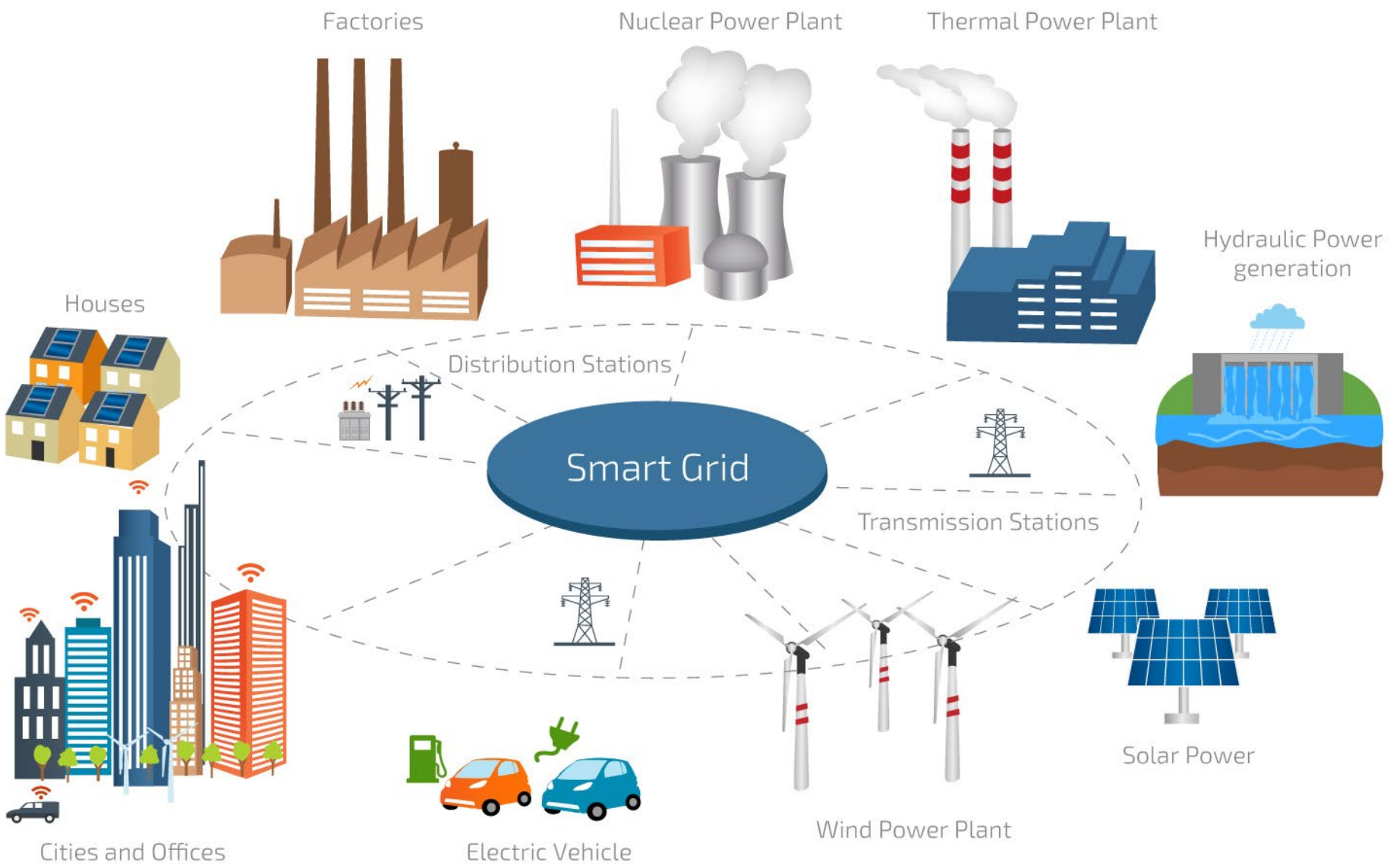
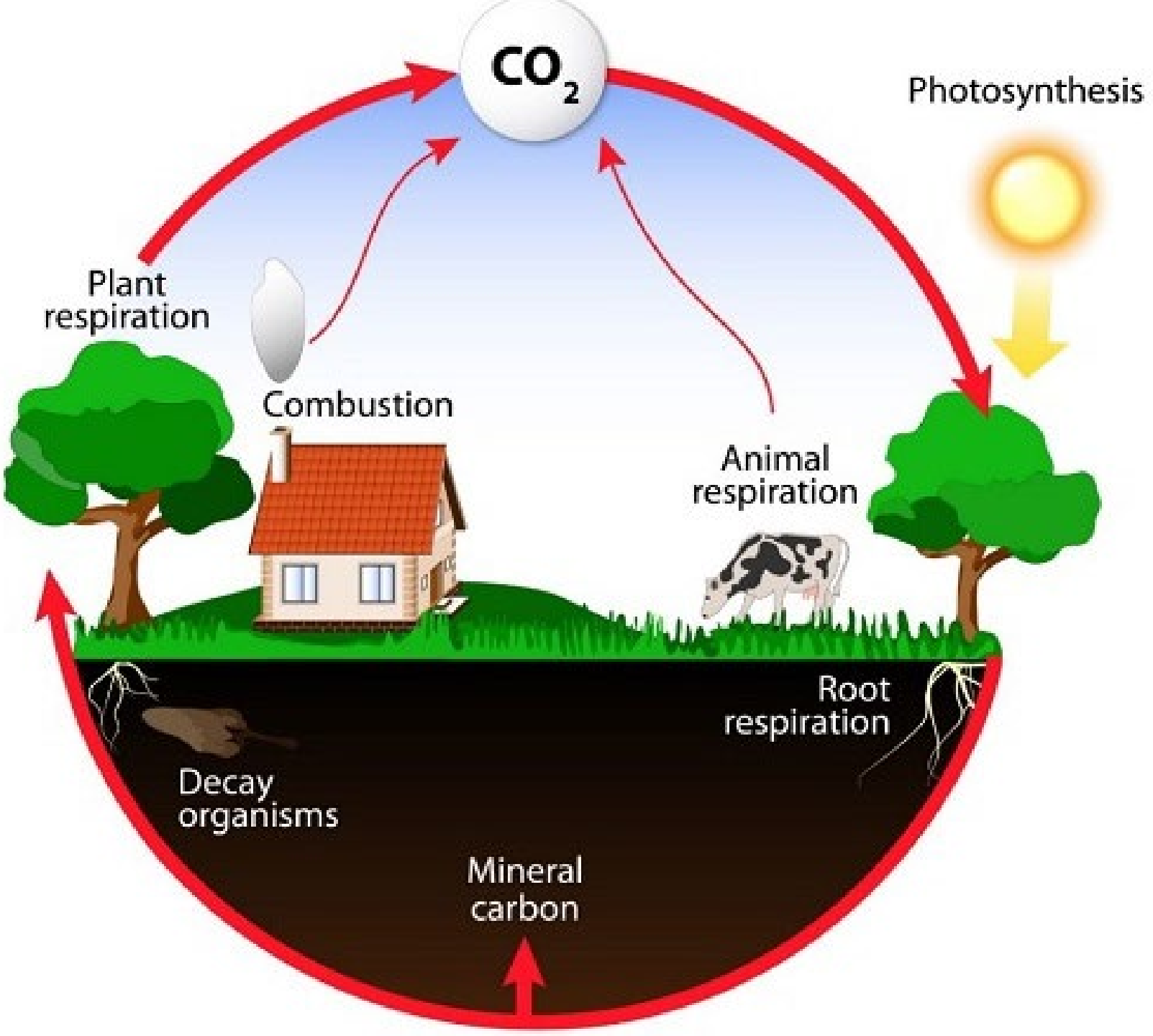
Energy

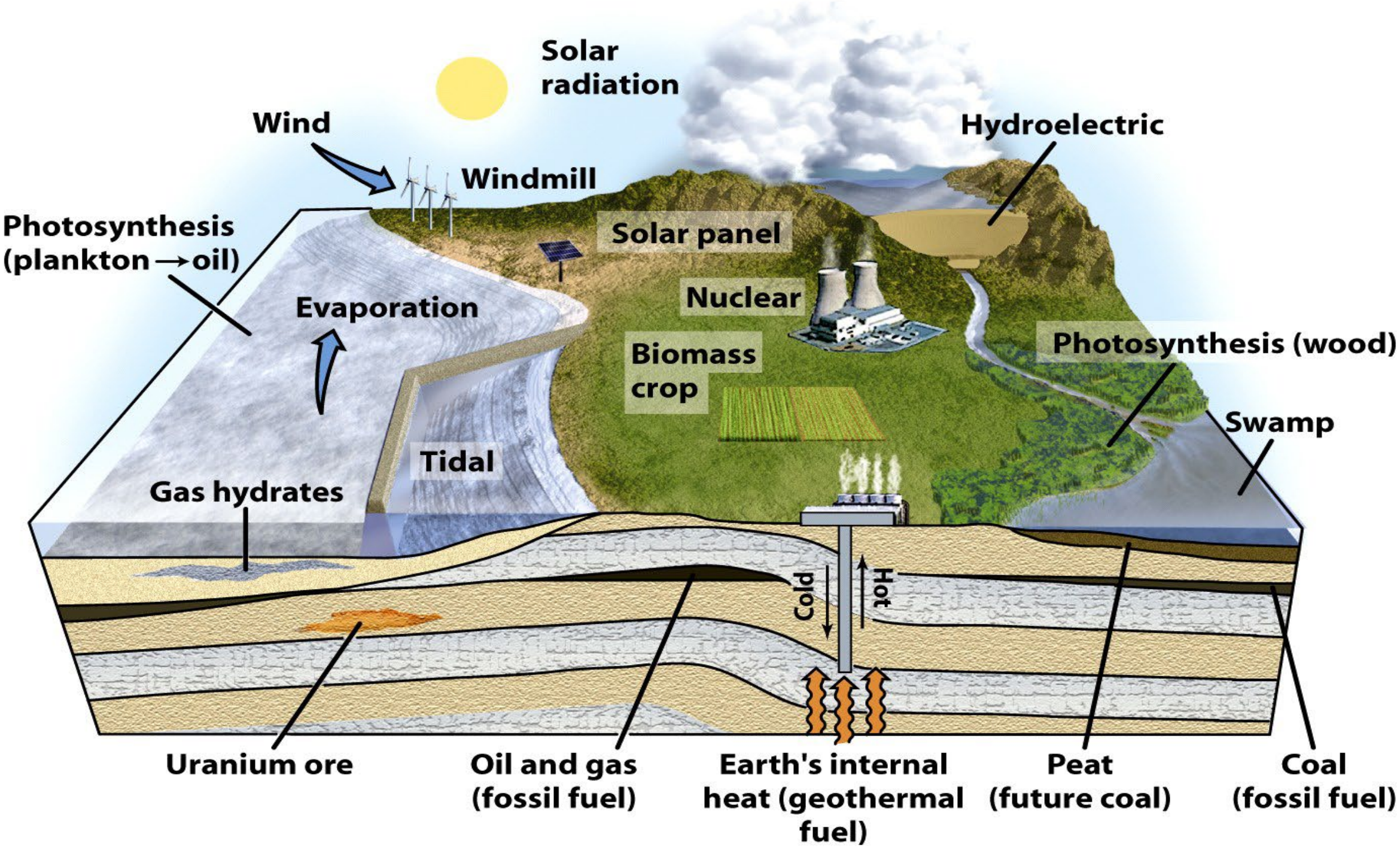

Renewable Energy and Smart Grid Technology
Factories
Nuclear Power Plant
Thermal Power Plant
Houses
Hydraulic Power generation
Distribution Stations
Smart Grid
Transmission Stations
Solar Power
Cities and Offices
Electric Vehicle
Wind Power Plant

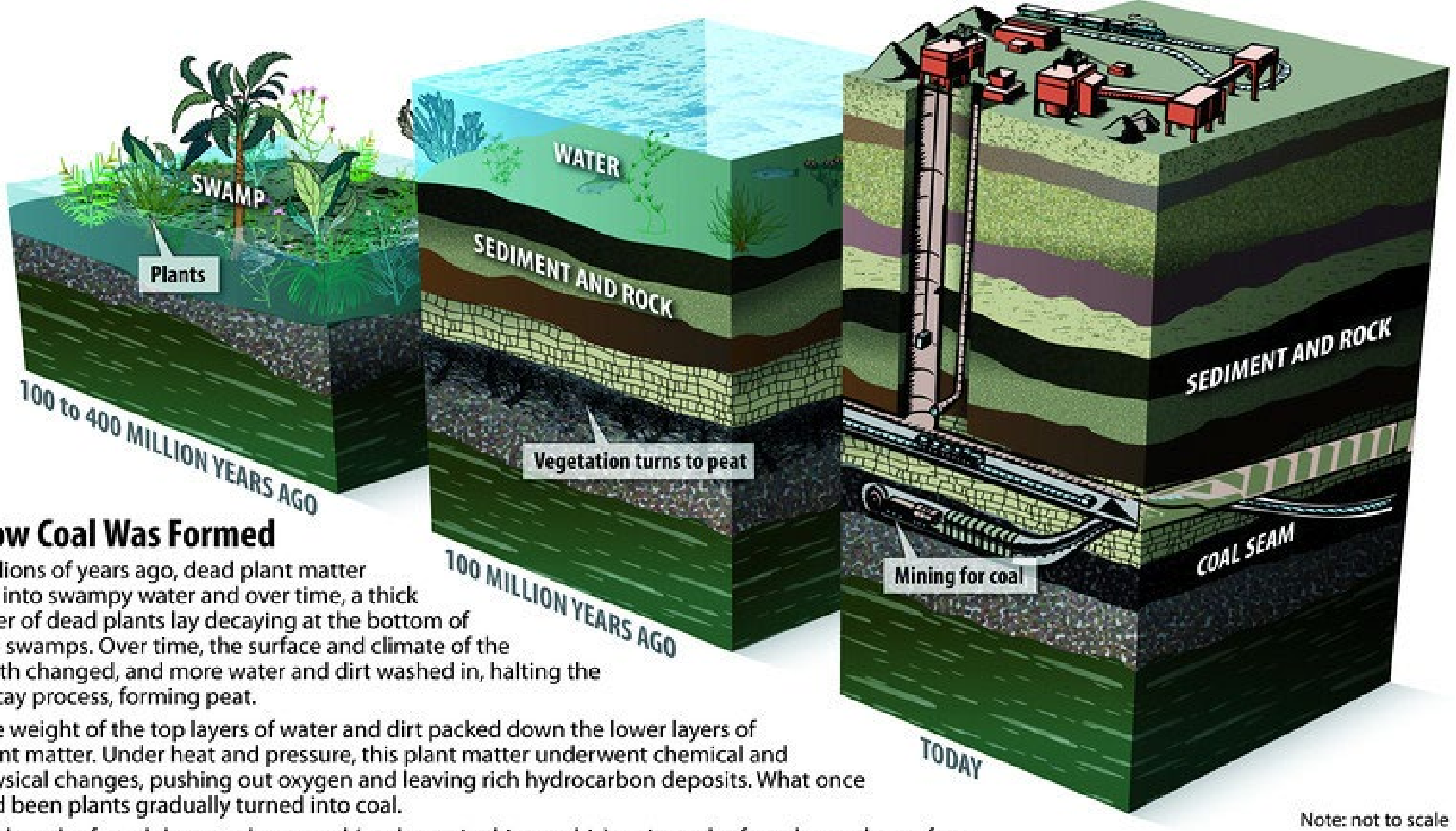

CO_2
Photosynthesis
Plant respiration
Combustion
Animal respiration
Root respiration
Decay organisms
Mineral carbon

What to learn…

- Fossil fuels are linked to the Sun’s energy, depositional environments, biology and geologic time.
- Heat, pressure and time convert organic material to fossil fuel.
- How fossil fuels are recovered
- Pros and cons of non renewable and renewable energy

Energy Resources





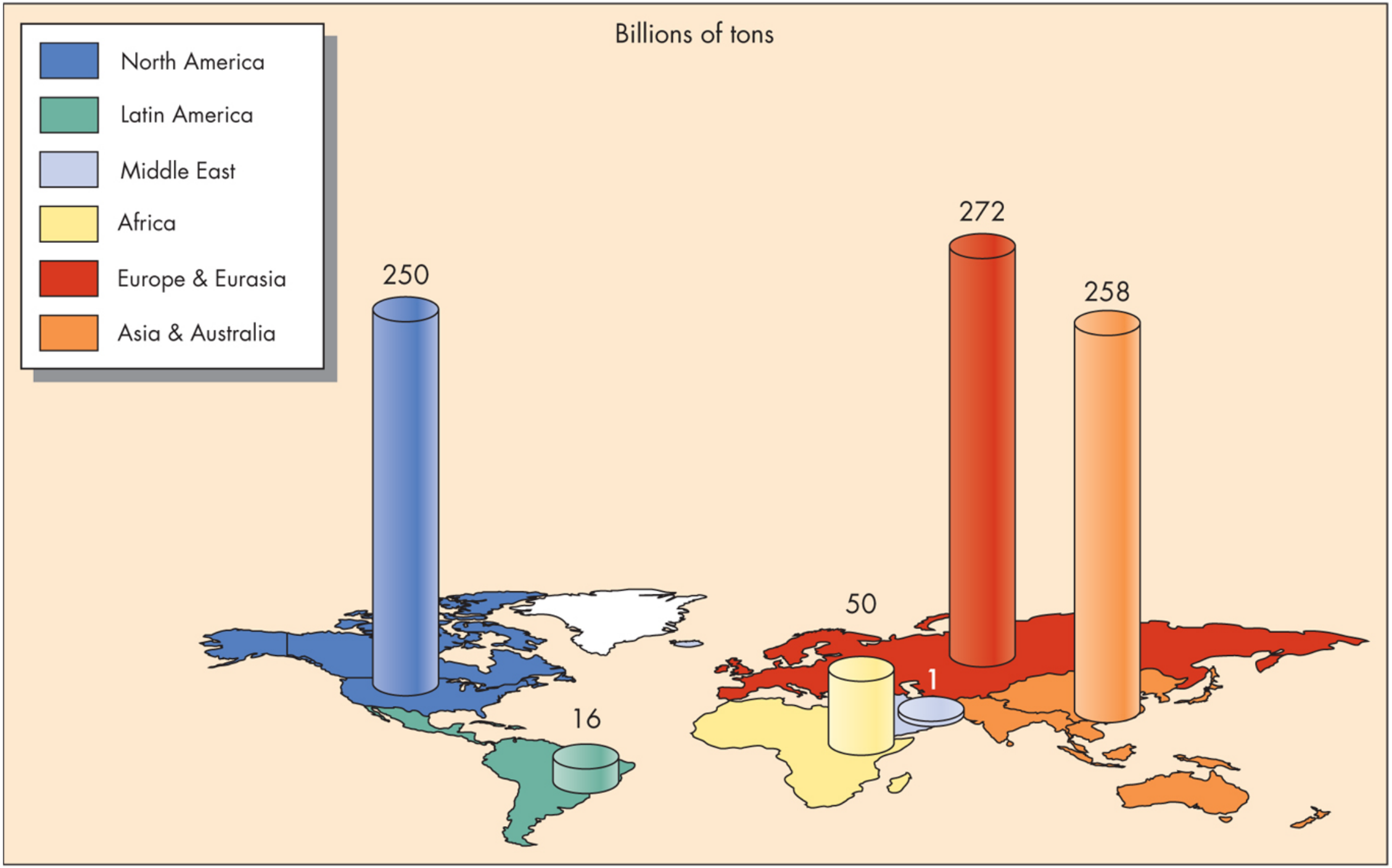
How Coal Was Formed

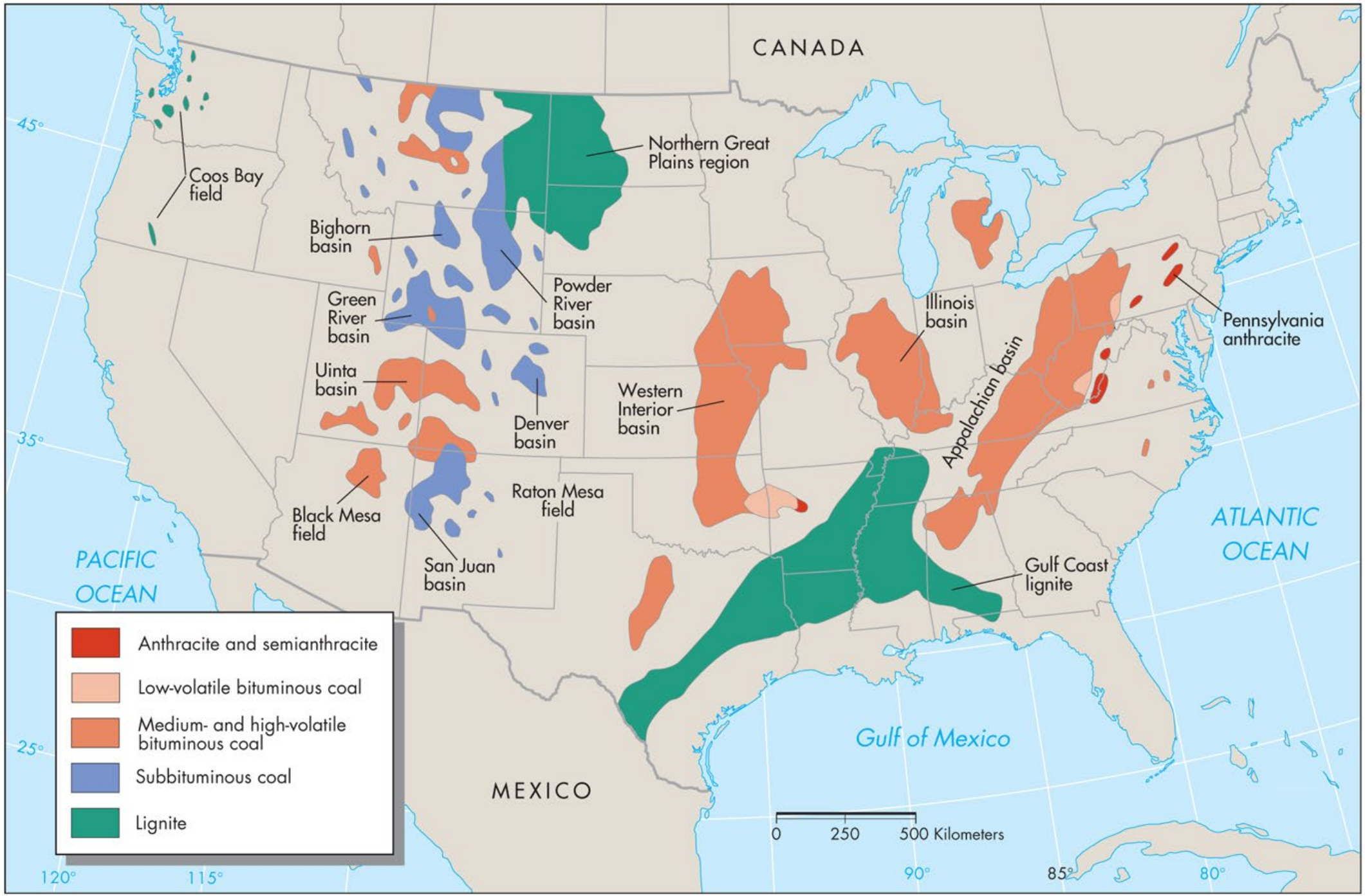
Millions of years ago, dead plant matter fell into swampy water and over time, a thick layer of dead plants lay decaying at the bottom of the swamps. Over time, the surface and climate of the Earth changed, and more water and dirt washed in, halting the decay process, forming peat.

The weight of the top layers of water and dirt packed down the lower layers of plant matter. Under heat and pressure, this plant matter underwent chemical and physical changes, pushing out oxygen and leaving rich hydrocarbon deposits. What once had been plants gradually turned into coal.

Coal can be found deep underground (as shown in this graphic), or it can be found near the surface.

Note: not to scale

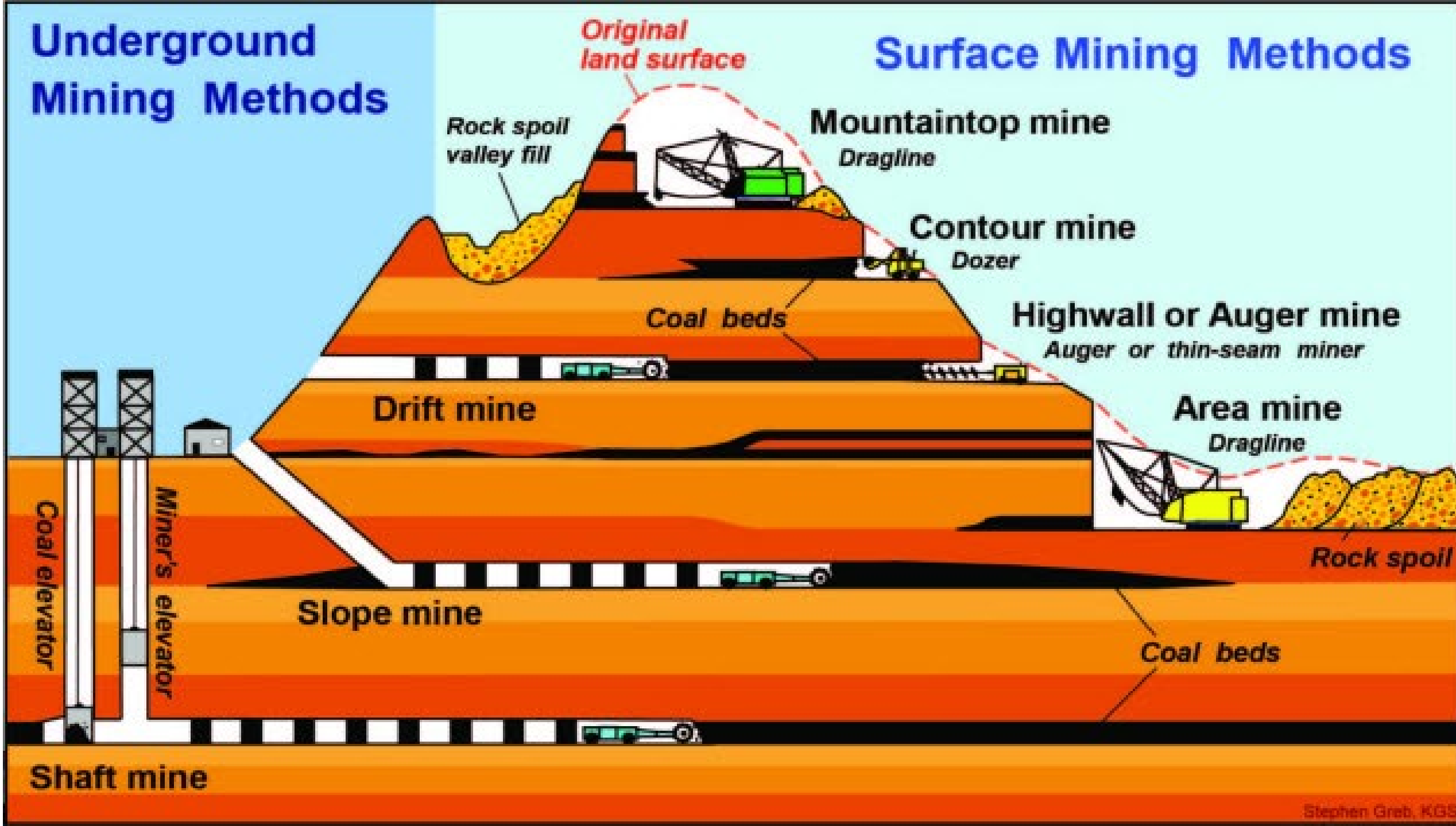

Billions of tons
North America
Latin America
Middle East
Africa
Europe & Eurasia
Asia & Australia
250
16
50
1
272
258


CANADA
Coos Bay field
Northern Great Plains region
Bighorn basin
Powder River basin
Green River basin
Uinta basin
Denver basin
Western Interior basin
Illinois basin
Appalachian basin
Pennsylvania anthracite
Black Mesa field
Raton Mesa field
San Juan basin
Gulf Coast lignite
PACIFIC OCEAN
ATLANTIC OCEAN
Gulf of Mexico
MEXICO
Anthracite and semianthracite
Low-volatile bituminous coal
Medium- and high-volatile bituminous coal
Subbituminous coal
Lignite
0 250 500 Kilometers
45°
35°
25°
120°
115°
90°
85°
80°

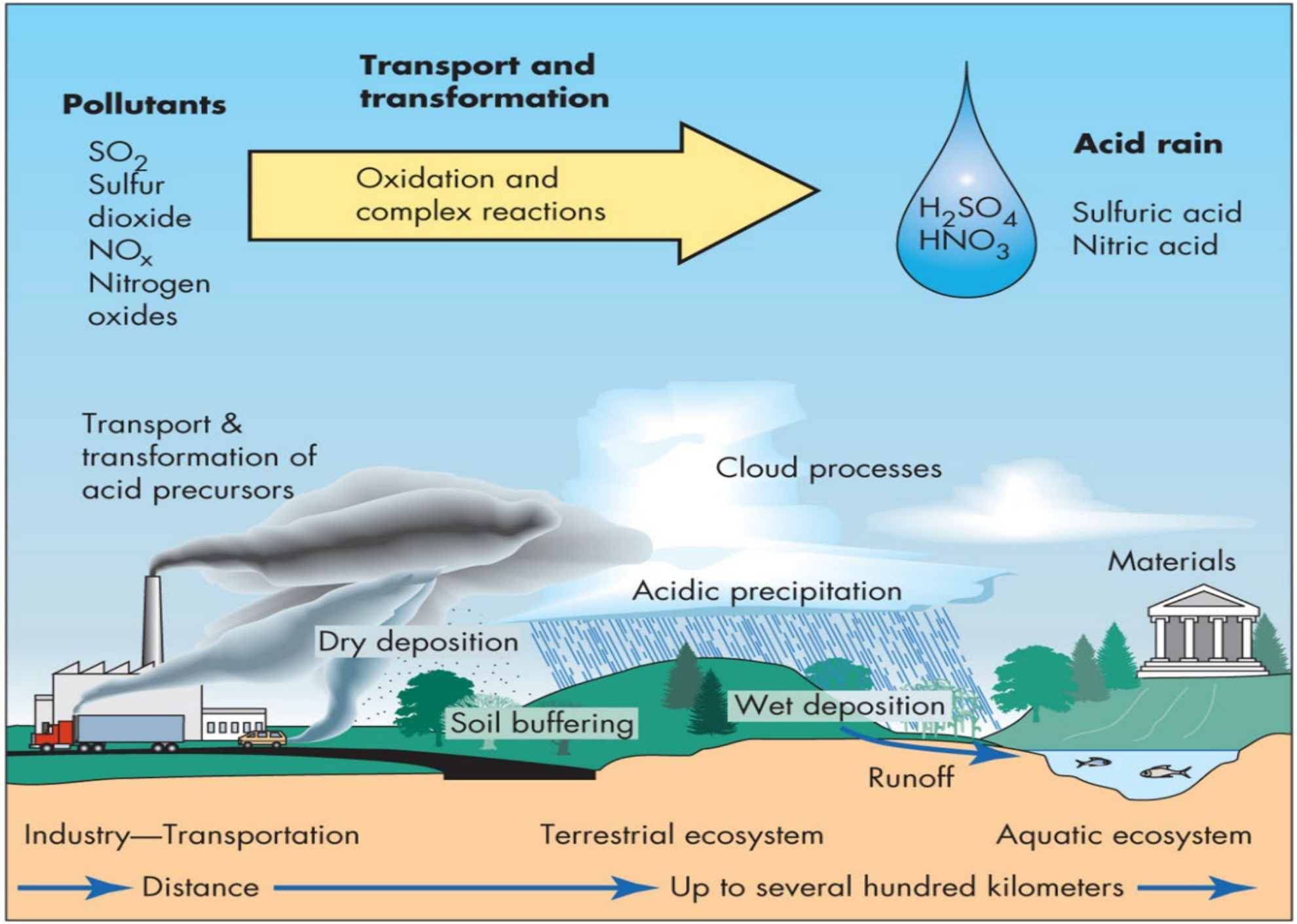
Iowa Coal

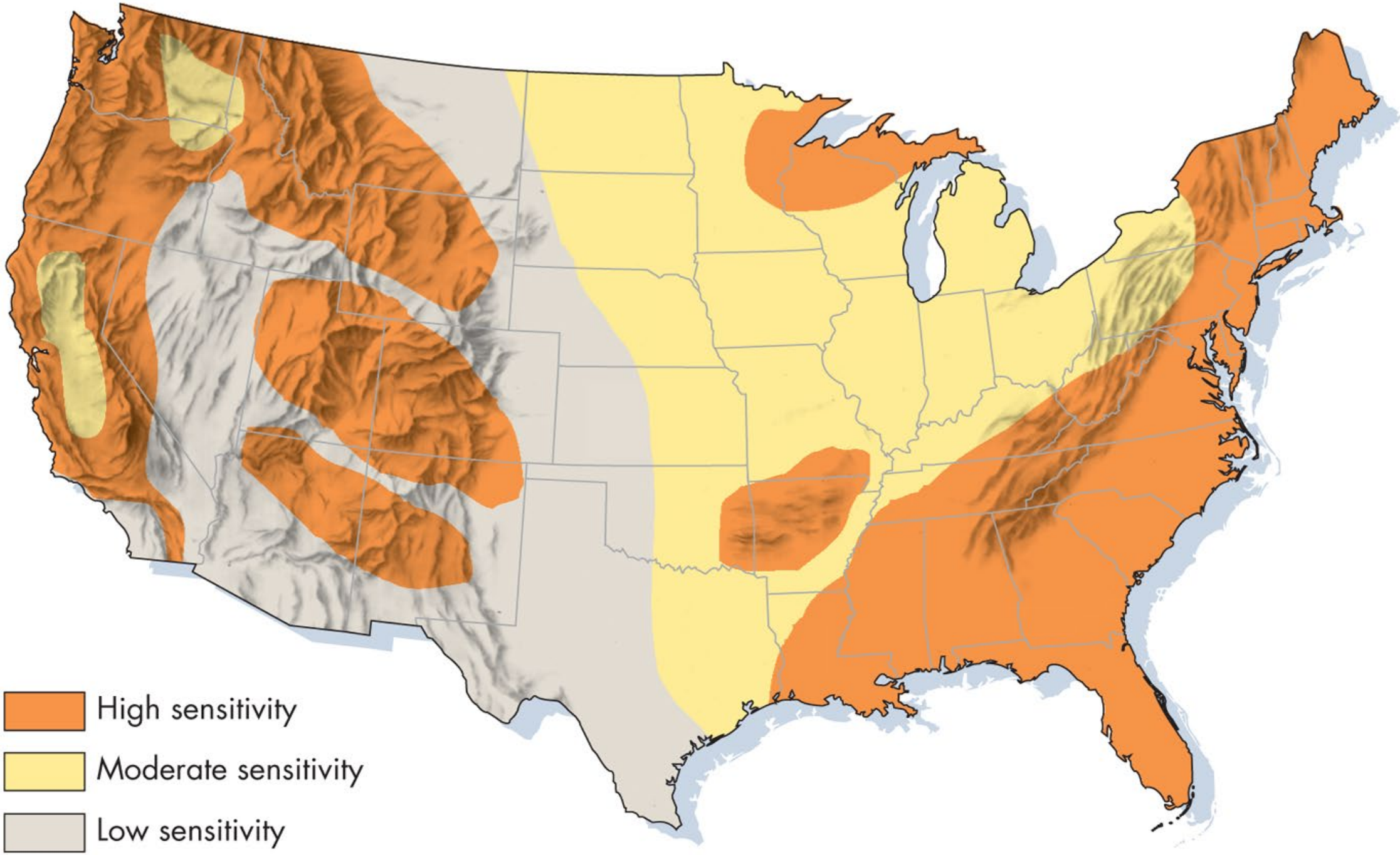
- Sub-Bituminous to Bituminous
- High ash and sulfur content (FeS_2)
  - Ash results from sediment (impurities) that were washed into the swamps

Ottumwa Coal Palace 1890

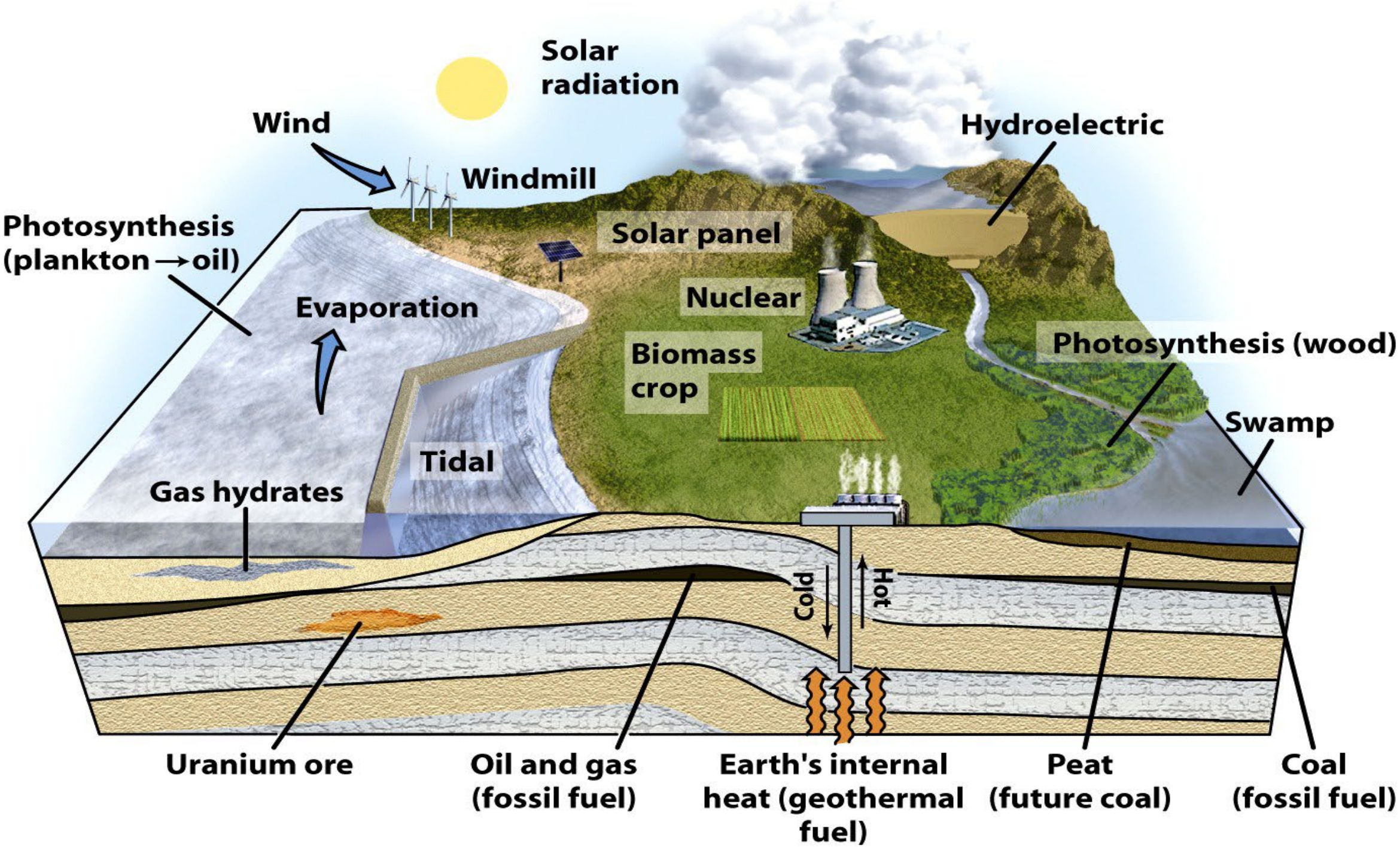

Underground Mining Methods
Surface Mining Methods
Original land surface
Rock spoil valley fill
Mountaintop mine
Dragline
Contour mine
Dozer
Coal beds
Highwall or Auger mine
Auger or thin-seam miner
Drift mine
Area mine
Dragline
Coal elevator
Miner's elevator
Rock spoil
Slope mine
Coal beds
Shaft mine
Stephen Greb, KGS

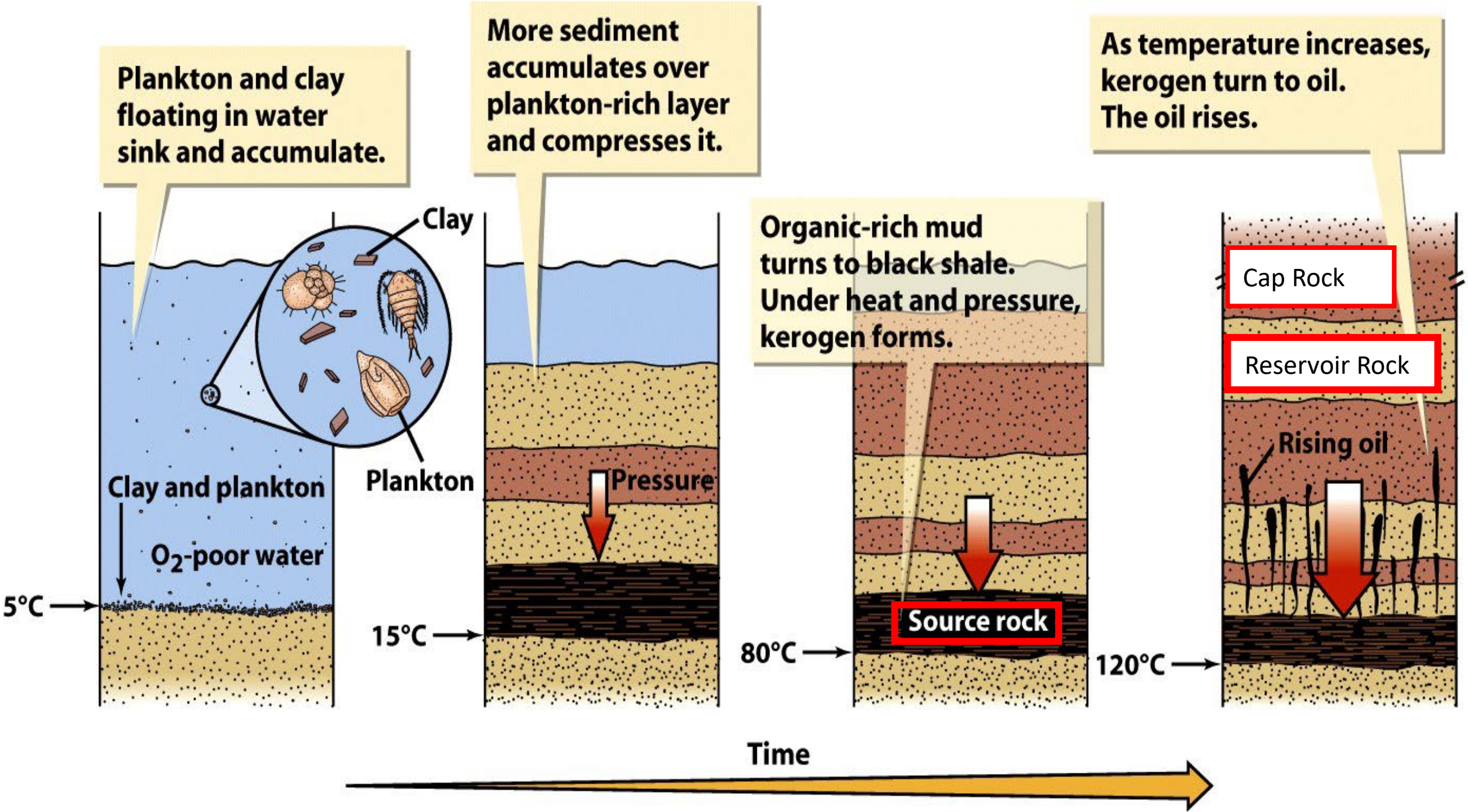
Reclamation

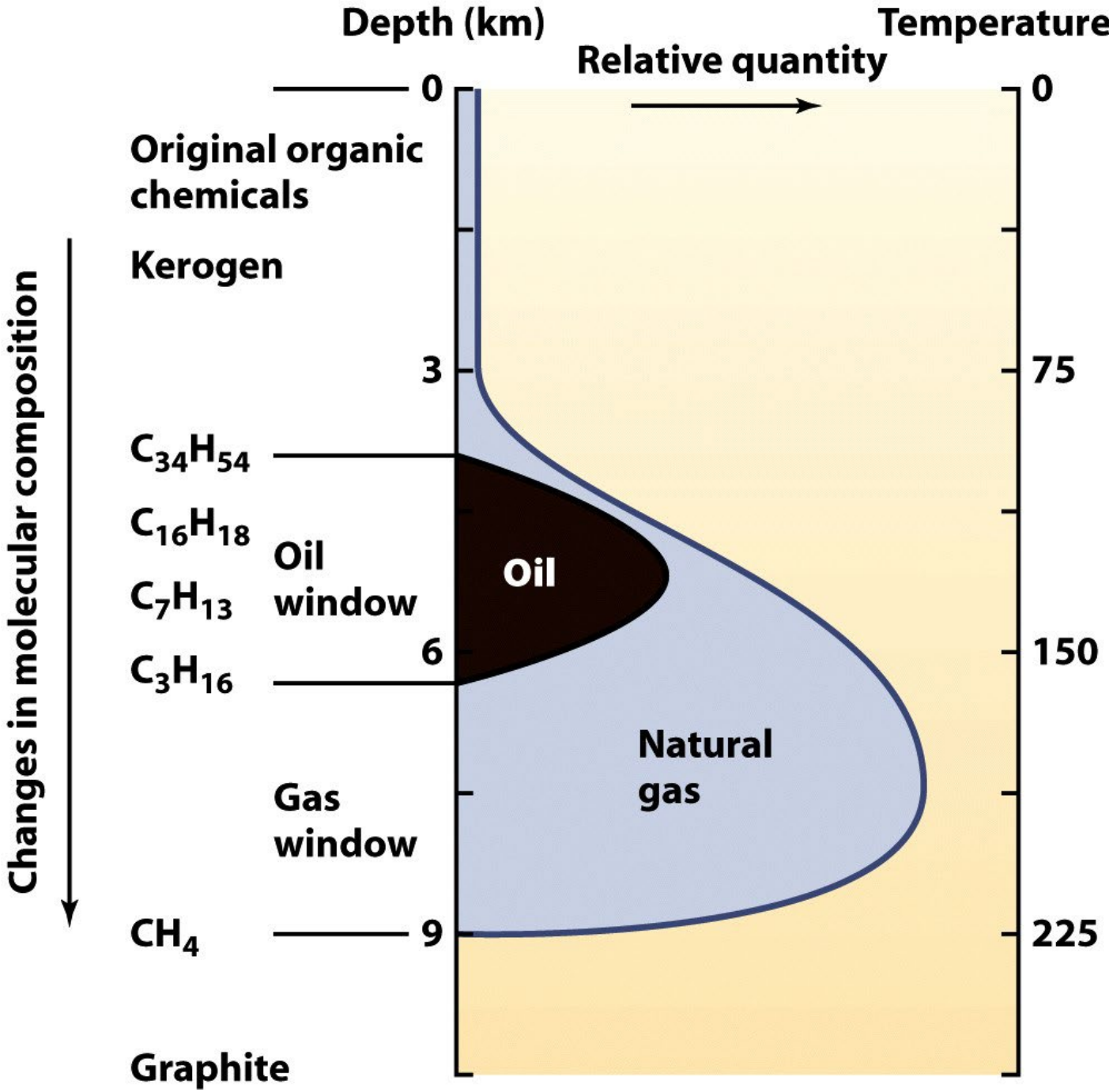

Pollutants
SO_2 Sulfur dioxide
NO_x Nitrogen oxides
Transport and transformation
Oxidation and complex reactions
H_2SO_4
HNO_3
Acid rain
Sulfuric acid
Nitric acid
Transport & transformation of acid precursors
Cloud processes
Materials
Acidic precipitation
Dry deposition
Soil buffering
Wet deposition
Runoff
Industry—Transportation
Terrestrial ecosystem
Aquatic ecosystem
Distance
Up to several hundred kilometers


High sensitivity
Moderate sensitivity
Low sensitivity

Energy Resources

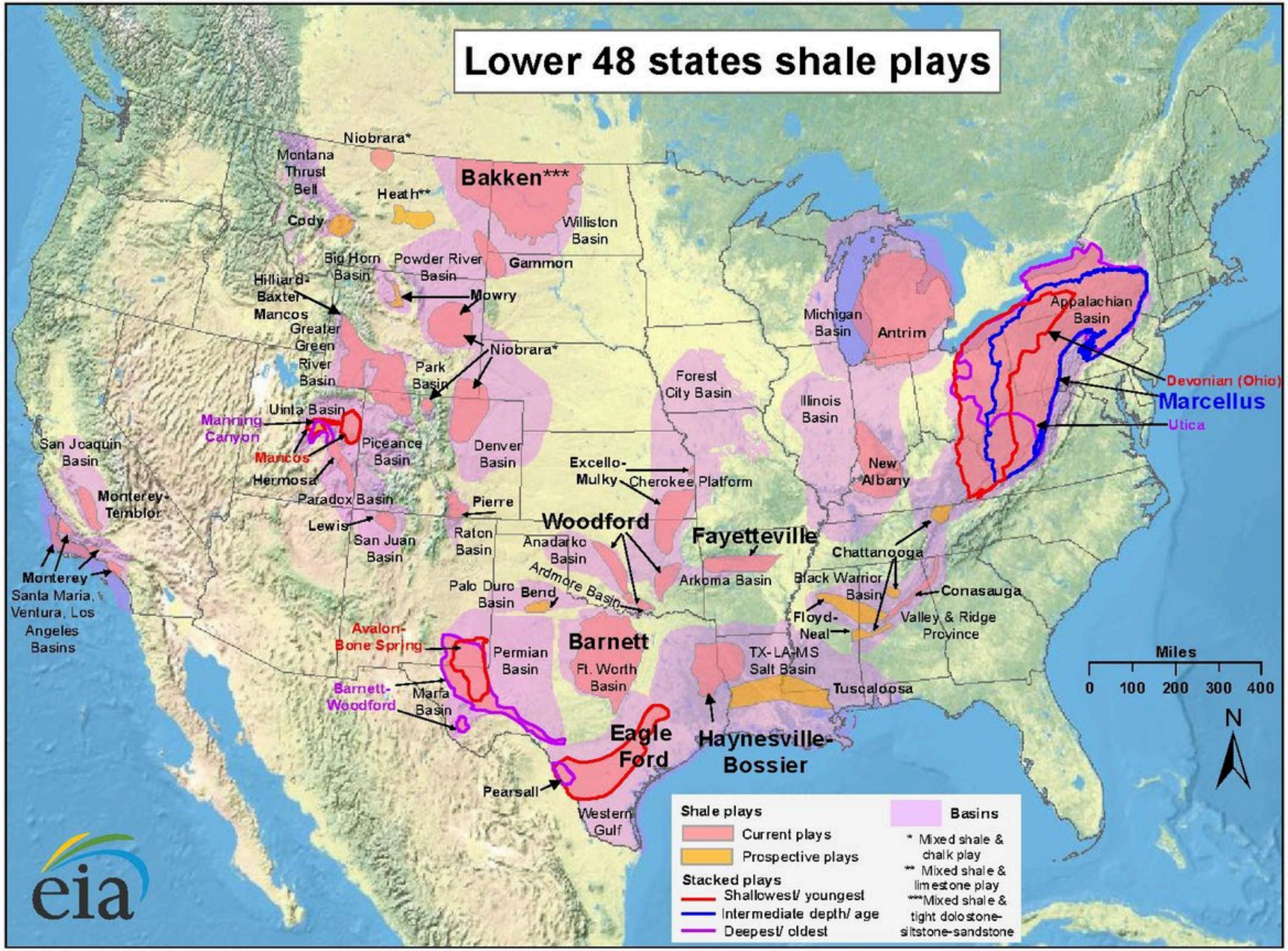



Plankton and clay floating in water sink and accumulate.
More sediment accumulates over plankton-rich layer and compresses it.
Organic-rich mud turns to black shale. Under heat and pressure, kerogen forms.
As temperature increases, kerogen turn to oil. The oil rises.
Clay
Plankton
Clay and plankton
O_2-poor water
5°C
Pressure
15°C
Source rock
80°C
120°C
Cap Rock
Reservoir Rock
Rising oil
Time



Coal window

- Oil window
  - Depth 4 to 6 km
  - Temp. 125 to 160 C
- Natural gas window
  - Depth 6 to 9 km
  - 150 to 225 C



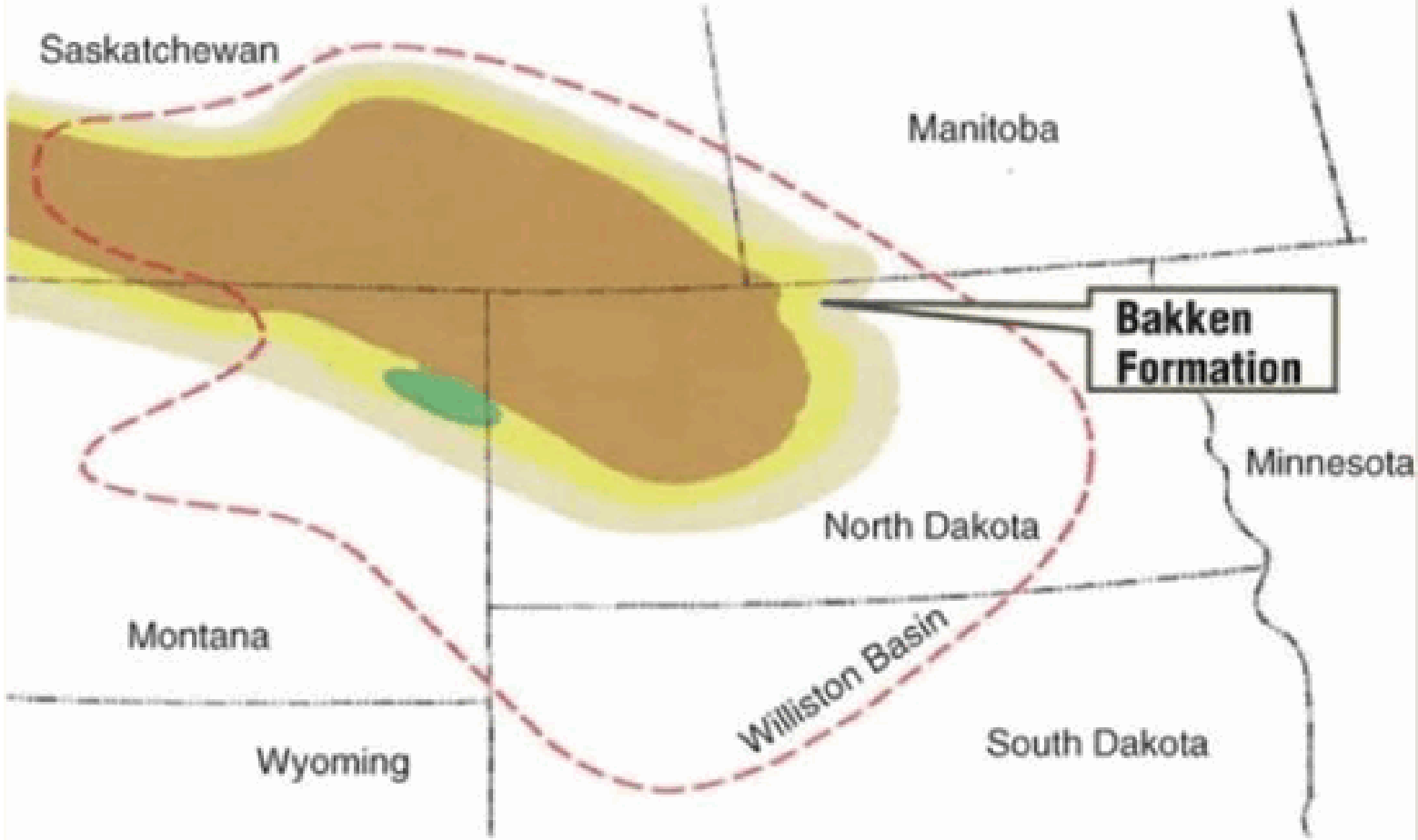
Source: Energy Information Administration based on data from various published studies

Gas

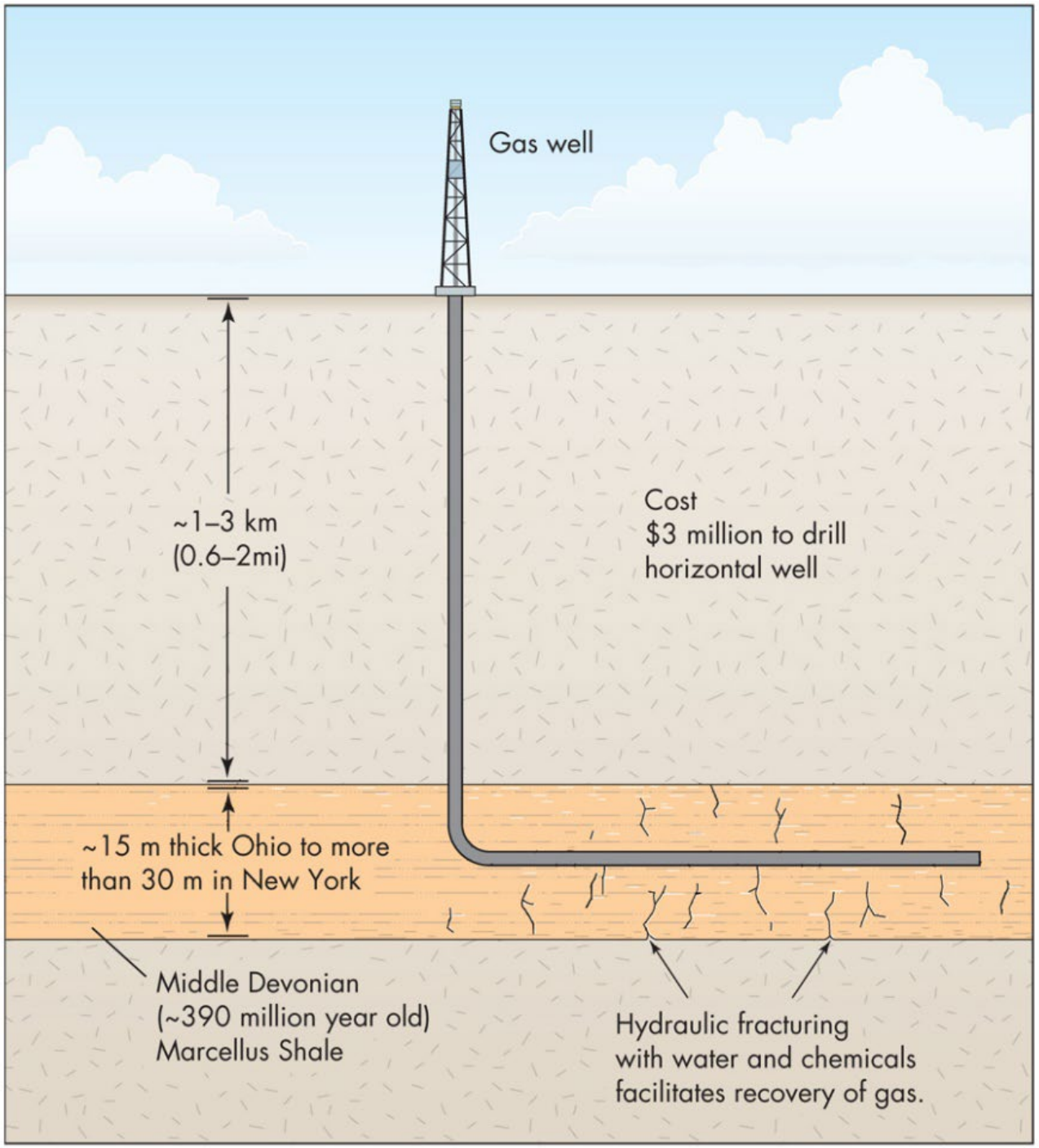
Extent of Devonian Shale

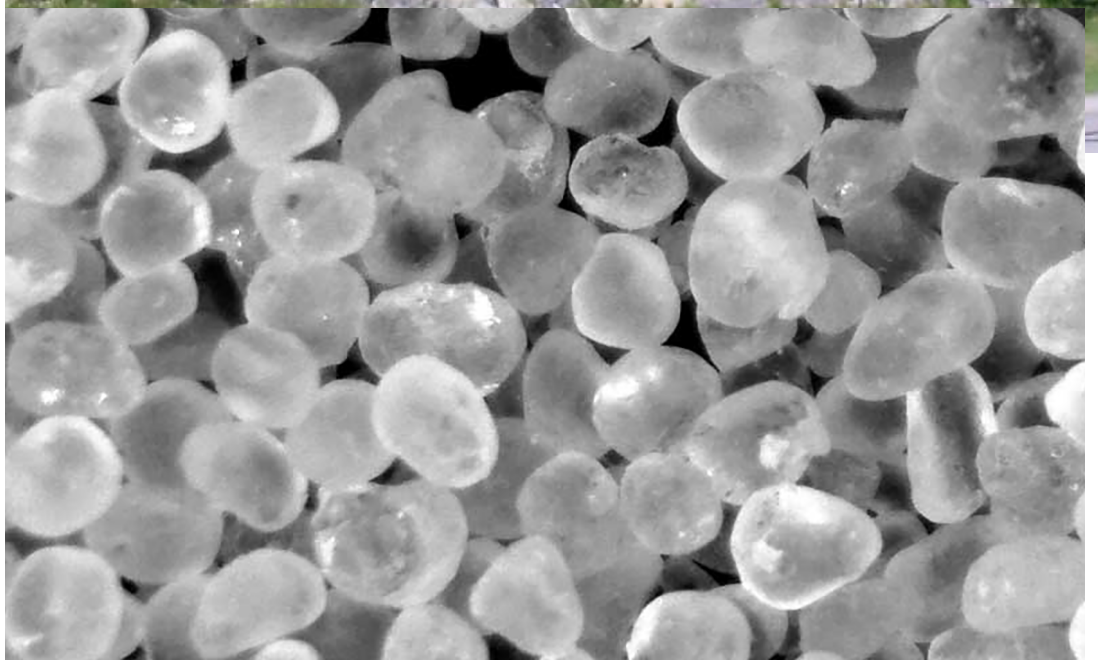
Marcellus Shale

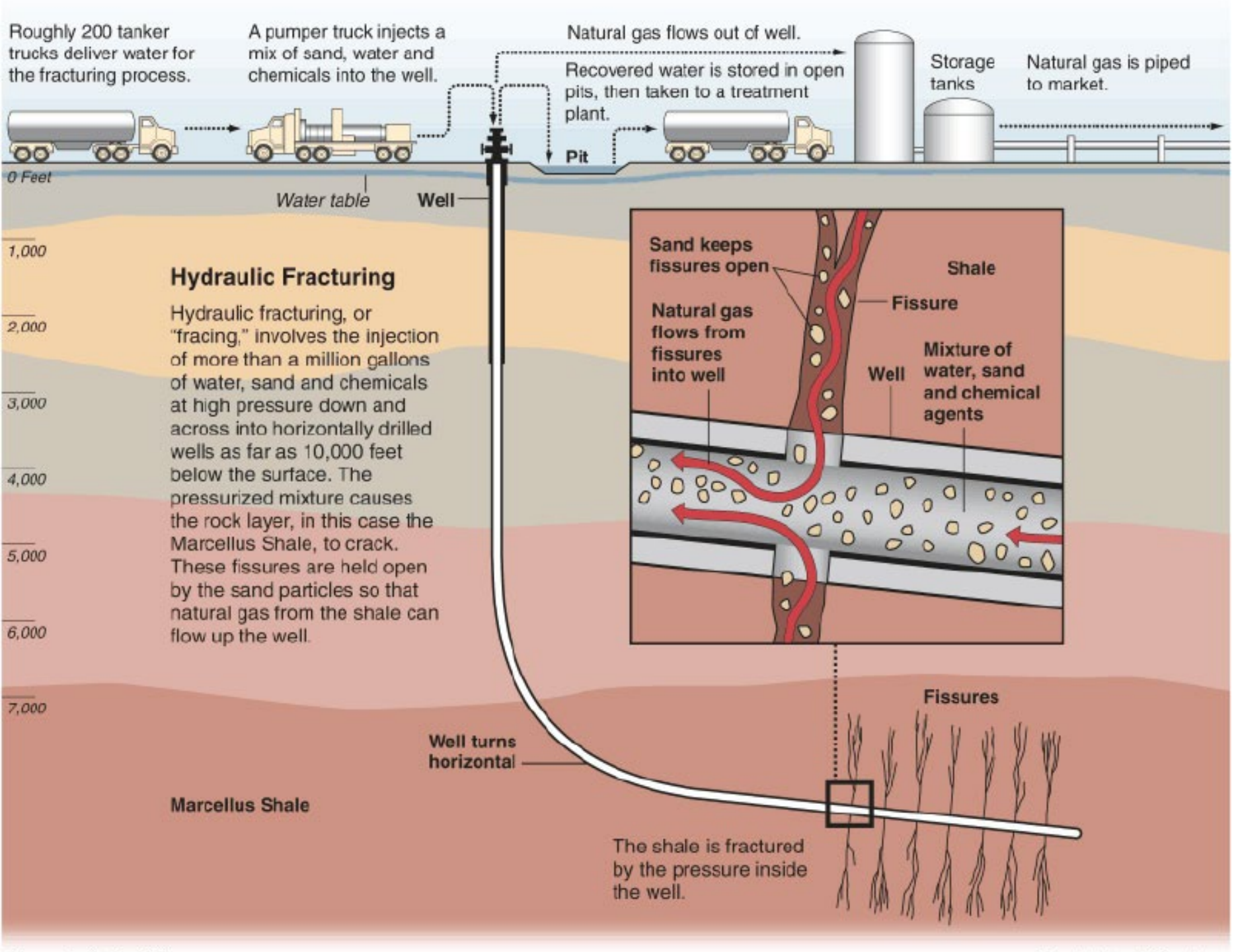
The Bakken Formation was deposited in the more central and deeper portion of the Williston Basin.



Source: USGS


Gas well
~1–3 km
(0.6–2mi)
Cost
$3 million to drill
horizontal well
~15 m thick Ohio to more
than 30 m in New York
Middle Devonian
(~390 million year old)
Marcellus Shale
Hydraulic fracturing
with water and chemicals
facilitates recovery of gas.

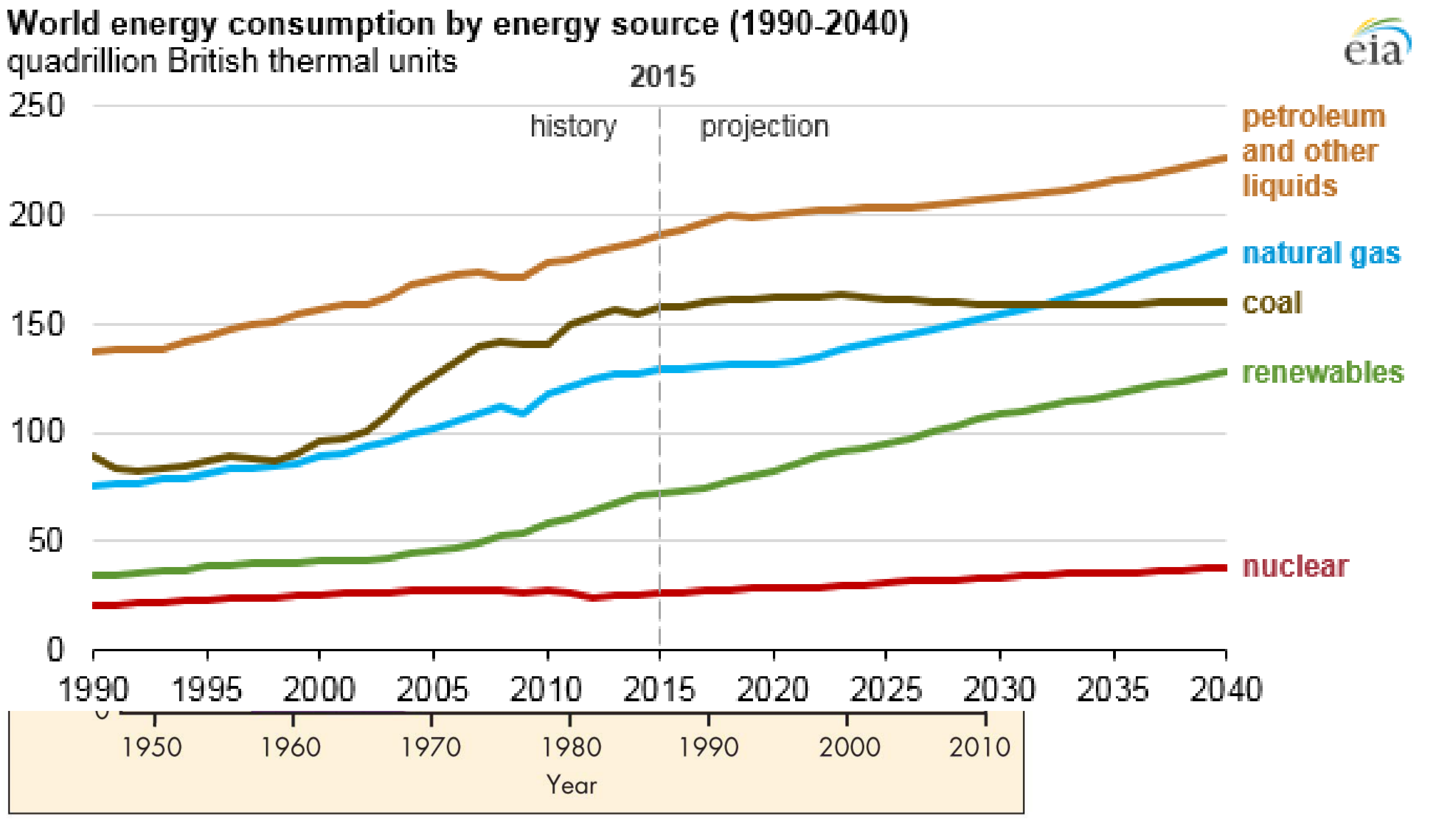




Hydraulic Fracturing 'Fracing'

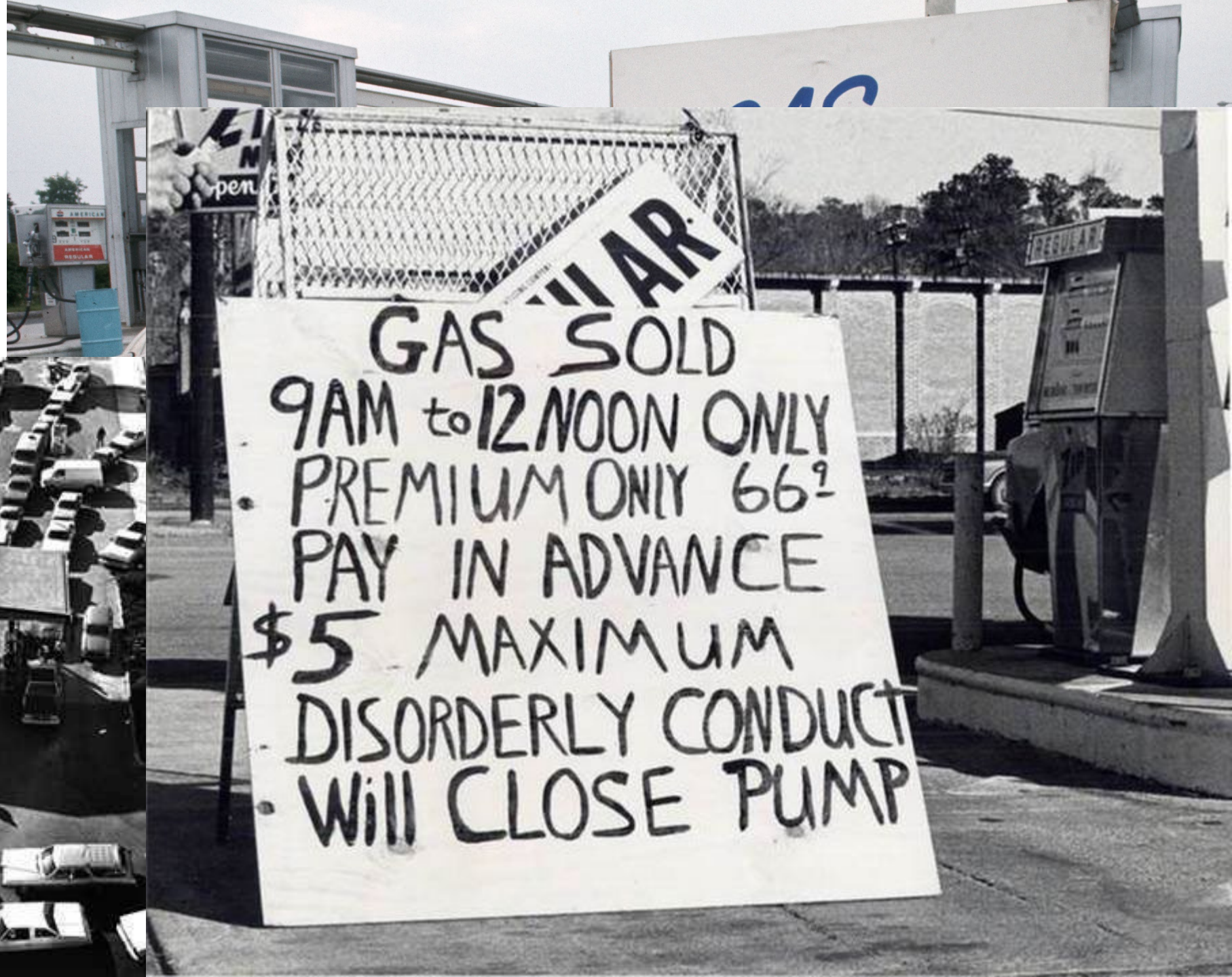
Energy Transition

Part 2


World energy consumption by energy source (1990-2040)
quadrillion British thermal units
eia
2015
history
projection
250
200
150
100
50
0
petroleum and other liquids
natural gas
coal
renewables
nuclear
1990
1995
2000
2005
2010
2015
2020
2025
2030
2035
2040
1950
1960
1970
1980
1990
2000
2010
Year

1974


STANDARD


AMERICAN
REGULAR
REGULAR
GAS SOLD
9AM to 12 NOON ONLY
PREMIUM ONLY 66¢
PAY IN ADVANCE
$5 MAXIMUM
DISORDERLY CONDUCT
Will CLOSE PUMP

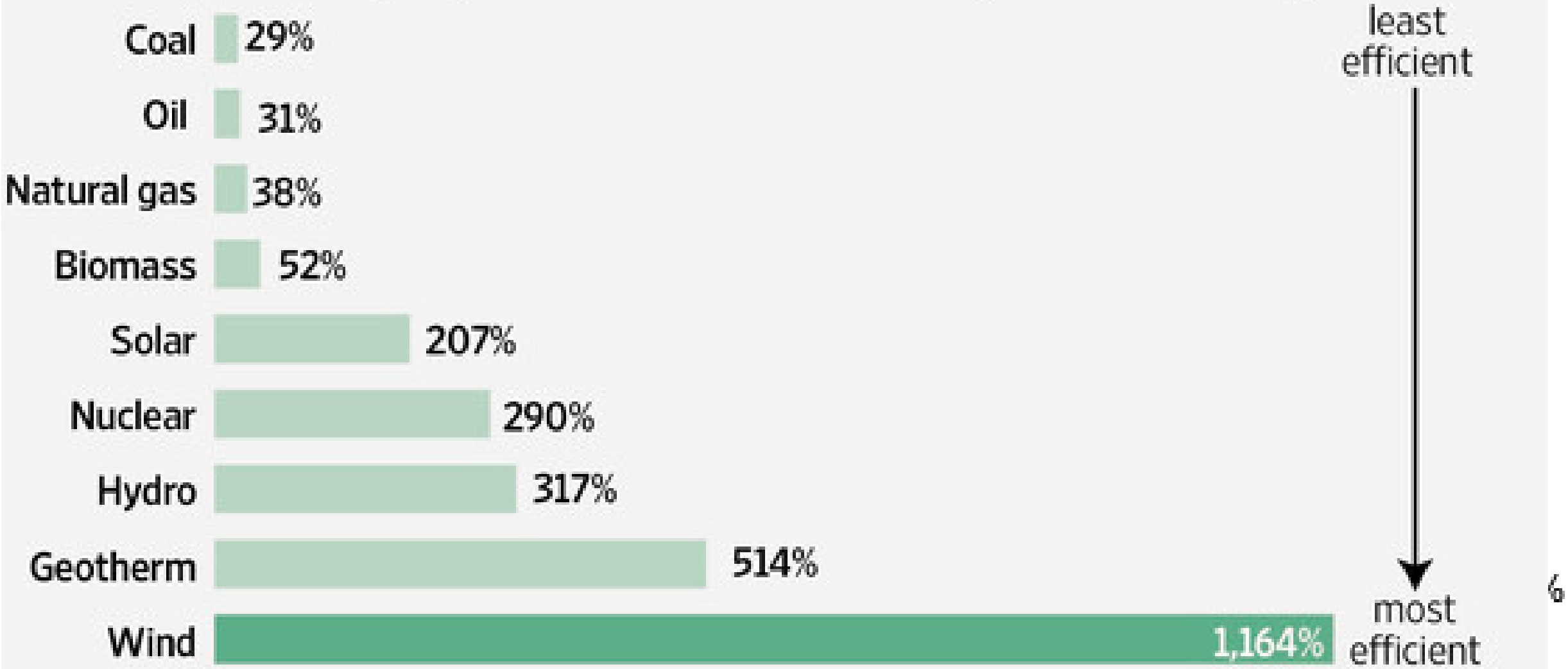
Organization of Petroleum Exporting Countries (OPEC)

- 1960 - Iran, Iraq, Kuwait, Saudi Arabia and Venezuela
- Qatar (1961), Indonesia (1962), Libya (1962), the United Arab Emirates (1967), Algeria (1969), Nigeria (1971), Ecuador (1973), Gabon (1975), Angola (2007), Equatorial Guinea (2017) and Congo (2018)

- Mission ‘Coordinate and unify the petroleum policies of its member countries and ensure the stabilization of oil markets, in order to secure an efficient, economic and regular supply of petroleum to consumers, a steady income to producers, and a fair return on capital for those investing in the petroleum industry’

Energy Efficiency

Percentage of energy input retained when converting fuel to electricity



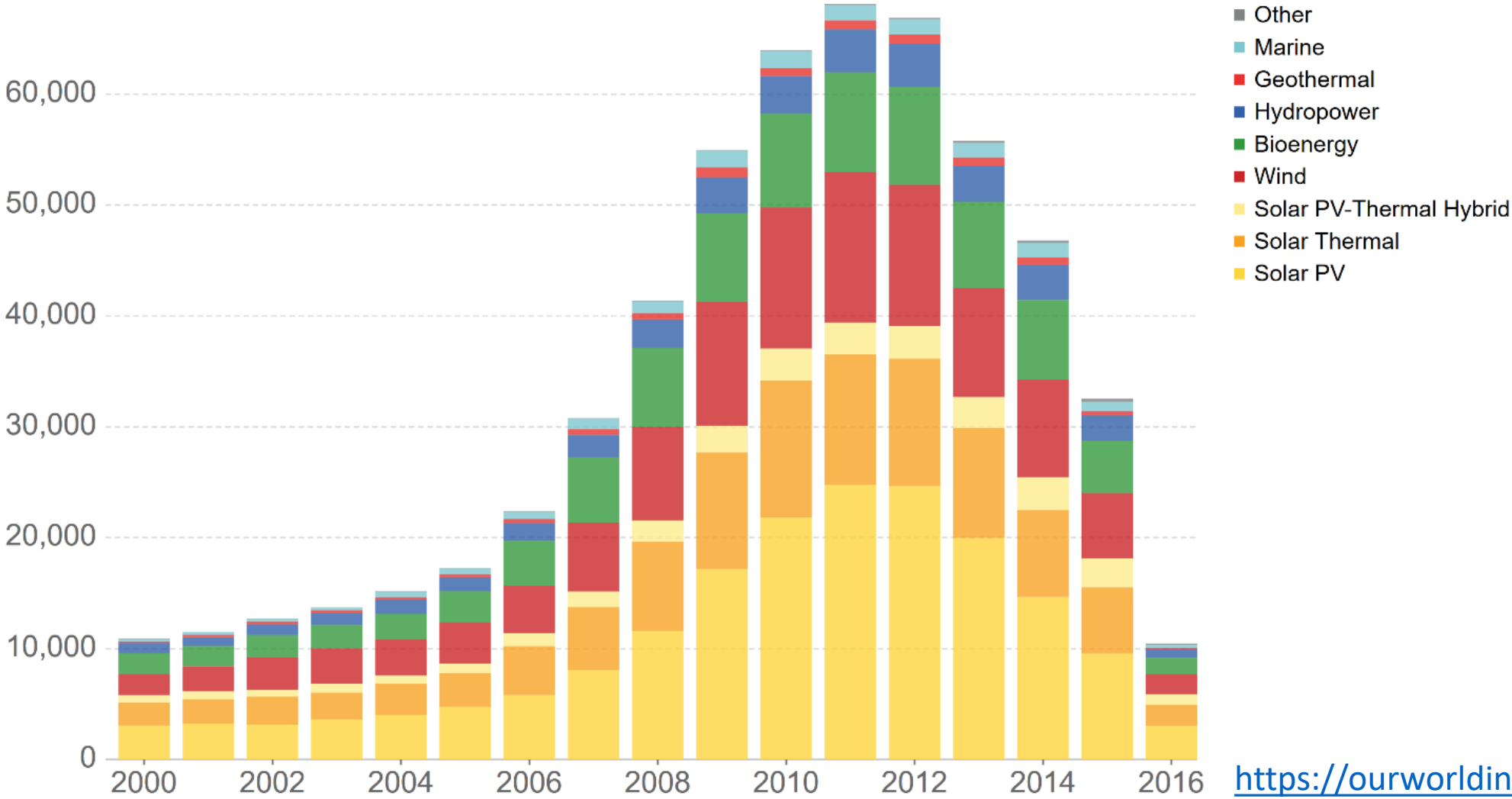
Source: Energy Points

The Wall Street Journal

Number of patents filed for renewable energy technologies, World

Our World in Data

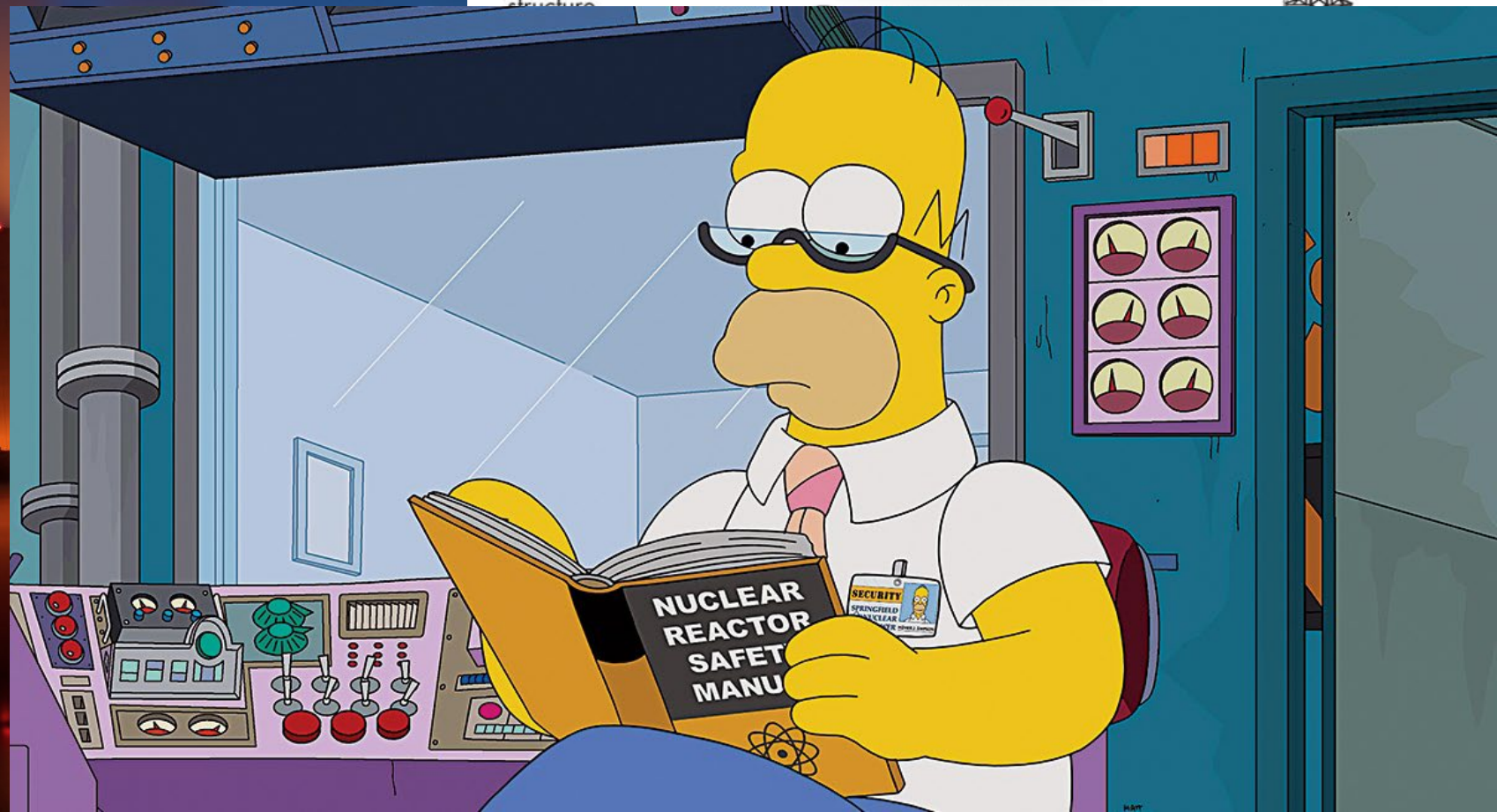
Global number of patents filed under each renewable technology category per year. Note that figures for 2014-16 may be subject to a time lag; processing times of patent applications vary and some patents submitted over this period may not yet be recorded in statistics. These figures will be updated with time if additional patent applications are recorded.

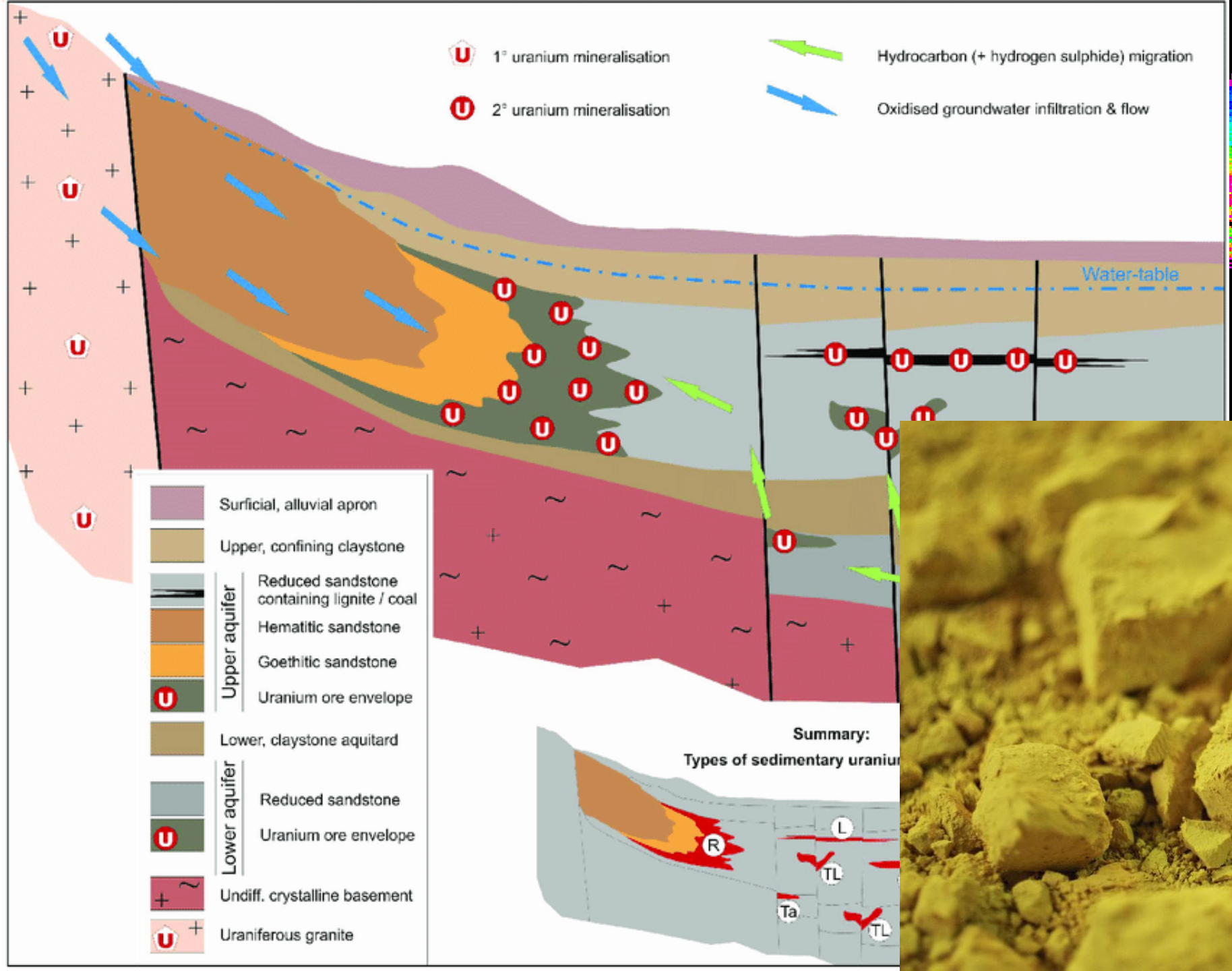


https://ourworldindata.org/renewable-energy

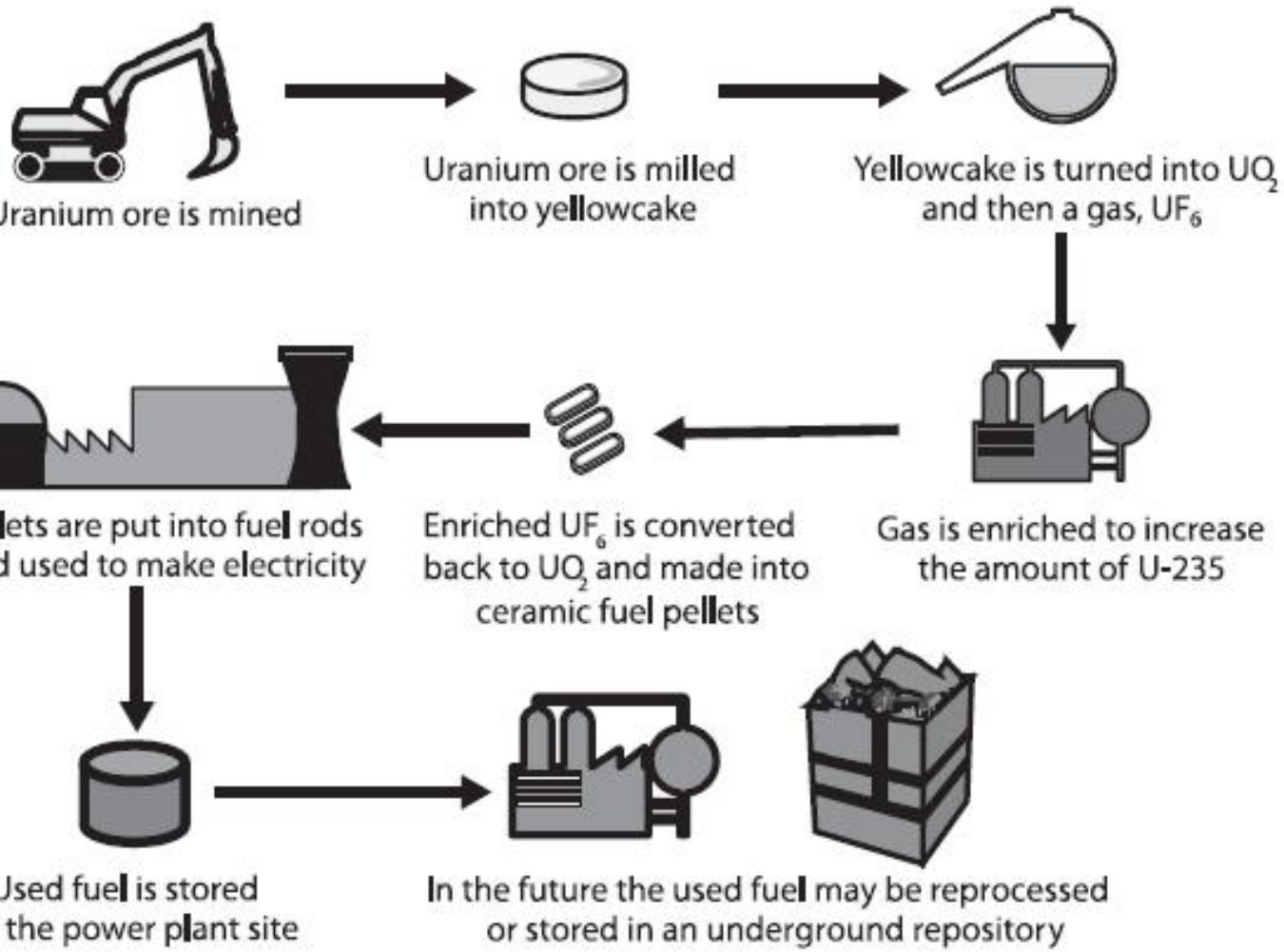
Source: IRENA (& EPO PATSTAT)

Nuclear Energy

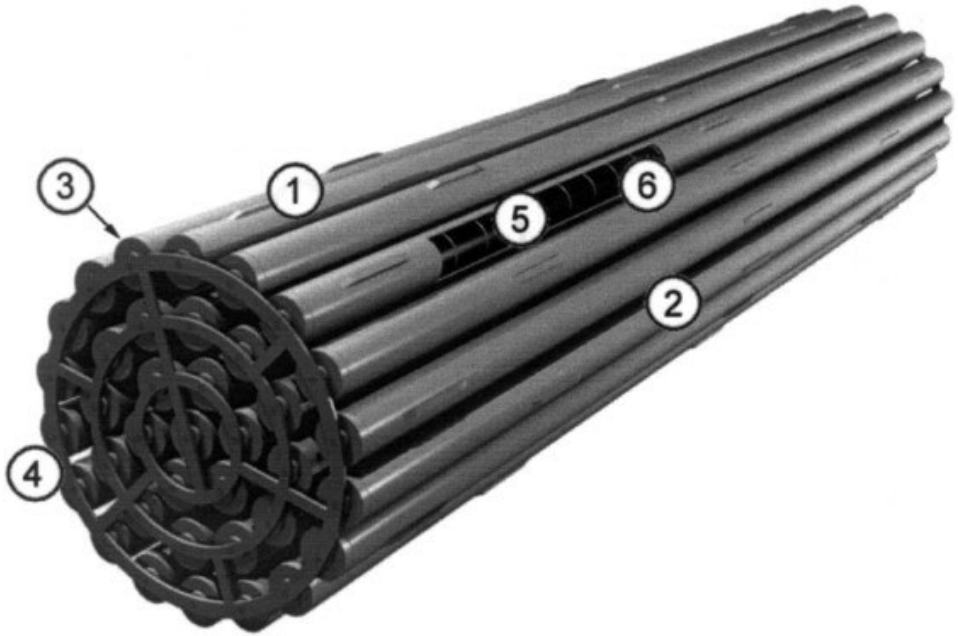



1° uranium mineralisation
2° uranium mineralisation
Hydrocarbon (+ hydrogen sulphide) migration
Oxidised groundwater infiltration & flow
Water-table
Surficial, alluvial apron
Upper, confining claystone
Upper aquifer
Reduced sandstone containing lignite / coal
Hematitic sandstone
Goethitic sandstone
Uranium ore envelope
Lower, claystone aquitard
Lower aquifer
Reduced sandstone
Uranium ore envelope
Undiff. crystalline basement
Uraniferous granite
Summary:
R
L
TL
Ta
TL

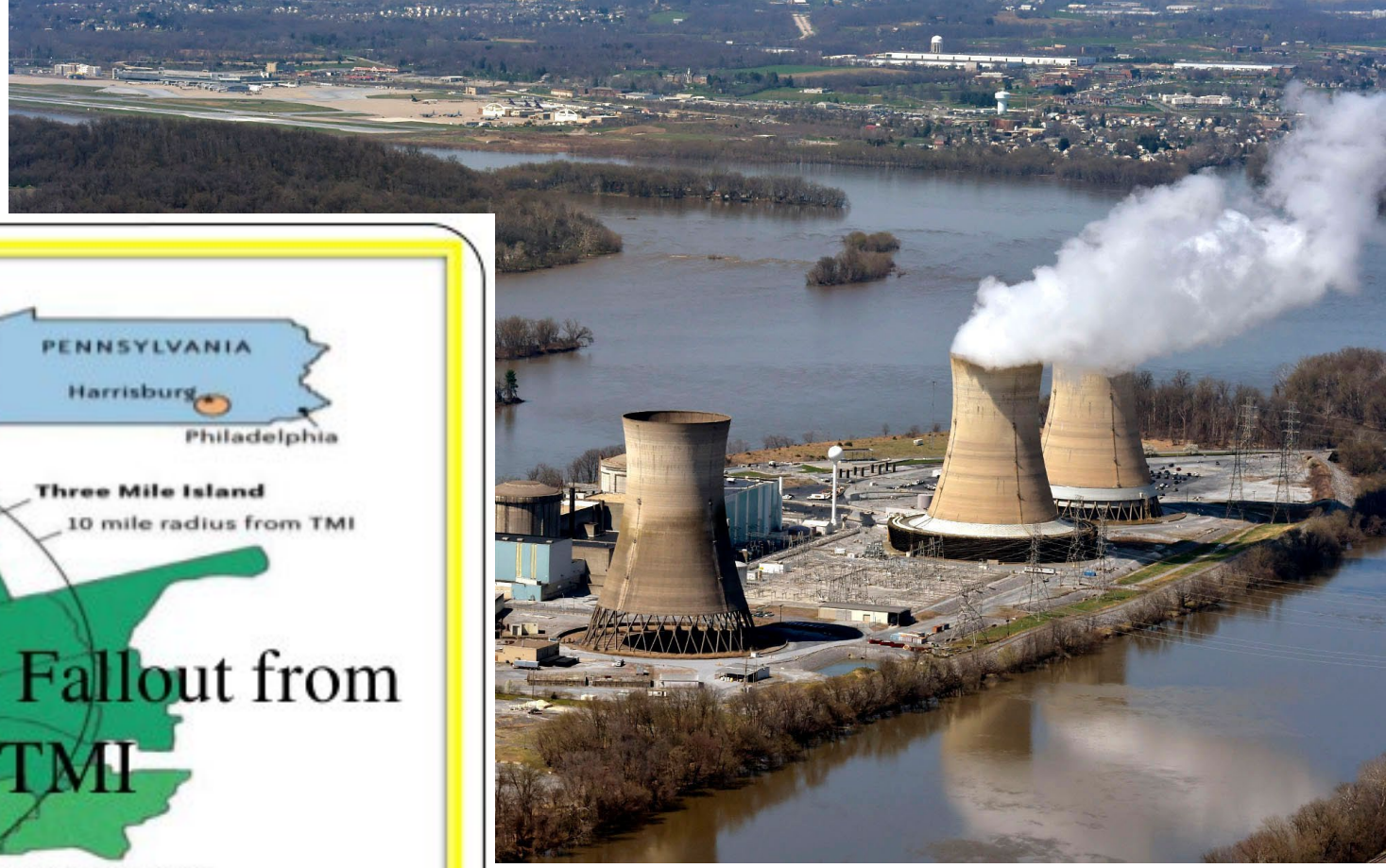
Uranium Fuel Cycle

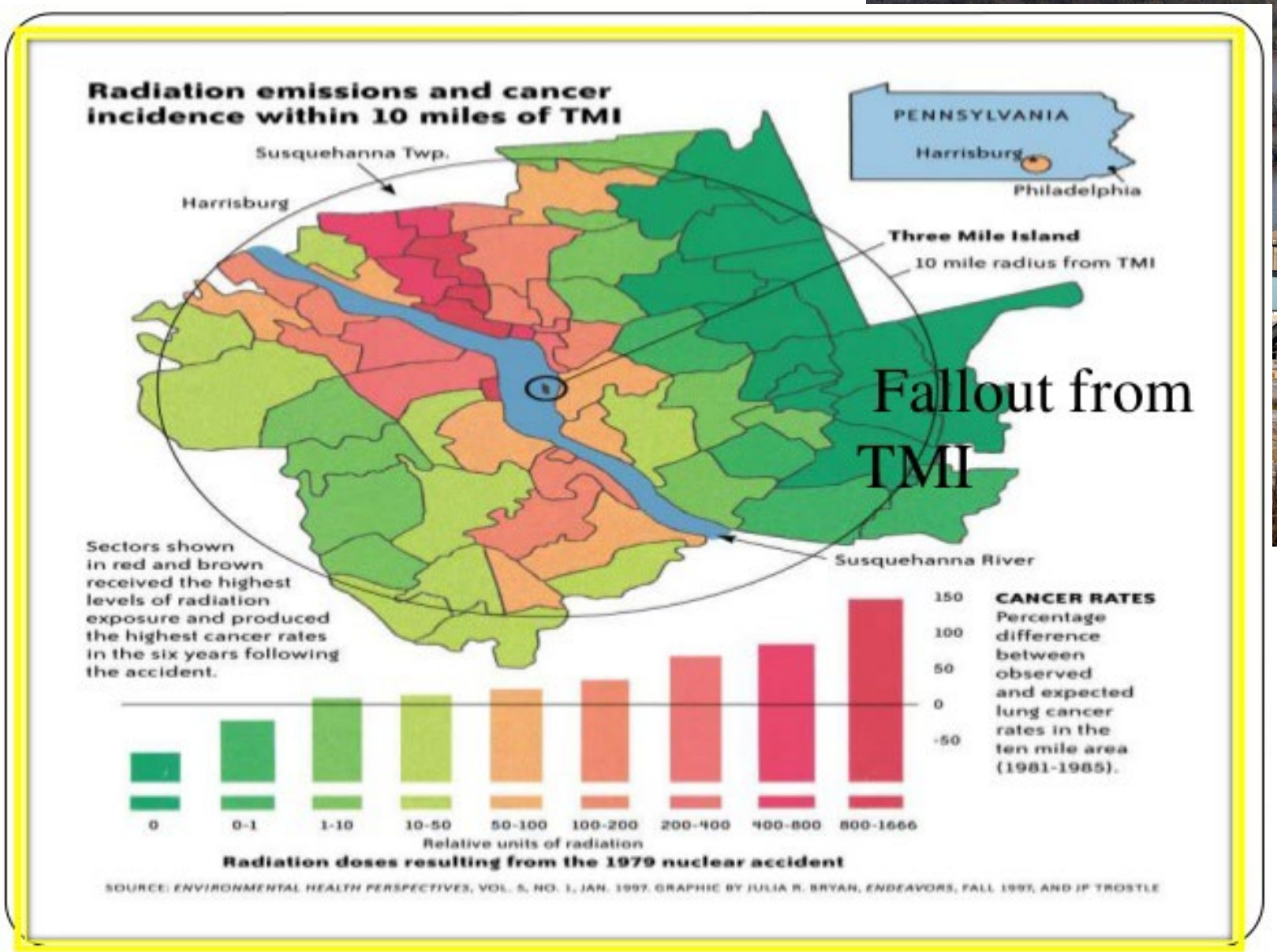


Isotope	Half-Life (Years)
U-234	2.455×10^5
U-235	7.038×10^8
U-238	4.468×10^9

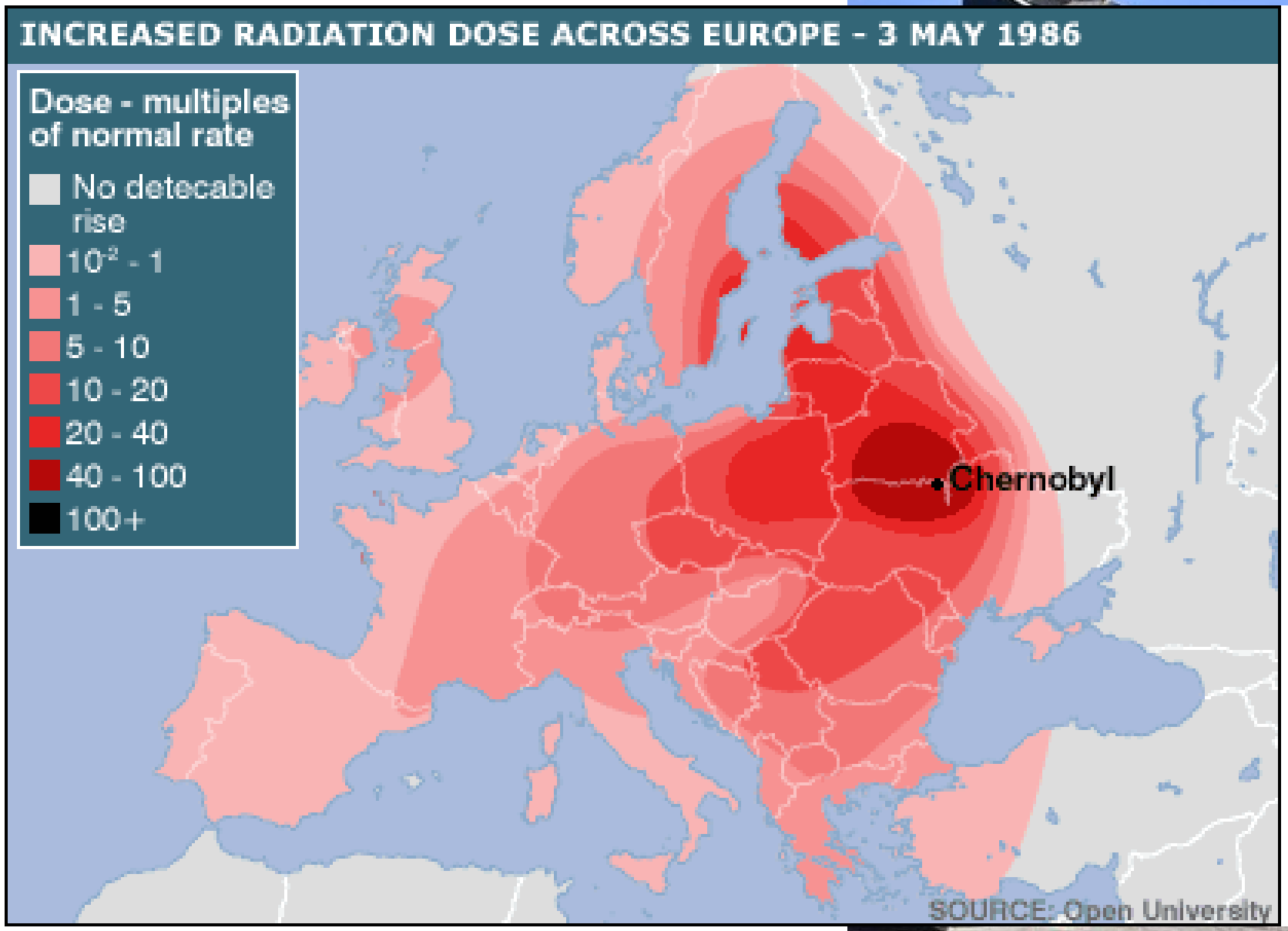


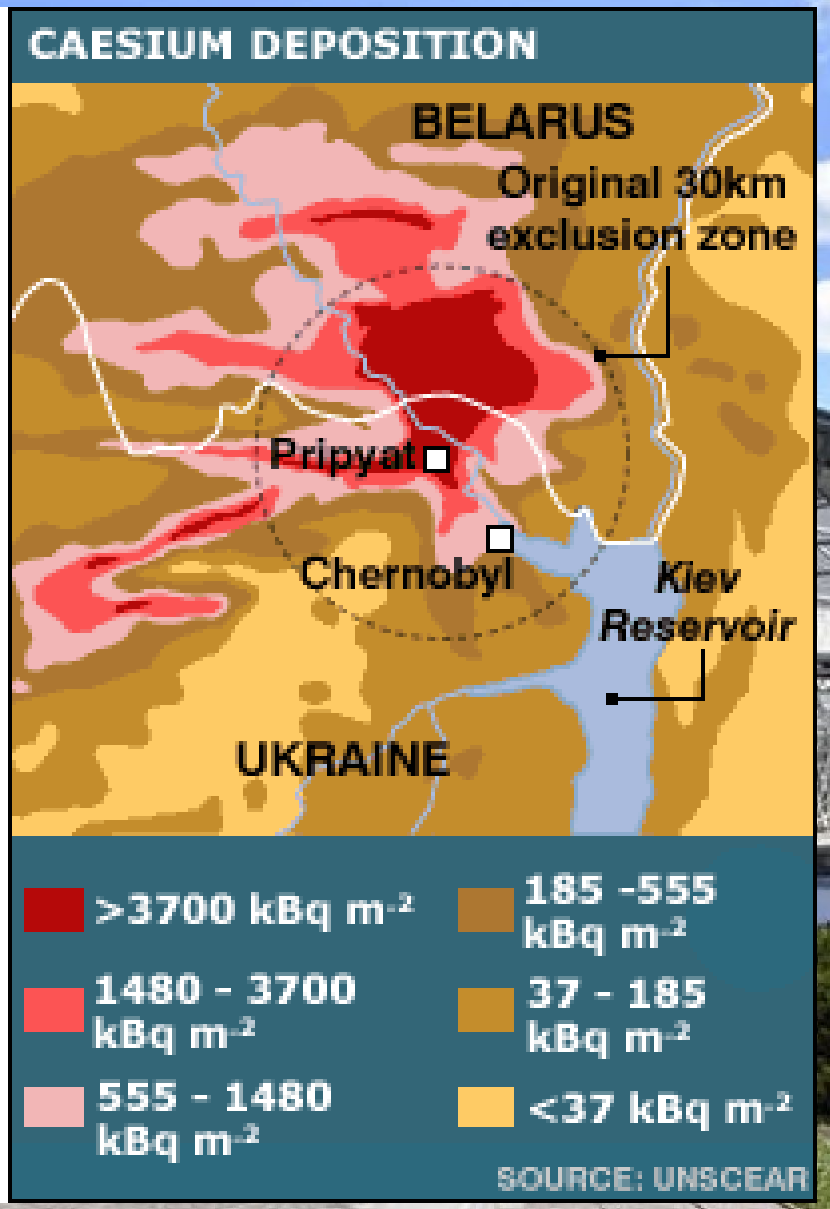
Three Mile Island



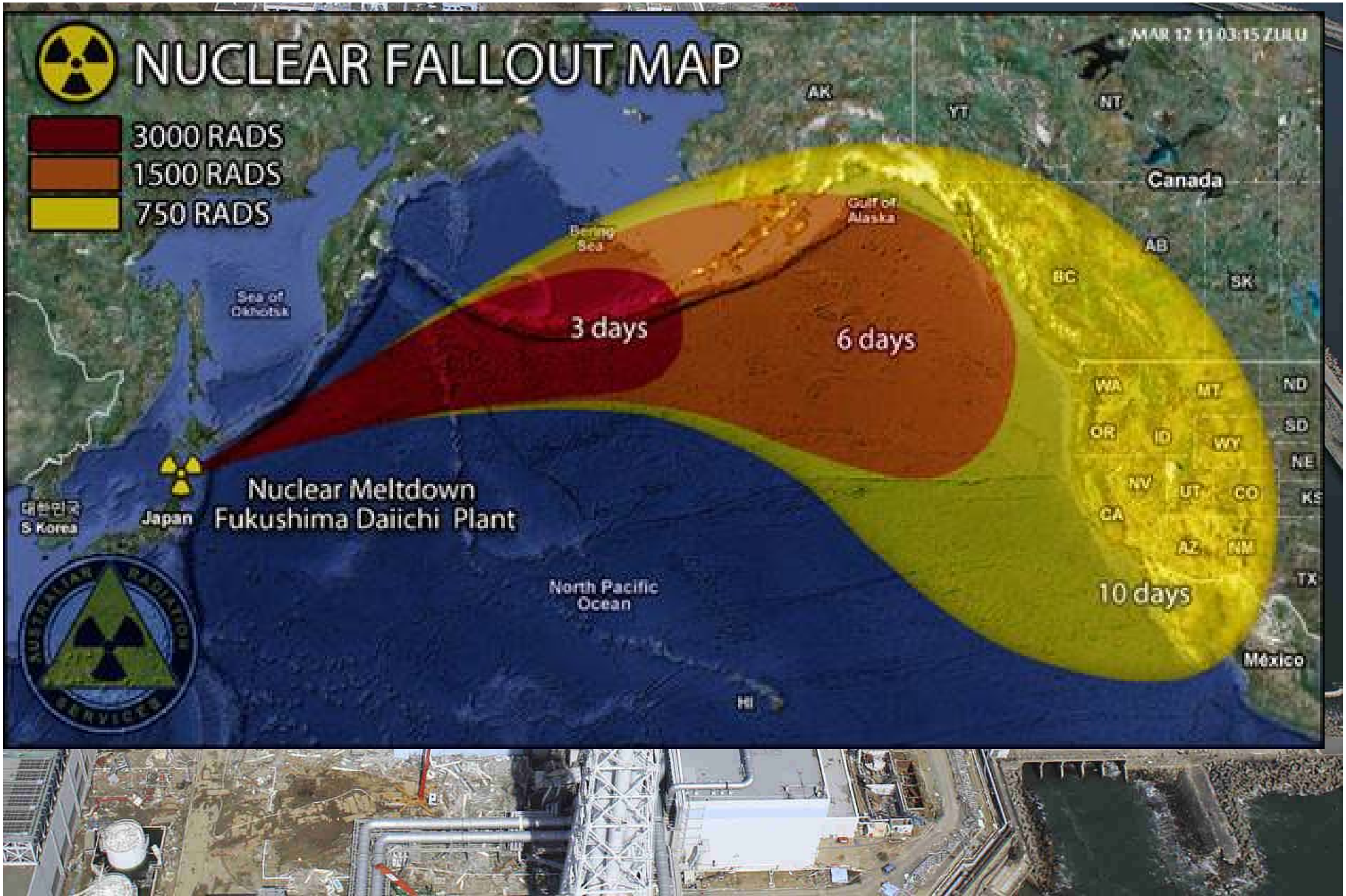


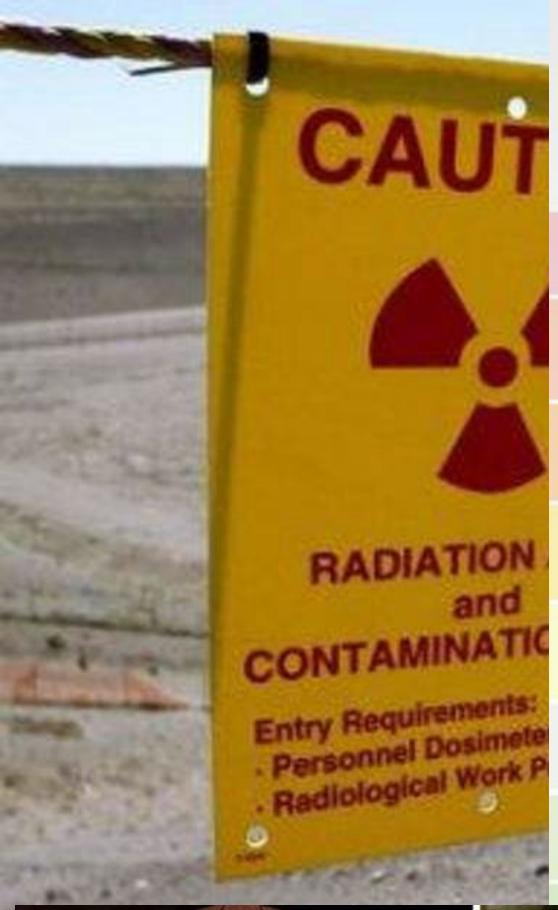
Chernobyl


INCREASED RADIATION DOSE ACROSS EUROPE - 3 MAY 1986
Dose - multiples of normal rate
No detecable rise
10-2 - 1
1 - 5
5 - 10
10 - 20
20 - 40
40 - 100
100+
Chernobyl
SOURCE: Open University


CAESIUM DEPOSITION
BELARUS
Original 30km exclusion zone
Pripyat
Chernobyl
Kiev Reservoir
UKRAINE
>3700 kBq m-2
1480 - 3700 kBq m-2
555 - 1480 kBq m-2
185 -555 kBq m-2
37 - 185 kBq m-2
<37 kBq m-2
SOURCE: UNSCEAR

Fukushima, Japan





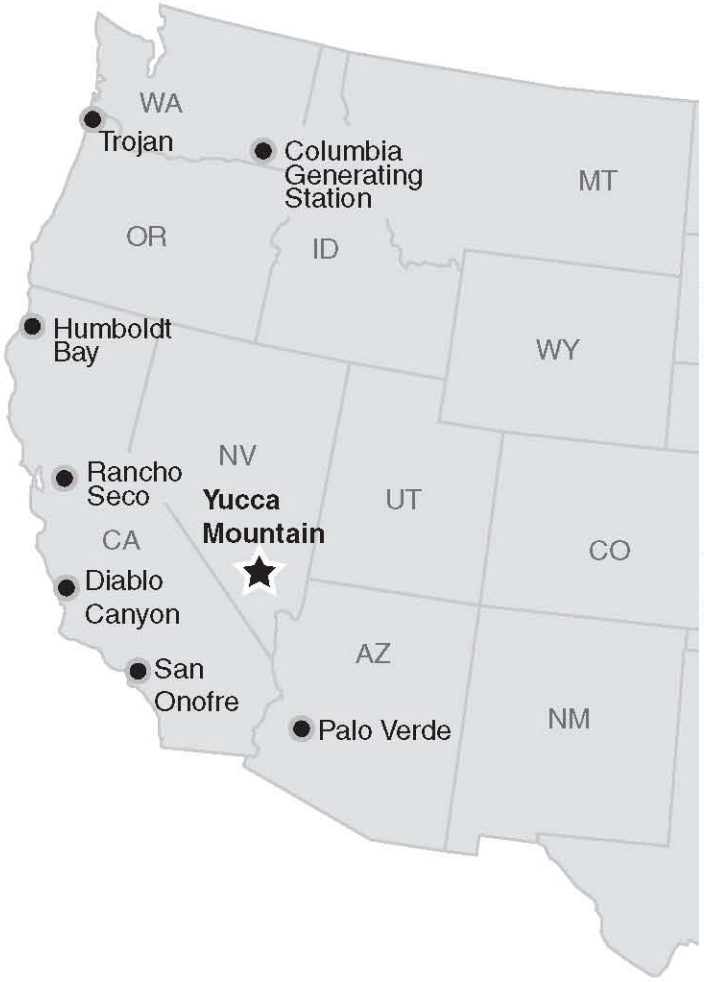
Radiation and the human body

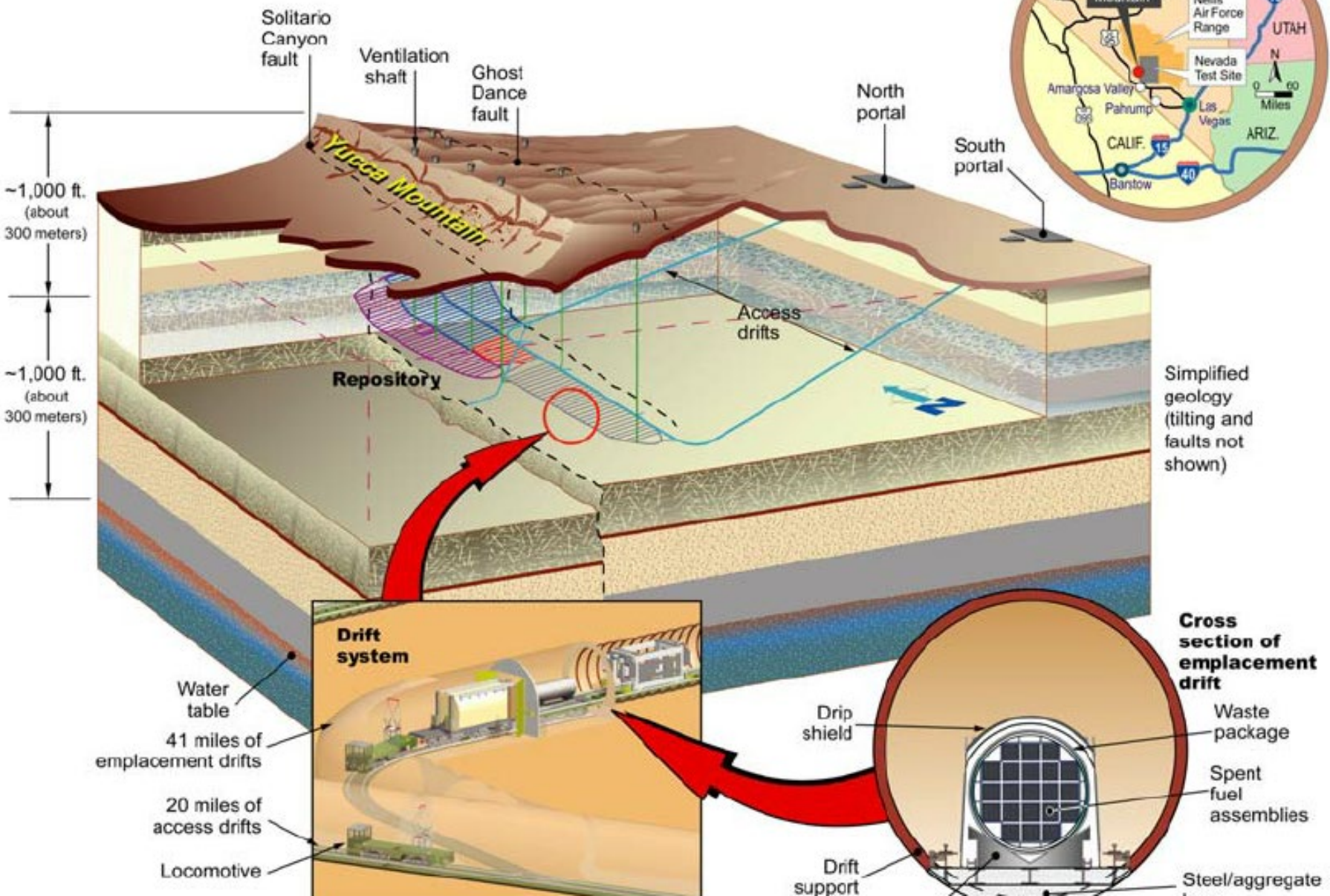
In microsieverts μSv	Effects
800,000 - 16,000,000	Radiation dose of first responders to Chernobyl
Above 7,000,000	Instant radiation dose - vomiting, internal bleeding, death within 2 weeks
3,000,000	50% chance of dying within 60 days if untreated
680,000	Highest dose received by a worker at 2011 Fukushima disaster
350,000	Approx dose rate if you lived in Chernobyl's "Red Forest" area for one year
20,000	Annual limit for nuclear workers in Europe
10,000	Instant radiation from a whole body CT scan
,100	Annual natural background radiation in US
000	Approx annual dose above natural background in the less contaminated parts of Chernobyl Exclusion Zone
60	Radiation dose from a London to Los Angeles flight

rposes, not to scale

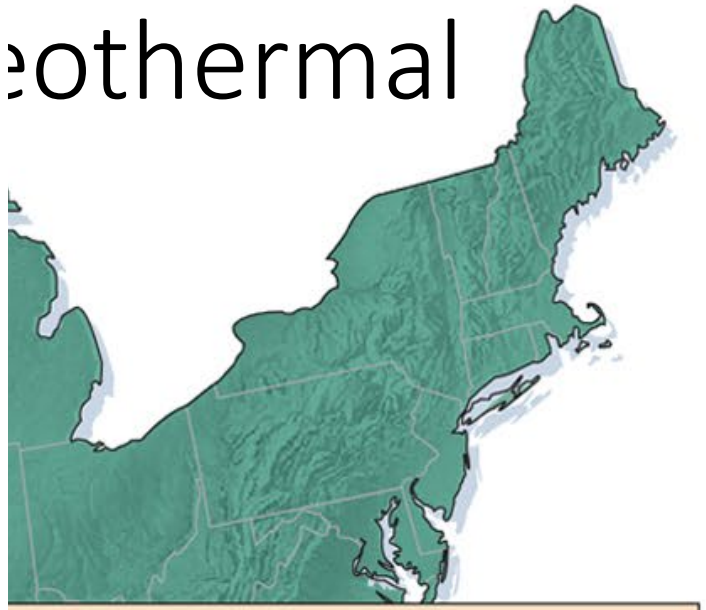
clear Energy Agency, American Nuclear Society, Prof. J.T. Smith School
mental Sciences, University of Portsmouth

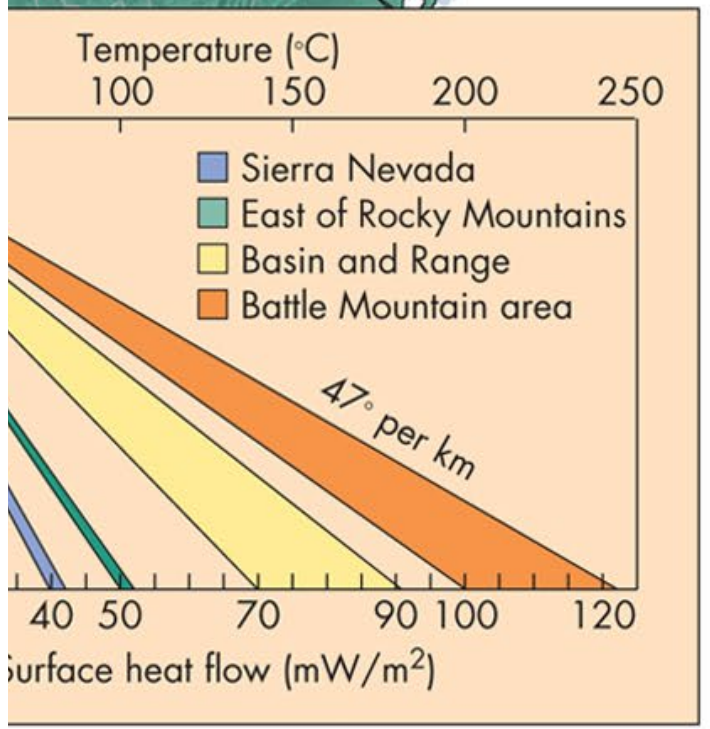
BBC


WA
Trojan
Columbia Generating Station
MT
OR
ID
Humboldt Bay
WY
NV
Rancho Seco
Yucca Mountain
UT
CA
CO
Diablo Canyon
AZ
San Onofre
Palo Verde
NM


Solitario Canyon fault
Ventilation shaft
Ghost Dance fault
North portal
South portal
~1,000 ft. (about 300 meters)
~1,000 ft. (about 300 meters)
Yucca Mountain
Access drifts
Repository
Simplified geology (tilting and faults not shown)
Drift system
Water table
41 miles of emplacement drifts
20 miles of access drifts
Locomotive
Cross section of emplacement drift
Drip shield
Waste package
Spent fuel assemblies
Drift support
Steel/aggregate
NEVADA
Yucca Mountain
Nellis Air Force Range
UTAH
Nevada Test Site
Amargosa Valley
Pahrump
Las Vegas
CALIF.
ARIZ.
Barstow
Miles

eothermal



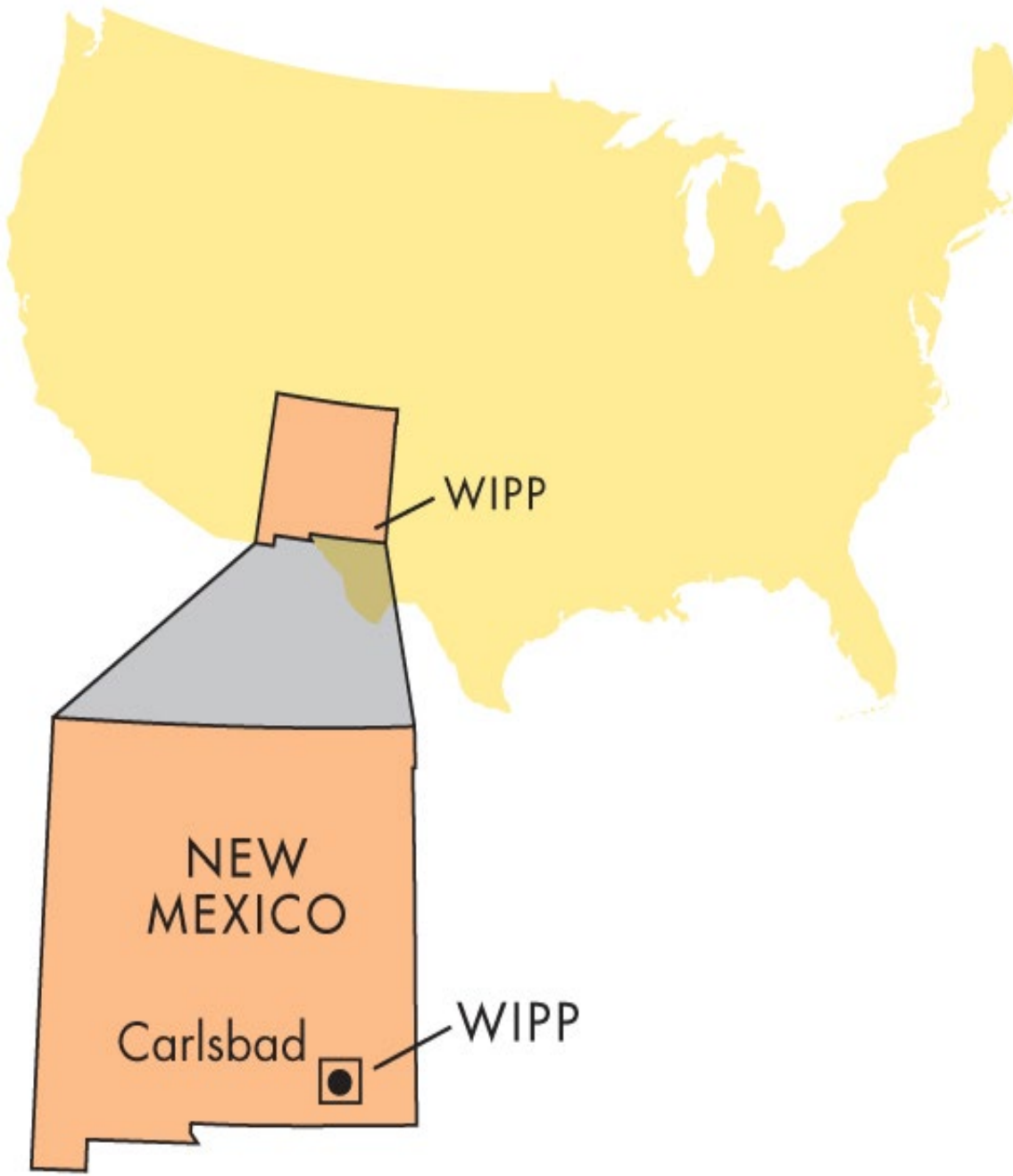


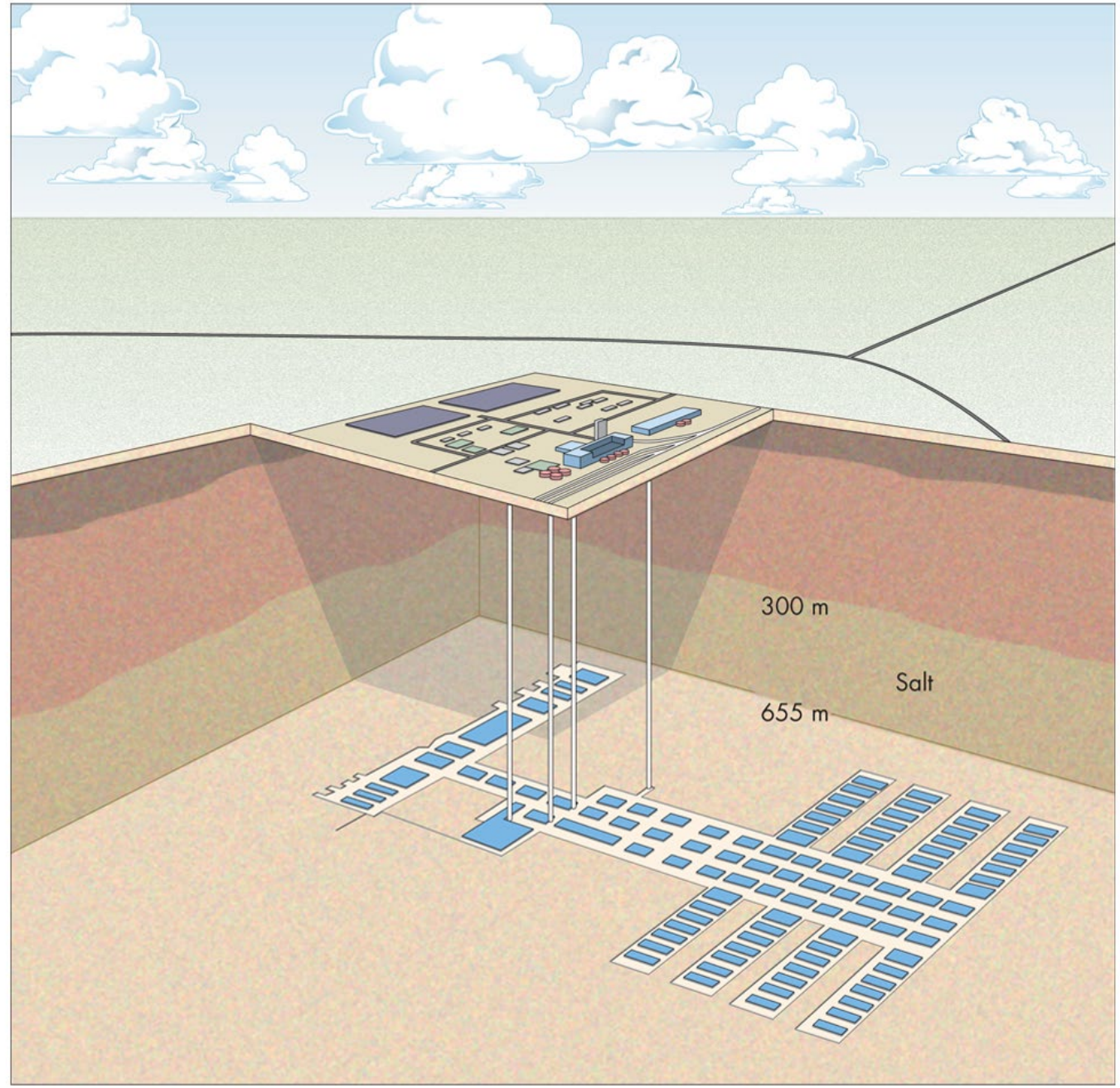
(b)

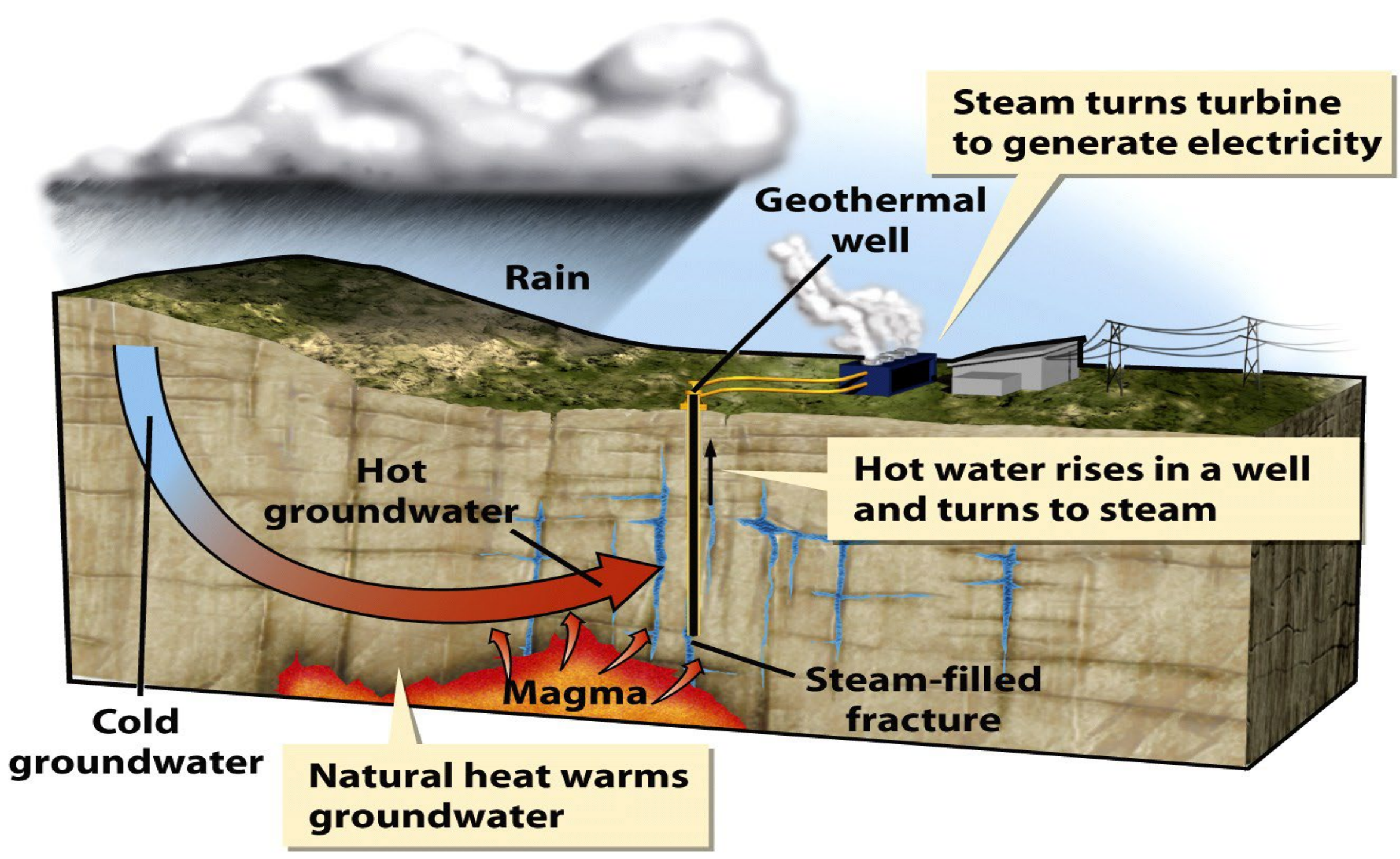
N

Oregon
Idaho
Montana
Wyoming
Cascade Range
Rocky Mountains
Battle Mountain High
Nevada
Utah
Colorado
Colorado Plateau
Rift
Basin and Range
Sierra Nevada
California
LV
COSO
G
Arizona
New Mexico
Rio Grande
Salton Trough
PACIFIC OCEAN
Gulf of California
MEXICO
Texas
0 100 200 Miles
0 100 200 Kilometers

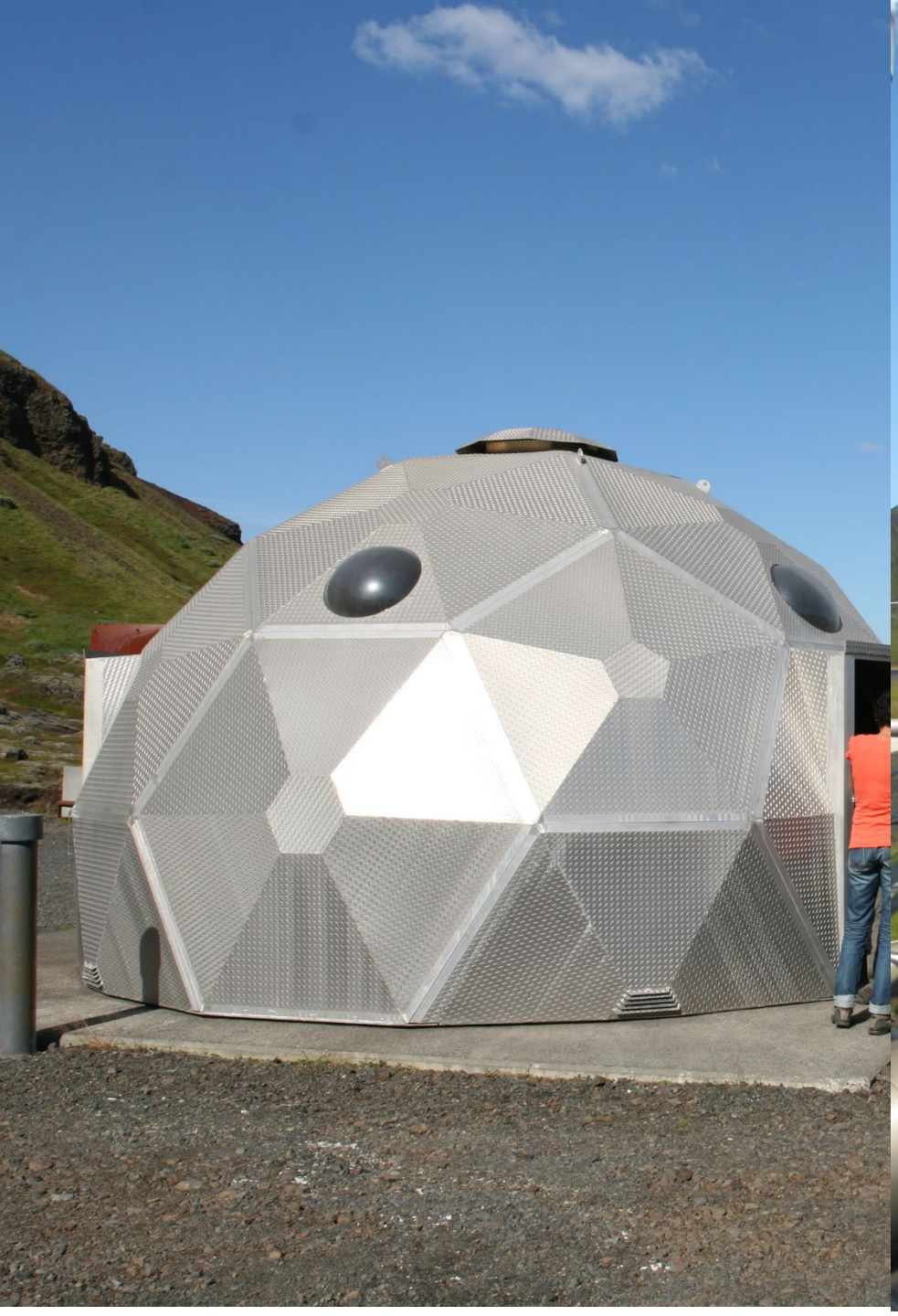
EXPLANATION
Heat flow, in milliwatts per square meter
- Less than 40
- From 40 to 60
- From 60 to 100
- Greater than 100
- Power plant location

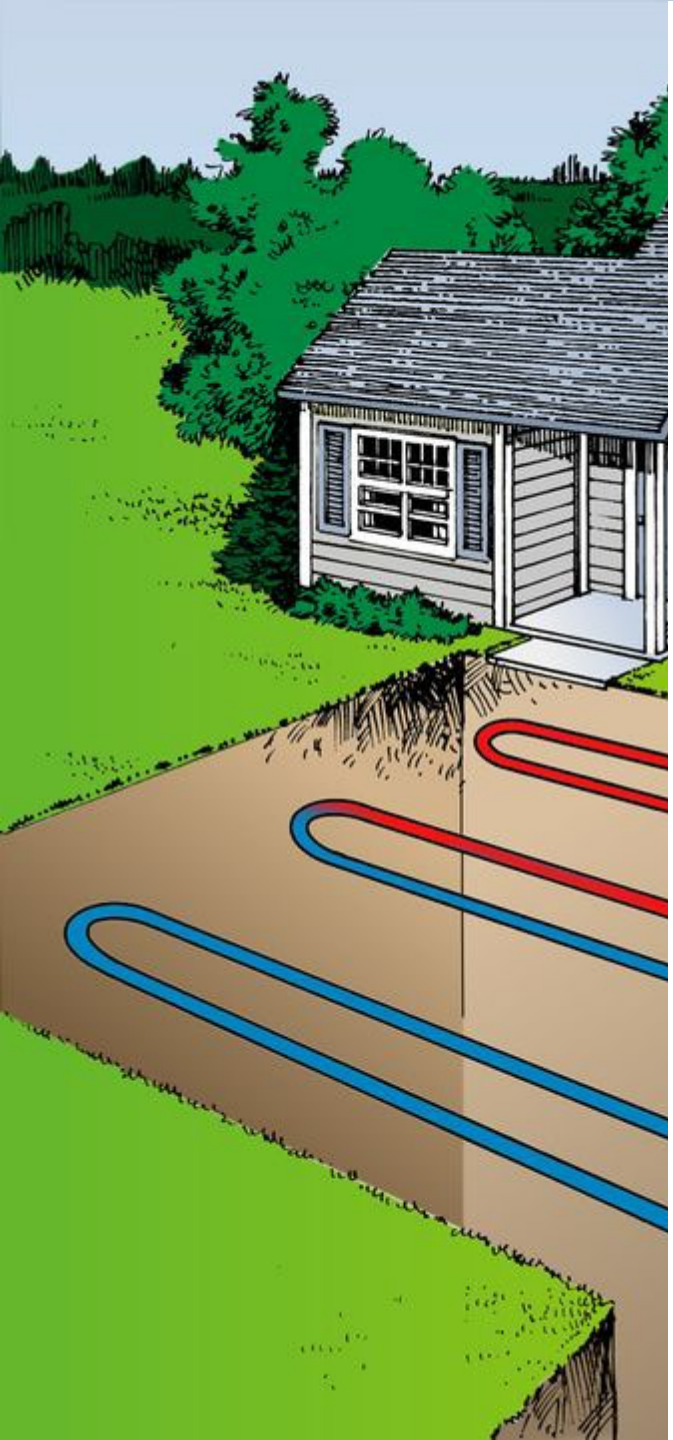

WIPP
NEW
MEXICO
Carlsbad
WIPP


300 m
Salt
655 m



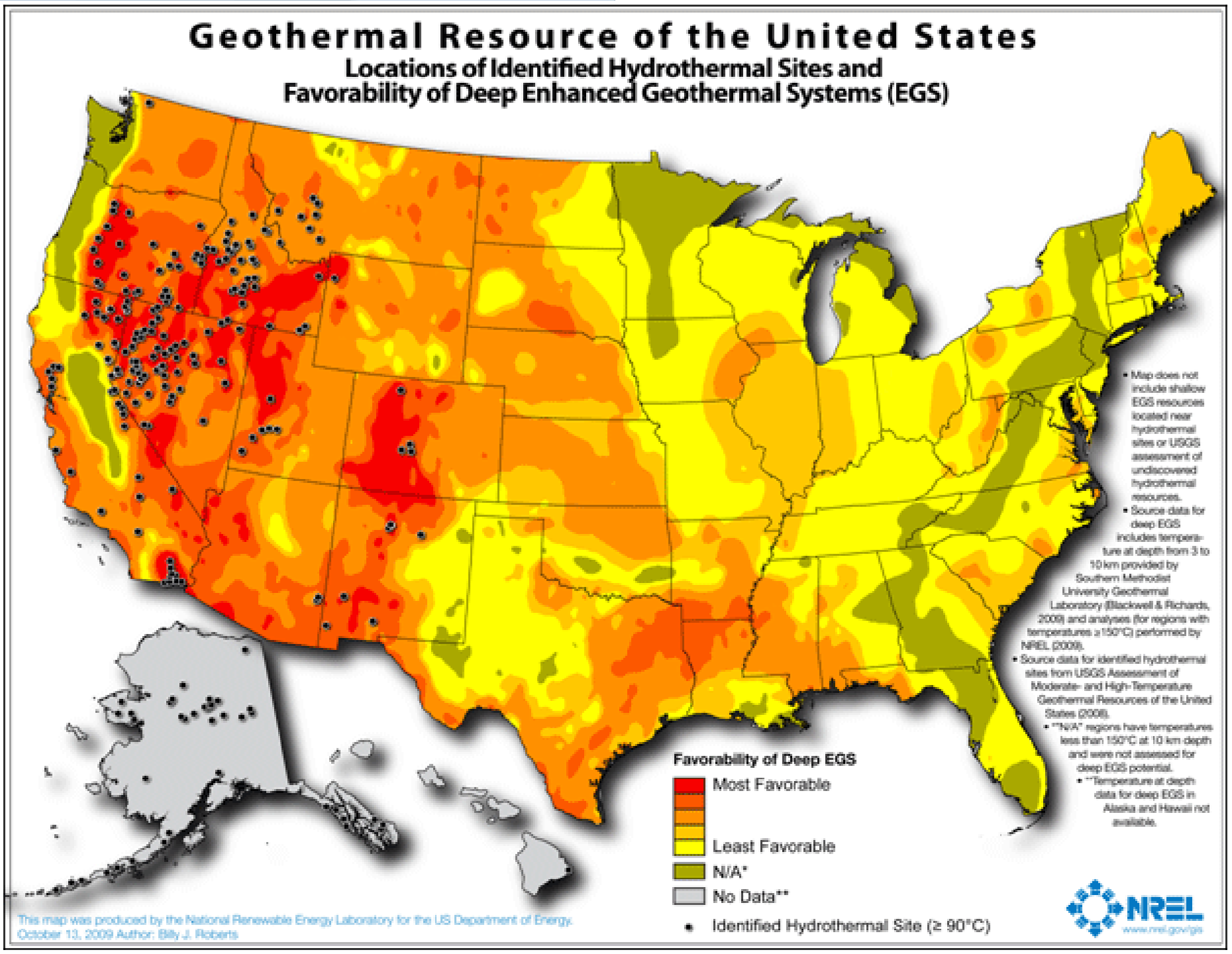
Renewable energies





Geothermal Resource of the United States

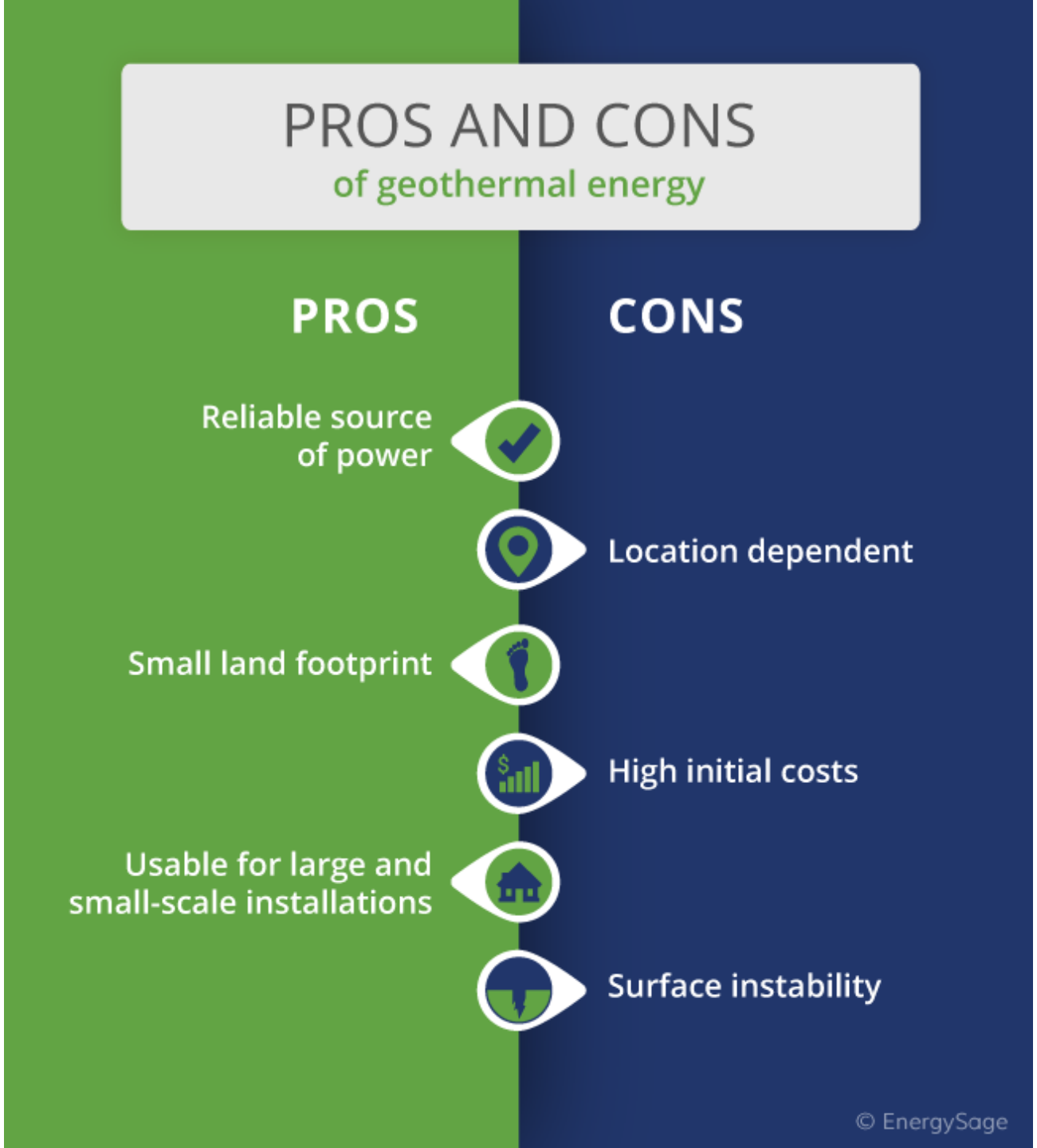
Locations of Identified Hydrothermal Sites and Favorability of Deep Enhanced Geothermal Systems (EGS)

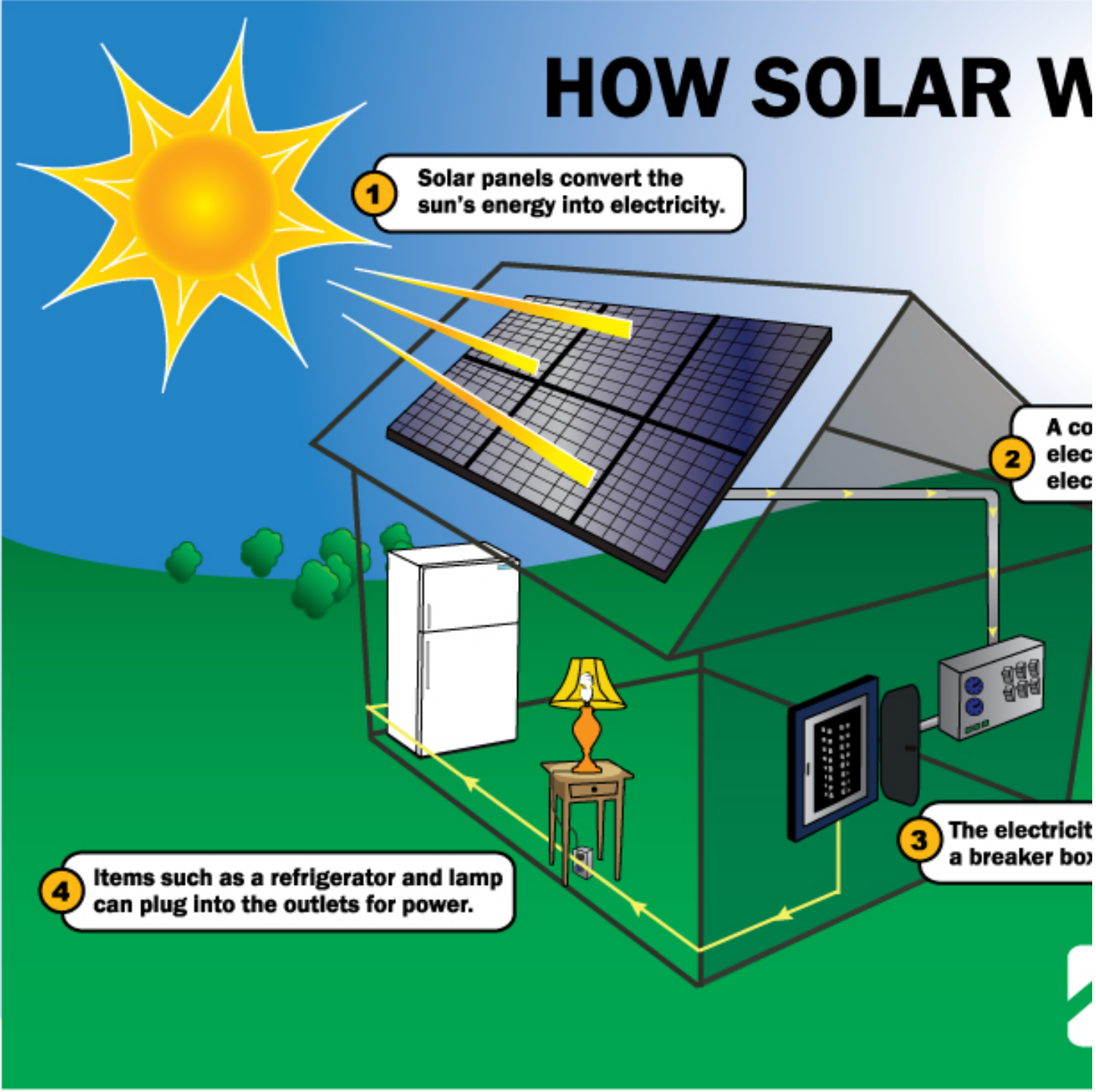


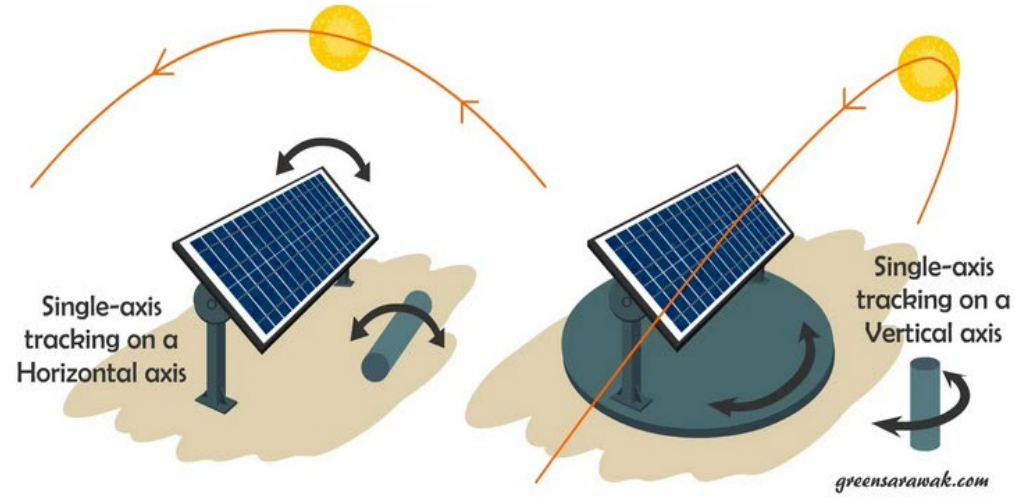
Geothermal issues – Open vs. Closed systems

- Water use and contamination
- Air contamination
- Land use
- Emissions – Climate change

https://www.ucsusa.org/resources/environmental-impacts-geothermal-energy

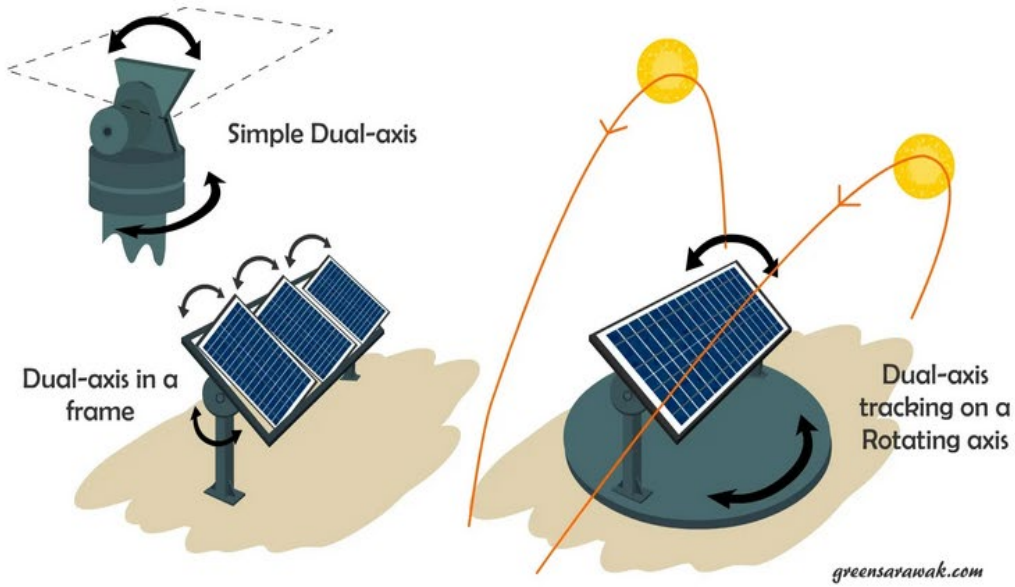


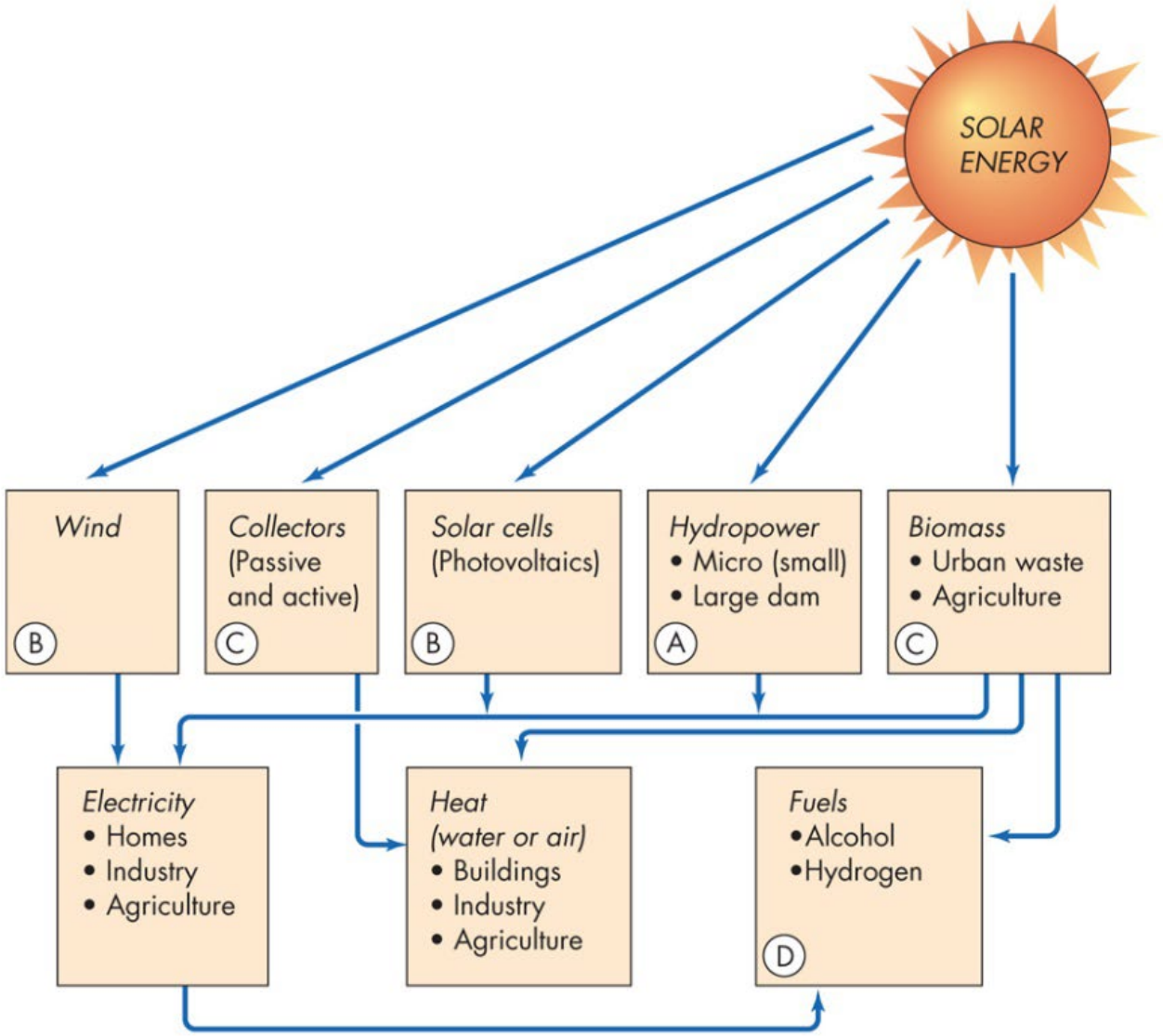




Dual axis solar tracker

This tracker not only tracks the sun as it moves east to west, but also follows it as it moves from north to south. Two axis trackers are more common among residential and small commercial solar projects that have limited space, so they can produce enough power to meet their energy needs.





(A) Produces most electricity from renewable solar energy

(B) Rapidly growing, strong potential; wind and solar are growing at 30% per year!

(C) Used today; important energy source

(D) Potentially a very important fuel to transition from fossil fuels

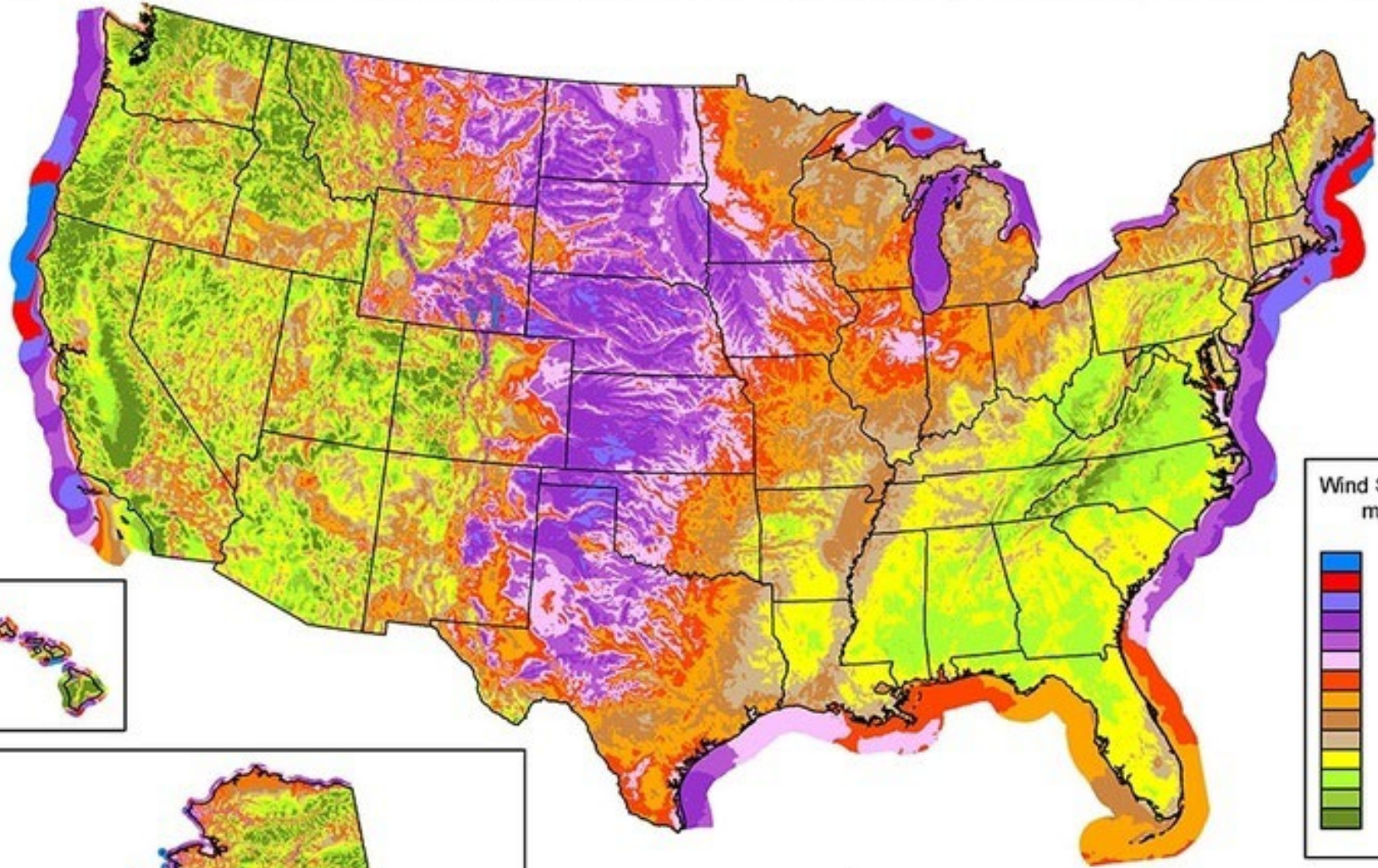

RIVIAN

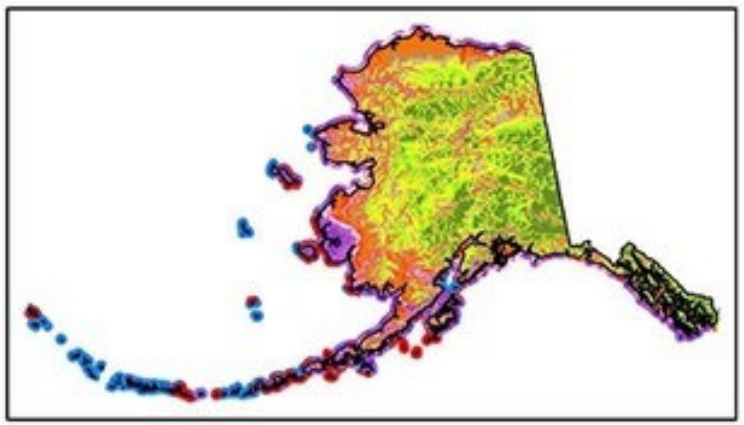
Tengger Desert Solar Park – 1500MW – China

Solar

- Resources - REEs
- Battery storage

United States - Land-Based and Offshore Annual Average Wind Speed at 100 m





Wind Speed
m/s

>10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
< 4.0

Source: Wind resource estimates developed by AWS Truepower, LLC. Web: http://www.awstruepower.com. Map developed by NREL. Spatial resolution of wind resource data: 2.0 km. Projection: Albers Equal Area WGS84.

AWS Truepower™
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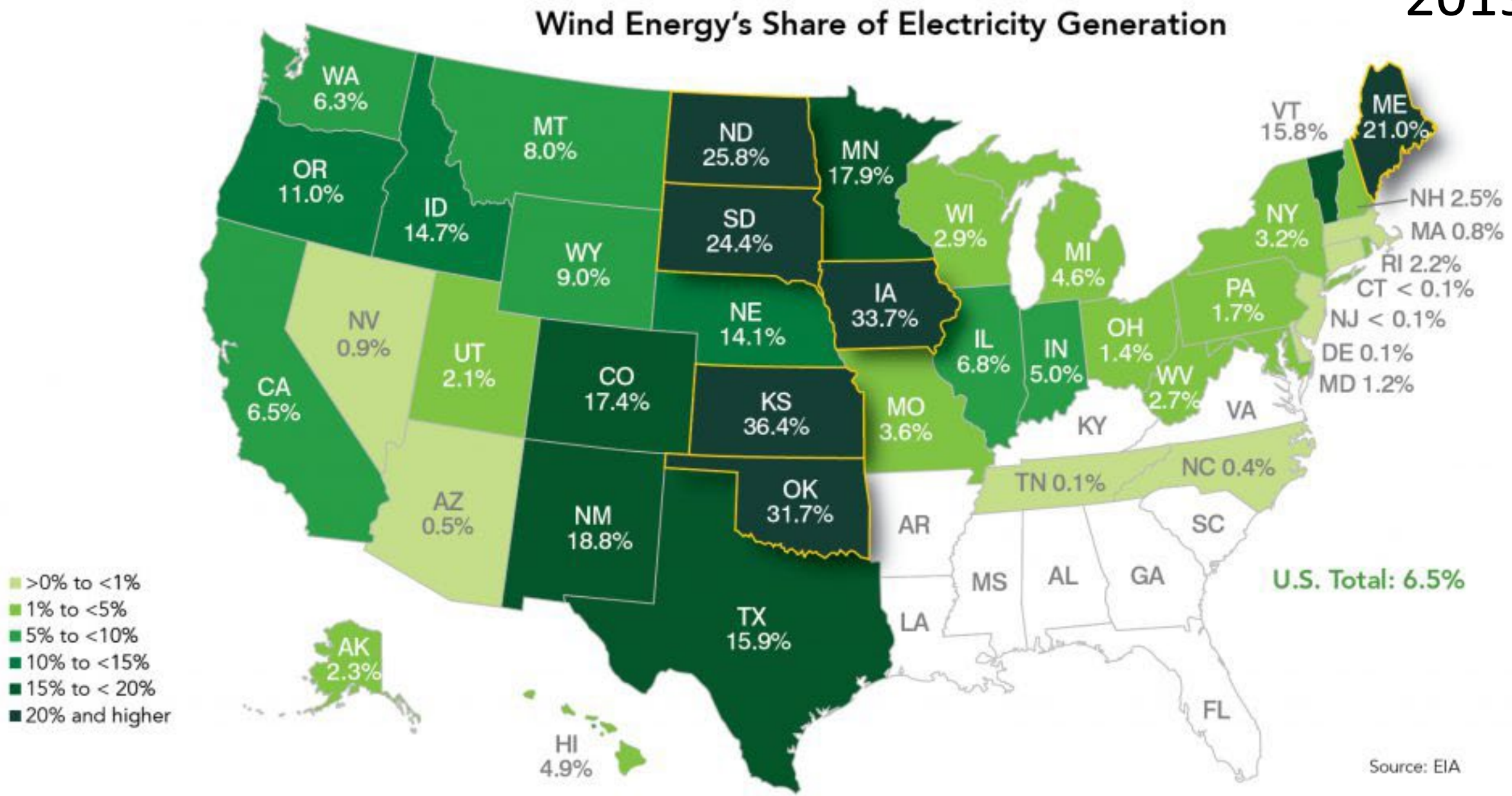
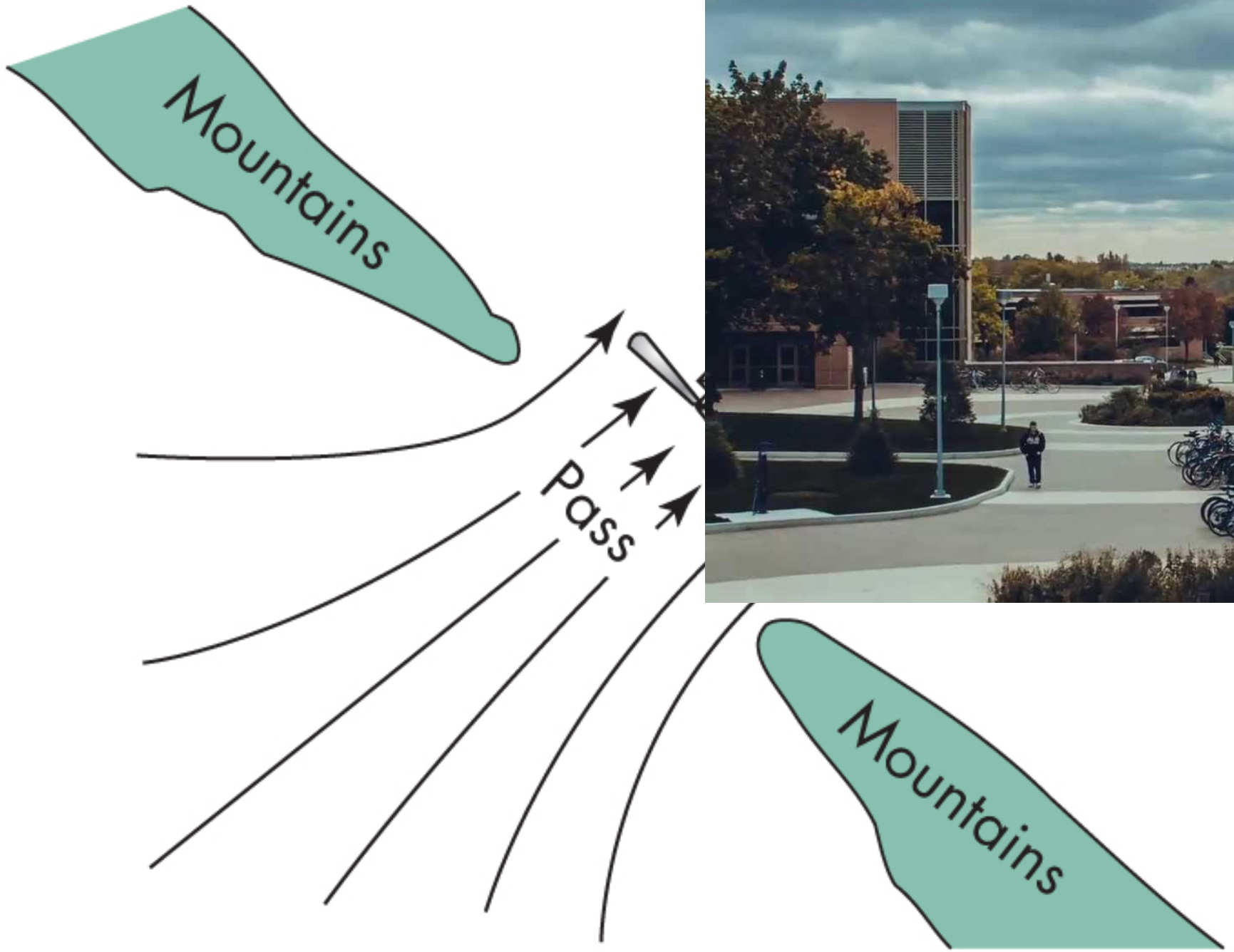
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

2019


Wind Energy's Share of Electricity Generation
WA 6.3%
OR 11.0%
CA 6.5%
ID 14.7%
NV 0.9%
MT 8.0%
WY 9.0%
UT 2.1%
AZ 0.5%
CO 17.4%
NM 18.8%
ND 25.8%
SD 24.4%
NE 14.1%
KS 36.4%
OK 31.7%
TX 15.9%
MN 17.9%
IA 33.7%
MO 3.6%
AR
LA
WI 2.9%
IL 6.8%
MI 4.6%
IN 5.0%
OH 1.4%
KY
TN 0.1%
MS
AL
GA
FL
SC
NC 0.4%
VA
WV 2.7%
PA 1.7%
NY 3.2%
VT 15.8%
ME 21.0%
NH 2.5%
MA 0.8%
RI 2.2%
CT < 0.1%
NJ < 0.1%
DE 0.1%
MD 1.2%
AK 2.3%
HI 4.9%
>0% to <1%
1% to <5%
5% to <10%
10% to <15%
15% to < 20%
20% and higher
U.S. Total: 6.5%
Source: EIA


Mountains
Pass
Mountains

Wind

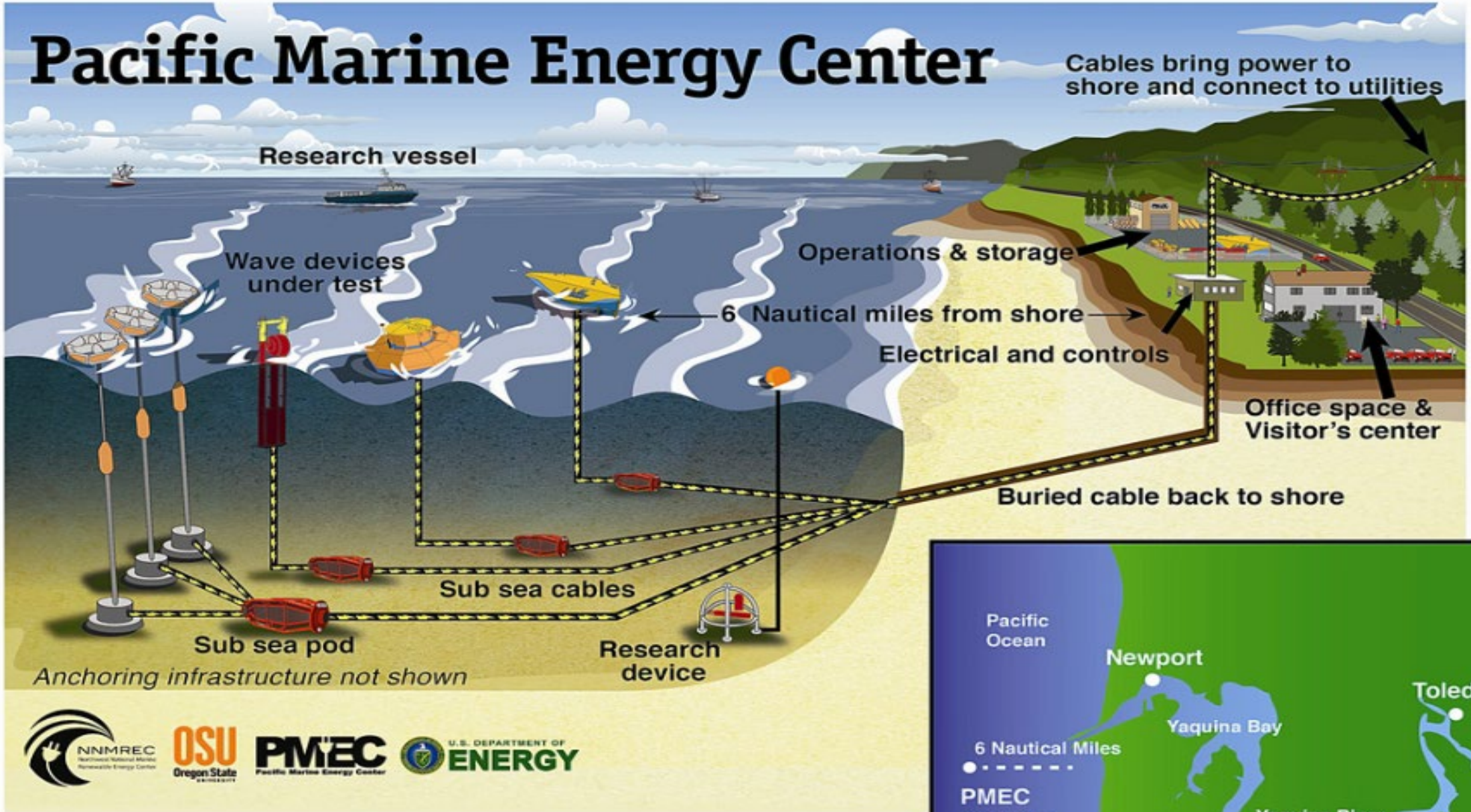
PROS AND CONS
of wind energy

PROS	CONS
Renewable & clean source of energy	Resources and Recycling?
	Intermittent
Low operating costs	
	Noise and visual pollution
Efficient use of land space	
	Some adverse environmental impact

Tama County farmer sues to stop new wind turbine projects

- https://iowacapitaldispatch.com/2022/07/11/tama-county-farmer-sues-to-stop-new-wind-turbine-projects

Pacific Marine Energy Center



NNMREC · OSU Oregon State · PMEC Pacific Marine Energy Center · U.S. Department of Energy

PROS AND CONS
of hydropower

PROS	CONS
Renewable source of energy	
	Some adverse environmental impact
Pairs well with other renewables	
	Expensive up-front
Can meet peak electricity demand	
	Lack of available reservoirs