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**

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Introduction

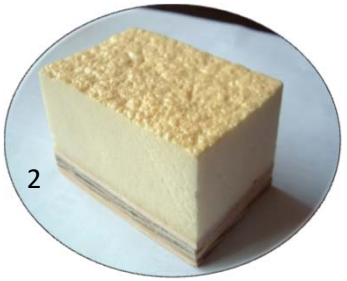
Chemicals and Materials

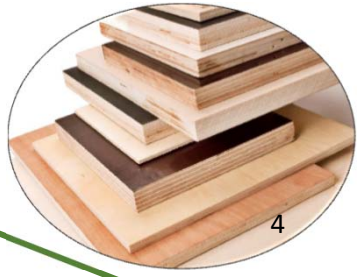
”**42%** of petroleum industry revenue”

PU foams

PF resins

Epoxy resins





Challenges

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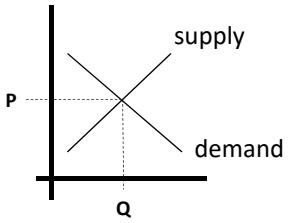

Why not to build more biorefineries?

Wood Lignin

”Green alternative replacement for petroleum-based polymers”

Sources: 1: https://goo.gl/hQixpM 2: https://goo.gl/2pKxp0 3: https://goo.gl/IMWsVx 4:https://goo.gl/SmyWNw 5: https://goo.gl/ChzfQd 6: https://goo.gl/lllmab

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

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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

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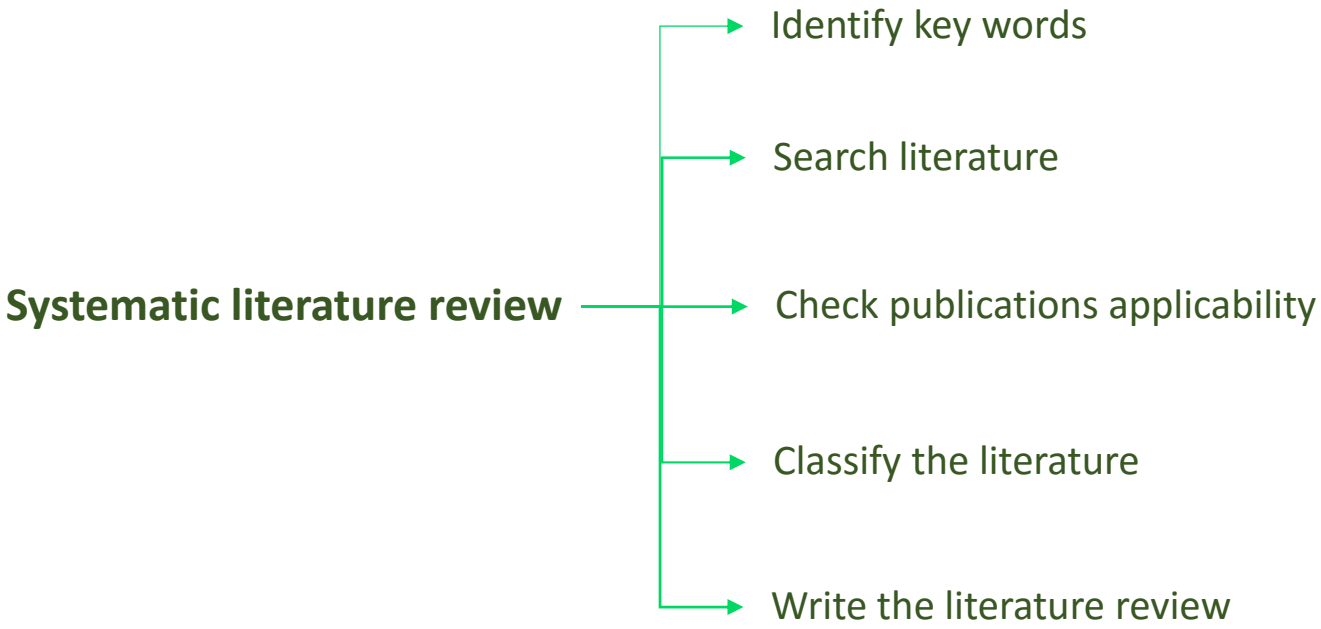
Materials and Methods



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

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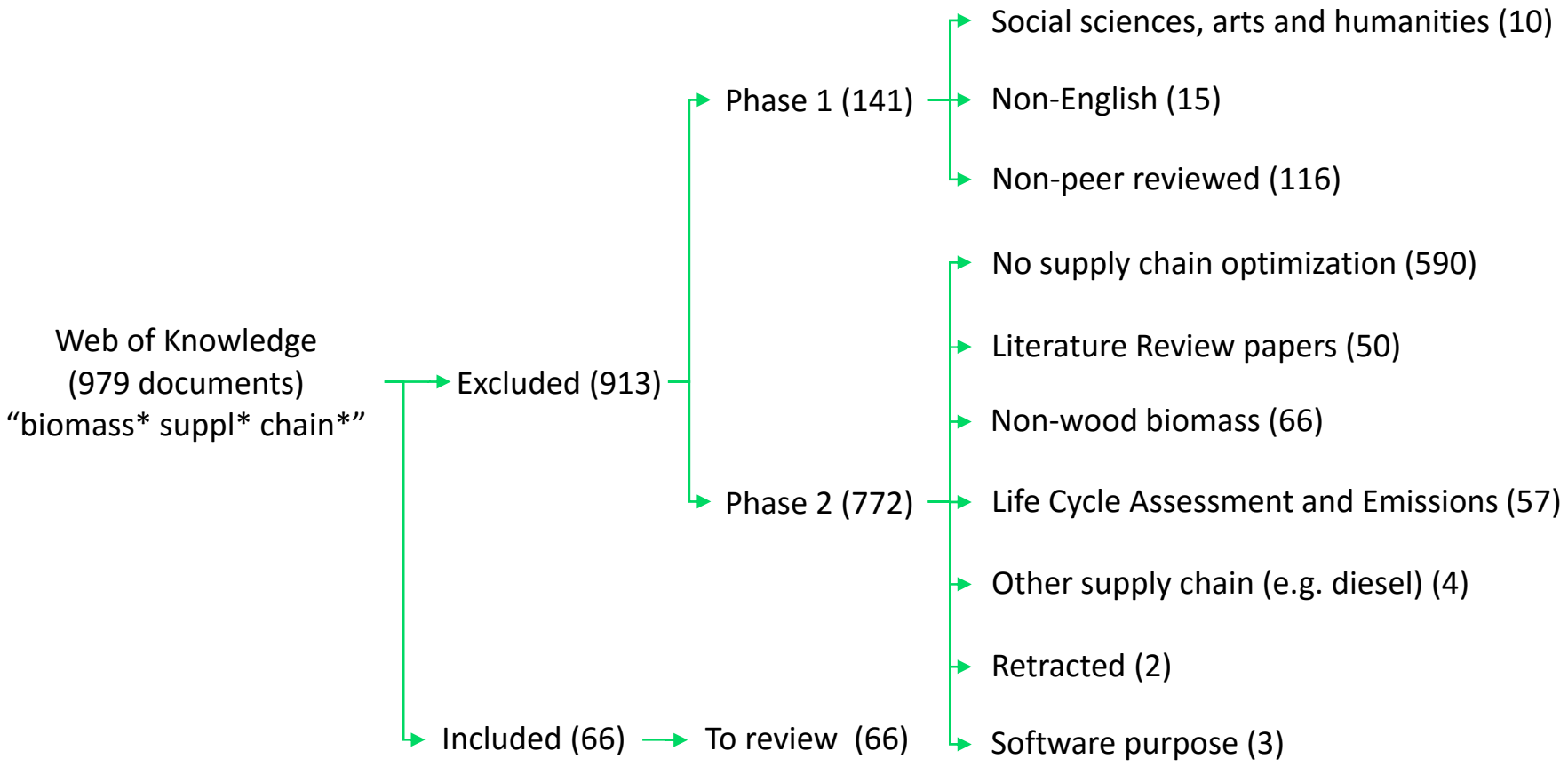
Materials and Methods



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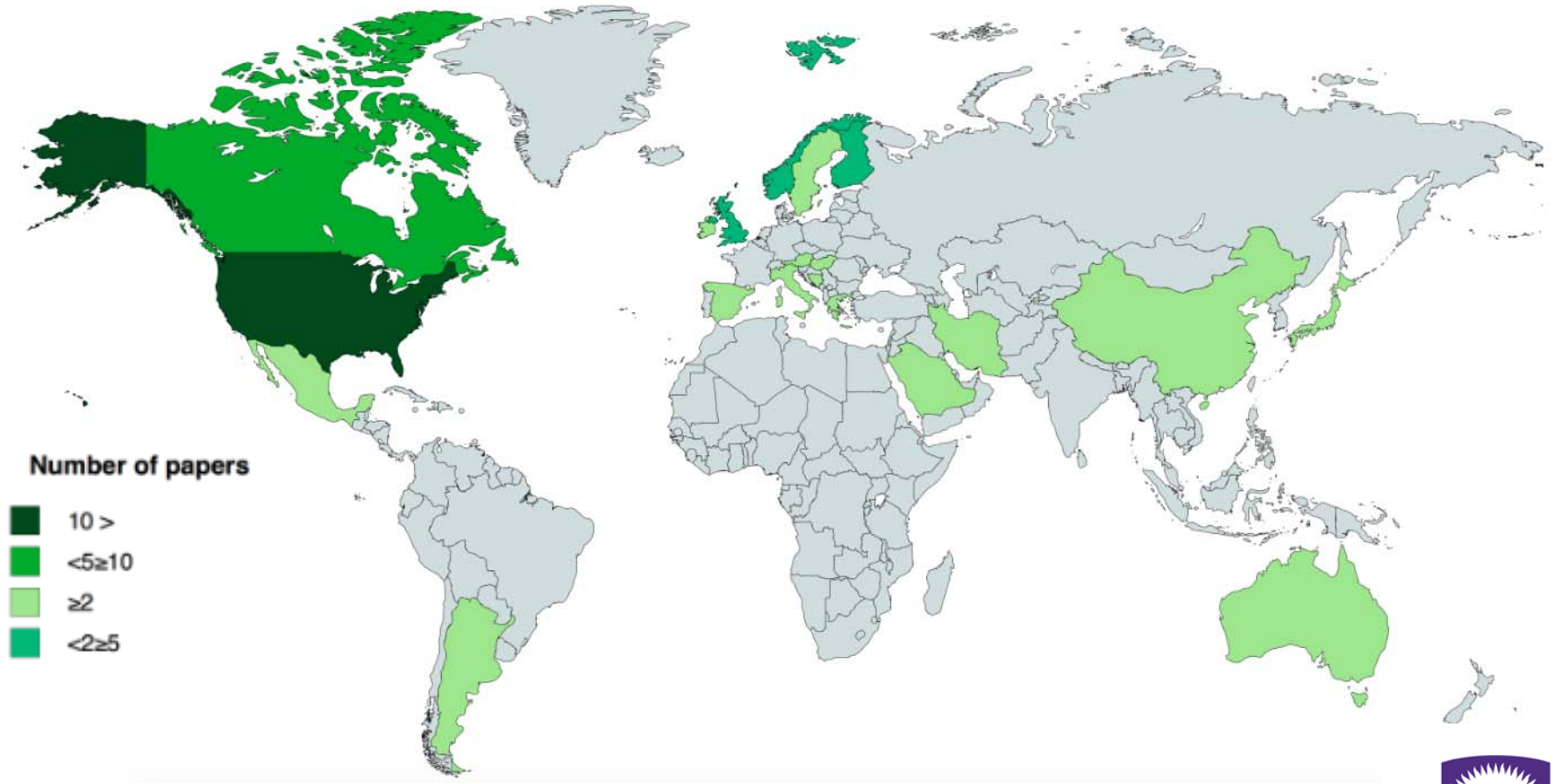
Findings

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



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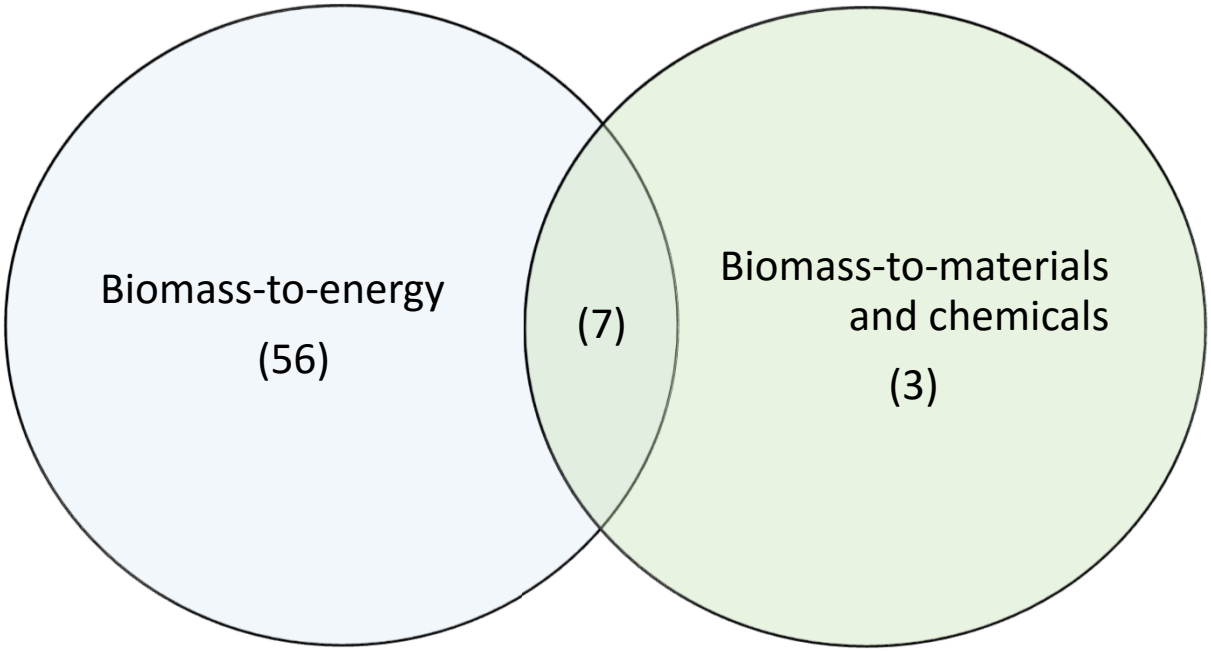
Findings

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%)

Dessbesell, L., et al 2016. Canadian Journal of Forest Research: 277–288. doi:10.1139/cjfr-2016-0336.

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

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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

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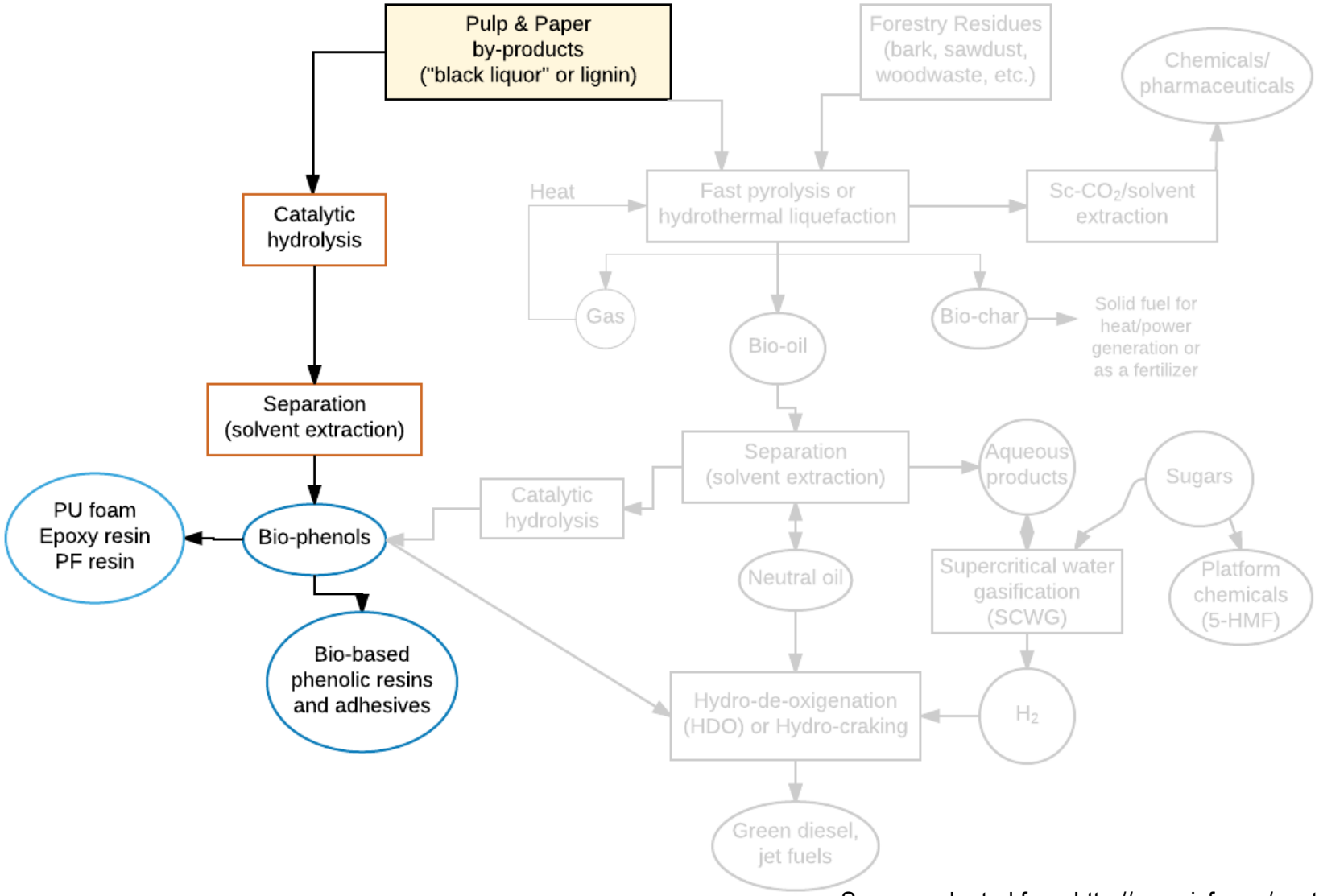
Work in progress

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

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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)

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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.

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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

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Thank you
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Source: goo.gl/5svr7v