Submitted to the Agricultural Research Foundation to the Oregon Seed Council and Oregon Department of Agriculture Alternatives to Field Burning Research Financial Assistance Program.

"Lane County Ryegrass Straw Conversion to Renewable Energy and Biofuel Production Project/Feasibility Study"

Fiscal Year 2007-2008

Project Type: Short-term Research

Lane County
Lane County Community & Economic Development
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Funds Requested: $250,000

Abstract

Lane County is requesting $250,000 from the Field Burning Research Fund for a short-term research project to identify near-term viable options for adding economic value to Ryegrass straw through renewable energy and fuel production. Specifically, our research will answer: Is it possible to convert Ryegrass straw into energy as an economic alternative for seed growers to field burning?

We have identified nine research elements as follows:
Research Element 1: Harvesting, Bailing and Transportation Costs and Issues
Research Element 2: Anaerobic Digester Energy Conversion Process
Research Element 3: Pyrolysis Energy Conversion Process
Research Element 4: Cellulosic Ethanol Energy Conversion Process
Research Element 5: Pellets for Boilers Energy Conversion Process
Research Element 6: Pilot Project Research on Elements 2-5
Research Element 7: Facility Siting Elements Costs and Issues
Research Element 8: Financial Model Comparison and Return on Investment (ROI)
Research Element 9: Recommendations from Finding

Agricultural biomass energy conversion projects are successfully launching throughout the world. New and refined technologies are being applied in successful projects in California, Kansas, Missouri, Iowa, Tennessee, and Georgia to name a few[1]. While these projects provide examples and base knowledge for the conversion of agricultural biomass, including straws, into energy, each geographic region has different inputs and capacities for biomass. In order to understand the potential for the use of Ryegrass straw as an energy feedstock, it is imperative to conduct a specific research study in Oregon.

Our project will build on existing research and the collection of new data through a multi-partner collaboration with the University of Oregon, Oregon State University, and other public and private partners leading to a determination of financially feasible options for the conversion of Ryegrass straw to energy.

One of the key elements of our research, the financial model, will include site specific location options; the capacity needed by a bioenergy facility to process grass straw; and will take into account tax and energy credits and a life cycle sustainability audit to include the value of Ryegrass straw as an energy feedstock compared to burning it.

Objective(s)

We will determine the feasibility of the conversion of Ryegrass straw to energy as an alternative to straw burning. Our research will focus on the following energy conversion processes that have already been identified as processes that can convert other sources of agriculture waste to energy:

- Anaerobic Digestion
- Pyrolysis
- Conversion to Cellulosic Ethanol
- Conversion to pellets for Boiler System Technology

[1] Biomass Magazine Online. BBI International Media, Grand Forks, North Dakota, 2007.

The Feasibility research will include:

- What tonnage of Ryegrass Straw can growers supply as a feedstock seasonally and annually?
- How, where, and when will the straw be collected, stored, pretreated, and transported?
- What energy conversion processes offer the best potential for Ryegrass straw?
- What construction, operations, and maintenance costs will be associated with new or improved facilities to accommodate these processes?
- Is there enough feedstock production to equal the quantity that will be needed to make energy production cost effective?
- Where might plants be located and what are the advantages of those sites?
- What is the potential Return on Investment (ROI) for the energy conversion options?
- Is it possible to incorporate the technology into a sustainable harvesting, baling, and transportation system for Ryegrass straw?

Justification

In 2006 an estimated 131,800 acres of Annual Ryegrass were harvested in Oregon. Approximately 66% of up to 50,000 acres of grass straw burned each year in Oregon is from Ryegrass. The straw from other types of grasses is used in a variety of value added products. These products have created economic reasons that have greatly reduced the burning of these straws. The seed industry has looked at other uses for Ryegrass straw, but none have proved to have enough economic value to make financial sense for the growers to do anything but plow it under for several years and burn it every third year or so to add nutrients to the ground. A viable economic option for the use Ryegrass straw may now exist. Numerous recent studies and reports have identified the opportunities for biomass, like waste straws, to be converted to energy and liquid fuel. To determine the current energy opportunities for Ryegrass straw, we are proposing to conduct a feasibility study of looking at four technologies that could turn Ryegrass straw to energy while providing an economic alternative to field burning.

In the white paper "Conversion of Oregon Biomass to Liquid Transportation Fuels" by the Biomass Conversion Technologies Working Group (BCTWG) from Oregon State University last revised on November 9, 2007, the BCTWG identifies a strong potential for the conversion of lignocellulosic biomass to liquid fuel but also determines the need for continued study:

> *"This White Paper does not provide a detailed description of the types, amounts, and distribution of lignocellulosic biomass found within Oregon. Furthermore, a technical and economic discussion of the collection and transportation issues associated with Oregon biomass is beyond the scope of this White Paper…We have described in this White Paper that the state of Oregon has abundant and unique forms of cellulosic biomass such as grass straw, wheat straw, and softwood forestry residues that can be converted to liquid transportation fuels such ethanol and Fischer-Tropsch diesel…However, since these biomass feedstocks are unique to Oregon, development and deployment of process technology tailored to these feedstocks is of regional interest and so must be initially supported at the state level by the state of Oregon…"*

According to the study, "Feasibility of a Producer Owned Ground-Straw Feedstock Supply System for Bioethanol and Other Products" by Idaho National Laboratories completed in September of 2006:

> *"Biomass feedstock collection, preprocessing, and transportation are integral components of biomass utilization. Feedstock cost constitutes about 35-50% of the total production cost of ethanol or power. The actual percentage depends upon geographical factors such as*

biomass species, yield, location, climate, local economy, and the type of systems used for harvesting, collection, processing, and transportation…"

Such a study has not been done specific to Ryegrass straw in the Willamette Valley, which is why an element of our research is potential methods and costs for the collection, preprocessing, and transportation of Ryegrass straw. This will help determine the geographic distance from which it is feasible to transport Ryegrass straw to an energy processing facility while still providing a revenue-neutral or even revenue-positive option for the growers of Ryegrass.

The University of Davis, Biogas Energy Project, has identified rice straw as a potential co-digestion agent for anaerobic digestion of food waste. Wheat Straw has also been found to work well in a manure-based digester. No one has done a similar study for Ryegrass straw. Lane County has applied for funding to study the financial feasibility of constructing and operating a Lane County owned anaerobic digestion facility to process local food waste into energy. In this study we would research if Ryegrass straw improves digestibility of food waste while creating enough energy to make the collection of ryegrass straw feasible.

The Canadian Resource Efficient Agricultural Production (REAP) project has been working on research and development for liquid and solid biofuel applications for over fourteen years. Though their research focuses on Switchgrass, their research shows that the conversion of Switchgrass to fuel pellets has a higher net energy gain and landuse efficiency than firing with coal, conversion to cellulosic ethanol, and grain/corn ethanol, and that cellulosic ethanol is more efficient than corn/grain ethanol[2]. The results of REAP's research show that the "direct combustion of densified fuels represents the best biofuel cycle in terms of energy, land use, and economics." It also claims that perennial grasses hold the potential to become a major source of renewable energy and greatly benefit rural areas[3]. While this information shows a potentially high value for the conversion of Ryegrass to boiler pellets and/or cellulosic ethanol, it is necessary to conduct specific research to determine if Ryegrass has similar energy yields.

The existing research shows that establishing the value of bioconversion processes must include linking feedstock harvest/collection/transport/storage (ie feedstock assembly) and preprocessing processes with conversion processes in order to evaluate technology options and trade-offs. The lack of specific local information for many of these elements, justifies the need to research all the elements that determine the specific cost of Ryegrass straw energy development as an alternative to field burning.

Materials and Methods

In this section, we present the nine research elements of our feasibility study and the questions we intend to answer. This is followed by the data that will be collected and analyzed; the specific activities we will undertake to accomplish the study; and the deliverables that we will bring together into the final report.

The grants funds we are requesting will be used by the County to accomplish the needed research by contracting out the research elements. We have identified the specific expertise needed to accomplish this project. Some of that expertise we have already brought together for this project (see Additional Partners). Others will be chosen through an RFP process.

[2] Samson, Roger., "The Potential for Biomass Energy Crop Production in Canada", Resource Efficient Agricultural Production. www.reap-canada.com

[3] Samson, Roger, Ibid.

We anticipate starting the study upon signing of a funding contract, approximately March 1, 2008. By June 16, 2008, we will present an interim report. The final report will be presented in two sections: the first section on September 1, 2008 and the second section, which will include recommendations and next steps, on December 1, 2008. (See Proposed Project Schedule).

Research Element 1: Harvesting, Bailing and Transportation Costs and Issues

Financial Model - What will it cost for Harvesting, Baling, Transportation and Storage of Ryegrass straw? What will it cost for Nutrient replenishment/Pest control for fields where the grass straw is removed?

Data that will be collected/analyzed and the specific activities we will undertake:
We will perform a literature search and conduct interviews with industry members to determine the costs of harvesting, nutrient replenishment/pest control, baling, hauling, and storage.

Deliverables – A chart detailing the costs of harvesting, nutrient replenishment/pest control, baling, hauling, and storage.

Research Element 2: Anaerobic Digester Energy Conversion Process

Pretreatment – What are the pretreatment options and costs to maximize the use of Ryegrass straw in an Anaerobic Digester?
Treatment – What is the best Anaerobic Digester process for Ryegrass straw? Will Ryegrass straw mixed with food waste enhance AD performance for both feedstocks? What type of pilot project can we conduct to test Ryegrass and AD performance?
Energy Facility Outputs – What are the potential energy outputs, how much of each output will be generated and what are their uses? What are other outputs and their potential beneficial uses?
Financial Model – What are all the expenses and revenues associated with constructing and operating an Anaerobic Digester for Ryegrass straw?

Research Element 3: Pyrolysis Energy Conversion Process

Pretreatment – What are the pretreatment options and costs to maximize the use of Ryegrass straw for Pyrolysis? What type of pilot project can we conduct to test Ryegrass as a feedstock for Pyrolysis?
Treatment – What is the best Pyrolysis process for Ryegrass straw?
Facility Outputs – What are the potential energy outputs? How much of each output will be generated and what are their uses? What are other outputs and their potential beneficial uses?
Financial Model – What are all the expenses and revenues associated with constructing and operating a Pyrolysis facility for Ryegrass straw?

Research Element 4: Cellulosic Ethanol Energy Conversion Process

Pretreatment – What are the pretreatment options and costs to maximize the use of Ryegrass straw to produce Cellulosic Ethanol? What type of pilot project can we conduct to test Ryegrass as a feedstock for Cellulosic Ethanol production performance?
Treatment – What is the best Cellulosic Ethanol Conversion process for Ryegrass straw?
Facility Outputs – What are the potential energy outputs? How much of each output will be generated and what are their uses? What are other outputs and their potential beneficial uses?
Financial Model – What are all the expenses and revenues associated with constructing and operating a cellulosic ethanol facility for Ryegrass straw?

Research Element 5: Pellets for Boilers Energy Conversion Process

Pretreatment – What are the pretreatment options and costs to convert Ryegrass straw into pellets for use in boilers. Will Ryegrass straw pellets enhance boiler performance? What type of pilot project can we conduct to test Ryegrass pellets as a feedstock for boilers?

Treatment – Which is the best Cellulosic Ethanol Conversion process for Ryegrass straw?

Facility Outputs – What are the potential energy outputs? How much of each output will be generated and what are their uses? What are other outputs and their potential beneficial uses?

Financial Model – What are all the expenses and revenues associated with constructing and operating a pellet making system for Ryegrass straw?

Data that will be Collected and Analyzed & Specific Activities we will undertake common to Research Elements 2-5:

Pretreatment –We will evaluate methods for receiving Ryegrass at the site and pretreatment requirements specific to each conversion technology.

Treatment –We will perform a literature search and conduct interviews to assess the specifications, and performance of Ryegrass in energy & biofuels plants in North America and Europe. We will determine the type of equipment to be used, efficiencies and costs for each conversion technology.

Facility Outputs – For each conversion technology, the type of energy outputs, the estimated quantity of each output that will be generated using industry standard calculations based on the amount of feedstock. We will develop technical scenarios for utilizing each of the energy outputs from each process. Other outputs, including nitrogen and biosolids, will be determined and their potential beneficial uses will be analyzed.

Financial Model –We will develop a financial model for the development of a Ryegrass straw to energy project for each conversion/processing technology. Capital expenditure, operations and maintenance, revenue, expenses, avoided costs, environmental credits, state and federal tax credits, funding sources, and costs of capital will be incorporated to assess the return on investment of the projects. Additional data will be collected from relevant projects and interviews with technology process and energy experts.

Deliverable – The deliverable for Research Elements 2-5 is to provide a report analyzing the various distributed energy technologies that may be applicable to the goals of this project. This report will evaluate the opportunity for energy production from the energy conversion technologies, as well as the financial, regulatory and technical element to using the technologies in the conversion of grass straw to energy.

Research Element 6: Pilot Project Research on Elements 2-5

Using the information gathered in Study Elements 2-5, we will work with researchers in each of the energy conversion methods identified to determine specific pilot research projects to conduct that will identify the best short-term, mid-term and long-term project opportunities. We have already identified researchers for pilot research projects for Anaerobic Digestion, Pyrolysis and Cellulosic Ethanol and will work with OSU to identify additional pilot project opportunities.

Our potential pilot project list currently includes:

- Anaerobic Digestion Projects
    1) MWMC digester – with food waste
    2) On-Farm – with food waste

3) At slaughter house – with animal carcasses

- Pyrolysis
  1) Tech Fuels - National Energy Technology Laboratory in Albany Oregon. bench test of Ryegrass straw
- Ethanol

1) Trillium Fiber Fuels - bench test of biochemical conversion of Rye grass straw to ethanol

2) Will Klausmeier Ph.D. working with team at OSU - Test of thermochemical conversion of Ryegrass straw to ethanol.

- Pellets

1) UO Resource Innovations is working with several pellet makers. We are currently contacting them to identify one or more to test turning Ryegrass straw to pellets.

Deliverables –
This deliverable will include summary steps from each pilot project and data that includes the costs to convert grass straw to energy and the energy generated for each technology tested.

Research Element 7: Energy Facility Siting Elements
We will review the potential sites for a Ryegrass Straw to Energy Conversion processing plant in Lane County. We will take into account the potential for its inclusion in the envisioned "Integrated BioEnergy Business Park." We will also determine issues of smell, noise, and other potentially undesirable aspects of production. We will review planning and zoning restrictions and local, state, and federal regulations for energy production facilities. With all these factors in mind we will determine the best potential site for a facility. The siting of the facility will also include a study of the farthest distance from which it is still profitable to transport Ryegrass straw in Oregon.

Research Element 8: Financial Model Comparison and Return on Investment
ROI – What Tax and Energy Credits (including Carbon Credits) are available for each step of the process? What is the life cycle sustainability value of Ryegrass straw as a product compared to burning it? What type of private and public funding is available for these type of projects?

Data that will be collected/analyzed and the specific activities we will undertake:
We will develop a matrix to compare the relative projected costs and benefits of the alternative energy conversion models. We will identify which alternatives have the greatest potential revenue for the growers and processors of Ryegrass straw. We will also identify potential project funding sources.

Deliverables – The deliverable of this Research Element will include projected costs of each of the researched energy conversion technologies. It will include a revenue and expense report for each alternative that can be used to determine long-term project feasibility. And a summary of funding sources that are being used successfully to finance renewable energy projects.

Research Element 9: Recommendations from Research Findings
The element will include the answers to the all research questions asked in this feasibility study. It will answer: What have we learned? and What are the next steps?

Deliverables – This section will include an analysis of our finding regarding construction costs and annual operations; conclusions regarding SWOTs; conclusions regarding risks and benefits of a Ryegrass straw to energy project and identification of next steps to be taken. This project deliverable

incorporates project recommendations into the development of a strategy that includes next steps to take.

Additional Funding Sources

Lane County has recently applied for a grant of $50,000 from the Renewable Energy Feasibility Fund, to be matched by $25,000 in County funds, to study the financial feasibility of constructing and operating a Lane County owned anaerobic digestion facility to process local food waste into energy. A portion of these funds will be used to determine the potential use of bulking agents in the process of Anaerobic Digestion. In addition some of those funds will be used to develop site specific characteristics for the siting of an anaerobic digester. Though the REFF funds are limited to studying food waste and anaerobic digester issues, those funds do make the Smoke Funds study stretch farther.

This grant will give Lane County and its partners the specific information needed to apply for future grants and loans from sources that include the Oregon Energy Loan Program, Biorefinery grants, Biomass Research and Development grants, Renewable Energy grants and loans, and Value-Added Producer Grants. As the project develops, the processing facility will potentially become eligible for energy and biofuel production tax credits and exemptions and the Ryegrass growers will become eligible for Feedstock commodity tax credits and subsidies.

The Larger Research Project

Lane County is currently engaged in several projects that build on a local vision of an Integrated Bioenergy Business Park where renewable energy facilities are co-located in order to maximize the uses of infrastructure and facility outputs. As part of that process, Lane County formed the Willamette Valley Biomass Study Group, a multi-discipline team working to identify opportunities for biofuels from local biomass materials. Members include Lane County Community and Economic Development; Resource Innovations - UO Institute for a Sustainable Environment; Lane MicroBusiness; Northwest Cooperative Development Center; Lane Council of Governments; Oregon Environmental Council; Trillium FiberFuels, Inc.; Mater Engineering, Ltd.; Ater Wynne; Novus Group; Good Company; Sylvatex and Essential Consulting Oregon.

The Study Group is currently working with a $95,000 USFS Working Partnership grant, awarded to Lane County, to study bio-energy and biofuels opportunities from woody biomass. As mentioned above, the County has also recently applied for a $50,000 grant from the Renewable Energy Feasibility Fund. We are currently also preparing grant applications for several other funding sources and have been meeting with private venture and equity funding organizations.

Proposed Project Schedule and Report Due Dates

Research Elements	Start Date	Interim Report	Final Report
1: Harvesting, and Transportation	March 1, 2008	June 16, 2008	Sept.1, 2008
2: Anaerobic Digester Conversion	March 1, 2008	June 16, 2008	Sept.1, 2008
3: Pyrolysis Conversion	March 1, 2008	June 16, 2008	Sept.1, 2008
4: Cellulosic Ethanol Conversion	March 1, 2008	June 16, 2008	Sept.1, 2008
5: Pellets for Boilers Conversion	March 1, 2008	June 16, 2008	Sept.1, 2008
6: Pilot Project Research	March 1, 2008	June 16, 2008	Dec. 1, 2008

7: Facility Siting Elements	March 1, 2008	June 16, 2008	Dec. 1, 2008
8: Financial Model Comparison and ROI	March 1, 2008	June 16, 2008	Dec. 1, 2008
9: Recommendations from Finding	N/A	N/A	Dec. 1, 2008

Funding Availability

Lane County Community and Economic Development manages numerous grant projects. Our standard grant draw down procedure is once a contract is in place with a grant funder, the County fronts the funds for the work to be done and then applies for reimbursement from the grant funder on a schedule worked out in cooperation with the funder. The County anticipates doing that same thing in this project, drawing down funds as project milestones – like interim and final reports – are met.