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Running Green: Making the Switch to Biofuels

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Regional Biofuels Workshop, Hickory

August 22, 2014

Goal of this Presentation

To give the audience an understanding of

- What biofuels are,
- Where they come from,
- Why they are important
- Consideration in their usage
- Where they can be sourced in Western North Carolina or the surrounding region

Why the interest in biofuels?

- The USA (both President Bush and President Obama) has made energy security a priority
- Europe has made addressing climate change a priority
- Brazil (and other developing nations) see biofuels as an important driver of economic growth and rural development

Energy Independence and Security Act of 2007

- Legislation that created the second version of the US Renewable Fuel Standard (aka "RFS2")
- A biofuels mandate which requires that 36 billion gallons of renewable fuels be used in the United States by 2022.
- Went into effect in mid-2010. Large impact on US Biofuel production.

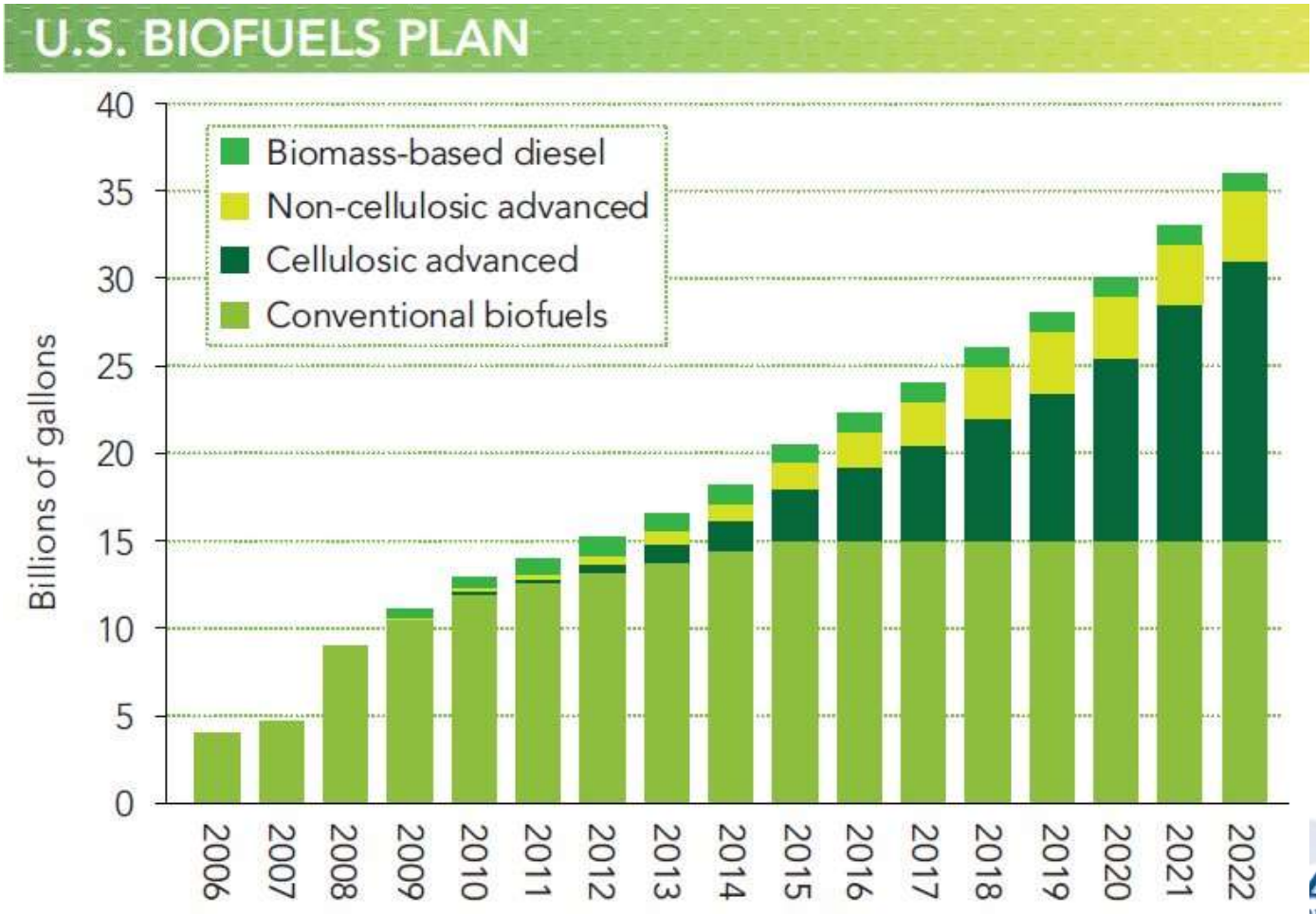
EISA Renewable Fuel Volume Requirements (billion gallons)

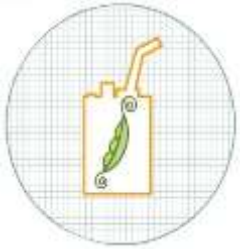
Year	Cellulosic biofuel requirement	Biomass-based diesel requirement	Total Advanced biofuel requirement	Total renewable fuel requirement
2008	n/a	n/a	n/a	**9.0**
2009	n/a	0.5	0.6	**11.1**
2010	0.1	0.65	0.95	**12.95**
2011	0.25	0.80	1.35	**13.95**
2012	0.5	1.0	2.0	**15.2**
2013	1.0	a	2.75	**16.55**
2014	1.75	a	3.75	**18.15**
2015	3.0	a	5.5	**20.5**
2016	4.25	a	7.25	**22.25**
2017	5.5	a	9.0	**24.0**
2018	7.0	a	11.0	**26.0**
2019	8.5	a	13.0	**28.0**
2020	10.5	a	15.0	**30.0**
2021	13.5	a	18.0	**33.0**
2022	16.0	a	21.0	**36.0**
2023+	b	b	b	**b**

[a] *To be determined by EPA through a future rulemaking, but no less than 1.0 billion gallons.*

[b] *To be determined by EPA through a future rulemaking.*

US Renewable Fuel Standard





What are biofuels?

Biofuels are liquid fuels derived from biomass, or recently living plant or animal material.

Petroleum-based fuels are derived from plant or animal material that was alive millions of years ago.

Biofuel Types

- Ethanol (dominant biofuel in USA)
  - 13 billion gallons in 2012, 12 billion corn ethanol, 1 billion sugarcane ethanol (mostly from Brazil)
- Biodiesel & Renewable Diesel
  - 1.8 billion gallons in 2013
- Advanced Biofuels (Cellulosic Ethanol, Algal Fuels)
  - 5-6 Plants coming online in 2014/early 2015

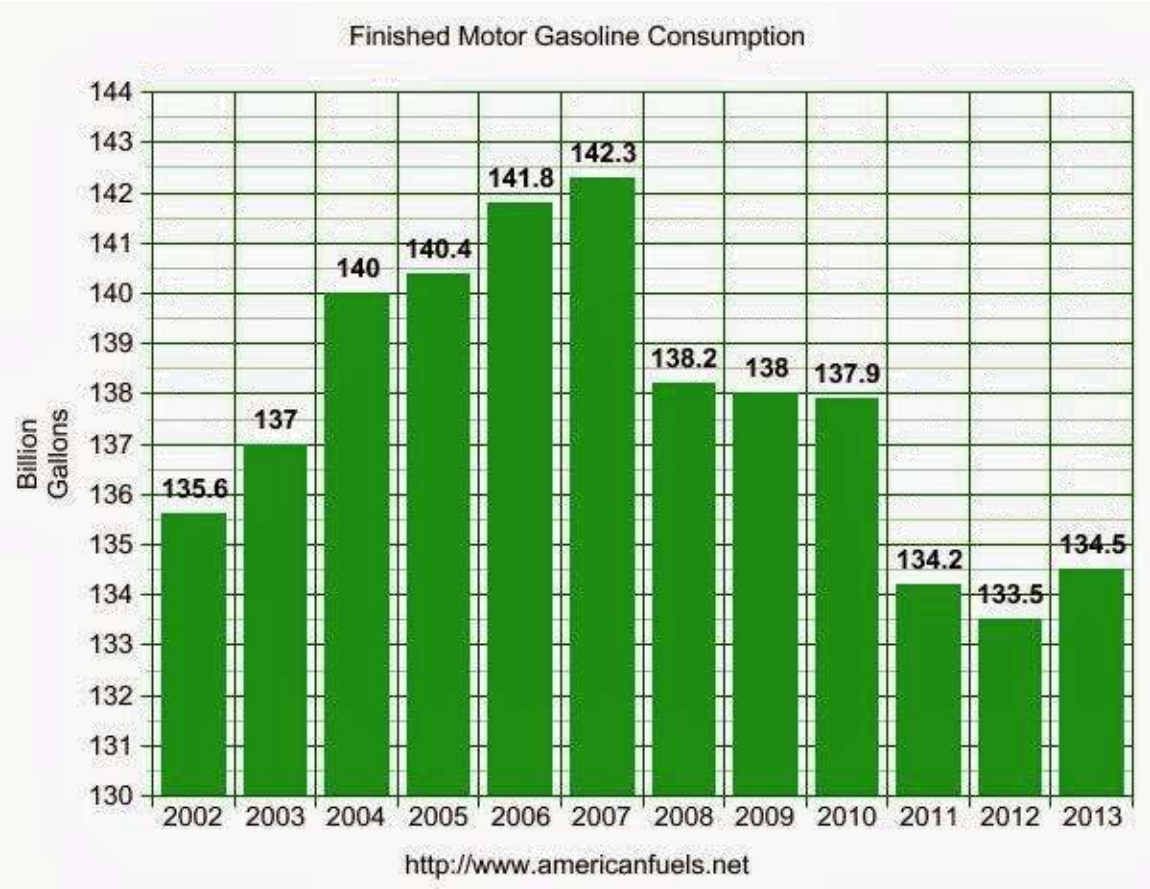
Biofuels for Gasoline Engines

FUEL ETHANOL

Rise of corn ethanol in the USA

- Growth in the US ethanol market due to following factors:
  - Need for a replacement for MTBE (oxygenate replacement) to boost octane and improve air emissions
  - Desire from agricultural industry for better corn prices (additional market for corn)

Gasoline Consumption in the USA

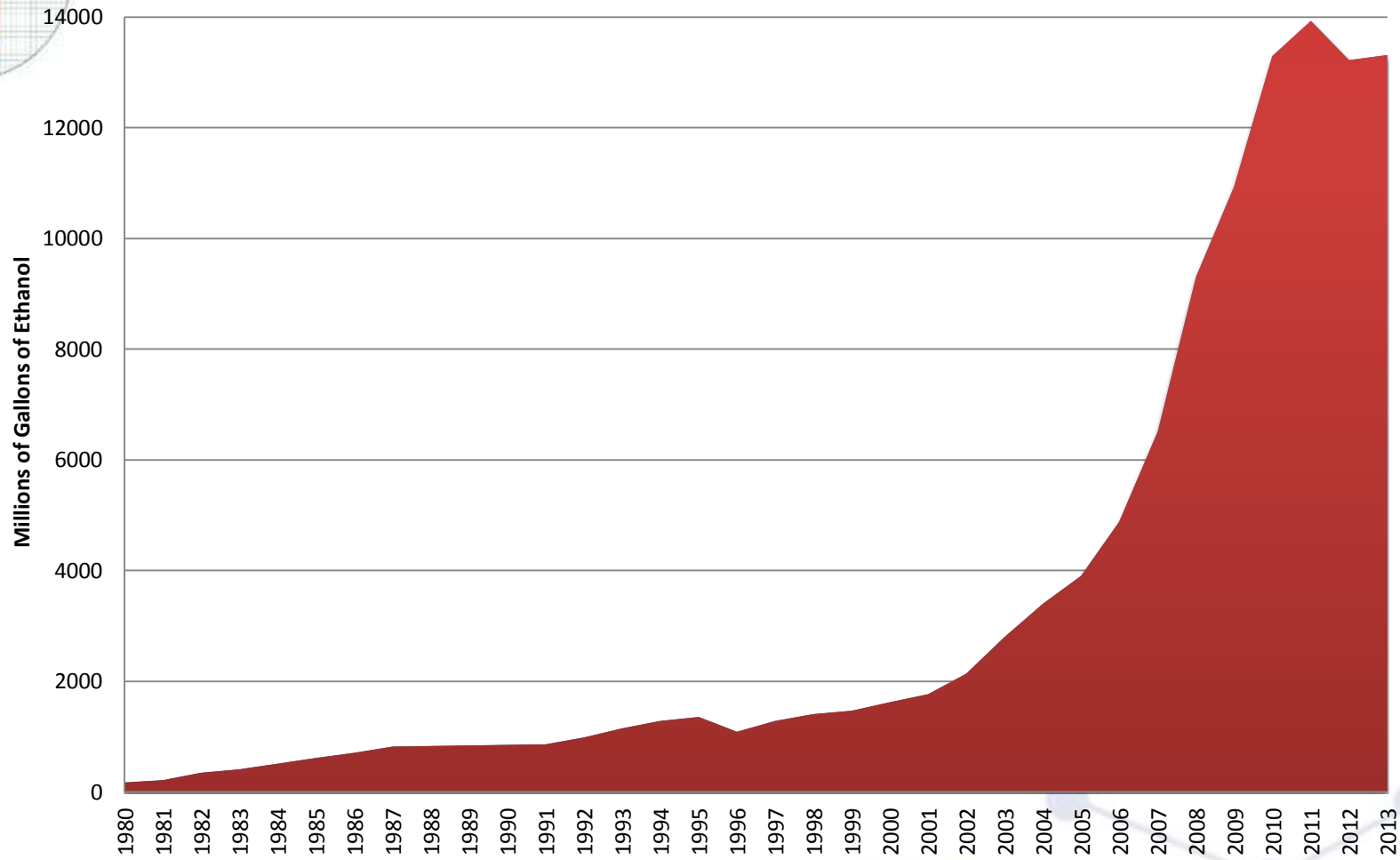


The USA consumed approx. 134.5 billion gallons of gasoline last year.

The United States relied on net imports (imports minus exports) for about 40% of the petroleum

Dependence on Foreign Oil has decreased since its peak in 2005.

US Ethanol Production



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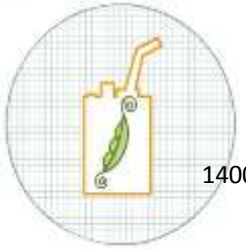
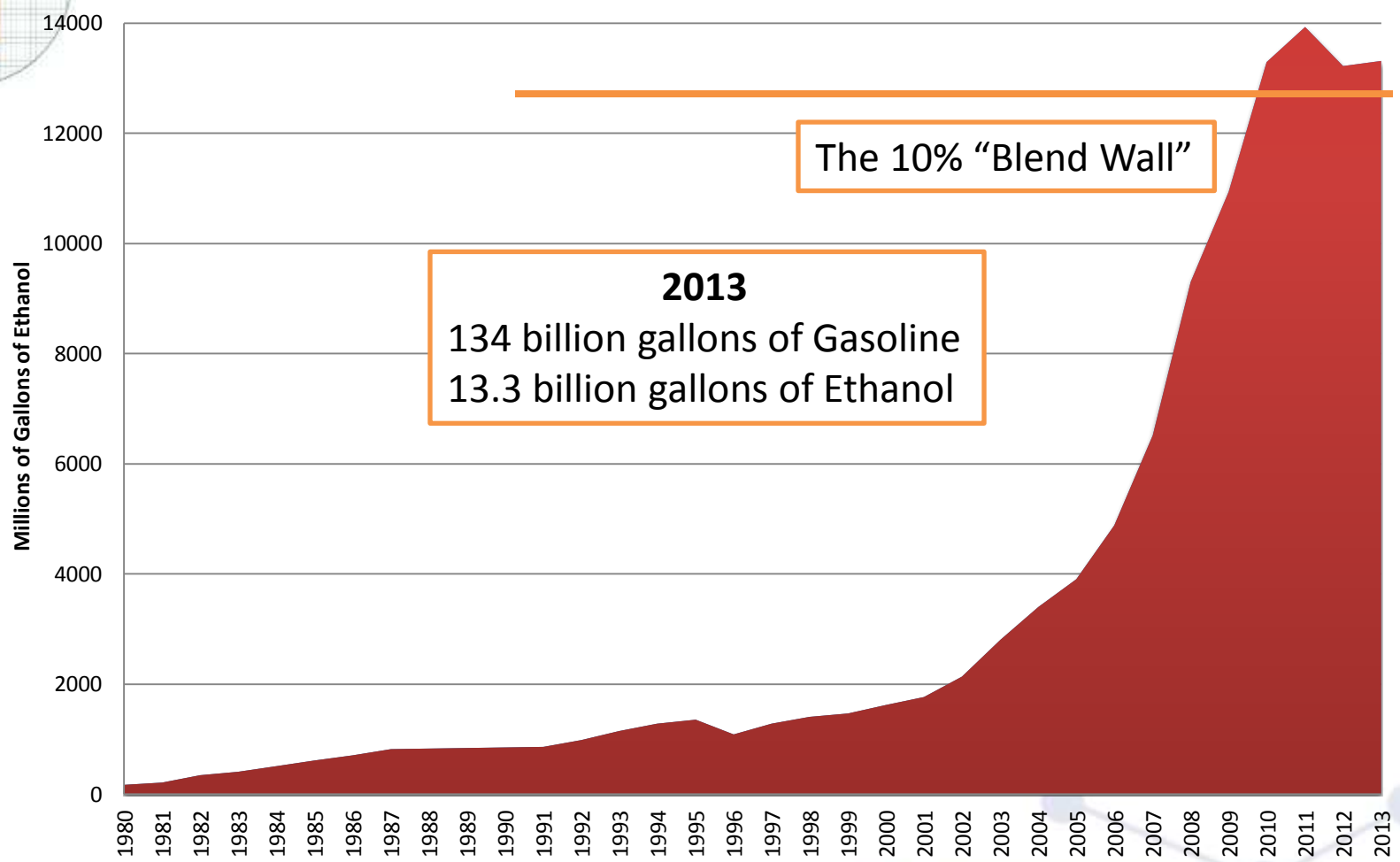


US Ethanol Production



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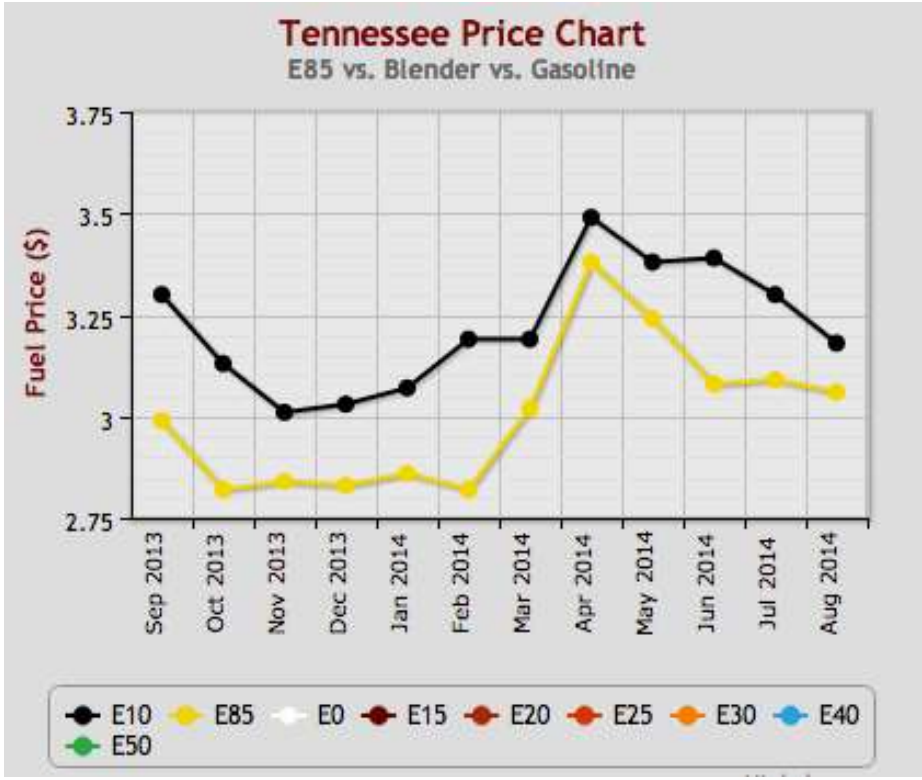
E85 and Flex Fuel Vehicles

- >16 million E85 capable vehicles on the road in the USA, approx. 3,200 stations
- FFVs typically get about 25-30% fewer miles per gallon when fueled with E85
  - Ethanol's energy content ~34% lower per unit volume than gasoline
- Simple modifications to the vehicles
  - Sensor automatically detects the alcohol/gasoline mix
    - *Adjusts fuel injection and spark timing according to the gas/EtOH blend level*
  - Material compliant elastomers used



Avg. Price Spread of 4.43%

FLEXFUEL E85 ETHANOL

FLEX FUEL

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Where to get fuel ethanol?

- Most gasoline in the United States contains about 10% ethanol
- Only about 3200 stations have E85 pumps, out of a total of about 176,000 stations (1.8%)
- Previously there were E85 stations in Western NC
- Closest E85 Stations to you can be located through the DOE's Alt Fuels Data Center: http://www.afdc.energy.gov

Biofuels for Diesel Engines

BIODIESEL

What is Biodiesel?

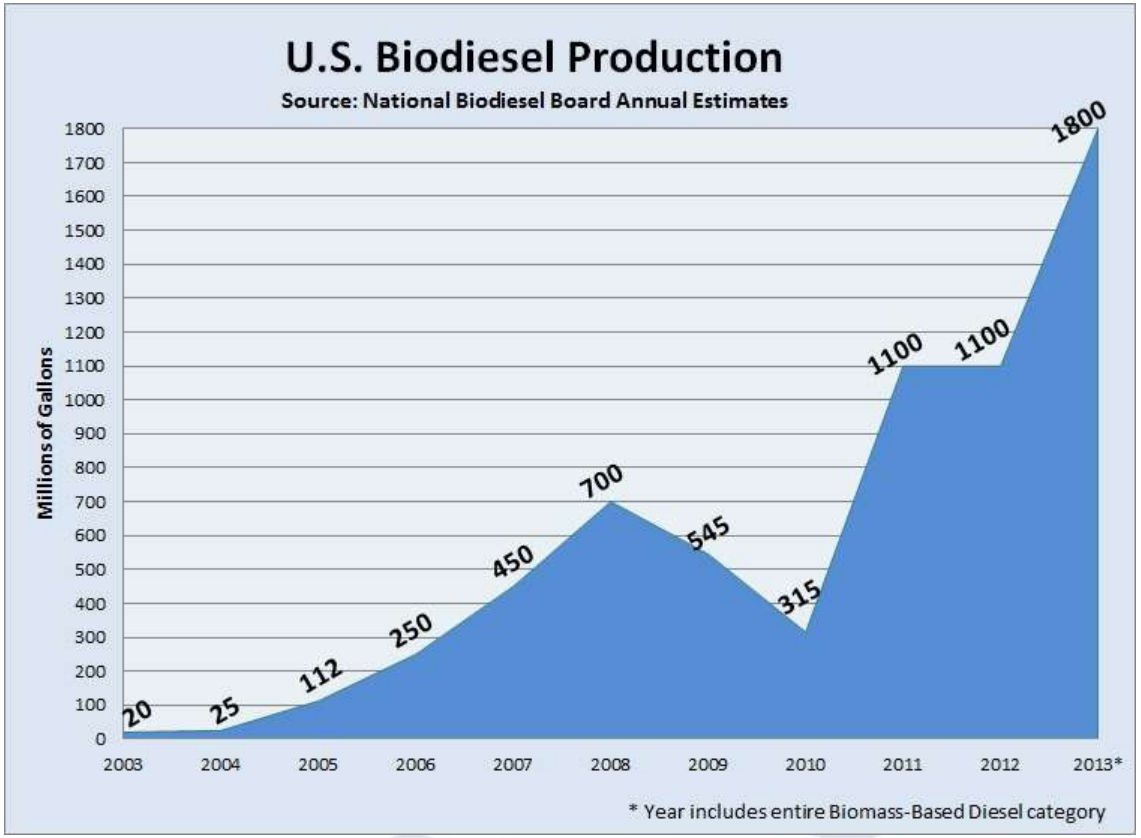
- Biodiesel: a renewable fuel produced to an ASTM standard (d6751) that can be used as an additive, supplement, or substitute for diesel fuel and heating oil.
- Biodiesel is made from vegetable oil or animal fats. (Biodiesel is *not* vegetable oil.)
- Biodiesel is recognized as a fuel by the US Dept. of Energy, US Dept. of Transportation, and US Environmental Protection Agency.

US Biodiesel

- **Dollar tax credit**
  - In both 2011 and 2012 it was retroactively approved at the end of the year. In 2012 it was applied for 2 years.
  - Still no word on a retroactive producers credit for 2014.

Recent News

- Home heating oil is now approved for RFS



Applications of Biodiesel

- As a neat fuel (B100).
  - All diesel vehicles can use up to 100% biodiesel without modification, however there are special considerations to be aware of (see next slides)
- As a medium-level blend (B20-B50).
  - Most OEMs moving to officially approve up to 20% blends
  - Practically, all vehicles can use of up to 20% with no difference in performance
- As a low-level blend (1% - 5%). Small amounts of biodiesel can restore lubricity to low-sulfur fuels.
  - Current ASTM definition of diesel fuel (d975) includes up to 5% biodiesel
  - No labeling requirement for up to 5% blends
- Bioheat
  - Biodiesel can be used as supplement for home heating oil

Biodiesel is easy to use (no modifications required)

- Biodiesel works in nearly any diesel engine from B5-B100
- Up to B20 may use existing fueling infrastructure.
- Biodiesel is widely available
- Biodiesel Handling and Use Guidelines available online **(Google "NREL Biodiesel Handling & Use")**

Materials Compatibility

- Biodiesel is a solvent – it may dislodge and "clean" the fuel system.
  - Any dirt or debris on the inside of the fuel tank or in the fuel lines may be dissolved and lead to fuel filter clogging.
- Biodiesel will remove paint, varnish, and will dissolve asphalt with prolonged exposure.
  - Always clean spills, and wipe any fuel off that spills around the vehicle fuel filling port.
- Hoses, seals, & gaskets – All rubber components should be replaced with biodiesel compatible elastomer materials.
  - Usually less of an issue for vehicles produced after 1994.
  - Not generally an issue for biodiesel blends of B20 and less.
  - For blends from B20 to B100, Viton is the generally recommended elastomer material, though others have also been shown to work
  - Alternating use of biodiesel and diesel fuel can cause leaking gaskets (shrinking and swelling).
- Metals - brass & copper fuel system components may be a concern.

Cold Weather Performance

Biodiesel will begin to freeze ("cloud point" and "pour point") at relatively high temperatures, depending on the feedstock and the blend level.

- In Western NC, B100 from UCO is fine during non-winter months, and blends ≤B50 may be used during the winter months to avoid problems.

Table 5. Cold Flow Data for Various B100 Fuels[15]

Test Method for B100 Fuel	Cloud Point (ASTM D2500)		Pour Point (ASTM D97)	
	(°F)	(°C)	(°F)	(°C)
Soy Methyl Ester	32	0	25	-4
Canola Methyl Ester	26	-3	25	-4
Lard Methyl Ester	56	13	55	13
Edible Tallow Methyl Ester	66	19	60	16
Inedible Tallow Methyl Ester	61	16	59	15
Yellow Grease 1 Methyl Ester	–	–	48	9
Yellow Grease 2 Methyl Ester	46	8	43	6

Source: NREL Biodiesel Handling & Use Guide, 4th Edition

Biodiesel Shelf Life

Biodiesel is less stable than diesel fuel, and needs to be used more quickly

- Biodiesel should normally be used within 6 months.
  - Never store more than one year, unless specific storage precautions are taken.
- Storage is best in a cool, low moisture vessel, shaded from direct sunlight.
- Keep the storage tank as full as possible.
- Recommended to use biocide and a tank vent desiccant.

Biodiesel Energy Content

Biodiesel has a lower energy content than diesel fuel:

- Soy biodiesel has 12.5% less energy than diesel per pound. However, biodiesel is slightly denser than diesel, so when measured by volume biodiesel contains just 8% less energy.
- Improved combustion due its higher cetane number and superior lubricity of biodiesel make up for loss in energy content.
- Most drivers will not notice any power or mileage loss due to use of biodiesel (even B100), though very minor loss is theoretically possible.

	Btu/lb	Btu/gal
• **#2 Diesel**	18,300	129,050
• **Biodiesel**	16,000	118,170
	(12.5% less)	(8.5% less)

Biodiesel Quality

ASTM D 6751 Standards

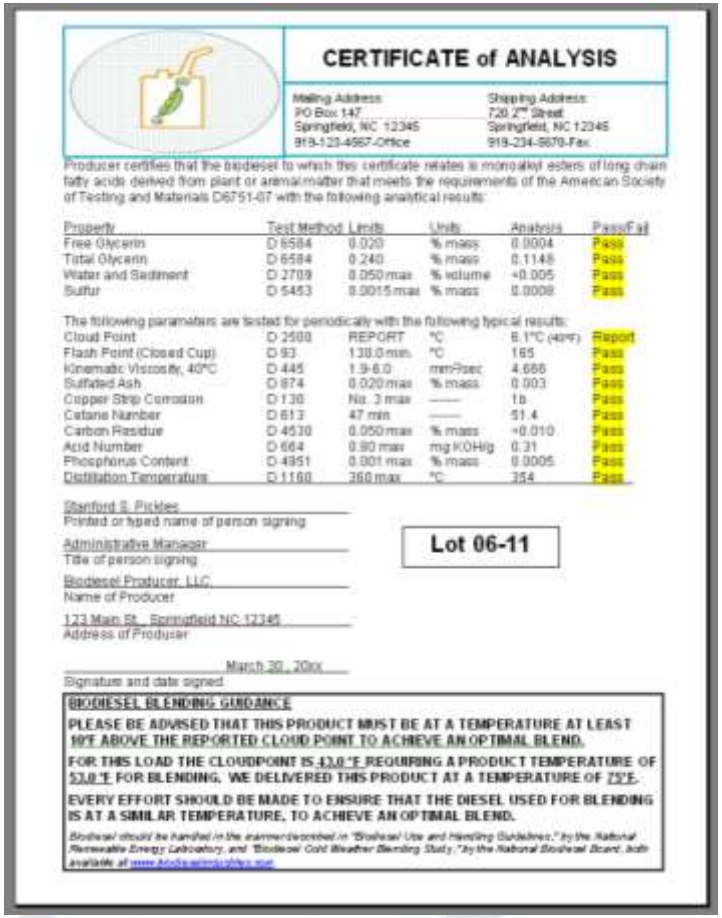
- Fuel quality is critical for proper functioning
- Standards ensure satisfactory operation in diesel engines

BQ 9000 Certification

- Certifies biodiesel producers and marketers
- Provides confidence in biodiesel quality for:
  - Biodiesel Producers
  - Engine and Vehicle Manufacturers
  - Distributors
  - Consumers

Certificate of Analysis

- Provides consumers with the assurance that the fuel they are purchasing meets ASTM standards set for biodiesel.
- Should clearly state each test performed on fuel being sold by producer.
- Failure of any quality control test should prevent the sale of fuel for on-road use



CERTIFICATE of ANALYSIS

Mailing Address	Shipping Address
PO Box 147	720 2nd Street
Springfield, NC 12345	Springfield, NC 12345
919-123-4567-Office	919-234-5678-Fax

Producer certifies that the biodiesel to which this certificate relates is monoalkyl esters of long chain fatty acids derived from plant or animal matter that meets the requirements of the American Society of Testing and Materials D6751-07 with the following analytical results:

Property	Test Method	Limits	Units	Analysis	Pass/Fail
Free Glycerin	D 6584	0.020	% mass	0.0004	Pass
Total Glycerin	D 6584	0.240	% mass	0.1148	Pass
Water and Sediment	D 2709	0.050 max	% volume	<0.005	Pass
Sulfur	D 5453	0.0015 max	% mass	0.0008	Pass

The following parameters are tested for periodically with the following typical results:

Cloud Point	D 2500	REPORT	°C	6.1°C (43°F)	Report
Flash Point (Closed Cup)	D 93	130.0 min.	°C	165	Pass
Kinematic Viscosity, 40°C	D 445	1.9-6.0	mm²/sec	4.666	Pass
Sulfated Ash	D 874	0.020 max	% mass	0.003	Pass
Copper Strip Corrosion	D 130	No. 3 max	------	1b	Pass
Cetane Number	D 613	47 min	------	51.4	Pass
Carbon Residue	D 4530	0.050 max	% mass	<0.010	Pass
Acid Number	D 664	0.80 max	mg KOH/g	0.31	Pass
Phosphorus Content	D 4951	0.001 max	% mass	0.0005	Pass
Distillation Temperature	D 1160	360 max	°C	354	Pass

Stanford S. Pickles
Printed or typed name of person signing

Administrative Manager
Title of person signing

Biodiesel Producer, LLC
Name of Producer

123 Main St., Springfield NC 12345
Address of Producer

March 30, 20xx
Signature and date signed

Lot 06-11

BIODIESEL BLENDING GUIDANCE

PLEASE BE ADVISED THAT THIS PRODUCT MUST BE AT A TEMPERATURE AT LEAST 10°F ABOVE THE REPORTED CLOUD POINT TO ACHIEVE AN OPTIMAL BLEND.

FOR THIS LOAD THE CLOUDPOINT IS 43.0 °F REQUIRING A PRODUCT TEMPERATURE OF 53.0 °F FOR BLENDING. WE DELIVERED THIS PRODUCT AT A TEMPERATURE OF 75°F.

EVERY EFFORT SHOULD BE MADE TO ENSURE THAT THE DIESEL USED FOR BLENDING IS AT A SIMILAR TEMPERATURE, TO ACHIEVE AN OPTIMAL BLEND.

Biodiesel should be handled in the manner described in "Biodiesel Use and Handling Guidelines," by the National Renewable Energy Laboratory, and "Biodiesel Cold Weather Blending Study," by the National Biodiesel Board, both available at www.biodieselhelp.com

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Engine Warranties

- Most engine manufacturers have agreed to warranty vehicles for use up to B20.
  - Some (e.g. Daimler-VW) still only officially allow up to B5.
- Magnuson-Moss Warranty Act is a federal law protecting consumers from deceptive warranty practices, however if you are using a biodiesel blend over the allowed amount, and you have a **fuel system failure**, the dealership may choose not to cover the repair under your warranty, especially if it is difficult to determine the specific reason for the fuel system problem.
- More details on biodiesel and engine warranties can be found on the National Biodiesel Board website.

Upcoming technologies

RENEWABLE DIESEL AND GASOLINE
CELLULOSIC ETHANOL
ALGAE-DERIVED FUELS

Cellulosic Ethanol

- Ethanol production from cellulosic plant material
  - Enzymatic and thermochemical pathways
- First commercial plant in the USA was Ineos Bio (Vero Beach, FL). Yard Waste. Still in commissioning (over 1 year).
- Poet, Abengoa, and Dupont all in final stages of construction. Planned to come online in the next six months.
- Chemtex had one of the first plants globally to go online, in Crescentino, Italy. Next plant planned for eastern NC.

Cellulosic Feedstocks

- Corn Stover and other Agricultural Residues
- Forestry Residues and Thinnings
- Perennial Grasses (Miscanthus, Switchgrass, Big Blue Stem)
- Other (Arundo Donax, etc…)

Renewable Diesel

- "R-Diesel" became a commercial reality around 2011.
- Main technology providers: UOP, Syntroleum, Neste Oil
- Neste has three plants online outside of the USA:
  (Two plants in Europe and one in SE Asia)
- Dynamic = Syntroleum + Tyson JV, recently became **REG Geismer**
  (75 MMGY, Geismar, LA)
- Diamond Green Diesel = JV Between Valero and Darling, UOP technology (142 MMGY, Narco, LA)
  - ~11% of the USA's used cooking oils and animal fats will be processed at the facility
- In June 2013 the NBB agreed to allow Renewable Diesel producers into its membership

SUSTAINABILITY ISSUES FOR BIOFUELS

Greenhouse Gas Emissions

GHG emissions of biofuels may be listed in absolute terms – "Carbon Intensity" or relative to the fossil fuel they replace (diesel / biodiesel & gasoline / ethanol).

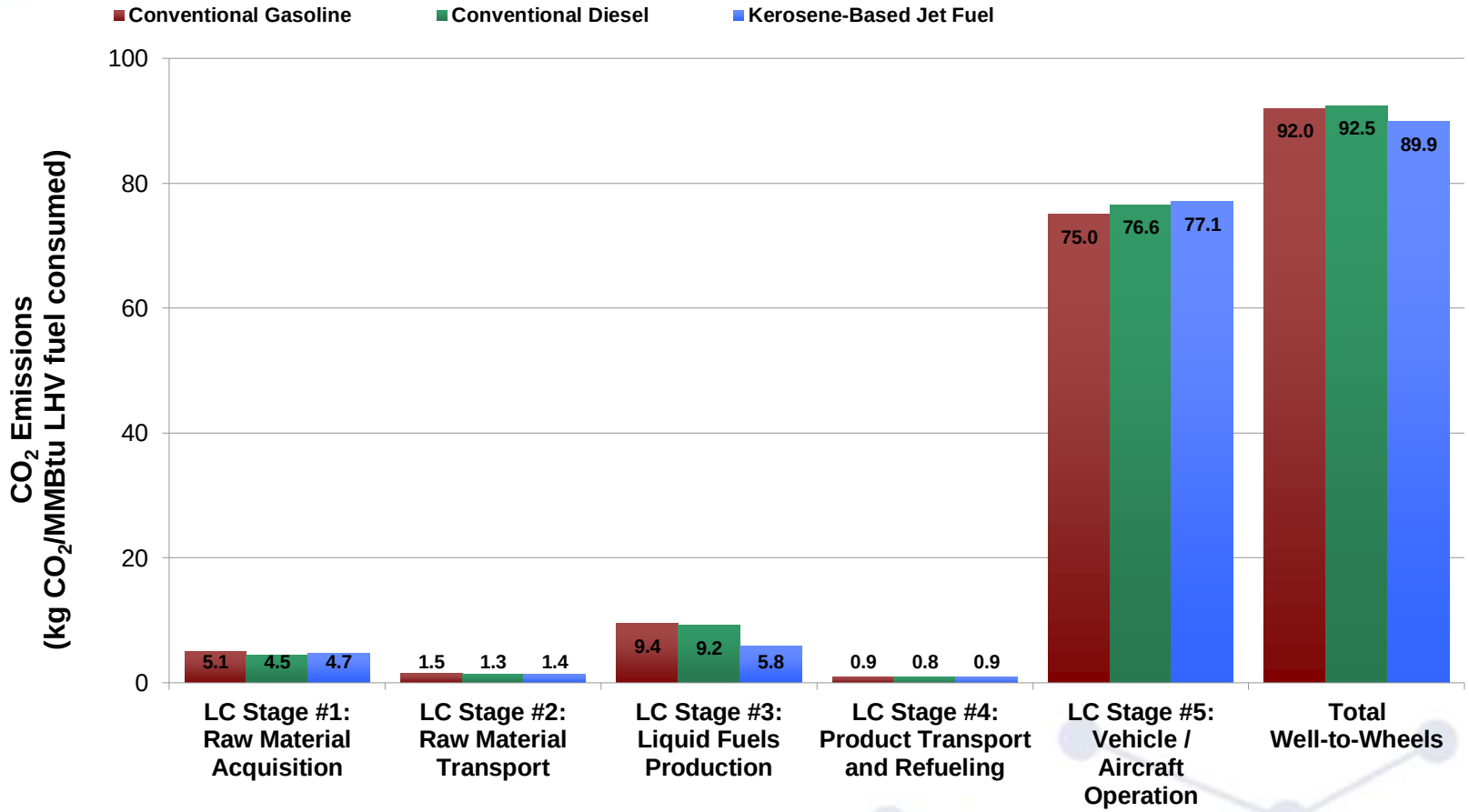
- Units: Absolute – g CO2 eq/megajoule; Relative – XX % of fossil fuel comparator

Different types of biofuels & feedstocks have very different carbon characteristics.

Different regions of the world have different fossil fuels that are being replaced.

2005 National Fossil Fuel Baselines in USA (NETL, 2009) (kg CO2 / MMBtu LHV fuel consumed)	
Gasoline	92.0
Diesel	92.5
Jet Fuel	89.9

Fossil Fuel Baselines in USA



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Greenhouse Gas Emissions
CAL-GREET Model

Biofuel Pathway	Direct Emissions	Indirect Effects (e.g. iLUC)	Total	Fossil Fuel Baseline	% Emission Reduction
Soybean Biodiesel	21.25	62	83.25	98.03	15%
UCO Biodiesel	15.84	0	15.84	98.03	84%
Corn Ethanol	65.66	30	95.66	99.18	3.5%
Sugarcane Ethanol	27.40	46	73.40	99.18	26%

Based on default values from Cal GREET
Credit: California Air Resources Board

Indirect Land Use Change (iLUC)

- Biofuels have been beneficial to agricultural commodity prices, helping raise prices for both corn and soybeans in the USA
- Agricultural commodities are fungible – price changes in a commodity affect other types
- As agricultural prices in one part of the world increase, farmers in other parts of the world are encouraged to clear more land and plant more crops

This phenomena is known as:
“Indirect Land Use Change” or “iLUC”

Crop Expansion & Food vs. Fuel

- Economics dictate that high agricultural prices will cause one of three things to happen: (1) *Expansion*: farmers expand into new lands, (2) *Intensification*: farmers become more efficient, or (3) *Reduced demand*: Higher prices cause demand to decrease.

- Crop expansion (1) is the manifestation of indirect land use change, whereby new lands are cleared in other parts of the world.
  - Because GHG emissions is a global phenomena, land clearing in SE Asia releases carbon that impacts all of mankind

- Reduced demand (3) is one manifestation of food vs. fuel, whereby those in the world who spend the largest percentage of their income on food are forced to reduce consumption due to high agricultural prices.

A FINAL WORD…

…Conservation

It's important to remember that while sustainable biofuels are a better option than petroleum diesel; the use of less natural resources is ultimately the right answer.

As the population increases, the demand for natural resources will also rise. Conservation and efficiency are a must for our society to continue enjoying the quality of life we have come to know.

Conserve First: The only thing better than using biofuel is not using any fuel at all.