Oil and Gas Markets: Pricing and Potential Interactions with Economic Activity

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All views expressed are those of the author and should not be construed to reflect the policies or views of the United States Department of Energy, the National Energy Technology Laboratory, or Argonne National Laboratory.
Overview

- History
- Recent trends
- Current situation
- Future energy sources
- Economic impacts
US Energy Consumption by Fuel: 1949-2025

Source: EIA; 1948-2003: Annual Energy Review 2003, Table 1.3; 2004-2025: Annual Energy Outlook 2005, Tables 1, 2, and 17, Peter Balash
Scale of Challenge

Vehicle Stock Increases 63%

Source: AMIGA Reference Run

Millions of Vehicles

- Small Car
- Large Car
- Conv. SUV
- Large SUV
- HEVs
Pressure Comes from Growing Demand for Oil

Traffic in Shanghai
West Texas Intermediate, NYMEX Front-month, $2004

Saudi-Led Price Collapse

“Cheap Oil” and Technology

OPEC Discipline

Competitive Level?

Saudi-Venezuela Price-War

Iraq War, China, Yukos, Nigeria, etc.

9/11 Economic Shock

Sources: EIA, BEA (GDP Deflator), Peter Balash
Real Gasoline Pump Price: Annual Average 1919-2005

All-time US Peak $2.83
1981

Downward Trend Until 1999
Refining Economies

Average Price
10 May '04:
$1.94

Source: EIA Short-Term Energy Outlook, Peter Balash
US Petroleum Trends, 1949-2004

Note: Figures include crude oil, natural gas liquids, merchant oxygenates, and imported petroleum products. Source: EIA, AER 2003, Table 5.1 Petroleum Overview, 1949-2003; Petroleum Supply Monthly, January 2005, Table S1, Peter Balash
N. Gas Prices in All Regions Have Been Trending Upward

- Areas with constrained pipeline supply, i.e., New York City, see higher spikes in times of volatility.

- Chicago is well supplied by the Gulf Region and Canada so its gas price closely tracks Henry hub.

- In recent years, the West Coast Market has been also following Henry hub prices.

- So far this November over the U.S., it has been warmer than usual, taking some pressure off gas prices.
Average Monthly Spot Gas Prices

$/mmBtu

Source, EIA, Natural Gas Weekly Update, April 2002-November 2005, Peter Balash calc.
Natural Gas Prices Linked to Oil

- Natural gas normally trades between the price of diesel-fuel/heating-oil and the price of residual oil.
  - On the low end, gas and resid compete as boiler fuel
  - On the high end, gas and distillate compete for use in combustion turbines for peak-load power generation
  - Gas and heating oil also compete for space heating in buildings

- This is a relatively narrow trading band because residual oil is no longer dumped on the market at low prices. Instead refiners upgrade resid to lighter products with catalytic cracking, hydrotreating, and/or thermal coking.
Natural Gas Prices Linked to Oil (cont.)

- The world price of crude oil has had a large effect on gas prices

- Oil prices are unlikely to fall much in the next few years; thus gas will almost certainly remain above $6.00 / mmBtu, and probably over $7.00 / mmBtu
Daily Gas Trading Range, Gulf Coast

Source, EIA, Natural Gas Weekly Update, April 2002-November 2005, daily spot prices. EIA, Petroleum Marketing Monthly online tables, Peter Balash
The Elasticity of Demand in the Short-Run seems to be Small.

- When supplies are constrained going into New York, prices have spiked very high.
- Dual infrastructure and dual-fuel capability have decreased since the “energy crisis” of the 1970’s
- Equipment permitting by EPA has also limited switching from gas to oil, even when oil is cheaper
- In recent weeks, with the hurricane shut-in production, some natural gas combined cycle (NGCC) generators in New York have been running on diesel fuel
Daily Gas Trading Range, New York City-gate

Source, EIA, Natural Gas Weekly Update, April 2002-November 2005, daily spot prices. EIA, Petroleum Marketing Monthly online tables, Peter Balash
Longer Term Natural Gas and Oil Price Behavior

WTI Cushing (mmBtu basis) v Henry Hub, Real Spot Prices

NGCC power plant boom; Approach of LNG?
18-month comprehensive assessment of North American supply & demand

Broad industry participation

Revised 2015 production estimate downward by 7.5 tcf or 22% compared to NPC’s 1999 Study

North America may provide only 75% of long-term US needs

Import Dependence/Price tradeoff
Natural Gas Prices, Rig Count, and Production

Rig count responds to recent price increases;

Since trough in 2Q2002, 81% increase in drilling;
Gas rigs at record levels;

production FLAT
(EIA: slight decline)

2-qtr lag between price and rig count

Source: Prices, Production, EIA, *Natural Gas Monthly*; Rigs, *Baker Hughes Rig Count*, Peter Balash
The Rise of Supplementary Energy Sources

- Resources becoming more dear
  - Light sweet crude oil
    - *West Texas Intermediate*
    - *North Sea Brent*
  - Natural Gas

- Resources likely to grow in importance
  - Nonconventional oil
  - Liquefied Natural Gas (LNG)
  - Coal-based co-production of electricity and liquid fuels
  - Large wind turbines
  - Distributed smaller wind generators
  - Biomass, eventually cellulostic (woody, high fiber)
  - Solar collectors with rapid advances in photovoltaics (PV)
  - Geothermal & heat pumps
  - End-use efficiency and conservation
Seismic Visualization of Resource Deposits
Horizontal Drilling Finds More Oil and Gas at Lower Cost
Heavier Crude Oils Accounted for Import Growth

Approximate Quality Mix of U.S. Crude Oil Imports

Source: EIA
Modeling Petroleum Refining with a Long-term Energy and Technology Focus

- Importance of estimating conversion impacts
  - Trends in crude oil gravity and sulfur content as light, sweet crude becomes relatively less abundant
  - Greater conversion process investments and associated energy consumption and emissions

- Supply constraints on gasoline vs. diesel mix in LDV stocks

- Future refinery complex as advanced technology incubator
  - Advanced gasification with multiple feedstocks
  - Coproduction, including use of byproduct steam in the refinery
  - Carbon capture from Fischer-Tropsch synthesis
  - Relatively familiar refinery management and technical staff

- Canadian Oil Sands Extraction and Upgrading
  - Large and growing consumer of Natural Gas
  - May substitute hydrocracking and coal gasification for electricity, heat, and hydrogen production
Overview of the MARS Model and Refinery Products

Crude Distillation

Light Liquids

Kerosene (Jet Fuel)

Distillate Hydrotreaters

Gasoline

Low Sulfur Diesel and Distillate Fuel Oil

Concentration Processes

Residual Fuel Oil

Asphalt

Fuel Grade Coke

Liquefied Petroleum Gas (LPG)

Crude oils by type

gas oil and heavy ends

Light gases
Process Detail on the Components of Gasoline

Crude Distillation

- n-butane
- light straight run
- naphtha
- other

C4 Isomerization

- isobutane
- olefins from catalytic cracking

C3/C4 Alkylation

- bottoms

C5/C6 Isomerization

Naphtha Hydrotreater

Dehexanizer

Low-Pressure Catalytic Reformer

Gasoline

from catalytic cracking, hydrocracking, and thermal cracking of heavier oils

gasoline bottoms from catalytic cracking, hydrocracking, and thermal cracking of heavier oils
Heavy Oil Conversion to Lighter Products

- Atmospheric Crude Distillation
  - LPG
  - Naphtha
  - Kerosene
  - Distillate
- Vacuum Crude Distillation
  - LVGO
  - HVGO
  - VRC
- Desulfurization
- Gas Oil Hydrotreater
  - Atmospheric Gas Oil
- Fluidized Catalytic Cracker
  - HCC Naphtha
  - LCC Naphtha
  - CC Distillate
  - CC Slurry Oil to Resid Oil
- Hydrocracker
  - HC Kerosene
  - HC Distillate
- Coker
  - Coker Distillate
  - Coker Naphtha
  - Pet Coke
- CC Gasoline Desulfurization
- CC Distillate
- CC Naphtha
- LCC Naphtha
- CC Slurry Oil to Resid Oil
- HC Kerosene
- HC Distillate
- Coker Distillate
- Coker Naphtha
- Pet Coke
Petroleum Market Equilibrium: Product Prices, Crude Quantities, Investments

Marginal Cost Functions for Resources

Production by Crude Type

Derived Demand for Crude Inputs

Willingness to pay by crude type

Refiner

- Cash flow
- Profit rate $\pi$
- Relative value of crude oils (rents)
- Refining costs by crude type
- Yields
- Investments by type to meet capacity needs Should earn a return $\pi$

Prices (solve)

- Product spreads
- Level

Consumer

Derived Demand for Crude Inputs

Interface with rest of economy and environment
Economies of Scale Drive Down Wind Cost

20 Years of Wind Technology Development

<table>
<thead>
<tr>
<th>Year</th>
<th>Rotor (meters)</th>
<th>kW</th>
<th>Total Cost</th>
<th>Cost/kW</th>
<th>MWhr</th>
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<tbody>
<tr>
<td>1981</td>
<td>10</td>
<td>25</td>
<td>$65</td>
<td>$2,600</td>
<td>45</td>
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<tr>
<td>1985</td>
<td>17</td>
<td>100</td>
<td>$165</td>
<td>$1,650</td>
<td>220</td>
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<tr>
<td>1990</td>
<td>27</td>
<td>225</td>
<td>$300</td>
<td>$1,333</td>
<td>550</td>
</tr>
<tr>
<td>1996</td>
<td>40</td>
<td>550</td>
<td>$580</td>
<td>$1,054</td>
<td>1,480</td>
</tr>
<tr>
<td>1999</td>
<td>50</td>
<td>750</td>
<td>$730</td>
<td>$973</td>
<td>2,200</td>
</tr>
<tr>
<td>2002</td>
<td>70</td>
<td>1,500</td>
<td>$1,100</td>
<td>$733</td>
<td>5,600</td>
</tr>
<tr>
<td>2005</td>
<td>80-85</td>
<td>&gt;2,000</td>
<td></td>
<td></td>
<td></td>
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</table>

Bottom Line: 1981-1999 = 49x the power, 11x the cost;
1999-2000 = 2.6x the power, 1.8x the cost
Source: GE Wind Energy
Wind Resource Colors: Brown = Marginal, Yellow = Fair, Pink = Good, Purple = Excellent

United States - Wind Resource Map

Wind Power Classification

<table>
<thead>
<tr>
<th>Wind Power Class</th>
<th>Resource Potential (W/m²)</th>
<th>Wind Power Density at 50 m (W/m²)</th>
<th>Wind Speed at 50 m (m/s)</th>
<th>Wind Speed at 50 m (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 Marginal</td>
<td>200 - 300</td>
<td>5.6 - 6.4</td>
<td>12.5 - 14.3</td>
<td></td>
</tr>
<tr>
<td>3 Fair</td>
<td>300 - 400</td>
<td>6.4 - 7.0</td>
<td>14.3 - 15.7</td>
<td></td>
</tr>
<tr>
<td>4 Good</td>
<td>400 - 500</td>
<td>7.0 - 7.5</td>
<td>15.7 - 16.8</td>
<td></td>
</tr>
<tr>
<td>6 Excellent</td>
<td>600 - 800</td>
<td>7.5 - 8.0</td>
<td>16.8 - 17.9</td>
<td></td>
</tr>
<tr>
<td>9 Outstanding</td>
<td>800 - 1000</td>
<td>8.0 - 8.8</td>
<td>17.9 - 19.7</td>
<td></td>
</tr>
<tr>
<td>9 Superb</td>
<td>1000 - 1600</td>
<td>8.8 - 11.1</td>
<td>19.7 - 24.8</td>
<td></td>
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</table>

*Wind speeds are based on a Weibull k value of 2.0


U.S. Department of Energy
National Renewable Energy Laboratory
Roughly One Billion People in Developed World; Three Billion rapidly Developing; Two Billion Lagging
Change in LNG Trade Flows in 2015

- **Gain**
  - Trinidad: 2.3 Tcf
  - SE Asia: 5.7 Tcf

- **Loss**
  - Australia: 0.5 Tcf

Source: CRA
Economic Drag from Energy

■ Expenditures
  – Expenditures on energy is the sum for all forms of energy of quantity purchased times price
  – Expend = P x Q
  – For oil, price has gone up and the quantity imported continues to grow
  – For natural gas, the same trend may also occur with LNG (history repeating itself with a natural gas OPEC?)

■ Economic Impact
  – Oil and gas import bill will rise
  – This cash flow overseas, primarily to the Middle East, lowers U.S. income available for consumer goods, investments, and defense
  – Consumers have chosen to consume more and save less
  – Hence, less investment in capital equipment and in education will lead to a slower rate of economic growth
Conclusion

- We need a portfolio of energy sources to diversify risks and to be prepared for future developments

- We need more effective end-use efficiency and conservation

- We need more efficient vehicles, as major consumers of petroleum

- Plug-in vehicles could supplement oil supplies, especially if more grid electricity came from renewable sources like wind generators (car batteries are an ideal storage tank for intermittent renewable generation)