

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

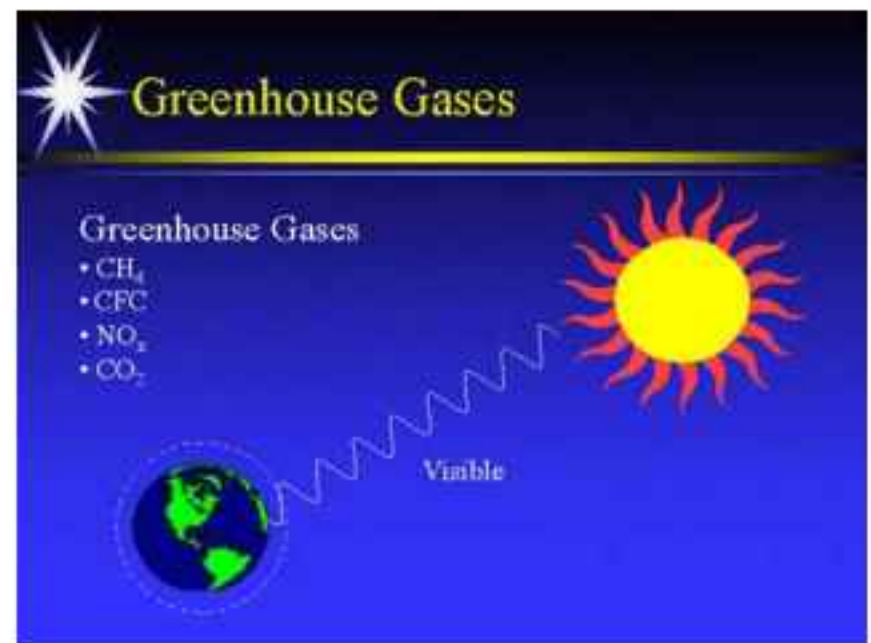
- Greenhouse gases in the atmosphere behave much like the glass panes in a greenhouse.
- Sunshine enters the Earth's atmosphere passing through the blanket of greenhouse gases.



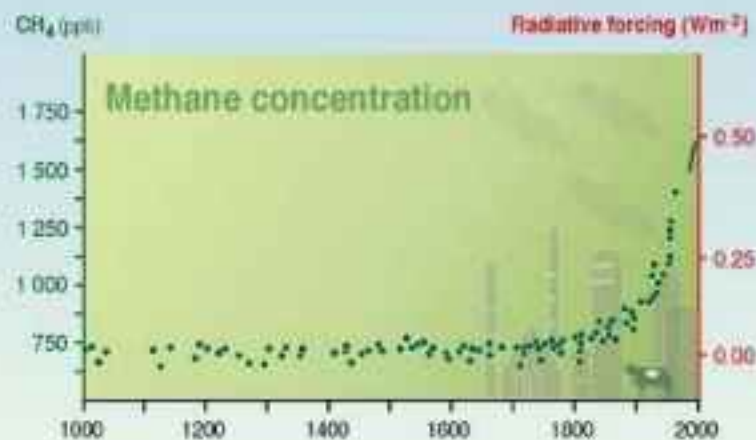
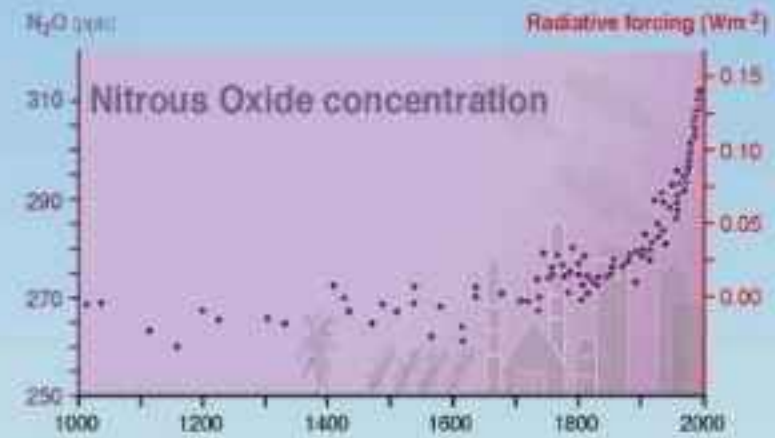
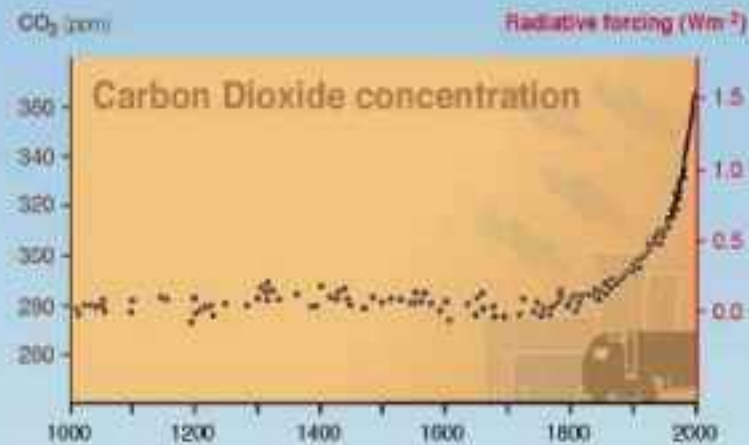
As it reaches the Earth's surface, land, water, and biosphere absorb the sunlight's energy! Once absorbed this energy is sent back into the atmosphere.

Greenhouse Effect

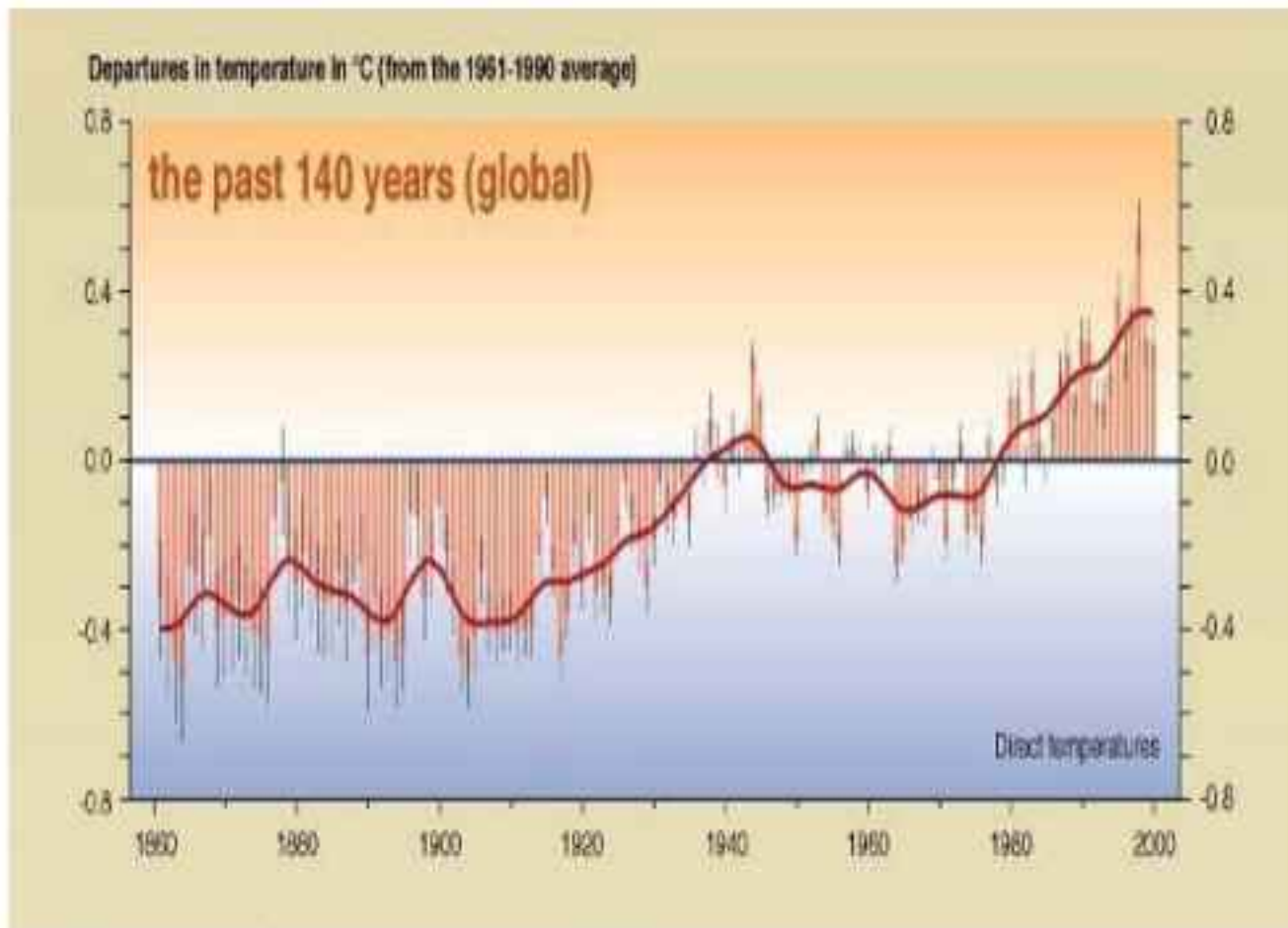
- Without these gases, heat would escape back into space and Earth's average temperature would **be about 60° F colder.**
- Because of how they warm our world, these gases are referred to as **greenhouse gases.**



Human activity influence



Variation of the temperature on Earth



CLIMATE CHANGE

- Human activities are releasing greenhouse gases (GHG) into the atmosphere.
- Climate change is a global issue:
1 tCO₂ emitted in India = 1 tCO₂ 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.

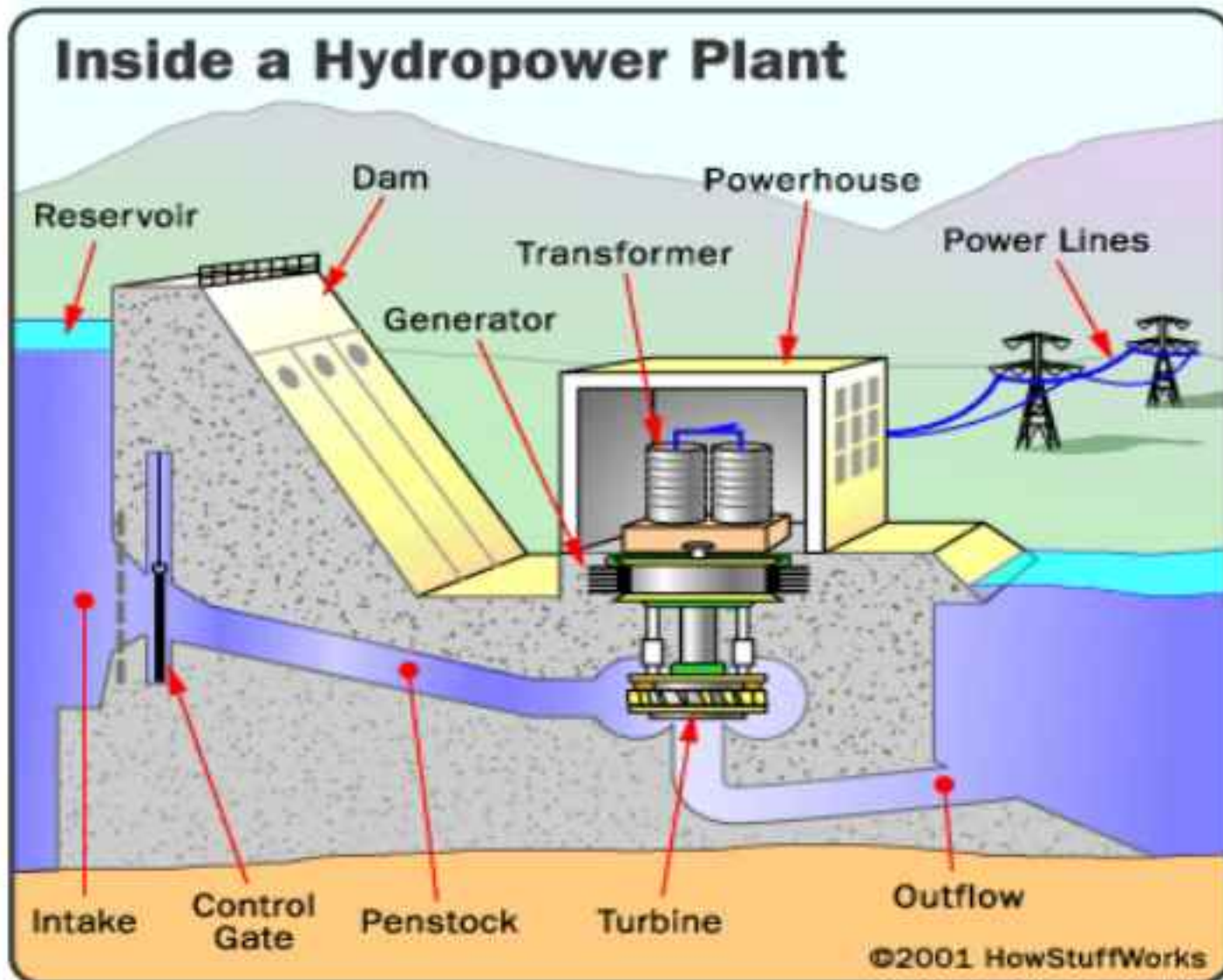
Examples

- 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

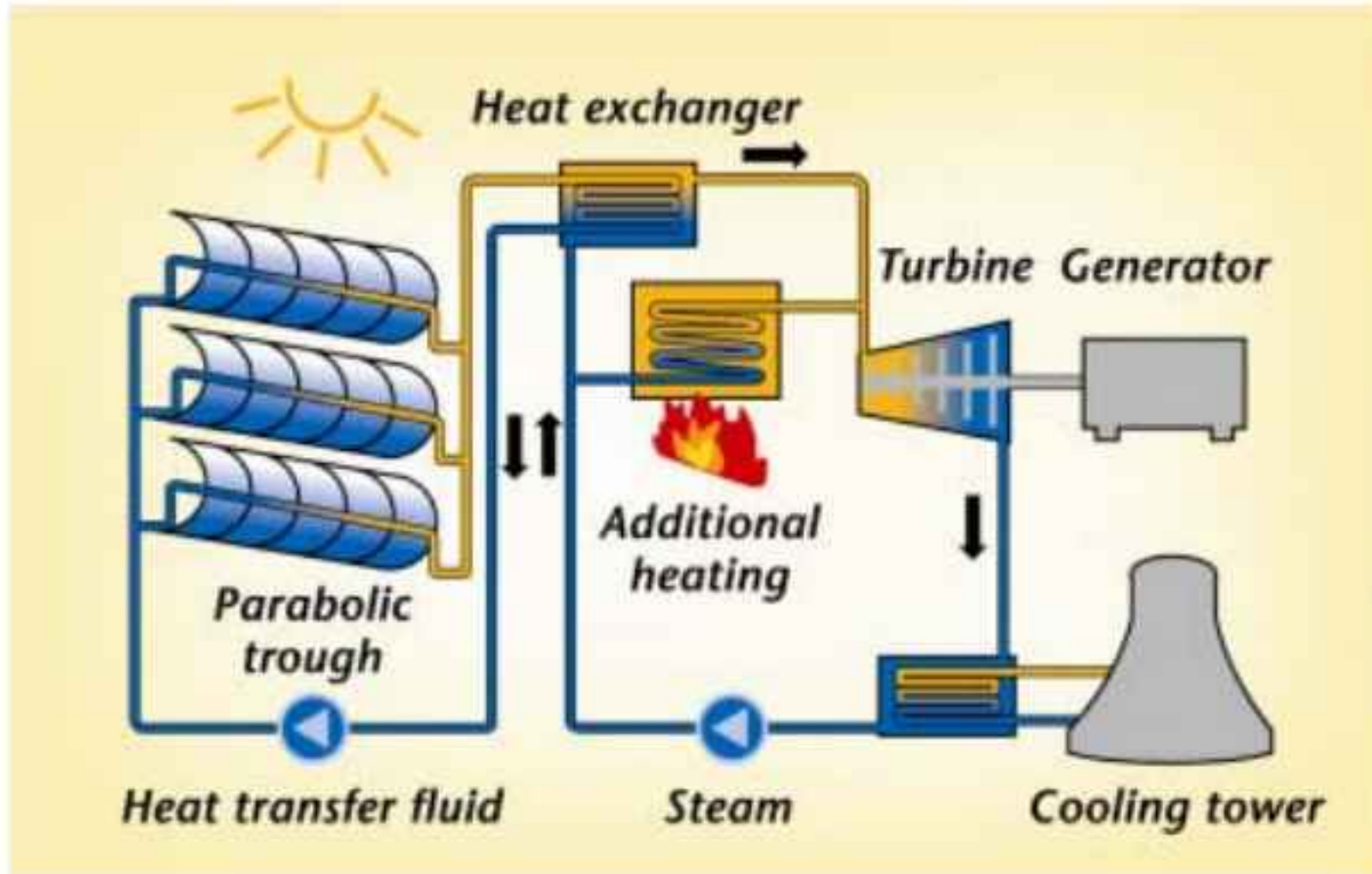


Photovoltaics (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect.



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>

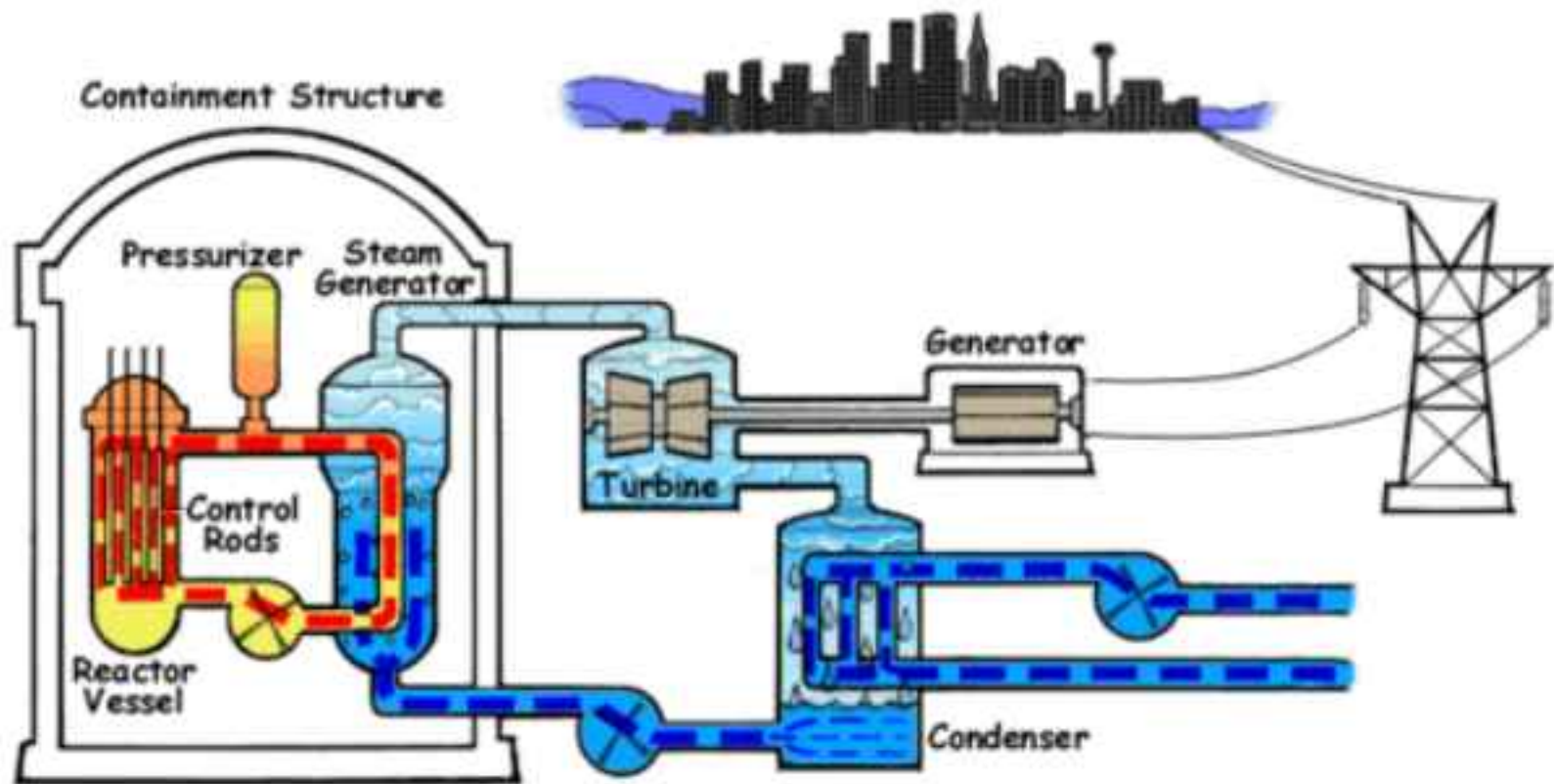
Biofuel





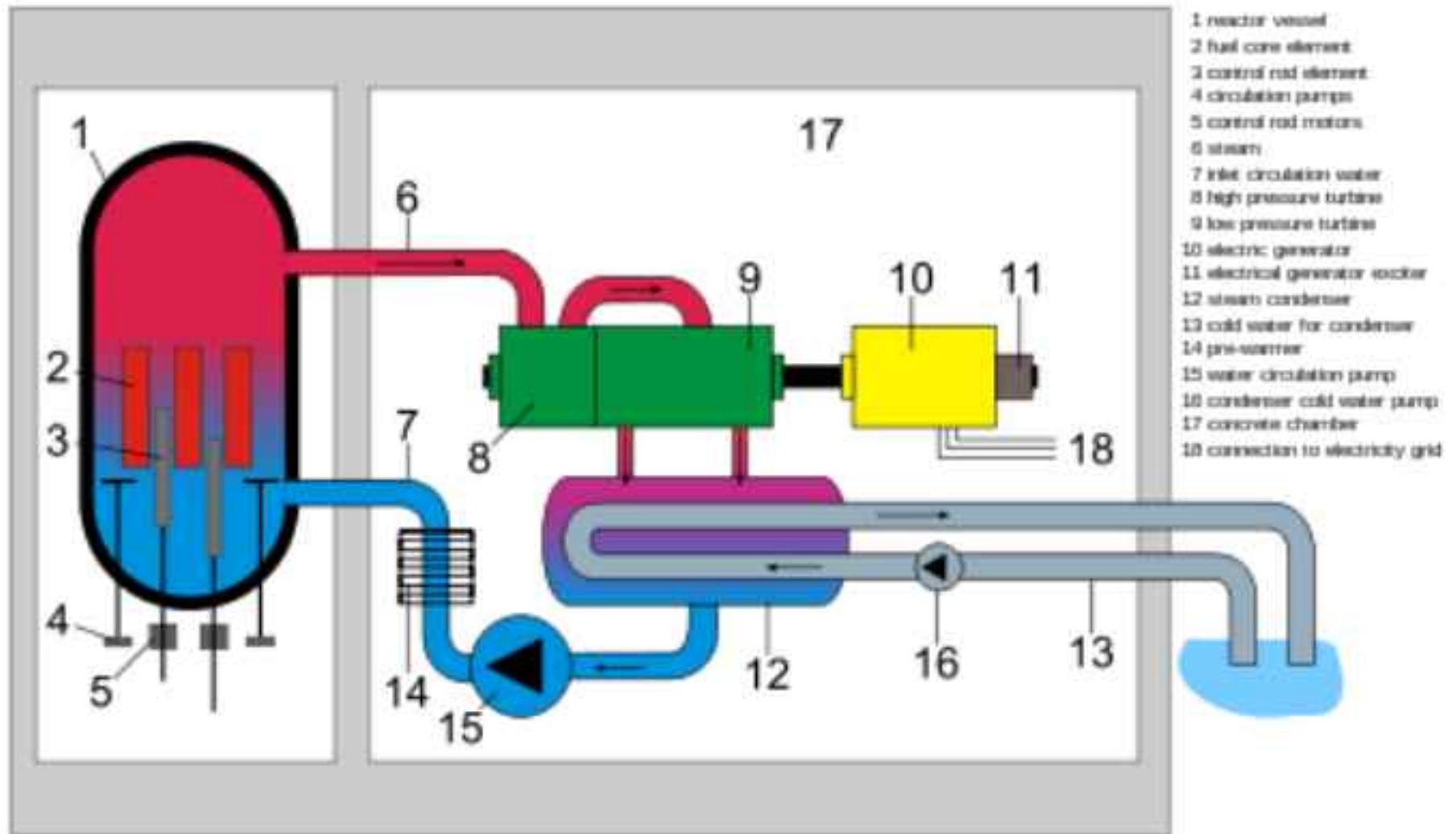
Nuclear

Pressurized water reactor



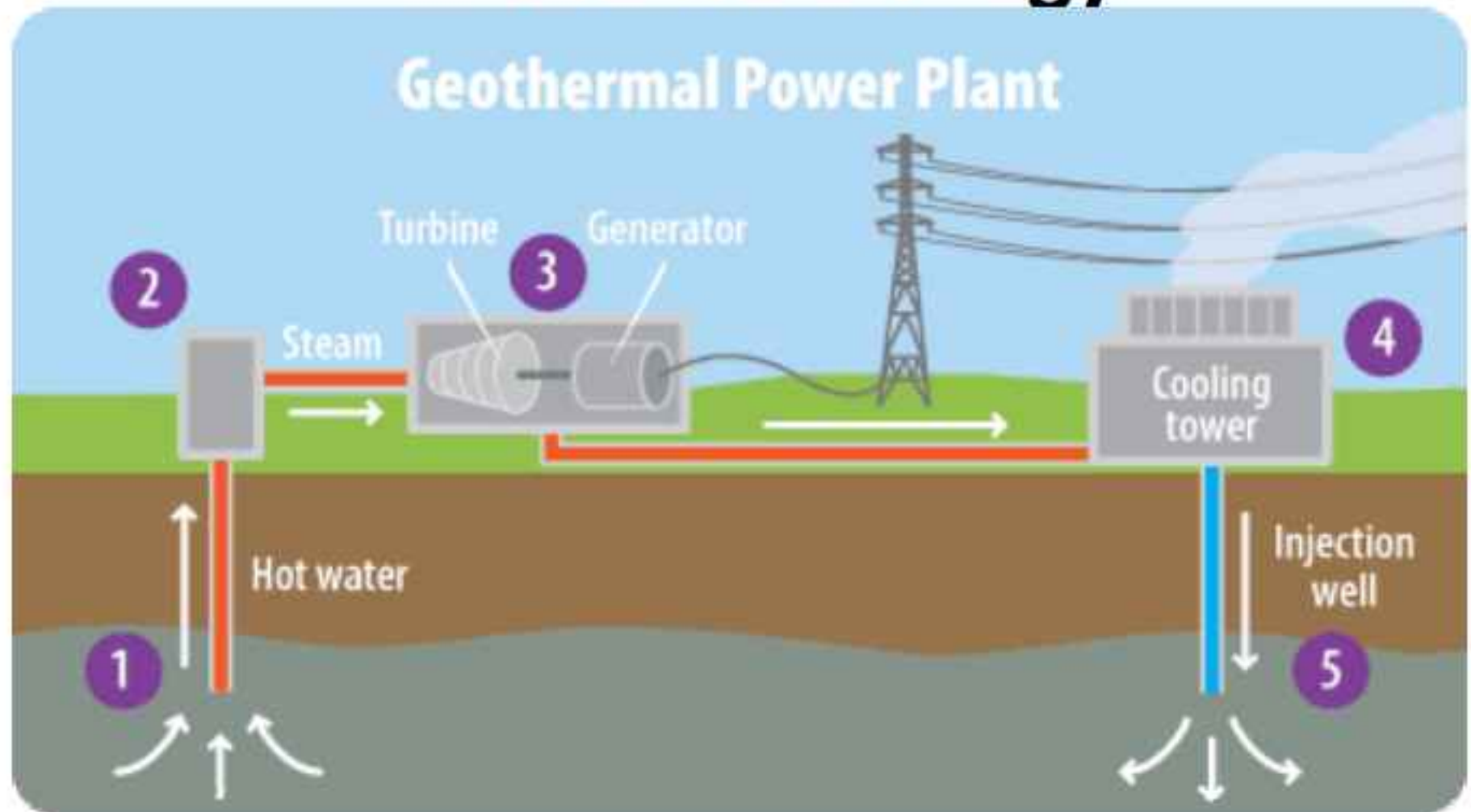
http://en.wikiversity.org/wiki/Power_Generation-nuclear_Power/Part2

Boiling water reactor (BWR)



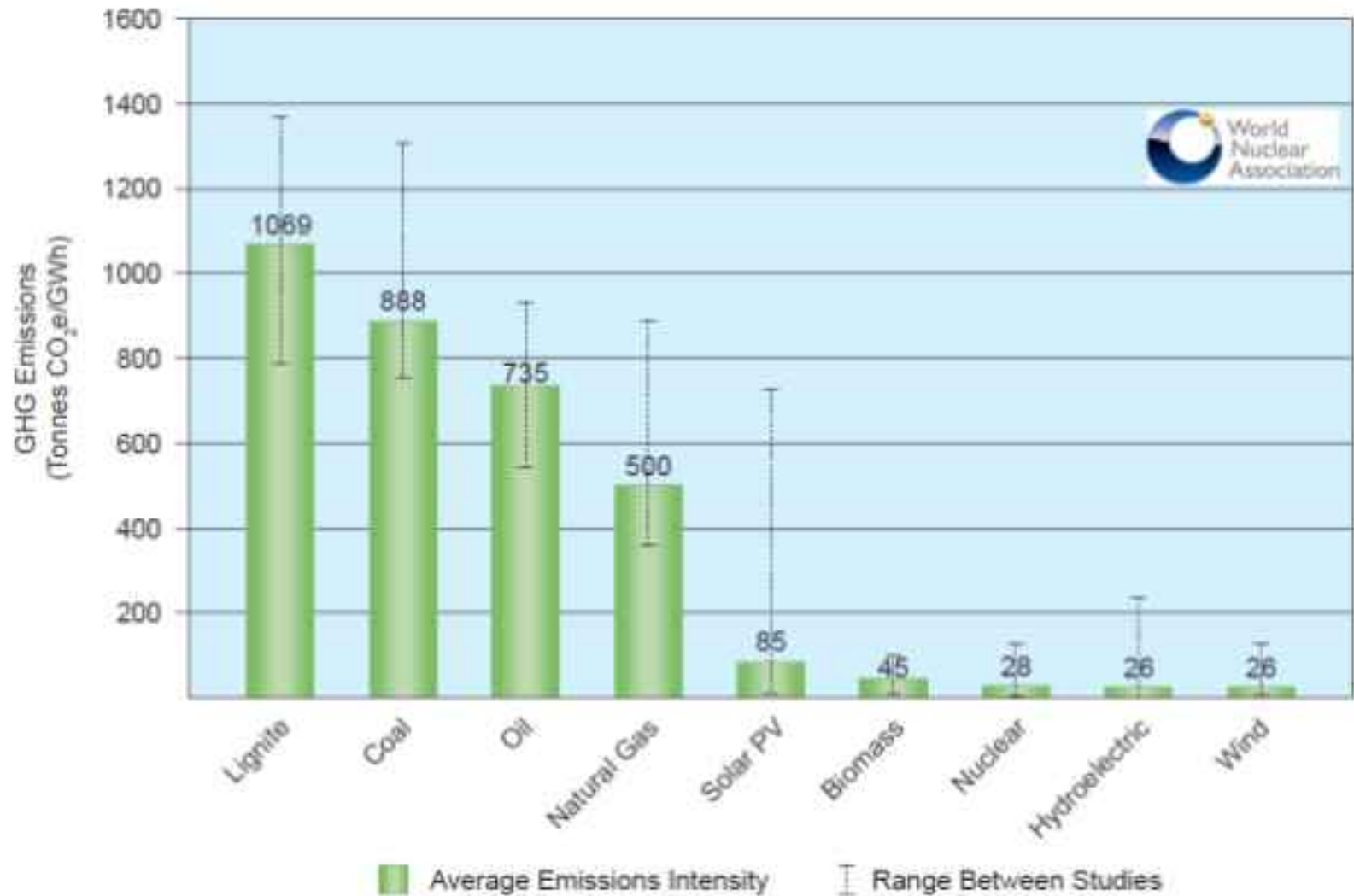
Source: http://en.wikipedia.org/wiki/Boiling_water_reactor

Geothermal energy



[Source:www.epa.gov/climatestudents/solutions/technologies/geothermal.html](http://www.epa.gov/climatestudents/solutions/technologies/geothermal.html)

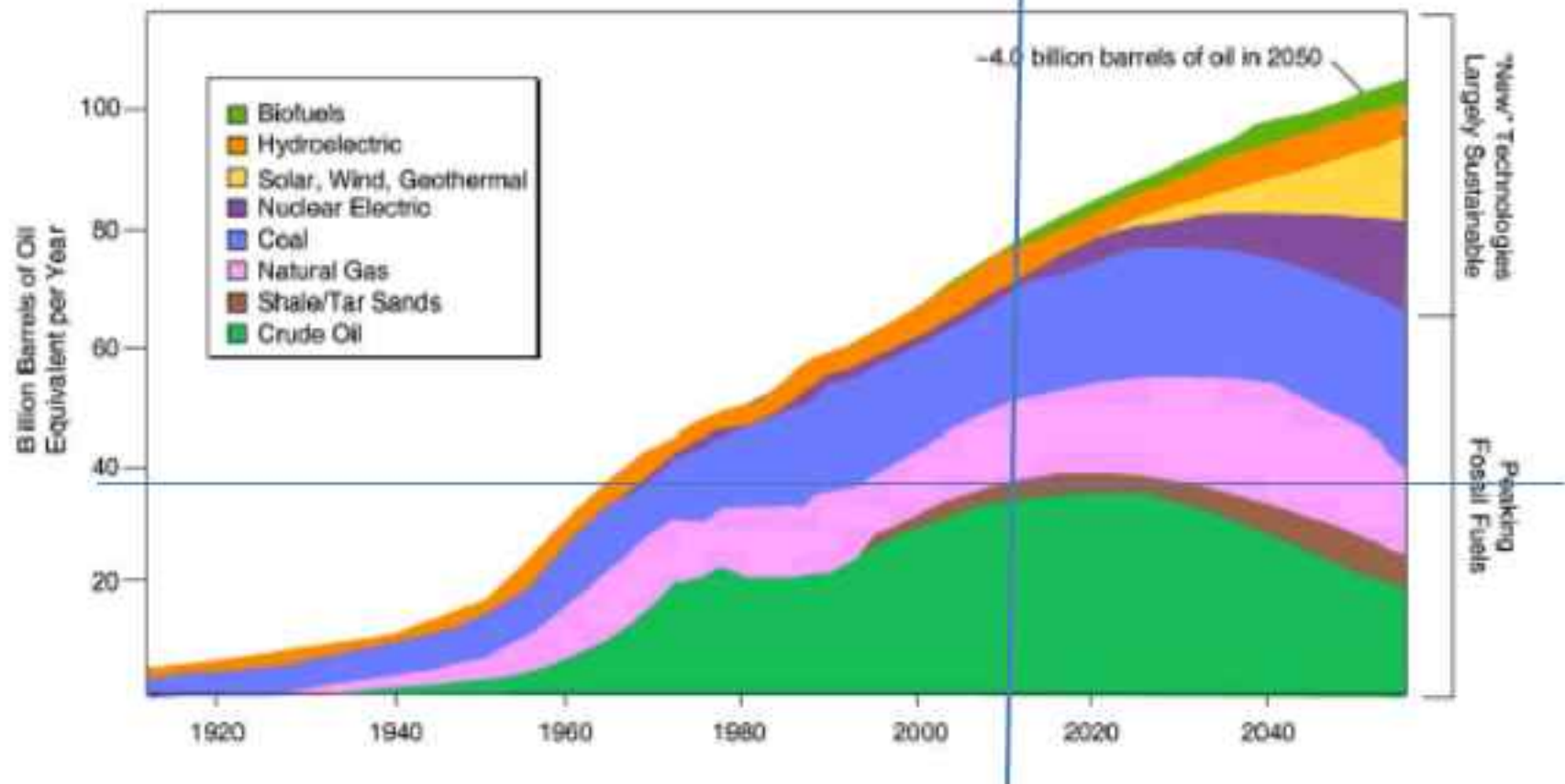
GHG emissions from different fuels



**1 barrel =(42 US gallons
or 158.9873 litres)**

~ 6.1 GJ (HHV)

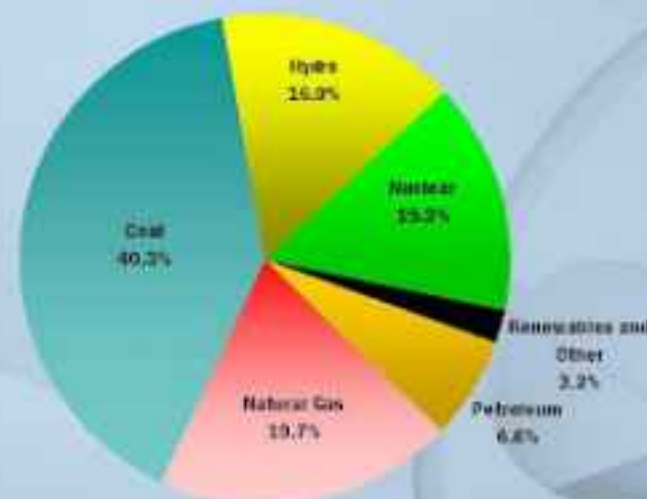
World Energy Demand—Long-Term Energy Sources



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



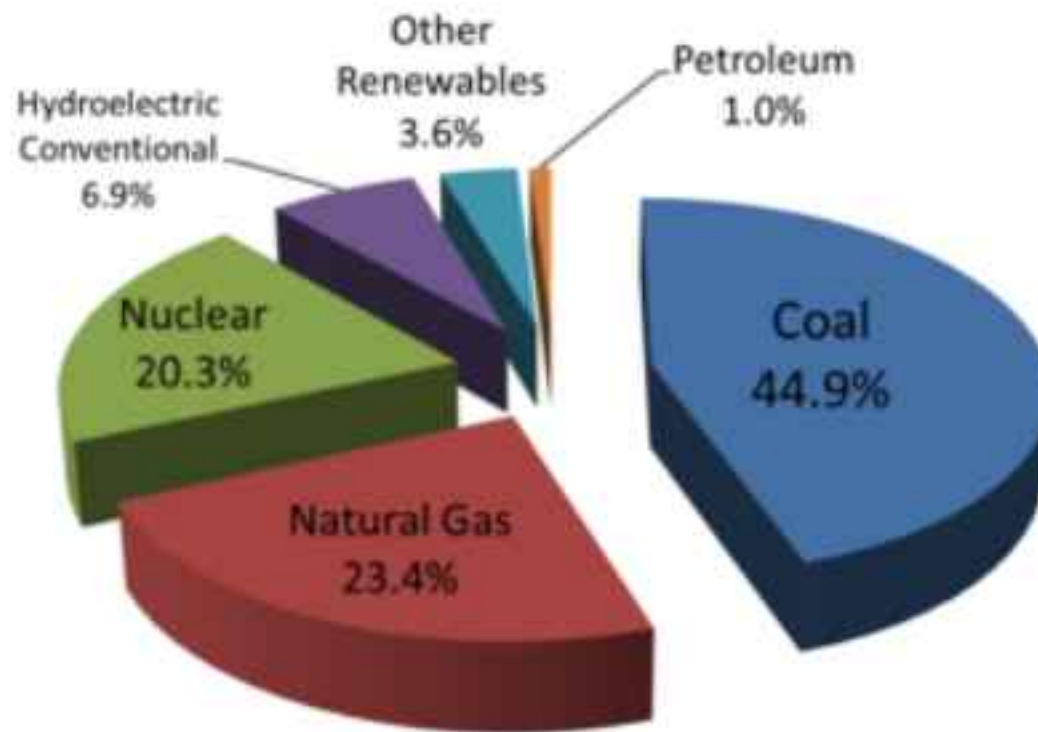
NEI

Nuclear
Energy
Institute

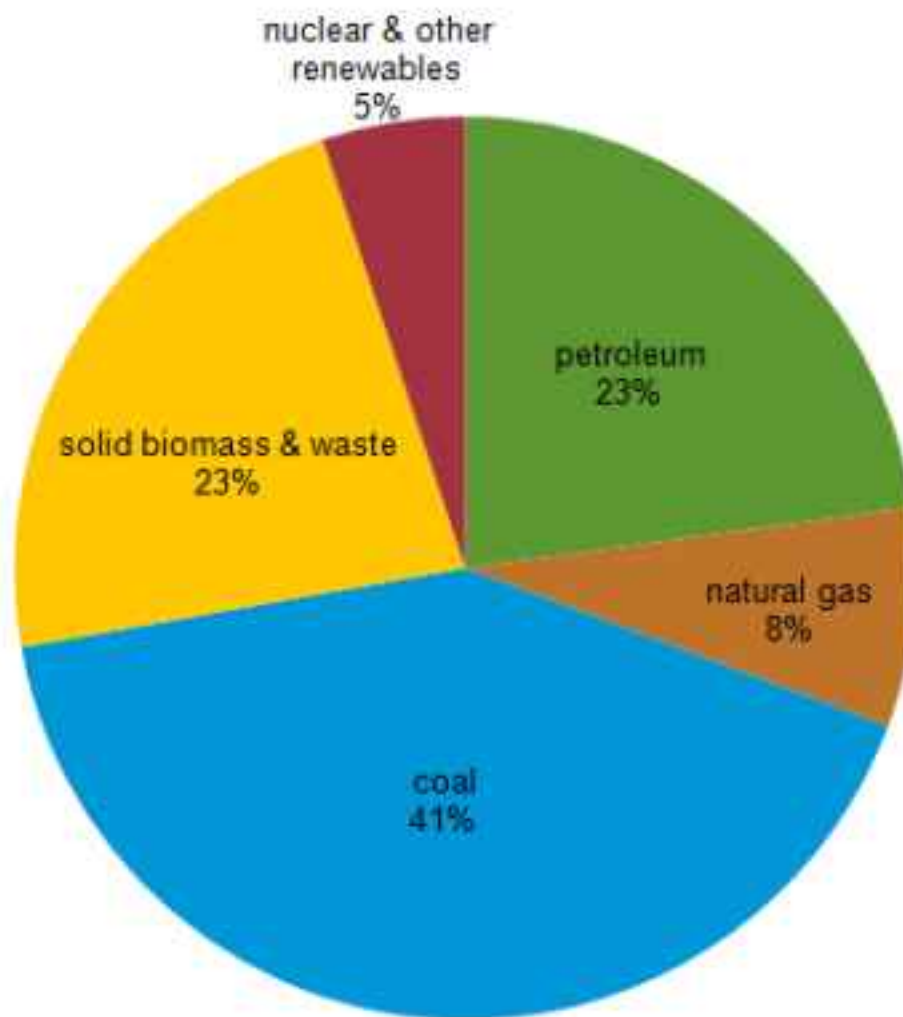
Source: International Energy Agency's Key World Energy Statistics 2007

Updated 1/08

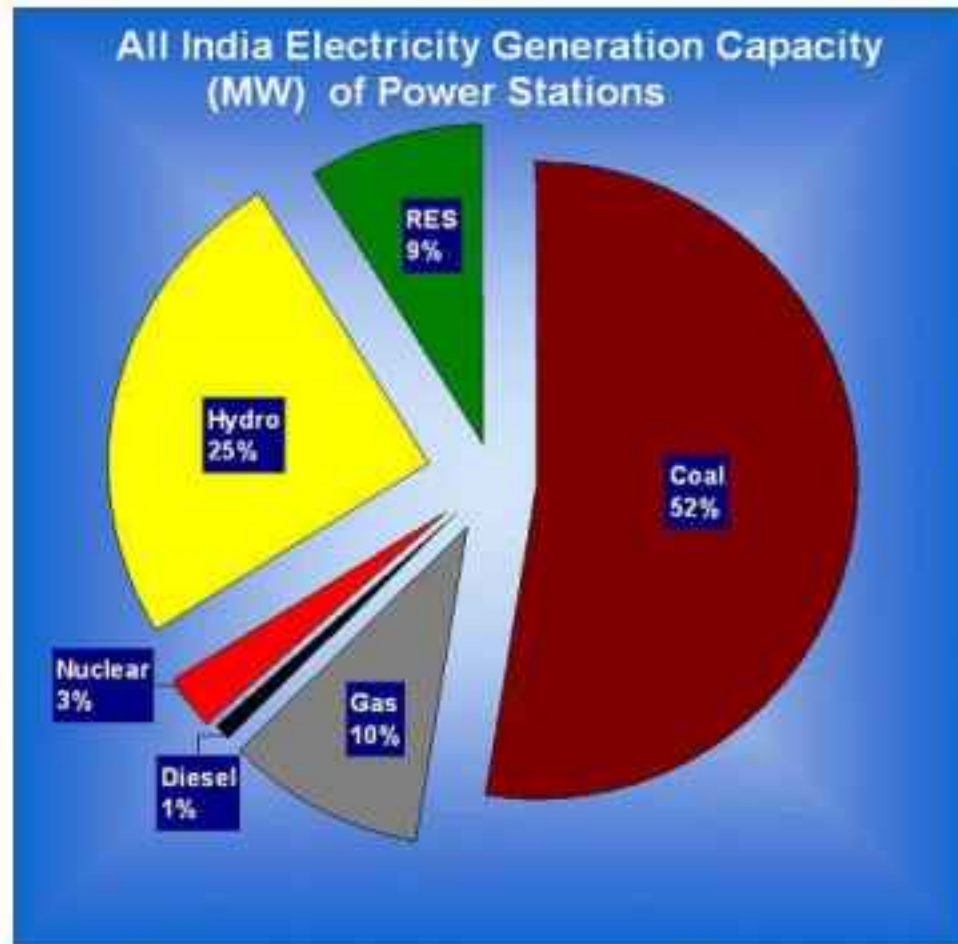
2009 U.S. Electricity Generation by Source



Total energy consumption in India, 2011

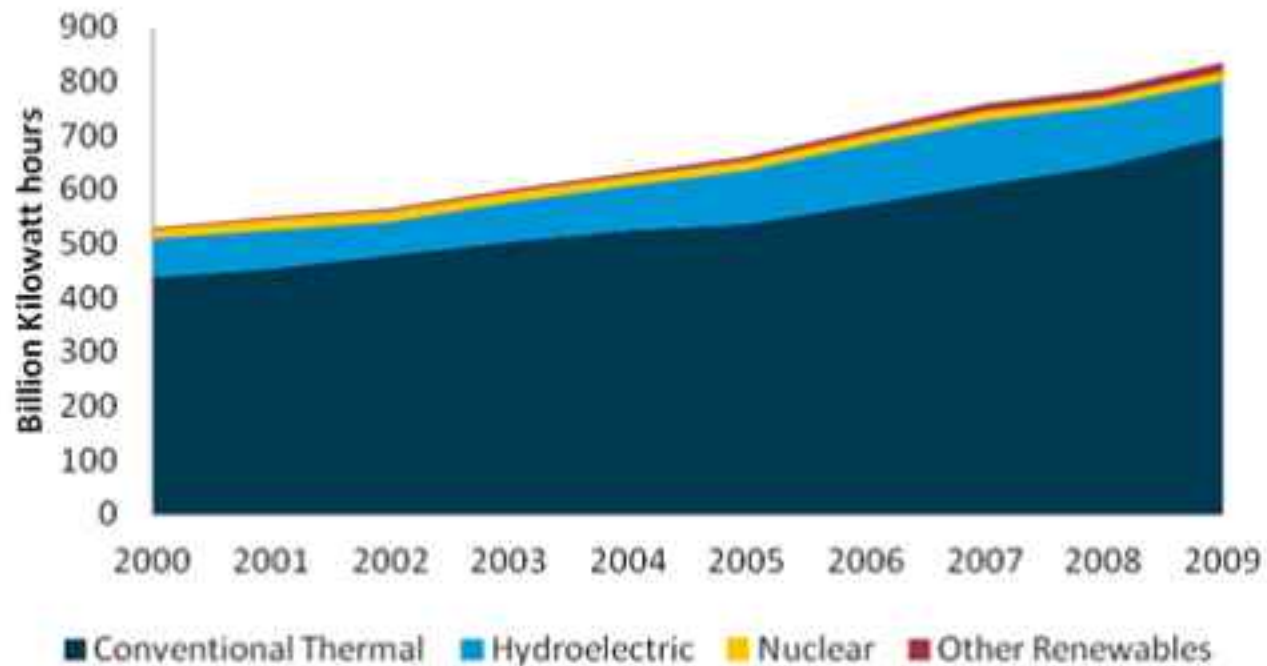


Source: U.S. Energy Information Administration, International Energy Statistics



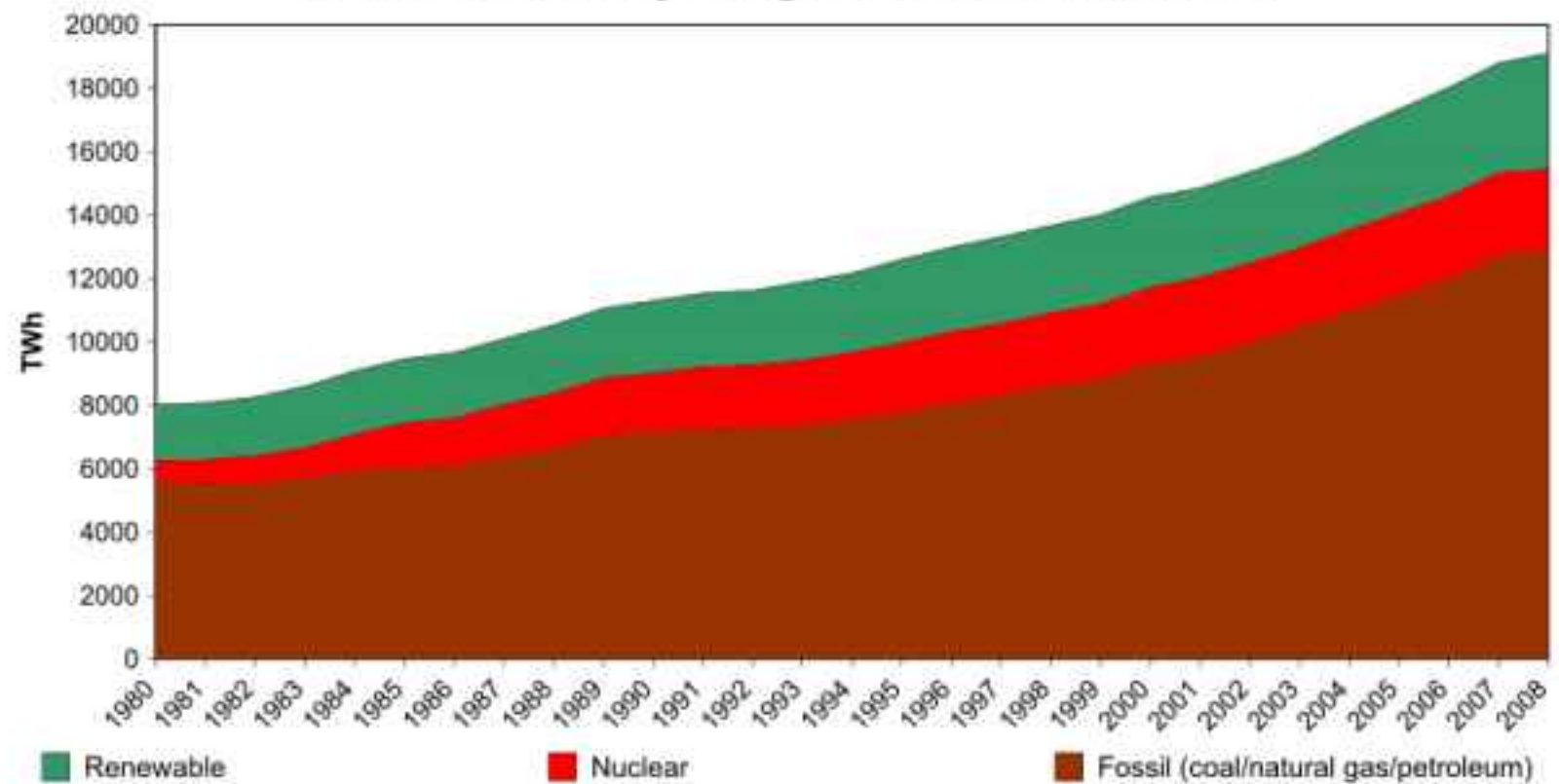
Source: <http://fewww.wordpress.com/2009/11/29/radioactive-leak-contaminates-water-in-india/>

Indian Electricity Generation By Type, 2000-2009



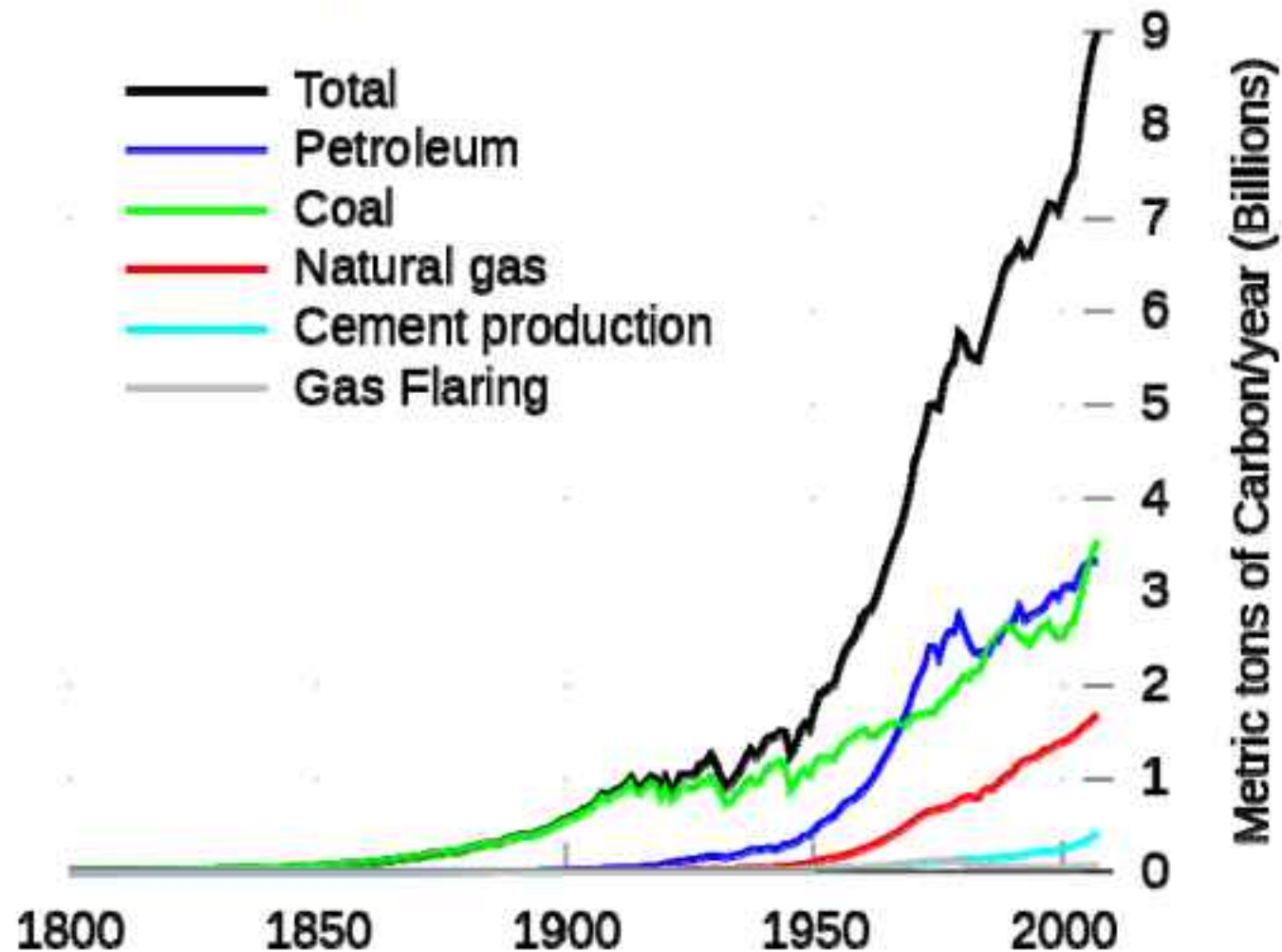
Source: U.S. Energy Information Administration, *International Energy Statistics*

Annual electricity net generation in the world



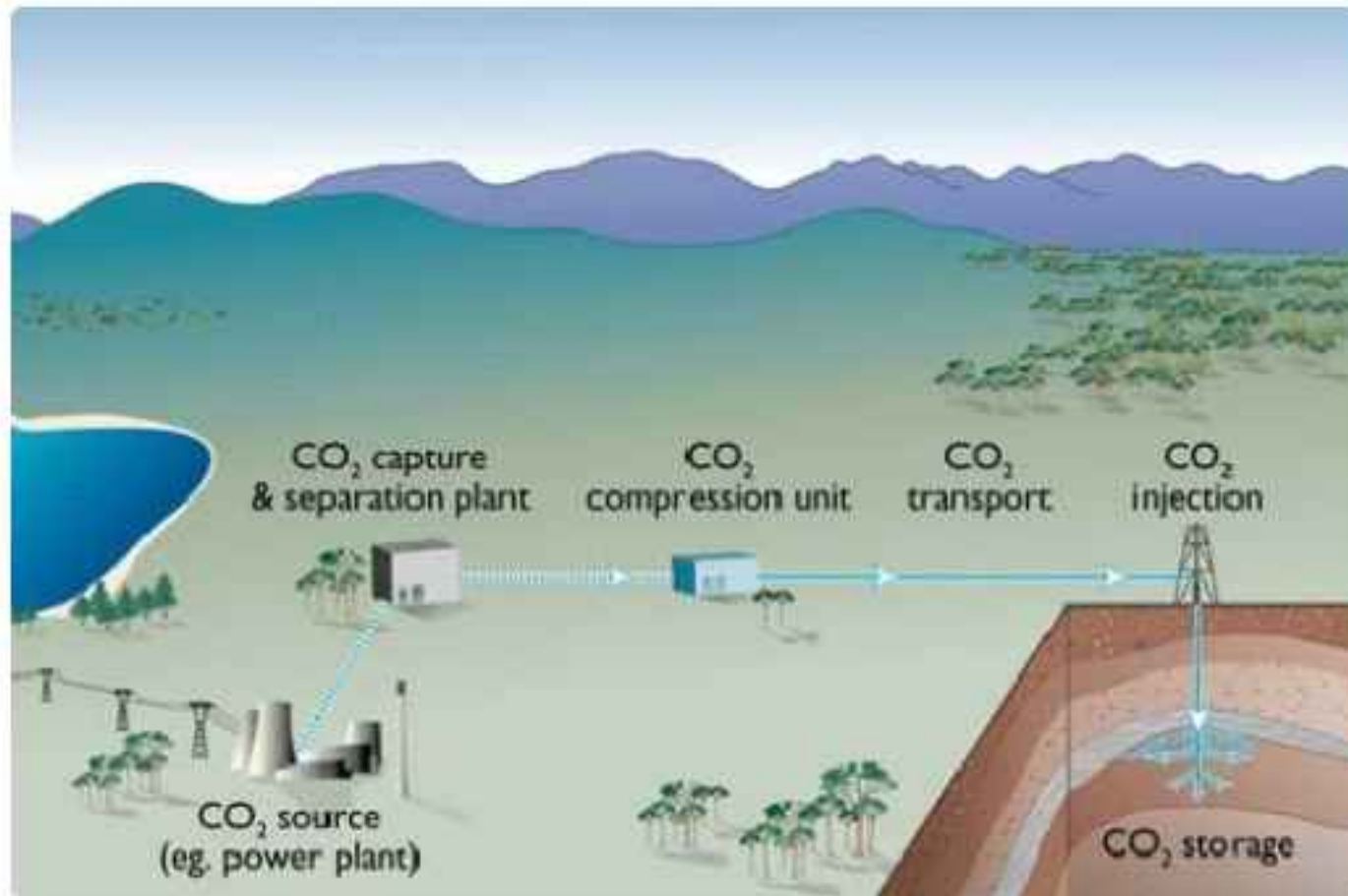
Source: http://en.wikipedia.org/wiki/Electricity_generation

Modern global anthropogenic carbon emissions



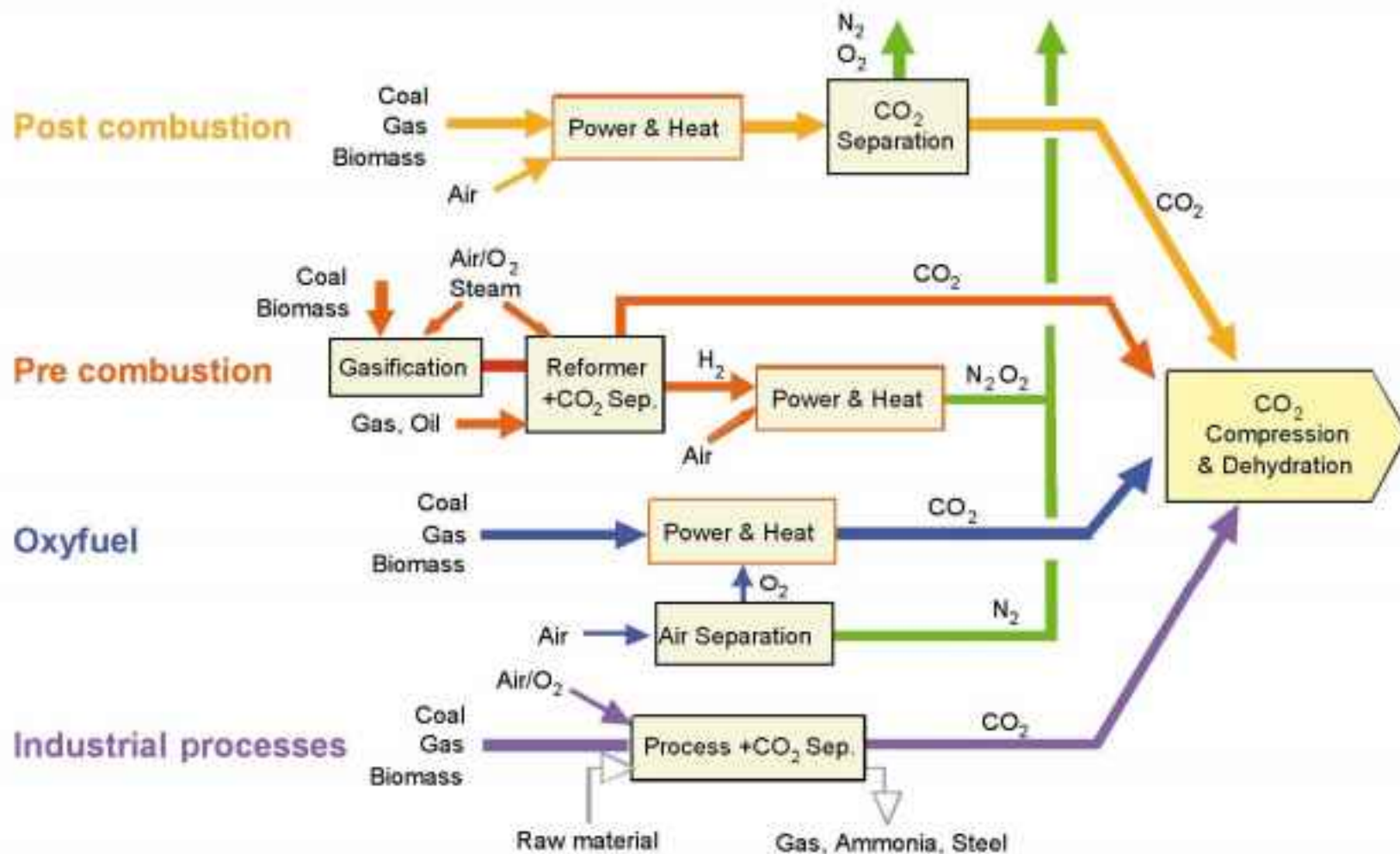
Source: https://en.m.wikipedia.org/wiki/List_of_CO2_emitted_per_million_Btu_of_energy_from_various_fuels

Carbon Capture and Storage (CCS)



Source: IPCC SRCSS

Capture of CO₂



Stabilization Wedges

Tackling the Climate Problem with Existing Technologies



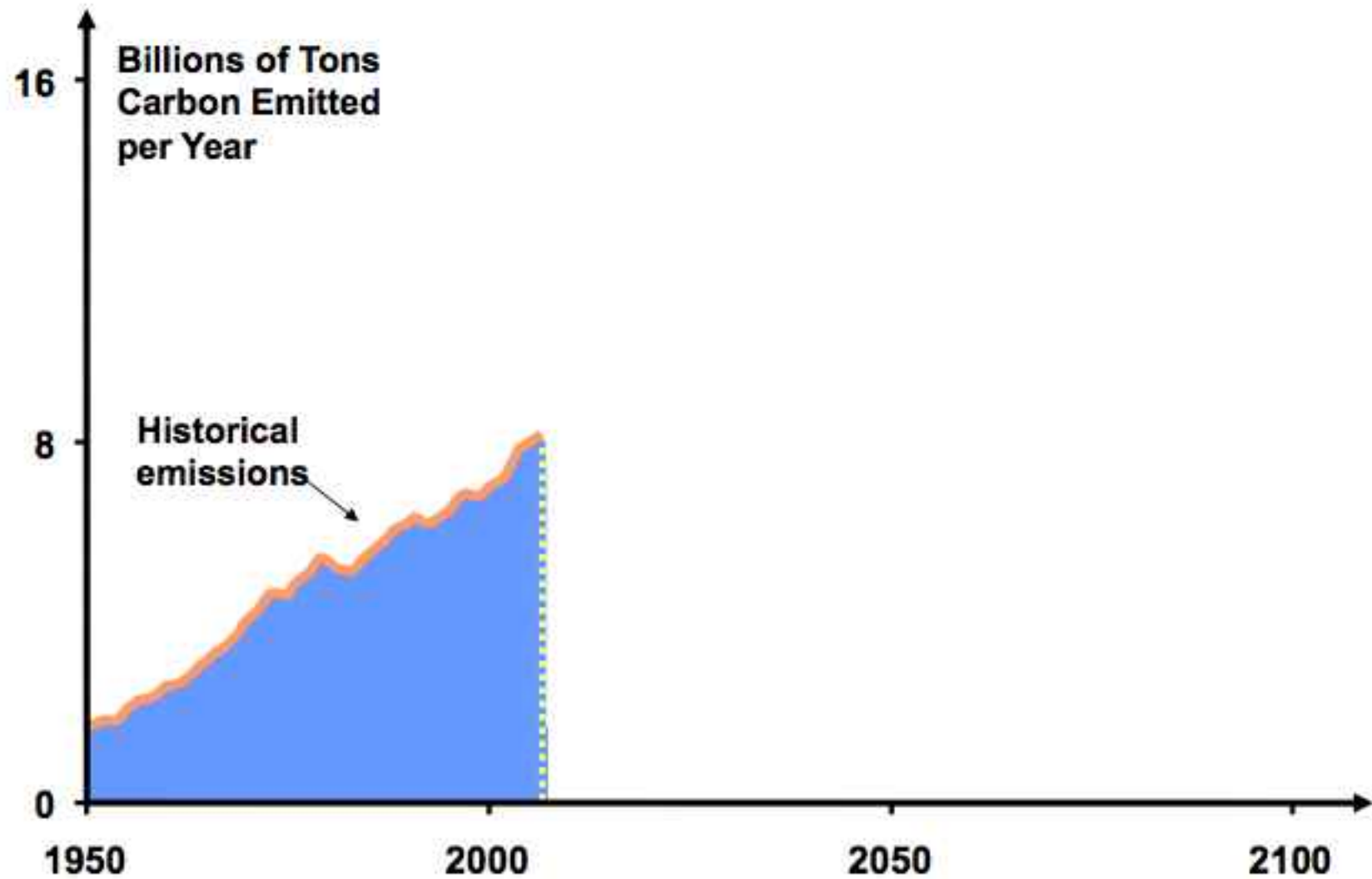
This presentation is based on the "Stabilization Wedges" concept first presented in

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

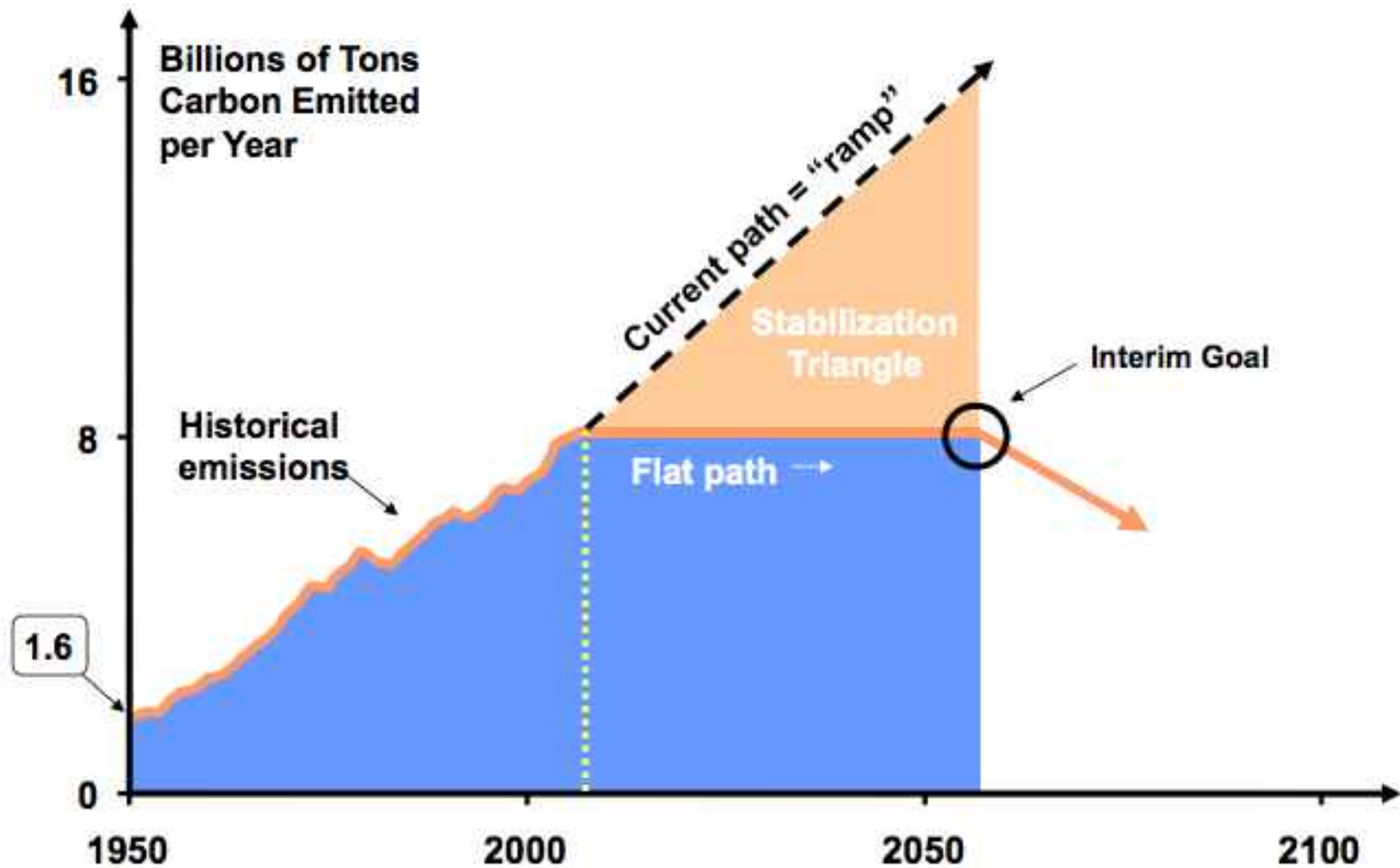
Source: Carbon Mitigation Initiative, Princeton University

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Princeton University**

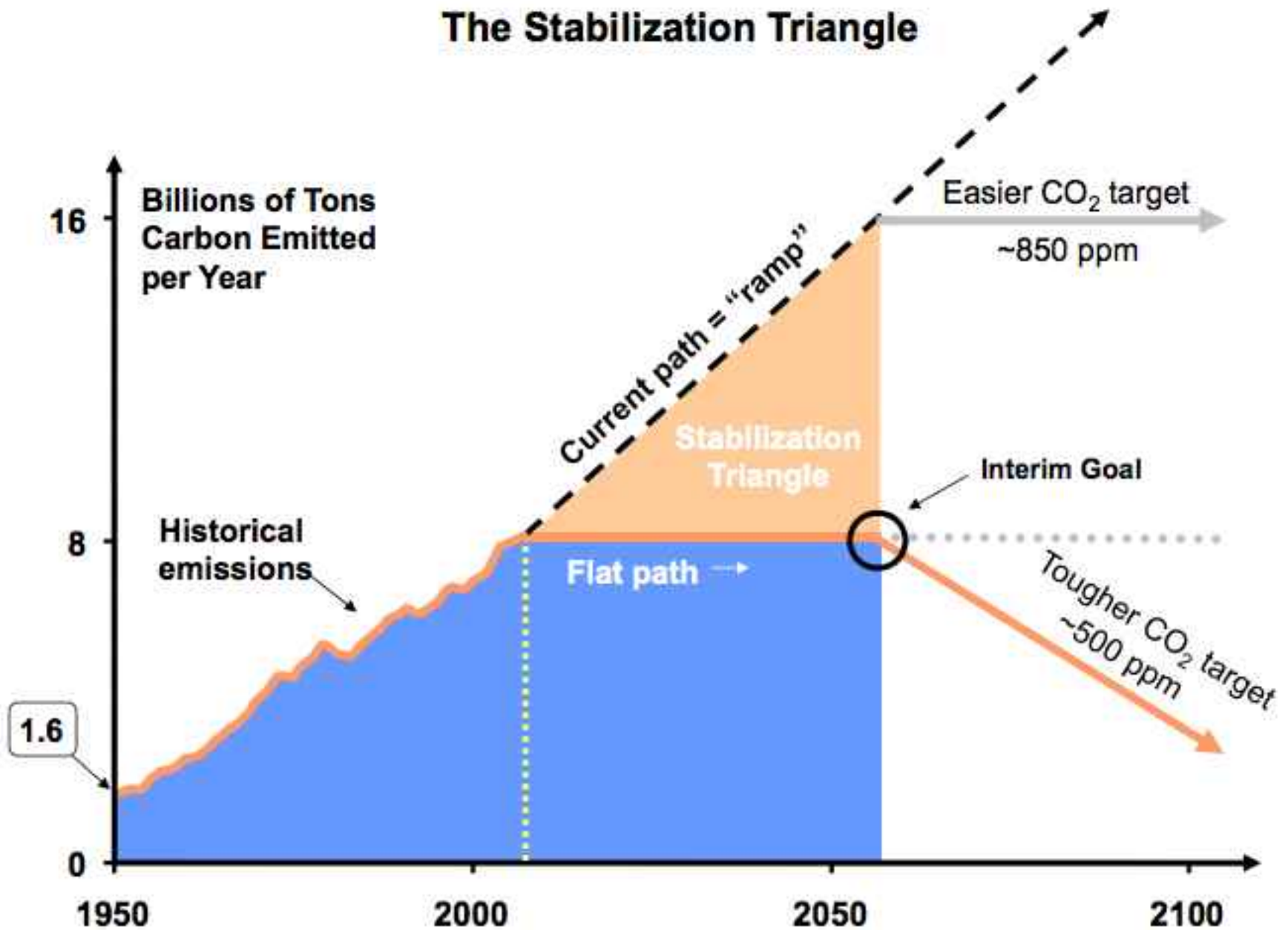
Historical Emissions



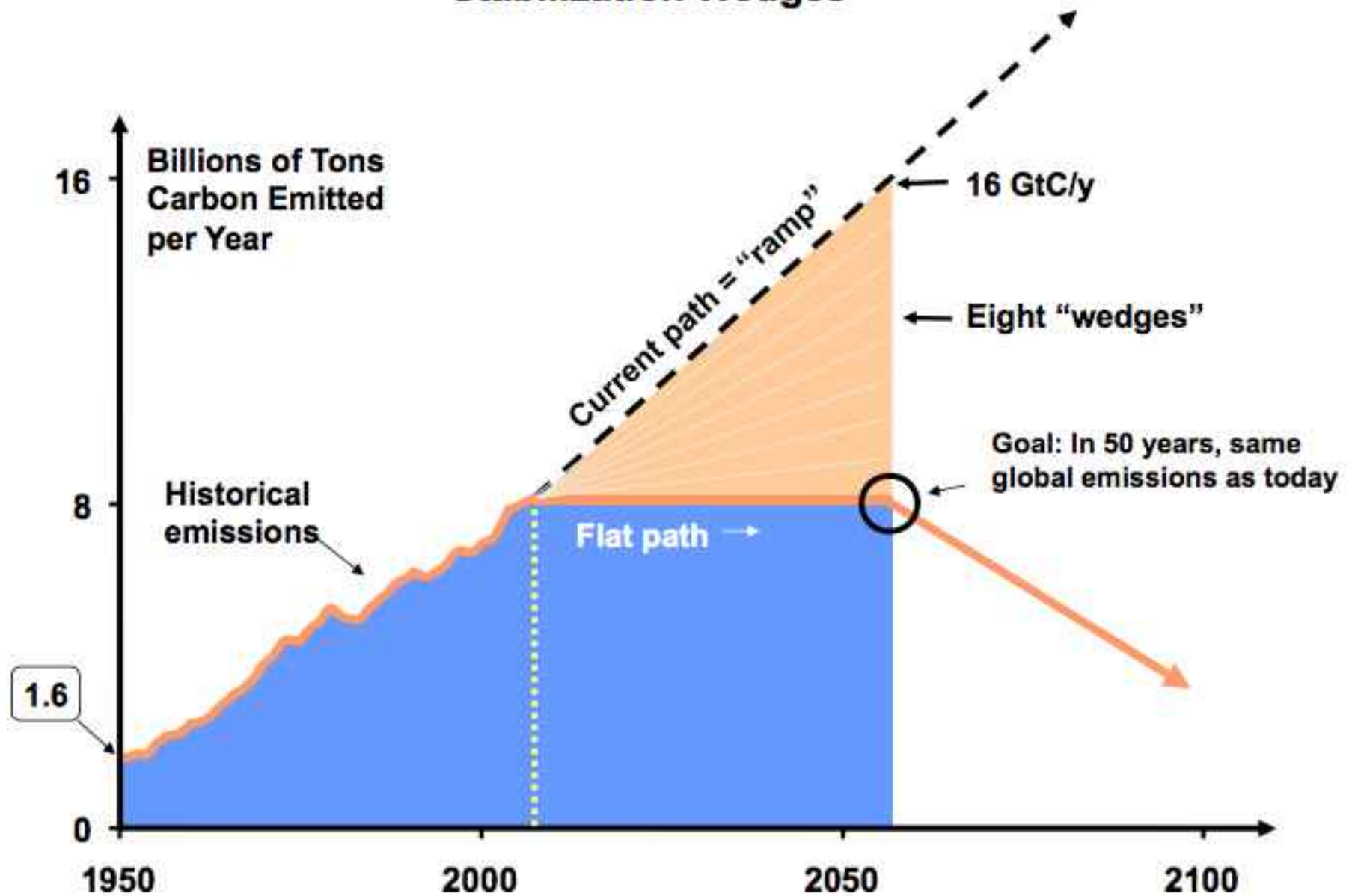
The Stabilization Triangle



The Stabilization Triangle

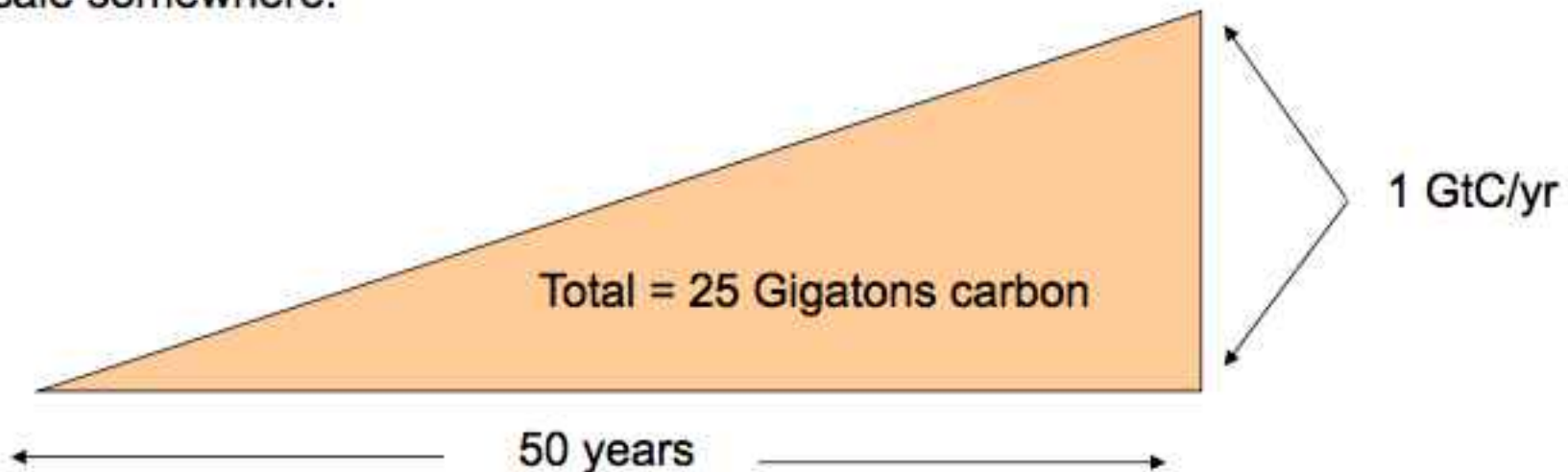


Stabilization Wedges



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 CO₂ problem should provide at least one wedge.



15 Wedge Strategies in 4 Categories

**Energy Efficiency
& Conservation**



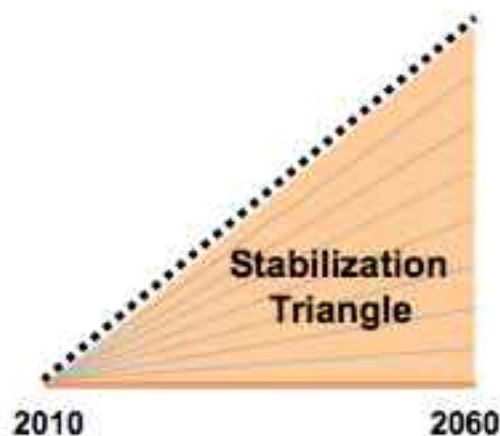
Nuclear Power



**Fossil Fuel-
Based
Strategies**



**Renewables &
Biostorage**



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**



Sectors affected:

E = Electricity, T = Transport,

H = Heat

Cost based on scale of \$ to \$\$\$

Photos courtesy of Ford Motor Co., DOE, EPA

Fuel Switching



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



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

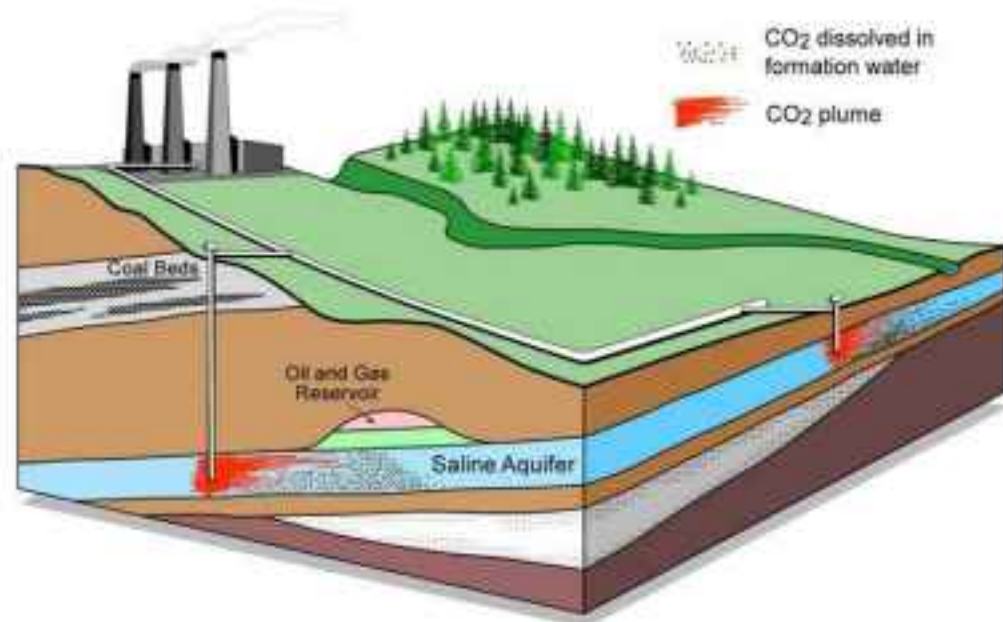
E, H / \$

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



Graphic courtesy of Alberta Geological Survey

E, T, H / \$\$

There are currently three storage projects that each inject 1 million tons of CO₂ 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 / \$\$\$

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)**

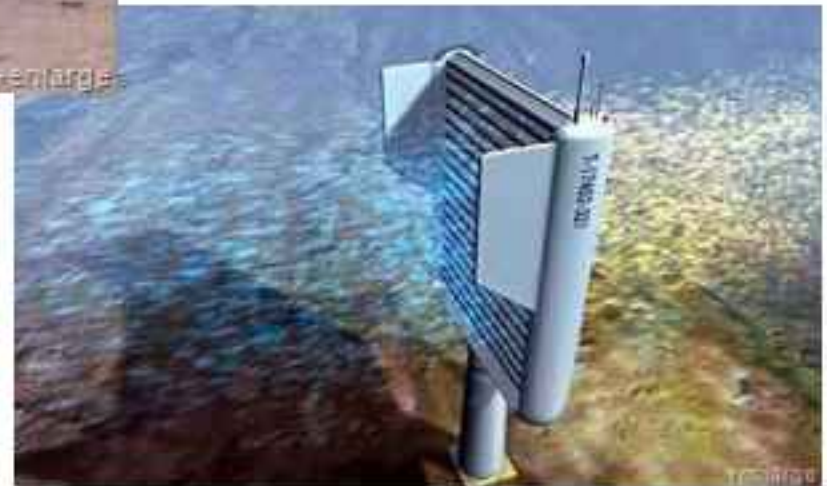
**Conservation tillage is currently practiced
on less than 10% of global cropland**

B / \$

Take Home Messages

- In order to avoid a doubling of atmospheric CO₂, 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 CO₂ doubling
- Every “wedge” has associated impacts and costs

Synthetic trees to scrub CO₂ from the atmosphere



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

“If you ask a scientist how much more CO₂ 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