

Beyond Hubbert: What down slope can we expect?

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3rd Biophysical Economics Conference, April 16, 2011

What will the world down-slope of oil production look like?

- ▶ Individual areas often follow a Hubbert Curve
- ▶ Does this mean that the world will also?

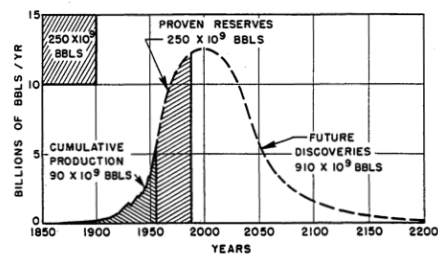


Figure 20 - Ultimate world crude-oil production based upon initial reserves of 1250 billion barrels.

Source: M. King Hubbert, Nuclear Energy and the Fossil Fuels, 1956

What conditions are required for Hubbert Curve?

- ▶ Hubbert model developed for areas where development can proceed “normally”
 - ▶ Financial system and international trade working well
 - ▶ Adequate food
 - ▶ Pollution not an overwhelming problem
 - ▶ Metals production as usual
 - ▶ Reasonable political stability
- ▶ Net energy from all fuels adequate to maintain systems
- ▶ Otherwise, Liebig’s Law of the Minimum will take over
 - ▶ Production will drop sooner

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Hubbert saw nuclear taking over, even before oil peak

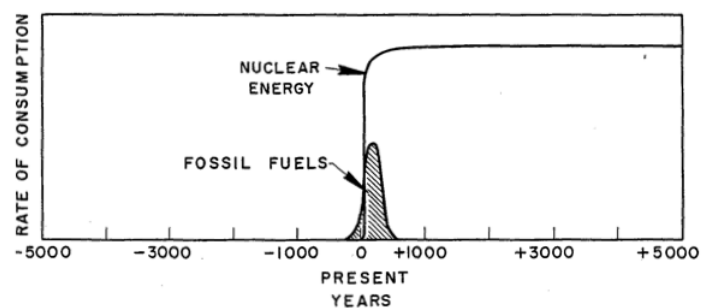


Figure 30 - Relative magnitudes of possible fossil-fuel and nuclear-energy consumption seen in time perspective of minus to plus 5000 years.

Source: M. King Hubbert, Nuclear Energy and the Fossil Fuels, 1956

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Hubbert also included solar (wind, wave, biofuels, wood)

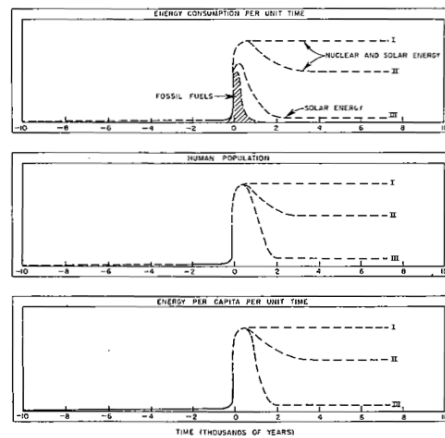


Figure 61. Human Affairs in Time Perspective

Source: M. King Hubbert, Nuclear Energy and the Fossil Fuels, 1956

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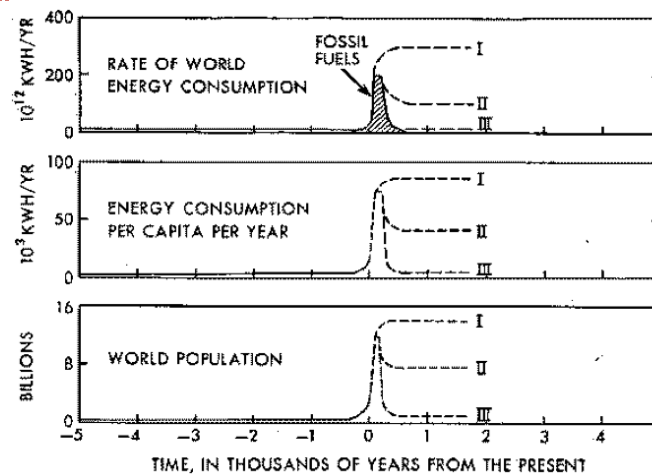
Hubbert expected to reverse combustion

- Energy + CO₂ + H₂O = Fuel + O₂
 - Make fuel
 - Take care of pollution



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Hubbert forecast population up to 15 billion



M. King Hubbert, Exponential Growth as a Transient Phenomenon in Human History, Presentation to World Wildlife Fund Conference, 1976

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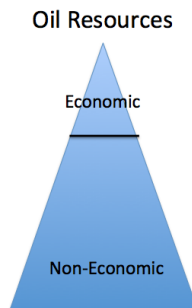
Hubbert's assumptions not true in today's world

- ▶ Hubbert curve close to a best-case scenario
 - ▶ Need other approaches
- ▶ Ways to raise down slope
 - ▶ Technology
 - ▶ Alternative fuels
- ▶ Ways to steepen down slope
 - ▶ Liebig's Law of the Minimum
 - ▶ EROEI becomes too low for society
 - ▶ Demand not high enough

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One simple approach – resource triangle

- ▶ How much can be made to be economic?

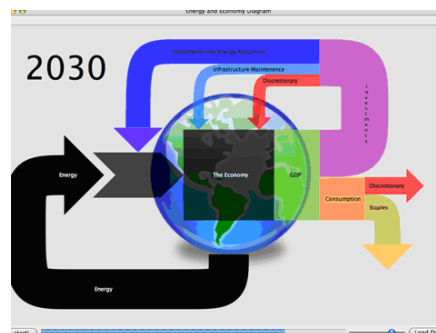


- ▶ Technology lowers bar; taxes raise bar
- ▶ Once the economic oil is gone, quick down slope

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Many resources identified today will likely never prove economic

- ▶ EROEI too low
- ▶ Price too high for consumer (recession)
- ▶ Capital requirement higher than economy can support



Cheese slicer model by Charles Hall.

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Another approach: Limits-to-Growth type analysis

- ▶ Consider several variables simultaneously – LTG used:
 - ▶ Population
 - ▶ Food per capita
 - ▶ Industrial output per capita
 - ▶ Resources
 - ▶ Pollution
- ▶ The more variables added, the more chance of hitting a limit quickly
- ▶ Limits-to-Growth left out Financial System
 - ▶ Capital is now often borrowed
- ▶ Didn't consider US / China – India / Exporters split
- ▶ Didn't consider peak phosphorus

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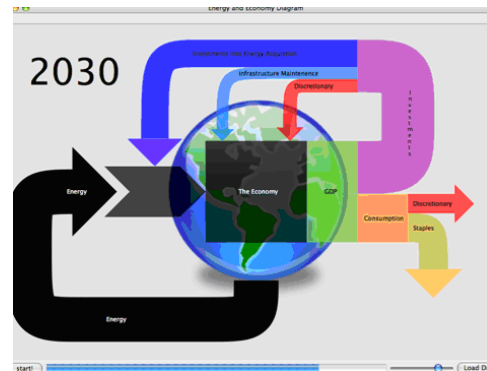
Limits to Growth Conclusions

- ▶ **“The basic mode of the world system is exponential growth of population and capital, followed by collapse.”**
- ▶ Authors didn't know what would happen after collapse
- ▶ **“What validity our model has holds up only to the point in each output graph at which growth comes to an end and collapse begins.”**

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Another issue: High priced oil is generating too little demand

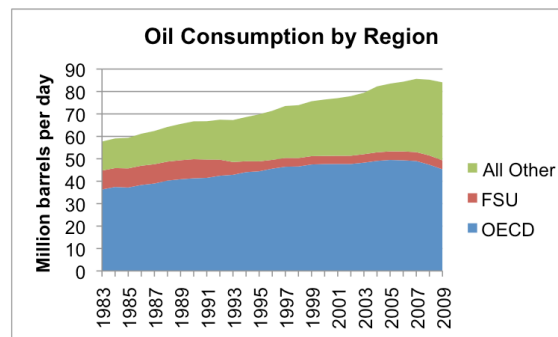
- ▶ Seems to reflect issues of Charlie Hall's cheese slicer model



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Declining Demand is Not Uniform

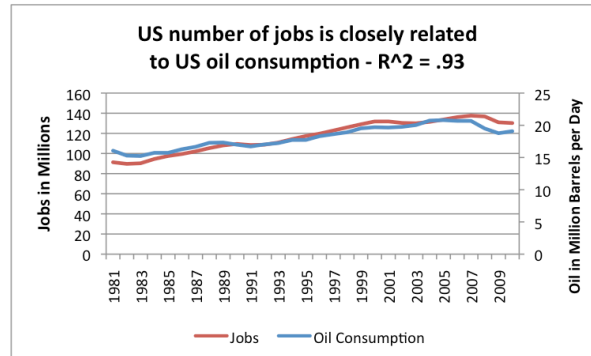
- ▶ When is price too high?
- ▶ Should vary by country
 - ▶ Most built infrastructure -> highest EROEI needs -> hit first



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Why does oil demand decline?

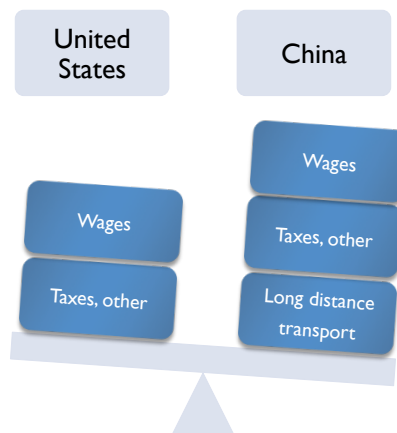
- ▶ 1. Inadequate manufacturing
- ▶ 2. Inadequate employment – If people aren't working they can't afford vacations, cars, new homes



Note: Based on Bureau of Labor Statistics and EIA data.

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Why do jobs move overseas?



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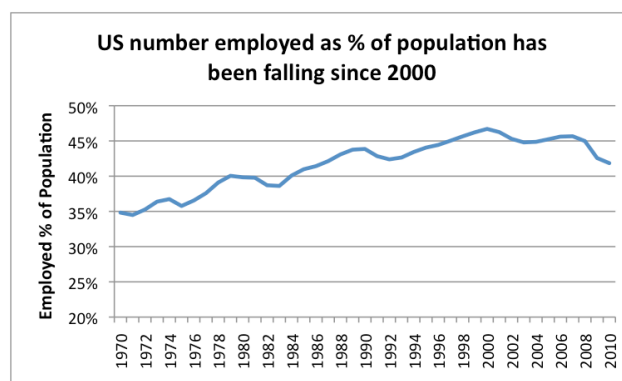
Potential savings in several areas

- ▶ Wages – Chinese have simpler homes, no cars, less fuel
- ▶ Taxes – Fewer roads to maintain, employees earn less
- ▶ Employee benefits – Chinese get less
- ▶ Electricity – Cheap coal electricity, no carbon price

- ▶ We are trading
 - ▶ Our higher energy requirements for their lower energy requirements
 - ▶ Our high cost electricity for their lower cost electricity (sometimes)

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US jobs seem to be moving overseas

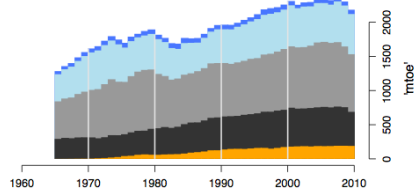


Based on Bureau of Labor Statistics and Census Bureau data.

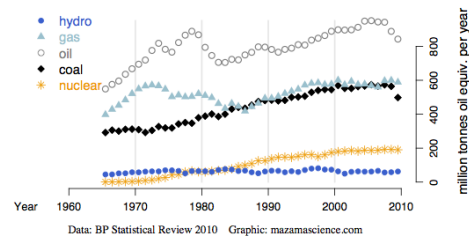
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After 2000 – US jobs lower, energy needs flat

2009 : Total energy consumed decreased by 5.2 %



United States : Consumption

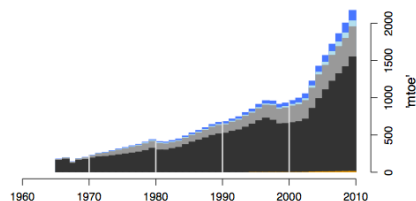


Data: BP Statistical Review 2010 Graphic: mazamascience.com

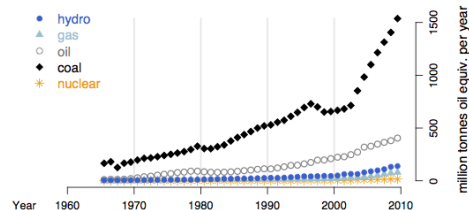
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After 2000, Chinese energy use soaring

2009 : Total energy consumed increased by 8.4 %



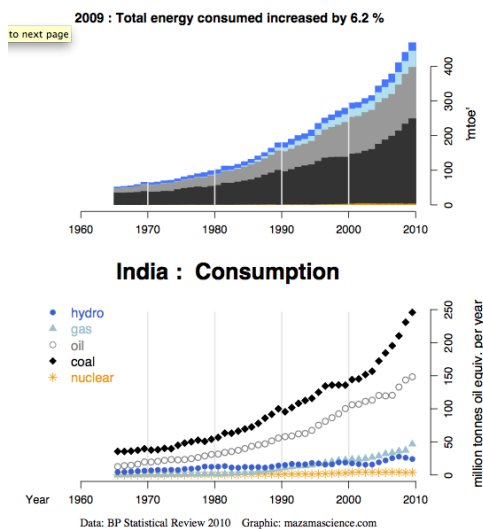
China : Consumption



Data: BP Statistical Review 2010 Graphic: mazamascience.com

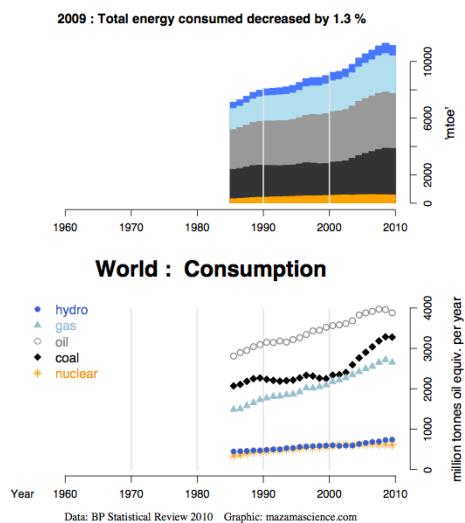
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After 2000, Indian energy use soaring



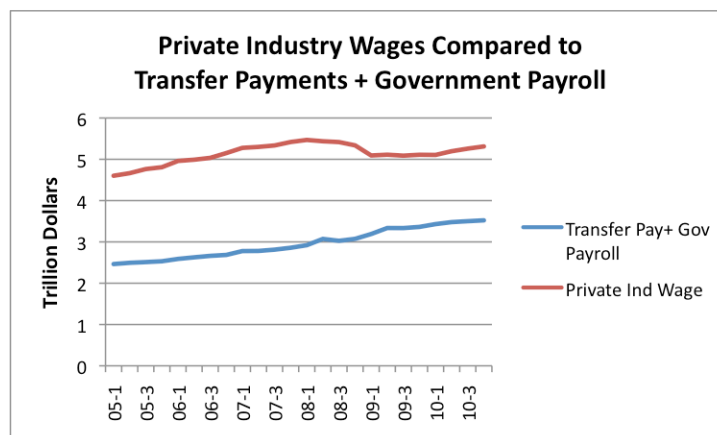
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After 2000, world coal soaring, oil flattening



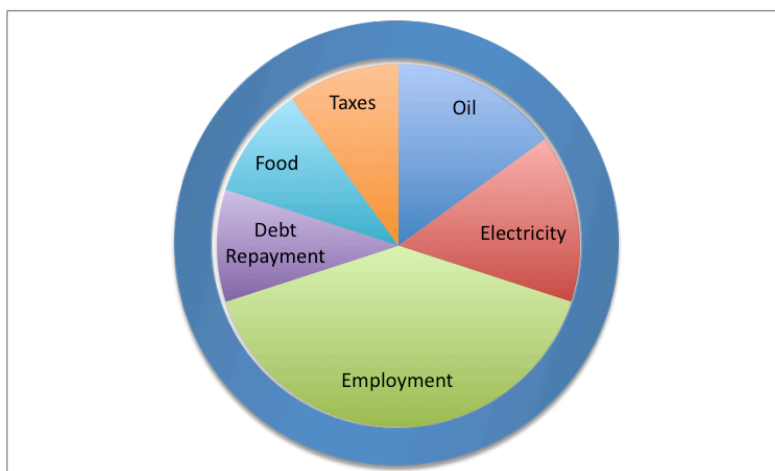
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US no longer has enough employed to pay for government + transfer payments



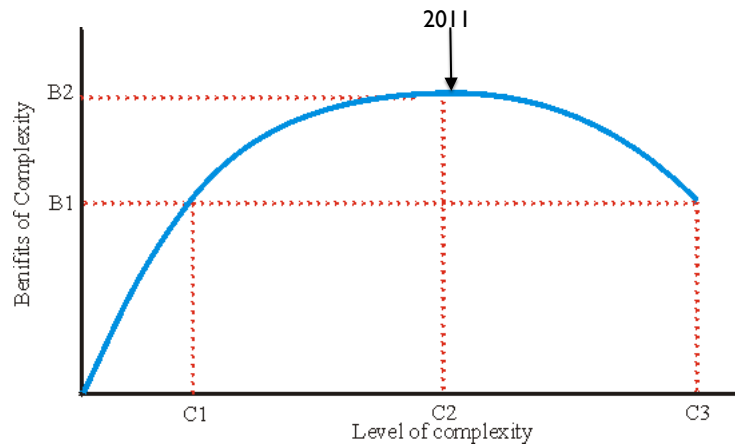
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How is missing petroleum like a missing cup of flour?



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We seem now to be near a potential
downturn

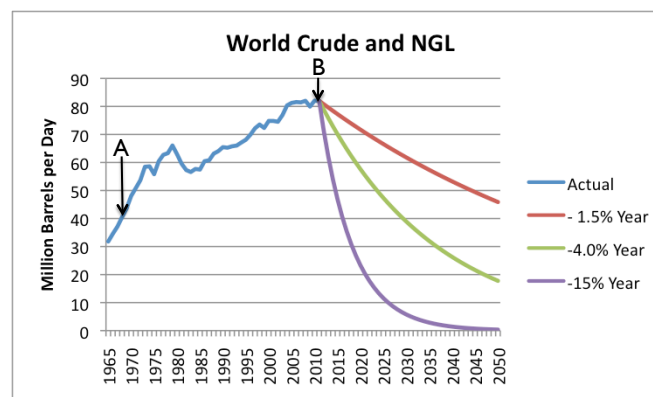


Source: Chart (without arrow) by Joseph Tainter, from "Complexity, Problem Solving, and Sustainable Societies" from *Getting Down to Earth: Practical Applications Of Ecological Economics*, Island Press, 1996.

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Don't know what is ahead, but slope could
be steep

► We will need to work together.



Note: Actual based on BP data.

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Questions

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