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# Energy 101:
## Ten Things Everyone Should Know About Energy

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Seattle Biotech Legacy Foundation
Environmental Health Lecture Series
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# The List

1. Energy cannot be created, destroyed or recycled.

2. Energy from the sun--past and present--create the conditions necessary for life to exist.

3. The climate of Earth is determined by the balance between energy entering and leaving the atmosphere.

4. Natural selection operates on evolutionary strategies that capture and allocate energy among competing uses.

5. Energy transitions are social transitions.

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# The List

6. Energy and economic well-being go hand-in-hand.

7. Struggle for the control of energy generates violent conflict.

8. Energy is a fundamental driver of environmental change and human health at local, regional, and global scales.

9. Energy quality varies markedly among sources.

10. Net energy is an ultimate limit to energy supply.

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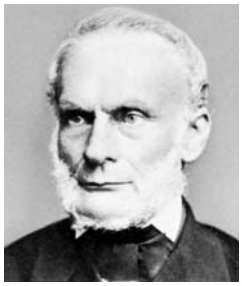
# Principle #1: Energy Cannot be Created, Destroyed or Recycled

- First Law: Conservation of energy



Rudolph Clausius (1822-1888)

- Second Law
  - Energy conversion < 100% efficient
  - Entropy
  - Direction to energy conversion

Sadi Carnot (1796-1832)

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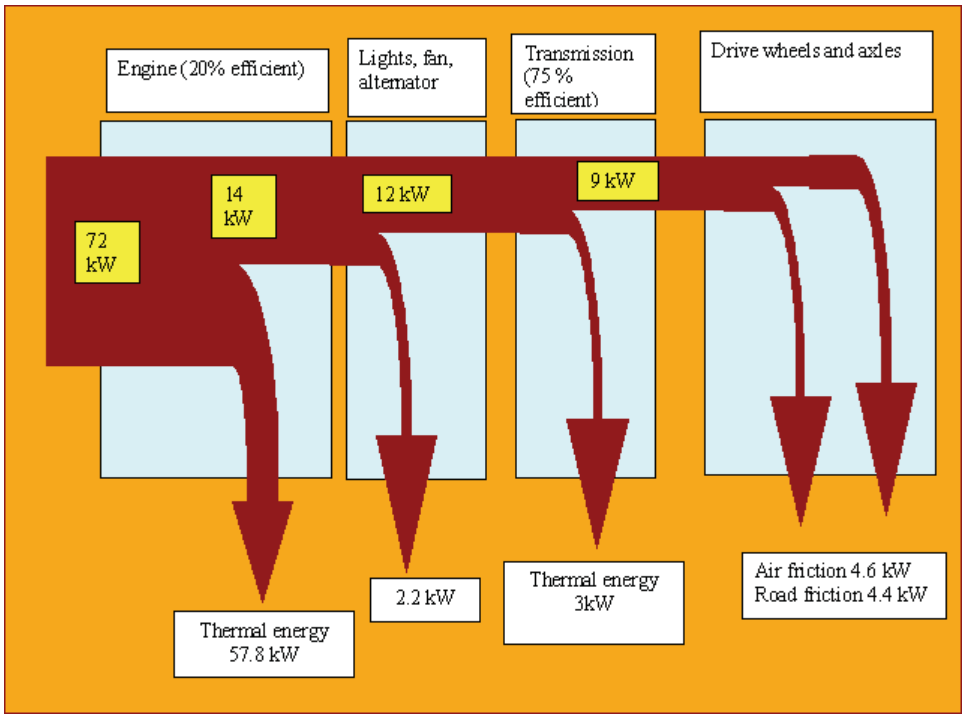
# Second Law



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# Entropy

- Universal tendency towards disorder

- Directionality to energy conversion processes

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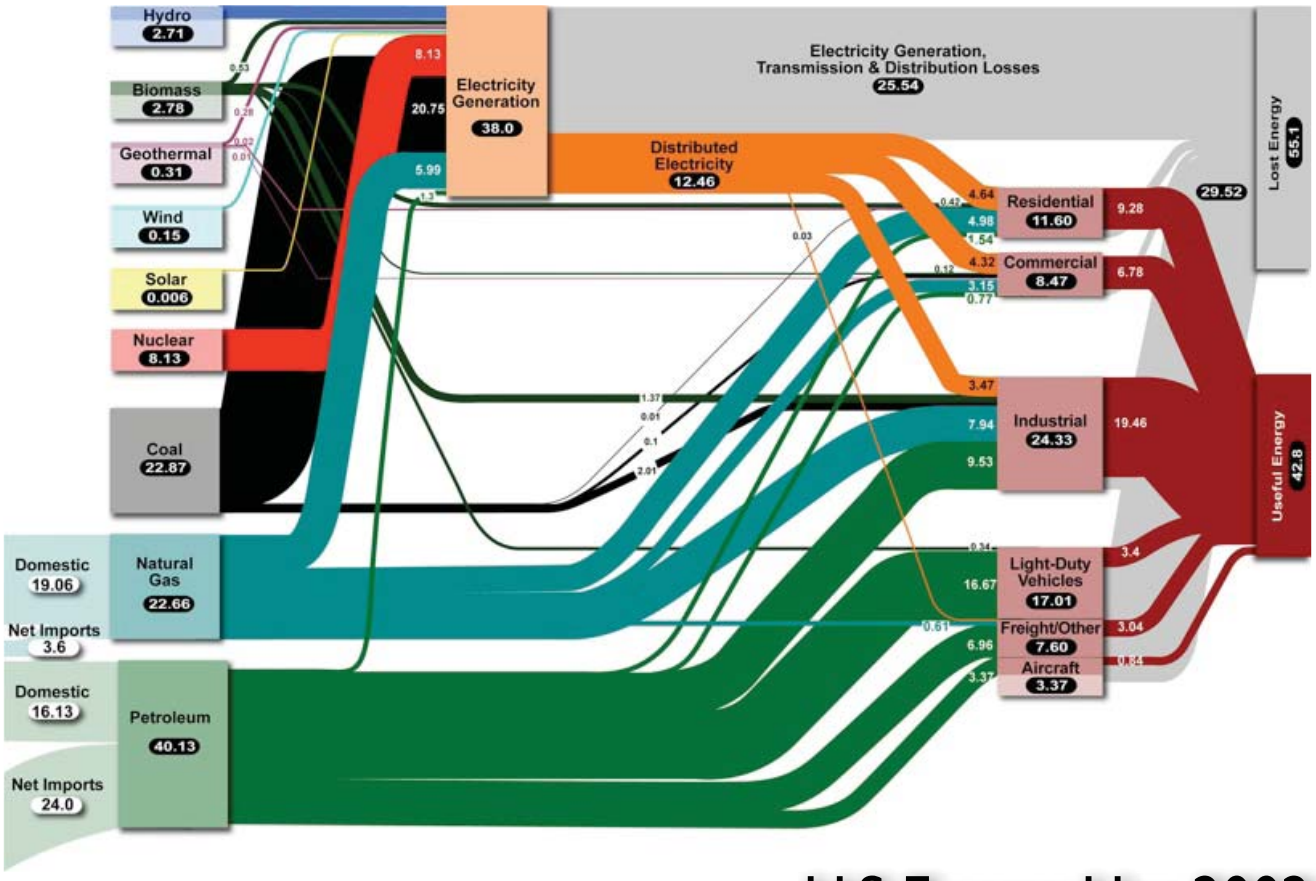


U.S Energy Use 2002

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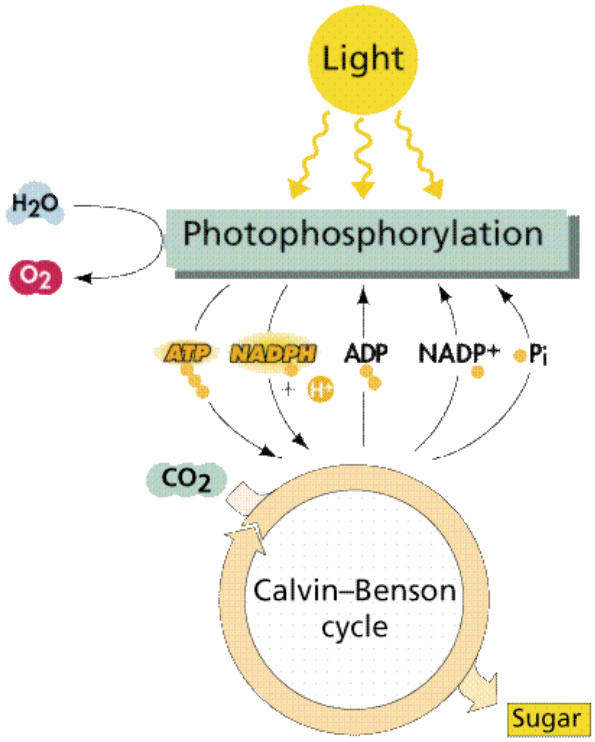
# Principle #2: Solar Energy and Life

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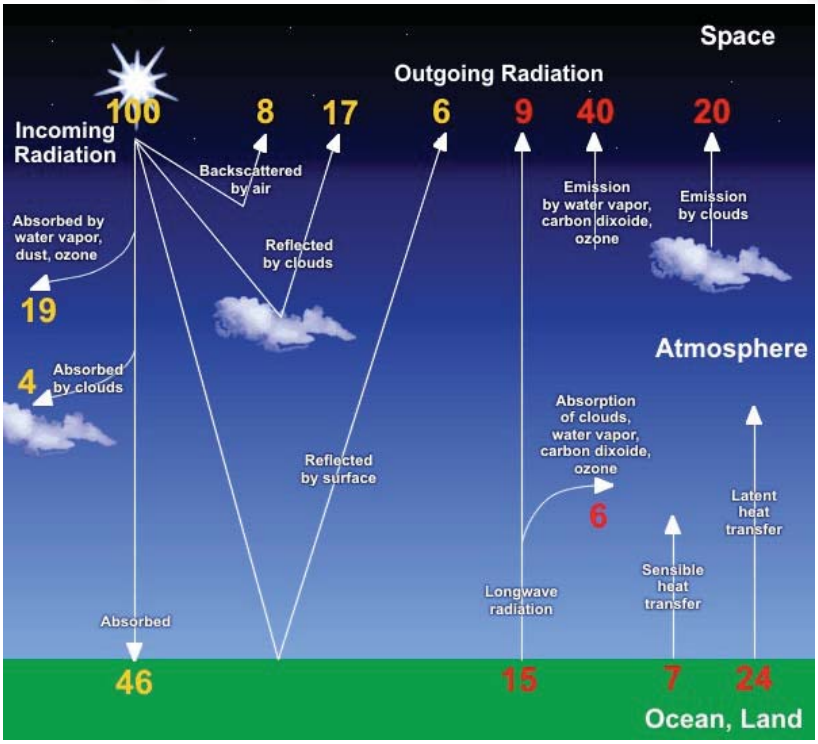
# Principle #3: Climate and Energy

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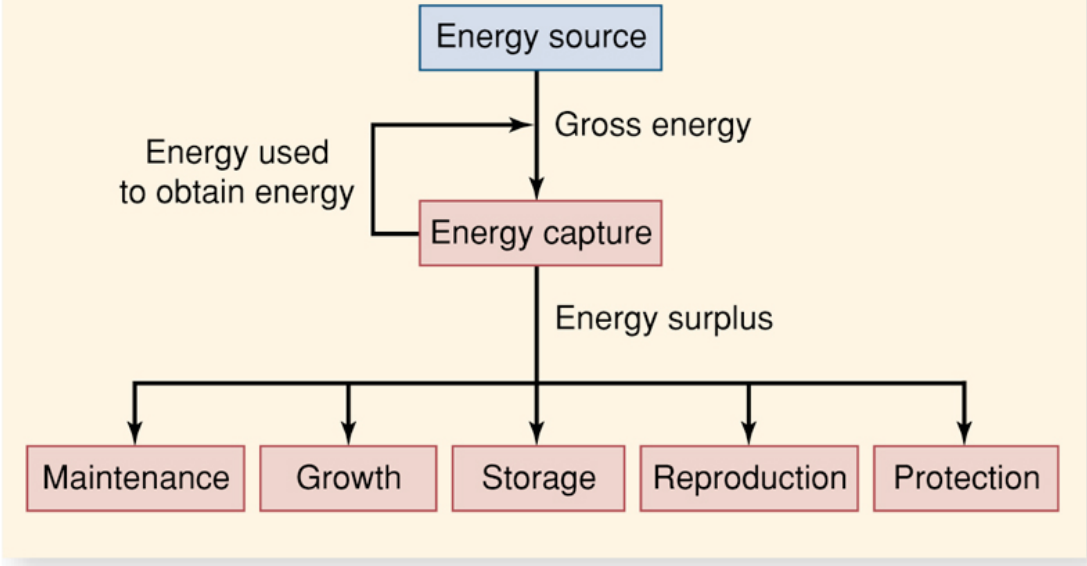
# Principle #4: Energy and Evolution



$$\text{Energy return on investment} = \frac{\text{Gross energy}}{\text{Energy used to obtain energy}}$$

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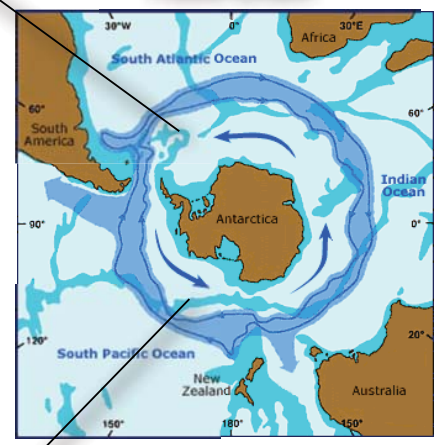
# Principle #4: Energy and Evolution

Blue Whale

Krill

Diatoms

Southern Ocean Food Chain



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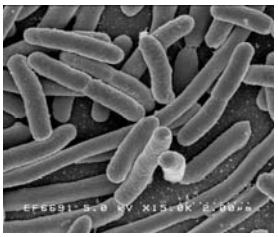
# Principle #4: Energy and Evolution

## Why Breathe Oxygen?

$$C_6H_{12}O_6 \longrightarrow 2C_3H_6O_3 + \text{Energy}$$

glucose — lactate — **47 Units**



Anaerobic pathway

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6\,CO_2 + 6\,H_2O + \text{Energy}$$

glucose — oxygen — carbon dioxide — water — **686 Units**

Aerobic pathway

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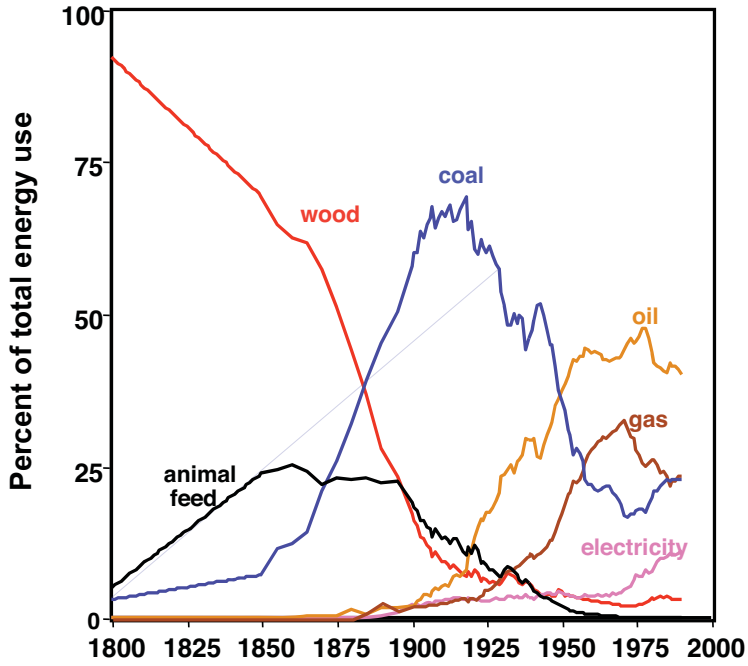
# Principle #5: Energy Transitions Are Social Transitions

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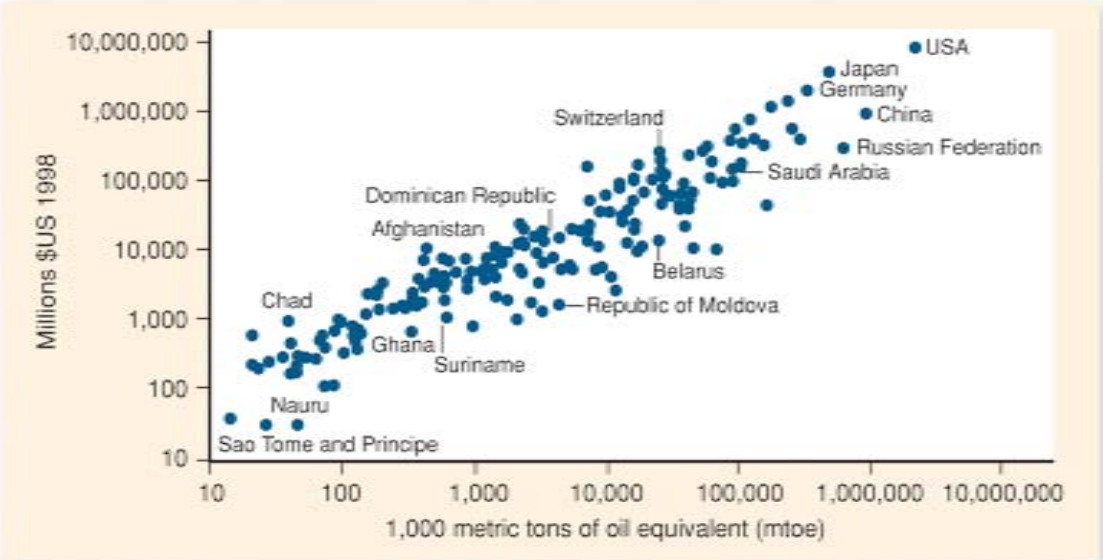
# Principle #6: Energy & Economic Growth



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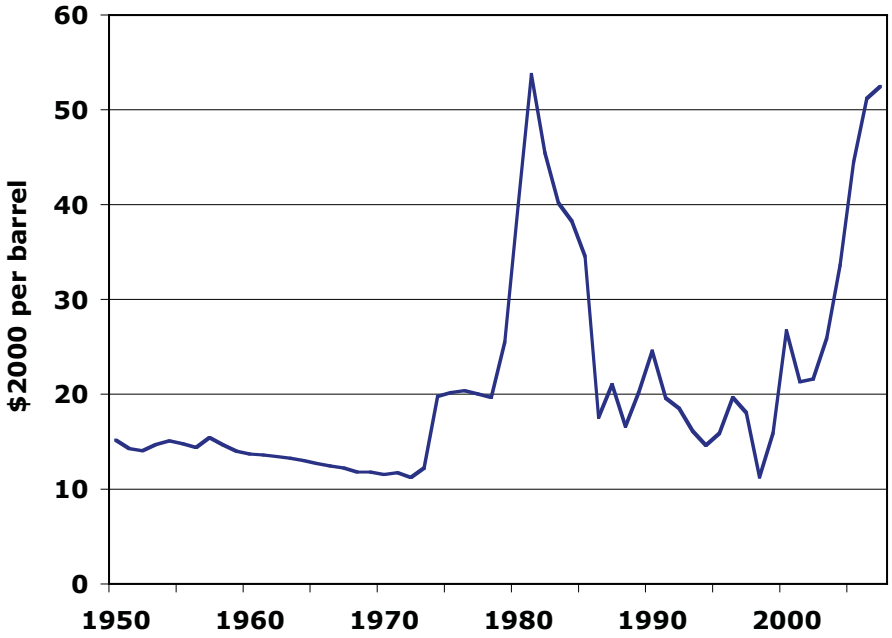
# Crude Oil Prices, 1950-2007

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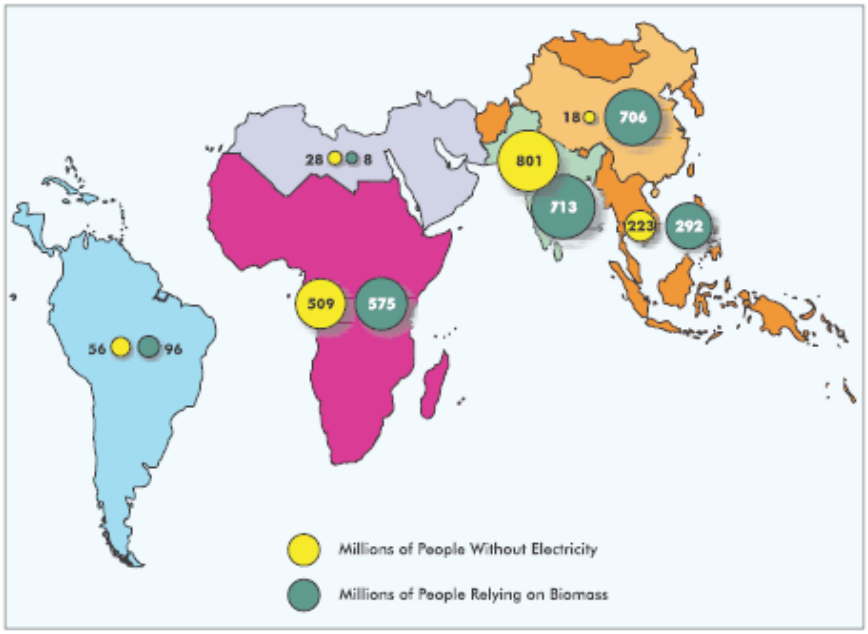
# Energy and Well-Being




Source: IEA analysis.

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# Principle #7: Energy and Conflict

Access to sufficient amounts and types of energy is a central strategic, economic and political goal for nations:

- land (ability to fuel people and animals)
- timber
- hydropower
- coal
- oil and gas

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# Energy and Conflict: "Spar" Timber


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# Energy and Conflict: Oil

- World War I: Armenian and British forces defend Baku oil fields for Russia against German and Turkish invaders

- World War II:
  - oil is central to the execution and strategy of war
  - Japan invades oil-rich Indonesian islands after U.S. export embargo
  - Germany invades USSR to gain possession of Russian oil fields in Caucasus mountains

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# Energy and Conflict: Oil

- U.S. and Britain orchestrate 1953 overthrow of Prime Minister Mohammed Mossadegh of Iran

- Gulf War erupts after Iraq invades Kuwait and seizes control of its oil fields

- In Nigeria, armed ethnic militias and government forces vie for spoils of oil rich Niger delta

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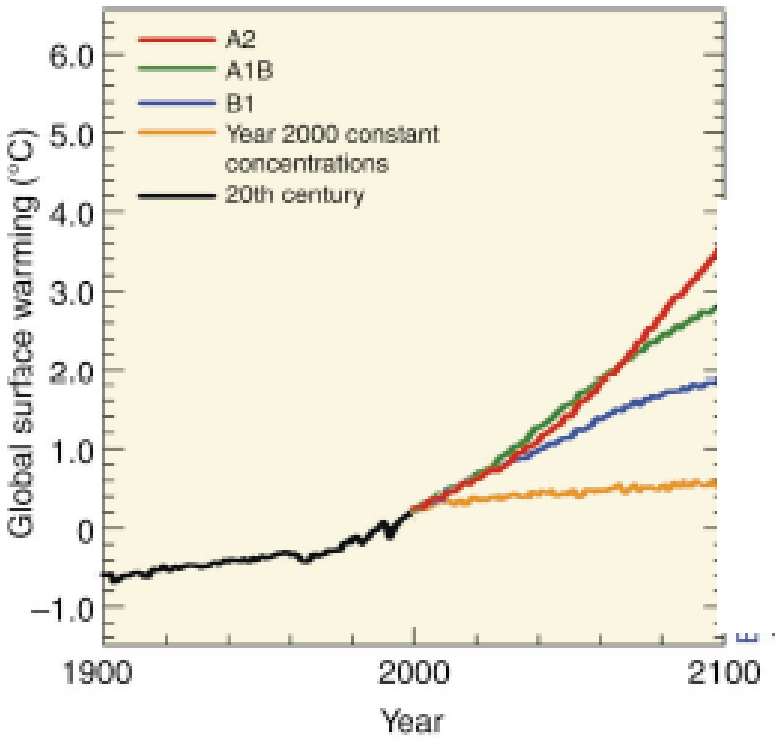
# Principle #8: Energy and Environmental/ Human Health



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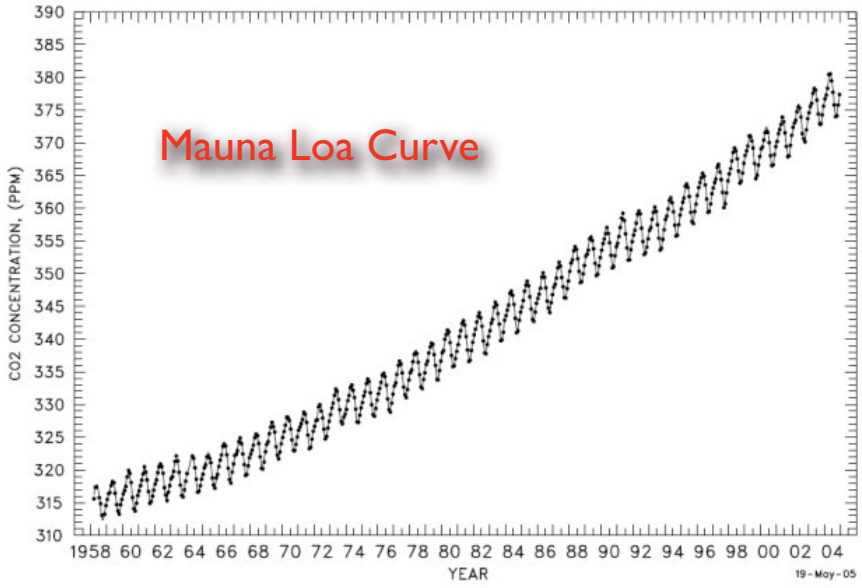
# Energy & Climate Change

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# Energy and Human Health

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# Principle #9: Energy Quality

- The economic usefulness of a heat unit of fuel or electricity:
  - How much GDP can 1 joule produce?
- What determines energy quality?
  - cost
  - weight
  - density
  - safety
  - amenability to storage
  - heat content
  - pollution intensity
  - conversion efficiency
  - ease of transport
  - intermittency
  - spatial distribution

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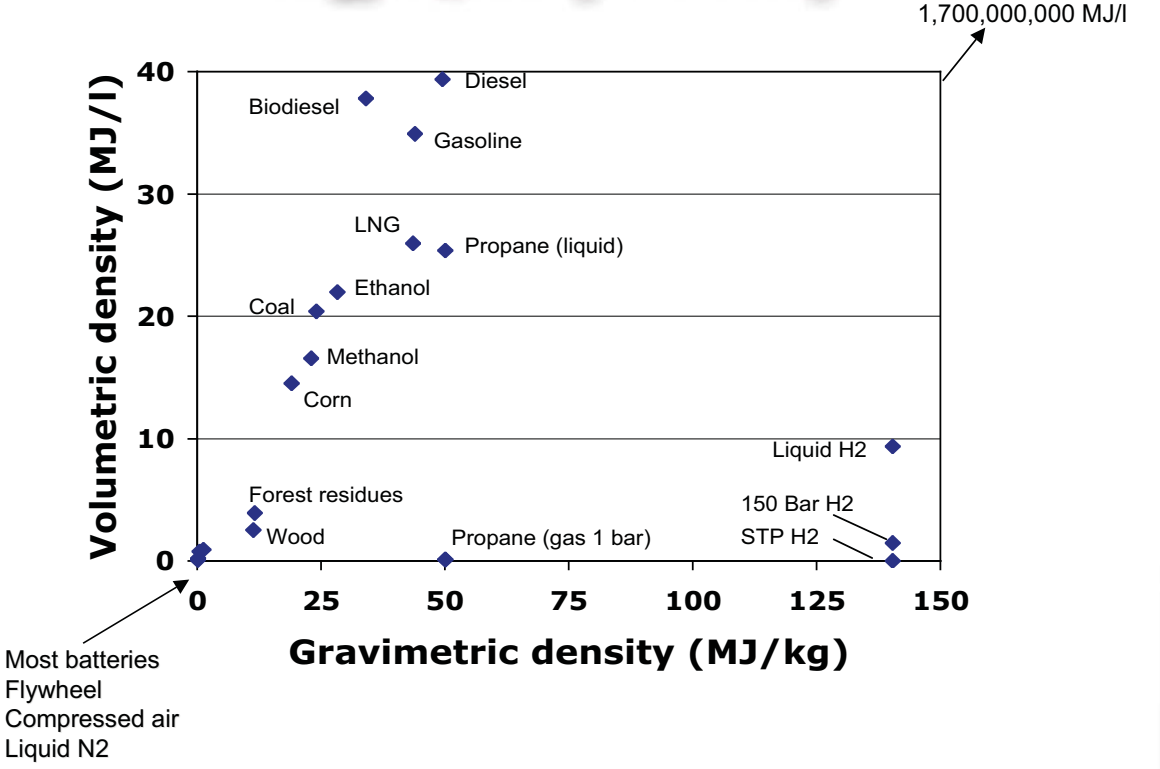
# Energy Quality: Density



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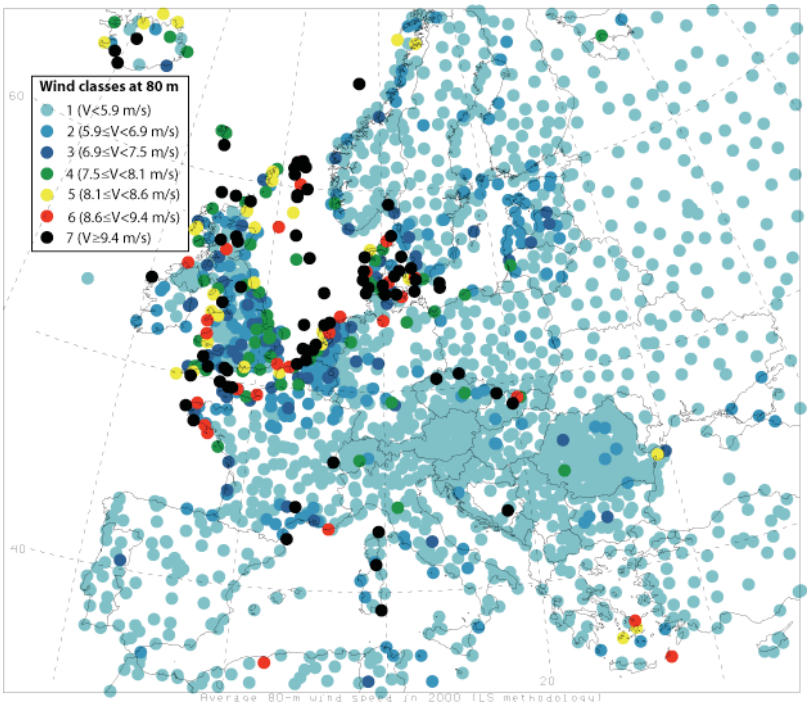
# Energy Quality: Spatial Distribution

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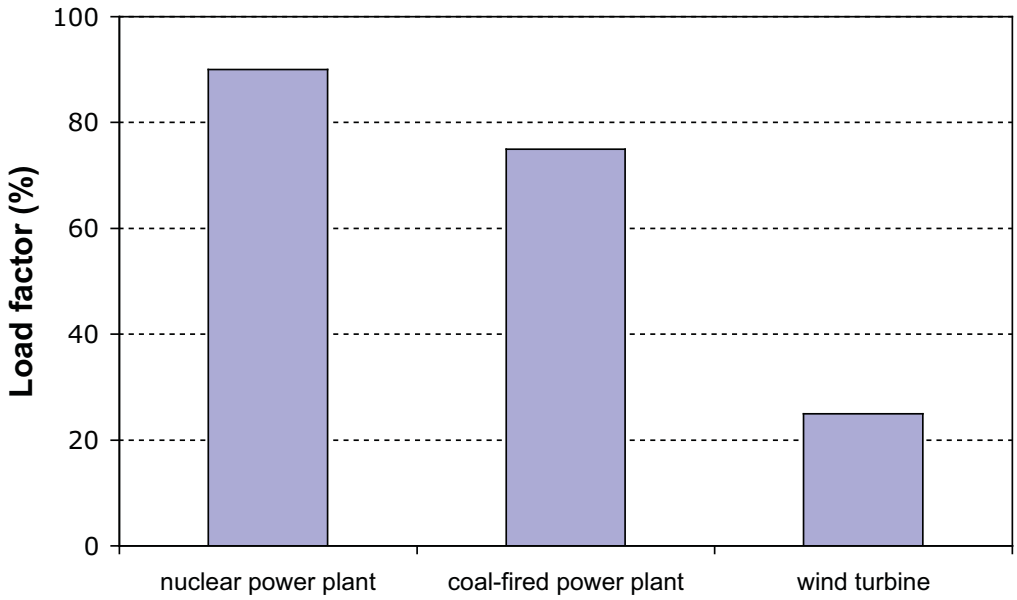
# Energy Quality: Intermittency

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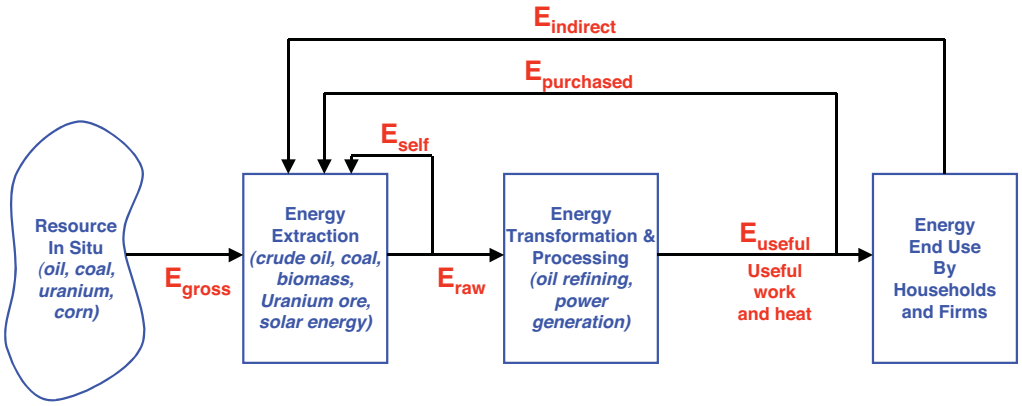
# Principle #10: Net Energy is Ultimate Limit




$$\text{Energy Return on Investment} = \frac{E_{useful}}{E_{self} + E_{purchased} + E_{indirect}}$$

$$\text{Energy Surplus} = E_{useful} - \frac{E_{useful}}{E_{self} + E_{purchased} + E_{indirect}}$$

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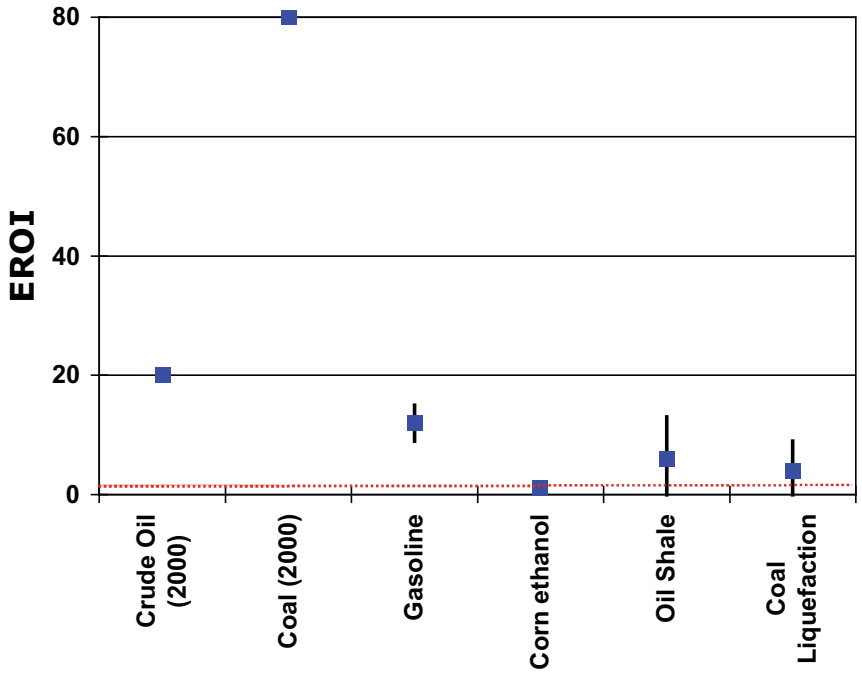
# EROI for Fuel Systems

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# Concluding Thoughts

- Attributes of future energy systems will constrain future economic and social aspirations
- The struggle for the control of remaining supplies of oil will intensify
- Carbon issue may trump everything

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