

VISION 21

Energy Plant of the Future



**EPGA Power Generation
Conference
Hershey, PA
October 24-26, 2001**



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National Energy Technology Laboratory

Drivers Changing Power Industry

- **Deregulation and electric utility restructuring**
 - Market-driven environment
 - Profitability and investment concerns
 - Aversion to risk
- **Low cost of natural gas**
 - Gas technologies favored over alternatives
 - Most new capacity to be gas-fired turbines and combined cycles
- **Environment**
 - Pressure to reduce emissions, especially NO_x, fine particulate, mercury
 - Concern over global climate change (CO₂ emissions)

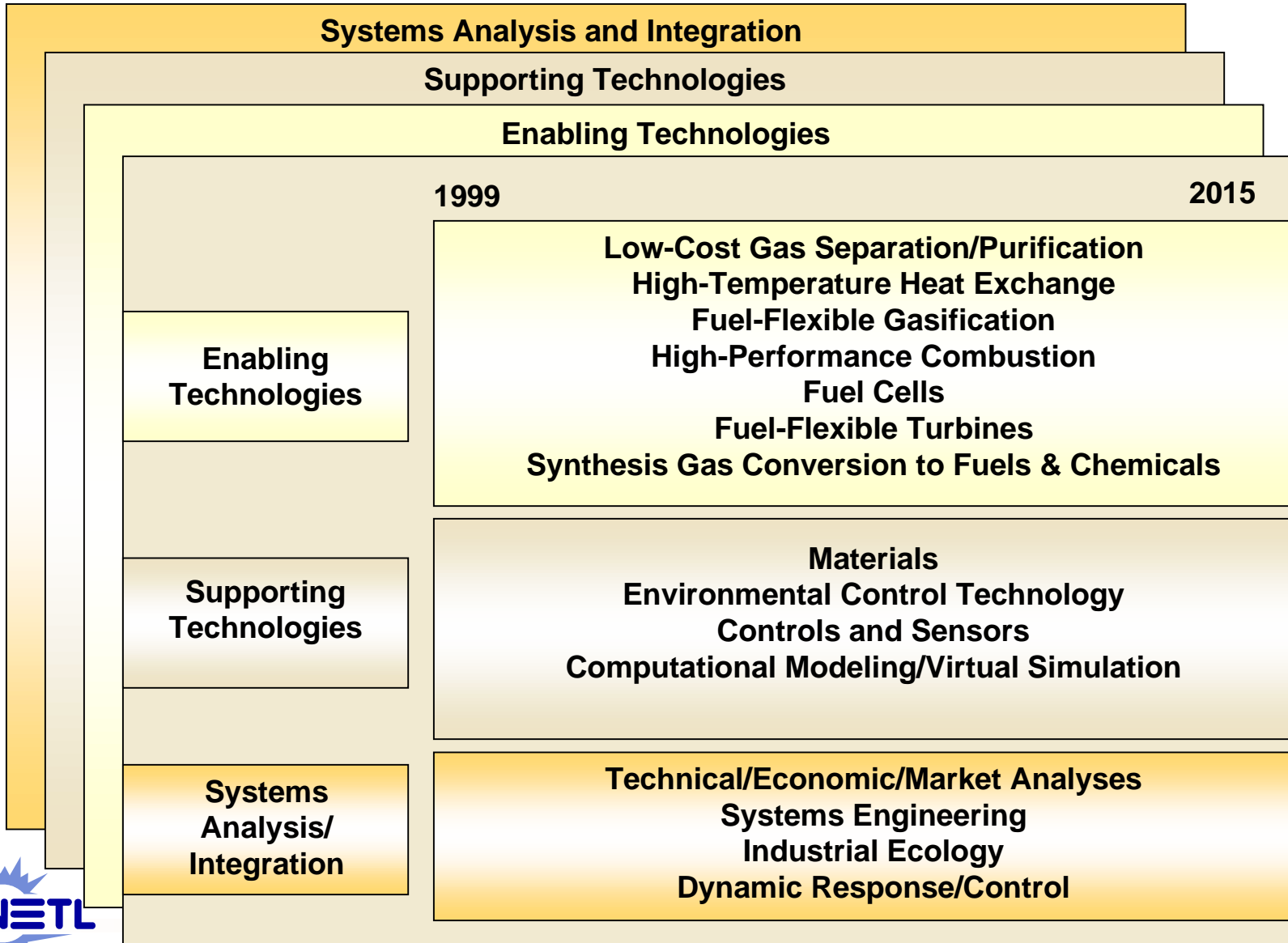
Technology innovation is the best way to address the coming challenges to our electric power and fuel supply infrastructure.



Vision 21 Is Crosscutting Program



VISION 21 Technology Roadmap



Vision 21 Program Objectives

Capital & Operating Costs/RAM

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

Emissions

- $< 0.01 \text{ lb}/10^6 \text{ Btu SO}_2$ and NO_x
- $< 0.005 \text{ lb}/10^6 \text{ Btu PM}$
- $< 1/2$ organic compounds in *Utility HAPS Report*
- $< 1 \text{ lb}/10^9 \text{ Btu Hg}$

Schedule of Benefits

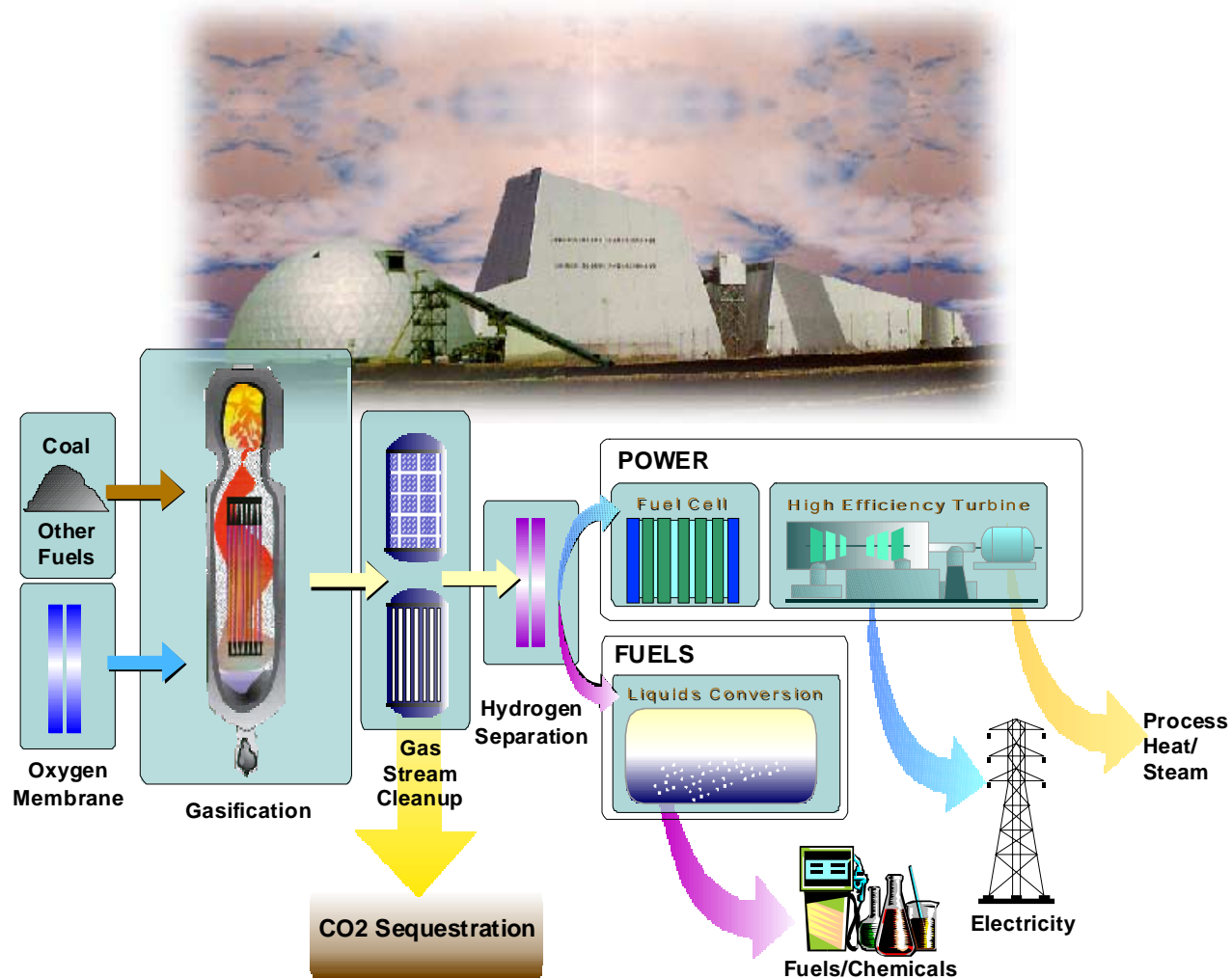
- Technology spinoffs by 2005
- Designs for modules by 2012
- Commercial plant designs by 2015

Efficiency

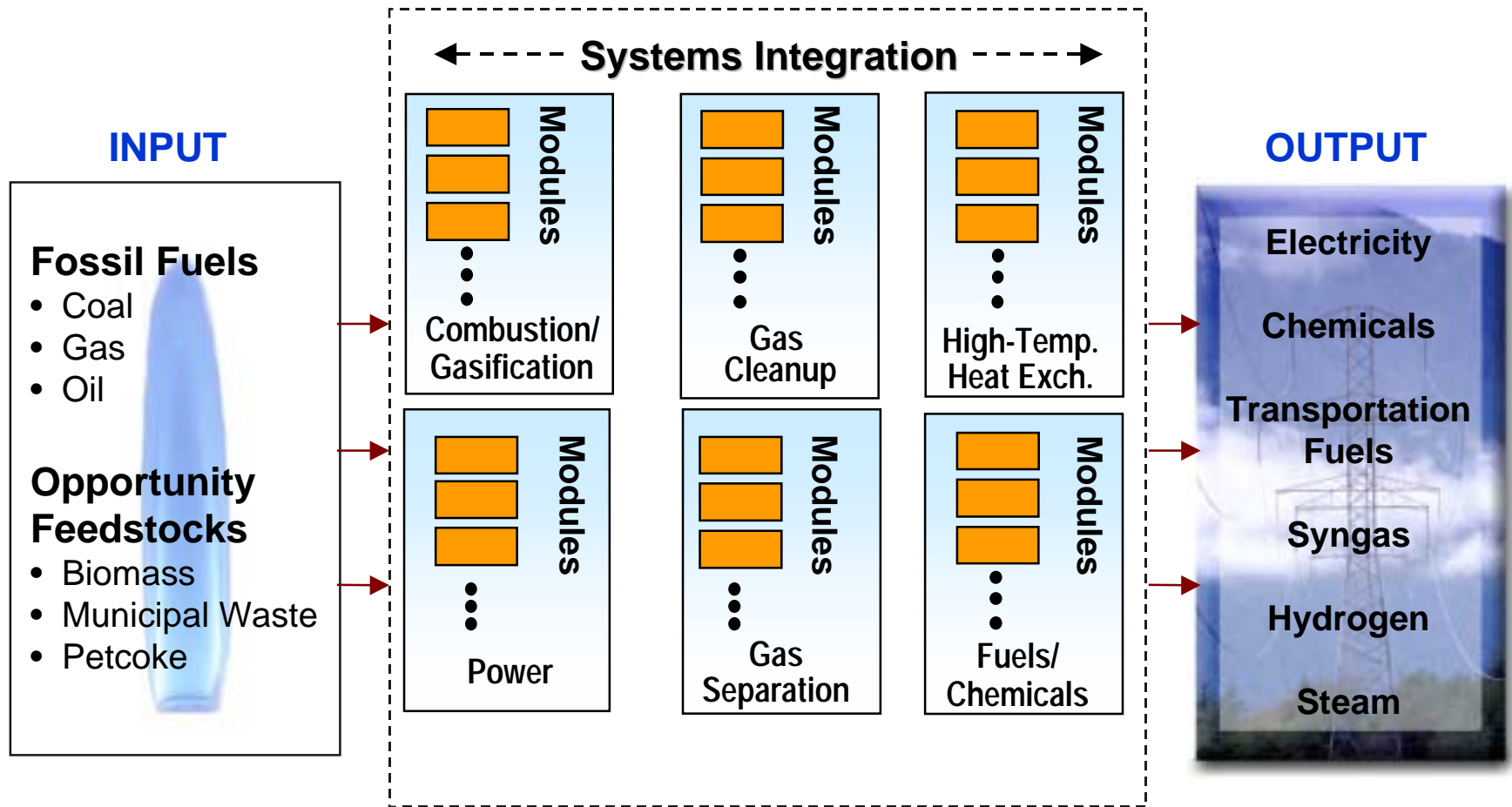
- Electricity generation
 - coal based 60% (HHV)
 - gas based 75% (LHV)
- Fuels only plants 75%



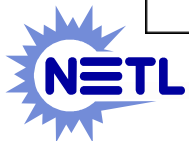
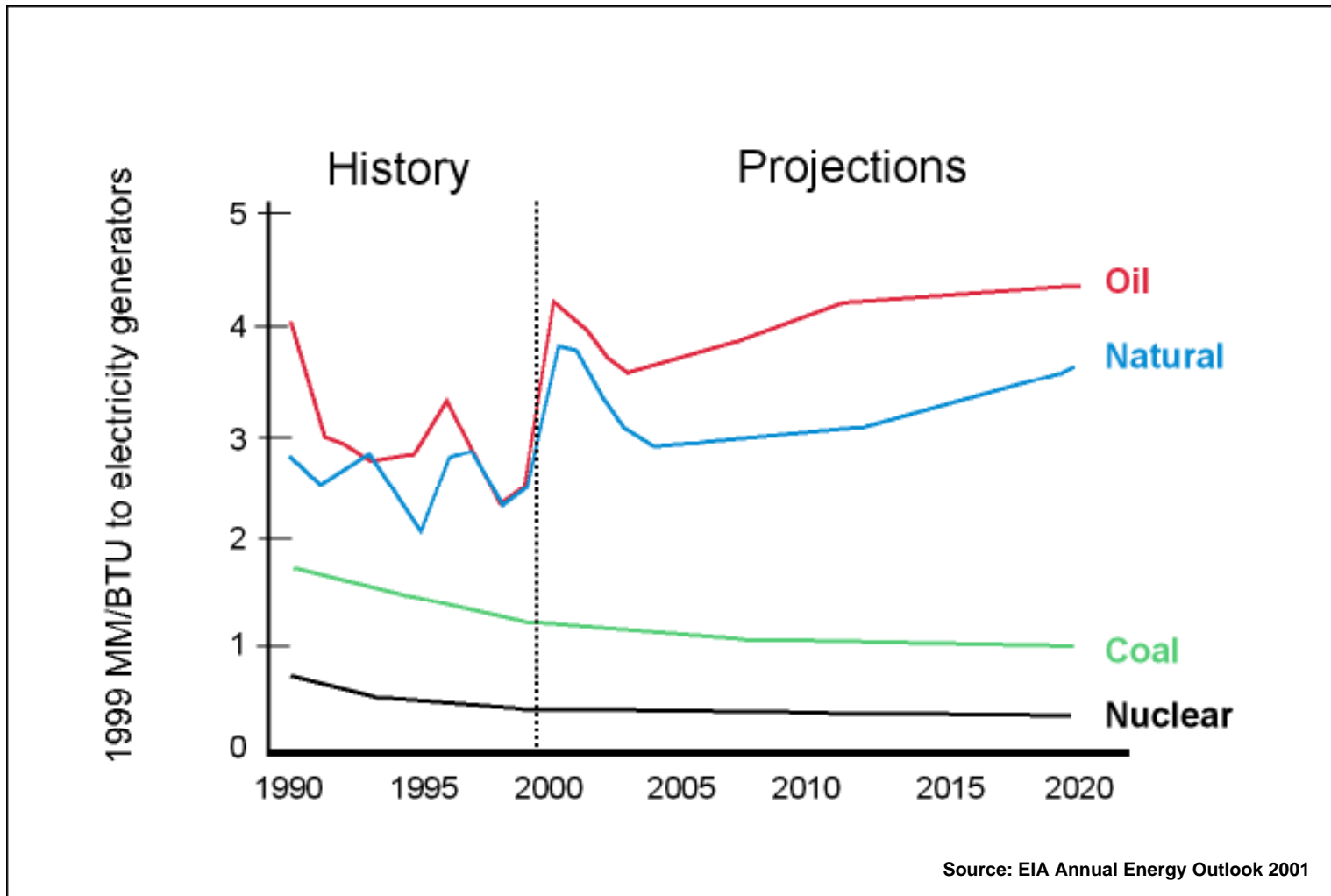
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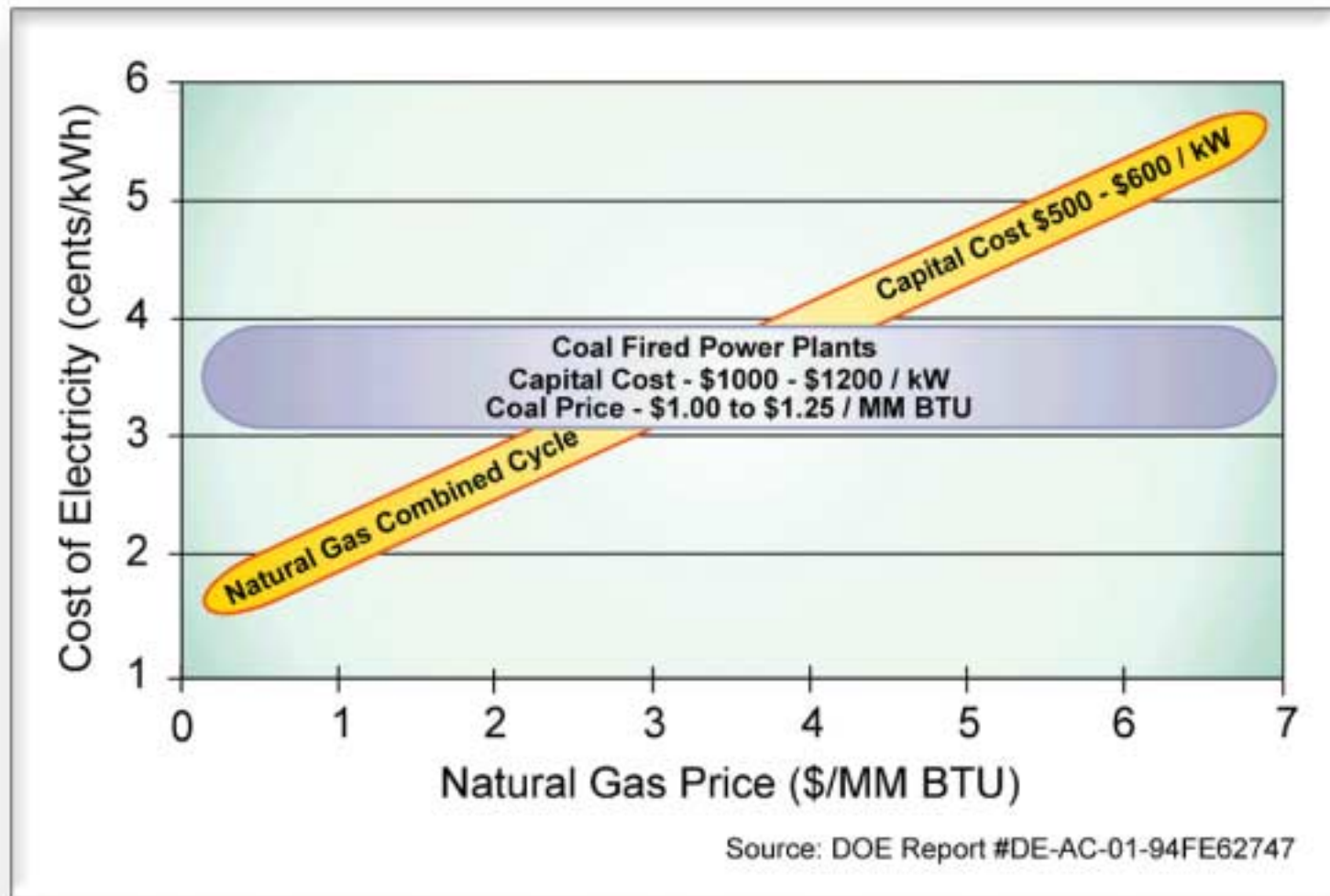
Modular Technology



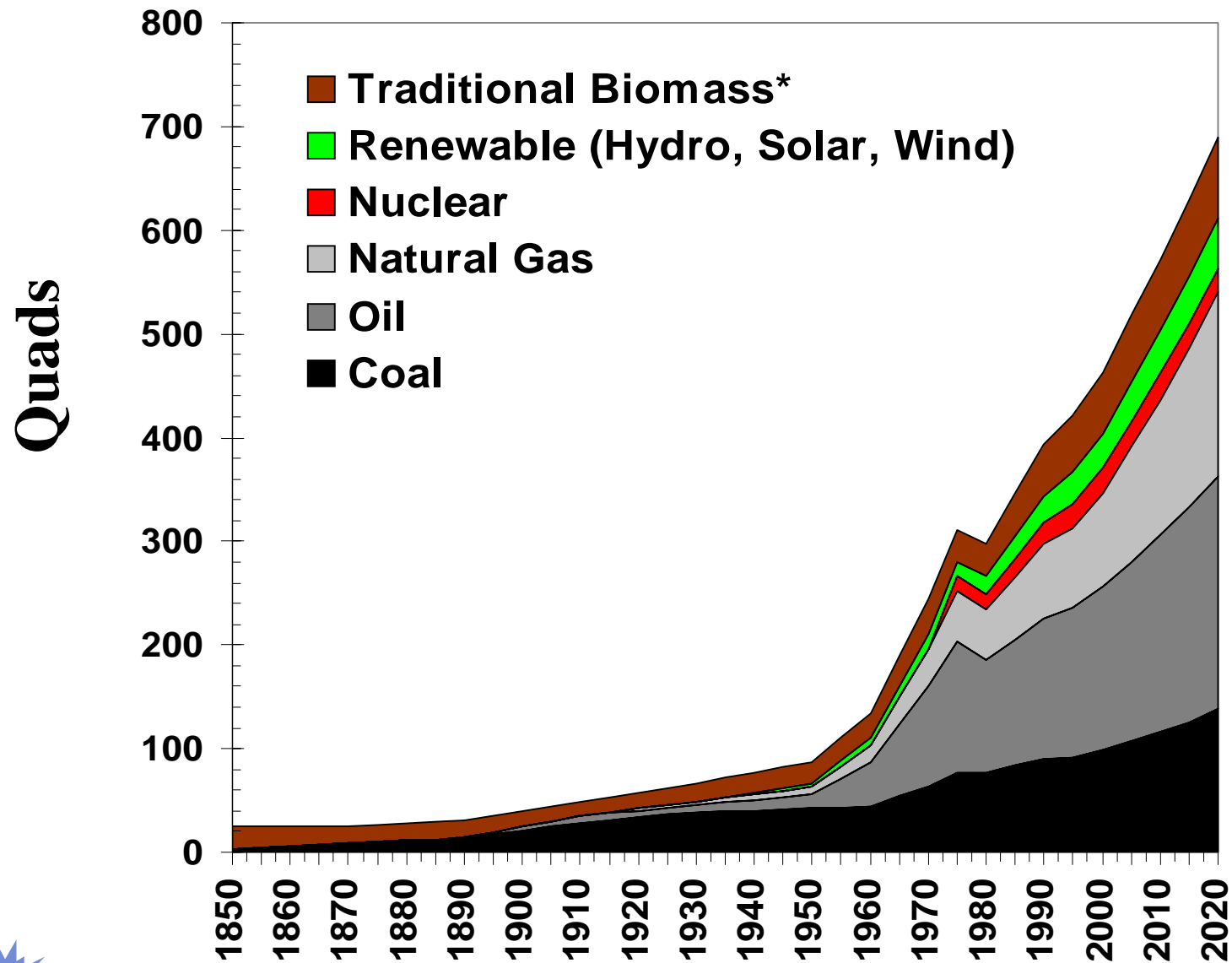
Stable Coal Prices Erratic, Rising Natural Gas Prices



Coal Technologies are Cost Competitive



History and Projections of World Fuel Consumption

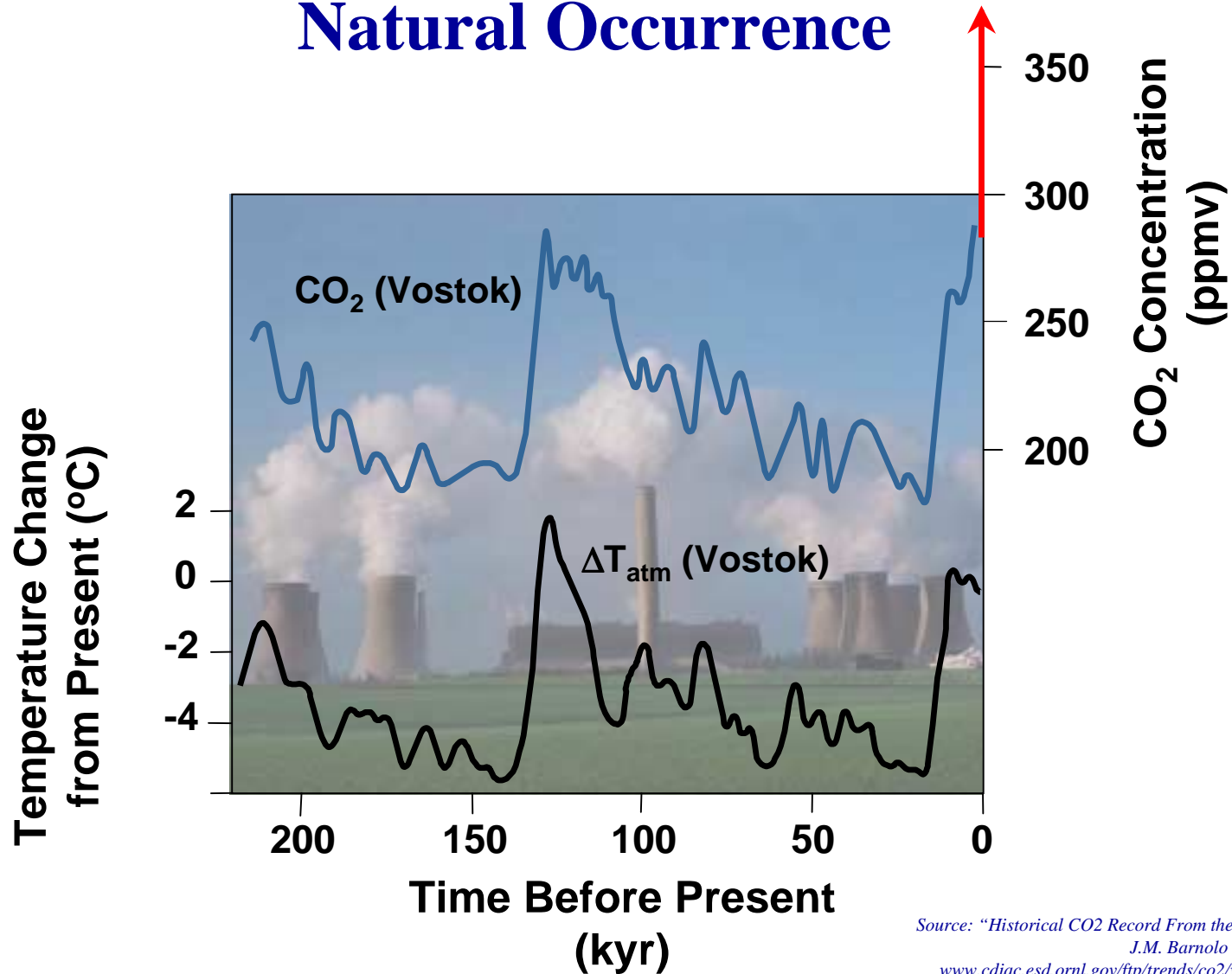


Historical data from the World Energy Council and projections from EIA.

*Traditional biomass is mainly wood, charcoal, dung, etc. used in developing countries.

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CO₂ Concentrations Beyond Range of Natural Occurrence

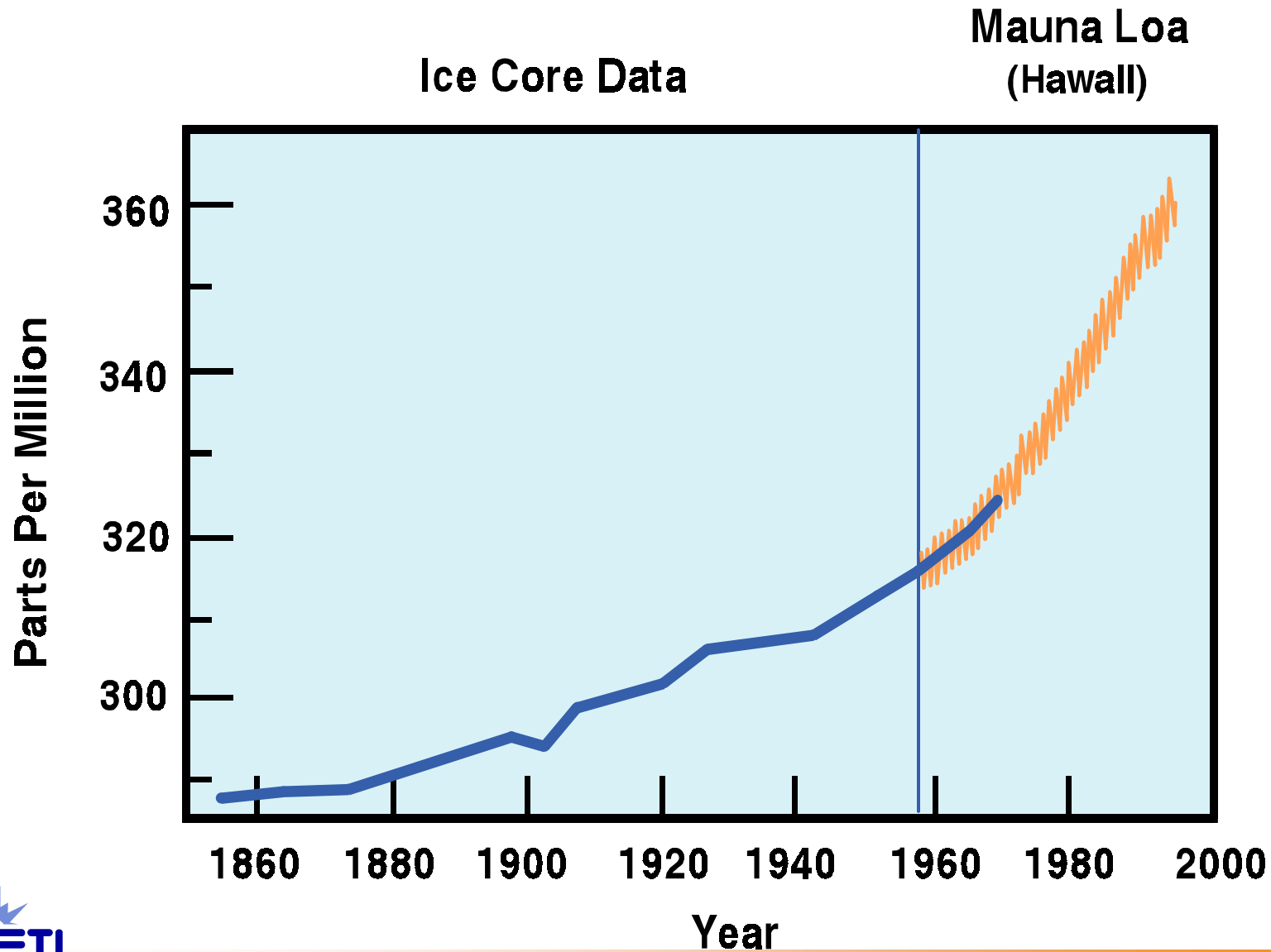


Source: "Historical CO₂ Record From the Vostok Ice Core"
J.M. Barnolo et al, August 1999
www.cdiac.esd.ornl.gov/ftp/trends/co2/vostok.icecore.co2

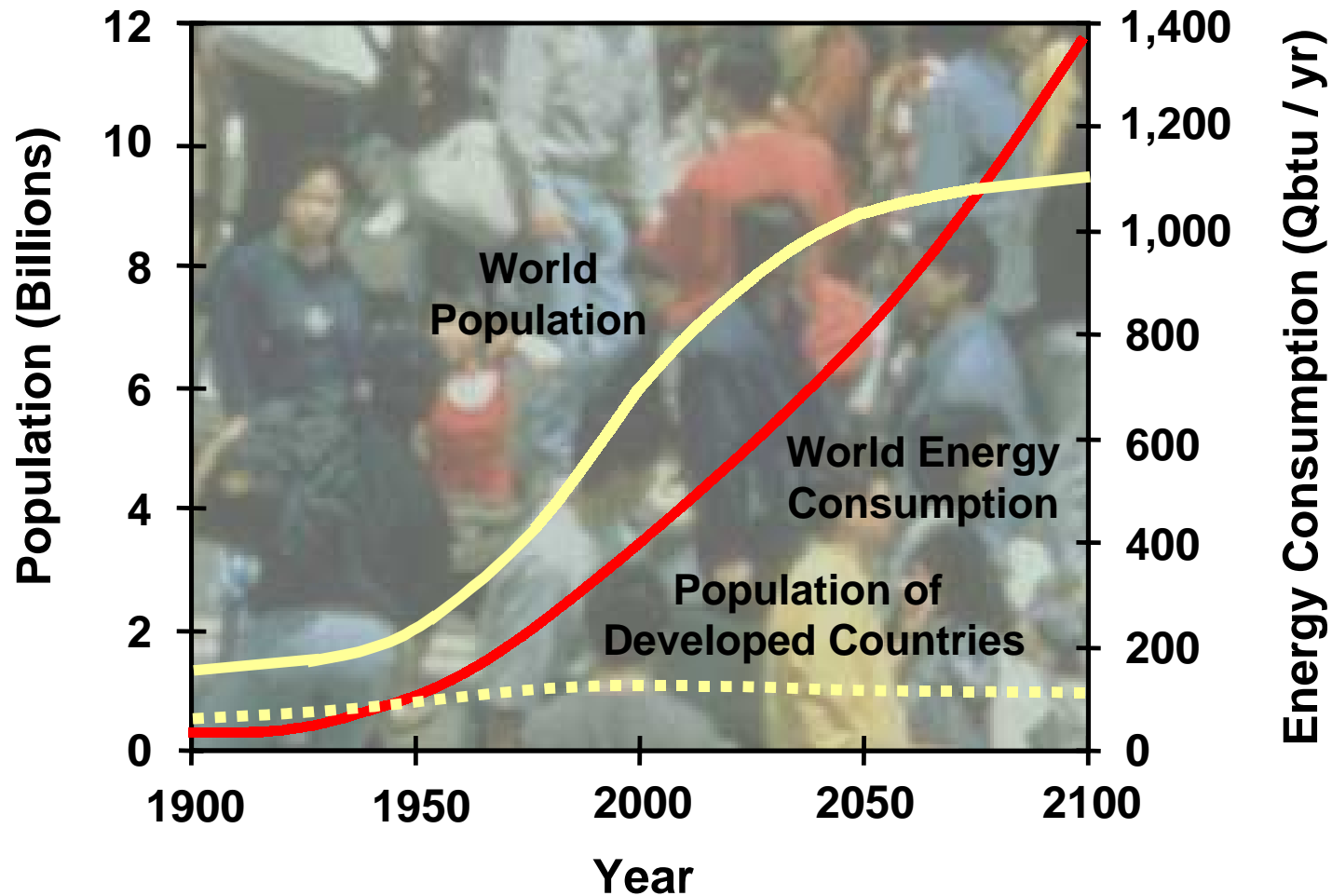
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Atmospheric Carbon Dioxide Concentration



World Energy Use Is Growing Dramatically

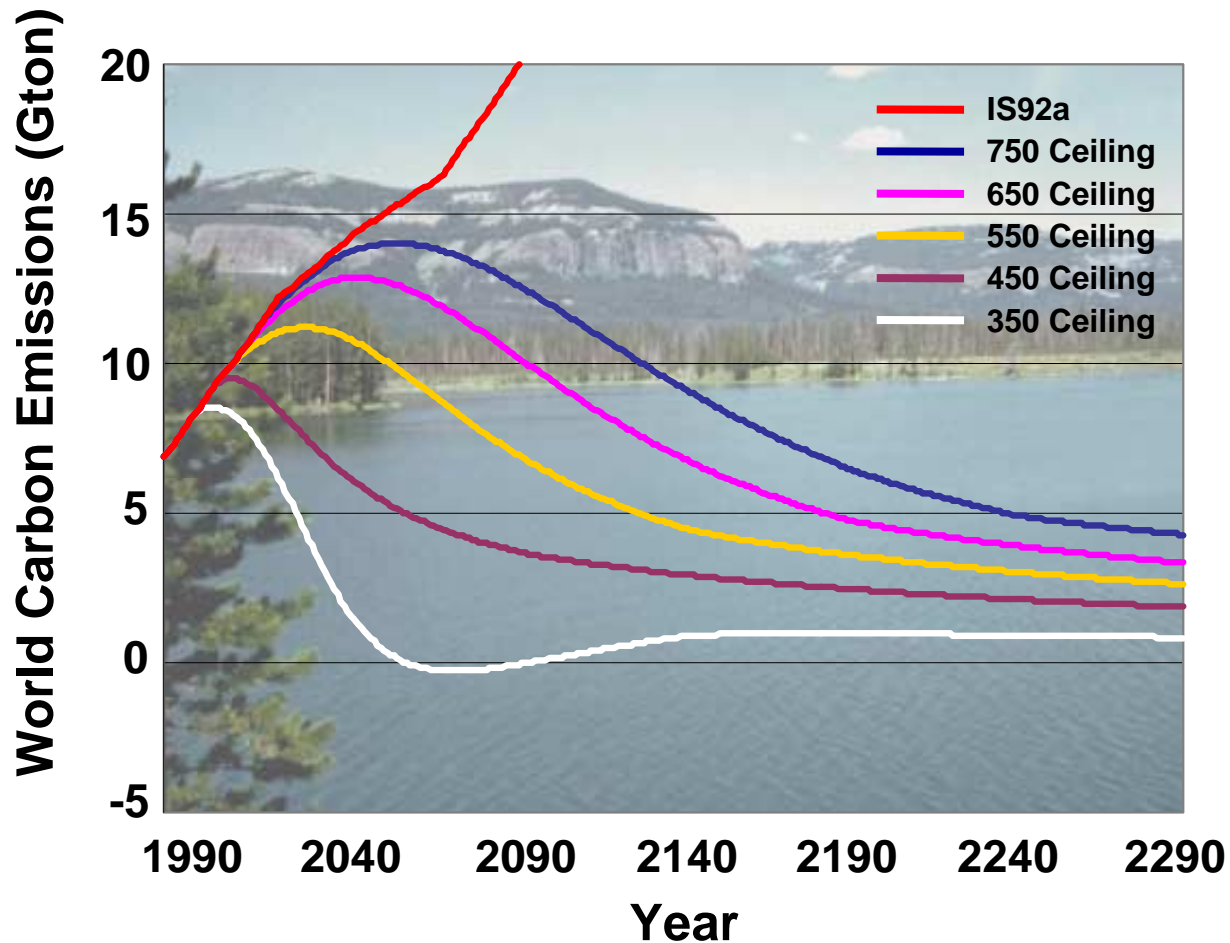


Population Projections: United Nations "Long-Range World
Population Projections: Based on the 1998 Revision"

Energy Projections: "Global Energy Perspectives" IIASA / WEC



Scenarios to Stabilize CO₂ Concentrations



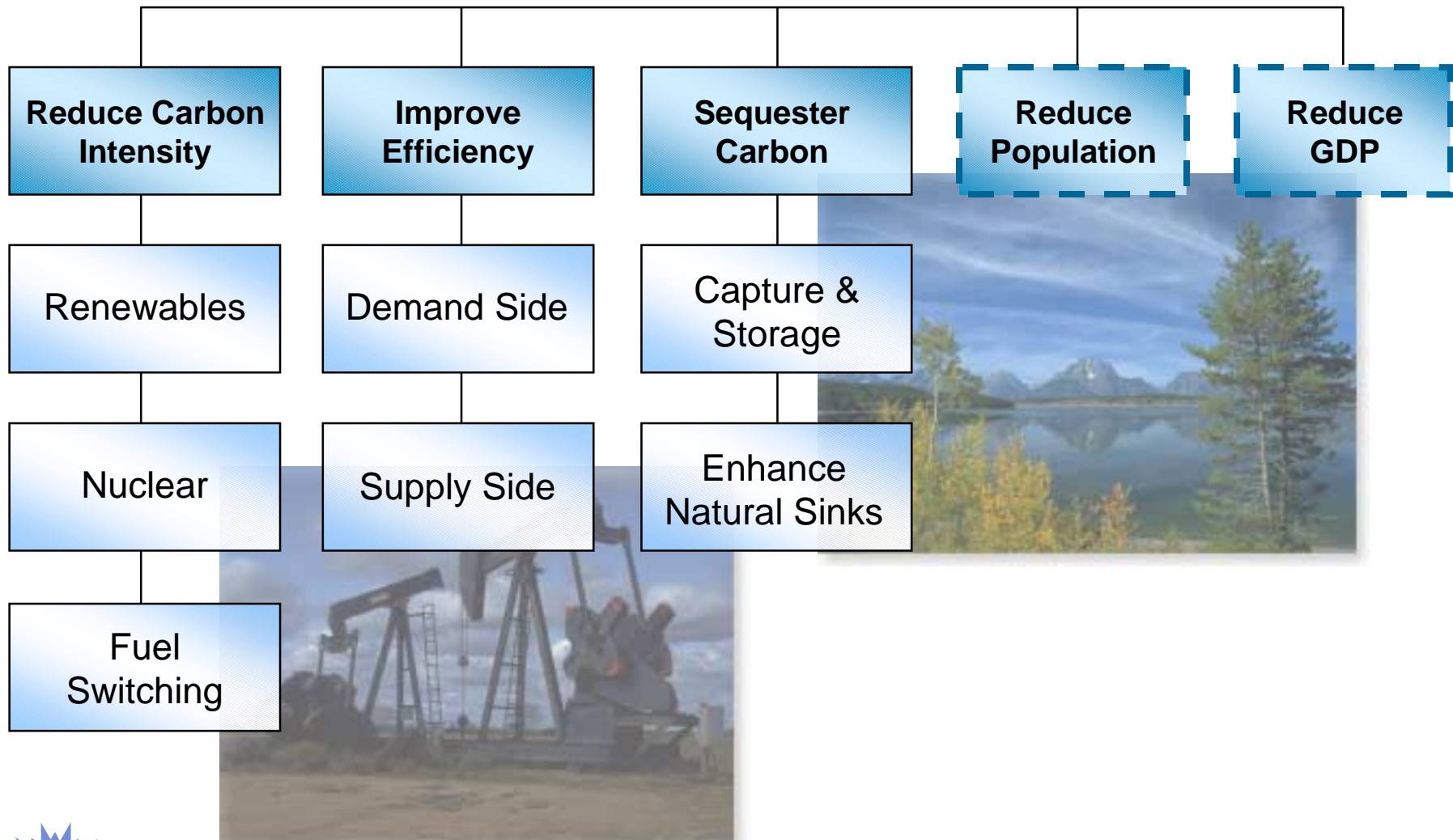
Stabilizing CO₂ concentrations at 550 ppmv implies 60% reduction below 1990 emission rates



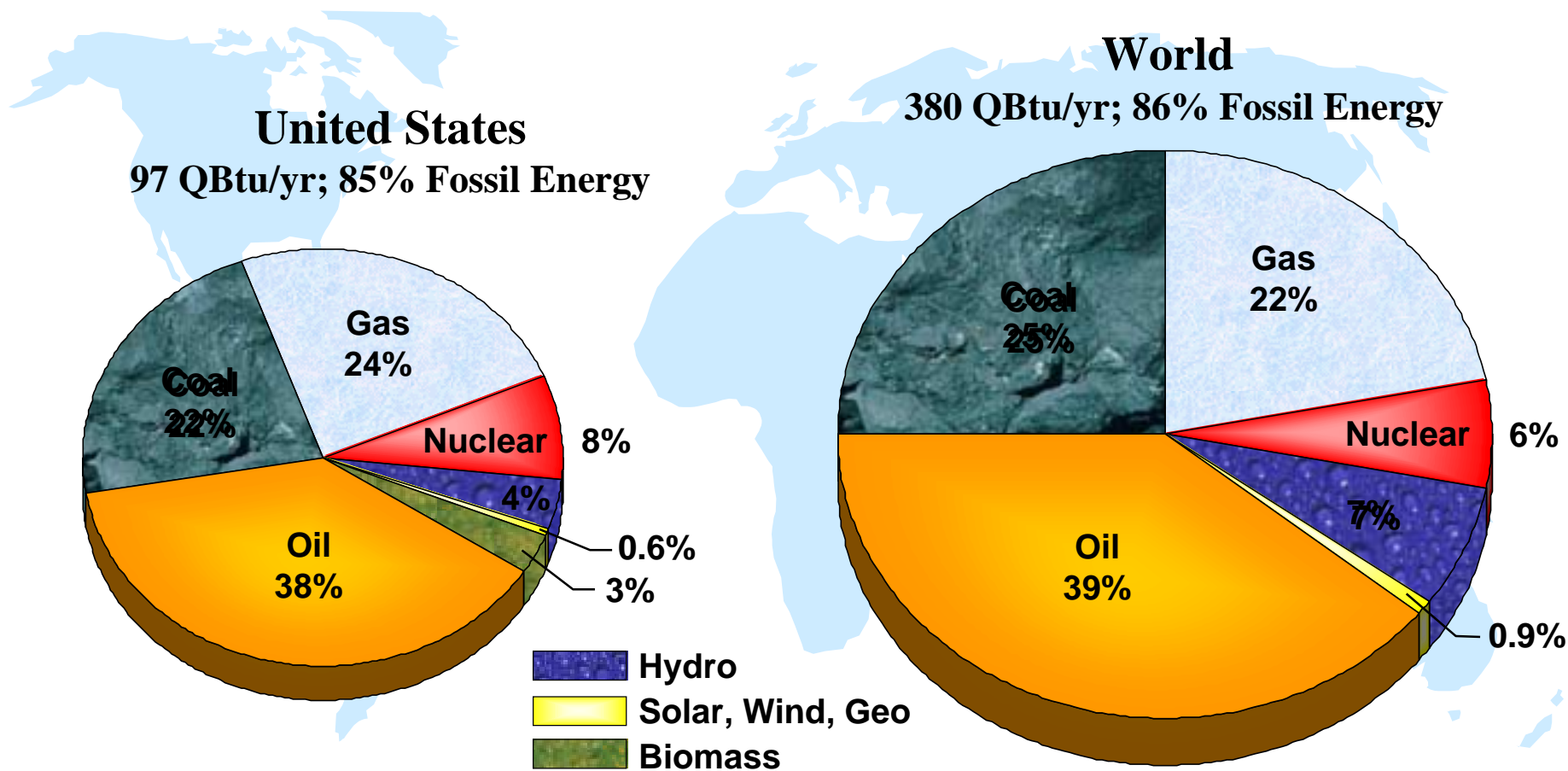
Source: Wigley, T.M.L., Richels, R., and Edmonds, J.A. *Nature* 379, 240-243 (1996)

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CO₂ Mitigation Options



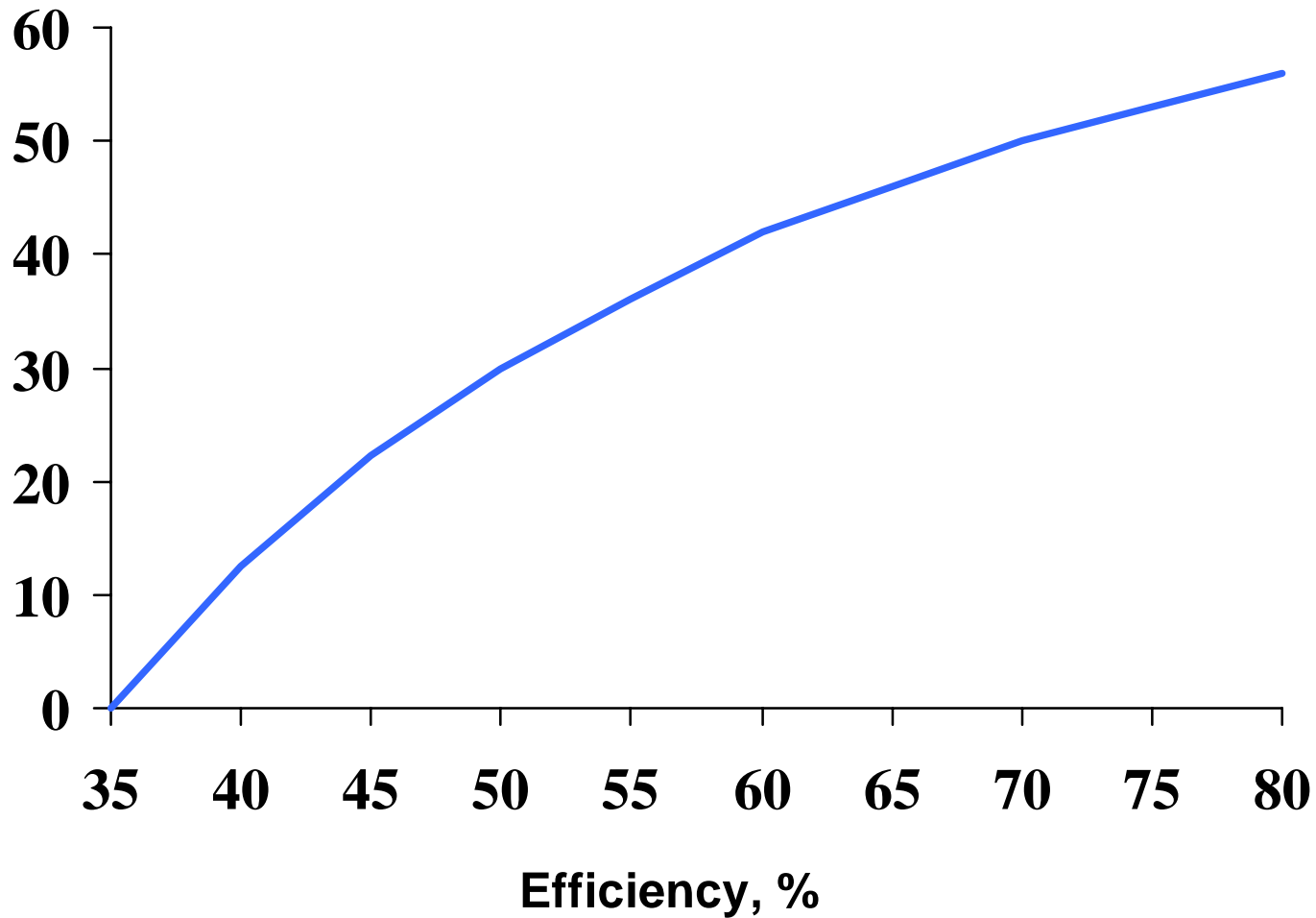
Fossil Fuels Are the World's Dominant Energy Source



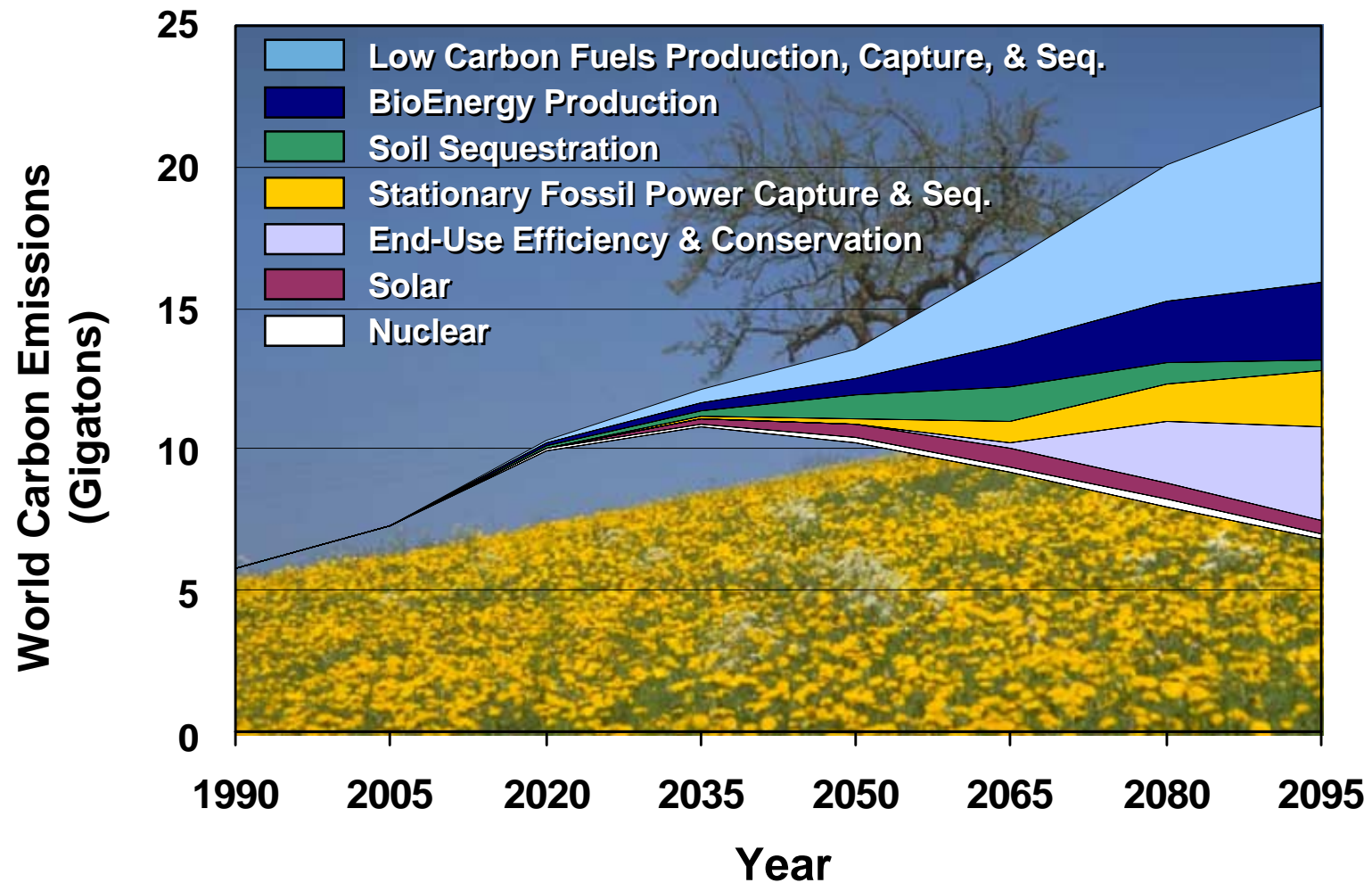
World Data from EIA96. Does not include non-grid-connected biomass.
U.S. Data from Table 2 of EIA REA 97 & AEO98 Table A2

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Percent Reduction in CO₂ Emissions (relative to 35% efficient plant)



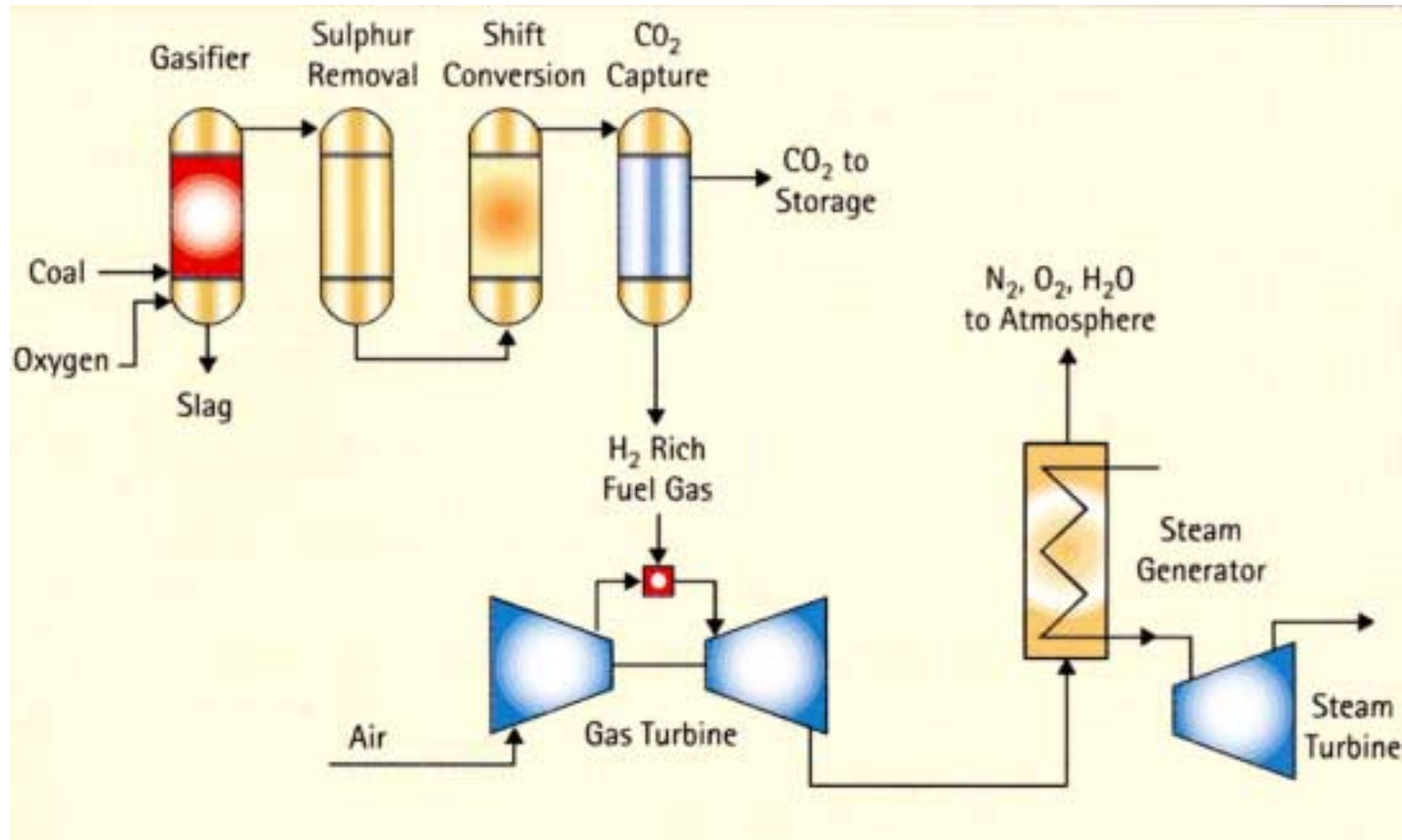
Technologies to Fill the Gap



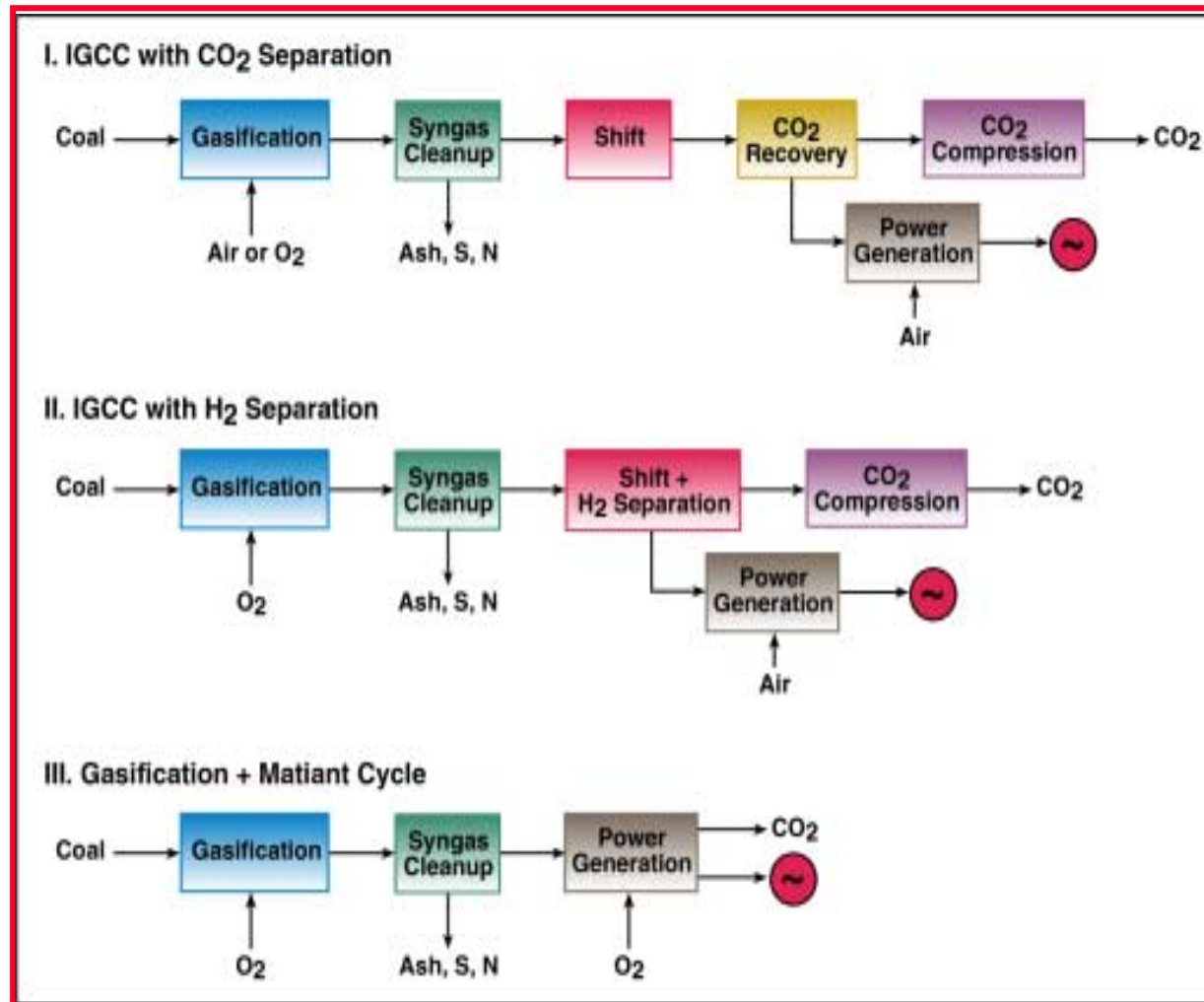
Source: Pacific Northwest National Laboratory

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Coal-Fired IGCC with Pre-combustion Capture of CO₂



Three Approaches to Power Generation from Coal with CO₂ Capture



Advanced Combined Cycle Generation Technologies with Carbon Capture Will Cost Less Than We Thought

<u>Technology</u>	<u>Thermal Efficiency, HHV, %</u>	<u>Carbon Emissions, kg CO₂/kWh</u>	<u>Total Plant Cost, \$/kWh</u>	<u>LCOE @ 80% cf, Mills/kWh</u>
NGCC-H	53.6	0.338	496	30.7
NGCC-H 90% capture	43.3	0.04	943	48.8
IGCC-H	43.1	0.718	1263	45.1
IGCC-H 90% capture	37.0	0.073	1642	56.4

Source: "Evaluation of Fossil Fuel Power Plants with CO₂ Removal," EPRI, 2000.
http://www.netl.doe.gov/product/power1/gasification/30_publications.htm



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



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<http://www.netl.doe.gov>

