CO_2 reduction through Energy Efficiency in Coal Fired Boilers

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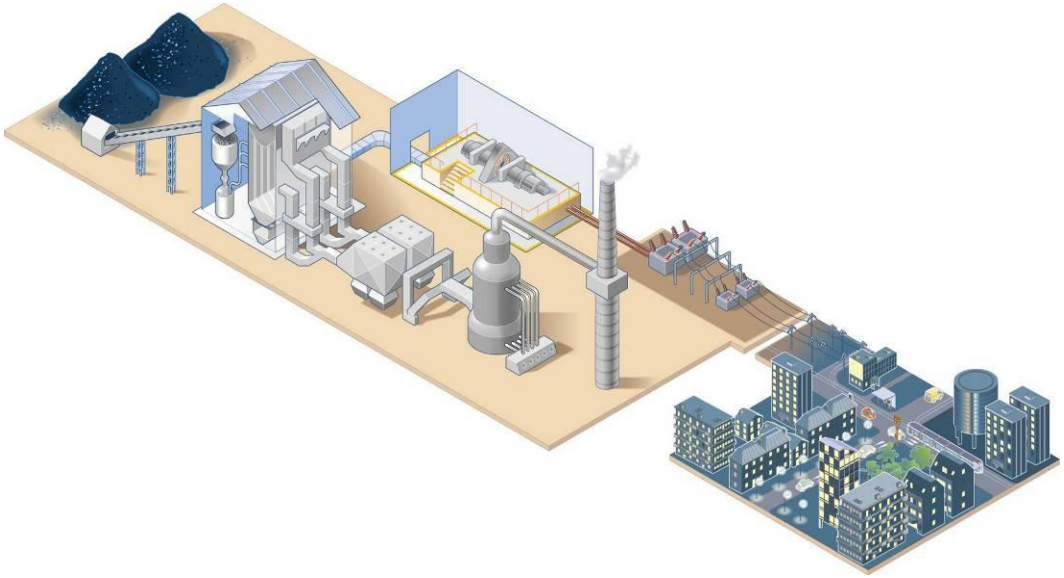
Today's Coal Power Plant Market Reality

- Drive to zero emissions for coal power plants
  - Water
  - Gas
  - Combustion Residues
- Older, less efficient coal fired units shut down
- Surviving units struggle to
  - Optimize position on the dispatch curve
  - Keep pace with regulatory changes on water, air, and Combustion residues
  - Minimize impact of potential Carbon taxes or efficiency legislation



US Boiler CO_2 production intrinsically related to coal mining

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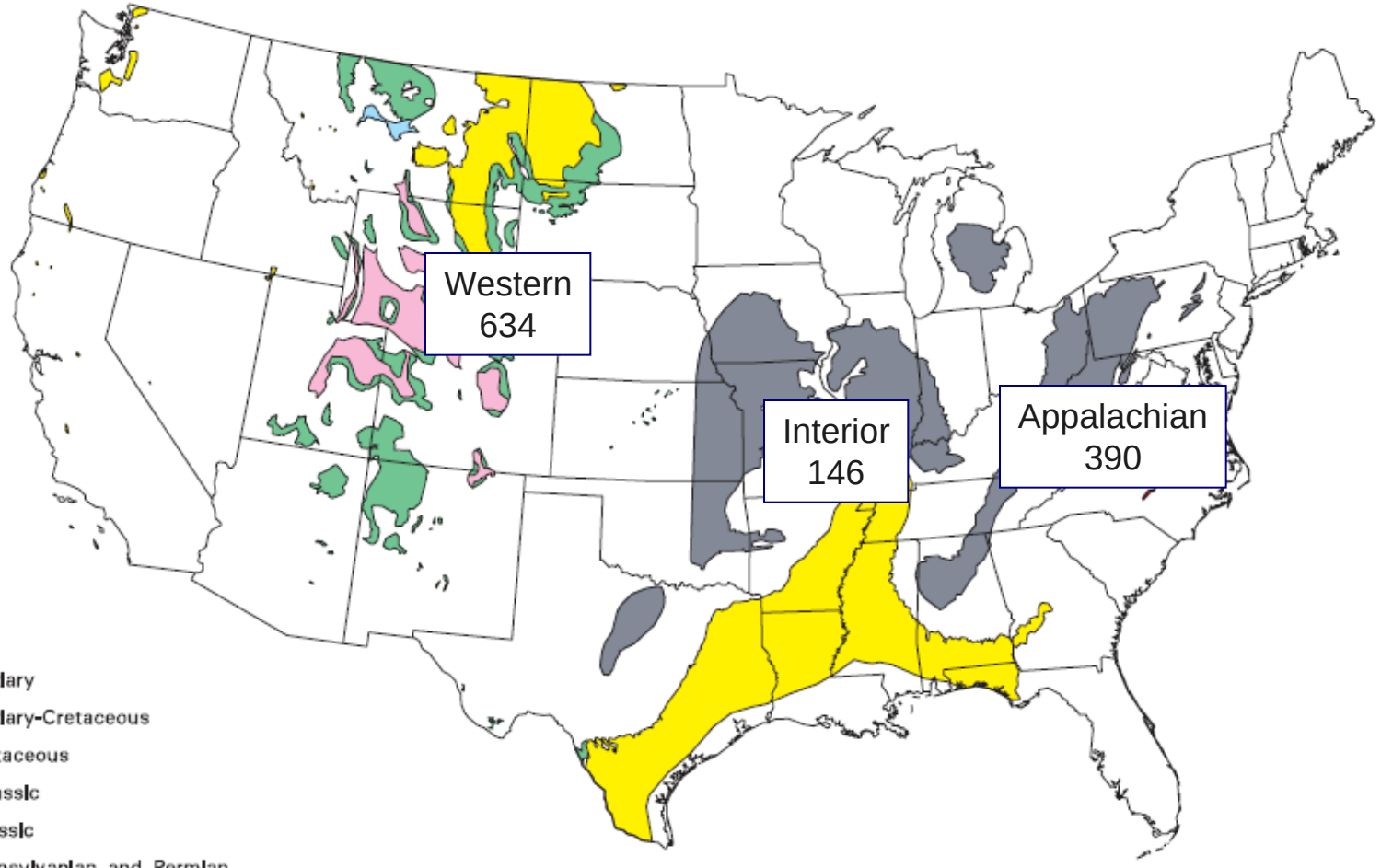
US coal **1.171.809** million Short Tons

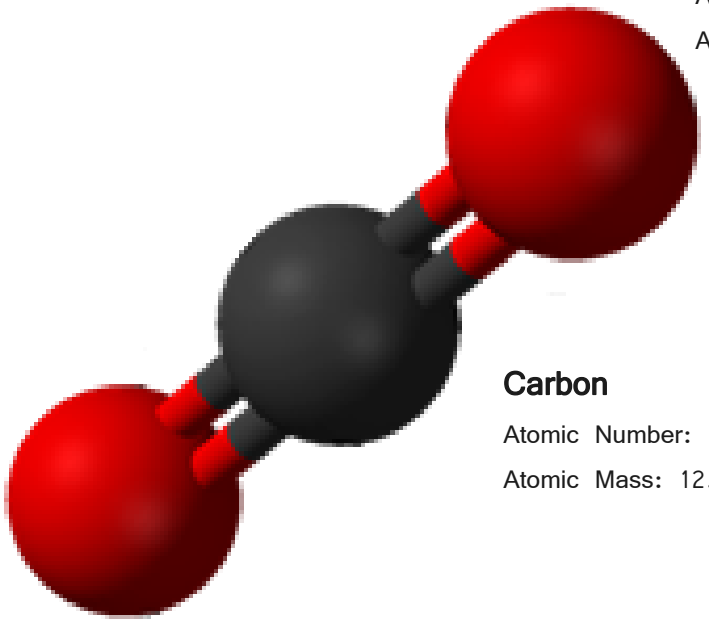


1 Ton of Coal = 3.7 Tons of CO2

Oxygen

Atomic Number: 8

Atomic Mass: 15.9994 amu



Carbon

Atomic Number: 6

Atomic Mass: 12.0107 amu

Oxygen

Atomic Number: 8

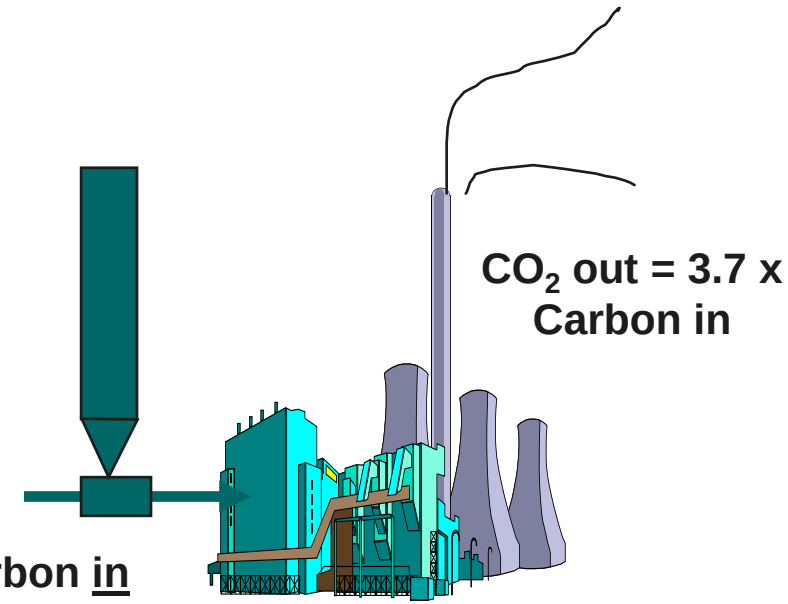
Atomic Mass: 15.9994 amu

Wt Ratio = (12+32)/12)=3.7

US Coal Plants 2008 CO2 Data
Weighting typical ultimate values

Coal Source	Fixed Carbon (%)	Higher Heating Value (Btu/lb)	Coal Fired in Utility Boilers (Million Tons)	Carbon Fired (Million Tons)	CO2 produced (Million Tons)	Heat Produced (Million Btu's)
Western	47%	8000	565.5	263.0	964.2	9.0E+09
Appalachian	77%	13650	347.9	266.5	977.0	9.5E+09
Interior	62%	11200	130.2	80.2	294.1	2.9E+09
Total			1043.6	609.6	2235.3	2.1E+10

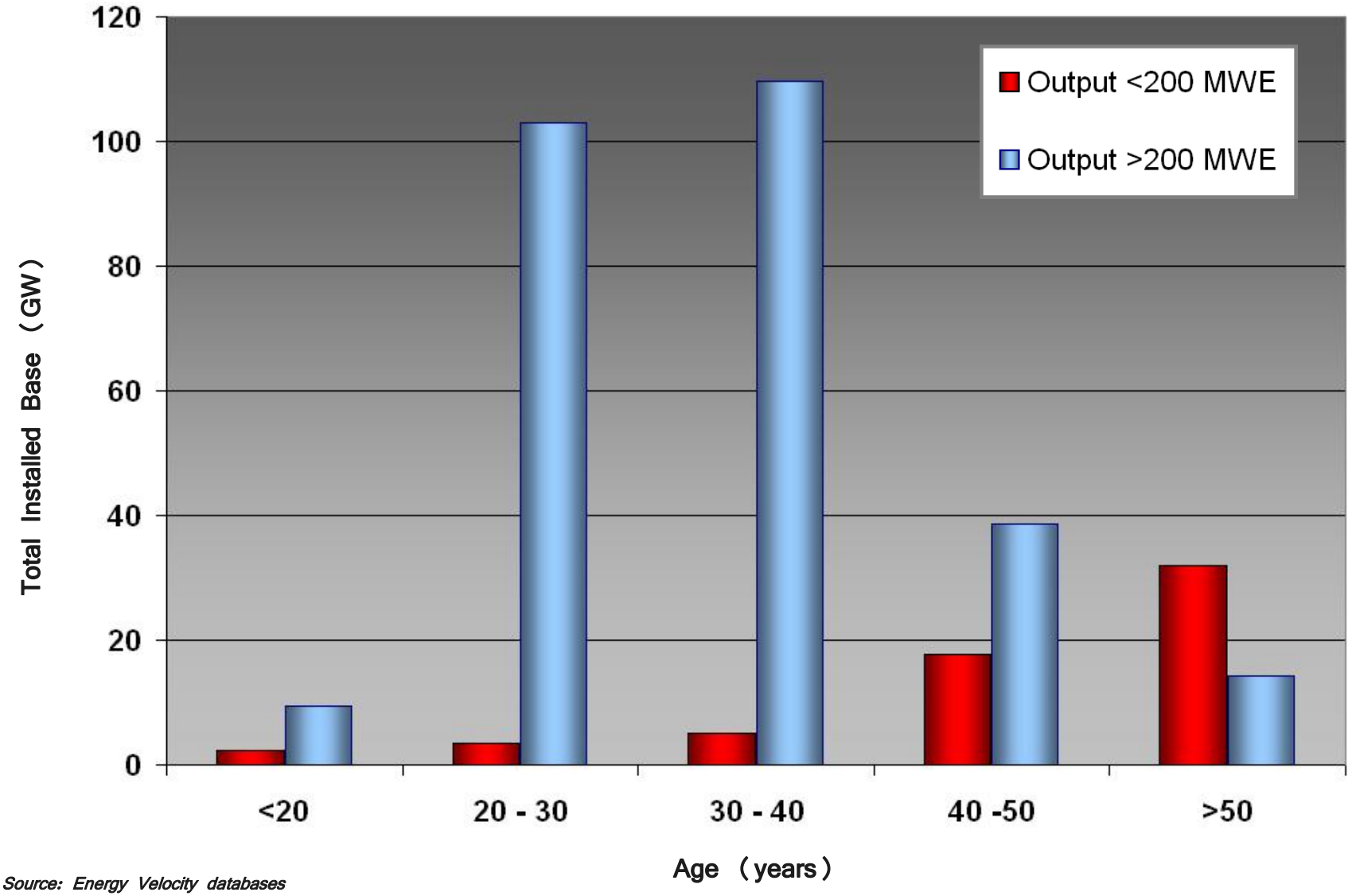
US Electricity Production	2.0E+12	KW-hr
US CO2 Production	2.1E+09	Tons
US Coal Thermal Energy	2.1E+16	BTU
Net Plant Heat Rate	10,761	BTU/kw-hr
Overall Efficiency	31.71	%
CO2 Conversion Rate	0.10	Ton CO2/MMBTU
CO2 Efficiency	2.15	lbs/kwhr



Source: US EIA and Alstom Fuel databases.

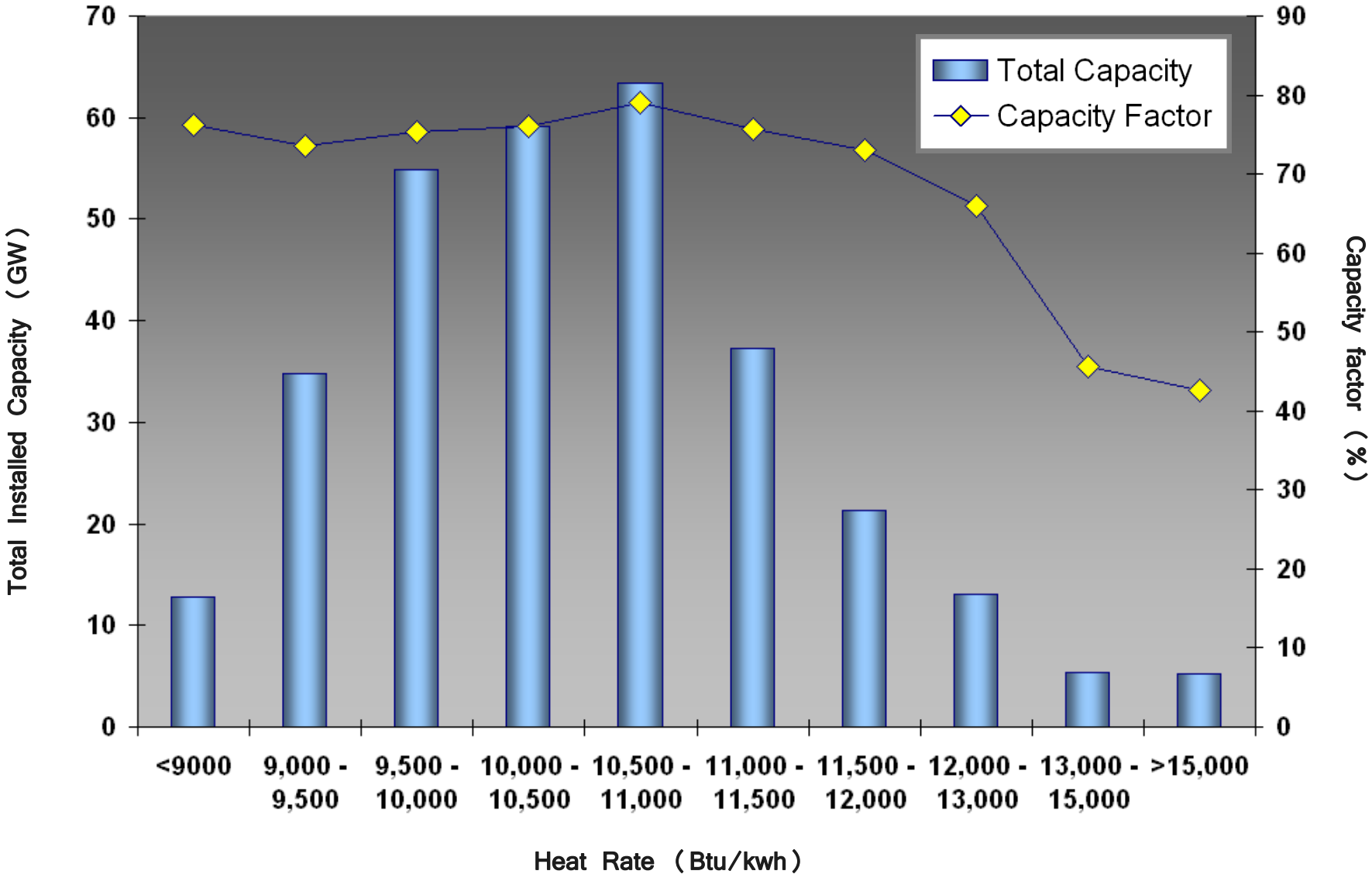
CO2 in top table from fuell analysis CO2 in lower table from eia

US Coal Power Plants
Installed Base (GW) vs Age (years)

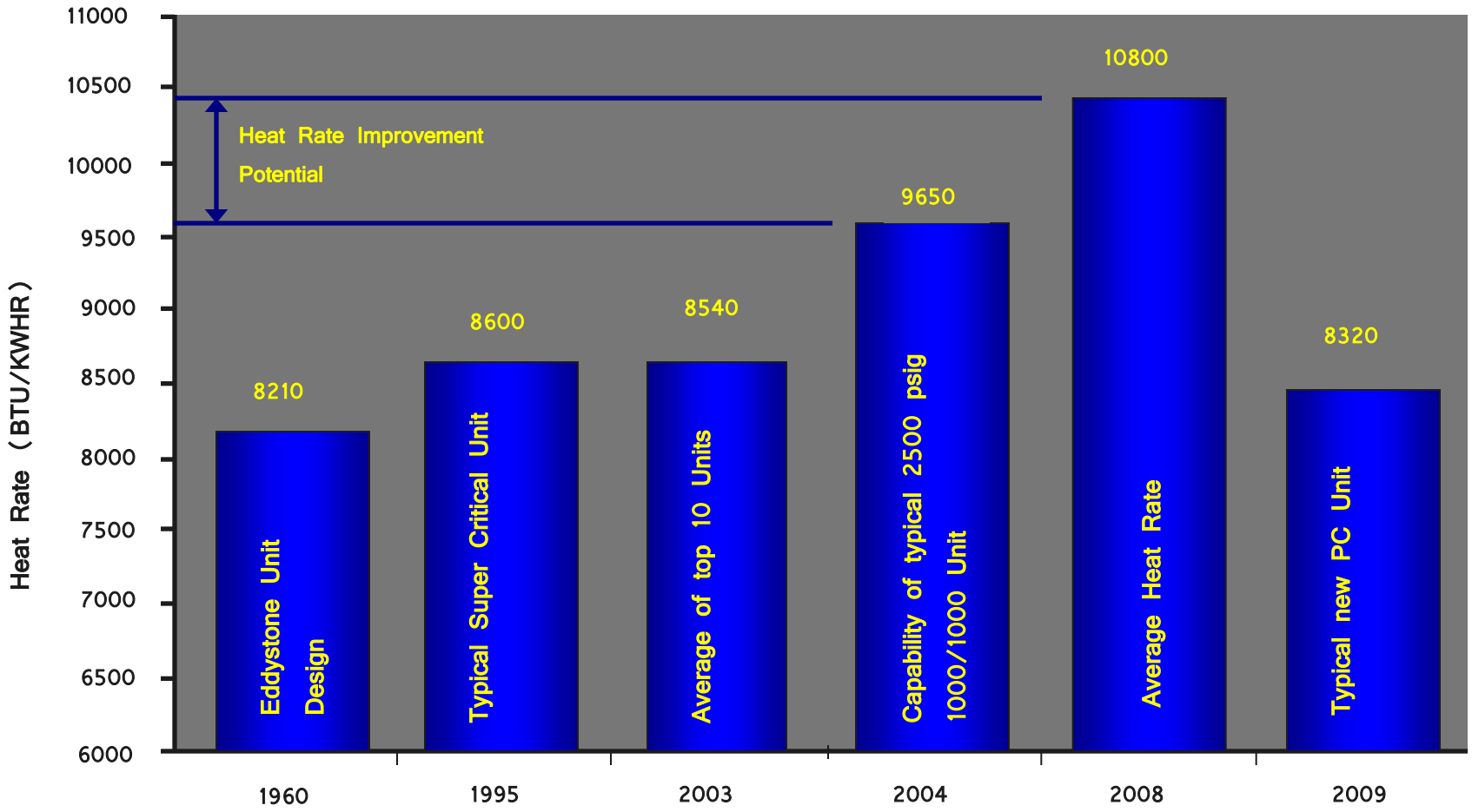


Source: Energy Velocity databases

Coal Power Plant
Installed GW and Capacity Factor vs Heat Rate



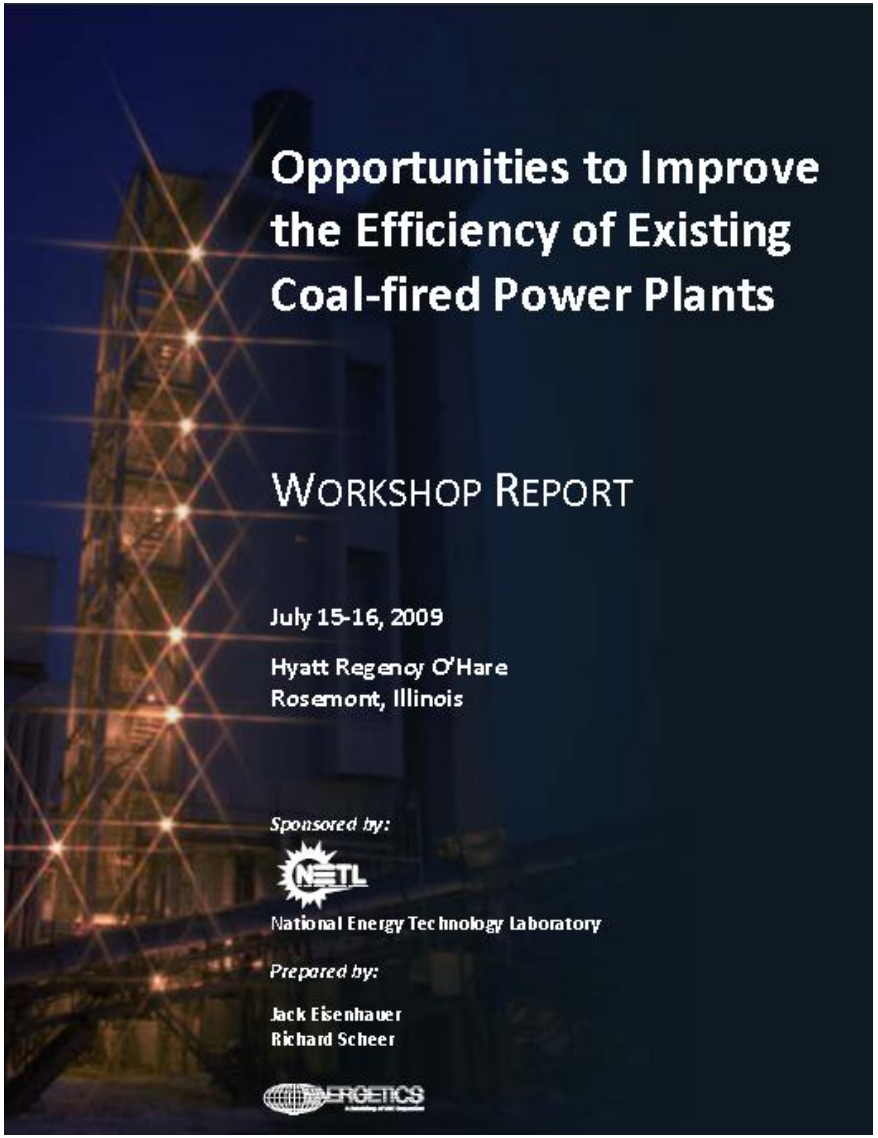
Heat Rate Capability



National Energy Technology Laboratory (NETL) Efficiency Analysis

- "The analysis of U.S. fleet of coal-fired power plants shows a wide variation in efficiency levels but the basic message is that these levels have been largely stagnant for decades and that there is "headroom" for efficiency improvements among all plants including those that currently operate at below average, average, and above average efficiency levels. "

- Claim 10% improvement potential



Market Challenges and Potential Issues

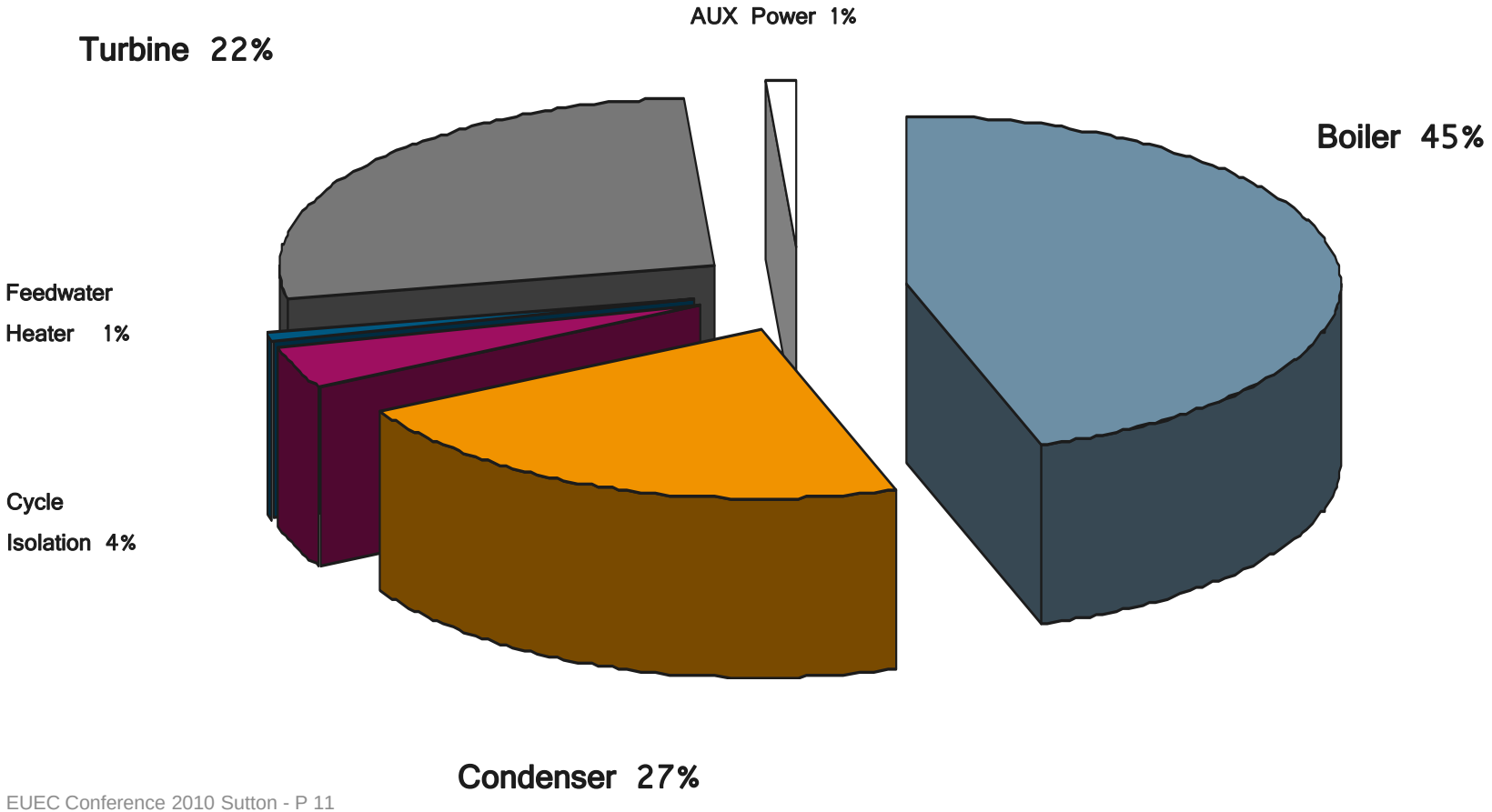
- Making changes in plants to improve efficiency is hampered by the New Source Review provisions of the Clean Air Act, which can trigger potentially lengthy and costly regulatory proceedings when capital improvements and other changes in the plant are made.

- The lack of economic incentives to address efficiency improvements due to the presence of fuel adjustment clauses in approved electricity rates that enable power companies to “pass-through” changes in fuel costs directly to customers.

- Concerns about regulatory proceedings, combined with the lack of economic incentives, make it difficult to get management commitment for power plant efficiency programs that must compete for scarce corporate capital and labor resources. At the same time, the primary aim for power plant operators is to optimize the profitability of the units and ensure they are available to serve load

Case Study: 760 MW Midwest Coal Boiler
Analysis of Energy losses

Design Heat Rate	8960 BTU/kWhr
As found Heat Rate	9602 BTU/kWhr



Case Study: 8 Units (1000MWE) low sulfur fuel conversion – Power Savings from ESP Transformers

After SIR Upgrade, Before EPOQ

Unit 4				
T/R	Size (kV/mA)	kV avg	mA avg	kW
4A1	70/800	56	579	32
4B1	70/800	57	594	34
4A2	70/800	51	743	38
4B2	70/800	51	734	37
4A3	60/1000	52	638	33
4B3	60/1000	51	793	40
4A4	60/1000	54	756	41
4B4	60/1000	50	828	41
Unit 4 Boiler Load		96.9 MW		**296 kW Total**
Total Plant Capacity		1,028 MW		
Stack Opacity		13%		
Unit 4 Coal SO_2 Content		1.5 lb SO_2/MBtu		

After SIR Upgrade, With EPOQ

Unit 4				
T/R	Size (kV/mA)	kV avg	mA avg	kW
4A1	70/800	51	238	12
4B1	70/800	51	225	11
4A2	70/800	41	294	12
4B2	70/800	39	250	10
4A3	60/1000	45	505	23
4B3	60/1000	44	482	21
4A4	60/1000	46	511	24
4B4	60/1000	38	274	10
Unit 4 Boiler Load		103 MW		**124 kW Total**
Total Plant Capacity		1,030 MW		
Stack Opacity		13.5%		
Unit 4 Coal SO_2 Content		1.0 lb SO_2/MBtu		

Case Study: 2 x 500 MW Boiler Combustion Optimization Tuning

- Reduce overall excess air levels with optimum adjustment of air introduction (7% reduction)
- Decrease cold air to Pulverizers (5% reduction)
- Increase Pulverized Coal Fineness (Before – 69% thru 200, After – 78% thru 200 mesh)
- Eliminate Leaks in Ductwork and Casing
- Alstom believes that optimizing existing equipment lowers CO_2 production by up to 0.5%

Summary

- US electric power production from coal results in more than 2,100 million Short Tons on CO_2
- Improvements in coal power plant efficiency result in a decrease in CO_2 emissions and improved power plant economics
- A 5% reduction in CO2 / KW-hr produced appears to be feasible
- Case studies showing results for both larger projects and smaller efficiency improvements confirm the concept.

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