Supercritical Biodiesel Production Technology

A Guide To the Supercritical Biodiesel Process

Jatro Renewables®
SUSTAINABLE CHEMISTRY FOR EARTH

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Why Biodiesel?

Strong demand, less than a 24 month payback, EBITDA margins[1] = $0.70/gal +

- 50b gallon/year diesel fuel market
- No blend wall issues
- Warranty covered by 85% of truck manufacturers (to 20% blend)
- Reduced emissions a minimum 50% (vs. straight ULSD)
- No changes to vehicle engines
- EPA/RFS approved Advanced Biofuel

Note 1: See Margins 2015/2016. Page 14 and historical margins 2009-Present, Page 15-17

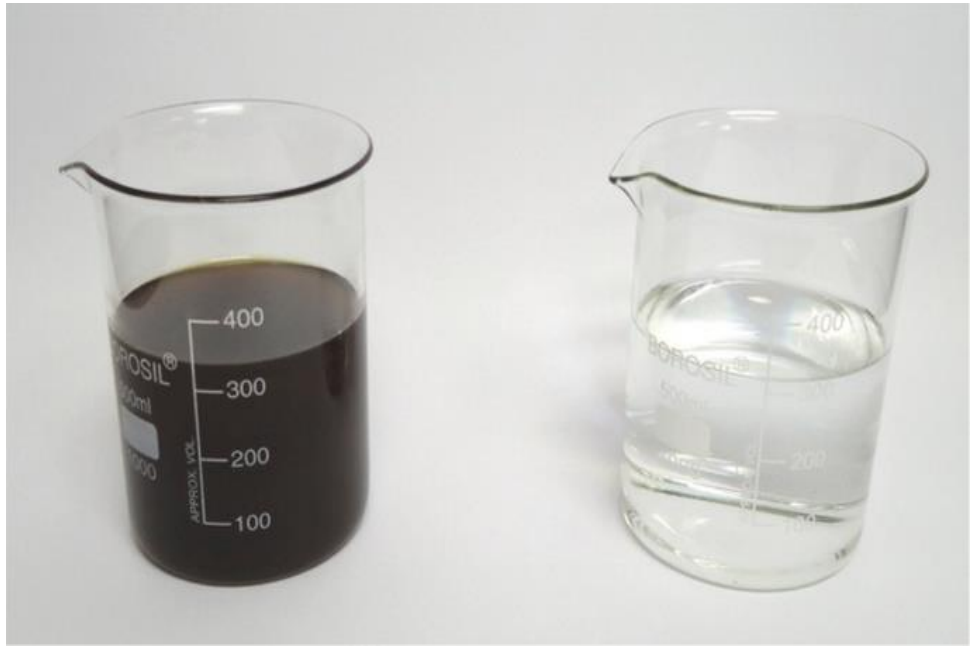
Transportation use of diesel fuel: Represents 78% of the diesel fuel market at 47bgy, plus in the northeast U.S. heating oil at about 4bgy. Just 10% of those figures using biodiesel represents a market of 5bgy (billion gallons per year). Current biodiesel production capacity is 2.1bgy and growing.

Why Supercritical Biodiesel?

It significantly simplifies refining, improves fuel quality and costs less to make

- 38% the approximate amount *Super*™ lowers total biodiesel production cost
- Up to 100% FFA feedstocks can be used to lower the cost of feedstock choice
- 95% pure glycerin by-product, as the *Super*™ process uses no catalyst
- 0°C cloud point after final distillation, renders a clear biodiesel, makes it more suitable for use in sub-freeze conditions[1]

Note 1: When blending low cloud point feedstocks to <0°C such as soy and corn oil



(Left) A feedstock blend of used cooking oil, corn oil and trap grease with a combined FFA of 65%.
(Right) ASTM 6751, B100 after processing with Super process

Supercritical vs. Traditional Process: The combined additional margin at EBITDA adds up to approximately $0.40/gal. However, if blending in 50% of high FFA feedstocks the EBITDA can increase an additional $0.50 to $0.80/gallon

The Super™ Process Explained

Five main steps, (vs. 10 for traditional plants) makes refining a simpler job

Super™ was invented to cut production costs; refine low cost, high FFA feedstocks; and increase biodiesel quality.
The net result is a commercial plant with others now under construction or planned

Pretreatment

Regardless of the feed-stock oil or its FFA %, all oils go into the feed-stock tank and gently mixed and moved through a filtering system consist-ing of a proprietary type of clay. This insures the feedstock is of a high purity and totally free of any contaminants.

Super Process

At a temperature of about 350°C and a pressure of about 2,500 psi, methanol is added to the oil which causes the glycerin to separate from the oil.

Methanol Recovery

After the reaction in the *Super*™ Reactor, the Methanol is recovered from the biodiesel by distillation and the by-product glycerin through a glycerin distillation column.

Washing

Biodiesel is separated from trace glycerin and washed to remove trace quantities of "free" glycerin

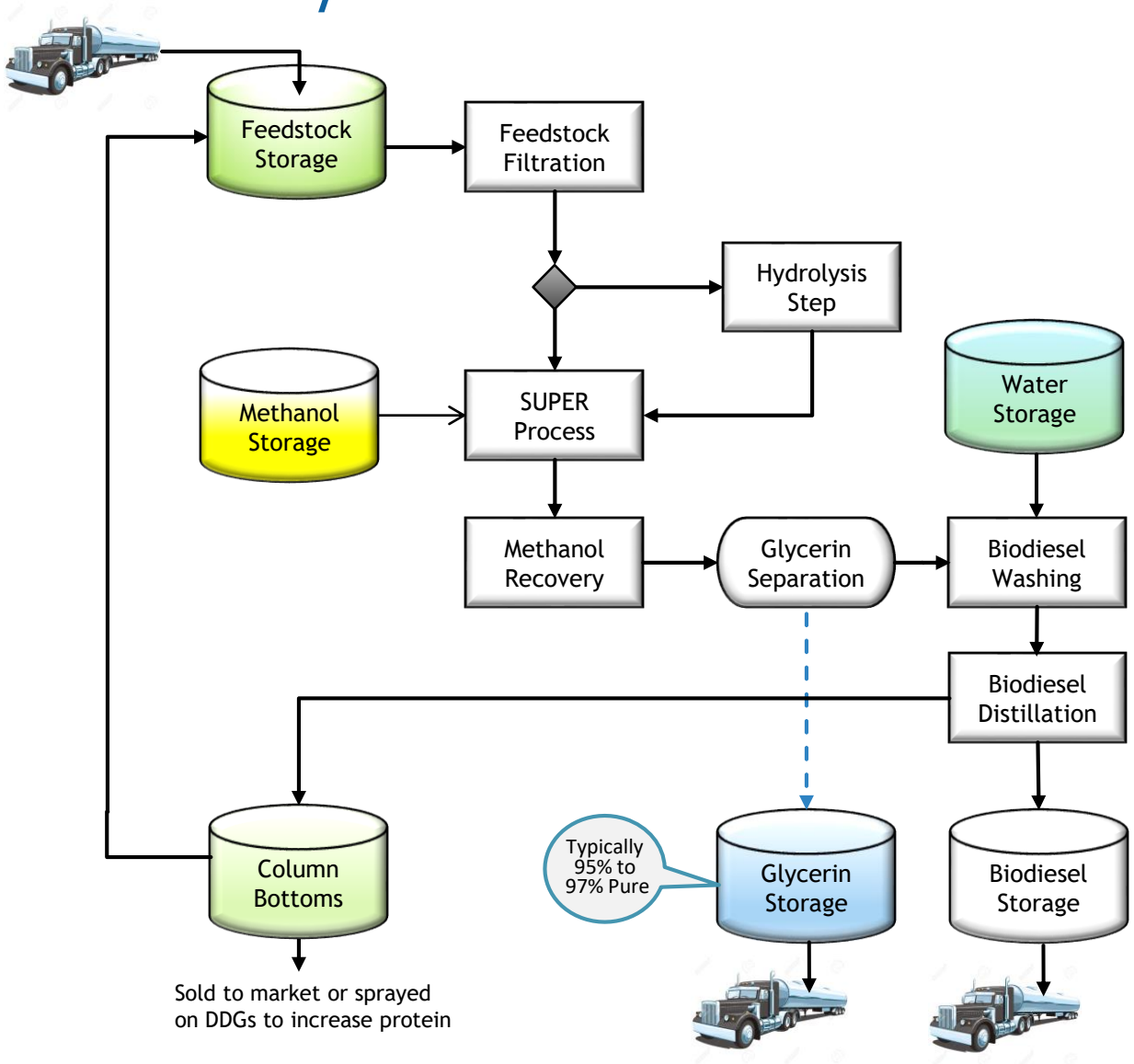
Distillation

The final step is biodiesel distillation where three basic outcomes occur:
(i) the sterols are removed, as these cause filter plugging in very cold weather;
(ii) the color of the biodiesel is rendered clear;
(iii) trace impurities are removed. The net result is a very high level of purity to the finished biodiesel. (about 90% of traditional systems do not use distillation).

See Page 9 & 10 for more on distillation

Regardless of feedstock oil choice, its FFA, or whether a virgin or non-virgin oil, the biodiesel quality will always be the same and meet ASTM 6751 biodiesel specification. Also multiple feedstocks make it easier to meet customer cloud or acid point preferences

The Super™ Process Schematic



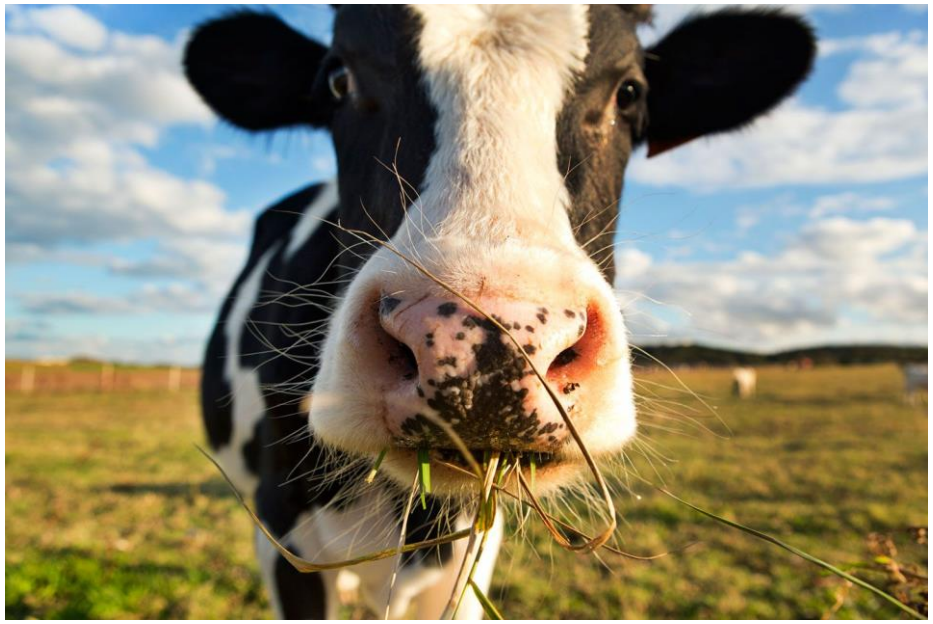
(Top) Typically it takes one system Operator per shift with an on-site utility person and a chemist. (Lower) Chemistry lab with chromatography unit and other equipment.

Multiple Feedstocks Benefit Everyone!

Predictable pricing and availability, best properties and lowest carbon intensities

- Feedstock flexibility frees producers from the instability of the market
- A multi-feedstock refinery can switch to an alternative feedstock and not negatively affect the finished biodiesel
- The ASTM 6751 specification does not differentiate between feedstocks; there is no "best" feedstock option in ASTM
- Blending FFAs from different feedstocks, as in a recipe, enables making a fuel with properties customers want
- Blends can be modified, such as using inedible feedstocks, to meet a carbon intensity score under California's LCFS.

Used cooking oil (UCO) restaurant pick-up truck

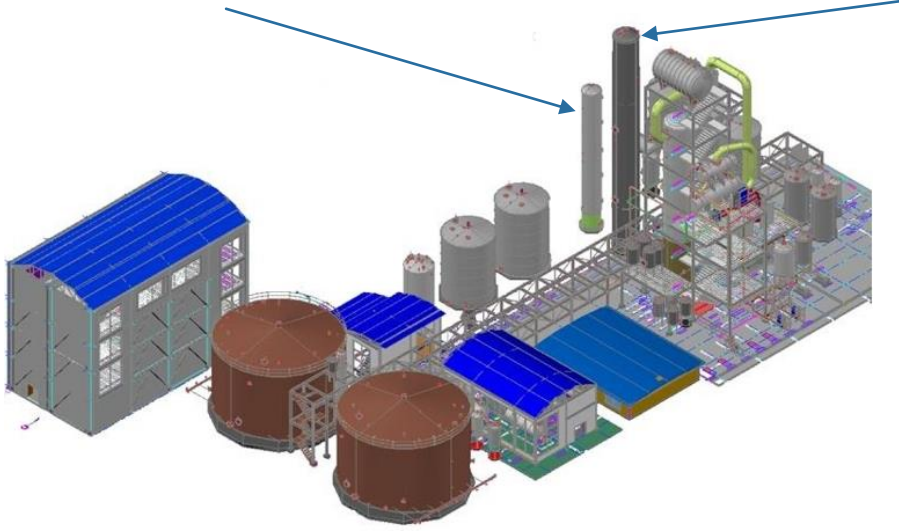


Biodiesel can be made from animal fats, fish and poultry oil, used cooking oil, oils from municipal sewer systems, palm oil derivatives, and from many virgin oils (typically edible) such as corn, soy and canola.

What Creates Distilled Biodiesel?

Pure biodiesel just works better . . . it retains customers and maintains margins

1. After the *Super™* reactor, the Methanol is recovered from both the Biodiesel and the Glycerin through methanol distillation.



2. The biodiesel is moved to the biodiesel distillation column. Here the process eliminates most of the remaining components to produce the purest form of biodiesel by removing . . .

(i) Any pigmentation intrinsic to the feedstock is rendered as clear as water (corn oil is reddish, used cooking oil is light yellow, trap grease is dark grey etc.)
(ii) High sulfur found in poultry fats
(iii) Metal and salt content which are typically found in yellow grease and other animal fat feedstocks
(iv) Any unreacted mono-, di- and triglycerides from the column bottoms are are recycled back through the system for reprocessing.

In the *Super™* process the typical losses are only between 0.5% and 1.5%. By contrast, traditional system losses are up to 5%, and unlike *Super™*, are feedstock dependent. Since *Super™* biodiesel distillation reduces mono and diglycerides to less than .001%, any filter plugging of a diesel engine are eliminated, at least to its stated Cloud Point.

Example of Super™ biodiesel distilled at the final stage

Why Is Distilled Biodiesel So Important?

Top 10 reasons biodiesel should be distilled in the refining process

Superior Performance

- Distillation offers superior cold weather performance
- Distillation is excellent at removing sterols and typically present in vegetable oils as sterols impact fuel filter plugging
- In very cold weather, even at a higher cloud point, a distilled biodiesel will typically outperform biodiesel that has not been distilled

Emissions Reduction

- Distillation provides biodiesel a lower carbon intensity score
- As school districts and municipalities etc. struggle to maintain clean air days, a distilled biodiesel will help mitigate unhealthy air issues
- Distillation removes a variety of undesirable elements in biodiesel such trace methanol, glycerin, metals and acids - all of which deteriorate its purity.

Biodiesel Availability

- By distilling biodiesel it makes using a blend of multiple feedstocks easier to process
- Having a choice of multiple feedstocks provides assurance of biodiesel availability especially in a commodity market where certain types can become scarce or too costly.

Biodiesel Blending

- Distillation makes it easier to blend biodiesel with ultra low sulfur diesel (ULSD)
- Distilling biodiesel removes all color . . . as different feedstocks will have varying tints from yellow (UCO) to pink (corn oil).
- A clear biodiesel will not change the retailer's existing fuel color after blending (and possibly confuse customers about the reliability of the fuel).

Quick Biodiesel Technical Overview

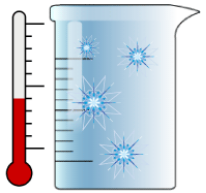
Description of some key biodiesel terms – specifically when using Super™

Transesterification

A chemical process in which an oil-based feedstock is reacted with methanol to make biodiesel

Catalyst

A chemical used in traditional biodiesel processing but NOT used in a plant using Supercritical technology



Cloud point

Temperature at which wax crystals cause fuel to appear cloudy and require an alternate feedstock blend and/or additives to lower it

Supercritical

Conversion of vegetable oil to biodiesel via a transesterification reaction, where the triglyceride is converted to the methyl ester plus glycerol. This is done using methanol and a caustic catalyst, but is achieved without a catalyst in a Supercritical system. This has the advantage of allowing use of a greater range of feedstocks, some going as a high as 100% FFA. Also, the biodiesel needs no heavy washing to remove a catalyst including the by-product glycerin which is 95% pure, 15% to 20% higher than in traditional systems.

Distillation

Process of purifying biodiesel using evaporation and condensation

Cetane number

A measure of the combustion speed of diesel fuel and typically an indicator of its quality

Fatty Acid Methyl Esters

The technical term for biodiesel

Triglycerides

Are oils from animals including cattle, poultry and fish; also, certain crops such as soybean, rapeseed, canola, palm, sunflower, peanuts and from oil extracted from corn. Biodiesel can even be made from recycled cooking grease and grease waste collected by municipalities in the sewer system. The common thread shared by all biodiesel sources is that they all contain fat in some form.

Maximizing Supercritical For Profit

Feedstock flexibility is the main system feature of Super™

The *Super*™ process allows blending of different feedstocks, yet achieves the same ASTM 6751 specifications with all the desired product attributes . . . and without compromising the producer's profit. Example below using three widely available feedstock sources :



1 **Corn Oil:** 12% FFA
Cloud Pt. -2.8°C
Cost/lb 0.28
Blend % 30
Cost/lb .08

2 **Trap Grease:** 68% FFA
Cloud Pt. 8°C
Cost/lb .09
Blend % 30
Cost/lb .03

3 **UCO:** 8% FFA
Cloud Pt. 7°C
Cost/lb .26
Blend %: 40
Cost/lb: .10

AVG. COST /lb = $0.21 ($1.58/g) vs. 100% Corn Oil = $0.28 ($2.11/g). **MULTI-FEEDSTOCK ADVANTAGE** = $0.53/g
ORDER: Customer requests a Cloud Point of less than<5°C. Here' s the math: -2.8 x 30% + 5.0 x 30% + 7.0 x 40% = 4.36°C

How Strong Are Biodiesel Netbacks?

Table shows costs, revenue and margin yield for various feedstock blends

Entry Items	100% Corn Oil	50% Corn, 50% UCO	30% Corn, 35% UCO, 35% Brown	15% Corn, 15% UCO, 70% Brn.
Feedstock Cost Per lb	$0.28	0.25	0.21	0.18
Total Feedstock Cost/gal	2.11	1.89	1.59	1.36
Processing	0.53	0.53	0.53	0.53
G&A	0.06	0.06	0.06	0.06
TOTAL COGS	2.70	2.48	2.18	1.95
Glycerin Revenue	0.08	0.08	0.08	0.08
Biodiesel Revenue	3.20	3.20	3.20	3.20
TOTAL REVENUE	3.28	3.28	3.28	3.28
Margin (ebitda)/gal	$0.58	0.80	1.10	1.33

Avg. blended feedstock cost dlvd. per lb and per gallon (lbs x 7.55 = gals)

Processing includes: feedstock losses, chemicals, energy, labor and plant maintenance

General and administrative: accounting, insurance, commissions, rent etc.

Value per gallon of biodiesel is double or more vs. glycerin from traditional processes

Annual Averages

EBITDA: $0.74/gal

B100: $3.20/gal

Feedstock: $0.27/lb

Methanol: $1.34/gal

Glycerin: $0.08/lb

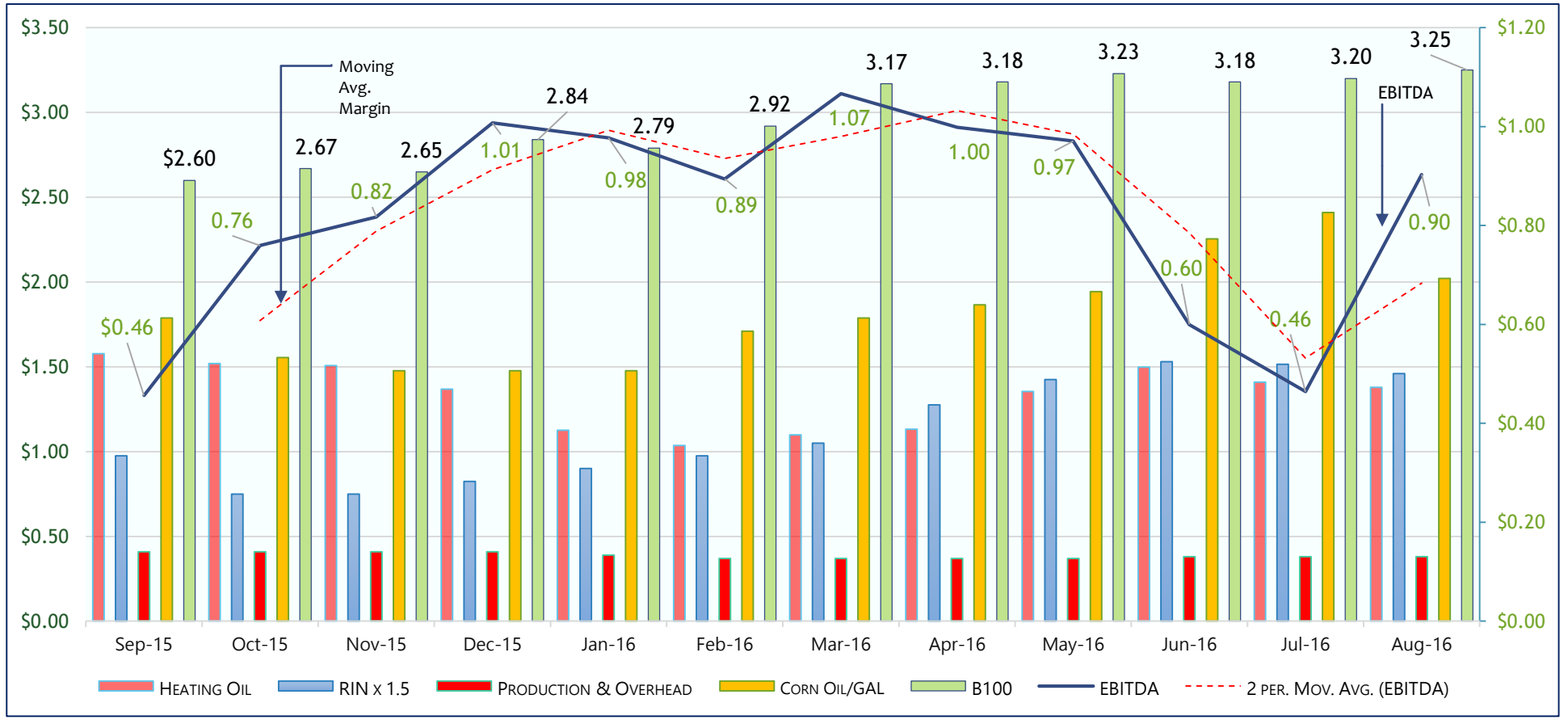
Margin Analysis 2015/16

See detail on next page >

Take care of the land and it will take care of you!

Biodiesel Margins for 2015/2016

The graph shows a year ending "moving average margin" of $0.74/gallon



NOTES: (1) Market data provided by CME, OPIS, TheJacobsen, USDA and PFL. (2) Production and Overhead numbers based on a Supercritical plant co-located at an Ethanol plant

Historical Biodiesel Margins

Looking back at 70 months of biodiesel statistics . . . a glimpse into the future

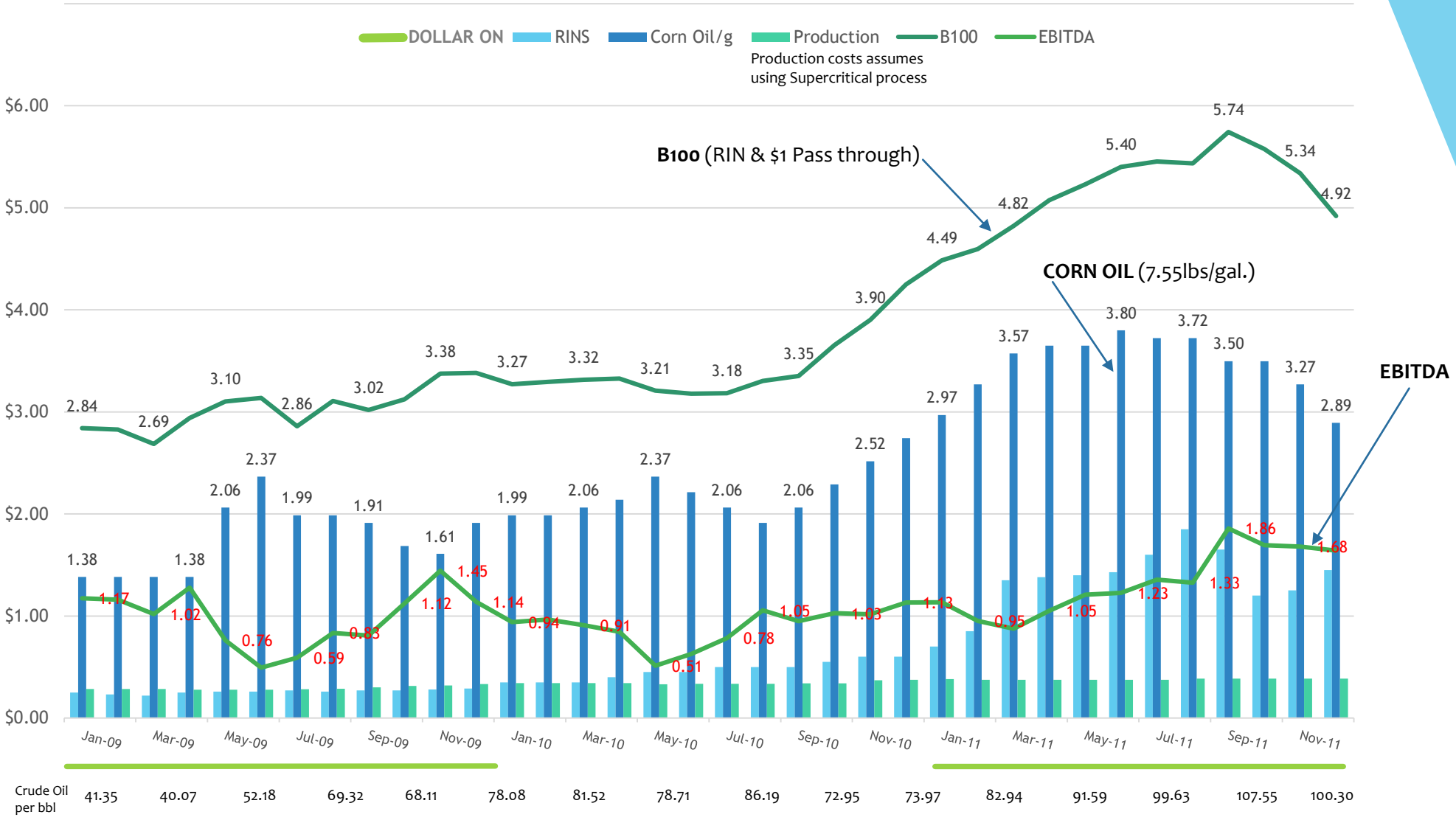
Stats on the next 3 pages include:

- Spread between feedstock and B100
- Effect of no $1 credit on margins
- Crude oil avg. price per month
- RIN traded values (x 1.5)
- Month ending margin per gallon
- Total revenue per gallon of biodiesel (includes glycerin contribution)

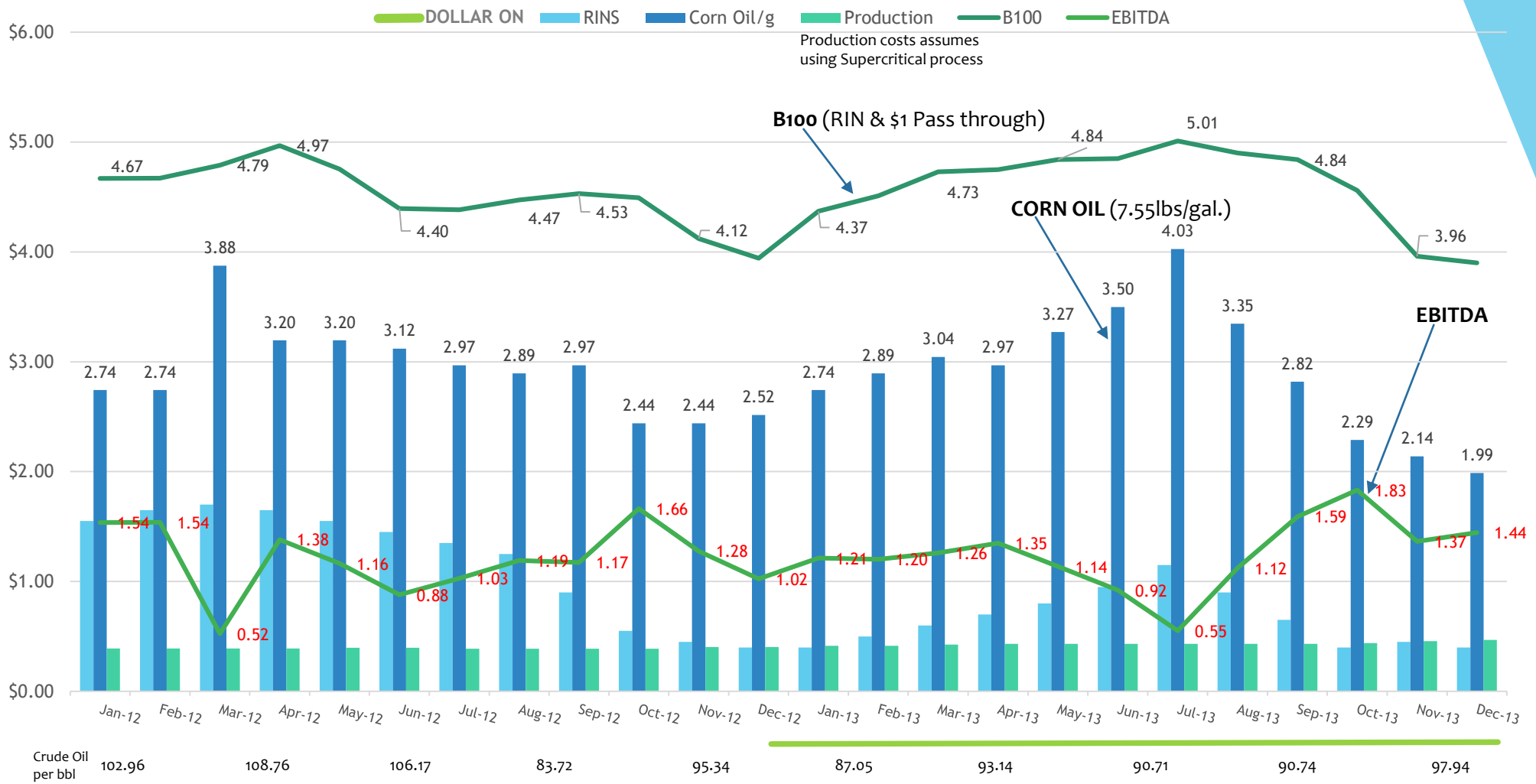
Patriot Renewable Energy, biodiesel plant (now owned by CHS, Inc.), Annawan, IL

On the next three pages, all data was obtained from The Jacobsen, OPIS, PFL and the U.S. Government (USDA and EIA)

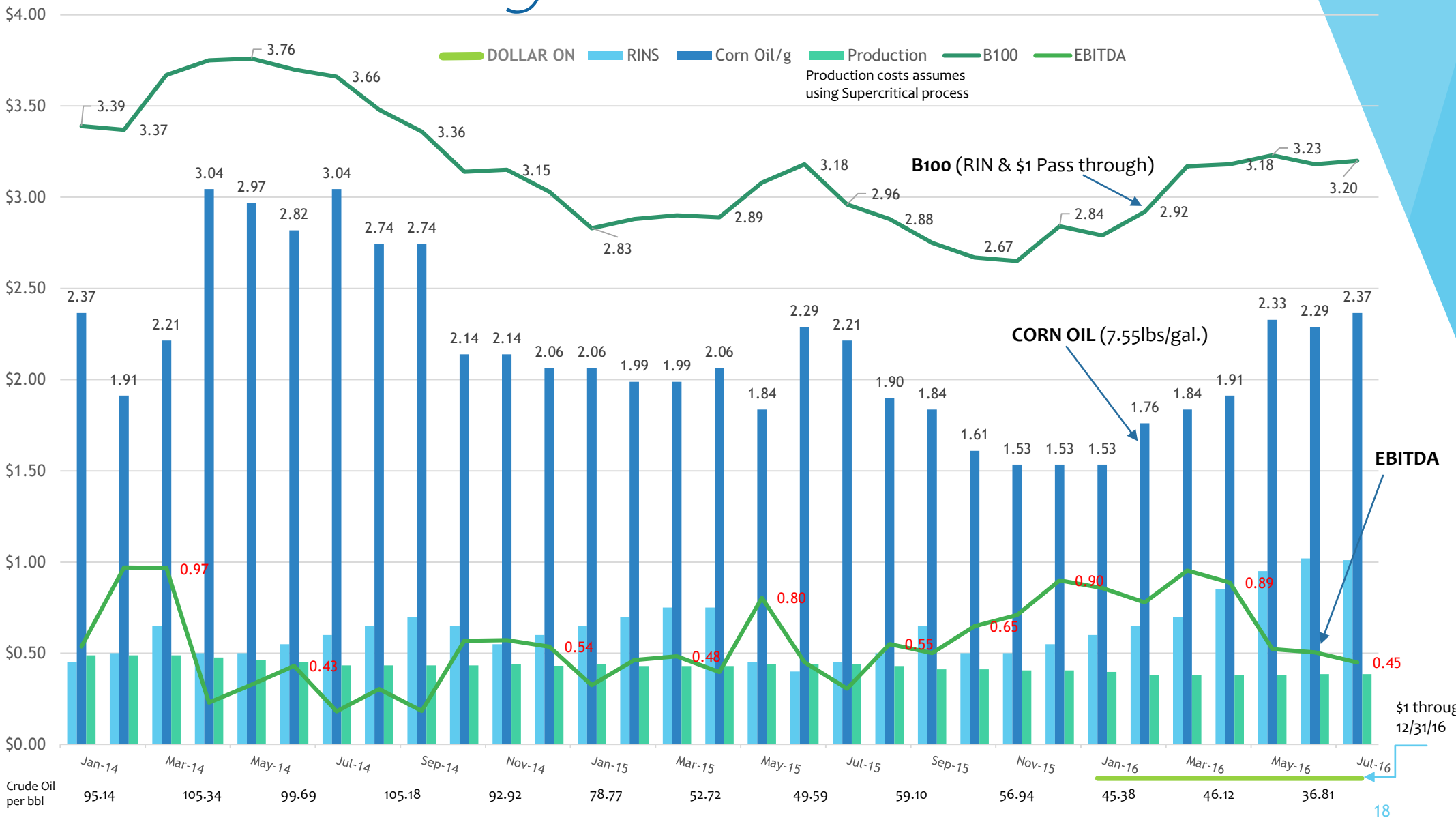
Biodiesel Margins - 2009 to 2011



Biodiesel Margins - 2012 to 2013



Biodiesel Margins - 2014 to 2016



Brief History of JatroRenewables

First a biodiesel producer, then builder of plants, and now a leading innovator

Background

- Founded in 2004
- Based near Dayton, OH at Miamisburg
- Biodiesel technology & production innovator

Experience

- Biodiesel producer 2006 to 2010
- Engineered or built 18 biodiesel plants
- Patented production techniques
- Developed patented supercritical processing technology in 2014, one operating commercially, others under construction or in planning stages (as of 10/16).

Vanguard Synfuels, 15MMgy biodiesel plant , Pollock, LA

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Thank you for your interest in JatroRenewables