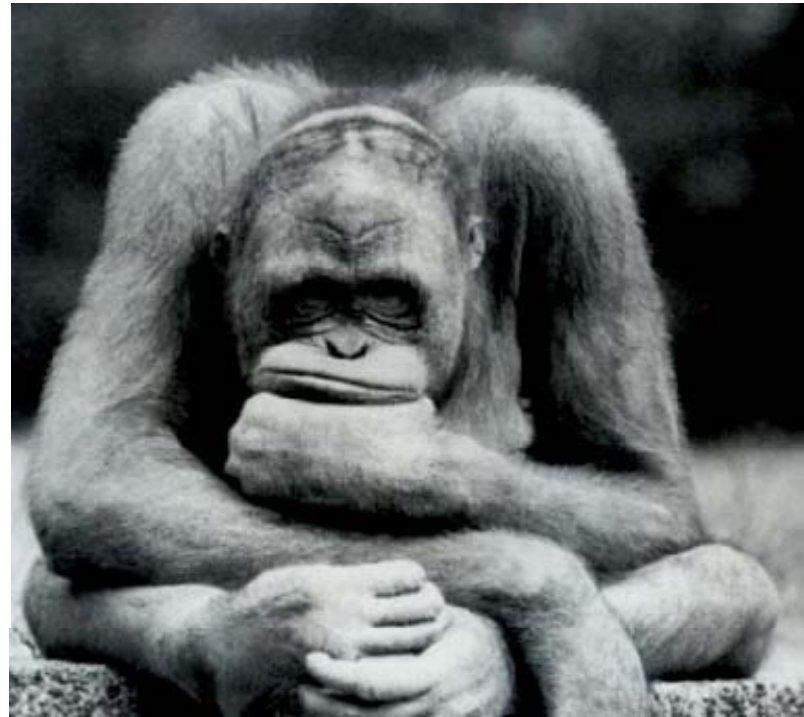


# *Energy, What now?*



# ***Outline for “Energy, Now What?”***

- ***Why do we need it and how much do we need?***
- ***How much are we using?***
- ***Where do we get our energy?***
- ***All Fossil Fuels are not created equal: Coal is a real threat***
- ***What are the trends in energy use?***
- ***Who is using all this energy, anyway?***
- ***How can we cover our future needs? A hypothetical scenario.***
- ***Renewables: which ones make sense?***
- ***Efficiency: A revolution waiting to happen***
- ***What is our concept of sustainability?***
- ***Are Eco-freaks protecting the planet?***

How Much energy do we need to  
survive?

# **The 100 Watt survival level**

*The human body needs about 100 Watts of power to run*



*some need more than others...*

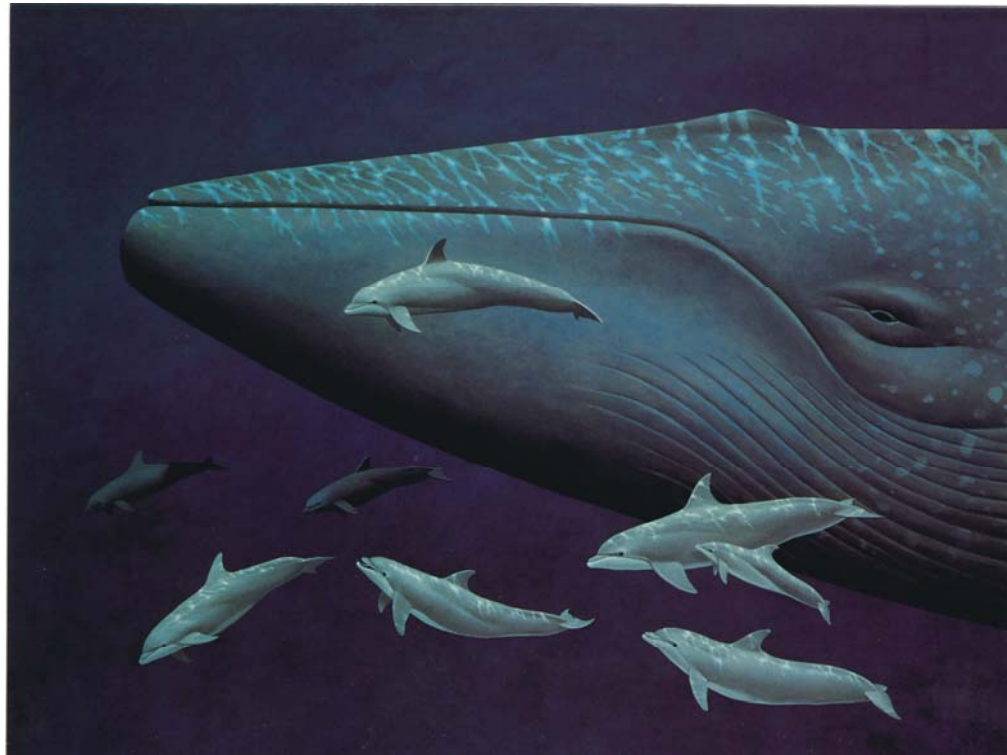
How Much energy are we using?

*The average western energy consumption for an individual is the equivalent of 50-100 human power*



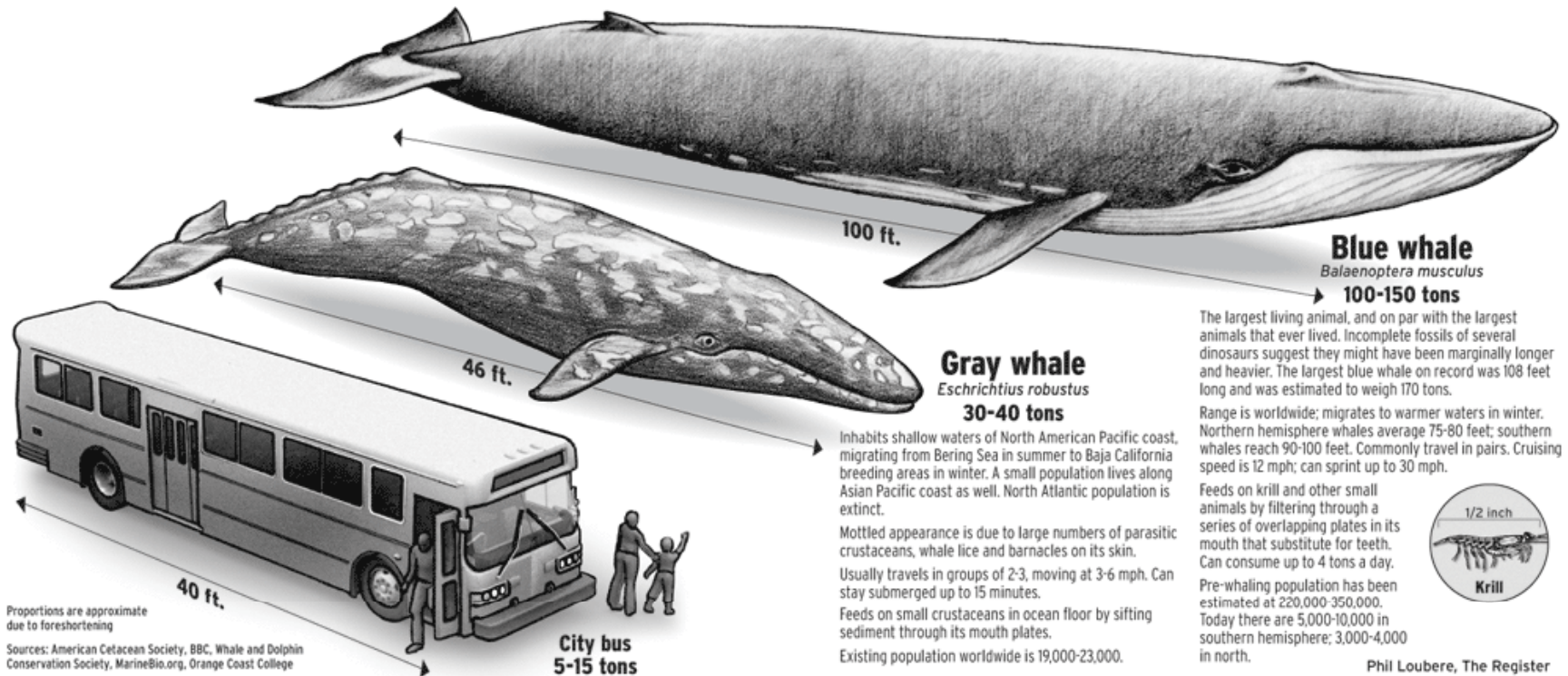
*Why do we all need so many slaves?*

*The mass of coal needed to produce the energy for a family of four for one year in the US today is about the same as that of a healthy blue whale.*



*This is about the same amount of Carbon pollution produced by that family in one year.*

*The size of things: An average US family burns a pile of coal equal to the mass of a Blue whale every single year.*



*In Germany, energy use is lower and things aren't as bad. It is only a gray whale.*



# A conversation in a parallel universe where CO<sub>2</sub> sinks

*Morning Ma'am!  
What would you like  
us to do with your  
gray whale next year?*



*Oh Dear...*

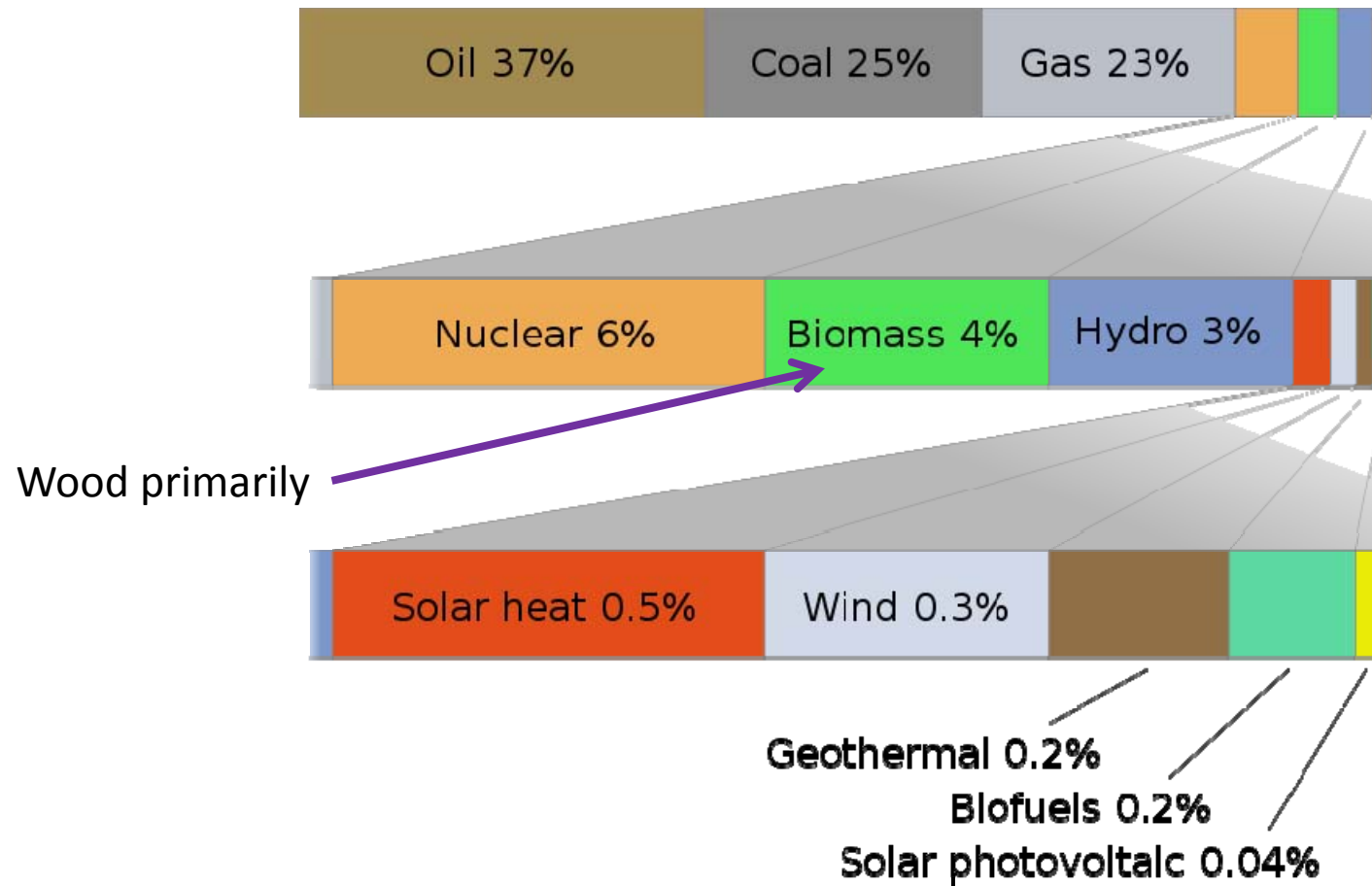


*Where does our energy come from?*



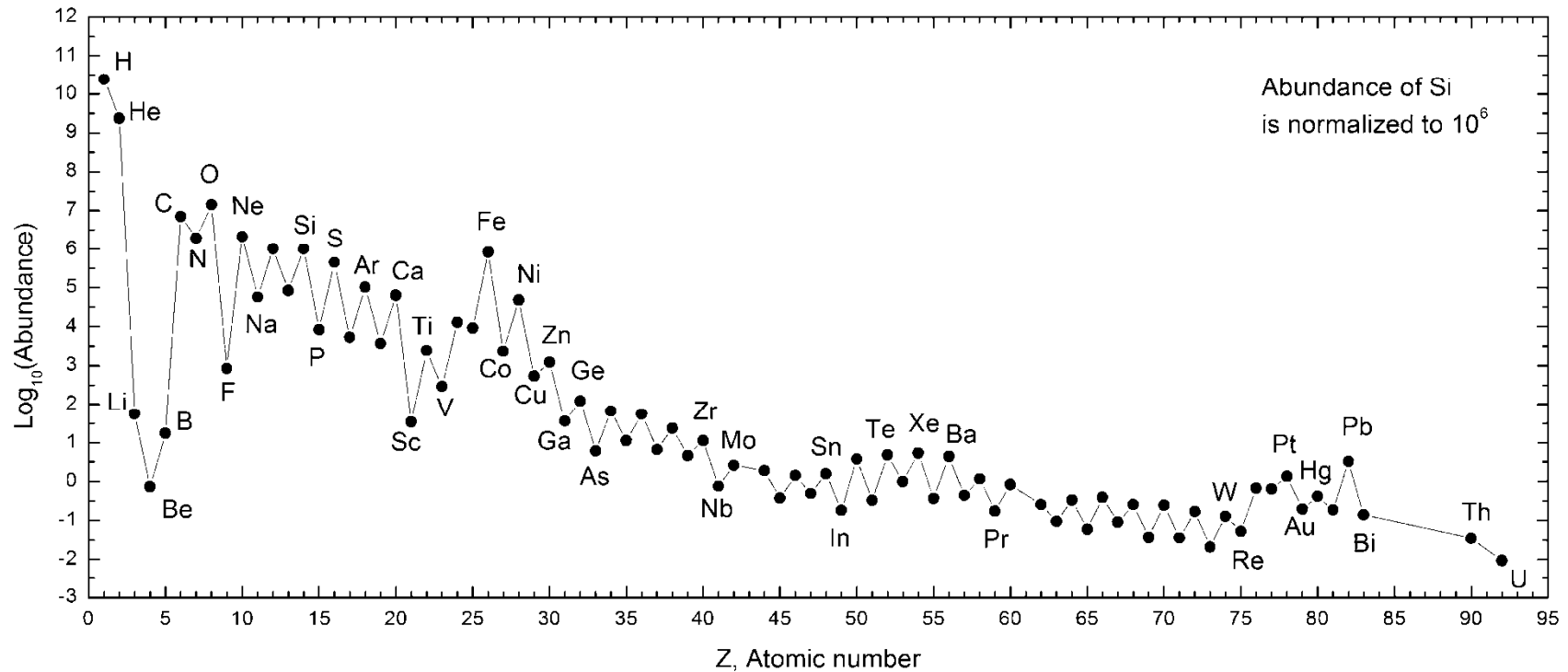
*The short answer is: We burn things!*

# *Where does our energy come from?*

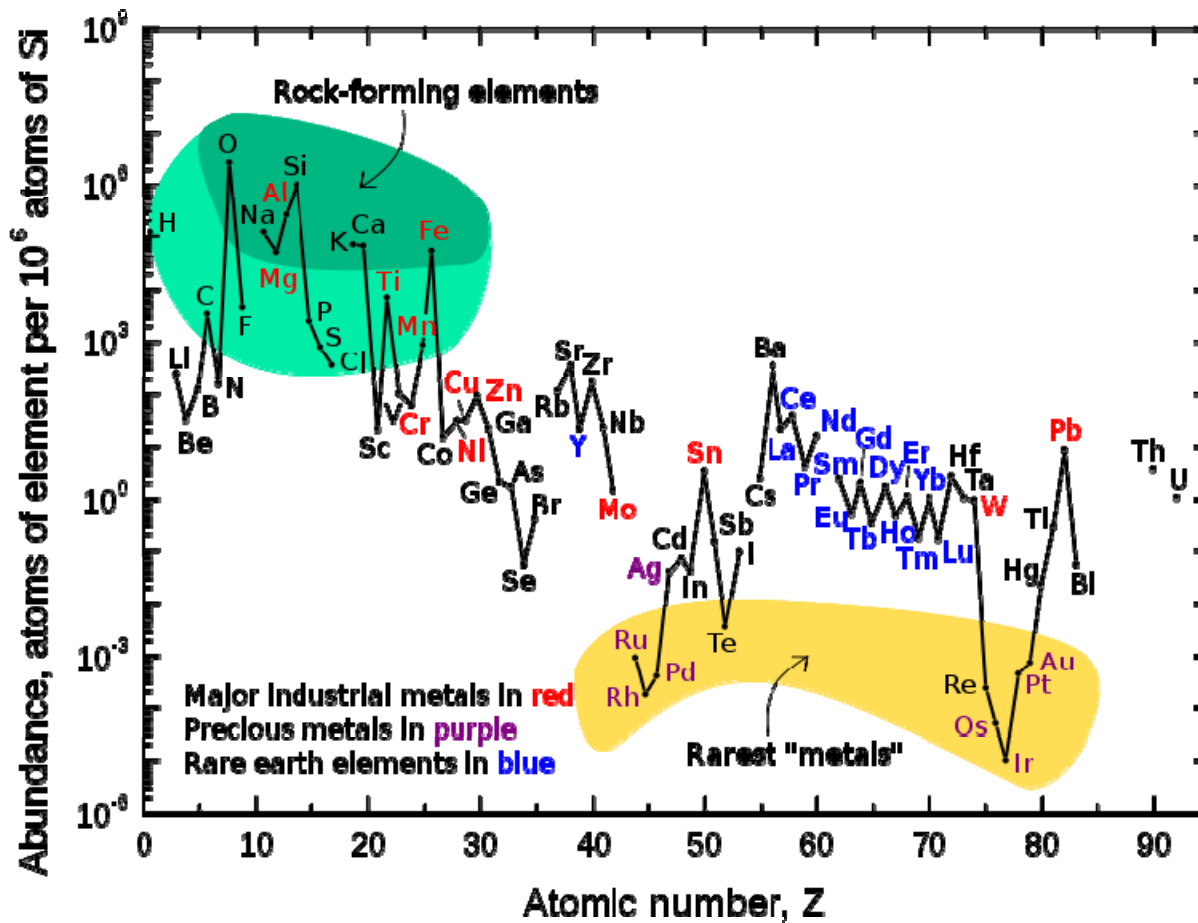


# Where does all the carbon come from?

*Natural abundance of the elements in the universe*



# Natural abundance in the Earth's Crust

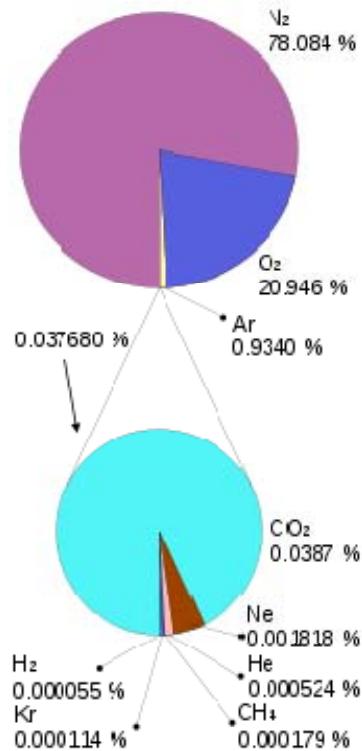


# *The Earth's crust is loaded with Carbon*



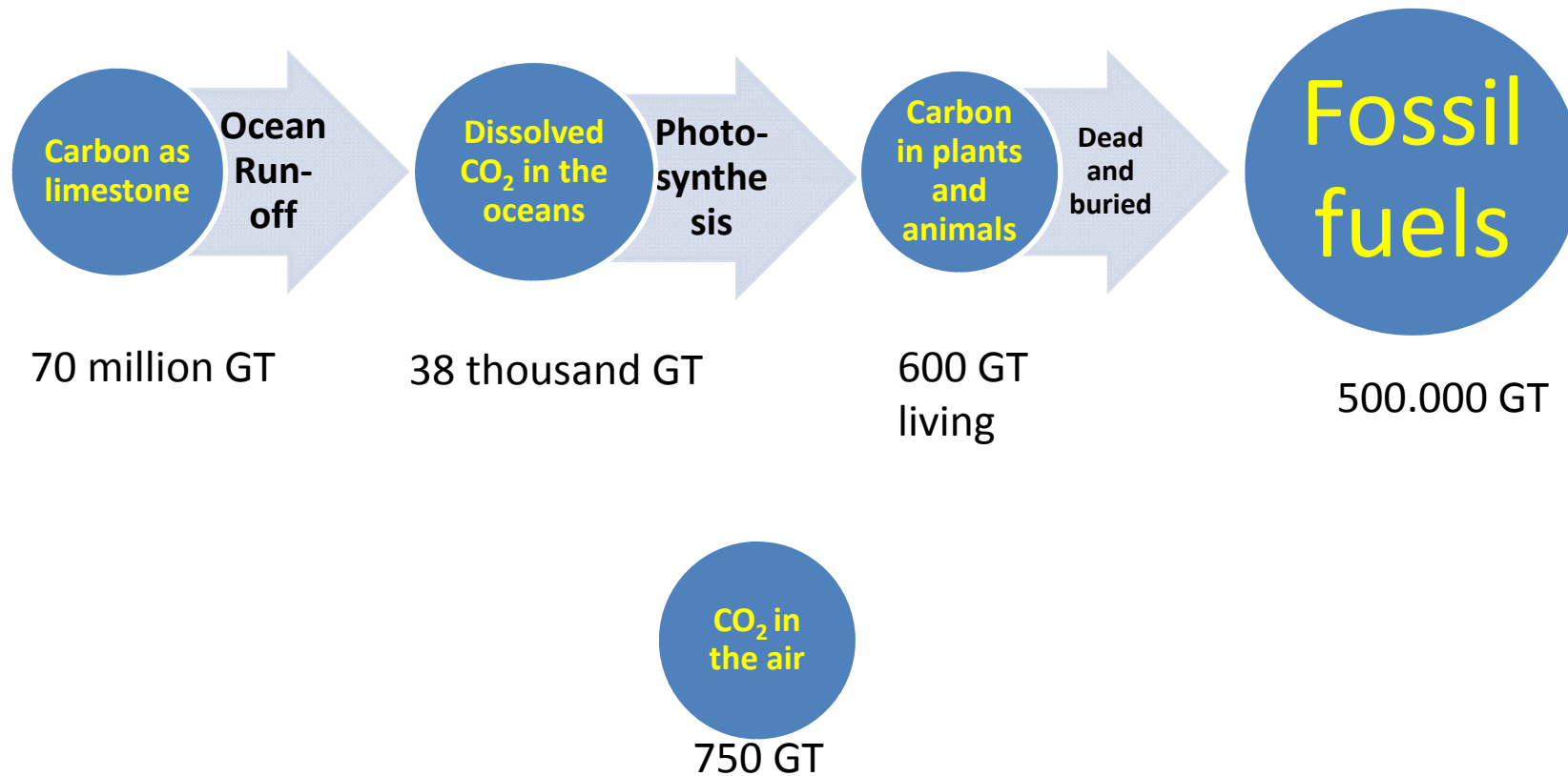
*Limestone ( $\text{CaCO}_3$ ) Cliffs in Corsica France*

# The Earth's modern atmosphere containing Oxygen comes from photosynthesis



*CO<sub>2</sub> is absorbed  
O<sub>2</sub> is emitted  
And Carbon is built into the plant's body*

# Carbon migration over the last 500 million years





**Dissolved CO<sub>2</sub> in  
the oceans  
38.000 GT**

**Carbonates in rock  
e.g. Limestone  
70.000.000 GT**

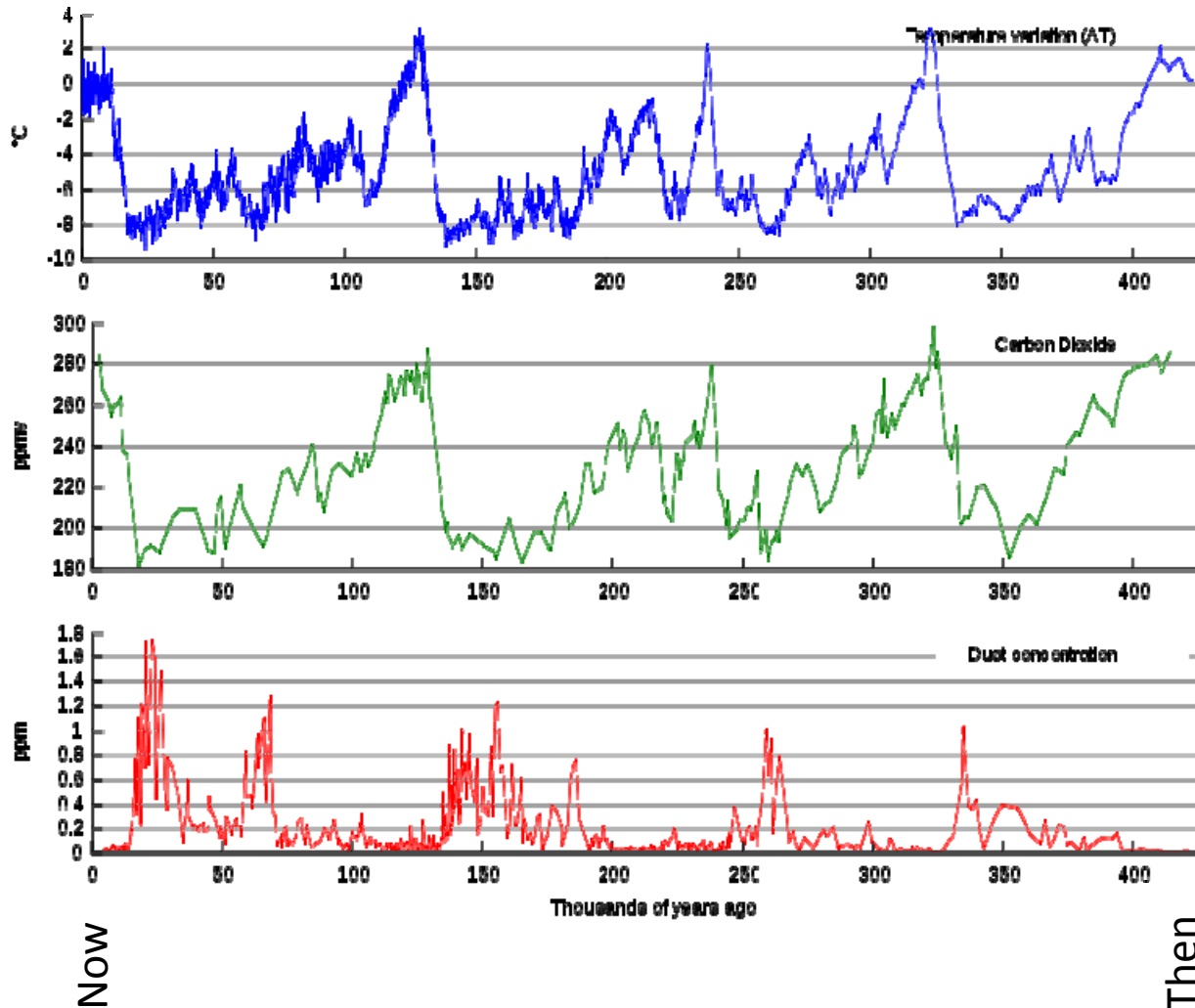
**Carbon in Plants and Animals  
living and dead  
(nominally fossil fuels  
accessible or not)  
500.000 GT**

**Carbon  
involved in  
deforestation  
450 GT**

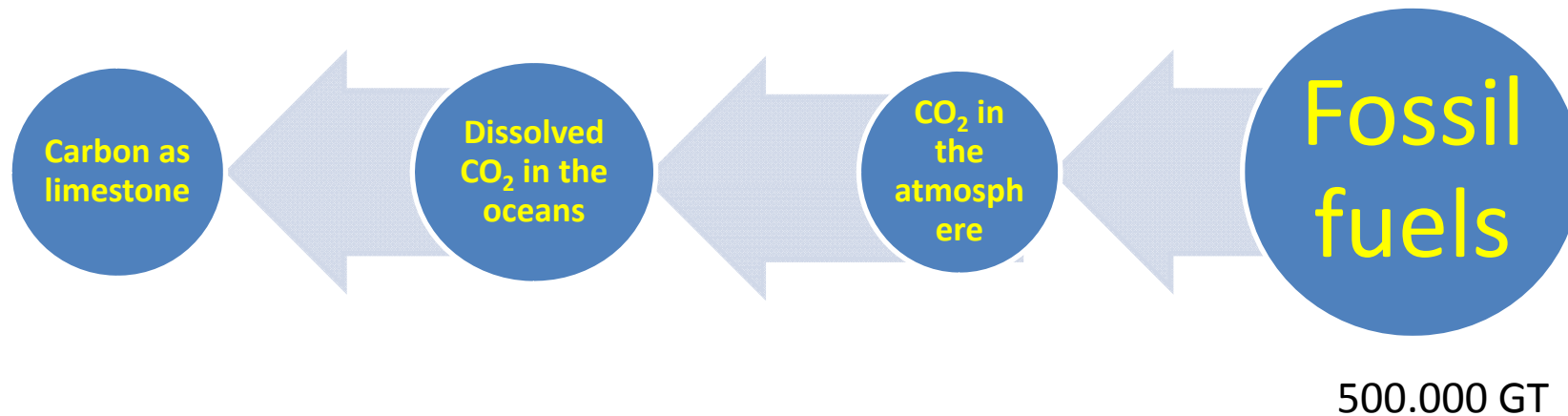
**Carbon in  
living plants  
and animals  
600 GT**

**CO<sub>2</sub> in the  
air  
700 GT**

# *The Carbon record over the last 400.000 years*

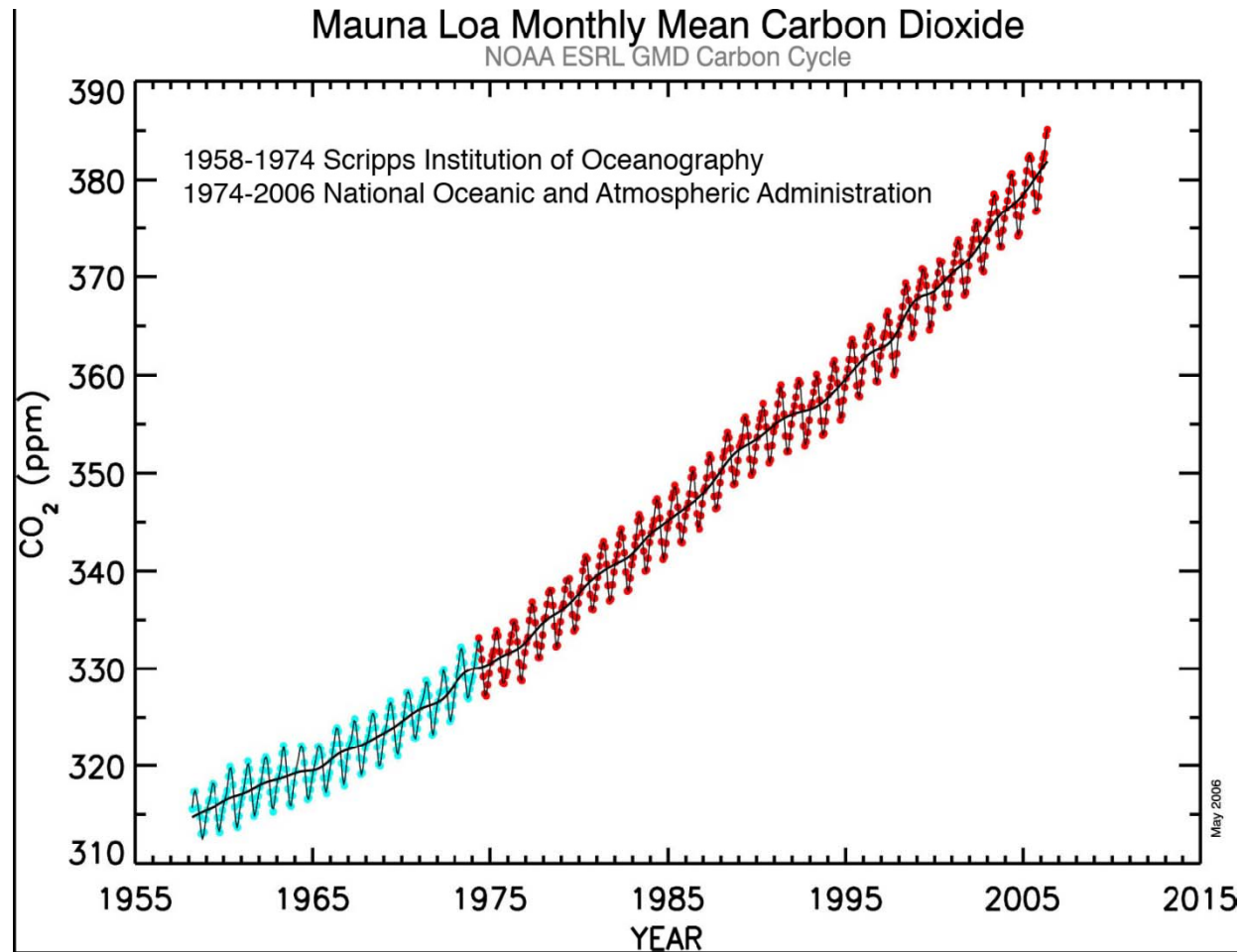


# We've reversed the carbon migration direction



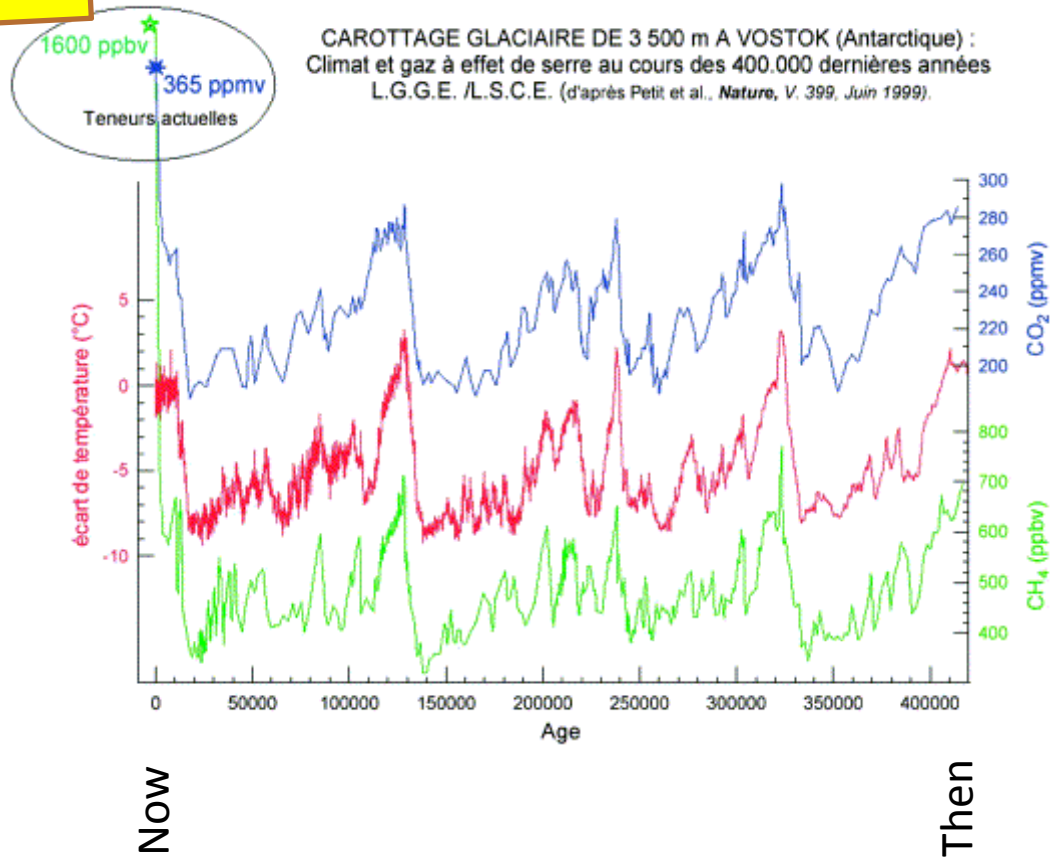
*And sped it up by a factor of one million*

# *Modern atmospheric carbon record*



Highest known concentrations of CO<sub>2</sub> and methane in planetary history

# Vostok Ice-core Data



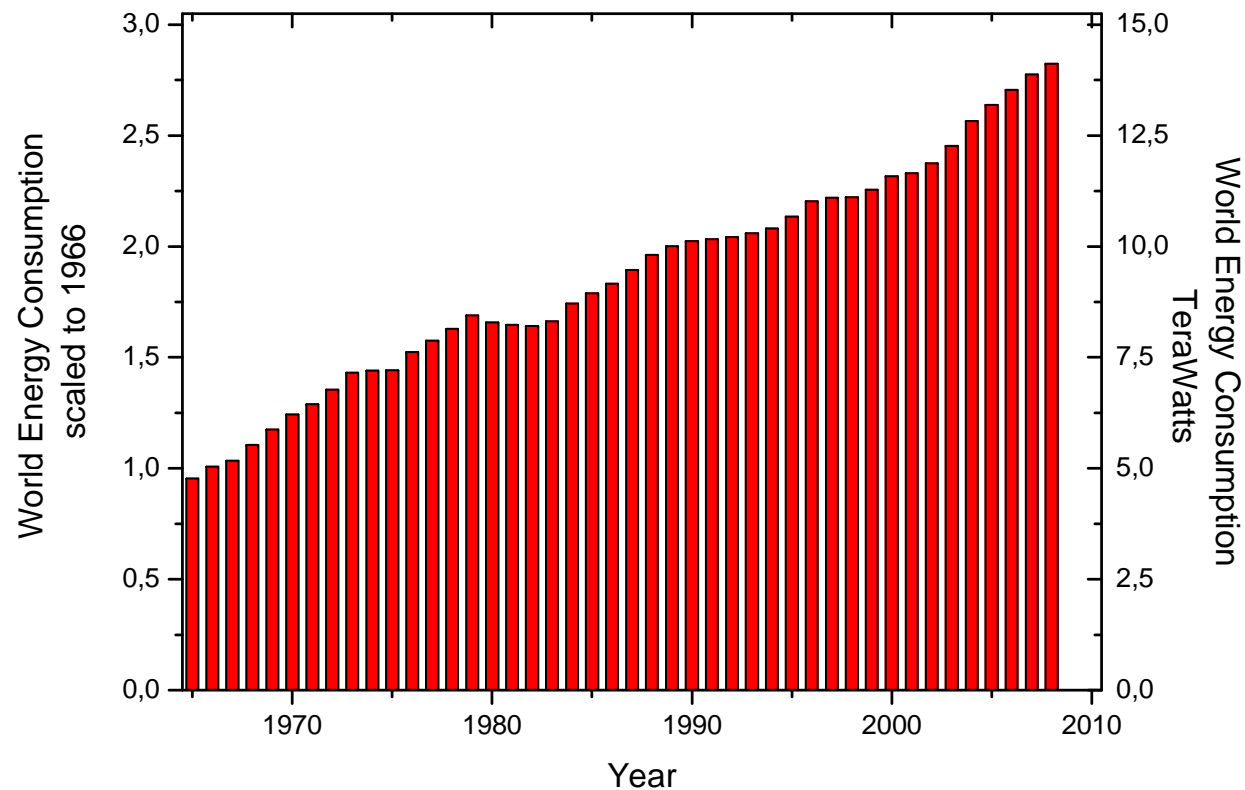
*We are doing an experiment on the planet, whose outcome is unknown...*



*The outcome of this experiment is too uncertain to continue on the only planet we have.*

What are the trends in energy  
consumption

*World energy consumption over the last 50 years. Three times increase.*



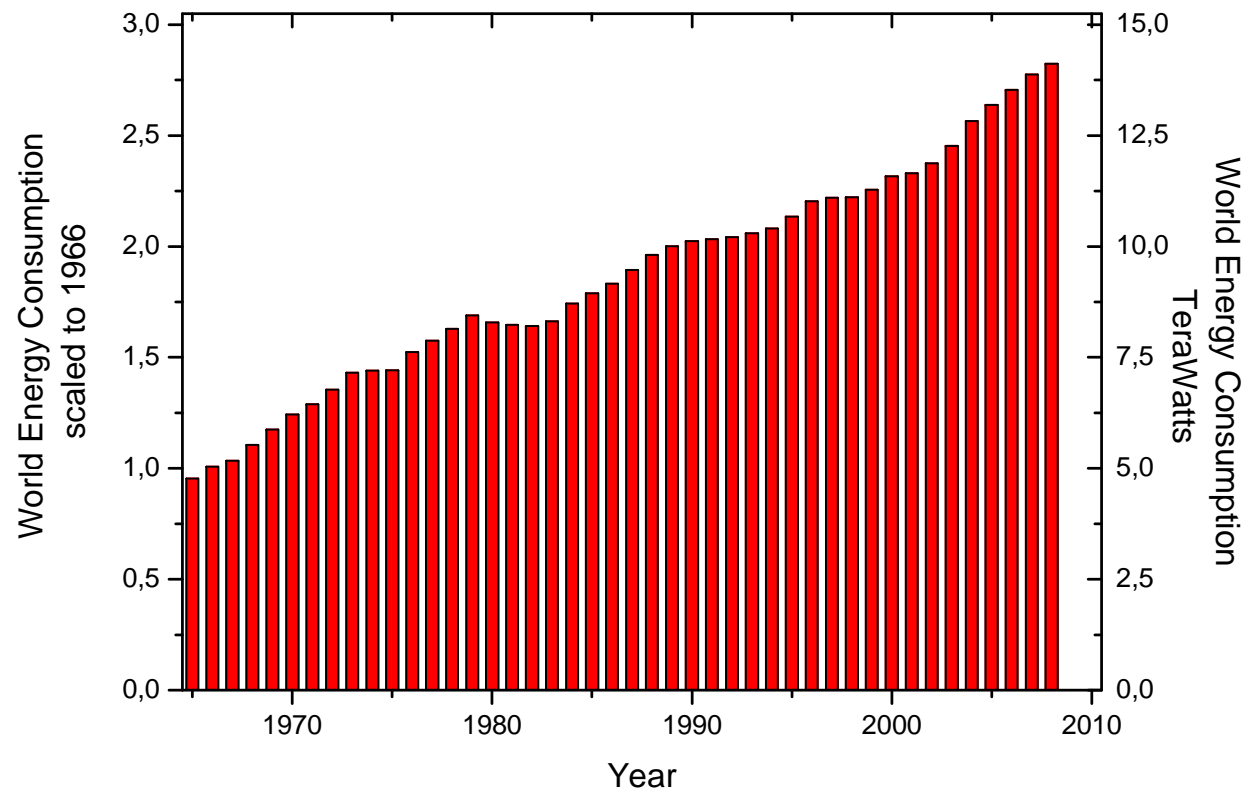


# *How much is a Terawatt?*



If everyone in the world turns on a Color TV that's about a **TeraWatt**. The world uses 15 TWatts and consumption is growing.

*World energy consumption over the last 50 years. Three times increase.*



*If it takes us 50 years to find a new way and to put into place a plan to produce 15 TWatts of power, will the world be using 25 TWatts by the time we are done?*

# It's a question of lifestyle, not population

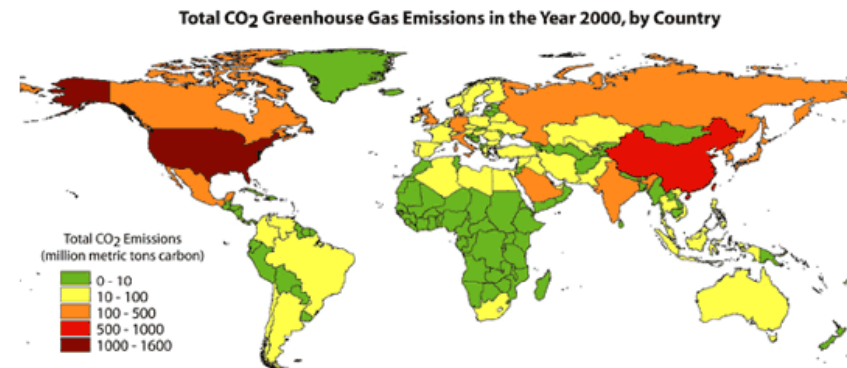
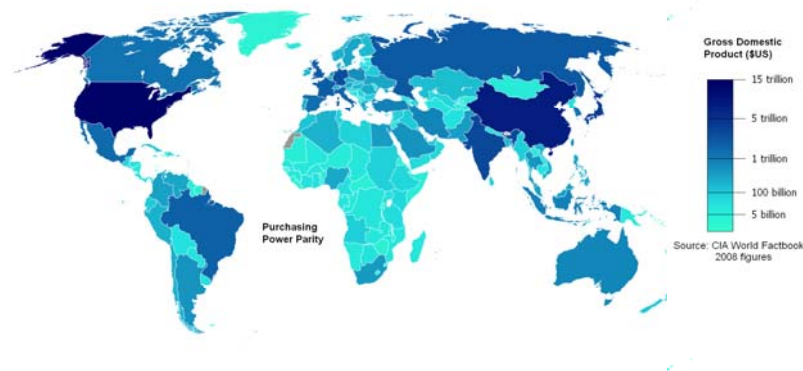


*So-called primitive cultures live closer to the 100 Watt survival level than we are accustomed to.*



*We in the so-called developed countries have a different lifestyle.*

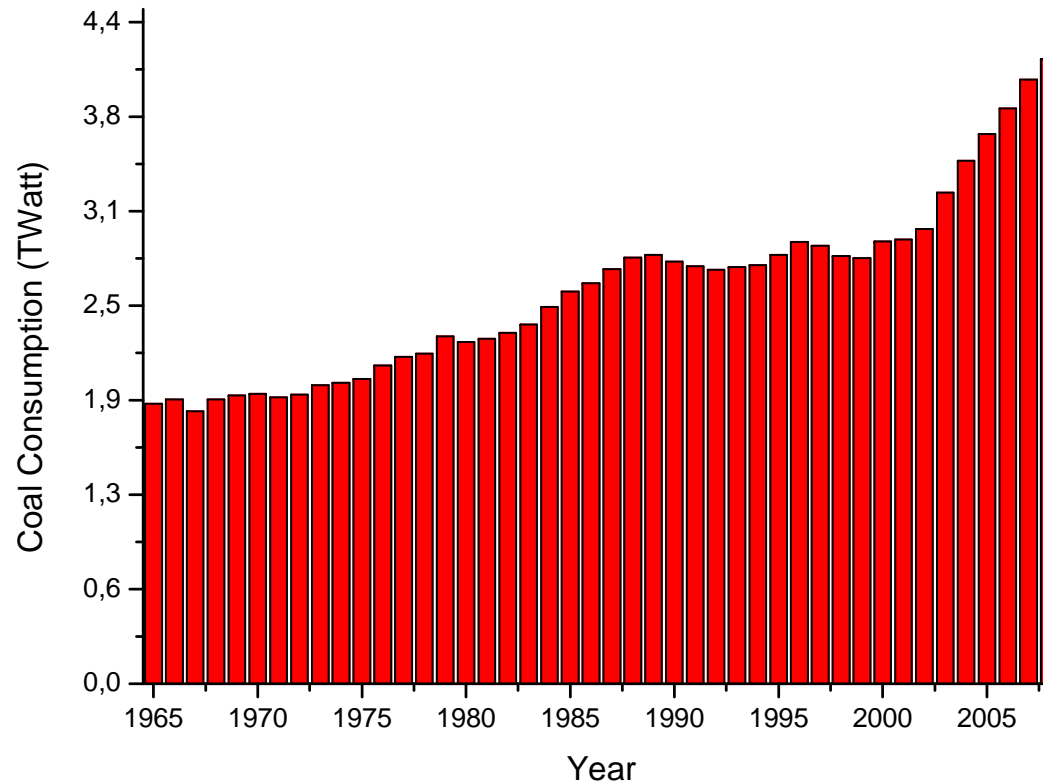
# Who consumes energy?



*CO<sub>2</sub> pollution roughly correlates with the wealth of a nation.*

*Its not the “population bomb” we have to worry about. It’s the “Affluence Bomb”*

# *Coal – A major threat to the Climate*



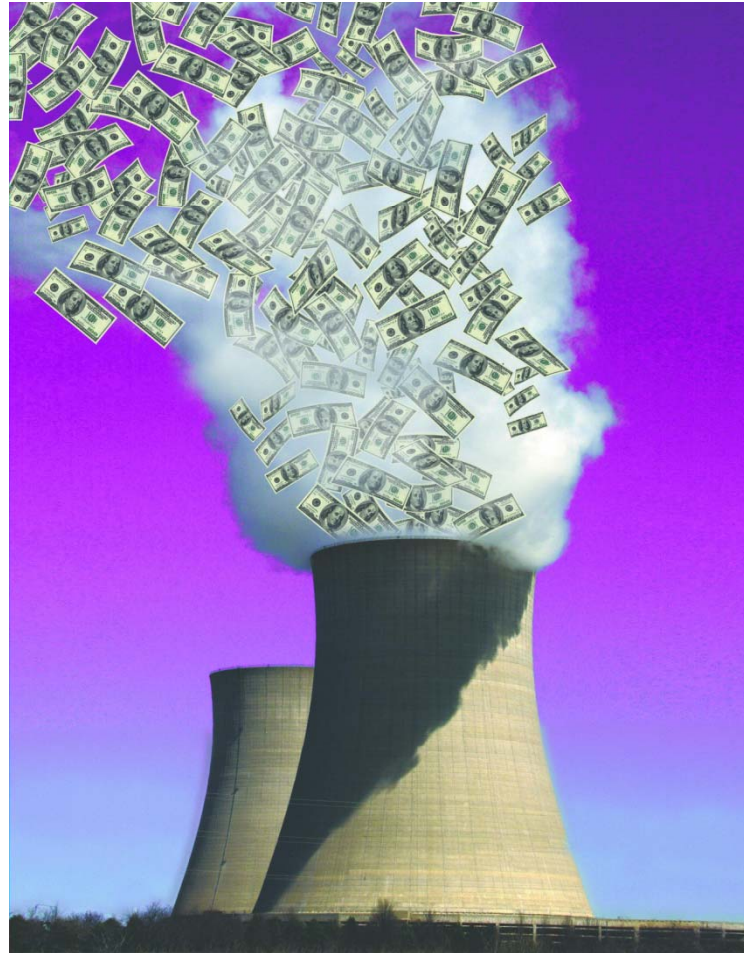
*Coal produces twice as much CO<sub>2</sub> for every unit of energy compared to natural gas. And it is the fastest growing source of power in the world.  
An increase of 1.5 TWatts since 2000.*

# All fossil fuels are not created equal



*If we manage to convert all coal usage to natural gas, we could reduce Carbon emissions by twice the Kyoto protocol.*

*How can we cover our future energy needs without fossil fuels?*



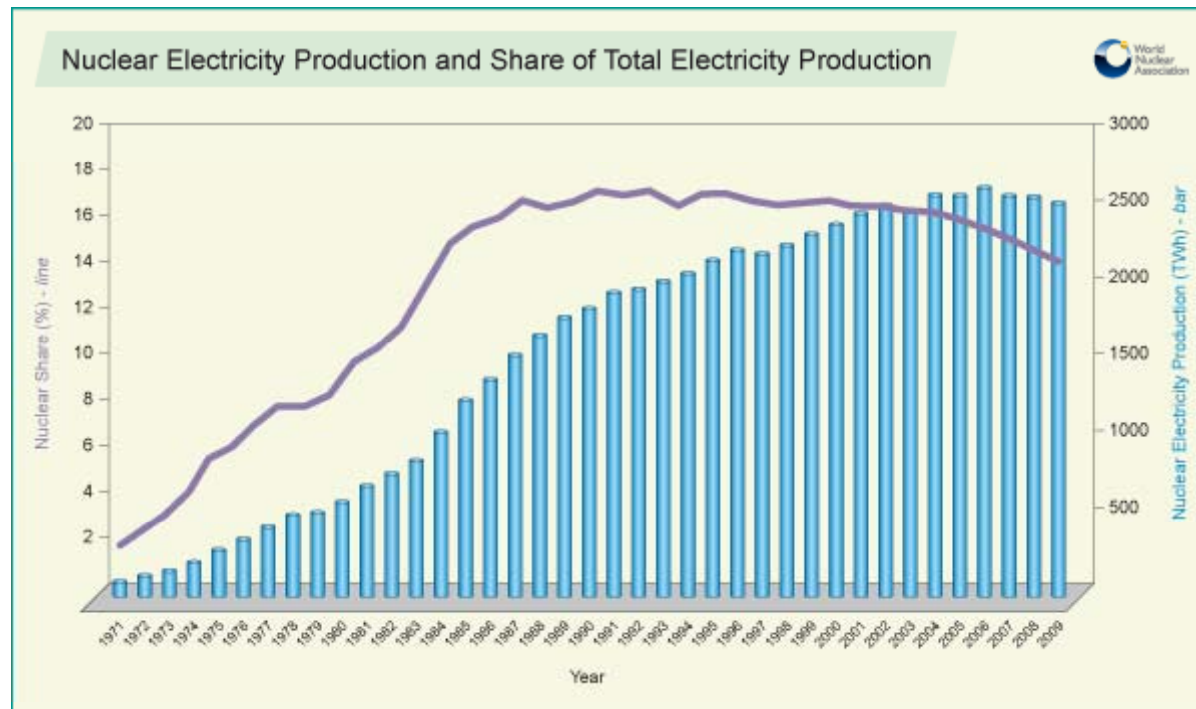
*We would need 15-30.000 new nuclear reactors in the next 50 years*



*There are presently 500 world wide and 60 under construction*



# *Nuclear power: The only sector of the energy industry that is actually shrinking*

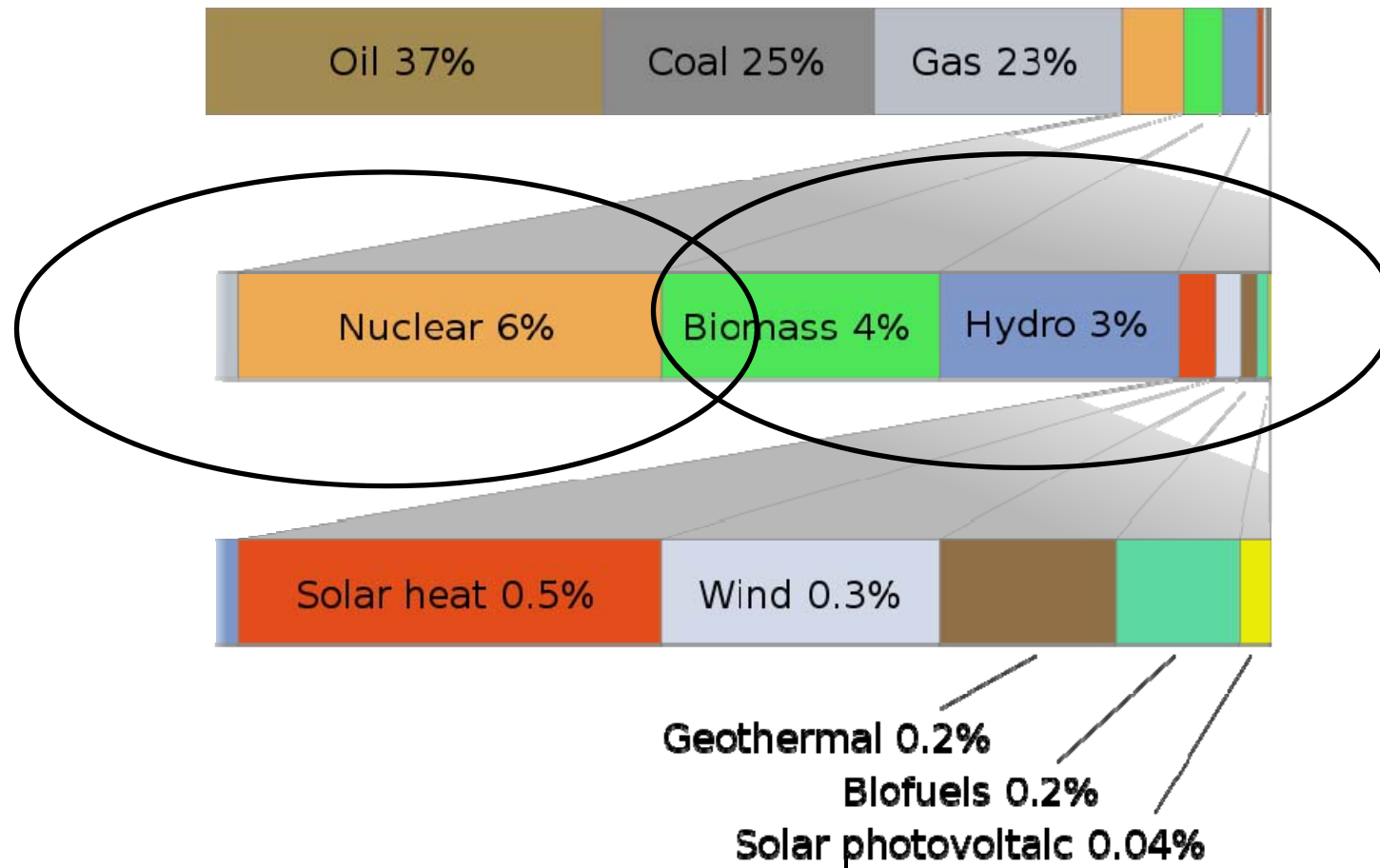


*Nuclear powers share of the electricity production has been falling for 25 years and the total [electricity production](#) from nuclear has been falling for 5 years. This during a “Nuclear Renaissance.”*

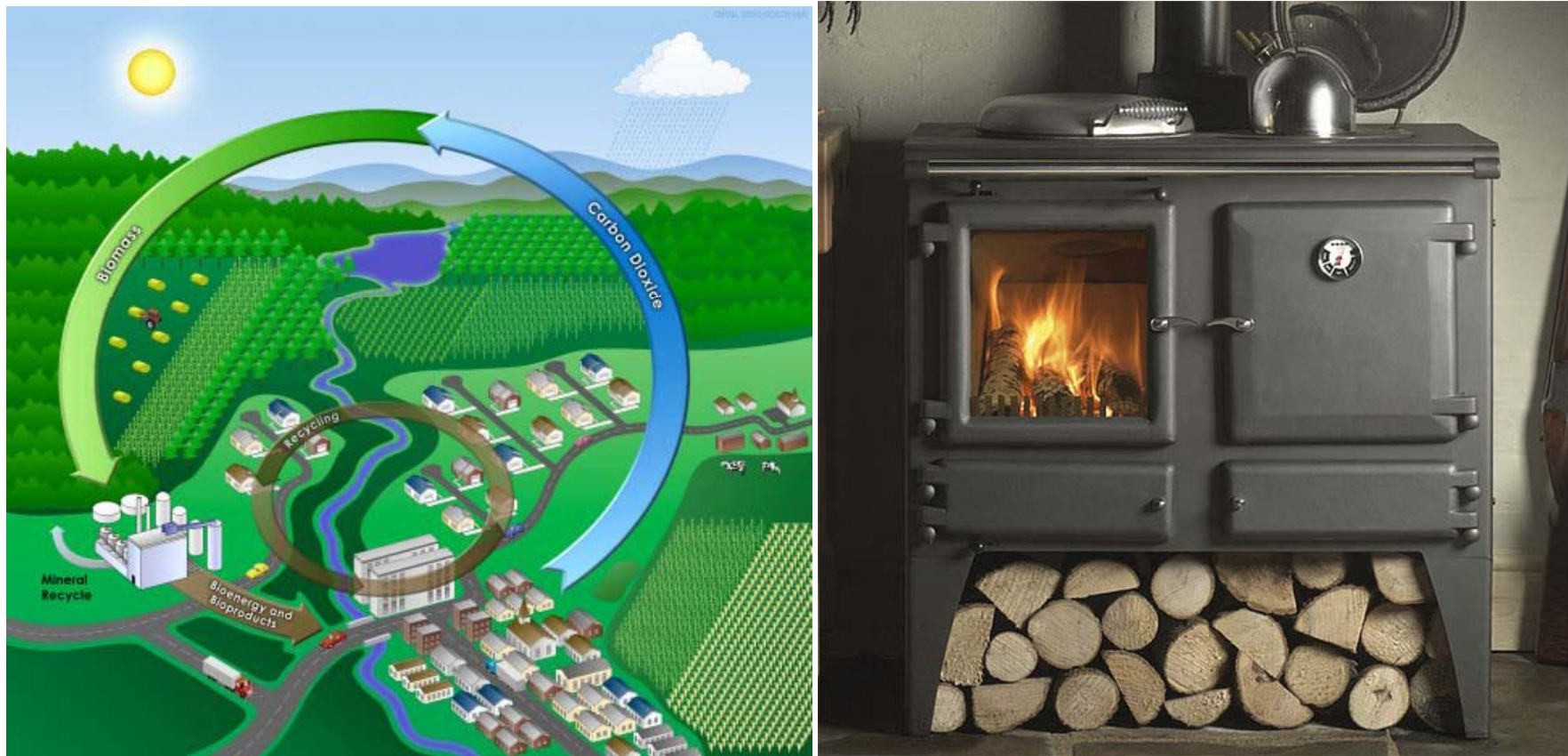
*The political winds are shifting*



# *Where our energy comes from*



# In 2011 biomass means burning wood



*Reforestation has the potential to remove hundreds of GTons of Carbon from the atmosphere.*

# *Hydro-electric*



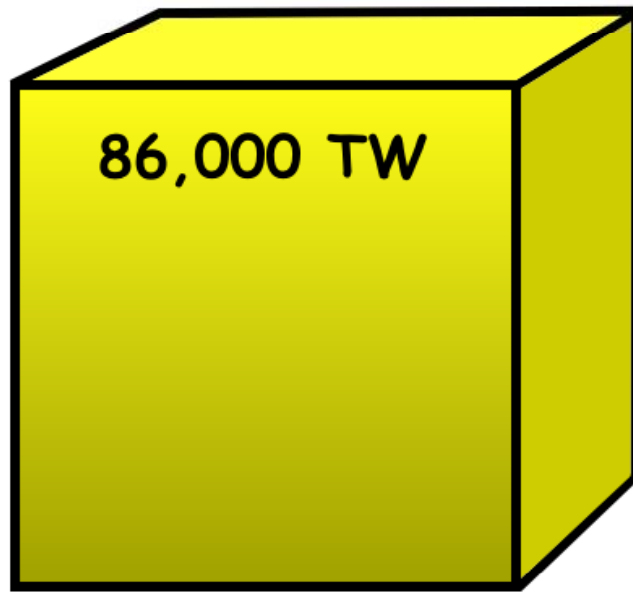
*No more room to build dams*

# *Biofuels are a little less than exciting*



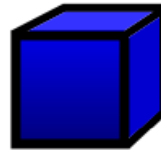
*If you have to burn fossil fuels to make biofuels, are we really winning?*

# *Where are the big energy pools?*



**Solar**

870 TW



**Wind**

32 TW



**Geothermal**

15 TW



**Global  
Consumption**

*We need 100 x growth in Solar wind and geothermal to cover 15 TWatts. Can we do this in 50 years?*

## *A possible scenario 50 years in the future*

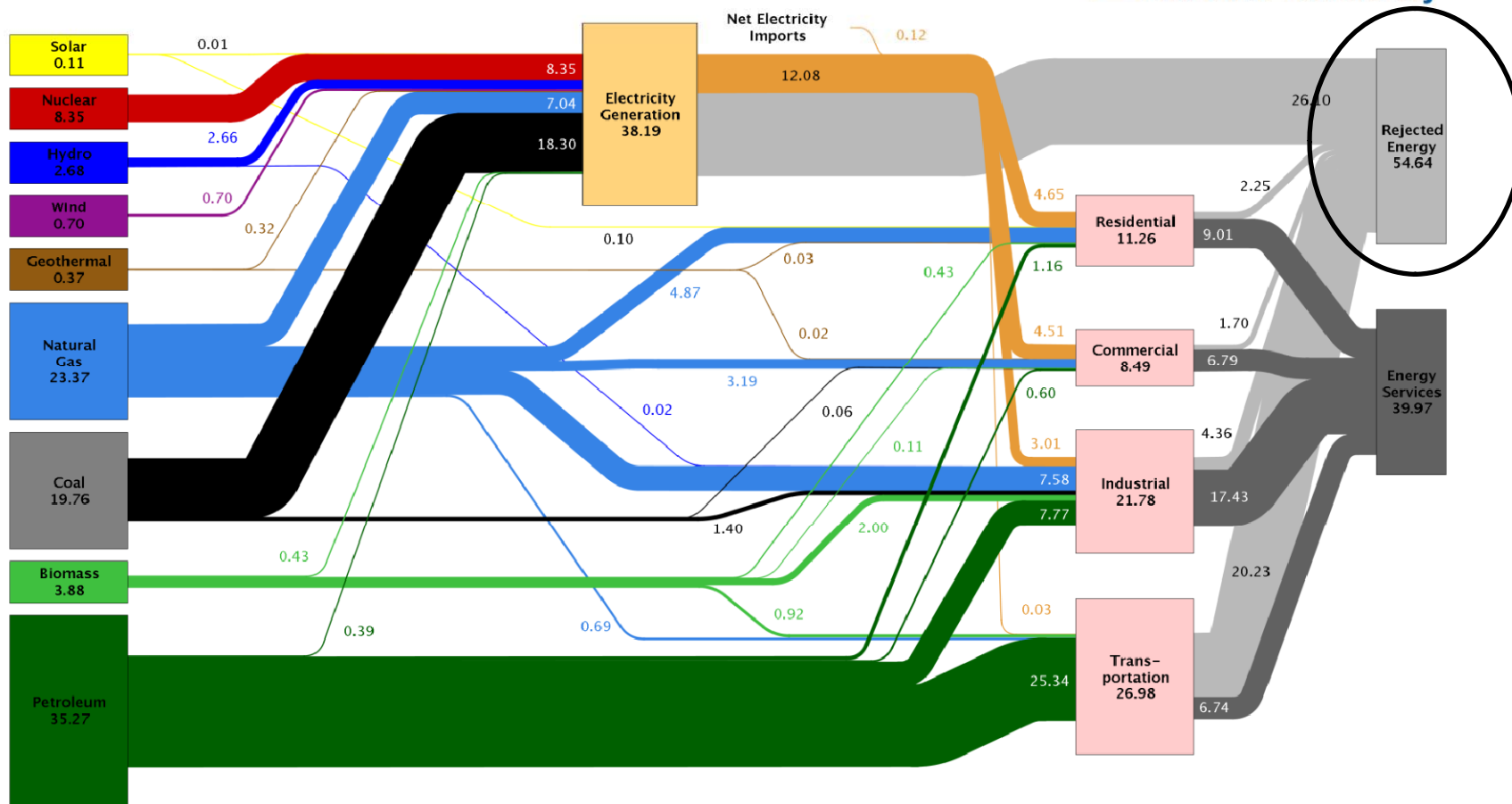
- 15 TWatts from Solar thermal, Wind and Geothermal
- 10 TWatts from natural gas
- Major improvements in consumption habits and fuel efficiency
- Liquid Fuels will have run out
- Coal will have been controlled by international agreement like CFCs were.



# Energy Efficiency

# Energy flow in the US

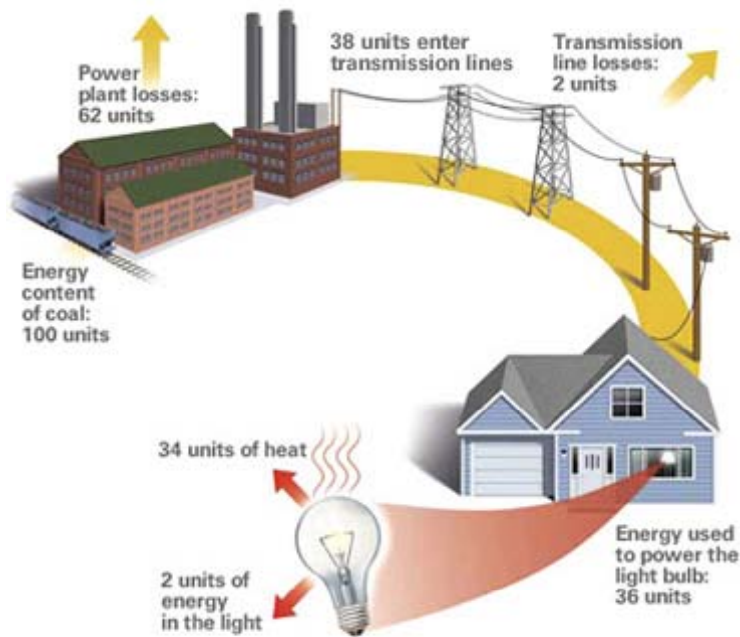
Estimated U.S. Energy Use in 2009: ~94.6 Quads



Source: LLNL 2010. Data is based on DOE/EIA-0384(2009), August 2010. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports flows for non-thermal resources (i.e., hydro, wind and solar) in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 80% for the residential, commercial and industrial sectors, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

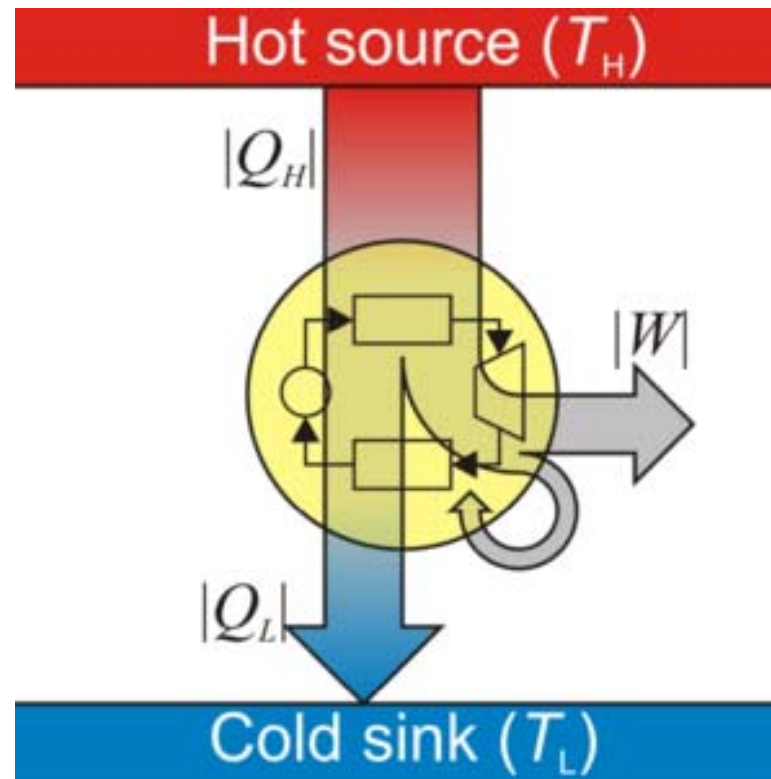
About 60% of the energy consumed in the US in 2009 went up the smoke stack as "rejected energy"

# Incandescent light-bulbs are 2% efficient



- Production losses burning coal to produce electricity
  - 62% goes up the smokestack
- Transmission losses
  - 2% lost heating the transmission lines
- Incandescence produces heat and light
  - Mainly heat

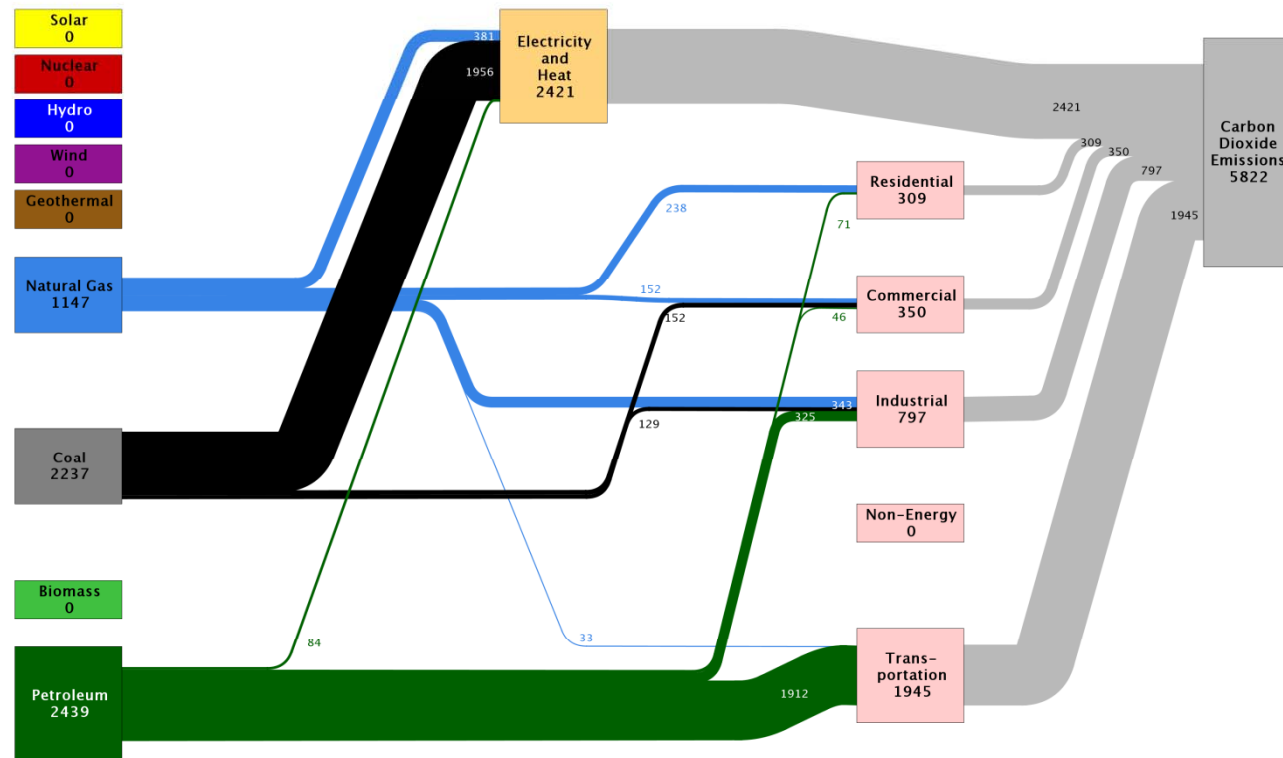
*Natural Laws mean that heat engines have efficiencies of about 35%*



*And the 65% wasted energy is up the stack as  $CO_2$*

# Carbon flow tracks the wasted energy flow

United States Carbon Dioxide Emissions  
in 2006: ~5,822 Million Metric Tons



Source: LLNL, 2009. Data is based on IEA's Extended Energy Balance Data for OECD Countries. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the U.S. Department of Energy, under whose auspices the work was performed. Totals may not equal sum of flows due to statistical differences. IEA considers biomass to be a net-zero carbon energy resource. Non-energy uses of fossil fuels are omitted. Petroleum includes the non-renewable portion of waste. Industry includes energy used in coal, oil and gas extraction and processing as well as agriculture, forestry and fishing. Transportation includes fuel delivered to international aviation and marine bunkers. LLNL-MI-410527.

# *The ingredients of a solution 50 years down the road*

- 15 TWatts from Solar thermal, Wind and Geothermal
- 10 TWatts from natural gas
- Major improvements in consumption habits and efficiency
  - Especially concerning electricity generation and transportation
- Liquid Fuels will have run out
- Coal will have been controlled by international agreement like CFCs were.
- International agreement and initiative on reforestation to relieve the CO<sub>2</sub> traffic jam in the atmosphere.

# *Six nations in confederacy*

*The real Americans*



*The Iroquois believed in taking into consideration the interests of the 7<sup>th</sup> generation in making political decisions. This is what a politics of sustainability would look like.*

*The planet doesn't need saving*





*Easter Island failed because they could not imagine that they might*



*Never saw it coming*



**END**