Review of activities | 2010-2011

# Building the future on innovation.

# Today.

# One success at a time.

2010-2011

FPInnovations

# FROM IDEA TO INNOVATION

There's R&D. And then there's innovation. Focused on markets. On end-users. On partnerships that share risks – and rewards. Innovation, united with R&D, increases the potential tenfold. Welcome to FPInnovations.

FPInnovations is unique in the world. Funded by more than 280 Canadian forest sector companies in conjunction with 11 Canadian, provincial and territorial governments, FPInnovations explores pathbreaking ways of taking full advantage of the scientific, technological and commercial capital developed within Canada's forest sector.

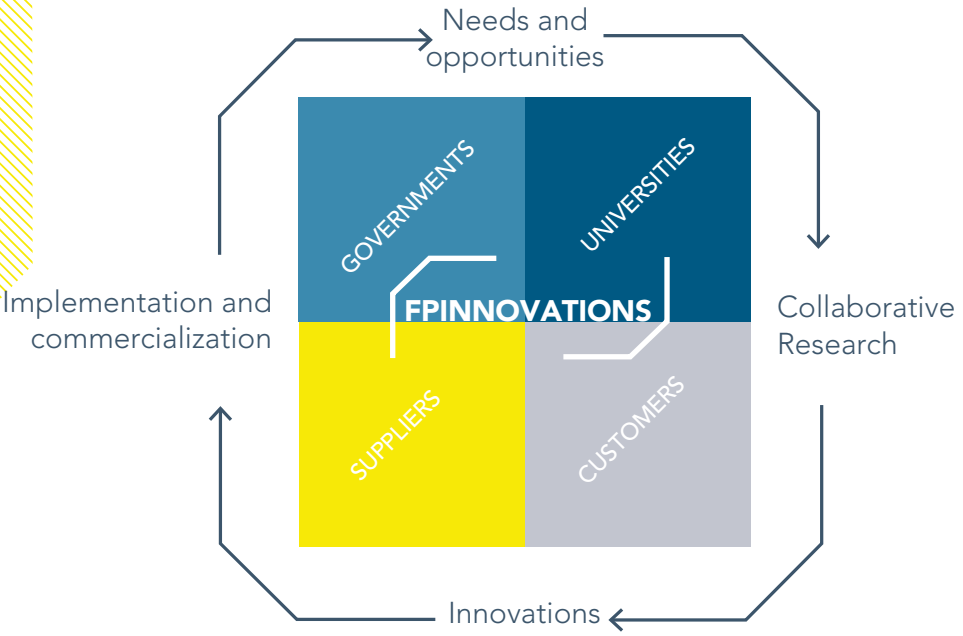
We are proud of our strong roots, and we are serious about serving our members from the Canadian forest industry, for whom our work has made a difference worth over a billion dollars in recent years. We promote innovation to help them find new solutions, as well as new market opportunities. Using an integrative approach, we endeavour to open up new possibilities, whether in the form of business partnerships, contractual services, intellectual property agreements or shared-risk research projects.

These possibilities are now leading us, and our partners, well beyond the forest industry's traditional markets. And in fact, well beyond the limits of the 20th century.

- Next-generation building systems.
- Next-generation pulp and paper.
- Energy and chemicals from biomass.
- Novel bioproducts.

Our research is leading us to explore new territory. Transportation. Clean energy. Green biochemistry. We are moving boldly into the age of the bio-economy and sustainable development, and the applications of our research are inestimable.

# FPInnovations, an innovation hub for the Canadian forest sector




We are seeking to position ourselves as an innovation hub that can align the skills, needs and solutions of different sectors of the Canadian economy. At the organization level, we have implemented the innovation process developed by SRI International*. We use the NABC method that focuses on the analysis of customer needs, our approach to the solution, the benefits and the competition.

This year, we played a key role in creating synergies between 11 governments (provincial, territorial and federal), academia and the industry. Working with universities under the NSERC Forest Sector R&D Initiative, FPInnovations was instrumental in renewing and creating eight specialized networks focused on new products' development, leveraging no fewer than 70 active collaborations with universities. Through these networks we are capitalizing on the innovation capacity of more than 60 professors and 250 graduate students from 24 Canadian universities, while building new relationships with the various industrial partners.

We have been engaged in a transition from conventional methods of research to innovative ones for the past three years, and our efforts came to fruition in a spectacular fashion in 2010-2011. Along with the cutting-edge work you will find outlined in this report, 13 pilot-plant projects for next-generation products were started under the Transformative Technologies Program funded by Natural Resources Canada (NRCan), provincial governments, industry and other partners. These are projects with significant commercial potential but a high level of risk. Over the course of the fiscal year, NRCan invested about $33 million in the Transformative Technologies Pilot-Scale Demonstration Program, a substantial investment leveraged with those from the public and private sectors. The 13 pilot-plant projects, in locations right across the country, have a developmental and multiplier effect on the regions where they are situated and can translate into significant job creation, whether in New Brunswick, Québec, Ontario, Alberta, Saskatchewan or British Columbia.

Our contribution to these start-ups was made possible by integrating our R&D work with state-of-the-art engineering and a strategic approach to marketing. This integration meant that, right from the start, each project's value proposition and its potential for success could be accurately defined.

* SRI International is an independent non-profit research institute based in Palo Alto, California.

This was the case, notably, for the new nanocrystalline cellulose (NCC) demonstration plant which is currently being built in partnership with Domtar in Windsor, Québec, under the corporate identity of CelluForce. This plant will be completed in a fraction of the development time of using the traditional R&D process because the research, engineering and marketing were aligned in advance. We are confident that, in the near future, NCC will bring the forest sector into the world of nanotechnology, and that this will take it far beyond its traditional markets.

At AbitibiBowater's Thunder Bay mill, in partnership with the Centre for Research and Innovation in the Bio-Economy (CRIBE), the Ontario Ministry of Research and Innovation and NRCan, we were involved in the building of a pilot plant that is already producing its first batches of industrial lignin. Lignin is a residual substance from the pulping process that can be converted into eco-efficient and commercially viable fossil fuel alternatives and any number of petroleum-derived substances: fuels, resins, rubber additives, thermoplastic blends, nutra- and pharmaceuticals, etc.

In Crofton, British Columbia, a pilot plant developed in collaboration with Catalyst and Paradigm Environmental Technologies makes use of MicroSludge™ technology to transform waste-activated sludge from pulp mills into biogas. This conversion of production waste into an environmentally friendly fuel will have a number of benefits, including lower greenhouse gas emissions and less residual sludge for disposal.

Opposite is a summary of these projects and others started this year. Each has the same kind of outstanding potential.

By getting all partners to share the cost and the risks, as well as the benefits and the marketable intellectual property, we believe that we are helping our members and business partners to move quickly and successfully from idea to innovation, and from innovation to a leading position in the new economy of the 21st century.

Take a look at our main achievements over the past year. See how our approach to innovation enables us, with our partners, the governments and the universities, to transform problems into opportunities, and opportunities into potential profits for our members, our clients and our partners.

And if you believe that innovation can make a difference for you, too, we should talk. You know our name. It's innovation.

# TRANSFORMATIVE TECHNOLOGIES PROGRAM

## PILOT-SCALE DEMONSTRATION PROJECTS ANNOUNCED IN 2010-2011

### CELLUFORCE AN FPINNOVATIONS – DOMTAR JOINT VENTURE
WINDSOR, QUÉBEC

Plant producing nanocrystalline cellulose from kraft pulps, with radically different properties than those of the original cellulose fibre.

Key elements

- 30 full-time employees.
- Completed for one-quarter of the initial budget.

Potential benefits

- New outlets for fibreboard in non-traditional sectors: biomedicine, pharmacology, cosmetics, construction, paints and coatings, automobile, aeronautics and others.
- Stable and continuous production of one metric tonne of first-quality NCC per day.

PARTNERS

Domtar Corporation

FPInnovations

PUBLIC FUNDING

| | |
|---|---|
| Natural Resources Canada | $11.2 M |
| Ministère des Ressources naturelles et de la Faune du Québec | $10.2 M |
| Value of project | $41.8 M |

### CRIBE PROJECT
THUNDER BAY, ONTARIO

Plant for development of new products and new processes from lignin, a pulp processing residue.

Key elements

- Use of an FPInnovations technology.
- Perfecting products that can be substituted for petroleum-based products.
- Use of a green and renewable resource to replace resources with a heavy carbon footprint.

Potential benefits

- Opening of non-traditional markets for the forest industry.
- Replacement of products derived from fossil fuels, greenhouse gas reduction, job creation in rural regions.

PARTNERS

AbitibiBowater (Thunder Bay mill)

FPInnovations

PUBLIC FUNDING

| | |
|---|---|
| Natural Resources Canada | $4.0 M |
| Ontario Ministry of Research and Innovation / Centre for Research & Innovation in the Bio-Economy (CRIBE) | $4.0 M |
| Value of project | $8.0 M |

## AV CELL PROJECT
### ATHOLVILLE, NEW BRUNSWICK

Plant allowing biogas production by anaerobic treatment of effluents with hollow-fibre contactor pre-treatment of evaporator condensate for sulphur recovery.

Key elements

- Use of a patent-pending FPInnovations technology.
- Potential savings of $2 million per year.

Potential benefits

- Increase in renewable energy production.
- Reduction of fossil fuels and atmospheric emissions.

PARTNERS

AV Cell

FPInnovations

PUBLIC FUNDING

| | |
|---|---|
| Natural Resources Canada | $5.0 M |
| Efficiency New Brunswick | $0.08 M |
| Value of project | $17.9 M |

## ZELLSTOFF CELGAR PROJECT
### CASTLEGAR, BRITISH COLUMBIA

Plant using the GAP-S system for sulphuric acid recovery from chlorine dioxide generator effluent and its recycling to pulp mill operations.

Key elements

- Use of a technology developed and patented by FPInnovations and Eco-Tec, and available from NORAM.
- High sales potential with pulp mills all over the world.

Potential benefits

- Reduction in sulphuric acid and sodium hydroxide consumption.
- Elimination of effluent releases from chlorine dioxide generators.

PARTNERS

Zellstoff Celgar

Eco-Tec

NORAM

FPInnovations

PUBLIC FUNDING

| | |
|---|---|
| Natural Resources Canada | $1.7 M |
| Value of project | $3.3 M |

## TOLKO PROJECT
### MEADOW LAKE, SASKATCHEWAN

Demonstration mill allowing the development of new generation strand-based wood products.

Key elements

- Use of an FPInnovations technology.
- Possibility of producing a family of strand-based products on a single production line – a first in North America.
- Establishment of a system allowing detection of high levels of fines and making the appropriate corrections to the process.

Potential benefits

- Transformation of mill from its previous commodity OSB-only status.
- Reduction of panel production costs by reducing the density and using less resin.
- Improvement of the mill's competitiveness and greater job stability in the region.

PARTNERS

Tolko Industries Ltd.

FPInnovations

PUBLIC FUNDING

| | |
|---|---|
| Natural Resources Canada | $1.3 M |
| Government of Saskatchewan | $0.3 M |
| Value of project | $3.2 M |

## LAUZON DISTINCTIVE HARDWOOD FLOORING PROJECT
### ST-NORBERT, QUÉBEC

Technology creating surface densification per area.

Key elements

- Use of an FPInnovations technology.
- Better positioning in the face of competition from offshore.
- Differentiation of products compared to exotic types.

Potential benefits

- Increase in the mechanical performance of the products.
- Increase in the added value of the products.

PARTNERS

Lauzon Distinctive Hardwood Flooring

FPInnovations

PUBLIC FUNDING

| | |
|---|---|
| Natural Resources Canada | $392 000 |
| Value of project | $392 000 |

## STRONGWOOD PROJECT
### CHEMAINUS, BRITISH COLUMBIA

Plant allowing testing and optimization of the performance of a prototype (full-scale) stranding and mat lay-up system for organizing and orienting veneer strands of uniform density.

Key elements

- Close collaboration with the industrial partner in the design, manufacturing and installation of the equipment.
- Responsible and eco-efficient use of the natural resource.

Potential benefits

- A 30% lower volume of timber (for an equal output) than the most efficient of the current engineered wood processes.
- Production costs at least 30% lower than those of any other engineered lumber product will accelerate market penetration.

PARTNERS

StrongWood Technologies

FPInnovations

PUBLIC FUNDING

| | |
|---|---|
| Natural Resources Canada | $0.9 M |
| Government of British Columbia | $0.9 M |
| Value of project | $2.3 M |

## STRUCTURLAM PROJECT
### PENTICTON, OKANAGAN FALLS, BRITISH COLUMBIA

Demonstration plant (expansion) for the production of cross-laminated timber panels.

Key elements

- Collaboration with European suppliers for selection, shipping and installation of the most suitable systems.
- Work with regulatory authorities for certification of the plant and the product.
- Creation of 15 full-time jobs.

Potential benefits

- Creation of a new market for new-generation construction systems.
- Promotion of practices geared to the use of wood by the construction industry in a sustainable development perspective.

PARTNERS

Structurlam

FPInnovations

PUBLIC FUNDING

| | |
|---|---|
| Natural Resources Canada | $3.2 M |
| Government of British Columbia | $2.5 M |
| Value of project | $14.6 M |

## TEMBEC FIBREBOARD PROJECT
### TÉMISCAMINGUE, QUÉBEC

Construction of a demonstration plant for manufacturing of new fibre-based composites from pulp.

Key elements

- Build a pilot plant to help determine technical and economic feasibility of a scale-up through prototype manufacturing and testing.
- Field-test commercial prototype's performance.

Potential benefits

- Creation of new value-added products from forest resources, particularly for the railway, industry and other infrastructures.
- Possible extension of the service life of current infrastructures and reduction of the environmental impacts related to waste disposal.

PARTNERS

Tembec

FPInnovations

PUBLIC FUNDING

| | |
|---|---|
| Natural Resources Canada | $3.5 M |
| Government of Québec | $3.5 M |
| Value of project | $8.7 M |

## ALBERTA NEWSPRINT CANADA PROJECT
### WHITECOURT, ALBERTA

Mill using dispersed air flotation to allow use of wood attacked by the mountain pine beetle.

Key elements

- Use of an FPInnovations technology.
- Mill using dispersed air flotation to allow use of wood attacked by the mountain pine beetle.
- Preservation of a mill's viability despite a change in its wood supply caused by propagation of the mountain pine beetle.

Potential benefits

- Reduction of bleaching chemicals and scum.
- Potential use of pine attacked by the mountain pine beetle for production of top-quality paper.

PARTNERS

Alberta Newsprint Canada

FPInnovations

PUBLIC FUNDING

| | |
|---|---|
| Natural Resources Canada | $1.1 M |
| Alberta Innovates Bio Solutions | $0.8 M |
| Value of project | $3.0 M |

## BIOXFOR (AIREX) PROJECT
### LASARRE, QUÉBEC

Development of industrial-scale unit for biomass torrefaction.

Key elements

- Assembly of a pilot-scale unit with a production capacity of 250 kg of biochar/hr.
- Support trials for the substitution of fossil fuels with biochar in various industries.

Potential benefits

- Reduction in greenhouse gas emissions from the substitution of charcoal, natural gas or oil.
- Diversification of the forest sector and development of new revenue streams from underutilized biomass.

PARTNERS

Cyclofor

Airex

FPInnovations

PUBLIC FUNDING

| | |
|---|---|
| Natural Resources Canada | $0.6 M |
| Value of project | $1.2 M |

## CANFOR PULP PROJECT
### PRINCE GEORGE, BRITISH COLUMBIA

Implementation of novel on-line technologies for transformation of an NBSK fibre value chain.

Key elements

- Use of an FPInnovations technology.
- State-of-the-art on-line wood, fibre and pulp quality analyzers.
- Optimizing the fibre value chain, from chip supply to end products.

Potential benefits

- Increase in margins by adaptating pulp products to specialized applications.
- Maximization of the value of high-quality fibre.

PARTNERS

Canfor Pulp

FPInnovations

PUBLIC FUNDING

| | |
|---|---|
| Natural Resources Canada | $2.4 M |
| Government of British Columbia | $2.1 M |
| Value of project | $10.2 M |

## CATALYST PAPER – ELEMENTAL ENERGY PROJECT
### CROFTON, BRITISH COLUMBIA

Plant allowing production of a clean and renewable energy, biomethane, from sludge generated by pulp and paper production.

Key elements

- Use of MicroSludge™ technology and anaerobic digestion.
- Conversion four times faster than for untreated sludge.

Potential benefits

- "Green" biomethane production on an industrial scale.
- Reduction of fossil fuels used by the mills, greenhouse gases and residual materials.

PARTNERS

Catalyst Paper

FPInnovations

Elemental Energy Inc.

Paradigm Environmental Technologies

University of British Columbia

PUBLIC FUNDING

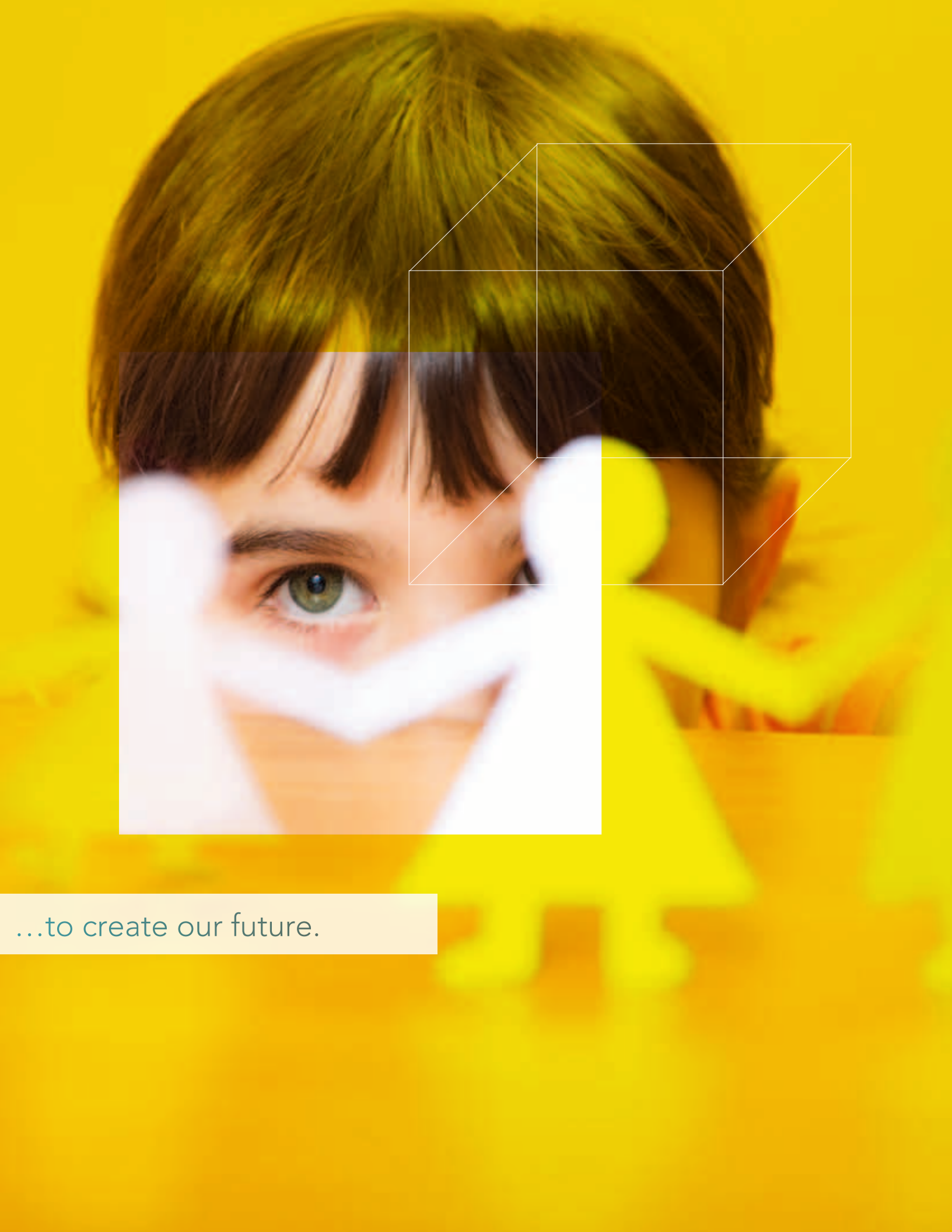
| | |
|---|---|
| Natural Resources Canada | $2.5 M |
| British Columbia Ministry of Forests, Lands and Natural Resource Operations | $1.0 M |
| BC Bioenergy Network | $1.5 M |
| Value of project | $6.1 M |

An overview of our projects in 2010-2011

# NEW CHALLENGES. NEW SOLUTIONS. NEW FUTURES.

Building on innovation...

Zhi-Hua Jiang, Principal Scientist, Biomaterials – Nanotechnology Group, Pointe-Claire.



...to create our future.

## NEW PILOT-SCALE LIGNIN PLANT IS A FIRST FOR NORTH AMERICA

Lignin is the focus of a pilot plant and product development laboratory for new forest-based bio-materials at FPInnovations' new $2-million Bio-economy Technology Centre in Thunder Bay. The primary purpose of the centre is to facilitate pilot and commercial-scale demonstrations of new forest-based biomaterials as a key step towards full commercialization.

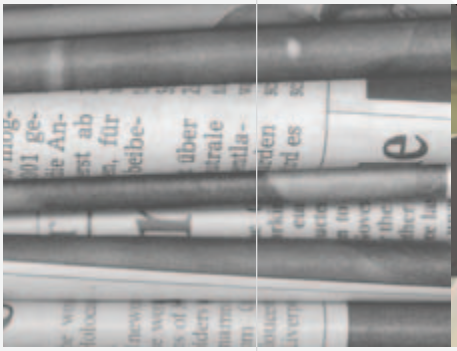
The project is the result of a partnership between the Ministry of Research and Innovation of Ontario and the Centre for Research and Innovation in the Bio-Economy (CRIBE), FPInnovations (which is contributing research and technology developments from the Transformative Technologies Program funded by Natural Resources Canada), and AbitibiBowater's Thunder Bay mill, where the pilot plant and an on-site support laboratory are hosted.

Lignin is one of the most abundant organic polymers on earth. It is also the only compound with aromatic properties that can be extracted from biomass. Despite that fact, conventional technology has led to few industrial uses other than as a low-value fuel. The end commercial goal of lignin extraction from the kraft pulp process is to develop novel products, such as resins, carbon fibre and thermoplastics, the value of which will be four to ten times that of the base fuel equivalent.

Considerable research has already been done on extracting lignin from kraft black liquor, but there remains the critical step of bringing the scientific know-how from the lab bench to pilot scale. The lignin pilot plant—the first of its kind in North America—will make it possible to complete this work in an industrially significant manner, allowing future commercial investment to move forward with confidence in a sound process and existing markets.

The lignin pilot plant comes at a critical time for partners and members considering diversification into bio-based markets. It is also timely for the developing bio-economy in Canada. The high cost of capital required for supporting technologies such as material handling, heat and power islands and effluent treatment systems, makes the implementation of stand-alone processes for lignin or other new forest-based bio-materials difficult. The successful launch of a new technology is therefore dependent on the use of existing infrastructure. The new facility provides a tremendous opportunity for those member companies and partners with existing conventional operations within the forest sector that plan to diversify and expand into the emerging bio-economy.

**1.** The new lignin pilot-plant is the result of a partnership among CRIBE, the Ontario Ministry of Research and Innovation, AbitibiBowater's Thunder Bay mill and FPInnovations.



## AUTOMATIC REFINER CONTROL HELPS PRODUCE HIGH-END PAPER

FPInnovations is using its knowledge about process control and optimization and the fundamentals of refining to help member newsprint mills implement refiner control and produce higher end papers, in order to ensure their long-term survival.

Newsprint mills are facing considerable challenges related to high energy and production costs, a shortage of good raw materials, tighter environmental regulations, and, most importantly, a shrinking market. One way to stay competitive is to produce a new paper for the high-end market where demand is strong and competition less intense.

However, making even the smallest change in paper quality can be a significant undertaking. Moving to a high-end paper requires producing "tailor-made" pulp with unique properties and low variability suitable for the new product. That requires close attention to the thermomechanical process. The production of thermomechanical pulp (TMP) often involves multiple refiners and many related processes. As process design becomes more complex, the potential for increased variability in the final product also increases due to interactions between process areas. Thus, when moving to the production of a high-end product, uniform pulp quality becomes an important target that can be achieved only through advanced automatic refiner control.

FPInnovations has contributed by designing refiner control algorithms that have been successfully implemented in many member mills. One newsprint mill was even able to produce high-end paper from 100% TMP. A graphic way to illustrate the difference between manual and automatic refiner control is by looking at shive levels, which provide an indication of fibre development. A shive is a small bundle of wood fibres that have not yet separated. High shive levels often mean poor fibre development, while shives in a paper machine can cause web breaks, therefore lower numbers are better. Lower, more uniform shive levels indicate better pulp development and a more uniform pulp quality. Implementation of the automatic refiner controls also resulted in energy savings of at least 5%.


## HELPING MEMBERS CAPTURE A GREATER SHARE OF THE CHINESE MARKET

China is now the world's leading producer and consumer of paper and board products, and Chinese demand for market pulp has been growing rapidly. Through a successful Canada-China joint research program, FPInnovations is using its connections and understanding of the Chinese market—in addition to its technical strength and global reputation—to help member companies gain a considerable competitive edge.

One of the research project objectives is to develop new technologies and strategies to increase the content of high-yield pulp (HYP) in high-quality coated papers from the current 15% to 50%. Chinese papermakers are very interested in utilizing the unique characteristics of Canadian HYP to enhance the performance of their paper products, but there are technical issues to be addressed in papermaking and printing when a large amount of HYP is used.

Given the recently increased brightness target for high-end coated papers, HYP producers have been challenged to help their customers minimize the use of optical brightening agents (OBA), as HYP has lower initial brightness and OBAs are less effective for high-yield pulps compared to kraft pulp. To solve the problem, a research partnership that involves FPInnovations and the University of New Brunswick developed new coating formulation strategies by using an additive to boost OBA efficiency and by optimizing its distribution in basestock, pre-coating and top coatings to minimize its overall usage. The new strategy has helped convince Chinese papermakers that they can use more HYP to replace kraft pulp in producing high-end coated papers.

Since Canada is a major producer of HYP and China is a major user, the joint research program, funded by International Science and Technology Partnerships Canada and the Chinese Ministry of Science, is benefiting the pulp and paper industry in both countries. It is also improving business ties, as pulp and paper companies in both Canada and China are actively involved as industry partners in the research program. FPInnovations has already built strong connections with China through technical and personnel exchanges, and through sponsoring and actively participating in a HYP workshop that has been held in China annually since 2009. Increasing the exposure of Canadian companies and technical expertise to the Chinese industry further boosts the potential for improving Canada's competitive position in China.

**1.** High-yield pulp technology workshop held in China as part of the Canada-China joint research program.

## FLOTATION COLUMN HELPS CLEAN UP PAPERMAKING

As part of the Transformative Technologies Program, FPInnovations has successfully transferred a key technology from the mining industry–first, to recover valuable fibres from waste streams in recycled papermaking and, most recently, to clean mill whitewaters. As a pilot project in an Alberta mill, a giant flotation column is currently being used to remove dark and contaminated fibre particles from whitewater – the dilution water from the papermaking process.

Thermomechanical pulp contains "lipophilic extractives" or "pitch" – natural fatty and dark materials from trees – that hamper the brightness of the finished paper and stick to fibre particles and papermaking equipment. The flotation column installed by FPInnovations injects air bubbles into the base of the column against the flow of whitewater injected into the top of the column. The fatty extractives on the small whitewater fibre particles stick to the air bubbles as they rise up the column, where they can then be skimmed off the top. This helps clean the whitewater so that both the leftover fibre particles and the water itself can be reused.

The sheer size of the flotation column that FPInnovations created for the Alberta mill – 28 cubic metres – represents a sevenfold scale-up from FPInnovations' columns used to recuperate valuable fibre from recycling rejects. Early results from the mill indicate that the column has increased the strength of the finished paper and the speed of the machines, while decreasing both fibre loss and the amount of chemical bleaching agents used.

Going forward, FPInnovations, the Federal and Alberta governments, and the mill where the flotation column is housed are looking at whether this technology can address a mounting industry problem: as more pine is affected by the mountain pine beetle, more of the sticky "pitch" substance that compromises paper quality and paper machine operations is secreted. Research is ongoing to see whether the flotation column can allow the mill to use more mountain pine beetle-affected wood while continuing to make a prime paper product.

**1.** The flotation column represents a sevenfold scale-up from previous FPInnovations flotation columns.

## A HUGE FUTURE FOR NANOCRYSTALLINE CELLULOSE

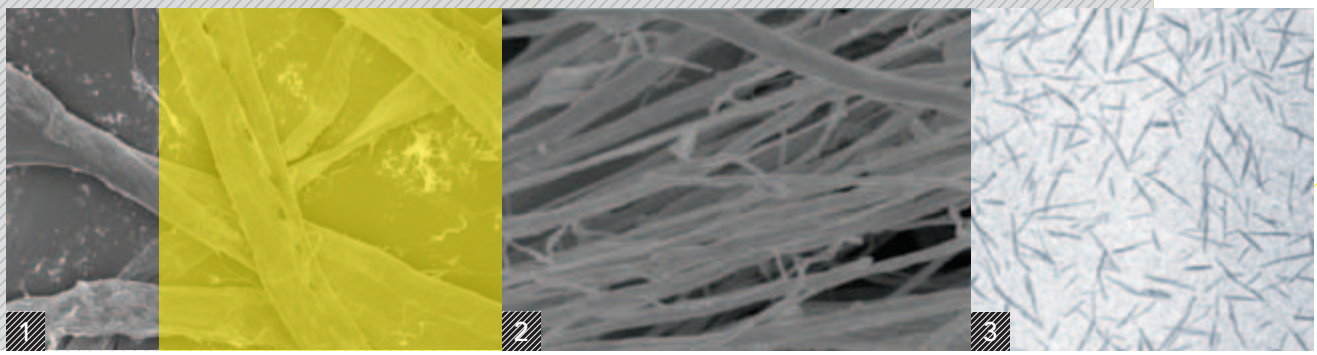
Exciting developments are continuing in the research and production of nanocrystalline cellulose (NCC). NCC – cellulose in crystalline form – is a fundamental building block of trees that FPInnovations extracts from forest biomass using its own patented process. NCC has unique optical, electrical, magnetic and strength properties that offer a wide range of potential applications. One significant advantage of NCC over most other existing nanomaterials is that in addition to being an abundant, renewable and biodegradable resource, it has also been shown to be virtually non-toxic.

One of the year's major events was the kick-off for the construction of an NCC demonstration plant project, a joint venture between FPInnovations and Domtar Corporation, in Windsor, Québec: CelluForce. This new plant, which has also received funding from the Federal and Québec governments and from Domtar, will produce one metric tonne of NCC per day.

During the construction of the Windsor plant, a small-scale 3-kg/day NCC plant was built in FPInnovations' facilities in Pointe-Claire. This plant will serve to meet the demand for NCC for university research and other purposes. Another important development was the purchase and installation of instrumentation for the new FPInnovations lab facilities in Pointe-Claire and Québec City, with 80% of the funding provided by a grant from Québec's *Ministère du Développement économique, de l'Innovation et de l'Exportation,* and 20% by NRCan.

In addition to meeting the growing demand for NCC both internally and from our research collaborators, the new pilot plant will allow us to develop new grades of NCC, scale-up some of the NCC processes, and pave the way for industrial-scale production. Ongoing R&D at these labs will allow us to make detailed characterizations of different grades of NCC, and study new approaches to its compatibility with different materials such as plastics. This will allow the development of new applications and potential applications in new areas that will make use of NCC's unique features, including its optical and electrical properties.

**1.** Jean Bouchard, Principal Scientist, Biomaterials – Nanotechnology Group, Pointe-Claire.



## CELLULOSE FILAMENTS: REINVENTED FIBRE

With the discovery of cellulose filaments, the fibre products' program has enriched its family of cellulosic products with a new material, situated somewhere between NCC and traditional wood fibre. These filaments have the same chemical composition and properties as fibre, but they are 100 to 400 times thinner and only 3 to 5 times shorter. This increases their reinforcement potential in fibre mats and thin films.

In fact, these are cellulose fibres cut lengthwise that form filaments from 100 to 300 nanometres in diameter and from 0.2 to 1 millimetre in length. This permits a much tighter mesh on the same surface, thereby creating the ideal reinforcement structure for paper and carboard. Added to wet paper, cellulose fibre doubles its tensile strength, which reduces the chances of the paper coming apart in the machines. The first thought for the use of these filaments is in paper products, but the bioplastics and composite markets are also being considered.

Even though they are the result of extensive research, cellulose filaments are produced using very traditional methods, stemming from current pulp and paper industry expertise. Since the process requires existing mechanics, mills can be adapted to produce these filaments at a very reasonable cost. The filaments themselves can be equiped and used in ordinary paper machines without any modification.

The possible industrial applications of cellulose filaments are numerous. For example, when added to reinforce paper, they make it possible to use a more substantial mineral filler. This could also contribute to a 20% reduction in the weight of paperboard made from recycled fibres. It is also possible to make paper that is almost transparent, as thin as plastic wrap, which could be applied to cardboard to make it more waterproof.

## HELPING RECYCLING MILLS "SEE THE DIFFERENCE" IN PULP CONTAMINANTS

An ongoing challenge for every mill producing recycled paper is the range of contaminants found in the old paper products that they use – contaminants that stick to papermaking machinery, slowing down production and compromising the quality of the finished product. A new diagnostic tool created by FPInnovations is letting recycling mills better see and identify these contaminants in their papermaking pulp. Programmed to perform pulp-stream diagnostics 96 times per day, the FPAuto-Speck™ requires maintenance only once a week – allowing for a complete paradigm shift in the frequency and accuracy with which pulp contaminants are generally identified and treated.

**1.** Wood fibres.

**2.** Cellulose filaments.

**3.** Nanocrystalline cellulose.

Coupled to a pulp classifier, the new FPAutoSpeck™ accomplishes a pulp analysis in 15 minutes that would take a technician about 90 minutes to complete in a lab. Because properly identifying contaminants is traditionally such an arduous and costly process, many mills treat all contaminants as though they're "stickies" – undissolved matter from sticky labels and glues in recycled paper. With the FPAutoSpeck™, contaminants are separated out based on their ability to float or sink in water, and mills see clear images of these contaminants on a computer screen – whether they're stickies or other matter, like dirt or fibre bundles. Trials at three mills have demonstrated that the FPAutoSpeck™ allows the mills to better adjust their processes to address these contaminants, with an aim to improving runnability issues at the printer.

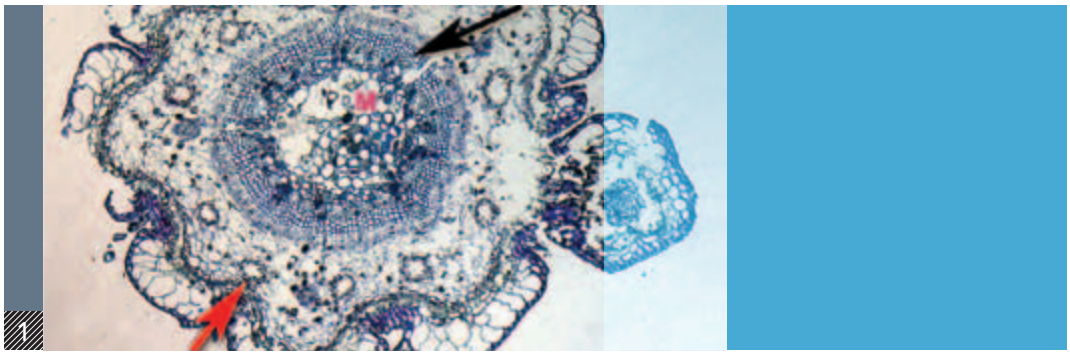
FPInnovations has partnered with Technidyne Corporation, a global company that specializes in quality control equipment for papermaking, to manufacture the FPAutoSpeck™. As of spring 2011, Technidyne has received expressions of interest from 15 Canadian and U.S. paper mills. Currently, FPInnovations is working on increasing the unit's capacity, which would extend its usefulness to the tissue production industry, where large sample size is a necessity due to the relatively low contaminant levels of the tissue pulp.

## BIOMASS FUEL FOR COMMUNITY HEATING PROJECTS

There is a growing interest in using forest residues to replace fossil fuels; however biomass has a low energy density, making the cost of transportation one of the main hurdles to its use. Biomass heating projects are an attractive option for forest-based communities since the feedstock is a local resource, the volume requirements are moderate and the transportation distances may be shorter.

The Amqui Hospital biomass heating project in Québec's Matapedia Valley, started by the *Coopérative forestière de la Matapédia*, has demonstrated the feasibility of using biomass from local forests as an economically beneficial replacement for fuel oil. Harvest residues from a nearby forest management unit are chipped after drying at the roadside for a year or more, and then stored before being used as fuel. The hospital's two automated biomass boilers, one rated at 500 kW and the other at 800 kW, have been in operation since 2009. Not only have the hospital's fuel costs been reduced, but the project provides work for local businesses and other direct economic benefits to the community.

**1.** Energy chips transportation and storage at the *Coopérative forestière de la Matapédia*.



FPInnovations provided support in analyzing supply, implementing the supply chain and optimizing biomass harvesting and transport activities. We also helped organize the biomass fuel storage strategy and optimize the supply flow to reduce storage constraints related to the seasonal delivery schedule. Metla, the Finnish Forest Research Institute, also supplied state-of-the-art expertise, which was vital to the overall success of the project. The Amqui project has become a flagship for community biomass fuel development in Canada.

In British Columbia, two case studies in Cowichan Lake and Smithers analyzed the feasibility of utilizing harvest residues for bioenergy and biofuels. Currently, forest companies in BC have to burn residue piles to reduce fire risk and provide for regeneration, a costly activity that generates large quantities of $CO_2$ and small particulate matter emissions. The Cowichan Lake case study looked at the possibility of converting local harvest residues into fuel pellets or briquettes in a biomass densification plant. The Smithers case study analyzed potential venues for disposing of residues from the salvage logging of lodgepole pine stands killed by the mountain pine beetle (MPB). These case studies provided valuable information to the two BC communities in their work toward developing renewable energy plans.

Another project, in Fort McPherson, Northwest Territories, was initiated following a workshop organized by FPInnovations to look at local bioenergy solutions that could lower the dependence on fossil fuels. Local sources of feedstock for a proposed central heating plant include willow growing on islands and along the river banks, and highway right-of-way trimmings. The project provided the community with information on the volumes of willow available, harvesting opportunities and seasonal constraints. The project also outlined a potential supply chain the community can use to further develop a business plan.

## SPRUCE IN SPACE

Forestry may be one of Canada's oldest industries, but FPInnovations has given it a taste of the Space Age: a joint project involving the Canadian Wood Fibre Centre (CWFC)* and the Canadian Space Agency (CSA) sent two dozen white spruce seedlings on a trip to the International Space Station (SSI).

This historic occasion – a first for Canada – gave the CWFC's forest genomics research team a rare chance to grow trees in microgravity conditions. This was done to better understand how wood develops in general, in order to produce wood that has special attributes. Canada is currently the only country to study the effects of gravitational changes on trees.

White spruce was chosen for this project because of its strategic and economic importance. It is widely used by Canada's forest industry, particularly as saw logs and for pulp and paper. White spruce is one of the most important species in terms of reforestation in Canada. It is also a species

**1.** Histological cut of a shoot of a white spruce that grew in the International Space Station in microgravity conditions. The black arrow shows lignified cells while the red one shows resin canals.
(Photo: Dr. Danny Rioux and Mrs. Marie Simard, NRCan)

* CWFC was created by the Canadian Forest Service (CFS) of Natural Resources Canada to support FPInnovations' various activities.


about which we have a lot of genetic information and for which genomic resources have recently been developed.

The year-old seedlings, supplied by J.D. Irving Ltd., were launched into space aboard the Space Shuttle Discovery, and then transferred to the ISS's Destiny Lab where they spent 30 days growing in an incubator developed by NASA. Light, temperature and atmospheric conditions inside the incubator were controlled, and the astronauts watered the seedlings as necessary. Meanwhile, back on earth, a group of control seedlings were kept under similar conditions at the Kennedy Space Center for later comparison.

At the end of the experiment, the new shoots that had grown in space were collected and brought back to Earth on the Discovery's historic final flight in March 2011. They will be studied to determine the effects of gravity on tree growth and cell organization, as well as on the genetics of wood formation. The final goal is a more competitive Canadian forest industry.

## PROFITABILITY FROM HARDWOOD FORESTS

Hardwood sawmills in the Laurentides area of Québec are noticing a significant positive impact thanks to Biolly II, a decision-support system designed by the Canadian Wood Fibre Centre (CWFC) as part of the Eastern Hardwood Initiative.

Effective management produces healthy, profitable forests, but this is only possible with a thorough knowledge of the structure and dynamics of different stands and how they are affected by various harvesting systems. Under the Eastern Hardwood Initiative, the CWFC is collaborating with *Signature Bois Laurentides*, an umbrella group for silviculture businesses and wood-using industries in Québec's Laurentides region. Together they carry out research aimed at providing advice and tools that will help profitably harvest mature trees while favouring the regeneration of desired species in each stand.

An important part of this research applies to Biolley ll, a decision-support program designed to help optimize prescriptions for partial harvesting in hardwood forests, and analyze the robustness of the solutions provided. It takes into account a wide range of factors, some of which have an inherent level of uncertainty (growth and market projections, for example). The goal is to increase the profitability of partial harvests while improving the value of the trees remaining for future harvests. Past selective cutting in Canada's eastern hardwood forests has often resulted in relatively heterogeneous stands with low densities of mature and high-quality trees. Biolley II uses a model to search for partial-cutting rules that will maximize the profitability of these stands sustainably, while benefiting the entire hardwood value chain.

**1.** A white spruce plant inserted into a tube containing oasis foam, labelled and ready to be placed into a Ziploc® bag for transportation to the International Space Station. (Photo: Dr. Luchino Cohen, CSA)

The first results of this analysis and optimization of partial harvest strategies and practices has been very successful. The decision-support tool has contributed to a 7% increase in harvest volume along with a $350 per hectare increase in the value of residual trees (which can be maintained up to 30 years following harvest). Other hardwood-using regions of the province also stand to benefit from the research. The anticipated end result will be a healthier, more sustainable forest resource combined with present and future economic benefits.

## INITIATIVES LENGTHEN HAUL SEASON FOR FOREST TRANSPORTATION

FPInnovations' ongoing collaboration with government agencies, universities, and forest companies and their trucking contractors is shedding light on ways to extend the haul season and maximize payloads on public highways. This innovative research seeks to shape government initiatives and policies that utilize transportation infrastructure more effectively and sustainably.

Tire Pressure Control Systems (TPCS) are a proven technology to manage and vary truck tire pressures. TPCS improve truck mobility and reduce road impacts. FPInnovations' research in British Columbia, Ontario and Manitoba has supported government initiatives that exempt TPCS trucks from spring load restrictions (SLR) on approved routes.

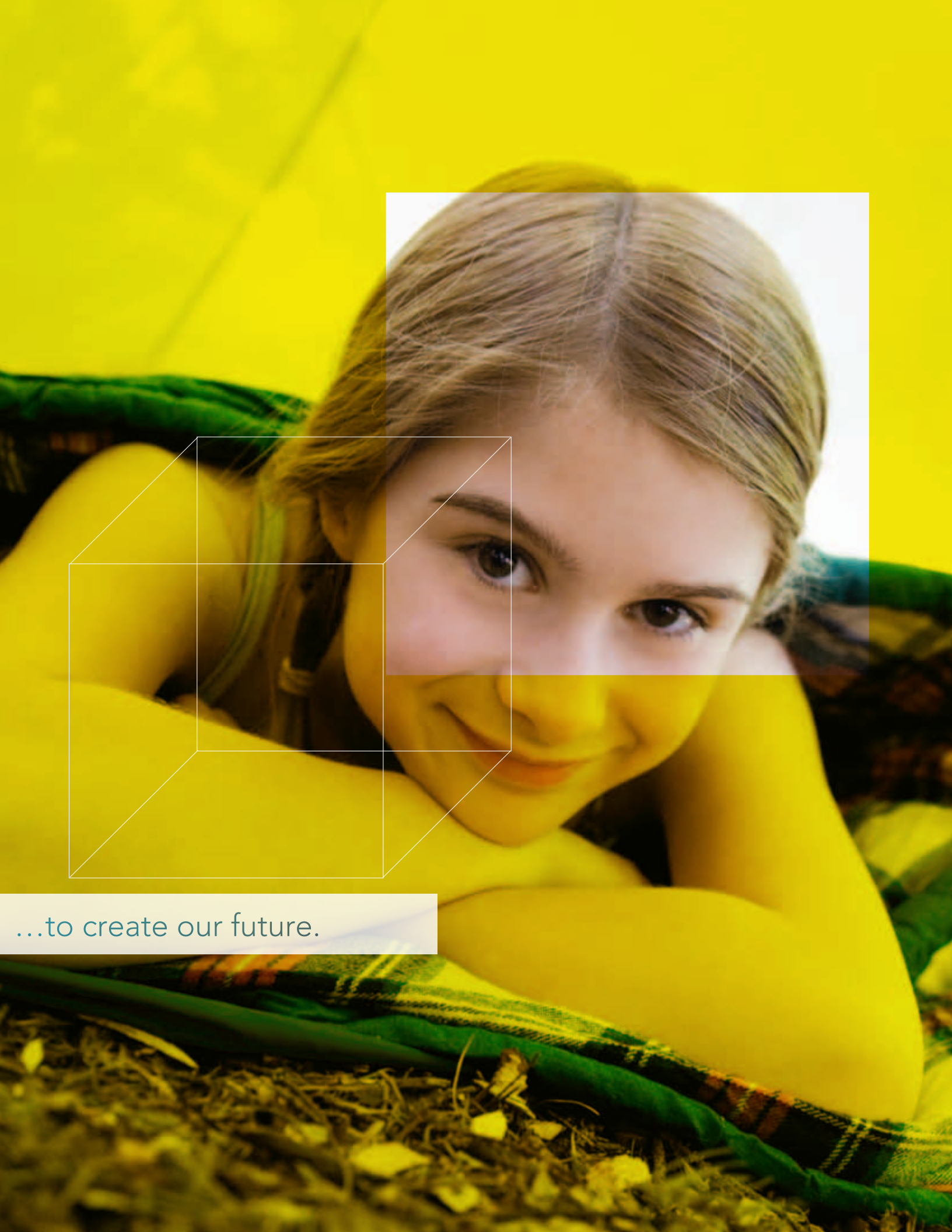
SLR programs protect thaw-weakened highways, and typically begin and end on fixed dates. This approach is not responsive to climate change and can result in overly long SLR durations or pavement damage. FPInnovations, with the Manitoba government, the University of Manitoba, Laval University and the Manitoba forest industry, have created a novel approach to both start and end their provincial SLR based on weather indices. This will shorten the SLR duration and better protect the infrastructure.

Winter weight premium (WWP) programs permit heavier payloads during the winter, when frozen highways are stronger. Like SLR programs, many WWP programs start and end on fixed dates. FPInnovations, with the government and forest industry of Manitoba, is creating a new approach to start and end WWP based on weather indices. This approach may extend WWP duration by 2 to 4 weeks, when cold conditions permit. Going forward, FPInnovations is aiming for this new approach to play a key role in maximizing profitability for Québec's *Plan Nord*, a sweeping, 25-year provincial initiative to develop the region's energy potential.

**1.** New initiatives are helping forestry operators haul more wood for a longer allowable period.


# Building on innovation…

Mithun Shetty, Researcher, Forest Operations – Transportation Group, Vancouver.


...to create our future.


## FACILITATING THE MEASUREMENT OF PRODUCTION IN FORESTS

Determining the exact yield and production of forestry equipment is of major importance in the forest. FPDat™ was designed to facilitate this task. It is an on-board computer comprised of a navigation system, a GPS tracking system and sensors for capturing production and usage data. In development since 2008 and funded by FPInnovations' industry members and the federal Transformative Technologies Program, the system has successfully passed through the prototype stage. The first units will be delivered this summer.

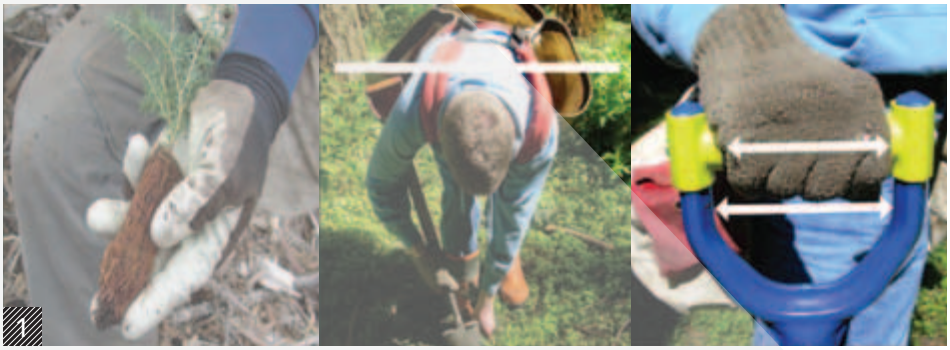
FPDat™ answers a variety of needs related to navigating in the woods:

- offers a visualization of the borders of a cut block;
- allows the operators to choose the best approach for cutting, which makes subsequent hauling operations easier;
- collects the utilization rates of the equipment and causes of stoppages;
- allows the operators to enter production data at various stages of the process.

Dashboard software, FPTrak™, completes the system. It consists of a cartographic Web platform that combines the yield data generated by FPDat™ or other systems. Its purpose is to simplify the life of forestry supervisors and contractors by allowing them to quickly compile detailed reports on their operations.

The forest industry has been following the development of the system with interest. Among the technical challenges that were successfully met were the design of an on-board computer robust enough for work in the forest and the implementation of a web site capable of hosting client data. We believe that the first 40 units delivered are only the beginning of what will prove to be widespread acceptance of the system.

**1.** The FPDat™ visualization screen.



## NEW TOOL HELPS TREE PLANTERS REDUCE INJURY

As many as 600 million trees are planted in Canada every year, and 90% of tree planters will experience a work-related injury during their planting career. Musculoskeletal injuries (MSIs), which include tendonitis and other repetitive and muscle strain injuries, are among the most troublesome injuries found in manual silvicultural operations.

For the past seven years, FPInnovations has been working to understand MSI in tree planters and, based on the research, to develop tools that would help prevent such injuries. This spring it released a new, interactive, audio-visual version of its best-selling Tree Planter's Guide to Reducing Musculoskeletal Injuries, previously published in Info-Flip format (over 7,000 copies sold). The online guide, available at http://fpi.na5.acrobat.com/tree-planters, allows viewers instant access to any part of the Planter's Guide and has narrated video clips that illustrate injury reduction exercises and stretches, as well as good and poor planting techniques for both Eastern and Western Canada.

FPInnovations has been running workshops for planting supervisors on how to implement the Guide's recommendations. The new, free online version will make the information more widely available to individual tree planters and allow information to be updated as new material is developed.

Tree planters are predisposed to MSIs because their work is hard and repetitive. By following the ergonomic tips in the Guide, they can learn how to warm up properly, prevent injuries with exercise, choose the right equipment and use it safely, and practice safe planting techniques. A healthy tree planter is a better, faster, more productive tree planter, to the benefit of the individual, the planting contractor and the forest company.

Financial support for the project came from Natural Resources Canada (under the NRCan-FPInnovations Core Program Agreement), WorkSafeBC, Weyerhaeuser Company Limited - Alberta Operations, the BC Forest Safety Council, the Western Silviculture Contractors' Association, *Association des entrepreneurs en travaux sylvicoles du Québec, Association de la santé et de la sécurité de l'industrie forestière du Québec, Fédération québécoise des coopératives forestières* and *Regroupement des sociétés d'aménagement forestier du Québec.*

**1.** A new tool is now available to help tree planters reduce the risk of musculoskeletal injuries.

## ENSURING RENEWABLE DIESEL MEETS INDUSTRY NEEDS

A field study conducted by FPInnovations has concluded that biodiesel in low percentage blends is a viable fuel for off-road machinery in the highway construction and forest industries. The study was a response to the federal government's initiative to require all fuel producers and importers to blend 2% biodiesel into their diesel fuel.

In partnership with Natural Resources Canada's National Renewable Diesel Demonstration Initiative, FPInnovations chose several project locations and separate industrial activities for the study: a sawmill in Prince George, BC, a highway project in Coquitlam, BC, and forest harvest operations in Merritt, BC. Two logging operators in Saint-Ludger-de-Milot, Québec, participated as well. A total of 47 machines across the different locations were tested on biodiesel blends, with a range of usage hours from as high as 350 hours/month to as low as 8 hours/month, to get a sense of how the biodiesel performed, both when used continually and after sitting idle for some time.

The results of the study were positive, with over 370,000 litres of biodiesel blends used and some 13,000 hours of problem-free usage with just a few simple preventative measures. These results were used by FPInnovations to publish two biodiesel user guides, one for the forest industry and the other for highway construction operations. The guides, as well as details on the study, are available on FPInnovations' biodiesel website: fptransport.org/biodiesel. FPInnovations also held a series of biodiesel workshops and presentations across the country for the forest, road construction, mining and railway industries, as well as municipalities.

Thanks largely to the results of this study and others mandated by NRCan, the federal government is going ahead with the implementation of their 2% mandate – an encouraging start in the greening of fuels.

## SOFTWARE APPLICATIONS PROMOTE BIOMASS USE

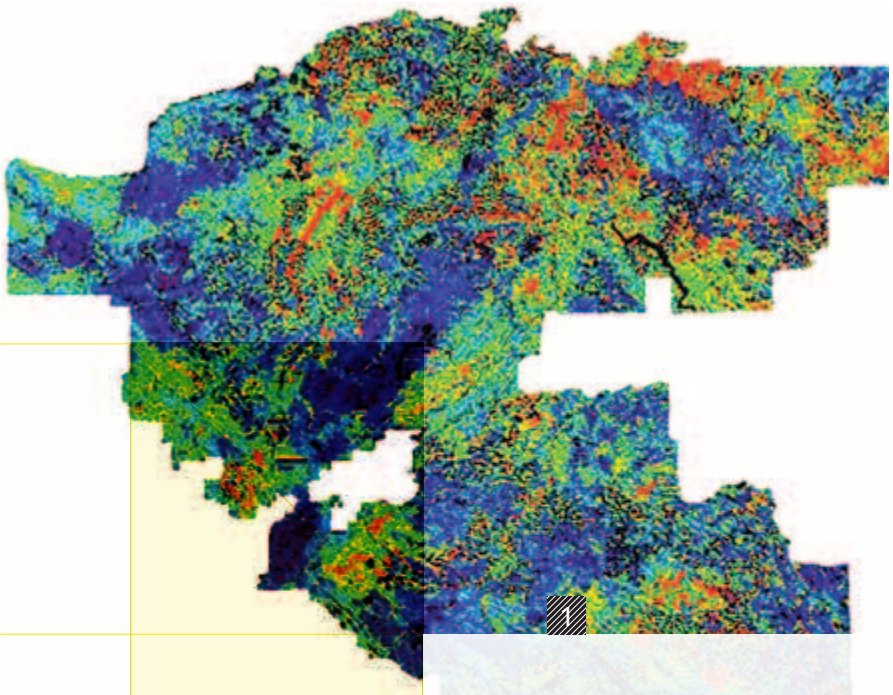
Two software applications created by FPInnovations are helping show the opportunities and advantages of using forest biomass, the material left over from harvesting and processing wood, as the preferred feedstock for the emerging bioeconomy.

BiOS (Biomass Opportunity and Supply), a module within the FPInterface™ software, helps forest operations' planners estimate the cost of their biomass and choose the best supply scenario for their particular harvest systems and supply chains. The BiOS module is highly customizable, taking factors such as tree species, terrain, harvesting systems and equipment into account to best reflect the real figures for a wide range of operating conditions.

First developed for the Ontario forest industry, BiOS was then customized for Québec, where it's now being used extensively. In the past year, FPInnovations has tailor-made versions of BiOS for Saskatchewan and Alberta, where it will play an important role with Weyerhaeuser Pembina in estimating realistic supply for the Drayton Valley Bio-Mile project. The next frontier: expanding its application to British Columbia, based on the Quesnel pilot project, and optimizing the module for the highly particular and challenging conditions of BC's coastal area.

In the past year, FPInnovations unveiled another computer application to estimate biomass value: FPJoule™. FPJoule was originally developed as a spreadsheet for helping members to make decisions based on detailed parameters affecting energy values. A simplified web-based application was then developed in collaboration with Québec's Ministry of Natural Resources and Wildlife, as well as the *Centre technologique des résidus industriels (CTRI)* and the *Syndicat des producteurs de bois de l'Abitibi-Témiscamingue*. The web version of FPJoule™ is now online and available to any biomass user or promoter. FPJoule lets users determine the value of forest biomass and perform a cost comparison between biomass and the fuel they're currently using, be it gas, electricity or oil. The results of the analysis can then be viewed online or printed. FPJoule can be found on the FPInnovations website at fpinnovations.ca/fpjoule.

**1.** Denis Cormier, Associate Program Leader, Silviculture Operations and Bioenergy Group, Pointe-Claire.



## LODGEPOLE PINE PARTNERSHIP TAKES LIDAR TO THE NEXT LEVEL

The Canadian Wood Fibre Centre (CWFC) has reached a significant milestone at the second of four sites where they are testing LiDAR (Light Detection and Ranging) technology to enhance forest inventory. Although LIDAR is widely used to map terrain in a digital elevation model, CWFC has now shown that it is also well suited to "mapping" tree height, diameter, volume and biomass in Canadian forests.

As part of the CWFC Inventory Tools Project, the Lodgepole Pine Partnership is the second focus area to use LiDAR to generate high-resolution geographic information system (GIS) layers for forest inventory. The first pilot project was completed last year in collaboration with the Ontario Ministry of Natural Resources and Tembec. This time, CWFC teamed up with Alberta Sustainable Resource Development, West Fraser Mills - Hinton Wood Products (HWP) and scientists from the Canadian Forest Service and UBC on the Hinton Forest Management Area in the foothills of the Rocky Mountains.

When HWP compared weigh-scaled volume records from 250 recently harvested blocks to LiDAR predictions, they found LiDAR was far more accurate than volume table estimates, which have long been the industry standard. LiDAR is used to spatially identified within-stand variability of metrics such as merchantable volume and stem size in a way that just isn't possible with the traditional approach. It is estimated that improved inventory data like these should generate substantial cost savings and help capture higher value from our timber.

The CWFC's Inventory Tools Project partners with FPInnovations members, and scientists from the Canadian Forest Service and universities across Canada, to develop remote sensing tools to enhance existing forest inventory for operational decision making. The current focus is on developing LiDAR and other forms of digital imaging as "operations-ready" tools to identify and map species, biomass, and wood or fibre quality indicators such as wood density, stiffness, taper, knot size, fibre length and coarseness.

**1.** LiDAR forest maps offer richer inventory data than conventional systems.

## DRIVER TRAINING MAKES A DIFFERENCE

Fuel costs are always a serious concern for transport companies and organizations with fleets of vehicles. But fuel efficiency is never just a matter of a vehicle's technical specifications. Studies done by FPInnovations' Programme Innovation Transport (PIT) team have shown that the way a vehicle is driven can make up to a 30% difference in fuel consumption. The PIT team has been working to develop and test new programs for FPInnovations' members. In particular, it is providing expertise, logistics and research assistance to member companies to help reduce their research and operational costs.

One training program for light vehicle drivers was developed by CAA-Québec in cooperation with the *Agence de l'efficacité énergétique du Québec*, Québec's energy efficiency agency, with financing from Natural Resources Canada. PIT managed the project, installing on-board computers and analyzing the data. Results to date have been very encouraging.

For nine years, members of the PIT team and the Transportation and Energy Program have been assigned by Natural Resources Canada to develop training programs for heavy vehicle drivers, primarily in the forest industry. On-board computers were installed, entire fleets were benchmarked, driver training was provided and the computer data was used to track driver performance. Significant improvements in fuel consumption were noted. PIT is now accredited to train truck drivers in the entire goods transport industry coast-to-coast through the SmartDriver program. The following are a few notable improvements in fleet fuel consumption using the SmartDriver program for logging trucks: CBPP - 6%; Bowater - 9%; Claude Guérin -10%; Coop St-Félicien - 12%.

PIT is also involved in an ongoing in-depth study of hybrid technology for city delivery trucks operated by Agropur and the *Société des alcools du Québec (SAQ)*. In addition to monitoring and analyzing data, PIT has published a best-practices guide for drivers to help them get the maximum benefit from their hybrid vehicles. Also for the SAQ, PIT co-developed a hugely successful training video on driving in rush-hour traffic.

PIT has provided guidance to NB Power as it implements green fleet management to improve fuel consumption. One of the most important aspects of the project was the production of a comprehensive training module for employees whose primary work is customer service, but who also have to drive a vehicle as part of their job, such as line workers and meter readers. PIT saw a group reduction of 27% in over-revving occurrences, and individual driver improvements of 62%. One driver was able to reduce speeding occurrences by 50%, while the overall reduction for the group was 25%.

**1.** A truck driver from Gaspé, Québec.

**2.** A forestry haul truck from Co-op St-Félicien, Québec.


PIT's approach to training is continually evolving and the team is currently developing custom training packages for member fleets, as well as a SmartDriver training package for municipal fleets.

## IMPROVING THE ENERGY EFFICIENCY OF FLEETS

NB Power, New Brunswick's electricity producer and distributor, is one of the important partners of the PIT program. The company operates a fleet, of more than 600 vehicles, of which one-third are medium- and heavy-duty trucks. It wanted to reduce its greenhouse gas emissions by 7% over a period of three years. This is why it approached PIT in 2009 to study new approaches to fleet management.

One of the most effective measures involved launching an anti-idling campaign. A number of the employees had the habit of leaving their motors running when stopped, which was not always justified. The company fought against this useless expense by distributing a map identifying company sites as anti-idling zones, by using signs as a reminder of this policy and by conducting training on alternatives to idling.

Among the new approaches adopted was an improved process for specifying needs, so that new vehicles could be less energy-consuming and better used. Training in eco-driving was also given to pickup and truck drivers. These courses, developed by PIT specifically for utility vehicle drivers, were aimed at teaching driving techniques that minimize fuel consumption.

The impact of this training was measured using on-board computers installed in 25 trial vehicles. Data collected before and after training was compared in order to evaluate improvements in driving habits. One of the findings was that there were a lot fewer occurrences of excessive speed (over 120 km/h) and over-revving (over 3000 rpm) of the pickup trucks in the months following the training.

This research has shown that sometimes it is the sum of small changes that produces appreciable overall results. It also shows that while the implementation of new technologies is necessary, simple management measures can also make a difference.

**1.** NB Power meter reader and boom truck.


## ASSESSING THE INTEREST IN HYBRID TRUCKS FOR DELIVERY OPERATIONS

Hybrid motor technology has been offered on certain trucks since 2005, but its adoption has been slow, particularly in Canada. The possible savings, although impressive on paper, do not always justify the additional cost for purchasing the vehicle. However research is beginning to identify applications where hybrid technology is advantageous.

The PIT program recently conducted tests on two hybrid trucks, one that was rented by Agropur in partnership with FPInnovations and the other belonging to the *Société des alcools du Québec*. This experiment, financed by the *Ministère des Transports du Québec*, took one year and evaluated this technology from two points of view: energy performance and profitability.

From the energy efficiency viewpoint, the experiment confirmed that it is possible to reduce fuel consumption by approximately 30%, as stated by the manufacturers. However, the travel needs to be primarily in urban areas and the vehicle cannot be driven too aggressively. The savings can fall below 10% when you combine travel outside urban areas, very cold temperatures and an aggressive driving style.

It would seem, therefore, that successful adoption of hybrid vehicles will require training, not only of the fleet managers, but also of the drivers. For this purpose, PIT has written a guide describing the best practices for driving hybrid trucks, which is essential in order to maximize the advantages of this technology.

Since these vehicles are 30% to 40% more expensive and they give their best results on relatively short urban trips, the study shows that the level of profitability of hybrid trucks is not yet satisfactory, in spite of *Transports Québec* subsidies. However, the expected increase in the price of fuel and the reduction in the cost of the technology promise a brighter picture for the future.

While waiting for the cost of these trucks to drop, certain applications already seem promising. For example, hybrid tool trucks use the electric motor rather than the diesel motor to supply their hydraulic systems. This eliminates long idling periods on work sites, which are costly in fuel. This is one of the avenues that PIT would like to explore.

**1.** The Agropur hybrid truck tested by PIT.


## CHOOSING THE GREENEST TECHNOLOGIES

Fleet managers face a bewildering number of choices when it comes to products that claim to enhance the fuel efficiency of trucks. But which ones are truly effective and in just what context do they provide the best return? Since 2007, we have been able to test 110 different technologies using Energotest road tests.

The tests are rigorously conducted according to recognized standards and several parameters. The requirements for one truck travelling long distances and another that is often idling while waiting are not the same. The tests take this factor into account, as well as driving at constant speeds or specific work cycles, and are conducted on a closed track at Blainville, Québec. The results are made available to the 30 members of the PIT program in the form of detailed reports.

The tests have also provided the basis for decision-support tools. With these computational tools, equipped with basic interfaces, several factors can be specified (type of truck, diesel cost, consumption, maintenance costs, etc.). This makes it possible to obtain results that closely correspond to the realities of each company in terms of fuel savings, reduction in greenhouse gas emissions and return on investment.

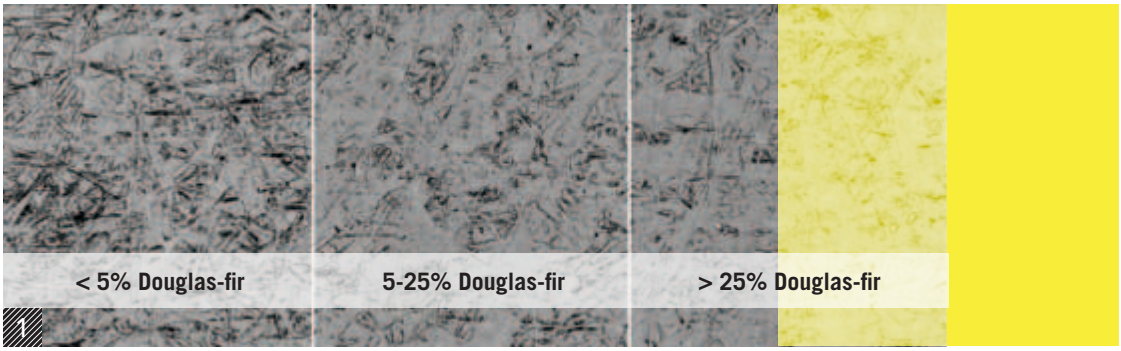
Several technologies have been successfully tested and their use is now spreading within the trucking industry. For example, trailer side skirts and wide-base tires have both proven their effectiveness, however, the results are not always so convincing. Testing makes it possible for the industry to avoid costly errors.

PIT also produces reference guides on other subjects. These guides, intended for fleet managers, are based on a compilation of existing technical documentation, road tests and the experience of program members.

For example, the Guide to the Functioning and Use of Selective Catalytic Reduction Systems and the Biodiesel User Guide offer handling procedures and performance studies on diesel exhaust fluid and biodiesel. As another example, the Guide to Evaluating Embedded Systems for Tire Pressure Management presents various types of equipment with their advantages and specific applications.

Among the ongoing projects, there is a guide to the life cycle of a truck. It will be used to determine the optimum useful life of a vehicle according to the type of vehicle, the sector of activity and the operating conditions.

**1.** A truck with trailer side skirts.




## LAB EVALUATION PROVIDES SUPPORT FOR SIMPLIFYING NBSK MANUFACTURING

Canadian Northern Bleached Softwood Kraft (NBSK) has been a prime choice as a reinforcement pulp in producing printing and writing grade papers. One of its main applications is in coated wood-free papers, with a typical usage of about 25% in the basestock, the rest being hardwood kraft pulp. However, when used in coated papers, NBSK must have no adverse effect on coating holdout—the ability of the base paper to resist coating penetration—or coating coverage.

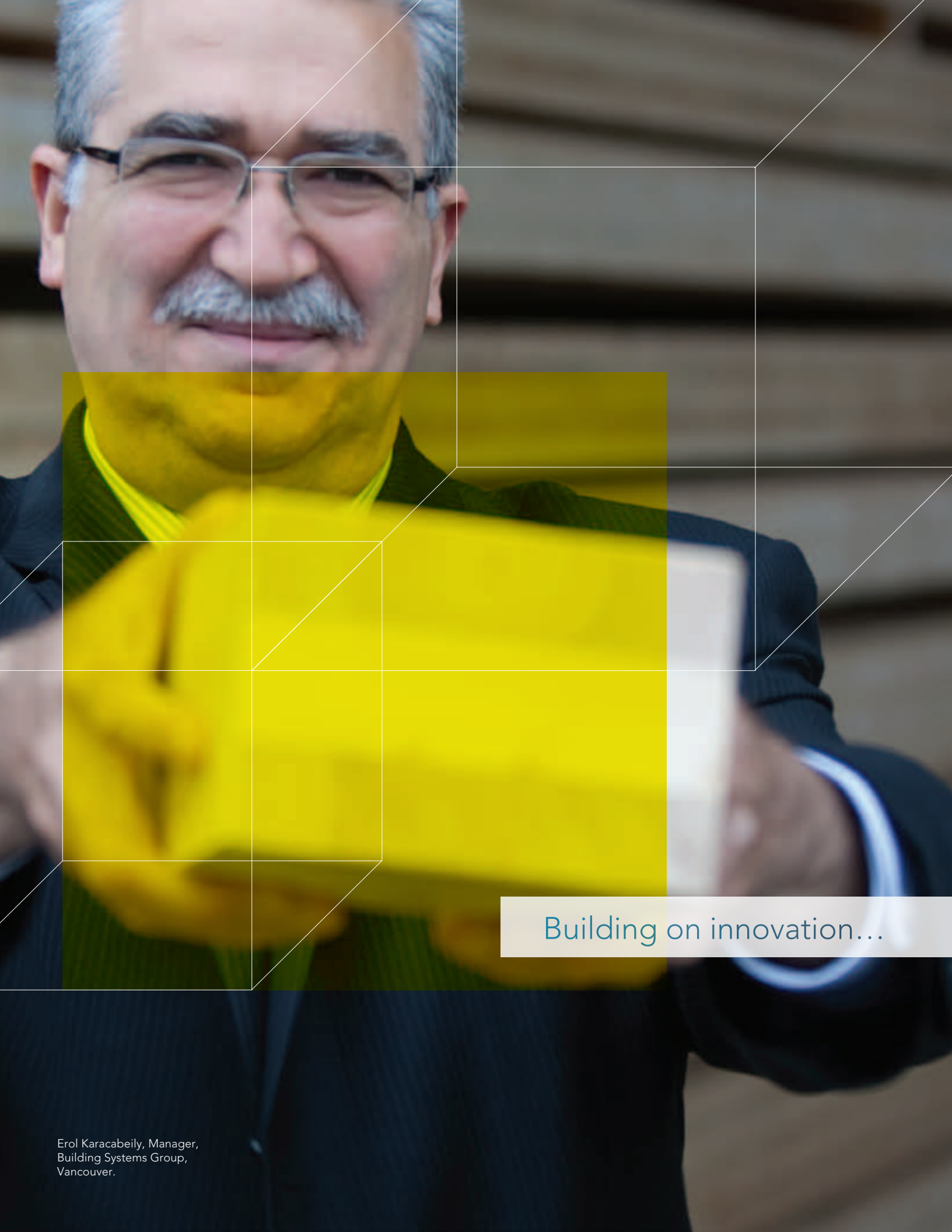
This poses a challenge to some member mills as they use increasing amounts of Douglas-fir in their NBSK (hard pine, spruce and hemlock are the major wood species used to make such NBSK). Because this species is known to have coarser fibres, NBSK containing a significant amount of it is perceived by papermakers to adversely impact coating holdout and coverage, as well as surface quality characteristics, such as smoothness and gloss.

NBSK mills are currently producing different grades of pulp with varying amounts of Douglas-fir; the grade with the minimum amount of it is sent to coated wood-free paper producers. This creates operational complexity and increases manufacturing costs. The mills would like to change the practice, but they need to convince their customers that such a change has no effect on their coated paper quality.

FPInnovations has used its expertise and advanced microscopy/image analysis tools to evaluate how increasing the amount of Douglas-fir in NBSK pulp might impact basestock properties and final coated paper quality. Results have shown that increasing the content of Douglas-fir in NBSK has no negative impact on the optical or physical properties of coated paper. In fact, coating holdout and coating coverage, as well as ISO brightness and gloss, were slightly improved with the addition of Douglas-fir.

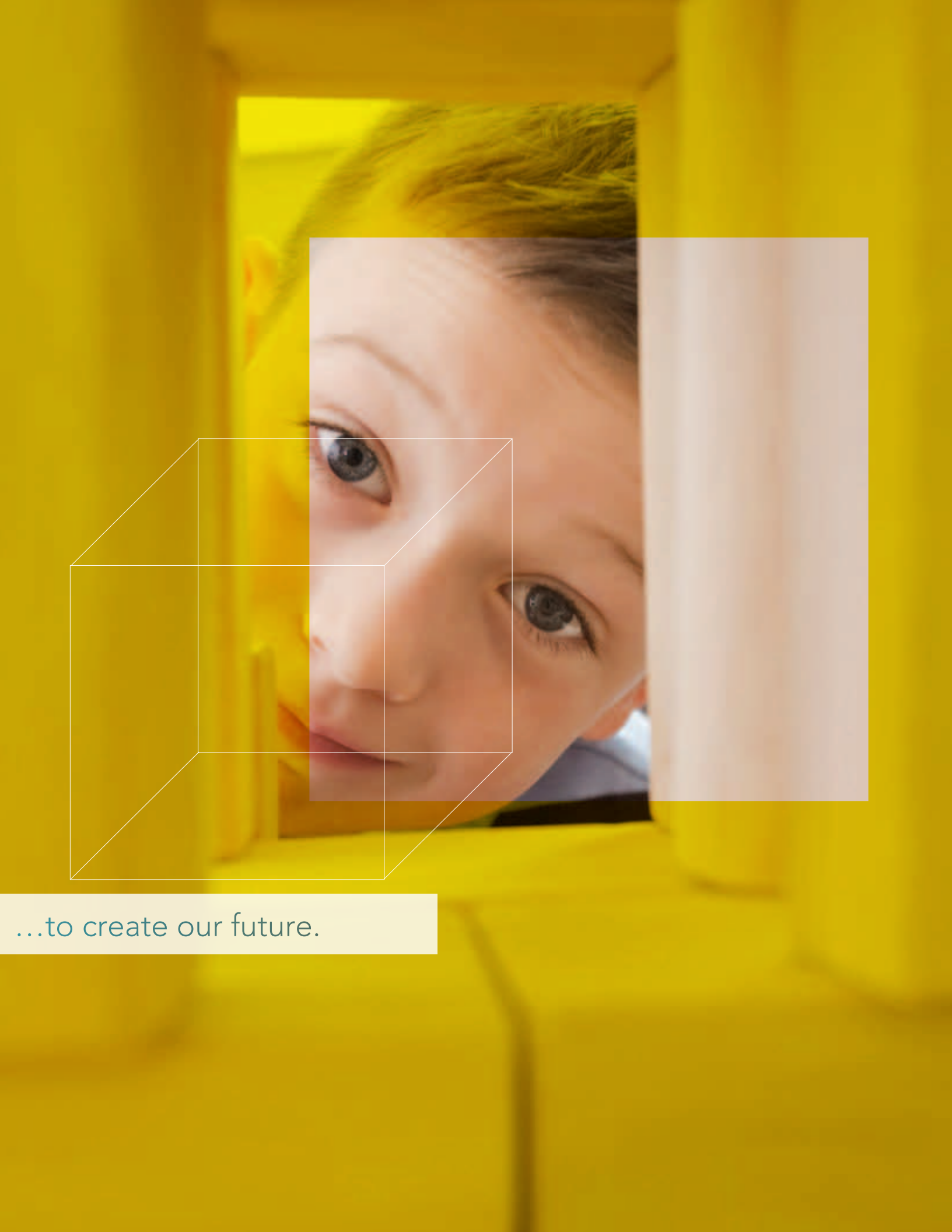
One FPInnovations member company is very pleased with the NBSK study results and is planning to use them to convince their customers to take NBSK with a higher Douglas-fir content. This would result in significant cost saving and simplify the manufacturing of NBSK for the mill.

**1.** Douglas-fir fibres in NBSK pulp.



Building on innovation…

Erol Karacabeily, Manager,
Building Systems Group,
Vancouver.



...to create our future.

## NEW TOOLS ARE IMPROVING PAPER MACHINE EFFICIENCY

Declining demand for printing and writing papers is creating significant pressure on paper mills to reduce manufacturing costs and produce new grades to expand their markets. This makes paper machine efficiency a critical issue, as frequent web breaks significantly increase downtime, lead to increased paper loss, and in some cases, create difficulty in achieving consistent product quality. One approach is to improve wet web strength by using more reinforcement pulp and/or further refining the pulp furnish, but this is costly and only minimally successful, as web breaks are a complex system problem.

FPInnovations has worked with university partners to develop a set of analysis tools that provide a mechanistic understanding of the problem, thereby making it easier to identify the causes of web breaks. The tools include a dynamic simulation tool for the open draw system that can analyze complex interactions of process variables and web properties; a stochastic process analysis tool that provides insight into the relationship between break events and underlying processes; two-point, laser Doppler sensors that detect draw variations at high frequencies; and PapTune™, for calculating strength variability.

Using these tools in conjunction with the vast amount of process data existing in the mill, FPInnovations can help identify root causes of web breaks, design remedies based on solid data, and ultimately implement the best practice. Funding from Natural Resources Canada for the Short-Term Competitiveness Initiative (STCI) has enabled FPInnovations to work with member mills to implement these new tools and knowledge, and deliver significant benefits.

Measurements and data analysis made possible by the new software and tools, along with FPInnovations' insight into the root causes of web breaks, have allowed the mill to take major initiatives to reduce web breaks on its two paper machines. As a result, the number of web breaks dropped by about 25% in 2010. This has reduced paper loss and increased production to create total savings of about $2 million a year for the mill.

**1.** On-line sensors monitor paper web variations on a fast-running paper machine.

## A BREAKTHROUGH IN LOG SCALING FOR REMOTE SITES

In collaboration with Western Forest Products and British Columbia's Ministry of Forests, Lands and Natural Resource Operations*, FPInnovations identified a more efficient method of scaling logs in remote locations such as BC's coast. "Simple sampling" offers a cost-saving alternative to the two scaling methods currently permitted in BC: stick scaling, in which every log is scaled individually, and weight scaling, in which every load is weighed and volumes taken from sample loads determine a weight-to-volume conversion ratio.

Neither currently accepted method is optimal in remote locations where access is only by water and the annual harvest volume is low. Individually scaling each log is time consuming, and weight scaling requires a platform weigh scale, which is impractical and expensive to install for small volumes in remote locations. In simple sampling, all truck loads are counted, random loads are selected as samples to be stick-scaled, and the average volume from these sample loads is applied to all loads to calculate the total volume. Simple sampling is a scaling method recognized by the U.S. Forest Service.

Load sizes must be consistent for simple sampling to be accurate. In the study, Western Forest Products achieved consistent load sizes by using onboard truck weigh scales. A target truck load weight was set, and loader operators and truck drivers used the onboard weigh scales to reach this weight. The technique was tested on Northern Vancouver Island from January to March 2010.

The results of this study were very encouraging: 70,000 cubic metres of second-growth timber were accurately scaled, meeting the BC Ministry of Forests, Lands and Natural Resource Operations* Scaling Regulation on volume precision. Cost savings from this pilot project were 24 cents per cubic metre, and would likely increase significantly at sites where the harvest volume is under 10,000 cubic metres. Simple sampling can also reduce the amount of log handling where the supply chain is more complex than at the study site, thus achieving further cost savings.

**1.** Simple sampling is a viable solution for remote scale sites.

* Previously the British Columbia Ministry of Forests, Mines and Lands.

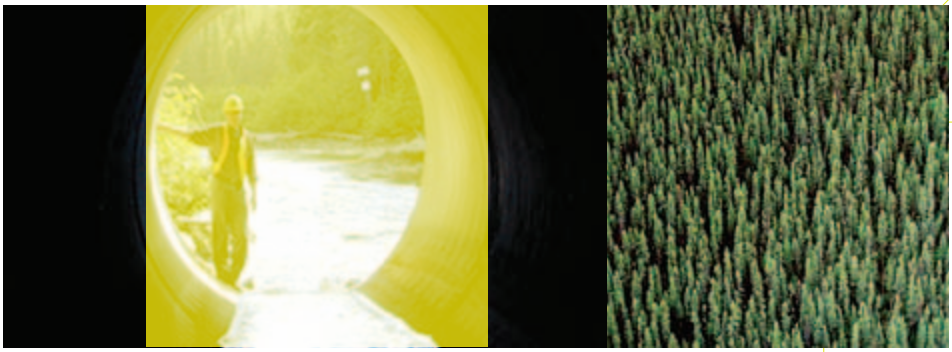
## OPTIMIZING FOREST OPERATIONS

Planning forest operations has always been carried out by the industry in Québec. But this will change starting April 2013, when the Québec Ministry of Natural Resources and Wildlife will be taking over. Since the Ministry has never prepared such plans, FPInnovations is currently conducting an ambitious training and technology transfer program to familiarize them with certain tools designed to facilitate their task.

The organization is in a good position to manage this transition since we developed one of the software packages that the Ministry will use. With this software, called FPInterface™, designed for the forest industry in 1997 and continuously improved since, forest operations can be planned in a very detailed manner. For example, it is possible to know in advance what the purchasing cost would be for a given parcel of land based on parameters such as the harvesting process, characteristics of the terrain, layout of the roads, and forest conditions.

An initial phase of training conducted in December 2010 will be followed by the training, from June to September, of 120 government employees who will be called upon to prepare these plans. In particular, they will learn the importance of a well-designed operating plan, since the software can immediately calculate the cost difference between an effective plan and one that is less effective.

Furthermore, the new forest regime provides for 25% of the harvest volumes to be put up for auction rather than allocated to companies. It also provides that only sectors that are representative of the plan, neither better nor worse than the average for the forest, should be sold in this way. The FPInterface™ software will help identify these sectors, taking into account factors determined by the Ministry. Therefore, it will be playing an important role in the implementation of Québec's new forest regime.



## EASTERN HARDWOOD INITIATIVE FOCUSING ON RESULTS

The over-arching purpose of the Eastern Hardwood Initiative is to study the entire hardwood value chain from forest to end product, gain better knowledge of the hardwood resource, and propose improved, integrated strategies and processes that will benefit both industry and end-users while being environmentally sustainable and cost effective. The Initiative includes the provinces of New Brunswick, Nova Scotia, Québec and Ontario, and receives federal government support under the Transformative Technologies Program. In the past year, we concentrated on delivering results from active projects before initiating new activities.

Work began on 12 research projects in 2009-2010, and another project started in 2010-2011. So far, six projects have been completed. These include studies identifying secondary and tertiary manufacturing industry user needs, linking user needs with lumber dimensions and quality, and demonstrating the impact of getting the right piece of wood to the right user. Our research also showed that an automated merchandizing system could considerably increase profitability when used to identify high-value logs – such as birdseye maple, for example – for niche markets.

The Life Cycle Analysis (LCA) project has been completed for the harvesting, lumber manufacturing and hardwood flooring sectors. LCAs are currently in progress for pallets, furniture and kitchen cabinets, as well as for pellets, an additional sector proposed by the steering committee.

In ongoing projects, we are working with industry stakeholders to develop optimum regeneration and harvesting prescriptions, improve stand productivity, and identify forest management strategies that are costeffective, environmentally sustainable, and beneficial to the value chain. Commercial thinning, shelterwood and selective cutting approaches using the 1-2-3 method have been shown to lower costs and increase the quality of the product basket. New trials are also looking at the impact of forest management methods on biodiversity indicators.

Fieldwork with respect to biomass harvesting methods in the hardwood sector has been done in a number of provinces and the results are being analyzed. We are also continuing to look at the uses, costs and benefits of LiDAR (Light Detection and Ranging) mapping for planning road systems and harvesting operations.

Future Eastern Hardwood Initiative projects will study various aspects of wood appearance and quality, log characterization and needed manufacturing technologies.

## APPLYING RAPID DRYING TECHNOLOGIES TO LUMBER

Under the federally funded Transformative Technologies Program, FPInnovations has been studying the impact of applying various rapid drying technologies to the production of Canadian SPF (spruce-pine-fir) lumber. The overall objective was to determine whether the benefits associated with lean manufacturing could be achieved by using rapid drying techniques both to streamline the drying process and to enhance the industry's ability to target specific final moisture content requirements for end-users.

The project began with a thorough review of potential technologies to determine which ones could be used successfully on Canadian softwood lumber. Laboratory testing was conducted on white spruce, Jack pine and lodgepole pine using ultra-high temperature (UHT), press (platen), and radio frequency (RF) drying techniques. Regardless of the technique used, the pine species performed best in terms of drying rate and product quality.

As a stand-alone drying system, UHT showed the most promise from a technical and economic perspective. Drying times as short as 4 hours were achieved for 2-inch lodgepole pine lumber at temperatures up to 160°C with high airflow (approx. 1500 fpm). Although the specialized UHT equipment is costly, the high turnover allowed by this process makes it economically viable on an annual production basis. The estimated capital cost for a UHT drying system is $33.80 per thousand board feet of annual drying capacity versus $40.40 for a conventional system. These savings add up very quickly.

**1.** Jack MacDonald, Program Leader, Harvesting Operations Group, Vancouver.

**2.** Sylvain Gagnon, Researcher, Building Systems Group, Québec.

RF drying was tested both as a full drying treatment and for re-drying the "wets" – pieces of lumber with excessive moisture content – remaining after a primary drying phase. Due to the high equipment and operating costs, RF is not viable as a stand-alone drying technique. However, in a re-drying application, it has the potential to improve the productivity of the primary drying system and increase the quality of the final product. FPInnovations will be working with industrial partners to more fully explore RF as a re-drying technique.

Because lumber drying is primarily a batch process, it is difficult to achieve the full benefits of lean manufacturing in a sawmill. As part of this project, an exercise was conducted to apply lean manufacturing principles to drying operations. The results indicate that significant advantages in inventory reduction and responsiveness to customers can be achieved using existing drying technologies, continuous flow kilns, and rapid drying techniques. Further work is planned to explore and define the possibilities of a more agile lumber manufacturing process.

## PLANTING FOR OPTIMUM LUMBER QUALITY

A study based on the oldest initial spacing trial established by the Ontario Ministry of Natural Resources in Thunder Bay has shown how plantation spacing affects the quality of white spruce lumber.

In the past, wider spacings were commonly used to maximize individual tree growth and reduce the cost of establishing a plantation. However, little attention was paid to wood quality.

Now, 60 years later, the long-term effects of initial spacing on tree characteristics and on the quality and value of the resulting lumber have also been quantified. Three initial plantation spacings were examined:  1.8 m, 2.7 m and 3.6 m. The study sample consisted of 58 trees from across the diameter-at-breast-height (DBH) classes represented. These trees were bucked into 16-ft logs and converted into lumber, which was then visually graded and tested for stiffness and strength.

**1.** Field work at the initial spacing trial in Thunder Bay, May 2010.


The testing revealed that the slower-growing trees that had been planted closest together provided the best quality of lumber. The larger initial spacings had a major detrimental effect on lumber stiffness and strength. Lumber stiffness decreased from a maximum of 9427 MPa in the 1.8 m plantation to 8031 MPa and 7476 MPa in the 2.7 m and 3.6 m spacings. Lumber strength decreased from 37.2 MPa to 30.1 MPa and 27.1 MPa through the same range of spacings. Thus, the 2.7 m and 3.6 m spacings decreased lumber stiffness by 15% and 21%, lumber strength by 19% and 27%, and wood density by 2% and 4%, respectively. There was nothing in the appearance of the wood to indicate this, however, so the effect could not be seen during visual grading.

The study concluded that the optimal plantation spacing to maintain good mechanical properties in the lumber is 1.8 m for white spruce.

## BIOLOGICAL INCISING PRE-TREATS WOOD NATURALLY

A study conducted by FPInnovations has shown that a naturally occurring red-heart fungus shows promise in making wood more permeable to treatments. The study was initiated to address the impermeability of many Canadian wood species, such as spruce and pine. Though this characteristic makes the woods slightly less susceptible to rot, it also makes the application of various treatments and the "upgrading" of the wood for different uses a major challenge.

To help wood soak up treatments, it's typically "incised"– the wood is perforated to create deep pathways for the treatments to be absorbed. The conventional incision method uses a toothed roller, which creates multiple slit-like holes all over the wood. The drawbacks to conventional incising are the pock-marked appearance of the incised wood, as well as a considerable strength loss: about 25%.

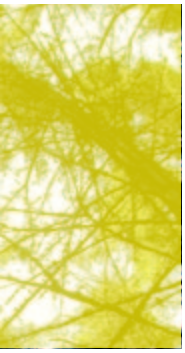
With this as a catalyst, FPInnovations investigated whether wood could be "biologically" incised by inoculating it with the *Dichomitus squalens* fungus, which naturally occurs in standing trees. The study treated spruce and pine samples with the fungus and left them to incubate for 4- and 6-week periods. At the end of these incubation periods, the fungus was killed by heat treatment during kiln drying and the planed wood samples were treated with two different wood treatments. The spruce results after 6 weeks were most promising, with an average of 80% of the samples achieving thorough treatment , and a minimum depth of penetration of twice what is achievable using tooth roller incisions (10 to 19 mm for the biologically incised wood versus an industry average of 5 mm for tooth rolling). This process could reduce the competitive disadvantage of Canadian species versus plantation pines in uses where decay-, termite-, wear- and fire-resistance are required.

FPInnovations hopes to focus further biological incising research on creating an optimal balance of penetration time while minimizing strength loss, as well as mapping out a detailed cost analysis of this new method in comparison with conventional incising.

## NEW DECKING PRODUCT

A new value-added wood product created by FPInnovations may put wood back on the map when it comes to decking. "Profile Decking" is the result of several years of research and testing by FPInnovations' Durability and Protection Group, as well as the Markets & Economics Group, whose challenge was to create a wood product that offered similar advantages to composite decking products.

Wood plastic composite (WPC) decking mixes wood fibres with various plastics and preservatives. WPC's popularity is largely thanks to reports that it requires less maintenance than traditional wood decking, and it offers greater design appeal. Figures show that consumers are willing to pay for these merits: WPC decking products boast a 30% market share in the U.S. even though the product is up to five times the price of conventional wood decking.



To FPInnovations, this presented an opportunity to create a competitive product. Profile Decking is pressure treated and factory coated on all four sides, which means users don't have to re-coat for many years. And, rather than the traditional flat boards of a conventional wood deck, Profile Decking has a ribbed look. As well as testing very well for visual appeal in consumer studies, the ribbed finish dramatically reduces and controls cracking and offers a cooler feel on bare feet in the summertime.

Profile Decking is made from Pacific Silver Fir, which is prevalent on the BC coast. It's a natural choice for decking: first, it's the coast's most permeable wood species, making it very resistant to decay once it has been treated. Pacific Silver Fir is also more dimensionally stable than Western Hemlock, the BC coast's other treatable species.

FPInnovations assembled the entire supply chain for Profile Decking, bringing together various BC companies with different areas of expertise. The end result is a product that comes in at less than half the price of the top-quality WPC alternative. FPInnovations is aiming for Profile Decking, which is currently being sold in BC's Lower Mainland, to see a national rollout in the near future.


## COALITION BRINGS WOOD TO THE FORE IN BC BUILDING INDUSTY

A new coalition has given FPInnovations a clear role in enacting BC's Wood First Act, which requires all new provincially funded building projects to be made primarily from wood. The Wood Enterprise Coalition (WEC) joins FPInnovations with the provincial associations WoodWORKS! BC and BCWood Specialties. The WEC is the province's way of making the "Living and Building with Wood" culture that the Act envisions a reality in the BC building industry. The coalition will act as a united resource for builders, municipalities, architects and industry members to enable the use of wood in new structures.

One of the first steps undertaken by the WEC was the publication of a comprehensive guide to the Wood First Act entitled "Putting Wood First to Work in BC." The guide, available on the WEC's website at wecbc.ca, reprints and contextualizes the legislation, and provides resources and next steps for compliance. It also offers historical detail on the use of wood in BC, as well as economic and environmental rationales to answer the question "why wood?".

Another initiative undertaken by the WEC is the creation and inclusion of the Appropriate Use of Wood Matrix in the guide. The matrix is a visual chart that summarizes the current best practices for the use of various wood building materials and systems. It also offers clear case studies and examples that users can draw upon in their own projects. To further support the use of engineered wood in building structures, a symposium on the use of cross-laminated timber (CLT) was organized by the WEC.

A key aspect of bringing the Wood First Act from paper to reality is the WEC's oversight of a number of "demonstration projects": new building projects that use innovative wood products and wood in non-traditional ways in structural and/or architectural applications. FPInnovations and its partners are overseeing these demonstration projects, providing assistance in funding, technical knowledge, testing, analysis and code interpretation.

Currently, over 30 different communities in BC are implementing Wood First projects – and the Wood Enterprise Coalition is playing a key role in making these innovative initiatives a reality.

**1.** A user-friendly guide to BC's Wood First Act.

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## STAINING WITH SPORES: COLOURING WOOD NATURALLY

With support from Natural Resources Canada and the Québec Ministry of Natural Resources and Wildlife, FPInnovations has found that different species of fungi can be used to colour wood naturally. FPInnovations launched this initiative to address an increase in demand for different shades of wood.

As part of the Eastern Hardwood Initiative, the researchers focused on fungal species that showed an ability to change wood colour by producing pigments during their growth. FPInnovations selected 35 different fungal species it had developed in the laboratory and applied them to sugar maple, white birch and yellow birch wood specimens provided by a local Québec company. Samples were dipped in a liquid suspension of the fungi for 30 seconds, then incubated for up to 4 weeks. Wood colour changes were checked weekly, and final results were measured with a colorimeter. The outcome was a painter's palette of naturally coloured wood samples. Of the 35 fungal species tested, 15 successfully coloured the wood in an array of different shades, including purple, red, green, black, grey, greyish-blue and many different brown hues. Many wood samples had totally transformed their colour in as little as 2 weeks.

The FPInnovations testing showed another possible use for the colourful fungi: on some wood samples, three or more fungal species were used together, which created various multicoloured rainbow patterns. If such patterns could be produced on a industrial scale, it could be a valuable new product for the decorative market. The same research team is also looking at the ability of fungal species to naturally bleach wood to a brighter shade or to remove colour inconsistencies – which would offer an exciting alternative to chemical bleaching.

**1.** Fungi create a range of natural wood dyes.


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## CLT HANDBOOK: A NEW GUIDE FOR THE CANADIAN BUILDING INDUSTRY

FPInnovations has been a catalyst in the introduction of cross-laminated timber (CLT) into the Canadian marketplace. The new CLT Handbook, written by FPInnovations with financial support from Natural Resources Canada as part of the Transformative Technologies Program (TTP), will help building professionals better utilize this engineered wood product.

CLT is made by bonding together timber boards in a criss-cross pattern to produce a solid panel that's stronger than traditional timber, and limits the impact of shrinkage and swelling. It also has proven advantages over other timber products in the areas of fire safety, noise transmission and building enclosure heat insulation. In Canada, it's becoming increasingly popular to consider for buildings with more than four storeys.

The CLT Handbook was developed to promote the implementation of CLT in Canadian construction. As CLT was originally created in Europe, the Canadian building industry desperately needed specific guidelines on the product for use in this country. The Handbook helps Canadian building professionals determine how to apply CLT to current Canadian codes and standards.

The CLT Handbook is the result of years of intensive research and real-world application by FPInnovations and a number of collaborators, including members, Natural Resources Canada, and many of the provinces – as well as experts in the international scientific communities and consultants from the technical, financial and industrial sectors.

The Handbook is also an exemplary deliverable from the TTP. FPInnovations not only wrote the book on CLT usage, but is also working directly with the industry to enable and encourage its use. With FPInnovations' support, a new Canadian CLT plant, located in Québec, started producing this spring, and two BC-based plants are set to start production in 2011.

**1.** A new Canadian resource for cross-laminated timber.

The numerous research projects described in this Review of Activities were made possible by the inquisitive minds, dedication and passion of FPInnovations' employees. For this, we sincerely thank them.

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