


## Resources of the lithosphere

Introduction, significance, examples and extraction processes

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### Resource types



- Recall that resources break broadly down into two categories:
  - Renewable resources: either unlimited or able to be replenished within a human lifespan (30-70 years).  
Examples: trees, animals, wind energy, etc.
  - Nonrenewable resources: not able to be replenished OR replacement time so long that this might as well be non-existent. Examples: fossil fuels, most minerals, metals.
- Ideally, we would focus on using renewable resources, but this is not always possible



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### What are lithosphere resources?




- Any resource or commodity collected, mined, or extracted from the Earth
- Typically found in soils and rocks and can be the soils and rocks themselves
- Almost all are nonrenewable
- Many require expensive or environmentally harmful extraction processes

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### Importance of lithosphere resources

- Usually harder to extract than biosphere resources
- Tend to be more multi-purposed and ubiquitous than renewable commodities
- Most materials and goods, especially in the developed world, have at least some lithosphere resource component

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### Importance of lithosphere resources

- Almost anything you can think of!
  - Metals
  - Building materials
  - Plastics (from petroleum)
  - Electronics
  - Glass






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Fossil fuels and their extraction

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### What are fossil fuels?

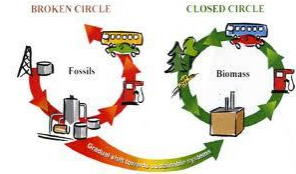
- Fossilized biological material that died millions of years ago
- Nonrenewable resource
- Are typically (especially in modern times) mined or drilled for
- Energy released by burning the fuel and breaking C-C bonds



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### Problems with fossil fuels

- Both extraction and consumption are dirty, energy expensive processes
- World dependencies, especially in MEDC's, focuses on **nonrenewable** fossil fuels
- Pollution
- Relied upon in economic sectors that might make them harder to replace (transportation)



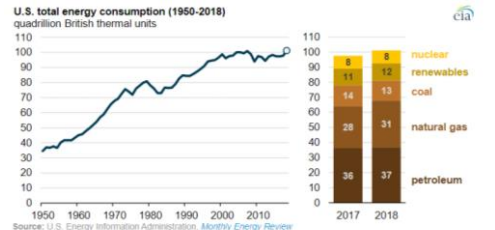
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### Fossil fuel consumption

- Energy consumption certainly not universal or evenly distributed
- United States has one of the highest per capita consumptions of fossil fuels, with per capita energy consumption of 309 MILLION Btu's (British Thermal Units) as of 2018 (US Energy Information Administration).
  - This equals 895 billion GALLONS of gasoline for our nation annually, 95% of which is produced domestically
  - As of 2010, USA is a net exporter of fossil fuels
- Global average in 2017 was 77 million Btu per capita
- Remember the theory of demographic transition:
  - More developed = more technology = more fuel consumption per capita

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### In 2018, the United States consumed more energy than ever before



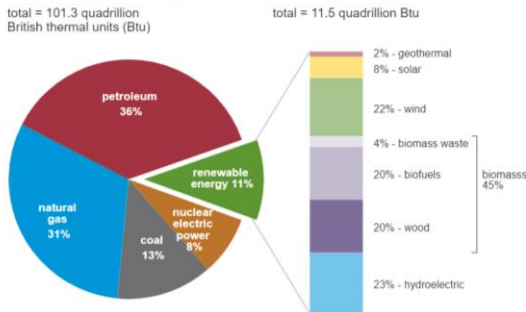
Primary energy consumption in the United States reached a record high of 101.3 quadrillion British thermal units (Btu) in 2018, up 4% from 2017 and 0.3% above the previous record set in 2007. The increase in 2018 was the largest increase in energy consumption, in both absolute and percentage terms, since 2010.

Consumption of fossil fuels—petroleum, natural gas, and coal—grew by 4% in 2018 and accounted for 80% of U.S. total energy consumption. Natural gas consumption reached a record high, rising by 10% from 2017. This increase in natural gas, along with relatively smaller increases in the consumption of petroleum fuels, renewable energy, and nuclear electric power, more than offset a 4% decline in coal consumption.

Source: US EIA <https://www.eia.gov/todayinenergy/detail.php?id=39092>

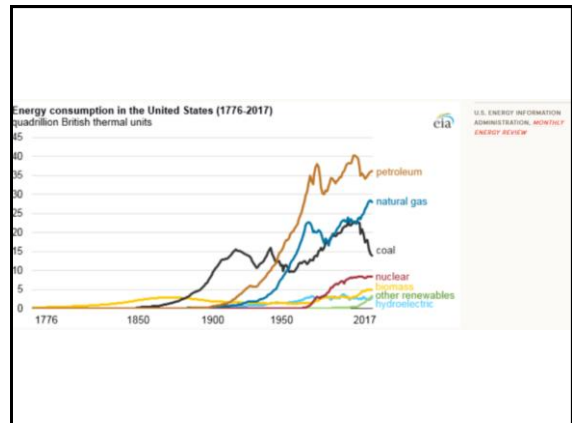
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### U.S. primary energy consumption by energy source, 2018



Note: Sum of components may not equal 100% because of independent rounding.  
Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.3 and 10.1, April 2019, preliminary data

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### Why fossil fuels?

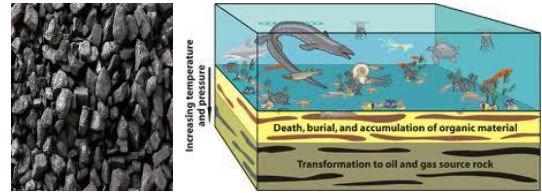
- Often most efficient for the job they are set to do
  - Gasoline is compact, ignites quickly, and has a lot of energy— good for cars
  - Coal is easy to transport and contains lots of energy in solid form— good for electric plants.
- Up until relatively recently, they were comparatively easy to extract
- Value of fuel far exceeds manufacturing costs
- Seek out the most efficient source for whatever job you're doing
  - Example: electricity



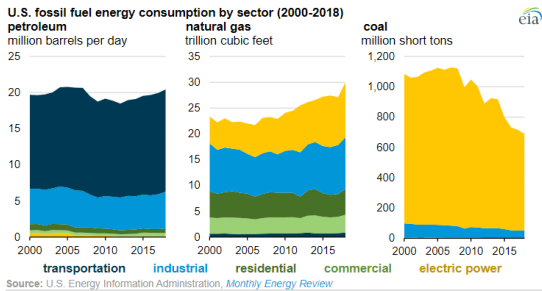
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### Creation of fossil fuels

- Originally organic matter (dead stuff)
- Heat, pressure, LONG amounts of time!
- Requires that decomposers like bacteria don't break down all of the initial biomass (doesn't re-enter food chain like usual)

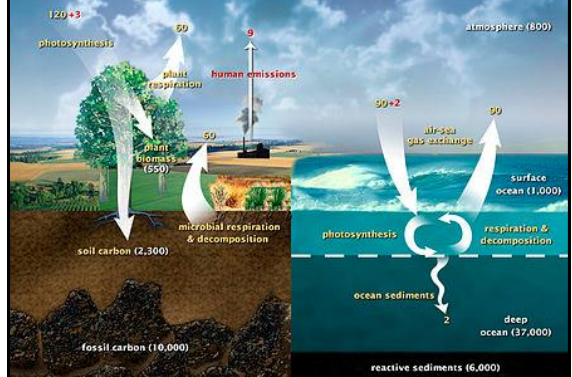


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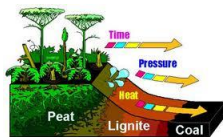
### The carbon cycle



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### coal

- Solid fuel primarily from plants
- 280-360 million years old
- Four tiers of aged coal:
  - Lignite
  - Sub-bituminous
  - Bituminous
  - Anthracite
- “Peat” is a precursor often extracted from bogs.
- Coal is relatively cheap, until it becomes expensive to extract.
- US coal consumption has declined from 2013-2018, falling an additional 4% from 2017 to 2018



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### Advantages and Disadvantages of coal




- Advantages:
  - Comparatively cheap to extract
  - Easy to transport via surface infrastructure
  - Little processing to burning; all countries can use it
- Disadvantages:
  - Chemical impurities cause atmospheric pollution (sulfur, mercury, arsenic, etc.)
  - Remnants of ash difficult to dispose



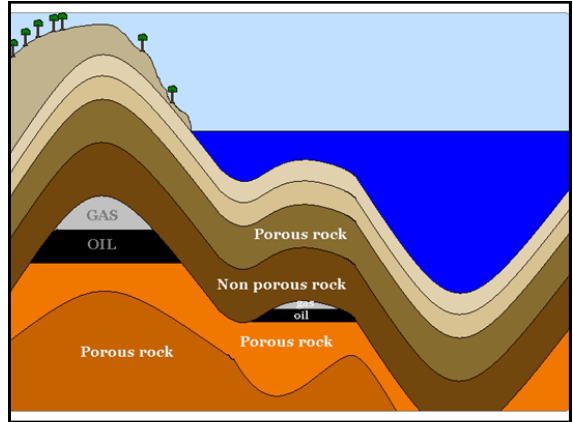
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### petroleum

- Fluid fossil fuel found in underground reservoirs
- Remains of ocean-dwelling plankton
- 50-150 million years old
- Collects between barriers in porous and nonporous rock
- Collects with natural gas (some burns off naturally)

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### Crude oil

- Liquid petroleum pulled straight from the Earth
- Refined into various materials: tar, kerosene, gasoline, diesel, asphalt
- ~135 oil refiners in the USA, biggest are capable of handling 500-600,000 barrels of petroleum a day
- Top producing countries by volume (2019): USA (18% of global production), Saudi Arabia (12%), Russia (11%), Canada (5%—expected to double by 2050), China (5%)
  - Creates varied and COMPLEX political interactions


Product	Volume (gallons)
gasoline	19.5
distillate fuel oil	9.2
jet fuel	4.1
residual fuel oil	2.2
liquefied gases	1.9
still gas	1.9
petroleum coke	1.2
asphalt/bitum oil	1.2
feedstocks	1.2
lubricants	0.8
kerosene	0.2
other	0.3

Source: API. Totals more than 44 gals, because of "processing gain"

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### Advantages and Disadvantages of Petroleum




- Advantages:
  - Liquid, so convenient for transport and use
  - Ideal for mobile combustion engines
  - Produces only about 85% the CO2 emissions of coal
- Disadvantages:
  - Poisonous trace components like coal
  - Oil drilling seeps oil into the environment in small and large catastrophic quantities (spills)
  - Drilling destroys habitats, fragile ecosystems, and kills organisms



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### Natural gas

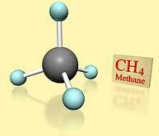

- Gaseous fossil fuel
- 80-95% Methane, 5-20% ethane, propane, and butane
- Generally extracted concurrently with petroleum
- Used for electricity generation and industrial processes
- Can be liquefied as a fuel (like propane in grills)

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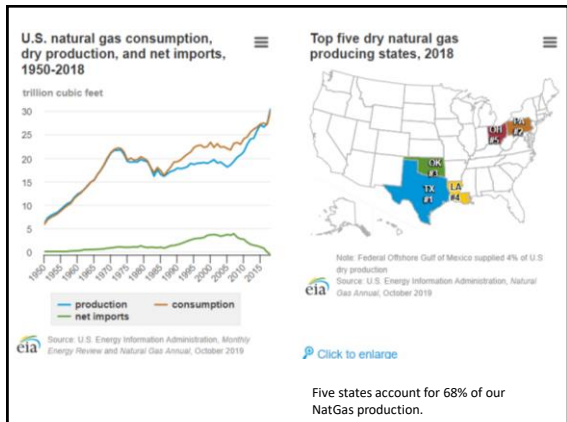
### Advantages and Disadvantages of Natural Gas

- Advantages:
  - Extensive pipelines make it available to about half of the homes in the US
  - Fewer impurities and emits virtually no particulates
  - Emits only 60% of the CO2 of Coal
- Disadvantages:
  - Natural gas itself can be a greenhouse gas if leaked
  - Mining for natural gas on its own (called "fracking") is secretive and potentially very dangerous to the environment, especially for groundwater contamination
    - Has enabled most growth of natural gas industry

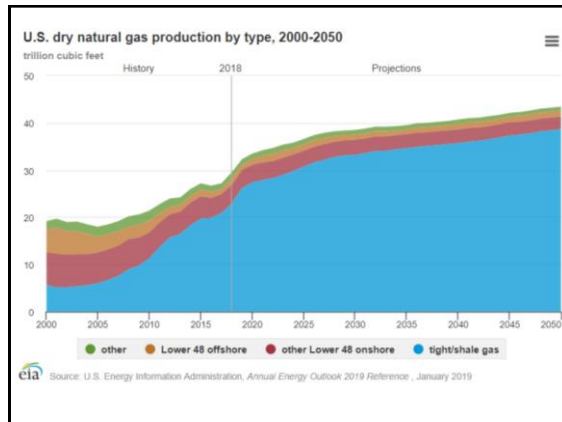



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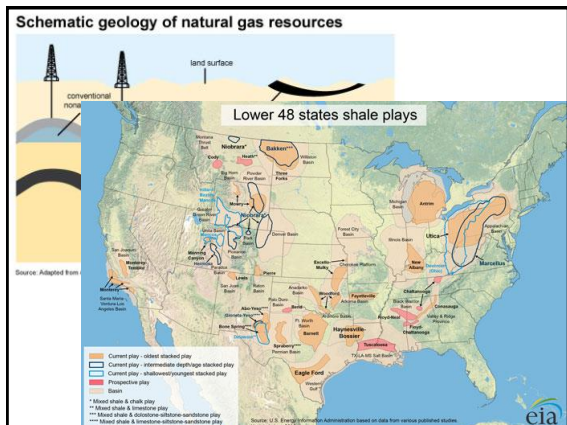




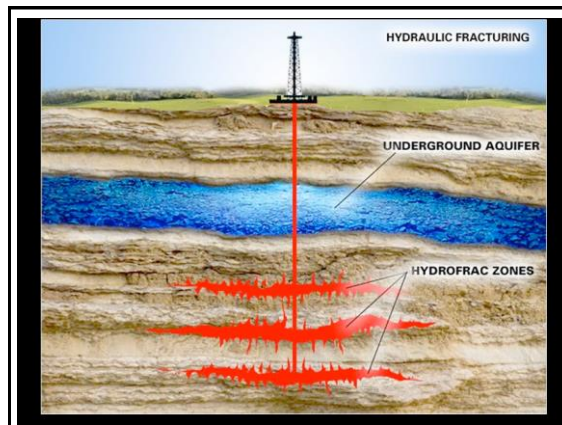
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**Other fossil fuels: Oil/Tar sands**

- Viscous sands mixed with **bitumen**
- Bitumen is degraded petroleum, called tar or pitch close to the surface
- Mining is much more energy-intensive and can be more degrading to the environment
- Heavy water use in extraction, 12% higher CO2 emissions than conventional oil

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**Other fossil fuels: Liquefied coal**

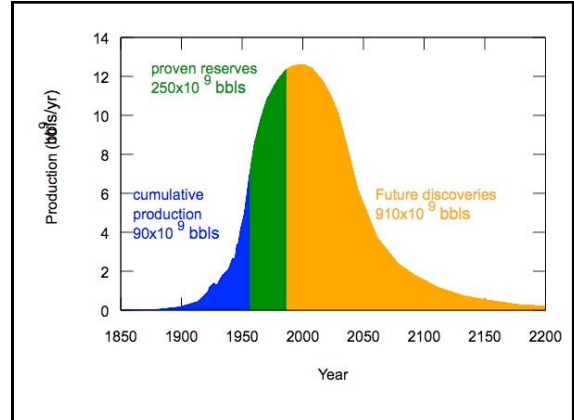
- When coal is converted to liquid via... CTL (coal to liquid) technology
- Heavily researched in China and USA due to large coal reserves
- Comparatively expensive
- Many of the same drawbacks of oil sands PLUS coal mining is dirty AND CTL is dirty as well

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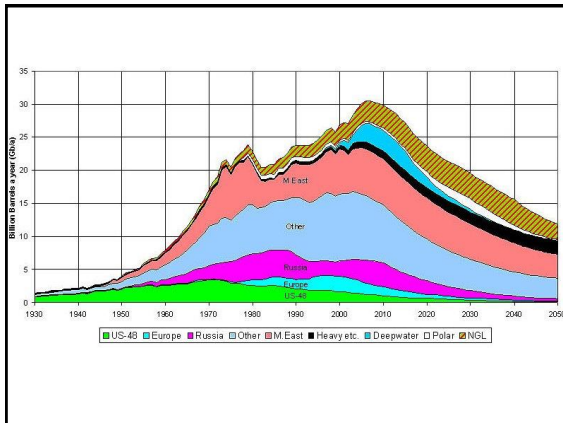
### The Hubbert curve

- Though energy efficiency has increased, our overall consumption has as well, meaning we use more, faster
- Hubbert Curve: predicted by geophysicist M. King Hubbert, predicts when we will reach peak oil production and when oil will run out
  - Used both upper and lower estimates, but didn't influence when we would run out of oil
  - Peak oil: extraction and use begin to decline.
- Hubbert's predictions say we've already hit peak oil, though US volumes increased until 2017. Predictions from other sources find regardless, oil will run out within a relatively narrow margin of time

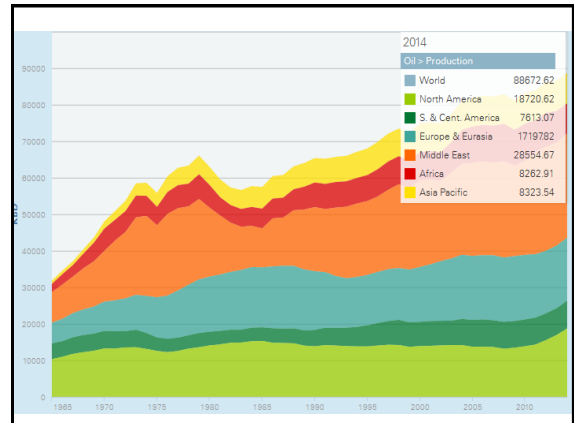
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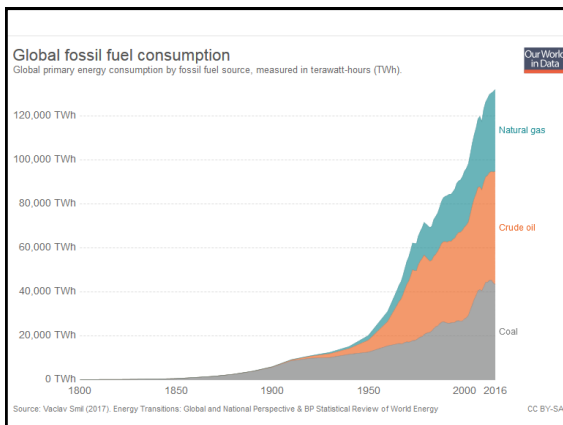
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