Global Warming
What is it?

Earth has warmed by ~ 1°F over the past 100 years. But why? And How?

Scientists are not exactly sure.

The earth could be getting warm on its own.

However ....

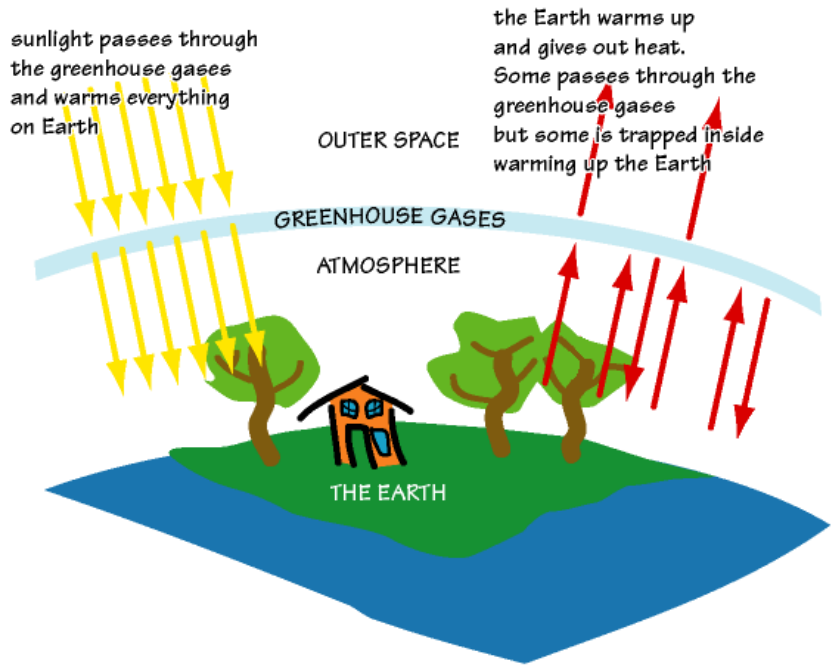
- **Scientists are sure about the greenhouse effect. They know that greenhouse gases make the earth warmer by trapping energy in the atmosphere.**

- **Many of the world's leading climate scientists think that things people do are helping to make the Earth warmer.**

The Greenhouse Effect

- **Greenhouse gases in the atmosphere behave much like the glass panes in a greenhouse.**

- **Sunshine enters the Earth's atmosphere passing through the blanket of greenhouse gases.**

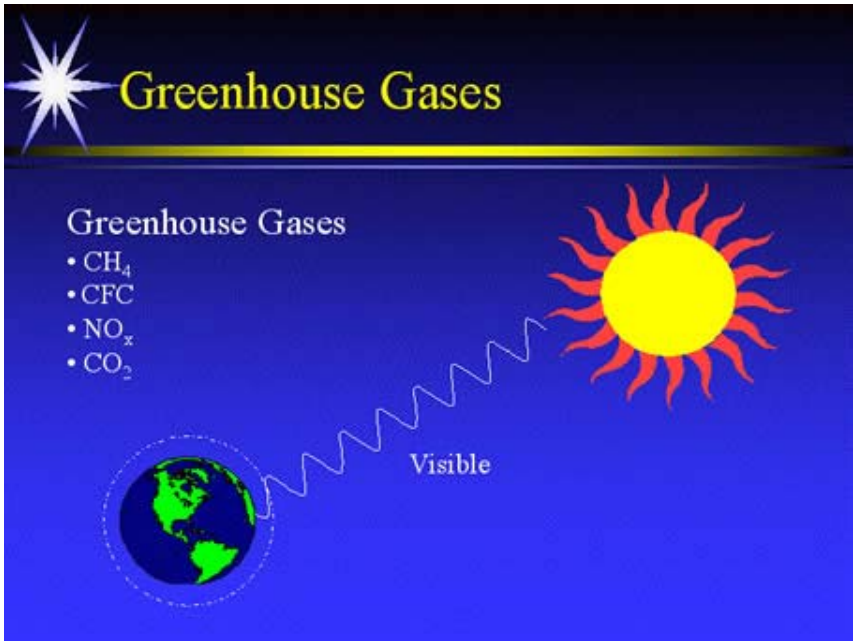


As it reaches the Earth's surface, land, water, and biosphere absorb the sunlight's energy! Once absorbed this energy is sent back into the atmosphere.

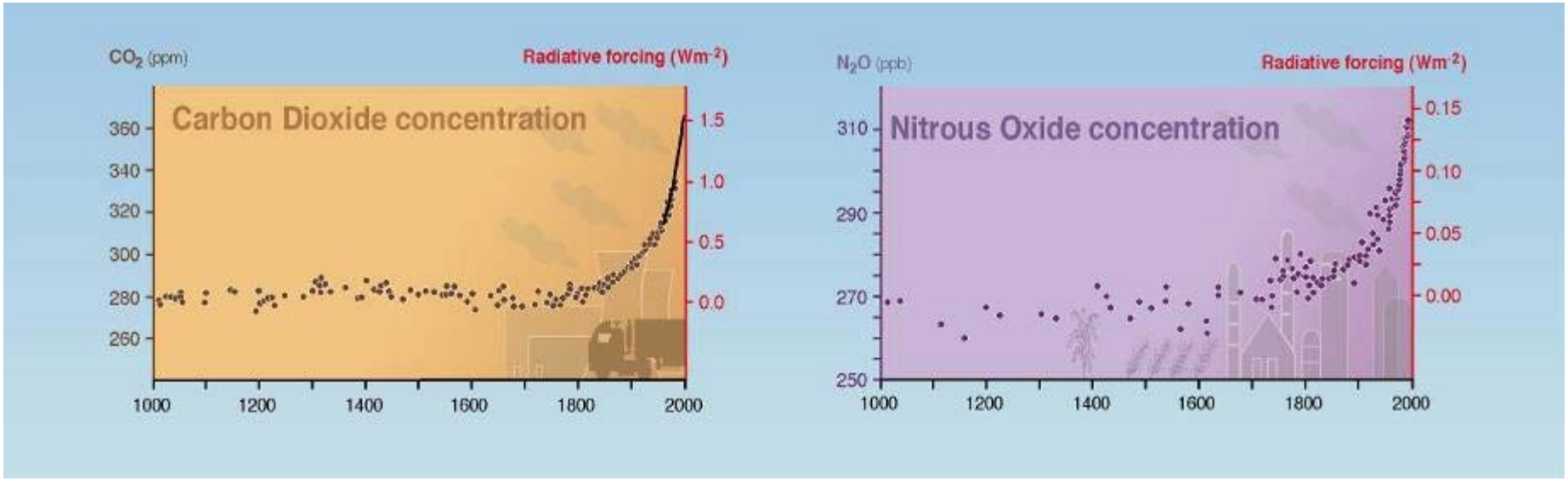
Greenhouse Effect

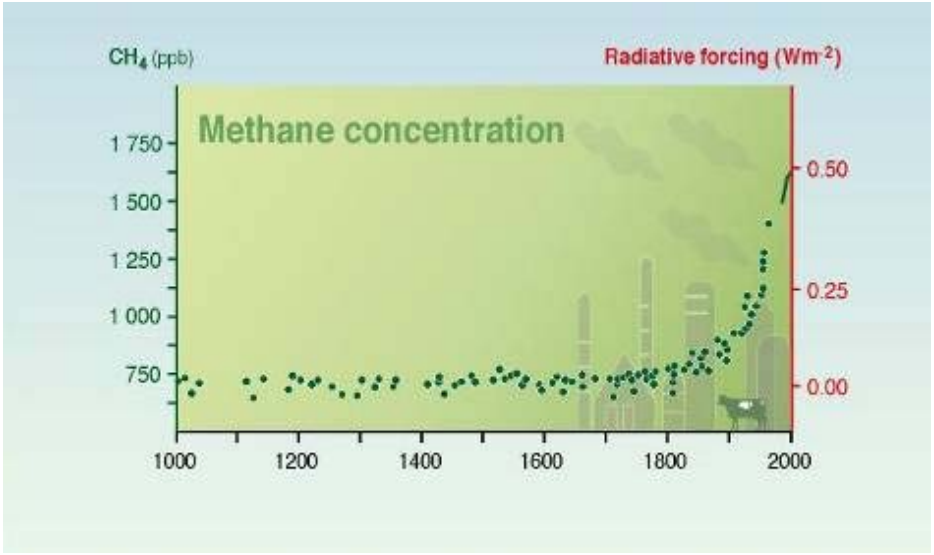
- **Without these gases, heat would escape back into space and Earth's average temperature would be about 60° F colder.**

- **Because of how they warm our world, these gases are referred to as greenhouse gases.**



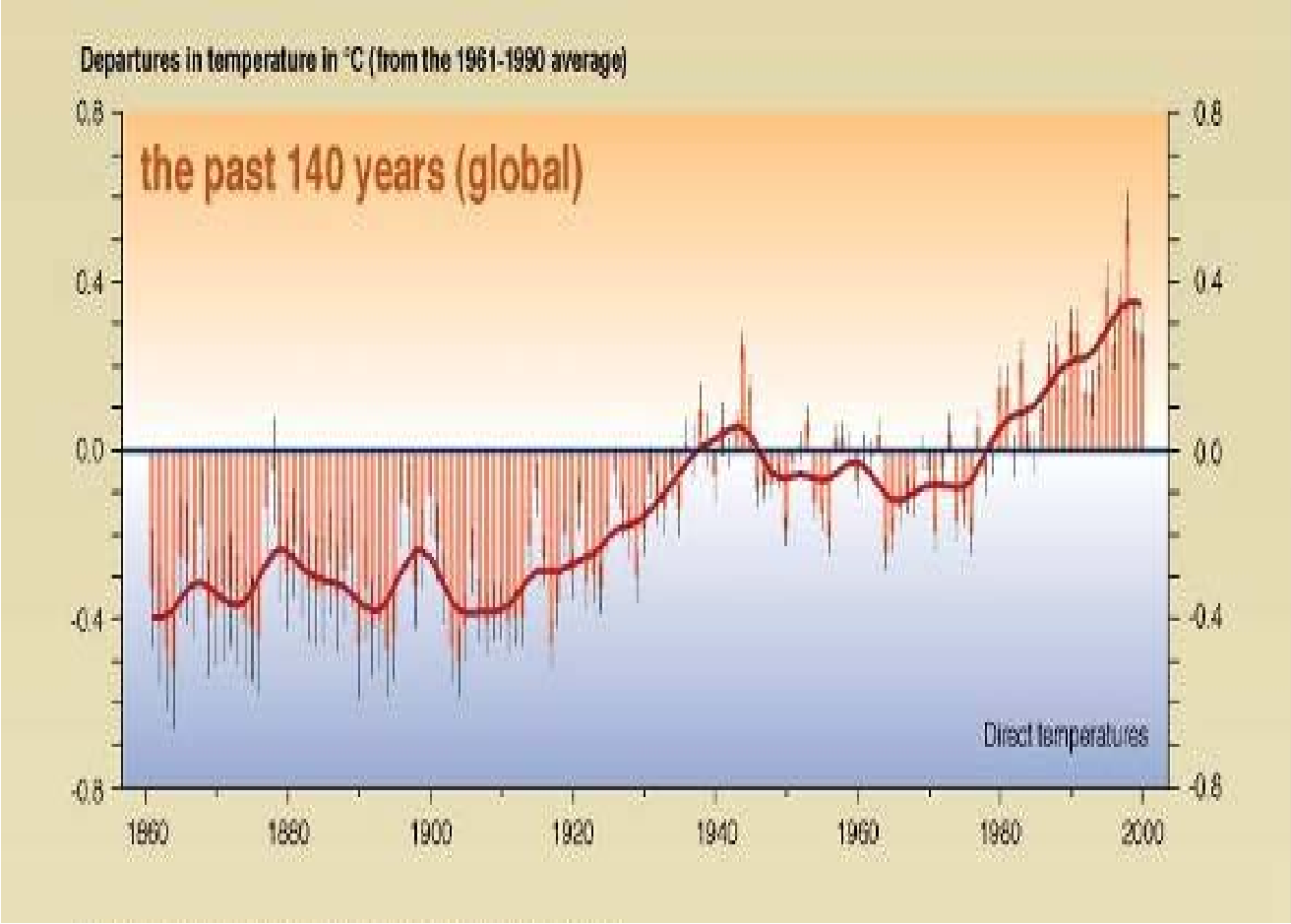
Human activity influence





www.unep.fr/shared/publications/cdrom/.../session04_**UNFCCC**.**ppt**

Variation of the temperature on Earth



www.unep.fr/shared/publications/cdrom/.../session04_**UNFCCC**.**ppt**

CLIMATE CHANGE

- Human activities are releasing greenhouse gases (GHG) into the atmosphere.
- Climate change is a global issue:
  1 tCO_2 emitted in India = 1 tCO_2 emitted in USA.
- Rising levels of greenhouse gases are already changing the climate.
- Climate models predict the global temperature will rise by ~1.4 - 5.8 degree Celsius by 2100.
- Climate change is likely to have a significant impact on the global environment, economy and society.

Green Technology

Go Green

What is Green Technology

What is Green Technology

Green Technology is an application of a technology with one or more of the following objectives:

- Lowering greenhouse gas emissions,
- Increasing the efficient use of natural resources, and
- Improving air, water quality or other environmental aspects

Green Technology

- **Environmental technology or green technology or clean technology is the application of one or more of environmental science, green chemistry, environmental monitoring and electronic devices to monitor, model and conserve the natural environment and resources, and to curb the negative impacts of human involvement.**

- **Sustainable development is the core of environmental technologies.**

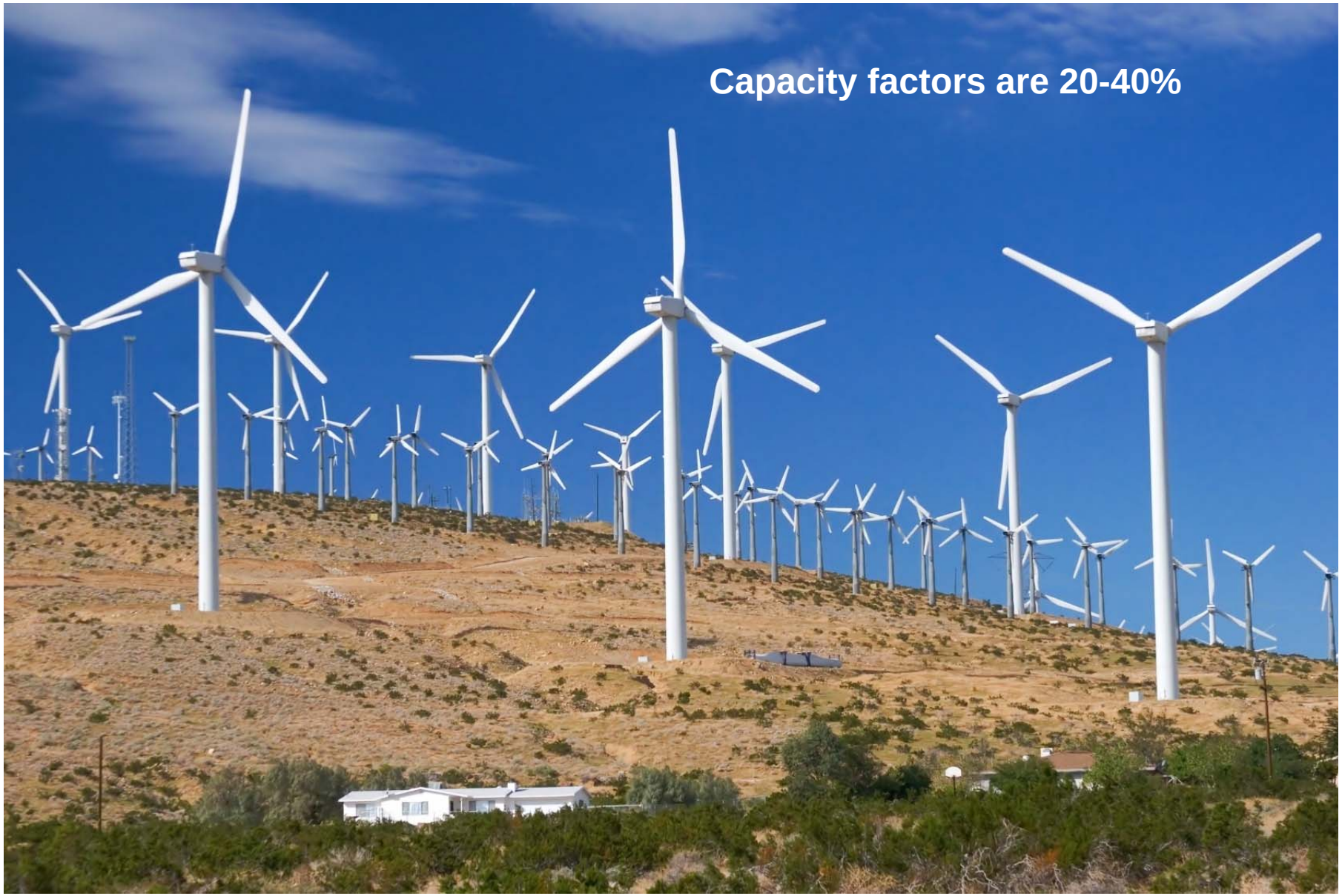
What is green technology?

- **Green technology** is the application of environmental sciences to conserve natural resources and to address the negative impacts of human activities.
- **Green technology** is a low-carbon technologies and more environmentally friendly than existing technologies. When we use green technology, we use resources such as energy, water and a minimum to produce a product
- **Any technology** that contributes to the reduction of Green House Gas emissions, or used to develop products and services that generate less greenhouse gas emissions.
- **Green Technology** applications is in line with the concept of sustainable development in which development is undertaken to meet current needs without compromising the needs of future generations.

Source: http://sekolah07.tmmelaka.com.my/2.0%20file_en/Q&A/1_en.html

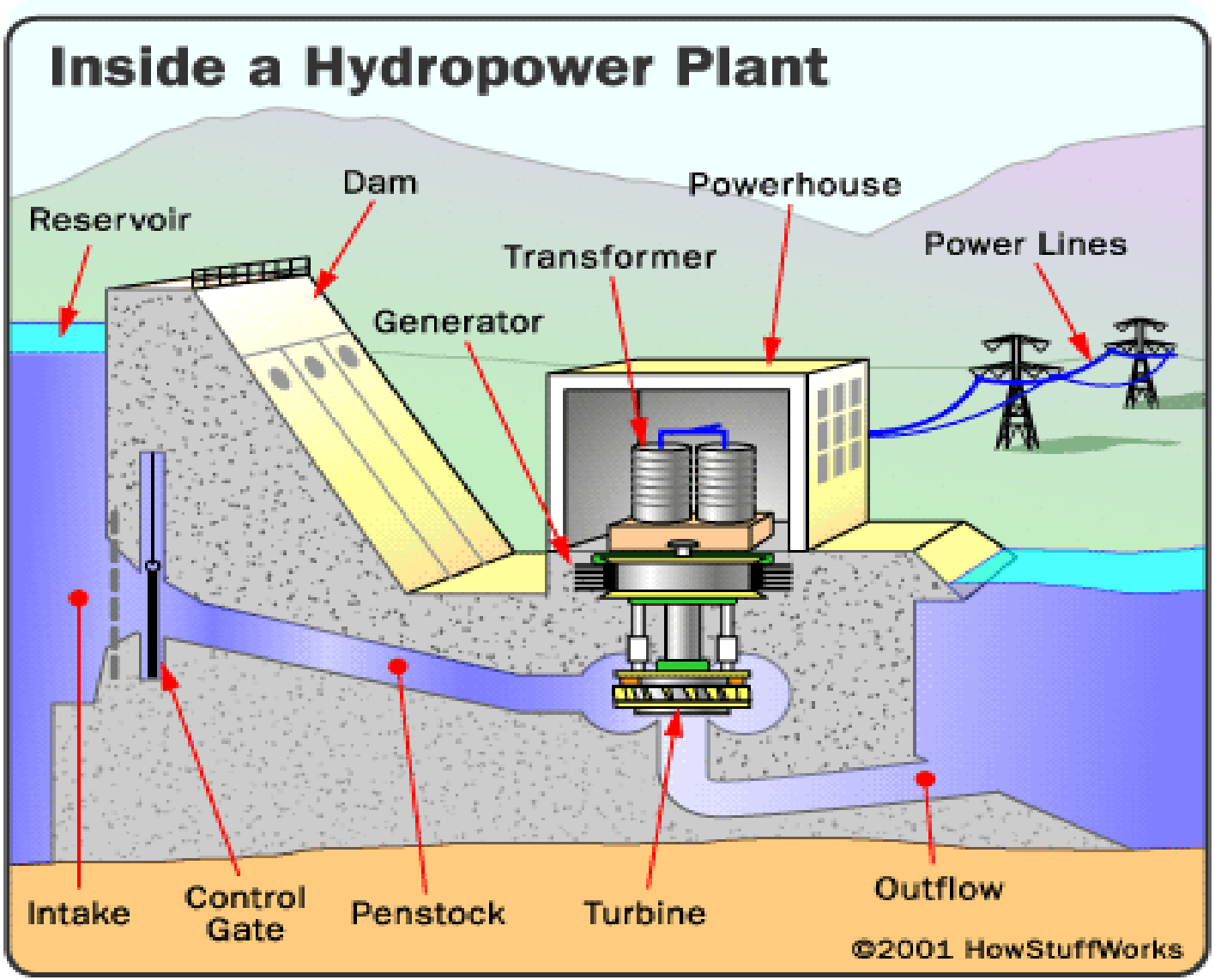
Examples

- Recycling
- Water Purification
- Air Purification
- Sewage treatment
- Environmental remediation
- Solid waste management
- Renewable energy
- Energy Conservation/ efficiency



Source: http://studentenergy.wordpress.com/2013/06/10/june-2013-enertheme-wind-energy/

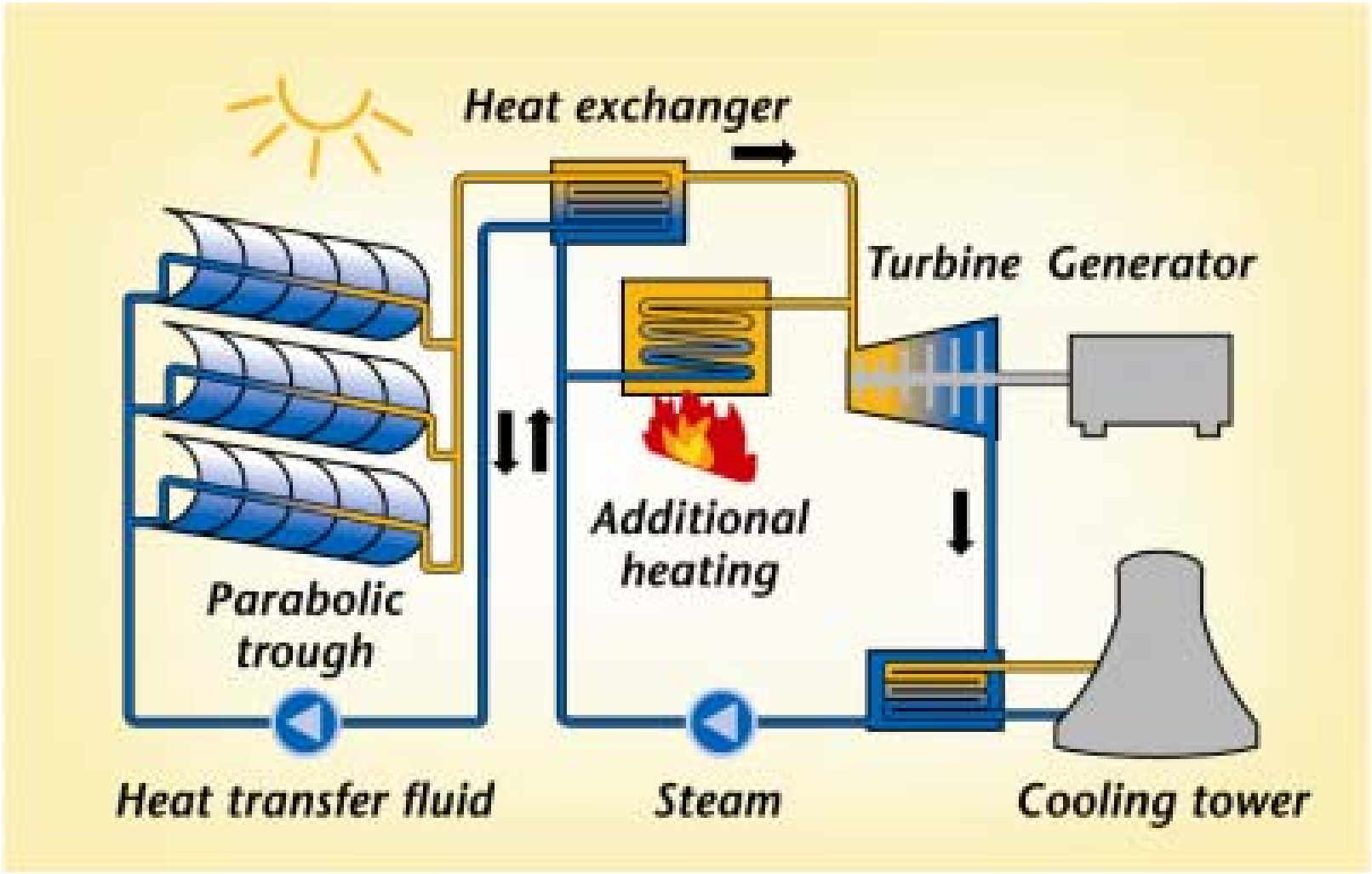
Hydropower


Inside a Hydropower Plant
Reservoir
Dam
Powerhouse
Transformer
Power Lines
Generator
Intake
Control Gate
Penstock
Turbine
Outflow
©2001 HowStuffWorks

Photovoltaics (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect.

Source: http://pulse72plus.com/blog/the-hindrance-to-renewable-energy/

Solar Thermal Parabolic Trough

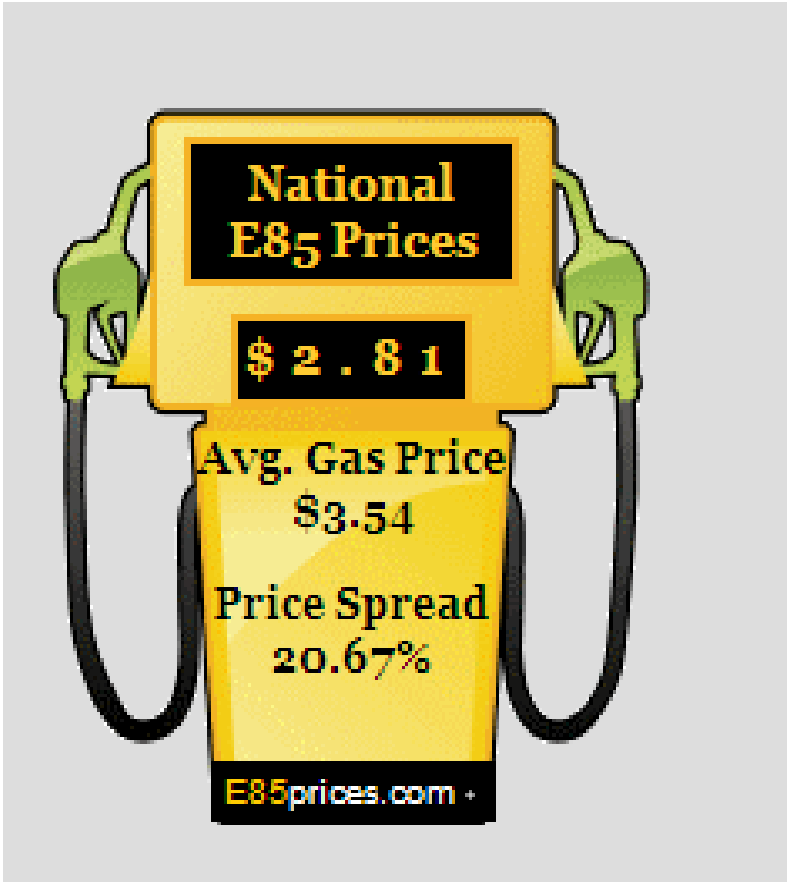


Source: http://greenterrafirma.com/solar-thermal-for-electricity.html

Biomass

Source: http://www.biw.kuleuven.be/lbh/lbnl/forecoman/eng/projbeschrijving.asp?n=40

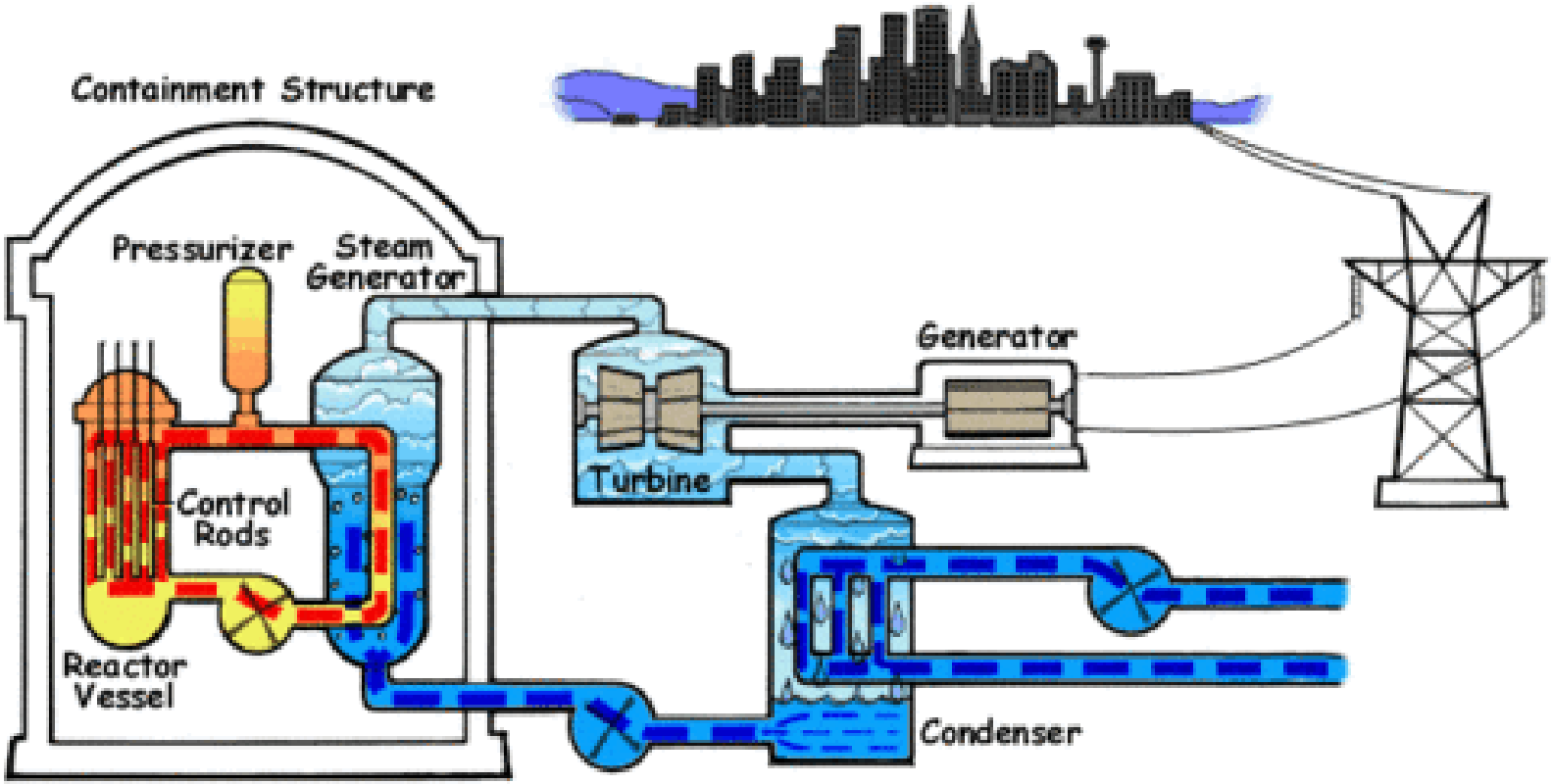
Biofuel


National
E85 Prices
$ 2 . 8 1
Avg. Gas Price
$3.54
Price Spread
20.67%
E85prices.com


SOYBEAN POWERED

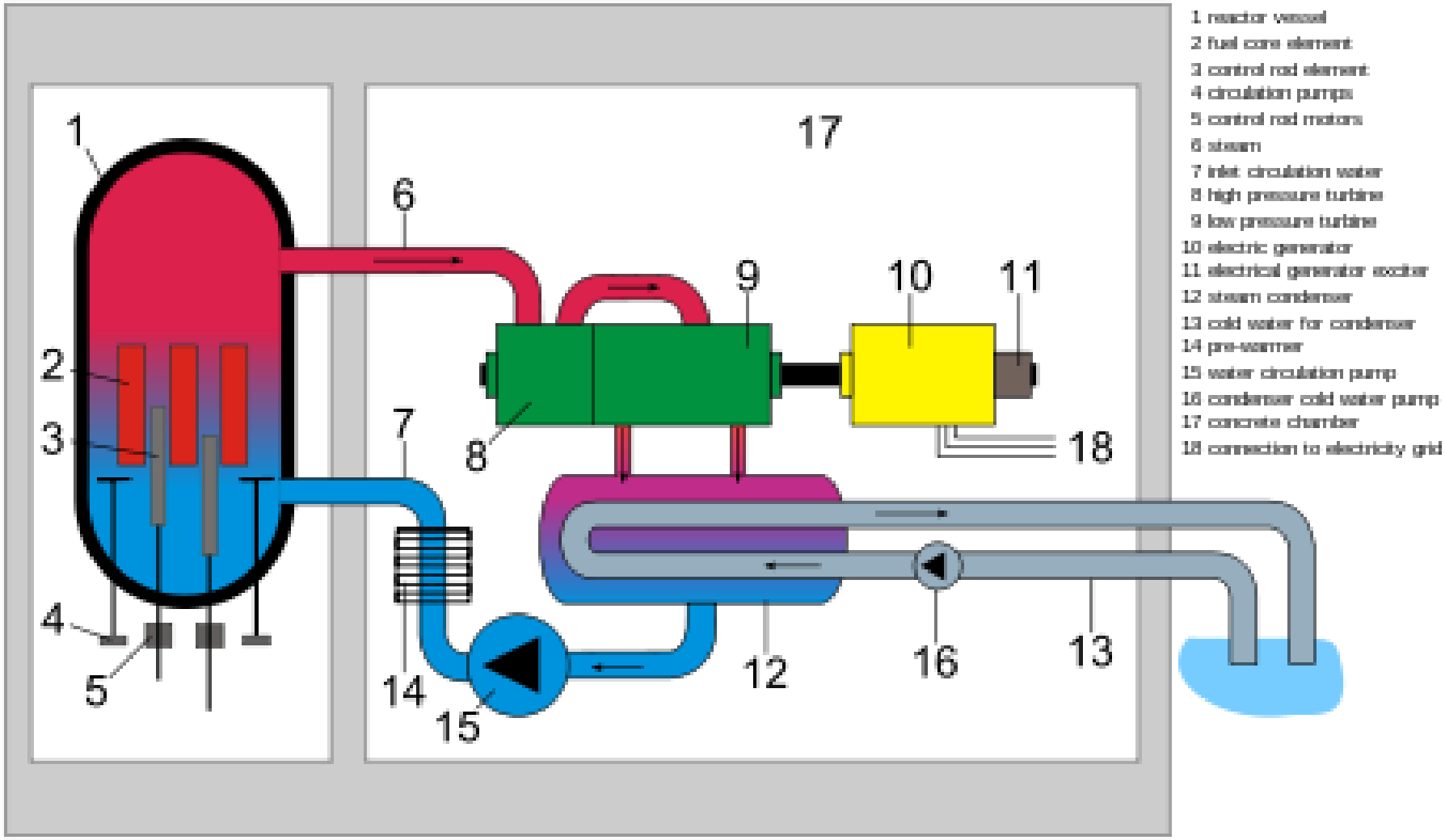
Nuclear

Pressurized water reactor



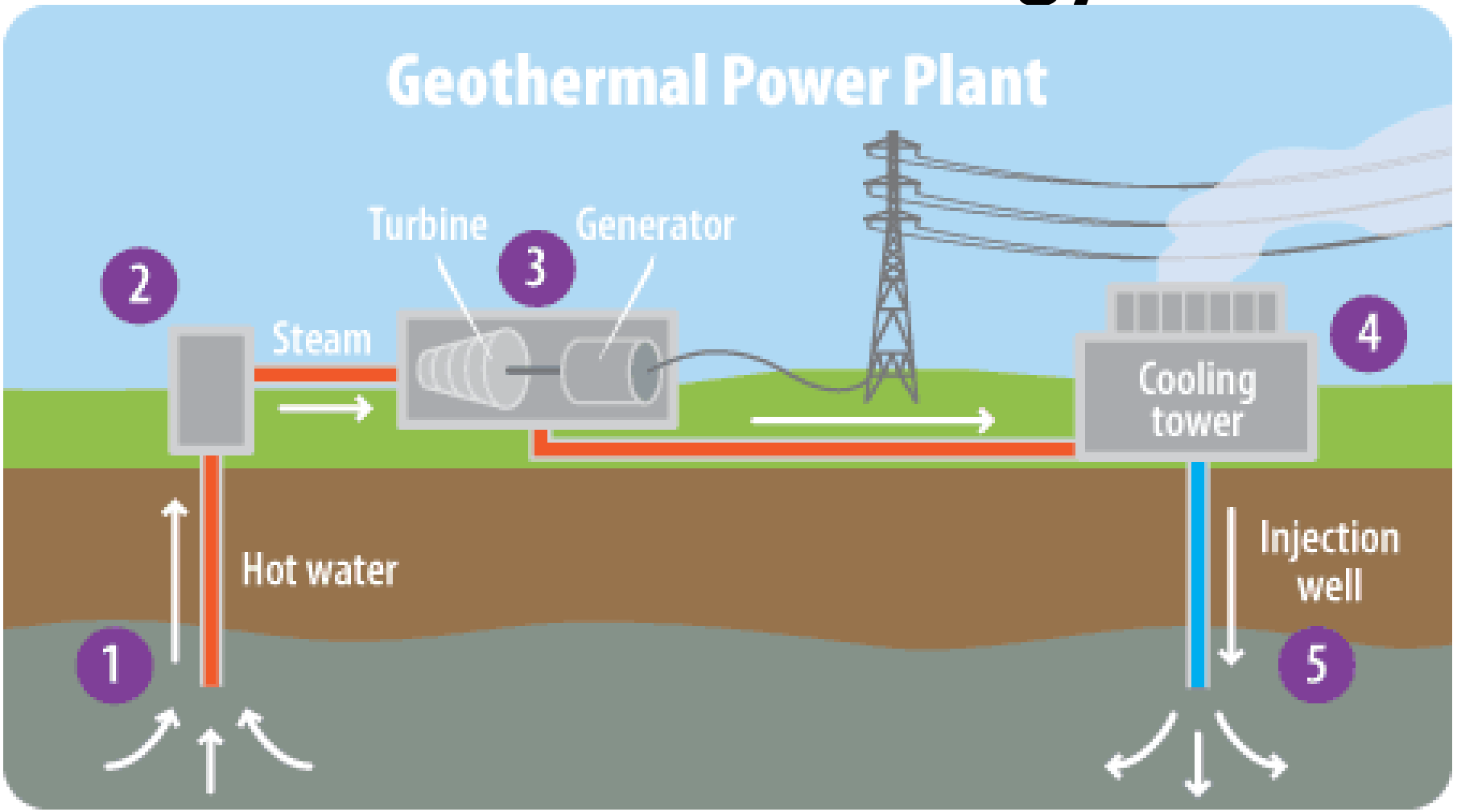
http://en.wikiversity.org/wiki/Power_Generation-nuclear_Power/Part2

Boiling water reactor (BWR)



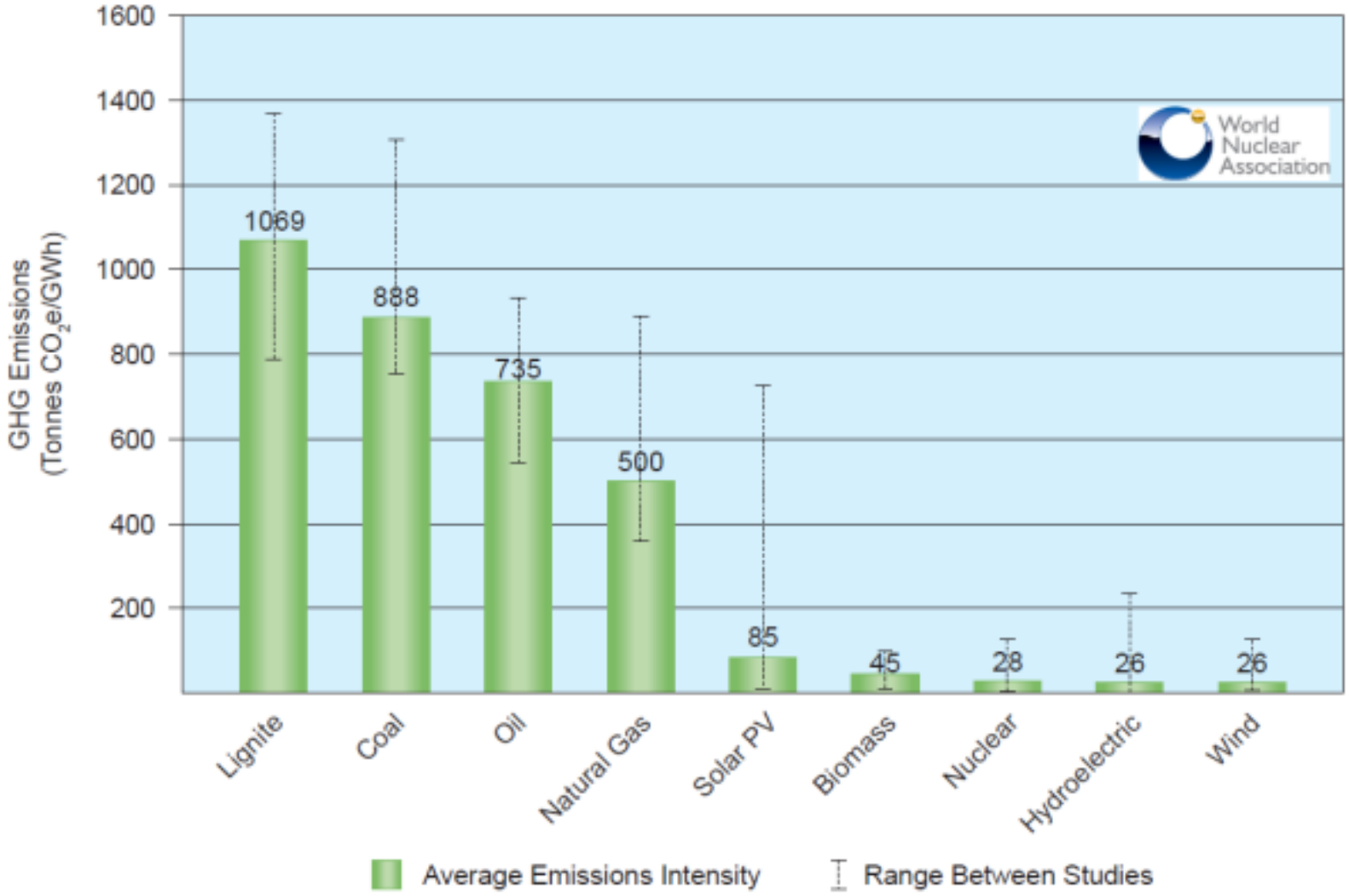
Source: http://en.wikipedia.org/wiki/Boiling_water_reactor

Geothermal energy



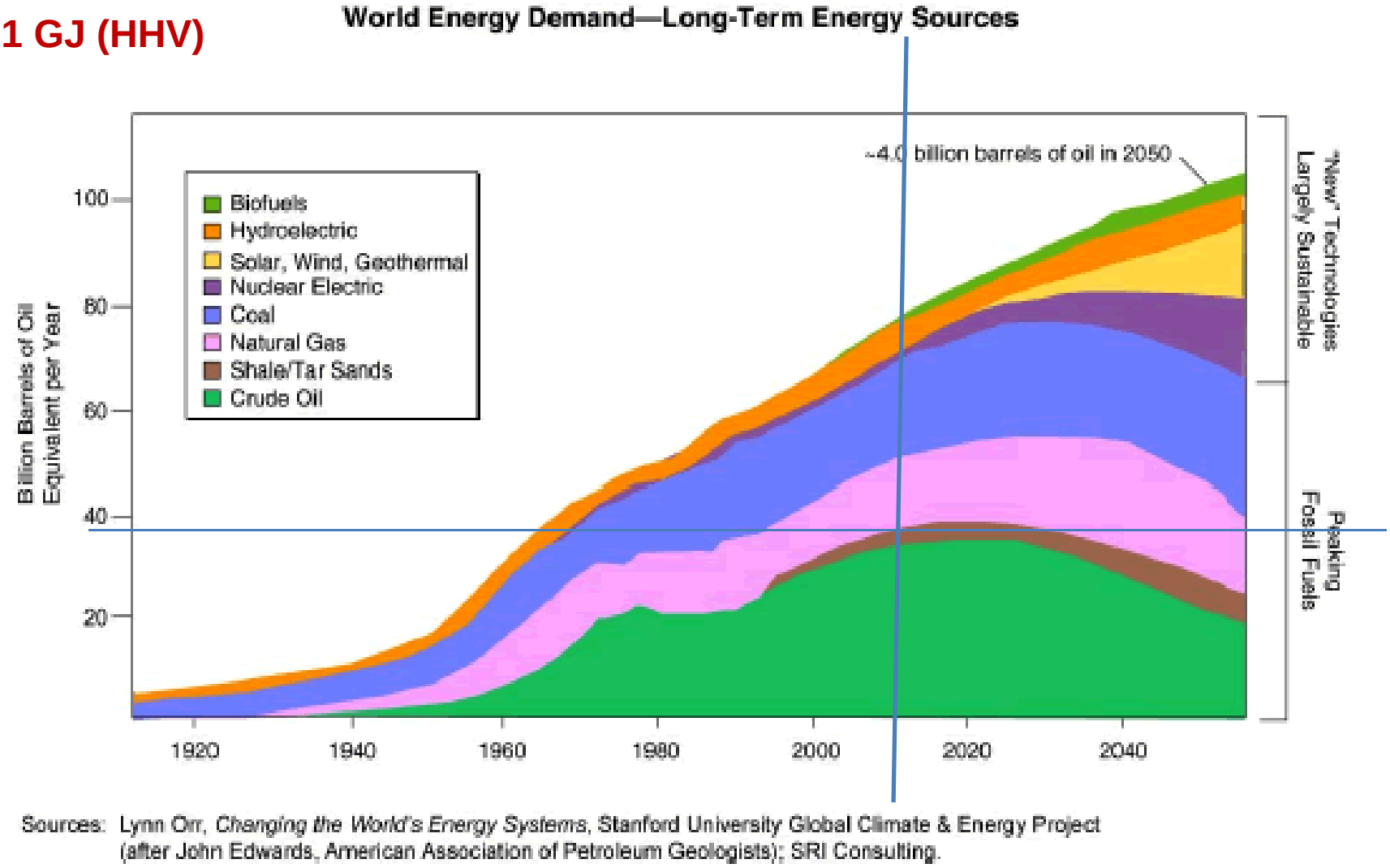
Source:www.epa.gov/climatestudents/solutions/technologies/geothermal.html

GHG emissions from different fuels

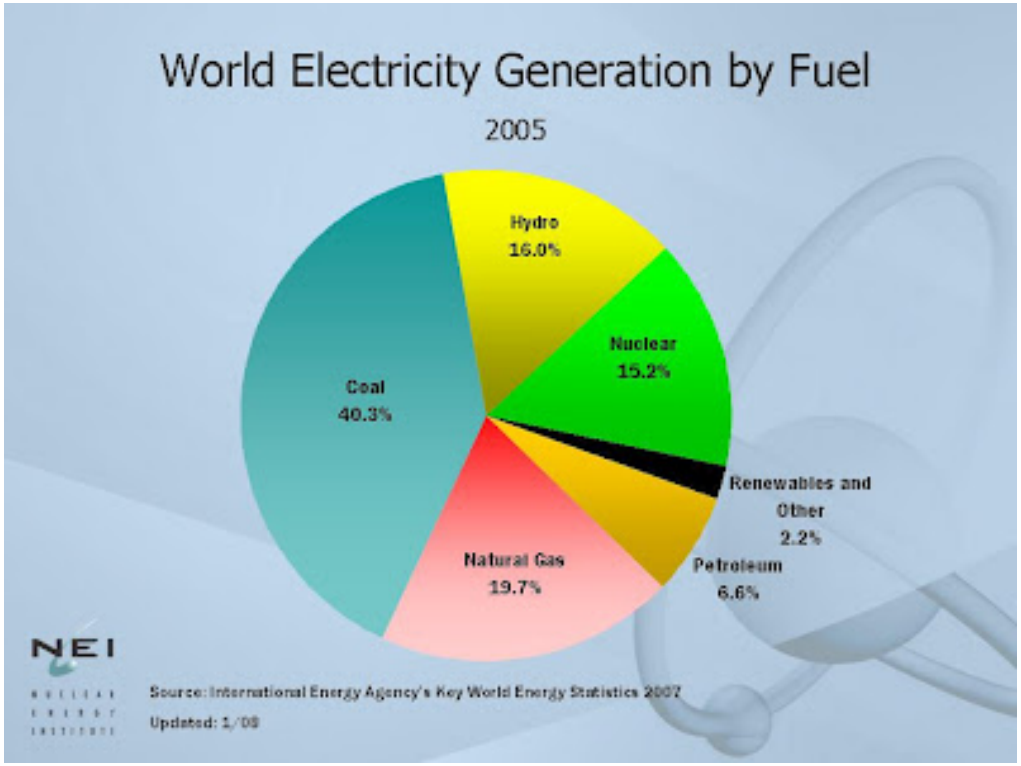


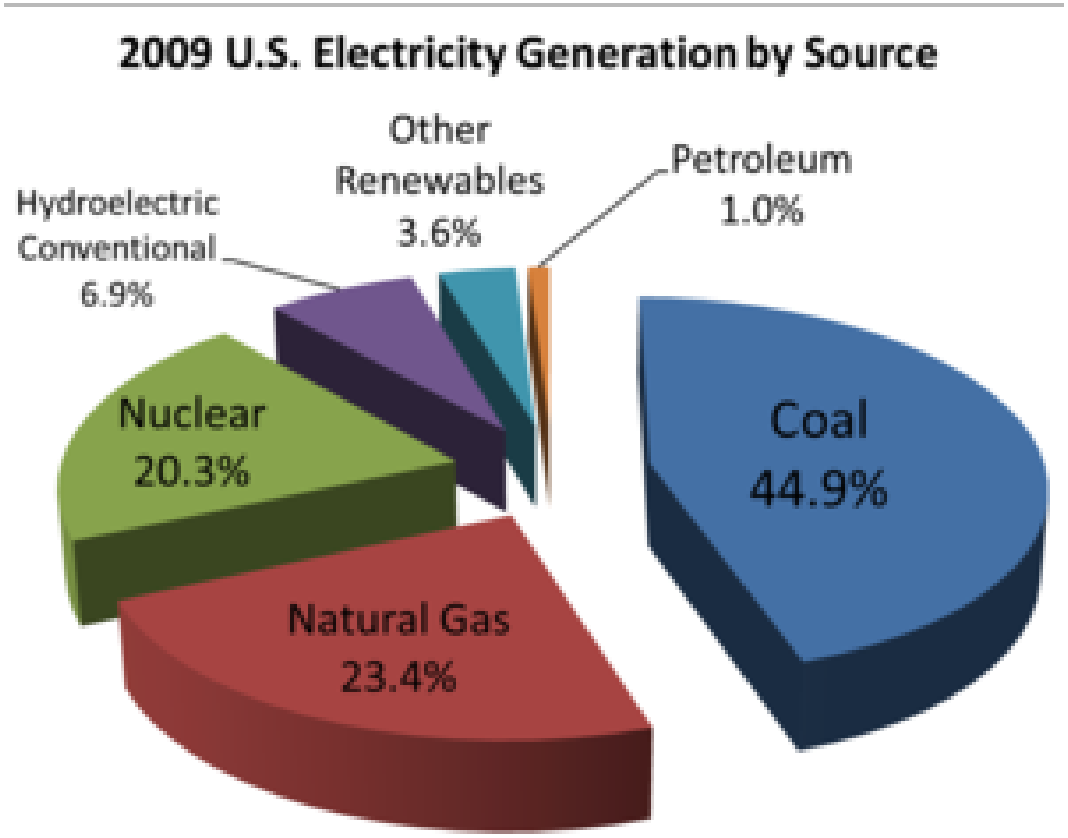
1 barrel =(42 US gallons or 158.9873 litres)

~ 6.1 GJ (HHV)

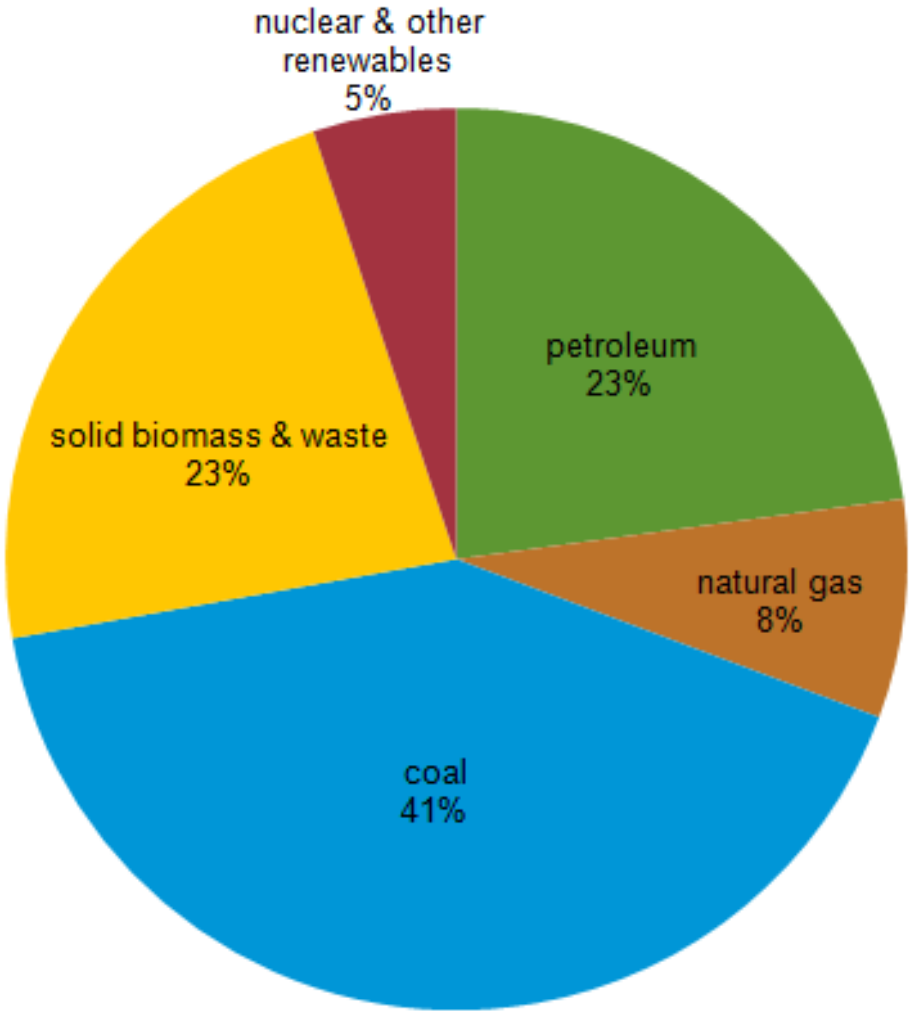


Sources: Lynn Orr, *Changing the World's Energy Systems*, Stanford University Global Climate & Energy Project (after John Edwards, American Association of Petroleum Geologists); SRI Consulting.

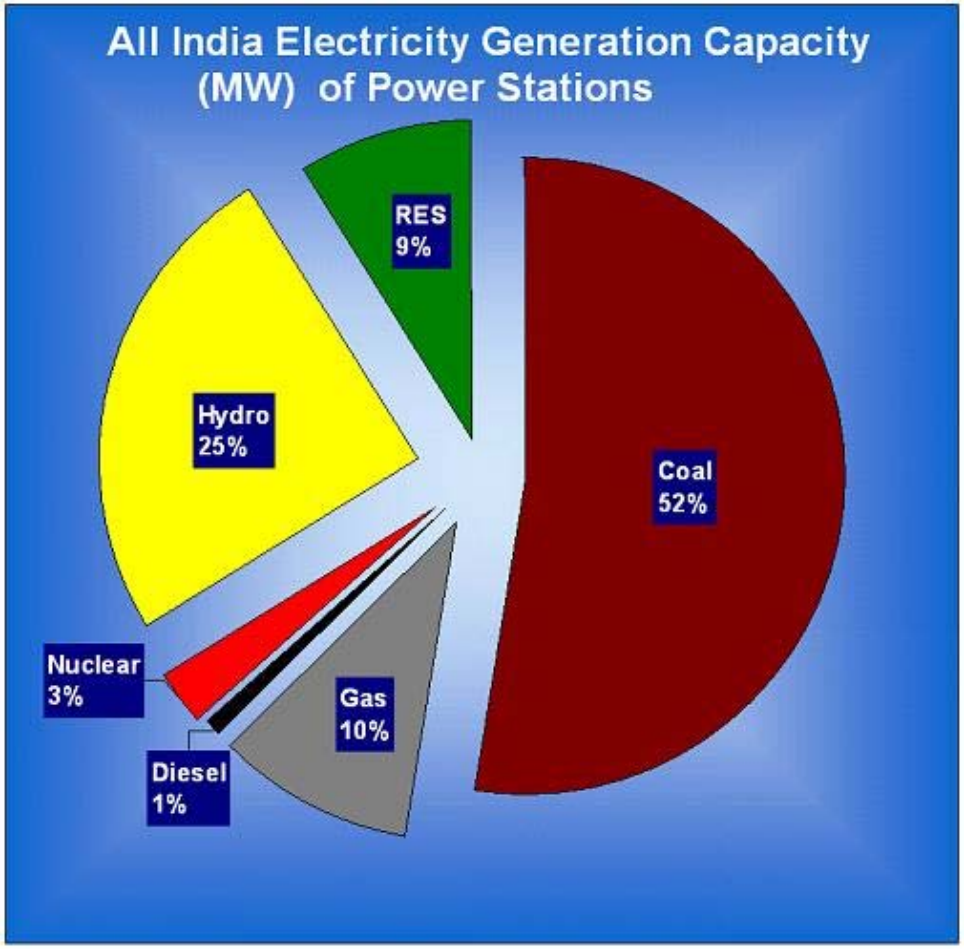

World Electricity Generation by Fuel
2005
Hydro
16.0%
Nuclear
15.2%
Coal
40.3%
Renewables and
Other
2.2%
Natural Gas
19.7%
Petroleum
6.6%
NEI
Source: International Energy Agency's Key World Energy Statistics 2007
Updated: 1/08


2009 U.S. Electricity Generation by Source
Other Renewables 3.6%
Petroleum 1.0%
Hydroelectric Conventional 6.9%
Nuclear 20.3%
Coal 44.9%
Natural Gas 23.4%

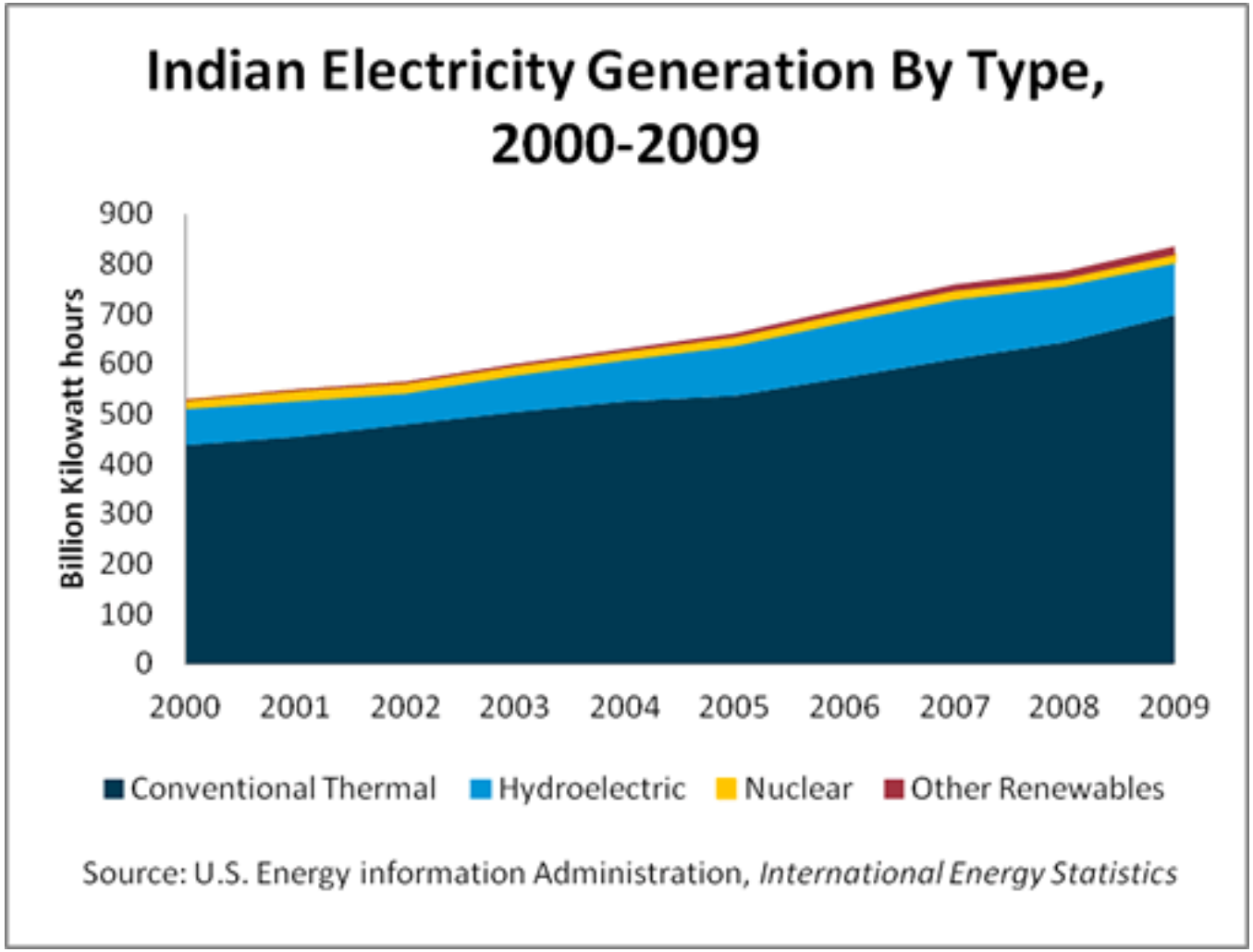
Total energy consumption in India, 2011

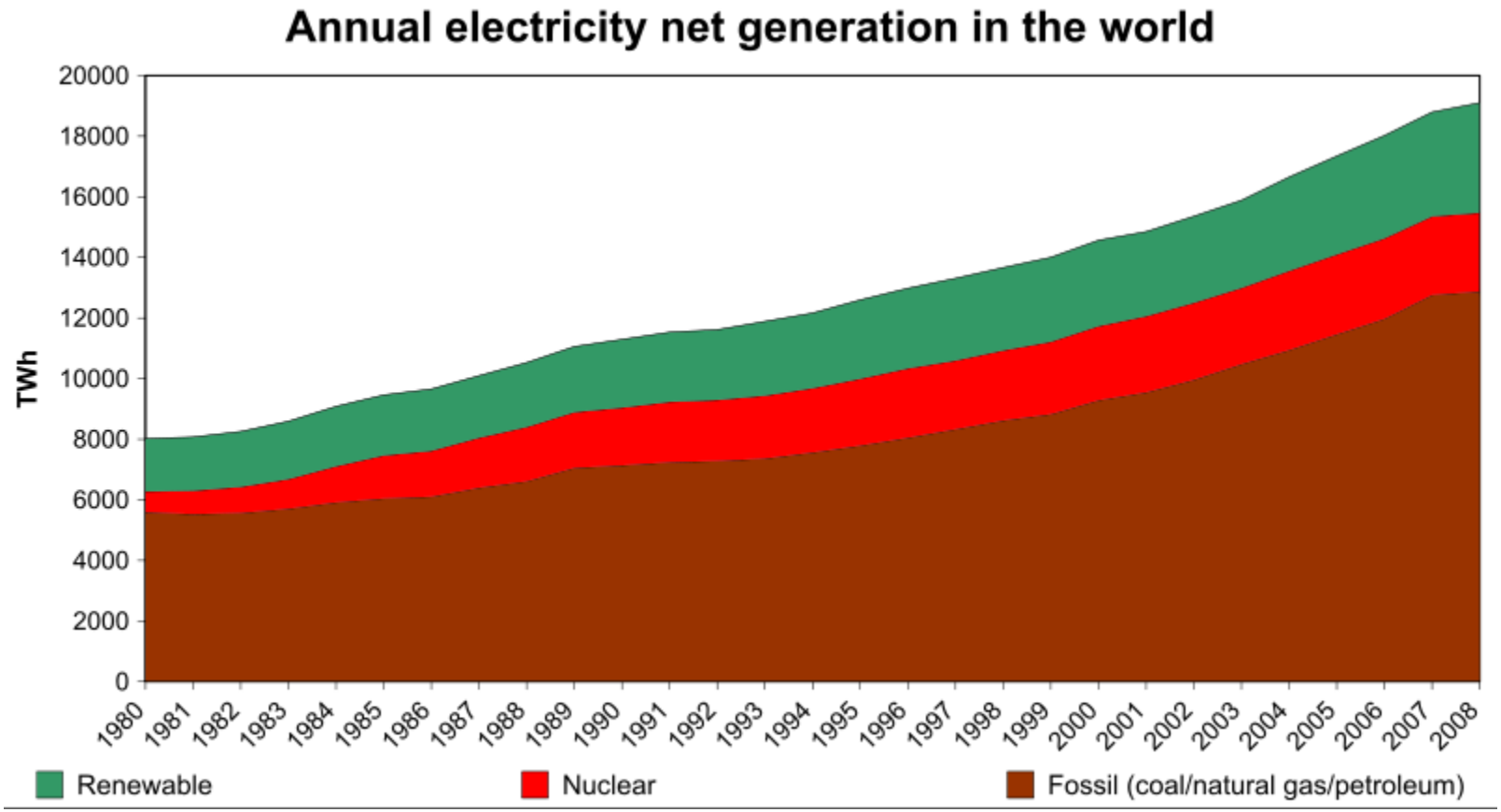


Source: U.S. Energy Information Administration, International Energy Statistics



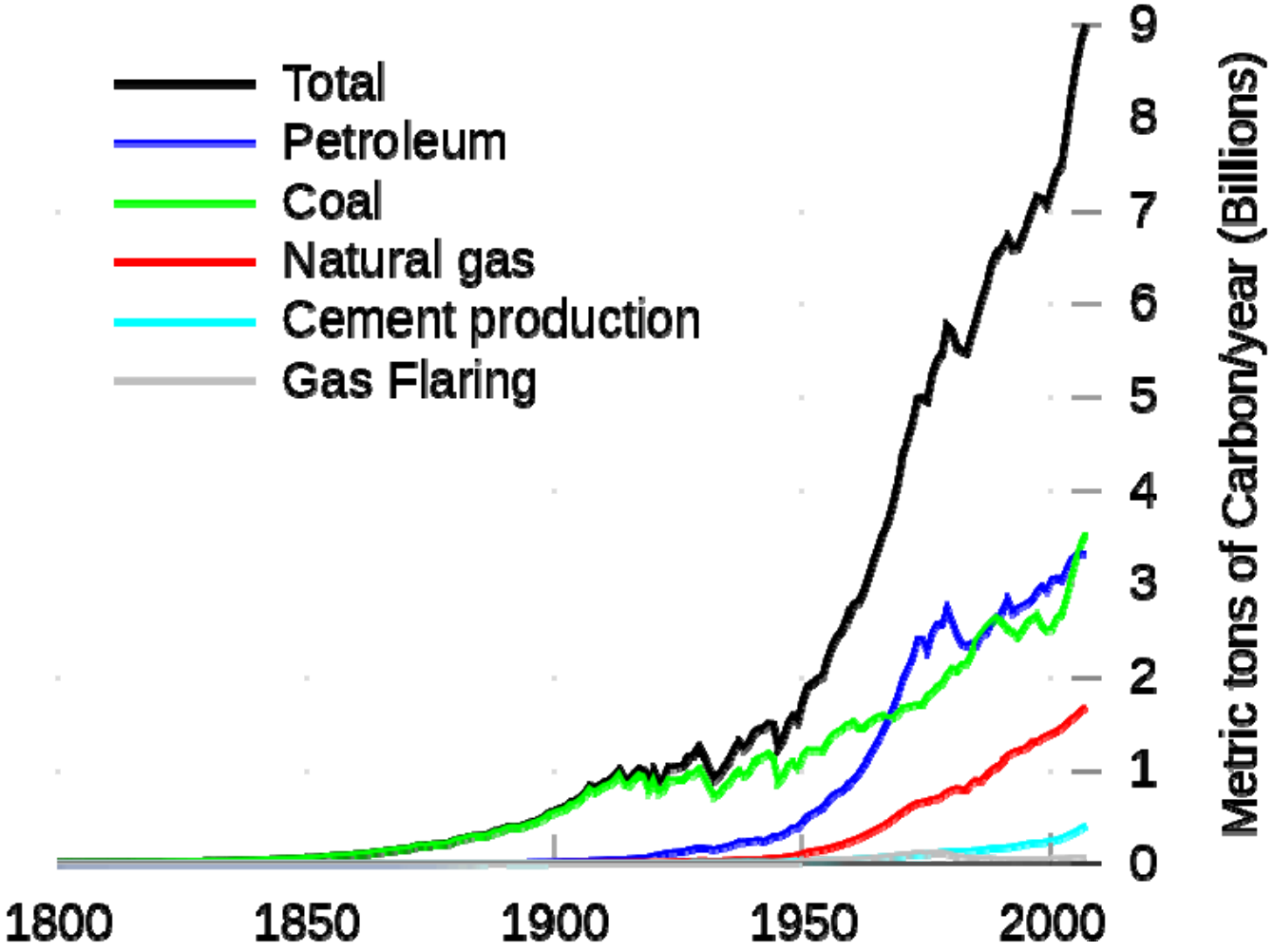
Source: http://feww.wordpress.com/2009/11/29/radioactive-leak-contaminates-water-in-india/


Indian Electricity Generation By Type, 2000-2009
Billion Kilowatt hours
900
800
700
600
500
400
300
200
100
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Conventional Thermal
Hydroelectric
Nuclear
Other Renewables
Source: U.S. Energy information Administration, International Energy Statistics



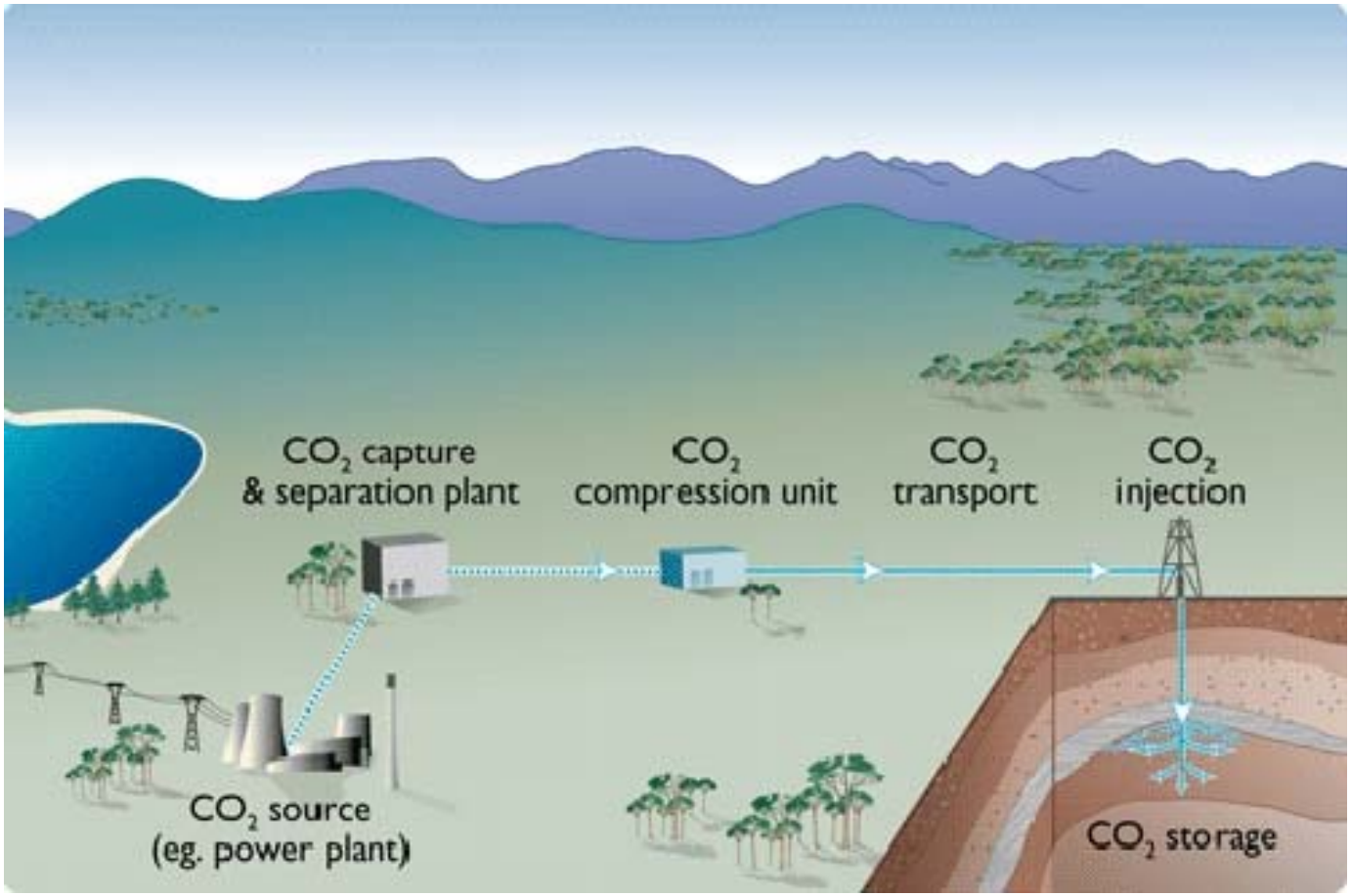
Source: http://en.wikipedia.org/wiki/Electricity_generation

Modern global anthropogenic carbon emissions



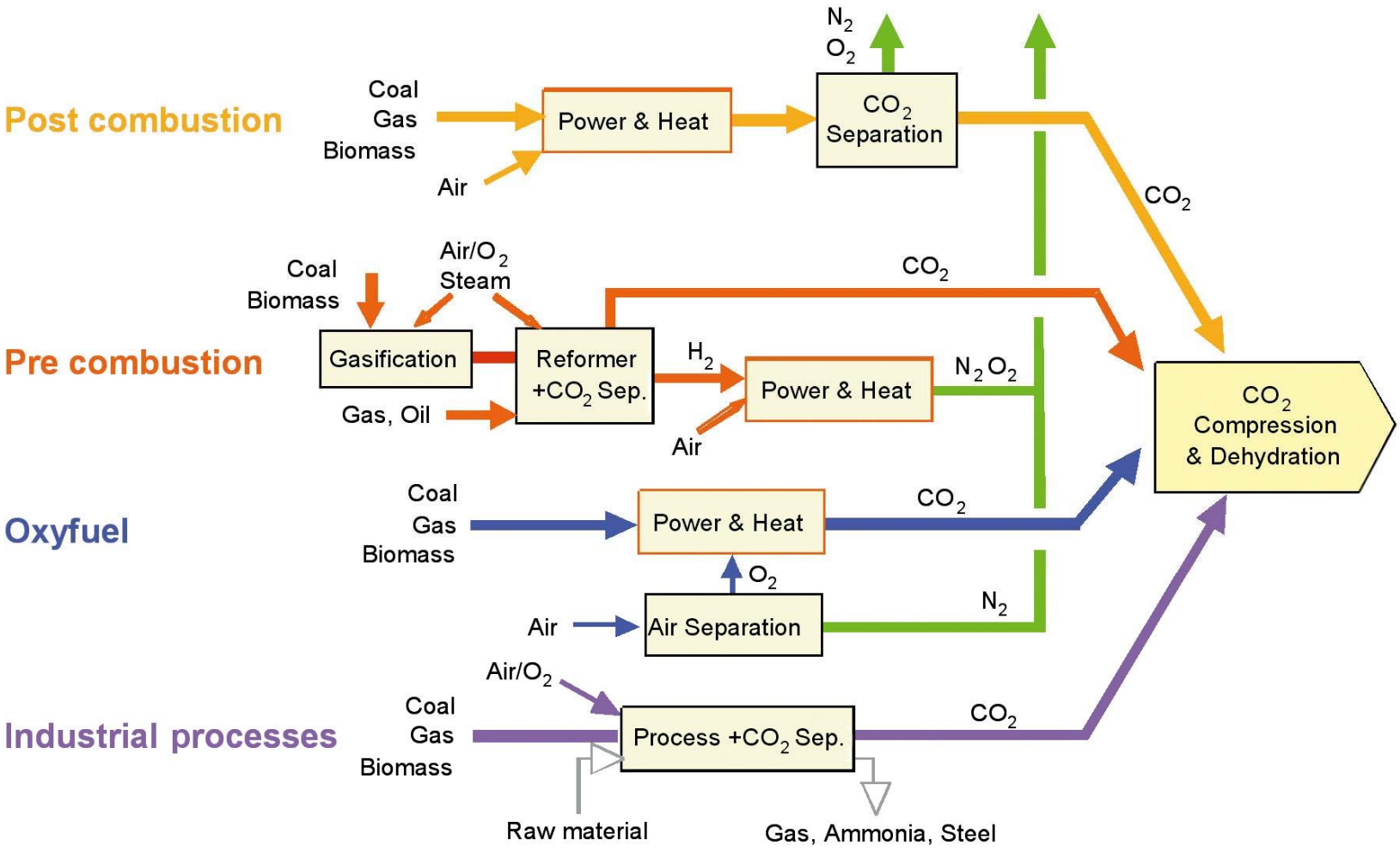
Source: https://en.m.wikipedia.org/wiki/List_of_CO2_emitted_per_million_Btu_of_energy_from_various_fuels

Carbon Capture and Storage (CCS)



Source: IPCC SRCCS

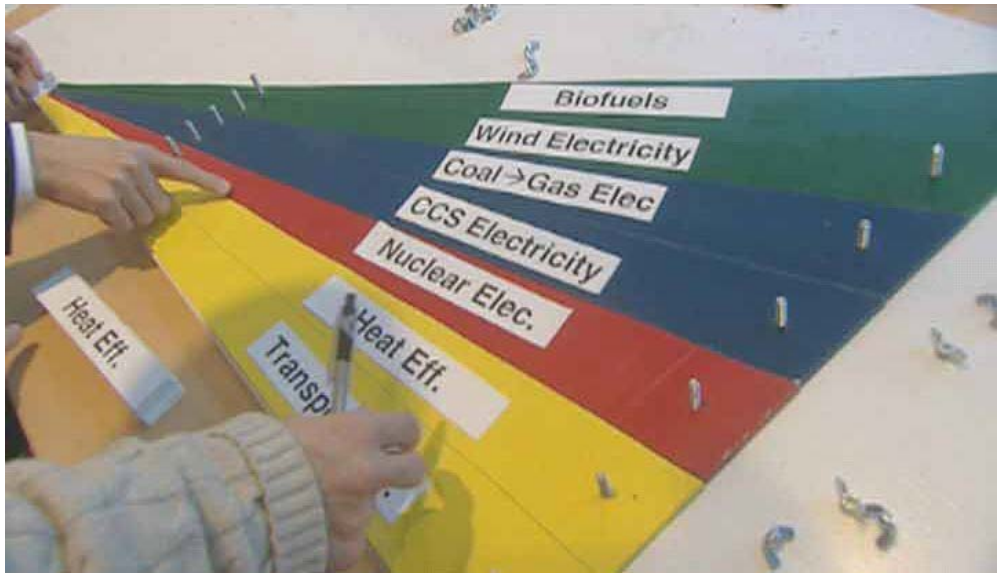
Capture of CO_2



Source: IPCC SRCCS

Stabilization Wedges

Tackling the Climate Problem with Existing Technologies



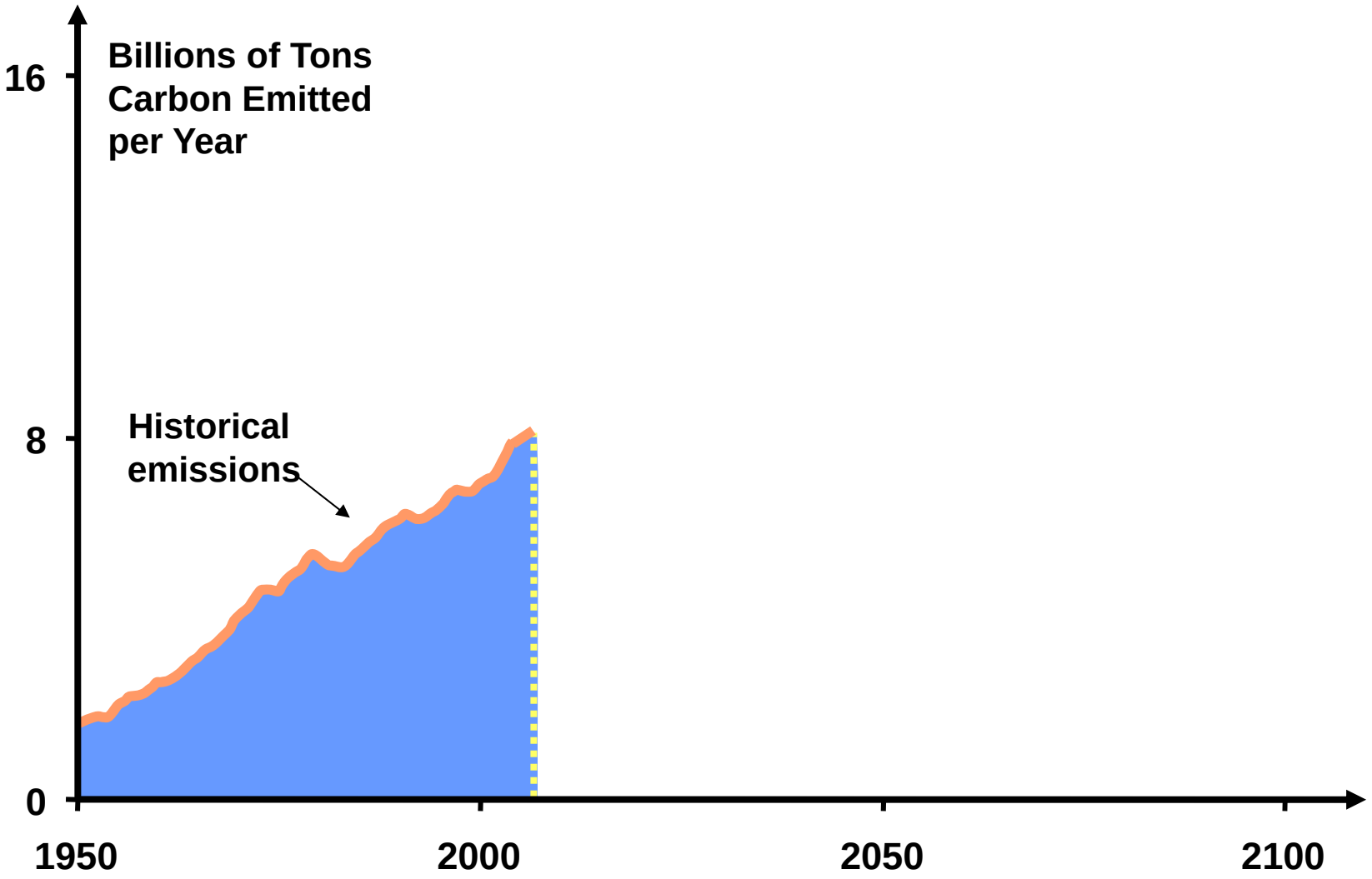
This presentation is based on the “Stabilization Wedges” concept first presented in

"Stabilization Wedges: Solving the Climate Problem for the next 50 Years with Current Technologies,” S. Pacala and R. Socolow, Science, August 13, 2004.

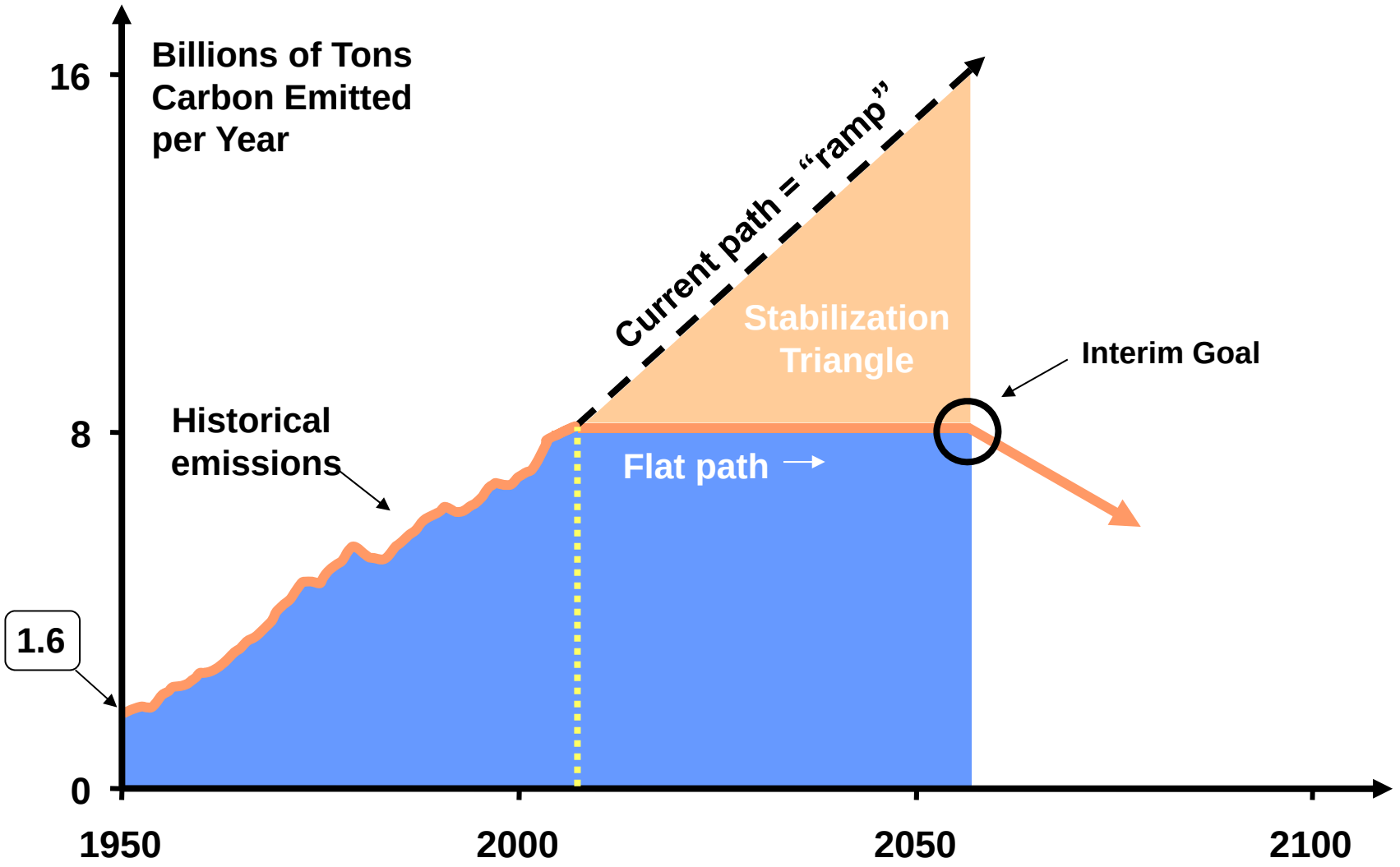
Source: Carbon Mitigation Initiative, Princeton University

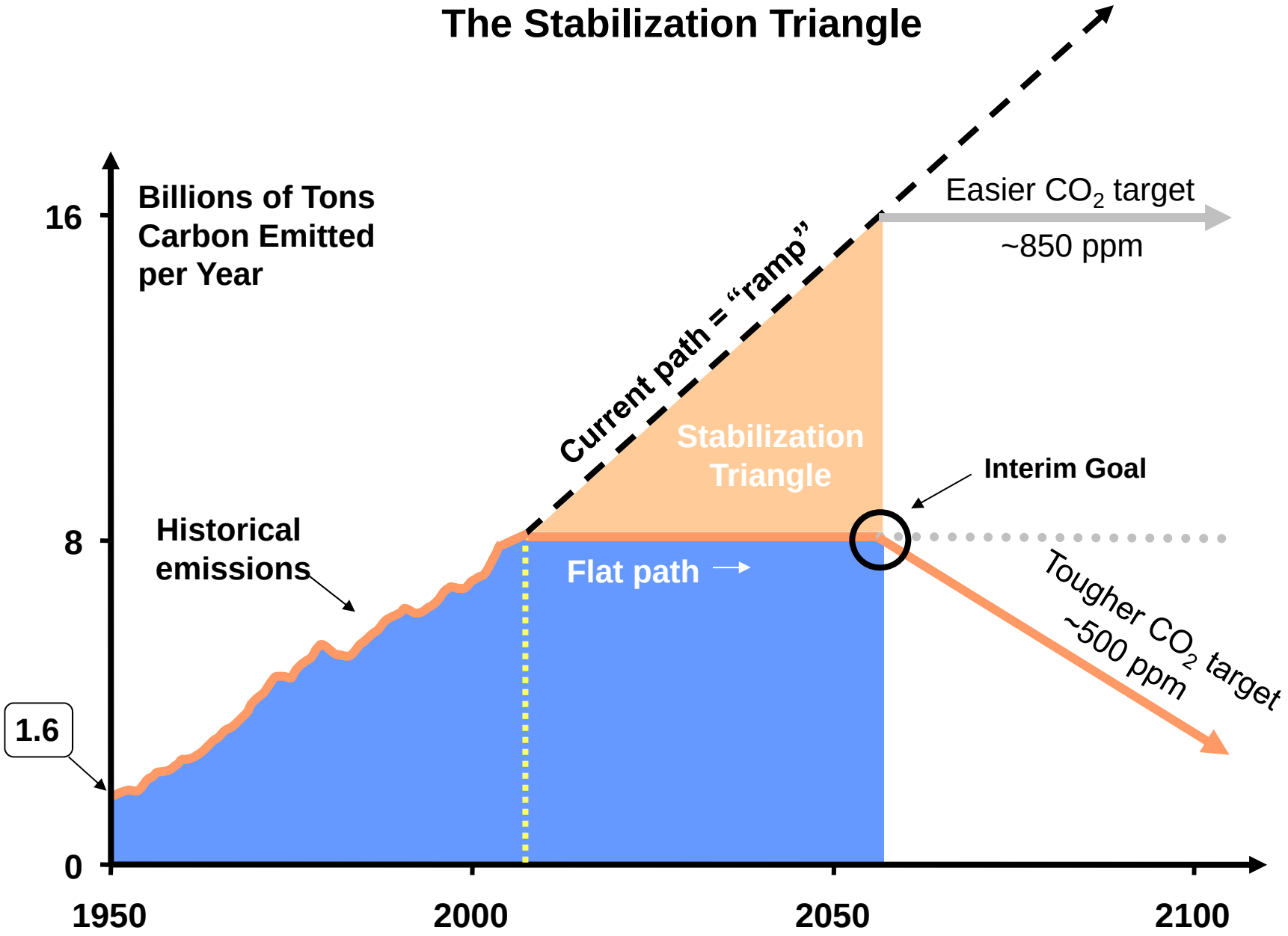
Source: Carbon Mitigation Initiative, Princeton University

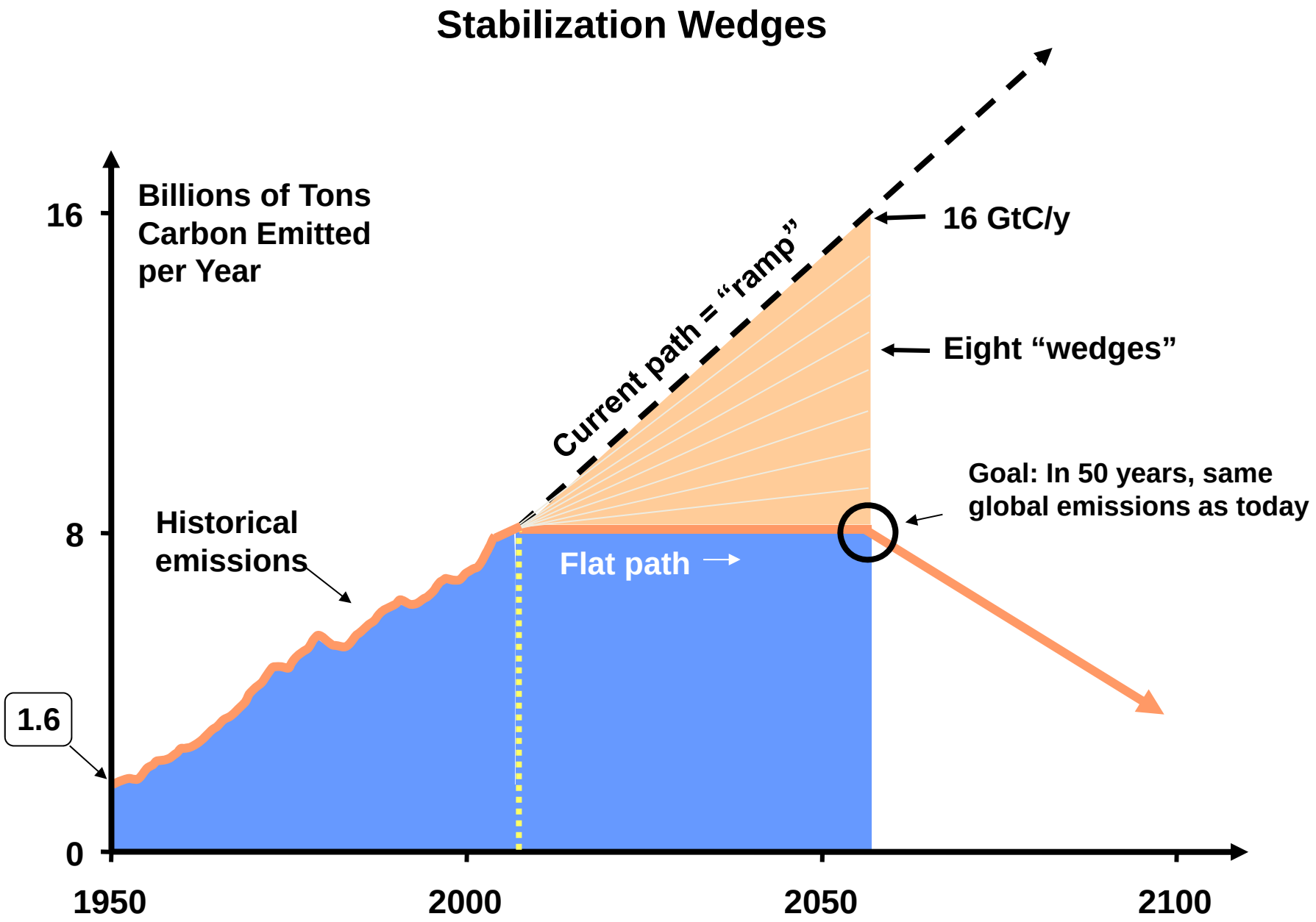
Historical Emissions



The Stabilization Triangle

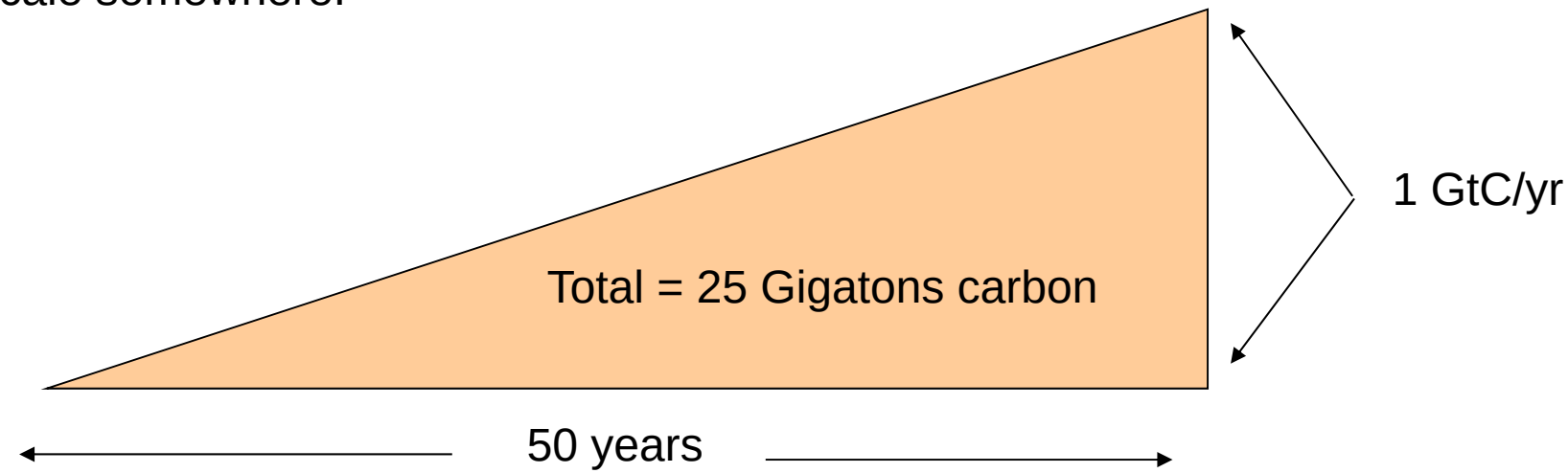



The Stabilization Triangle
Billions of Tons Carbon Emitted per Year
16
8
1.6
0
1950
2000
2050
2100
Current path = "ramp"
Easier CO_2 target
~850 ppm
Stabilization Triangle
Interim Goal
Historical emissions
Flat path
Tougher CO_2 target
~500 ppm


Stabilization Wedges
16
8
0
1.6
Billions of Tons
Carbon Emitted
per Year
Current path = "ramp"
16 GtC/y
Eight "wedges"
Goal: In 50 years, same
global emissions as today
Historical
emissions
Flat path
1950
2000
2050
2100

What is a “Wedge”?

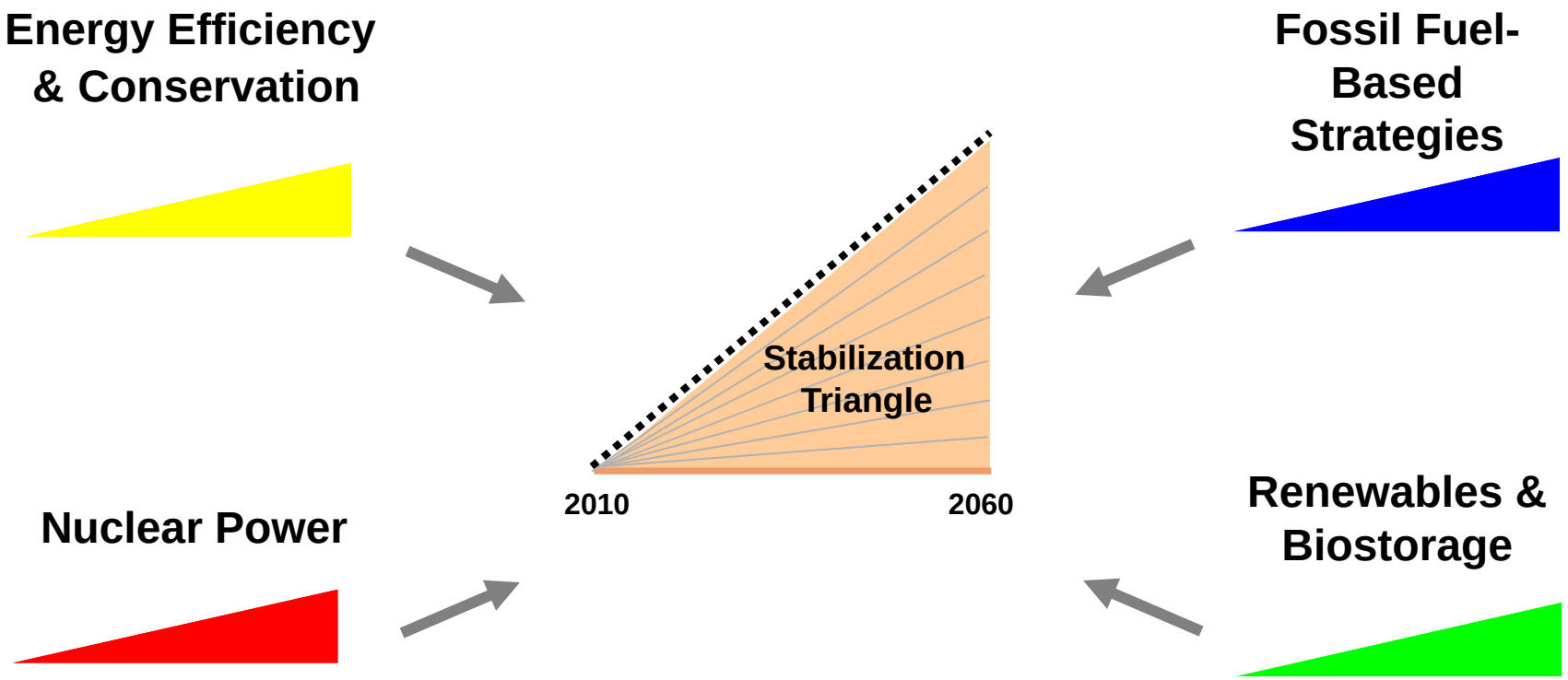
A “wedge” is a strategy to reduce carbon emissions that grows in 50 years from zero to 1.0 GtC/yr. The strategy has already been commercialized at scale somewhere.



Cumulatively, a wedge redirects the flow of 25 GtC in its first 50 years. This is 2.5 trillion dollars at $100/tC.

A “solution” to the CO_2 problem should provide at least one wedge.

15 Wedge Strategies in 4 Categories



Efficiency

Produce twice today's quantity of coal-based electricity in 2054 at 60% efficiency

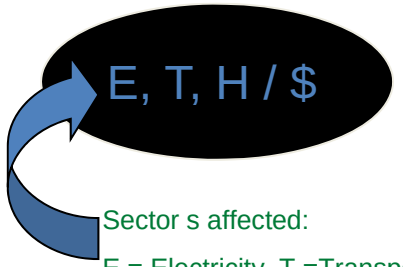
Average coal plant efficiency is 32% today

Double the fuel efficiency of the world's cars or halve miles traveled

There are about 600 million cars today, with 2 billion projected for 2055

Use best efficiency practices in all residential and commercial buildings

Replacing all the world's incandescent bulbs with CFL's would provide 1/4 of one wedge



Sector s affected:

E = Electricity, T =Transport,

H = Heat

Cost based on scale of $ to $$$

Photos courtesy of Ford Motor Co., DOE, EPA

Fuel Switching

Photo by J.C. Willett (U.S. Geological Survey).

Substitute 1400 (1GW each) natural gas electric plants for an equal number of coal-fired facilities

E, H / $

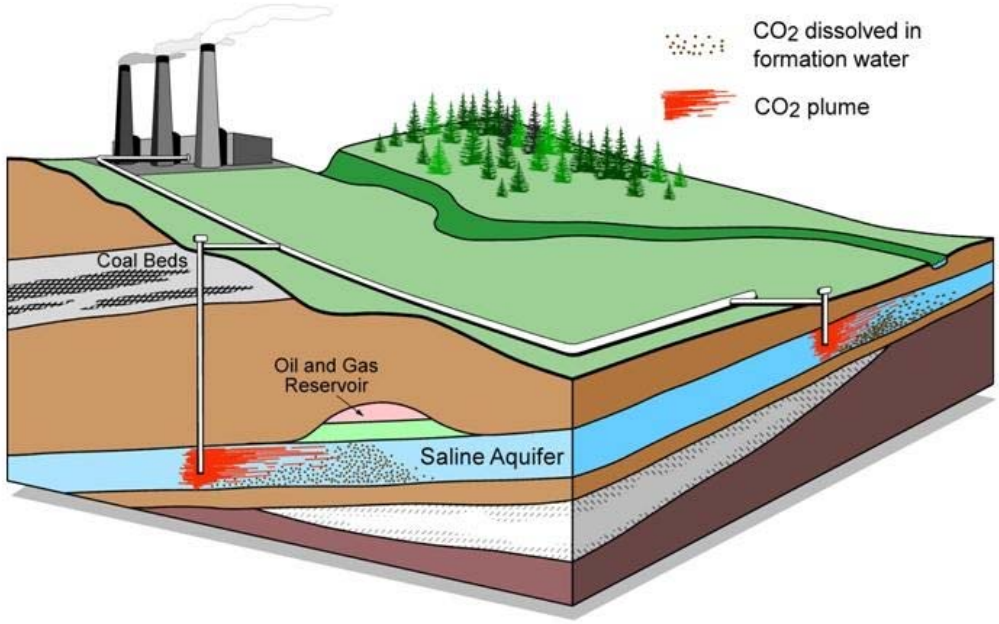
A wedge requires an amount of natural gas equal to that used for all purposes today

Carbon Capture & Storage

Implement CCS at

- **800 GW coal electric plants or**
- **1600 GW natural gas electric plants or**
- **180 coal synfuels plants or**
- **10 times today's capacity of hydrogen plants**

E, T, H / $$

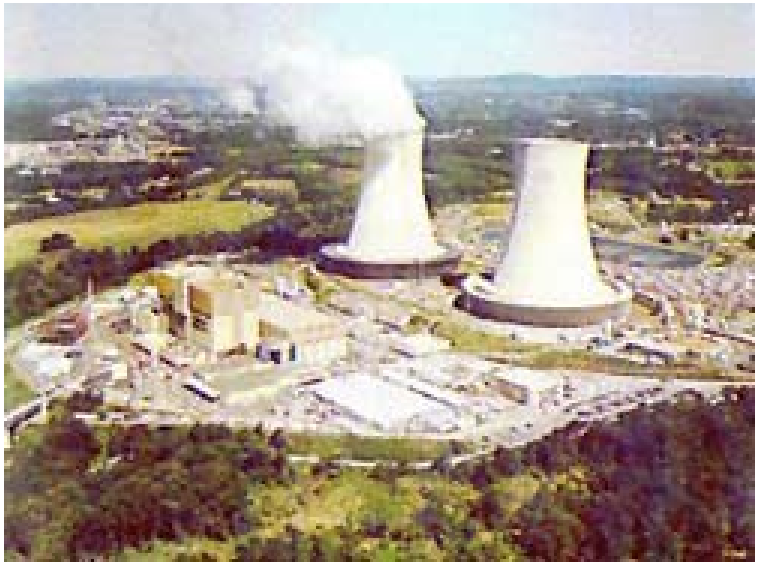


Graphic courtesy of Alberta Geological Survey

There are currently three storage projects that each inject 1 million tons of CO_2 per year – by 2055 need 3500.

Nuclear Electricity

Triple the world's nuclear electricity capacity by 2060



Graphic courtesy of NRC

The rate of installation required for a wedge from electricity is equal to the global rate of nuclear expansion from 1975-1990.

E/ $$

Wind Electricity

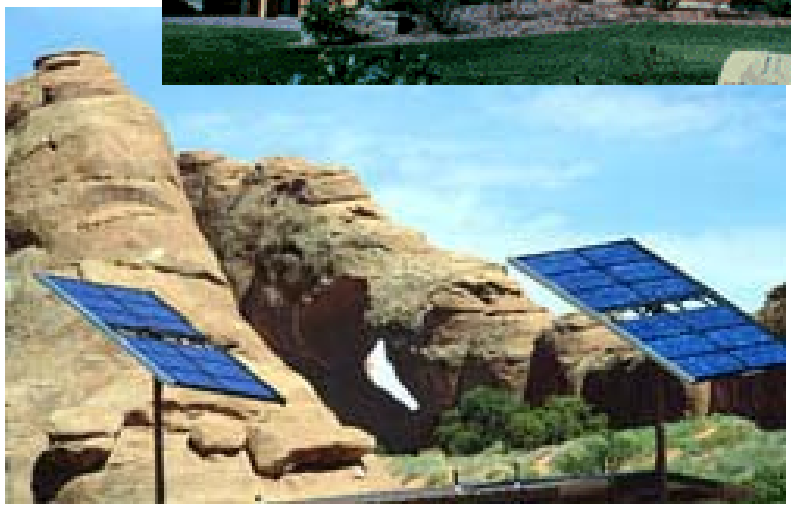
Photo courtesy of DOE

Install 1 million 2 MW windmills to replace coal-based electricity

E, T, H / $-$$

A wedge worth of wind electricity will require increasing current capacity by a factor of 10

Solar Electricity



Install 20,000 square kilometers for dedicated use by 2060

A wedge of solar electricity would mean increasing current capacity 100 times

E / $$$

Photos courtesy of DOE Photovoltaics Program

Biofuels

Scale up current global ethanol production by ~12 times

Photo courtesy of NREL

Using current practices, one wedge requires planting an area the size of India with biofuels crops

T, H / $$

Natural Sinks

Eliminate tropical deforestation

OR

Plant new forests over an area the size of the continental U.S.

OR

Use conservation tillage on all cropland (1600 Mha)

Conservation tillage is currently practiced on less than 10% of global cropland

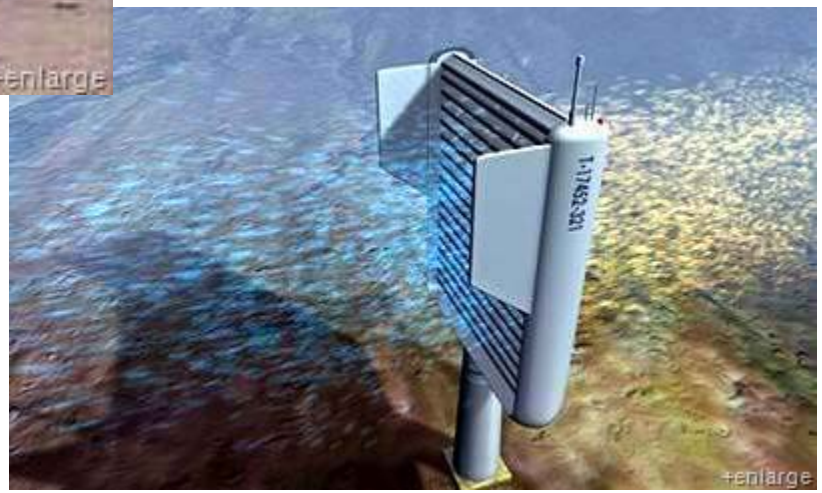
B / $

Photos courtesy of NREL, SUNY Stonybrook, United Nations FAO

Take Home Messages

- In order to avoid a doubling of atmospheric CO_2, we need to rapidly deploy low-carbon energy technologies and/or enhance natural sinks
- We already have an adequate portfolio of technologies to make large cuts in emissions
- No one technology can do the whole job – a variety of strategies will need to be used to stay on a path that avoids a CO_2 doubling
- Every “wedge” has associated impacts and costs

Synthetic trees to scrub CO_2 from the atmosphere



Source: http://greenupgrader.com/3744/synthetic-trees-could-be-environmental-co2-scrubbers/

"If you ask a scientist how much more CO_2 do you think we should add to the atmosphere, the answer is going to be none. All the rest is economics".

-Gavin A. Schmidt

NASA Goddard Institute for Space Studies

and

Center for Climate Systems Research, Columbia University, New York, USA