
- Assorted Economic and Technical Assumptions.
- Modeled with Monte-Carlo Simulator.

**Figure 11. Multipollutant Simulation Results**

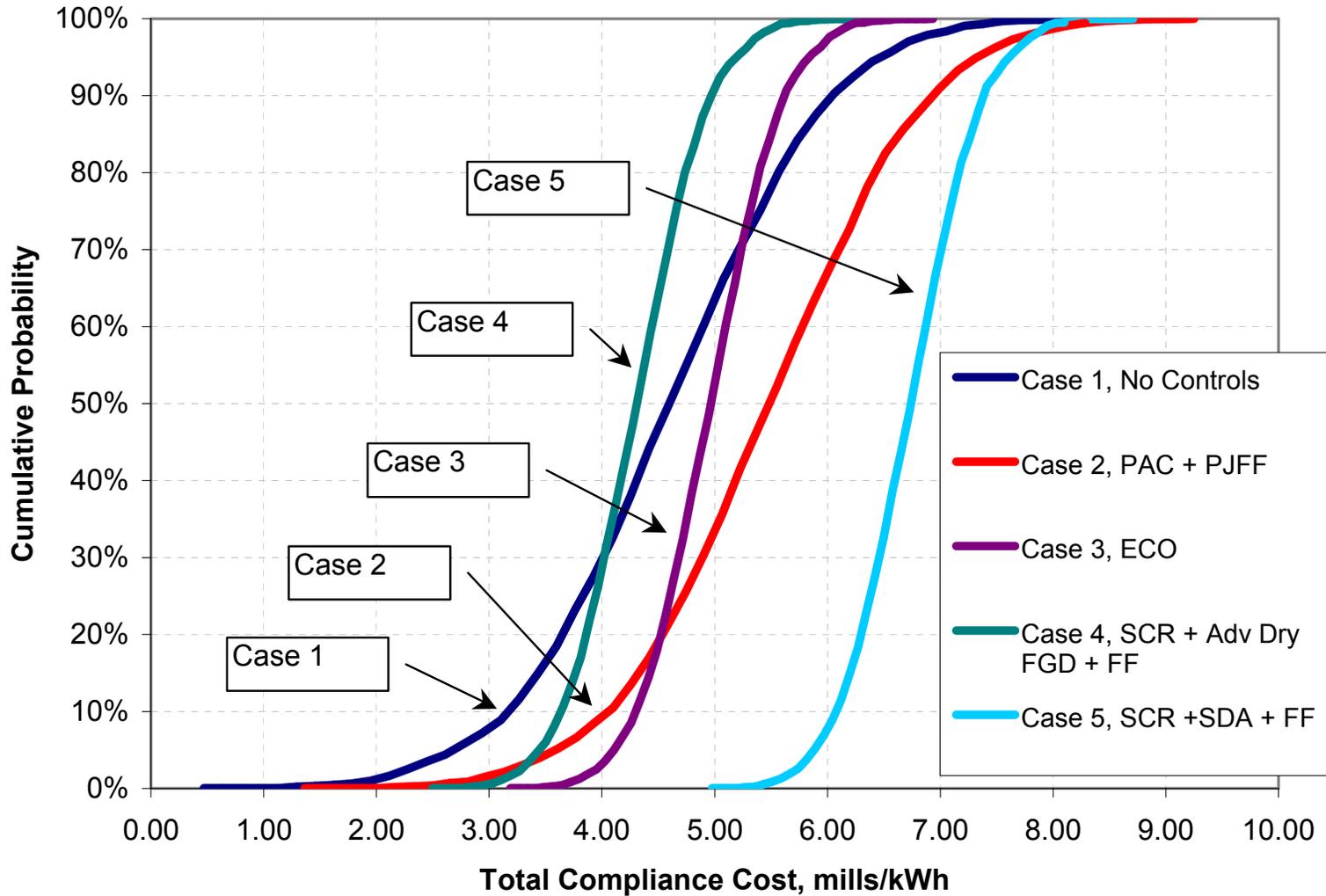


Figure 12. Multipollutant Simulation with Options

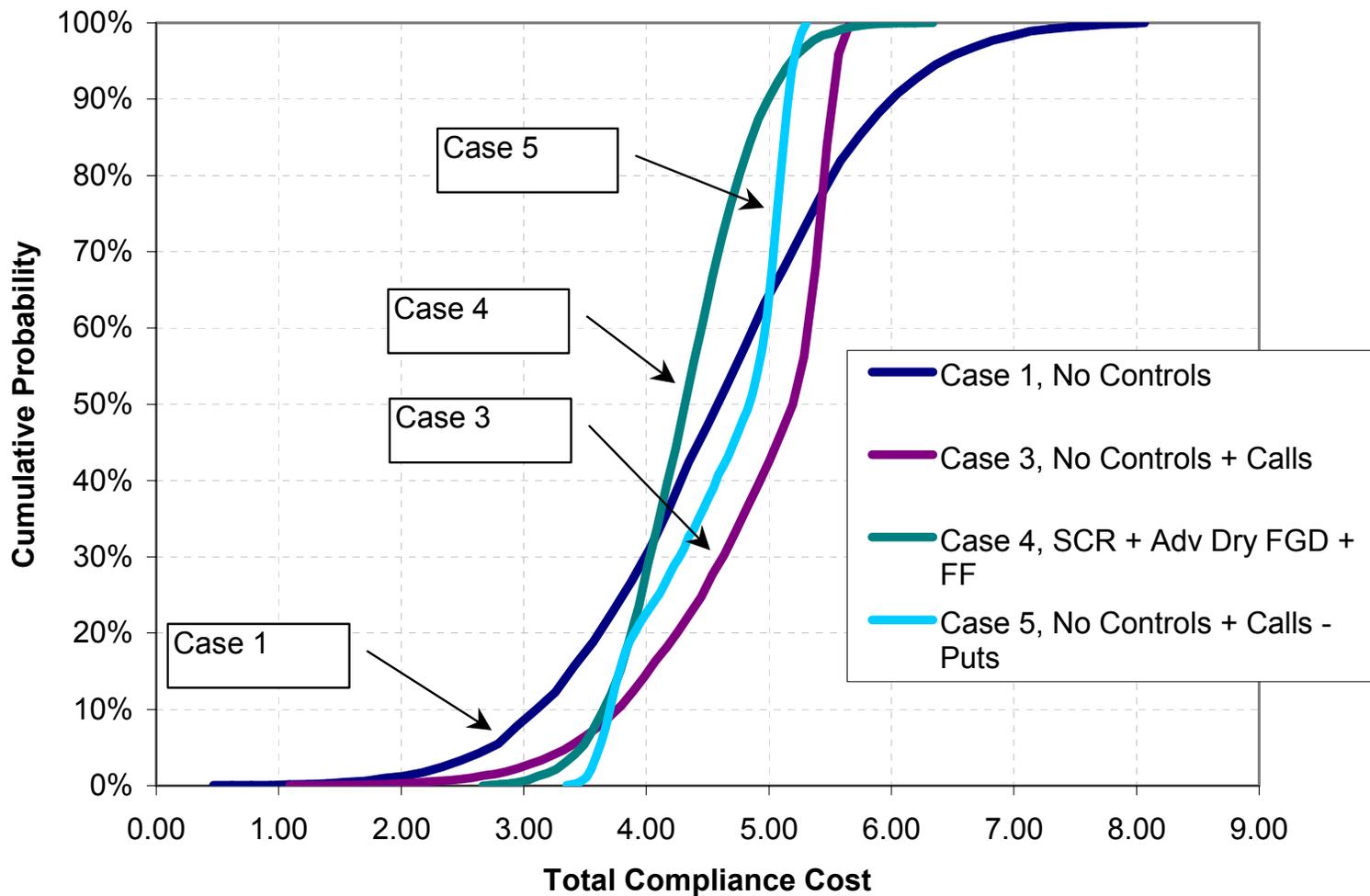


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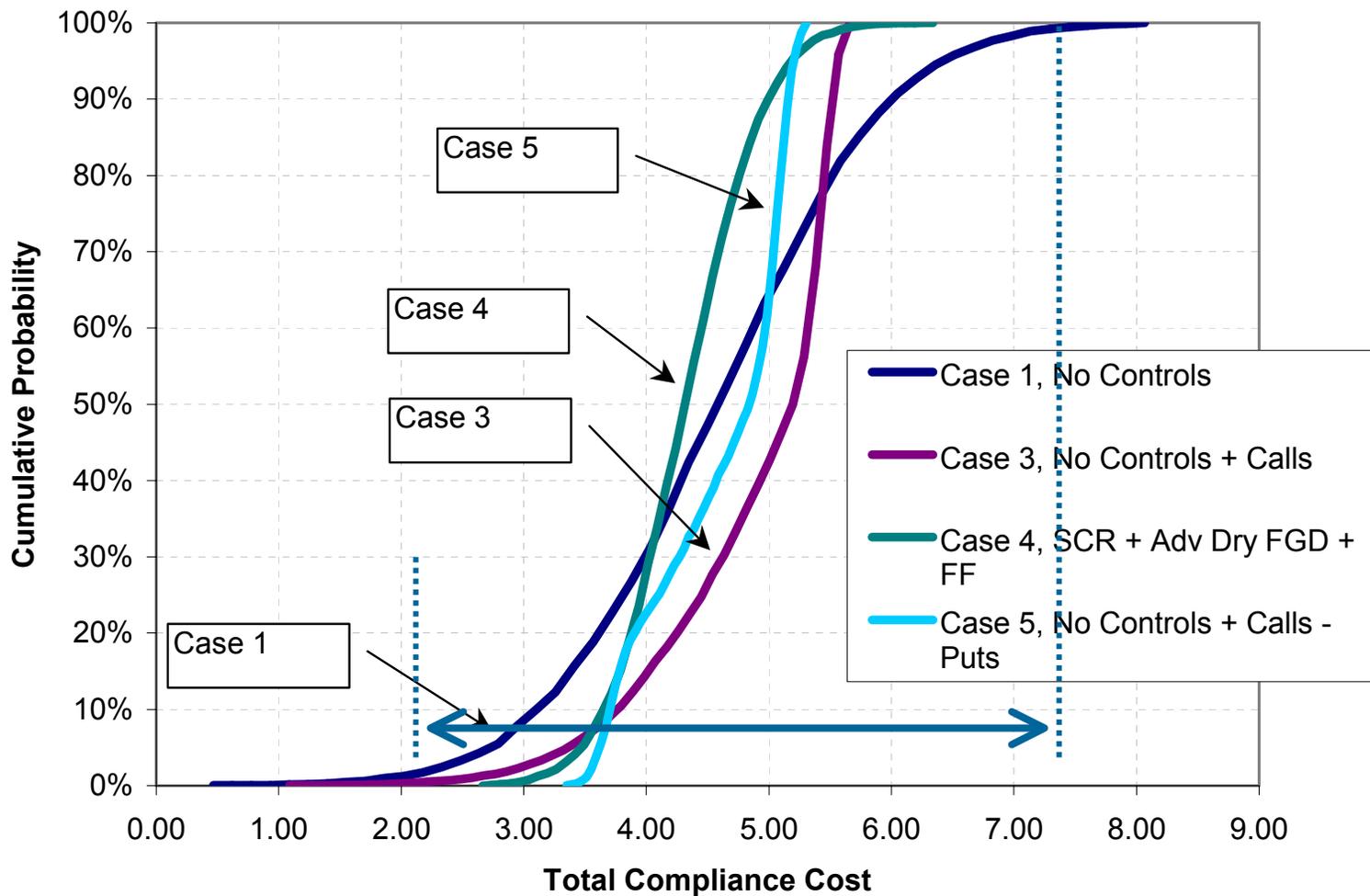


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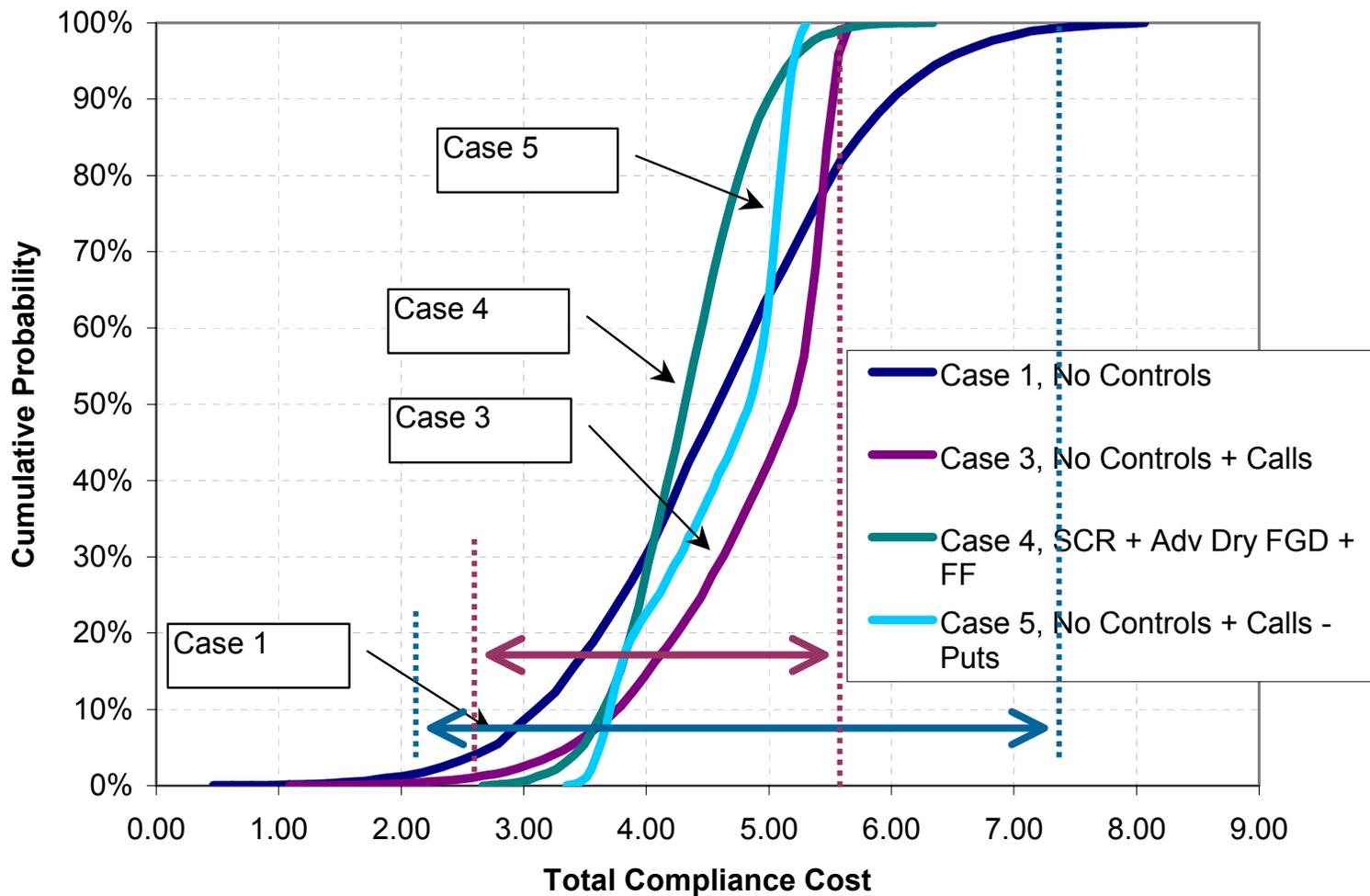


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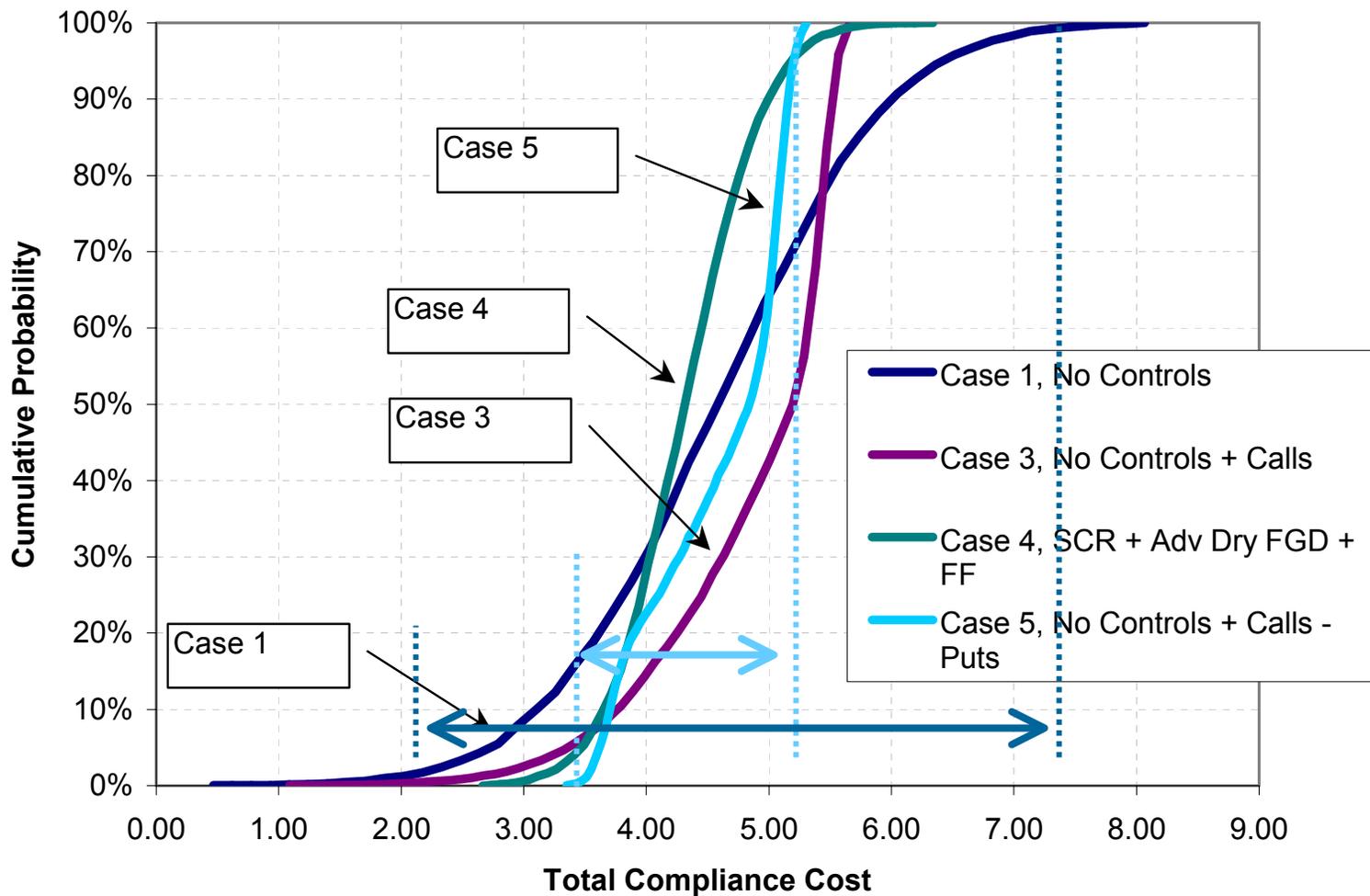
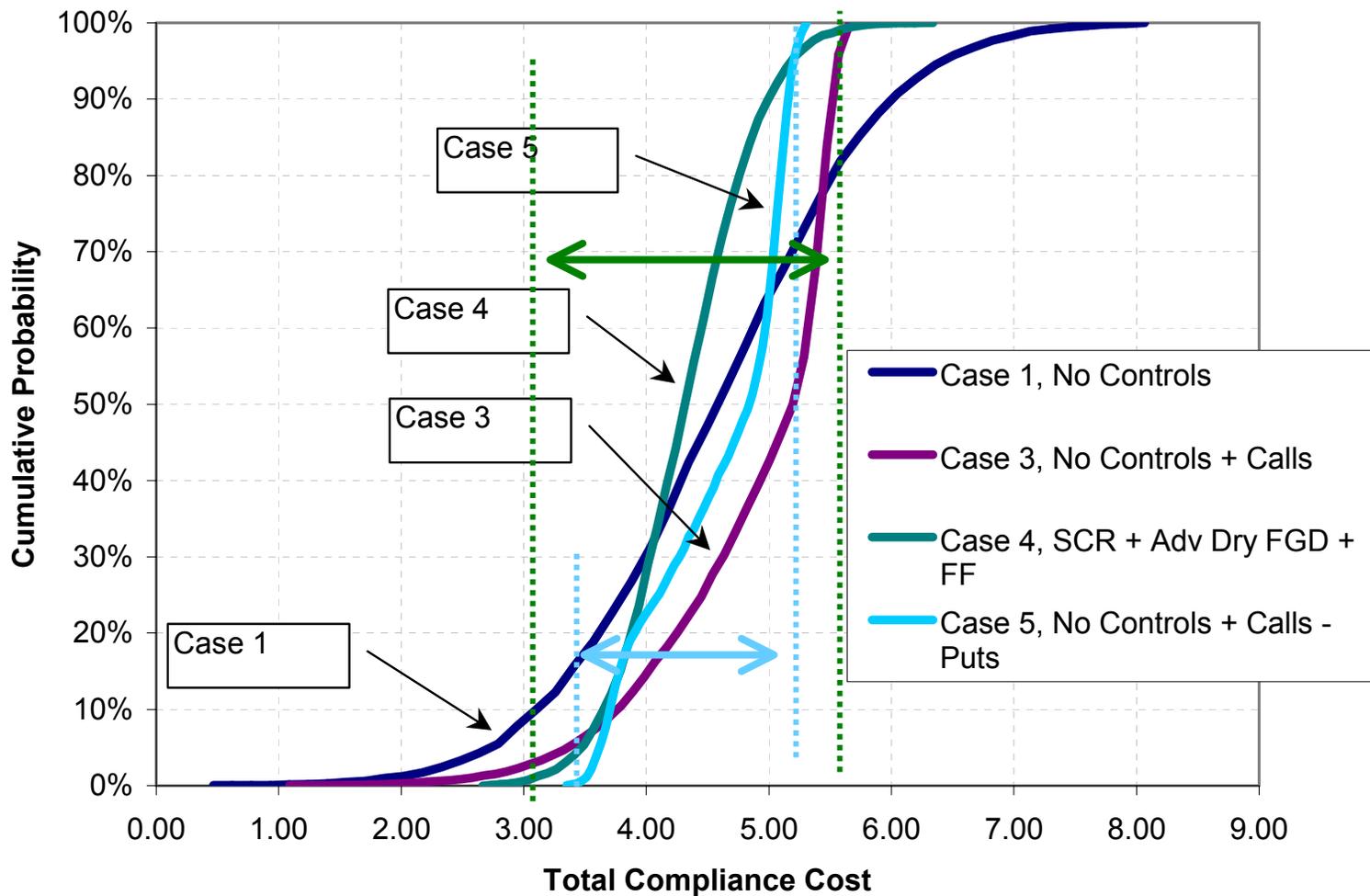


Figure 12. Multipollutant Simulation with Options



# For Multipollutant Control Situation

- Possible to characterize cost and risk of various technology approaches
- Possible to test combinations with market derivatives to manage risk
  - Tailor your risk and capital expenditure
- In real life you'd want to test several allowance price distributions you think are reasonable
  - other uncertainty parameters besides allowance prices might be tested as well
    - Wholesale power cost
    - Capacity factor
    - Reagent costs

# What about multiple years?

- Expected price distributions or other factors may differ significantly from one year to the next
- Relatively straightforward to run cash flow analysis (with probability distributions) over multiple years

# Summary

- Compliance at Risk™ approach lets you analyze and compare complex, multipollutant control scenarios
- Find the right balance between reliance on technology and reliance on the market
- Tailor your risk profile to your needs using allowance market derivatives
- Reduce risk while avoiding or delaying capital commitments

# Future Plans

- Currently offered as a service
  - may be developed further to an integrated software product, if interest is there
- Looking for input from key stakeholders (industry, government agencies, and financial community) on best direction for further development
- If interested, contact me at:
  - [staudt@AndoverTechnology.com](mailto:staudt@AndoverTechnology.com)