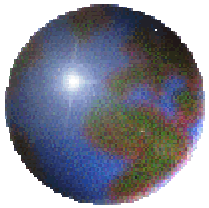


Electric Power and Climate Change in China

Current Context and Future Growth Options

Regional Electrification Initiative Workshop

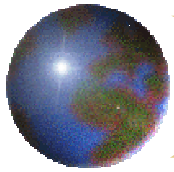
EPRI

Washington, DC

7 June 2002

Jeffrey Logan, Advanced International Studies Unit

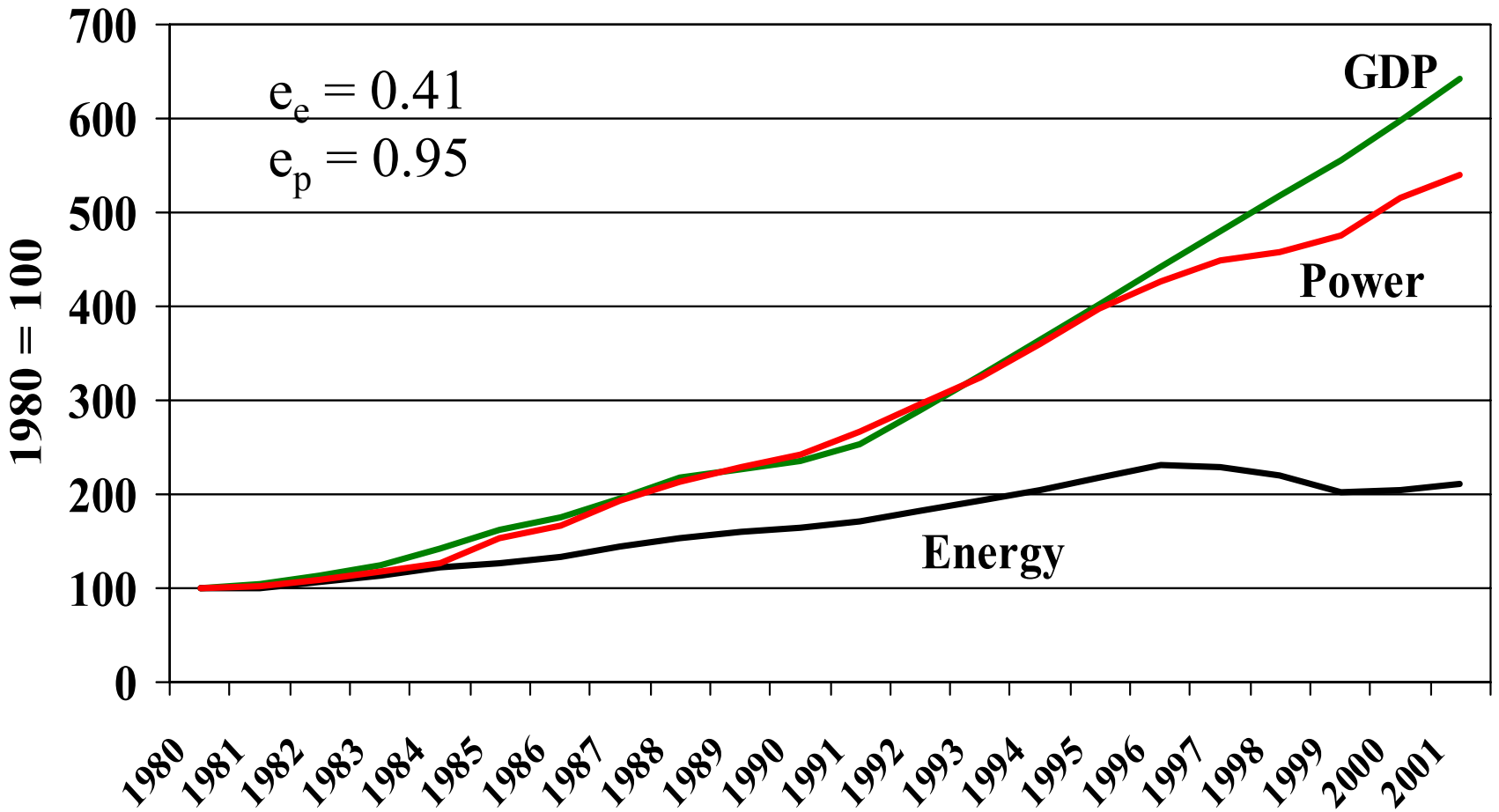
Joint Global Change Research Institute



Outline

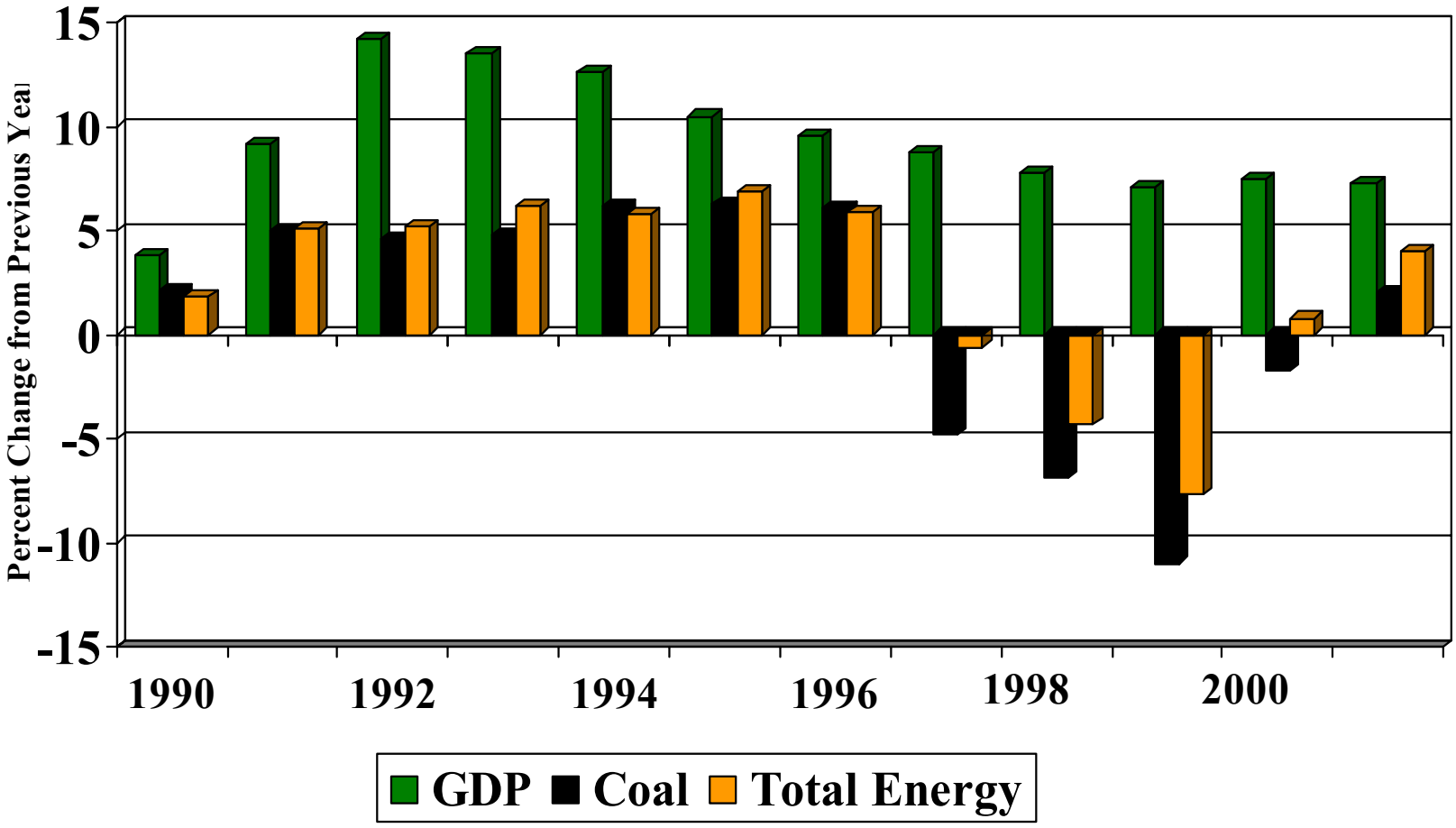
- Energy and Power in China's Economy
- Overview of China's Power Sector
- Environmental Issues
- Economics of Power Options
- Forecasts

Reported GDP, Energy and Power Consumption Growth in China



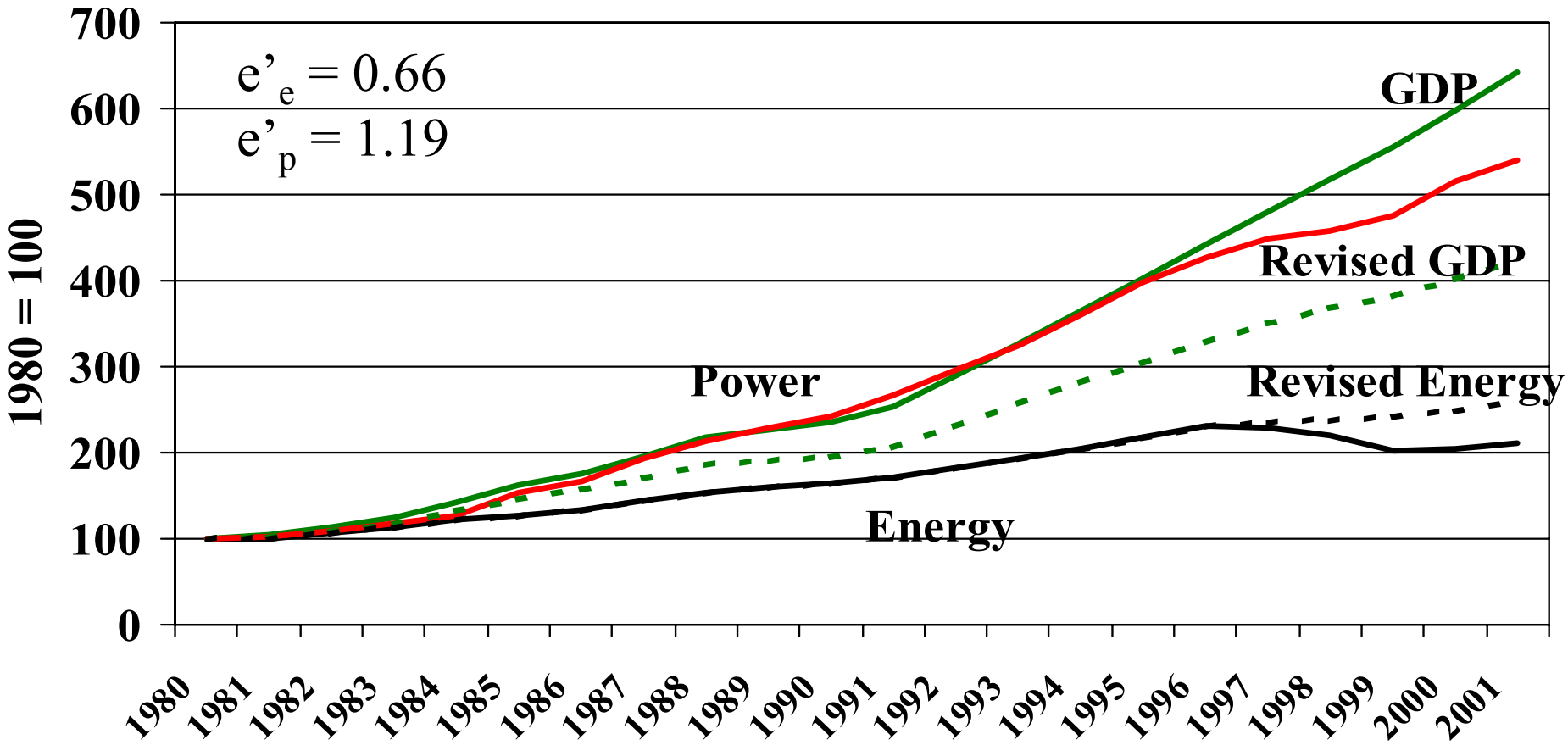
Source: China Statistical Yearbook. Data for 2000 and 2001 are estimated.

Controversial Data in Late 1990s

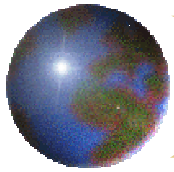


Source: China Statistical Yearbook. Data for 2000 and 2001 are estimated.

Estimated Revised GDP and Energy Use Growth in China



Source: Estimated revisions by JGCRI.



Snapshot of China's Power Sector

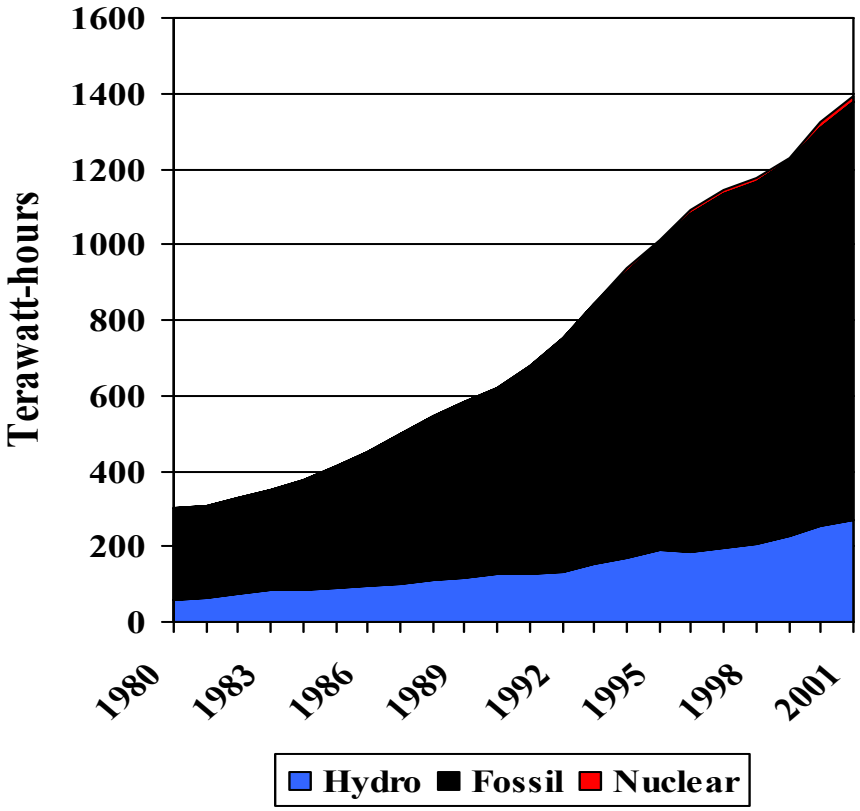
- 76 percent of generation from coal
- 330 GW of installed capacity in mid-2002, 1410 billion kwh generated (810 GW and 3800 b kWh in US)
- Environmental issues
  - Emissions, coal slag, mining, large hydro
- Regional imbalances (fuel and markets)

Snapshot (continued)

- Many subsidies removed; high prices in rural areas (15¢/kWh) due to add-on fees
- Power sector to anchor new natural gas infrastructure
- Nuclear option scaled back
- Domestic technology maturing
- Regulatory and commercial functions recently restructured, but FDI down
- Competition in generation looms

China's Power Sector in 2000

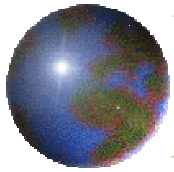
- Coal consumption: 520 million tons
- Petrol consumption: 10 million tons
- Gas consumption: 0.2 EJ
- Main power consumers: building material, chemicals, metallurgy



Power Plant Emissions in China

Plant Type	SO_2 (g/kWh)	NO_x (g/kWh)	CO_2 (g/kWh)	Efficiency (%)
Coal (PC)	**8-20**	**3-5**	**860**	**37**
Gas (CC)	**~0**	**1-2**	**370**	**50**
IGCC	**0.1-1**	**0.5-1**	**790**	**42**
Oil (CC)	**1-2**	**2-3**	**540**	**49**
Coal w/ Scrubber	**1-2**	**3-5**	**880**	**36**

Source: JGCRI.

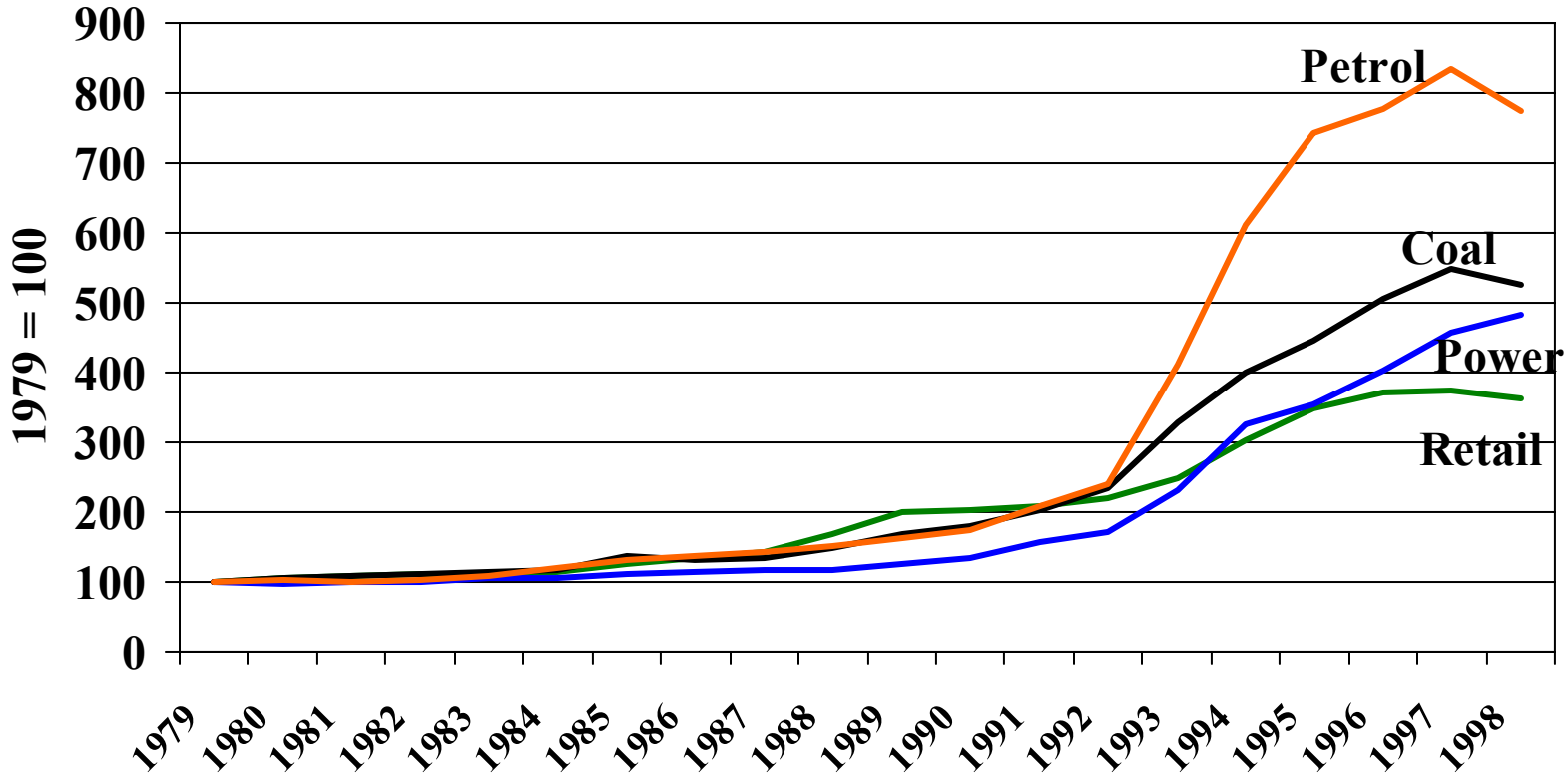


Main Environmental Issues Affecting the Power Industry in China

- Nearly 400,000 premature deaths resulting from air pollution
- Up to 8 percent of GDP lost due to environmental degradation
- 40 percent of land area affected by acid deposition
- Particulates largely controlled; sulfur and nitrogen oxides remain a problem

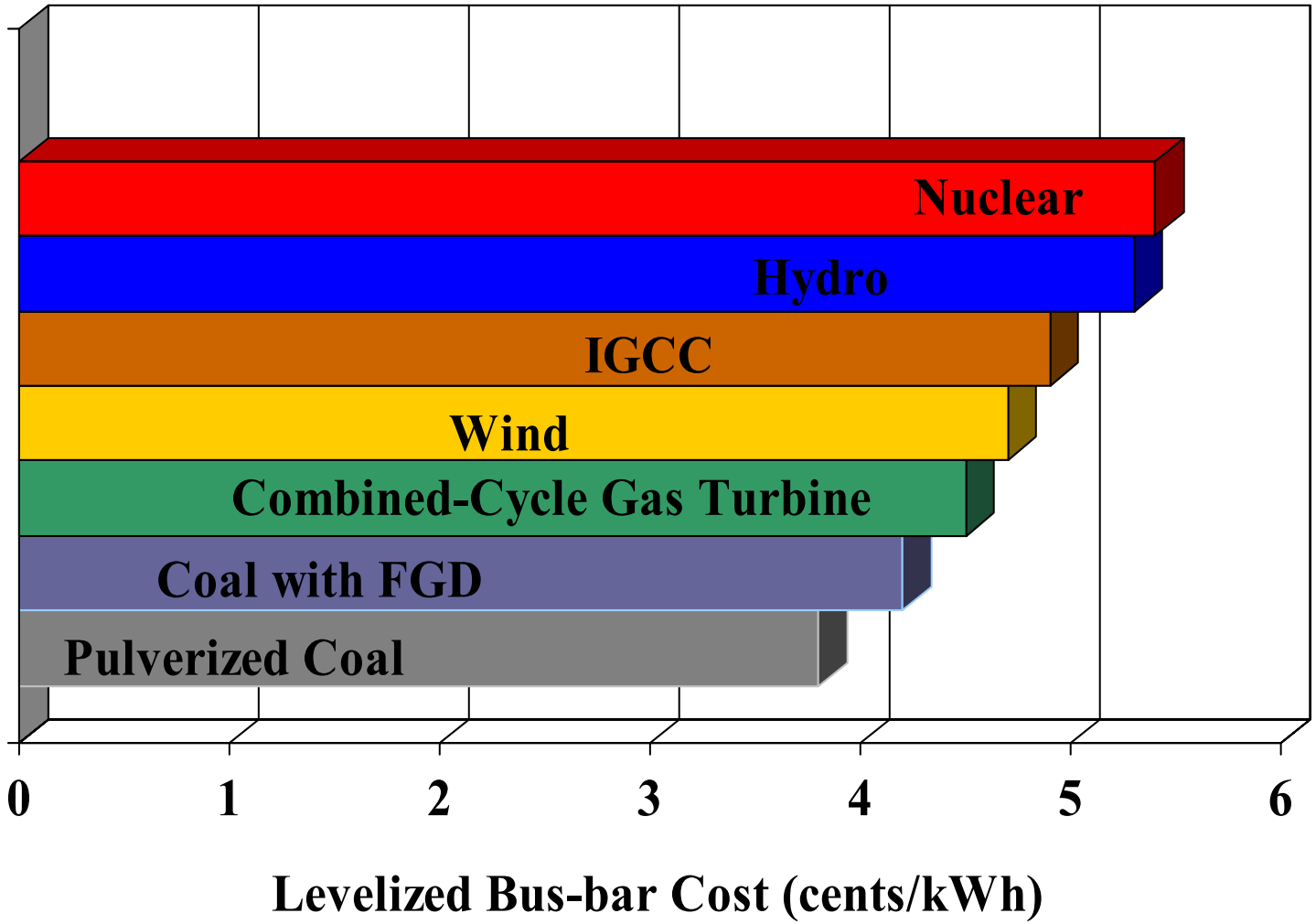
Source: World Bank (1998), PNNL (1998).

Price Indices in China



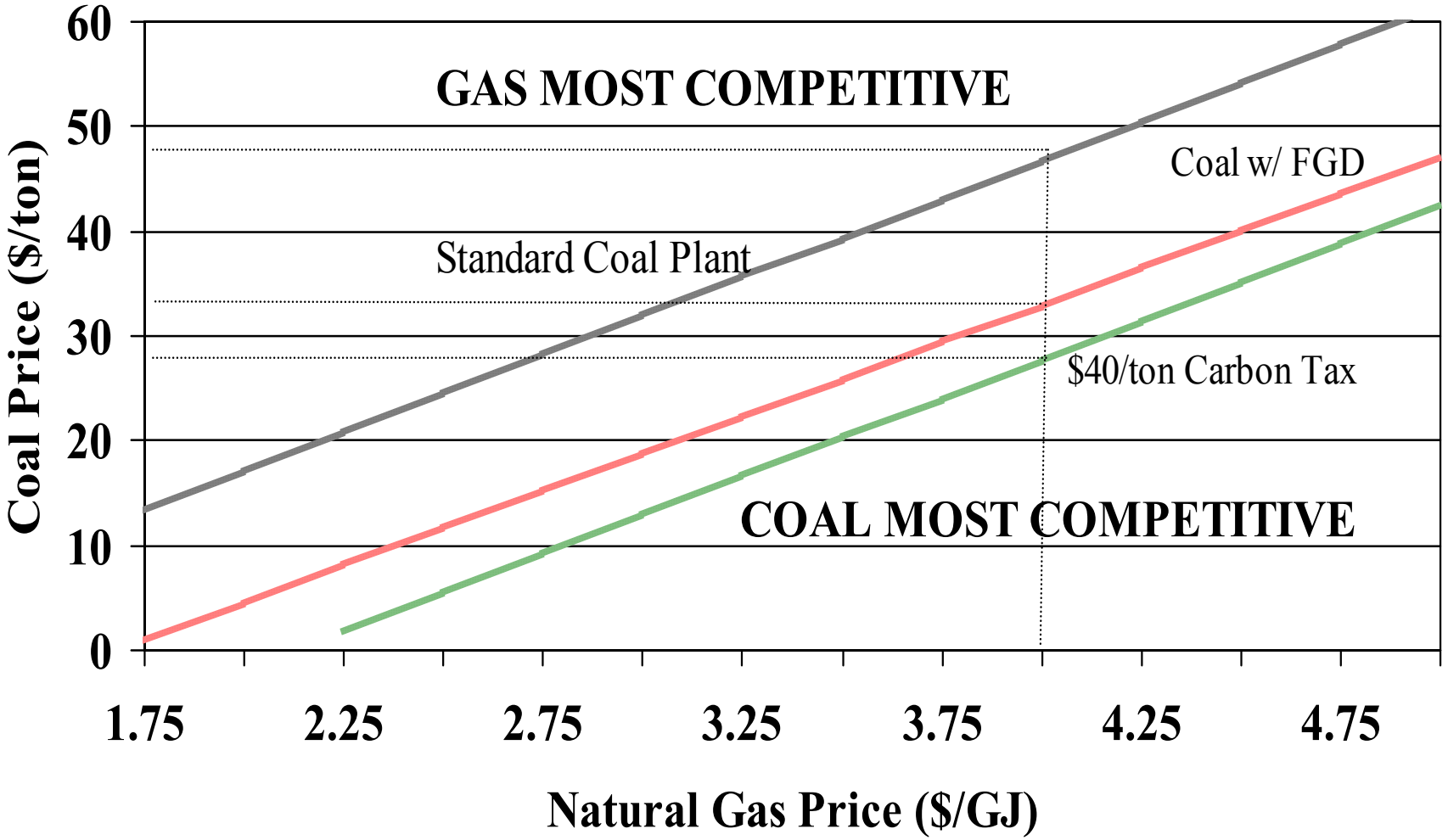
Source: China Statistical Yearbook 1999.

Levelized Power Costs in Southern China in 2000



Source: JGCRI.

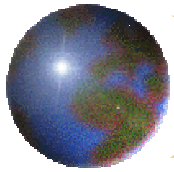
Fuel Economics of Power Generation in China



Source: JGCRI.

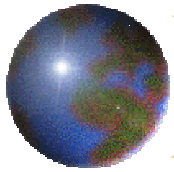
Technology Assessments

- Pulverized coal
  - 600 MW subcritical boiler; supercritical capability close
- Fluidized-bed and IGCC
  - Small demonstrations of FBC; IGCC not commercial
- Nuclear
  - Imported technology dominates; domestic capability growing
- Gas turbines
  - Little domestic manufacturing capability for large units; JVs
- Wind, solar
  - Imported technology dominates; JVs progressing
- Fuel Cells
  - Fundamental research growing
- Carbon capture/Integrated systems
  - On radar screen



China's Emerging Gas Sector

- More domestic gas than once thought
- Infrastructure expanding rapidly
- Incentives needed for end-users
- Imports remain important variable



Factors Influencing Development of China's Power Sector

- Macro
  - State-owned enterprises reform
  - Non-performing bank loans
  - Corruption
  - Population/wealth imbalance
  - Local protectionism
  - End-use energy efficiency policy
  - Natural gas policy
  - Environmental policy
  - Rule of law
  - International climate treaties

Factors Influencing Development of China's Power Sector

- Sector-specific
  - Policy introducing competition in power generation
  - Enforcement of legal and environmental provisions
  - Import tariffs on technology and fuel
  - R&D on energy technology

Modeling Alternative Scenarios

- Least-cost optimization model
- Exogenous GDP and power demand
- 17 power generation options, 5 regions
- Limited feedback, but wide variety of user-defined constraints
- Optional environmental costs
- Thru 2020 at 5 year intervals

Growth Scenarios

- Baseline and High GDP Growth
  - Successful "dynamics as usual"
- Efficiency
  - End-use demand reduced 10% by 2020
- Environmental Externalities
  - Fee on local pollutants ($300/ton each by 2020)
- Natural Gas
  - Policies to expand availability and stablize price
- Carbon Tax
  - Fee of $30/ton-C by 2020
  - Capital costs for advanced technologies decline due to RD&D

Baseline Assumptions

- Average annual growth of power demand through 2020 = 4.9 percent; total demand = 3715 TWh in 2020
- Natural gas availability for power generation expands (4 EJ in 2020)
- Environmental policies steadily improve
- Energy prices rise slowly

Assumptions for East China in 2020

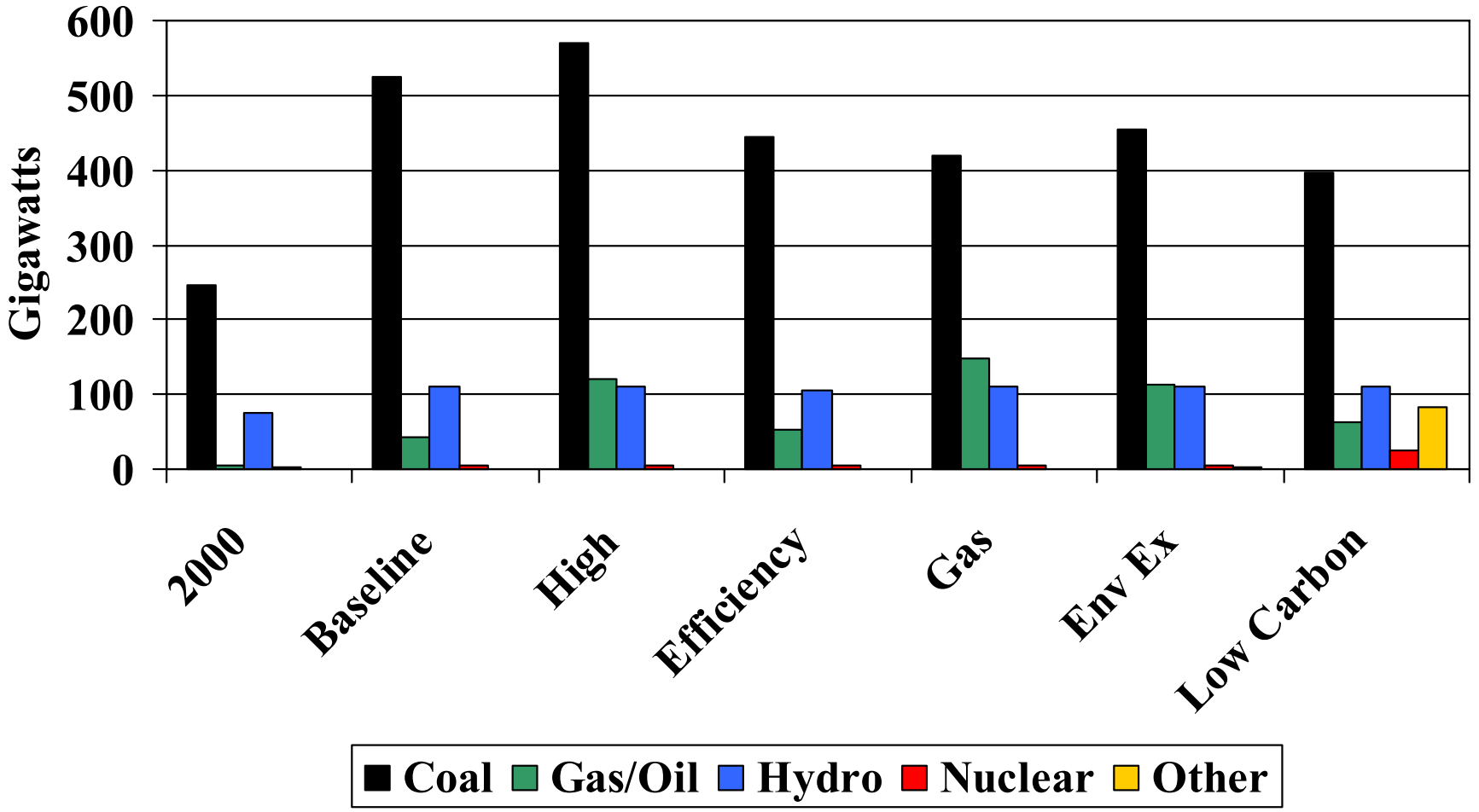
	Capital Cost ($/kW)	Efficiency/ CF* (%)	Fuel Cost	Levelized Cost (¢/kWh)
Pulv. Coal	800	38	$38/ton	4.0
CCGT	500	60	$4.3/GJ	4.2
Wind	900	34*	--	4.3
SC Coal w/ FGD	1050	40	$29/ton	4.5
Nuclear	1550	75*	$0.007/kWh	4.9
Hydro	1200	43*	--	5.0
IGCC	1400	44	$29/ton	5.5

Scenario Results in 2020

	Capacity (GW)	CO_2 (M ton-C)	SO_2 (M ton-SO_2)	Cost (B$)
2000	305	283	13	--
Baseline	688	713	28	581
High GDP	817	807	30	849
Efficiency*	623	641	26	519
Environ. Ext.	692	648	24	602
Natural Gas	690	620	23	583
Low Carbon*	681	575	22	621

* Costs to achieve scenario assumptions not included

Generation Capacity in 2020



Conclusions

- Rapid growth in power use and emissions likely to continue, but will remain well below U.S. levels in 2020
- Nuclear, cleaner coal, hydro and other options remain expensive in baseline
- Strong opportunities for co-benefit policy options using natural gas
- End-use efficiency has significant potential to lower demand affordably
- International cooperation can dramatically reduce carbon dioxide emissions
- U.S.-China cooperation essential