

CENTRAL FINLAND

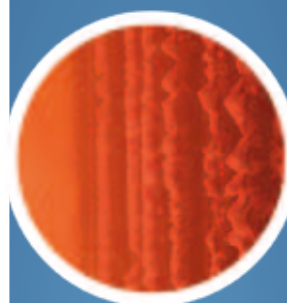
Research Agenda 2020 for sustainable use of biomass



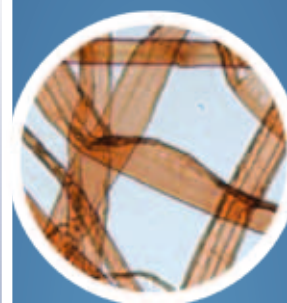
Biomass
production,
handling &
processing



Biomass
logistics and
storage



Biomass
combustion
technologies



Fibre processes
and biomass
refinery



From research to products and services

INTRODUCTION

This document is the *strategic research agenda* (SRA) of Central Finland. It aims at orientating and strengthening research activities and capacity building in select research fields related to sustainable use of biomass. The agenda supports expertise development and cooperation in the regional research-driven cluster and BIOCLUS consortium. It helps the research-driven cluster to choose the focus of research activities and supports the authorities in directing human and financial resource use. In addition, it provides input to the regional joint action plan.

The SRA was established by the regional research and development organisations in cooperation with the regional authorities and companies. There were several analyses performed to yield background information, which was then supplemented with comments obtained from interviews with figures from the industrial sector. The analyses are available on the BIOCLUS website (www.bioclus.eu).

SRA introduced to the fields of knowledge that Central Finland has strategic research competence, and has indicated the fields which research-driven cluster would like to further develop. Moreover, some areas of expertise have been acknowledged to have strategic importance at the regional level. The strategic research areas of the Central Finland BIOCLUS cluster are:

- Biomass production, handling and processing
- Biomass logistics and storage
- Biomass combustion technologies
- Fibre processes and biomass refinery
- Sustainability assessment
- From research to products and services

This document focuses attention on the special characteristics and strengths of the regional research-driven cluster of Central Finland. It promotes sustainable use of biomass resources in economic, social, cultural and environmental terms and supports regional competence and well-being.



Region of Central Finland

The area of Central Finland has a population of 270,000 it covers nearly 20,000 km²; lakes comprise nearly 3,000 km². The most remarkable biomass resources are forests, in total almost 1.4 million hectares (14,000 km²). The strongest branches of economic activity are pulp and paper, wood products, forestry and production of machineries and equipment. The regional machinery and equipment manufacturing, along with the basic metal industry, are closely connected to the forest industry. Central Finland is also a region of learning and expertise with highly popular educational institutes.

Central Finland is recognized as the Bioenergy Region in Finland. Not only is utilisation of bioenergy at an exceptionally high level in Central Finland, but R&D and the training sector in bioenergy represent the top in Finland. Today, half of the total energy consumption is covered by local biomass (including traffic). Biomass resources constitute 80% of the fuels used in heat and electricity production. A large variety of conversion technologies are used with success. The regional aim of Central Finland is to be fossil fuel free – excluding use in transportation – by 2020.



Photo: Jyväskylän Energia Ltd

Photo: UPM

Photo: Jyväskylän Energia Ltd

Photo: Honkarakenne Ltd

Biomass resources in Central Finland

The annual use of wood in Central Finland is about 6 million solid m³. That is less than the annual growth and more than the annual harvest in Central Finland. The wood is typically processed into paper and timber products, or converted into bioenergy or refined products. The forest industry produces by-products and residues that are considered to be valuable materials for other internal and external processes.

The region supplies more than 6 TWh (21.6 PJ) energy out of wood-based materials, such as forest chips, black liquor and saw dust. The energy is primarily used in large-scale heat and power generation, in industrial processes and in district heating.

Peat is also an important biomass resource for Central Finland. It is used mainly as a source of energy. Peat enables co-firing of alkali rich biomass fuels like logging residue chips and herbaceous biomass fuels. Peat prevents slagging, fouling and hot corrosion in steam boilers. It also promotes the security of the domestic fuel supply. The annual peat production in Central Finland is 2 million loose m³ (1,8 TWh, 6,5 PJ) and it covers about ¼ of the regional peat consumption.

Central Finland has proper climate conditions for herbaceous feed and crops production. Arable land in the region measures around 1,000 km² and peatlands total nearly 0.34 million hectares (3,400 km²). The field origin biomass are mostly used for food and feed production, but also for energy production.

Biomass use in Central Finland in 2008

Biomass source	Dry matter (million tonnes)
Wood	1.9
Agrobiomass	0.2
Peat	0.3

Research-driven cluster of Central Finland

The future aim of the research-driven cluster of Central Finland is to strengthen regional development, promote competitiveness and ensure sustainability. Therefore the cluster has provided a strategic research agenda for 2020. In this paper the regional joint vision and mission are introduced, and strategic research areas have been recognised as well.

Vision 2020

Central Finland is an internationally recognised region of knowledge in sustainable use, research and development of biomass, especially in the fields of bioenergy and forest industry supply chains, enhancing new biomass-based business.

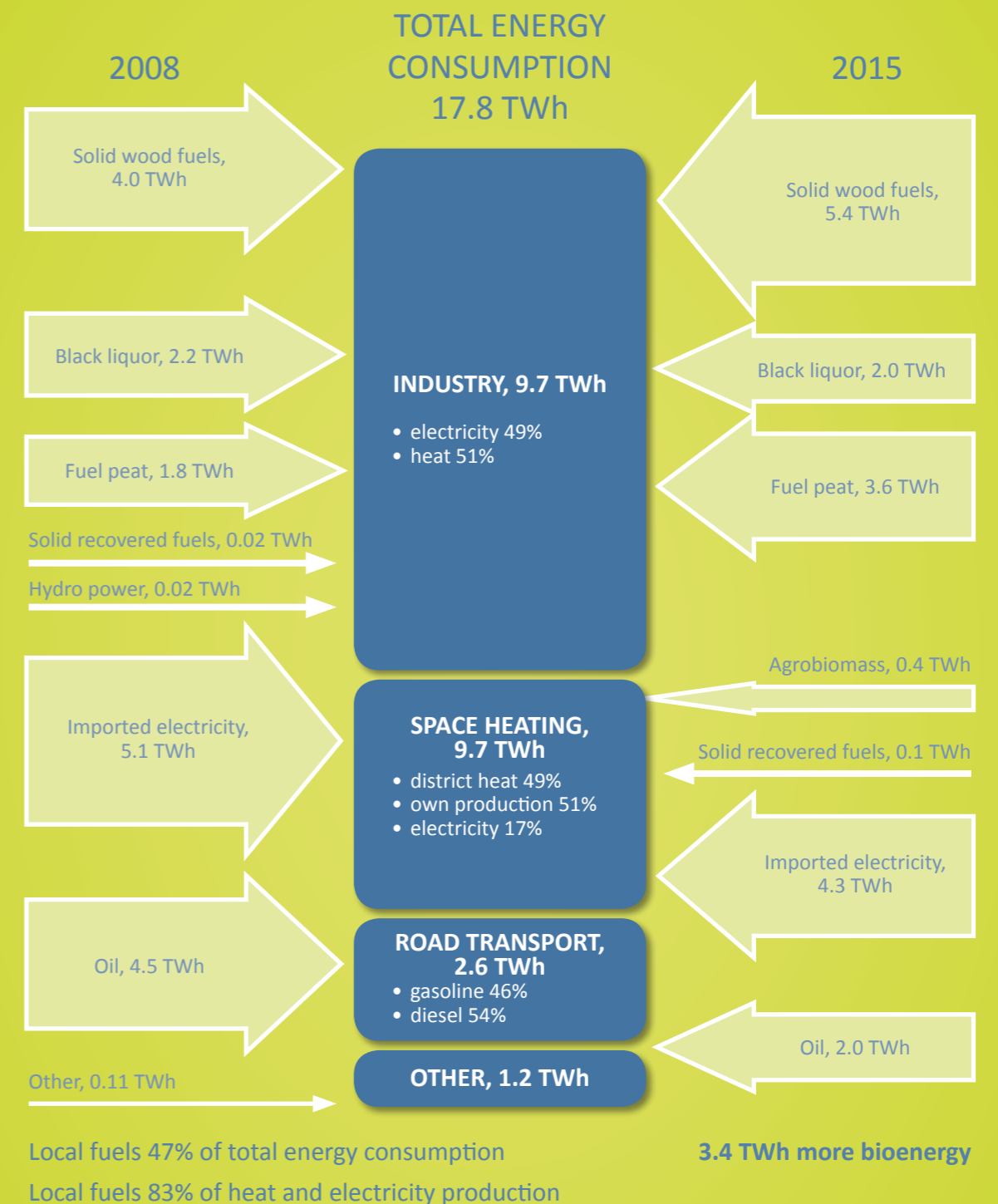
The research-driven cluster supports

- Development of innovative use of biomass
- Development of regional biomass market
- Export of expertise and technology

Mission 2020

Central Finland research-driven biomass cluster will supply qualified research, development and testing services for companies, research organisations and public entities. The services are provided in the fields of sustainable biomass supply chains, bioenergy and forest industries.

Use of energy in Central Finland in 2008 and target for 2015



STRATEGIC RESEARCH AREAS

Biomass production, handling and processing technologies

Most of the locally utilised biomass originates from woody sources and is used in mechanical and chemical wood processing and in energy production. Research focuses on supply chains of the raw materials for the forest and energy industries. Agrobiomasses are mainly used for feed and food production, and to some extent for energy. Furthermore, there is also a wide range of other biomasses available that are considered residues from industrial and agricultural processes.

Biomass production, handling and processing machineries have to be adjusted in variable weather conditions year-around. The biomass machinery development in Central Finland has mostly concentrated on wood harvesting technologies, such as grapples and harvesting heads for timber, and for small-diameter wood, chipping and crushing machinery. The region features a globally operating company that produces tractors and a wide selection of accessories, as well as multi-operational national companies producing and developing solid and liquid biofuel products.

Lately biomass upgrading has become more and more important. Processes such as drying, pelletizing and biomass torrefication, in addition to the production of liquid and gaseous fuels, add to the end-product value. However, overall economics, energy efficiency and the sustainability of upgraded supply chains have to be further assessed. Moreover, there are plans for large-scale production of upgraded products. This requires secure large-scale supply chains, which rises new challenges.

A large variety of available biomass has unfavourable characters such as e.g. high moisture, ash or nutrient content or a heterogeneous structure. The anaerobic digestion, biogas production and nutrient recirculation of biodegradable residues have been a focus of research and development in the region during the last ten years. Agrobiomass cultivation supplies a higher annual production rate per land area than forest biomass. Therefore, energy crops have been recognised as having the potential to increase biomass production. Energy supply chains for combusting agrobiomass still have some challenges to overcome. Anaerobic digestion and biogas production offer alternative, decentralised supply chains and efficient nutrient recirculation pathways.



Photo: VTT

Biomass production, handling and processing technologies

Expertise by 2020

Sustainable and cost-effective harvesting and handling technologies for woody and herbaceous biomass supply chains

Development needs

Procurement technology for large-scale use of wood: cost efficiency, sustainability, chain reliability

- Cuttings of small-diameter wood and delimiting: cost efficiency, sustainability
- Stump handling: reduction of impurity content, pre-treatment & transportation

Cultivation practices for fodder, energy and fibre products; energy efficiency, sustainability

- Short rotation coppice for energy: technology and practice development

Quality management of biomass fuels

Understanding quality-related issues in different management stages

Upgrading technologies and processes

Technologies, economy and sustainability of upgrading biomasses

- Densifying technology; pelletizing, torrefication
- Understanding of upgraded product sustainability

- torrefication
- pelletizing

Cost-efficient technologies for production of biogas and upgrading of biogas and digestate to value-added end products

Biogas-related processes and technologies

- Digestate processing for fertilizer and soil-improving media: improving the nutrient cycle and preventing water nutrient load
- Developing sustainable crop cultivation for biogas production
- Developing the use of biogas and landfill gas as vehicle fuel

Biomass logistics and storage

Due to numerous biomass-based industries and a large regional biomass-based energy supply, the volume of biomass market in Central Finland is remarkable. The biomass logistics is based on road and railway transportation. Recently, the storage issues have become more important. Biomass is biogenic material and as such, is difficult to store due to its bacterial activity and decomposition. Therefore, there is a risk of material and energy losses, accidental fires and emissions (toxic and greenhouse gases), in addition to a decrease in quality.

Improving security of the biomass supply during transportation and storage will demand improvement of storage management and technology. The issue hasn't been truly recognised yet partly because the storage e.g. for wood chips is still rather modest. Regarding the pellets, the temperatures and carbon monoxide (CO) content of the transporting ships are being strictly monitored. The growing use of biomasses in energy production is a challenge. The supply chains are in many cases "hot chains", and they must be ensured in any weather circumstances year-round. This demands new technologies and practices in overall logistics, as well as more sophisticated management and control systems.

In the future, there will be a need to add existing information to potential technologies and practices. It requires analyses and comparisons of different supply systems in social, environmental and economic terms. It requires overall understanding of transportation, forestry, land-use, ITC and environment-related issues. For example, the benefits and disadvantages of biomass terminals have to be studied and compared with optional solutions. The results of R&D&I work have yet to be demonstrated and put into practise. This way the best available planning know-how, control systems, technologies and practices can improve the economics and sustainability of logistic chains.



Photo: LHM Hakkuri Ltd



Photo: JAMK



Photo: JAMK



JAMK has well-equipped logistics research environment. Photo: JAMK

Biomass logistics and storage

Expertise by 2020

Reliable, efficient biomass supply chains for processing large-scale industries and energy supply; consideration of sustainability

- Ability to provide logistical expertise for other biomass intensive regions (other biomasses, other climates, etc.)

Effective and environmentally friendly storing; monitoring and solutions

Development needs

To create new operational models and technologies for modern, efficient and qualified supply chains (transportation, storage & management and control)

- To improve understanding of the relation between biomass production and logistics and land use
- To increase cooperation with experts of various fields of knowledge (transportation, forestry, land use, ITC, environment, etc.)

To gain overall understanding of sustainability issues in logistics

To gain understanding of physical and chemical phenomena during the storage process (quality, composition)

- To develop storage management technology
- To develop production technology for storage of biogenic material, e.g. to fulfil the same parameters as fossil coal

Biomass combustion technologies

Large-scale combustion

Central Finland is highly respected throughout Europe for the research area of biomass combustion technologies including co-firing. Particularly, research related to fluidised bed combustion and grate firing technology includes high-class, unique research facilities for bench and pilot scale combustion. It has led to several industrial applications and new innovations, which are also commercially exploited.

Lately, research has been concentrated on the fluidised bed technologies of biomass combustion and biomass and fossil fuel co-firing. For example, the excellent understanding of high temperature ash chemistry has generated new commercial innovations that increase conversion efficiency from waste to energy. Technologies to reduce emissions from



VTT has high-class, unique, fluidised bed firing and grate firing research facilities in Jyväskylä. Photos: VTT

fossil fuel combustion have also been developed; VTT, for instance, was the first in the world to perform successful oxy-fuel firing experiments and still continues research in that area. The technology is in commercial use in

combined heat and power production in Finland and other countries. The oxy-fuel combustion enables carbon capture and storage (CCS).

The strengths of large-scale combustion research in Central Finland are unique experimental units, understanding of the whole biomass supply chain and capability to combine experimental and theoretical knowledge into combustion process models. The future research focus is to offer research service for wider fuel selection and for poorer fuel quality, e.g. with challenging biomass fuels and wastes. The aim is to improve the efficiency and reduce emissions of heat and power generation in multi-fuel operations.

Small-scale combustion

During the past years small-scale combustion research has concentrated especially on reducing fine particle emissions and improving efficiency of appliances. The extensive testing and research experience of VTT has benefitted in particular stove manufactures to meet strict international emission limits. At the moment VTT offers EN 303-5 up to 300 kW. Nowadays also Bioenergy Development Centre (BDC) of JAMK University of Applied Sciences provides development services for biomass system suppliers and user. The services can be adapted for biomass systems from 3 kW up to 3 MW. In the future BDC also offers boiler testing according to EN 303-5 up to 500 kW. Additionally, BDC of Central Finland will focus on the characterization of solid biofuels.



BDC has capability to develop and test systems up to 3 MW. Photo: JAMK

Biomass combustion technologies

Expertise by 2020

- Power plant technology & operation (CFB)
 - Maximizing electricity output and overall efficiency (up to 600 – 800 MW)
 - Controlling ash behaviour during combustion (e.g. chemical addition)
 - Monitoring and calculation methods to optimise multi-fuel operations at CHP plants
- Reduce all emissions
 - Zero-emission power generation technology based on oxy-fuel and chemical looping firing
 - Unique fluidised bed firing and oxy-fuel research facilities
- Researching, testing, developing and training services environments (max 1 MW) biomass-fuelled energy systems
 - Testing according to the most applied standards (solid biomass boilers, sauna stoves and heat-retaining stoves)
 - Biomass-based fuel classification and quality management
 - Process management and control (e.g. emissions, efficiency)
- Recover and recycling of nutrients
 - Ash handling, densifying, logistics, storage, management

Development needs

- To improve CFB technology and practices
 - To develop solutions to avoid corrosion and deposit formation, especially in fluidised bed firing (with low-quality agrobiomass fuels)
 - To reduce CO2 emissions by oxy-fuel and chemical looping firing (with fossil fuels)
- To gain understanding of and experience with the oxy-fuel process
- To develop new technologies and practices in small-scale firing process fuelled wood chips and other biomass based fuels
 - To get accreditation to test small-scale biomass-based systems up to 500 kW according to the standards (e.g. EN 303-5)
 - To develop and support the use of biomass-based fuel classification and quality management
 - To follow up on the standardisation processes
 - To support the use of standards in business
- To gain understanding of ash recovery and recycling management; recycle nutrients from biomass in the form of ash

Ash recycling

The increase of biomass utilisation in energy production also increases the need for developing new ash recycling concepts. It supports more efficient nutrient recirculation and decreases the amount of waste fractions. The ash properties depend on a variety of parameters such as the origin of biomass, cofiring of fuels with different properties, energy conversion technology and process implementation, possible new

additives used (e.g. for inhibiting corrosion) and the chosen flue gas cleaning concepts. One of the biggest issues for R&D in this field might be contamination of unwanted components such as heavy metals in some ash fractions. The future focus is on converting the majority of biomass origin ash to a recyclable, value-added product that can be easily stored, handled and spread, and provide nutrient supplement without unacceptable environmental impacts.

Fibre processes and biorefinery

The Jyväskylä region is known for its papermaking competence and there are many large forest industry companies. Research and development in this field is concentrated in VTT and University of Jyväskylä, which both are home to a wide range of laboratory and pilot-scale experimental facilities to support development. International cooperation is fostered through many research networks, which are primarily supported by regionally operating companies. Research is carried out in cooperation with global pulp-and-paper, paper machine and device manufacturing and chemical companies, together with a large research partner network.

VTT has the strong know-how for improving the energy, water and raw material efficiency of fibre processes and the development of fibre-based products, and efforts will continue in this area. Along with the more traditional papermaking industry,



VTT has unique pilot-scale facilities for papermaking products. Photo: VTT

University of Jyväskylä and VTT are actively taking part in biorefinery research, which focuses on the more efficient utilisation of different biomass components in producing a versatile range of products. Research is largely integrated to the pulp and paper industry and thus to wood-based raw material. In the future, peat and other biomass resources will also be studied more closely.

The existing and future products of woody biomass

The green boxes indicate the focus areas in Central Finland

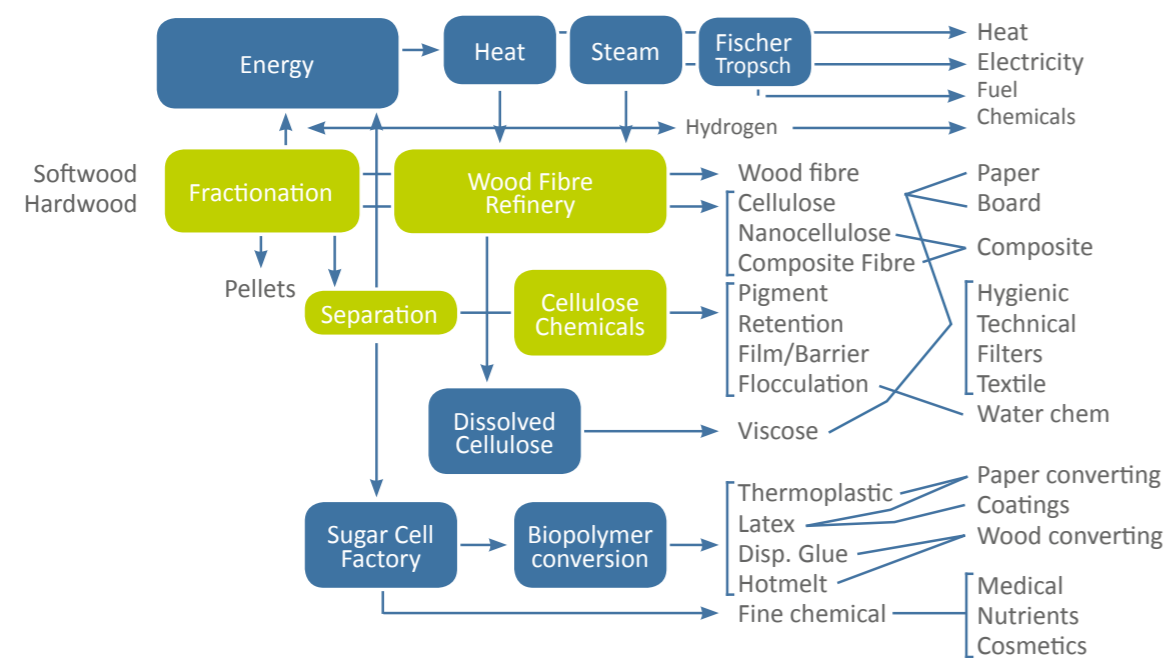


Figure: VTT

Fibre processes and biorefinery

Expertise by 2020

Fibre processes

- Energy, water and raw material and cost efficiency of fibre processes and products

Biorefineries

- Known educator of cellulose- and hemicellulose-based carbohydrate specialised chemists
- Cellulose- and hemicellulose-based carbohydrate chemistry
- Peat as resource for biorefining

Development needs

- Develop new concepts for a wide variety of fibre-based products and utilisation of new raw materials in fibre processes
- To utilise extensively the modelling and simulation tools and fruitful collaboration between the modelling and experimental studies
- Develop unit processes and concepts for paper-making to improve the overall energy efficiency and quality of papermaking
- Study the environmental effects of producing biomass-based products
- Large-scale production and management of new refining methods for peat, also non-energy use
- Marketing of the existing production of cellulose- and hemicellulose-based carbohydrate chemicals
- Establishment of Bio Valley concept: combining the know-how in Central Finland of the forest industry and versatile biomass research in JYU and VTT, including Bioeconomy.

Sustainability assessment

Sustainability assessment is a central theme in all the strategic research areas described above. For future research and development activities, the sustainability of biomass production and utilisation has to be considered as a standard proceeding. The evaluation has to be carried out both for single processes and in relation to the larger scale. Sustainability research already has a strong multidisciplinary approach in the region that links together scientists from disciplines such as economics and the social and environmental sciences at the University of Jyväskylä, and other sectoral research organisations like VTT and MTT Agricultural Research Centre. The research has mainly focused on assessing and developing sustainable energy solutions with methodological approaches such as Industrial Ecology (IE) and Life Cycle Assessment (LCA).

Sustainability issues are gaining more and more influence in decision-making. It is crucial to assess whether policies and local targets are on the intended development track. **Energy efficiency and greenhouse gas (GHG) balances** of bioenergy production chains have been modelled since the mid-1990s by researchers in Central Finland. These kinds of calculations are used today for, to cite an

example, certification of pellets and evaluating what influence emissions trading will have on e.g. biomass allocation within the local energy system. New EU directives, such as the RES Directive and the Fuel Quality Directive, also increase the need for calculations of product-specific greenhouse gas emissions associated with whole supply chains.

However, we need to further develop the calculation methodology for assessing sustainability; parameters like **value addition, employment, land use and security of supply** are locally of great interest for decision makers, and such parameters must be included in the assessments. One of the future challenges is the assessment of how changes in a single process affect the whole system; such approaches give us insight into what processes are more urgent to develop than others. To make such assessments possible there must be closer cooperation between system analysis of sustainability and technical R&D. In the future, biomass cultivation, production and utilisation will probably more often be classified in terms of sustainability.

Sustainability assessment

Expertise by 2020

Multidisciplinary and multifaceted sustainability assessment of biomass production and utilisation systems

Energy efficiency and greenhouse gas balances of biomass processes and production systems

Sustainability accounting

- focus on biomass utilisation
- e.g. regional approach on annual basis

Development needs

More cooperation

- between disciplines
- between system analysis and technical R&D
- between researchers and decision makers

Development of methodologies, incorporation

- sustainability classification of biomass cultivation, production and utilisation
- carbon and nutrient flow model

Adaption of models in other regions

Virtual biomass processing model

- Data from cultivation activity and characteristics of biomass fractions
- Biomass production processes
- Implementation of new indicators of sustainable development (value addition, employment)

Accounting tool

- development of methodology
- demonstration and testing
- adaption
- updating

From research to products and services

Fuel analyses and standardisation

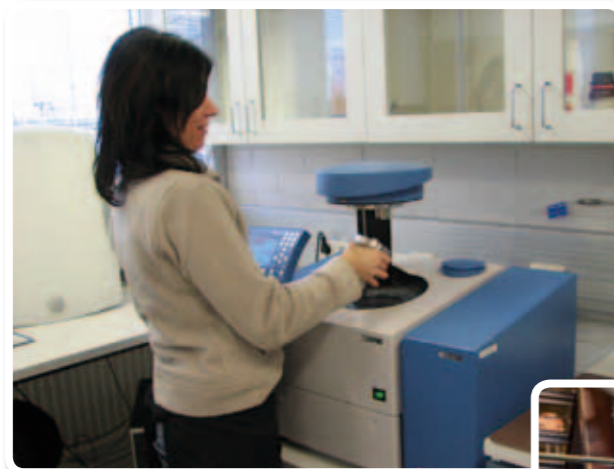
Central Finland has extensive experience in developing new biomass fuel analysis methods to determine physical, mechanical and chemical properties at VTT. In Central Finland, fuel analysis services are concentrated in an accredited fuel analysis laboratory. VTT is leading European and international standardisation of solid biomass

centres of expertise in the fields of energy technology and forest industry, as well as regional clusters of bioenergy, machinery manufacturing and housing technologies. Moreover, the research entities of the cluster have their own processes that support innovation development. Funding for R&D result commercialisation is scattered. It is more difficult to obtain funding for proof-of-concept and prototyping phases than for research and surveys.

In the future, further development activities have to be carried out in order to achieve regionally significant results.

Process modelling & optimising

In order to understand the complicated phenomena and manage the data of industrial processes, mathematical models



Biomass fuel analysis at ENAS Ltd, which is an accredited fuel analysis laboratory. Photo: ENAS Ltd

fuels and also actively participating in the standardisation of small-scale equipment for solid fuel firing. These standardisation activities are supported by several research and testing projects and cooperation with the industry. Implementing standards in practice is also supported by certification systems.

Innovation management

Finland is known for its successful innovation. In addition, Central Finland has made great efforts to commercialise ideas from R&D activities. There are cooperational innovation management processes, such as regional



VTT has developed fouling monitoring services for multi-fuel boilers. By using VTT's methods, solid fuel-fired power plants can enhance process monitoring and control, and study the cost effects of different fuel blends on boiler operation. Photo: VTT

From research to products and services

Expertise by 2020

Fuel analyses and standardisation

- Maintain the lead position in fuel analysis and standardisation services through continuous international co-operation

Innovation management

- Business from research
- Contiguous process of developing commercial products based on research results

Process modelling and optimising

- Better methods and tools developed and commercialised for international markets

Development needs

- International cooperation requires increasing knowledge of exotic biomass fuels from Asia and Africa

- Contiguous innovation support system

- To develop better methods and tools for evaluating carbon, energy and emission balances of different processes in biomass production and use
- Continuous learning of the processes by process monitoring and control

are often needed. In Central Finland, research organisations and companies offer modelling, simulation and optimisation services. Development of processes is also supported by laboratory analyses and field measurements at power plants and production mills. These are developed to match the future needs. For example, there is a growing international interest in utilising renewable fuels

and in multi-fuel applications. The main reason for this is the objective to reduce carbon dioxide (CO₂) emissions. The use of challenging biomass fuels often increases plant operational problems, such as fouling and high temperature corrosion at boiler heat transfer surfaces, which can be avoided by developing service business for power plant operators to overcome these operational problems.



What is BIOCLUS?

The BIOCLUS project is funded by the EU Seventh Framework Programme for Research and Technological Development. It is part of the EU's Regions of Knowledge programme (FP7), which aims to enhance R&D&I activities and boost regional competitiveness by strengthening the cooperation of local actors and increasing cluster activity. The objective of the BIOCLUS project is to boost the regional competitiveness and growth in five European cluster regions: Central Finland, Navarre (Spain), Western Macedonia (Greece), Slovakia and Wielkopolska (Poland). It promotes collaboration and integration of cluster regions and strengthens the innovation environment by improving research potential and innovation management, and also supports sustainable development by improving the use of biomass resources. The total budget of the BIOCLUS project is € 3.5 million, of which € 1.5 million is targeted for Central Finland.

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