

Advanced Pulverized Coal Combustion

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ABSTRACT

The mission of the Advanced Pulverized Coal Combustion product line is to develop very clean, efficient, and affordable power generating system technologies, based on coal firing, for application to new plants and to improve existing plants. The current program scope includes the development of the Low Emission Boiler System (LEBS), a highly advanced pulverized coal-fired power plant, and High Performance Power Systems (HIPPS), highly efficient systems based on the indirectly fired combined cycle.

LEBS uses a low-NO_x slagging combustion system that has been shown in pilot-scale tests to emit less than 0.2 lb/10⁶ Btu of NO_x. Additional NO_x removal can be provided by a moving bed copper oxide flue gas cleanup system, which also removes 97-99% of sulfur oxides. If needed, stack levels of NO_x can be reduced to below 0.02 lb/10⁶ Btu. Construction of an 80 MWe LEBS proof-of-concept plant is scheduled to begin in the spring of 1999.

Engineering development of two different HIPPS configurations is continuing. Recent tests of a radiant air heater, a key component of HIPPS, have indicated the soundness of the design for air temperatures to 2000°F. LEBS and HIPPS applications include both new power plants and repowering/upgrading existing plants.

About half of the electricity in the U.S. and about a third worldwide is generated with coal, and most coal plants use pulverized coal combustion. Hence, there is a substantial investment in infrastructure for this technology. A need exists for advances in pulverized coal combustion technology that would improve the performance of existing plants. Also needed is technology that would allow new coal-based plants to compete with gas-fired combined-cycles. Research and development opportunities include the development of advanced materials that would permit higher plant efficiencies, combustion controls for lower NO_x, "opportunity" fuels cofiring, improved control system technology, more efficient alternative cycles, and capital cost reduction.

The status of LEBS and HIPPS will be discussed along with several R&D opportunities, with emphasis on improved materials for higher plant efficiency.



Advanced Pulverized Coal Combustion

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Advanced Pulverized Coal Combustion

Mission

- To develop very clean, efficient, affordable electric power generating system technologies, based on coal firing, for application to new plants and to improve existing plants.

Advanced Pulverized Coal Combustion *Program Scope*

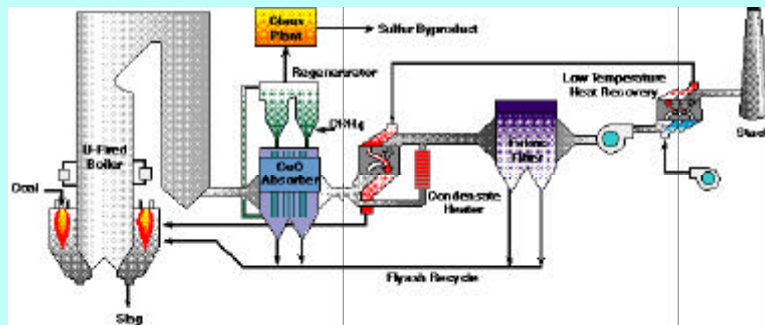
LEBS: highly advanced pulverized coal-fired power plant

HIPPS: high efficiency, indirectly fired combined cycle

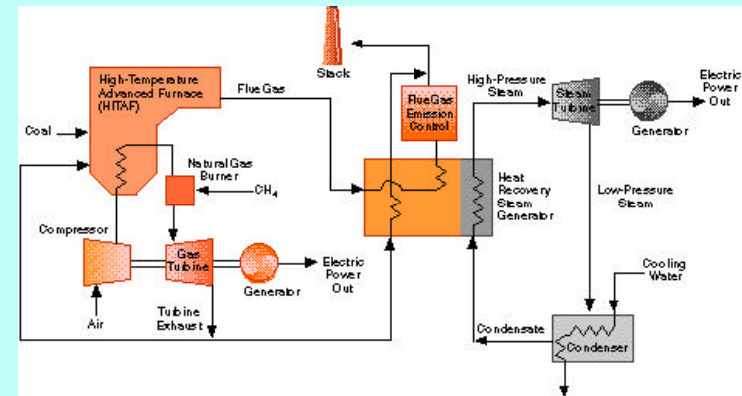
Participants: team approach, DB Riley, FW, UTRC, FETC R&D, Nat'l. Labs

Applications: new plants, repowering, Vision 21

LEBS



HIPPS



LEBS and HIPPS Performance/Cost Objectives

	Conventional PC Plant	2000 LEBS	2005 HIPPS	2010 HIPPS
Thermal Efficiency, net, hhv (%)	35	42-45	47-50	55+
Emissions (lb/10 ⁶ Btu)				
SO ₂	0.6	0.1	0.06	0.06
NOx	0.6	0.1	0.06	0.06
pm	0.03	0.01	0.003	0.003
Cost-of -Electricity (conv. plant = 100)	100	90	85	80

LEBS Program

■ DB Riley Team Selected for Proof-of-Concept

- new 80 MWe plant at Elkhart, IL, adjacent to Turris Coal Company mine
- low-NOx U-firing, slag by-product, and regenerable CuO - SO₂/NOx capture
- Sargent&Lundy, Thermopower, Reaction Engineering International, University of Utah, Southern Illinois University, AEP Resources, Zeigler Coal, Illinois Dept. Commerce & Community Affairs

■ Project Financing Focus of FY98 Activities

- \$127 million total project cost with DOE share \$34 million
- power purchase agreement being developed
- state and private funding to be confirmed

■ Commercialization to Provide Substantial Benefits

- 42% efficiency cuts CO₂ emissions 20% compared to typical coal-fired plants
- SO₂, NOx emissions 1/6th of current allowable (NSPS) levels, or lower if needed
- sales of vitreous granulate slag and ammonium sulfate fertilizer
- LEBS ready for new plant market in developing countries, retrofit market in U.S.

HIPPS Program

■ HIPPS Adaptable to Many Applications

- unique advantages: no oxygen plant, no hot gas cleanup, fuel flexible
- efficiency 47-50% for 1st gen.; 55%+ for advanced; NO_x/SO₂ 10% NSPS or lower
- applicable to new plants or repowering and key subsystem for energyplexes

■ Advances in Combustion/Heat Transfer/Materials

- UT and FW teams developing high-temp. furnace and coal pyrolyzer/char burner
- successful test of UT 2000°F coal-fired radiant air heater
- FETC in-house R&D on ash/slag properties, slag screen design, materials life

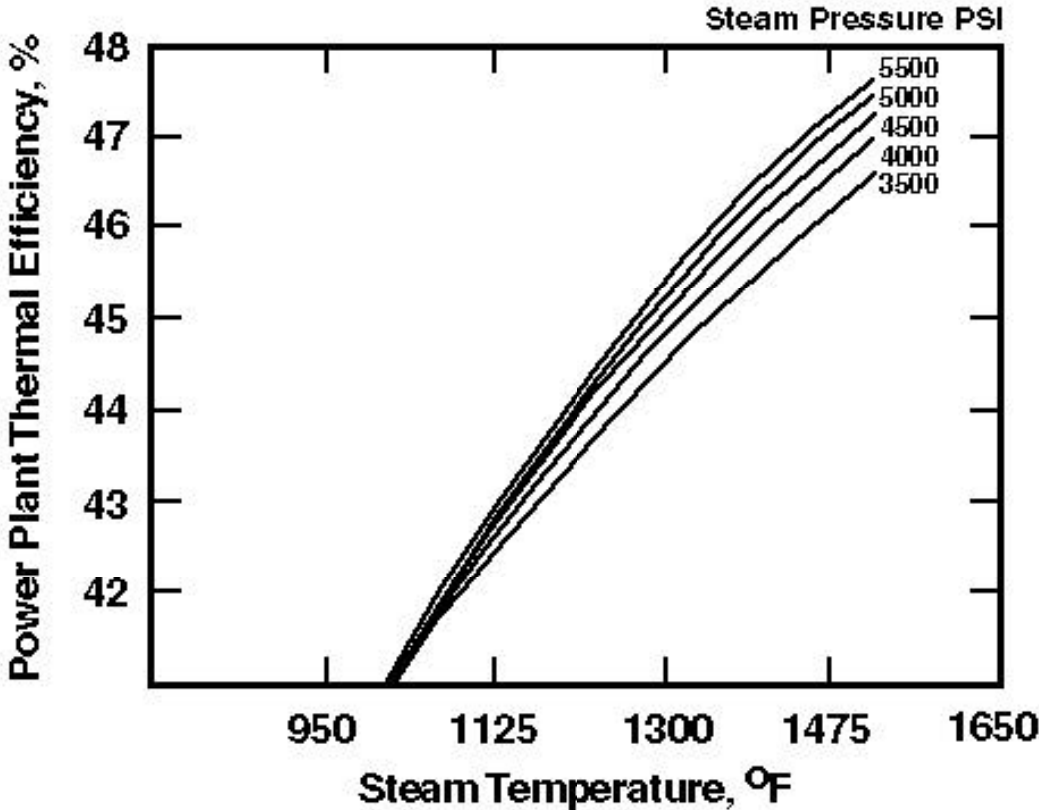
■ Program Refocused to Meet Changing Needs

- emphasize technology and components that support Vision 21
- HIPPS systems development effort extended two years
- GOAL: designs for large commercial plants, prototype plants, and repowering

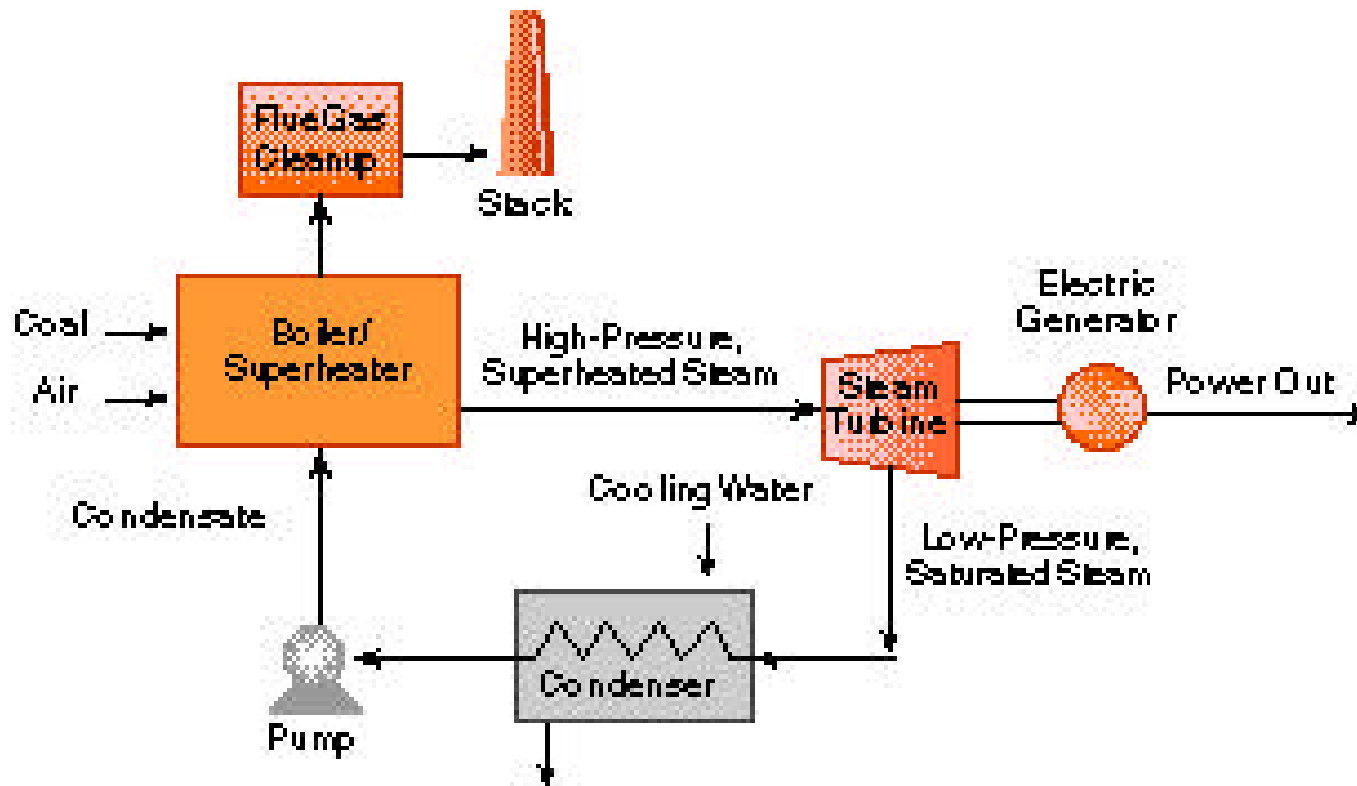
Advanced Pulverized Coal Combustion *Opportunities*

- advanced materials for higher efficiency
- combustion controls for lower NO_x
- “opportunity” fuels cofiring
- advanced control system technology
- alternative cycles
- capital cost reduction
- Vision 21

Effect of Steam Temperature and Pressure on the Thermal Efficiency of Steam Cycle Power Plants



Coal-Fired Steam Cycle Power Plant



Operating Conditions for Materials in Steam Power Plants

Application	Environment	Temperature, °F		Pressure, psi	
		Conventional Plant	Advanced Plant	Conventional Plant	Advanced Plant
boiler superheater, reheater tubes	flue gas, steam	1070-1120	1170-1380+	2400	3500-6000
steam turbine blades, rotors	steam	1000-1050	1100-1300+	2400	3500-6000
headers, piping	steam	800-1050	800-1300+	2400	3500-6000
furnace waterwalls	flue gas, steam, water	840	1020-1110	2400	3500-6000

Materials Issues for Advanced Coal-Fired Boilers/Furnaces

- **Mechanical strength at temperature**
- **Resistance to environmental attack**
- **Ease of fabrication**
- **Weldability**
- **Thermal conductivity**
- **Cost**

Materials Needs for High Efficiency Coal-Fired Power Plants

- **Design information for coal combustion environments**
 - Alloys with adequate high-temperature strength available but corrosion resistance uncertain
- **High-temperature alloys and ceramics for air heaters used in indirectly fired cycles**
- **New materials engineered for coal combustion service**

Advanced Pulverized Coal Combustion

Summary

- **Substantial Advances in Power Plant Technology**
 - LEBS U-firing reduces NO_x 80% by combustion modification
 - NO_x levels with copper oxide cleanup approach natural gas firing
 - granular slag by-product preferable to flyash
 - salable products from coal sulfur
 - successful tests of **HIPPS** 2000°F radiant air heater
- **LEBS Moving Towards Commercialization**
 - POC groundbreaking next spring
 - high industry awareness
- **Solid Opportunities for LEBS and HIPPS Applications**
 - new plants in developing countries: China, India, east-central Europe
 - U.S. market for upgrading/expanding existing plants
 - future, clean, high efficiency U.S. plants