ELECTRIC POWER RESEARCH INSTITUTE

Evaluation of Steam Cycle Upgrades to Improve the Competitiveness of US Coal Power Plants

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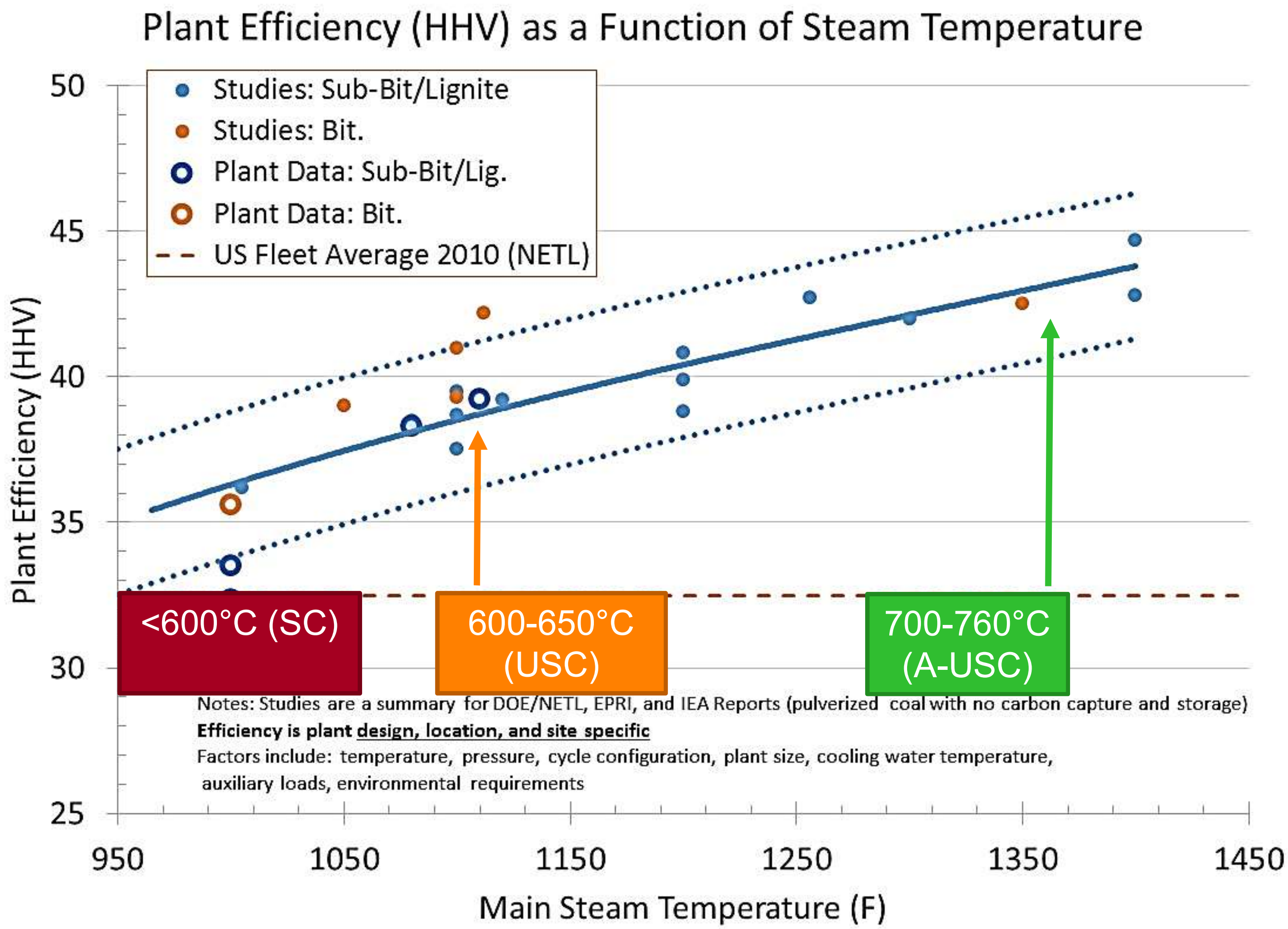
Background – Strategy

- Reduce coal consumption of existing utility fleet by decreasing heat rate, via increase in steam cycle efficiency
- Upgrade steam temperature for higher cycle efficiency
  – Average efficiency of US coal-fired fleet = 33% HHV
  – Efficiency increases to 41.4% HHV at 1,350°F steam temperature
- Advanced Ultra-supercritical (A-USC) steam conditions
- Employ advanced high-temperature materials
  – Result of DOE-funded materials R&D
- Expect higher capacity factor from increased plant efficiency

Motivation for A-USC Coal-Fired Power Plants



Background – Challenges for A-USC Technology

- Greenfield A-USC steam plants may not be cost effective
  - Conventional USC (1100°F or 593°C) power plants use lower cost materials
- A-USC retrofits may be more cost effective option
  - Significant reuse of existing equipment – decreased capital cost
  - Increase only steam temperature – not steam pressure
    - Limit the scope of equipment replacement
      - Superheater and reheater panels
      - Steam turbine
      - Piping between the superheater/reheater and steam turbine

Technical Approach - Summary

- Maximize the applicability of the study results to existing fleet
  - 300+ units with 2,400 psia (16.6 MPa) main steam (subcritical)
  - 100+ unit with 3,500 psia (24.1 MPa) main steam (supercritical)
- Insure that results reflect actual situations in US fleet
  - Data from existing operating units supplied by Southern Company
- Employ an experienced technical team that has worked together on prior DOE-funded AUSC project (ComTest)

Technical Approach – Upgrade Cases Planned

Case Name	Main Steam Pressure	Main Steam Temp.	Reheat Steam Temp.
Subcritical Base Case	2400 psi (16.6 MPa)	1000°F (538°C)	1000°F (538°C)
Subcritical USC Option	2400 psi (16.6 MPa)	1100°F (593°C)	1100°F (593°C)
Subcritical A-USC Option 1	2400 psi (16.6 MPa)	1200°F (649°C)	1200°F (649°C)
Subcritical A-USC Option 2	2400 psi (16.6 MPa)	1000°F (538°C)	1350°F (732°C)
Subcritical A-USC Option 3	2400 psi (16.6 MPa)	1350°F (732°C)	1350°F (732°C)
Supercritical Base Case	3500 psi (24.1 MPa)	1000°F (538°C)	1000°F (538°C)
Supercritical USC Option	3500 psi (24.1 MPa)	1100°F (593°C)	1100°F (593°C)
Supercritical A-USC Option 1	3500 psi (24.1 MPa)	1200°F (649°C)	1200°F (649°C)
Supercritical A-USC Option 2	3500 psi (24.1 MPa)	1000°F (538°C)	1350°F (732°C)
Supercritical A-USC Option 3	3500 psi (24.1 MPa)	1350°F (732°C)	1350°F (732°C)
Supercritical A-USC Molten Salt	3500 psi (24.1 MPa)	1350°F (732°C)	1350°F (732°C)

Project Objectives

- Technical and economic feasibility of steam cycle upgrades to typical U.S. pulverized coal power plants
  - Subcritical: 2300–2600 psi (16.6–17.9 MPa)
  - Supercritical: 3400–3600 psi (23.4–24.8 MPa)
- Maintain steam pressures at their original values, and increase main and reheat temperatures from 1000°F (538°C)
  - USC (i.e., 1100°F or 593°C)
  - A-USC conditions (≥1300° or 704°C)

Improve heat rate while minimizing power plant modifications

Project Structure - Tasks

- 1 Project management and planning
- 2 Evaluation of technical feasibility
  - 2.1 Thermodynamic performance models of base case at full load
  - 2.2 Impact of upgrades to base cases at full load
  - 2.3 Part load performance for flexible operation scenarios
  - 2.4 Dynamic modeling of system for fluid circulation
- 3 Unit dispatch modeling (EPRI's US-REGEN model) to 2050
- 4 Capital cost estimation to AACE Class III (+/-30%)
- 5 Overall economic evaluation

Project Structure – Team

Team Member	Funder	Role
US DOE NETL	✓	Funder
EPRI	✓	Lead Organization, Ecomomic Evaluation, Unit Dispatch Model
GE / Alstom Power	✓	Boiler and Steam Turbine Costs, Dynamic Modeling
AECOM (EPC)		Blance of Plant Costs
Hendrix Engineering		Thermodynamic Performance, Modeling & Analysis Calculations

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