

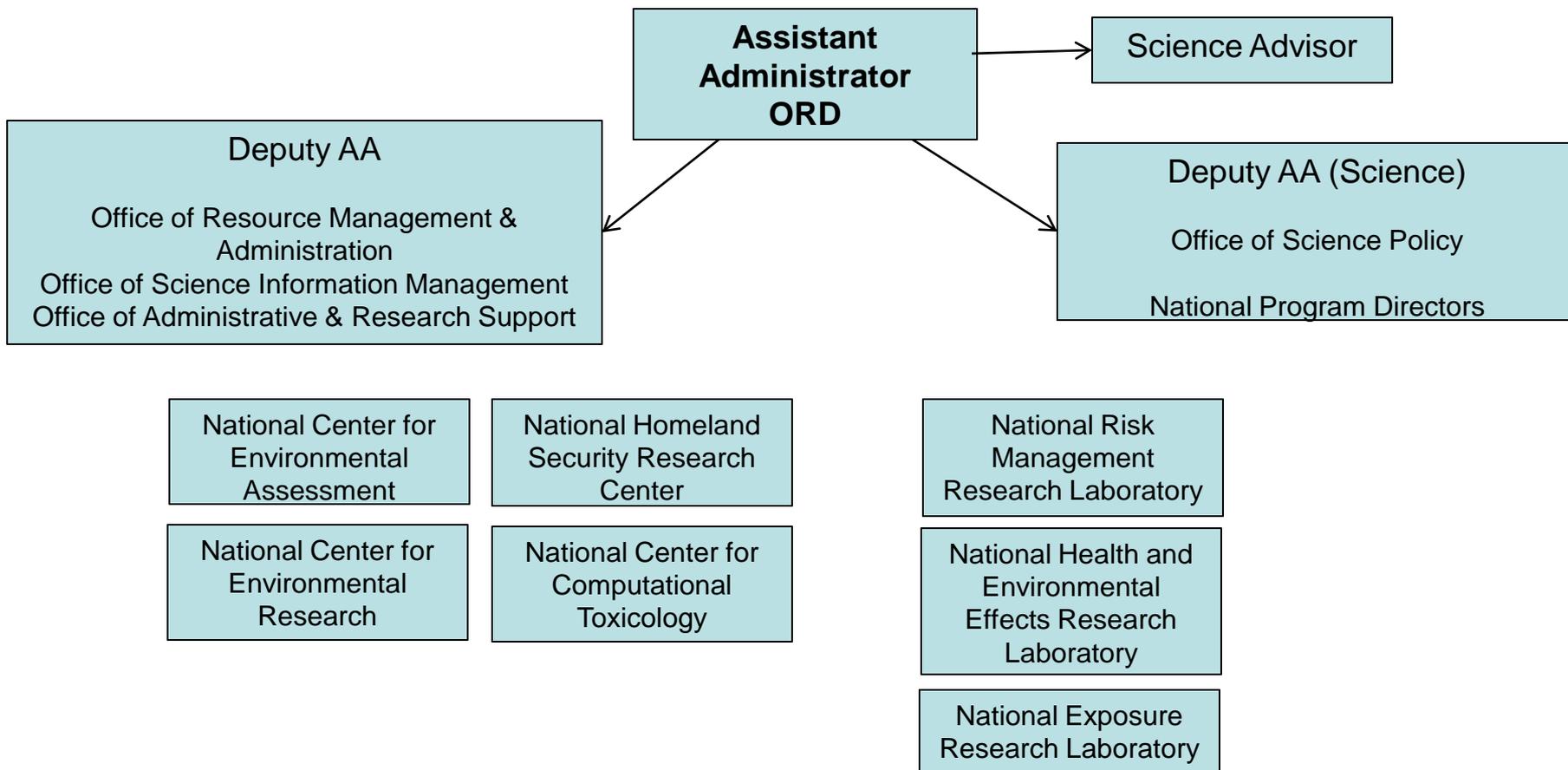


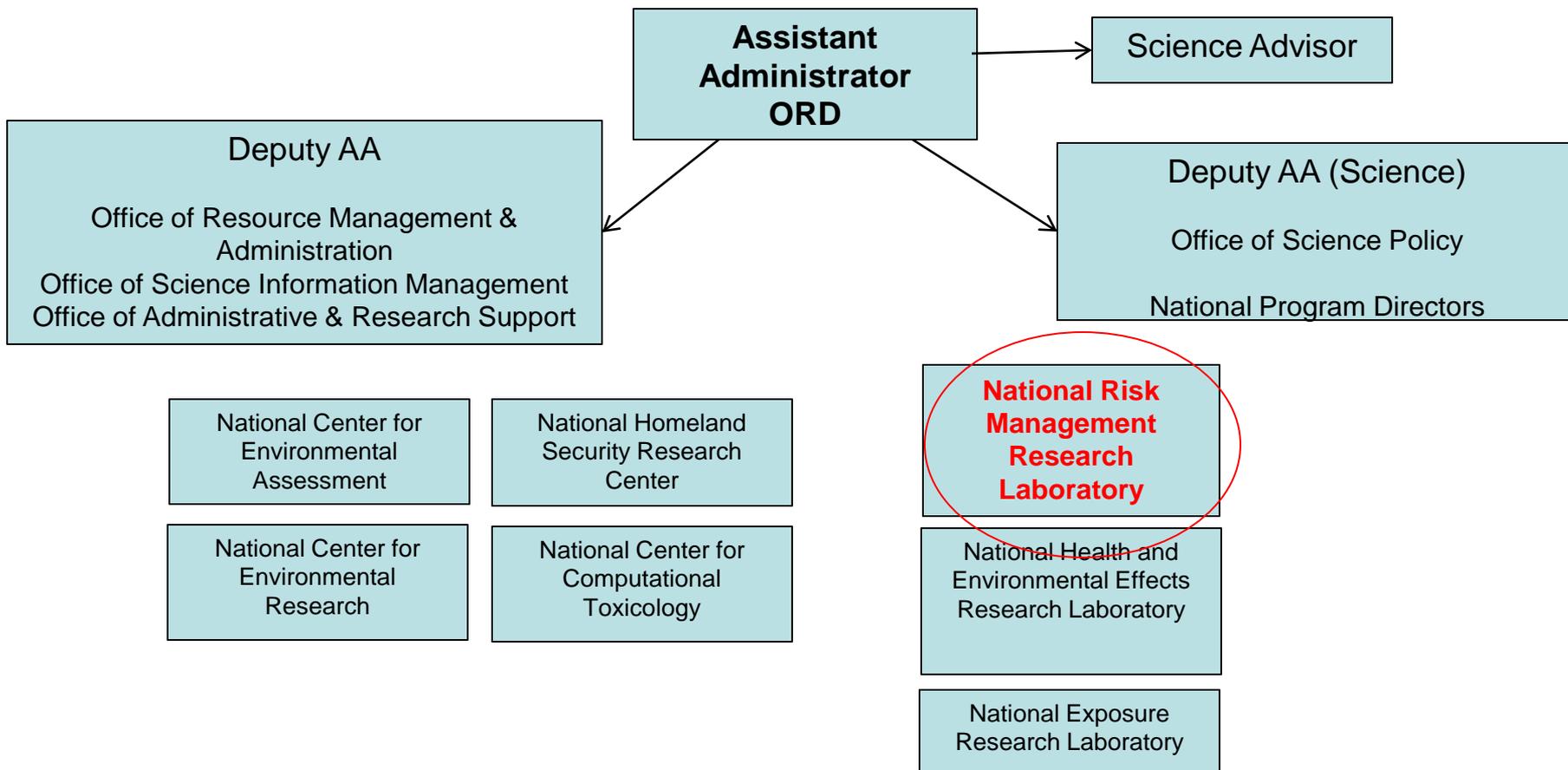
# EPA's Greenhouse Gas Mitigation Research Program

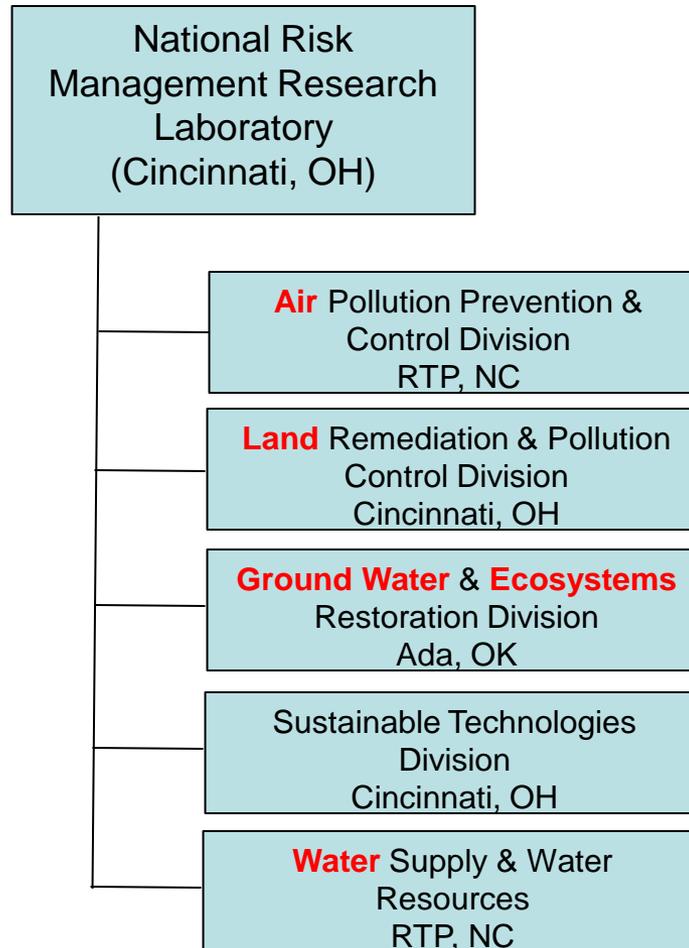
*Nick Hutson*

*Air Pollution Prevention & Control Division  
Research Triangle Park, NC*

*2010 NETL CO2 Capture Technology Meeting  
Sept 13 – 16, 2010  
Sheraton Station Square Hotel - Pittsburgh, PA*







# ORD's Global Change Research Program (GCRP)

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- Mitigation
- Vulnerability
- Adaptation

# ORD's Global Change Research Program (GCRP)

- Provide scientific information to stakeholders and policymakers as they decide whether and how to respond to global change.
- Provide the science needed
  - To understand the cause of and methods for reversing climate change (**Mitigation**)
  - To understand the effects on humans and ecosystems (**Vulnerability**)
  - To understand and develop responses to changes (**Adaptation**)

# ORD's Global Change Research Program (GCRP) – Focus Areas

## **Sustainable Energy Systems and GHG Mitigation**

- Environmental effects of greenhouse gas mitigation technologies
- Emissions measurement, monitoring, and analyses to support EPA regulatory or voluntary programs
- Decision tools to evaluate policy outcomes

## **Air Quality Adaptation**

- Tools and scientific information for adaptation options in air management programs
- Future air quality, health effects of air quality changes due to climate change, short-lived climate forcers
- Methods development, including metrics
- Monitoring and measurements, evaluation of sources of uncertainty in coupled climate-air quality models

## **Water Adaptation**

- Tools and scientific information to inform water adaptation decisions
- Water infrastructure, Water quality and aquatic ecosystems
- Sustainable Methods and Approaches
- Monitoring and evaluation

## **Vulnerability Assessment**

- Methods for characterizing and estimating vulnerability
- Human health, human well being, and vulnerable populations
- Ecosystems
- National Climate Assessment

# ORD's Global Change Research Program (GCRP) – Focus Areas



## **Sustainable Energy Systems and GHG Mitigation**

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## **Water Adaptation**

- Tools and scientific information to inform water adaptation decisions
- Water infrastructure, Water quality and aquatic ecosystems
- Sustainable Methods and Approaches
- Monitoring and evaluation

## **Vulnerability Assessment**

- Methods for characterizing and estimating vulnerability (general)
- Human health, human well being, and vulnerable populations
- Ecosystems
- National Climate Assessment

# Sustainable Energy Systems and GHG Mitigation

- **Industrial Sectors Integrated Solutions (ISIS) Model**
- **GHG Mitigation Database**
- **Environmental Impacts of GHG Emission Control Technologies**
- **Regional- and State-level Decision Support Tools (e.g., MARKAL)**
- **Retrofit-ability Assessment of GHG Mitigation Technologies for Coal-fired Power Plants**
- **Methods for GHG Emission Measurements**
- **NCER – external Science To Achieve Results (STAR) grants**

- Sector-based techno-economic model
- Minimize the cost of production and emission control over the time horizon of interest, subject to:
  - meeting the demand for the commodities; and
  - satisfying any emissions related requirements.
- Dynamically evaluate
  - multi-product industries operating with regional markets over a number of years with applicable controls.
  - multi-pollutant policies with short and long time horizons
    - Criteria pollutants (NO<sub>x</sub>, SO<sub>2</sub>, PM, CO) – emission limits and/or cap-and-trade
    - Hazardous Air Pollutants (e.g., Hg, HCl) – emission limits
    - CO<sub>2</sub> – cap-and-trade and/or emission taxes
    - Long and short time horizons
    - CO<sub>2</sub> (decades) + O<sub>3</sub> (seasonal)
    - Regional or national requirements

# GHG Mitigation Database

Information from literature,  
vendors, government  
agencies, states, others

Information on GHG mitigation  
technologies for *power, generation,  
transportation, industrial sectors,  
waste management*

Policy makers  
(EPA, other  
federal  
agencies,  
states, foreign  
governments)

Technology  
developers  
(DOE,  
academia,  
industry and  
vendors)

Technology  
evaluators  
(federal  
agencies,  
states, foreign  
governments,  
industry,  
vendors.

The database will help answer the following questions for key technologies:

- *What is the stage of development / demonstration and availability?*
- *What are the projected utilization costs?*
- *What are the ancillary impacts of technology deployment?*
  - *Water use, parasitic power load, solid waste generation, others*

- **Stakeholders Workshop – April 2009**
  - Government (federal, state, local) – incl. EPA, DOE, USDA, etc.
  - Technology providers / technology users
  - Energy Efficiency experts
  - Sector-specific experts
  - etc.
- **Power (Utility) Specific Workshop – November 2009**
  - Government (federal, state, local) – incl. EPA, DOE, GAO, etc.
  - Technology providers / technology users
  - Industry experts and advocacy groups
  - NGOs, etc.
- **Database Development Team**
  - Eastern Research Group (ERG) / Andover Technology Partners
  - University of North Carolina Institute for the Environment (UNC-IE)
  - EPA ORD (with input from OAR/OAQPS)

- **Beta Version released for Review – April 2010**
  - Agency reviewers (ORD, OAR, Regional, etc.)
  - Small external group coordinated by CAAAC GHG BACT working group
    - State/local regulators
  - Comments / Suggestions are being addressed now
- **Version 1.0 released – end of Sept 2010**
  - Power (Utility) and Cement Sectors only
- **Subsequent versions**
  - Additional industrial sectors (petroleum refineries, pulp & paper, iron & steel, etc.)
  - Transportation / mobile sources
  - Additional or refined information in the Power and Cement sectors



# United States Environmental Protection Agency Greenhouse Gas Mitigation Strategies Database Search Application

Beta

[Home](#)   [Downloads](#)   [Back](#)

Welcome to the US EPA Greenhouse Gas (GHG) Mitigation Strategies Database (MSD). This database contains sector-based information on strategies and control technologies for mitigation of GHG emissions.

Select a sector from below, and click **Search**

Sectors :

- Electric Utility/Power
- Cement
- Electric Utility/Power

**Drop down menu to select sector – “Electric Utility/Power” or “Cement”**

# United States Environmental Protection Agency Greenhouse Gas Mitigation Strategies Database Search Application

Beta

Home Downloads Back

Guided Search for Sector: Electric Utility/Power

- Define search parameters below, then click **Search**
- To select multiple values, hold down the **Control** button (*Command* on a Mac) while selecting values.

Search Reset

**Mitigation Technique :**

- All from Mitigation Technique
- Chemical Looping
- No Carbon Capture and Storage
- Oxy Fire - Air Separation Unit
- Oxy Fire - Ceramic Autothermal Recovery
- Oxy Fire - Membrane
- Post Combustion - Carbonate
- Post Combustion - Carbozyme Membrane
- Post Combustion - Chilled NH3

**Source Type :**

- All from Source Type
- CFB Boiler
- Cyclone Boiler
- Geothermal
- IGCC
- NGCC
- Other Boiler
- PC Boiler
- Photovoltaic

**Primary Fuel :**

- All from Primary Fuel
- Biomass
- Coal
- Geothermal Fluid
- Natural Gas
- Solar Insolation
- Wind

**Facility Status :**

- All from Facility Status
- Existing
- New
- Retrofit

**Stage of Development :**

- All from Stage of Development
- commercial
- concept
- laboratory
- mature
- pilot

 **United States Environmental Protection Agency**  
**Greenhouse Gas Mitigation Strategies Database**  
**Search Application**

Beta

Home Downloads Back

Search Summary for Sector: Electric Utility/Power

**Technologies found: 8**

**Properties and search values:**

**Mitigation Technique:** Post Combustion - MEA  
**Source Type:** All from Source Type  
**Primary Fuel:** Coal  
**Facility Status:** All from Facility Status  
**Stage of Development:** All from Stage of Development

Summary view – for search of a coal-fired boiler with post-combustion MEA carbon capture

• Right-click on the table column headers to enable additional table functionality

Views : Summary Change View

<input type="checkbox"/>	Report	Technology	Sector	Facility Status	Source Type and Type Subcat	Primary Fuel	Mitigation Technique
<input type="checkbox"/>	<a href="#">Report</a>	New Coal fired PC Boiler (Supercritical) with Post ...	Electric Utility/Power	New	PC Boiler, Supercritical	Coal	Post Combustion - MEA
<input type="checkbox"/>	<a href="#">Report</a>	New Coal fired PC Boiler (Supercritical) with Post ...	Electric Utility/Power	New	PC Boiler, Supercritical	Coal	Post Combustion - MEA
<input type="checkbox"/>	<a href="#">Report</a>	New Coal fired PC Boiler (Ultrasupercritical) with ...	Electric Utility/Power	New	PC Boiler, Ultrasupercritical	Coal	Post Combustion - MEA
<input type="checkbox"/>	<a href="#">Report</a>	Retrofit Coal fired PC Boiler (Subcritical) with Pos...	Electric Utility/Power	Retrofit	PC Boiler, Subcritical	Coal	Post Combustion - MEA
<input type="checkbox"/>	<a href="#">Report</a>	Retrofit Coal fired PC Boiler (Subcritical) with Pos...	Electric Utility/Power	Retrofit	PC Boiler, Subcritical	Coal	Post Combustion - MEA
<input type="checkbox"/>	<a href="#">Report</a>	Retrofit Coal fired PC Boiler (Subcritical) with Pos...	Electric Utility/Power	Retrofit	PC Boiler, Subcritical	Coal	Post Combustion - MEA
<input type="checkbox"/>	<a href="#">Report</a>	Retrofit Coal fired PC Boiler (Subcritical) with Pos...	Electric Utility/Power	Retrofit	PC Boiler, Subcritical	Coal	Post Combustion - MEA
<input type="checkbox"/>	<a href="#">Report</a>	Retrofit Coal fired PC Boiler (Supercritical) with P...	Electric Utility/Power	Retrofit	PC Boiler, Supercritical	Coal	Post Combustion - MEA



# United States Environmental Protection Agency Greenhouse Gas Mitigation Strategies Database Search Application

Beta

Home **Downloads** Back

Search Summary for Sector: Electric Utility/Power  
**Technologies found: 8**  
**Properties and search values:**  
**Mitigation Technique:** Post Combustion - MEA  
**Source Type:** All from Source Type  
**Primary Fuel:** Coal  
**Facility Status:** All from Facility Status  
**Stage of Development:** All from Stage of Development

The data can be downloaded into an MS Excel spreadsheet

• Right-click on the table column headers to enable additional table functions

Views : Summary Change View

	Summary	Sector	Facility Status	Source Type and Type Subcat	Primary Fuel	Mitigation Technique	Stage of Development
<input type="checkbox"/>	Report Cost	r (Supercritical) with Post ...	New	PC Boiler, Supercritical	Coal	Post Combustion - MEA	laborato
<input type="checkbox"/>	Report Cost Comparison (English)	r (Supercritical) with Post ...	New	PC Boiler, Supercritical	Coal	Post Combustion - MEA	pilot
<input type="checkbox"/>	Report Cost Comparison (Metric)	r (Supercritical) with Post ...	New	PC Boiler, Supercritical	Coal	Post Combustion - MEA	pilot
<input type="checkbox"/>	Report Emissions (English)	r (Ultrasupercritical) with ...	New	PC Boiler, Ultrasupercritical	Coal	Post Combustion - MEA	pilot
<input type="checkbox"/>	Report Emissions (Metric)	oiler (Subcritical) with Pos...	Retrofit	PC Boiler, Subcritical	Coal	Post Combustion - MEA	pilot
<input type="checkbox"/>	Report Energy	oiler (Subcritical) with Pos...	Retrofit	PC Boiler, Subcritical	Coal	Post Combustion - MEA	pilot
<input type="checkbox"/>	Report Waste and Life Cycle	oiler (Subcritical) with Pos...	Retrofit	PC Boiler, Subcritical	Coal	Post Combustion - MEA	pilot
<input type="checkbox"/>	Report Retrofit Coal fired PC Boiler (Subcritical) with Pos...	Electric Utility/Power	Retrofit	PC Boiler, Subcritical	Coal	Post Combustion - MEA	pilot
<input type="checkbox"/>	Report Retrofit Coal fired PC Boiler (Subcritical) with Pos...	Electric Utility/Power	Retrofit	PC Boiler, Subcritical	Coal	Post Combustion - MEA	pilot
<input type="checkbox"/>	Report Retrofit Coal fired PC Boiler (Supercritical) with P...	Electric Utility/Power	Retrofit	PC Boiler, Supercritical	Coal	Post Combustion - MEA	pilot



# United States Environmental Protection Agency

## Greenhouse Gas Mitigation Strategies Database

### Search Application

Beta

Home Downloads Back

Search Summary for Sector: Electric Utility/Power

**Technologies found: 8**

**Properties and search values:**

**Mitigation Technique:** Post Combustion - MEA

**Source Type:** All from Source Type

**Primary Fuel:** Coal

**Facility Status:** All from Facility Status

**Stage of Development:** All from Stage of Deve

Hyperlinked reports are available for each technology

• Right-click on the table column headers to enable

Views : Summary

<input type="checkbox"/>	Report Technology	Sector	Facility Status	Source Type and Type Subcat	Primary Fuel	Mitigation Technique
<input type="checkbox"/>	<a href="#">Report</a> New Coal fired PC Boiler (Supercritical) with Post ...	Electric Utility/Power	New	PC Boiler, Supercritical	Coal	Post Combustion - MEA
<input type="checkbox"/>	<a href="#">Report</a> New Coal fired PC Boiler (Supercritical) with Post ...	Electric Utility/Power	New	PC Boiler, Supercritical	Coal	Post Combustion - MEA
<input type="checkbox"/>	<a href="#">Report</a> New Coal fired PC Boiler (Ultrasupercritical) with ...	Electric Utility/Power	New	PC Boiler, Ultrasupercritical	Coal	Post Combustion - MEA
<input type="checkbox"/>	<a href="#">Report</a> Retrofit Coal fired PC Boiler (Subcritical) with Pos...	Electric Utility/Power	Retrofit	PC Boiler, Subcritical	Coal	Post Combustion - MEA
<input type="checkbox"/>	<a href="#">Report</a> Retrofit Coal fired PC Boiler (Subcritical) with Pos...	Electric Utility/Power	Retrofit	PC Boiler, Subcritical	Coal	Post Combustion - MEA
<input type="checkbox"/>	<a href="#">Report</a> Retrofit Coal fired PC Boiler (Subcritical) with Pos...	Electric Utility/Power	Retrofit	PC Boiler, Subcritical	Coal	Post Combustion - MEA
<input type="checkbox"/>	<a href="#">Report</a> Retrofit Coal fired PC Boiler (Subcritical) with Pos...	Electric Utility/Power	Retrofit	PC Boiler, Subcritical	Coal	Post Combustion - MEA
<input type="checkbox"/>	<a href="#">Report</a> Retrofit Coal fired PC Boiler (Supercritical) with P...	Electric Utility/Power	Retrofit	PC Boiler, Supercritical	Coal	Post Combustion - MEA



## Control Technology Report

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### Name

New Coal fired PC Boiler (Supercritical) with Post Comb - MEA

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### Description

Technical literature described the mitigation strategies as follows. It should be noted, that a degree of uncertainty is generally expected in cost and performance data. As a technology moves along the continuum of development from concept through commercial maturity uncertainty improves:

New 320 MW Supercritical Bituminous Wall-Fired Pulverized Coal Boiler, Air-Fired, with MEA Carbon Capture and Storage (CCS) for 90% CO<sub>2</sub> Removal

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### Sector

Electric Utility/Power

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### References

Technical information collected from the following source(s):

- U.S. Department of Energy, "Carbon Dioxide Capture from Flue Gas Using Dry Regenerable Sorbents", Final Report, January 2009
  - EPRI and U.S. Department of Energy, "Evaluation of Innovative Fossil Fuel Power Plants with CO<sub>2</sub> Removal", Interim Report, December 2000
- 

### Life Cycle

Technical literature described the mitigation strategies as follows. It should be noted, that a degree of uncertainty is generally expected in cost and performance data. As a technology moves along the continuum of development from concept through commercial maturity uncertainty improves:

Carbon dioxide transportation and sequestration technologies are commercially available today and will be more widely demonstrated over the next 10 -15 years. In the US, there are 35+ years of experience transporting and injecting CO<sub>2</sub> into the deep subsurface. While this experience is concentrated in the oil and gas sector - existing CO<sub>2</sub> pipelines and injection wells are used primarily for enhanced oil and gas recovery - it provides a strong foundation and many of the technologies needed for commercial-scale Carbon Capture and Storage (CCS). In the US, the Department of Energy leads efforts to advance CCS through fundamental R&D and Regional Carbon Sequestration Partnerships designed to build capacity and deploy demonstration projects.

# Environmental Impacts of GHG Mitigation Technologies

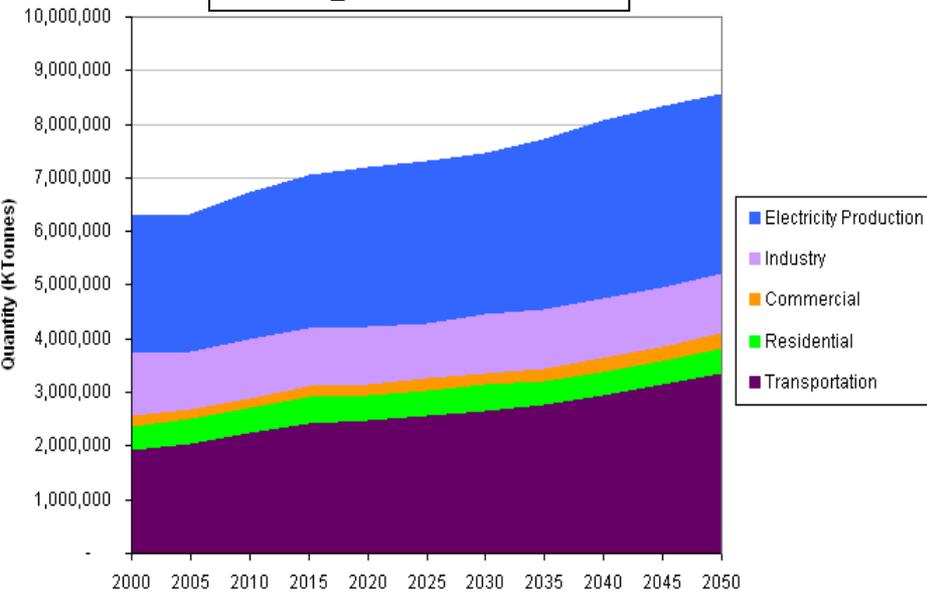
- **Testing of promising CO<sub>2</sub> capture technologies (e.g., RTI solid sorbent and membrane processes) in the pilot-scale combustion research facility.**
- **Characterization of the effects of CO<sub>2</sub> capture technologies on other air emissions (e.g. criteria and hazardous air pollutants).**
- **Characterization of emissions and product impurities in combustion/capture/pressurization technologies (e.g, oxy-fuel).**

- Performance verification of commercial-ready or near ready technologies
  - Data to support technology performance claims
  - In-field testing of full scale units
  - Fully public, transparent process (all results posted on web)
  - Stakeholder driven, voluntary, open process
  - Testing performed by contractor (SRI) and substantially funded by vendor
- To date about 40 processes have entered the ETV-GHGT center for verification
  - Advanced Energy (19)
  - Oil & Gas Industries (9)
  - Transportation Industry (6)
  - GHG Monitoring (3)
- Substantial external funding (NYSERDA, DoD/ESTCP, EPA/SBIR)
- Complete information, at <http://www.epa.gov/nrmrl/std/etv/center-ggt.html>

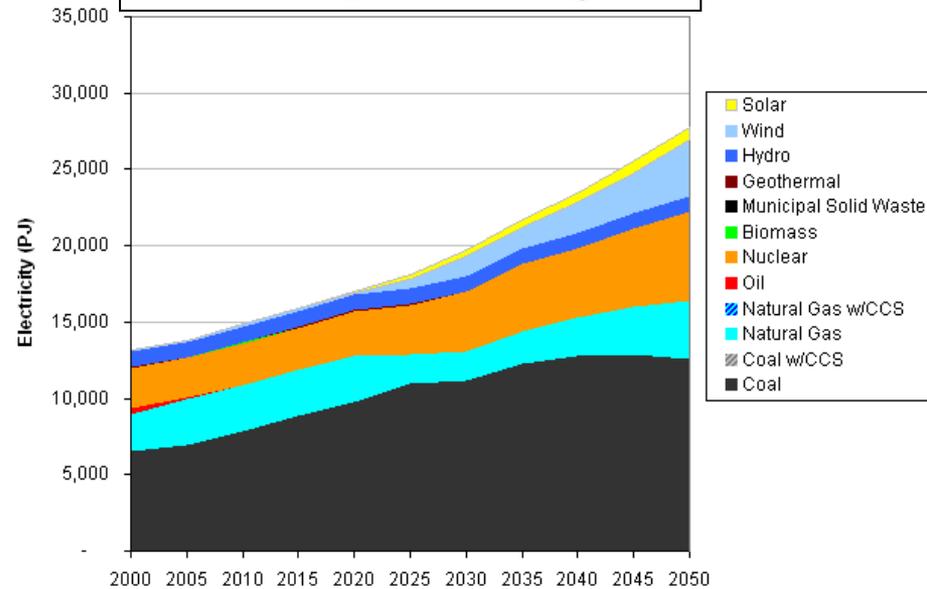
- ORD Energy & Climate Assessment (ECA) team
  - using the MARKAL energy system model
  - evaluate scenarios of the evolution of the U.S. energy system
- MARKAL represents the competition of fuels and technologies for market share
- EPA has developed a 9-region U.S. database for use with MARKAL
  - Resolution: 9 U.S. census regions
  - Time Horizon: 2000 through 2050
  - Coverage: Electricity production, industrial, residential, commercial, and transportation sectors

# MARKAL Illustrative results: No GHG policy

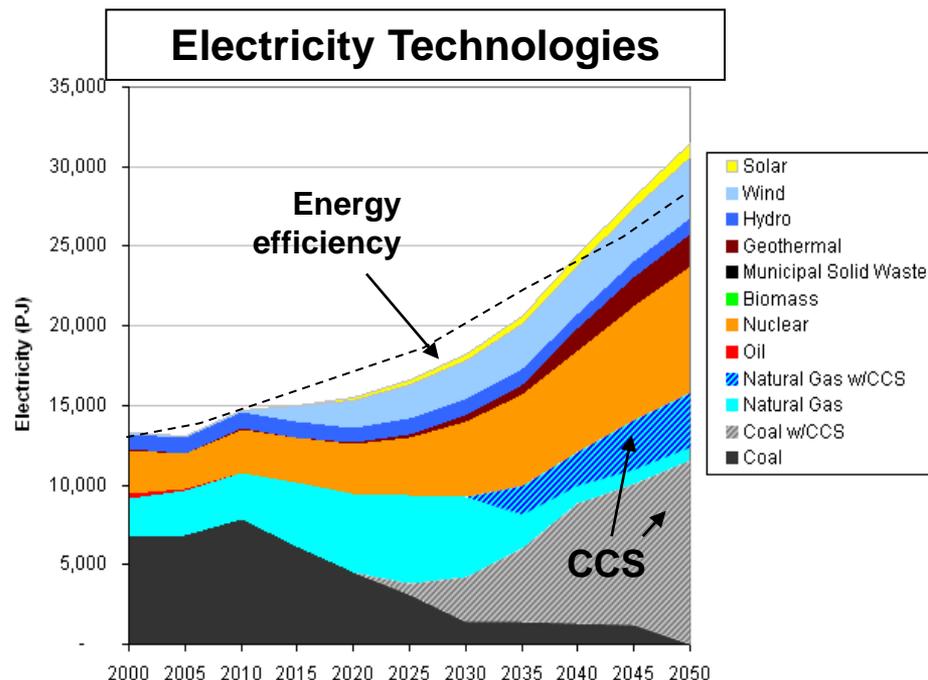
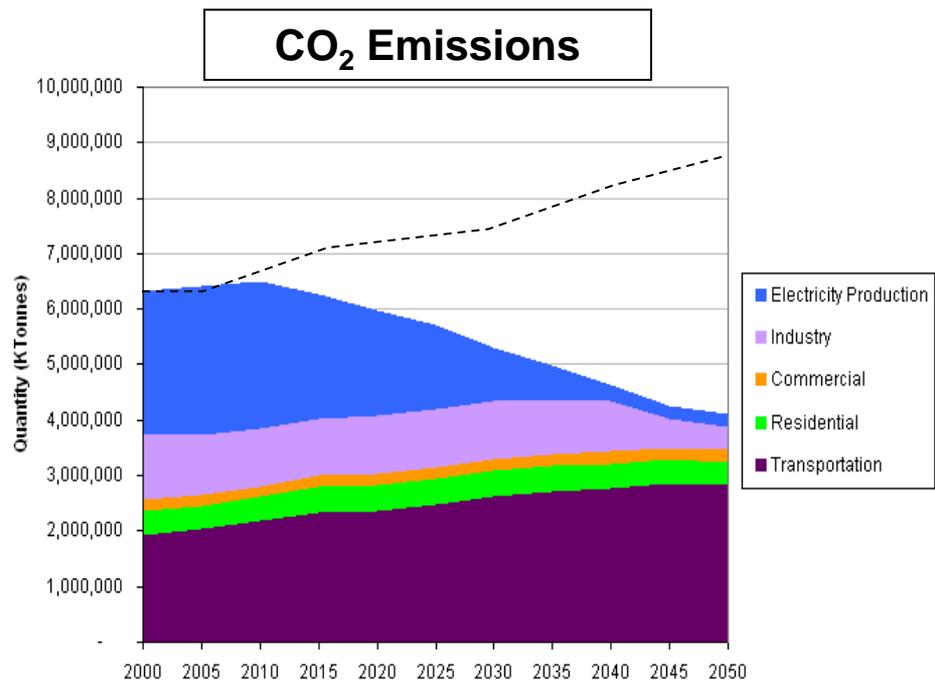
## CO<sub>2</sub> Emissions



## Electricity Technologies



# MARKAL Illustrative results: A GHG policy - 40% Reduction by 2050



# Additional Mitigation Projects

- Retrofit-ability Assessment of GHG Mitigation Technologies for Coal-fired Power Plants.
  - Addresses existing plants and how effectively mitigation technologies can be retrofitted ... and effects on other air pollutants, etc.
- Methods for GHG Emission Measurements
  - Diversity of sources and inherent variability
  - Landfills, oil and gas production, agriculture, fugitive emissions
  - Carbon dioxide, methane and nitrous oxide
  - Open path emission measurement methods

# Contact Information

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919 541-2968