Near Ready, Real Potential

The Feasibility of Using Natural Fibres for Reinforcing Thermoset Composite Parts for Ground Transportation Applications

Biofibres Development Approach

- Use existing plant varieties initially
- Review current harvesting techniques, develop & implement alternates
- Develop new decortication technologies to provide a natural fibre source
- Define composite part & engineered mat req's
- Identify & implement a holistic fibre grading approach

- Develop a material preparation and mat making capability
- Investigate and develop suitable fibre surface treatments
- Identify and select suitable resins
- Identify/develop additional test methods

- Perform panel and part manufacturing trials
- Evaluate composite panel properties
- Produce and test in-service composite parts

- Market Size (E-glass Composites)
  - The demand for E-glass fibre in North America in 2004 was estimated to be around 1.4 billion lbs, or over 632,000 tonnes
  - Available in a variety of forms, of which chopped strand and chopped strand mat are initially the most favourable forms for biofibres
- Oilseed Flax Fibre Availability (Canada)

Flax Volume

Low Estimate	**36,562**	**m^3**
High Estimate	**138,571**	**m^3**

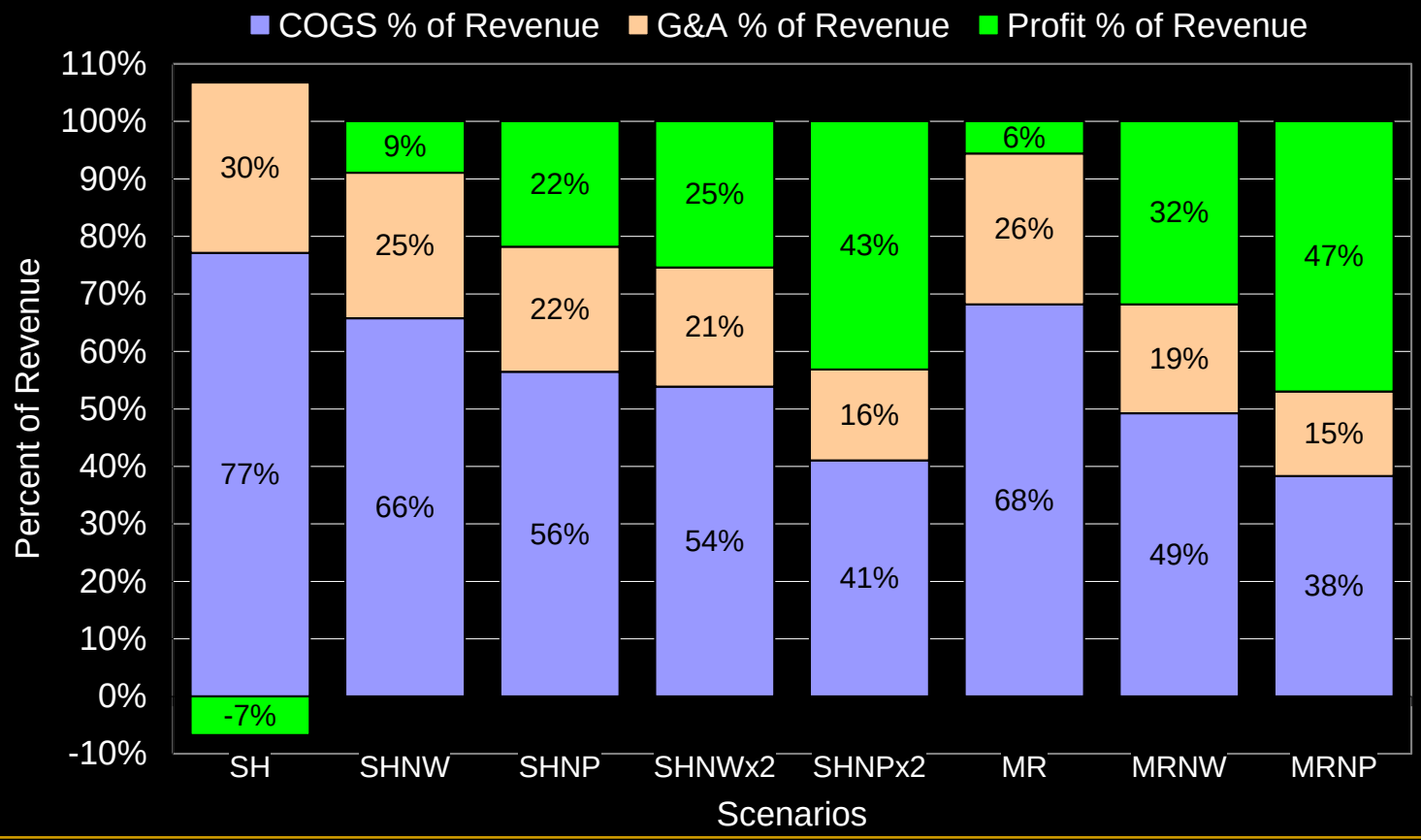
Favourable Glass Forms Volume

Canada	**4,213**	**m^3**
North America	**42,130**	**m^3**

Scenarios Investigated

Scenario Abbre.	Raw Fibre Input	Primary Processing	Secondary Processing	Glass End Market Target
SH	Salvaged Oilseed	Hammer Mill + Screening		Loose Fibre, Low Quality
SHNW	Salvaged	Hammer Mill +	Nonwoven Mat	Chopped Strand Mat,
SHNP	Salvaged Oilseed	Hammer Mill + Screening	Nonwoven + Needle Punch	Chopped Strand Mat, Low Quality
SHNWx2	Salvaged Oilseed	Hammer Mill + Screening	2 lines Nonwoven Mat	Chopped Strand Mat, Lowest Quality
SHNPx2	Salvaged Oilseed	Hammer Mill + Screening	2 lines Nonwoven + Needle	Chopped Strand Mat, Low Quality
MR	Managed Oilseed	Roller / Shaker		Loose Fibre, High Quality
MRNW	Managed Oilseed	Roller / Shaker	Nonwoven Mat	Chopped Strand Mat, Low Quality
MRNP	Managed Oilseed	Roller / Shaker	Nonwoven + Needle Punch	Chopped Strand Mat, Mid Quality

Calculated COGS, G&A and Gross Profit As % Of Revenue



MARKET POTENTIAL

- Scenarios incorporating a biofibre mat line(s) suggested sizable profits could be gained.
- The production of loose fibres from oilseed flax was the only form that was not considered commercially viable
- Hemp also has some potential to be more economical than flax due to increased biomass per hectare

- Full Marketing Report available for download at:

  http://www.compositesinnovation.ca/FTP/website/biofibre.php

  - Fibre Processing Scenario Comparison Tool (Excel) available with Marketing Report to produce custom scenario analysis

MARKET POTENTIAL

- Baseline Technical Ability
  - Objectives
    - Establish a method to manufacture composite panels from flax fibre mat using existing industry practices
    - Determine baseline properties through physical and mechanical testing and compare results to E-glass panels of similar fibre volume content
  - NOT optimized – a starting point from which optimization can occur
  - Process selected was resin infusion using a polyester thermoset resin matrix

Properties

Properties	Comparative Results for Flax Panel
Acoustic Transmission Loss	• Better sound damping capabilities than glass
Water Absorption	• Small increase in water absorption over glass in 2 hr submersion • Large increase in water absorption over glass in 24 hr submersion • No measurable swelling
Surface Flammability	• Reduced flammability resistance compared to glass
Heat Distortion	• Reduced performance at high temperatures compared to glass • Improved performance over neat resin
Charpy Impact	• Significantly reduced performance compared to glass • Reduced performance compared to neat resin

Properties Continued

Properties	Comparative Results for Flax Panel
Corrosion Resistance	• Properties similar to glass
Operating Temperature	• No visual degradation • Properties similar to glass
Flexural Strength	• Significantly reduced performance compared to glass • Reduced performance compared to neat resin
Tensile Strength	• Significantly reduced performance at high temperatures compared to glass • Reduced performance compared to neat resin
Flexural Modulus	• Reduced stiffness compared to glass • Improved stiffness over neat resin
Tensile Modulus	• Reduced stiffness compared to glass • Improved stiffness over neat resin

- Areas for Optimization
  - Fibre Matrix Bond
  - Reducing impurity content in flax
  - Fibre consistency
  - Engineered mat structure
- Current Applications
  - Non-structural, dry environments where weight savings with comparable acoustic damping needed
    - Ducts
    - Headliners

- Compatibility of the Matrix/Fibre Bond
  - Objective
    - Identify a commercially available thermosetting resin which exhibits strong bonding capability with natural fibres
    - Assess the strength of an interface bond and fibre/resin compatibility using multiple test methods
  - Constraints
    - Several thermosetting polymeric resins to be investigated
    - Resin selection will be based on typical industry practices and material prices
    - Oilseed flax fibre currently grown in Canada
    - Vacuum assisted resin infusion processing

- Compatibility of the Matrix/Fibre Bond
  - Multiple evaluation techniques in consideration, minimum of three to be used
    - Atomic Force Microscopy
    - Single Fibre Pull-Out
    - Confocal Laser Scanning Microscopy

- Compatibility of the Matrix/Fibre Bond
  - This slide will contain data on the results we have collected as of September
  - Scheduled end of project for Beginning of October

Developing Engineered Mats

- Objective
  - Develop an engineered mat from natural fibres to replace E-glass chopped strand mat (CSM) in fibre reinforced thermoset components
  - Targeted end-use is in resin infusion processes to produce parts for the ground transportation industry
  - Primary fibres are flax and hemp varieties currently cultivated in Canada, although other materials may be added to meet performance specifications

- Developing Engineered Mats
  - Specifications are finalized for a mat product: purity, consistency, physical and mechanical properties and compatibility with thermoset resins and processes
  - Four potential sources are identified capable of mat manufacture and/or development of pre-commercial equipment to produce the mat
  - Existing flax and/or hemp mats are obtained from other sources, panels fabricated, tested and compared with E-glass
  - Mat process method(s) is/are selected for upgrade to pre-commercial pilot plant scale
  - Economic processing data is generated sufficient to prepare a business case that supports economic viability of the processes selected

- Developing Engineered Mats
  - This Slide will contain information on the current status of the project by September
  - Project has just started (June 11th)
  - Project scheduled to be completed March 2008

ONGOING DEVELOPMENT PROJECTS

Fibre Testing Protocol

- Objectives
  - Identify relations between fibre properties and affect on composite performance
  - Establish test methods to quantify fibre properties which affect performance and document the procedures
  - Perform multiple fibre tests and create composite samples from fibre forms to build statistical data on fibre properties vs composite performance
  - If possible, identify acceptable ranges of variation in fibre properties which do not adversely affect the composite end product for use in quality control

- Fibre Testing Protocol
  - Proposed Fibre Tests may include, but are not limited to:
    - Degree of Ret
    - Fineness
    - Straightness
    - Impurity Content
    - Strength
    - Density
    - Fibre Constituents (wax, cuticle, lignin and or pectin content)
    - Hydrophobicity

- Fibre Testing Protocol
  - Proposed Composite Tests may include, but are not limited to:
    - Microstructure analysis
    - Resin/matrix interface properties
    - Density
    - Water Absorption
    - Flexural Strength
    - Tensile Strength
    - Impact Resistance
    - Fibre Content

- Fibre Testing Protocol
  - This slide will discuss any progress achieved or test results collected before September
  - Project scheduled to start Mid July
  - Project schedule for completion March 2008

- Near Ready, Real Potential
  - Producing fibre for the composites industry has potential to make money for farmers, processeors and composite manufacturers
  - Current baseline flax material harvested in Canada and processed using known technology is able to manufacture non-structural composite parts and show a weight saving
  - Resins will be selected to optimize matrix/ fibre bonds
  - Engineered mats to be produced to introduce natural fibres to structural applications
  - Fibre assessment system to be developed to quantify fibres with their composite performance and ultimate lead to standardized testing and grading systems