http://www.interregeurope.eu/bridges/

Value chain mapping of the forest industry side-streams in Kainuu

September 2022

Table of contents

List of Figures

List of Tables

1. Introduction

1.1 Legal reference & summary

Assignment	The *Value chain mapping of the forest industry side-streams in Kainuu* study was assigned by the Regional Council of Kainuu to the University's of Oulu MITY department, following a restricted offer for expression of interest. The study implements BRIDGES' project additional activities action plan (2021-2023). The BRIDGES project additional activities (5th call) application was approved by the Interreg Europe Programme on 1.7.2021, approval applicable as of 26.2.2021[1].
Procurement	This procurement is under the national Finland's threshold and thus, this procurement falls outside the scope of application of the Finnish Act on Public Procurement and Concession Contracts. However, under the BRIDGES project, the principles of the aforementioned legislation are followed. Thus, the following process has been followed: — Finland Act on Public Procurement and Concession Contracts 1397/2016. — Restricted procedure, Section 33 of Law 1397/2016. — This call for offers is sent to three institutions.

Summary

The purpose of the study is to map forest industry side-streams in Kainuu, identify their competitive advantage, and propose operational and strategic development initiatives strengthening sustainable (economical and otherwise) in-shoring programmes and benefitting from near-shoring options. The value chain and competitive advantage identification follows a methodology developed during and by the BRIDGES project. Competitive advantage identification is done following the location quotient method, applied to different aspects of the economic base, i.e. not only to exports. Emerging strengths are also taken into account.

The Finnish Forest sector contributes around 19% of the total value of export in goods, and wood-based production employed, in total, nearly 74,000 persons (about 3% of the employed) in 2018. Thus, economically, forests and their utilization have a major impact on the whole economy in Finland.
Kainuu has two key ecosystems (Renfors ranta Kajaani and Kuhmo) related to forest bioeconomy side-stream value chain utilization. Each one of the eco systems has developed around large, key-businesses. The Kuhmo ecosystem consists of more companies. The key player is Kuhmo Oy. It manufactures a wide range of high-quality products for the packaging and construction industries, the carpentry and furniture industries, and the construction and prefabricated home industries. Woodpolis in Kuhmo is coordinating the collaboration and development actions between companies. Side streams of the Kuhmo ecosystem are well identified and utilised. Pölkky Oy has a sawmill in Kajaani located in the former paper factory area Renfors ranta, operating now as an industrial park. Pölkky Oy is the key actor in Kajaani ecosystem. The Kajaani ecosystem has fewer companies compared to Kuhmo.
In terms of education and research, the Kajaani university consortium is a relatively compact research and innovation unit in Kainuu consisting of the university of Oulu and the university of East Finland. They offer to the region's economy, excellence in forest bioeconomy. The Unit provides applied research services and ensures a rather comprehensive research infrastructure to bio-based economy related actors in Kainuu. Collaboration with businesses is based on contract research and on development projects.

The in-shoring arguments in the case of Kainuu are four: (i) the national Circular Economy programme (8.4.2021) with the provisions for public procurements (KEINO), and the reform of the Building Act (including wooden construction), provides an overall strongly enabling framework with which regional policy is aligned (see item (iv)); in Kainuu, (ii) the abundance of natural resources and associated activities in Kainuu minimises production costs. Transportation distances are moderate for local biobased industries in comparison with production plants in most regions in Finland; (iii) access to specialised research resources allows for product development and innovative

[1] Approval of additional activities, Annex 1.

solutions, and (iv) conducive regional policy supporting through policy, regional and national funding initiatives on circular economy, follow up actions and the additionality between the two. Bio-based economy, research, green transition and digital transformation are all distinct thematic units of the Kainuu 2021-2027 RIS3.

Recommended initiatives:

- RAW MATERIALS Intensification of the harvesting process – JTF & ERD funding.
- STORING AND TRANSPORTATION Vehicles using alternative non-fossil fuels; Investments for bio circular economy terminals; wood-based side streams produced in Kajaani ecosystem has already potential for producing biogas for transportation fuels and hydrogen economy. In Kuhmo ecosystem biogas production from bioeconomy side streams is under investigation; JTF & JTM funding.
- PROCESSING 1) Machinery; Investments for modernisation of manufacturing processes following I4.0 principles. 2) New product development based on side-streams ingredients, in reference to the wood construction industry, and benefitting from the recently voted law on construction.

1.2 Authors and collaboration team

- Authors: University of Oulu, Jarkko RÄTY, Research Manager and Petri ÖSTERBERG, Post Graduate Researcher
- Collaboration and facilitation team: Regional Council of Kainuu, Jouni and Ninetta (full names to be added)

1.3 Structure of the report

The value chain mapping report consists of the following chapters:

- Part 1, Introduction.
- Part 2, Background.
- Part 3, Value chain mapping & identification of competitive advantage.
- Annex 1, Letter of approval.

2. Background

2.1 The BRIDGES project additional activities

On the 28.6.2021, the Interreg EUROPE programme approved BRIDGES project's application submitted on 31.5.2021, for additional activities (letter of approval Date: 28/06/2021, RE: Interreg Europe Call for additional activities (5th call) – decision Project: PGI00040 BRIDGES).

The purpose of the additional activities of the BRIDGES project is to enhance the resilience of regional economies. This is done by exploring value chains in two ways and in a coordinated, twofold way: a) enhancing the economic base of smart specialisation through inshoring and reshoring of value chains and b) benefitting from knowledge-based interregional complementarities & collaborations related to the selected value chains of the partner regions.

The following value chains were selected by the respective regions:

Table 1 BRIDGES project additional activities, selected value chains

Region & partner	Value chain selected
Kainuu, PP2 & LP; FI	Forest-industry sidestreams
Helsinki-Uusimaa, PP4; FI	Bio-based & recyclable textiles
Western Macedonia, PP5; GR	Diversification of the dairy industry
Soča Valley, SVDC, PP6; SI	Diversification of the dairy industry
Western Transdanubia, PBN, PP7; HU	Living lab testing facilities for physical rehabilitation.

2.2 Purpose of the value chain mapping task

The purpose is to map the competitive advantage of the forest industry side streams in Kainuu, as a tool for long-term, knowledge-based, sustainable growth of the region. In particular, the present exercise aims at identifying such aspects of the value chain that can be interpreted into in-shoring or re-shoring activities, and, in parallel, to become aware of near-shoring options. Becoming aware of such options is expected to lead to regional, national and interregional projects and -especially- investments implying diversification and expansion of the economic base of the region.

2.3 EU and national policy context

In 2020, the European Commission adopted the New Circular Economy Action Plan[2] and the European Green Deal [[3]], Europe's new agenda for sustainable growth. The EU's transition to a circular economy will reduce pressure on natural resources and will create sustainable growth and jobs. It is also a prerequisite to achieve

[2] https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN . COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A new Circular Economy Action Plan For a cleaner and more competitive Europe. COM/2020/98 final. EC page: https://environment.ec.europa.eu/strategy/circular-economy-action-plan_fi .

[3] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS The European Green Deal, https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1576150542719&uri=COM%3A2019%3A640%3AFIN. For updates: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en .

the EU's 2050 climate neutrality target and to halt biodiversity loss. The New Circular Economy Action Plan is a building block of the Green Deal. The New European Innovation Agenda [4].

In Finland, circular economy is an absolute priority. The Ministry of Environment[5] prepared a strategic programme to promote a circular economy. With this programme, the Finnish Government wants to strengthen Finland's role as a leader in the circular economy. The transition into a circular economy is also a step towards achieving the Government's carbon neutrality target by 2035. The Finnish Government adopted the resolution on promoting a circular economy on 8 April 2021[6]. The vision of the programme is that in 2035, "a carbon-neutral circular economy society will be the foundation of our successful economy in Finland, in which: sustainable products and services will be part of the mainstream economy and the sharing economy will a normal part of daily life; integrated development: a future-proof and strengthening, fair, welfare society. The circular economy breakthrough has been made with the help of innovations, digital solutions, smart regulation and responsible investors, companies and consumers. Circular Economy Finland will influence the world and provide sustainable solutions in international markets". Specific measures accompany this ambitious and humanitarian approach to circular economy, based on incentives (including guidance for public procurement *Sustainable and innovative public procurement, KEINO centre of competence*[7]), the creation of a circular economy market, circular economy promotion in specific sectors, such as construction (reform of the building act[8] and Finland's national architectural policy programme 2022-2035[9]), and circular economy innovations, digitalisation, and competences [10].

2.4 Regional profile[11]

Kainuu is located in north-East Finland. It has an area of 22 687 km2 and a population of 72 506 inhabitants (31.12.2019), 1,3 % of Finland. In 2019 the GDP per capita was € 34 082[12], compared to a national average of € 38,370.04 (Statistics Finland, 2019). Kainuu's unemployment rate is around 10.8% (2017). In 2017, the top 5 industries in Kainuu were: (Regional Council of Kainuu, 2018) 1. Bioeconomy (renewable natural resources) (502M €); 2. Mining (300.7M €)3. Energy (226.9M €); 4. Forestry (193.6 M €)5. Metal (152.5M €). Kainuu has

---

4 COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS. A New European Innovation Agenda. COM(2022) 332 final. https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13437-A-New-European-Innovation-Agenda_en

5 https://ym.fi/en/strategic-programme-to-promote-a-circular-economy .

6 GOVERNMENT RESOLUTION ON THE EGIC PROGRAMME FOR CIRCULAR ECONOMY, 8.4.2021. https://ym.fi/documents/1410903/42733297/Government+resolution+on+the+Strategic+Programme+for+Circular+Economy+8.4.2021.pdf/309aa929-a36f-d565-99f8-fa565050e22e/Government+resolution+on+the+Strategic+Programme+for+Circular+Economy+8.4.2021.pdf?t=1619432219261.

7 KEINO osaamiskeskus, https://www.hankintakeino.fi/sites/default/files/media/file/KEINO-hankintojen-strat-johtamisen-tilan-kartoitus-2021.pdf .

8 https://mrluudistus.fi .

9 https://julkaisut.valtioneuvosto.fi/bitstream/handle/10024/164413/VN_2022_62.pdf?sequence=1&isAllowed=y .

10 https://ym.fi/en/strategic-programme-to-promote-a-circular-economy/circular-economy-innovations-digitalisation-and-skills .

11 The text in Chapter 2 is inserted from the Kainuu Policy Instrument Recommendations Improvement Report, available at https://projects2014-2020.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1664808350.pdf .

12 Data 2019, https://www.statista.com/statistics/1150699/finland-gross-domestic-product-gdp-per-capita-by-region/ .

an important research and knowledge base relating to measurement technology, ICT, and data analytics. One of the eight European supercomputers is located in Kainuu. BERRY+ is of strategic importance to Kainuu, as addressing the small economic critical mass of the region through research-based entrepreneurship and value chain integration are prioritised development objectives. According to the Regional Innovation Scoreboard 2019, Kainuu is a strong+ innovator region.

According to the Regional Innovation Scoreboard 2019[13] , the Regional Profile dedicated to Finland[14] "Pohjois- ja Itä-Suomi (FI1D) is a Strong + Innovator; innovation performance has increased over time (10.7%). … The radar graph shows relative strengths compared to Finland (orange line) and the EU (blue line), showing relative strengths (e.g. Lifelong learning) and weaknesses (e.g. Employment MHT man. + KIBS services):4", Figure 1.

Figure 1 Relative innovation system strengths of NorthEast Finland (source: Regional Innovation Scoreboard 2019[15])

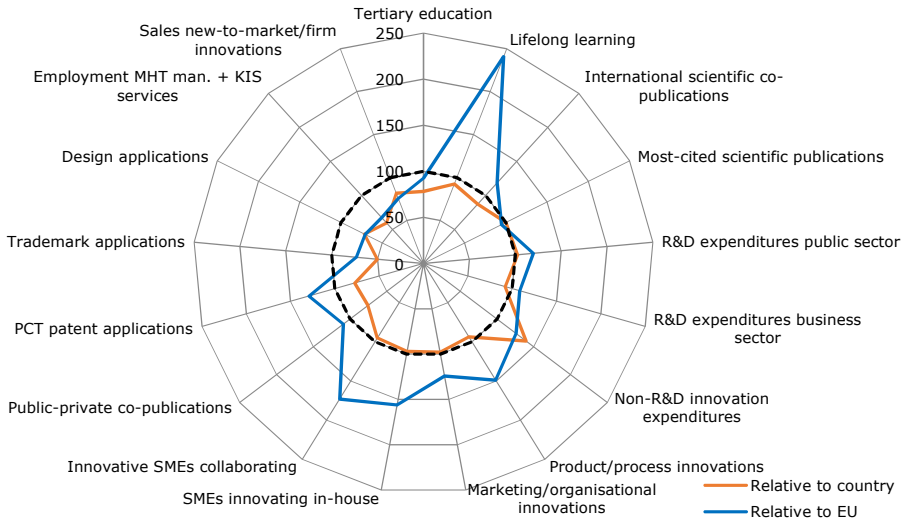

Figure 1 indicates that among the fields with the weakest performance are those classified under the *Sales impacts category*, namely: medium and high-tech products exports, sales of new-to-market or to-the-firm innovations, exports of knowledge intensive business services (KIBS); also trademark applications, and R&D expenditures of the business sector (BERD). These tendencies appear to be persistent and are confirmed by the European Innovation Scoreboard of 2020[16], too. They are addressed by the revised Kainuu RIS3 2021-2027 as well as by the policy instrument recommendations[17].

The export-related employment comparative advantage of Kainuu, i.e. concentrations of exports-related employment compared to total regional employment (i.e. the Balassa-Hoover index) indicates that the most important concentrations are found in nine (9) domains, however, more than 40% is concentrated in the Mining and Quarrying sectors (Table 2). In turn, this overconcentration implies that the Herfindahl-Hirschman index,

[13] For 2020 results: https://ec.europa.eu/growth/sites/growth/files/eis2020_leader_map-01.png

[14] Finland report: http://ec.europa.eu/growth/industry/innovation/ facts-figures/regional_en. For the comprehensive 2019 EU report: https://ec.europa.eu/growth/sites/growth/files/ris2019.pdf

[15] https://ec.europa.eu/docsroom/documents/36284 .

[16] https://ec.europa.eu/docsroom/documents/41874 .

[17] Kainuu Policy Instrument Recommendations Improvement Report, available at https://projects2014-2020.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1664808350.pdf

measuring regional resilience in the sense of the market base[18], indicates the need for Kainuu to expand its economic base, since it is rated 14th out of the 19 Finnish regions. Clearly, this overconcentration applies also to the RIS3 industries.

Table 2 The RIS3 industries, excerpt from the Balassa-Hoover analysis (source: University of Turku)

Comparative advantage of Kainuu 2017	Number of jobs	Share	B-H 2017
07 Mining of metal ores	650	2,4 %	25,55
B Mining and quarrying	797	2,9 %	11,65
30 Manufacture of other transport equipment	468	1,7 %	5,72
02 Forestry and logging	730	2,7 %	4,11
08 Other mining and quarrying	137	0,5 %	4,04
03 Fishing and aquaculture	43	0,2 %	3,53
79 Travel agency, tour operator and other reserve-tion service and related activities	154	0,6 %	2,92
82 Office administrative, office support and other business support activities	353	1,3 %	2,16
A Agriculture, forestry and fishing	1609	5,9 %	2,07
55 Accommodation	285	1,0 %	1,91
26 Manufacture of computer, electronic and optical products	418	1,5 %	1,81
Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	221	0,8 %	1,66
16 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	339	1,2 %	1,58
O Public administration and defence; compulsory social security	2039	7,5 %	1,52
01 Crop and animal production, hunting and related service activities	836	3,1 %	1,42
23 Manufacture of other non-metallic mineral products	191	0,7 %	1,39
95 Repair of computers and personal and household goods	45	0,2 %	1,33
81 Services to buildings and landscape activities	1082	4,0 %	1,32
86 Human health activities	2740	10,1 %	1,32
42 Civil engineering	265	1,0 %	1,30
N Administrative and support service activities	2444	9,0 %	1,21
49 Land transport and transport via pipelines	972	3,6 %	1,20
Q Human health and social work activities	5519	20,3 %	1,20
63 Information service activities	99	0,4 %	1,17
69 Legal and accounting activities	318	1,2 %	1,16
93 Sports activities and amusement and recreation activities	311	1,1 %	1,16
36 Water collection, treatment and supply	34	0,1 %	1,14
88 Social work activities without accommodation	1594	5,9 %	1,10
09 Mining support service activities	10	0,0 %	1,10
87 Residential care activities	1185	4,4 %	1,10

[18] The HHI is calculated by squaring the market share of each firm competing in the market and then summing the resulting numbers. https://www.justice.gov/atr/herfindahl-hirschman-index .

The **location quotient**[19] and **the shift share analysis**[20] indicate that:

- The location quotient (LQ) confirms the B-H index relating to the regional comparative advantage and selection of RIS3 industries. However, it also indicates that it is necessary to increase knowledge inputs to the industries such as primary production and strengthen the manufacturing industry. Location quotient identifies concentration strengths and internal discrepancies between, for example, primary production (A) or manufacturing (C) and knowledge inputs (M). The regional potential is understood as a projection of strengths and improvement of performance weaknesses. Radical diversification is understood as part of such projections.
- The shift-share analysis (SSA) indicates that the competitive advantage of Kainuu is based on the ICT sector which has been largely enhanced by the award of the LUMI supercomputer from the EC. On the other hand, the primary production and manufacturing show positive growth projection (expected change) but negative competitive effect. This finding confirms the location quotient finding that Kainuu needs to strengthen science – based inputs to its primary and manufacturing industries.
- All of these findings were taken into account in the revision of the Kainuu RIS3.

Table 3 Kainuu RIS3 2021-2027

RIS3 Governance instruments: (Instrument I) Stakeholder involvement; (Instrument II) Entrepreneurial discovery process; (Instrument III) Monitoring; (Instrument IV) Funding & financing; Instrument V) Technical assistance reserve.	**THEME 1: Increasing research and promoting innovation** Theme 1 is planned to reinforce the existing R&D base	**THEME 2: Strengthening and diversifying the specialisation base** An important part of the Theme 2 projects is based on the utilization of applied research results produced in Theme 1.		**THEME 3: Connectivity and integration, measures for interregional collaboration** Theme 3 is designed as a tool to support the effectiveness of Themes 1 and 2
	DEVELOPMENT OF INNOVATION (APPLIED RESEARCH) 1. Measurement technology 2. Gaming and advanced simulation techniques (3D, VR, AR) 3. Big data analytics and high-performance computing 4. Circular economy in mining and bioeconomy	**2A) INDUSTRIES: Bioeconomy, mining, metals and ICT** Promoting industrial modernisation through investments in: 1. New product development. 2. Improve production processes (eg introduction of Industry 4.0). 3. Improve the environmental and quality of products	**2B) KNOWLEDGE-BASED SERVICE INDUSTRIES** 1. Professional (winter) sports and sports coaching and training technologies and applications 2. Activity tourism 3. Social and health services (Innovations using digitalisation will be used to increase the efficiency of service production (especially social services) and to increase the added value of services. Increase international cooperation in RDI activities related to service development.	**BETTER FUNCTIONING OF THE REGIONAL INNOVATION SYSTEM** 1. Innovation infrastructures 2. Access to interregional demand-driven innovation processes 3. Emerging industries and innovation platforms, incl. interregional value chains, clusters, S3 partnerships 4. Platform economy 5. Attracting investment in RIS3 industries
	Cross-cutting themes and objectives for all RIS3 priorities			
	THEME 4. Digital transformation Theme 4 concerns the strengthening of digital change for the industries prioritized in Theme 2. To this end, Theme 4 projects may make use of the interregional options offered in Theme 3 and / or the innovative solutions developed in Theme 1.			
	1 Deployment of Industry 4.0, including robotics and automation applications			
	2. Big data analytics and high-power computing (HPC) utilisation			
	THEME 5. Green deal Theme 5 covers both the application and development of Green Deal solutions, which will effectively lead to an environmentally friendly industrial change in Theme 2. To this end, Theme 5 projects may make use of the interregional options offered in Theme 3 and / or the innovative solutions developed in Theme 1.			
	1. Production and use of clean, affordable and secure energy			
	2. Increasing the circular economy and environmentally sustainable production in industry			
	3. From field to table: a fair, healthy and environmentally friendly food system			
	4. Climate change mitigation and adaptation			
	5. Preservation and restoration of ecosystems and biodiversity			
	6. "Keep everyone involved" (just transition)			

[19] **Location quotient** (LQ) is a way of quantifying the concentration of a particular industry, cluster, occupation, or demographic group is in a region as compared to the nation. It can reveal what makes a particular region "unique" in comparison to the national average. https://www.economicmodeling.com/wp-content/uploads/2007/10/emsi_understandinglq.pdf .

[20] **Shift share** is an economic indicator that tells you which industries (or occupations) are competitive in your region. Shift share shows you the national growth (in terms of jobs) of a particular industry. Based on this national growth, it then calculates how much the industry is likely to grow in your region, and compares this estimation with how much the industry *actually grew.* https://www.economicmodeling.com/2020/02/27/understanding-shift-share-2/ .

http://www.interregeurope.eu/bridges/

The Kainuu RIS3 2021-2027 (Table 3) proposes to confront the challenges very briefly described in the section 3.1 as part of a comprehensive process by building on strengths. The revised Kainuu RIS3: (i) includes into the RIS3, as a separate priority (Theme 1) the reinforcement of the research & innovation infrastructure base domains linked to existing strengths; (ii) maintains the RIS3 2014-2020 priorities (Theme 2); (iii) supports interactions between the research and RIS3 industries base (Theme 2); (iv)provides options for follow up projects foreseen to increase the TRL of research projects under Theme 1 and associated actions for research results commercialisation; (v) includes a separate cross-cutting theme on Digital Transformation (Theme 4) addressing also interdisciplinary issues (technology capabilities x management skills) as well as data analytics issues thus linking also to the potential of the LUMI innovation infrastructure; (vi) invests in a separate theme (Theme 3) dedicated to different forms of transregional collaboration and also include into it a sub heading dedicated to innovation infrastructures as a potential tool of supporting the realisation of the LUMI potential; (vii) through Theme 3 and S3 – based collaborations, to support European Value Chain participation (EVC) and through that, scaled-up entrepreneurship and support export of innovations to access markets.

2.5 Reminder of the value chain mapping methodology[21]

The value chain mapping was initially made in the context of the BRIDGES project 5th call, additional activities. It is selected and contributes to the implementation of the BERRY+ S3 partnership (https://s3platform.jrc.ec.europa.eu/berry).

The value chain methodology was selected for the following reasons: value-chains (i) can support long term interregional collaboration: the Phase 1 and Phase 2 of the BRIDGES project confirmed, on the one hand, the importance of interregional complementarities and, on the other hand, the luck of systematic approach towards them. Value chains can be an instrument, a carrier for interregional complementarities; (ii) can contribute to competitive advantage and through that to regional specialisation and diversification; (iii) can contribute to internationalisation of regional economies through the integration of businesses and innovation system actors integrate into collaborative efforts; (iv) are priorities of EU's new the industrial strategy as factors supporting European autonomy[22], confirmed also by the Council's conclusions 16.11.2020[23] and further reinforced by the New Industrial Strategy update COM(2021)350final.

According to the approved BRIDGES project AF, the objective is to reinforce regional resilience by in-shoring and re-shoring value-chain based productive activities, while, at the same time, also identifying those activities that is best to be done in collaboration with other regions (near shoring). On the other hand, the whole BERRY+ effort is reaching and benefitting from interregional complementarities based on the value-chain approach.

---

[21] All this section is an insert from the Value chain mapping methodology, available at https://projects2014-2020.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1665901233.pdf and https://projects2014-2020.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1665894064.xlsx

[22] "Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe's recovery ", 05 May 2021. https://ec.europa.eu/info/sites/default/files/communication-industrial-strategy-update-2020_en.pdf .

[23] Council conclusions on "A recovery advancing the transition towards a more dynamic, resilient and competitive European industry" adopted by written procedure on 16 November 2020. https://data.consilium.europa.eu/doc/document/ST-13004-2020-INIT/en/pdf.

The focus of the whole effort is on in-shoring and re-shoring competitive advantage in relation to specific value chains and, in parallel, to identify and invest in near-shoring value chain segments in which a region is not specialised or in which it is not interested. The terminology of reshoring is fundamentally territorial[24]. It is a question of where manufacturing is located, rather than by whom it is performed (that is, whether the manufacturing is insourced or outsourced). Much of the literature on reshoring also tends to present the concept as a reversal of offshoring (Gray et al., 2013[25]). Near-shoring refers to manufacturing being relocated to a country closer to 'home'.

The following value chains were selected to be mapped: forest industry side-streams (Kainuu, FI), recyclable and renewable textiles (Helsinki-Uusimaa, FI), dairy industry side-streams (Western Macedonia, GR and Western Slovenia, SI), and e-health equipment (Western Transdanubia).

The value chain mapping was done by applying a methodology devised by the BRIDGES project Phase 1, namely through the action plan of the LP/PP2, and the feasibility study for the renewal of the berry industry of Kainuu (Action 2)[26]. The feasibility study included a supply chain mapping of the berry industry as a whole, with detailed reference to technologies, end products, inputs, markets and policies, Table 4.

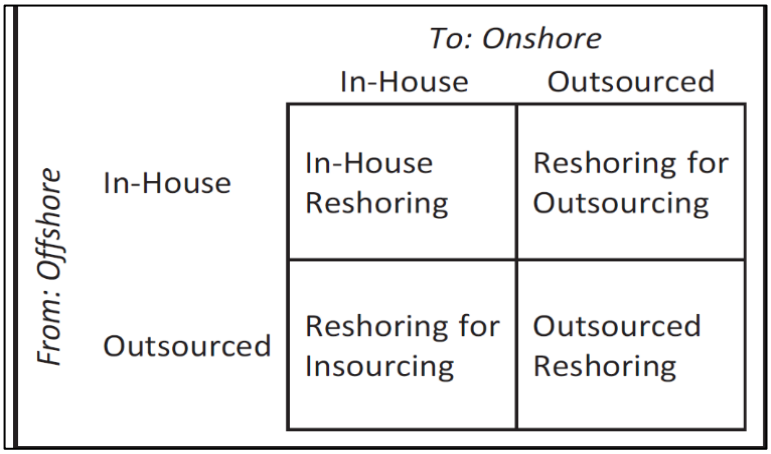

Figure 2 Models of re-shoring[27]

[24] European Parliament Research Service (EPRS) (2021). Post Covid-19 value chains: options for reshoring production back to Europe in a globalised economy. Policy Department for External Relations Directorate General for External Policies of the Union PE 653.626 – March 2021. https://www.europarl.europa.eu/RegData/etudes/STUD/2021/653626/EXPO_STU(2021)653626_EN.pdf

[25] Gray, J. V. et al. (2013) 'The Reshoring Phenomenon: What Supply Chain Academics Ought to know and Should Do', Journal of Supply Chain Management, 49(2), pp. 27–33. doi: 10.1111/jscm.12012.

[26] Kainuu action plan; https://projects2014-2020.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1565773671.pdf

[27] Gray, J. V. et al. (2013) 'The Reshoring Phenomenon: What Supply Chain Academics Ought to know and Should Do', Journal of Supply Chain Management, 49(2), pp. 27–33. doi: 10.1111/jscm.12012:p28.

Table 4 The berry industry supply chain grid[28]

	Key technologies		Products	Application	Key in-vestment	Promotion	Policy, 3S, industrial modernisation/ agrifood	Partnership/ Markets
Input / raw material	Cultivation development in field an forest (wilderness)	Facilitative: ICT and logistics	Cultivars, lines, material from specified production	Correct raw material to correct process	Plant breeding	Economic sustainability	Rural (innovation) policy	Horticulture, agriculture, forestry,
Harvesting	Harvesting technology	Primary supply networks	Harvester: robot or hand-held tools	Intensification of the harvesting process	Automatic, robotics	Sustainability, naturalness	(Rural) innovation policy	Robotic, censor technology markets
Storing	Storage manufacturing	Logistics	Optimization	Balancing of the input to processing	Renewable energy, material efficiency	Clean technology	Energy and climate policy	Energy technology
Cleaning	Sorting, cleaning, grading – utilization of side flows	Robotics, blockchain technologies	Fresh products	Food and food ingredients	Automatization	Naturalness, organic, freshness, cleanness, health impacts, sustainability	Nature-based innovation, clean investment, competition, health, SDG	Manufacturing
Processing	Extraction – utilization of side flows, deoil	Assembling critical masses, stabilizing (drying and freezing)	Berry juice concentrates, berry nfc juices and syrups. Purees with seeds.	Food, feed, end ingredients	Extraction facilities-concentration –(hot water, ethanol, supercritical l-CO2 circulation	Naturalnes, organic, freshness, cleanness, health impacts, sustainability, techn. quality	Nature-based innovation, clean investment, competition, health, SDG metrics	Food technology
	Dewater, dry, deoil, grinding		Berry powders for feed, food Grinded material for cosmetics compensate plastic beans	Food, feed, cosmetic ingredients	Mill/grinder, separator, drier, cocentrator SFE	Naturalness, organic, cleanness, health impacts, sustainability, techn. quality	Innovation (purity), clean investment, competition, transparency, health, SDG metrics	Food technology, cosmetics technology
	Functional food and cosmetic ingredient processing	Critical quality of the raw material, wide spectrum	Aromatic ingredients, functional polyphenolics, seed oil, fibre, stains	Cosmetics	Extraction facilities-concentration –(hot water, ethanol, supercritical l-CO2 circulation	Naturalness, organic, cleanness, health impacts, sustainability, techn. quality	Innovation (purity), clean investment, nature-based competition, transparency, health, SDG metrics	Cosmetics technology
	Consumer product processing	Encapsulation (micro, nano) fron the extract during the drying process	Consumer product for feed, for food, for cosmetic	Consumer products in combination with oat ingredients (together with Valio and Dermosil etc.)	Food technology investments	Taste, applicability, naturalness, organic, health impacts, cleanness, sustainability, image building	Health, food, Innovation (purity), clean investment, nature-based competition, transparency, SDG metrics	Food, feed, heath care, hotel services, sports, fashion and life style enterprises and NGOs

During Phase 3 (additional activities) of the project, the initial grid was further developed into a value chain mapping methodology with policy-making linkages. The development steps consisted of linking the supply chain grid to regional and interregional development & investment initiatives, by building on regions' mapped

[28] Kainuu action plan, page 10. Grid developed by LUKE professor Dr. Sirpa Kurppa. https://projects2014-2020.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1565773671.pdf

competitiveness (peaks) and addressing weaknesses (valleys). The intended value chain integration ensures market access for final and intermediate goods, and it is a pull factor for orienting diversification and scaling up. Regional competitiveness can be measured in various ways, including entrepreneurship, technological readiness, and quality of institutions[29].

Researchers confirm that measuring regional competitiveness by GDP alone is not sufficient[30]. The definition of the criteria for mapping the value chains in the BRIDGES regions aimed at discussing regional strengths and weaknesses, as well as regional potential, i.e. strengths that can be revealed, realised in the future. We took into account baseline findings about value chains as expressed, e.g. by the IMF research paper on *Measuring competitiveness in a world of global value chains*[31], and the reference to Paul Armington who showed that "in a world in which goods produced by different countries were imperfect substitutes for each other" (page 6). We also took into account the discussion raised by Stöllinger et al 2018[32], indicating how industrial value chains turn into regional value chains and how they differ than global value chains.

We came up and tested a mix of criteria, quantitative and qualitative, and we relied on the Martin report, page 7-1[33]: "The competitiveness of a region resides not only in the competitiveness of its constituent individual firms and their interactions, but also in the wider assets and social, economic, institutional and public attributes of the region itself. Therefore, the notion of regional competitiveness is as much about qualitative factors and conditions (such as untraded networks of informal knowledge, trust, social capital, and the like) as it is about quantifiable attributes and processes (such as inter-firm trading, patenting rates, labour supply and so on). Furthermore, the causes of competitiveness are usually attributed to the effects of an aggregate of factors rather than the impact of any individual factor". Our proposed criteria include business, product, research (on going + programmes), research results, solutions available, education and skills, and policies, Table 5.

Table 5 Criteria for identifying regional value-chain related peaks and valleys

Criteria[34]	Competitiveness measures	Data collection methods
Business	Turnover, exports, employment, location quotient	Statistical data and statistical analysis
Product	Product range, product added value, product innovation, exports	Statistical data and statistical analysis

[29] Moirangthem, N.S. and Nag, B. (2022), "Measuring regional competitiveness on the basis of entrepreneurship, technological readiness and quality of institutions", *Competitiveness Review*, Vol. 32 No. 1, pp. 103-121. https://doi.org/10.1108/CR-11-2020-013.

[30] Barna, K. (2007). Measuring regional competitiveness. Journal of Central European Agriculture, CC BY-ND 4.0.

[31] Tamim Bayoumi ; Maximiliano Appendino ; Jelle Barkema ; Diego A. Cerdeiro (2018). Measuring Competitiveness in a World of Global Value Chains. IMF working papers, https://www.imf.org/en/Publications/WP/Issues/2018/11/01/Measuring-Competitiveness-in-a-World-of-Global-Value-Chain-45544 . Page 6.

[32] Roman Stöllinger (coordinator), Doris Hanzl-Weiss, Sandra Leitner, and Robert Stehrer (2018). Global and Regional Value Chains: How Important, How Different?. Vienna Institute for International Economic Studies. Research report 427. https://wiiw.ac.at/global-and-regional-value-chains-how-important-how-different-dlp-4522.pdf .

[33] Cambridge Econometrics and ECORYS NEI, Prof. Ronald L. Martin (.....). A Study on the Factors of Regional Competitiveness. A draft final report for The European Commission, Directorate-General Regional Policy. https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/3cr/competitiveness.pdf .

[34] Competitive advantage criteria.

Criteria[34]	Competitiveness measures	Data collection methods
Research	On-going research programmes dedicated to addressing the selected domain.	Field data (interviews) with research units in the region. We are seeking concentrations of research
Research results, solutions	Patents, registered IPR, TRL achievement level in projects related to the selected industry.	Review of patents; field data (interviews) with research units in the region.
Skills available	University faculties and educational programmes including technical education dedicated to improving entrepreneurship, management and implementation skills in the selected industry.	Review of educational programmes in the region; field data (interviews) with educational units in the region.
Policy enablers	Strategies and project calls for (i) increasing research inputs to product development; (ii) bringing innovations to market; (iii) commercialising research; (iv) supporting national & interregional collaboration for technology transfer; (v) entrepreneurship programmes in diversified domains of traditional sectors; (vi) incentives for attracting investments related to in-shoring and / or re-shoring evidence-based potential.	Field data (interviews) with educational units in the region.

These criteria were mapped against the supply chain grid categories. The value chain mapping approach is summarised in Table 6 below, and an excel template is also available to facilitate the application of this model and attached to the value chain mapping directory.

Table 6 Summary of the value chain (VC) mapping approach.

Criteria	R&D based supply chain references						
	Key technologies	Products	Application	Key in-vestment	Promotion	Policy, 3S, industrial modernisation/ agrifood	Partnership/ Markets
Business							
Product							
Research (on going)							
Research solutions (TRL, IPR:ed,..)							
Skills in the labour force and in education							
Policies (enabling context)							

3. Value chain mapping & identification of competitive advantage

3.1 The forest industries side-streams as an industrial domain

Industries such as sawmills, plywood mills, paper and board mills, semi-mechanical, and chemical pulp mills are typical in many countries. Various industrial processes in forest industry produces different types of wood-based residues and their by-products (termed hereafter as "side streams"). A side stream can be considered to be any type of wood waste, wood-based intermediate chemical (i.e. black liquor and green liquor), and/or by-product, either organic or inorganic, that was produced when raw wood was processed into a (wood-derived) final product (i.e. lumber, plywood, paper, board, and mechanical or chemical pulp). Some side streams are further processed, and new side streams are produced such as lignin from bioethanol production from the saw dust[35].

Side streams in sawmills

Sawmills transform wooden logs into lumber by applying a variety of manufacturing operations. Prior to sawing, the wood logs are sorted and stored according to species, diameter, length, and end use. A brief description of typical side streams and their stages of generation in sawmills is presented in Table nn.

Table 7 Typical side streams and their stages of generation in sawmills[36]

Type of side stream	Stages of side-stream generation
Wood chips	Sawing and bulk chipping of wood logs
Sawdust	Sawing of wood logs, headrig, gang sawing
Bark	Debarking, peeling of wood logs
Slabs and endings	Gang sawing, edging, remanufacturing, trimming of wood logs
Dry wood residue	Grading and sorting of wood logs, sorting of lumber
Wood ash	Kiln drying, combustion process for upgrading of lumber

Side streams in plywood mills

Premium quality birch and coniferous wood logs are processed in the plywood mills. Logs of suitable size and quality are sorted in the log yard upon arrival and subsequently processed through a series of operations, including debarking, sawing, conditioning, peeling, clipping, drying, veneer upgrading, assembling, pressing, trimming, and grading. A brief description of typical side streams and their stages of generation in plywood mills is presented in Table 8.

[35] PLEASE ADD REFERENCES, I CAN DO IF YOU WANT ME TO DO IT, BUT WE NEED TO ADD REFERENCES.

[36] PLEASE ADD SOURCE

Table 8 Typical side streams and their stages of generation in plywood mills[37]

Type of side stream	Stages of side-stream generation
Pulp chips	Rotary cut of wood logs, peeling, and clipping of logs
Fuel chips	Cutting edge, type setting of processed materials
Sawdust	Sawing, processing of wood raw materials
Bark	Debarking, peeling of wood logs
Sander dust	During incubated wood-processing operations
Wood ash	Drying of veneer sheets

Side streams in paper and board mills

Some processes and techniques applied in the independent, integrated, or multiproduct pulp, paper, and board mills appeared to be common, e.g. debarking and pulping operations. However, the paper and board mills can be integrated with the pulp mill after the pulp is pumped to the paper or board machine. Another option is the non-integrated paper and board mill, where dried pulp is transported to the mill and converted into a diluted suspension of water, wood fibres, fillers, dyes, and other chemicals to make paper or board. A brief description of typical side streams and their stages of generation in paper and board mills is presented in Table 9.

Table 9 Typical side streams and their stages of generation in paper and board mills[38]

Type of side stream	Stages of side-stream generation
Fiber sludge	Cleaning and processing of raw materials
Bark	Debarking, peeling of wood logs
Primary sludge	Primary waste water treatment
Fly wood ash	Burning of fuel for energy production in boiler
Recycled fiber	Waste water treatment
Biosludge	Secondary waste water treatment
Bottom wood ash	Burning of fuel for energy production in boiler
Rejects	Processing of raw material, recovery from screening, causticizing

Side streams in semi-mechanical pulp mills

There are different processes to produce mechanical pulp. These mills implement two processes: stone groundwood pulping and thermomechanical pulping (TMP). In stone groundwood pulping, the pulp is produced by grinding wood into relatively short fibres. However, in TMP, wood particles are softened by steam before a pressurized refiner is applied. In addition to TMP, chemo-mechanical pulping (CMP) and chemo-thermomechanical pulping (CTMP) are also used.

[37] PLEASE ADD SOURCE

[38] PLEASE ADD SOURCE

A brief description of typical side streams and their stages of generation in Typical side streams and their generation in semi-mechanical pulp mills is presented in Table 10.

Table 10 Typical side streams and their stages of generation in Typical side streams and their generation in semi-mechanical pulp mills[39]

Type of side stream	Stages of side-stream generation
Fiber sludge	Cleaning and processing of raw materials
Bark	Debarking, peeling of wood logs
Fly wood ash	Burning of fuel for energy production in boiler
Dry wood residue	Grading and sorting of wood logs
Bottom wood ash	Burning of fuel for energy production in boiler
Biosludge	Primary and secondary waste water treatment
Rejects	Processing of raw material, recovery from screening, causticizing

Side streams in chemical pulp mills

In chemical pulping, wood logs are processed for chipping and then cooked with chemicals in a high-pressure vessel, in a batch or a continued basis. The cooking removes lignin and separates the wood into cellulose fibres. The resulting slurry contains loose but intact fibres that retain their strength. During the process, approximately half the wood dissolves into black liquor. The cooked pulp is then washed and screened to achieve a uniform quality. It then undergoes an additional pulping process (mostly in the case of sulphate processing or kraft pulping), in which the black liquor is separated from the pulp before the bleaching process. Black liquor is burned for energy (electricity) for the mill's own consumption. After burning the black liquor in a recovery boiler, the concentrated lignin remains as green liquor, which is used for causticizing and cooking chemicals.

A brief description of typical side streams and their stages of generation in Typical side streams and their generation in chemical pulp mills is presented in Table 11.

Table 11 Typical side streams and their stages of generation in chemical pulp mills[40]

Type of side stream	Stages of side-stream generation
Black liquor	Kraft pulping process
Bark	Debarking, peeling of wood logs
Biosludge	Biological wastewater treatment
Green liquor and dregs	Causticizing process, chemical recovery
Dry wood residue	Grading and sorting of wood logs
Tall oil	Kraft pulping process, burning and evaporation
Lime mud	Recovery and causticizing processes
Fly wood ash	Burning of fuel for energy production
Primary sludge	Primary waste water treatment
Rejects	Processing of raw material, recovery from screening, causticizing
Bottom wood ash	Burning of fuel for energy production in boiler
Turpentine	Kraft pulping process, burning and evaporation
Screenings	Fiber lining

[39] PLEASE ADD SOURCE.

[40] PLEASE ADD SOURCE.

In considering the utilisation of side streams, the generated side streams were categorized as high-value, medium-value, and low-value side streams. The high-value side streams, such as tall oil and turpentine, are used to produce liquid biofuels (green renewable diesel); however, some of them are sold to other manufacturers. In fact, liquid, medium-value side streams, such as black liquor and green liquor, are mainly used for the mills' own energy consumption during kraft pulping. Almost all black liquor is used for electricity production; in some cases, lignin is extracted from black liquor for bio-chemical processes and other products. On the other hand, green liquor is further processed for causticizing processes as a cooking chemical. Thus, black liquor and green liquor are not true waste streams under the present kraft pulping production layout. However, solid, medium-value side streams, such as bark, wood chips, sawdust, slabs and endings, dry wood residue, and recycled fibres are used both to produce energy and for purposes not related to energy. In terms of energy, these side streams are mainly used as fuel for electricity, heat, and pellet production. Other purposes are mainly as raw material for pulp, chipboard, and roof materials, and even for landscaping. Some solid wood side streams, such as wood chips, sawdust, and slabs and endings, are used for the mill's own industrial symbiosis (in which the side streams are used as raw materials for other products). Some mills sell these side streams to other manufacturers if they do not have the facilities to utilize the side streams.

Liquid, low-value side streams, such as fibre sludge, bio-sludge, primary sludge, green liquor dregs, and lime mud, are seldom explored for economic purposes. Liquid, low-value side streams, such as fibre sludge, bio-sludge, primary sludge, green liquor dregs, and lime mud, are seldom explored for economic purposes. Only a small portion of fibre sludge and bio-sludge is used for economic purposes, especially to produce heat energy and organic compost/fertilizer. In fact, almost all green liquor dregs, and most of the fibre sludge, bio-sludge, primary sludge, and lime mud are useful for landscaping. However, a lesser amount of solid, low-value side streams such as fly ash, bottom ash, recycled fibre, rejects, screenings, and sander dust are used for non-energy purposes, including civil engineering, organic fertilizer, mulch and mould manufacturing; the rest is disposed of, especially for landscaping.

Wood-processing industries, such as sawmills and plywood mills, generate a high proportion of solid wood-based side streams such as woodchips, sawdust, and bark. Almost all these side streams are used as raw materials to produce pulp and other products and/or as fuel for heat and electricity. Unlike wood-processing industries, the paper and board mills produce fewer side streams. The main side streams of paper and board mills are fibre sludge and primary sludge.

Currently mainly saw- mills and plywood mills are located in Kainuu region which are processing forest based raw materials. Some further processing mills have been established in medium scale such as bioethanol production plant using saw dust as raw material in Kajaani. Moreover, there are plans for a modern chemical pulp mill in Paltamo and currently the is environmental license process under evaluation stage. The plan consists also processing many industrial side streams as well in same mill area.

3.2 List of funded initiatives with TRL results, and description of the TRL levels reached.

MITY (the Measurement Technology Unity of the University of Oulu, located in Kajaani)[41], as a research organisation, has invested in the study of specific forest industry side-streams issues during recent years. A knowledge base has started being formed since 2017. Most of the projects listed below are funded by the regional ERDF:

- *EXTREAM project,* 2018-2019, ERDF. It focused on the extraction of valuable compounds from bioeconomy industry side streams. The proof of concept was done to extract chemicals following the super critical fluid extraction method (by SFE) from pine branches and is utilising CO2. The raw material is almost free, as it comes from the waste of the large ST1 unit located in Kainuu. The method was tested also in Austria, with a larger operator. TRL level reached is 3.
- *Innobio project* (2019-2021) developed concepts for SFE extraction of birch bark and piloted it in bigger pilot instrument in Austria. TRL levels was raised from 1 to 3. At the moment, a larger piloting unit for the extraction of petulin is under construction in Kajaani. The concern for near-shoring and accessing markets with stronger demand, is an important factor of this effort. Commercialisation of the research findings could be done in collaboration with a larger business operator located in Tornio (Lapland) as well as following deeper exchanges with the Austrian network.
- *TELI project, 2019-on-going*, ERDF and SILTA funding. It aims at increasing the water solubility of lignin, to produce glue and paint for the wood processing industry. Lignin's water solubility presented challenges; however, results have been reached, and today they are at TRL3. Follow up projects were submitted to the national innovation agency (Business Finland), and potential commercial and near-shoring operators were also included (Portugal). The TELI project is funded by the regional ERDF and also by SILTA (national) funding.
- *BIOSFE project (2020-2021)* aimed for planning and manufacturing of the pilot scale continuous supercritical fluid extraction (SFE) module within the previous batch operated SFE instrument. The project increased the TRL level of the technology from 1 to 3. The TRL level is currently being further developed to level 4, through a diploma thesis work. During the interview MITY explained that further testing of the method and size of initiative are needed in order to apply to industrial level. For this purpose, MITY is running a project that might make it possible to develop the method further as of 2023 onwards.
- *The BJM project* optimises the St1 bioethanol production process by improving the related measurements. The project relies on a professorship work to achieve this result: Biojalostuksen mittausten professuuri, 2019 -2021/ Professorship about Biorefining Measurements. The work included several subtasks e.g. estimating the saw dust mass flow and moisture content indirectly. BJM increased the TRL level of technologies from 1 to 2. The project was co-funded by two large companies, ST1 and Valmet. The "product" of this research would be process measurement technology and applications, knowledge and the utilisation of data and measurement technology. The measurement methodology is applicable also to the mining industry. At the moment, there are efforts to identify correlations and classify data for certain applications of similar profile.
- *There are also projects dedicated to biogas production and optimisation*, focusing on process automation and measurement studies. This is done in collaboration with a business located near Oulu. The aim is developing new measurements for the biogas production.

The conclusion is that Kajaani is hosting a strong and positively evolving knowledge base of side-streams extraction methods, measurement technology, and gradually evolving applications of the extracted side streams. It is important

[41] The Measurement Technology Unit (MITY) develops measurement technology research and technology. The unit operates in two application areas: cleantech and health and well-being.The unit offers related services to companies, research institutes and other organizations through co-financed projects and as individual assignments. https://www.oulu.fi/fi/mittaustekniikka .

to explore this knowledge base, capitalise on its economic potential, and in parallel continue strengthening the expertise. Large businesses located in Kainuu are necessary and active stakeholders. In the next steps, a feasibility plan focusing on the capitalisation of the knowledge base is recommended as a way to effectively encourage economic growth.

3.3 Forest industry side streams supply chain grid

Table below presents the Forest industry sidestreams technology-based supply chain in Kainuu region. The grid starts with forest plantation and growth tasks followed by harvesting, storing and transportation. The most significant part of the value chain is the wood processing and especially saw milling with highest turnover in the region. Furthermore, wood-based construction has important role in Kainuu bioeconomy. The main forest industry side streams are thus originated from these operations. In addition, Kainuu has strong export driven key companies in measurement and automation industry related to forest bioeconomy and utilization of forest-based side streams.

Table 12 Forest industry sidestreams technology-based supply chain[42]

Key technologies			Products	Side streams	Application	Key in-vestment	Promotion	Policy, 3S, industrial modernisation	Partnership/ Markets
Input	Forest plantation, seedling growing	Facilitative: Machinery	Instrumentation, seedling, mature trees		Service	Seedling	Economic sustainability, efficiency	EU and national policies	Forestry
Raw material harvesting	Harvesting technology: harvesters, forwarders,	Supply networks (classification/sorting)	Logs, pruning residues, lumps (=invalid trunk blocks), stumps		Intensification of the harvesting process – JTF & ERD funding	Automatic, robotics	Sustainability, naturalness, efficiency	Innovation	Robotic, automation
Storing/transportation	Storage terminals, alternative non-fossil fuels	Logistics and storing	Storage management, alternative non-fossil fuels		Correct raw material to correct process, management of material flows	Vehicles using alternative non-fossil fuels; Investments for bio circular economy terminals – JTF & JTM funding	Clean technology	Energy and climate policy	Energy technology
							sustainability		
Processing	Saw mills		Sawn timber, boards, planks etc.			Machinery; Investments for modernisation of manufacturing processes following I4.0 principles	Automation	(Rural) innovation policy; Kainuu RIS3 (I4.0)	Automation
	- barking	debarking machine	Raw materials	bark	combustion -> heat & electricity				

[42] Source: Authors (Jarkko Räty).

Key technologies			Products	Side streams	Application	Key in-vestment	Promotion	Policy, 3S, industrial modernisation	Partnership/ Markets
	- sawing	Saw	Wooden products	saw dust	combustion -> heat & electricity, bioethanol producion, trail coating	Industrial investments to manufacturing high TRL products from sideflows of current bio economy production			
	- drying		Wooden products	steam, VOCs	Not utilized currently				
	- cutting	saw	Wooden products	board blocks	combustion -> heat & electricity, chipped?				
	Construction								
	- CLT board elements	gluing, pressing and cutting machiney	CLT-board elements	board blocks	combustion -> heat & electricity	Machinery; Investments for modernisation of manufacturing processes following I4.0 principles	Quality. Precision	(Rural) innovation policy, Building regulations	Regulatory, automation
	- Log construction		Log houses	board blocks, saw dust, wood chips	combustion -> heat & electricity	Machinery	Quality. Precision	(Rural) innovation policy, Building regulations	Regulatory, automation
	- Wooden 3D-elements?		Flat modules	board blocks	combustion -> heat & electricity	Machinery	Quality. Precision	(Rural) innovation policy, Building regulations	Regulatory, automation

Key technologies			Products	Side streams	Application	Key in-vestment	Promotion	Policy, 3S, industrial modernisation	Partnership/ Markets
	- Kitchen fittings		Kitchen cupboards etc.	board blocks	combustion -> heat & electricity	Machinery	Quality. Precision	(Rural) innovation policy, Building regulations	Regulatory, automation
	- Window elements		Windows	board blocks	combustion -> heat & electricity	Machinery	Quality. Precision	(Rural) innovation policy, Building regulations	Regulatory, automation
	Surfacing /Coating								
	- Wood panels	surfacing and painting lines	Clean, painted elements	board blocks	combustion -> heat & electricity	Machinery	Quality. Precision	Innovation	Construction, Manufacturing
	Biofuels								
	- Burning	boiler	district heat, electricity	Ash	combustion -> heat & electricity	Technology	Energy and climate policy	(Rural) innovation policy	Energy technology
	- Bricets/pellets	small scale boiler	building heat	Ash	combustion -> heat & electricity	Technology	Energy and climate policy	(Rural) innovation policy	Energy technology
	- Bioethanol		Fuels	-	Transportation	R&D&I	Innovation	Regulatory	R&D (universities, research institutes),
	Fertilizers		Ash						
	Other		Drying materials for animals, Wooden packages						
	Pulp industry	grinding, cooking	pulp eg. for sft/hard paper or card board industry, sustainable textile industry	Multiple	Paper and pulp products	Production, automation	Sustainability, efficiency, renewable, eco-friendliness	Innovation, regional, national and international policies	R&D (universities, research institutes), other small, medium and large

Key technologies			Products	Side streams	Application	Key in-vestment	Promotion	Policy, 3S, industrial modernisation	Partnership/ Markets
									companies (Ecosystems to utilize different streams)
Measurement technology & Automation	- Measurement instrument - Automation systems	Manufacturing, electronics, programming	Instruments, automation systems, services		Paper and pulp industry	Automation, robotics, R&D	R&D, Data processing, renewable, efficiency	Innovation, regional, national and international policies	Data analytics, R&D (universities, research institutes)

3.4 Competitive advantage and recommendations

Finnish industries should invest in wood-based side stream and waste utilization to increase added value and decrease virgin wood uses to succeed in these scenarios. However, this would require investments in non-wood energy sources to release these secondary wood flows from energy uses[43].

Effective long-term strategies are even more difficult to form on a country level since the economic capabilities greatly rely on the international policy environment and markets. In Finland, our case study country, forest lands are 86% of the land use and are a significant natural resource in volume, and the national strategy for sustainable transition heavily relies on them. The Finnish forest sector contributes around 19% of the total value of export in goods, and wood-based production employed, in total, nearly 74,000 persons (about 3% of the employed) in 2018. Thus, economically, forests and their utilization have a major impact on the whole economy in Finland. Foresight methods, such as scenario techniques, are suitable for exploring potential long-term structural changes in wood-based markets as well as their consequences [44]. The diversification of wood-based products has been studied by applying these methods in, e.g., studies by Hagemann et al. (2016) [45] and Hurmekoski et al. (2018a) [46]. Generally, wood-based product markets are expected to renew, and new and emerging wood-based applications, such as wood-based composites, textiles, and chemicals, are expected to increase their market shares when the policy priority is to substitute non-renewable applications [47]. However, there is a knowledge gap regarding individual countries' sectoral development reflecting on general global scenarios, which expose the wider market environment and difficulties humankind may face in the future. In Europe, four types of scenario approaches have emerged over the last decade: management scenarios, environmental scenarios, optimization scenarios, and participatory scenarios. According to Hoogstra-Klein et al., 2017 [48], despite the benefits of participatory scenario development, only a small number of participatory studies appear to be participatory in nature [49].

Our in-shoring argument in this value chain mapping is fourfold: (i) the national Circular Economy programme with the provisions for public procurements, and the focus on the construction sector (including wooden construction), provides an overall strongly enabling framework with which regional policy is aligned (see item (iv)); in Kainuu, (ii) the abundance of natural resources and associated activities in Kainuu minimises production costs. Transportation distances are moderate for local biobased industries in comparison with production plants

---

[43] Kunttu, J.; Wallius, V.; Kulvik, M.; Leskinen, P.; Lintunen, J.; Orfanidou, T.; Tuomasjukka, D. Exploring 2040: Global Trends and International Policies Setting Frames for the Finnish Wood-Based Economy. Sustainability2022,14,9999. https://doi.org/10.3390/su14169999.

[44] Finnish Forest Industries. Forest Industries in Numbers. 2020, p. 1. Available online: https://www.metsateollisuus.fi/uutishuone/metsateollisuus-numeroina#tyollisyysvaikutus (accessed on 30 December 2021).

[45] Hagemann, N.; Gawel, E.; Purkus, A.; Pannicke, N.; Hauck, J. Possible futures towards awood-based bioeconomy: A Scenario Analysis for Germany. *Sustainability* **2016**, *8*, 98. [CrossRef]

[46] Hurmekoski, E.; Jonsson, R.; Korhonen, J.; Jänis, J.; Mäkinen, M.; Leskinen, P.; Hetemäki, L. Diversification of the forest industries: Role of new wood-based products. *Can. J. For. Res.* **2018**, *48*, 1417–1432. [CrossRef]

[47] Cook, C.N.; Inayatullah, S.; Burgman, M.A.; Sutherland, W.J.; Wintle, B.A. Strategic foresight: How planning for the unpredictable can improve environmental decision-making. *Trends Ecol. Evol.* **2014**, *29*, 531–541. [CrossRef]

[48] Hoogstra-Klein, Marjanke A. & Hengeveld, Geerten M. & de Jong, Rutger, 2017. "Analysing scenario approaches for forest management — One decade of experiences in Europe," Forest Policy and Economics, Elsevier, vol. 85(P2), pages 222-234.

[49] Ministry of Agriculture and Forestry. *National Forest Strategy 2025*; Ministry of Agriculture and Forestry: Ankara, Turkey, 2015.

in most regions in Finland; (iii) access to specialised research resources allows for product development and innovative solutions, and (iv) conducive regional policy supporting through policy, regional and national funding initiatives on circular economy, follow up actions and the additionality between the two. Bio-based economy, research, green transition and digital transformation are all distinct thematic units of the Kainuu 2021-2027 RIS3.

Kainuu has two key ecosystems (Renfors ranta Kajaani and Kuhmo) related to forest bioeconomy side-stream value chain utilization. Each one of the eco systems has developed around large, key-businesses. The Kuhmo ecosystem consists of more companies. The key player is Kuhmo Oy. It manufactures a wide range of high-quality products for the packaging and construction industries, the carpentry and furniture industries, and the construction and prefabricated home industries. Woodpolis in Kuhmo is coordinating the collaboration and development actions between companies. Side streams of the Kuhmo ecosystem are well identified and utilised.

Pölkky Oy has a sawmill in Kajaani located in the former paper factory area Renfors ranta, operating now as an industrial park. Pölkky Oy is the key actor in Kajaani ecosystem. The Kajaani ecosystem has fewer companies compared to Kuhmo.

Finally, a Paltamo ecosystem is currently being planned, with the objective to build and operate a state-of-the-art pulp (NBSK) and bioproducts mill. If the plans are realized, it opens significant opportunities to utilize side streams.

In terms of education and research, the Kajaani university consortium is a relatively compact research and innovation unit in Kainuu consisting of the university of Oulu and the university of East Finland. They offer to the region's economy, excellence in forest bioeconomy. The Unit provides applied research services and ensures a rather comprehensive research infrastructure to bio-based economy related actors in Kainuu. Collaboration with businesses is based on contract research and on development projects.

Recommendations for initiatives derive from the grid mapping (Table 12) and the preceding analysis:

First of all, at a very operational level, and based on screening of Table 12 grid-mapping the following types of initiatives are prioritised:

- RAW MATERIALS Intensification of the harvesting process – JTF & ERD funding.
- STORING AND TRANSPORTATION Vehicles using alternative non-fossil fuels; Investments for bio circular economy terminals – JTF & JTM funding.
- PROCESSING Machinery; Investments for modernisation of manufacturing processes following I4.0 principles.

Secondly, at a more strategic level,

- To benefit from the national level priority for wooden construction and focus aspects of side-streams value chain on it, e.g. as in the case of lignin which is being developed for glues and paints of the wood construction business.
- Good practises from Kuhmo ecosystems could be adopted in Kajaani ecosystem to increase the value of the produced side streams.
- Research and innovation activities are required between research institutes and companies to develop more high value products from forest industry sidestreams.

- New activities are needed to increase knowledge in companies and their personnel to develop novel products from their sidestreams and activation actions like KAMBIO-project is required to increase dialogue between companies and research institutes in Kainuu. More deepen involvement of Kajaani university consortium members, university of Oulu and university of Eastern Finland, to the region, especially forest bioeconomy sector is needed and models to enhance this should be developed. This would increase the critical mass of knowledge, which local companies could be utilise.
- Wood based side streams produced in Kajaani ecosystem has already potential for producing biogas for transportation fuels and hydrogen economy. In Kuhmo ecosystem biogas production from bioeconomy side streams is under investigation.
- If Paltamo mill plans are realized, it opens significant opportunities to utilize side streams in Kainuu and research institutes should start planning actions for utilization of the streams together with the company. Smart specialization strategy is already steering the research towards it.
- The green transition in European level opens new possibilities also in Kainuu companies and research institutes. Funding for new innovations for bioeconomy sector is available and more deepen collaboration between companies and research institutes is required.
- Skill and knowledge level of employees in forest bioeconomy sector companies needs to be raised. This enables better understanding of the current processes and possibilities to innovate new products.

Annex 1 BRIDGES project approval of the 5th call application

Interreg Europe
European Union | European Regional Development Fund

Sharing solutions for better regional policies

Your contacts
Messmer, Luka
+33 328 144 100
l.messmer@interregeurope.eu

Milloir, Camille
+33 328 144 112
c.milloir@interregeurope.eu

Lead partner contact
Regional Council of Kainuu
Kauppakatu 1
87100 - Kajaani
Finland (SUOMI / FINLAND)

Date: 21/09/2021
RE: Approval of request for change related to 5th call additional activities
Project: PGI00040 BRIDGES

Dear Jouni Ponnikas,

We are pleased to confirm that the request for change for your project has been approved. The request covered multiple areas:

- partnership, i.e. withdrawal of partner Lubelskie Voivodeship(PL)
- 5th call additional activities

As a result, the approved budget is as follows:

Total ERDF:	EUR	1,719,086.75
Total Norwegian funding:	EUR	0.00
Total Interreg Europe project budget:	EUR	2,022,455.00

This change is applied as of 26/02/2021.
Please note that the latest version of the application form (with the control number da060389ba40415daf52affc987c8618) as available in the programme's online system iOLF forms annex1 and that this letter forms annex 2 of the subsidy contract.

We wish you all the best for the continuation of your project.

Yours sincerely,

Erwin Siweris
Programme Director