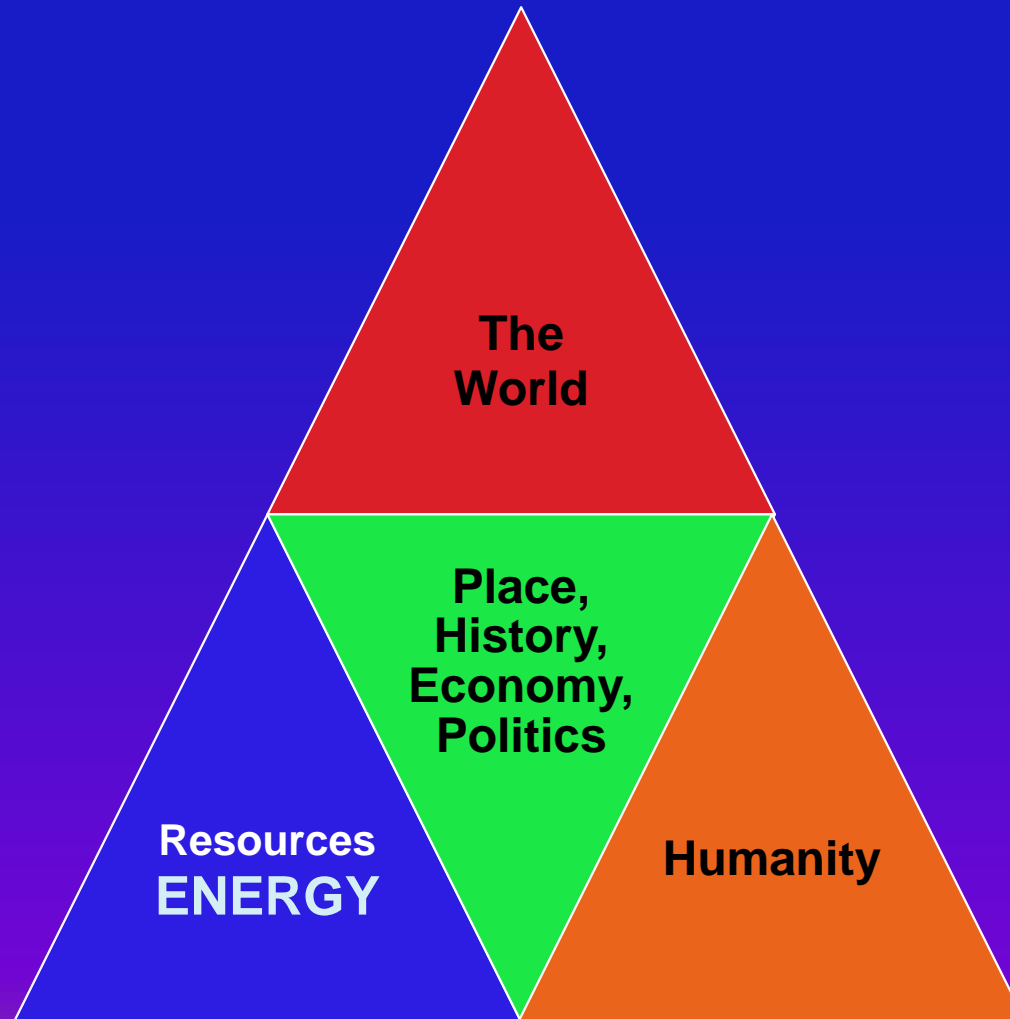


LECTURE # 7

The World, its Resources, and Humankind



ENERGY

Energy - History

Greek: **“Energeia”** means **“activity, operation”**

(I'd add: *“doing things”*)

4th Cent. BC – Aristotle - A philosophical concept

17th Cent. Gottfried Leibnitz – **“vis viva”** (living force)

1807 – Thomas Young – First to use the term “Energy”
conceptually

1843 – **James Prescott Joule** discovered the link
between mechanical work and the
generation of heat

Energy Definition

“The ability of a system to perform work“

“Energy, measured in **joules**, is defined as being the
“Energy transferred to an object by
the mechanical work of moving it a distance of
1m against a force of 1newton”

Newton (Unit of force) = the amount needed to
accelerate 1kilogram of mass at the rate of 1meter per
second squared

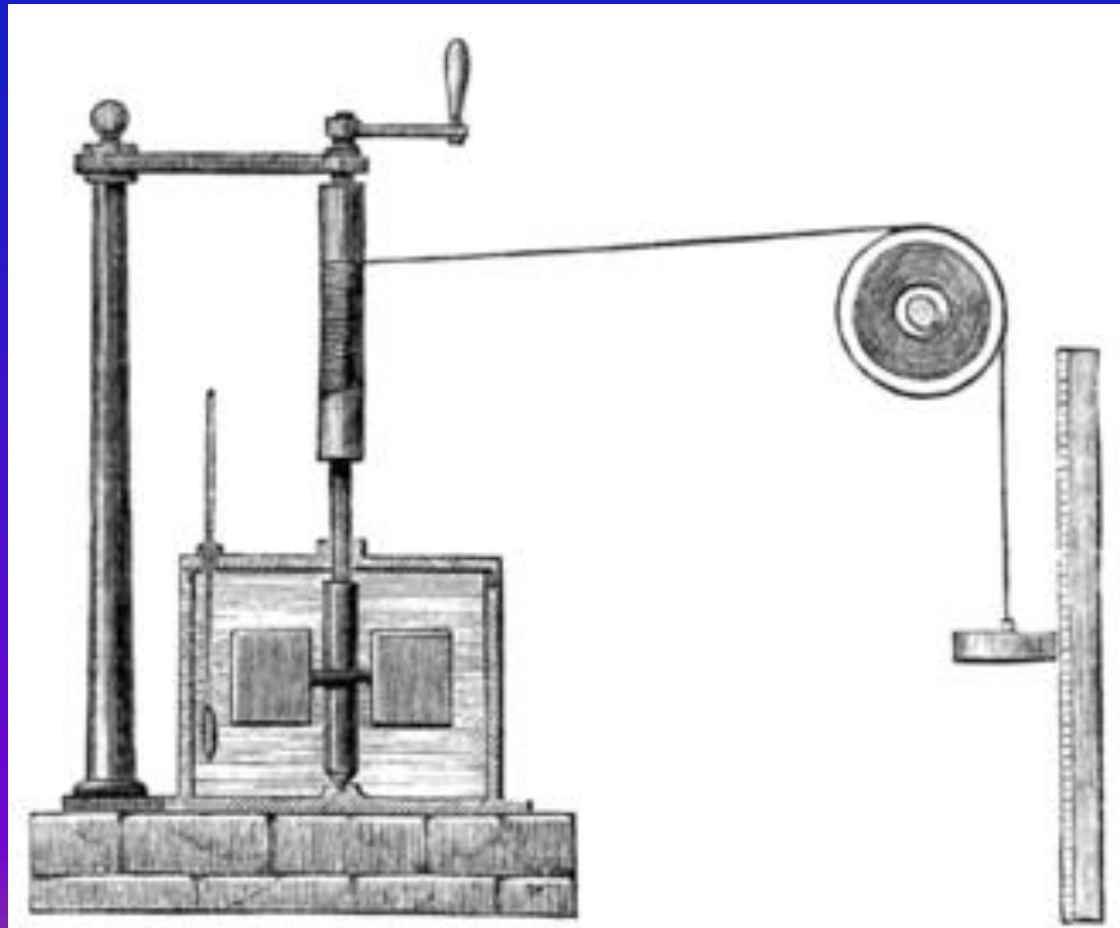
Types of Energy

1. Kinetic
2. Mechanical
3. Chemical
4. Thermal
5. Electric
6. Magnetic
7. Radiant (light, sound)
8. Nuclear
9. Ionization
10. Elastic
11. Gravitational

It's impossible to create or destroy energy
Energy transforms: e.g., heat energy \Rightarrow electric energy

“Joule's Apparatus” for Measuring the Mechanical Equivalent of Heat (1843)

A Descending Weight Attached to a String Causes a Paddle Immersed in Water to Rotate and to Generate Heat



Albert Einstein's Rest Mass Energy (1905)

$$E = mc^2$$

Energy = Mass x speed of light (Speed of light =
299,792,458 meter/second, or about 670,616,629 mph)

**Every mass must possess energy even at rest. This is
proportional to the mass**

Energy Transformation

Energy may be transformed btw. different forms

The system acting btw. the forms of energy is called
a **transducer**

A **battery** – Chemical to electric energy

A **dam** – Gravitational potential energy \Rightarrow
kinetic energy of moving water \Rightarrow
moving the blades of a turbine \Rightarrow
electric energy

Lightning Strike

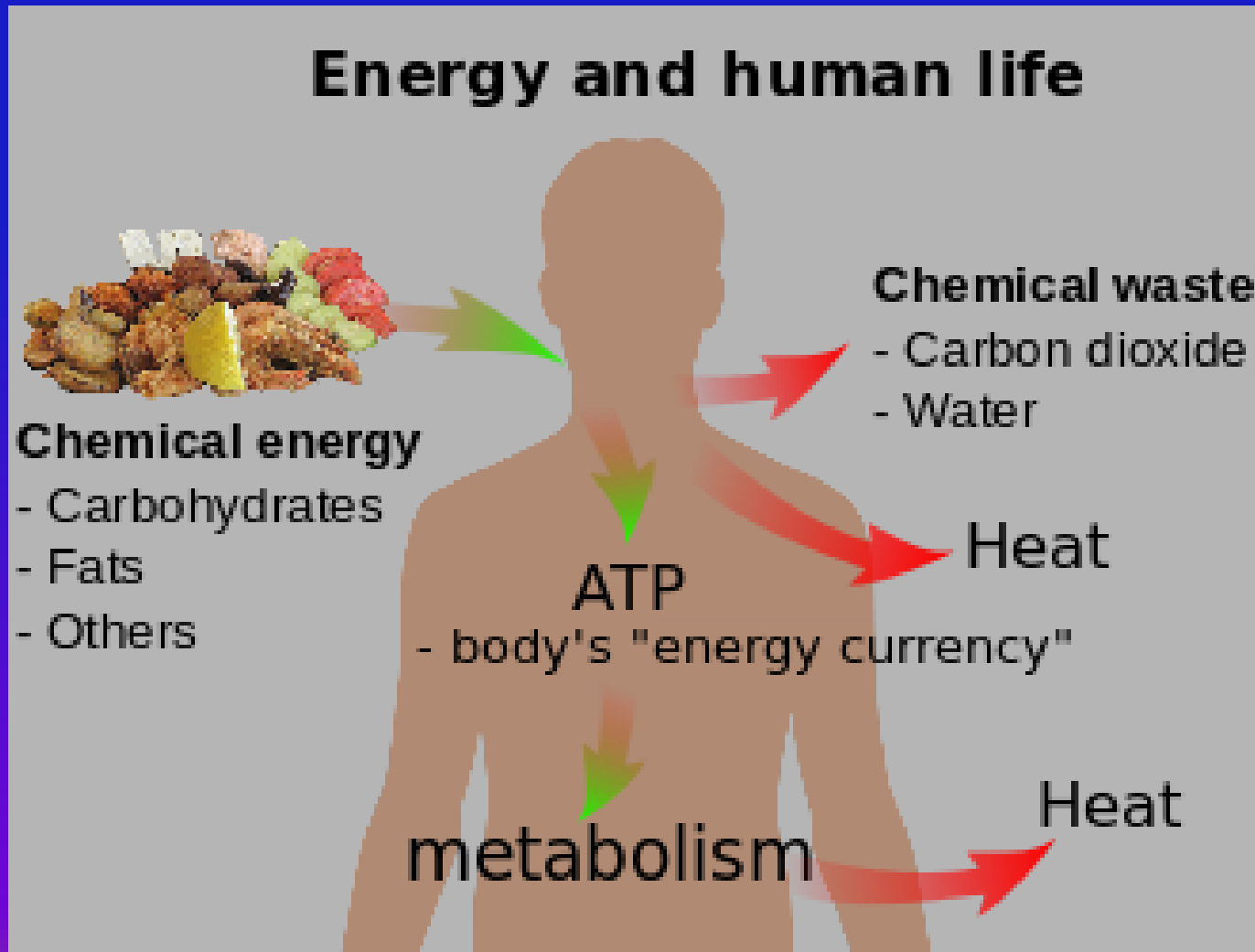
500 Megajoules of Electric Potential Energy is Converted into the Same Amount of Energy in other Forms, mostly Light Energy, Sound Energy, and Thermal Energy



Generator Transforms Steam into Electrical Energy



Energy and Human Life



ENERGY RESOURCES

Fossil

Coal

Oil

Gas

Renewable

Solar

Wood/Forests

Hydraulic

Wind

in Development

Nuclear

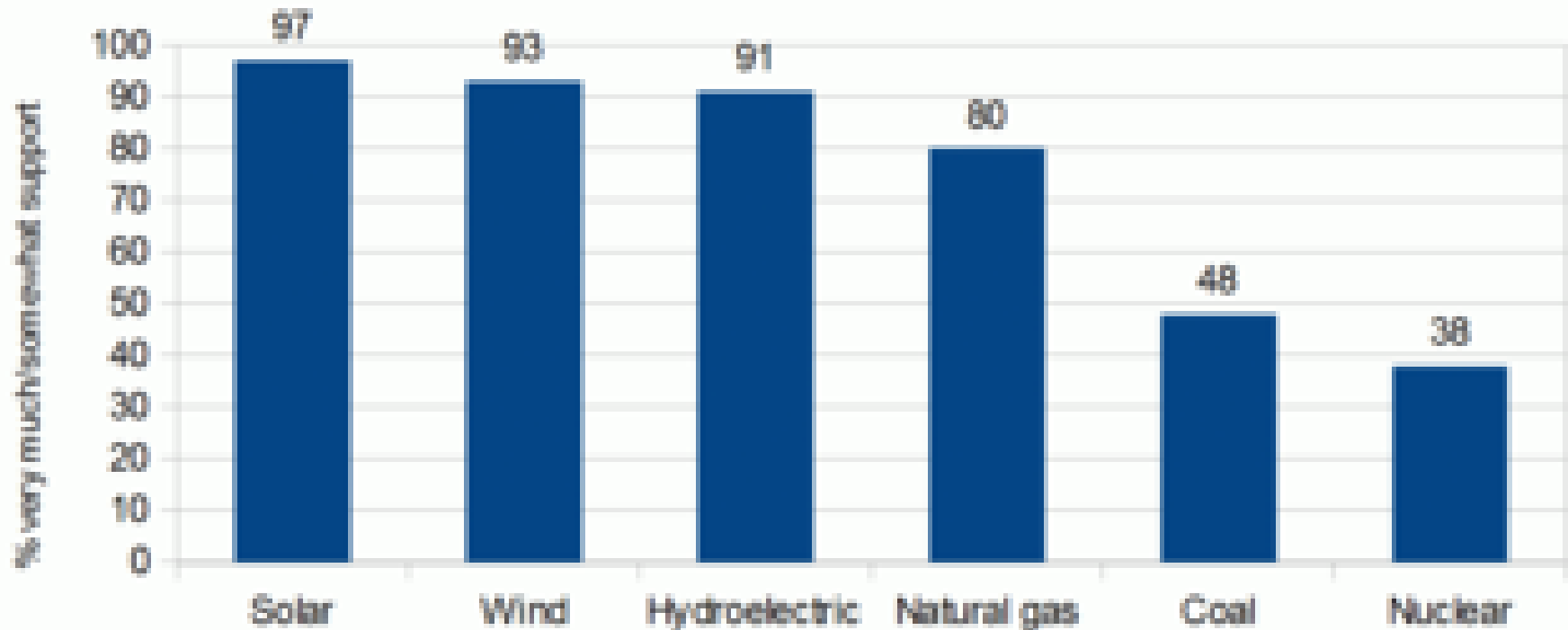
Geothermal

Biomass

Biogas

Global public support for energy sources

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

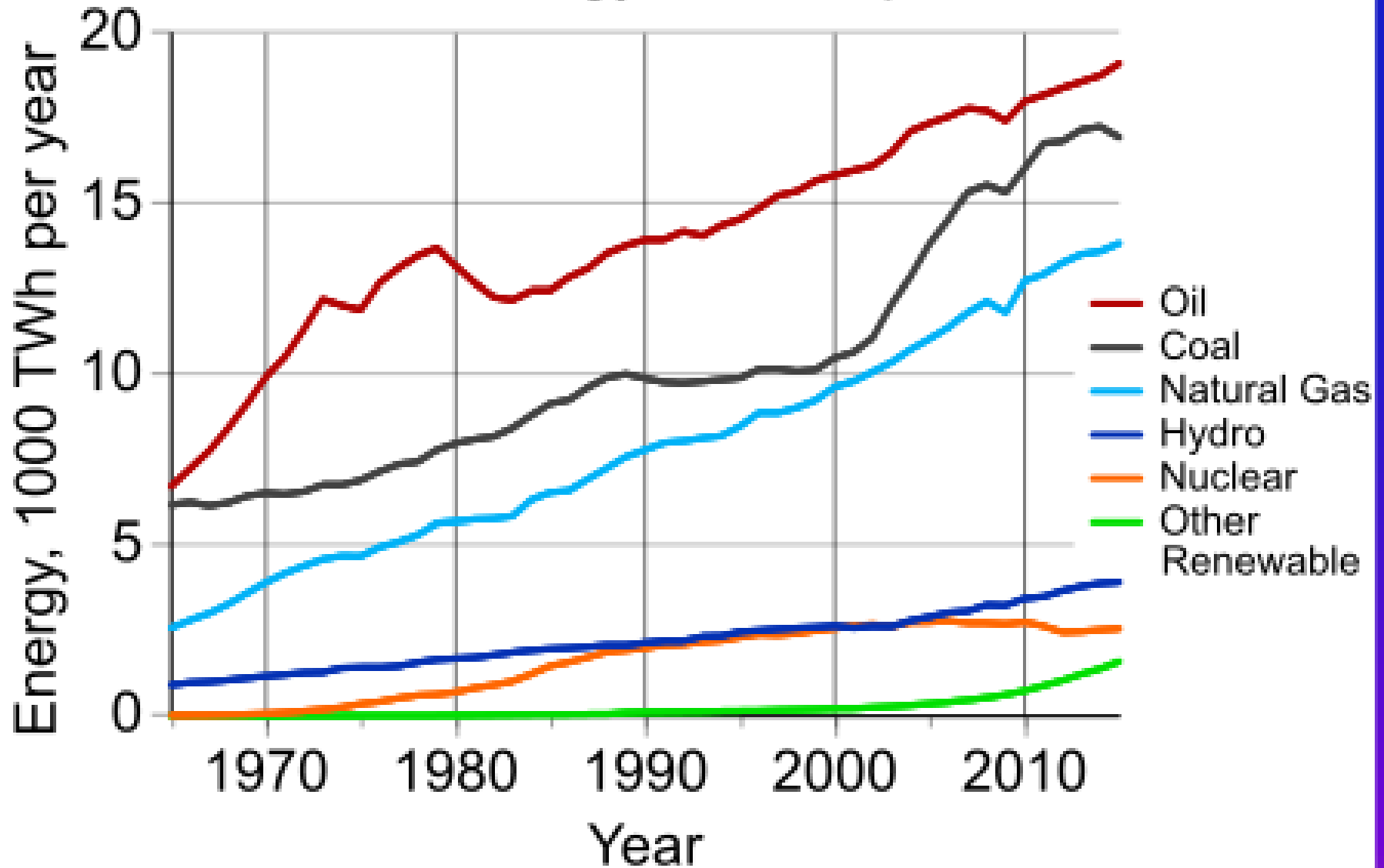


Source: Ipsos, May 2011

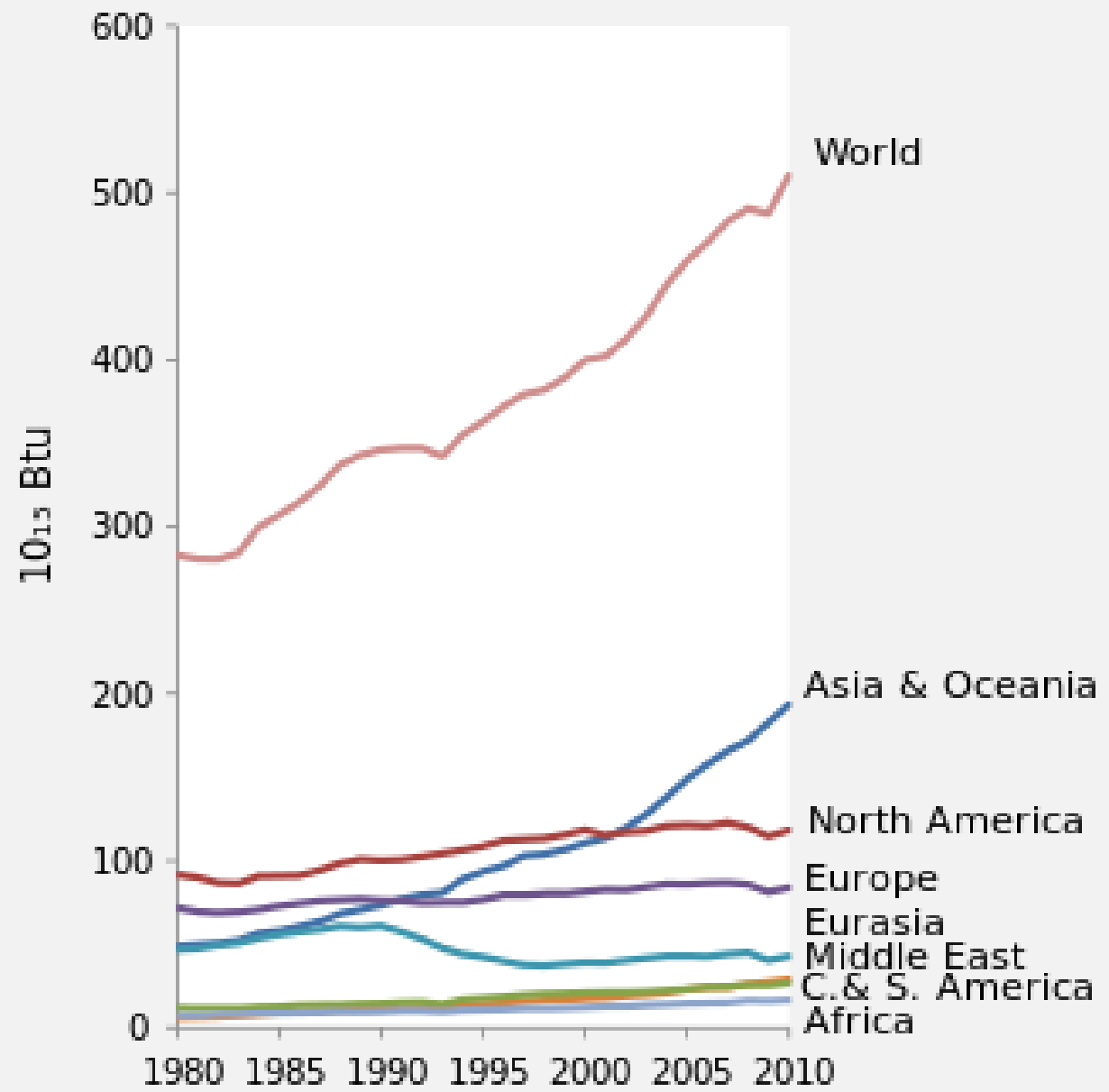
World Consumption of Fuels in 2012

Oil	40.7%
Electricity	18.1%
Natural gas	15.2%
Biofuels and waste	12.4%
Coal/Peat/Shale	10.1%
Others (renewable)	3.5%

World energy consumption



Annual Energy Demand by Region



COAL (Carbon = C)

Coal Formation and Uses

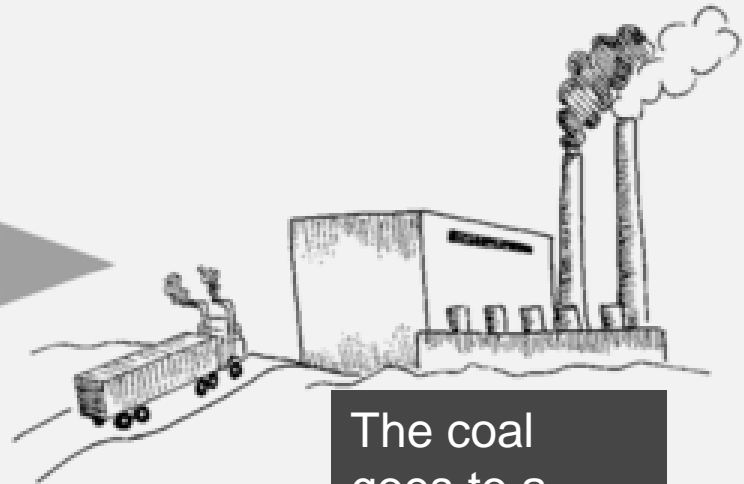
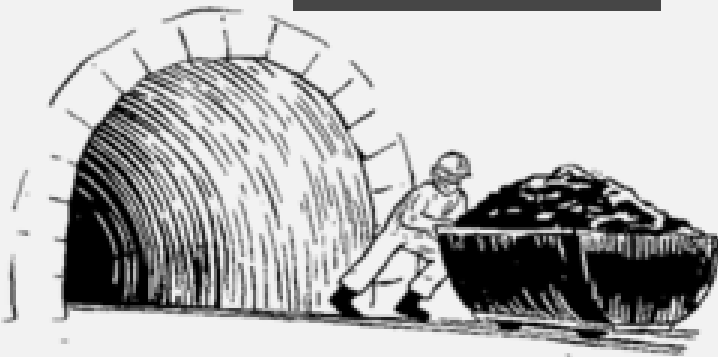
Volcanic activity ⇒ dead forests in wetlands ⇒
buried under soil ⇒
pressure of soil ⇒
carbonization ⇒ peat ⇒ lignite ⇒
sub-bituminous coal ⇒
bituminous coal ⇒
anthracite
graphite

Uses: - Heating

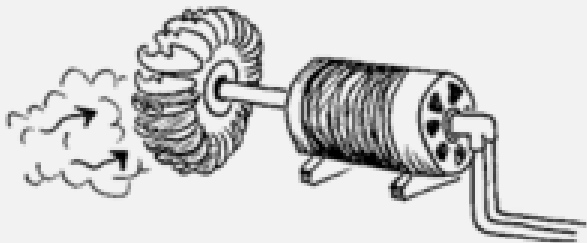
- Fuel for generation of electric power (40%
made with coal)

Coal Mining ⇒ Energy

Coal is dug from the earth

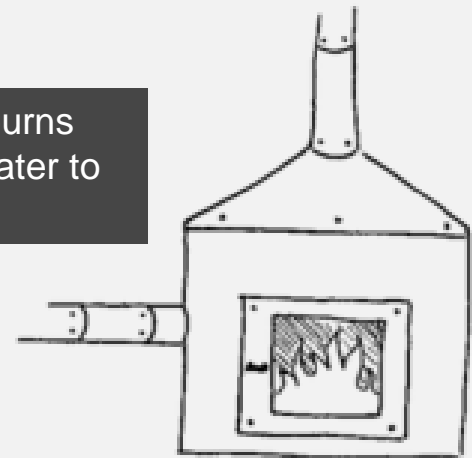


The coal goes to a power plant



The steam turns a machine called a turbine, which makes an electric current

The power plant burns the coal to heat water to make steam



Proved Coal Reserves - 2011 (in million tons)

Country	Amount	% of World Total
USA	237,295	22.6
Russia	157,010	14.4
China	114,500	12.6
Australia	76,400	8.9
India	60,600	7.0

Coal – Production and Uses

1947 – 750,000 miners in Britain, 2004 - only 5000

2001 – China – 50% of world production

USA, India, EU, Australia

Largest importer – Japan

Uses: Heat

Electricity – 40% world's electricity. USA coal use is declining since 2012

Petro-Chemicals – increasing output due to **gasification** ⇔ **syngas** ⇔ **electricity**

Coal as Fuel to Generate Energy

Fuel

Coke

Gasification

Liquefaction

Production of Chemicals

2012 World (Civil) Electricity Generation by Fuels

Coal/Peat	40.4%
Natural Gas	22.5%
Hydro	16.2%
Nuclear fission	10.9%
Oil	5.0%
Renewable	5.0%

COKE

Coke = solid residue derived from bituminous coal,
baked in an oven at 3,600°F

High carbon content, few impurities.

Produced in “beehive” furnaces coal \Rightarrow coke

Uses: Fuel and reducing agent in smelting iron ore

Fine heating fuel. No smoke.

Used to make “**producer gas**” (CO + N₂)

High shielding properties – space craft

Production of Syngas

Gasification and Petrochemicals

Coal + oxygen + steam – Heated under pressure

Oxygen and water molecules oxidize coal \Rightarrow CO + H₂ =

“**SYNGAS**” used to fire engines \Rightarrow **electricity**

Syngas \Rightarrow **gasoline and diesel**

Syngas \Rightarrow **methanol** \Rightarrow **gasoline**

Since 1950s - **Petrochemicals: Olefins, acetic acid, formaldehyde, ammonia, urea, etc.**

“Black Lung” Disease

Anthracosis = “Black lung” disease of the miners

Coal particles are inhaled and deposited into the bronchi (wind pipes) lining and into the lungs, causing a fibrous (scar tissue) reaction and restriction of gas exchanges

Severe chronic lung disease ⇒ Death

Anthracosis

[Coal Workers Pneumoconiosis (CWP) or Black Lung Disease]

Federal Coal Mine Health and Safety Act of 1969 ⇒
“Black Lung Disability Trust”

Anthracosis reduced by 90% but recent increase
reported

New data - 2% of surface miners (48% of workforce)
develop CWP after one year of work

Normal and “Black Lung” in Anthracosis



OIL

2012 World (Civil) Electricity Generation by Fuels

Coal/Peat	40.4%
Natural Gas	22.5%
Hydro	16.2%
Nuclear fission	10.9%
Oil	5.0%
Renewable	5.0%

PETROLEUM (OIL)

Definition: A fossil fuel formed by decomposition of dead organisms, buried underneath earth's crust rock under high pressure and heat. Kerogen \Rightarrow liquid \Rightarrow gas

Hydrocarbons: Heavy are liquid; Lighter are gaseous: methane, ethane, propane, and butane

Fractional distillation \Rightarrow components

- Internal combustion for engine - gasoline
- Commercial aviation
- Industrial chemical industry
- Synthesis of plastics
- Fertilizers, insecticides
- Electricity

PETROLEUM & NATURAL GAS FORMATION

OCEAN
300-400 million years ago



Tiny sea plants and animals died and were buried on the ocean floor. Over time, they were covered by layers of silt and sand.

OCEAN
50-100 million years ago



Over millions of years, the remains were buried deeper and deeper. The enormous heat and pressure turned them into oil and gas.



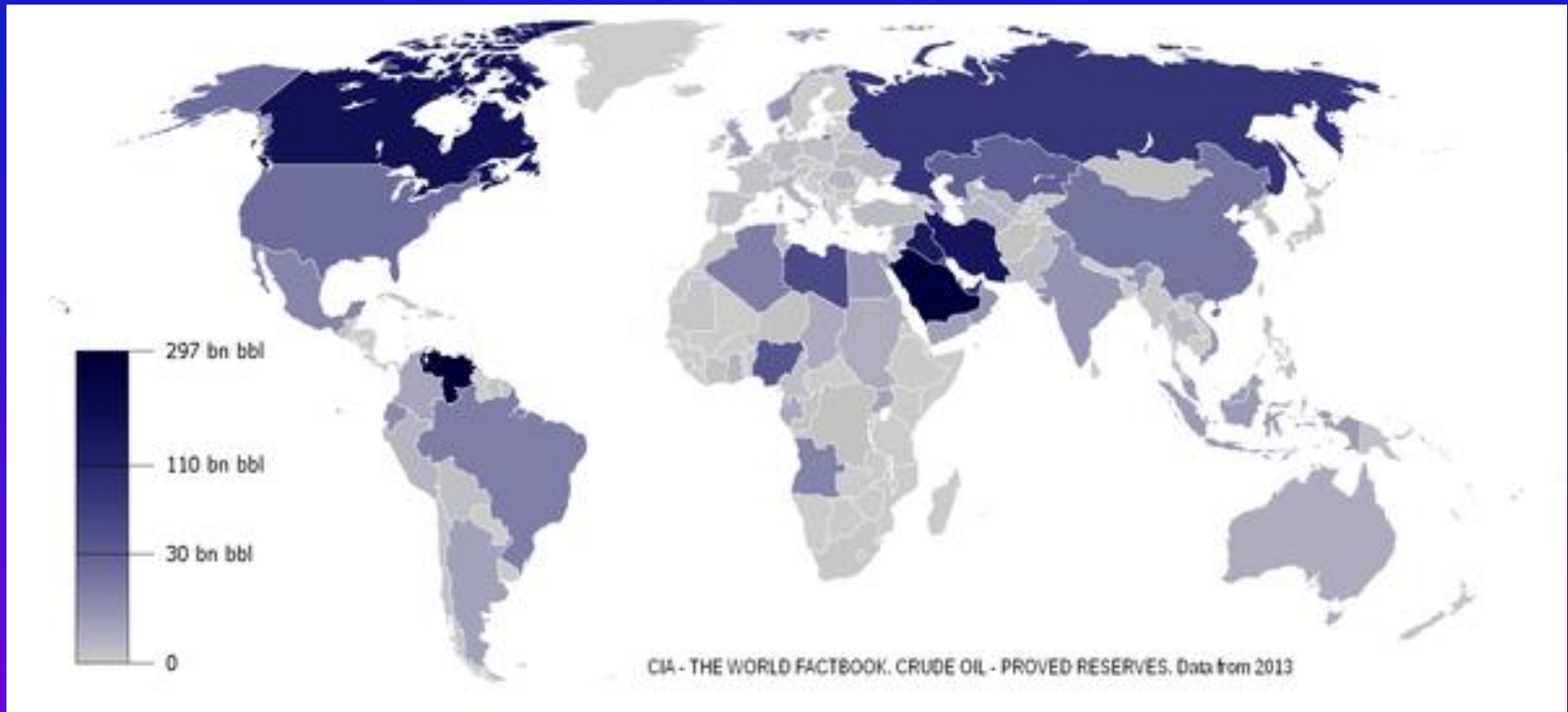
Sand & Silt
Rock

Oil & Gas Deposits

Today, we drill down through layers of sand, silt, and rock to reach the rock formations that contain oil and gas deposits.

OIL

Proven World Oil Reserves, 2013



Petroleum - History

2,400 BC – Asphalt used in the construction of Babylon

347 CE – Oil from bamboo-drilled wells in China

1,745 – Pechelbronn, NE France – Oil sands mined

1,795 – Hand-dug wells in Myanmar

1,848 – J. Young – seepage of oil in Scotland

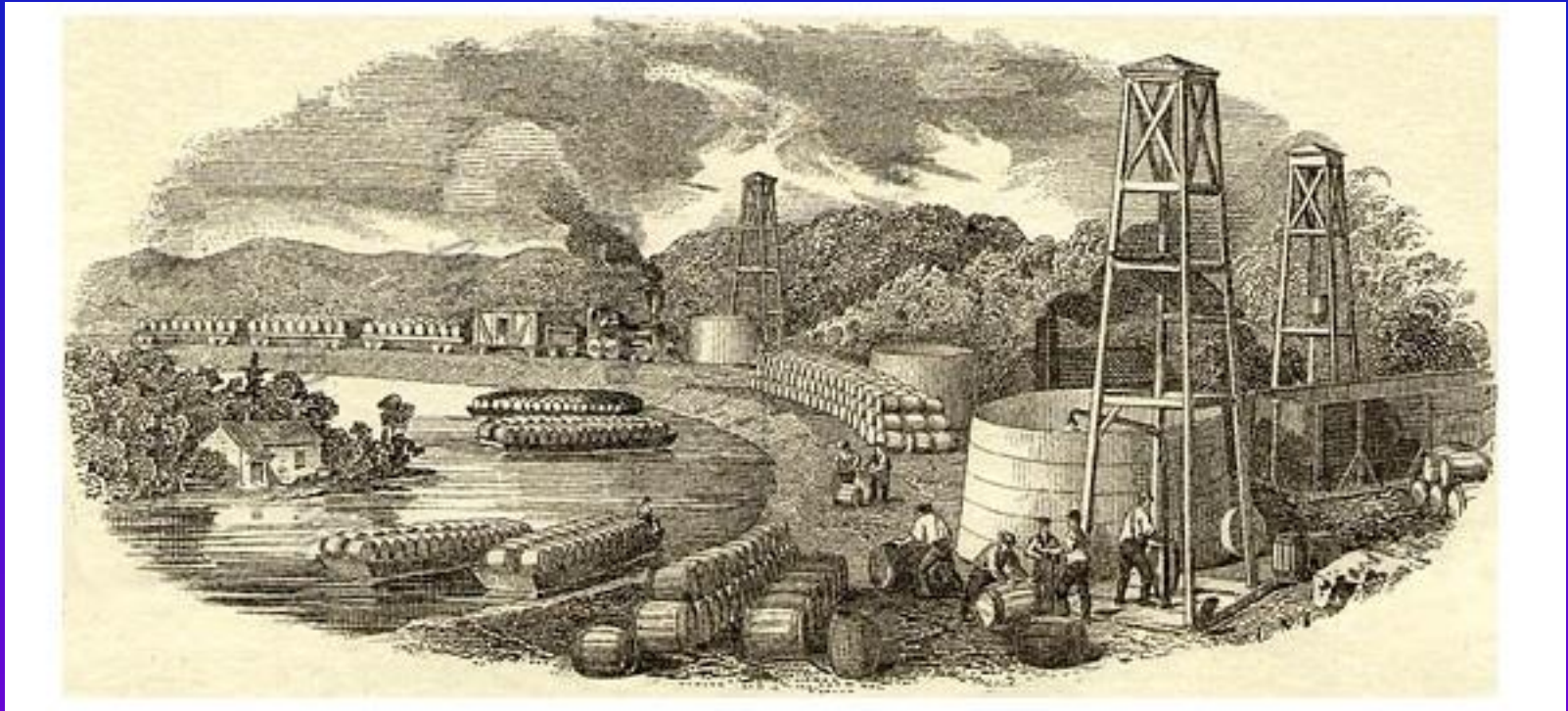
1,851 – First oil refinery – Scotland

1,857 – First oil well and refinery – Romania

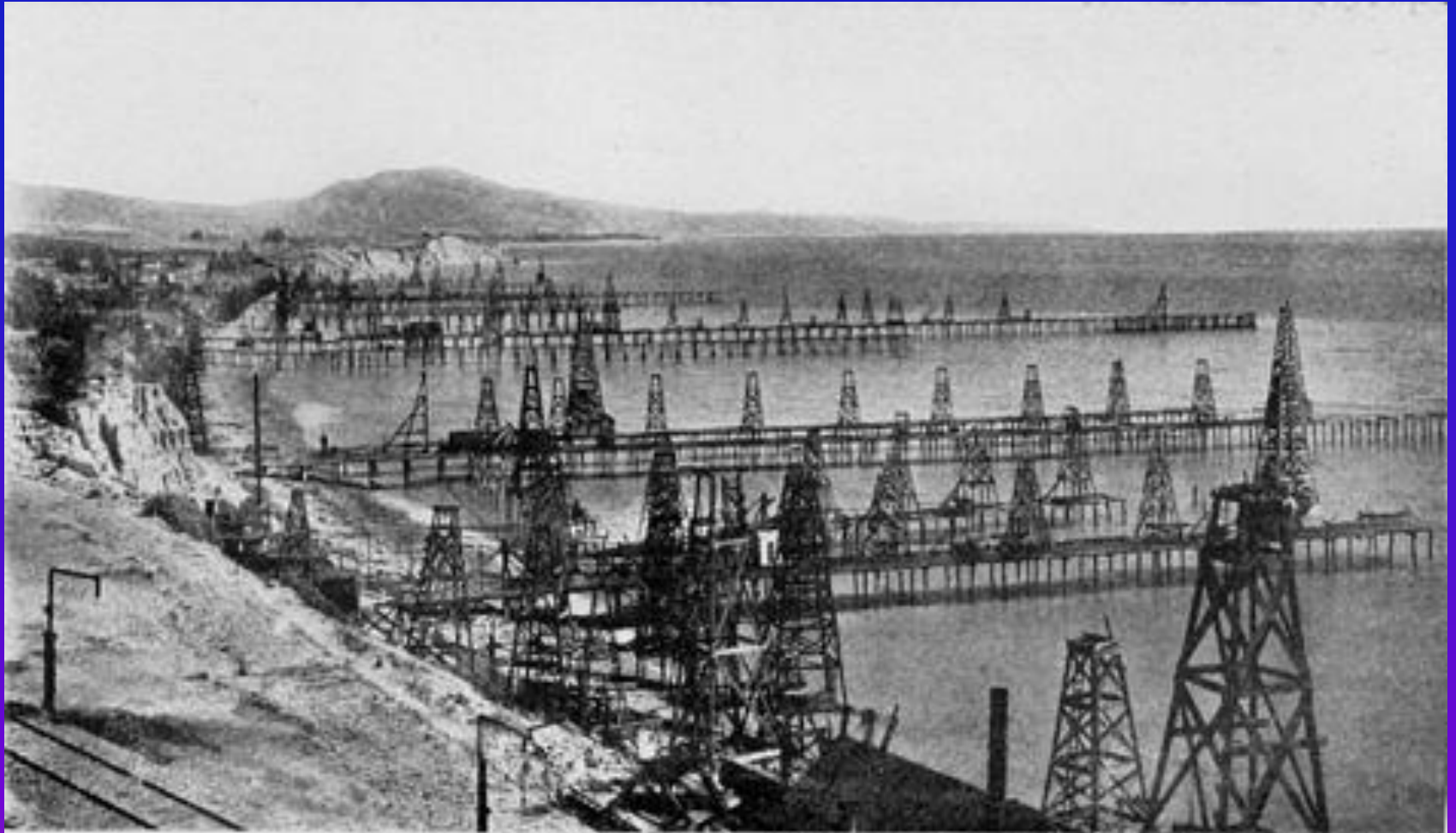
1,859 – **First modern well – Titusville, PA** – The 42-gallon barrel was introduced (300 pounds)

1,872 – “Barrel” measure adopted for oil

Oilmen Decided a 42-gallon Barrel was Best for Transporting Oil - 1872



An Oil Field with Dozens of Wells, Santa Barbara, CA, 1906



Oil Derrick in Oklahoma - 1922



Ansel Adams' "Angel of Sorrows" in the Sunnyside Cemetery, Signal Hill - 1939



The Coastline of Huntington Beach - 1940

LA Times November 1, 2016



Pumpjack of an Oil Well in Texas



Offshore Platform Holly South Ellwood Field, CA



Hydraulic Fracturing (Fracking)

Definition: A technique of increasing the oil/gas capture.

Rock is fractured by pressurized water, steam, and sand.

Started in 1947. More than 2.5 Million fracking operations in the world. More than 1 Million in USA.

Highly controversial.

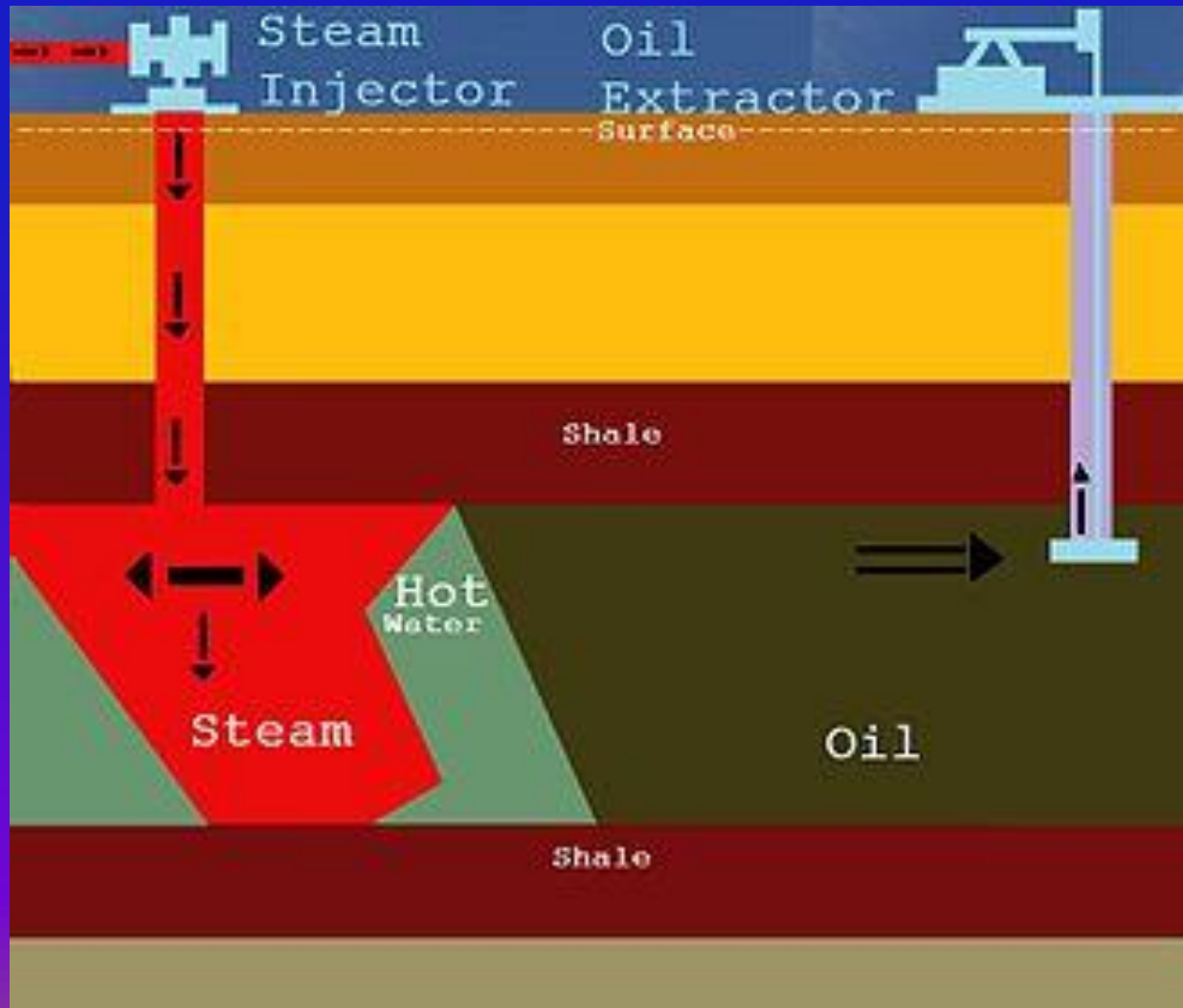
Pro: Economic benefits of increased production

Con: Environmental impacts

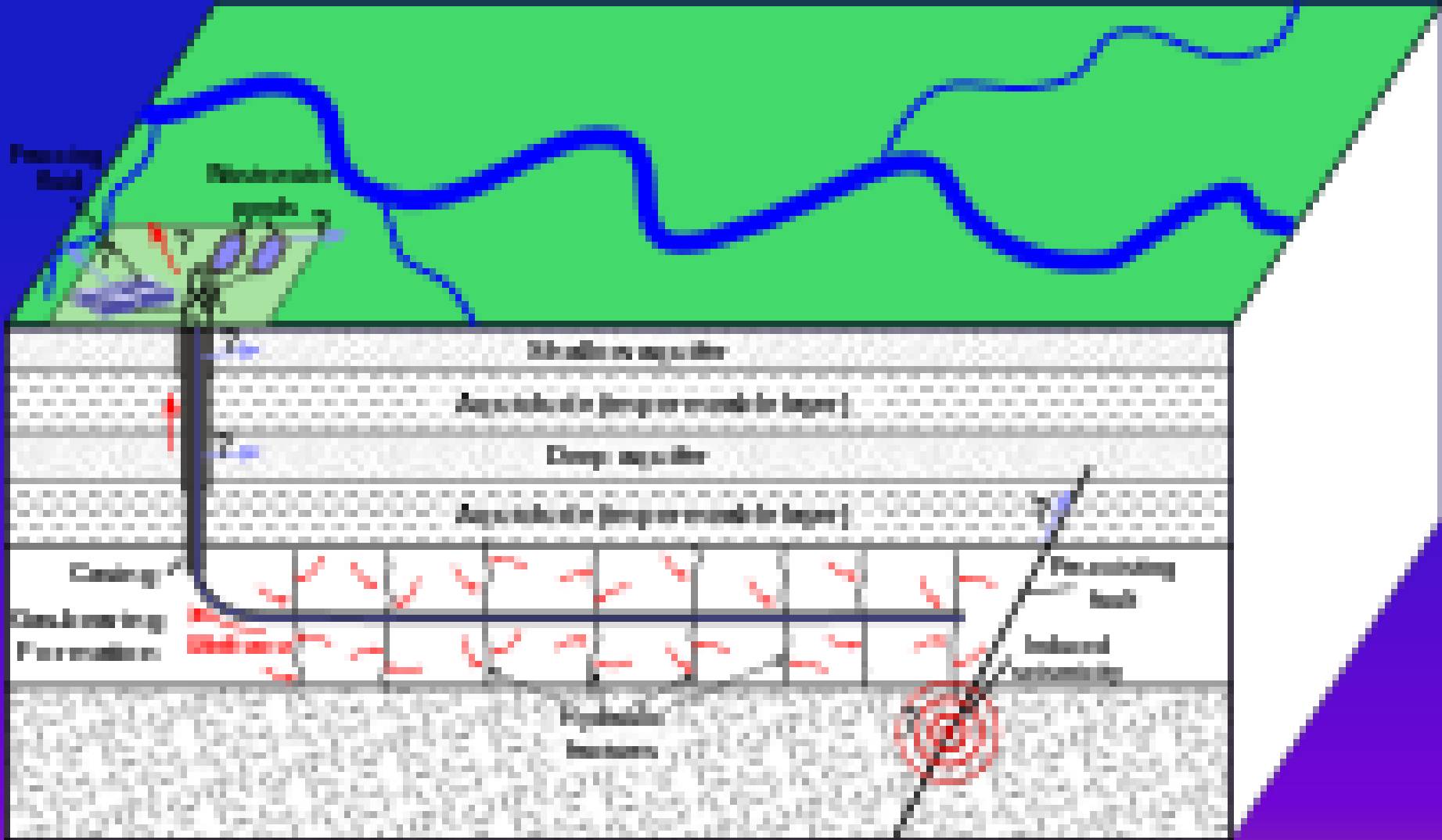
Contamination of water sources ⇔ Health hazards

Increased seismic activity

Steam is Injected into Oil Fields where the Oil is Thicker than Normal Oil



Hydraulic Fracturing (Fracking)



Fracking And Earthquakes – TIME, March 21, 2016

Nation

In 2007, Oklahoma had one earthquake. Last year, there were more than 900. What happened? **Greed, politics and the biggest oil boom in decades**

BY JOSH SANBURN/OKLAHOMA CITY

Fracking, Society, and Politics

- World opposition to fracking
- Protests
- Press activism

Politicizing Fracking

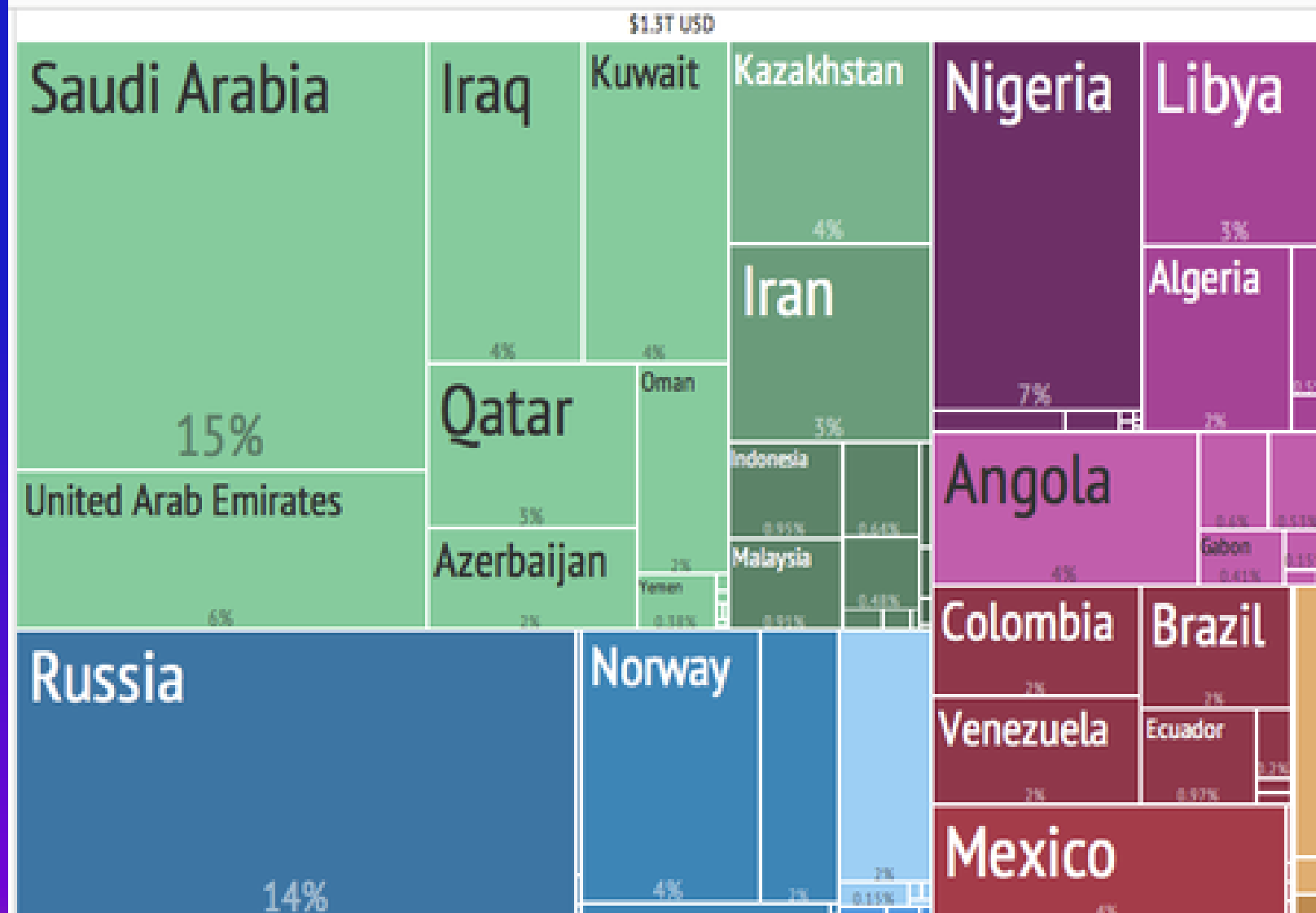
Russia against fracking in Eastern Europe. Why?

1. More gas in Eastern Europe countries ⇨
2. Less dependence on Russia gas supply ⇨
3. Decrease Russia's geopolitical influence

World Share of Production

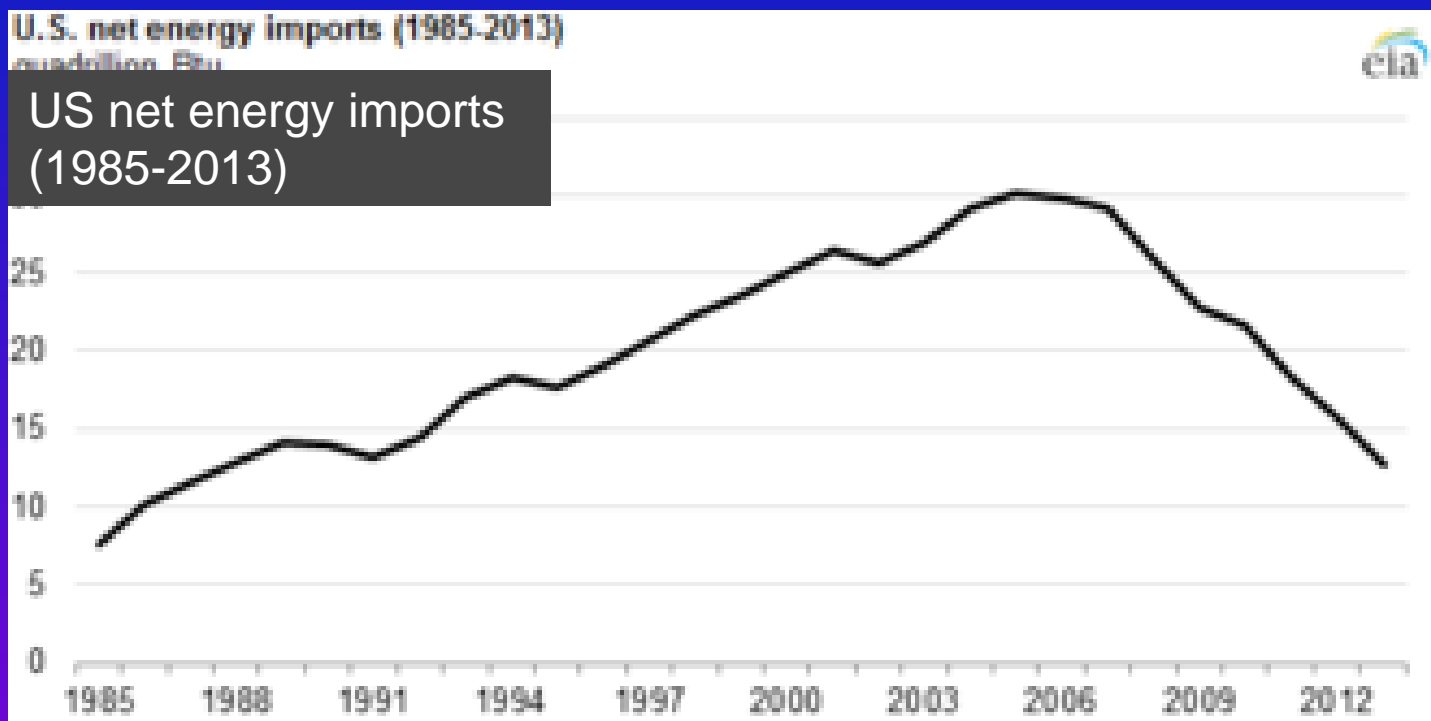
Country	10³bbl/d	% Share
Russia	9,934	12.0%
Saudi Arabia (OPEC)	9,760	11.8%
United States	9,141	11.1%
Iran (OPEC)	4,177	5.1%
China	3,973	4.8%
Canada	3,350	4.0%
Mexico	3,185	3.6%
UAE (OPEC)	2,795	3.4%

Who exported Petroleum oils, crude in 2012?



Oil Consumption

World consumes 30 Billion barrels of oil/year

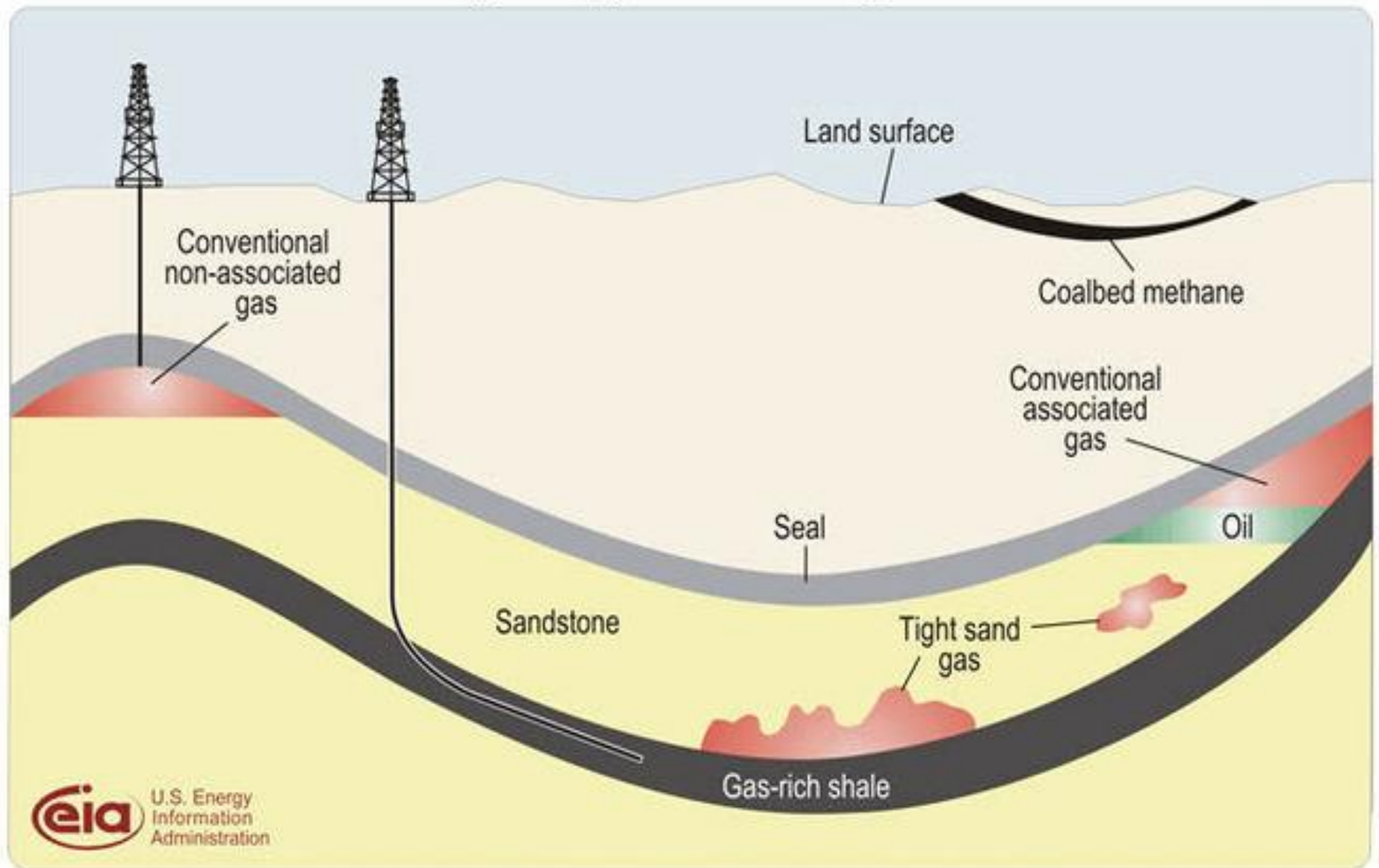


NATURAL GAS

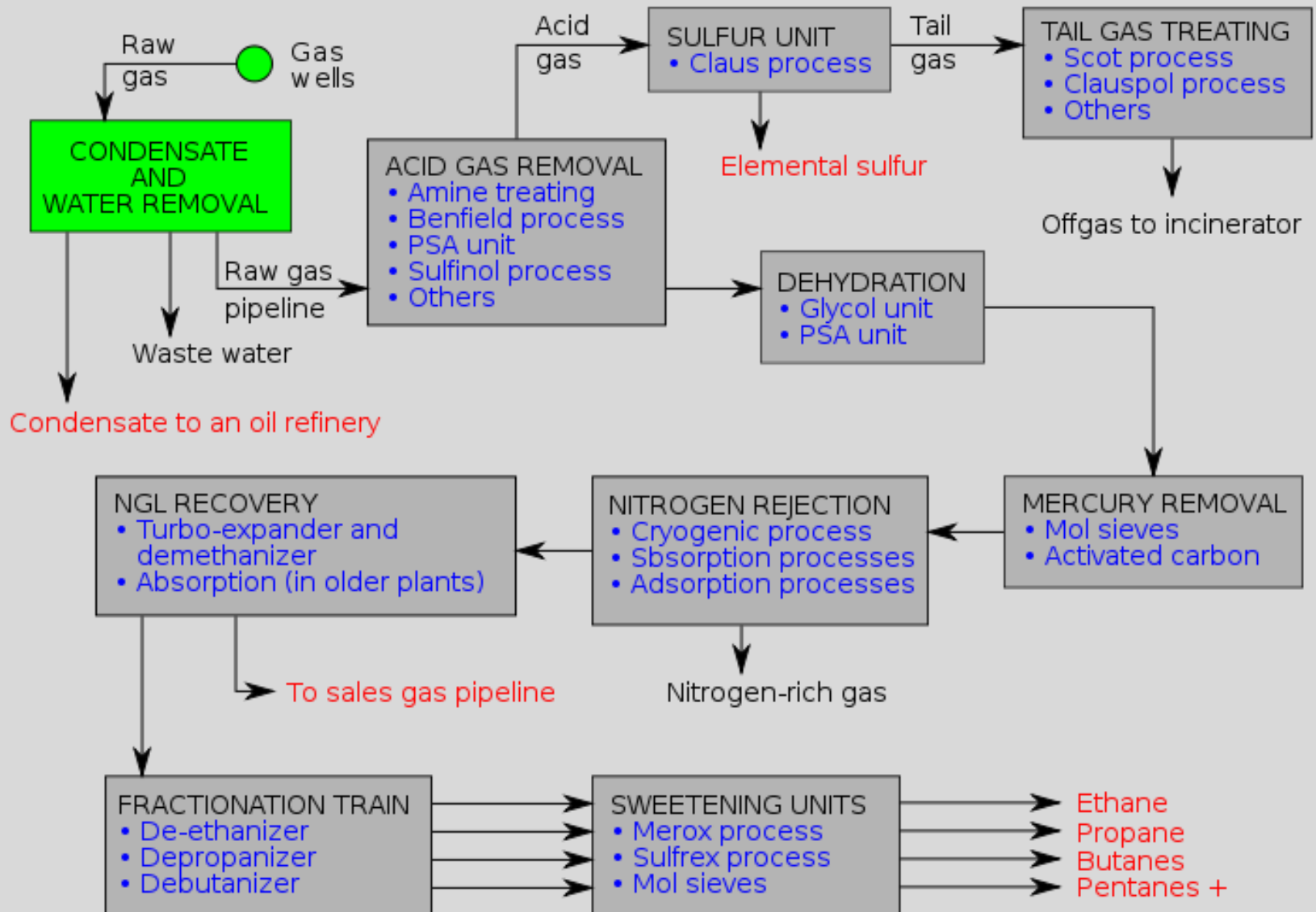
Natural gas coming out from the ground - Taiwan



Schematic geology of natural gas resources



Natural Gas Production



Natural Gas Production - Steps

Gas wells ⇨ Raw gas ⇨

Condensate and water removal ⇨

Acid gas removal ⇨ Dehydration ⇨

Mercury removal ⇨ Nitrogen rejection ⇨

NGL recovery ⇨ Fractionation train ⇨

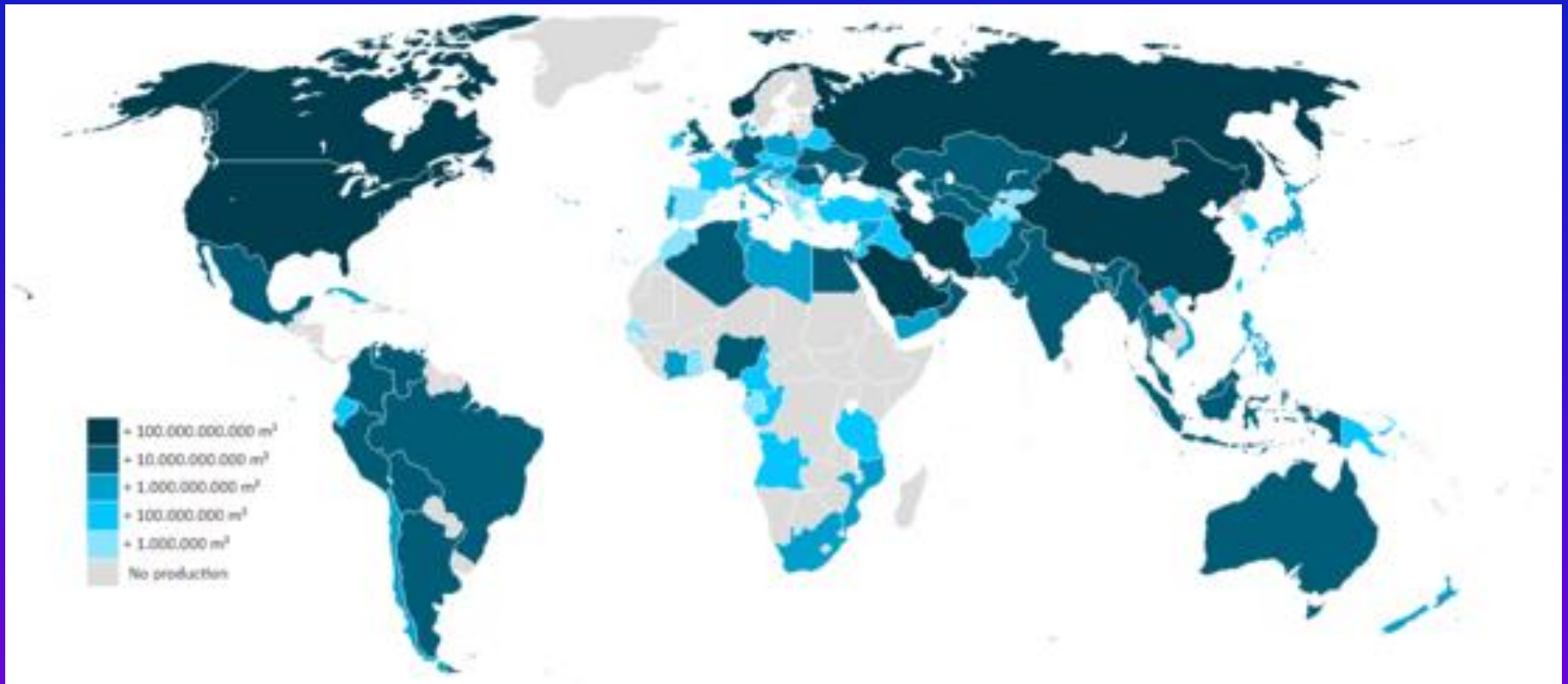
“Sweetening Unit” ⇨ Ethane

⇨ Propane

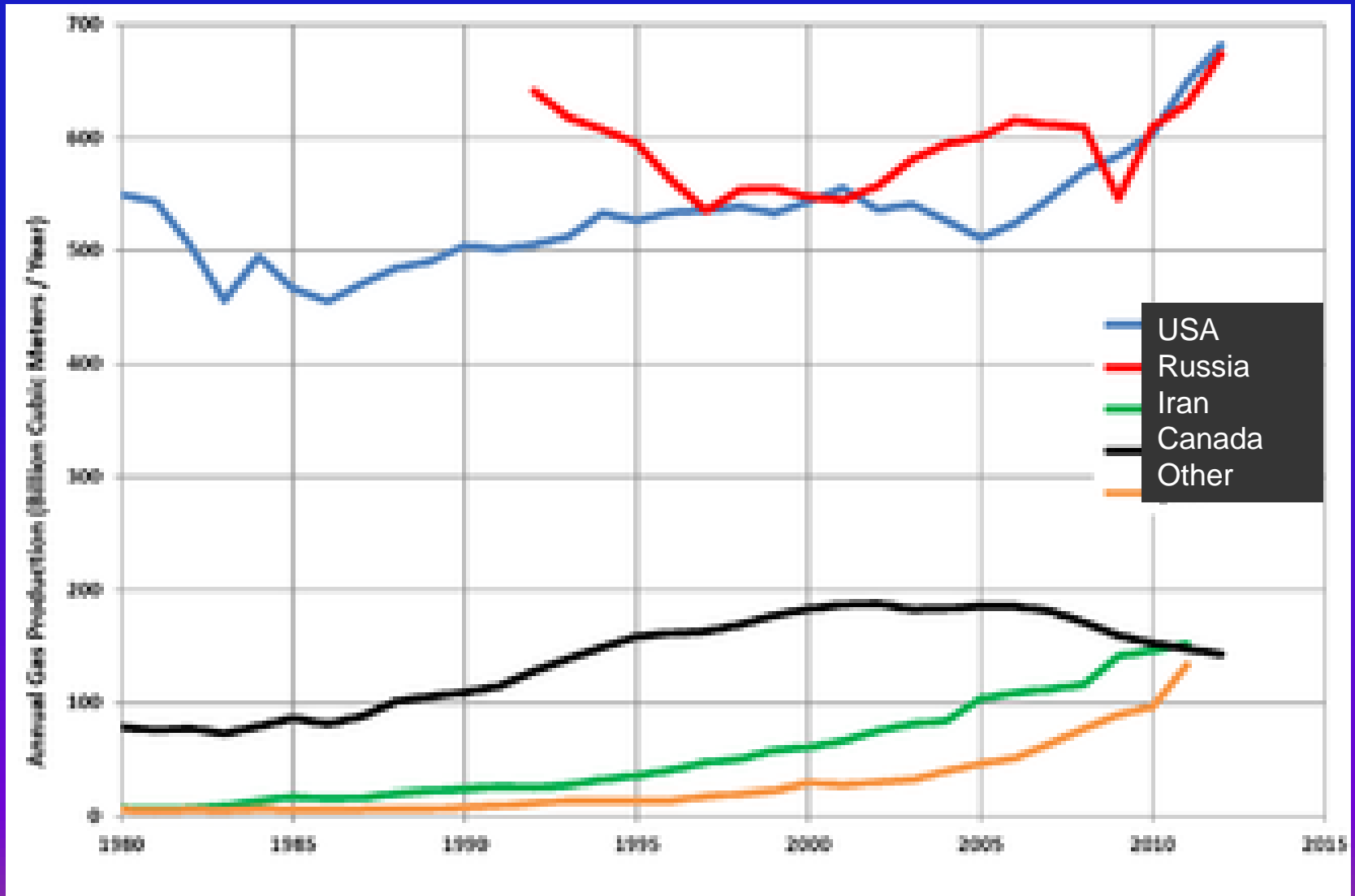
⇨ Butanes

⇨ Pentanes +

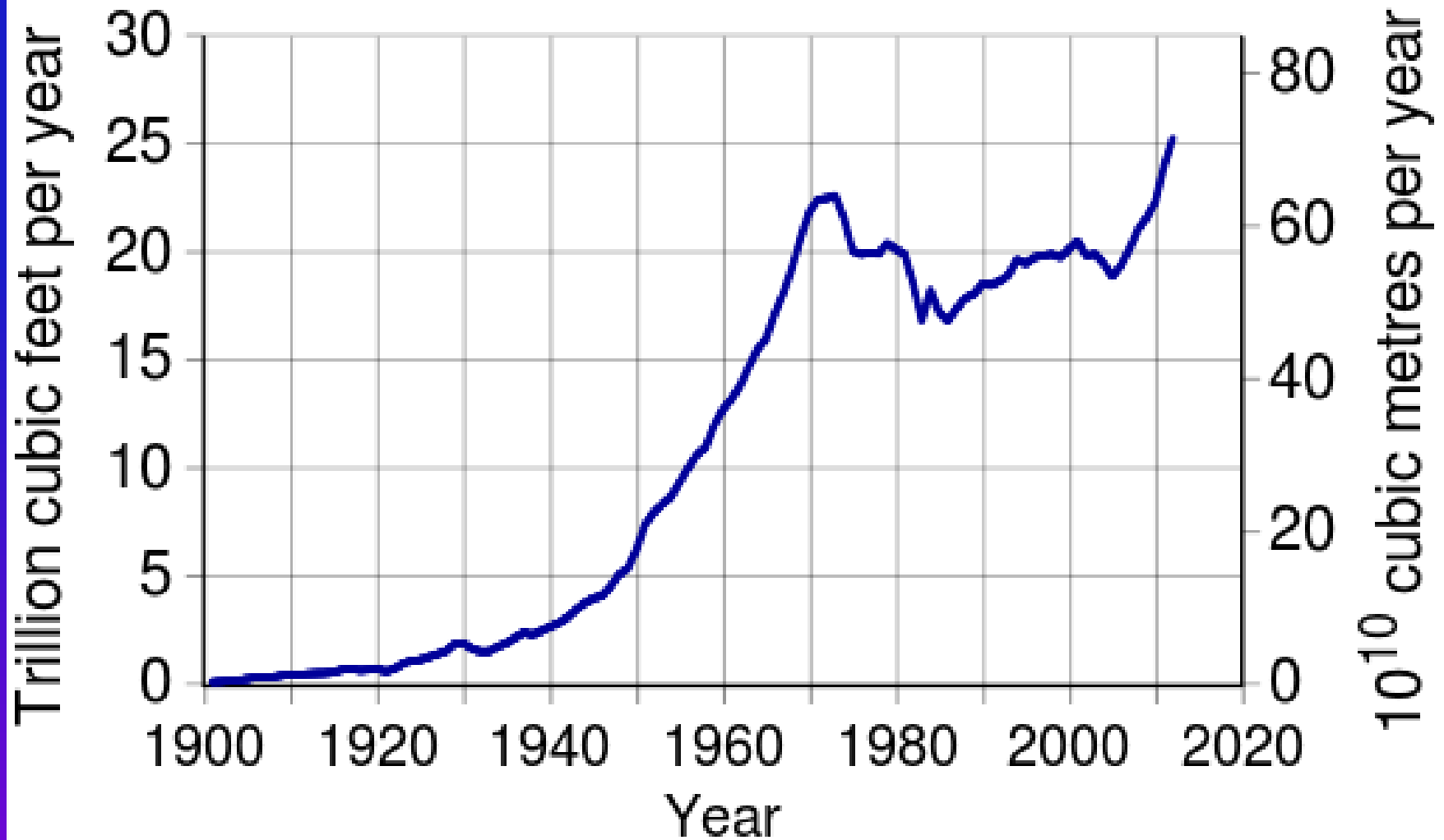
Natural Gas Production



Top Natural Gas Producing Countries



U.S. Natural Gas Production



Natural Gas - Uses

Electricity - from power plants

Heating - space, water and air conditioners

Industry - Pulp and paper, metals, chemicals,
glass, plastic, food processing

2012 World (Civil) Electricity Generation by Fuels

Coal/Peat	40.4%
Natural Gas	22.5%
Hydro	16.2%
Nuclear fission	10.9%
Oil	5.0%
Renewable	5.0%

Natural Gas Toxicity

Natural gas chiefly composed of **methane**

Inhalation: Headache, dizziness, nausea, fatigue

Methane in air = 84 times the global-warming effect of CO₂

Emissions into air = 3.2% of global production

Controversy on the leak rate of methane into the air

Methane burned ⇔ 50% less CO₂ than burned coal

Preferred to coal and oil as fuel

Nuclear vs. Renewable Energy

1. **Energy from carbon dioxide sources is on the way out b/o air pollution**, green house gas levels, and global warming
2. Nuclear power develops slowly because of public reservations and opposition
3. Nuclear power is economical
4. **Solar, wind, and hydropower are the safest and cleanest**
5. Introduced in several European countries in 20-50% of applications
6. Could account for 80+% of the world energy in 40 years at a cost of 1% of global GDP annually.

RENEWABLE ENERGY

SOLAR ENERGY

SOLAR ENERGY

Chiefly Thermal and Radiant Energy



SOLAR ENERGY

Most important and eternal source of energy on Earth

2000 - UN Development Program: Annual potential of

Solar Energy = 1,575 - 49,837 Exajoules (EJ)

1 EJ = 10^{18} = 1,000,000,000,000,000,000 joules

SOLAR ENERGY - Global advantages:

Security, Sustainable, Low-cost,

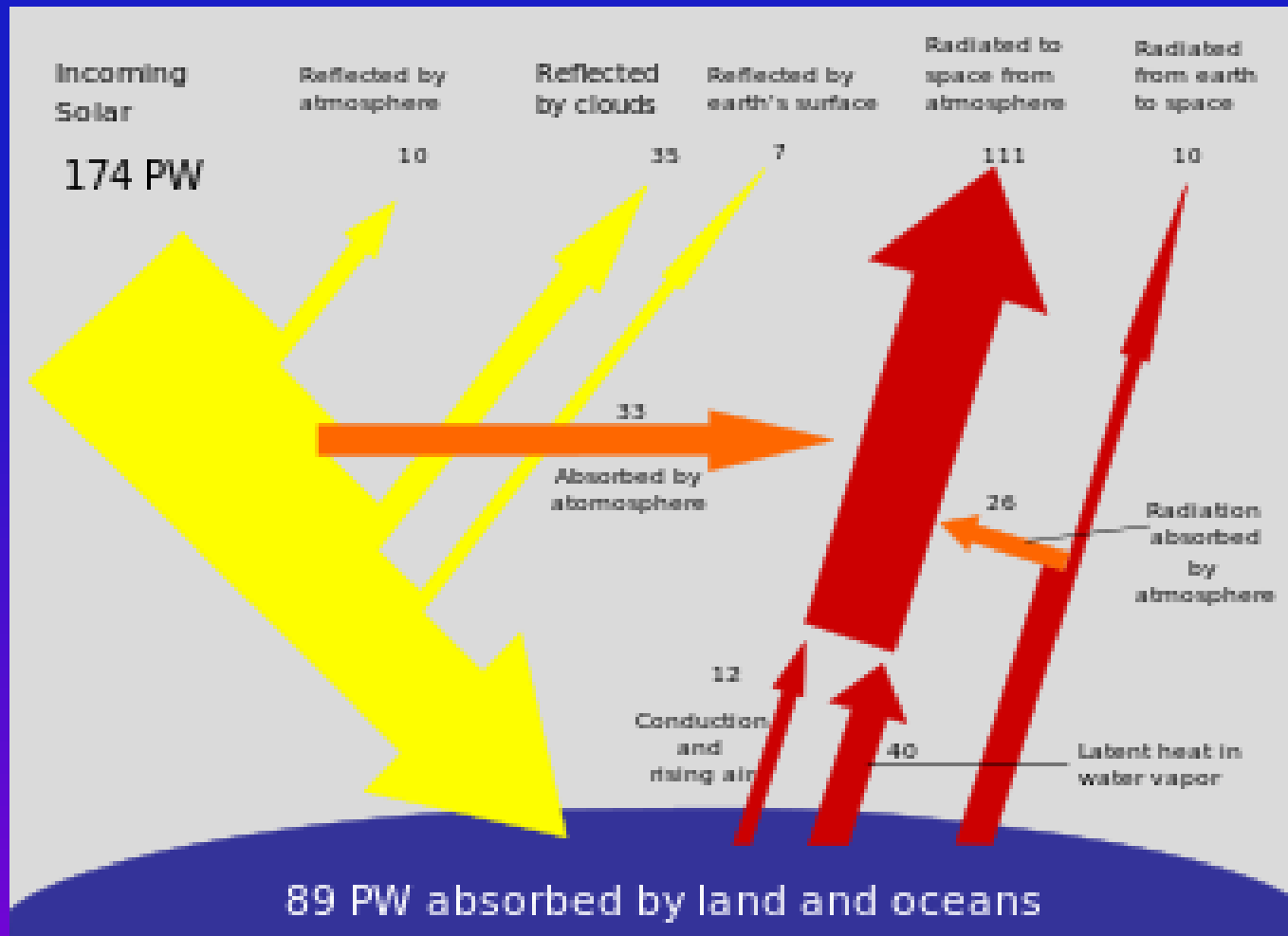
Indigenous, inexhaustible, independent resource,

Reducing pollution,

Mitigating global warming

Solar Energy

About Half of the Incoming Solar Energy Reaches the Earth's Surface



Solar Energy

**Incoming (insolation) solar energy = 174,000 TW (terawatts) =
174 petawatts**

1 terawatt – 1 Trillion wats

1 petawatt = 1 Quadrillion watts)

Reflected by atmosphere	10 PW
Reflected by clouds	33 PW
Reflected by Earth's surface	7 PW
Absorbed by atmosphere	33 PW
Radiated to space from atmosphere	11 PW
Radiated from Earth to space	10 PW
Absorbed by land and oceans	89 PW

Solar Panels

Solar Water Heaters Facing the Sun to Maximize Gain



11MW Solar Power Plant, Serpa, Portugal



Parabolic Dish Produces Steam for Cooking Auroville, India



Greenhouses in Netherlands



Solar Water Disinfection in Indonesia



World Solar Challenge in Australia, 2013. Winner's speed 57 mph



Solar Electric Aircraft Circumnavigating the Globe - 2015



Solar Panels on the International Space Station



Thermal Energy Storage

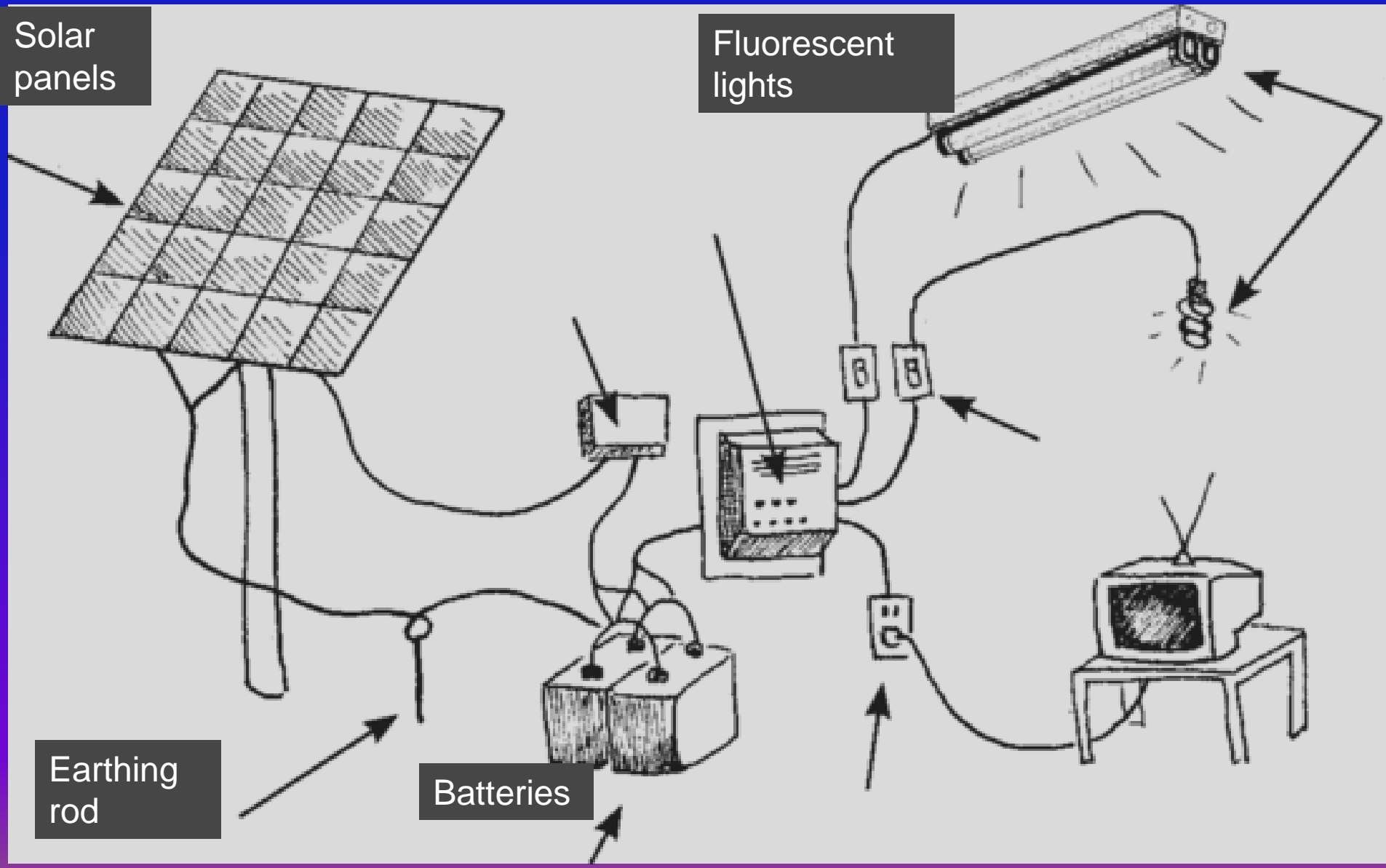
The Andasol CSP Plant - Uses Tanks of Molten Salt to Store Solar Energy



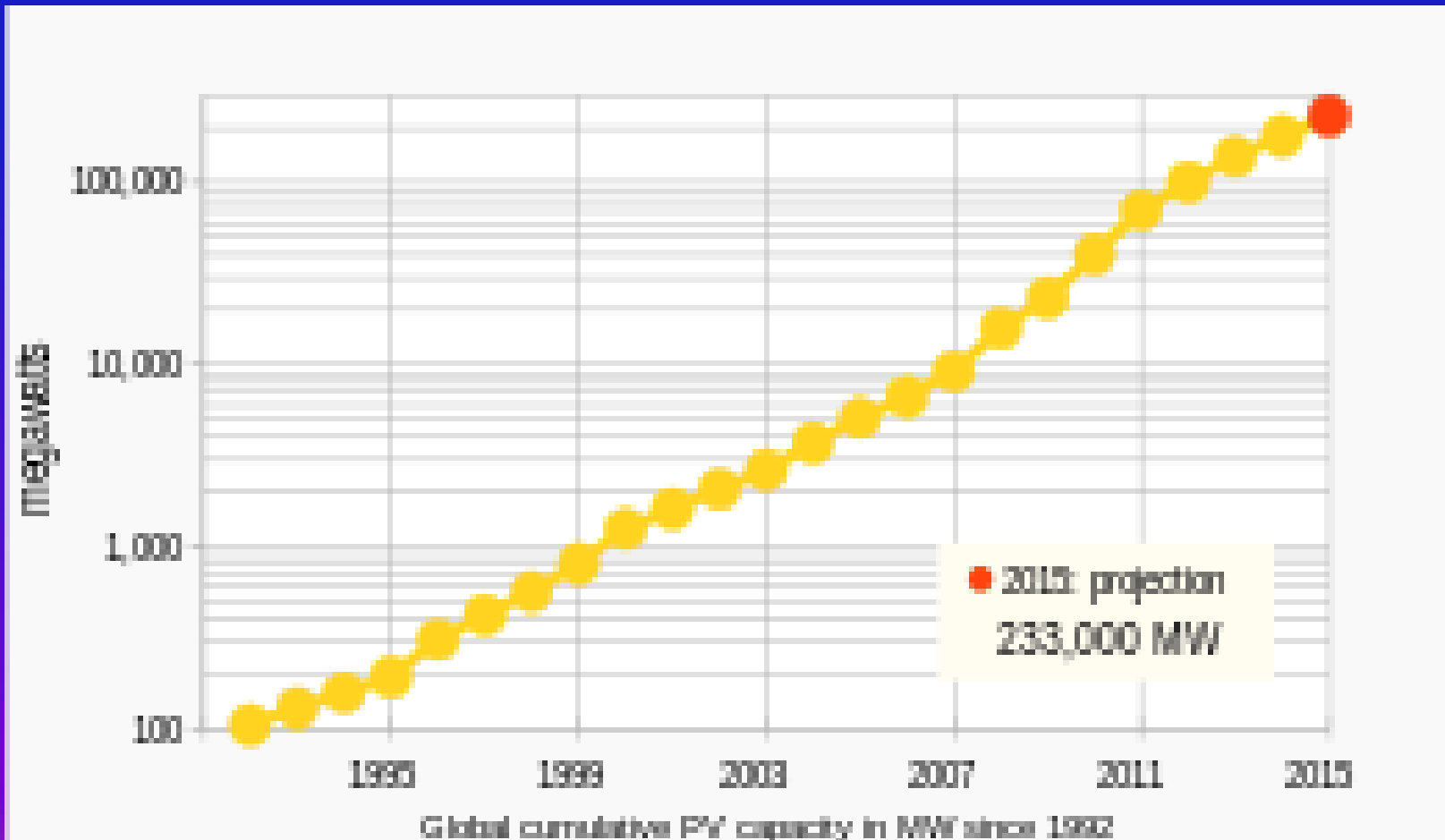
Solar Power Stations (CPS)



The Parts of a Solar Electric System



Projected Global Growth of Photovoltaics



“People will make all the mistakes
they can before doing the
correct thing that was always
apparent but ignored...”

John Maynard Keynes
(1883 - 1946)

WOOD

WOOD

Essential to Human Civilization

- Heating
- Construction
- Navigation

Hardwood - for burning

Softwood - 80% of timber

Neolithic Wood Artifacts



Dugout Canoe of Ancient Americans



Roman Soldiers Felling Trees for Construction - Column of Trajan, Rome



Spanish Galleon – 16th century



The Log Cabin



Logs in Bellingham Harbor, WA



DEFORESTATION

DEFORESTATION

Definition: ***“Removal of a forest where the land is converted to a non-forest use”***

30% of Earth's surface is covered by forests

US - Of 6 Million Mi² of forest only 2.4 Million Mi² remain = **40%**

Central America – 40% deforested btw.1950-1980

Africa – 23% deforested

By 2030 – 10% of forests will remain in the world

More than half of all animal and plant species live in forests

Deforestation - History

300 Mil. years ago – “Rainforest Collapse” ⇨ ↓

tropical forests. Rainforests covered 14% of Earth’s surface

Deforestation:

8000 BC - Neolithic agriculture required more land
⇨ fires used for deforestation

Bronze Age – Severe deforestation – Minoan
Crete - copper furnaces

500 BC - 500 CE – **Soil erosions ⇨ Silting harbors:**

Ephesus, Priene, Miletus. Later – Bruges (Belgium)

Roman Era – Metallurgy – Forests destroyed ⇨ Expansion
in search of wood in Syria, Dacia

Deforestation History (cont'd)

1,100–1,500 CE – **Human populations growth needed heating**

15th cent. – Europe building **wooden ships - Exploration**

16th cent. – England – **Nutritional deficiency** – Loss of forests
caused loss of game proteins

16th cent. Europe – **Fuel and nutritional disaster**

Burning soft coal, eating potatoes and maize

17th cent. American colonies – **flooding after clearing forests**

17th cent. - J.B. Colbert (France) planted oak trees for
ships...

18th Cent. – Fuel and agricultural expansion ⇔ Use of coal

Deforestation



Deforestation of Brazil's Atlantic Forest – c. 1825



Deforestation for Agriculture in Brazil



Deforestation - Forest Burned to Clear Land for Agriculture - Borneo



Deforestation for Illegal Logging in Madagascar



DEFORESTATION

Deforestation is an ongoing, chronic problem with great impact on our life

Inherent problems: **Atmospheric**

Hydrologic

Soil

Biodiversity

Deforestation - Atmospheric Problems

Contributes to **global warming**

Tropical deforestation ⇨

CO₂ no longer cleared by vegetation ⇨

1/3 of total CO₂ = 20% of world greenhouse gas

emissions ⇨ Radiation from the sun trapped ⇨

Radiation converts to heat ⇨

Global warming (“greenhouse effect”)

Deforestation - Hydrologic Problems

The **water cycle** is affected by deforestation

Trees roots extract water from soil and release it in the air through “**transpiration**”

Deforestation **reduces the soil water content** and the atmospheric moisture ⇒ **drier climate** ⇒ surface water runoff

Deforestation - Soil and Biodiversity Problems

SOIL - Deforestation increases the rate of soil loss

The roots system holds the soil

Many years ago, China cleared a plateau ⇒ much

loss of soil into the **Yellow River** ⇒

(“China’s sorrow”)

BIODIVERSITY

~80% in the tropical rainforests - may be affected

Extinction of many species ⇒ Change in our

biodiversity

Deforestation - Causes

Trees are cut to be used for: Agriculture 32-60%
Construction 15-25%
Fuel 25%

Poor people – no alternatives

Inequitable distribution of wealth and power

Government corruption, overpopulation, urbanization,
construction, roads

Industrialization

Agent Orange – UK - Malaya, USA - Vietnam

Deforestation - Remedies

United Nations and the World Bank – REDD Program
\$30 Bil.

1. Conserving forests
2. **Transferring land rights to indigenous inhabitants**
3. Farming – Cyclic agriculture
4. Forest management
5. Monitoring deforestation – Aerial and satellite imagery
6. **Afforestation**

AFFORESTATION

Afforestation - Reforestation

Definitions:

Afforestation = The establishment of a forest in an area where there was no previous tree cover

Reforestation = The reestablishment of forest cover

- Extensive deforestation in Brazil and China
- Major efforts of reforestation and afforestation in most countries
- In Israel, the Jewish National Fund planted
- >250,000,000 trees

JNF Trees in the Negev Desert, Israel. Man-made Dunes Help Keep in Rainwater, Creating an Oasis



Afforestation in England



Planting Trees with my Sons in Israel



Wood – Economy and Politics

17th Cent. – USA – 820 Million acres of forest

Rising population, construction, and agriculture ⇒

deforestation

Need of wood from British Columbia

1982 - **Trade dispute** with Canada – 24 years

1996 - “Softwood Lumber Agreement” till 2001

2001 - More conflict

2009 - London Court of International Arbitration

Wood – Modern Times

Demand for wood is increasing annually

- Construction
- Housing - new and renovations
- Furniture
- Paper
- Tools
- **Plywood**
- **Glulam**

PLYWOOD

Egyptians and Chinese used laminated wood

17th-18th Cent. - English and French used plywood

1865 – John Mayo of NYC patented laminated wood

1905 – Portland, OR – World's fair – **“3-ply veneer wood”**

1905-1934 – Technical improvements

1934 – Fully waterproof adhesive

1938 – Standardized commodity **“Plywood”**

1940 – **WWII** – Barracks, gliders, PT boats, assault boats

1975 – 16 Bil. sq. ft. production

Making Plywood, USA Portland, OR, 1905



New Woods

Particle boards

Glulam – “glued laminated timber”

Wood I-joists

Rim Board

Engineered wood – house floors

Glulam (Glued Laminated Wood) Glulam Arches of the Sheffield Winter Garden, UK



Richmond, BC, Olympic Oval



WOOD AND HOUSING

Housing, Resources, and Humankind

No equal rate of progress occurred throughout the world

Progress did lag in some areas, to occur some centuries later

The rate of progress depended on:

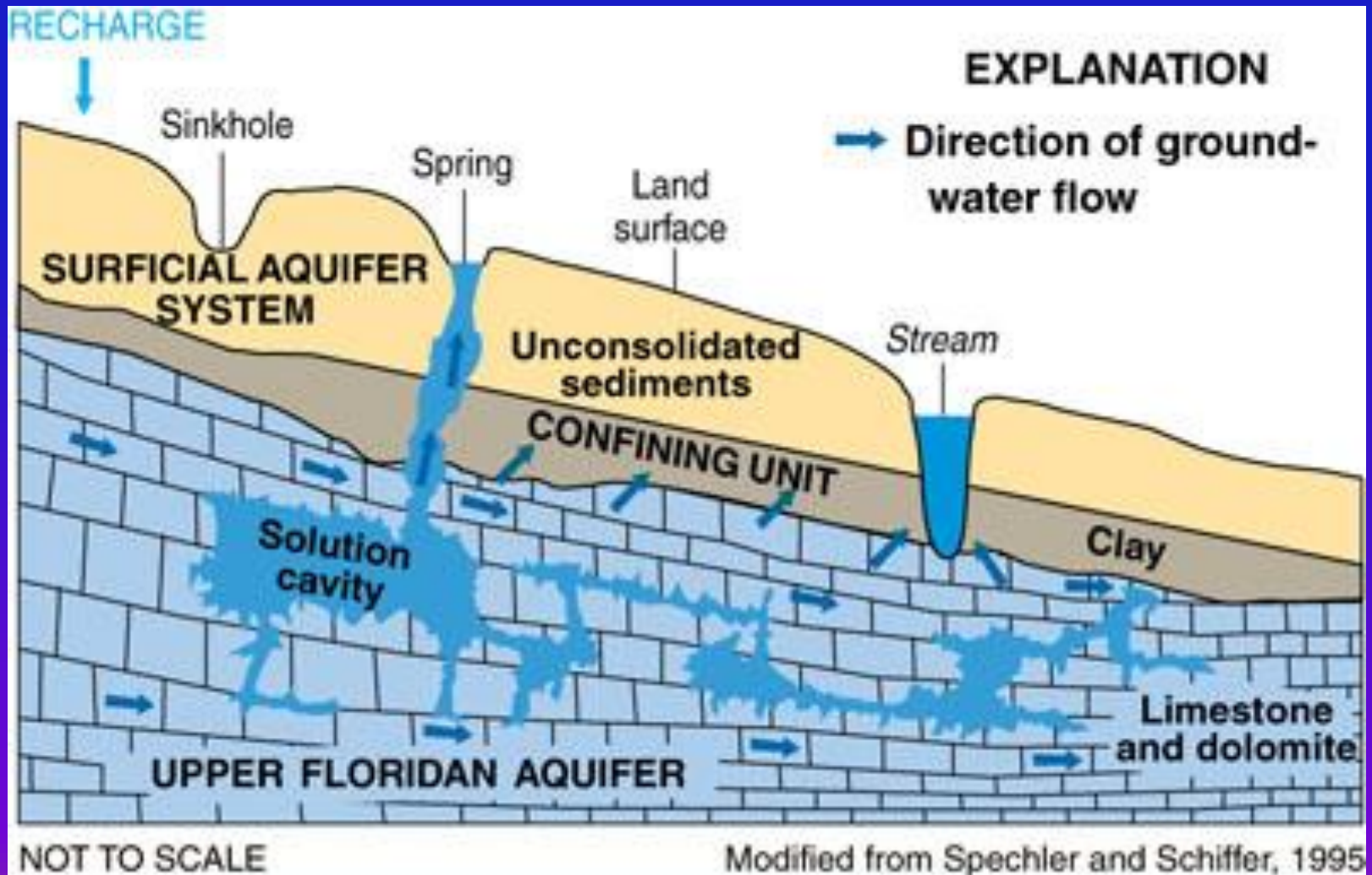
- Availability of Resources
- Creativity and Industriousness of the People
- Social-Financial-Political Status of Citizens
- Ways of Communication

Evolution of the House

c.100,000 BC – **Hunter-gatherers** lived in trees or
caves

c.10,000 BC - **Agrarian society - Natufian** (Middle East)
- **circular huts** 10-20 ft. in diameter ⇔ villages

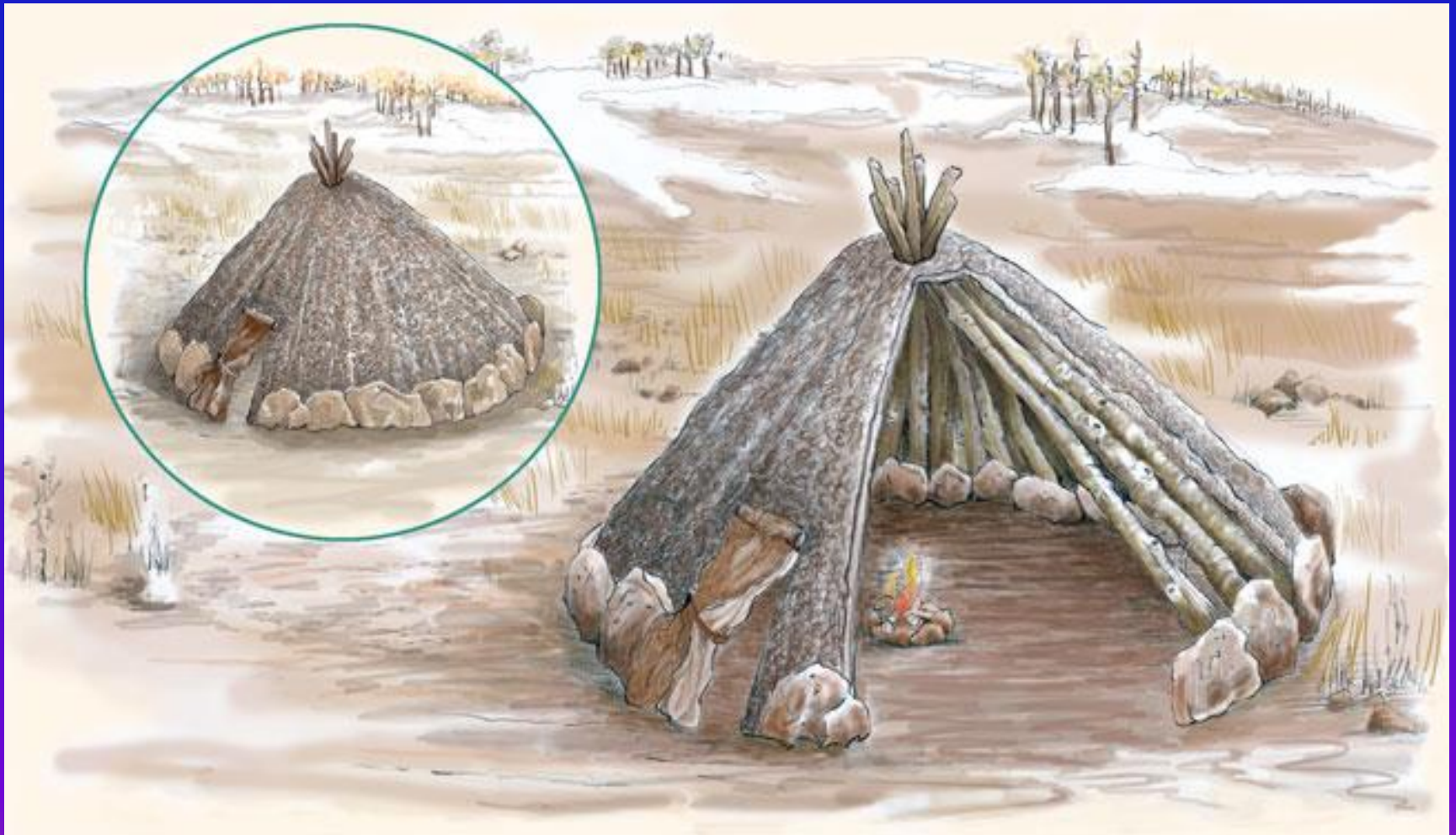
Formation of Caves



First Huts



Indian Pueblo



Amerindian Hut



Harappa Civilization (3300 – 1300 BC)

Mohenjo-daro

(Excavated ruins in Sindh, Pakistan)



Contemporaneous with the Civilizations of Ancient Egypt, Mesopotamia, Minoa (Crete), and Norte Chico

Cappadocia, Turkey



Derinkuyu, Cappadocia, Turkey



Kaymakli, Cappadocia, Turkey

Volcanic rock with holes used for cold copper processing – 5th - 7th Cent. BC



Segovia Castle, Spain

High Middle Ages



Housing and the Society (1)

	Rich	Poor
20,000 BC	Caves or tents of mammoth skins	
6000 BC	Mud brick	Huts
	No doors, windows, or chimneys	Huts
4000 BC	Huts/wattle/daub (Farming spread)	
Indus Valley	Brick houses	Huts
Minoan Civil.	Wooden columns	Huts
Egypt	Big houses	Mud bricks
Greece	Large houses	Mud bricks

Housing and the Society (2)

Rich

Poor

650 BC – Celts

Round houses **Wood pole w/ radiating poles**

Roman

Villas/mosaics

Mud/wattle/daub

Saxon

Wooden huts w/ thatched roofs. **No windows**

Middle Ages

Stone-castles of **wood**

Wooden huts

No windows or chimney

1,180 CE

Glass windows

Linen soaked in tallow

16th Cent.

Stone, **chimneys**

Huts, no floors

19th Cent.

Stone, **toilets & BR**

Brick houses/windows

20th Cent.

Modern houses

Taos Pueblo, New Mexico

~ 1,000 CE



The Log Cabin



Medieval Merchant's House In England



Tudor Style House – England

1485 - 1605



END OF LECTURE # 7