The Future of Fossil Fuels: Neo-Malthusians, Cornucopians, Greenies and Roughnecks

Richard Hillis
Professor of Petrophysics
Reverend Thomas Robert Malthus

An Essay on the Principle of Population (1798)
Peter Paul Rubens

Abundance (c. 1630)
energy production trends unsustainable and we will soon run out of energy resources
planet cannot sustain population growth and economic progress
famines, shortages and environmental degradation will result from growth
favour birth control, conservation of resources and preservation of the environment
favour government regulation

no scarcity of energy resources which will continue to become more widely available at lower cost
population growth and economic progress are sustainable
quality of life is improved as world population grows
argue against contraception, believe free markets will ensure supply and environmental concerns exaggerated
favour less government
<table>
<thead>
<tr>
<th></th>
<th>Known Reserves</th>
<th>Known Reserves</th>
<th>Known Reserves x5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1972</strong></td>
<td><strong>2003</strong></td>
<td><strong>1992</strong></td>
<td><strong>2022</strong></td>
</tr>
<tr>
<td><strong>Petroleum</strong></td>
<td><strong>2003</strong></td>
<td><strong>1992</strong></td>
<td><strong>2022</strong></td>
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<tr>
<td><strong>Natural Gas</strong></td>
<td><strong>2010</strong></td>
<td><strong>1994</strong></td>
<td><strong>2021</strong></td>
</tr>
<tr>
<td><strong>Coal</strong></td>
<td><strong>4272</strong></td>
<td><strong>2083</strong></td>
<td><strong>2122</strong></td>
</tr>
</tbody>
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Meadows et al. (1972)
1970s Oil Price Predictions for 2000

EXXON

$US100

energy.gov
U.S. DEPARTMENT OF ENERGY

$US250
Hubbert Curve

Ultimate cumulative production

Production Rate vs. Time
Hubbert (1956) Predictions of US Production
Crude Oil Price and Production Trends

Simon et al. (1994)
Reserves

The identified accumulations that can be extracted profitably with existing technology under present economic conditions

\[
\frac{\text{reserves}}{\text{production}} = \text{Club of Rome predictions}
\]
US Crude Oil Reserves and Production

Billion bbl


McCabe (1998)
Additions to U.S. Oil Reserves

(McCabe, 1998)
Evolution of Seismic Data in Oilfield Exploration and Development

Before 1980
2D: 25-30% oil recovery

1980-95
3D: 40-50% oil recovery

1996-future
4D: 65-75% recovery

Slices

Volumes

Changes

BP/Shell’s Foinaven field estimate, Petroleum Engineer International (Jan, 1996)
Resources

Reserves plus all the accumulations of a fossil energy resource that may eventually become available - either known accumulations that are not currently economically or technologically recoverable, or unknown accumulations, rich or lean, that may be inferred to exist, but have not yet been discovered.
Resources Pyramid

Increasing cost of extraction

Better quality resource
successive resource assessments
slice lower in the pyramid
US Oil Production and Resource Estimates

(McCabe, 1998)
USGS Energy Resource Assessments

1500 billion bbl oil in oil shales of Green River Formation in Colorado, Wyoming and Utah (Smith, 1981)

660,000 tcf methane trapped in hydrates (Kvenvolden, 1993)
Evolution of Seismic Data and Resource Pyramid

refraction
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refraction
Evolution of Seismic Data and Resource Pyramid

refraction

future developments
Reserves and Resources

Reserves are fossil fuel accumulations economically exploitable now. Resources are those likely to be exploited in the future.

No resource estimate attempts to quantify the total crustal abundance of fossil fuels.

All resource estimates require a subjective assessment of how far down the resource pyramid to extend.

History has shown that technology allows us to slice progressively further into the resource pyramid.
Investment in Technology

USGS 1991 Assessment

USGS 1995 Assessment
Hubbert Curves

Hubbert successfully predicted peak of US oil production.

Bell-shape of Hubbert curve perhaps misleadingly resembles normal curve of statistical analysis.

Area under curve is ultimate cumulative production, but this requires a subjective assessment of where to slice through resource pyramid.

Updated Hubbert-type plots using more recent reserve and resource assessments similarly ignore our ability to slice deeper into the resource pyramid with time.

Geologists should abandon the notion that there is a finite amount of energy resources that is quantifiable in a manner useful to society.
Ohio Crude Oil Production to 1955

(McCabe, 1998)
Ohio Crude Oil Production to 1955

(McCabe, 1998)
Annual Production of Pennsylvania Anthracite

(McCabe, 1998)
Price of Pennsylvania Anthracite

Price Per Short Ton in 1995 $

(McCabe, 1998)
Open Market: Cornucopian

Lower prices stimulate demand. Price of substitute energy source results in decreased demand. Cheaper substitutes result in decreased demand. Lower prices stimulate demand.

(McCabe, 1998)
Sheikh Zaki Yamani

“The stone age did not end because the world ran out of stones, and the oil age will end long before the world runs out of oil.”
Conclusions

Neo-Malthusian vs. cornucopian debate is a fundamental and broad-reaching one

Exploitation of a finite resource vs. historical trends

The total fossil fuel energy resource is astronomic

Any resource assessment requires subjective judgement on how far down the resource pyramid to extend.

Historically, in an open market, cheaper and more convenient energy sources have replaced previous energy resources before depletion of the previous resource.
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