Advanced Biofuels
A Truly Sustainable Renewable Future

Advanced Biofuels USA
www.AdvancedBiofuelsUSA.org
301-644-1395

Advocates for the adoption of advanced biofuels as an

- energy security,
- military flexibility,
- economic development
- climate change mitigation
- pollution control

solution.

Advanced Biofuels USA

501(c)3 Nonprofit
Educational Organization

Founded April 2008

Website:
www.AdvancedBiofuelsUSA.org

Frederick, MD

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Advanced Biofuels USA: promoting the understanding, development and use of advanced biofuels around the world

Select Language

ADVANCED BIOFUELS USA

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

HOME | ABOUT US | MAKE A DIFFERENCE | BIOFUEL BASICS | R&D FOCUS | RESOURCES | EDUCATION | POLICY | MILITARY | NEWS | PHOTOS | CONTACT

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advanced biofuels call to action »

Call to Action for a Truly Sustainable Renewable Future

August 8, 2013 – 5:07 pm | No Comment

-Include high octane/high ethanol Regular Grade fuel in EPA Tier 3 regulations.
-Use a dedicated, self-reducing non-renewable carbon user fee to fund renewable energy R&D.
-Start an Apollo-type program to bring New Ideas to sustainable biofuel and …

Read the full story »

What are advanced biofuels? Click here for definition.

coming events »

Mid-Atlantic Bioenergy Conference and Expo (MABEX) 2018 — September 12-14, 2018 — Philadelphia, PA

5th Annual Leaders in Energy Green Jobs Forum "Growing the Regional Clean Economy" — August 16, 2018 — Washington, DC

2018 Biodiesel Seminar Tour Exploring Biodiesel — June 12 – September 18, 2018 — Various locations

Before we start:

What do you think of when you hear "*biofuel*"?

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“Advanced Biofuels: Transportation, Cooking and Energy Storage”

Overview

- Advanced Biofuels Basics
- Renewable Cooking Fuel
- New Research on Liquid Energy Storage
- Q&A throughout

Advanced Biofuels Basics

What are they?

Why do we need them?

What are they used for? (Yesterday, Today, Tomorrow)

How are they made?

Sustainability

Policy Considerations

Markets

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Advanced Biofuels Basics

What are they?

Why do we need them?

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How are they made?

What Are Advanced Biofuels?

Ethanol is a biofuel, not the only biofuel.

Biodiesel
Renewable Diesel
Biojet
Biobutanol
Drop-in Hydrocarbons
Rocket Fuel
BioHeat ®

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Corn-based ethanol (nearly 200 proof moonshine or 100% ethanol) is **one of** the few currently commercially available biofuels you can buy for vehicles in the US today.

- And the ethanol molecule is part of many other things too.

- Wine
- Beer
- Whiskey

AND, **ethanol can be made from many things**, not just corn. More on that later….

Advanced Biofuels Basics

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What We Have

What We Can Have

Why Replacing Fossil-Fuel Oil With Advanced Transportation Biofuels is Important—

Windmills and solar can produce electricity

Virtually no oil is used to produce electricity in the US– just 1%.

but cannot power jet airplanes.

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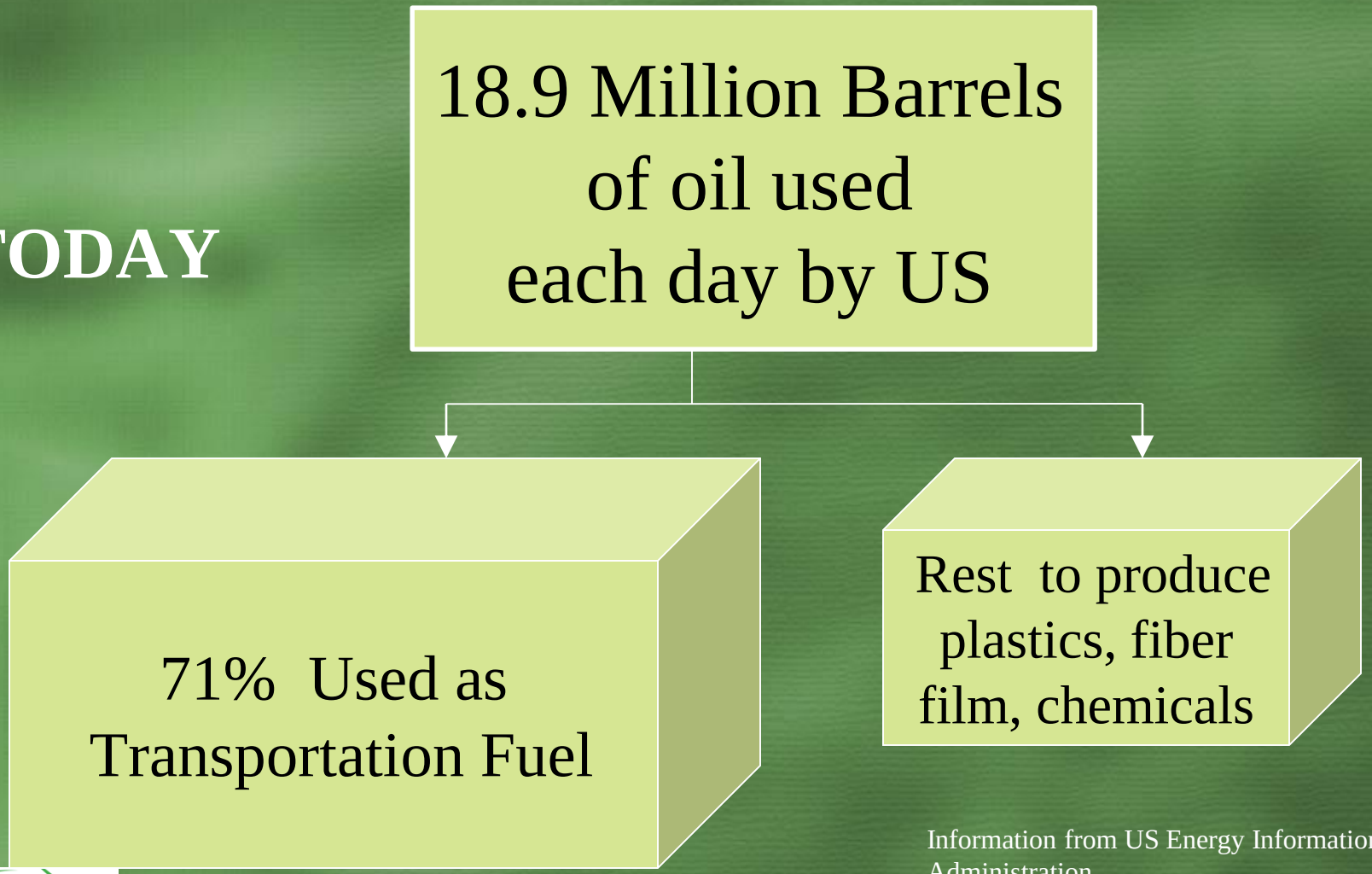
Why Replacing Fossil-Fuel Oil With Advanced Transportation Biofuels is Important—

TODAY



Information from US Energy Information Administration

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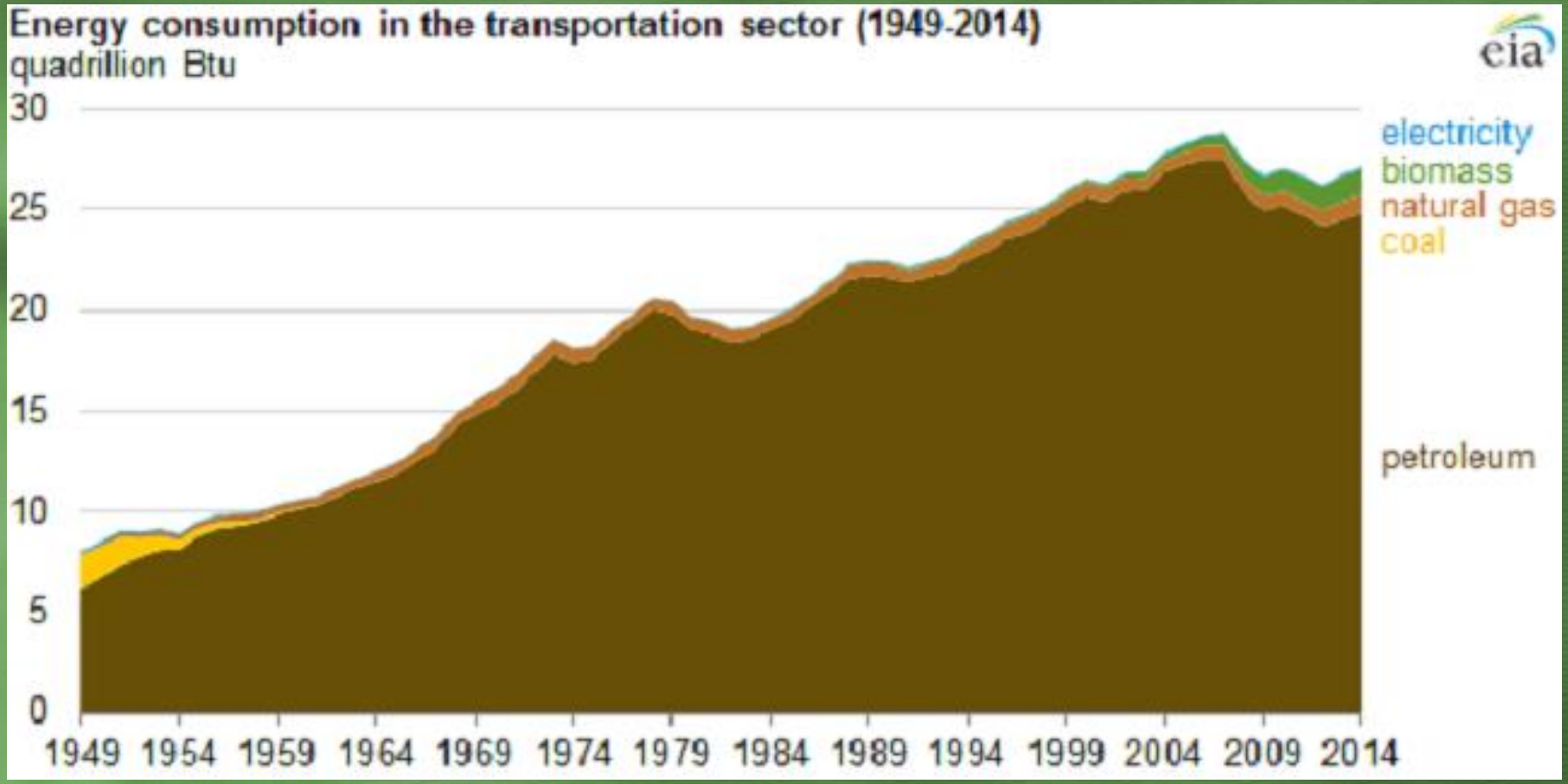
Why Replacing Fossil-Fuel Oil With Advanced Transportation Biofuels is Important—



Oil has held more than a 90% share of the transportation market for more than 60 years.

Information from US Energy Information Administration

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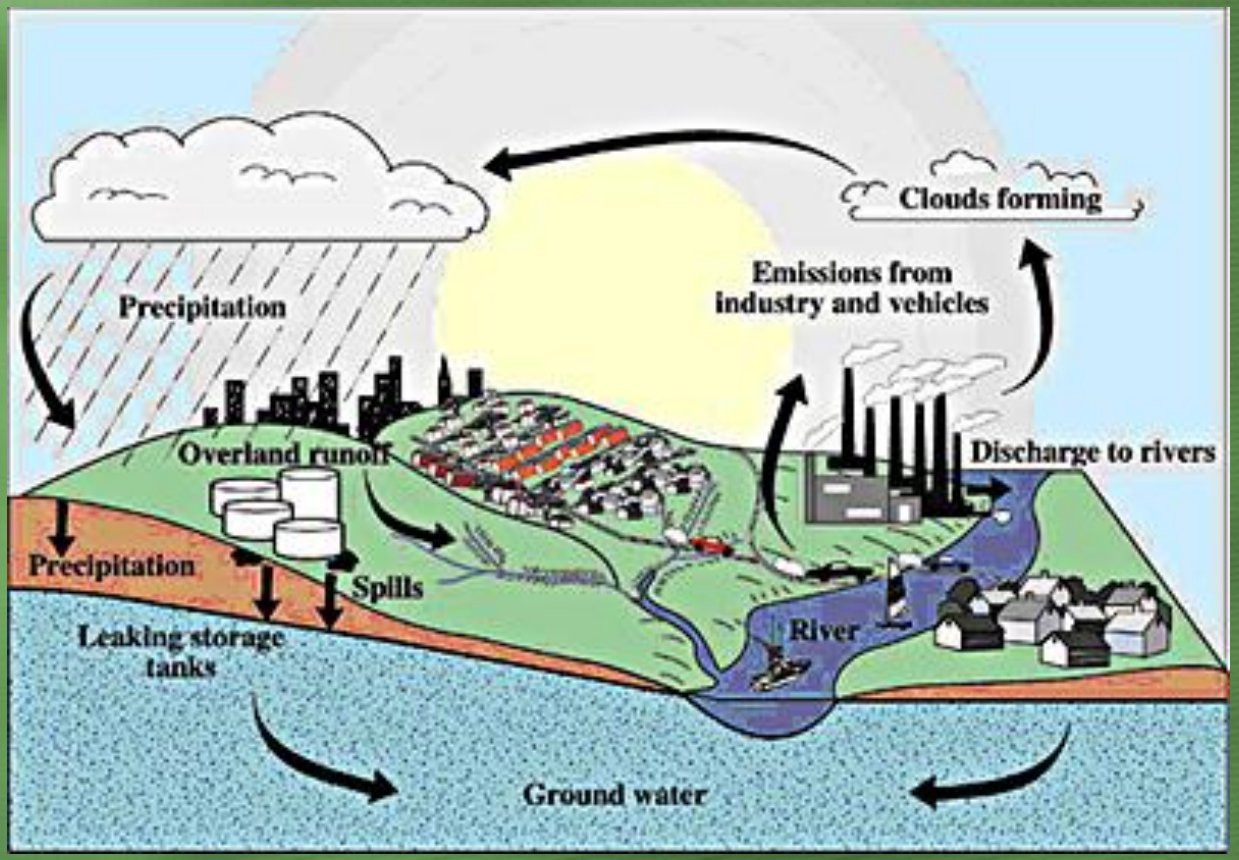
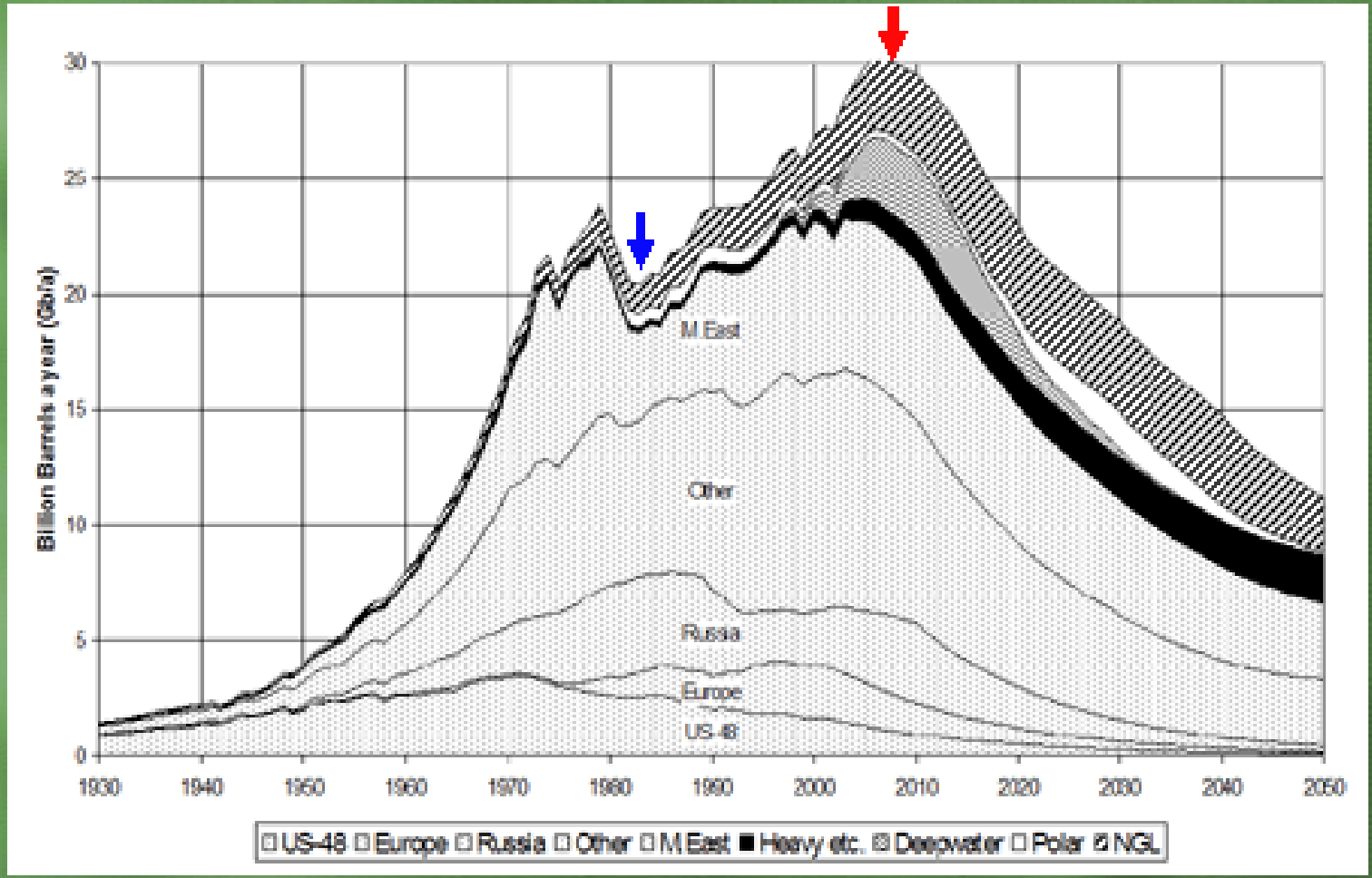
Why Replacing Fossil-Fuel Oil With Advanced Transportation Biofuels is Important—

Replaces MTBE as an oxygenate.



Why Replacing Fossil-Fuel Oil With Advanced Transportation Biofuels is Important—

Peak Oil



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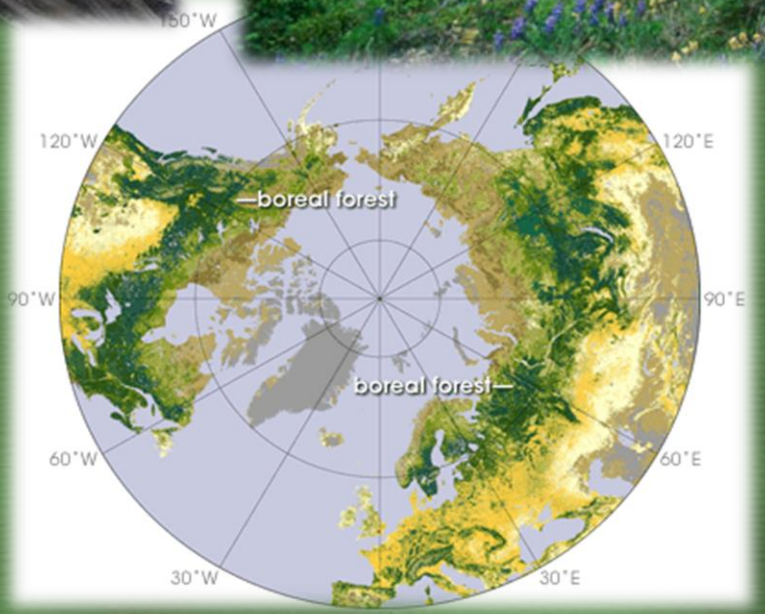
Why Replacing Fossil-Fuel Oil With Advanced Transportation Biofuels is Important—

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



ADVANCED BIOFUELS USA

Why Replacing Fossil-Fuel Oil With Advanced Transportation Biofuels is Important—

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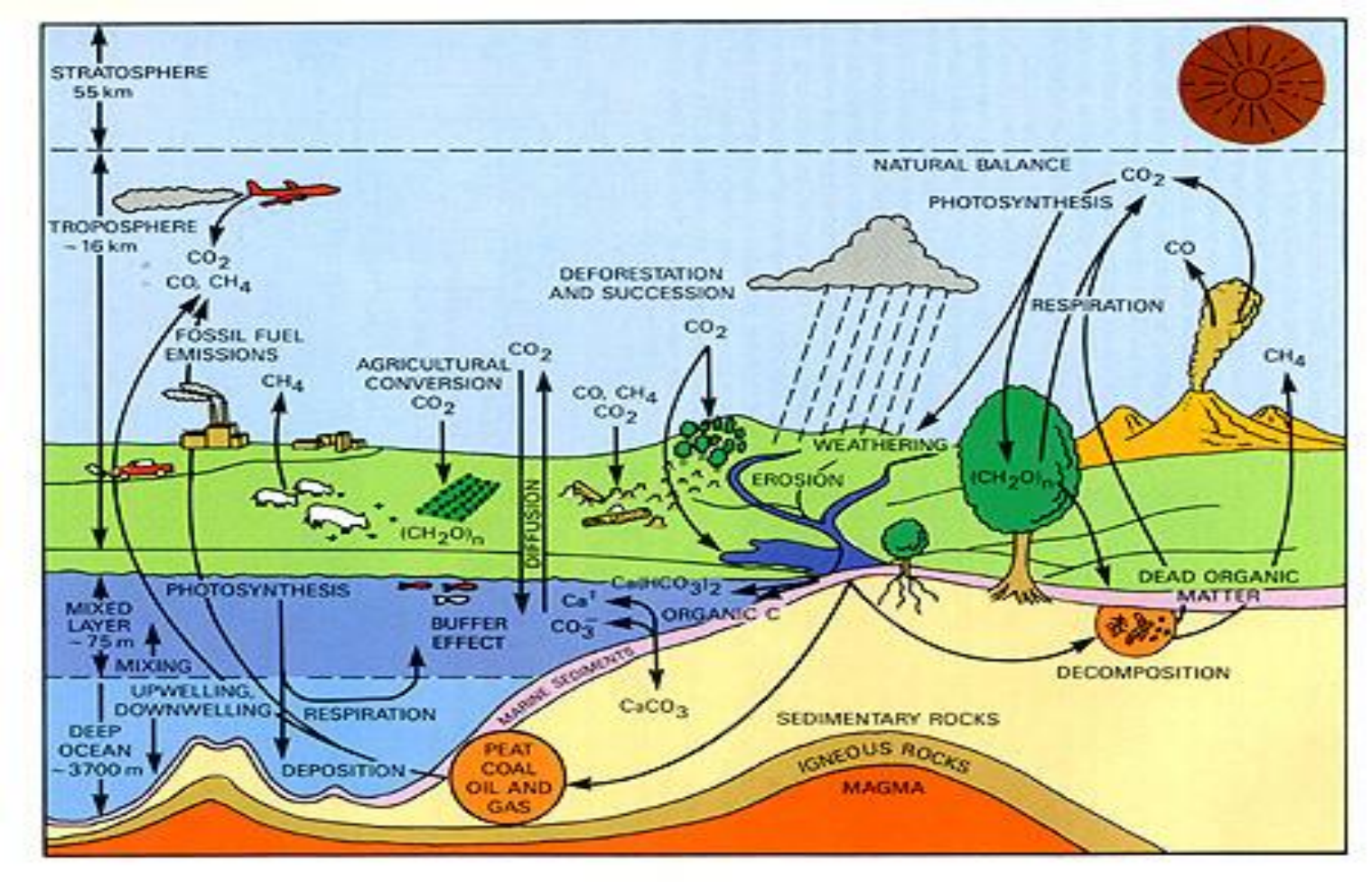
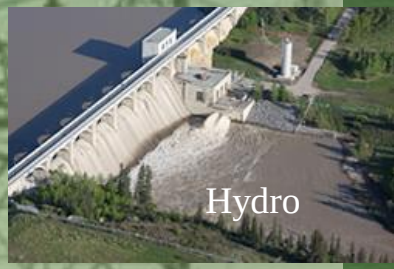


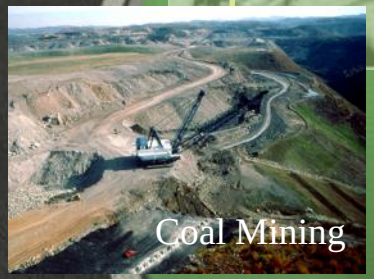
Part of a low life cycle carbon emissions climate change mitigation solution

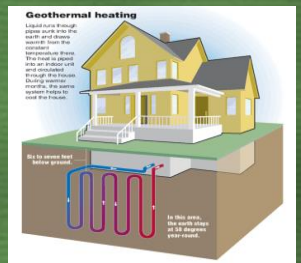
The Road to Electric Vehicles

GHG Emissions



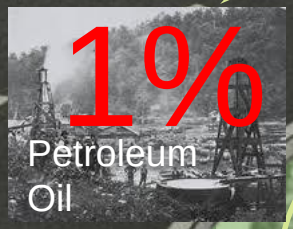
GHG Emissions



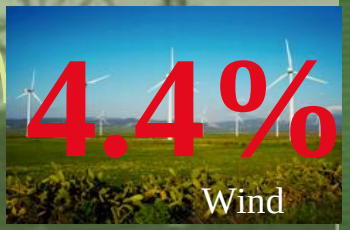


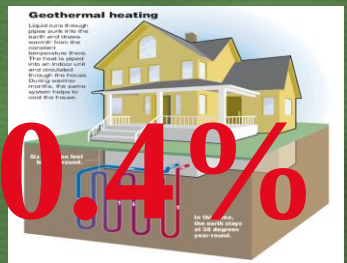
The Road to Electric Vehicles

GHG Emissions



GHG Emissions

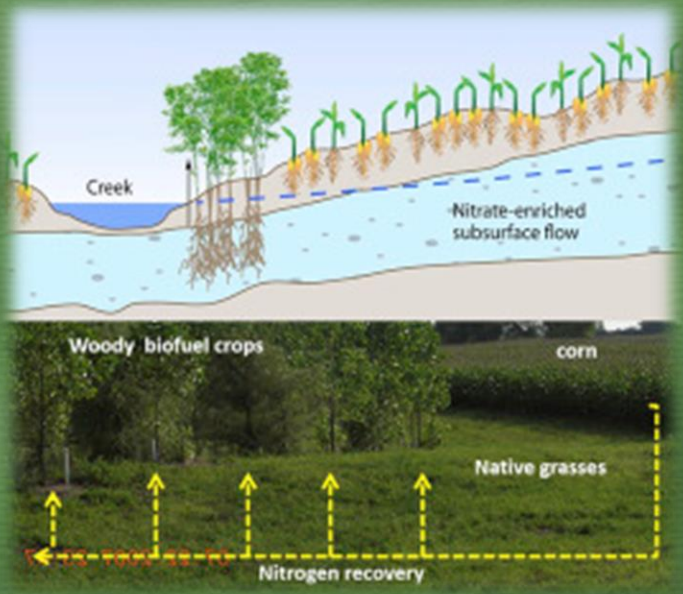




Other gas: less than 1%

Solutions

- Reduce carbon footprints
- Erosion control
- Waste water treatment
- Remediation of contaminated soil
- Nutrient management
- Carbon Sequestration
- Alternative to Carcinogens / Air Quality
- Landfill Relief



What Are Advanced Biofuels?

What are they?

Why do we need them?

What are they used for? (Yesterday, Today, Tomorrow)

How are they made?

Sustainability

Policy Considerations

Markets

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Yesterday: Early Automobiles

The Citröen Rosalie

Ford Model T

What Are Advanced Biofuels Used For?

Today

- Fueling Cars and Trucks

- Fueling Aircraft

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What Are Advanced Biofuels Used For?

Today

Ethanol Cook Stoves
Project Gaia: Nigeria,
Ethiopia, Haita, Brazil

What Will Advanced Biofuels Be Used For Tomorrow?

- **High octane fuels** for high mileage vehicles

- Hydrogen Carriers for **Fuel Cells**

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What Will Advanced Biofuels Be Used For Tomorrow?

- Military Aviation Fuels

- Military Marine Fuels

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What Will Advanced Biofuels Be Used For Tomorrow?

The Great Green Fleet

2012 Pacific Rim Exercises

2016 Expanded Emphasis

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What Will Advanced Biofuels Be Used For Tomorrow?

Rocket Fuel: Resupply Missions to the International Space Station

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What Are Advanced Biofuels?

How are they made?

Feedstock

Logistics

Technology

Agriculture and Forestry:

The Foundations of the Bioeconomy

Feedstocks

Logistics

Technology

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Feedstocks:

- Sugars, Starches
- Oil seed crops
- Grasses
- Trees and Forest Waste
- Agricultural Residues
- Algae
- Food/Animal Processing
- Energy Crops
- Thin Air

ADVANCED BIOFUELS USA

- **Advanced Biofuels USA Online Library Articles in Category: Atmosphere**
- **From Water to Hydrogen Biofuel – ASU Uses Light-Driven Energy Extraction** **July 9, 2018 –** by Helena Tavares Kennedy (Biofuels Digest) In Arizona, Arizona State University researcher Kevin Redding is working on biological, light-driven energy extraction. Redding, a biochemist who leads the Center for Bioenergy and Photosynthesis at ASU, is producing hydrogen …
- **Can Climate Change Be Stopped by Turning Air into Gasoline?** **June 20, 2018 –** by David Fridley and Richard Heinberg (Renewable Energy World) The headline of this article was composed simply by rephrasing the title of a popular recent piece in The Atlantic — "Climate Change Can Be Stopped by Turning Air into …
- **Solar Fuels Come Nearer: Direct-from-Air CO2 Capture Cost Drops below $100/Ton Threshold** **June 8, 2018 –** by Jim Lane (Biofuels Digest) A technology for direct air capture of carbon dioxide from the atmosphere, with a cost that "fully burdened with interest on capital, ranges from 94 to 232 $/t-CO2 depending on financial …
- **Bio-CCS and Bio-CCUS in Climate Change Mitigation–Market and Regulatory Issues Related to Bio-CCUS** **February 27, 2018** (International Energy Agency Bioenergy Task 41) The fourth IEA Bioenergy Task 41 workshop on Bio-CC(U)S was organized in Brussels 16 January 2018. The topic of the workshop was Market and regulatory issues related to Bio-CCUS. The workshop was …
- **Solar-to-Fuel System Recycles CO2 to Make Ethanol and Ethylene** **September 21, 2017 –** (Lawrence Berkeley National Laboratory) Solar-to-Fuel System Recycles CO2 to Make Ethanol and Ethylene — Scientists at the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) have harnessed the power of photosynthesis to convert carbon …
- **A Smart, Faster Path to Zero Lifecycle Emission: Advances from the EU in Direct Carbon Capture from Air** **August 8, 2017 –**
- by Jim Lane (Biofuels Digest) … The most scalable solution is liquid fuels that use water, captured CO2 and renewable electricity.
  … Thinkers have been coming around to the realization that this might be the most sustainable …

Process: 4th Generation

Direct-to-Fuel

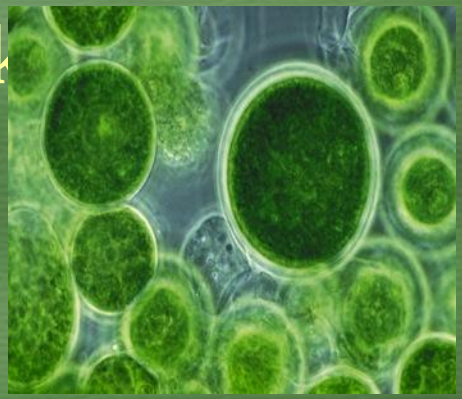
Solar Fuels

Electrofuels

Algenol's cyanobacteria

Examples of Potential Feedstock or Energy Crops

- Algae
- Corn stover
- Corn cobs
- Energy cane
- Sorghum
- Forestry waste
- Municipal waste
- Sawdust
- Chicken manure
- Agricultural residues
- Grasses such as
  - Switchgrass
  - Miscanthus
- Sugar beets
- Coffee grounds
- Jatropha
- Camelina
- Paper/pulp mill waste
- Used telephone poles
- Halophytes…



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

Sorghum

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

Sunflower or Jerusalem Artichoke

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

Canola

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

ENERGY GRASSES

Phragmites

Miscanthus

Arundo or Giant Reed

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

ENERGY GRASSES

Switchgrass

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

ENERGY GRASSES

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

AGRICULTURAL RESIDUES

Corn Stover, Cobs

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

Sugar Beet/Sugar Beet Pulp

Energy Beets

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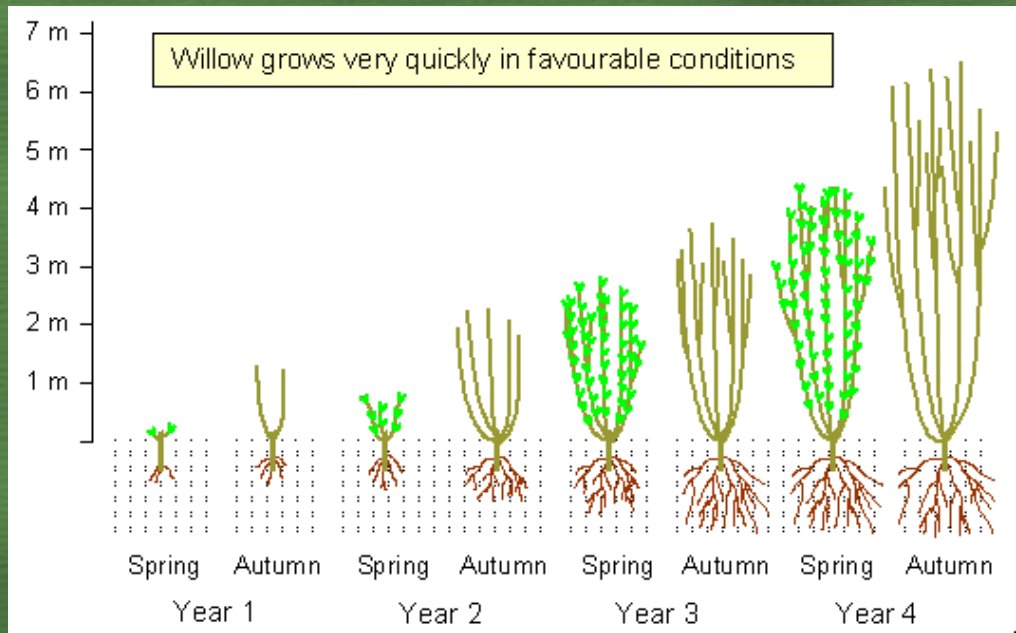
Examples of potential crops/plants which can be used for production of biofuels

Short Rotation Coppice
Willow
Poplar



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

Kenaf

Examples of potential other things which can be used for production of biofuels

Woody Biomass

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Examples of potential other things which can be used for production of biofuels

Sorted Municipal Solid Waste

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Examples of potential other things which can be used for production of biofuels

Algae

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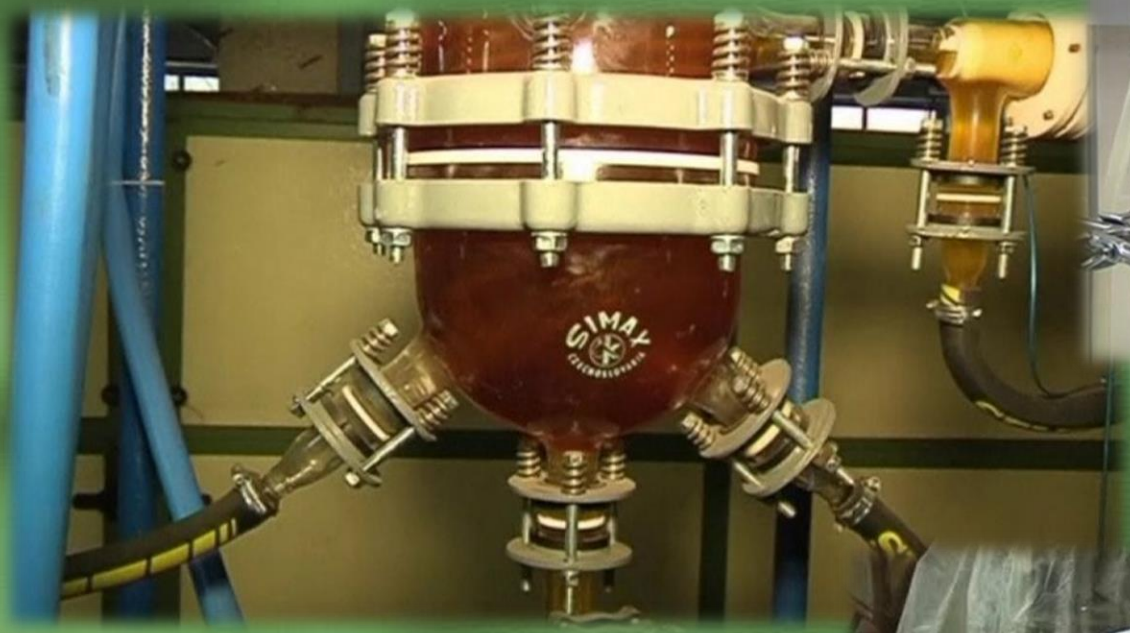

Leather “Fleshings”

Used cooking oils and grease

Landfill Refueling Stations

Agriculture:

The Foundation of the Bioeconomy

Feedstocks

Jobs Related to Feedstocks

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A Few Types of Jobs Available in Advanced Biofuels Feedstock Development and Production

- Agronomists
- Farmers
- Farm workers
- Farm equipment designers
- Biologists
- Biologists specializing in genetic research
- Biologists specializing in plant cells
- Chemists

Chemical engineers

Researchers into bioenergy crop development

- Agriculture/horticulture experts
- Freight railroad operators, engineers, loaders, unloaders
- Equipment operators, technicians
- Farm product purchasers/traders
- Agricultural and Forestry Supervisors
- Agricultural Inspectors
- Computer Software Engineers
- Others?

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What Are Advanced Biofuels?

How are they made?

Feedstock

Logistics

Technology

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Logistics: Harvest, Storage, Transport

Single-Pass Combination Harvester

AGCO Corporation's single-pass combination harvester saves time and money on corn stover collection by simultaneously harvesting grain and baling corn stover residues in one operation.

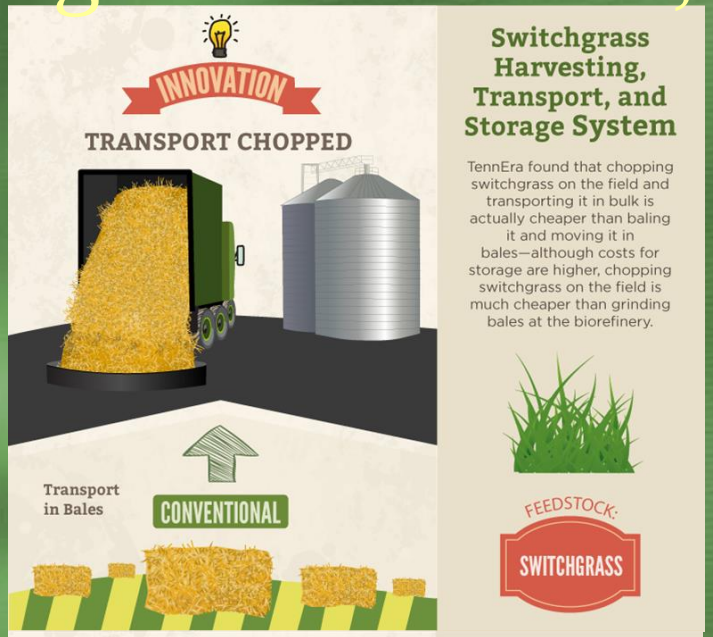
FEEDSTOCK: CORN STOVER

Self-Propelled Bale Picking Truck

Instead of picking up corn stover bales one by one, FDC Enterprises' bale picking truck picks up two at a time for a full load of 36 bales instead of 12 and can transfer them straight onto a truck bed.

FEEDSTOCK: CORN STOVER

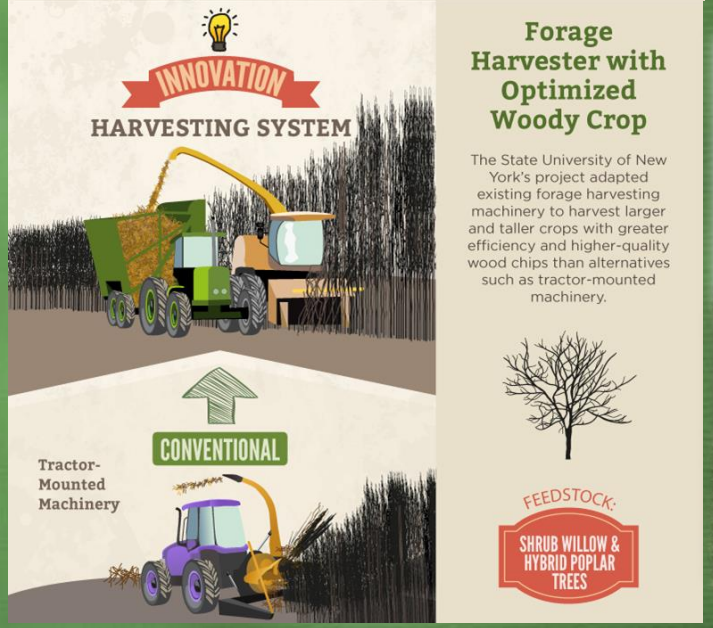
Logistics: Harvest, Storage, Transport



Switchgrass Harvesting, Transport, and Storage System

TennEra found that chopping switchgrass on the field and transporting it in bulk is actually cheaper than baling it and moving it in bales—although costs for storage are higher, chopping switchgrass on the field is much cheaper than grinding bales at the biorefinery.

FEEDSTOCK: SWITCHGRASS



Forage Harvester with Optimized Woody Crop

The State University of New York's project adapted existing forage harvesting machinery to harvest larger and taller crops with greater efficiency and higher-quality wood chips than alternatives such as tractor-mounted machinery.

FEEDSTOCK: SHRUB WILLOW & HYBRID POPLAR TREES

Logistics: Harvest, Storage, Transport

What Are Advanced Biofuels?

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Processes

Biochemical

- Fermentation
- Plant extraction
- Transesterification
- Hydrolysis
- Enzymatic Catalysis
- CO2-to-liquid bio-catalytic conversion

Thermochemical

- Gasification
- Plasma arc gasification
- Pyrolysis
- Thermochemical conversion of sugars

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Aviation Fuel Processes

- Alcohol to Jet (ATJ)
- Catalytic Conversion of Oil to Jet (CCOTJ)
- Catalytic Conversion of Sugar to Jet (CCSTJ)
- Catalytic Hydrothermolysis, Hydroprocessing to Jet (CH-HRJ)
- Direct Fermentation of Sugar to Jet (DFSTJ)
- Fischer-Tropsch Synthesized Paraffinic Kerosene (FT-SPK)
- Hydrotreated Depolymerized Cellulosic Jet (HDCJ)
- Hydroprocessed Esters & Fatty Acids (HEFA)
- Synthesized Iso-Paraffinic Fuel (SIP)

Certification: Continuing Our Progress

SIP
June 1, 2014

2015
2014
2013
2012
2011
2010
2009

Sugar

Also Called
DSHC

Also Called HRJ or
Bio-SPK

HEFA
July 1, 2011


Plant/Animal
Oils

Drop-In Fuel
Spec

ASTM D7566
Sept 1, 2009

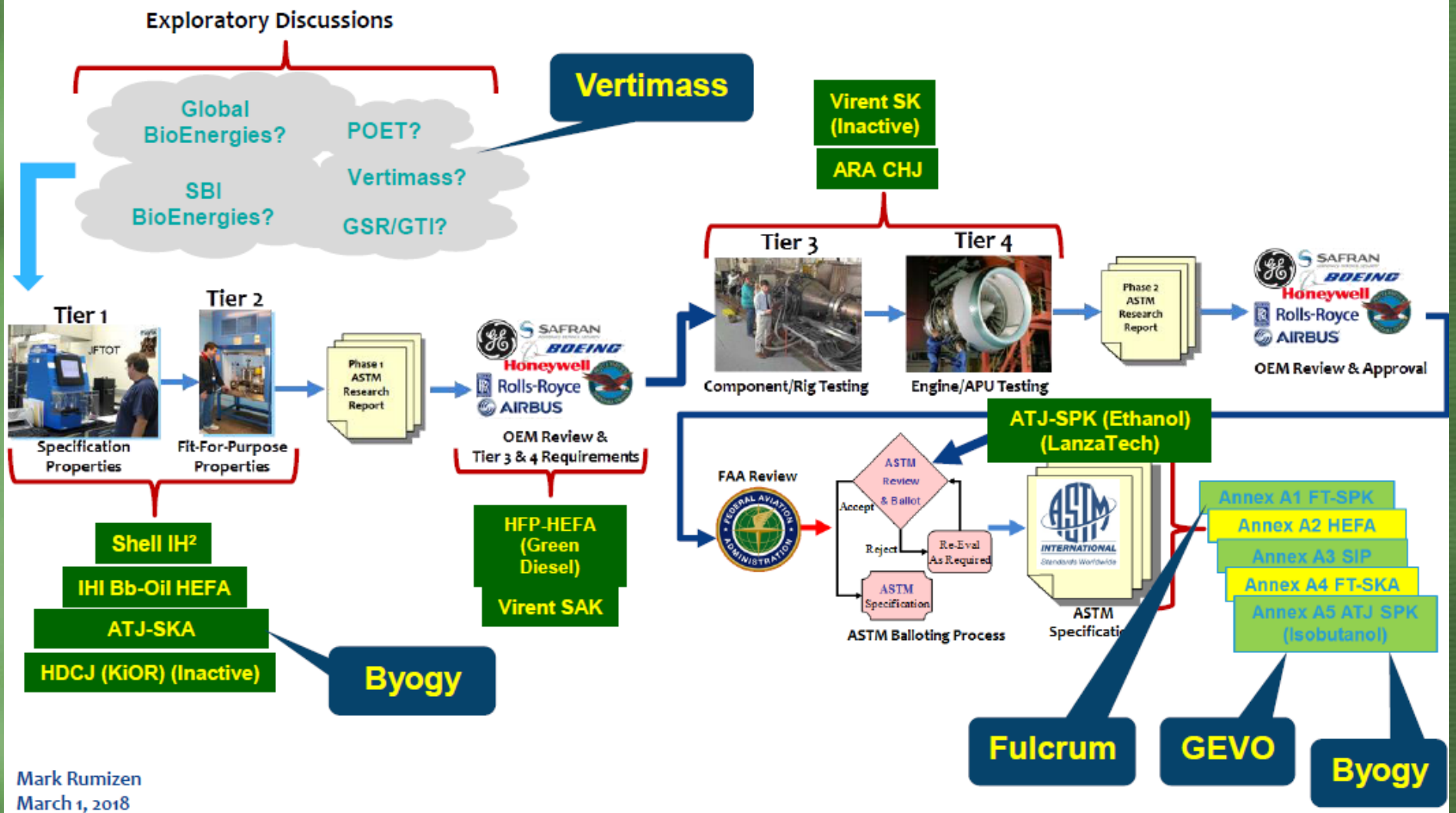
FT
Sept 1, 2009


Coal


Biomass


Natural
Gas

ASTM D4054 Qualification Status



Mark Rumizen
March 1, 2018

A Few Types of Jobs Available in Advanced Biofuels Production

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

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Project Gaia---based in Gettysburg, PA

Ethanol Cook Stoves
Project Gaia: Nigeria, Ethiopia, Haita, Brazil

Eradicating Energy Poverty by Increasing Access to Sustainable Cooking Fuels

Ethanol cook stoves

Articles in Category: Cooking Fuel

- **Vivo Energy Kenya and Koko Networks Form Ethanol Cooking Fuel Partnership** **July 3, 2018 –** (Koko Networks) Vivo Energy becomes first multinational fuels company to enter Kenyan market for ethanol cooking fuel, using KOKO technology to enable affordable mass-market access.
  Vivo Energy Kenya today announces a partnership with KOKO Networks ("KOKO") that …
- **Cenergy Launches Global Biogas Capture and Utilization Program** **June 15, 2018 –** (Cenergy Solutions/NGV Journal) Cenergy Solutions has a Biogas Capture and Utilization System (BCU System) to help farms and communities around the world economically store and use their biogas instead of venting or flaring it. It is …
- **'Biogas Backpack' Successfully Tested in Uganda** **May 15, 2018 –** (Bioenergy Insight) A Ugandan and German team called 'Agali Awamu' has developed an 'innovative and feasible' solution for electricity and biogas supply in Uganda.
  The project was facilitated by the lab of tomorrow, an organisation run by the …
- **Burning of Biofuels, Suspended Dust Emit 48% of Total Pollution in Mumbai** **May 7, 2018** by Virat A Singh (Daily News and Analysis India) … "The sector-wise figures would not have changed substantially though its a 2016 study and one has to understand that apart from industries, the main contributor …
- **New Research Shows the Health Benefits of Ethanol-Fueled Cookstoves** **May 7, 2018 –**by Jieyi Lu (Environmental and Energy Study Institute) Today, about three billion people still cook and heat their homes with traditional stoves and solid fuels worldwide. These fuels and stoves are major contributors to household air …
- **New Fuels Project in China Targets Cooking in the Commercial Sector** **May 3, 2018 – 3:54 pm** (Global Alliance for Clean Cookstoves) The Alliance partnered with China's Ministry of Agriculture, Shell, local governments, and SSM to develop and launch a new clean cooking project in Zhejiang province of China. The project aims to …

Project Gaia---based in Gettysburg, PA
Humanitarian Assistance, Refugee Camps

Families living in refugee camps suffer from energy poverty at its most extreme. Already high levels of environmental degradation are exacerbated by fuelwood collection. Increasing deforestation forces refugee women and girls to travel greater and greater distances in search of already scarce resources, leaving them vulnerable to violence and injury.

Project Gaia became an official implementing partner of the United Nations High Commissioner for Refugees (UNHCR) in 2005 and administers the organization's Safe and Clean Household Energy Program.

Project Gaia---based in Gettysburg, PA refugee camp project

Other projects:

Project Gaia---based in Gettysburg, PA

Less than 2% of Haiti's forest cover remains — but Haitians continue to depend on charcoal and firewood, both polluting fuels that have devastated the environment of both Haiti and the Dominican Republic. Haiti is a case of extreme energy poverty – one which calls for sustainable & domestic fuel solutions.

Haiti was once a leading alcohol-producing nation but currently produces only a fraction of its potential. Project Gaia believes that sugarcane mills and alcohol distilleries represent a ready infrastructure for a clean energy future.

Project Gaia and partners are working to commercialize the stove and fuel, revitalize local agriculture, diversify crops, build industry, and lay the groundwork for a sustainable supply of fuel production both internationally and locally. We are working closely with the Haitian company Novogaz, as our local partner on the ground, for the dissemination of clean ethanol stoves and fuel. The US ethanol producer, POET, one of the world's largest ethanol producers has helped to catalyze the Haitian market with the first batch of donated ethanol. POET is continuing to provide technical support to all partners and actively engage in seeing the market for clean fuel in Haiti become a commercial success. The first rollout of stoves and fuel began in early 2015.

Project Gaia---based in Gettysburg, PA -- INDIA Project

A Gendered Problem

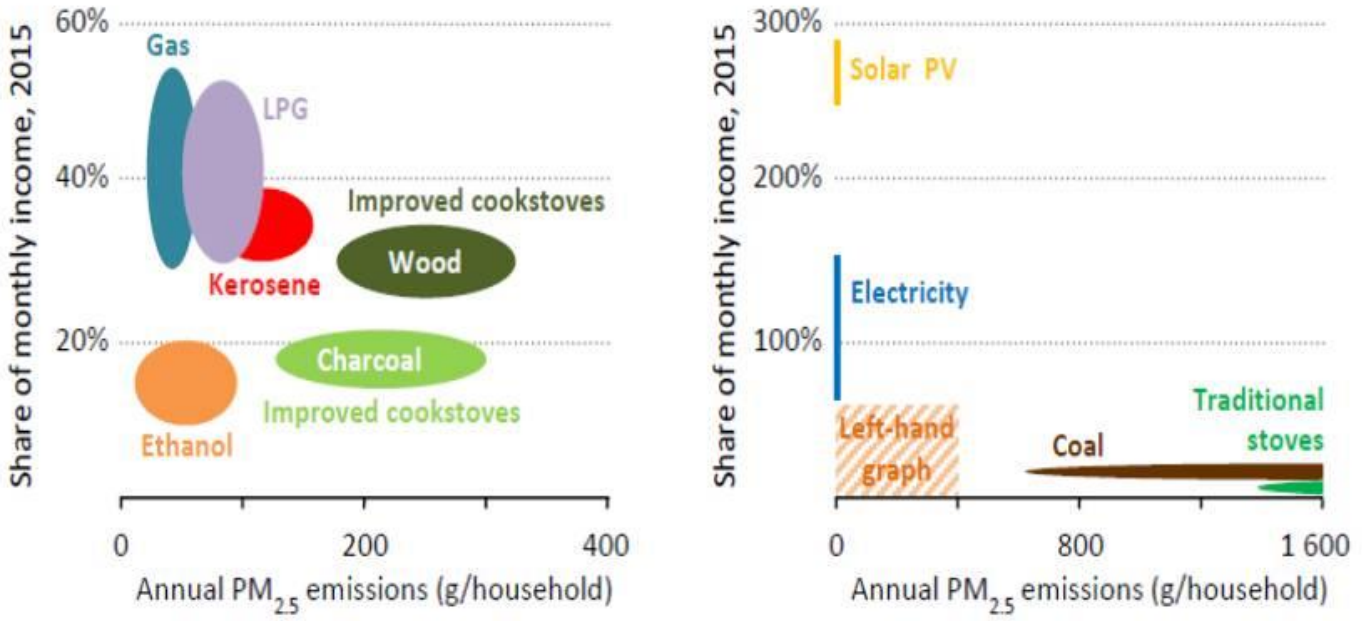
Approximately 400 million people in India are exposed to indoor air pollution from cooking fires and subsequently suffer from a number of directly-related ailments, including respiratory and pulmonary disease, cataracts, and premature death. As is the case around the world, women are disproportionately affected. Being the primary preparers of food, women comprise nearly 90% of those most extensively exposed in India. Beyond exposure to indoor air pollution, Indian women must spend five to eight hours each day on cooking-related activities when using traditional solid fuels, with 20% of that time spent on fuel collection.

Beyond the Household Level: Effect of Cookstove Smoke on the Himalayas

The negative effects of solid fuel use are not confined to the household level; indeed, they have a much larger impact. The incomplete combustion of biomass produces black carbon, the second most heat-trapping pollutant in our atmosphere after CO2. This black carbon settles on Himalayan glaciers, accelerating the melting process and consequently threatening India's water supply.

Renewable Cooking Fuel—India Study

Figure 3.9 ▷ Investment cost of cookstoves as a share of an Indian household's monthly average income and associated $PM_{2.5}$ emissions



Notes: g/household = grammes per household. $PM_{2.5}$ emissions are calculated as the absolute level of emissions emitted in one Indian household over a year with their cookstove.

Source: GACC (2016).

“Advanced Biofuels: Transportation, Cooking and Energy Storage”

Overview

- Advanced Biofuels Basics
- Renewable Cooking Fuel
- New Research on Liquid Energy Storage
- Q&A throughout

ADVANCED BIOFUELS USA

Articles tagged with: energy storage

Compound Could Transform Energy Storage for Large Grids **February 7, 2018** (Phys.Org/University of Rochester) In order to power entire communities with clean energy, such as solar and wind power, a reliable backup storage system is needed to provide energy when the sun isn't shining and the …

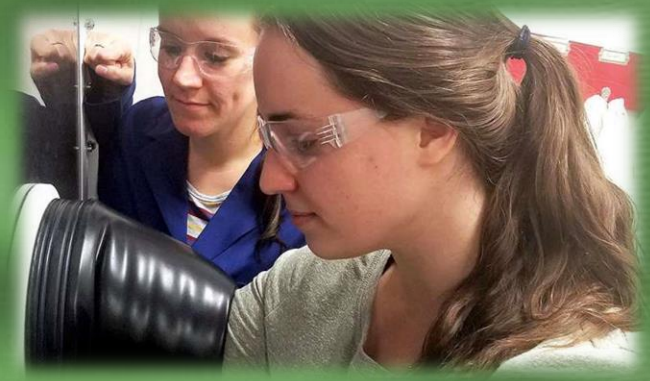
Ethanol's Next Breakthrough? Turning Greenhouse Gas into Fuel. **February 5, 2018** by Kevin Hardy (Des Moines Register) … Scientists at Oak Ridge National Laboratory unintentionally uncovered a process that uses tiny bits of carbon and copper to convert the greenhouse gas carbon dioxide into ethanol fuel.
While the research remains in …

What is Renewable Methane? **December 14, 2017 –** by Cliff Gladstein (ACT News) … Attitudes toward the utility of natural gas as the environmentally preferred fuel began to change when technologies to effectively extract natural gas from local shale formations—a process called hydraulic fracturing, or …

SoCalGas Model Energy Design Includes RNG Focus **December 14, 2017 –** by Betsy Lillian (NGT News) Southern California Gas Co. (SoCalGas) is partnering with the University of California-Irvine's Advanced Power & Energy Program to design an "Advanced Energy Community" in an underserved neighborhood in Huntington Beach.
The community …

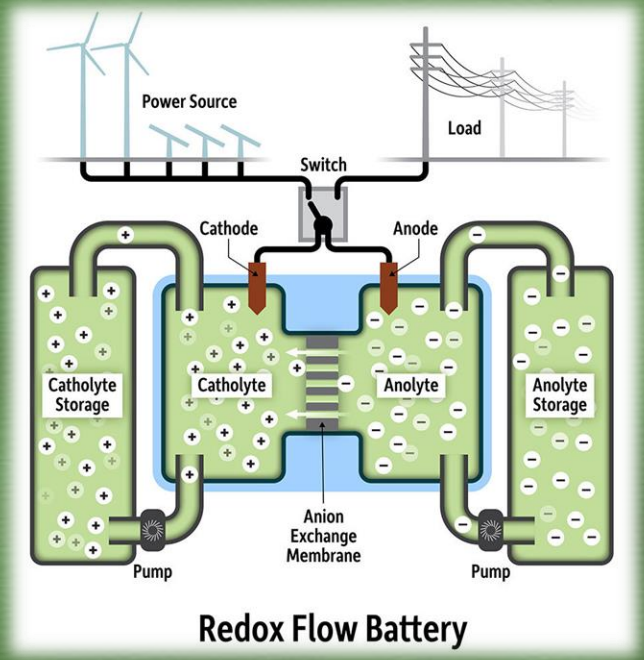
Turning Brewery Wastewater into Battery Power **October 12, 2016 –** (University of Colorado Boulder) CU Boulder engineers have developed an innovative bio-manufacturing process that uses a biological organism cultivated in brewery wastewater to create the carbon-based materials needed to make energy storage cells.

Ethanol and Methanol derived compounds as energy storage for Redox Flow Battery



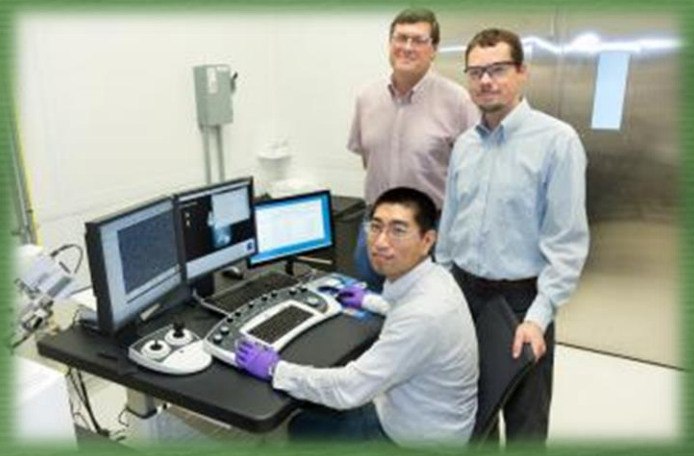
Ellen Matson, left, assistant professor of chemistry, and PhD student Lauren VanGelder at work in Matson's lab. VanGelder is lead author on a paper describing modifications to a redox flow battery that make it nearly twice as effective for electrochemical energy storage.

Credit: University of Rochester photo / Matson Lab



- The key to this technology, called a redox flow battery, is finding chemicals that can not only "carry" sufficient charge, but also be stored without degrading for long periods, thereby maximizing power generation and minimizing the costs of replenishing the system.
- Replacing the compound's methanol-derived methoxide groups with ethanol-based ethoxide ligands—the team was able to expand the potential window during which the cluster was stable, doubling the amount of electrical energy that could be stored in the battery.

Nano-spike catalysts convert carbon dioxide directly into ethanol



- Oak Ridge National Laboratory have developed an electrochemical process that uses tiny spikes of carbon and copper to turn carbon dioxide, a greenhouse gas, into ethanol.
- The team used a catalyst made of carbon, copper and nitrogen and applied voltage to trigger a complicated chemical reaction that essentially reverses the combustion process.
- The solution of carbon dioxide dissolved in water turned into ethanol with a yield of 63 percent.

Energy Storage in Renewable Methane via Power-to-Gas

- By running an electric current through water, the water molecule decomposes into hydrogen and oxygen. The hydrogen is then captured and is either used directly or mixed with carbon dioxide to create methane.
- The methane can be injected into existing natural gas infrastructure where it can be stored indefinitely, or used for power production, vehicle fuel, residential heating and cooking, manufacturing or as an industrial feedstock.
- Power-to-Gas, provides a solution to renewable energy storage, helps communities decarbonize their gas supply and can supply potentially endless volumes of clean hydrogen and renewable methane to power transportation.
- Natural gas engines can replace diesel engines. To ensure that we can both enjoy the air quality and climate protection benefits of near zero emission natural gas engines, they should be fueled by renewable methane.

1930's Huntington Beach, CA post 1920's oil boom

Southern California Gas Co. (SoCalGas) is partnering with the University of California-Irvine's Advanced Power & Energy Program to design an "Advanced Energy Community" in an underserved neighborhood in Huntington Beach.

Energy options: solar, wind and renewable natural gas (RNG) and storing wind- and solar-generated energy with power-to-gas technology.

- In 2016, the University of California-Irvine demonstrated the use of power-to-gas technology to use excess solar-generated electricity on the university's campus.

- Installation of a novel bioreactor system that will be used to test power-to-gas technology at the U.S. Department of Energy's National Renewable Energy Laboratory in Golden, Colo.
-
- By 2025, between 3,300 and 7,800 GWh of excess solar and wind energy will be curtailed in California.

- If all that excess solar and wind energy were converted to methane through the biomethanation process and stored as RNG, it would provide enough renewable energy to heat 158,000 to 370,000 homes or provide renewable electricity to 80,000 to 187,000 homes, according to the utility.

1950's Oil gusher in Huntington Beach, CA

Huntington Beach, California, USA. 20th Jan, 2018. Offshore oil rig platforms off the coast of Huntington Beach in Orange county. The Trump administration recently proposed the largest expansion of offshore oil and gas drilling in U.S. history, releasing a plan to allow new drilling off the coasts of Northern, Central and Southern California.'Today we're embarking on a new path for energy dominance in America, ' U.S. Interior Secretary Zinke said. Credit: ZUMA Press, Inc./Alamy Live News

What we have now

What we could have

University of Colorado Boulder engineers have developed an innovative bio-manufacturing process that uses a biological organism cultivated in brewery wastewater to create the carbon-based materials needed to make energy storage cells.

- They can't just dump it into the sewer because it requires extra filtration.
- A fast-growing fungus, *Neurospora crassa*, cultivated in the sugar-rich brewery wastewater
- One of the most efficient naturally-derived lithium-ion battery electrodes known to date while cleaning the wastewater in the process.

- The findings were published recently in the American Chemical Society journal *Applied Materials & Interfaces*.
- If the process were applied on a large scale, breweries could potentially reduce their municipal wastewater costs significantly while manufacturers would gain access to a cost-effective incubating medium for advanced battery technology components.

Find out more: **www.AdvancedBiofuelsUSA.org**

For a Truly Sustainable, Renewable Future

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