Reducing CO_2 Emissions from Fossil Fueled Power Plants

James E. Staudt, Ph.D
For questions: staudt@AndoverTechnology.com

West Virginia University College of Law

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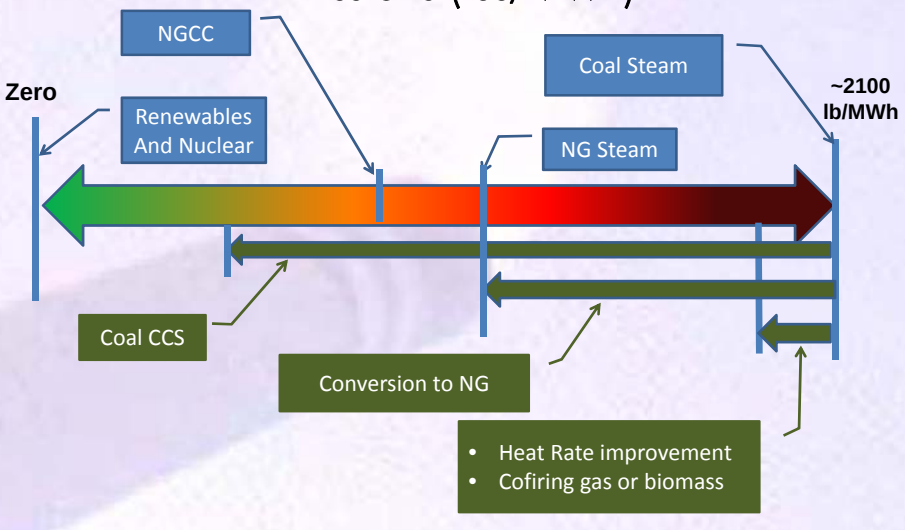
Andover Technology Partners 978-683-9599
Clean Air, Clean Energy Consulting

Spectrum of Approximate Power Plant CO_2 Emissions (lbs/MWh)



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Reducing CO_2 Emissions from Existing Coal

- **Heat Rate Improvement** **(reduce the fuel required per kWhr produced)**
  - Improve boiler efficiency
  - Improve steam plant efficiency
  - Reduce auxiliary loads
- **Less Carbon-Intensive Fuels**
  - Gas co-firing or reburn
  - Gas conversion
  - Cofiring of biomass or biomass conversion/repower
- **CCS**
  - Unlikely to play a significant role

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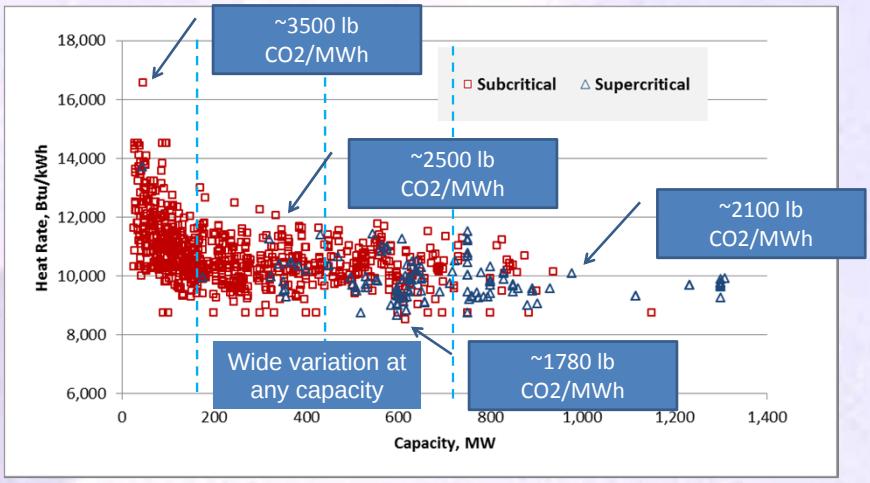
Digging into the data on Heat Rates for Existing Coal Units (NEEDS v4.10)



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Digging into the data on Heat Rates for Coal Units

- Important factors
  - Capacity, especially below 200 MW
  - Steam pressure for small, subcritical units
  - Steam cycle – but the lowest HR units are subcritical!
  - Fuel type, CFB versus PC, etc.
- Not so important factors
  - APC equipment (best units get scrubbers)
- Missing data from EIA submittals
  - Steam temp/pressure, cooling water temp

Examples of Methods for HR Improvement

(not an exhaustive list, to be sure)

- Coal Drying (esp., lignite coals)
- Variable Speed Drives
- Centrifugal to Axial fan conversion
- Steam turbine modifications
- Intelligent soot-blowing system
- New APH seals
- Repair boiler casing and duct in-leakage
- Condenser cleaning

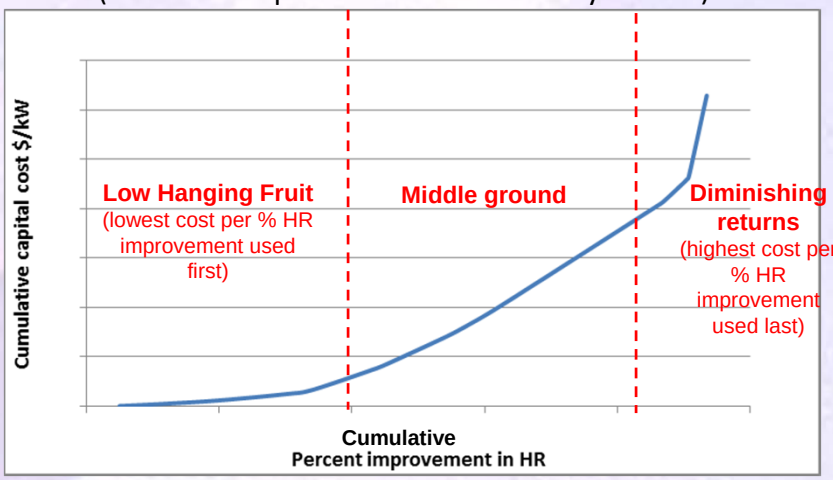
Capital improvements

Maintenance

Capital cost versus HR improvement

lowest cost per percent improvement applied first

(curve developed from 2009 S&L study for EPA)



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Staudt's three categories of units – HR improvement potential

- Flagships
  - Little or no low hanging fruit
  - A few middle ground opportunities
  - Mostly left with higher cost opportunities
- Old Clunkers
  - Lots of low hanging fruit, but . . .
  - Might be a candidate for retirement on economic grounds
  - If worth keeping around, might be well suited for a gas conversion
- Rest of the fleet
  - More variability in what may be feasible
  - Typically some, but probably not a lot of low hanging fruit
  - Varying degrees of middle cost improvements
  - Higher cost opportunities

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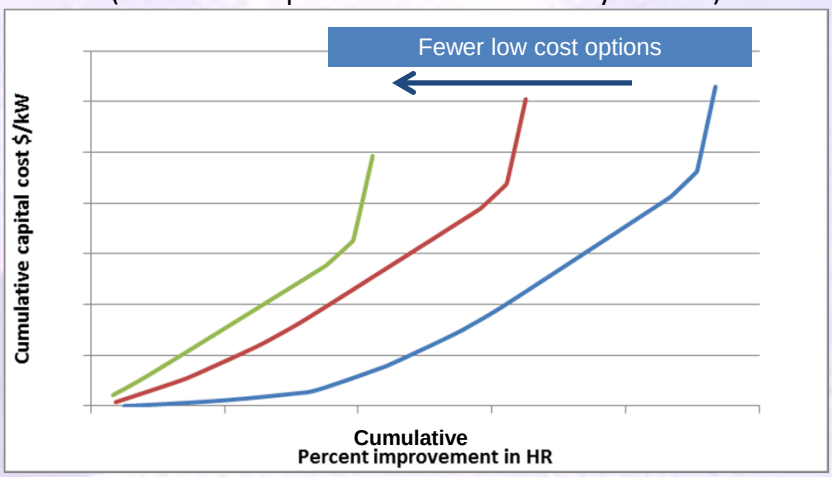
Cost versus improvement

lowest cost per percent improvement first

(curve developed from 2009 S&L study for EPA)



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Questions on Heat Rate Improvement

- Will a HR improvement provide a positive ROI?
- What is the current condition of the unit?
  - For some units may be little opportunity for further improvement, or may not be worth the investment
- What is the planning horizon?
- NSR trigger?
- What is the economic environment?
  - merchant versus utility
  - investor owned versus co-op versus government owned
  - local power market dynamics
  - company budget constraints

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Gas Conversion/Cofiring/Reburn

- **Conversion** (convert to 100% gas)
  - Being pursued by several utilities
  - Capital cost ~$80/kW (with gas on site)
  - *Gives the owner options*
- **Cofiring/Reburning** (10-15% gas)
  - Modest cost (somewhat higher for reburn), assuming gas is on site
  - Reburning may allow for additional NOx reduction

Biomass

- **Co-firing ***
  - Pulverized Coal ~$500-600/kW
  - Cyclone ~$300-400/kW
- **Repower**
  - PC to biomass fired CFB
    - (50 MW Schiller) $1600-1700/kW**

* Renewable Energy Technical Assessment Guide—TAG-RE: 2006. EPRI, Palo Alto, CA: 2007. 1012722 and escalated to 2012 dollars
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Improving HR is also possible for Gas Turbines!

- Compressor inlet modifications (guide vanes, etc.)
- Inlet Air Cooling
- Combustor upgrades
- Hot section coatings
- New seals
- Most of these will increase turbine output!

Recap

- Most likely options for existing coal to reduce CO_2 emissions are heat rate improvement or lower carbon fuel
  - No “one size fits all” solution
  - Best choice determined by several factors
  - CCS not expected to play a significant role
- Options for HR improvement exist for gas turbines as well
  - May also increase power output
- Methods that are low in capital and offer optionality will be preferred.

Thank you!

- For questions:
  - Email: staudt@AndoverTechnology.com
  - Phone: 978-683-9599
- More info at: www.AndoverTechnology.com