Impact of the U.S. Biodiesel Industry on the U.S. Soybean Complex and Livestock Sector

Prepared for:
National Biodiesel Board
# Table of Contents

I. EXECUTIVE SUMMARY ................................................................................................................................. 1

II. INTRODUCTION .................................................................................................................................................. 5
  A. BIODIESEL INDUSTRY BACKGROUND ........................................................................................................ 5

C. THE SOYBEAN COMPLEX PRIOR TO THE EMERGENCE OF THE U.S. BIODIESEL INDUSTRY ............ 11
  A. IMPACT OF LARGE SOYBEAN OIL INVENTORIES ON THE U.S. SOYBEAN COMPLEX................................. 11
  B. SOYBEAN OIL USE FOR BIODIESEL HELPED OFFSET THE IMPACT OF TRANS-FAT LABELING ON SOYBEAN OIL USE .......................................................... 14
  C. BIODIESEL RESULTED IN INCREASED DEMAND FOR SOYBEAN OIL IN THE U.S. .......................................................... 17
  D. THE PRICE OF SOYBEAN OIL BECAME CLOSELY LINKED TO THE PRICE OF DIESEL .......................................................... 18
  E. KEY TAKEAWAYS ........................................................................................................................................ 24

D. IMPACTS OF THE BIODIESEL INDUSTRY TO U.S. LIVESTOCK PRODUCERS ........................................ 26
  A. IMPACT OF BIODIESEL ON SOYBEAN OIL PRICES .................................................................................. 26
  B. IMPACT OF THE BIODIESEL INDUSTRY ON LIVESTOCK FEED COSTS .......................................................... 30
  C. BIODIESEL RESULTED IN INCREASED PRICES FOR ANIMAL FATS AND GREASES .......................................................... 34
  D. KEY TAKEAWAYS ........................................................................................................................................ 36

E. IMPACTS OF THE BIODIESEL INDUSTRY TO U.S. SOYBEAN CRUSHERS ............................................. 38

F. WHAT IF THE BIODIESEL STOPS OPERATING? .......................................................................................... 40
List of Exhibits

Exhibit 1: U.S. Biomass Based Diesel and Renewable Diesel Production and Use History .......................................................7
Exhibit 2: U.S. Biomass Based Diesel Existing Capacity and Utilization .....................................................................................8
Exhibit 3: U.S. Soybean Oil Use by Major Use Category ........................................................................................................9
Exhibit 4: U.S. Biodiesel Production by Feedstock Used .........................................................................................................10
Exhibit 5: Soybean Oil Share of Soybean Product (meal and oil) Value ..................................................................................12
Exhibit 6: Price Spread between Soybean Oil Illinois (Processor Price) and Gulf (Export Price) ...................................................13
Exhibit 7: Market Share of U.S. Vegetable Oil Use for Food Uses ..............................................................................................15
Exhibit 8: U.S. Soybean Oil Consumption LOST to other Oils vs. Soybean Oil Consumption GAINED by Biodiesel Relative to 2004/05 ............................................................................................................16
Exhibit 9: U.S. Domestic Soybean Oil and Biodiesel Share of Usage and Production.................................................................18
Exhibit 10: Correlation between Soybean Oil and Diesel Prices .................................................................................................22
Exhibit 11: 1998-2006 Monthly Correlation of Spot Diesel and Soybean oil Prices .................................................................23
Exhibit 12: 2007 to 2012 Monthly Correlation of Spot Diesel and Soybean oil Prices .................................................................23
Exhibit 14: Prices of Soybean Oil in Btu Equivalent .....................................................................................................................27
Exhibit 15: Impact of Biodiesel on Soybean Oil Prices .................................................................................................................28
Exhibit 16: Impact of Biodiesel on the Price of Soybean Oil .........................................................................................................29
Exhibit 17: The Effect of Soybean Oil Prices on Soybean Meal and Soybean Prices .................................................................31
Exhibit 18: Impact Range on SBM for Domestic Livestock Feed Price ......................................................................................32
Exhibit 19: U.S. Soybean Meal Used by Species .........................................................................................................................33
Exhibit 20: Animal Fats and Yellow Grease Prices Discount Relative to Soybean Oil Prices (2000-2012) .....................................35
Exhibit 21: Impact of Biodiesel on the Price of Animal Fats and Yellow Grease ........................................................................36
Exhibit 22: Soybean Oil Refining Margin (NY Refined minus Decatur Crude) ........................................................................39
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Acronyms

EPA = Environmental Protection Agency
UAB = Undifferentiated Advanced Biofuel
RFS = Renewable Fuel Standard
FDA = Food and Drug Administration
USDA = United States Department of Agriculture
SB = Soybeans
SBO = Soybean oil
SBM = Soybean meal
bgy = billion gallons per year
mmgy = million gallons per year
Cts/lb = cents per pound
$/gal = dollars per gallon
$/bu = dollar per bushel
I. EXECUTIVE SUMMARY

Impact of the U.S. Biodiesel Industry on the U.S. Soybean Complex and Livestock Industry

The objective of this project is to evaluate the broad impacts the biodiesel industry has had on the U.S. soybean and livestock industries; the key takeaways of this study are summarized below.

Impact on Soybean oil Prices

- Soybean oil use for biodiesel positively shifted demand for vegetable oil in the U.S. allowing soybean oil to price at comparable or higher levels to soybean oil stocks than during the pre-biodiesel era. In fact, empirical evidence suggests that demand for soybean oil prior to biodiesel was supply driven with soybean oil stocks often viewed in the market as a “drag” which in turn placed pressure on soybean meal prices.

- The impacts of biodiesel throughout the soy complex are a consequence of increased demand of soybean oil and an increased correlation or link between the price of biodiesel feedstocks - including soybean oil - and the price of energy (e.g., diesel, heating oil).
  - Since 2005¹ soybean use for biodiesel increased from 0.67 to 5.0 billion pounds for 2013/2014. During the same period, U.S. soybean oil use for food applications declined 3.7 billion pounds, with the decline directly linked to trans-fat ² labeling and related government policies. Hence, biodiesel has offset the decline of soybean oil use for food.
  - Energy markets compete for vegetable oils in addition to food and other non-biodiesel uses. This shifted the demand for soybean oil in a significantly positive direction which effectively sets a floor price for soybean oil (and all biodiesel feedstocks) below which increasingly incremental demand for biodiesel would push soybean oil prices up to at least this floor price. Essentially, soybean prices and energy prices are now statistically linked and soybean oil, independent of the intended end use, can trade at its energy value to biodiesel.

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¹ 2005 is when the biodiesel production started to grow more significantly in response to Minnesota's biodiesel use legislation which was implemented in September of 2005 and the federal Renewable Fuels Standard (RFS1).

² On July 11, 2003, the Food and Drug Administration (FDA) issued a regulation requiring manufacturers to list trans fat on the Nutrition Facts panel of foods and some dietary supplements. The new labeling rule became mandatory across the board on January 1, 2008. In 2005, Montgomery County, Maryland approved a ban on partially hydrogenated oils; New York City embarked on a similar campaign in 2005 to reduce consumption of trans fats
From late 2006/07 to 2014/15\(^3\), the combined impact of biodiesel to the price of soybean oil (and the overall soy complex) has been on average, an increase of 11 cents per pound\(^4\); this value translates into a cumulative increase of soybean oil revenues alone of $18.8 billion from 2006/07 to 2013/14. These 11 cents per pound have effectively increased the price of soybeans by $0.625 per bushel and decreased the price of soybean meal by $21 per ton.

The soybean oil share of product value (i.e., the value of soybeans expressed by its content and value of oil and meal) increased from a historical average of 37% to 41% during the 2007/08 marketing year through 2011/12. However, in the last two years soybean oil share declined to an average of 33%, this is consequence of the very tight soybean and meal markets, both of which were influenced by lower production and thus very strong prices. Also, the lower energy market price market experienced in late 2014 and thus far in 2015 resulted in lower soybean oil prices. The lower share of product value of soybean oil is not linked to biodiesel nor should be viewed as the shift of the benefits from biodiesel. In fact, without biodiesel the share of soybean oil of product value would have been lower.

Impact on Livestock Producers and Processors

The livestock industry has endured a very changing period over the past seven years as feed prices increased significantly driven by increased global demand, including for biofuels and, in the later part of the period, adverse weather events that constrained global feed supplies. However, the increased demand for vegetable oils for biodiesel helped offset part of the impact by reducing soybean meal feed cost and provided increased demand and pricing for animal fats and greases that are produced by the meat packing and rendering industry.

Meat processors got higher prices and increased domestic markets for animal fats as the rendered products increased in price in parallel to soybean oil. Rendering and meat processing companies got higher prices for tallow (+17 cts/lb), poultry fat (+15 cts/lb), choice white grease (+16 cts/lb), and yellow grease (+15 cts/lb), the full impact on these feedstocks was felt since 2009.

The estimated 11 cents per pound biodiesel impact on soybean oil prices results in a price decline of soybean meal with an average soybean meal price decline for the period 2006/07 to 2014/2015 of $21 to up to $42 per ton. If

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\(^3\) First six months of 2014/2015 (October 2014 to March 2015)

\(^4\) Contribution was highest in 2011 at 16.0 cents per pound in spite of soybean oil’s lower market share of biodiesel feedstocks.
soybean oil prices had not increased from pre-biodiesel levels, soybean meal prices would have to be higher to maintain a soybean price to effectively compete for corn acreage. From 2006/07 to 2014/15, the cumulative impact of biodiesel on soybean meal prices resulted in lower feed costs for U.S. livestock producers, mainly poultry and hog producers, that range from $5.9 billion (i.e., average estimate using a soybean meal price impact of $21 per ton) to $11.8 billion (maximum estimate using a soybean meal price impact of $42 per ton).

Going forward though, crushers will remain driven by U.S. meal demand and thus actions/market conditions that increase soybean oil prices independently of the prices for soybean and/or meal (e.g., increased demand for soybean oil from biodiesel or other uses) will help keep soybean meal (and thus other vegetable meals such as canola or cottonseed meal) priced lower than they would be otherwise.

What if Biodiesels Production Stops

Short Term Effect (1-12 months): soybean oil prices decline by 8.2 cts/lb reflecting a large decline of soybean oil demand which would push prices to its lowest floor price at least while the markets adjust to the new fundamentals. In summary, the short term impact will be

a. soybean oil price decline of 8.2 cts/lb;
b. corresponding lower prices for soybean ranging from 0.47 to 0.94 cts/bu;
c. corresponding higher soybean meal prices ranging from 16 to 32 dollars per short ton; and
d. lower soybean crush margins (due to lower soybean oil basis) ranging of around 16 cts/bu.

As noted before, these estimates are based on the market conditions experienced in 2013/2014; for perspective the results for marketing year 2012/13 and the first six months of 2014/15 would be have been a drop of soybean oil prices of 16.3 cents/pound or 12.9 cts/lb respectively

Mid Term Effect (over 12-18 months): soybean oil prices decline by 5.50 cts/lb still reflecting a large decline of soybean oil demand prices start to adjust to historical patterns – full adjustment to historical patterns will happen in the long term but it difficult to estimate how long with it take. Additionally, soybean oil export basis would improve relative to the short but still reflect a difficult environment for crushers not well located to serve the export market. In summary, in the mid-term the impact will be

a. soybean price decline of 5.50 cts/lb;

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5 2014/15 estimate based on actual data through March 2015
b. corresponding lower prices for soybean ranging from 0.32 to 0.64 cts/bu;
c. corresponding higher soybean meal prices ranging from 11 to 22 dollars per short ton; and
d. lower soybean crush margins (due to lower soybean oil basis) of around 11 cts/bu.

For perspective the results for marketing year 2012/13 and the first six months of 2014/15 would be have been a drop of soybean oil prices of 14.3 cents/pound or 10.9 cts/lb respectively.
II. INTRODUCTION

The objectives of this project are (i) to update key areas of the 2012 study “Impact of the U.S. Biodiesel Industry on the U.S. Soybean Complex” which was developed by Informa on behalf of the Minnesota Soybean Growers Association, and (ii) to expand the analysis related to the impact of biodiesel on livestock producers via supply and prices of soybean meal.

a. Biodiesel Industry Background

A key factor driving the demand for soybean oil – and, by extension, for soybeans – over the last decade has been the growth in the U.S. biodiesel industry. While federal incentives fostered the growth of U.S. biodiesel production during the early part of the last decade and the Energy Policy Act of 2005 established a Renewable Fuel Standard (“RFS”) toward which the usage of biodiesel counted, it was the Energy Independence and Security Act of 2007 that provided a solid foundation for future consumption by expanding the Renewable Fuel Standard (now referred to as “RFS2”) and carving out a requirement for biomass-based diesel usage within RFS2. The biomass-based diesel requirement started at 500 million gallons in 2009 (which was combined with a 650-million-gallon requirement in 2010) and was a minimum of one billion gallons annually starting in 2012, which the administrator of the Environmental Protection Agency has the authority to increase. Indeed, the volume requirement increased to 1.28 billion gallons for 2013 and was originally proposed by EPA to be 1.28 billion gallons in 2014.

Although the policy foundation for biodiesel has been accommodative over the last decade and has provided a volume floor via RFS2 in recent years, the trajectory of the biodiesel industry has not been smoothly upward.

- U.S. biodiesel production steadily increased from 2005 to 2008. A significant portion of production was exported to the EU during this time.

- U.S. biodiesel production fell from 678 million gallons in 2008 to only 516 million gallons in 2009 as a result of the combination of the 2009 and 2010 RFS2 requirements and the imposition of anti-dumping and countervailing duty investigations on U.S. biodiesel by the European Union (formerly a large-scale importer).

- Production fell further to 343 million gallons in 2010 due to a lapse in the federal tax credit for biodiesel blending.
Then, with the restoration of the blender’s tax credit in 2011 and an increase in the RFS2 biomass-based diesel mandate to 800 million gallons, production rebounded to 993 million gallons\(^6\) of biomass based diesel and 45\(^7\) million gallons of renewable diesel (i.e., combined production of 1,013 million gallons).

With the increase in the mandate to 1 billion gallons in 2012, production appears to have continued apace. In 2013 and 2014, record biomass based diesel and renewable diesel production volumes of 1.62 billion gallons (1.4 billion gallons of biomass based diesel) and 1.59 billion gallons (1.27 billion gallons of biomass based diesel) respectively far surpassing that year’s RFS mandate of 1.28 billion gallons; however, despite this the EPA proposed in 2013 to hold the RFS biodiesel volume at the same volume for the 2014 and 2015 program years.

EPA has yet to finalize its 2014 or 2015 RFS targets, which were due by November 30, 2013, and November 30, 2014, respectively. This action (or lack of) adds to the policy uncertainty and any potential to increase the mandate for biodiesel. In April of 2015, the EPA proposed to finalize the RFS biomass-based diesel volume requirement up to 2017 by November 30\(^{th}\) with an initial proposal coming by June 1\(^{st}\).

Beyond 2015, production and use levels are highly dependent of how the EPA will implement the RFS for those years. Note that EPA in the past has examined a scenario in which biomass based diesel reaches 1.8 billion gallons by 2022.

U.S. biodiesel production capacity increased substantially during 2007 and 2008 due to favorable biodiesel production margins benefiting from a biodiesel blender tax credit of $1.00 per gallon.

As of January 2015, biodiesel capacity as reported by the EIA was 2,032 million gallons per year, note that several plants ceased operations permanently in 2010 when active capacity estimates reached 2.5 billion gallons. Also, EPA estimated that in 2012 that biodiesel production capacity for all registered and unregistered biodiesel facilities was about 3.6 billion gallons per year. Furthermore, this capacity estimate does not include renewable diesel capacity which is estimated to be around 225 million gallons per year (renewable diesel production estimated based on EPA data to reach 325 million gallons for 2014).

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\(^6\) Source: EIA  
\(^7\) Source: EPA
Exhibit 1: U.S. Biomass Based Diesel and Renewable Diesel Production and Use History

Source: EIA, EPA Informa Economics (2015 estimate)
Increased soybean oil usage in biodiesel production initially offset the ongoing decline in non-biodiesel (mainly food) domestic usage of soybean oil.
Impact of the U.S. Biodiesel Industry on the U.S. Soybean Complex and Livestock Industry

Exhibit 3: U.S. Soybean Oil Use by Major Use Category

Source: USDA, EIA, Informa Economics
Exhibit 4: U.S. Biodiesel Production by Feedstock Used

Source: U.S. Census, EAI, Informa Economics
c. The Soybean Complex Prior to the Emergence of the U.S. Biodiesel Industry

a. Impact of Large Soybean Oil Inventories on the U.S. Soybean Complex

In the early 2000’s, soybean oil was viewed as a “drag” to the soybean complex. In the U.S. market, supply chased demand and in fact, soybean crushers and soybean oil distributors stored soybean oil for longer periods until there was sufficient export demand to market soybean oil. While there is no adequate data series to show the relative longer inventory turnover rates prior to the emergence of biodiesel, conversations with industry members (i.e. soybean crushers and vegetable oil traders) provide ample examples or anecdotal information to support this point. The so called “drag” was significantly reduced by the emergence of biodiesel, particularly after 2006, when soybean oil use for fuel increased to meaningful volumes\(^8\) the market structure for soybean oil shifted from oversupply to potentially undersupplied (for example in 2007 soybean oil use for biodiesel could have been 2 to 3 times higher if soybean oil prices were low enough to bring existing biodiesel capacity to full production) and more recently to a more balanced supply/demand structure.

Also, the pricing structure shift of vegetable oils that reflected the energy value to biodiesel on soybean oil prices helped eliminate the “drag” on the soybean oil and the overall price/margin structure of the soybean complex. Two indicators provide supporting evidence:

- The soybean oil share of product value (i.e., the value of soybeans expressed by its content and value of oil and meal) increased from a historical average of 37% to 41% during the 2007/08 marketing year through 2011/12. However, in the last two years soybean oil share declined to an average of 33%, this is consequence of the very tight soybean and meal markets, both of which were influenced by lower production and thus very strong prices. Also, the lower energy market price market experienced in late 2014 and thus far in 2015 resulted in lower soybean oil prices. The lower share pf product value of soybean oil is not a linked to biodiesel nor should be viewed as the shift of the benefits from biodiesel. In fact, without biodiesel the share of soybean oil of product value would have been lower.

\(^8\) Soybean oil use for biodiesel increased from 675 thousand pounds in 2005 to 1.8 and 2.9 billion pounds in 2006 and 2007 respectively.
The spread between the price of soybean oil in Illinois and the Gulf has expanded. Exhibit 6 shows the average spread prior to 2007 was 0.70 cts/lb and after 2007 was 2.64 cts/lb. This indicates the margin for soybean oil exporters improved (this behavior was corroborated by anecdotal information) and that soybean oil exports were previously discounted (thus a “drag” to the soybean complex). For example, the negative spread shown in Exhibit 6 indicates that prices at the Gulf (export prices) did not cover freight cost from an Illinois processor to the Gulf. While part of the increased price spread between Illinois and the Gulf prices is due to increased freights, the majority of this spread can be attributed to improve supply/demand balance for soybean oil.
Exhibit 6: Price Spread between Soybean Oil Illinois (Processor Price) and Gulf (Export Price)

Source: Trade News Services, Informa
b. Soybean Oil Use for Biodiesel Helped Offset the Impact of Trans-Fat Labeling On Soybean Oil Use

- In July, 2003, the U.S. Food and Drug Administration (FDA) started to regulate the labeling of trans-fats for foods sold in the U.S. In January of 2008, such labeling became mandatory for all vegetable oil sold at retail outlets. While food service institutions are not required to label trans-fats, many high-profile food service chains such as McDonalds started to shift away from trans-fats as consumers learned about the health risks associated with the consumption of trans-fats oils.

- The result was a very rapid transition away from trans-fats vegetable oils (mainly hydrogenated soybean oil\(^9\) in North America) and towards more stable (i.e., stable for frying purposes) oils such as palm and towards vegetable oils perceived as healthier than trans-fat such as rapeseed/canola oil or sunflower oil.

- Exhibit 7 shows the rapid decline of soybean oil share for non-biodiesel (mostly food market), particularly after 2005, at the expense of palm and canola oil. Soybean oil is still the primary oil used in the U.S. for all non-biodiesel uses accounting for 56% in 2013/14 which is down from 72% in 2004/2005.

- For perspective, U.S. soybean oil consumption for non-biodiesel uses started to decline after 2005 and since then domestic use for non-biodiesel has declined 4.0 billion pounds from 2004/2005 to 2013/2014. The decline is a consequence of the substitution of soybean oil mainly for palm and canola. Note than in the last three years canola oil use has increased substantially as the production of canola in North America has increased and canola oil maintains a “healthier” advantage over soybean oil.

- Exhibit 8 shows the use of soybean oil for biodiesel has offset the losses soybean oil sustained due to the trans-fat issue for the increased popularity and availability of canola oil. That is, absent a biodiesel market, soybean oil processors/traders would have had to find alternative export markets and incur additional marketing, logistics costs and potentially reduce soybean processing.

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\(^9\) Note that the trans-fat content of soybean oil is a consequence of the hydrogenation process which was widely used to increase the stability and shelf life of soybean oil.
Exhibit 8: U.S. Soybean Oil Consumption LOST to other Oils vs. Soybean Oil Consumption GAINED by Biodiesel Relative to 2004/05

Source: USDA, Informa Economics
c. Biodiesel Resulted in Increased Demand for Soybean Oil in the U.S.

- Exhibit 9 shows how biodiesel has, over time, become a major market for soybean, accounting for 27% of SBO domestic use for the 2013/2014 marketing year and 20% of all vegetable oil use in the U.S.

- Although small in total magnitude in 2004, the use of soybean oil in biodiesel production increases rapidly since 2004 at the same time as non-biodiesel use of soybean oil also begins to decline.
d. **The Price of Soybean Oil Became Closely Linked to the Price of Diesel**

A key impact throughout the soy complex has been the increased correlation or link between the price of biodiesel feedstocks - including soybean oil - and the price of diesel and heating oil (i.e., referred to as energy prices) which are substitute products for biodiesel and bioheat respectively.
The biodiesel market (i.e., a fuel/energy market) now competes for vegetable oil (and other feedstocks) in addition to food and other non-biodiesel uses. This shifted the demand for soybean oil in a significantly positive direction effectively setting on-average a higher floor price for soybean oil as long as the potential to increase biodiesel production from soybean oil remains a potential opportunity for biodiesel producers.

**Before biodiesel** - a floor price for soybean oil was its energy value as compared, in Btu\(^{10}\) basis, to heating oil (i.e., burn value). That is, if soybean oil prices declined below their Btu equivalent to heating oil, consumers could use soybean oil instead of heating oil, as the former becomes an economical substitute. Historically, there has been no correlation between the two prices, and only in a few instances was soybean oil actually less costly than heating oil. However, anecdotal information suggests that in these few instances soybean oil was used for energy purposes.

**After biodiesel** - a floor price for soybean oil became equivalent to its value to the biodiesel industry, which on-average, has been roughly equivalent to the break-even value of biodiesel which would be the price of biodiesel minus the cost to process soybean oil into biodiesel. So, the first impact is an increase in the value/price of soybean oil relative to the era prior to biodiesel. Soybean oil’s burn value for energy normally acts as a floor for soybean oil futures. However, soybean oil prices usually have been above this level and have been closer to their biodiesel breakeven level (which is higher than their burn value) since U.S. biodiesel production capacity began expanding significantly in 2006 and 2007.

The correlation between soybean became much tighter to the price of biodiesel/diesel/heating oil because the biodiesel industry has the capacity to use a substantial share of soybean oil and thus other users (mostly food manufactures/retails) of soybean oil need to bid up the price of soybean oil high enough to limit the use of soybean oil into biodiesel. From 2007 to 2012, soybean oil prices and energy prices were statistically linked and soybean oil traded at its energy value to biodiesel. However, in 2013 and 2014, the correlation between the prices of diesel and soybean oil declined (Refer to Exhibit 10) and the soybean oil market started to be influenced by multiple factors beyond biodiesel use of soybean oil.

**The Changes in 2013 and 2014**

The biodiesel blender credit has been in place since 2005, but has expired several times in recent years. The biodiesel industry operated without the credit for most or all of 2010, 2012 and 2014 before Congress eventually extended it retroactively. Availability of the credit during 2011, 2013 and the last two weeks of 2014 boosted biodiesel prices such that soybean oil prices were below their biodiesel breakeven level, but still well above their burn value.

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\(^{10}\) **BTU**: British thermal unit is a traditional unit of energy equal to about 1055 joules. It is approximately the amount of energy needed to heat one pound of water by one degree Fahrenheit.
A record-large 2014 U.S. soybean harvest is expected to allow soybean stocks to build significantly, bringing lower soybean prices in 2015. While the soybean fundamentals appear decidedly bearish, the fundamental picture for soybean oil prices is not as clear. U.S. soybean crushing is expected to remain strong well into 2015 due to high crush margins and ample soybean supplies, while biodiesel production could be hampered by the absence of the blender credit and uncertainty about the biomass-based diesel mandate. However, soybean oil prices are, and may continue to be, solidly above their burn value because this year’s U.S. soybean crop has a low oil yield, U.S. soybean oil stocks still are relatively low, U.S. soybean oil exports have been relatively strong in recent months, and there is concern that recent flooding in Malaysia and Indonesia will reduce palm oil production.

Some of the reasons that explain the lower link to energy experienced in the last two-years include the following:

- Greater supply of vegetable oils for food use as well as biodiesel use. For example, U.S. consumption of canola oil increased from an average of 2.7 billion pounds in 2010-2012 to a high of close to 4 billion pounds in 2014. Also, use of industrial corn oil for biodiesel increased from an average of 2010-2112
- At biodiesel production levels of ~1.6 billion per year (including renewable diesel), the industry is reaching high levels of capacity utilization levels (note that biodiesel production reached 1.62 billion gallons in 2013 when margins exceed 1 dollar per gallon).
- Lack of clarity from EPA regarding the role that biomass based diesel will (or not) play as an undifferentiated advanced biofuel.
- Overall uncertainty about the biodiesel tax credit and future of the RFS and biodiesel’s role (biomass based diesel and renewable diesel).
- Soybean oil prices traded below their burn value for a brief period in early 2014 and again during much of August and September as soybean meal prices rallied amid extremely tight U.S. soybean supplies.
- Although U.S. soybean oil stocks were reduced to the lowest level since 2004, the rally in soybean meal prices pressured soybean oil prices because global vegetable oil supplies still were at a comfortable level. A collapse in petroleum prices during the past four months of 2014 substantially reduced soybean oil’s burn value and pressured biodiesel margins.

Furthermore, while the link to energy prices has been weaker, changes to the RFS that support increased production of biodiesel would tend to strengthen this link again. Also, biodiesel has now become a key domestic market for soybean oil accounting for 25% of U.S. production and thus supporting U.S. crushers, particularly those that are not well positioned to export soybean oil.
Exhibit 10 provides a visual representation of the correlation between soybean oil and energy prices after the periods indicated. The two year rolling correlation between diesel spot prices and soybean oil was very inconsistent prior to 2007. The correlation coefficient on the left vertical axis is the indicator of the common relationship shared by soybean oil and diesel. The closer the correlation is to “1.0”, the closer the relationship is between soybean oil and diesel prices. Since it is a two year correlation, during the two years ending in 2007 through to 2012, soybean oil and diesel were highly correlated despite significant price swings in the market. Since then, the correlation has declined but still remains higher than prior to the biodiesel era. Also, notice that the correlation since mid-2014 started to increase again; the 2013 to mid-2014 period is viewed as an outlier period in which the price of soybean oil was driven more by the supply/demand dynamics of the soybean complex than by energy prices.

Exhibit 11 and Exhibit 12 present similar conclusions; scatter plots graphically illustrate the lack of correlation prior and after 2007, tight correlation from 2007 to 2012, and renewed correlation in 2014 and 2015.
Impact of the U.S. Biodiesel Industry on the U.S. Soybean Complex and Livestock Industry

Exhibit 10: Correlation between Soybean Oil and Diesel Prices

Source: EIA, USDA, & Informa
Exhibit 11: 1998-2006 Monthly Correlation of Spot Diesel and Soybean oil Prices

Exhibit 12: 2007 to 2012 Monthly Correlation of Spot Diesel and Soybean oil Prices

Source: CBOT, EIA, Informa.
e. **Key Takeaways**

- Empirical evidence gathered from U.S. soybean crushers suggested that demand for soybean oil prior to biodiesel was supply driven with soybean oil stocks often viewed in the market as a "drag". Post biodiesel, demand for soybean oil is more demand driven as soybean oil can be used as an energy product via biodiesel at a competitive price. In fact, biodiesel in 2014 accounted for 25% of domestic soybean oil production.

- Since 2005 soybean oil use for biodiesel increased from 0.67 to 5.0 billion pounds for 2013/2014. During the same period, U.S. soybean oil use for food applications declined 4.0 billion pounds as a consequence of new FDA regulation on trans-fats labeling for foods sold in the U.S which started in July of 2003 but became mandatory in January of 2008. The decline of soybean oil use for food uses allowed other vegetables oils including palm and canola oil to increase their market share of the U.S. food market.
The impacts of biodiesel throughout the soy complex are a consequence of increased demand of soybean oil and the correlation or link between the price of biodiesel feedstocks - including soybean oil - and the price of energy (e.g., diesel, heating oil).

Energy markets now compete for vegetable oil in addition to food and other non-biodiesel uses. This shifted the demand for soybean oil in a significantly positive direction which effectively sets a floor price for soybean oil (and all biodiesel feedstocks) below which increasingly incremental demand for biodiesel would push soybean oil prices up to at least this floor price.

While the link to energy prices was weaker, changes to the RFS that support increased production of biodiesel would tend to strengthen this link again. Also, biodiesel has now become a key domestic market for soybean oil accounting for 25% of U.S. production and thus supporting U.S. crushers, particularly those that are not well positioned to export soybean oil.
d. **Impacts of the Biodiesel Industry to U.S. Livestock Producers**

The livestock industry has endured a very changing period over the past six to seven years as feed prices increased significantly to record highs squeezing livestock and meat margins that overtime resulted in increased meat prices. The increased global demand for grain and vegetable oils to support biofuel policies/mandates mainly in the U.S. and Europe but also in Brazil and Argentina certainly had an impact on feed prices.

However, a key objective of this analysis to examine is to point out some of the positive impacts that the development of the biodiesel industry has had on livestock producers; these include the following:

- Increased soybean oil prices driven by increased biodiesel production as well as increased energy prices generally helped reduced soybean meal prices (as well as other vegetable meals).

- Biodiesel demand for soybean oil in the U.S. helped soybean crushers operate more effectible and at high capacity utilization levels in spite of a very challenging/declining U.S. soybean meal market.

- Meat processors got higher prices and increased domestic markets for animal fats as the rendered products increased in price in parallel to soybean oil.

The first step to measure the impact of biodiesel on soybean meal prices is to isolate the impact of biodiesel production on soybean oil prices – increased prices of energy (i.e., heating oil) also influenced soybean oil prices.

a. **Impact of Biodiesel on Soybean Oil Prices**

A key impact of the emergence of the biodiesel industry has been its positive support to soybean oil prices via the creation of a new and large demand market for soybean oil as well as other vegetable oils and animal fats and recycled cooking oil or yellow grease. To estimate this impact, Informa examined historical tendencies of soybean oil as it typically has had an effective floor price equivalent to its energy value as compared, in Btu basis, to heating oil (i.e., burn value).

If soybean oil prices become low enough relative to the price of heating oil, soybean oil becomes an economical substitute for one or more marketable uses of heating oil. This “burn value” floor price for soybean oil was reached recently in the fall of 2008 and during parts of 2005 and 2006 (i.e., when energy prices were increasing rapidly but a close link to soybean oil had not been established) and more recently in 2014 when soybean and soybean oil prices declined.
(Exhibit 14). In the 2005-2006 period in particular, soybean oil was indeed used as a heating oil substitute in small quantities - thus providing an observable floor for soybean oil prices.

With the development of biodiesel, the floor price for soybean oil became equivalent to its value to the biodiesel industry which on-average has been closer to the break-even value of biodiesel (i.e., the price of biodiesel minus the cost to process soybean oil into biodiesel). So, as illustrated in Exhibit 14, the value of soybean oil increased relative to the era prior to biodiesel increased.
Impact of the U.S. Biodiesel Industry on the U.S. Soybean Complex and Livestock Industry

Of course not all the soybean oil price increase from the low 20 cts/lb to around 50 cts/lb can be attributed to biodiesel nor the decline to the mid 30s cts/lb. That is, soybean oil prices would have increased during the high energy price environment of the late 2000s independent of the existence of the biodiesel industry. Why? To keep soybean oil competitive with heating oil and to keep soybeans and soybean meal competitive with other crops such as corn. A key consequence of this price behavior was that higher vegetable oil prices helped lower soybean meal prices.

The estimated economic impact is what portion of the soybean oil price increase is attributed to biodiesel only; Exhibit 16 shows the results of the Informa estimated impact attributed to biodiesel only; this impact is a function of the prices of diesel, biodiesel, heating oil and soybean oil.

Findings from the analysis suggest the following:

- From October 2006/07 to mid-2014/2015 (marketing years), the combined impact of biodiesel to the price of soybean oil has been on average +11 cents per pound.

- The cumulative impact of increased soybean oil prices from October 2006/07 to March of 2015 is equal to an increase of soybean oil revenues alone of over $18.8 billion during this period.

- The effect of biodiesel on the price of soybean oil declined in 2012/2013 and 2013/2014 to 10.2 cts/lb and 3.4 cts/lb respectively; however it picked up again in 2014/2015 which averaged 7.5 cts/lb during the first half of the marketing year. While these estimates are lower than previous years, it still represents a positive contribution to the soy complex in an environment in which:
  - soybean oil used for food has seen increased pressure and actually lost market share mainly to canola oil,
  - soybean oil exports have declined,
  - energy prices, including diesel and biodiesel, declined significantly, and
  - the biodiesel market remains with uncertainty about the credit and has in fact operated without one.

Exhibit 15: Impact of Biodiesel on Soybean Oil Prices

<table>
<thead>
<tr>
<th>Period</th>
<th>Actual SBO Price</th>
<th>Impact of Biodiesel on SBO Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005/06</td>
<td>23.8</td>
<td></td>
</tr>
<tr>
<td>2006/07</td>
<td>32.3</td>
<td>+ 7.4</td>
</tr>
<tr>
<td>2007/08</td>
<td>54.1</td>
<td>+14.8</td>
</tr>
<tr>
<td>2008/09</td>
<td>34.6</td>
<td>+12.4</td>
</tr>
<tr>
<td>2009/10</td>
<td>38.8</td>
<td>+11.3</td>
</tr>
<tr>
<td>2010/11</td>
<td>55.3</td>
<td>+18.6</td>
</tr>
<tr>
<td>2011/12</td>
<td>52.6</td>
<td>+13.3</td>
</tr>
<tr>
<td>2012/13</td>
<td>48.2</td>
<td>+10.2</td>
</tr>
<tr>
<td>2013/14</td>
<td>38.9</td>
<td>+3.4</td>
</tr>
<tr>
<td>2014/15e</td>
<td>32.1</td>
<td>+7.5</td>
</tr>
<tr>
<td>2006/2015</td>
<td>44.4</td>
<td>+11</td>
</tr>
</tbody>
</table>

2014/15 estimate based on 6 months of the marketing year (i.e., October 2014 to March 2015).

Source: Informa
Exhibit 16: Impact of Biodiesel on the Price of Soybean Oil

Source: Informa Economics
b. Impact of the Biodiesel Industry on Livestock Feed Costs

- As noted in the previous section, the emergence of the biodiesel industry resulted in an increase — on average—of soybean oil by 11 cts/lb from 2006/2007 to mid-2014/2015. If soybean oil prices had not increased from pre-biodiesel levels, soybean meal prices would have to be higher to maintain a soybean price to effectively compete for corn acreage and/or soybean prices would have to be lower to reflect the lower value of the oil in the overall crush value.

- The 11 cents per pound of soybean oil is reflected in the soybean complex via a combination of a price increase of soybeans and/or a decrease in the price of soybean meal.
  - An average estimate is that soybeans increased by $0.63 per bushel and the price of soybean meal declined by $21 per ton.
  - The results can also be interpreted as an average increase of \textit{up to} $1.25 per bushel for soybeans or a decrease of \textit{up to} $42 per ton of soybean meal for the period.
  - Relative to the 2012 report, the impact results are slightly lower (e.g. up to $1.25 vs $1.48 per bushel for soybeans and $42 vs $50 per ton for meal) due to the lower impact of biodiesel on soybean oil prices experienced in 2013 and 2014. However, these findings continue to point a favorable and meaningful impact of the biodiesel industry on feed prices, and hence, livestock producers and the overall soy complex.
  - It is important to point out that for the post-biodiesel era, soybean crushers' main objective remained — for the most part- to crush for meal and thus crush volumes were driven more by feed demand than by biodiesel and food demand for soybean oil. Of course during 2011 and 2012, the high prices of soybean oil gave soybean oil a record high share of value that exceeded 50% and a few crushers did indeed “crush for oil”. Going forward though, crushers will remain driven by U.S. meal demand and thus actions/market conditions that increase soybean oil prices independently of the prices for soybean and/or meal (e.g., increased demand for soybean oil from biodiesel or other uses) will help keep soybean meal (and thus other vegetable meals such as canola or cottonseed meal) priced lower than otherwise.

- Exhibit 17 shows for each year the \textit{maximum impact} that the soybean oil price increase (e.g., 13.3 cts/lb in 2011/2012) could have on soybean meal (e.g., a decline of $51/ton) or soybean (e.g., increase of $1.52/bu). The “maximum impact” means that the change in soybean oil is reflected exclusively in meal or beans, not both.
In reality, the impact of higher soybean oil prices has resulted in a combination of both higher soybean and lower soybean meal prices. While one would expect the impact to be reflected more in a decline of meal prices than in an increase of soybean prices, there is no good method to calculate the difference.

The overall results can be interpreted as follows: The biodiesel industry through its effect on soybean oil prices resulted in an increase of up to $1.25 per bushel for soybeans or a decrease of up to $42 per ton of soybean meal.

Another way to measure the impact of the biodiesel industry on feed prices is to estimate the total dollar impact since the industry started to develop.

From 2006/07 to 2014/15 (2014/15 estimated based on actual October to March data), the cumulative impact of biodiesel on soybean meal prices resulted in lower feed costs for U.S. livestock producers, mainly poultry and hog
producers, that range from $5.9 billion (i.e., average estimate using a soybean meal price impact of $21 per ton) to $11.8 billion (maximum estimate using a soybean meal price impact of $42 per ton). The cumulative impact as well as year-to-year impact is illustrated in Exhibit 18.
Poultry and swine account for about 83% of the domestic animal consumption of soybean meal and thus would be the most influenced by lower soybean prices.

Note that estimates presented include the effect of biodiesel on soybean meal prices which accounted for 83% of the vegetable meals consumed in the U.S. in 2013/14 by U.S. livestock producers. However, soybean meal is the vegetable meal price leader and hence a change in its price would also have resulted in lower prices for canola meal which accounted for 13% of the vegetable meal consumed in the U.S. in 2013/14.

From 2006/07 to 2014/15 (2014/15 estimated based on actual October to March data), the cumulative impact of biodiesel on canola meal via lower soybean meal prices resulted in lower feed costs for U.S. livestock producers, mainly dairy and cattle farmers, that ranged from $443 million (i.e., average estimate using a soybean meal price impact of $21 per ton) to $885 million maximum, estimated using a soybean meal price impact of $42 per ton).
c. Biodiesel Resulted in Increased Prices for Animal Fats and Greases

Historically animal fats and yellow grease prices (i.e., recycle cooking oil and other greases) traded at a discount to soybean oil. These commodities were used as feed ingredients and in a multitude of industrial uses. Also a large portion of U.S. production was exported. As these feedstocks started to be used as a lower priced feedstock alternative to soybean oil in the production of biodiesel, their prices started to reflect their value as fuel for biodiesel more and more. Consequently, the prices of animal fats and yellow grease started to increase relative to soybean oil.

Thus, value provided by the biodiesel industry is derived from three sources:

- The increase of soybean oil prices attributed to biodiesel (i.e., 11 cts/lb from 2006/7 to mid-2014/15), but adjusted to reflect the price relation (discount) that exists between soybean oil and animal fats and grease. The correlation coefficient between the prices of soybean oil and various animal fats and greases exceeds 0.90.

- The reduction of the price discount that animal fats and grease have relative to soybean oil prices is illustrated in Exhibit 20.

- Creation of a large new and domestic market for animal fats.

Exhibit 20 shows how the soybean oil premium relative to animal fats and yellow grease has declined particularly starting in 2009 when the amount of animal fats and yellow grease used for biodiesel started to increase substantially.

The price increase attributed to the development of biodiesel and that benefited rendering companies (i.e., meat processors such as Tyson and independent rendering companies such as Darling) as shown below in Exhibit 20. This added economic benefit is directly received by livestock processors and independent renderers. Increases to the cutup value of livestock, including increased value of byproducts, has an indirect impact on the price of live animals; however it is difficult to quantify what has been the actual impact to livestock producers.
Exhibit 20: Animal Fats and Yellow Grease Prices Discount Relative to Soybean Oil Prices (2000-2012)

Source: Informa Economics
Impact of the U.S. Biodiesel Industry on the U.S. Soybean Complex and Livestock Industry

Exhibit 21: Impact of Biodiesel on the Price of Animal Fats and Yellow Grease

<table>
<thead>
<tr>
<th>Impact Due to SBO Price Increase</th>
<th>Impact Due to Lower Discount to SBO</th>
<th>Combined Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renderer Tallow, Chicago</td>
<td>9.4</td>
<td>9.7</td>
</tr>
<tr>
<td>Choice White Grease, Chicago</td>
<td>9.2</td>
<td>9.4</td>
</tr>
<tr>
<td>Poultry Fat, Southeast Points</td>
<td>8.4</td>
<td>8.8</td>
</tr>
<tr>
<td>Yellow Grease, Chicago</td>
<td>7.9</td>
<td>8.3</td>
</tr>
</tbody>
</table>

* Adjusted for the relation between SBO and each animal fat and yellow grease.
Source: Informa Economics

d. Key Takeaways

- Biodiesel created support to move the historical floor price of soybean oil or its “burn value” for energy (based on its Btu equivalent to heating oil) to a price floor that is more linked to its relative value for biodiesel.

- From late 2006/2007 to 2014/2015\(^{11}\), the combined impact of biodiesel to the price of soybean oil (and the overall soy complex) has been on average, an increase of on average 11 cents per pound\(^{12}\); this value translates into a cumulative increase of soybean oil revenues alone of $18.8 billion from 2006/2007 to 2013/2014.

- The 11 cents per pound have effectively increased the price of soybeans for the time period examined by $0.63 per bushel and decreased the price of soybean meal by $21 per ton.

- It is important to point out that for the post-biodiesel area, soybean crushers’ main objective remained – for the most part- to crush for meal and thus crush volumes were driven more by feed demand than by biodiesel and food demand for soybean oil. **Going forward** though, crushers will remain driven by U.S. meal demand and thus actions/market conditions that increase soybean oil prices independently of the prices for soybean and/or meal (e.g., increased

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\(^{11}\) For 2014/2015, information through March 30 2015 was used
demand for soybean oil from biodiesel or other uses) will help keep soybean meal (and thus other vegetable meals such as canola or cottonseed meal) priced lower than otherwise.

- From 2006/07 to 2014/15\(^{13}\), the cumulative impact of biodiesel on soybean meal prices resulted in lower feed costs for U.S. livestock producers, mainly poultry and hog producers, that range from $5.9 billion (i.e., average estimate using a soybean meal price impact of $21 per ton) to $11.8 billion (maximum estimate using a soybean meal price impact of $42 per ton).

- Poultry and swine account for about 83% of the domestic animal consumption of soybean meal and thus would be the most influenced by lower soybeans prices.

- Rendering companies (including meat processing companies) got higher prices for tallow (+17 cts/lb), poultry fat (+15 cts/lb), choice white grease (+16 cts/lb), and yellow grease (+15 cts/lb), but the full impact on these feedstocks was felt only since 2009.

\(^{13}\) 2014/15 estimate based on actual data through March 2015
e. **IMPACTS OF THE BIODIESEL INDUSTRY TO U.S. SOYBEAN CRUSHERS**

The soybean crushing positively benefited from the expansion of soy based biodiesel industry; this positive impact is driven by the following factors.

**Increased domestic soybean oil use for biodiesel**

- Increased domestic use resulted on improved pricing for soybean oil relative to export alternatives; that is, improve soybean oil price basis; the impact on soybean basis bid would have been stronger in specific regions where supplies that have a large vegetable oil surplus and/or have a higher cost access to export transportation routes (e.g., Minnesota, Indiana or Ohio).

- In the absence of biodiesel, 5.0 billion pounds of soybean oil in 2013/14 (25% of production and 1.5 times larger than the highest export volume in the past ten years and 4.4 higher than 2013/2014 stocks) would have to priced itself competitively into the world market and marginally into the domestic food use markets. Inevitably soybean crushers would have carried significantly larger soybean oil stock levels as the global market adjusted to record high soybean oil exports from the U.S.

- Input from U.S. crushers also indicated that soybean oil basis would have been so negative in certain areas (potentially over 3 cts/lb) that crushing volumes would have declined affecting overall capacity utilization levels and hence crush margins. Note again that the largest effect of a non-biodiesel scenario in the late 2000’s on the crushing sector would have been on specific crushers (i.e. those not well positioned to export or far away from domestic consumption centers). Also, it is important point out that average crushing capacity (based on NOPA’s reported capacity information) actually expanded about 3% since 2007 without any notable deterioration to crush margins or utilization levels.

- Furthermore, the “timing” of the ramp up of biodiesel soybean oil use (i.e., late 2000) was crucial since it coincide with the large and rapid decline of soybean oil use for food (Refer to Exhibit 8).

- Based on changes of relative soybean oil prices and input from crushers, Informa estimates that soybean oil basis increased on average of 1.0 to 1.5 cts/lb with improvement of up 3 cts/lb for a few facilities, after the late 2000’s and as consequence of increased domestic biodiesel use. Note that the impact estimate excludes the impact to the price of soybean oil estimated earlier (i.e., 11 cts/lb average impact from 2006/07 to 2014/15) which influenced soybean and soybean meal prices, but meaningfully crush margins.
If one take the more conservative estimate of 1 ct/lb impact on soybean oil basis, then the impact on average crush margins would be an 11.2 cts/bu improvement relative to average cash crush margins for the 2006/07 to 2014/2015 period and for an Illinois processor; for perspective cash crush margins for the same period averaged 77.6 cts/bu.

**Increased soybean oil refining margins**

- Most of the biodiesel capacity, particularly the capacity constructed in the first few years of development was designed to use refined soybean – not crude. While some facilities had feedstock pre-treatment equipment and can source either crude or refined oil most, particularly facilities under 30 mmgy did not have pre-treatment and can only source refined soybean oil or other refined oils. Hence, the relative demand for refine soybean oil increased and refining margins increased substantially as shown in the Exhibit below.

**Exhibit 22: Soybean Oil Refining Margin (NY Refined minus Decatur Crude)**
f. **WHAT IF THE BIODIESEL STOPS OPERATING?**

While examining the impact of a complete and relatively sudden halt of the biodiesel is a hypothetical exercise, it is very instructive to evaluate the effect that an industry that accounts for 25% of soybean oil production would have on the soybean complex. Note that the difference between this analysis and the analysis that estimated above the impact of biodiesel on soybeans oil prices is that here the assumption is that the industry stops operating and thus would have short, medium and long term effects as crushers and traders initially struggle to “push” substantial amounts of soybean oil (5 billion pounds in 2014) into the global market in competition with palm and other vegetable oils, before the market stabilizes and finds a new equilibrium in production and price structures.

The potential impact varies by year based on soybean oil price relative to its historical floor price and soybean oil export basis which would initially collapse. Naturally the impact in terms of cents per pound would have been much larger in 2010 or 2011 when average vegetable oil prices were high at the low 50s than in 2014 when prices are back the low 30s.

Informa examined this scenario using 2013/14 average prices as a starting point; however, note for this year vegetable oil prices are low and the impact of biodiesel production estimated (3.4 cents/lb) is the lowest for the period examined (2005/06 to 2013/2014). The findings are presented below:

**Short Term Effect** (1-12 months): soybean oil prices decline by 8.2 cts/lb reflecting a large decline of soybean oil demand which would push prices to its lowest floor price at least while the markets adjust to the new fundamentals. Additionally, soybean oil export basis will decline sharply in the short term (i.e., historically export basis have traded even below Decatur soybean oil prices when stock levels have been high). Also crushers also will incur increased soybean oil storage. In summary, the short term impact will be
   a. soybean price decline of 8.2 cts/lb;
   b. corresponding lowerprices for soybean ranging from 0.47 to 0.94 cts/bu;
   c. corresponding higher soybean meal prices ranging from 16 to 32 dollars per short ton; and
   d. lower soybean crush margins (due to lower soybean oil basis) ranging of around 16 cts/bu.

As noted before, these estimates are based on the market conditions experienced in 2013/2014; for perspective the results for marketing year 2012/13 and the first six months of 2014/15 would be have been a drop of soybean oil prices of 16.3 cents/pound or 12.9 cts/lb respectively. This estimated impact reflects average prices for the short term; daily/weekly prices following the hypothetical halt of biodiesel industry would likely be higher.
**Mid Term Effect** (over 12-18 months): soybean oil prices decline by 5.50 cts/lb still reflecting a large decline of soybean oil demand prices start to adjust to historical patterns – full adjustment to historical patterns will happen in the long term but it difficult to estimate how long with it take. Additionally, soybean oil export basis would improve relative to the short but still reflect a difficult environment for crushers not well located to serve the export market. Increased storage cost will remain as long as no additional domestic markets are developed (e.g., soybean oil taking a larger share of the food market). In summary, in the mid-term the impact will be

- e. soybean price decline of 5.50 cts/lb;
- f. corresponding lower prices for soybean ranging from 0.32 to 0.64 cts/bu;
- g. corresponding higher soybean meal prices ranging from 11 to 22 dollars per short ton; and
- h. lower soybean crush margins (due to lower soybean oil basis) of around 11 cts/bu.

For perspective the results for marketing year 2012/13 and the first six months of 2014/15 would be have been a drop of soybean oil prices of 14.3 cents/pound or 10.9 cts/lb respectively. This estimated impact reflects average prices for the short term; daily/weekly prices following the hypothetical halt of biodiesel industry would likely be higher.