A Forest Residues Biorefinery: some techno-politico-economic analyses based on the La Tuque project

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The main objective of the La Tuque biorefinery project is to valorize the about 1.2 million metric tons of forest residues originating from regular forest harvesting of Quebec forest area 04 (the “Haut-Saint-Maurice”). However, notwithstanding many myths, as for instance: “We do not have enough biomass” or “Commercialization of large scale production of lignocellulosic fuels is just around the corner”, the reality remains that such a large scale project requires – and it is not just necessary but mandatory – an in-depth due diligence techno-economic evaluation. The thorough evaluation of all project facets is needed not only to select the best available process line but also to validate the availability of biomass delivered at the biorefinery at a low cost and over a long period of time, i.e. 25 years, exceeding the amortizing period of such projects. The political aspects are first related to the regulations concerning the biomass availability at a reasonable cost. The second but most probably the most important one, is related to the existence or not of a mandate for inclusion of biofuels in regular fuels. There is a need for a political coherence between the “political announcements” and the regulations. Our experience proves that no significant investments will occur if the mandates are not clear and ambitious. A rather stunning counter-example is Finland which seems to attract such investments. The presentation will outline the La project and use it as a case study to elaborate on all the techno-economic-political aspects, all required to successfully develop in Canada both the bioeconomy and the bioenergy industries.

1 Titles of actual presentations to be made at the Advanced Biofuels Conference in Gotheburg, Sweden, May 17-19, 2017
Outline

► Introduction
  ► The project context, background, and summary

► The main challenges
  ► A “man to the moon” type of project...
  ► Supply, logistics, technologies, economics, risk mitigation, social acceptability, ....

► Proposed approaches for solutions
  ► A “no compromise” strategy

► Conclusions
  ► From project vision to a feasible, realistic project.
The Canadian landscape for biofuels
Reducing the national GHG emissions profile

- Policy for a significant reduction of GHG
- Plus demand for "non-food" bio-renewable fuels
- Canada’s pulp and paper industry is already the largest generator of bioenergy
  - Integrate with forest industry operations
- Longer-term integration of biofuels into national fuel infrastructure is challenging, but...
  - Significant opportunities are in reach
    - Residues are available: security of supplies to attract investments
    - Incentives to attract project investors
- Pull from industry players is becoming compelling
  - Bio-jet fuels ICAO (International Civil Aviation Organization)
    - Aviation fuels – Air Canada, Westjet, SkyNRG, GARDN...
    - RNG – Canadian Gas Association
    - Diesel – BioÉnergie La Tuque

Quebec positioning
Energy-wise

- Quebec energy demand (2014)
  - 563 TWh
  - 56% imported
  - Value: 16 G$
- Quebec energy supply (2014)
  - Hydro: 34%
  - Biomass: 8%
  - Petroleum: 41%
  - Others: 17%

Commercial deficit (trade balance)
- 29.8 G$ (2012)
- 54% due to energy import!

Quebec new 2030 energy policy

- The government has adopted ambitious, demanding targets to be achieved by 2030

1. **ENHANCE** energy efficiency by 15%

2. **REDUCE by 40%** the amount of petroleum products consumed

3. **ELIMINATE** the use of thermal coal

4. **INCREASE by 25%** overall renewable energy output

5. **INCREASE by 50%** bioenergy production

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Strategy

*Basic-simple model*

- Start with **ONE** product: renewable fuels
  - Actually it is more a range/category of products (diesel, gasoline, light fuels, …) due to process

- **FOCUS** on it and keep the focus
  - Various proposals for “add-on chemicals” to optimise economics

- **“DO IT RIGHT”**: learn from past-failures
  - Still an essential part of the challenge

- **“MAKE MONEY”**: risk management issues

- “Make NO COMPROMISE on ECONOMY” (risk management) and ENVIRONMENT (social acceptability)
  - Diversify (if need be) only at a later stage
**Project vision**

*A short history (for a long pregnancy)*

- **Fall 2009**
  FPInnovations report: biomass = 0.65 MT/y (area 04 – Haute Mauricie, La Tuque area)

- **April 2010**
  initial proposal at La Tuque city council

- **March 2011**
  first trade mission (Scandinavia)

- **2013-2015…**
  approach key potential technology/R&D providers

- **Oct. 2014**
  Quebec chief forester: biomass =1.2 MT/y

- **Feb. 2015**
  creation of BioEnergy La Tuque (BELT)

- **May 2016**
  FPInnovations becomes key partner

- **Sept. 2016**
  Quebec 1.5 M$ funding announced

- **Jan. 2017**
  Neste Corporation “public” as key partner – potential investor

- **March 2017**
  Atikamekw Nation supports project
**Vision La Tuque 2023-2025**

**Objective**
- To exploit/valorize the forest residues from harvesting of forest area 04 in Mauricie through the implementation of a large scale biorefinery
- **First of the type in Canada**
  - No trees cut for energy feedstock (NGO issues)
  - **Product**: “drop-in” quality (bio) renewable diesel and/or jet fuel
  - **Agenda**: demonstration plant decision by end 2018 and commercial plant by 2023-2025 (!).
- **La Tuque**: 15,000 inhabitants but slightly larger than Belgium (30 528 km²)….
- **Second most productive forest in Quebec**
- **Forest harvest residues unused**!

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**BioÉnergie La Tuque**

**First Canadian forest residues-based refinery**

- **Capacity**:
  - Feedstock: forest residues 1.2MT/year*
  - Production: **210 ML/year** “drop-in” renewable diesel**
  - Displaces 4.3% of Quebec transport diesel consumption.
- **233 MW** renewable diesel from 350 MW wood feedstock
  - CO₂ reduction: 0.575 MT/y
  - Vehicles off the road: 143,750/y
- Capital investment: 1 G$
- CO₂ capital cost index**: 70 $/T CO₂
- Jobs created: 490

* Green Metric Tons at 40-50% humidity
** Bio-jet fuel considered – gasoline (by-product)
***Calculated from capital invested and 25 years amortising
Regional assets
Winning conditions 1/2

- Strong OVERALL motivation & support
  - Project is on TOP LIST of both Quebec and federal governments agenda
  - Fully aligned with new Quebec 2030 energy policy
  - Strong business & community support
  - Committed partners
  - Already good social acceptability, including Atikamekw (First Nations)
- A-team secured for in-depth, due diligence techno-economic evaluation
- No competition for forest harvest residues
  - New Quebec policy will increase the available biomass level in area 04 significantly

Regional assets
Winning conditions 2/2

- Significant heritage bark landfill for 20 years (430 T/day)
- Reserved location for biorefinery: Vallières site
- 30 000 kms of forest roads with no load restriction
- Natural gas station nearby (hydrogen)
- Railway across territory, down to Trois-Rivières
- Trois-Rivières commercial harbour has all facilities and storage capacity
- Validated implementation agenda

- Project implemented by BioÉnergie LaTuque (BELT) as the sole and main promotor.
Challenges & Issues
Pathways to success

Technologies

Policies

Economics

Techno-politico-economic questions

- Technologies (related to)
  - Supply
  - Process
  - Products

- Economics (related to)
  - Supply
  - Process
  - Products (markets)
  - Distribution
  - CAPEX and OPEX

- Policies (politics?)
  - “New industry sector”
  - Legislation/regulations
    - Mandate
    - Carbon tax, credits, standards,....
    - Environment (sustainability, carbon/water footprint, etc...)  
  - Social acceptability
  - Provincial vs national vs international positioning
On the potential issue
Canada bioenergy positioning

27.7% BRAZIL
23% DENMARK
26.7% FINLAND
21.5% SWEDEN
26.6% CHILE
19.9% AUSTRIA

Canada 5.4%

Room for improvement!!!

Combustible renewables and waste (% of total energy use)

Other Major the Queen in Right of Canada, as represented by the Minister of Natural Resources, 2016

Courtesy of Marzouk Benali, CanMetEnergy - NRCan

Project implemented in 4 Phases
Thru a comprehensive no compromise approach

- **Phase 1 main objective** is to perform an in-depth thorough evaluation thru 12 studies by A-team from top level organizations...
  1. Supply logistics, integration of forest residues harvesting to standard forest operations;
  2. Energy densification strategies to reduce biomass mill delivered costs, including CAPEX/OPEX;
  3. Analysis of markets (e.g. P.E.T. Dorval airport), regulations, diesel type (e.g. jet fuel versus road transport) and quality/standards (e.g. ASTM,...) to define process manufacturing lines.
  4. Techno-economic evaluation and screening of technology process lines to produce “drop-in” high quality diesels.

- **Selection of top 3 most promising, risk-free, process lines.**
Implementing a “no compromise” approach

Due diligence – PHASE TWO

- Phase 2 consists of a thorough technology assessment or first level due technology diligence of the 3 pre-selected process lines for final selection of demonstration plant design. Performed mainly by FPInnovations & selected partners
- Phase 2 objective is two-fold:
  1. Obtaining a design level 30 proposal for the demonstration refinery that constitutes Phase 3 of the La Tuque project by fall 2018.
  2. Establishing a top level FPInnovations team with the necessary high level expertise to enable duplication of similar projects elsewhere in Canada.

Implementing a “no compromise” approach: PHASES THREE & FOUR

- Phase 3 objective: demonstration plant
  1. Decision to go for a demonstration biorefinery plant
  2. Design level 10 proposal for the demonstration biorefinery.
- Phase 4 objective: commercial plant
  1. From data gathered in Phase 3 demonstration plant operation: decisions related to commercial plant investment
  2. Built, commission, and operate.
Mandatory Studies

Close integrated cooperation, performed concomitantly

for

SUCCESS

ECONOMICS

Supply
Logistics
Environment
Integration
Technologies
Processes
Economics & finances
Risk management

BIOMASS SUPPLY

TECHNOLOGIES ANALYSIS & OPTIMISATION

Partners*

Studies

- FPInnovations
- Neste Corporation
- Laval University – Forestry department
- FOR@C, Laval University
- University of Québec in Trois-Rivières (UQTR)
- Montreal Polytechnical Engineering School
- La Tuque Forestry School (Energy Commission)
- VTT, Helsinki, Finland
- CanmetENERGY, Varennes, Quebec
- CanmetENERGY, Ottawa, Ontario

*All under NDA or personal confidentiality agreement
Selecting the A-team

45 people

20
Supply, logistics, environmental impact, social acceptability
FPInnovations – U. Laval-For@c – VTT
+ Patrice Bergeron, SDÉF-BELT

25
Technologies, process selection, techno-economics, risk management
FPInnovations – CanmetENERGY – E.Polytechnique Montreal/UQTR
+ Patrice Mangin, BELT/UQTR

BELT Team Project Kick-Off Meeting
La Tuque – September 6-8, 2016

Some of the experts involved!
Team work...

Selecting the A-team to ensure success!

BELT has succeeded in building a team of top recognized experts to develop and implement a world leading class forest biorefinery project.

Total cost: 7.8 M$ - in fact very little, less than 1% of project estimated capital cost.

Key Issues & Features

Solution pathway: focus on “best available solution”
- Technology pull vs technology push
- Supply of biomass to the refinery and process issues are here critical

Addressing investors-banks criteria
- CAPEX-OPEX
- Security of fibre supply: 25 years
- Minimum mandate (long term) required
  - Credits (OK but not mandatory)
- Based on use of residues: fully sustainable
- Propose a “Bullet-proof solution”
  - Does not yet exist BUT it is feasible to minimize and manage risk to acceptable levels.
**Biomass issues**

*Quebec perspective*

- **Biomass** from saw mill operation **too expensive**: rate of loss too high, distances, operation costs,…
- Energy valorisation requests **long term supply security**, 25 years for high capital investments amortizing
  - Presently difficult with Quebec “forest regime”, market free access wood is 25% of allocated volumes through BMMB (Bureau de Mise en Marché des Bois)
- Saw mill financial equilibrium linked to a) US housing market, b) paper mills…. presently of high concern, c) 6th Canada–United States softwood lumber dispute (OR).
- Harvesting/logging operations: stumpage royalties to government on a m³ basis ⇒ need for a “cutting/logging” incentive but also a need for new customers.

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**Biomass challenges**

- Reduce biomass supply cost delivered at mill: harvest, transport, and integration strategies,… mainly.
  - Previous studies: from 88 to 128$/DMT*
- Pulp supply in excess (drop in paper demand)
  - Energy system economy cannot pay traditional paper mills chip value (100-115$/DMT)
  - Presently prices are lower… but what in 15 years ?
- Ensure long term (25 years) security of supply
- Due to integration needs, develop/propose an adequate share of costs/profits in integrated operation strategies
- Oil prices directly affect any biorefinery project…
  - Diesel costs affect logging/harvesting operation costs

✔ **Think long term, GHG reduction, and carbon exchange market**  

*DMT: dry metric tons*
**Biomass potential solutions**

- Increase the allowed « top diameter » (tree top/branches) to increase commercial values of products obtained from wood log:
  - Tests in progress by Quebec government
- Optimize commercial harvest operations *with* forest residues harvesting:
  - Stumpage royalties (15-20$/m³ versus 0.10$/m³)
  - Integration to commercial operations
- Consider/evaluate various energy densification scenarios (*pyrolysis/torrefaction*);
- Regional “valorisation” centre to allocate wood/biomass according to “4B” concept: *best wood, best mill, best use, and best price!*

**Available biomass La Tuque area** ...

- **Theoretical** availability (Forestier-en-chef studies)
  - 1,856,000 GMT (includes leaves, branches, tree tops but no stumps)
  - 1,200,000 GMT (excluding leaves)
  - Still marginal for “minimum refinery size”
- **Techno-economical** availability
  - Supposed as above for quantity but needs to be confirmed with distance/cost factor for economics
- **Economical AND sustainable** availability
  - Yet unknown....
Sensitivity to biomass harvesting

Localisation of environmental sensitivity levels for forest biomass harvesting - FER Mailhot (La Tuque)

About 90% of territory presents a moderate to weak environmental sensitivity (analysis includes biodiversity)

Technologies

One of the “promising” standard process line

- Forest residues chips, etc.
- Feed Prep. (drying, size red.)
- Biomass
- TORRE FACTION
- H₂
- HDT
- Diesel (high quality)
- FT
- Water
- GAS CLEANING
- O₂
- GASIFIER
- SIZE REDUCTION
- 600+ technologies evaluated (TRL/MRL, expertise, public information, …)
- 15 pre-selected
Technologies
One of the “promising” standard process line

- Forest residues, chips, etc.
- Feed Prep. (drying, size red.)
- Biomass

- PYROLYSIS
- CHAR
- MIX
- OIL
- GASIFIER

- H2
- HDT
- FT
- GAS CLEANING

- Diesel (high quality)
- Water

600+ technologies evaluated (TRL/MRL, expertise, public information, …)
15 pre-selected

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On the economics

- Technology development plant
  BioTFuel-Dunkerque, France – 15 MW
  Cost – 190 M$

- Gasifier – 15 MW
- Fischer-Tropsch
- Syngas cleaning
- LT demo plant 30-60 MW?
- LT commercial plant 600-700 MW

- Biomass feed and size reduction
  3 storage silos
**Demonstration plant challenge**

*Questions to answer*

- Actual required size
  - Private investors ➔ minimum size
  - Bankers ➔ at least 10% of commercial size
- Capital costs
  - Around 200 M$ - amortizing?
- Operation costs
  - NO “break-even” operation potential
- Integration in commercial plant (or not?)
- Demo plant disposal issue

- Solving bottlenecks and/or technology gaps.
- Long term operating conditions – Mill overall operating efficiency

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**Economics & competitiveness**

*think energy value…*

<table>
<thead>
<tr>
<th>Market value ($Can/GJ)</th>
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<tbody>
<tr>
<td>Wood Pellets</td>
<td>10,7 $</td>
</tr>
<tr>
<td>Diesel (Canada)</td>
<td>28,7 $</td>
</tr>
<tr>
<td>Diesel (EU)</td>
<td>45,8 $</td>
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<tr>
<td>Pyrolytic oil (EU)</td>
<td>13-17 $</td>
</tr>
<tr>
<td>Crude Oil WTI</td>
<td>12,02 $</td>
</tr>
<tr>
<td>Crude Oil Brent</td>
<td>12,69 $</td>
</tr>
<tr>
<td>Natural Gas (Alberta)</td>
<td>2,50 $</td>
</tr>
</tbody>
</table>

**Forest residues**

- FOEX (March, 2017)         | 7,5 $ |
- 3 studies                  | 4,4-5,0 $ |
- PJ Mangin study - 2012     | 4,8 $ |

(3-5 mm, 10% Humidity)

At the pump!

Nothing can compete…

4-5 $/GJ ➔
60-70 $/DMT
Regulations – mandates
Transport (renewable fuels)

**EU**
- 10% in 2020 (mandatory)

**Finland**
- 10% today
- 20% in 2020
- 40% target in 2030!

**France**
- 15% target in transport by 2030
- E10 available in 40% of gas stations
- E85 available

**Germany**
- 6% GHG reduction by 2020

**China**
- 15% in 2020

**India**
- 20% target in 2017

**USA**
- RFS: 16 bn gallons 2G EtOH
- Low Carbon Fuel Standard (CA)
- Clean Fuels Program (OR)

3 MEGA PROJECTS
- Kaidi (China) 1,6 G$ (announced)
- Kemijärvi (China) 1,15 G$ (announced)
- Metsä, Äänekoski 1,75 G$ (on-going)

Need for provincial mandate
Essential !!!!

**Legislation**: a mandate is a key way to create a market to attract investors; presently renewable diesels cannot compete on markets; could be a « bridging scenario.

No Quebec mandate

Source: How harmonized regulations would improve the biofuel blending system, Canadian Fuels Association, Jan 28, 2016
Credit incentives
GHG reduction linked

- Carbon tax for renewable fuels producers
- RIN (Renewable Identification Number, USA)
- Producer credits
- ....

<table>
<thead>
<tr>
<th>Liquid Biofuels</th>
<th>First 150 ML</th>
<th>Over 150 ML</th>
</tr>
</thead>
<tbody>
<tr>
<td>First generation ethanol or other fuel alcohols</td>
<td>0.10 $</td>
<td>0.06 $</td>
</tr>
<tr>
<td>Second generation ethanol or other fuel alcohols</td>
<td>0.14 $</td>
<td>0.09 $</td>
</tr>
<tr>
<td>Renewable diesel, biodiesel, pyrolysis oil</td>
<td>0.13 $</td>
<td>0.09 $</td>
</tr>
</tbody>
</table>

Conclusions 1/3

- La Tuque is the BEST LOCATION for the first Canadian biorefinery to produce renewable drop-in quality fuels based on harvest forest residues biomass.
- Quebec forest are mainly government owned, harvest rights allocated for 5 years (X4), for a total of 25 years, residues remain government property ➔ biomass supply can be guaranteed for 25 years.
- Government harvest policy is modified to favour the development of the bioenergy sector.
- Studies objective of 4-5 $Can/GJ target is quite feasible and could reach the 4$/GJ. Very competitive.
- Required mandate: minimum 5% (2017) with a 10% target (2020) or better mandate before 2030
Conclusions 2/3

- Alignment of all parties is **almost** attained (**Quebec mandate still lacking**): industry, federal, and provincial governments, policy makers, and research organizations
- **success probability**
- The project is structured for replication in Canada to maximize impact on Canadian (bio)economy.
- The question of “demonstration plant or not” and “size of the demonstration plant” are an integrated part of studies.
- There will be **no compromise** on
  - a) economic risk,
  - b) environmental impact, and
  - c) social acceptance.

Conclusions 3/3

- **Pre-feasibility** studies are encouraging
- **NO** set mind for technology-process line solution as
  - Best technology solution not necessarily equivalent to lower techno-economic risk solution
  - **NO** technology can provide **THE** answer if studied **SEPARATELY**
    - Constant need to always go back and think, re-think, and re-think the whole process line and project steps
    - Although technologies need first to be pre-screened for feasibility and initial choices (**NEW TECH.?**)
- **Lots of work in progress… more questions and more challenges…**
Pierre Lapointe, CEO, FPInnovations and Patrice J. Mangin, CEO BELT signing the partnership agreement. In the background: left to right : Luc Marchand, Louis-Serge Gagnon, BELT Board, members, Normand Beaudoin, La Tuque mayor and Patrice Bergeron, BELT chairman of the Board.

BELT-NESTE Partnership - January 17, 2017

ATIKAMEKW NATION supports BELT project
March 1, 2017

Sitting: P. Mangin, BELT, C. Awashish, Atikamekw Nation Council Great Chief (CNA) – Standing: P. Boucher, consultant (CNA), D. Boivin, Grand Chief political advisor (CNA); D. Bouchard, general director (CNA); P. Bergeron, BELT; F. Fournier, FPInnovations.
Professor Patrice Mangin holds the regional bio-economy/bio-energy development chair at University of Quebec in Trois-Rivières (UQTR). He is CEO of BIOENERGY LA TUQUE (BELT) and a member of the Renewable Materials (CRMR) and of the Sustainable Development (CIRODD) research centers. He is also a member of US Agenda 2020 CTO Committee (Washington), of the Quebec Association for Renewable Energy Production (AQPER), and a researcher within BioFuelNet Network. With over 40 year experience in the forest products industry, he was CEO of Integrated Pulp and Paper Research Centre (CIPP, Trois-Rivières) and of Centre Technique du Papier (Grenoble, France); scientific director of a Swedish research network, and section head/researcher at FPInnovations. He held two industry research chairs (KTH, Stockholm, and UQTR). He has been on over 30 boards and was chairman of PAPTAC, PAPIER, TAGA, TAPPI International Research Management Committee, of the CEPI European research group, and an FAO expert. He has managed projects up to 300 M$. He is (co)author of over 300 articles and presented twice as much all over the globe. He contributed many strategic ventures/documents in Europe, Canada, and the USA. He received many awards for excellence in research, including gold medals and Fellowships.