APPLICATION CHECKLIST

Use this checklist as a tool to ensure that you have all of the components of the application package. Please note, this checklist is for your use only and does not need to be included in the package.

☒	Application
☒	Transmittal Letter
☒	$100 Application Fee
☐	Tax Liability Statement
☒	Letters of Support (If Applicable)
☒	Other Appendices (If Applicable)

When the package is completed, send an electronic version to Ms. Karlene Fine at kfine@nd.gov, and 2 hard copies by mail to:

Karlene Fine, Executive Director
North Dakota Industrial Commission
State Capitol – 14th Floor
600 East Boulevard Ave Dept 405
Bismarck, ND 58505-0840

For more information on the application process please visit:
http://www.nd.gov/ndic/renew/info/submit-grant-app.pdf

Questions can be addressed to Ms. Fine at 328-3722, or Andrea Holl Pfennig at 328-2687.

Renewable Energy Program

North Dakota Industrial Commission

Application

Project Title: Commercial Application of Soybean Stalk as a New Alternative Fiber in Particle Boards

Applicant: North Dakota State University and Masonite PrimeBoard Inc.

Principal Investigator: Dilpreet S Bajwa

Date of Application: August 30, 2013

Amount of Request: $200,400

Total Amount of Proposed Project: $400, 800

Duration of Project: 3 years

Point of Contact (POC): Amy Scott

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POC Address: Department 4000, PO Box 6050

North Dakota State University, Fargo, 58108

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Commercial Application of Soybean Stalk as a New Alternative Fiber in Particle Boards

ABSTRACT

In the last decade, significant progress was made in the utilization of biomass feedstock for producing renewable energy, value added products, as well as a wide range of biochemicals and biomaterials to replace their petroleum analogs. There is an increasing pressure on agricultural biomass utilization for developing sustainable building products. One North Dakota industry that sustainably uses agricultural biomass (wheat straw) is Masonite PrimeBoard, Inc. Wahpeton, a manufacturer of particle board core material for composite residential doors. Increased demand of wheat straw and decreasing/fluctuating acreage effectively doubled the in the price of wheat straw in the Upper Midwest Region over the last six years. The industry is currently economically threatened by the decline of available wheat straw and the increasingly higher cost of procuring sufficient quantities to support its operation. A small scale study was conducted to understand the feasibility of soy and corn stalks to replace wheat straw for manufacturing low density particle boards (18 lbs/cuft.). The results are shown in ***Appendix A***. The results from this study showed that soy stalk is a promising feedstock to partially substitute the wheat straw. Some of the mechanical properties of soy and wheat straw blend boards were similar to or better than the 100% wheat straw particleboard that are currently produced by the industry. Therefore, a larger-scale study is require understand the feasibility of using soy stalk – wheat straw blends for low density fiber boards at commercial scale, and also to optimize the manufacturing process to reduce the amount of fiber wasted as fines during the processing.

Objective:

1. To understand the logistics of collection, baling, and transferring agricultural biomass (primarily soybean stalk) from the field to commercial processing plant.
2. To understand the factors affecting the efficiency of processing agricultural biomass.
3. Identifying changes in the equipment/machinery required to minimize the amount of fines generated during processing of the material.
4. To optimize the composition of the low density particleboards that uses a blend of soybean stalk and wheat straw to have similar or better physical and mechanical properties than the currently manufactured boards.

Expected Results:

The project will develop 100% biomass based light weight particleboard for the $ 35.5 billion commercial building products industry. It will help a North Dakota based company to continue to be viable and successful, while creating new demand for soybean stalk which will help soybean growers to increase their income. The projected economic impact by the success of

this project is estimated to be $6 million/yr. Approximately 35,000 tons of biomass will be procured from the local farmers.

1. The industry will discover a 100% safe and sustainable raw material incentivizing their long term viability, stability and expansion in North Dakota.

2. It will create additional wealth for the agriculture producers to generate revenue from crop residues.

3. It will create additional employment opportunities in the rural areas.

4. Additional biomass utilization companies will be attracted to North Dakota.

Duration:

The expected duration of this project is **3 years**.

1. Year 1 will focus on collecting information on raw material availability, available volume, location sites, bailing and transportation logistics, and costs. The data collected will help us to do financial analysis and establish true cost of the delivered material.
2. Year 2 will focus on the understanding the changes required in the board manufacturing process for processing soy stalk material efficiently. Equipment modifications, process and formulation optimization will be carried out. The manufacturing process will be optimized to reduce the processing time and processing loss. Also, lab scale samples will be produced with different blend ratios and by changing other variables to identify a few (~3) formulations to experiment at commercial scale.
3. In Year 3, the identified formulations will be produced at commercial scale to evaluate the formulations as well as manufacturing process. The commercial production will be initiated and process and production changes will be further optimized for improving the overall efficiency of the plant and product quality.

Total Project Cost:

The total estimated cost of the project is around $400,800. Masonite PrimeBoard Inc., will contribute $200,400 for raw materials, personnel time as well as in kind (equipment time, new equipment cost, etc). We request ND Industrial Commission to contribute $200,400 towards student salary, travel, equipment and supplies, etc.

Participants:

North Dakota State University, Fargo, ND

Masonite PrimeBoard, Inc. Wahpeton, ND

PROJECT DESCRIPTION

The last decade has seen a significant progress in the utilization of biomass feedstock for producing renewable energy; value added products, as well as a wide range of biochemicals and biomaterials to replace their petroleum analogs. Low density fiber board manufactured by Masonite PrimeBoard Corporation is one such example of sustainable use of agricultural products. They utilize 30,000 tons of wheat straw each year to make particleboards that are primarily used in the interior doors. Increased demand for wheat straw, unfavorable weather conditions, and fluctuating acreage has doubled the price of wheat straw and also added uncertainty in the availability of good quality wheat straw in the Upper Midwest Region. All these changes have stimulated interest in agricultural related biomass feedstocks. An opening of a $10.25 million a Soy-straw Particle Board start-up plant - Agristrand Mankato**, LLC, at Mankato, IA, underscores the importance of agricultural biomass utilization.

The increased price and the limited availability is currently risking the success of the Masonite plant in Wahpeton. In order to survive and thrive, it is imperative that this industry find alternated feedstock. Last year a small scale study was conducted in collaboration with Masonite PrimeBoard at Wahpeton to understand the feasibility of soy and corn stalks to replace wheat straw for manufacturing low density fiber boards. Masonite Corporation is one of the largest door manufacturers in the World. Masonite Primeboard Inc. has been producing door core material at the Wahpeton facility since 1995. On average they use approximately 30,000 tons of wheat straw every year. Traditionally wheat straw has been their material of choice. Increased demand for wheat straw and shrinking acreage has caused straw prices to double over the last six years. This has prompted Masonite PrimeBoard to investigate alternate agricultural biomass materials that can serve as potential feedstocks to replace or substitute wheat straw. Some of the challenges associated with biomass processing include high moisture content, dirt, material feeding, and production of fines (small particles). Therefore it is essential the processing method should be re-evaluated to overcome all these issues. Ultimately the success of this project will enable Masonite to manufacture particleboards from diversified biomass sources at their Wahpeton, ND plant contributing to the economic well-being of North Dakota.

Objectives:

The funds for this project will be used to develop low density particleboards from agricultural biomass. This project is expected to identify a new biomass material for use in industrial application. The scope of this project includes:

***(Agristrand pays $45 per ton for soy straw, baled and delivered, for a net farm return of about $15 per acre)- Ag Innovation News, Apr–Jun 2012, Vol. 21, No. 2.*

1. To understand the logistics of collection, baling, and transferring agricultural biomass from the field to commercial processing plant.
2. To understand the factors affecting the efficiency of processing agricultural biomass.
3. Identifying changes in the equipment/machinery and material formulation required to minimize the amount of fines generated during processing of the material.
4. Analyzing physical and mechanical properties of boards made from agricultural biomass.

Methodology:

The schematic of the commercial low density particleboard manufacturing process is shown in figure 1. The first step involves the procurement of raw material soy stalks in the form of bales delivered to plant. Economics of material cost, baling, and transportation cost will be calculated to estimate the true cost of raw material. The second step will focus on material processing. Important material characteristics (moisture content, bale density, contamination) that influence the processing will be identified. Details are shown in ***Appendix B***. Research will aim at identifying engineering changes required to hammermills, refiners, driers and dust collection equipment to process soybean stalk material. Minimizing the amount of fines (particles smaller than 40 mesh) during processing will be a key challenge. Past research has shown optimal moisture content, type of hammers, and screen size can influence particle size distribution of biomass during processing. We will run trials with different fiber moisture contents, type of hammer mills and screen size to identify the optimal setting for efficient processing that would reduce the fines. Particle size analysis will be conducted after processing fibers at each engineering/equipment setting. After material sizing and drying, the dried particles will be treated with a formaldehyde-free binder and fed to conveyor sheets and mats will be laid. The boards will be pressed using hot press.

In addition to the trials to optimize processing equipment settings, we plan to conduct several laboratory trials to optimize the formulation of boards using different blends of wheat and soy stalk fibers. The experimental design will evaluate particleboards at two different densities of 18 and 30 cu.ft. with five different wheat and soybean stalk formulations as shown in Table 2.

Test boards measuring 4 feet by 8 feet will be manufactured during each trial. Sample boards from each trial will be tested for their physical and mechanical properties as per ASTM standards followed by the industry. The physical properties tested will include board surface quality, density, and dimensional stability. Mechanical properties tested will include board stiffness (modulus of elasticity), strength, screw withdrawal strength, hardness and internal bond strength.

Table 2. Design of Experiment for Soy and Wheat Straw Boards

Variables		
Biomass Material	Soybean Straw	Wheat Straw
Densities	18 cu.ft.	30 cu.ft.
Resin	1%	2%
Mat Particle Type	Homogenous	Heterogeneous
Formulations	100%, 75%, 50%, 25%, 0%	100%, 75%, 50%, 25%, 0%

Replications – 4-6 (Depending on the availability of plant time)

After all the test results are collected and statistically analyzed, optimal formulation and processing conditions will be determined for conducting commercial trial using modified equipment and process. Boards from the commercial trial will be again tested for their physical and mechanical properties to validate primary test results. Based on test results, additional optimization or changes in the formulation and manufacturing process will be implemented.

We strongly believe that this project will lead to qualification of soybean stalk material as a blend material with wheat straw for manufacturing particle boards. Overall this is a low risk high success project as our industrial partner is heavily investing in capital, raw material, and plant trial times for its success. This project is vital for the success of the partnering industry. It will also have major economic impact in ND as it will result in another reliable application for soybean stalks.

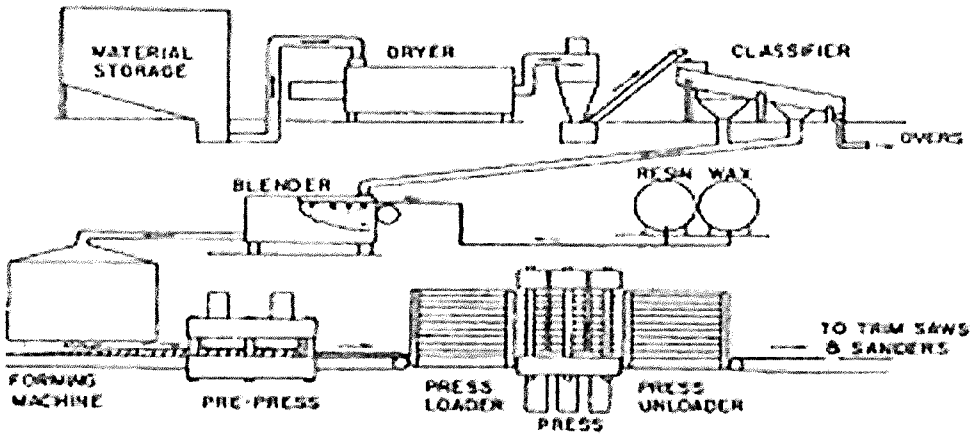

Figure 1. Low density fiber board manufacturing process

Anticipated Results:

The project will result in the commercialization of the technology quickly. Overall the project will results in:

- Development of low and medium density particle board from agricultural biomass sources.
- Strengthen the local industry by providing safe and stable raw material feedstock.
- The production facility will be using locally produced biomass thereby supplementing the income of local farmers.
- Additional job opportunities for North Dakotans.
- The resulting product will be used in Masonite interior residential doors in North Dakota and across the nation.
- The research may lead to additional products and applications for agrifiber-based fiber particleboards.
- Incentive to expand and attract other industries.

Facilities:

- Biomaterial Laboratory, Department of Agri. & Biosystems Engg., NDSU
- Material Processing and Testing Laboratory, Department of Mechanical Engineering, NDSU
- Masonite PrimeBoard, Commercial Production Facility, Wahpeton, ND
- Masonite Corporate Research Center Laboratory, West Chicago, IL

Resources:

- Masonite PrimeBoard processing equipment located at Wahpeton, ND
- Material Characterization Equipment – Particle size analyzer, Fiber length, Density
- Biomass Processing Equipment – Hot press, Glue (binder) applicator, Mixers
- Physical and Mechanical Testing Equipment – Tensile tester, Testing jigs,
- Data Analysis – SAS Software
- Research – Graduate and Undergraduate students
- Technical support from Masonite PrimeBoard

Techniques to Be Used, Their Availability and Capability:

Economic analysis will be used to calculate the true raw material cost. Field survey will be conducted by a graduate student and Masonite PrimeBoard purchasing officer to collect all the information required for cost calculation model.

Engineering changes to processing equipment will be facilitated in consultation with industrial partner as well as equipment manufacturer. Plant engineer, Principal Investigators and graduate student will be involved in this task.

Formulation optimization work will be conducted as per design experiment shown in table 2. SAS statistical software will be used to analyze the data. Experimental and commercial trials will be conducted on the production lines of Masonite PrimeBoard facility. Testing will be conducted in the Materials Testing laboratory located in the Department of Mechanical Engineering , North Dakota State University.

Environmental and Economic Impacts while Project is Underway:

1. Sale of soybean straw will generate additional income for farmers.
2. Soil health may improve with the removal of biomass carrying disease pathogens.
3. The additional income from selling the stalk is expected to more than adequately cover the cost of nutrients removed from the field.
4. Soybean farmers may see reduction in the use of insecticide or pesticide saving farmers some money.
5. Soybean farmers will likely see a reduction in fuel in the fuel consumption and elimination of the need for chopping the soy stalks at the discharge of their combines.
6. Baling and transportation of the stalks will generate additional jobs.
7. Identification of a new raw material will help the industrial partner to continue as a viable operation in North Dakota.
8. Environment will benefit from locking the carbon in a sustainable product that will stay in place for a relatively long span of time.
9. The research may lead to additional products and markets that will have positive impact on ND economy, and may attract new bio-based industries to ND.

Ultimate Technological and Economic Impacts:

Technology: The project will promote innovation and may result in the development of new technology to process biomass for manufacturing particleboards of varying densities without creating too many fine particles. The research will assist Masonite PrimeBoard to qualify different kinds of agri-biomass materials to manufacture particleboards. This project will be a good example of mutually beneficial industry-university partnership that results in innovative technologies and economic development.

Economic Impacts:

1. Promote long term growth and stability of ND biobased industry.
2. Create jobs for the state.
3. Generate additional tax dollars for the state.
4. Add wealth for landowners and agriculture producers.
5. Build a robust rural economy.

Why the Project is needed:

There are several reasons the project is needed in North Dakota.

1. It will help to identify and qualify a sustainable biomass based feedstock for industry, which is facing trouble finding enough traditional feedstock for their current operations.
2. It will give industry incentive to stay and expand in North Dakota.
3. It will create additional wealth for stakeholders.
4. It will result in development of new technology.
5. It will create employment opportunities.

STANDARDS OF SUCCESS

Standards of Success should include: The measurable deliverables of the project that will determine whether it is a success; The value to North Dakota; An explanation of what parts of the public and private sector will likely make use of the project's results, and when and in what way; The potential that commercial use will be made of the project's results; How the project will enhance the education, research, development and marketing of North Dakota's renewable energy resources; How it will preserve existing jobs and create new ones; How it will otherwise satisfy the purposes established in the mission of the Program.

The value to North Dakota:

- It will strengthen North Dakota's industry by helping utilize biomass available in the state. Local industry will be empowered to serve a $35.5 Billon building industry.
- It will boost the income of North Dakota farmers; over 35,000 ton of biomass valuing over $2.0 Million will be utilized.
- Increased industrial output will create additional tax revenue for the state. Over $6 million/yr revenue will be generated by use and sale of different materials.
- It will encourage biomass utilization and attract other companies to state.

Public and Private Sector that would benefit (when and what way):

Public Sector:

- It will increase revenue of the state from a local industry. (Immediate)
- Create opportunities for education, research, training and improving technical skills of students (Immediate)
- Help to market ND based biomass resources for industrial products. (Future)
- Knowledge gained from project will be incorporated into engineering courses. (Future)
- The project will add wealth for landowners and agriculture producers to build and maintain a robust rural economy. (Immediate and Future)
- Project will create awareness about biomass utilization and environmental benefits.

Private:

- The project will help Masonite PrimeBoard to qualify a new biomass material. (Immediate)
- The project will provide help to cut cost of their current raw material. (Immediate)
- It will help to improve their profit margin. (Immediate and Future)
- Project will help them to expand their production in ND. (Future)

Potential that commercial use will be made of the project:

It is a **low risk and high success** project as the industrial partner is located in North Dakota and they are willing to heavily invest in the success of this project. The proof of concept work has been done successfully. The industrial partner has been manufacturing building products for several years and has extensive network to market this product throughout U.S. and Canada.

How project will enhance education, research and development and marketing of ND renewable resources:

Education – The investigators will employ graduate and undergraduate students from North Dakota State University in the research work of this project. The project will help them to achieve their education goals, and improve their engineering skills relevant to this project.

How will it preserve jobs and create new ones:

The long term viability and stability of this company will help to preserve jobs and its growth will create future employment opportunities for North Dakotans. Biomass collection and transportation will create additional jobs.

How it will serve the purpose and mission of the program:

The proposed project will serve the mission and program in the following ways:

- The project will significantly contribute towards economic development of ND.
- This research will foster efficient, economic and environmentally safe development of biomass based industry in ND.
- It will promote research, development and commercialization of biobased industrial products in the ND.
- It will create jobs and growth opportunities for biobased industries in ND.
- This project will also lead to public awareness of the benefits and opportunities that are hidden in large volumes of biomass in ND.

BACKGROUND/QUALIFICIATIONS

Please provide a summary of prior work related to the project conducted by the applicant and other participants as well as by other organizations. ***This should also include summary of the experience and qualifications pertinent to the project of the applicant, principal investigator, and other participants in the project.***

*(*For detail CV's please see ***Appendix C****)*

The project investigators have 28 years of combined experience in the field bio-composite. Dilpreet Bajwa has worked on plant-fiber based composites since 1994 as part of his graduate research (for 6 years), and also worked for composite industry for 12 years. Sreekala Bajwa has successfully received grant funding and collaborated with industries in investigating the use agricultural residues in composite materials for the last 10 years. Both of these investigators currently have multiple grants exploring the use of agricultural fibers in composite materials.

John Robinson will be the collaborator from Masonite PrimeBoard Inc. He has been with Masonite for the past 27 years, and has tremendous experience in the manufacturing low density fiber boards and particle board as core materials for Masonite interior doors.

This project will benefit NDSU by implementing research finding into a real-world application. It will further our understanding of how different fibers and fiber blends alter the physical and mechanical properties of particlefiber boards. By looking at different density boards at lab scale and characterizing their properties, we hope to identify other uses for the higher density boards. We also plan to further our research by investigating the application on bio-based glues in fiber boards.

Masonite PrimeBoard will benefit from this study by identifying a more readily available raw material for their product and also by optimizing their manufacturing process to suit the new raw material. They will also be able to improve the efficiency of the operation by reducing the fines or wastage in biomass feedstock, and maintaining better environment inside their plant.

MANAGEMENT

*A description of **how** the applicant will manage and oversee the project to ensure it is being carried out on schedule and in a manner that best ensures its objectives will be met, **and a description of the evaluation points to be used** during the course of the project.*

Dr. Dilpreet Bajwa will be responsible for the overall management of the project. He has a time line developed for each of the tasks to perform. He will also conduct periodic meeting with the other investigators, students working on the project and the industrial collaborator. The biomaterials group at NDSU meets on a weekly basis to discuss the progress of research projects. Once this project is funded, this project will also be included in the weekly discussions. There will be project group meetings at least twice a year with the industrial partner to assess the progress of the project, and more often on as-needed basis. We will also use conference call to discuss issues and progress on a need basis. Twice a year, the PI will prepare a progress report that will be circulated to the industry partner as well as the ND Industrial Commission. Representatives from the NDIC will be given opportunity to visit the labs and see the progress made on research, if it is so desired.

TIMETABLE

Please provide a project schedule setting forth the starting and completion dates, dates for completing major project activities, and proposed dates upon which the interim reports will be submitted.

Tasks	Jan-Jun 2014	July-Dec. 2014	Jan-Jun 2015	July-Dec. 2015	Jan-Jun 2016	July-Dec. 2016
1. Hiring students	X					
2. Data collection on soybean stalk data for economic analysis	X					
3. Economic analysis		X				
4. Experiment to optimize processing		X	X			
5. Lab experiment to identify formulation			X	X	X	
6. Commercial trial				X	X	X
7. Optimization of process					X	X
8. Report	X	X	X	X	X	X

BUDGET

*Please use the table below to provide an **itemized list** of the project's capital costs; direct operating costs, including salaries; and indirect costs; and an explanation of which of these costs will be supported by the grant and in what amount. The budget should identify all other committed and prospective funding sources and the amount of funding from each source.* ***Please feel free to add columns and rows as needed.*** *Higher priority will be given to those projects have matching private industry investment equal to at least 50% or more of total cost.*

(For details please see ***Appendix D***)

Project Associated Expense	NDIC's Share	Applicant's Share Masonite Co. (Cash Expenditures)	Applicant's Share Masonite Co. (In-Kind)	Other Project Sponsor's Share
$400,800	$200,400	$109,400	$91,000	
Project Investigators		$6,375		
Graduate Assistant	$63672			
Student Help	$16,500			
Technical Support		$18,519		
Equipment	$45,000		$15,000	
Materials and Supplies NDSU	$18,000			
Material Supplies Masonite PrimeBoard Inc.		$84,506		
Travel	$9,000			
Other costs (Equipment and Plant Trials Cost)			$76,000	
Indirect Cost	$48,228			

Note – The funding request is for **3 years project** duration.

Please use the space below to justify project associated expenses, and discuss if less funding is available than that requested, whether the project's objectives will be unattainable or delayed.

CONFIDENTIAL INFORMATION

Any information in the application that is entitled to confidentiality and which the applicant wants to be kept confidential should, if possible, be placed in an appendix to allow for administrative ease in protecting the information from public disclosure while allowing public access to the rest of the application. Such information must be clearly labeled as confidential and the applicant must provide all required information set forth in NDCC 54-63-02. If there is no confidential information please note that below.

The proposal does not contain any confidential information.

PATENTS/RIGHTS TO TECHNICAL DATA

Any patents or rights that the applicant wishes to reserve must be identified in the application. If this does not apply to your proposal, please note that below.

At this point of time the investigators don't anticipate any patent or rights from this technology.

APPENDIX - A

PRELIMINARY STUDY RESULTS (CONFIDENTIAL)

The preliminary laboratory scale study was conducted to understand the feasibility of agricultural biomass for manufacturing particleboards by principal investigators at North Dakota State University. The study was supported by a small grant from Agricultural Products Utilization Commission in 2012. Corn stalk, soy stalks and wheat straw was locally purchased and processed using current equipment (Hammermill, Refiner and Drier) at Masonite PrimeBoard facility in Wahpeton, ND. The processed material was analyzed for particle size distribution, bulk density, and moisture content. Fibers were mixed with thermoset resin and boards were pressed using a small hot press (24x24 inch platen). The design of experiment included: 3 – Materials, 7- Formulations, and Replications – 3. Board thickness and density was similar to commercial product. The formulations tested in this study are show in table 1.

Table 1. Formulations

	Wheat Straw (%)	Corn stalk (%)	Soy straw (%)
1	100 (control)	-	-
2	-	100	-
3	-	-	100
4	50	50	-
5	50	-	50
6	25	75	-
7	25	-	75

The physical and mechanical properties of the boards were tested according to ASTM D1037 standard. The physical properties tested included moisture content, particle size analysis, bulk density of fibers, and density of the boards. Corn stalks showed higher moisture content than soy and wheat straw. The bulk density of three different processed fibers varied between 6.50 -4.27 lbs/cuft with wheat being highest and corn lowest. Corn fibers showed highest amount of fines and soy straw showed lowest amount of fines. The pith is corn stalk contributed significantly towards fines. The density of finished product was slightly higher for soy straw boards (340 Kg/m^3) as compared to 100% wheat straw (control) (314 Kg/m^3). Mat thickness of corn straw boards was higher than soy and wheat straw mat.

The mechanical properties analyzed included modulus of elasticity, flexural strength, internal bond strength and screw withdrawal strength. The tests were conducted using a universal testing machine. It was found that modulus of elasticity of 100% soy straw board was higher than control and corn. Flexural strength of 100% soy straw boards was slightly lower than control and corn stalk boards. Internal bond strength of the 75% soy straw plus 25% wheat straw board was comparable or better than control. Screw withdrawal strength of these boards is currently under evaluation. The results obtained so far show that either 100% soy straw or a blend of soy straw with wheat straw would be desirable to manufacture commercial particle boards of varying densities.

APPENDIX B

Raw Material

Moisture Content – Onsite measurement of moisture content (MC) of soy and wheat straw will be conducted as it significantly impacts the storage life of the material. The MC data will be collected at three intervals after harvesting of soy beans (week 1, 2 and 3).

Bale Density – Square bales are preferred as they are easy to transport and store. Soy straw bales of multiple densities will be packed to understand the handling and processing in the hammer mills. Higher density bales also reduce the cost of transportation.

Contamination – One major source of contamination is the soil or dirt present in the raw material. It has a detrimental effect on the processing equipment and the quality of the product. Therefore raw material will be analyzed for different kinds of contamination (soil, packing strings or ropes and pods) that can impact the material quality.

Processing Equipment

Hammermill – It is used to process the material into desirable particle size. The hammers and screen size can significantly impact the particle size distribution and fines (undesirable component). Therefore to reduce the amount of fines and improve the particle size distribution screen size and hammer will be replaced in consultation with the OEM equipment supplier. We envision to trial two different hammer types and multiple screen sizes ranging from 0.25 inch to 0.75 inch diameter to optimize the output of hammermill.

Refiners - The purpose of the refiner is to segregate any fines in the hammer milled material so a good quality mat is formed. The filters on the refiners will be optimized to handle soy straw fibers as compared to wheat straw.

Drier – It is used to dry the material to appropriate moisture content. Typically moisture content of the agricultural biomass varies from 15-25%. Therefore initial moisture content of raw material will dictate the drying time. Ideally a minimum drying time is preferred as it is energy intensive process. Our objective will be to identify the ideal baling time for raw material that can result in lowest moisture content of baled material. This will help plant to conserve energy and improve product quality and efficiency.

Curriculum Vita
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PROFESSIONAL PREPARATION:

B.S. - Punjab Agricultural University, India - January 1991, Forestry and Natural Resources

M.S. - University of Illinois at Urbana-Champaign, 1996, Wood Science and Technology

Ph.D. - University of Illinois at Urbana-Champaign, 2000, Wood Science and Technology

APPOINTMENTS:

Associate Professor, Department of Mechanical Engineering, North Dakota State University, Fargo, ND. April 2012
Consultant, Greenland Composites Inc., and HCC Brand, Fayetteville AR. February 2012
Adjunct Professor, Department of Biological and Agricultural Engineering, University of Arkansas. December 2010 to February 2012.
Director, Research and Development. Greenland Composite Products Inc., and HCC Brands, Fayetteville AR. July 2005 to February 2012.
Director of Research and Development. Epoch Composite Products Inc., Lamar, MO. December 2003 – May 2005.
Research Scientist. Quality and Process Improvement. Coates Technical Center, Masonite International Corporation, West Chicago, IL. April 2002 – December 2003.
Senior Product Development Engineer. Engineered Wood Products Division. International Paper Company, Loveland, Ohio. July 2000 – December 2002.

RESEARCH INTERESTS

Research interests include characterization and processing of natural fiber composite materials, bio-based polymers degradation mechanisms, durability engineering, bio-waste for energy applications.

PUBLICATIONS (~16 Peer-reviewed papers and 28 conference presentations):

Bajwa, S. G., D. S. Bajwa, and G. Holt. 2011. Commercial application of cotton burr/stem and module wrap in thermoplastic composites: Effect of scaling from laboratory to commercial. *Journal of Thermoplastic Composites*. (Submitted)
Bajwa, S. G., D.S. Bajwa, and G. Holt. 2009. Optimal substitution of cotton burr and linters in thermoplastic composites. *Forest Product Journal* 59(10): 40-46.
Bajwa, S. G., D.S. Bajwa, and G. Holt. 2008. A novel filler for natural fiber polymer composites from cotton gin waste. *Tenth International Conference on Progress in Biofibre Plastic Composites*. May 12-13, 2008. Toronto, Canada.
Nakayama, F. S., S. H. Vinyard, P. Chow, D. S. Bajwa, J. A. Youngquist, J. H. Muehl and A.M. Krzysik. 2001. Guayule as a wood preservative. *Industrial Crops and Products* 14(2):105-111.
Chow, P. and D.S. Bajwa. 2005. Oriented Strandboard (OSB) Panels made from Kenaf Stalks and Aspen. *Journal of Natural Fibers* 2(1): 83-89.
Bajwa, D.S., and P. Chow. 2003. Some Performance Characteristics of Aspen-Kenaf Composite Boards. *Forest Products Journal* 53(10): 30-35.
Authored several chapters in books on the utilization of natural fibers for composite materials.

APPENDIX C

Sreekala Gopalapillai Bajwa

Professor & Chair, Department of Agricultural & Biosystems Engineering
North Dakota State University, Dept. 7620, PO Box 6050, Fargo, ND 58102
Phone: 701-231-7265; Email: SReekala.Bajwa@ndsu.edu

EDUCATION:

Ph.D. -University of Illinois at Urbana-Champaign, 1996-2000, Agricultural Engineering
M.S. -Indian Institute of Technology at Kharagpur- India, 1992-1994, Agricultural Engineering
B.S. -Kerala Agricultural University at Tavanur – India, 1987-1991, Agricultural Engineering

EXPERIENCE:

Professor & Chair, Dept of Agricultural & Biosystems Engineering, NDSU, Feb. 2012 - present
Associate Professor, Dept of Biological and Agricultural Engineering, University of Arkansas, 2007- 12
Visiting Professor, Dept of Agricultural & Food Engineering, Indian Inst. of Tech., Kharagpur, India, Jul-Dec. 2009
Assistant Professor, Dept of Biological and Agricultural Engineering, University of Arkansas, Aug. 2001- 2007
Post-doc. Research Assoc., Dept of Agricultural Engineering, University of Illinois at Urbana-Champaign, 2000-01
Assistant Professor, Kelappaji College of Agricultural Engineering, Kerala Agric. Univ., Tavanur, India, 1994-96

RESEARCH INTERESTS &ACCOMPLISHMENTS

Research interests include bio-fiber composites from agricultural fibers and byproducts, as well as sensing and modeling applications in agriculture and environment.
PI or Co-PI in competitively funded grant projects from funding agencies such as USDA, USEPA, NSF, NASA, United Soybean Board, ND APUC, ND Corn Utilization Council, Cotton Foundation, and Cotton Incorporated.

AWARDS AND HONORS:

Outstanding Agricultural Engineer awarded by ASABE Arkansas Section, 2008
AMA – SHIN-NORINSHA – AAAE Young Researcher Award by AAAE, 2007
Honorable mention for Superior Paper Award by ASABE, 2007
Best Undergraduate Research (faculty mentor) Paper Award from UA Teaching Academy, 2006

SYNERGESTIC ACTIVITIES

Panel member/reviewer: USDA (2004-2012), NSF-CBET (2007-2010), NIH (2011), USBR (2006, 2011), USDA-NRI (2004-05), NSERC - Canada (2009)
Associate Editor: ASABE IET Division, 2002-2013, Technical/Professional Reviewer for 15 journals
Professional Society Membership: ASABE, AAIC, AAAE, ACE, ASEE
President – Ozark Chapter of Association of Women in Science, 2008-12
Chair (2013-14) & Vice-chair (2012-13), Kishida International Award Committee of ASABE
Chair (2012-13), Vice-chair (2011-12), Secretary (2010-11)- INTL 601 Inter. Affairs Comm. - ASABE
Chair (2009-10), Secretary (2006-09) - Arkansas Section of ASABE

STUDENT ADVISING

Currently supervise 1 Ph.D. student, 1 postdoc, 2 visiting scholars, 3 UG researchers, & 4 thesis committees.
Supervised 11 graduate students, 3 honors thesis, 1 freshmen honors project, 35 undergraduate researchers, and served on 4 honors thesis committees and 12 graduate thesis committees.

SAMPLE PUBLICATIONS (2 book chapters, 41 peer-reviewed and 100 presentations/papers):

Bajwa, D. S., S.G. Bajwa, G.H. Holt., R. Srinivasan, T. Coffelt, F. Nakayama, and R. Gesch. 2013. Recycling of ligno-cellulosic and polyethylene wastes from agricultural operations in thermoplastic composites. *Waste and Biomass Valorization.* DOI: 10.1007/s12649-013-9263-6 (Online First)

Bajwa, S. G., D. S. Bajwa, and G. Holt. 2012. Commercial application of cotton burr/stem and module wrap in thermoplastic composites: Effect of scaling from laboratory to commercial. *Journal of Thermoplastic Composites*. DOI: *10.1177/0892705708091857* (online)

Bajwa, S. G., D. S. Bajwa, G. Holt, T. Coffelt, and F. Nakayama. 2011. Properties of thermoplastic composites with cotton and guayule biomass residue as fiber fillers. *Industrial Crops and Products* 33(3):747-755.

Bajwa, S. G., D. S. Bajwa, and G. Holt. 2009. Optimal substitution of cotton burr and linters in thermoplastic composites. *Forest Product Journal* 59(10): 40-46.

Bajwa, S. G., D. S. Bajwa, and A. S. Anthony. 2009. Effect of laboratory aging on the physical and mechanical properties of wood-polymer composites. *Journal of Thermoplastic Composite Materials* 22(2): 227-243.

APPENDIX-C

JOHN GORDON ROBINSON
1784 Oak Ct.
Wahpeton, ND 58075
(701) 591-0238 jgrobin@wah.midco.net

SUMMARY

- Lean Manufacturing Facility Manager with more than twenty five years of diverse experience and proven advancement with leading companies in the building products industry
- Proven ability to improve production processes and reduce costs through focused leadership in a team based approach
- Hands-on leadership style with strong technical problem solving skills
- Strong written and verbal communications skills

EXPERIENCE & RELEVANT ACCOMPLISHMENTS

MASONITE INTERNATIONAL CORPORATION
January 2007 to Present
Wahpeton, North Dakota

Masonite International is a leading manufacturer of doors and entryway systems for the commercial and residential construction markets.

Plant Manager

- Management of all activities inherent with the operation of a wheat straw particleboard manufacturing facility including operations, customer service, logistics, engineering, maintenance, environmental health & safety, accounting and human resources.
- Leadership of a salaried staff of 7, and a non-union hourly production workforce of 48 operating three shifts, five days a week.
- Administration of a $10 million operating and sales budget
- Led efforts to drive improvements in operating efficiency resulting in a 36% improvement in overall productivity in the last four years
- Leadership of a strong safety focus towards the evolution of a safety culture conducive to an injury-free workplace and OSHA VPP Star consideration - work still in process

KNIGHT CELOTEX, LLC
December 2003 to January 2007
Lisbon Falls, Maine

Knight Celotex was a leading manufacturer of insulation sheathing, sound deadening and roofing fiberboard for the residential and commercial construction industry. The company's fiberboard products served manufacturers of bulletin, dry mark and magnetic boards, office partitions, interior doors, laminated furniture, and packaging.

General Manager

- Management of all activities inherent with the operation of a fiberboard manufacturing

facility including operations, customer service, logistics, engineering, maintenance, environmental health & safety, accounting and human resources.
- Leadership of a salaried staff of 18, and a non-union hourly production workforce of 96 operating three shifts, seven days a week.
- Administration of an operating budget of $20 million, with over $26 million in sales
- Responsibility for directing and supporting capital strategy and deployment activities across Knight Celotex's four manufacturing locations
- Led efficiency improvements, new product development and commercialization, and cost reduction activities to bring the mill from a 5% ROCE eight years ago to well over 12%
- Led strong safety and environmental agendas to achieve recertification of OSHA VPP Star safety status in February 2006 and the 2001 Maine Governor's Environmental Excellence Award
- Devised and implemented a machinery and work systems improvement effort that resulted in a 15% improvement in labor productivity
- Successfully managed the facility's multi-million dollar energy budget to save hundreds of thousands through hedging strategies, efficiency and conservation efforts, and continuous usage monitoring and feedback
- Participated on the acquisition team for the company's acquisition of the Danville, Virginia hardboard manufacturing facility, and then led the successful $1.8 million project to convert the facility to soft board production

MASONITE INTERNATIONAL / INTERNATIONAL PAPER COMPANY
June 1998 to December 2003
Lisbon Falls, Maine

Masonite International is a leading manufacturer of doors and entryway systems for the commercial and residential construction markets and International Paper Company is one of the world's largest producers of paper and forest products

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Plant Manager

- All of the same facility level leadership responsibilities as listed above
- Initiated, developed and led the $1.5 million capital project for the production of Conflex® expansion joint filler in 2000
- Led strong safety and environmental agendas to achieve recertification of OSHA VPP Star safety status in March 2001 and recognition with the 2001 Maine Governor's Environmental Excellence Award
- Led the project to rationalize Masonite's fiberboard production capacity through the closure of the Pilot Rock fiberboard facility and the transfer of product lines to the remaining three facilities
- Represented International Paper at the facility level in the sale of the Lisbon Falls facility to Knight Celotex including the preparation of all due diligence documentation, human resource management and business continuation and transition

MASONITE INTERNATIONAL / INTERNATIONAL PAPER COMPANY
December 1994 to June 1998
Cordele, Georgia (Oriented Strand Board Manufacturing Facility)

Engineering / Maintenance Manager (May 1995 to June 1998)

- Responsible for all aspects of capital expenditure and maintenance of an oriented strand board manufacturing facility
- Managed a $2.2 million maintenance budget, and a $2.5 million capital expenditure budget
- Directed a lean salary staff of 6 and a skilled hourly electrical and mechanical staff of 24
- Implemented advanced PM and PdM maintenance systems that reduced unscheduled downtime from 23% to less that 6%
- Diagnosed and discovered a press misalignment problem and successfully negotiated a rebuild by the manufacturer at no cost to International Paper. After rebuild, product yield losses dropped from 4% to 0.25%.

Engineering Manager (December 1994 to May 1995)

- Recruited internally through the International Paper system to join the Cordele startup team as the engineering manager
- Responsible for all aspects of capital expenditure of an oriented strand board manufacturing facility with an annual budget of $2.5 million
- Directed a staff of four engineers
- Responsible for the design and layout of machinery and equipment as well as the generation of technical drawings using AutoCAD

MASONITE INTERNATIONAL / INTERNATIONAL PAPER COMPANY
January 1984 to December 1994
Pilot Rock, Oregon (Fiberboard Manufacturing Facility)

Engineering Superintendent (February 1987 to December 1994)

- Responsible for all aspects of capital expenditure and maintenance of a wood fiberboard manufacturing facility
- Responsible for environmental compliance and implemented an internal environmental self-audit compliance system
- Managed a $2 million annual budget in maintenance and capital expenditure

Senior Project Engineer (August 1985 to February 1987)

- Responsible for a $1.8 million capital expenditure budget and operation of the plant's steam production unit
- Directed a staff of two engineers and four boiler operators
- Managed a $1.0 million project to convert the mill's boilers from gas to wood fuel
- Participated on the product development team to develop the process necessary to produce the Conflex® expansion joint product line and managed the $800,000 capital project to install the equipment

Project Engineer (January 1984 to August 1985)

- Responsible for capital expenditure projects totaling $450,000

EDUCATION, TRAINING & OTHER SKILLS

B.S. Mechanical Engineering 1983- Oregon State University

Professional Training: Masonite International Lean Sigma Green Belt Certified, International Paper's Quality Management Concepts, Facilitator Training and Media Communications for Plant Managers courses, PML Associates Positive Management Leadership Course, Kellogg School of Business Executive Marketing Leadership Course, Jack Franchetti Communications, Inc. Media Communications Course

Computer Skills: MS Word, Excel, PowerPoint, AutoCAD, MS Project, MS Access

Professional references available upon request.

APPENDIX-C

Bradley W. Edwardson

520 4th St N
Wahpeton, ND 58075
701-640-0052
bedwardson@wah.midco.net

Professional History

5/12 - Present **Operations Manager** – Masonite PrimeBoard – Wahpeton, ND
* Manage 30 operations employees operating 3 shifts.
* Implemented Lean Manufacturing methods in all machine centers including Kaizen events, 6S, and Lean Manufacturing training to employees.
* Improved net productivity of press line by 15% and finish end machine centers by 17% over year prior to position change through elimination of waste and optimizing operator efficiency setting multiple production records.

12/08 – 5/12 **Maintenance Manager** – Masonite PrimeBoard – Wahpeton, ND
* Managed a crew of 12 Maintenance Technicians that provided a variety of maintenance functions including; PLC programming, welding fabrication, machine troubleshooting and repair, and rolling equipment maintenance.
* Developed a comprehensive machine rebuild program that after the second year contributed to an annual operational productivity improvement of 17%.
* Implemented a preventive maintenance program that focused individual maintenance technicians on individual production areas. Produced better machine ownership and more detailed work orders resulting in fewer major equipment failures.

12/03 – 12/08 **Maintenance Manager** – Integrity Windows and Doors – Fargo, ND
* Managed crew of 16 Controls and Maintenance Technicians to provide maintenance needs for over 400 machines used in the manufacture of windows and doors.
* Instrumental in preparing facility for OSHA VPP Star Certification in 2004 and implementing further improvements for re-certification in 2007.
* Implemented a comprehensive preventive maintenance program that is machine needs oriented which contributed to a 50% reduction in unplanned downtime.

5/95 – 12/03 **Technical / Production Manager** - PrimeBoard, Inc. - Wahpeton, ND
* Worked in nearly all facets of manufacturing and personnel management including; scheduling, training, employee evaluations, and establishing department budgets.
* Managed a work force of over 75 employees in board production, value added production, and engineering and maintenance staff.
* Supervised a team to develop and document all process control procedures, training guides, quality control procedures, and troubleshooting guides.
* Optimized raw material yield and labor efficiency to reduce overall production costs by over 25% from original start up estimates.

9/94 - 5/95 **Plant Manager** - Deerhorn Bean and Seed Co. - Dwight, ND
* Managed seed cleaning and edible bean exporting operation.
* Trained employees in cleaning, bagging, and loading agricultural products.
* Performed routine maintenance on all equipment.
* Scheduled shipping and receiving of trucks and overseas containers.

Education and Achievements

Bachelor of Science - Criminal Justice — Minot State University – 1990
Dale Carnegie Leadership Course — Dale Carnegie of North Dakota - 2013
Yellow Belt Six Sigma & Lean Sigma — Masonite Corporation – 2011 & 2012
Employers Association Leadership Series — Integrity Windows and Doors - 2006
Czech and Spanish Linguist of the Quarter — 110th MI Bn, 10th Mountain Division, US Army - 1994

APPENDIX D

North Dakota Industrial Commission Proposal – Budget Justification

Bajwa, D. S., Bajwa, S. G. and J. Robinson

Amount requested from NDIC: $200,400 (For 3 years)

Salaries

One graduate student will collect information on availability, logistics and costs in year 1, in year 2 they will optimize processing, equipment modifications and blend ratios. Year 3 they will assist with data analysis. Salary is $20,000 in year 1 with 3% salary adjustment the next two years. $61,818

One undergraduate student worker will assist the graduate student with sampling and data entry for 500 hours a year @ $10/hour for 3 years. $15,000.

Fringe Benefits

Fringe benefits are computed at 3% for graduate student, 10% for undergraduate student. $3,355

Total Salaries and Fringe Benefits **$80,173**

Equipment

In year 1, one hot press for $5000, Instron testing machine $40,000 Total equipment $45,000

Materials & Supplies

sieve shaker $3,000
moisture meter $2,000
drying oven $1,200
balance $850
water bath $2,300
contact angle analyzer $2,200
glue and other lab supplies $1450
Test jigs for Instron $2,000
calipers $800
glue application kit $1,000
batteries, thermometer, humidity sensor $1,200 Total Materials & Supplies $ 18000

Travel

Out of state travel consists of four trips to the Chicago Masonite Research Center for lab testing @ $1,230 per trip per person based on the following estimates: ($558 transportation, $366 for hotel @ $122 per night for 3 nights, $184 per diem) $4920

In state travel consists of twelve trips per year for 3 years to the Masonite PrimeBoard facility in Wahpeton at $55 per trip. Reimbursement will be made according to NDSU travel policies. (Motor pool 0.34 to .52 per mile depending on vehicle). Meals $17.50 to $35/day. $1980

One trip for the grad student to attend a national conference to present research results $700

The two PIs attend a regional meeting to present research results, $700 each. $1400

Total travel $9,000

Total operating costs	**$72,000**
Total Direct costs (Salaries, FB, & Operating)	**$152,173**
Facilities and Administrative Costs (45%)	$48,228
Total Request	**$200,400**

Industry Matching Funds *Total in-kind match from Masonite: $101,600,Total cash match from Masonite PrimeBoard: $146,894*

Salaries and Fringe Benefits

Key Personnel – John Robinson year 1-3 $6,375 S

This is calculated at 25 hours of John Robinson's time per year at $82.5/hour for year 1, with a 3% inflation adjustment assumed for years 2 &3

Brad Edwards & other production staff years 1-3 $18,519

Brad Edwardson's time is calculated at @ $56.65/hour for 50 hours in year 1 ($2,500), and 150 hours per year with a 3% inflation adjustment in years 2 & 3

Total Salaries & Fringe Benefits $24,894

Equipment

Hammermill screens, equipment modifications at Masonite Plant $15,000

Materials & Supplies

Wheat straw, soybean stalks, resin purchases by Masonite $84,506

$50,000 for 1000 tons of Soybean stalk @ ~ $50/ton, $26,506 for 408 tons of Wheat straw @ ~$65 per bale; Resin and lubricating agents for $8,000. Supplies will be bought on the basis of availability and need.

Other Direct Costs

Equipment and Plant Time $76,000

In kind support from Masonite for use of plant and equipment time. The estimated cost of plant & equipment use time together is $800/hour for 10 hours in year 1 ($8,000) in year 1, and 45 hours in year 2 ($32,000), and 40 hours in year 3 ($36,000).

Total Industry Match **$200,400** Total Project Cost $400,800