Community-scale resource recovery and biorefining approach

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Resource recovery & biorefining must first have local impacts

Each community must initiate biorefining activities to create new industrial synergies and relaunch local economics
Common products from biomasses

**ENERGY**
- Power
- Heat
- Biogas (e.g. CH₄)

**MATERIAL**
- Food
- Animal feed
- Fertilizers
- Wood products and non lignous products
- Pulp and paper
Biobased products from biorefining

**BIOENERGY**
- ✓ Power
- ✓ Heat
- ✓ Biogas (e.g. methane)
- ✓ *Biofuels (ethanol, butanol, diesel...)*
- ✓ *Hydrogen*

**BIOPRODUCTS**
- ✓ Food
- ✓ Animal feed
- ✓ Fertilizers
- ✓ Wood products and non lignous products
- ✓ Pulp and paper
- ✓ *Biomaterials, composites with natural fibers*
- ✓ *Chemicals* (sugars, organic acids, fatty acids...)
- ✓ *Microbial products* (enzymes, antimicrobial agents, proteins, oils...)

- ✓ Marketable
- ✓ Usable on site
- ✓ Usable locally
Biorefining approaches

1. Stand alone biorefinery
2. Integrated biorefinery to a existing factory or plant
3. Repurposing abandoned plants
4. Upgrading existing facilities to improve fiber quality and then diversify its end-use
5. Eco-industrial cluster
6. Community-scale biorefining
Eco-industrial cluster

Industrial plants and local businesses in close proximity that maximize the share and exchange of products, energy and waste for beneficial uses, and creating value from surrounding biomasses
Eco-industrial cluster, small-scale biorefinery, focused on:

- **Local realities**: e.g. local factory shutting down; rural exodus of young and elderly people; mono-industrial culture; lack of business initiative; reliance on fossil resources...

- **Regional assets**: e.g. local expertise or businesses that can harvest biomass and residues; industrial activities with existing or potential synergies; organizations dedicated to regional economics; presence of university, technical colleges...
Community-scale biorefining

Eco-industrial cluster, small-scale biorefinery, focused on:

- **On-site or local uses of coproducts:** To reduce fossil based products consumption and dependency in region; each coproduct should attract new businesses in town or create a division/spin-off of a local business.

- **Raising local biomass processing depots:** To prepare biomass (drying, grinding...) or produce biobased ingredients and secure the biomass chain supply (at appropriate abundancy and quality).
Community-scale biorefining

Eco-industrial cluster, small-scale biorefinery, focused on:

• **SOCIO-ECONOMIC SUSTAINABILITY:**
  - Improving the social situation of workers, their families and the communities in general
  - Creating and retaining jobs
  - Catalyzing partnerships, business growth and economic activity
  - Revitalizing infrastructure and local expertise in the region
  - Curbs the exodus of youth and elders in the region
  - Stimulating entrepreneurship, especially among young people in the region
Examples of community-scale biorefining projects in Quebec

Case study 1: Agricultural biorefining using crop residues

Case study 2: Forest residues densification for further biorefining

Case study 3: Value added production from pulp and paper mill residues (e.g. sludges)

Case study 4: Microalgae production in co-location with industrial plants
Case study 1: Agricultural biorefining using corn crop residues – Agrosphere project (2007-...)

UQTR, Ferme Olivier Lépine, Ferme Sébastien Lépine, La Coop Profid’Or, DuPont Industrial Biosciences, Innofibre, CNETE & collaborators
Lanaudière (QC, Canada)

- Active agri-businesses
- Farmers facing financial difficulties
- Young people must be encouraged to take over the family land
- Tons of lignocellulosic residues available annually located in small areas
- Local infrastructure and expertise to revitalize
Agrosphere project

• Integrating an agri-biorefinery to an existing farm
• First, target of 12-16M L bioethanol from corn crop residues
• Now focusing on producing sugar hydrolysates & coproducts
Agrosphere, at the center of a regional & international coalition, multi-sectorial ... Able to undertake the entire chain value and biggest challenges in cellulosic biofuels and sugars!
Integrating a cellulosic ethanol pilot plant to an existing farm

*Agrosphere project*

**Ferme Olivier Lépine**

- Wet storage + grinding
- Reactive fractioning

**Organic residues from the farm or local businesses**

- Sustainable & clean harvesting of corn crop residues in 30km radius
- Biocontrol agents production in bioreactors

**Local micro-plant for enzyme production on site**

*DuPont industrial Biosciences Kruger Inc.*
(co-location with a local pulp & paper plant at Crabtree, QC)

- Separated enzyme hydrolysis & fermentation
- DDG
- Pig feeding

**On site or local uses of coproducts**

- Valuable lignin
- Nutritive hemicelluloses
- Highly digestible cellulose
- Heat for plant & farm
- Biopesticide ?
- Local markets
- Pig feeding
- Bioplastics ?

**Biocontrol agents production in bioreactors**
Agrosphere: a model of advanced local biomass processing depot with new assets

Advanced regional biomass processing depot
(co-locate with a farm with unique harvesting and manutention techniques, and flexible fractioning process)

Local enzymes and industrial microorganisms production module
(for value added production from wastes and to reduce enzyme or microbial treatment costs)

On site or local uses of coproducts

Coproducts module
(for on-site or local uses)

Prehydrolysates or Cellulosic sugars

2nd generation biofuel plants
Chemical Industries
Bacterial bioplastics production
Algae production – algae farm

DuPont local micro-plant for enzyme production
Dupont industrial Biosciences
Kruger Inc.
(possibility of co-locate with a Kruger pulp mill)

Organic residues from the farm or local businesses

Sustainable & clean harvesting of corn crop residues in 30km radius

Biocontrol agents production in bioreactors

Nutritive hemicelluloses

Heat for farm

Local markets

Bioplastics?

Reactive fractioning

Wet storage + size reduction

Ferme Olivier Lépine

Valuable lignin
An advanced model of regional biomass processing depot

Similar to Bruce Dale approach (Michigan state University)

Supply value-chain and biomass conditioning are taken care of by local expertise
Local impacts of Agrosphere depots

- Use of local expertise for the biomass value-chain
- Driven by a new generation of young farmers who want to assure the sustainability of farm jobs
- Possibility of having a profitable biomass market
- Generating new income from residues
- Attracting new businesses
- Revitalizing local infrastructure and expertise
Establishment of a bioindustrial park at Bécancour (Quebec, Canada)
(based on the experience of the Sarnia bioindustrial park Ontario, Canada)

To attract new businesses

- BASF
  The Chemical Company

Jungbunzlauer
  From nature to ingredients

Integrated biorefinery for manufacture of platform molecules

Cellulosic sugars, lignins & other coproducts

Network of regional biomass processing depots

For other users in the region

- Soprema
- Sanimarc Group

For local plants

- Arkema
- CEPSA
- Lin
- Chlor Alkali products
- TRT ETGO du Québec

To attract new businesses

Note: The diagram illustrates the various components and stakeholders involved in establishing a bioindustrial park, including the integrated biorefinery and network of regional biomass processing depots.

For local plants

Integrated biorefinery for manufacture of platform molecules

For other users in the region

Cellulosic sugars, lignins & other coproducts

Network of regional biomass processing depots

To attract new businesses
Case study 2: Forest residues densification for further biorefining – La Tuque project (2009-...)

UQTR, Ville de La Tuque, Rock Tenn, Coopérative forestière du Haut-St-Maurice, Groupe Rémarbèc, Innofibre, CERFO, École Forestière de La Tuque & collaborators
Realities of Haut-St-Maurice (QC, Canada)

- 2\textsuperscript{nd} worst population decline in Canada
- Plants shutting down or lowering operation
- Monoindustrial
- Very few next generation of foresters
- Still relying on fossil fuels

A sawmill recently shut down… 300 jobs lost!
Assets of Haut-St-Maurice (QC, Canada)

- Industrial activities generating about 650k tons/year of forest residues
- Presence of foresters with leadership
- Experimental forest on site
- Projects under progress (pellets, forest mushrooms)
- **Opportunities to overcome socio-economic problems with community-scale biorefining**
The Haut-St-Maurice supported by local institutions and businesses to implement a forest biorefinery
Facing a big challenge!

Forest residues spread over >10 000 km$^2$

...Must resort to biomass densification!

Proportion of solids in forest fuels. All loads have the same solid content. (Modified after Nilsson 1983).
Vision 2023 La Tuque
Preparing the field to build a forest biorefinery, to produce bioenergy for local uses, obtain coproducts for specific markets and to welcome new companies relying on biorefining activities.
Vision La Tuque 2023 : Update

• Purchase of a pilot mobile pyrolysis unit with DEC (2,5T/day)

• La Tuque Mission in Scandinavia (Oct 2014)

• Rising an industrial research chair on regional bioenergy & bioeconomy (Dec 2015)

• Vision La Tuque proposed to be a flagship project for Quebec (March 2015)

• Establishment of *Bioénergie La Tuque* (BELT) (May 2015)
Case study 3: Value added production from pulp & paper sludges to obtain bioproducts usable on site or locally (2008-2015)

UQTR, University of Manitoba, Kruger, Cascades, Innofibre & collaborators
Biobased ingredients or products usable on site to replace chemicals or fossils fuels

Monoculture of industrial microorganisms

Projects lead by UQTR
- H2, 3rd gen ethanol, organic acids (acetate, lactate, formate) from C. thermocellum
- Cellulolytic enzymes cocktails with cellulases & xylanases from T. reesei et Bacillus sp.
- Inoculants for wet storage of cellulosic biomasses, PGPr for agri crops
- Bacterial bioplastics (PHAs)

White waters toward value added production

E.g.: Kruger plants

Wastewaters

Twin-screw extruder

Deinking sludge

G. xylinus

Bacterial cellulose

Other local users (near the plant or in the region)

Pulp & paper sludge

Commercial bioreactors or modified pulp & paper vessels

Additives for packaging or composites

(autres boues ou résidus organiques locaux)
Community scale resource recovery and biorefining to relaunch local economics

- Residual biomasses or waste streams are rallying, endogenous tools for local development
  - Diversifying products and coproducts from biomass can give a boost to rural economics and bring new or additional income
  - Be successful locally before going globally
- Cooperate, co-locate and co-produce (3C rule)
  - Cover the entire chain of value with local key players
  - Find end users in your region that could benefit from biobased products or materials even unusual local businesses
How can we have more biorefining activities in NB?

- Individually, NB biomass based companies are going well in diversifying products... Together, they can do more!
- Involve woodlot owners, farm and fish cooperatives
- Involve municipality stakeholders (mayors)
- Seek for unusual biomasses (e.g. sludges, recycled woods) and synergies with other sectors
How can we have more biorefining activities in NB?

- Bioenergy is a good start
- Prepare the field to attract a chemical industry (e.g. with cellulosic sugars or sugar beet sugars)
- Promote a flagship project
- FORM CLUSTERS – Regionalize yourselves around biomasses
- Have your own approach of « inter-community biorefining »!
Here the best tip for implementing biorefining activities:

**Socio-economic sustainability**

Involve the next generation of farmers and foresters, show them the possibility of new incomes and their role in securizing biomass supply at appropriate quality and abundancy for biorefining.
Training in technical colleges, universities and professional schools is essential for implanting successful biorefining activities on a territory!

Incite local businesses to recruit HQP or train directly their employees

**Advanced Biofuel Course**

Lecture 12: Community-scale resource recovery and biorefining approach
Simon Bambé & collaborators
Industrial Research Chair on Environment & Biotechnology (CAER)
Renewable Materials Research Center
University of Quebec at Trois-Rivières (UQTR)
Don’t forget microalgae biomass production in co-location using waste nutrients and waste energy...
It easily creates eco-industrial clusters!

RTA project (2010-2015)

VERTECH I project (2014-2016)

Alga-Fuel pilot tank 10m³, RT-Algae process

EBI project (2015-2017)
VERTECH CITY 2 student international contest

The selected team will have the chance to present their ideas at VERTECH 2016 symposium at Namur, Belgium, next March!