NATIONAL ENERGY TECHNOLOGY LABORATORY

An Update of Proposed CO_2 Regulations for Coal- and Gas-Fired Power Plants

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14th Annual SECA Workshop

July 23, 2013

U.S. DEPARTMENT OF ENERGY

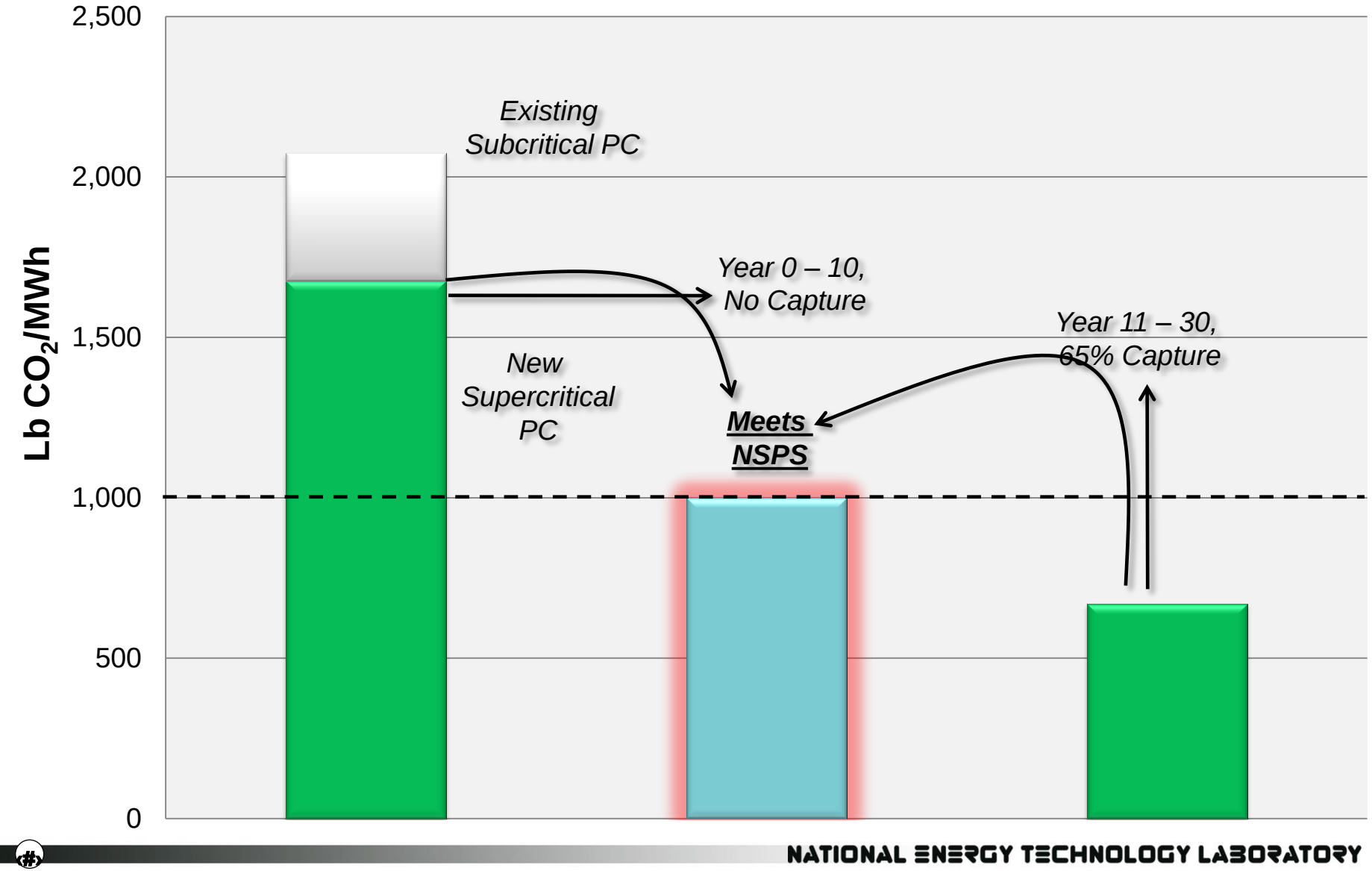
Summary of EPA Greenhouse Gas New Source Performance Standard*

- **All new generation must meet an emission standard of 1,000 Lb CO_2/MWh**
  - Uncontrolled coal ~ 1,675 Lb CO_2/MWh

* http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2011-0660-0001

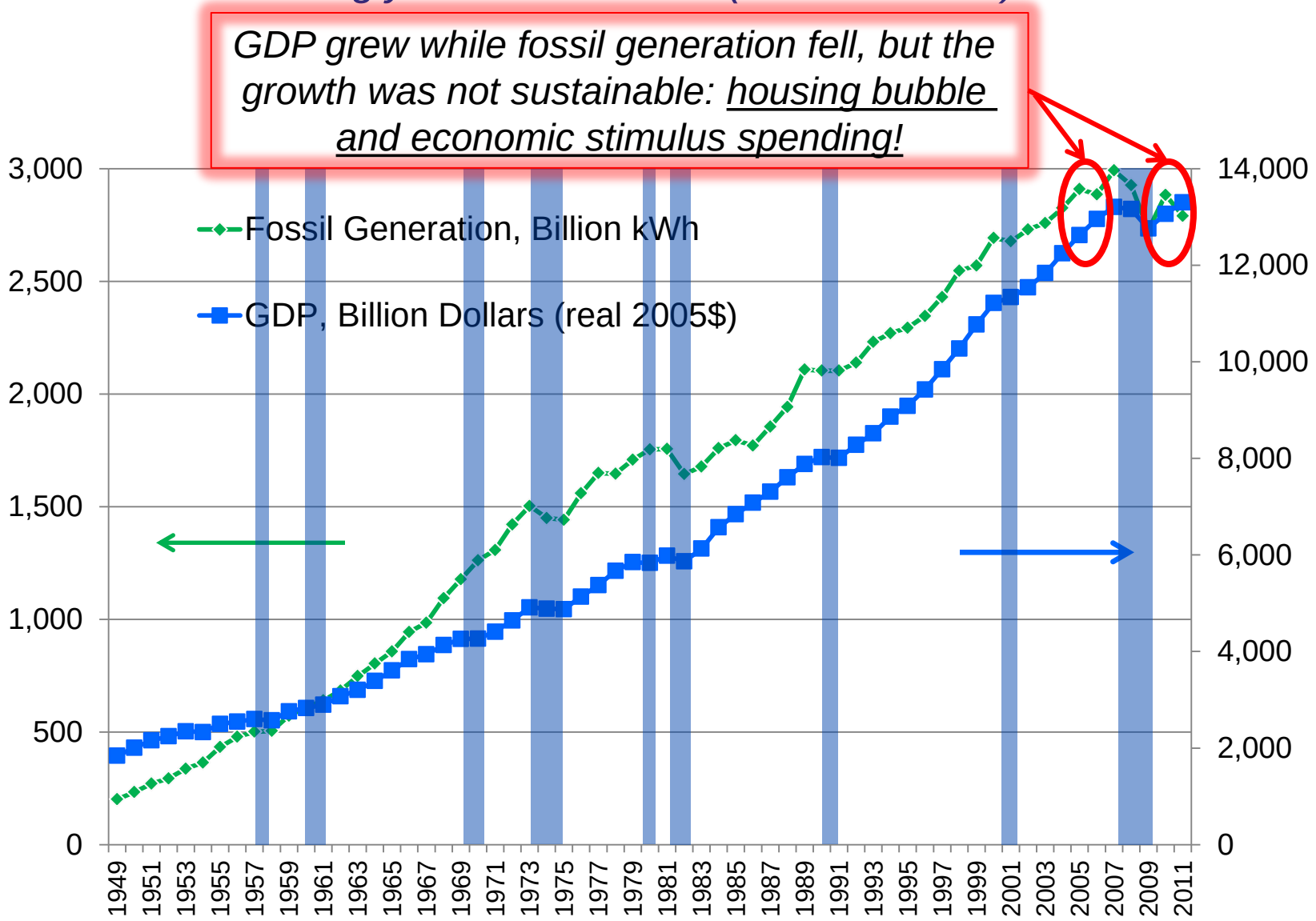
Greenhouse Gas New Source Performance Standard

NSPS is a formidable challenge for coal to remain in the energy mix…



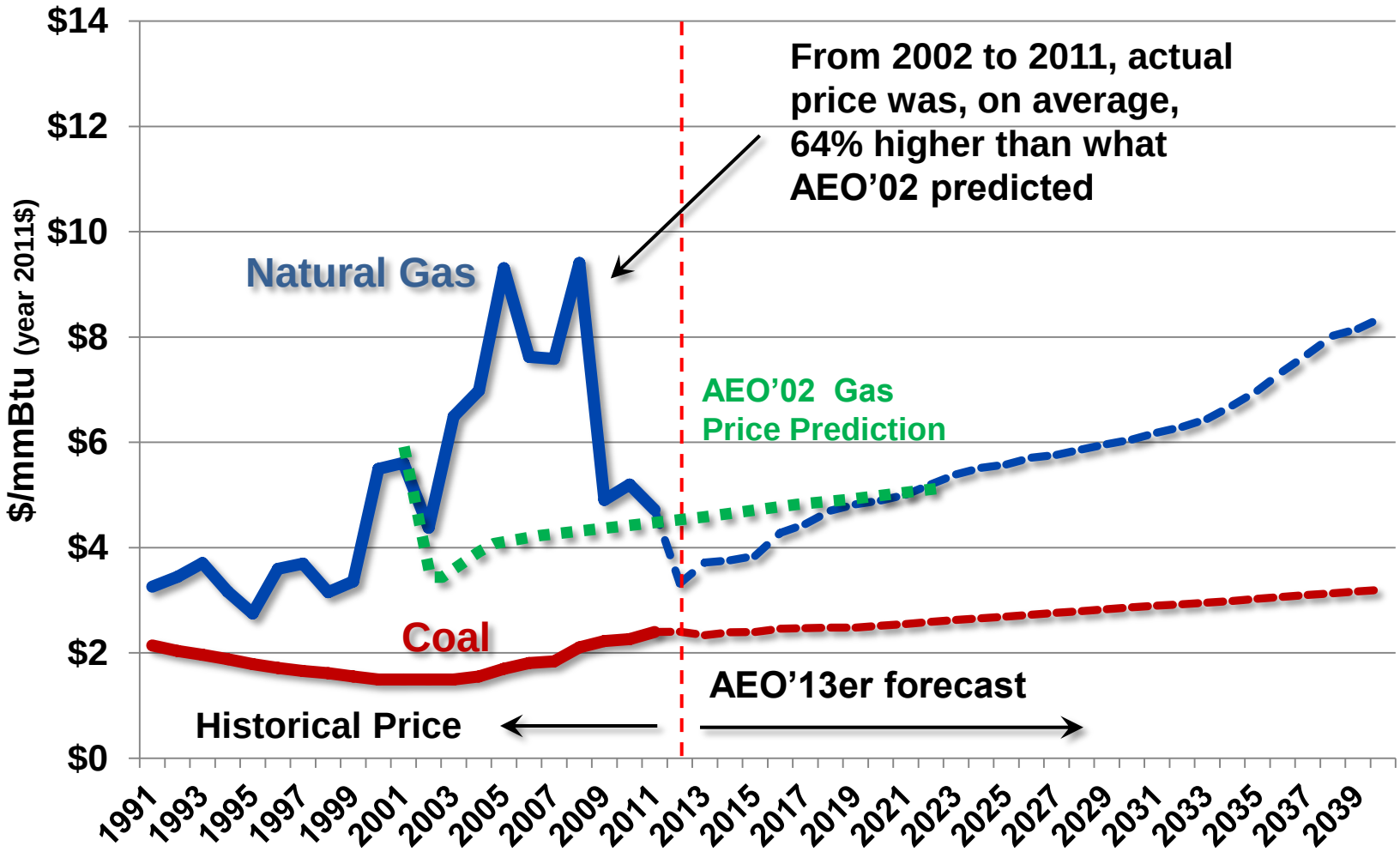
Energy Consumption and U.S. GDP: 1949 - 2011

U.S. GDP Strongly Linked to Fossil (Coal and Gas) Generation



Sources: EIA, Annual Energy Review; BEA: NIPA Table 1.1.6

Coal and Natural Gas Price History and Forecasts

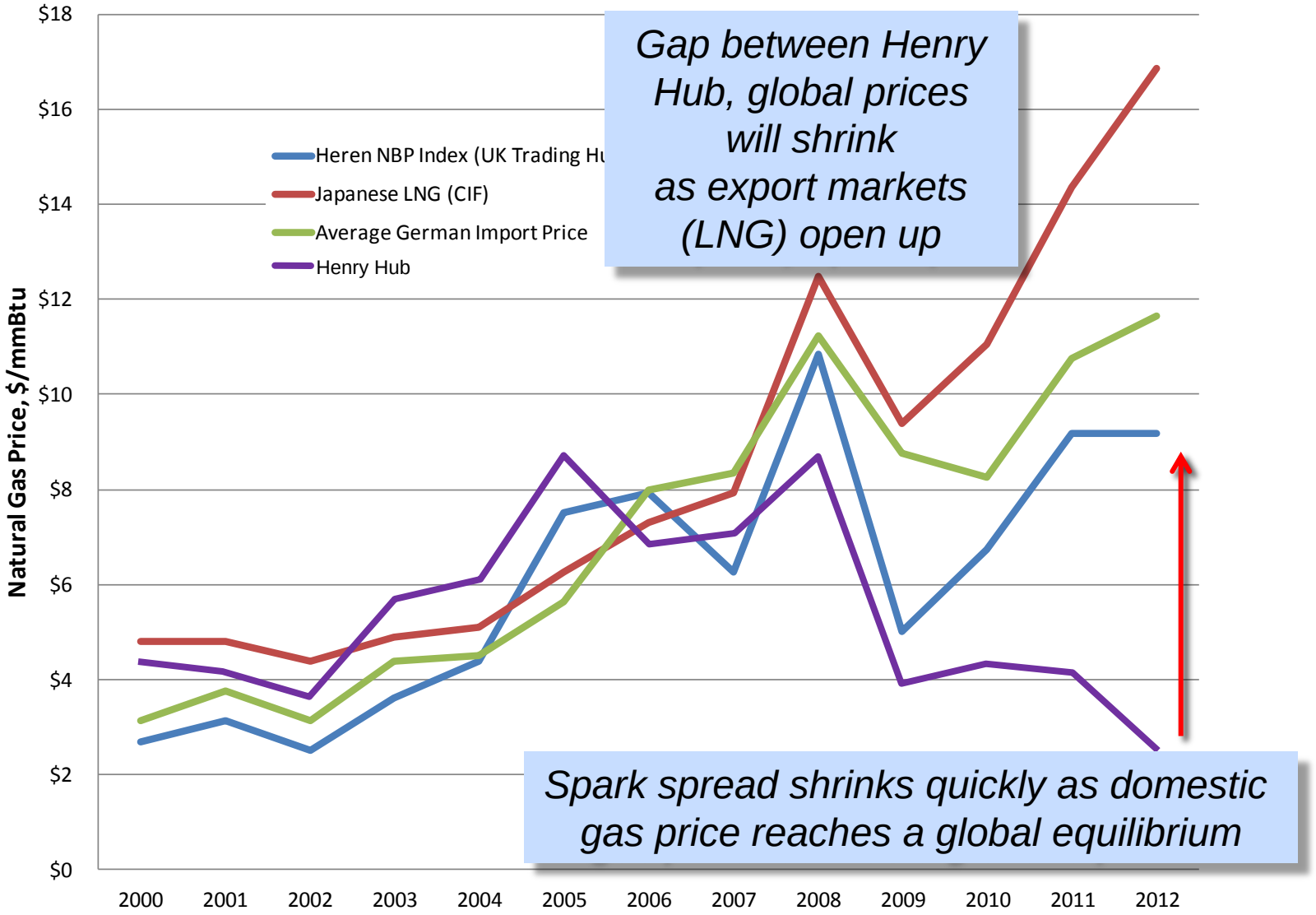


Sources: EIA, Electric Power Monthly, Table 4.1; AEO 2013er; AEO 2002

**Electric Power Sector prices*

Global Natural Gas Price Comparison*

What is the likelihood that natural gas prices will remain at historic lows?



*"*An Unconventional Bonanza – Special Report, Natural Gas*," The Economist, July 14-20, 2012

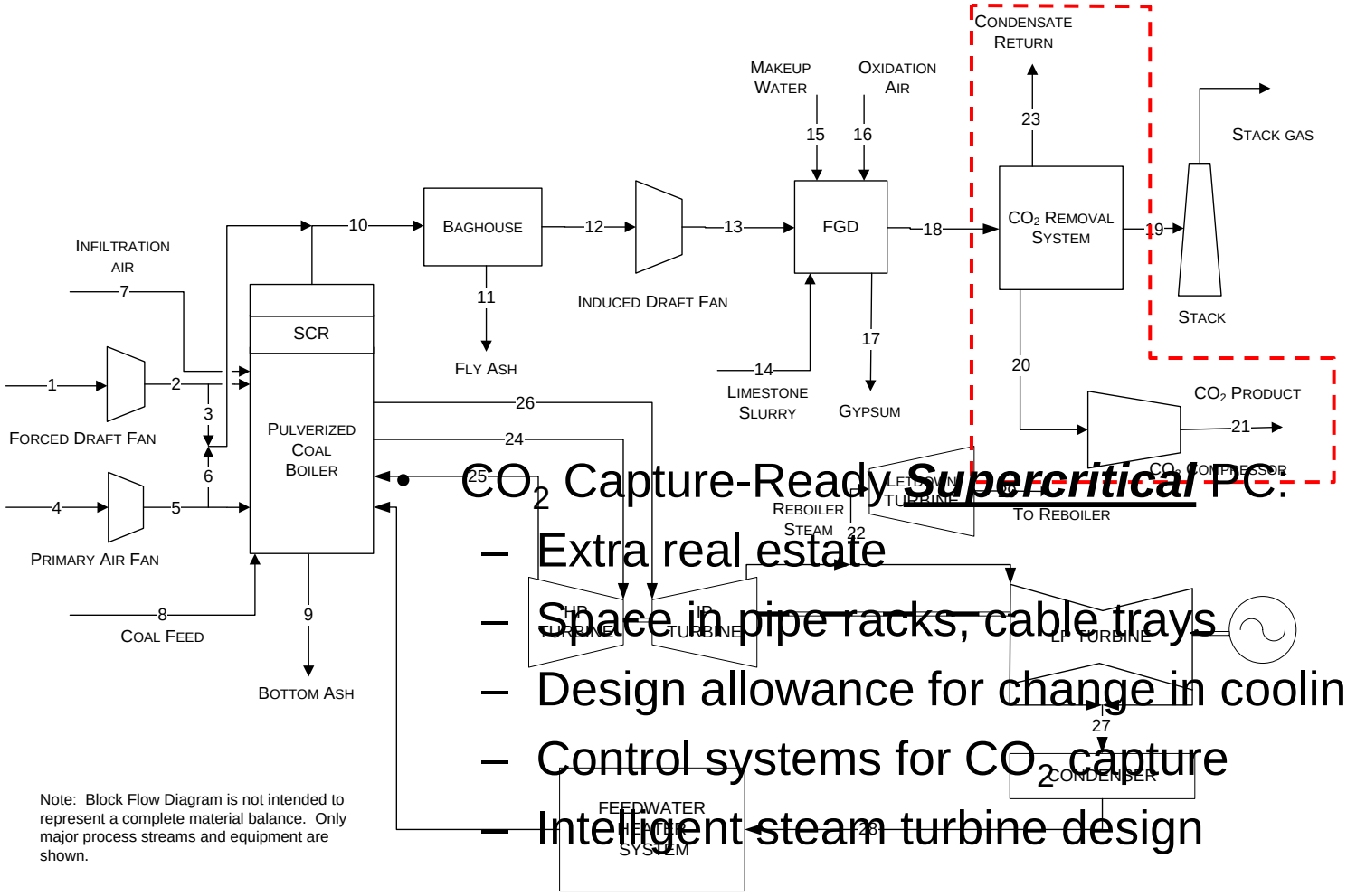
CO_2 Capture-Ready Coal Units

A continued investment in coal R&D via CO_2 capture-ready units can provide the following returns…

1. **Keeps a proven fossil resource in play:** *Power generation and U.S. economic growth directly linked. New generation needed to drive economic growth, and capture-ready coal units in compliance with EPA's proposed GHG NSPS*
2. **Capital Cost savings:** *Capture-ready coal has a 60% capital cost savings over other baseload options, e.g. nuclear*
3. **Insurance Policy:** *A mechanism to keep natural gas prices in check through promotion of energy diversity. Also, a proven way to serve baseload, as spark spreads* shrink due to a global natural gas price equilibrium.*

**Spark spread = Theoretical gross profit margin of gas-fired generation from selling a unit of electricity, given a specific fuel price.*

CO_2 Capture-Ready Definition



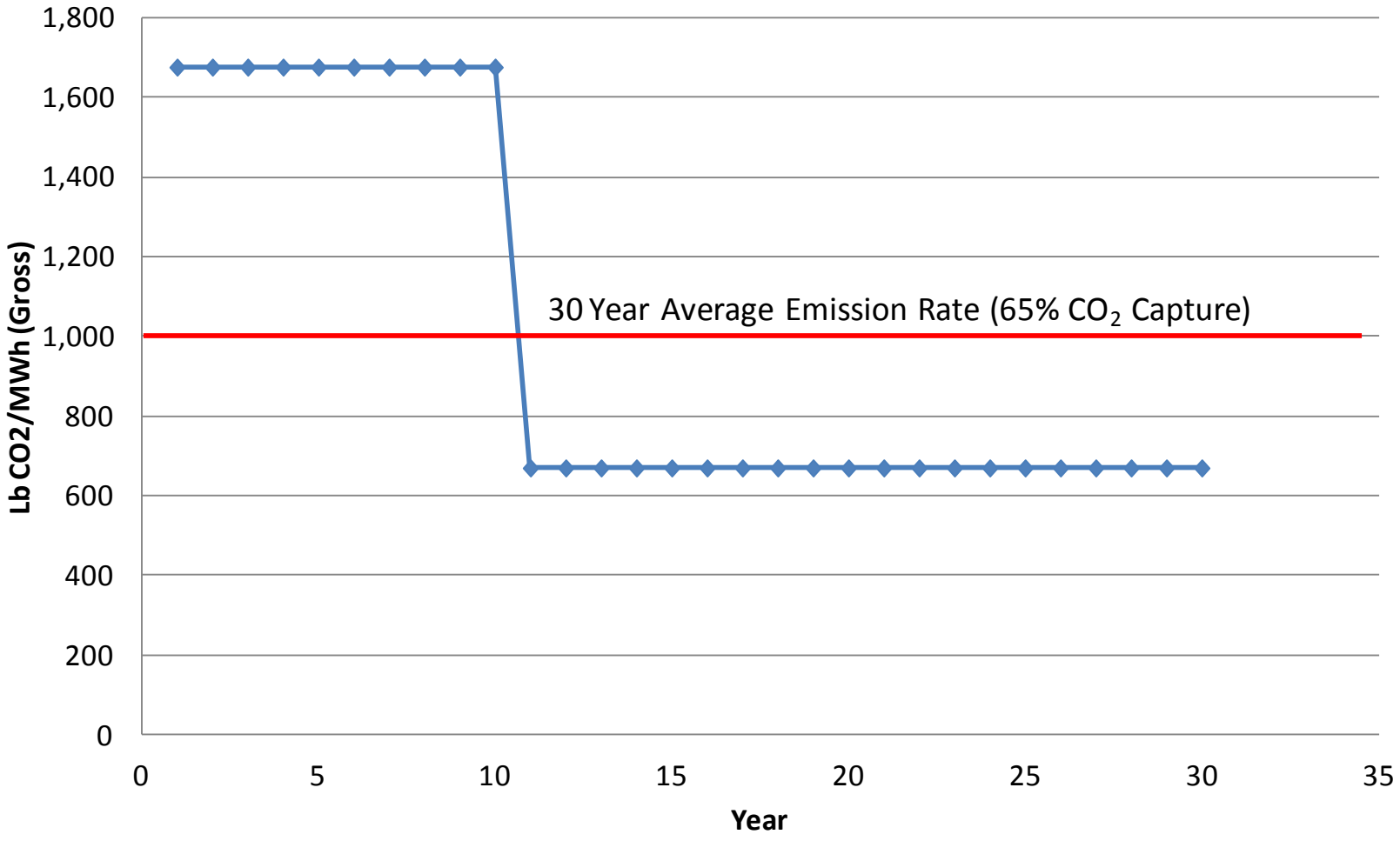
- CO_2 Capture-Ready ***Supercritical*** PC:
  - Extra real estate
  - Space in pipe racks, cable trays
  - Design allowance for change in cooling load
  - Control systems for CO_2 capture
  - Intelligent steam turbine design

Design Strategy

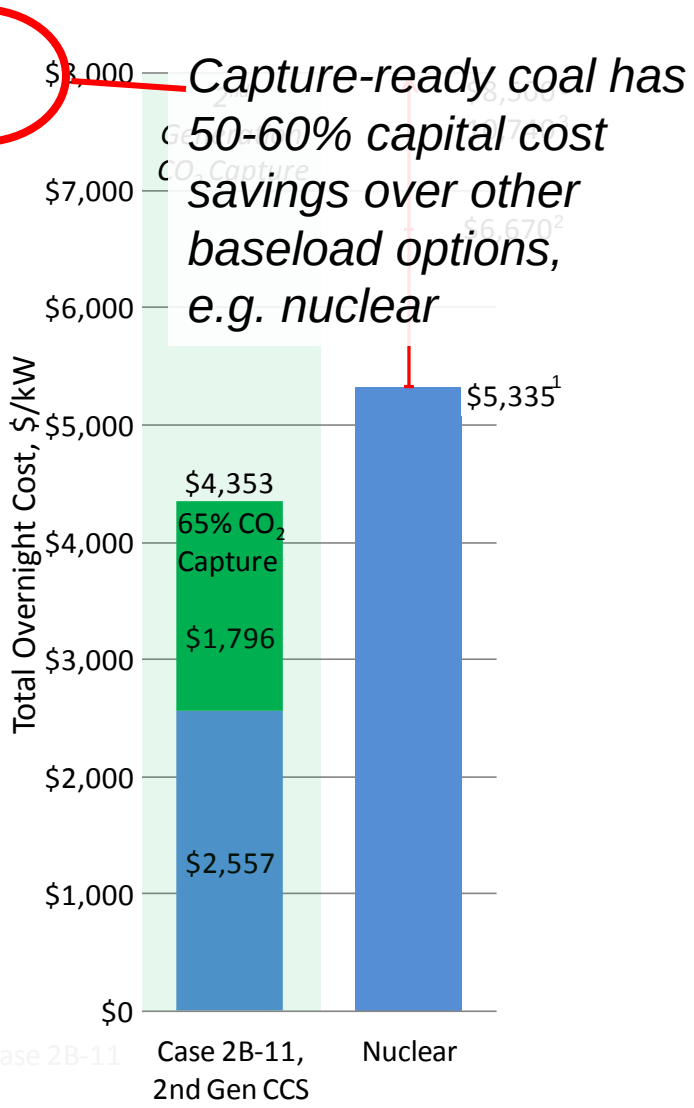
$$COE\left(\$/_{MWh}\right) = \frac{\left(TOC * CCF\right) + OC_{fixed} + \left(Cap.Fac. * OC_{\text{var}}\right)}{Cap.Fac. * MWh}$$

- Minimize cost of electricity by keeping capital costs low, or maximizing power output

Capture-Ready 30-Year CO_2 Emission Schedule

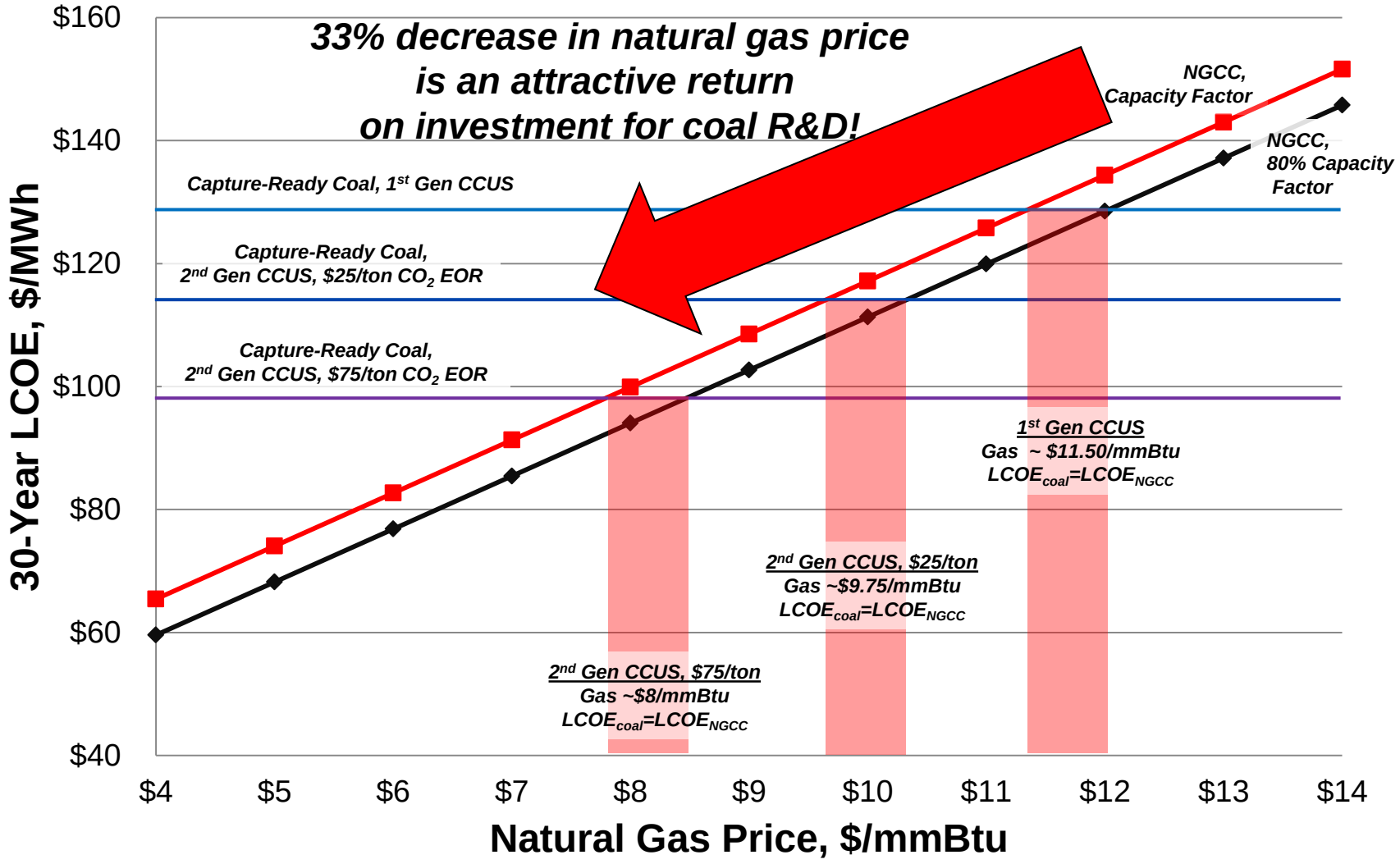


Capital Cost Results ($/kW)



1. 2012 Annual Energy Outlook, EIA
2. Atlanta Business Chronicle, May 14, 2012, http://www.bizjournals.com/atlanta/morning_call/2012/05/vogtle-nuclear-plant-faces-900m-in.html
3. World Nuclear News, May 2, 2012, http://www.world-nuclear-news.org/NN_Levy_nuclear_project_moved_back_by_three_years_0205122.html

LCOE's for Capture-Ready Coal and Uncontrolled NGCC



Final Thoughts

Understanding project risk and market dynamics are critical:

- **Project Risk:** *Industry needs assurance that either 1) CCUS will be available at the end of the first decade, or 2) they won't be penalized if it isn't. Without this, there is little incentive for developers to take the risk on capture-ready units.*

Greenhouse Gas New Source Performance Standard

Recent Developments…

- **EPA missed an April 13, 2013 deadline to finalize GHG NSPS**
- **Considerations:**
  - Coal and gas combined into the same category, an unprecedented approach by EPA

Regulation of CO_2 from Existing Coal Plants

- **EPA has consistently downplayed any regulation of CO_2 from existing coal units, but it is widely believed to be forthcoming**