Energy Quest: Solving two problems for the price of one

Stephen R. Humphrey - University of Florida
Oil depletion and climate change

- Two **existential** problems
- One imminent, one slower
- Solving one will solve the other
- Which quest is more appealing?
Adding 2.5 billion people by 2050 will drive or trump all other factors

- Using 70% more of earth’s resources
- Must provide more energy, food, fiber
- Avoid depleting the life support system
  - Cropland, forest, & ecosystem services (productive soil, clean air & water, wetlands, biodiversity)
- Despite disrupted climate patterns
- Despite water shortages
- Despite higher cost of everything
Civilization rose in an equable climate

What will be the consequences to society, when we’ve warmed the climate above our “comfort zone”? 
To preserve a human-friendly climate...

We must halt and reverse carbon release from fossil fuels, forests, and sediments, back to 350 ppm CO₂ (see 350.org)
Rethinking natural resources

- People are remarkably confused about:
  - The nature of natural resources
  - What is truly renewable
  - What is sustainable use

- Sharper thinking will lead us to better solutions
All non-renewable resources are exhaustible

- Depleted when used, but the depletion rate can be managed
- Amount of stock is uncertain, but stocks can be reserved
Renewable natural resources are ambiguous

- Renewable resources can be used sustainably, or not
- But only **physical-force** RRs are truly inexhaustible
- **Biological-force** RRs can be used sustainably or **unsustainably**
Key insight: don’t confuse stock and flow

- The supply in “supply and demand” is not a resource stock!
- Supply is **flow**, or periodic production from stock
- **Stock** is the resource that may be used sustainably or exhausted
Simple Model 1: sustainable use of a renewable resource

It’s crucial to visualize how biophysical & human behavior integrate. Roughly 1-5% harvest is the most biological systems can sustain.

Stock is renewed indefinitely, if...

And price is dependable, like a utility, if...

If flow is constrained so as to not draw down stock

It’s crucial to visualize how biophysical & human behavior integrate. Roughly 1-5% harvest is the most biological systems can sustain.
**Corn: sustainable use, disruptive tech**

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<tr>
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</table>

**Mass selection**

**Mendelian hybrid trait selection**
General Model 2: non-renewable resource with high demand and no substitute

Stock is steadily depleted, flow rises-peaks-drops, and price drops-bottoms-rises; use seems sustainable temporarily.

In this zone, use looks sustainable, but isn’t.
Price phases of the resource development-depletion model for oil

First half of U-shaped price curve, calmed by elastic flow. When flow becomes inelastic, depletion will bring severe economic disruption.

Event I: US oil production peaked; Arab oil embargo, Iranian revolution, Iran-Iraq War, stagflation

Event II: Demand growth at supply plateau; price rises, then demand drops

Innovation phase (Moore’s law, cheap revolution)

Utility phase

Competition, combination, monopoly, anti-trust, depression, WW I, WW II, import tariffs & quotas, export controls, price controls, cartel, nationalization
When will world oil production peak?

- BP Statistical Review data:
  - world oil production peaked in 2008
- Dr. Sadad Al-Husseini (former Saudi Oil Minister)
  - capacity outlook: 10-year production plateau
- Association for the Study of Peak Oil: “2010”
- Former Shell CEO van der Veer: “2015”
- International Energy Agency 2008: “trends in energy supply and consumption are patently unsustainable”
- Deutsche Bank: 2016-17
- Business calls oil crunch a threat to UK economy:

Opinions vary about the timing, but not about the outcome
World oil flow forecasts, based on population demand vs. geological fundamentals

A bumpy plateau or “practical peak” has begun
Adding plausible **price** volatility to the lifecycle of exhaustible oil

Business cycles mask the long-term depletion uptrend. High, volatile prices will cause recessions & defaults! Demand destruction offers a solution, if we make it happen early.
Global oil “budget” outlook

- Existing oil fields produce 85m b/day
- Production is declining by 4m b/day
- New discoveries are 4m b/day to 2014
- Reserve capacity ~6m b/day, mostly in Middle East, very uncertain
- New deepwater discoveries off Brazil and Mexico need new technology to produce, 10 years in future, maybe not feasible
- How the factors play out depends on future demand, technology, and potential CO₂ limits and/or alternative energy policies
Energy gap, inflection in 2012

From US Department of Energy. What unidentified projects?
Forecasts of Oil Production, 2010

A crash program to adjust to declining oil will take 20 years (Hirsh-SAIC). These estimates suggest that we have only 5-10 years.
Renewable #1, northern cod used unsustainably, rapidly depleted

Disruptive technology & policy (too many boats & quotas) destroyed the sustainable fishery (shifted from Model 1 to Model 2)

Numerous, small technological advances in fishing gear

1960 factory freezer-trawler, Fairtry III
Renewable #2, whale oil flow & price

Renewable but used unsustainably, so follows model 2; note the demand destruction by kerosene after 1859.
The substitution puzzle (Solow 1974)

If we can easily substitute other factors for natural resources, then we can “...get along without natural resources, and exhaustion is just an event, not a catastrophe.”

But, if no substitute is found, catastrophe is unavoidable.

In between are many cases where the problem is real, interesting, and not foreclosed.

So, substitution needs disciplined thinking, puzzling out Solow’s uncertain outcomes by focusing on innovation.
Vinod Khosla’s system for driving innovation/adoption of energy tech

- **Principles:** promising technologies must be:
  - Inexhaustible or truly renewable
  - Affordable, low start-up cost, short innovation cycle
  - Capable of scaling up to demand, with declining costs
  - Competitive without subsidy in ~10 years
  - Not energy intensive

- **Policies:** government must:
  - Encourage capitalists to invest
  - Subsidize next-least-cost tech

See khoslaventures.com
Listing the essential elements will outline a new vision

- Particular elements of a renewable-energy future
  - A long, difficult transition away from fossil fuels
  - Energy-efficient buildings and urban design
  - Electrification of surface transport
  - New nuclear plants for massive baseload near the world’s largest cities
- Distributed renewable energy produced at appropriate scale where it is consumed
  - Capturing energy flows, not depleting stocks
  - Wind, solar, tide/current, non-food biofuels
  - Energy storage
  - An efficient, resilient transmission grid
Good renewable energy substitutes for FL

Biofuels

Solar
Good renewable energy substitutes for FL
Ocean current
Even better if plugged into power plants fired by natural gas, renewables.

Electrified transport (60% of oil use) yields a massive efficiency increase.

2010 Chevy Volt

1909 Baker Electric
To develop new electricity at 2008 prices, natural gas (#5) is cheapest
Wind (#6) is cheaper than coal
Concentrating solar (#8) is expensive to build, but the fuel is free!
Nuclear (#1) is most costly
Summary of energy R&D subsidies

Federal Subsidies (2002-08)

FOSSIL FUELS: $72.5 billion
- $2.3 billion for Carbon Capture and Storage*
- $53.9 billion for Tax breaks
- $16.3 billion for Direct spending

RENEWABLE ENERGY: $29.0 billion
- $12.2 billion for Traditional Renewables
- $16.8 billion for Corn Ethanol

Total: $70.2 billion for Traditional Fossil Fuels

* all subtotals in $ billions
Are we using other resources sustainably?

Shall we assume a crash mat?