Oil & Gas Production
The Future is Bright

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Where I Am Coming From:

- Oil & Gas Background
  - Geologist & Geophysicist
  - Enhanced Recovery
  - Technological Approach
- Energy is the Basis of Civilization
- Resource is Adequate
  - Insufficient Investment
  - Geopolitical Questions
- Can Provide Energy & Protect the Environment
- Hydrocarbons Are Our Major Energy Source Through the Middle of this Century

"Yo! Everyone down there! This is the Jackal! I'm tired of slinking around in the shadows! I'm coming down to the kill! Is that gonna be cool with everyone?...I don't want trouble!"
A Barrel of Crude Provides:

- Gasoline: 19.5 gallons
- Fuel Oil: 9.2 gallons
- Jet Fuel: 4.1 gallons
- Asphalt: 2.3 gallons
- Kerosene: 0.2 gallons
- Lubricants: 0.5 gallons
- Petrochemicals, other products: 6.2 gallons

One Barrel = 42 gallons

American Petroleum Institute, 1999
In 2004
Economic Growth at 15 Year High
China’s Oil Consumption is increased 15%, 900,000 b/d
World Oil Consumption Increased 2.5 million b/d

- Resource
  - Forecast and Price Trends
  - Changes in H/C Ratio
  - Future is NOT a Bell Curve
  - Future Production Requires Investment
    - 50% Per Decade

- Technology and People
  - Investment

- Geopolitics (Access)

- Environment
U.S. Primary Energy Consumption by Fuel, 1960-2030
(quadrillion Btu)

History Projections

Annual Energy Outlook 2006
U.S. Primary Energy Consumption by Fuel, 1960-2030
(Billions of Barrels of Oil Equivalent)

- Coal
- Natural Gas
- Petroleum
- Nuclear
- Renewables

History Projections

Annual Energy Outlook 2006
An Energy Dependent Civilization

Drivers

- Steam
- Steam locomotive
- Power stations
- Internal combustion engine
- Air travel
- Population growth
- Global markets
- Living standards
- Nuclear
- Internet
- Micro-processor
- Satellite
- WWII
- WWI
- Energy issues
- Telecommunications

Modifiers

- Coal
- Hydrocarbons
- Energy Usage

Cook and Sheath, 1997
RATIO OF HYDROGEN (H) TO CARBON (C) FOR GLOBAL PRIMARY ENERGY CONSUMPTION SINCE 1860 & PROJECTIONS FOR THE FUTURE

- Methane: H/C = 4
- Oil: H/C = 2
- Coal: H/C = 1
- Wood: H/C = 0.1

Ausbetel (1996)

Year

1800 1850 1900 1950 2000 2050 2100 2150

Δt = 300 years (length of process)

1935 (midpoint of process)
Geologically-determined peak could have consequences up to and including “war, starvation, economic recession, even the extinction of homo sapiens” (Campbell in Ruppert 2002).

“Civilization as we know it is coming to an end soon. This is not the wacky proclamation of a doomsday cult, apocalypse bible prophecy sect, or conspiracy theory society. Rather, it is the scientific conclusion of the best paid, most widely-respected geologists, physicists and investment bankers in the world.”
A successful oilman remarked
“I would never hire an exploration geologist who is not an optimist, or a petroleum engineer who is not a pessimist.”

“There are 195 deepwater fields slated for development from 2005 to 2009 with a total of 37,279 MMBOE”

“If past history was all there as … the richest people would be librarians” (Warren Buffet)
Projected World Energy Supplies

![Projected World Energy Supplies graph](image)

**World Energy Demand**

- **Crude Oil**: Decreasing
- **Natural Gas**: Increasing
- **Coal**: Decreasing
- **Nuclear Electric**: Increasing
- **Solar Wind Geothermal**: Increasing
- **Hydroelectric**: Increasing

**New Technologies**

- Decreasing Fossil Fuels

*after Edwards, AAPG 8/97*
Supply & Technology

US Proved Reserves

Trillion Cubic Feet (Tcf)

EIA, 2005
Proved oil reserves at end 2004

Thousand million barrels

Middle East 733.9

Asia Pacific 41.1
North America 61.0
S. & Cent. America 101.2
Africa 112.2
Europe & Eurasia 139.2
Oil Reserves-to-Production (R/P) Ratios

The world's oil reserves-to-production ratio fell to 40.5 years in 2004, down from 43.3 in 2002. Reserves have continued to increase and now stand 17% above the 1994 level; production is 20% higher.

BP Statistical Review of Energy, 2005
Proved natural gas reserves at end 2004

Trillion cubic metres

Europe & Eurasia 64.02
Middle East 72.83

S. & Cent. America 7.10
North America 7.32
Africa 14.06
Asia Pacific 14.21
Natural Gas Reserves-to-Production

The world's gas reserves-to-production (R/P) ratio declined to 66.7 years in 2004, but remains well above the oil R/P ratio. Gas reserves are 26% higher than the 1994 level; production is 28% higher.

BP Statistical Review of Energy, 2005
Catch – About 50% of the daily volume in 10 years is not online. At present, requires approximately $100 billion a year.
World refinery throughputs increased sharply in 2004 in response to very strong demand growth. The largest increases were in Asia Pacific, Europe and Eurasia, and South and Central America. As a result, global average refinery utilization increased to 87%, the highest level for at least 25 years.
Today, 1.6 billion people – one quarter of the world population have no access to electricity.

In 2030, 1.4 billion people 17% of the world population will still not have electricity.

2.4 billion people rely on traditional biomass – wood, agricultural residues and dung – for cooking and heating.

- Evolution of Technology
- Available Expertise
- Geopolitics
  - Access
  - Investment Climate
- Price
Technical Challenges

WHO estimates that 2.5 million women and young children die prematurely each year from fumes from biomass stoves. Shifting to LPG reduces health risk by > 100

In sub-Saharan Africa only half the population has access to an improved water source (energy for pumps and purification)

In India, up to seven hours a day are devoted to collecting fuel for cooking.
Energy Production is High-Tech Science

- Multiple Discipline Professionals evaluate “Mountains” of data to maximize reservoir recovery.
- The extraction process is based primarily on:
  - management of the pressure and fluids
  - placement of wells to maximize efficiency.
- Historically,
  - Traditional “pumping” technologies extracted 20 percent of hydrocarbons in a reservoir
  - New Computer Models and technologies improve recovery to greater than 35 percent (75% Goal).
- This Science Continues to Improve with new breakthroughs
### Petroleum Technology Breakthroughs

<table>
<thead>
<tr>
<th>Year</th>
<th>Technology</th>
<th>Description</th>
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<tbody>
<tr>
<td>1883</td>
<td>Anticlinal Theory</td>
<td>Concept of ‘Where-to-Drill’</td>
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<tr>
<td>1900s</td>
<td>Rotary Drilling</td>
<td>Drill deeper</td>
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<tr>
<td>1914</td>
<td>Seismograph</td>
<td>1D Subsurface imaging</td>
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<tr>
<td>1924</td>
<td>Well Logging</td>
<td>Subsurface rock and fluid properties</td>
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<tr>
<td>1930s</td>
<td>Offshore Drilling</td>
<td>Access to new areas and basins</td>
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<tr>
<td>1960s</td>
<td>Digital Computer</td>
<td>2D Subsurface imaging data</td>
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<tr>
<td>1970s</td>
<td>Directional Drilling</td>
<td>Cost efficient reservoir management</td>
</tr>
<tr>
<td>1980s</td>
<td>3D Seismic</td>
<td>More precise subsurface imaging</td>
</tr>
<tr>
<td>1990s</td>
<td>3D Simulation</td>
<td>Predicting fluid movement</td>
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<tr>
<td></td>
<td>4-D Seismic</td>
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<tr>
<td>1990-2000s</td>
<td>Reservoir Creation</td>
<td>Heavy Oil (SAGD), Tight Gas, Shale Gas, Coalbed Methane, CO2 Flooding</td>
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<tr>
<td>2000s</td>
<td>Immersive Image Viewing / Network</td>
<td>Multi-discipline collaboration, Improved time to decision, success rate, risk assessment, ROI</td>
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Data Models for Energy Recovery

- Data Models are collected utilizing seismic readings.
- Computer Models are put in place to view these readings in a 3D Model.
- Data is collected over time intervals for a 4D view of the data and changes over time.
- Data sets are in Terabyte range with future projections in Petabyte range as information improves.
Key Technologies

3D Seismic, Computer Assisted Exploration

Deep-water, Sub-sea, FPSO

Horizontal Drilling, Geosteering, & Rotary Steering Systems

Source: Bates, 2002, GCAGS
Baker Hughes
Ultra-Deep Water

SUNK COSTS
A single floating production platform can take in oil from wells scattered across miles of sea floor. High-tech monitoring devices keep everything flowing.
Oil Sands - In Situ Deposits

- 80% of resource in situ
- too deep to mine
- current in situ production of 325,000 b/d bitumen + diluent for pipeline
- new technology developments:
  - cyclic steam stimulation
  - Steam Assisted Gravity drainage (SAGD)
  - VAPEX, MSAR

Source: PetroCanada
Oil Sand Cost Trends

**Fig. 7**

*How Canadian Oil Sands Costs Are Declining*

Revolutionary

Evolutionary

Source: Syncrude Ltd.

Environmental Impact
Tarr Farm, Pennsylvania

Same View in 1991
Atmospheric Concentration of CO\textsubscript{2}

1000 Year History

How much of change is natural versus mankind’s use of fossil fuels?

Cook and Sheath, 1997
Figure 1. Regional Carbon Emissions - Reference Case

Economic Model Projections of Global CO$_2$ Emissions (No Kyoto)
Geopolitics and Atlantic Gas Access

St. John’s

Anticosti Basin

Magdalen Basin

Halifax

Deep Panuke

SOEI ~ 500 MMcf/d

Scotian Basin

400 MMcf/d – 2005

Boston
Geopolitical Decision: Restricted Access to Gas Resource Base

Approximately 29 trillion cubic feet (TCF) of the Rockies gas resources are closed to development and 108 TCF are available with restrictions.
Urban Legends (Energy)

- Conventional oil & gas near a peak
- Tar sands and other unconventional resources are too dirty or costly to be produced
- Energy output from ethanol is negative
- Environmental impact from oil and gas production and use cannot be mitigated
- Easy oil is gone, costs are rising
- Geologists are young and handsome
“... you must in the first place realize this that the world has now grown old and does not abide in that strength in which it formerly stood. ... Less and less marble is quarried out of the mountains, and veins of gold and silver are dwindling day by day...... So no one should wonder nowadays that everything begins to fail, since the whole world is failing, and is about to die.”

St. Augustine
3th Century

Quoted in: St. Augustine
Rebecca West, 1933, p.159