Forest-Based Sector
Technology Platform

Developing the Strategic Research Agenda (SRA)

for the Forest-Based Sector Technology Platform (FTP)

Collected themes: Bioenergy

May 24, 2005

Theme 1 Biofuel production

Title: Biofuel production
Positioning:

- Customer: Expected response to future consumer needs.
- Energy: Expected impact on energy production and use (energy from forest biomass, energy efficiency etc).

Challenges and Opportunities:

- Helping society to mitigate climate change.
- Providing products and services that respond to changes in societal needs.
- Responding to new competition from other regions.
- Becoming a major producer of "green electricity", biofuels and other bio-energy products.

Description: Biofuel production aims to decrease the need of fossil fuels in transportaion sector and to provide innovative new area of economic growth to forest sector. Transportaion depends largely on use of fossil fules as source of motive power for trucks and automobiles. The dependancy of fossil fuels can be decreased by produing automotive fuels from forest sector raw materials. Using forests to make automotive fuels means larger areas of forests can be used to produce added value. There is no shortage of woods, but there is shortage of new products that can be made.

Research approach: Biofuel utilization in transportation is technically established. What is needed is launching trial schemes to make consumers aware of these productsa nd to make manufactirers of automotives to build such cars that can use biofules as partial mixtures with fossil fuels or as 100 % fuel

Theme 2 Less polluting firewood

Title: Less polluting firewood
Positioning:

- Customer: Expected response to future consumer needs.
- Environment: Expected impact on main environmental drivers (water consumption, wastes, emissions/effluents, climate, chain issues etc).

Challenges and Opportunities:

- Obtaining an economic and environmental balance in using forest biomass for products and energy, as well as substantially improving the industry's energy efficiency.
- Meeting the growing impact of large retailers.
- Responding to new competition from other regions.

Description: Traditional fireplaces that burn wood produce significant amounts of dust, carcnogenes, organic pollutants and soot, because they do not work optimally. Wooden logs can be thermally treated / saturated with organic chemcicals to make more environmentally friendly firewood.
Research approach: there is an established, but small field that studies domestic fireplaces. 1. Search what properties of firewood (dryness, volatiles, combustion temperature, ..) help to minimize pollutants 2. Establish clear guidelines on what emissions from fireplaces are most harmful and need to be reduced 3. Innovate new types of firewood and try them on fireplaces to see their effect on pollutants

Theme 3 Heat pump based heating for P&P processes

Title: Heat pump based heating for P&P processes
Positioning:

- Environment: Expected impact on main environmental drivers (water consumption, wastes, emissions/effluents, climate, chain issues etc).
- Energy: Expected impact on energy production and use (energy from forest biomass, energy efficiency etc).
- Competitiveness: Expected impact on the competitiveness of European industry/companies in global competition.

Challenges and Opportunities:

- Helping society to mitigate climate change.
- Securing the availability of renewable raw materials, while supporting the varied uses of forests and safeguarding biodiversity, through sustainable forest management.
- Obtaining an economic and environmental balance in using forest biomass for products and energy, as well as substantially improving the industry's energy efficiency.
- Achieving a significant decrease in capital intensity and increased production flexibility through process innovations.
- Becoming a major producer of "green electricity", biofuels and other bio-energy products.
- Taking advantage in process and product developments of alliances with other sectors and of exploiting emerging technologies.

Description: CO2 trading and green energy certificates has changed the energy economics in P&P mills. They produce their energy with the most valuable fuel without getting any benefit of it. For compensating the economy the production of bio waste should be maximised. One option is local generation of biopower instead of CHP. All the heat for P&P mill processes (mainly drying or distillation) can be produced by heat pumps which recover waste heat by condensing evaporated steam in exhaust flows. All the main heat consuming processes of mechanical and chemical forest industry are analysed. Such processes include timber drying, black liquor evaporation, pulp drying and paper drying etc. Their design bases are modified so that heat pump heating can be optimised. One criteria is to close the air loops for effective dehumidifying of process exhaust air. High COP values can be expected 6-30. As a result the net sales of biopower can be substantially increased and the economy of the mills can get more gain from the valuable biopower market.

Research approach: Heat pump technology is very far developed and immediately utilised. However the willwide utilisation of heat pumps is still very little studied. Profound exergy analysis (second law analysis) is needed because such first law methods as Pinch analysis used for energy savings are not feasible for power producing systems and thereby for minimising of the use fuel in the whole mixture energy systems.

Theme 4 Virtual bio-energy power station

Title: Virtual bio-energy power station
Positioning:

- Energy: Expected impact on energy production and use (energy from forest biomass, energy efficiency etc).
- Competitiveness: Expected impact on the competitiveness of European industry/companies in global competition.

Challenges and Opportunities:

- Providing products and services that respond to changes in societal needs.
- Increasing the availability of renewable resources, e.g. through afforestation, and extending their use in new and existing applications thus securing forest-based materials as the material of choice.
- Becoming a major producer of "green electricity", biofuels and other bio-energy products.

Description: Bio-energy has typically lower energy density than fossil fuels, which favour smaller scale power stations distributed close to the energy source. On the business point of view separate small power stations are not economical as such due to higher service, operation, maintenance etc. costs compared to large station. Further, on the power grid point of view a large number of separate small power stations is a challenge, especially when in CHP use. A single unit is too small to be operated directly by the grid authority, but large unit may not be enough for power adjustment if considerable part of power is produced in small units. These issues will be major obstacles for the increase of bio-energy, and more generally for most of the renewable energy resources, in power generation and, accordingly, in the technology development to utilise bio-energy. Virtual bio-energy power station is a concept, where a large number of small distributed bio-energy power stations are operated by a single operator. To the grid authority it looks like one large power station, what comes to power adjustment and related issues. On power generation point of view, major savings are expected in operation, maintenance, service, logistics etc. areas compared to small unit operated separately. Virtual bio-energy power station will provide a product, service and business concept for distributed small scale power station. It will improve employment in rural areas, speed up the technology development for distributed power generation based on bio-energy, decrease capital intensity, increase production flexibility, create a new business concept etc.

Research approach: Research should include the following approaches: - An analyses on the optimal density of bio-energy power stations related to the density of the energy source. This would be an optimisation problem including transportation costs, investment and production costs, efficiency, life cycle etc of the power station as a function of power generation capacity and of corresponding issues. - Automation, control and protection systems of the virtual power station and of separate units. - Business concept for the virtual power station - Strategy for efficient production as a whole, especially on the CHP point of view, where the heat production is in many cases a constraints. The research

needs competence of the whole bio-energy chain from collection of the bio-energy to transportation, utilisation of bio-energy, power generation, connection to the grid and from the power grind (even from the usage of electric energy in special cases like having a station in the area of a week grid).

Theme 5 Biomass-based IGCC plant for industrial CHP production

Title: Biomass-based IGCC plant for industrial CHP production
Positioning:

- Energy: Expected impact on energy production and use (energy from forest biomass, energy efficiency etc).
- Competitiveness: Expected impact on the competitiveness of European industry/companies in global competition.

Challenges and Opportunities:

- Helping society to mitigate climate change.
- Obtaining an economic and environmental balance in using forest biomass for products and energy, as well as substantially improving the industry's energy efficiency.
- Becoming a major producer of "green electricity", biofuels and other bio-energy products.

Description: In Finland, the co-combustion of biomass and REF in fluidised-bed boilers has been the most common method to produce both the heat and power in the same boiler. This has leaded a high overall efficiency in energy use. However, integrated pressurised gasification combined-cycle (IGCC) enables essentially higher power-to heat ratios of combined heat and power (CHP) production than conventional steam boiler and steam turbine cycles. The gasification approach to co-combustion has significant potential since it permits the use of biomass and REF in natu-ral gas-fired systems, boilers and combined cycle-installations. In Finland, the main focus has been to develop an IGCC-concept based an air gasification and subsequent hot gas cleaning suitable for medium-size CHP-plants (30-100 MW). Especially within the forest industry the main fuel supply would be based on woody biomass. Process integration of the required proc-ess units within the forest industry is expected to lead to considerable investment and produc-tion cost savings. Both the combined raw material and wood fuel supply, i.e., economy of joint supply and the integration benefits of common process will offer cost savings. To achieve the benefits of economy of scale in large-scale biomass supply there are needs to develop novel logistical supply systems

Research approach: In near future, a medium-size IGCC-plant will be invested also in Finland. Before this, there is need for a comprehensive feasibility study to optimise the whole IGCC-concept including also fuel supply. One of LUT's expertises in bioenergy research is the studies of biomass logistics and supply systems for large-scale use. For instance, IGCC-plant having capacity of 80 MW needs 0.6 TWh biomass. Most of the woody biomass will come from forest. Together with conventional supply systems also new supply methods are needed based on long-distance bio-mass supply chains using transportation modes such as trains and vessels. These transportation modes are also suitable for international biomass trade. One element of the feasibility study is to find suitable sites for IGCC-plants within forest industry in Finland. From the fuel supply point of view, the power plants location and the fuel supply problem can be approached through location modelling. The availability and cost of biomass fuels is strongly

dependent on location of plants. The regional differences in infrastructure and distribution of biomass re-sources in relation to the location of possible plant sites and also possibilities to import biomass from abroad will define the most promising sites to invest IGCC-plants in Finland

Theme 6 Advanced energy and biofuel production from pulp and paper mills

Title: Advanced energy and biofuel production from pulp and paper mills
Positioning:

- Environment: Expected impact on main environmental drivers (water consumption, wastes, emissions/effluents, climate, chain issues etc).
- Energy: Expected impact on energy production and use (energy from forest biomass, energy efficiency etc).

Challenges and Opportunities:

- Helping society to mitigate climate change.
- Obtaining an economic and environmental balance in using forest biomass for products and energy, as well as substantially improving the industry's energy efficiency.
- Developing new industrial activities based on "green chemicals" from wood.
- Becoming a major producer of "green electricity", biofuels and other bio-energy products.

Description: The task requires both research and demontration (funding)activity. The research includes: material reseach against corrosion, CFD modelling + new measuring technology for the feedback from the operating units (present technology for CFD), gas cleaning research, high temperature chemistry research and process chemistry development. The roles of the research institutes and the companies should be clear - and the target

Research approach: The task requires both research and demontration (funding)activity. The research includes: material reseach against corrosion, CFD modelling + new measuring technology for the feedback from the operating units (present technology for CFD), gas cleaning research, high temperature chemistry research and process chemistry development. The roles of the research institutes and the companies should be clear - and the target

Theme 7 Combustion or gasification of biofuels in Fluidised Bed

Title: Combustion or gasification of biofuels in Fluidised Bed
Positioning:

- Environment: Expected impact on main environmental drivers (water consumption, wastes, emissions/effluents, climate, chain issues etc).
- Energy: Expected impact on energy production and use (energy from forest biomass, energy efficiency etc).

Challenges and Opportunities:

- Helping society to mitigate climate change.
- Obtaining an economic and environmental balance in using forest biomass for products and energy, as well as substantially improving the industry's energy efficiency.
- Achieving a significant decrease in capital intensity and increased production flexibility through process innovations.
- Increasing the availability of renewable resources, e.g. through afforestation, and extending their use in new and existing applications thus securing forest-based materials as the material of choice.
- Becoming a major producer of "green electricity", biofuels and other bio-energy products.
- Taking advantage in process and product developments of alliances with other sectors and of exploiting emerging technologies.

Description: Fluidised Bed Combustion of Biofuels Fluidised Bed Gasification of Biofuels Co-combustion of different fuels (biofuels & coals& biofuel mixtures) Emissions (NOx, fine particles) Bed Hydrodynamics, mixing, bubbles, experiments and CFD. Combustion of wastes, sludges and waste derived fuels. Oxygen -enchanced combustion (sludges & CO2-separation) Also pressurised combustion and gasification
Research approach: Development of more advanced design tools (e.g. CFD+optimisation) Better understanding of process by using CFD-modeling and further validitation of CFD-models based on measurements, Small scale experiments in laboratory and Large scale experiments.

Theme 8 Chemical Issues in Forest Biorefineries

Title: Chemical Issues in Forest Biorefineries
Positioning:

- Environment: Expected impact on main environmental drivers (water consumption, wastes, emissions/effluents, climate, chain issues etc).
- Energy: Expected impact on energy production and use (energy from forest biomass, energy efficiency etc).

Challenges and Opportunities:

- Developing and designing products that can be recycled, reused and finally converted to bio-energy.
- Attracting young talent to the sector.
- Becoming a major producer of "green electricity", biofuels and other bio-energy products.

Description: Future Forest Biorefinery Concepts have to handle the many inpurities or trace substances (trace metals etc) in the wood raw material - and other raw materials - one way or another. In many process suggestions the control of these impurities substancies may be crucial to the realization of the concept. Fouling, unwanted sidereactions, unwanted catalytic effects, corrosion, unwanted emissions etc. may be the bottleneck or even "killing" to the whole concept. I suggest a research program around the fate, role and control of foreign elements in biorefineries. The research program would be mostly of generic nature, naturally with clear connections to concepts or processes being planned. It would be wise to launch research activities in these aspects already now, and not at the stage when the concepts are locked and large scale demonstrations are underway. A lot of useful studies on the fate of metals, trace metals, sulfur, chlorine, potassium etc. in various biorefinery concepts can be done by laboratory work and advanced chemical and process modelling.

Research approach: Life cycle studies of foreign elements in forest refineries and their products. Partly laboratory work, partly experimental data collection based on sampling and analysis in existing unit processes, partly advanced chemical and process modelling. Exfcellent competence in Finland in several groups, including ÅA Process chemoistry Centre.

Theme 9 Supply chain for scattered biofuel resources

Title: Supply chain for scattered biofuel resources
Positioning:

- Society: Expected impact on prioritized social and general economic goals of the EU (employment in rural areas, development of SMEs, etc).
- Environment: Expected impact on main environmental drivers (water consumption, wastes, emissions/effluents, climate, chain issues etc).
- Energy: Expected impact on energy production and use (energy from forest biomass, energy efficiency etc).
- Competitiveness: Expected impact on the competitiveness of European industry/companies in global competition.

Challenges and Opportunities:

- Helping society to mitigate climate change.
- Securing the availability of renewable raw materials, while supporting the varied uses of forests and safeguarding biodiversity, through sustainable forest management.
- Obtaining an economic and environmental balance in using forest biomass for products and energy, as well as substantially improving the industry's energy efficiency.
- Providing products and services that respond to changes in societal needs.
- Developing and designing products that can be recycled, reused and finally converted to bio-energy.
- Balancing forests as a resource for renewable raw material with other important functions such as offering recreation and safeguarding biodiversity.
- Increasing the availability of renewable resources, e.g. through afforestation, and extending their use in new and existing applications thus securing forest-based materials as the material of choice.
- Developing new industrial activities based on "green chemicals" from wood.
- Becoming a major producer of "green electricity", biofuels and other bio-energy products.

Description: It is very important to collect maximally local yield of biomass feasible to energy production. One option is to develop a nationwide public service similar to waste management for biomass sector also. Public biofuel collection service can help collecting marginal biofuel batches which have not direct link to other businesses as wood harvesting e.g. composts, cuttings, agricultural residuals, occasional forest residuals. Biomass can be collected, pretreated, mixed, stored and sold into regulated biofuel market.

Research approach: The whole supply chain from biomass growing to the combustion or conversation process should be analysed. Following disciplines sould be scoped: 1.Combutions designing 2.Fuel related chemistry (corrosion, slagging, sintering, emissions) 3.Handling hazards (explosions, fires) 4.Logistigs (waste management, timber transportation) 5.Harvesting 6.Pretreatment (drying, crushing)

Theme 10 Connection of distributed bio-energy power station to an electricity distribution network

Title: Connection of distributed bio-energy power station to an electricity distribution network
Positioning:

- Energy: Expected impact on energy production and use (energy from forest biomass, energy efficiency etc).
- Competitiveness: Expected impact on the competitiveness of European industry/companies in global competition.

Challenges and Opportunities:

- Providing products and services that respond to changes in societal needs.
- Increasing the availability of renewable resources, e.g. through afforestation, and extending their use in new and existing applications thus securing forest-based materials as the material of choice.
- Becoming a major producer of "green electricity", biofuels and other bio-energy products.

Description: Bio-energy has typically lower energy density than fossil fuels, which favour smaller scale power stations distributed close to the energy source. On the power distribution company point of view separate small power stations are a challenge and a problem. Regulation is typically made for large power unit and the same goes with automation, control, protection etc. A single unit is too small to be operated as a large unit like nowadays. Present standards and regulations applied by the distribution companies are major obstacles in most countries for the connection of small scale bio-energy power stations to the grid. The major problem is that electricity distribution companies have typically their own standards, regulation and procedures for the connection to the grid. On the power generation company point of view this is a major obstacle, because they have to follow different procedure and rules with each distribution company. To overcome these obstacles for the development and increase of bio-energy based power generation, the standards, regulations and procedures for the connection to the grid must be harmonised a far as possible. Common rules should apply at least on national level, but, most importantly, on EU level. Creating common rules and procedures for connecting small scale power generation to the electric grid will enable bio-energy based power generation concepts to be used, first, in the EU are and gradually globally. It will improve employment in rural areas, speed up the technology development for distributed power generation based on bio-energy, increase production flexibility, create a new business concept etc.

Research approach: Research should include the following items: - An analyses of the present standards, regulations and procedures for the connection to the grid applied on national level and on the EU level. - An analyses of the protection, control and automation needed for connecting small scale bio-energy power generation to the grid both on national level and on the EU level. - A technology feasibility study for fulfilling the needs for automation, control and protection systems for small bio-energy power

units. - Creation of recommendations for the standards, regulations and procedures for the connection to the grid, which take into account the needs related to automation, control and protection of both the grid and the bio-energy power unit. The research needs competence related to utilisation of bio-energy in general and especially to power generation, connection to the grid and of the power grid. The research could start on a national level as a pilot followed by an overall EU level project based on the results from the pilot phase. However, a better approach might be to have selected countries to work in a coordinated project both on national level and on the EU level at the same time.

Theme 11 Biofuel-based advanced steam cycles

Title: Biofuel-based advanced steam cycles
Positioning:

- Energy: Expected impact on energy production and use (energy from forest biomass, energy efficiency etc).
- Competitiveness: Expected impact on the competitiveness of European industry/companies in global competition.

Challenges and Opportunities:

- Helping society to mitigate climate change.
- Obtaining an economic and environmental balance in using forest biomass for products and energy, as well as substantially improving the industry's energy efficiency.
- Becoming a major producer of "green electricity", biofuels and other bio-energy products.

Description: Efficiency of bio-based production of electricity has potential to be improved when utilising steam cycles. Production is rather inefficient when compared to power production by conventional solid fuels, such as coal. Efficiency is mainly limited by moderate steam pressures and temperatures which are needed in order to avoid corrosion and fouling related to higher steam values. In integrated plants of forest sector there exists a potential to raise the overall efficiency of bio-based electricity. This can be targeted by developing concepts to raise the properties of lower quality steam utilising biofuel energy. This may be obtained by developing methods to provide corrosion free environment for final superheaters of steam cycle. A target for steam values can be set according to the visions set for advanced coal fired power plants. In this field there exists a wide competence base in Finland. This research theme will support utilisation of forest based materials and address challenges relating to climate change. Supports a vision towards bio-based European economy by increasing production of green electricity.
Research approach: Typical steam production units of forest sector are biofuel and recovery boilers. Direct contact of flue gases and heat exchanger surfaces limits maximum steam temperatures due to corrosive and fouling components in combustion gas. Research activities are needed to study the concepts to tranfer heat from combustion to steam especially through indirect methods. In fluidised bed boilers separate fluid bed heat exchangers have been utilised to reduce risks of corrosion and to increase steam temperatures allowed. Such concepts can be developed further by modelling and testing of behaviour of process phenomena both in laboratory and in industrial scale. Material flow, heat transfer and requirements for corrosion free heat transfer environment need especially be studied. Furthermore, supercritical steam cycle and possible coupling of process components such as recovery and biofuel boiler will require process analyses and simulation of integrated processes. LUT has expertise in modelling of fluid bed processes supported by experimental fluid bed test facilities. In addition, LUT has also available industrial expertise which has lead into numerous patents of fluid bed heat exchangers. Research activity will be enhanced by a cooperation between research organisations and

industry. Finland has a strong competence of manufacturers and research organisations in the field.

Theme 12 Development of the pulp mills towards low energy consumption

Title: Development of the pulp mills towards low energy consumption
Positioning:

- Environment: Expected impact on main environmental drivers (water consumption, wastes, emissions/effluents, climate, chain issues etc).
- Energy: Expected impact on energy production and use (energy from forest biomass, energy efficiency etc).

Challenges and Opportunities:

- Helping society to mitigate climate change.
- Obtaining an economic and environmental balance in using forest biomass for products and energy, as well as substantially improving the industry's energy efficiency.
- Becoming a major producer of "green electricity", biofuels and other bio-energy products.

Description: The energy consumption of pulp mills can be clearly decreased by innovative process solutions. This gives space for higher energy and biofuels production, and reduces greenhouse gas emissions
Research approach: The mill process has to be rethougt according to continuing process idea, utilizing the exergy principle. Here the focus is in the industrial development work and in demonstration. The required time for the full penetration is long

Theme 13 Combustion and Gasification Submodels for Biofuels and Waste Materials

Title: Combustion and Gasification Submodels for Biofuels and Waste Materials
Positioning:

- Environment: Expected impact on main environmental drivers (water consumption, wastes, emissions/effluents, climate, chain issues etc).
- Energy: Expected impact on energy production and use (energy from forest biomass, energy efficiency etc).

Challenges and Opportunities:

- Helping society to mitigate climate change.
- Obtaining an economic and environmental balance in using forest biomass for products and energy, as well as substantially improving the industry's energy efficiency.
- Balancing forests as a resource for renewable raw material with other important functions such as offering recreation and safeguarding biodiversity.
- Increasing the availability of renewable resources, e.g. through afforestation, and extending their use in new and existing applications thus securing forest-based materials as the material of choice.
- Substituting non-renewable materials through innovative solutions from forest-based materials.

Description: Description: Kinetic studies on reactivity of solid fuel particles give a very fundamental background for detailed understanding of the conversion phenomena in all kinds of combustion applications. The studies provide information on overall particle (i) gasification, (ii) devolatilization and (iii) combustion rates that are controlled either by (1) the chemical reactions that take place on the carbonaceous surfaces of the particle or by (2) the combined effects of intrinsic reactivity and pore diffusion limitations. The information gained will be applicable in combustion applications governing pulverized fuel combustion, fluidized bed combustion and fixed bed combustion. The pre-heating of materials in fixed bed combustion is possible to imitate in the measurement equipment. Particular interest will be put on the phenomena at elevated pressures (ptot > 1 atm) and at elevated oxygen concentrations (yO2 > 21 vol-%) of the combustion gas. Also, kinetics of the origin of harmful emissions, including NOx, SOx, etc., will be investigated. The Phyllis database on the composition of biomass and waste (http://www.ecn.nl/phyllis/info.asp) will be extended by the knowledge of kinetics of each biofuel and waste material studied. In conclusion, the research theme would enable construction of more accurate overall models for design of burners, furnaces and boilers after implementation of the validated submodels into the CFD-codes.

Research approach: Research approach: The employed research tools will comprise a laminar drop tube furnace, an entrained laminar flow reactor and different kinds of fluidized bed reactors in which the parent materials are exposed to conditions relevant to commercial combustion applications (furnaces and boilers). Devolatilization, gasification and combustion reactivities are experimentally determined in the above-mentioned equipment both in a pressurized thermogravimetric analyzer (PTGA). The measured results are interpreted based on programs constructed in previous research projects.

Further, the kinetic models that are constantly updated according to the latest knowledge are compared with experimental results. A good adjustment of the data with the calculated results validates the tested model. The final goal of the research theme is to obtain the information needed to understand how the reactivities (in i-iii) of the materials are related to parent material properties. Special competence in the research theme is needed particularly in the measurements both in the modelling of the kinetics.

Theme 14 Thermal conversion of biomass

Title: Thermal conversion of biomass
Positioning:

- Environment: Expected impact on main environmental drivers (water consumption, wastes, emissions/effluents, climate, chain issues etc).
- Energy: Expected impact on energy production and use (energy from forest biomass, energy efficiency etc).
- Competitiveness: Expected impact on the competitiveness of European industry/companies in global competition.

Challenges and Opportunities:

- Helping society to mitigate climate change.
- Securing the availability of renewable raw materials, while supporting the varied uses of forests and safeguarding biodiversity, through sustainable forest management.
- Obtaining an economic and environmental balance in using forest biomass for products and energy, as well as substantially improving the industry's energy efficiency.
- Achieving a signifi cant decrease in capital intensity and increased production flexibility through process innovations.
- Balancing forests as a resource for renewable raw material with other important functions such as offering recreation and safeguarding biodiversity.
- Increasing the availability of renewable resources, e.g. through afforestation, and extending their use in new and existing applications thus securing forest-based materials as the material of choice.
- Becoming a major producer of "green electricity", biofuels and other bio-energy products.

Description: The analogy between wood and raw mineral oil can be seen in many respects. In sustainable future more and mineral oil as the raw material for chemical industry can be minimised by using wood instead. The material flows through forest industry include many potential ways for utilising some of it as raw material for refining it to eliminate mineral oil based products. Most of wood is volutile as raw oil and most of woods inpurities lie in bottom char similarly to bottom oil in oil refineries. So thermal batch type distillation, or pyrolysation of wood based materials have obvious potentials for technology development.

Research approach: Besides of gasification (developed for black liquor in Sweden) there are several other conversion possibilities for utilising wood as raw material. Thermal treatment is a common separation process in chemical industry, mainly in oil refining. So a mixture of talents from wood conversion research institutes and oil refining institutes are needed in this research. Several technologies can be feasible technically but not economically. so millwide evaluations are important already in early stages of the research projects.

Theme 15 Integration of pulp and paper mills with the societies

Title: Integration of pulp and paper mills with the societies
Positioning:

- Environment: Expected impact on main environmental drivers (water consumption, wastes, emissions/effluents, climate, chain issues etc).
- Energy: Expected impact on energy production and use (energy from forest biomass, energy efficiency etc).

Challenges and Opportunities:

- Helping society to mitigate climate change.
- Becoming a major producer of “green electricity”, biofuels and other bio-energy products.

Description: The low temperature "waste" energy from mills will be used in low temperature needs of the societes, as floor heating etc
Research approach: Find the potential integrations, the costs, are there new solutions for the energy transfer

Theme 16 Black liquour combustion in recovery boilers

Title: Black liquour combustion in recovery boilers
Positioning:

- Environment: Expected impact on main environmental drivers (water consumption, wastes, emissions/effluents, climate, chain issues etc).
- Energy: Expected impact on energy production and use (energy from forest biomass, energy efficiency etc).

Challenges and Opportunities:

- Helping society to mitigate climate change.
- Obtaining an economic and environmental balance in using forest biomass for products and energy, as well as substantially improving the industry's energy efficiency.
- Achieving a signifi cant decrease in capital intensity and increased production flexibility through process innovations.
- Developing new industrial activities based on "green chemicals" from wood.
- Becoming a major producer of "green electricity", biofuels and other bio-energy products.

Description: To understand the process better (CFD-modelling and experiments)Development of more advanced design tools (e.g. CFD + optimization) Emissions (NOx, chemicals, CO, deposition formation, fine particles) Materials in boiler Higher electric efficiency of process, higher steam pressure and temperature
Research approach: CFD-modelling Experiments in laboratory and in large scale. - Better understanding of the process by using CFD-modeling, and further validation of CFD-models based on measurements