Biofuels and forest biorefineries

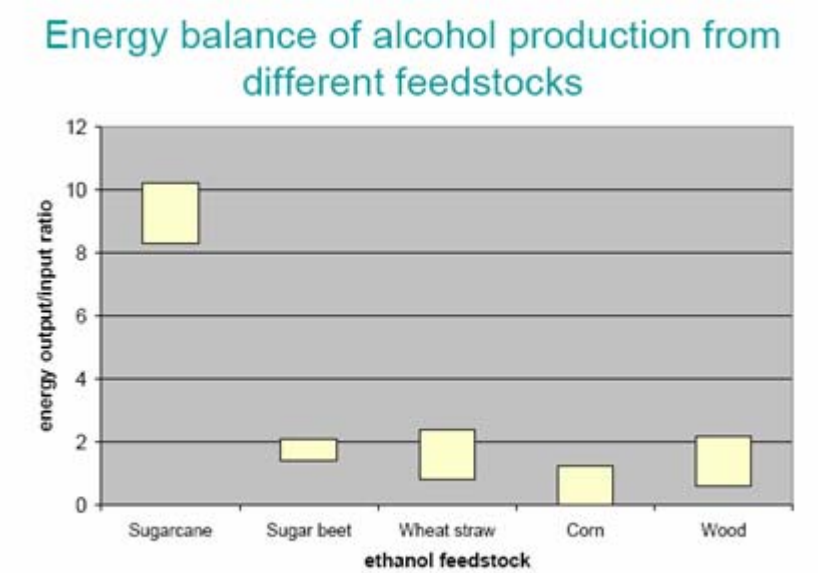
John Lindahl
Deputy President of Forest Industry business group

Biofuels

- Generally, biofuels are divided into first- and second-generation fuels. The most rational base for this division are their properties, but sometimes also the feedstock.
- First-generation biofuels, which are derived from sugar cane or corn (starch) crops (bioethanol) or from vegetable or animal oils (biodiesel) are already a mature technology.
- They can be used as a substitute for other fuels in existing vehicles
  - Depending on the manufacturer, 100 % biodiesel is already allowed
  - High substitution (> 10 %) with ethanol will require engine modifications
  - FFVs (flexible fuel vehicles) can use blends with up to 100 % ethanol
- Second-generation biofuels comprise a range of alternatives, such as ligno-cellulosic ethanol, syngas gas-based fuels, pyrolysis oil-based biofuels and others.
  - Second-generation biofuels should be equivalent to modern automotive fuels without major limitations to their use (might require modifications to cars).

First-generation biofuels

- Ethanol is mainly produced in Brazil and USA (2005 production 42 Mt):
  - Brazil 16 Mt
  - USA 23 Mt (target 46 Mt in 2012)
  - EU production of ethanol was only 0.5 Mt
- Biodiesel is mainly produced in the EU and the production capacity is increasing rapidly:
  - 2005: 3.2 Mt
  - 2006: 6 Mt
  - 2007: 10 Mt (estimate)
- Pira Int., 2007: ”After 2007 demand for biodiesel will increase in all countries and regions, but bioethanol will continue to have a larger share than biodiesel until about 2017, when their share could be almost equal.”



Sources: (Macedo et alii, 2004; UK DTI, 2003 and USDA, 1995)

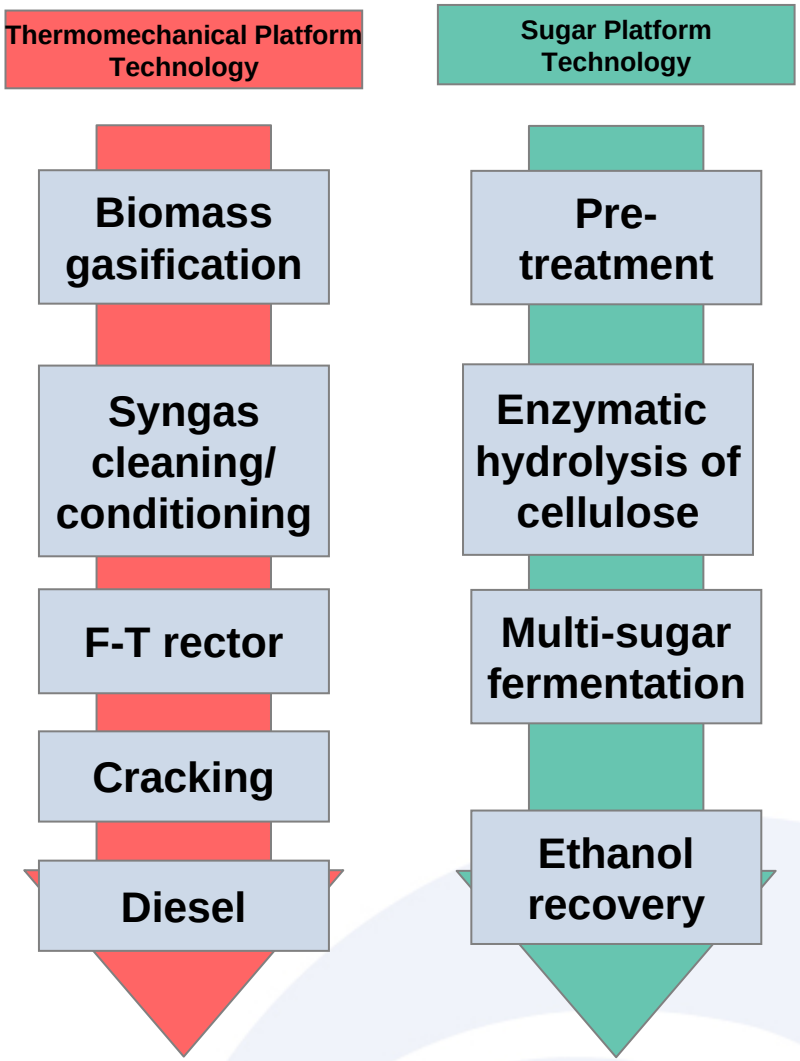
Productivity comparison based on first-generation techniques

First-generation biofuels

- First-generation biofuels cannot compete with petrol-based fuels
  - Opinions differ about Brazil's sugar cane-based production
  - Bioethanol reaches break-even when the oil price is about EUR 90/ barrel, biodiesel at about EUR 60/barrel (Pira Int., 2007)
- Market development is driven by national obligations but implementation will depend on the price of oil
- The environmental performance of first-generation biofuels is already being debated in public
  - Efficiency improvement possible, but e.g. GM (genetic modification) is strongly resisted
  - Raw materials are a part of the food chain
  - Land use is also a concern
  - CO_2 balance: Debate on how the balance calculations should be done is ongoing

Second-generation biofuels

- Second-generation biofuels comprise a range of alternatives such as lignocellulosic ethanol, syngas gas-based fuels, enzymatic hydrolysis of cellulose and fermentation, pyrolysis oil-based biofuels and others.
- Known processes can be used to produce high-quality diesel fuel from synthetic gas (Fischer-Tropsch diesel, methanol or dimethylether, DME) in the so-called BTL (biomass-to-liquid) process
- Wood waste, peat, reed canary grass and organic waste can be used as raw material
- Synthetic gas can also be manufactured from coal, natural gas or biomass
  - These fuels are not from renewable sources
  - They can contribute to security of supply and promote cleaner fuels for transport



Second-generation biofuels

- It is expected that second-generation biofuels can compete when crude oil prices are EUR 46-77 per barrel (VIEWLS 2005).
  - production costs will be influenced by future fuel specifications, end-use issues and other aspects such as by-product markets.
- If the development and scale-up of second-generation biofuels is successful and woody biomass becomes and remains cheaply available, second-generation biofuels can compete at about EUR 31 per barrel.
- All second-generation biofuels are still in the R&D/pilot phase and are not yet available on the market because of technical limitations.
- Compared to first-generation biofuels, cellulosic bioethanol, FT biodiesel and HTU diesel are expected to yield far higher reductions in greenhouse gas emissions.
- The main environmental drawback of second-generation biofuels concerns the sources of the biomass required
  - waste streams vs. cultivated

Source PIRA, 2007

Regulations play a major role

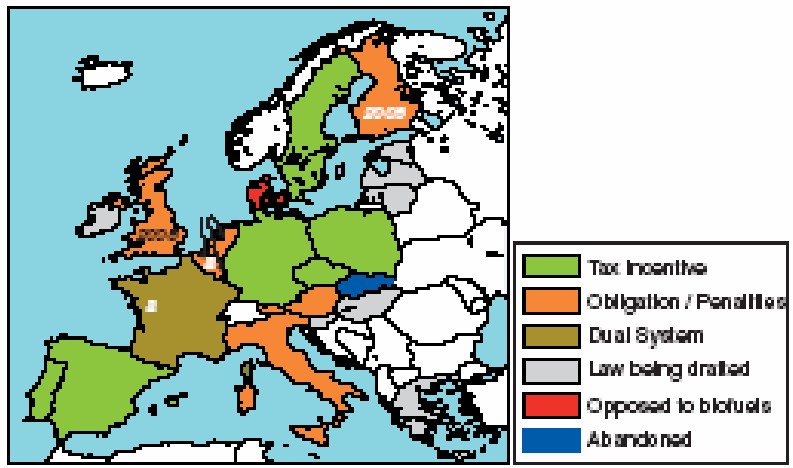
- There are major governmental initiatives all over the world to promote the use of biofuels, e.g.:
  - Brazil/Philippines: blending stipulation
  - USA: major federal funding, tax exemptions for alcohol fuels
  - Japan: tax incentives
  - China: production subsidies
- Russia has so far no significant government policy for promoting biofuel production or usage
- As regulations are required to ensure the economic feasibility of biofuels, it seems reasonable to expect that such regulations will be put in place.

Fig. 2 Biofuel taxation in Europe

United Kingdom: Law being revised. New system planned for 2008

Benelux countries: New biofuel regulations, effective 2006-2007

Germany: Incentive system being revised. New system, effective 2007



a = appointed suppliers

Source: Based on data from Total (adapted and updated), Jacques Blondy, presentation made at World Biofuels 2006, Seville, May 2006.

Source: Ifp

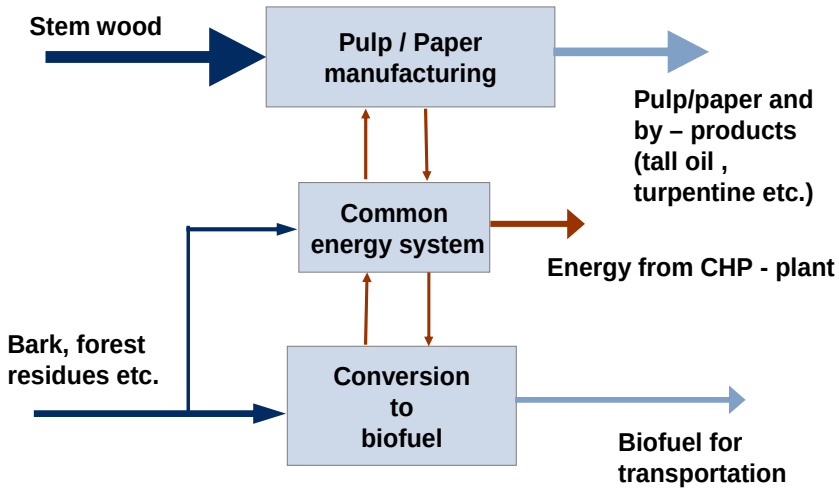
Forest biorefineries

Integrated forest products refinery
Advantages and challenges

Co-production at pulp and paper mills

- Full utilisation of the incoming biomass and other raw materials, including energy, for simultaneous production of fibres for paper products, chemicals and energy
- Examples of current products:
  - Kraft pulp mill: tall oil and derivatives, turpentine and derivatives
  - Sulphite pulp mill: Ethanol, lignosulfonate, yeast, animal feed stock, xylose, furfural, vanillin etc.
- New products:
  - Biofuels, methanol, lignin-based chemicals etc.

Co – production at pulp and paper mills



The main benefit of integration is the high utilisation factor for biomass, up to 90 %, which is a significant competitive advantage in future markets, where demand for renewable energy and forest raw material is much intensified.

Advantages of integration

- **Integrated wood procurement and harvesting chain** for both pulpwood and forest residues for on-site energy generation.
- **On-site CHP plants are already utilising** residues and by-products from pulp and paper processes and other wood-based fuels.
- **Optimisation** of both energy generation (steam and power ratio) and usage possible
- Synthesis gas production and conversion produces a large amount of high-grade by-product energy, which offers **a significant potential benefit if integrated with any energy-demanding industrial facility**.

Technical and economic challenges 1(2)

- **Process technology risks**
  - risks related to limited process yields, process thermal efficiencies, manufacturing materials, gas cleaning requirements etc.
- **Process flexibility**
  - a mill should be able to achieve targeted returns for the integrate under a range of volatile market and economic circumstances.
    - optimisation and adjustment of carbon consumption to produce pulp and paper, bioenergy, green chemicals or structural material products.
  - what are the most attractive process variations that a mill should consider?
- **Energy generation**
  - how can energy systems best be integrated and optimised between the BTL plant and the existing mill?

Technical and economic challenges 2(2)

- **Existing pulp and paper production must remain efficient and be able to sustain target product quality**
  - contaminants (distribution between pulp and paper manufacturing and biorefining operations)
    - need for additional process stages for NPE removal
  - evaporator scaling
  - sulphur in the biorefinery feedstock
  - Na/S ratio adjustments in the pulping process
  - environmental impacts
- **Risks will increase with increased process complexity**
  - for example, an integrated forest biorefinery vs. integrated biofuel production

Conclusions

- Preliminary calculations indicate that the **wood-paying capability of paper production is still significantly higher than that of biofuel production**
  - taxation and subsidies will determine the competitiveness of liquid biofuels
- However, some assessments of economic performance indicate that the **profit from co-production of FT (Fischer-Tropsch) liquids could be of similar** to that from paper production. (VTT, Lahti, Nov. 2006)

Recent research and project initiatives

Biofuels – recent research

- Interest has shifted from developing techniques to making ethanol from lignocellulosic materials.
  - The USA concentrates on corn and western millet, Brazil on by-products from sugar industry and the EU on wheat straw as feedstock
- Interest in producing biofuel from woody raw materials exists in the EU (Sweden, Finland and France) and Canada
  - In Finland, Sweden, France and Germany, forest residues offer the greatest potential.
  - Gasification-based biodiesel is being studied by VTT of Finland
  - Sweden started trials in 2004 with a plant at Örnsköldsvik to produce 400-500 litres of ethanol per day from woody feedstocks.
  - Iogen in Canada has started a demonstration plant with straw.
  - Choren at Freiberg in Germany is constructing the first industrial-scale (15,000t) BTL plant to commence production at the end of 2007

CHOREN is constructing the world's first industrial-scale BTL plant (Beta-Plant) at its Freiberg site in Germany.

A Sigma plant project will be initiated with Linde AG. The project will start in September, 2007

Recent announcements: projects and feasibility studies

- Four major paper companies have recently announced biofuel initiatives:
  - Norske Skog in May 2006,
  - UPM in October 2006
  - Stora Enso in March, 2007
  - Weyerhaeuser Company in April 2007
- UPM's and Stora Enso's projects are gasification-based biorefineries where the final product is biodiesel.
- Stora Enso is partnering with the Finnish company Neste Oil, who will be responsible for final refining and marketing of the biofuels.
- Norske Skog cooperates with Norsk Hydro and their partnership will most likely be based on the same type of arrangement.
- Weyrhauser has created an alliance with Chevron.

Logging residues can be used to produce biofuels for energy production (Stora Enso, 2007)

DOE selects six cellulosic ethanol plants for up to USD 385 million in federal funding:

- **Abengoa Bioenergy Biomass of Kansas, up to USD 76 million** (corn stover, wheat straw, milo stubble, switchgrass, and other feedstocks)
- **ALICO, Inc. of LaBelle, Florida, up to USD 33 million (**yard, wood, and vegetative wastes and eventually energy cane)
- **BlueFire Ethanol, Inc. of Irvine, California, up to USD 40 million** (sorted green waste and wood waste from landfills)
- **Broin Companies of Sioux Falls, South Dakota, up to USD 80 million.** (corn fiber, cobs, and stalks)
- **Iogen Biorefinery Partners, LLC, of Arlington, Virginia, up to USD 80 million** (agricultural residues including wheat straw, barley straw, corn stover, switchgrass, and rice straw as feedstocks)
- **Range Fuels (formerly Kergy Inc.) of Broomfield, Colorado, up to USD 76 million (**wood residues and wood-based energy crops)

More information at: http://www.energy.gov/news/4827.htm

Pöyry biofuel activities

Current activities
Opportunities

Pöyry's strengths and current activities

- We are already actively working on first-generation biofuels projects both in the Energy and Forest Industry business groups.
  - We can combine Energy and Forest Industry know-how
  - We have the necessary competences for different technologies
  - We have chemical industry expertise
  - We have a global resource pool characterised by effective networking and collaboration
- Pöyry has a multidisciplinary biofuel team, which is actively involved in current pulp and paper industry biorefinery projects
- Pöyry's renewable energy specialists are engaged in ethanol and biodiesel plant projects in Europe and Asia
  - Project management and engineering services for SCBI's 125 000 lt/d integrated bioethanol plant in the Philippines
  - Contractor engineering for ELECNOR's 500 000 lt/d biodiesel plant in Spain
- Pöyry is developing ethanol plant projects in North America, four projects ongoing
- Pöyry's Chemical Industry business area is pursuing biofuel plant projects with several different process alternatives and raw materials such as vegetable and animal oils

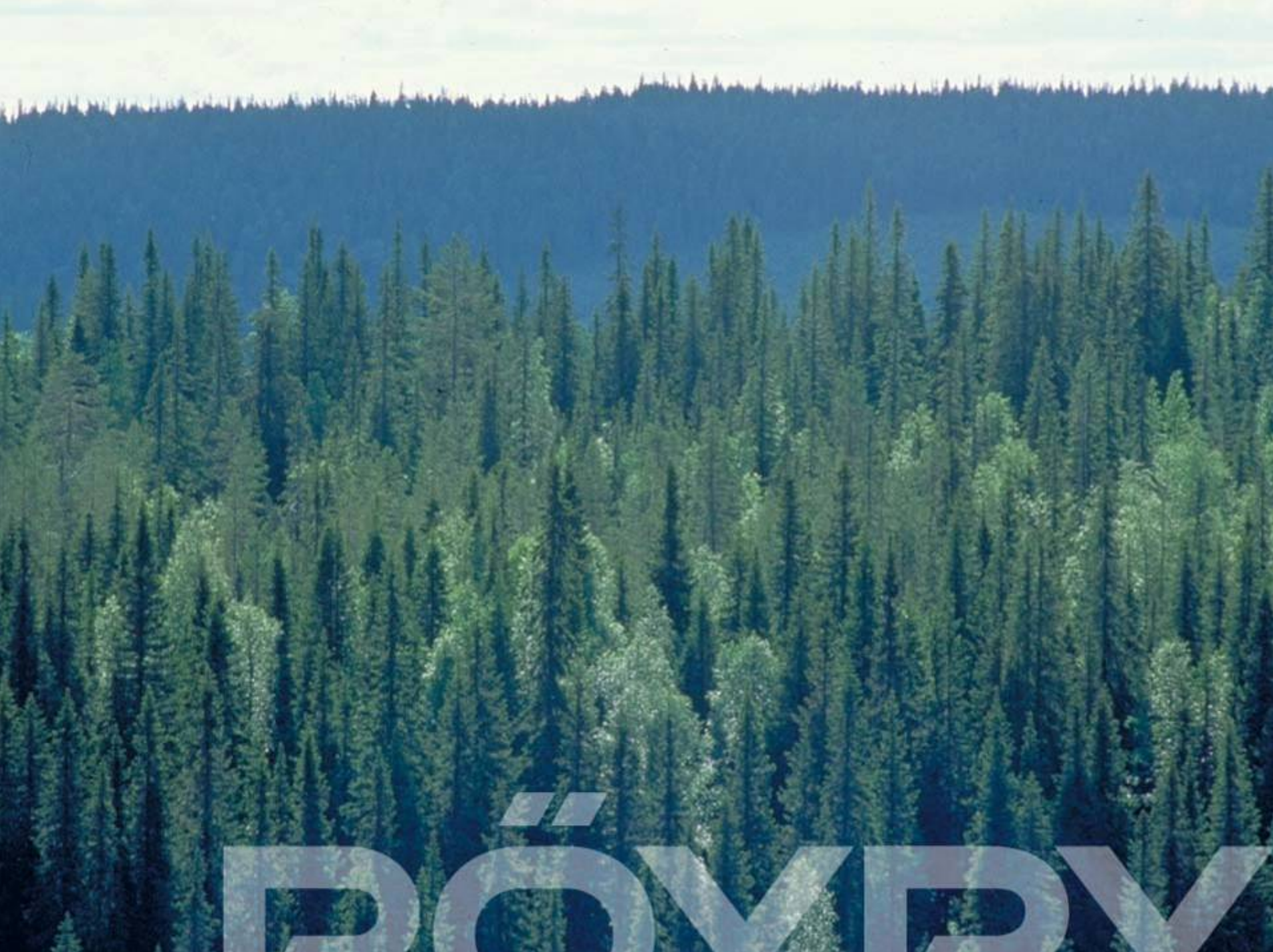
Service offerings

- Strategic evaluations
- Feasibility studies with technology partners
- Pre-engineering studies
- Biodiesel plant detail engineering (40-50 000 manhours)
- Ethanol plant detail engineering (25-35 000 manhours)
- Bioethanol project management and balance-of-plant engineering (150-200 000 manhours)
- Wood-based biodiesel pilot plant engineering
- EPCM services

- Net sales in 2007 estimated at EUR 25-30 million. We estimate the business to grow.

Summary

- The future of biofuels depends heavily on renewable energy policies which in turn depend on climate change and the price of oil
  - Biofuels are still more expensive than oil-based fuels (a strong driver, should oil prices continue to increase)
  - Regulations are the main driver, and they seem to be there for some time.
  - Wood-based biodiesel production could be an alternative, but technology still needs to be developed.
- Biofuels will be on the scene for at least 20 more years (US biofuels expectations targeting 2030 to complete).
- All businesses that use wood as their main raw material are of concern to pulp and paper companies, which is the main reason for their activity in this field.
- Development of agriculture waste and energy crops could reduce the pressure on wood-based feedstock for biofuels.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