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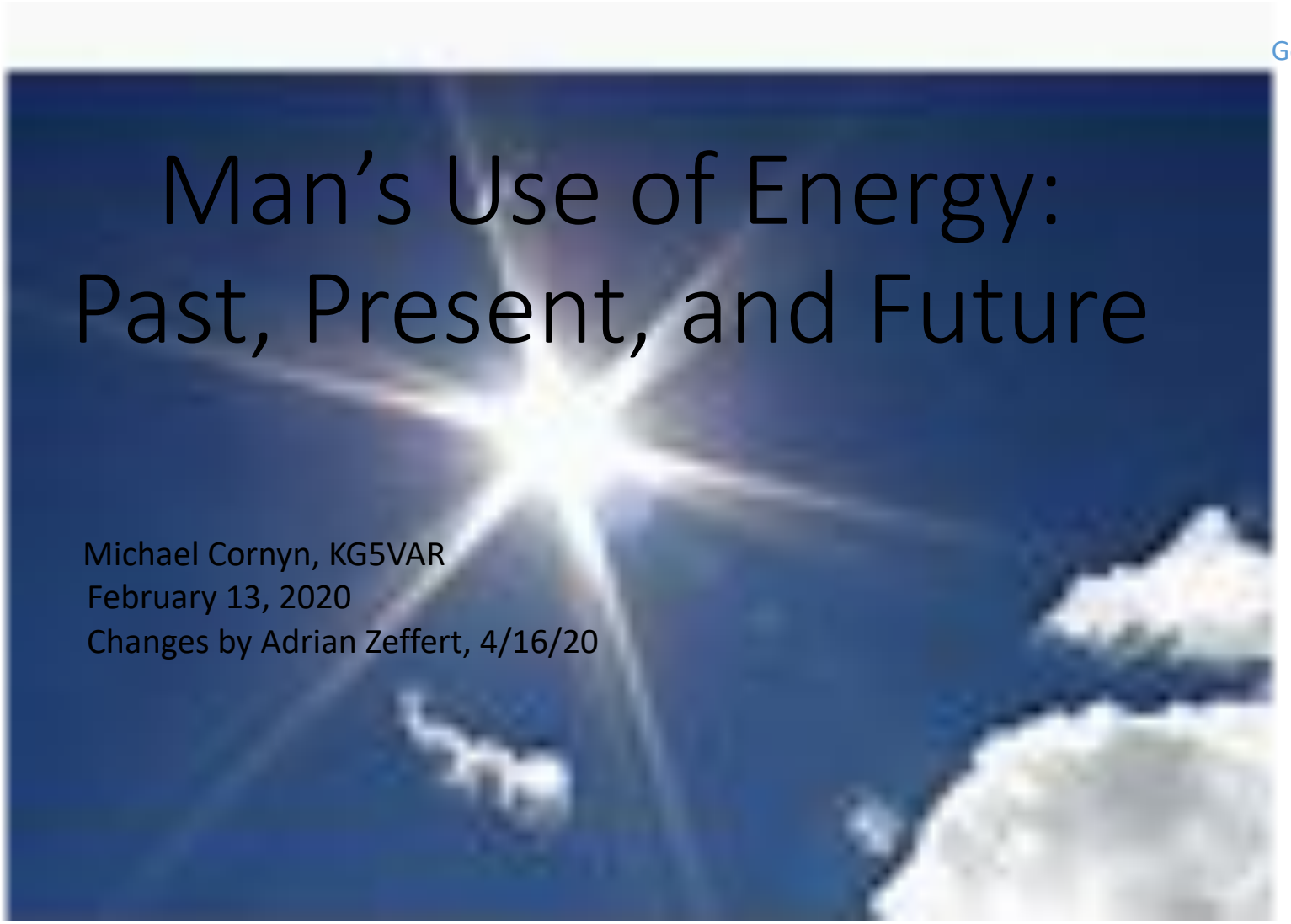

Man's Use of Energy: Past, Present, and Future

Michael Cornyn, KG5VAR
February 13, 2020
Changes by Adrian Zeffert, 4/16/20

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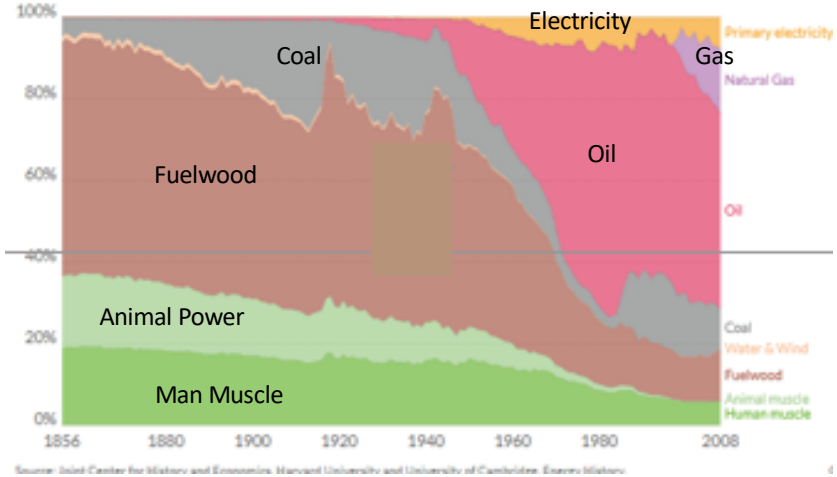
Mankind's survival and growth …..

Three of those needs are……

- Nourishing food
- Clean water
- Easily accessible energy

Energy usage for Portugal 1856 – 2008
(Third World Country)



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All Energy Used On Earth …..

Has two ultimate sources……

- Sun

Bing.com

- Natural radioactivity of rocks

Uranium Ore

Wikipedia

All Energy Used On Earth .....

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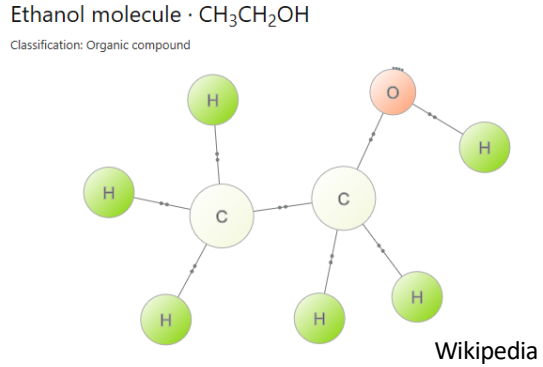
A portion of the Sun's energy is stored in ……

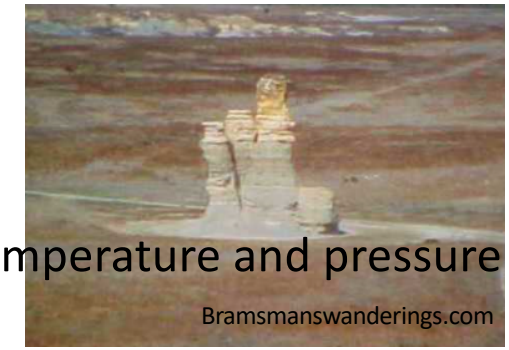
- Plants
  - Wood
  - Ethanol

Wikipedia



Wikipedia

- Coal
  - Buried freshwater swamp plant material cracked by temperature and pressure



Bramsmanswanderings.com

- Oil and Natural Gas
  - Buried marine life whose remains are cracked by temperature and pressure

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All Energy Used On Earth …..

A direct portion of the Sun's energy can be used through ……

- Solar Cells

Wholesalesolar.com

- Wind Turbines

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All Energy Used On Earth …..

Useable energy from natural occurring radioactivity ……

- Electricity from heat conversion in Nuclear Reactors

Wikipedia

World Population Versus Sources of Energy Used Over Time…..

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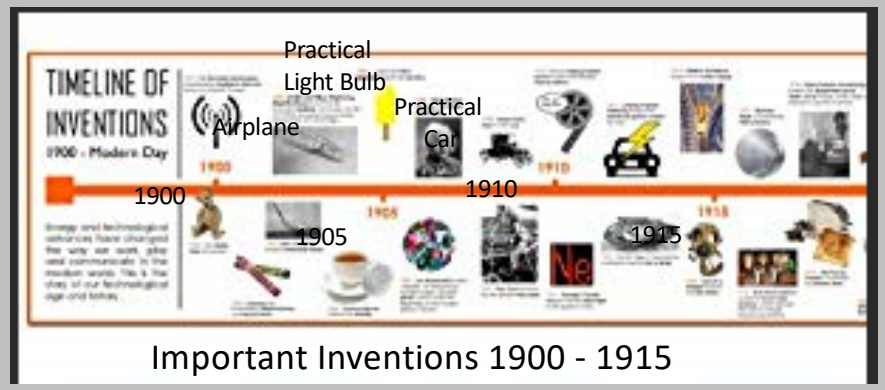
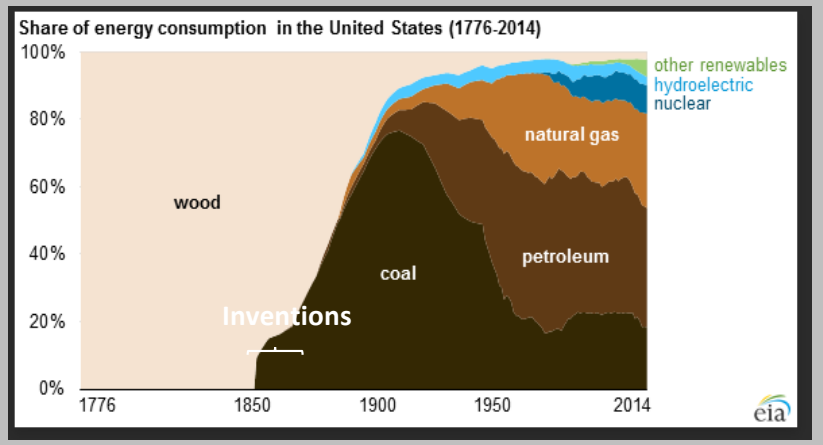


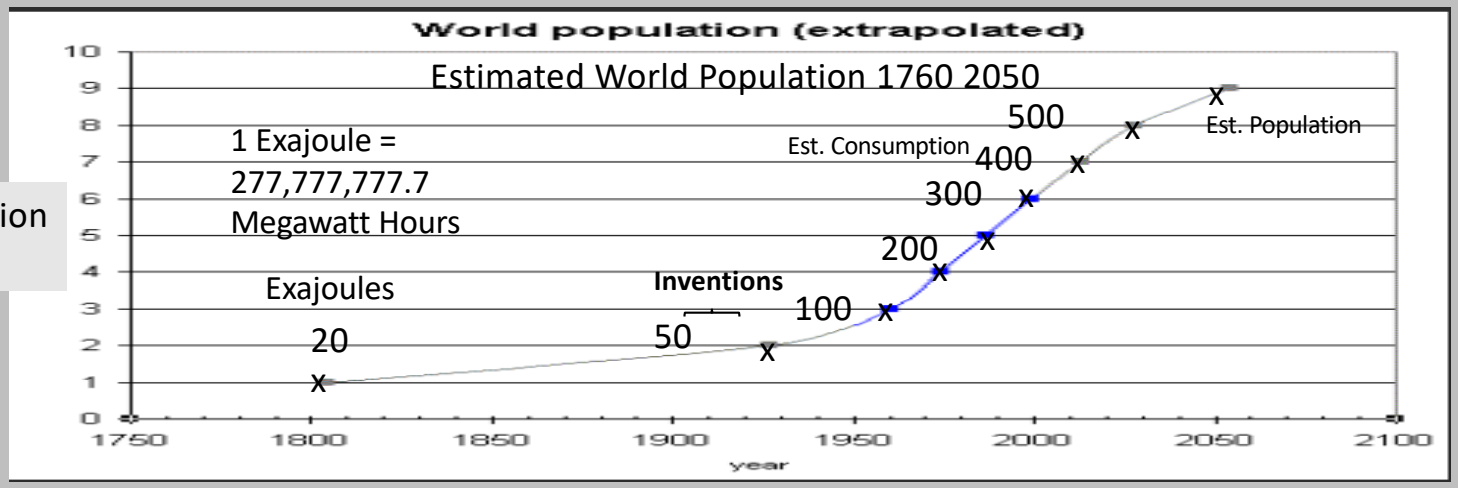
Important Inventions 1900 - 1915



Big 3 inventions for energy:

- Light bulb
- Car
- Airplane

Most important invention:
Practical Light Bulb



Estimated World Energy Consumption (**Black Numbers, Exajoules/year**)

Man and Animal Power …

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From Man's First Recorded Appearance until the Mid 19th to 20th Century….

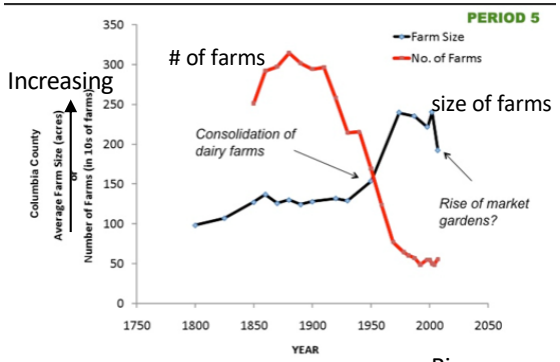
- Man and Animal Power were the common energy sources used for:
  - Transportation
  - Farming
    - Most citizens lived on farms
    - Lack of availability or affordability of farm machines
    - Most food was grown for local used (lack of refrigeration)

Bing.com

Bing.com

- After the Mid 20th Century Machines Replaced Man and Animal
  - Number of farms decreased
    - People moved to cities for better life
  - Farms consolidated into larger farms
  - Farms became more efficient with machinery
    - One man and a ox could plow roughly one acre per day
    - Two 1500 lb. horses and a man could plow 1.5 – 2 acres in 10 hours
    - A modern tractor could plow roughly 60 – 150 acres per day

Comparison Number of Farms versus Size
1750-2050



Bing.com

This has been a period of dramatic changes in the size and number of farms in the County.

Fuel Wood

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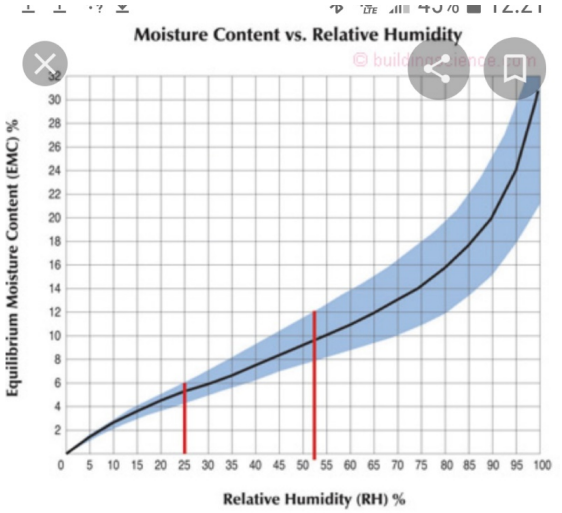
Until the mid – late 1950's wood was a major energy source on farms and in home

Pros

- Plentiful until 1950's
- Need can be provided by one or larger work force
- Can be stored for long time and heat content can improve

Cons

- Water content of new non-dried wood cuts output BTUs
- Storage can take up alot space
- With time and growing user base wood becomes less plentiful



(Source: buildingscience.com)

Heat content of one pound of oven dry wood is ……. approximately 8600 BTU.
Resinous softwoods , short leaf pine, can have a average heat content of 9050 BTU per oven-dry pound.

(Source: University of Missouri)

Note: Woods replacement (Coal) heat content is between 12,000 -15,000 BTU

Coal

Formation .....

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Coal is the resultant product of the decay, burial, compression, and concentration of the resultant carbon content of fresh and/or brackish water plant material in swamps, lagoons or river deltas

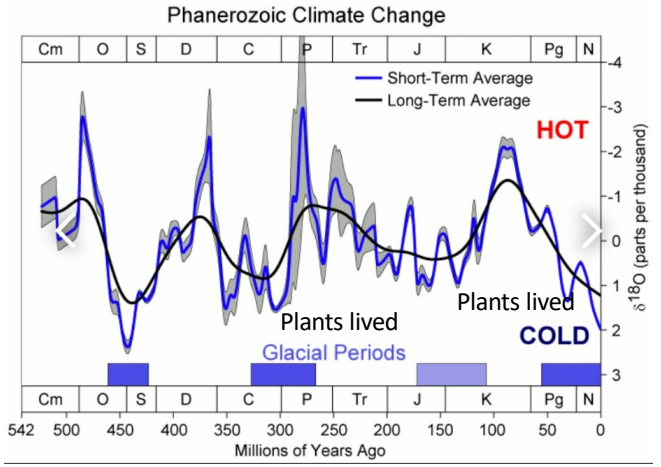
- Process called Coalification
- The Rank of a coal signifies it's quality and output heat content

TABLE 6-8: TYPICAL CONTENT OF DIFFERENT COAL RANKS

RANK	MOISTURE CONTENT	VOLATILE MATTER	FIXED CARBON CONTENT	HEAT VALUE (BTU)
Lignite	30% - 60%	25% - 30%	25% -35%	4000 - 8300
Subbituminous	10% - 45%	30% - 40%	35% -45%	8500 - 12,000
Bituminous	5% - 15%	20% - 40%	45% -86%	12,000 - 15,000
Anthracite	~5%	~5%	86% -98%	13,000 - 15,000

BTU = British Thermal Unit or the amount of heat needed to raise one pound of water one degree Fahrenheit

Coal



Coal >=50% Carbon

Coal

Facts……

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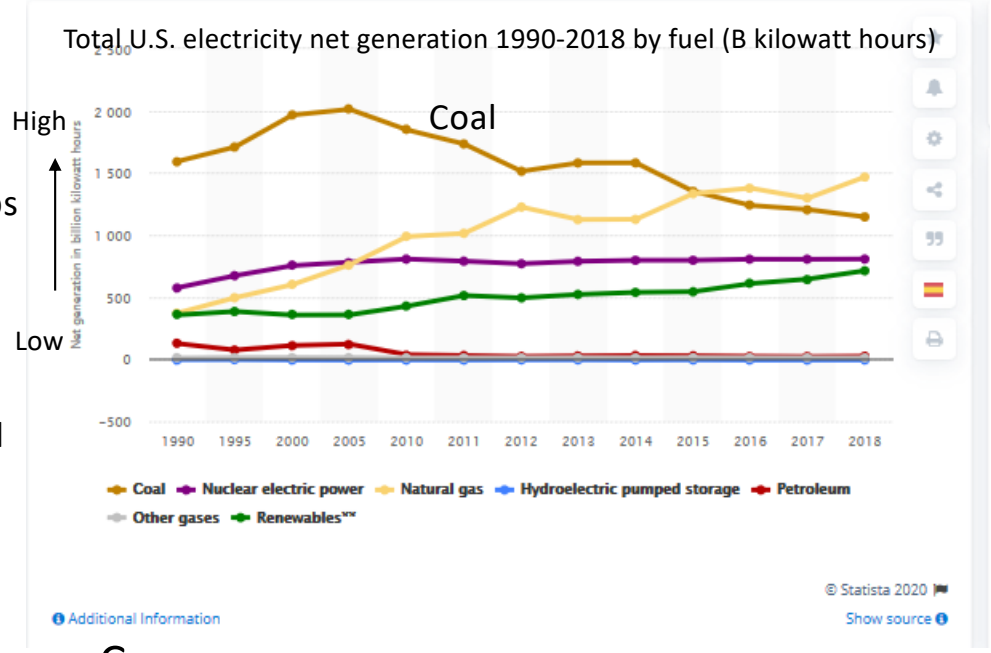
First uses of Coal:

- Chinese used it ~3000 years ago
- In 1850's used to manufacture goods and power steamships
- First used in US to generate electricity in 1880's
- By 1961 Coal was major fuel to generate electricity
- Present major uses of Coal
  - Electricity generation – called thermal coal
  - Steel production – called coking (or metallurgical) coal
  - Cement manufacturing (www.worldcoal.org)



Pros:

- Cheapest form of raw energy
- US mined fuel – US reserves are 20% of World's Reserves
- Employs a large number of people

Cons:

- Environmental concerns

Coal

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Mining, Environmental Issues, Coal Electrical Generation ….

Coal Mining Areas in United States

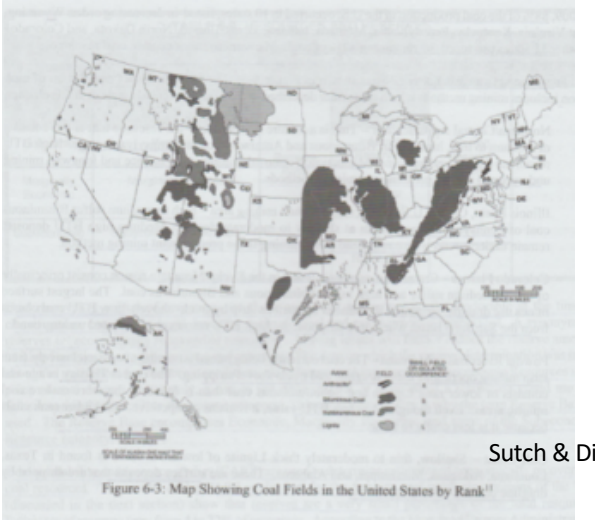


Figure 6-3: Map Showing Coal Fields in the United States by Rank[1]

Sutch & Dirth,2011

East of Mississippi mining predominately underground
West of Mississippi mining predominately surface

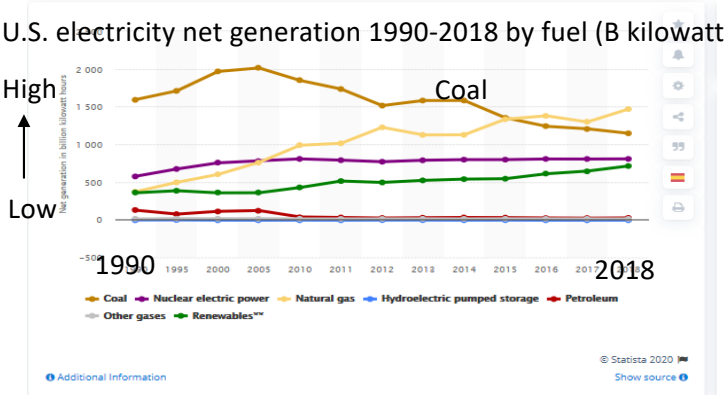
Note: US has World's largest coal reserves (250 B tons)
Third largest consumer (317 M tons)
But: Coal dust is a fire hazard
Coal requires a large storage area
Heat content: 1 ton coal = 203 gallons of fuel oil

Environmental Issues ……

- Fly ash from high fusion materials leave improperly designed furnace
  - Arsenic can be associated with fly ash, and contaminate groundwater
  - Possible future hazardous waste

- Mercury can be emitted during the burning of coal
  - Coal-fired power plants are largest source of mercury emissions in US
  - Considered a Hazardous Air Pollutant by US EPA
  - Number of coal electric generation stations has decreased since 1990

Total U.S. electricity net generation 1990-2018 by fuel (B kilowatt hours)



Oil and Gas

Uses Thru Time.....

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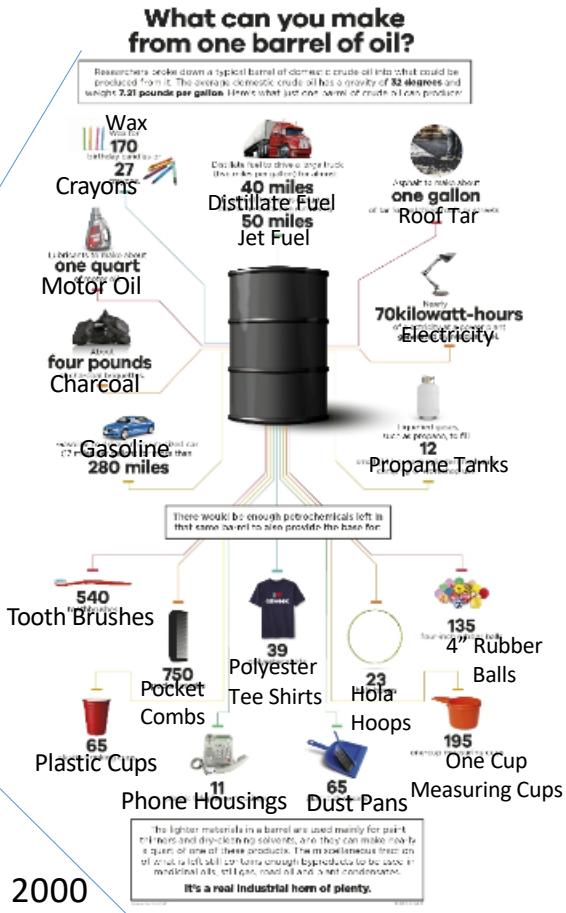

Man's Quality of Life

Airplane

Car

Light Bulb

Kerosene

Whale Oil

Other Fuels

Fuelwood

Candles

Uses

Heat/Light

Medicinal

Lubricant

Lubricant

Trenton Field Discovery 1880

WWII

Spindle Top 1914

WWI

Drake Well 1859

1300 1400 1500 1600 1700 1850 1900 1950 2000

Source

Oil/Gas

Climate, Hydrocarbon Source, Traps.....

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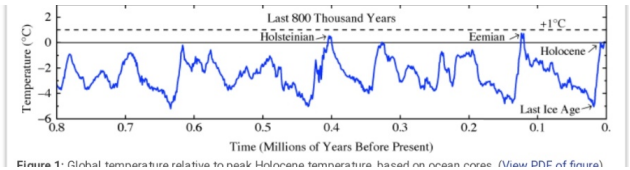
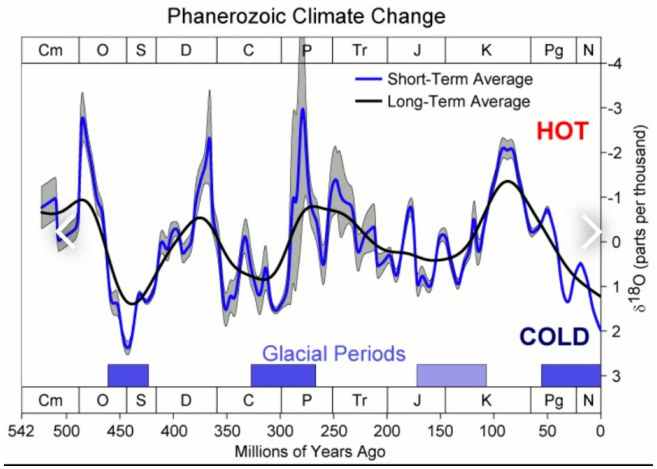
Climate Last 800,000 years



NASA GISS

Climate Last 500,000,000 years

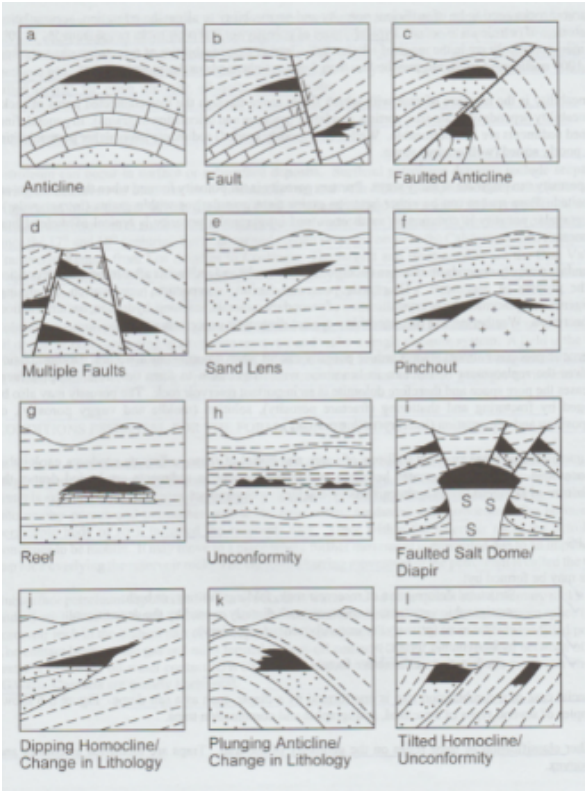


Wikipedia

Climatic Change Oil/Gas Sources

- Lower mean temperatures
  - Mean sea level lowers
  - Surface erosion on continent increases
  - Fewer animals/plants
  - Dead animals/plants are buried by sediment
- Warm mean temperatures
  - Mean sea level rises
  - Continental erosion decreases
  - More animals and plants.

Structural and Stratigraphic Traps



Ditch and Suth,2015

Indiana Oil/Gas History.....

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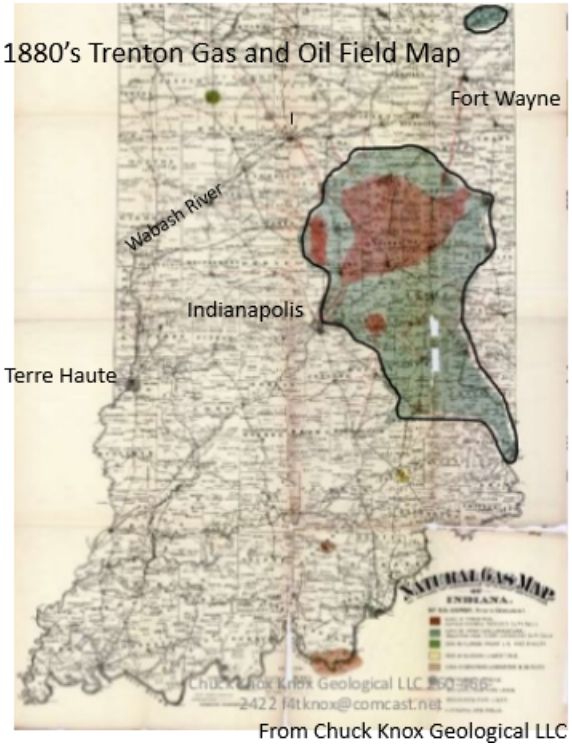
~100 Years Ago Indiana was the Saudi Arabia of the World

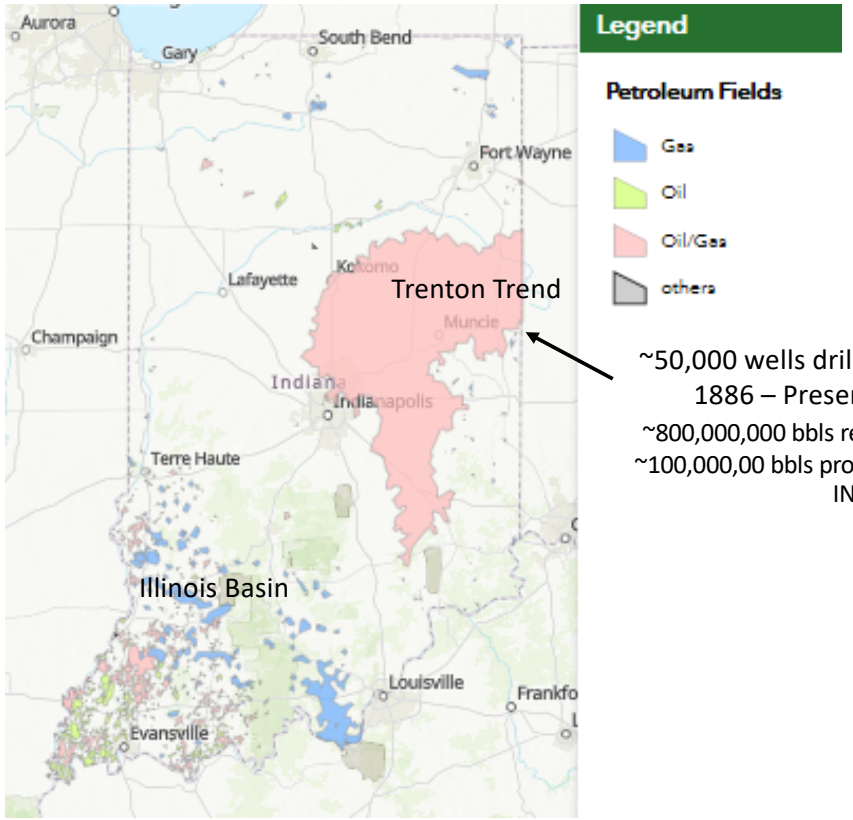
Past



From Chuck Knox Geological LLC

1837 – gas in Findley area used in house, groundwater had SO
1884 - Dr Charles Oesterlin, formed first gas drilling company in Findlay, Ohio
1886- Significant gas discovery at Eaton, Delaware County, IN started gas boom
1889- Commercial oil production began near Keystone, Wells County, Indiana
1904- Peak oil production 1910- Field gas is depleted (From Indiana DNR)

Present



~50,000 wells drilled
1886 – Present
~800,000,000 bbls remain
~100,000,00 bbls produced
INDNR

Source: Indiana DNR

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U.S. Areas That Have Produced Oil/Gas

Left: Areas of historical oil (red), gas (green), or mixed (yellow) production in the contiguous United States as of 2005 (immediately prior to the shale boom). Right: Current (solid orange, plus blue and black outlines) and prospective (solid red) shales for oil/gas production, overlain on major sedimentary basins (tan), as of 2016. Image credits: Laura R.H. Biewick, U.S. Geological Survey;[1] U.S. Energy Information Administration.[2]

Source: AmericanGeosciences.org

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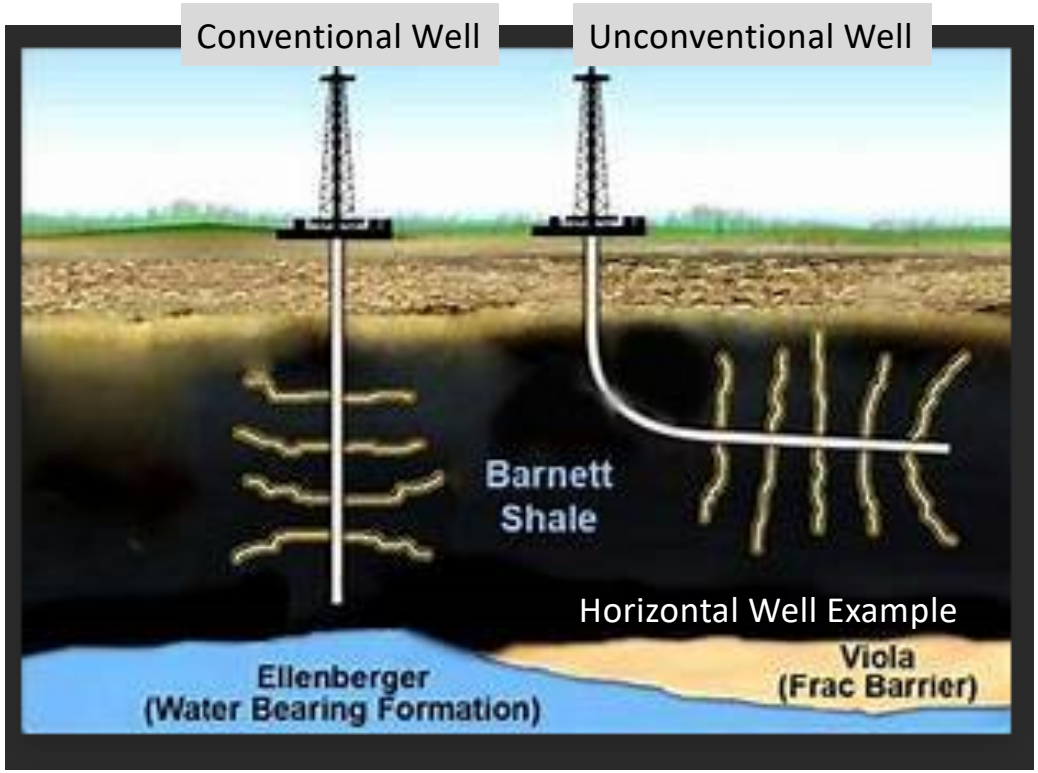
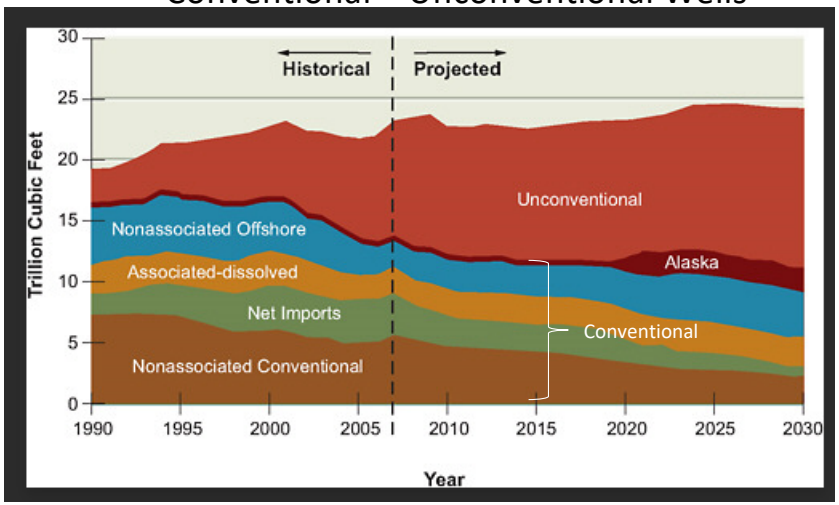
Oil/Gas

Conventional, Unconventional (Horizontal).....



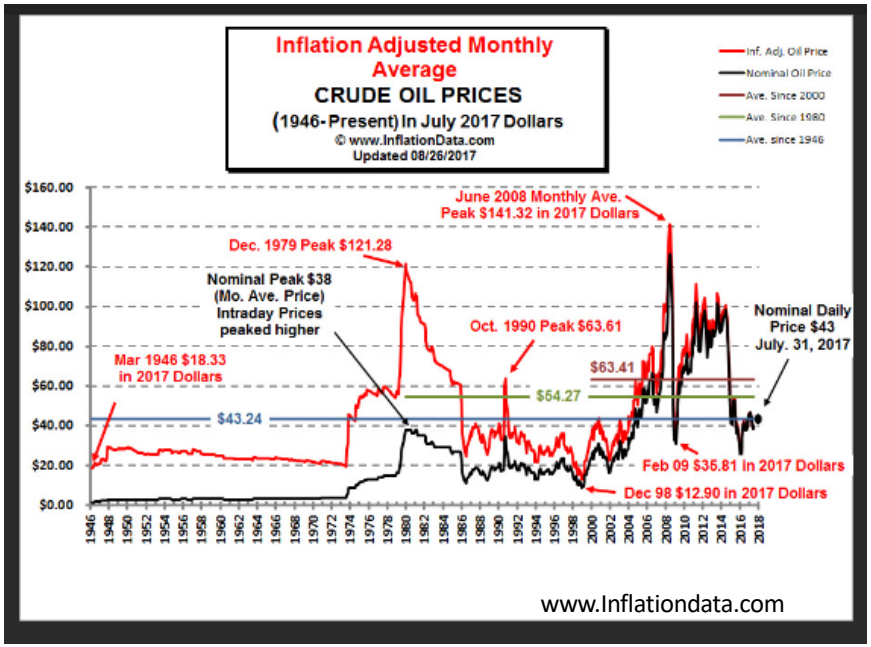
www.horizontaldrilling.org

Gas Production Versus Time
Conventional – Unconventional Wells



Oil/Gas Prices (This was written before the current drop in Gas prices)

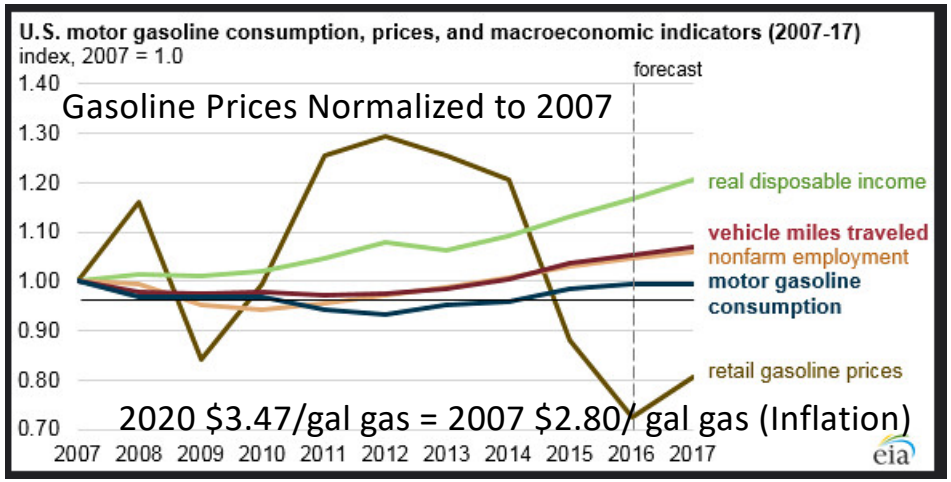
Demand, Politics and Inflation

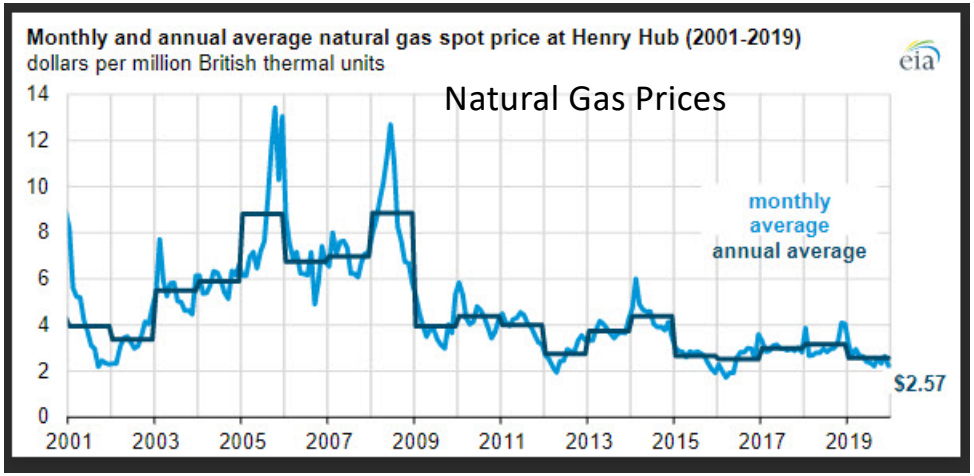


Federal fuel tax 2019 18.3 cents/ gasoline
24.3 cents/ diesel

Indiana fuel tax 2019 30 cents/ gasoline
49 cents/ diesel

Inflation: 2007 $1.00 = $1.2394 in 2020 (lendingtree.com)





www.fuelsmarketnews.com

Oil/Gas Producers Past and Today……..

Effect of Risk/Reward

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Six Largest Oil/Gas Companies……..

- Exxon
- Chevron
- EOG Resources
- Occidental Petroleum
- Marathon Petroleum

Source: technavio blog

All Public Stock Owned Companies……

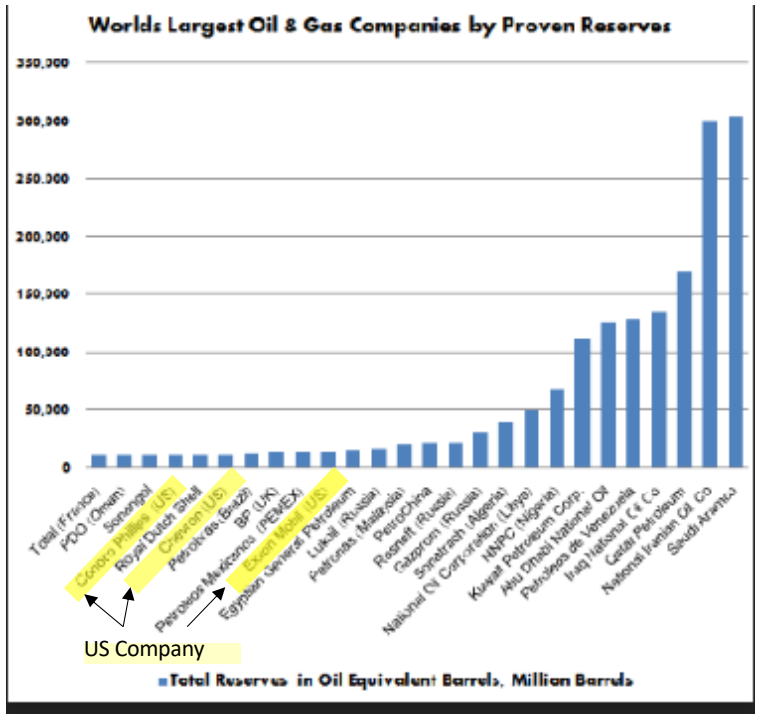
Effect of inflation, risk and reward……..

1980 US Companies
Many Were Household Names

31 Contributing Companies

- Amerada Hess Corporation
- Amoco Production Company
- Ashland Oil, Inc.
- Atlantic Richfield Company
- BP Alaska
- Champlin Petroleum Company
- Chevron Oil Company
- Cities Service Company
- Columbia Gas Development Corporation
- Continental Oil Company
- Diamond Shamrock Corporation
- ERA North America, Inc.
- Exxon Company, U.S.A.
- Getty Oil Company
- Gulf Energy and Minerals Company
- Kerr-McGee Corporation
- Marathon Oil Company
- Mobil Oil Corporation
- Ocean Production Company
- Pennzoil Company
- Phillips Petroleum Company
- Placid Oil Company
- Shell Oil Company
- Skelly Oil Company
- Sun Oil Company
- Superior Oil Company
- Tenneco Oil Company
- Texaco, Inc.
- Texas Eastern Transmission Corporation
- Transco Exploration Company
- Union Oil Company of California

As of 2018 only 3 US Companies In World's Largest



Source: technavio blog

Nuclear Electricity Power Generation.....

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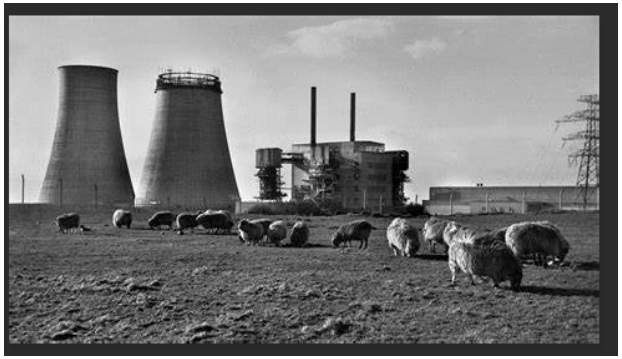
The Promise.....



Hack College

First nuclear reactor: University of Chicago, 1932
First nuclear power plant: Obninsk, Russia in June 1954. (sciencing.com)
Number of nuclear power plants: 96 (US) 439 (World) 13.8% of World's power
How much power does a nuclear power plant generate: 8 TWhr /yr.
Useful life: 20 – 40 years (Last US nuclear plant completed in 1996, a plant in Ga is under construction)
Estimated cost to construct: $4000/kW (scitizen.com, Nov., 2008)

Pros

- Non-green house gas emitter
- Consistent base load supplier of energy
  - Good to use with renewable energy sources because output can be raised or lowered
- Low operating cost supplier

Ohio Governor Signs Coal and Nuclear Bailout at Expense of Renewable Energy

https://Insideclimatenews.org

Cons:

- Potentially high environmental damage and controversial
  (Ex. Chernobyl, Ukraine, Fukushima, Japan and Three Mile Island, USA)
- High startup and yearly regulation costs
- Radioactive waste disposal – storage
  - 80,000 metric tons spent fuel rods, stored at 75 sites, 35 states, $.5 B/ yr
  - Radioactive waste from weapon manufacturer, 4 sites, 4 states $6 B/ yr
  - Yucca Mt, Nevada waste site, authorized 1982, $4 B spent, still not open
- Limited or no US supplier of certain materials for construction or re-conditioning of nuclear plants

Solar PV Electrical Power…….

Renewal Energy Source …..

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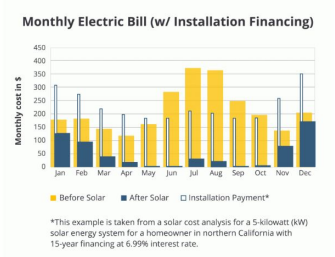
Solar



Solar PV Effect: 1839
French physicist Edmond Becquerel

First solar cell: 1883
American Charles Fritts

Cost for typical 1500 sq ft house: $7-26K
(3 kWh – 10 kWh solar panel system, typically 6 kWh ~$18,500)

Solar ROI: 7 – 20 years

Pros

- Once installed requires little maintenance, lasts 25-30 years
- Generated electricity sold directly to utility which could reduce monthly electric utility bill
- Federal and State governments give incentives for installing working panel systems
  - State of Hawaii plans to have ~100% of its electricity needs produced by residential solar PV by 2045
- Cost of Solar PV systems are decreasing

Cons

- Only generates electricity when sun is out
- No or limited electric storage capabilities available
  - A Tesla battery to store the energy equivalent of one barrel of oil (3000 lbs.) would weigh 20,000 lbs. and cost $200,000. (Econonics21, July 2019)
- Site and ground surface area needed for panels

Wind Turbines…….

Renewable Power…..

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Pros

- Able to generate electricity 24/7
- Can generate enough electricity for 1 – 1000s of homes
- Most environmentally friendly of electricity generation methods

Cons

- Utility generators need an average wind of ~ 13 mph
- Doesn't have method to store electricity
- Site and footprint of tower and Wind Farm, and sound of turbine when in operation.

Wind was used in antiquity to:

- Power, pump water, grind wheat, etc.

First used to generate electricity:

- In 1887 by Prof James Blyth in Glasgow
- In 1887 Charles F Brush in Cleveland, OH

First utility scale wind turbine (100kw):

- 1931 in Balaklava, USSR

First Megawatt size wind turbine:

- 1941 in Castleton, Vermont

1973-2000 US Wind Turbine Development:

- NASA, DOE, and industry work to develop large commercial wind turbines
- Many of the NASA design and parts used today
- Oil price crash of 1980-1990 kills US industry
- Vestas, Siemens get in business with 2MW power plant and parts
- Teachers and students from the Tvind school built the first 3 blade wind turbine seen today
- By 2014, 240,000 wind turbines produce 4% of world's energy

Wind Turbines…….

Western Ohio Wind Farm Example…..

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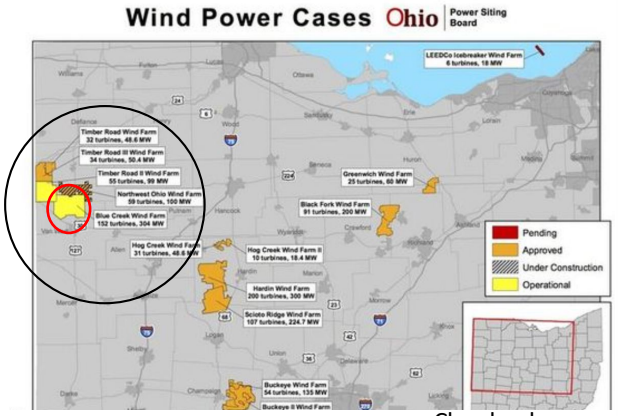
www.power-technology.com

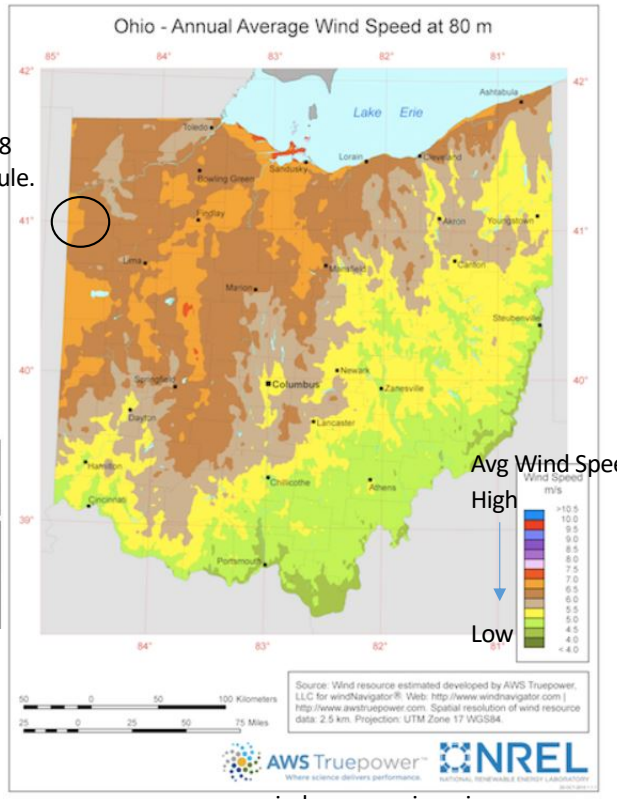
Ohio has the wind potential to generate 152 TWh./ yr.

- The state used 160 TWh of energy in 2005.
- World's largest hydroelectric plant generated 80 TWh in 2008
- 2014 Ohio legislation hurt wind farm investment with new rule.

Wikipedia.org



Cleveland.com

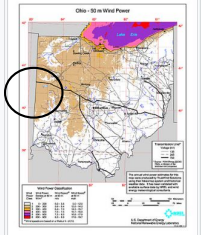


windpowerengineering.com

Wind Turbine Generated Power MW

Year	Ohio	Texas	California	US
1999	0	180	1,646	2,500
2000	0	181	1,646	2,566
2001	0	1,096	1,714	4,261
2002	0	1,096	1,822	4,685
2003	3.6	1,293	2,043	6,374
2004	7.2	1,293	2,096	6,740
2005	7.2	1,995	2,150	9,149
2006	7.4	2,739	2,376	11,575
2007	7.4	4,296	2,439	16,596
2008	7.4	7,116	2,517	25,410
2009	7.4	9,403	2,798	34,863
2010	9.6	10,089	3,252	40,267
2011	112	10,394	3,917	46,916
2012	428	12,214	5,542	60,005
2013	428	12,355	5,830	61,107
2014	435	14,098	5,917	65,880
2015	443	17,713	6,108	74,471
2016	545	20,321	5,662	82,171
2017	617	22,637	5,609	89,078
2018	729	24,899	5,855	96,487

Wind Map



Average annual wind power density map for Ohio at 50m above ground

Example: Blue Creek Wind Farm (Red Circle):

- Located in Van Wert and Paulding Counties, Ohio
- 152 2MW turbines on 27,000 of 40,500 acers
- Generates 304 MW, enough power for 76,000 homes
- Total cost $600 million, owned by Iberdrola Renewables

In 2014 total wind turbine power generation 336 GW with China, US, Germany, Spain, Italy in lead.

Wikipedia.org

Present Energy Consumption…….

World & US Values…..

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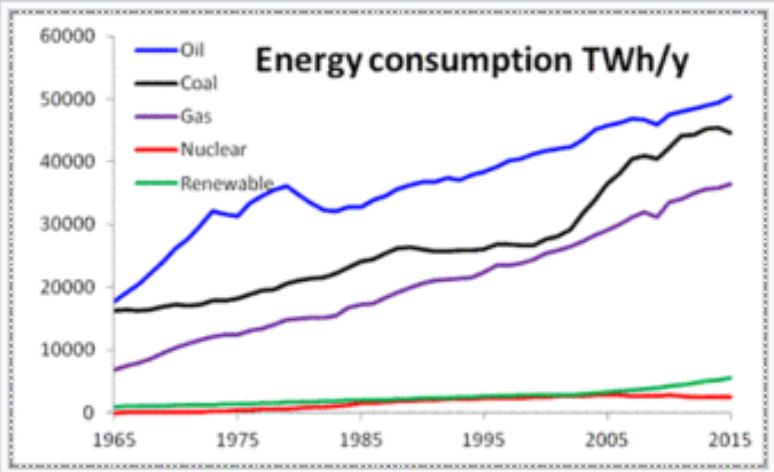
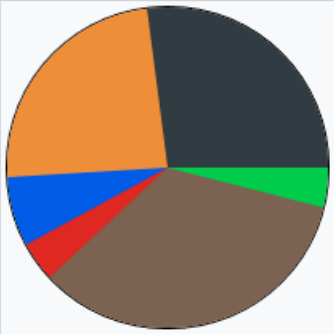
World Consumption



The world's energy consumption (2015 data)[1]
Each 10000 TWh/y corresponds to an average value of about 1.142 TW.

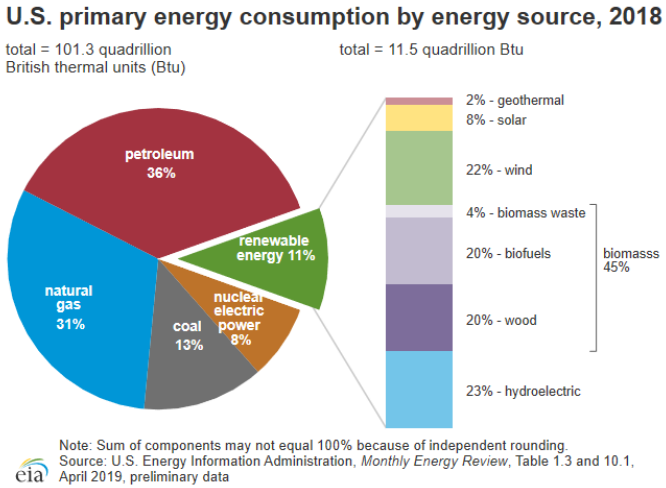
Wikipedia.com

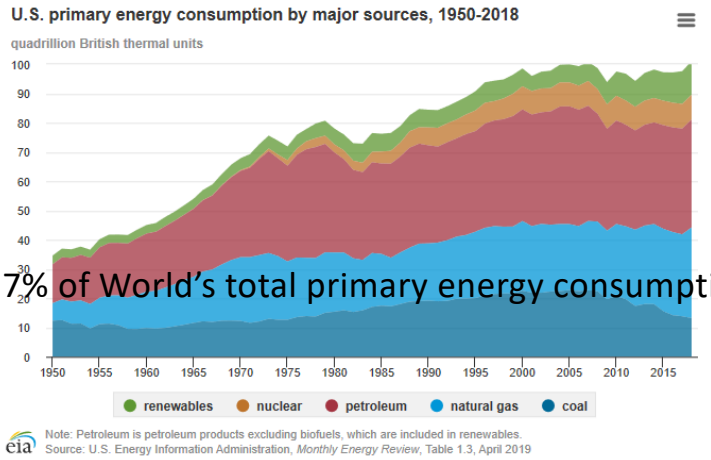
World Consumption Sources



World total primary energy consumption by fuel in 2018[2]

- Coal (27%)
- Natural Gas (24%)
- Hydro (renewables) (7%)
- Nuclear (4%)
- Oil (34%)
- Others (renewables) (4%)





US 17% of World's total primary energy consumption

China is the largest total primary consuming nation

Future World Energy Consumption…….

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bp

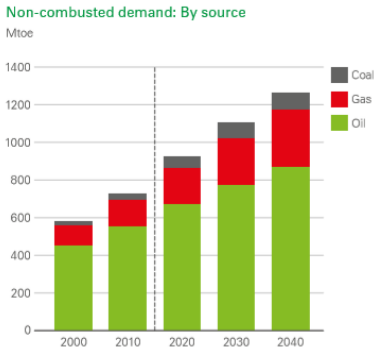
Energy Outlook Forecast 2019 - 2040…..

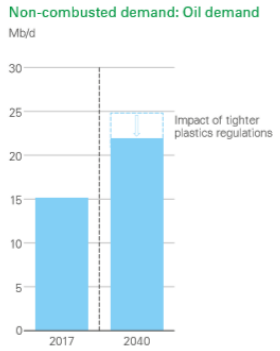
The demand for energy is set to increase significantly driven by increases in prosperity in the developing world

Key Points of BP Forecast

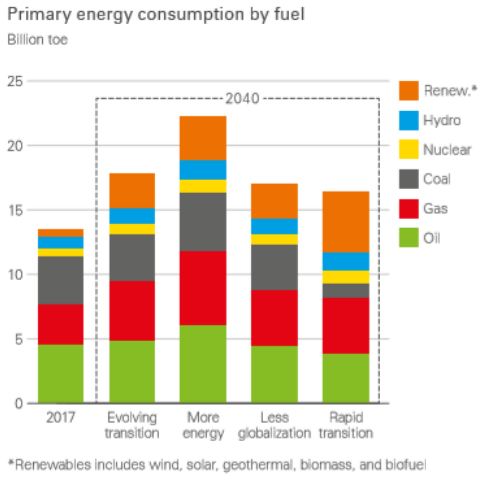
- World GDP more than doubles by 2040
- Improved living standards (especially in China and India) drive energy consumption up by 33%
- Most of the world (67%) still have a low energy consumption
- Industry and buildings account for 75% of energy increase
- Electric cars (~25% of fleet) sharply slow transportation needs
- Electrical power generation absorbs 75% of new energy consumption
- Natural gas use increases, oil grows then plateaus, US tight oil replaced by OPEC
- Coal consumption is relatively flat

Non Fuel Consumer Products (Plastics, clothing, medicine, etc……)



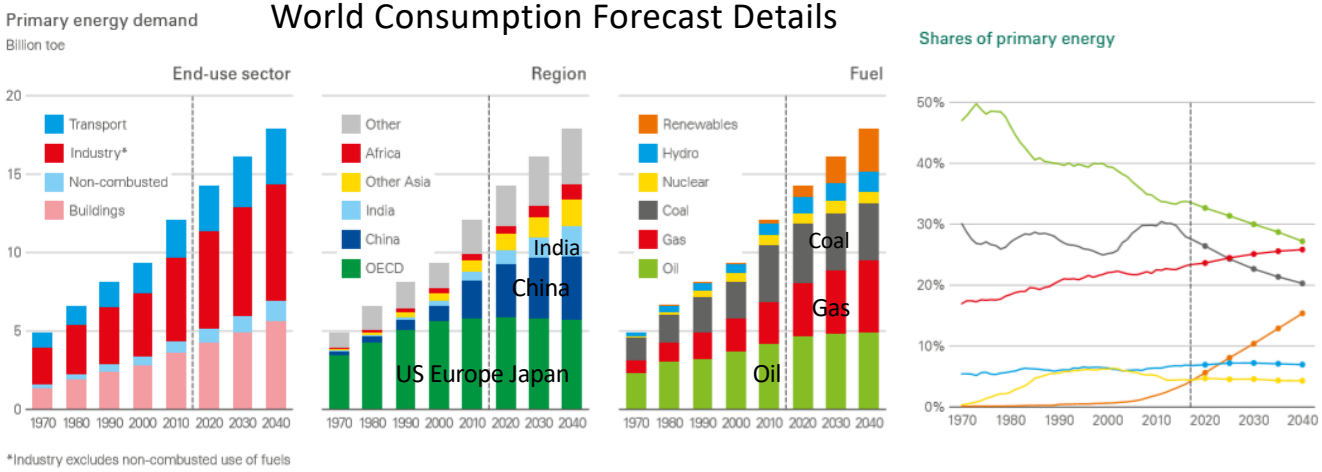


Energy Consumption Forecast Scenarios



*Renewables includes wind, solar, geothermal, biomass, and biofuel

World Consumption Forecast Details



*Industry excludes non-combusted use of fuels

Present and Future US Electricity Sources…….

Trends and Cost Comparison…..

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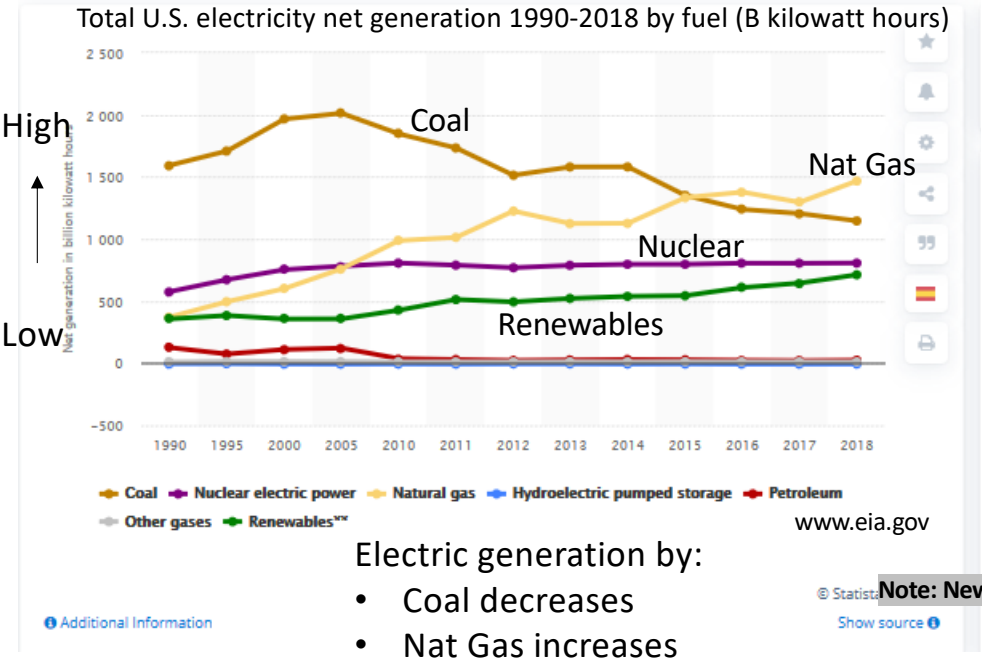
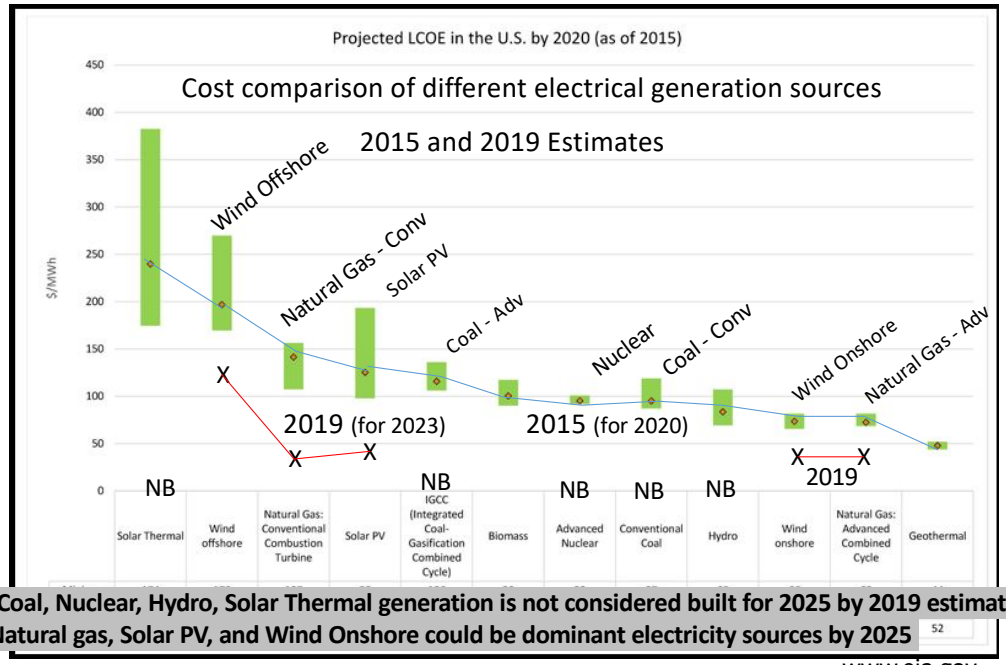
If the US's energy industry remains consumer driven, not government dictated then the following may continue.



www.eia.gov

Electric generation by:

- Coal decreases
- Nat Gas increases
- Renewables (Solar, Wind) increases



Note: New Coal, Nuclear, Hydro, Solar Thermal generation is not considered built for 2025 by 2019 estimates
Natural gas, Solar PV, and Wind Onshore could be dominant electricity sources by 2025

www.eia.gov

Levelized Cost of Energy (LCOE): minimum price electricity must be sold over project lifetime to break even….. NB = Not Built

Future Oil/Gas Trends

Forecasting Can Be Difficult…

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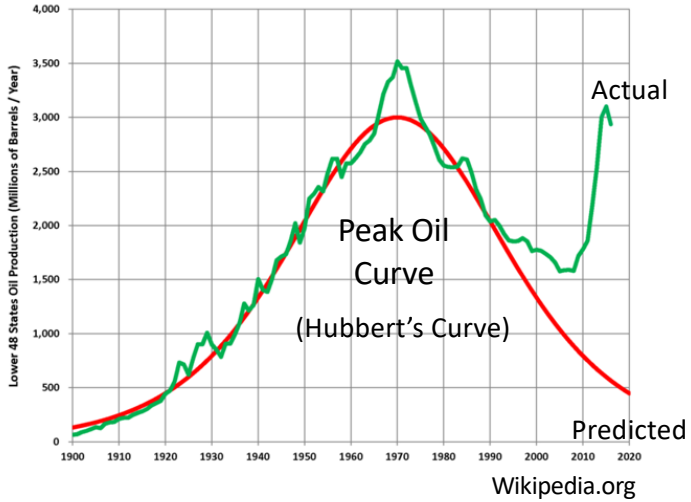
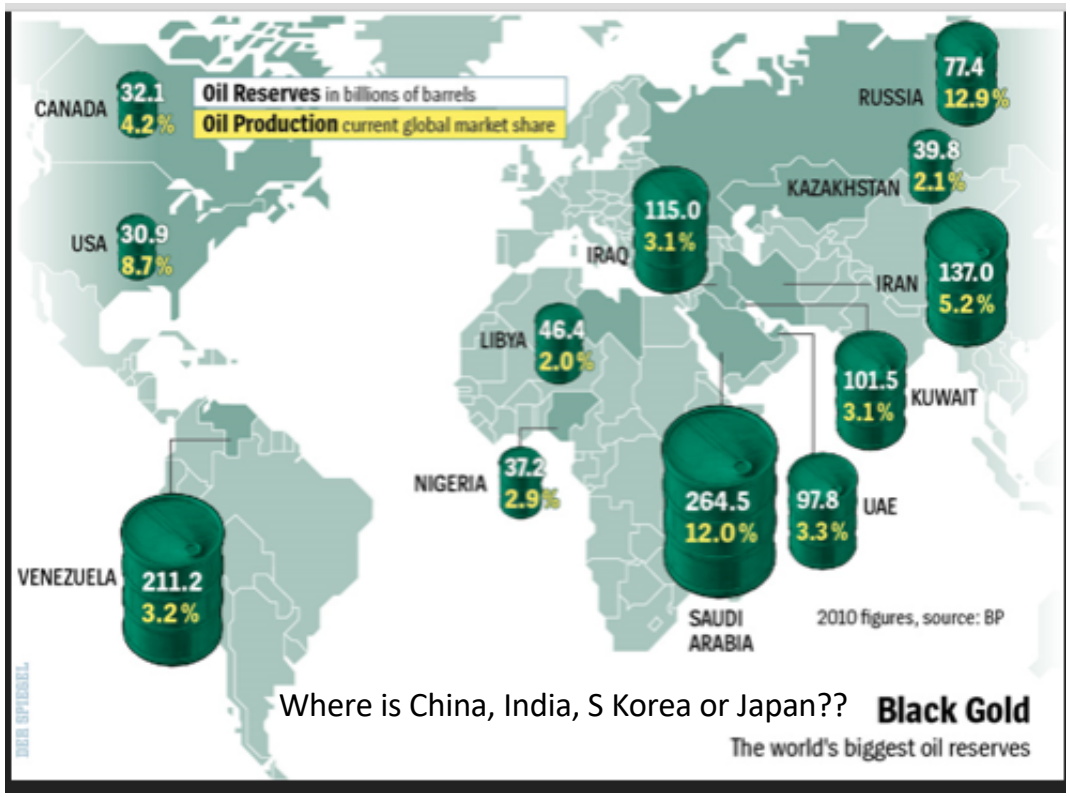
Remember Peak Oil Predictions??

US Oil Production 1900-2020



Wikipedia.org

Countries with Largest Oil Reserves – Future Powers ??



Where is China, India, S Korea or Japan??

Other Future Energy Sources…….

Decade or More Away…….

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Advanced enhanced oil recover technology

- Present oil recovery technology leaves 70% or more of the oil in a reservoir
  - If oil recovery could be improved by 10%

Recovery of Methane Hydrate from vast deposits formed under great pressure and low temperatures

- Vast deposits of Methane gas is trapped in ice crystals at approximately 2600 feet
- These Methane deposits are found bordering most continents and in the Artic Permafrost
- Production techniques to produce it have been elusive.

Fusion Reactor

- Produces vast amount of energy with no waste

Mine Helium 3 on the moon and use it on Earth or in orbit to generate electricity

- Proposed by Dr. Harrison Schmitt, NASA astronaut/geologist who visited the moon on Apollo 14
- In his book “Return to the Moon

Conclusions

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Man's "Quality of Life" is directly related to the availability and quantity of energy that can be used

- Go without electricity for one day

All "Man Kind" probably aspire for the same "Quality of Life and, therefore the energy needed for that goal.

The non-renewable energy forms (oil and gas) are useful for other material needs then burning

- Oil – plastics, fabrics, plants, medicines, etc. Natural Gas - plastics

Renewable energy forms are good and are improving in cost for generating electricity

The US is "energy" rich a) 20% of the World's coal reserves, b) 40% of the World's Uranium Reserves, c) large mass in the lower 48 useful for renewable energy generation from Wind and Solar PV, d) second largest shale oil reserves, plus the technology, and e) second to fourth largest shale gas reserves

We are in an enviable position and need to protect ourselves from outside and inside groups that could threaten our freedom to allow millions of people to vote daily on our energy sources and use.

As seen in Ohio Wind , politicians are already working at making some decisions for us… Get Involved……

If you would like to explore this Presentation in more detail, please go to the CMARA Website, 'Presentations', to download a copy. It should be on the site by, Apr 20. I am sure that Michael would be interested in any additions or corrections.

Credit:

Michael Cornyn, KG5VAR

- Is a Licensed Professional Geologist (LPG) in Indiana
- President of Manteo GeoResources LLC, a Louisiana LLC
- A graduate of Wright State University, Dayton, OH BS 74 Geology and MS 77 Geology
- Worked 42 years in the Oil and Gas Industry as a geophysicist and geologist
  - Onshore Gulf Coast and Appalachian Basin
  - Offshore and Deep- Water Gulf of Mexico
  - China, Mediterranean, and Venezuela
- Until recently lived in Lafayette, Louisiana and Houston, Texas