

**DOE Sensors & Automation
2005 Annual Portfolio Review**

**Remote Automatic Material On-line
Sensor**

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Project Description

- **Need**

- Improved measurement capability for process control
 - › Forest Products – moisture in lumber and wood chips
 - › Mining – moisture and hydrocarbons in coal and ore
 - › Steel – hydrogen content of coke and quicklime
- Want rapid, non-destructive and preferably non-contacting

- **Goal**

- Desired moisture content accuracy
 - › Forest Products – 1%
 - › Coal – 0.25%

- **Core Technology**

- Low-field (~0.1T) Nuclear Magnetic Resonance (NMR)
 - › Uses electronics developed by Quantum Magnetics (now part of GE Security)

Project Description

- **Novel/Transformational Element(s)**

- Ability to measure liquid/solid ratios
- Low cost
 - › Low-field implies inexpensive magnets
 - › Considerable progress in system cost reduction

- **Initial Industry for Application**

- Forest Products
 - › Wood chips - Beta test site Paprican in Vancouver, BC
 - › Lumber – contract negotiations underway for feasibility demonstration

Project Description

- **Key Project Deliverable(s)**
 - Final report
 - › Design documentation
 - › Results of beta testing

Barriers and Pathways

■ Barriers

- Lack of a means for rapidly and accurately measuring moisture content above the fiber saturation point (typically 28%)
 - Oven drying is accurate, but it may take hours or days and is destructive
- Inability of prompt gamma neutron activation analysis to distinguish chemical forms of elemental constituents
 - Hydrogen – present as water or hydrocarbons?

■ Pathway

- NMR will allow rapid, accurate and non-destructive measurement of moisture content
- Great progress has been made in reducing cost of NMR electronics

Energy Savings

- **How will energy be saved?**
 - Reduced over-drying of lumber
 - Improved control of pulping process
- **Assumptions used in calculation**
 - 50 millions tons softwood lumber per year (US), 2% decrease in drying possible
 - 2.4 quadrillion BTU used annually by paper industry, assume 0.02% reduction
- **How much energy will be saved?**
 - 2 trillion BTU/year for softwood lumber
 - 0.5 trillion BTU/year for paper

Other Important Metrics

- **Improvement in quality**
 - Improvement in lumber grade through more uniform drying
 - Reduction of insufficiently dried lumber
- **Better information for raw material pricing**
 - Paper and pulp producers buy wood chips for fiber, not moisture
 - Similar issue for recycled paper

Accomplishments to Date

- **Demonstrated accuracy of NMR moisture content of wood**
 - Moisture content varying from 3% to 140%
 - $\pm 0.5\%$ at low MC's in laboratory system
- **Demonstrated feasibility of measuring Hydrogen content in CaO (quicklime)**
- **Designed and Fabricated prototype system**
- **Substantial (~13 dB) sensitivity improvements achieved with new low noise amplifier**
 - Allows for potentially same accuracy in less time
 - May allow for much cheaper magnet design
- **Prototype shipped to Paprican May 27th**

Anticipated Economic Impact

- **Reduction in energy consumption**
 - Assume \$10 per million BTU
 - \$20 million year softwood lumber
 - \$5 million per year paper
- **Increased revenues from improvement in lumber grade**
 - \$250 million per year

Continuation after ITP-Sponsored Project

- **Work with Paprican on implementing process control for paper and pulp industries**
 - They have the skills in process control, we have the instrumentation knowledge
- **Work with a major lumber company on measuring moisture content of green lumber**
 - Goal is improved drying control
 - Feasibility funding from customer

Value Proposition for End User

- **Wood chips for paper and pulp**
 - Pay for fiber, not water (useful for paper recyclers)
 - Savings on energy consumption and process chemicals
- **Engineered wood**
 - Better product from improved control on moisture content
 - Savings on energy used in drying
- **Lumber**
 - Potentially higher selling price from improvement in grade
 - Savings on energy use in drying
 - Decrease in loss of high priced hardwoods

Commercialization Plan

- **Work with Paprican to integrate technology with paper and pulp process control**
 - Paprican will have IP on process control
 - We will have IP on instrumentation
 - Amec has expressed interest
- **Work with Innovec for lumber industry**
 - Innovec would manufacture, and market systems
 - Innovec is well known in lumber industry
- **Potential applications in agriculture**
 - Driven by quality control
 - Increased market for systems could reduce cost per unit

Commercial/Technical Risks Remaining

- **Cost/Benefit**

- Does the benefit (reduced cost plus increased revenue) justify the cost of purchase, installation and operation?

- **Magnet fabrication**

- Can a magnet be built that has the needed field quality at a sufficiently low cost?
- Trade-off between magnetic field quality and complexity of data analysis

- **Fate of other NMR/NQR programs at GE Security**

- Low costs electronics development funded by other programs
- Goal is for many applications for core electronics

Showcasing Opportunities

- **Beta-testing at Paprican**
- **Biomass assay?**
 - Energy value of biomass related to cellulose content
 - Don't want to pay for water