



CO₂ Sequestration: The Utility Perspective

KASB Building

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We gotta catch it
before we can
sequester it!



Today's Discussion

- How can we capture CO₂ associated with energy production?
- What are the costs?
- How mature is the technology?
- A path forward.

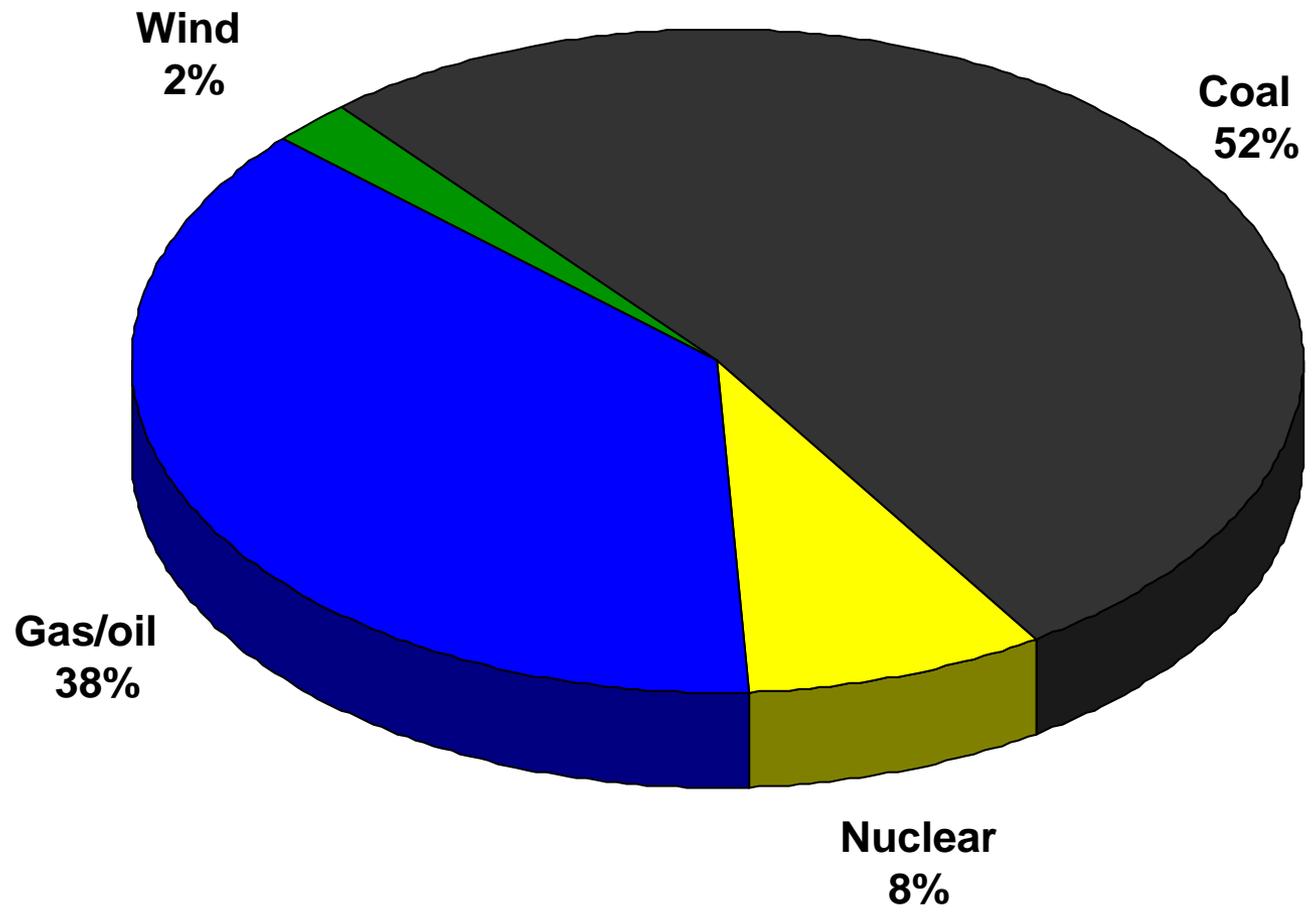


EPRI

ELECTRIC POWER
RESEARCH INSTITUTE



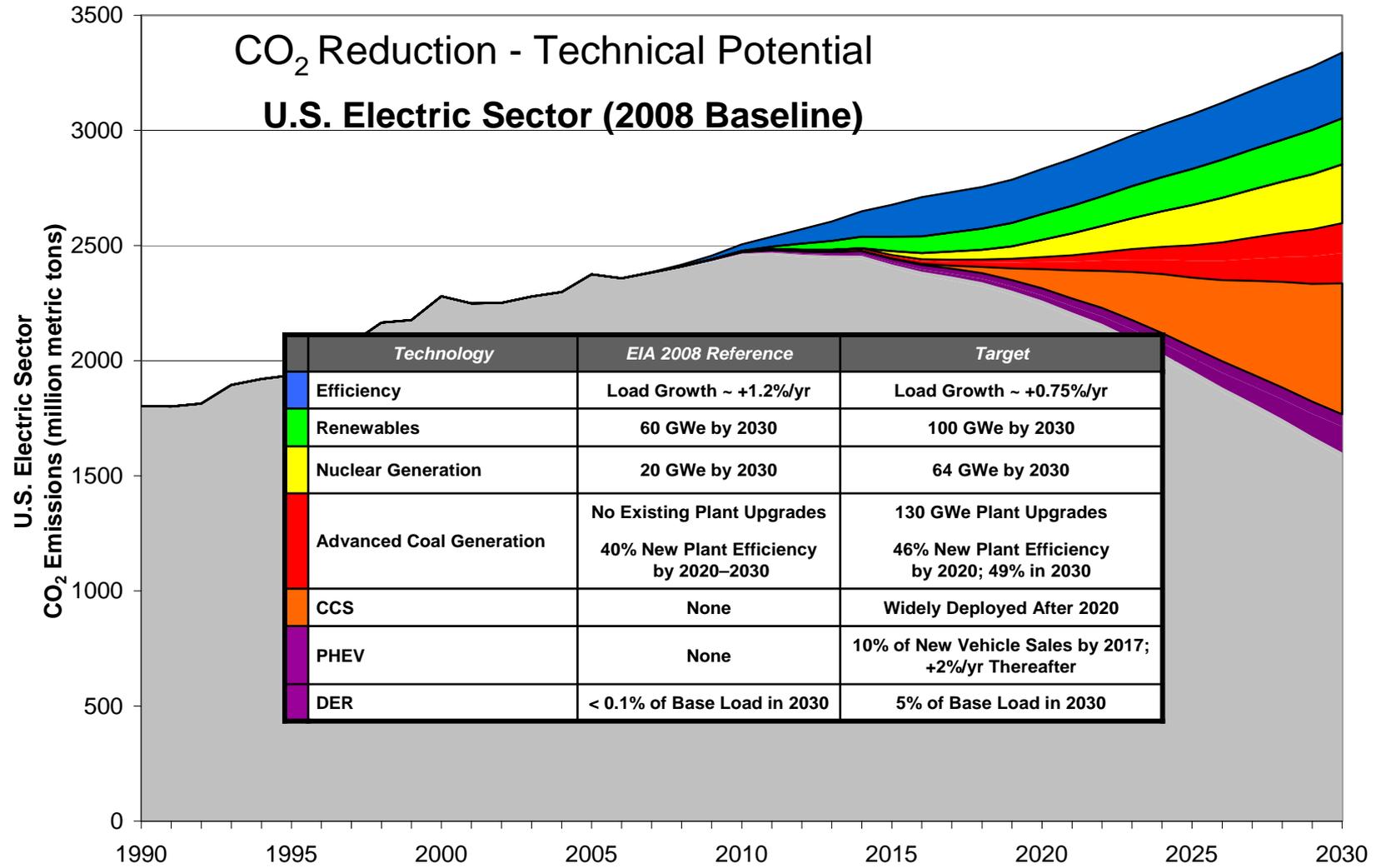
Westar Energy Installed Capacity





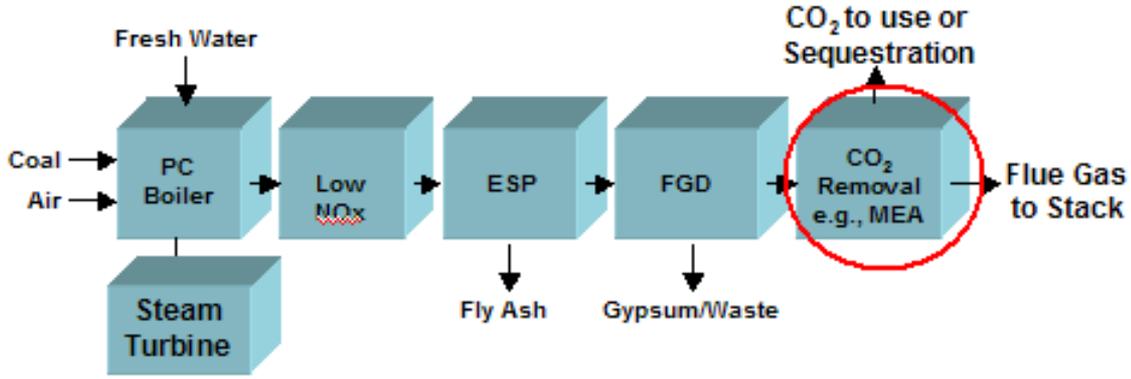
Gotta Catch it!

CO₂ Reduction - Technical Potential U.S. Electric Sector (2008 Baseline)



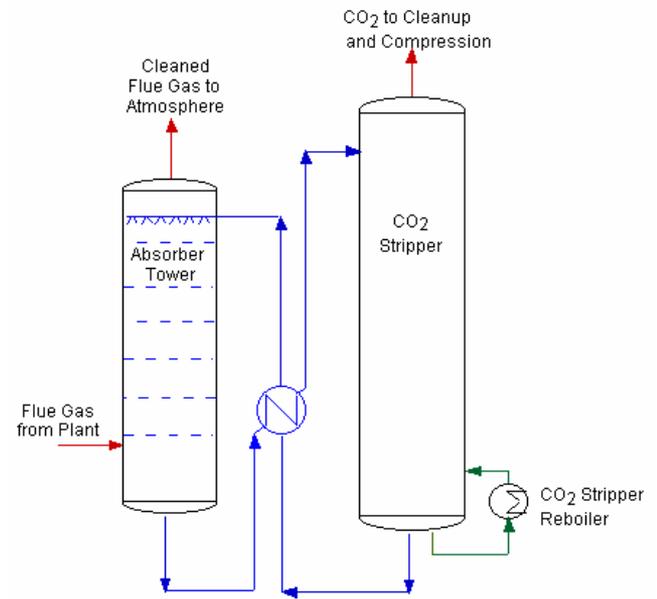


Pulverized Coal with Amine CO₂ Capture



**Output Penalty:
Up to 30%**

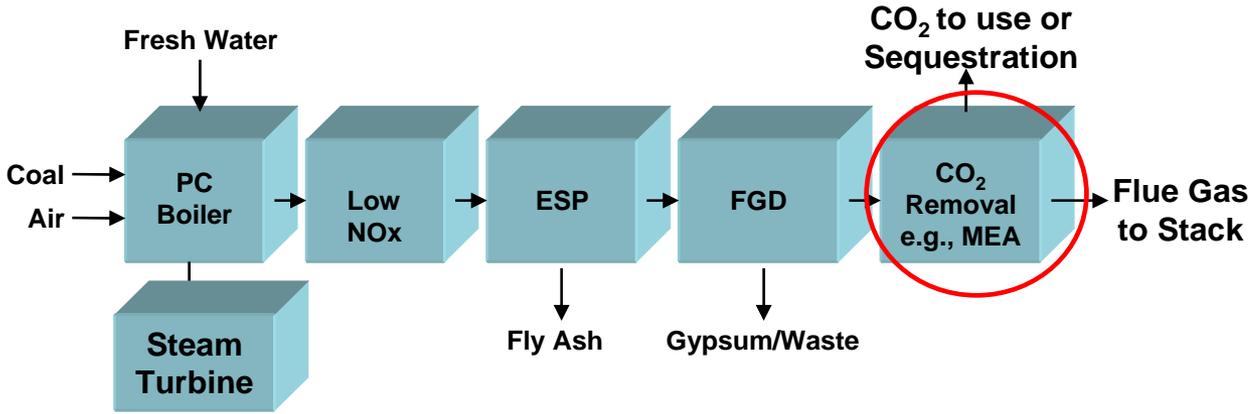
- Amine processes commercially available at relatively small scale; considerable re-engineering and scale-up needed (ultra-low inlet SO₂ and NO₂ also required)
- Steam extraction for solvent regeneration reduces flow to low-pressure turbine; significant operational impact
- Plot space requirements significant; back-end at existing plants often already crowded by other emission controls



CO₂ Capture = \$, Space, Ultra-Low SO₂, and Lots of Energy

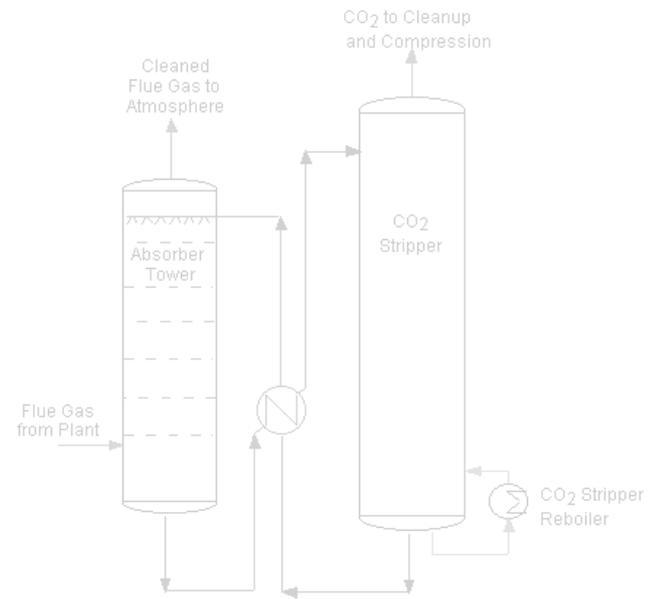


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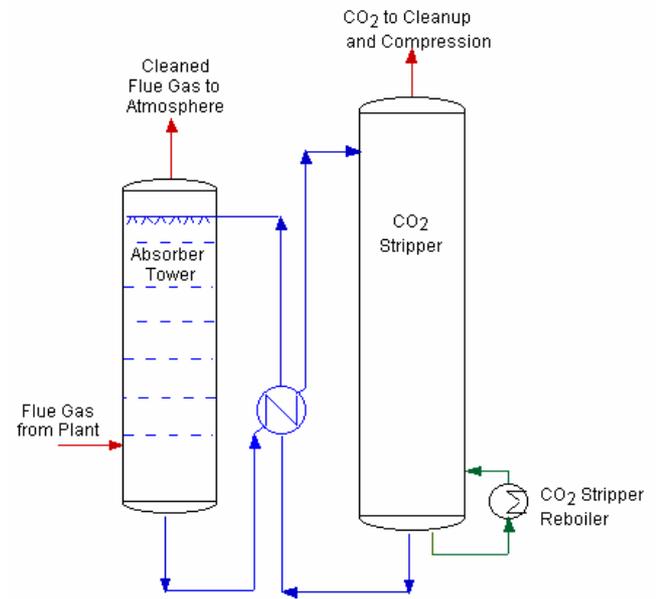


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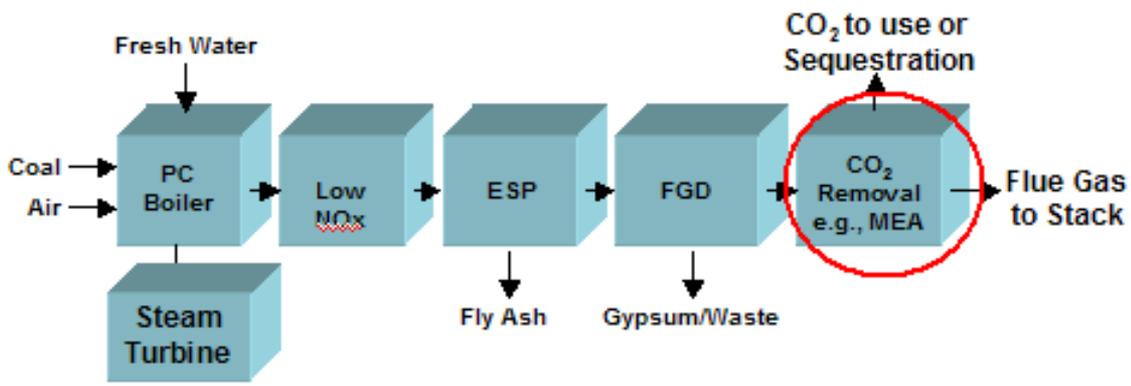
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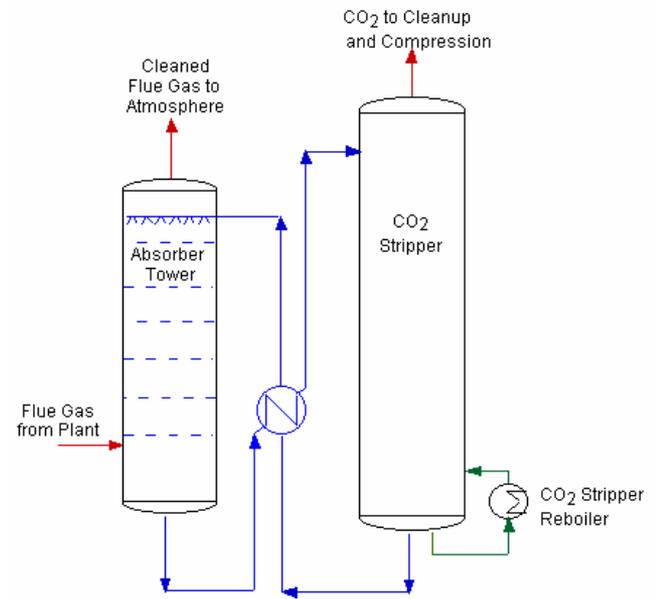


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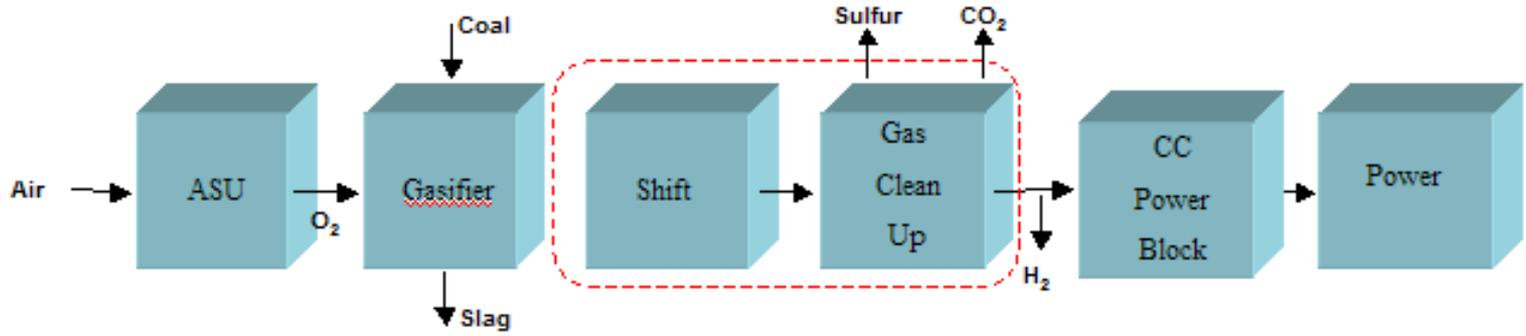
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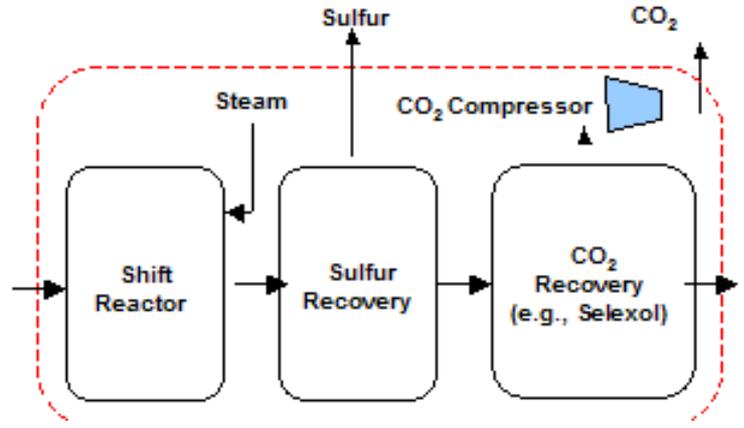


IGCC with Capture



CO₂ Capture/Integration Issues

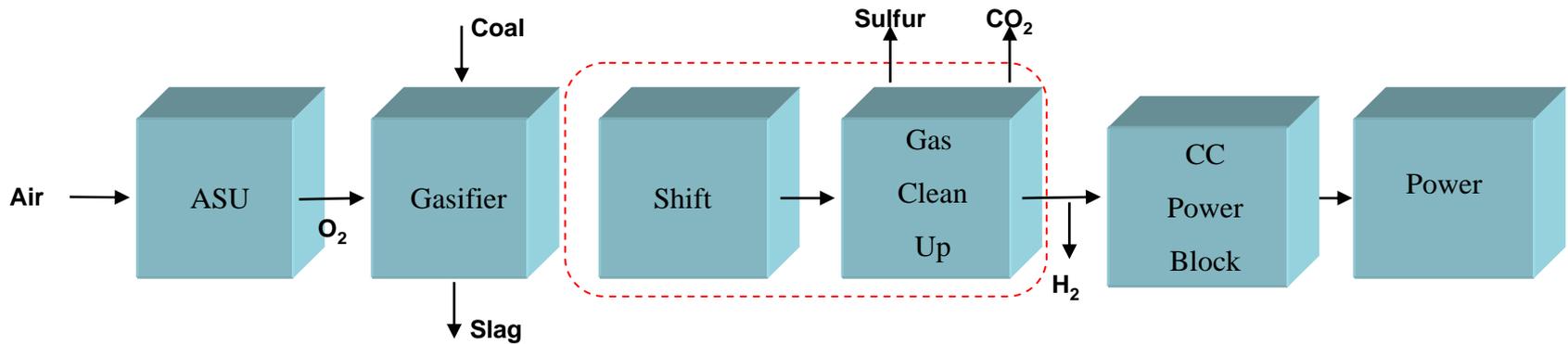
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- Equipment design given different syngas composition and heating value
- Little experience with H₂-firing gas turbines
- Need for new capture-optimized reference plant designs



CO₂ Capture = \$, Space, H₂ Firing, Energy

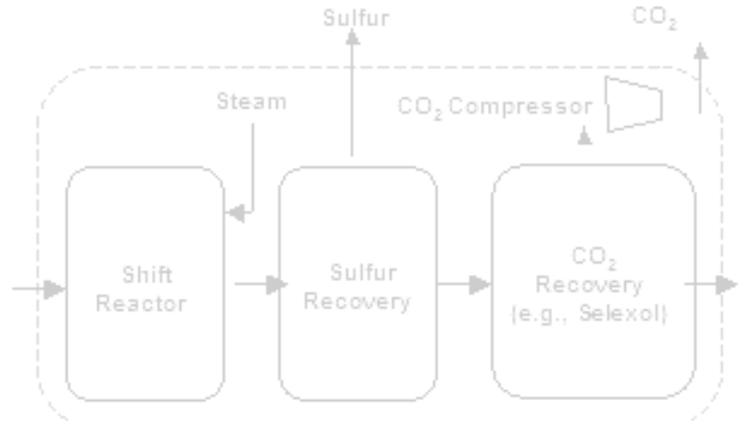


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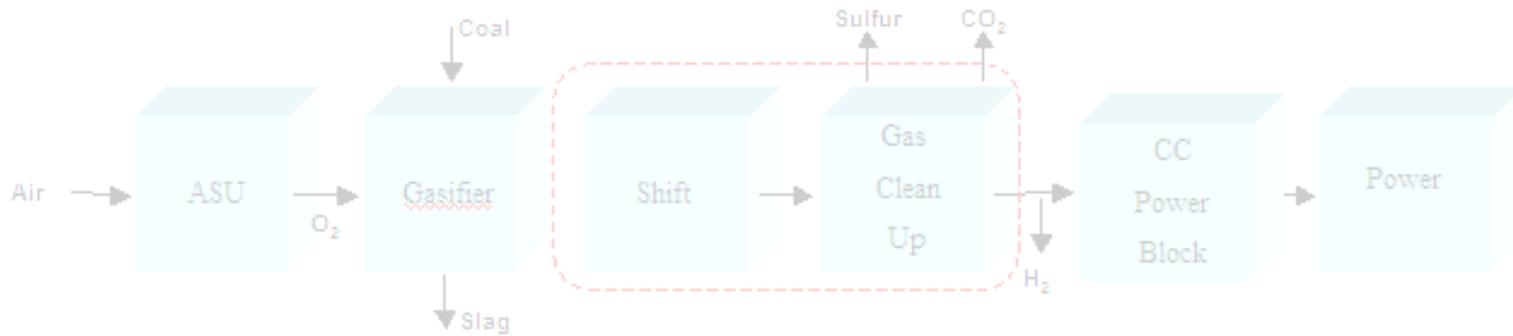
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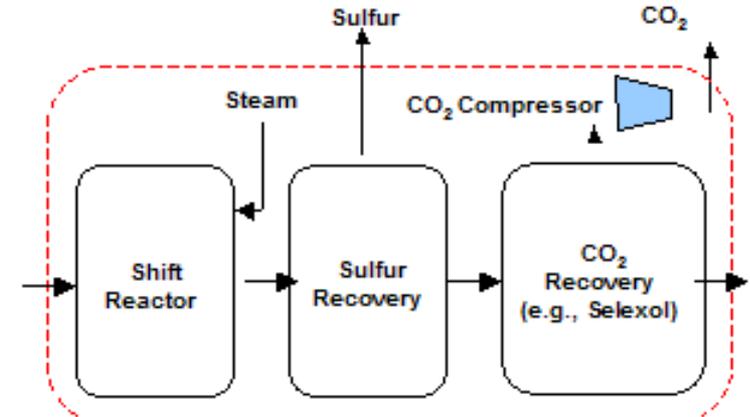


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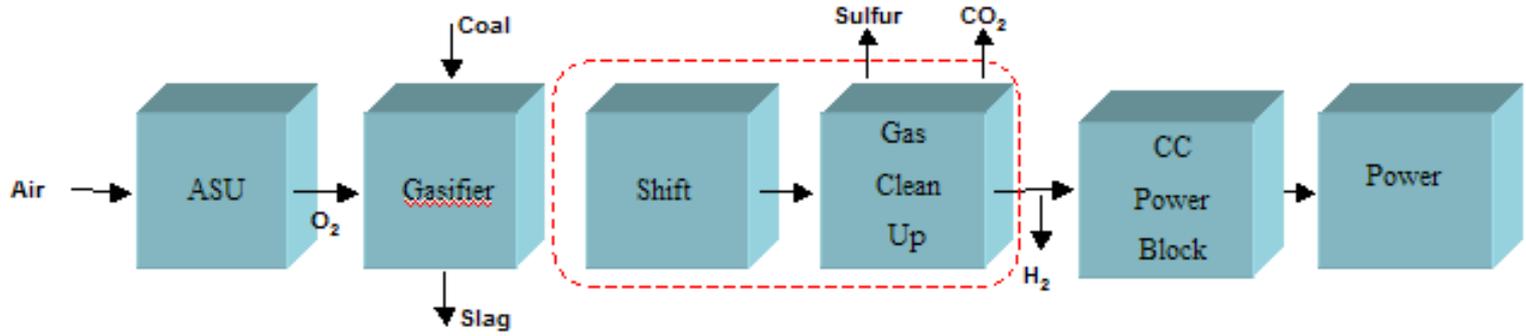
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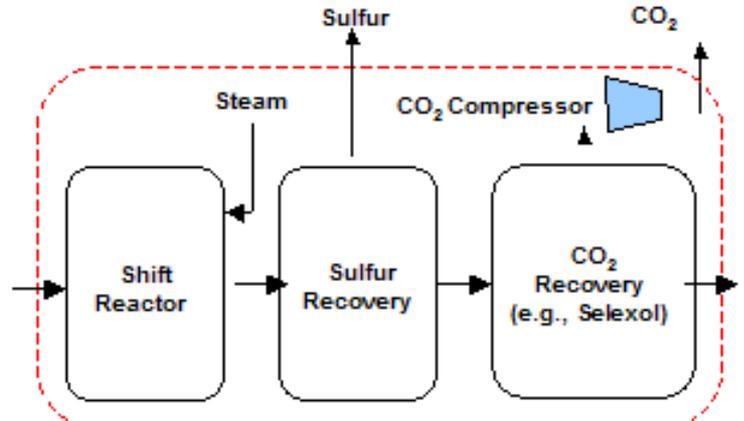


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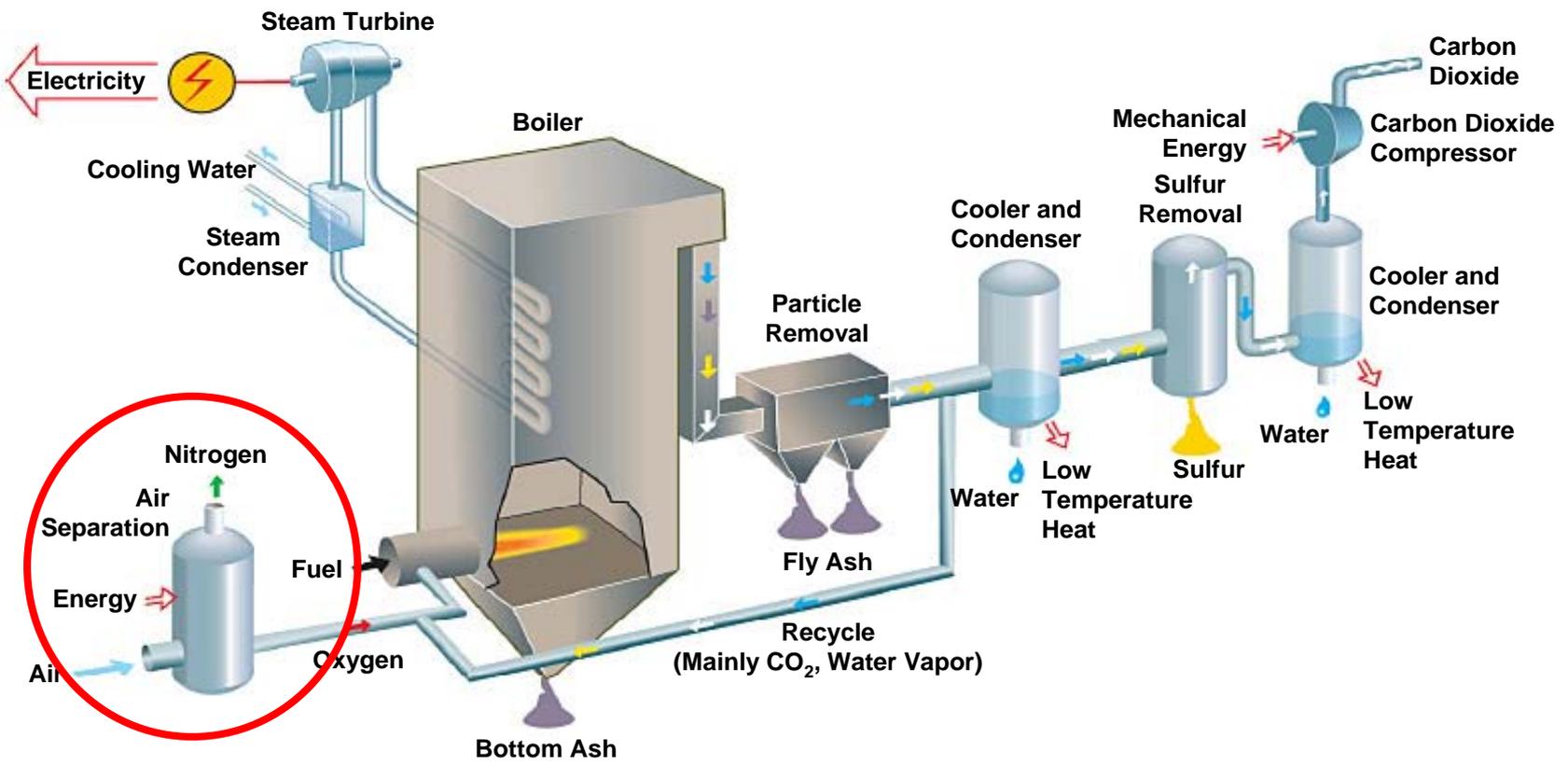
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Oxy-Combustion with Capture



Significant Energy & Capital Required for O₂ Production



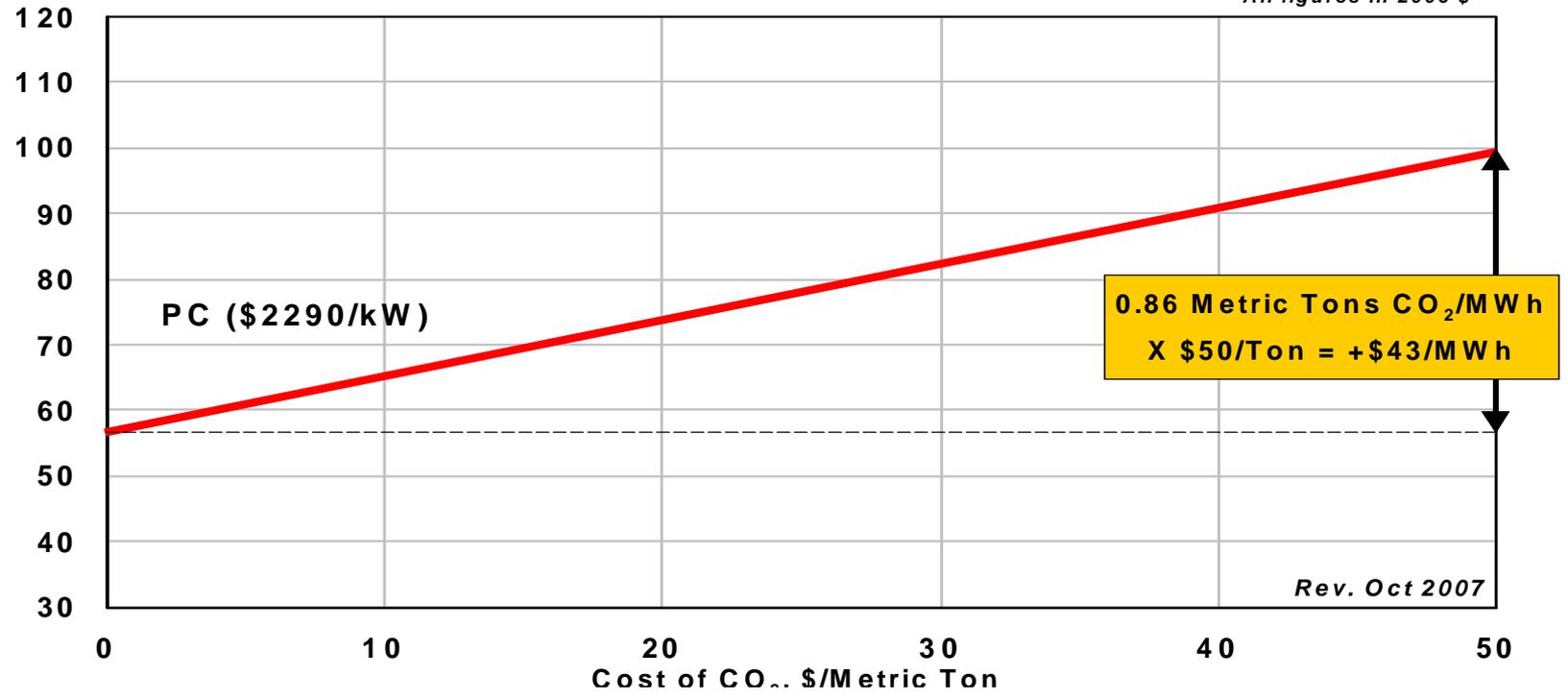
Costs?



Pulverized Coal Combustion 2010-2015

Levelized Cost of Electricity, \$/MWh

All figures in 2006 \$





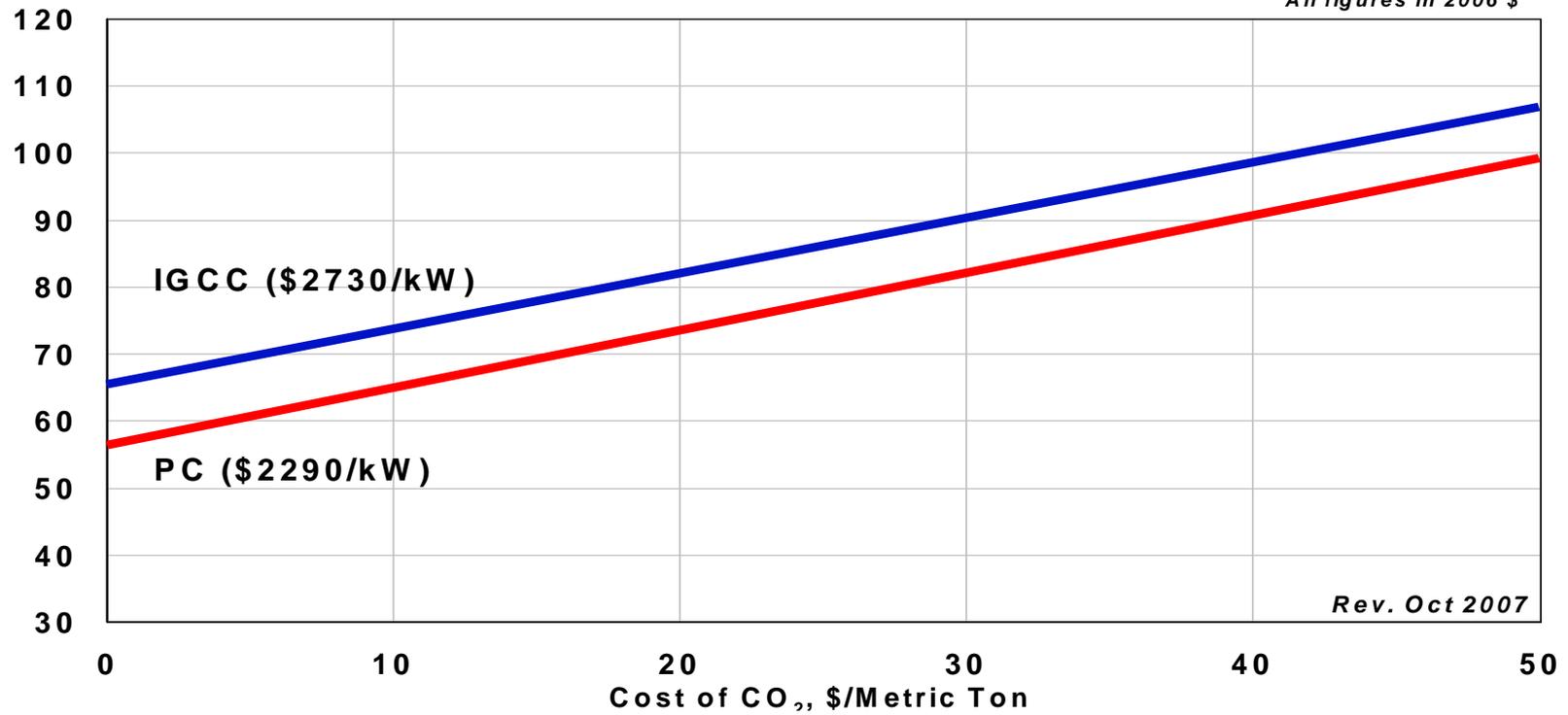
Costs?

Comparison of PC and IGCC 2010-2015



Levelized Cost of Electricity, \$/MWh

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Rev. Oct 2007

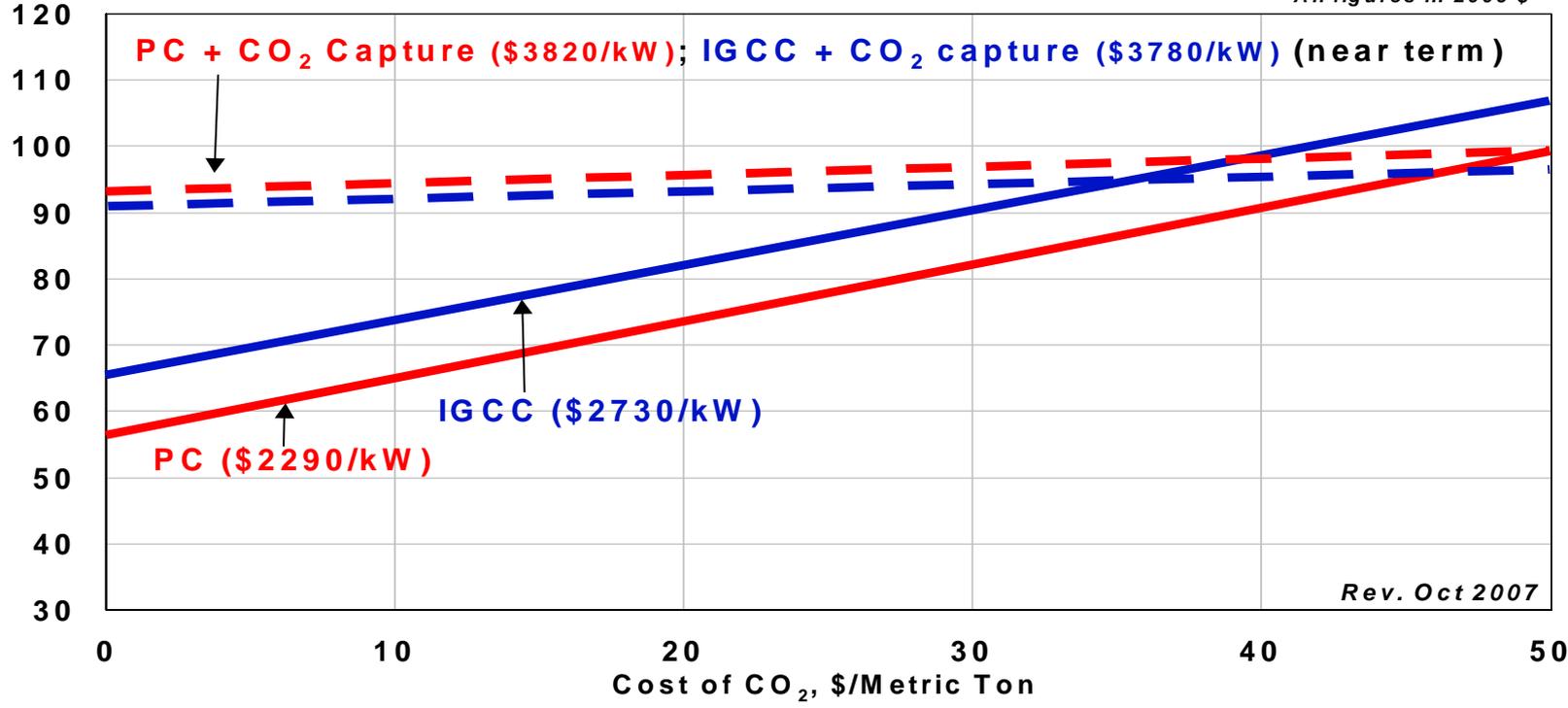


Costs?

Integrated Gasification Combined Cycle, Pulverized Coal with CO₂ Capture

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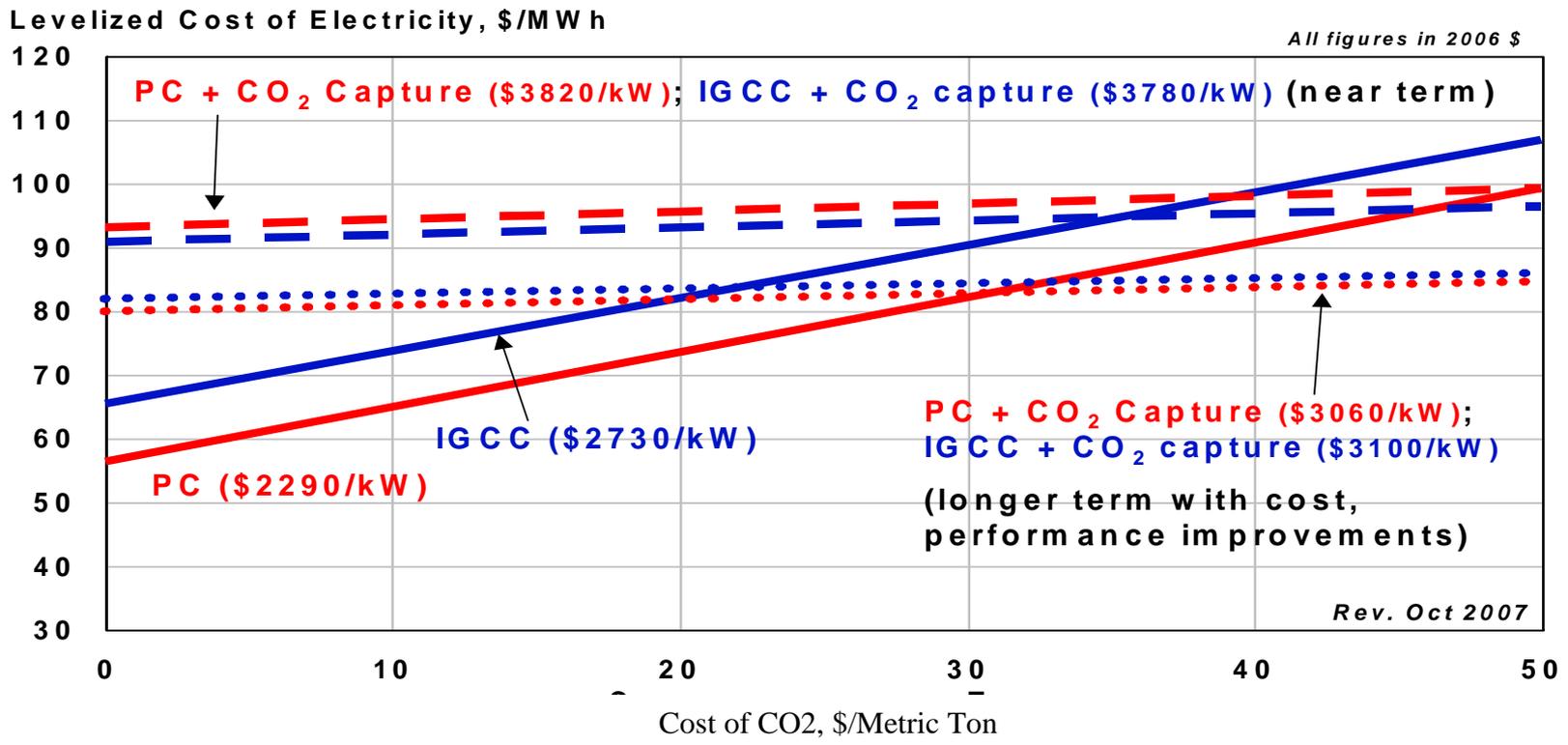


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Costs?

Impact of Anticipated Cost, Performance Improvements on PC, IGCC with CO₂ Capture





How mature is the technology?

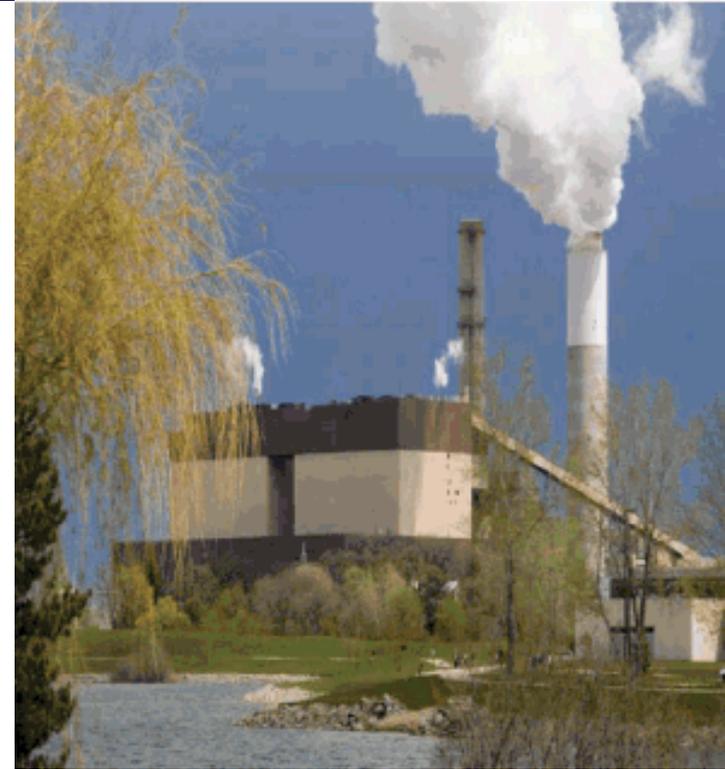
Currently, there are 3 plants in the US capturing CO₂ with amines from a portion of their exhausts. The portions total the exhaust from the equivalent of a 40 MW power plant.





How mature is the technology?

Chilled Ammonia technology is being tested at Pleasant Prairie Power Plant in Wisconsin to capture the equivalent of CO₂ from a 4 MW coal plant. Alstom is the vendor with more than 37 US and international utilities funding. Testing through mid-2009 with hope to reduce parasitic load to below 25%.



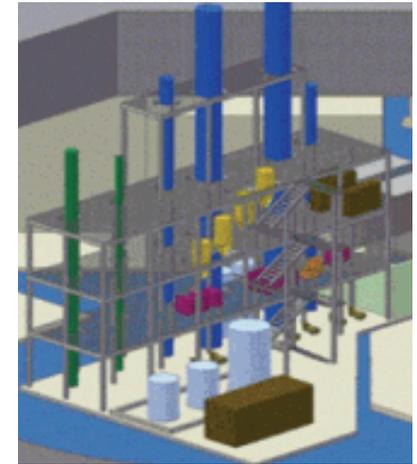
AEP is developing a ~ 20 MW chilled ammonia capture module with storage at their West Virginia Mountaineer Plant.



How mature is the technology?

While CO₂ can be captured with IGCC, it is very expensive so no IGCCs are currently doing this.

- Southern Company, with the federal government's help, is considering a ~ 600 MW IGCC plant in Mississippi, with a projected 25% CO₂ capture rate. CO₂ for EOR.



- FutureGen, a 275 MW IGCC project with capture and sequestration in Illinois was slated for construction until DOE withdrew funding in June 2008.

- Other projects being discussed.

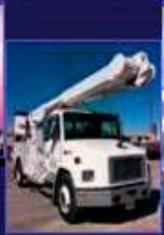


How mature is the technology?

Due to the high cost of producing O₂, no commercial oxy combustion plants are in operation.

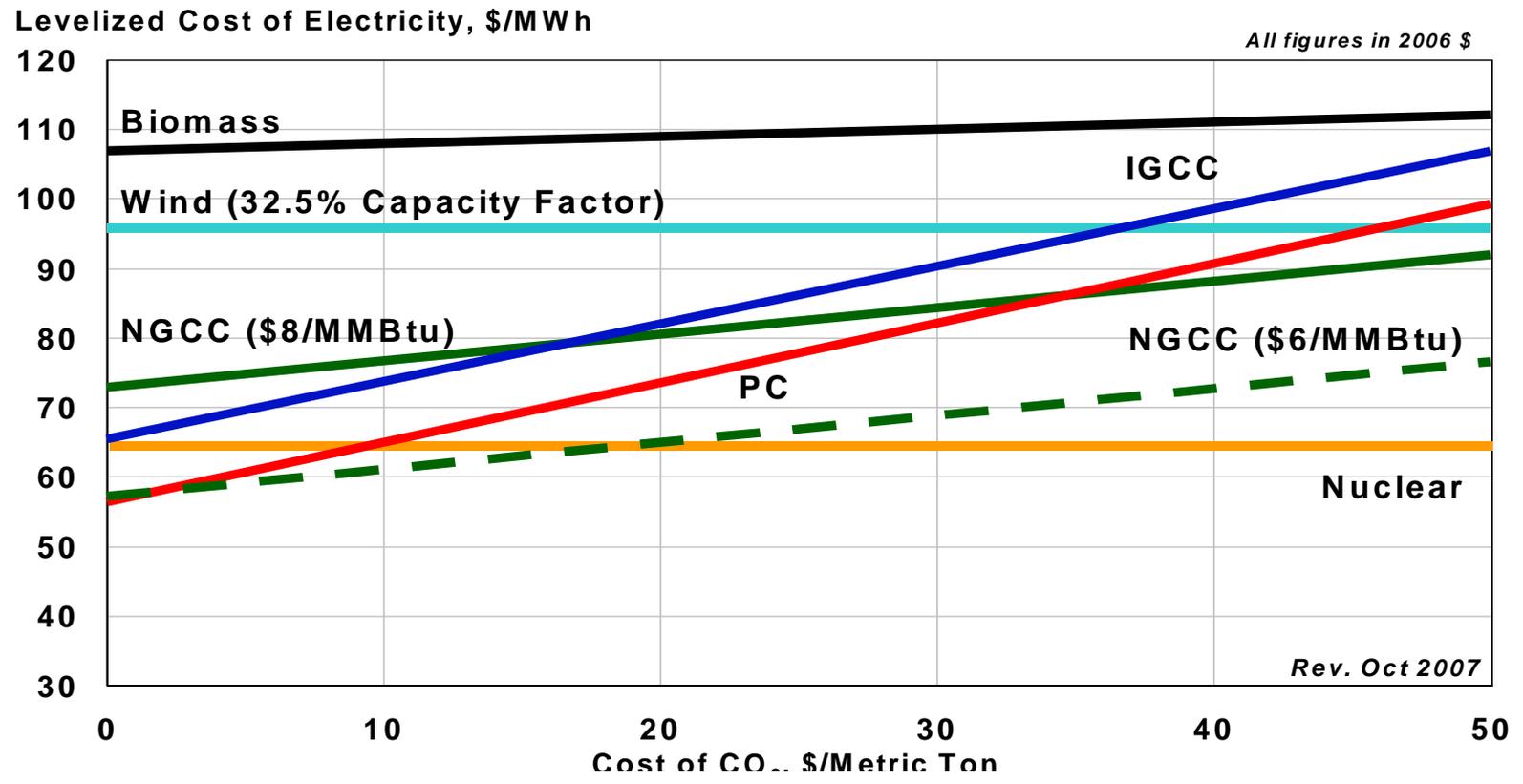
- Three 10-30 MW test plants are operating or near completion in the US and abroad.
- Improved Ion Transport Membrane technology development is the current research focus.





A Path Forward

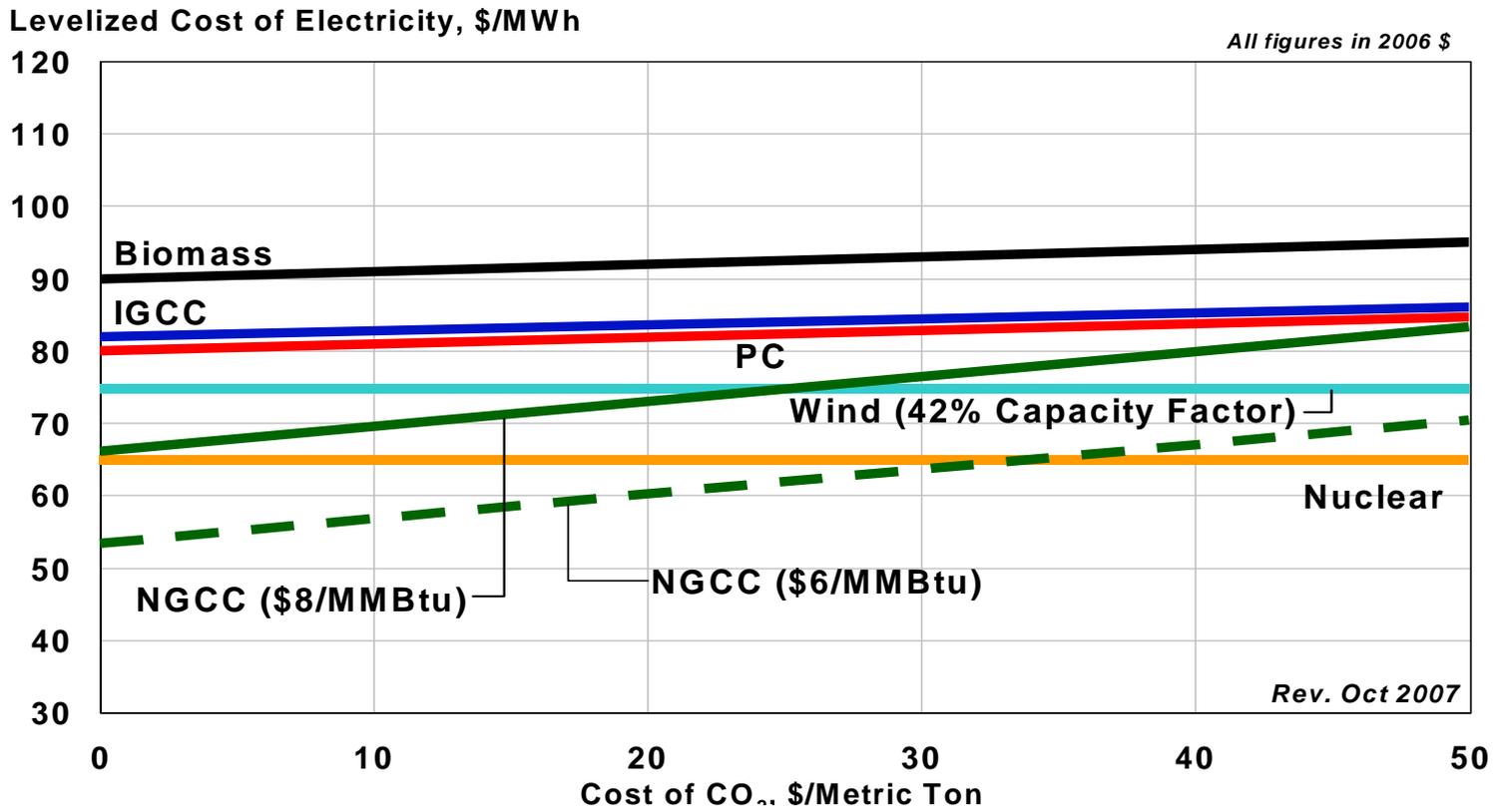
Comparative Levelized Costs of Electricity 2010–2015





A Path Forward

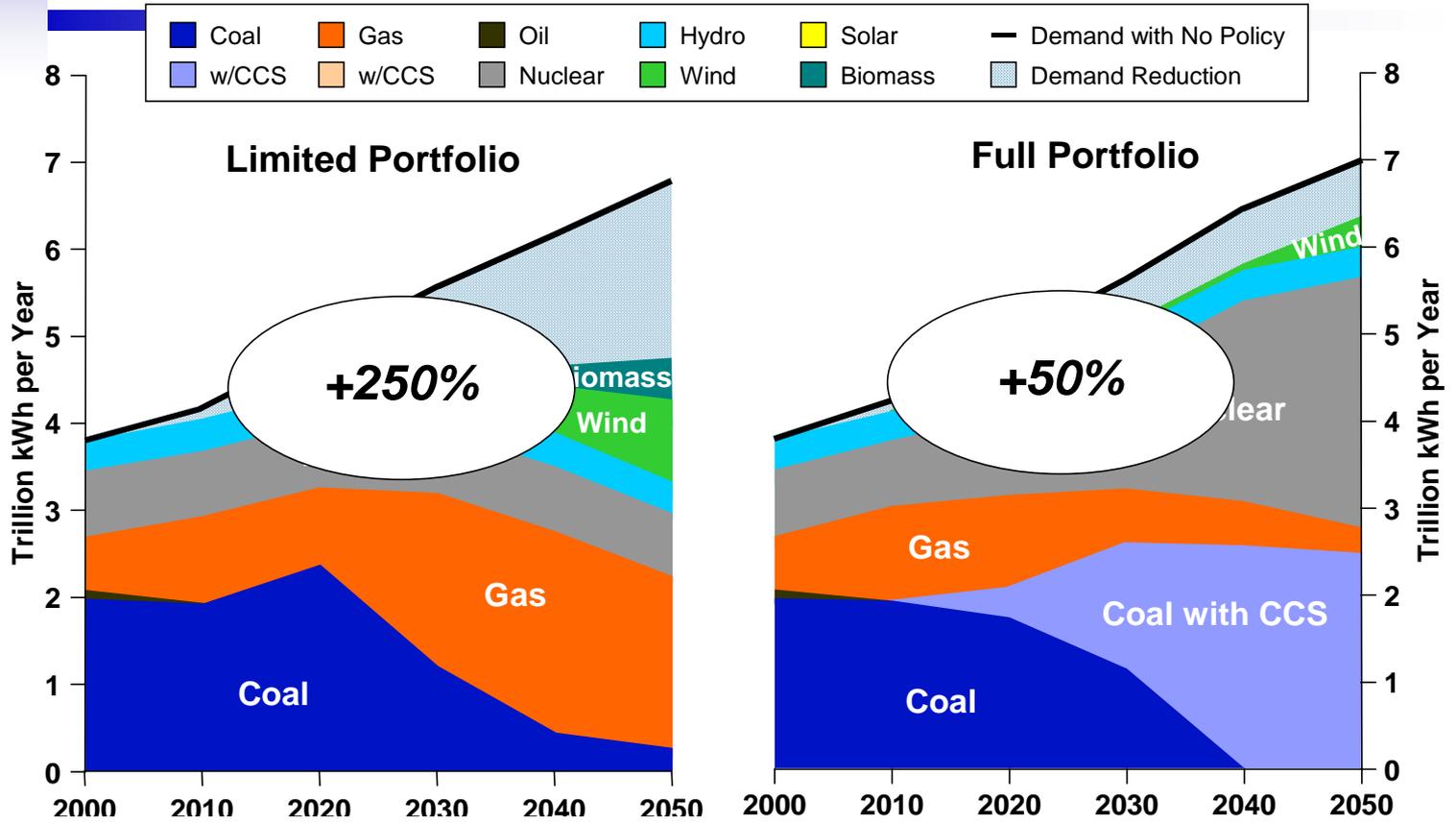
Comparative Levelized Costs of Electricity 2020–2025





A Path Forward

Meeting Economy-wide Cap* Impact on Future U.S. Generation Mix Increase in Real Electricity Prices...2000 to 2050



*Economy-wide CO2 emissions capped at 2010 levels until 2020 and then reduced 3%/yr.



THE END

