Peak Everything
Running Out of Commodities
in a Crowded World

Gary McMurtry
History of Earth’s Human Population

1. THE GEOLOGICAL RECORD
   - Earth formed
   - Oldest known rocks
   - First signs of life (fossil algae, bacteria)
   - Explosion of life (Cambrian)
   - Dinosaurs

2. APES AND MEN
   - Primitive apes evolving
   - Last common ancestor of man and chimpanzees
   - Man-like apes
   - Hominids
   - Homo sapiens

3. THE HUMAN POPULATION SPIKE
   - Caused by exploitation, then exhaustion, of fossil fuels
   - Invention of Agriculture
   - Industrial Revolution

Graph Credit: Dr. William Stanton

From: Nate Hagens; http://www.theoildrum.com/node/4450
Peak Oil, Carrying Capacity & Overshoot:

From: http://canada.theoildrum.com/node/2516 (Paul Chefurka)
Peak Oil, Carrying Capacity & Overshoot:

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Peak Oil, Carrying Capacity & Overshoot:

World Oil Production 1900-2080

You Are Here

From: http://canada.theoildrum.com/node/2516 (Paul Chefurka)
Type of Energy Use for Past 200 Years

Graph Credit: Cutler Cleveland Boston University

From: Nate Hagens; http://www.theoildrum.com/node/4450
Properties & Uses of Oil

- Amazing Energy Density (45 MJ/kg, compared with 10-30 MJ/kg for coal, 16 MJ/kg for dry wood)
- Easily Transportable
- Safe (relatively)
- Cheaply Storable

Major Uses:

- Transportation Fuel for motor vehicles, trains, ships & airplanes
- Fuel for Power Plants
- Industrial Applications, e.g. mining, farming, manufacturing
- Source of Petrochemicals, including chemical fertilizers (N,P,K)*, pesticides*, herbicides*, plastics & pharmaceuticals

*Basis of the “green revolution”, as a means to ‘fix’ or reduce atmospheric nitrogen. In this usage, I include natural gas, another limited fossil fuel, and mineable phosphate, probably next on the global depletion list. K is abundant.
USA Oil Production History & Projection

The US lower-48 production peak (Texas + Rest of USA) occurred in 1970; in 1956, M. King Hubbert predicted this outcome to within a few years.
Where the USA Currently Gets Its Imported Oil (>60%)

<table>
<thead>
<tr>
<th>Country</th>
<th>Mbd</th>
<th>Country</th>
<th>Mbd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>2.28</td>
<td>Nigeria</td>
<td>0.62</td>
</tr>
<tr>
<td>Venezuela</td>
<td>1.38</td>
<td>Angola</td>
<td>0.52</td>
</tr>
<tr>
<td>Mexico</td>
<td>1.23</td>
<td>Brazil</td>
<td>0.40</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>1.12</td>
<td>Algeria</td>
<td>0.28</td>
</tr>
<tr>
<td>Russia</td>
<td>0.84</td>
<td>Iraq</td>
<td>0.27</td>
</tr>
</tbody>
</table>

Cantarell Giant Oil Field, Mexico
Export Land Model
Jeffery Brown and Sam Foucher - www.theoildrum.com
Hubbert’s Predictions

Exxon Mobile data

M. King Hubbert
1903-1989

From: K. S. Deffeyes, Hubbert’s Peak (2001)

Hubbert’s Global Production Predictions, 1970

Exxon Mobile

Past discovery based on ExxonMobil (2002).
Revisions backdated.

Fig. 1: Discovery of Regular Oil (based on Exxon Mobil)

Figure 6. M. King Hubbert’s projected cycles for world crude production for the extreme values of the estimated total resource. (Source: M. K. Hubbert, Resources and Man)
Predictive Global Models
from “WebHubbleTelescope”, TheOilDrum.com

Source: http://www.theoildrum.com/node/2376 and links therein.
World Liquids Production, 1980-2008

From: EIA data; http://www.theoildrum.com/node/3439#more
Crude Oil Production by Country
2001-2008

Data source: EIA International Petroleum Monthly
Bottom-Up (Mega-Projects) Prediction

Possible future supply capacity scenario for crude oil and NGL based on the Wikipedia Oil Megaproject database. The resource base post-2002 decline rate is a linearly increasing rate from 0% to 4.5% between 2003 and 2008 then constant at 4.5% afterward. The decline rate for each annual addition is 4.5% after first year. The observed data points are the monthly crude oil + NGL estimates from the EIA.

From: Khebab, Ace, et al., http://www.theoildrum.com/node/4419#more
Net Oil Exports & Crude Prices

Net Oil Exports of Top 20 Exporters

- Exports
- Oil Price

NetOilExports.blogspot.com
Oil Prices Over Time

Oil Price: NYMEX Light Sweet Crude / WTI

Crude Oil Prices
2007 Dollars

- OPEC 10% Quota Increase
  Asian Econ Crisis
- PDVSA Strike
  Iraq War
  Asian Growth
  Weaker Dollar
- Iran / Iraq War
- Series of OPEC Cuts
  4.2 Million Barrels
- Gulf War
- Suez Crisis
- Yom Kippur War
  Oil Embargo
- U.S. Price Controls
- 9/11

1947 - May 2008
WTRG Economics ©1998-2008
www.wtrg.com
(479) 293-4081

- U.S. 1st Purchase Price (Wellhead)
- "World Price"*
- Avg U.S. $24.98
- Avg World $27.00
- Median U.S. & World $19.04
The Staircase Model

Economy

Oil Price

Time

$147

$200?

??

We're here now
"Oil is a “key commodity” because almost everything in our industrial economy depends on the continued flow of cheap oil for either the manufacture, processing, storage, or delivery of “whatever it is”.

With ordinary commodities, a shortage of tulips or flour or pork bellies isn't likely to affect the typical commuter's ability to get to work, heat the home, etc, unless perhaps that person works directly in one of the affected industries.

It takes only as little as a 5% decline in availability of this key commodity to affect a 50%+ change in pricing."

-- Bette Williams, “Nudge” of CFN

![Diagram of Peak Oil and History of Whale Oil](image)
The World According to Oil

Who has the oil?

World Reserves of Oil

<table>
<thead>
<tr>
<th>Country</th>
<th>Reserve (Bbls)</th>
<th>Percentage of World Reserve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saudi Arabia</td>
<td>262.7B</td>
<td>22.2%</td>
</tr>
<tr>
<td>Iran</td>
<td>152.6B</td>
<td>13.2%</td>
</tr>
<tr>
<td>Iraq</td>
<td>155.8B</td>
<td>13.7%</td>
</tr>
<tr>
<td>Kuwait</td>
<td>99.6B</td>
<td>8.6%</td>
</tr>
<tr>
<td>United Arab Emirates</td>
<td>97.8B</td>
<td>8.3%</td>
</tr>
<tr>
<td>UAE</td>
<td>77.7B</td>
<td>6.5%</td>
</tr>
<tr>
<td>Russia</td>
<td>72.2B</td>
<td>6.1%</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>39.9B</td>
<td>3.4%</td>
</tr>
<tr>
<td>Libya</td>
<td>39.1B</td>
<td>3.2%</td>
</tr>
<tr>
<td>Nigeria</td>
<td>39.2B</td>
<td>3.2%</td>
</tr>
<tr>
<td>United States</td>
<td>21.3B</td>
<td>1.8%</td>
</tr>
<tr>
<td>China</td>
<td>17.6B</td>
<td>1.5%</td>
</tr>
<tr>
<td>Canada</td>
<td>16.8B</td>
<td>1.4%</td>
</tr>
<tr>
<td>Qatar</td>
<td>15.8B</td>
<td>1.3%</td>
</tr>
</tbody>
</table>

Each country’s size is proportional to the amount of oil it contains. Source: EIA International Energy Annual 2014 & Energy Information Administration.
Campbell’s Predictions

**World Oil Production**

Figure 1. World oil production from 1600 to 2200, history and projection, in millions of barrels per year (Source: C. J. Campbell)

**World Population**

Figure 2. World population from 1600 to 2200, history and projection, assuming impacts from oil depletion, in millions (Source: C. J. Campbell)

Colin J. Campbell, Founder, ASSOCIATION FOR THE STUDY OF PEAK OIL AND GAS
It’s about the Food…

Made available to plants by fossil fuel (natural gas reductant)

Population Disaster!

Figure 2. World population from 1600 to 2200, history and projection, assuming impacts from oil depletion, in millions (Source: C. J. Campbell)
Growing Global Demand

Misguided Diversion of Food Crops into Biofuel Production

Chronic Low Productivity of Farmers in Poorest Countries

Climate Change => Droughts


Is there any cause for alarm?
Nature Takes Care of Her Own…

St. Mathews Is. Deer: Ran out of Lichens.

Overfishing Caspian Sea Sturgeon

First Introduced

Rapid Depletion of a Critical Resource?

From: Ugo Bardi, Peak Caviar, http://europe.theoildrum.com/node/4367#more
Peak Oil, Carrying Capacity & Overshoot:

From: http://canada.theoildrum.com/node/2516 (Paul Chefurka)
Global Oil Production & Prediction

Figure 7a. World oil production, history and projection. (Source: ASPO)
Global Oil & Natural Gas Depletion

Global Peak Coal

(Source: Energy Watch Group)

From: http://www.theoildrum.com/node/2396
USA Coal - Net Energy (BTU) Peak

Coal production in USA

M short tons

1200
1100
1000
900
800
700
600
500
400
300
200
100
0


Year

anthracite

lignite

subbituminous

BTU PEAK 1998

Source: EIA 2006
Magnitude of the Problem

or

Why Most Alternatives Won’t Work, or Not in Time

To make up for the coming oil depletion, a 1 Gigawatt nuclear power plant needs to be built every day for the next 30 years*

* To replace 10 Terawatts or $10^{13}$ watts = 10,000 new 1 Gigawatt ($10^9$ watt) plants; David Goodstein, “Out of Gas, The End of the Age of Oil”, 2004.
Net Primary Resource Consumption ~97 Quads

Source: Production and end-use data from Energy Information Administration, Annual Energy Review 2002.
*Net fossil-fuel electrical imports.
**Biomass/other includes wood, waste, alcohol, geothermal, solar, and wind.
# The List of Alternatives

<table>
<thead>
<tr>
<th>Category</th>
<th>Brief Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>• Heavy Oil</strong></td>
<td>Most helpful in near future</td>
</tr>
<tr>
<td><strong>• Oil Sands</strong></td>
<td>Moderate supply</td>
</tr>
<tr>
<td><strong>• Coal-Derived Liquids</strong></td>
<td>Moderate supply</td>
</tr>
<tr>
<td><strong>• Liquefied Natural Gas</strong></td>
<td>Minor supply</td>
</tr>
<tr>
<td><strong>• Natural Gas</strong></td>
<td>N.A. post-peak; world will soon follow</td>
</tr>
<tr>
<td><strong>• Coal</strong></td>
<td>Maybe 100-200 more years--see CDL</td>
</tr>
<tr>
<td><strong>• Methane hydrates</strong></td>
<td>Abundant on and off-shore--impacts unknown</td>
</tr>
<tr>
<td><strong>• Solar-voltaic</strong></td>
<td>Moderate supply</td>
</tr>
<tr>
<td><strong>• Hydro-electric</strong></td>
<td>Moderate supply--local impact</td>
</tr>
<tr>
<td><strong>• Wind</strong></td>
<td>Moderate supply--local impact</td>
</tr>
<tr>
<td><strong>• Tidal, Waves, Currents</strong></td>
<td>Minor supply--local impact</td>
</tr>
<tr>
<td><strong>• OTEC</strong></td>
<td>Scaleable to 5 TW, but impacts unknown</td>
</tr>
<tr>
<td><strong>• Biomass</strong></td>
<td>Land forms are net energy losers; marine?</td>
</tr>
<tr>
<td><strong>• Geothermal</strong></td>
<td>Minor supply--local impact</td>
</tr>
<tr>
<td><strong>• Nuclear Fission, Nuclear Fusion</strong></td>
<td>Most helpful in far future--probably probably</td>
</tr>
</tbody>
</table>

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![Graph](image-url)
Tidal Power Solar PV Array
Algae Biodiesel
Offshore Wind
Can They Scale to Need? Fossil Fuel Platform?
Like windmills on the sea, alternative energy technology rests upon a vast pool of fossil-fuel energy that will decrease and become more expensive over time. Industries that make alloys, turbines, solar panels, batteries, & construction equipment and transportation all rely on fossil fuels. Even coal is mined with diesel-powered equipment.
What’s Wrong with This Picture?

HINT: Study this chart as if your life depended upon it!

Annual Global RENEWABLE Energy Resources (in Terawatt hours*)

- Direct Solar Radiation: 350,000,000
- Wind: 200,000
- Ocean/Thermal: 100,000
- Biofuels: 50,000
- Geothermal: 10,000
- Tidal/Wave: 5,000

Total Global NON-RENEWABLE Energy Resources (Terawatt hours*)

- Coal: 6,000,000
- Natural Gas: 1,500,000
- Uranium 235: 1,500,000
- Oil: 1,000,000
- Tar Sands: 800,000

Total: 10,800,000

The amount of solar energy available each year (yellow circle) dwarfs supplies of any other source of power, including total reserves of all the fossil fuels on Earth (small circle, right).

*1 terawatt hour is equal to 1 billion kilowatt hours

SOURCE: SUNCELL BY CHRISTOPHER C. SWAN, UPDATED BY STEVE HECKEROTH
Different Infrastructure Requires Different Power Densities

From: Nate Hagens; http://www.theoildrum.com/node/4450
Crude Oil Alternatives--Canadian Oil Sands

* currently 1 million barrels (MB)/day
* projected to 3 MB/day in 2020
* projected to 6 MB/day “in future”—tops
* reserves equal to oil of Saudi Arabia
* environmental impacts huge & scaleable

ERoEI: Energy Returned on Energy Invested

Or, If it takes a barrel of oil to recover a barrel of oil, why bother?

General resource example

Oil well, field example
ERoEI summary chart: USA

Source: Charles Hall; http://www.theoildrum.com/node/3786
ERoEI Futures

Per Prof. Deffeyes, $300 per barrel oil = 15% GDP.
⇒ ERoEI = 5-6 at point of collapse (below).

World Oil Production vs. Price, with % World GDP (Gross Domestic Product)


From: Euan Mearns, theoildrum.com
Working Near the Net Energy Cliff

From: Chris Martenson;
http://www.chrismartenson.com/peak_oil
Peak Minerals (cont.)

World Uranium Production

Uranium demand according to IEA scenarios and possible supply from known resources

Supply deficit 2006-2020: 180 – 260 kt Uranium
Uranium Stocks: appr. 200 kt Uranium

WEO 2006-Alternative Policy Scenario
WEO 2006 Reference Scenario
Constant Capacity as of 2005

RAR+IR \( < 130 \text{ $/kg} \): 3.286 MktU
RAR \( < 40 \text{ $/kg} \): 1,947 ktU

Source: Miquel Torres; http://www.theoildrum.com/node/2379
Who’s Got the Uranium?

2007 Uranium Mining

- Canada: 23%
- Australia: 21%
- Kazakhstan: 16%
- Russia (est): 8%
- Niger: 8%
- Namibia: 7%
- Uzbekistan: 6%
- USA: 4%
- Ukraine (est): 2%
- South Africa: 1%
- China (est): 2%
- Other: 3%
US Energy & Minerals Policy?

Thelma & Louise (1991)

Cliff
Deer Caught in the Headlights?

“May you live in interesting times”…

Old Chinese wish or a curse?
Future of Hawaii

Burdens
• >1.2 million people living thousands of miles from the nearest land
• ‘Standing crop’ of >0.1 million tourists, >0.1 million military
• Small land area, with limited water resources
• Surrounding ocean waters are oligotrophic (biological desert)

Advantages
• Equitable climate, inspiring natural landscape & educated, cosmopolitan culture
• History of self-sustainability and export agriculture
• Geothermal, wind, biomass and OTEC/cold-water agriculture potential on Hawaii Island

Disadvantages
• Current reliance on all things imported, including most food, goods & energy
• AC high-rises, suburban sprawl & outmoded land transportation system
• Economic reliance on tourism, military & soon-to-be-extinct cheap airline industry
• Active volcanoes?
Conclusions

Peak Everything is not The End, but is certainly a warning “shot across the bow”.

We already live in a post-peak world for many commodities, e.g., mercury, gold, etc. These are scarce and expensive (valued), and heavily recycled.

Living with the effects of Peak Oil may be different, but only because we have foolishly allowed it and the other fossil fuels to heavily permeate our culture.

Besides not checking our general population growth, perhaps one of mankind’s greatest mistakes has been implementation of the “green revolution”, whereby we have unwittingly used fossil fuels to grow human populations well past the Earth’s finite carrying capacity. We are now in Overshoot (bad!).

Going forward, we will have to recycle, close open cycles, and learn to live within our means once again. We must “make other living arrangements”, and soon.

Peak Everything, Climate Change, and the Anthropocene Mass Extinction Event are all part of the same problem: Human Overpopulation & Over-Consumption.
Hey, It’s a Finite Planet!
Recommended Reading

The Party's Over (2003, 2005) by Richard Heinberg
Power Down (2005) by Richard Heinberg
Peak Everything (2007) by Richard Heinberg
Hubbert's Peak (2001) by Kenneth Deffeyes
Beyond Oil (2005) by Kenneth Deffeyes
Out of Gas (2004) by David Goodstein
Twilight in the Desert (2005) by Matthew Simmons
Big Coal (2006) by Jeff Goodell

Related:
Overshoot: The Ecological Basis of Revolutionary Change (1980) by William R. Catton
Collapse: How Societies Choose to Fail or Succeed (2005) by Jared Diamond
The Long Emergency (2005) by James H. Kunstler