Thermodynamics, Economics and Politics
The practical constraints in climate change mitigation
& Implications for Investment and Planning

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Big, fast reductions – the three possibilities

- Offsets
- New technologies
  - Hyper efficient
  - Non-emitting or non-fossil energy
- Behavioral — Reduce consumption (don't drive/leave all the lights on)

Big, fast reductions – the three problems

- Offsets — Limited access?
- New technologies
  - Time element to invent and/or deploy
  - Thermodynamics – can't create energy, perpetual motion machine, miracle breakthroughs unlikely (fusion?)
- Behavioral — Reduce consumption (don't drive/leave all the lights on)

Where do we get “reductions” (how do we emit less)?

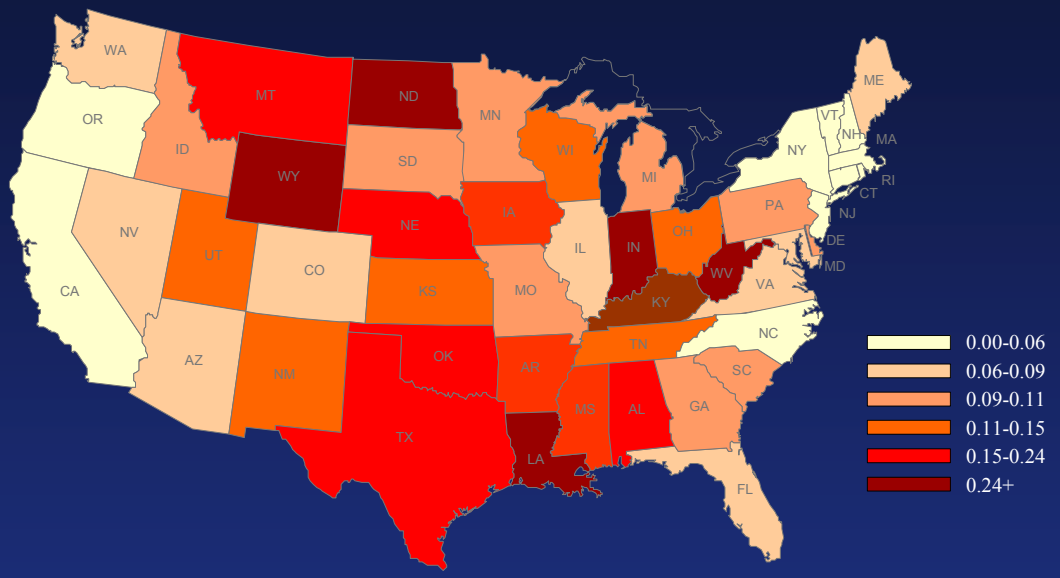
Less value → High value

Offsets → Power Sector → Transport

- Power sector tech reductions – 1 to 5% in first 15 years
  - No BIG reductions until CCS and nuke deployment post 2025
  - 1500 coal plants
  - $25 to $45/ton CO2
- No significant transport reductions until very high CO2 price (or more costly non-market approaches)
- Consumer becomes source of most reductions –
  high CO2 prices → high power prices → conservation
- Efficiency vs. political sustainability

Carbon Intensity of Commercial and Industrial Output varies by state (2001 data)

- Industrial and energy producing regions particularly vulnerable
  - States taking lead on climate have little exposure to regulations in terms of their relative carbon intensity per unit of economic activity (service industries or small exposure to coal)
- Various means to dampen macro-economic impacts of lower economic growth, price shocks, program unraveling
  - Offsets – maintain cap, but uncertainty re availability, durability and quality. Political pressure to limit
  - Safety valve – limits top portion of price volatility
- Firm or sector level impacts can be addressed through free allocation of allowances



(Metric tons carbon per thousand $2005)

Source: Abt. Associates (forthcoming), Carbon Emissions Economic Intensity Index: Development and Technical Enhancements, prepared for Climate Protection Division, U.S. Environmental Protection Agency: Washington, D.C.

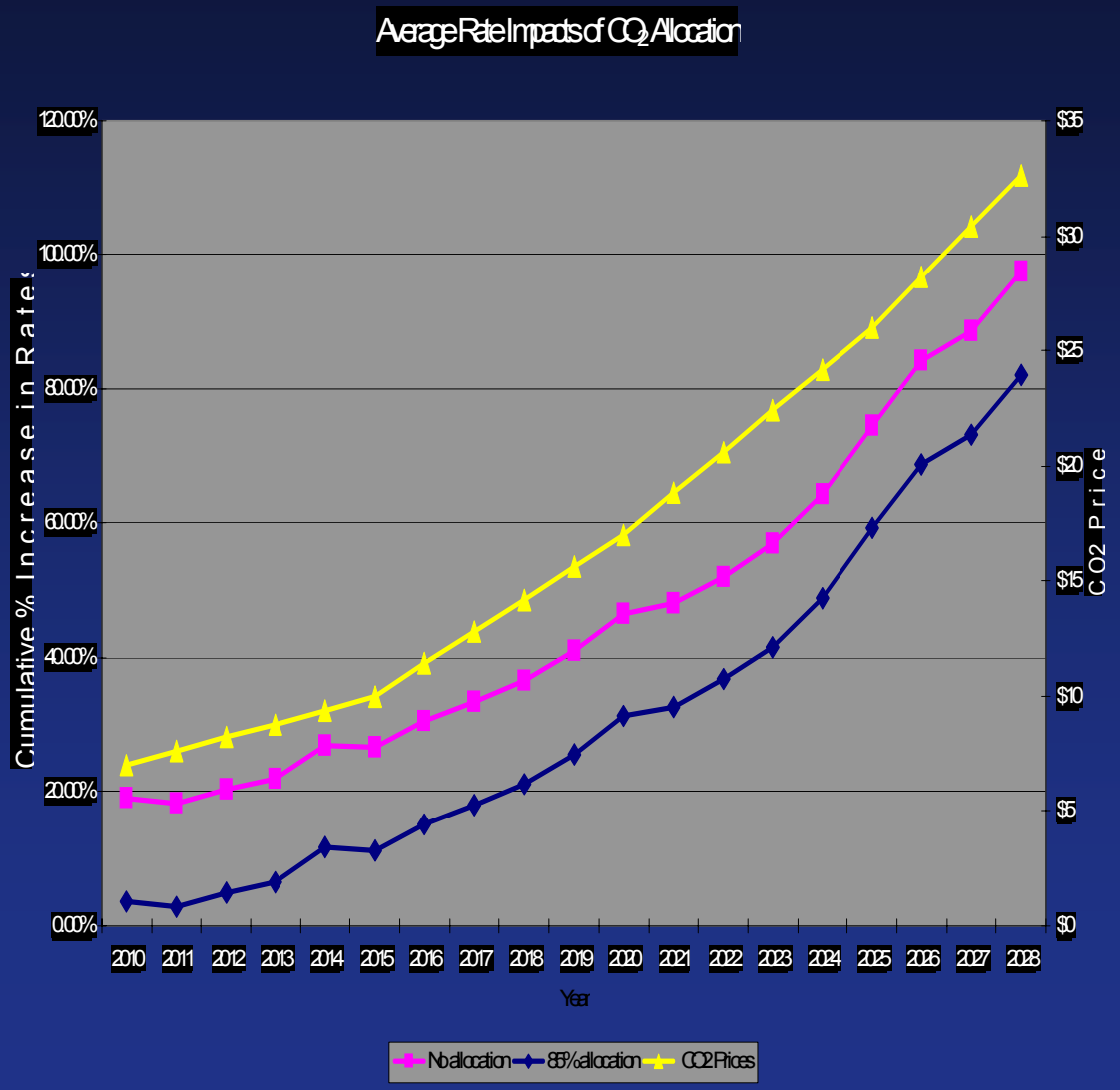
Fairness: Carbon Intensity of Commercial and Industrial Output varies by state (2001 data)

Allocations can help dampen price shock – 85% allocation example

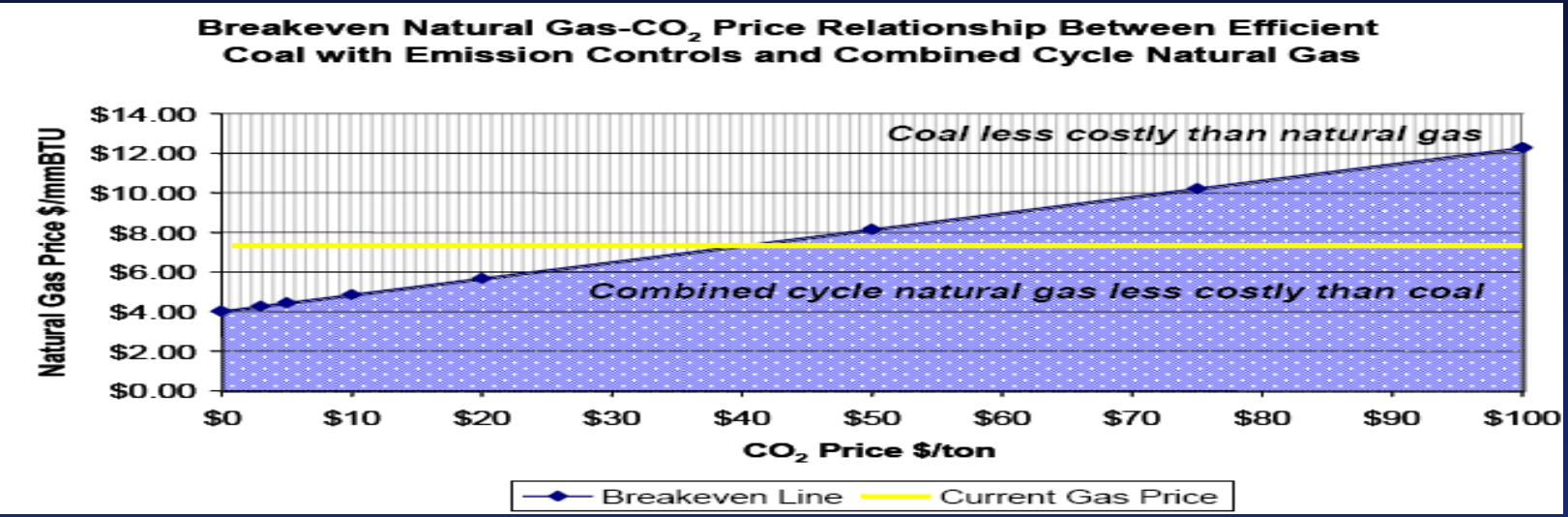
- Rates still rise over time due to investment in new, low emitting techs
  - Regulators push us based on economics – marginal, not average costs – to do otherwise harms ratepayers in long run
- No windfalls in regulated states

Not “Acid Rain II”

- Allocations to impacted entities, not regulated entities
- Minimize windfalls

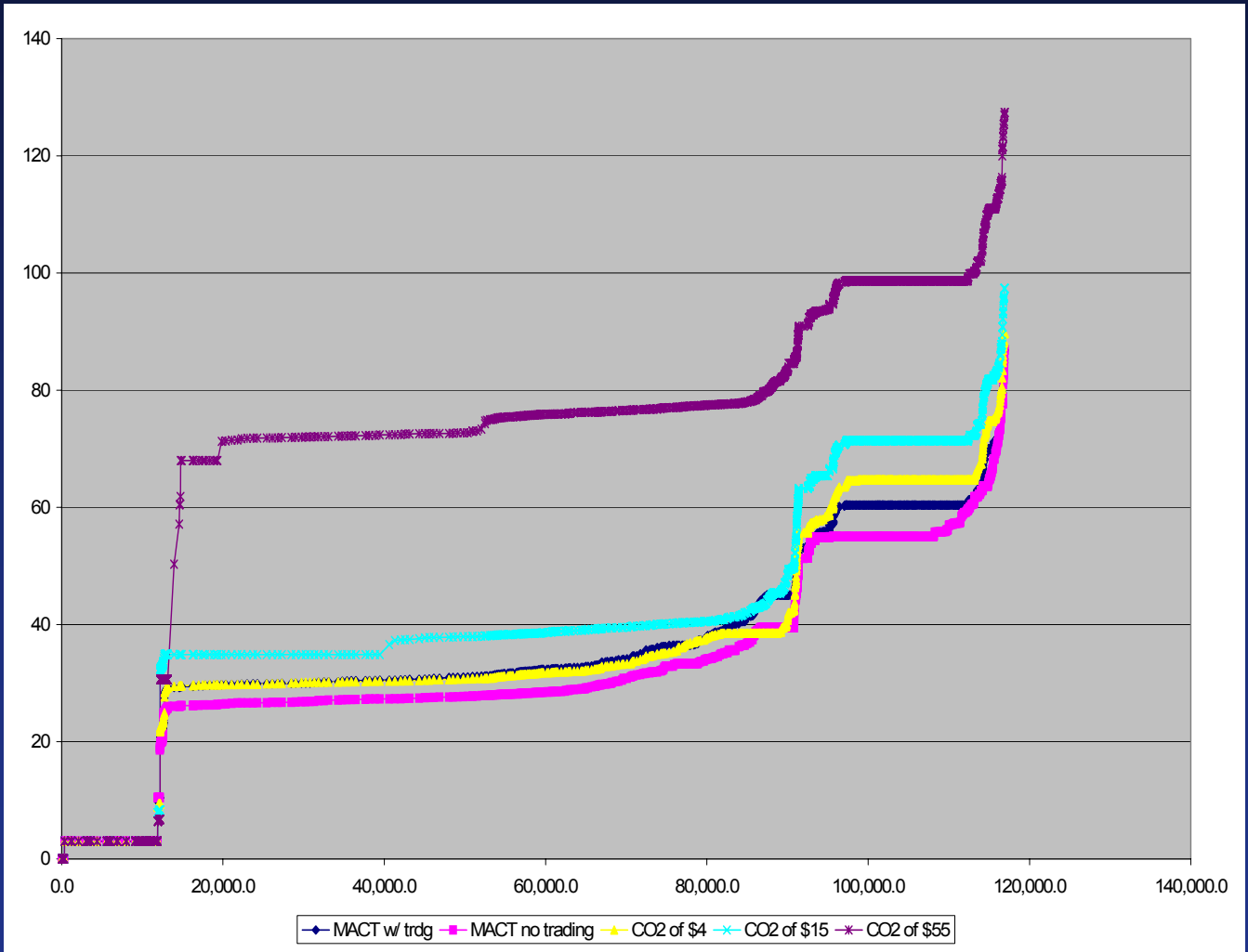


The Coal – Natural Gas – CO2 Linkage



- Model shows Natural Gas substitutes for Coal b.c. Natural Gas prices remain "low"
  - Will put greater pressure on build out of LNG terminals – but this exposes electricity consumers to risk of global energy market
- What if – N.G. is constrained? No LNG or strong demand internationally, esp is we assume a global climate regime.
  - If constrained, supply curve is at inflection point where slope is increasing – approaching vertical?
  - If so, additional demand will push price up until demand is destroyed in industrial and power sector
  - However, electricity sector will demand NG and push price up until additional NG units are not competitive with coal
  - Implies that coal's share of power gen will remain mostly unchanged, therefore reductions will not come from power gen as generally predicted, except in electricity consumption drop
  - Therefore, allowance prices will have to increase along w/NG prices
  - Pushing reductions to other sectors – prices will have to go high enough to begin influencing changes in industrial and transport emissions

Scenarios where gas supply/LNG not limitless – gas prices increase with higher CO2 as demand shifts to gas



In this world, gas supplies, while still depending on LNG, creep up with tighter CO2 caps.

Coal still enjoys cost spread with gas CT of about $20, while CC move ahead of coal in dispatch in extreme case.

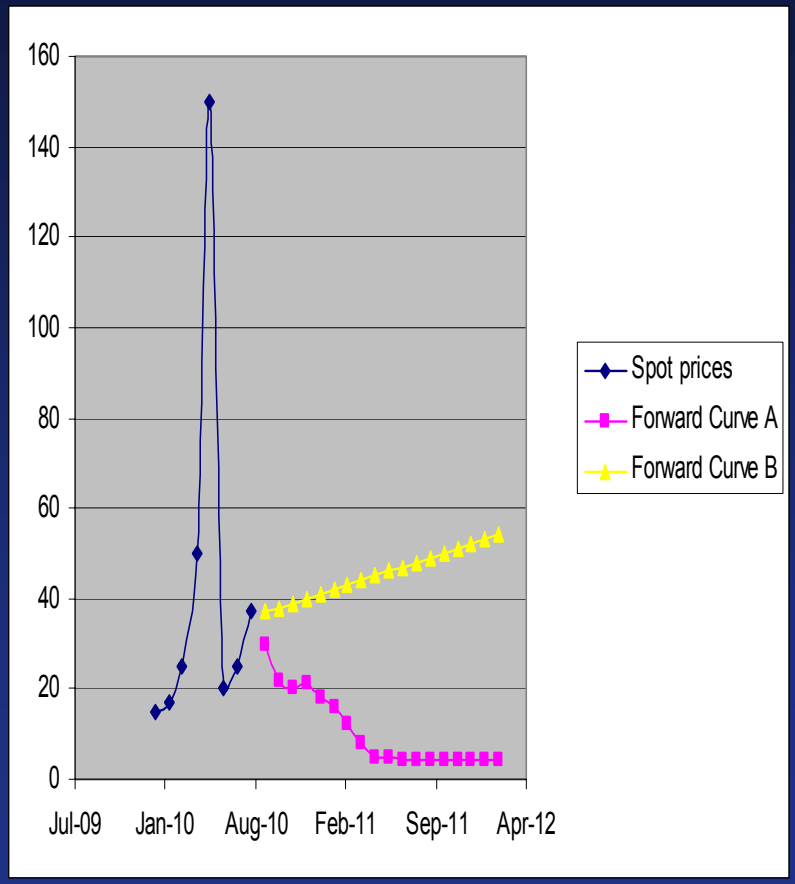
Base case, NG =$4.50 (long term est of LNG priced US mkt)

CO2 = $4, NG = $4.77
Col/NG spread = $35

CO2 = $15, NG = $5,
Col/NG spread = $30

CO2 = $55, NG = $6,
Col/NG spread = $25

Price spikes and unraveling
Not: "the solution to high prices is high prices"



- Presumes full auction, no allocations
- Spike causes 250+% price jump in electricity in coal states (allocations can help, pushing to transport & industrials)
  - 120% in 50% coal/industrial states
- $1.50/gallon gasoline price jump
- Can't happen? Nat gas constraints, hot weather & hot economy.
- History of RECLAIM, California, Midwest
- Some form of price limits in traders' interest

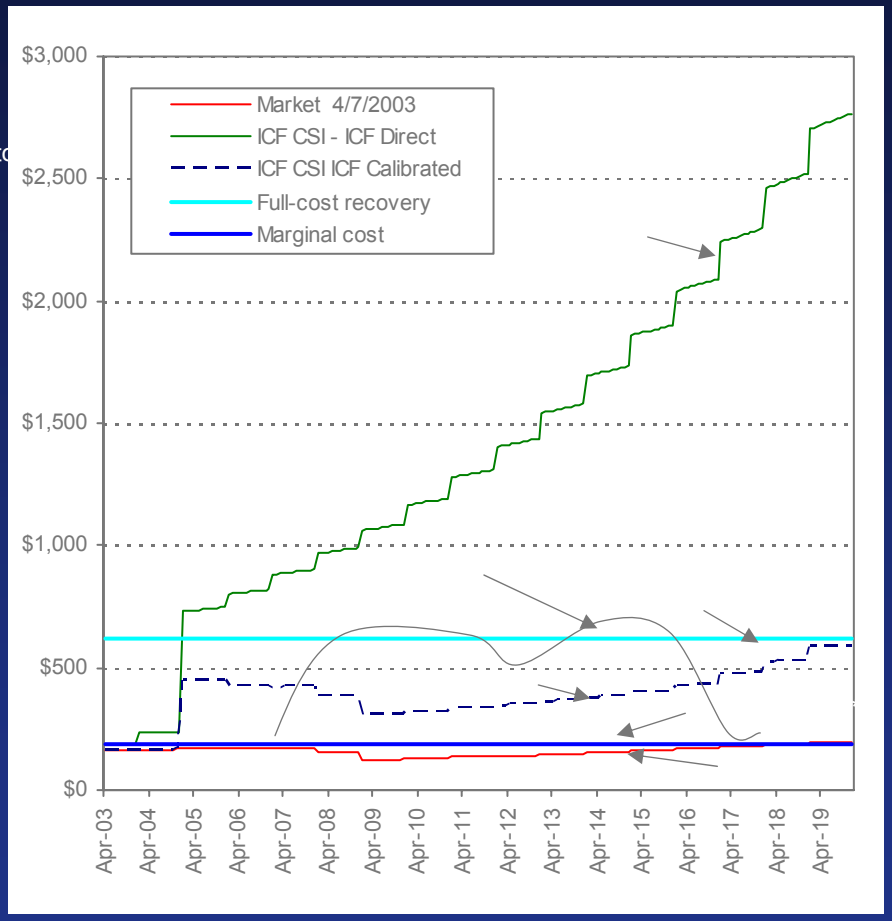
[EU-ETS & slow stop reverse prices]

Seeing the future

- Markets tend to be very near sighted
- Models can help, but not too good at anticipating games
- Blind spots
- Fun with NOx, SOx and Mercury

From June, 2003 internal Cinergy Presentation: Market prices for SO2 will likely oscillate between full-cost recovery and marginal cost of scrubbing – this is currently reflected in neither ICF nor market curves

ICF-CSI v. market price for coal, 2003-2019



* Full-cost recovery and marginal cost figures based on capital, fixed and variable costs for limestone forced oxidation applied to a 100 MW unit at 60% capacity factor

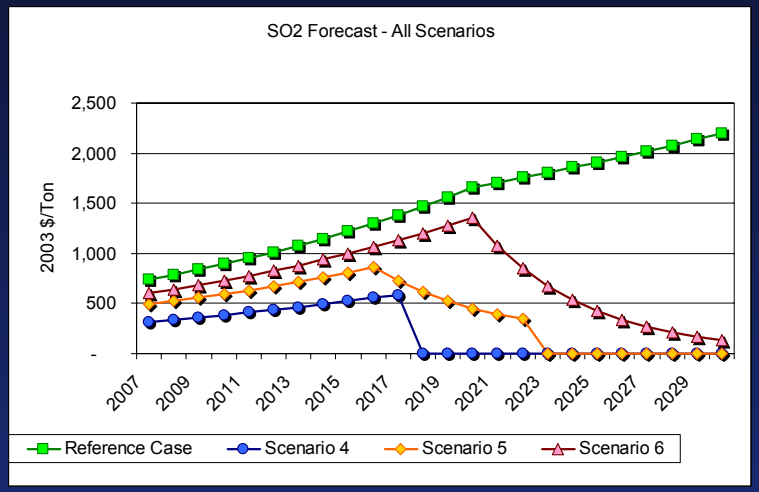
Discussion

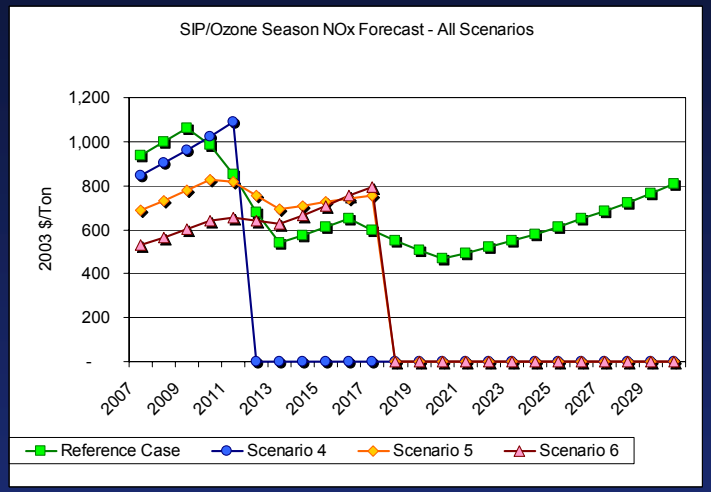
- We should expect SO2 prices to oscillate between full cost recovery and marginal cost of scrubbing
- The market should tighten around the imposition of constraints in 2011 and 2015 – this should drive prices above full cost recovery to encourage investment in scrubbers from 2007-2015
- Beyond 2015, SO2 prices should return to marginal cost of scrubbing

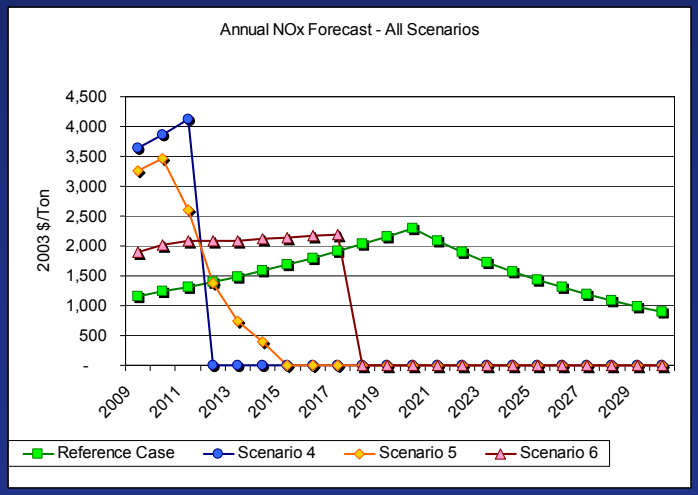
The Challenge:

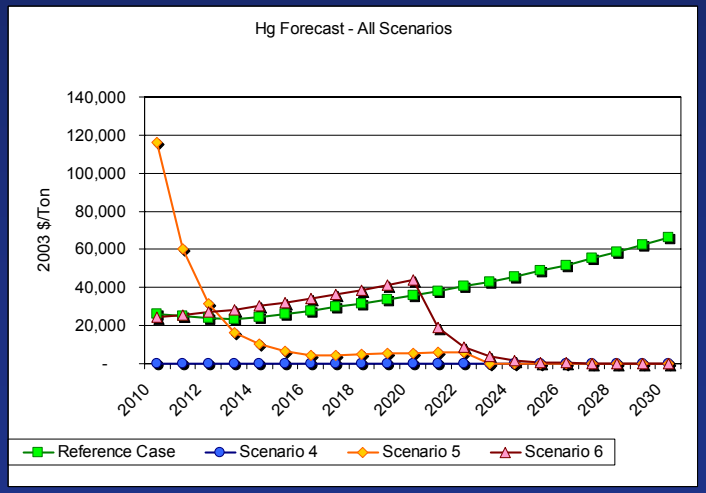
- While this dynamic might more closely reflect actual market price behavior, reflecting this dynamic in the SO2 price curve for the calibrated case will introduce inconsistencies with the other forward prices
- Any adjustments to SO2 prices must be fundamentally integrated into the full set of price curves

Prices for criteria pollutants fall away with CO2
Reflects retirement of smaller non-controlled units
(2006 model runs)









False premise

"Technologies that might be employed to render coal more environmentally benign, such as IGCC and carbon sequestration are either not economic without subsides or are technologically unproven."

- Q: Economic relative to what or under what conditions?
  - Certainly true if CO2 price = 0
- With a carbon constraint? -- $25 to $40/ton CO2
  - Bingaman's bonus allowances
- What timeframe?
- Have to decide now? Will uncertainty resolve?

Delay options for base load investments

- Stall, yet invest in capacity
  - No base load – build combined cycle or CTs
  - Capacity risk much worse than fuel price risks – Midwest 98/99 experience and California
- Go half way
  - Build likely CCS candidate without the CCS hardware
  - Drill some holes – ensure good geology nearby
- Stall with increased Energy Efficiency Investment

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To be cost effective, environmentally effective and fair i.e., Maybe not your typical compliance mandate

- Things a policy shouldn't include
  - No point source mandates
  - No facility or company specific targets
  - No sectoral targets (electricity, transport, cement, etc.)
  - Wide use of performance or efficiency standards

- Policy should include
  - Emissions cap for the entire economy
  - Fewest regulated entities possible (fuel producers)
  - Offset opportunities (non-regulated gasses or emission sources – methane, SF6, NO2, etc.)
  - Allocations to compensate negatively impacted firms, sectors, regions
  - Support for large scale technology demonstrations so that they're ready when needed -- Carbon Capture and Sequestration is critical

Duke Energy Climate Principles and Policy Positions

Environmentally effective, cost effective and fair

Is economy-wide in its reach, rather than targeting a single industry or sector for emission reductions

- Covers the entire economy's carbon emissions including transportation, electric sector and other emitting sources with a single CO2 cap, resulting in a single CO2 market price
- Point of regulation should be "upstream" at or close to where fossil fuels enter the economy (e.g. on oil refineries for motor vehicles – with the coal exception)

Is national in scope, yet considers varying impacts across regions and economic sectors

- Should be federal policy, not state / regional patchwork - more economically efficient way to respond to the issue
- Appropriate allowance allocation is given to entities that incur a disproportional amount of economic harm from the program
- Regulated electric utility will lower price impact on consumer in hardest hit regions
- Allowance allocation should be based on recent historical emissions or heat input ("input" basis)

Is market-based, with price signals leading to technological innovation and investment, energy efficiency and conservation

- Support a "cap and trade" program that incents new technology development and allocates the majority of the emission allowances for free
- Special programs to "jump start" deployment of large projects in preparation for full roll-out

Begins to reduce greenhouse gas emissions, now, and does so gradually over time

- Support a "slow, stop, reduce" emissions trajectory
- Phase in over multiple decades with increasingly more stringent caps

Is simple to administer and provides price certainty

- Emission allowance price caps should be used during the initial compliance phase to mitigate unintended economic consequences and prevent price shocks

Resources for Further Information

Duke Energy
www.duke-energy.com/environment/climate-change.asp

EEI's Climate Change Principles
www.eei.org/industry_issues/environment/climate/070208_climate_principles.pdf

IPCC's 4th Assessment Report
http://www.ipcc.ch/SPM2feb07.pdf

American Institute of Physics History of Climate Science
http://www.aip.org/history/climate/

Resources for the Future for Environmental Economic Analysis
http://www.rff.org/Climate.cfm

EPRI for general economics on climate
http://my.epri.com/portal/server.pt?space=CommunityPage&cached=true&parentname=CommunityPage&parentid=0&in_hi_userid=2&control=SetCommunity&CommunityID=205&PageID=225

U.S. Climate Action Partnership
http://www.us-cap.org/