FOREST BIOMASS SUPPLY CHAIN OPTIMISATION TO PRODUCE BIOENERGY, BIOMATERIALS AND BIOCHEMICALS: A SYSTEMATIC LITERATURE REVIEW

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Outline

- Introduction;
- Our project;
  - Motivation
  - Goals
- Literature review paper in CJFR (Dessbesell et al. 2016);
  - Objective
  - Methodology
  - Findings
- Work in progress;
- Expected results.
Introduction

- **Canadian forest industry** is seeking to diversify its portfolio

- Yet bioenergy alone is not enough to **transform the forest industry**

- **Higher-value products** like biochemicals can complement lower-value bioenergy

- Improvements in the conversion processes towards **commercial scale facilities**
Introduction

"Green alternative replacement for petroleum-based polymers"

Chemicals and Materials

"42% of petroleum industry revenue"

Challenges

Why not to build more biorefineries?

Techno-economic Analysis and Supply Chain Design for a Forest Biorefinery to Produce Value-added Bio-based Products from Lignin and Forestry Residues

Project Objectives

- Review the advancements on thermochemical technologies and biorefinery supply chain studies
- Techno-economic analysis for a kraft lignin biorefinery to produce bio-polymers
- Capacity design model for a kraft lignin biorefinery with supply and market uncertainties
- Supply chain capacity design and facility location model for forest biorefineries
Literature Review

Objectives

- Summarize recent achievements in the production of bio-based products from lignin and forest residues

- Provide an overview of forest biomass Supply Chain (SC) optimization studies

- Identify the bio-based products targeted in forest biomass supply chain studies
Materials and Methods

- All database years of ISI were taken into consideration
- Analysis: Endnote and Microsoft Excel
Materials and Methods

Web of Knowledge (979 documents) “biomass* suppl* chain*”

Excluded (913)

Phase 1 (141)
- Social sciences, arts and humanities (10)
- Non-English (15)
- Non-peer reviewed (116)

Phase 2 (772)
- No supply chain optimization (590)
- Literature Review papers (50)
- Non-wood biomass (66)
- Life Cycle Assessment and Emissions (57)
- Other supply chain (e.g. diesel) (4)
- Retracted (2)
- Software purpose (3)

Included (66)
To review (66)
Findings

Forest biomass SC optimization has gained intensive attention in the past two years, in particular in the USA and Canada.
Findings

Final product of the forest biomass SC optimization from the 66 reviewed papers

- Emphasis in energy production in the SC studies

- Ethanol (40%)
- Electricity (23%)
- Heat (23%)

Findings

- Lignin based products can provide alternatives for diversifying the forest industry portfolio

- Promising technologies are depolymerisation, pyrolysis and gasification

- Main journals (43%): Computers & Chemical Engineering, Bioresource Technology, Biomass Bioenergy and Applied Energy

- An increasing number of forest biomass SC studies in the past 15 years

- Leading countries are United States and Canada

- Ethanol, electricity and heat are the main final products
Conclusion

- A complete economic analysis and biomass SC design is crucial to the introduction of bio-based products into the market.

- There is a need for further studies focusing on SC optimization for the production of value-added bio-based materials and chemicals from forest biomass and residues.
Work in progress  Techno-economic analysis for a kraft lignin biorefinery

- Design and recipe (patent filed)

Source: adapted from http://www.icfar.ca/content/projects
Work in progress

- Economic analysis;
  - Net Present Value (NPV)
  - Discounted Pay Back Period
  - Unity Cost
  - Internal Rate of Return (IRR)

- Sensitivity analysis of NPV
  - Kraft Lignin and depolymerized kraft lignin cost
  - Bio-based polymer and phenol selling price
  - Capital investment
Findings so far

- The investment in a 10 t.day\(^{-1}\) kraft lignin biorefinery is feasible;

- Sensitivity analysis NPV:
  - The NPV of the investment is highly affected by fluctuations on:
    - 1st Bio-based polymer selling price
    - 2nd Capital investment
    - 3rd Raw material cost (KL)
Work in progress

- Capacity design model for a kraft lignin biorefinery with supply and market uncertainties
  - Model maximize the NPV of the biorefinery considering the production and capacity constraints
  - Incorporate capacity flexibility in the model
  - Include demand and price uncertainties in the SC model
  - Incorporate feedstock supply uncertainties in the model, completing the framework for a forest biorefinery SC.
Expected contributions from our project

- Assist the forest based industry to find high value usage for its residues, such as sawdust, black liquor and harvesting residues

- Develop a valuable tool for capacity and location planning for a forest biorefinery

- Contribute to introduce to the market renewable alternatives for petroleum-based products
Acknowledgements
Thank you

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Source: goo.gl/5svr7v