Bachelor's thesis

International Business

2020

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IMPACTS OF LOCALLY SITUATED R&D IN FOREST INDUSTRY

– A Comparative case study between Joensuu, Finland and Prince George, Canada

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TURKU UNIVERSITY OF APPLIED SCIENCES

BACHELOR'S THESIS | ABSTRACT

TURKU UNIVERSITY OF APPLIED SCIENCES

International Business

2020 | 51

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IMPACTS OF LOCALLY SITUATED R&D IN FOREST INDUSTRY - A COMPARATIVE CASE STUDY BETWEEN JOENSUU, FINLAND AND PRINCE GEORGE, CANADA

The object of this thesis was to explore different factors of how locally situated Research and Development (R&D) institutes shape the forest industries in Joensuu, Finland, and Prince George, Canada. Another object was to explore what kind of role the local governments have on accepting the new forestry products relating to bioeconomy. The aim was also to discover underlying factors of how Joensuu has succeeded leveraging the industry as becoming the "European forest capital". Through comparative analysis in socio-political aspects the study analyses government's role and the social acceptance in the communities. The thesis showcases different projects implemented in the city related to wood construction and bioenergy as a measure of support from the city to the forest industry.

The study discovered how regional policies in Finland have affected positively the forest industry in Joensuu, enhancing cluster development, and locating important research facilities in the city. Large investments and the local governments' active role in enhancing the local knowledge networks and implementing strategies and programs related to forest-based bioeconomy have influenced the industry to gain recognition internationally. It was also evident that the presence of R&D institutes are attracting investment and expertise in the region. Comparing the industry in Prince George, it is evident that these two industries are differing in terms of research capacity and focus, and how local governments are supporting the industry by different strategies, policies, and programs.

KEYWORDS:

forest industry, bioeconomy, forestry R&D, bioenergy, government policies, cluster, Joensuu, Prince George

CONTENT

PICTURES

LIST OF ABBREVIATIONS

B2B	Business to business sales
B2C	Business to customer sales
CHP	Combined Heat and Power
CLT	Cross-Laminated Timber
CNC	College of New Caledonia
EFI	European Forest Institute
FIBRE	Forest Innovation by Research and Education
KUAS	Karelia University of Applied Sciences
LUKE	Natural Resources Institute Finland
Metla	The Finnish Forest research institute
PCP	Partners for Climate Protection Program
R&D	Research and Development
RDI	Research, development and innovation
SMEs	Small and Medium enterprises
SYKE	The Finnish Environment Institute
UNBC	University of Northern British Columbia

1 INTRODUCTION

Often different industries have a large presence in a certain region or a nation, for example, avocado farming in the Petorca province of Chile and the oil and gas industry in Norway. Underlying factors such as the role of resources, economic structures, institutions, history and government policies may have impacted how it has developed in their unique locations. Yet there are underlying factors in terms of research and development (R&D) that allow one to become more advanced over the other. Regions with specific industries can attract or create more R&D capacity, which can lead to a higher profit, economic development and impact the infrastructure of the region. Two similar regions within the same industry in different nations can differ tremendously in terms of productivity and innovative activities. Therefore, this thesis is about understanding what kind of underlying factors enhanced the forestry industry through research and development (R&D), in Joensuu, Finland, and compare those differences of the factors in R&D activities in Prince George, Canada.

Joensuu is located in the North Karelian region in Eastern-Finland and has a large concentration of foresty related companies and research institutes. Research and Development (R&D) enterprises in North Karelia together with the clustered forest industry have become an important hub for forest research and expertise in Europe (ENF, 2020), and Joensuu is known as the forest capital of Europe. North Karelia consists of one of the most important concentrations of forestry research and education organisations in Europe. (Business Joensuu. n.d.). Natural Resources Institute Finland (LUKE), European Forest Institute (EFI), and comprehensive forestry education programs in University of Eastern Finland and Karelia University of Applied Sciences have made Joensuu one of the forefront regions in forest research and development in Finland. There are over 600 forestry experts and over 500 forestry-related companies located in Joensuu, which consists the whole supply chain for the forestry: education and research, machinery manufacturing and wood processing. (Global Education Park Finland, 2014) The conditions are also favourable for the development of a bioeconomy, as local authorities are supporting the green sustainable development with different strategies, such as a goal to have an oil-free and carbon neutral North Karelia (Global Education Park Finland, 2014)

among other plans. As Joensuu is the capital of North Karelian region with a population of 76 000 people, it is visible to see the new innovations and projects being implemented within the city, such as new wood building projects and usage of bioenergy-based district heating.

Similarly, the Prince George region has a large concentration of forest related companies and is an important forestry centre in British Columbia, Canada, with population of nearly 80 000 (City of Prince George, 2017). Prince George has a large concentration of forestry enterprises that consist of the entire supply chain in forestry. Prince George is a home to pulp mills, sawmills, pellet plants, trucking operations, tree nurseries, forestry research and government offices, research forests, comprehensive forestry education and research programs in University of Northern British Columbia and College of New Caledonia. In 2014, Wood innovation and Design Centre was built in the downtown Prince George and the University of Northern British Columbia has its own Wood innovation research laboratory for testing and developing wood products. The three pulp mills in Prince George are some of the largest and most technologically advanced in Canada. (City of Prince George, 2017).

However, while Prince George is the hub of the forest industry in British Columbia, the important research and development institutes in Canada are located in the lower mainland and have no significant presence in the city. For example, the federal government's western forestry research centre is located in Victoria, British Columbia, and the forest industry's main research arm FP Innovations is headquartered in Quebec, but have one of the main sites in Vancouver at the University of British Columbia. All of these important research institutes and operations are located outside of Prince George, which leaves the city at a disadvantage regarding the R&D presence in the region. Meanwhile, the forest industry in Joensuu has succeeded leveraging their industry as a foundation for research and innovation, which leads to the question: what kind of circumstances and factors have been in favour for Joensuu to achieve it's position as a centre of forest research and why does it matter in regards of the industry and product development?

1.1 Research questions and objectives

The purpose of this research is to gain a better understanding about the conditions that enhance forest industry's R&D to concentrate into a certain region and how these R&D enterprises influence the industry competitiveness and product development. Through a case study, this research explores the underlying factors showcasing how Joensuu have become a center for forest research and innovation over Prince George. The purpose is to create a basis for a comparative analysis by analysing how R&D is supported in these cities, and what kind of conditions regionally are enhancing the activities of R&D enterprises and institutes. The analysis is made in 2-dimension approach, where the differences are identified in terms of political and social aspects. The results could bring a new perspective on identifying how the presence of R&D institutes are enhancing the product development in the industry and what kind of actions local governments are taking in order to support the development. By identifying the underlying factors that have enhanced research and innovation in Joensuu, this could also bring information on what kinds of actions have been taken in the past and how it differs from the actions in Prince George. The research idea was given to the researcher by the Director of External Relations of the City of Prince George together with Business Finland in Canada.

Objectives:

1. To identify underlying factors and actions that enhance the Research and Development (R&D) of forest industry in a certain region.
2. To identify underlying factors as a case study that have enhanced R&D capacity in Joensuu compared to Prince George.
3. To identify the differing roles of government – especially local governments – in establishing Joensuu and Prince George as centres of forest research and innovation.

Research questions:

- What are the characteristics of the forest industry cluster in Joensuu and Prince George and how do they differ?
    - Are there particular conditions that favour Joensuu over Prince George as a centre for forest research and innovation, such as government incentives, political factors or social dynamics?
- How has the presence of research and innovation enterprises influence actual product development, the competitiveness of the forest industry, and local utilization of wood products?

1.2 Thesis structure

The structure of the thesis is divided into 5 parts; introduction, literature review, case study, comparative analysis, and conclusion. The literature review explains the theoretical framework behind the study by defining what R&D and cluster theory are. The case study section introduces forest industries in Joensuu and Prince George and explores the forestry clusters and R&D institutes in both regions. As wood construction and bioenergy are lifted as examples of how these industries support the transition towards bioeconomies and new innovations, projects that are implemented in the cities are introduced in this section. After that, comparative analysis discovers more what kind of role local governments have in supporting the product development and promoting the new bioeconomy solutions and what kind factors affect the social acceptance of new forestry innovations.

2 LITERATURE REVIEW

2.1 Definition of R&D

The purpose of research and development (R&D) is to develop new products, improve already existing ones by increasing the knowledge base and to create new or more efficient processes. R&D comprises creative and systematic work to increase the knowledge in achosen field. The term R&D can be explained with the three following activities: fundamental research, applied research and experimental development. Fundamental research is defined as an experimental or theoretical work to research underlying factors and foundations of a phenomena. (OECD 2015, p.45). While doing basic research, there is no specific application of the findings in mind. Therefore, applied research has a directed aim or objective to acquire specific knowledge, and it is considered as an original investigation that determines possible uses of the basic research. Experimental development is where acquired knowledge from the research is put into action by producing new or improving existing products or processes. The order of these three activities can vary, and it does not mean all of the activities are always being implemented in the R&D process. (OECD 2015, p.51).

The R&D is typically performed in universities, government departments, business enterprises and private non-profit organizations. Usually R&D-intensive companies choose their location based on opportunities where they can benefit from knowledge flows of other research institutes such as universities and other public research institutes in the same industry. When industry becomes concentrated in a certain region, it can start to attract more expertise and investments. (Karlsson & Andersson, 2005. p.8). Joensuu is an example of concentration of forest industry R&D, where research institutes and wide expertise attract investments and new enterprises in the area. When R&D laboratories, factories, innovation centers and resources are located in the same area, development of new innovations, products and processes can be efficient. This creates a fast-moving innovative environment where companies and research institutes are collaborating consistently. R&D projects requires usually a high amount of private and public funding. Companies and

institutions can receive funding from federal programs, grants, tax incentives or different private investors. Funding is a major indicator on if R&D projects will be executed. (OECD, 2015).

2.1.1 How innovations support the economic growth

Innovations achieved through R&D support the competitiveness of industry by creating new producing and improving methods for products and services or making the production process more efficient (Porter, 1990). While increasing innovations, it has an impact on production levels, which in return leads to a growth in economy. Therefore, innovation and economic growth are reciprocal: innovations make growth possible, but growth enables more investment and demand in R&D that leads to more innovations (Boyd, 2015). Innovations and productivity lead a direction of how the development in the industry progress, as while experiencing growth through innovations and productivity it may attract more investment.

Porter (1990) argues that industry's capacity and ability to create innovations reflects the nation's competitiveness. The underlying factors on how the competitiveness is achieved lies on nation's economic structure, culture, values, different institutions and history. Therefore, other nations have better basis for growing their industries through creation of innovations than others. Porter (1990) also indicates that highly localized processes result in competitive advantage, where cooperation with other related and unrelated companies to the industry creates benefits for each other by operating more productively. Therefore, certain area can to start attracting more experts on the field, which creates virtuous circle where knowledge and expertise attracts more investment and expertise.

2.2 Cluster theory

The cluster theory by Porter explain the benefits and social dynamics in a competitive industry concentration (Porter, M. 1998). According to Porter (1998), clusters are formed when a particular region becomes a concentration of institutes and

enterprises of a certain field that are interconnected. The concentration creates competitive advantages to the firms involved in a cluster, as a strong supportive networks and interaction between firms and institutes can enhance the productivity and innovative activities. In addition, geographic concentrations form a competitive advantage that other rivals cannot copy (Sjölund & Virkkala, 2009). Clusters can form enormous amounts of new knowledge and advantage that it can create globally preeminent position for the industry. A good example of a clustered industry is the Silicon Valley in the United States, which is the best-known technology cluster in the world. (Porter, M. 1998).

Governments are also recognizing the benefits and competitive advantages that can be acquired through clustered industry. Clustered industry brings economic benefits for not only for the companies itself, but also for the nation, which creates an incentive for government to encourage industries to form new knowledge and industry clusters. Also, government supported cluster increases investment attractiveness by creating an image of an environment that is favorable for business activities (Maxwell Stamp, 2012). Porter (1998) suggests that government should promote existing industry clusters to enhance their actions and networks rather than trying to form entirely new clusters, as clusters usually evolve itself to specific region with an internal stimulus. These could be the availability of resources such as raw material, specific climate conditions, cultural factors or being close to a market for example. Porter (2000) also recommends that government should locate educational units and research institutes to support the clustered industry and to improve the infrastructure in the region. When highly educated and skilled people are located in the same area as the competitive industry itself, the more likely these people will stay in the cluster and add more value for not only to the R&D activities, but all operational work that is required in the field. Therefore, when a certain industry is in the process of developing a base for more advanced technology and solutions to increase the competitiveness, companies in private sector should also make investments in training programs, laboratories and infrastructure when there is recognized potential to enhance the productivity and new product development. The competiviness of the cluster also depends on the final product sales in the markets of B2B and B2C, which can be outside or inside the cluster. When public and private sectors in the cluster work cooperatively, they can enrich the competitive advantage they have in the cluster. (Porter, 1998).

For example, in the 1980's, Finland started executing regional policies on cluster development, which led to the development of different sectors in numerous areas of Finland, such as forestry cluster in Joensuu. The purpose of the regional policies were to enhance the economy of the regions that had fallen behind in terms of industry development. (Kinnunen, 2006). To keep these regions competitive and create jobs for people to be able to live there, forming major clusters helped these regions to become important sectors for the Finnish economy. Therefore, developing industry clusters is one major indicators of how R&D becomes concentrated in a certain region, as R&D institutes are supporting the competitiveness and innovativeness of a cluster.

Industry benefits by being localized in specific region or city. It creates competitive advantage and enables industry to become important contributor to nation's GDP. In order for the industry to grow, they need to grow their productivity and innovations, which means increasing R&D capacity. For R&D activities, clusters are important hubs for knowledge flows and concentration of professionals in the field. Karlsson and Andersson (2005) points out how production and innovative activities in a company itself can be more efficient if the company is located in a cluster with other research institutes and universities to have an access to these knowledge flows. On the other hand, because of that, some companies choose to locate their private R&D separately from clusters for this reason, as they want to prevent knowledge outflows to the rival companies.

2.3 Product development and innovation

Product development means creating products that have new benefits and different qualities as previous products. It can be entirely new product or an adjustment from already existing product. (BusinessDictionary, n.d.) Product development includes the whole process from designing to marketing, whereas innovation is often defined as a new product, service, or other improved methods that bring value to a customer instead of the whole process. (BusinessDictionary, n.d.b)

For any industry, product development and innovation are crucial steps in order to stay competitive by introducing new products and methods on the market. Examples

of new forestry products are different construction materials designed from wood, the creation of bio-oil and bio-diesel from woody biomass, and implementing new machinery in mills that use renewable power, and the creation of new digital technology in forestry practices.

3 CASE STUDY

Joensuu

3.1 Forest R&D institutes in Joensuu

To understand how R&D developed in Joensuu, it is important to learn about the history behind the Finnish forest industry and how Joensuu has benefitted from the political decisions made in the past. When a regional development policy was created in the 1960s, it started concentrating and enhancing certain industries to specific areas. One of the focus areas was decentralization of government offices and university faculties. In Finland, universities are public government-funded institutions and the faculties are specifically located in the areas where there is a large presence of the industry to enhance the knowledge base and the presence of professionals. Up until the 1950's, universities were only located in southern Finland, and due to regional development, the plans for new universities were established. The idea was to bring universities in these areas to enhance the region by educating the youth and to focus on the issues of the surrounding areas. (Kinnunen, 2006 p.87). In the 1970's, the focus of regional development policy was to enlarge the universities that had already been established instead of creating new ones. The Faculty of Forestry was only located in Helsinki up until 1982 when new forestry programs were established at the University of Joensuu (now the University of Eastern Finland) after years of discussion. The decision was made based on political reasons with intentions of enhancing the economy in North Karelia by bringing the main forest education unit to Joensuu, as the location was in the boreal forest zone and forestry was the main industry in the region. (Kinnunen, 2006). The new Faculty of Forestry became the main campus for forest sciences in Finland and is called The School of Forest Sciences.

Today, The School of Forest Sciences is an internationally recognized R&D unit. Research is focused on wood material sciences, where renewable biological resources are utilized in creating bio-based materials, different energy forms and chemicals. Other focus points are on forest management and planning, timber

harvesting, remote sensing by laser scanning, forest ecology and procurement logistics. (Wood Joensuu, n.d.)

Metla / LUKE

In the 1980s, not only did the main faculty changed its location from Helsinki to Joensuu but also the Finnish forest research institute (Metla) was to be located with the new faculty due to the close-knit collaboration in research between these units (Kinnunen, 2006). The Finnish Forest research institute is a subordinate agency to the Ministry of Agriculture and Forestry that had been created in 1917. The institute advocates ecological, economical and sustainable management and use of the forests through research. On 2015, the Finnish Forest research institute became a part of the Natural Resources Institute Finland (LUKE), which is a research institute that is comprised of the Finnish Game and Fisheries Research Institute, MTT Agrifood Research Institute, and the statistical services of the Information center to promote the sustainable use of renewable natural resources (The Natural Resources Institute Finland, 2015). The location of LUKE headquarters remained in Joensuu.

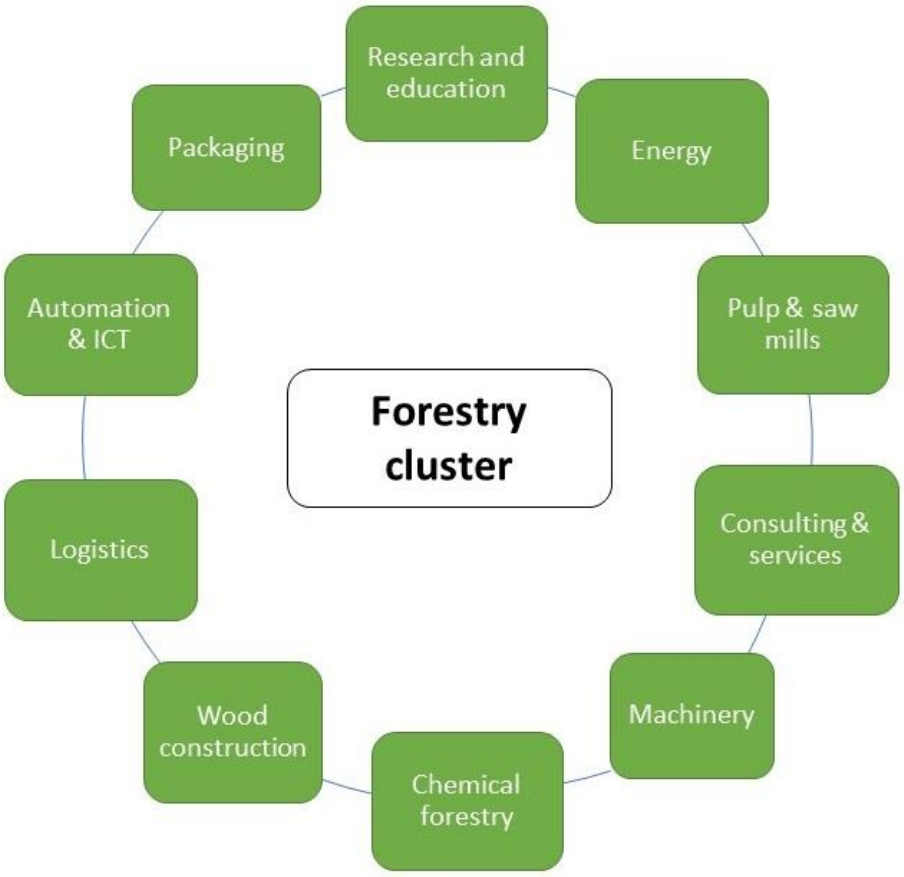
European Forest Institute

In the late 1980s, after the new Faculty of Forestry was established, a former Director of the Central Association of Finnish Forest Industries created the idea of a research organization that would connect European policymakers and provide support on issues at the international level related to forestry. The idea gained a lot of support and the Ministry of Agriculture and Forestry launched a preparatory project to kickstart the process in 1991, followed by the establishment of the European Forest Institute (EFI) in 1993. After long discussions on location, between Helsinki and Joensuu, it was decided that it would remain in Joensuu with the main Faculty of Forestry and the Finnish Forest research institute. From there, EFI has grown to become an international organization that has 29 member countries in Europe with offices in Barcelona, Bonn, Brussels, and the Headquarters in Joensuu. It has enhanced the image of Joensuu to become the European forest capital, as it is an important center connecting forestry experts. EFI has also expanded its operations to Asia and has project offices in China and Malaysia. (Colling, 2013).

Karelia University of Applied Sciences (KUAS)

In 1992, another educational R&D unit, North Karelia Univerisity of Applied sciences (now Karelia University of Applied Sciences) was established in Joensuu bringing more expertise to the region. KUAS is a limited company owned by the City of Joensuu, which also maintains the facility. The board of directors are responsible for the KUAS administration and organization of operations, and the rector is the CEO of the company (Karelia.fi, n.d.). The institute participates actively in regional development in the city, and conduct research, development, and innovation (RDI) activities with a focus on wood construction and renewable energy projects. (European Social Fund, 2020). KUAS was part of constructing the tallest wooden building in Finland in 2018, which is a 50-meter tall student-housing building in Joensuu. This project led the way to multiple other wooden construction projects around Finland. (Mertanen, 2019).

3.2 Forestry cluster in Joensuu



Picture 1 Forestry cluster in Joensuu. Information adapted from slideshow by Karvonen, J. (2014)

The North Karelia region is home to over 500 forestry-related enterprises and comprehensive forestry education from vocational training to Ph.D. programs. The concentration in the area is remarkably for dense regional innovation networks between the research institutions and industrial production, engineering, and services companies. EFI, LUKE, UEF, and KUAS provide a strong base for high-end forest research and have gained a professional reputation internationally. (Global Education Park Finland, 2014). The supporting network also consists of regional development organizations, such as Joensuu Science Park, the Finnish Forest Center, the Finnish Environment Institute (SYKE), and business development agencies. Institutions have close-knit collaboration executing strategic plans on

bioeconomy by creating new forms of renewable energy, wood construction, and biofuel. Another important actor, the Council of North Karelia, which is a council bringing together different municipalities in North Karelia, is responsible for creating regional development plans and oversees development programs related to national and EU structural funds. (Council of North Karelia, 2018). The environmental assets ensure North Karelia's position as a forerunner for new renewable energy innovations, as the supply of biomass is consistent and secured (OECD, 2012). Having the whole supply chain and world-class expertise in forestry in the region, the cluster is attracting more investment as a forestry capital of Europe. The regional innovation network enables research institutes and universities to be strongly linked in business development, which gives a possibility to ensure the research is focusing on specific and needed areas in forestry and is contributing to the forest industry's competitiveness (Mikkola, 2017). Besides the research and traditional sawmilling and logging industry, Joensuu has also one of the biggest forest machinery factories, John Deere, which exports forest machinery globally.

Focus

The different policies and regional development strategies have given a direction for R&D activities in North Karelia with a focus on developing new sustainable use of forests and creating alternative energy forms and systems to replace fossil fuels. Also is it important to note, Finland does not have natural sources of oil and gas, therefore importing oil from abroad is not sustainable nor secure, creating an incentive to develop alternative energy forms and become independent from imported fossil fuels. North Karelia has a domestic supply of wood chips and woody biomass to utilize in biofuels and bioenergy (OECD, 2012). Joensuu is also known for its advanced chemical forestry, where new forms of renewable fuel are developed to replace the fossil fuels, such as diesel oil and ethanol from cellulose, and liquid fuel from pyrolysis (OECD, 2012).

Development strategies

North Karelia has a history of creating new bioeconomy solutions. Different strategies have taken place starting in the 1990s to enhance the use of forest products in energy. For example, in 1993, the Wood energy program for East-Finland promoted the use of wood chips in district heating systems, and in 1998, the first bioenergy strategy for North Karelia was established (North Karelia, 2019). By the time when the targets of EU energy and climate strategy were enacted legislation for the first time in 2009, the Finnish government required different regions to establish their climate strategy to meet the common goals. In North Karelia, 5 communities including Joensuu created a common strategy to reduce greenhouse gas emissions by 16% to 2005 levels by 2020, add energy efficiency 20% from the predicted amount, turn 38% of the whole energy production into renewable energy, and replace 10% of fossil fuels by biofuels. (Joensuun seutuhallinto, 2009). The climate strategy gave an incentive for R&D in forestry to start focusing even more on wood innovations to reduce the emissions in construction, energy forms, and fuel production and usage.

Since then, new projects have been implemented. The EU launched a Smart Specialisation Strategy as a part of the EU's cohesion policy and the Europe 2020 Strategy, aiming for each region to focus on their competitive strengths through embracing innovation that stimulates the region's growth. Through another EU project, Bio4Eco, the Regional Council of North Karelia launched a new Smart Bioeconomy Strategy, to bind the regional Climate and Energy Programme and the Smart Specialisation Strategy. The strategies are developed to enhance the bioeconomy in the region, to focus more on the creation of innovation to meet the targets. North Karelia is aiming to be a fossil oil-free and low-carbon region by the year 2040. (Council of North Karelia, 2018). What this means for the R&D and the industry around Joensuu, projects related to bioenergy and wood construction have taken place through different projects in the city, benefitting the local economy and leveraging the position as a bioeconomy leader in Finland.

The strategies are not only focusing on reducing the carbon emissions in the city by using wood in new innovative ways, but also enhancing the forestry networks between educational and research institutes and forestry enterprises. The Green Hub -network was established to bring together the forestry experts, researchers, and developers to find solutions in challenges regarding business development, sustainable business

practices and circular economy. The participating organizations are LUKE, KUAS, UEF, EFI, Riveria, Forest center, SYKE and Business Joensuu (Pitkänen & Varis, 2018).

Prince George

3.3 Forest R&D institutes in Prince George

The City of Prince George was incorporated in 1915 and manufacturing forest products was a founding industry and employer. The location where two rivers meet in the middle of large forested areas was perfect for loggers and sawmillers to settle in. Forestry has been the backbone of the local economy for much of the City's history. Prince George is formerly known as the "Spruce Capital" of the north, as it is a major lumber and pulp provider. Nowadays Prince George has three pulp mills, seven lumber mills, two pellet mills, and one paper mill. (History of Prince George, n.d.) Even though the economy in Prince George has been driven by forestry and being an important logging and sawmilling concentration for decades, all the major forestry-related research institutes are located elsewhere. The University of Northern British Columbia (UNBC) was established in the 1990s, with Forestry being one of the first degree programs offered at the University. Since then, the research network has grown in the area.

UNBC

The University of Northern British Columbia (UNBC) was established in 1990 and the campus was officially opened in 1994 by Queen Elizabeth II. The opening of the new university was an important step for residents in Prince George, as before only vocational and technical training was offered in the city. UNBC advertises itself as "Canada's Green University", as the campus was built sustainably and the programs include sustainable practices. UNBC has a Green University Planning Committee (GUPC) that provides a forum for the implementation of sustainability in University. One example is a bioenergy plant that uses wood residue from the local sawmills, which gained an international award for campus sustainability in 2014. UNBC offers forestry-related programs in forest ecology and management, natural resources, and

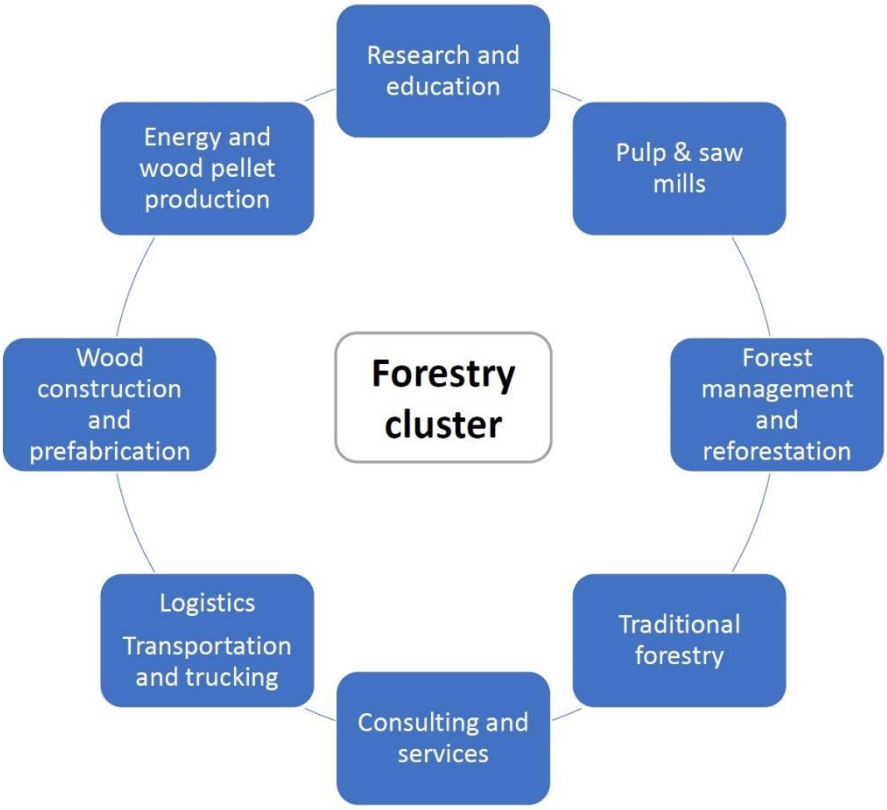
engineering. UNBC's research focuses on issues in the north on environmental, economic, social, and cultural aspects. (UBC, 2017).

In 2014, UNBC built a Wood Innovation and Design Center in downtown Prince George, and it created a new space for the Master of Engineering in Integrated Wood Design program. The building displays a new technology in wood construction and is meant to attract visitors from around the world. When the center was built, it was Canada's largest wooden building ever made. The Wood Innovation research laboratory was also built downtown in 2018 to accompany the Innovation and Design center, which gives wood science and engineering students a space to build and test large-scale wood projects. It is a space for top research on wood construction materials and methods and creating new designs. (The Wood Innovation and Design Center, n.d; The Wood Innovation Research Laboratory, n.d.).

College of New Caledonia

Another post-secondary educational unit, College of New Caledonia (CNC), has a long history in Prince George. It was established in 1969 and it is mainly focused on vocational training and applied research. CNC offers technical training and programs in natural resources and forest technology. In 2009, the research forest was founded for natural resource management students to practice applied research and learn the required skills for working in the field. The research in CNC is focused on in-field forestry practices and management. (College of New Caledonia, 2020).

3.4 Forestry cluster in Prince George



Picture 2 Forestry cluster in Prince George. Information adapted from the City of Prince George's Forestry and pulp & paper sector profile (n.d.)

The Prince George region has over 300-forestry related companies in the region that provides forest products and services. It has the largest forestry concentration in northern British Columbia, located almost in the middle of the province. The forestry in Prince George has been concentrating on traditional logging and sawmilling for decades. Prince George is specialized in the production of softwood lumber, paper, pulp, and wood pellets. The CN (Canadian National) railway network goes through the city enabling exporting wood products to international markets. The forestry cluster consists of multiple consulting companies, the Ministry of Forests, Lands and Natural Resources office, University of Northern British Columbia, College of New Caledonia, several harvesting, trucking, plantation, logging companies, and tree

nurseries among the different wood processing mills. (The city of Prince George, 2017). On 2016, the forestry and logging employed over 2200 people in Prince George alone, and generated approximately $1,528 billion in total GDP in British Columbia (MNP, 2018).

UNBC and CNC have partnerships with Canfor, which has the largest number of mills in the area and is the largest company operating in the area. Through the partnership, Canfor offers workforce development and hands-on training for students. UNBC is also part of a Forest Innovation By Research and Education (FIBRE) forest research network with other universities and research institutes in British Columbia, such as the University of British Columbia (UBC), FPInnovations, and BC Institute of Technology (BCIT) among other institutes. The network brings together world-class research, technology development, and education, which also is an attraction for students and researchers around the world. (Genome BC, 2014). As UNBC is the only major research facility located in Prince George, the networks outside of the city are important for industry development.

Focus

For the past few years, Prince George is in a transition towards more sustainable and greener city development. The economic development is shifting towards renewable energy, and the city is promoting the new cleantech cluster in the region to attract more investment and expertise in the region. Similar to Joensuu, Prince George has a consistent supply of wood biomass from the local mills to utilize in bioenergy plants and projects. (The City of Prince George, n.d) However, British Columbia has been struggling with a pine beetle epidemic for several years, which has caused trees to die faster making it hard for loggers to collect the trees while they are still in usable conditions for traditional forest products. A new shift towards bioenergy and bio-production has enabled the use of these pine beetle affected trees as a source of biomass for energy production. (Coady and Picketts, 2012). The sustainability research in UNBC together with rising interest towards bioenergy and products supports the formation of a new bio-based economy in the region.

In 2002, the City of Prince George made commitments on energy and greenhouse gas reduction, which directed focus on making the city municipalities carbon-neutral

on its operations. The bioenergy-based district heating system was built to achieve these goals in 2012. (The Sheltair Group, 2007).

3.5 Bioenergy and wood construction projects

This section consists of examples of the forestry innovations that have been implemented in the cities to show how local R&D is part of regional development. The examples consist of wood construction and bioenergy projects, as these are implemented in both regions.

3.5.1 Joensuu

Karelia University of Applied Sciences (KUAS) has an extensive collaboration with local companies in wood construction projects. In 2014, sustainability and wood construction became one of the focus areas on education. KUAS has actively been part of most of the wood construction projects that have been executed in the region. In 2018, KUAS started a new project “Towards carbon neutrality in construction – The Wood City Joensuu”, with a goal to create a foundation for the carbon-neutral construction in the city. (Mertanen, 2019). As KUAS is owned by The City of Joensuu, it enables the city to direct the needed research attention on lowering the carbon emissions on construction methods and reaching the goal of becoming carbon neutral by 2025. As the city has a strong will to become the leading region in wood construction, one way the city is increasing the amount of wooden housing is by creating new student housing buildings, which have been in great demand. By creating a solid foundation for new construction designs and methods in the city can be used as a learning tool for future projects. The city is recognizing the value in the creation of a value chain that brings together local contractors, designers, researchers, and suppliers in wood materials to work collaboratively and learn the new techniques in wood construction. (Mertanen, 2019). The government of Finland is supporting the construction of multistorey wooden buildings by giving 20 per cent increased grants for these projects through ARA (The housing Finance and Development center of Finland). Supporting wooden construction is important, as in

Finland building with wood is still more expensive than building with concrete. (Valtanen, 2020).

1. Lighthouse

Picture 3 Lighthouse in Joensuu. Source: https://ereijonen.fi/oma-asuntotuotanto

Lighthouse is the tallest wooden building that has ever been built in Finland. It is a 14-floor multistorey student-housing building that was completed in 2019. The construction process required intense collaboration between local companies as it was the first over 8-story construction project using only wooden materials. The structure is built using cross-laminated timber (CLT) and before the project, it required a lot of testing and research before it was utilized in the project, as it was used to replace the concrete base of the building. The building was built for Student Housing Company Joensuun Elli, and KUAS was part of the project together with other local companies. The Lighthouse was a breakthrough in multistorey wood construction and after the finish, new project plans have been started around Finland utilizing the knowledge gained from the building process. (Mertanen, 2019).

2. Student housing in Noljakka

Picture 4 Student houses in Noljakka, Joensuu. Source: Arcadia Oy

In 2013, the first larger-scale CLT-construction project was made to increase the number of student-housing in Joensuu. The project consisted of six two-story wooden passive houses with 96 units. The successful project in Noljakka encouraged the Lighthouse project to take place later on. KUAS utilized project in student research and on educational purposes by gathering data that would otherwise not be available (Mertanen, 2019).

3. Pihapetäjä

Picture 5 Apartment building "Pihapetäjä". Source: joensuunpihapetäjä.fi

Pihapetäjä is another 6-story apartment building that was completed in 2017. KUAS and the University of Eastern Finland were collaborating in the construction process with the local companies. UEF focused on researching mold resistance, fire-resistance, and biodegradation on wooden materials, whereas KUAS focused on the constructional side. The building brought a lot of new knowledge on sustainable multi-story construction and it has been used as an educational example for engineer programs and wood sciences. It provided valuable data on the construction process and also afterward about the behavior of the material. (Aaltonen, 2017).

4. Kindergarten ”Hukanpesä” in Hukanhauta

Picture 6 Kindergarten ”Hukanpesä” Source: Ville Mertanen, KUAS 2018

Hukanpesä Kindergarten was built in 2018 using CLT-method in the construction process. KUAS was taking part of the construction process and performed research in all the stages of the process, which included designing, project implementation, and operations. (Mertanen, 2018).

5. Metla – building

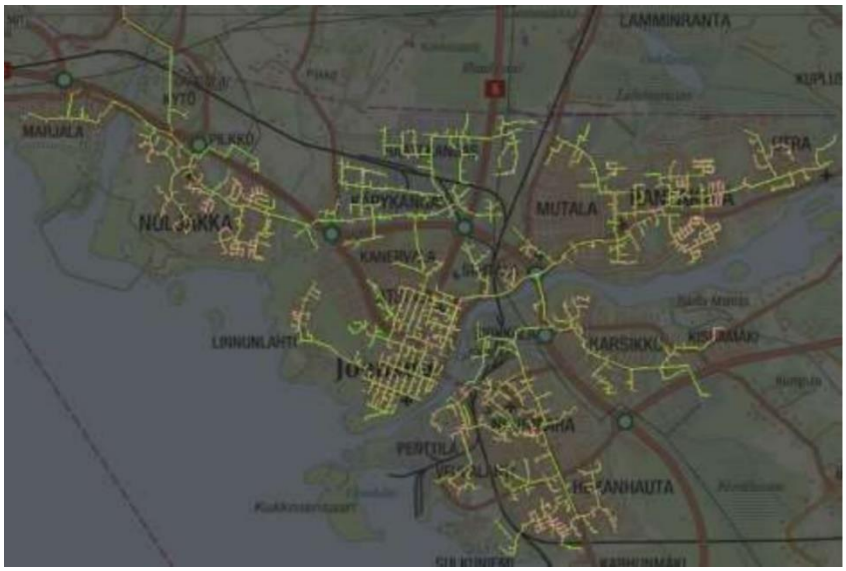
Picture 7 Metla - office building. Source: Senaatti.fi

In 2004, the new office building was completed for the Finnish forest research institute (Metla). The design of the building was selected through an architectural competition held in 2002. When it was completed, it was the largest 3-story wooden

office building at the time ever built in Finland. The building won several awards and gained recognition around Europe. The location is in the campus area of the University of Eastern Finland. (Luonnonvarakeskus, n.d.)

Other examples of the usage of wood in construction in Joensuu dates back to 1999 when first all wooden school in Heinävaara was built. In 2004 the City of Joensuu built a sports hall “Joensuu Areena”, and in 2018 a baseball stadium was renovated and built by using the wood structure on the stand with seats for 2500 people. (woodjoensuu.fi, n.d.)

6. District heating network



Picture 8 District heating network in Joensuu. Source: BioPAD, Case study Fortum Joensuu

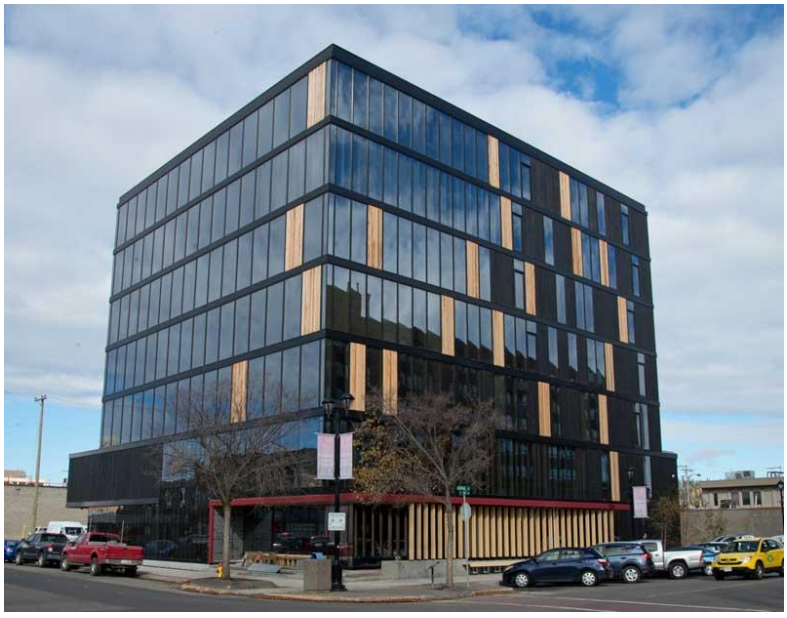
The district heating network in Joensuu was established in 1986 and it covers about 200 kilometers providing heat and electricity for over 40 000 people (Biopad.eu, 2013). Regarding to the statistics made by Finnish Energy (2019), the district heating network connected 2670 buildings, which 2121 were residential buildings, 119 industrial buildings and 450 buildings listed as “other”. The plant is combined heat and power (CHP) system which uses mainly peat and wood. In 2014, a bio-oil production plant was integrated into the power plant, and it was the world’s first CHP-plant with an integrated pyrolysis unit on an industrial scale. It has the capacity to

produce 50 000 tonnes of bio-oil per year from wood biomass. Bio-oil can be used in energy production and replacing fossil fuels in the future. (Biopad.eu, 2013; IRENA, 2018).

3.5.2 Prince George

Wood has been utilized in construction for years, but to create large buildings almost entirely made out of wood is a new development in Canada. In order to adapt new solutions to reducing carbon emissions on construction, wood has gained more recognition as a renewable and sustainable material in tall construction projects to replace the concrete and steel. Natural gas is most commonly used in heating systems in Prince George, where houses have individual furnaces to heat the air. The first district heating system was introduced in 2011 when the university established the first bioenergy plant that heats the campus area through district heating. (UNBC, n.d)

Wood Innovation and Design Center



Picture 9 The Wood Innovation and Design Center in Prince George. Source: UNBC

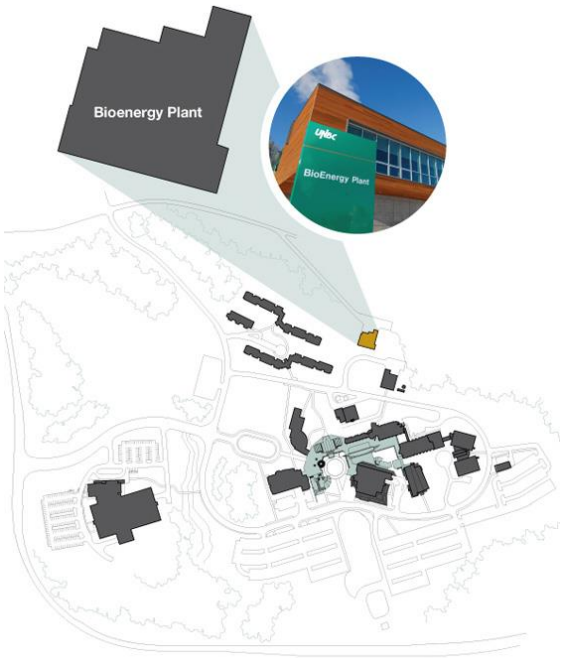
In 2014, the Wood Innovation and Design Center was completed and was the tallest wooden building in Canada. It consists of 8-floors and in the structures, it utilizes cross-laminated timber and glued laminated timber. The building was designed the way it is easily replicated in the future mass timber projects. The building was also a showpiece to demonstrate people that it is possible to build with wood in new innovative ways. 13 businesses across British Columbia took part in the construction process. (UNBC, n.d.)

The Wood Innovation Research Laboratory (WIRL)

Picture 10 The Wood Innovation Research Laboratory. Source: UNBC

The Wood Innovation Research Laboratory was built to meet the passive house requirements, meaning that the energy consumption in the building is 90 percent less than in standard buildings. It was the first educational passive house unit built in North America and it was finished in 2018. The construction project gave a lot of new information and research for the students in the engineering program at UNBC. The laboratory is 10 meters high, enabling testing different qualities and characteristics of large wood structures and products. The project partners included the University of Northern British Columbia (UNBC), the University of British Columbia (UBC), the Center for Interactive Research on Sustainability (CIRS) together with the Government of Canada and British Columbia, and other companies. (Naturally Wood, 2018).

1. Bioenergy plant in UNBC



Picture 11 Bioenergy plant UNBC Source: UNBC

The bioenergy plant at the University of Northern British Columbia (UNBC) was completed in 2011 as UNBC Energy Initiative Phase 2. Phase 1 was established in 2009 and consisted of a wood pellet system to heat the enhanced forest laboratory on the campus. After the successful implementation of the pellet heating system, the bioenergy plant was built to produce enough heat to use in all of the campus buildings, including the sports center and student housing buildings. It uses local sawmill residue as fuel. (UNBC, n.d.)

2. Downtown District Energy System

Picture 12 A map of the District heating system in Prince George. Source: The City of Prince George

The Downtown District Energy System was installed in 2012. The energy system uses wood residue from a local sawmill to heat the water in the piping, which then circulates in the system heating eleven connected buildings in the city. Bioenergy based district heating systems are not common in Canada, and even though it has nearly been a decade since this system was created, it's still one of only a few bioenergy systems in Canada that are operated by a municipality (news.princegeorge.ca, 2020). The transfer into bioenergy based district heating was a number one initiative in the "Energy and Greenhouse Gas Management Plan" created by the City (Radloff, 2010).

4 COMPARATIVE ANALYSIS

Joensuu, Finland, and Prince George, Canada are two communities of similar size and with similar industries on opposite sides of the world. Both cities have invested resources and energy into becoming forestry leaders in their respective areas of the world. To assess how R&D institutes are influencing the industry at the community level, it is important to look at the political and social inputs that have been invested in their forestry industries. While forestry has long been an economic staple for Joensuu and Prince George, growing interest in low-carbon, renewable products – as well as a need for diversification and resilience within the industry and the communities that rely on it – have led to an evolution of the forest industry into a modern bioeconomy. Wood is recognized as a sustainable and renewable source for energy, construction, and other bio-products which result in new ways of implementing wood products in everyday-life. To perform a comparative analysis, there are ways in which both cities can learn from one another that will allow for future growth and sharing of ideas.

4.1 Political aspect

The economic benefits of R&D are difficult to assess because there are multiple factors to take into account, but it is emphasized in many theoretical works that R&D is an important contributor to a nation's economic growth (Blanco, et. al. 2013). Investing in R&D likely has positive impacts on innovation and overall productivity, which leads to growth. It is evident that forestry plays a leading role in both the Joensuu and Prince George economies. The benefits are not only the financial gains for the community from the industry, but more importantly, it is a large employment provider in both regions.

However, when looking closely into the forest industries in both regions, these two very similar cities by characteristics are in very different positions in terms of local product development, innovations, and policies promoting innovation and implementing them, as well as tax reductions at the national level. As stated in the section 3, besides the traditional forestry production (paper, pulp, and lumber), forest

machinery manufacturing, and chemical forestry in Joensuu, it has also a large concentration of research and educational institutes, whereas the industry around Prince George is mainly focused on traditional forestry production.

Political decisions can have a role in the development of R&D institutes in certain regions. Through these decisions, it is possible to direct the necessary development and resources to enhance the industry. Different political decisions could come from national and regional levels, which would show as tax benefits, strategic plans, incentives, or other couraging ways for the companies to direct their activities in the desired way. (Porter, 2000). To transform the industries successfully towards sustainable practices and bioeconomy, a framework is needed to come from “top-down”, and to have clear and motivated local authorities leading the way in implementation. (Nordregio, 2017). The example of this is the European Union’s strategies on climate change as a framework, which are then directed to different countries and regions to create their own specialized programs to follow the framework. EU is a major funder for these projects, and therefore the top-down effect is visible. However, the top-down effect is not possible if the acceptance is not at the grass-level, as the citizens vote for these policymakers into the cabinet based on their own interest. Also to mention, national and regional policies might not always provide a flexible context for local action, and therefore, it in some cases it might be a barrier in the new implementation of new products. (Nordregio, 2017).

Different political decisions in the past have shaped the forest industry to its current state in Joensuu. Before regional policies and lobbying for forestry started, forestry around Joensuu was mainly focused on sawmilling. In 1967, part of the new regional policy a new modern pulp mill was established in North Karelia to help to restore the employment rate in the region (Rytsä, 2008). Other important decisions were made by the Finnish government when the main Faculty of forestry was transferred to the University of Joensuu (now the University of Eastern Finland) on campus together with the Finnish Forest research institute (Metla). By moving these important forestry institutes in the region, the industry became more attractive for professionals and researchers to settle in, as well as establishing new forestry companies in the region. When comparing this to Prince George, where the establishment of UNBC benefitted the city, the university was still competing with every university in British Columbia

and Canada. In Joensuu, however, the city gained a leading position in Forest education and research from these political decisions.

Large focus on paper production got a hit in early 2000 when the demand for paper decreased, making the forest industry struggle in Finland. For the future, it was clear that diversifying forestry activities and developing new forestry products was vital in order for the industry to stay profitable. There comes the transition into the new era of forestry, bioeconomy. (Silvennoinen & Anttila, 2014).

In Joensuu, the local governments (The city of Joensuu and the Council of North Karelia) implemented multiple strategies related to fighting climate change through a transition into bioeconomy practices. The funding for such projects largely came from European Union, and distributed through programs that follow the current themes of the economy, encouraging companies, public institutions, and private people to establish projects that will bring the region towards the strategic goals. In Finland, companies can receive tax deductions if the companies are investing in more energy efficient solutions in their actions, for example, it is possible to receive investment aid for companies that are doing projects and research on the production or use of renewable energy, enhancing the energy production or use and energy savings, or changing the energy system into a low-carbon solution. (Laukkanen, 2020). In British Columbia, energy efficiency incentive programs have been established to direct people using renewable energy by giving tax exemptions for 7% for alternative energy generation. Other incentives for British Columbia residents are related to energy efficiency in houses and different programs offer information and building codes for building new energy efficient houses. (Urban, 2020). Likewise, the City of Prince George has no financial incentives for energy efficiency or building with wood.

The forest bioeconomy is one of the focus points in the Smart Specialisation strategy in North Karelia, and to reach the ambitious goals of becoming an oil-free and low-carbon region, the local governments are the forerunners by making the framework and guidelines to follow. Regarding the Road map towards oil-free and low carbon North Karelia 2040 plan (2018, p.13), the local government has also lifted the attention for not only investing in the main R&D institutes but also securing the SME's research and innovation activities with financial solutions and lower threshold assistance and services. The forestry R&D institutes (KUAS, UEF, EFI, LUKE, and

the Science Park Oy) are also working together with the city of Joensuu to enhance the business community and competitiveness in the region by being part of growth agreement implementation (Pitkänen & Varis, 2019).

The city of Joensuu is also the owner of the Karelia University of Applied Sciences, which enables the city to directly influence the focus areas of the research, which has made the wood construction as one of the focus points. In KUAS alone, in the past years ten R&D projects have taken place regarding enhancing innovation networks, digitalization in construction processes, low-carbon construction projects, and the knowledge transfer of construction methods (Karelia.fi, n.d.).

As different strategies and policies influence the direction of the industry development through focusing research into a certain focus, here are some examples on how local governments in Joensuu are directly and indirectly shaping the focus on the forest innovations through strategies regarding bioeconomy:

- Shift all fossil-fuels into bio-fuels and be self-sufficient in renewable energy production by the year of 2040
  - ➔ meaning it is required to use bio-fuels in the city
- Regulations promoting sustainable construction methods
  - ➔ future construction will have stricter regulations regarding sustainability in construction practices and materials with building codes. The Ministry of the Environment is preparing limit values for new buildings in regards of the lifecycle of carbon emissions and the regulations are meant to put into force by 2025. Therefore, projects and research implemented by KUAS regarding low-carbon construction is giving valuable information and knowledge for becoming the forerunner in this field. Incentives for multistorey wood construction is coming from the government of Finland, where these projects are supported by 20 per cent increased grant to help making wood construction projects as affordable as building with concrete. (Matveinen, 2020; Valtanen, 2020)

The shift towards bioeconomy has already been seen in the city by multiple wood construction projects. The Joensuu Lighthouse, 14-story wooden building was the

first tall wooden building using new methods and designs. After it was finished, it has brought a lot of valuable information and knowledge regarding the construction process, which can be used now as a research object and an example for future projects. The location for the building was naturally in Joensuu, as all of the participating parties from research to contractors were from there. The projects in this thesis has been focused on public sector, as these projects are focused in enhancing the knowledge base and the local R&D institutes have been actively part of the building processes. Public sector also shows the lead for private sector.

When comparing how political factors, such as regional policies and strategies regarding to bioeconomy, have been affecting Joensuu versus Prince George, it is noticeable that the strategies regarding forestry and bioeconomy forestry in Prince George are limited in comparison to Joensuu. However, Joensuu has been creating and implementing bioeconomy-related strategies for years, and therefore the plans that we see nowadays are very ambitious. In Prince George, the concept of bioeconomy is still fairly new and developing. However, similarities can be found as a new Climate Mitigation Plan 2020 (the City of Prince George, 2020) is addressing new targets for 2025 and 2030 in regards of reducing carbon emissions. The plan will be followed by the action plan later to include concrete ways of achieving the set goals. However, before the new 2020 plan, earlier action plans towards climate change and carbon neutrality are dated back to 2007 and 2010 for an example. On these plans, however, different corporations are reducing their carbon emission through changes in the company actions, and also changing the city's municipalities' heating system into bioenergy district heating was achieved. (The City of Prince George, 2010; The Sheltair Group, 2007). In fact, Prince George was one of the first municipalities in Canada to achieve all five milestones set in the the Federation of Canadian Municipalities (FCM) Partners for Climate Protection Program (PCP) (the City of Prince George, 2020), which included creating an emission analysis, setting targets on green house gas reduction, creating a local action plan identifying required actions for reducing energy usage and green house gas emission from the community and municipal operations, creating a program for implementing tasks to reduce green house gas emissions, and continuous monitoring, reporting and verifying of the achievements.

On the economic development plan (2017-2019) possible opportunities regarding forestry innovation and technology and engineered wood products are identified as a high investment attraction. Biofuels are not seen as a high potential in the region, nonetheless, the plan does not outline the possibility in the future. (The City of Prince George, 2019). Other plans found regarding green development are more focused on attracting investment in the city. The difference on how Joensuu and Prince George are approaching this subject is that in Joensuu the local government is focusing on becoming self-sufficient with the resources they already have (natural resources and expertise), as in Prince George outside investment is needed (cleantech companies to invest in the area for an example). This could be part of how in Joensuu there are multiple research institutes and the network between these institutes are regularly enhanced through different projects and programs, whereas in Prince George the research is limited to university and the close-knit networking needs to be with other cities in British Columbia, making the networks province-wide, whereas in Joensuu the intense knowledge hub is local.

4.2 Social aspect

Successful transition into a bio-based economy takes time. It is argued that social acceptance and attitudes towards bioenergy and bioeconomy influence market development (McCormick and Kautto, 2013). There needs to be enough interest and acceptance in the community to be successful in implementing new bio-based projects in the city. It is essential for the municipalities to be in an active role in coordinating the efforts in not only promoting the low-carbon economy but also in the creation of employment in the region. Public opinion together with the support from policymakers creates a foundation for acceptance for new products, energy-systems, and other bio-projects. The public opinion is usually shaped through how much information and knowledge is available, and how receptive the community is.

Forestry has been the main industry in both Joensuu and Prince George for decades. Through these years it has become part of the cities' identity, which also modifies how people are viewing the industry. Forestry has been taken a big hit in the last few years in northern British Columbia, which has caused uncertainty about the future of forestry. Many mills have been closed due to different factors influencing the industry,

such as the pine beetle epidemic, forest fires, low price for timber for an example. (BCGEU, 2011).

Joensuu has gained a reputation of being the Forestry capital of Europe, due to its extensive network between educational institutes, governmental offices, and forestry-related enterprises. The city is actively participating in promoting the low-carbon future, directing needed research on achieving the goals of becoming carbon emission-free by the year 2040. With these plans and projects, the city wants to be an example for the other regions in Finland and Europe. The Council of North Karelia has taken an active role in creating strategic plans and overseeing projects. The region has a strong network of municipalities, research institutes, and local enterprises that can execute these plans in the city. What is different from Joensuu and Prince George, is that Joensuu is focusing on creating local value chains by connecting companies and research institutes to support the cluster in the region. As knowledge inflows and outflows circulate in clusters, many local companies benefit from being part of the cluster and learn valuable skills form participating in pilot projects.

In Prince George, increasing interest in diversifying the forest industry through bioenergy and wood construction started later in the 2000s. The city signed its first plan on reducing carbon emissions in 2007. Through the research in UNBC and UBC, with a collaboration with other bioenergy experts in British Columbia, the first bioenergy plant was built on the campus of UNBC. This was a crucial step for not only the university but also for the city in adapting a new system for heating and transition towards a low-carbon economy. Slowly through these projects, social acceptance for new forestry products can be gained, as oil and gas are still widely used in not only Prince George area, but also in most of the communities in northern British Columbia.

When it comes to the presence of R&D institutes in Joensuu, the institutes have created a solid foundation and identity for the city as a forerunner in forest innovations. Also, the City’s active role in branding itself as a future bioeconomy region, the image of the city starts to change in people’s minds. It becomes socially part of the identity, as people are not only surrounded by new bioeconomy solutions around the city, but also the campaigning for the change in the name of climate

change. It can affect also not only people working in the forest industry but also everyone living in the city. When public acceptance of biobased materials is gained, the successful implementation of new innovations becomes easier, as people are working towards the same goal. For example, when biomass was first introduced in North Karelia to change the use of oil in heating, it was not a success at first. It took time to build trust between the stakeholders and regional actors for changing households to use bioenergy. Financial factors helped in the change, as bioenergy was going to be cheaper and more secured than imported oil form abroad, and also the profits from generating the energy locally would stay in the region. To make the switch easier from oil to bioenergy district heating, the Regional Council created a call center for local residents providing information regarding the switching process. (Berlina and Mikkola, 2017).

However, gaining social acceptance in the implementation of new forest-based bioeconomy products does not necessarily depend on the presence of R&D institutes in the region, nevertheless, they are important actors in bringing together forestry experts and partners and raising awareness of bioeconomy solutions. The action towards more social acceptance should come from the local authorities, which can build markets for bioeconomy by implementing bioenergy heating systems to their own municipalities, creating regulations for sustainability on construction practices, and highlighting sustainability in actions to show examples for the community. (Nordregio, 2017). The common concern of climate change has made people being more accepting of new sustainable products and also supporting the local industries.

5 CONCLUSION AND DISCUSSION

As with the majority of studies, this research is subject to limitations. The design of this study uses already existing secondary material, which might lead to having data access limitations. As COVID-19 affected the world during this research took place, the restrictions affected the accessibly to data in any libraries, as some of the material did not have online access to them. The researcher was going attend the Canadian Bioeconomy Conference in June 2020 to collect data there, but because of the COVID-19 restrictions the conference was cancelled and changed into a webinar. Also, the researcher was not subject to travel to Finland to use local databases there, as the travel restrictions due to COVID-19 were not allowing international travel. However, the majority of the needed data was available online, which this study uses as a base for the research findings.

The aim of the thesis was to discover factors that have resulted in differences in forest industries in Joensuu, Finland, and Prince George, Canada. The main focus was to find out if the presence of R&D institutes are enhancing the forest industry and what kind of role the local governments have in new innovations and product development in the region.

The aim was to answer these following questions:

- What are the characteristics of the forest industry cluster in Joensuu and Prince George and how do they differ?
    - Are there particular conditions that favour Joensuu over Prince George as a centre for forest research and innovation, such as government incentives, political factors or social dynamics?
- How has the presence of research and innovation enterprises influenced actual product development, the competitiveness of the forest industry, and local utilization of wood products?

Based on the findings, the forest industry in Joensuu is more diverse, larger in terms of how many companies are in the region and the local governments have a more active role in overseeing projects and programs related to forest-based bioeconomy. The political factors have affected how the industry has grown in the region, as changing the location of the main Faculty of Forestry and the Finnish forest research institute from Helsinki to Joensuu brought new expertise in the region and a foundation for other environmental institutes to settle in the city. The change of the location of these institutes into Joensuu could be considered as a fortunate event, as other cities were also competing to be the host for the faculty. The study demonstrated the differences in the industry clusters between Joensuu and Prince George by identifying the main sectors and focus points in both clusters. The clusters are differing by the focus areas in how the forestry in Prince George is mainly focused in the production of pulp, paper, lumber, and pellets with UNBC being the major research facility, whereas Joensuu is a major provider of chemical forestry products (bio-oil, bio-diesel), forest machinery and production of pulp and lumber with multiple research facilities and economic development centers. The innovative network in Joensuu is extensive, as the local governments and the research institutes are working together towards the goals of implementing forest-based bioeconomy solutions in the region. The research focus is also wide as Karelia University of Applied Sciences is focusing new wood construction methods and actively participating in projects implemented in the city, the University of Eastern-Finland focus on chemical forestry with digital technology solutions, European Forest Institute connects the European policymakers and provide support on forestry-related issues at the international level, Natural Resources Finland provides research and development on bio-based products, support the circular economy and the use renewable natural resources and create business opportunities.

Different political and social factors have enhanced the R&D in Joensuu. The political decisions and policies need to have acceptance and wide enough interest among the community to implement new forestry products. As change can cause opposition and skepticism, it is important that knowledge and information are widely available. Local governments in Joensuu are actively bringing together R&D institutes, forestry companies, and educational institutes to solve issues and challenges in the transition towards a bio-based economy. The industry in Prince George has still a large focus

on traditional forestry production, but in 2010s new bioenergy plants have been implemented and a new wood laboratory and innovation center have been built to have a place to enhance the research on wood construction and also to show an example for future projects.

Based on the findings, the forest industry in Joensuu was a center for traditional forestry practices until the Finnish government's actions on regional policy were in favour of Joensuu to be the host the main faculty of Forestry and the Finnish forest research center. From there, the experts in Joensuu created the new European forest institute and the location was to be in the same city as the faculty of forestry and the main forest research center. After that, the forestry cluster in Joensuu has grown to be the center of world-class research and attracting forestry experts globally.

Therefore, the location of R&D institutes has enhanced the forest industry in Joensuu by introducing more diverse forestry products in the city, enhancing the city's image as a forestry leader, and attracting investment and expertise in the region. The active role of local government enhancing the local networks through programs and strategies support for the knowledge flows in the cluster.

5.1 Suggestion for future research

As the length of the Bachelor's thesis creates limitations on how profound the research can be in comparing two different forest industries, this research is rather shallow and more of an introduction of the topic for further research.

For future research, it could be useful for focusing on deeper into how the government is involved in the business operations, lobbying forestry and what kind of strategies have been the most beneficial and what kind of effect it has had on the competitiveness of the forest industry. Other further research could focus on exploring more of the social aspect of how different attitudes and acceptance the community in Prince George have on regarding bioenergy and bioeconomy, and how does it affect the product development and implementation processes and how it could be improved, as for now the community largely uses oil and gas as an energy

source. Another research could benefit the industry in Prince George regarding what ways the local governments can enhance the attractiveness of investment opportunities in bioeconomy. Other idea for research would be to understand the factors that led to Joensuu's emergence as a bioeconomy leader in order to replicate some of those actions in another place (like Prince George). To explore the topic even wider perspective, research on what kind of roles and actions EU, national, and local/regional governments have in successful creation of functional bioeconomy and how bioeconomy solutions are promoted and regulated in each level.

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