



Electric Power Options in Developing Countries:  
Case Studies from China, India, and Korea

Jeffrey Logan

Battelle, Advanced International Studies Unit

28 September 1999

# Presentation Overview

---

- ◆ Study Overview and Goals
- ◆ Power Sector Snapshots
- ◆ Modeling Results
- ◆ Conclusions

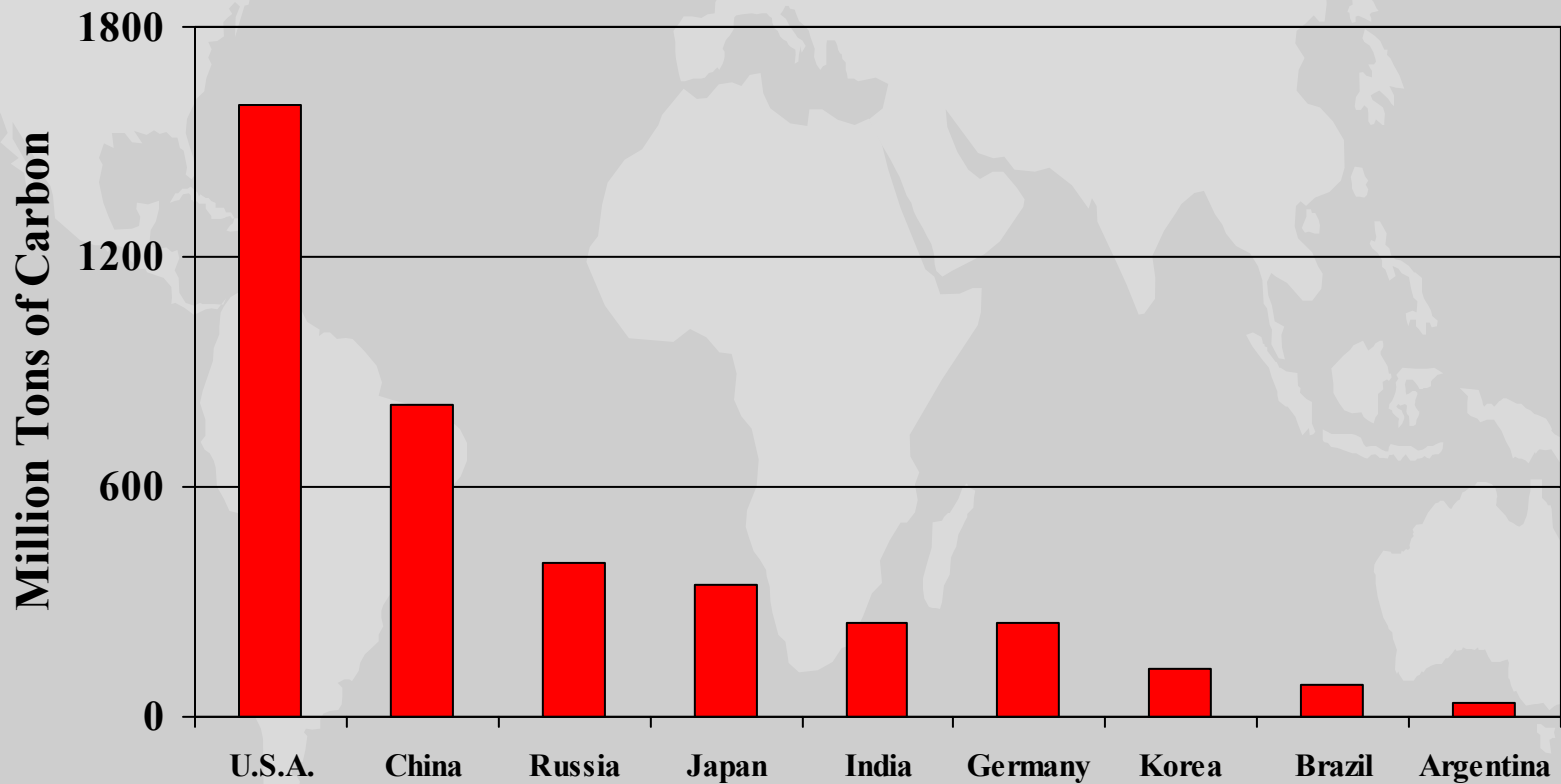
# Background and Caveats

---

- ◆ Sponsor: Pew Center on Global Climate Change
- ◆ Five teams: China, India, Brazil, Korea, Argentina
- ◆ Goals
  - ∞ Describe context for new investment
  - ∞ Present options for alternative growth
- ◆ Except for Korea, all results are preliminary
- ◆ Team leaders will present results in Bonn (COP-5)

# Carbon Emissions from Fossil Fuel Combustion in Selected Countries, 1998

---



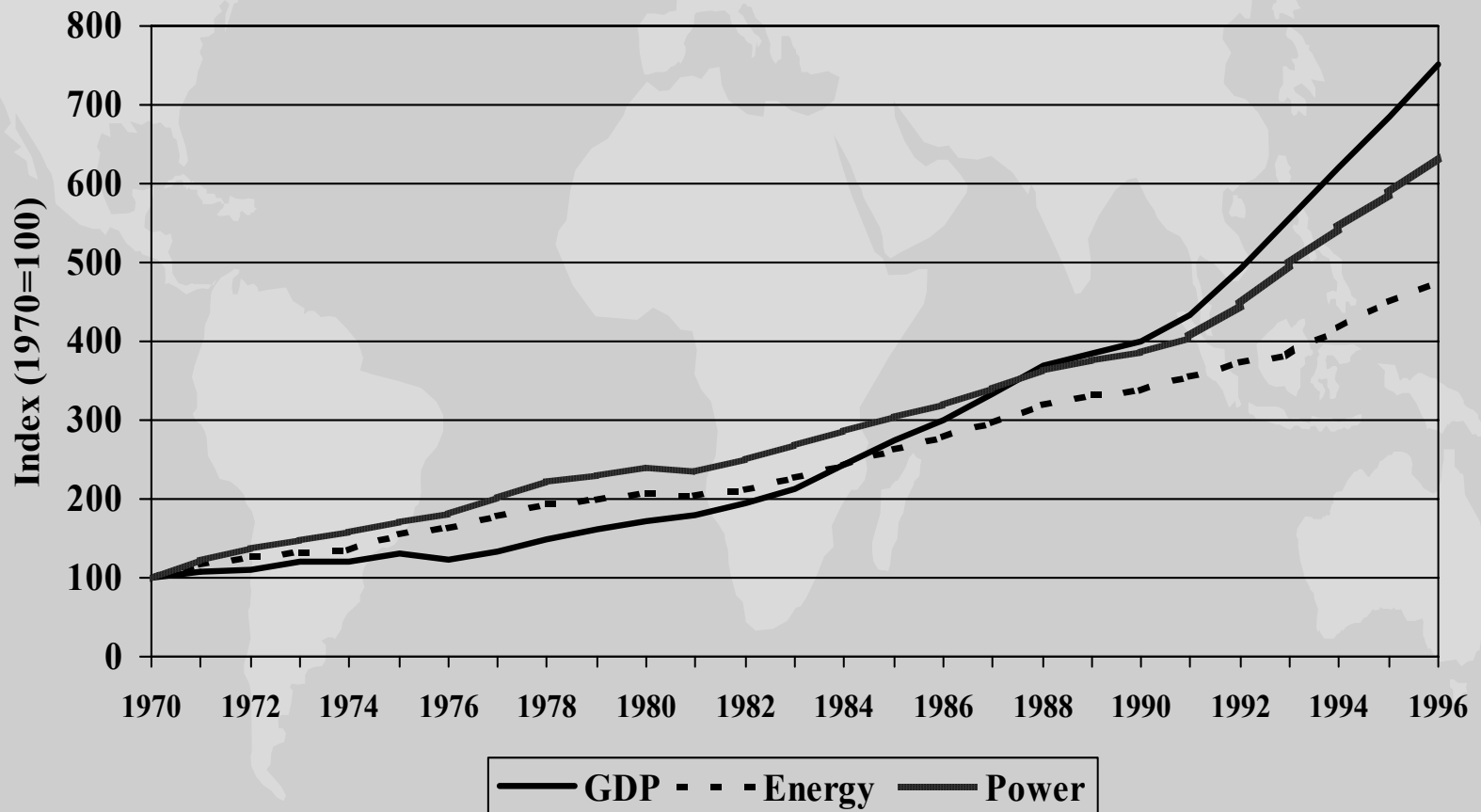
Source: Calculated from *BP-Amoco Statistical Yearbook of Energy 1999*.

# Snapshot of China's Power Sector

---

- ◆ Coal generates 8 of every 10 kilowatt-hours
- ◆ Low income elasticity of power consumption
- ◆ Severe environmental pollution
- ◆ Cautious reform and restructuring
- ◆ Rapid transition from power shortage to glut

# Energy and Power in China's Economy



# Power Plant Emissions in China

<b>Plant Type</b>	<b>SO<sub>2</sub></b> (g/kWh)	<b>NO<sub>x</sub></b> (g/kWh)	<b>CO<sub>2</sub></b> (g/kWh)	<b>Efficiency</b> (%)
<b>Coal (PC)</b>	<b>8-20</b>	<b>3-5</b>	<b>860</b>	<b>37</b>
<b>Gas (CC)</b>	<b>~0</b>	<b>1-2</b>	<b>370</b>	<b>50</b>
<b>IGCC</b>	<b>0.1-1</b>	<b>0.5-1</b>	<b>790</b>	<b>42</b>
<b>Oil (CC)</b>	<b>1-2</b>	<b>2-3</b>	<b>540</b>	<b>49</b>
<b>Coal w/ Scrubber</b>	<b>1-2</b>	<b>3-5</b>	<b>880</b>	<b>36</b>

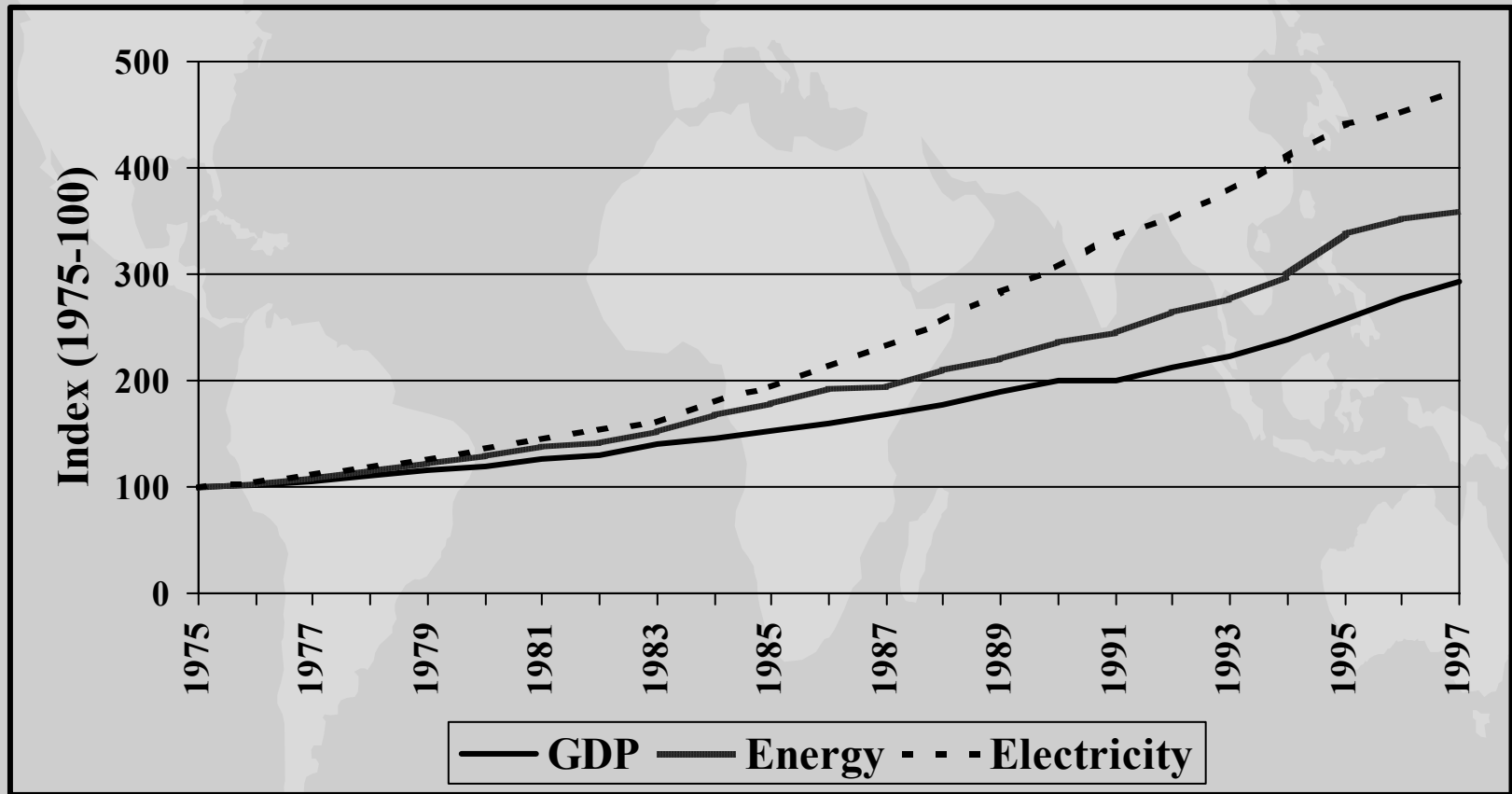
Source: Battelle Memorial Institute

# Snapshot of India's Power Sector

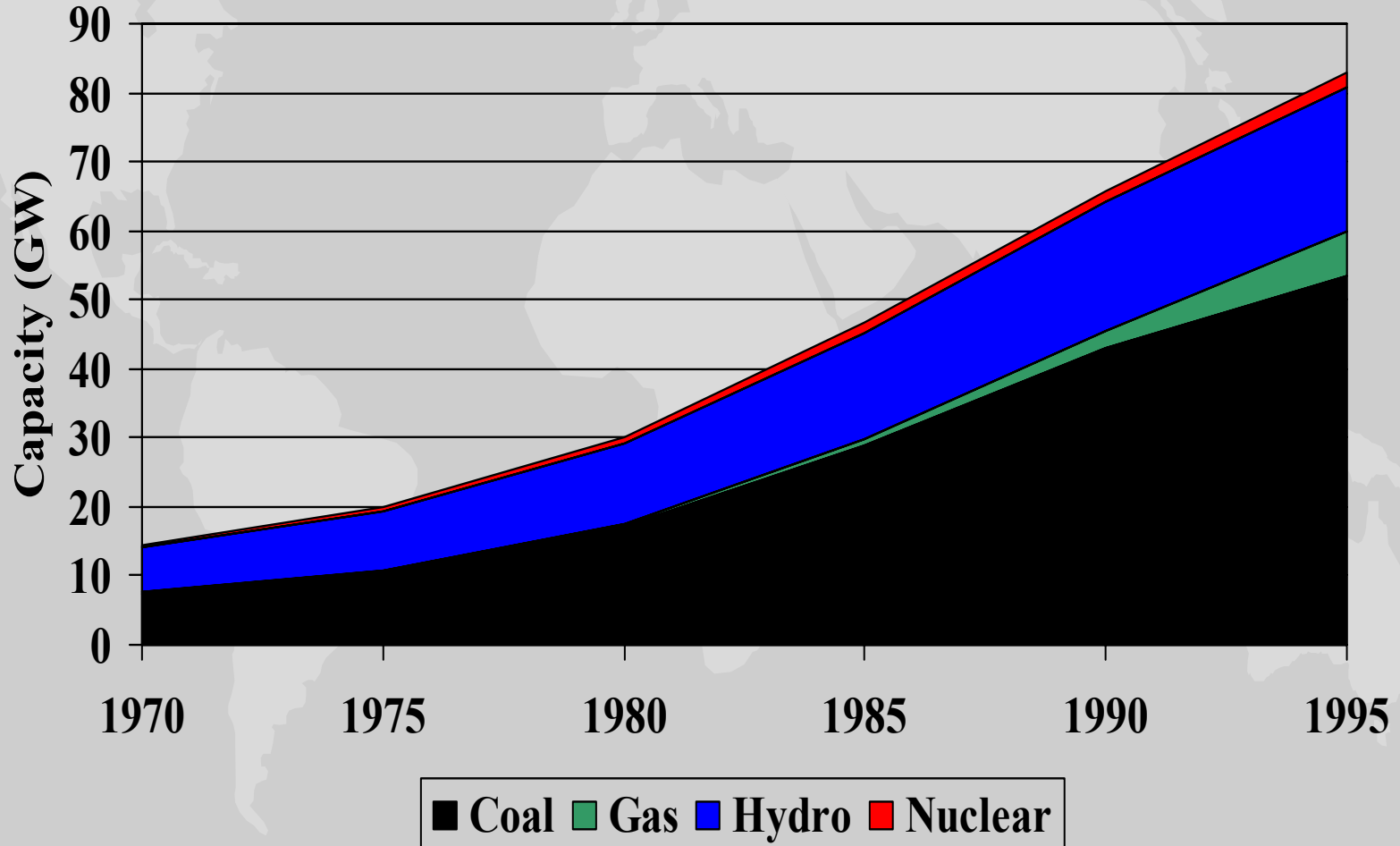
---

- ◆ Power shortages
- ◆ Subsidized power to agricultural sector
- ◆ High elasticity of power demand
- ◆ Cautious reform and restructuring
- ◆ Heavy reliance on coal (low-sulfur, high ash)

# Energy and Power in India's Economy



# Power Capacity in India

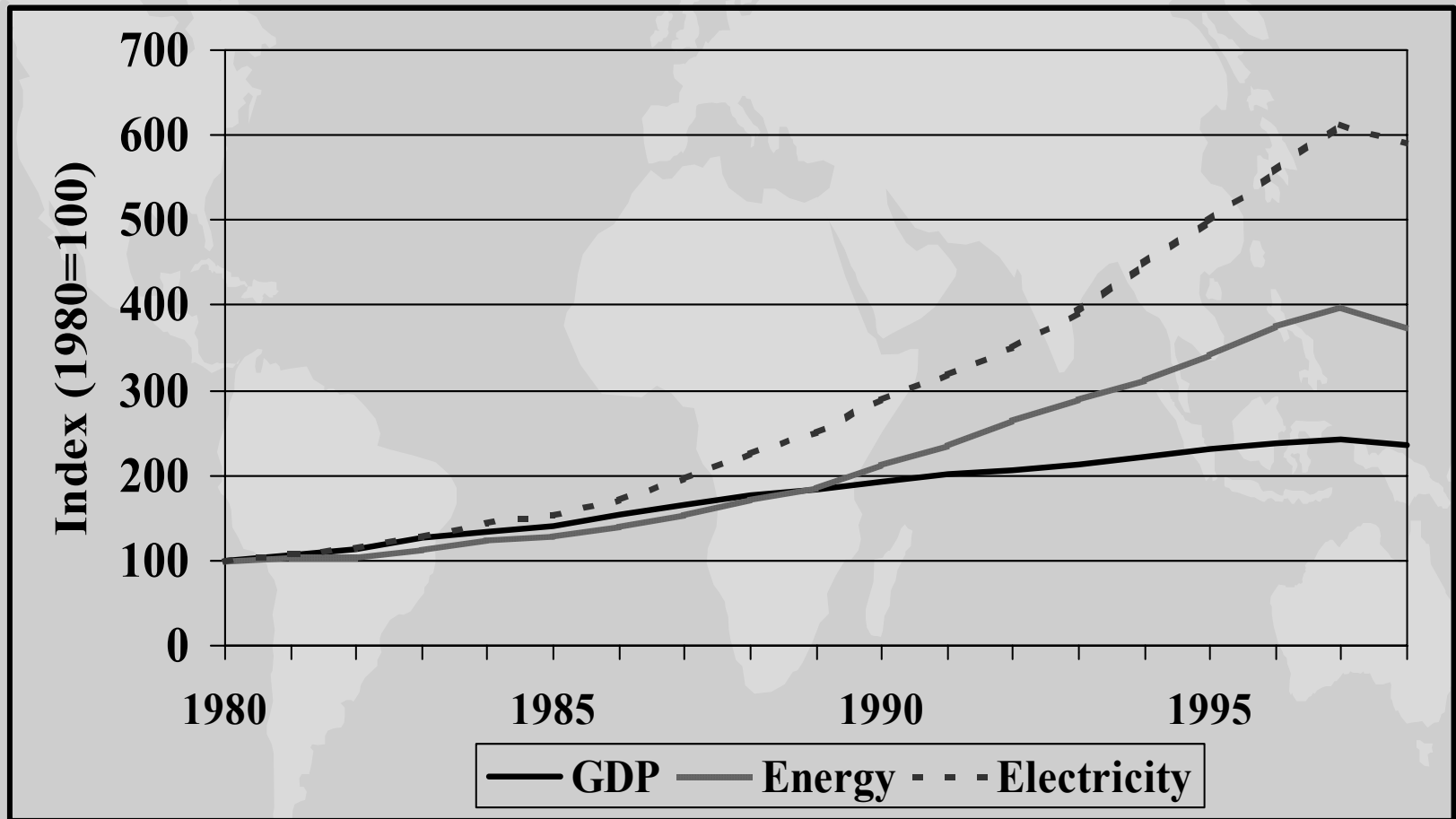


# Snapshot of Korea's Power Sector

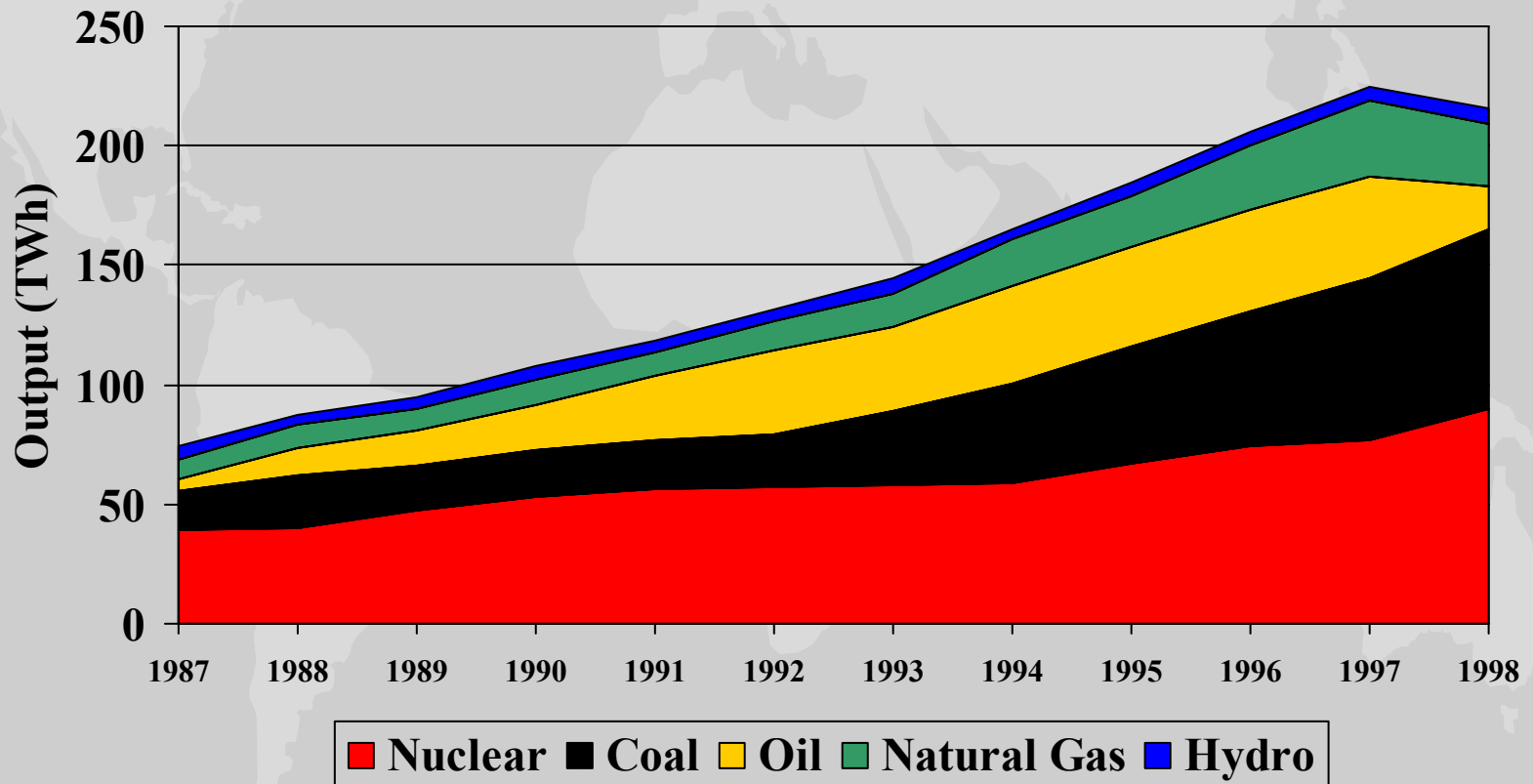
---

- ◆ Rapid growth in power demand and high elasticity (*Chaebols*)
- ◆ Over 90 percent of fuel is imported
- ◆ State-owned KEPCO restructuring
- ◆ Very efficient operation of power plants

# Energy and Power in Korea's Economy



# Fuel Mix in Korean Power Generation



# Modeling Power Options

---

- ◆ Generic linear programming model modified for each country
- ◆ Model Structure
  - ✧ Simulates up to 17 generation technologies
  - ✧ Divides country into 5 interconnected regions
  - ✧ Optimizes power mix to 2015 based on levelized costs; environmental costs optional
- ◆ Exogenous scenario analysis
  - ✧ Policy levers

# Results for Korea

---

## ◆ Scenarios

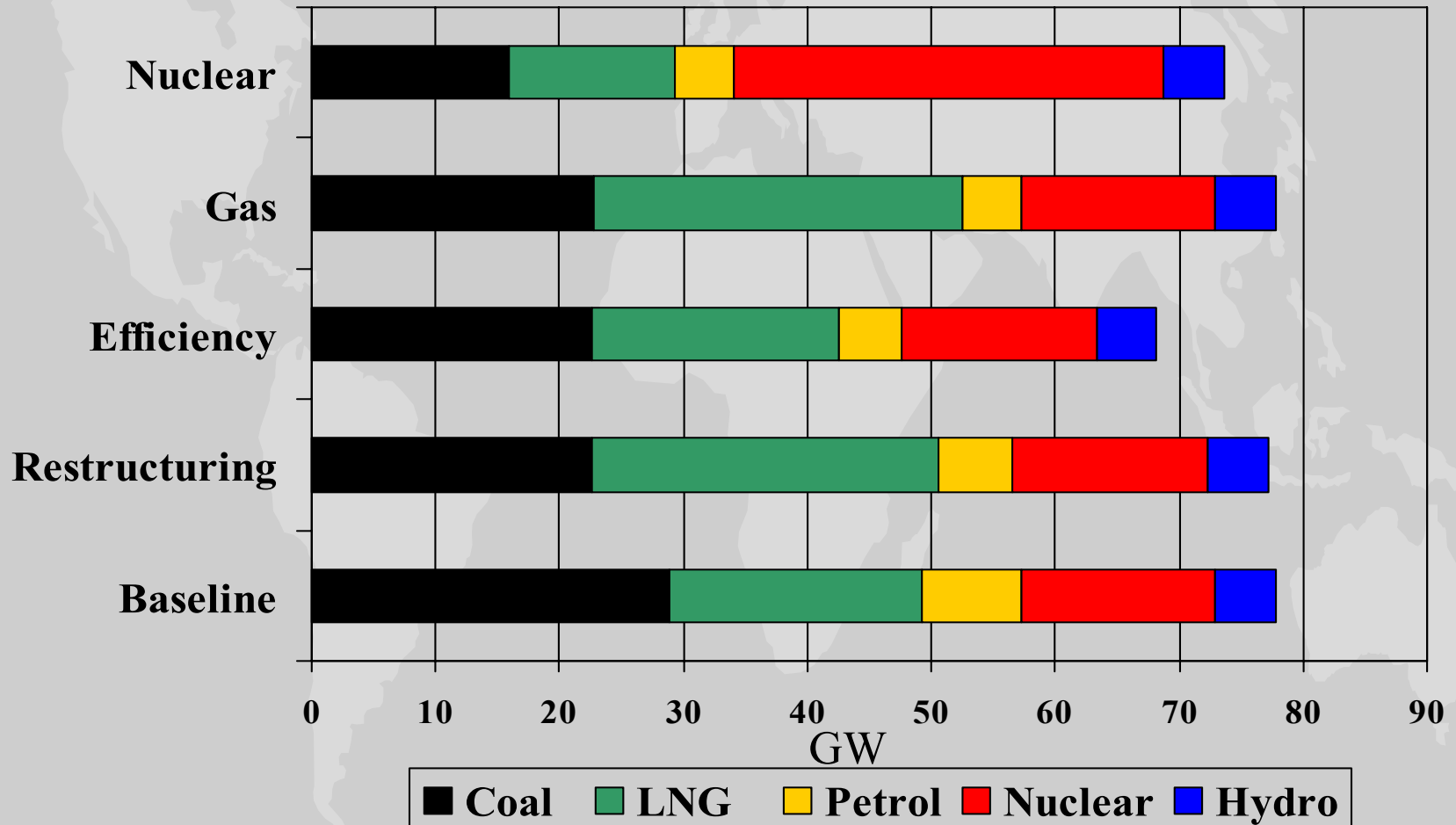
∞ reform

∞ efficiency

∞ natural gas

∞ nuclear

# Scenario Results in Korea, 2015



# Baseline Results for Korea

---

	Units	1995	2015
<b>Generation</b>	TWh	185	430
<b>Capacity</b>	GW	32	78
<b>Cumulative Discounted Cost</b>	Billion \$	--	130
<b>Coal</b>	M tons	21	66
<b>Petrol</b>	M tons	9	7
<b>LNG</b>	M tons	4	12
<b>SO<sub>2</sub></b>	K tons	357	259
<b>CO<sub>2</sub></b>	M tons C	21	51

# Results for India

---

## ◆ Scenarios

↻ reform

↻ efficient technology

↻ sustainable development

↻ growth

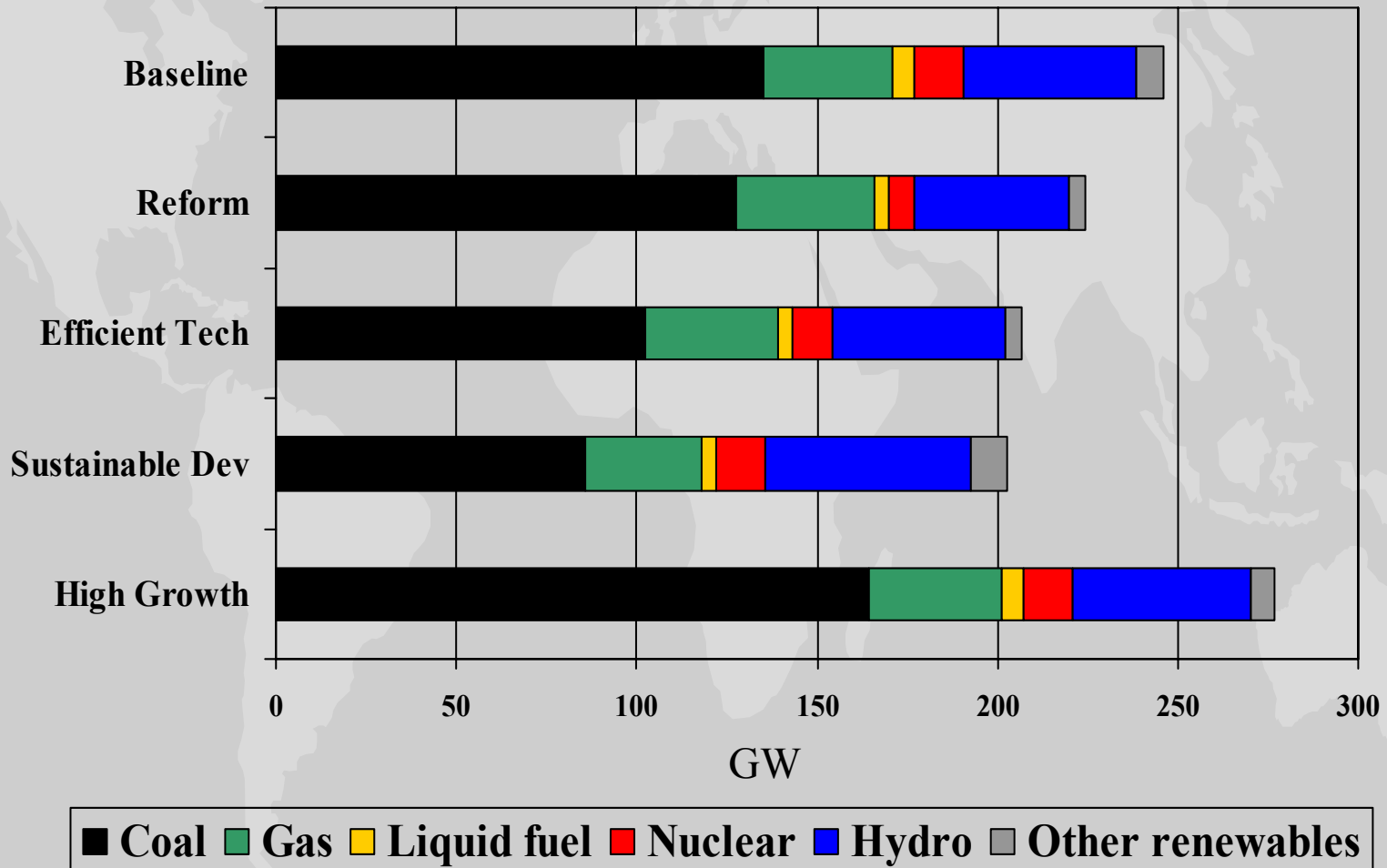
# Scenario Results for India

---

	Cost (\$B)	SO <sub>2</sub> (Mt)	CO <sub>2</sub> (MtC)
Baseline	811	5.9	217
Reform	862	2.6	203
Efficient Technology	749	2.3	168
Sustainable Development	751	2.3	141
High Growth	1,031	1.9	225

Note: Cost includes capital, fuel and O&M for new and existing plants from 1995-2015.

# Scenario Results for India, 2015

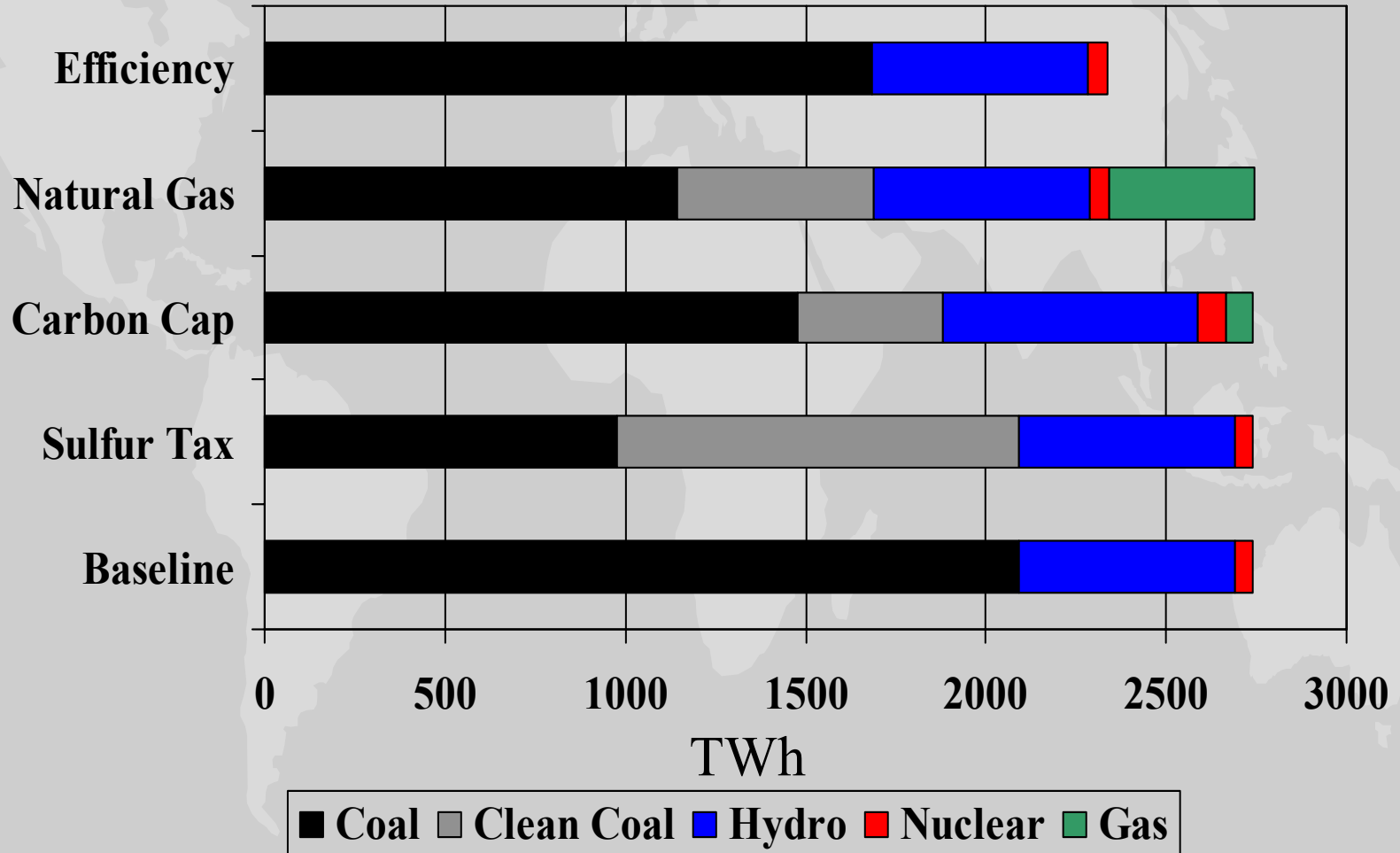


# Results for China

---

- ◆ Scenarios
  - ∞ sulfur tax
  - ∞ carbon cap
  - ∞ natural gas
  - ∞ efficiency

# Scenario Results in China, 2015



# Results for China, 2015

---

	Cost (B\$)	CO <sub>2</sub> (MT-C)	SO <sub>2</sub> (MT)
Baseline	449	491	20
Sulfur Tax	465	477	13
Carbon Cap	532	444	17
Efficiency	394	395	16
Natural Gas	462	422	13

Costs include capital, fuel, and O&M from 1995 to 2015 for new plants only.

# Conclusions

---

- ◆ Multiple Benefits of Efficiency
- ◆ Natural Gas Sector Reform Critical
- ◆ Rapid Economic Growth *Can* Help
- ◆ Restructuring Often Benefits Environment