

# The CURC-EPRI Clean Coal Technology Roadmap

**CURC**

COAL UTILIZATION RESEARCH COUNCIL<sup>SM</sup>

# The CURC-EPRI Roadmap

Cleaner, Affordable, More Efficient  
Energy from Coal



# The Roadmap Described

- Industry developed long-term RD&D blueprint that identifies what needs to be done to pursue and develop technologies:
  - to enable industry to generate cost-effective electricity from coal with CO<sub>2</sub> capture;
  - to prevent or control emissions (SO<sub>2</sub>, NO<sub>x</sub>, mercury, particulates and CO<sub>2</sub>) at near zero levels.
- The cost over the next 18 years is roughly \$17.0 billion.

# Roadmap Technology Development Areas

- Gasification
- Advanced Combustion
- Turbines
- Fuel Cells
- Existing Plants
  - Focus on carbon capture and storage
- Carbon Storage
- Advanced Research
  - Materials Research Needs

**Timeframe: 2025**

**Focus: Power generation**

# Summary of Technical Needs Identified in the Roadmap

- IGCC
  - Improved reliability & flexibility of gasifier
  - O<sub>2</sub> separation
  - H<sub>2</sub> turbines and fuel cells
  - Carbon capture
  - FutureGen
- Combustion
  - Advanced materials for USC
  - Oxy-Firing
  - Carbon capture
- Existing Plants
  - Carbon capture and storage retrofit applications
- Turbines
  - Higher temperature operation
  - Hydrogen compatibility
  - Oxycombustion turbines
- Fuel cells
  - Decrease cost
  - Increase size
- Carbon Storage
  - Large scale, long term injections in saline formations
  - 5 sites (includes FutureGen)

# Roadmap Emission Performance: An order of magnitude reduction for traditional pollutants by 2025.

PC and IGCC Systems	Year	
	2005	2025
<b>Emissions</b>		
PM, lbs/MW-hr	0.09	0.01-0.02
SO <sub>2</sub> , lbs/MW-hr	0.8-0.3 (90-99%)	0.07-0.01 (98-99.9%)
NO <sub>x</sub> , lbs/MW-hr	0.5-0.4	0.2-0.1
Mercury, %	> 80%	98-99%
CO <sub>2</sub> , lbs/MW-hr	1770-1940	1410-1670
<b>Efficiency, Btu/kWh (HHV)</b>	38-39%	44-49%

# CURC-EPRI Roadmap Updated From Original Estimates Made in 2005

## 2007 Updates Made to Reflect:

- Current market price escalation for steel and other commodities (nearly 80%)
- New emphasis on timing and need for cost-effective methods to prevent or capture and store CO<sub>2</sub>

# Summary of Roadmap Update

- Expanded carbon storage effort from 3 demonstrations to 5
  - 4 large scale injections + FutureGen
  - Demonstration sites focus on geologic saline reservoirs
  - Included costs of CO<sub>2</sub>, reflected in a range from low cost (~\$30/ton) to high cost (~\$50/ton)
- Included carbon capture on all major demonstration projects (both IGCC and Combustion)
  - 4 IGCC with CCS demonstrations by 2025 (includes FutureGen)
  - 9 Combustion with CCS demonstrations by 2025
- Included a CCS retrofit program focused on existing units

# 2007 CURC-EPRI Roadmap Update: Key Funding Changes

	FutureGen	IGCC	Combustion	IEP	Sequestration (Storage)	Fuel Cells	Turbines	TOTALS
R&D	\$1,480	\$1,155	\$575	\$480	\$225	\$730	\$485	\$5,130
Demos		\$4,020	\$4,620	\$1,200	Low CO <sub>2</sub> - \$1,080 High CO <sub>2</sub> - \$1,480	\$855	\$425	\$12,200 to \$12,600
TOTALS	\$1,480	\$5,175	\$5,195	\$1,680	Low CO <sub>2</sub> - \$1,305 High CO <sub>2</sub> - \$1,705	\$1585	\$910	\$17,330 to \$17,730

**~\$17.5 Billion through 2025**

**Federal Share ~ \$10.5 Billion**

**Industry Share ~ \$7 Billion**

# Conclusions

- "Heroic" goals of Roadmap are achievable only if we act now
- **If technology is to be the centerpiece for addressing concerns about climate change -**
  - adequate funding and focus is urgently required; and
  - sufficient time to develop cost effective CO<sub>2</sub> capture technologies is needed.

# ROADMAP BACKUP DOCUMENTS

The following pages provide more details about the technology needs of the various Roadmap program elements.

# Innovations for Existing Plants

- Original roadmap targets improvements in SO<sub>2</sub>, NO<sub>x</sub>, Hg, PM, SO<sub>3</sub> in 2010 and 2015
- Existing fleet of 300 GW in the US is combustion based; will need new technologies to address CO<sub>2</sub> capture if carbon requirements imposed
- New roadmap focus on CCS retrofits
  - integration issues
  - CO<sub>2</sub> compression
  - post combustion capture and oxycoal retrofits
  - reductions in water use
  - emissions controls for hazardous and criteria air pollutants

# IGCC

- Continual improvements in capital cost, reliability, and air emissions.
- Focus on carbon capture technology development
- Key needs:
  - warm gas cleanup
  - improved materials of construction (reliability)
  - cheaper oxygen
  - advanced turbines and fuel cells
  - carbon capture

# Advanced Combustion

- Continual improvements in capital cost and increased efficiency.
- Key needs
  - advanced materials for USC stress
  - low cost carbon capture technologies
  - oxyfuel plant integration

# Gas Turbines

- Goals include Hydrogen capability, higher efficiency, availability, and lower NOx
- Need resources for 2 alternative designs and oxy-water combustion concept (for CO<sub>2</sub> capture)
- Key research areas
  - H<sub>2</sub> turbine development
  - oxyfuel turbine development
  - low NOx combustion
  - sensors/monitoring
  - improved materials

# Carbon Management

- Capture program balanced between gasification and combustion systems
- Focus on large long-term injections in saline formations
- Integration of injection projects with CO<sub>2</sub> capture projects
- Cost reduction opportunities are primarily in capture arena
- Research opportunities - possible co-disposal of other pollutants?

# Fuel Cells

- CURC-EPRI generally on common ground with DOE program
- Major push to decrease costs and increase size of fuel cell modules