Biorefinery opportunities in the Netherlands: Learnings from “Redefinery”

USDA – EZ&K workshop: March 19, 2018

“Pitching Biorefinery Cases”

Agro meets Chemistry and Markets

Rop Zoetemeyer
Foundation Biobased Delta: 
Ecosystem for the Circular Bioeconomy.

**Mission:**
To increase the economic value and decarbonize in the Biobased Delta via Agro meets Chemistry and Markets

Biobased Delta is connecting and promoting:
- SME’s (start-ups, scale-ups and others)
- Large international companies (with their sustainability agenda)
- Education
- Knowledge Institutes

With regional and local governments in facilitating mode
Ecosystem Circular Bioeconomy: 17 top locations

Seaports, Industry-parks and Pilot-Service plants

5 Port of Rotterdam
6 Port of Moerdijk
7 Nieuw Prinsenland
11 North Sea Port
12 Biopark Terneuzen
13a Biobase Europe Training Center
13b Biobase Europe Pilot plant

Application, Innovation & Knowledge Centers

2 Biotech Campus Delft
3 Yes! Delft Incubator
4 Veenweide – Dairy Innovation center
8 Green Chemistry Campus
9a Natural Fibre Appl. Center
9b Colour Appl Center
9c Biopolymer Appl. Center
10 Biobased Innovation Center
14abc Centres of Expertise Biobased Economy (CoE BBE)
Closeness of key markets and decision makers

- Antwerp – Rotterdam – Rhein – Rhur Area covers 40% of Europe’s Chemical Industry
- It hosts a large number of downstream customers and value chain decision makers
- Infra-structure by pipe-line network
Three Flag-ship projects

Sugar Delta
• Economic growth using locally grown 2.5 million t/a 1\textsuperscript{st} gen carbohydrates (sugar beets, wheat, potato and corn)

Redefinery
• Large scale bio-refinery of lignocellulosic biomass (2\textsuperscript{nd} gen carbohydrates and lignin)

Biorizon
• Development of bio-aromatics from biogenic feedstock (waste, sugars, lignin)
Towards a RE(DE)FINERY implementation for Green Chemicals, Fuels and Energy

The conversion of lignocellulose into chemical building blocks and biofuels (2G)
Two over arching Material Markets

- **Building & Construction** – coatings – sealants – adhesives - textiles

  New Buildings  Renovation  Infrastructure  Public space

- **Packaging** – flexible packaging – rigid packaging – printing inks - adhesives

confidential
Two over arching Energy Markets

- Biojet fuel - alcohols to jet – oils to jet – syngas to jet – sugars to jet

- Heavy Trucks & Shipping – biodiesel – Bio-LNG – bio Bunker oil
**Bio-refinery is the heart of REDEFINERY**

**Bio-refinery:**
- Converts lignocellulose to sugars and lignin
- Delivers utilities: steam, electricity and (waste) water (treatment)
- Supplies logistics and procurement of raw materials

**Other fringe benefits of colocation:**
- Safety management
- Risk management
- Co-buying of chemicals
- Maintenance, etc..

**Biorefinery is owned by:**
- Investors, Corporations, Public Sector

**Technology:**
- Steam Explosion followed by enzymatic hydrolysis
- Separate streams for C5 & C6 sugars

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**Hard Wood**
- 0.5 to 1 Mtpa

**Energy comp. (CHP)**

**Operator**

**Port Authority**

**Inventors ‘Others’**

**Grants**

**Bio Refinery**

**Chemical comp. (gasif)**

**Ferment. comp. (fuels)**

**Ferment. comp. (chem.)**

**Lignin**

**Sugars**
The ingredients for success: Lessons Learned

- Large scale 1st gen bio-refineries: wheat, corn, sugar beet
- Industrial size 2nd gen ethanol plants: pre-treatment!
- Integrated industrial chemical clusters: over the fence, joint actions
- Use strength of total chemical cluster and closeness of markets: supply chain!
- Scalability e.g. P&P industry: scale matters = f(biomass)
- Biomass availability & Logistics: as important as B.C.
- CO₂ as leading principle in project: also for future optimized B.C.
- Outlets for pure C5 and C6 sugars: different markets, value
- Outlets for Lignin:
  - Phase 1: energy (default)
  - Phase 2: bio-asphalt – bio-bitumen (focus)
  - Phase 3: Bio-aromatics (future)
Redefinery Specifics – Technology

Biomass feedstock
- Hard wood residues
  - Mild acid soak + steam explosion

Hydrolysis
- Hemi-Cellulose
  - C5 sugars

Separation
- C5 sugars
  - C6 sugar
    - Glucose >90%
      - Lignin isolation
  - Enzymatic Hydrolysis
    - Pentose
      - xylose

Fermentation
- confidential
Bio-bitumen with lignin

- 3 roads ZL
- N272 NB
- Bike path GL
**Redefinery Specifics – BC (>3RD time)**

**Biomass feedstock**
- Hard wood residues
- Wood pellets
  - 150 €/dbt
  - 185 $/dbt

**Mild acid soak + steam explosion**

**Hydrolysis**
- C5 sugars
  - Pentose - xylose
- Lignin isolation
- Glucose >90%

**Separation**
- C6 sugar

**Enzymatic Hydrolysis**

**Filtration**

**Cellulose**

**Lignin**

**Fermentation**
- TP: 360 €/t (445 $/t)
  - (Y = 95%)
- TP: 350 €/t (430 $/t)

**TP: 230 €/t**
- (285 $/t)
- (Y = 91%)

**IRR 27%**

**Scale:**
- 625 ktpa plant (dbt)

**€/$ 0.81**

**TP:**
- 230 €/t
- (285 $/t)
- (Y = 91%)

**TP:**
- 360 €/t
- (445 $/t)
- (Y = 95%)

**TP:**
- 350 €/t
- (430 $/t)

**IRR:**
- 27%
Profitable projects and de-risking for financing
Redefinery Status

- **Business Case:** Scale ~ 625 kt/a (db)
- **Feedstock:** Woody Biomass (preferably hardwood residues). Develop local market for woody residues
- **Technology:** Validation almost finished **Technology Provider:** Track record
- **Other partners required:** Engineering services; Enzymes and/or catalyst providers
- **Operator:** Experienced in running bio-refineries
- **Markets and Off-take partners:** C5 ➔ Bio-fuels
  - C6 ➔ Lactic Acid / PLA
  - Lignin ➔ Bio-asphalt
- **Supply Chain:** Long term contract.
- **Location:** NL deep sea harbour or close to it.
- **Policy & Permits:** Dependent on location.
Main challenges

- Building the first consortium of this kind.
- Financing first consortium.
  - Pre-feasibility, Feasibility, etc., etc..
  - Financing of mitigation of risks especially in the first consortium.
- Supply chain – Biomass / availability & future price stability in feedstock and supply.
- Market growth for Bio-bitumen.
- Public (a.o. NGO) and governmental acceptance.
- ...
- ...
THANKS FOR YOUR ATTENTION!

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