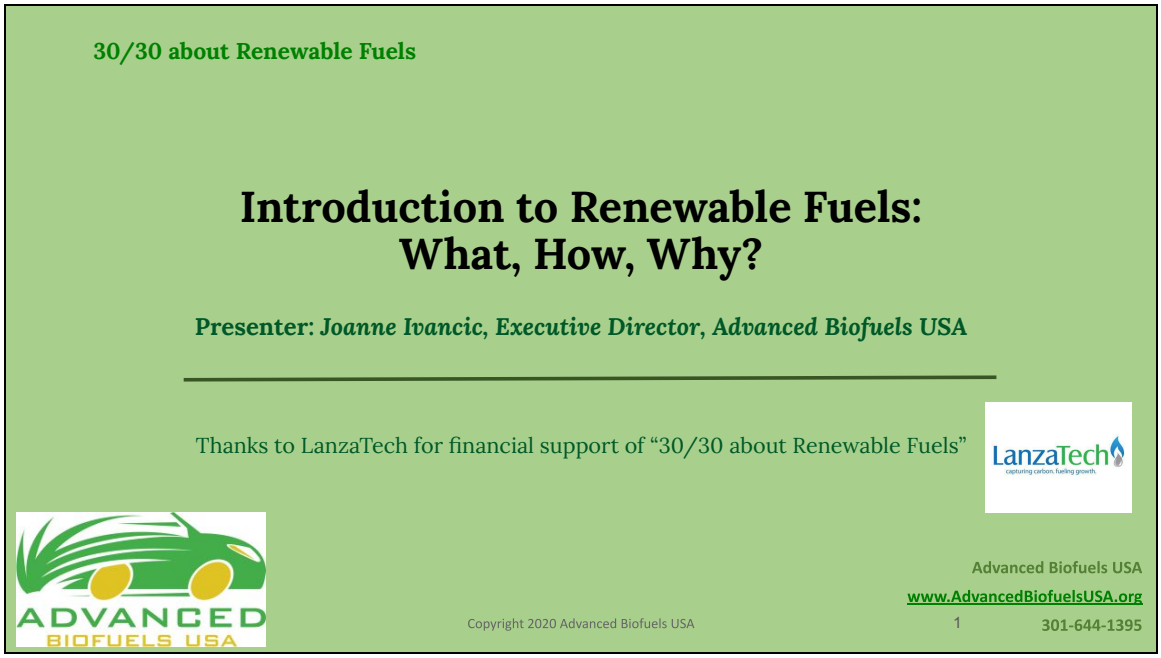


Introduction to 30/30
Hello. Are you interested in learning about how to reduce our carbon footprint right away? Join us for 30 minutes to learn about renewable fuels, the kind that are used in planes, trains, automobiles and more.

I'm Joanne Ivancic, executive director of Advanced Biofuels USA, a nonprofit educational organization. Our 30/30 sessions will provide you with 30 minutes of a recorded presentation about topics related to renewable fuels. The free package also includes a copy of the text of the presentation, along with links to references and a 30-minute discussion guide. I want to thank LanzaTech for funding that makes these 30/30 sessions possible.

And to thank the Advanced Biofuels USA team for creating and presenting 30/30.

So, let's get started with the first in the series, an Introduction to Renewable Fuels: What, How and Why.

Background/Resources

Our key tool for accomplishing this is our web site, www.AdvancedBiofuelsUSA.org, a resource for everyone from opinion-leaders, decision-makers and legislators to industry professionals, investors, feedstock growers and researchers; as well as journalists, teachers and students.

In addition, we prepare technology assessments, present briefing documents to Congressional staff, participate in international conferences on renewable fuels, provide both background and attributed interviews for a wide range of journalists and broadcast reporters, consult with international conference organizers, conduct presentations and lectures for civic and school groups, and provide general assistance to those interested in any facet of the world of advanced biofuels.

To begin:

What do you think of when you hear "*bioenergy*"? Or "*renewable energy*"?

Does it include energy for transportation?

Before we get into details, I have a question.
What do you think of when you hear the word "bioenergy? Or renewable energy?"

Do you think about energy for transportation? For cooking? For heating?

We are going to talk about all of these during the next half hour.

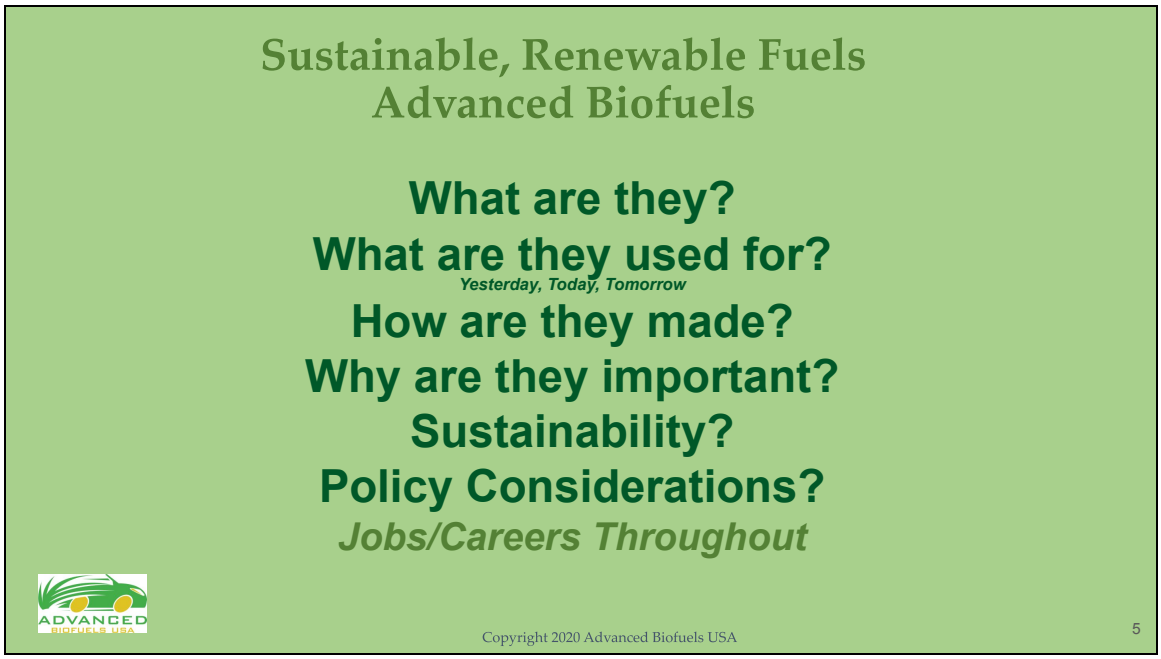
What do you think of when you hear the word "biofuel"?

Many people in the US will answer corn ethanol because in the US about 10% of the gasoline is ethanol molecules that are made from corn.

In the EU, people might say biodiesel or renewable diesel and think of used cooking oil, canola or rapeseed used to make it.

In Africa, Asia and Brazil, you might say ethanol from sugar cane or from cassava.

Or maybe you think of renewable jet fuel.



This is what we are going to talk about in this session. We'll go through this pretty quickly. You can always come back to the slides to look at the details later.

At the end of the presentation, you should be able to answer these questions and discuss these topics. At least a little bit.

Future sessions will delve into more details.

Sustainable, Renewable Fuels
Advanced Biofuels

What are they?

What are they used for?

Yesterday, Today, Tomorrow

How are they made?

Why are they important?

Sustainability

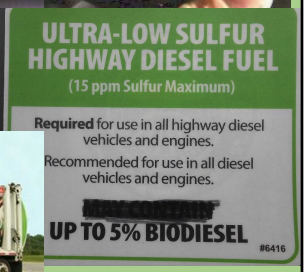
Policy Considerations

Jobs/Careers throughout

First, What are advanced renewable fuels?

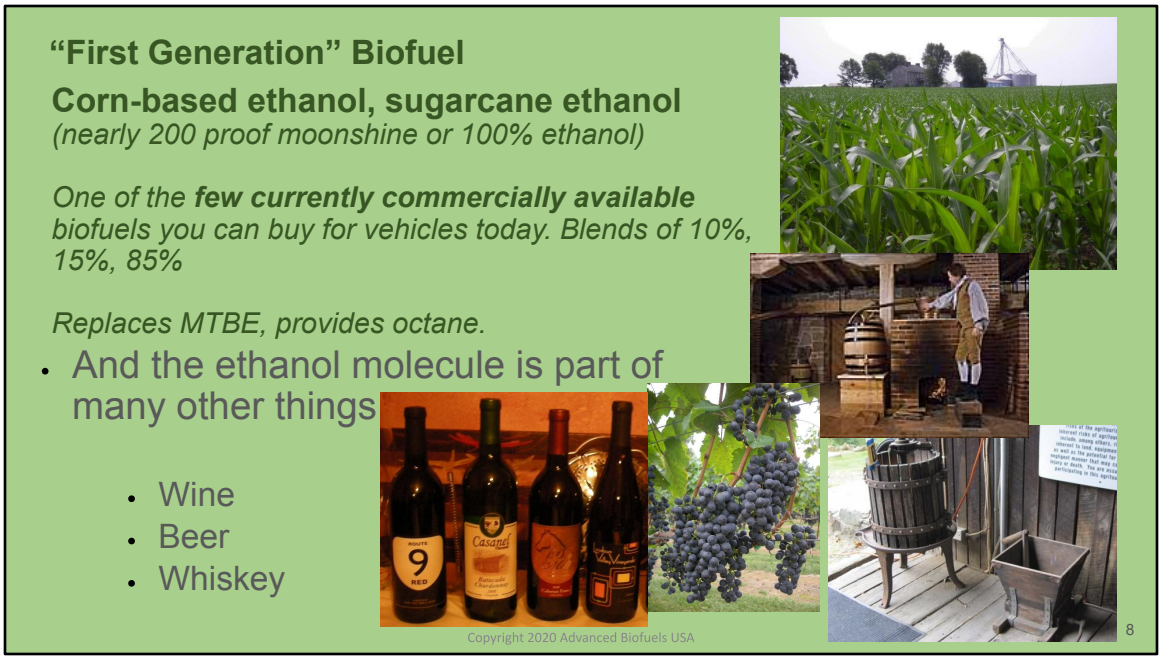
What Advanced Biofuels Are Used for Transportation?

Ethanol *is a biofuel, not the only biofuel.*
Biodiesel
Renewable Diesel
Sustainable Aviation Fuel (SAF)
Bio-isobutanol
Renewable Natural Gas
rDME
Drop-in Hydrocarbons
Maritime/Marine Fuels



7

Many people have heard of ethanol used as a fuel as we talked about earlier. Ethanol is not the only fuel that can be made from renewables. These others are, too.



But let's start with ethanol.
Many people don't realize that the ethanol that we talk about with regard to fuel is the same molecule as the ethanol or alcohol in wine, beer, whiskey Corn ethanol has long been nick-named "moonshine."

Background/References:

Important note: Ethanol for use as a transportation fuel must be highly distilled, basically 200 proof or nearly 100% ethanol. As soon as the ethanol is distilled and ready for transport from a biorefinery, some gasoline is added to "poison" it so that it will not be drinkable, and will not be diverted to beverage purposes (denatured ethanol).

Fuel ethanol: Ethanol intended for fuel use. Fuel ethanol in the United States must be anhydrous (less than 1 percent water). Fuel ethanol is denatured (made unfit for human consumption), usually prior to transport from the ethanol production facility, by adding 2 to 5 volume percent petroleum, typically pentanes plus or conventional motor gasoline. Fuel ethanol is used principally for blending in low concentrations with motor gasoline as an oxygenate or octane enhancer. In high concentrations, it is used to fuel alternative-fuel vehicles specially designed for its use. See

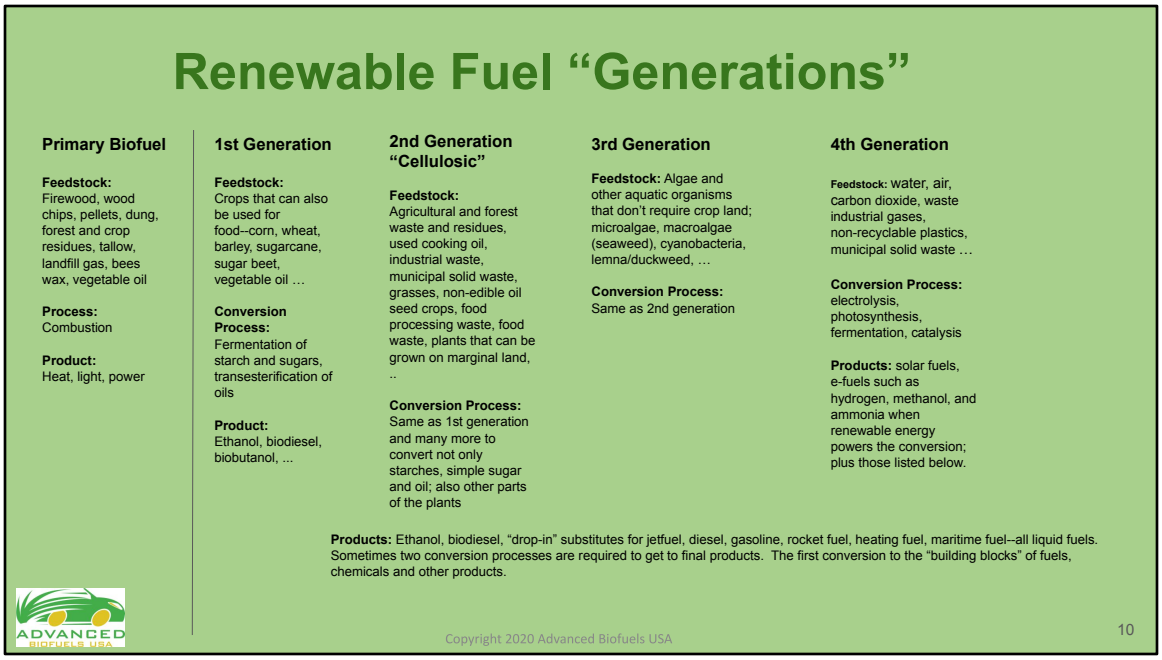
Alternative-Fuel Vehicle, Denaturant, E85, Ethanol, Fuel Ethanol Minus Denaturant, and Oxygenates.

Fuel Ethanol Minus Denaturant: An unobserved quantity of anhydrous, biomass-derived, undenatured ethanol for fuel use. The quantity is obtained by subtracting the estimated denaturant volume from fuel ethanol volume. Fuel ethanol minus denaturant is counted as renewable energy, while denaturant is counted as nonrenewable fuel. See Denaturant, Ethanol, Fuel Ethanol, Nonrenewable Fuels, and Oxygenates .

Photos are an old crusher and presser which might be used for grapes (similar ones for apples and other fruit); and the distillery at Mount Vernon, VA, a re-creation of the distillery operated by George Washington on his plantation.

If you want to add a history lesson, or integrate this with lessons in the history department, you can talk about how corn was converted to liquid (moonshine whiskey) to both increase its value and make it easier to move large volumes across the Appalachian mountains in the early days of the United States. The Whiskey Rebellion is a related topic.

Note the parallels in the problems that people have today moving large volumes of raw biomass to biorefineries to those of the European settlers who lived west of the mountains; their markets to the East.



You will hear people talk about 1st generation and 2nd generation biofuels. Generally, the higher the generation, the more sustainable the fuel was thought to be; although we will see that it's a lot more complicated than that. This gives you some idea about the factors considered when using generational descriptions.

Background/Resources:

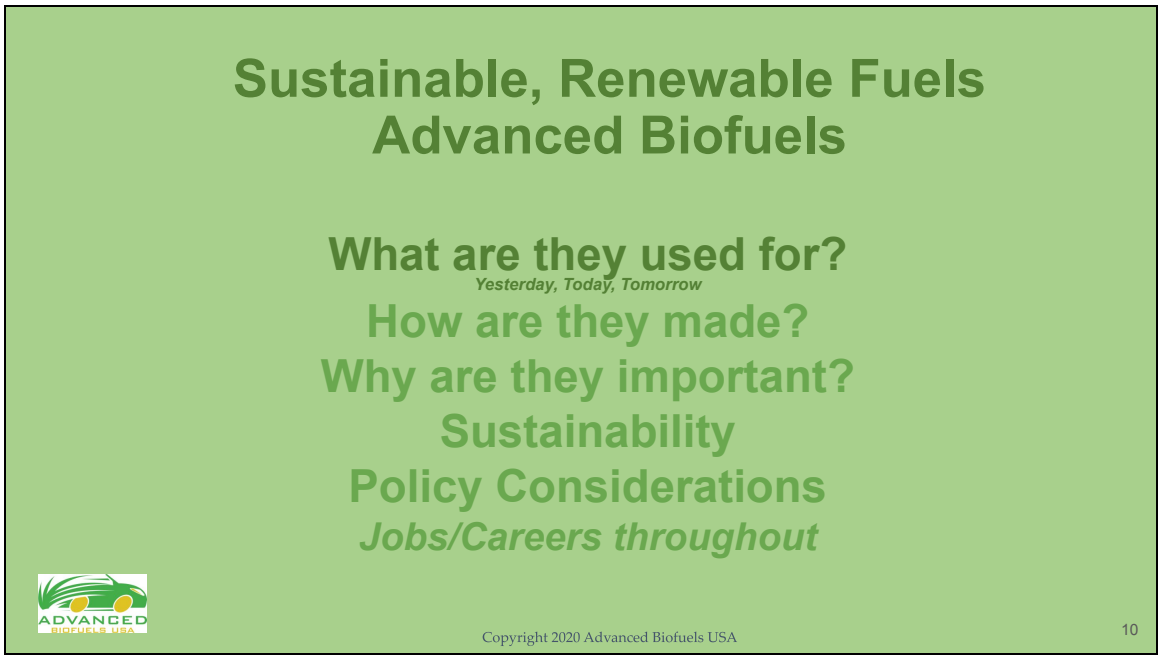
This is a very inexact system of description and less relevant as renewable fuels develop; but still often used.

2nd generation biofuels
3rd generation biofuels
4th generation fuels

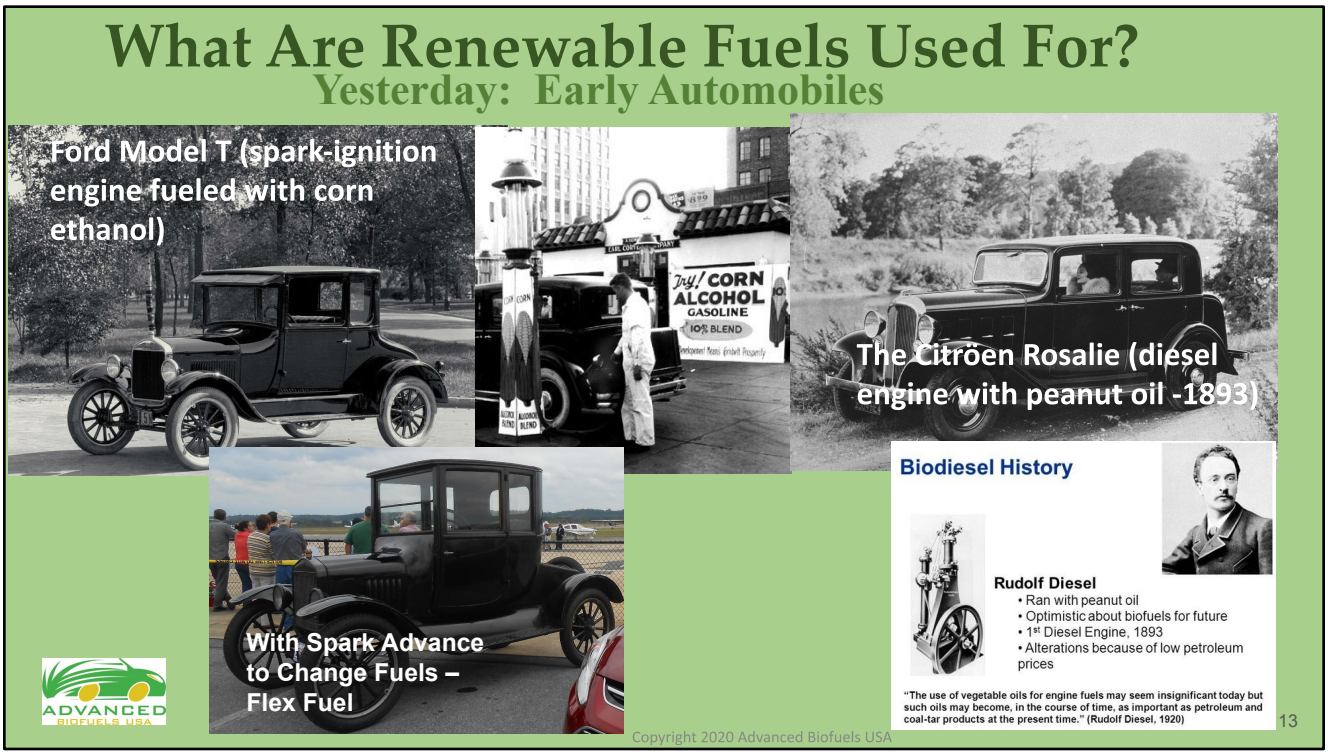
See also Generations 1, 2, 3 and 4: Talking about biofuels
https://advancedbiofuelsusa.info/biofuels-basics/biofuels-basics/#gen

"Next Generation" refers to anything past the 1st Generation. For example in the "Next Generation Fuels Act" introduced in the US Congress by Rep. Cheri Bustos (D-IL

17) https://advancedbiofuelsusa.info/bustos-introduces-next-generation-fuels-act/



Now we know, generally, what advanced renewable fuels are. What are they used for?



Think about it. In the early days of cars and trucks, there wasn't a system of gas stations or fueling statior People used horses, oxen, mules and other animals for transportation and work. So cars and trucks were built to use the fuel that could be made on farms or near where the cars and trucks were used. Thus, the original Ford Model T ran on ethanol and the first diesel engines used peanut oil.

When gasoline came into use, later Model Ts were the first "flex-fuel" vehicles. They could use ethanol an gasoline. And, eventually, gasoline was sold mixed with ethanol, as we do today.

Background/Resources

cleanfuelforthought.wordpress.com
http://en.wikipedia.org/wiki/Citro%C3%ABn_Rosalie
http://www.fuel-testers.com/ethanol_fuel_history.html
http://advancedbiofuelsusa.info/up-with-octane-and-down-with-aromatics-continuing-health-risks-with-p etroleum-fuels-and-the-need-for-engine-efficiency/ good history

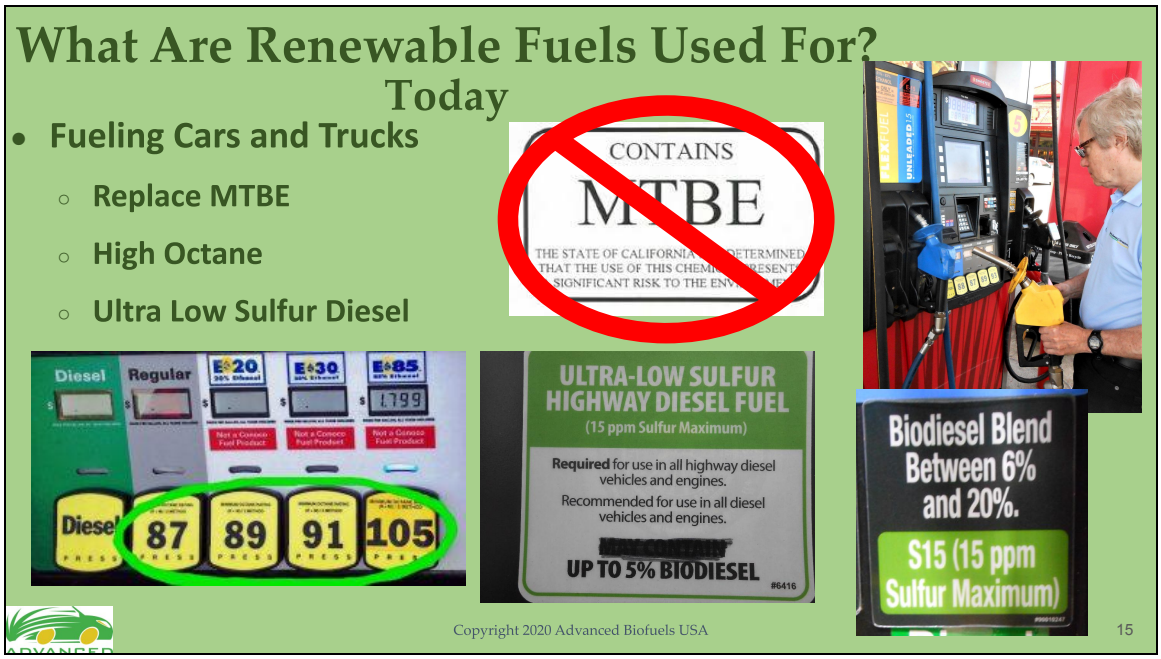
The Ford Model T was designed to run on corn ethanol.
In 1933, Citroën introduced the Rosalie, the first commercially available passenger car with a diesel engin developed with Harry Ricardo. https://en.wikipedia.org/wiki/Citro%C3%ABn

Inspired by Sadi Carnot's writings to create a more efficient engine, he began working on his project in 1885, and eventually secured financial support from Maschinenfabrik Augsburg (forerunner of Maschinenfabrik Augsburg-Nürnberg and the present-day MAN Diesel) and Friedrich Krupp AG (now ThyssenKrupp). He received a patent for his heat-driven oil engine, now called the diesel engine, in 1892,

and powered up the first working diesel engine — fueled by peanut oil — on 10 August 1893. After working out some problems with the design, he introduced a 25-horsepower, four-stroke, single cylinder compression engine in 1897, which gained widespread use after being displayed in the Munich Exhibition of 1898.

The diesel engine is an internal-combustion, compression-ignition mechanism which works by heating fuels (either petroleum-based or bio-derived) and causing the fuel to ignite. Driven solely by high compression in its cylinders, the diesel engine is generally more energy-efficient, quieter, and needs less maintenance and repairs than other internal combustion engines. As Diesel himself wrote, "It is the diesel's higher compression ratio that leads to its greater fuel efficiency. Because the air is compressed, the combustion temperature is higher, and the gases will expand more after combustion, applying more pressure to the piston and crankshaft".
http://www.nndb.com/people/906/000082660/

Yes, Tin Lizzie Was an Alcoholic
https://advancedbiofuelsusa.info/yes-tin-lizzie-was-an-alcoholic/



Today, you buy biofuels at the "gas" or "petrol" station. In the US, almost all the regular gasoline is E10—or 10% ethanol, a biofuel; some is 15%, E15. You might also see 20% and 30% ethanol blends. The more ethanol in the fuel, the higher the octane.

Ethanol use increased as a replacement for MTBE, an animal carcinogen that leaked into groundwater from gas station tanks. After many lawsuits, it was banned in about half the US states. However, it is still used in gasoline in other parts of the world and could be replaced with safer ethanol.

Background/References:

Octane https://advancedbiofuelsusa.info/tag/octane/

Better performance from ethanol means higher compression ratios, lower heat of vaporization, higher torque.

MTBE Bans Boost Ethanol

https://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2005/06/06/mtbe-bans-boost-ethanol#:~:text=Of%20those%2019%20states%2C%20California,still%

20using%20gasoline%20with%20MTBE

MTBE in Gasoline: Clean Air and Drinking Water Issues
https://www.everycrsreport.com/reports/RL32787.html

You can also buy biodiesel blends. In the US often 2-5% of petroleum diesel is biodiesel; and some *fleets* use 20% or even 100% biodiesel, in public works equipment and farm equipment or in specially adapted cars and trucks.

So, you do use biofuels today, even if you don't know it.

Lawsuit Over Md. Groundwater Pollution Settled
https://baltimore.cbslocal.com/2014/06/04/lawsuit-over-md-groundwater-pollution-settled/

https://www.unionleader.com/news/courts/six-law-firms-to-represent-state-in-lawsuit-over-pfas/article_e6f2e6d9-c46d-5c0b-8cbd-c509e0d51b3d.html

Gas station in Fallston tied to leaks of MTBE and fouled wells is closed
https://www.baltimoresun.com/bal-md.ha.mtbe28apr28-story.html

Gansler eyes lawsuit over well contamination
https://www.baltimoresun.com/news/environment/bs-md-mtbe-litigation-20141205-story.htm l

Maryland Sues Petroleum Companies over Groundwater Contamination
https://www.baltimoresun.com/news/environment/bs-md-mtbe-lawsuit-20171213-story.html

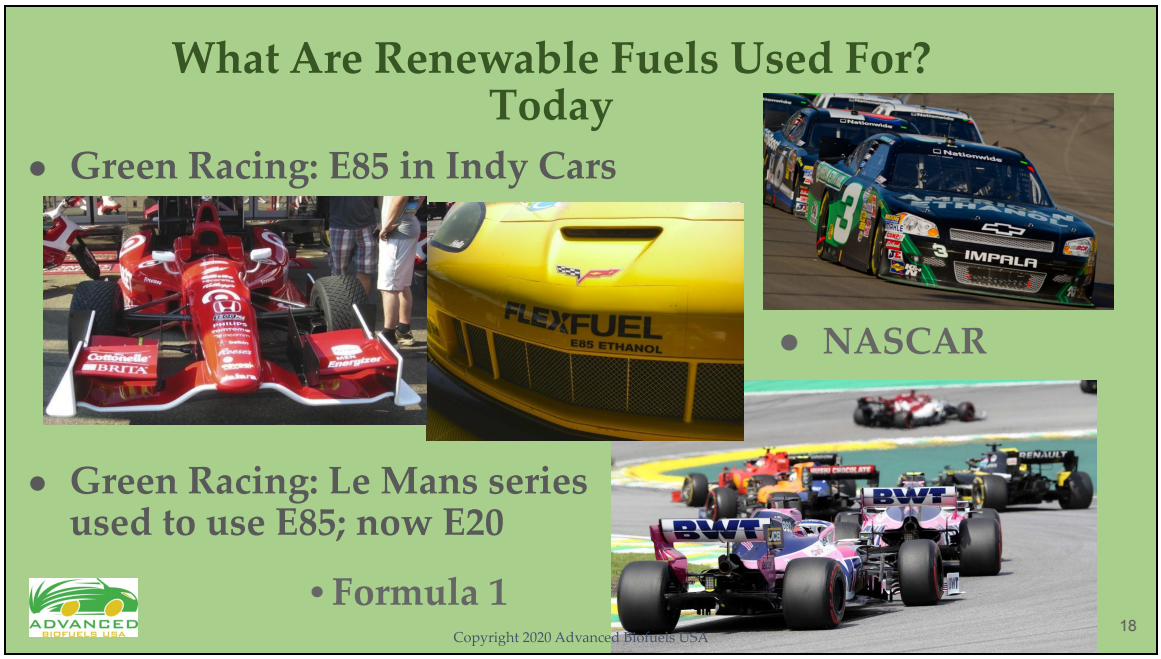
Federal Judge Allows Maryland's MTBE Lawsuit Against Gasoline Companies to Move Forward
https://conduitstreet.mdcounties.org/2019/10/11/federal-judge-allows-marylands-mtbe-lawsuit-against-gasoline-companies-to-move-forward/#:~:text=Federal%20Judge%20Allows%20Maryland's%20MTBE%20Lawsuit%20Against%20Gasoline%20Companies%20to%20Move%20Forward,-Les%20Knapp&text=A%20Daily%20Record%20article%20(2019,contamination%20from%20a%20gasoline%20additive

Vermont Attorney General Announces Settlement of MTBE Lawsuit

https://ago.vermont.gov/blog/2019/03/15/vermont-attorney-general-announces-settlement-of-mtbe-lawsuit/

Banned in how many states?

21 states
https://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2005/06/06/mtbe-bans-boost-ethanol#:~:text=Of%20those%2019%20states%2C%20California,still%20using%20gasoline%20with%20MTBE.



Ethanol does have less energy density, therefore E85 has up to 25% lower mileage per gallon than E10, BUT, it has better performance. Indy Cars use 85% ethanol. Cars racing in the old ALMS (American Le Mans Series) used a variety of renewable fuels experimenting with biobutanol, cellulosic E85, E10 and E20. NASCAR uses E15. Now cars racing IMSA to participate in the Le Mans Series use E20. Formula 1 plans to increase biofuel use from 10% to 100%.

Background/References:

Green Racing: https://advancedbiofuelsusa.info/category/green-racing/
America's sports car racing series embraces being green again
https://arstechnica.com/cars/2019/06/americas-sports-car-racing-series-embraces-being-green-again/

F1 already uses biofuels, but the current technical regulations say that fuel must include 5.75% of bio-components. In 2021, Symonds says that F1 is "looking to increase to 10%" with a view to get to 100% advanced sustainable fuels.
Two years after this rule was brought in by the FIA, this was also made a law for commercial fuels in Europe. The FIA regulations state that the fuels used in a Formula 1 car must be similar to what can be purchased at the pump for a road car.

https://f1chronicle.com/what-fuel-do-formula-1-cars-use/

E15 for NASCAR: Cellulosic Ethanol is on the Table
https://advancedbiofuelsusa.info/e15-for-nascar-cellulosic-ethanol-is-on-the-table/

American Ethanol steps in as sponsor of two NASCAR races
http://ethanolproducer.com/articles/8814/american-ethanol-steps-in-as-sponsor-of-two-nascar-races
NASCAR Photo by Greg Latza for Growth Energy

Renewable aviation fuel is called "Sustainable Aviation Fuel" or SAF. Globally, more than 40 airlines are already using SAF at some level, with about 200,000 commercial flights using SAF since 2011.

Background/References: And 1.6 billion gallons of SAF committed to forward purchase agreements. Put another way, sustainable aviation fuel is already here. It's powering aircraft with much less greenhouse gas emissions - up to 80 percent less carbon dioxide equivalent on a lifecycle basis compared to conventional jet fuel. SAF also emits less pollution, which contributes to cleaner air in communities located near airports.
https://www.aviationpros.com/gse/fueling-equipment-accessories/fuel-distributors-suppliers-manufacturers/article/21144761/neste-north-america-now-is-the-time-to-let-sustainable-aviation-fuel-take-off

https://advancedbiofuelsusa.info/category/aviation/

Virgin Atlantic Takes Flight with First Waste-to-Fuel Mix
http://www.cleantechconcepts.com/2018/10/virgin-atlantic-takes-flight-with-first-waste-to-fuel-mix/

Virgin Atlantic flight VS16, from Orlando to Gatwick using a Boeing 747, ushered in a new era for low-carbon aviation that has been years in the making. Through a combination of chemistry, biotechnology, engineering and catalysis, the two

organizations (plus Virgin Atlantic and Boeing) have shown the world that carbon can be recycled and used for commercial flight. Passengers on the historic flight were welcomed by a familiar face on arrival as the airline's founder **Sir Richard Branson marshalled the aircraft into the gate** (**see video**). This flight follows hot on the heels of a £410K UK government ***Future Fuels for Flight and Freight*** grant to determine the feasibility of building a 40-50M US gallon jet fuel plant in Britain.

LanzaTech, a Chicago based company, produces next-generation 'advanced' fuels by recycling waste industrial gases like those produced from steel making and other heavy industrial processes. LanzaTech takes these waste, carbon-rich gases to first make ethanol. The ethanol can be used for a range of low-carbon products, including jet fuel.

Today Virgin Atlantic is calling on the UK government to commit to making this fuel a commercial reality in the UK. Allowing access for new carbon capture and utilisation technologies like LanzaTech's to incentives already given to earlier generations of 'biofuels' and providing critical investor support will enable first plants to be swiftly built.

ADVANCING SUSTAINABLE AVIATION FUEL
HTTPS://WWW.WSP.COM/EN-US/INSIGHTS/ADVANCING-SUSTAINABLE-AVIATION-FUEL

https://advancedbiofuelsusa.info/tag/commercial-flights/

https://advancedbiofuelsusa.info/tag/commercial-flights/
For example, United Airlines flights between Los Angeles and San Francisco use a biofuel blend. Some Nordic countries are mandating renewable jetfuel use.
https://advancedbiofuelsusa.info/proposal-for-sweden-to-follow-norways-lead-and-mandate-use-of-sustainable-aviation-fuels-from-2021/

What Are Renewable Fuels Used For?

Today

Fueling Buses with Renewable Natural Gas (RNG)

Table 2-29: Annual well-to-wheels GHG emissions for selected types of road vehicles (low WTT greenhouse gas emissions scenario)

Vehicle type	Annual well-to-wheels CO_2e emissions (tonnes per year)			Percentage change in [illegible] emissions	
	Petrol/diesel	Natural gas	Biomethane	Natural gas vs petrol/diesel	[illegible]omethane vs petrol/diesel
Passenger car (petrol)	1.70	1.39	0.20	-18%	-88%
Passenger car (diesel)	1.31	1.39	0.20	+6%	-85%
LCV	3.98	4.28	0.82	+8%	-79%
Small rigid truck	18.07	20.43	4.91	+13%	-73%
Large rigid truck 26 t	48.21	55.94	10.61	+16%	-78%
Articulated truck (>32 t)	135.38	136.23	82.00	+1%	-39%
Bus	57.53	60.96	10.10	+6%	-82%
Coach	46.14	53.12	9.60	+15%	-79%

Note: for passenger cars, the baseline comparator vehicle is petrol powered; for all other vehicles, [illegible]line vehicles are diesel powered.

Well-to-wheel comparison of CO2 emissions / Source: The role of natural gas and biomethane in the transport sector
https://euinmyregion.blogactiv.eu/2016/07/04/biogas-buses-are-the-green-solution-for-cities/

15

Some buses around the world use renewable natural gas or biomethane for fuel in engines that can use compressed natural gas. This chart compares the greenhouse gas emissions among different fuels. You can see the greenhouse gas emissions benefit over petroleum diesel that you get RNG.

Background/References:

Renewable Natural Gas Project in Spain Targets Use for Transportation
https://www.ngvglobal.com/blog/renewable-natural-gas-project-in-spain-targets-use-for-transportation-1221

Scania "Biogas bus: Bristol
https://euinmyregion.blogactiv.eu/2016/07/04/biogas-buses-are-the-green-solution-for-cities/

Trucks on the roads today can also use renewable natural gas (RNG), as well as biodiesel blends and renewable diesel, also known as HVO or green diesel. It can completely replace petroleum diesel.

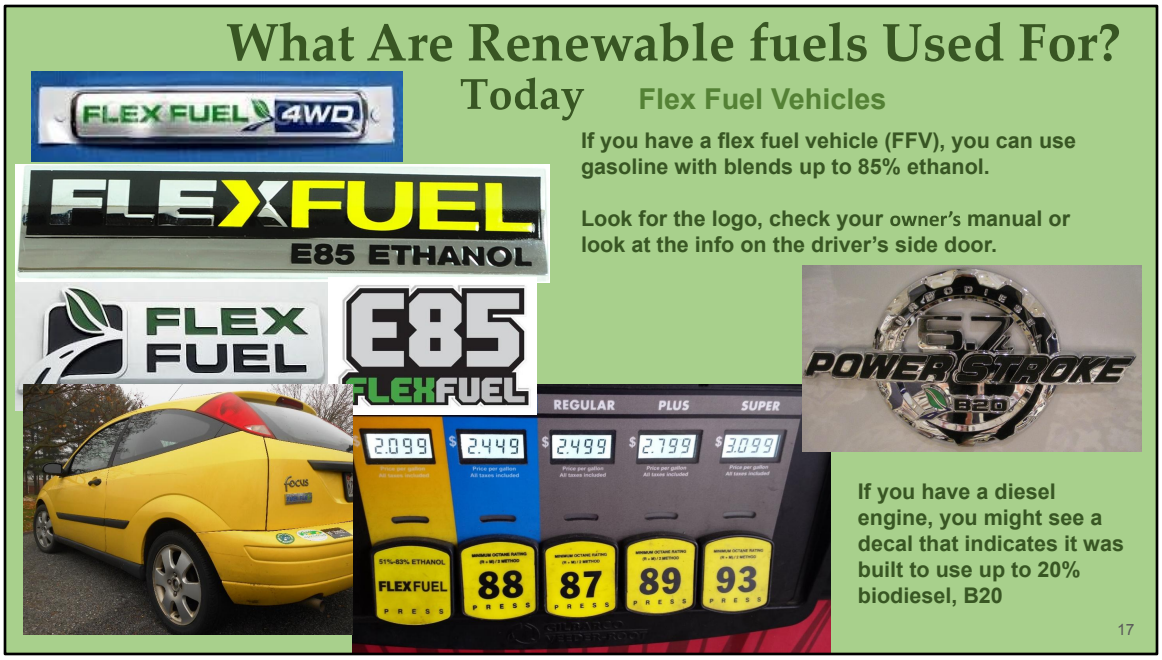
Background/References:

Anheuser-Busch, a wholly owned subsidiary of global brewer AB InBev, will convert 30% of its dedicated fleet to RNG. The vehicles, comprising of two fleets, will travel more than 8.5 million miles each year.
Anheuser-Busch has placed an order from Agility Fuel Solutions to equip new class-8 trucks with Compressed Natural Gas (CNG) Fuel systems that can run on RNG.
https://www.edie.net/news/6/Anheuser-Busch-to-run-180-trucks-on-renewable-natural-gas/
https://www.wastetodaymagazine.com/article/waste-management-trucks-seattle/
Waste Management to launch new green fleet of garbage trucks in Seattle
The fleet of 101 vehicles will be powered by either renewable natural gas or by electricity.
May 30, 2019 by Adam Redling

https://www.fuelsfix.com/2019/07/biodiesel-vehicle-wrap-program/ Biodiesel vehicle wrap program 2019

https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.neste.us%2Fneste-my%2Ffind-fuel&psig=AOvVaw3SKmnfnUpa_7su70j3UcgS&ust=1604185856888000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCOjnkJq43ewCFQAAAAAdAAAAABAD

http://www.biodieselmagazine.com/articles/2516343/biodiesel-ranks-first-among-fleets-for-alternative-fuel-use

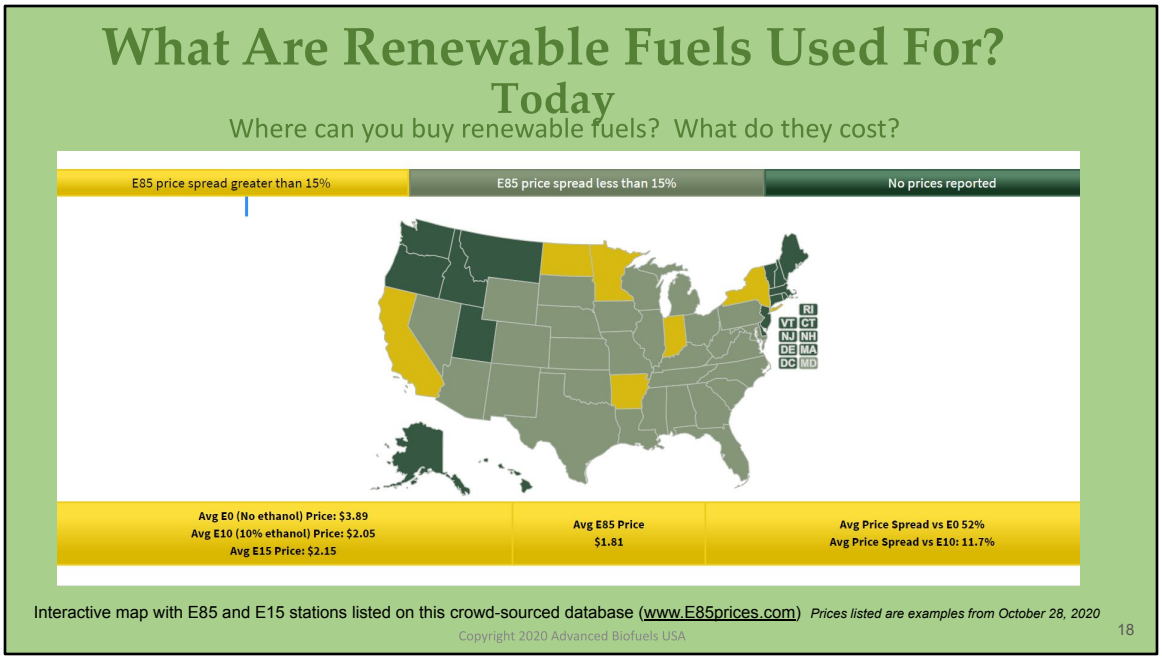


If you have a flex fuel vehicle, you can use gasoline with up to 85% renewable fuel--ethanol.

In the US, you can use E15 or 15% ethanol fuel in vehicles built since 2001. At this time motorcycles may only use up to 10% ethanol fuel, E10, the most common fuel at gas stations in the US. Thailand plans to make E20 a standard fuel.

Much diesel fuel in the US is 5% renewable biodiesel. Some diesel engine manufacturers build for 20% biodiesel use (B20). Some countries are looking at 30 and 40%.

Background/References:
to find out if you have a flex fuel vehicle or FFV, look for a logo on the car, check the owner's manual or look at the information on the drivers' door.



There are a number of apps you can download to help you find stations that sell the kind of fuel you need that are near you or along the roads you travel.

Background/Resources:

Interactive map with E85 and E15 stations listed on this crowd-sourced database (www.E85prices.com) Prices listed are examples from October 28, 2020

The National Biodiesel Board publishes maps for retail pumps and information for fleets and heating fuel. https://www.biodiesel.org/using-biodiesel/finding-biodiesel

In January 2020, the international maritime organization's regulation to reduce dangerous sulfur oxide emissions from ships went into effect. Low sulfur renewable fuels help the shipping industry meet these requirements.

Background/References:

The new upper limit on sulphur content on ships fuel oil is .50%, causing a 77% drop in overall SOx emissions from ships. This regulation will also lead to a decrease in particulate matter and prevent ocean acidification. Some other benefits to this regulation include reduction of stroke, asthma, cardiovascular disease, and benefit aquatic species and forests.

https://www.imo.org/en/MediaCentre/PressBriefings/Pages/34-IMO-2020-sulphur-limit-.aspx#:~:text=%E2%80%8BFrom%201%20January%202020,the%20limit%20is%20already%200.10%25

What Are Renewable Fuels Used For?

Today?

- **Military Aviation Fuels**

- **Military Marine/Maritime Fuels**

Military aircraft and ships around the world can use renewable fuels.

Background/References:

On March 25, 2010, the Air Force successfully conducted the first flight test of an aircraft powered by a 50-50 camelina-based biofuel blend. As of mid-2011, 99 percent of the Air Force fleet has been certified to fly on biofuel blends.15 The Air Force expects to complete all flight testing by February 2012 and all certifications by December 2012.

The Navy also is actively engaged in testing and certifying advanced biofuels for planes and ships—flying the "Green Hornet" on a camelina-based jet fuel and floating Riverine Command Boat-Experimental (RCB-X) on a biofuel derived from algae.16

The Navy is planning to demonstrate a carrier strike group powered solely by alternative fuels in 2012. Dubbed the Great Green Fleet, the ships and planes are expected to conduct an extended mission in 2016, and all energy provided to operational platforms is to be 50 percent alternative by 2020.

What Are Renewable Fuels Used For?

Today or Tomorrow?

29

Multi-country military exercises have proved that renewable fuels can be used interchangably with other military spec fossil fuels

Background/References:

On March 25, 2010, the Air Force successfully conducted the first flight test of an aircraft powered by a 50-50 camelina-based biofuel blend. As of mid-2011, 99 percent of the Air Force fleet has been certified to fly on biofuel blends.15 The Air Force expects to complete all flight testing by February 2012 and all certifications by December 2012.

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2014 marks the first time the U.S. Navy is including biofuels in its annual procurement for bulk fuels.

More details can be found at https://www.fbo.gov, solicitation number SP060014R0061. READ MORE and MORE (Biofuels Digest; includes 10 backgrounders on the Navy's biofuels's program)

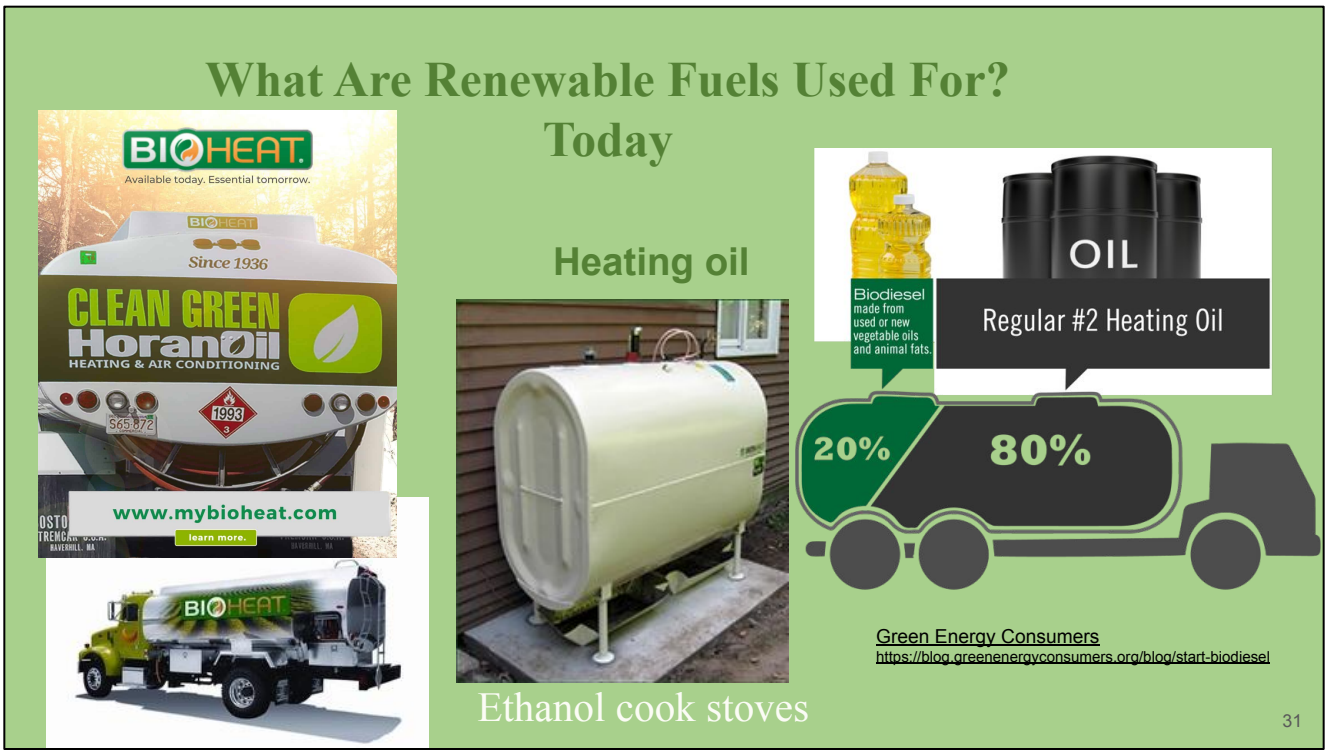
Washington, the Department of Defense has awarded $210 million under the Defense Production Act to Emerald Biofuels, Fulcrum BioEnergy and Red Rock Bio towards the construction of biorefineries that produce cost-competitive, drop-in military biofuels.

Under the grants, the companies will build biorefineries to produce military spec fuel that is expected to cost the US military, on a weighted average, less than $3.50 per gallon

— or cost competitive with petroleum-based fuels, with availability expected as soon as 2016, and have a 50 percent of greater reduction of emissions compared to conventional fuels.

The biorefineries, once complete, will have a combined capacity for producing 100 million gallons of military-spec jet fuel and marine diesel. READ MORE and MORE (US Department of Energy)

These aspirations were effectively put on hold between 2017-2020.



Biofuels can also be used for heating. ***Bioheat®*** *fuel is a blend of cleaner-burning ultra-low-sulfur heating oil and biodiesel.*

Background/References:
Over 5 million U.S. households use heating oil as a main source of heat The biodiesel industry has attempted to grow the Bioheat fuel market, a blend of biodiesel and ultra low sulfur heating oil, since 2006.

"It hasn't been easy," Paul Nazzaro, supply chain adviser to the National Biodiesel Board, said. "We've been through years of studies and testing, years of developing and getting an ASTM standard approved, and faced opposition from some of the equipment manufacturers," he said.

However, Nazzaro feels the product has potential to make headway with the home heating oil industry, especially in the Northeastern part of the country.
September 2019 the New England Fuel Institute (NEFI) adopted a resolution stating the home heating industry would reduce greenhouse gas emissions based on 1990 levels by 15% by 2023, 40% by 2030, and to net zero emissions by 2050.
https://www.agri-pulse.com/articles/13125-biodiesel-optimistic-for-bioheat-after-carbon-reduction-pledge

Green Energy Consumers
https://blog.greenenergyconsumers.org/blog/start-biodiesel

Biodiesel is a solvent, which is what makes it burn cleaner than regular heating oil, however in high concentrations it has been known to degrade the rubber seal on fuel pumps for oil burners or furnaces. Of course, a service technician can simply come and replace the seal.

What Are Renewable Fuels Used For? Today

Ethanol Cook Stoves

Project Gaia:

Nigeria
Ethiopia
Haiti
Brazil
Tanzania

KOKO's "ATM" Dispensers

Kenya






In some parts of the world gathering wood or dung for cooking fires can be dangerous and can cause deforestation. Also, indoor smoke from wood, charcoal and dung fires is very unhealthy. The United Nations and other international organizations support replacing those with cleaner burning stoves such as ethanol stoves.

Background/References:

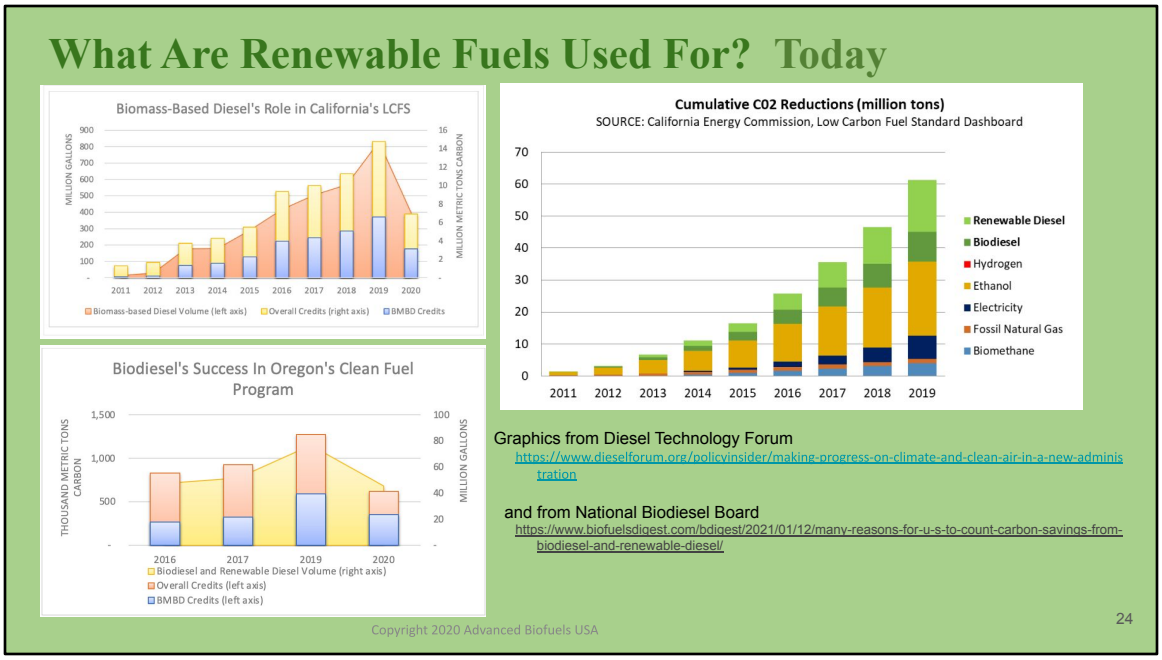
For more information: Project Gaia: https://projectgaia.com/
https://advancedbiofuelsusa.info/atm-style-machines-used-to-dispense-bioethanol-in-kenya/

The problem: https://projectgaia.com/our-approach/the-problem/
from indoor air pollution from the dependence on biomass such as charcoal and firewood to the potential dangers faced in gathering solid fuel. Women are the most vulnerable because they disproportionately bear the burden of providing cooking fuel. Fuelwood collection journeys are often arduous, spanning many kilometers and taking hours and leave women vulnerable to injury and assault. Also, deforestation which can be seen over the years particularly around refugee camps.

The smoke from wood, charcoal, dung stoves causes illnesses such as heart disease, lung disease, cataracts and 4 million deaths each year.

The solution: https://projectgaia.com/our-approach/the-solution/

Clean alcohol fuel stoves (ethanol or methanol) No smoke or soot. No long, dangerous journeys to gather fuel. Possibility of microdistilleries using local agricultural and food/market waste.



To get an idea of the benefit we see TODAY from renewable fuels, look at California's Low Carbon Fuel Standard and Oregon's Clean Fuel Program results. As you can see, biodiesel, renewable diesel, ethanol and biomethane are generating the greatest reduction in greenhouse gas emissions in the transportation sector. These benefits exceed those from the electrification of cars, trucks and buses by almost 4:1. This demonstrates how today's use of biofuels can provide the greatest amount of carbon footprint reduction in the least amount of time for the lowest price because you can do it with existing vehicles and infrastructure.

Background/References:

Making Progress on Climate and Clean Air in a New Administration
https://www.dieselforum.org/policyinsider/making-progress-on-climate-and-clean-air-in-a-new-administration
While commercial trucks and buses make up a much smaller share of the vehicles on the road, they are responsible for about 24 percent of GHG emissions from the transportation sector. Within the population of trucks and buses, larger Class 8 trucks are responsible for 60 percent of all emissions, and the largest opportunity.
…
While expectations are high for zero-emission trucks, an overlooked immediate term

strategy to reduce carbon is using advanced biofuels - renewable diesel fuel and biodiesel - in all existing diesel engines. Capable of reducing GHG emissions by at least 50 percent and in the case of renewable diesel fuel over 80 percent, these advanced biofuels are growing in availability and have a proven track record.

Consider that the biggest GHG reductions from the transportation sector in California come from the use of renewable diesel and biodiesel fuel, eliminating more GHG emissions than the switch to electric cars, trucks and buses by almost 4-to-1.

Compared to the investments required for a switch to all-electric vehicles or other alternative fuels, the switch to biodiesel and renewable diesel is easy and comes at a low cost, with no need to invest in new trucks, engines or refueling or recharging stations. These fuels may be distributed in existing fuel infrastructure and may be used in existing diesel engines.

Fuels that Work: Ultra-Low Sulfur Diesel and Biodiesel Power the U.S. Economy
https://advancedbiofuelsusa.info/fuels-that-work-ultra-low-sulfur-diesel-and-biodiesel-power-the-u-s-economy/
https://www.dieselforum.org/policyinsider/fuels-that-work-ultra-low-sulfur-diesel-and-biodiesel-power-the-u-s-economy

Advanced Biofuels Deliver Big Benefits at Low Cost
Both biodiesel and renewable diesel fuel are considered advanced biofuels by the U.S. Environmental Protection Agency defined as reducing greenhouse gas reductions at least 50 percent. Renewable diesel fuel is capable of reducing greenhouse gas emissions upwards of 80 percent. The use of these fuels are generating large greenhouse gas reduction benefits with least cost compared to other alternatives.

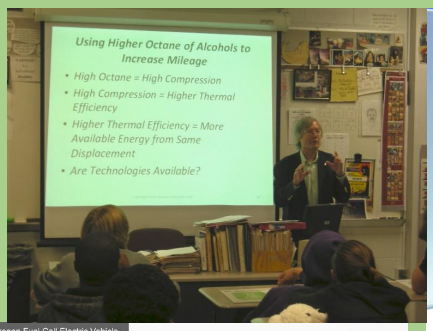
In California, that requires the gradual reduction in the carbon content of transportation fuels sold in the state through the Low Carbon Fuel Standard, biodiesel and renewable diesel fuel are generating the greatest reduction in greenhouse gas emissions in the transportation sector. These benefits exceed those from the electrification of cars, trucks and buses by almost 4:1. A key advantage to the use of renewable biodiesel fuels is that compared to competing alternatives, they do not require the purchase of new vehicles, equipment or engines nor do they require expensive additional investments in refueling or recharging infrastructure. Their benefits can be felt immediately across entire fleets of vehicles, rather than only in newly acquired vehicles dependent on new infrastructure. Biodiesel fuels can be stored, used, pumped and handled virtually the same way as petroleum diesel products.

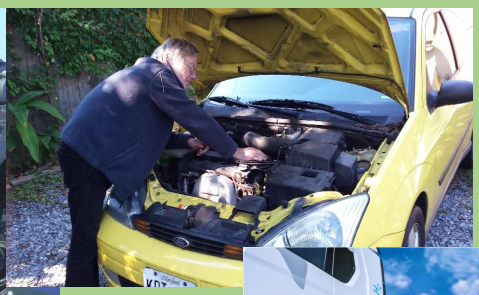
Many Reasons for U.S. to Count Carbon Savings from Biodiesel and Renewable Diesel
National Biodiesel Board

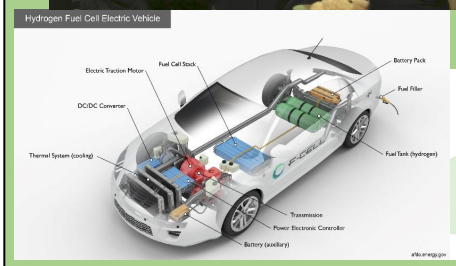
https://www.biofuelsdigest.com/bdigest/2021/01/12/many-reasons-for-u-s-to-count-carbon-savings-from-biodiesel-and-renewable-diesel/

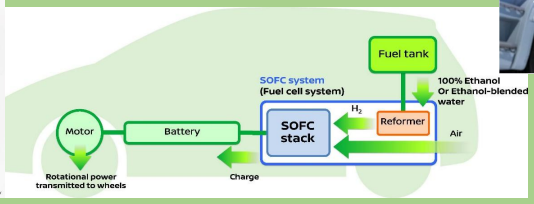
What Will Fuel Ethanol Be Used For?

Tomorrow — Fuels for high performance vehicles









Hydrogen or Ethanol for Fuel Cells

How about in the future? In addition to continuing and expanding what works now, in the future we can expect to use renewable hydrogen or ethanol for fuel cell powered cars and trucks. And work is being done to optimize gasoline engines for E30, 30% ethanol. Who knows, maybe the other 70% will be green gasoline.

Background/References:

"Designer" fuels tailored to obtain the most efficient, most powerful performance from specific engines

Hydrogen Carriers for **Fuel Cells**

Tier 3 and E30 certification fuels

3.5-liter V6 EcoBoost® racing engine and EcoBoost for consumer vehicles.
"At Ford Racing, we really put great emphasis on racing production-based vehicles as well as production-based technologies," says Jamie Allison, director, Ford Racing. "We're proud to bring a direct-injected, twin-turbo 3.5-liter V6 EcoBoost engine to the United SportsCar Championship in a field of competitive V8-powered entries. We want to show Ford EcoBoost's capabilities as an engine that provides both performance and fuel economy, on and off the track." --2014

"This engine is the future," says Doug Yates, CEO, Roush Yates Racing Engines. "This Ford EcoBoost engine includes all the newest technologies – direct injection, turbocharging and high efficiency. We're looking at taking it to the next level through this sports car racing program."

http://www.imsa.com/articles/ford-debut-new-ecoboost-race-engine-rolex-24

New Engine Technologies Could Produce Similar Mileage for All Ethanol Fuel Mixtures

Get photo from NEVO MOtors once they go online. https://nevomotors.com/

High-capacity electric vehicles (HCEV's) from Nevo Motors are designed for heavy cargo and long range by using on-board range extender generators powered by renewable natural gas (RNG), with future electric truck models designed to use patented hydrogen and ethanol range extenders.
https://advancedbiofuelsusa.info/aemetis-enters-electric-vehicle-market/

Latest Fuel Cell Vehicle and Hydrogen Station Data Released:

California Fuel Cell Partnership, December 1, 2020
https://cafcp.org/by_the_numbers

According to the latest data from the California Fuel Cell Partnership, as of December 1, 2020, 8,890 fuel cell cars had been sold and/or leased in the U.S. In addition, 48 fuel cell buses have been placed in operation in California with another seven under development. The state has 42 hydrogen stations available and another 15 in various stages of development.

What about rockets and missiles? Research is being done to use renewable fuels in these, too.

Background/Reference:

Orbital Completes First Operational Cargo Mission to International Space Station for NASA--Cygnus Cargo Logistics Spacecraft Reenters Earth's Atmosphere Over Pacific Ocean --Company's Next CRS Mission to ISS to Take Place in Early May

(Dulles, VA 19 February 2014) – Orbital Sciences Corporation (NYSE: ORB), one of the world's leading space technology companies, today announced the successful completion of the first of eight CygnusTM operational cargo logistics spacecraft missions to the International Space Station (ISS) as part of the company's $1.9 billion Commercial Resupply Services (CRS) contract with NASA. **About Antares**

The Antares medium-class launch vehicle represents a major increase in the payload launch capability that Orbital can provide to NASA, the U.S. Air Force and commercial customers compared to its heritage small-class space launch vehicles such as Pegasus, Taurus and Minotaur. The Antares rocket can launch spacecraft weighing up to 14,000 lbs. (6,400 kg.) into low-Earth orbit, as well as lighter-weight payloads into higher-energy orbits. Orbital's newest launcher has completed three successful missions and is currently on-ramped to both the NASA Launch Services-2 and the U.S. Air Force's Orbital/Suborbital Program-3 contracts, enabling the two largest U.S. government space launch customers to order Antares for "right-size and right-price" launch services for medium-class spacecraft. For more information

on Antares, visit http://www.orbital.com/SpaceLaunch/Antares/.

About Cygnus

Orbital developed the Cygnus cargo spacecraft as part of its Commercial Orbital Transportation Services (COTS) joint research and development initiative with NASA. visit http://www.orbital.com/NewsInfo/Publications/Cygnus_fact.pdf.

About Orbital

Orbital develops and manufactures small- and medium-class rockets and space systems for commercial, military and civil government customers. http://www.orbital.com. Follow the company on Twitter @OrbitalSciences.

 # # # http://www.orbital.com/NewsInfo/release.asp?prid=1887

ISRO (India Space Research Organization) working on green fuels like hydrogen peroxide for rockets

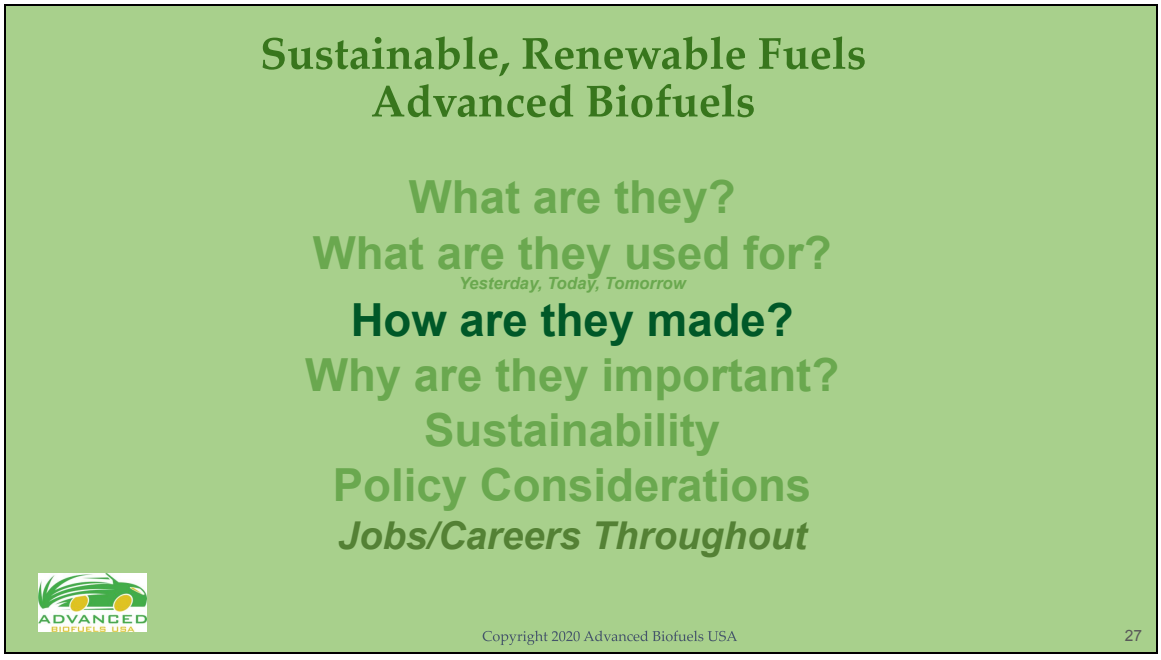
https://energy.economictimes.indiatimes.com/news/renewable/isro-working-on-green-fuels-like-hydrogen-peroxide-for-rockets/80045159

ISRO is also looking at rocket engines powered by hydrogen peroxide as a mono-propellant or as a bi-propellant along with ethanol.

ISRO is also developing another green fuel - LOX/Methane- liquid oxygen as oxidiser and methane as fuel.

Weather Delays Launch of Biofuel Rocket Made by Maine Company

https://advancedbiofuelsusa.info/weather-delays-launch-of-biofuel-rocket-made-by-maine-company/



So, how are these renewable fuels made? That is, how do you store the energy of the sun in plants or other materials and then make it available to move a car, truck, train or plane?

What Are Renewable Fuels?

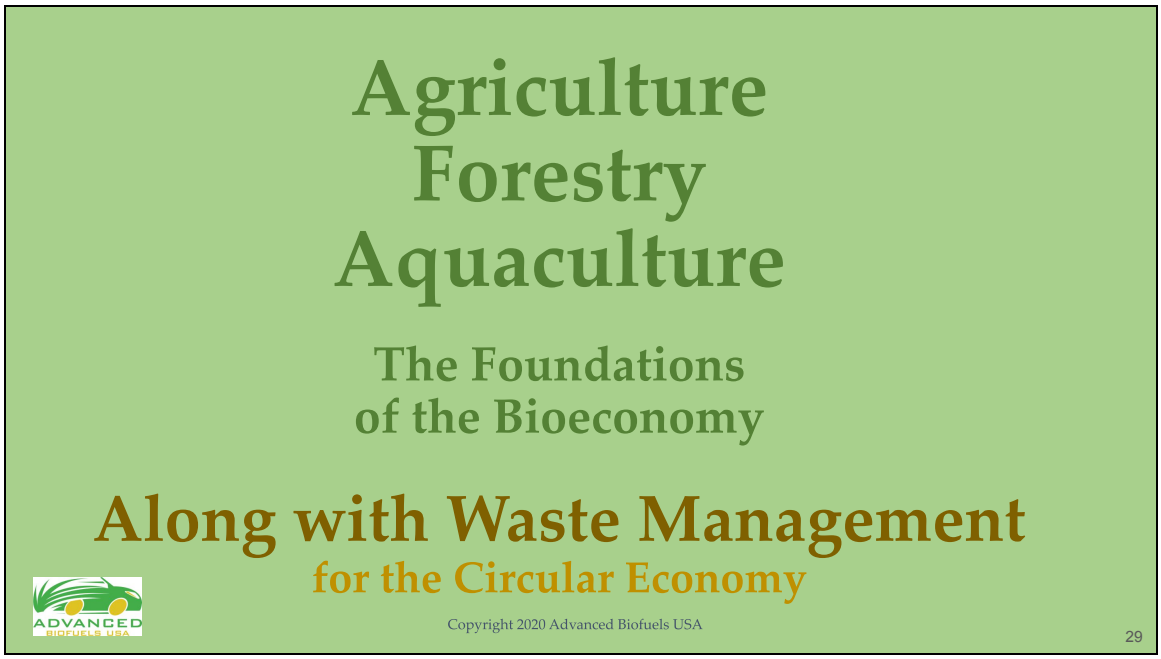
How are they made?
Feedstock
Logistics
Technology

There are three parts to making renewable fuels:

-feedstock—the stuff that goes into the recipe;

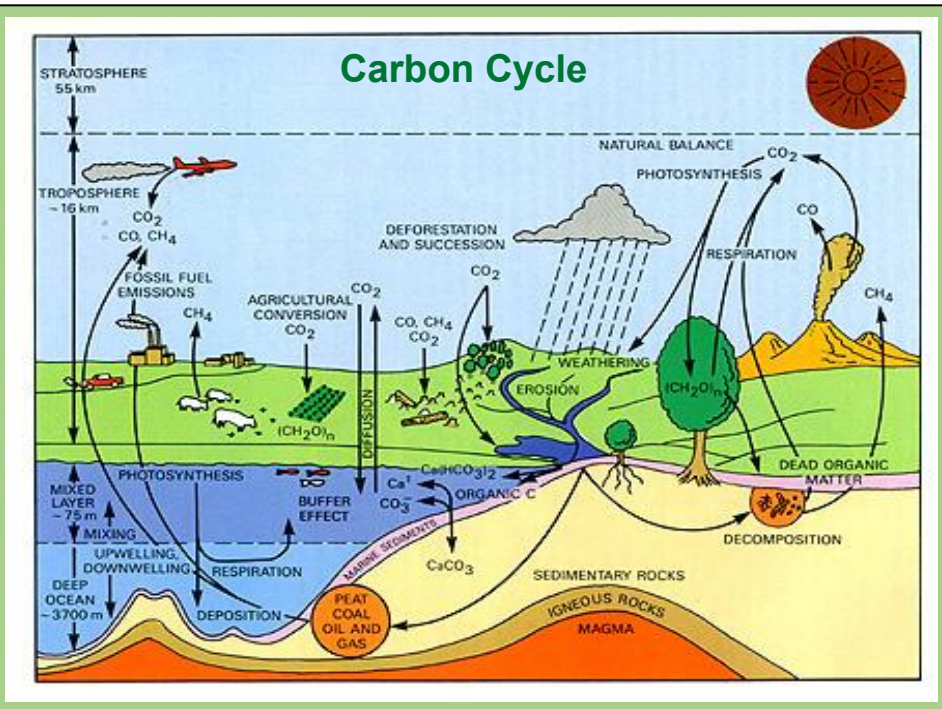
-logistics—how do you get the feedstock from where it grows or is produced to the biorefinery;

-and the technology—how do you convert the feedstock into fuels.



If we stop using fossil carbon; stop using petroleum and natural gas to make fuels, plastics, chemicals, all kinds of products; then we will replace those building blocks with products from agriculture, forestry, aquaculture, and waste management. Those will be the foundations of our bio- and circular economies. That way we will recycle and re-use carbon that is already on land and in the air.

Thus, Agriculture, Forestry, Aquaculture and Waste Management are the foundations of our future.



First, let's look at how we do that with plants. Remember, plants take carbon that is already in the air and use it to grow by a process called photosynthesis. Basically, they recycle carbon and store solar energy. Using fuels made from this recycled carbon reduces the need to take old carbon out of deep storage in the Earth.

Background/References:

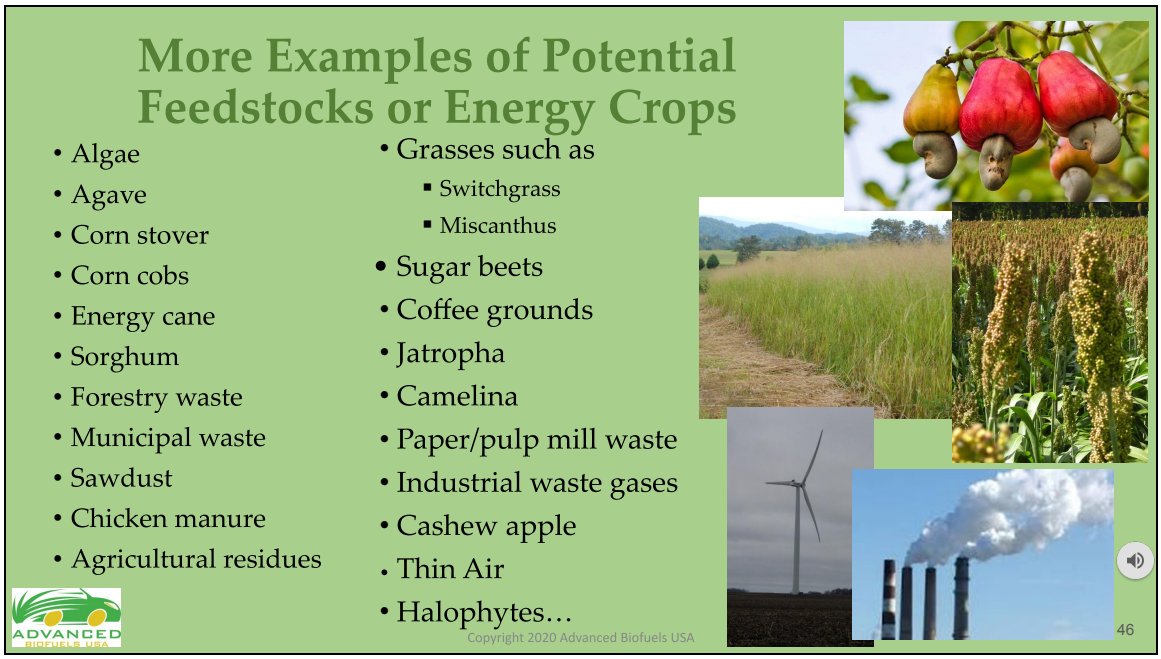
Less pollution

In addition, fuels like ethanol, biodiesel, renewable diesel, SAF and RNG and renewable heating and shipping fuel burn cleaner, don't put as many pollutants into the air.

In this country, mostly for transportation; but in other countries ethanol and biodiesel can replace wood and dung which put lots of soot into the air which also causes climate change.

Biofuels are carbon neutral, don't contribute to an increase in greenhouse gases related to the carbon they take out of the atmosphere when they are growing. Think of it. Plants that you can see are made out of the air that you can't see.

And recycling the carbon already on land in the form of plastics and industrial flue gases also reduces the carbon that needs to be taken out of deep storage.



There are many things that store solar energy via photosynthesis that you might use to make renewable fuels. Here's a quick scroll through pictures of some examples.

Background/References:

Sugars, Starches

Oil seed crops

Grasses

Trees and Forest Waste

Agricultural Residues

Algae

Food/Animal Processing Residues

Energy Crops

Thin Air

University of Maryland Center for Environmental Science
($324,439) **Feng Chen**, associate professor, Institute of Marine & Environmental Technology, works with **Dayton-based HY-TEK Bio LLC** to develop a system for extracting nutrients from chicken manure to speed the growth of microalgae, which HY-TEK Bio uses in its photobioreactor-based systems to mitigate greenhouse gas emissions on an industrial scale, and develop a bacteria-based process that will separate algae from water that will make harvesting algae fast and inexpensive.
- See more at:
http://www.mtech.umd.edu/news/press_releases/mips_r52_release.html#sthash.1Zj3gA4S.dpuf

Different Kinds of Sorghum

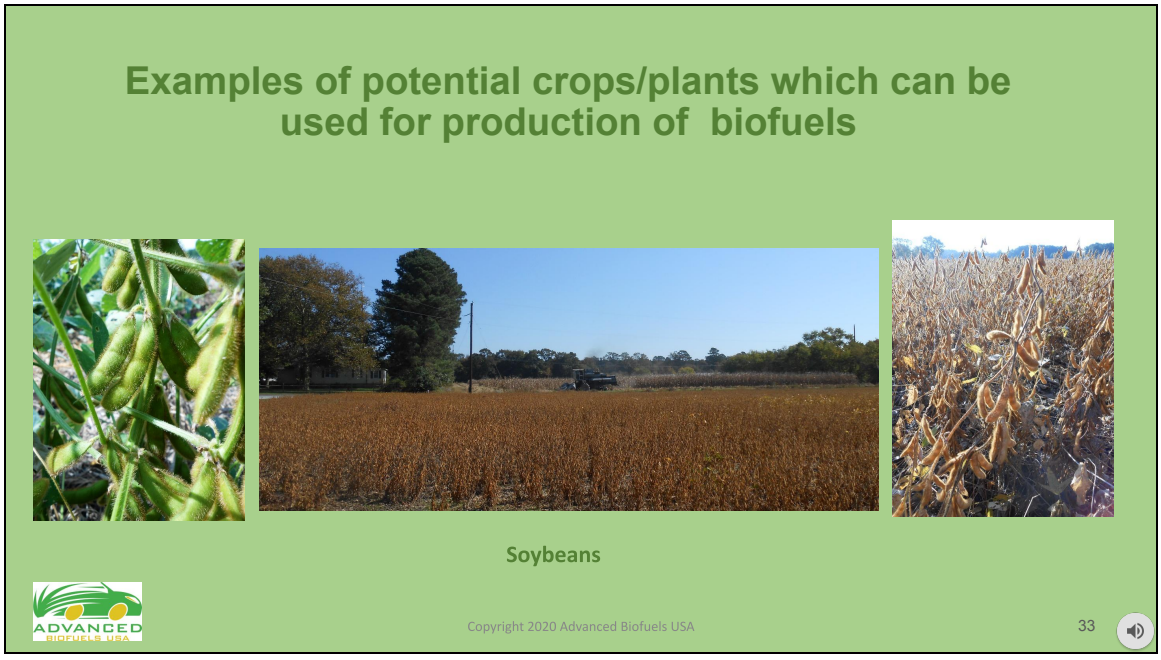
Background/References:

NIck, please get tag links for these

Grain Sorghum/Milo https://advancedbiofuelsusa.info/tag/grain-sorghummilo/

Forage Sorghum

Sweet Sorghum



<u>Soybeans</u> Soybeans are grown mostly to make animal feed. The oil needs to be taken out to make the soybean meal digestible. That oil is used to make fuel.

Background/Resources:

Soybean Meal: Soybean meal is such an important commodity for animal feed and, to a lesser extent, for human food that the oil has been described as a by-product.

https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/soybean-meal

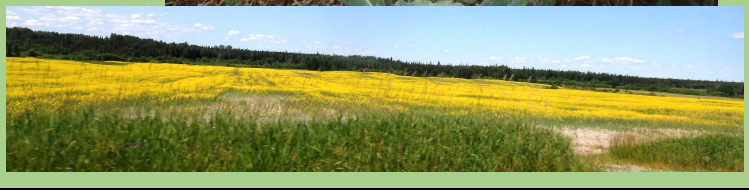
Examples of potential crops/plants which can be used for production of biofuels

Sunflower

Jerusalem Artichoke

Oil seed crops like Sunflowers or Jerusalem Artichokes

Examples of potential crops/plants which can be used for production of biofuels



Canola/Rapeseed
Carinata
Camelina
Pennycress

ADVANCED BIOFUELS USA

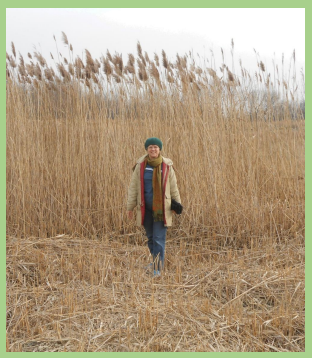
Tiny oil seed crops like Canola, Rapeseed, Carinata, Camelina and pennycress which might be grown as winter crops or cover crops in more southern latitudes.

Background/References:
Canola/rapeseed
http://advancedbiofuelsusa.info/tag/canola/

Pennycress
https://advancedbiofuelsusa.info/tag/pennycress/

Examples of potential crops/plants which can be used for production of biofuels

Grasses



Phragmites

Miscanthus

Arundo or Giant Reed
And many others

36

Grasses like Phragmites, Miscanthus or Arundo, Giant Reed that grow high as houses. Something called lignin is what makes them--and trees-- stand up straight. More about lignin later.

Background/References:

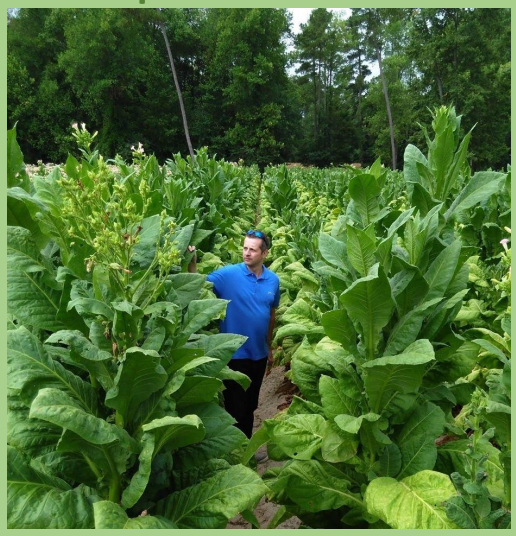
Clarinet reeds are made out of giant reed plants.
In the US this is considered an invasive species. No federal funds are available to research using this as an energy crop in the US.

<u>Switchgrass</u> Not only does switchgrass grow higher than the height of the man, but the root system of the grass grows even longer than that. So, when you talk about sustainability; places that need soil erosion control might be good candidates for growing switchgrass as an energy crop.

Background/Resources:

https://www.bayjournal.com/news/pollution/use-of-switchgrass-growing-in-popularity-for-ag-conservation/article_85e96b90-0efd-11eb-8145-a790aafd9a56.html

Examples of potential crops/plants which can be used for production of biofuels



Energy Tobacco

Tyton Bioenergy Systems

Ready to Harvest, Danville, VA

Energy tobacco is being tested in Virginia as a way to use swine manure for fertilizer in a safe and sustainable way.

Background/References:

Smithfield Foods' Hog Production Division, Murphy-Brown, LLC, and Tyton BioEnergy Systems announced a research partnership to develop new applications for Tyton's dedicated, non-smoking tobacco crop and the resulting soil amendment, filtration, and feed products within Smithfield's hog production processes. The companies are pursuing mutual goals of protecting the environment while improving economic efficiency through this collaboration.

The two companies are establishing field trials with non-smoking tobacco using hog manure as fertilizer. High absorption rates of hog-fertilizer by non-smoking tobacco would enhance environmental outcomes and assist Tyton in obtaining lower-cost fertilizer for its industrial crop. In addition, the companies are pursuing the development of ethanol products using tobacco as raw material rather than corn.

Smithfield and Tyton also will develop applications for Tyton's tobacco-based biochar and activated carbon products, which can be used for a wide-range of filtration, land remediation, and soil amendment purposes. Other research activities with Tyton co-products will occur in parallel.
Gregg Schmidt, president of Smithfield's Hog Production Division, said, "This innovative project is a great opportunity for us and we are excited to be collaborating with Tyton

BioEnergy Systems. We are always seeking novel ways to manage hog manure that demonstrate continual improvement, and we are also excited about the opportunity to pursue the development of ethanol options that utilize tobacco as their primary raw material source."

Tyton BioEnergy Systems president Peter Majeranowski remarked, "Through our partnership in Virginia and North Carolina, Tyton and Smithfield can develop new applications for non-smoking tobacco to deliver value to farmers, value to the agriculture industry, and protect the environment. We see it as a responsibility to secure America's food, energy and environmental futures, and we are so pleased to be working with Smithfield who joins us in advancing towards these goals."

http://globenewswire.com/news-release/2015/06/22/746180/10139256/en/Smithfield-Foods-Hog-Production-Division-and-Tyton-BioEnergy-Systems-Announce-Research-Partnership.html

Examples of potential crops/plants which can be used for production of biofuels

Kenaf

Agave

Agave, used to make tequilla, might also provide domestically-produced fuel in some parts of the world.

Kenaf is also being looked at.

Background/Resources:

Agave https://advancedbiofuelsusa.info/tag/agave/
Kenaf: https://advancedbiofuelsusa.info/tag/kenaf/

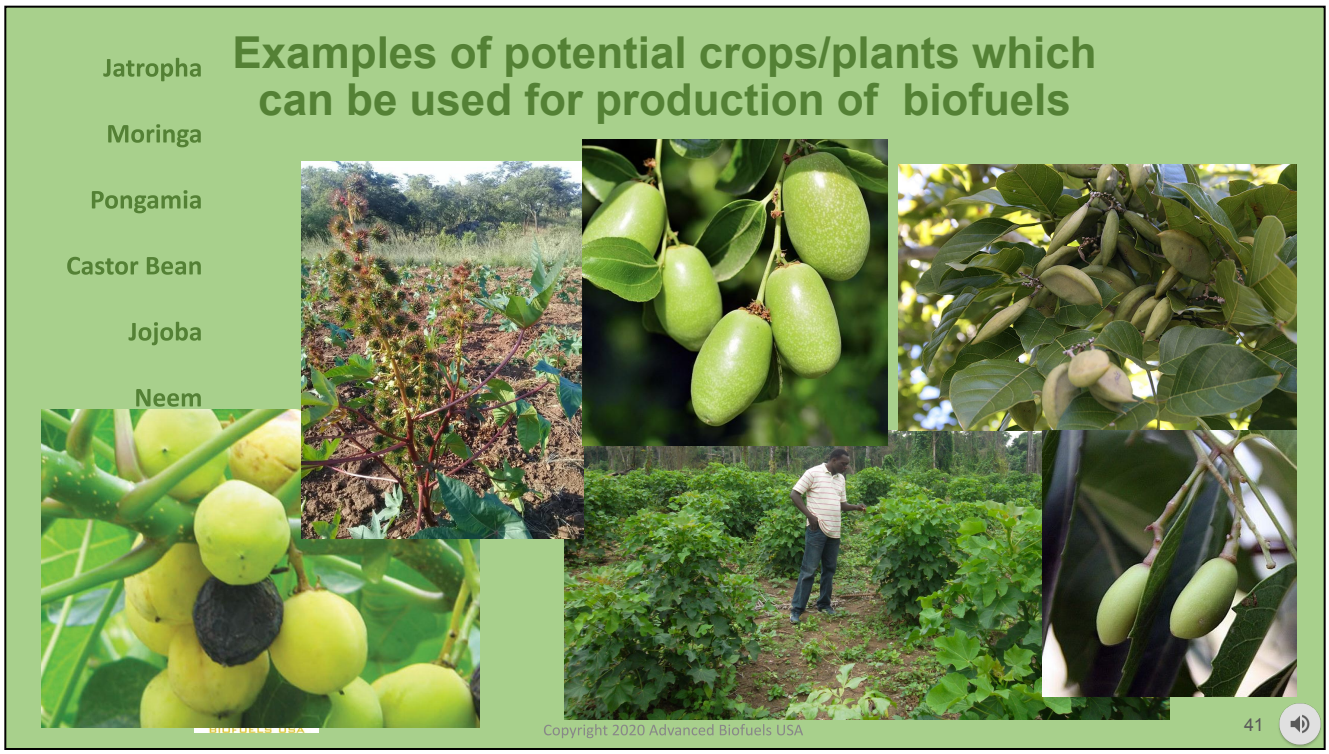
Examples of potential crops/plants which can be used for production of biofuels

Cassava

<u>Cassava</u> In tropical areas, cassava is the choice for ethanol production along with sugarcane.

Background/Resources:

Cassava: https://advancedbiofuelsusa.info/tag/cassava/



Jatropha, Moringa, Pongamia, Castor Bean, Jojoba Neem These productive legume and oil seed trees can be grown on marginal land with minimal fertilizer inputs in places like Florida, Hawaii, India and Nigeria.

Background/References:

photo of neem seed: By Hayavadhan - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=19413946

Sustainable biodiesel from neem tree trans-esterification https://techxplore.com/news/2020-12-sustainable-biodiesel-neem-tree-trans-esterification.html

Pongamia Trees & Sustainable Agriculture

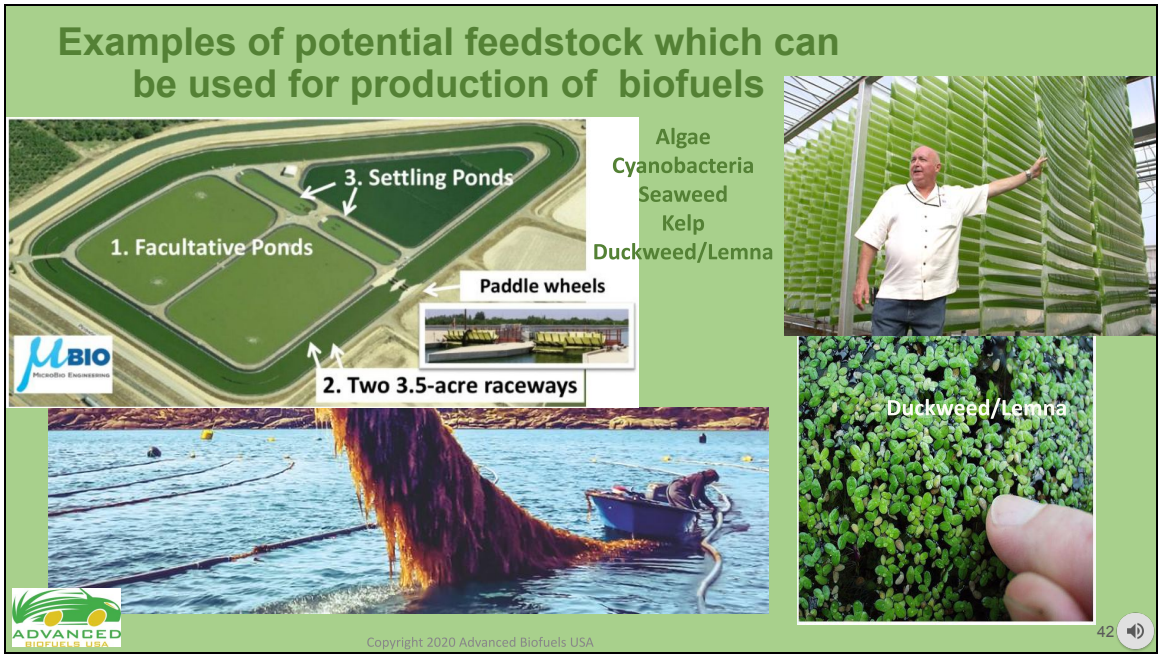
Jatropha https://advancedbiofuelsusa.info/tag/jatropha/

Moringa https://advancedbiofuelsusa.info/tag/moringa-tree/

Pongamia https://advancedbiofuelsusa.info/tag/pongamia/

Castor Bean https://advancedbiofuelsusa.info/tag/castor-bean/

Jojoba https://advancedbiofuelsusa.info/tag/jojoba/



Some feedstocks can be grown in water, like algae, duckweed and seaweed like kelp. The top image shows algae being grown to treat wastewater in California, a process also being researched in Spain and News Zealand. This is another example of how growing biofuel feedstock can solve other problems, too.

Background/References:

https://eandt.theiet.org/content/articles/2020/10/is-seaweed-the-future-of-fuel/
Image credits: AtSeaNova

Algae, Cyanobacteria, Seaweed, Kelp, Duckweed or Lemna
There are lots of different ways to grow algae.
https://advancedbiofuelsusa.info/tag/duckweed/
https://advancedbiofuelsusa.info/the-thing-to-remember-is-that-its-agriculture-a-new-way-to-think-about-algal-biofuel/

Algae for nutrient management/wastewater treatement MBio
https://www.biofuelsdigest.com/bdigest/2020/12/22/microalgae-for-recycling-water-and-nutrients-the-digests-2020-multi-slide-guide-to-microbio-engineering/16/

Examples of potential crops/plants which can be used for production of biofuels—wastes/residues

AGRICULTURAL RESIDUES

Corn Stover, Corn Cobs

After corn kernels are harvested, what's left is stalks, leaves and cobs that could also be used to make biofuels. Most US ethanol is made from corn starch sugars; many biorefineries are also using the fibers from the kernel and sending the leftover corn oil to biodiesel refineries. The high protein remains are a valuable animal feed.

Background/References:

Corn Stover and Corn Cobs

Examples of potential crops/plants which can be used for production of biofuels—wastes/residues

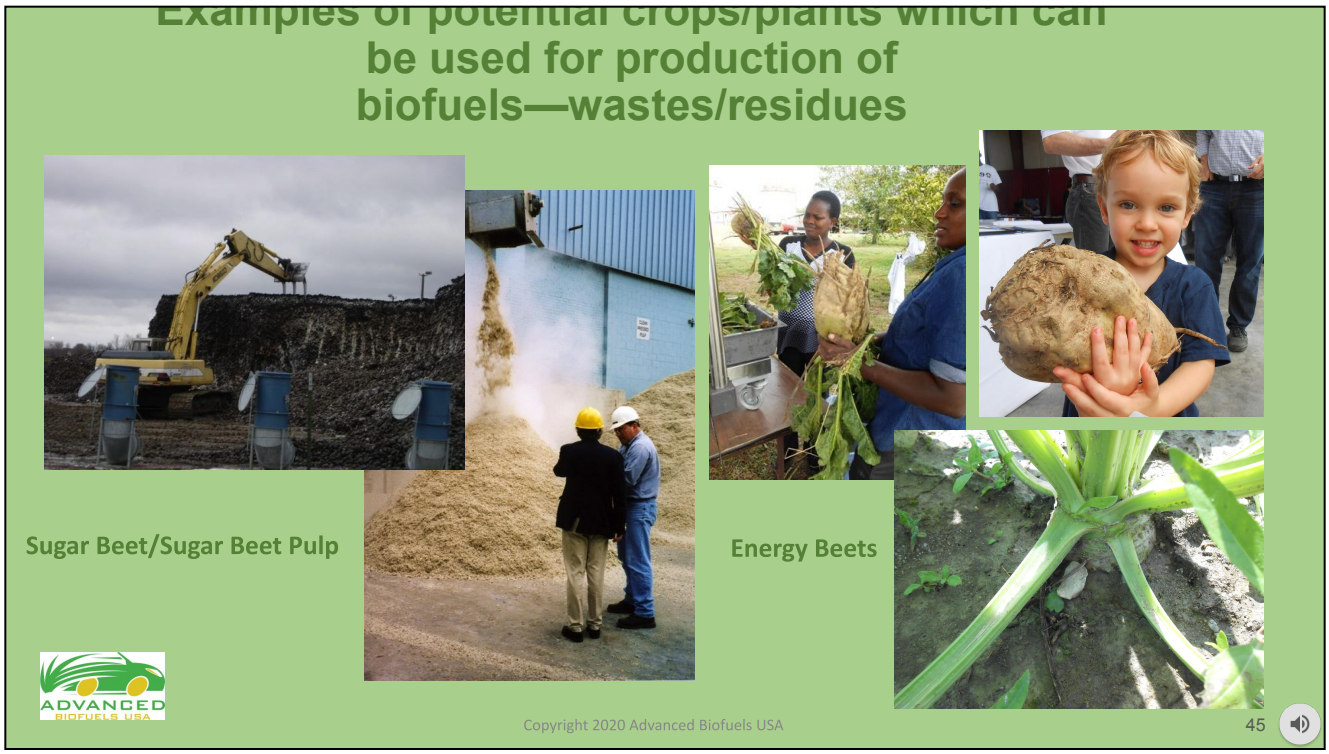
Sugarcane

Sugarcane Bagasse

Similarly, the sugars in Sugarcane are used to make ethanol, especially in Brazil and other countries with tropical climates. The residue left after making table sugar, bagasse, can be burned for electricity or, in the future, used to make advanced biofuel.

Background/Resources:

Sugarcane https://advancedbiofuelsusa.info/tag/sugar-cane/

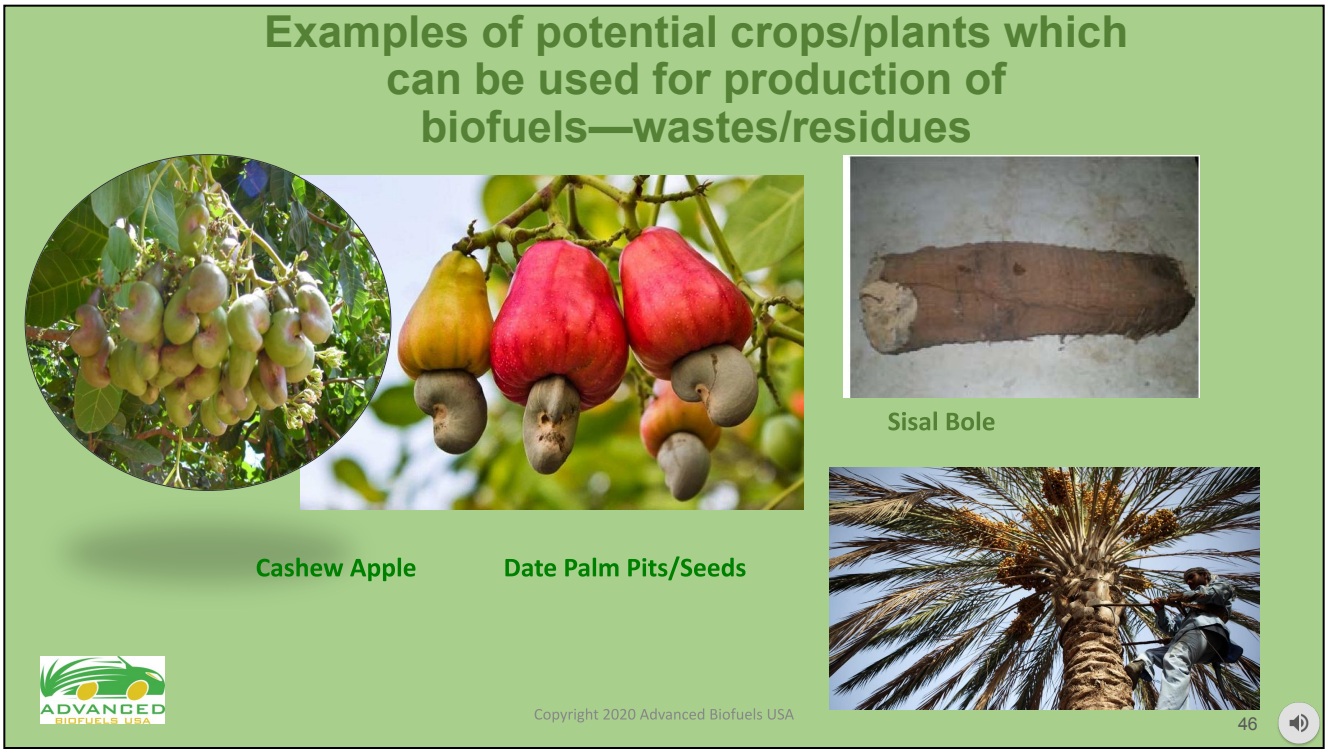


Along those lines, in Europe, sugar beets are used to make ethanol and in the US, research on leftover sugar beet pulp and energy beets indicate they can be used to make fuel.

Background/References:
During sugar beet harvest, people in the area know to drive far behind the trucks full of sugar beets as some bounce out of the truck and hit and break windshields.

Sugar Beets, Sugar Beet Pulp and Energy Beets

http://advancedbiofuelsusa.info/tag/sugar-beet/



Did you know that for every cashew, there is a cashew apple residue? In tropical areas, Cashew Apple, Sisal Bole, Date Palm Pits/Seeds are being looked at as potential biofuel feedstock.

Background/References:
UAE researchers produce biofuel from date seeds
https://www.thenationalnews.com/uae/environment/uae-researchers-produce-biofuel-from-date-seeds-1.1135668 and
https://www.thenationalnews.com/uae/science/uae-university-scientists-test-potential-of-date-palms-as-source-of-biodiesel-1.676723

Cashew Apple

Sisal Bole

Date Palm Pits/Seeds

With medical and recreational marijuana and CBD oil made from hemp using only the buds of the plants, the need to find some use for the residue leaves and stems has lead some to research their use for biofuels.

Background/References:

Hemp and Cannabis Residues

These agricultural and food processing residues might also make good biofuel. India is a hub for some of this research.

Background/References:

Nut Shells, Cotton Seed and Hulls, Rice Hulls, Husks, Rice or Wheat Straw; https://advancedbiofuelsusa.info/tag/almond-hulls-shells/

Examples of potential crops/plants which can be used for production of biofuels—wastes/residues

Woody Biomass

Forest Waste and Residues

Much is being done with Woody Biomass, and Forest Waste and Residues especially in the Northwest US and upper New York state and in Finland and other Nordic countries with large forest-based industries.

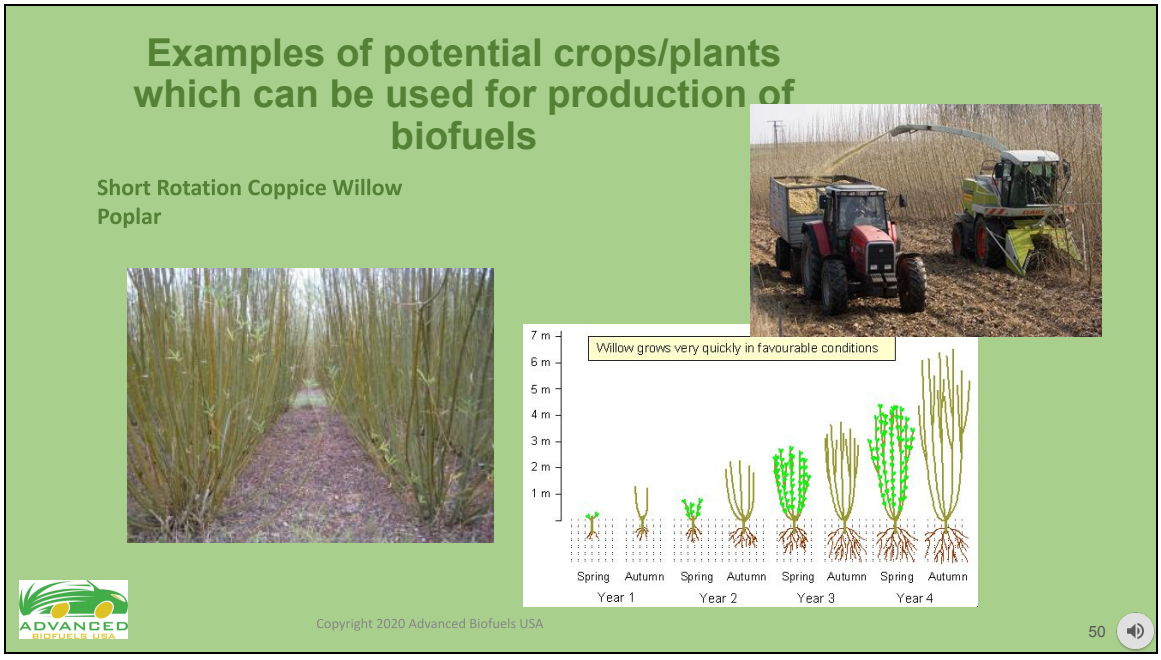
Background/References:

Sawdust https://advancedbiofuelsusa.info/tag/sawdust/
Wood chips might be left-overs or residues of other forest products processes. For example from sawmills. Or from slash and waste at forest harvest sites—materials that would otherwise be burned in the open. But then you have a logistics issue—getting the waste wood from the forest to the biorefinery for an economical price.

You might also have purpose-grown wood, just as you have for some pulp/paper mills; especially when those have gone out of business.

Woody Biomass

Forest Waste and Residues



You can also get woody biomass from willow and poplar that are coppiced, cut to the ground so that many shoots grow back, increasing the yield per acre over the years.

Background/References:

Willow

Poplar

Coppice https://advancedbiofuelsusa.info/tag/coppice/

The more often you cut them near ground level to harvest, the more shoots grow.
http://www.crops4energy.co.uk/short-rotation-coppice-src/

Examples of potential feedstock which can be used for production of renewable fuels—wastes/residues

The organic portions of Sorted Municipal Solid Waste or Food Waste

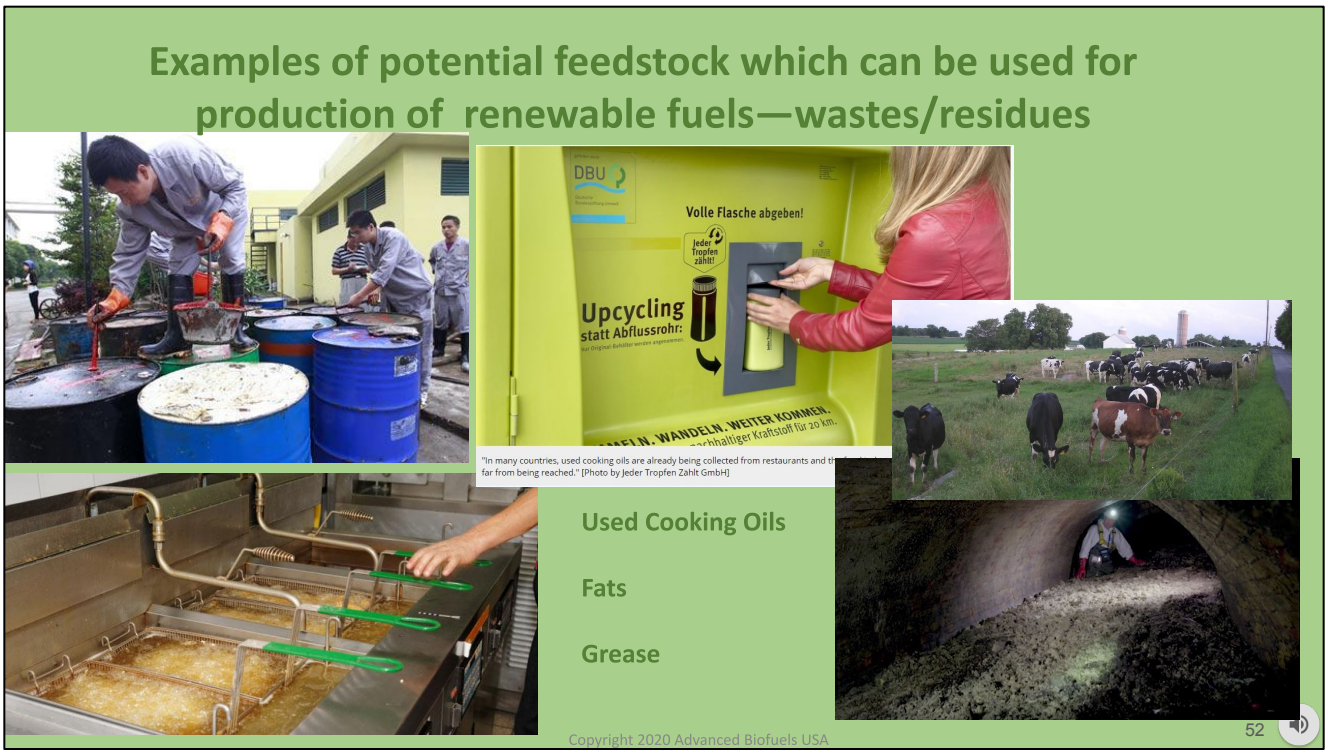
Brewers and Distillers Waste

The organic portions of Municipal Solid Waste, Food Waste and Distillers and Brewers Waste are being used to make biofuels.

Background/References:

https://advancedbiofuelsusa.info/no-carbon-left-behind-the-digests-2019-multi-slide-guide-to-lanzatech-2/

https://advancedbiofuelsusa.info/tag/breweries/



And all over the world, biofuels like biodiesel, renewable diesel and jetfuel are being made from used cooking oil, grease and tallow or animal fat from food processing. The additional benefit from this is to prevent people from dumping grease into sewer systems causing backups known in England as "fatbergs". It also keeps unhealthy, contaminated used cooking oil from being re-used, a serious problem in some countries.

Background/References:

Used Cooking Oil and Grease
http://advancedbiofuelsusa.info/tag/used-cooking-oil/

Increased household collection of used cooking oil means better climate protection
Jeder Tropfen Zahlt (Every Drop Counts)
https://www.euractiv.com/section/energy-environment/opinion/increased-household-collection-of-used-cooking-oil-means-better-climate-protection/

If you or students are interested something really disgusting, check out the stories about fatbergs: https://advancedbiofuelsusa.info/?s=fatberg

fatberg
https://nerdist.com/wp-content/uploads/2017/09/Monster-Fatberg-Feature-Image-09132017.jpg

Examples of potential feedstock which can be used for production of renewable fuels—wastes/residues

Leather Tannery Waste, "Fleshings"

Tannery waste called Fleshings" can a source of biofuel. This sludge would otherwise turn toxic and be burned.

Background/References:

Tamil Nadu to Have World's First Biorefinery Using Tannery Waste
Submitted by admin on June 26, 2012 – 7:00 pm No Comment by Kumar Chellappan (Daily News and Analysis India) Tamil Nadu will be home to the world's first biorefinery which will use solid waste generated from tanneries in Vellore district.

The Central Leather Research Institute (CLRI) at Chennai, a unit of the Council for Scientific and Industrial Research (CSIR) has succeeded in developing a biorefinery which will produce biodiesel, bioethanol, biohydrogen and biomethane.

"With this bio refinery we will ensure that tanneries across the country do not discharge any kind of solid waste. There will not be any waste to be discharged because we will use it as raw materials," Palani Shanmugam (42), the CLRI scientist who designed the refinery told *DNA*. READ MORE

Giving off harmful gases into the atmosphere. Turning the sludge into a renewable fuel is a safer and healthier alternative.

naindia.com/india/report_tamil-nadu-to-have-worlds-first-biorefinery_1706301
(leftover subcutaneous ligament and fat) from leather production

<u>Landfill Gas</u> and <u>Biogas</u> from food and animal waste can be used to make electricity or as transportation fuel.

Background/References:

<u>https://civileats.com/2020/04/24/are-dairy-digesters-the-renewable-energy-answer-or-a-false-solution-to-climate-change/</u>

<u>http://www.greentechlead.com/news/clean-energy-opens-lng-fueling-station-in-seville-ohio-to-support-truck-fleet-operated-by-dillon-transport-serving-owens-corning-826</u>

The opening
of this new Clean Energy LNG truck fueling station, the first in the industrial heartland of America, is a major step toward realizing our program to create a national LNG fueling infrastructure that will extend along major truck routes nationwide.

<u>http://www.quasarenergygroup.com/pages/cng.html</u>

<u>https://www.biocycle.net/innovation-in-food-scraps-collection/</u>

Not all renewable fuels are made from plants. Some can be made from other carbon sources such as industrial waste gas, hard-to-recycle plastics, old tires.

Background/References:

Flue Gas, Industrial Waste Gas

Recycling Carbon: https://advancedbiofuelsusa.info/tag/carbon-recycling/

University of Maryland Center for Environmental Science

($324,439) **Feng Chen**, associate professor, Institute of Marine & Environmental Technology, works with **Dayton-based HY-TEK Bio LLC** to develop a system for extracting nutrients from chicken manure to speed the growth of microalgae, which HY-TEK Bio uses in its photobioreactor-based systems to mitigate greenhouse gas emissions on an industrial scale, and develop a bacteria-based process that will separate algae from water that will make harvesting algae fast and inexpensive.

-See more at:
http://www.mtech.umd.edu/news/press_releases/mips_r52_release.html#sthash.1Zj3gA4S.dpuf

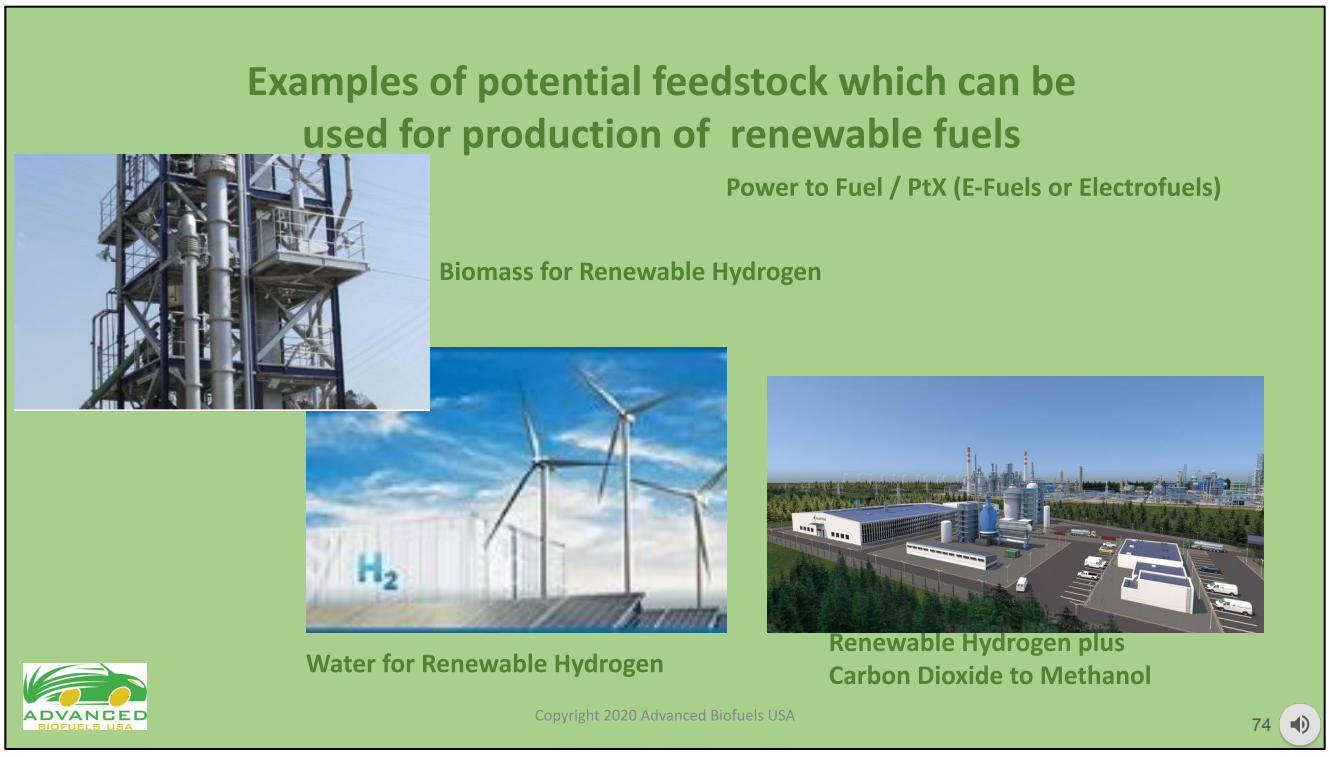
-http://advancedbiofuelsusa.info/category/feedstocks/

Get link for LanzaTech, for recycling tires into fuel
Municipal solid waste:

plastic in Finland
https://www.neste.com/releases-and-news/plastics/neste-successfully-completed-its-first-industrial-scale-processing-run-liquefied-waste-plastic

Agilyx and Braskem Announce Collaboration to Explore Advanced Recycling Project in North America
https://www.braskem.com.br/usa/news-detail/agilyx-and-braskem-announce-collaboration-to-explore-advanced-recycling-project-in-north-america

Development Renewable Fuels paper as support to the UPEI 2050 vision
http://www.studiogearup.com/wp-content/uploads/2019/10/19_0927_sGU_UPEI_Renewable-Fuels-Paper_FFV.pdf



Other examples of renewable fuels not made from plants: Renewable hydrogen from electrolysis of water could replace the fossil hydrogen in the recipe for renewable diesel and jetfuel, or could be mixed with carbon dioxide to make methanol. Both of these can be used as fuel on their own or as building blocks to make other fuels and products.

Background/References:

"Power to X" stands for "power to liquid" or "power to gas." First thought of as a way to store excess solar and wind power so it wasn't lost, the electricity was used to split water into hydrogen and oxygen, with hydrogen available for later use in fuel cells for transportation as we talked about before or for electricity production. Now, the idea has expanded.

Water and Carbon Dioxide with Renewable Energy

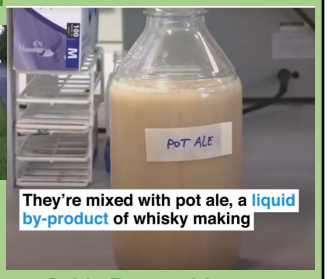
Advanced fuels, produced with hydrogen that is obtained from the electrolysis of water. The term electrofuels is referring to the process rather than the fuels itself. These are similar or identically to the ones produced with different processes. The terms for the conversion processes of electricity and variable renewable energies (e.g. solar or wind power), to produce electrofuels, are: Power-to-X (PtX), Power-to-Gas (PtG) and Power-to-Liquid (PtL).

https://advancedbiofuelsusa.info/tag/hydrogen-renewable-hydrogen/
https://advancedbiofuelsusa.info/category/feedstocks/water/

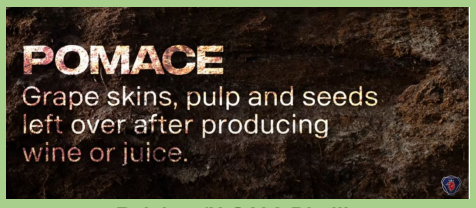
process to produce hydrogen as part of a waste management system. The company explains, “It is a self-sustainable thermal conversion treatment of organic waste, including plastics, which breaks down the waste matter and extracts the hydrogen they contain. Since it is not incineration, our process does not create or emit hazardous chemical and, unlike conventional gasification solutions, it produces no tar. This process was engineered, refined and enhanced over more than 15 years in Japan by Japan Blue Energy Co., Ltd.” https://ways2h.com/solutions/
https://advancedbiofuelsusa.info/?s=Ways2H

Not Just Renewable Fuels -- Co-Products!

- Amimal Feed
- Agricultural and Forest Residues
- Agricultural Co-Products
- Food Processing Co-Products
- Animal Manure/Waste (dairy cows, swine, poultry)
- Brewery/Vineyard/Whisky
- Biochar, Fertilizer
- Carbon dioxide for dry ice, beverages and medical uses



Celtic Renewables



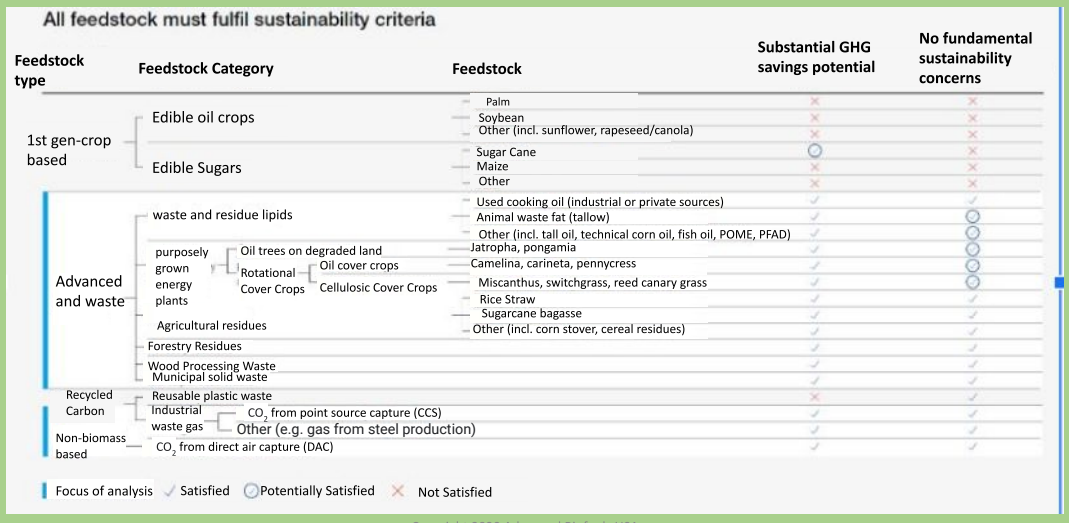
Raisinor/U.C.V.A Distillery

You might have noticed that the renewable feedstocks we have talked about are not just grown for fuel alone. Many are grown for other purposes and the leftovers or co-products are used to make fuel. Also, fuels made from plant-based materials have co-products such as dry ice, animal feed, fertilizer or other healthy soil amendments.

Background/References:

Corn oil https://advancedbiofuelsusa.info/tag/corn-oil/
Soybean meal https://advancedbiofuelsusa.info/tag/soy-meal/
Animal fat https://advancedbiofuelsusa.info/tag/animal-fat/
Potato https://advancedbiofuelsusa.info/tag/potato/
Whisky waste https://www.irishexaminer.com/news/munster/arid-40072076.html
Wine making pomace How wine waste powers Scania ethanol buses in France
https://www.youtube.com/watch?v=6SpL-Te0NDQ&ab_channel=ScaniaGroup
https://www.webwire.com/ViewPressRel.asp?aId=242557

Feedstock Sustainability Criteria



When thinking of sustainability and feedstock, you can think of the life cycle greenhouse gas reduction compared to fossil fuels. You can also think of the co-products and the additional benefits they provide such as avoiding burning agricultural waste in fields, preventing fatbergs or helping prevent erosion.

Background/References:

Clean Skies for Tomorrow: Sustainable Aviation Fuels as a Pathway to Net-Zero Aviation (World Economic Forum)
https://www.biofuelsdigest.com/bdigest/2020/12/13/wefs-clean-skies-for-tomorrow-outlines-pathway-to-net-zero-aviation-the-digests-2020-multi-slide-guide-to-sustainable-aviation-fuel/11/

A Few Types of Jobs Available in Renewable Fuels Feedstock Development and Production

- Agronomists
- Farmers
- Farm workers
- Farm equipment designers
- Biologists
- Biologists specializing in genetic research
- Biologists specializing in plant cells
- Chemists
- Agricultural Inspectors
- Computer Software Engineers
- Commodity Traders
- Chemical engineers
- Researchers into bioenergy crop development
- Agriculture/horticulture experts
- Freight railroad operators, engineers, loaders, unloaders
- Equipment operators, technicians
- Farm product sales/traders
- Agricultural and Forestry Supervisors
- Agriculture Economists

And a list of the kinds of jobs involved with the feedstock part of renewable fuels.

What Are Renewable Fuels?

How are they made?

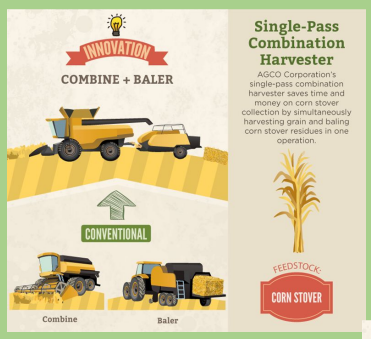
Feedstock

Logistics

Technology

Now let's take a quick look at logistics—how do you get the feedstock from where it grows or is produced to the biorefinery.

Logistics: Harvest, Storage, Transport



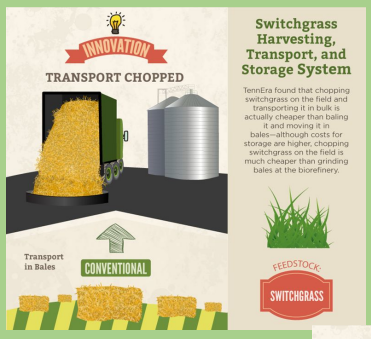
ADVANCED BIOFUELS USA

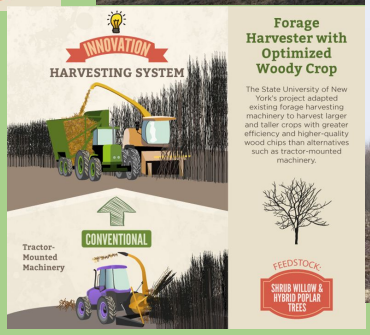
As more research has been done, practical problems became apparent. For example, unwanted rocks and dirt got harvested along with agricultural residues that used to be left on the field or burned on the field. Engineers and farmers got together to figure out better ways to harvest this new product.

Background/References:

http://www.energy.gov/eere/articles/five-harvesting-technologies-are-making-biofuels-more-competitive-marketplace

Logistics: Harvest, Storage, Transport





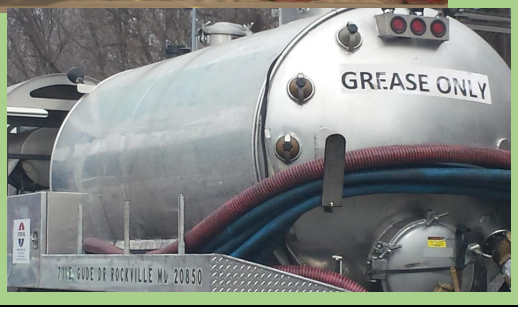
ADVANCED BIOFUELS USA

Similarly, the new product needed to be stored without spoiling or bursting into flames. And it had to be chopped to the proper size.

Background/References:
http://www.energy.gov/eere/articles/five-harvesting-technologies-are-making-biofuels-more-competitive-marketplace

Harvesting: https://advancedbiofuelsusa.info/tag/harvesting/

Logistics: Harvest, Storage, Transport



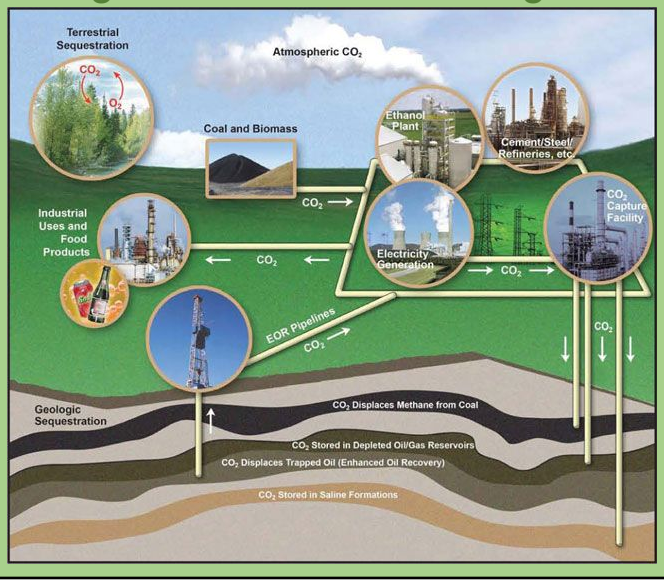
63

The feedstock and the finished renewable fuel have to be transported to their destinations by appropriate rail, truck and pipelines. Some adjustments were needed in these areas, too.

Background/Resources:

Terminals, transport:
https://advancedbiofuelsusa.info/category/invrastructure/infrastructure-terminals-transport/

Logistics: Harvest, Storage, Transport



Storage of co-product, carbon dioxide (CO2), for carbon sequestration

Graphic from Rocky Mountain Coal Mining Institute

http://www.rmcmi.org/education/carbon-capture-storage#.X-zZi9hKhPY

64

At ethanol refineries, logistics may also include sequestering the co-product, carbon dioxide (CO2), to obtain carbon capture and storage credits.

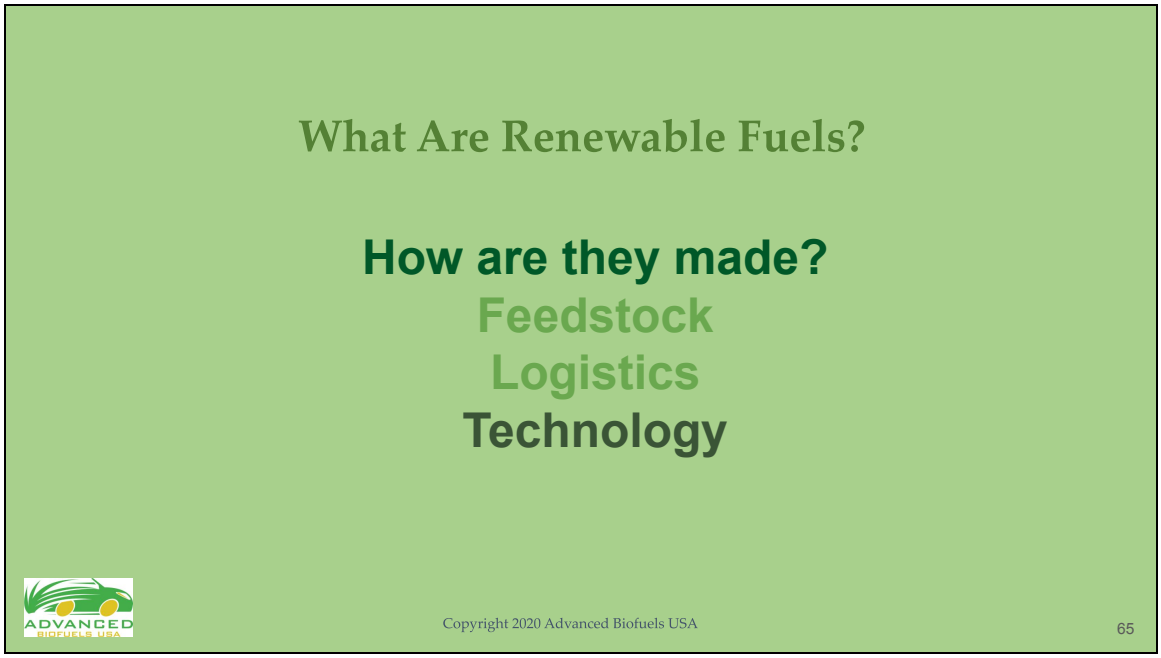
Background/References:

Graphic from Rocky Mountain Coal Mining Institute: Carbon Capture And Storage

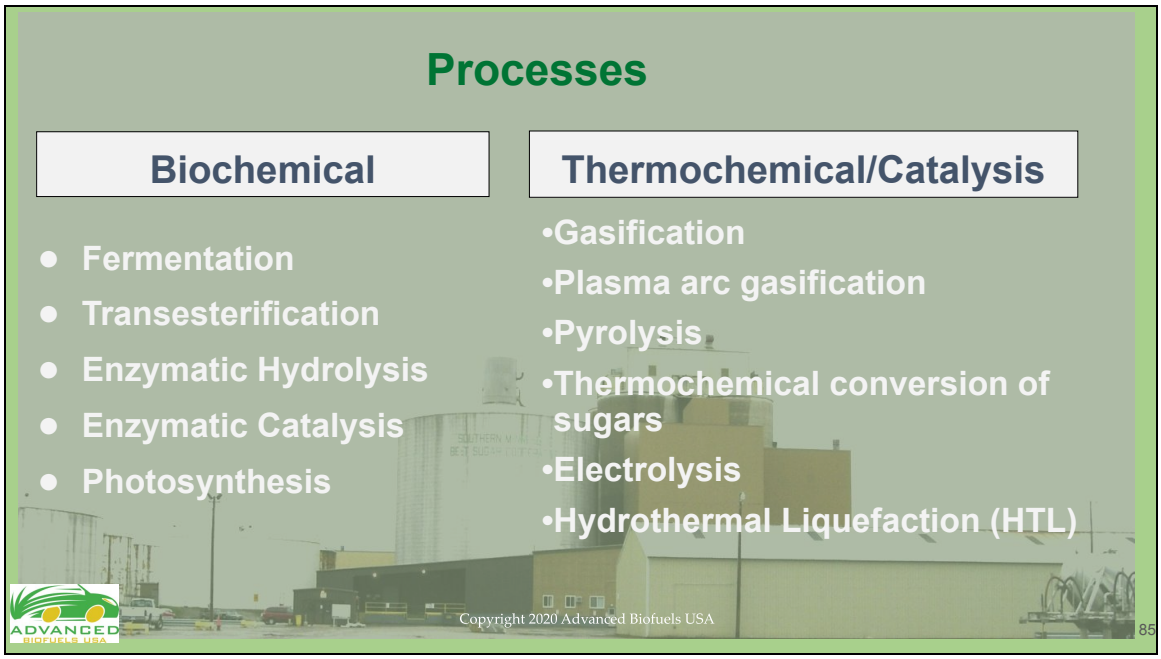
http://www.rmcmi.org/education/carbon-capture-storage#.X-zZi9hKhPY

45Q - The Drive to Qualify

EThanol Producer Magazine: The road to qualifying for the 45Q tax credit can be confusing, with strict limitations on project phases and what constitutes start of construction. But, navigated properly, the credit is a promising opportunity.
http://www.ethanolproducer.com/articles/17813/45q-the-drive-to-qualify



A much more difficult challenge, converting the feedstock into fuels, required new technologies--or old technologies used in new ways.



These are names of some of the processes that take the feedstock and make it into renewable fuels or the building blocks for fuels and co-products.

I usually think of these as fitting into two general categories--seductive and bullying

The seductive technologies take place at pretty much ordinary temperatures and pressures and encourage feedstock to convert faster than they might otherwise do--and in a particular desired direction. For example, making things "rot" or break down under controlled conditions by fermentation or enzyme use. Or making them grow with photosynthesis.

On the other side, high temperatures and pressures are used to force feedstock to convert.

Both of these approaches are needed, depending on the feedstock. For example, HTL is useful to convert wet biomass such as food waste and sewage sludge. Gasification and pyrolysis are good for feedstock high in lignin which is hard to convert by enzymes or yeast. Think of woody biomass, agricultural wastes like straw or nut shells or municipal solid waste.

Background/References:
Fermentation https://advancedbiofuelsusa.info/tag/fermentation/
Transesterification https://advancedbiofuelsusa.info/tag/transesterification/
https://advancedbiofuelsusa.info/advanced-biofuels-usa-publishes-updated-whats-the-difference-between-biodiesel-and-renewable-green-diesel/

Hydrolysis https://advancedbiofuelsusa.info/tag/enzymatic-hydrolysis/
Enzymatic Catalysis https://advancedbiofuelsusa.info/tag/enzymatic-conversion/
Photosynthesis https://advancedbiofuelsusa.info/tag/photosynthesis/

Gasification https://advancedbiofuelsusa.info/tag/gasification/
Plasma arc gasification (no link)
https://advancedbiofuelsusa.info/?s=plasma+arc+gasification
Pyrolysis https://advancedbiofuelsusa.info/tag/pyrolysis/
Thermochemical conversion of sugars
https://advancedbiofuelsusa.info/tag/thermochemical-conversion/
Electrolysis https://advancedbiofuelsusa.info/tag/electrolysis/ Electrolysis is the passing of a direct electric current through an electrolyte producing chemical reactions at the electrodes and decomposition of the materials

hydrothermal liquefaction:
https://advancedbiofuelsusa.info/tag/hydrothermal-liquefaction/

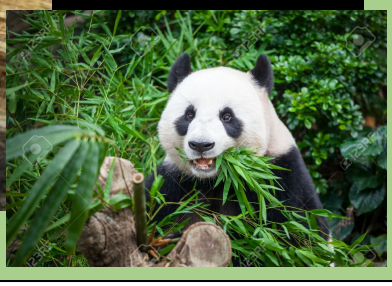
Explain enzymes—like the saliva in your mouth.

Making Plant Biomass Available for Biofuel Production Overcoming Biomass Recalcitrance

Discover enzymes that will "deconstruct" cell wall matrices

Examples: Leaf Cutter Ants, Termites, Horse or Panda Feces.

Difficulty: Lignin



There's a reason we talk about agricultural and forest waste and residues--because they were the stuff that's not easy to make useful except for burning or bedding. Often that part of a plant has a lot of lignin--the stuff that makes trees and grasses stand tall. It is very hard to break down. This is known as "biomass recalcitrance." Think of a two year old who resists going to bed at bedtime.

So, we look for clues in nature. What animals eat wood? Maybe those enzymes can be made to work for humans, too.

Background/References:

When we start with a plant-based feedstock, some parts convert easily. We have been doing that for thousands of years making wine and beer using fermentation and extracting oils for lubrication and cooking.

https://www.glbrc.org/news/gina-lewin-explores-how-ants-break-down-cellulose?utm_source=Spring+Education+%26+Outreach+Newsletter+2015&utm_campaign=Feb-2015-GLBRC-E-O-Newsletter&utm_medium=email leaf cutter ants at Great Lakes Bioenergy Research Center

http://www.sciencedaily.com/releases/2013/04/130411194641.htm

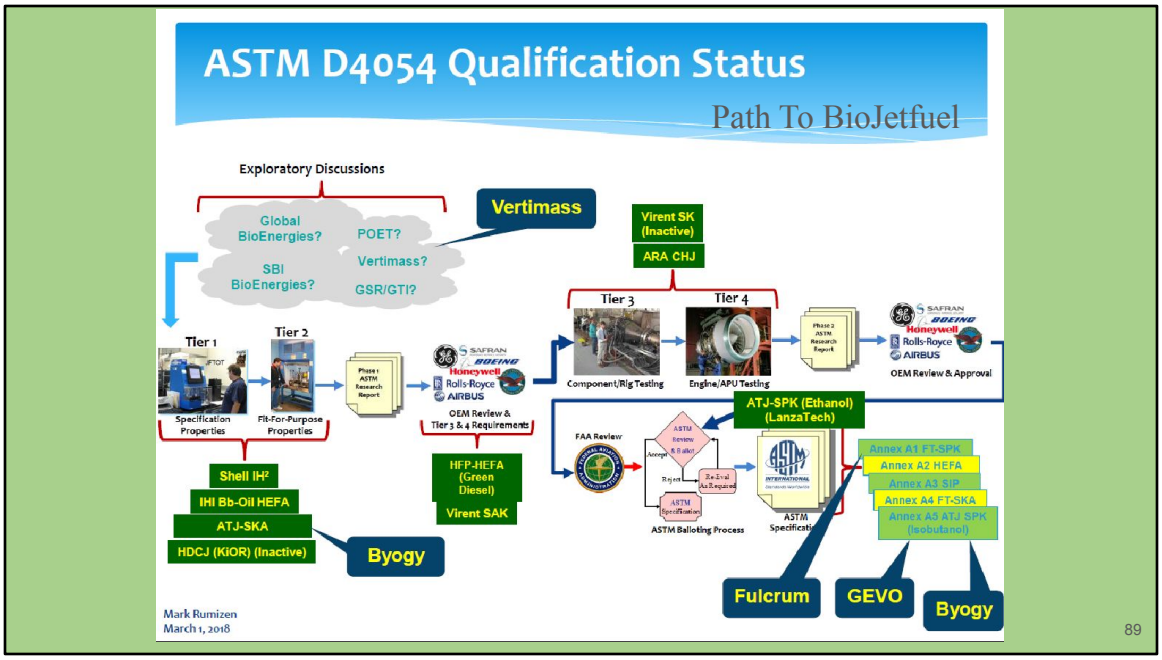
Scientists have described the discovery of a potential treasure-trove of candidate enzymes in fungi thriving in the feces and intestinal tracts of horses.
They reported on these enzymes -- the key to economical production of biofuels from non-food plant material -- at the 245th National Meeting & Exposition of the American

Chemical Society (ACS) currently going on in New Orleans.
Michelle A. O'Malley, Ph.D., explained that cellulose is the raw material for making biofuels from non-food plant materials. Cellulose, however, is sealed away inside a tough network of lignin within the cell walls of plants. To produce biofuels from these materials, lignin must be removed through an expensive pretreatment process. Then, a collection of enzymes breaks cellulose down into sugars. Finally, in a process much like production of beer or wine, those sugars become food for microbes to ferment into alcohol for fuel, ingredients for plastics and other materials.

So, what are we trying to do with that feedstock? Often, the first step is to convert feedstock into the building blocks of renewable fuels, such as sugars and oils that then go through other processes to make the finished product.

It's relatively easy to unlock the solar power stored in plants to make first generation biofuels like ethanol out of sugars in corn or sugarcane and biodiesel out of soybean oil or used cooking oil.

Panda poo



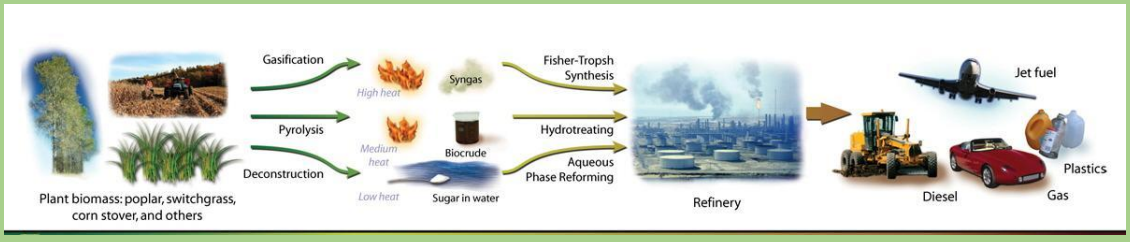
After the feedstock is converted to building blocks, other processes are used to make the fuels. Here are some examples of conversion processes or pathways used to make renewable jetfuel.

This shows the steps that renewable aviation fuels have to go through to get approved by the international standards organization, ASTM, to assure that they can work as good as or better than petroleum jetfuel in aircraft engines. You can see the names of some of the fuels, the companies working on them and where they were on the path to approval in 2018.

Background/Resources:

ASTM https://advancedbiofuelsusa.info/tag/astm/
ASTM D4054 https://advancedbiofuelsusa.info/tag/astm-d4054/
ASTM D7566 (Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons)
https://advancedbiofuelsusa.info/tag/astm-d7566-standard-specification-for-aviation-turbine-fuel-containing-synthesized-hydrocarbons/
ASTM standards https://advancedbiofuelsusa.info/tag/astm-standards/

Process Path: Biomass-to-Fuels and Products

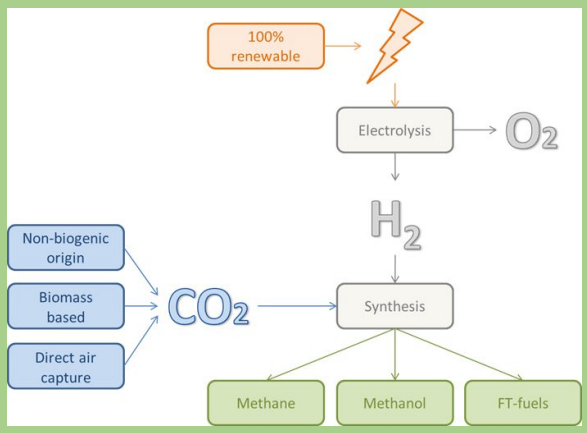


Graphic by Zina Deretsky, National Science Foundation

This shows what we've talked about so far--starting with some plant or biomass, converting that to building blocks of fuels that will then be converted to fuels and other products that can substitute for or replace those made with petroleum or natural gas fossil carbon.

Electrofuels (E-Fuels)

Electrofuels/E-fuels	Power-to-X (PtX)	Power-to-Gas (PtG)	Power-to-Liquid (PtL)
Hydrogen (H2)	X	X	
Methane (CH4)	X	X	
Ammonia (NH3)	X	X	
DME (C2H6O)	X	X	
Methanol (CH3OH)	X		X
FT-liquids	X		X
Gasoline components	X		X
Diesel components	X		X
Jet components	X		X



We also mentioned water and carbon dioxide as feedstocks. Here's a diagram that describes that process and a list of the kinds of fuels that can be made from them, depending on what catalysts are used.

Background/References:

The hydrogen produced by electrolysis (breaking water into hydrogen and oxygen with electricity) is either used alone or combined with carbon, to form gaseous or liquid hydrocarbons through synthesis processes. Depending on the desired product, these use different catalysts to produce either methane, methanol, jetfuel, renewable diesel, etc.

The sustainability and GHG emission reduction potential of electrofuels is determined by the origin of electricity and carbon. Using renewable electricity and bio-based carbon increases the sustainability.

Following, a list of different carbon sources:

Electrofuels from non-biogenic origin: CO2, which would have been emitted through e.g. fossil fuel burning, is captured and re-used.

Biomass based electrofuels: CO2 from biomass processing such as fermentation, anaerobic digestion, gasification, combustion is captured and re-used.

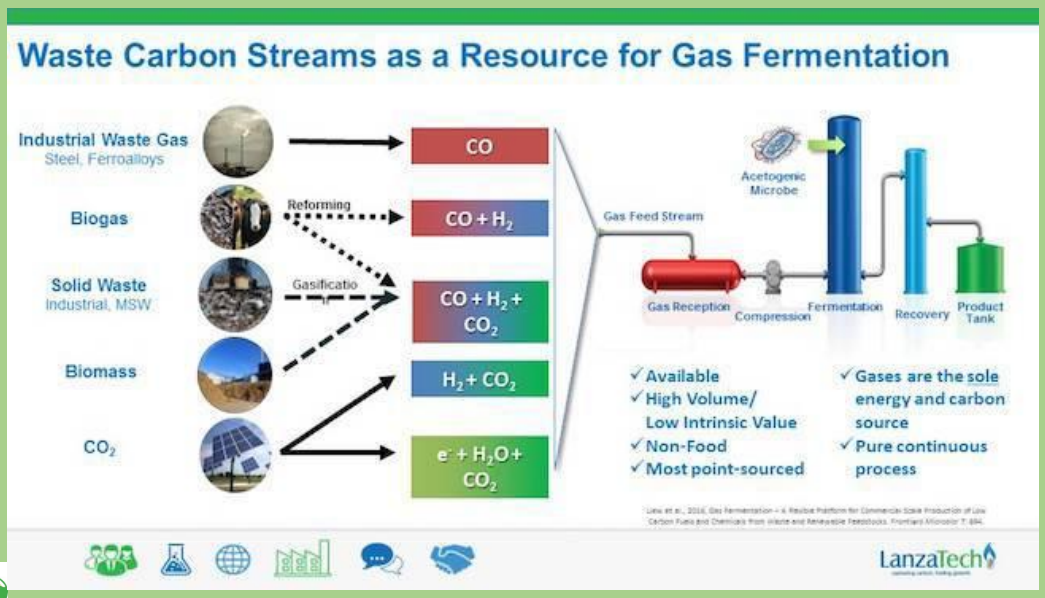
Direct air capture (DAC): CO2 is directly captured from air and re-used.

https://www.etipbioenergy.eu/value-chains/conversion-technologies/electrofuels

Electro/Renewable H2 could also be used to replace fossil hydrogen used to make renewable diesel, renewable jetfuel, etc.

electrofuels https://advancedbiofuelsusa.info/tag/electrofuels/
electrolysis https://advancedbiofuelsusa.info/tag/electrolysis/

Recycling Carbon



We also talked about making fuels from other things that are not plants. We also had industrial waste gases, MSW or municipal solid waste. LanzaTech has developed a biological process to take the gasified MSW or gases from steel mills and other industries to ethanol and to jetfuel.

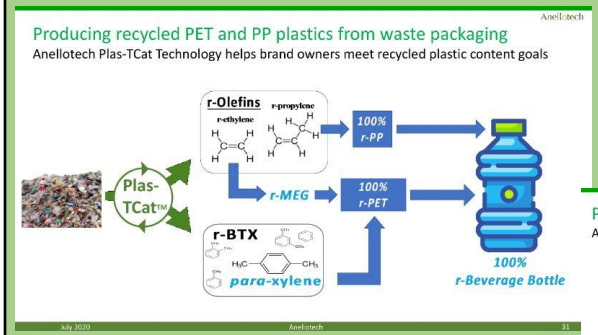
Background/Resources:

On the jetfuel slide earlier, you saw a photo of a celebration of a flight by Virgin Airlines from Miami to London using a mixture of jetfuel with this company's renewable jetfuel.

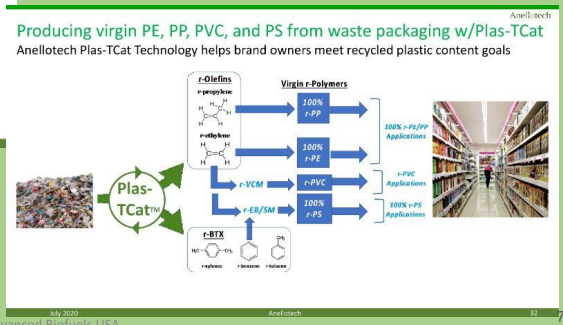
LanzaTech https://advancedbiofuelsusa.info/?s=Lanza

EU warms to plastic waste 'recycling' as transport fuel
https://www.euractiv.com/section/energy/news/eu-warms-up-to-plastic-waste-recycling-as-transport-fuel/

Recycling Plastics



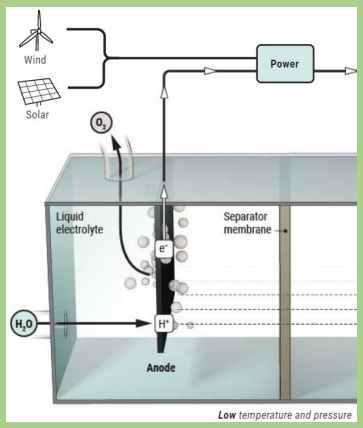
Anellotech catalytic process

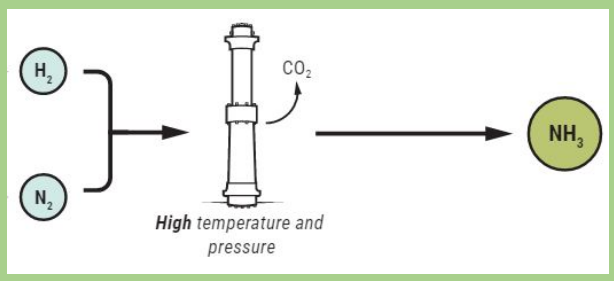


Anellotech has pivoted from making aromatics used in fuels to working on a catalytic process to recycle plastics into new plastics.

Background/References:
https://advancedbiofuelsusa.info/?s=Annellotech and
https://advancedbiofuelsusa.info/?s=Anellotech

“Green” Ammonia for Maritime Fuel





Yara International is building a pilot facility to make renewable ammonia fuel for maritime use.

Yara has started a pilot plant for making renewable ammonia fuel for maritime use by combining nitrogen which has been obtained from air, with renewable hydrogen.

Background/References:

What Is The Haber Process | Reactions | Chemistry | FuseSchool

https://www.youtube.com/watch?v=NWhZ77Qm5y4&ab_channel=FuseSchool-GlobalEducation

Yara is taking a first step toward greening that process with a pilot plant, set to open in 2019, that will sit next to the existing Pilbara factory. Instead of relying on natural gas to make H2, the new add-on will feed power from a 2.5-megawatt solar array into a bank of electrolyzers, which split water into H2 and O2. The facility will still rely on the Haber-Bosch reaction to combine the hydrogen with nitrogen to make ammonia. But the solar-powered hydrogen source cuts total CO2 emissions from the process roughly in half.

N2, is easily separated from air, which is 77% nitrogen.

Ammonia https://advancedbiofuelsusa.info/tag/ammonia/

https://www.yara.com/news-and-media/news/archive/2020/green-hydrogen-catapult/

As Yara observed, “Ammonia’s chemical properties make it ideally suited for the hydrogen economy. It does not require cooling to extreme temperatures, and has a

higher energy density than liquid hydrogen, making it more efficient to transport and store. Ammonia is therefore the most promising hydrogen carrier and zero-carbon shipping fuel."

They say: Ammonia is therefore the most promising hydrogen carrier and zero-carbon shipping fuel. Absolutely, there's a lot of hydrogen in ammonia compared to other molecules. Ammonia is 18 percent hydrogen by weight, only methane (20 percent) has more hydrogen content among common, stable molecules. By contrast, water is 11 percent hydrogen and typical biomass is around 8 or 9 percent biomass taking in account the water weight.

But, is there a real reason to make ammonia as a transport fuel? Rather, there are plenty of applications in fertilizers, green chemistry and stationary power before we need to turn to solving the problems of hydrogen transport fuels. For example, the world makes roughly 175 million tons of fertilizer, and needs millions more tons of green hydrogen for chemical applications.

In the end, we're obtaining hydrogen from water and nitrogen from the air, and we're using green electrons to perform the electrolysis to split the water into oxygen and hydrogen, and the same energy also powers the separation technology to obtain pure nitrogen from the air.

Once you have nitrogen and hydrogen, the Haber-Bosch process is used to produce ammonia.

https://www.biofuelsdigest.com/bdigest/2020/12/15/yaras-green-ammonia-behemoth-the-500000-tonner-that-will-de-fossilize-agriculture/

Chemical & Engineering News: That massive carbon footprint exists because although the Haber-Bosch process represents a huge technological advancement, it's always been an energy-hungry one. The reaction, which runs at temperatures around 500 °C and at pressures up to about 20 MPa, sucks up about 1% of the world's total energy production. It belched up to about 451 million t of CO_2 in 2010, according to the Institute for Industrial Productivity. That total accounts for roughly 1% of global annual CO_2 emissions, more than any other industrial chemical-making reaction….

The carbon footprint of ammonia synthesis goes well beyond its energy demands. Hydrogen used for the reaction comes from natural gas, coal, or oil through processes that release CO_2. According to a 2013 joint report from the International Energy Agency, the International Council of Chemical Associations, and the Society for Chemical Engineering and Biotechnology, CO_2 emissions from hydrogen production account for more than half of those from the entire ammonia production process. In total, from hydrocarbon feedstocks to NH_3 synthesis, every NH_3 molecule generated releases one molecule of CO_2 as a coproduct.

And our hunger for ammonia fertilizer is increasing. According to the Food and Agriculture Organization of the United Nations, nitrogen fertilizer demand is projected to increase from 110 million t in 2015 to almost 119 million t by 2020.

sustainable. Some are working to power the reaction with renewable energy sources and to generate hydrogen without fossil fuels. Others want to find a more efficient reaction than Haber-Bosch to synthesize ammonia. The researchers admit that progress has been slow but worth it. READ MORE https://cen.acs.org/environment/green-chemistry/Industrial-ammonia-production-emits-CO2/97/i24

Ammonia—a renewable fuel made from sun, air, and water—could power the globe without carbon

https://www.sciencemag.org/news/2018/07/ammonia-renewable-fuel-made-sun-air-and-water-could-power-globe-without-carbon

A Few Types of Jobs Available in Renewable Fuels Production

- Biologists
- Biologists specializing in genetic research
- Biologists specializing in plant cells
- Chemists
- Chemical engineers
- Mechanical Engineers
- Equipment operators, technicians
- Computer Software Engineers
- Refinery Equipment Manufacturers
- Welders
- Boilermakers
- Systems engineers
- Research assistants
- Lab technicians
- Industrial engineers
- Industrial architects
- Construction workers, Managers
- Truck drivers
- Plant operations managers
- Pipe Fitters
- Others?

Here are some of the jobs involved with converting the feedstock to renewable fuels.

Sustainable, Renewable Fuels
Advanced Biofuels

What are they?

What are they used for?

Yesterday, Today, Tomorrow

How are they made?

Why are they important?

Sustainability?

Policy Considerations?

Jobs/Careers Throughout

So, why are renewable fuels important?

Why replacing fossil fuel is important

We are in the process of making choices about our energy resources. This is what we have with fossil fuels.

Why replacing fossil fuel is important

This is what we could have if we turn to renewables.

Why replacing fossil fuel is important

Virtually no oil is used to produce electricity in the US.

Windmills and solar can produce electricity but cannot power jet airplanes.

If our goal is to replace imported oil and petroleum-based fossil fuels, then transportation fuel is the way to go. Only about 1% of electricity is produced from petroleum. Although there is work on electrifying short flights in small planes, even renewable electricity won't power large jet planes for a very long time.

Background/References:

Aviation biofuel: https://advancedbiofuelsusa.info/tag/aviation-biofuel/
Petroleum derived electricity statistics:
https://www.eia.gov/tools/faqs/faq.php?id=427&t=6

Before oil runs out, it becomes more difficult and dangerous to extract. These photos represent "before and after" images of a boreal forest that has been turned into tar sands petroleum production.

Background/References:

This oil is fossil fuel. It will run out some day. Before it runs out, it becomes very difficult, dangerous and expensive to find and to extract. Remember the oil spill in the Gulf of Mexico in 2010—drilling for oil very, very deep wells

Also the tar sands in Canada
In Canada's boreal forests, there are almost 3000 square miles of mineable oil sands. Getting to the oil sands means removing the forests. It means that large scale, heavy equipment moves into the landscape, removing the plants, impacting animal populations, and damaging soil, water and air. Shifting Sands documents the work in the oil sands with photos of the oil sands landscapes during and after this process. Some consider this to be a cost of oil production. Others consider this to be an environmental disaster.
http://www.decodedscience.com/the-tar-sands-fueling-controversy/4981 by Tricia Edgar is a science writer and educator from the beautiful, wet Pacific Northwest. She

has a Master's degree in Environmental Management.

Map:
http://www.google.com/imgres?hl=en&sa=X&biw=1280&bih=685&tbm=isch&prmd=imvns&tbnid=YeF5QzLiRLZv9M:&imgrefurl=http://earthobservatory.nasa.gov/Study/BorealThreshold/&docid=omIRY8y0hG362M&imgurl=http://earthobservatory.nasa.gov/Features/BorealThreshold/Images/boreal_forest_map.gif&w=428&h=370&ei=CkO0TrbAJM-CsgKimNnmAw&zoom=1&iact=hc&vpx=607&vpy=226&dur=11401&hovh=209&hovw=241&tx=103&ty=113&sig=117376384788423915804&page=1&tbnh=141&tbnw=163&start=0&ndsp=18&ved=1t:429,r:8,s:0

http://www.platts.com/RSSFeedDetailedNews/RSSFeed/Oil/8662080?WT.mc_id=&WT.tsrc=Eloqua
"The challenge for producers such as the UAE is to continue producing oil and gas from existing reservoirs while, at the same time, developing new opportunities," he said. "It is no secret that the days of easy oil are coming to an end. Increasingly we are being forced to go down the route of enhanced oil recovery and developing ultra sour oil and gas from complex reservoirs."

These challenges had turned the oil-rich region to become a center for development of new technologies and innovation, Hamli said, referring to the UAE's expansion into renewable energy and its decision to build the zero-carbon Masdar City in Abu Dhabi.

"Our commitment to widening our domestic energy mix and promoting renewable energy does not mean that we have turned our backs to the oil industry," Hamli said.

"Our growing population and fast-moving industrial developments have forced us to choose between continuing burning fossil fuels which would otherwise be exported and finding complementary energy solutions for use at home. We realized that by widening our domestic fuel mix, we could release more hydrocarbons for export," he added.

The UAE has set a target of switching to nuclear power for 25% of its power generation requirements, Hamli said, adding that national peak demand for electricity was set to more than double by 2020 while demand for other forms of energy is growing.

The UAE expects to have its first nuclear power station commissioned in 2017 while at the same time developing solar energy. Abu Dhabi has set a target of generating 7% of its energy needs from renewable sources including solar.

"We believe that the best way of securing a sustainable economic future in a carbon constrained world is to develop a balanced portfolio of clean energy sources in which

nuclear, renewable energy, oil and natural gas all have a role to play," Hamli said.

Why replacing fossil fuel is important

Before oil runs out, it becomes more difficult and dangerous to extract.

Remember the oil spill in the Gulf of Mexico in 2010?—drilling for oil very, very deep wells. These are the people working 10 hour shifts for $10/hour in stifling heat wearing plastic protection to clean it up on the beaches. And don't forget the 11 people who died in that explosion and the terrible loss for their families and friends.

Background/References:

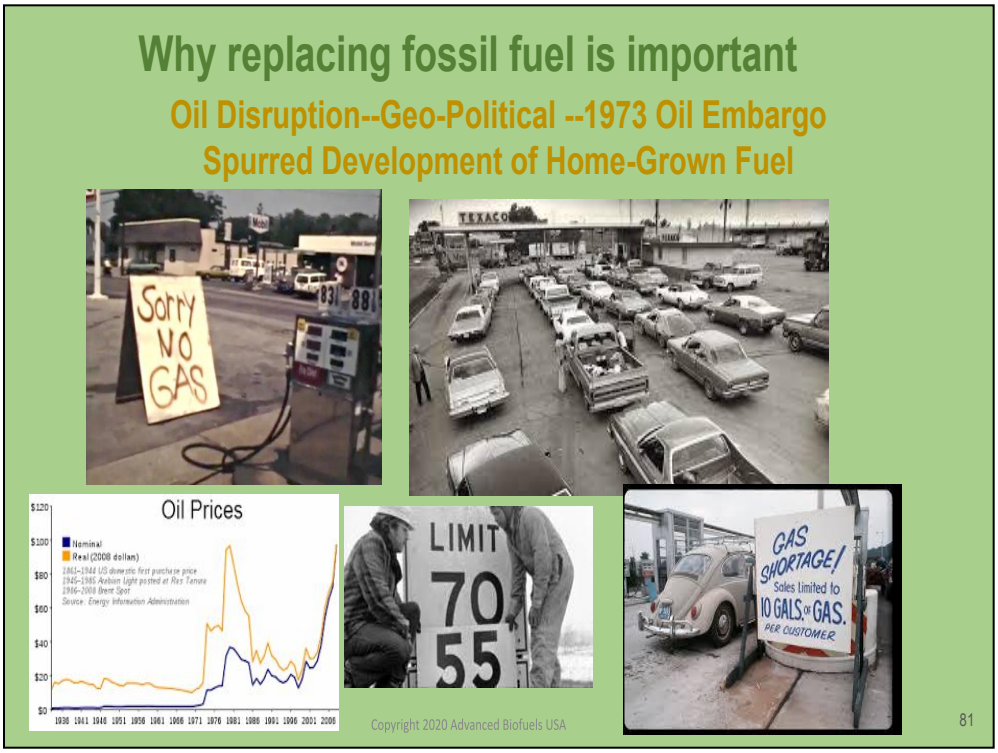
Articles about the oil spill: https://advancedbiofuelsusa.info/?s=%22oil+spill%22

About the oil spill's implications for renewable fuels:
What's Next for Oil Spill Affected Areas? Advanced Biofuels?
by Joanne Ivancic (Advanced Biofuels USA) Before Hurricane Katrina hit, Grand Isle State Park's beaches on the tip of a Louisiana marsh sticking into the Gulf of Mexico hosted over 100,000 visitors per year. After Hurricanes Katrina, Gustav and Ike, the number fell to "4000-8000, depending on if there was a…

May 24, 2010 Read Full Article https://advancedbiofuelsusa.info/whats-next-for-oil-spill-affected-areas-advanced-biofuels/

See more photos of the oil spill and clean-up here:
https://advancedbiofuelsusa.info/bpoilspill/photos-british-petroleum-oil-spill-grand-i

sle-port-fourchon-and-fourchon-beach/



There are also geo-political reasons to replace fossil fuel. The oil embargo in the 1970s, showed us the vulnerability of relying of imports for energy. If done right, every country should be able to minimize its reliance on imported energy, increase their energy security and energy independence.

Background/References:

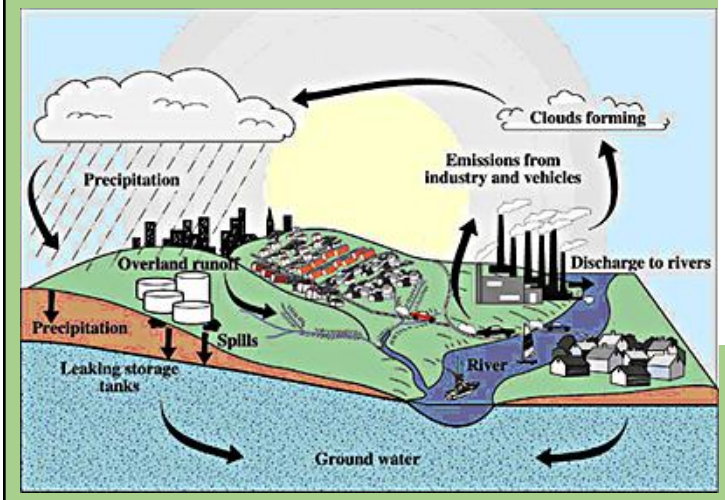
https://mpt.pbslearningmedia.org/resource/bln12.socst.ush.now.oilcrisis/the-oil-crisis-1979/#.W1TuTkjRU2w

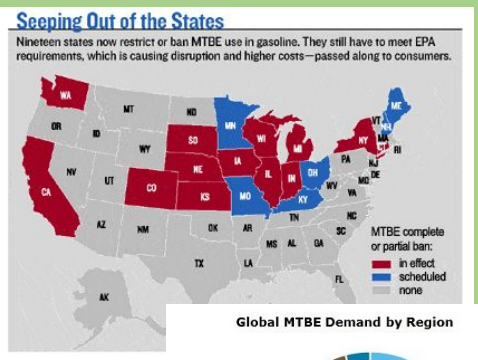
Oil Embargo, 1973–1974. During the 1973 Arab-Israeli War, Arab members of the Organization of Petroleum Exporting Countries (OPEC) imposed an embargo against the United States in retaliation for the U.S. decision to re-supply the Israeli military and to gain leverage in the post-war peace negotiations.

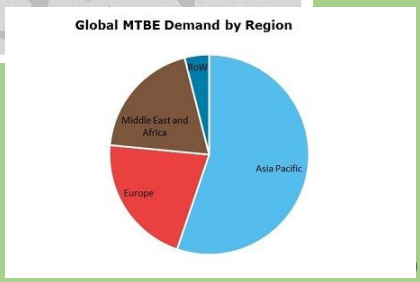
The 1979 (or second) oil crisis or oil shock occurred in the world due to decreased oil output in the wake of the Iranian Revolution. ... The price of crude oil more than doubled to $39.50 per barrel over the next 12 months, and long lines once again appeared at gas stations, as they had in the 1973 oil crisis.

Why Replacing Fossil-Fuel Oil Is Important

Replaces MTBE as an octane enhancer.







Carcinogenic MTBE enters the water supply from leaking underground storage tank systems including those at gas stations. MTBE is highly water soluble, not easily absorbed into soil, and sticks around for a long time. When it was banned in many states, ethanol replaced it.

Background/References:

MTBE is highly water soluble, not easily absorbed into soil, and sticks around for a long time.

Thus, with widespread use, MTBE has the potential to occur in high concentrations in groundwater, travel far from leak sources, and accumulate to become a concern for the entire region.

http://www.cvwd.com/Documents-MTBE-Project.aspx

http://www.epa.gov/mtbe/

MTBE Map- Nathan Vardi Forbes

https://www.forbes.com/forbes/2004/1115/173.html?sh=2fe727906110

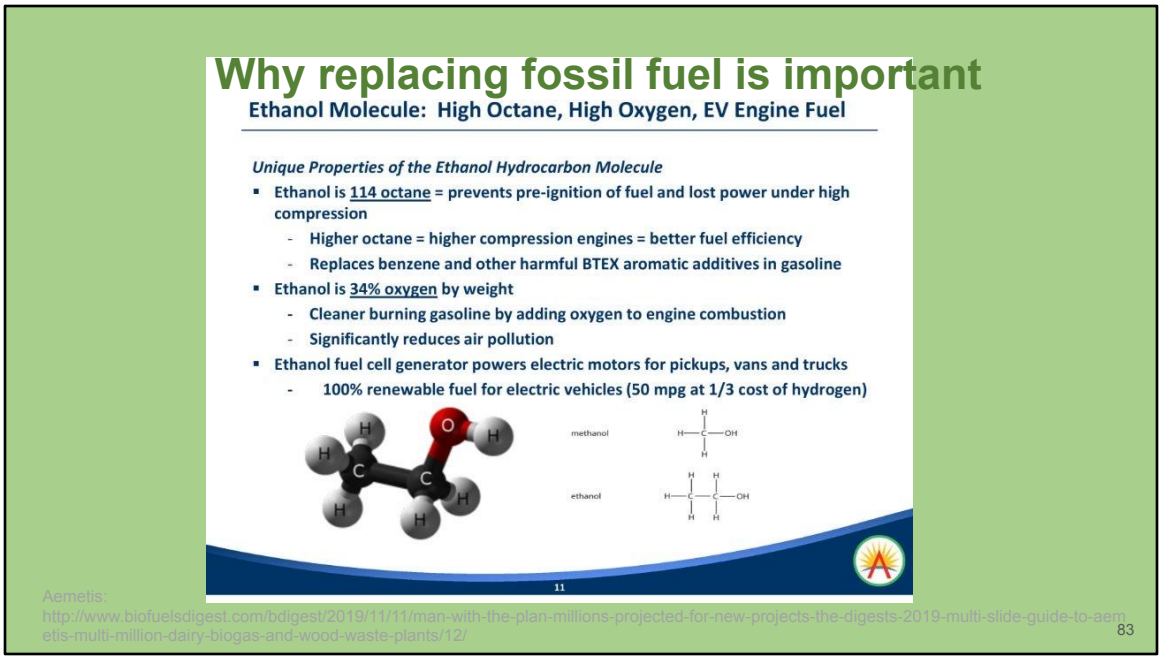
Methyl Tertiary Butyl Ether (MTBE): 2020 World Market Outlook and Forecast up to 2029

https://mcgroup.co.uk/researches/methyl-tertiary-butyl-ether-mtbe

Methyl tertiary butyl ether market trends, developments and prospects:

As methyl tertiary butyl ether (MTBE) has been recognized dangerous to the

environment, USA, Canada, Japan and Western Europe countries shift to ETBE, ethanol and other alternatives and close MTBE facilities
On the contrary, Eastern Europe and Asia Pacific countries build new MTBE capacity
Global MTBE market has been flat in the past years; on the one hand, developed countries lowered MTBE consumption, but on the other hand the demand grew in Asia Pacific, Latin America and the Middle East due to increased gasoline consumption and requirements for cleaner fuel in those areas
World methyl tertiary butyl ether production is foreseen to decrease; China will continue to introduce new capacity but operation rates will go down
Overall MTBE demand growth will be low: USA, Canada, Japan and Western Europe markets will keep on decreasing, but Asia Pacific, Latin America and the Middle East MTBE industries will post growth



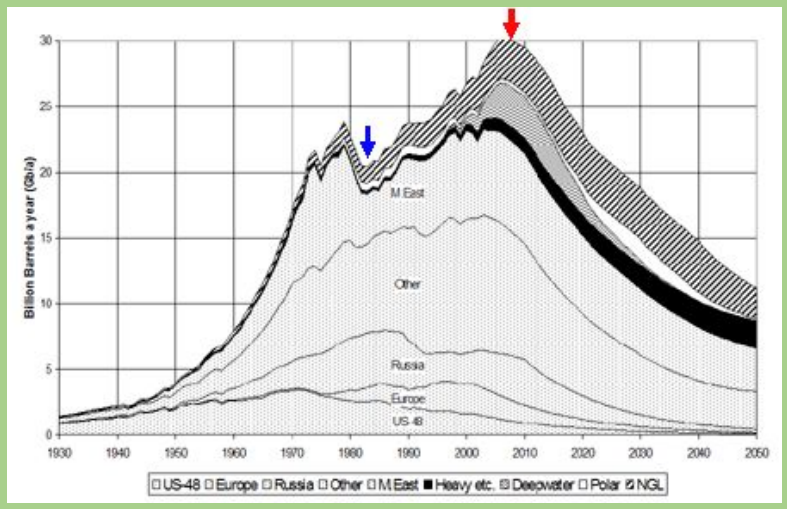
Ethanol fuel has a lot of benefits. It burns clean, has high octane, replaces harmful chemicals in gasoline and can be used in fuel cells.

Background/References:

Aemetis:
http://www.biofuelsdigest.com/bdigest/2019/11/11/man-with-the-plan-millions-projected-for-new-projects-the-digests-2019-multi-slide-guide-to-aemetis-multi-million-dairy-biogas-and-wood-waste-plants/12/

Why Replacing Fossil-Fuel Is Important

Peak Oil



When the oil is gone, the well does not produce more. Or, the economics of extracting the oil mean that it stays in the ground.

Background/References:

This is a diagram of how production of oil has peaked in the US, while our need for petroleum fuels has increased, so we have to import oil that we can't produce ourselves. This same dynamic of oil fields being used up is going on around the world. They don't replenish, are not renewable. When the oil is gone, the well doesn't grow more.

What Ever Happened To Peak Oil? Forbes (2018)
https://www.forbes.com/sites/michaellynch/2018/06/29/what-ever-happened-to-peak-oil/?sh=3ab3e91b731a

Peak Oil Is Suddenly Upon Us - Bloomberg (2020)
Now "peak oil" refers to peak in demand for petroleum, not peak supply.
https://www.bloomberg.com/graphics/2020-peak-oil-era-is-suddenly-upon-us/

Peak Oil
By WILL KENTON Updated Feb 12, 2020
https://www.investopedia.com/terms/p/peak_oil.asp
What Is Peak Oil?
Peak oil refers to the hypothetical point at which global crude oil production will hit its maximum rate, after which production will start to decline. This concept is derived from geophysicist Marion King Hubbert's "peak theory," which states that oil production

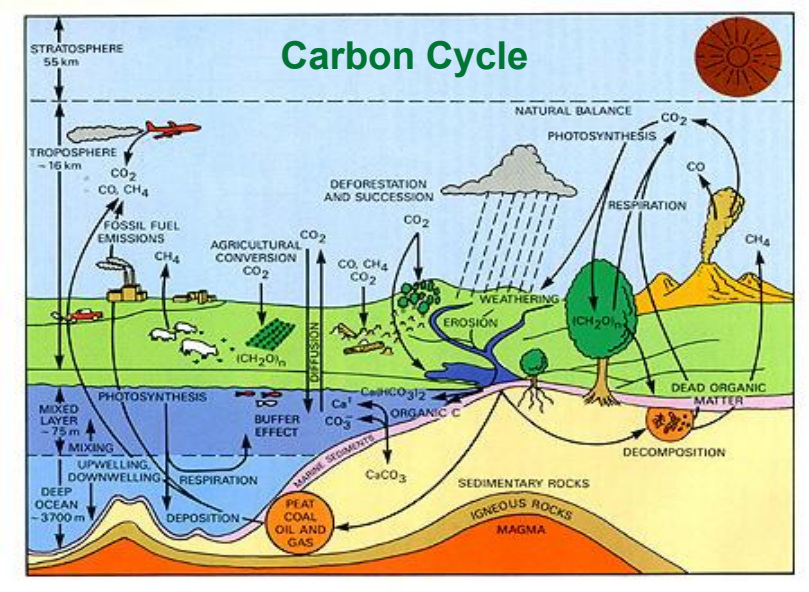
follows a bell-shaped curve.

In the traditional vision of peak oil, the production decline accelerates as the challenge of extracting new reserves grows. This would put pressure on existing reserves that are drawing down overtime. If new reserves are not brought on line more rapidly than the existing reserves drawdown, then peak oil has been reached. Peak oil has been declared several times, but each deceleration has proved premature because of new extraction technologies like hydraulic fracturing and better surveying revealing previously undiscovered reserves.

Peak Oil Supply and Demand

Because oil is a non-replenishing resource, there is a limit to how much the world can extract and refine. However, the scenario of total depletion is just one version of peak oil. In theory, peak oil can be brought on by the production squeeze—the drawdown as adding new reserves gets more challenging—but it can also be caused by a production decline when oil alternatives become more cost-effective, pricing oil out of the market, and making exploration and production unprofitable.

Why replacing fossil fuel is important



Renewable fuels recycle the carbon that is already on land and in the air. We won't have to take fossil carbon out of deep storage and add it to the atmosphere.

Background/References:

Burning hydrocarbons that used to be buried deep in the Earth releases carbon dioxide into the air. More than we need to grow plants and to sustain life. So it stays for a very long time in the atmosphere causing climate change.

Less pollution

In addition, fuels like ethanol, biodiesel, renewable diesel, SAF and RNG and renewable heating and shipping fuel burn cleaner, don't put as many pollutants into the air.

Biofuels are carbon neutral, don't contribute to an increase in greenhouse gases related to the carbon they take out of the atmosphere when they are growing. Think of it. Plants that you can see are made out of the air that you can't see.

And recycling the carbon already on land in the form of plastics and industrial flue gases also reduces the carbon that needs to be taken out of deep storage.

And there are these and other ancillary benefits along the value chain or supply chain of renewable fuels.

Background/References:

Nick: Could you put the tag links to these words?

Solutions https://advancedbiofuelsusa.info/tag/solutions/
Fatberg https://advancedbiofuelsusa.info/?s=fatberg
Rice Straw https://advancedbiofuelsusa.info/tag/rice-straw/
Wheat Straw https://advancedbiofuelsusa.info/tag/wheat-straw/

100 kg of paddy straw can produce 36 litres of ethanol while wheat stalk of the same quantity can produce 53 litres. PTI File Photo
https://www.deccanherald.com/state/top-karnataka-stories/iisc-researchers-turn-stubble-into-ethanol-932667.html

There's a lot of talk about a transition from liquid fueled vehicles to electric ones. Certainly, it will take a long time for liquid-fueled vehicles to be off the roads, even if we get to half of on-road vehicles being EVs, that means half still need liquid fuels. So someone needs to make sure those liquid fuels are as clean and green as possible.

So, the question is how to make and deploy the most sustainable renewable fuels.

Here's the current situation where I live for people who have EVs. Not much of the power is from renewable sources.
So, until EVs are affordable, available, powered by renewable sources and use fair trade batteries, vehicles fueled with advanced biofuels look like our best option to reduce the greatest amount of our transportation carbon footprint as quickly as possible for the least expense.

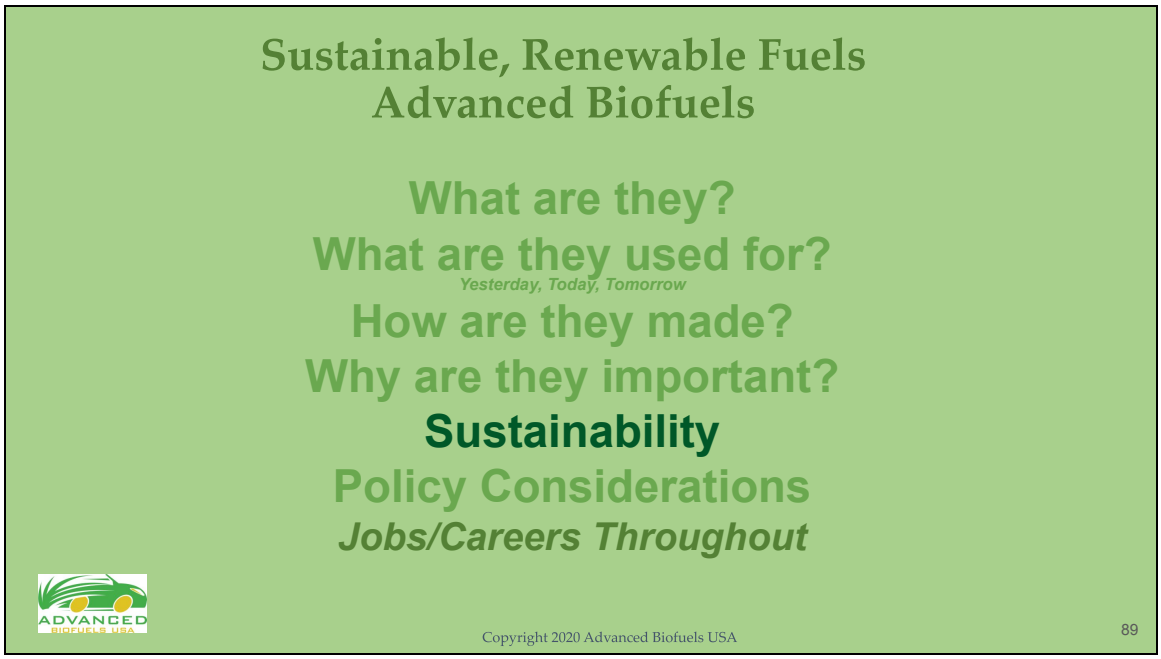
Background/References:

There's a lot of talk about a transition from liquid fueled vehicles to electric ones. Certainly, it will take a long time for liquid-fueled vehicles to be off the roads, even if we get to half of on-road vehicles being EVs, that means half still need liquid fuels. It is necessary to make sure those liquid fuels are as clean and green as possible.

https://www.firstenergycorp.com/content/dam/customer/billinserts/9412-MD-Environmental-Disclosure-0920.pdf Potomac Edison Environmental Inormation required bill insert for year ending Dec. 31, 2019.

See also
https://www.pjm.com/-/media/markets-ops/ops-analysis/capacity-by-fuel-type-2020.ashx the electricity fuel source list for PJM, the regional transmission organization

(RTO) that coordinates the movement of wholesale electricity in all or parts of 13 states and the District of Columbia.



We've already talked a lot about sustainability. Let's spend a couple of minutes more.

Principles of Sustainability

Economic Environmental Social

What does "sustainable" mean? Endurance? Lasts for a long time? Or, something you can keep doing over and over without it degrading?

People talk about the three-legged stool of sustainability If any leg is missing, the stool falls over.

So, when we talk about sustainability and fuels, we mean that they have to have economic viability over a long term; have to allow or enable the environment to be unharmed or helped; and have to have social acceptance, fit into the fabric of a culture.

Let's look at each briefly.

Background/References:

Advanced biofuels are the ones that are more sustainable, do less damage to the environment, while still being economical to produce and that meet the demands of the society for social values such as the ones we talked about before—energy security, for example.

Sustainability is the capacity to endure. For humans, sustainability is the long-term maintenance of well being, which has environmental, economic, and social dimensions, and encompasses the concept of stewardship, the responsible management of resource use. In ecology, sustainability describes how biological systems remain diverse and productive over time, a necessary precondition for human well-being. Long-lived and healthy wetlands and forests are examples of sustainable biological systems (from Wikipedia)

Here are some concepts that might be considered when talking about economic aspects of sustainability.
Everyone in the value chain from "seed to wheel" making a living from a financially stable operation because the price of the product is competitive.

Background/References:

The inflection point

Credit worthy feedstock supplier, 15 year terms US $50/tonne

Demonstration of technology at scale

Credit worthy offtake partner 10-15 years (tough for airlines, although they say they will buy whatever can be produce and although they seem stable, they don't have good balance sheets from the perspective of financiers)

Parity with $80 oil, unsubsidized on comparable BTUs

(Jim Lane, Biofuels Digest 11 2006)

Principles of Sustainability

- Economic Environmental Social

As a biofuel producer or investor, how do you determine:

- What feedstock?
- What conversion technology?
- What location?

Here are some questions with regard to the economic leg of the sustainability stool.

Background/References:

Biofuel/Bioproduct Biomass Grower Decision Tool Box

Need for the Tool Box

In order to meet expanding national needs for the production of non-food crop biofuels, biomass production will have to be substantially increased without decreasing food or forest product production. In large part, this increase in biomass will have to come from perennial grasses, energy crops, and non-forest product managed stands. Specific programs proposed for increasing bioenergy biomass production include:

Intercropping,
Prairie Recovery,
Pastureland Preservation,
Grass Land Cropping, and
Forest Harvesting

Since the economic margins of growing biomass for commodity biofuels are thin, it is of prime importance that growers have a reliable source of information on the best species/strains to grow and what their expected yields would be. In most cases, yields

are not only a product of macroclimate conditions, but also of microenvironmental conditions including rain fall, soil conditions, and runoff. Questions that growers need to have answered would include:

What species/strains are suitable for their land?
What is the minimum tonnage/acre needed for profitable cropping?
What is the ratio of yield to nutrient inputs?
What is the minimum acreage needed to be profitable?

Tool Box Design

Answers to these questions could be provided by a grower-oriented decision making tool box. The decision making model would be statistically based and would use a database composed of: in-field production data, USDA and state soil condition data, NOAA climatological information, and demand and price information from biofuel/bioproducts markets and technologies. Information would be presented to the grower using maps and charts. Users would have the ability to enter data for specific parameters and could choose output types. Output options would include graphs depicting ranges and what/if solutions.

Objective/Work Program for Phase 1Funding

The objective of Phase 1 funding would be to determine the data needs and the programming requirements for the Biomass Grower Decision Tool Box. In order to reduce production and maintenance costs and to maximize existing resources, the starting point for this project could be the knowledge base already existing in University of Minnesota, College of Food, Agricultural and National Resources FINBIN Farm Financial Database. On the successful completion of a Phase 1 design study, a pilot program would be developed and tested on a state or regional basis. Once that has been accomplished the program would expand to a national scope.

Principles of Sustainability

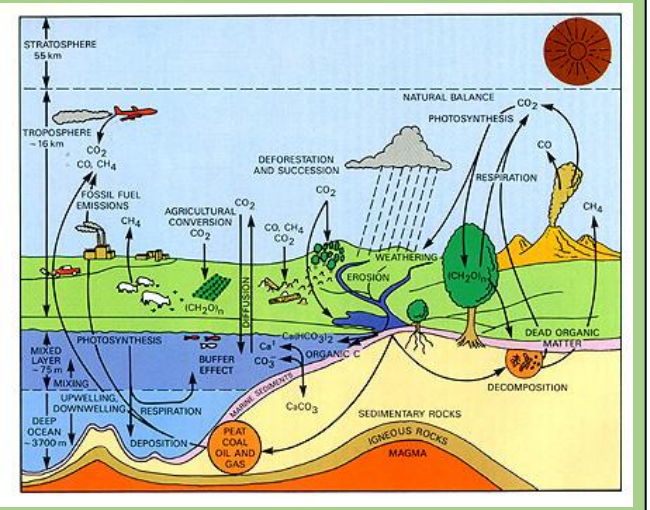
- **Economic** **Environmental** **Social**

Carbon Cycle/Climate Change

- Reduce use of **fertilizer**
- Reduce use of **water**

Use of **renewable energy**

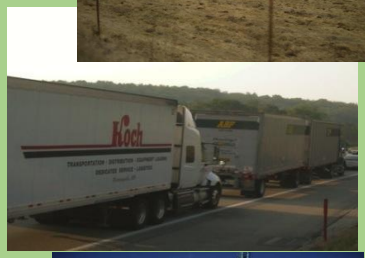
- **Climate Smart Agriculture**
- to help **sequester carbon**

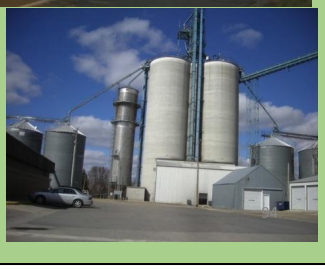


When thinking of the Environmental aspects and climate change, we aspire to carbon neutrality; that the fuel production and use does not contribute to an increase in greenhouse gases. And, we consider other aspects of environmental sustainability- air and water pollution; energy use; feedstock benefits.

Principles of Sustainability

- Economic Environmental Social
  - Government
  - Land ownership
  - Transportation
  - Infrastructure
  - Education

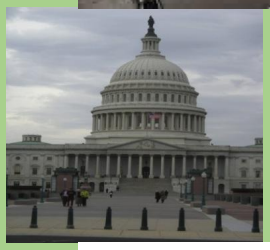




A successful sustainable renewable fuels project must fit into the culture of a society. For example, it needs government policies as well as public opinion support. It must fit into social infrastructures. It helps if education systems (formal and informal) enhance understanding of it.

Principles of Sustainability

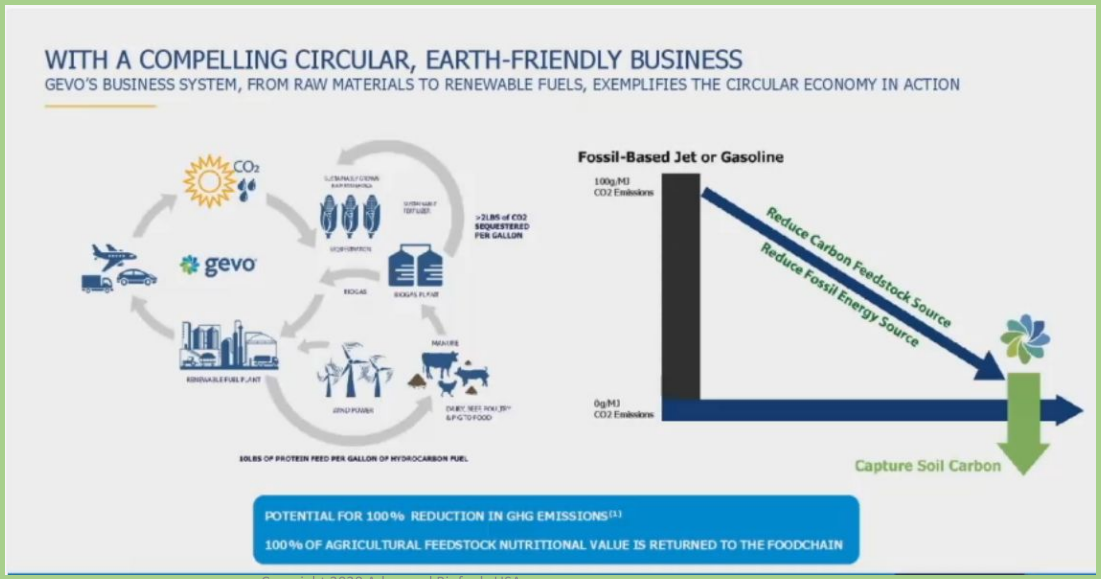
- **Economic** **Environmental** **Social**
  - Land Use Practices
  - Energy Security/Independence
  - Decision-Making
    - Form of Government
    - Cultural Values and Traditions
  - Economic System
    - Market-Based
    - Community/Public Benefit
    - Level of Government Influence
  - Prestige and Aspirations



Here are some specific social aspects that influence renewable fuels understanding, development and use.

Principles of Sustainability

- Economic Environmental Socal



Here's a company, GEVO, that combines all three aspects of sustainability in what they call a Net-Zero Project Concept.

Environmental: They produce energy dense liquid hydrocarbons using renewable energy (photosynthetic, wind, renewable natural gas, biogas) with the potential to achieve net-zero greenhouse gas emissions across the whole lifecycle of the liquid fuel and produce extensive high protein animal feed co-products.

Social: The fuel fits the current culture and is for use in traditional engines (cars, planes, trucks, and ships).

Economic: Citigroup is investing and GEVO has designed the program to enhance the local economies and provide a range of green job opportunities in rural areas.

Background/Resources:

Pat Gruber (CEO, Gevo) at ABLC 2020

https://video.ibm.com/recorded/128227770

Gevo Announces Net-Zero Project Concept
https://advancedbiofuelsusa.info/gevo-announces-net-zero-project-concept/

Net-Zero Projects for the production of energy dense liquid hydrocarbons using renewable energy and Gevo's proprietary technology. The concept of a Net-Zero Project is to convert renewable energy (photosynthetic, wind, renewable natural gas, biogas)

from a variety of sources into energy dense liquid hydrocarbons, that when burned in traditional engines, have the potential to achieve net-zero greenhouse gas (GHG) emissions across the whole lifecycle of the liquid fuel: from the way carbon is captured from the atmosphere, processed to make liquid fuel products, and including the end use (burning as a fuel for cars, planes, trucks, and ships). Gevo announces that its project currently planned to be constructed at Lake Preston, South Dakota will be the first Net-Zero Project and will be named "Net-Zero 1." Gevo expects that Net-Zero 1 would have the capability to produce liquid hydrocarbons that when burned have a "net-zero" greenhouse gas footprint.

Net-Zero 1 is currently expected to have a capacity of 45MGPY of hydrocarbons (for gasoline and jet fuel, based on current take-or-pay contracts), to produce more than 350,000,000 pounds per year of high protein feed products for use in the food chain, to produce enough renewable natural gas to be self-sufficient for the production process needs, and also to generate renewable electricity with a combined heat and power system. Net-Zero 1 is also expected to utilize wind energy.

Because of the low-carbon footprint feedstocks, the sustainable agricultural practices used to produce feedstock, and the use of renewable energy for the production processes, much of which is expected to be generated on-site, the hydrocarbon fuel products produced at Net-Zero 1 have the potential to achieve net-zero greenhouse gas emissions as measured across the whole of the lifecycle based on Argonne National Laboratory's GREET model, the pre-eminent science-based lifecycle analysis model. The GREET model takes into account emissions and impacts "cradle to cradle" for renewable resource-based fuels including: inputs and generation of raw materials, agriculture practices, chemicals used in production processes of both feedstocks and products, energy sources used in production and transportation, and end fate of products, which for fuel products is usually burning to release energy.

The capital cost for Net-Zero 1 is projected to be on the order of $700M including the hydrocarbon production and related renewable energy infrastructure which includes anaerobic digestion to produce biogas to run our plant and generate some electricity on-site. Citigroup is assisting Gevo in raising the necessary capital for Net-Zero 1.
…
Our Net-Zero 1 Project isn't just about capturing renewable energy and carbon, and transforming it into liquid renewable energy; it's also about generating enormous quantities of protein, and nutrition for the food chain. The high protein feed would be low-carbon footprint too—and we are happy to help farmers raise beef, pigs, chicken, and dairy in a way that lowers GHG emissions. We've got work to do to make it all happen," said Dr. Patrick R. Gruber, Chief Executive Officer, Gevo.

Gradable™ to Present Grain Carbon Scoring Program to California Air Resources Board

Gradable, which was launched by Farmers Business Network (FBN) in September 2020, provides new technology and services that facilitate the scoring, sourcing, and pricing of Low-Carbon Grain, making environmental transparency in the grain industry a reality now. Gradable enables comprehensive environmental transparency and supports a market for premium, environmentally-scored grain. Gradable also provides buying intelligence software that directly connects farmers with consumer packaged goods companies, animal feed providers, biofuel makers and the world's other major grain buyers.

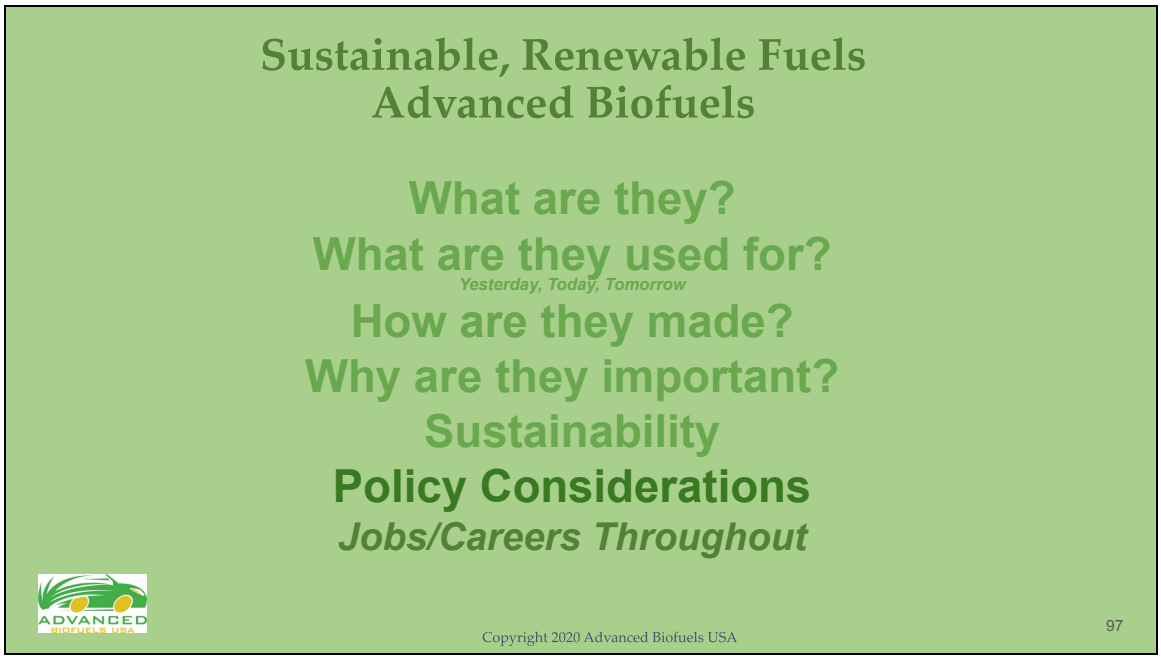
To learn more, visit www.fbngradable.com

see also:
http://www.aemetis.com/aemetis-carbon-zero-solar-energy-and-energy-efficiency-upgrades-supported-by-16-8-million-of-california-cec-and-utility-grants/

Aemetis "Carbon Zero" Solar Energy and Energy Efficiency Upgrades Supported by $16.8 million of California CEC and Utility Grants

Aemetis' Carbon Zero production plants commercialize patented technology exclusive to Aemetis for agricultural and forest waste wood feedstock. Carbon Zero plants are integrated with existing Aemetis production facilities to produce energy dense renewable fuels using renewable energy and below zero carbon intensity waste feedstocks.

Carbon Zero production plants are designed to convert below zero carbon feedstocks (waste wood and ag wastes) and renewable energy (solar, renewable natural gas, biogas) into energy dense liquid renewable fuels. Aemetis expects that such renewable fuels, when used in hybrid electric vehicles or other vehicle engines, will have a "below zero carbon" greenhouse gas footprint across the entire lifecycle of the fuel based on the Argonne National Laboratory's GREET model, the pre-eminent science-based lifecycle analysis measurement tool.



We have mentioned policy influence on renewable fuels a few times. The topic is vast and complex. Here are a few items to watch for.

Policy Considerations

Presidential Exhortations to "Get off Our Addiction to Oil" in One Way or a Another

http://www.cc.com/video-clips/n5dnf3/the-daily-show-with-jon-stewart-an-energy-independent-future

98

Some years ago, Jon Stewart on The Daily Show had a long skit that included videos of presidents from Richard Nixon through Barack Obama urging energy security and energy independence. The point was that there has been much talk, but little achievement of that goal.

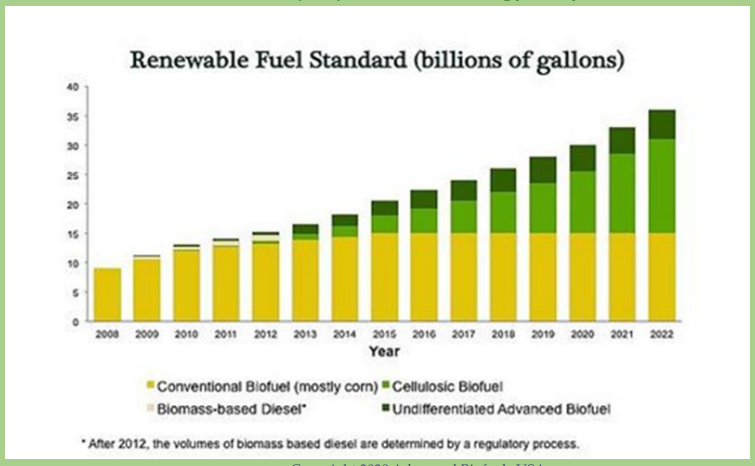
Background/Resources:

An Energy-Independent Future Video:
http://www.cc.com/video-clips/n5dnf3/the-daily-show-with-jon-stewart-an-energy-independent-future

Policy Considerations

"Get off Our Addiction to Oil" -- President George W. Bush's call to action.

Result was the Renewable Fuel Standard (RFS) in the 2007 Energy Independence and Security Act

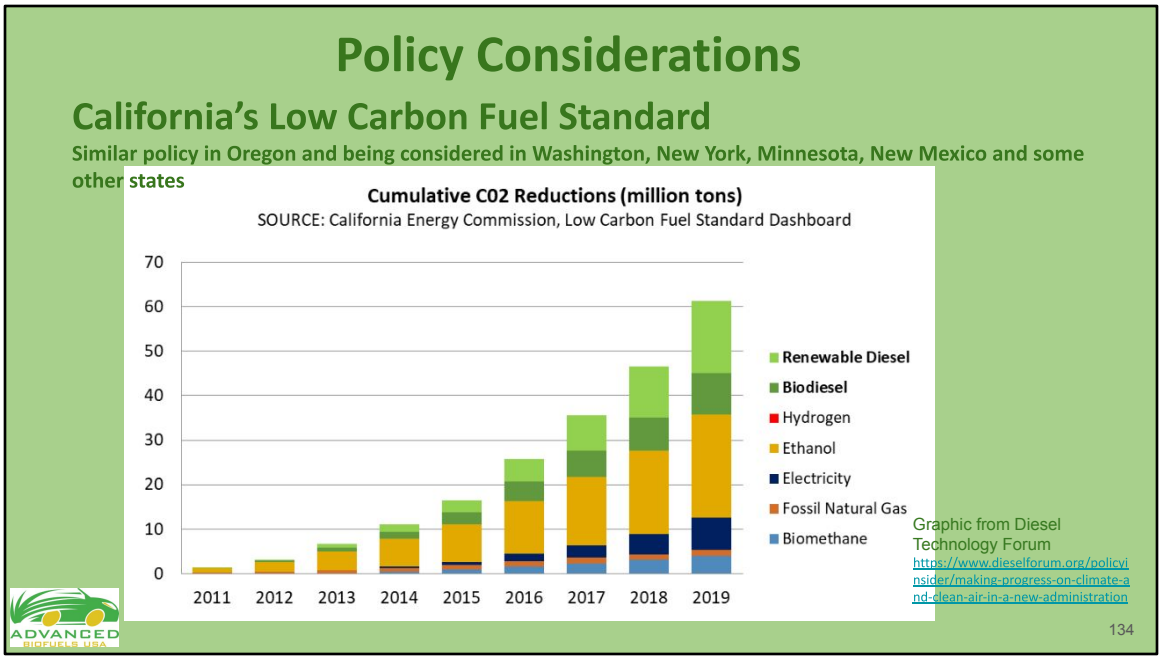


In 2007, the Renewable Fuel Standard was passed with the intent to wean the US off of petroleum by requiring oil refiners or importers to put into their products specific kinds of renewable fuels in increasing amounts over time. The amounts set for corn ethanol have been met and exceeded. Oil refiners have fought hard against giving up any market share for amounts of ethanol or any other renewable fuels beyond the amounts needed to replace MTBE.

Background/References:

The amounts were to grow each year, with a limit to the amount of corn ethanol that would be counted toward achieving their goals. Because advanced renewable fuels had not been developed yet, the Environmental Protection Agency could decrease the required amounts based on what they ascertained was available. In 2022, EPA would determine the required volume amounts, calculated with attention to six specific criteria.

Renewable Fuel Standard:
https://advancedbiofuelsusa.info/tag/renewable-fuel-standard-rfs-and-rfs2/



The other key US policy is California's Low Carbon Fuel Standard which, instead of volume-based is criteria-based and linked to a carbon credit trading scheme. Thus, fuels are credited for the amount of fossil carbon for which they substitute according to strict multi-factor "seed-to-wheel" or "well-to-wheel" calculations called "carbon intensity". Oregon has adopted a version of this and the US Congress and a number of state legislatures are considering it. Canada is in the process of implementing a Clean Fuel Standard.

Background/References:

Low Carbon Fuel Standard (LCFS)
https://advancedbiofuelsusa.info/tag/lcfs-low-carbon-fuel-standard/

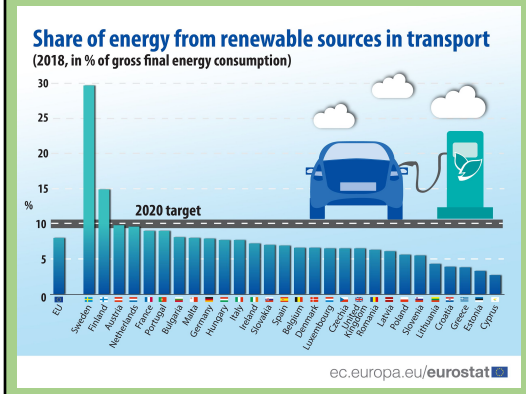
Canada's Clean Fuel Standard:
https://advancedbiofuelsusa.info/canada-unveils-its-new-clean-fuels-standard-carbon-price-and-2-25b-in-new-sector-investment/

Graph from Diesel Technology Forum:
https://www.dieselforum.org/policyinsider/making-progress-on-climate-and-clean-ai

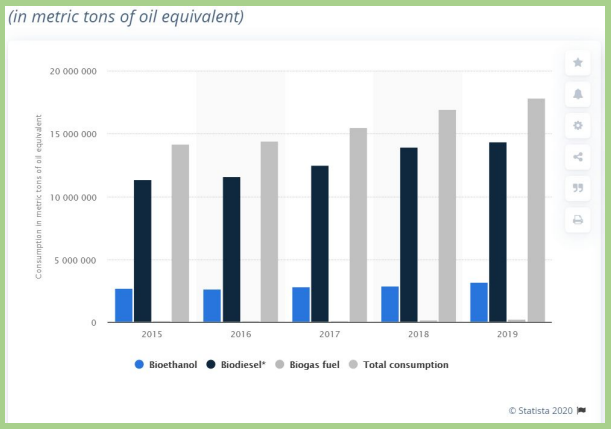
r-in-a-new-administration

Policy Considerations

European Union's Renewable Energy Directive



Consumption of biofuels for transport in the European Union (EU-28) from 2015 to 2019, by fuel type *(8% from renewable sources)*



The main policy in the European Union is the Renewable Energy Directive II which targets greenhouse gas reduction for all types of energy use, including transportation with targets for renewable transportation fuel at 14% by 2030. The EU is now revising targets as part of its Green Deal.

Background/References:

Energy for transport: 8% from renewable sources (European Commission)
The share of energy used for transport that comes from renewable sources stood at 8.0% in the European Union (EU) in 2018, compared with 7.1% in 2017, 3.9% in 2008 and 1.4% in 2004, the first year for which data are available.

Compared with 2017, the share of energy from renewable sources used for transport increased in 21 of the 28 Member States in 2018, remained stable in two Member States and decreased in five.

Sweden had by far the highest share - lowest share in Cyprus

Sweden, with 29.7%, had by far the highest share of renewable energy in transport

fuel consumption in 2018, ahead of Finland with 14.1%, the Netherlands 9.6% and Austria 9.8%.

At the opposite end of the scale, the lowest proportion was recorded in Cyprus (2.7%). Low shares (below 4%) were also recorded in Croatia, Greece and Estonia.
https://ec.europa.eu/eurostat/web/products-eurostat-news/-/DDN-20200123-2

Biofuels consumption for transport in the European Union (EU-28) 2015-2019
Published by N. Sönnichsen, Sep 29, 2020
Biofuels consumption for transport in the 28 European Union members continuously rose over the years. Between 2015 and 2019, total biodiesel consumption increased by some 3.62 million metric tons. In 2019, total biofuel consumption reached 17.83 million metric tons, of which roughly 14.35 million metric tons of oil equivalent were biodiesel, making them the most consumed biofuel in Europe.
https://www.statista.com/statistics/613238/biofuels-consumption-transport-eu/

As part of the European Green Deal, the Commission proposed in September 2020 to raise the 2030 greenhouse gas emission reduction target, including emissions and removals, to at least 55% compared to 1990.
https://ec.europa.eu/clima/policies/strategies/2030_en

https://ec.europa.eu/jrc/en/jec/renewable-energy-recast-2030-red-ii

SUSTAINABILITY CRITERIA
The RED II defines a series of sustainability and GHG emission criteria that bioliquids used in transport must comply with to be counted towards the overall 14% target and to be eligible for financial support by public authorities. Some of these criteria are the same as in the original RED, while others are new or reformulated. In particular, the RED II introduces sustainability for forestry feedstocks as well as GHG criteria for solid and gaseous biomass fuels.

Member States must require fuel suppliers to supply a minimum of 14% of the energy consumed in road and rail transport by 2030 as renewable energy.

“Recycled Carbon Fuels” are now included in this policy.
http://www.studiogearup.com/wp-content/uploads/2019/10/19_0927_sGU_UPEI_Renewable-Fuels-Paper_FFV.pdf

Policies that influence sustainable aviation fuel (SAF) development and use are CORSIA and the EU ETS.
The Carbon Offsetting and Reduction Scheme for International Aviation is a carbon offset and carbon reduction scheme to lower CO_2 emissions for international flights, to curb the aviation impact on climate change. Developed by the International Civil

Aviation Organization

CORSIA 101 – A Beginner's Guide by Stillwater Associates:
https://stillwaterassociates.com/corsia-101-a-beginners-guide/?cn-reloaded=1

European Emissions Trading System. https://ec.europa.eu/clima/policies/ets_en
To achieve a climate-neutral EU by 2050 and the intermediate target of an at least 55% net reduction in greenhouse gas emissions by 2030, the Commission is proposing to revise and possibly expand the scope of the EU ETS. The Commission has published an inception impact assessment and launched an open public consultation on the revision of the system. A 'cap and trade' system.

Policy Considerations

© The Bangkok Post A worker wears a protective mask at a Bangchak petrol station. Officials want E20, a mix of 20% ethanol and 80% unleaded gasoline 95, to gradually replace gasohol 91. Somchai Poomlard

Biofuels DIgest January 6, 2021 https://www.biofuelsdigest.com/bdigest/2021/01/06/the-digests-biofuels-mandates-around-the-world-2021/

102

The other key renewables fuels policies appear as mandates. Although well-intentioned, many mandates have proven in practice to be more aspirational than enforceable.

Background/Resources:
Biofuels DIgest Sept. 11, 2020
https://www.biofuelsdigest.com/bdigest/2020/09/11/from-americas-to-eu-asia-africa-whos-got-what-the-digests-2020-multi-slide-guide-to-biofuel-mandates-around-the-world-2020/

E20 set to be leading fuel by July 2021 -- The Bangkok Post
https://www.msn.com/en-xl/news/other/e20-set-to-be-leading-fuel-by-july-2021/ar-BB1ciDcr

Photo: http://bhartiyabiodiesel.com/

Policy Considerations

- Carbon Pricing or Carbon Tax
- Bans on Vehicles
- Eliminating Fossil Fuel Government Subsidies
- Requiring Government Entities to Use Renewable Fuels
- Requiring Disclosure of Climate Change Risks by Publicly Traded Companies
- Production Tax Credits
- Investor Focus on Non-financial Factors (Environment, Social, Governance (ESG)

What other policies might work? Here are some more ideas being implemented and considered.

A Few Types of Jobs in Communicating Importance of Advanced Biofuels

- Public Relations
- Economic Development
- Marketing/Sales
- Elected Official
- Federal Agency Staff
- State Agency Staff
- Advocates
- Lawyers
- Office Administrative Staff
- Book Publishers
- County/Local Administrative Staff
- Journalists
- Writers
- Photographers
- Broadcast Media Professionals
- Teachers
- Teaching Assistants
- Nonprofit Organization Staff
- Event Organizers
- Fundraisers
- Others?

Jobs that help us better understand and make informed decisions about renewable fuels have a crucial value to all aspects of transitioning from fossil fuel to renewables. Teaching, advocating, funding and more.

You can help make a difference. All the jobs, all the feedstock, all the technologies we have talked about today will help us transition to a truly renewal sustainable energy future.

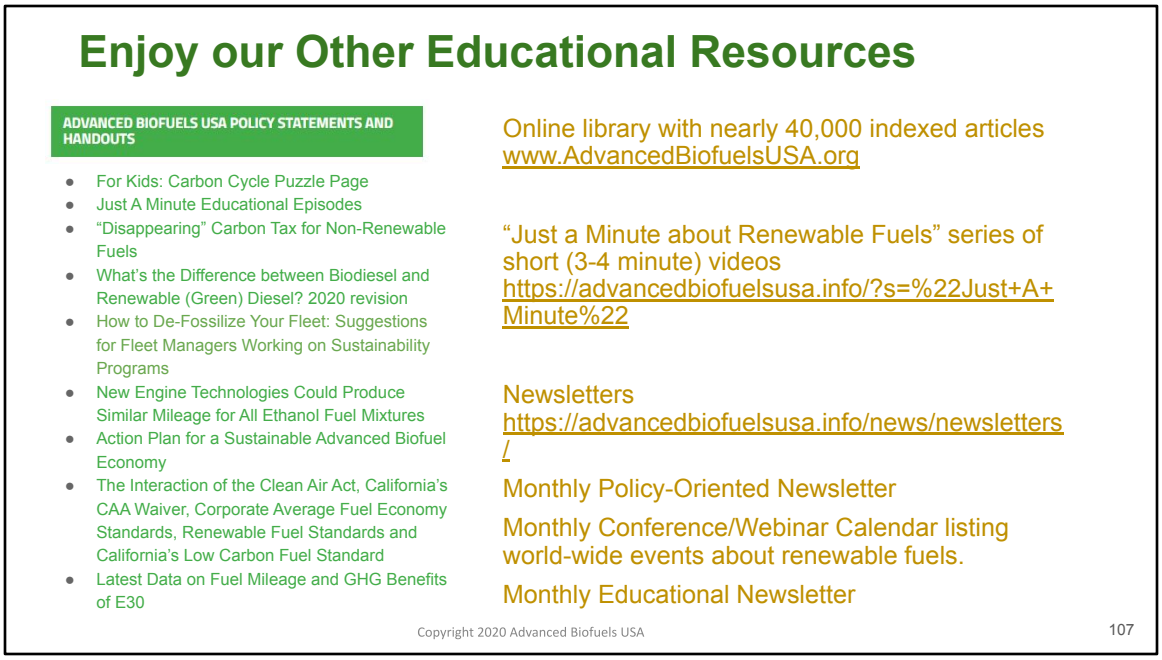
Background/Resources:

Advanced Biofuels USA, a nonprofit educational organization advocates for the adoption of advanced biofuels as an energy security, military flexibility, economic development and climate change mitigation/pollution control solution.

Advanced Biofuels USA's resources are here for you to use--free.

Background/References:

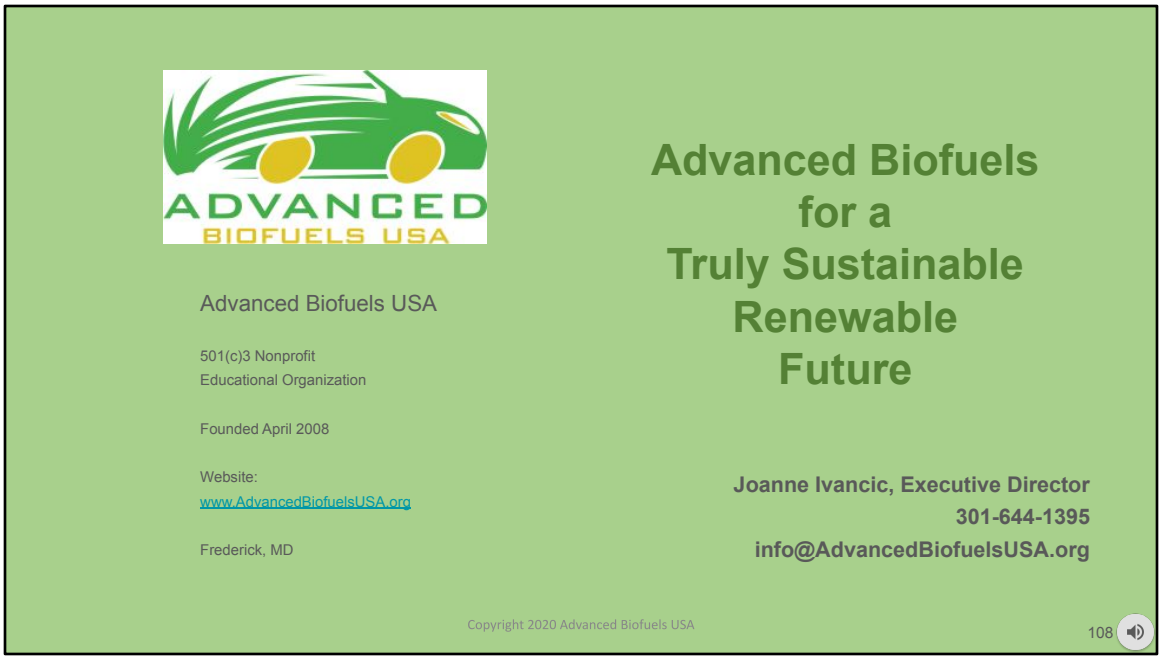
Our key tool for accomplishing this is our website, www.AdvancedBiofuelsUSA.org, a resource for everyone from opinion-leaders, decision-makers and legislators to industry professionals, investors, feedstock growers and researchers; as well as journalists, teachers and students.



Just some examples.

Background/References :

In addition, we prepare technology assessments, present briefing documents to Congressional staff, participate in international conferences on renewable fuels, provide interviews for journalists and broadcast reporters, consult with international organizers, conduct presentations and lectures for civic and school groups, and provide general assistance to those interested in any facet of the world of advanced biofuels.



Don't hesitate to contact us.

Background/References:
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In addition, we prepare technology assessments, present briefing documents to Congressional staff, participate in international conferences on renewable fuels, provide both background and attributed interviews for a wide range of journalists and broadcast reporters, consult with international conference organizers, conduct presentations and lectures for civic and school groups, and provide general assistance to those interested in any facet of the world of advanced biofuels.