HONR 229L: Climate Change: Science, Economics, and Governance

Discussion #13: Biofuels

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Class Web Site: http://www.atmos.umd.edu/~rjs/class/honr229L

ELMS Page: https://myelms.umd.edu/courses/1269254

http://www.taxpayer.net/library/article/federal-subsidies-for-corn-ethanol-and-other-corn-based-biofuels

15 October 2019

HONR 229L: Climate Change: Science, Economics, and Governance

AT 12a, Q1

The Krupp and Horn (KH) book (first published in 2008; the paperback editions are dated 2009 and 2010), industry research firm Clean Edge makes a prediction of the total installed capacity for solar photovoltaics (PV) in year 2015.

a) What was the prediction?

b) What was the actual worldwide installed capacity reached at the end of year 2016, according to wiki https://en.wikipedia.org/wiki/Photovoltaic ?

Also, do you think Fred Krupp and Miriam Horn would be pleased with what has actually happened?

a) (Page 22) "...industry research firm Clean Edge predicts that revenues in the solar photovoltaic industry will grow to $50 billion a year by 2015, reaching a total installed base of 75 gigawatts, a tenfold increase from today."

b) (Via Wikipedia Article) "At the end of 2016, worldwide installed PV capacity increased to more than 300 gigawatts..."

Overall, I think that *Fred Krupp and Miriam Horn would be pleased with what has actually happened*. The actual worldwide installed capacity is four times higher than was to be expected.

Nonetheless, *a little math from the figures on page 22 reveals that this still only has the ability to supply 2.0% of the total amount of electricity needed*. Thus, while Krupp and Horn would be pleased with what has happened, they would be the first to point out that there is still a lot of work left to be done.

…

there is always need for radical change to improve the quality of our environment, and clearly based on 2017 estimates the solar sector only accounted for 6% of the renewable energy consumed by the US, and the total renewable energy only accounted for 11% of the 97.7 quadrillion BTU used in the US.

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AT 12a, Q2

The KH book gives a numerical value for how much the price per peak watt for solar energy must be, for solar energy to be able to compete with "coal-fired electricity virtually everywhere". This number appears twice in the reading; also the wiki page provides the same price per peak watt cost for solar energy to achieve economic parity with the grid.

a) what is the price per peak watt for solar energy needed to achieve cost parity with coal?

b) according to http://solarcellcentral.com/markets_page.html , when was this parity achieved?

c) according to KH, what other additional critical hurdle must be overcome to enable solar-generated electricity to compete with coal-fired electricity virtually everywhere?

a) The price per peak watt is $1

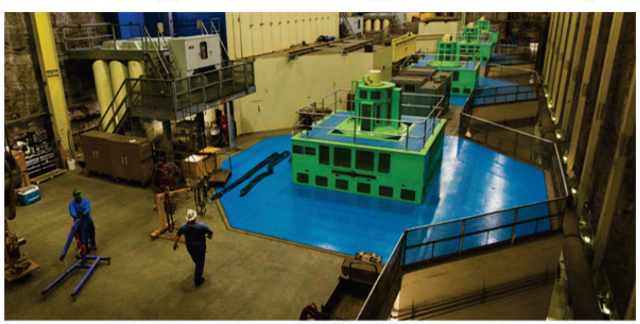
b) Around 2011

c) The other additional hurdle that must be overcome is the storage problem. Solar generated energy is traditionally stored in batteries. Batteries can be inexpensive to provide short-bursts of power, but using them to store large amounts of energy, especially when the sun isn't shining can be expensive.

Researchers need to make technology to improve these batteries and develop alternate storage technology, so that photovoltaics are cheap enough to compete at scale. This would include creating more efficient technology such as crystalline-silicon cells and make cheap next-generation technologies.

Scientists are still working on the storage issue. Here is a link with a few interesting articles on innovation in this arena occurring in the state of Massachusetts: https://www.wbur.org/tag/renewable-energy-holy-grail

New England's Largest Battery Is Hidden Inside A Mass. Mountain



The upper reservoir is the battery that powers the Northfield Mountain pumped hydroelectric station. (Jesse Costa/WBUR)

Northfield Mountain is a naturalist's wonderland. But if you look around, you'll see an unnatural site: a 5-billion-gallon battery.

http://www.wbur.org/bostonomix/2016/12/02/northfield-mountain-hydroelectric-station

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AT 12a, Q3 & 4

The KH book tells the story of three companies, led by Conrad Burke, Dave Pearce, and Bill Gross.

State the name of these companies and for each provide a succinct description of the innovation each was attempting to bring to market. Then pick one of the companies and state what has happened since the time the book was written.

Conrad Burke's Innovalight uses cheap, unpurified silicon to make nanosilicon powder, which can be chemically solubilized in ink. They then add impurities to adjust the properties of the film they make, before printing it onto a surface. This "silicon ink" is an innovation that lets them bypass the expensive market for silicon, and could potentially drive solar prices down to around 30 cents per watt.

Innovalight was bought by DuPont Captial Management, and, rather than manufacturing new high-efficiency modules, it has instead switched to a proprietary licensing model where they sell the ink to other manufacturers, who pay them to use the efficiency-increasing ink in their solar cells. Essentially, they turned their competitors into customers.

https://www.forbes.com/sites/toddwoody/2011/07/25/dupont-acquires-silicon-valley-solar-startup-innovalight/#16cc64c537fe

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Dave Pearce's Miasole is also in the thin film business. Rather than silicon, however, Pearce's company uses a copper, indium, gallium, and selenium mixture (CIGS for short) mixture in their film. A 1 micron thick CIGS mixture has the same photovoltaic effect as a 200-300 micron thick crystalline silicon wafer, and despite low global indium supplies, Pearce hopes to one day create a product "simple enough for your average Home Depot consumer to do it themselves."

Miasole is still an American solar energy company that is still marketing products made with a mixture of copper, indium, gallium, and selenium (CIGS). In 2011, the company hit a major milestone: producing their 50,000,000th solar cell. Additionally, the company was acquired by a large Chinese clean energy company in 2013. As of this year, the company has a commercial efficiency of 17.5% for their solar cells, a record for flexible solar cells. Their company website claims that they are "the leader in flexible, lightweight, powerful solar, pioneering the shift from rigid solar panels and all their limitations to flexible solar and all of its possibilities." Overall, the company appears to be doing quite well since the time the KH book was written and appears to be in good order for further advancement in the future.

Since this KH book was written, Miasole has created one of the most flexible and lightweight thin film solar panels. These can be glued to surfaces like curved structures and metal roofs. These cells have a 16.5% efficiency. Interestingly, since Miasole doesn't use silicon, they are not required to pay a solar tariff on imported panels. This tariff was created by the Trump administration in 2018.

Their efficiency has gone all the way up to 17.5% in 2019. They are even looking into mounting solar panels on mobile devices.

The company also has created China's first solar-powered bus stations where solar cells are used to generate electricity for wifi or vending machines. Currently, Miasolé is working on producing solar cell roof tiles and a solar car.

AT 12a, Q3 & 4

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State the name of these companies and for each provide a succinct description of the innovation each was attempting to bring to market. Then pick one of the companies and state what has happened since the time the book was written.

Bill Gross' Energy Innovations aims to concentrate light to make solar cells more effective, instead of making cheaper photovoltaic cells. One design his company made, called the Sunflower, involved arranging mirrors in a circular fashion around a lens, which would focus the energy down onto a high-efficiency photovoltaic cell. The scarce materials that go into solar cells can thus be used more efficiently.

Since the writing of Krupp and Horn's book, the founder and CEO of Energy Innovations, Bill Gross has moved on to another project. In 2011, he started Edisun Microgrids that creates sun trackers to be placed under solar panels so that it can follow the sun throughout the day and harness 30% more energy. The company has also worked on storing the sun's energy so that it can be used even when the sun's energy is not hitting the panels at its highest potential.

AT 12a, Q5

The KH book provides an estimate of how much land would be needed to produce enough electricity to power the entire US from solar photovoltaic technology. This estimate is based on a certain assumption for the efficiency of the solar PV.

a) what is the "length of the square" (KH use the word "side") that would be needed for the US to get all of its electricity needs from solar PV?

b) what did KH assume about the efficiency of solar PV to arrive at this estimate?

c) what would the "length of the square" (or "side") be if the efficiency would rise to the highest achieved using a proprietary triple-junction by the Boeing Spectrolab, that is described on this wiki page: https://en.wikipedia.org/wiki/Photovoltaics ?

a) 100 miles by 100 miles, or 10,000 square miles

b) 40.9% (note the website stated other high efficiencies; use of any of these received full credit)

c) 50 miles because the *required area* scales inversely with the assumed efficiency of the respective panels.

The first area is 10,000 square miles.

The area needed for the more efficient panels is 10 / 40.9 × 10,000 square miles or 2445 square miles. Need to take the square root of 2445 square miles to find this area is 50 miles per side.

Note: U.S. electric usage in 2018 of 4.178 billion MWhr (https://www.eia.gov/tools/faqs/faq.php?id=427&t=3) combined with actual output of Nevada Solar One (118,000 MWhr) means the entire electricity needs of the U.S. could be met using existing concentrated solar technology, for a collection area 4.178×10^9 / 118,000 = 35,000 times that of Nevada Solar One, which collects over 400 acres

This would be an area equal to 35,000 × 400 acres = 35,000 × 0.625 square miles = 21875 square miles, which is ***148 miles*** by ***148 miles***.

Of course, would also have to figure out how to transmit and store this energy.

AT 12b, Q1

Describe the difference in operating principle between solar photovoltaics and solar thermal

In solar photovoltaics, sunlight is highly concentrated and interacts with a semiconductor. This creates separates electrons from the semiconductor and creates an electric current which generates electricity. Solar thermal, on the other hand, involves uses sunlight to produce heat which can be then utilized to generate electricity. Solar thermal energy has an intermediate step to generate electricity, while solar photovoltaics directly converts sunlight into electricity.

The reading seems to not give due justice to the technology of solar thermal; *operating equipment continuously at very high temperature is not easy* *!*

AT 12b, Q2

KH note "a key advantage of solar thermal over solar PV". What is this key advantage and how, possibly, might this key advantage play a role in overcoming a major shortcoming of renewable energy.

The key advantage is that solar thermal can store energy as heat whereas PV cannot. Because the storage of energy in heat is cheaper than storing electricity, it can aid in making renewable energy a cheaper option to be able to integrate into the market, making renewable energy a viable option for clean energy on a mass scale..

See https://flipboard.com/@raymondbranke/csp-1akv1hhuz for more info.

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AT 12b, Q3

a) What is a "renewable portfolio standard" (appears in KH, Chapter 3) and what is a "feed-in tariff" (KH, Chapter 2)?

b) According to https://en.wikipedia.org/wiki/Concentrated_solar_power, as of 2017, what country presently is the world leader in electricity generation from solar thermal?

c) Which of the two policy options mentioned in a) did this country employ to facilitate the growth of solar thermal? And is this policy still in place within this country, for new projects?

a) A renewable portfolio standard requires utilities to buy a set percentage of their total power from clean sources. A feed-in tariff requires utilities to buy electricity from renewable-energy producers, including owners of rooftop systems, at above market rates.

b) According to the link, Spain was the world's leader in electricity generation from solar thermal.

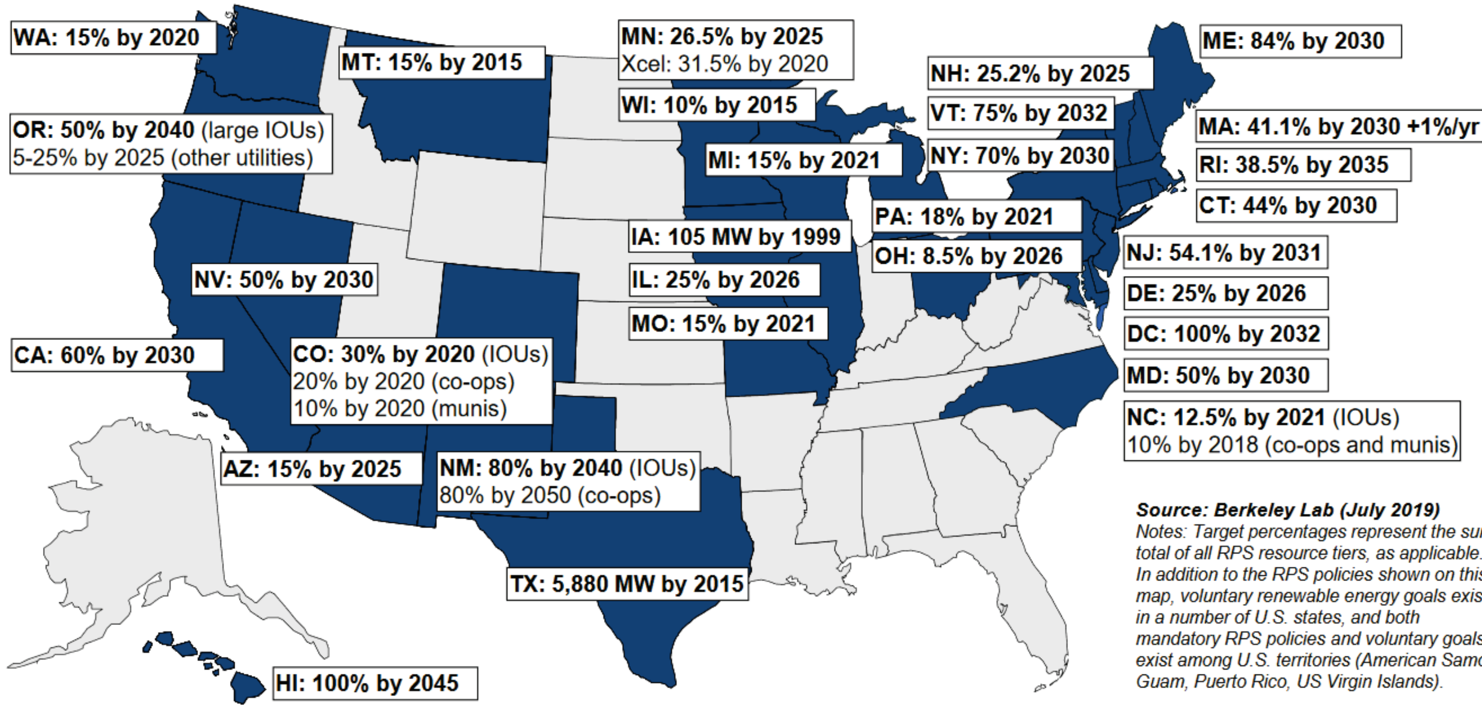
c) Spain employed feed-in tariffs, however as time has been going on these tariffs have been reduced, and for the new projects this feed-in tariff has been halted..

Left: Parabolic troughs (150 MW total) and two towers (30 MW) of the first three units of Solnova power station, Southern Spain.
Right: close up of parabolic trough unit, Solnova.
https://en.wikipedia.org/wiki/Solnova_Solar_Power_Station

RPS: Renewable Portfolio Standard

RPS Policies Exist in 29 States and DC

Apply to 56% of Total U.S. Retail Electricity Sales



Source: Berkeley Lab (July 2019)
Notes: Target percentages represent the sum total of all RPS resource tiers, as applicable. In addition to the RPS policies shown on this map, voluntary renewable energy goals exist in a number of U.S. states, and both mandatory RPS policies and voluntary goals exist among U.S. territories (American Samoa, Guam, Puerto Rico, US Virgin Islands).

BERKELEY LAB

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Map from http://eta-publications.lbl.gov/sites/default/files/rps_annual_status_update-2019_edition.pdf
See also http://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx

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Why Do States Adopt Renewable Portfolio Standards?: An Empirical Investigation

Thomas P. Lyon and Haitao Yin***

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6. CONCLUDING REMARKS

We have presented a quantitative empirical analysis of the factors leading states to adopt RPS policies. Our results show that the adoption of an RPS is more likely in states with strong renewable potential, a restructured electricity market, a small share of natural gas in the electricity fuel mix, strong Democratic presence in the state legislature, and organized renewable energy interests. Surprisingly, our study suggests that neither local environmental benefits nor economic benefits of job creation seem to be driving forces for RPS adoption, although they are often widely touted in the legislative process.

The Energy Journal, Vol. 31, No. 3.

Map from http://eta-publications.lbl.gov/sites/default/files/rps_annual_status_update-2019_edition.pdf
See also http://www.ncsl.org/research/energy/renewable-portfolio-standards.aspx

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AT 12b, Q4 & Q5

This KH reading again tells the stories of numerous companies: one led by David Mills, one led by Arnold Goldman, and one led by Susan D. Nickey. Give the names and briefly state the mission goal of each company. Then, pick one of the companies state and describe what has happened since publication of the book

David Mills- Austra: The goal is to use steam at lower temperatures that can tolerate fluctuation to run the system in a wider range of lighting environments without the need for external power sources such as natural gases.

No longer in business.

Arnold Goldman- Luz: Use a field of flat mirrors to concentrate the sun's energy on a central tower, providing a consistent high temperature and pressure for a more efficient conversion of energy.

Focused on solar PVs

Susan D. Nickey- Acciona Energy: Use a parabolic-trough system but with glass that has the same thermal coefficient as steel so that the two components of the mirror work together to offset temperature fluctuations, making the system more efficient.

Acciona Energy has remained relatively successfull since the 2007 publication of the Krupp Horn book. The company has continued to produce its PV products. The company has had successed in funding for projects not just in the US, but also in other countries, such as Spain. According to the wikipedia of the company, in 2014, the international business of the company got a funding of $567 million. There have been many continuing projects that the company produces, and according to their website, it seems like they also have other technologies such as wind power, hydroelectric, CSP, and biomass.

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AT 12b, Q6

The KH reading quotes John O' Donnell as stating financing is "the last big obstacle to large-scale renewable energy deployment". The book then goes on to name three additional obstacles.

a) What are these three additional obstacles?

b) Based either on the class readings, your intuition, or your own research, which of these three obstacles do you think is truly the hardest to overcome and how do you think it could possibly by overcome?

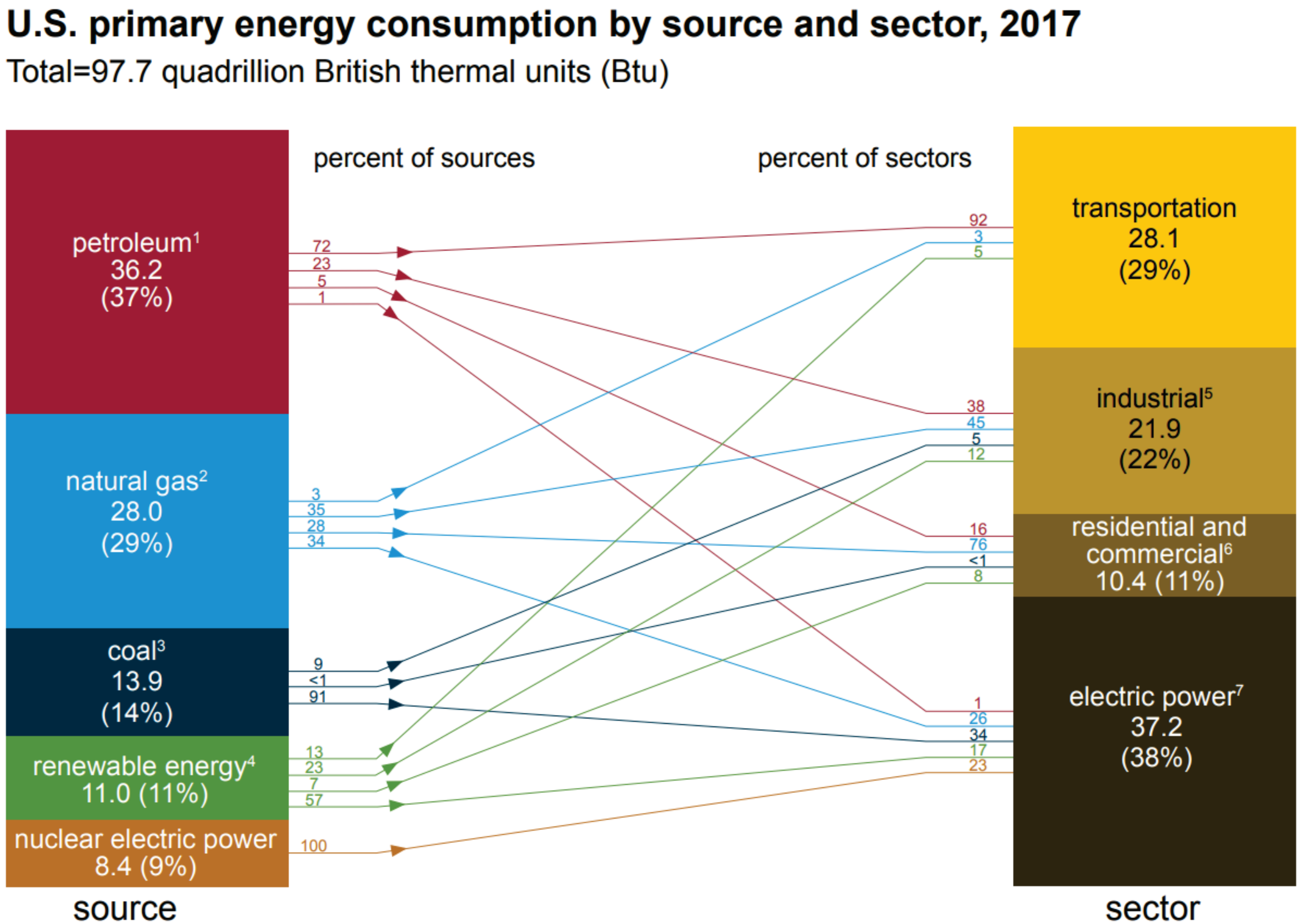
a) Three other obstacles to integration of renewable energy into industry, governments, private homes, and more areas of society are access to renewable energy for urban, suburban, and rural populations, financing, as John O'Donnell stated, and reliability in light of the dependent balance between supply and demand.

b) I think that accessibility is the hardest issue to overcome when implementing large-scale renewable energy development. Although cost and reliability are two large obstacles as well, renewable energy is impractical if it cannot reach all populations of people for use. To develop a more sustainable, clean energy based society, renewable energy must be accessible to industries, government, and the general public in rural, urban, and suburban areas. I think that this issue could be overcome with new technologies in solar energy, especially with different technologies to store solar energy in batteries or other ways.

I think one of the most difficult obstacles to overcome is cost. *The transmission lines have to be long to reach the solar field and the field usually has to be quite far away as it is so large*. Additionally, the fact that the lines are sometime not active increases cost, so people either won't lay the lines or renewable energy wont be a feasible option for the public. Cost is almost always the driving factor of businesses so if the cost of transmission lines is too high, the business won't succeed. I think a way to tackle this would be to create a system that is efficient enough to function all the time. This way, the transmission lines will always be in use, reducing their cost.

Since large-scale solar thermal plants are in the middle of nowhere there need to be transmission grids in place to transport the generated power to demand centers. Not all companies have the money or resources to effectively harness energy this way. While there is cost involved, and reliability is a question, the issue of access dominates as not everyone is able to complete such as feat, thus posing the biggest difficulty of energy deployment

Petroleum (including biofuels) used mainly for transportation (72%) and industry (23%), with only minor applications in residences & commerce (5%) and electric power (1%)



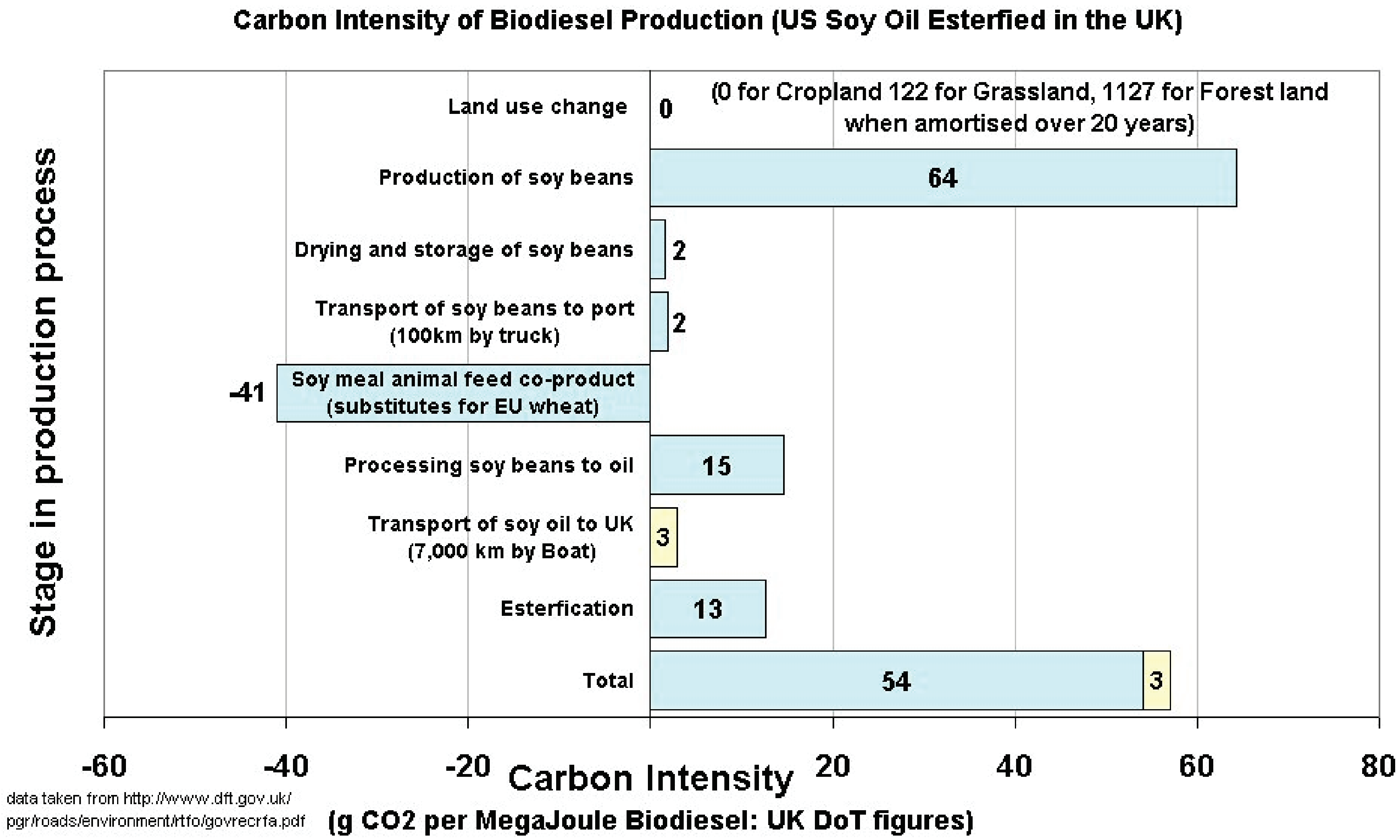
https://www.eia.gov/totalenergy/data/monthly/pdf/flow/css_2017_energy.pdf

Biofuels

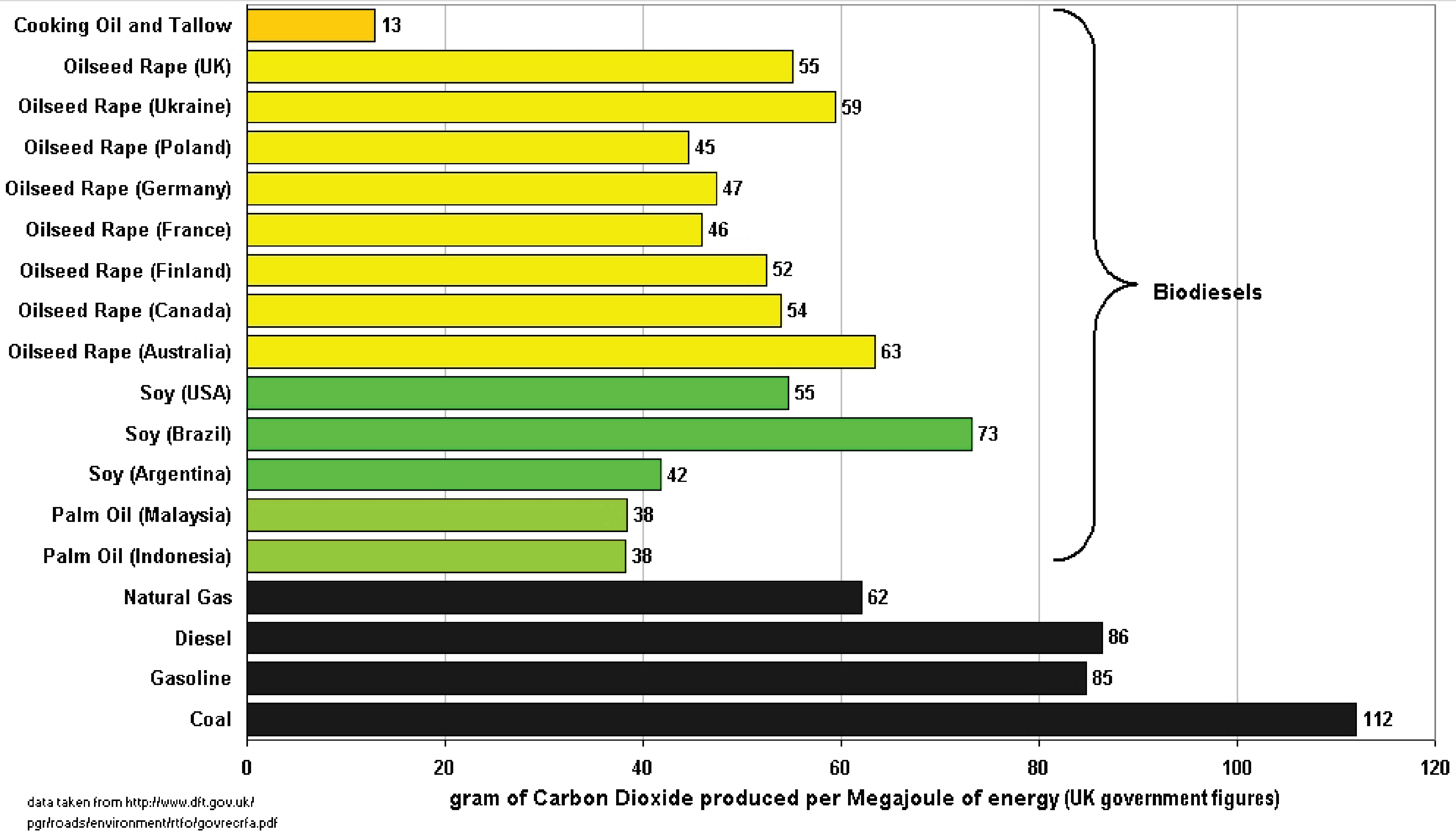
Ammar Masood

Introduction to Biofuels

- Play a smaller role than photovoltaics or solar thermal energy in reducing carbon emissions.
- Industry has increased demand for coal.
- Brazil has replaced 40 % of gas with biofuels using its abundant sugar crop.
- With the global oil supply becoming increasingly problematic, biofuel-startups have much in their favor.



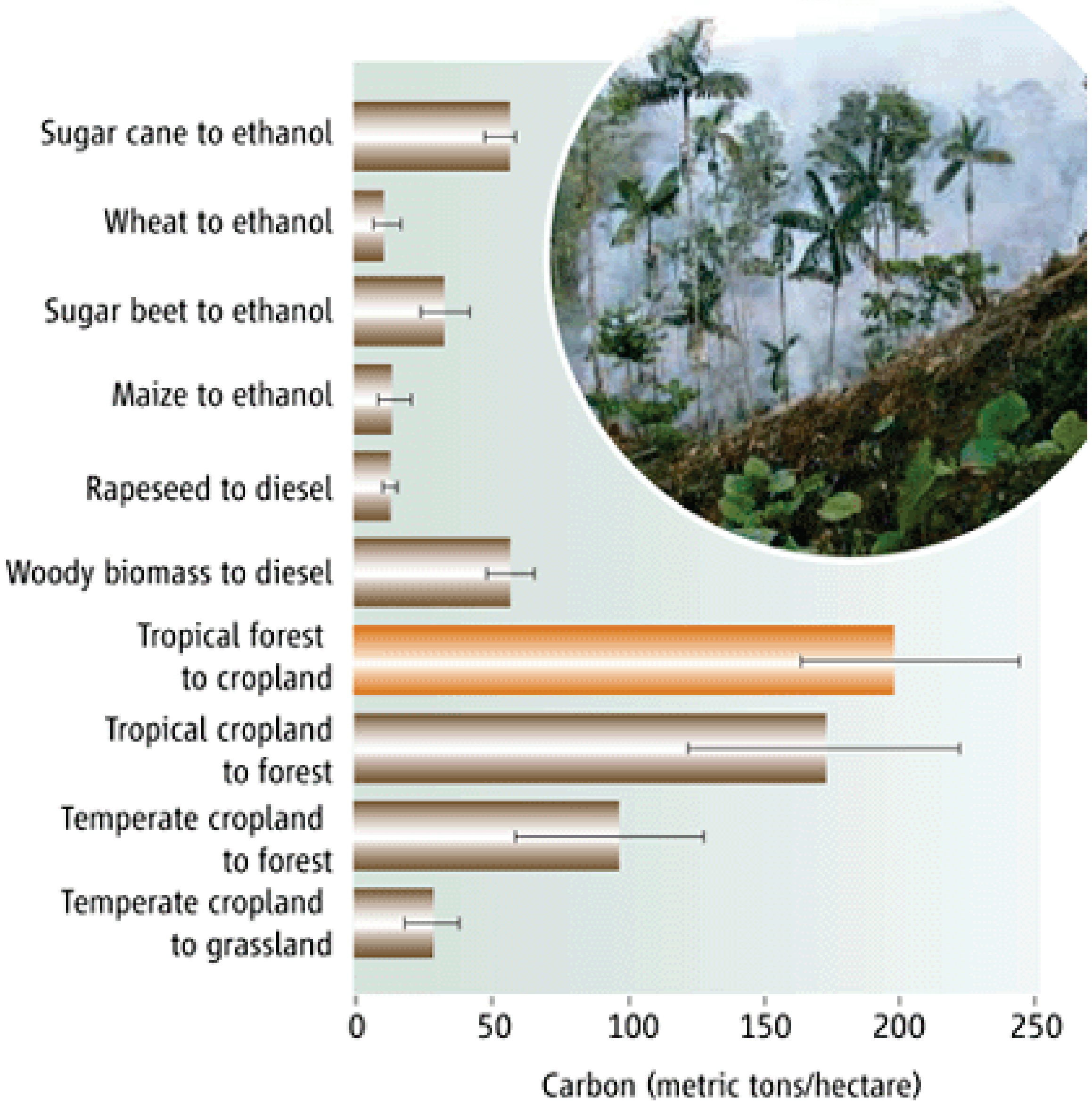
Carbon Intensity of Biodiesel Production (US Soy Oil Esterfied in the UK)
Stage in production process
Land use change
0
(0 for Cropland 122 for Grassland, 1127 for Forest land when amortised over 20 years)
Production of soy beans
64
Drying and storage of soy beans
2
Transport of soy beans to port (100km by truck)
2
-41
Soy meal animal feed co-product (substitutes for EU wheat)
Processing soy beans to oil
15
Transport of soy oil to UK (7,000 km by Boat)
3
Esterfication
13
Total
54
3
-60
-40
-20
20
40
60
80
Carbon Intensity
(g CO2 per MegaJoule Biodiesel: UK DoT figures)
data taken from http://www.dft.gov.uk/pgr/roads/environment/rtfo/govrecrfa.pdf



By Mike Young - Own work, Public Domain, https://commons.wikimedia.org/w/index.php?curid=3473497

Investment in biofuels is quite controversial because some scientists argue apparent positive benefits might disappear when scrutinized over the entire life cycle of a large-scale effort. Summarize, in your own words, the tenant of either the August 2007 Science article OR the “unintended consequences of biofuels made from a particular oil” as stated in Chapter 4.

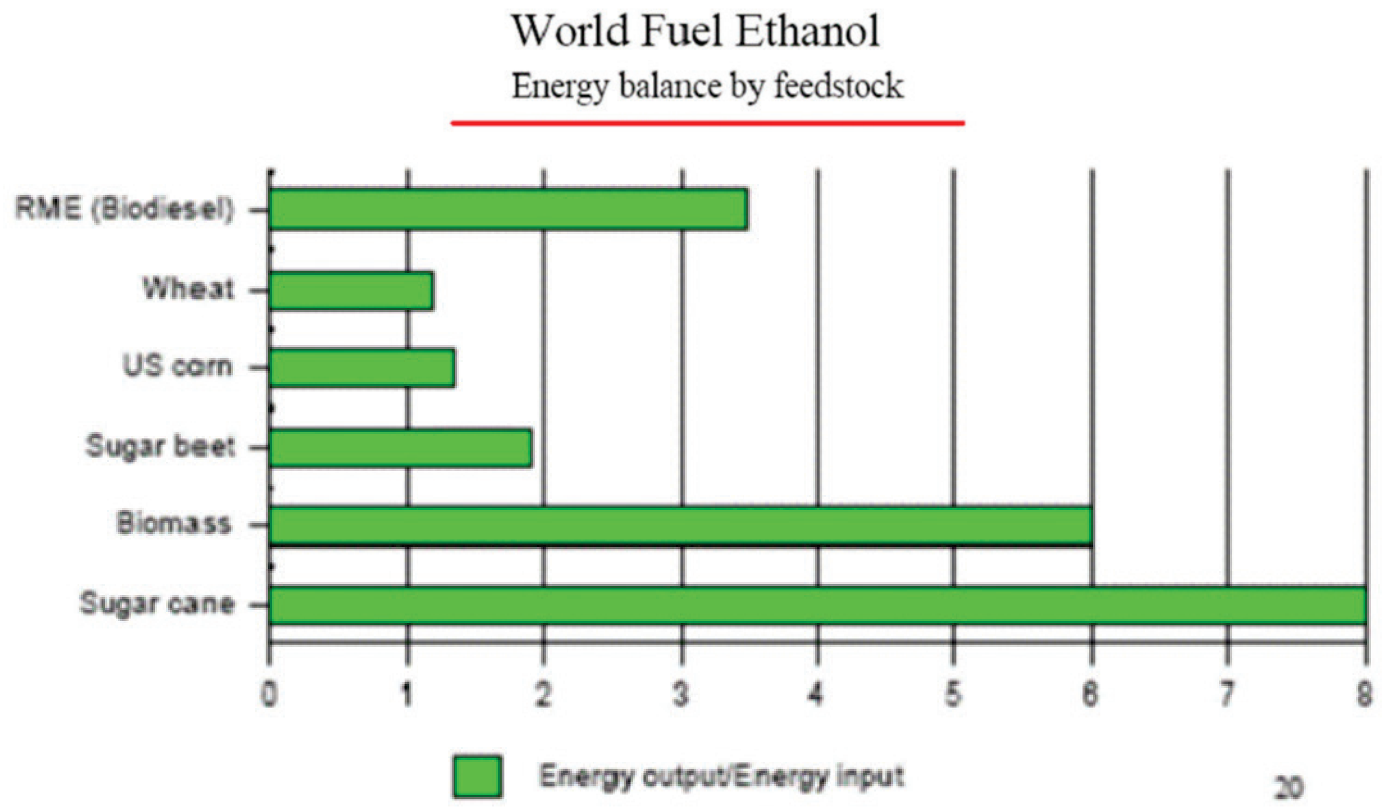
- Palm oil: Rainforests were being felled across southern Asia to meet their demand, resulting in a net increase of carbon. 87 % of the deforestation in Malaysia was caused by palm oil plantations.
- Burning of peatlands in Indonesia releasing even more CO2 into the atmosphere



In the United States a major effort had occurred to produce ethanol from corn, to supply a more sustainable source of liquid hydrocarbon fuel. This policy had been motivated by the "United States' overwhelming dependence on foreign oil" being "a direct risk to national security". In Brazil, a similar effort was extended to produce ethanol from sugar.

In terms of sustainability, which effort seems better: ethanol from corn or ethanol from sugar? Feel free to use the term "Global Warming Impact"

- Ethanol from corn- 70 % energy capacity of oil, requires huge amounts of energy to separate ethanol from fermentation, must be transferred in fuel-based trucks. Higher Global Warming Impact
- Ethanol from Sugar- Comes from Cellulose materials which can be broken down by yeast with no emissions of greenhouse gases, provides more energy then energy used to extract it. Low Global Warming Impact



https://www.ambientediritto.it/dottrina/Politiche%20energetiche%20ambientali/politiche%20e.a/food_crops_lanzini.htm

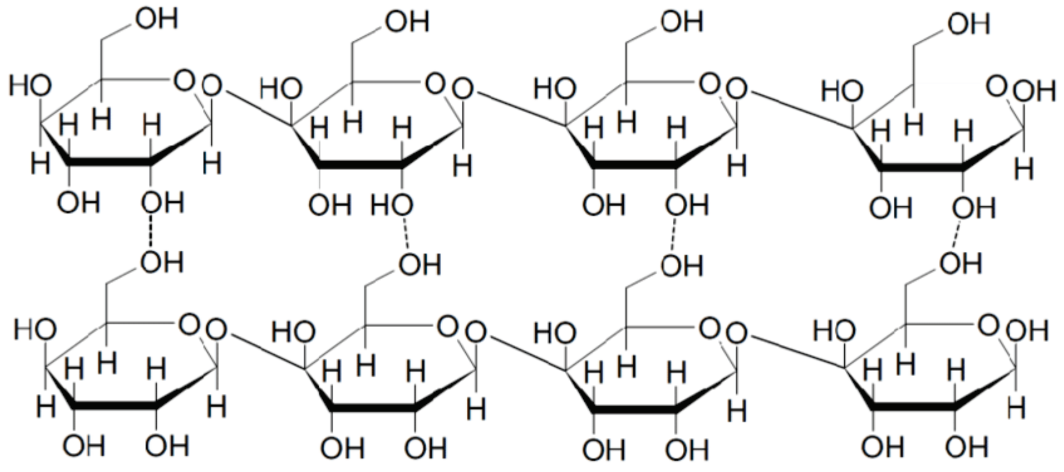
Chapter 5 describes two approaches for obtaining combustible fossil fuels from cellulose: the use of enzymes as well as the use of thermochemical systems.

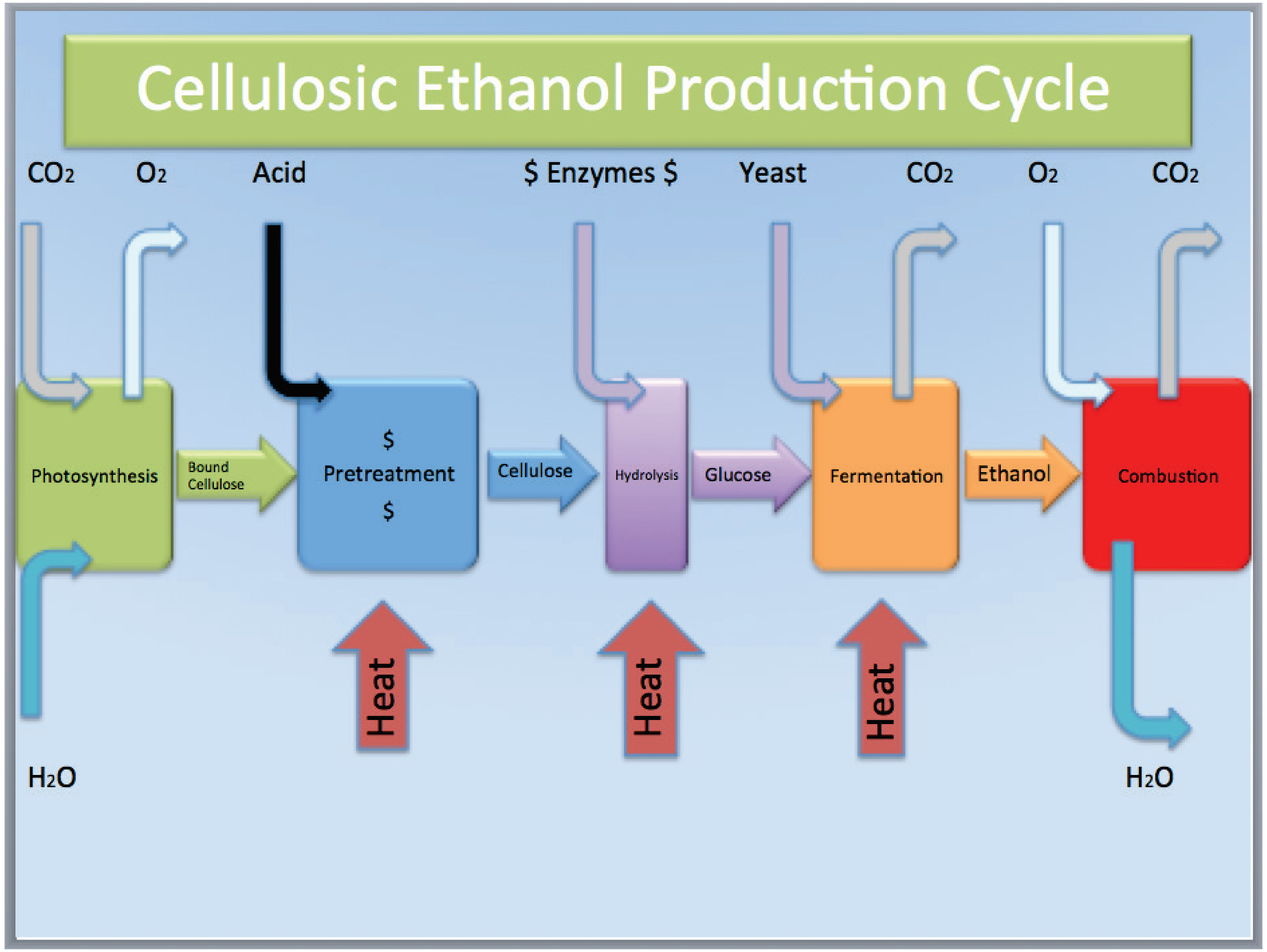
a) briefly describe cellulose and explain why so much effort is being exerted to extract combustible fuels from cellulose

b) what are the potential advantages of the enzyme approach and what hurdles must be overcome to make this approach viable?

c) what are the potential advantages of the thermochemical approach and what hurdles must be overcome to make this approach viable?

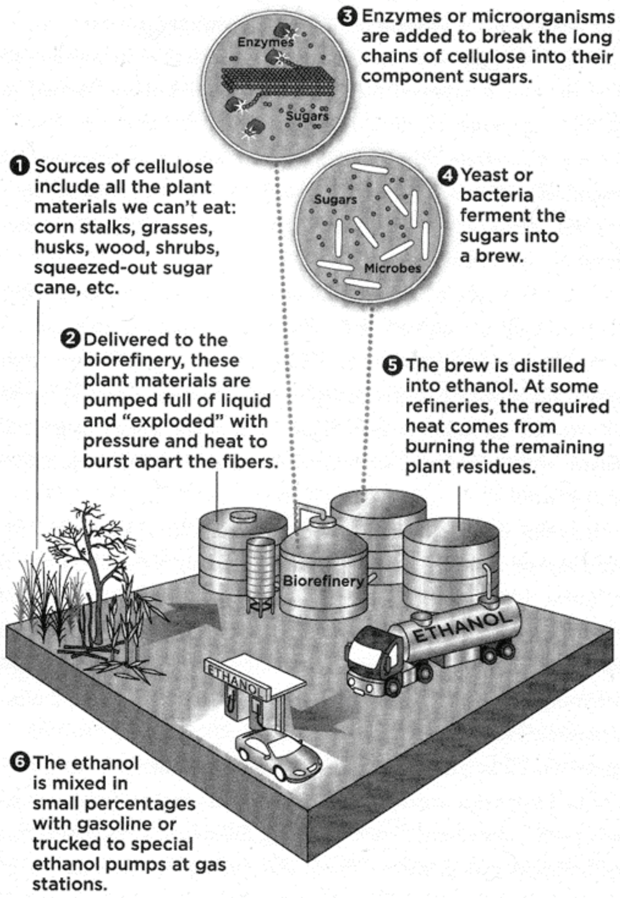
- Cellulose is the tough, fibrous material that makes up the “hard stuff” of plants such as tree trunks branches.
- Most prevalent source of carbon in nature, not a source of food, has an excellent energy balance.
- The crystalline structure makes it hard to dismantle cellulose.
- Special enzymes are required to break those chains, however the energy and price required for the enzymes can cost too much. Also different chains of cellulose in different plants require different enzymes.
- Using thermochemical approaches it is much easier to extract cellhouse, however excess greenhouse gas is also produced as a byproduct.
- If technology for efficient enzymes is developed CO2 emissions can be dramatically reduced.





$$\text{Cellulosic material} \underset{\text{pretreatment}}{\rightarrow} (C_6H_{12}O_5)_n \underset{\text{enzyme}}{\rightarrow} C_6H_{12}O_6 \underset{\text{yeast}}{\rightarrow} 2\ CH_3CH_2OH + 2\ CO_2$$

Distilling Fuel from Agricultural Waste



Cellulose is the most difficult kind of biomass to turn into liquid fuel (one method is shown here). But it may also be the best kind, dramatically reducing carbon dioxide emissions, ecosystem damage, and competition with the food supply.

Biofuel Companies

amyris

VERENIUM
INDUSTRY, EVOLVED.™

GREENFUEL

Amyris

- Wanted to make an ideal fuel from sugar, either from cane or cellulose materials.
- Yeast catabolizes sugar: Extracts energy for its own use and excretes ethanol.
- Need a more efficient way of designing a genome for the yeast with high productivity.

Market Summary > Amyris Inc
NASDAQ: AMRS

3.65 USD +0.19 (5.49%) ↑

Closed: Oct 11, 4:00 PM EDT · Disclaimer
After hours 3.65 0.00 (0.00%)

1 day | 5 days | 1 month | 6 months | YTD | 1 year | 5 years | **Max**

Open	3.44	Div yield	-
High	3.67	Prev close	3.46
Low	3.25	52-wk high	8.80
Mkt cap	377.41M	52-wk low	1.87
P/E ratio	-		

Amyris, Inc.

Science research company

amyris

amyris.com

Amyris NASDAQ: AMRS is a science and technology leader in the research, development and production of pure, sustainable ingredients for the Health & Wellness, Clean Beauty and Flavors & Fragrances markets. Wikipedia

Headquarters: Emeryville, CA

Revenue: 143.4 million USD

Founded: 2003

Number of employees: 300–350

Subsidiaries: Total Amyris BioSolutions B.V, Draths Corporation, MORE

Founders: Jay Keasling, Neil Renninger, Kinkead Reiling, Jack D. Newman, Vincent Martin

Verenium

- In 2007 they began construction of a 1.4 million-galloon demonstration plant that will make fuel from bagasse- left over fiber after juice has been squeezed from a sugar cane.
- Locating plants so sufficient biomass will be available within 10 miles.
- Utilizing heat and pressure to break down hemicellulose, which will be put into a tank of bacteria capable of fermenting 5-carbon sugars.

BASF

We create chemistry

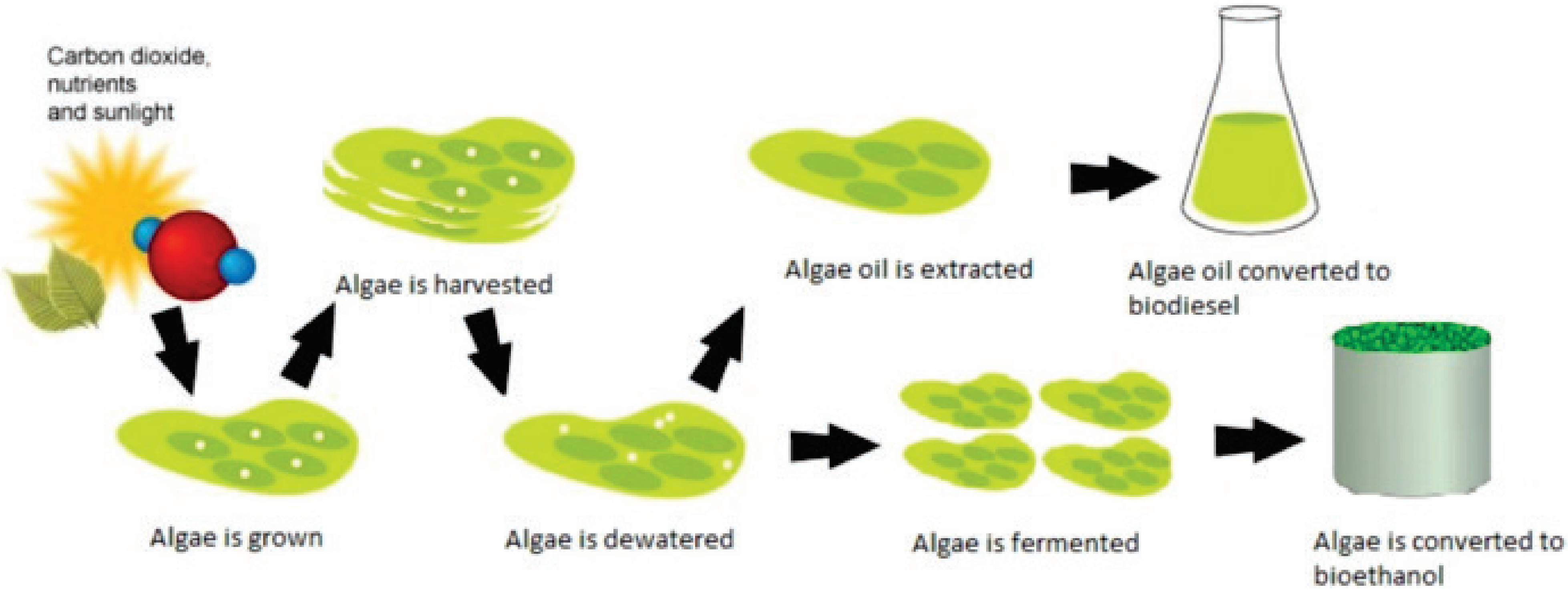
Why are researchers in the United States focusing on restoration of the native perennial grasses that once extended across the Great Plains?

followed by:

Why are researchers so interested in potential uses of algae, nature's building block, for various applications in the area of biofuels?

GREENFUEL

Species	Known maximum CO_2 concentration	References
Cyanidium caldarium	100%	Seckbach et al., 1971
Scenedesmus sp.	80%	Hanagata et al., 1992
Chlorococcum littorale	60%	Kodama et al., 1993
Synechococcus elongatus	60%	Miyairi, 1995
Euglena gracilis	45%	Nakano et al., 1996
Chlorella sp.	40%	Hanagata et al., 1992
Eudorina spp.	20%	Hanagata et al., 1992
Dunaliella tertiolecta	15%	Nagase et al., 1998
Nannochloris sp.	15%	Yoshihara et al., 1996
Chlamydomonas sp.	15%	Miura et al., 1993
Tetraselmis sp.	14%	Matsumoto et al., 1995


Carbon dioxide,
nutrients
and sunlight
Algae is harvested
Algae oil is extracted
Algae oil converted to
biodiesel
Algae is grown
Algae is dewatered
Algae is fermented
Algae is converted to
bioethanol

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Biofuels: Last Word

Ross Salawitch

15 October 2019

Another Interesting Cameo

cameo: 3) a usually brief literary or filmic piece that brings into delicate or sharp relief the character of a person, place, or event
https://www.merriam-webster.com/dictionary/cameo

Another Interesting Cameo

cameo: 3) a usually brief literary or filmic piece that brings into delicate or sharp relief the character of a person, place, or event
https://www.merriam-webster.com/dictionary/cameo

Frances Arnold, a chemical engineering and biochemistry professor at Caltech and a member of the Amyris scientific advisory board, sees a challenging path ahead, for Amyris and for her own biofuels company, Gevo, which makes biobutanol, another energy-dense fuel. "None of us really knows yet how to lower costs. We engineer organisms to do our bidding, but they don't have high enough productivity. And switching out genes is like writing *Moby-Dick* by pulling discrete paragraphs off the Web; you end up with a kludgy design." Arnold's researchers have developed strategies for using evolution as an "editor" to smooth out any inelegant passages in the genomes they write. They design a genome for their desired organism, but then introduce thousands of random changes in the DNA. From those mutations, they select the best, then do it again. The approach is called "directed evolution" or "semi-rational design," because it mixes the high-speed, directionless shuffling of mutations with the conscious writing of genetic code.

page 87 of my paperback copy of *Earth: The Sequel*

Another Interesting Cameo

Caltech

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10/03/2018

Frances Arnold Wins 2018 Nobel Prize in Chemistry

Frances H. Arnold, the Linus Pauling Professor of Chemical Engineering, Bioengineering and Biochemistry, has won the 2018 Nobel Prize in Chemistry for "the directed evolution of enzymes," according to the award citation. Directed evolution, pioneered by Arnold in the early 1990s, is a bioengineering method for creating new and better enzymes in the laboratory using the principles of evolution. Today, the method is used in hundreds of laboratories and companies that make everything from laundry detergents to biofuels to medicines. Enzymes created with the technique have replaced toxic chemicals in many industrial processes.

Frances Arnold [FULL SIZE]

Credit: Caltech

http://www.caltech.edu/news/frances-arnold-wins-2018-nobel-prize-chemistry-83926
https://www.youtube.com/watch?time_continue=85&v=h_OTCQ_fxuc

Updates to Reading

Much of Chapter 5 is devoted to **use of algae to scrub CO_2 from power plant stacks**

Power

The campus receives most of its power from a combined heat and power plant (CHP), which uses natural gas to produce steam and electricity simultaneously. CHP is already an efficient process but planned projects will make it and campus buildings even more efficient, thereby decreasing the carbon intensity of each facility. By 2020, all electricity coming from sources other than CHP must be produced renewably and any carbon emissions associated with powering new facilities must be offset. New technologies including algae-based carbon capture may drive carbon emissions even lower. There is plenty of opportunity for every person on campus to contribute toward reaching these goals! The UMD campus community can collectively save over 44,000 MTCO2e by 2025 through everyday behaviors like turning off computers, lights, and other equipment when not in use.

https://sustainability.umd.edu/progress/climate-action-plan

Updates to Reading

Much of Chapter 5 is devoted to **use of algae to scrub CO_2 from power plant stacks**

Carbon Capture Technology

TARGET: Capture approximately 3,000 MTCO2e of power plant emissions by 2020; 6,000 MTCO2e by 2025 **ACTIONS:** Use algae-based carbon capture technology to absorb carbon dioxide from the Combined Heat and Power Plant's flue emissions. Capture 3,000 MTCO2e by 2020 and, with advances in technology, capture 6,000 MTCO2e by 2025. **LEADER:** Office of Sustainability and Facilities Management - Engineering & Energy **STATUS:** The university is currently negotiating with a carbon capture company to find a suitable site on campus for the technology	120,000 MTCO2e	$80/MTCO2e

https://sustainability.umd.edu/progress/climate-action-plan

Algae To Reduce Smokestack Emissions

https://www.youtube.com/watch?v=Y471u3SMwzc
http://www.hytekbio.com

Electricity from Waste

Baltimore RESCO (Refuse Energy Systems Company) Plant
Russell Street & U.S Interstate 95 (shadow of Ravens Stadium)

- Opened in 1984
- Site of old pyrolysis plant
- Burns 2,250 tons of trash per day
- Metals recovered; volume of trash reduced by factor of 10
- Capacity to generate 60 MW of electricity ⇨ ~6% typical nuclear plant
- Heat used for direct steam heating / cooling downtown Baltimore
- One of 16 such plants in the US

https://www.nmwda.org/baltimore-resco/
http://www.eia.doe.gov/kids/energy.cfm?page=RESCOE_Plant

Updates to Reading

Page 76 states "U.S. vehicle fleet pumps 1.3 billion tons of CO_2 into the atmosphere every year, and $820 million in capital is exported every day for the oil needed to do so:

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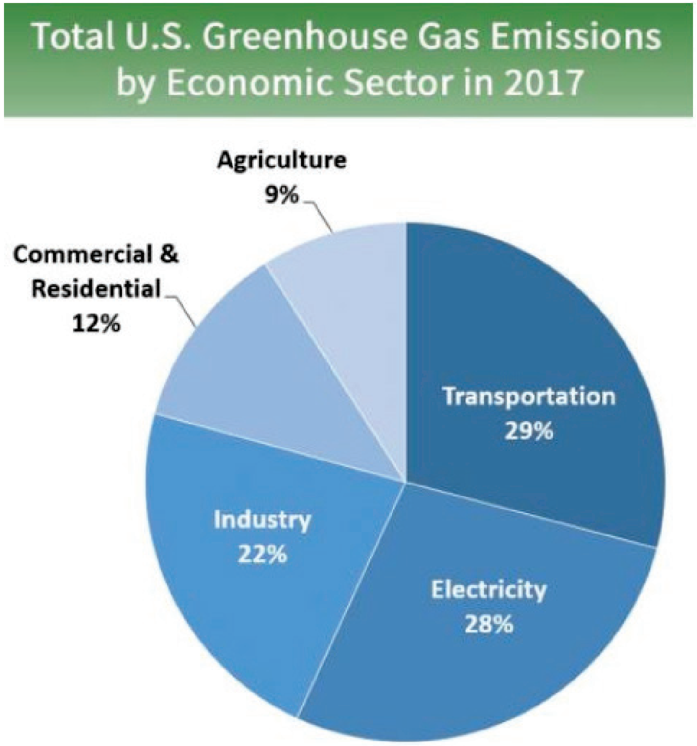

Total Emissions in 2017 = 6,457 Million Metric Tons of CO_2 equivalent. Percentages may not add up to 100% due to independent rounding.

https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

6,457 million tons × 0.29 × 1 billion / 1000 million =
1.9 billion tons of CO_2 pumped into the atmosphere by the U.S. vehicle fleet in 2017

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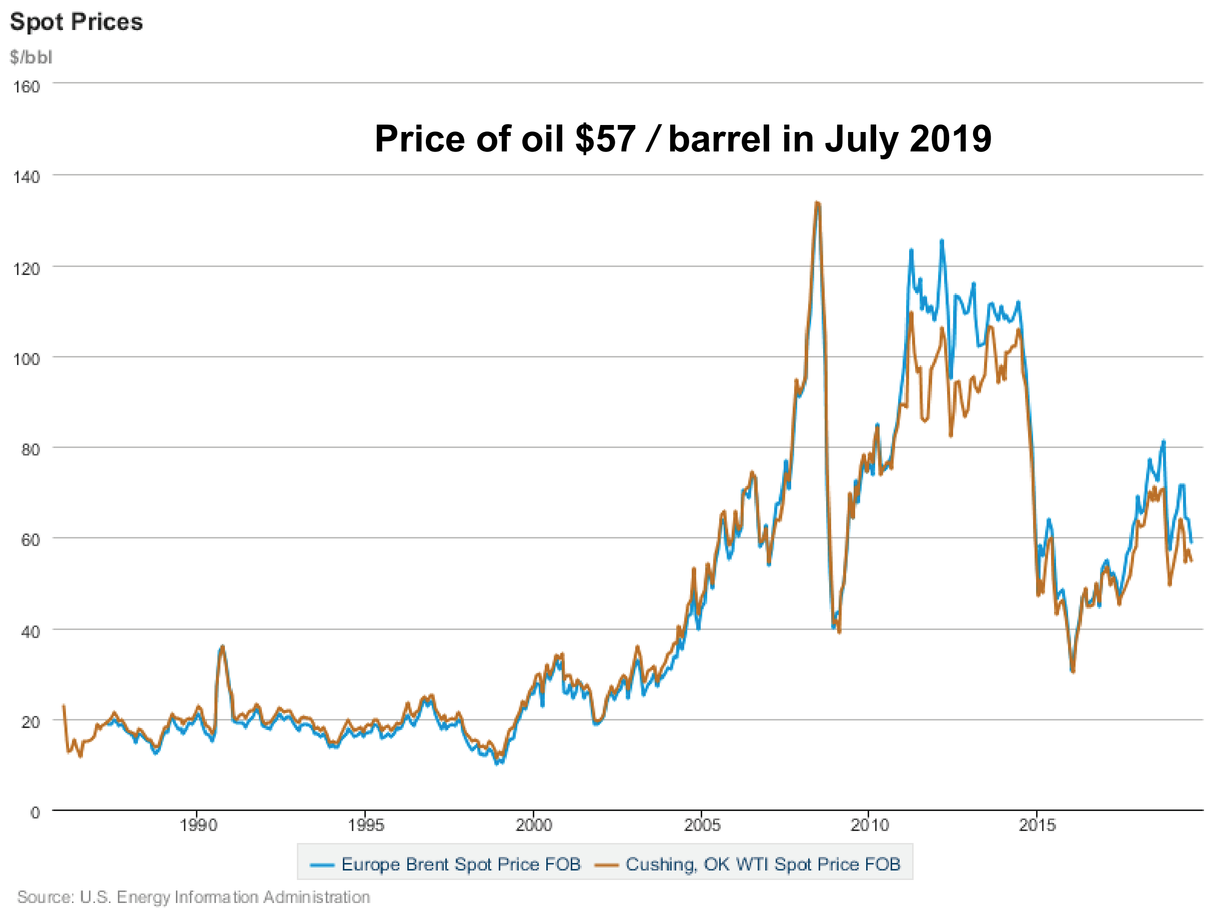

https://www.eia.gov/dnav/pet/pet_pri_spt_s1_m.htm

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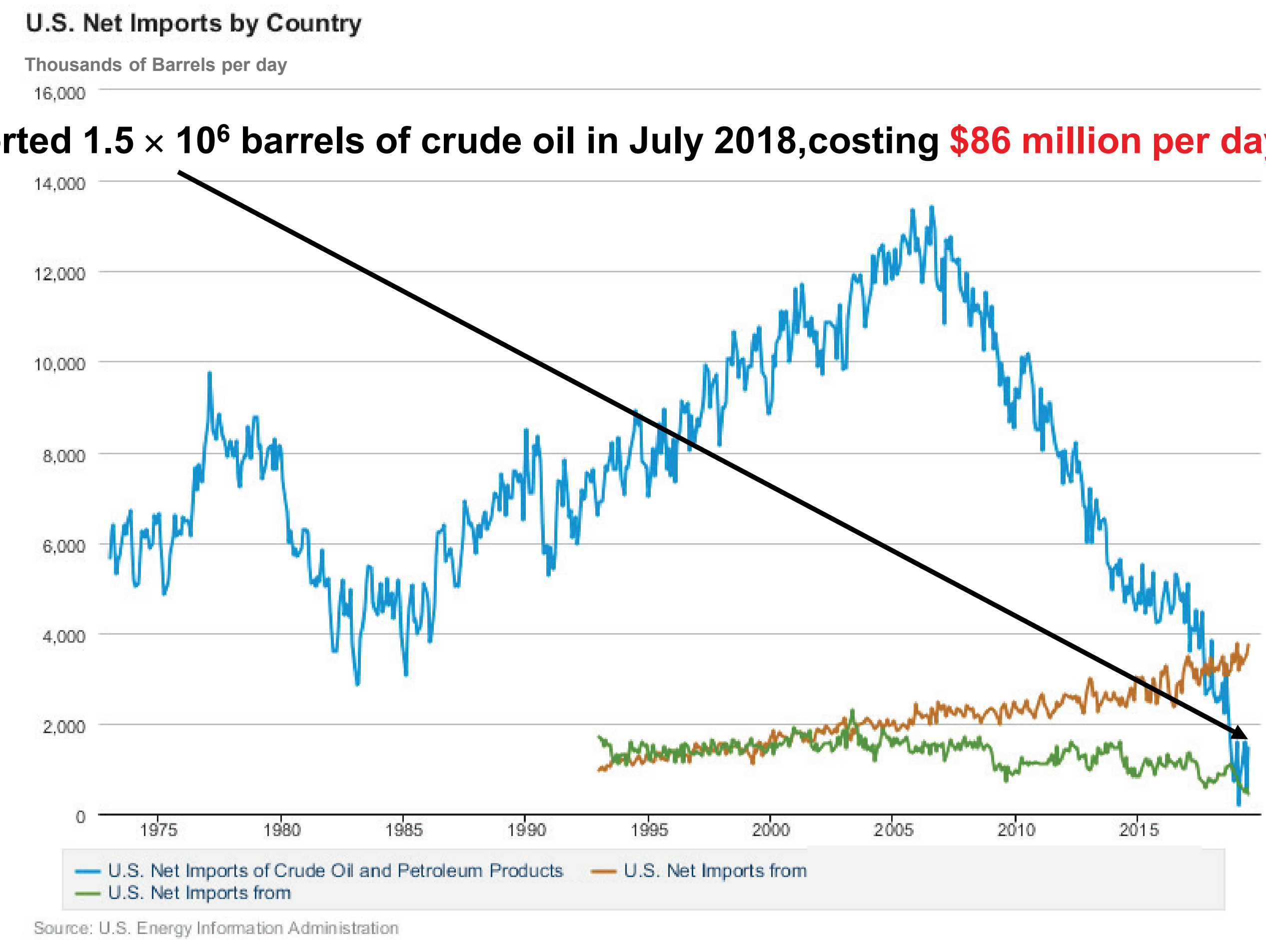

https://www.eia.gov/dnav/pet/pet_move_neti_a_EP00_IMN_mbblpd_m.htm

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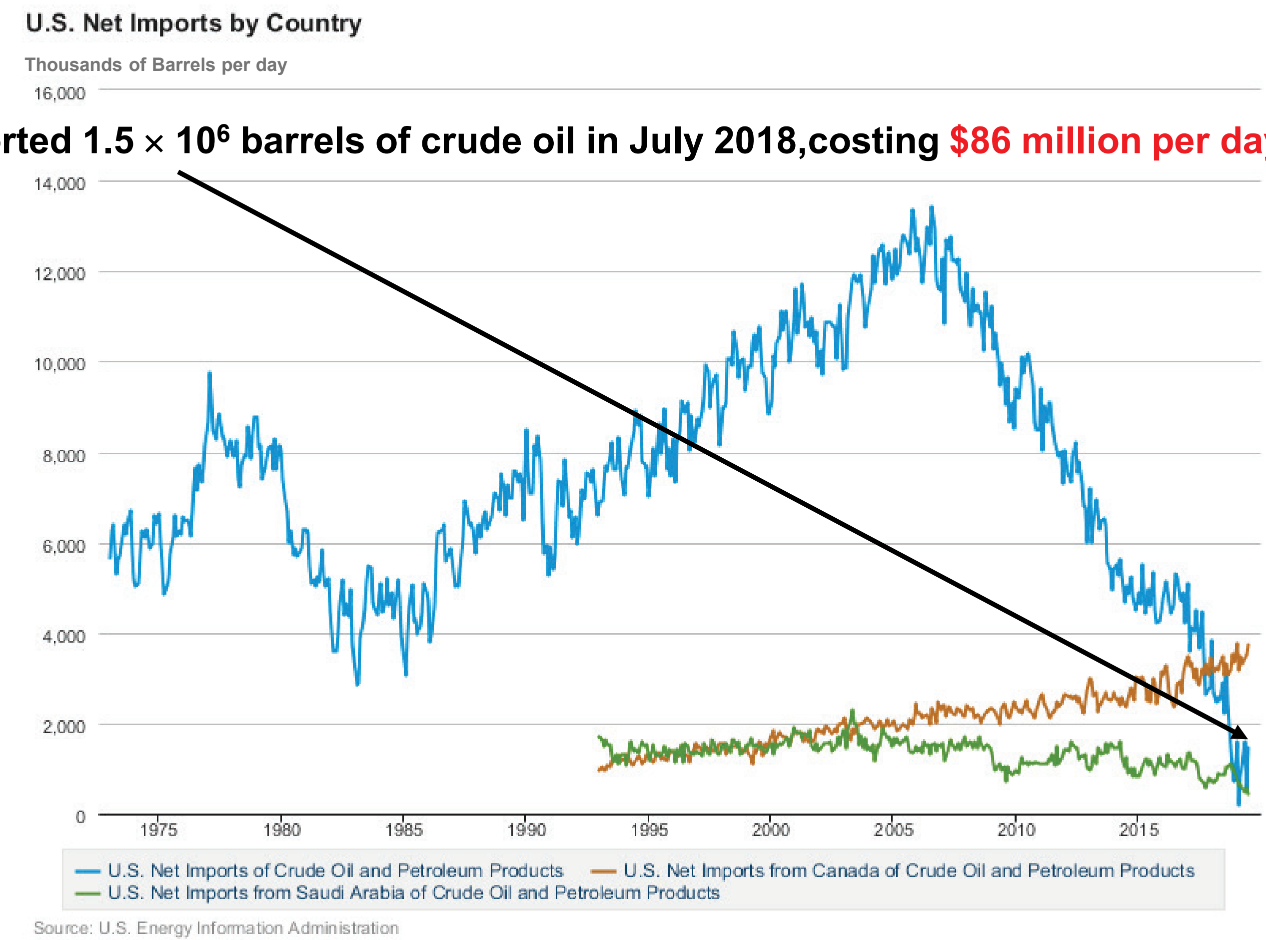
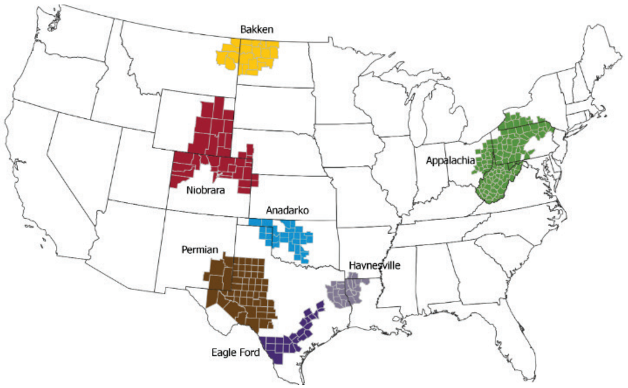


https://www.eia.gov/dnav/pet/pet_move_neti_a_EP00_IMN_mbblpd_m.htm

Updates to Reading

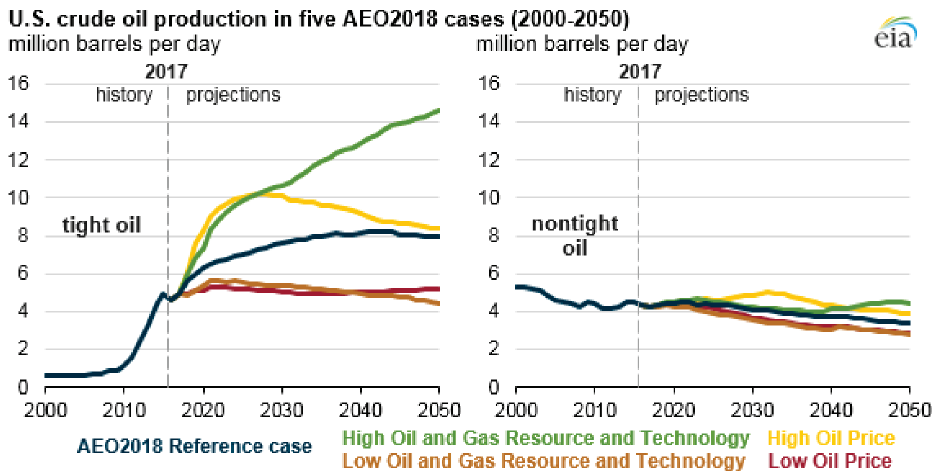
U.S. has greatly expanded production of so-called tight oil https://en.wikipedia.org/wiki/Tight_oil from the Permain, Bakken, and Eagle Ford deposits since the book was written



https://www.cnbc.com/2018/06/13/permian-will-soon-pump-enough-oil-to-be-opecs-2nd-biggest-producer.html

FEBRUARY 22, 2018

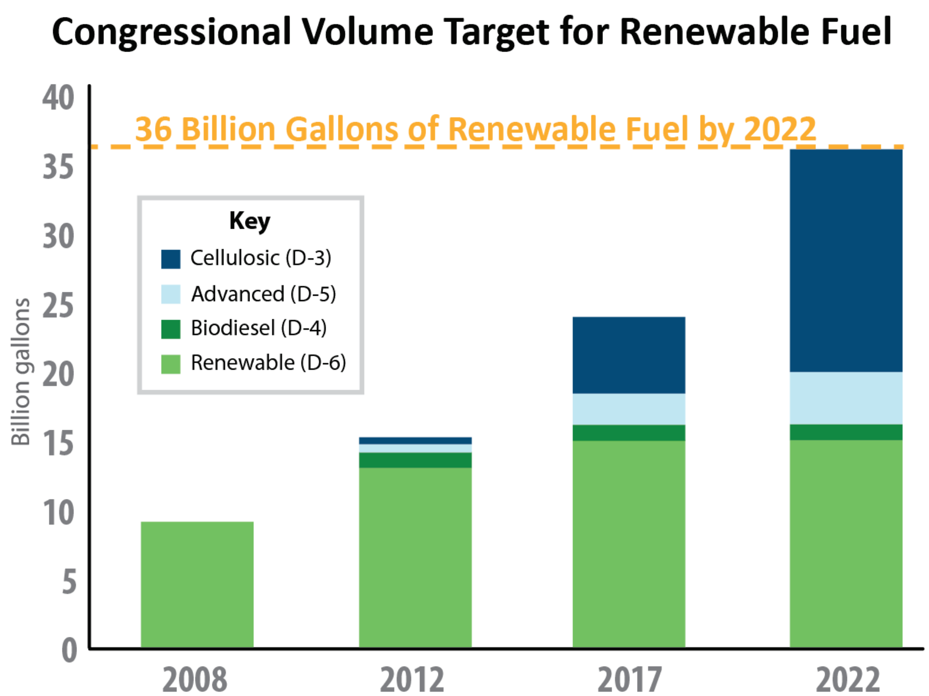
Tight oil remains the leading source of future U.S. crude oil production



https://www.eia.gov/todayinenergy/detail.php?id=35052

Updates to Reading

Page 88 mentions the US renewable fuel standard:



https://www.epa.gov/renewable-fuel-standard-program/overview-renewable-fuel-standard

Updates to Reading

THE HILL

Trump sides with farmers in ethanol proposal, angering oil industry

BY REBECCA BEITSCH - 10/04/19 12:11 PM EDT

© Getty Images

The Trump administration unveiled a fuel proposal Friday that would buoy corn farmers and ethanol producers to the detriment of the nation's oil industry.

The proposal from the Environmental Protection Agency (EPA) would require oil refineries to blend more ethanol into gasoline, while also paving the way for year-round "E15" fuels that are blended with 15 percent ethanol.

The proposal from the EPA would require refineries starting next year to blend a minimum of 15 billion gallons of ethanol into fuel, one of the escalating targets laid out in current law that has never been met.

https://thehill.com/policy/energy-environment/464390-trump-sides-with-farmers-in-ethanol-proposal-that-angers-oil

Updates to Reading

Fill in the blanks: Ethanol from corm

Ethanol is one area in which Senator **Person A** strongly disagrees with his (or her) **Dem or Reb** opponent, Senator **Person B** of **State**. While both presidential candidates emphasize the need for the United States to achieve "energy security" while also slowing down the carbon emissions that are believed to contribute to global warming, they offer sharply different visions of the role that ethanol, which can be made from a variety of organic materials, should play in those efforts.

Person B advocates eliminating the multibillion-dollar annual government subsidies that domestic ethanol has long enjoyed. As a free trade advocate, he (or she) also opposes the 54-cent-a-gallon tariff that the United States slaps on imports of ethanol made from sugar cane, which packs more of an energy punch than corn-based ethanol and is cheaper to produce.

…

The candidates' views were tested recently in the Farm Bill approved by Congress that extended the subsidies for corn ethanol, though reducing them slightly, and the tariffs on imported sugar cane ethanol. Because **Persons A and B** were campaigning, neither voted. But **Person B** said that as president he (or she) would veto the bill, while **Person A** praised it.

http://www.nytimes.com/2008/06/23/us/politics/23ethanol.html

Updates to Reading

Fill in the blanks

Ethanol is one area in which Senator **Barack Obama** strongly disagrees with his (or her) **Republican** opponent, Senator **John McCain** of **Arizona**. While both presidential candidates emphasize the need for the United States to achieve "energy security" while also slowing down the carbon emissions that are believed to contribute to global warming, they offer sharply different visions of the role that ethanol, which can be made from a variety of organic materials, should play in those efforts.

McCain advocates eliminating the multibillion-dollar annual government subsidies that domestic ethanol has long enjoyed. As a free trade advocate, he (or she) also opposes the 54-cent-a-gallon tariff that the United States slaps on imports of ethanol made from sugar cane, which packs more of an energy punch than corn-based ethanol and is cheaper to produce.

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The candidates' views were tested recently in the Farm Bill approved by Congress that extended the subsidies for corn ethanol, though reducing them slightly, and the tariffs on imported sugar cane ethanol. Because **McCain** and **Obama** were campaigning, neither voted. But **McCain** said that as president he would veto the bill, while **Obama** praised it.

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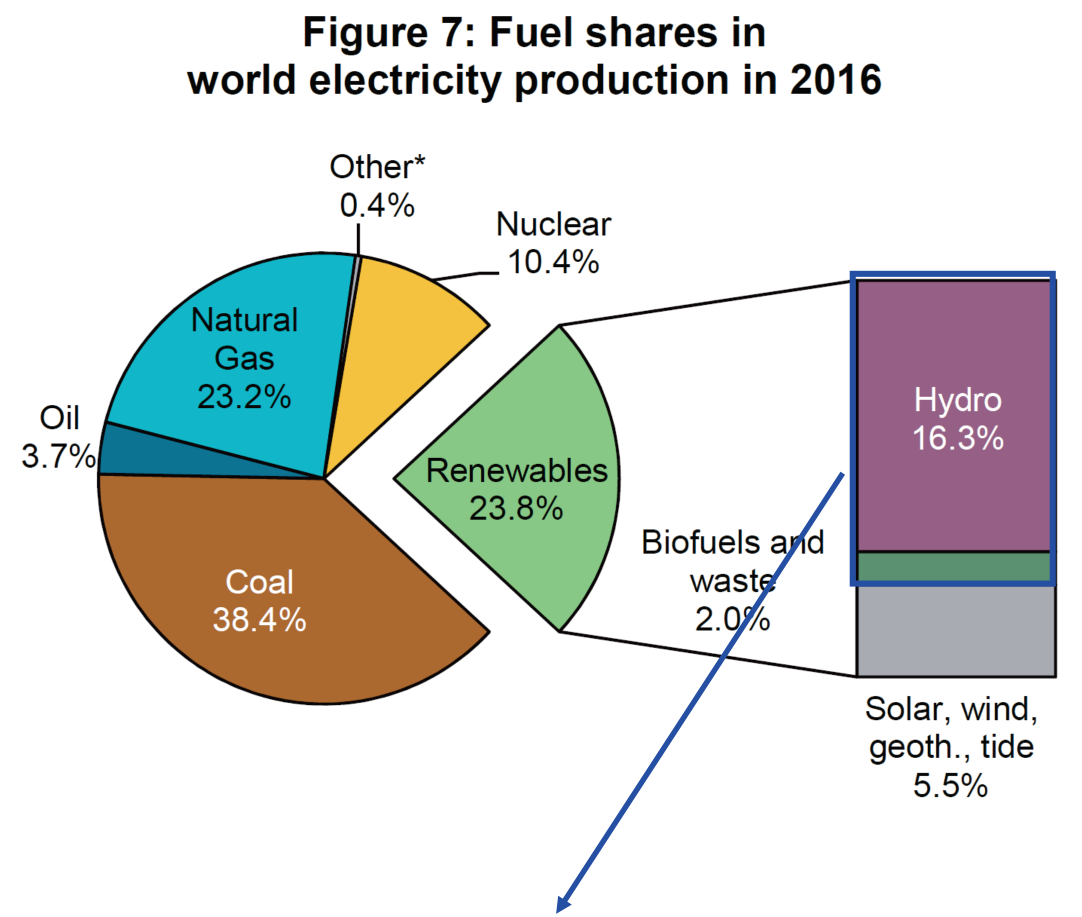
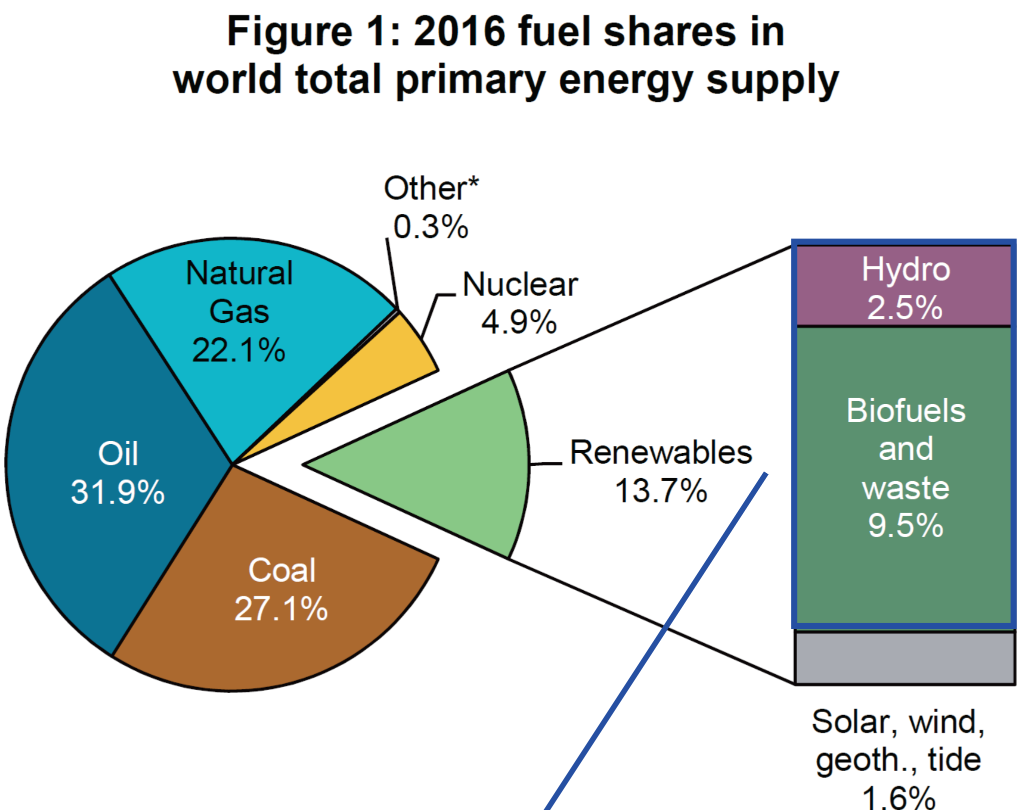
World Electricity Supply, 2016



We'll discuss biofuels on Tues & hydroelectricity on Thurs

https://webstore.iea.org/download/direct/2260?fileName=Renewables_Information_2018_Overview.pdf

World Energy Supply, 2016



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https://webstore.iea.org/download/direct/2260?fileName=Renewables_Information_2018_Overview.pdf

ENVIRONMENT: Indoor Air Pollution - Silent Killer of Women

print send share

By T V Padma

2007

NEW DELHI, Jan 3 (IPS) - Women and young girls coughing and choking as they cook food over traditional stoves that burn wood, leaves or dung is a common a sight in poor homes across Asia, Africa and Latin America. But no one notices the deleterious effects.

Over 1.5 million females die prematurely every year by inhaling poisonous fumes as they cook or heat their homes with these organic fuels but catch little attention from governments, policy experts, scientists and medical experts.

Almost three billion people burn traditional fuels indoors for cooking and heating and their numbers are expected to "rise substantially by 2020," John Mitchell, coordinator of the partnership for clean indoor air at the United States Environmental Protection Agency told IPS at an international meeting on better air quality held in Yogyakarta, in December.

Most people in the region rely on firewood for cooking and heating, but this not only destroys the local forest but also causes serious health problems due to indoor air pollution. TNC initiated an alternative energy programme in 2001 to protect the rich biodiversity in northwest Yunan and use energy strategies.

http://ipsnews.net/news.asp?idnews=36052

Residential Biofuels in South Asia: Carbonaceous Aerosol Emissions and Climate Impacts

C. Venkataraman,[1*] G. Habib,[1] A. Eiguren-Fernandez,[2] A. H. Miguel,[2] S. K. Friedlander[3]

High concentrations of pollution particles, including "soot" or black carbon, exist over the Indian Ocean, but their sources and geographical origins are not well understood. We measured emissions from the combustion of biofuels, used widely in south Asia for cooking, and found that large amounts of carbonaceous aerosols are emitted per kilogram of fuel burnt. We calculate that biofuel combustion is the largest source of black carbon emissions in India, and we suggest that its control is central to climate change mitigation in the south Asian region.

4 MARCH 2005 VOL 307 SCIENCE

An analysis of the climate response of soot emissions from fossil fuel and biofuel combustion has suggested that control of soot, in addition to greenhouse gases, is an important measure to slow global warming, especially on short time scales (*6*, *7*). Our results suggest that biofuel combustion could significantly affect atmospheric BC concentrations in the south Asian region. The climate effects of biofuel combustion aerosols have been combined with the effects of open biomass burning in the scientific consensus reports of the Intergovernmental Panel on Climate Change (*29*). We suggest that biofuel combustion needs to be addressed as a distinct source, and that cleaner cooking technologies not only could yield significant local health and air quality benefits but also could have an important role in climate change mitigation in the south Asian region.