The Future of Coal

Options for a Carbon-Constrained World

Cambridge-MIT Electricity Policy Conference

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MIT

September 27, 2007

Newsweek, April 16, 2007

Coal is the cheapest and dirtiest source of energy around. If we cannot get a handle on the coal problem, nothing else matters.

POWER SOURCE: Coal plant in Jilin, China

96 NEWSWEEK APRIL 16, 2007

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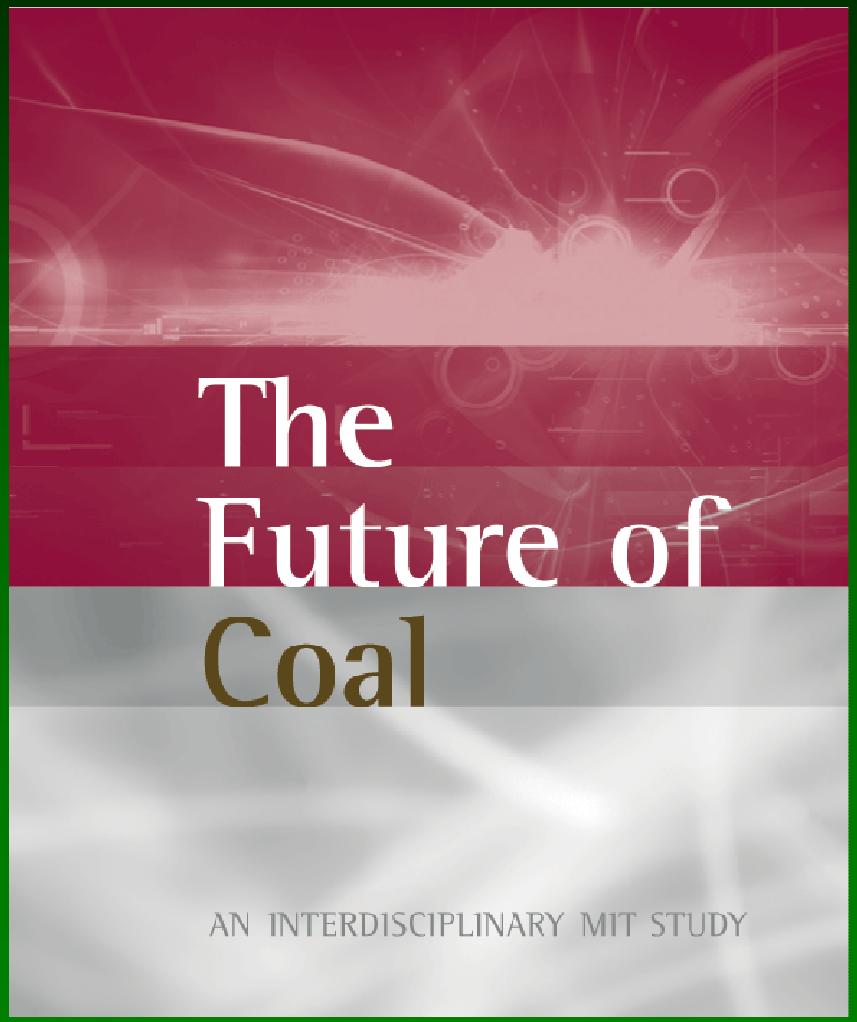
Howard Herzog / MIT Laboratory for Energy and the Environment

The MIT Coal Study



- Released March 14
  - On web at mit.edu/coal
- Key question: What actions regarding the technology do we take now to impact GHG emissions on a Gigatonne scale in 2050?

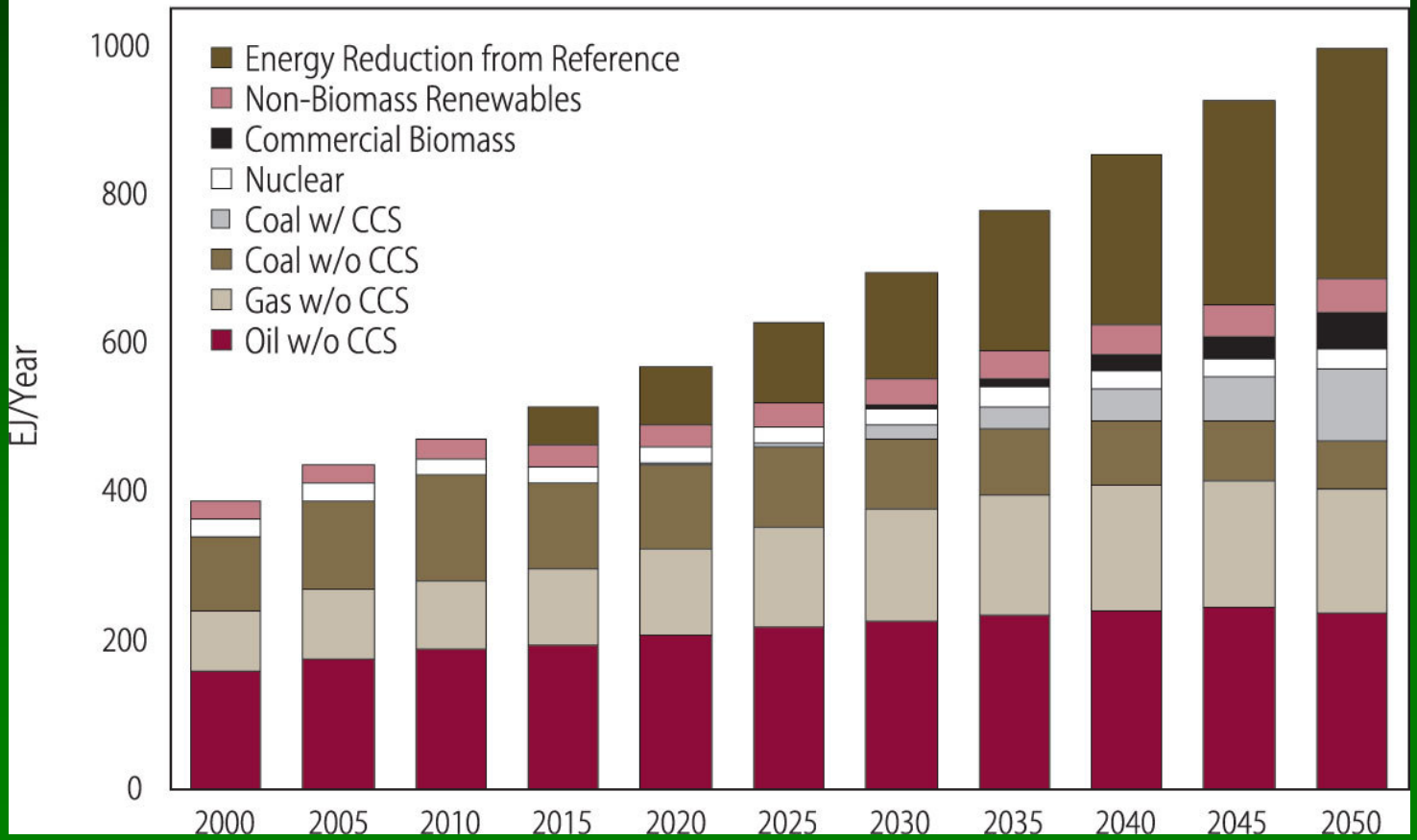
CO_2 Capture and Storage

- We conclude that CO_2 capture and sequestration (CCS) is the critical enabling technology that would reduce CO_2 emissions significantly while also allowing coal to meet the world's pressing energy needs.

from MIT Coal Study - Executive Summary

Carbon-Constrained Scenario
High CO_2 Prices - Limited Nuclear

Figure 2.4 Global Primary Energy Consumption under High CO_2 Prices *(Limited Nuclear Generation and EPPA-Ref Gas Prices)*



from MIT Coal Study

CCS Status Today

- All major components of a CCS system are commercially available today. However, significant challenges still remain:
  - Reducing costs primarily associated with capture
  - Reducing the uncertainty associated with geologic storage at scale (both scientific and regulatory)

Technology Choice

- It is premature to select one coal conversion technology as the preferred route for cost-effective electricity generation combined with CCS.
  - Variability in location, coal type, etc.
  - Uncertainty in technological progress

MIT Coal Study – Finding #6

Geologic Sequestration

- Current evidence indicates that it is scientifically feasible to store large quantities of CO_2 in saline aquifers
  - Analogous Activities
    - » Enhanced Oil Recovery (CO_2 Pipelines)
    - » Acid Gas Injection
    - » Natural Gas Storage
  - Current Sequestration Projects (~million tons/yr)
    - » Sleipner, North Sea, Norway – 1996
    - » Weyburn, Saskatchewan, Canada - 2000
    - » In Salah, Algeria – 2004
- Moving from the megatonne scale to the gigatonne scale is a major challenge
- Moving forward, large-scale demonstration projects are key

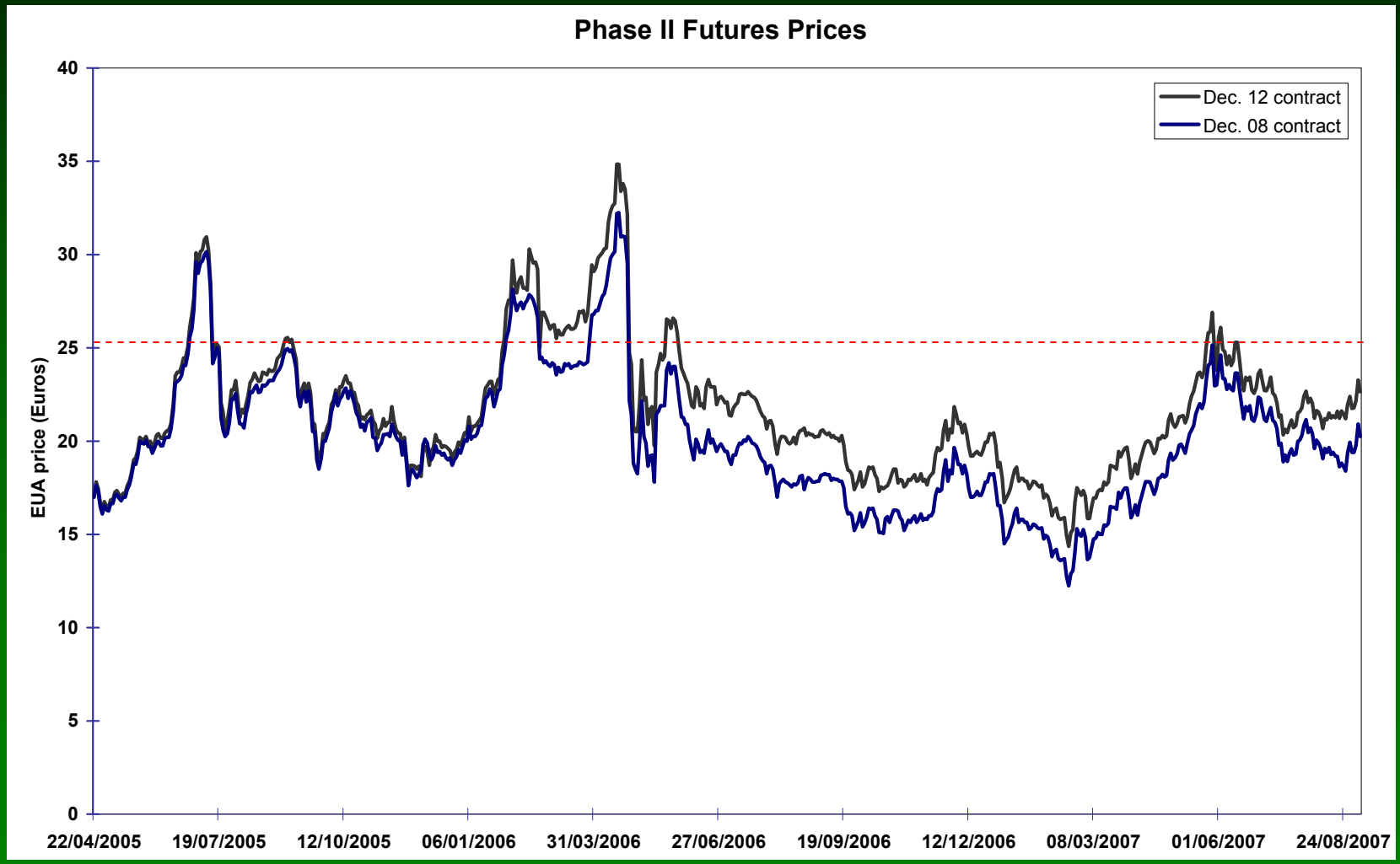
MIT Coal Study – Finding #5

CCS Economics

- Successful implementation of CCS will inevitably add cost for coal combustion and conversion. We estimate that for new plant construction, a CO_2 emission price of approximately $30/tonne (about $110/tonne C) would make CCS cost competitive with coal combustion and conversion systems without CCS. This estimate of CCS cost is uncertain; it might be larger or with new technology, perhaps smaller.

from MIT Coal Study - Executive Summary

Carbon Prices – EU Trading System



BP Abandons Plans to Build UK Carbon Capture Plant

Reuters News Service – May 24, 2007

British oil company BP on Wednesday abandoned plans to build a carbon capture and storage plant in Scotland, after a government energy review delayed a subsidy award.

Duo ditch costly Draugen CO_2 plan

Upstreamonline.com – 29 June 2007

Statoil and Shell have dropped plans to inject carbon dioxide into the Draugen reservoir in a bid to enhance oil recovery, saying the move is uneconomical.

SaskPower Shelves Clean-coal Project

Globe and Mail – September 7, 2007

It was supposed to herald the era of "clean coal," but Saskatchewan now says a proposed coal-fired power plant that would capture and store carbon dioxide is simply too expensive.

Mr. Youzwa said the feasibility study conducted by the utility over the past year concluded that the technology is sound.

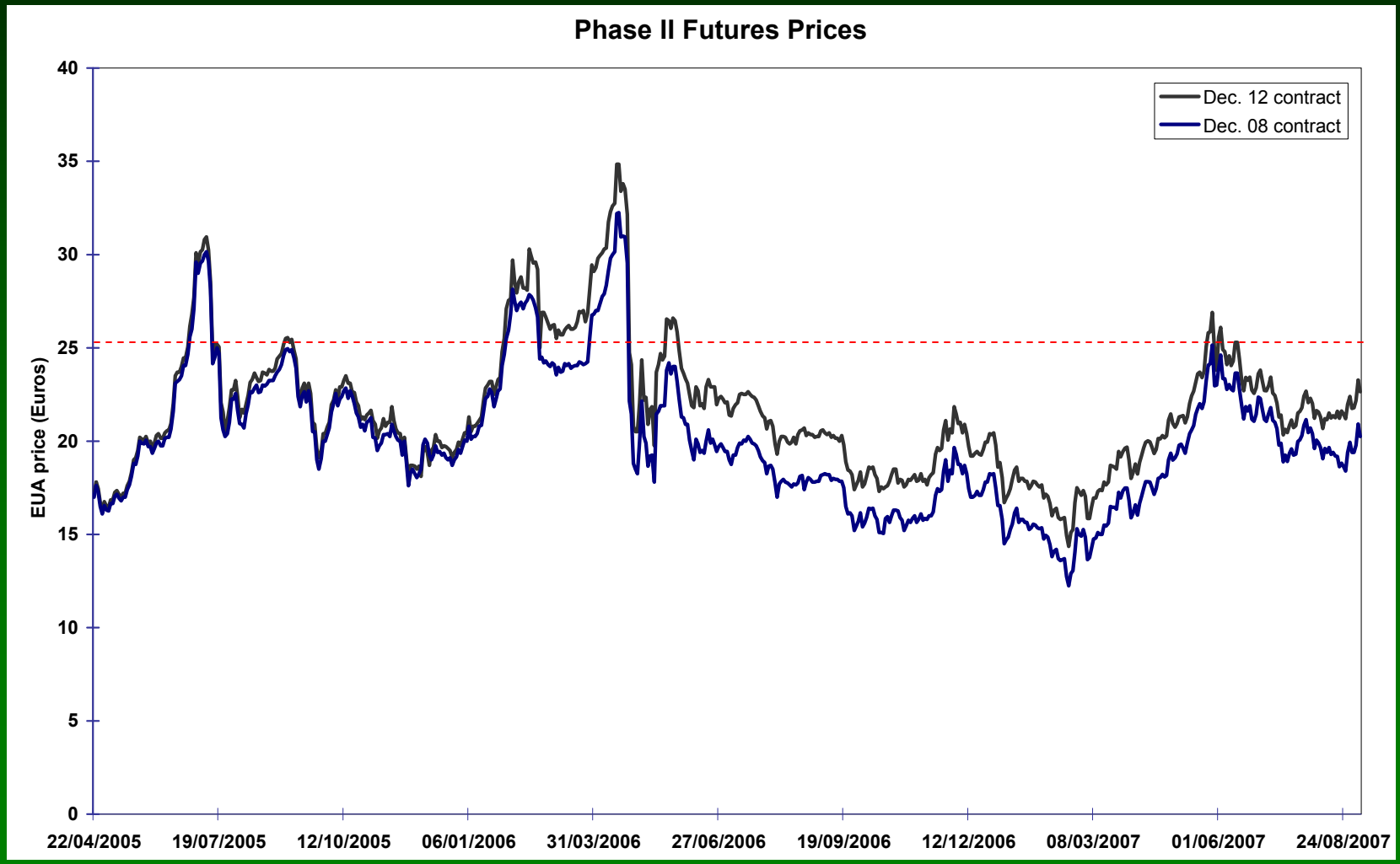
"But given the need for new supply by 2010, and given the costs of clean coal at this early stage in its development, it would have been premature to proceed to the construction phase at this time.“

Gary Wilkinson, senior vice-president at SaskPower, said the projected capital cost of the project soared to $3.8-billion from $1.7-billion.

Critical Question

- Is it reasonable to expect to build 100s of coal-fired power plants with CCS by 2050 when we are having so much trouble building just one today?

Carbon Prices – EU Trading System



MIT Coal Study
Implied Roadmap

- Through 2020 – Large-scale demonstration projects (~10 worldwide) to provide technological and institutional readiness
- 2020 – Commercial implementation (assumes carbon policy creates a market)
- 2050 – Reach GtC/yr level (3.7 $GtCO_2$/yr) level -- 600 GW coal-fired power plants with capture

MIT Coal Study
Key Takeaways

- Technology readiness is critical – there are myriad options to pursue.
- Don't preclude options by anointing winners prematurely.
- We need to drastically increase R&D to bring CO_2 capture technologies to fruition. There is urgency to move ahead now if we are to reach Gt scale by 2050. Large scale demonstration projects are key.
- No showstoppers, but moving from the Mt scale to the Gt scale is a major challenge.

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