Energy and Energy Resources: Carbon Dioxide Perspective

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Outline

• A half century of economic growth
• What does a fully developed China look like?
• Strategies for managing carbon dioxide emissions
• Closing thoughts
A half century of economic growth

Per capita GDP (2000 $)

$0 $1,000 $2,000 $3,000 $4,000 $5,000

Year

0 4 8 12 16 20 24 28 32 36 40 44 48
Growth has demanded energy

Primary Energy
Coal dominates energy portfolio

Distribution at end of half century

Primary Energy

- coal
- natural gas
- petroleum
- renewables
“...first take the log out of your own eye, and then you will see clearly to take the speck out of your neighbor’s eye.”

U.S.A. 1850-1900
So what about China?
Primary Energy 1971-2004,
http://www.iea.org
Electricity generation by “fuel”

Coal Reserves–2000

- China: 12%
- U.S.A.: 25%
- Russia: 16%
- Africa: 6%
- India: 9%
- Australia: 8%
- Rest of World: 24%

Graph showing the increase in kWh from 1971 to 2004 with pie charts for different countries and types of energy sources.
Sedimentary Basins of China

Coal Resource/Primary Energy = 2090 years
What does a fully developed China look like from an energy perspective?

"We even see huge brown clouds of sulfur making their way across the ocean... The haze in L.A. is not just from L.A. anymore." Lisa Mastny, Worldwatch Institute project director.

2005: 6000 coal mine fatalities
-12 fatalities per million tons

2006: 4800 coal mine fatalities

Economy and Energy
2005 Statistics

$GDP per capita vs. energy (MJ) per person per year

- China (28 MJ/$GDP)
- Mexico (9.1 MJ/$GDP)
- European Union (5.8 MJ/$GDP)
- Japan (5.2 MJ/$GDP)
- U.S.A. (8.9 MJ/$GDP)
Economy and Energy
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"developed" beginning of industrialization

Ideal path
Projected CO\textsubscript{2} Emissions

“Kaya Identity”

\[
\text{CO}_2 \text{ Emissions} = (\text{Population}) \times (\text{GDP/person}) \times (\text{Energy/GDP}) \times (\text{CO}_2/\text{energy})
\]

- **2025**
  - 1.48 billion people
  - $6800 per capita
  - 8.9 MJ/$GDP
  - 7.5x10\textsuperscript{-8} kgCO\textsubscript{2}/J

- **2050**
  - 1.52 billion people
  - $27,200 per capita
  - 8.9 MJ/$GDP
  - 7.5x10\textsuperscript{-8} kgCO\textsubscript{2}/J
Projected CO₂ Emissions

- Index, USA 2005 = 1
- USA
- China

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<tr>
<th>Year</th>
<th>USA</th>
<th>China</th>
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Strategies for Reducing CO$_2$ Emissions

• Change fuel mix (switch coal to gas)
• Nuclear
• Energy efficiency
• Geological CO$_2$ sequestration
• Renewables
  – hydro
  – wind
  – biogas
Lifecycle CO\textsubscript{2} Emissions from Electricity Generation
Fuel Mix: Petroleum

**World**
- conservative prediction
- best prediction
- actual data

**China**
- Production
- Consumption

- **Million barrels per day**
- **Year**

- **Rate (Bbbl/yr)**
- **Year**

- **1800 1850 1900 1950 2000 2050 2100 2150**
Energy Efficiency

Use Japanese Efficiency of 5 MJ/$GDP, same fuel mix as today

![Bar chart comparing energy efficiency for USA and China in 2005, 2025, and 2050. The index is normalized such that USA 2005 = 1. The chart shows a significant increase in efficiency for China by 2050.]
Geological Storage of CO\textsubscript{2}

Efficiency goes down

<2\% of Emissions to 2050

20-45\% of Emissions to 2050

45\% of Emissions to 2050

90\% of Emissions to 2050

20-500 \% of Emissions to 2050

20-185\% of Emissions to 2050

IEA: Comparative potentials at storage costs of up to $20/t CO\textsubscript{2}


Source: Freund, IEA
Renewable Energy Law

- took effect Jan 1, 2007
- 15% renewable energy by 2020 (2 times current)
- $180 billion investment
- $0.03 per kWhr subsidy
- includes large hydropower

Inner Mongolia

Three Gorges (18,200 MW Projected)
Hydroelectric Potential of China

- 378-540 GW potential = 15-22 times Bonneville Power Administration
- current utilization is about 25%
- by 2020, about 50% utilization
- ~12 power plants on upper Yangtze River
Top Ten Problems of the World
(Richard Smalley 1996 Nobel Laureate in Chemistry)

1. Energy

Some or all of these problems are solved if economic, environmentally acceptable, energy sources are found:

- Water
- Food
- Environment
- Poverty
- Terrorism/war
- Disease
- Education
- Democracy
- Population
Technical Resources

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- Perry-Castañeda Library Map Collection, http://www.lib.utexas.edu/maps/
- Xuemin, C. and Chengchang, Z., “China’s Hydropower and Its Utilization, Geojournal 10(2) 1985, 141-149."