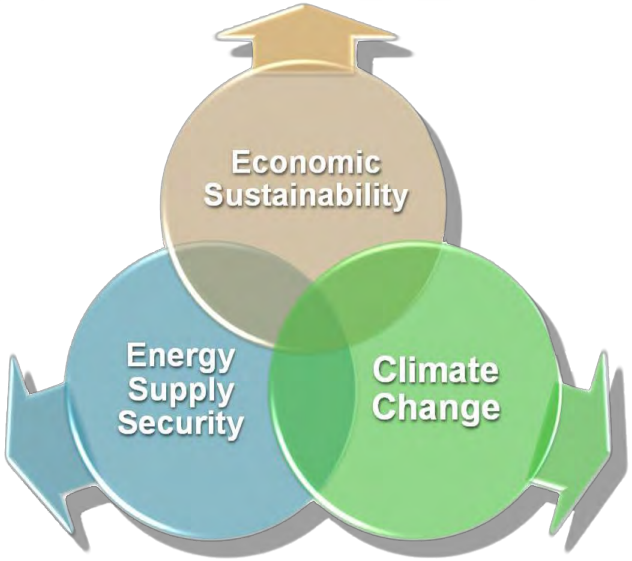
NATIONAL ENERGY TECHNOLOGY LABORATORY



Carbon Capture and Sequestration: Challenges and Costs for Coal

2009 WV Energy Summit: WV's Commitment to Energy Security

Stonewall Resort – Roanoke, WV

December 8, 2009

John Wimer

Director, Systems Division

Carbon Capture and Sequestration (CCS)

An Unprecedented Challenge

Doable Today, but Costly

R&D will Reduce Costs

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GHG Endangerment Finding
December 7, 2009

Today, I'm proud to announce that EPA has finalized its endangerment finding on greenhouse gas pollution, and is now authorized and obligated to take reasonable efforts to reduce greenhouse pollutants under the Clean Air Act.

Administrator Lisa P. Jackson,
Remarks on the Endangerment Finding on Greenhouse Gases,
As Prepared *12/07/2009*

Waxman-Markey (HR 2454)
Unprecedented Environmental Challenge

- **Passed House 6-26-09, awaiting Senate action**

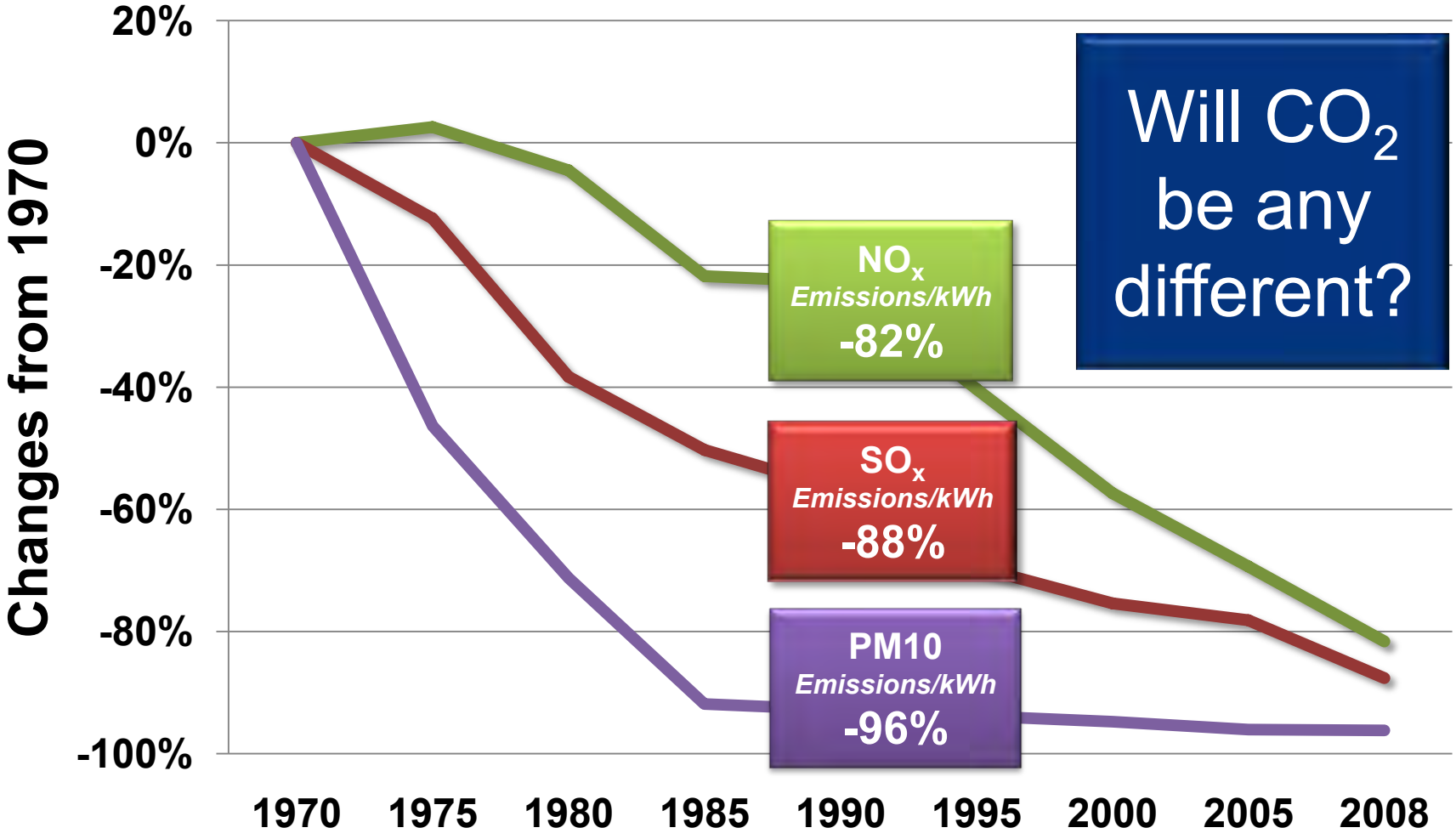
- **Section 703 caps 2050 GHG emissions at 17% of 2005 levels**
  - an 83% reduction (reiterated in 11/25/09 pre-Copenhagen White house press release)
  - CCS is essential for meeting cap

- **Section 116 would amend the Clean Air Act to apply Performance Standards to <u>New Coal Plants</u> (and only to coal)**
  - **EXEMPT** – if permitted before Jan-2009
    - but must still acquire emission allowances
  - **50% REDUCTION**
  - **65% REDUCTION**
  - **BEST ACHIEVABLE** – no later than 2025

~ 1,100 lb/MWh

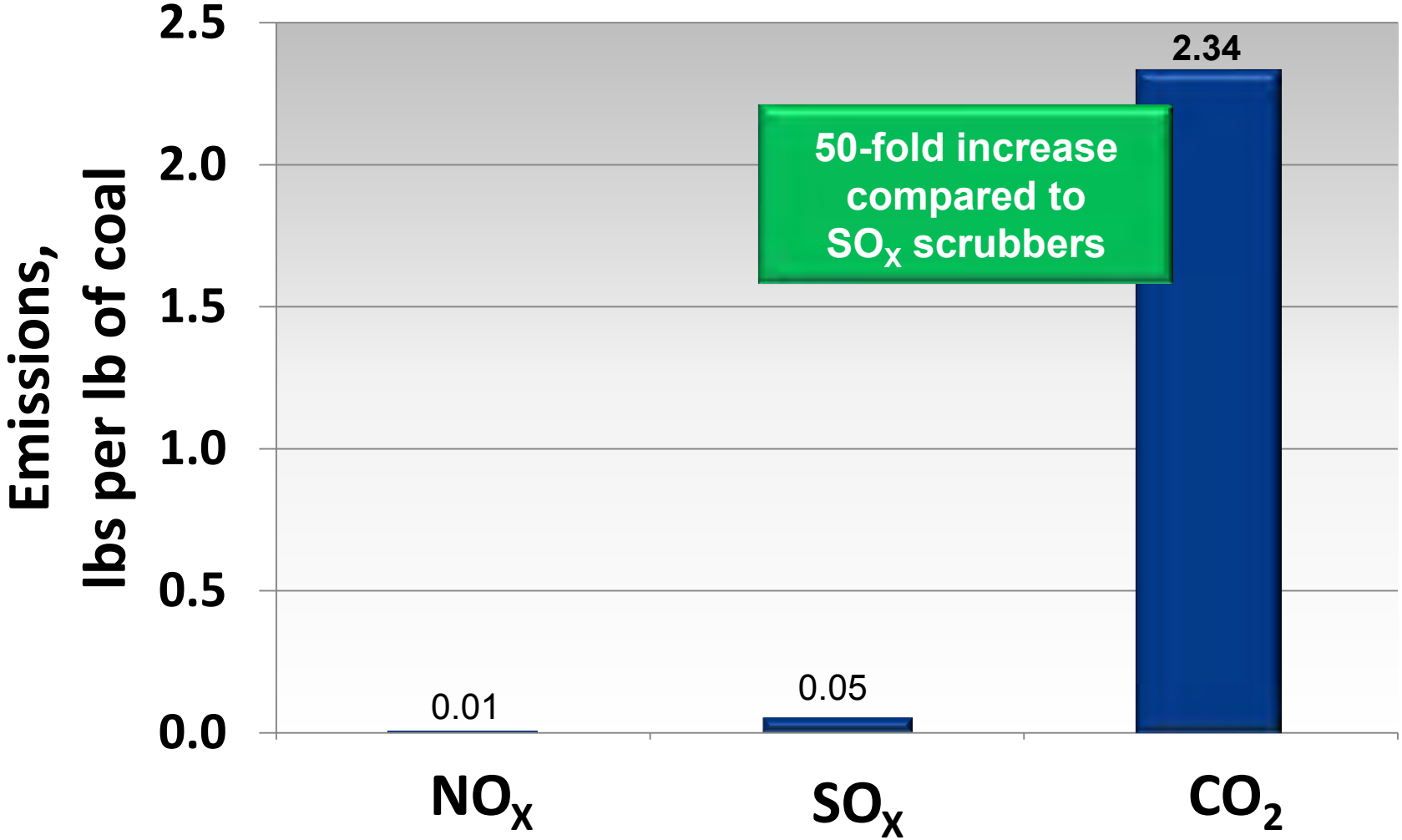
~ equal to least efficient existing NGCC

Coal Has Dealt with Previous Environmental Challenges

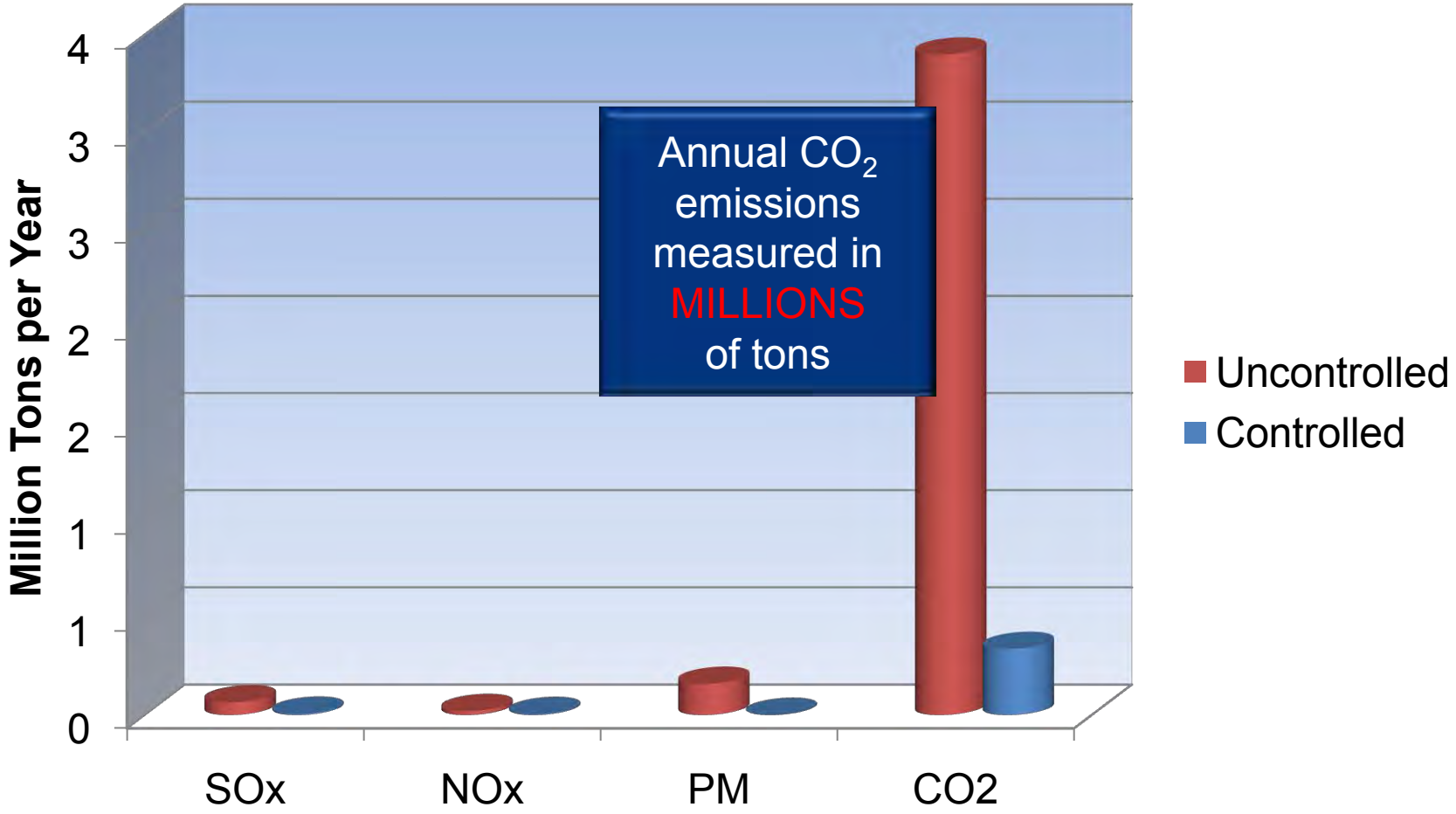


Sources: EPA National Air Pollutant Emission Trends
EIA Annual Energy Review

Pound per Pound, CO_2 Control is Unprecedented in Magnitude



Annual Emissions from a Typical 500-MW Coal Plant



Source: Steam 40th Edition, Babcock & Wilcox 1992, page 32-2

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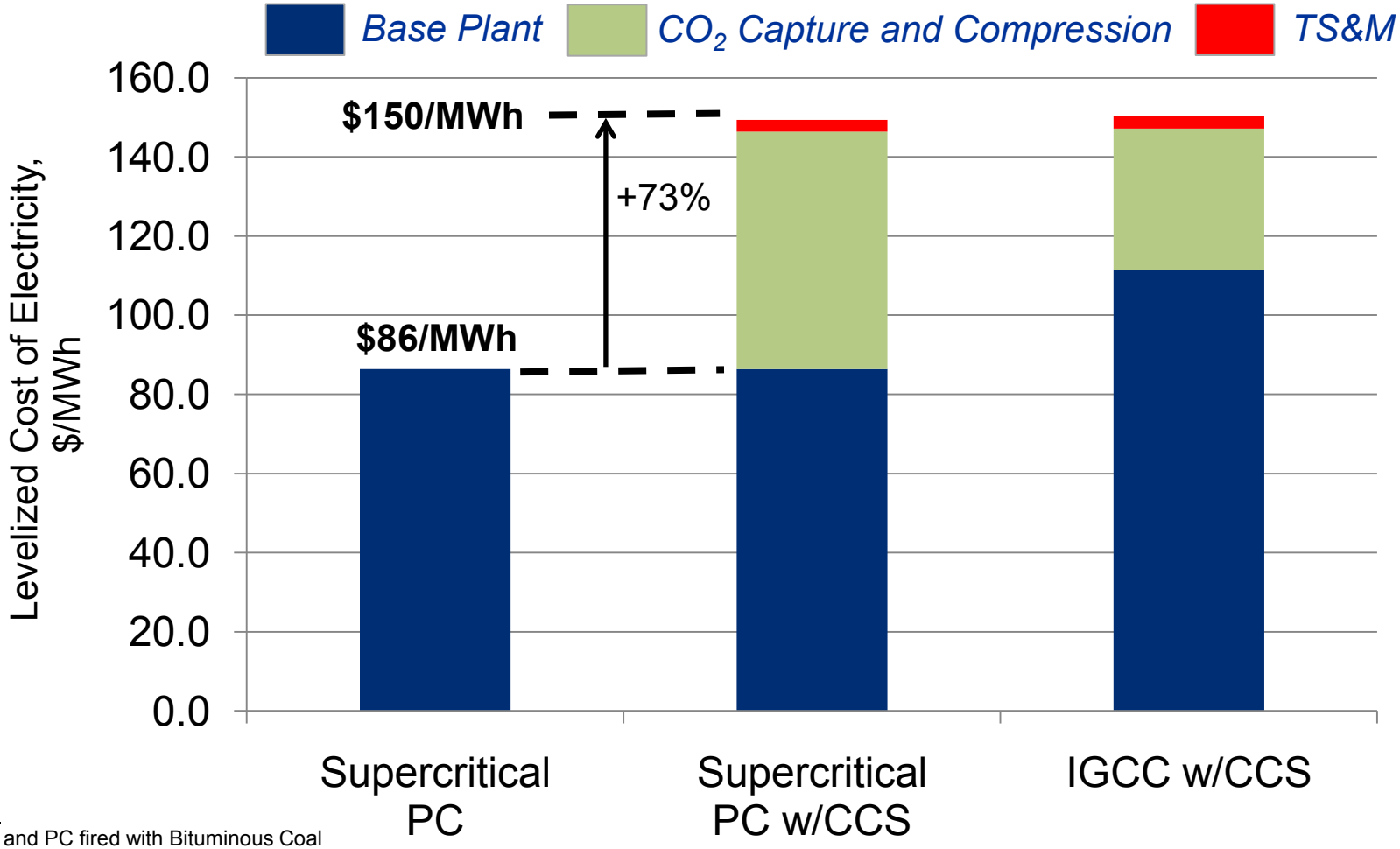
New Coal Plants, Current Technology: CCS Adds over 70% to Electricity Cost

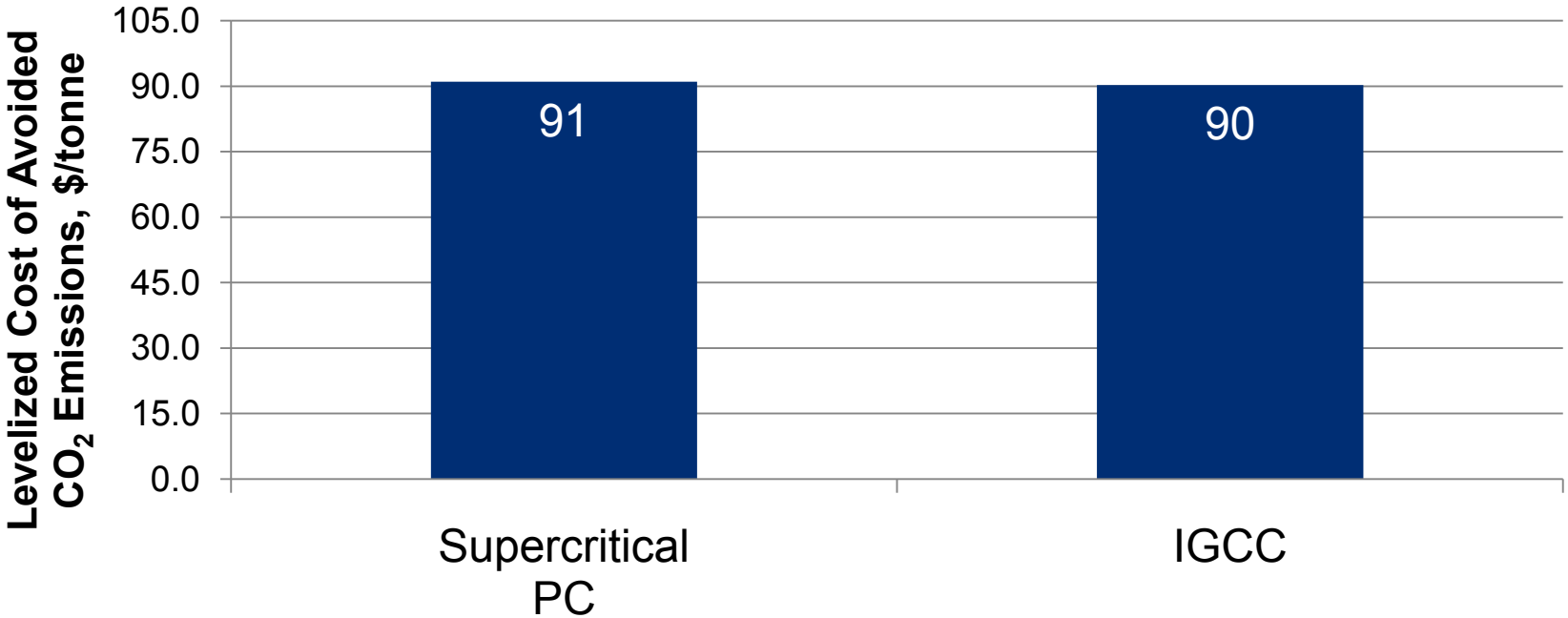


Notes
IGCC and PC fired with Bituminous Coal
CF for IGCC = 80%, PC = 85%
30-Year, Current -Dollar Levelilized Cost of Electricity

Draft Final Results – Subject to Revision

Cost of Avoiding CO_2 Emissions in New Coal Plants

Compared to Supercritical PC without Capture



- **If the cost to emit CO_2 is…**
  - < $90/tonne, cheaper to pay for emissions
  - > $90/tonne, cheaper to avoid emissions with CCS
  - (somewhat simplified)

Notes: IGCC and PC fired with Bituminous Coal
CF for IGCC = 80%, PC/NGCC = 85%

Draft Final Results – Subject to Revision

An Unprecedented Cost for New Coal Plants

- **Relating cost of avoiding CO_2 to the coal cost:**

$$2.34 \frac{\text{tonne } CO_2 \text{ produced}}{\text{tonne coal}} \times 0.6 \frac{\text{avoided tonne } CO_2}{\text{tonne } CO_2 \text{ produced}} \times 90 \frac{\$}{\text{avoided tonne } CO_2} = 126 \frac{\$}{\text{tonne coal}}$$

Levelized cost of avoiding CO_2 is $126 per tonne of coal.

2.5 to 4 times coal cost of ~$30-50/tonne.

Eliminates coal's cost advantage?

The 0.6 factor is based on capturing 90% of produced CO_2 and reflects efficiency reduction inherent with CCS.

CO_2 Emissions Cost

- **Under a simple, across-the-board, CO_2 emission cost…**
  - Power plants would add CCS only if the CO_2 emission cost approached $90/tonne (their cost of avoiding CO_2)

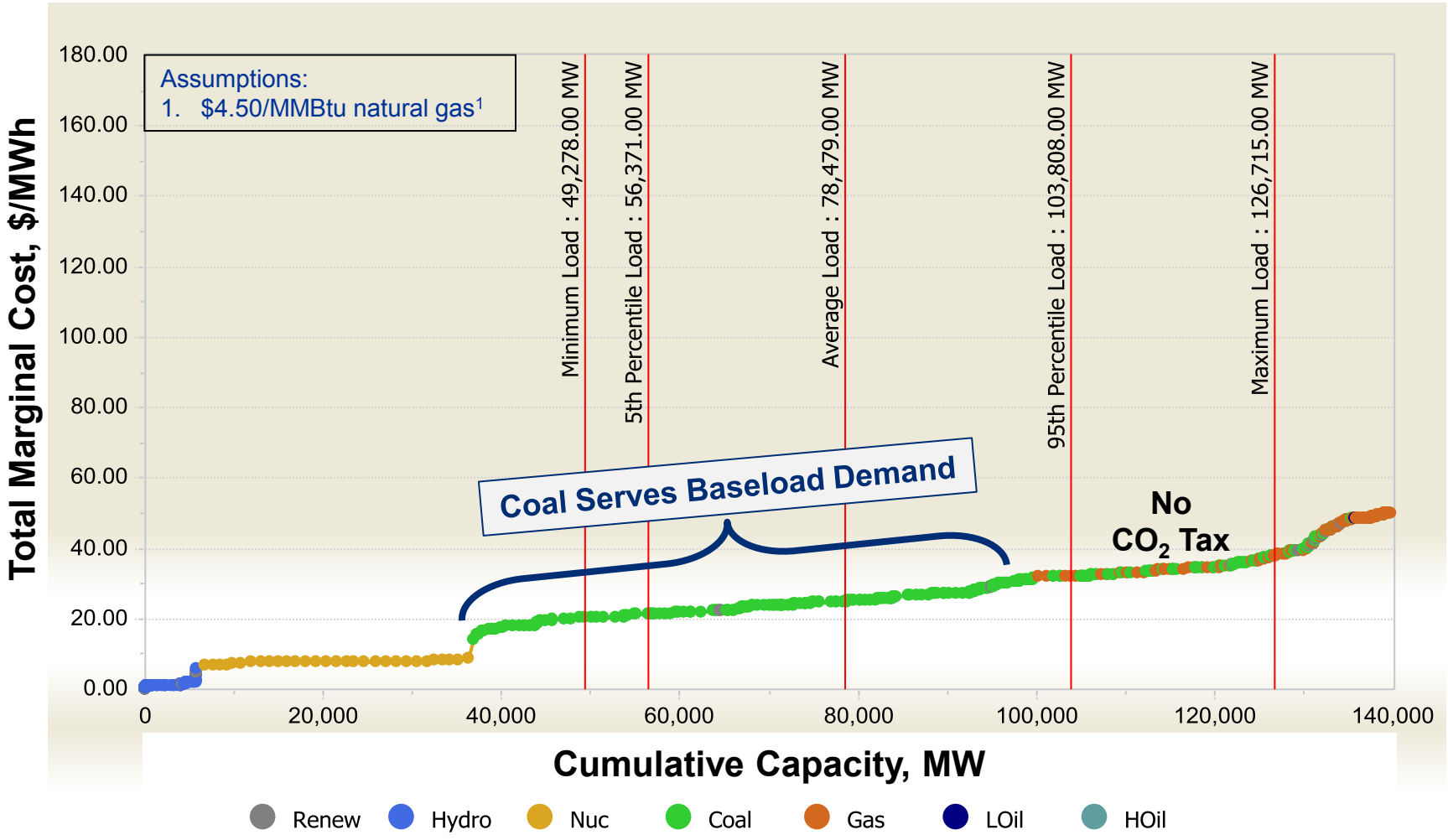
- **If a ~$90/tonne CO_2 cost is unacceptable, will a "price collar" be applied?**
  - "price collar" being debated for proposed Kerry-Boxer Senate bill (~$30/tonne limit?)
  - if so, new plants will not include CCS, unless…

- **Congress <u>mandates</u> CCS for new coal (a la W-M)?**
  - would equate to a targeted $86/tonne cost for new coal compared to $30/tonne for other plants

What would be the effect of a $90/tonne CO_2 emissions cost?

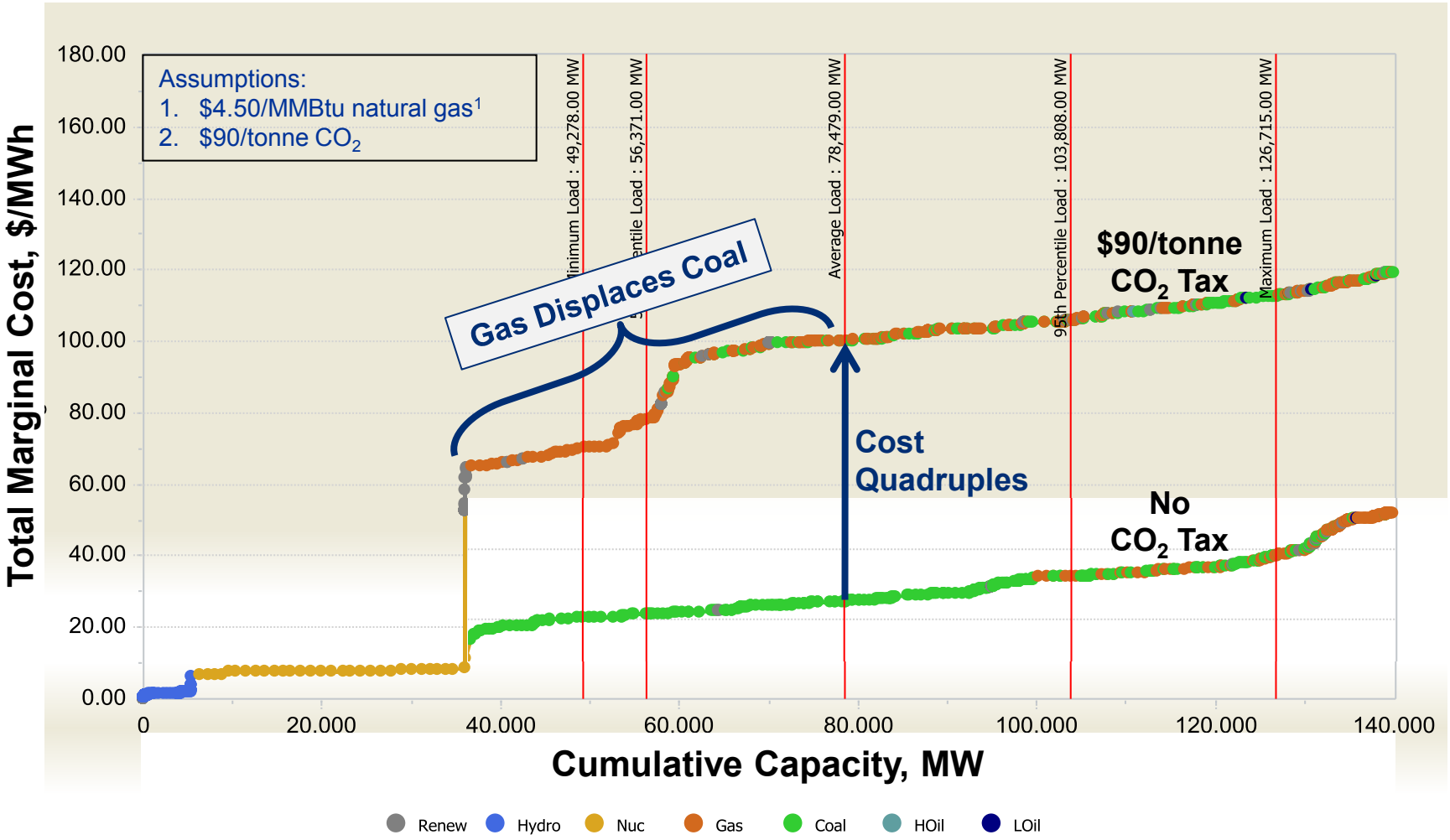
(tax or traded allowance)

PJM – Current Conditions (November 09)



1. *Representative of delivered gas price paid by utilities (summer 2009, http://tonto.eia.doe.gov/dnav/ng/ng_pri_sum_dcu_nus_m.htm)*

PJM with CO_2 Emissions Cost



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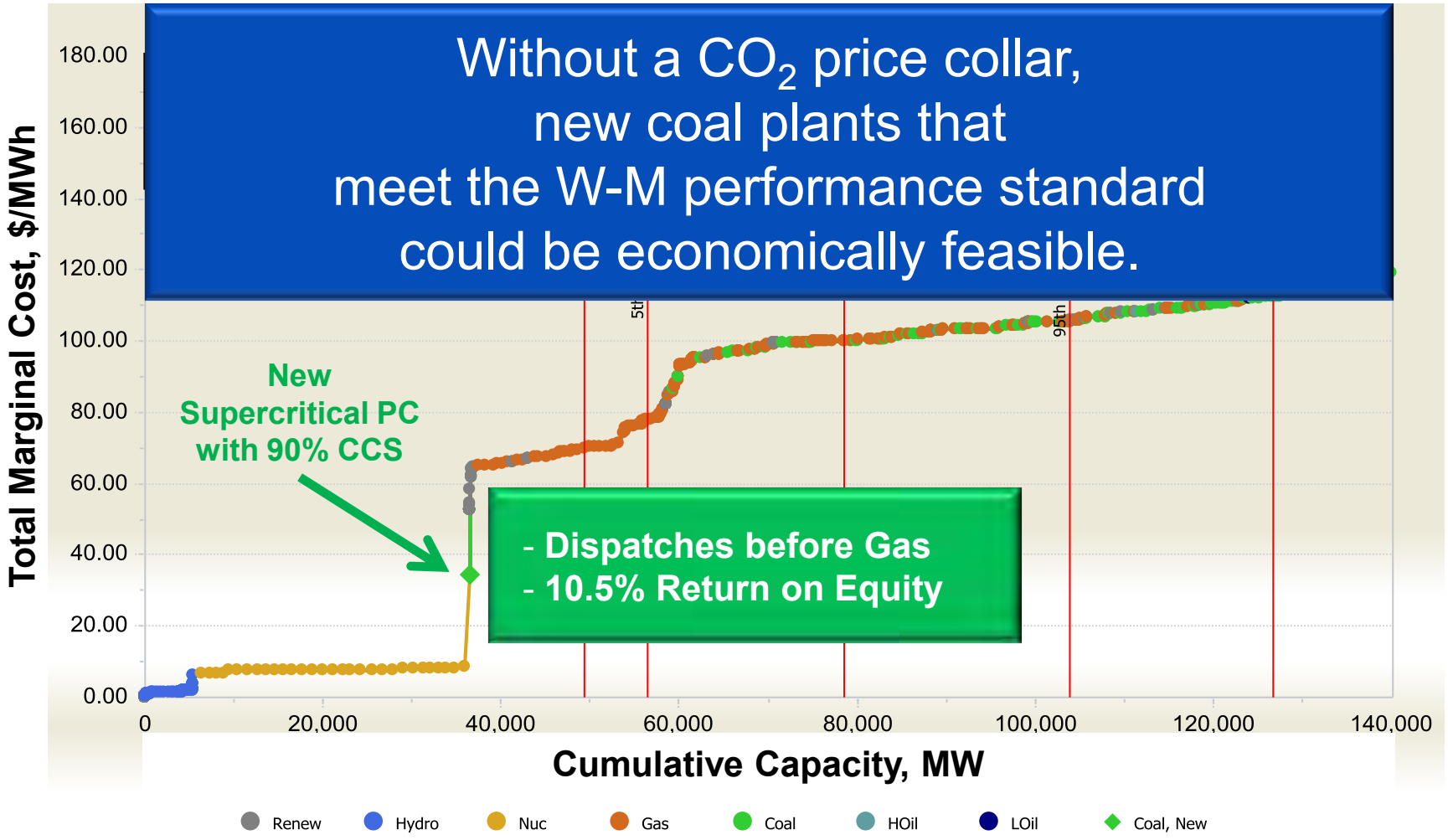
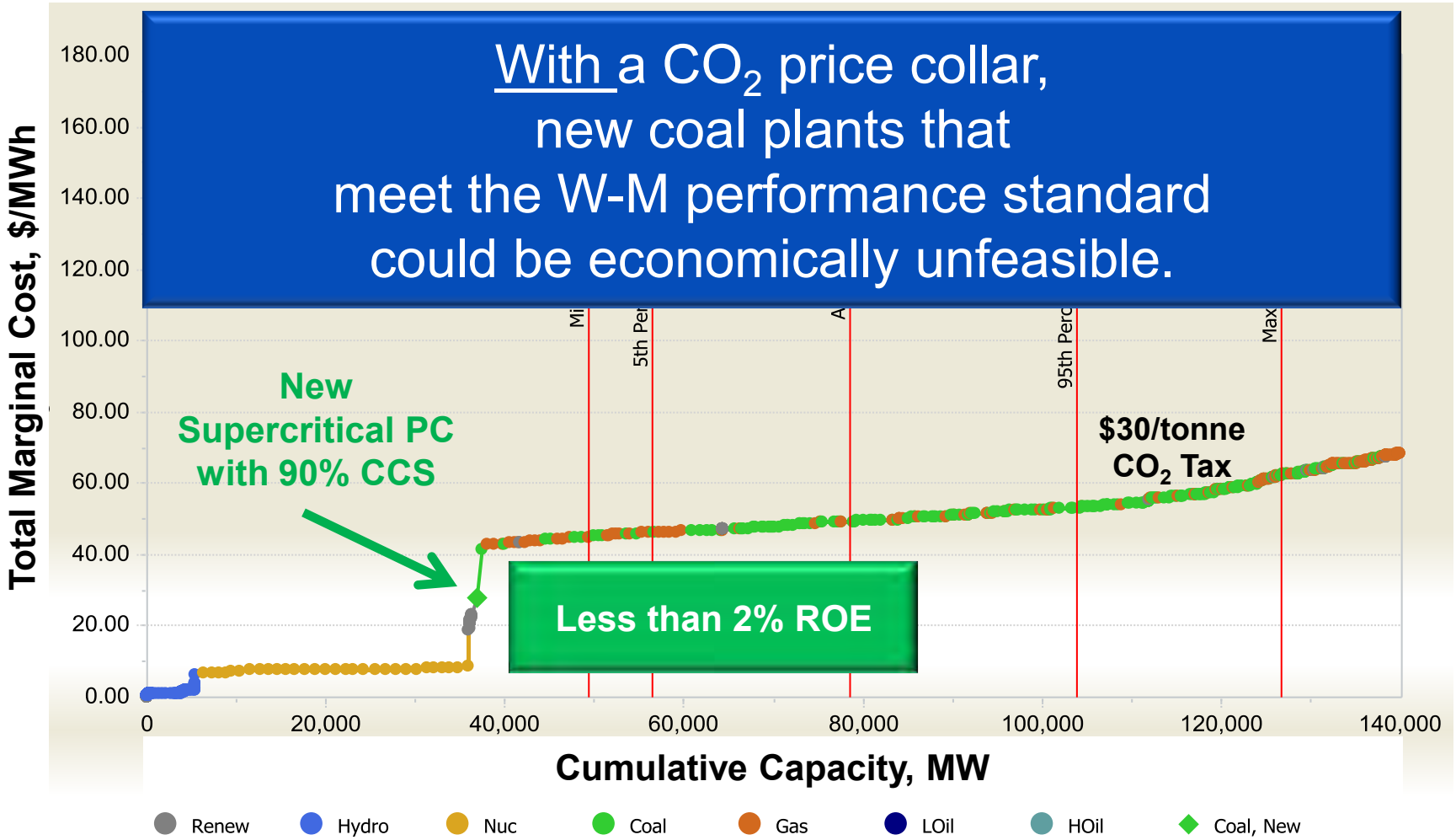
PJM with CO_2 Emissions Cost and Coal Performance Standard



1. *Representative of delivered gas price paid by utilities (summer 2009, http://tonto.eia.doe.gov/dnav/ng/ng_pri_sum_dcu_nus_m.htm)*
2. *http://www.ferc.gov/market-oversight/mkt-electric/pjm/elec-pjm-rto-cap-pr.pdf*

PJM with CO_2 Emissions Cost, Coal Perf. Standard AND a Price Collar



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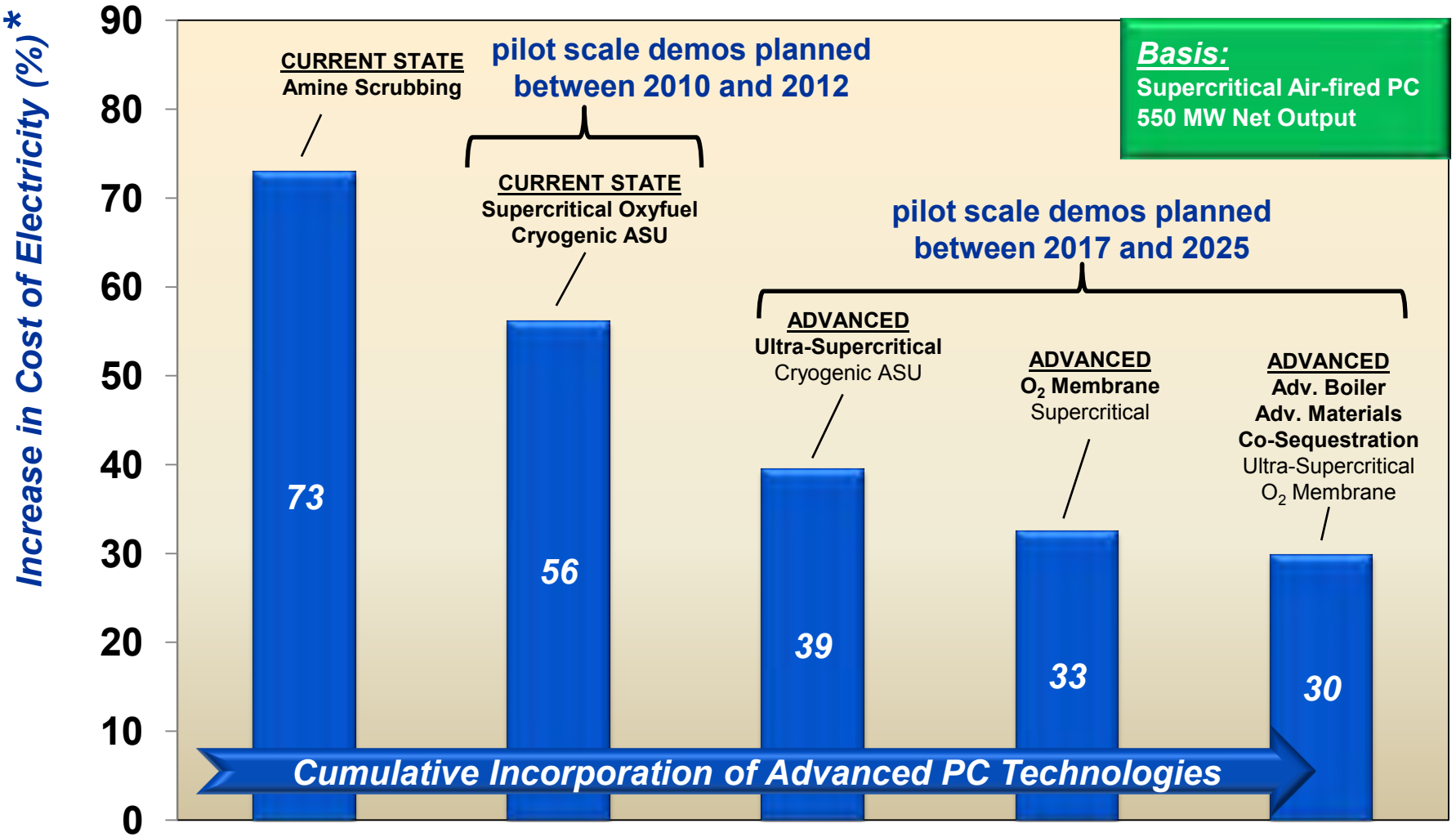
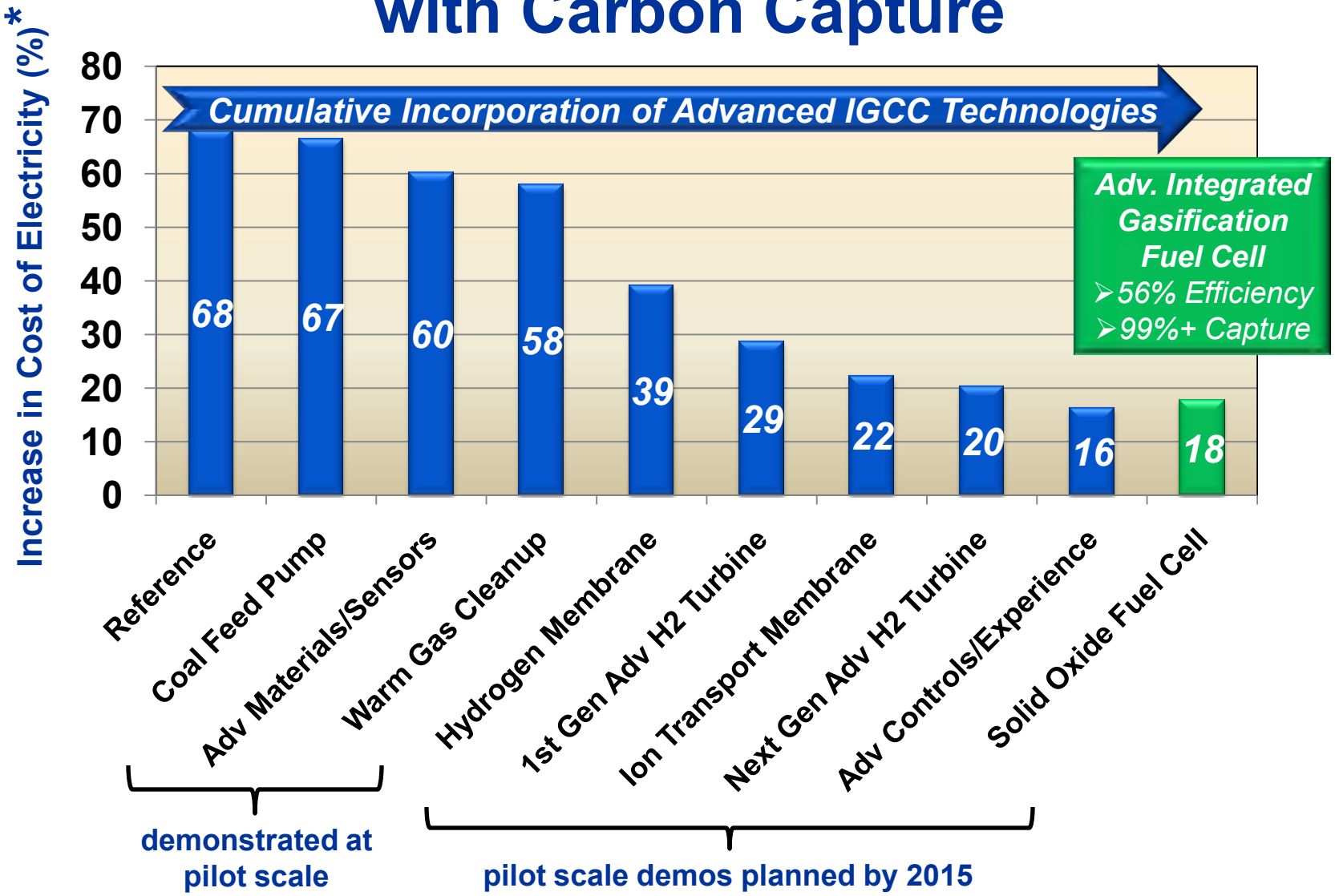
R&D will Reduce Cost of CCS for Coal Combustion



* *Relative to a Greenfield Supercritical Pulverized Coal Plant Without Carbon Capture*

Reference: Pulverized Coal Oxycombustion Power Plants, U.S. Department of Energy/National Energy Technology Laboratory, Final Report, August 2008

Advanced Technologies Pathway for IGCC with Carbon Capture



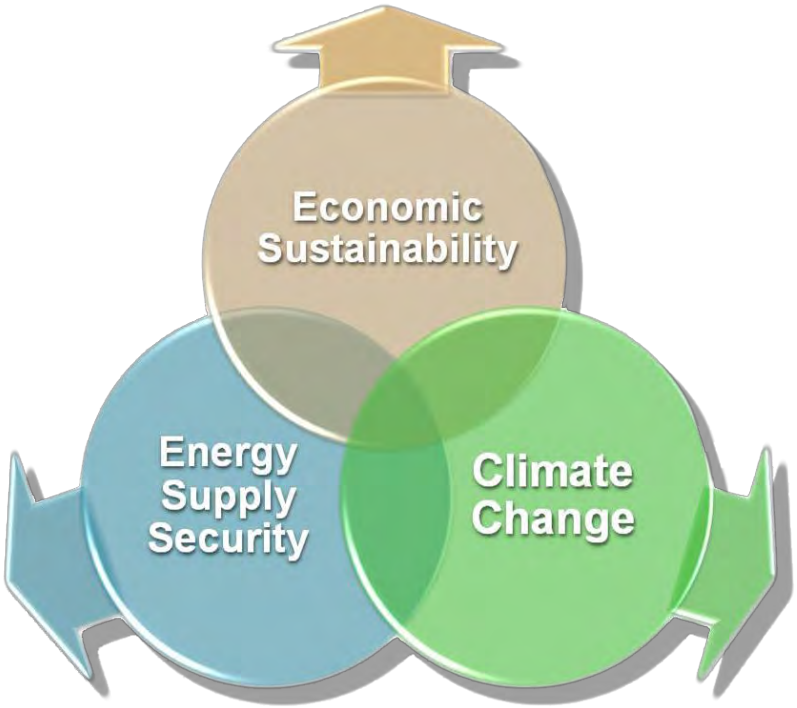
* *Relative to a Greenfield Supercritical Pulverized Coal Plant Without Carbon Capture*

Conclusions

- **CCS is an unprecedented challenge for coal**
  - CCS needed to meet W-M's 83% reduction by 2050
  - 50-fold increase compared to sulfur scrubbers

- **CCS is doable today, but costly**
  - Adds 70% to cost of electricity from new coal plants
  - CO_2 emission cost approaching $90/tonne needed to justify CCS
  - $90/tonne CO_2 emission cost could quadruple PJM electricity cost
  - Double regulatory burden for coal?
    - Performance Standard AND CO_2 Price Collar
    - Could make new coal plants unacceptable to developers
    - Could disproportionately impact economies of coal-reliant states

- **R&D will reduce costs**
  - 16% to 30% adder for CCS instead of 70% adder



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