The SPE Distinguished Lecturer Program is funded principally through a grant from the **SPE Foundation**.

The society gratefully acknowledges the companies that support this program by allowing their professionals to participate as lecturers.

Special thanks to the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) for its contribution to the program.

Society of Petroleum Engineers
Distinguished Lecturer Program
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The Role of Oil and Gas in the Energy Mix of the Next 100 Years
Shifts in Demand, Supply and Utilization of Energy

Wolfgang E. Schollnberger
Independent Business Adviser

2009-2010

Society of Petroleum Engineers Distinguished Lecturer Program
www.spe.org/dl
References


References (cont’d)

Scope of Lecture

• Demand, Supply and Peak Oil

• Price

• Security of Energy Supply

• Climate Change

• Energy Mix of the Future

• Conclusions
Energy Spectrum 1945 to 2004

Schollnberger, 2006
Relentless Growth - Small Dents
Explanation of Events Slowing Global Energy Consumption
(1-8 in Slide 3)

• 1: 1953 Change of Government in Iran
• 2: 1956 Suez Canal Crisis
• 3: Early 1960s World Coal Crisis
• 4: 1967 Arab-Israel War; Suez Canal closed until 1975
• 5: 1973 War between Egypt/Syria and Israel
• 6: 1979 Change of Government in Iran
• 7: 1990-1991 First Gulf War; Disintegration of Soviet Union
• 8: 1997-1998 Asian and Russian Banking Crises
Demand and Supply, Peak Oil
Coal, Oil, and Natural Gas Will Remain Indispensable

1980
288 QUADRILLION BTU

2004
445 QUADRILLION BTU

2030
678 QUADRILLION BTU

NATURAL GAS
OIL
COAL
WIND / SOLAR / GEOTHERMAL
HYDRO
NUCLEAR
BIOMASS

Source: IEA REFERENCE CASE

Global Oil and Gas Study
Traffic in Beijing

Beijing, known for its traffic, banned about a third of the more than 3 million cars normally on its streets in a test run for the 2008 Olympics.

Chinese Media Told to Play Up Positives of Traffic Test

Washington Post, 2007
Shanghai is constantly building and rebuilding to accommodate its growing population, which stands at about 20 million. Some 10,000 high-rises have been built in the past 25 years, and there is no end in sight.

Washington Post, 2007
Hubbert’s Method and World Oil Production

• Some use Hubbert’s Method to predict volume and timing of global oil production

• They fail on both accounts
World Oil Production

Doesn’t look like a Hubbert Curve

Schollnberger, 2007
Access Determines Supply

Source: Schlumberger
Better Subsurface Illumination
Turbidite Reservoirs, West Africa

Source: BP
Figure 2b. Relatively low relief salt cored anticlinal structures in Walker Ridge.

Meyer, Zane, Yun 2007
Deeper Drilling

Schollnberger, 1998
Deeper Drilling and Producing

Taking the plunge
Maximum operational depth of offshore fields*, km

Auger  Mars  Ursa  Hoover/ Diana  Horn Mountain  Devils Tower  Atlantis  Independence Hub  BW Peace  Perdido


Source: Mustang Engineering, Offshore Magazine
*In first operating year

The Economist, 2010
More Hydrocarbons in Existing Fields...

Valhall Historic Production Overview

Oil & LNG (BoPd)

- Up & Under Completion
- Gravel Packing Initiated
- First Horizontal Well
- Started Installing Automatic Chokes
- First Multiprop Frac Horizontal Well
- Start of sim drilling and completion ops.

H. Kol, 1998
More Hydrocarbons through Optimizing the Value Chain

- Feedstocks
- Competition
- Transportation Tariffs
- Pipeline blend
- Existing fields
- New field start-ups
Potential Profiles of Oil/Gas Global Production

Schollinberger, 1998
Hubbert Linearization
Based on “Selected” Data Gives an Erroneous Line

Cum. Discovery (Trillion Barrels)

Annual Discovery/Cum. Discovery, %

Deffeyes, 2005
Hubbert Linearization Based on All Reserves: Where is the line?

Schollnberger 2008; Data from BP Statistical Review 2008
Potential Profiles of Oil/Gas Global Production

Schollnberger, 1998
Hubbert’s Method Fails for Global Predictions, because (as it is currently being used) it

- Doesn’t recognize the difference in access to acreage between US and most of world
- Neglects the role of economics and politics in E&P decisions and activities
- Omits important new additions of reserves and resources
- Neglects the dynamics that make today’s unconventional resources tomorrow’s conventional reserves
There is a Better Way than “Hubbert”

Start with Oil and Gas in-place
then estimate how much of this can be recovered.

Oil in Place
15,000 billion barrels = 2,040 billion tons
(without oil shale), only 7.5% produced so far

Gas in Place
45,000 trillion feet³ = 1,300 trillion m³
(without gas hydrates), only 7% produced so far

(Schollnberger 1998, 2006)
A Relevant Question:

Why would consumers use other primary energy sources as long as hydrocarbons are abundant?

The Answer:

Because of Concerns about:

- Price
- Security of Energy Supply
- Global Warming
Price
Oil: The Price is Still Attractive

The price of light sweet crude in U.S. dollars from 1990 to 2008.

Source: Bespoke Investment Group (http://bespokeinvest.typepad.com)
Security of Energy Supply
The Global Flow of Oil

The Global Flow of Gas

Major trade movements
Trade flows worldwide (billion cubic metres)

USA
Canada
Mexico
S. & Cent. America
Europe & Eurasia
Middle East
Africa
Asia Pacific

Natural gas
LNG

BP Statistical Review of World Energy 2007
Facts about Energy Independence

• Energy INDEPENDENCE is an ILLUSION
  Energy, INTERDEPENDENCE is REALITY
  for the US, EU, China, India…, at least for
  the next three decades.

• However, certain countries treat their energy
  resources as a ticket to power by selectively
  limiting access.
## Access to Global Oil and Gas Reserves

<table>
<thead>
<tr>
<th>Category</th>
<th>1970</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full IOC Access</td>
<td>85%</td>
<td>7%</td>
</tr>
<tr>
<td>Soviet Reserves</td>
<td>14%</td>
<td>-</td>
</tr>
<tr>
<td>Reserves held by Russian Co’s</td>
<td>-</td>
<td>16%</td>
</tr>
<tr>
<td>NOC Reserves (limited IOC equity access)</td>
<td>1%</td>
<td>65%</td>
</tr>
<tr>
<td>NOC Reserves (IOC equity access)</td>
<td>-</td>
<td>12%</td>
</tr>
</tbody>
</table>

Source: NPC Global Oil and Gas Study, 2007
Taking Geopolitics into Account…. 

DEMAND for Primary Energy is expected to increase by 50 percent between now and 2030 (NPC, 2007)

However, because of geopolitics, OIL and GAS SUPPLIES may not always keep pace with demand. This will bring ALTERNATIVES into play.
Climate Change
The Challenge

Growing Number of Americans See Warming as Leading Threat
Most Want U.S. to Act, but There Is No Consensus on How

Washington Post, 2007
Tiny Bubbles Tell All

Vostock and EPICA Dome C Ice records. Note the present day spike in methane and CO2 above background. (Figure modified from ”Tiny Bubbles Tell All” Edward J. Brook  Science 25 November 2005: Vol. 310. no. 5752, pp. 1285 – 1287)
Increasing CO₂

Keeling Curve. Monthly average atmospheric carbon dioxide concentration versus time at Mauna Loa Observatory, Hawaii (20°N, 156°W) where CO₂ concentration is in parts per million in the mole fraction (p.p.m.). http://scrippsco2.ucsd.edu/
The world’s temperature has seen a marked increase in the past 30 years
Emissions and Economic Growth
(BP Statistical Review of World Energy 2007)

GDP: Gross Domestic Product.
OECD: Organisation for Economic Co-operation and Development
Emissions Growth Continues (Despite Kyoto)

Source: Energy Information Administration

Source: Energy Information Agency
The Solutions to Manage Green House Gas Emissions

....are gradually coming into focus,

....will be complex,

.... and they will have to be based on joint actions in both, developed AND developing countries
The Energy Mix of the Future
Non-Fossil Primary Energy Options

• Traditional Firewood, Peat and Dung
• Hydro
• Nuclear
• Wind
• Biomass
• Solar
• Geothermal
• Other, incl. Hydrogen
The largest misconception in the public debate about energy:

- The energy mix of the future is treated as “a problem that can be solved” ...

…implying that there are “good” energy forms and “bad” ones and that central planning in some way can fix the mix.
Reality:

All forms of primary energy have upsides and downsides, therefore…

• The energy spectrum is and will be a result of trade-offs. and thus is not a problem to be solved, but …
the result of dynamic dilemmas that we need to deal with on an ongoing basis.
Biomass is not Necessarily CO$_2$-Neutral

Source: sturmberger.co.at
Biomass is not Necessarily CO$_2$-Neutral

A worker at VeraSun loads grain as part of the process to produce ethanol.

1/25/07 washingtonpost.com
Biomass is not Necessarily $\text{CO}_2$ - Neutral

Source: sturmberger.co.at
Today’s Dream, Tomorrow’s Reality?

World Population and Energy Consumption

Schollnberger, 2006

modified from Nakicenovic et al., 1998

after Lutz et al., 1997
In Energy Decisions, What will be Important to Consumers, Governments and Businesses?

Assumptions for the 21st Century:

• Economic Growth (weighted 50%)
• Security of Energy Supply (weighted 30%)
• A Clean and Safe Environment for Our and Future Generations (weighted 20%)
Scenario: Ecologic Precaution

Component: ECOLOGIC PRECAUTION

Source for data 1945-2004: BGR; BP; Author's investigations

Schollinberger, 2006
Energy Spectrum 1945 to 2100 (SCHOLLNBERGER, 2006)
## Oil + Gas Production: Actual vs. Prediction (million tons OE)

<table>
<thead>
<tr>
<th>Year</th>
<th>Predicted</th>
<th>Actual</th>
<th>Difference %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>5410</td>
<td>5391</td>
<td>- 0.35</td>
</tr>
<tr>
<td>2000</td>
<td>5815</td>
<td>5832</td>
<td>+ 0.29</td>
</tr>
<tr>
<td>2004</td>
<td>6370</td>
<td>6309</td>
<td>- 0.97</td>
</tr>
<tr>
<td>2005</td>
<td>6382</td>
<td>6403</td>
<td>+ 0.33</td>
</tr>
<tr>
<td>2006</td>
<td>6505</td>
<td>6507</td>
<td>0.00</td>
</tr>
<tr>
<td>2007</td>
<td>6630</td>
<td>6560</td>
<td>- 1.07</td>
</tr>
<tr>
<td>2008</td>
<td>6753</td>
<td>6707</td>
<td>- 0.79</td>
</tr>
</tbody>
</table>

2005-2008: SCHOLLNBERGER 2006 (Most Likely Case)  
Actual: BP Statistical Review  
Difference: Actual vs. Predicted Production as % of Actual Production
Conclusions: By 2100....

• Hydrocarbons’ share will diminish relatively to other primary energy forms for economic, geopolitical and environmental reasons, NOT because ‘We Are Running Out of Oil’

• Hubbert’s Curve of (conventional) global oil production will be seen as interesting, but irrelevant

• Each energy form will be used efficiently and for best purpose

• Hydrocarbons will be increasingly used for non-energy purposes
Conclusions cont’d:

• Hydrocarbon production volumes in 2100 could be similar to those in 1995

• The R/P ratio for hydrocarbons could be 60 or more in the year 2100

• Responsible re-investment and transparent business practices are essential

• ONGOING LEARNING, e.g. through SPE and professional societies IS A MUST
Balance is the Key to a Sustainable Energy Future

...the three goals may soon converge!
The Genie is out of the Bottle

Paris: La Defense

Foto: Schollnberger, 2000
Back-Up
Global Hydrocarbon Production Through 2100

Elasticity of Reserves and Resources
New Basins and Under-Explored Basins
(Especially for Natural Gas)

Schollnberger, 1998
West Africa: Turbidite Reservoirs
All Sources of Energy Will Be Needed

Source: IEA REFERENCE CASE

Global Oil and Gas Study

NPC
Oil Production, Germany: Not a Hubbert Curve

ErdoelErdgasKohle, 2008

Erdölförderung

3,52 Mio. t
Oil Production, Germany: Not a Hubbert Curve

Erdgasförderung (Rohgas)

19.67 Mrd. m³(Vₙ)

ErdoelErdgasKohle, 2008
Unconventional Reserves Rejected by Hubbert Followers:

- Bitumen and Heavy Oil (< 17.5 API)
- Deepwater Oil (>200m WD)
- High Temperature/High Pressure Oil
- Oil from hostile environments
- Oil from late infill drilling
- Oil from Enhanced Recovery
The Global Flow of Oil

Major trade movements 2006
Trade flows worldwide (million tonnes)

USA
Canada
Mexico
S. & Cent. America
Europe & Eurasia
Middle East
Africa
Asia Pacific

BP Statistical Review of World Energy 2007
There is a Trend....

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

1935 (midpoint of process)
$\Delta t = 300$ years (length of process)

AUSUBEL, 1996
Scenario: Strong Economic Growth

Source for data 1945-2004: BGR; BP; Author’s investigations

Schollnberger, 2006
Scenario: Security of Energy Supply

Component: SECURITY OF ENERGY SUPPLY

Source for data 1945-2004: BGR; BP; Author's investigations

Schollnberger, 2006
Wolfgang E. SCHOLLNBERGER
Vienna, January 20, 2010