A Global Perspective on Energy Markets and Economic Integration

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.
Over the Near to Medium Term, Oil and Gas Markets Face Many Uncertainties

What will be the effect of

- Iraqi Domestic instability on Iraqi oil production
- Negotiations surrounding Iranian nuclear technology on Iranian oil supplies
- Saudi commitment to expanded oil production
- President Putin’s policies on Russian oil and natural gas supplies
- President Chavez’s policies on Venezuelan oil supplies
- Higher oil prices on world economic growth
  - Effect of economic growth on oil demand in China, India, U.S., etc.
- Higher oil prices on non-OPEC oil supplies
- Katrina’s impact on crude and refined products
Over the Longer Term, World Energy Demand and Carbon Emissions will Grow Over 40 Percent

Energy Demand

Carbon Dioxide Emissions

and Developing Countries will Account for 70 % of the Increase

Source: USDOE EIA IEO 2004 Reference Case
The Climate Change Policy Problem is Enormous

- The theoretical climate change relationship is between atmospheric concentrations of GHG and climate change, not annual emissions.

- According to the Intergovernmental Panel on Climate Change, stabilizing atmospheric concentration of GHG at current levels would require permanent emissions reductions of 60% or more below current levels.
  - Kyoto Protocols: Industrialized countries agreed to reduce emissions, on average, 5.2% from 1990 levels by 2008-2012.
Current Fossil Alternatives are Hydro/Renewables and Nuclear, with Carbon Sequestration being Explored

World Energy Demand

Source: USDOE EIA IEO 2004 Reference Case
Carbon Sequestration Technologies will Add Costs to Fossil Fuels

Capture Cost Ranges

$25/Ton CO2 = About $13/bbl Oil

CO2 Seq. < $3/Ton CO2 (2015) USDOE Program Target

Sources: Heddle et al., 2003.
Over the Longer Term, Electricity Demand will Grow Almost 60%

and Developing Countries will Account for 2/3 of the Increase

Source: USDOE EIA IEO 2004 Reference Case
Current Renewable Electricity is Largely Hydro

Source: Renewable Information 2002, IEA
Nuclear Contributes to Electric Power in Many Countries

Percent Share

(Source: WNA, 2004)
New Nuclear Electricity Plants are Cost Competitive in US, Depending on Capital Cost and Perceived Risk
## World Conventional Proved Fossil Fuel Reserves are Geographically Concentrated

### (Percent Share)

<table>
<thead>
<tr>
<th>Region</th>
<th>Oil</th>
<th>Gas</th>
<th>Coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key P.G.</td>
<td>64</td>
<td>40</td>
<td>*</td>
</tr>
<tr>
<td>Saudi</td>
<td>25</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Iraq</td>
<td>11</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Iran</td>
<td>10</td>
<td>15</td>
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<td>Kuwait</td>
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<td>1</td>
<td>0</td>
</tr>
<tr>
<td>UAE</td>
<td>6</td>
<td>3</td>
<td>0</td>
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<tr>
<td>Qatar</td>
<td>2</td>
<td>15</td>
<td>0</td>
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<tr>
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<td>6</td>
<td>28</td>
<td>16</td>
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<tr>
<td>Venezuela</td>
<td>5</td>
<td>2</td>
<td>*</td>
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<tr>
<td>China</td>
<td>2</td>
<td>1</td>
<td>12</td>
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<tr>
<td>U.S.</td>
<td>2</td>
<td>3</td>
<td>25</td>
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<tr>
<td>India</td>
<td>*</td>
<td>*</td>
<td>9</td>
</tr>
<tr>
<td>ROW</td>
<td>21</td>
<td>26</td>
<td>38</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: EIA 2003. Excludes Oil Sands. * Less than 0.4 %
A Wide Range of Prospects for Alternative Liquid Fuels, But Will Take Time to Develop
National Economies are Becoming Increasingly Intertwined

Trade in Goods (% of GDP)

Gross Private Capital Flows (% of GDP)

So Are Manufacturing Processes

**All Over the Map**

When a U.S. customer orders an HP Pavilion laptop, the request travels all the way to China in just days. A look at the process, and China’s increasing role not just as manufacturer, but supplier of more sophisticated laptop parts.

**Outsourcing ratio for world’s top laptop PC brands, 2004:**

- Dell: 100%
- Apple: 100%
- Gateway: 100%
- Acer: 100%
- H-P: 95%
- NEC: 50%
- Sony: 50%
- IBM: 40%
- Toshiba: 35%

*Dell takes care of final assembly in its factories.

Source: Merrill Lynch

**Worldwide laptop PC production by country, 2005:**

- China: 68%
- Japan: 17%
- Taiwan: 8%
- Others: 5%
- Korea, U.S.: 1%

Source: IDC

**Filling the order**

1. Order placed online in the U.S.
2. Validated order transmitted to Taiwanese-owned Quanta plant in Shanghai.
3. Laptop assembled from parts from China and all over the world.
4. Computer shipments consolidated at Shanghai airport and flown freight to the U.S.
5. Individual laptops sent to customers.

**Putting it together**

- **Hard disk drives:** Japan, China, Singapore, U.S.
- **Power supplies:** China
- **Magnesium casings:** China
- **Memory chips:** S. Korea, Taiwan, U.S., Germany
- **Liquid-crystal display:** S. Korea, Taiwan, Japan, China
- **Microprocessors:** United States
- **Graphics processors:** Designed in U.S., Canada; made in Taiwan

Note: List does not include every country that manufactures a given part.

Sources: Hewlett-Packard; IDG research

And Even Universities

Study Abroad - Singapore has courted top-tier schools:

• **1998: French business school INSEAD**
  – Offers MBA, executive education

• **2000: University of Chicago**
  – Graduate School of Business opens a Singapore campus

• **2003: Johns Hopkins Singapore**
  – Operates as a full division of the university

• **2003: Duke**
  – Medical school agrees to open a school at the National University of Singapore

• **2005: MIT**
  – Grants engineering master’s degrees in a joint venture with two Singaporean universities

And this Trend Toward Interdependency will Accelerate

- The Internet and silicon revolution will continue to break down communication and economic barriers
  - Greater numbers of countries will participate in the world economy and financial markets
  - Integrated supply chain logistics of service & manufacturing industries will seamlessly cross national borders
    - As will distance education and technology transfer
- Both global economic competition and global economic cooperation will intensify
And this Trend Toward Interdependency will Accelerate (continued)

• Scope for national public policies with major economic impact will become more limited
  – Can’t afford to have costs out of line with competitor countries
  – Growing need to send domestic energy consumers and producers consistent market signals, and to integrate domestic energy security, environmental and economic objectives and polices
  – Driven toward greater policy and regulatory harmonization (lowest common denominator?)
And this Trend Toward Interdependency will Accelerate (continued)

- Supply and demand shocks will be transmitted more rapidly

Country  ➔ Global Market  ➔ Country

- Science and technology developments will accelerate and transcend high tech national borders
  - But they are unlikely to “solve” energy and environmental problems any time soon
Some Governments and Car Companies are Aiming for a Hydrogen Economy

- **Hydrogen may solve many problems:**
  - Lowered, or even zero, carbon emissions
  - Energy security
  - Limited fossil fuels and uneven distribution

- **Many hurdles to overcome:**
  - Lifetime of fuel cell
  - Economic hydrogen production
  - Lack of hydrogen infrastructure
  - Sequestration of carbon if hydrogen derived from fossil fuels
  - Unlikely to be cost competitive until at least mid 2020s

Source: Fuelcell.org
Source: GM
Over Several Decades, Advanced Energy Technologies Could “Disrupt” The Current System

- Nanotechnology has the potential to fundamentally change energy supply and demand

- Examples:
  - Solid State Lighting Using “Quantum Dots” could cut power for lighting use by 50%
  - Ultra-high strength lightweight nanophase materials could improve car, airplane efficiency
  - Nanoparticles and Nanoarchitectures for Energy Conversion and Storage may offer solutions to low cost fuel cells and batteries.
Conclusions

• Over the nearer term
  – Many uncertainties in oil and natural gas markets remain

• Over the longer term
  – The world economy and its energy markets will become increasingly integrated and interdependent
  – Energy use and carbon emissions will grow substantially, driven by the developing world, and mostly fueled by fossil energy
  – The potential for oil and natural gas supply shocks will grow, as will the economic transmission of those shocks
  – Oil and natural gas price instability will increase
  – Major new energy technology platforms that transform economies and energy could emerge
Conclusions (continued)

• At the same time
  – Both economic competition and cooperation will intensify
  – Scope for national public policies with major economic impact will become increasingly limited
  – Need for clear domestic consumer-producer energy price signals and consistent energy security, environmental and economic objectives and policies will grow
  – Pressure for policy and regulatory harmonization will increase, as will requirements for decision-making speed, and the cost of mistakes will grow
Conclusions (continued)

- International flexibility, cooperation and partnering on many fronts, including public policy and science & technology investment, will be critical to
  - Avoid bumps in the road
  - Support national political economic security
  - Improve the health and well being of the developing world
  - Provide a foundation for global and regional prosperity and environmental sustainability