REPLICATING COMMERCIAL SUCCESS IN THE CANADIAN FOREST INDUSTRY

DRIVING FORWARD CONTINUED SUCCESS IN THE BIOECONOMY
DOMTAR’S BIOMATERIALS

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## DOMTAR PULP AND PAPER OVERVIEW

<table>
<thead>
<tr>
<th>Segment</th>
<th>Description</th>
<th>LTM Sales %</th>
<th>GDP %</th>
<th>LT Growth Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication UFS papers</td>
<td>Business, commercial print and publishing papers</td>
<td>52%</td>
<td>12%</td>
<td>3-5%</td>
</tr>
<tr>
<td>Pulp</td>
<td>Manufacturer of paper grade, fluff and specialty market pulps</td>
<td>19%</td>
<td>1-2%</td>
<td>1.2%</td>
</tr>
<tr>
<td>Specialty papers</td>
<td>Leading manufacturer of premium, technical and specialty packaging papers</td>
<td>12%</td>
<td></td>
<td>12%</td>
</tr>
<tr>
<td>NEW BioMaterials</td>
<td>Lignin, Extractives, Cellulosic Sugars, Hydrocarbon Fuels, Advanced Fibers</td>
<td>TBD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Investing our capital in new innovative, high growth businesses*
DOMTAR’S CHEMICAL PULP SUPPLY CHAIN
13 MAJOR SITES IN NORTH AMERICA

- Kamloops BC
- Dryden ON
- Espanola ON
- Windsor QC
- Plymouth NC
- Hawesville KY
- Ashdown AR
- Johnsonburg PA
- Kingsport TN
- Rothschild WI
- Nekoosa WI
- Port Huron
- Marlboro SC
- Port Huron

25 million green tons/yr of biomass
Over 4.4 million tons/yr of pulp
Over 3.4 million tons/yr of uncoated freesheet paper

Strong balance sheet; 170 year old company; 10,000 employees+; >$500 MM EBITDA/yr
DOMTARS BIOMATERIALS PROGRAM
Projects & Products Organized Across 5 Platforms

- **Biomaterials Business Unit**: Its main objective is to reduce Domtar’s exposure to paper market decline by creating high growth, high value businesses via leveraging Domtar’s assets

1. **Advanced Fibers and Fiber Derivatives**
   - Specialty Pulps
   - Fiber Reinforced Materials
   - NCC (thru Celluforce)

2. **Extractives and Volatiles**
   - Turpentine and its derivatives
   - Soap and its derivatives
   - Tannin and its derivatives

3. **Lignin and Lignin Derivatives**
   - Lignin precipitation
   - Lignin into thermoplastic blends and products
   - Other Lignin based specialty chemicals & materials

4. **Hydrocarbons and Biofuels**
   - Biomass boilers, Pyrolysis, Gasification

5. **Cellulosic sugars**
   - Fermentation products, organic acids, biopolymers, etc

Diverse multi-product, multi-project portfolio approach to development of new forest based bioproducts
Domtar has an internal “Mapping” and “Screening” process using which it first identifies all potential opportunities and after evaluating them in different perspectives including economic profitability and sustainability performance, selects the promising opportunities for short, medium and long term.

**IDENTIFY PROMISING OPPORTUNITIES**

**MAPPING AND SCREENING**

- **Mapping** (>Hundreds of opportunities are identified)

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- **Domtar’s Screening Process**
  - Tens of Identified Promising Opportunities
COMMERCIAL BIOMATERIALS PLANTS
PUBLICLY FUNDED AND PUBLICLY ANNOUNCED BIOREFINERY INITIATIVES

- **Lignin Manufacturing**
  - North Carolina-US
    - De-bottleneck mill, increase production
    - Manufactures Lignin (Lignoboost technology)
    - Use lignin as a platform for new products
    - With support from USDA-NIFA BRDI program

- **Lignin Valorization (lignin-thermoplastic)**
  - Espanola Ontario-CA
    - Valorizes lignin into value-added products (dried lignin pellets, lignin-thermoplastic, compound pellets, blown film, cast sheet)
    - With support from NRCan (IFIT Program)

- **Advanced Fiber (SEPF) Manufacturing**
  - Dryden Ontario-CA
    - High strength fibres
    - Market and applications development
    - With support from NRCan (IFIT program)

- **Advanced Fiber (NCC) Manufacturing**
  - Windsor Quebec-CA
    - Manufactures NCC
    - Market and applications development
    - In partnership with FP Innovations
    - With support from NRCAN and Quebec Provincial Government.
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LIGNIN PRECIPITATION

- In early 2013 Domtar took a lead in lignin production by implementing the first of its kind and only modern commercial demonstration kraft lignin isolation plant (lignoboost process) at its Plymouth, NC mill.

- Domtar’s lignin isolation plant is full commercial scale with a design production rate of 30,000 ton per of very pure kraft lignin called BioChoice lignin.

- This project was supported by USDA NIFA- BRDI.
CRUDE LIGNIN

Advantages of lignin:
- Abundant, relatively low cost poly-phenolic material
- 100% renewable
- Biodegradeable
- Water resistant
- Fire retardant
- UV Stabilizer
- Anti-microbial, anti-bacterial agent

Some challenges of crude lignin powder:
- High moisture (up to 40%)
- Friable, dusty powder
- Poor bulk solids flow properties
- Odor & colour

Domtar has valorized its BioChoice lignin into different value added products including polymers, adhesives, coatings, aromatics, biocomposites, feed, carbonaceous materials, etc.

Crude lignin can be valorized into a wide range of value-added products
LIGNIN VALORIZATION

- One of top 10 lignin valorization projects coming out of our internal selection process
  - (A) Convert wet, friable lignin powder into dried, stable lignin pellets
  - (B) Compound lignin with thermoplastic polymers
  - (C) Use lignin-thermoplastic compound pellets for producing “demonstration” products

Supported in part by NRCAN IFIT program.
In collaboration with National Research Council of Canada (NRC)

Forest-to-Farm (F2F)
LIGNIN VALORIZATION

- Reaction extrusion of lignin to simultaneously dry and agglomerate crude lignin into fused pellets and also to compound lignin with different thermoplastic polymers.

- Dried lignin pellets & lignin composites are a cost-competitive, bio-based substitute for thermoplastics, which show similar and sometimes superior performance
  - First successful demonstration in an agri-film application

Domtar's Twin-Screw Extruder
(Commercial Demonstration Scale, up to 0.75 ton/hr)
Commissioning: Q3 2017

NRC's Twin-Screw Extruder
(Lab and Pilot Scale)
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DOMTAR’S ADVANCED FIBER

- A skid-mounted, transportable, 50-75 tpd system to produce advanced fiber was designed, built, installed and commissioned at the Dryden mill.

- The advanced fiber is blended with Dryden’s NBSK pulp in different formulations and combinations, and then dried and packaged using the existing pulp line.

- These fibers are unique in that they simultaneously have extremely high relative surface areas, relatively long fiber length, and relatively low fines content.

- This project is supported by NRCan IFIT.
Domtar’s pulp mills are, in essence, biorefineries designed to separate and extract the natural chemical building blocks of wood, and integrated biorefinery is a next chapter in this industry.

Domtar uses a financially successful manufacturing system as a platform for new bioproducts to maximize synergies between the current and future business.

Domtar’s Biomaterial Team is actively committed to building up the next generation of integrated biorefinery and biomaterials.

Domtar has successfully produced a set of bioproducts including nano, micro and macro scale advanced fiber; cellulosic polymers; aromatic polymers; biobased and renewable feedstock (preexisting supply chain and infrastructure); and is valorizing them into a wide range of value-added bioproducts.

One of the unique competitive advantages we have is Canada’s Bioeconomy and Innovation ecosystem.
ACKNOWLEDGEMENT

We would like to acknowledge:

- NRCan IFIT (Investment in Forest Industry Transformation)
- NRC (National Research Council of Canada)
- US DOE (Department of Energy)
- USDA NIFA-BRDI (Biomass Research and Development Initiative)
- All other collaborators who contributed in Domtar biomaterials projects