Future Petroleum Supply – Exploration or Development?

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Future Petroleum Supply
Exploration or Development

• Additions to reserves
  – Exploration
    ▪ New-field discoveries
  – Development of existing fields
    ▪ Reserve growth

Maulavibazar Field, Bangladesh
Photograph courtesy of UNOCAL
Future Petroleum Supply
Exploration or Development

• Volumes of petroleum added to reserves by field development are comparable to those added by new-field discoveries!

Taft, California
Photograph courtesy of Ken Takahashi, USGS

Petroleum: crude oil, natural gas, natural gas liquids/condensate, and tar
Future Petroleum Supply
Exploration or Development

• Exploration
  – Accessibility
  – Significant capital
  – Risks
    ▪ Economic
    ▪ Technological
    ▪ Environmental
    ▪ Political

Hassi Messaoud Field, Algeria
Future Petroleum Supply
Exploration or Development

- Development
  - More cost effective than exploration
  - Risks
    - Technological
    - Environmental
  - Finite volumes

Development = Reserve growth

Jalalabad Field, Bangladesh
Photograph courtesy of UNOCAL
Reserve Growth

Definition

Increases in successive estimates of recoverable volumes of crude oil, natural gas, and natural-gas liquids in discovered fields

- Delineation of additional in-place volumes (geologic)
- Increases in recovery efficiency (engineering)
- Recalculation of viable reserves in dynamically changing conditions
  - Economic, operating (technological), and political/regulatory
Reserve Growth

• Studied initially for U.S. assessments
• Address reserve growth in World Petroleum Assessment 2000
  – Test hypothesis that reserve growth is not only a U.S. phenomenon
    ▪ U.S. history, SEC regulations
    ▪ Databases
  – “Reserve Growth of the World’s Giant Oil Fields” (Klett and Schmoker, 2003)
Reserve Growth

Magnitude

Recoverable Oil in 186 Giant Oil Fields ($\geq 0.5$ BB), Reported in 1981

The 186 giant oil fields contain 50% of the world’s recoverable crude oil (excluding U.S. and Canada)

Data from IHS Energy Group (1981 to 2003)
Recoverable Oil in 186 Giant Oil Fields, Reported in 1996 (15 years)

- The 186 giant oil fields contain 50% of the world’s recoverable crude oil (excluding U.S. and Canada)

Data from IHS Energy Group (1981 to 2003)

The 186 giant oil fields contain 50% of the world’s recoverable crude oil (excluding U.S. and Canada)
Reserve Growth
Magnitude

Net Change in Recoverable Oil in 186 Giant Oil Fields, 1981 to 2003

Red: 1997 to 2003 (7 years)
Green: 1981 to 1996 (15 years)

Data from IHS Energy Group (1981 to 2003)
Reserve Growth
Magnitude

Percent Change in Recoverable Oil, Relative to Volumes Reported in 1981, in 186 Giant Oil Fields, 1981 to 2003

Data from IHS Energy Group (1981 to 2003)

Red: 1997 to 2003 (7 years)
Green: 1981 to 1996 (15 years)

Reserve Growth

Magnitude

Additions to Reserves, Net Change in Recoverable Oil in 186 Giant Oil Fields, 1981 to 2003

Data from IHS Energy Group (1981 to 2003)

Exclusive of U.S. and Canada
Reserve Growth
Magnitude

Additions to Reserves, Reserve Growth and New-Field Discoveries, 1981 to 2003

Orange: New-field discoveries
Blue: Change in recoverable oil in 186 giant oil fields

Volumes added to reserves in 186 giant oil fields equals volumes added from new-field discoveries

Data from IHS Energy Group (1981 to 2003)
Reserve Growth

Magnitude

• 1981 to 2003
  - New-field discoveries and reserve growth of 186 giant oil fields will supply World for 14 years (7 years each)

• 1997 to 2003
  - New-field discoveries and reserve growth of 186 giant oil fields will supply World for 5 years (2 and 3 years, respectively)

  – Assuming World consumption at 28 BB per year, as reported for 2001 (Degolyer and MacNaughton, 2003)
Changes in Reserve Growth Through Time

Change in Recoverable Oil Volumes in 186 Giant Oil Fields, 1981 to 2003

Data from IHS Energy Group (1981 to 2003)
Changes in Reserve Growth Through Time

Percent Change in Recoverable Oil in 186 Giant Oil Fields, 1981 to 2003


Rates and volumes of reserve-growth changes through time
Reserve Growth
Significance

- Observed worldwide
- Makes up significant portion of resources
- Reported reserves change through time
- Political and business decisions are made on reported reserves
  - Economic and strategic security
  - Decisions can be in error if changes in reported reserves are not considered
Reserve Growth
U.S. Geological Survey Studies

• Reserve growth models
  – Additions to existing fields
  – Sizes of undiscovered accumulations

• Specific (custom) models
  – Magnitude and significance
  – Homogeneous populations of data
  – Independent variables
Reserve Growth
U.S. Geological Survey Studies

• North Sea fields
  – Excellent data set
  – Comparison
  – Analog
North Sea Oil Fields
1985 to 2000 (15 years)

Cumulative Recoverable Oil Volumes in Oil Fields as Reported in 1985

Data from DEA, DTI, NPD (1985 to 2001)

Oil fields of the Northern and Central North Sea
North Sea Oil Fields
1985 to 2000 (15 years)

Cumulative Recoverable Oil Volumes in Oil Fields as Reported in 1990

Data from DEA, DTI, NPD (1985 to 2001)

Oil fields of the Northern and Central North Sea
North Sea Oil Fields
1985 to 2000 (15 years)

Cumulative Recoverable Oil Volumes in Oil Fields as Reported in 1995

Data from DEA, DTI, NPD (1985 to 2001)

Oil fields of the Northern and Central North Sea
North Sea Oil Fields
1985 to 2000 (15 years)

Cumulative Recoverable Oil Volumes in Oil Fields as Reported in 2000

Data from DEA, DTI, NPD (1985 to 2001)

Oil fields of the Northern and Central North Sea
Magnitude of Reserve Growth
North Sea Oil Fields – 1985 to 2000 (15 years)

- **Reserve growth**
  - $1.9 \times 10^9$ Sm$^3$ ($12 \times 10^9$ bbls) added since 1985
  - 57 existing oil fields

- **New-field discoveries**
  - $0.3 \times 10^9$ Sm$^3$ ($2 \times 10^9$ bbls) added since 1985
  - > 25 oil fields discovered after 1985

Data from DEA, DTI, NPD (1985 to 2001)

Greatest volume increase (reserve growth) from 1990 to 1995
Magnitude of Reserve Growth
Southern North Sea Gas Basin Fields – 1986 to 2001 (15 years)

• Reserve growth
  – $19 \times 10^{12}$ ft$^3$ ($0.5 \times 10^{12}$ Sm$^3$) added since 1986
  – 240 existing gas fields

• New-field discoveries
  – $28 \times 10^{12}$ ft$^3$ ($0.8 \times 10^{12}$ Sm$^3$) added since 1986
  – > 259 gas fields discovered after 1986

Data from IHS Energy Group (1986 to 2001)

Greatest volume increase (reserve growth) from 1996 to 2001
Recoverable Oil Volumes in Oil Fields as Reported in 1985

Recoverable oil volumes represent field sizes

Data from DEA, DTI, NPD (1985 to 2001)
Application of Reserve Growth Models
Oil-Resource Assessments

Recoverable Oil Volumes in Oil Fields as Reported in 1985

Data from DEA, DTI, NPD (1985 to 2001)

Green: Recoverable oil volumes reported in 1985

Extrapolations to estimate sizes of undiscovered fields
Application of Reserve Growth Models
Oil-Resource Assessments

Recoverable Oil Volumes Forecasted to 2000 Based on 1985 Volumes

Green: Recoverable oil volumes reported in 1985
Yellow: 1985 recoverable oil volumes forecasted to 2000

Data from DEA, DTI, NPD (1985 to 2001)

Reported volumes may be forecasted to a future size
Application of Reserve Growth Models
Oil-Resource Assessments

Recoverable Oil Volumes Forecasted to 2000 Based on 1985 Volumes

- **Green**: Recoverable oil volumes reported in 1985
- **Yellow**: 1985 recoverable oil volumes forecasted to 2000

Data from DEA, DTI, NPD (1985 to 2001)

Extrapolations are made on forecasted sizes
Application of Reserve Growth Models
Oil-Resource Assessments

Recoverable Oil Volumes in Oil Fields as Reported in 2000

Open: Recoverable oil volumes reported in 1985
Solid: Recoverable oil volumes reported in 2000

Volumes of individual fields are variable, some decreasing.
Application of Reserve Growth Models
Oil-Resource Assessments

Recoverable Oil Volumes in Oil Fields as Reported in 2000

Open: Recoverable oil volumes reported in 1985
Solid: Recoverable oil volumes reported in 2000

Extrapolations based on forecasted sizes provide better estimates.
Application of Reserve Growth Models
Natural-Gas Resource Assessments

Recoverable natural-gas volumes as reported in 1986 and extrapolated line for enveloping undiscovered fields

Forecasted recoverable natural-gas volumes with envelope based on 1986 volumes forecasted to 2001

Green: Recoverable oil volumes reported in 1985
Yellow: 1985 recoverable oil volumes forecasted to 2000

Data from IHS Energy Group (1986 to 2001)

Envelope adjusted upwards based on forecasted 2001 field volumes
Application of Reserve Growth Models
Natural-Gas Resource Assessments

Volumes of individual fields are variable, some decreasing.
Application of Reserve Growth Models
Natural-Gas Resource Assessments

Recoverable natural-gas volumes in gas fields discovered before 1986 as reported in 2001

Envelopes based on 1986 reported and forecasted volumes

Open: Recoverable oil volumes reported in 1985
Solid: Recoverable oil volumes reported in 2000

Data from IHS Energy Group (1986 to 2001)

Envelope adjusted for reserve growth provides better estimates
Future Petroleum Supply

Conclusions

• New-Field Discoveries
  – Smaller volumes in mature areas
  – Contribute more upon opening of new areas for exploration

Point Lobos, California
Photograph courtesy of Ken Takahashi, USGS

USGS

Exploration = New-Field Discoveries
Future Petroleum Supply
Conclusions

- Reserve growth
  - Significant
  - Magnitude is comparable to new-field discoveries
  - Make up significant portion of the world’s resources

Midway-Sunset Field, California
Photograph courtesy of Ken Takahashi, USGS

Development = Reserve Growth
Report finds most new oil around the world comes from old fields

Anyone looking for an upturn in the exploration business is likely to be disappointed by the latest set of figures from IHS Energy in its annual report on 10-year trends in oil and gas E&P. We publish the highlights here with comments from one of its authors.