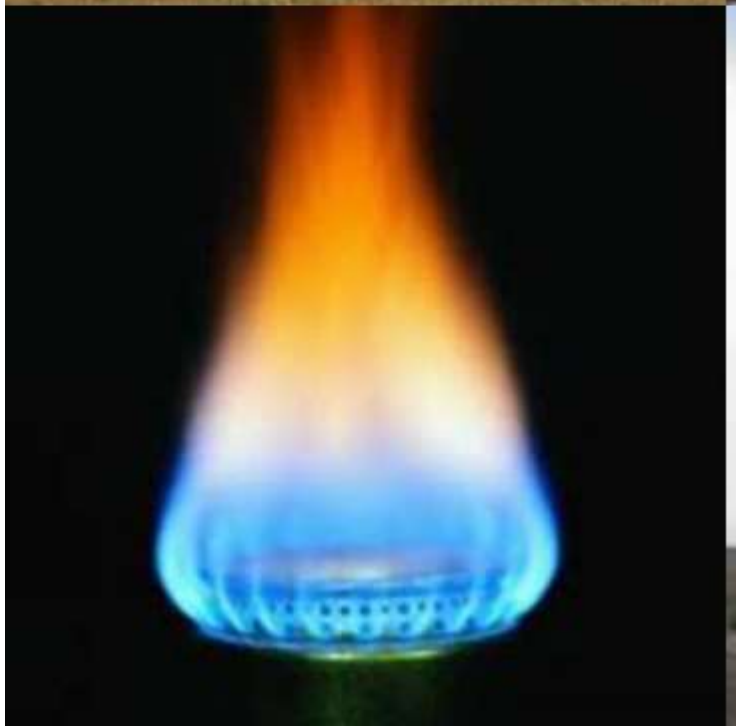
Renewable Energy

Nonrenewable

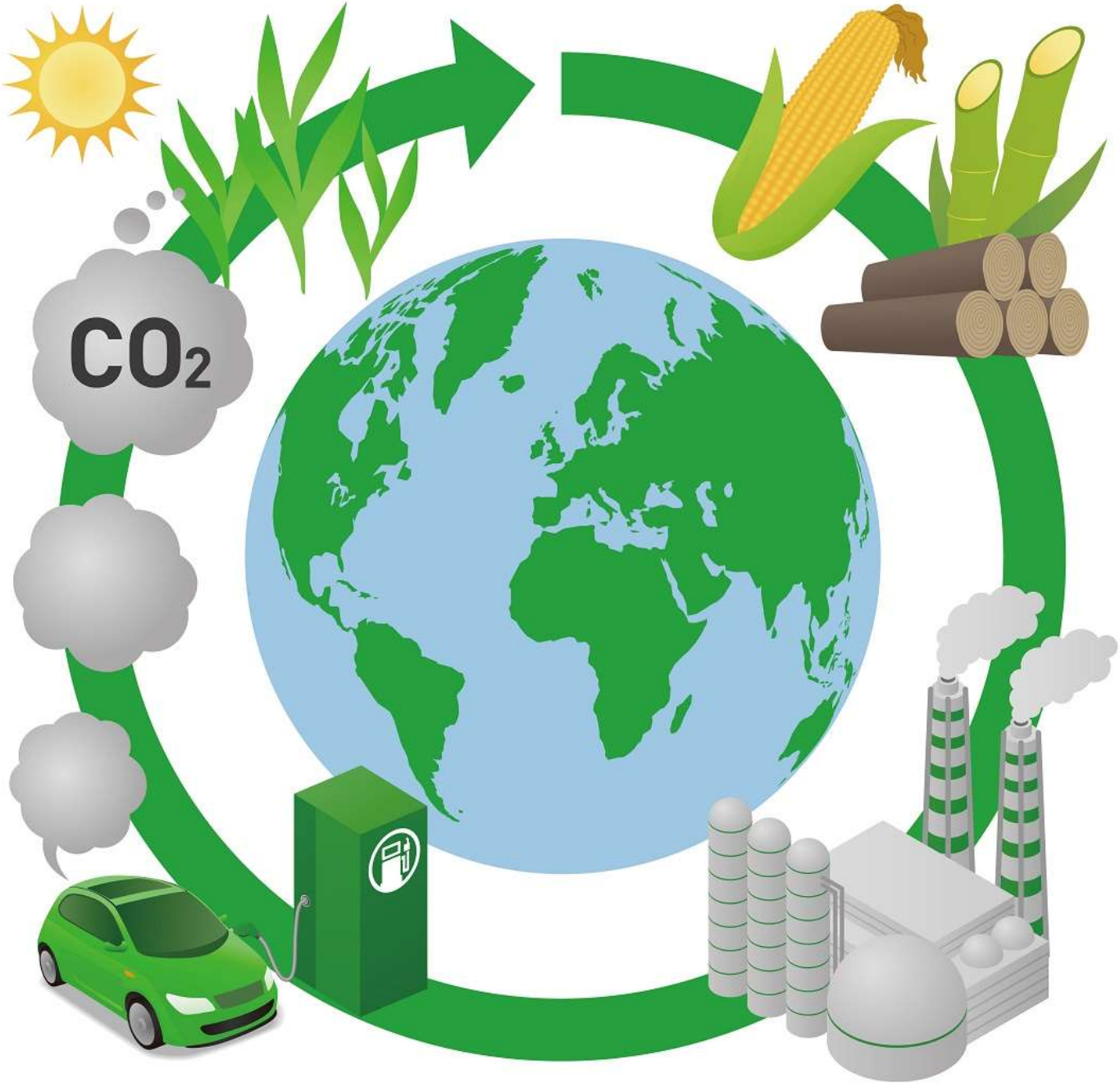


Nondepletable / Renewable

- Wind
- Solar
- Hydro
- Geothermal

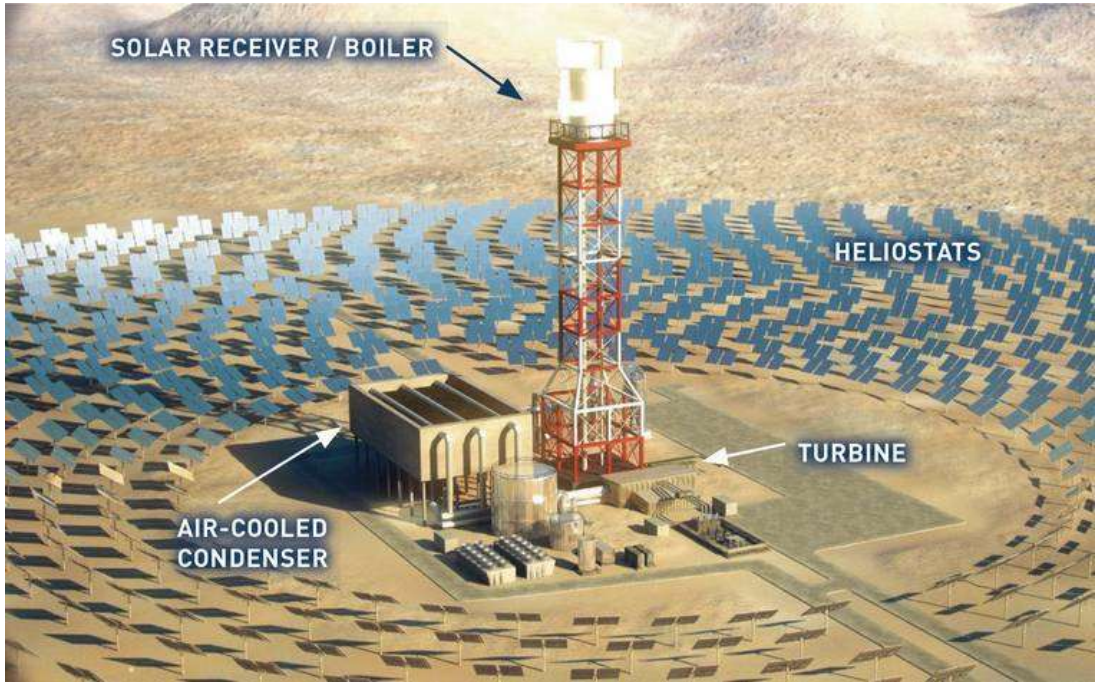
Potentially Renewable

- Wood / biomass
- Biofuels



Direct Solar

- Solar thermal electric
- Photovoltaics (pv cells)
- Passive and active solar heating



Indirect Solar

Hydro concerns and case studies

Altered Aquatic Environment

- Dams → habitat fragmentation
- (Lotic → lentic) (temp changes)

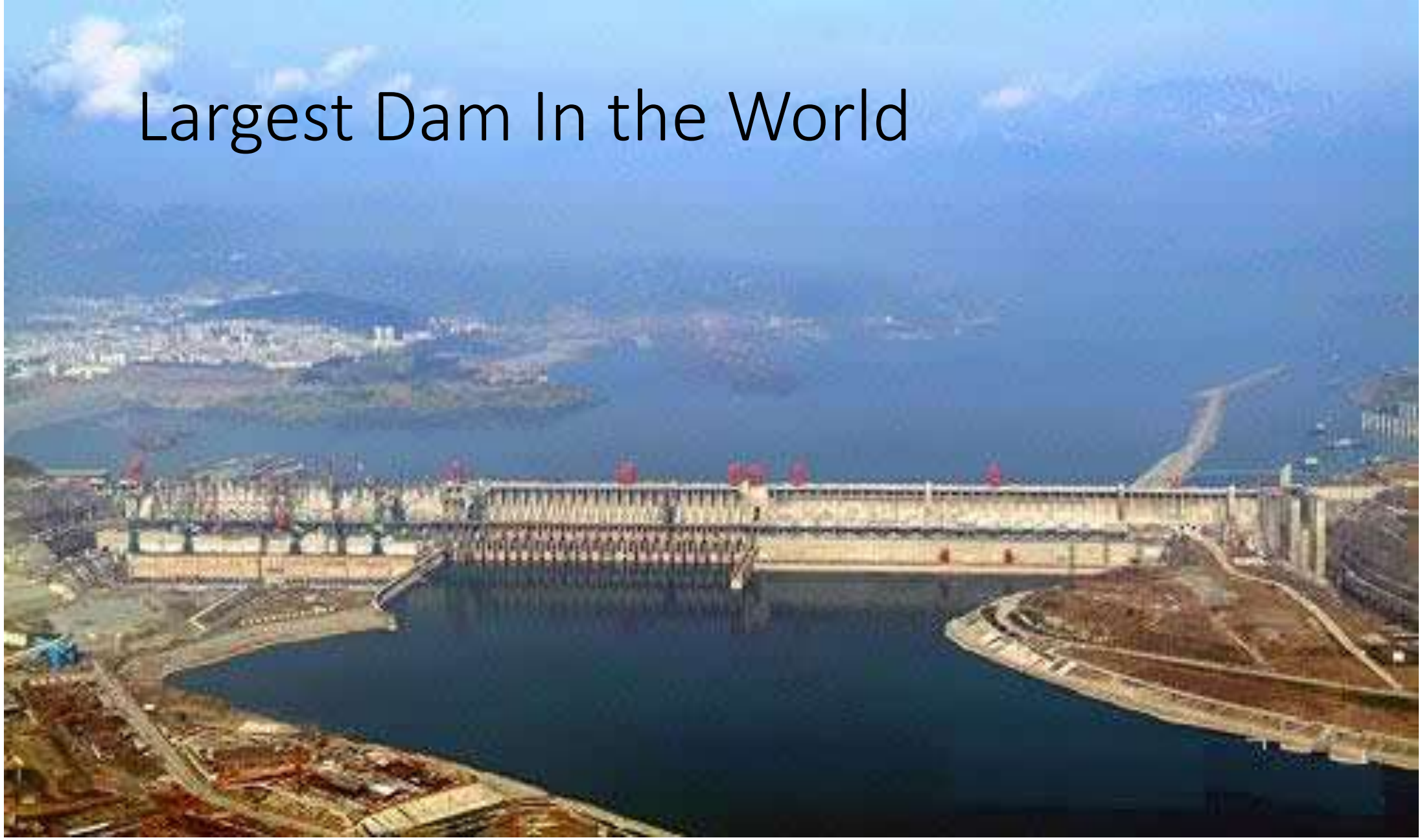
Flowing water – LOTIC systems

Standing water – LENTIC systems

Dams and climate change → warmer water → increased water borne diseases

- Reservoirs = breeding grounds for
  - cholera,
  - typhoid fever,
  - schistosomiasis (parasitic worm)

Largest Dam In the World



3 Gorges Dam in China

Impacts of 3 Gorges Dam

- 22,500 MW
- Displaced more than 1.2 million people, 13 cities, 140 towns, 1,350 villages, World heritage sites

James Bay, Hydro Quebec
Largest in North America

Impacts of James Bay

- 7,722 MW

- 10,000 caribou drowned while migrating
- Coastal marshes degraded → decrease in eel grass (keystone species),
- decrease in salmon
- Increased mercury released from soil → bioaccumulation

Review

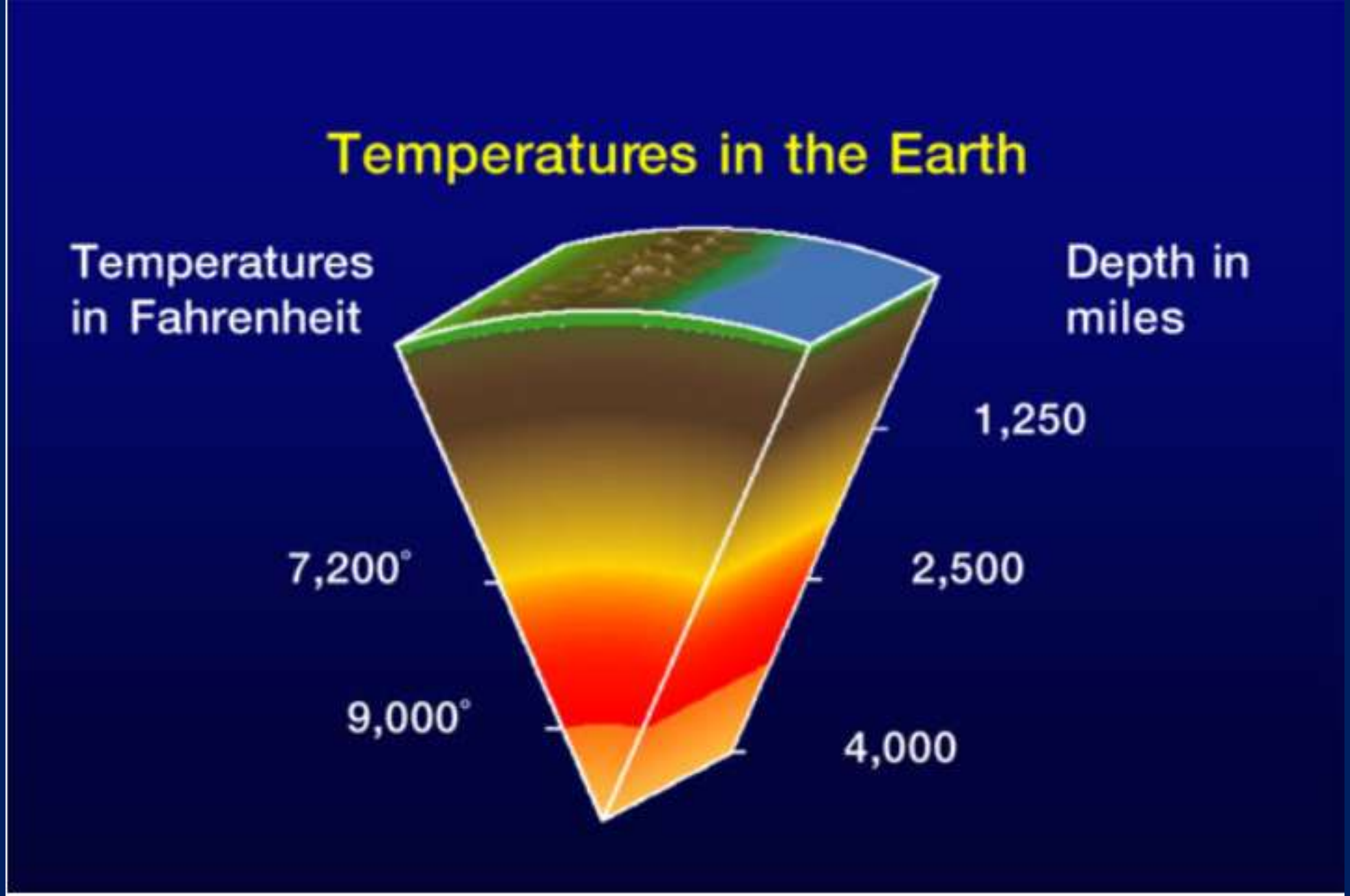
- Keystone species
- Indicator species
- Ecosystem services

Read about Eelgrass

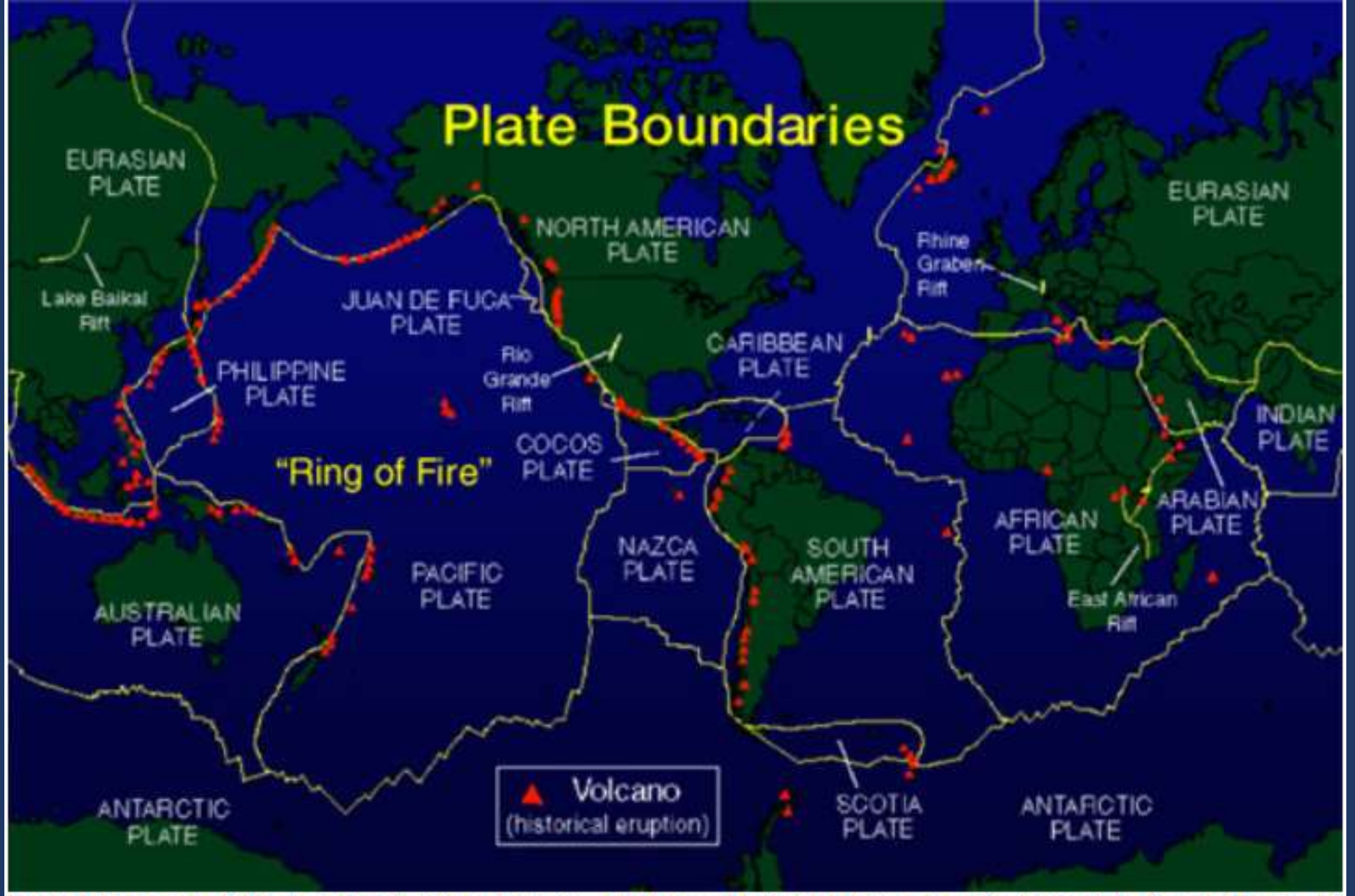
Geothermal Energy

Review

- Magma
- Lava
- Convection

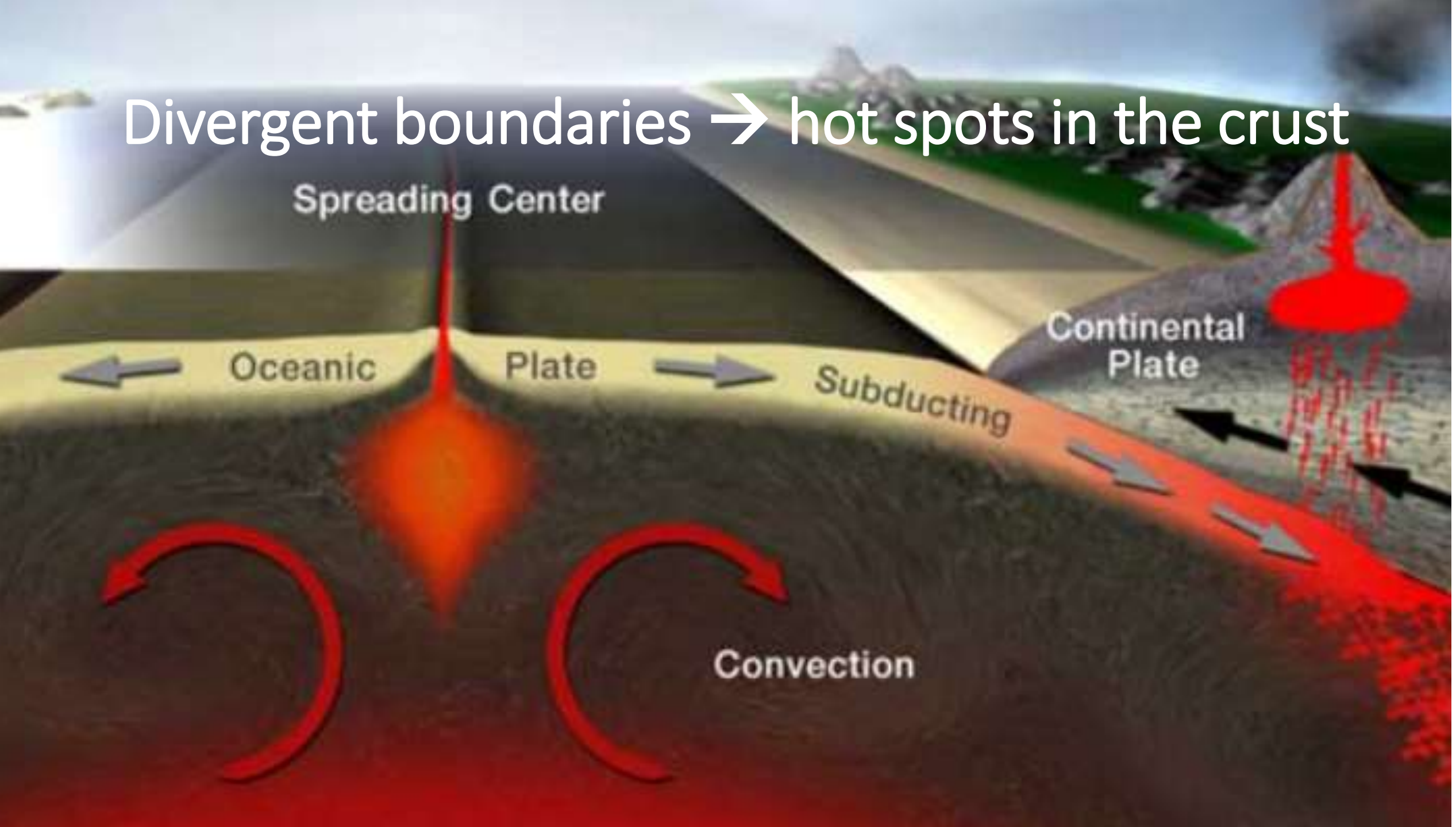


The deeper you go, the hotter it gets (in Fahrenheit and miles).

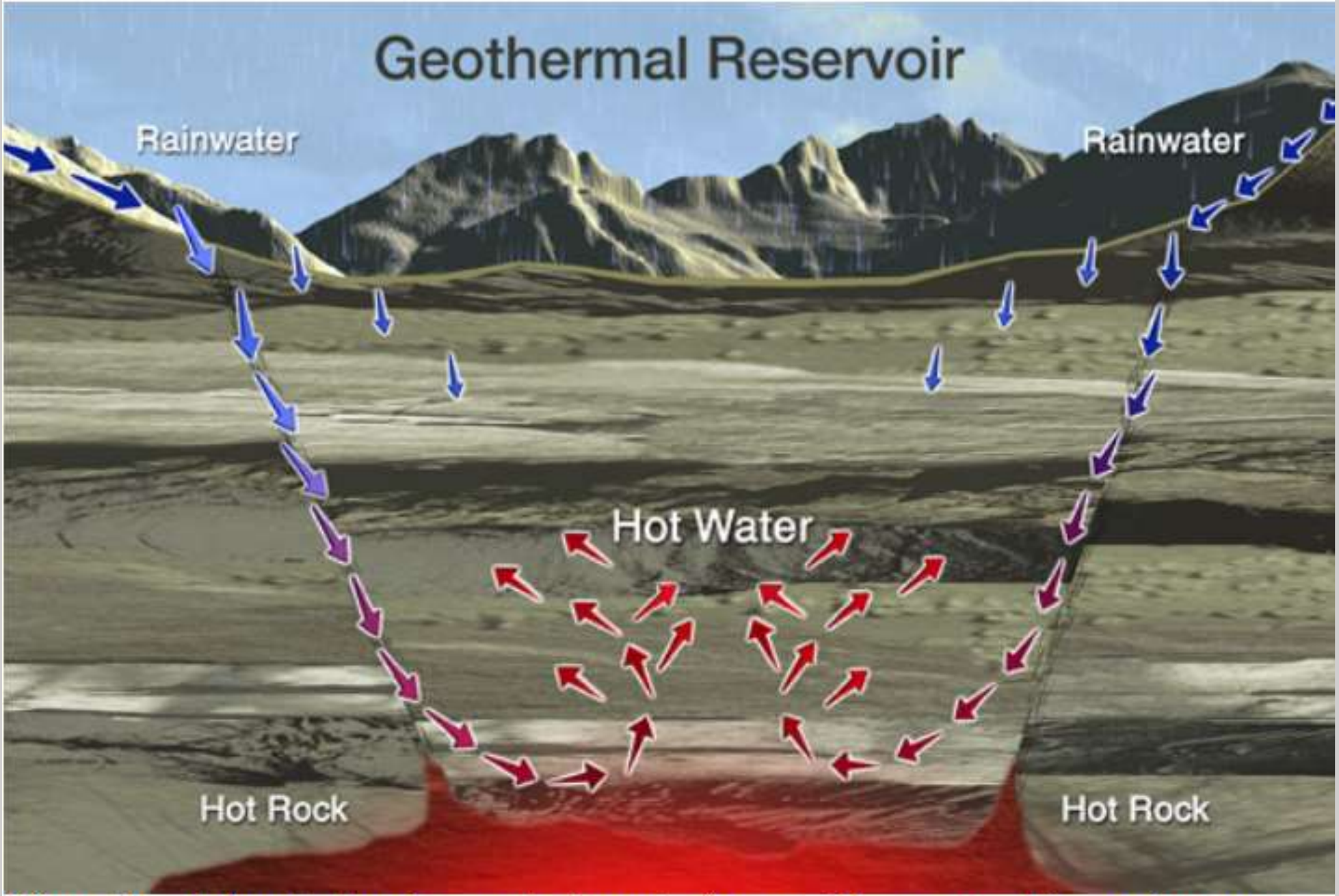


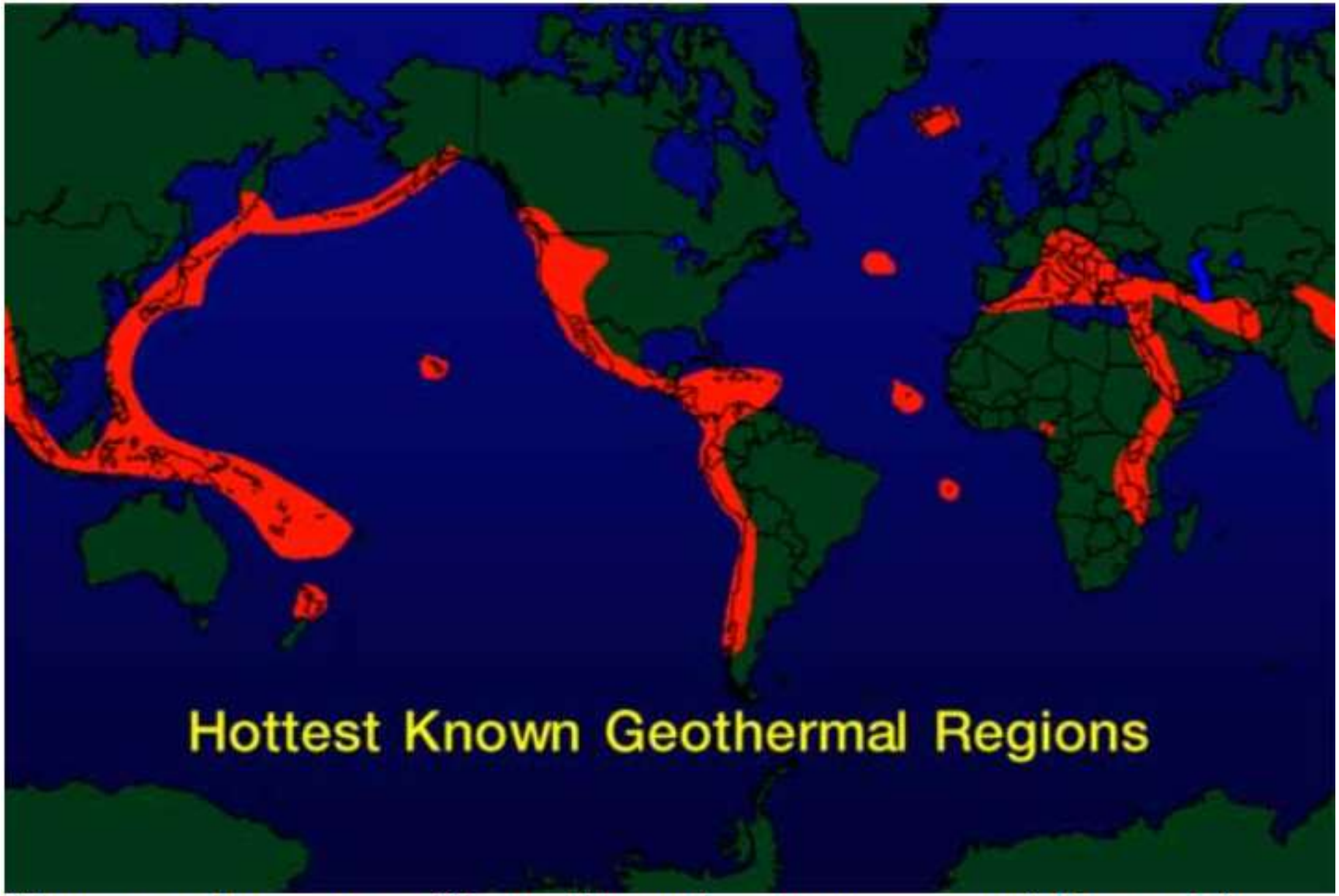
Earth's crust is broken into huge plates that move apart or push together at about the rate our fingernails grow. Convection of semi-molten rock in the upper mantle helps drive plate tectonics.

Divergent boundaries → hot spots in the crust



Thinned or fractured crust allows magma to rise to the surface as lava. Most magma doesn't reach the surface but heats large regions of underground rock.


Geothermal Reservoir
Rainwater
Rainwater
Hot Water
Hot Rock
Hot Rock

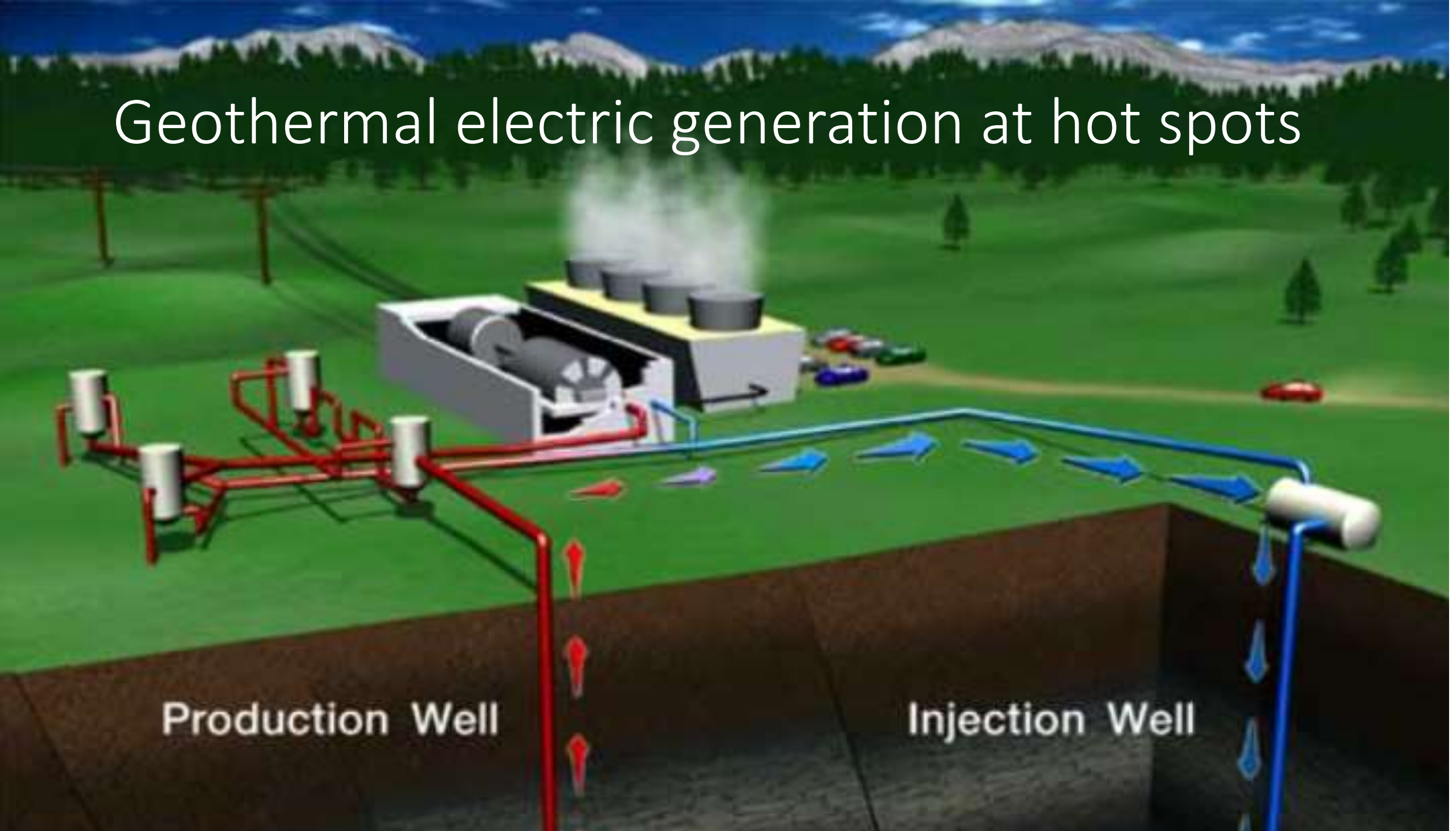


Many areas have accessible geothermal resources, especially countries along the circum-Pacific "Ring of Fire," spreading centers, continental rift zones and other hot spots.

Thermal energy at plate boundaries and hot spots → electricity

- Where this occurs
  - Convergent plates → subduction zones
  - Divergent plates → spreading centers
  - Transform boundaries → Cracks and fractures in crust
  - Hot spots (volcanoes and hot springs)

Geothermal electric generation at hot spots



What uses most of the energy in a home

- Heating and cooling

Why

- Second Law of Thermodynamics

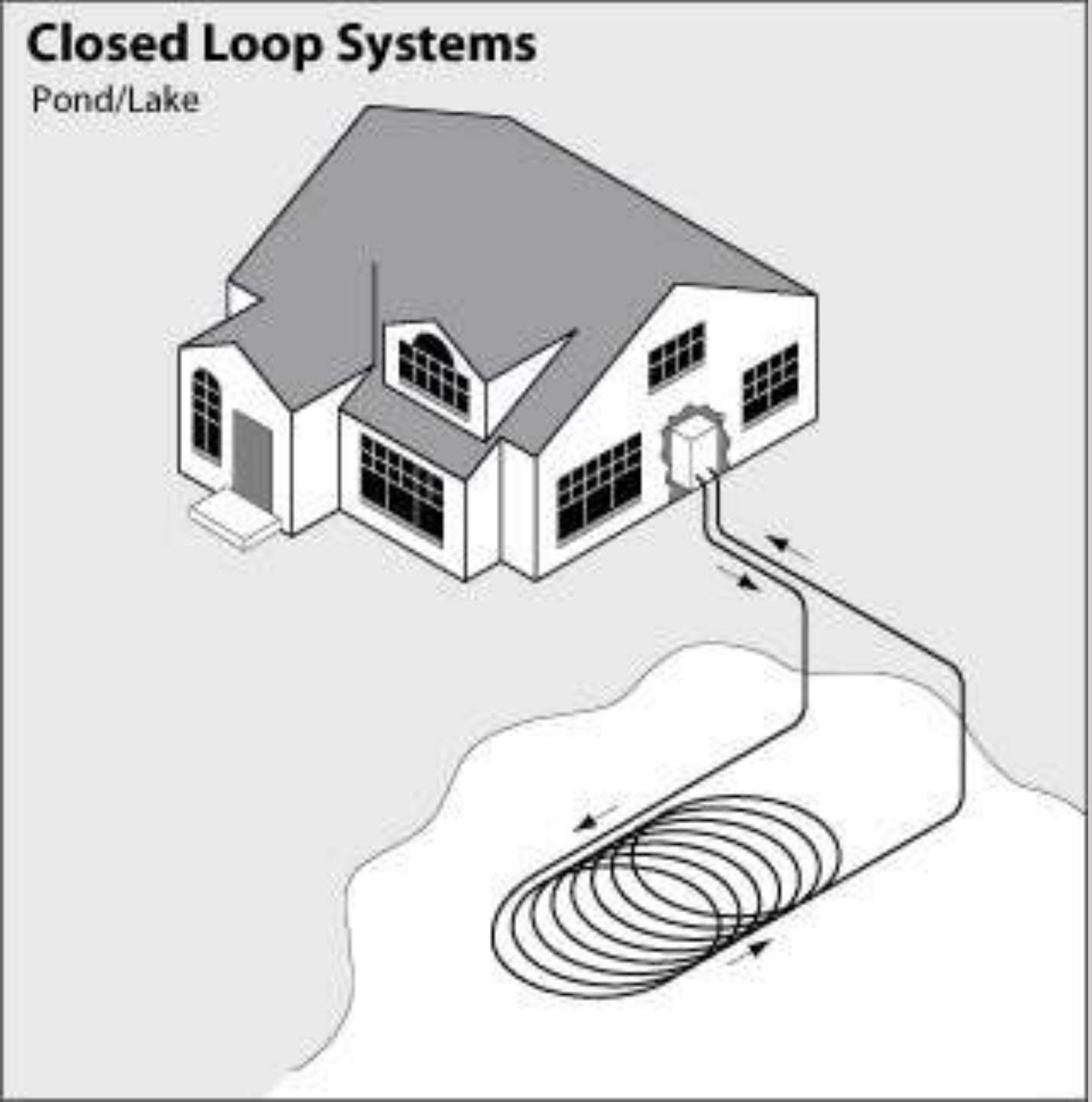
Geothermal Heat Systems Available worldwide→ heating and cooling

Geothermal Heat Pumps

- Rely on the fact that earth's crust remains at a constant temp (48-58ºF)

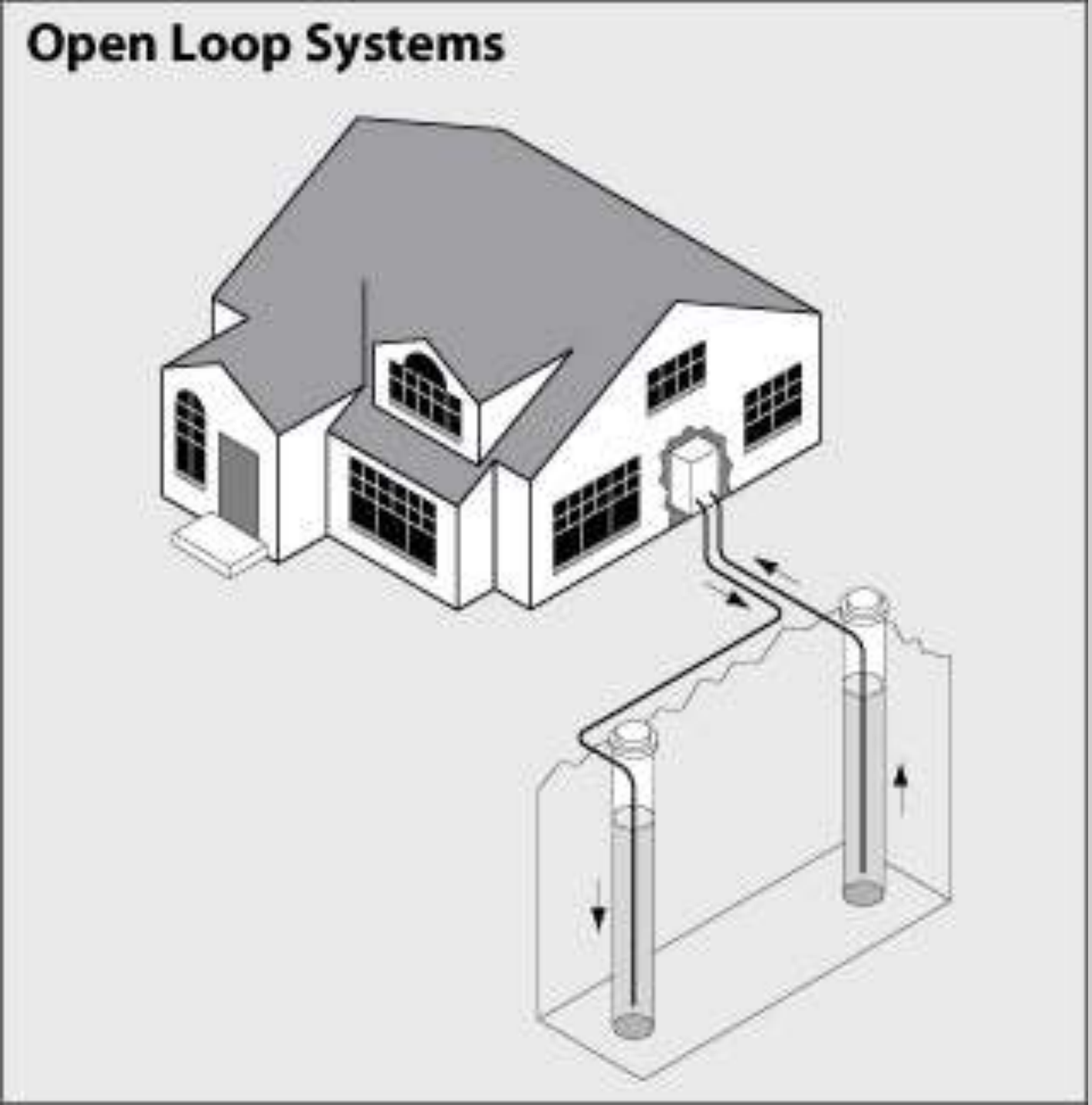
- Fluid warmed by earth
- Pumped through a heat exchanger
- Circulated through building then returned to ground

- Can be used to heat and cool homes economically



Closed units =

loops of antifreeze run through underground coils



Open loops =
well water filtered through heat exchanger

Water returns to groundwater reservoir *(more efficient in NE and no chance of antifreeze leak but requires more maintenance)*

http://www.freedomenergysystems.com/Geothermal/HowItWorks.html

Practical and efficient for the Adirondacks

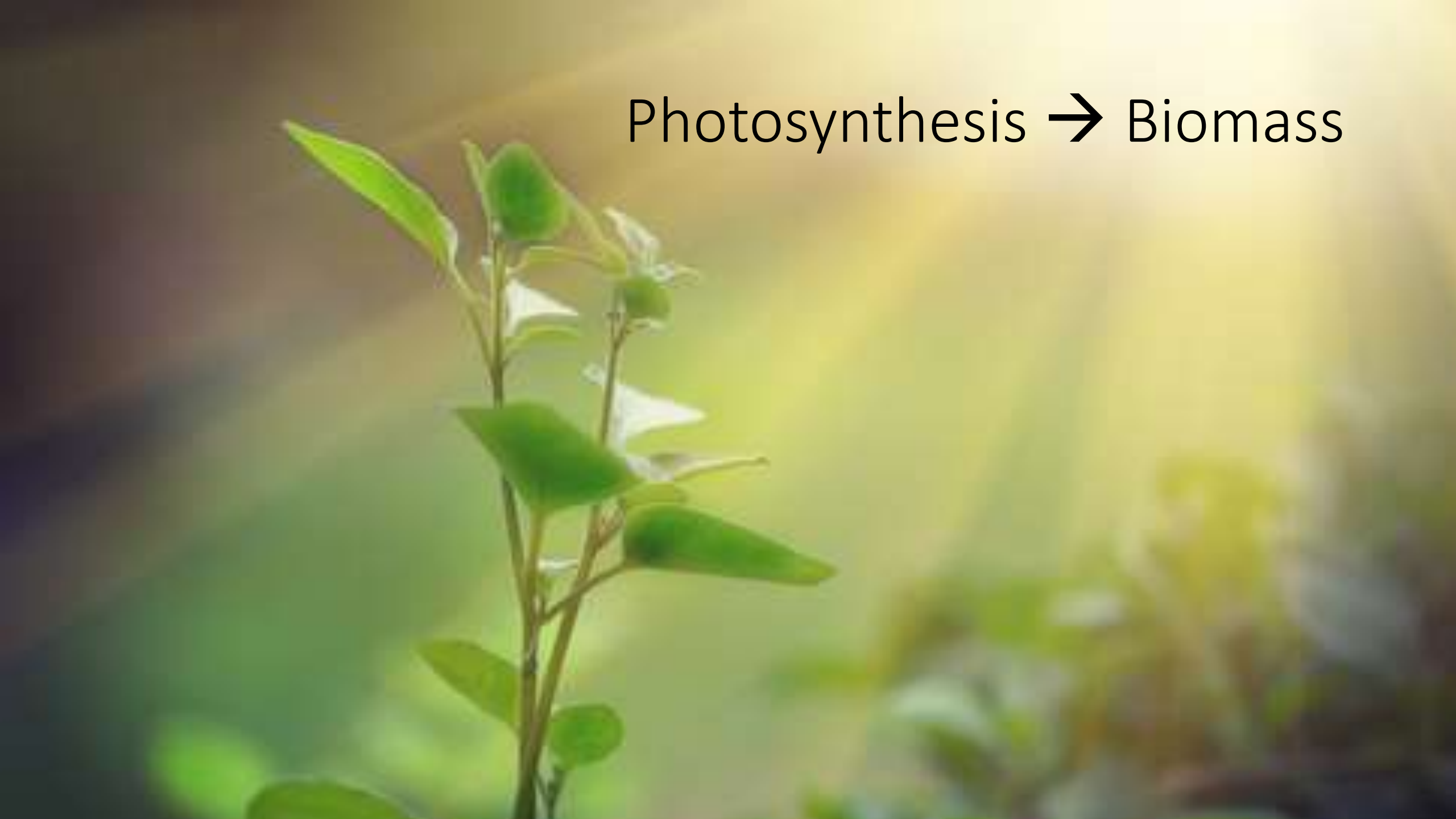
- **80% of their energy dollars → heating and cooling**
  - Geothermal = Expensive to install
  - But once installed 70 – 75% of **energy source is free** = no fuel cost

- Needs to be below the frostline = 4-6 feet

- For more information contact:

  Smart-Energy
  Queensbury, NY 12804
  Phone: (518) 744-8220

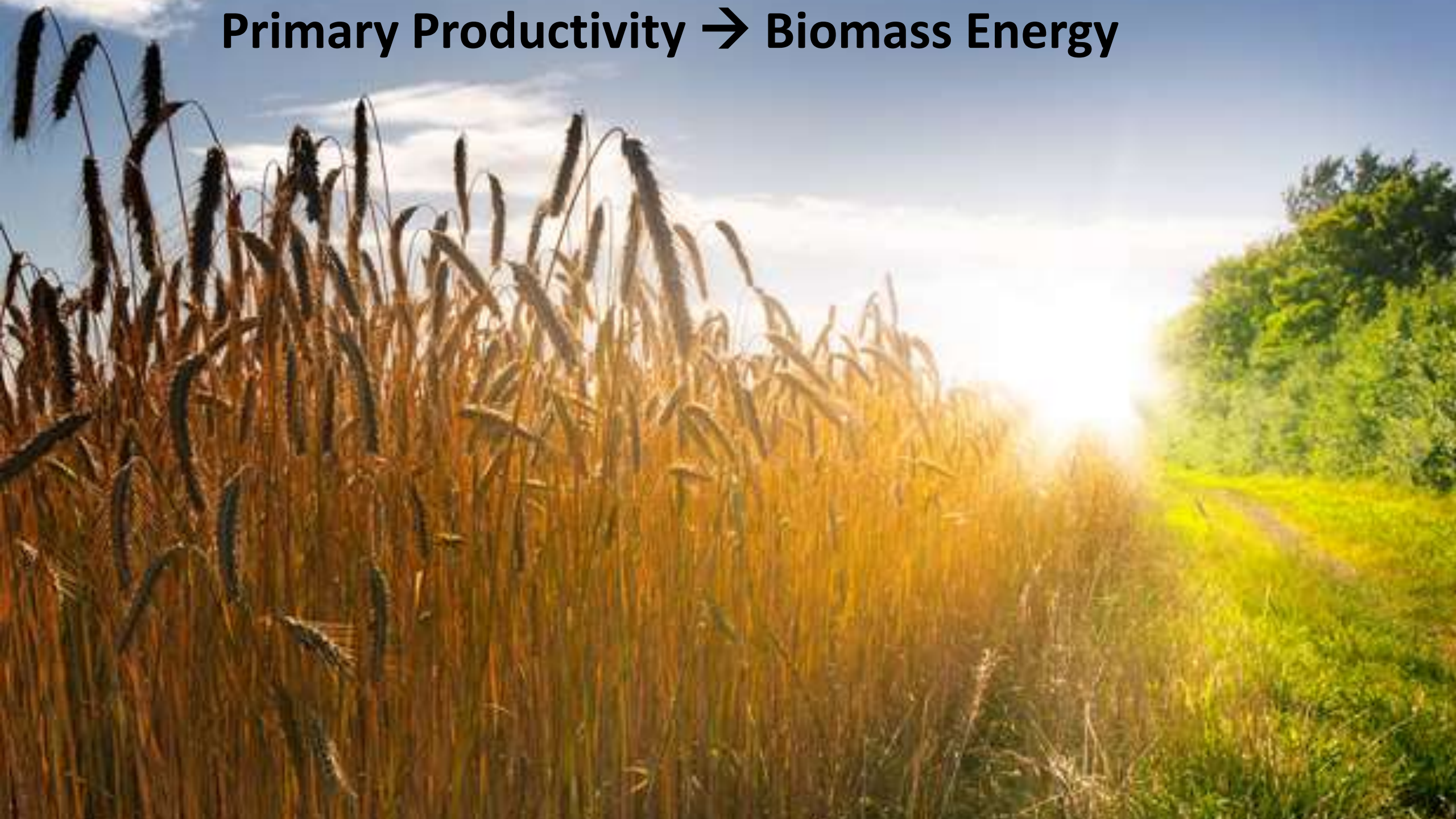
BIOMASS AND BIOFUELS

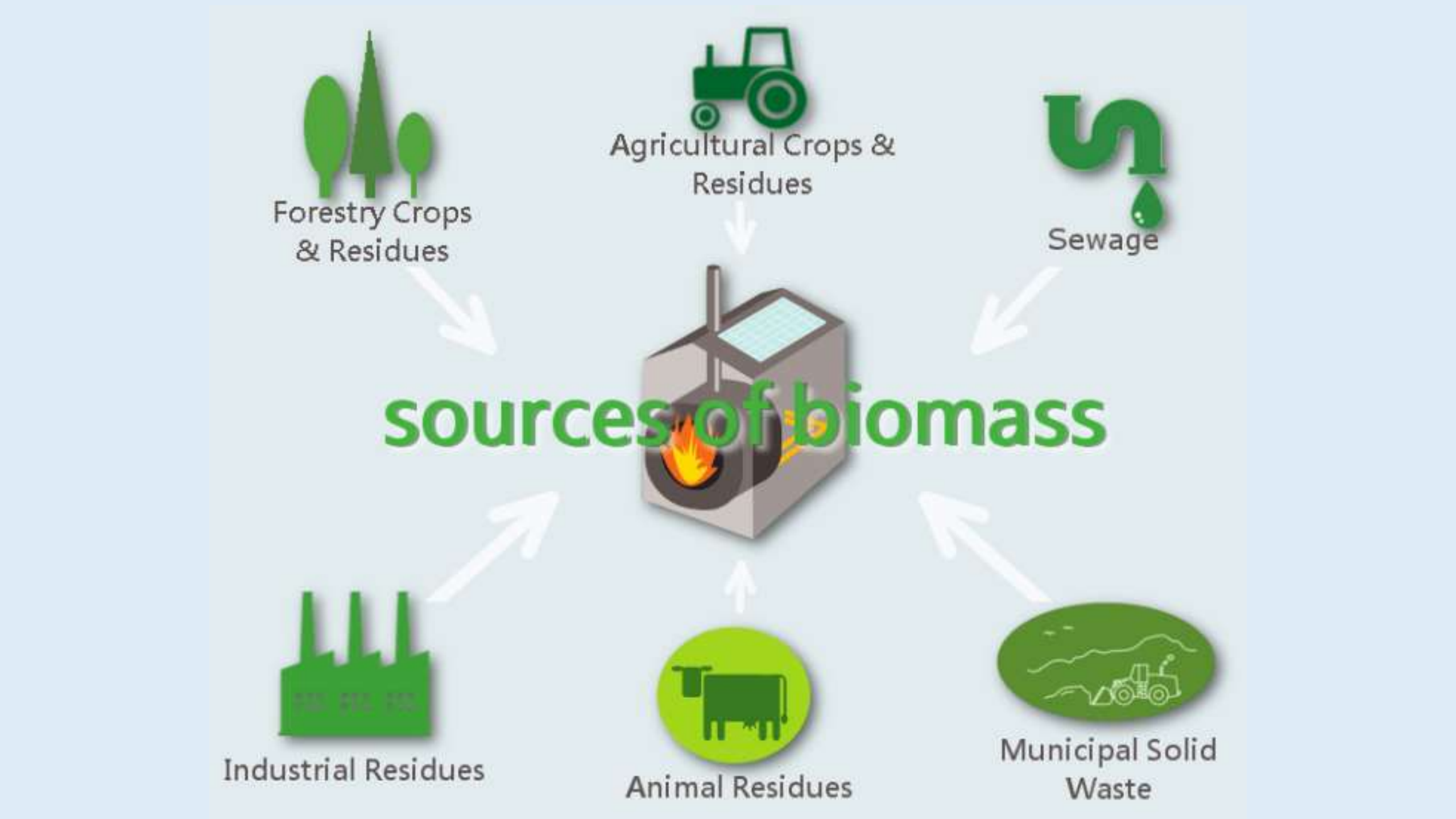

Photosynthesis → Biomass

Review

- Net Primary Productivity
- Gross Primary Productivity

Primary Productivity → Biomass Energy




Forestry Crops & Residues
Agricultural Crops & Residues
Sewage
sources of biomass
Industrial Residues
Animal Residues
Municipal Solid Waste

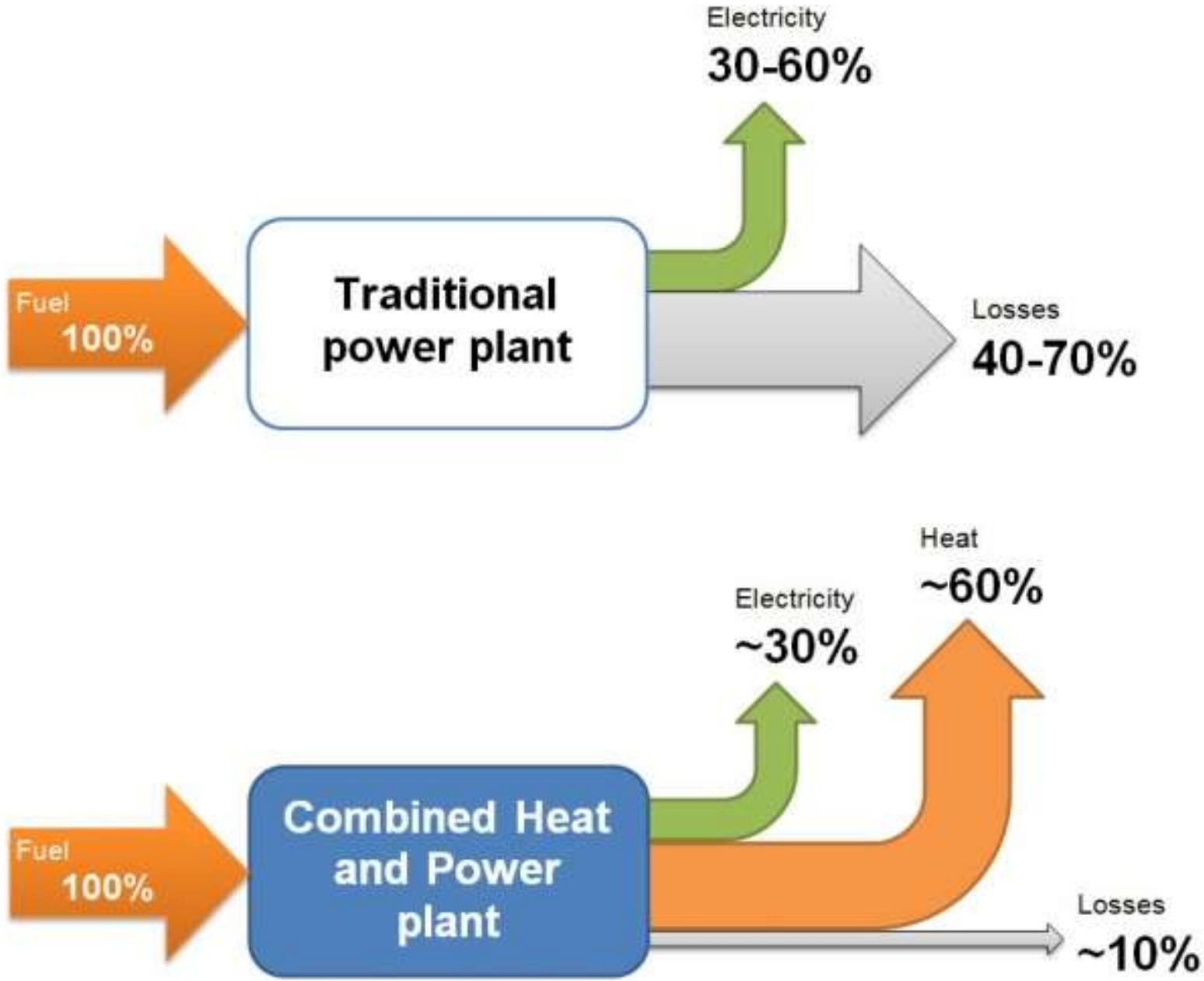

Algae = Biomass

Biomass = living matter

- Burned → heat, electricity
- Review:

- What do you call it when one fuel → 2 types of energy?

- Cogeneration


Electricity
30-60%
Fuel
100%
Traditional power plant
Losses
40-70%
Heat
~60%
Electricity
~30%
Fuel
100%
Combined Heat and Power plant
Losses
~10%

Biomass can be harvested unsustainably

- Charcoal = wood that has been partially burned
- Wood and charcoal are main sources of fuel for cooking in most African countries


Charcoal trade → Deforestation and habitat loss

Peat = partially decayed plant matter from bogs and swamps

- Over 90% of peat lands are in the temperate north
- Ecosystem services of peat bogs
  - Biogeochemical cycling
  - Carbon sequestration
  - Water quality and management
  - Habitat

Ireland’s peat

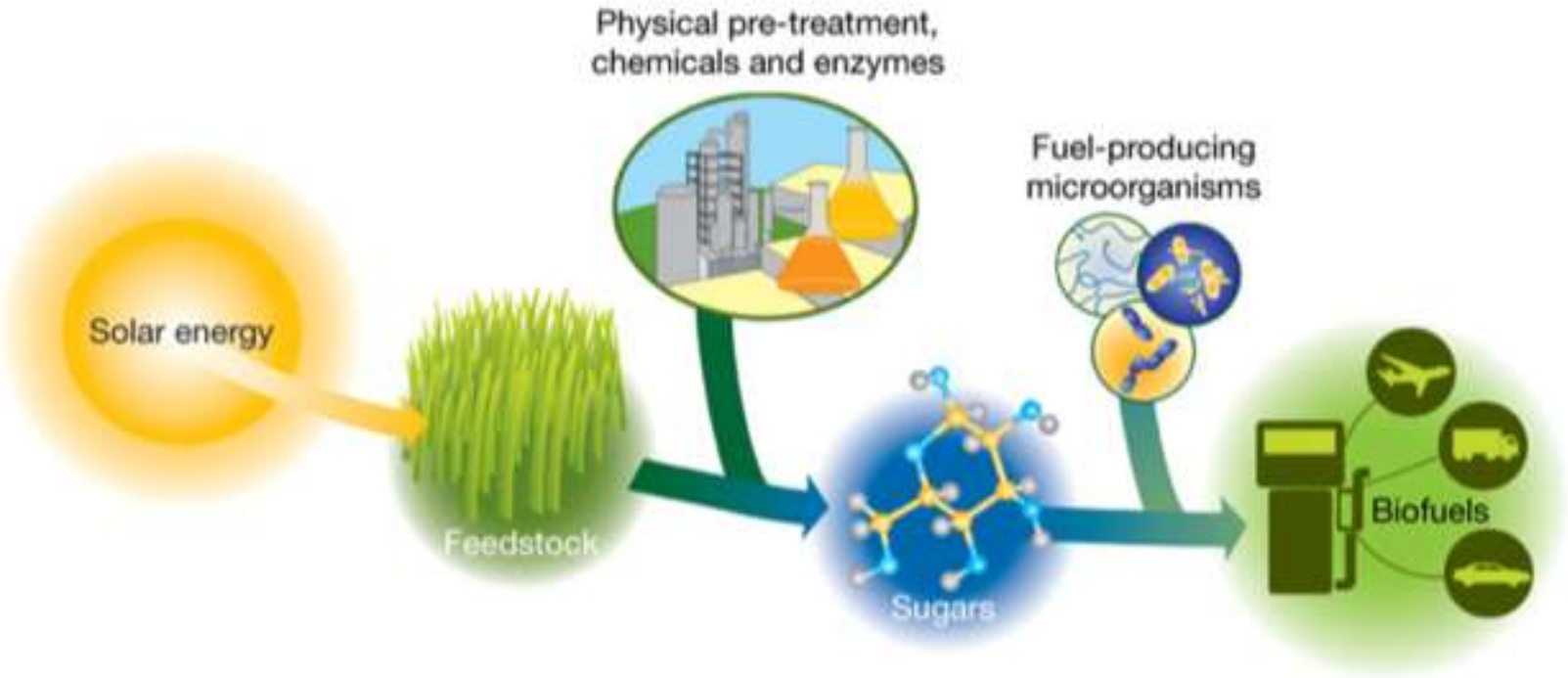
- Due to slow regeneration rates peat bogs are often considered nonrenewable

- But when you harvest sphagnum it does re-grow and research aims at increasing growth rates

Biomass can be converted to Biofuels

Examples:

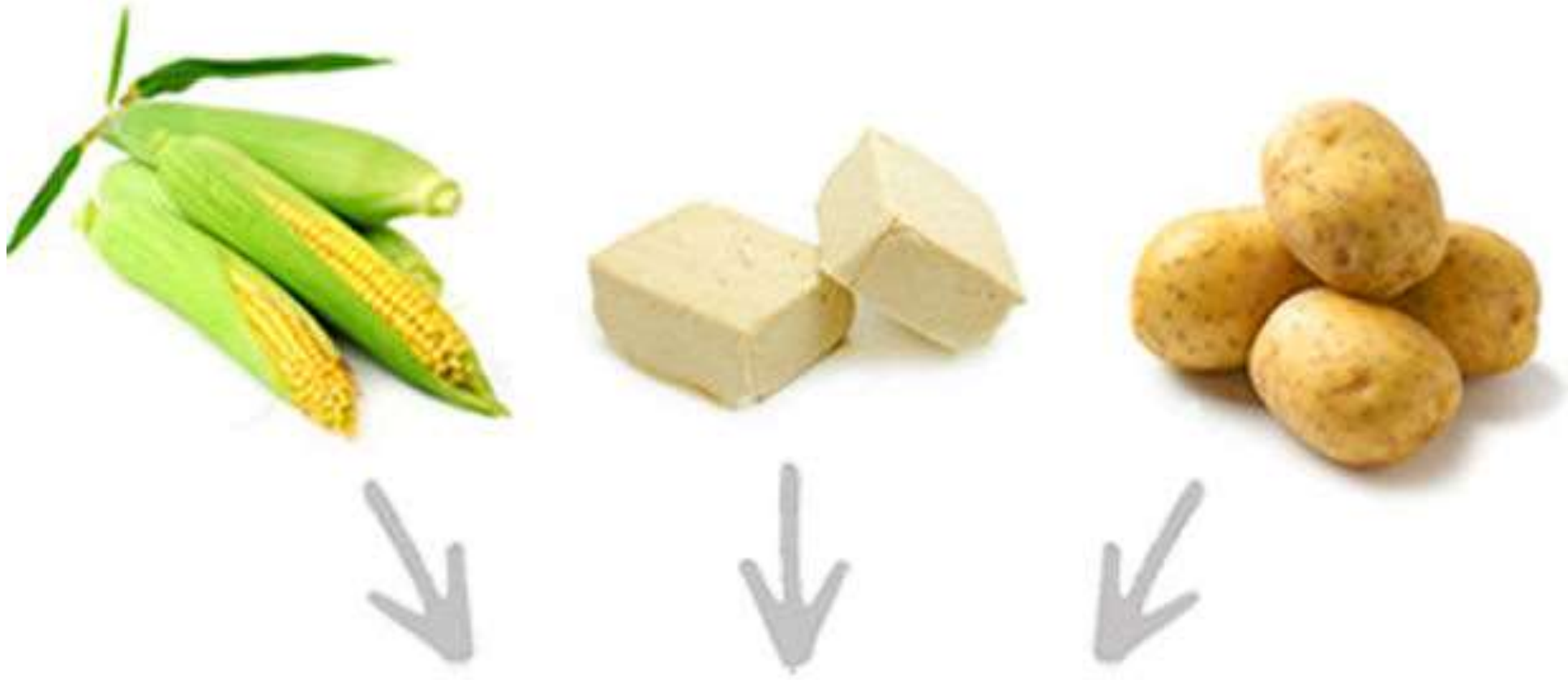
- Bioethanol
- Biodiesel
- Biogas



Biofuels → Transportation, heat, or Electricity

http://www.china.org.cn/business/2012-05/25/content_25472345.

Fermentation of sugars → ethanol


C_2H_5OH
Bioethanol

Ethanol is a substitute for gasoline

Sugar

Starch

Cellulose

DID YOU KNOW?

The United States is the largest producer of **Bioethanol.**

C_2H_5OH

There are 2 different types of feedstocks to make ethanol

- 1st generation (high in sugar)
- 2nd generation (high in cellulose)

1st Generation Feedstocks

Sugar Beet

Corn Grain

Sugar Cane

Bioethanol from Starch & Sugar

A mature technology that is currently in use (E10, E85, E100)

Corn

Sugar beets

Cane Sugar

Fermentation

* Microorganisms (bacteria, yeast, algae)

Ethanol

2nd Generation Feedstocks

Hybrid Poplar

Hybrid Willow

Miscanthus

Corn Stalks

Switchgrass

Bioethanol from cellulosics (2 steps)

Hybrid Poplar

Corn Stalks

Cellulose hydrolysis

Enzymes breakdown cellulose

Fermentation

* Microorganisms (bacteria, yeast, algae)

Ethanol

Ethanol fuels

Pros

- Renewable
- Decreased CO_2 emissions
  - comes from crops that absorb CO_2
- Decreases use of fossil fuels

Cons

- Land and water for fuel vs food
- Fossil fuels are used → corn
- 10% Rule → decreased efficiency (bacteria use up most of the energy originally stored in plants)

Cellulosics

- Advantages
  - Can grow where corn can’t
  - Can use waste products from food processing plants
- Disadvantages
  - Have to break down cellulose using enzymes = extra step = less efficient

Fats and Oils → Biodiesel

Biodiesel can be used in regular diesel engines

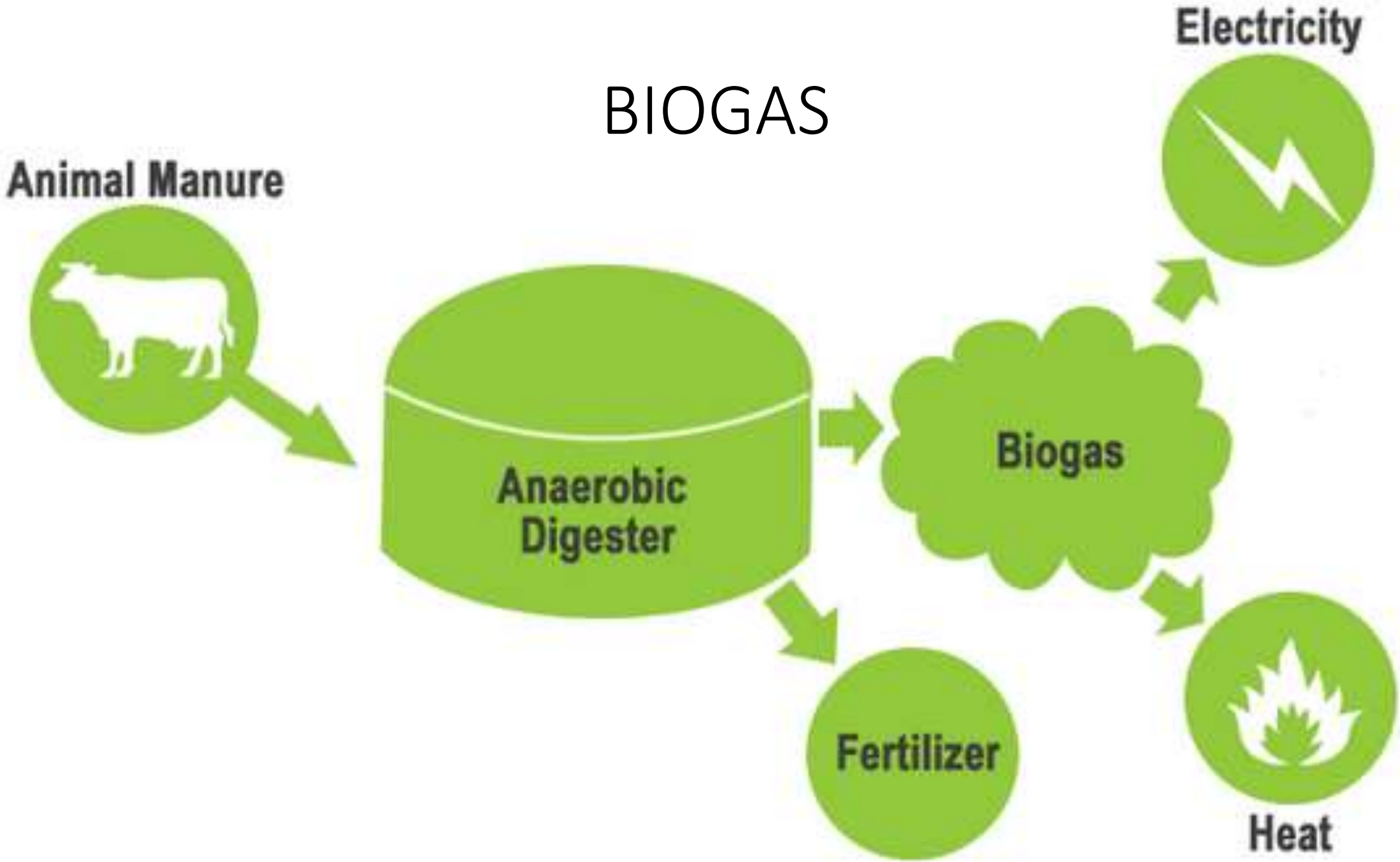
- Sources of oils =
  - Waste oil, soybeans, sunflower seeds, and rape seed oil

Microalgae produces more oil per acre

Pros and cons of diesel

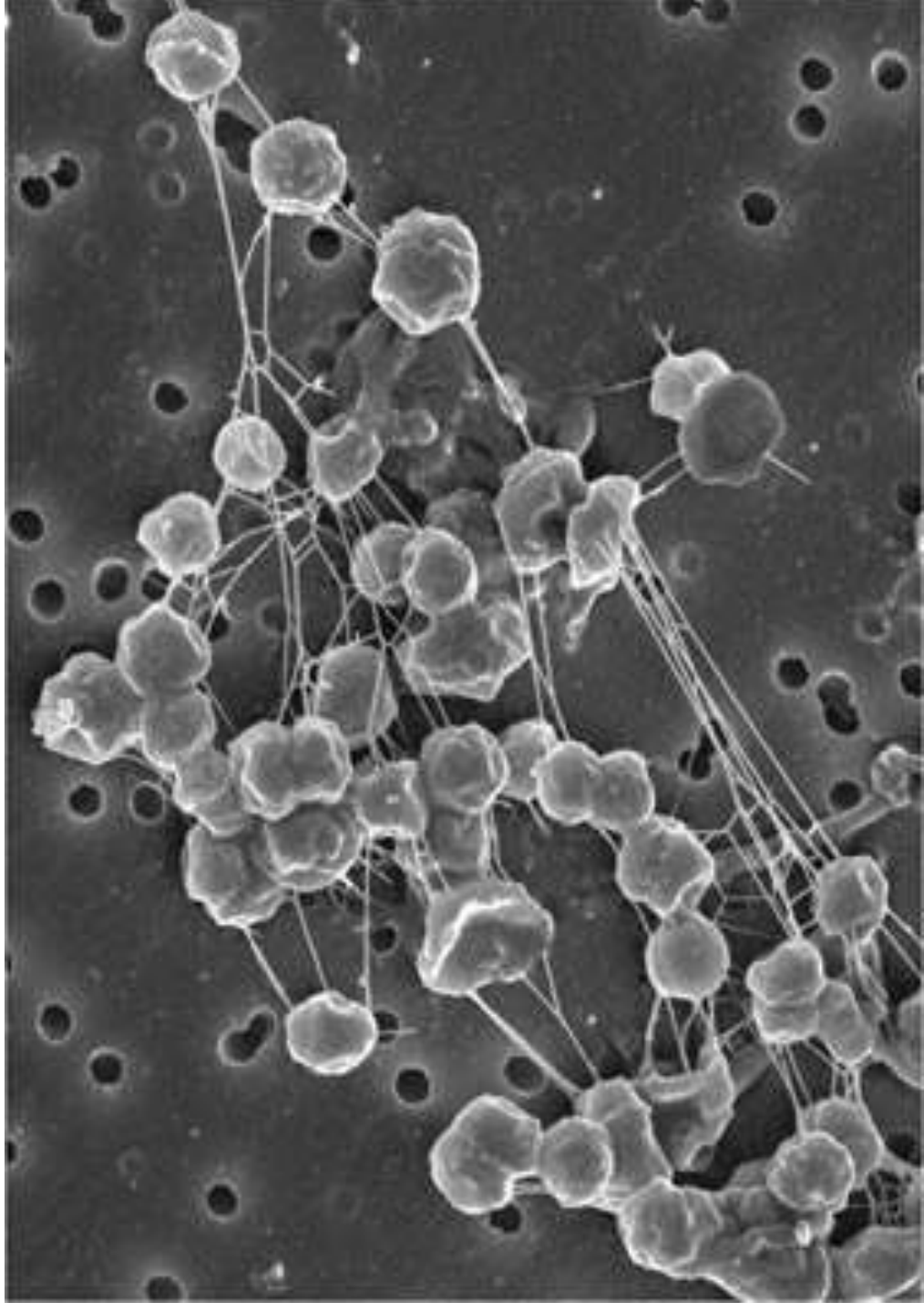
- Advantage
  - More efficient → more miles / gal than gasoline
- Disadvantage
  - More polluting → increased air pollution

BIOGAS


Electricity
Animal Manure
Anaerobic Digester
Biogas
Fertilizer
Heat

Anaerobic digestion → Biogas (60-70% methane)

- Bacteria breakdown biomass in an anaerobic environment (no oxygen)



Case study: Blue Spruce Farm (Vermont) converts manure → biogas → electricity

1300 cows →30 mil lbs of milk and 1600 MWH

1300 cows → Lot of poop = environmental disaster

- Contaminates water supplies
- Nitrogen and phosporus
- Eutrophication
- Pathogens

Solution

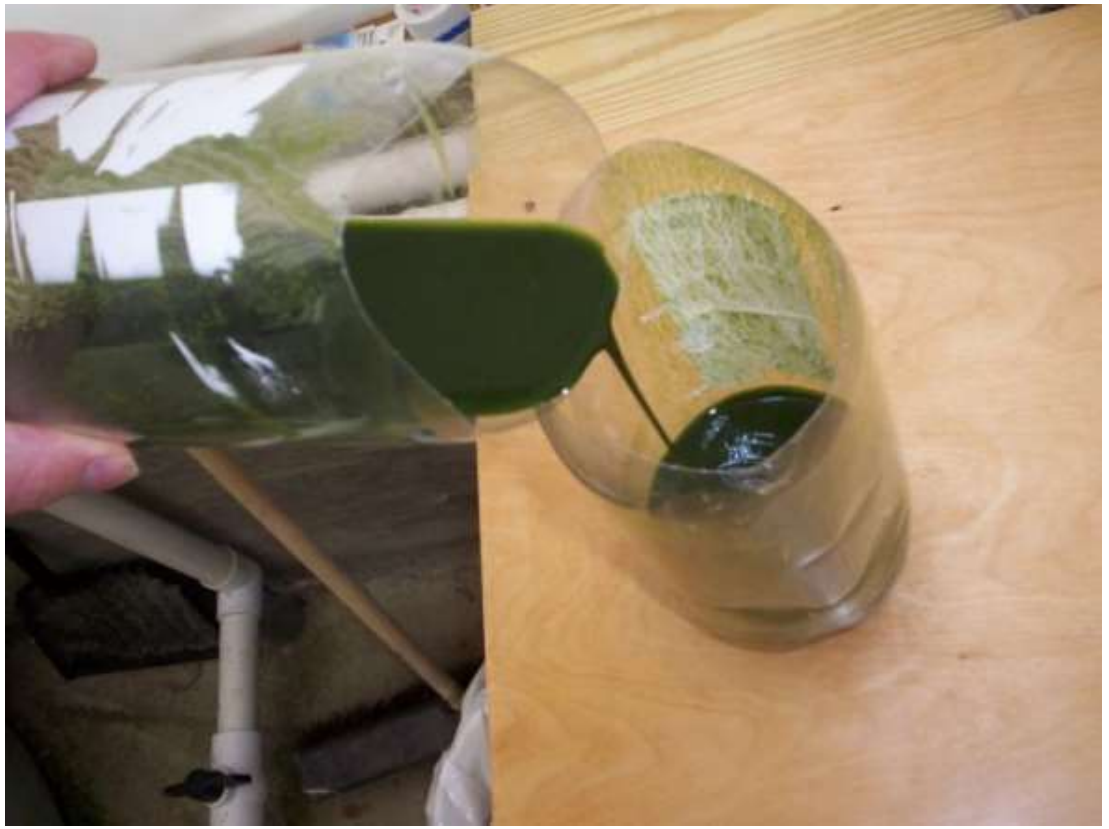
- Manure circulates 21 days through Underground anaerobic digester

Solids → used as bedding for cows

Liquids fertilize fields

Excess heat from generators

- Used to heat water for the farm
- Used to heat a greenhouse → grow algae → biodiesel for farm equipment



Microalgae → 15,000 oil yield gallons per acre
corn → 20 gallons/acre.

Case Study #2:
Potential digester for food waste in town of North Elba

- 2013 North Elba received a Regional Economic Development Award

- $1,061,000 to build an anaerobic digester at the North Elba transfer station

BIOFERM™
ENERGY SYSTEMS

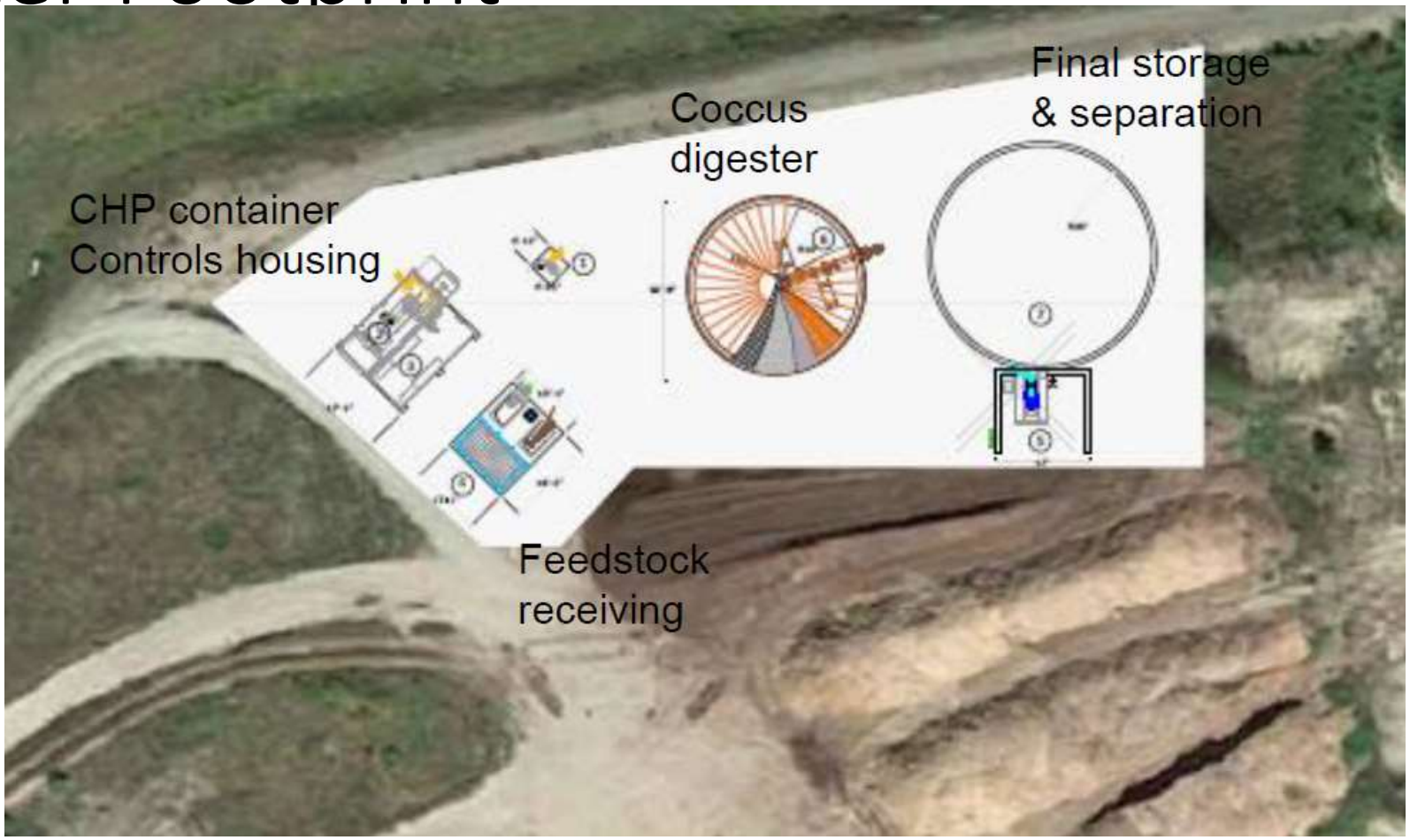
VIESMANN Group

Eucolino model

- Initial feedstock 1100 tons
- Capacity = 6,000 tons
- Market value = $600,000


Buttonwood Way
Circle Ln

Digester Footprint



Electricity sold to grid

Digestate

Over 300,000 lbs compost

180,000 gallons liquid nutrient rich digestate → irrigate athletic fields

2015 Pilot Study → food waste potential

Feedstock analysis and consumer savings based on 2015 pilot

Organization	Wt / month	landfill costs ($180/ton)	compost costs ($70/ton)	Casella ($280/ton)
AMC	2653.07	238.78	92.86	371.43
Wild Center	578.14	52.03	20.23	80.94
St. Joes	2348.01	211.32	82.18	328.72
Blue Line Brewery	702.67	63.24	24.59	98.37
FCI Ray Brook	10837.71	975.39	379.32	1517.28
Green Goddess	1215.86	109.43	42.56	170.22
Crowne Plaza	3381.64	304.35	118.36	473.43
Lisa G	3454.64	310.92	120.91	483.65
Casa del sol	2206.25	198.56	77.22	308.88
High School	544.44	49.00	19.06	76.22

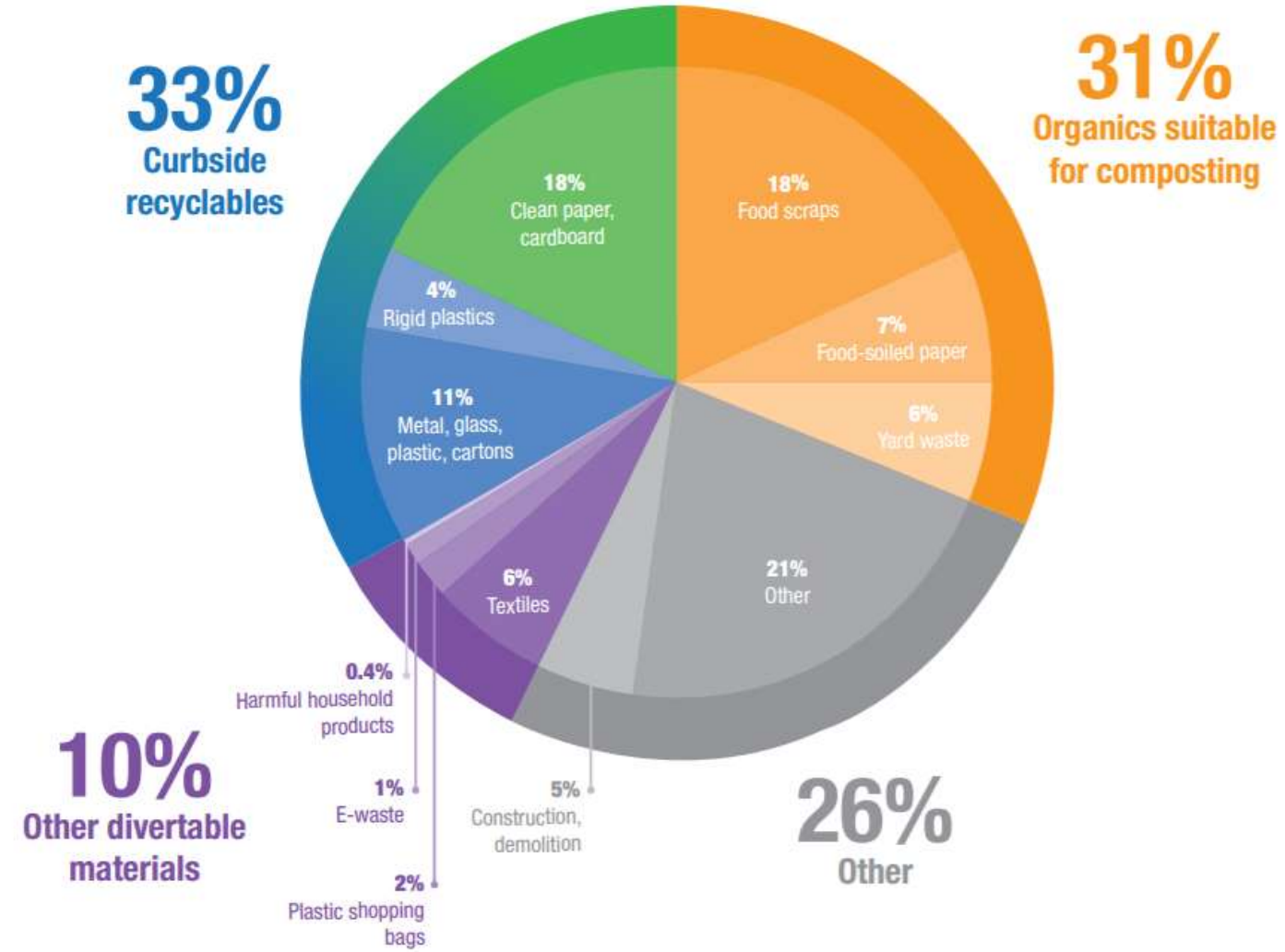
Annual operational budget show that facility → more income than needed to run

Annual Income	**$.06/kwh & $70/ton**
Electrical production	$ 15,338.40
Tipping Fees ($70/ton)	$ 77,000.00
Total Income	**$ 92,338.40**
Annual Costs	
Maintenance & Repairs	$ 14,525.00
Digestate Land Application ($.06/gal)	$ 8,640.00
Plant Labor ($35/hr)	$ 22,628.00
rrm costs	$ 20,000.00
Total Plant Operating Costs	**$ 65,793.00**
Annual Net Surplus to town	**$ 26,545.40**

North Elba Town Board failed to complete the project

Without a digester town pays $200-300 thousand annually on landfill costs

1/3rd of that could be recycled by a digester



Hydrogen gas = energy carrier

- Advantage = H is everywhere
- Disadvantage = needs to be purified

- Advantage = portable and storable in compressed form
- Disadvantage = infrastructure needs to be built (current vehicles and gas stations build for liquid fuels)

- Advantage = Clean burning → water vapor only

Replacing oil = new vehicles

- Hybrids = (2 engines – gas and electric) more efficient
- Electric = no tailpipe emissions but emissions from power plants
- Ethanol = replace gasoline but takes up land and energy to grow fuel
- Biodiesel = replace petro diesel but takes land and energy to grow fuel
- Biogas and hydrogen = requires infrastructure

- All biofuels are less energy dense than fossil fuels therefore need more efficient vehicles (lighter weight, aerodynamic…)