GCEP

Global Climate and Energy Project

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Diesel Engine Emissions Reduction Conference
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"This is the century that human beings will have to come to grips with whether they can continue to live on this planet…"

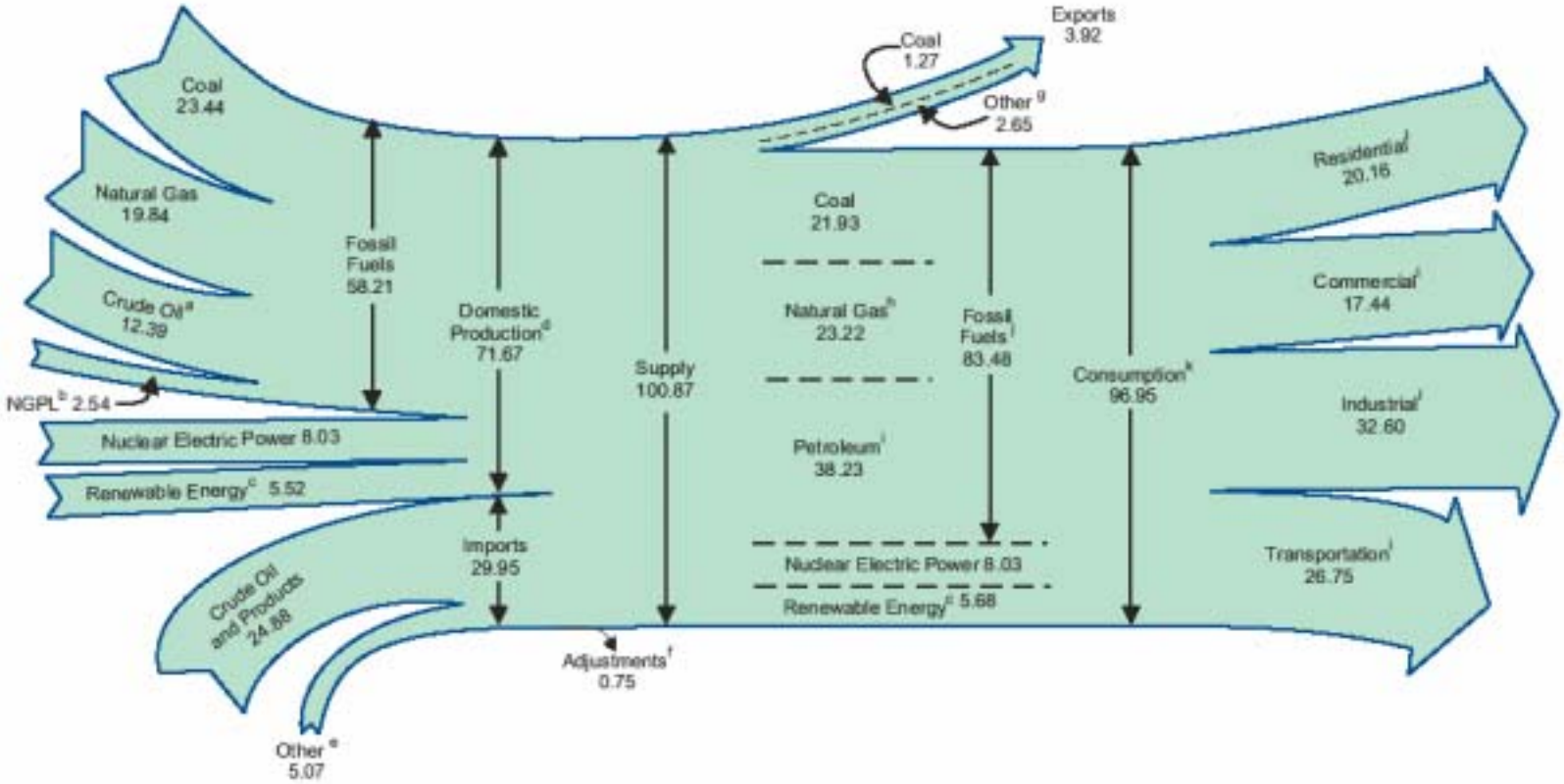
Franklin M. Orr

(former Dean of Earth Sciences,
Director, Global Climate and Energy Project)

Energy

- There is no Energy shortage. Energy can neither be created nor destroyed.
- Our problem is one of the Availability of energy.
- Energy is made available for our use only by interaction with the environment.

Diagram 1. Energy Flow, 2001
(Quadrillion Btu)



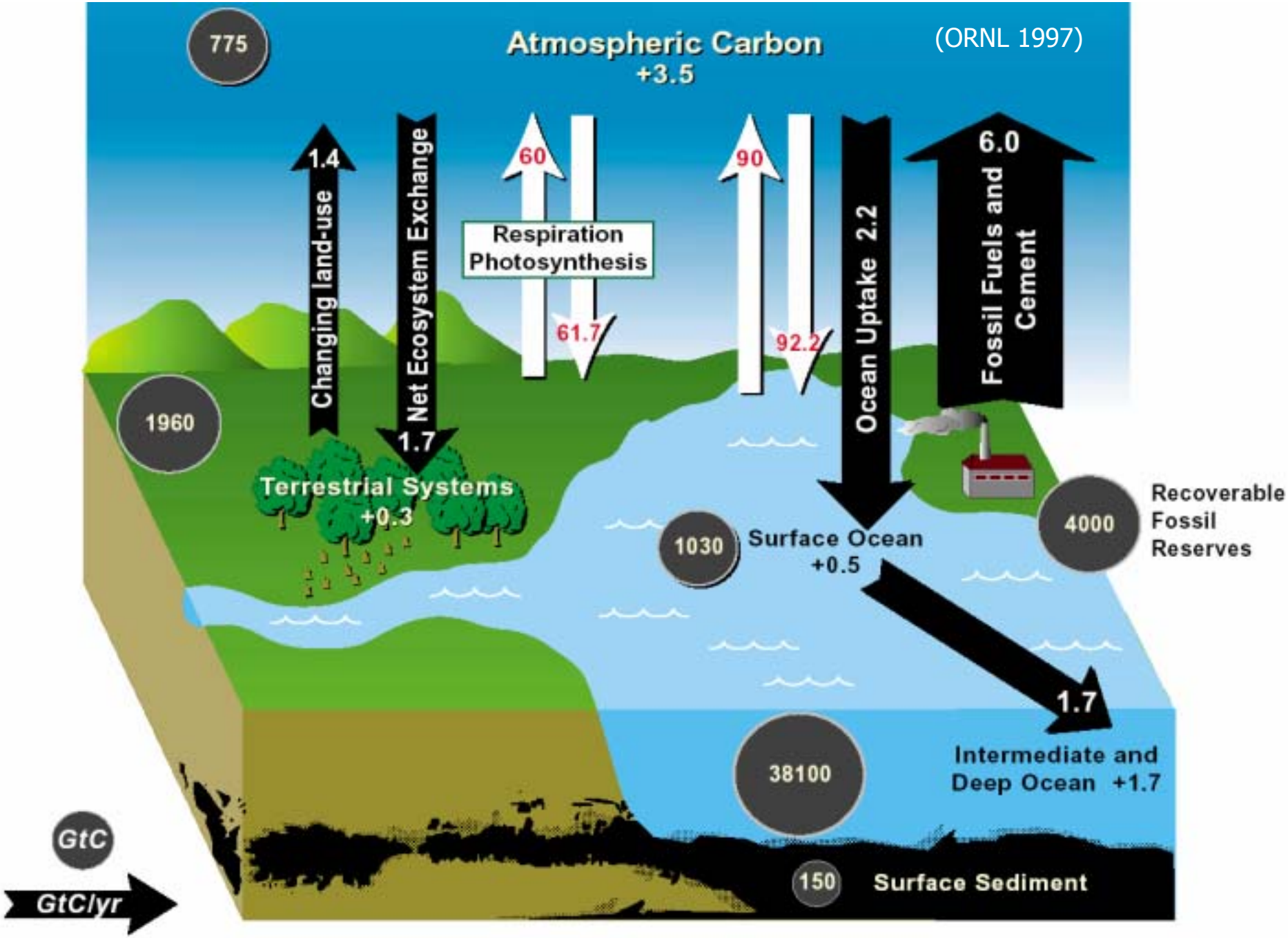
[a] Includes lease condensate.
[b] Natural gas plant liquids.
[c] Conventional hydroelectric power, wood, waste, ethanol blended into motor gasoline, geothermal, solar, and wind.
[d] Includes -0.09 quadrillion Btu hydroelectric pumped storage.
[e] Natural gas, coal, coal coke, and electricity.
[f] Stock changes, losses, gains, miscellaneous blending components, and unaccounted-for supply.
[g] Crude oil, petroleum products, natural gas, electricity, and coal coke.
[h] Includes supplemental gaseous fuels.
[i] Petroleum products, including natural gas plant liquids.
[j] Includes, in quadrillion Btu, 0.04 coal coke net imports and 0.05 electricity net imports from fossil fuels.
[k] Includes, in quadrillion Btu, -0.09 hydroelectric pumped storage and -0.15 ethanol blended into motor gasoline, which is accounted for in both fossil fuels and renewable energy but counted only once in total consumption.
[l] Primary consumption, electricity retail sales, and electrical system energy losses, which are allocated to the end-use sectors in proportion to each sector's share of total electricity retail sales. See Note 1 at end of Electricity section.

Notes: • Data are preliminary. • Totals may not equal sum of components due to independent rounding.

Sources: Tables 1.1, 1.2, 1.3, 1.4, and 2.1a.

Environment

- The environment is not an infinite reservoir.
- The scale of human endeavors is now such that we must take responsibility for maintaining equilibrium with our environment.
- This requires that byproducts be returned to nature in such a way that they can equilibrate on nature's terms & time scale.


(ORNL 1997)
775
Atmospheric Carbon
+3.5
1.4
Changing land-use
Net Ecosystem Exchange
1.7
60
61.7
Respiration
Photosynthesis
90
92.2
Ocean Uptake 2.2
6.0
Fossil Fuels and Cement
1960
Terrestrial Systems
+0.3
1030
Surface Ocean
+0.5
4000
Recoverable Fossil Reserves
1.7
38100
Intermediate and Deep Ocean +1.7
150
Surface Sediment
GtC
GtC/yr

The key to learning to live on this planet is for engineers and scientists to view as an intrinsic part of their task development of a collaboration with nature.

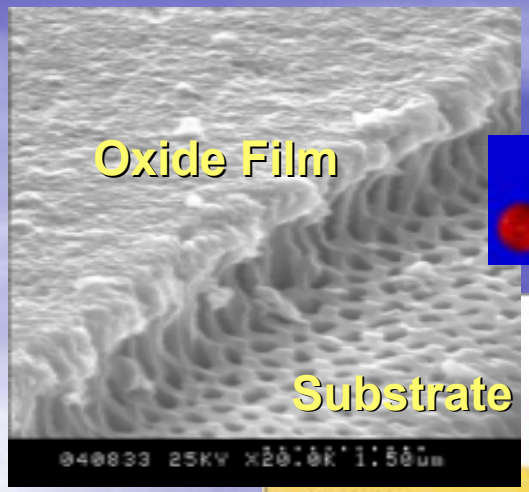
Uncertainty

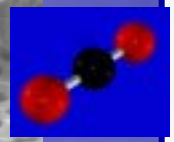
- Future fuel supplies, energy technologies, and the consequences of greenhouse gas emission are uncertain.
- Uncertainty can lead to inaction until it is too late. (Inverse Apollo effect.)
- Engineers are in a unique position to provide options that allow us to choose a better future despite uncertainty.

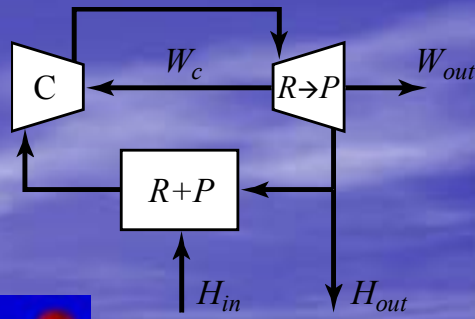
The Global Climate and Energy Project

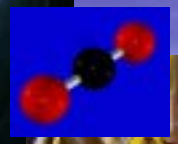
GCEP

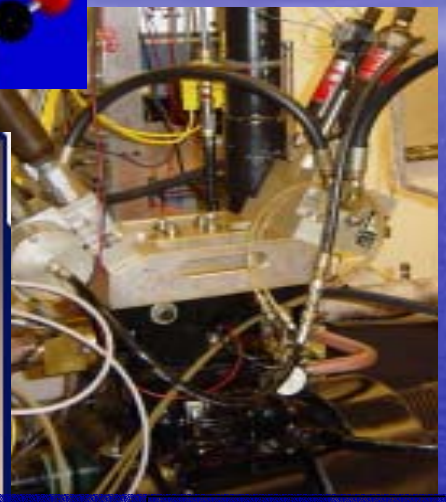
- Objective is to create new technologies for a low-greenhouse-gas energy future.
- Four industrial sponsors (ExxonMobil, General Electric, Toyota, Schlumberger) have committed $225 million over 10 years.
- Perform research at Stanford and at leading research institutions worldwide.
- Create a sustained university/industry collaboration and flow of talented students.

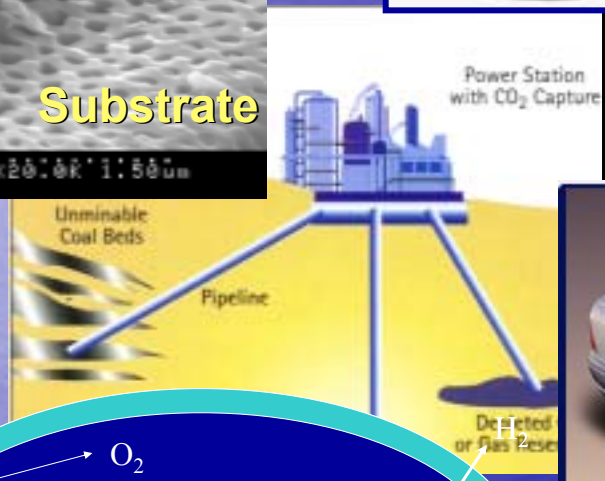

Oxide Film
Substrate
040833 25KV X20.0K 1.50um

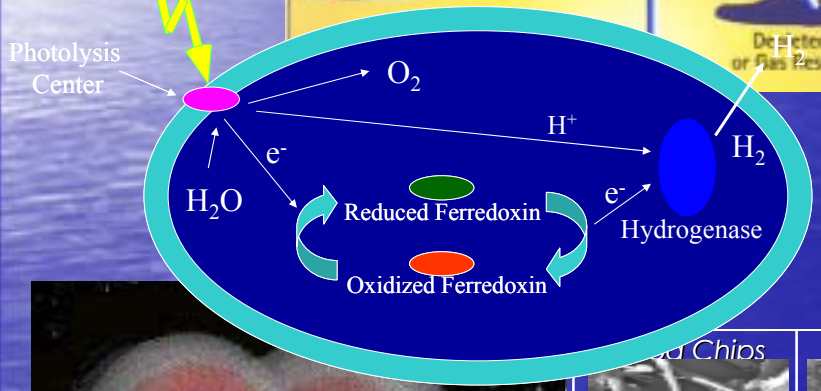


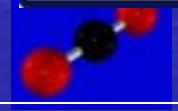

C
W_c
R→P
W_{out}
R+P
H_{in}
H_{out}

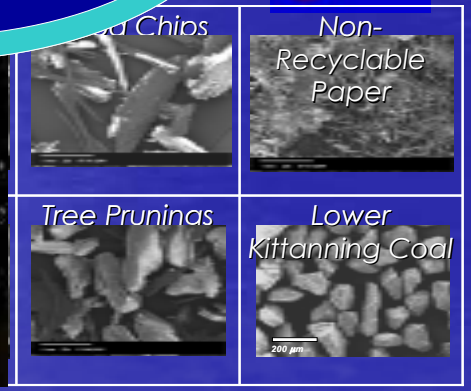


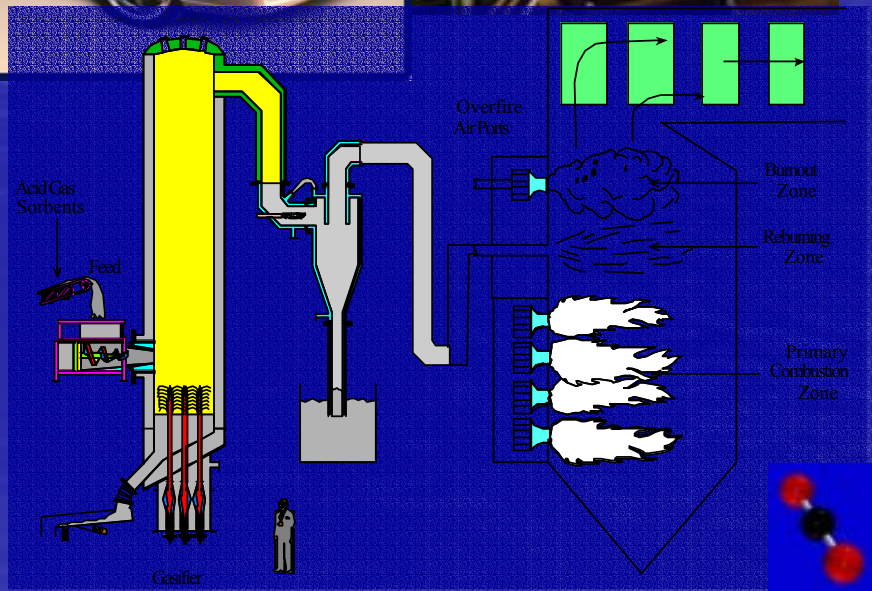



Power Station
with CO_2 Capture
Unminable
Coal Beds
Pipeline


Solar Energy
Photolysis
Center
O_2
H^+
H_2
e^-
H_2O
Reduced Ferredoxin
e^-
Hydrogenase
Oxidized Ferredoxin




Non-
Recyclable
Paper
Tree Pruninas
Lower
Kittanning Coal
200 µm

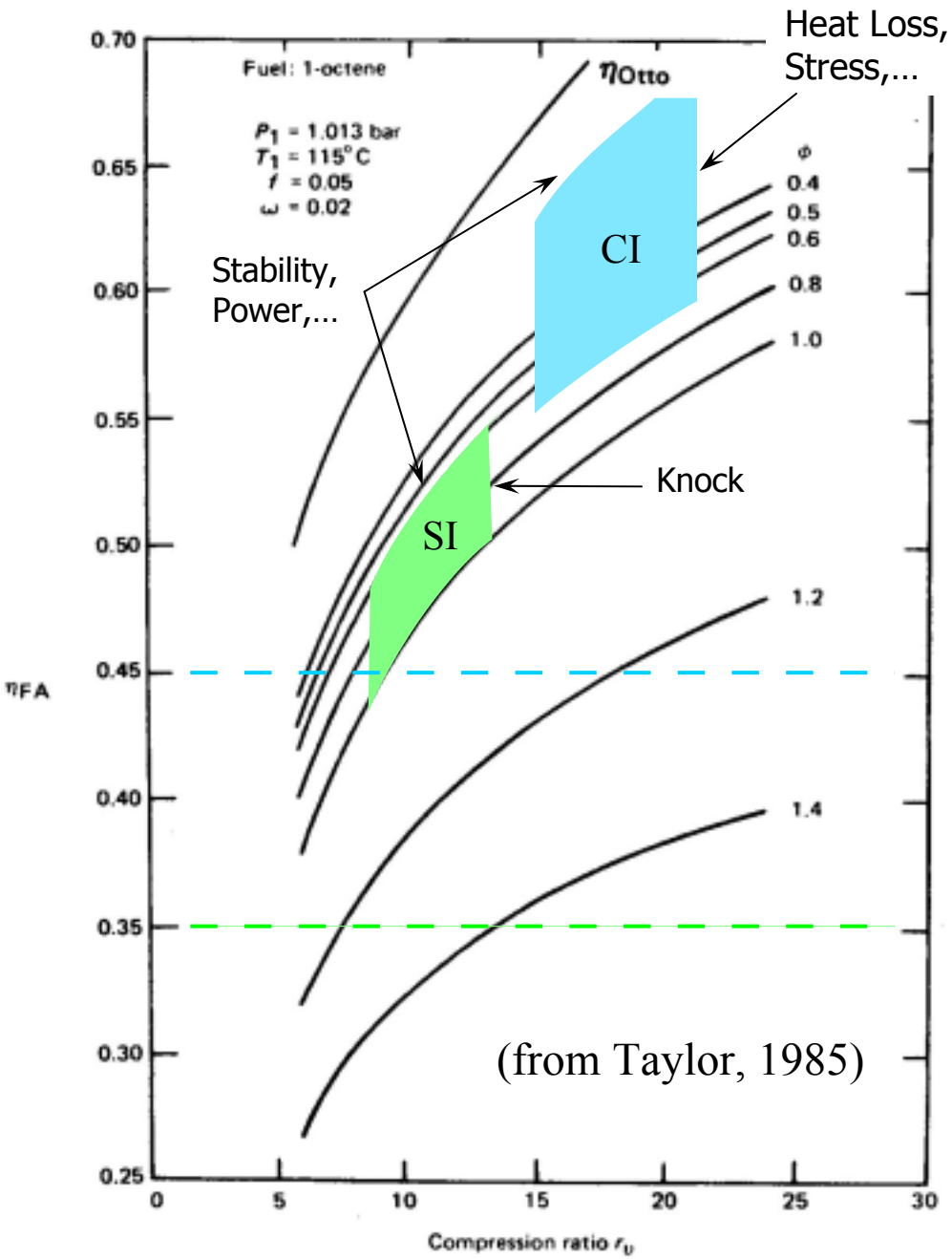

Overfire
Air Ports
Burnout
Zone
Rebuming
Zone
Primary
Combustion
Zone
Acid Gas
Sorbents
Feed
Gasifier

Achieving a sustainable collaboration with nature will be required to provide a safe and secure energy future.

Engineers and scientists will play a leadership role in realizing that collaboration.

Diesel

- As a thermodynamic cycle…
- As a petroleum-derived fuel…
- As an engine…
- As an energy pioneer…



Criteria Emissions

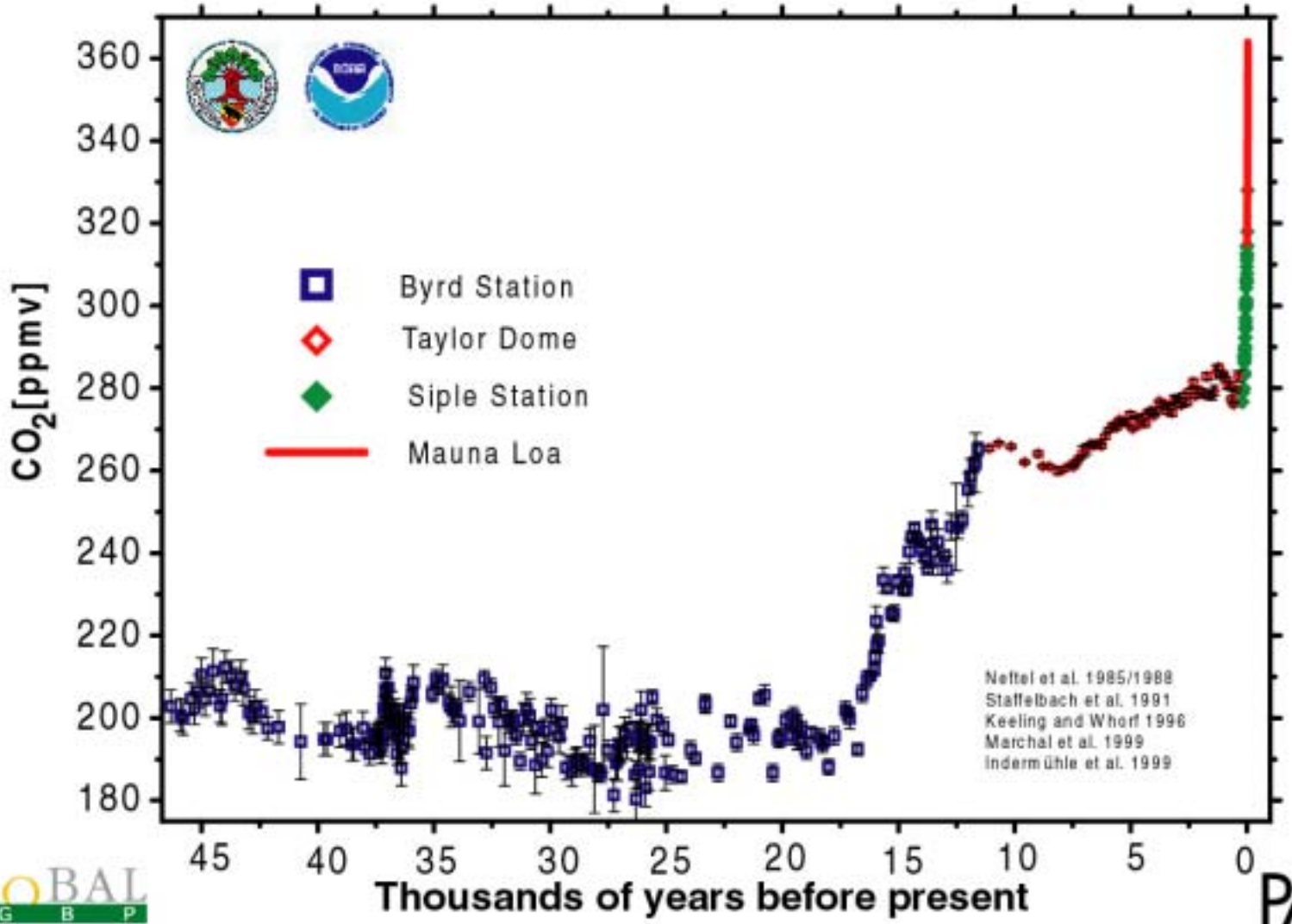
- EGR, Injection Control…
- HCCI…
- Aftertreatment…
- Other…

Carbon Emissions

- Efficiency…
- Reduced-Carbon Fuel…
- Carbon-Neutral Fuel…
- On-Board Carbon Capture…
- Carbonless Fuel…
- Other…

Atmospheric CO_2 Concentration

Last Glacial Maximum to present

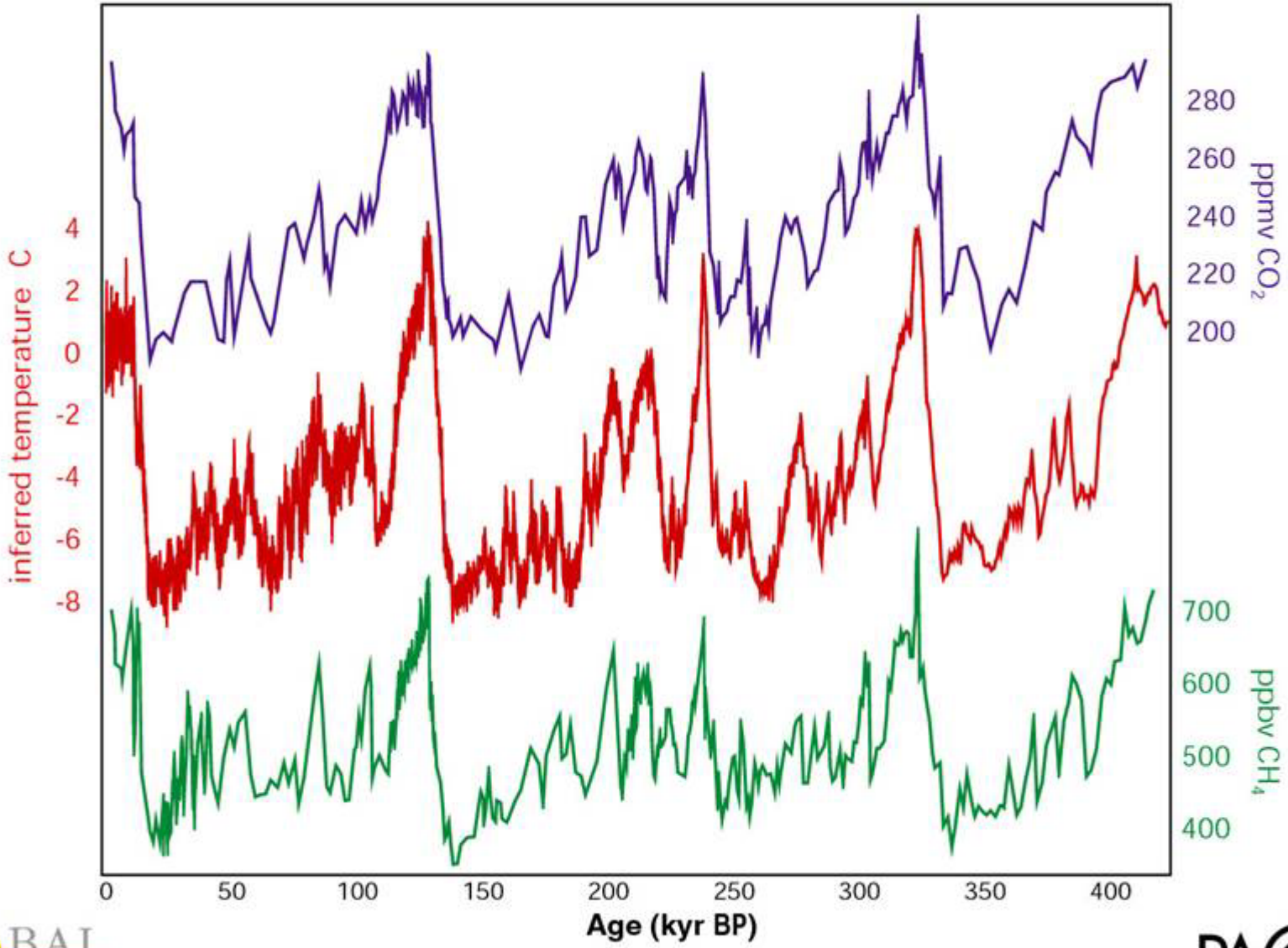


Adapted from: http://www.climate.unibe.ch/gallery_co2.html

GLOBAL CHANGE IGBP

PAGES PAST GLOBAL CHANGES

4 glacial cycles recorded in the Vostok ice core



J.R. Petit et al., *Nature,* **399**, 429–36, 1999.

GLOBAL CHANGE IGBP

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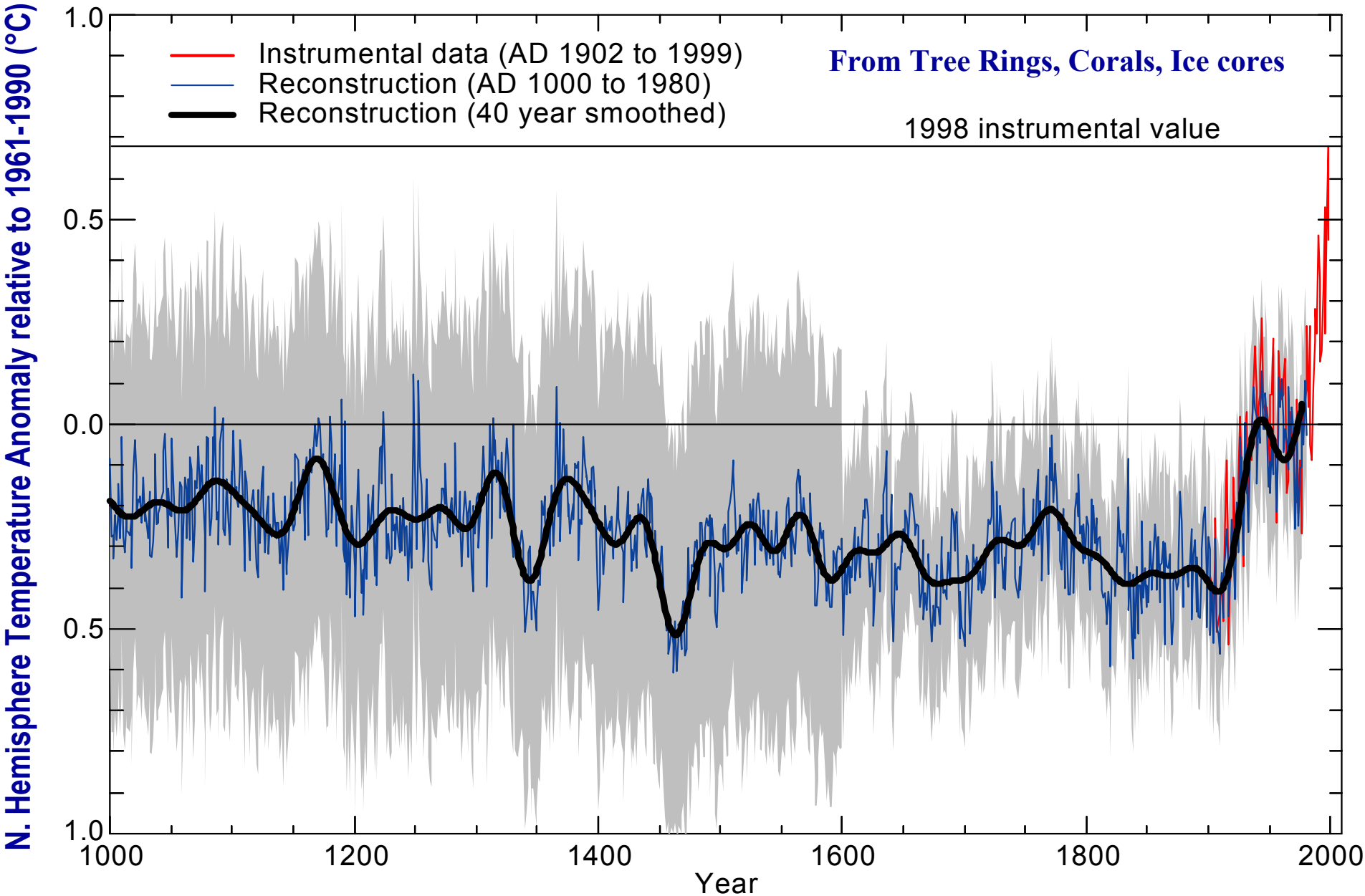
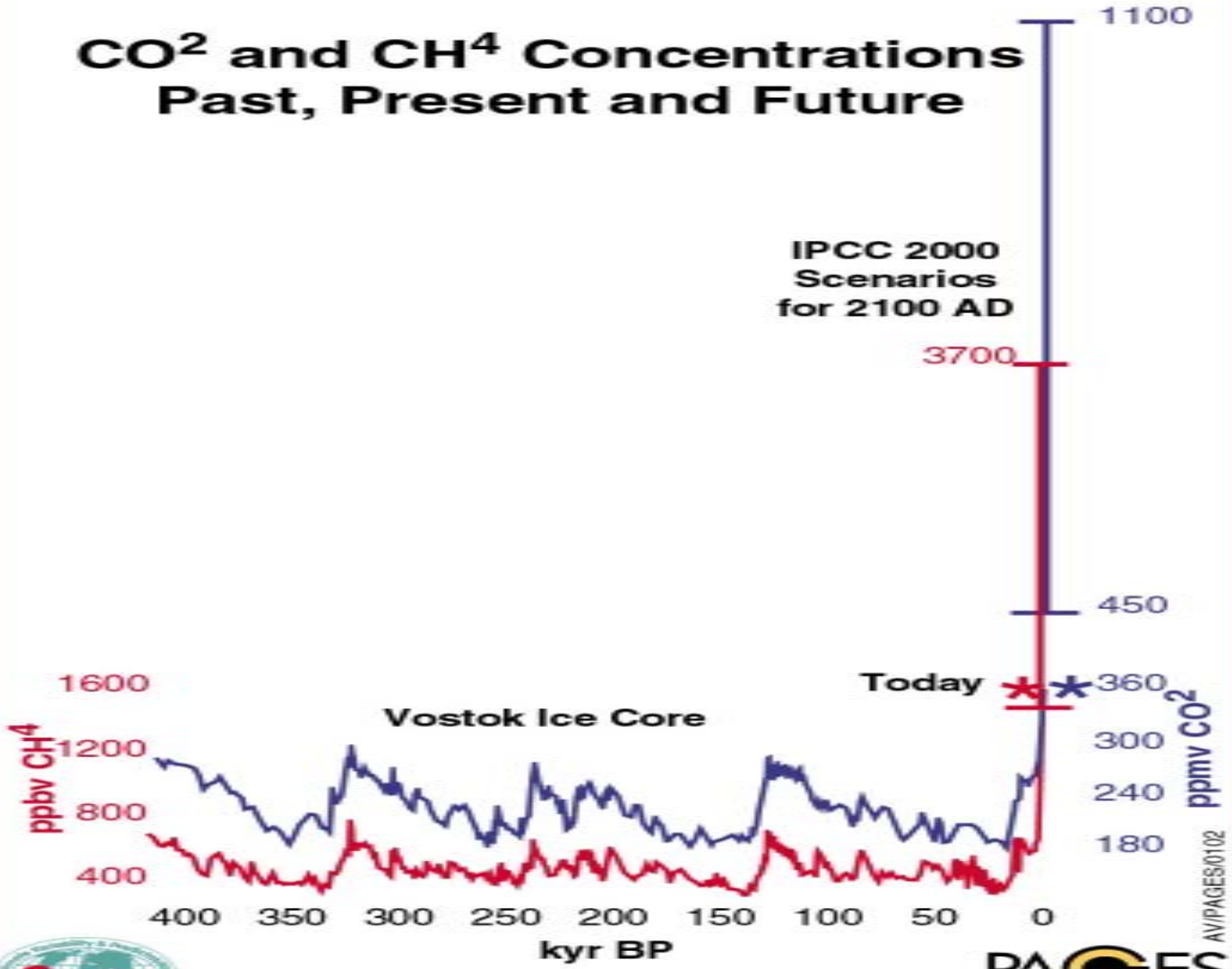
IPCC 3rd Assessment Report (2001)



CO^2 and CH^4 Concentrations Past, Present and Future



Compiled by K. Alverson, PAGES IPO

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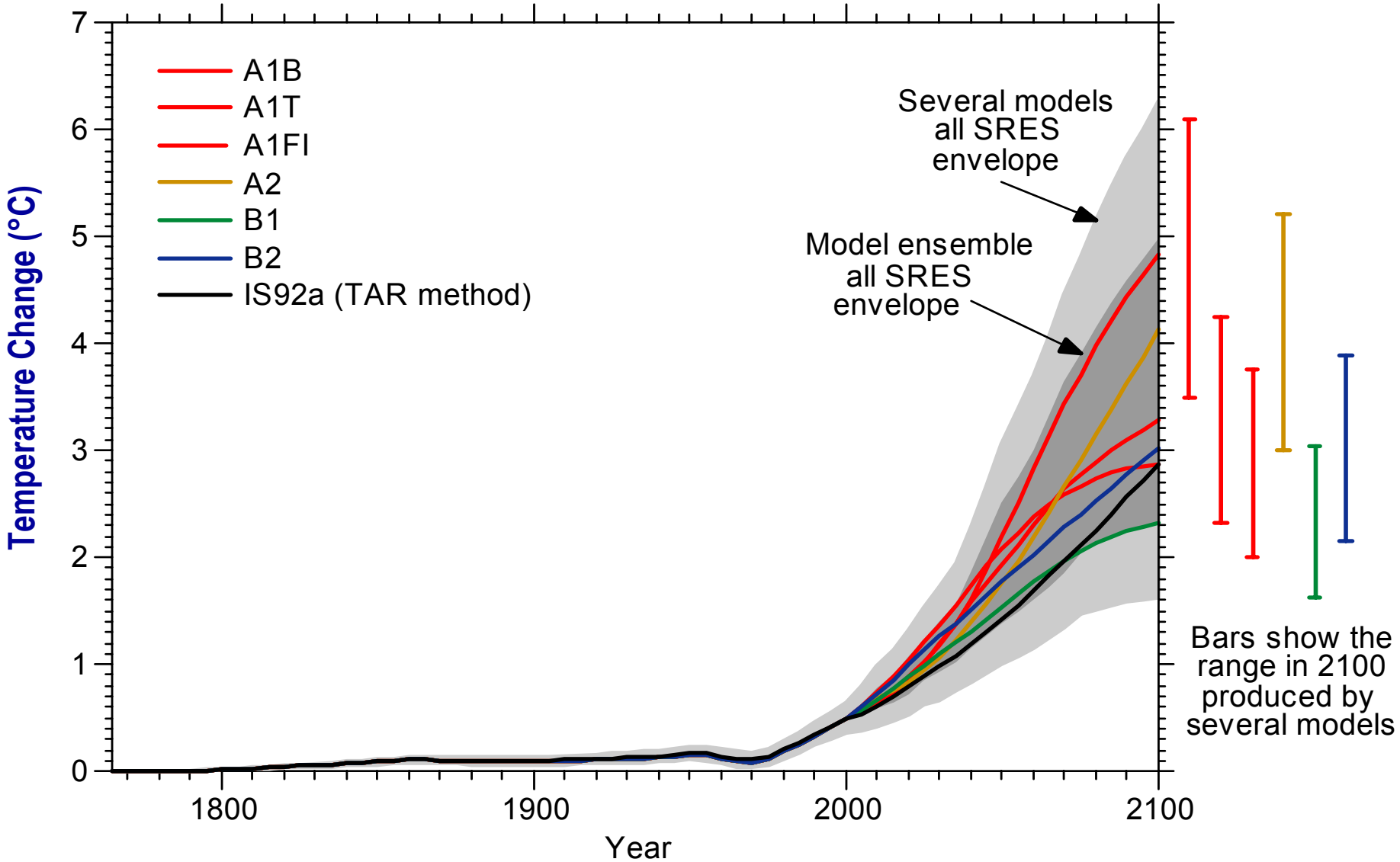
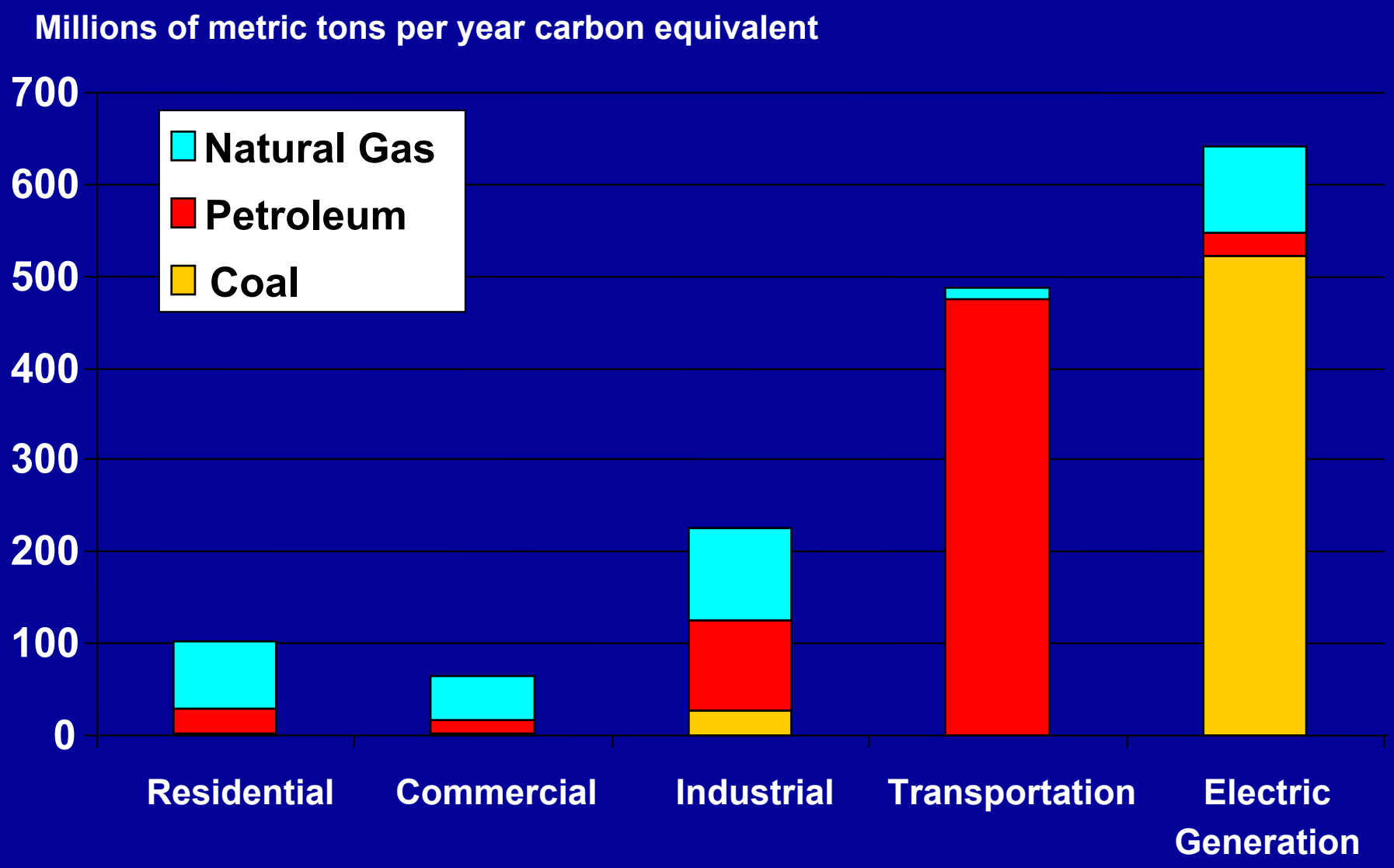
IPCC 3rd Assessment Report (2001) – Projected Global Temperature Change

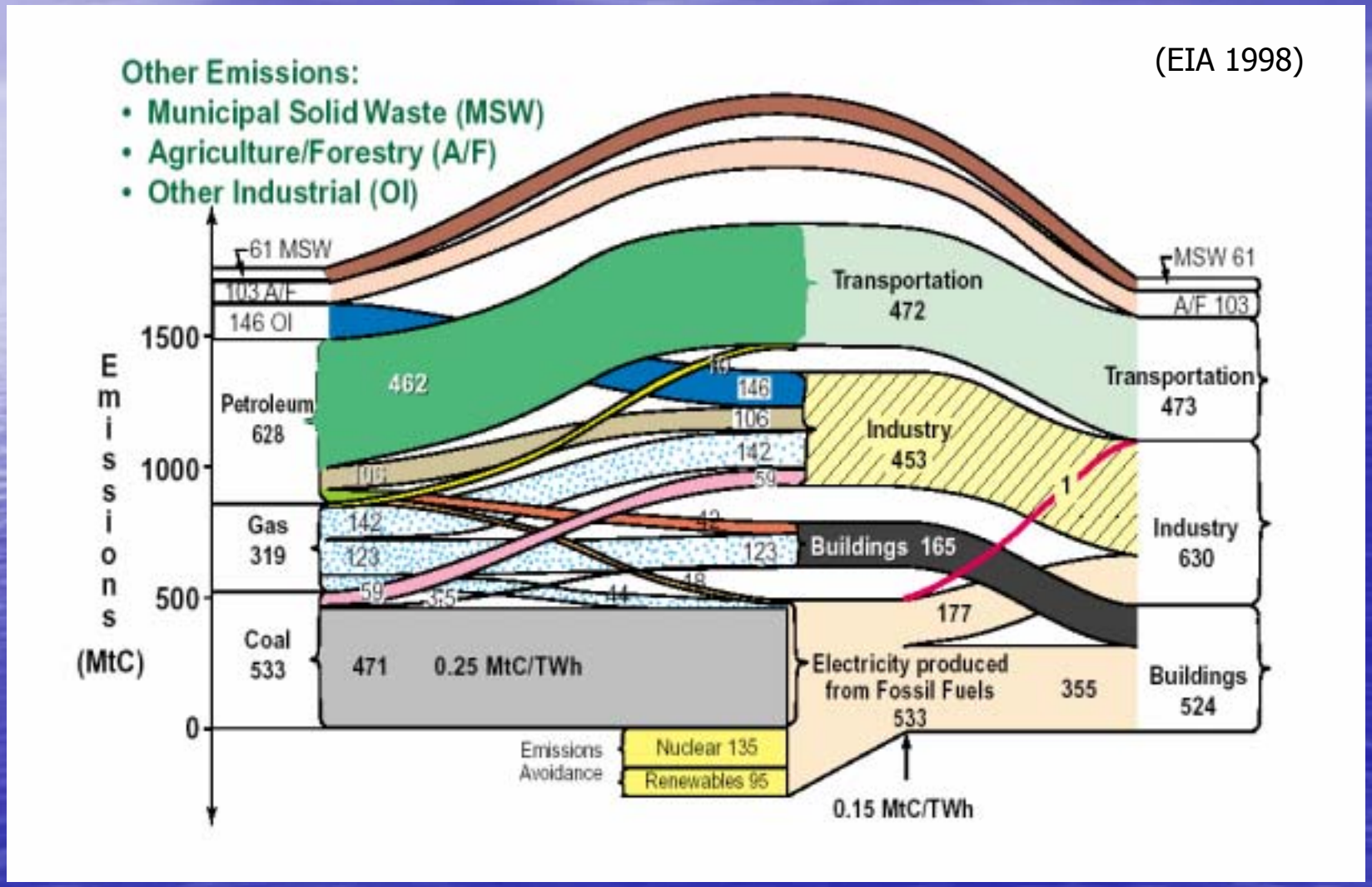


United States CO_2 Emissions by Sector and Fuels 2000

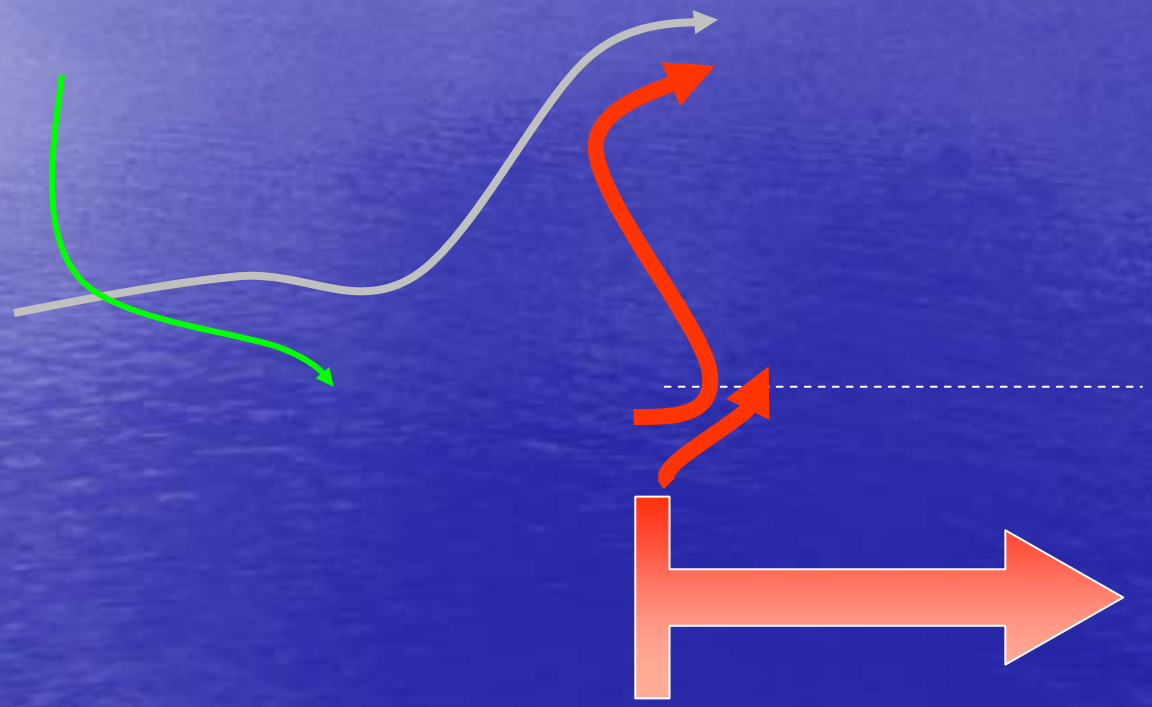


Source: U.S. EPA Inventory of Greenhouse Gas Emissions, April 2002

Carbon Flow in the U.S. in 1995



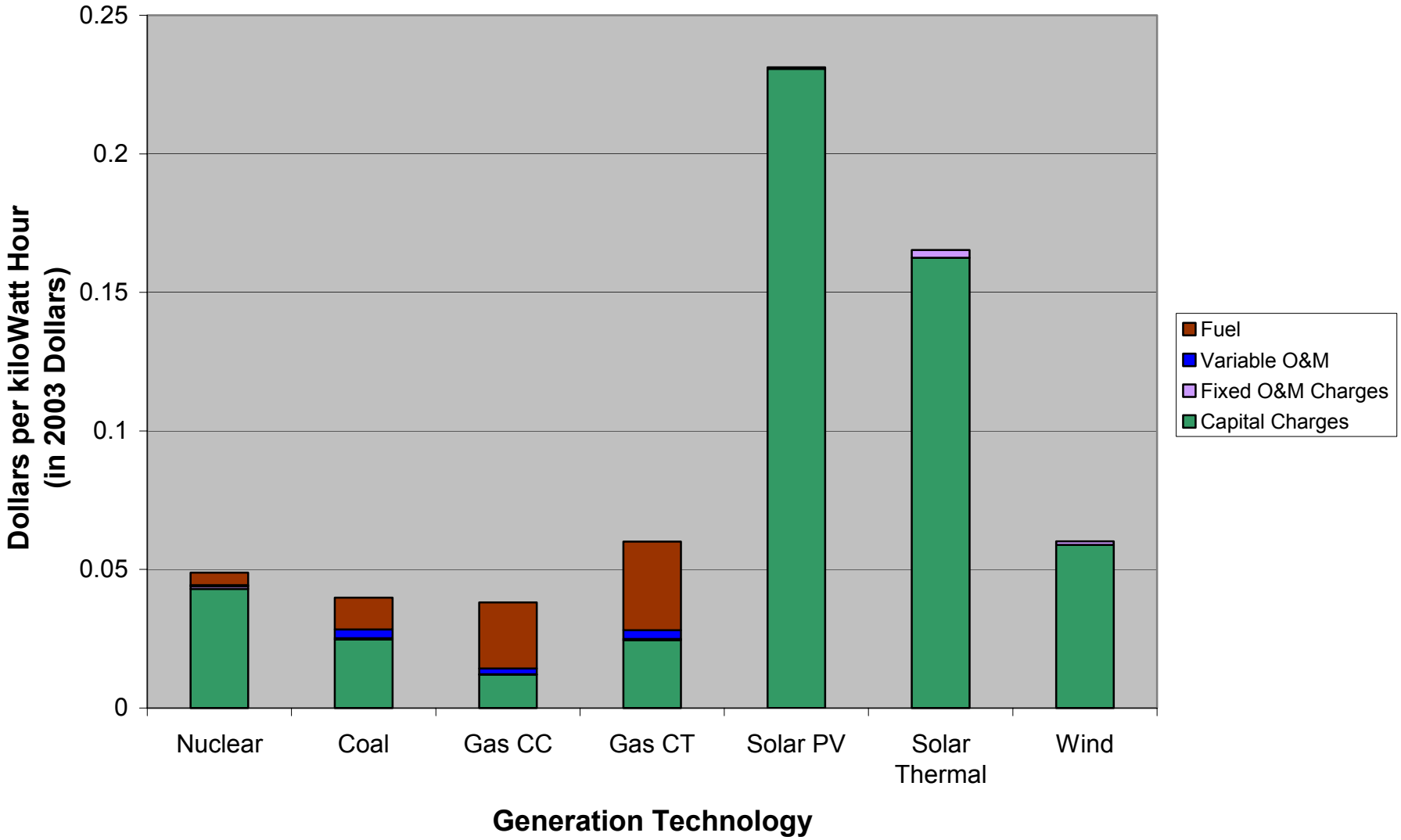
CURRENT U.S. ENERGY FLOW



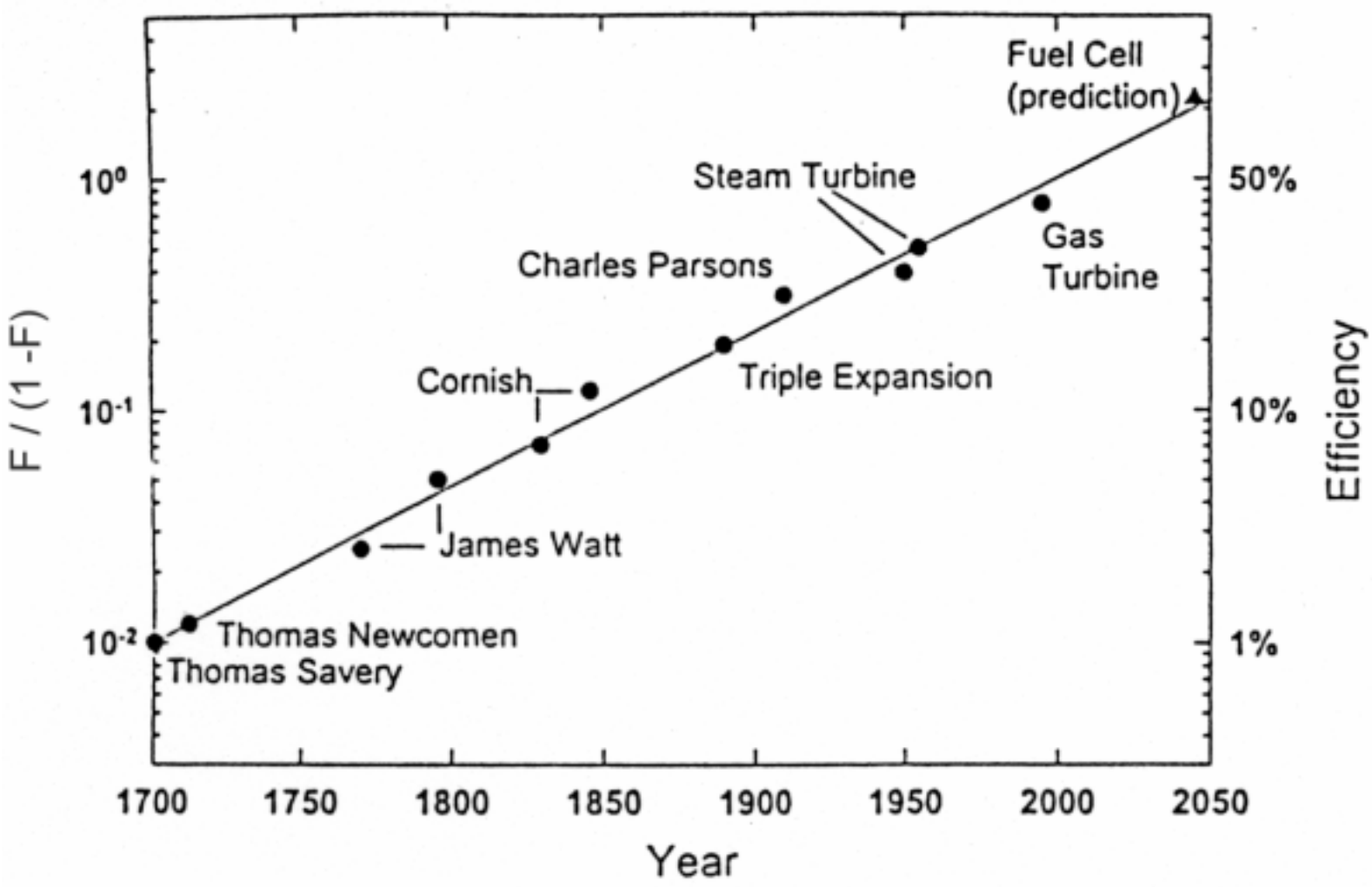
- Overall energy efficiency for U.S. is only 45%
- Transportation and power generation have greatest opportunities for improvement

Source: LLNL/DOE

Levelized Cost Comparison for Electric Power Generation

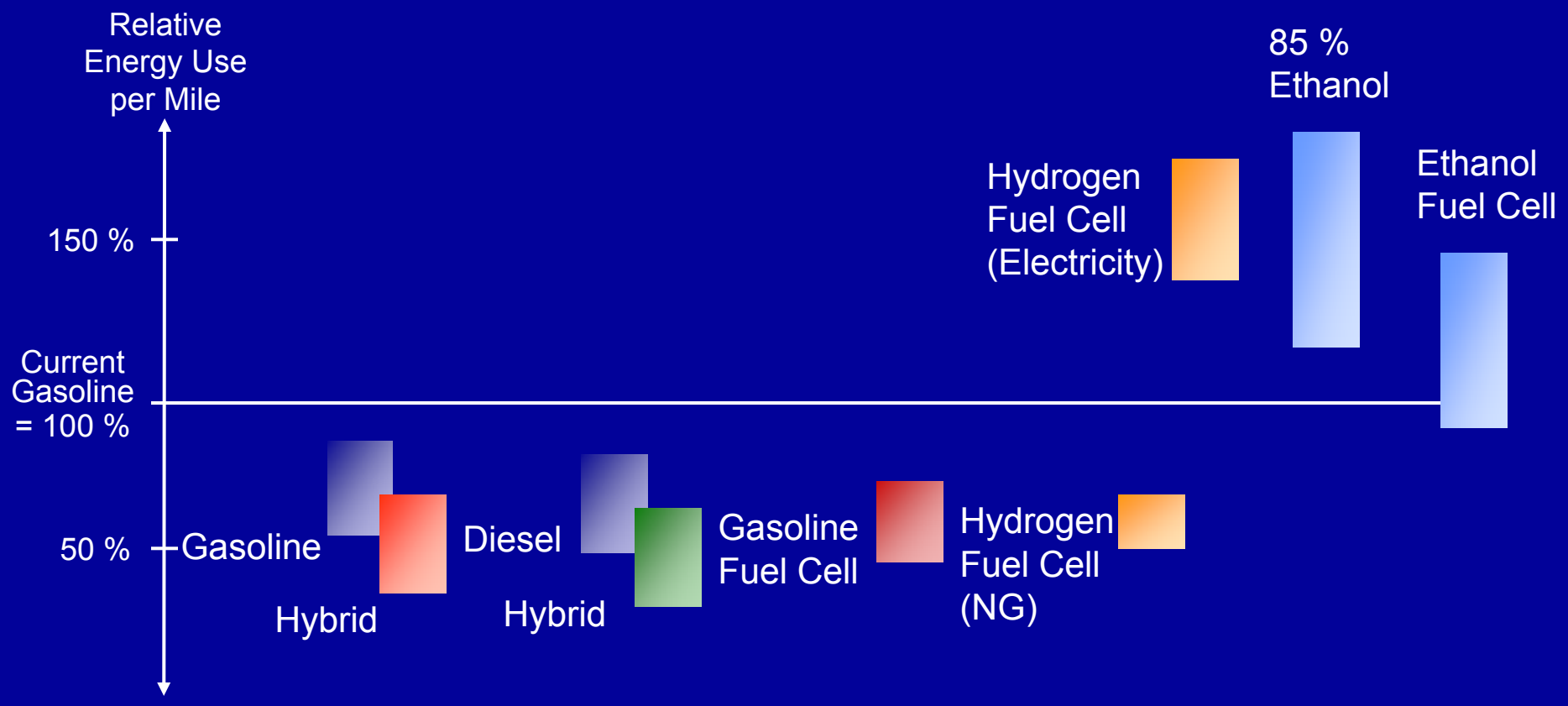


Source: Weyant, Stanford Energy Modeling Forum



After Ausubel, Marchetti

WELL TO WHEEL ENERGY USE



Source: ANL et al.