Development and commercialization of a biorefinery for processing DDGS in biofuels and other value-added products (Phase 2, Continuation)

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Minnesota Corn Research & Promotion Council
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Project Goals for the Current Period:

Our project, "Development and commercialization of a biorefinery for processing DDGS in biofuels and other value-added products (Phase II, Continuation)" was completed in accordance with the research and development plan, which was proposed to MCR&PC/MCGA in FY 2012 plus additional, previously not planned work on the technology of Zein manufacturing.

The continuation of this project in FY12 was based on research previously performed at NRRI (2005-2009) and with the support of MCR&PC/MCGA and IREE in FY11. Our Proposal to MCR&PC/MCGA in year 2010 was planned for two years (FY11 and FY12). This proposal for continuation did not repeat the previous Problem Statement and other general information, which has not changed since the period of FY11. This report focuses on reporting the results and conclusions of our work in FY12/FY13 (Phase 2).

Objectives and Hypothesis.

The main idea behind our approach to DDGS value-added products was the selective extraction of by- products of dry grind corn ethanol plants and then the transformation of extracts into additional ethanol and biodiesel. This idea and technology were discovered at Natural Resources Research Institute (UMD) and patented by the University of Minnesota. The main project goal for the current period was to develop industrially viable methods of DDGS processing for the following commercially valuable products:

- Post-fermented corn oil
- Biodiesel from post-fermented corn oil
- Mono- and disaccharide solubles as feed products
- Transformation of solubles into second generation ethanol
- High Protein Distillers Grains (HPDG), consisting of a 34% protein feed with 2% oil
- Corn Zein

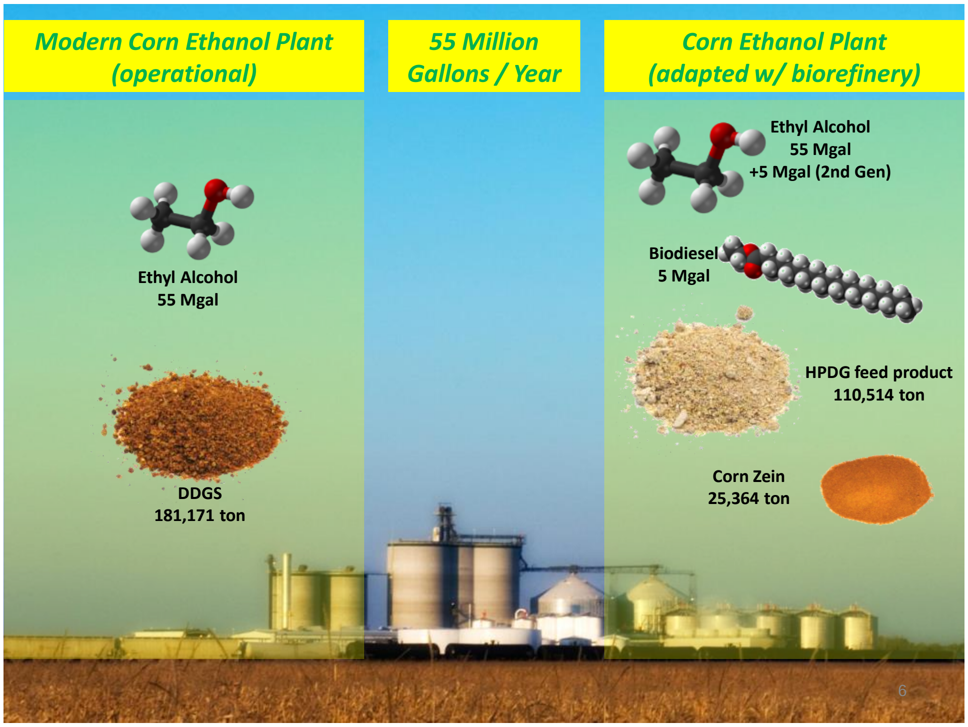
The goal of project commercialization should be characterized as an additional and very important part of our project. This goal has been achieved through broad project publicity, presentations, and communication activity with ethanol plants and companies which are working with corn ethanol manufacturing.

Describe Goals Accomplished During the Period:

With this report we inform our investors - MCR&PC/MCGA and AURI - that all the listed goals of project were accomplished successfully and the project was advanced to the level of readiness for transferring to industrial partners for final industrial tests and plant construction and implementation.[1] Picture 1 delivers a final statement of the project results. According to this statement, the average ethanol plant (55Mgal/year),if modified in accordance with project conception and technology development will produce in addition to ethanol, the following quantities of products:

- 5 million gallons of additional secondary ethanol
- 5 milion gallons of biodiesel B100
- 25,364 tons of corn Zein , a new valuable product
- 110,514 tons of HPDG with2% oil & 34% protein – new corn feed product;

[1] We must admit that the pilot development of soluble bioconversion into secondary ethanol was not provided because the deficit of funding. Please, see explanations in Chapter "Describe Factors Limiting Progress", page 14.



Picture 1. Assortment and quantities of value added products which will be produced on modified 55 Mgal ethanol plant

It is important to emphasize that the above summarized results of project are substantially better than promised in the 2012 Proposal Continuation "Development and commercialization of a biorefinery for processing DDGS in biofuels and other value-added products (Phase II, Continuation)." Additional extraction of zein was not mentioned in proposal continuation, because of uncertainty about the amount of this product and its quality. Our current research provides a technology of Zein separation from HPDG with a yield near 14% of the original HPDG material. This means that we have added to our value-added products a high volume production of valuable corn protein. The yield of Zein was increased by 7 fold compared to the initial proposal to MCGA. Table 1 presents the prices and the resulting value of projected new products in comparison with theoriginal DDGS product. At baseline prices total value of new products is 3 times higher than the value of starting DDGS.

Table 1. Value of new technology of DDGS processing					
Products	DDGS	Biodiesel from oil	Additional Ethanol from Solubles	Zein	Final feed product
Amount in kg	1000kg	90kg	80 kg	140 kg	610 kg
Price per 1 kg	$0.24	$1.36	$0.87	$3.11	$0.15
(Cost)/Rev per Mt DDGS	$240	$122	$70	$435	$91
% on sale		17	9.7	60.6	12.7
Revenue Mt DDGS	$122+$70+$435+$91-$240= $718- $240 = $478*				

*718:240 x100%= 299%. Total value of DDGS could be increased by 2.99 or 299%

These goals were achieved through the process of research and development, specifically the process of DDGS extraction and ethanol removal was optimized on pilot scale equipment at Crown Iron Works Company. The main lesson learned by these trials was that counter-current extraction of DDGS with 99% ethanol at ratio Ethanol/DDGS = 1.0 could give good yields of post fermented oil. (~10% oil extracted from dry DDGS product) and (~15% solubles extracted from dry DDGS product) (Table 2).

Table 2. Results on DDGS counter current extraction of DDGS with 99% ethanol						
Sample	Retention	Solvent / Feed	% Moisture	% DB Fat NRRI tests	Yield of Fat (oil +FFA)	Yield of extract (Fat+Soluble) on Raw Feed
Raw Feed	-	-	14.05	10.56		
#1	60 min	1.5 : 1	17.59	1.8	83%	25%
#2	30 min	1.5 : 1	2.41	1.3	88%	26%
#3	30 min	2 : 1	5.81	2.5	76%	24%
#4	30 min	1 : 1	1.59	1.5	86%	25%
#5	20 min	1.5 : 1	2.77	2.1	80%	23%

Picture 2. Pilot scale counter current extractor Model II.

Picture 3. Apparatus for ethanol extract – micelle processing (ethanol removing, oil separation from solubles).

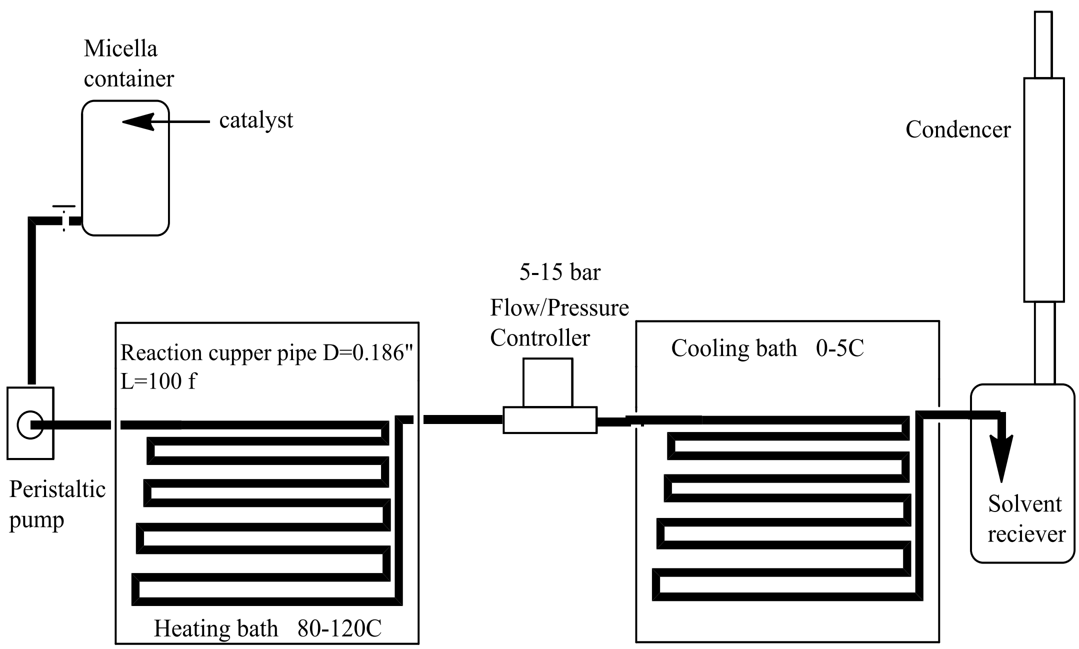
The process of ethanol removal and post fermentation corn oil separation from solubles was developed on pilot scale 72L apparatus at the Laboratory of Chemical Extractives (LCE) (NRRI, UMD) (Picture 3). The apparatus shown in Picture 3 allowed processing of 55L of micelle and produced nearly 10 L of oil and 15L of Solubles per batch. Optimized parameters were obtained for transferring this process to high scale industrial level.

This process could be scaled up to industrial level with the use of high scale industrial apparatus for ethanol distillation or recycling. The process of oil separation from solubles could be provided in a high scale continuous apparatus for immiscible liquids separation.

The process of biodiesel synthesis has been reported to AURI in a previous report. Because this process is the most important for whole DDGS processing technology, we decided to repeat previously reported information in this final report. This inclusion is offered to give a more complete understanding of all technically connected stages of DDGS processing.

The pilot model of the continuous transesterification process was constructed at the Laboratory of Chemical Extractive, NRRI, UM of Duluth. This continuous model (Picture 4) includes a regulated pumping feeder of the mixture of DDGS extract, a high-accuracy diaphragm metering pump (max PSI 250, Pulsatron-Pulsafeeder "E-plus" series, ethanol and catalyst at different ratios, thermo regulated cupper pipe - internal diameter 0.186" and length 100 f - which allows regulating retention time of the reaction mixture in pipe for from 0.5 hour-2.5 hours and temperature ranging from 80°C-115°C. Copper pipes were placed in temperature regulated baths. Heating baths supported temperature regimes of pipes at 80-130°C and cooling baths supported temperatures from 0°-10°C.

Scheme of continuous biodiesel synthesis station



Picture 4. Principal scheme of continuous biodiesel synthesis station.

Further improvement of the process of DDGS processing has been achieved by the development of the process of High Protein Distillers Grains (HPDG) extraction for producing potentially valuable product Zein – corn protein. Initially we proposed production of this product directly from the corn oil extracted from the DDGS. The yield of zein in this process did not surmount 2%. Then we designed a new technology for Zein separation from HPDG resulting in a yield of 14%. The projected price of Zein and its yield ($1.40/lb) will make this product the most valuable product of DDGS processing, representing nearly 61% of new products sales (see Table 1).

Parallel to zein production, the remaining feed product (34% protein content) would be produced with the yield of 61% on starting DDGS product.

These achievements allowed us to reach better product diversification and economics of DDGS processing into high value-added products.

Economic analyses of the process has been performed by co-PI of the project Douglas Tiffany, Assistant Extension Professor of the University of Minnesota. Tiffany designed a techno-economic model to perform economical analyses of a proposed biorefinery including DDGS processing through ethanol extraction and ahighly diverse group of value added products from DDGS. The installed costs of the NRRI Integrated Technology are presented in Table 3.

This project identifies a path of development that offers refinement, integration, and verification of proven processes that should prove economically attractive to a majority of corn dry-grind ethanol plants. The great opportunity is to extract more of the valuable coproducts from the shelled corn that is already being processed. When earlier plants could make over 80% of their revenue from the sale of ethanol, little effort was expended on extraction and refinement of alternative by-products beyond DDGS.

However, economic modeling can verify and provide assurance to investors, bankers and ethanol plants that may wish to investigate how these integrated processes capture more economic value from every bushel of ground corn while improving the life cycle net energy balance of the ethanol produced at these plants. The rates of return on invested capital are calculated for conventional dry-grind ethanol plants, those that also produce corn oil by centrifuge processes, and plants that would install the NRRI Integrated Technologies. Table 3 contains the baseline assumptions for the installed cost of the NRRI Technologies and prices for corn, ethanol, DDGS, solubles, biodiesel, spun corn oil, HPDG, zein, carbon dioxide sales, natural gas, propane, electricity as well as predicted extraction or conversion rates.

Table 3.

Key Assumptions Applied		
Installed Cost-NRRI Integrated Technologies	**$30,000,000**	$30,000,000
Output Market Prices		
Ethanol Price (denatured price) $/gal.	**$2.48**	$2.48
DDGS Price $/T	**$240.00**	$240.00
HPDG Price Factor of DDGS	**0.80**	0.80
HPDG Price	**$192.00**	
Zein Price per lb.	**$ 1.40**	$ 1.40
CO2 Price ($ per Ton liq. CO2)	**$6.00**	$6.00
Biodiesel Price per gallon	**$ 4.50**	$ 4.50
Soybean Oil Price per Pound	**$0.50**	$0.50
Solubles Price per Ton as Factor of DDGS	**1.20**	1.20
Solubles Price per Ton	**$ 288.00**	**$ 288.00**
Government Subsidies		
Federal Small Producer Credit ($/gal.)	**$0.00**	$0.00
Feedstock Delivered Price Paid by Processor		
Corn Price ($ per bu.)	**$5.50**	$5.50
Corn Oil Percentage in Corn Delivered	**3.70%**	3.70%
Corn Oil % Extracted (NRRI-Integrated)	**80%**	80%
Energy Prices		
Natural Gas Price ($ per 1,000,000 Btu)	**$5.00**	$5.00
Electricity Price (Plant is Buyer) ($ per kWh)	**$0.07**	$0.07
LP (Propane) Price ($ per gallon)	**$2.00**	$2.00
Factor of Elect. Energy Reqd--NRRI-Integrated	**1.10**	1.10
Denaturant Price / gal	**$2.50**	$2.50
Denat/100 gal Anhyd.	**2**	2
Factor of Labor Requirement--NRRI-Integrated	**1.05**	1.05
Feedstock-to-Ethanol Conversion Yields		
Ethanol Yield--Corn (anhydr. gal per bu)	**2.795**	2.795
Percent Loss in Ethanol Yield--NRRI-Integrated	**2.00%**	2.00%
DDGS per bushel of corn	**17.5**	17.5

The goal of economic analyses is to determine if this technology can be competitive with others already installed. To achieve this goal if was necessary to recall the volatility of returns in biofuels in recent years and demonstrate how well returns of the NRRI Technologies perform during times of narrow margins for traditional ethanol plants that produce only DDGS. During times of narrow margins, the NRRI Technologies really shine by delivering excellent returns for plants that are capable of segregating and extracting more valuable products from DDGS.

- Our Techno-Economic Model helps us:
- Account for all product flows and mass balance
- Represent baseline operating conditions
- Permit sensitivity analysis by varying key prices of products and inputs
- Represent policy incentives -advanced biofuels status of the ethanol derived from glycerin
- Understand economic viability of competing technologies
- Focus lab efforts on most critical issues

Results of techno-economic model calculations are presented in the Top Half of Proforma of Debt-Free Plant, with NRRI-Integrated Technology (Table 4, which shows capital costs, revenue streams, and the development of the gross margin after payment for the corn.) The Bottom Half of Proforma is presented in Table 5, which shows more detail on the costs of production for an ethanol plant that installs and uses the NRRI Technology.

Table 4. Top Half of Proforma of Debt-Free Plant, with NRRI-Integrated Technology

1	**Pavel05**				By: Douglas Tiffany		Pavel05 Baseline
2	Dry-Grind, NG, Oil Extraction @80%, CO2 Sales, HPDG (38% protein selling at 80% of DDGS Price, Zein Selling for $1.40 /lb, Solubles selling for 120% of DDGS, Biodiesel Selling f/ $4.50	Cost/Denat. Gal. Ethanol	Ranges for Column C			1/10/2009	Plant Totals
3	Solubles	42,000,000			$ 64,180,000		
4	Investment per Nameplate Gallon	$2.242			$30,000,000	Plant Cost	$ 94,180,000
5	Factor of Nameplate Capacity	1.405	(80%- 150%)				
6	Debt-Equity Assumptions					Plant Profits	$ 113,706,627
7	Factor of Equity	0.84					
8	Factor of Debt	0.16				Initial Debt	$ 15,000,000
9	Interest Rate Charged on Debt	0.07				Payback of Addl Invest	0.43
10	Rate of Return Reqd. by Investors on Equity	0.12				Rate of Return	120.73%
11							
12	Conversion Efficiency Assumptions				Annual Production		
13	Anhydrous Ethanol Extracted (Gal. per Bu.)	2.795	2.5-2.9 gal/bu		Bushels Ground	Denat. Gallons	Tons of HPDG Sold
14	HPDG per Bushel (lb. per Bu.)	10.675	15-19 lb./bu		20,705,263	59,010,000	110,514
15	CO2 extracted per Bushel (lb. per Bu.)	17.8125	15-19lb./bu		CO2 Sold(Tons)	Tons of Zein	Biodiesel Sold (gal)
16	Corn Oil Percent of Corn D.M	3.70%	Percent of Oil Removed	80%	184,406	22,103	5,146,905
17	Zein Extraction Factor from Original DDGS	14.00%				Tons of Solubles	34,784.842
18	Establishment of Gross Margin	Price per Unit			Revenue/Bu. Ground	Revenue/Gal. Denatured Sold	Plant Totals
19	Ethanol Price (denatured price) $/gal.	$2.48			$7.0680	$2.4800	$ 146,344,800
20	High Protein Distillers Dried Grains	$192.00	Factor of DDGS Valu	80%	$1.0248	$0.3596	$ 21,218,754
21	Biodiesel Sales ($/Gal.)	$4.500			$1.1186	$0.3925	$ 23,161,072
22	Zein Sales per pound	$ 1.40	Price per Pound		$2.9890	$1.0488	$ 61,888,032
23	CO2 Price ($ per Ton liq. CO2)	$6.00	$2- $12 / liq.Ton		$0.0534	$0.0188	$ 1,106,438
24	Federal Small Producer Credit	$0.00			$0.0000	$0.0000	$ -
25	Sales of Solubles ($/ Ton)	$ 288.00			$0.4838	$0.1698	$ 10,018,035
26	Max.Prem for Low-Carbon Imprint for Ethanol	$0.00	Reduction Factor	0	$0.0000	$0.0000	$ -
27	Revenue per Unit				$12.7377	$4.4694	$ 263,737,129
28							
29	Corn Price Paid by Processor ($ per bu.)	$5.50	$1.60---$3.25		$5.5000	$1.9298	$ 113,878,947.37
30	Gross Margin				$7.2377	$2.5395	$ 149,858,181.99

Table 5 shows the cost detail per bushel of corn ground, per gallon of ethanol produced and for the plant as a whole. Depreciation for the existing plant plus the NRRI Technology and the interest expense of the additional assumed debt for the NRRI Technology are shown.

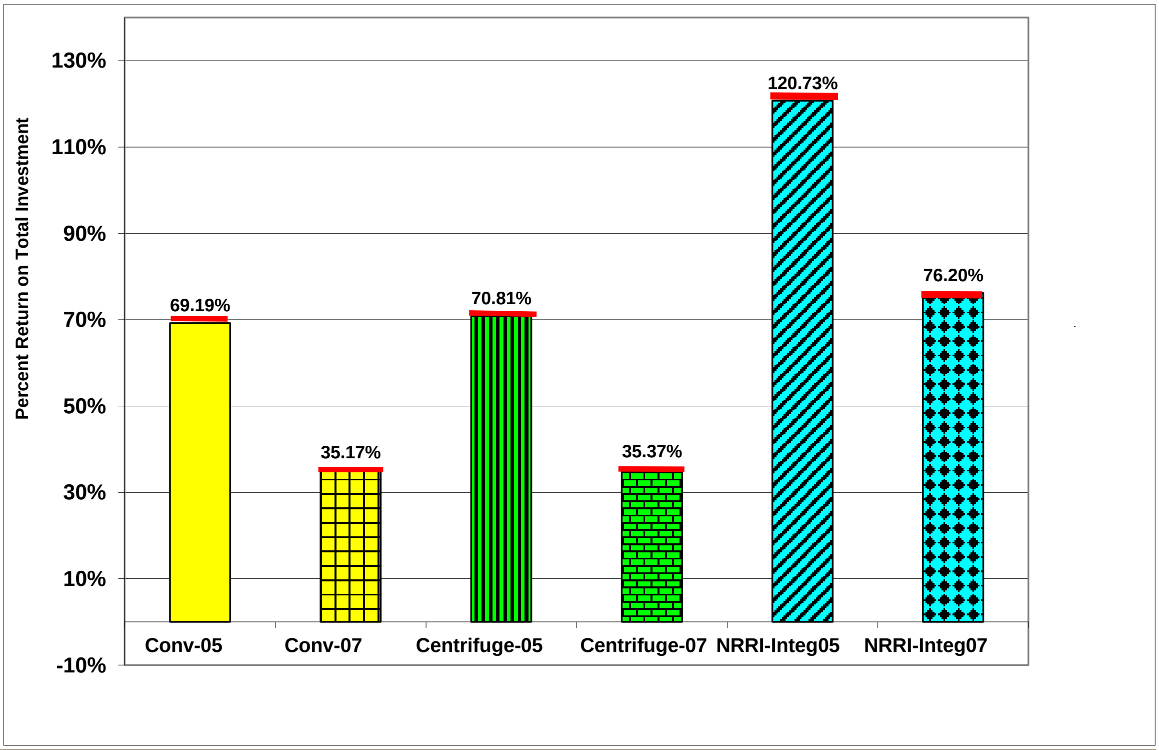
Table 5. Bottom Half of Proforma of Debt-Free Plant, with NRRI-Integrated Technology

		Price per Unit			Cost /Bushel Ground	Cost /Gal. Denatured Sold	Plant Totals
32	**Operating Expenses Per Bushel**						
33	Natural Gas Price ($ 1,000,000 Btu)	**$5.00**	($3-$15/Dtherm)		$0.4748	$0.1666	$ 9,831,066
34	LP (Propane) Price ($ per gallon)	**$2.00**	$.80- $2.00/gal.		$0.0423	$0.0039	$ 876,131
35	Factor of Time Operating on Propane	**0.02**	0-.12				
36	BTU's of Heat fr Fuel Req./ Denat. Gal.	**34,000**	28,500-55,000				
37	Combined Heating Cost				$0.5171	$0.1814	$ 10,707,197
38	Electricity Price ($ per kWh)	**$0.07**	$.025-$.090/kWh				
39	Kilowatt Hours Required per Denat.Gal.	**0.825**	.70 -1.25 kWh/denat. gal.				
40	Electrical Cost				$0.1646	$0.0578	$ 3,407,828
41	Total BTU's of Fuel and Electricity	**42,250**					
42	**Total Energy Cost**				**$0.6817**	**$0.2392**	**$ 14,115,025**
43							
44		**Cost/Denat. Gal. Ethanol**					
45	Enzymes	**$0.0400**			$0.1140	$0.0400	$ 2,360,400
46	Yeasts	**$0.0040**			$0.0114	$0.0040	$ 236,040
47	Other Proc.Chemicals & Antibiotics	**$0.0200**			$0.0570	$0.0200	$ 1,180,200
48	Boiler & Cooling Tower Chemicals	**$0.0050**			$0.0143	$0.0050	$ 295,050
49	Water	**$0.0030**	$.005-.010		$0.0086	$0.0030	$ 177,030
50	Denaturant Price per Gal.	**$2.50**	Denat/100 gal Anhyd.	**2**	$0.1370	$0.0481	$ 2,837,019
51	**Total Chemical Cost**				**$0.3422**	**$0.1201**	**$ 7,085,739**
52							
53	Depreciation based on C49 asset life	**15**	Years		$0.3032	$0.1064	$ 6,278,667
54	Maintenance & Repairs	**$0.0400**			$0.1140	$0.0400	$ 2,360,400
55	Interest Expense				$0.0507	$0.0178	$ 1,050,000
56	Labor	**$0.0525**	$.04--$.06		$0.1496	$0.0525	$ 3,098,025
57	Management & Quality Control	**$0.0167**	$.010-$.022		$0.0475	$0.0167	$ 983,500
58	Real Estate Taxes	**$0.0020**			$0.0057	$0.0020	$ 118,020
59	Licenses, Fees& Insurance, Waste Mgmt.	**$0.0140**	.0030-.0050		$0.0399	$0.0140	$ 826,140
60	Other Expenses	**$0.0040**	$.01-$.03		$0.0114	$0.0040	$ 236,040
61	**Total of Other Processing Costs**				**$0.7221**	**$0.2534**	**$ 14,950,792**
62	**Total Processing Costs**				**$1.7460**	**$0.6126**	**$ 36,151,555**
63	**Net Margin Achieved Per Unit**				**$5.4917**	**$1.9269**	**$ 113,706,627**
64	**Investor Reqd. Return on Equity**	**12.00%**			**$0.4589**	**$0.1610**	$ 9,501,600
65	**Increment of Success/Failure to Meet Required Return**				**$5.0328**	**$1.7659**	**$104,205,027**
66							
67	**Ethanol Plant Profits for Shareholders and Principal Reduction**			**50MM**	**$113,706,627**	**$113,706,627**	**$ 113,706,627**
68							
69						**EBITDA**	**$ 121,035,293**

Picture 5 graphically shows the rates of return for equally sized ethanol plants of three competing technologies,,, the conventional, the conventional + centrifuge oil separation, and the ethanol plants + NRRI Technology. Cases of debt-free ethanol plants like those built in 2005 (05) are contrasted with those built in 2008 (08), which cost more and are assumed to carry substantial debt.

The blue bars in the histogram show the superior rates of return on invested capital that would be achieved by plants operating since either 2005 or 2007 with the NRRI-Integrated technologies versus the yellow bars showing the rate of return for conventional ethanol plants put in service in those years and not installing that technology. The green shaded bars represent the rates of return on invested capital of the ethanol plants that have installed various centrifuge technologies to extract corn oil from wet stillage.

Picture 5. Baseline on return investment



NRRI integrated technology (NRRI-Integ05) gives 120.73% of return on total investment compared to 69.19% for conventional ethanol plants without debts (Conv-05).

NRRI integrated technology (NRRI-Integ07) gives 76.20% of return on total investment compares to 35.17% for conventional ethanol plants with debts (Conv-07).

It is important to emphasize that both NRRI-Integ technologies give better returns compared to centrifuge technology of corn oil processing from DDGS - Centrifuge-05 (without debts) and Centrifuge-07 (with debts (see **Picture 5**).

These economic results confirm the economic competitiveness of the newly developed technology of DDGS processing with ethanol extraction.

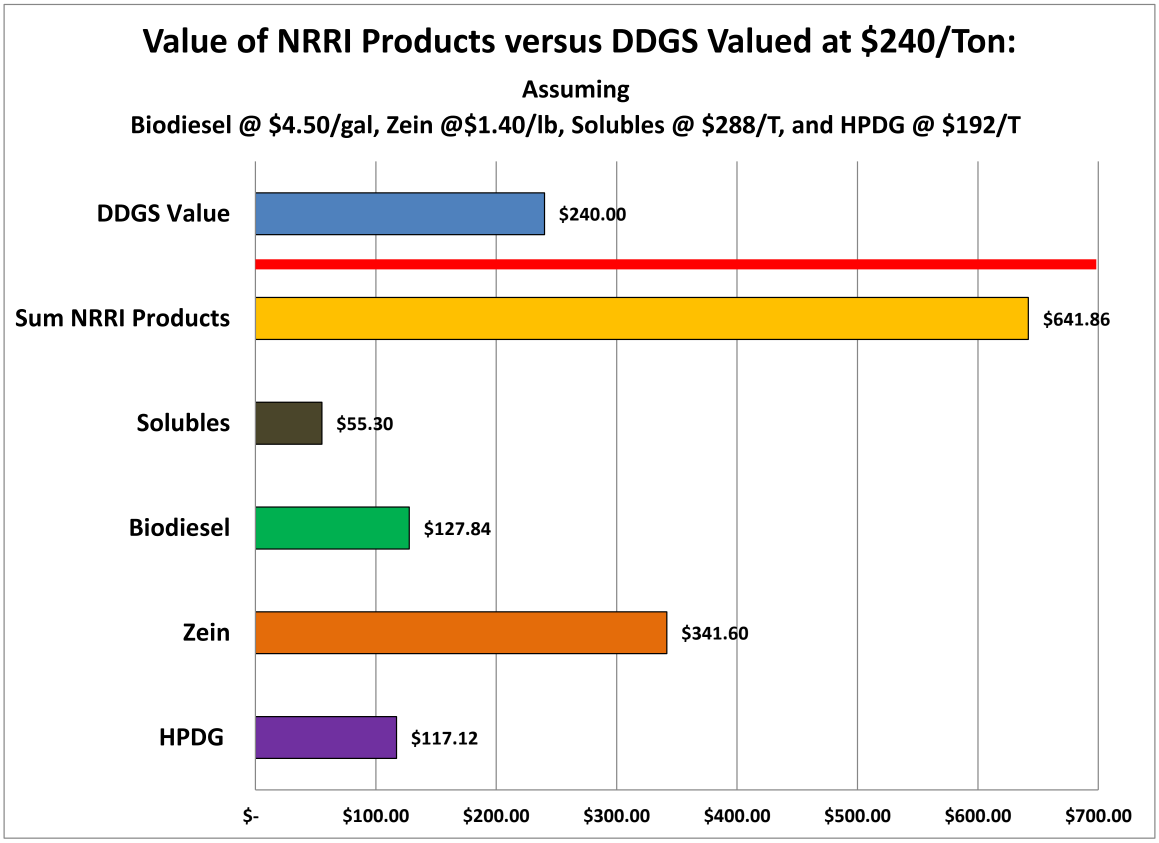
Table 6 demonstrates comparison of profits of conventional and projected NRRI-Integrated Technology plants. Profit of NRRI-Integ05 is 2.56 time higher than for conventional ethanol plant without debts (Conventional 2005).

Table 6. Comparison of profits of conventional and projected NRRI-Integrated Technology plants

	Baseline Conditions		10-Sep-13
	Conventional (2005)		NRRI-Integrated Tech. (2005)
Revenue			
Ethanol Sales	$ 146,344,800		$ 146,344,800
DDGS	$ 43,481,053		
CO2	$ 1,106,438		$ 1,106,438
Sm. Producer Payment	$ -		$ -
HPDG			$ 21,218,754
Biodiesel			$ 23,161,072
Sale of Solubles			$ 10,018,035
Zein			$ 61,888,032
Total Revenue	**$ 190,932,291**		**$ 263,737,131**
Expenses			
Corn	$ 113,878,947		$ 113,878,947
Natural Gas	$ 9,831,066		$ 9,831,066
Propane	$ 876,131		$ 876,131
Electricity	$ 3,098,025		$ 3,407,828
Enzymes, Yeast, Chem	$ 7,085,739		$ 7,085,739
Depreciation	$ 4,278,667		$ 6,278,667
Interest	$ -		$ 1,050,000
Labor & Managemt.	$ 3,934,000		$ 4,081,525
Maintenance	$ 2,360,400		$ 2,360,400
Other	$ 1,180,200		$ 1,180,200
Total Expenses	**$ 146,523,175**		**$ 150,030,503**
Profit	$ 44,409,116		$ 113,706,628
Years to Payback			**0.43**

Picture 6 shows the cost of DDGS, assumed at $240 per ton and the sum of the $642 value of the products that can be extracted from that ton of DDGS by using the the NRRI Integrated Technologies at baseline assumptions.

Picture 6.



<u>Describe Factors Limiting Progress:</u>

Proposal for Project continuation included the following provisional budget (Table 7):

Table 7. Provisional Budget of MCGA / MCR&PC Support

MCGA REQUEST (FY 2012)	
Personnel	$ 94,033
Supply/Materials	$ 4,300
Heartland Alliance	$ 13,333
Crown Iron	$ 15,000
GlycosBio	$ 50,000
Travel	$ 3,333
Chemicals	$ 20,000
Total Costs	$ 200,000

Because the granted dollars were cut from $200,000 to $150,000.00, the supposed work with GlycosBio could not be accomplished on a pilot scale level, as it was proposed in previous plans. This partially limited progress of this project.

The other limiting factor was pilot scale tests with industrial partners. Within the budget of this work we could not afford construction of pilot scale equipment for biodiesel synthesis with an industrial partner. Therefore we decided to do this part of work at the scale of our LCE's equipment. We constructed a continuous pipe-type line for the process of oil transesterification within the moving hood of our Laboratory (LCE).

Despite these limiting factors, the final goals of the project have been achieved successfully, and the project is ready for its commercialization and transfer to industrial partners.

Outline Goals to be Completed Next Period:

The next period of work with this project will be devoted to the development of efficient collaboration with industrial partners. This process has been partially and successfully started. Our efforts on project publicity and advertising gave good results. Information about our project has been presented in the following publications and conferences:

1. Making Most of DDGS, Distillers Grains, June 06, 2011, ***Ethanol Producer Magazine***

2. Distillers grains' Hidden Reserves. June 29, **2011**, ***Biodiesel Magazine.***

3. Pavel A. Krasutsky, ***27th Annual International Fuel Ethanol Workshop & Expo (Indianapolis)*** , June 27, **2011**, Presentation and Abstract "Integrated biorefinery to process DDGS into biofuels and other value added products"

4. Douglas Tiffany, ***27th Annual International Fuel Ethanol Workshop & Expo (Indianapolis)*** *,* June 27, **2011**, Presentation and Abstract "Economics of Processing DDGS to High Protein Feed, Biofuels, and Zein."

5. ***Minnesota Agri-Growth Council Newsletter***, ***Minnesota Researcher Extracts More Value from Distillers Grains***. *New processes could improve economics of ethanol production. (**2/7/12)***

6. ***Minnesota Corn Growers & Minnesota Soy Bean Growers Ag MN Expo, Poster presentation by*** NRRI, UMD, **2010**.

7. ***Minnesota Corn Growers & Minnesota Soy Bean Growers Ag MN Expo, Poster presentation*** by NRRI,UMD, **2012**.

These efforts stimulated a lot of connections and communications with potential industrial partners. During this report period contacts with three producers of corn ethanol -have been established.

The main goal of this project is transferring NRRI Integrated Technology to industrial partners for plant implementation and construction. We are planning the following steps to achieve this main goal:

Establishing contractual relations with an Industrial Partner involved in the dry mill ethanol industry, preferably an equipment and/or services provider.

Licensing of the intellectual property of the University of Minnesota on the technology of DDGS processing to an Industrial Partner.

Provide additional research and development work in cooperation with Industrial Partner to successfully commercialize the technology.

Creation of the portfolio of necessary data and information for plant design.

Consulting Industrial Partner on plant construction.

Consulting on the process of startup of a plant utilizing NRRI Integrated Technology.