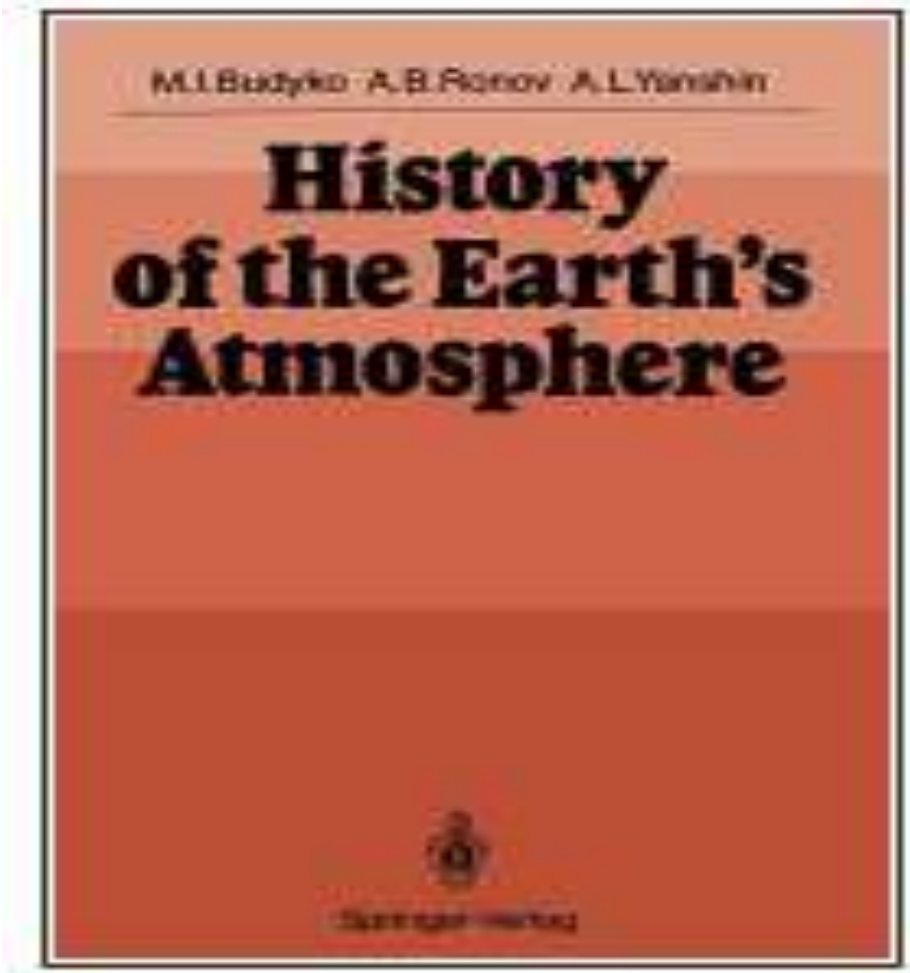
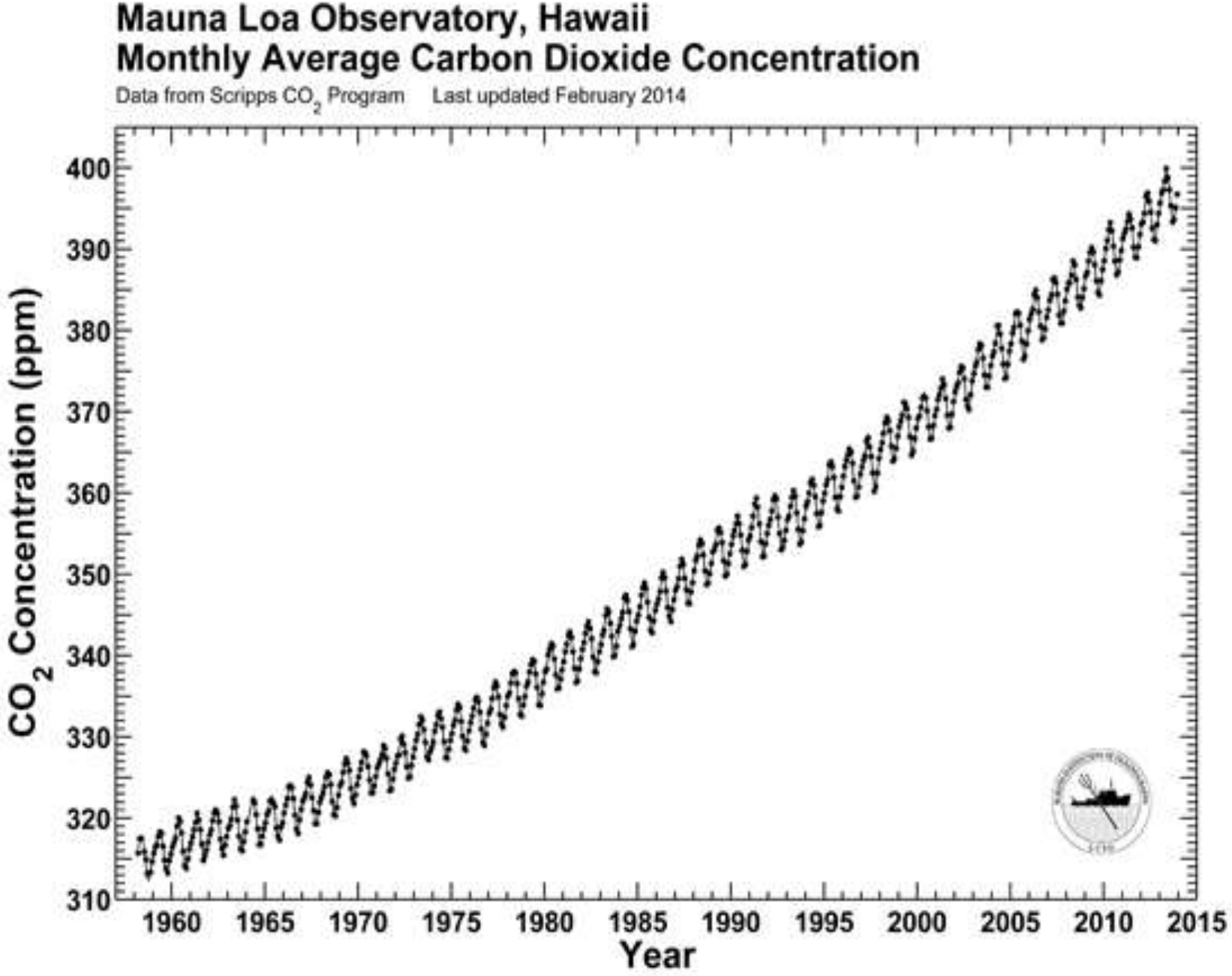
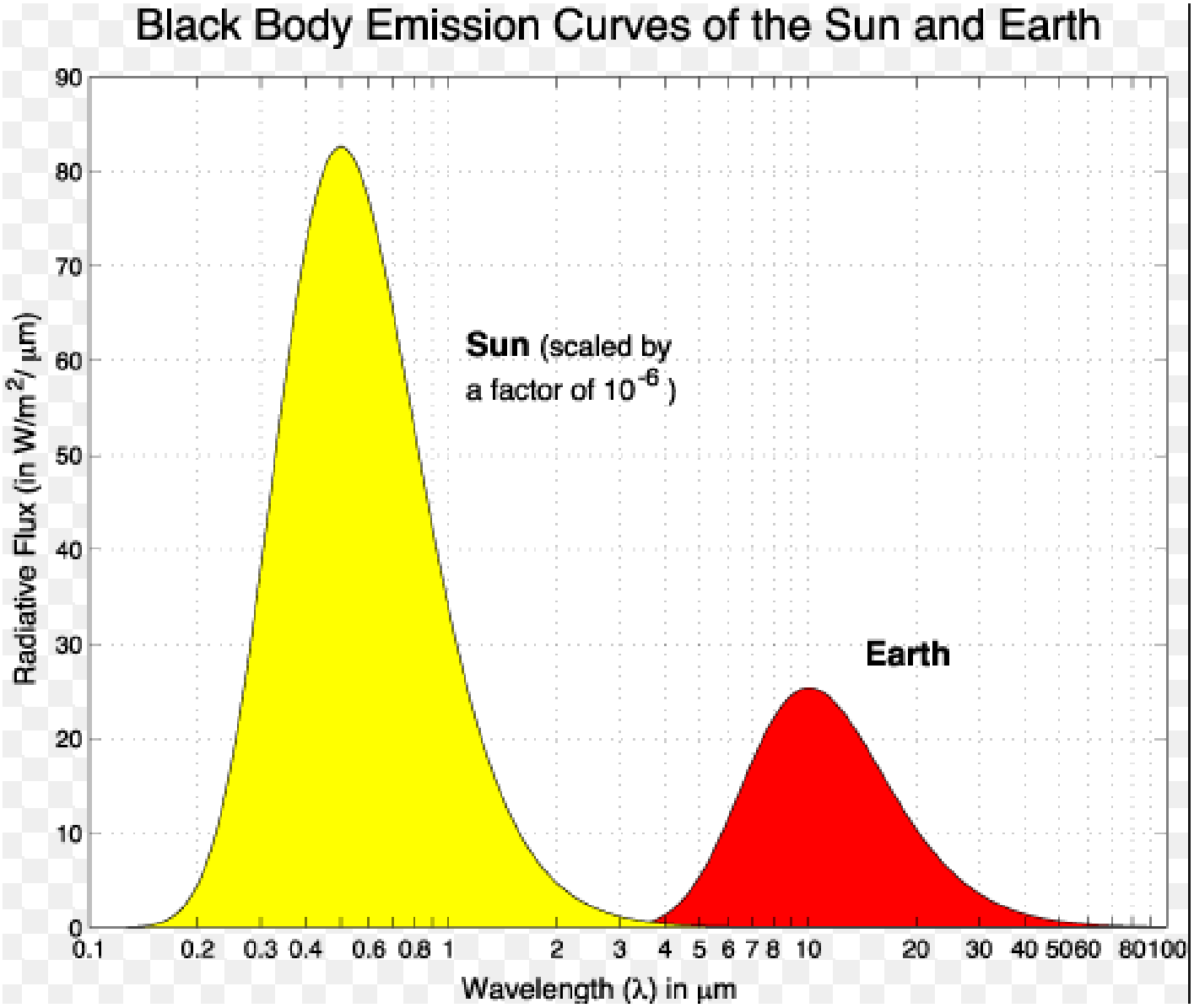
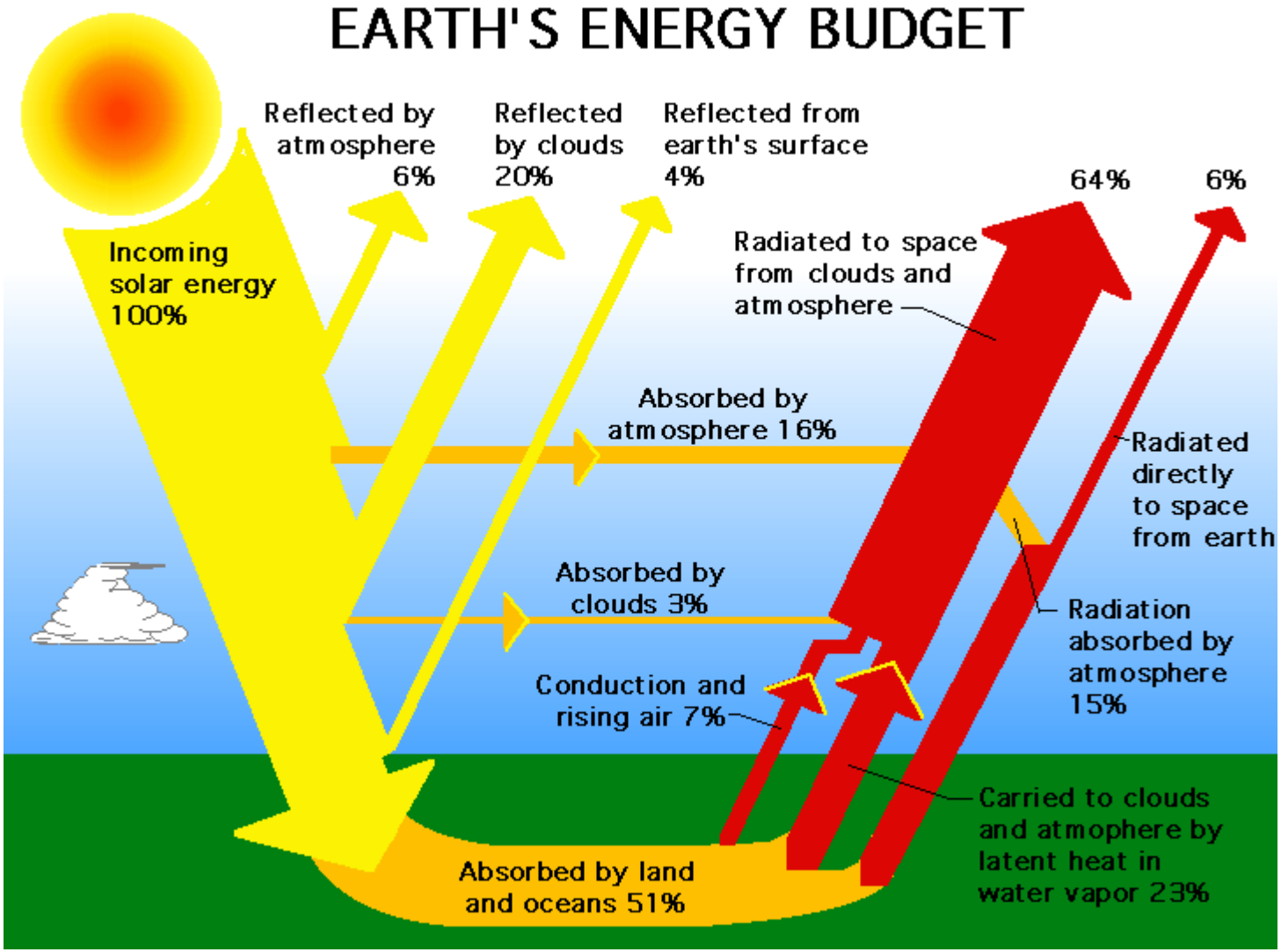
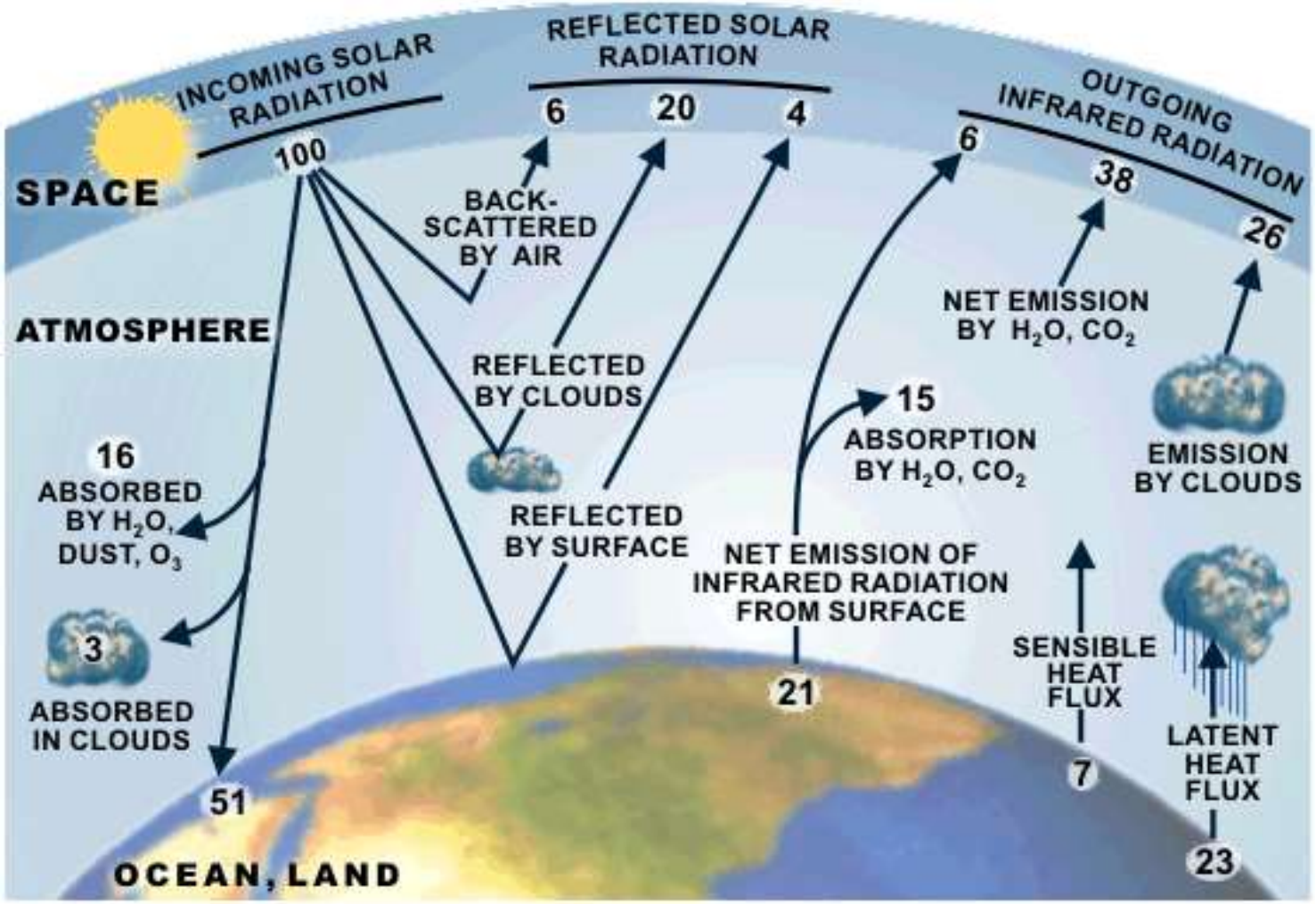


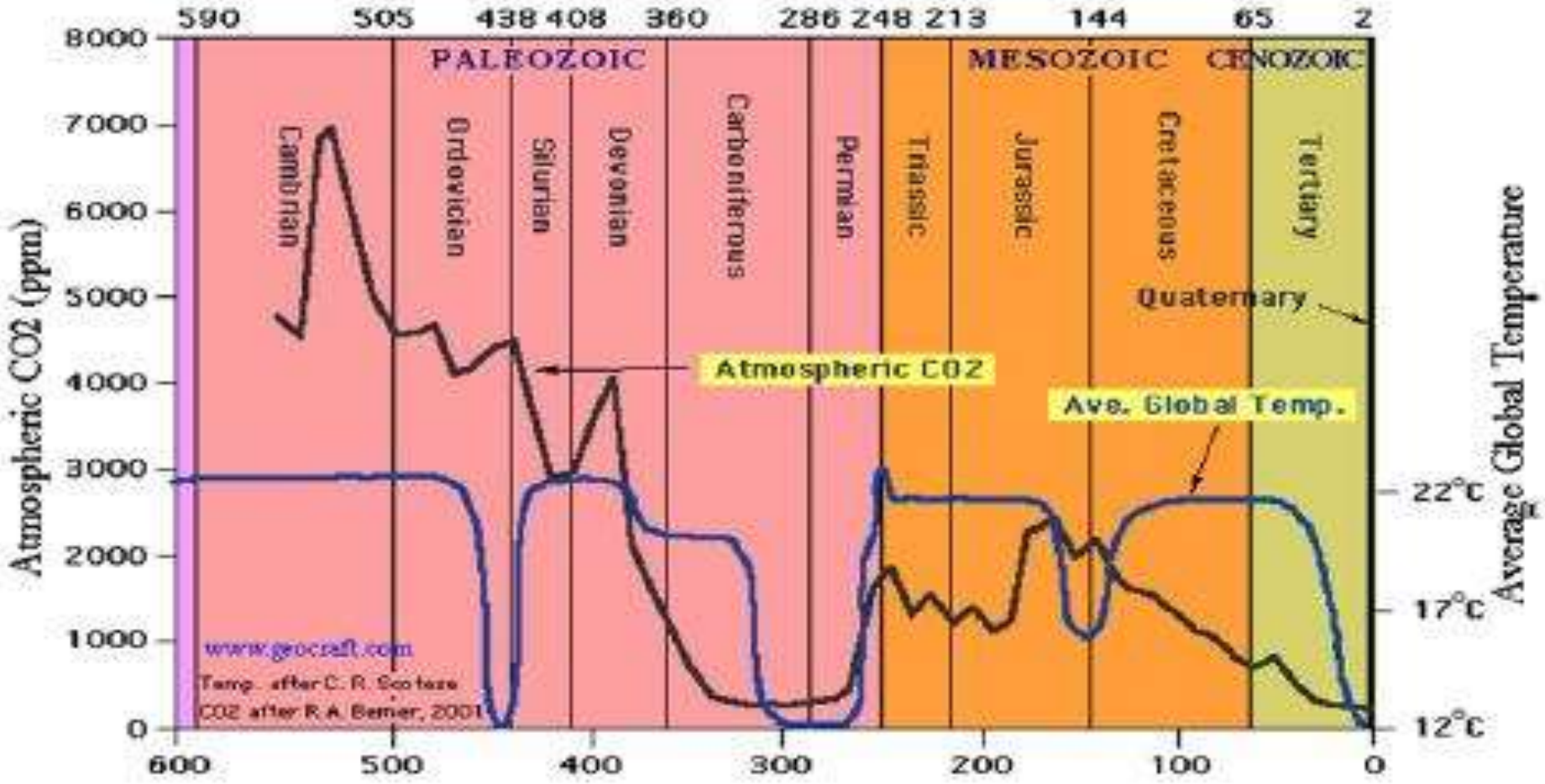
Mikhail Ivanovich Budyko (1920-2001)


Mauna Loa Observatory, Hawaii
Monthly Average Carbon Dioxide Concentration
Data from Scripps CO2 Program Last updated February 2014
CO2 Concentration (ppm)
400
390
380
370
360
350
340
330
320
310
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
Year


Black Body Emission Curves of the Sun and Earth
Radiative Flux (in W/m^2/ μm)
Sun (scaled by a factor of 10^{-6})
Earth
Wavelength (λ) in μm
0
10
20
30
40
50
60
70
80
90
0.1
0.2
0.3
0.4
0.6
0.8
1
2
3
4
5
6
7
8
10
20
30
40
50
60
80
100


EARTH'S ENERGY BUDGET
Reflected by atmosphere 6%
Reflected by clouds 20%
Reflected from earth's surface 4%
64%
6%
Incoming solar energy 100%
Radiated to space from clouds and atmosphere
Absorbed by atmosphere 16%
Radiated directly to space from earth
Absorbed by clouds 3%
Radiation absorbed by atmosphere 15%
Conduction and rising air 7%
Carried to clouds and atmophere by latent heat in water vapor 23%
Absorbed by land and oceans 51%

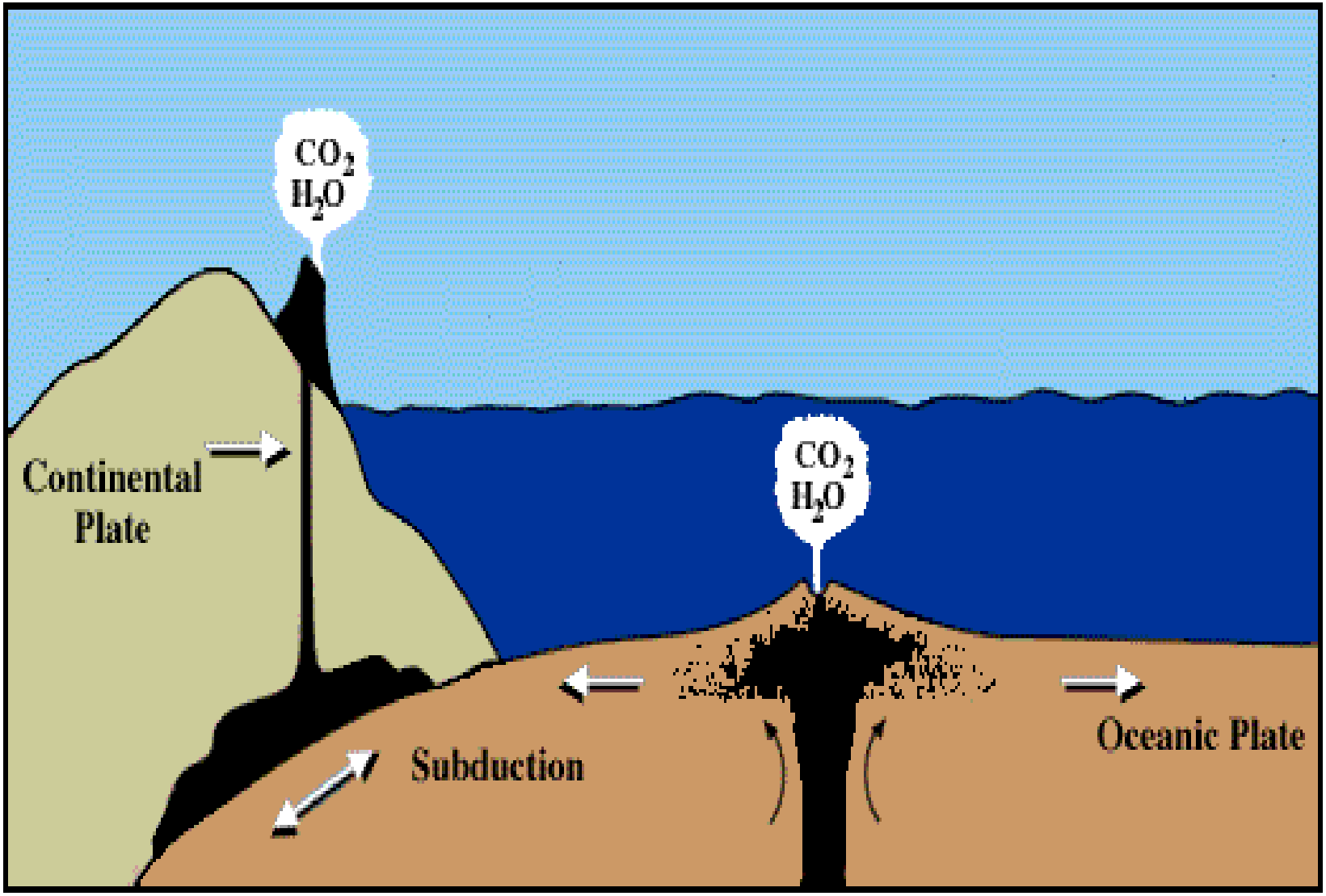

INCOMING SOLAR RADIATION
100
REFLECTED SOLAR RADIATION
6
20
4
OUTGOING INFRARED RADIATION
6
38
26
SPACE
ATMOSPHERE
BACK-SCATTERED BY AIR
REFLECTED BY CLOUDS
REFLECTED BY SURFACE
16
ABSORBED BY H_2O, DUST, O_3
3
ABSORBED IN CLOUDS
51
OCEAN, LAND
15
ABSORPTION BY H_2O, CO_2
NET EMISSION BY H_2O, CO_2
EMISSION BY CLOUDS
NET EMISSION OF INFRARED RADIATION FROM SURFACE
21
SENSIBLE HEAT FLUX
7
LATENT HEAT FLUX
23

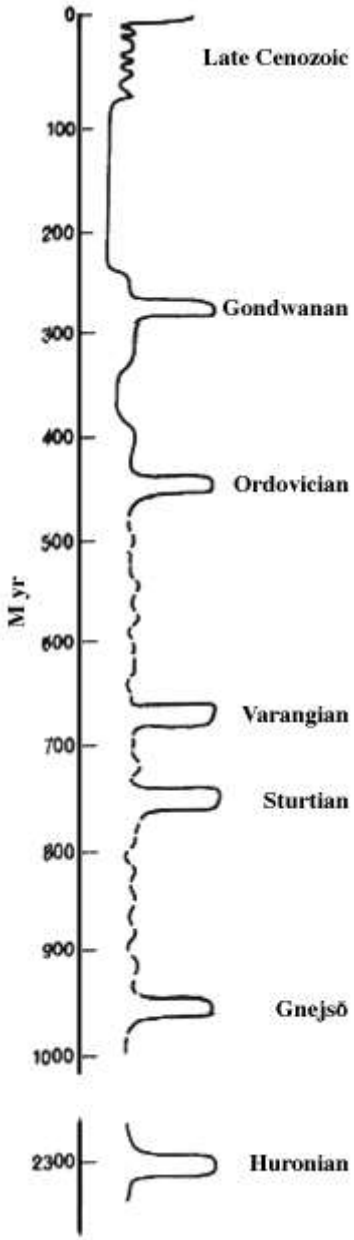


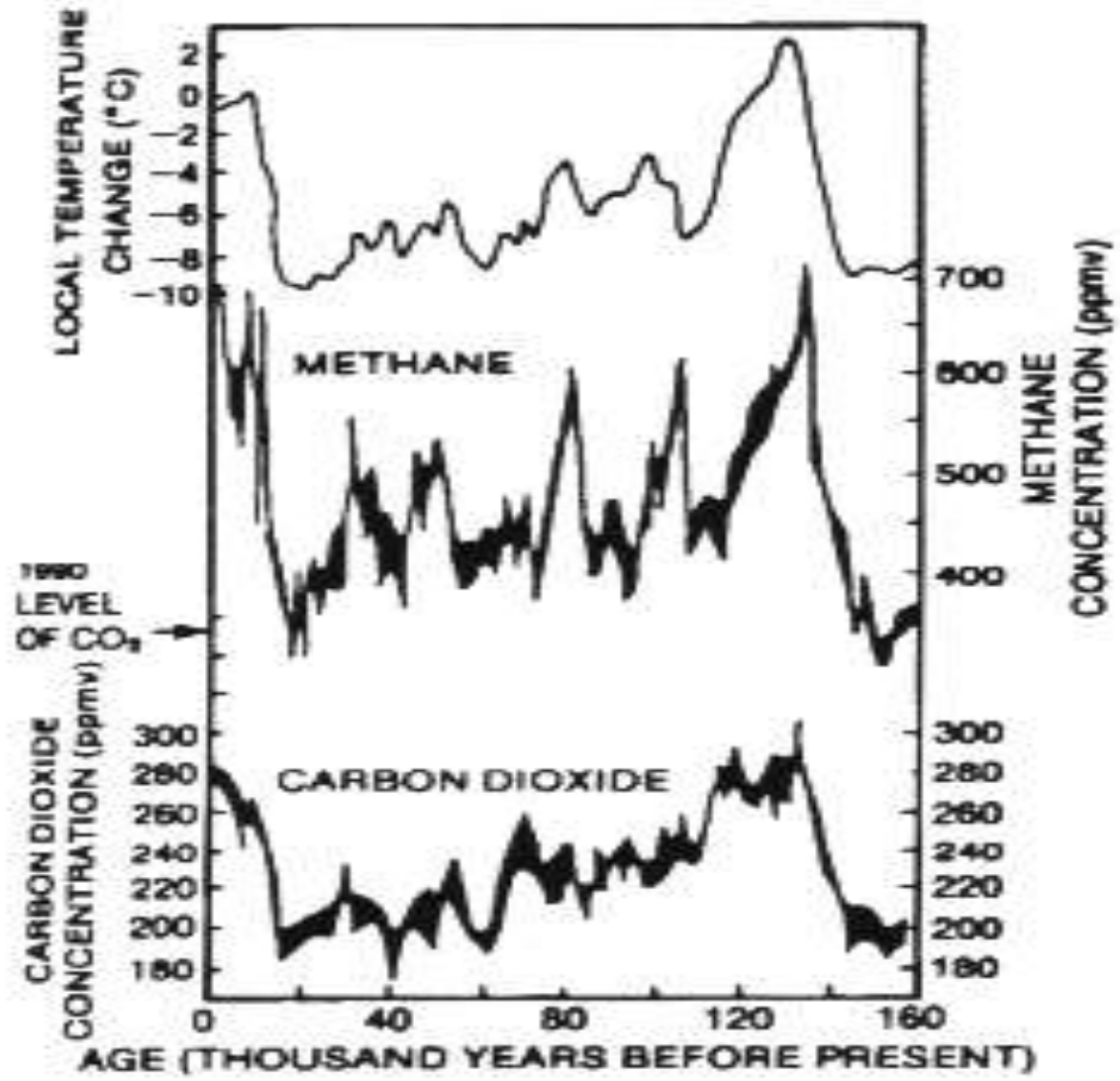
Throughout the past 600 million years, almost one-seventh of the age of the Earth, the mode of global surface temperatures was ~22 °C, even when carbon dioxide concentration peaked at 7000 ppmv, almost 20 times today's near-record-low concentration. If so, then the instability inherent in the IPCC's high-end values for the principal temperature feedbacks has not occurred in reality, implying that the high-end estimates, and by implication the central estimates, for the magnitude of individual temperature feedbacks may be substantial exaggerations. Source: Temperature reconstruction by C.R. Scotese; CO2 reconstruction after R.A. Berner; see also IPCC (2007).

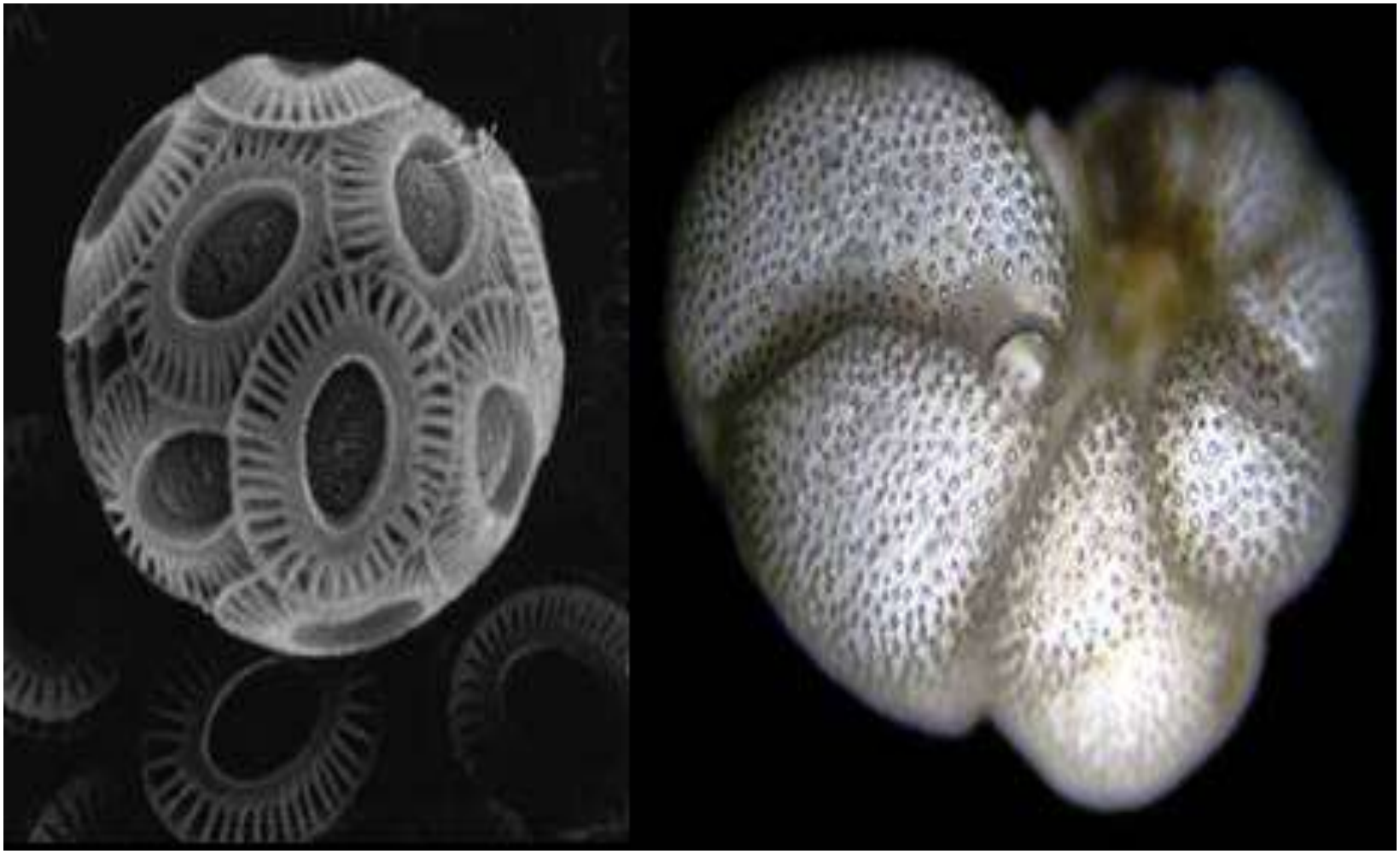
In 1954, Harrison Brown, a highly-regarded geoscientist at the California Institute of Technology, published a book that suggested solving world hunger by pumping massive amounts of carbon dioxide into the atmosphere to stimulate plant growth.

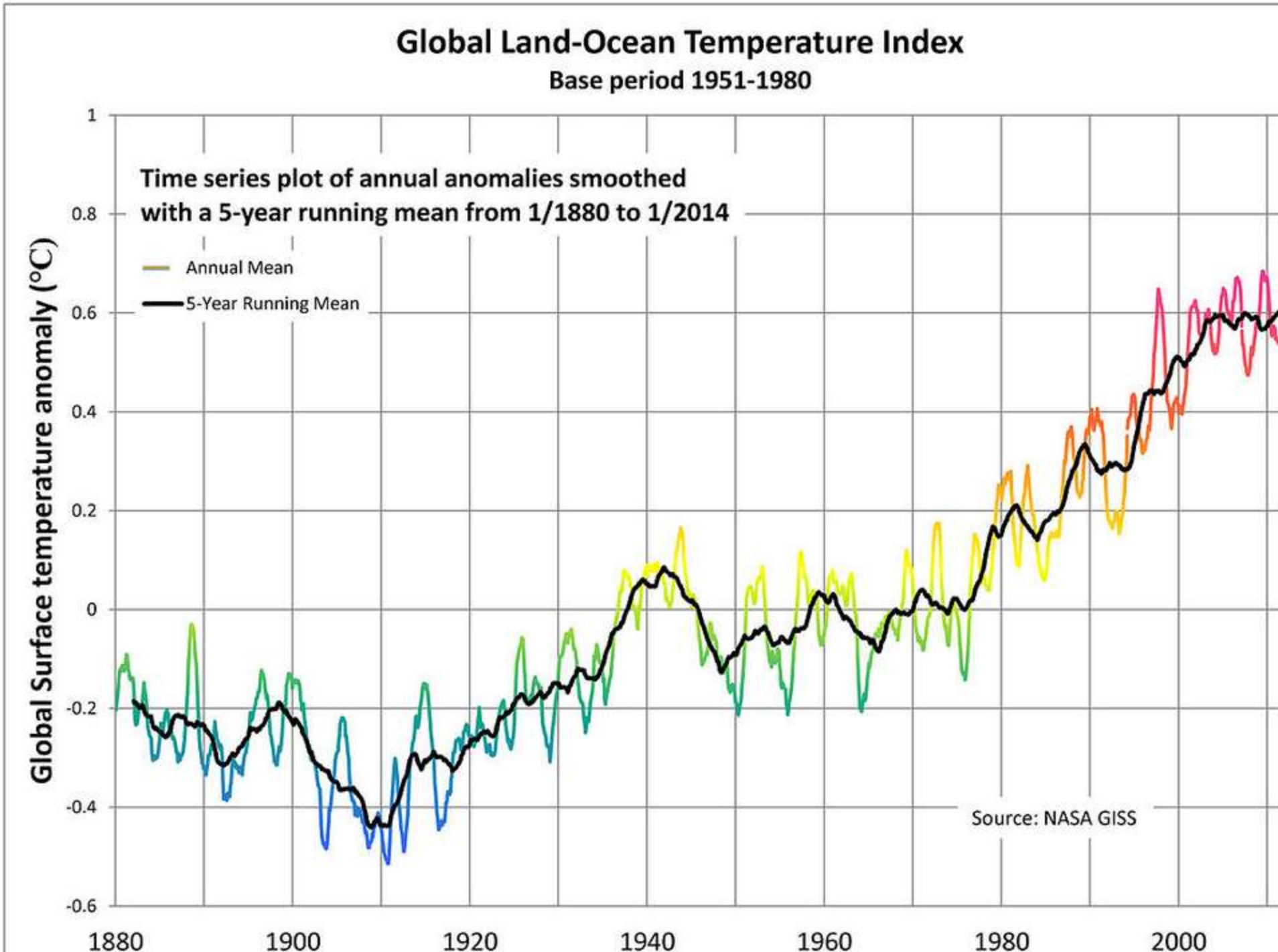
In The Challenge of Man's Future, Brown proposed the construction of "huge carbon-dioxide generators pouring gas into the atmosphere" and calculated that doubling the amount in the atmosphere would require the burning of at least 500 billion tons of coal. Albert Einstein hailed Brown's book as a work of genius.

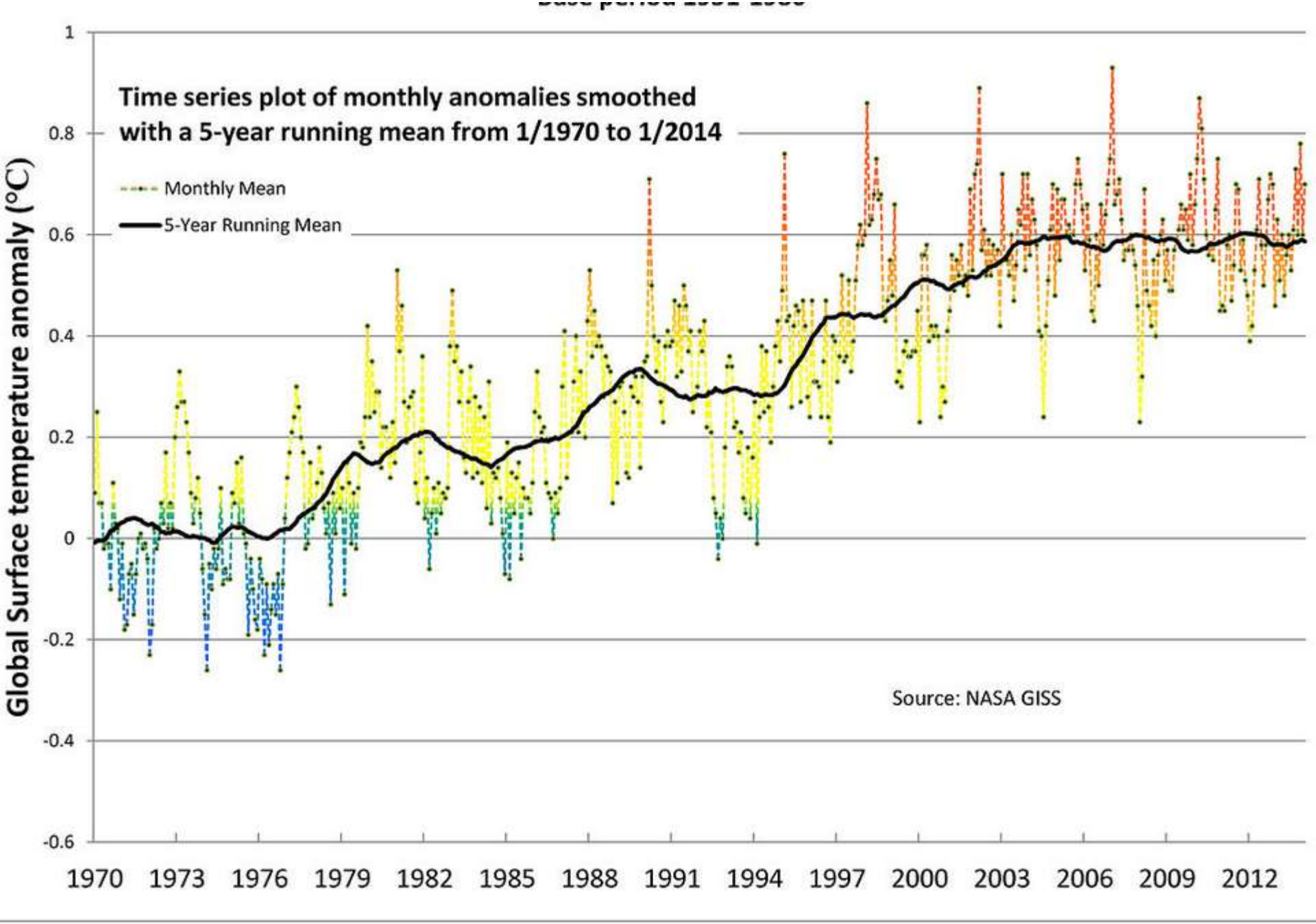

CO_2
H_2O
Continental Plate
CO_2
H_2O
Subduction
Oceanic Plate

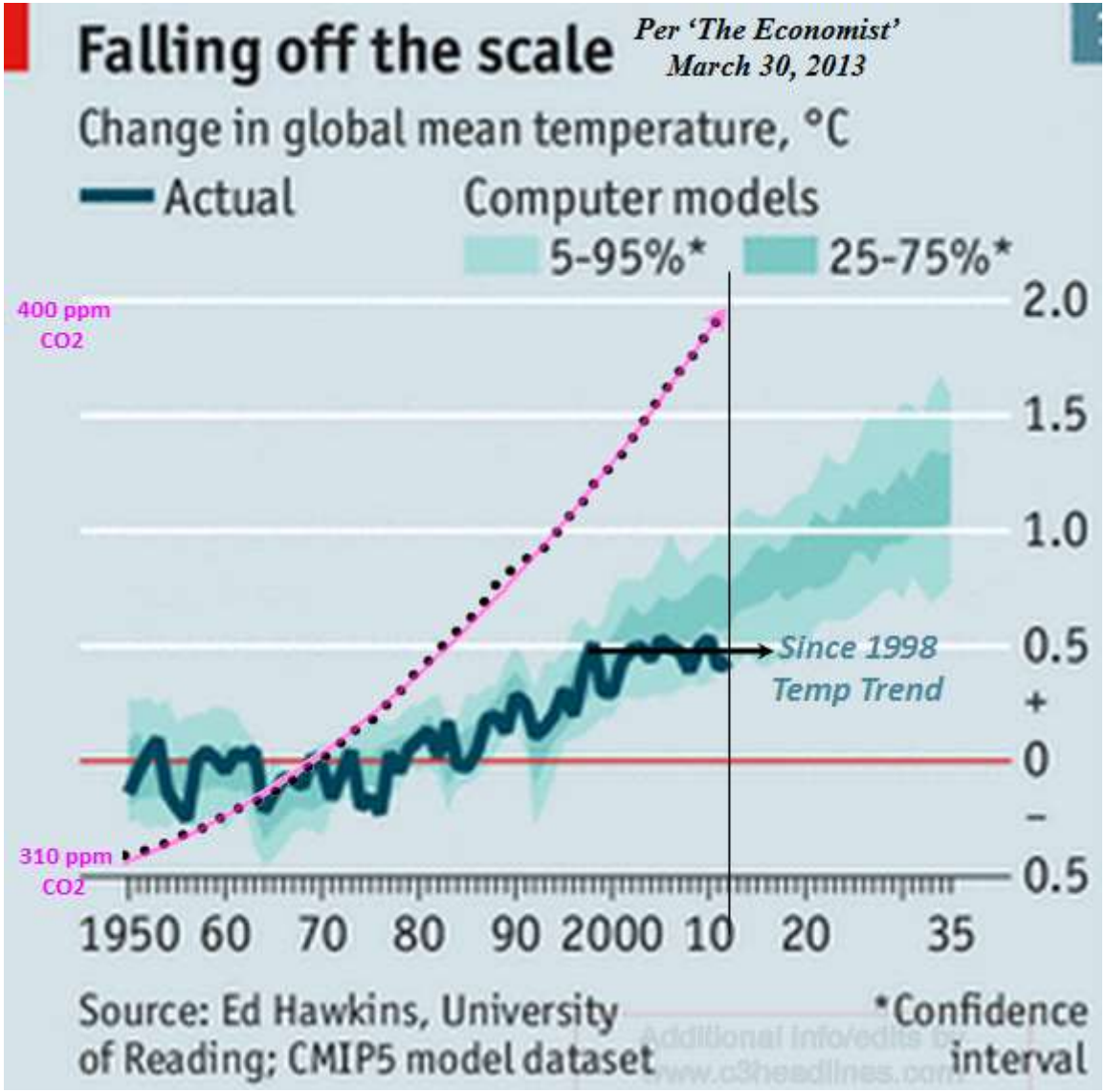

0
100
200
300
400
500
600
700
800
900
1000
2300
Myr
Late Cenozoic
Gondwanan
Ordovician
Varangian
Sturtian
Gnejsō
Huronian


LOCAL TEMPERATURE CHANGE (°C)
2
0
−2
−4
−6
−8
−10
METHANE
700
600
500
400
METHANE CONCENTRATION (ppmv)
LEVEL OF CO_2
CARBON DIOXIDE CONCENTRATION (ppmv)
300
280
260
240
220
200
180
CARBON DIOXIDE
0
40
80
120
160
AGE (THOUSAND YEARS BEFORE PRESENT)

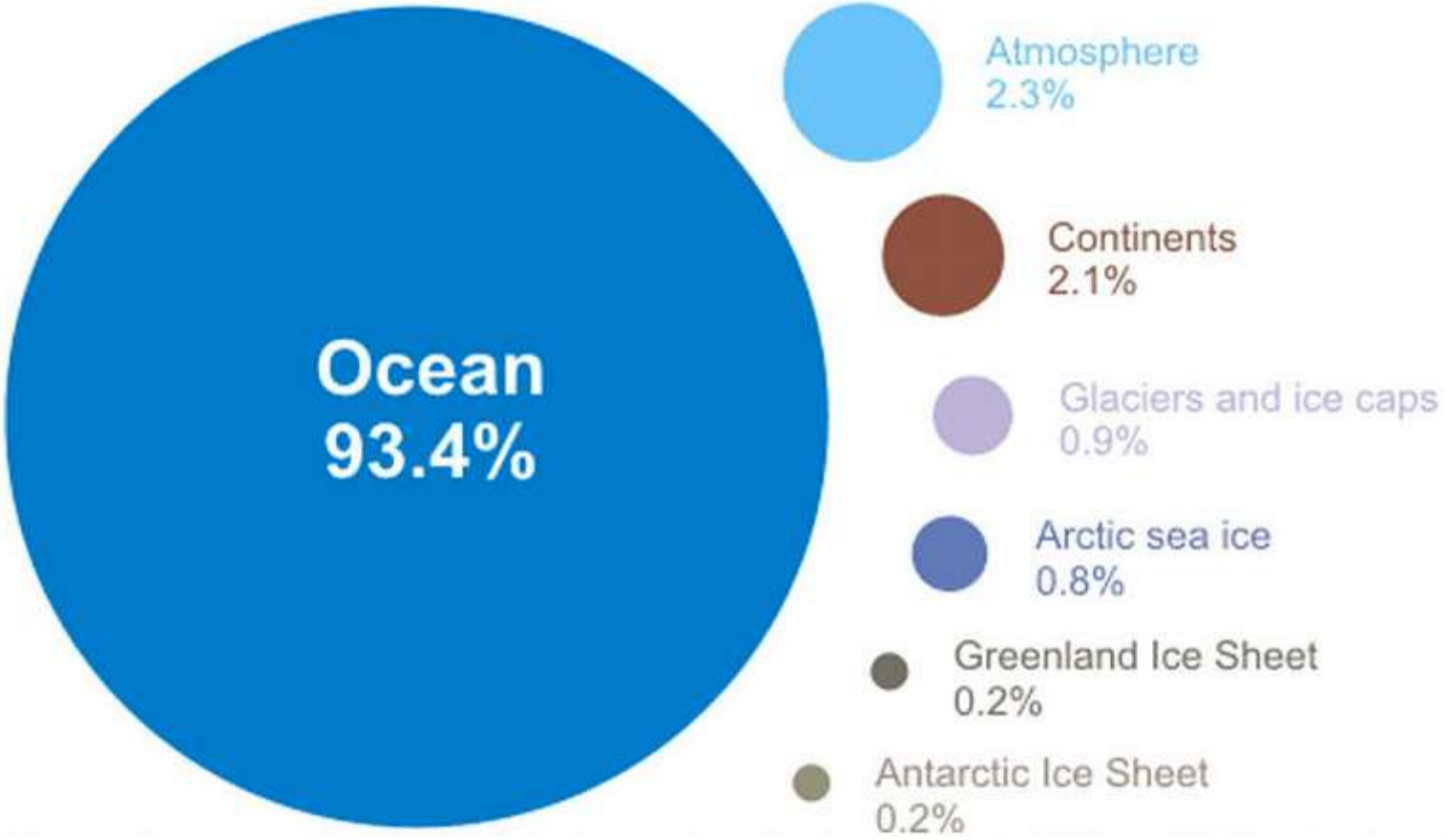



Global Land-Ocean Temperature Index
Base period 1951-1980
Time series plot of annual anomalies smoothed
with a 5-year running mean from 1/1880 to 1/2014
Annual Mean
5-Year Running Mean
Global Surface temperature anomaly (°C)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
1880
1900
1920
1940
1960
1980
2000
Source: NASA GISS

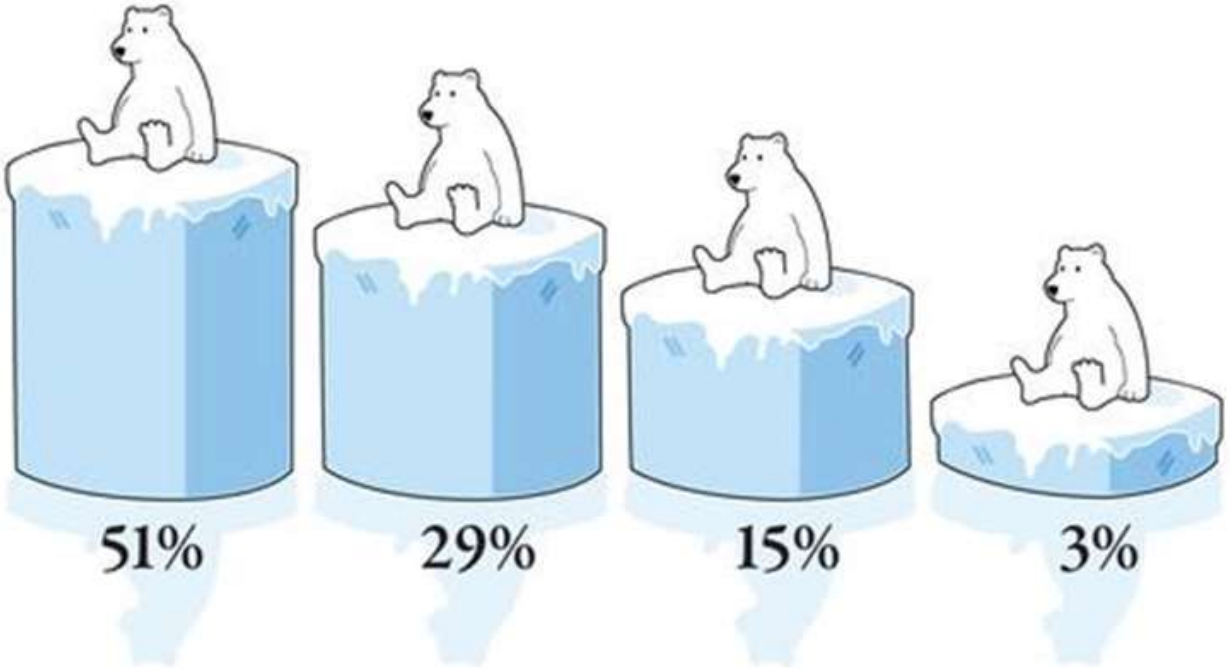

Time series plot of monthly anomalies smoothed with a 5-year running mean from 1/1970 to 1/2014
Monthly Mean
5-Year Running Mean
Global Surface temperature anomaly (°C)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
2009
2012
Source: NASA GISS


Falling off the scale
Per 'The Economist'
March 30, 2013
Change in global mean temperature, °C
Actual
Computer models
5-95%*
25-75%*
400 ppm CO2
310 ppm CO2
Since 1998
Temp Trend
2.0
1.5
1.0
0.5
+
0
–
0.5
1950 60 70 80 90 2000 10 20 35
Source: Ed Hawkins, University of Reading; CMIP5 model dataset
*Confidence interval

Where is global warming going?



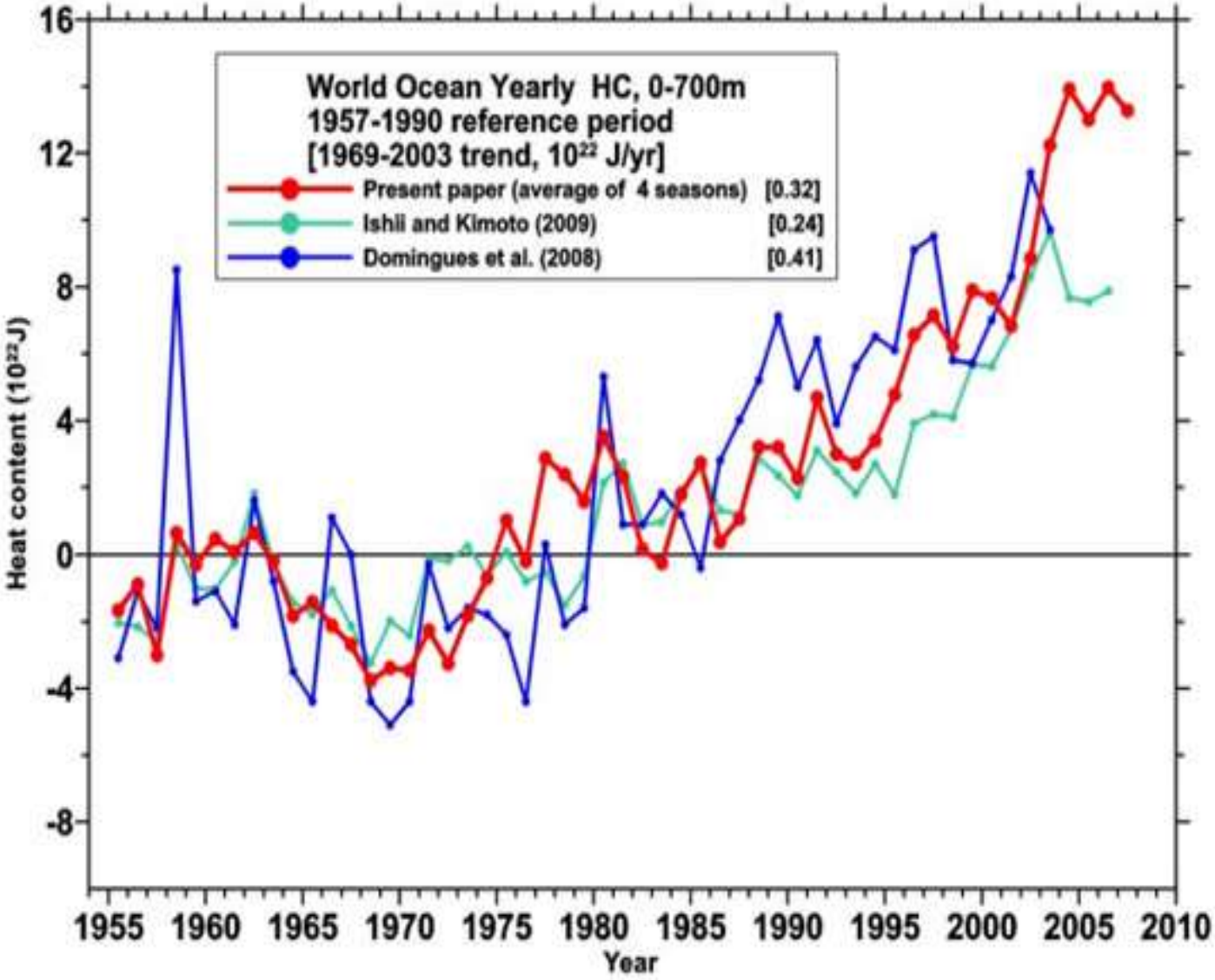
Most Americans Believe Global Warming Exists



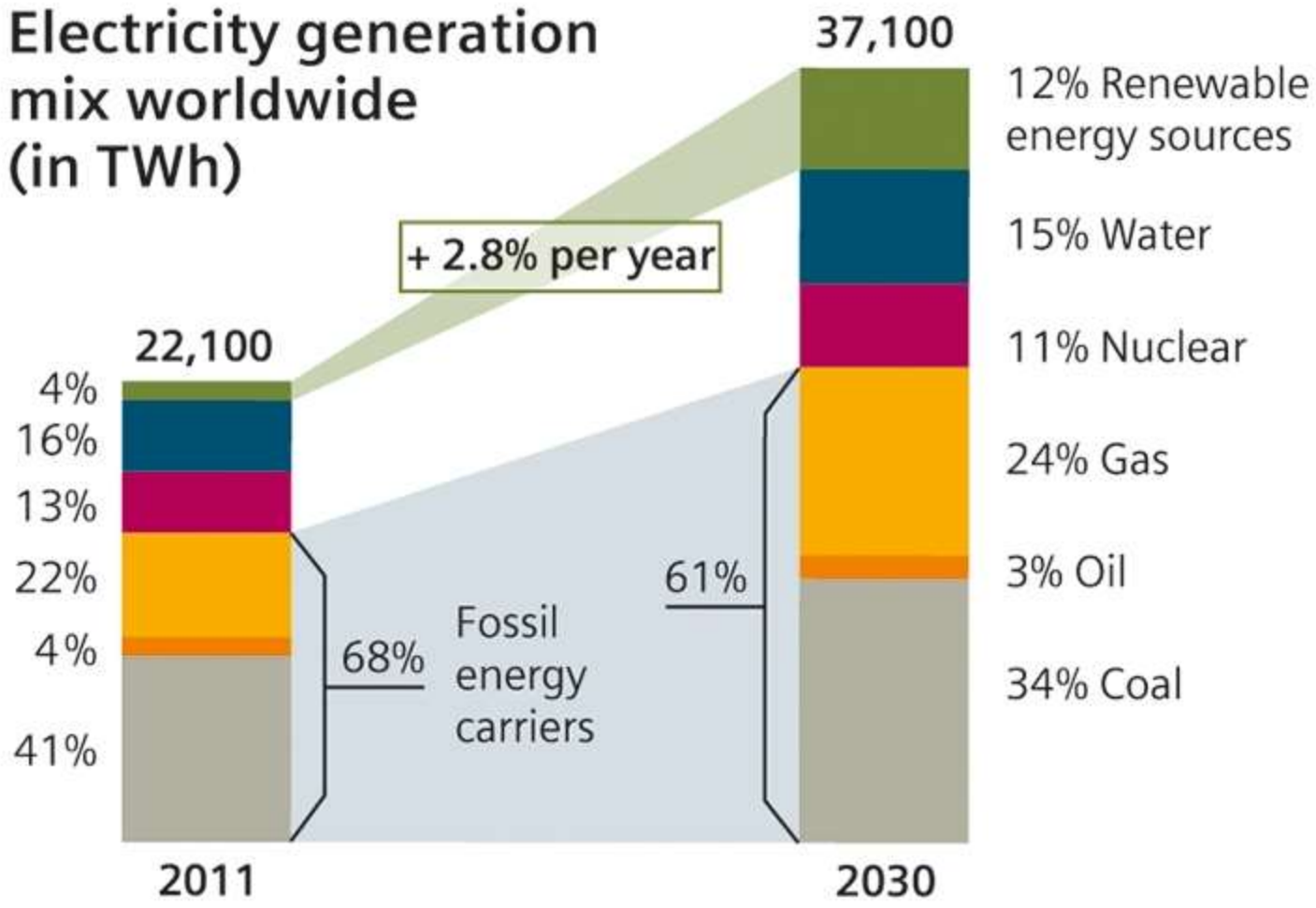
- 51% believe climate change is caused by human activities
- 29% believe it's occurring naturally
- 15% believe it needs to be proven scientifically either way
- 3% believe it doesn't exist

enviromedia® SOCIAL MARKETING

Commissioned by EnviroMedia Social Marketing (enviromedia.com).
Survey of 1,000 Americans by Opinion Research Corporation Jan. 23-26, 2009.
Margin of error +/- 3.2%.


World Ocean Yearly HC, 0-700m
1957-1990 reference period
[1969-2003 trend, 10^22 J/yr]
Present paper (average of 4 seasons) [0.32]
Ishii and Kimoto (2009) [0.24]
Domingues et al. (2008) [0.41]
Heat content (10^22 J)
16
12
8
4
0
-4
-8
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

Demand for Power



Source: Siemens

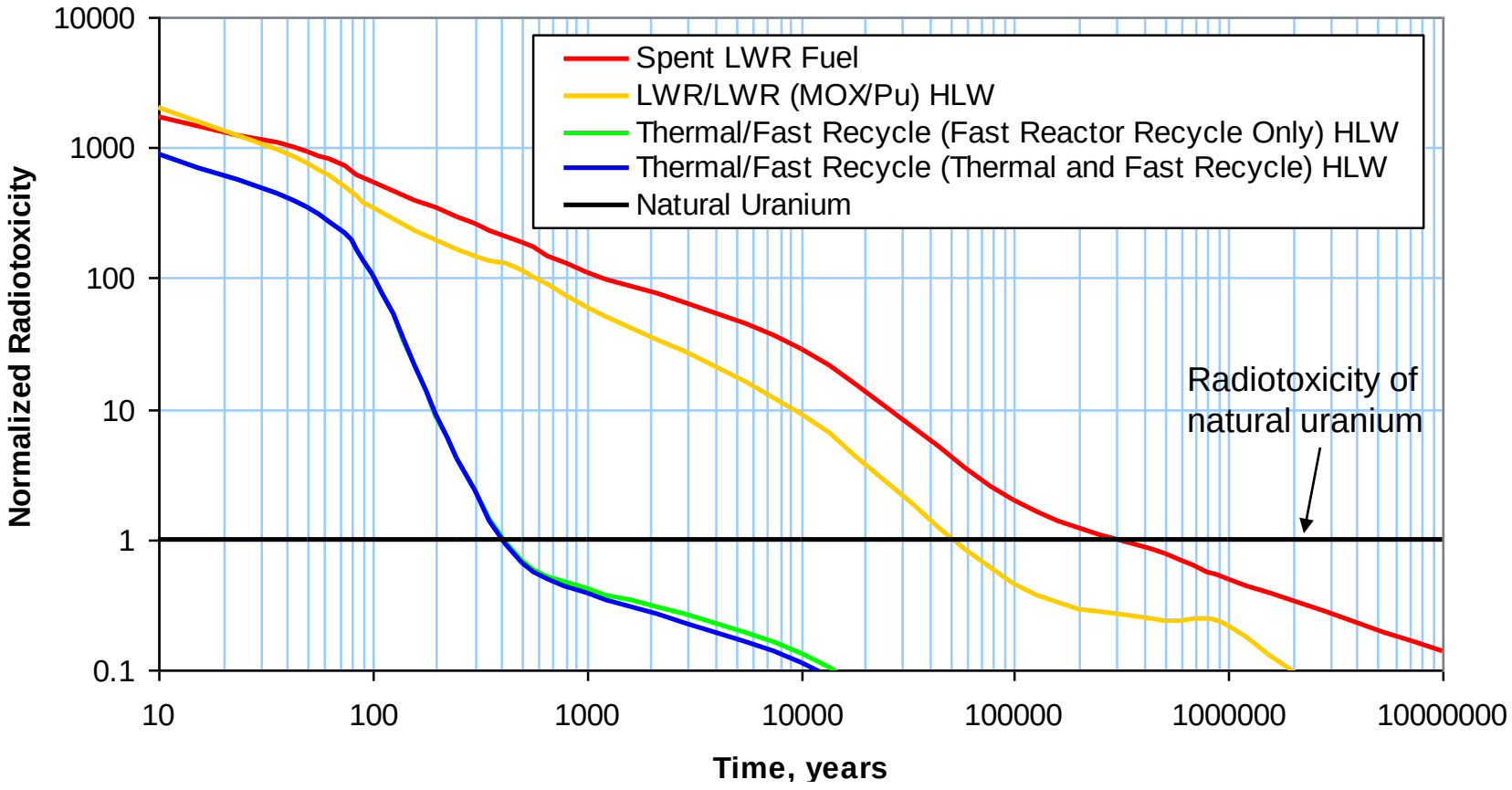
❑ Advantages of Nuclear power plant:

- Space required is less when compared with other power plants.
- Nuclear power plant is the only source which can meet the increasing demand of electricity at a reasonable cost.
- A nuclear power plant uses much less fuel than a fossil-fuel plant.
  1 metric tonne of uranium fuel = 3 million metric tonnes of coal = 12 million barrels of oil.

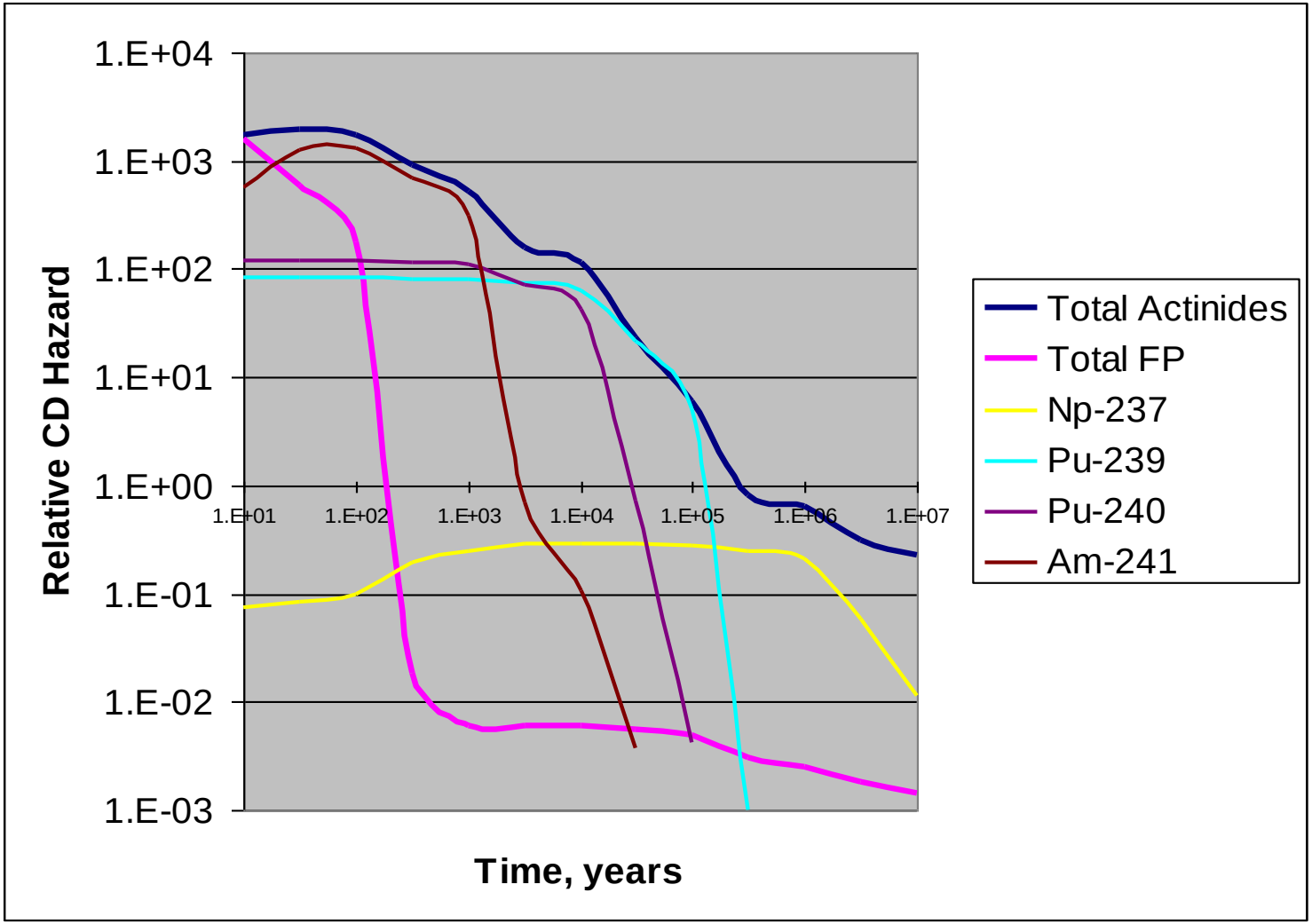
❑ Disadvantages of Nuclear power plant:

- Radioactive wastes must be disposed carefully, otherwise it will adversely affect the health of workers and the environment as a whole.
- Maintenance cost of the plant is high.

Another benefit of a closed fuel cycle is reduced long term radiotoxicity of material placed in geological storage



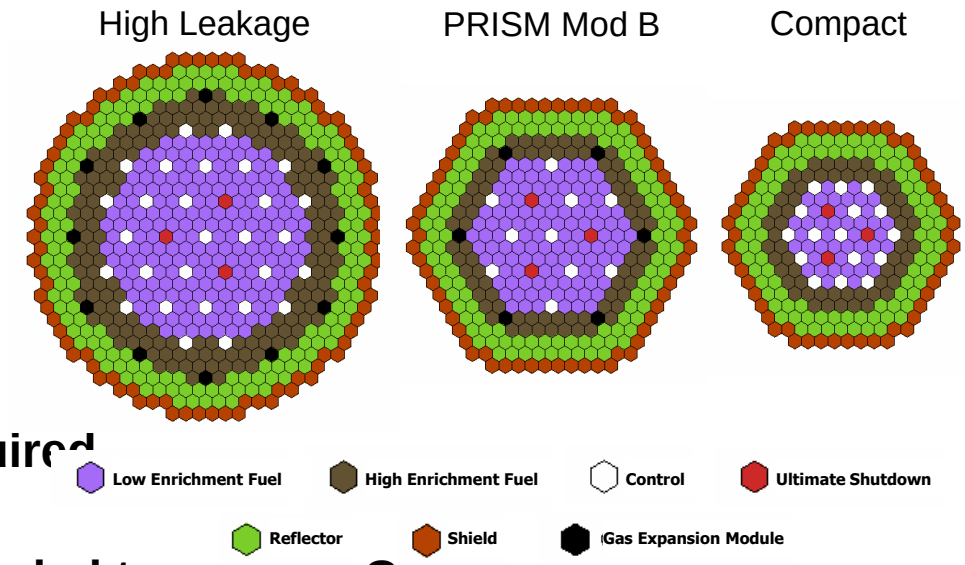
Radiotoxicity of LWR Spent Fuel



Fast Reactor Transmutation Analyses

Fast reactors with closed fuel cycle can effectively manage TRU

- **Can be configured as modest breeders (CR≥1) to moderate burners (CR≥0.5) with conventional technology**
- **Low conversion ratio designs (CR<0.5) have been investigated for transmutation applications**
  - **High enrichment fuels are required (~50% TRU/HM for CR=0.25)**
  - **Non-uranium fuel would be needed to achieve CR=0**
- **Safety performance will change at low uranium content (e.g., reactivity losses, reduced Doppler coefficient)**
  - **Detailed safety analysis conducted for CR=0.25 SFR system**
  - **Passive safety behavior is not compromised**
- **Compact low conversion ratio design COE is similar to reference system**
  - **High leakage configuration increases cost by 20%**
  - **Fuel cost and capacity factor differences roughly offset each other**



Fast Reactor Experience

U.S. experience

- **First usable nuclear electricity was generated by a fast reactor – EBR-I in 1951**
- **EBR-II (20 MWe) was operated at Idaho site from 1963 to 1994**
  - **Closed fuel cycle demo**
  - **Passive safety tests**
- **Fast Flux Test Facility (400 MWt) operated from 1980 to 1992**

International Experience

- **BN-600 power reactor since 1980 at 75% capacity factor**
- **Operating test reactors: PHENIX (France), BOR-60 (Russia), JOYO (Japan)**
- **Most recent construction was MONJU (280 MWe) in 1990**

Basic viability of sodium-cooled fast reactor technology is demonstrated

How Far can Transmutation Go?

- In a Hard-Spectrum Fusion Transmutation Blanket, Nuclear Performance can be Maintained (M_b~10) at least after Destroying 75% of the Spent Fuel Actinides
- Fraction of Minor Actinides (Am and Cm) in the Residual Actinides ~ 30%
- Fraction of Pu239+Pu241 in Pu ≤ 46%

Cost of Transmutation

- Cost of Electricity without Transmutation
  - Estimated for Pure Fusion Power Plant ~ $0.11/kWh ($0.07/kWh, 1991)
  - Market Price of Electric Energy [e.g., San Diego ~ $0.062/kWh, August 2004, Averaged over 1,223 kWh Charges]
- Cost of Electricity with Transmutation
  - Expected to be Lower in a Fusion Based Transmutation Plant, ~$0.085/kWh

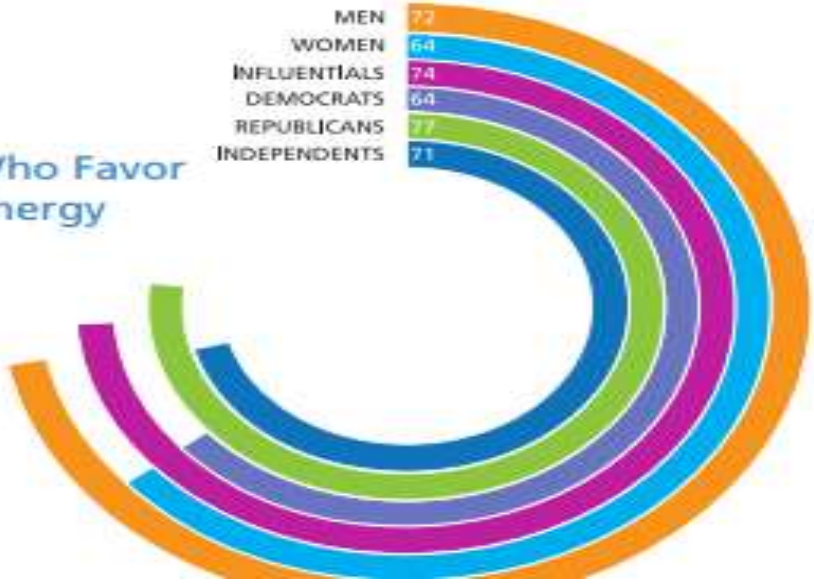
Recommendations by the Blue Ribbon Commission on America's Nuclear Future: A Plan for Managing Spent Nuclear Fuel and High-Level Nuclear Waste.

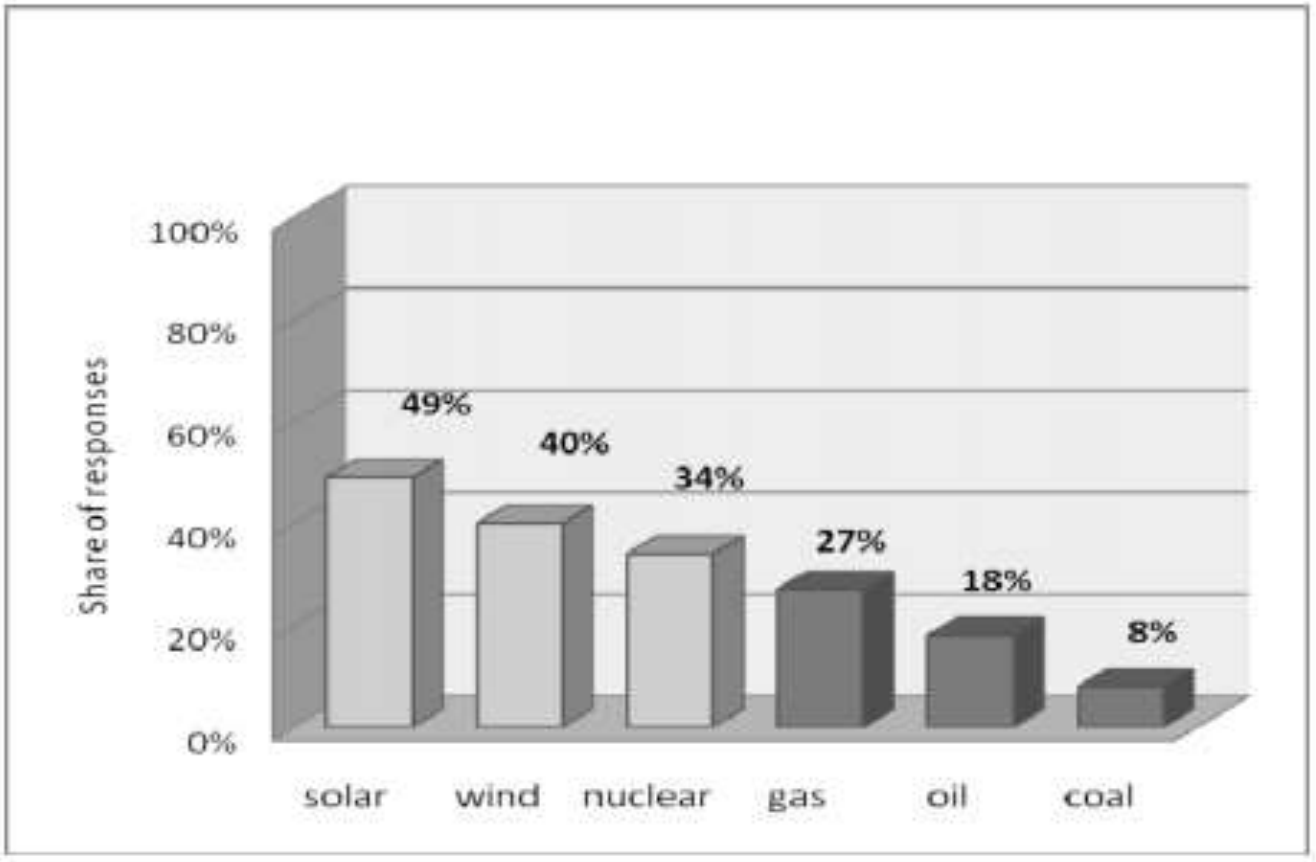
According to the president’s Blue Ribbon Commission, “We know what we have to do, we know we have to do it, and we even know how to do it.”

Percent Who Favor and Oppose Nuclear Energy: Annual Averages 1983 to 2013

"OVERALL, DO YOU STRONGLY FAVOR, SOMEWHAT FAVOR, SOMEWHAT OPPOSE, OR STRONGLY OPPOSE THE USE OF NUCLEAR ENERGY AS ONE OF THE WAYS TO PROVIDE ELECTRICITY IN THE UNITED STATES?"

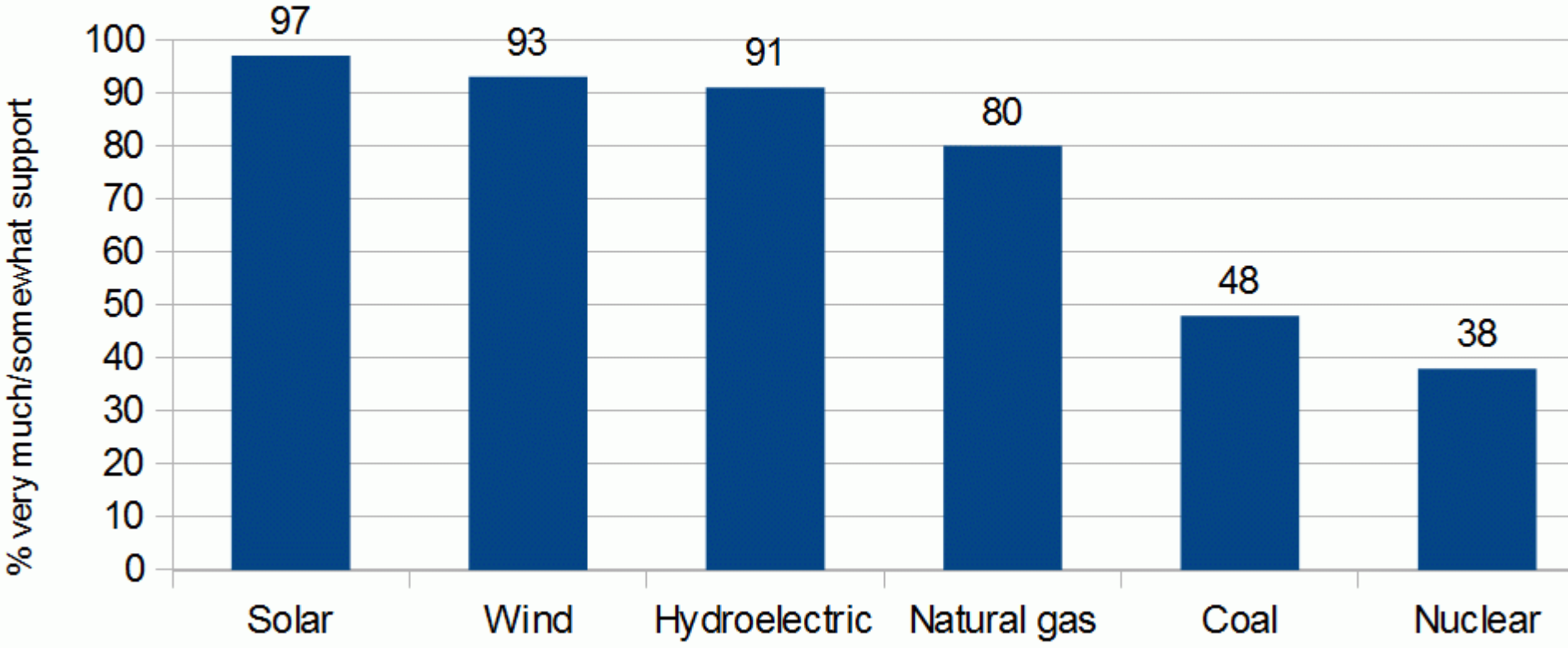
Percent Who Favor Nuclear Energy




Share of responses
100%
80%
60%
40%
20%
0%
49%
40%
34%
27%
18%
8%
solar
wind
nuclear
gas
oil
coal

Global public support for energy sources

"Please indicate whether you strongly support, somewhat support, somewhat oppose or strongly oppose each way of producing energy"



Source: Ipsos, May 2011

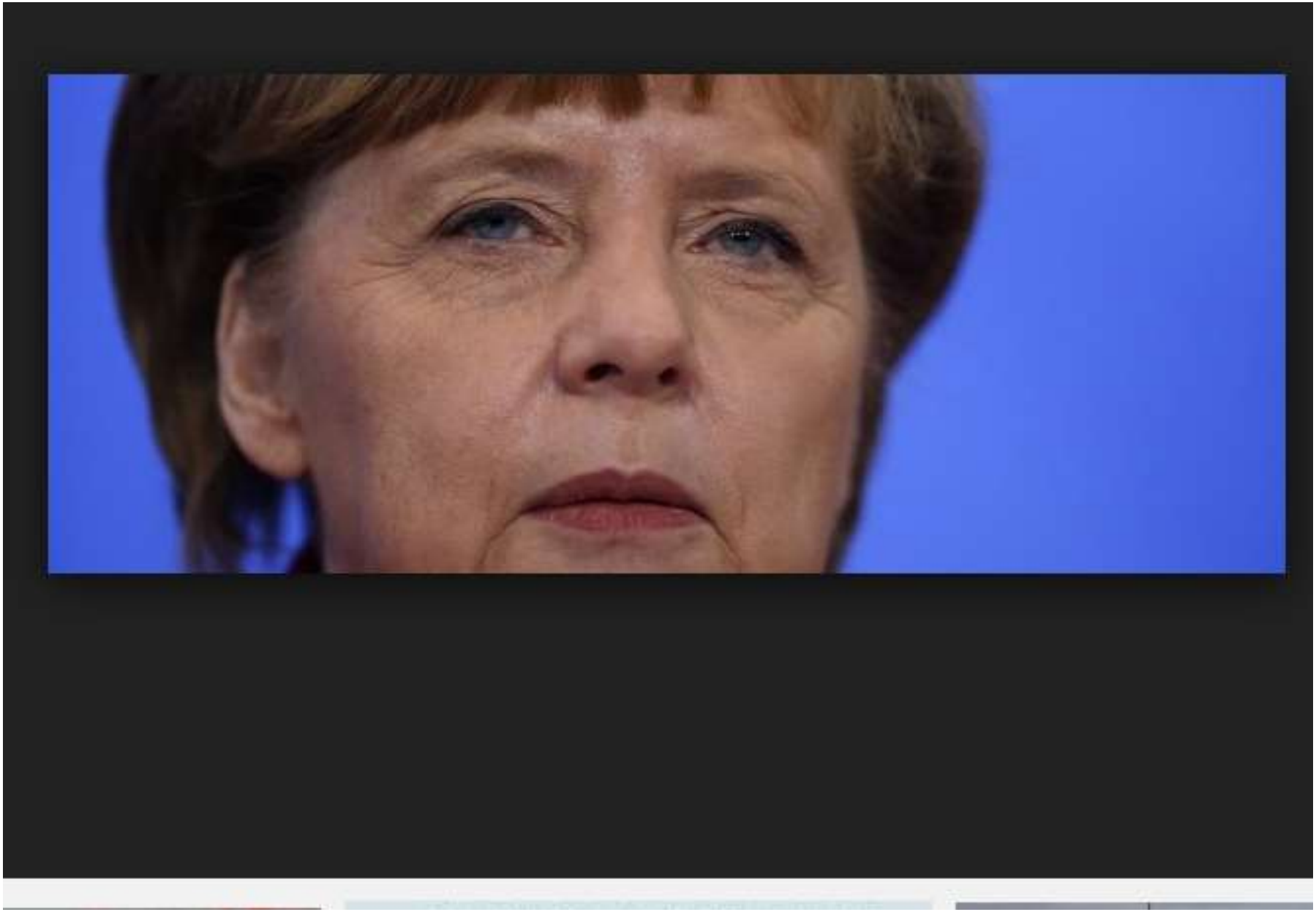
According to a 2012 Pew Research Center poll, 44 percent of Americans favor and 49 percent oppose the promotion of increased use of nuclear power, while 69 percent favor increasing federal funding for research on wind power, solar power, and hydrogen energy technology.

Germany was once touted by President Obama as a shining example of green energy policy. The country aims to get 80 percent of its power from green energy by 2050 in an effort to drastically cut its carbon dioxide emissions, which scientists say cause global warming.

A mix of subsidies and production quotas have allowed the country to rapidly expand its green energy production, growing from 4.3 percent of total energy consumption in 1990 to a whopping 23.5 percent in 2012 (this includes hydroelectric power). But the cost has been astronomical to consumers.

Consumer energy bills have been spiking for years to the point where electricity in the country has been called a “luxury good” by major media outlets. German households have seen electricity prices more than double in the last decade “increasing from €0.14/kilowatt hour (kWh) ($0.18) in 2000 to more than €0.29/kWh ($0.38) in 2013,” according to FAA. This is compared to U.S. household prices, which have been stable at $0.13 per kilowatt hour over the last decade.

FAA also reports that German consumers will pay $31.1 billion for energy subsidies this year alone. Furthermore, in the past five years Germany has suffered $67.6 billion in net export losses from high energy costs — a huge blow to an export-led economy like Germany.



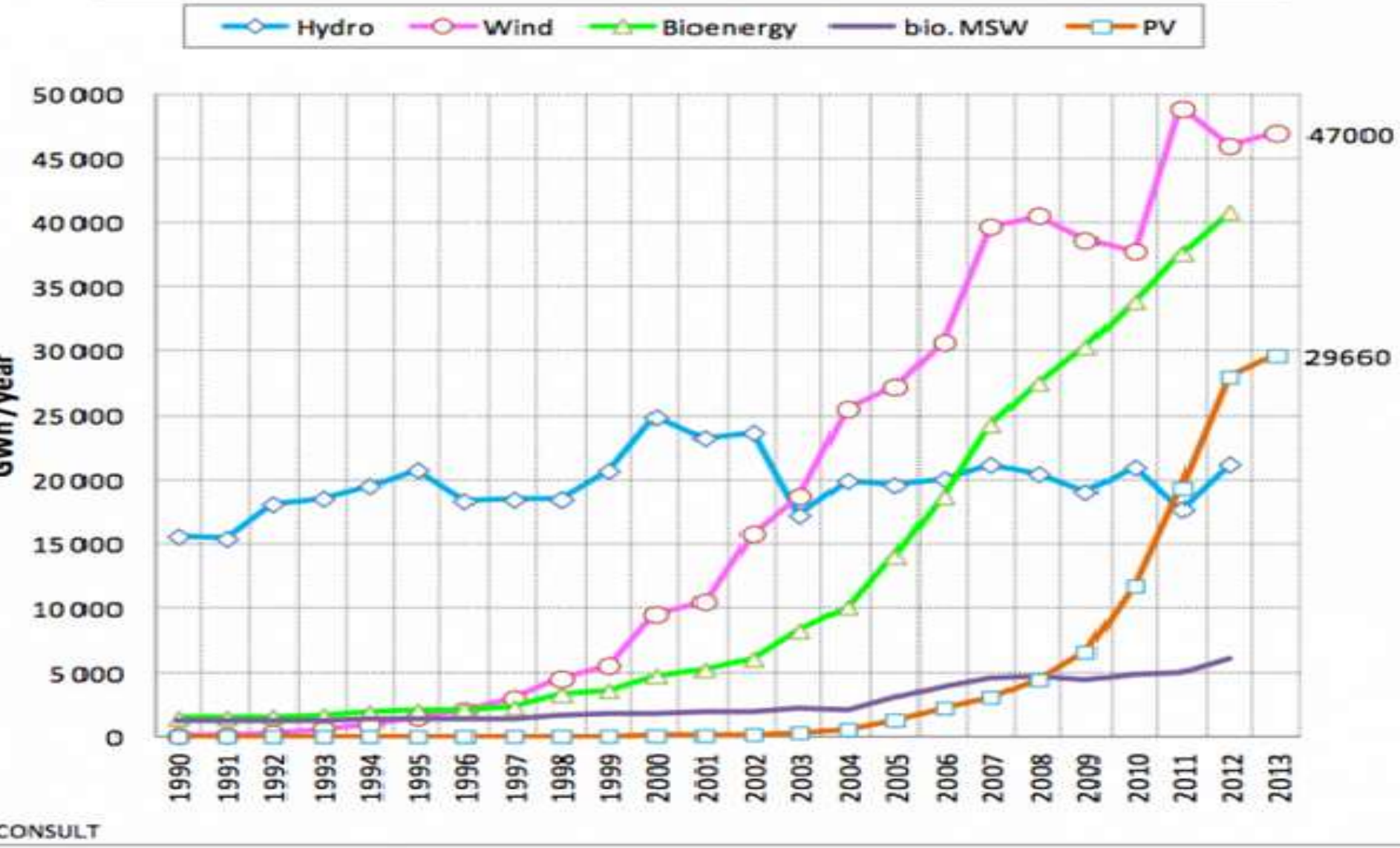
German “Energiewende”

The Energiewende is a huge opportunity to pave the way for a highly industrialised, sustainable green economy. Ambitions are high:

Full phase-out of nuclear energy by 2022
80-95% reduction in greenhouse gases by 2050
Minimum of 80% renewables in the power sector
50% increase in energy efficiency by 2050

Renewable Electricity Production in Germany

GWh/year, source of data: BMU. Total 2012: 136 TWh, 22.9 % of demand



CONSULT

CREDIT: BERNARD CHABOT

BRING ON THE DIRTY COAL MINING MONSTERS

(courtesy of Wikipedia)

g Archives: *german green energy*

eality Check: Germany's Defective Green Energy Game Plan 3)

sted on October 28, 2013 by Jack

ermany pretends to be a pioneer in the green revolution. But its massively expensive nergiewende has done nothing to make the environment cleaner or encourage genuine ficiency. One writer argues: Either do it right, or don't do it at all. … Continue reading →

sted in Featured | Tagged german green energy | Comments Off

vans-Pritchard: Germany's green dream is becoming a ightmare (2)

sted on September 26, 2013 by Jack

ermany's top economic adviser has called for a radical rethink of the country's energy olicies, warning that the country's green dream is going badly wrong as costs spiral out ntrol. "We need a drastic policy shift," said Christoph Schmidt, … Continue reading →

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erman Energy Plan Plagued by Lack of Progress

sted on October 13, 2012 by Jack

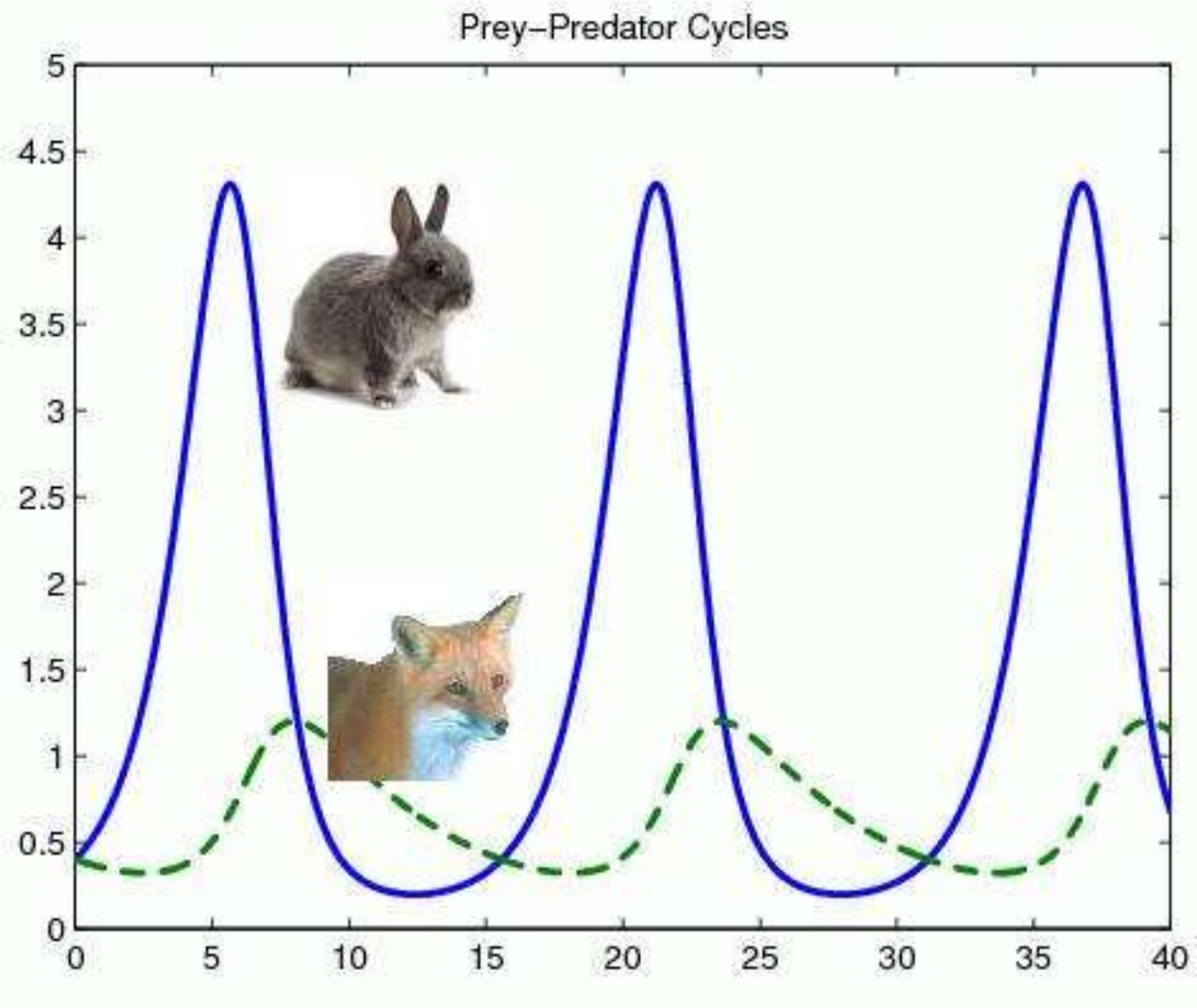
ermany plans to abandon nuclear power by 2022, but its government hasn't been doing

Ecological Economics
Volume 101, May 2014, Pages 90–102

Methodological and Ideological Options Human and nature dynamics (HANDY):

Modeling inequality and use of resources in the collapse or sustainability of societies

Safa Motesharrei, Jorge Rivas, , Eugenia Kalnay


Prey–Predator Cycles
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
5
10
15
20
25
30
35
40