

The energy challenge: A tough choice ahead

Current practices of energy production and use are unsustainable:

- Supplies are becoming scarce, and it is hard to meet demand
- Energy production and use threaten the environment

But energy use is central to our way of life, and the consequences of not meeting future energy demands are dire:

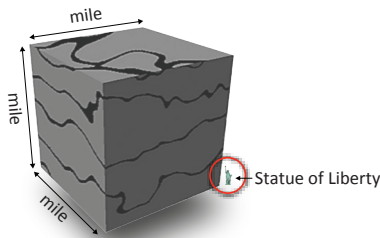
- We will condemn large segments of the population to lives of poverty
- Energy scarcity may lead to unrest and conflict over resources

A comprehensive energy policy must acknowledge the magnitude of the problem

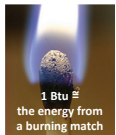
How much energy do we use?

Energy from various sources is measured in different units

To facilitate a discussion of energy, we introduce a new unit of energy, a **cubic mile of oil (CMO)**, which is a term for a visual unit of measure coined by SRI's Hew Crane while he waited in the 1970s gas lines. His realization: **annual global oil consumption was then approaching one cubic mile!**



- 1 CMO \approx 1.1 trillion gallons of oil (26 billion (10^9) barrels oil)
- 1 CMO \approx current annual worldwide oil consumption
- 1 CMO is equivalent to:

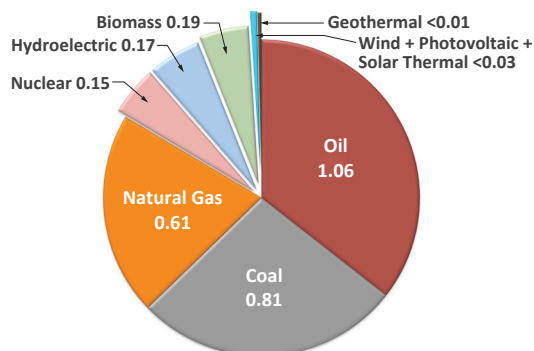


153 quadrillion (10^{15}) Btu (Quads)
 6.4 billion (10^9) tons of hard coal
 15.3 trillion (10^{12}) kWh electricity
 (Numbers calculated at 10,000 Btu/kWh, which is a more realistic conversion factor than the standard of 3,412 Btu/kWh)



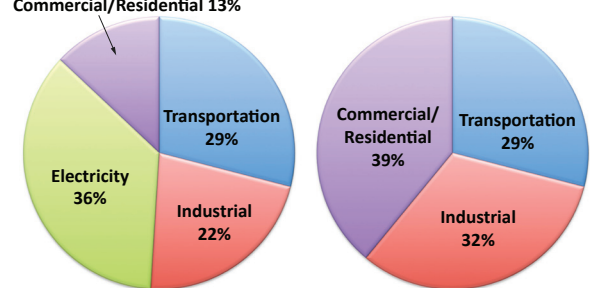
8 hours of cardio:
 \approx 1 kWh \approx 0.1 gal of oil

In 2006, global energy consumption was 3 CMOs/year!



How do we use energy?

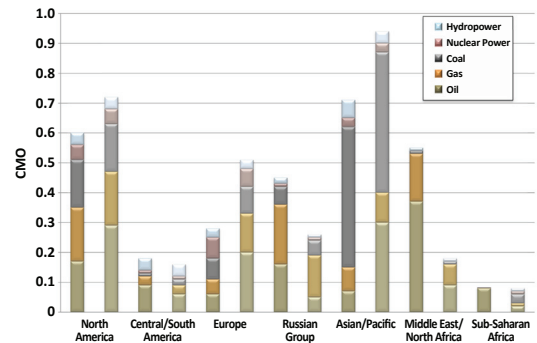
In the USA



More than a third goes into producing electricity, which is used in other sectors

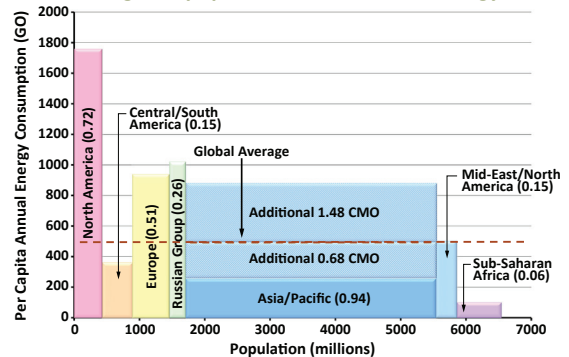
Distribution after apportioning the energy for electricity into sectors that use it

Where is energy produced and consumed?

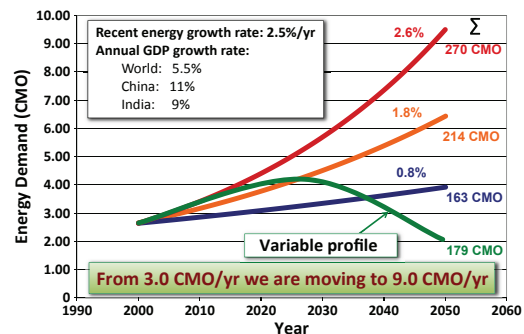


What drives energy consumption?

Standard of living, not population alone, drives energy use



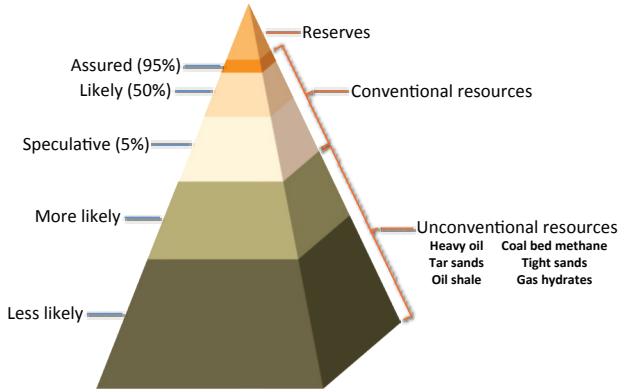
Projected energy demand by 2050



Solutions must scale to the level of 1 CMO/year to make a meaningful impact!

Reserves depend on technology and price!

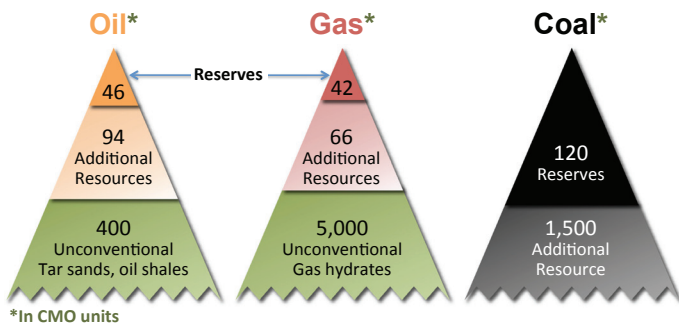
Additional resources become viable with improved technologies and at higher prices...



How much oil, gas, and coal do we have left?

We have plenty of fossil resources, but mostly in unconventional reserves

Conventional fuels will be needed to support energy needs while we switch to other sources



*In CMO units

Continued use of these energy sources increases atmospheric CO₂ levels

Considerations in changing the global energy mix

Does the source have CMO-scale potential to supply energy?

What infrastructure is required for large-scale deployment?

- Is it plug-and-play?
- Will it require new pipelines, transmission structures?

What is its environmental footprint?

- Energy return on fossil energy invested?
- Competing land and water use issues?
- Biodiversity, habitat destruction?



Can it compete with oil at \$50/barrel?

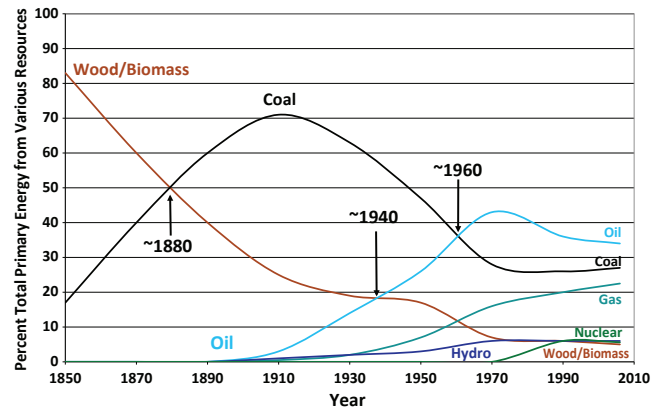
Competition for green energy comes from cheap fossil sources, not other green sources

Producing 1 CMO/year from various sources is an enormous task requiring trillions of \$

What are the alternative energy sources?

The sun offers 23,000 CMO/year in the form of heat, wind, hydroelectric, photovoltaic, and biomass sources

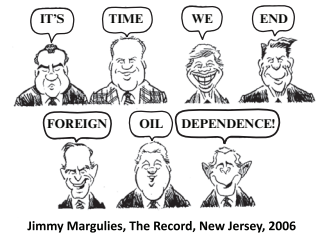
But changing the energy mix takes many decades!



Problems associated with scaling up alternative technologies

Expansion slowed by:

- Inertia of the incumbent system (sheer size)
- Market acceptability (cost)
- Resource limitation
- Infrastructure requirement
- Lack of trained personnel
- NIMBY (not in my backyard)
- NOPE (not on planet earth)
- BANANA (build absolutely nothing, anywhere near anything!)



More rapid penetration possible when aided by:

- Strategic importance to military
- High-value products for niche markets

Producing 1 CMO/year from alternative technologies

Hydroelectric

18 GW with 50% availability (av.)
200 dams – 1 every quarter for 50 years

Nuclear

900 MW with 90% av.
2,500 plants – 1 a week for 50 years

Solar CSP

900 MW with 25% av.
7,700 solar parks – 3 a week for 50 years

Windmills

1.65 MW with 35% av.
3 million – 1,200 a week for 50 years

Solar Roofs

2.1 kW with 20% av.
4.2 billion – 250,000 roofs a day for 50 years

What is the path forward?

Time is of the essence!

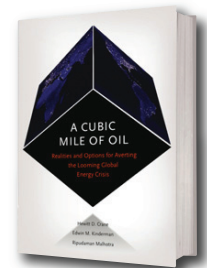
Innovation is needed on all fronts to meet future energy needs

Reducing demand from 9 to 6 CMOs will be a major international effort requiring new technologies

Our planning cycle needs to last 40 years, not 4 years, and transcend the prevailing price of oil

To make an impact, we need all technology options and more...

AND is the operative conjunction!



Don't waste
Be informed
Get involved