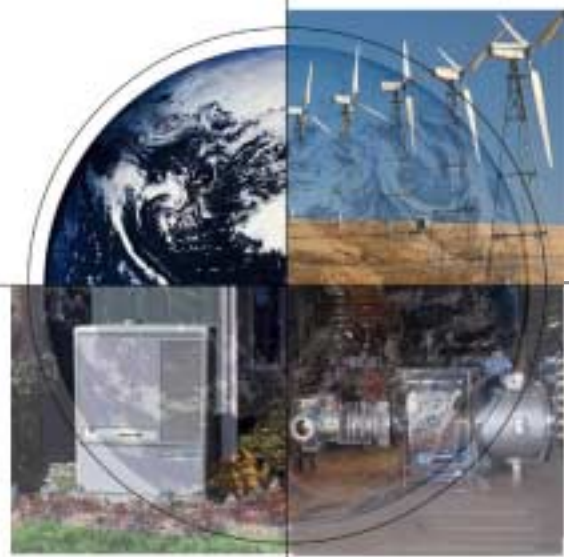
Natural Gas and Renewables
Greener Sooner



U.S. DOE Natural Gas/ Renewable Energy Hybrids Workshop

August 7-8, 2001

Rita A. Bajura, Director

National Energy Technology Laboratory

NETL Plays Key Role in Fossil Energy Supply, Delivery, and Use Technologies

Electric Power Using Coal

Coal Production

Environmental Control

V21 Next Generation

Carbon Sequestration

Clean Liquid Fuels

Exploration & Production

Refining & Delivery

Alternative Fuels

Natural Gas

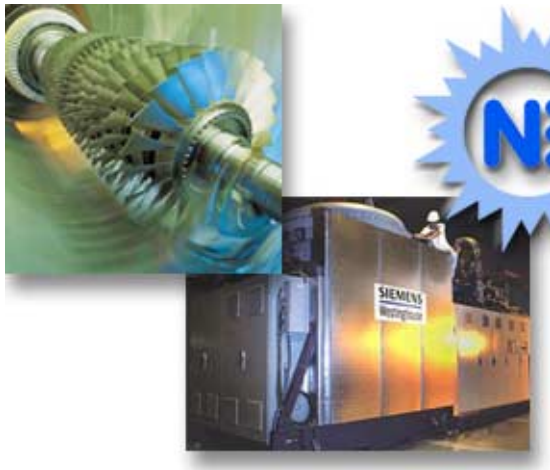
Exploration & Production

Pipelines & Storage

Fuel Cells

Combustion Turbines

Energy: Our Core Mission



NETL

National Energy Technology Laboratory

National Renewable Energy Laboratory

NREL

Natural Gas / Renewable Energy Journey

11/99
Informal Gas/ Renewable Discussion

12/99
Strategic Center for Natural Gas Established at NETL

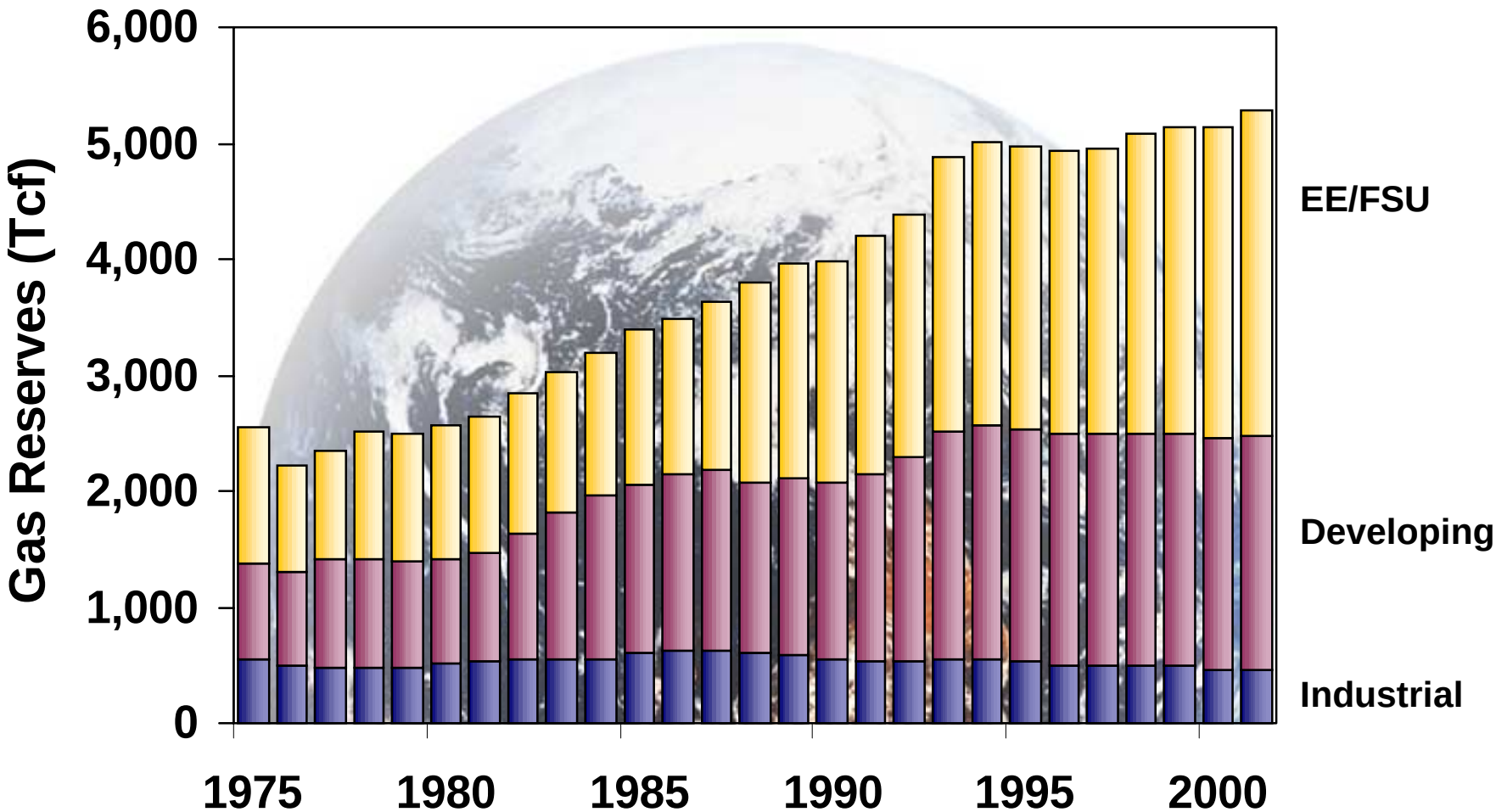
Gas/Renewable Industry Roundtables
03/00 04/00 06/00

07/00
Natural Gas Renewable Energy Alliance Announced

01/01
MOU Fossil/Renewable Collaboration

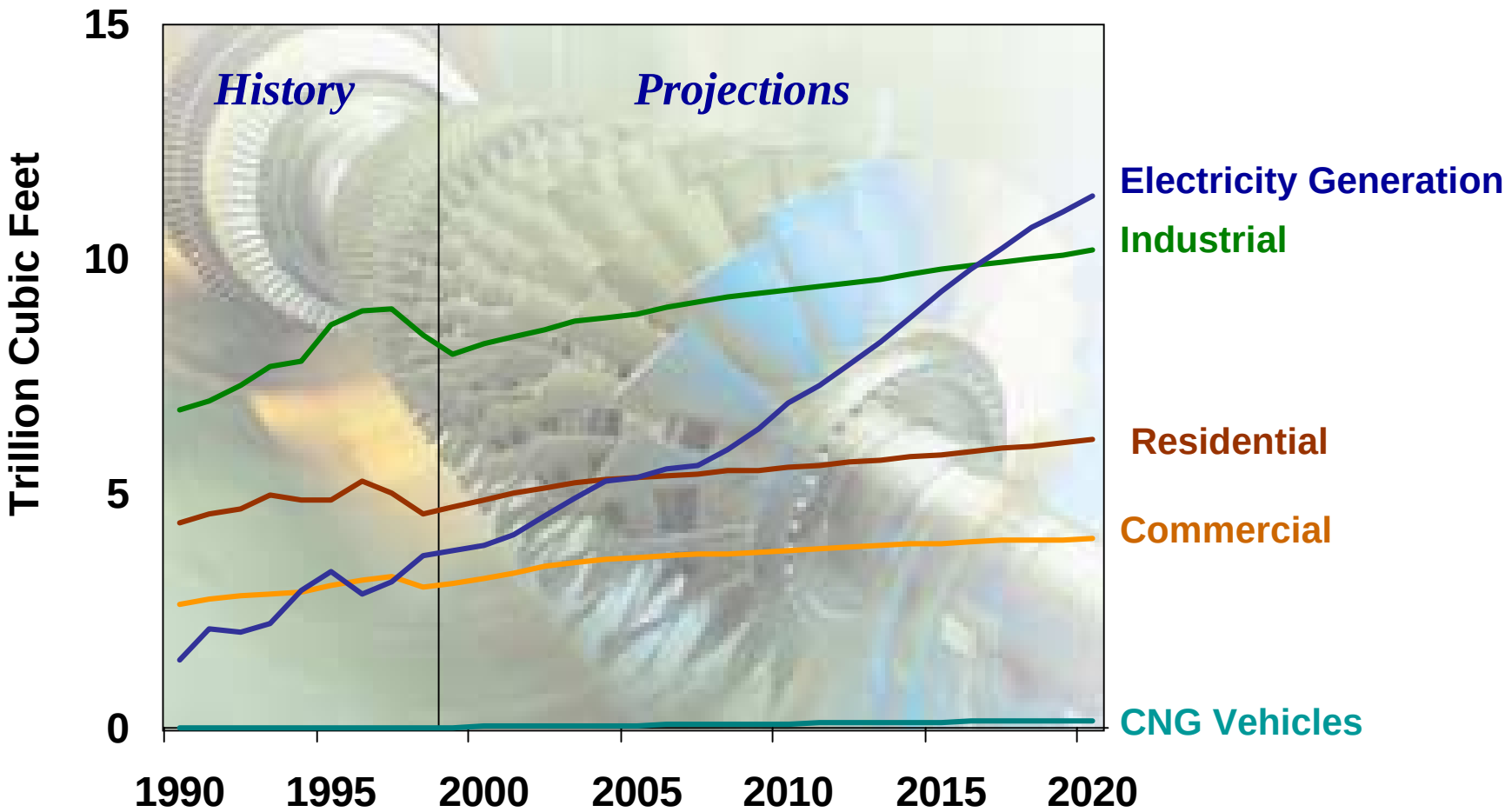
Natural Gas/ Renewable Workshops 08/01

Abundant Worldwide Gas Reserves



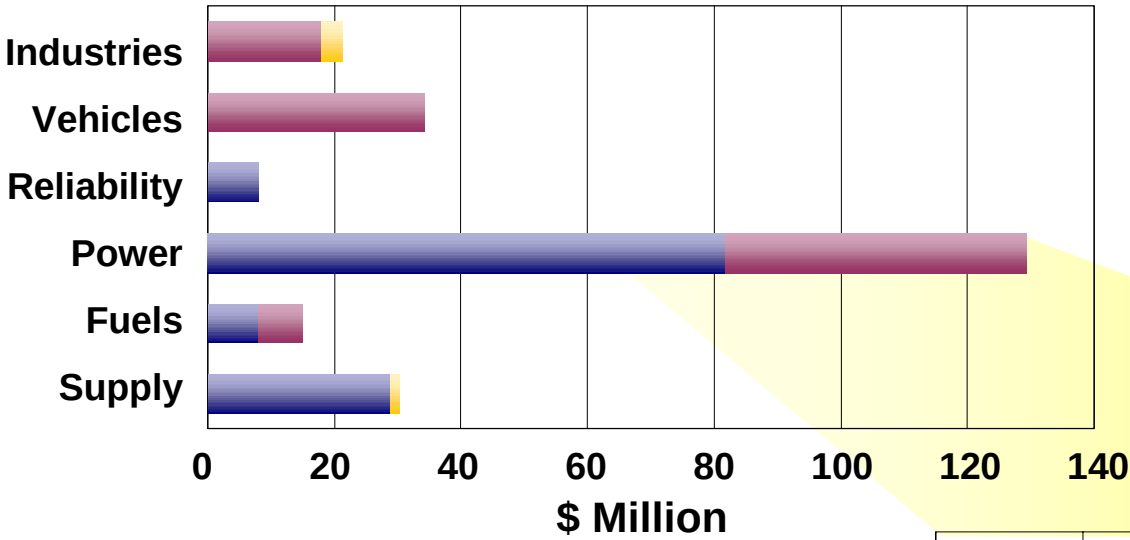
International Energy Outlook 2001, Figure 40

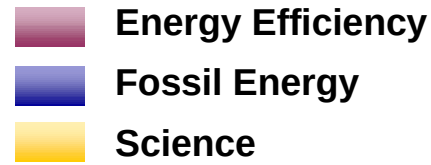
U.S. Natural Gas Consumption by Sector
1990-2020

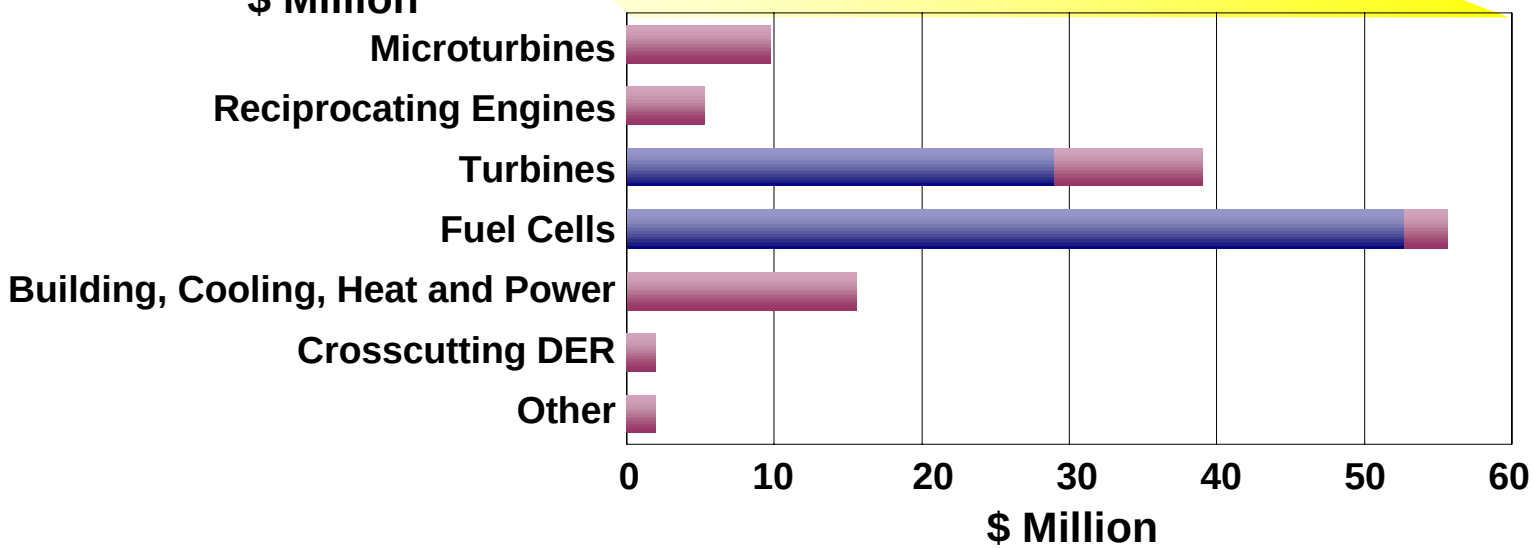


DOE's Natural Gas Portfolio

$238 million/year







Hybrid
Oxford English Dictionary, Second Edition

hybrid ("halbrId, "hIbrId), *n. and a.*

Offspring of two animals or plants of different species, or (less strictly) varieties; a half-breed, cross-breed, or mongrel

1601 Holland *Pliny* II. 231. . . and verily such hogs in old time they called Hybrides, as a man would say, halfe wild

1623 Cockeram, *Hibride*, a Hog ingendred betweene a wilde Boare and a tame Sow

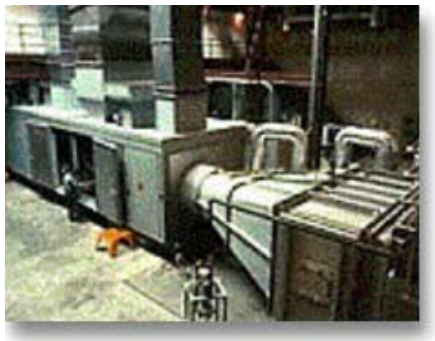
Hybrid Systems

Natural Gas Power Systems

Renewable Technologies and Fuels

Hydro plant photo by Warren Gretz, NREL

Distributed Generation Technologies



Small Turbines

Fuel Cells

Fuel Cell/Turbine Hybrids

Microturbines

Solar

Wind

Vision 21
Ultra-Clean Power Plant of the Future

Energy Plants for Post-2015

- **Use available feeds:**
  - Coal, gas, biomass, waste
- **Electricity is primary product**
  - May co-produce fuels, chemicals, steam, heat

Goal:

Absolutely minimize environmental implications of use of fossil energy!

Approach:

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

Natural Gas / Renewable Characteristics

	Natural Gas	Renewable
Capital Cost		
Fuel Costs		$0
Availability	24/7	
Efficiency	60% +	Varies
Public Acceptance	?	YES ☑ ☐ NO
Emissions		

Natural Synergies for Reliable, Environmentally Friendly Power

NETL

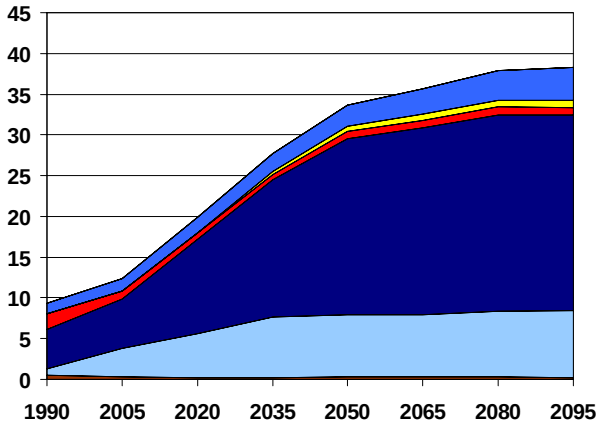
Public Benefits

Natural Gas / Renewable Energy Hybrids

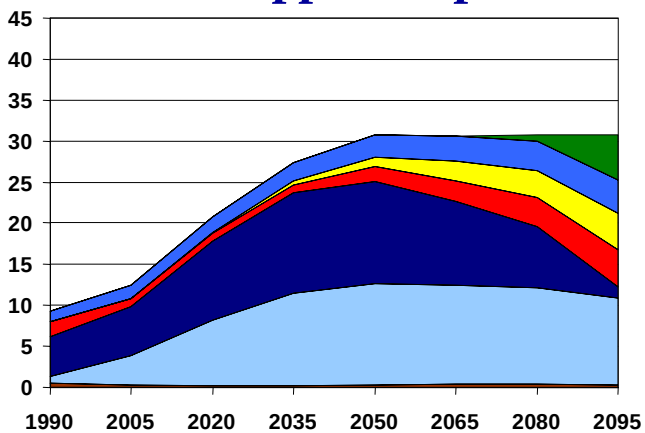
- **Reduce emissions**
- **Improve reliability**
- **Provide fuel diversity**
- ***Greener Sooner***

Transition to the Future
U.S. Electricity Generation

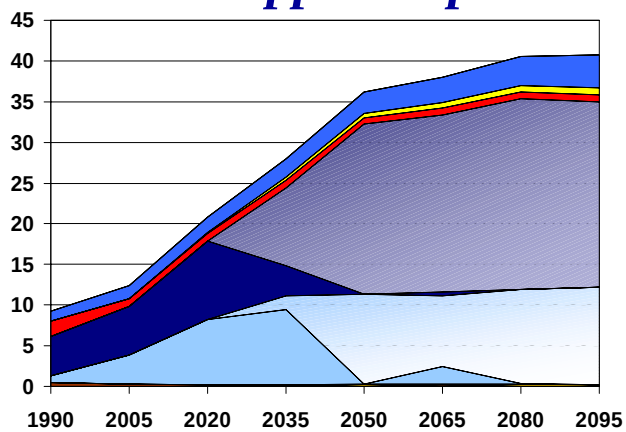
Reference Case
No CO_2 cap



No Sequestration
550 ppmv cap



Sequestration Option
550 ppmv cap

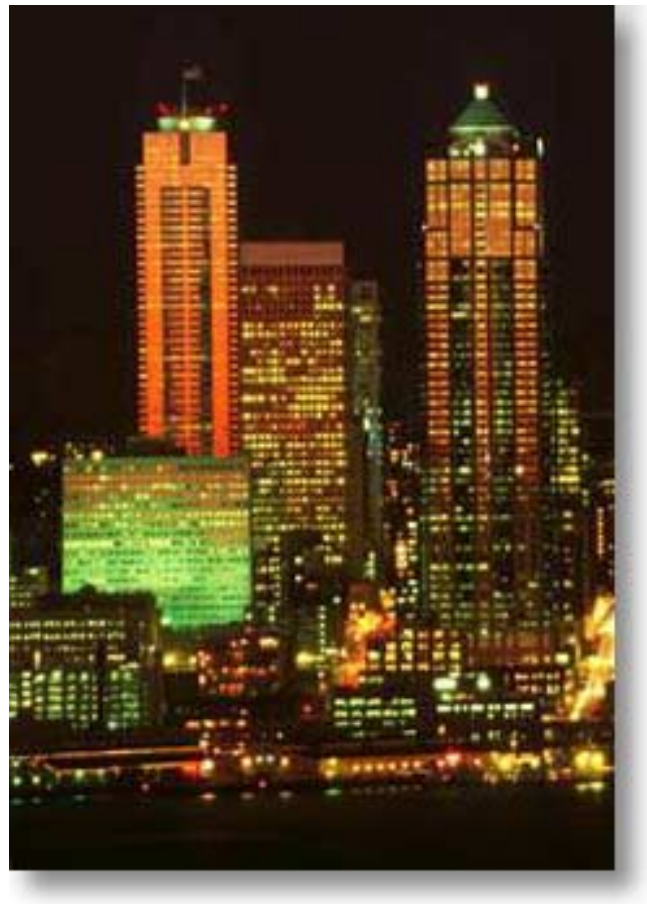


Biomass
Hydro
Solar
Nuclear
Coal
Gas

PNNL Report No. 13095; "Potential for Advanced Carbon Capture and Sequestration Technologies in a Climate Constrained World"

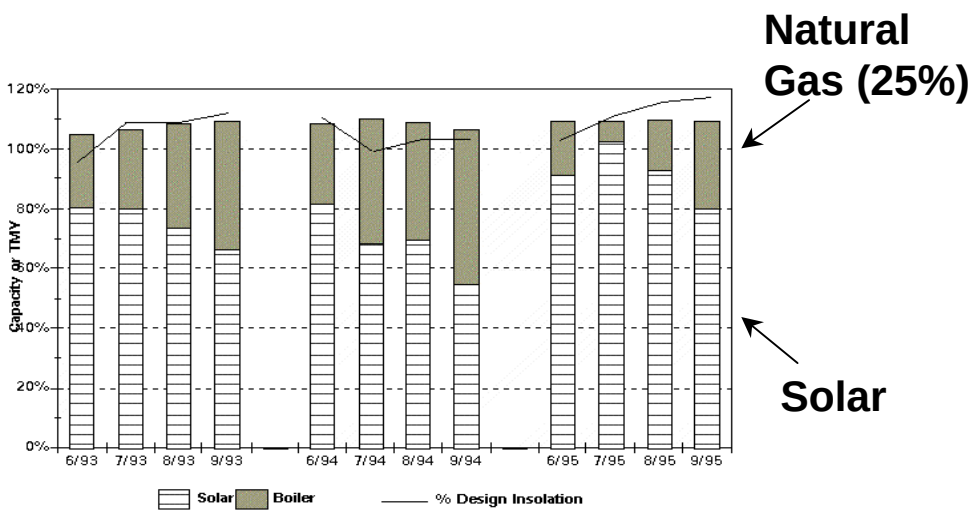
Commercial Advantages
Natural Gas / Renewable Energy Hybrids

- **Power 24/7**
- **Public acceptability**
- **Financial incentives (renewable tax credits)**
- **Portfolio standards**



Solar / Natural Gas Hybrid

- **9 SEGS plants in California**
  - Solar Electric Generating System
- **354 MW combined capacity**
- **Produce >90% of world's solar electric**



On-Peak Capacity Showing Hybrid Operation

SEGS Plant in Kramer Junction, CA

Photo courtesy of KJC Operating Company

Geothermal / Natural Gas District Heating
Zakopane, Poland

- **Geothermal wells produce hot water for district heating**
- **Gas-fired hot water boilers**
  - Supply peaking needs
  - Drive absorption heat pumps
- **Significantly reduces emissions**

Biomass / Natural Gas Hybrid

McNeil Generating Station
Burlington, VT

- **Largest U.S. utility-owned wood-burning plant**
- **In operation since 1984**
- **Plant retrofit 1989 to burn natural gas**
- **First demonstration of biomass gasifier**

Photo by Warren Gretz NREL

USDA Agricultural Research Service
Waste to Energy Project

- **Project partners:**
  - USDA
  - EERE
  - NETL
- **Demonstrate advanced low emission technology on animal waste digester gas**

Pleasant Hills Sewage Treatment Plant
Pittsburgh, Pennsylvania

- **Digester gas currently flared**
- **NETL working with local municipality to install microturbine CHP system**
- **Plant to produce 30 kWe from digester gas**
- **Potential for 270 kWe gas-fired microturbines**

Objectives for Today's Workshop

For hybrid systems, identify

- **Opportunities**
- **Barriers to use**
- **Technology gaps**
- **System integration tools**

Photo by Warren Gretz NREL

Hybrid Natural Gas / Renewable Energy Systems

Greener Sooner