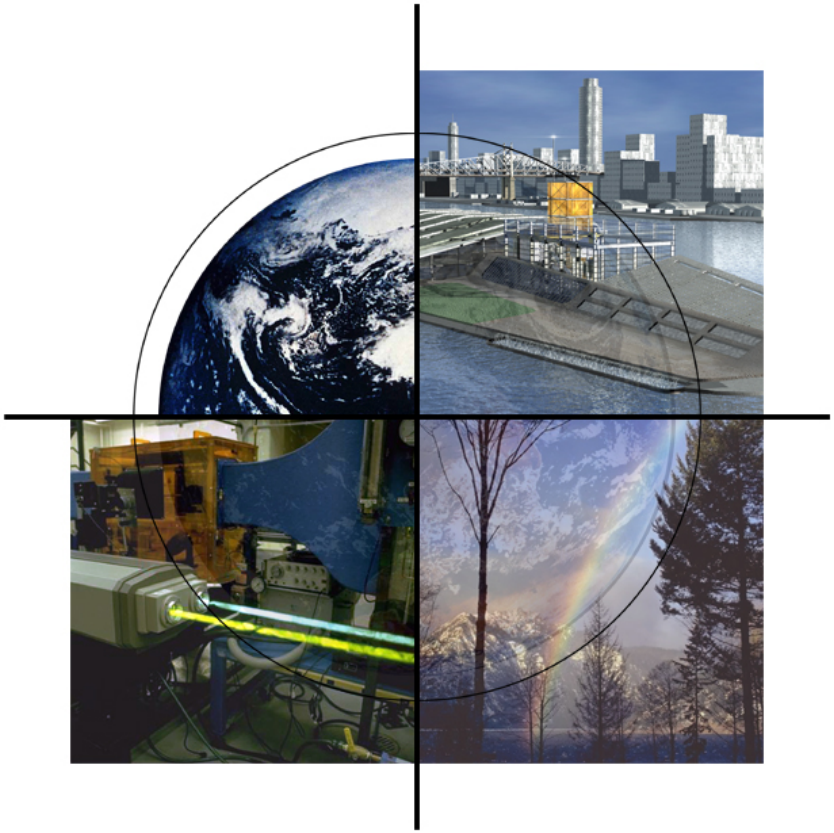
Tipping Point or Opportunity for Clean Coal Technologies?

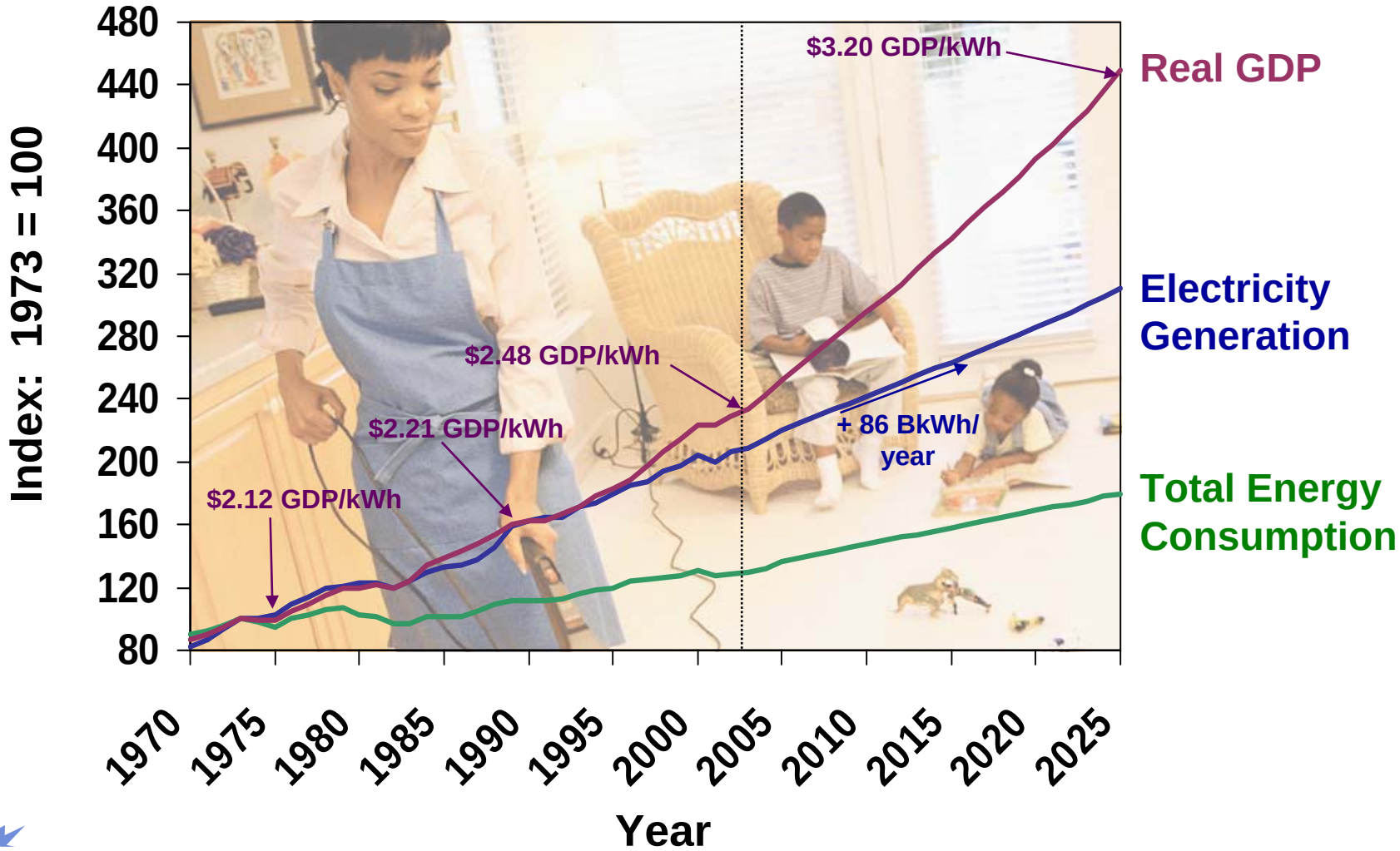


Presented at:
ProcessLink™
Users Summit - 2004

By:
Mike Eastman, Manager-Clean Coal Technology Demonstrations
February 10, 2004

National Energy Technology Laboratory

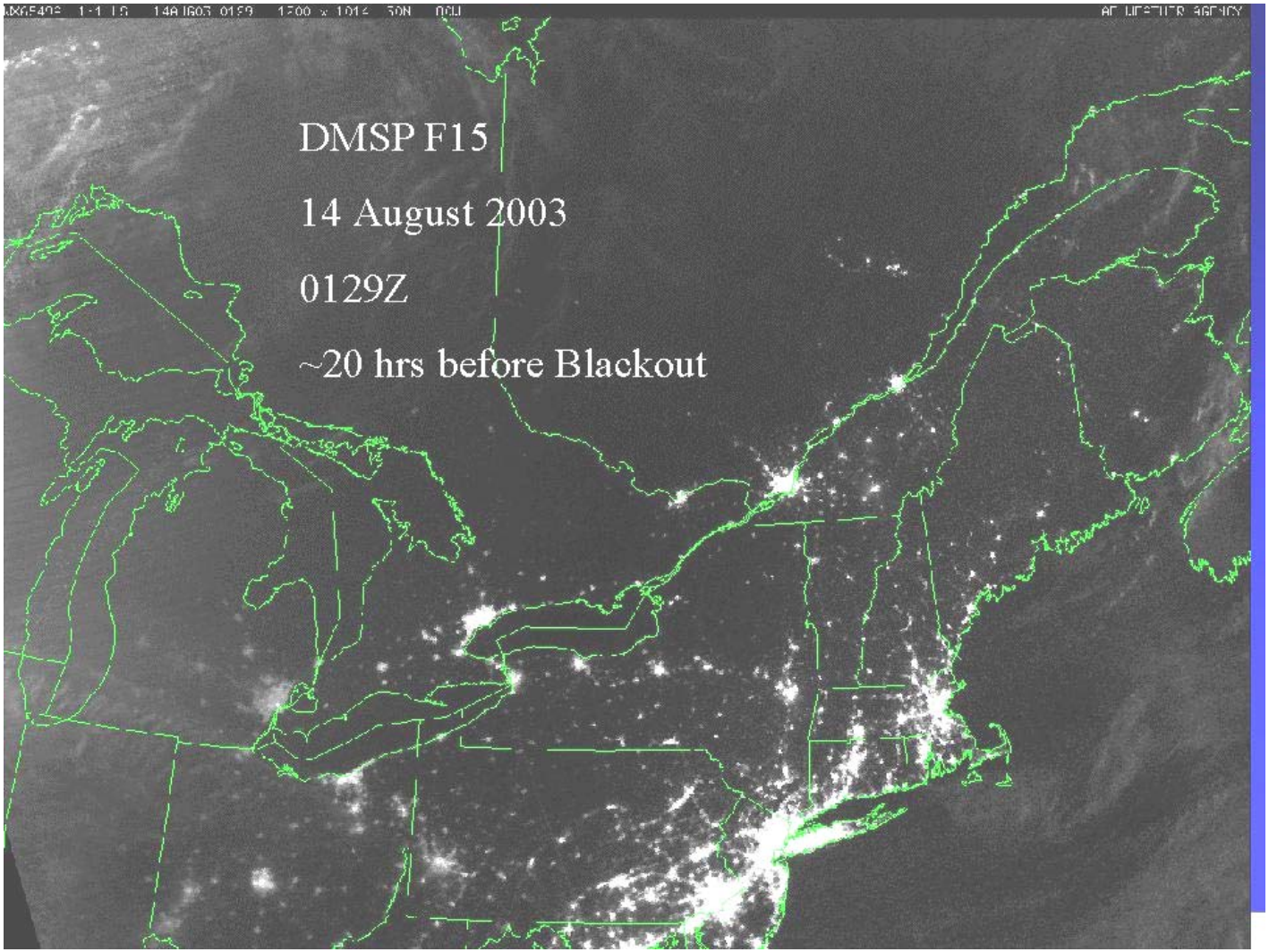
Energy Use Compared to Economic Growth



GDP: History - U.S. DOC, Bureau of Economic Analysis; Forecast - Annual Energy Outlook 2004
Energy & Electricity: EIA, Annual Energy Review 2002; Annual Energy Outlook 2004

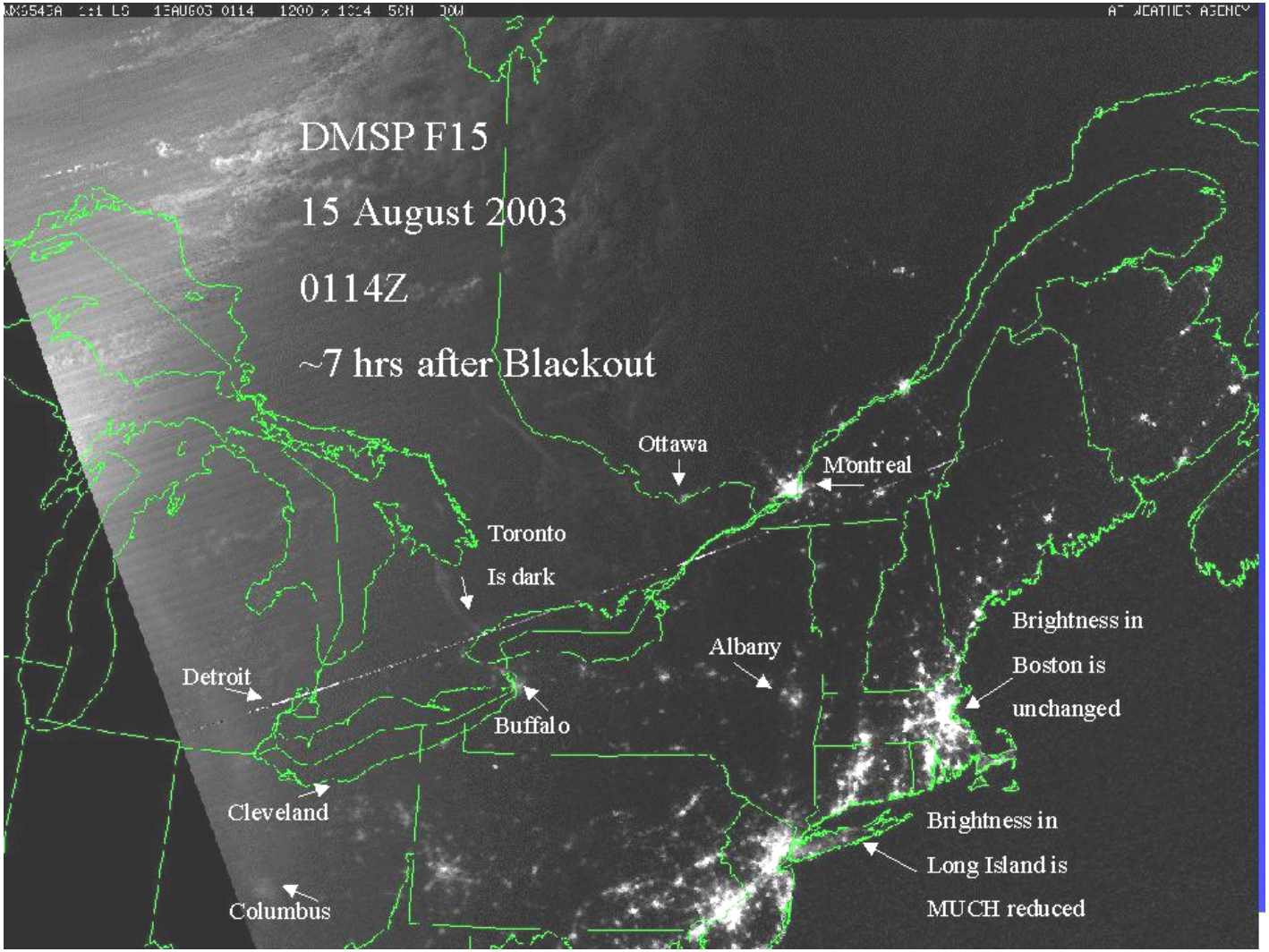
2003 Electric Power Blackout (before)

(photos courtesy of NOAA)

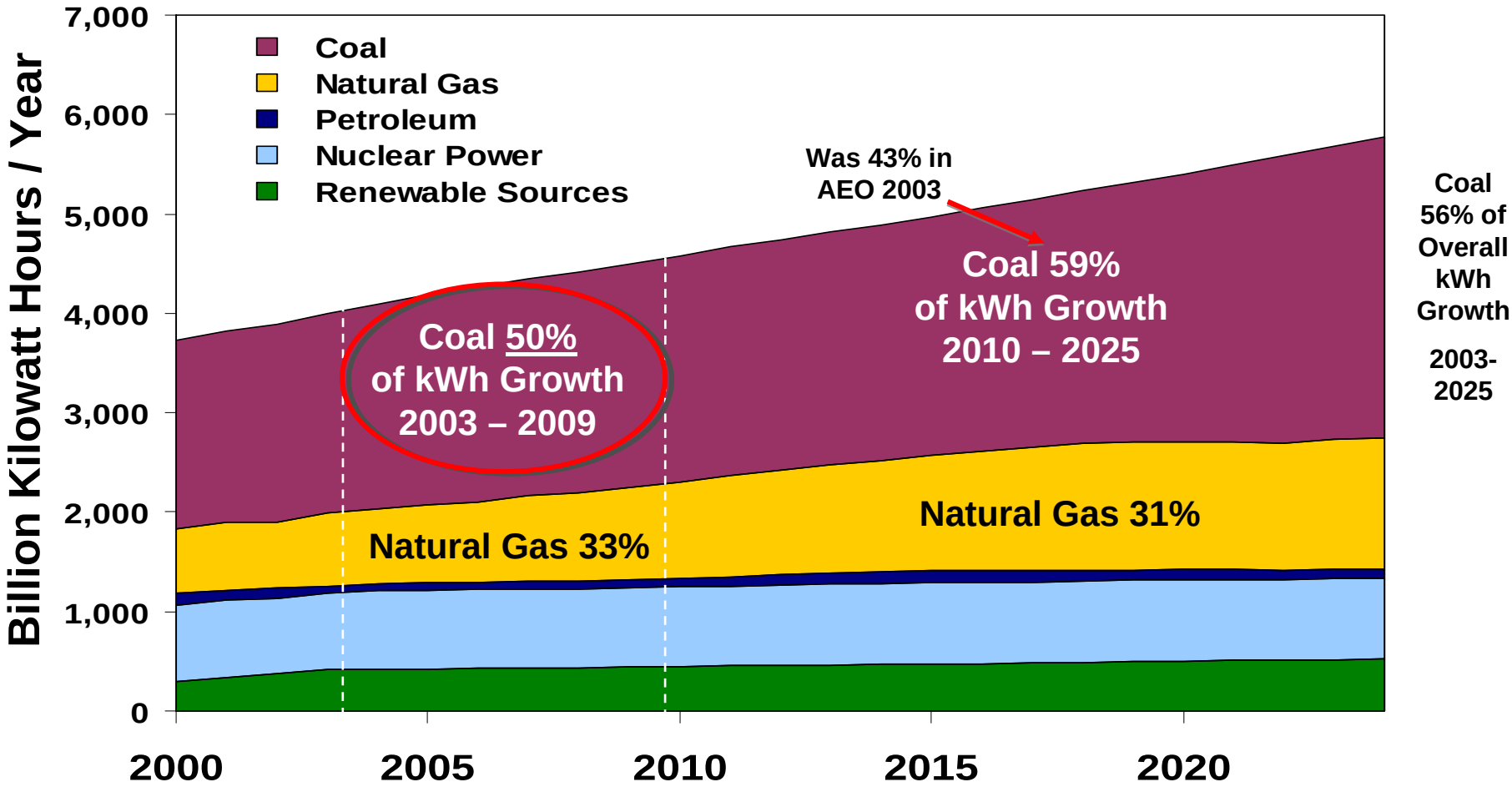


2003 Electric Power Blackout (after)

(photos courtesy of NOAA)

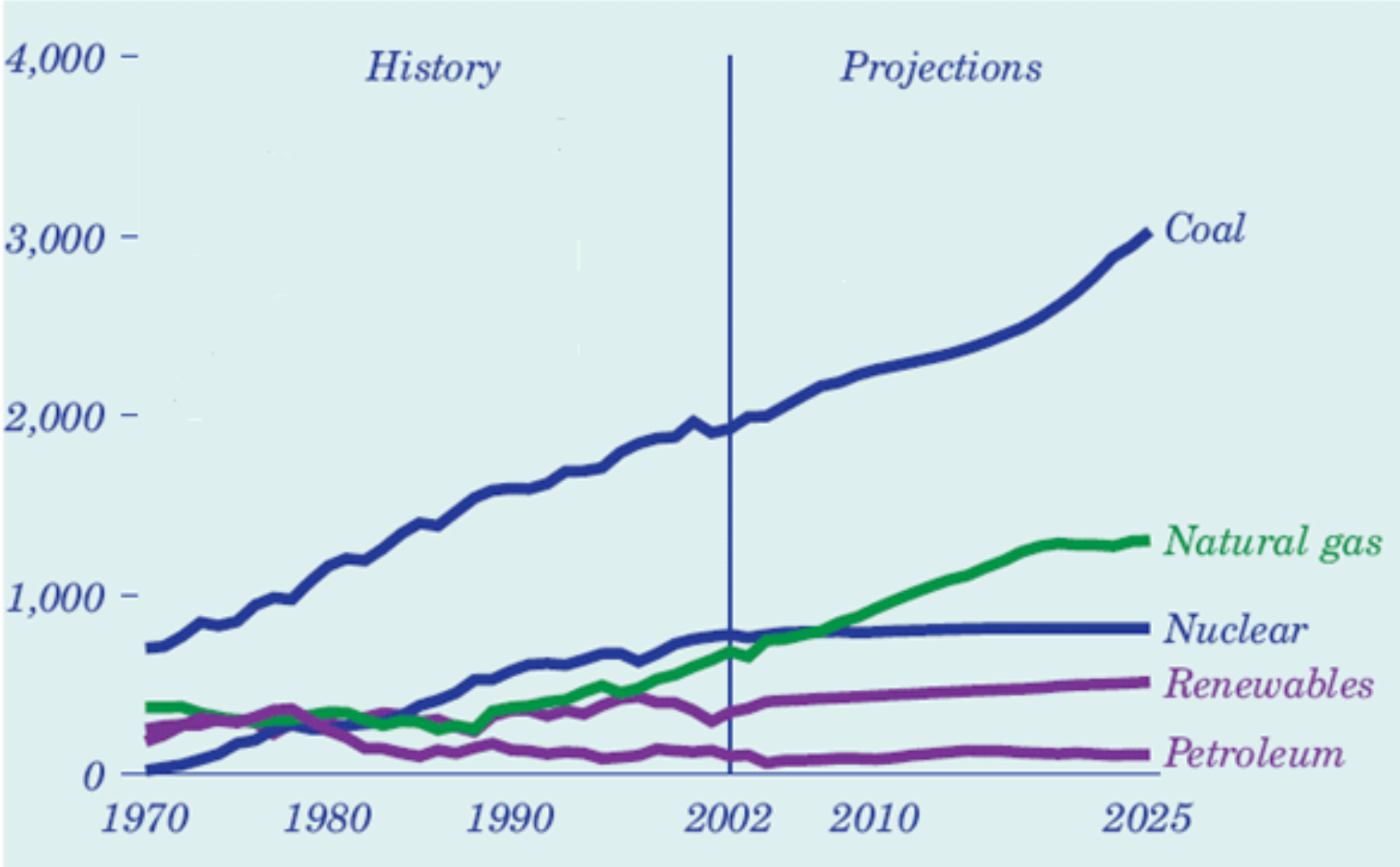


Fuel Mix for Electricity Growth AEO'04

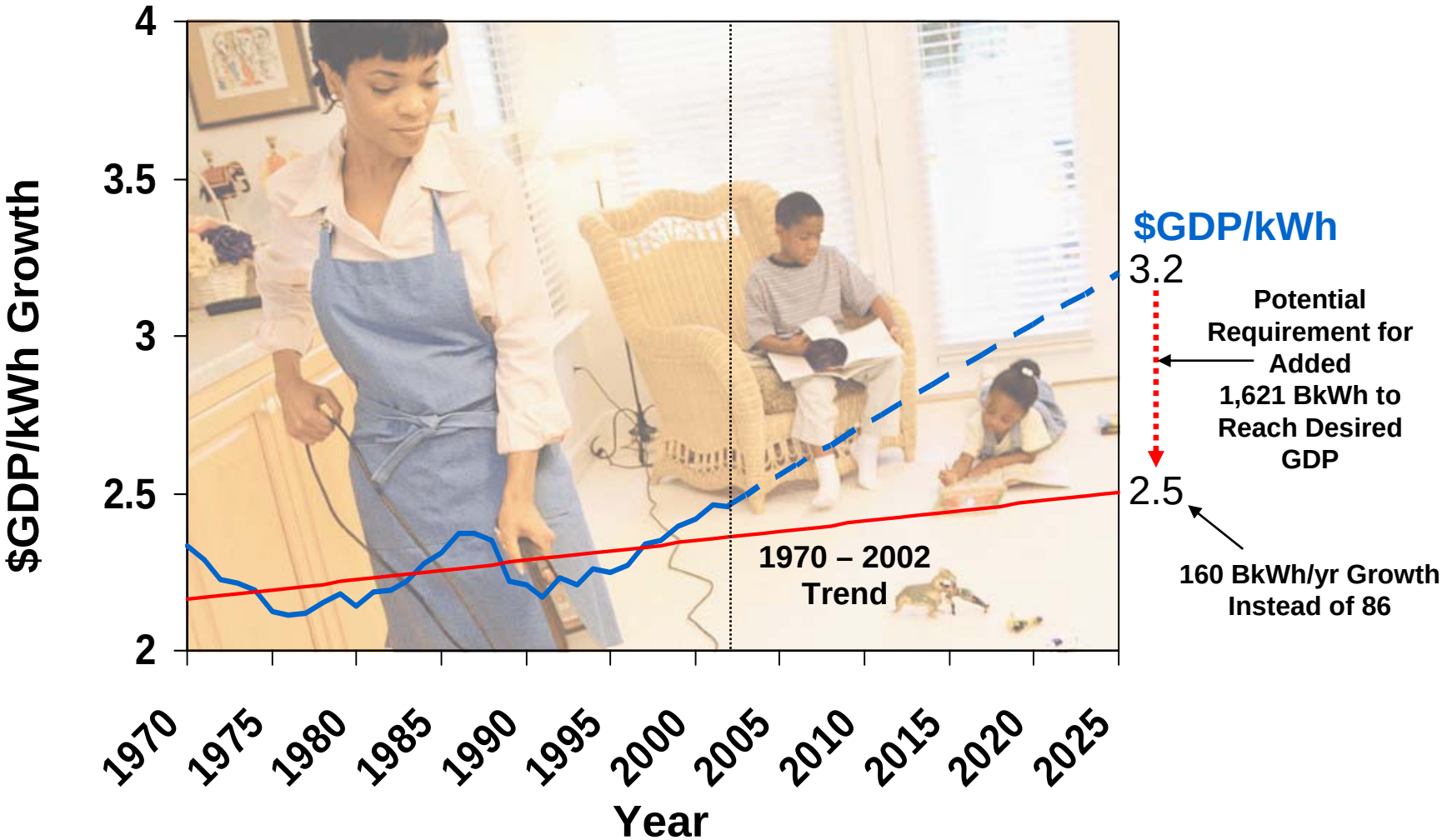


Coal Expected To Provide 50% of Incremental kWhs (2003 to 2009) Despite Few Additions

Electricity generation by fuel, 1970-2025 (billion kilowatthours)



Electricity & Economic Growth

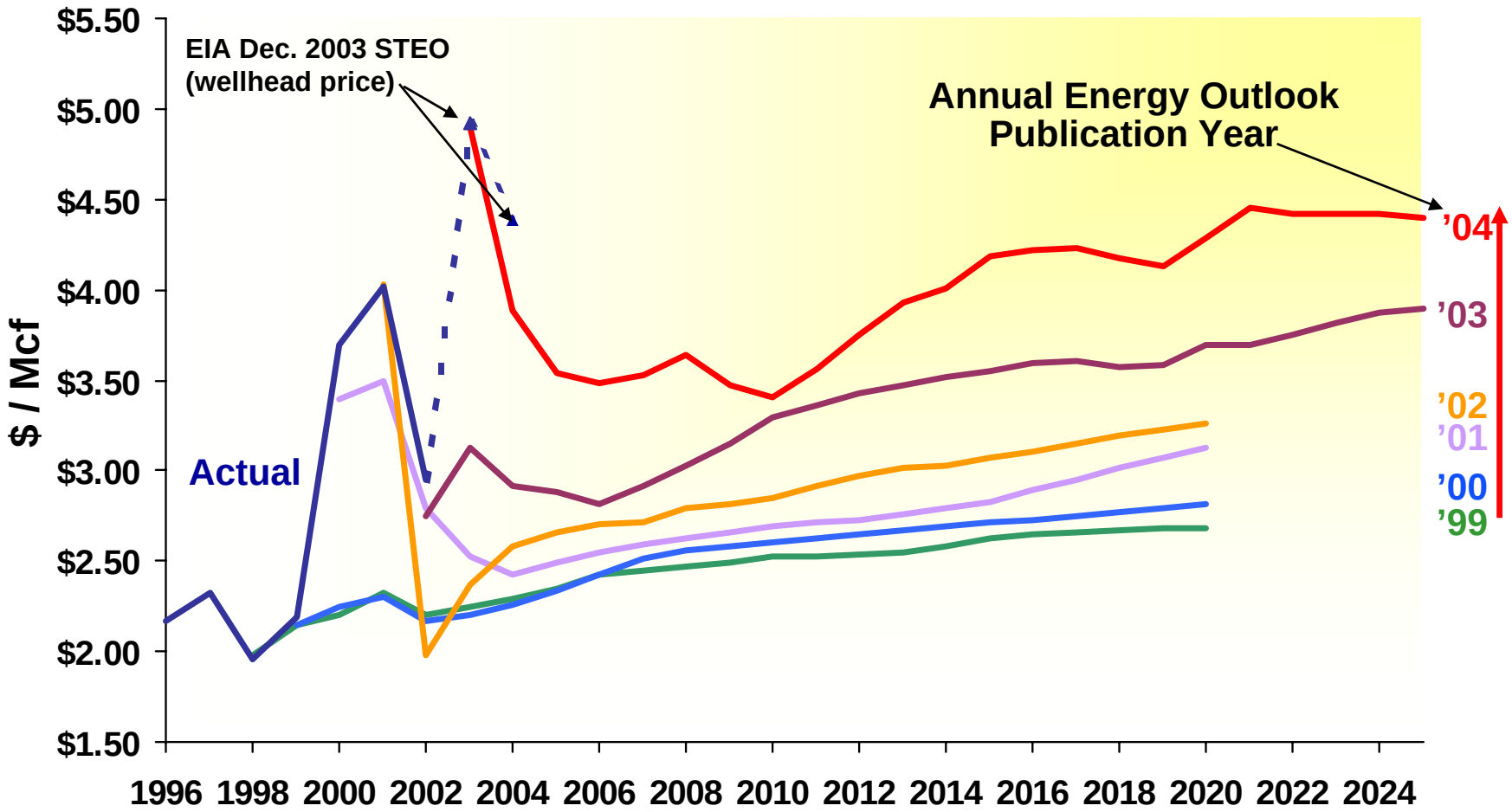


Disengagement of Forecast GDP and Electric Generation May Underestimate Electricity Growth Requirement by 74 BkWh/yr (46%)

GDP: History - U.S. DOC, Bureau of Economic Analysis; Forecast - Annual Energy Outlook 2004
Energy & Electricity: EIA, Annual Energy Review 2002; Annual Energy Outlook 2004

Changing Forecasts After 4 Years of High Price

Paradigm Shift in a Fuel Price for Electricity?

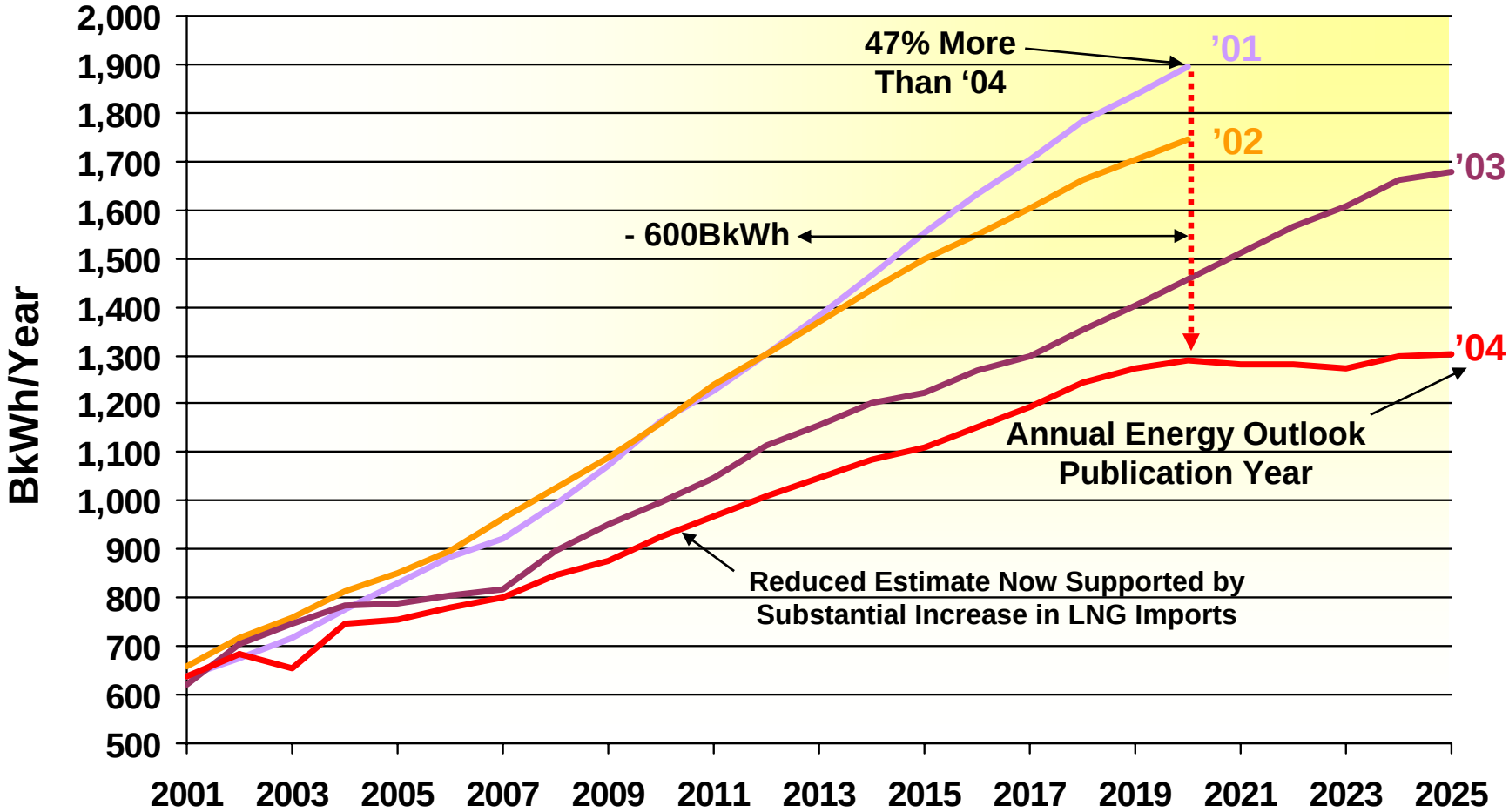


Growing Recognition of New Price Plateau at $4–5 /MMBtu

AEO 2004 Near Term Optimism Based on LNG, Increased Drilling

Changing Natural Gas Generation Forecasts

Paradigm Shift in Fuel Use for Electricity

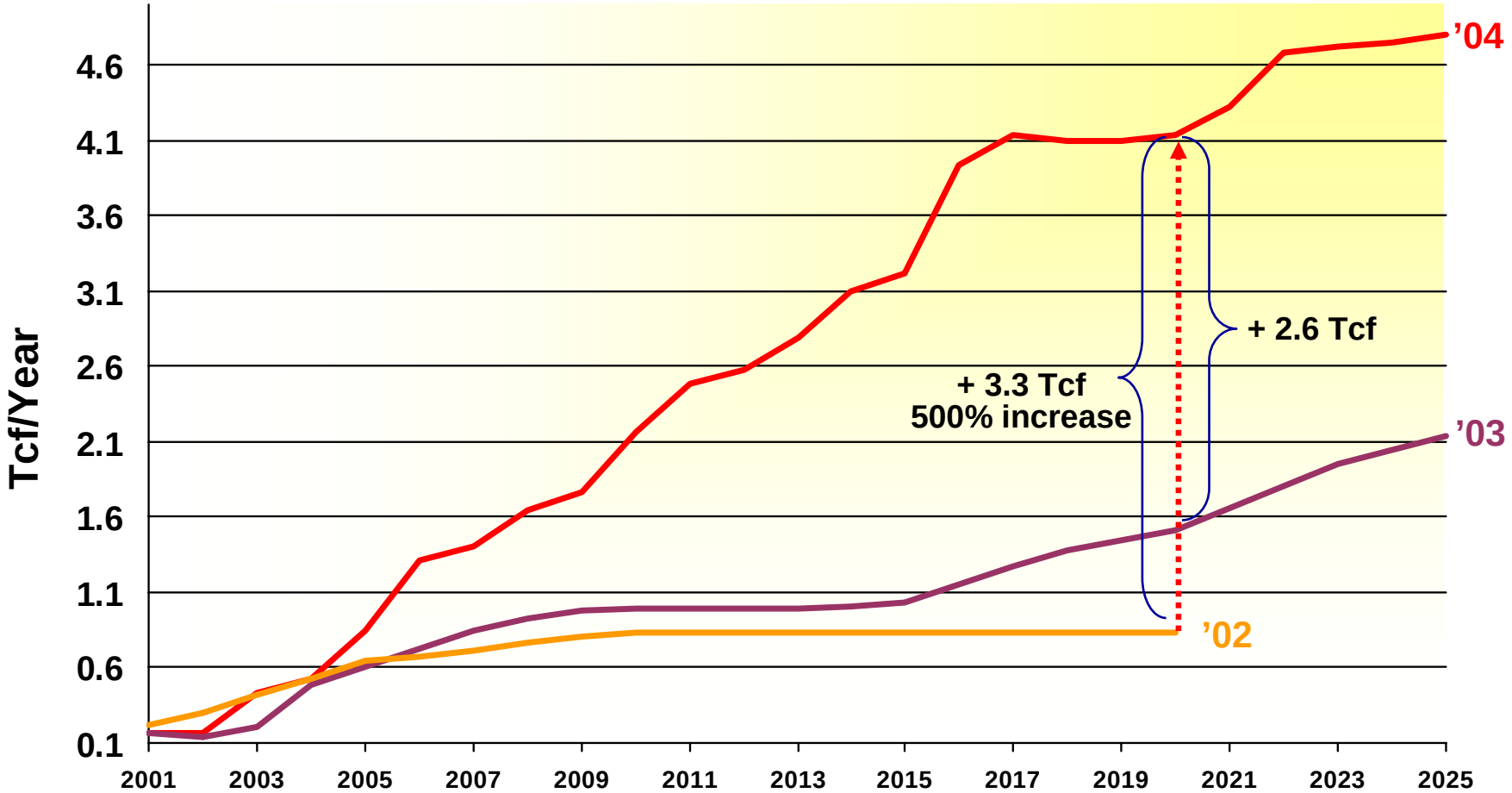


Gradual Recognition of Natural Gas Supply Constraints

Three Year Decline (2020) Nearly Equal to Today's Gas kWh Production

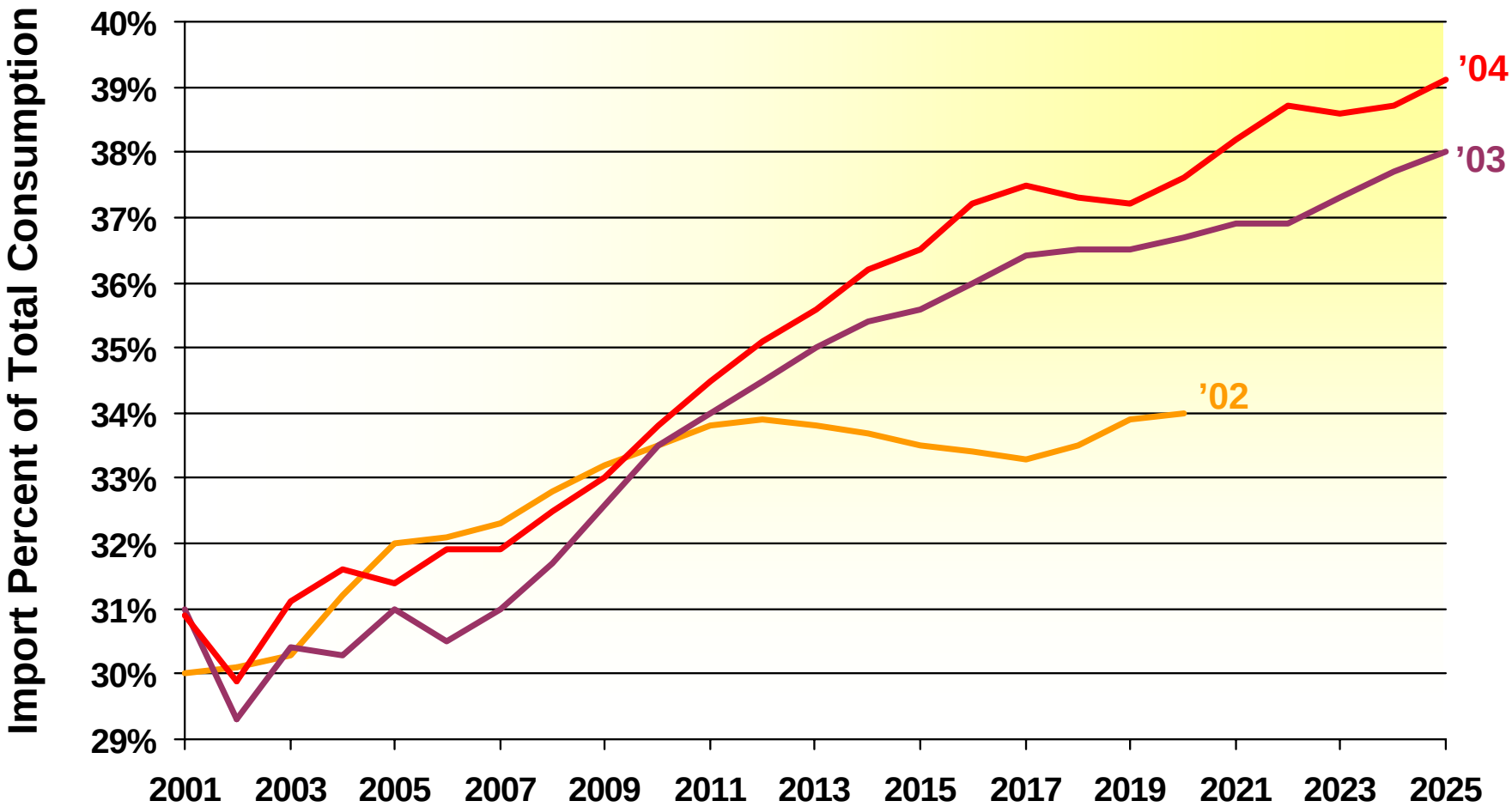
Changing LNG Import Forecasts

Shift in Imported Fuel for Gas-fired Generation



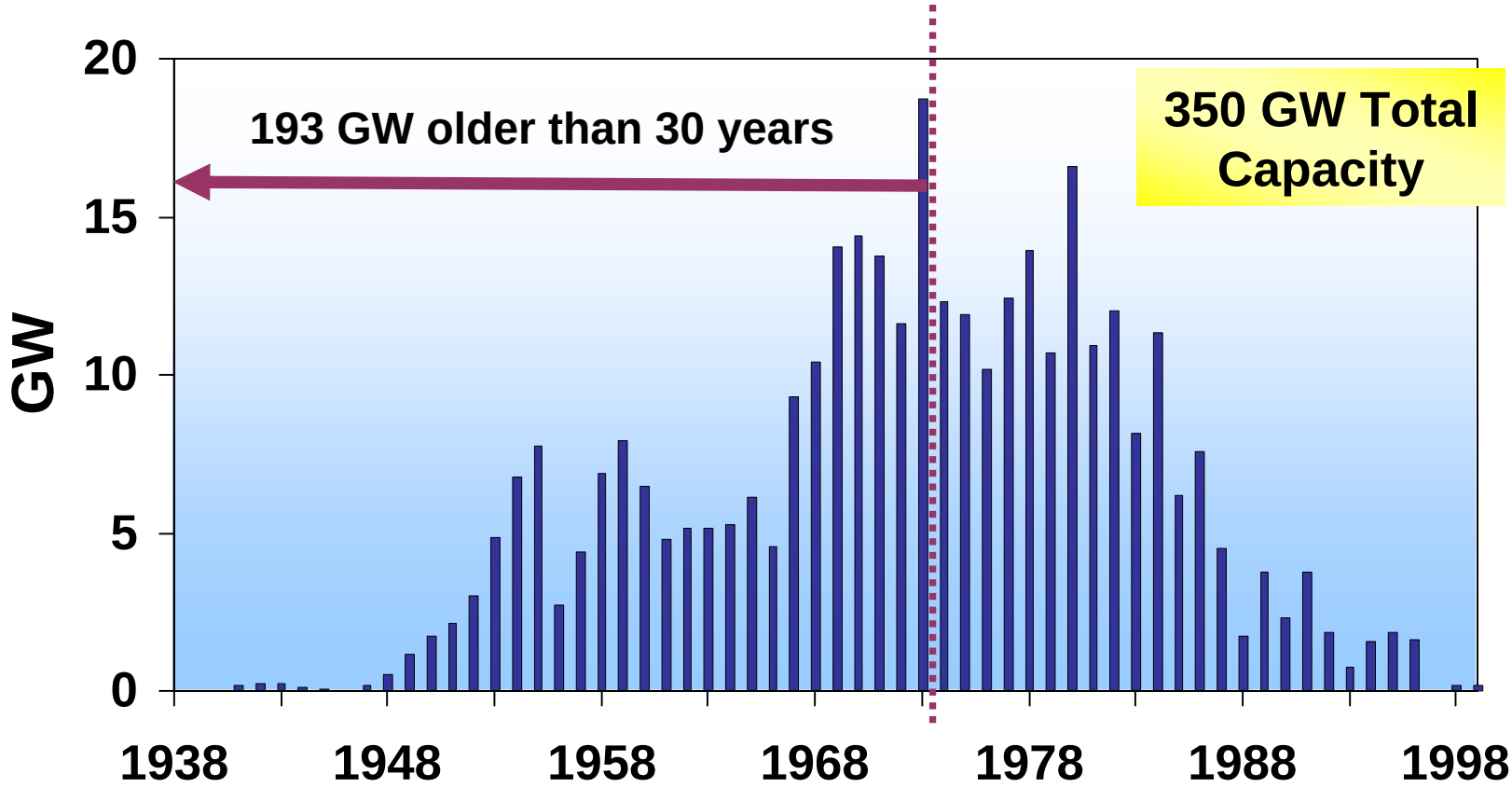
Rapid Increase in LNG Supply Assumption Supports Natural Gas Generation Potential

Increasing Dependence On Energy Imports



Rise in Foreign Energy Dependence → Decline in Energy Security

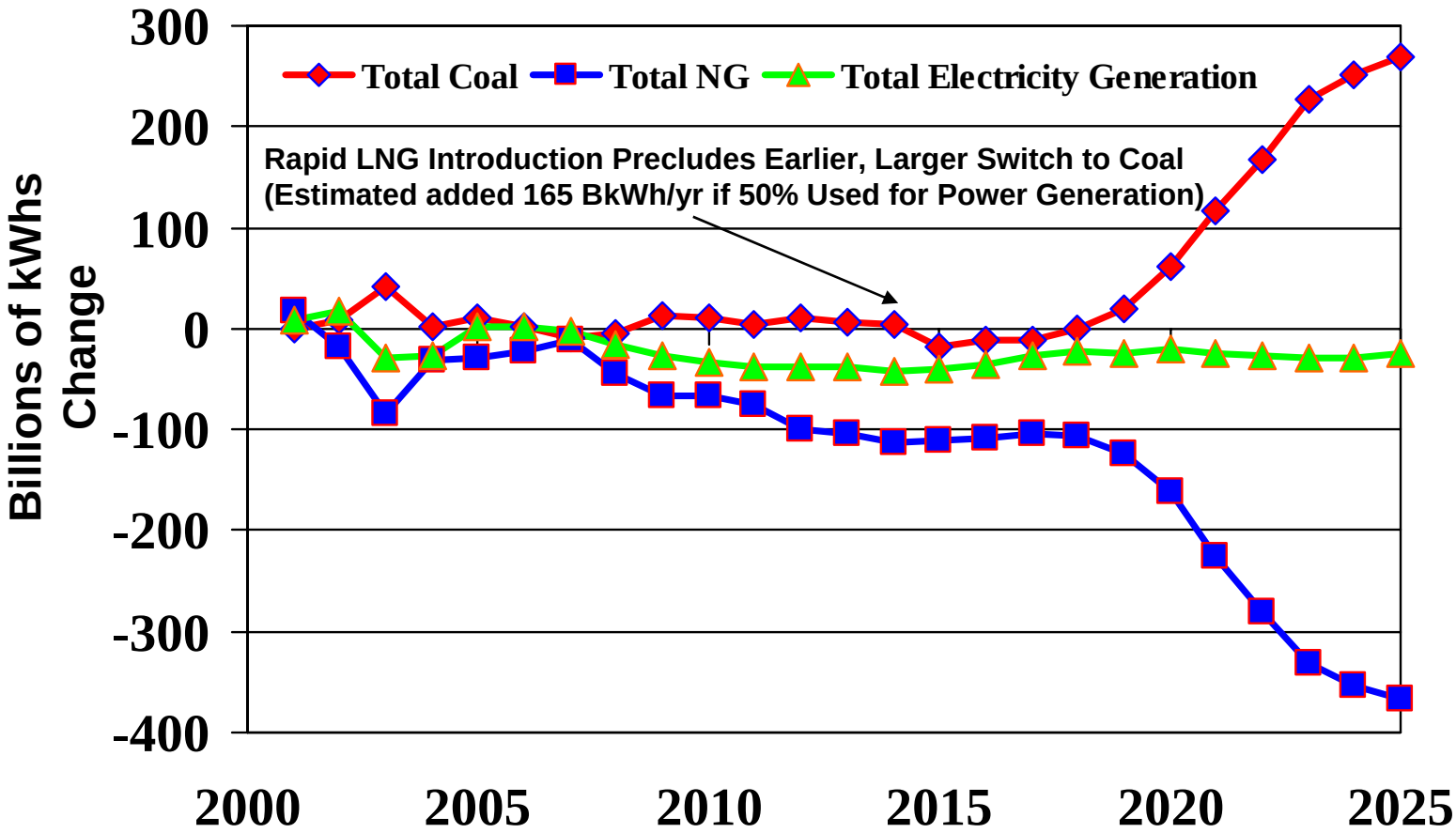
North American Coal Units
First Year of Operation



Many coal plants will need to be replaced or repowered starting in 2020

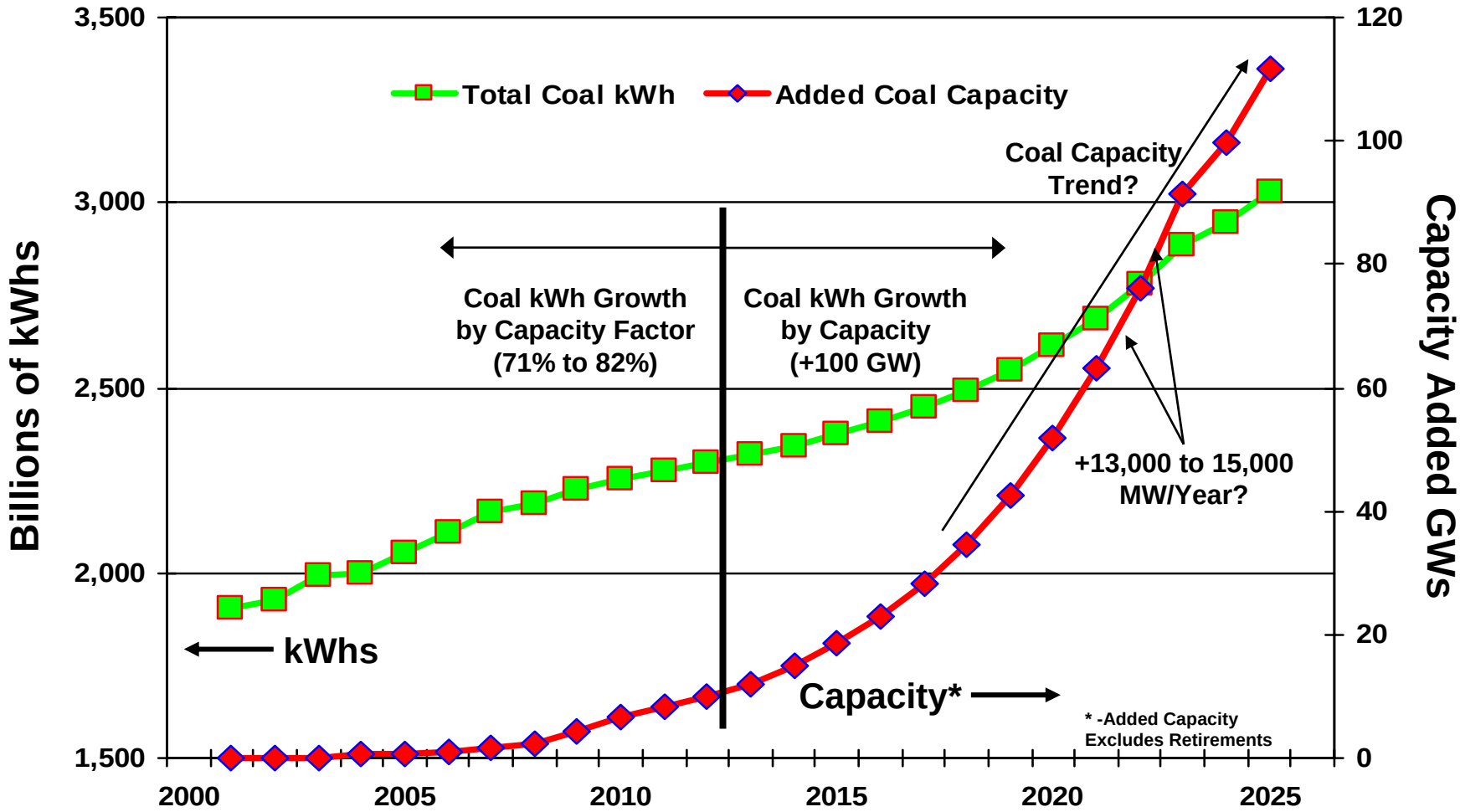
UDI 2000 Data

kWh Forecast Delta AEO'03 to AEO'04



Substantial Back-end Switch to Coal from Natural Gas for Incremental kWh Production

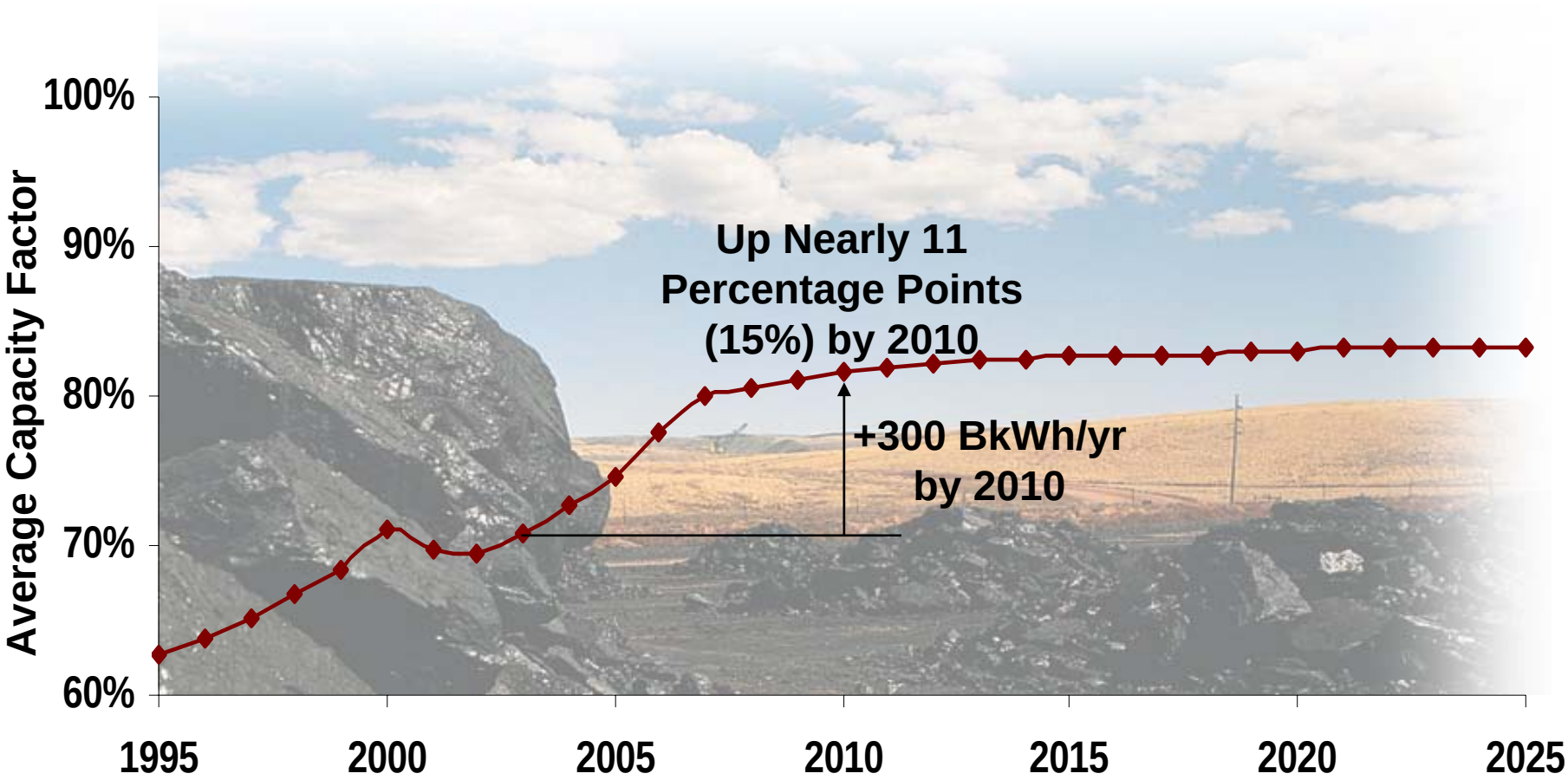
Coal kWh and Capacity Forecast AEO'04



Back-end Reliance on Coal-fired Capacity Growth

Can Coal-fired Power Industry Wait 20 Years for Meaningful Business?

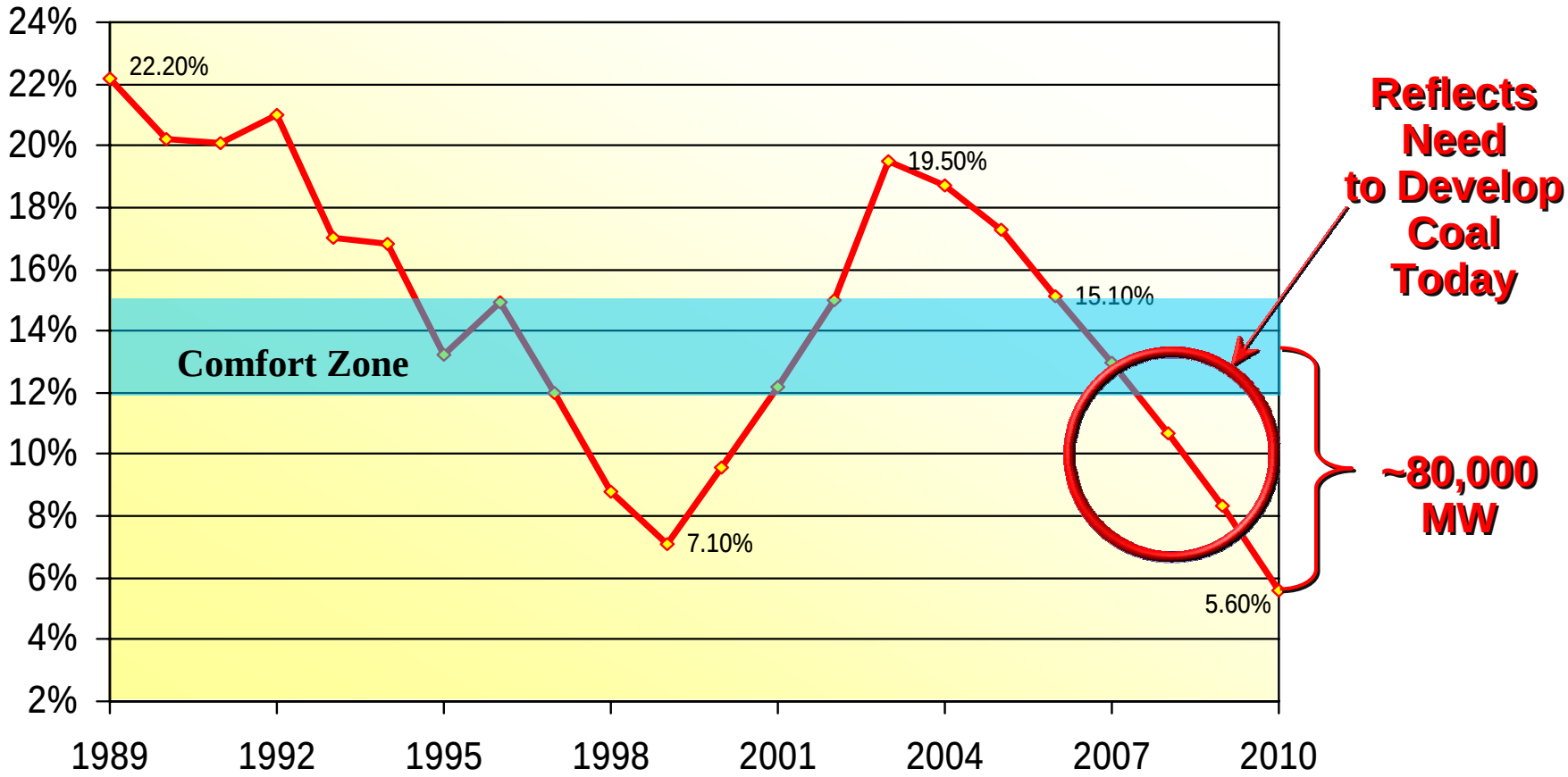
Coal Capacity Factors Increase (AEO'03)



Coal Capacity Factors Continue to Provide Over Half of Incremental Electricity Production Over Next Several Years

EIA Annual Energy Outlook 2003, Reference Case, (all coal units)

U.S. Capacity Margins



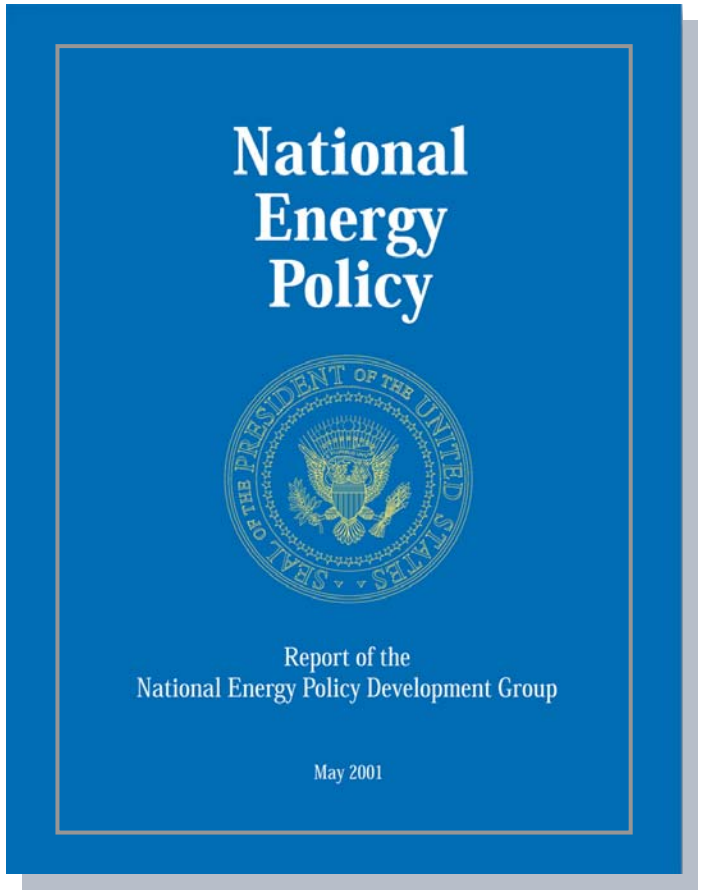
Natural Gas Fuel Constraints Will Likely Cause Near-Term Margin Deficiencies; Can LNG Respond?

So What?

- **Putting megawatts on the grid at the rates required to meet forecasts will require—**
  - Getting absolute most from existing fleet
    - process optimization will play big time!
  - Getting reliable operation from new (more complex) plants
    - process control will play big time!
- **Realizing a reliable power grid is highly dependent on reliability of individual plants**

National Energy Policy

- Increasing America's domestic energy supplies
- Protecting America's environment
- Ensuring a comprehensive delivery system
- Enhancing national energy security



Elements of Coal & Power Program

Core R&D Program

- Innovations for Existing Plants
- FutureGen Support

FutureGen

- Integrated Sequestration, Hydrogen, and Power Research Facility

Demonstration Program

- Clean Coal Power Initiative

All Program Elements Support Presidential Initiatives

Clean Coal Technology Roadmap Addresses Near- and Long-range Needs

- **Short-term: existing fleet**
  - Cost-effective environmental control technologies to comply with current and emerging regulations
- **Long-term: future energy plants**
  - Near-zero emissions power and clean fuels plants with CO_2 management capability

Can be found on CURC website
www.coal.org
and NETL
www.netl.doe.gov/coalpower

Coal Power Program Roadmap
New Plant Performance Targets
(Represents best integrated plant technology capability)

	Reference Plant	2010	2020 Vision 21
Air Emissions	98% SO_2 removal	99%	>99%
	0.15 lb/10^6 Btu NOx	0.05 lb/10^6 Btu	<0.01 lb/10^6 Btu
	0.01 lb/10^6 Btu Particulate Matter	0.005 lb/10^6 Btu	0.002 lb/10^6 Btu
	Mercury (Hg)	90% removal	95% removal
By-Product Utilization	30%	50%	near 100%
Plant Efficiency (HHV)	40%	45-50%	50-60%

Coal Power Program Roadmap

New Plant Performance Targets[1]

(Represents best integrated plant technology capability)

	Reference Plant	2010	2020 Vision 21
Availability[(3)]	**>80%**	**>85%**	**≥90%**
Plant Capital Cost[(2)] **$/kW**	**1000 – 1300**	**900 – 1000**	**800 – 900**
Cost of Electricity[(4)] **¢/kWh**	**3.5**	**3.0 - 3.2**	**<3.0**

(1) Targets are w/o carbon capture and sequestration and reflect current cooling tower technology for water use

(2) Range reflects performance projected for different plant technologies that will achieve environmental performance and energy cost targets

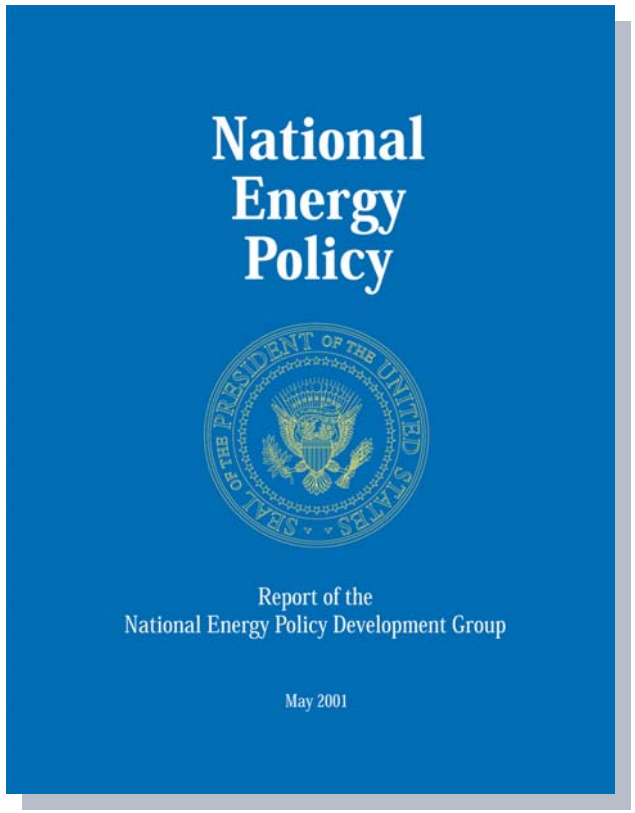
(3) Percent of time capable of generating power (ref. North American Electric Reliability Council)

(4) Bus-bar cost-of-electricity in today's dollars; Reference plant based on $1000/kW capital cost, $1.20/$10^6$ Btu coal cost

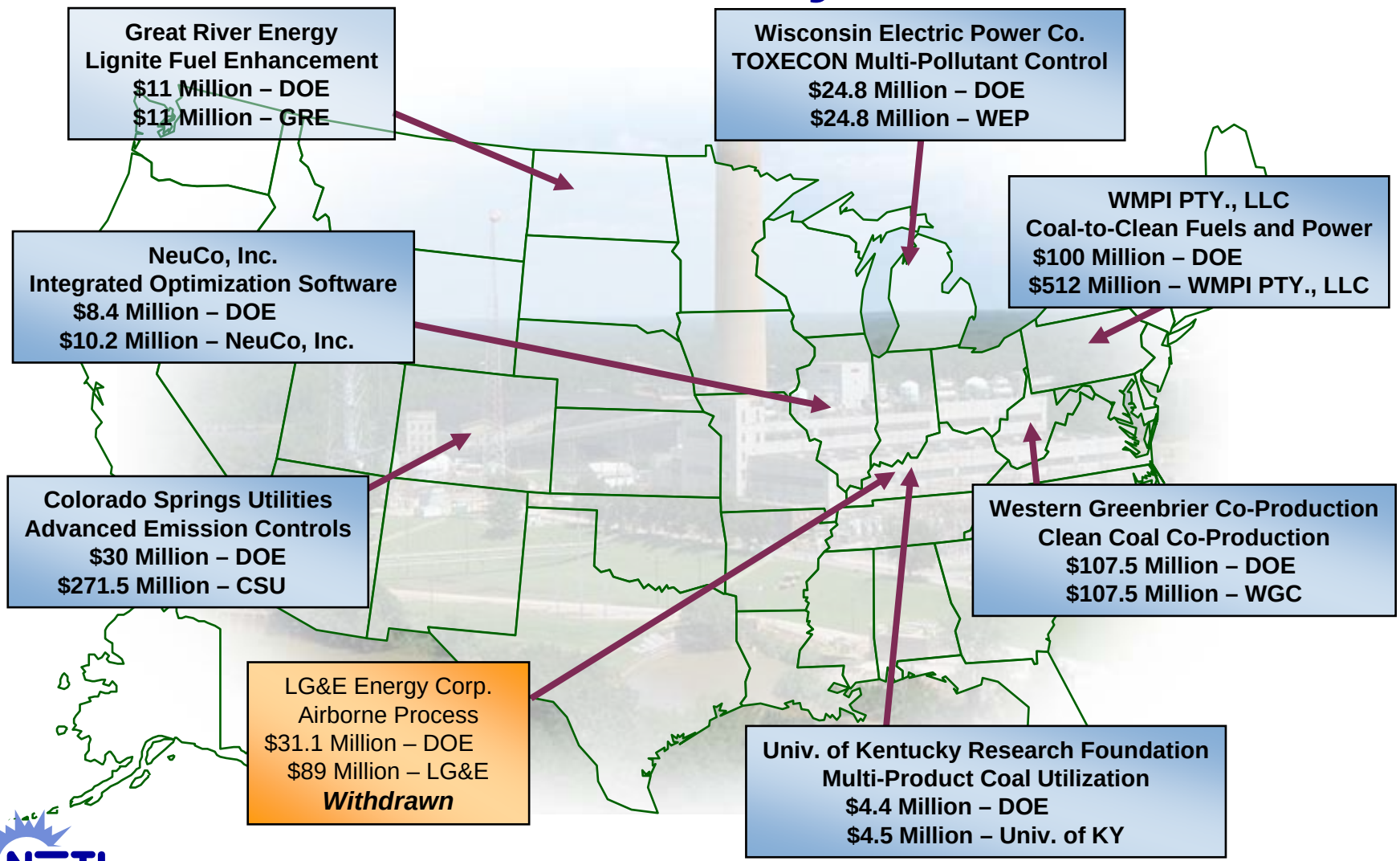
Clean Coal Power Initiative

- **Implemented NEP recommendation to increase investment in clean coal technology**

- **$2 billion over 10 years starting in FY 02**
  - Anticipates series of competitive solicitations
  - Industry cost share of at least 50%
  - Builds off CCT and PPII demonstration efforts

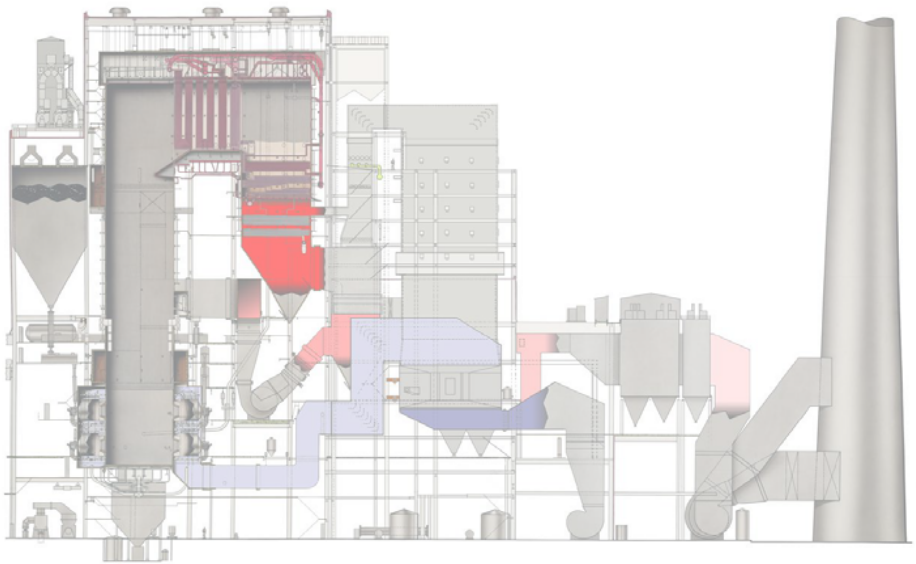


Clean Coal Power Initiative (CCPI) – Round 1 Projects



NeuCo, Inc.

- Integrated optimization software on three 600 MW units reduces emissions, increases efficiency, and increases reliability.
- Five optimization modules: cyclone combustion, soot blowing, SCR operations, thermal performance, and profit optimization.
- Higher efficiencies help to meet Climate Change goals.
- Total project funding: $18.6 million (DOE share: $8.4 million).



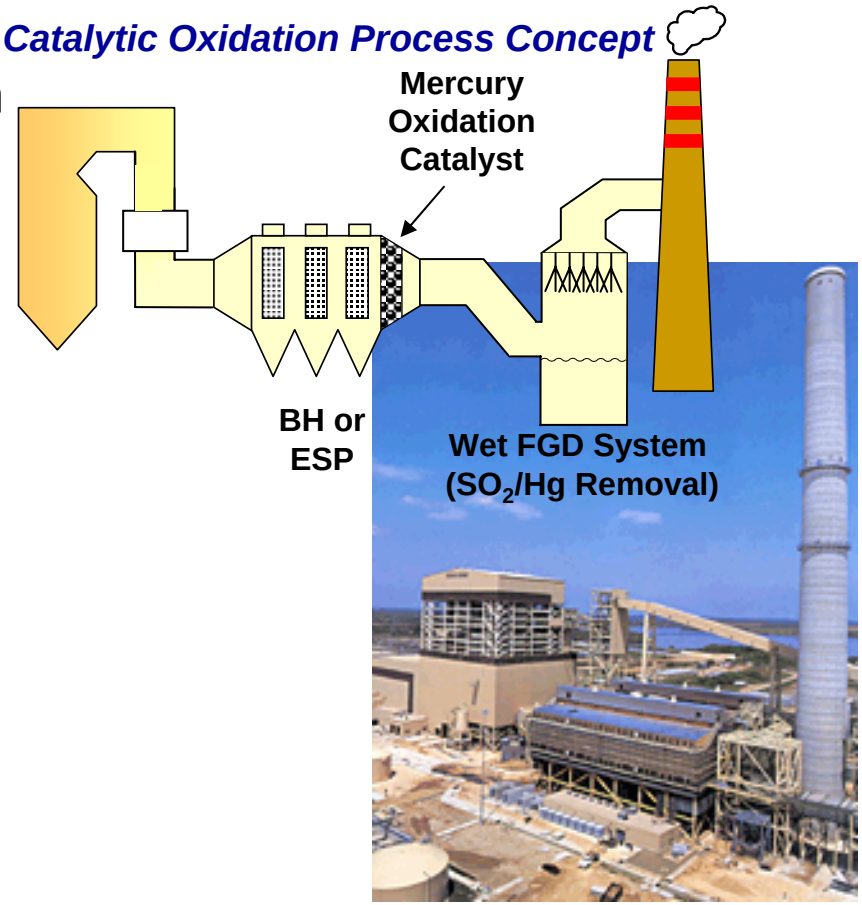
Dynegy Midwest Generation's Baldwin Energy Complex

A CCPI Round 1 Project

Mercury Control R&D
Catalytic Mercury Oxidation for Low-Rank Coals

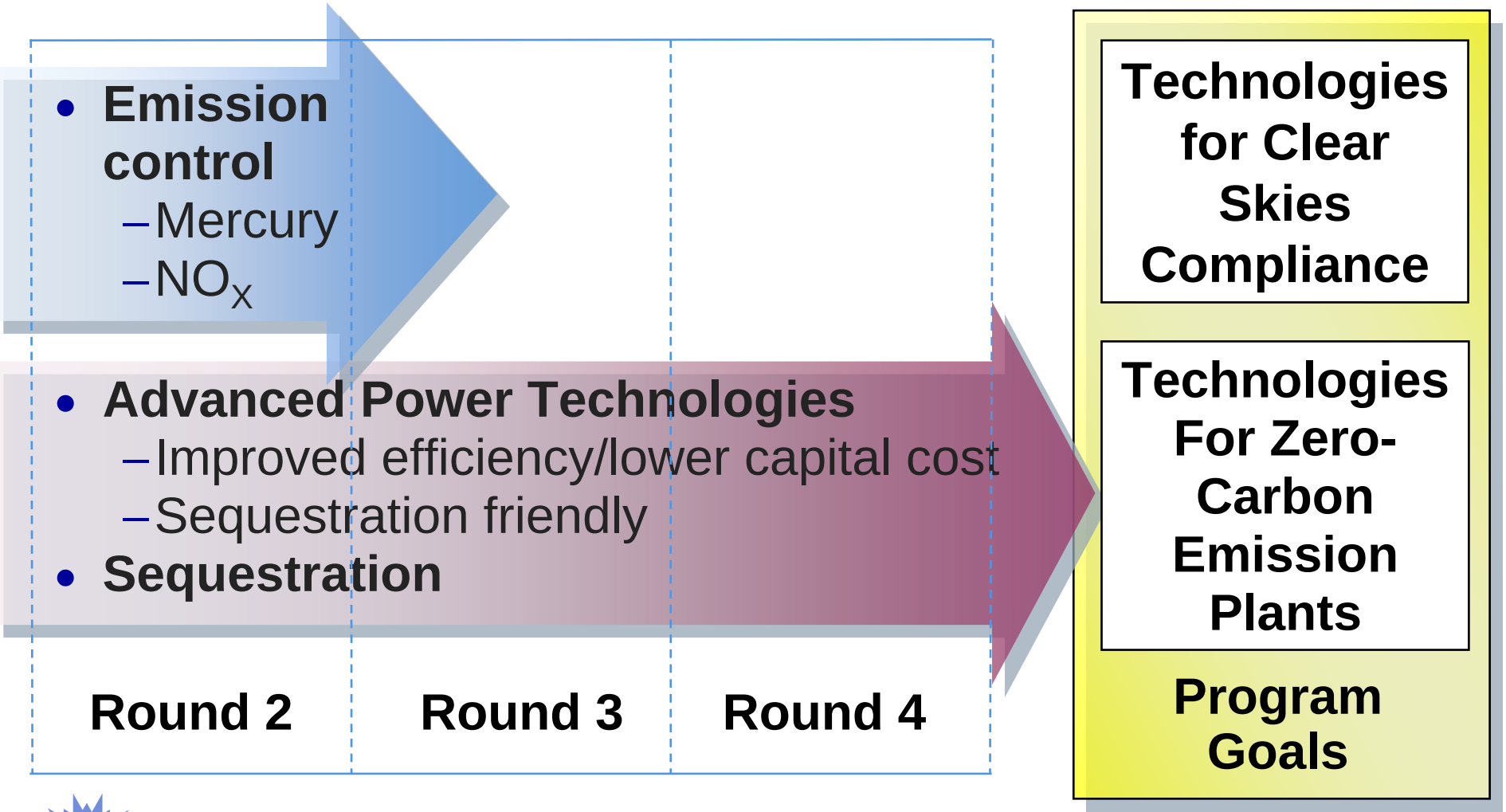
- **URS, CPS, EPRI & NETL conducting pilot scale tests with catalysts to oxidize elemental mercury to a form that can be scrubbed in WFGD**
- **Commercial concept is to install a 4-inch catalyst depth at PCD outlet to achieve +80% Hg^0 oxidation to ensure +90% Hg capture in WFGD**
- **Testing at J.K. Spruce Plant**
  - 546 MW T-fired boiler
  - Fires PRB & PRB/Pet Coke
  - Equipped with BH and WFGD

Catalytic Oxidation Process Concept

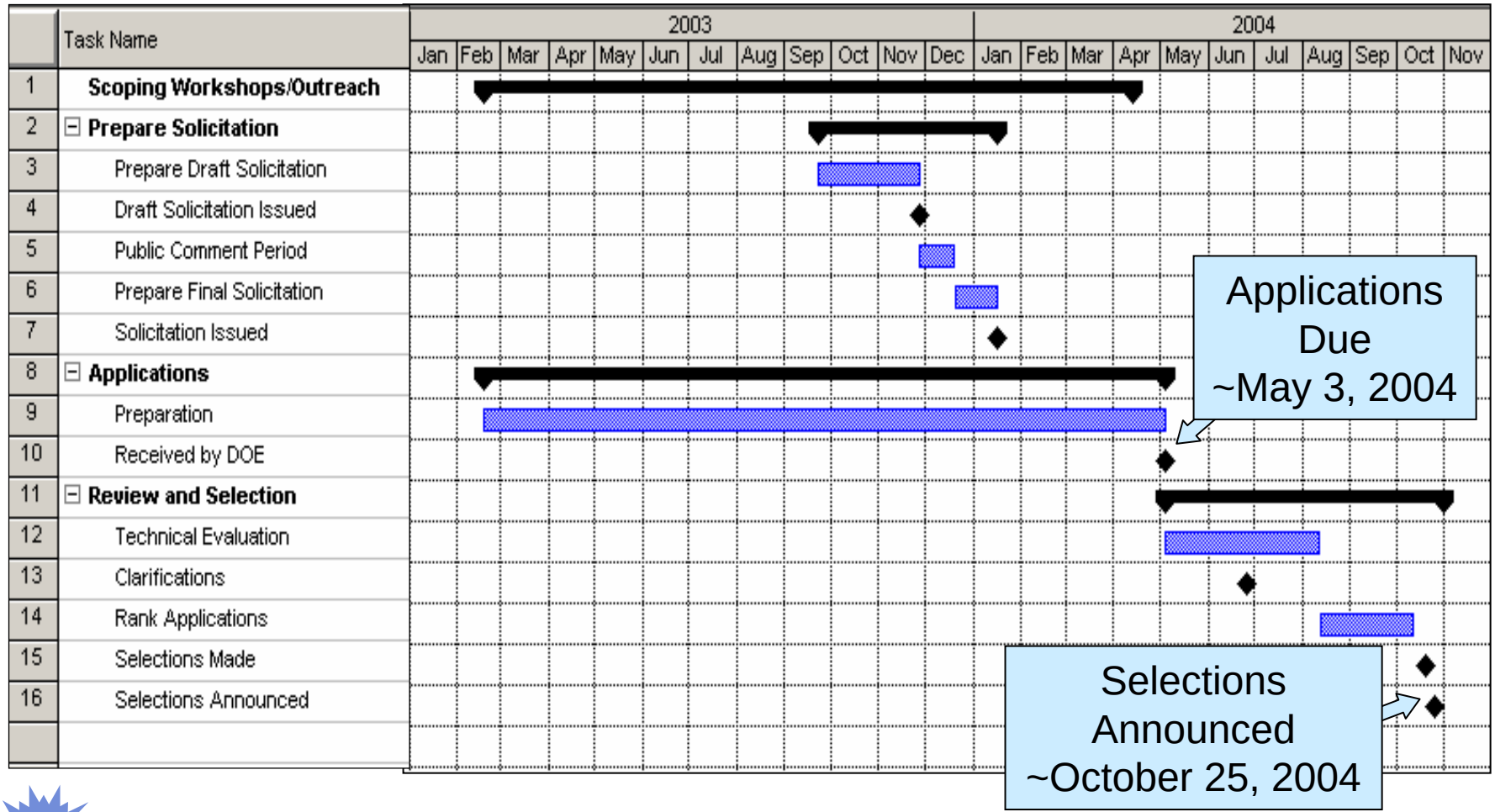


CPS's J.K. Spruce Plant
Bexar County , Texas

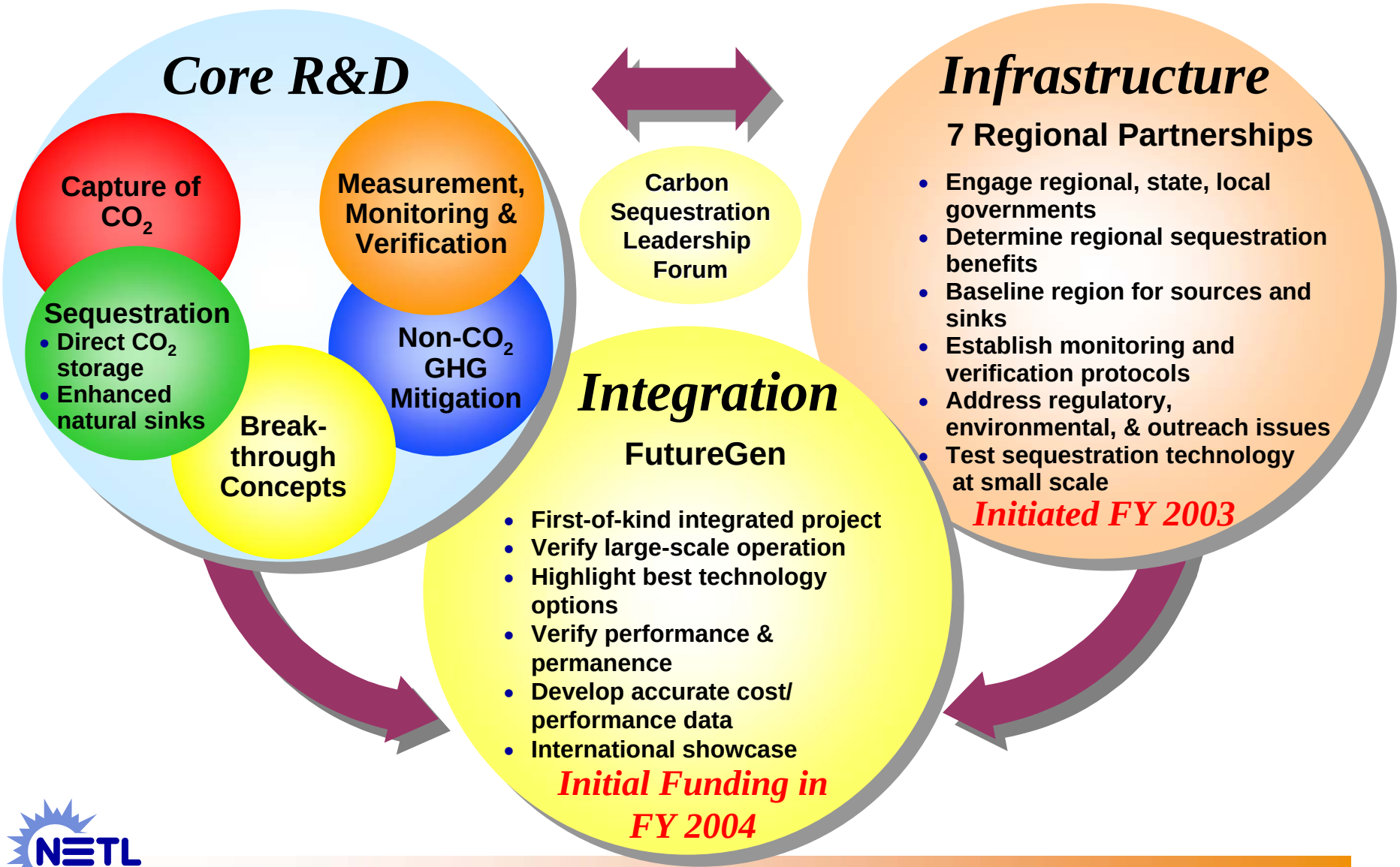
Tentative Priority Technologies
Future CCPI Rounds



CCPI Round 2 Schedule
Path to Selection
(Dates Approximate)



Carbon Sequestration Program Structure



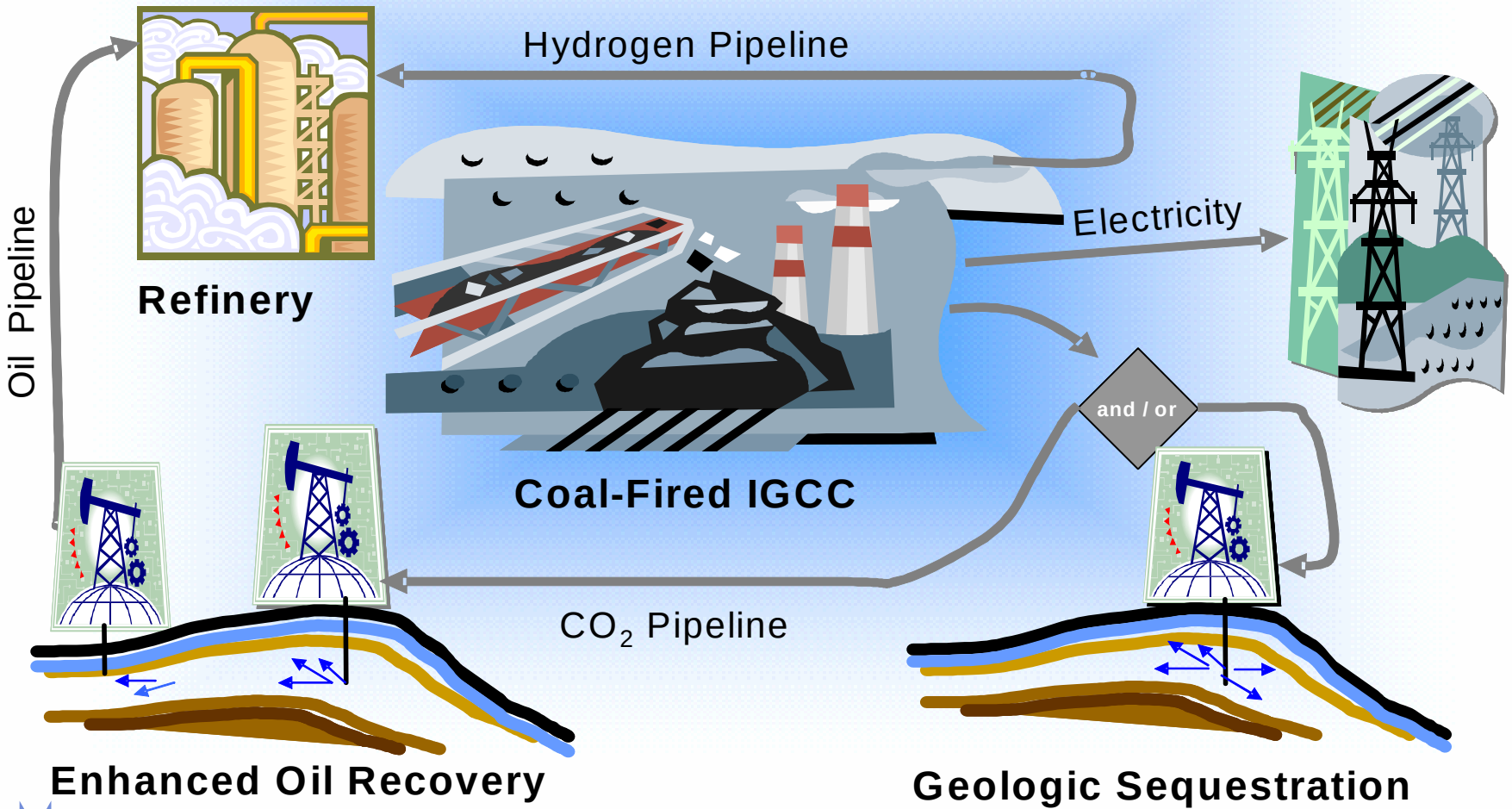
FutureGen: A Presidential Initiative

One-billion-dollar, 10-year demonstration project to create world's first coal-based, zero-emission electricity and hydrogen plant

President Bush, February 27, 2003

- **Produce electricity and hydrogen from coal using advanced technology**
- **Emit virtually no air pollutants**
- **Capture and permanently sequester CO_2**

FutureGen Concept



Closing Comments

- **Coal must play a key role to secure a healthy economy**
  - Is recognized in Presidential-level initiatives; Clear Skies, Climate Change, FutureGen, Hydrogen, Sequestration
  - Coal can play an important role in a potential future carbon-constrained world
- **Regulatory uncertainty improving (e.g. NSR)**
- **CCT Roadmap charts challenging but doable path forward**
  - Best ideas needed
  - Sustain Federal and private sector investments

Visit Our NETL Website

www.netl.doe.gov

Visit Our OCES Website

www.netl.doe.gov/coalpower/