

# Vision 21: Charge to Roadmapping Participants



## *Vision 21 Roadmapping Workshop*

*August 30-31, 2000*

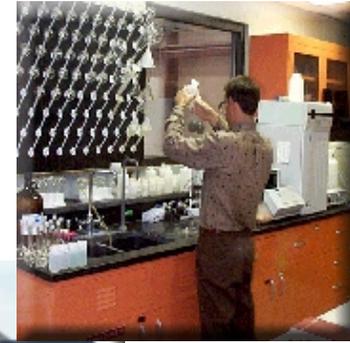
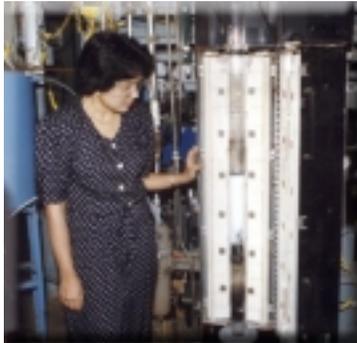
**Rita A. Bajura, Director**  
**Larry A. Ruth, Senior Management and Technical Advisor**



# National Energy Technology Laboratory

## *Who We Are*

- One of DOE's 15 National Laboratories
- 1,100 Federal and Contractor Employees
- Sites in Morgantown, WV, Pittsburgh, PA, and Tulsa, OK



# NETL's Mission

- **Resolve the environmental, supply, and reliability constraints of producing and using fossil resources to provide Americans with a stronger economy, healthier environment, and more secure future**
- **Support development and deployment of environmental technologies that reduce the cost and risk of remediating DOE's weapons complex**
- **Contribute to best business and management practices within DOE**



# Our Program Areas

## Strategic Center for Natural Gas

*Borehole to Burner Tip*

## Electric Power Using Coal

*Mining to Light Switch*

## Climate Change Policy Support

*The Key Issue in Use  
of Fossil Energy*

## Fuels

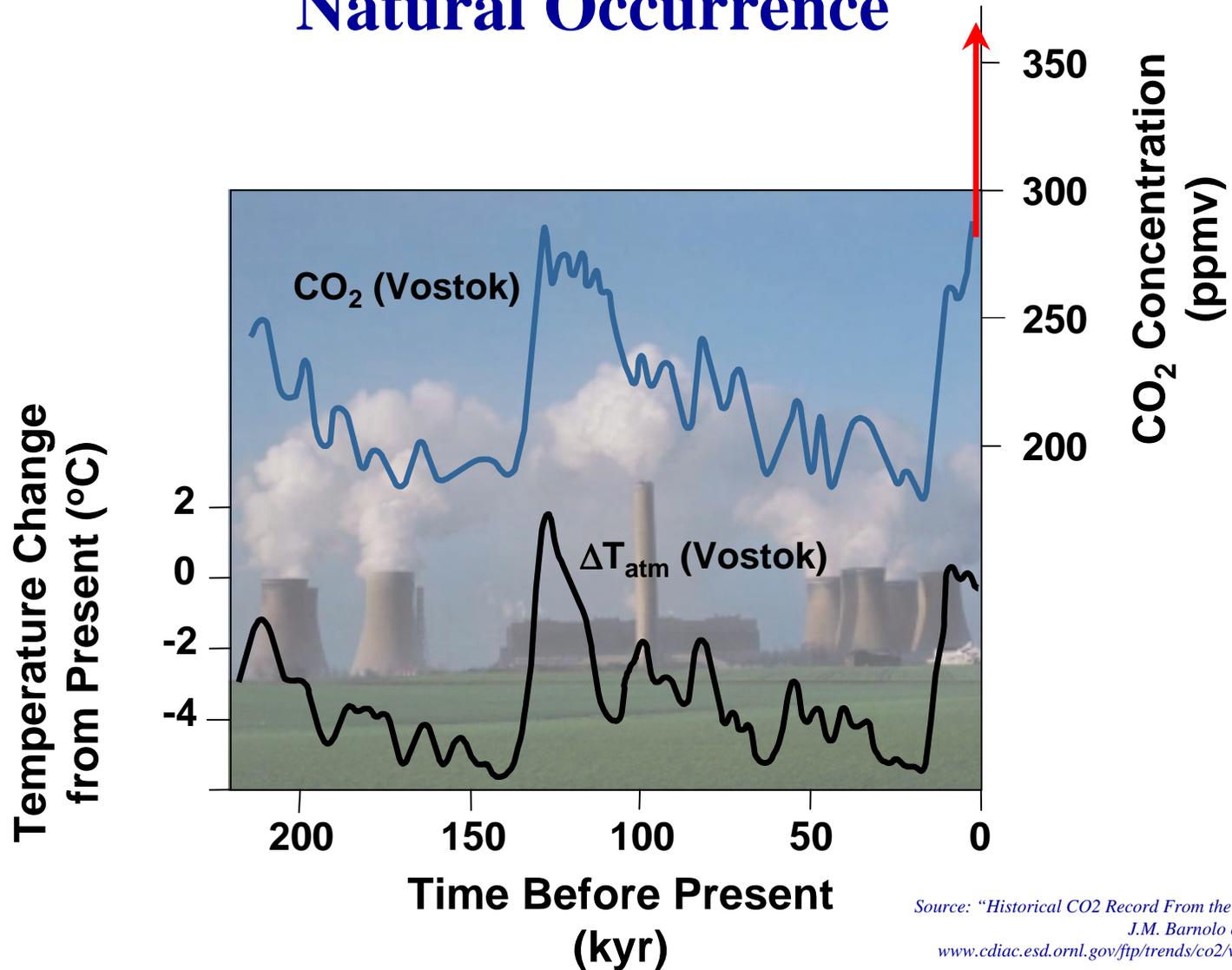
*Supply and Delivery of Clean  
Fuels for Transportation  
and Other End-Use  
Sectors*

## Environmental Quality/Nuclear Security

*Supporting the DOE  
Complex*

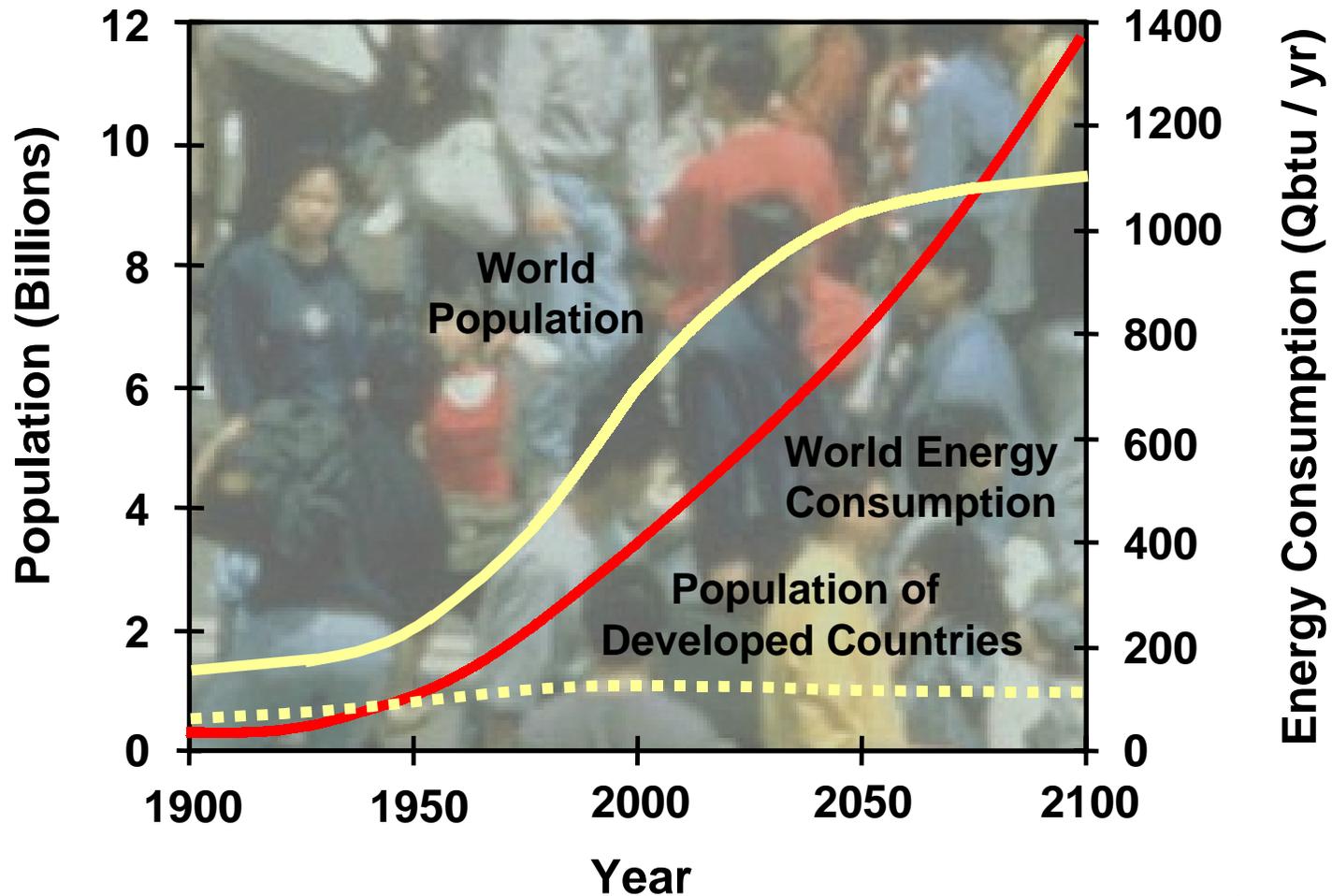


# CO<sub>2</sub> Concentrations Beyond Range of Natural Occurrence



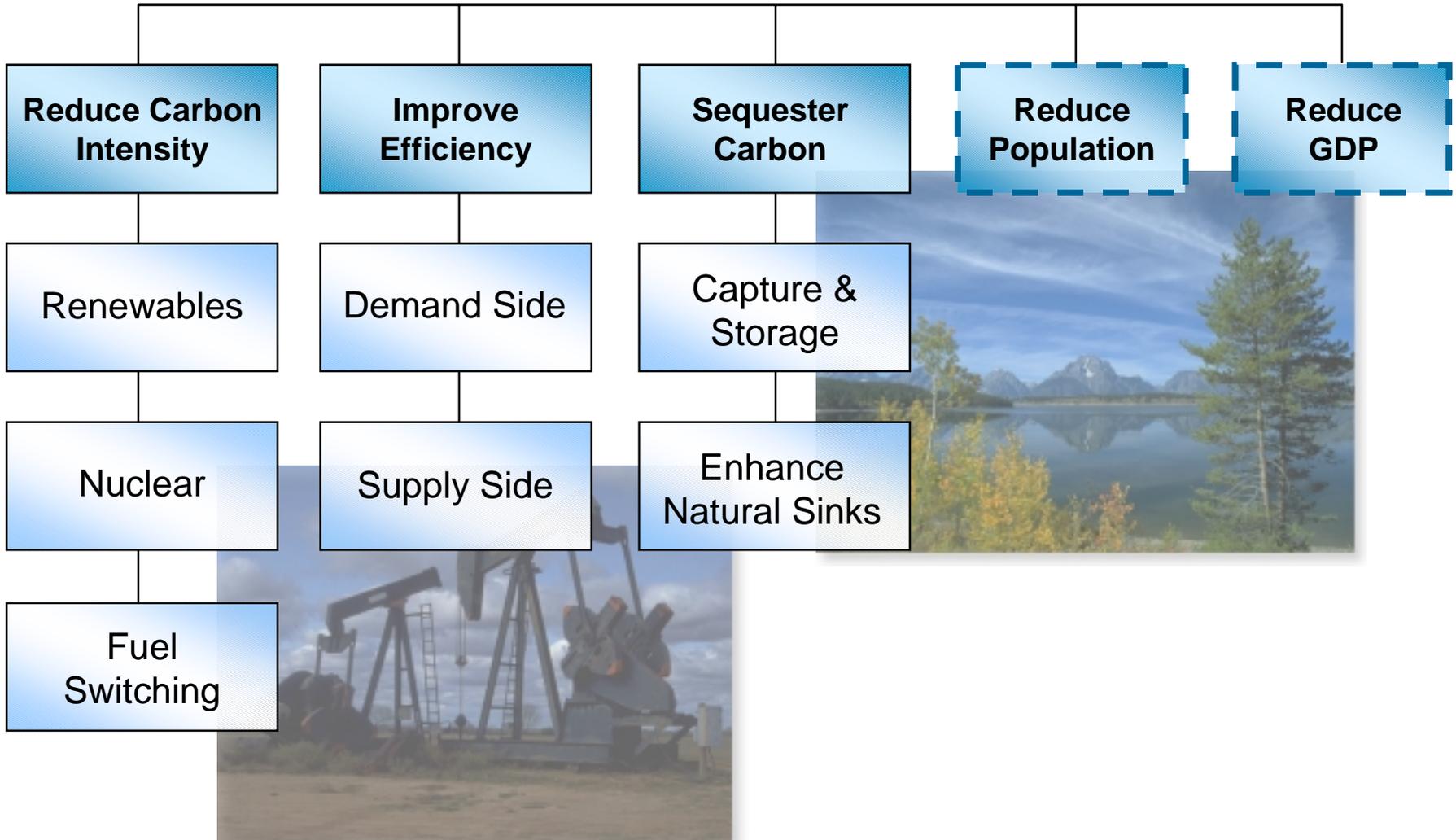
Source: "Historical CO<sub>2</sub> Record From the Vostok Ice Core"  
J.M. Barnolo et al, August 1999  
[www.cdiac.esd.ornl.gov/ftp/trends/co2/vostok.icecore.co2](http://www.cdiac.esd.ornl.gov/ftp/trends/co2/vostok.icecore.co2)

# World Energy Use Is Growing Dramatically

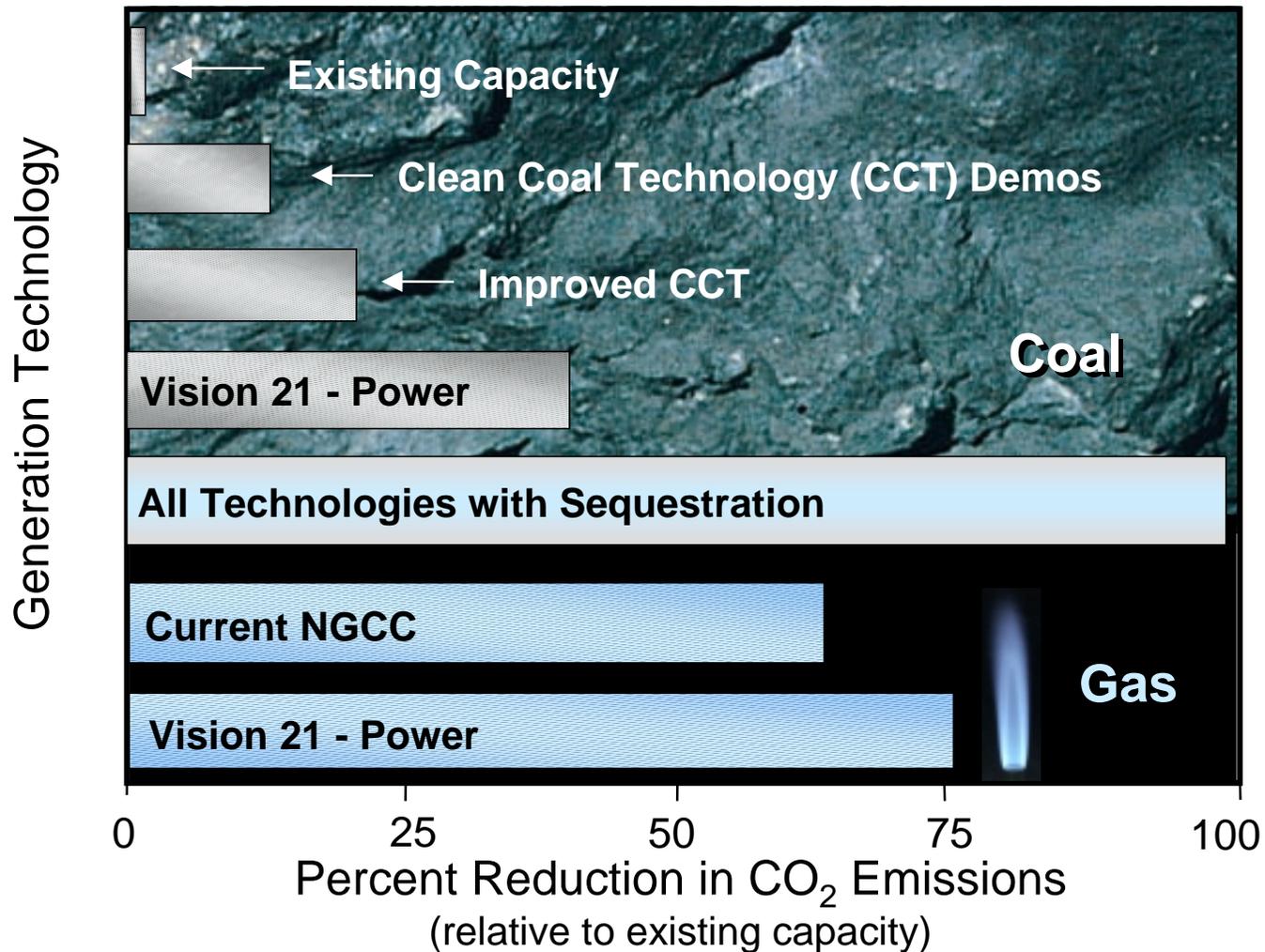


Population Projections: United Nations "Long-Range World  
Population Projections: Based on the 1998 Revision"  
Energy Projections: "Global Energy Perspectives" ITASA / WEC

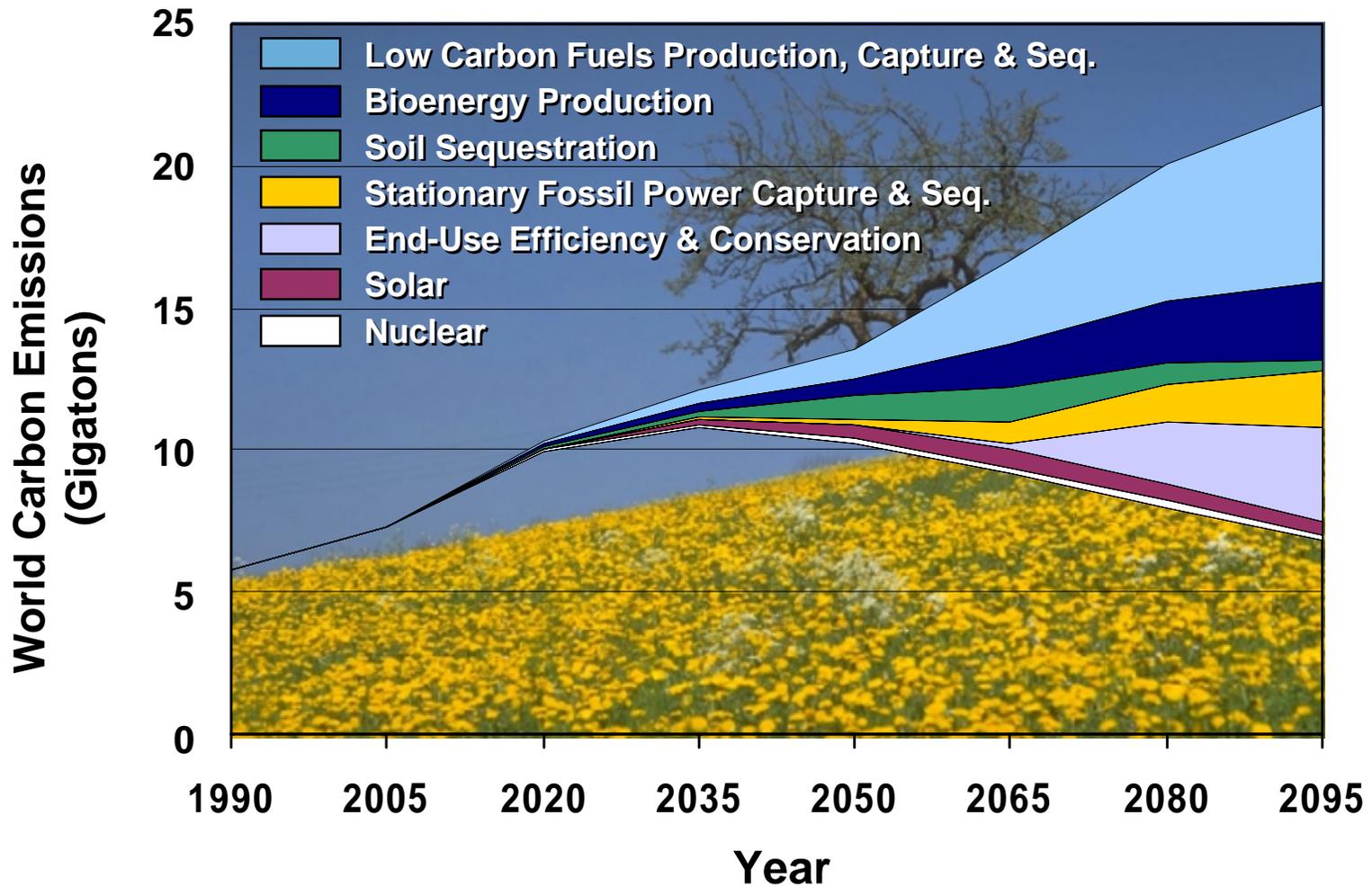
# CO<sub>2</sub> Mitigation Options



# Technology Can Reduce CO<sub>2</sub> Emissions From Fossil-Fueled Power Plants



# Technologies to Fill the Gap



Source: Pacific Northwest National Laboratory

# Drivers for Vision 21

- **Recognition that fossil energy will be part of future energy mix**
  - Environmental concerns must be addressed
- **Restructuring of energy industry**
  - New players open to multiple feedstocks/products
  - Under-investment in research and technology development
- **Recognition of value of “future options”**
  - Hydrogen economy?

# Vision 21

## *The Ultra-Clean Energy Plant of the Future*



### *Goal:*

**Absolutely Minimize  
Environmental  
Implications of Use  
of Fossil Energy!**

### *Approach:*

- **Maximize efficiency**
  - 60% coal-to-electric
  - 75% gas-to-electric
  - 75% fuels production
- **Near-zero emissions**
  - Option for carbon sequestration

# Vision 21 Program Goals

## Capital/Operating Costs/RAM

- Vision 21 must be competitive with other energy systems with comparable environmental performance

## Emissions

- < 0.01 lb/MMBtu SO<sub>2</sub> and NO<sub>x</sub>
- < 0.005 lb/MMBtu PM
- <1/2 HC rates in *Utility HAPS Report*
- <1 lb/trillion Btu Hg

## Schedule of Benefits

- Improved supporting technologies by 2006
- Designs for modules by 2012
- Commercial plant designs by 2015



# The Vision

*Effectively remove  
environmental concerns  
associated with using  
fossil fuels to produce  
electricity and  
transportation fuels  
(at competitive costs)*



# What's Different About Vision 21?

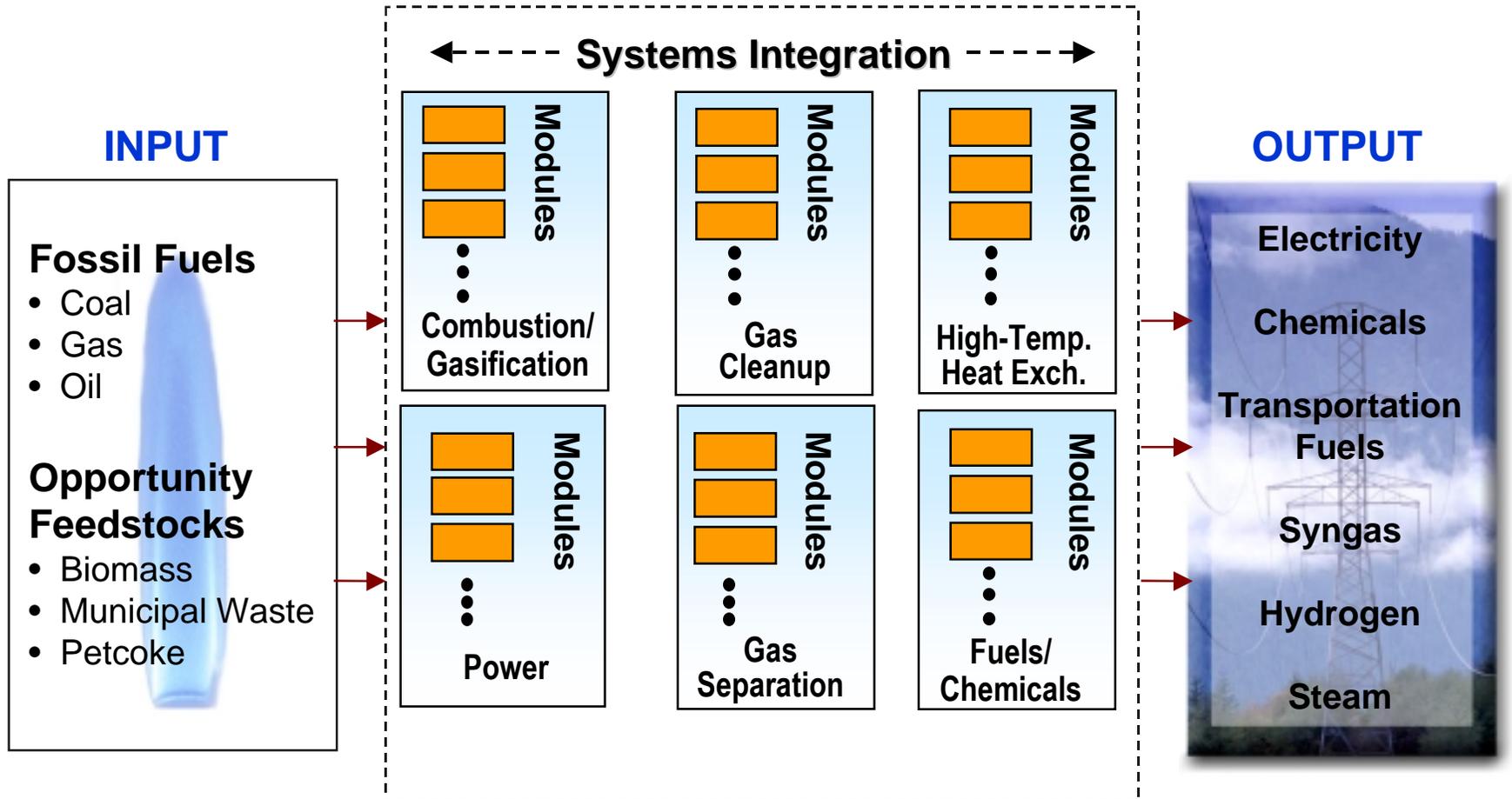
## *Traditional Coal Plant*

- Based on single technology
- Emission control “added on”
- Produces electricity only
- Single point design
- Reliability by overdesign
- Simple controls

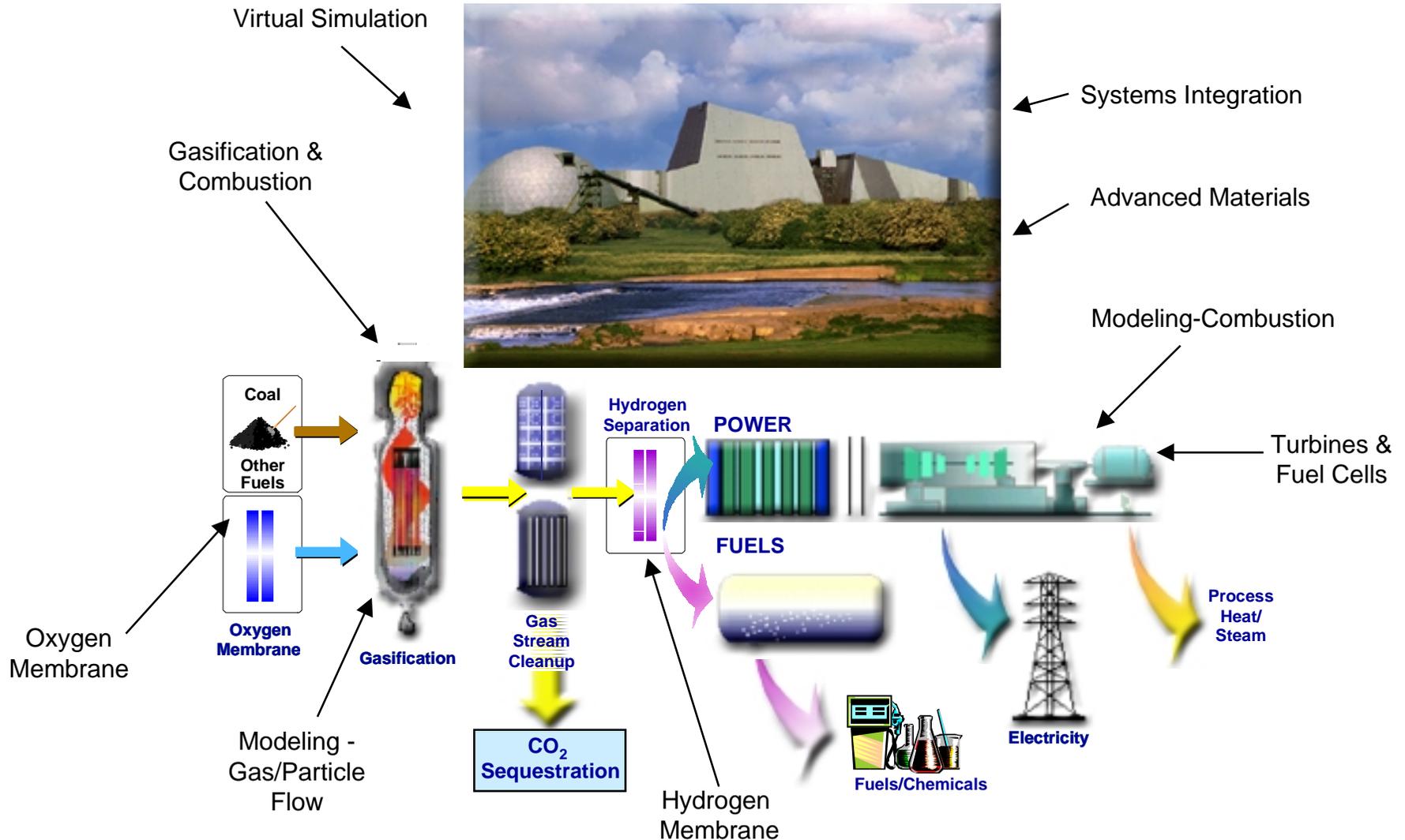
## *Vision 21*

- 
- Integrates multiple technologies
  - Industrial ecology
  - Multiple products
  - Defined design range
  - Reliability by smart design
  - Sophisticated controls

# Modular Technology



# New Projects Contribute to Ultra-Clean Energy Plant



# New Projects Contribute to Ultra-Clean Energy Plant

- **Systems Integration**
  - National Fuel Cell Research Center
- **Computational Modeling & Virtual Simulation**
  - Reaction Engineering International
  - Fluent, Inc.
  - Princeton University
  - CFD Research Corp.
- **High-Temperature Materials**
  - Huntington Alloys
- **Gasification & Combustion**
  - Foster Wheeler
  - GE Energy and Environmental Research Corporation
  - Clean Energy Systems
- **Turbines & Fuel Cells**
  - Fuel Cell Energy
- **Advanced Separation Technology**
  - Siemens Westinghouse
  - Eltron Research
  - ITN Energy Systems

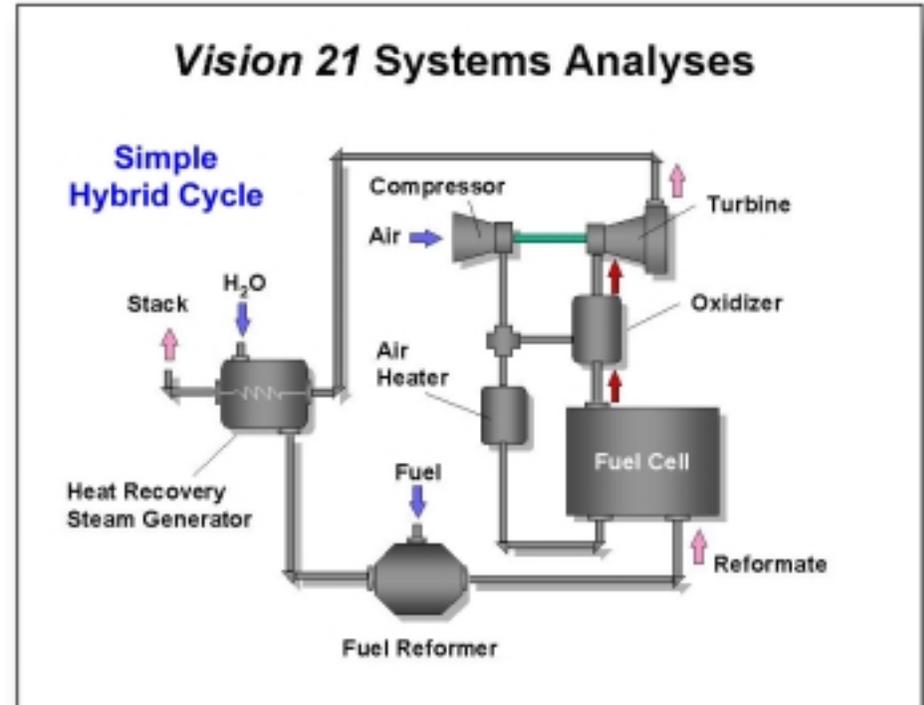
# Systems Integration

**National Fuel Cell Research Center**  
(Irvine, CA)

KraftWork Systems  
(Amston, CT)

Spencer Management Associates  
(Diablo, CO)

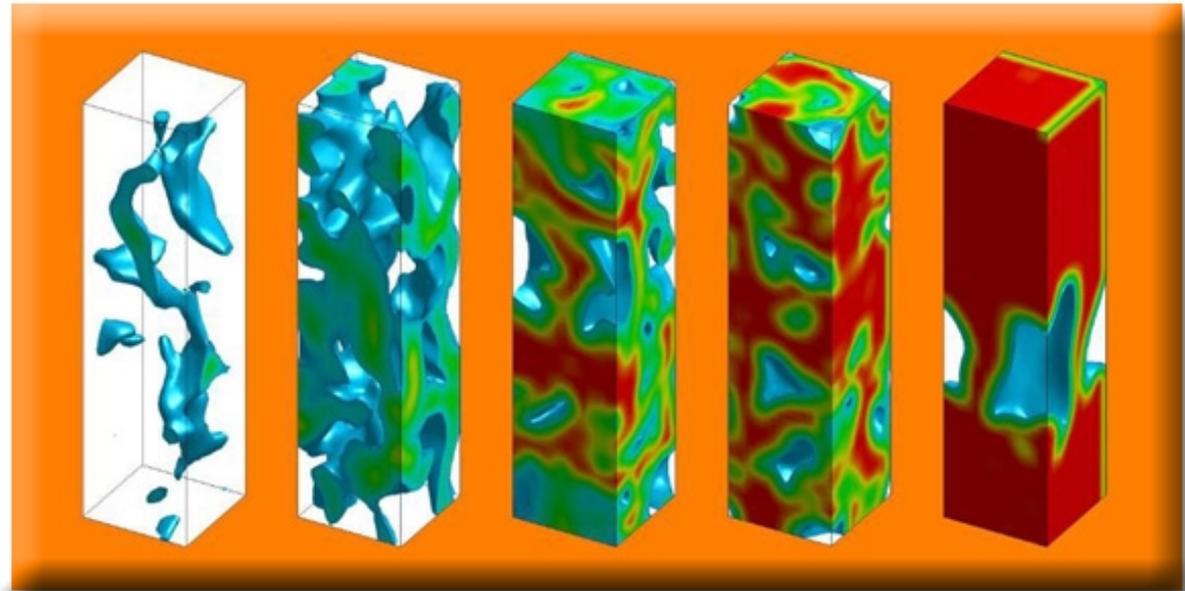
Pratt & Whitney Aircraft  
(East Hartford, CT)



***Define engineering issues associated with integrating key components and subsystems into Vision 21 plants***

# Computational Modeling and Virtual Simulation

*Princeton University  
(Princeton, NJ)*



*Computer software to simulate gas-particle flow in fluidized beds, including gasifiers, fluidized bed combustors, and pneumatic transport*

# High-Temperature Materials

**Huntington Alloys**  
(Huntington, WV)

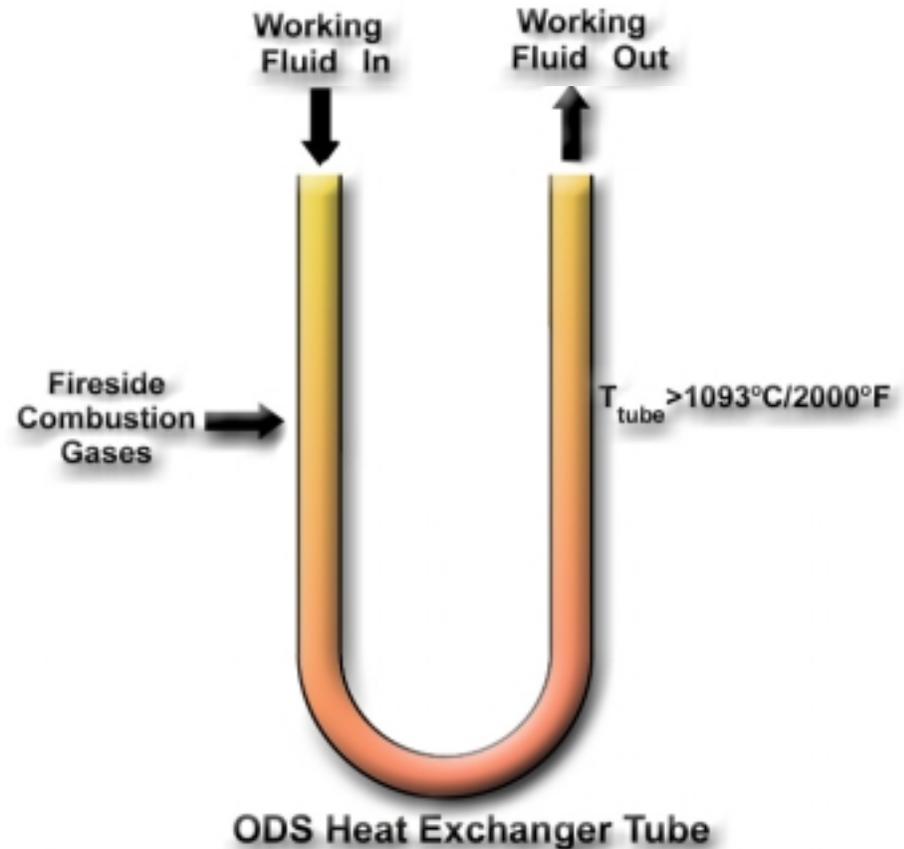
Foster Wheeler Development Corp.  
(Livingston, NJ)

ORNL (Oak Ridge, TN)

University of California at San Diego

Michigan Technological University  
(Houghton, MI)

Edison Welding Institute  
(Columbus, OH)



***Stronger, corrosion-resistant, high-temperature oxide dispersion strengthened alloys for Vision 21 heat exchangers***

# Gasification and Combustion

***Clean Energy Systems***  
*(Sacramento, CA)*



***“Rocket engine” steam generator to power an advanced turbine, generating electricity and emitting only water and a stream of CO<sub>2</sub> ready for sequestration***

# Computational Modeling and Virtual Simulation

## **Reaction Engineering International**

(Salt Lake City, UT)

Visual Influence

(Sandy, UT)

RECOM

(Magstad, Germany)

Foster Wheeler

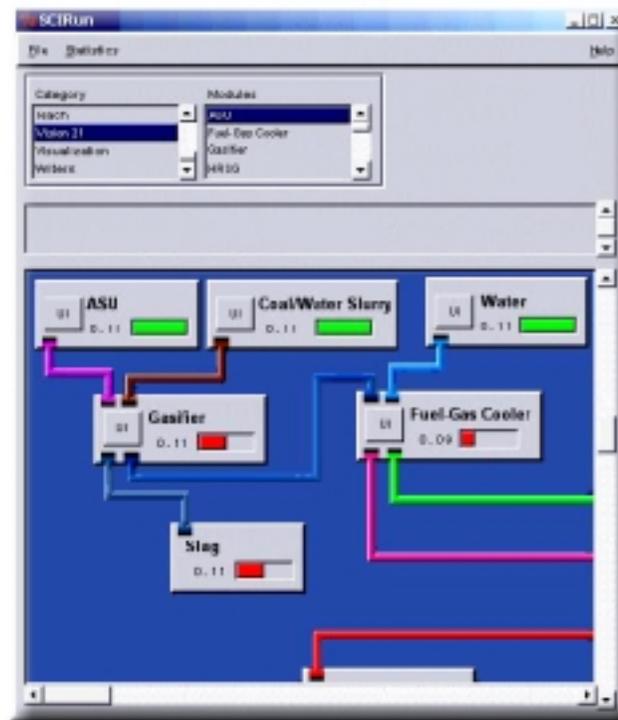
(Livingston, NJ)

MIT

(Cambridge, MA)

Iowa State University

(Ames, IA)



## **Fluent, Inc.**

(Lebanon, NH)

Alstom Power

(Windsor, CT)

Aspen Technology

(Cambridge, MA)

Intergraph

(Huntsville, AL)

West Virginia University

(Morgantown, WV)

***Begin building a “virtual simulation” system that would allow designers to model a fully functional Vision 21 plant on a computer***

***Computational virtual “workbench” to simulate Vision 21 technology modules and complete plants***

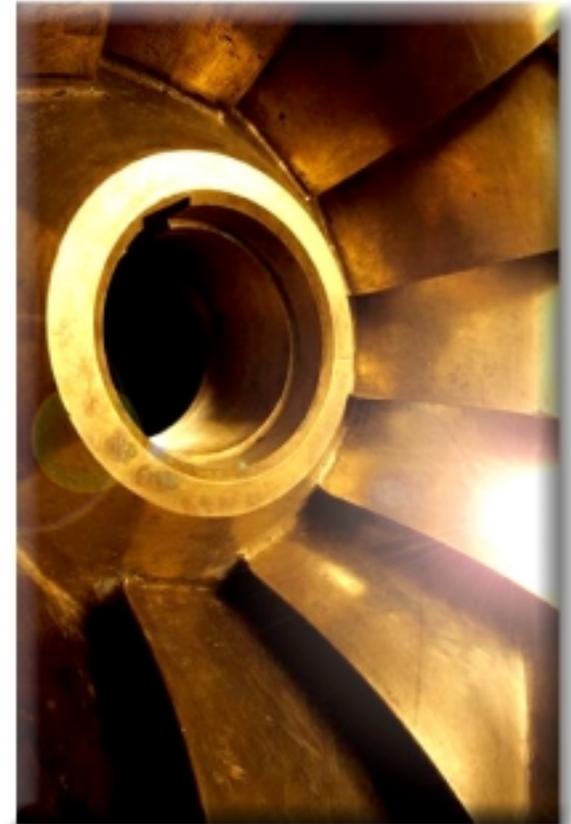
# Computational Modeling and Virtual Simulation

**CFD Research Corp.**  
(Huntsville, AL)

UC-Berkeley  
(Berkeley, CA)

Georgia Institute of Technology  
(Atlanta, GA)

Industrial consortium (Siemens-Westinghouse,  
Pratt & Whitney, GE Power Systems, Solar  
Turbines, Honeywell, Coen Co., MTI  
Technologies, Vapor Power Group)



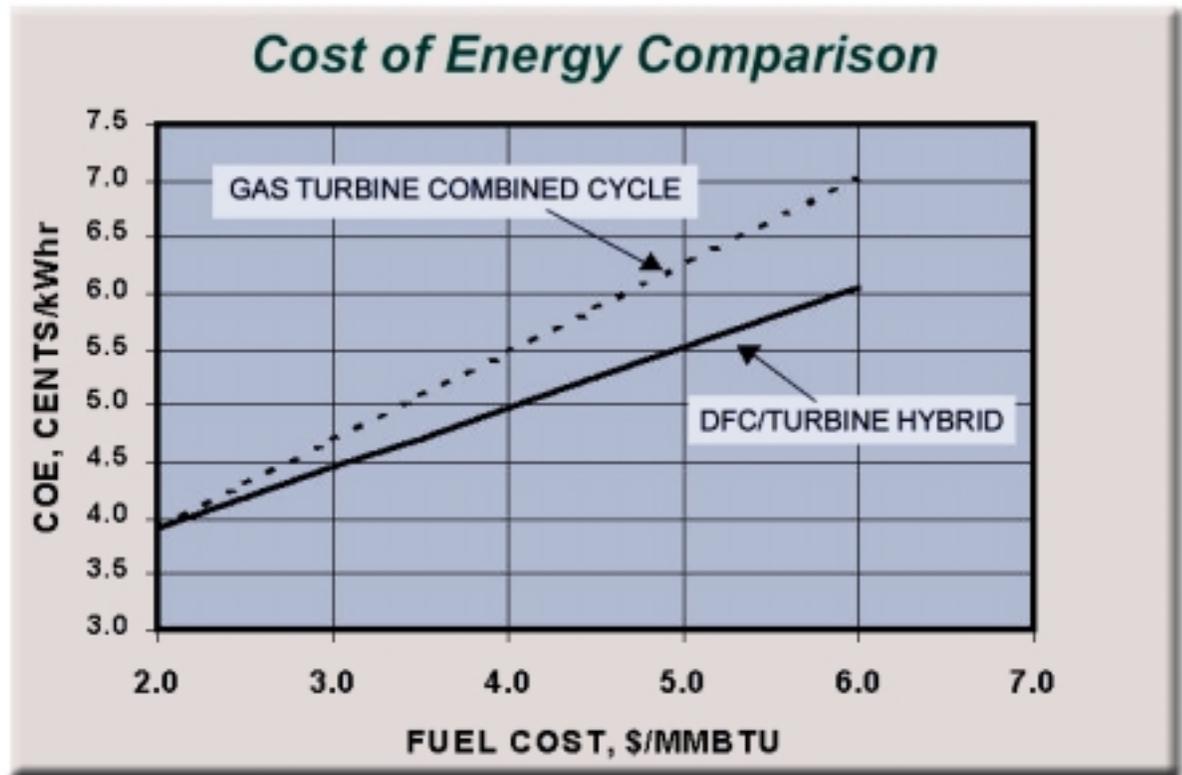
***Advanced computational tool to design low-emission combustion systems for gas turbines***

# Turbines and Fuel Cells

## **Fuel Cell Energy** (Danbury, CT)

Capstone Turbine  
(Woodland Hills, CA)

Allison Engine  
(Indianapolis, IN)



**Fuel cell/gas turbine “hybrid” power system with 65-80% efficiency**

# Gasification and Combustion

## ***Foster Wheeler Development Corporation***

*(Livingston, NJ)*

Nexant

*(San Francisco, CA)*

Praxair

*(Danbury, CT)*

REI

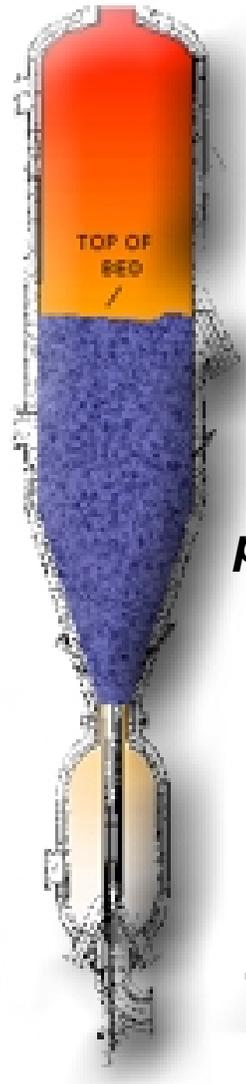
*(Salt Lake City, UT)*

Corning

*(Elmira, NY)*

ADA Technology

*(Livermore, CA)*



## ***GE Energy & Environmental Research Corporation***

*(Irvine, CA)*

team members - proprietary

***Advanced combustion/  
gasification concept that  
produces hydrogen for fuel cells  
or combustion turbines and  
sequestration-ready CO<sub>2</sub>***

***Pressurized circulating fluidized  
bed partial gasification module  
that produces gaseous and  
solid fuels for use in fuel-flexible  
high-efficiency plants***

# Advanced Separation Technology - Hydrogen

***Eltron Research*** (Boulder, CO)

Chevron Chemical (Houston, TX)

Coors Ceramics (Golden, CO)

McDermott International/F&W (Alliance, OH)

United Catalysts (Louisville, KY)

ANL (Argonne, IL)

ORNL (Oak Ridge, TN)

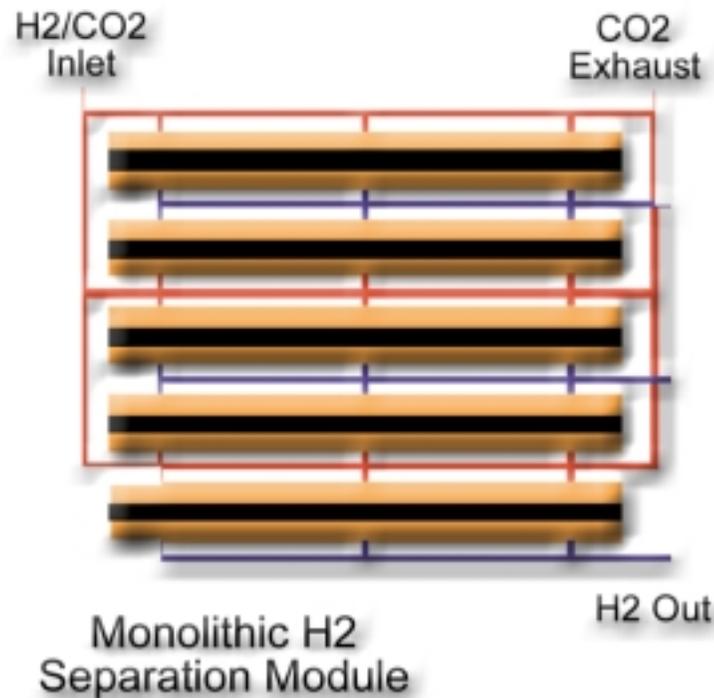
***ITN Energy Systems*** (Wheat Ridge, CO)

INEL (Idaho Falls, ID)

Nexant (San Francisco, CA)

ANL (Argonne, IL)

Praxair, Inc. (Danbury, CT)



***Ceramic membrane to separate hydrogen from gas streams***

# Advanced Separation Technology - Oxygen

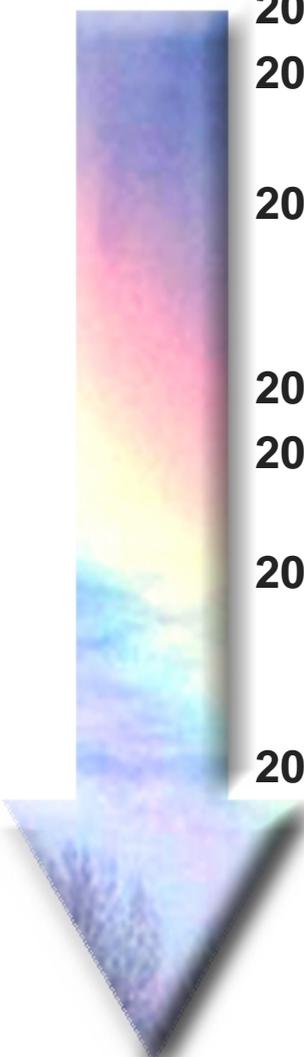


**Siemens Westinghouse Power Corporation**  
(Pittsburgh, PA)

Praxair, Inc.  
(Tonawanda, NY)

***Zero emission power plant integrating solid oxide fuel cells with oxygen separation membranes***

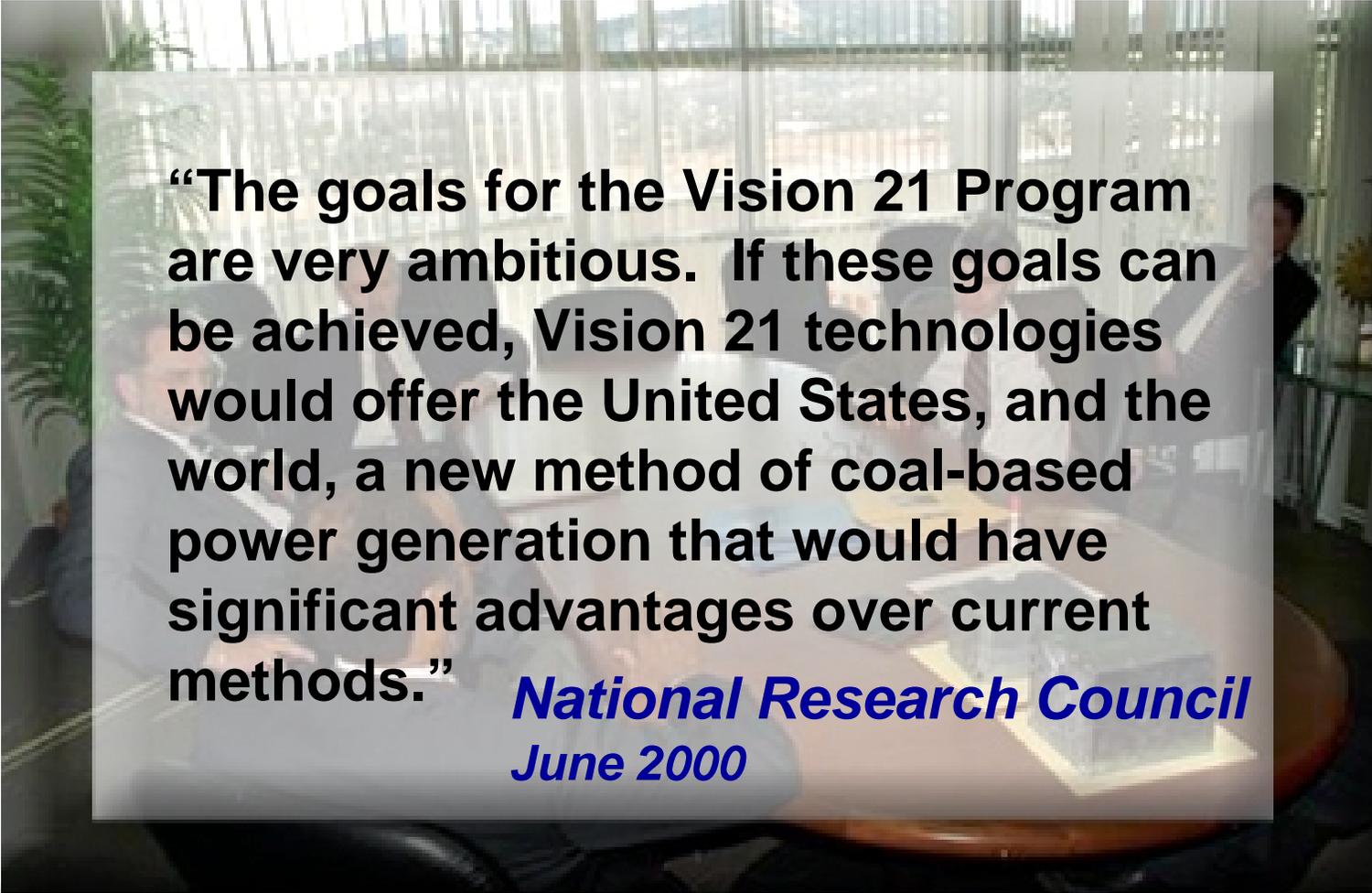
# Timeline for Vision 21 Spinoffs

- 
- 2003** - 60% efficient hybrid system demonstrated
  - 2004** - High-temperature (2,300 °F) air heater 1,000-hour test
    - Improved materials for high-temperature service
  - 2005** - Computer visualization integrated with scientific and engineering simulations
    - Computer design and simulation tools
  - 2006** - Prototype air separation module tested
  - 2007** - Advanced PM<sub>2.5</sub> control technology ready for standards implementation
  - 2008** - Commercial air separation membranes provide low-cost oxygen
    - Advanced fuel-flexible gasifiers commercial
    - Advanced turbine technology available
  - 2010** - Hydrogen separation membranes provide low-cost hydrogen for power and fuels processing
    - Ultra high-temperature (3,000 °F) air heater tested
    - 70% efficient hybrid system demonstrated
    - Highly efficient fuel cell/turbine hybrids
    - Improved materials for high-temperature service

# Vision 21 Is Crosscutting Program



# NRC Report on Vision 21

A group of people in a meeting room, with a large quote overlaid on the image. The quote is in black text on a semi-transparent white background. The background image shows several people sitting around a table in a modern office setting with large windows.

**“The goals for the Vision 21 Program are very ambitious. If these goals can be achieved, Vision 21 technologies would offer the United States, and the world, a new method of coal-based power generation that would have significant advantages over current methods.”**

***National Research Council  
June 2000***

# NRC Recommendations

- **Vision 21 should become the primary focus of FE's program in coal and power systems**
- **Vision 21 should be a separate program area within FE with its own clearly defined budget**
- **Develop links with other science and engineering programs within and beyond DOE**
- **Accommodate a range of environmental scenarios, especially carbon management**
- **Establish tradeoff criteria for early commercialization of Vision 21 technologies**
- **Facilities at PSDF, CCT projects, and NETL should be available to test and develop Vision 21 technologies**

# What's Important?

- Leapfrog performance improvement
- Near-zero environmental impact
- Zero CO<sub>2</sub> emission option
- Feedstock and product flexibility
- Industrial ecology
- Technology development focus
- Systems integration



# What We Need from Participants

- **Identify missing technologies and capabilities**
- **Review and revise Vision 21 performance and cost objectives**
- **Review and revise current technology performance and cost**
- **Identify missing barriers and clarify stated barriers**
- **Review and revise accuracy of current status**



## More of What We Need

- **Develop approach to overcome barriers**
  - Review and revise tasks
  - Identify missing tasks
- **Indicate priorities**
  - Barriers
  - Tasks
- **Focus on addressing Vision 21 needs, not solving current problems**



# What Happens After Workshop?

- **Feedback from workshop will be compiled**
- **Draft roadmaps will be revised**
- **Revised roadmaps will be distributed to participants**
- **“Messages” from workshop will be incorporated into program planning**
- **Future workshops/conferences will be held to:**
  - Further define program needs
  - Obtain stakeholder feedback and guidance



# Logistics

## Wednesday

- **Self-organize within each group**
- **Work in your assigned group this morning and afternoon**
- **Evening roundabout session: an opportunity to consider integration issues with other technology areas**
- **Resource people available**



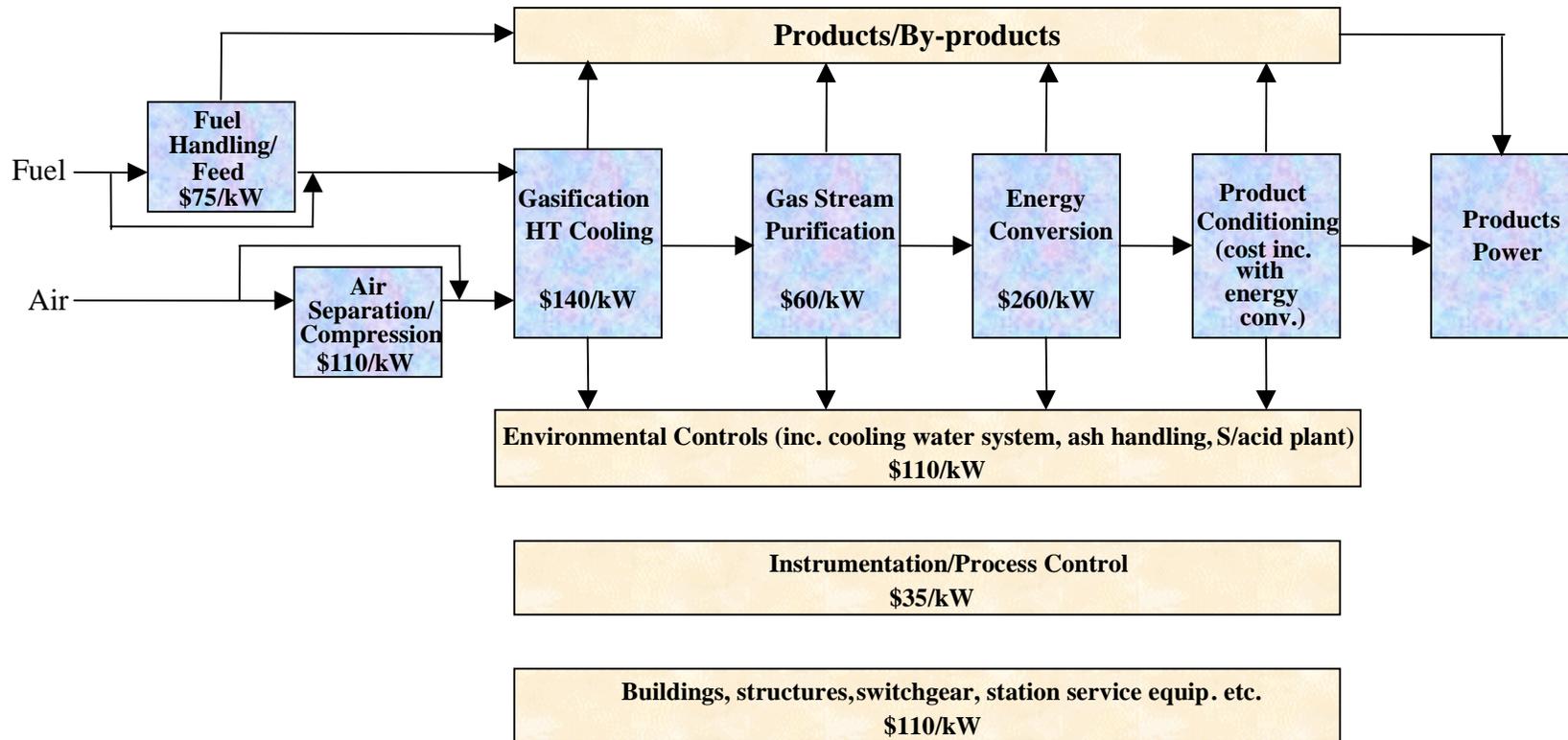
# *More Logistics*

## Thursday

- **Document results**
  - Revise draft roadmap using computer in breakout room
  - Submit comments on other roadmaps that relate to your roadmap
- **Presentations**
  - Brief summary (8 minutes)
  - Highlights, not presentation of revised roadmap
    - Priority objectives and barriers
    - Priority tasks to overcome barriers



# Vision 21 Plant – Capital Cost Example



**Reference Plant Capital Cost: \$900/kW**

**Nominal 500 MW Oxygen-Blown Gasification Based Vision 21 Plant for Power Generation – Efficiency 60%**