Introduction

Many pulp and paper companies around the world are pursuing a substantial part of the future lignocellulosic biorefining industry, partly because it is a logical extension to their current core business and partly because new revenue streams are necessary for P&P companies to survive. Currently the technologies and markets for the bio-products are however only in initial stage generating big uncertainties for the decision making. For this industry to emerge, right decisions need to be made already in near term based on currently available information.

A “bottom-up” approach for strategic decision making in the case of retrofit biorefinery implementation into a pulp and paper mill is proposed: available process data and knowledge, and forecasts of future possibilities are transformed into a business modelling framework which can better reflect the business opportunities of retrofit biorefinery implementation in order to be able to screen out non-promising design options. This business model uses process modelling and Activity Based Costing (ABC) principles to evaluate production costs. This is then combined with capital spending planning in order to be able to estimate the impacts of integration on financial performance of the pulp and paper mill and the entire forestry company. Uncertainties are considered with stochastic risk analysis (Monte Carlo simulation).

Overall Objectives

Main objective
To develop an early stage design decision making methodology for retrofit biorefinery implementation into an existing forestry company that will better serve the capital spending planning process

Specific objectives
- To develop a method for estimating profitability of possible forest biorefinery design options under uncertainty in order to be able to screen out less promising design options
- To develop an operations driven cost modelling framework for calculating the manufacturing and marginal costs of the production in an integrated forest biorefinery, considering the given uncertainties
- To develop a company-level evaluation method for defining interpretable financial and non-financial decision making measures in order to justify biorefinery projects and the transformation of business strategy
**Potential Benefits**

- A methodology for analysing the integration impacts and the benefits of different retrofit project options
- Better understanding of the reasons to make strategic (biorefinery) retrofit decisions
- Improved link between volume/turnover focused mill operations analysis and value focused company level financial planning in case of strategic retrofit decision making

**Methodology**

A case study methodology is developed that uses:

- 1) Process based data from existing P&P mill process and 2) simulated data of new biorefinery processes as basis for operations driven cost analysis. This leads to better understanding of the cost structure of the core business (chemical pulping) and the impacts of integration of different processes on that cost structure.
- 1) Future capital planning of the entire mill in different biorefinery scenarios combined with 2) capital cost analysis of different integrated processes to evaluate the impact of the retrofit project on mill and company level financial performance.
- Mill level financial and non-financial performance measures in panel based multi-criteria decision making process using Analytical Hierarchy Process (AHP) to screen-out non-promising retrofit project options.

A case study mill is used for methodology demonstration

**Preliminary Results**

- A traditional techno-economic analysis of forest biorefinery scenarios producing biofuels (ethanol, mixed alcohols and Fischer-Tropsch liquids) integrated into a Kraft pulp mill was conducted. Main conclusions:
  - Due to differences in the availability of different feedstocks and differences in product yield and cost, studied design options seem to be profitable with different capacities
  - Thermochemical processes seem to be more profitable than biochemical processes
  - Integration into existing pulp mill can enhance profitability but the impact is dependent on plant capacity
- Applying Monte Carlo risk analysis in techno-economic analysis of integrated forest biorefinery retrofit project options to produce biofuels. Main conclusions:
  - Incorporating stochastic uncertainty in economic analysis will give a clearer picture of the possible worst case scenario profitability of considered project options in order to guarantee better informed screening-out
  - Biochemical design options need lower capital intensity to have comparable economic performance with thermochemical designs
  - Set of promising design options can be selected, however, different set might be
attractive if also other measures were used (e.g. capital investment)

**Figure – Overall methodology**

**Data gathering**
- Process data from mill operations and literature
- Accounting data from mill accounting system
- Economic data
- Raw material data

**Conventional techno-economic evaluation**
- Capital investment estimation
- O&M cost calculation
- Profitability estimation

**Q&M costing framework definition**
- Activity Based Costing principles

**Company-level evaluation method definition**

**Multi Criteria Decision making**
- Analytical Hierarchy Process
- Economic criteria

**Future Work**
- Development of the operations driven cost modelling framework for multi-product facility for cash flow calculation
- Definition of a set of suitable metrics describing the financial decision making process related to forest industrial retrofit projects

**References**
