

The Geology of Fossil Fuels

By

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❖ **Geology of fossil fuels**

- History of formation
- Physical structure and substance
- Process to make these usable

❖ What are fossil fuels?

- Fuels formed by natural resources such as anaerobic decomposition of buried dead organisms.
- These were formed hundreds of million years ago, mainly in carboniferous period. (345-286 million years ago)
- Some deposits were found during late cretaceous period. (70 million years ago).

Table 25.1 : Geological Time Scale (Redrawn from Taylor, 1981).

Era	Period	Epoch	Duration in millions of years	Began millions of years ago
CENOZOIC	Quaternary	Recent	Last 5000 years	
		Pleistocene	2.5	2.5
	Tertiary	Pliocene	45	7
		Miocene	19	26
		Oligocene	12	38
		Eocene	16	54
		Paleocene	11	65
MESOZOIC	Cretaceous		71	136
	Jurassic		54	190
	Triassic		35	225
PALEOZOIC	Permian		55	280
	Carboniferous	Pennsylvanian	45	325
		Mississippian	20	345
	Devonian		50	395
	Silurian		35	430
	Ordovician		70	500
	Cambrian		70	570
PRECAMBRIAN			4030	4600

❖ Types of Fossil Fuels

- Coal
- Oil
- Natural gas.



❖ Origin of Coal

In carboniferous period, land was covered with swamps filled with huge trees, leafy plants.



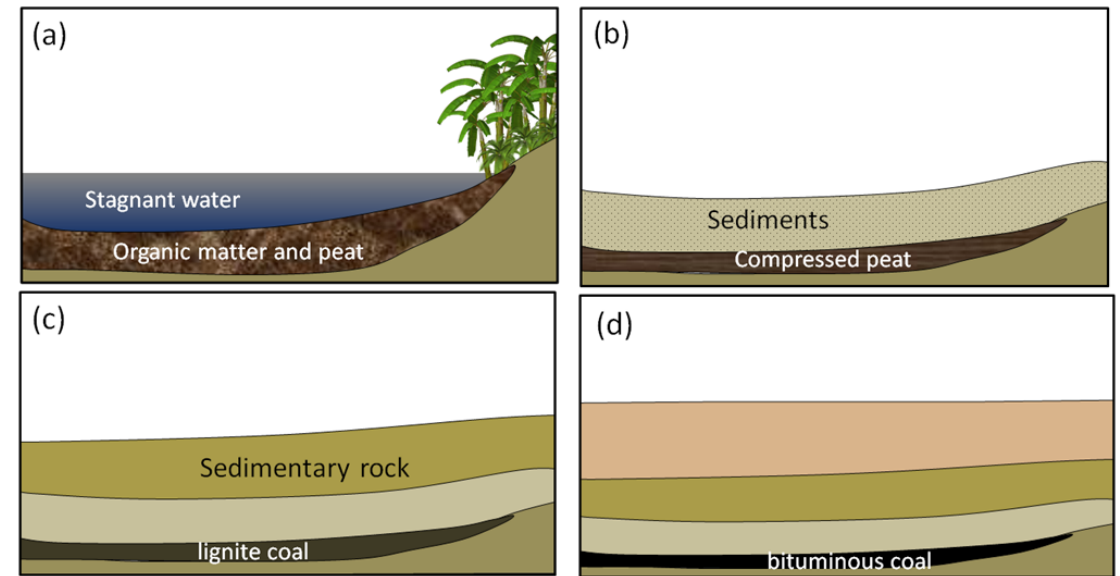
As the trees and plants died, sank to the bottom of the swamps of oceans to form layers of spongy materials called peat.



Over many hundred years, peat was covered by sand, clay which turned into sedimentary rocks.



More and more rock piled on top of old rock and began to press on the peat. It was squeezed and eventually turned into fossil fuels.



❖ Coal : Physical structure and substance

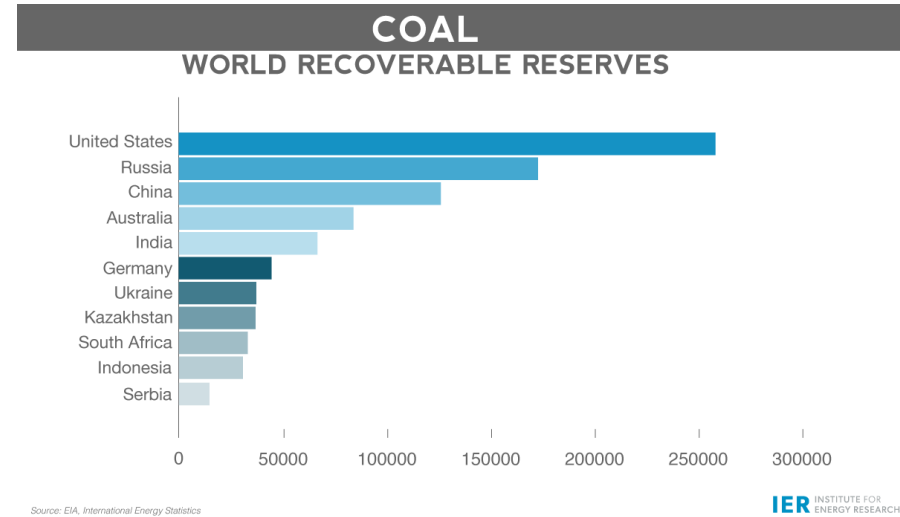
- Coal is made up of carbon, hydrogen, oxygen, nitrogen and sulphur.
- The three main types of coal are anthracite, bituminous and lignite.
- Anthracite coal is the hardest and has more carbon.
- Lignite is the softest and is low in carbon but high in hydrogen and oxygen content.
- Bituminous is in between anthracite and lignite.

Types of Coal (Metamorphic grade)

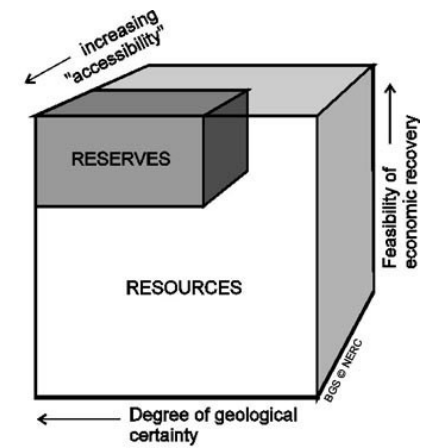
Based on pressure applied to dead biotic materials

1. **Peat** is a fibrous, soft, spongy substance in which plant remains are easily recognizable. It contains a large amount of water and must be dry before use.
2. **Lignite** is formed when peat is subjected to increased vertical pressure from accumulating sediments.
3. **Bituminous Coal** is greatly used in industry as a source of heat energy.
4. **Anthracite** is also known as "hard coal" because it is hard and has a high lustre.

❖ Coal resources and reserves

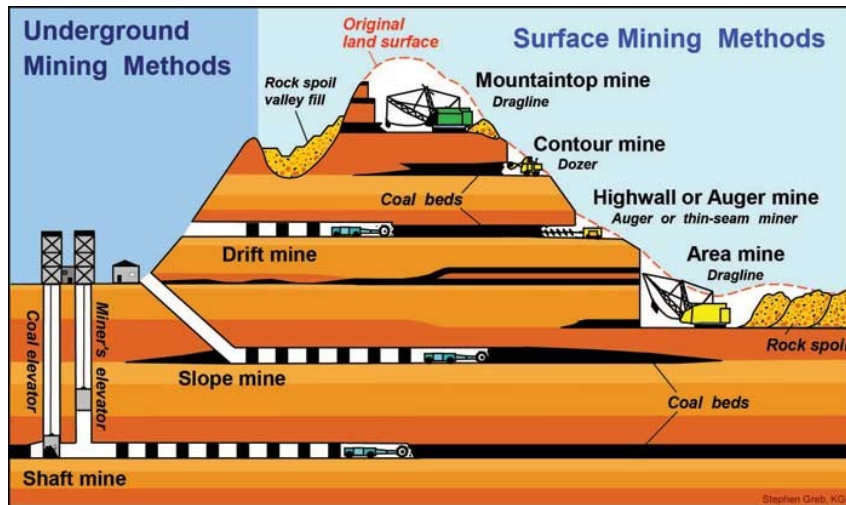


Quality
Economics
Safety



❖ Geology of coal mining

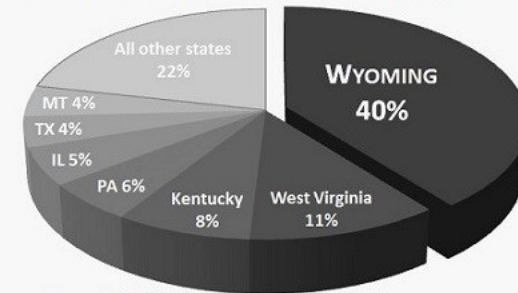
- **Underground mining:** far beneath the ground surface, accessed by tunnels
- **Surface mining:** close to ground surface, accessed by large excavation



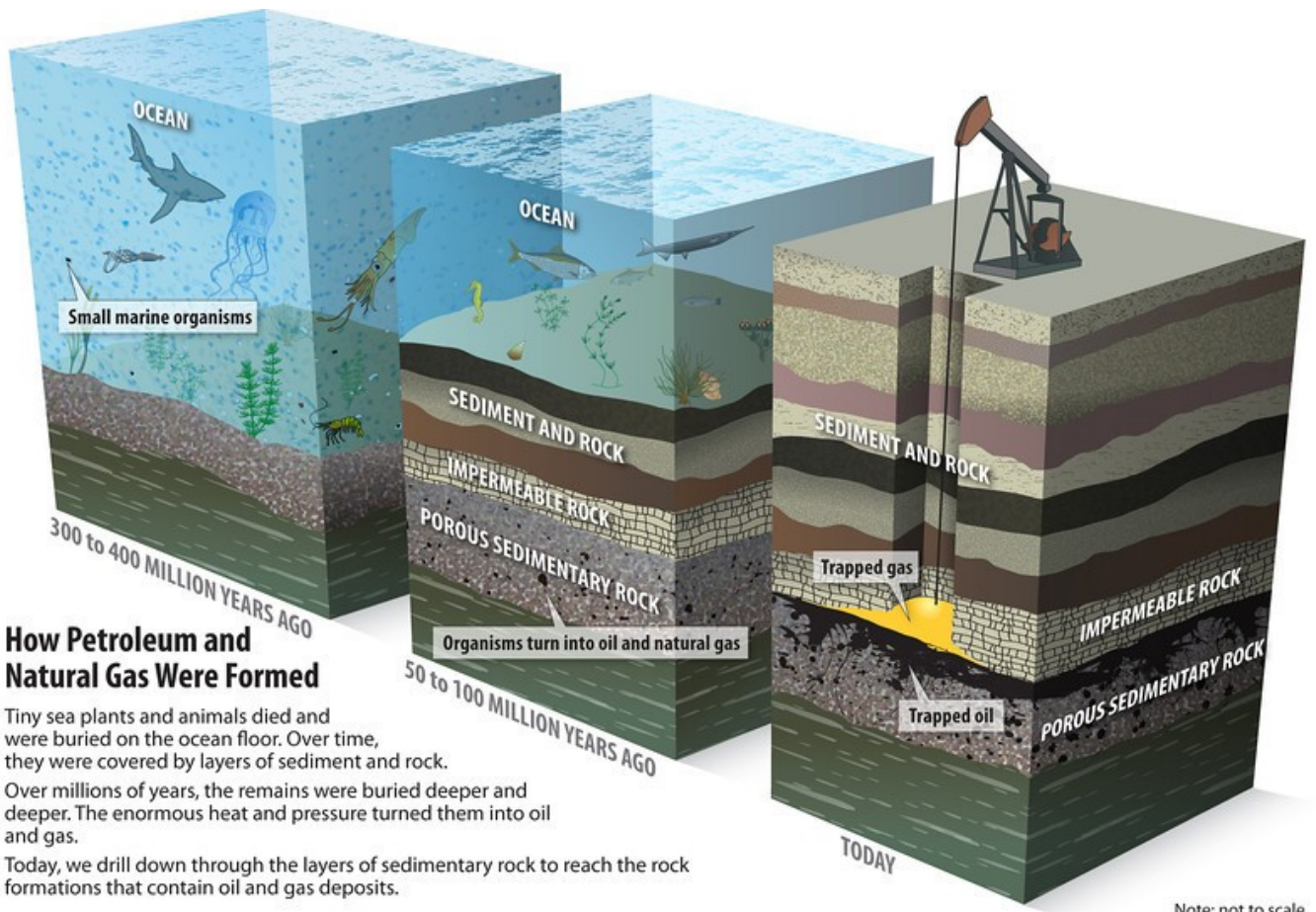
World's top hard coal producers

	Million tonnes (Mt)
China	3,162
USA	932
India	538
Australia	353
South Africa	255
Russia	248
Indonesia	173
Kazakhstan	105
Poland	77
Colombia	74

2014 U.S. Coal Production by State



❖ Origin of petroleum and natural gas



How Petroleum and Natural Gas Were Formed

Tiny sea plants and animals died and were buried on the ocean floor. Over time, they were covered by layers of sediment and rock. Over millions of years, the remains were buried deeper and deeper. The enormous heat and pressure turned them into oil and gas. Today, we drill down through the layers of sedimentary rock to reach the rock formations that contain oil and gas deposits.

Note: not to scale

❖ Petroleum as a substance

- Yellow to black liquid found beneath earth's surface
- Petroleum covers both naturally unprocessed crude oil and petroleum products separated by fractional distillation.
- Mostly recovered by oil drilling.

Composition by weight

Element	Percent range
Carbon	83 to 85%
Hydrogen	10 to 14%
Nitrogen	0.1 to 2%
Oxygen	0.05 to 1.5%
Sulfur	0.05 to 6.0%
Metals	< 0.1%

Composition by weight (4types)

Hydrocarbon	Average	Range
Alkanes (paraffins)	30%	15 to 60%
Naphthenes	49%	30 to 60%
Aromatics	15%	3 to 30%
Asphaltenes	6%	remainde

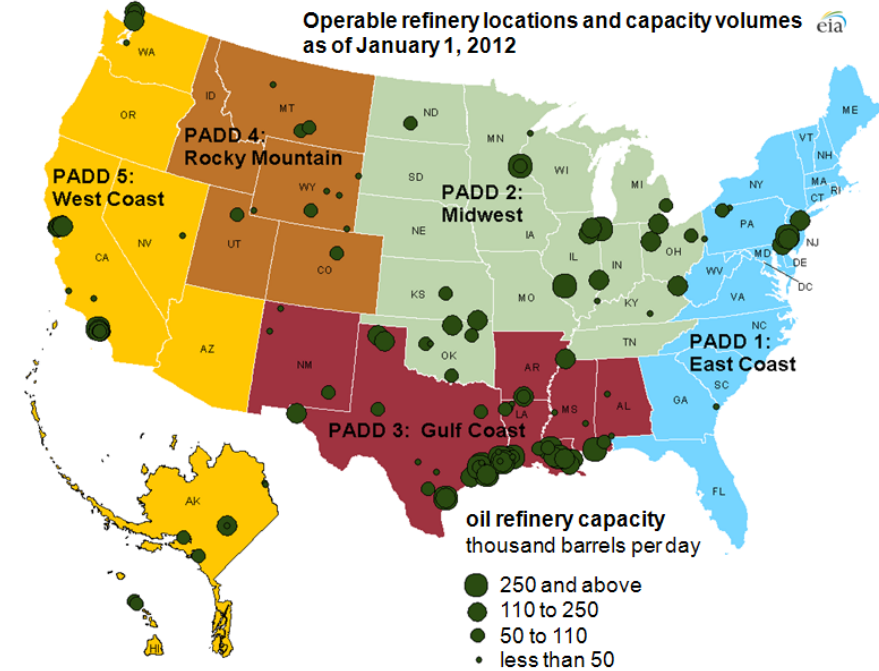
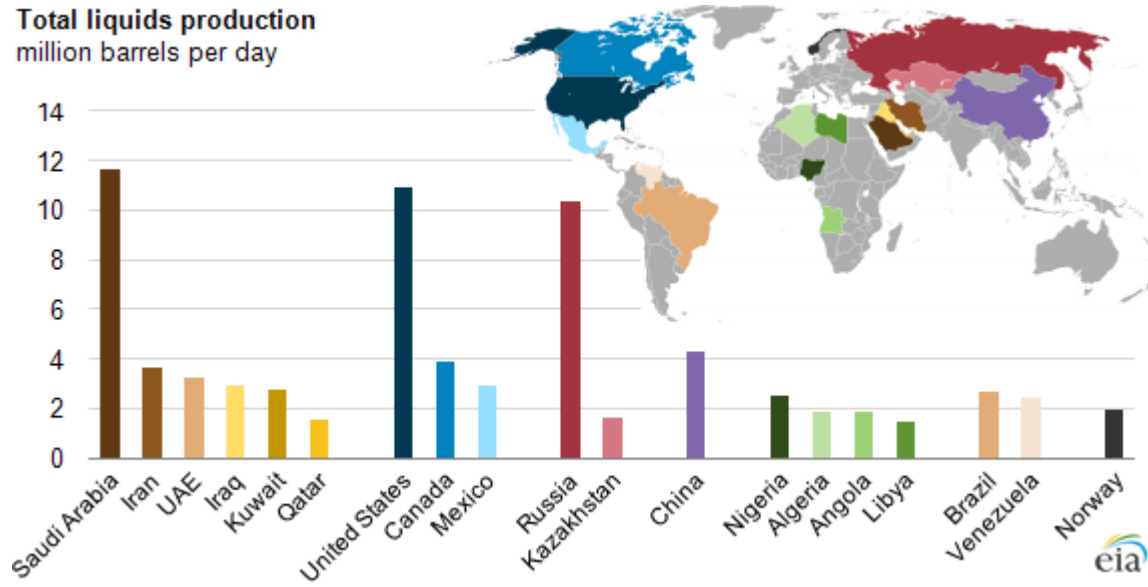
❖ Petroleum geology

Principally concerned with 7 key elements in the sedimentary basin:

1. Source (quantification of organo-rich rocks)
2. Reservoir (Unit with high permeability: Porosity check)
3. Seal (Unit with low permeability: chalk, shale, evaporates: effectiveness quantification)
4. Trap (Ensuring position of reservoir and seal)
5. Timing (Timing of hydrocarbon generation and expulsion)
6. Maturation (analyzing thermal history of source rock to predict timing)
7. Migration (Analyzing how to safely move from source to reservoirs)

❖ Petroleum production

Total liquids production
million barrels per day



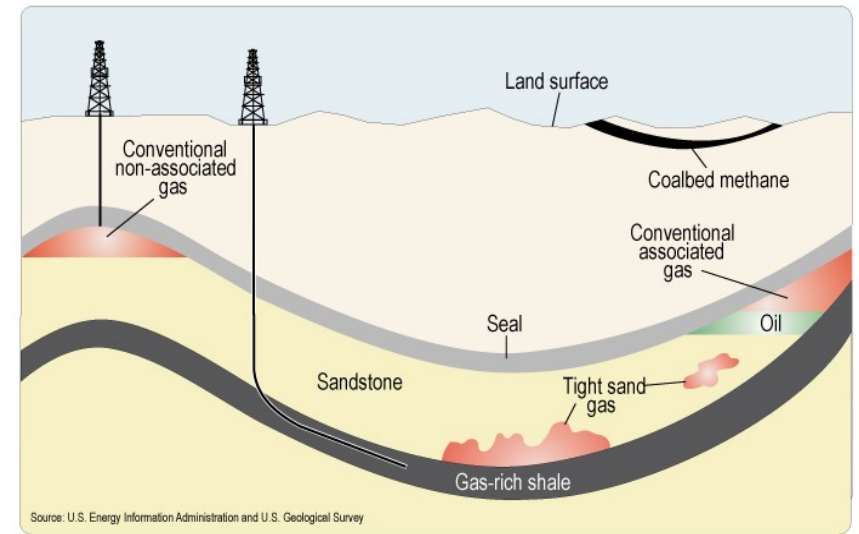
❖ Chemical Composition of Natural Gas

Natural gas is a naturally occurring gas mixture, consisting mainly of **methane**.

Component	Typical Analysis (mole %)	Range (mole %)
Methane	95.0	87.0 - 97.0
Ethane	3.2	1.5 - 7.0
Propane	0.2	0.1 - 1.5
iso - Butane	0.03	0.01 - 0.3
normal - Butane	0.03	0.01 - 0.3
iso - Pentane	0.01	trace - 0.04
normal - Pentane	0.01	trace - 0.04
Hexanes plus	0.01	trace - 0.06
Nitrogen	1.0	0.2 - 5.5
Carbon Dioxide	0.5	0.1 - 1.0
Oxygen	0.02	0.01 - 0.1
Hydrogen	trace	trace - 0.02

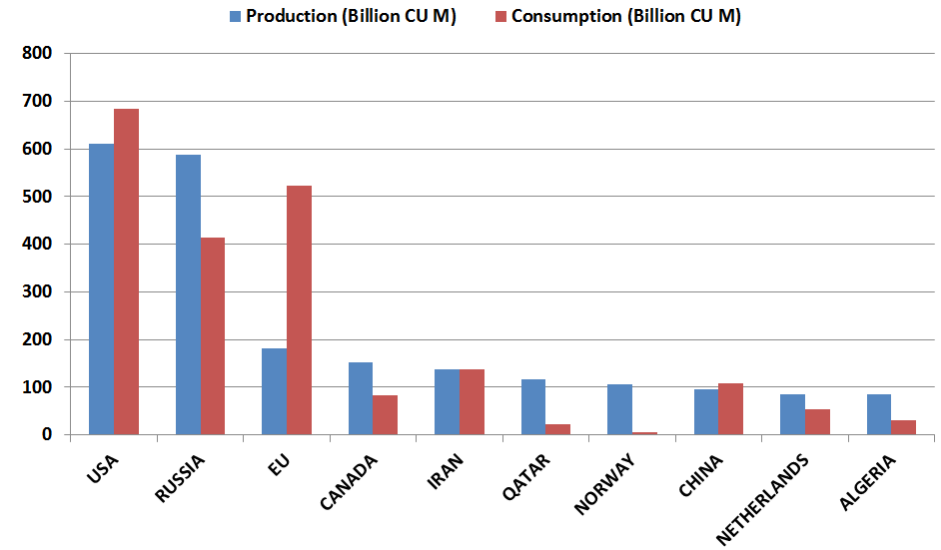
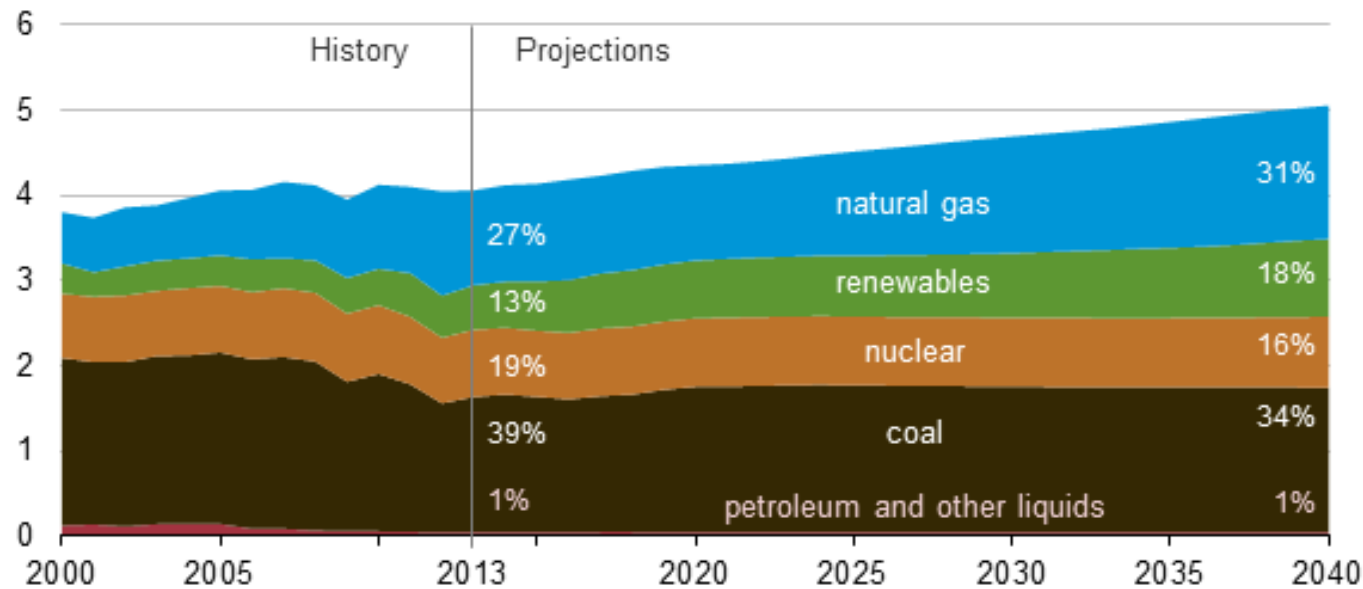
❖ Geology of Natural Gas

- **Gas-rich shale** is the source rock for many natural gas resources, but, until now, has not been a focus for production.
- **Conventional gas accumulations** occur when gas migrates from gas-rich shale into an overlying sandstone formation, and then becomes trapped by an overlying impermeable formation, called the seal.
- **Tight sand gas accumulations** occur where gas migrates from a source rock into a sandstone formation, but is limited in its ability to migrate upward due to reduced permeability in the sandstone.
- **Coalbed methane** does not migrate from shale, but is generated during the transformation of organic material to coal.



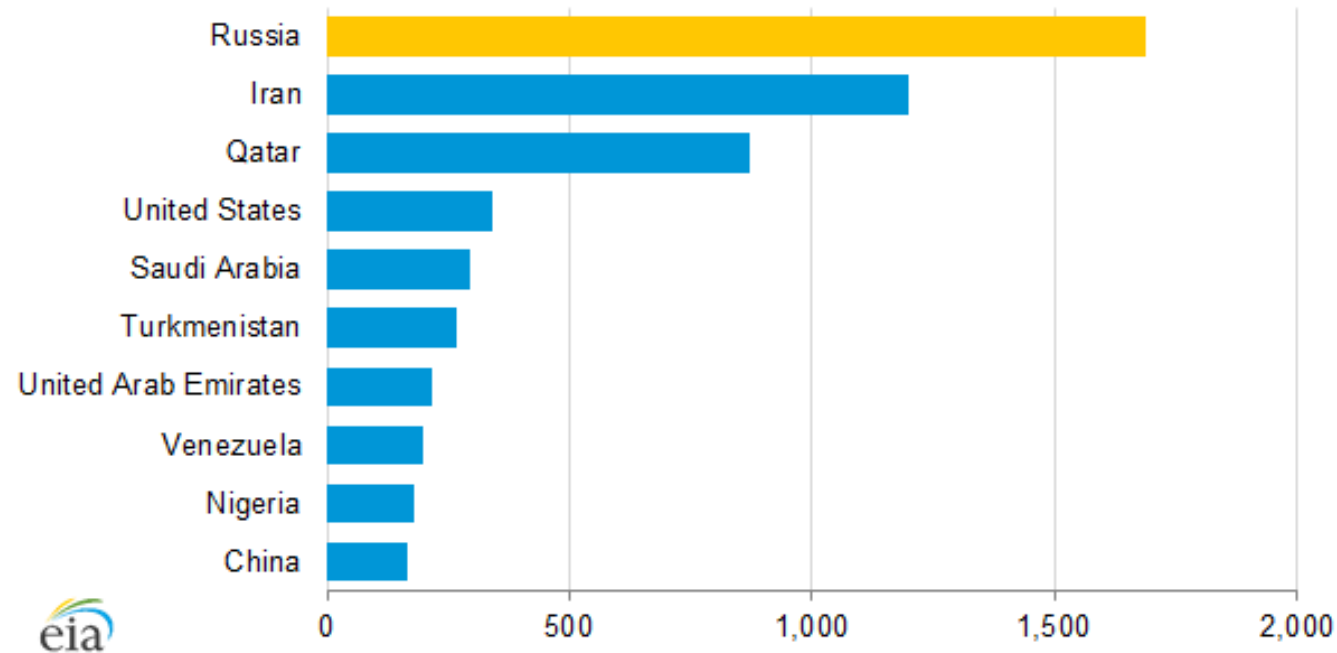
❖ Natural gas Production

Electricity generation by fuel type in the AEO2015 Reference case, 2000-2040
trillion kilowatthours



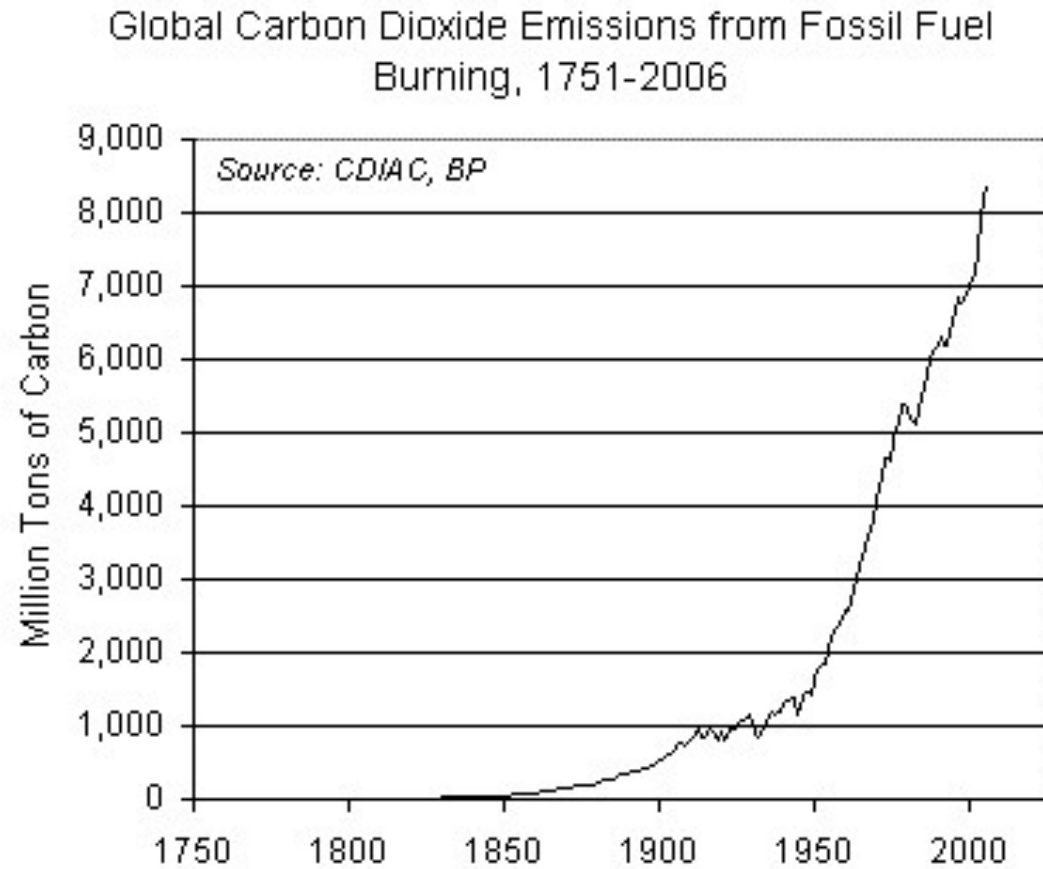
❖ Further details about natural gas

Figure 5. Estimated proved natural gas reserves, as of January 1, 2015
trillion cubic feet



Source: *Oil & Gas Journal*, "Worldwide Look at Reserves and Production," December 1, 2014.

❖ Threat from fossil fuel



Information Sources

<http://www.ucsusa.org>

<http://www.eia.gov/>

<https://www.wikipedia.org>

<https://www.uniongas.com>

