FOREST PRODUCTS INDUSTRY OF THE FUTURE
PORTFOLIO STUDY AND EVALUATION

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FOREST PRODUCTS INDUSTRY OF THE FUTURE PORTFOLIO STUDY AND EVALUATION

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Executive Summary

Los Alamos Technical Associates, Inc. (LATA) conducted an evaluation the potential impact and value of a portion of the current portfolio of R&D projects supported by the Office of Industrial Technology and the Forest Products Industry of the Future

The mission of the evaluation was to:

- a) Assess the potential impact of the projects to meet the critical goals of the industry as identified in the vision and roadmapping documents.
- b) Evaluate the relationship between the current portfolio of projects and the Agenda 2020 Implementation Plan. In addition, evaluate the relationship between the portfolio and the newly revised draft technology strategy being created by the industry.
- c) Identify areas where current efforts are making significant progress towards meeting industry goals and identify areas where additional work may be required to meet these goals. Identify how much of the potential energy benefits can be realized through the current portfolio of activities. Identify the economic impacts of this portfolio on the industry in years 2010 and 2020, including reduced capital intensity, productivity improvements, reduced environmental costs, and safety improvements.
- d) Make recommendations to the DOE and the Forest Products Industry on possible improvements in the portfolio and in the current methodology that DOE uses to assess potential impacts on its R&D activities.

Projects were evaluated using existing DOE energy and environmental metrics. In addition, a Project Evaluation System was developed to address other measures of potential impact and to supplement the existing metrics. A scale to assess the stages of development appropriate to each of the projects was also developed to give visibility to the progress made in moving research projects along the path toward deployment. DOE and industry representatives collaborated with LATA in the development of these systems for evaluation.

Thirty-nine projects from the total portfolio of 105 projects were evaluated; they were distributed among the six areas of research. The Steering Group collaborated with the industry Chief Technical Officers (CTOs) to perform the down-selection on the basis of satisfying two criteria—those projects that were believed to have the greatest potential for impacting the industry's goals and those projects that allowed a test of the metrics. From an energy perspective, these thirty-nine projects accounted for almost all of the projected energy savings.

The Agenda 2020 program was found to be effective and well managed. The high degree of cooperation and collaboration existing between DOE and the forest products industry was unmistakable. A detailed discussion of each of the items in the mission of this evaluation can be found in the body of this report. Although it contains some critical findings and conclusions, the recommendations included herein should be considered in the context of making improvements to an already effective program.

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In general, the review of the portfolio demonstrated:

- The Agenda 2020 program shows noteworthy progress in tangible, quantifiable terms and has the potential to produce a substantial positive effect on energy and cost savings for the forest products industry and the nation as a whole.
- There are significant R&D projects in the portfolio that were made possible by the shared risk aspects of the Agenda 2020 program—the Black Liquor Gasification Project is a good example.
- The Agenda 2020 program facilitates the industry's efforts to clarify needs, establish priorities, and focus the technology R&D effort for the economic health of the industry and the nation.
- The forest products industry has taken the lead in redefining, reorganizing, and updating the original Agenda 2020 R&D strategy.
- The Agenda 2020 program has stimulated the development of procedures to effectively evaluate the worth and diversity of R&D projects necessary to maintain a robust program.
- The degree of collaboration that has developed between the industry, the government, and research organizations (including universities and national laboratories) fosters an environment with potential for more effective problem solving.

In conclusion, the Agenda 2020 program shows noteworthy progress in tangible, quantifiable terms and has the potential to produce a substantial positive effect on energy and cost savings for the forest products industry and the nation as a whole. The current portfolio represents a substantial level of real contribution across the full range of Agenda 2020 R&D goals. The majority of projects evaluated in this study have the potential to produce a high impact. The progression toward commercial implementation shown by the projects evaluated in this study demonstrates that significant progress is being made toward the Agenda 2020 goals. Based on these conclusions, one of the primary recommendations in this report is to continue support for the Agenda 2020 program.

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Section 1

Introduction

1.1. Background

"The Forest Products Industry was the first energy intensive industry to develop a technology vision and research agenda for the future. Published in November of 1994, Agenda 2020¹ has become the basis for creating a path forward for the industry in pursuing common energy and environmental goals and to work with the U.S. Department of Energy (DOE) to create an effective industry research program".² The purpose of this program is to evaluate opportunities of one of the largest energy users in the industrial sector to adopt more energy-efficient practices and technologies, thereby improving the efficiency of and reducing the Nation's future utilization of fossil energy and its emissions of greenhouse gases. A cooperative effort between the DOE's Office of Industrial Technology (OIT) and the Forest Products Industry provides the support necessary to enable this program. This support is channeled through a number of research and development projects that constitute the "R&D Portfolio." In February 2001, DOE commissioned a study to evaluate the potential impact and value of selected projects within the R&D portfolio. Los Alamos Technical Associates, Inc. (LATA) and their subcontractor, Mid-South Engineering Company (MSECO), were awarded the contract to perform this study. This report presents the results of that study.

1.2. Steering Group

The study process was carried out in close collaboration with DOE and forest product industry officials. A Steering Group was convened to provide direction and guidance for the study through a series of regularly scheduled conference calls. The Steering Group consisted of the following members:

Ben Thorp – Director of Pulp and Paper Engineering, Georgia Pacific Corporation
John Glomb – Vice President, Corporate Research, Westvaco (Retired)
Valri Robinson – Forest Products Team Leader, Department of Energy
David W. Robertson – Project Manager, Department of Energy

1.3. Additional Participants

The Principal Investigators (PI) and/or field project managers for each of the projects studied provided a first-hand perspective and specific information regarding their projects through a series of discussions. The Agenda 2020 Task Group Co-Chairs provided an overview and a broader perspective on the projects within the groups under their cognizance.

¹ *Agenda 2020: A Technology Vision*

² *Statement of Work*

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1.4. Report Organization

This report is organized and presented in four main sections. Section 1 is a brief introduction to the report. Section 2 describes the evolution of the approach used to perform this study. Section 3 presents the highlights of the data collected and/or generated during the study and pertinent observations in that regard. Section 4 presents conclusions reached and recommendations for the future based on the study work that was performed. Specific portions were included to group all of the acronyms and abbreviations that were used in the report and to list references that were cited in the report. Appendices to the report collect study details such as data sets, project rating sheets, discussion notes, etc.

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Section 2

Approach

2.1. Mission

The Request for Proposals (RFP) for this study listed several objectives in its *Statement of Work* (SOW). These were as follows:

- Assess the potential impact of the portfolio of projects selected for this study to meet industry goals.
- Evaluate the relationship of these projects to the Agenda 2020 Implementation Plan.³
- Evaluate the relationship of these projects to the newly revised draft technology strategy.⁴
- Identify areas of significant progress and areas where additional work may be required.
- Assess the validity of energy and environmental metrics for each selected project and, if appropriate, discuss reasonable adjustments to the estimates of potential impacts.
- Identify the potential energy benefits of the portfolio of projects selected for this study.
- Identify the potential economic impacts—reduced capital intensity, productivity improvements, reduced environmental costs, and safety improvements—to the forest products industry in 2010 and 2020.
- Recommend improvements to the portfolio.
- Recommend improvements to the methodology used to assess potential impacts.

2.2. Projects Evaluated

At the time of commencement of the study, the DOE/Industry portfolio of projects to support the Agenda 2020 Implementation Plan included one hundred and five projects with additional projects under negotiation. In addition, there were nine projects funded by the U.S. Department of Agriculture. At the outset, it became apparent that the resources necessary to evaluate all of the projects in the portfolio in the depth required to develop useful conclusions and recommendations for the Agenda 2020 program were not available. Accordingly, the Steering Group took the initiative to reduce the scope for the study to fit within the funding limitations for this work. The number of projects to be evaluated was reduced to a total of thirty-nine projects distributed among the six areas of research. The Steering Group collaborated with the industry Chief Technical Officers (CTOs) to perform the down-selection on the basis of satisfying two criteria— those projects that were believed to have the greatest potential for impacting the industry's goals and those projects that allowed a test of the metrics. From an energy perspective, these thirty-nine projects accounted for almost all of the projected energy savings.

Appendix A is an index of the thirty-nine projects that were selected for this study. The projects are organized into the areas of research and task groups under which they are being performed. An item number and short project description identifies each project. The item numbers were assigned sequentially and are of reference value only for purposes of this study. Additional information listed in Appendix A for each project includes the recipient of the contract, contact information, Office of Industrial Technologies Information System (OITIS) number, contract agreement number, a checklist of project information available for

³ *Agenda 2020: The Path Forward*

⁴ *Technology Summit*

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the study (data sheets, quarterly and/or final reports, and proposal), and the filename for the metrics data sheet.

2.3. Designation of Projects for Evaluation

During the course of evaluating the projects, it was noted that certain projects were so closely related to each other that considering them independently led to a high level of redundancy in reporting of results. Consequently, Project #0a (Biomass Gasification Combined Cycle), Project #0b (Demonstration of Black Liquor Gasification at Big Island), and Project #3 (Black Liquor Gasification Demonstration) were combined for study purposes into a single group identified as Project #3 (Gasification Group of Projects). It should be noted that the R&D costs and the benefits associated with the Gasification Group of Projects represent additional projects as well. Project #32 actually consisted of two projects—Feedstock-to-Product Characterization Tools for the Wood and Pulp Industry AND/OR Development of a Field-Mobile NIR for Measurement of Standing Wood Properties—with individual proposals and metrics data sheets. These two projects were combined into a single project identified as Project #32 (Development of a Field-Mobile NIR for Measurement of Standing Wood Properties) and only its data sheet was used to avoid double-counting of the benefits attributed to these closely related projects. The net result of combining these projects resulted in the designation of thirty-seven projects numbered 1 through 37 for purposes of this report.

2.4. Existing Metrics

The Government Performance and Results Act of 1993 (GPRA) was enacted to create and institutionalize processes within all federal agencies that would enhance performance and management for results. Inherent in these processes was the need to establish appropriate performance measures. In order to implement the GPRA requirements with regard to R&D and demonstration projects receiving assistance from the OIT, a method of obtaining and quantifying technology impacts for R&D projects was devised. This method employs Technology Impact Projections spreadsheets, referred to hereinafter as GPRA spreadsheets, that are intended to address a wide range of industries including the forest products industry. The information contained in these spreadsheets was generated in accordance with a set of instructions that are included as Appendix B to this report.

The metrics data sheets provided for this study consisted of a set of energy, environmental, and cost metrics that had been developed previously, in the form of GPRA spreadsheets for most of the projects to be evaluated under this study. The GPRA spreadsheet model contains a data table with factors such as combustion emission rates for various fuels, industrial energy prices, energy content of fuels, and projected fossil fuel generation mixes. The assumptions used in this table and the results are updated annually. The GPRA spreadsheets for the projects reviewed contained projections based on calculations made using the data tables from the various years in which these projects started. For purposes of this study, the data tables in all of these GPRA spreadsheets were updated to reflect the most current data thereby normalizing the projected impacts for the evaluations made herein.

Projected energy savings benefits for the selected Forest Products project portfolio were based on OIT's analyses of 36 individual projects and the Biomass and Black Liquor Gasification Demonstration Initiative. One older project never had a GPRA spreadsheet completed; therefore no energy savings were contributed to it.

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The Principal Investigators (PIs) filled out data collection sheets that provided the inputs used to by OIT to model the impacts shown on the GPRA spreadsheets for their respective projects. The PI's were provided data regarding forest products to assist them in developing their assumptions. Each PI's submission was reviewed by OIT to ensure that the assumptions were reasonable and realistic. In some cases, when OIT transcribed data from the data collection sheets into the GPRA spreadsheets the narrative assumptions were omitted. In a few cases adjustments were made to PI assumptions and calculations.

The benefits for the Forest Products Industry include the projected impacts of the Biomass and Black Liquor Gasification Demonstration Initiative, even though this project is carried in the OIT Combustion Program. The analysis of the Initiative was based on industry assessments of the power generation potential of black liquor and biomass gasification systems prepared by Larson *et al.*⁵ It is the data for the initiative as a whole that is included in the Forest Products GPRA spreadsheet, rather than the benefits estimated for the individual, enabling research projects being funded by the Forest Products program.

The benefits for the projects in the current study include some overlap and the assumption of one hundred percent technical success; therefore, the implied overall impact for these projects is a considerable overstatement of the true potential. It is not practical to remove the redundancy or to develop more accurate estimates for probabilities of technical and commercial success at this time; however, a substantial level of real contribution is implied for the current portfolio.

2.5. Development of the Project Evaluation System

The existing metrics were recognized as important but insufficient to provide all of the data necessary to meet the objectives of this study. As a result, a Project Evaluation System was developed through a collaborative effort. The expectations of the Agenda 2020 program were used to establish some basic measures for evaluating the significance of the contributions made by individual projects. A scheme was devised to subjectively evaluate these projects as to their significance towards achieving these expectations and accelerating the demonstration, evaluation and implementation of the technologies and new scientific knowledge. Because these expectations were broad in nature and sometimes embodied multiple considerations, they were broken down into a set of goals to provide a clearer focus for the evaluation process. An initial set of fourteen parameters was proposed for the evaluation of each project against these goals. The Steering Group reviewed these parameters with the CTOs and these parameters were reduced to a set of eleven that further refined the focus and eliminated duplication and overlap. A compact numerical scale was devised with the bottom of the scale receiving a "0" for those parameters for which a project's contributions have "no significance or applicability" and the top of the scale receiving a "5" for "highly significant" contributions. The sum of the values assessed for these parameters for each project produced a "Raw" rating. The relative importance of each of the eleven parameters was established by assigning a numerical "weighting value" to each on a scale between 1 and 10 with 10 being given to the most important parameter and proportionally lower numbers to parameters of lesser importance. The Steering Group

⁵ E.D. Larson, T.G. Kreutz, S. Consonni, *Combined Biomass and Black Liquor Gasifier/Gas Turbine Cogeneration at Pulp and Paper Mills*; E.D. Larson, T.G. Kreutz, S. Consonni, *Preliminary Economics of Black Liquor Gasifier/Gas Turbine Cogeneration at Pulp and Paper Mills*; E.D. Larson *et al.*, *A cost-benefit assessment of BLGCC technology*.

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collaborated with the CTOs to establish a consensus for these weighting values. The raw numbers for each parameter were multiplied by its weighting factor and the sum of these products produced a "Weighted" rating for each project.

The eleven parameters for evaluation, the "0 to 5" rating scale, and the weighting factors that constitute the Project Evaluation System for this study are presented in the Table 2-1 below.

#	Parameter	Rating Scale (Significance)						CTO Weighting
		N/A 0	Some 1	2	Moderate 3	4	High 5	
1	Sustained forest resource management							10
2	Size and extent of market for the new technology							9
3	Energy performance							8
4	Economic attractiveness							8
5	Technology champion							7
6	Scientific insights derived from project							7
7	Improved environmental performance							7
8	Technological leadership							7
9	Recycled wood and paper materials							6
10	Risk							6
11	Alternate uses for biomass							5

Table 2-1
Project Evaluation System

2.6. Project Evaluation Parameters

During the course of evaluating projects, it was noted that the eleven parameters selected for evaluation are subject to varied interpretations and results. Generally these parameters were found to be influenced by a number of factors. In order to take these factors into account and make the evaluation process as consistent as reasonably possible, guidelines were developed for assigning values to each parameter. Intermediate numbers were interpolated as appropriate to the project being evaluated. The windowpane diagrams presented below depict the guidelines that evolved and were used for this study.

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The *Sustained Forest Resource Management* parameter was considered to be most heavily influenced by tree growth rate and the degree of utilization of forest resources (recycling, use of waste materials, etc.) that would reduce the demand for trees. The diagram below indicates the guidelines for assigning raw rating numbers for this parameter.

<i>Sustained Forest Resource Management</i>	Low Tree Growth Rate	High Tree Growth Rate
High Utilization of Forest Resources	3	5
Low Utilization of Forest Resources	1	3

The *Size and Extent of the Market for the New Technology* was considered to be most heavily influenced by the potential number of mills, units, plants, sites, etc. where the new technology could be implemented, and the existence of drivers (economic, regulatory, political, business growth, etc.) that would encourage the implementation of the technology. The diagram below indicates the guidelines for assigning raw rating numbers for this parameter.

<i>Size and Extent of Market for the New Technology</i>	Small Potential Market (Few Amenable Units)	Large Potential Market (Many Amenable Units)
Multiple Drivers (Economic, Regulatory, Political, Growth)	3	5
No Apparent Drivers	1	3

Energy Performance was considered to be most heavily influenced by the improvement in energy performance on a per unit basis and the potential number of units (mills, plants, sites, etc.) that were amenable to the new technology. The diagram below indicates the guidelines for assigning raw rating numbers for this parameter.

<i>Energy Performance</i>	Small Improvement in Energy Performance per Unit	Large Improvement in Energy Performance per Unit
Broad Range of Application (Many Amenable Units)	3	5
Narrow Range of Application (Few Amenable Units)	1	3

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Economic Attractiveness was considered to be most heavily influenced by the anticipated value of the benefit and implementation cost for the technology. The diagram below indicates the guidelines for assigning raw rating numbers for this parameter.

<i>Economic Attractiveness</i>	Low Benefit Value	High Benefit Value
Low Implementation Cost	3	5
High Implementation Cost	1	3

The *Technology Champion* parameter was considered to be most heavily influenced by the degree of industry support and the enthusiasm expressed by the technologists. The diagram below indicates the guidelines for assigning raw rating numbers for this parameter.

<i>Economic Attractiveness</i>	Low Industry Support	High Industry Support
High Technologist Enthusiasm	3	5
Low Technologist Enthusiasm	1	3

The *Scientific Insights Derived from Project* parameter was considered to be most heavily influenced by the envisioning of new applications or significant improvements to current applications and the degree of knowledge gained from the project. The diagram below indicates the guidelines for assigning raw rating numbers for this parameter.

<i>Scientific Insights Derived from Project</i>	No New Applications or Improvements Envisioned	Significant New Applications or Improvements Envisioned
New or Deeper Knowledge Gained	3	5
Little Knowledge Gained	1	3

Improved Environmental Performance was considered to be most heavily influenced by the improvement in environmental performance on a per unit basis and the potential number of units (mills, plants, sites, etc.) that were amenable to the new technology. The diagram below indicates the guidelines for assigning raw rating numbers for this parameter.

<i>Environmental Performance</i>	Small Improvement in Environmental Performance per Unit	Large Improvement in Environmental Performance per Unit
Broad Range of Application (Many Amenable Units)	3	5
Narrow Range of Application (Few Amenable Units)	1	3

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Technological Leadership was considered to be most heavily influenced by the expected range of issues or products affected by the project and the size of the impact sought by the project. The diagram below indicates the guidelines for assigning raw rating numbers for this parameter.

<i>Technological Leadership</i>	Narrow Industry Focus (Single Issue/Single Product)	Broad Industry Focus (Cross-cutting Issues/Products)
Seeks Revolutionary or Breakthrough Technology	3	5
Seeks Incremental Changes or Improvements	1	3

The *Recycled Wood and Paper Materials* parameter was considered to be most heavily influenced by the degree of beneficial utilization of waste materials and the degree of avoidance of waste treatment and disposal processes anticipated from the project. The diagram below indicates the guidelines for assigning raw rating numbers for this parameter.

<i>Recycled Wood and Paper Materials</i>	Low Utilization of Waste Materials	High Utilization of Waste Materials
High Avoidance of Waste Treatment/Disposal	3	5
Low Avoidance of Waste Treatment/Disposal	1	3

Risk was considered to be most heavily influenced by the probability of project success and the probability of success at the next stage of development for the technology. In this case, high-risk prospects were given a rating of 0. The diagram below indicates the guidelines for assigning raw rating numbers for this parameter.

<i>Risk</i>	Moderate Probability of Project Success	High Probability of Project Success
High Probability of Success at Next Stage of Development	3	5
Moderate Probability of Success at Next Stage of Development	1	3

The *Alternate Uses of Biomass* parameter was considered to be most heavily influenced by the degree of innovation for biomass utilization and the anticipated volume of biomass to be used. The diagram below indicates the guidelines for assigning raw rating numbers for this parameter.

<i>Alternate Uses of Biomass</i>	Existing Application for Biomass Utilization	New Application for Biomass Utilization
High Volume of Biomass Use	3	5
Low Volume of Biomass Use	1	3

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2.7. Validation of the Project Evaluation System

An initial group of six projects, one from each of the six technology groups, was evaluated using the Project Evaluation System. The results of these were reviewed with the Steering Group to see if the system produced reasonable results. Although not all of the results corresponded with intuitive expectations, discussions about the ratings of these projects in each of the parameters required by the system provided a more comprehensive view of these projects and resulted in the decision to proceed systematically with further evaluations. The next evaluations considered the technology groups in which the highest and lowest project ratings were initially produced. In the group with the highest rating, the project that was intuitively expected to produce the lowest rating was selected for evaluation. Similarly, in the group with the lowest rating, the project that was expected to produce the highest rating was also selected. The results of these evaluations were subsequently reviewed with the Steering Group and a consensus emerged that the Project Evaluation System provided a new perspective regarding the potential impacts of the projects that could be useful. Based on that consensus, the decision was made to proceed with the evaluation of a complete group of projects and consult with the Co-Chair for that group to bring in an additional perspective that might temper the evaluations. The ratings of projects in this first complete group were reviewed with the Steering Group with the resultant decision that this system should be used to evaluate the remainder of the projects selected for this study.

2.8. Project Evaluation Process

The process for evaluating each project began with an internal review of the data provided for the study (project proposals, project data sheets, quarterly and final reports, and GPRA spreadsheets). These reviews were followed by a discussion with the Principal Investigator (PI) for the project. The discussion was structured around an agenda that was developed for this study to provide consistency in the process. Prior to the discussions, this agenda was reviewed by the Steering Group and adjusted to address potential concerns. Appendix C contains the initial discussion agenda that was developed for this process. This agenda was used during the first round of discussions to solicit the information for the initial project evaluations. Following validation of the Project Evaluation System, the discussion agenda was reorganized to focus specifically on the evaluation parameters used for this study. The revised discussion agenda is also presented in Appendix C.

Following the discussion with the PI, a raw rating for each project was developed. After raw ratings of all of the projects in a Task Group were developed, a second discussion was held with the Co-chair(s) for that Task Group.⁶ The preliminary results of the evaluations (raw ratings) were discussed with the Co-chairs to gather additional input from a different perspective. Adjustments were made to the raw ratings to address disparities in views as

⁶ The Task Group Co-Chairs consulted with were as follows:
Energy Performance Group: Paul Tucker, International Paper
Environmental Performance Group: Dan Sjolseth, Weyerhaeuser
Sustainable Forestry Group: John Pait, The Timber Co.; and Marshall Jacobson, The Timber Co.
Improved Capital Effectiveness Group: John Huyck, Mead; and Ben Thorp, Georgia Pacific
Recycling Group: Tom Friberg, Weyerhaeuser
Sensors and Controls Group: G. Ron Brown, Westvaco

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appropriate. Once the final raw ratings were established, weighted ratings were generated and graphed and these were then reviewed in conference with the Steering Group.

Other approaches to the project evaluation process were considered and abandoned. A discussion of these may be found in Appendix D.

2.9. Stage of Development Approach to Portfolio Evaluation

The difficulties encountered in attempting to relate individual projects to a schedule-based measure of progress along the Agenda 2020 R&D pathways highlighted the need for an approach that focused on the R&D process itself. There were several instances of projects with high evaluation ratings that, in and of themselves, showed little or no energy savings, environmental performance improvements, or economic advantages. These projects were variously recognized as “enabling” or “gateway” projects meaning that they were precursors to follow-on projects that might possibly demonstrate and quantify these benefits. There were also some basic research projects, such as gene mapping that were designed to obtain fundamental knowledge which might lead to any number of unforeseeable future projects. Although these individual projects often lacked a clear logical relationship to other projects, the R&D process in general consisted of a number of stages that followed a logical progression.

As a result, six stages of development were identified, defined, and associated with a numerical scale that represented the progression of these stages. Table 2-2 presents these stages and their definitions.

Scale	Stage Description	Definitions
1	Basic/Fundamental Research	Fundamental, theoretical or experimental investigation to advance scientific knowledge, the immediate practical application of which is not a direct objective.
2	Applied Research	Research directed toward using knowledge gained by basic research to make things or to create situations that will serve a practical or utilitarian purpose.
3	Process or Equipment Development/Improvement	The work required to determine the best techniques and/or equipment required to bring a new process to the production stage, generally includes lab/pilot scale work.
4	Technology Scale-up; Equipment Improvement	Design of a production unit based on lab/pilot scale work.
5	Technology/Equipment Demonstration	Demonstration in a production environment.
6	Commercial Deployment	Equipment available, sold, installed, and in use in one or more additional production facilities.

Table 2-2
Stages of Development

As with the Project Evaluation System, the Stages of Development scale was reviewed by the Steering Group through a series of conference calls. The projects evaluated to date were categorized using this scale and a consensus was reached that this approach was viable and could provide useful data. During these reviews it was noted that these Stages of Development provided a simple mechanism for relating the projects being evaluated to the general progression of the Agenda 2020 R&D effort. This approach thus provided a tool to view the balance between projects of various types within the portfolio. Whereas

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consideration of basic research and enabling/gateway projects previously was given on an ad hoc basis, these types of projects now could be viewed systematically using this tool. Such a practice could provide the benefit of greater assurance that each task group had projects that spanned the range of stages of development and kept their R&D pipelines filled. This benefit took on additional significance when viewed as a management tool to move R&D efforts through the pipelines with a focus on advancing knowledge through the system thus facilitating the development of more comprehensive large-scale demonstration projects.

2.10. Development of Graphic Presentations of Data

Several formats were proposed for the presentation of data collected and generated during the course of the study. These included various forms of bubble charts and barcharts showing data from the GPRA spreadsheets, Project Evaluation System, and Stage of Development determinations. Through a process of systematic reviews with the Steering Committee, it was decided to use seven sets of two bubble charts and two stacked barcharts to graphically present the results of this study. The two bubble charts depicted energy savings from the GPRA spreadsheets vs. weighted ratings from the project evaluations and Stages of Development vs. weighted ratings from the project evaluations. On both bubble charts the size of the bubble was proportional to the R&D funds committed to the project. One set of charts was prepared for each of the six task groups and one set was prepared to summarize the results for all of the projects that were evaluated. The two stacked barcharts depicted total energy displaced vs. time and total annual cost savings vs. time.

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Section 3

Data and Observations

3.1. Project Evaluations

Each of the thirty-seven projects considered in this study were evaluated using the Project Evaluation System described in Section 2 of this report. A full set of Rating Sheets showing the details of each project's ratings by specific evaluation parameters with the evaluator's comments are presented in Appendix E. It should be noted that these evaluations were based on a "snap shot" of the projects at the time of evaluation and would be subject to change according to additional information obtained from the ongoing R&D program or external sources in the future. Under the Project Evaluation System, the theoretical maximum weighted rating possible is 400. From a practical perspective, the diversity of factors considered in the evaluations effectively precludes any project from achieving such a high rating and ratings in the proximity of 300 should be considered exceptionally high and those in the range of 150 to 250 should be considered highly rated. Those projects receiving ratings below 150 were perceived to be technically well conceived but lower rated on the basis of the evaluation parameters that were determined for this study. A summary of the low, high, and average weighted ratings arranged by technology group is presented in Table 3-1.

Technology Group	Group Low	Group High	Group Average
Energy Performance	194	307	229
Environmental Performance	144	277	196
Sustainable Forestry	224	303	282
Improved Capital Effectiveness	85	246	204
Recycling	175	265	229
Sensors and Controls	44	293	198

Table 3-1
Weighted Ratings by Technology Groups

The overall average of the weighted ratings for all thirty-seven projects is 219. Each of the technology groups has average ratings of this general magnitude with individual projects having ratings above this overall average. One group, Sustainable Forestry, stands out in this comparison because of its notably high group average and the fact that all of the projects in this group are above the overall average. Two of the groups, Improved Capital Effectiveness and Sensors and Controls show at least one project with a rating below 100. A summary of the project evaluation ratings and observation highlights organized by technology group is presented in the following paragraphs.

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Energy Performance Group Project Evaluations

The raw and weighted ratings for the projects in the Energy Performance group are shown in Table 3-2.

Project #	Project Name	Raw Rating	Weighted Rating
01-785	Multiport Cylinder Dryer	27	201
02-933	Methane DeNO _x	31	216
03-993	Gasification Group of Projects	42	307
04-1110	Intermediate Sized Entrained Particles	26	194
05-1166	3-D Characterization of Structure	31	229

Table 3-2
Energy Performance Group Project Ratings

The weighted ratings of the projects in the Energy Performance group ranged from a low of 194 to a high of 307 with a group average of 229 for the five projects that were evaluated. The Energy Performance group of projects demonstrated a high degree of consistency in the weighted ratings with four of the five projects in this group showing ratings between 194 and 229. Within this group, the evaluation parameters "Size and Extent of Market for the Technology" and "Scientific Insights Derived from the Project" showed the highest raw rating averages (>4.0 on a scale of 0.0 to 5.0). The "Sustained Forest Resource Management", "Recycled Wood and Paper Materials" evaluation parameters showed the lowest raw rating averages (<1.0 on a scale of 0.0 to 5.0).

The one "outlier" in this group, the Gasification Group of Projects rated well above the group average with a weighted rating of 307, the highest rating among the thirty-seven projects that were evaluated. The Gasification Group of Projects consists of three projects including the largest single project funded under the Agenda 2020 program, the Big Island Black Liquor Gasification Demonstration project. Associated with this project is the Engineering Study project, which had its own separate project number and was preliminary to the demonstration project. The GPRA spreadsheet energy data available for these projects dealt with the whole gasification scenario including not only black liquor gasification at kraft mills (Big Island is a soda mill), but also the energy that could ultimately be generated from the gasification, on a large scale, of forest biomass materials. As a consequence, the three gasification projects, Big Island Black Liquor engineering study and demonstration projects and the New Bern Biomass Gasification project were grouped and treated as a single gasification effort for this study. In addition to showing the highest weighted rating, the Gasification Group of Projects is projected to produce the greatest benefits as well. Assuming success with the efforts that are required in the continuing demonstration in larger scale kraft mills, and with recognition and development of biomass as a significant renewable energy source, the gasification efforts should result in major beneficial national impacts. It should be noted that other R&D projects addressing Integrated Gas Turbine Combined Cycle designs and investigation of issues regarding full scale kraft mill implementation will be required to achieve the large benefits available from full implementation of this technology. The Office of Power Technologies is supporting some R&D work in this area.

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Environmental Performance Group Project Evaluations

The raw and weighted ratings for the projects in the Environmental Performance group are shown in Table 3-3.

Project #	Project Name	Raw Rating	Weighted Rating
06-669	High Efficiency ClO ₂ Delignification	29	213
07-685	VOC Control in Kraft Mills	21	151
08-687	Low VOC Drying of Lumber and Wood	26	193
09-941	Mill Designed Bio-Bleaching Technologies	36	277
10-961	Water Removal Using Hydrogels	20	147
11-1150	Use of Residual Solids in Concrete	20	144
12-1151	Low Temperature Plasma Technologies for Treating VOC Emissions	32	236
13-1152	Control of Emissions from Wood Waste Burners and Wood Dryers	29	208
14-1154	NPE Removal using Functionalized Monolayers on Mesoporous Supports	26	191

Table 3-3
Environmental Performance Group Project Ratings

The weighted ratings of the projects in the Environmental Performance group ranged from a low of 144 to a high of 277 with a group average of 196 for the nine projects that were evaluated. Within this group, there were no evaluation parameters that showed raw rating averages in excess of 4.0 on a scale of 0.0 to 5.0. The evaluation parameters, "Sustained Forest Resource Management", "Recycled Wood and Paper Materials", and "Alternate Uses for Biomass" showed the lowest raw rating averages (<1.0 on a scale of 0.0 to 5.0).

The projects in the Environmental Performance group fall into two primary areas of emphasis—improvements to the bleach process and reduction of VOC and HAP emissions. Of the nine projects reviewed in this effort, three were concerned with the bleaching process and four were related to air emissions.

Sustainable Forestry Group Project Evaluations

The results of the evaluations of the projects in the Sustainable Forestry group are shown in Table 3-4.

Project #	Project Name	Raw Rating	Weighted Rating
15-None	Effects of Fertilization and Competition Control	37	280
16-677	Model-Based Diagnosis of Soil Limitations	30	224
17-681	Marker-Aided Selection Methods	39	288
18-758	Molecular Physiology Allocation in Poplar	40	298
19-794	Dominant Negative Mutations of Floral Homeotic Species	40	297
20-795	Pine Gene Discovery Project	41	303

Table 3-4
Sustainable Forestry Group Project Ratings

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The weighted ratings of the projects in the Sustainable Forestry group ranged from a low of 224 to a high of 303 with a group average of 282 for the six projects that were evaluated. Within this group, the evaluation parameters "Sustained Forest Resource Management", "Technology Champion", "Scientific Insights Derived from the Project", and Risk/Benefit Ratio" showed the highest raw rating averages (>4.0 on a scale of 0.0 to 5.0). The "Recycled Wood and Paper Materials" evaluation parameter showed the lowest raw rating average (<1.0 on a scale of 0.0 to 5.0).

Generally the Sustainable Forestry Group projects reviewed were all given above average ratings because they involve solid fundamental research that offers many potential benefits for the industry and for society as a whole. All of these projects have consistently high ratings except in the areas of energy performance, improved environmental performance, biomass use alternatives, and in the recycling of wood and paper materials. Sustainable forestry would appear to be in conflict with recycling, but when one considers the many uses of wood combined with the potential of new, engineered wood products, then sustainable forestry plays a key role in the long-term objectives of both the industry and the DOE.

Even though these projects have high ratings, they all have very low energy benefit projections as compared to the other projects reviewed in this report. High ratings with low energy benefits are a function of the ratings system used and the weighting given to each parameter of the Project Evaluation system. The low energy benefits that were estimated probably result from the fundamental nature of this research. Although it is easy to envision that the potential benefits from genetics and soils research will be immense, equating those benefits to energy and cost savings is very difficult. Historically foresters and forest researchers tend to be very conservative in their projections, most likely because of the long cycles between planting and harvesting. This conservative tendency combined with the fundamental nature of much of this research results in very conservative, low estimates for energy benefits. By contrast many of the projects in other technology groups that were considered in this study have extremely optimistic (in some cases overly optimistic) estimates for energy savings and project benefits. If accurately forecasting the future were possible, the sustainable forestry portfolio of projects might prove to be as significant and beneficial as many of these other projects.

Improved Capital Effectiveness Group Project Evaluations

The results of the evaluations of the projects in the Improved Capital Effectiveness group are shown in Table 3-5.

Project #	Project Name	Raw Rating	Weighted Rating
21-1481	Lateral Corrugator	11	85
22-1482	Improved Dryer and Press Efficiencies	30	221
23-1483	Directed Green Liquor Pulp	30	241
24-1484	High-Capacity Gas-Fired Dryer	21	155
25-1485	Continuous Displacement Dewatering	32	241
26-1486	Borate Autocauticizing	32	238
27-1487	Fast Curing of Wood Composites	33	246

Table 3-5
Improved Capital Effectiveness Group Project Ratings

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The weighted ratings of the projects in the Improved Capital Effectiveness group of projects ranged from a low of 85 to a high of 246 with a group average of 204 for the seven projects that were evaluated. Within this group, the evaluation parameter "Economic Attractiveness" showed the highest raw rating average (>4.0 on a scale of 0.0 to 5.0). The "Sustained Forest Resource Management", "Recycled Wood and Paper Materials", and "Alternate Uses for Biomass" evaluation parameters showed the lowest raw rating averages (<1.0 on a scale of 0.0 to 5.0).

This group, with two exceptions demonstrated a remarkable consistency in the weighted ratings, with five of the seven projects rated between 221 and 246. The two "outliers", Lateral Corrugator and High Capacity Gas-Fired Dryer, with weighted ratings of 85 and 155 respectively, fell well below the group average. Taken as a whole, the projects in this group rated lowest in the Sustained Forest Resource Management, Recycled Wood and Paper Materials, and Alternate Uses for Biomass evaluation parameters. The group was fairly balanced across the other parameters with Energy Performance and Economic Attractiveness showing the highest ratings.

While the projects reviewed under the Capital Effectiveness group all deal with important technical issues, many projects in the group attempt to solve the problem of capital effectiveness by trying to increase process throughput without significantly increasing capital costs. This approach promotes incremental improvement solutions, promoting the biggest and fastest projects, with their high capital intensity, in order to maintain a competitive advantage. While this approach may result in reduced capital per ton of product numbers, overall capital expenditures continue to rise. A broader perspective that includes the consideration of breakthrough technologies in the capital effectiveness aspects of new processes, new devices and/or scientific insights into equipment or processes derived as a result of the Agenda 2020 program might produce additional solutions to the capital effectiveness problem.

Recycling Group Project Evaluations

The results of the evaluations of the projects in the Recycling group are shown in Table 3-6.

Project #	Project Name	Raw Rating	Weighted Rating
28-772	Acoustic Separation Technology	23	175
29-944	Easily Removable Cationic PSAs	35	254
30-945	Replacing Chemicals in Recycle Mills	36	265
31-1198	Surfactant Spray to Improve Flotation De-Inking	30	222

Table 3-6
Recycling Group Project Ratings

The weighted ratings of the projects in the Recycling group of projects ranged from a low of 175 to a high of 265 with a group average of 229 for the four projects that were evaluated. Within this group, the evaluation parameters "Size and Extent of Market for the Technology" and "Economic Attractiveness" showed the highest raw rating averages (>4.0 on a scale of 0.0 to 5.0). The "Sustained Forest Resource Management" and "Alternate Uses for Biomass" evaluation parameters showed the lowest raw rating averages (<1.0 on a scale of 0.0 to 5.0). The weighted ratings for these projects are clustered in the middle of all the projects reviewed. The average rating for this group is virtually the same as that for all the projects reviewed, but the variance is much less.

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The very successful Replacing Chemicals in Recycle Mills with Mechanical Alternatives project is moving forward with several mill trials and clear support from an equipment vendor and from industry. The Surfactant Spray project to improve flotation de-inking is very promising and will soon move to pilot scale testing. The Acoustic Separation Technology project received the lowest rating of the group. In this case, as the scale of the technology was increased from lab trials to demonstration project size, the transducers selected for development proved to be unreliable. The Synthesis, Characterization, and Application of Water-soluble and Easily Removable Pressure Sensitive Adhesives (PSAs) project is a successful research project. It has sponsorship and appears to be moving forward, although it has competition from the other projects in this portfolio.

Sensors and Controls Group Project Evaluations

The results of the evaluations of the projects in the Sensors and Controls group are shown in Table 3-7.

Project #	Project Name	Raw Rating	Weighted Rating
32-1158/699	Feed Stock-Product/Field Mobile NIR	41	293
33-827	Distributed Web Sensor for On-Line Measurement of Paper Weight	6	44
34-975	On-Line Fluidics Controlled Headbox	33	257
35-1157	Guided Acoustic Wave Monitoring of Corrosion & Erosion in Recovery Boiler Tubing	22	161
36-1491	Wireless Microwave Wood Moisture Measurement	30	222
37-1492	CFD Modeling of Black Liquor Nozzle Design	29	210

Table 3-7
Sensors and Controls Group Project Ratings

The weighted ratings of the projects in the Sensors and Controls group of projects ranged from a low of 44 to a high of 257 with a group average of 198 for the six projects that were evaluated. Within this group, there were no evaluation parameters that showed raw rating averages in excess of 4.0 on a scale of 0.0 to 5.0. The "Sustained Forest Resource Management", "Recycled Wood and Paper Materials", and "Alternate Uses of Biomass" evaluation parameters showed the lowest raw rating averages (<1.0 on a scale of 0.0 to 5.0).

The Sensors and Controls group produced the widest range of weighted ratings among all of the groups of projects that were evaluated. The Field Mobile NIR project received a very high rating while the On-line Basis Weight Sensor Project received the lowest rating. The balance of the projects clustered in between. The Field Mobile NIR project is exciting and promising technology because it offers the ability to predict wood strength characteristics and properties prior to harvesting in the woods or prior to machining at the mill and it appears to be relatively inexpensive technology. Once this NIR technology matures, it may well provide much greater benefits than are currently envisioned.

The On Line Fluidics Controlled Headbox also is a very attractive project. It offers reasonable energy savings and, potentially, a 5% to 10% reduction in the pulp required for producing the same strength linerboard. As a group, these projects are all well conceived

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for this technology area of research and development. Even the lowest ranked project, the On Line Basis Weight Sensor, is conceptually very promising. It was originally anticipated that this project would rate much higher, however, the R&D performed to date has proven that the sensing and data gathering technology selected for this project is too slow to meet the response characteristics necessary for control of high speed paper machines.

Because the paper industry has sophisticated electronic control systems in virtually all of the mills operating in the US today, the ability to make process improvements and reduce energy consumption through improvements in sensors and controls technology offers significant potential benefits in terms of energy savings and other industry benefits.

3.2. Stages of Development of Projects

Each of the thirty-seven projects considered in this study was characterized by its current Stage of Development using the definitions discussed in Section 2 of this report. None of these projects were judged to have reached Stage 6 (Commercial Deployment) which is consistent with the nature of the projects that were selected for this study. The current Stages of Development for these projects are arranged by technology group and presented in the tables below.

Energy Performance Group Projects Stages of Development

The Stages of Development for the projects in the Energy Performance group are shown in Table 3-8.

Project #	Project Name	Stage of Development
01-785	Multiport Cylinder Dryer	3
02-933	Methane DeNO _x	5
03-993	Gasification Group of Projects	1 to 5 ⁷
04-1110	Intermediate Sized Entrained Particles	2
05-1166	3-D Characterization of Structure	1

Table 3-8
Energy Performance Group Stages of Development

The projects in the Energy Performance group are fairly well distributed among the Stages of Development with projects in Stage 1 (Basic/Fundamental Research), Stage 2 (Applied Research), Stage 3 (Process or Equipment Development/Improvement), and two projects in the Stage 4 to Stage 5 range (Technology Scale-up/Equipment Improvement and Technology/Equipment Demonstration). The Big Island Black Liquor Gasification is a demonstration/development project and the Methane DeNOX Reburning project is late in the demonstration stage and is moving into commercialization. A small gap exists in that no projects evaluated in this group were found to be in Stage 2 – Applied Research.

⁷ This range represents gasification projects in addition to the three that were considered in this study.

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Environmental Performance Group Projects Stages of Development

The Stages of Development for the projects in the Environmental Performance group are shown in Table 3-9.

Project #	Project Name	Stage of Development
06-669	High Efficiency ClO ₂ Delignification	1.5
07-685	VOC Control in Kraft Mills	2
08-687	Low VOC Drying of Lumber and Wood	3
09-941	Mill Designed Bio-Bleaching Technologies	1.5
10-961	Water Removal Using Hydrogels	1.5
11-1150	Use of Residual Solids in Concrete	2
12-1151	Low Temperature Plasma Technologies for Treating VOC Emissions	3.5
13-1152	Control of Emissions from Wood Waste Burners and Wood Dryers	3
14-1154	NPE Removal using Functionalized Monolayers on Mesoporous Supports	1.5

Table 3-9
Environmental Performance Group Stages of Development

Six of the nine projects in the Environmental Performance group fall within the range of Stage 1 – Basic/Fundamental Research to Stage 2 (Applied Research). Two of the remaining three projects fall in Stage 3 (Process or Equipment Development/Improvement) and the other falls between Stage 3 and Stage 4 (Technology Scale-up/Equipment Improvement). There were no projects evaluated in this group that fell in Stage 4 or above.

Sustainable Forestry Group Projects Stages of Development

The Stages of Development for the projects in the Sustainable Forestry group are shown in Table 3-10.

Project #	Project Name	Stage of Development
15-None	Effects of Fertilization and Competition Control	3
16-677	Model-Based Diagnosis of Soil Limitations	3
17-681	Marker-Aided Selection Methods	2
18-758	Molecular Physiology Allocation in Poplar	1
19-794	Dominant Negative Mutations of Floral Homeotic Species	2
20-795	Pine Gene Discovery Project	1

Table 3-10
Sustainable Forestry Group Stages of Development

Only two of these projects, the Effects of Fertilization and Competition Control project and the Model-Based Diagnosis of Soil Limitations project have reached Stage 3 (Process or Equipment Development/Improvement). Considerable time and effort will be required to bring the other projects to the implementation phase and the benefits of the genetic research involved in these other projects will probably not be realized for many years to come, in many cases beyond the year 2020.

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Improved Capital Effectiveness Group Projects Stages of Development

The Stages of Development for the projects in the Improved Capital Effectiveness group are shown in Table 3-11.

Project #	Project Name	Stage of Development
21-1481	Lateral Corrugator	3
22-1482	Improved Dryer and Press Efficiencies	2
23-1483	Directed Green Liquor Pulping	1.5
24-1484	High-Capacity Gas-Fired Dryer	3
25-1485	Continuous Displacement Dewatering	3
26-1486	Borate Autocausticizing	3
27-1487	Fast Curing of Wood Composites	3

Table 3-11
Improved Capital Effectiveness Group Stages of Development

Five of the seven projects in the Improved Capital Effectiveness group were concentrated in Stage 3 (Process or Equipment Development/Improvement). Of the other two, one was between Stage 1 (Basic/Fundamental Research) and Stage 2 (Applied Research) and the other was in Stage 2. There were no projects in this group in Stages 4 through 6, the Technology Scale-up, Demonstration, or Commercialization stages.

Recycling Group Projects Stages of Development

The Stages of Development for the projects in the Recycling group are shown in Table 3-12.

Project #	Project Name	Stage of Development
28-772	Acoustic Separation Technology	2.5
29-944	Easily Removable Cationic PSAs	4
30-945	Replacing Chemicals in Recycle Mills	5
31-1198	Surfactant Spray to Improve Flotation De-Inking	3

Table 3-12
Recycling Group Stages of Development

The projects in the Recycling group were spread between Stage 2 (Applied Research) and Stage 5 (Technology/Equipment Demonstration). There were no projects in this group in Stage 1 (Basic/Fundamental Research). Although the smallest group to be evaluated, this group better represents the full range of the Stages of Development than any of the other technology groups that were evaluated. Clearly, the projects selected in this group had good potential for early success. If the Acoustic Separation Technology had been more fortunate in the development of transducers for the project, all of these projects would be highly successful.

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Sensors and Controls Group Projects Stages of Development

The Stages of Development for the projects in the Sensors and Controls group are shown in Table 3-13.

Project #	Project Name	Stage of Development
32-1158/699	Feed Stock-Product/Field Mobile NIR	5
33-827	Distributed Web Sensor for On-Line Measurement of Paper Weight	2
34-975	On-Line Fluidics Controlled Headbox	3
35-1157	Guided Acoustic Wave Monitoring of Corrosion & Erosion in Recovery Boiler Tubing	3
36-1491	Wireless Microwave Wood Moisture Measurement	2.5
37-1492	CFD Modeling of Black Liquor Nozzle Design	2

Table 3-13
Sensors and Controls Group Stages of Development

Five of the six projects in the Sensors and Controls group were concentrated between Stage 2 (Applied Research) and Stage 3 (Process or Equipment Development/Improvement). One project was in Stage 5 (Technology/Equipment Demonstration). There were no projects in this group in Stage 1 (Basic/Fundamental Research) or in Stage 4 (Technology Scale-up/Equipment Improvement).

The Field Mobile NIR project could probably qualify as Stage 1 or Stage 2 research, but its success and the resulting industry interest seems to have this technology on a fast track toward implementation. In general, the projects in this group are direct application projects that don't involve as much fundamental research as many of the other projects that were evaluated. Therefore, they may offer the potential for implementation and significant market penetration much earlier than year 2020.

Progression through Stages of Development

The Stages of Development discussed above were based on the current status of the projects that were evaluated. There are some instances wherein projects entered the Agenda 2020 R&D program at earlier stages and subsequently progressed to the current stage. There are other instances where projects are currently at their entry stage. In order to present these data, the Table 3-14 was developed.

Table 3-14 indicates that nineteen of the thirty-seven projects that were evaluated are in their entry Stage of Development, seven have progressed somewhat, and eleven have progressed from one stage to another or more. The greatest progression was registered by Project 29-944 (Easily Removable Cationic PSAs) with a progression of three full stages from its entry into the Agenda 2020 program as a Basic/Fundamental Research project to its current status as a Technology Scale-up/Equipment Improvement project. Five other projects, 03-933 (Gasification Group of Projects), 12-1151 (Low Temperature Plasma Technologies for Treating VOC Emissions), 13-1152 (Control of Emissions from Wood Waste Burners and Wood Dryers), 30-945 (Replacing Chemicals in Recycle Mills), and 32-1158/699 (Feed Stock-Product/Field Mobile NIR) also show a progression through more than one stage.

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Approximately half of the projects evaluated in this study show progress beyond their initial entry stages of development. This would indicate a significant level of progress in general, particularly in view of the fact that several projects are comparatively recent awards that have not had sufficient time to register progress of the magnitude required to move from one stage of development to another. This explains why the Capital Effectiveness group of projects is the only task group wherein none of the projects evaluated appear to have made progress.

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Project #	Title	Initial Stage of Development	Current Stage of Development
01-785	Multiport Cylinder Dryer	2	3
02-933	Methane DeNO _x	4	5
03-993	Gasification Group of Projects	1	1 to 5 ⁸
04-1110	Intermediate Sized Entrained Particles	2	2
05-1166	3-D Characterization of Structure	1	1
06-669	High Efficiency ClO ₂ Delignification	1	1.5
07-685	VOC Control in Kraft Mills	2	2
08-687	Low VOC Drying of Lumber and Wood	2.5	3
09-941	Mill Designed Bio-Bleaching Technologies	1	1.5
10-961	Water Removal Using Hydrogels	1	1.5
11-1150	Use of Residual Solids in Concrete	2	2
12-1151	Low Temperature Plasma Technologies for Treating VOC Emissions	2	3.5
13-1152	Control of Emissions from Wood Waste Burners and Wood Dryers	1	3
14-1154	NPE Removal using Functionalized Monolayers on Mesoporous Supports	1	1.5
15-None	Effects of Fertilization and Competition Control	3	3
16-677	Model-Based Diagnosis of Soil Limitations	3	3
17-681	Marker-Aided Selection Methods	1	2
18-758	Molecular Physiology Allocation in Poplar	1	1
19-794	Dominant Negative Mutations of Floral Homeotic Species	1	2
20-795	Pine Gene Discovery Project	1	1
21-1481	Lateral Corrugator	3	3
22-1482	Improved Dryer and Press Efficiencies	2	2
23-1483	Directed Green Liquor Pulping	1.5	1.5
24-1484	High-Capacity Gas-Fired Dryer	3	3
25-1485	Continuous Displacement Dewatering	3	3
26-1486	Borate Autocausticizing	3	3
27-1487	Fast Curing of Wood Composites	2	3
28-772	Acoustic Separation Technology	2	2.5
29-944	Easily Removable Cationic PSAs	1	4
30-945	Replacing Chemicals in Recycle Mills	3	5
31-1198	Surfactant Spray to Improve Flotation De-Inking	3	3
32-1158/699	Feed Stock-Product/Field Mobile NIR	3	5
33-827	Distributed Web Sensor for On-Line Measurement of Paper Weight	2	2
34-975	On-Line Fluidics Controlled Headbox	2	3
35-1157	Guided Acoustic Wave Monitoring of Corrosion & Erosion in Recovery Boiler Tubing	3	3
36-1491	Wireless Microwave Wood Moisture Measurement	2	2.5
37-1492	CFD Modeling of Black Liquor Nozzle Design	2	2

Table 3-14
Progression through Stages of Development by Project

⁸ This range represents gasification projects in addition to the three that were considered in this study.

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3.3. Energy Savings

GPRA spreadsheets provided the data used in this study regarding energy and cost savings. In general, estimates of capital and non-energy variable costs (or other payback terms data) for the projects evaluated in this study did not appear in the GPRA spreadsheets. Provisions for estimating these data are included in the spreadsheet format and instructions (Appendix B).

It was also noted that energy savings attributable to use of renewable energy sources and waste energy are not included in the calculation of total primary energy displaced. The renewable, waste, and other energy cost formula essentially treats those energy sources as zero cost in the GPRA spreadsheet calculation.

Energy Performance Group Projects GPRA Energy Savings Data

Potential energy savings for projects in the Energy Performance Group are shown in Table 3-15.

Project #	Project Name	Total Primary Energy 2030 (10^{12} BTUs)
01-785	Multiport Cylinder Dryer	23.0
02-933	Methane DeNO _x	3.7
03-993	Gasification Group of Projects	2560.0
04-1110	Intermediate Sized Entrained Particles	92.3
05-1166	3-D Characterization of Structure	19.8

Table 3-15
Energy Performance Group Potential Energy Savings

This group of projects targets areas that provide large potential energy savings and as a group demonstrates the greatest potential for energy savings.

The potential energy savings for the Gasification Group of Projects takes credit for all of the savings currently projected for the entire Biomass and Black Liquor Gasification Demonstration Initiative. These potential savings overwhelm the other projects in the Energy Performance group and all of the projects in the other technology groups as well. However, the magnitude of the estimated savings may not be totally accurate considering that the total current annual energy use in the pulp and paper sector (SIC Code 26 - Paper and Allied Products) of the industry is on the order of 3,000 trillion BTUs. In fact OIT is reassessing the impact of the Gasification Initiative at this time. It should be noted that the Gasification Group of Projects is also the highest rated as demonstrated in Table 3-2.

The next greatest potential energy savings found in this group is for the Intermediate Sized Entrained Particles project, which illustrates the potential benefit of improving existing recovery boiler operations.

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Environmental Performance Group Projects GPRA Energy Savings Data

Potential energy savings for projects in the Environmental Performance Group are shown in Table 3-16.

Project #	Project Name	Total Primary Energy 2030 (10 ¹² BTUs)
06-669	High Efficiency ClO ₂ Delignification ⁹	0.1
07-685	VOC Control in Kraft Mills	5.8
08-687	Low VOC Drying of Lumber and Wood	70.3
09-941	Mill Designed Bio-Bleaching Technologies	43.4
10-961	Water Removal Using Hydrogels	31.2
11-1150	Use of Residual Solids in Concrete	38.7
12-1151	Low Temperature Plasma Technologies for Treating VOC Emissions	1.4
13-1152	Control of Emissions from Wood Waste Burners and Wood Dryers	20.6
14-1154	NPE Removal using Functionalized Monolayers on Mesoporous Supports	172.6

Table 3-16
Environmental Performance Group Potential Energy Savings

The focus of the environmental group is not energy savings. However, the table demonstrates that there can be significant potential energy savings associated with environmental performance projects.

The NPE Removal using Functionalized Monolayers on Mesoporous Supports project shows the largest projected energy savings in this group of projects. Because the number stands out, it may be useful to reconsider the assumptions used for this project's estimate of energy savings.

The Low VOC Drying of Lumber and Wood project is an example of a special case where the current process energy consumption is low, but new equipment is expected to be installed to satisfy more stringent environmental emission requirements. This new equipment is projected to consume large quantities of energy. Therefore, the potential energy savings is not in comparison to current energy use but rather represents a savings in comparison to the projected additional energy usage that is expected to result from a stricter environmental requirement.

⁹ No energy savings data were available for this project therefore an arbitrary energy savings of 0.1 trillion BTUs was assigned so that this data point would show on the Energy vs. Weighted Rating bubble charts.

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Sustainable Forestry Group Projects GPRA Energy Savings Data

Potential energy savings for projects in the Sustainable Forestry Group are shown in Table 3-17.

Project #	Project Name	Total Primary Energy 2030 (10 ¹² BTUs)
15-None	Effects of Fertilization and Competition Control	2.8
16-677	Model-Based Diagnosis of Soil Limitations	2.8
17-681	Marker-Aided Selection Methods ¹⁰	0.1
18-758	Molecular Physiology Allocation in Poplar	2.8
19-794	Dominant Negative Mutations of Floral Homeotic Species	0.8
20-795	Pine Gene Discovery Project	5.1

Table 3-17
Sustainable Forestry Group Potential Energy Savings

The ultimate potential for these projects lies in the ability to produce trees with physical properties tailored to improve the products that are to be produced or to reduce costs within the processes used to produce that product. Since wood is also a viable energy source, sustainable forests represent a long-term renewable energy resource. The forest products industry in general considers the management of sustainable forests as one of the most important objectives for remaining competitive as an industry. The Department of Energy supports sustainable forestry research through several offices, including the Office of Power Technologies (OPT), Office of Transportation Technologies (OTT), as well as OIT. OIT has the specific mission of reducing energy consumption in industrial processes. The constraints in the energy accounting system used only allow OIT to account for potential energy savings associated with industrial processes.

Improved Capital Effectiveness Group Projects GPRA Energy Savings Data

Potential energy savings for projects in the Improved Capital Effectiveness Group are shown in Table 3-18.

Project #	Project Name	Total Primary Energy 2030 (10 ¹² BTUs)
21-1481	Lateral Corrugator	26.6
22-1482	Improved Dryer and Press Efficiencies	109.9
23-1483	Directed Green Liquor Pulping	27.2
24-1484	High-Capacity Gas-Fired Dryer	29.8
25-1485	Continuous Displacement Dewatering	217.0
26-1486	Borate Autocausticizing	13.8
27-1487	Fast Curing of Wood Composites	23.6

Table 3-18
Improved Capital Effectiveness Group Potential Energy Savings

¹⁰ No energy savings data were available for this project therefore an arbitrary energy savings of 0.1 trillion BTUs was assigned so that this data point would show on the Energy vs. Weighted Rating bubble charts.

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In process industries, capital equipment improvements are often accompanied by improved energy efficiencies as demonstrated by the projects in the Table 3-18. This table also demonstrates there are significant potential energy savings associated with projects that increase water removal efficiencies.

In some cases these benefits appear to be overstated. As an example, the energy savings projected for the gas-fired dryer are based on a reduced usage of natural gas. However, most mills currently use excess low-pressure steam for drying energy. Consequently, they would have to buy and burn additional natural gas or generate a synthetic gas in order to use this device. Furthermore, they would cease to recover this energy from their low-pressure steam, possibly having to use condensers to reject this heat as "waste" instead. The economic analysis also did not take into account the use of alternative fuels (wood waste, bark, biomass, black liquor, etc.) at the mills where they are available.

Recycling Group Projects GPRA Energy Savings Data

Potential energy savings for projects in the Recycling Group are shown in Table 3-19.

Project #	Project Name	Total Primary Energy 2030 (10^{12} BTUs)
28-772	Acoustic Separation Technology	21.1
29-944	Easily Removable Cationic PSAs	26.9
30-945	Replacing Chemicals in Recycle Mills	108.0
31-1198	Surfactant Spray to Improve Flotation De-Inking	481.7

Table 3-19
Recycling Group Potential Energy Savings

The Industry recognizes the social and environmental benefits of using recycled fiber. Table 3-19 demonstrates these types of projects can also have significant potential energy savings. The Surfactant Spray to Improve Flotation De-Inking project reports the largest projected energy savings in this group. Because the number stands out, it may be useful to reconsider the assumptions used for this project estimate.

Sensors and Controls Group Projects GPRA Energy Savings Data

Potential energy savings for projects in the Sensors and Controls Group are shown in Table 3-20.

Project #	Project Name	Total Primary Energy 2030 (10^{12} BTUs)
32-1158/699	Feed Stock-Product/Field Mobile NIR	9.7
33-827	Distributed Web Sensor for On-Line Measurement of Paper Weight	26.7
34-975	On-Line Fluidics Controlled Headbox	97.2
35-1157	Guided Acoustic Wave Monitoring of Corrosion & Erosion in Recovery Boiler Tubing	102.4
36-1491	Wireless Microwave Wood Moisture Measurement	43.1
37-1492	CFD Modeling of Black Liquor Nozzle Design	88.3

Table 3-20
Sensors and Controls Group Potential Energy Savings

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Sensors and controls projects generally improve quality and productivity and have the potential for significant economic benefits over and above potential energy savings. However, Table 3-20 demonstrates they can have significant energy savings as well.

The two projects with the greatest potential energy savings illustrate the potential benefit of improving existing recovery boiler operations.

3.4. Value of the Agenda 2020 Program

Quantifiable Value of the Agenda 2020 Program

The energy and cost savings projected on the individual spreadsheets for each of the projects considered in this study were summarized by task group and presented in the stacked barcharts (Figures 3-1 and 3-2) below. These barcharts suggest that the technologies being explored and developed under the Agenda 2020 program could possibly generate energy savings in excess of 2,000 trillion BTUs per year by 2020 and 4,500 trillion BTUs per year by year 2030. It must be noted that these savings include some accumulation due to overlap among projects. They are also based on the assumption that all of the projects considered will achieve one hundred percent technical success. Therefore, the implied overall impact for these projects is a considerable overstatement of the true potential. It is not practical to remove the redundancy or to develop more accurate estimates for probabilities of technical and commercial success at this time; nonetheless, a substantial level of real contribution is implied for the current portfolio.

The implied cost savings to the Forest Products industry that would be attributable to the projects considered in this study are also impressive. Projected to reach nearly \$20 billion dollars per year by 2030, these cost savings are largely a function of the projected energy savings, which dominate the calculations performed in the GPRA spreadsheet. Because of this close linkage with the projected energy savings, these projected cost savings must be recognized as a considerable overstatement as well.

To put these figures in perspective, a benchmark number for the total annual primary energy consumed by the forest products industry was determined from data published by the Energy Information Agency (EIA).¹¹ The most recent data published by Standard Industrial Classification (SIC) Codes is for the year 1994. Two SIC Codes best represent the forest products industry, SIC Code 24 (Lumber and Wood Panel) and SIC Code 26 (Paper and Allied Products). The EIA data show that the total annual consumption for SIC Code 24 was 491 trillion BTUs of which 68 trillion BTUs were in the form of purchased electricity. When adjusted for heat rate, the total primary energy consumption for SIC Code 24 becomes 632 trillion BTUs. Similarly, the total energy consumption for SCI Code 26 was 2,665 trillion BTUs of which 223 trillion BTUs were purchased electricity. When adjusted for heat rate, the total primary energy consumption for SIC Code 26 becomes 3128 trillion BTUs. These data indicate a total primary energy consumption for the forest products industry of 3,760 trillion BTUs per year in year 1994. By comparison, the projections cited above would seem to indicate that the energy savings by year 2020 would amount to greater than one half of the total 1994 consumption and would exceed it by year 2030. Even with allowances for modest increases in consumption, it is highly unlikely that actual savings of this magnitude

¹¹ Manufacturing Consumption of Energy 1994

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could be realized. It is clear from this comparison that the simple accumulation of the energy and cost savings estimated on the individual GPRA spreadsheets results in totals that are overstated as noted above. Nevertheless, it is also clear that the energy and cost savings that can be expected from the Agenda 2020 program will have a substantial positive effect.

Several factors must be considered when drawing conclusions from Figures 3-1 and 3-2. First, the data represent only thirty-seven of the one hundred and five DOE supported projects initiated to date under the Agenda 2020 program. These thirty-seven projects were selected because they were thought to have the greatest potential impact on the program. Second, the methodology that has been adopted by DOE's Office of Energy Efficiency and Renewable Energy (EERE) for these projections assumes that every project will be technologically successful and that the technology will be successfully commercialized using a number of different market penetration assumptions. Third, the estimates of energy savings, market penetration factors, etc. rely upon the estimates provided by the PIs and these were not subjected to comprehensive industry review and analysis. Fourth, the summation methodology provides opportunities for the possible double counting of benefits in cases of similar competing technologies. Fifth, savings dollars are expressed in future year dollars for future benefits. Sixth, some of the projects are in the early R&D stages and the validity of the estimates of their benefits is highly speculative.

Figure 3-1 ¹²

¹² The energy displacement indicated include overlap among projects and the assumption of 100% technical success, therefore they considerably overstate the true potential.

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Figure 3-2 ¹³

Even with the above precautions and factors taken into account, the magnitude of the potential energy and cost savings represented in these barcharts indicates a program of significant value to the forest products industry and to the nation as a whole. The program is intended to focus on pre-competitive R&D projects and, already, a number of these projects are approaching commercial status. In the few short years since its inception, the Agenda 2020 program is expected to make remarkable progress in tangible, quantifiable terms. In addition to these potential benefits, the conduct of the program itself is providing further benefits of a systemic nature that may prove to be of even greater significance.

Systemic Value of the Agenda 2020 Program

In addition to the quantifiable benefits discussed above, the Agenda 2020 program has fostered several items of significant, albeit non-quantifiable value to the Forest Products industry. First, there are many R&D projects in the portfolio that were made possible by the shared risk aspects of the Agenda 2020 program—the Black Liquor Gasification Project is a good example. Second, the program has served as a catalyst to bring the industry members together with a unifying focus to collaborate on the definition of needs and establishment of priorities for the economic health of the industry and the nation. Third, the program has facilitated the industry's efforts to clarify and focus the technology R&D effort. Fourth, the program has stimulated the process of defining the criteria and procedures necessary to effectively evaluate the worth of R&D projects and establish the diversity of projects necessary to maintain a robust program. Fifth, the degree of collaboration that has developed between the industry, the government, and research organizations (including universities and national laboratories) fosters an environment that promises more effective problem solving with win-win outcomes in the future.

¹³ The cost savings indicated include overlap among projects and the assumption of 100% technical success, therefore they considerably overstate the true potential.

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3.5. Potential Economic Impacts of the Projects

One of the goals of this study was to identify the potential economic impacts of the projects that were evaluated in terms of reduced capital intensity, productivity improvements, reduced environmental costs, and safety improvements. Although the GPRA spreadsheets provide features for including estimates of capital and non-energy variable costs and assumptions regarding payback terms and other pertinent economic factors, these data were not available. Similarly, the data required to assess the economic impacts of these projects in terms of environmental costs and safety improvements were not available. Reasonable evaluations of the economic impacts of these projects were precluded.

In conjunction with the estimation of capital and non-energy variable costs, the understanding of economic impacts and the capital effectiveness aims of the industry could be enhanced by employing recognized value-engineering methods to systematically evaluate estimates of cost, worth, value, and benefits during the project selection process. The development of these methods should involve organizations such as TAPPI Engineering and the Construction Industry Institute (CII) to share their best practices for improving effectiveness in capital investment programs.

3.6. The R&D Process

The process for solicitations and project reviews involves crosscutting jurisdictions at the task group level, however, the intentions of these crosscutting efforts do not always filter down to the PIs. An emphasis on an integrated, problem-oriented focus for new R&D projects might provide a more directed focus for the researchers regarding the problem being addressed and should make it easier to identify the associated benefits to the industry. This is the way that the industry appears to be moving in the evolution of their proposed New Technology Strategy. A forum that would facilitate the exchange of information between researchers and the industry (prior to formal solicitations) regarding needs, issues, and goals should also improve the focus and quality of subsequent proposals. It may also be helpful to expand the mentoring program to include all projects in all stages of development to ensure that the PIs' understandings of the industry's perspectives on the issues remain current and the work remains targeted towards the appropriate problems. This may require different mentors to provide the appropriate operational or technical experience as projects proceed through the different stages of development, especially with regards to projects involving equipment modification or replacement during the performance of the project.

It is difficult to estimate the impacts of projects that consist of basic/fundamental research or the establishment of enabling technologies. In most cases these projects have a likelihood of producing information and knowledge that will be of value in the future even if one can't predict exactly how that information will ultimately be used. These projects may not have an immediate impact in and of themselves but rather provide information that is necessary to undertake the integrated, larger impact projects that the industry is targeting. A methodology that demonstrates the value of these projects in terms of accomplishing future/follow-on R&D in lieu of the immediate impacts projected by the GPRA spreadsheets could be helpful to justify their value and ensure that an adequate amount of basic/fundamental research remains in the pipeline to enable the larger follow-on projects.

It appears as though projects are cyclically selected on a technology group basis with the result that some research proposals were written to emphasize the potential benefits of most

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interest to that particular group. De-emphasizing the technology group and emphasizing larger, integrated projects should encourage proposals that present a more comprehensive picture of potential benefits and take better advantage of potential synergies across technology group lines.

Industry participation at the staff level is on a part-time basis with the attendant difficulties with priorities, availability, and continuity. The level of participation appropriate for industry participants to provide optimum benefit to the program should be determined. As a minimum the program would seem to require a full-time high-level staff person with leadership skills and access to strong analytical capabilities. DOE's continued support for this participation would ensure that a broad industry perspective regarding industry needs as well as sensitivity to national energy and environmental concerns is maintained.

Through discussions with the Steering Group, it is recognized that the forest products industry is taking steps to improve the R&D process and action is already underway in many instances.

3.7. Agenda 2020 Implementation Plan and Portfolio

The Agenda 2020 Implementation Plan was organized into six areas of research and development. The R&D pathways that represented the initial strategy for the Agenda 2020 Program were subordinated to these six areas in the form of the structure presented in Appendix F. The project work in each of these areas fell under the technological oversight of a specifically assigned Task Group in a one-to-one relationship. Each of these areas was fully represented by the projects that were evaluated in the course of this study. These projects will make significant contributions to the Agenda 2020 program in their respective areas of technology. Furthermore, the potential contributions to be made by many of the projects that were studied appear to have value in one or more of the other areas of R&D as well. Specific observations regarding the relationship of the projects evaluated to the Agenda 2020 Implementation Plan (on an area-by-area basis) are as follows.

Sustainable Forestry

All the Sustainable Forestry research projects that were evaluated can, in some respect, be classified as nutrient allocation or genetic research oriented towards lumber and fiber production and there appears to be some overlap in the various research projects. These projects are well aligned with three of the four R&D pathways envisioned in the Agenda 2020 Implementation Plan. The fourth pathway, "Remote Sensing Technologies to Improve Forest Inventory and Stand Management" is somewhat represented by projects in the Sensors and Controls technology group. Because of the fundamental nature of these research projects, the realization of benefits will in many cases occur beyond the implementation goal of year 2020.

It was noted that there are no R&D pathways in the Agenda 2020 Implementation Plan, nor are there any projects, that specifically target the potential for growing wood as a renewable source of energy although much of the current research could be applied to enhance wood as a renewable energy source. To a degree this situation reflects the historical product lines such as pulp, paper, panels, lumber, etc. that have driven the economics of the forest products industry. It also reflects historically cheap petroleum and natural gas energy supplies. In consideration of an increasing need to reduce dependence on imports of oil and natural gas, genetic research that provides the potential for converting underutilized and

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less fertile land to grow trees to produce a renewable supply of energy appears to be consistent with DOE objectives. Also, the use of wood as a source of chemicals that displace petroleum products as their feedstock could result in additional fossil fuel savings. DOE sponsors other projects and programs through the Office of Power Technologies (OPT) and the Office of Transportation Technologies (OTT) that are of a similar or related nature but outside of the scope of this study. These other efforts often involve the same industry participants as those in the Agenda 2020 program. Additional projects that build upon the genetics and soil productivity research already underway but with a focus on energy production should be coordinated for maximum overall benefit.

Environmental Performance

Air emissions and the bleach process were the two common threads throughout most of the projects in the Environmental Performance group. Other projects in the group dealt with reduction and treatment of liquid effluents and an alternative use of solid waste.

A comparative review of the three Environmental Performance R&D pathways and the nine related Focus Areas against the projects evaluated in this study indicates that the projects address at least eight of the nine Focus Areas listed in the Agenda 2020 Implementation Plan. The exception is the focus area of “*Human and Environmental Effects*” under the “*Improved Margins of Environmental Safety*” pathway. There were no projects in this group that considered the human impact of the environmental issues.¹⁴

Energy Performance

Three of the seven research projects reviewed in the Energy Performance group were gasification related. Two projects dealt with water removal/drying and the remaining two dealt with combustion processes. These seven projects dealt with four of the six Focus Areas on the Energy Performance R&D pathways in at least some aspect.

The two Focus Areas that the projects evaluated in this study did not address were “Technologies for Maximizing the Value of Waste Materials and Biomass as an Energy Source” and “Effective Partnerships with Energy Providers in Achieving Renewable Energy Goals”. Of particular note when comparing the Continuing Research bullets with the projects that were evaluated was the absence of projects in the areas of turbine research (2 bullets) and wood products processes (3 bullets). Research into turbines (or other devices) that will use gas from gasifiers is critical to the overall system on which the projections of significant energy displacement in the out years are based.¹⁵

Capital Effectiveness

The Capital Effectiveness group of projects evaluated in this study addressed the issues and needs of the System and Process Technologies” R&D pathway. A common approach among the projects in this group was to achieve capital effectiveness through economies of scale. The other two R&D pathways, “System Fabrication and Construction” and “Systems Efficiency” were well described in the Agenda 2020 Implementation Plan but were not addressed by any of the projects evaluated.

¹⁴ The Forest Products Industry has not been successful in pursuing collaborative efforts with the EPA.

¹⁵ DOE’s OPT is supporting research in this area.

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Recycling

The Recycling group of projects aligns fairly well with the Agenda 2020 Implementation Plan and addresses four of the five R&D pathways in this technology area. These projects are moving forward to implementation rapidly and therefore should make good contributions to meeting the Agenda 2020 objectives. The R&D pathway "Sorting and Collection/Methodologies and Tools" was not addressed by any of the projects that were evaluated.

Sensors and Controls

The Sensors and Controls group of projects also aligns well with the Agenda 2020 Implementation Plan and addresses three of the five R&D pathways in this technology area to a reasonable degree. The R&D pathways "Data Presentation, Interpretation and Human Interface" and "Control System Effectiveness" were not addressed by any of the projects that were evaluated.

3.8. Proposed New Technology Strategy

The New Technology Strategy has been under development for some time and is currently in a proposed status. The new strategy is intended to enhance the effectiveness of the Agenda 2020 program based on the experience gained to date. This strategy was the topic of a number of presentations at the Forest, Wood & Paper Industry Technology Summit in Atlanta, GA in May 2001. A book is currently being drafted and assembled that will document the presentations and deliberations upon which the proposed New Technology Strategy is based.¹⁶ The new strategy is organized along the lines of eight technology strategy platforms. The original Task Groups' projects are proposed to be aligned under six of these platforms. The proposed New Technology Strategy introduces two new strategy platforms (New Forest-Based Materials and Technologically Advanced Workforce). None of the projects that were evaluated in the course of this study would appear to relate to these two platforms.

The R&D pathways were reworked to some extent and subordinated to the eight technology platforms in the form of the revised structure presented in Appendix G. A review of this structure shows a clearer articulation of the vision for Agenda 2020 and the pathways to achieve that vision. The identification of gaps in knowledge and technology will provide a useful tool for soliciting and analyzing the value of future R&D projects. The incorporation of specific goals into the structure should provide a useful tool for measuring the performance of future projects in terms of their contributions to the whole of the agenda.

As with the Agenda 2020 Implementation Plan, the potential contributions to be made by many of the projects that were studied appear to have value in one or more of the proposed New Technology Strategy platforms. Specific observations regarding the relationship of these projects to the proposed New Technology Strategy (on a platform-by-platform basis) are as follows.

¹⁶*Forest, Wood & Paper Industry Technology Summit Book (Draft)*

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Higher Value Raw Material Supply

The Sustainable Forestry group of projects that were evaluated in this study appears to fit well under the goals and objectives of the Higher Value Raw Material Supply platform for the proposed New Technology Strategy. Much of the fundamental genetic research is already targeted at producing a higher valued raw material supply. Genetic engineering of trees for improved strength properties or enhanced pulping characteristics will clearly result in higher value raw materials. Genetic engineering also offers the potential to contribute to the success of other platforms such as Significantly Reduced Manufacturing Costs as well. Research in the area of soils productivity also has the potential to enhance raw material values.

Significantly Reduced Manufacturing Costs

The proposed New Technology Strategy transforms the former “Capital Effectiveness” task group into the “Breakthrough Technologies” group under the “Significantly Reduced Manufacturing Costs” platform. Doing so seems to give this group of projects a clearer focus and bring it more in line with the description of the R&D pathways reflected in the Agenda 2020 Implementation Plan details.

The alignment of the Recycling task group projects under the Significantly Reduced Manufacturing Costs platform for the proposed New Technology Strategy appears to be a simple structural shift that also improves the focus of projects within this group. The Recycling group of projects that were evaluated appears to fit well under the goals and objectives that were expressed for this platform of the proposed New Technology Strategy.

The alignment of the Sensors and Controls task group projects under the Significantly Reduced Manufacturing Costs platform for the proposed New Technology Strategy also appears to be a simple structural shift that improves the focus of projects within this group. The Sensors and Controls group of projects also appears to fit well under the goals and objectives that were expressed for this platform of the proposed New Technology Strategy. However, these projects do not address areas such as decision-making tools, process visibility sensors, and control system techniques as identified in the Technology Summit.

Improved Energy Performance

There is strong continuity from the Energy Performance technology group in the Agenda 2020 Implementation Plan to the Improved Energy Performance platform of the proposed New Technology Strategy in the area of biomass and black liquor gasification and defined targets against which progress may be gauged. The Energy Performance group of projects fits well with the new strategy in the gasification Area of Focus. However, these projects do not address the other Area of Focus identified as, “Reduce Energy Intensity of Manufacture and Use of Forest Products”, and “Extend Life of Durable Goods”.

Superior Environmental Performance

There is also strong continuity from the Environmental Performance technology group in the Agenda 2020 Implementation Plan to the Superior Environmental Performance platform of the proposed New Technology Strategy. The Environmental Performance group of projects aligns well with the restated technology platform. The refinements in the proposed New

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Technology Strategy serve to make the goals measurable and enhance investigator understanding of the overall industry goals.

New Forest-Based Materials

None of the projects evaluated in the course of this study would appear to be related to this platform.

Technologically Advanced Workforce

None of the projects evaluated in the course of this study would appear to be related to this platform.

3.9. Comparison of Agenda 2020 Implementation Plan to the Proposed New Technology Strategy

The Agenda 2020 Implementation Plan embodied the original R&D strategy and served as a point of departure for initiating the R&D program. Since the inception of the program a greater understanding of the roles played by the government and the forest products industry has developed. In addition, the unique needs for leading and managing collaborative research efforts involving numerous participants in forest products industry has evolved. The proposed New Technology Strategy has grown out of this experience. The forest products industry has taken the lead in redefining, reorganizing, and updating the original R&D strategy along the lines of eight proposed technology platforms which are intended to produce integrated projects with larger impacts for more substantial industry improvements. The six original task groups' projects have been realigned under six of the eight proposed new technology strategy platforms.

Figure 3-3 presents a comparison based on the projects that were evaluated in this study. Three of the original task groups' projects remain in a one-to-one correspondence with three of the platforms in the proposed New Technology Strategy. The remaining three task groups' projects are aligned under the Significantly Reduced Manufacturing Costs platform. Two of the platforms are not represented by projects that were evaluated in this study.

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Relationship of the Agenda 2020 Implementation Plan to the proposed New Technology Strategy		Agenda 2020 Implementation Plan Structure						Total Projects by Proposed New Technology Strategy Breakdown
		Sustainable Forestry	Environmental Performance	Energy Performance	Capital Effectiveness	Recycling	Sensors and Controls	
New Technology Strategy Structure	Higher Value Raw Material Supply	6						6
	Significantly Reduced Manufacturing Costs				7	4	6	17
	Improved Energy Performance			5				5
	Superior Environmental Performance		9					9
	New Forest-Based Materials							0
	Technologically Advanced Workforce							0
Total Projects by Agenda 2020 Breakdown		6	9	5	7	4	6	37

Figure 3-3
Agenda 2020 Implementation Plan vs. the Proposed New Technology Strategy

3.10. Impact Assessment Methodology

The methodology used to generate projections of project impacts is embodied in the GPRA spreadsheet. The calculations performed by the spreadsheet depend upon the initial inputs provided by the PIs and proposers and on the assumptions used for estimating and projecting the impacts. These projections can be improved by annually updating the inputs based on the project work and knowledge gained. Consistent transcription of the assumptions contained in the proposals to the spreadsheets would provide readily available information to facilitate an understanding of the impact projections without having to resort to additional documents.

The GPRA spreadsheets were designed to compare the impact of new equipment or process changes. However research and development projects by themselves do not produce widespread process changes or equipment installations. Therefore, when the GPRA spreadsheets calculate projections of impacts of R&D projects there is an implied assumption that the R&D will result in equipment or process changes. Because research and development projects may not be successful or several projects may be targeting the same benefit there is the possibility for overestimating or duplicating potential energy savings estimates. OIT recognizes this possibility in their approach and reduces the projected energy savings to 20% of that projected to compensate for the fact not all projects will be successful. However, the savings are not modified to take into account the

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duplication of the potential savings by projects addressing the same problem. Since there are no mitigating provisions for estimating high, low, and most likely numbers for the various parameters in the spreadsheet, there is insufficient data to enable a statistical evaluation of the data. Incorporation of statistical methods may improve the process for estimating these impacts.

The GPRA spreadsheets are used to collect and process technology impact information consisting of estimates of energy performance, environmental performance, cost performance, and market penetration. It appears as though the GPRA spreadsheets generated at the beginning of the project as part of an initial justification process are not updated annually or at the end of the project to reflect the knowledge gained from performing the project. As a consequence, the GPRA spreadsheets do not appear to contribute as much to the R&D process as they might.

In order to assess the impact of the proposed technology, the proposer must provide specific comparisons with the best available technology for each of the energy performance, environmental performance, and cost parameters. There are no independent means for selecting or confirming the best available technology and determining the appropriate performance parameter values to be used for the comparison.

The Agenda 2020 projects vary in their stages of development from fundamental, basic research to full-scale demonstration. Very reliable estimates of performance, cost, and market penetration factors can be made for full-scale demonstration projects where the process and equipment design are well defined and quantity-based estimates can be generated. At the other end of the spectrum, however, estimates of these same parameters for fundamental research projects are highly speculative. Furthermore, the fundamental knowledge gained from fundamental research may have applications that the researcher never considered and, conversely, that same knowledge may determine limitations, or even disprove the viability of applications that were initially anticipated.

There are also instances where several projects, even at the demonstration level, are also parts of a greater whole. An example of this would be the gasification and combined cycle projects. The potential exists to report technology impact values that would be expected for an integrated gasification combined cycle project as inputs for each gasification and gasification combined cycle project with a resultant multiplication and overestimation of benefits.

Although there are some limitations and shortcomings in the current methodology for impact assessments, the methodology demands the necessary discipline of requiring the submittal of data appropriate to the measurement of a project's value. It also requires consistency in treating these data once they are in the system. The comparisons made between projects are dependable to the extent that the input data is reliable and accurate. The methodology also uses of data tables for such factors as combustion emission rates for various fuels, industrial energy prices, energy content of fuels, and projected fossil fuel generation mixes. The use of these tables in the spreadsheet calculations ensures that the data reported by proposers is given a consistent treatment from that point forward. Furthermore, the table can be updated on an annual basis or upon any occasions where large changes are experienced in the national economy. This facility enables normalization of impacts for comparisons of projects that occur in different years and the adjustment of impact projections for varying economic conditions.

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3.11. Bubble Charts

In order to present the relationships between the project evaluation data, stage of development data, energy savings data, and project costs, two series of graphs were generated. A bubble chart format was used wherein the size of each bubble on the charts was proportional to the project cost for the project that it represented. Each series consists of seven bubble charts, one that presents data for all thirty-seven projects, and one for each of the six technology groups.

The first series of bubble charts plots the projected energy savings (in trillions of BTUs in the year 2030) versus weighted ratings for each of the projects evaluated. Because the projected energy benefits vary widely in magnitude, a log scale was used in order to make these figures presentable. The charts showing these data for all of the projects and for the Energy Performance group of projects used an upper limit of 10,000 trillion BTUs for this scale because of the magnitude of the projected energy savings attributable to this technology group. The chart for the other technology groups (with the exception of the Sustainable Forestry group) used an upper limit of 1,000 trillion BTUs on this scale to obtain the best presentation of data. The Sustainable Forestry group of projects had projections of comparatively small energy savings, all of which were less than 6 trillion BTUs. Consequently, a linear scale with an upper limit of 6 trillion BTUs was used for this particular chart. A linear scale was used for the weighted ratings with an upper limit of 400, which is the maximum weighted rating possible within the Project Evaluation System.

The second series plots the stages of development versus the weighted ratings for each of the projects evaluated. A linear scale with an upper limit of 6 was used for the Stages of Development and the linear scale with an upper limit of 400 was used for the weighted ratings. These scales were used for all seven charts in this series.

All Projects – Energy Savings

Figure 3-4 presents the projected energy savings for all of the projects evaluated during the course of this study. A different color was used to distinguish data associated with each of the six technology groups. The All Projects chart is unique from the energy perspective in that all of the projects can be compared using the same energy scale.

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All Projects - Research Budget vs Energy Savings vs Weighted Rating

Figure 3-4

One way to interpret these data is to begin by dividing the chart into quadrants. As discussed earlier, a weighted rating of 150 or more indicates a highly rated project therefore this value can serve as a useful vertical dividing line. A figure of 10 trillion BTUs in year 2030 for energy savings seems to be sufficiently significant to provide a horizontal dividing line. With the quadrants thus defined, the lower left quadrant would indicate those projects that are expected to produce the least impact and the upper right quadrant would indicate those projects that are expected to produce the greatest impact. Those projects in the upper left and lower right quadrants would both be expected to have a moderate impact with the upper left being more significant from an energy savings perspective and the lower right being more significant from a forest products industry perspective. Using this means, there are no projects (0%) in the lower left quadrant, five projects (13%) in the upper left quadrant, eleven (30%) in the lower right quadrant and twenty-one (57%) in the upper right quadrant. Because the Project Evaluation System took industry goals as the basis for defining and weighting its evaluation parameters, it may be concluded that 57% of the thirty-seven projects evaluated in this study have the potential to make a high impact on meeting the industry goals and the remaining 43% have the potential to produce a moderate impact. Significantly, there were no projects that lacked the potential to make a noteworthy impact. Even those projects that scored very low weighted ratings were projects that addressed important problems in the industry and their low scores merely indicate that more effective, marketable solutions remain to be found.

Also immediately apparent is the one very large bubble in the upper right of the chart that dominates the picture. This bubble represents the gasification group of projects, which in turn represents the majority of the resources that were committed to the projects that were

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evaluated. Several considerations regarding the interpretation of this data point are noted on the chart.

Energy Performance Group – Energy Savings

Figure 3-5 presents the projected energy savings for the five projects in the Energy Performance group of projects. A different color was used to distinguish data associated with each of the projects in this group.

Figure 3-5

Using the quadrant definitions discussed previously, there are no projects (0%) in either the lower left or the upper left quadrants, one project (20%) in the lower right quadrant, and four (80%) in the upper right quadrant.

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Environmental Performance Group – Energy Savings

Figure 3-6 presents the projected energy savings for the nine projects in the Environmental Performance group of projects. A different color was used to distinguish data associated with each of the projects in this group.

Figure 3-6

Using the quadrant definitions discussed previously, there are no projects (0%) in the lower left quadrant, two projects (22%) in the upper left quadrant, three (33%) in the lower right quadrant, and four (45%) in the upper right quadrant.

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Sustainable Forestry Group – Energy Savings

Figure 3-7 presents the projected energy savings for the six projects in the Sustainable Forestry group of projects. A different color was used to distinguish data associated with each of the projects in this group.

Figure 3-7

Using the quadrant definitions discussed previously, there are no projects (0%) in the lower left, upper left and upper right quadrants. All of the projects in this group are in the lower right quadrant.

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Improved Capital Effectiveness Group – Energy Savings

Figure 3-8 presents the projected energy savings for the seven projects in the Improved Capital Effectiveness group of projects. A different color was used to distinguish data associated with each of the projects in this group.

Figure 3-8

Using the quadrant definitions discussed previously, there are no projects (0%) in the lower left and lower right quadrants, one project (14%) in the upper left quadrant, and six (86%) in the upper right quadrant.

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Recycling Group – Energy Savings

Figure 3-9 presents the projected energy savings for the four projects in the Recycling group of projects. A different color was used to distinguish data associated with each of the projects in this group.

Figure 3-9

Using the quadrant definitions discussed previously, there are no projects (0%) in the lower left, upper left and lower right quadrants. All of the projects in this group are in the upper right quadrant.

The energy savings benefit appears to be significant for each of these *Recycling* projects. This group of projects includes the second and the fifth highest energy savings and the project with the lowest savings is higher than many of the other projects reviewed.

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Sensors and Controls Group – Energy Savings

Figure 3-10 presents the projected energy savings for the six projects in the Sensors and Controls group of projects. A different color was used to distinguish data associated with each of the projects in this group.

Figure 3-10

Using the quadrant definitions discussed previously, there are no projects (0%) in the lower left quadrant, one project (17%) in the upper left quadrant, one (17%) in the lower right quadrant, and four (66%) in the upper right quadrant.

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All Projects – Stages of Development

Figure 3-11 presents the Stages of Development for all of the projects evaluated during the course of this study. A different color was used to distinguish data associated with each of the six technology groups.

A manner similar to that used to interpret the bubble charts that show energy savings data can be adapted to the bubble charts that show Stages of Development data. In this case, however, the ideally balanced portfolio would show a distribution of projects across all of the stages of development. Therefore a horizontal dividing line is not useful and the chart can more effectively be considered in terms of a right and left section with a vertical dividing line between them. As discussed previously, a weighted rating of 150 or more in this study indicates a highly rated project and can be used in a generalized fashion to serve as a point to divide the graph into sections to make common observations. With the sections thus defined, the left section would indicate those projects that are expected to produce the least impact and the right section would indicate those projects that are expected to produce the greatest impact. Using this means, there are five projects (14%) in the left section and thirty-two projects (86%) in the right section.

The five projects represented in the left section are in the three earliest stages of development. The thirty-two projects in the right section are well distributed amongst the five stages.

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Energy Performance Group – Stages of Development

Figure 3-12 presents the Stages of Development for the five projects in the Energy Performance group of projects. A different color was used to distinguish data associated with each of the projects in this group.

Figure 3-12

Using the section definitions discussed previously, there are no projects (0%) in the left section. All five projects (100%) are in the right section.

The right section shows an even distribution of projects amongst the five stages of development.

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Environmental Performance Group – Stages of Development

Figure 3-13 presents the Stages of Development for the nine projects in the Environmental Performance group of projects. A different color was used to distinguish data associated with each of the projects in this group.

Figure 3-13

Using the section definitions discussed previously, two projects (22%) are in the left section and seven projects (78%) are in the right.

The two projects represented in the left section are in the two earliest stages of development. The seven projects in the right section are distributed amongst the first four stages, however, there are no projects in the group that have advanced to Stage 5.

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Sustainable Forestry Group – Stages of Development

Figure 3-14 presents the Stages of Development for the six projects in the Sustainable Forestry group of projects. A different color was used to distinguish data associated with each of the projects in this group.

Figure 3-14

Using the section definitions discussed previously, there are no projects (0%) in the left section. All six projects (100%) are in the right section.

The right section shows an even distribution of projects amongst the first three stages of development. There are no projects in the group that have advanced to Stages 4 and 5.

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Improved Capital Effectiveness Group – Stages of Development

Figure 3-15 presents the Stages of Development for the seven projects in the Improved Capital Effectiveness group of projects. A different color was used to distinguish data associated with each of the projects in this group.

Figure 3-15

Using the section definitions discussed previously, one project (14%) is in the left section and six projects (86%) are in the right.

The only project represented in the left section is in Stage 3. The six projects in the right section are distributed amongst the first three stages; however, there are no projects in this relatively new group that have advanced to Stage 4 or beyond.

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Recycling Group – Stages of Development

Figure 3-16 presents the Stages of Development for the four projects in the Recycling group of projects. A different color was used to distinguish data associated with each of the projects in this group.

Figure 3-16

Using the section definitions discussed previously, there are no projects (0%) in the left section. All four projects (100%) are in the right.

The right section shows a distribution of projects amongst the final four stages of development. The initial stages of development may not be well represented in this group: however, this may be merely a reflection of the fact that only four projects in this group were evaluated.

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Sensors and Controls Group – Stages of Development

Figure 3-17 presents the Stages of Development for the six projects in the Sensors and Controls group of projects. A different color was used to distinguish data associated with each of the projects in this group.

Figure 3-17

Using the section definitions discussed previously, one project (17%) is in the left section and five projects (83%) are in the right.

The only project represented in the left section is in Stage 2. The six projects in the right section are grouped in the middle stages with one that has progressed to Stage 5. There are no projects in the group in either Stage 1 or Stage 4.

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Section 4

Conclusions and Recommendations

4.1. Conclusions

The Agenda 2020 R&D Program

- The Agenda 2020 program shows noteworthy progress in tangible, quantifiable terms and has the potential to produce a substantial positive effect on energy and cost savings for the forest products industry and the nation as a whole.
- There are significant R&D projects in the portfolio that were made possible by the shared risk aspects of the Agenda 2020 program—the Black Liquor Gasification Project is a good example
- The Agenda 2020 program facilitates the industry's efforts to clarify needs, establish priorities, and focus the technology R&D effort for the economic health of the industry and the nation.
- The forest products industry has taken the lead in redefining, reorganizing, and updating the original Agenda 2020 R&D strategy.
- The Agenda 2020 program has stimulated the development of procedures to effectively evaluate the worth and diversity of R&D projects necessary to maintain a robust program.
- The degree of collaboration that has developed between the industry, the government, and research organizations (including universities and national laboratories) fosters an environment with potential for effective problem solving.
- In addition to Agenda 2020 projects, DOE sponsors projects and complimentary programs through the Office of Power Technologies and the Office of Transportation Technologies.

Portfolio Management

- The current portfolio represents a potential for major contributions across the full range of Agenda 2020 R&D goals. The majority of projects evaluated in this study have the potential to produce a high impact.
- Even projects that scored low weighted impact ratings addressed important problems in the industry and their low scores merely indicate that more effective, marketable solutions remain to be found.
- The project reviews performed by task groups are not uniformly structured or consistently reported to the CTO level in a manner that would facilitate portfolio management activities.
- A method that demonstrates the value of basic/fundamental research projects without depending on the metrics projected by the GPRA spreadsheets could be helpful to justify

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these projects on the basis of their contributions toward enabling and accomplishing future/follow-on R&D.

- The magnitude and complexity of the Agenda 2020 program would be more effectively managed by a full-time, high-level staff person with leadership skills and access to strong analytical capabilities.
- Future projects will be aligned under the proposed New Technology Strategy with the intent of more effectively advancing projects through their stages of development and encouraging the pursuit of major, integrated projects with larger impacts.

Impact Projections

- Impact assessments are a complex blend of quantified projections and subjective evaluations that demand a formal impact assessment methodology to treat all aspects with consistency in order to maintain and balance a long-term program.
- The simple accumulation of energy and cost savings tabulated on individual GPRA spreadsheets results in totals that are overstated.
- The cost savings projected in the GPRA spreadsheets are largely a function of the energy savings. Estimates of capital and non-energy variable costs and assumptions regarding payback terms and other pertinent economic factors were not available, which precluded complete evaluations of economic impacts.
- The assumptions and magnitudes of projected energy and cost savings need to be reviewed and periodically updated by the industry for reasonableness and potential overlap with other projects.

Project Performance

- The progression through the stages of development shown by the projects evaluated in this study suggests significant progress toward the Agenda 2020 goals.
- The valuable contribution of routine industry reviews of projects could be enhanced by structuring these reviews around common measures applicable to the Agenda 2020 program as a whole.
- The intentions of crosscutting efforts at the task group level during solicitation and project reviews do not always filter down to the PIs.

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4.2. Recommendations

The Agenda 2020 R&D Program

- The forest products industry and DOE should continue support for the Agenda 2020 program
- Provide a forum to facilitate the exchange of information, prior to the submittal of proposals, between researchers and the industry to improve the researchers' understanding of needs, issues, and goals for the Agenda 2020 program.
- The forest products industry and DOE should continue to coordinate the support provided through OIT, OPT and OTT for projects that build upon the current genetics and soil productivity research with a focus on high energy production. Incorporate new projects, as appropriate, into the Agenda 2020 portfolio.

Portfolio Management

- Continue the practice of having experts from the applicable technology groups contributing inputs to the proposal evaluation and project selection process.
- Maintain the focus of future projects on the development of major, breakthrough technologies in preference to projects that seek incremental improvements in efficiencies, economies of scale, etc.
- Incorporate measures into the project evaluation process that capture the full range of projected impact data. Such measures should include the use of a database or set of standardized numbers that represent consensus values provided through a recognized industry source.
- Incorporate recognized value-engineering practices into the proposal evaluation and project selection process. Involve organizations such as TAPPI Engineering and the Construction Industry Institute (CII) to share their best practices for improving effectiveness in capital investment programs.
- Establish a methodology that demonstrates the value of basic/fundamental research projects in terms of enabling future/follow-on R&D.
- Establish a methodology for defining the optimum portfolio structure.
- Implement a structured, periodic portfolio review process at the CTO level that draws upon the project reviews performed by task groups to determine if the projects in the portfolio continue to address the high priority industry needs and provide the correct mix of projects in the appropriate stages of development for sustainable success.
- Evaluate cost competitiveness of projects/technologies at all stages of development.
- Provide full time industry leadership for the Agenda 2020 program to ensure effective management of the portfolio.

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Impact Projections

- Continue to use a formal impact assessment methodology that incorporates the GPRA spreadsheet projections and a refined project evaluation process similar to that used in this study.
- Incorporate measures to eliminate the accumulation of benefits whenever multiple projects compete for the same energy savings and/or emissions reduction benefits.
- Require estimates of capital and non-energy variable costs, assumptions regarding payback terms and other pertinent economic inputs on the GPRA spreadsheets for those projects in their later stages of development.
- Complete industry reviews of the reasonableness of assumptions and the magnitude of numbers projected in the GPRA spreadsheets.
- Provide PIs/Project Managers with the GPRA spreadsheet data that was used in the evaluations of their proposals and instructions for generating updated inputs and require annual updates of these inputs. Update the documentation of assumptions and methods for generating estimates on the GPRA spreadsheets.

Project Performance

- Implement a means to measure individual project progress against the Agenda 2020 Implementation Plan that uses tangible measures such as Stages of Development and/or industry goals.
- Apply common measures for evaluating goals and technical approaches on future proposals/projects.
- Expand the mentoring program to include all projects in all stages of development to ensure that the PIs' understandings of the industry's perspectives on the issues are current and the work remains targeted towards the appropriate problems.

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Acronyms and Abbreviations

ABB	Asea Brown Boveri
AF&PA	American Forest and Paper Association
ANL	Argonne National Laboratory
AOX	Absorbable Organic Halides
BC	Boise Cascade
BTU	British Thermal Unit(s)
CFD	Computational Fluid Dynamics
CII	Construction Industry Institute
ClO ₂	Chlorine Dioxide
CO	Carbon Monoxide
CO ₂	Carbon Dioxide
COD	Chemical Oxygen Demand
CTO	Chief Technology Officer
CTOC	Chief Technology Officers Committee
D ₀	One of a number of stages in the bleaching process
DOE	U.S. Department of Energy
EERE	Office of Energy Efficiency and Renewable Energy
EIA	Energy Information Administration
EPA	Environmental Protection Agency
FPS	Forest Products Society
G-P	Georgia-Pacific
GPRA	Government Performance and Results Act
HAP	Hazardous Air Pollutant(s)
IGCC	Integrated Gasification Combined Cycle
INEEL	Idaho National Energy and Environmental Laboratory
IP	International Paper
IPST	Institute of Paper Science Technology
LLN L	Lawrence Livermore National Laboratory
LP	Louisiana Pacific
MDF	Medium Density Fiberboard
MOE	Modulus of Elasticity
MOR	Modulus of Rupture

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NCASI	National Council for Air and Stream Improvement
NCG	Non-Condensable Gasses
NCSU	North Carolina State University
NIR	Near-Infrared
NO _x	Nitrogen Oxides
NPE	Non-Process Elements
NREL	National Renewable Energy Laboratory
NSF	National Science Foundation
OCC	Old Corrugated Containers
OIT	Office of Industrial Technologies
OITIS	Office of Industrial Technologies Information System
OPT	Office of Power Technologies
ORNL	Oak Ridge National Laboratory
OSB	Oriented Strand Board
OSU	Oregon State University
OTT	Office of Transportation Technologies
PI	Principal Investigator
PNNL	Pacific Northwest National Laboratory
PSA	Pressure Sensitive Adhesive(s)
R&D	Research and Development
RFP	Request for Proposals
RPTA	Recycled Paperboard Technical Association
RTO	Regenerative Thermal Oxidizer(s)
SAMMS	Self-Assembled Monolayers on Mesoporous Supports
SOW	Statement of Work
TAPPI	Technical Association of the Pulp and Paper Industry, Inc.
TSS	Total Suspended Solids
UGA	University of Georgia
USFS	U.S. Forest Service
VOC	Volatile Organic Compound(s)
VPI	Virginia Polytechnic Institute
VTT	Technical Research Center of Finland (<i>Valtion Teknillinen Tutkinuskeskus</i>)
WSU	Washington State University

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Appendix A

Index of Projects Selected for Study

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OIT Forest Product Projects										
Energy Performance										
Item	Project	Recipient	Contact Phone Email	OITIS	Agrm't Number	Data Sheet	Q'tly	Final	Prop.	Metrics Data Sheet
0a	Biomass Gasification Combined Cycle	Weyerhaeuser	Del Raymond	707	96GO10173	X		X		
0b	Demonstration of Black Liquor Gasification at Big Island	Georgia Pacific	Robert DeCarrera	1630	01NT40850				X	
1	Multiport Cylinder Dryer Demonstration	ANL	Choi	785	NA	X	X		X	multiport_demo.anl
2	Development of Methane DENOX Reburning Process	IGT	Rabovitser	933	99GO10418	X	X		X	methdenox02
3	Black Liquor Gasification Demonstration	G-P	DeCarrera	993	99ID13818		X		X	total blg initiative.use for G-P.02
4	Intermediate-Sized Entrained Particles: Characterization, Formation, and Control	SNL	Baxter	1110	NA	X	X		X	intermed- sized.entrained.part.01
5	3-D Characterization of the Structure of Paper and Paperboard and Their Application to Optimize Drying and Water Removal Processes and End-Use Applications	U MN	Ramaswamy	1166	00ID13873	X	X		X	3D paper chars.01

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OIT Forest Product Projects										
Environmental Performance										
Item	Project	Recipient	Contact Phone Email	OITIS	Agrm't Number	Data Sheet	Q'tly	Final	Prop.	Metrics Data Sheet
6	High Efficiency ClO ₂ Delignification	IPST	McDonough	669	96ID13442	X	X		X	
7	VOC Control in Kraft Mills	IPST	Zhu	685	96ID13438	X	X		X	VOC_Control_ continued.ipst
8	Low VOC Drying of Lumber and Wood	IPST	Banerjee	687	96ID13439	X	X		X	lowvoc.RFwood.dry.01
9	Mill Designed Biobleaching Technologies	IPST	Ragauskas	941	99GO10374	X	X		X	mill biobleach.01
10	Water Recycling/Removal Using Temperature Sensitive Hydrogels	Auburn	Gupta	961	99GO10417	X	X		X	water.recycle- hydrogel.01
11	Use of Residual Solids in Ready-Mixed Concrete	U WI	Naik	1150	00ID13867	X	X		X	residual solids.01
12	Assessment of Low-Temperature Plasma Technologies for Treating VOC Emissions from Pulp Mills and Wood Product Plants	U IL Chicago	Fridman	1151	00ID13868	X	X		X	plasmatech.VOC.01
13	Control of Emissions from Wood Waste Burners and Wood Dryers	U WA	Malte	1152	00ID13869	X	X	Y'rly	X	control.emiss.burners& dryers.01
14	NPE Removal Using Functionalized Monolayers on Mesoporus Supports	PNNL	Robert Leugemors	1154	NA	X	X	Paper	X	npe removal3.01

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OIT Forest Product Projects										
Sustainable Forestry										
Item	Project	Recipient	Contact Phone Email	OITIS	Agrm't Number	Data Sheet	Q'tly	Final	Prop.	Metrics Data Sheet
15	Effects of Fertilization and Competition Control on Carbon and Nutrient Allocation and Physiology in Loblolly Pine Plantations	U GA	Hendrick		98GO10363		X			effects.fertilization.on. C,N,&Phys.99
16	Model-Based Diagnosis of Soil Limitations to Forest Productivity	ORNL	Luxmoore	677	NA	X	X			model.diagnose.soil.01
17	Development and Validation of Marker-Aided Selection Methods for Wood Property Traits in Loblolly and Poplar	ORNL	Tuskan	681	NA	X	X		X	
18	Molecular Physiology of Nitrogen Allocation in Poplar	U FL	Davis	758	97ID13529	X	X		X	molec.physiol of nitrogen.01
19	Dominant Negative Mutations of Floral Homeotic Genes for Genetic Engineering of Sterility in Forest Trees	OSU	Brunner/Strauss	794	97ID13552	X	X		X	DRAFT2.dom-neg mutation.02
20	Pine Gene Discovery Project	NC State	Whetten	795	97ID13550	X	X	Draft	X	pine gene.01

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OIT Forest Product Projects										
Improved Capital Effectiveness										
Item	Project	Recipient	Contact Phone Email	OITIS	Agrm't Number	Data Sheet	Q'tly	Final	Prop.	Metrics Data Sheet
21	Lateral Corrugator	United Container	Agronin	1481	01GO10616		X		X	lateral corrugator Agronia-GPRA 2002_0512
22	Improving Dryer and Press Efficiencies through the Combustion of Hydrocarbon Emissions	IPST	Banerjee	1482	01GO10620		X		X	improve dry press Banerjee-GPRA 2002_0512
23	Directed Green Liquor Utilization Pulping	IPST	Lucia	1483	01GO10626		X		X	novel pulping.D- Glu.Lucia-2002_0512
24	High Capacity Gas-Fired Dryer	IGT	Kurek	1484	01GO10621		X		X	high_cap_ppr_dryer.igt
25	Continuous Process for Displacement Dewatering	Voith	Beck	1485	01GO10622		X		X	proprietary.feasib.disp. dewatering.Beck
26	Use of Borate Autocausticizing to Supplement Lime Kiln and Causticizing Capacities	W MI U	Cameron	1486	01GO10623		X		X	borate autocaust Cameron
27	Fast Curing of Composite Wood Products	IPST	Ragauskas	1487	01GO10625		X		X	fast curing Ragauskas

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OIT Forest Product Projects										
Recycling										
Item	Project	Recipient	Contact Phone Email	OITIS	Agrm't Number	Data Sheet	Q'tly	Final	Prop.	Metrics Data Sheet
28	Acoustic Separation (Underwater Pulsed Power) Technology	IPST	Ahrens	772	97ID13553	X	X		X	acoustic sep.01
29	Water Soluble and Easily Removable Cationic Pressure Sensitive Adhesives	IPST	Deng	944	99GO10379	X	X		X	Cat.PSAs.01
30	Replacing Chemicals in Recycle Mills with Mechanical Alternatives	IPST	Banerjee	945	99GO10381	X	X		X	repchem.01
31	Surfactant Spray – A Novel Technology to Improve Floatation Deinking	IPST	Zhu	1198	00ID13879	X	X		X	surfsprtech.01

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OIT Forest Product Projects										
Sensors and Controls										
Item	Project	Recipient	Contact Phone Email	OITIS	Agrm't Number	Data Sheet	Q'tly	Final	Prop.	Metrics Data Sheet
32	Feedstock-to-Product Characterization Tools for the Wood and Pulp Industry AND/OR Development of a Field-Mobile NIR for Measurement of Standing Wood Properties	NREL	Stephen Kelley (303) 384 6123 stephen_kelley@nrel.gov	699	NA	X	X		X	feed to prod.99 field mobile.NIR.01
33	Distributed Web Sensor for On-Line Measurement of Paper Basis Weight	PNNL	Griffin	827	NA	X	X		X	full web sensor Griffin-02
34	On Line Fluidics Controlled Headbox	IPST	Aidun	975	99GO10416	X	X		X	headbox-ipst.02
35	Guided Acoustic Wave Monitoring of Corrosion and Erosion of Recovery Boiler Tubing	LLNL	Chinn	1157	NA	X	X		X	guided.monit.c&e. recovery.b.01
36	Wireless Microwave Wood Moisture Measurement	U TN, ORNL	Moschler	1491	01GO10618		X		X	wireless_microwave.U of TN
37	CFD Modeling, Shape Optimization and Feasibility Testing of Advanced Black Liquor Nozzle Designs	INEEL	Detering	1492	NA		X		X	CFD_Modeling.INEEL

FOREST PRODUCTS INDUSTRY OF THE FUTURE
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Appendix B

Instructions for Providing Technology Impact Projections

FOREST PRODUCTS INDUSTRY OF THE FUTURE PORTFOLIO STUDY AND EVALUATION

Technology Impact Projections

Revised 5/31/00

The Office of Industrial Technologies (OIT) needs to understand the impact on energy use, waste production, and production cost each technology or project is likely to have. Estimating the potential benefits and impacts which may accrue from the results of research, development, and demonstration (and related) projects is important for both existing and proposed projects. It is an important criterion in evaluating projects as well as in presenting the merits of both individual projects and, through aggregation, the overall portfolio of projects in a given area. The potential energy savings, types of energy saved, types of emissions reduced, and economic benefits are among the factors of importance.

Proposers responding to a Solicitation or Request for Proposals should review the governing documents for instructions on when and how to submit the necessary information; existing project managers/principle investigators should have received this request through an OIT program manager. A spreadsheet version of the Technology Impact Projection input forms and supporting information are on the same disk or e-mail you are using to read this message. It allows you to enter key information about your proposed technology and its expected market, and facilitates calculating the potential energy and emission reductions and other impacts of your project in a relatively rapid and consistent manner.

Please provide your best estimate for each piece of information required to complete the spreadsheet. Be realistic about your estimates: if you are awarded a contract, you will be required to update this information annually. Note that not all inputs are necessarily applicable or available for all possible technologies. If you can only estimate the differential between the proposed new and the current state-of-the-art technology, reflect that in the spreadsheet by setting values for the current technology to "0". Placeholder values are included for some variables to (1) trigger the appearance of the Supplementary Table, which only appears if non-zero values are entered for use of feedstocks, renewables, waste, or "other" energy forms, and (2) illustrate where market data is entered on the sheet. These values must be changed to reflect your technology.

Per Unit Impact

Please provide key information on the performance of single installed units or applications of your technology. The performance of the new technology should be consistent with the performance goals in your proposal. For comparison, provide information on the performance of the best available technology for the application, not the average of all in-place technology units.

Unit Description

Describe what constitutes a typical process unit for your technology, in terms of annual output (production capacity times duty factor). For simplicity, the analysis will assume that all units in the industry have the same capacity. A realistic, average, or typical unit capacity should be chosen, particularly for situations where the unit size may vary in different installations. By convention and to enable comparisons, units for the new technology and the current state-of-the-

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art should be equal in output capacity, even if, in reality, the new technology might have a different capacity for various reasons.

The new technology also might not be a physical item of hardware. Rather, it could be a process change, a computer model or control system, operational change or other non-physical technique. In such cases, a unit should be defined as the typical or average process or plant that would utilize the new technique. The annual energy inputs based on the expected energy consumption of the process or plant with the new technique would then be compared with annual energy consumption required by existing techniques.

Energy Use

Please provide energy use per year for the new and conventional units, by fuel. If feedstock energy use is expected to change, it should be accounted for under Other. Please also indicate the price of any feedstock, renewable, waste, and other fuels on the supplementary table. Prices for waste used as fuels may be negative, reflecting the avoided cost of conventional waste disposal.

Electricity - Includes direct electricity.

Natural Gas - Includes pipeline fuel natural gas and compressed natural gas.

Petroleum - Includes distillate fuel, jet fuel, motor gasoline, residual fuel, liquid petroleum gas, and other petroleum.

Coal - Includes metallurgical coal, steam coal, and net coal coke imports.

Feedstock - Includes fossil fuels consumed in non-energy uses such as process feedstocks.

Biomass - Includes the use of biomass (for energy or as feedstock).

Wastes - Includes the use of fuels that are generated as wastes or process by-products. Examples of such fuels are refinery fuel gas, blast furnace gas, hog & bark fuel, and sewage sludge.

Total Primary Energy - Is calculated from individual energy inputs. Note that the primary equivalent of direct electricity consumption includes losses in electricity generation and distribution.

Environmental

Environmental impacts of your new technology can generally be divided into impacts that are a direct result of energy savings and non-energy-savings-related emissions impacts. The energy-savings-related environmental emissions are calculated automatically by the spreadsheet from the energy savings (and fuel substitutions or use of renewable energy) and typical emissions factors for various fuels and electricity use. The spreadsheet contains emission factors for electricity and fossil fuels. You may enter emission factors for feedstocks, renewables, wastes, or other fuels needed to assess your technology on the supplementary table included with the spreadsheet system.

Please provide estimates for the non-energy-related waste production associated with the new and conventional technologies. Please specify what type of solid waste is being affected, if any.

Other Greenhouse Emissions Displaced

Estimate of the amount of greenhouse emissions other than CO₂, NO_x, and VOCs if germane to your technology. These could include methane, perfluorocarbons, or other gases. Identify which gas and insert the appropriate multiplier for that gas as provided in the attached tables. The

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spreadsheet allows for three such other gases; if more are involved in your process, the carbon equivalent can be calculated separately, summed and inserted. An explanation should be provided.

Cost

Please provide rough estimates of the initial capital cost and non-energy variable costs associated with your technology new and old on a per-unit basis. Leave these blanks if you do not know the impact. Non-energy costs are non-fuel related annual costs that are affected by the technology substitution. This should include items such as operation and maintenance costs.

Market Projects and Impacts

To determine the potential impact of the new technology as it becomes adopted, it is necessary to estimate the total market for the technology, reduce that to the likely actual market, and estimate when and the rate at which the new technology will penetrate the market.

Total Market

The next step in projecting the overall potential impact of your technology is to identify the total market: the number of units that perform the same task as your proposed technology. Only the domestic U.S. market should be included. World market and export potential are important factors which may be considered separately, but this analysis is to estimate domestic energy and emissions reduction impacts.

Number of Units in Total Market

Please define that market as narrowly as possible: i.e. the smallest group of applications that covers all potential applications that you may have some data for. You may base your estimate on the energy use of the state-of-the-art technology and the energy use data provided in this package. Please also indicate for which year the data that you provided applies.

Overall Market Growth Rate

Is provided by OIT and based on EIA's projection of macroeconomic trends over future years.

Potential Market Share

Please estimate the accessible market: the market that the new technology could reasonably access given technical, cost, and other limitations of the technology. For example, certain technologies may only be applicable to a certain scale of plant, certain temperature range processes, certain types of existing equipment or subsystems, or only certain segments of the industry.

Likely Market Share

In some instances, in addition to technical and cost factors, your technology may compete with other new technology approaches, or with other companies for the market. Please estimate the likely market share. Use current market share information or base your estimate market share on the basis of the number of competitors in the market, assuming they are using different technologies not resulting from this project. This is different than the possibility of "copycats"

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which should not be considered as competing. That is, if others adopt essentially the same, or slightly modified, technology due to this new technology, that adoption was triggered by the project being described and that project should be “credited” with causing that trend. This is potentially the case for techniques where the intellectual property cannot be, or is not, protected and becomes general knowledge throughout the industry.

Market Penetration

To understand how rapidly the potential impact of the technology may be felt, the market penetration of the technology must be projected. Please indicate when the technology is likely to be introduced to the market on a commercial or similar basis. This date should be consistent with your technology development program plans. The date will normally occur after a significant demonstration or operating prototype and after an adequate test and evaluation period along with allowances for the beginnings of production, dissemination of information, initial marketing and sales or other “start up” factors.

New technologies normally penetrate a market following a familiar “s” curve, the lower end representing the above uncertainties overcome by “early adopters.” The curve tails off at the far future where some may never adopt the new technology. Of importance is the major portion of the “s” curve where the new technology is penetrating the market and benefits are being reaped. The rate at which technologies penetrate their markets varies significantly: penetrations of heavy industrial technologies generally takes place over decades, while simple process or control changes can penetrate much more rapidly. The actual penetration rate varies due to economic, environmental, competitive position, productivity, regulatory, and other factors.

To assist you, a large volume of actual penetration rates of past and present technologies were analyzed, normalized, and grouped into five classes based on a number of characteristics and criteria (see Figure 1 below). In Table I, circle the class (column) which you believe your technology best fits for each characteristic (row). Note that the characteristics (rows) are relatively independent and a given technology will likely fit best in different classes for different characteristics. By examining the pattern, however, one can, based on best judgement and experience, select the most likely class (rate) at which the new technology may penetrate the market. This may be a “subjective average” of the circled best fits, or it may be that one or two characteristics are believed to so dominate future adoption decisions that a particular class of penetration rate is justified. There also may be “windows of opportunity” where significant replacements of existing equipment may be expected to occur at some point in the future for other reasons. The proposer should insert into the spread sheet the class of penetration rate believed most likely, all things considered, and provide a narrative of the rationale for selection if not obvious from Table I.

If your completed spreadsheet will be delivered in hardcopy only, please attach a copy of the completed Table I to the printout of the spreadsheet together with any supporting information. If your completed spreadsheet will be delivered in electronic form, please enter X’s in the cells of Table I instead of circling the hardcopy, save the changes, and deliver the instruction file (Tech Imp Projections4.wpd) as well as the completed spreadsheet file.

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For additional assistance, Table II shows actual technologies and the class of their historical penetration rates. Comparison of the new technology, by analogy or similarity, with these examples provides additional insight into selecting the appropriate penetration rate that might be expected for the new technology. The spreadsheet, based on the unit performance, market size, and penetration rate class, will then calculate the estimated overall energy and environmental impacts and benefits over time which the new technology may bring to the industry and to the nation.

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Table I. Selecting the Market Penetration Rate Class

Characteristic	A	B	C	D	E
Time to Saturation (ts)	5 yrs	10 yrs	20 yrs	40 yrs	>40 yrs
Technology Factors					
Payback* discretionary	<<1 yrs	<1 yrs	1-3 yrs	3-5 yrs	>5 yrs
Payback* non-discretionary	<<1 yrs	< 1 yrs	1-2 yrs	2-3 yrs	>3 yrs
Equipment life	<5 yrs	5-15 yrs	15-25 yrs	25-40 yrs	>40 yrs
Equipment replacement	None	Minor	Unit operation	Plant section	Entire plant
Impact on product quality	++	++	++	+	O / -
Impact on plant productivity	++	++	++	+	O / -
Technology experience	New to US only	New to US only	New to industry	New	New
Industry Factors					
Growth (%p.a.)	>5%	>5%	2-5%	1-2%	<1%
Attitude to risk	open	open	cautious	conservative	averse
External Factors					
	forcing	forcing	driving	none	none
Gov't regulation					
Other					

* Payback is defined as capital outlay for new technology divided by savings before taxes and depreciation. In the case of Discretionary investments (i.e. replacements of existing equipment before the end of its economic life), capital outlay is total cost of new technology. In the case of non-discretionary investments (i.e. replacements of existing equipment at the end of its economic life and new installations), capital is the capital cost of the new technology - capital cost of current technology.

You can circle the criteria that apply to your technology and identify which category fits best.

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Table II. Examples

Class	A	B	C	D	E
Aluminum		Treatment of used cathode liners	Strip casting, VOC incinerators		
Chemicals	New series of dehydrogenation catalyst (incremental change)	CFCs -> HCFCs, incrementally improved catalysts, membrane-based chlor-alkali	Polypropylene catalysts, solvent to water-based paints, PPE-based AN	Synthetic rubber & fibers	
Forest Products			Impulse drying, de-inking of waste newspaper	Kraft pulping, continuous paper machines	
Glass		Lubbers glass blowing, Pilkington float glass	Particulate control, regenerative melters, oxygenase in glass furnaces		
Metals Casting	New shop floor practice				
Petroleum	New series HDS catalysts	Alkylation gasoline	Thermal cracking, catalytic cracking	Residue gasification, flexicoking	
Steel	Improved EAF operating practice (e.g. modify electric/ burner heating cycle to minimize dust generation)	BOF steel making	Oxyfuel burners for steel, Level II reheat furnace controls, Continuous casting, particulate control on EAF, Hightop pressure blast furnace	Open hearth technology, EAF technology	
Other		Advanced refrigerator compressors, oxygen flash copper smelting, solvent extraction with liquid ion exchange	Fluegas desulfurization (coal-fired utilities), low Nox industrial burners, industrial gas turbines, ore beneficiation		Dry-kiln cement, industrial ceramic recuperators Industrial heat pumps

If you can think of good examples for your industry, we'll add them!

Appendix C

Discussion Agenda

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Discussion Agenda (initial)

Project Title _____ OTIS Number _____ LATA Item _____
Date of Discussion _____ Phone Number _____
Discussion Participants, Organization- _____

Background:

Opportunity/Problem being addressed:

Commercialization discussion:

Strategic competitive position:

Environmental benefits:

Energy benefits:

GPRA Metrics discussion/thoughts about accuracy and advisable changes to estimating process:

Current energy markets discussion:

Breakthroughs / Scientific Insights:

National Impacts:

Other:

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Principal Investigator Discussion Agenda (revised)

Project Number:
OTIS Number:
Project Title:
Date of Discussion:
Discussion Initiator:
Principal Investigator/Organization:

PROJECT BACKGROUND

EVALUATION PARAMETERS

Sustained forest resource management:

Size and extent of market for the new technology:

Energy performance:

Economic attractiveness:

Technology champion:

Scientific insights derived from project:

Improved environmental performance:

Technological leadership:

Recycled wood and paper materials:

Risk:

Alternate uses for biomass:

Appendix D

Discussion of Abandoned Alternatives

FOREST PRODUCTS INDUSTRY OF THE FUTURE PORTFOLIO STUDY AND EVALUATION

Schedule-Based Approach to Portfolio Evaluation

One of the more difficult challenges of the study was the search for a meaningful and useful way to relate the results of the project evaluations to the Agenda 2020 R&D pathways in a fashion that conveyed a sense of direction and progress over time. An examination of the Agenda 2020 Implementation Plan revealed twenty-five R&D pathways covering the six technology areas of the program. Each of these pathways was characterized by the identification of a number of focus areas, continuing research areas, future research directions, knowledge and tools to be delivered and assimilated, and results to be realized. The data defining these pathways was excerpted from the plan, compiled, and presented in Appendix E. Although the characterization was presented in a logical format, this logic did not lend itself readily to association with timelines or schedule milestones. However, the descriptions of the continuing research areas and the future research directions had the possibility of being associated with the portfolio of projects and with time in a broad sense. A Gantt chart format was developed to show the areas of continuing research and future research as individual bars on a schedule. An arbitrary date of the end of year 2005 was established as the cutoff date for continuing research and the beginning date for future research. Future research was assumed to complete at the end of year 2020. The projects being evaluated were then associated with the particular pathway that appeared to provide the best fit. Since the projects being evaluated in this study were either completed or underway, they all fit within the category of continuing research. Each of these projects were shown as individual tasks on the schedule with project start and finish dates that were taken from project information sheets. To relate these project task bars with the project evaluations, circles were superimposed over the project task bars and numerical, weighted ratings were inserted within the circles for those projects that had been evaluated up to that time. A Gantt chart was developed in this manner for each of the twenty-five pathways and the most complete of these was presented to the Steering Group for review and discussion.

This presentation led to several observations that argued against pursuing a schedule-based approach. First, there are no clear one-to-one relationships between individual projects and the R&D pathways as evidenced by cases where particular projects could reasonably span a number of R&D pathways. Second, by reducing the number of projects to be considered in this study to a subset of the total number of projects in the Agenda 2020 portfolio, important R&D activity is not represented which can lead to invalid conclusions as to whether all of the pathways are being adequately addressed by the Agenda 2020 program. Third, the descriptions for many of the areas of research do not correlate well with either future areas of research or with specific projects, which makes it difficult to envision logical paths forward. Fourth, for the most part there are few apparent, logical relationships between individual projects, which hinders the use of this approach as a management tool. Fifth, there is an underlying philosophical disconnect regarding the application of schedule-based techniques to the evaluation of a program that spans the spectrum of the Agenda 2020 projects. While it might be useful when projects are in their latter stages of technology demonstration and fairly well-defined, it is inadequate for understanding those projects that are in the beginning stages of fundamental research where specific objectives that are related to follow-on projects are unknown or vague. On the other hand, the schedule-based approach did point out the need for a means define follow-on projects more clearly for future solicitations. An example of this was the apparent absence of any gas turbine or heat recovery steam generator development/demonstration projects although they would be necessary to achieve the goal of demonstrating an integrated gasification combined cycle (IGCC) plant. As a result of these observations it was decided to abandon the schedule-based approach in order to seek out one that would be a better fit.

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Report Card Analogy for Project Evaluation

The Project Evaluation System can yield a mathematical maximum score of 400. Such a score is practically impossible, even for a “perfect” project since some of the parameters of evaluation tend towards mutual exclusivity. However, the concept of achieving a score would facilitate using a report card system like that used in academia. It would even be possible to grade the projects evaluated “on a curve”. The problem with this approach is that it could unfairly represent those projects that received scores on the low end of the scale as “barely passing” or even “failing” when, in fact, all of the projects evaluated in this study were chosen on the basis of their positive merits and contributions to the Agenda 2020 program. Any score, including a low score, must be interpreted within the context of the evaluation parameters. It is possible for some projects to be remarkably successful and still receive a low score because some of the parameters for evaluation simply don’t apply to that particular project. Because of the potential for misinterpretation and confusion, the report card system was also abandoned for this project.

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Appendix E

Individual Project Rating Sheets

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01-785 Multiport Cylinder Dryer

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 0	Weighted Rating 0	Not applicable.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 5	Weighted Rating 45	Because this technology addresses the largest energy usage in papermaking and it will be retrofitable to existing machines, the market includes the entire paper machine installed base plus the new machine market as well. Technology is transferable to drum drying applications in other industries. (Boric acid, powdered milk, other powdered or granular slurry operations.)
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 2	Weighted Rating 16	Technology deals with increasing the heat transfer and ultimately allowing drying at higher machine speeds. Energy consumption per ton is unaffected. Motive power consumption will be reduced because of removal of "rimmed" condensate from the system.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 5	Weighted Rating 40	Economically attractive for two main reasons 1) the retrofit cost is estimated to be approximately 20% of new cost. 2) the higher heat transfer allows several options - a) running the machine at higher speed, b) reconfiguring the machine with fewer dryer cylinders and using the space for a longer press.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 2	Weighted Rating 14	
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	Design of lighter weight cylinders having no pressure vessel requirements.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 1	Weighted Rating 7	
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	Not applicable.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 5	Weighted Rating 30	Project is very low risk. Device will be retrofitable to existing dryers at a reasonable cost, estimated to be about \$10k per cylinder.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 0	Weighted Rating 0	Not applicable.

Totals

27 201

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02-933 Methane DeNox

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 10	Raw Rating 0	Weighted Rating 0	Not applicable.
2	Size and extent of market for the new technology	Very Small 0	Small 1	Medium 2	Large 3	4	5	CTO Weighting 9	Raw Rating 3	Weighted Rating 27	There are very many boilers that could use this technology but competing technologies may be able to fill the function without trying something new. This is apparently not a single compelling new technology that trumps all others. Also many locations are not under pressure to deal with NOX and CO simultaneously as this system can do.
3	Energy performance	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 8	Raw Rating 3	Weighted Rating 24	Increased ability to use biomass and maintain consistent steam supply. Ability to reduce excess air by approximately half, with benefits in reduced electrical load from FD and ID fans resulting in lower volumes of stack gases and lower firebox velocities helping to achieve more stable and efficient combustion.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	Attractive 2	Highly Attractive 3	4	5	CTO Weighting 8	Raw Rating 5	Weighted Rating 40	Low capital cost and ability to retrofit to most stoker boilers have lead to paybacks less than 1 year at Cogentris Power boiler operations. May eliminate the need for future control devices to limit Nox emissions. Installation can recovery energy form waste materials while eliminating the disposal cost of the waste materials.
5	Technology champion	None 0	Assigned Champion 1	Independent Champion 2	Multiple Champions 3	4	5	CTO Weighting 7	Raw Rating 1	Weighted Rating 7	Very enthusiastic PI. The industry interest is from mild to moderate.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Knowledge of 3- stage combustion process, including design and operational insights covering how to balance the combustion process across the three stages. Knowledge that non-condensable gases can be use in place in some of the natural gas thereby eliminating the necessity of incineration of these gases.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Lowered Nox with simultaneous control of CO. Potential obviation of the NCG incineration process by use of these gases in the De-Nox process.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 7	Raw Rating 1	Weighted Rating 7	Knowledge of combustion process.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	Not applicable.
10	Risk	High Risk 0	Moderate Risk 1	Low Risk 2	Very Low Risk 3	4	5	CTO Weighting 6	Raw Rating 5	Weighted Rating 30	Very low cost and quick payback as well as no extra downtime for installation and ability to revert to previous operational methods make this a very low risk project
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 5	Raw Rating 5	Weighted Rating 25	Greatly improves the ease of using biomass fuels. BC Int'l Falls tripled their ability to use mill sludge as a fuel.

Totals

31 216

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

03-993 Gasification Group of Projects

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 2	Weighted Rating 20	The ability to separate and direct pulping liquor into qualitatively different components and use appropriately can result in a 5-10% yield improvement in the pulping process. This has some significance to the Sustainable Forestry efforts because it lowers the required annual harvest.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 5	Weighted Rating 45	There are 13 soda mills and 200 Kraft mills that are candidates for this technology. Gasification itself also has high potential to move into other industries as well.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 5	Weighted Rating 40	Energy consumption for chemical recovery in soda liquor mills will go from a negative to a positive with the production of the gas that can be used for fuel, eliminating the current need for purchased auxiliary fuel. The Kraft liquor process will also have significant positive energy benefits from the fuel gas production. Gasification success in black liquor and biomass combined with combined cycle generation can move the industry from a consumer of electricity to a net producer of electricity generating a net 5-20 gigawatts in excess of consumption.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 4	Weighted Rating 32	Although the development of this project is high risk, success demonstration of the process will make the gasification option the preferred chemical and energy recovery method for the industry. The recovery boiler replacement or life extension projects will eventually all go to gasifier installation projects without mandates or government incentives.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 5	Weighted Rating 35	PI indicates there are multiple "champions" for this technology.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 5	Weighted Rating 35	Multiple insights will be developed.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Compared to BL recovery boilers, the gasification units will be superior in the areas of particulate emissions, sulfur emissions, and carbon dioxide emissions.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 5	Weighted Rating 35	Replacement of Recovery Boilers in the next two decades will be higher in NA than in other parts of world. Replacement with BLG units will result in lower capital, lower emissions, lower energy and be safer and easier to maintain and operate.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 1	Weighted Rating 6	There will be some benefit from the ability to recycle waste products into fuel with the gasification process on biomass. Mill sludge is a potential example.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 1	Weighted Rating 6	Although there are significant developmental risks with this project, success in this effort will have major nationally significant benefits for the country and the pulp and paper industry.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 5	Weighted Rating 25	Gasification of the lignin into a usable, multipurpose, transportable fuel makes the biomass energy available on a broader scale of uses. E.g. electric power generation with gas turbines or reciprocating engine generators, direct mechanical power from gasifier fuel in turbines or reciprocating engines, waste heat recovery boilers downstream of generating units.

Totals

42

307

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

04-1110 Intermediate Sized Entrained Particles

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 0	Weighted Rating 0	Not Applicable.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 5	Weighted Rating 45	Technology affects every recovery boiler and can significantly improve the operation and availability of recovery boiler operations at all installations.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 3	Weighted Rating 24	Estimated savings (2030) are 93 trillion BTU's. Energy savings come from reduced power boiler demand for high-pressure steam for soot blowing. Co chair believes energy benefits probably overstated.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 2	Weighted Rating 16	Economic attractiveness is high because the technology will increase the availability of the recovery boilers and will allow mills to avoid major capital expenditures to resolve mill production limits resulting from recovery boiler capacity limits.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	None identified other than those in project.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	Identification of particle sources and understanding of development of the particles contributing to these intermediate sized entrained particles.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	2.3 MMTCE displaced (2030) resulting from the reduced emissions because of lower steam requirements. Co-chair believes energy benefits overstated and the GPRA environmental benefits come primarily from the lowered energy requirements which would cause the GPRA environmental benefits to be overstated also. However, because some of the intermediate-sized particles can deteriorate into smaller particles, the GPRA data may not fully recognize all the environmental benefits.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	Work in this area is not exclusive to US efforts. VTT (Finland) is working on it and the PI will be using a probe developed by VTT. Because of the older recovery boilers found in the US, success in this area will be closing a competitive gap that currently exists. (Offshore mill are not as likely to be recovery boiler limited because of the generally younger age of offshore recovery boilers.)
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	Not Applicable.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 3	Weighted Rating 18	How this technology will be commercialized is not yet known. However, the probable modifications to the boiler peripheral equipment should be minor compared to the cost of expansion projects or replacement/life extension of recovery boilers.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 0	Weighted Rating 0	Not applicable.

Totals

26 194

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

05-1166 3-D Characterization of Structure

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 1	Weighted Rating 10	Optimizing the fiber in the refining processes can significant fiber in the tissue and towel production.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 4	36	All paper production is a market for the knowledge to be developed in this project. Devices that might be developed to routinely investigate the internal structure have a more limited market.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 3	24	Success characterizing the structure and in subsequent research on ways to make paper that releases water more rapidly will provide substantial energy benefits but this "enabling technology" itself is of minor energy significance.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 3	24	
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 4	28	Interest in knowledge to be developed is widespread but tempered by the realization of the difficulty of translating the knowledge into practical process that will materially affect paper production methods.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 5	35	Knowledge of the internal structure will allow correlation of structural properties with observable and measurable properties of the paper. That knowledge will enable work into identifying and controlling variables that alter the structure.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 1	7	Indirect connection to possible changes in pulp and paper processes could reduce environmental impacts by lowering energy requirement or perhaps water requirements.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 5	35	This technique will be an enabling technology to allow efforts in "designing" desirable physical properties into the sheet and developing methods to manufacture sheets meeting the desired design specifications.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 4	24	Ability to determine differences in recycled product from the structure of non-recycled product is very significant.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 1	6	This is a speculative investment in research. Low risk that the internal structure can be examined, but riskier than it can be meaningfully quantified and that correlation with process variables can be identified.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 0	0	Not applicable.

Totals

31 229

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

06-669 High Efficiency ClO₂ Delignification

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 0	Weighted Rating 0	Not applicable.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 5	Weighted Rating 45	This research is highly important to the bleached Kraft paper business.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 2	Weighted Rating 16	Limited energy benefits, deriving from shorter bleach stage cycles and indirectly from reduced demand for and, consequently, lower production of ClO ₂ .
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 4	Weighted Rating 32	Very attractive to mills that are adding bleaching capacity. PI (McDonough) believes a rapid D ₀ stage might cost only \$1-2 Million as compared to \$30-45 million for alternatives.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 2	Weighted Rating 14	PI considers himself a long time champion for this technology. He has engaged in dialog with two different companies about projects to incorporate the technology.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 5	Weighted Rating 35	Understanding, at the molecular level, of the fundamental mechanisms of ClO ₂ delignification and interactions of phenolic hydroxyls, beta-o-aryl ethers and hexenuronic acids.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 2	Weighted Rating 14	Research will lead to lower usage of ClO ₂ and consequently lower formation of AOX.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	Research team confirmed earlier Scandinavian research on hexenuronic acids.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 2	Weighted Rating 12	Some significance to recycling of OCC which can be upgraded by bleaching.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 4	Weighted Rating 24	Research project was successful. Commercialization of rapid D ₀ stage poses little risk. There could be unknowns that might be uncovered in a scale-up effort but they are thought to be small.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 0	Weighted Rating 0	Not applicable.

Totals

29	213
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FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

07-685 VOC Control in Kraft Mills

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 0	Weighted Rating 0	Not applicable.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 3	Weighted Rating 27	If commercialized, the, membrane technology could be widely applied to VOC/HAP problems. The technology works on methanol, the predominant component of the gas phase in the pulp and paper emissions, as well as on the other, higher molecular weight VOC/HAP emissions. Large potential market limited by cost. PI of membrane research doesn't think it will go anywhere unless something else forces it.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 2	Weighted Rating 16	Paper companies are under mandates to control VOC and this technology, while beneficial to identifying the sources, will be most useful in sizing control devices rather than directly contributing to the amelioration of the problem.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 1	Weighted Rating 8	The use of the software in the model is attractive and is currently being used. The use of membrane technology to remove methanol is unattractive. The economics are location dependent but in most cases the value of methanol recovered does not warrant a switch to this technology.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 0	Weighted Rating 0	None identified.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Development and validation of the model to predict the generation of VOC.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	GPRA numbers for environmental benefit seem low for a project that ultimately could be used in the control of most of VOC/HAPs from the pulp and paper process. However, manufacturers are already under regulatory requirements to control these emissions and are doing so with other technologies. Consequently, the net environmental benefit is not as great as might be initially imagined.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Development of the VOC/HAP emission model software.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	Not applicable.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 3	Weighted Rating 18	Model development successful. Use of the model can be a way to reduce risk by developing control measure design specifications that are properly designed and sized for the VOCs being controlled. Risk in the use of the membrane separation technology is a moot question.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 1	Weighted Rating 5	The analytic methods developed in this project would be applicable to modeling emissions from other processes that might be used on biomass.

Totals

21	151
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FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

08-687 Low VOC Drying of Lumber and Wood

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 0	Weighted Rating 0	Not applicable.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 5	Weighted Rating 45	VOC control in solid wood product production is a large potential market. Technology for lumber drying operations has not been commercialized. If successful and economical, this technology could be widely applied.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 1	Weighted Rating 8	Use of low-pressure steam will drive off VOCs at lower temperatures in a more concentrated fashion. Collection or destruction of the VOCs still must be accomplished.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 3	Weighted Rating 24	Installation of unit in Maine at 1/3 of cost of RTO is an attractive alternative to the conventional RTO installation and operation of an RTO.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	G-P (Lawrence Otwell) is champion for this project.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 5	Weighted Rating 35	Timing of emissions during the drying and pressing cycles.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 5	Weighted Rating 35	Technology will facilitate control of VOCs and HAPs from solid lumber operations.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 1	Weighted Rating 7	Since work on lumber application has been discontinued, the application of this technology is limited to the wood panel industry. Incremental benefits are expected over current technology although the economics may be better.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	Not applicable.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 3	Weighted Rating 18	Low risk to technical success in research. Risk to commercialization depends on economics, which is thought to be low.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 0	Weighted Rating 0	Not applicable.

Totals

26

193

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

09-941 Mill Designed Bio-Bleaching Technologies

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 4	Weighted Rating 40	Technology can increase yield by being able to de-lignify higher Kappa number pulps which will allow shorter digester times resulting in higher pulp yields and reduced harvest demand.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 5	45	Applicable to all bleached Kraft operations.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 4	32	Reduction in process time in the digesters. This will use less energy while giving a higher pulp yield with a higher Kappa number, which can be effectively de-lignified with the LMS process. Technology also allows the elimination of a bleaching stage, either O ₂ or 1st stage of D ₀ stage. LMS operates at lower temperature and at lower pressure.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 5	40	This offers an alternative bleaching process with a low capital requirement and low operating expense. No major capital expenditures are required to implement. Economic benefits will be higher pulp yield, lower water usage with reduced chloride/AOX/COD in bleach effluents.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 3	21	Enzyme manufacturers.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	28	Development and validation of the model to predict the generation of VOC.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	21	Reduction of Chlorides/AOX and COD levels in the bleach plant effluents. Indirect benefits in reduced energy at the digester from lower cycle times and in the production of ClO ₂ .
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	21	Paprican, NC State and Hercules are working on this but IPST has demonstrated the pulp yield benefits.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	0	Not Applicable.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 4	24	Research project: Some concern is finding the most cost efficient mediator. Commercialization: The technology poses little risk to operations since it can be initiated with almost no capital and does not require abandonment of current practices. Some operational risks inherent in Kraft pulp mills are reduced since process runs at lower temperature and pressure and has less chloride/AOX/COD in the effluents.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 1	5	PI and Co-PI believe that there may be a good possibility that these methods can lead to a process of direct production of electricity from biomass.

Totals

36 277

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

10-961 Water Removal Using Hydrogels

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 10	Raw Rating 0	Weighted Rating 0	Not applicable.
2	Size and extent of market for the new technology	Very Small 0	Small 1	Medium 2	Large 3	4	5	CTO Weighting 9	Raw Rating 2	Weighted Rating 18	Group co-chair expressed concern that the economics were not sufficiently developed to interest the industry in this technology. If successful and further developments indicate that the economics are attractive, all chemical pulping mills should be potential users of this technology. Presently, this technology seems limited to side-stream applications.
3	Energy performance	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 8	Raw Rating 4	Weighted Rating 32	Use of hydrogels could save large amounts of energy being used at evaporators. While this project is focusing on only the three areas listed, any low-cost, effective means to remove water in the liquid phase thus avoiding evaporation is at least moderately significant. This technology could be highly significant if the hydrogels can be used in some larger energy-intensive water removal applications.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	Attractive 2	Highly Attractive 3	4	5	CTO Weighting 8	Raw Rating 2	Weighted Rating 16	The PI's example estimates an annual cost of \$20,000 to use hydrogel to remove 400 gallons/minute of water from a 500-gallon/minute stream. This works out to about \$0.10 per thousand gallons of water removed—which would represent large savings in energy as well as money. However, the economics have not been developed sufficiently and more work is necessary in this area before affirming this conclusion.
5	Technology champion	None 0	Assigned Champion 1	Independent Champion 2	Multiple Champions 3	4	5	CTO Weighting 7	Raw Rating 0	Weighted Rating 0	None.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	Knowledge of how to design a fast acting hydrogel. Understanding of the effects of salts in black liquor on hydrogel performance.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	This basic research will be important in achieving a "closed mill" with recycle water. This first step has identifiable environmental benefits in (1) not having to evaporate 80-90% of the water as currently required before waste lignin can be burned, or (2) reducing stream volume to treatment plants.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	This is a new application of this technology to the industry and PI is not aware of other work being done in hydrogel applications for pulp and paper.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 6	Raw Rating 1	Weighted Rating 6	Can be used in de-inking applications. May be an alternative to current methods or a supplement to current technology in recycle mills.
10	Risk	High Risk 0	Moderate Risk 1	Low Risk 2	Very Low Risk 3	4	5	CTO Weighting 6	Raw Rating 2	Weighted Rating 12	PI can't envision any unknowns to completing the research successfully. Risk to commercialization are minimal, since the technology would be a scalable add-on initially that would not require abandoning existing processes or equipment. Since Dr. Gupta's hydrogel is not commercially available yet, the issue of who will manufacture it and how it will be priced represent some small risk to commercialization.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 5	Raw Rating 0	Weighted Rating 0	Not applicable.

Totals

20 147

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

11-1150 Use of Residual Solids in Concrete

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 0	Weighted Rating 0	Not applicable.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 2	Weighted Rating 18	The potential market for fiber reinforced concrete is large but penetration will likely be slow due to the fragmented nature of the ready-mix industry and the reluctance to try new technology.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 1	Weighted Rating 8	The energy savings as described in the proposal claims that the new "sludge" reinforced concrete will last longer and ultimately will not require replacement as frequently. These energy "benefits" are questionable since they will come only as fewer replacement yards of concrete are needed in the future because of a longer life of the fiber reinforced concrete.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 4	Weighted Rating 32	Minimal Capital required. Assuming a reasonably low price to ready-mix plants (approximately the same as disposal cost ~\$35/ton) the cost to furnish fiber reinforced concrete would not be much greater than non-fiber reinforced concrete. The longer life of the product might allow ready-mix concrete producers to compete more effectively with asphalt producers for government paving jobs.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 0	Weighted Rating 0	None.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	Breakthroughs in first year. (1) % of sludge material to maximize concrete strength; analysis of properties of concrete made with paper mill sludge; (2) confirmation that sludge components do not interfere with or degrade concrete.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	Based on the assumption that this fiber reinforced concrete will ultimately result in decreased need for new concrete in the future, fewer tons of cement (at 6x106 BTUs per ton to produce and 1 ton of CO ₂ released per ton of cement produced) would be produced. Also, lesser amounts of sludge would be sent to solid waste disposal sites.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 2	Weighted Rating 14	Concept is not new although use of paper mill sludge could provide a good synergistic solution to the need for fiber reinforcement and the problem of disposing of the sludge.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 4	Weighted Rating 24	Paper mill sludge used as fiber reinforcement for ready-mixed concrete.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 1	Weighted Rating 6	Essentially no risk to success of the research. Risk in commercialization is variable sludge characteristics and quantities and lack of interest by the various paper companies in providing a consistent supply of sludge. PI mentioned a similar issue with the use of fly ash in concrete. Fly ash was first used over 60 years ago and yet some producers of fly ash still throw theirs away rather than selling it to concrete producers.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 0	Weighted Rating 0	Demonstration that wood fibers can be successfully used for concrete could lead to other fibrous biomass products that might be used in concrete.
Totals								20	144		

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

12-1151 Low Temperature Plasma Technologies for Treating VOC Emissions

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 0	Weighted Rating 0	Not applicable.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 5	Weighted Rating 45	Technology applicable to higher volume, low-concentration airstreams (concentrations less than 3000 ppm). Applicable to many industries as well.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 3	Weighted Rating 24	Quarterly report indicates lower energy requirements than RTOs because the destruction mechanism is not heat but low temperature plasma containing radicals (OH) that react with the organic pollution molecules in the air stream. Will obviate the use of natural gas or other purchased fuel for RTOs on high volume, low-concentration airstreams.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 4	Weighted Rating 32	Capital cost is expected in the range of 30-50% of the capital cost for an RTO with an additional operating cost advantage on concentrations below 3000 ppm.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	G-P has stated they would like to have all field tests done at G-P facilities. NCASI has planned to involve other companies in the project.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Ability to grow field quickly and to be able to pulse the plasma generation device at 1KHZ in 100 nanosecond bursts.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 5	Weighted Rating 35	Provides way to economically treat low concentration airstreams and destroy VOCs with low energy usage.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	This work is not the only effort in this area but is a leader in the low temperature plasma work.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	Not applicable.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 3	Weighted Rating 18	Low risk to project success. Low scientific risk in commercialization. Some risks in adapting technology to industrial environment (ruggedness, technological support).
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 1	Weighted Rating 5	May facilitate the use of more material that would emit naturally occurring VOCs and HAPs. Could perhaps be used on biomass piles.

Totals

32

236

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

13-1152 Control of Emissions from Wood Waste Burners and Wood Dryers

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 0	Weighted Rating 0	Not applicable.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 4	Weighted Rating 36	Applicable to a wide area of the forest products industry. Suspension burning is common in the forest products business.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 2	Weighted Rating 16	This research will facilitate the continued use of wood waste fuels and save fossil fuels that might otherwise be used to replace renewable wood fuels.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 4	Weighted Rating 32	Application of the knowledge gained from this research promises to be relatively easy to implement at low cost.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 2	Weighted Rating 14	None specifically identified although Co-chair indicates that there is wide interest in this project.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	Knowledge of combustion and how to control suspension burners to minimize generation of NO _x . Co-chair described this project as "really important work".
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Wood waste burners are responsible for a significant fraction of the NO _x emitted from burning of industrial wood wastes. PI states that NO _x emissions can be controlled to less than 100 ppm. This will be significant to enable the increased use of waste wood fuels.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Co-chair described this work as "superb". Little other work being done in this area.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	Not Applicable.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 3	Weighted Rating 18	PI states risk is mid range. Risk to application is more social/cultural than technological. Potential hardware changes to control fuel injection and air patterns are relatively easy to accomplish.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 3	Weighted Rating 15	This will facilitate increased use of biomass as a fuel.

Totals

29 208

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

14-1154 NPE Removal Using Functionalized Monolayers on Mesoporous Supports

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 0	Weighted Rating 0	Not applicable.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 2	Weighted Rating 18	Market is bleached paper. Co chair expressed concern about material plugging the media and has doubts about reaching commercial readiness because of the nature of industrial environment. Project manager pointed out that the system, to be effective does not have to remove all the NPEs, only to keep the concentration below the scaling limits. This is important technology for bleach plant operations. Test unit that has been designed is portable and will be used in field trials as a "side-stream" filtration system.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 4	Weighted Rating 32	Provides an alternative to energy intensive methods for controlling buildup of NPEs.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 3	Weighted Rating 24	Capital equipment cost will probably be reasonably low with the exception of the media itself. PIs are unsure of the ultimate cost of media until a manufacturer is identified. Media will have a much longer life (indefinite) as compared to classic ion exchange on an organic media which breaks down.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 1	Weighted Rating 7	Interest on part of Weyerhaeuser and other companies, but no strong "champion" yet identified.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Insights into the industrial application of SAMMS.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 5	Weighted Rating 35	Project will facilitate the adoption of a closed loop bleach plant with the elimination of discharge streams that are environmental concerns.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 5	Weighted Rating 35	PNNL is the leader in this technology. This project is a marriage of previous scientific breakthroughs in SAMMS technology.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	Not significant.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 2	Weighted Rating 12	PI believes there is little risk to completion of research. One hurdle to commercialization is finding an industrial partner that can manufacture the media.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 0	Weighted Rating 0	Not applicable.

Totals

26	191
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FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

15-None Effects of Fertilization and Competition Control

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 5	Weighted Rating 50	The main benefit from the study in regards to sustainable management will be in more per unit area production by either generating more fiber from a given land base and time period or by shortening harvest rotations through accelerated growth.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 4	Weighted Rating 36	PI believes that carbon sequestration and the ability to manipulate the allocation of carbon will generate broad interest in the research. Preliminary results have shown that both competition control and fertilization can increase growth rates but competition control tends to cause carbon allocation in the bole of the tree more than in other parts of the tree in Slash. PI believes that this will be true in Loblolly as well. Co-chair perceived that the market impact would be great for this technology.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 3	Weighted Rating 24	Some indirect energy benefits can be realized through more efficient use of fertilizers and herbicides. More carbon (biomass) can be accumulated through increased growth.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 4	Weighted Rating 32	The proper timing and rates of application for competition control and fertilizer to obtain increased growth are the driving forces behind the economic attractiveness to industry. Competition control and fertilization give similar results in different ways. Understanding these differences and proper use of competition control and fertilization will make the use of the improvement practices more economically attractive.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 5	Weighted Rating 35	Nine industry collaborators have endorsed the project. Some companies have been purchased and consolidated, but all of the original collaborators are still behind the project and PI has received good feed back from the collaborators. Co-chair indicated that there are wide interests in the research with most industrial companies.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	The major scientific insight that will result from the research will be in determining the relationships between biological mechanisms and growth enhancements. This could be a relationship that applies to other tree species and other plant species. A paper in the latest quarterly report addresses the scientific insights from the research.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	Improving the efficiency of nutrient utilization will require less nutrients per unit of growth and can reduce the amount of fertilizers needed. Increased growth will also aid in carbon sequestration.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 2	Weighted Rating 14	According to the PI, no new major technologies are anticipated from the research. Understanding nutrition requirements can make existing technologies more efficient.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	This research does not apply to recycled wood and paper.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 5	Weighted Rating 30	When data is published on expected yield increases from proper timing for competition control and fertilization, then a more accurate risk/benefit analysis can be made. The potential for substantially improved growth rates in plantation timber makes the speculative risk seem small considering the approximately \$250,000 research investment. Co-chair thought that this project progressed well with good results and deserved a high ranking overall.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 2	Weighted Rating 10	Although the research could lead to increased quantities of biomass, the research does not address alternative uses for biomass.

Totals

37	280
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FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

16-677 Model-Based Diagnosis of Soil Limitations

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 4	Weighted Rating 40	The benefits to sustained resource management from the research will be in being able to model nutrient utilization and soil limitations and thus implement activities to reduce soil limitations to tree growth. This will increase the yield of fiber from a given land base through more productivity.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 3	Weighted Rating 27	The two primary models that are being developed are for Loblolly pine and Douglas fir. These two species constitute a large percentage of industrial forest plantations. Decision guidance models will be made available via the world wide web so access to the research will be readily available to timberland owners. The usefulness and the applicability of the models to a large audience may be limited.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 2	Weighted Rating 16	Increases in fiber production could make more biomass available as a fuel source. Increasing nutrient utilization efficiency could result in more efficient utilization of fertilizers, which will make the fertilization process more energy efficient.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 3	Weighted Rating 24	The ability to increase site productivity and enhance the efficient utilization of fertilizers in loblolly pine and Douglas fir could produce appealing economic benefits for timber producers.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	There are four sub-recipient institutions, (Desert Research Institute, Texas A&M, University of New Hampshire, University of Washington), four industry collaborators (International Paper, The Timber Company, Potlatch, and Weyerhaeuser), and the North Carolina State University Forest Nutrition Cooperative that are involved in the research. According to the PI, there is widespread support for the research. According to the co-chair, industry support is not very strong.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 2	Weighted Rating 14	This research could lay the groundwork for additional research and advancements in site preparation and fertilizer formulation technologies. However, much of the research, according to the co-chair, is based on existing climate and soils data.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	Increased productivity resulting from more efficient utilization of nutrients can result in less land base required to meet productivity requirements. Higher plant growth rates result in more carbon sequestration. More efficient uptake of nutrients could also result in less nutrient leaching and runoff.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	PI indicated that this research was leading edge in this area and that it was much needed to understand the relationships of trees and nutrient utilization. Co-chair stated that some good results were generated early on but that project currently needs direction.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	This research is not specifically related to recycling.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 5	Weighted Rating 30	The potential benefits that could result from this and future related research projects are quite substantial compared to the developmental risks. Co-chair suggested that this research might be able to be tied-in with the module for the effects of fertilization and competition control.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 2	Weighted Rating 10	Although the project does not specifically address alternative uses for biomass, it does address issues that could enhance the production of biomass. Co-chair suggested that this research might be able to be tied-in with the module for the effects of fertilization and competition control.

Totals

30 224

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

17-681 Marker-Aided Selection Methods

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 4	Weighted Rating 40	The ultimate impact of the research will be mostly process related in the pulp industry with manipulation of cellulose and lignin allocation within trees. This will result in higher yields and less inputs to the process. Ultimately, the results will be more useable fiber from the given land base. From a fiber quality standpoint, the microfibril angle in wood can be linked to certain genes. Modifying traits could allow wood quality properties to be improved as well. End result... more useable, higher quality fiber from a given land base.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 3	Weighted Rating 27	This particular research was geared more towards pulp and paper and bio-fuels. The research is foundational in nature to other research that could lead to much larger market impacts.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 4	Weighted Rating 32	As reported with the nitrogen allocation project (OTIS 758) this research could lead to substantial shifting of cellulose/lignin allocation within trees which could be beneficial from an energy standpoint to pulping, bleaching, and bio-fuel production.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 4	Weighted Rating 32	PI had not performed any economic analysis on the project. The potential for yield increases both in the forest and at the mill provide the basis for an attractive scenario to industry for developing transgenic trees that utilize some of the knowledge gained from the research.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	The University of Washington was a collaborator on the project as well as the US Forest Service. Boise Cascade and Weyerhaeuser were industry collaborators. All participants were involved from beginning to end. Weyerhaeuser and USFS seemed to show the most interest in the project. University of Washington worked to develop a genetic map.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	PI believes that this research could be beneficial to other researchers as they study different species. Information is already being requested from other researchers as they are involved in new studies.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	PI reported that implementation of the research findings in the pulping process for this particular research could result in a 10% reduction in chemical use for fiber from transgenic trees. Other benefits could also result from research stimulated from these research findings.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	PI felt that this research was leading edge research in the area of identifying the function of specific genes in trees.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	This research did not specifically address recycling.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 5	Weighted Rating 30	The potential benefits directly from this research as well as future discoveries that may be derived from this research are estimated to be relatively high compared to the research investment.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 3	Weighted Rating 15	This research could lead to methods for producing bio-mass with greater fuel properties.

Totals

39	288
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FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

18-758 Molecular Physiology Allocation in Poplar

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 5	Weighted Rating 50	The driving benefit to sustained resource management is in being able to produce higher yields or shorter rotations for a given unit of land as the result of more efficient utilization of nutrients through transgenic trees. Opportunity also exists to improve or design wood qualities through genetic manipulation of carbon allocation to either cellulose or lignin.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 3	Weighted Rating 27	Research was performed on hybrid poplars because they are relatively easier to genetically manipulate than species from the pine family. Poplars are riparian species that are subject to sudden doses of nitrogen through flooding. Poplar leaves can have as high as 10% N by weight which compares to alfalfa. In comparison, Pines have approximately 1% to 2% N by weight. This research applies to poplars, which could be a substantial market in pulp and paper. Evidence of pines being photosynthetically inefficient indicates that opportunity for great advances exist in pines and the market for pines is huge. International Paper will develop the transgenic poplar specie and pine research should follow although not a part of this project.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 4	Weighted Rating 32	Creating nitrogen fertilizer (Urea) requires great amounts of energy (30,200 BTU/LB) and typical historical application rates are approximately 200 LB/Acre. New application rates could be as low as 100 LB/Acre, which could decrease energy use for N production by one-half. Working with genes to allocate more carbon to cellulose rather than lignin can result in less energy required to digest pulp and less chemical use as well.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 4	Weighted Rating 32	PI reported that average pulp mill uses 4.7MMBTU/Ton for pulping and 7.5 MMBTU/Ton for bleaching. Estimates for energy reduction for 10% carbon allocation to cellulose rather than lignin are 10% reduction in BTU requirements. For every 1/100% of US raw materials from transgenic trees there could be a 6.6 billion BTU/year energy savings.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	International Paper (Union Camp) was the original industry collaborator. Washington State University was a sub-recipient on the project and their task was to perform a field trial on the transgenic trees developed by Union Camp. It was determined that the Union Camp trees were not transgenic and the WSU work was not needed. Daniel Caraway with International Paper has been a good industry contact and has helped with the project.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 5	Weighted Rating 35	Biologists are interested in the question of fundamental allocation relationships in plants and this research has provided more information in that area. Carbon/nitrogen balance and productivity within plants has attracted the attention of other scientist to this research. There is also widespread interest in zylem and vascular development that this research could provide some fundamental pathways to further research. Evolutionary biologists are also interested in the research from the standpoint of how plants adapt to certain environments.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	PI stated that environmental performance is a key issue regarding most all genetic research and stated that this type of research could be shut-down by political and social issues. The scientific consensus on genetic research in trees is that it has no more risk than hybrid breeding but that caution should be taken. The goal of the research is to provide meaningful alternatives that are subject to scrutiny before implementation. This particular genetic research has very little negative environmental impact in contrast to arguments that might be made about insect resistant trees that could result in the decline of some insects. However, PI stated that even disease and insect resistant trees were much more environmentally friendly than herbicides and pesticides. Trees with more growth will provide more carbon sequestration because they will be stronger CO2 sinks. Poplars that act as stronger nitrogen sinks can be used as nitrogen barriers to protect/restore aquifers and watersheds from nitrogen leaching. This could also help in preventing nitrogen leaching from organic fertilizers.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Bio-technology as a whole has high probability for producing breakthrough technologies. This research has discovered new genes and has prompted work on gene expression arrays. PI feels like that this research is on the leading edge of forestry research and is at least par with other biological research. He feels like a good indicator of this is in the quality of graduate students that have been attracted to the program.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	This research does not apply to recycled wood and paper.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 5	Weighted Rating 30	Although the total benefits to industry resulting from this research have not been quantified, the magnitude of the total potential benefits would appear to be quite large.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 3	Weighted Rating 15	The cellulose/lignin work could provide for better ethanol processes. Being able to shift more lignin production to bark could also create new, more valuable markets for bark. For example, PI referred to one study that is focusing on extracting resins from bark and using the resins to glue the bark back together as a panel product.

Totals

40

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FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

19-794 Dominant Negative Mutations of Floral Homeotic Genes

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 5	Weighted Rating 50	Eventually, the ability to utilize the sustained resource benefits of transgenic trees could hinge on the ability to genetically engineer sterility into the trees. From the social and political standpoint of enabling the use of transgenic trees, the potential impact to sustained resource management from this research is huge. From a physiological standpoint, flowering and reproduction requires large amounts of carbohydrates. Genetically engineering sterility into trees could free more carbohydrates for merchantable fiber production.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 4	Weighted Rating 36	This research is being conducted on poplars. The process and methodology used to develop sterility in poplars can crossover into developing sterility in other angiosperms as well as provide a basis for the process in developing sterility in gymnosperms. The exact methodology will probably be limited to close species. The development of sterility in transgenic trees will ultimately influence a potentially huge market.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 2	Weighted Rating 16	As with sustainable management, sterility can be an enabling technology to improve energy for transgenic trees that can be designed to have better pulping qualities or more energy content.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 3	Weighted Rating 24	The economic attractiveness of the research is high because it is an enabling technology that may allow future advances and applications of genetically engineered trees.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 5	Weighted Rating 35	The research has several industrial collaborators... Alberta Pacific, Boise Cascade, International Paper, Potlatch, The Timber Company, Westvaco, Weyerhaeuser, and Aircruise Cellulose. PI reported that feedback has been good from collaborators. Co-chair stated that this research is very important to industry and it can have immediate impacts on applied technology.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 5	Weighted Rating 35	In order to speed the testing in the lab, the researchers have made advancements in promoting early flowering in the research plants. PI reported that this advancement is useful in the lab but it is inadequate for commercial applications at this time. Researchers are studying genes that could be used to stimulate early flowering. Co-chair indicated that the early flowering was a significant development.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	The driving force behind this research is to improve environmental performance of intensively managed plantations by genetically engineering sterility into transgenic trees to prohibit "genetic pollution" through pollen spread from transgenics. Although this technology has environmental benefits, its transgenics are developed. Some would argue that developing transgenics is an environmental risk.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 5	Weighted Rating 35	PI believes that this research is leading edge in the areas of trees and in other areas of plant study. Researchers are discovering phenomena that are not evident in annuals. Researchers in other areas have indicated interest in this research.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	This project does not specifically address recycling.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 5	Weighted Rating 30	Considering that the future of implementing transgenics into production could be directly related to the ability to produce sterile trees, the potential benefits of this research are great versus the cost of the research.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 3	Weighted Rating 15	This research does not specifically address alternative uses for biomass but it could have a big impact on the ability to utilize transgenic trees that are designed to be higher in lignin (fuel) content.

Totals

40

297

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

20-795 Pine Gene Discovery Project

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 5	Weighted Rating 50	Identifying the genes of loblolly is foundational to learning how all of the genes work in a tree. From this research it will be possible to understand and manipulate productivity in plantations and to understand productivity in natural forests. This is also foundational to producing trees with better quality. The implications of benefits to sustainable resource management from research that will build from the discovery of pine genes is enormous.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 4	Weighted Rating 36	This research could eventually have an influence on the entire wood products market worldwide. Fuel wood makes-up over one-half of the world's wood fiber use. Developing transgenic trees with higher fuel values could also greatly affect this market. Although this specific technology might not have a large market, it is an enabler to other technologies with huge markets.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 3	Weighted Rating 24	In a broad scale, this research could lead to ways to improve energy utilization from trees as a fermentation source (cellulose) as well as a direct energy source (lignin). Methods for increased yields and utilization, better pulping and bleaching qualities and various other energy saving benefits could build from this research.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 3	Weighted Rating 24	This research lays the foundation for a whole list of new developments that would be very economically attractive.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 5	Weighted Rating 35	Four industry collaborators (G-P, Rayonier, International Paper, and Westvaco) were initially involved in the research and the researchers continue to interact with representatives from all four collaborators. In addition to the original collaborators, companies from New Zealand, Japan, England, Portugal, and Brazil have expressed interest in the research.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 5	Weighted Rating 35	Research in genetics is growing and the gene catalogue is a fundamental element of the research. Through the DOE project, the PI stated that one of the most valuable insights learned was not scientific but was in how to manage this type of research project with multiple researchers in different locations.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	PI stated that the environmental risks associated with transgenic trees are greatly overstated. This research promotes an increasing rate of domestication in trees similar to what has been done in agricultural crops. As with agricultural crops, specialized trees cannot survive in a competitive environment outside the controls of the plantation. From a scientific perspective, transgenic trees offer advantages in environmental performance i.e., insect resistant trees versus pesticides and bottom nutrient utilization. However, there are scientific, political, and social issues mainly in the areas of bio-diversity and genetic "pollution" that pits transgenics against the environment.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	PI stated that this research team is the world leader in gene research in pines. Sweden leads in poplar gene research. New Zealand leads in Eucalyptus research and a new project is underway in Canada to perform gene research in spruce and poplar. PI also stated that there is also another DOE project to sequence the entire genome in poplar. Using the genome of arabidopsis as a basis, poplar has 5 to 6 times more genes, the human genome contains 20 times more genes and the pine genome contains 200 times more genes. Co-chair was complimentary of research team.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	This project does not address recycling directly. However, PI stated that recycling is inefficient, economically non-justifiable and could be eliminated through improvements with transgenic trees.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 5	Weighted Rating 30	According to the PI environmental benefits associated with transgenic trees greatly outweigh the perceived environmental risks. This research is foundational, pathway type research that establishes the basis for a vast amount of new research and technologies. The research is essential to further research in tree genetics.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 4	Weighted Rating 20	This research did not specifically address alternative uses for bio-mass but again, it lays the foundation for all kinds of future research to develop alternative uses for biomass

Totals

41

303

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

21-1481 Lateral Corrugator

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 1	Weighted Rating 10	The new lateral corrugator is projected to use 15% less fiber to achieve the same strength corrugated board. A 15% reduction is significant but the total production of corrugating medium coupled with the limited market for new corrugating machines limits the relevance of this project to sustainable forestry.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 2	Weighted Rating 18	Market overcapacity in corrugating medium severely limits both the new machine market and the replacement.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 1	Weighted Rating 8	Energy savings from producing fewer tons of corrugating medium (9.5 Mtons/yr.)
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 1	Weighted Rating 8	Market overcapacity in corrugating medium severely limits both the new machine market and the replacement.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 0	Weighted Rating 0	None. Project has lost its corporate sponsor.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 1	Weighted Rating 7	Knowledge of matching the strength properties of the paper with the construction design of corrugated containers.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 2	Weighted Rating 14	Assuming success in both research and commercialization, the corrugator would have minor environmental impact because of reduced production and lowered tonnage of post-consumer waste material.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 2	Weighted Rating 14	Development of higher stacking strength corrugated containers with 15 % less fiber consumption.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	Not applicable.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 1	Weighted Rating 6	Risks to the research success are technical problems of synchronous, high-speed material handling. The likelihood of commercialization is poor because there is no "market pull" under today's economy.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 0	Weighted Rating 0	Not Applicable.

Totals

11	85
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FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

22-1482 Improved Dryer and Press Efficiencies

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 10	Raw Rating 0	Weighted Rating 0	Not applicable.
2	Size and extent of market for the new technology	Very Small 0	Small 1	Medium 2	Large 3	4	5	CTO Weighting 9	Raw Rating 3	Weighted Rating 27	Universally applicable to the wood panel industry.
3	Energy performance	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 8	Raw Rating 4	Weighted Rating 32	Collection of VOCs and HAPs at specific times and sections in the drying and press cycles can result in lower energy requirements by concentrating the emissions and treating only the volumes with the concentrated emissions.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	Attractive 2	Highly Attractive 3	4	5	CTO Weighting 8	Raw Rating 5	Weighted Rating 40	Success in this technology will significantly reduce capital expenditures required to capture and destroy VOCs and HAPs.
5	Technology champion	None 0	Assigned Champion 1	Independent Champion 2	Multiple Champions 3	4	5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Lawrence Otwell, GP; others from industry.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	Knowledge of the timing of emission of VOCs and HAPs is new and important information.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Technology will simplify and reduce size of compliance devices. Will reduce capital required to construct and recurring expense to operate the smaller devices.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	Knowledge in this area has been used to support the development and adoption of the new Production Based Limits approach to emissions control in the industry.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	Not applicable.
10	Risk	High Risk 0	Moderate Risk 1	Low Risk 2	Very Low Risk 3	4	5	CTO Weighting 6	Raw Rating 4	Weighted Rating 24	Fairly low risk of project failure. A lot of progress has been made. Since the budget is less than a million dollars, if only one plant is able to avoid installation of an RTO or can reduce to size of the control device substantially, then this will be a big financial success.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 5	Raw Rating 0	Weighted Rating 0	Not applicable.

Totals

30 221

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

23-1483 Directed Green Liquor Pulping

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 5	Weighted Rating 50	4% increase in pulp yield contributes significantly to sustainability efforts by lowering required annual cut to sustain current pulp and paper production levels.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 5	Weighted Rating 45	All Kraft mills are candidates for this technology. GPRA calculated energy savings on only those mills that require bleaching since the elimination of a bleaching is the point of the electrical energy savings. However, the pulping benefits are not limited to the bleached mills.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 3	Weighted Rating 24	Energy savings are estimated for bleached mills based on the elimination a bleach stage. Commercialization success will probably hinge on process benefits rather than energy benefits even though they will contribute to the overall economics.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 5	Weighted Rating 40	4% yield increase and a 20-40 % pulp fiber increase with very little capital expenditure!
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Capital effectiveness co-chair states this is a very popular project among his industry contacts. PI has had companies indicate strong interest in adopting this technology.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	Beneficial effect of GL pre-treatment. How to economically get the benefit of directed green liquor pre-treatment.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 0	Weighted Rating 0	Increase in sulfur make increase odor problems.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	Although other work is underway in this area of research, much of it is proprietary. This effort will make the technology more widely available. IPSTs structure of industry advisory boards helps focus research efforts on critically important areas.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	Not applicable.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 2	Weighted Rating 12	Very low capital required - tank for pre-treatment of chip with green liquor chemicals. Corrosion is thought not to be a problem but has not been extensively investigated. Green liquor is known to increase the solubility of some iron compounds and adding the green liquor pretreatment could initiate some corrosion. Increased sulfur could be an odor risk issue.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 0	Weighted Rating 0	Not applicable.

Totals

30	241
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FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

24-1484 High-Capacity Gas-Fired Dryer

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 0	Weighted Rating 0	Not applicable.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 3	Weighted Rating 27	The potential market includes the retrofit market for the installed base (945) of paper machines and new orders for paper dryers. The estimated market penetration is 18% of this base. Market will be for machine speed-up project when machine is dryer limited.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 2	Weighted Rating 16	Moderate energy impact at best. Industry uses low-pressure steam for drying now, which recovers energy that has little other use. PI has not envisioned using a medium BTU gas from a gasifier. The gas would have to have a similar Wobbe index for the two gasses for BL gasifier gas to easily work. A plant energy balance for each location would be required to determine the economic viability of this for that location.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 3	Weighted Rating 24	Economics have not factored in competing energy resources. Manufacturing costs are undetermined. Fuel supply and installation cost of supply lines and equipment are assumptions. Interruptability issues need to be addressed.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 1	Weighted Rating 7	This is a project of limited interest even to the industry partner.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Success in this research could lead to understanding of dimple combustion technology and combustion air preheat and reach other industry applications through technology transfer. The expected improvement in thermal efficiency to 75% will be a significant achievement.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 1	Weighted Rating 7	Potential lower NOx production because the combustion is expected to take place at lower temperatures, however, this is a case of combustion replacing the use of excess steam for a net emissions generation increase.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Project could be significant in its understanding of dimple combustion but is not a break-through technology in paper drying or capital effectiveness. This technology could, however, find a niche in dryer-limited operations.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	Not applicable.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 3	Weighted Rating 18	Risk to successful completion of the research is not high but the risk of achieving commercialization is high. Competing technologies in drying need to rely on purchased fuel and to change heat source at existing mills, scarce capital dollars that all projects will compete for and modest level of benefits from this project make it unlikely to find wide commercial acceptance in the paper industry.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 0	Weighted Rating 0	Not applicable.

Totals

21	155
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FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

25-1485 Continuous Displacement Dewatering

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 0	Weighted Rating 0	Not applicable.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 5	Weighted Rating 45	All paper machines are candidates for this technology. Since the largest energy use in the industry is heat to dry water from the paper, this mechanical method will have large positive economic benefits which will enhance it market penetration.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 5	Weighted Rating 40	Process will increase solids at prior to the nip from approximately 40 % to nearly 60% - in effect removing by mechanical means one third of the water currently removed by the dryers. GPRA preparer took issue with Pls BTU / ton assumptions but in any event, success with this technology will have a highly significantly energy impact.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 4	Weighted Rating 32	Cost to build and install is unknown but PI believes this will be retrofitable to existing machines. The combination of this technology with the promise of the dryer efficiency research being conducted should allow relatively easy installation and providing higher speed capabilities through the dryers.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 5	Weighted Rating 35	High interest among the industry for this technology.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	Voith is willing to disclose providing some means of intellectual property protection is in place.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	1/3 less heat energy (for drying) required per ton will bring indirect environmental benefits - Lower CO2, particulate on solid fuel.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Mechanical means for removal of water is not new but this application and its potential benefits to the industry are a significant step forward.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	Not applicable.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 2	Weighted Rating 12	Project risk is lower after early successes in lab paper machine and lower pressures achieved 50% solids. Risk in scale-up issue and commercialization to potential owners is disruption of existing production facilities.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 0	Weighted Rating 0	Not applicable.

Totals

32	241
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FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

26-1486 Borate Autocausticizing

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 1	Weighted Rating 10	1-1.5 % pulp yield increase has been seen in the trials. Efforts are underway to confirm this yield increase can be repeated. Confidence is not yet high that other trial will see the yield increase.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 4	Weighted Rating 36	Given success with research and mill trials, process could become the standard causticizing method. No technical reason why 100% borate autocausticizing could not be used.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 3	Weighted Rating 24	Elimination of the lime kiln with attendant reduction of its energy requirements is the major energy benefit of the technology.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 5	Weighted Rating 40	Will allow capacity expansion of the furnace and digester with essentially no capital.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Charles Bair industrial partner representative. Mill personnel at mills where trials have been held.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Furnace decarbonizing reactions occur as predicted. Causticizing efficiency appears to increase. Borate may increase the efficiency of the pulping reaction. Less energy required for calcining.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 2	Weighted Rating 14	CO2 reduction from reduced fuel at the lime kiln.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Project will take concept and demonstrate that 100% autocausticizing, while possible is not required. Understanding and demonstrating the proposed stoichiometry of borate autocausticizing.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	Not applicable.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 5	Weighted Rating 30	Risk to research success is very low. Risk to commercialization also very low. Essentially no capital required. A mill can revert to its existing systems if any problems arise. Transition to use of borates can be gradual.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 0	Weighted Rating 0	Not applicable.

Totals

32

238

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

27-1487 Fast Curing of Wood Composites

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 0	Weighted Rating 0	Not Applicable.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 5	Weighted Rating 45	Universally applicable to panel and laminated wood product business.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 4	Weighted Rating 32	Benefit will be shorter press cycles and lower temperatures required for each cycle. Consequently, significant reductions in energy consumption will be realized.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 5	Weighted Rating 40	Since many mills are press limited, this will have the effect of de-bottlenecking the mill with out new capital. Further, since it is expected that there would be real, measurable reductions in Emissions, permitting to use the increased (de-bottlenecked) capacity can reasonably be expected. Since no "exotic" accelerators are anticipated, the glue cost should be a reasonable as well.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 5	Weighted Rating 35	Scott Johnson at GP, Roger Shantz at Weyerhaeuser, Ernest Hughes L.P. and John Huyck, Mead.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	According to PI(s) only about half of the story of resin chemistry is in the open literature. The commercial resin companies want more information on the overall polymerization process. PI believes they will develop this these scientific insights.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	Although environmental improvements are not the focus of this project, PI indicates that, because of the lower temperatures and shorter times required for each press cycle, there will be lower emissions in three forms. CO2 will decrease because of the overall reduction in energy consumption. VOCs and HAPs will decrease also because the press process will occur at a lower temperature.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	Composite wood studies work are going on at VPI and the University of Maine but the studies are unique in utilizing the Institute's NMR capabilities as a screening tool to identify the chemistry involved in curing UF and PF resin products and identifying new chemical technologies to improve the overall cure process.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	Not applicable.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 4	Weighted Rating 24	This is a low risk proposition. Essentially no capital will be required to adopt this technology at existing composite wood operations. Additionally, the process can be implemented on a trial basis to prove the attractiveness. Regarding commercialization, this is a low risk proposition. Essentially no capital will be required to adopt this technology at existing composite wood operations. Also, the process can be implemented on a trial basis to prove the attractiveness.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 0	Weighted Rating 0	Not applicable.

Totals

33

246

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

28-772 Acoustic Separation Technology

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 0	Weighted Rating 0	Not applicable for sustainable forestry.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 5	Weighted Rating 45	Market potential is good, but the fundamental nature of the technology takes a long time to penetrate the market and the developmental problems with the transducers may slow market penetration.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 2	Weighted Rating 16	Offers potential improvement in energy consumption, but to some degree this improvement is tied to design refinements and savings that result as the technology matures over several years.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 4	Weighted Rating 32	Good economic attractiveness because of its simplicity.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 0	Weighted Rating 0	State of Georgia has agreed to fund for another year, but no real industry champion.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	The science has wide application even in other industries, however the failure to identify a reliable transducer for this application is critical to other applications as well as to this one.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Offers good, solid environmental improvements because this technology replaces an open system with a closed system.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	Good technology that needs to be proven in a pilot operation, but the failure to develop a functional transducer makes this project vulnerable to ultimate failure, i.e. they may probably run out of funding before they solve the transducer problems.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 1	Weighted Rating 6	This project would enhance the use of recycled fiber, but is not essential technology.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 1	Weighted Rating 6	The poor performance and reliability of the transducers during pilot runs and testing seem to indicate that there are a number of risks with this technology. However, if the next round of testing were to successfully develop a functional dependable transducer, then the risks of this project would be substantially altered.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 0	Weighted Rating 0	Not applicable.

Totals

23	175
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FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

29-944 Easily Removable Cationic PSAs

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 10	Raw Rating 1	Weighted Rating 10	Some significance since no fiber is saved, but this technology enhances the use of recycled fiber in the industry.
2	Size and extent of market for the new technology	Very Small 0	Small 1	Medium 2	Large 3	4	5	CTO Weighting 9	Raw Rating 4	Weighted Rating 36	Even though cost will be 8-10% higher than competitive for the pressure sensitive adhesives, the market should be driven by the demand for recycled products and an environmentally friendly adhesive that facilitates the use of recycled fiber. However, the sparker project is an alternate solution to the stickies problem and is closer to commercialization.
3	Energy performance	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 8	Raw Rating 3	Weighted Rating 24	Depends on the ability to increase the use of recycled fiber and to reduce downtime frequency.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	Attractive 2	Highly Attractive 3	4	5	CTO Weighting 8	Raw Rating 4	Weighted Rating 32	Only stumbling block is 8 to 10% higher costs for the PSAs and the potential competition from the sparker project (Replacing Chemicals with Mechanical Alternatives).
5	Technology champion	None 0	Assigned Champion 1	Independent Champion 2	Multiple Champions 3	4	5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	EcoSynthetix, Inc. is a technology partner and is willing to go forward with commercialization if pilot runs and a suitable reactor can be demonstrated.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	Has some applicability to other products, specifically polystyrenes.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Reduces the use of chemicals as well as potentially increases the use of recycled fiber.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	When research started, H.B Fuller was believed to a cationic PSA product, but that appears to not be the case, therefore, this project is leading the industry in this area and offers one method of dealing with "stickies"-- P4, and since this project is nearing commercialization, might reduce the significance of this project.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 6	Raw Rating 5	Weighted Rating 30	By eliminating "stickies", one of the major obstacles to increased use of recycled paper is eliminated.
10	Risk	High Risk 0	Moderate Risk 1	Low Risk 2	Very Low Risk 3	4	5	CTO Weighting 6	Raw Rating 4	Weighted Rating 24	This seems to be good science, at least in the lab. Unless unanticipated problems develop, there should be very limited risks.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	Moderate Significance 2	High Significance 3	4	5	CTO Weighting 5	Raw Rating 0	Weighted Rating 0	No contribution.

Totals

35	254
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FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

30-945 Replacing Chemicals in Recycle Mills

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 1	Weighted Rating 10	There is some significance to Sustainable Forestry because the higher recovery of recycled products ultimately results in lowered required annual harvests.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 5	45	PI thinks ultimate market is greater than that stated in GPRA sheet. Success with biocide effects will make this attractive to many process industries outside the paper industry.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 3	24	Estimated energy savings of 41 million kWh per installation.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 5	40	Units are comparatively low cost and are expected to have a very short payback.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 4	28	Sparktec, Inc. has signed a license agreement to sell the device for the stickies application and presumably for other applications, and potential installations are moving forward.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	21	Effective range of biocidal effects, effect of charge balance on particle agglomeration, effect on sheet quality (brightness, hole count, de-tackifying pitch on metal surfaces).
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	28	Lowered chemical usage, potentially lowered biocide usage if effect range issues can be resolved or managed, more materials recycled resulting in lowered solid waste space requirements, 10% lower water usage. Accomplishes the desired result at lower capital and operating cost. Advancement of mill closure procedures by reducing/elimination of residual chemical build-up.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	21	Lowered production cost, maintenance cost, higher up-time rates from reduction of pitch coating and stickies deposition, more efficient fiber refining.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 5	30	Removing "stickies" with the new technology will lower cost of recycled products and make them more competitive. Higher quality paper (brightness and lower hole count) will enhance market potential for recycled products.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 3	18	Ultimately, low to very low risk in proper installation and use of this technology. Necessity of doing all work in mill trials has created some experimental control issue that will ultimately be resolved as more trials are done.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 0	0	No contribution.

Totals

36 265

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

31-1198 Surfactant Spray to Improve Flotation Deinking

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 1	Weighted Rating 10	The only impact is the increased use of recycled fiber, but its contribution is process enhancement and is not a major driver in the conversion to recycled fiber.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 4	Weighted Rating 36	Good market potential for Voith systems, which have about 60% of the market. Also applicable to other deinking systems that use flotation.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 5	Weighted Rating 40	
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 4	Weighted Rating 32	Good benefits and relatively inexpensive to install plus it can be retrofitted to existing systems. Installed cost estimated at \$6,000 per bone dry ton per day.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	Voith Sulzer Paper Technology.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 1	Weighted Rating 7	Generally limited to the chemistry and prices of deinking recycled paper.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 2	Weighted Rating 14	This is primarily a cost savings project, but to the extent it saves fiber and chemicals plus enhances the use of recycled paper, it will improve environmental performance.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 2	Weighted Rating 14	This is technology leadership in deinking, but limited to deinking and other flotation systems in other industries.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 4	Weighted Rating 24	This project improves deinking, plus it reduces chemical consumption and fiber loss. This will enhance the use of recycled paper.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 4	Weighted Rating 24	Low risk project with good benefits.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 0	Weighted Rating 0	No impact in alternate uses for biomass.

Totals

30 222

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

32-1158/699 Feed Stock-Product/Field Mobile NIR

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 2	Weighted Rating 20	Relationship to this area is primarily as a tool used in research efforts. Its significance is more than being a new tool because the understanding of wood chemical and physical properties in standing timber on a virtually instantaneous basis brings a new level of information about the effects of forest management practices and can affect the decision cycle times in sustainable forestry research.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 5	Weighted Rating 45	Technology has demonstrated applications in forestry, wood processing, and pulp production. PI believes there are other crossover applications in recycling paper and treated wood products. There may be other non-forest products applications. Relatively low cost will expand the market.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 1	Weighted Rating 8	Not a primary objective of the research. Energy benefits will come from lowered process energy required for the wood because of better-defined sorting characteristics.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 5	Weighted Rating 40	Probable unit cost of less than \$10,000 makes this a very attractive device for forestry research. Integrated application in processing should also be reasonably priced and attractive.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 5	Weighted Rating 35	Ron Brown Westvaco, Peter Arranson Weyerhaeuser, Allistair Twaddle, IP.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 5	Weighted Rating 35	Development of correlation of NIR Spectral data with physical and chemical properties is highly significant.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 1	Weighted Rating 7	
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 5	Weighted Rating 35	High, received R&D 100 award.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 4	Weighted Rating 24	Moderate to High significance because of ability to sort on chemical and physical properties.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 4	Weighted Rating 24	Low to both project successful completion and to commercialization.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 4	Weighted Rating 20	Ability to know chemical compositions quickly cheaply and at various stages in the growth and harvesting of biomass materials.

Totals

41 293

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

33-827 Distributed Web Sensor for On-Line Measurement of Paper Basis Weight

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 0	Weighted Rating 0	There does not appear to be any affect on forest resources.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 1	Weighted Rating 9	The market could be fairly large if there were a demand for this particular technology. The PI indicated that the slow response time (10's of seconds) was a factor in poor attractiveness in the market. The Co-Chair for these projects noted that this full web weight basis measurement device was desired by the industry.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 1	Weighted Rating 8	No measurable affect on energy consumption/savings.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 0	Weighted Rating 0	There is a low level of economic attractiveness. The PI commented that it would take another \$1-\$5 million to prepare for market.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 0	Weighted Rating 0	ABB Industrial Systems Inc. was the main support for this project.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 2	Weighted Rating 14	After Progressing through the steps of this project, I believe the research team learned some of the limitations of this technology and maybe there is a use for this type of density measurement in some other market that would better match this systems' performance.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 0	Weighted Rating 0	Use of radioactive elements.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 1	Weighted Rating 7	I could see some demand for a system that performed a real-time measurement of the paper web density, but this proposed system has some drawbacks (slow measurement speed and radioactive components).
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	Not applicable.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 1	Weighted Rating 6	A lot more money would have to be invested in development and commercialization of this technology. The current point source method works. Other methods are also being looked at.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 0	Weighted Rating 0	Not applicable.
Totals								6	44		

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

34-975 On-Line Fluidics Controlled Headbox

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 4	Weighted Rating 40	By producing a more isotropic distribution of the paper fiber the strength and quality are increased. In the linerboard plants the team indicates a 5-10% reduction in pulp to produce the same strength linerboard.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 5	45	The market should be fairly large based on continued successful results.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 3	24	There are energy savings related to less required fiber. Less fiber, less required drying energy and less energy for refining.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 4	32	The data results from the commercial trials of the vortigen block with static elements shows several benefits over the standard headbox designs.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 4	28	Multiple groups involved.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	28	The team is currently looking at options in controlling the vorticity generating elements by using memory shape metals and other devices.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	21	Better isotropic fiber orientation can lead to a reduction in fiber usage, which in turn would lead to a reduction in the pulping process and a reduction in any environmental problems.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	21	The IPST team has developed some of the fundamental technology behind this research.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	0	Not applicable.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 3	18	There already is success with the vortigen block with stationary elements setup in the commercial trials the team has conducted.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 0	0	Not applicable.

Totals

33 257

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

35-1157 Guided Acoustic Wave Monitoring of Corrosion & Erosion in Recovery Boiler Tubing

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 0	Weighted Rating 0	There does not appear to be any affect on forest resources.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 4	Weighted Rating 36	This technology can be applied to any boiler so the market could be fairly extensive.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 1	Weighted Rating 8	No real affect on energy performance.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 3	Weighted Rating 24	Using the acoustic sensors described in this project could reduce the number of days for a scheduled down time and provide more complete information on boiler tube status.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	There are two (2) groups assisting the technology team (Penn. State & Weyco.)
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	Existing technology being used for a new application.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 1	Weighted Rating 7	Not applicable.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 2	Weighted Rating 14	This will be the only source of this type of technology for boiler tube checking. Patents are being pursued.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	Not applicable.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 3	Weighted Rating 18	Low risk and good benefit.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 1	Weighted Rating 5	Not applicable.

Totals

22	161
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FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

36-1491 Wireless Microwave Wood Moisture Measurement

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 0	Weighted Rating 0	No real impact on sustainable forestry.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 4	Weighted Rating 36	The market should be fairly large based on continued successful results.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 4	Weighted Rating 32	According to the PI the energy savings for real-time moisture measurement on kilns could be around 20%.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 4	Weighted Rating 32	Cost of the system being developed should be comparable or less than the existing technology for sampling kiln moisture levels.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Multiple groups involved.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	The team is currently testing different configurations of microwave measurement systems.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	With a reduction in drying time due to better real-time moisture information would reduce any emissions associated with the drying process or required heat source.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	The concept of using microwave transmissions for measuring moisture is existing. This team is trying to design a microwave-based system that can operate in the harsh kiln environment on a real-time basis.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 0	Weighted Rating 0	Not applicable.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 4	Weighted Rating 24	If this research is successful, then the risk to reward ratio should be very low.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 0	Weighted Rating 0	Not applicable.

Totals

30

222

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

37-1492 CFD Modeling of Black Liquor Nozzle Design

Comments

1	Sustained forest resource management	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 10	Raw Rating 0	Weighted Rating 0	There does not appear to be any affect on forest resources.
2	Size and extent of market for the new technology	Very Small 0	Small 1	2	Medium 3	4	Large 5	CTO Weighting 9	Raw Rating 3	Weighted Rating 27	All paper mills would benefit from the successful results of this project through more efficient processing of black liquor.
3	Energy performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 8	Raw Rating 4	Weighted Rating 32	Better atomization and control of the black liquor nozzle spray would increase the energy (thermal) production of the chemical recovery boiler.
4	Economic attractiveness	Unattractive 0	Somewhat Attractive 1	2	Attractive 3	4	Highly Attractive 5	CTO Weighting 8	Raw Rating 3	Weighted Rating 24	Increasing the efficiency of processing black liquor in chemical recovery boilers would in turn save money in this process.
5	Technology champion	None 0	Assigned Champion 1	2	Independent Champion 3	4	Multiple Champions 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	McDermott Technologies Inc. has been the research team's main support for this project.
6	Scientific insights derived from project	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 3	Weighted Rating 21	There will be concepts learned in developing a CFD model for black liquor nozzles.
7	Improved environmental performance	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Improved nozzle performance means better combustion and fewer emissions.
8	Technological leadership	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 7	Raw Rating 4	Weighted Rating 28	Since there are no current models for black liquor nozzles this will be the first and only.
9	Recycled wood and paper materials	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 6	Raw Rating 1	Weighted Rating 6	Not applicable.
10	Risk	High Risk 0	Moderate Risk 1	2	Low Risk 3	4	Very Low Risk 5	CTO Weighting 6	Raw Rating 3	Weighted Rating 18	Low risk and good benefit.
11	Alternate uses for biomass	N/A or no Significance 0	Some Significance 1	2	Moderate Significance 3	4	High Significance 5	CTO Weighting 5	Raw Rating 1	Weighted Rating 5	Not applicable.

Totals

29	210
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FOREST PRODUCTS INDUSTRY OF THE FUTURE
PORTFOLIO STUDY AND EVALUATION

Appendix F

Agenda 2020 Implementation Plan R&D Pathways

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Continuing Research	Focus Area	SUSTAINABLE FORESTRY
					BIOTECHNOLOGY
					Locate and identify genes for important quantitative traits
					Improve tools for genetic transformation in tree species
					Improve tissue culture technology for tree species
					Marker-aided selection in model tree species
					Sequencing the active genome of model plant species: e.g. Arabidopsis
					Identification of genes controlling quantitative traits in tree species
					Developing mass propagation technologies for model tree species
					Sequence the active genomes of selected Pinus taeda and Populus genotypes
					Validate marker-aided selection methods
					Improve genetic engineering and mass propagation technologies for model tree species
					Develop information needed to address environmental/regulatory concerns
					Develop techniques for inducing and demonstrating sterility in model tree species
					"Library" of genes for use in genetic engineering of trees
					Reliable, economically-feasible methods for mass propagation of superior genotypes
					Environmentally-acceptable systems for testing and deployment of genetically-engineered trees
					Useful correlation of genetic markers and desirable tree traits
					Significant gains in productivity resulting from deployment of superior genotypes

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Continuing Research	Focus Area	SUSTAINABLE FORESTRY
					BASIC PHYSIOLOGY OF FOREST PRODUCTIVITY
					Research to understand critical limitations to accelerating plant growth
					Research to support genetic engineering
					Research to support forest management
					Research to support ecosystem management
					Tree development processes and their linkages to genetic controls
					Stand dynamics of plant forests
					Tree and stand interactions with environmental variables (ecophysiology)
					Interactions of timber management with other forest products and values
					Improve understanding of key physiological processes including carbon gain and allocation, wood formation and quality, nutrient uptake, juvenile/mature transition, secondary metabolism
					Develop better information on mechanisms of stand responses to silvicultural treatments
					Develop physiologically-based process models to test hypotheses and maximize the value of information from field studies
					Knowledge of tree development processes will enhance our ability to: (a) locate and identify genes controlling important quantitative traits, and (b) improve tissue culture technology
					Knowledge of tree/stand physiology will enhance our ability to design silvicultural systems and select genotypes that minimize environmental stress, optimize resource utilization, and increase productivity
					Knowledge of processes controlling productivity will enable us to model management results and fundamental ecosystem processes
					Significant gains in productivity resulting from: (a) more rapid advances in forest biotechnology, and (b) improvements in silvicultural practices

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Continuing Research	Focus Area	SUSTAINABLE FORESTRY
					SUSTAINABLE SOIL PRODUCTIVITY
					Understanding effects of intensive management on soil productivity
					Diagnosing soil limitations to productivity
					Treatments to enhance soil productivity
					Diagnosis and amelioration of nutrient limitations
					Effects of intensive management systems on soil organic matter, soil chemical/physical properties, and water quality
					Use of mill residuals as beneficial soil amendments
					Models of soil responses to biomass removals, atmospheric deposition and other processes
					Evaluate positive and negative effects of intensive management options for important soil types
					Develop nutrient budgets for important soil types, including effects of harvest
					Understand nutrient cycling processes in major forest/soil types
					Improve understanding of root diseases and other soil biological factors affecting forest productivity
					Develop model-based methods for diagnosing soil limitations to productivity
					Improved tools for diagnosing soil limitations to productivity
					Guidelines to prevent or ameliorate adverse effects of intensive management practices
					Knowledge of processes controlling productivity in important soil types
					New options for enhancing soil productivity
					Significant improvements in long-term soil productivity

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Continuing Research	Focus Area	SUSTAINABLE FORESTRY
					REMOTE SENSING TECHNOLOGIES TO IMPROVE FOREST INVENTORY AND STAND MANAGEMENT
					Significant cost reductions and quality improvements in systems for requiring stand-level information to support management decisions
					Application of existing technology to improve outdated nation-wide forest inventory program
					Development and testing of new methods for monitoring forest health and productivity
					Basic research on remote sensing and survey methods for forest inventory
					Large-scale ecological studies of forest community distributions, impacts of human activities (e.g. tropical deforestation), and forest biochemical processes
					Studies of methods for detecting forest stress
					Conduct intensive cooperative study during 1996-1997 to determine how best to incorporate modern remote sensing technologies/systems in the U.S. nation-wide forest inventory system
					Develop methods for cost-effective monitoring of forest growth in relation to target goals
					Develop methods for detecting and diagnosing growth-limiting conditions at the stand level. Conditions of interest include nutrient limitations, insect and disease problems, overstocking or understocking and excessive weed competition
					A cost-effective design for a revitalized U.S. nation-wide forest inventory system that meets the needs of industry and other user groups
					New methods for sub-regional monitoring of forest productivity
					New methods for stand-level determinations of factors that limit forest productivity
					Significant improvements in the timeliness and quality of information for national and regional assessments of timber availability, forest health and the effectiveness of management strategies
					Significant cost reductions and quality improvements in systems for requiring stand-level information to support management decisions

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Continuing Research	Focus Area	ENVIRONMENTAL PERFORMANCE
					IMPROVED MARGINS OF ENVIRONMENTAL SAFETY
					Human and environmental effects
					Energy and environmental tradeoffs
					Biological and health effects characterized and understood; e.g. bio-markers and hormone mimicking
					Risk assessment of HAPs
					Impact of pulping and bleaching alternatives quantified
					Environmental impact of LVHC and HVLC disposal by combustion assessed
					Expand scientific knowledge relative to areas of interest; e.g. aquatic effects and atmospheric chemistry
					Develop methodology to analyze resource and environmental burdens of technical and regulatory changes; e.g. pulping and bleaching alternatives, LVHC and HVLC management, recovery alternatives
					Understanding of new issues
					Credible scientific understanding of cause and effect relationships
					Rigorous modeling approach that will act as a basis for setting standards for new mills and recognizing site-specific needs of existing mills
					Resolution of identified concerns
					Scientific basis on which to prioritize impact issues and allocate resource commitments

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Continuing Research	Focus Area	ENVIRONMENTAL PERFORMANCE
					PROCESS ALTERNATIVES CONSISTENT WITH POLLUTION PREVENTION
					Impacts of liquid effluent
					Impacts of gaseous discharges
					Non-process elements
					Energy reduction
					Alternative pulping and bleaching processes that are in harmony with the environment
					Technologies for treating effluent streams for reuse
					Designs, sensors and controls for operating stable processes
					Methods for organic/inorganic separation
					Alternative pulping technologies; e.g. AQ, polysulfide, enzymes, split sulfidity
					Alternative bleaching technologies; e.g. ozone, pressurized peroxide, peracetic acid, enzymes
					Bleach effluent recycle technologies; e.g. supercritical water oxidation, membranes evaporation-crystallization, freeze crystallization, precipitator management
					Black liquor processing alternatives; e.g. black liquor gasification combined cycle
					Future options assessed
					Commercial demonstration
					Corrosion-resistant materials of construction
					Operating economics, availability and maintainability
					Flexibility to implement as part of normal modernization capital cycle
					Commercialization of preferred options pursued
					Economically attractive processes that improve the margin of environmental safety while maintaining global competitiveness

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Continuing Research	Focus Area	ENVIRONMENTAL PERFORMANCE
					TREATMENT AREAS
					Solid waste minimization
					Impacts of gaseous discharges
					Impacts of liquid discharges
					Processes for handling gaseous discharges
					Improvement and optimization of effluent treatment systems
					Processes for utilization or disposal of solid waste
					Thermal oxidation technologies, biofiltration
					Fundamentals of the impact of biological processes; e.g. AOX
					Waste minimization approaches
					Recycle
					Ethanol manufacture
					Supercritical water oxidation
					Commercial demonstration
					Corrosion-resistant materials of construction
					Flexibility to implement as part of normal modernization capital cycle
					Improved margin of environmental safety through waste minimization

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Continuing	Focus Area	ENERGY PERFORMANCE
					FUEL PRODUCTION AND ENHANCEMENT
					Technologies for maximizing the value of waste materials and biomass as an energy source
					Agricultural residues as fuel and as feedstock for chemicals
					Non-recyclable recoverable materials as a fuel
					Forest and plantation management strategies and prescriptions that will optimize "energy fiber" generation while enhancing overall productivity
					Collection and harvesting systems and techniques to increase forest residual availability and reduce costs
					Improved moisture reduction techniques, including drying
					Technologies for beneficiation of wastes and other recyclable materials
					Improved materials handling technologies
					New integrated systems for growing, harvesting, sorting, and developing energy fiber from forests and plantations
					Systems for collecting, sorting and beneficiating nonrecyclable recovered material for energy
					Maximum value of forest resources
					Flexibility to utilize the cheapest fuels
					Shelter from fossil fuel price perturbations and energy taxes
					Waste reduction

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Continuing Research	Focus Area	ENERGY PERFORMANCE
					FUEL CONVERSION AND ELECTRICITY PRODUCTION
					Independence from fossil fuel and purchased power needs
					Effective partnerships with energy providers in achieving renewable energy goals
					Biomass and black liquor gasification technology development, including hot gas cleaning
					Tomlinson furnace
					Black liquor gasification technology development
					Combustion turbines for dirtier and lower Btu fuels
					Smaller cost-effective turbines
					Cleaner and more efficient combustion
					Biomass and black liquor gasification combined cycle commercialization
					Improved understanding of the fundamentals of energy conversion technologies, including: 1) fluidized bed, 2) gasification, 3) combustion of fuels and black liquor
					Development of technologies; e.g. fuel cells; to be used in combination to enhance energy efficiency
					Model development to allow size and plant integration optimization
					Concept and technologies for life extension of Tomlinson furnaces
					Commercially demonstrated gasification combined cycle technologies
					Energy conversion technologies optimized from an operating and maintenance perspective
					Advanced combined cycle systems
					Reduced capital for energy conversion
					Successful partnerships with energy providers
					Major reductions in net dependence on fossil fuels and purchased power
					Smaller scale, cost-effective installations
					Environmentally effective combustion and generation

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Continuing Research Focus Area	ENERGY PERFORMANCE
				MANUFACTURING PROCESS EFFICIENCY AND HEAT RECOVERY
				Energy efficiency, including methods of low-level heat recovery
				Drying and other water removal concepts
				Pulping, bleaching and papermaking processes
				Wood products processes
				Process measurements and controls
				New technologies for recovery of low-level heat
				New or more effective approaches to water removal prior to drying
				Commercialization of new and improved drying concepts
				Reduced process variability/improved process control
				Improved wood products, pulping and paper manufacturing processes
				Effective and efficient lime kiln operation
				Commercial alternatives for low-level heat recovery
				Commercial alternatives for water removal, including drying
				Commercial process control techniques
				Commercial alternative manufacturing processes
				Operations that are globally competitive from an energy-use perspective
				Optimum utilization of process equipment
				Reduced use of fossil fuels
				Environmentally effective manufacturing

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Continuing Research	Focus Area	ENERGY PERFORMANCE
					ENVIRONMENTAL IMPACT OF ENERGY PRODUCTION AND UTILIZATION
					Energy and environmental tradeoffs
					Approaches for effective use of ash and sludge
					Modeling of environmental impact of a significant increase in use of renewable energy
					Combustion technologies
					Effect on global warming
					Ash utilization options
					Sludge utilization options
					Impact of ultimate disposal of ash components
					Improved combustion technologies
					Alternatives to combustion for VOC gases
					Increased efficiency and use of biomass fuels
					Economic options for ash and sludge use or disposal
					Accepted understanding of impacts on the environment of ash and sludge use or disposal
					Understanding of impacts of energy production and utilization, including the use of renewable materials
					Environmentally competitive options
					Lower environmental impact and improved environmental image
					Waste reduction
					Reduced use of fossil fuels

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Continuing	Focus Area	ENERGY PERFORMANCE
					WIDER USE OF RENEWABLE RESOURCES
					Technologies for maximizing the value of waste materials and biomass as an energy source
					Biomass-to-chemical conversion processes
					Technologies for recycling wood
					Life extension of wood products
					Commercialization of improved biomass-to-chemicals conversion technologies
					Process integration alternatives allowing for attractive chemical production opportunities
					Improved technologies for wood products recycling
					Understanding of the energy efficiency in production and use of forest and paper products relative to competing products
					Greater life of wood buildings via design and repair
					Options for effective partnerships with utilities, chemical and oil companies, designers and repair entities
					Substantial energy efficiency information for forest and paper products
					Maximum value of forest resources

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Continuing	Focus Area	CAPITAL EFFECTIVENESS
					SYSTEM AND PROCESS TECHNOLOGIES
					Systems and process technologies
					Lower cost, safer and more efficient processes
					Continued process design and enhancement by suppliers
					Continued fundamental research and innovation by key universities and technical institutions
			Future Research Direction	Focus Area	Raw Materials-Improved fiber processing and yield (through the system value)
					Raw Materials-Alternative fiber sources
					Pulping and Bleaching-Alternative processes
					Pulping and Bleaching-Bio-delignification
					Pulping and Bleaching-In-digester bleaching
					Pulping and Bleaching-Split sulfidity pulping
					Chemical Recovery-Black liquor and biomass gasification
					Chemical Recovery-Direct causticizing
					Paper Machines-Forming, pressing, high intensity drying
					Paper Machines-Faster machine speeds
					Paper Machines-Size press elimination
					Paper Machines-Improved uniformity
					Minimum-Impact Manufacturing-Reduced water usage
					Minimum-Impact Manufacturing-Multi-media closure
					New processes brought from concept through first commercial implementation
					Learnings and best practices from universities, technical institution and consortiums widely shared
					Improved understanding of fundamentals that allow early introduction of new, lower cost technologies and processes
					Improved global competitiveness by impacting the nature of technologies used to manufacture pulp and paper/wood products

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Focus Area	CAPITAL EFFECTIVENESS
				SYSTEM FABRICATION AND CONSTRUCTION
			Continuing Research	System fabrication and construction
				Sharing of best practices-TAPPI Engineering
				Sharing of best practices-CII
				Sharing of best practices-Owner/Supplier collaboration to optimize value
				Sharing of best practices-Other
				Continued supplier, engineering and construction industry development-Value engineering
				Continued supplier, engineering and construction industry development-Shop fabrication
				Continued supplier, engineering and construction industry development-Site construction and labor efficiency
				Continued supplier, engineering and construction industry development-Cooperation to reduce installed capital costs
				Continued supplier, engineering and construction industry development-3D CAD
				Support established programs at DOE in areas aligned with capital effectiveness (e.g., recovery boiler materials of construction)
				Simplified and standardized design
				Size and scale
				Paper machine speed, width, press loadings and roll covers
				Improved materials of construction-Boilers, digesters, bleach plants
				Improved materials of construction-Cheaper to use, less expensive to maintain and resilient to harsh environments
				Improved materials of construction-Improved durability (wear) in wood yards
				Improved construction-Foundation and structural
				Improved construction-Large scale/modular
				Improved construction-Modernizing existing mills
				Improved welding techniques
				Better understanding of the fundamental phenomenon impacting equipment failure and corrosion
				Best practices from suppliers, consultants, and engineering firms shared across the industry
				Partnerships developed
				Rapid application of new, lower cost equipment, processes and procedures
				Improved global competitiveness through the efficient application and implementation of the capital deployed by the forest products industry

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Continuing Research Focus Area	CAPITAL EFFECTIVENESS
				SYSTEM EFFICIENCY
				System efficiency
				Developing skilled resources for the industry-Maintenance and operations
				Developing skilled resources for the industry-Discipline engineers
				Developing skilled resources for the industry-Process engineers
				Continued development of process monitoring tools for the industry by suppliers
				Continued development of fundamental process knowledge by key technical institutions and suppliers
				Improved modeling, simulation, optimization and operator training tools
				Diagnostic and smart sensors to reduce unscheduled downtime
				Intelligent maintenance-Proactive
				Intelligent maintenance-Allow to design process and systems on the edge
				Intelligent maintenance-Maintain facilities "on the run"
				Reduced raw materials variability
				Chemical and energy optimization
				A diverse set of skilled resources capable of meeting the challenges of the future
				Improved process models and tools for optimization
				Improved economics, availability and maintainability of core manufacturing processes
				Improved global competitiveness through better manufacturing asset utilization

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Continuing Research	Focus Area	RECYCLING
				DEVELOP ENVIRONMENTALLY BENIGN PRESSURE SENSITIVE ADHESIVES (PSA)	
				Develop environmentally benign PSA	
				Adhesive properties to enhance separations technologies-size integrity for screening, density gradients for cleaning, surface chemistry for flotation	
				Characterize formation and behavior for microstickies	
				USPS and FPL work in developing recyclable PSAs	
				Understanding the true impact and cost of stickies on the industry	
				Testing procedures and standards for stickies and microstickies	
				Develop benign pressure sensitive adhesives (PSAs)	
				Reformulated adhesives for removal by conventional screening technologies by academic research institutions	
				Partnerships among suppliers, converters, end users, paper collection and recycling industry (e.g. USPS model program)	
				Cooperative relationships among colleges and universities, adhesive suppliers, converters, end users and paper recyclers aimed at the common goal of low cost, screenable PSAs	
				Standards for quantifying recyclability of final product stickies	
				Standards for measurement of final product stickies	
				Novel process equipment developments that control adhesive contaminants in a cost-effective manner with minimal impacts on energy requirements, fiber properties and yield	
				Decrease volume of PSA-contaminated paper going to landfills	
				Ability to cost-effectively utilize lower grades of recovered paper in higher quality recycled papers with no impact on quality and operability	
				Industry-supplier-end user-academic research working relationships that can serve as a model for future endeavors	
				Implementation of new and unique technologies contributing to the long term viability of the recovered paper industry	

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Focus Area	RECYCLING
			IMPROVING SEPARATION TECHNOLOGY
		Continuing Research	Improving separation technology
			Reduce maintenance costs (longer life of wearable parts)
			Improve efficiency of separation of lightweight contaminants (centrifugal cleaning, fine slotted screening, washing, flotation)
			More efficient processes-system design
			More efficient processes-operating conditions
			More efficient processes-unit operations
			Testing procedures and standards
			On-line testing/identification of contaminants, fiber properties, brightness, etc.
			Identification and removal of stickies
		Future Research Direction	Reduce number of unit operations (e.g. 2-stage systems)
			Reliable sensors for accurate on-line measurement of stickies, inks, etc.
			Reliable measurements to reduce variability in separation efficiency
			Improved chemical treatments to enhance separation techniques
			Novel approaches to separation technology
			Improved materials of construction for separation equipment
			Reduction in energy consumption
			Reduce water consumption per ton of recovered material processed
			Documented partnership between suppliers and user to develop knowledge and tools that measure/improve/optimize separation technology
			Improved fundamental understanding of processes and products (cause and effect relationship)
			Novel commercial methods/processes/equipment that meet criteria of maximum efficiency, minimum fiber loss and reduced specific energy consumption
			Improved methods for fabricating and maintaining equipment
			Lower effluent volumes to waste treatment
			Increased utilization of recycled fiber with improved economic justification
			Higher yield of fiber at lower energy consumption
			Reduced water consumption

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Continuing Research	Focus Area	RECYCLING
					SORTING AND COLLECTION/METHODOLOGIES AND TOOLS
					Sorting and collection/methodologies and tools
					Identify the most effective means of collection for an area's demographics, population density and economics
					New techniques or instrumentation that optimizes the quantity and quality of fiber recovered
					Development of standards which clarify recyclability
					Techniques to establish statistical characterization of recovered paper and recycled fiber raw material streams
					New designs that will result in lower equipment, labor and maintenance costs
					Improve material handling technology
					Develop on-line detection tools to measure and control efficiency of sorting
					Research on materials now considered nonrecyclable
					Reliable and economical methods for collection and sorting
					Reduced costs associated with fiber recovery
					Improved quality of fiber recovered
					Improved quality of finished product
					Increased percentage of paper recovered and utilized
					Industry's environmental impact minimized

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Continuing Research	Focus Area	RECYCLING
					SURFACE CHEMISTRY AND FIBER-FIBER BONDING
					Surface chemistry and fiber-fiber bonding
					Improve strength properties
					Chemical or enzyme treatment to increase and recover water retention/fiber conformability
					Fines reactivation and retention
					Fundamental studies to model fiber networks containing recycled fiber
					Mechanical treatments for recovery of performance properties
					Effect of cyclic humidity and the minimization of these effects
					Dimensional stability properties of sheet and board
					Improved sheet properties
					Biotechnology applications
					More efficient use of process chemicals
					Understanding of improved recycled fiber properties
					Understanding of process surface chemistry and influence on fiber yield
					Quality of recycled fiber comparable to virgin fiber

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Continuing Research	Focus Area	RECYCLING
					NEW TECHNOLOGIES FOR SLUDGE USE AND DISPOSAL
					Sludge use and disposal
					Fiber/clay minimization
					Impact of land application
					Efficient energy recovery
					Processes for fiber/ash utilization
					Efficient dewatering
					Waste minimization approaches
					Develop model-based methods for diagnosing soil limitation to sludge application
					Ethanol production
					Off-site fiber and ash recovery
					Alternative products from sludge
					Combustion and gasification of sludge
					Commercial demonstration
					Improved operating economics, availability and maintainability
					Credible scientific understanding of sludge disposal/reuse alternatives
					Energy conversion technologies
					Economically attractive processes that improve utilization of recycled paper sludge
					Environmentally competitive options
					Waste reduction
					Improved global competitiveness

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Continuing Research	Focus Area	SENSORS AND CONTROLS
					ACTUATORS AND CONTROL DEVICES
					Surface chemistry and fiber-fiber bonding
					Microprocessors at actuator level
					Improved flow control
					Head box dilution control
					Actuators to stabilize processes
					Techniques/methods to minimize/eliminate variability
					Actuators that keep up with control system development
					Actuators that satisfy product requirements
					Actuators for new processes
					Self-diagnostic
					Actuators for critical product variables
					Actuators for critical process variables
					Actuators for raw material variables
					Actuators for environmental variables
					Reliable and cost-effective actuators enabling optimal process operation, environmental performance, safe performance and customer satisfaction
					Productivity
					Quality

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Continuing Research	Focus Area	SENSORS AND CONTROLS
					MEASUREMENT AND DIAGNOSTICS
					Complexity of processes and need for maximum efficiency and low cost require significantly improved measurement and control systems
					Diagnostic capability that provides increased knowledge of fundamentals of structural, optical, etc. attributes is necessary to make possible higher product performance at less cost
					Raw Materials-Fiber and filler characterization
					Raw Materials-Tree analysis
					Product-Paper physics
					Product-Surface characterization
					Process-Chemical and physical analysis of process streams and equipment
					Process-Corrosion monitoring
					Environmental-Continuous emission monitoring
					Environmental-Lower detection limits
					Effective process measurement/monitoring sensors
					Measurement systems that allow significant product improvements
					Environmental-related sensors--internal and external
					Diagnostic tools
					Characterization of all critical product variables
					Characterization of all critical process variables
					Characterization of all critical raw material variables
					Characterization of all critical environmental impact variables
					Sensor validation
					Reliable and cost-effective measurements enabling optimal process operation, environmental performance, safe performance and customer satisfaction
					Economically acceptable tools that enable increased fundamental understanding

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Focus Area	SENSORS AND CONTROLS
				PROCESS AND PRODUCT MODELS
				Advanced control, expert and mill information systems will assist in efficient operations
				Cost-saving models will be available that can help achieve the desired performance and characteristics of wood and paper products
				Process-Unit operations
				Process-Total system
				Process-Predictive maintenance
				Product-Planning and scheduling
				Product-Finite element analysis
				Raw Materials-Wood density
				Raw Materials-Chemical composition
				Environmental-Dispersion
				Environmental-Impact models
				Environmental-Emission models
				Modeling Tools-Expert systems
				Modeling Tools-Neural networks
				Modeling Tools-Factor analysis
				User-friendly methodologies for modeling: -complex systems, -chaotic processes
				Productivity models that optimize relationships of raw materials and process characteristics to basic product char.
				Dynamic models that optimize raw material value and consumption, including chemicals
				Effective models for: -predictive maintenance, -environmental impact, -sustainable forestry
				Robust/accurate process models
				Effective integration of sub-system models
				Key individual learnings embedded in process models
				Fundamental understanding of process and product
				Predictive economic models
				Optimization-stump to customer
				Enhance product performance
				Consistent product/productivity
				Improve process design
				Safer workplace

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Continuing Research	Focus Area	SENSORS AND CONTROLS
					DATA PRESENTATION, INTERPRETATION AND HUMAN INTERFACE
					The view of the future includes highly automated equipment operated safely in comfortable environments
					Education and training of process managers, as well as scientists and engineers, will be of increasing importance
					Complexity of processes and need for maximum efficiency and low cost require significantly improved measurement and control systems
					Diagnostic capability that provides increased knowledge of fundamentals of structural, optical, etc. attributes is necessary to make possible higher product performance at less cost
					Automated data reduction
					Data reduction and validation
					Abnormal situation management
					Simulation
					Automated data validity checking and data reduction
					More effective modes of human process interaction
					More effective training tools
					Rapid prototyping of finished product
					Technologies that allow realistic displays of process equipment internals utilizing real-time data and tailorable to individual process manager's preferences
					Actual process is better documented
					Better alarm management, including predictive operation
					On-line trouble shooting
					Increased system security
					Effective information presentation
					Critical information available to users in effective and timely way
					On-line training capability utilizing real information and displays
					Safety and system security
					Agile manufacturing and product responsiveness

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Results Realized	Knowledge and Tools	Future Research Direction	Continuing Research	Focus Area	SENSORS AND CONTROLS
					CONTROL SYSTEM EFFECTIVENESS
					Advanced control, expert and mill information systems will assist in efficient operations
					Computer based control systems will extend into distribution and logistics networks to reduce inventories and shorten product delivery cycles
					See pathways 1-4
					Building robust algorithms
					Multi-variable and non-linear control
					Evaluation of existing system performance
					Open systems
					Reliable control systems that implement process and measurement developments
					Control systems for automating start-up and transitioning
					Advanced controls
					Control system diagnostics and sustained effectiveness
					Self-regulating and adaptive control systems with 100% utilization
					Skilled and trained process managers
					Optimizer for sensor and actuator placement and type
					Process design for effective control
					Mill-wide control optimization
					Uniform quality productivity
					Process variability minimized or eliminated
					Product loss during transitions minimized or eliminated
					Flexible manufacturing
					Safe manufacturing

FOREST PRODUCTS INDUSTRY OF THE FUTURE
PORTFOLIO STUDY AND EVALUATION

Appendix G

Proposed New Technology Strategy

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Goals	Areas of Focus	Vision	HIGHER VALUE RAW MATERIAL SUPPLY
			SUSTAINABLE FOREST PRODUCTIVITY TASK GROUP
			Significant and sustainable gains in forest productivity that will enable: <ul style="list-style-type: none"> • Industry competitiveness • Bioenergy strategies • Superior environmental performance
			Breakthrough Technologies that will be consistent with the two overall goals
			Biotechnology: <ul style="list-style-type: none"> • Gene Discovery & Function • Tissue Culture • Genetic Engineering • Social Acceptability
			Physiology of Forest Productivity: <ul style="list-style-type: none"> • Wood Formation and Wood Quality • Ecophysiology of Planted Forests • Nutrient Use Efficiency
			Soil and Stand Productivity: <ul style="list-style-type: none"> • Diagnosing Soil Limitations to Productivity • Soil Treatments to Enhance Stand Productivity • Effects of Intensive Management on Soil Processes • Interactions between soil, genotype, and climate
			Forest Information Technology: <ul style="list-style-type: none"> • Remote Sensing Applications to Improve Quality and Reduce Cost of Regional and Nationwide Forest Inventories • Improve Accessibility and Utility of Data from Regional and Nationwide Forest Inventories • New Integrative Information Technologies for Tree, Stand, and Landscape Management
			Higher Value Raw Material: <ul style="list-style-type: none"> • More wood and fiber production from less land • Proven forest sustainability with enhanced wood properties and growth rate • Environmental performance
			Reduced Manufacturing Cost: <ul style="list-style-type: none"> • Higher yield raw materials • Energy efficiency • Reliability and throughput • Environmental Performance

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Goals	Areas of Focus	Vision	SIGNIFICANTLY REDUCED MANUFACTURING COSTS
			BREAKTHROUGH TECHNOLOGIES TASK GROUP
			Slash the cost of manufacturing of pulp, paper, and wood products by as much as 50% without negatively impacting product quality
	Gaps		Extruding Engineered Structures: <ul style="list-style-type: none"> • Product/Process Uniformity • Finer Felts and Wires (3mm) • Fully Automated Process • 2x Filler, Equal Strength • Scale of Manufacturing Equipment • Contaminants in middle ply
			Fiber Liberation: <ul style="list-style-type: none"> • Selectivity • Scale of Manufacturing • Mass Transfer • Uniform Raw Material • Lignin Modification/High Yield • Processes with higher Oxygen Content
			Fiber Challenge – Commercially viable breakthrough production processes to dramatically reduce fiber cost and use in pulp, paper, and wood products production
			Simplification of the process challenge – Use breakthrough concepts to reduce or simplify pulp, paper, and wood products manufacturing processes
			Energy challenge – Improve the efficiency of production processes to greatly reduce energy use
			Chemicals challenge – Develop commercially viable breakthrough production processes to allow mills to greatly reduce the use and cost of chemicals
			Improved throughput challenge – Use breakthrough concepts to increase the throughput of pulp, paper, and wood products manufacturing processes

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Goals	Areas of Focus	Vision	SIGNIFICANTLY REDUCED MANUFACTURING COSTS	
			CREATING SUPERIOR STRUCTURES – FIBER ENGINEERING	
			Evolve the science and technology of fiber engineering by developing improved fibers through genetic, chemical, enzymatic, or mechanical means, or a combination of these, for the purpose of significantly reducing manufacturing costs and enabling enhanced and new sheet structures	
			Genetic Fiber Modification <ul style="list-style-type: none">Cell wall composition and structure	
			Chemical or Enzymatic Fiber Modification <ul style="list-style-type: none">Bulk and/or surface modification	
		Gaps	Mechanical Fiber Modification <ul style="list-style-type: none">“Microsurgical accuracy” not “sledgehammer” approach	
			Genetic modification	
			Chemical modification	
			Enzymatic modification	
			Mechanical modification	
			Improve performance/cost ratios for major grades by 50%, For example: <ul style="list-style-type: none">Engineer fibers to increase fiber-fiber bonding by 50% with little or no increase in costDevelop strategies that tailor specific fiber attributes to specific end uses	

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Goals	Areas of Focus	Vision	SIGNIFICANTLY REDUCED MANUFACTURING COSTS
			RECYCLING TASK GROUP
			Recycled fiber is interchangeable with virgin fiber with respect to product quality and economics
			Procurement
	Areas of Focus	Process	
		Product	
	Gaps	Public Perception	
		Industry Perception	
		Fiber Quality	
		Metrics Tools	
		Need for Revolutionary Thinking	
	Goals		Reduce the impact of contamination by 25% by 2010 and 50% by 2020
			Develop new separation technologies to reduce the energy and capital required per daily ton of production 25% by 2010 and 50% by 2020
			Increase the use of recycling mill residuals, waxed corrugated, and recovered wood 50% by 2020

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Goals	Areas of Focus	Vision	SIGNIFICANTLY REDUCED MANUFACTURING COSTS	
			PROCESS AUTOMATION TASK GROUP	
		Vision	Enhance effectiveness of decision making and competitiveness through innovation in sensors and process automation focused on:	
			<ul style="list-style-type: none">Reducing manufacturing costs per unit of productEnhancing effectiveness of decision making by 20%Enabling higher employee effectiveness	
			Information management	
			Streamlined communications standards	
			Sensor technology	
			More effective control systems	
			Specific sensor needs	
			Links with business systems (ERP)	
	Alarm management/abnormal situations			
	Gaps	Smart preprocessing of sensor information		
		Standardized applications – multi-vendor		
		Sensors – low cost, simpler, low maintenance		
		New online measurements		
		Expert systems		
		Hybrid systems		
		Robotics to supplement operator		
		Contribute to 50% reduction in manufacturing cost by:		
		<ul style="list-style-type: none">Reducing 50% – product not meeting first qualityReducing 10% – costs for materials, energy, labor, and maintenanceLower manufacturing costs by 10% through increased production rate without significant capital		
		Enhance effectiveness of decision making 20% (resource use and enterprise systems)		
	Contribute to technologically advanced workforce goals by:			
	<ul style="list-style-type: none">Providing training systems with realistic process simulationsImproving operator ability to handle abnormal situations			

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Goals	Areas of Focus	Vision	IMPROVED ENERGY PERFORMANCE
			ENERGY PERFORMANCE TASK GROUP
			Integrated pulp and paper manufacturing requires no fossil fuel and exports high-valued energy
			Durable wood products have 50% lower life cycle cost than those of 2000
			Black Liquor and Biomass Combined Cycle Gasification
			Reduce Energy Intensity of Manufacture and Use of Forest Products, and Extend Life of Durable Goods
			Life Extension of New/Old Buildings
			Energy/Process Efficiency Enhancements
			Conversion of Biomass to Energy/Products
			Implementation and Optimization
			Gasification:
			<ul style="list-style-type: none"> • Materials of Construction • Gas Clean-up • System Economics
			By 2015, decrease energy intensity of industry products by 50%
			By 2015, increase energy recovery from the pulping cycle by 30%
			Significantly increase the value of self-generated fuels (e.g. Combined-cycle gasification commercially available by 2008)
			Significantly increase the recovery of biomass residuals (e.g. \$1/MMBtu delivered cost)

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Goals	Areas of Focus	Vision	SUPERIOR ENVIRONMENTAL PERFORMANCE	
			ENVIRONMENTAL PERFORMANCE TASK GROUP	
		Vision	Significantly improved environmental performance at minimum cost through:	
			<ul style="list-style-type: none">• Scientific basis for performance targets• Detailed understanding of the life cycle impacts of processes and products• Cost-effective compliance assurance• Breakthrough process and treatment technologies• Reduced waste and beneficial use of residuals	
		Recycled fiber is interchangeable with virgin fiber with respect to product quality and economic		
		Prevent pollutant generation		
		Pollutant/stream volume reduction		
		Breakthrough end-of-pipe technologies		
		Beneficial reuse		
		Measurement and monitoring		
	Gaps	Maximize effluent reuse by understanding the impact on process chemistry, materials, and product quality		
		Develop and integrate new or improved pulping, bleaching, and recovery technologies		
		Identify and improve end-of-pipe technologies that reduce or eliminate specific contaminants of concern		
		Create cost-effective odor identification, prevention, and treatment technologies		
		Alternative manufacturing techniques that reduce emission volume and pollutant generation		
		Cost and energy efficient treatment technologies for HAP, VOC, and PM		
		Inexpensive ways to reduce losses (fiber, fillers)		
		Cost-effective low-risk beneficial use for producer and user		
	By 2020 and without increased cost or negative impact on product quality:			
	<ul style="list-style-type: none">• Water use and effluent load reduced by 50%• Odor eliminated at the fence line• VOC, HAP, and PM control costs reduced by 50%• Landfilled solid wastes from pulp, paper and wood product manufacturing reduced by 50%			

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Goals				NEW FOREST-BASED MATERIALS	
				NEW FOREST-BASED MATERIALS TASK GROUP	
				Areas of Focus	Vision
					Develop the enabling technologies to make possible new and novel forest based products that have higher value to end users
					Wood disassembly and utilization
					Novel manipulations of wood
					Composites
					Phytochemistry
					Higher competence substrates
			Gaps	Fundamental understanding and controlling of hydrogen bonding to disrupt and reverse	
				Plasticizing wood for forming and uses in adhesives – wood as thermoplastic	
				Fractionation of biomass into specific components – clean separation	
				Composite – physics and chemistry to recombine wood components in novel ways	
				Apply new and emerging innovations such as nano-technology to cellulose and lignin	
				Develop novel uses for currently low-value or unused forest based materials (e.g. hemicelluloses for plastics/fermentation)	
				Apply economical conversion processes to forest-based materials for the manufacture of chemical and carbon products	

FOREST PRODUCTS INDUSTRY OF THE FUTURE - PORTFOLIO STUDY AND EVALUATION

Goals	Areas of Focus	Vision	TECHNOLOGICALLY ADVANCED WORKFORCE
			TECHNOLOGICALLY ADVANCED WORKFORCE TASK GROUP
			Employees performing at world-class levels of safety, productivity and innovation
			Necessary future knowledge and skills
			Best future education programs for entry level positions
			Best future continuing education programs
			A new industry image and message
			Competitive industry recruitment
			Enrollments to match future demands
			Labor/management partnerships
	Gaps		Technically educated workforce, learning continuously, able to understand and operate complex new technologies
			Technically up-to-date and knowledgeable technical and manufacturing personnel able to understand and embrace complex, innovative technologies and empowered by their senior management to implement them
			A new national industry message and recruitment program to attract the best and brightest people to our industry
			Attract, recruit, and retain people with strong science, engineering and technology education
			Create the educational system that meets the basic, technical, and leadership skills required for entry-level positions in the industry
			Create an environment for life-long learning that enables and motivates the industry's people to continue to acquire the knowledge and skills required to drive the industry to perform at world-class levels of safety, productivity and innovation
			Attract, recruit and retain people with strong science, engineering and technology education
			Create an environment for lifelong learning
			Develop educational systems to support the needs of the industry

**INDUCED POLARIZATION WITH ELECTROMAGNETIC
COUPLING: 3D SPECTRAL IMAGING THEORY
EMSP PROJECT NO. 73836**

TOPICAL/ANNUAL PROGRESS REPORT

for Period September 15, 2001–September 14, 2002

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Prepared for

**THE U.S. DEPARTMENT OF ENERGY
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RESEARCH PROGRESS AND IMPLICATIONS:

This report summarizes the research work completed on the project between December 2001 and September 2002.

1. A model of all Spectral IP capacitive couplings revealed that potential bearing electrodes should be carefully chosen to obviate some of the capacitive coupling problems. This need becomes more important for borehole sampling. Thus, work had been done to design a porous pot electrode that has all the desired characteristics (low input impedance $\leq 100\Omega$, low noise $\leq 1\ \mu\text{V}/\sqrt{\text{Hz}}$, low temperature sensitivity $\leq 10\ \mu\text{V}/^\circ\text{C}$) and that can be implanted in a borehole for up to two years. Further constructional/fabrication details will be given in the final report. The attached pictures are from a sample of the prototype electrode. Four strings, each consisting of 14 electrodes (7 potential electrodes alternated with 7 metallic-copper current electrodes, each electrode 6ft apart), were constructed and are to be deployed into the four boreholes. (They were eventually deployed in Dec. 2002 and measurements acquired in March 2003).
2. The MIT's Earth Resources Laboratory (ERL) performed Spectral Induced Polarization (SIP) and Time Domain Induced Polarization (TDIP) measurements at the A-14 Outfall during the summer of FY01 as a participant in a DOE-sponsored exercise to assess the state-of-the-art in cross-borehole IP technology for delineating subsurface contaminants. To demonstrate the utility of SIP to map DNAPL contaminants, we inverted cross-borehole SIP data, taken within a very narrow frequency bandwidth of 1/32 to 9/32 Hz. The narrow bandwidth was selected after carefully studying when effects of emc, electrode polarization, etc. begin to set in. The upper frequency is limited by electromagnetic couplings (emc) and strong capacitive behavior observed for the electrodes and the low-frequency limit is set by the time to take measurements. Because below 9/32 Hz, the IP response seems to be greater than emc in all our measurements, the data was considered invertible by our existing 2D/3D complex resistivity codes. The results of this exercise were inconclusive because the ground-truthing phase of the operation failed to detect any concentration of NAPL above a requisite threshold of 40-50 $\mu\text{g/g}$. It is our understanding that this threshold level is based upon analytic chemical partition analysis, which is dependent upon the physicochemical properties of the soil, its pore-fluid, and organic constituents [Cohen and Mercer, 1993], and thus represents a necessary and sufficient condition to confirm the presence of NAPL. Therefore, since the ground-truthing phase never found PCE concentrations in excess of $\sim 3\ \mu\text{g/g}$, there is no irrefutable evidence of NAPL; hence, the objective of the FY01 exercise

could not be completed. Nonetheless, ERL's inversion results (an example is shown in Figure 1) agree well with the ground truth considering the sparseness of the CRS boreholes, low concentrations of 'PCE' ($< 3\mu\text{g/g}$), and despite poor electrodes. Note that the displacement of the center of the SIP phase anomaly from that of the ground truth data might be due to inaccuracies in the SIP inversion (which we are still working on improving) or sampling depth errors during the ground-truthing phase which could cumulatively amount to a meter or more.

3. As a continuation of the FY01 efforts, another set of surface and borehole SIP measurements were planned at another SRS site during FY02, which unlike the FY01 site, had been verified to have substantial DNAPL presence by SRS engineers. The plan to use Phoenix Geophysics SIP equipment could not materialize because Phoenix discontinued its SIP line and planned to introduce a new line in the Spring/Summer of 2003, which will be too late for us. So our planned second fieldwork of FY02 defaults again to Zonge Engineering and Research Organization equipment.
4. Developments on the modeling and inversion of the new complex resistivity code, that will incorporate inductive coupling, stalled to give way to the electrode design, fabrication and testing(s), which were not anticipated earlier.

Reference

Cohen, R., Mercer, J., Mathews, J. (EPA Project Officer), *DNAPL Site Evaluation*, C.K. Smoley, 1993

PLANNED ACTIVITIES

The following shows a timetable of activities planned for the remaining time of the project:

October 2002 to March 2003: Completion of the formulation of the forward and inverse algorithms.

October 2002 to March 2003: More field work using Zonge Engineering and Research Organization SIP equipment.

March 2003 to May 2003: Testing of the inverse algorithms using both synthetic and field data.

June 2003 to July 2003: More demonstration field work possibly at Savannah River Site A14 outfall.

July 2003 to September 2003: Interpretation of field results and writing of reports.

Figure 1 a: Porous pot electrode Potential- shown with protective (red) cover.

Figure 1 b: Porous pot electrode Potential- width.

Figure 1 c: Porous pot electrode Potential- showing the cap.

Below is an image that shows the interpolated ground truth concentration of an “unidentified” substance but labeled PCE by SRS ground-truthing team.

PCE-IP ground truth comparison at the A-14 Outfall

Figure 2 Comparison of the ground-truth PCE anomaly (a), the ERL's SIP anomaly (b), and the ERL's TDIP anomaly (c). Panel a has been generated by taking a slice along the MES-2/MES-4 panel from the volumetric PCE concentration (interpolated from the CRS series of boreholes, taken during the FY01 ground-truth exercise). Panels b and c are the ERL's inversion results along the MES-2/MES-4 panel. MES-4 is located on the right-hand side of all three panels.