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Author(s): Honkanen, Hannariina; Salmi, Janne; Sauranen, Tapani; Knuuttila, Kirsi

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EXPERIENCES AND CHANGES IN TESTING AND DEVELOPMENT ACTIVITY OF BIO HEATING SECTOR IN FINLAND DURING 2010-2020

Hannariina Honkanen, principal lecturer, School of Technology, JAMK University of Applied Sciences
PO BOX 207, FI-40101 Jyväskylä, Finland

Email: hannariina.honkanen@jamk.fi ; Phone: +358 50 432 5820

Janne Salmi, project manager, Institute of Bioeconomy, JAMK University of Applied Sciences
Tapani Sauranen, project manager, Institute of Bioeconomy, JAMK University of Applied Sciences
Kirsi Knuutila, project manager, Institute of Bioeconomy, JAMK University of Applied Sciences

ABSTRACT: The boiler testing environment operating at JAMK University of Applied Sciences has been a key tester and developer of solid biomass heating boiler operations in the less than 1 MW size range in Finland for ten years. The laboratories have also served as product development environment as well as well-equipped learning facility for demos and practical exercises in bioenergy activities and operations. Although the growth of renewable and bioenergy has been continuous in Finland and the use of bio based fuels has been emphasized, especially in the heating sector, combustion has lost some of its popularity due to the debate on the climate and adequacy of wood raw materials, among other things. Recently, the number of customers involved in energy related services and circular economy development projects have increased, referring to a more diverse range of fuels and more resource-efficient systems. In the future, with the mitigation of climate change, the share of renewable energy will increase in energy production, and more attention will be paid to flexible systems and emission control even in small scale heating systems.

Keywords: Bio heating, boiler testing, solid bio fuels

1 BACKGROUND AND OBJECTIVES

1.1 Bio heating industry relevance in Finland

In the cold climate of the Northern Europe, bioheating has a long tradition, and biomass has been quite well available locally, especially in sparsely populated areas. Finland's energy intensive industry and long cold and dark winter relate closely to great need of heating energy per person as well as demand for process energy and electricity. In Finland, security of supply is key issue in energy production and use schemes. The use of local biomass as an energy source develops the region's self-sufficiency, supports industry and employment, and helps combat the growth of greenhouse gas emissions. [1, 2]

According to the energy and climate strategy and the government program, Finland's goal is for renewable energy to account for at least 51 per cent of final consumption in 2030. The strategies were updated in 2016. [3] The total consumption of renewable energy in Finland in 2010 was 26,9 per cent, compared to 39,5 per cent in 2020 according to the preliminary forecast. [4] As a result, the share of total renewable energy consumption has risen by 27,6 per cent in ten years.

Wood is Finland's most common source of renewable energy covering 27,9 per cent of the whole energy consumption. [4] In EU, the share of wood based energy is also high, resulting more than 75 per cent in renewables in 2016, in Latvia, Estonia, Lithuania, Hungary and Poland [5]. Finland has long traditions in developing forest energy product chain, and one essential partner has been Sweden. [6]

Bioenergy has significant link to the exploitation of forest industry by-products. Wood energy production has based on sustainable forest management, which refers, among other things, to the use of thinning wood in energy production. The precondition for wood energy is the continued competitiveness of the forest and sawmill industry and the sustainable utilization of forests [2].

Figure 1 shows the trend and changes in solid wood consumption in heating and power plants in Finland. It should be noted that the graph does not show statistics on

black liquor, which has been the largest wood-based fuel in energy production relative to each year. The continuous growth in the use of solid wood fuel seems to have folded from 2019 to 2020, which is due to some decrease in utilization of forest chips and bark.

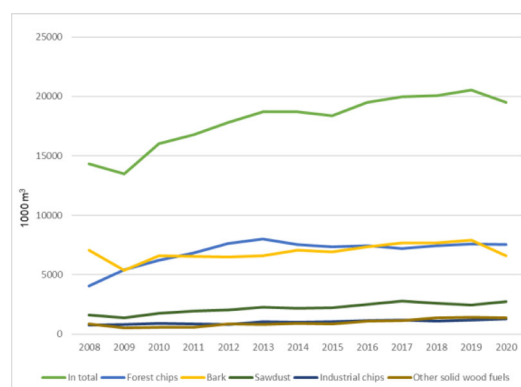


Figure 1. Solid wood consumption in heating and power plants in Finland by wood fuel assortment during 2008-2020. [7]

The use of bioenergy is distributed throughout Finland. In addition to the significant production and use of bioenergy, Finland has a center of expertise in bioenergy. Central Finland is one of the provinces in Finland that uses the most solid wood fuels. Other provinces that make significant use are South Karelia, Pirkanmaa and Uusimaa. [2] The developed use of biomass fuels in Central Finland is explained by the long history of wood processing, which is why wood energy has been available for a long time [8].

1.2 Initial boost for boiler testing in Central Finland

The establishment of the boiler-testing laboratory in Saarijärvi, Central Finland, was based on national targets for increasing renewable energy in the 21st century, strong co-operation between research institutes in Central

Finland and the need for companies for type testing of solid fuel boilers. By 2010, Central Finland had great potential for increasing the use of solid biofuels and increasing business. The highest potential was mostly seen in the use of wood chips but also some in the utilization of agro biomasses. [8] The aim of new grate boiler testing environment was to supplement the testing activity offered by VTT, which was more focused on fluidized bed research. Extensive test services covered the needs of companies of various types and sizes regionally.

JAMK provided a place for the testing environment and was supported by strong industry and research networks, experience in bioenergy projects and involvement in the active bioenergy cluster. The test environment was built with the support of European Union.

This publication provides an overview of the operation of the boiler-testing laboratory and its development, and discusses the change in the bioheating sector in Finland during 2010-2020. The material in the study has been collected from statistics and official publications, and the research results of the University of Applied Sciences and sales data for the period under review have been utilized. In addition, JAMK's subject area experts have been interviewed.

2 BIO HEATING SECTOR DEVELOPMENT DURING LAST DECADE

2.1 Development of renewable energy operational environment in Central Finland

According to the present Central Finland's provincial strategy, locally and sustainably produced energy will increase the regional economy. [9] Furthermore, according to the Regional Programme for Central Finland 2018-2021, by-product streams from the industries in bioeconomy must be utilized in various ways. Increasing renewable energy and promoting energy efficiency promote low carbon, increase local know-how and create jobs. [10]

The development environment seems to have changed somewhat over the last ten years. In addition to national strategies and objectives, EU level regulation and standardization work has influenced to the base and the development of bio heating research in Central Finland. Provisions related to emissions, waste incineration and eco-design have had a key impact on the development of boilers.

By the time of 2010, most relevant regional research and development areas in local bioenergy cluster were wood harvesting, logistics, combustion technology and especially co-combustion, agro biomasses for energy, hybrid systems for energy, and sustainable bioeconomy. From international cooperation perspective, the local focus in Central Finland's sustainable use of biomass was in biomass supply chains, refinery and combustion, sustainability assessment, and product and service development. [11] After ten years, the natural evolution of clusters and ecosystems has continued from networking to supporting innovation and related hubs with international partners.

Some changes in renewable energy use can also be seen in the regional energy balance (see Figure 2). The largest regional energy consumer is industry, followed by heating. In 2019, energy consumption in Central Finland

was 21,9 terawatt hours (TWh), which increased from 2016 to a total of 4,6 TWh. In 2019, the share of renewable energy was 66 per cent, when the share of renewable energy imported from outside the region is also taken into account. The share of renewable energy increased by a total of 11 per cent from 2016, and carbon dioxide emissions from energy procurement in the region decreased by 9 per cent. [12]

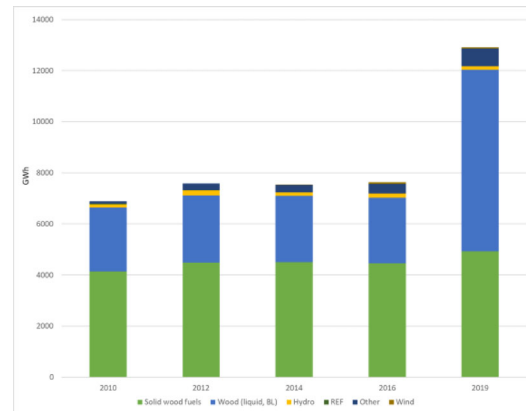


Figure 2. Renewable energy mix in Central Finland 2010-2019. [12, 13]

Between 2010-2019, the use of solid wood fuels has remained quite stable. The sharp increase in the use of black liquor is due to the investment in a new pulp mill in Äänekoski (MetsäGroup). Although the proportions are relatively small, it should be noted that the use of liquid biofuels for transport, geothermal energy and solar energy increased. In the figure, "other" includes biogas, heat pumps, traffic fuels, photovoltaics, tall-oil pitch and methanol.

The change in the value of local energy sources is directly linked to the local energy business. According to the energy balance [12], the monetary value of wood fuels has increased by 37,5 per cent from 2010 to 2019. The monetary value of the category "other" has more than increased tenfold over the same period.

2.2 Small-scale heating sector business

In 2019, there were a total of 1168 companies in the renewable energy sector in Finland. The number of enterprises decreased by 1,7 per cent compared to the previous year (see Figure 3). Most were heating companies. The number of bioenergy companies has decreased since 2014. [14] Bioenergy companies refer to companies producing e.g. bio fuels, firewood and pellets.

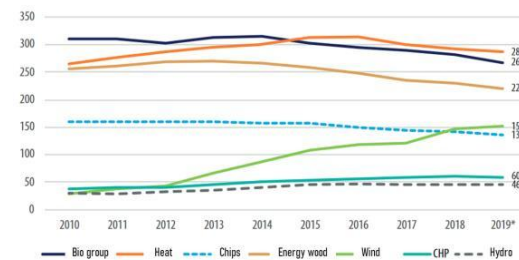


Figure 3. Number of companies in different renewable energy company groups in Finland in 2010–2019. [14]

Bioenergy companies operate either in its production chain or as users. Companies can also provide technology or various services for chain management. The expertise in the bioenergy sector that has emerged in Finland is in demand. [2]

Companies manufacturing boilers are interesting group of actors from testing activity point of view. The number of these companies has decreased in Finland over the last ten years, but boiler manufacturing is still seen as a potential export competence in Finland. Finnish boiler manufacturers are seen as number one in bids in Europe, when looking at a large boiler size range. In the future, bioenergy expertise in Finland will also be seen in harvesting technology expertise, fuel handling, transport fuels, flue gas cleaning, measurement technology and biogas plants. [2] Biogas is seen as one of the interesting potentials in heating in Finland, but its realized share has still been marginally small.

3 TESTING AND DEVELOPMENT ACTIVITY DURING LABORATORY LIFE SPAN

3.1 Activity profile

In the early years, type tests according to the EN 303-5 standard for boiler manufacturers and research, development and innovation projects in the bioenergy sector played the most significant role in the activity. The operations and services in the laboratories have also included following:

- Product development – wide possibilities with facilities and equipment
- Solid fuel analysis and testing
- Preparation of fuels for testing
- Training services
- Wide expertise in solid bio fuels and energy production
- Hiring of personnel for testing and rental of equipment

Over the years, the laboratory's experts have also participated in standardization work in the field. Testing activity implementation and development has been in close cooperation with VTT. Special expertise has been accumulated by the staff over the decade, and new experts have been trained for on-site assignments.

The team structure focused on bioenergy at Institute of bioeconomy in JAMK has changed over the last ten years, but the focus areas of research and development work can still be examined on a team-by-team basis during the review period. In 2010, the most relevant and strategic research and development topics were biofuel production, quality management and logistics, combustion technology and emission control (heating boiler size range less than 1 MW), and bioenergy entrepreneurship and business. When compared to focus areas in 2019, priorities have been identified type testing of boilers and RDI services for boilers, solid biofuels and biomass analysis services, solid biofuels and biomass processing services, construction of test environments for agriculture, water, circular economy and renewable energy and test implementation services, and bioenergy expert and training services.

Standardized heating boiler tests and fuel analysis

The JAMK's laboratory fulfills the requirements of standard EN 303-5 about the testing of solid biomass

heating boilers in 2021. The quality of the testing environment and the qualification of the testing staff were assured according to ISO 17025 in 2012 for the standard EN 303-5: 1999 and completed for EN 303-5: 2012 in 2013 [15, 16]. An update to the standard has been underway for the past few years.

Two out three testing benches in the boiler testing environment are accredited for EN 303-5. They are suitable for boilers 0-100 kW and 100-500 kW with nominal heat output. The third enables testing of larger boilers, heating efficiencies from 500 kW up to 3 MW. The heat produced in the laboratory activities is either used in the facilities or collected in the water in heat accumulator with the volume of 70 m³. All testing benches have opportunity for online emission measurements that are required in the standard. [15, 16]

The laboratory has also facilities for essential analyses of solid biomass quality testing such as moisture, ash and energy content, and particle size. Because wood chips are used in a wide variety of energy-related applications, its quality is of interest. Wood chips are used in power plants, small-scale heat production in rural areas as well as test fuels in the development and testing of new technology. Applications require different properties and quality of wood fuels.

Over the years, JAMK's laboratory has produced various types of test fuels and refineries, also in Finland from exotic biomasses. When tailored for the client, chips can even be high-tech product. Processing possibilities include crushing, screening, drying, moistening, mixing, blending, briquetting, debarking or separation of specific impurities or unwanted parts of the batch. The laboratory has also designed and built its own processing equipment.

Product development

The laboratory environment is versatile for various product development uses in small-scale energy production. In addition to performing standardized testing, more development-type work, both larger and smaller, has become involved in the laboratory's operations. An assignment or project can be the development of an energy generating device or its components. Various fuels and conversions have been tested, as has the development of emission control solutions. Energy efficiency and measuring emissions have continued to be emphasized over the decade.

Chapter 3.2 presents some examples about categorized company partners in cooperation during past five years.

Projects

During ten years, JAMK's laboratories have been the test environment for numerous EU and state and company-funded projects. One of the key partners has been the Finnish Forest Center, with which the quality and combustion of wood fuels in traditional farm and district heating boilers has been studied. Furthermore, the utilization of industrial production and agricultural by-products in production and heating has also been increasingly studied.

On concrete example of many years' development cooperation project is reducing emissions from maritime transport. The development work was conducted with large scale company. The target was a large cruise ship with a capacity of thousands of people, which produces large amounts of waste as well as sewage. The research was about developing treatment systems for dry and wet

waste. Concrete actions included processing experiments (briquetting, drying) for the waste material, stabilization of bio waste to biochar and thermal processing of the material. Three year product development project aimed at type approval for the examined system.

Another project example is relating to the effects of fuel and boiler use on fire safety of the heating boiler system. The subjects of the study were, more specifically, the effects of the use of waste oils among fuel chips, overpressure and boiler fouling on back-fire and the use of agricultural side products and oil plants in the woodchip boiler system.

Cooperation with education

In addition to the business and research field, the boiler testing environment has also served education. As a University of Applied Sciences, JAMK offers both bachelor and master level education programmes as well as various continuous training models and packages. With lifelong learning, trainees are of many ages and studying groups may consist students from many different fields. In continuous and master level education, trainees are usually already in employment, and training is provided in collaboration with employers.

Public development projects offer possibilities for demo's and teaching e.g. for deepening expertise in natural sciences and engineering. As part of the studies, training may include internships or working with theses. One example that evaluates the mention is a thesis done on the needs for testing activities caused by updating the boiler testing standard. The high-quality thesis was also noticed and awarded nationally in the field of agricultural sciences. Another example is collaboration with high schools in the province, which includes student lectures and visits to polytechnic laboratories.

3.2 Analysis in the present demand of services

Over the past five years, the laboratory has expanded operations and provided product development services in the field to more than 40 companies. The analysis focused only on the last five years, as reliable data on changed electronic systems were available from that period. The analysis data does not cover all public funded projects.

Figure 4 shows the results of cooperative companies categorized in eight different company groups. The most important group of co-operation companies was equipment manufacturers, the second most important was energy-related services.

Figure 5 presents the change between years in cooperation with different category company partners. The share of manufacturers was the highest in 2018, and the volume has been declining during past two years. The number of companies selling energy services has increased in recent years, which is in line with the general energy industry's view that the energy sector has become more service and customer-oriented in Finland.

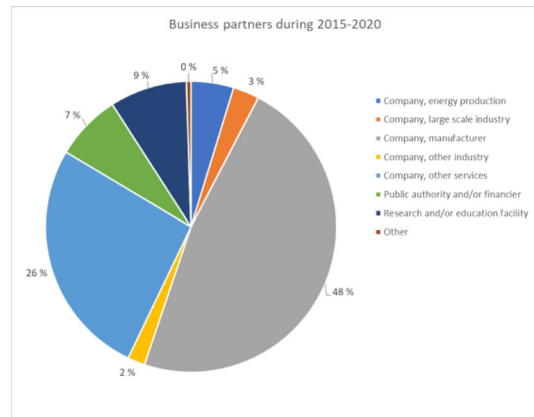


Figure 4. Cooperation partners in JAMK bio fuel analysis and boiler testing laboratory during 2015-2020, in sales volume shares.

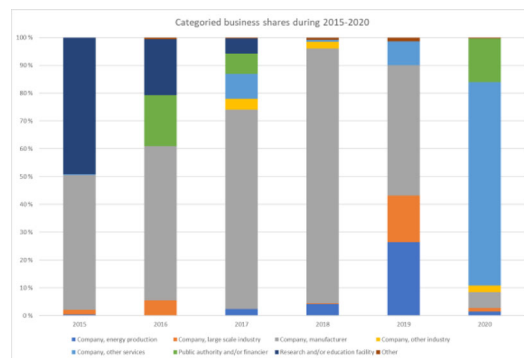


Figure 5. Cooperation partner change between years 2015-2020, in sales volume shares.

3.3 Changes in the activity and development

Over the past ten years, it has been learned that key drivers of development include the lack of small-scale emission legislation and restrictions, the importance of fuel quality, technological advances such as automation and flue gas cleaning, and boiler operators' understanding and expertise in boiler operation. Human factors in the efficiency and emissions of small-scale heating include awareness and attitude effect in decision-making e.g. choices in technology and fuels, the proper use of technology, as well as in the utilization of services [16].

Although the growth of renewable and bioenergy has been continuous in Finland and the use of bio based fuels has been emphasized, especially in the heating sector, combustion has lost some of its popularity due to the debate on the climate and adequacy of wood raw materials, among other things. The bioenergy business potential forecast in 2010 does not seem to have been fully realized in Central Finland. The sector is very sensitive to the effects of public policy. The importance of other renewable energy solutions such as solar energy and heat pumps has gradually increased in heating. With energy efficiency, companies have also increased their interest in the most flexible and optimized systems, such as hybrid and energy storage solutions, and recovery of waste heat.

In the future, wood-based raw materials will continue

to account for the largest share of renewable energy, but circular economy solutions related to environmental and waste management also have significant growth potential [14]. This is concretely reflected in the industry's development and service needs. The visible interest in boiler safety and services has also been reflected in the operations of JAMK's laboratories.

4 CONCLUSIONS

Over the last ten years, rising trends in heating boiler testing can be seen in relevance of wider spectrum of fuels, emission control relating to combustion management, relevance of maintenance and keep-up and safety. Wood based fuels quality has remained in interest in practical operations, but developments and investments in flue gas cleaning have, in practice, been expected to tighten legislation and emission limits in a small energy production size range. In general, the deterioration in fuel quality is very possible when good quality wood is used more precisely for higher value-added products, and at the same time, the circular economy directs the energy recovery of waste fractions that are unfit for material use.

During the ten years, there has been a stronger emphasis on utilizing the testing environment for more diverse and nationwide product testing activities. Recently, the number of customers involved in circular economy development projects has increased, referring to a more diverse range of fuels and more resource-efficient systems in bio heating development. Training and advice play an important role in increasing the skills of industry, businesses and consumers alike.

In the future, with the mitigation of climate change, the share of renewable energy will increase in energy production, and more attention will be paid to emission control even in small scale heating systems. The use of solid biomass-based fuels is believed to remain involved in Finnish heat production and the business of sparsely populated areas. Large megatrends such as digitalization will in the future also extend to smaller-scale energy production, bringing possibilities to improve energy efficiency and user-friendliness alongside automation solutions.

5 REFERENCES

- [1] Honkanen, H. & Kataja, J. 2017. Technological aspects of nonfood agricultural lignocellulose transformations. *Bioenergy Systems for the Future, Prospects for Biofuels and Biohydrogen*, p. 43-59. Woodhead Publishing.
- [2] Bioenergia-alan panos hiilinegatiiviseen tulevaisuuteen Suomessa [The contribution of the bioenergy sector to the carbon negative future in Finland] (2020). Report 1.6.2020. Bioenergy association in Finland.
- [3] Government report on the National Energy and Climate Strategy for 2030. 2017. Finnish Ministry of Employment and the Economy. <http://urn.fi/URN:ISBN:978-952-327-199-9>
- [4] Official Statistics of Finland (OSF): Energy supply and consumption. 2019. Helsinki: Statistics Finland. http://www.stat.fi/til/ehk/2019/ehk_2019_2020-12-21_tie_001_en.html
- [5] Archive: Wood as a source of energy. Eurostat, Agriculture, forestry and fishery statistics. Updated 27.3.2019. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Archive:Wood_as_a_source_of_energy&direction=next&oldid=435183
- [6] Hakkila, P. 2006. Factors driving the development of forest energy in Finland. *Biomass & Bio-energy* 30 (2006); 281-288.
- [7] Wood in energy generation 2020 (provisional). 2021. Natural Resources Institute Finland. https://stat.luke.fi/en/wood-energy-generation-2019-provisional_en
- [8] Pelli, P. 2010. Kiinteisiin biomassapolttoaineisiin liittyvä liiketoiminta Keski-Suomessa [Solid biomass fuels business in Central Finland]. Ministry of Employment and the Economy publications 59/2010.
- [9] Keski-Suomen strategia, Maakuntasuunnitelma 2040 [Strategy of Central Finland, Regional Plan for 2040] (2014). Regional Council of Central Finland. <https://www.keskisuomi.fi/filebank/23863-Keski-Suomen-liitto-Keski-Suomen-Strategia-maakuntavaltuustolle-netti.pdf>
- [10] Keski-Suomen maakuntaohjelma 2018-2021 [Regional Programme of Central Finland 2018-2021] (2017). Regional Council of Central Finland. https://www.keskisuomi.fi/filebank/25394-Keski-Suomen maakuntaohjelma 2018-2021_A4.pdf
- [11] Knuutila, K., Barberena, G., Sánchez, D., Ylimartimo, A., Echeverría, I., Malinen, H., Ketikidis, C., Krissakova, I., Hryniewicz, M. 2012. Joint Action Plan for Biomass In Bioclus Regions. Conference paper in 20th European Biomass Conference and Exhibition.
- [12] Regional energy balance of Central Finland (2020). Regional Council of Central Finland and Benet Ltd. <https://keskisuomi.fi/keski-suomen-kayttamista-energialahteista-66-uusiutuvia/>
- [13] Oikari, S. 2021. Personal communication. Benet Ltd.
- [14] Alm, M. 2020. Uusiutuva energia - kohti hiilineutraalia tulevaisuutta [Renewable energy - towards a carbon-neutral future]. MEAE Sector Reports 2020:1. Ministry of Economic Affairs and Employment, Finland.
- [15] Knuutila K., Oravainen, H., Raudasoja, N. & Honkanen, H. 2014. Experiences of quality management of solid biomass boiler R&D environment – case standard EN 303-5. Conference paper in 22nd European Biomass Conference and Exhibition.
- [16] Honkanen, H. 2018. Aspects of factors affecting performance and emissions of small-scale bio heating boiler in a Northern European country. Lappeenranta University of Technology.