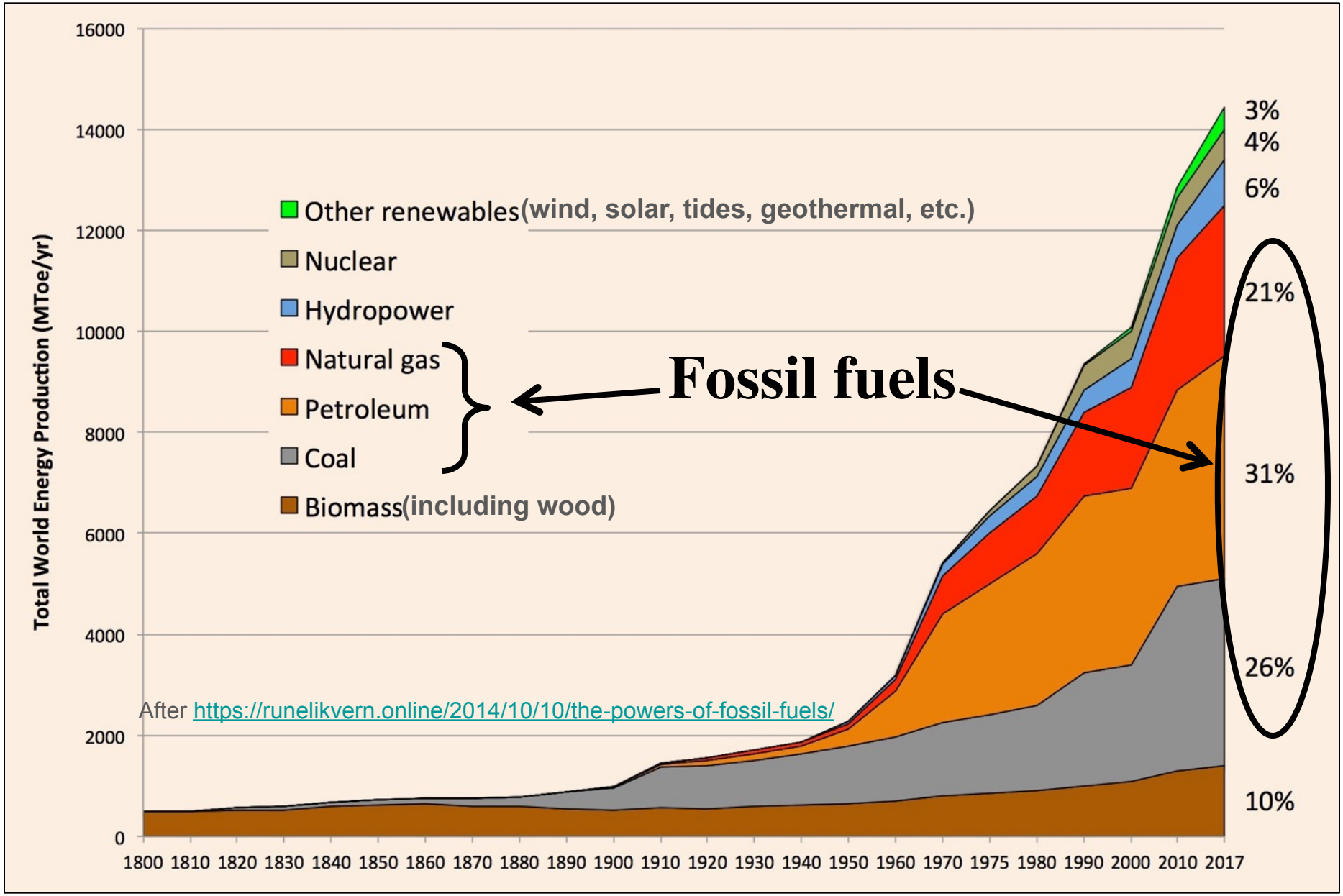
Fossil Fuel: Petroleum

Slides from lectures preceding
Petroleum Exercise

Eileen Herrstrom
herrstro@illinois.edu

2019

World Energy Sources



What Are Fossil Fuels?

- **Def: energy resources derived from the remains of organisms**
  - **Oil**
  - **Natural gas**
  - **Coal**
- **These are *non-renewable resources*:**
  - **Rate of use >> rate of renewal**

(millions of years)

http://pluspng.com/oil-barrel-png-4404.html

https://commons.wikimedia.org/wiki/File:Chuhuo.jpg

https://commons.wikimedia.org/wiki/File:Coal_mine_Wyoming.jpg

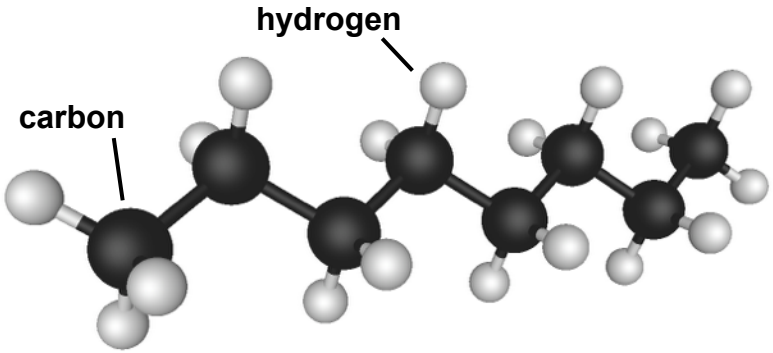
Origin: A → B → C

- ***A***ccumulation
  - Abundant organic matter
- ***B***urial in mud
  - Prevents decay
  - Preserves organics
- ***C***onversion
  - Organic matter → fuel

https://commons.wikimedia.org/wiki/File:Swamp_water_landscape.jpg

What is Oil / Petroleum?

- **Def: liquid *hydrocarbons***
  - **Form from chains of hydrogen & carbon**



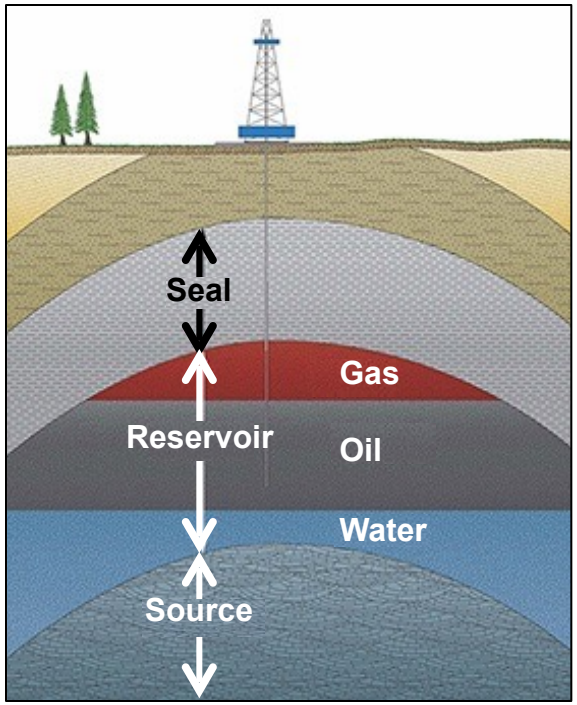
https://commons.wikimedia.org/wiki/File:Octane_molecule_3D_model.png

- **Origin: start by Accumulating *plankton* (tiny floating marine plants & animals)**
  - **Bury organic matter in mud**
  - **When T = 50-100°C, plankton Converts to oil, mud converts to shale *Source rock***

Problem: Shale is *impermeable*

- **Def: Liquids cannot flow easily through it, so…**
  - **Oil is hard to pump out**
- **Solution: oil *migrates* (seeps up)**
  - **Into a *permeable* layer**
    - **e.g. Sandstone**

Reservoir rock



http://www.wsgs.wyo.gov/energy/oil-gas-resources

  - **Blocked by another impermeable layer**

Seal rock

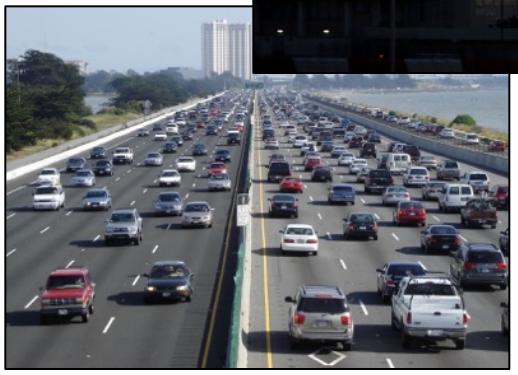
Uses of Oil

- **Transportation**
  - **55% of all petroleum is used to move things**
  - **95% of transport depends on oil**

https://commons.wikimedia.org/wiki/File:ANA_777-300_Taking_off_from_JFK.jpg

https://commons.wikimedia.org/wiki/File:Backing_it_in_2.jpg

https://commons.wikimedia.org/wiki/File:Ship2.jpg



https://commons.wikimedia.org/wiki/File:I-80_Eastshore_Fwy.jpg

https://commons.wikimedia.org/wiki/File:Three-loco-styles.jpg

Other Common Uses of Oil

- Food
  - Fertilizers, herbicides
  - Farm machinery
  - Food processing, transport
- Heating
  - 40% of homes in NE US

https://commons.wikimedia.org/wiki/File:Fertilizer_applied_to_corn_field.jpg

https://commons.wikimedia.org/wiki/File:20130920-OC-LSC-1156_(10637326386).jpg

https://commons.wikimedia.org/wiki/File:Gordon_Food_Service_Delivery_Truck.JPG

How Long Have We Been Using Oil?

- 1848 in Azerbaijan
  - First commercial production
    - o Very small
- 1859 in Titusville, PA
  - Freely-flowing well
  - PA: 3 million barrels in 1862

https://commons.wikimedia.org/wiki/File:Earlyoilfield.jpg

EROEI

- **"Energy Returned On Energy Invested"**
  - **How much energy is needed to extract barrel of oil, ton of coal, etc.?**

o High EROEI => very efficient energy source

o Low EROEI => inefficient energy source

o EROEI < 1 => energy "sink"

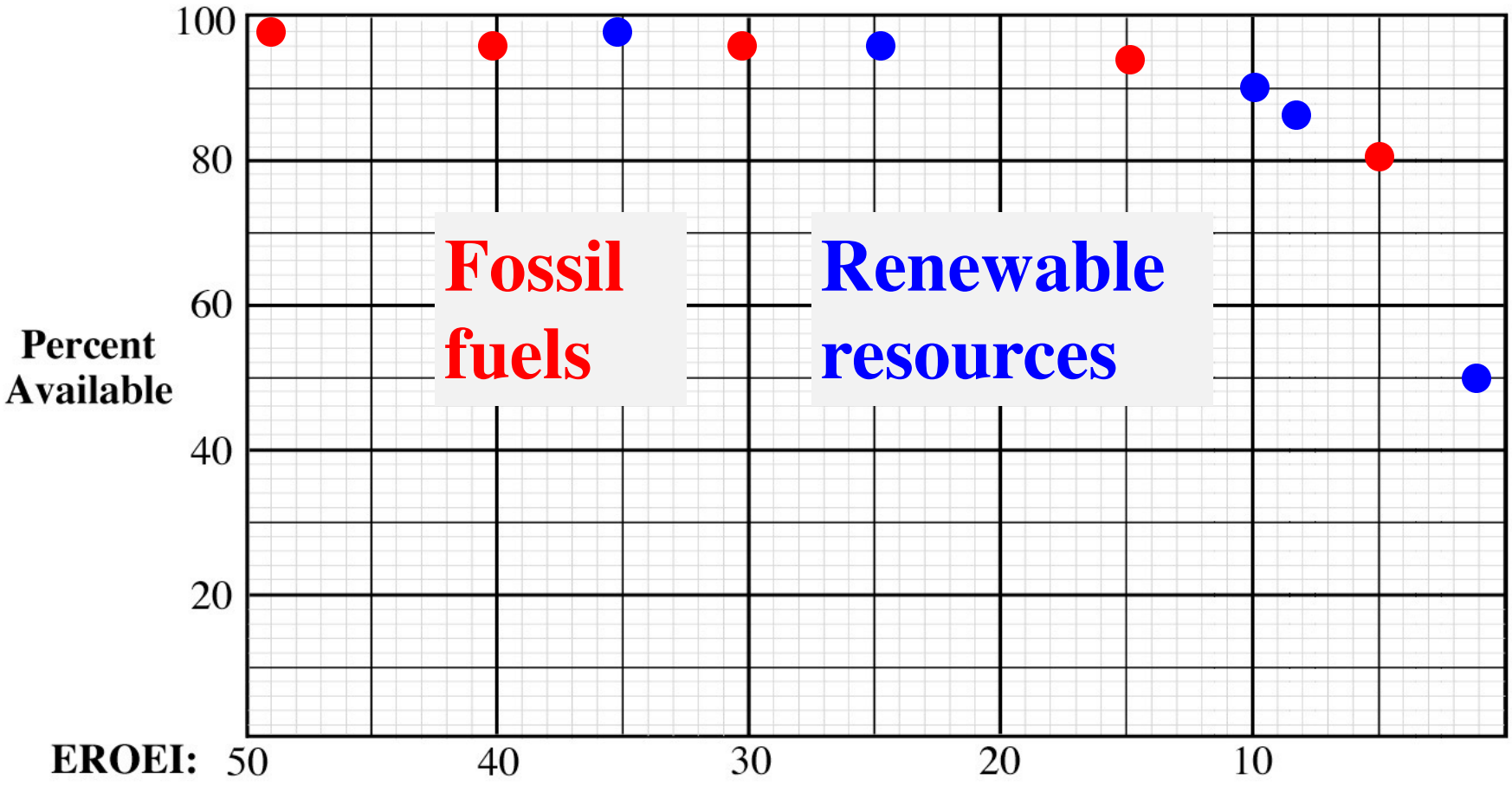
Early "gushers" had high EROEI.

https://commons.wikimedia.org/wiki/File:Gusher_Okemah_OK_1922.jpg

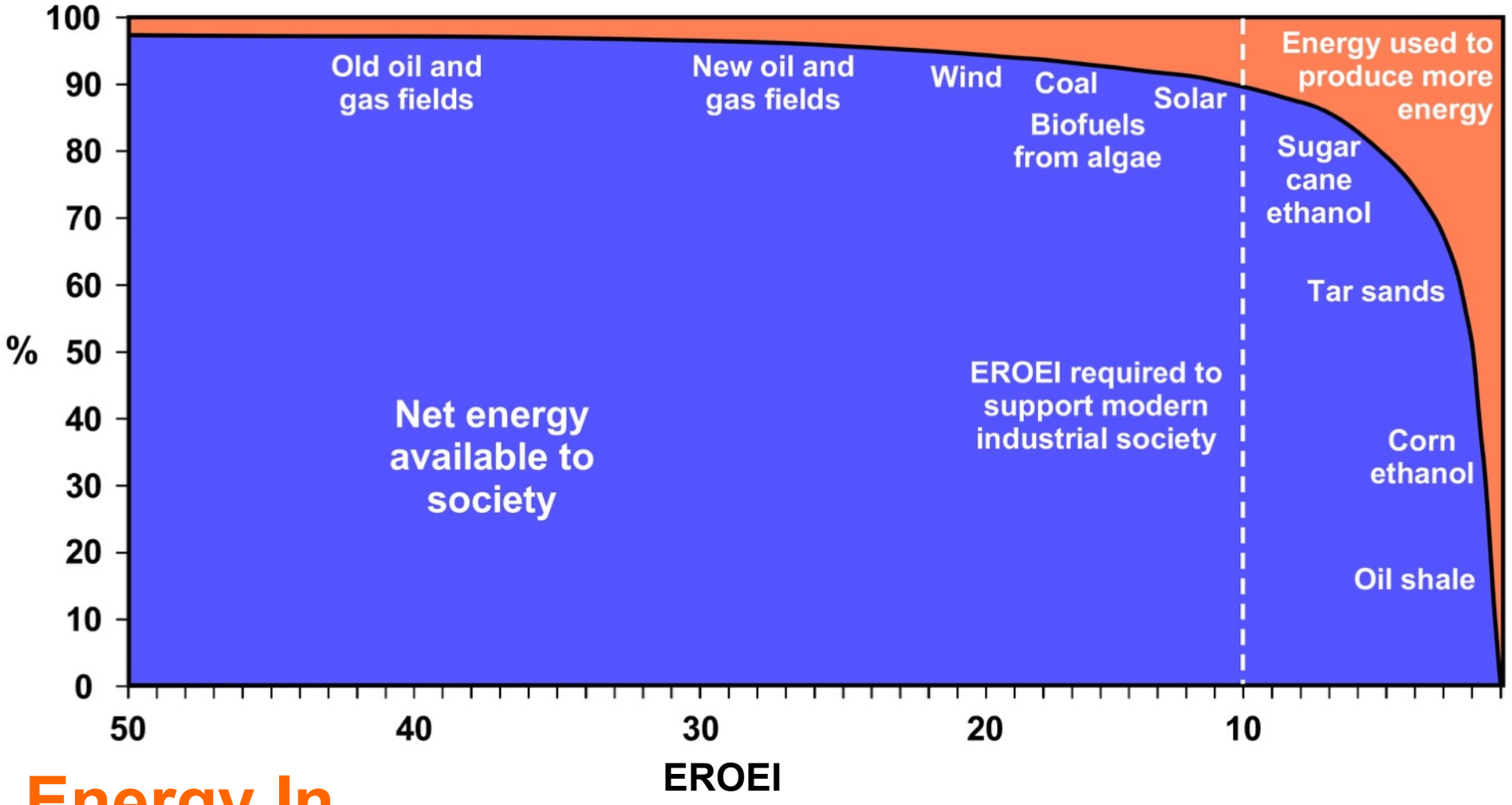
EROEI vs. % Available

	EROEI	Available:	
		Units	%
Oil before 1950	48	47	47/48=98
Global oil after 1950	30	29	29/30=96
US oil after 1950	15	14	93
Coal	40	39	97
Tar sands	5	4	80
Wind	35	34	97
Hydroelectric	25	24	96
Solar PV	10	9	90
Ethanol (sugarcane)	8	7	87
Biofuel (corn & soy)	2	1	50

EROEIs for Various Fuels from Previous Slide



The "Net Energy Cliff"



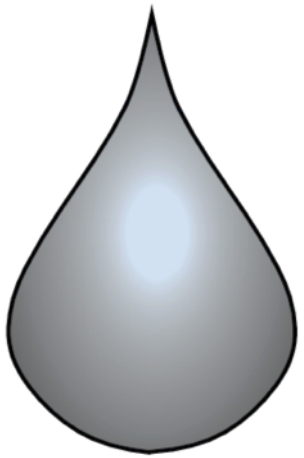
Energy In

Energy Out

Potential problem for society?

Future Energy Supplies: Oil

- **Unconventional oil**
  - **Def: forms of oil that require special processing before use**



o Tar sands (Alberta, Canada)

o Oil shales (North Dakota, Pennsylvania)

o Coal- or natural gas-to-liquid fuel

o Hydraulic fracturing / deepwater

Tar Sands, Alberta, Canada

https://commons.wikimedia.org/wiki/File:Athabasca_Oil_Sands_map.png

https://commons.wikimedia.org/wiki/File:Tar_sands_in_alberta_2008.jpg

Extracting Gas or Oil from Impermeable Source Rock: *Hydraulic Fracturing*

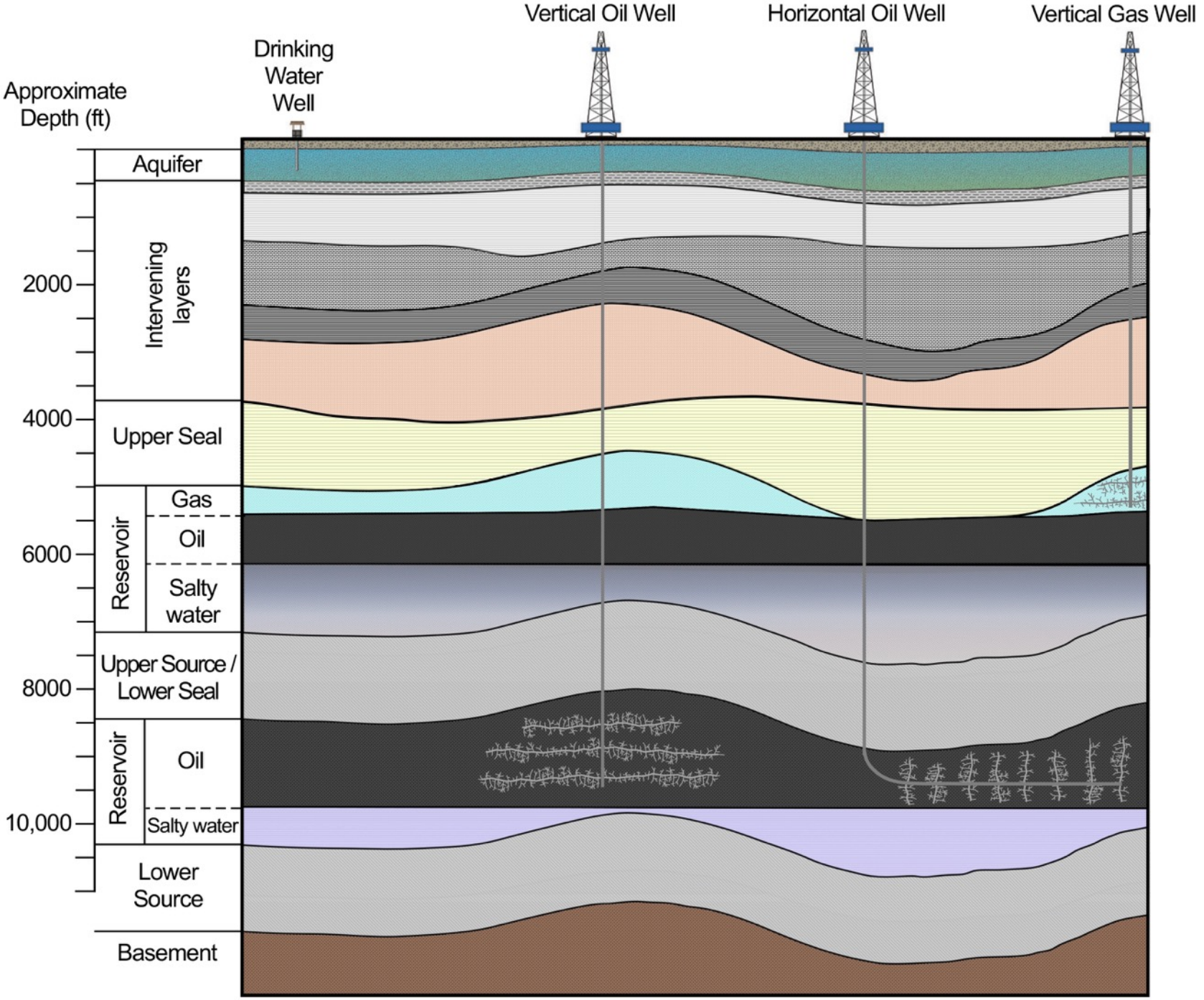
- **Def: technique to make source rock more permeable**
  - **Force pressurized fluid into rocks**
  - **Make cracks, then enlarge them until they intersect**
- **First developed in 1940s, current methods in 1980s**

How to Hydrofrack

- **Drill vertically and then horizontally**
  - **Pump in fluid under pressure**
    - **Water + additives (~2%) to improve efficiency**
  - **Fluid also carries sand or pellets to hold cracks open**
  - **Actual cracking occurs deep underground**

https://commons.wikimedia.org/wiki/File:Well_Head_where_fluids_are_injected_into_the_ground.JPG

Depth to Fracked Layer



Teaching Notes and Tips

This exercise is divided into three complementary sections. The exercise may be completed in one extended laboratory period, or individual sections may be assigned as separate, shorter activities or as homework.

The data used for this activity should be updated every year based on the sources listed in the workbook (scroll to the bottom of the data to see sources). Note that updating the data might require revising some of the questions.

Because computer software changes so rapidly, the instructions for accomplishing certain tasks with Excel might differ from those given in the student instructions. Thus, the instructor should be aware of possible difficulties using Excel.