Agricultural Processing Coproducts Assessment

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1 Executive Summary

We carried out a survey of Minnesota-based agricultural product processors to identify which, if any, lower value coproducts may present opportunities for value generation beyond current use. In particular, but not exclusively, we wanted to identify any material stream that may have marginal or negative value and whose current disposition, if not a waste, was marginal, at best. The target audience for the study was entities directly involved with the processing of agricultural commodities into food, fuel, or feed products. Excluded from the survey were coproduct and/or secondary production streams that are already well known and studied, such as DDG(S) in corn to ethanol production and beet pulp in beet sugar processing. The survey focused on these categories:

- Food processing facilities that convert primary agricultural commodities into consumer and industrial products
- Biofuel producers, corn ethanol plants and biodiesel plants
- Dairy processors; mainly cheese processors and milk derivate (e.g. whey protein) producers
- Meat processors, i.e., rendering and secondary processing plants

Slaughterhouses and confined animal feeding operations (CAFO) were excluded. We aimed to identify value generation and cost reduction opportunities that may not have been obvious.

Collecting the information proved a more difficult task than expected, but in the process a good database was developed, which should prove of value for future interactions with the audience of this study.

The main conclusions of this study are the following:

- The industry segments covered by this analysis in Minnesota are extremely efficient in using their feedstock, and a relatively small amount of underutilized coproducts are present.
- Some of these coproducts are subject to environmental regulation, and none are an environmental liability as of today.
- When coproducts are present, typically very little, if any, are a waste, i.e., intended as material ultimately destined to landfill, since the feed market readily absorbs any coproducts with nutritional value.
- The current relatively high cost of feed and the fact that most of the respondents have developed local supply chains, which do not require expensive transportation, has allowed in most cases, easy disposal of material as animal feed. This in turn typically ensures enough value to cover disposal costs and frequently also provides a modest income.
- Feed distribution represents an ideal solution to deal with seasonality and geographical constraints. The sales of coproducts as feed provides flexibility when, as it is often the case, the coproduct's availability is only seasonal. Because farmers are buying this feed to integrate in their rations, the market adapts quickly to variable supply. Feed demand is also highly distributed, each producer having developed its own cluster of local customers.

- The use of these materials as feedstock for bioenergy solutions, such as biogas from anaerobic digestion, has been studied in the past and often proves to be economically challenging even during times of higher energy pricing than today. This is likely to remain economically unattractive for the foreseeable future; however, under a changed economic or legislative environment, it may work well since the barriers are not technical.
- While compositional analysis was infrequently provided to us, it is nonetheless apparent that most of these streams are unlikely to contain high value components that could not be easily obtained from the original feedstock. Hence, market value feed is probably a very adequate representation of their greatest intrinsic value.
- The exception to the statement above relates to streams from the dairy industry, whose properties and composition are not quite as well known by the producers. Further investigation may be worthwhile, primarily to improve product characterization.

This report is a non-confidential version of a more extensive report which contains specific data and information which is maintained confidential to AURI to prevent identification of companies and possible dissemination of business -sensitive information.

2 Overview

This report is submitted in fulfillment of the AURI Project No. 13023IN titled “Agricultural Processing Coproducts Assessment”. The RFP and the submitted proposal as accepted by AURI are in the Appendices of this report.

2.1 Project Description and Scope

In mid-2013, AURI issued a request for proposal to carry out a survey of Minnesota-based agricultural processors in order to investigate which coproducts may present unrealized economic opportunities. The main goals were to provide guidance about possible areas of investigation and to increase insight and awareness about agricultural coproducts among specialists, including AURI staff, as well as the general public. The scope of the project, as described in the proposal: “Agricultural processing including but not limited to food and bio-fuels production generate a significant amount of coproducts (waste streams) that have the potential to be further utilized for value-added uses in a number of applications including heat, power, bio-fuels, intermediate chemicals, biobased products, soil amendments, and alternative livestock feeds.

The primary objective of the assessment is to identify, quantify and characterize the waste streams generated throughout Minnesota from agricultural processing. The assessment will also include an economic analysis of the current utilization of the waste streams including the market value of coproducts being utilized, cost of disposal, and potential value-added uses for undervalued and underutilized coproducts. *It is not the intent of this assessment to recommend the utilization of coproducts that already have a strong market demand and utilization.*

The project focused on determining potential value-added opportunities for those coproducts that are undervalued or underutilized. This project was accomplished in three phases. Phase I and II focused on identifying, quantifying the waste streams. Phase III involved an analysis of the coproducts and recommendations for value-added uses, and potential projects and collaborative opportunities to further utilize the waste streams.

A critical part of the project scope worthy of reiteration is that the focus was on *lesser known streams*, so, for instance, dried distillers grain (DDG) and glycerol, the key coproducts in the production of corn ethanol and biodiesel, are not in the scope of this study. Not only have these products been extensively studied already, but often have an economic value that is an integral part of their relevant production system. Again, DDG represents a considerable percentage of ethanol plants revenues, profit margin and overall material tonnage throughput. Because of this, we felt it was unnecessary to include these streams in the scope of the project and direct our focus on smaller, lesser known coproducts, often classified as waste, which, while offering potential good value opportunities, are not as critical for the economic performance of the producer.

2.2 Methodology

Achieving the project goal required the identification of businesses that generate coproducts of interest, as well as the collection and aggregation of quantitative data about the businesses and coproduct materials, including but not necessarily limited to, location, quantity, composition/characterization and any current relevant economic information, such as current value or cost of disposal, etc. Furthermore, we assumed that such data should be compiled into a database and significant amounts of like materials from individual sources and/or geographical clusters identified and the economic impact associated with their current disposition. In carrying out the project, the terms “coproducts” and “waste” for the scope of this study are clearly defined. We define “materials” as substances, which have either negative value (e.g. impose a disposal cost) or are neutral or marginally positive to the economic performance of the enterprise. **Specifically, these material streams, even when they may generate some revenue, will not significantly impact the balance sheet of the generating enterprise and most likely have a negative impact associated with their disposal.** Under this assumption, the difference between “waste” and “coproducts” is a subtle one, and the two terms are used somewhat interchangeably. The distinction is associated with the economic value of these streams. A negative economic value (e.g. a disposal cost) may be typical of a “waste,” while a positive economic value may be typical of a coproduct. However, these economic values are not fixed in time, and materials that had a disposal cost at one time may generate revenues at another given new economic circumstances; hence, we feel justified in seeing “waste” and “coproducts” as a part of a continuum.

Based on the quantity, geographical distribution, characterization, and current/potential economic impact, this aggregated data can be used to recommend further research and development opportunities for novel applications, identify and connect potential users, and identify opportunities to reduce waste and increase value by developing potential new uses. A key component of this analysis is the identification of critical gaps in the knowledge base associated with these coproducts, especially with respect to composition and other physical and chemical properties. While the filling of those gaps is not within the scope of this project, the identification of these gaps can ultimately facilitate the development of a framework for identifying and prioritizing future activities and resource requirements.

Here we review the methodology with which the project was approached, based on our original response to AURI's RFP with a critical analysis of mistakes identified as data was collected and critical learnings for future similar endeavors.

2.3 Phase I – Definition and data collection.

The original RFP encompassed the following activities under this project phase:

- Description of the purpose of the assessment, study area, project team and the project goals and objectives.
- Development of a list of coproducts generated in Minnesota from food and biofuel processing. The list should be categorized by type of coproduct, quantity produced and location by geographic region.

The planned execution encompassed the following activities:

- Questionnaire Development
- Identification of Target Audience
- Data Collection
- Data Organization
- Gap Analysis
- Data Analysis

The final results sometimes were different from the intended one for reasons which we will try to identify in the course of the report.

2.4 Questionnaire Development.

A questionnaire, included in Appendix 9.2, was developed in close collaboration with AURI for submission to identified parties via e-mail/fax and/or used via in-person and phone interviews. A cover letter under AURI letterhead, also included in the Appendix, was also developed and included with the questionnaire. The cover letter introduced the project team, outlined the purpose and scope of the project, and requested the cooperation and collaboration of the relevant parties, The questionnaire was developed to collect the following information as it relates to a processor of an agricultural commodity that creates streams of lesser value coproducts or waste:

- Material type, quantity and availability over time for seasonal or intermittent production
- When and how it is generated
- Current handling and disposition
- Economic impact of current handling and disposition
- Operational and environmental impact of the material
- characterization available from the producer
- Has the producer investigated opportunities for other uses and dispositions
- What is the interest of the producer in identifying new uses or dispositions
- If any investigation in new uses and disposition has been made what are the findings, and what

has been the barriers to further progress, if any.

2.5 Identification of target audience.

At large, the target audience for this analysis is agricultural commodity processors, where agricultural commodities are defined as crops, farm animal and their derivate products. Forestry products and associated production facilities were excluded. This definition is still broad since it includes, among the others:

- Food producers and agricultural commodities processors such as flour mills, sugar plants, vegetable oil processors, etc.;
- Processed food processors;
- Feed mills;
- Biofuel plants and ancillary operations;
- Dairy farms and dairy processors;
- Meat-packing and meat processing operations.

An initial attempt to utilize the 2012 North America Industry Classification System (NAICS)[1] in order to identify appropriate industry segments and companies proved over-inclusive, given the large amount of businesses included, the extremely granular classification of activities, and most important the lack of information it provided us to categorize the target business by size. Hence, we decided to simplify our definition and focus only on four categories defined as follows:

- **Biofuel and Biofuel processors**. These operations are producers of biofuels. It includes mainly corn ethanol and biodiesel processors.
- **Food Processors**. These are primarily processors of agricultural commodities, such as oil seed crush plants, cereal mills, sugar mills, vegetables and produce packagers and processors. It does not include meat and dairy processors (separate categories) and secondary food processors. Secondary food processors include, for example a bakery, which converts flour, vegetable oil and animal fats, all produced in facilities that are included in our survey, into baked goods. We felt that the inclusion of such secondary food processors would have created a wide expansion of the target with considerable consequences on the budget, without significant added value because those processors are often already quite detached from the agricultural system. Hence, our definition of "food processor" is a processor of a primary agricultural food commodity, which happens to be a substantially more narrow definition than what other studies may use.
- **Meat Processors**. The inclusion of meat processors was the subject of intensive scrutiny by the team because we felt that it could also have led to an explosion in the number of targets, considering the amount of small family-owned butcher and packing shops. We also felt that the industry has very little unaccounted for or under -studied waste coproducts. Eventually we decided to include the sector, but we drew the threshold for inclusion at larger, corporate -owned and managed facilities.

[1] http://www.census.gov/eos/www/naics/

- **Dairy Processors**. These are processors of raw fluid milk into products, including fluid milk for human consumption, cheese, butter and derivative products, such as whey protein and powdered milk.

In selecting these categories, we are aware of the somewhat arbitrary nature of the definition, and the possible lack of consistency with other definitions. Yet we felt that this classification was the best compromise between granularity and simplicity, which was required by this project. Geographically, we have used the Minnesota Department of Employment and Economic Development (DEED) regions[2] to segment the study regionally and aggregate target audience geographically. Also, we decided to include facilities outside Minnesota on border towns because those facilities will draw a considerable amount of their feedstock from Minnesota. Conversely, facilities located in Minnesota border towns will draw feedstock from the neighboring state. In either case, the economic impact on Minnesota is significant and, in our view, fully justified the inclusion.

3 Analysis of Responses (Data and Gap)

In total, we contacted 141 separate facilities across the four sectors selected for the survey. In total, we received 41 responses, which represents a return response ratio, defined as the ratio or responses to questionnaires sent, of 29.1%. Some of these responses were inconclusive. For example, several company representatives communicated that due to corporate policy, they declined to participate in the survey. Once those responses were removed, the overall number of information bearing responses dropped to 33 **for an effective response ratio of 23.4%.** These numbers are in line with expectation related to similar surveys where response ratios between 20% and 30% are considered normal and usually satisfactory. Table 1 summarizes the return ratio.

Sector	Questionnaires submitted	Questionnaires returned	% returned
Biofuels Producers	27	9	33%
Food Processors	67	19	28%
Meat Processors	11	2	18%
Dairy	36	11	31%
Totals	141	41	29%

Table 1 - Questionnaire returns by sector

The response ratio is fairly uniform across industry sectors with the exception of the meat sector, which not only has a significantly lower response ratio, but whose responses were all inclusive. This confirms the assessment we had carried out of this sector.

[2] http://www.positivelyminnesota.com/Government/Financial_Assistance/Community_Development_Funding/Small_Cities_Development_Program_3.aspx

3.1 Phase II – Compositional Analysis of Selected Material

The original intent of the survey was also to collect detailed information about the composition of selected material as collected during the survey. Later during the course of the project and in agreement with the AURI staff, we decided to drop this part of the project as it was clear that the collection of this data – which at this time was very fragmented and scattered – would have rapidly exceeded the scope and budget of the project. Some relevant information was included by respondents and is attached in an appendix to this document or quoted when appropriate.

3.2 Phase III – Economic Analysis and Recommendations

Based on the collected and aggregated data regarding the current value/cost of disposal of each material, their volume, the compositional analysis, and geographical location(s), the project team will categorize the streams of highest potential for further utilization and economic value based on parameters, such as cost avoidance from repurposing the material and/or novel, value -generating opportunities.

Finally, the project team will provide recommendations on high potential value-added opportunities, as well as specific potential projects/collaborations within clusters of similar NAICS groupings within/across geographical regions of the state.

4 Data Collection

4.1 Questionnaire Development

In developing the questionnaire, we tried to capture all the information that AURI requested. We also hoped that by collecting enough representative responses we could do meaningful extrapolations for the relevant industry in particular by relating waste/coproduct amounts with production levels. Nonetheless, we avoided directly asking specific questions regarding production levels of waste/coproducts, as we felt it may have been perceived as a confidential and sensitive inquiry, either further reducing response returns or forcing us to enter into non-disclosure agreements, which we wanted to avoid at this stage. Therefore, while the information was sometimes volunteered, we decided to rely on publicly available data with the intent of identifying possible areas of interest to justify further investigation and more detailed and complex data collection in the future.

4.2 List Development

This task proved more time consuming than anticipated. As mentioned earlier, our original goal was to use public and private databases to identify target businesses and appropriate personnel in each market segment. Our intent was to utilize the 2012 North America Industry Classification System (NAICS)[3] in order to identify appropriate industry segments and supplemented with information from AURI staff, officials at the Minnesota Department of Agriculture (MDA), and the Minnesota Department of Employment and Economic Development (DEED). We rapidly realized that such public databases do not exist or were not accessible to us if they do exist. Most importantly, critical information, such as revenues or turn-over necessary to estimate the business size, were either unavailable or aggregate in larger and less specific corporate entities, rendering them irrelevant to our project scope.

[3] http://www.census.gov/eos/www/naics/

The North American Industry Classification System proved to be insufficient in that it provided too granular of classifications of activities, didn't provide the ability to categorize target businesses by size, and did not provide specific contact information. Initial conversations with representatives of DEED did not yield specific businesses or contacts, but they were useful in providing contacts for Regional Economic Development Coordinators who were later moderately helpful in providing specific contacts at target businesses. Initial conversations with representatives of MDA provided access to lists of MN biofuel producers and some additional individual contacts in other sectors.

Ultimately, the list of contacts included in this report was compiled through an extensive effort carried out by the authors utilizing a variety of sources, including personal knowledge and contacts, conversations with professional and trade associations, AURI stakeholder lists and personal contacts of AURI staff, follow up efforts with representatives of MDA and DEED, along with significant web-based research. All this consumed a considerably larger amount of time and also elapsed the time of the project considerably.

The first task was to identify target businesses suitable for the scope of the project in each of the agreed-upon target segments. This involved a combination of heavy web-based research and individual calls/contacts to the targeted businesses. Web-based information was useful in identifying businesses in general, but did not provide useful information regarding business scope and specific contact information beyond mailing address and general phone numbers. As we began to categorize target businesses for the purpose of the study, numerous phone calls and contacts to each business were required to identify the proper contact person at the business and their direct contact information. Beyond this general description, additional detail for each of the agreed-upon categories is listed below.

- **Biofuel and biofuel processors.** The MDA maintains a current, web-based listing of biofuel facilities in the state, and a quick internet search provides an easy -to -find comprehensive roster. That list, along with personal knowledge of MDA staff, was utilized. The authors also contacted the appropriate trade association to glean specific contact information for each facility. That effort, coupled with the author's knowledge of the sector and follow up phone contacts to each facility, yielded a complete list of businesses and contacts.
- **Food processors**. This was a large and somewhat comprehensive grouping, which included processors of agricultural commodities, such as oil seed crush plants, cereal mills, sugar mills, and vegetables and produce packagers and processors. The authors quickly discovered that no comprehensive grouping or listing for this category and sub-categories exists. The resulting list of businesses was generated from a number of sources and involved significant effort and individual contacts. Initial information about the segments of this group was identified via personal knowledge of the authors, AURI staff, MDA and DEED contacts. There are only a handful of oil seed crush plants, which were readily identified. The sugar processing facilities are well-known to the authors, and we also utilized the appropriate trade association, as well as personal calling to each facility in order to identify specific contacts. The flour and cereal mills proved somewhat more challenging, requiring extensive web-based research and follow up to identify specific locations and direct contacts for each facility. In many cases, the mills are owned by corporate headquarters, so often it proved to be difficult gleaning location-specific direct contact information. Similarly, many of the vegetable and produce packagers are owned

by corporate entities, although in some instances after having broken though corporate headquarters, specific and direct plant contact information was provided. In the end, identifying and categorizing business in this grouping required extensive personal calls and contacts.

- **Meat processors**. As referenced earlier, the inclusion of meat processors was the subject of intensive scrutiny by the team and AURI staff. Eventually it was decided to draw the threshold for inclusion at larger, corporate -owned and managed facilities. We received an exhaustive and too broad "Food Manufacturer – Proteins" company inventory from DEED. To identify a shorter, more appropriate list of facilities, we drew upon knowledge of appropriate AURI staff, along with livestock associations.
- **Dairy processors.** While a relatively large grouping, the MDA provided a comprehensive "Dairy Plant Book Data" list of businesses in this sector. That list was most useful with respect to business name and location, however it did not always provide relevant information regarding business size, and it was devoid of individual, direct contact information. Along with input from relevant AURI staff, the resulting contact list was developed via numerous calls/contacts with the individual facilities.

4.3 Outreach

The authors realized there are a number of critical issues in reaching targets appropriate for this effort. Some general issues identified for future projects of a similar nature include:

- Clear definitions and scope of industries and company parameters. The time spent clearly defining the scope of the project was necessary as was deciding what types of businesses were to be included. For example, we had to decide if we should categorize by type or volume of raw materials, by type or volume of product streams, by size of business (eg. product volume, employees, sales), or other. In retrospect, more clearly defining the scope and the rationale for inclusion would have been valuable, before casting about for listings of potential business targets and then determining whether or not to include.
- Clear definitions and terminology. Regardless of the type of survey instrument or information gathering mechanisms, clearly defining terminology is critical. For example, in this project, the terms "waste stream" and "coproduct" were interpreted differently amongst the respondents.

5 Results of the survey

5.1 Overview

The data collected did not unveil any particular gap of knowledge nor indicate any unmet needs in terms of disposal or alternative utilization of possibly valuable, but currently undesirable and unwanted waste. In fact, in general the responders avoided the word "waste" and almost always preferred using the word "coproduct." Besides the implicit negative connotation of the word "waste", there was also an obvious sensitivity to possible regulatory and liability implications when talking about a waste in a survey whose results are likely to be externally scrutinized. Furthermore, and more importantly, in most cases the respondent showed actual economic value in these coproducts. The economic value, which we will discuss in detail later, is often not extremely high, but is nonetheless present and tied to economics of animal feed, which is almost the universal disposition of these coproducts. In the meat processing industry, such use of coproducts is now so engrained in their production system that the industry indicates itself as being "waste" free, since every part of their input stream is converted into products having economic value. In general, the respondents were vague about prices they were being paid from farmers, likely because this is largely a local market focusing on the production center with individual, private transactions between producers and consumers. It is not difficult to imagine that the price may be tied to the overall price of animal feed and in times of high animal feed price, the price paid to the producer may be at least adequate to cover their expense and provide some modest income.

Figure 1 shows the price evolution of two commodities that most directly indicate the cost of animal feed products, soybean meal and corn. Accounting for the most recent dip in corn price, both commodity prices remain historically high and marketing coproducts at prices at a fraction of those values compares favorably with landfilling or other disposal methods. While most respondents indicated a clear interest in solutions that may increase their coproduct value, only a few were actively engaged in looking for alternative solutions. Those who are interested stated that no solution met their return on investment requirement of demanding a payback in three years or less. Again, this shows that without a strong economic incentive, the industry will not embrace alternative solutions. Most respondents indicated that a return of three years or less is required for any capital expenditure. Active investigations in the past by some respondents involved conversion to energy. The most researched solution was anaerobic digestion for biogas production, since direct combustion is not practical given the high moisture levels of these materials and the desire to avoid decommissioning existing natural gas package boilers. These efforts occurred mostly in the mid -2000's when gas prices were rising, there were emerging concerns about US natural gas reserves, and the prospect of possible carbon regulations led many businesses to investigate bio-energy as a strategic alternative. These efforts largely tapered out with the onset of the recession, the emergence of shale gas, and carbon regulation disappearing from the political agenda. The conversion to energy presented a few practical problems mainly related to volumes and seasonality, although not insurmountable with appropriate incentives. Businesses with annual production often have modest volumes of material at each location, which may not justify the capital associated with biogas production. while businesses with seasonal production have the problem of large peak production of materials not suitable for long-term storage. Sizing a digestion plant to accommodate the seasonal peaks would lead to extremely inefficient use of capital and the plant sitting idle or grossly underutilized during large periods of the year. The solution to those problems is typically a centralized facility, a so-called commodity digester, which aggregates feedstock from various sources. This solution, while potentially eliminating these issues, would also impede the producer's direct access to the energy produced and most likely force a transfer price for the material, which may be competitive with the alternatives of either animal feed or landfilling. In general, the respondents remain interested in these technologies but are keenly aware of the economics which are seen as not favorable.

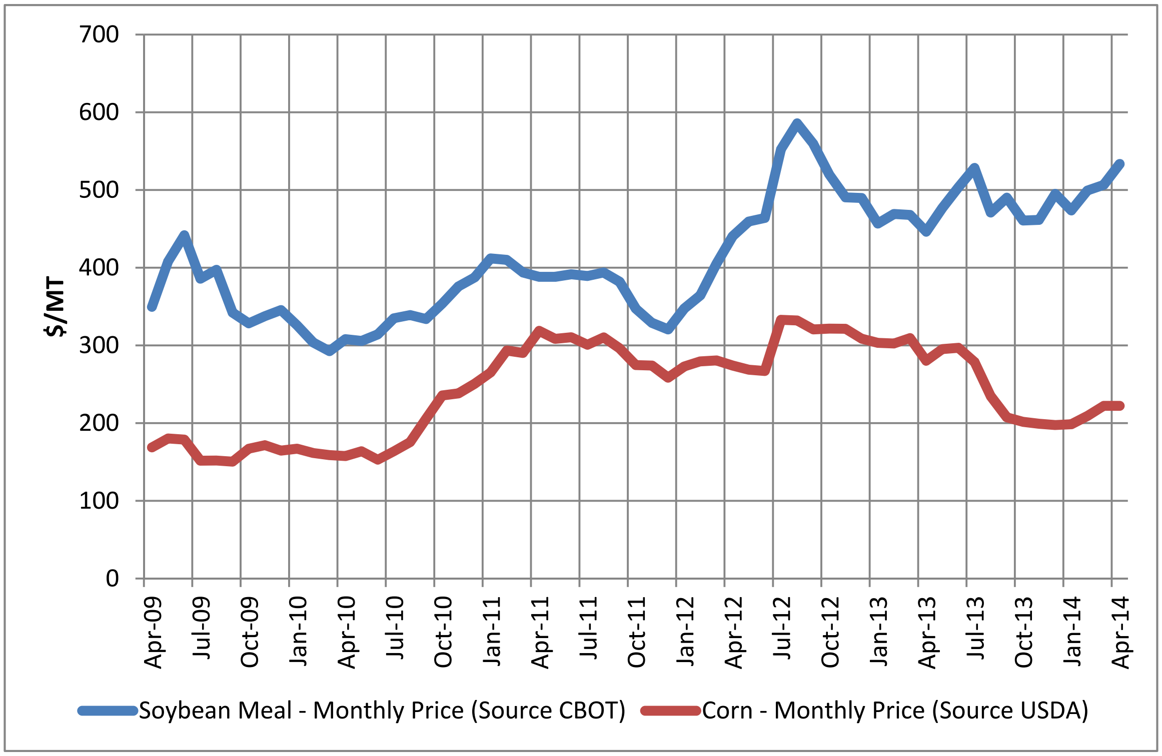

Figure 1 - Price of animal feed commodities

We have tried to identify correlations between production data and amount of waste generated; however, given the wide variety of products and production methods in most of these industries, this is an extremely complex, if not impossible, task. Instead, to the extent available with public data, we have tried to identify whether any opportunities of interest exist that may justify a targeted, follow-up study. Such a follow up study may be presented with a different value proposition to the companies of interest and therefore justify the need of more detailed investigation on their operations.

5.2 Ethanol refineries

Ethanol production is a very important activity in Minnesota. As of 2012, the State had 21 plants with an overall installed capacity of 1.1 billion gallons of fuel ethanol of which 79% is exported[4]. The State has one of the strongest biofuel programs in the nation[5] and has been a leader in the development of the industry. We received answers from several ethanol producers and we believe those answers are highly indicative of the industry. **This can be summarized in that the industry does not have a significant low value stream, nor are companies looking for economic upgrades**. Everything is sold at a profit. Again, Distiller Dry Grains with Solubles (DDGS) was excluded by our survey. Not only has DDGS been and continues to be extensively studied[6], but it is hardly a coproduct of low value. DDGS prices have been consistently above $250 per ton in the last few years and are, in general, comparable to those of corn. During periods of soft ethanol prices, DDGS often have been preserving overall margins for the ethanol producers due in part to the robust

[4] http://www.mda.state.mn.us/renewable/ethanol.aspx
[5] http://www.mda.state.mn.us/en/renewable/ethanol/about.aspx
[6] See for example this University of Minnesota dedicate site: http://www.ddgs.umn.edu/

international demand[7]. The industry remains active in increasing their overall value by generating new value -added streams, for instance, increasing oil recovery, possible fractionation of the solubles, and valorization of higher alcohols present in the fuel oil[8] stream. In any case, the object of these efforts is to develop product streams with sufficient value to return adequate payback for implementation. In the words of the plant manager of one of the plants which responded to our survey:

"Additional coproducts are possible with further separation equipment. Economies/markets are the greatest barriers. To sell the product, one needs a market; but to justify a market, someone must first make the product. We will make changes for the continued economic well -being of the company. "

The only stream we found in the industry that qualifies as "low value," as intended by the scope of this survey, is associated with production of lime from water treatment. Not all plants have this stream, depending on how water is treated. Specifically, this lime is obtained by the process "Cold Lime Softening" (CLS)[9]. A large majority of modern ethanol plants use a zero liquid water discharge process, and the water is recovered after the various products have been separated and concentrated, then it is sent back to the front end of the plant where is reused. This makes it necessary to control the inorganic compound concentration in the stream over time as it accumulates near desirable limits. The specific production of lime is relatively modest (around 0.05 lb. per gallon of ethanol produced), although we expect a large amount of variability around this average. Nevertheless, for a typical plant which may use CLS to control water quality, it may amount to several hundred tons per year of material, which needs to be disposed of. Extrapolating from the consumption of a single plant that reported their lime production, and considering that not every plant uses CLS, we estimate that across Minnesota's ethanol industry the amount of lime produced may be around 20,000 or more tons per year. The producer pays for disposal. Specialized contractors haul the lime away from the plant and typically land -apply it for soil pH adjustment. This use is regulated by the Minnesota Department of Agriculture. Producers did not volunteer the cost of disposal, but we expect the contractor to charge the producer around $50 per ton for the removal of the lime. The contractor is likely to generate other revenues by directly land applying the lime or possibly entering other distribution channels. The use of lime as a soil amendment is a well-known practice and is also available at the retail level in small quantities suitable for gardening. There is interest for alternative uses of lime if it would reduce the disposal cost for the producer. A representative analysis is reported in Figure 2.

[7] For detailed information about DDGS economics and markets see for example the US Grain Council: http://www.grains.org/buyingselling/ddgs

[8] Fusel oil or fusel alcohol is a mixture of higher alcohols produced during ethanol fermentation. The most common alcohol present in fusel produced during corn ethanol fermentation is amyl alcohol which if purified to chemical grade is a rather valuable chemical commodity used in a variety of industrial applications. See for example http://en.wikipedia.org/wiki/Fusel_alcohol

[9] For details about lime softening see the following US Dept. of Interior white paper: http://www.usbr.gov/pmts/water/publications/reportpdfs/Primer Files/07 - Lime Softening.pdf

	Dry Basis Result		Method RL	Method Reference
Wet Digestion				SW-846 3050
Moisture, Total	** 65.81	%	N/A	AACC 44-19
Calcium	30.2	%	0.013	SW-846 6010
Magnesium	5.96	%	0.013	SW-846 6010
Phosphorus	386	mg/Kg P	67.7	AOAC 958.01
Nitrogen, Total	< 0.03	%	0.03	AOAC 970.02
Sieve #8	100	% passed	N/A	
Sieve #20	100	% passed	N/A	
Sieve #60	100	% passed	N/A	
TNP(CCE)	80.7	%	N/A	
Fineness Index	100		N/A	
ENP(ECCE)	80.7	%	N/A	

CALCIUM AS CALCIUM OXIDE = 14.42% as received, 42.28% dry basis

MAGNESEIUM AS MAGNESIUM OXIDE = 3.32% as received, 9.89% dry basis

** No collection time supplied by the client.

** This analyte reported on As Received basis.

Figure 2 - Lime composition from CLS process in Ethanol refinery

Lime is an important feedstock for several industries and is used in a variety of applications.[10] Industrial grade lime has a large market, yet we believe it is highly unlikely that these MN coproduct streams can practically tap into the established applications given the relatively small amount created and lack of assured quality control.

5.3 Biodiesel

Excluding the nascent biobutanol industry (one 18 million gallon plant is still operating below design specs and was not targeted in this survey), the other major liquid biofuel producers in the state are the biodiesel plants. The State of Minnesota has an aggressive program in biodiesel.[11] Unlike ethanol, only three plants are in the State, though there are several just across the border in neighboring states. The main coproduct of the industry is glycerol, which is produced on a 1 to 10-weight ratio with the biodiesel. Like DDGS, glycerol has been studied extensively[12] and we consider it out of the scope for this report. Given the nature of the process, very little other waste/coproduct material, besides a small stream of chemicals associated with the salt recovery and product wash-out, is produced in a biodiesel plant. Some biodiesel plants are integrated with an oil seed crushing/vegetable oil production facility. These are dealt with separately in the food processor section.

5.4 Dairies

The dairy processing industry is an important one in the State with about 9 billion pounds of fluid milk produced, of which more than 95% is sold to dairy processing plants. Minnesota dairy processing plants

[10] See for example http://www.lime.org/uses_of_lime/index.asp
[11] http://www.mda.state.mn.us/renewable/biodiesel.aspx
[12] See for example: http://www.extension.org/pages/29264/new-uses-for-crude-glycerin-from-biodiesel-production - .U4I3n2RdUqZ

produce about 4.7 billion pounds of cheese, 500 million pounds of human grade dry whey (protein) and 1 billion pounds of other dairy products such as ice cream, yogurt, etc. Based on the results of the survey, most of the coproducts are disposed of and while there is a cost associated for many, others have some economic value, which compensates for their handling. Some dairies responded that they have no waste. We believe that means they have no coproducts imposing a cost. To the extent some of these materials are cost neutral, some producers will not consider them waste. Following are the mos ty pical classes of waste and coproducts generated:

- **Scrap cheese and waste whey**. Scap cheese and waste whey are Typically sold for animal feed, mainly to hog farmers. Based on one response, the value is $100 per ton or less, and the dairy processor considered that amount just sufficient to cover handling and delivery costs. Production level for a typical plant is in the hundreds of pounds per day. In aggregate, we believe that the dairy industry in Minnesota may produce several million pounds of this waste per year, assuming a very modest wastage percent. On the other hand, the dispersed nature of the sources makes it difficult to consider any industry -wide solution given high logistical costs and the variability of this material because of the fact that it is derived from many different consumer product processes. In the words of one of the respondents:

  "There is no value to the product scrap. The freight cost to the pork producer is about all it can stand. We are happy to have a free-of-charge disposal program."

- **Low grade protein powder**. Low-grade protein powder is produced only by protein isolate producers. The final disposition is similar to that of scrap cheese and waste whey. In this case, the value appears to be on the higher end of the scale. Because it is a relatively concentrated product, we believe there is a modest value realized by producers beyond receiving free disposal. Estimates based on extremely low wastage percentages put the system-wide availability of this material in the range of several hundred thousand pounds per year.

- **Biosolids**. There are three main sources of biosolids in the industry:

  - General biosolids which are suspended material in processing water which may or may not be separated from the relevant water stream
  - Serum solids
  - Sludge solids recovered from dissolved air flotation units (DAF).

  Production of biosolids from individual dairies accounts for several thousand pounds per month, and we believe that the total production of biosolids from the Minnesota industry accounts for a few million pounds per year on a dry basis. The cost of disposal is not insignificant and is in the range of the $0.12 to $0.30 per dry pound. Biosolids are largely land applied, and there has been consistent expressed interest for their use as an energy source. Part of the high disposal cost is due to storage needs during the winter months when the ground is frozen and land application cannot be carried out. The criticality of any disposal solution to the operations of the dairy is expressed by one of the respondents:

"The biosolids and serum solids are land applied to meet the Industrial Byproduct regulatory requirements implemented by the Minnesota Pollution Control Agency. Operational Impact: The unavailability of disposal of serum solids via land application would cause a closure to the processing facility. Alternative Uses: Serum solids were co-digested in an anaerobic pilot plant successfully with other agricultural by-products for a project funded by the Minnesota Department of Agriculture (NexGen- 2011). Alternative Use Barrier: Transportation costs to regional treatment facilities."

In the comment above, the desire to recover the expected high energy content of the biosolids faces a key barrier: the economical aggregation of volumes large enough to justify the cost of biogas recovery. Another processor expresses a similar sentiment with regards to sludge solids recovered in a DAF:

"Material is used as fertilizer by farm operators, but land application is regulated, monitored and reported. It is not an environmental liability. Operational impact: Not specifically. There is a desire to cease land application because there are periods of the year when the ground is too frozen to land apply, and that causes for there to be additional charges for storage. It would be preferable for this energy source to be returned to the feeding system instead of land application for the purposes of sustainability. Again, we don't currently use DAF chemicals that are food grade, but we certainly could, if we had an end use that justified the additional costs. Alternative Uses: Would have potential to feed an *anaerobic digester. Would require removing more water than we currently do. Have been unable to find an end user to use this as a feed source. 1. No nearby anaerobic digesters and 2. No interested feeding operations"*

Biosolids represent a potential considerable cost to the industry. Based on these few data points and extrapolating for the industry size from a few individual processors we assume again the amount of biosolids produced amounts to several million pounds per year across the whole State-wide system.

- **Acid whey permeates**. In the production of a variety of dairy products, the whey is concentrated via ultrafiltration and the resultant permeates needs to be disposed. This is typically done in a waste treatment plant that often is the local municipality system. The economic impact is variable since some municipalities may welcome the extra organic load to balance their own. Most likely though, the processor will incur high sewage charges. Once again, this material (See Figure 3 for a representative sample) would be an excellent feedstock for communal anaerobic digestions where logistical issues related to product volume and overall economic attractiveness of biogas production are solved.

Medallion Labs Sample ID: 2013-MED-1101-02		Permeate
Customer Sample ID: Permeate		
Assay Group	**Test**	**Results**
Sample Handling Processing Level 1	Sample Process Fee	Sample Processed
[2]Carbohydrates	Carbohydrates	4.6 %
[2]Calories	Calories	18 Calories/100 g
	Calories from Fat	0 Calories/100 g
Moisture	Moisture	94.891 %
Ash, Overnight	Ash	0.547 %
Protein, by Dumas	Protein (6.38)	<0.798 %
Fat, Gravimetric	Total Fat	0.01 %
Sugars including Galactose	Galactose	Less than 0.1 %
	Fructose	Less than 0.1 %
	Glucose	Less than 0.1 %
	Sucrose	Less than 0.1 %
	Maltose	Less than 0.1 %
	Lactose	3.72 %
	Total Sugar including Galactose	3.72 %

Figure 3 - Sample analysis of acid whey permeate

5.5 Meat Processor

Meat processors generally answered that they have no coproduct of consequence. We believe this is accurate. The only exception is from the rendering industry, which we have aggregated with the meat processors by economic connection. Some renderers have provided a detailed response about their use of anaerobic digestion to treat high BOD water. In these cases, anaerobic digestion was adopted as a less expensive alternative to aerobic treatment for the extremely high organic load in the wastewater, which is common in the industry. In these cases the recovery of biogas as an energy source is not considered economically viable given the high cost of gas conditioning compared to the relatively low cost of natural gas and existing equipment retrofitted to handle the low BTU value gas. Instead the biogas is flared. While not completely aligned with the scope of this survey, since this is a wastewater treatment strategy, this is the only case in which a significant waste stream was identified in the industry. We have no industry statistics to assess the amount of this specific waste stream and we did not do any further research being it is mainly a wastewater application.

5.6 Food processors

“Food processor” is a broad term that encompasses several productions. In our analysis we considered only those food processors with an immediate and direct connection with the primary output of farms and excluded a very large number of other processors further downstream in the supply chain. Relevant to Minnesota, this led us to identify three main groups:

- Sugar beets processing;
- Vegetable oil seed crushing; and,
- Fresh produce packaging.

5.7 Sugar beets processing

The production of white crystalline table sugar generates a variety of coproduct streams during the typical nine-month processing campaign, namely:

- Pulp pellets;
- Molasses;
- Sugar beet tailings and,
- Lime.

Of these, the lime is the only real waste since pulp pellet's value is $100-120 per ton and molasses about $100 per ton. Pulp pellets are sold into the animal feed market, while molasses finds use as fermentation feedstock, animal feed additive, and a binder for food and feed applications. Both are considerable contributors to the plant revenue stream and system-wide State production is in excess of 1 million tons. Lime is mostly landfilled, and the respondents have expressed interest to explore soil amendment application. As discussed above, this may be the only practical alternative to landfilling, but whether that is economical or not depends on the local nature of the soil's need for pH adjustment and the comparison with the current cost of landfilling (tipping fees). In any case, we do not believe there are other readily available alternatives to this possible use of lime for the reasons discussed above in relation to biofuel producers. Pulp pellets and molasses are well-established products in the industry, as DDGS is for the ethanol refineries; hence, despite the relatively low value, they are outside the scope of this survey. The industry is devoting considerable resources to exploring new value-added opportunities for these streams already and we consider them outside the scope of the survey. A producer alerted us to two possible and highly variable waste streams that are generated during beet storage. Once the beets are stored, they are considered industrial and not agricultural feedstock; therefore, more stringent regulations apply. Storage is carried out by loading the beets into large open piles. they are then frozen which provides natural preservation. Because of either late mild winter or early warm spring, sometimes freezing is delayed or thawing is anticipated. In both cases, some beets are spoiled and the liquid run-off from the pile needs to be treated. The latter is typically done at the plant wastewater treatment while any solid spoiled product is landfilled. Sugar beet tailings contain the outer skins on the beets along with tops. currently this coproduct is sold to cattle producers as a forage and energy source. Sugar beet tailings contain high levels of moisture and ash due to soil contamination.

5.8 Vegetable oil seed crush plants.

We have received no information from these plants. However, our knowledge of the industry lets us believe that there is no significant waste/coproducts that is not already accounted for and disposed in the most economical way given the high level of efficiency, consolidation and competitiveness of the industry. We believe the two material streams most likely to be in scope of this survey are bleaching clay and gums. For both, the industry has a long-standing tradition of disposing via gradual addition into animal feed products and, barring any regulatory change, there is no interest to look for alternative applications.

5.9 Fresh produce packaging

Fresh produce packaging processes a variety of products for distribution to the market as canned and frozen foods. The two most prevalent in Minnesota are green peas with a yearly production of about 100,000 tons and sweet corn which sits at a yearly production of over 800,000 tons. Production is highly seasonal and the processing is similarly seasonal. The waste materials in this case are all the fibrous parts that are not packaged for the consumer (e.g. husks, cobs, etc.) and any materials that do not pass quality requirement (See Figure 4). The product is typically ensiled where fermentative processes take place (See Figure 5) and sold locally as a feed product. Output levels fall from a few hundred to several thousand tons per plant. The materials in today's (late -2013 to mid -2014) market command between $7 to $15 per wet ton, sold as is. While the price is relatively low, the demand is strong and the industry has not experienced problems disposing of this product. Since the users are local farmers--who often pick up the material at the point of production – logistic costs are insignificant. The industry has actively looked for alternative uses, but found none that can be economically competitive. In the words of a processor:

> *"We have had numerous firms consider using the product for ethanol or methane production. None worked out for our site. Several companies for the last 20 years have proposed drying the material for feed. None worked out even as feed costs have risen. Silage contains 75-85% moisture. It just costs too much to transport the liquid and remove enough water to dry it. Even if dried on the site....too much liquid. It has value as is, so we sell it that way. Economically challenging. Selling the silage in its existing form makes most economic sense. We have a good market for it locally so transportation is reasonable. We have explored changes frequently as recent as December 2013. No plans for change."*

Once again the need to aggregate a very wet material, which is available only seasonally, makes the identification of other uses challenging despite the fact that there are strict environmental regulations regarding the handling of this material. In particular, the processors need to make it sure that any leacheate from the ensiled material is contained and prevented from contaminating below or above ground water.

Moisture	%	83.92%		
Dry Matter	%	16.08%		
		Dry Basis	Average	Normal Range
Crude Protein	%DM	10.12%	8.40	6.44 - 10.36
ADF	%DM	30.13%	25.68	18.66 - 32.70
Calcium	%DM	0.09%	0.27	.17 - .37
Phosphorus	%DM	0.30%	0.25	.19 - .31
Magnesium	%DM	0.20%	0.21	.13 - .29
Potassium	%DM	1.05%	1.17	.77 - 1.57
TDN 1x - ADF	%	66.75%		
Nel 3x - ADF	Mcal/cwt	67.22		

Figure 4 - Sample analysis of sweet corn refuse

Another product of some interest but with a very similar dynamic is the waste generated by potato processors, who peel and slice potatoes for the restaurant and food distribution industries. A typical plant will produce about 100,000 tons of waste per year without seasonality. Mostly the product is sold in the cattle feed market and is valued at about $8 to $10 per wet ton. Alternative uses that have been considered, especially for energy, have never demonstrated to be economically viable even when the processor already owned a digester to handle their wastewater. In this case, the cost of retrofitting and expanding the digester to handle the extra organic along with the opportunity cost associated with lost feed revenues and solid load was not justified by the potential energy production:

> *"We have done some work internally and have researched alternate uses. Unfortunately, the options have required capital expenditures that have not met our return hurdles. I can say that they are substantial given our scale. Operational Impact: Minimal (weather), Alternative Uses: Yes, digester researcher; economics don't look favorable. Hired external consultant to analyze Return on investment was not great enough to warrant further consideration. Have a digester and put wastewater through for natural gas. Other Alternatives: Looked into drying and pelletizing "Grain Millers"*

Silage 2013

Moisture	%	76.44%		
Dry Matter	%	23.56%		
pH		3.50		
		Dry Basis	Average	Normal Range
Crude Protein	%DM	8.55%	7.82	5.72 - 9.92
ADF	%DM	33.01%	24.66	17.06 - 32.26
aNDF (w/ Na2SO3)	%DM	56.73%	41.00	30.08 - 51.92
Lignin (Sulfuric Acid)	%DM	2.54%	3.67	2.23 - 5.11
Lignin	%NDF	4.48%		
uNDF240	%DM	5.31%	9.70	6.25 - 15.75
AD-ICP	%DM	0.47%	0.69	0.35 - 1.03
ND-ICP (w/o Na2SO3)	%DM	1.54%	1.10	0.52 - 1.68
Protein Sol.	%CP	60.58%	37.50	16.33 - 58.68
Starch	%DM	9.55%	31.84	18.46 - 45.22
Fat (EE)	%DM	4.92%	3.17	2.15 - 4.19
Total Fatty Acid (TFA)	%DM	2.85%	2.22	1.18 - 3.26
Ash	%DM	4.07%	3.80	1.42 - 6.18
Calcium	%DM	0.20%	0.24	0.12 - 0.36
Phosphorus	%DM	0.25%	0.24	0.18 - 0.30
Magnesium	%DM	0.13%	0.20	0.12 - 0.28
Potassium	%DM	1.20%	1.05	0.63 - 1.47
Sulfur	%DM	0.12%	0.11	0.09 - 0.13
Sugar (ESC)	%DM	1.11%	4.63	0.01 - 9.47
TDN 1x - OARDC	%	69.41%		
Adjusted Crude Protein	%	8.55%		
NFC	%	27.22%		
Nel 3x - OARDC	Mcal/cwt	71.84		
Nel 3x - ADF	Mcal/cwt	64.82		
Neg - OARDC	Mcal/cwt	43.56		
Nem - OARDC	Mcal/cwt	70.69		
DMI	% Body Wt	2.12%		

The uNDF value was an outlier.

Figure 5 - Sample analysis of sweet corn silage

6 Review

Not surprisingly, but probably to a larger extent than expected, the survey did not provide any novel revelation or insight, but confirmed and quantify perceptions that were already present. Furthermore, it provided a better picture of the economic impact of the coproducts, which were the object of this review. All the industry segments analyzed are in general extremely efficient and will try doing what is economically most advantageous for their operations. In fact, most respondents made it clear that they do not consider coproduct as a problem as long as they can be sold even if the sale may only cover costs. The current market condition of relatively low energy cost and relatively high animal feed value discourage solutions based on energy recovery. These are likely to require capital expenditures unlike the current approach based on selling these products to the local farming community. Most of the businesses in this survey are very integrated with the farming community either by geographical location or existing business relationship, so seeing the farming community as an outlet for these streams is not a difficult step. While in principle, an energy recovery solution – e.g. an anaerobic digester – may appear to provide higher value fails to provide satisfactory return on capital. Most of the businesses that did answer to the survey are open -minded about alternative uses and often have investigated it in the past, sometimes more than once. None are doing it today, because the economic opportunity has not been seen. In summary, this is what the survey let us conclude:

- **Biofuel industry.** As mentioned, the biofuel industry's main coproducts were not part of this survey. In general, the first generation biofuel industry (corn ethanol and biodiesel by transesterification of vegetable oils) is mature and no immediate need opportunity was uncovered. Being mature operations and in a tough competitive and economic environment, plant owners/operators are acutely aware of the need of improving their value proposition. They are actively pursuing optimization of their operations as even small improvement in its margin structure can lead to considerable competitive advantages. Beside process optimization, this is also done in the context of improving the value of the existing streams (e.g. DDG, stillage, syrup, oil, etc.) all of which already have a clear economic role in the plant performance. There is virtually no amount of the original feedstock, which has no economic value today.
- **Meat processors**. The old adage "sell everything but the squeal" applies. All the meat processors who replied to our survey were emphatic on not having any coproduct of consequence. The only one – a renderer – which replied, was referring to a high BOD wastewater stream which, if used, is treated in a digester. The driver for the capital expenditure was regulatory and the producer found that at current energy prices it is cheaper to flare the biogas rather than produce renewable energy for export and/or internal consumption.
- **Food processors**. Food processors have clear waste/coproduct streams of interest for this survey but little incentive to look elsewhere than disposal into animal feeding operations. The type of material disposed has composition directly related to the original feedstock so it does not provide any incentive from further valorization that may not be found in the original feedstock used by the processor. The economic incentive is often associated with reduced storage onsite because of the regulatory burden that may be associated with it (e.g. managing of leachate from silage). In general, these processors have found the value of their coproduct increase in the last few years and they all declare cost neutrality or even a small profit with the sales as animal feed.
- **Dairy processors**. Beside cheese waste, dairy processors have coproduct stream associated with serum, whey and protein isolates. Again in most cases, but not all, these streams find their way to animal feed although some processing step to reduce the water content may be at times necessary. It is our opinion that of all streams presented to us in this report; these may have the highest chance to allow the identification of increased value by further processing. **We believe this may be a most interesting opportunity for those waste, such as some serum and whey-processing streams, which do not find a use as feed.**

6.1 Economic Impact

In general, we found that the economic impact on processor operations is measurable but not in such a significant amount to be a large motivator for change. In many cases, the sale to the animal feed sector generates sufficient revenue for a modest profit or cost neutrality. Under these circumstances, most alternative technology would make it difficult to ensure the return on investment goals required, typically three years or less payback. Where costs are incurred, those are relatively modest when compared to the revenues and because are borne also by everyone in the industry do not pose any specific operator at relative disadvantage. Those costs are typically ranging from several tens of thousands to a few hundreds of thousands of dollars per year. No company appeared to consider the current disposal methods as particularly detrimental to their business model, although they often implied that any legislative initiative which may prevent them to continue the current practices, might impact their operation profoundly and also push towards plant closure in some cases. While one may be tempted to consider those statements as self-serving, it is certainly rooted in the strong belief that the impact of these streams is already optimized and not liable to improvement with any economically viable technology and business models. As mentioned many times already in the course of this project, energy solutions are typically not viable in today's market. The only energy solution, which is technically viable for these feedstocks, is anaerobic digestion given their high amount of moisture. Compared to present disposition methods and considering the poor capital utilization due to the highly seasonal supply of some of these materials, digestion remains economically very unattractive. Similarly unattractive and also mostly technically unfeasible would be the use for combustion. In the meat processing industry, biodiesel demand has already claimed some very low-grade material such as DAF sludge. It is highly unlikely that better value may be found. The remaining question is if some of these streams may contain compounds which if separated and purified may yield a higher value. The complexity and likely cost of such solution – assuming that it exists – will be such that it may not be realistically borne by an individual plant or in a distributed approach. Aggregation and transportation may be necessary. Any potential approach assuming aggregation and/or transportation will immediately be faced with the dire economics associated with transporting (or alternatively drying or dewatering before transportation) streams with high moisture content. This is highly unlikely to be economically viable for streams whose main contents are starches or vegetable proteins, which are likely to be more simply and more economically obtained from fresh feedstock. However, that opportunity may exist for some of the streams associated with the dairy industry. Overall, the handling of these coproducts doesn't present a current challenge to the economics of the processors we interviewed and, we believe, by extrapolation, to the industry segment they represent.

7 Conclusions and Recommendations

The Minnesota processors of agricultural commodities appear to be very efficient in using their feedstock and most organic waste material is recycled into the agricultural sector as animal feed. The only time when that does not happen is if the material has no obvious nutritional value or is otherwise regulated, the latter case also constrains any other possible alternative utilization. **Overall, the survey did not uncover any particular need which is not currently satisfied, nor identified obvious pockets of unrealized value.** While this survey has some clear limitations given the relatively small sample, we nonetheless feel this is an accurate assessment. While most processors would welcome and have considered alternative solutions to their current coproduct stream management approaches, none feel that these streams are a major problem for their current operations. A few have indicated that any restriction on existing regulation would have a negative impact to be judged on a case -by -case basis. All the processors have indicated that any alternative solution to be considered viable will need to satisfy their return on investment requirements. Obviously, this should not be a surprise. Typically, those ROI requirements entail a return of the capital employed in three years or less. Given the high price level of the feed market which allows relatively sustained value for many coproducts and relatively low natural gas prices which make solutions like anaerobic digestion economically not viable, we do not see a change in the immediate future. No processors have a current active program in these areas. a few had programs in the past, but are shelved now with no indication of that changing. In our view, this is a clear reflection of not being a high priority for their operations. Opportunities, if they exist, will have to uncover considerable added value to overcome what we see as clear challenges. Any new technology, especially in the current environment, needs to be inexpensive and often must replace a revenue source not just avoid a cost. Furthermore, any new technology will need to overcome the scale limitation and works effectively with the relatively small amount of material present at each location or add significant value to justify the transportation and/or the conditioning –e.g. drying – which may be required to consolidate any material into a centralized processing facility. As already pointed out, energy solutions do not offer any such opportunity short of a dramatic change in the US natural gas market or explicit change in carbon policy which in turn may provide a substantial boost to the use of biogas rather than natural gas. The food processing industry has well-established procedures to handle their waste, and are mostly centered around the use of such waste as animal feed. Given the nature of the feedstock employed, we believe there is little scope to identify any additional value in these streams, which may not be present already in the original feedstock. The only area where we see some possible opportunity and the ability for AURI to drive innovation is that of dairy processing. Unlike the streams coming from the food industry, some of the streams from the dairy industry may have properties and compounds which are unique and may offer opportunities for further valorization**. Our recommendation would be to have a follow -up study focused on the dairy industry to identify any opportunity to increase the value for the food and feed industry of streams such as residual whey or protein concentrate.**

8 Acknowledgements

The authors acknowledge the staff at AURI and in particular Randy Hilliard and Alan Doering for the many discussions and the patient review of data and draft documents during the course of this project. The authors are also deeply indebted to all the people who patiently answered our queries and provided contact information. Lastly, we want to thank all the people who took time from their busy daily schedule to answer our questionnaire and often made themselves available for follow- up discussions. While confidentiality reasons impede us to acknowledge them by name, we are grateful and appreciative of their time and their obvious passion for a fundamental sector of the Minnesota economy.

9 Appendixes

9.1 Questionnaire cover letter

The Agricultural Utilization Research Institute (AURI, http://www.auri.org) recognizes the potential value of under-utilized coproducts from the agricultural processing industry. AURI has directed funding to their study and has contracted VerdeNero LLC to generate an inventory of such materials in Minnesota; this questionnaire is sent to relevant parties in Minnesota by VerdeNero LLC on behalf of the AURI.

The purpose of this questionnaire is solely to collect data relevant to coproducts in the Minnesota agriculture processing industry. Agricultural processing, including but not limited to, food and bio-fuels production, generate a significant amount of coproducts, which are currently mainly dealt with as waste streams. However, some may have potential to be further utilized value-adding in a number of application including heat, power, bio-fuels, intermediate chemicals, bio-based products, soil amendments, and alternative livestock feeds. Our objective is to identify, quantify and characterize these streams generated. The assessment will also include an economic analysis of the current utilization of these waste streams, the market value of coproducts being utilized, cost of disposal, and potential value-added uses for undervalued and underutilized coproducts. **It is not the intent of this assessment to recommend the utilization of coproducts that already have a strong market demand and utilization, for example DDG(S) in ethanol production.**

Confidentiality is vital to the success of this survey. In publications or presentations resulting from the assessment, no personally identifiable information will be shared. In addition, VerdeNero and AURI will not report any group data for groups of fewer than five individual respondents, because those small cell sizes may be small enough to compromise confidentiality. Instead, VerdeNero and AURI will combine the groups or take other measures to eliminate any potential for demographic information to be identifiable. While AURI and VerdeNero will consider any individual response as confidential, feel free to indicate in the questionnaire any information that you consider critical or whether confidentiality issues prevent you from providing an answer. Upon completion of the projects, the confidential questionnaire will be archived by AURI and will not be made available to the public. The questionnaire can be completed by hand or electronically and any supporting material can be added as appropriate.

We have made every effort to make this questionnaire as simple as possible. Nonetheless, we realize the effort it requires to be completed. We are greatly appreciative of your time and thank you for your help and cooperation in this project. Your effort will contribute to make the Minnesota agricultural sector even more competitive.

If you have any questions regarding this questionnaire please do not hesitate to contact us.

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763-450-4296

AURI
Randy Hilliard
Sr. Project Manager
rhilliard@auri.org
218.280.8573

Please return the completed questionnaire by mail, fax or e-mail by 1/15/2014 to:

Bobbi Dahlstrom
VerdeNero LLC
1001 Twelve Oaks Center Dr, #1029
Wayzata, MN 55391
bobbi.dahlstrom@verdenerollc.com

tel. 763-445-2445
fax 763-210-674

9.2 Questionnaire

Respondent information: (for classification only, no identifying information will be shared or retained in the final report)

Company Name:	
Address:	
Website:	
Brief description of Activities:	
Address(es) of MN production facilities, if different from above:	

Prepared by:	
Title:	
Phone/e-mail:	

Please note if you have multiple production facilities. We would appreciate separate responses for each facility. Feel free to add pages and attach documents as you deem fit.

Can we contact you for any follow up and/or clarifying questions?

YES NO

1. **Location**. Location of facilities where the material is produced.
2. **Material type**. Please provide a brief description and any trade or common name used for each material.
3. **Production**. Please describe where and how materials are produced. Please feel free to attach any relevant information if appropriate.
4. **Analysis.** Is any analysis available: yes/no (if no skip to next question)?
    a. If an analysis is available could it be made available? If yes, please attach to the questionnaire or report any relevant data.
5. **Sample availability**. Could a small sample (1 lb or less) be made available to AURI if requested for analysis?
6. **Quantity**. Quantity produced (annualized basis). Please provide for each facility and each material, if applicable.
7. **Seasonality**. Is the production seasonal yes/no (if no skip to next question)? Please provide for each facility and each material, if applicable.
    a. Describe the seasonality:
8. **Disposition**. How is the material currently disposed? If sold can you describe where and what further use is made. Please provide for each facility, if applicable.
9. **Economic Impact**. What is the economic impact of the material disposition? Does the product have any value on the market or is it disposed of at a cost?
10. **Environmental Impact**. Is the material an environmental liability? Is it subject to regulation?
11. **Operational Impact**. Does the handling of the material impact your operations in any other way?
12. **Alternative uses**. Have you considered alternative uses/dispositions for the material? Yes/No (if no skip to the next question).

a. Would you be willing to share with AURI any study/information relevant to alternative uses or dispositions? Please attach any relevant information, if available
b. If yes, please briefly describe what your findings were.
c. What are the barriers, if any, (economical, regulatory, etc.) that prevent different uses and/or disposition?
d. If you plan or are executing changes, please describe them.

13. If you answered no to the previous question, would you have interest in new uses and disposition
14. Please provide any other information that may relevant. Feel free to attach documentation if appropriate and available.

9.3 Original RFP

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Crookston, MN 56716
800.279.5010

1501 State Street
Marshall, MN 56258
507.537.7440

U of M Biological Services
1475 Gortner Avenue
St. Paul, MN 55108
612.624.8816

PO Box 251
Waseca, MN 56093
507.835.8990

auri
Agricultural Utilization Research Institute

www.auri.org

Agricultural Processing Coproducts Assessment

REQUEST FOR PROPOSAL

The Agricultural Utilization Research Institute (AURI) is soliciting proposals for the development of a research assessment to identify, characterize and determine potential value-added uses for undervalued and underutilized coproducts generated in Minnesota from Agricultural processing including food processing and the production of bio-fuels. The organization making this solicitation request is the Agricultural Utilization Research Institute (AURI); P.O. Box 599, Crookston, MN 56716-0599, http://www.auri.org.

Overview:
AURI is seeking proposals for the development of an assessment of the coproducts generated from agricultural processing throughout Minnesota. The assessment will be used by AURI staff and other project partners and research organizations to help guide further research and project development efforts to utilize coproducts to the highest valued use. The assessment will be made available to the public in order to spur further interest in the utilization of coproducts in Minnesota.

Project Purpose:
Agricultural processing including but not limited to food and bio-fuels production generate a significant amount of coproducts (waste streams) that have the potential to be further utilized for value-added uses in a number of application including heat, power, bio-fuels, intermediate chemicals, bio-based products, soil amendments, and alternative livestock feeds. The primary objective of the assessment is to identify, quantify and characterize the waste streams generated throughout Minnesota from agricultural processing. The assessment will also include an economic analysis of the current utilization of the waste streams including the market value of coproducts being utilized, cost of disposal, and potential value-added uses for undervalued and underutilized coproducts. *It is not the intent of this assessment to recommend the utilization of coproducts that already have a strong market demand and utilization.* Instead the focus will be determining potential value-added opportunities for those coproducts that are undervalued or underutilized. This project will be accomplished in three phases. Phase I and II will focus on identifying, quantifying and characterizing the waste streams. Phase III will involve an economic analysis of the coproducts and recommendations for value-added uses, and potential projects and collaborative opportunities to further utilize the waste streams.

Scope of work:

Phase I

1. Description of the purpose of the assessment, study area, project team and the project goals and objectives.
2. Development of a list of coproducts generated in Minnesota from food and biofuel processing. The list should be categorized by type of coproduct, quantity produced and location by geographic region.

Phase II (AURI will provide compositional analysis data on selected coproducts)
Compositional analysis report that includes 1. The name of the co-product; 2. Total C, N, P, and K content; 3. C:N:P ratios; 4. Bulk density; 5. Water holding capacity; 6. Free air space; 7.PH; 8. EC; 9. Moisture content; 10. Ash content; and 11. Kcal/kg and other coproduct physical, chemical, and biological data as available for each coproduct.

The selected company is responsible for organizing and preparing a compositional analysis report utilizing the compositional information provided by AURI and other information sources.

Phase III

1. Economic analysis determining current market values and costs for disposal for each identified coproduct and identifying the underutilized waste streams that have the highest potential for further utilization.
2. Recommendations on value-added opportunities and specific projects by geographic region that is economically feasible.

Deliverable:
The end product of this study is a final report that includes relevant attachments and lists the assumptions that support the conclusions. All sources of information used in the report should be documented by the name of the source, resource document, website links, etc. The final report is to be delivered no later than **March 31, 2014**, unless a later date is agreed upon. All contact information and notes are to be the property of AURI.

Proposal requirements:
An emailed proposal to AURI should include the following information:

1. A signed cover sheet including name, address, phone and fax numbers, and e-mail address of applicant organization and principal contact.
2. Qualifications and experience of the proposing individual/organization including references.
3. Narrative of the methodology for addressing and completing the scope of work and deliverables outlined above, estimated completion time, and cost of the study.

Proposal should be emailed to: rhilliard@auri.org

Or mailed to:

AURI
Attn: Randy Hilliard
P.O. Box 599
Crookston MN 56716-0599

The deadline for submitting proposals is **Friday, August 30, 2013.** The Project Steering Committee will review the proposals and select the appropriate proposal.

All submissions will be held in confidence. Authorization to proceed will be given after reviewing proposals and completing final negotiations with the company selected. It is anticipated that a contract be awarded in September 2013.

For additional information, contact:
Randy Hilliard
Project Manager
Cell: 218-280-8573
rhilliard@auri.org