D

Energizing

The World One BTU At A Time

Advanced Coal Technologies

Colorado Joint House and Senate Committee

Dianna Tickner
Peabody Energy
April 3, 2013

Peabody ENERGY

Attachment D

What is 21st Century Coal?

Peabody ENERGY

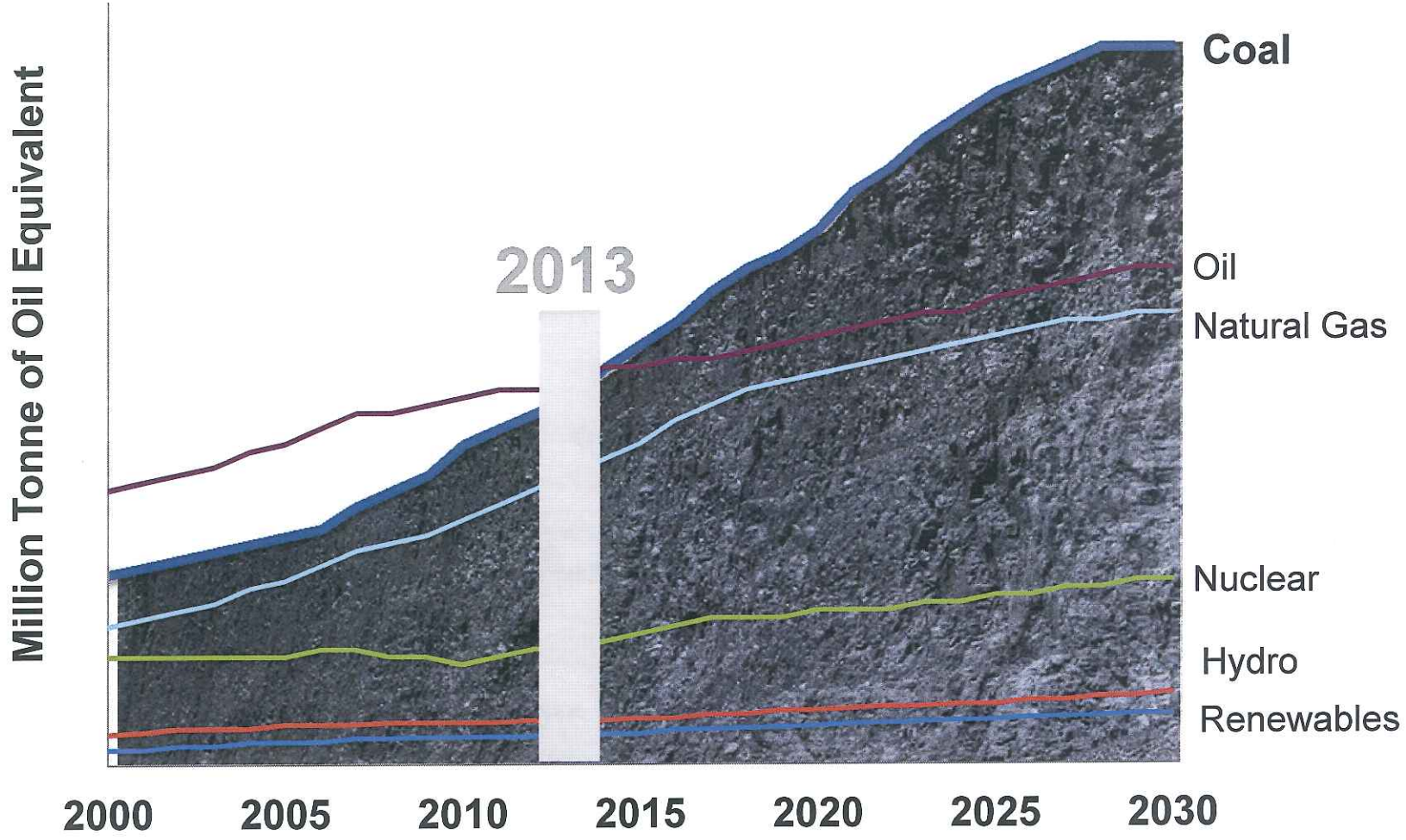
Clean Coal Defined…

- Use of modern, highly efficient methods and technology in the extraction and utilization of coal to produce valued products.
- Satisfying the desired global objective of economic sustainability, energy security, and environmental care.
- Wide scale deployment of clean coal technologies that enable the ultimate goal of continuous emission improvements leading to near-zero emissions.

Why Coal? World's Fastest Growing Energy Source, Expected to Overtake Oil

Peabody ENERGY

Total World Primary Energy Demand by Fuel

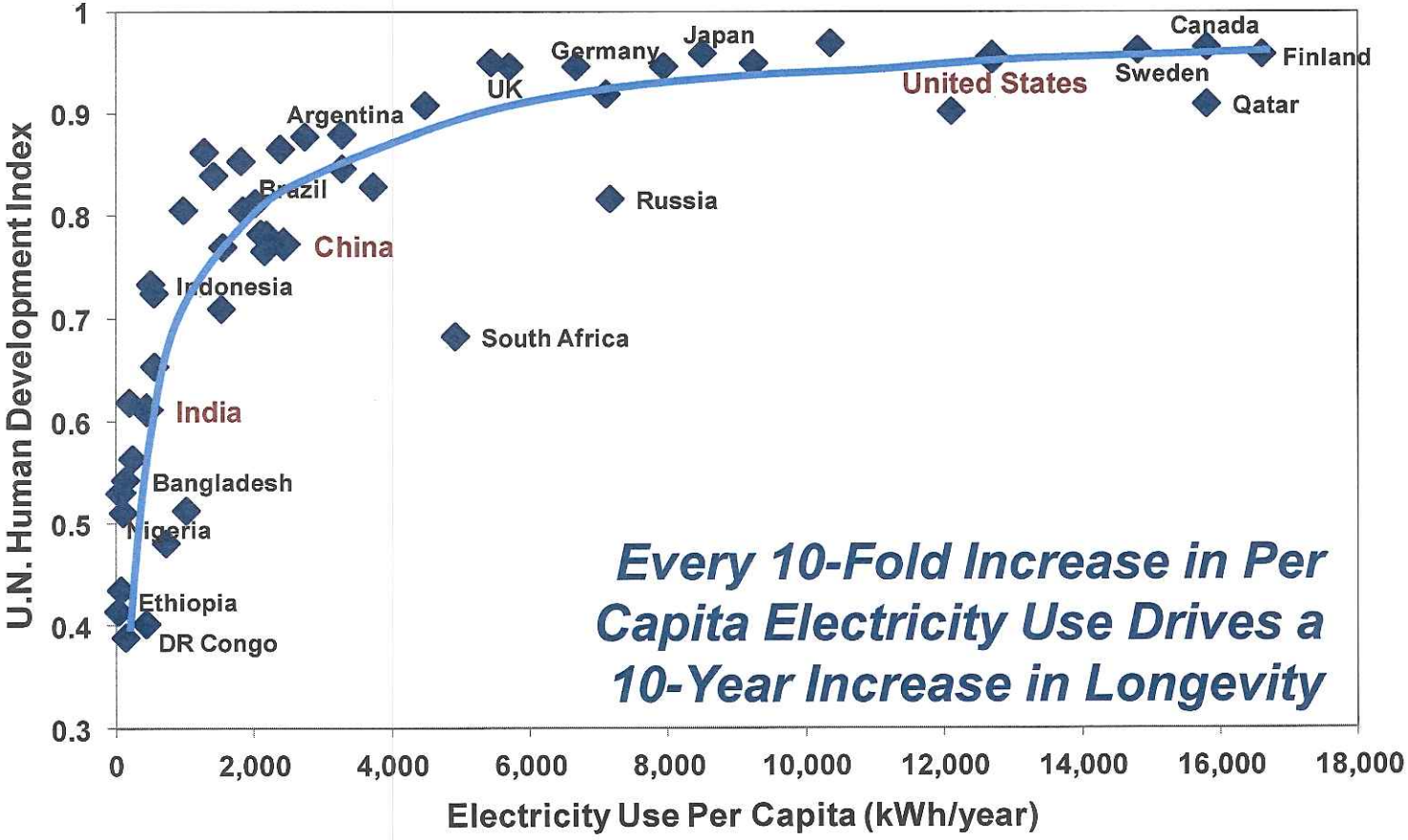


Source: Wood Mackenzie Energy Service.

Why Clean Coal?
To Improve Lives and Livelihoods

Peabody ENERGY

Affordable Electricity Enables People to Live Longer and Better

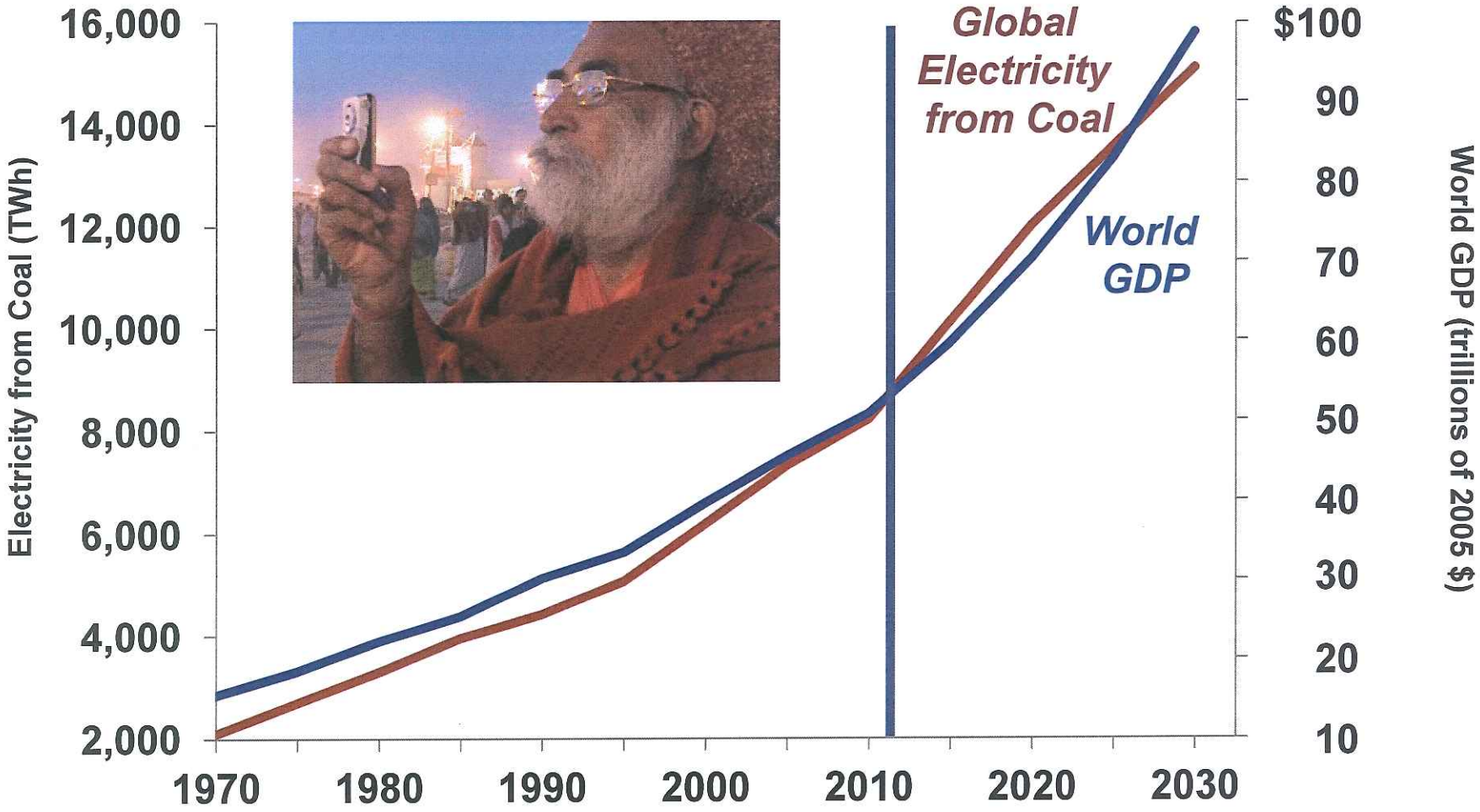


Source: CIA World Fact Book, United Nations Development Program's Human Development Report.

The Economic Miracle Powered by Coal

Peabody ENERGY

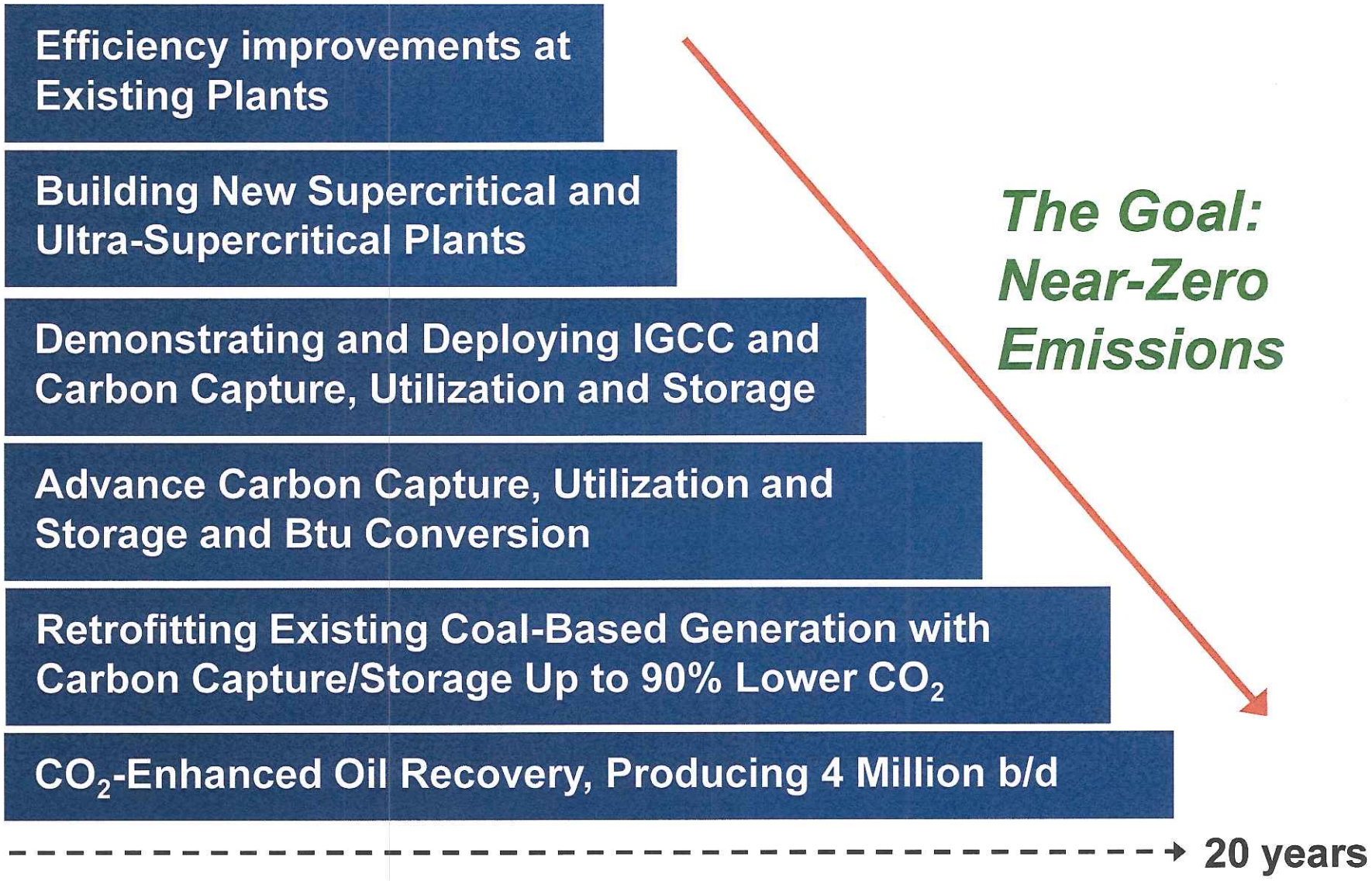
Near Perfect Correlation Between Coal Use and GDP Growth



Source: Developed from International Energy Agency World Energy **Outlook (1995-2011); USDA 2011.**

Technology is the Path to Achieve our Environmental Goals

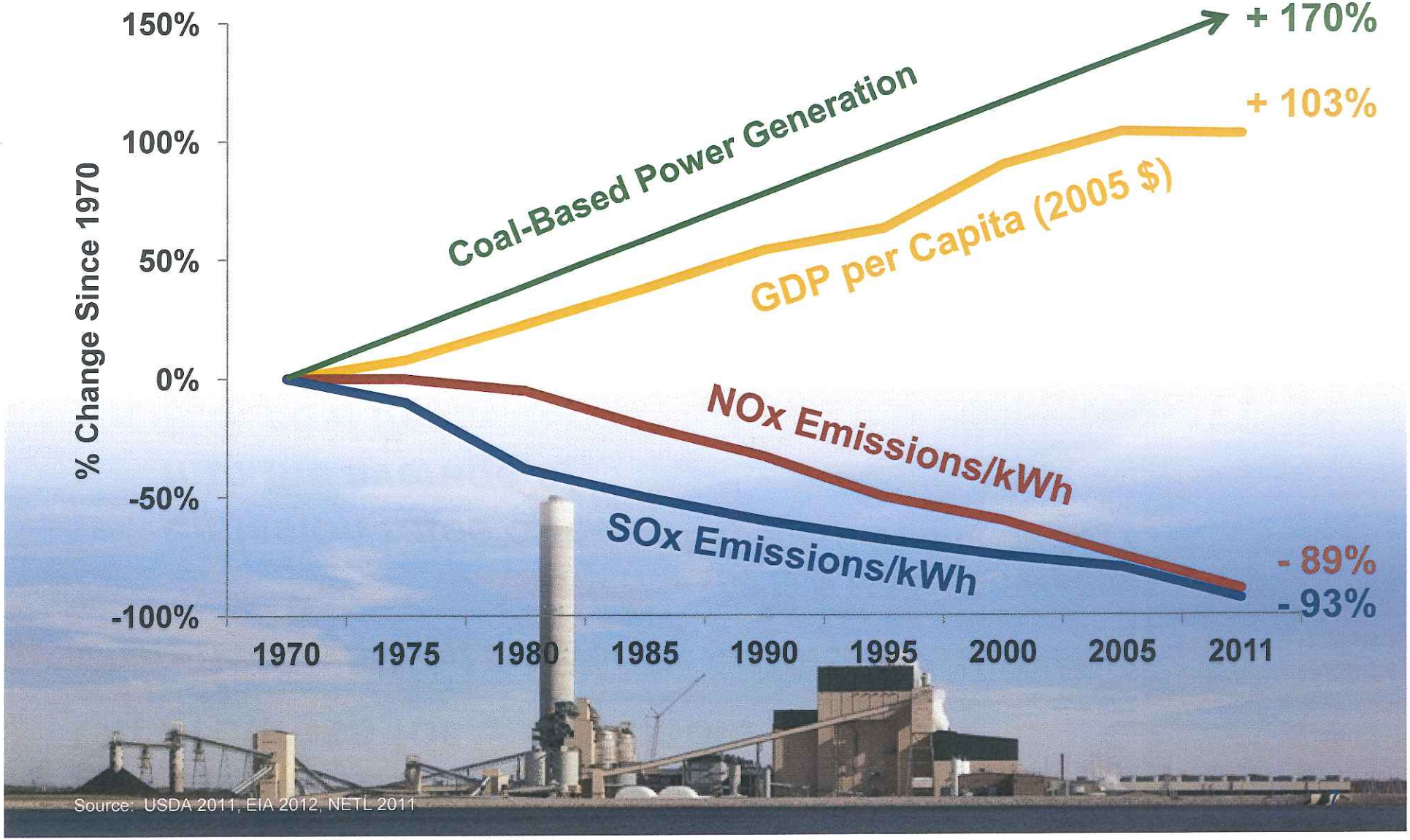
Peabody ENERGY



Clean Coal Technologies Are Environmental Success Story

Peabody ENERGY

Total Emissions Have Declined While Coal Consumption Increased



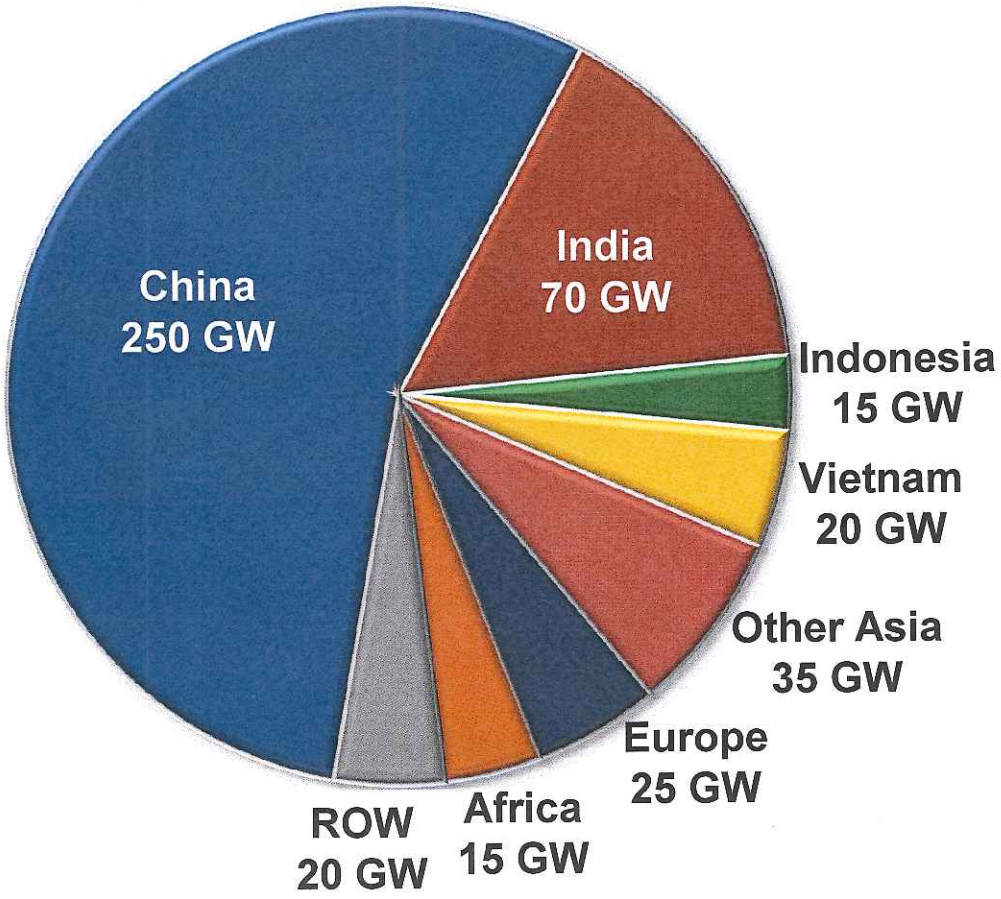
Source: USDA 2011, EIA 2012, NETL 2011

Advanced Technologies Build On Progress for Sustainable Future

China Houses 55% of the World's Advanced Coal Fleet

- ***Emission rates one-fifth the average of U.S. coal fleet…***
- ***Every 1% efficiency gain reduces lifetime emissions by 2,000 tons of NOx and SO_2 and 2.5 million tons of CO_2***

~450 GW New Generation Expected Online by 2017

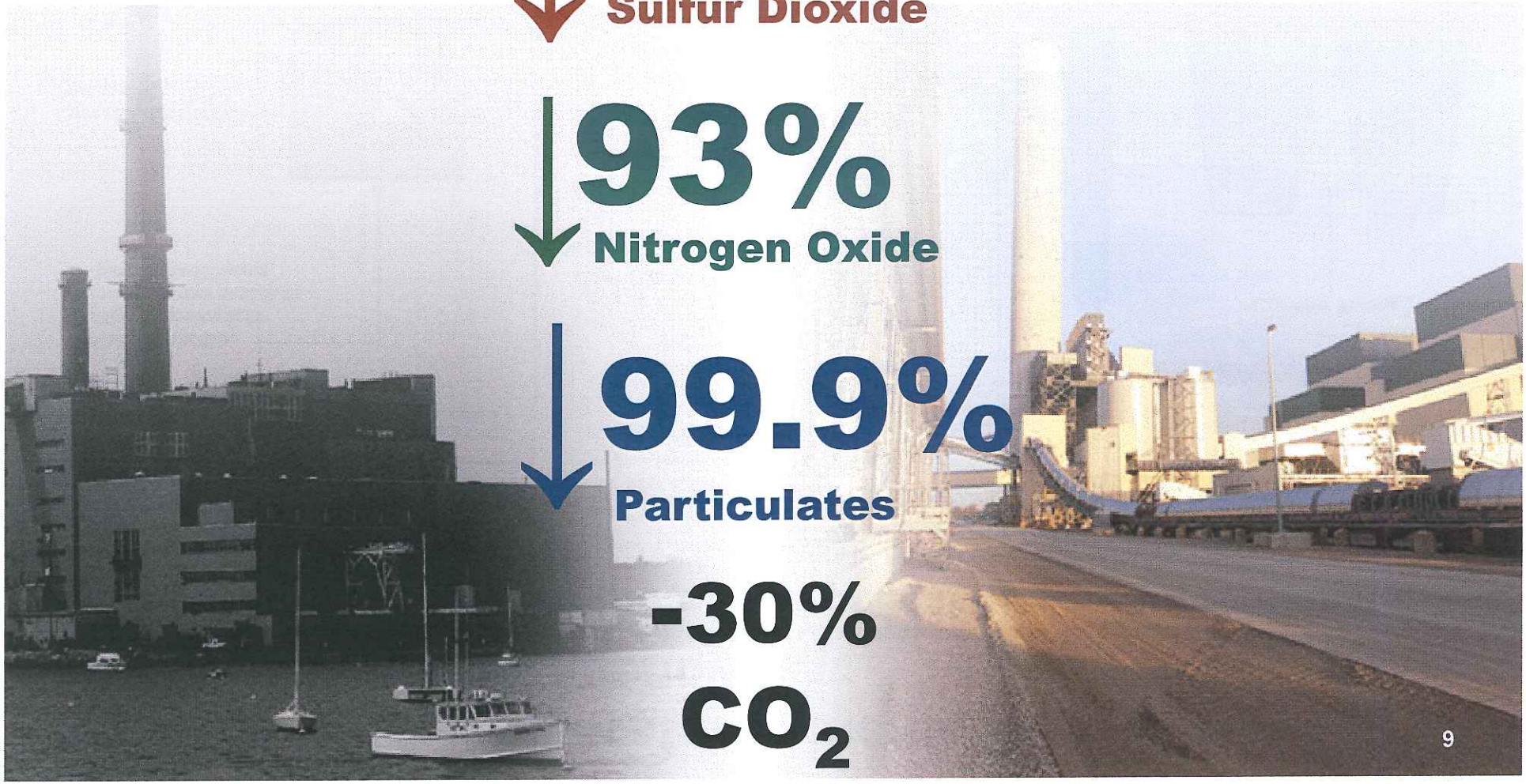


Source: Platts World Electric Power Plant Database, January 2013 and Peabody Energy Global Analytics.

21st Century Coal Technology Achieves Near-Zero Criteria Emissions

Peabody ENERGY

Older Fleet *Advanced Coal*



How? Higher Temperatures Increase Environmental Efficiencies

Typical Supercritical and Ultra-Supercritical PC Control Equipment Increase Power Per Unit

Selective Catalytic Reduction
Further Reduces NO_x and enhances mercury removal

Steam Generator
High efficiency boiler produces less emissions per megawatt output

Low NO_x Burners
Reduces NO_x

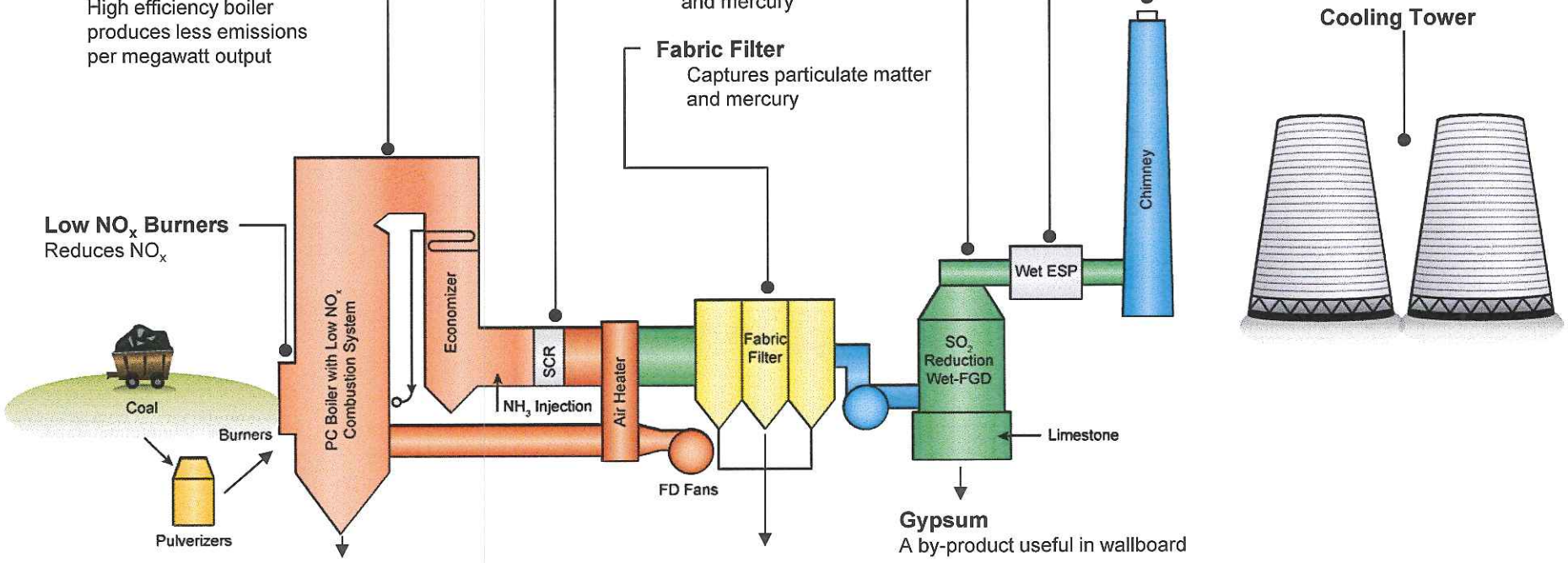
Wet ESP
Reduces fine particulate and sulfuric acid mist

Scrubber
Reduces SO_2 and mercury

Fabric Filter
Captures particulate matter and mercury

Emission Monitoring
Continuously monitors many types of emissions

Cooling Tower



Bottom Ash
A by-product useful in concrete and other products, or stored

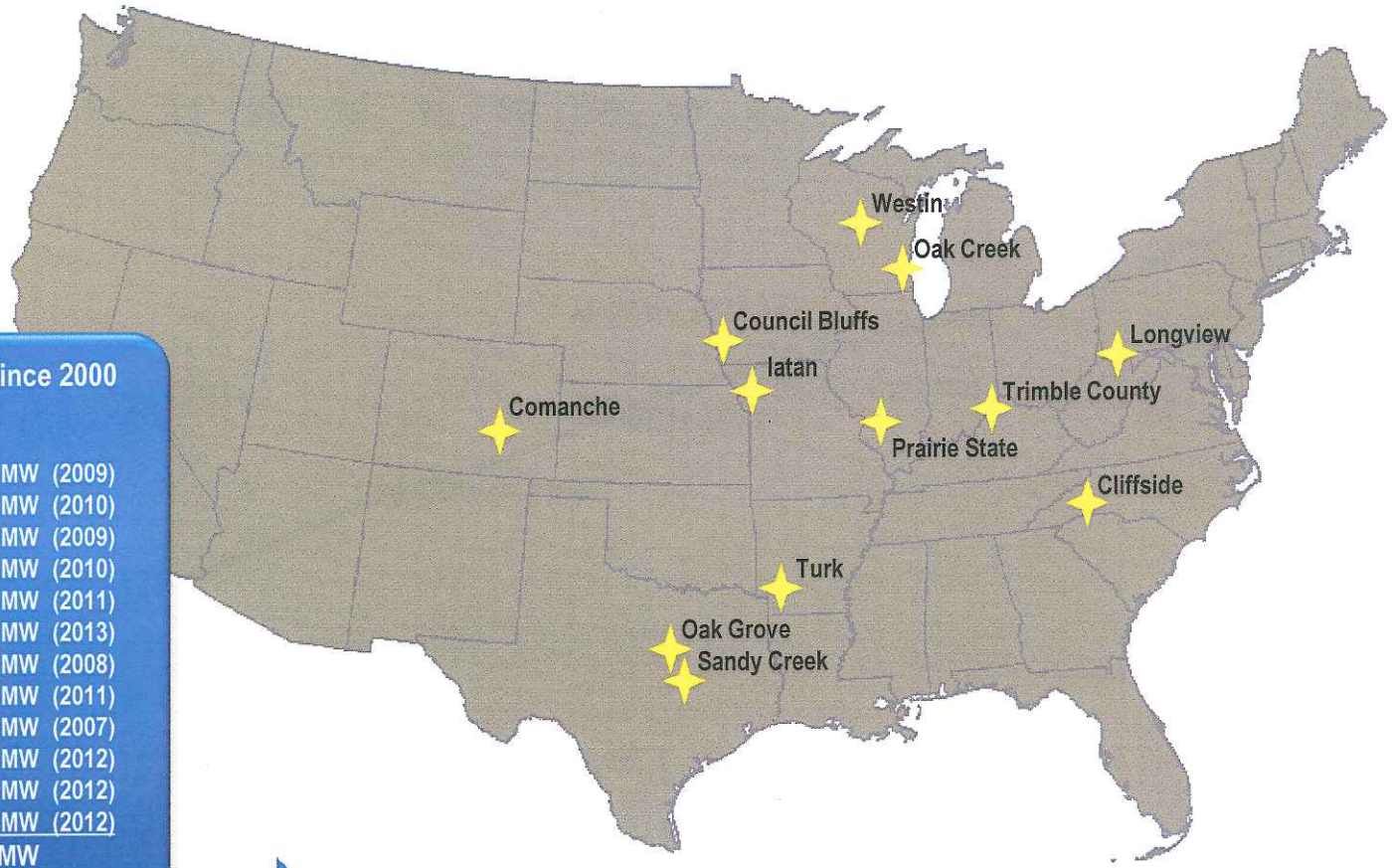
Fly Ash
A by-product useful in concrete and other products, or stored

Gypsum
A by-product useful in wallboard

U.S. Advanced Coal-Fueled Generating Fleet is Still Growing

Peabody ENERGY

More than 11 GW of New Supercritical Technology Capacity Added



Supercritical Technology Since 2000

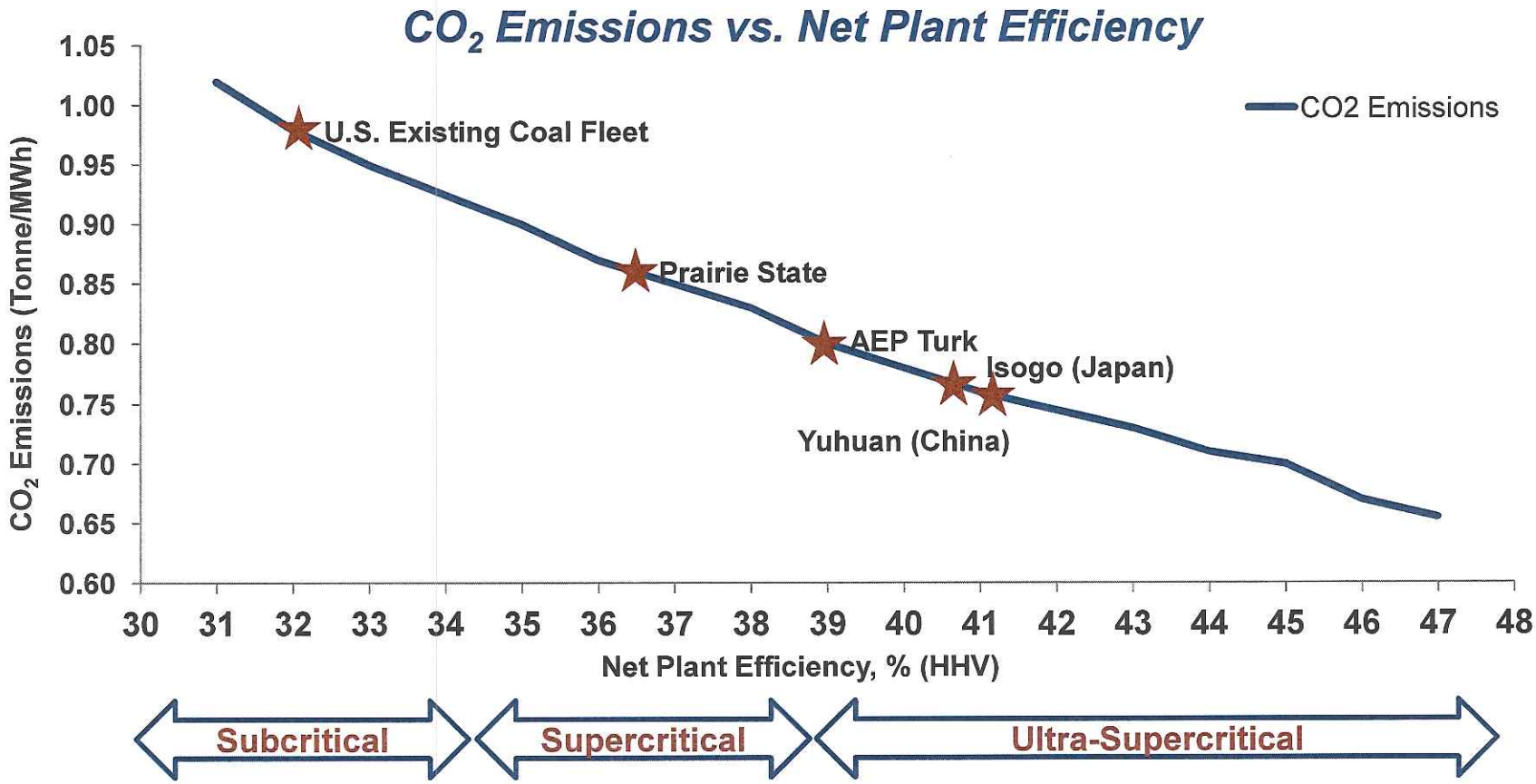
Operating

Oak Creek:	1,230 MW	(2009)
Comanche:	750 MW	(2010)
Oak Grove:	1,600 MW	(2009)
Iatan 2:	850 MW	(2010)
Trimble County 2:	750 MW	(2011)
Sandy Creek:	900 MW	(2013)
Westin 4:	530 MW	(2008)
Longview:	695 MW	(2011)
Council Bluffs 4:	790 MW	(2007)
Prairie State:	1,600 MW	(2012)
Cliffside:	825 MW	(2012)
Turk:	600 MW	(2012)
Total:	11,120 MW	

~ 40 million tons of coal annually in new operating plants

Each Investment Delivers Greater Efficiencies, Lower Emissions

Efficiency Improvement is the First CO_2 Mitigation Technology



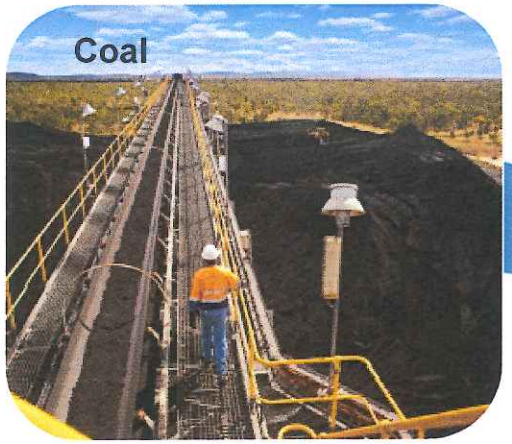
- Yuhuan CO_2 emissions are about 25% less than the typical U.S. coal plant
- Coal Utilization Research Council / Electric Power Research Institute R&D targets about 35% reduction in CO_2 emissions from coal combustion technologies

Source: Based on Booras and Holt (2004).

Coal's Versatility Adds to Energy Security

Peabody ENERGY

Btu Conversion Transforms Coal into Clean Electricity, Natural Gas & Transportation Fuels



Electricity

Industrial Gas

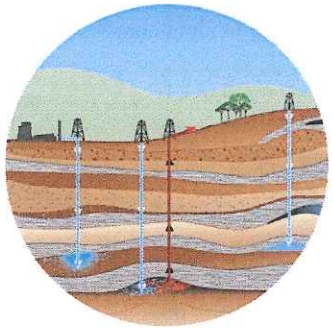
Pipeline SNG

Ethanol

Diesel

Jet Fuel

Hydrogen



CO_2 Capture and Sequestration

Harnessing Coal's Carbon Delivers Economic and Environmental Objectives

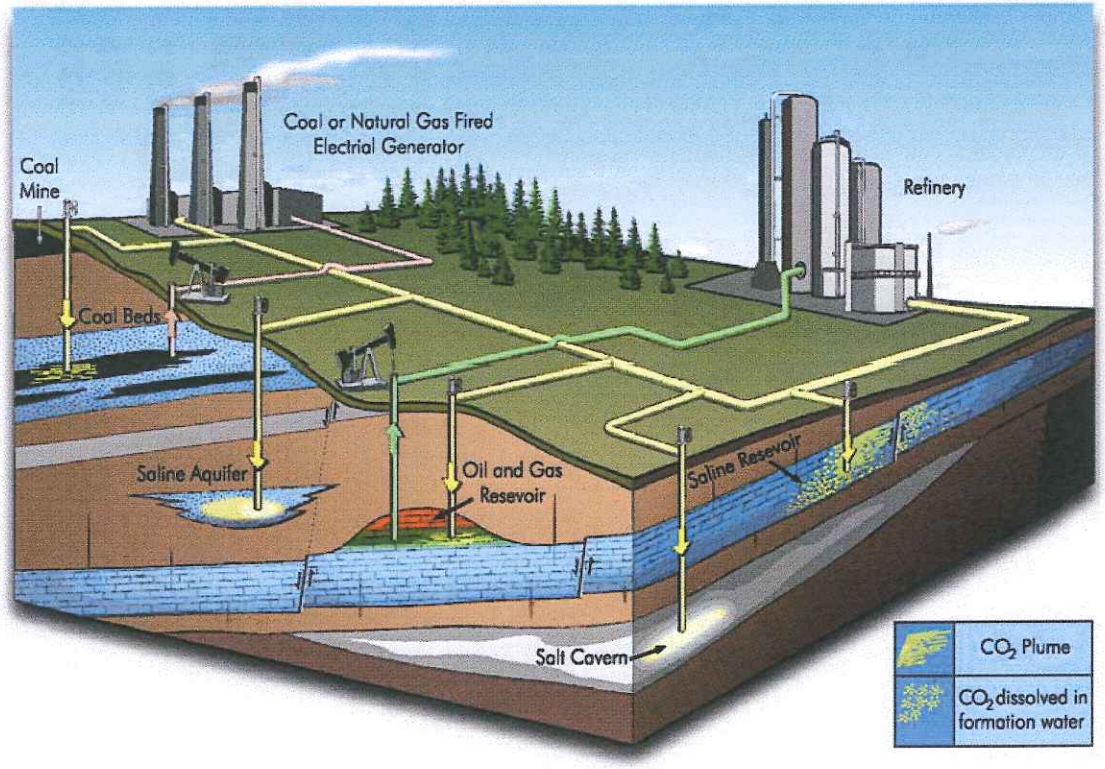
Peabody ENERGY

Carbon Capture Utilization & Storage (CCUS) Technologies

- **Pre-Combustion:** Operates like a "scrubber" to absorb the CO_2 from the boiler exhaust flue gas.
- **Post-Combustion:** Selectively absorbs and recover the CO_2 from the syngas. Commercially available.
- **Oxy-Combustion:** Combusts fuel in the presence of oxygen, rather than air, produces a highly pure CO_2 exhaust.
- **CO_2 Uses**
  - Deep geologic storage is beginning to be demonstrated globally.
  - Enhanced Oil Recovery (EOR) has been deployed for decades in the Permian Basin (west Texas) from natural CO_2 sources.

CCS for EOR Drives Down Technology Costs

Coal's CO_2 Content as the Preferred Feedstock



Over the next 30 years:

- 87 billion barrels in stranded oil could be recovered in the U.S. alone
- CO_2 is a necessary feedstock for EOR
- Maximum needed: 14 billion tons of CO_2 7 billion tons of coal

Source: National Energy Technology Laboratory, U.S. Department of Energy, "Storing CO_2 and Producing Domestic Crude Oil with Next Generation CO_2-EOR Technology," Jan. 9, 2009; International Energy Agency: "Coal-Fired Power Generation: Replacement/Retrofitting Older Plants," 2008; Management Information Services and Peabody analysis. Source: DOE/NETL_2012/1540-Figure 1.5.

Coal Provides the Best Deal for Baseload Power

Peabody ENERGY

No Subsidies Required for Coal to Be Cost Effective…
Yet U.S. Subsidizes Highest Cost and Least Abundant Generation

Oil & Gas $.64
Coal $.64
Hydropower $.82
Nuclear $3.14
Wind $56.29
Solar $775.64

Dollars per megawatt hour

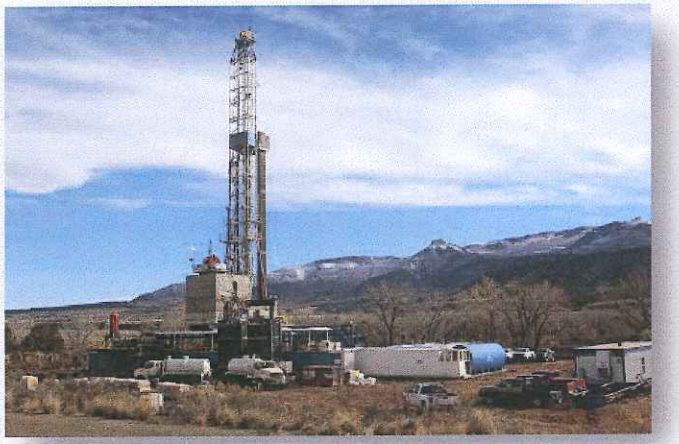
Sources: U.S. Department of Energy and Institute for Energy Research, 2011.

Alarmingly High Methane Emissions Raise New Questions About Gas

Peabody ENERGY

Up to 4% of Methane Could Be Escaping, 23x More Potent GHG than CO_2

- Study of Uinta Basin: 9% of production fugitive, **2x industry est. loss rates**
- Study of Denver–Julesburg Basin: Leakage rate **2x official figures**
- Latest U.S. EPA studies suggest 2.4% natural gas production **lost to leakage**
- Princeton/EDF conclude anything greater than 3.2% adds to warming



George Frey/Bloomberg

CIRES Cooperative Institute for Research in Environmental Sciences

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

"We were expecting to see high methane levels, but I don't think anybody really comprehended the magnitude of what we would see."

- Colm Sweeney, NOAA's Earth System Research Laboratory

Advanced Coal Delivers Real "Green" Jobs and Socioeconomic Benefits

Peabody ENERGY

100 Gigawatts of Green Coal Technology

Cumulative Benefits During Construction

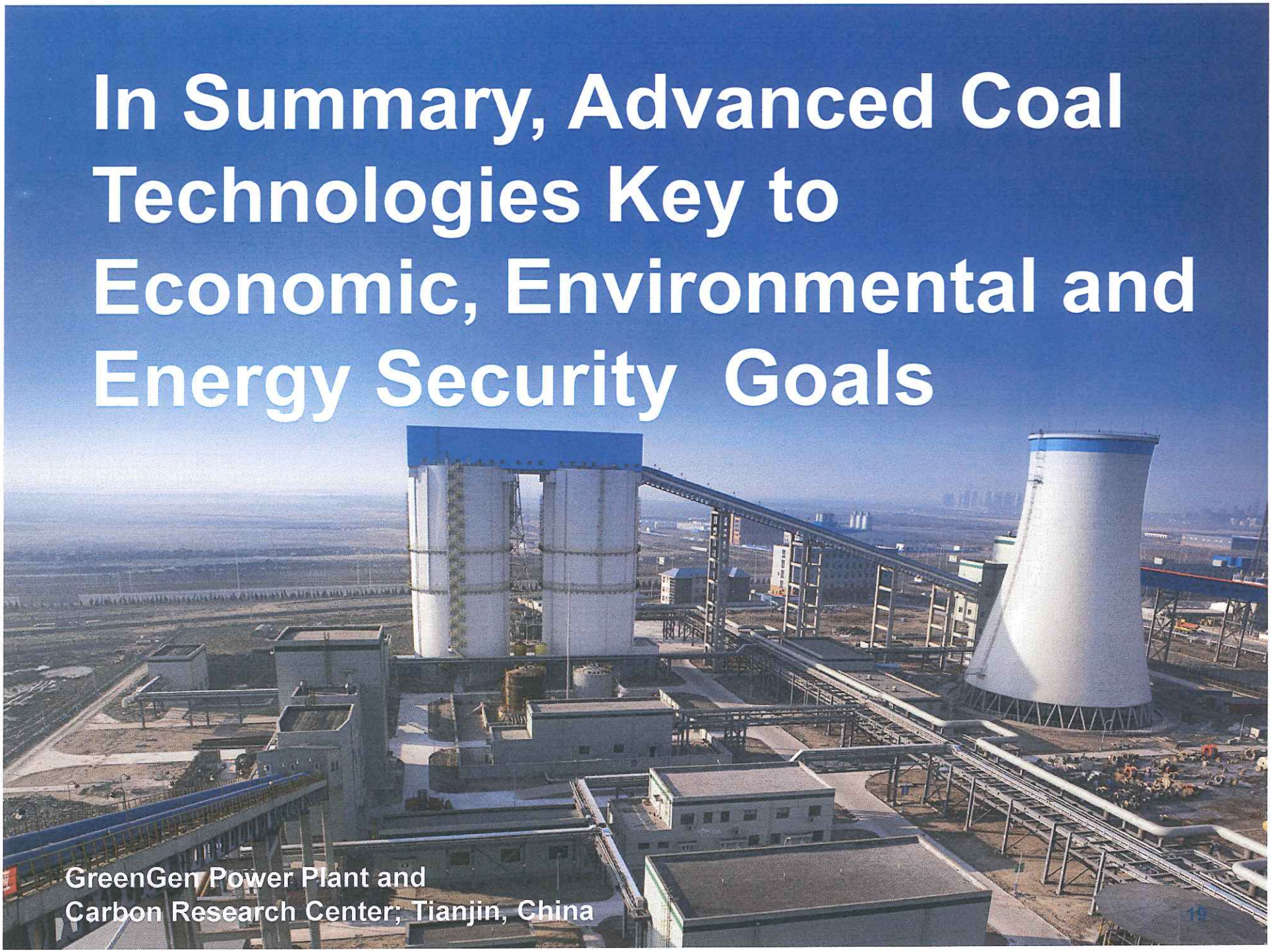
Benefits	100GW
Jobs (million job years)	6.9
Output (trillions)	$1.1
Labor Income (billions)	$368

Annual Benefits During Operations

Benefits	100GW
Jobs (thousands)	251
Output (billions)	$58
Labor Income (billions)	$17

Source: National Coal Council, 2012.

In Summary, Advanced Coal Technologies Key to Economic, Environmental and Energy Security Goals



GreenGen Power Plant and
Carbon Research Center; Tianjin, China