WOOD-BASED BIOREFINERIES PAVE THE WAY TO SUCCESSFUL BIOECONOMY

Sari Mannonen, Vice president, UPM Biofuels
FAO, AFCSI meeting, Rome
5.4.2018
UPM today

SALES €10 BILLION • PERSONNEL 19,100 • PRODUCTION PLANTS 54 • SHAREHOLDERS 90,000+

pulp, plantations, biofuels, timber

BIOCHEMICALS
BIOKOMPOSITES
Megatrends drive demand for sustainable and safe solutions

Biofore fits well into the changing world

Population growth, urbanisation
Resource scarcity, role of renewables
Digitalisation
Climate change
Responsibility and compliance

Efficient use of renewable materials and energy
Renewable and recyclable products
Innovations and new businesses
Responsibility integrated in all operations
Evolution of wood usage

Biomolecules
- Biofuels
- Biochemicals

Fibres
- Pulp
- Paper
- Packaging
- Tissue
- Labelling materials
- Biocomposites

Logs
- Sawn timber
- Plywood

Trees
- Energy
THE CHALLENGE – CLIMATE CHANGE
Climate change is driving search for greenhouse gas (GHG) savings

Road transport emissions moving wrong way

- Total GHG reduction per year in EU since 1990
  - 1990: -1.2%
  - 2005: +0.7%
  - 2015: +0.7%

- GHG increase in road transport sector per year in EU since 1990
  - 1990: +0.7%
  - 2005: +0.7%
  - 2015: +0.7%

Source: EEA
Exxon global outlook for energy 2018 – transportation & liquids supply
Significant emission cuts needed in transportation sector

EU’s greenhouse gas reduction targets cannot be met without significant emission cuts in transport – actions needed in all sectors

- 80% by 2050
- 60% by 2040
- 40% by 2030

25% of total emissions in Europe from transport

Transport emissions by sector

Drop-in biofuels are a solution for GHG reduction in all transport sectors

Electric vehicles can be applied in light-duty road transport
Biofuels are needed in road transport energy mix to meet EU’s GHG-reduction targets
UPM’S WOOD-BASED BIOFUELS
UPM’s journey in advanced biofuels

2006
UPM published its plans to become a significant producer of advanced biofuels.

2008
Development of various technologies. **Hydrotreatment** process development started in UPM R&D.

2012
First investment decision of 179 M€ for UPM Lappeenranta biorefinery. Produces renewable diesel from tall oil.

2015
UPM Lappeenranta biorefinery in commercial production in January. **Sales of UPM BioVerno starts** in Finland.

2016
Business case proven. Establishing UPM **Biofuels Development Programme** evaluating growth opportunities.

2017
Expanding UPM BioVerno diesel & naphtha sales to Scandinavia and EU.
UPM Kaukas, Lappeenranta, Finland

Industrial evolution of the world’s most versatile forest industry integrate

UPM KAUKAS
1. Main gate
2. Mutteri office
3. Research Center (NERC)
4. Biorefinery
5. Bio-power plant
6. Pulp mill
7. Sawmill
8. Paper mill
9. Effluent treatment plant
UPM Lappeenranta Biorefinery

Key facts

- Product: Renewable diesel
- UPM investment: 179 M€
- Capacity: 100,000 tonnes/a
- UPM patents and applications: 200
- Employs 250 persons (incl. indirect)
Crude Tall Oil (CTO) – a residue of pulp making process as raw material

Crude tall oil must be removed from the chemical cycle to secure pulping process functionality.
UPM renewable diesel and naphtha production process

CRUDE TALL OIL
A residue of chemical pulping process containing natural extractive components of wood.

PRETREATMENT
Crude Tall Oil is purified: salts, impurities, solid particles and water are removed.

HYDROTREATMENT
Pretreated Crude Tall Oil is fed together with make-up and recycled hydrogen to the reactor where the chemical structure is modified. Reaction water is separated and directed to waste water treatment.

FRACTIONATION
Remaining hydrogen sulfide and uncondensable gases are removed. The remaining liquid is distilled to separate renewable diesel.

RENEWABLE DIESEL
High quality advanced biofuel suitable for all diesel engines.

RENEWABLE NAPHTHA
Advanced renewable biocomponent for gasoline or raw material for bioplastics.
UPM BioVerno renewable diesel - Top of the line sustainable biofuel

<table>
<thead>
<tr>
<th>Feature</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen free hydrocarbon</td>
<td>100%</td>
</tr>
<tr>
<td>Renewable feedstock</td>
<td>100%</td>
</tr>
<tr>
<td>CO₂ emissions (vs. fossil fuel)</td>
<td>-80%</td>
</tr>
<tr>
<td>In food chain</td>
<td>0%</td>
</tr>
</tbody>
</table>
UPM Biofuels in existing and future end-use

- Fuel retail
- Dedicated green fleets
- Marine/Aviation
UPM BioVerno naphtha in bioplastics - Case Dow & Elopak

- 100% renewable and recyclable wood-based carton
  - **UPM Biofuels** produces wood-based UPM BioVerno naphtha
  - **Dow** converts naphtha to renewable resins to manufacture bioplastics (PE)
  - **Elopak** coats wood-based beverage carton with wood-based bioplastics
- Every tonne of UPM’s wood-based naphtha reduces one tonne of fossil raw materials
- Entire value chain ISCC Plus certified
UPM IS INVESTIGATING OPPORTUNITIES IN WOOD-BASED CHEMICALS
New business opportunities for UPM

Biofuels
- High volume products
- Economies of scale
- Drop-in applications

Biochemicals
- Bio-based chemical building blocks
- Life science prod. e.g. cell culturing and medical care
- Performance chemicals

Biocomposites
- Terrace materials
- New applications, e.g. acoustics pr.

Scaleup
Market entry
Market entry
Scaleup
Biochemicals biorefinery targeting to produce bio-MEG, bio-MPG and lignin from hardwood

**BIOREFINERY PROCESS**

**STEP 1: SUGAR PULPING**
Disintegrating wood into sugars, lignin and green energy

**STEP 2: CHEMICAL CONVERSION**
Conversion of sugars into targeted biochemicals

- Bio-Monoethylene glycol (MEG)
- Bio-Monopropylene glycol (MPG)
- Lignin

**BIOMASS**

- 40% Cellulose
- 30% Hemicellulose
- 25% Lignin

**SUGARS**

**GREEN ENERGY**
Biochemicals products are sustainable and competitive drop-in alternatives for brand owners

**Mono Ethylene Glycol**
- Existing fossil-based market
- Market demand > 26 mio tons
- CAGR >3%
- Application examples:
  - Textiles
  - Bottles & Packaging
  - Deicing fluids

**Mono Propylene Glycol**
- Existing fossil-based market
- Market demand >2 mio tons
- CAGR >5%
- Application examples:
  - Composites
  - Pharma & Cosmetics
  - Detergents

**Lignin**
- Performance chemical
- Application driven
- Strong IP position
- Application examples:
  - Wood resins
  - Plastics
  - Foams & Coatings
UPM IS STUDYING OPPORTUNITIES FOR GROWTH IN BIOFUELS
UPM studies the feasibility of possible new Biorefinery in Kotka, Finland

- Environmental impact assessment (EIA) started
- Planned capacity: 500,000 tonnes advanced biofuels
- Several sustainable feedstock different from UPM Lappeenranta Biorefinery
  - e.g. solid wood biomass and Brassica carinata
- Technology differs from Lappeenranta biorefinery
  - conversion of solid biomass and hydrotreatment
- Biofuels regulation decisions in Finland and EU will impact the future investment consideration

Mussalo, Kotka, Finland – the area of dismantled power plant formerly run by Pohjolan Voima