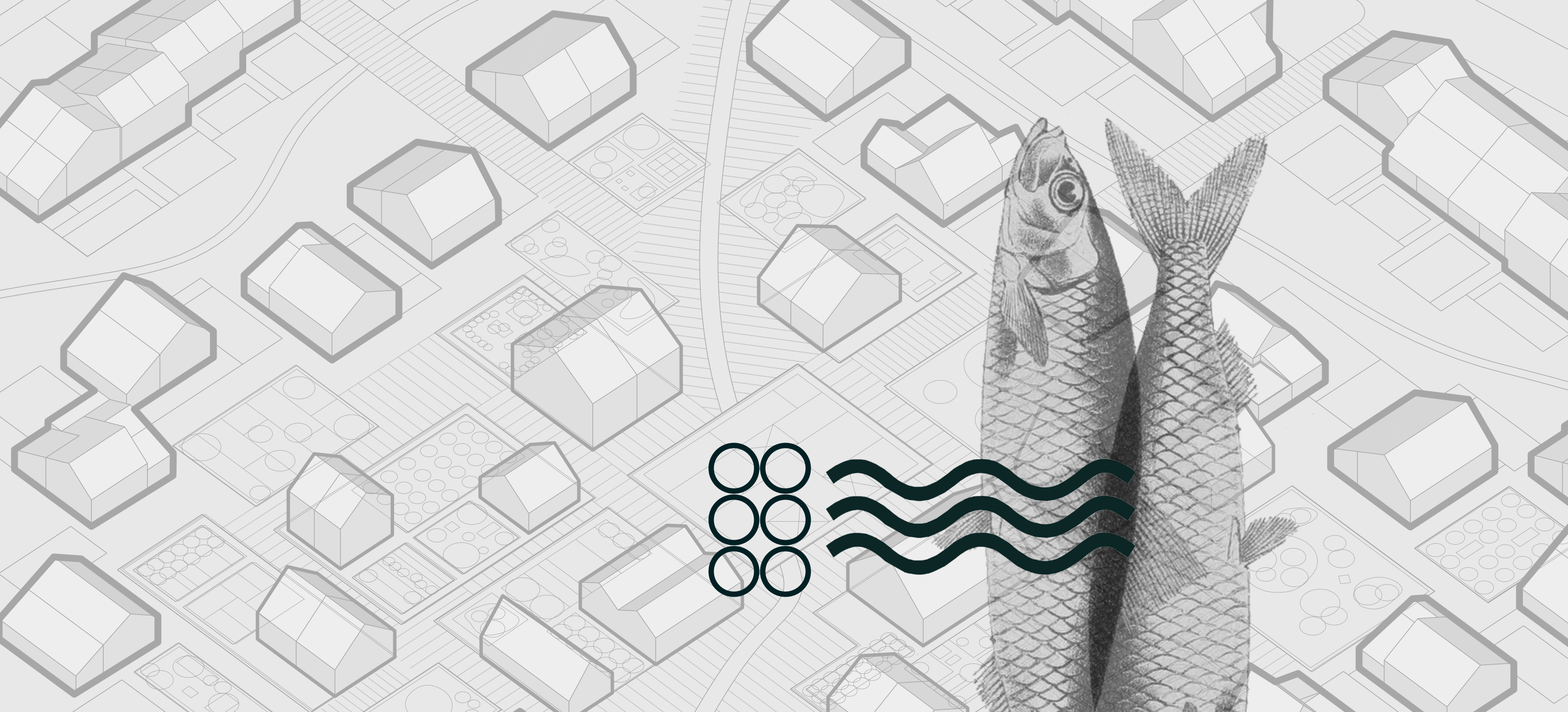

OULU BIOVILLAGE

Exploring blue bioeconomy ecosystem opportunities in Oulu, Finland

Master Thesis
Sustainable Urban Design
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Master Thesis Booklet

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Project Summary

By the year 2030, the world will need 50% more food, 45% more energy and 30% more water. This growth in demand will increase pressure on our natural resources. Ingenuitive and adaptive thinking will therefore be required in the ways we build our cities. Finland, with its abundance of natural resources: its forest, its lakes and its aquatic resources, as well as its expertise in sustainable resource use and development, has strategically placed itself as a pioneer in transitioning its economy from one reliant on fossil fuels into one which harnesses the full potential of renewable natural resources and unlocks the full potential waste: creating food, energy, products, services, and jobs in line with sustainable development. The project explores this opportunity further in Oulu, Finland; where one of mainland Finland's largest fish farms is being planned north of the city in Haukipudas. The project examines the potential of creating a fully-functional blue bioeconomy ecosystem, unlocking the full potential of sidestreams and waste, and exploring the synergies between fish, food, and energy production into a self-sustaining bio-district. The project seeks to integrate production activities: fish, vegetable produce, services, new industrial products; with everyday life, to enhance the relationship of citizens with nature and linking consumption with production.

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"The shift to new models and more diverse input can be unsettling...In the face of immediate deadlines and demands, such changes can be seen as messy, burdensome, and threatening, even overwhelming. But as Albert Einstein observed, if we are to solve the problems that plague us, our thinking must evolve beyond the level we were using when we created those problems in the first place"

- Michael Braungart & William McDonough
in Cradle to Cradle, 2009

PREFACE

THE ARRIVAL

One snow storm and approximately 8 hours later, the train from Helsinki stops at its final destination in Oulu, a snow-covered city of 200,000 in the Northern Ostrobothnian region of Finland. Located 160 kilometres south of the arctic circle, Oulu is sheltered away from the outermost parts of the Baltic Sea. Part of the subarctic climate, Oulu is the largest Finnish city entirely in this climatic zone. **In fact, there is no larger city, apart from one in Russia, which is more northerly than Oulu**. Upon arrival, the city centre exhibits an image of a typical Finnish coastal town, with a rigid grid street structure and plentiful of pastel-coloured buildings enveloped in pillow-like snow.

Upon this first inspection, one may have little expectations or awareness of the large-scale innovations happening in this very place. At most, it appears a quiet, modest city. But it is perhaps this quiet confidence that makes Oulu so special. **Oulu has grown into a key hub for new technology business, with world mobile, electronic, and medical technology leaders based in the city. It is also considered one of the 13 "brainbelts" in the world: with a high concentration of education, research, high technology and diverse talent pools, with approximately 18,500 hi-tech professionals working in companies of various backgrounds.** Because of this, the economic prosperity of the city is growing which has provoked a demand for attractive housing development providing higher and better standards of living.

Approximately 710 million euros will be invested in infrastructure development in the coming year and the City has managed to attract an exceptionally large proportion of investment in recent years (Business Oulu, 2018). But what makes Oulu so unique and therefore attractive for young professionals? Oulu prides itself on its eccentricity, to say the least. Whether it be the ice hole pitching events where entrepreneurs market their ideas for as long as they can stand in the frozen water, air-guitar competitions which are growing bigger and bigger every year, daily cycle commutes to work or school in 20+ centimetres of snow, "nap times" in the nest - all part of the Tellus - a cool and cozy but seemingly productive innovation platform as part of the Linnanmaa University campus, or the recent winning re-design of Oulu's Central Station, a design which emulates large tar barrels, revisiting a time where tar was transported from Oulu to different regions. In essence, one could say that most things have a sort of "Oulu-twist" to it.

"It is overall agreed that we citizens in Oulu have our pains and struggles but we also think about how to turn them into victories. For us, anything strange or different is a positive thing. As a culture in Oulu - well, we have a reputation of being quite 'nuts' in a positive sense....we are culture that highlights extremes" says Sari Hirvonen-Kantola, the University Representative for the Northern City with Attractive Opportunities ecosystem, one of five from Oulu's Innovation Alliance.

65.0121° N, 25.4651° E
Northern Ostrobothnia Region
Subarctic continental climate
Average annual temp. 2.7 degrees
Average annual precipitation 477m
(105 days per year)

PART 01
INTRODUCTION

Image Source: Business Oulu (2018). *Aerial Overview of Oulu.* Retrieved from https://www.businessoulu.com/fi/media/uutisarkisto/bbc-ylistaa-oulun-nousua.html

1.1 FROM TAR BARRELS TO INNOVATION CITY

A Brief History of Oulu

The area known today as the City of Oulu rose from the sea in approximately 3320 BC. The earliest and most natural migration was from the East: as the land descends from the Kainuu and Karelia areas towards the sea. **The first people to have settled were the resilient Finno-Ugric kind, many of which also continued their migration routes North to Lapland.** Migration from the South came when people came to collect taxes and where trade was mainly directed. The modern history of Oulu started in the 1300s, when the Pähkinäsaari Peace Pact was made between the Kingdom of Sweden and Novgorod (Russia) in 1323 (City of Oulu, 2018). When the borderlines of the peace pact were distinguished, Oulu remained on the Novgordian side. In this time, the most important route of communication between the Novgorod and its new settlement area was the river Oulujoki. Kastelli fortress was built at the mouth of the river in 1375 as a military support of the Swedish dominion against the Novgorod. After the completion of the fortress, people from the south moved to the area most likely due to the exigencies from authorities. Since then the Swedish power over the area was established (City of Oulu, 2018).

Oulu was founded in 1605 by King Charles IX of Sweden *"to the mainland opposite the castle and its island to a place where a new church had recently been built"* (City of Oulu, 2018). Five years later, the King gave town privileges to Oulu, where approximately 400 inhabitants lived and from this time exists some of the earliest known city maps. During the 1700s, the trade in Oulu slowly developed and the importance as well as the population of the town grew. **When Oulu got rights to have foreign trade, Oulu became an important shipping and shipbuilding town.** The most important export goods were tar, timber, salmon and butter. The heraldic fish of Oulu, the salmon, was a significant export item and very high valued cultural resource. The salmon also affected the supply of energy in the industrializing Oulu during the final years of the 17th century as the order was given that the water and saw mills in the channels of the River Oulujoki estuary were to be closed for fishing during migration of the salmon up the river (City of Oulu, 2018). With numerous rigorous efforts, the estuary provided enough power to equip the arising industry with machinery.

Like many Finnish towns, Oulu had been burnt many times. In 1822, the biggest fire in the history of Oulu destroyed practically the entirety of the wooden town (City of Oulu, 2018). According to archives, approximately 330 houses were burnt to the ground with only 65 being saved. During the following year, population decreased. Architect Carl Ludvig Engel, who was known for his neoclassical style buildings around the Helsinki Senate Square, was enlisted to provide a plan for rebuilding the city, and remains the basis for the layout of Oulu's town centre today. The bridges over the river were completed in 1869 and it was the first time the inhabitants could cross the river without using a boat (City of Oulu, 2018). **By the 1870s, Oulu has the largest commercial fleet in Finland, with the export mainly consisting of timber and tar. In that time, Oulu was the biggest exporter of tar in the world and the tar shipped was used in several commercial fleets and navies to make the wooden ships waterproof** (City of Oulu, 2018).

"Once a hub for trade in wood, tar and salmon, Oulu has evolved into a major high-tech centre with specialization in IT and wellness technology"

“Today, there are more ICT related jobs than in the glory days of Nokia, and with it, an even healthier structure which is not dependent on one monopoly enterprise, but where diversity and different fields of expertise are embedded with ICT”

Industrialization began with the construction of the railway line linking Helsinki to Oulu in 1886. It meant a new era for Oulu as the railway offered a more efficient way for transporting people and goods to the capital. Industry in Oulu developed during the first half of the 20th century when both the Toppila and Nuottasaari pulp mills were opened. **After the war, the population increased and by that time the University was founded in 1958.** The birth of the University had a critical impact on the growth of the city and its industry. **Nokia Group opened its first divisions in 1973 and contributed greatly to the city’s development into a hi-tech centre. In the beginning of the 1980s, the City of Oulu founded Technopolis and made a strategic decision on becoming a hi-tech city and centre of expertise.** Since then, development and population growth has been rapid and the number of inhabitants has risen to 125,970 with a land area covering 411,11 square kilometres (City of Oulu, 2018). Oulu differs from many other Finnish cities with its young age structure. This is largely due to the migration of students and young professionals into the city. **Once a hub for trade in wood, tar and salmon, Oulu has evolved into a major high-tech centre with specialization in IT and wellness technology.** Other prominent industries include wood refinery, chemicals, pharmaceuticals, paper and steel.

With the Oulu Innovation Alliance (OIA) beginning in 2009, Oulu has a long history of working together to make things happen. The OIA works as a strategic cooperation between the public sector and research organizations at the University of Oulu, Oulu School of Applied Sciences, Business Oulu, the City of Oulu, and private companies. **In reality, the OIA is just a formal manifestation of Oulu’s cooperation tradition**. ICT is particularly the root of this innovation, as a result of Nokia’s headquarters in the 70s. With such a large global enterprise in the city, it came with a lot of collaborative enterprises. The University of Oulu was also a key player in supporting this innovation with their main education specialties in ICT education and diverse modes. The role of the university remains crucial today, as it continues to feed new enterprises, bringing new start ups to life. During the economic crisis of the 2000s when Nokia took their operations elsewhere, over 20,000 jobs were cut. But when Nokia left, a large amount of engineers, with all of their knowledge they had acquired, stayed in Oulu. By 2009, the mayor and the rector at the university signed the first agreement which discussed the development of what they called *“Innovation Centres”*. **These Innovation Centres would be key collaborations between research organizations and private companies, producing different RDI projects and start-ups.** In 2016, these existing Innovation Centres were integrated and became “Open Innovation Ecosystems”, to which exists 5 core ones today.

These five ecosystems research, innovate, experiment, market and create services and products with different partners. There are currently five ecosystem “branches” within the OIA: Industry 2026, Northern City with Attractive Opportunities, ICT and Digitalization, Oulu Health, and Agile Commercialization. Each of these five branches collaborate with their multi-operational knowledge. Importantly, OIA’s main function is to serve enterprises who seek expertise on strategic fields. OIA serves as the contact point: *“We pretty much know everyone in the field and can find the right person for the companies to talk with. We also find funding opportunities for the enterprises” (S. Hirvonen-Kantola, personal communication, February 7, 2019).* **Today, there are more ICT related jobs than in the glory days of Nokia, and with it, an even healthier structure which is not dependent on one monopoly enterprise, but where diversity and different fields of expertise are embedded with ICT.**

3000 BC

Finno-Ugric migration ~ 3000 BC.

1323

Pähkinäsaari Peace Pact was made between the Kingdom of Sweden and Novgorod (Russia) in 1323.

1605

Oulu was founded in 1605 by King Charles IX of Sweden.

1700

In 1700s Oulu developed into important shipping/shipbuilding town. Most important export goods were tar, timber, salmon and butter.

1822

In 1822, the biggest fire in history of Oulu destroys whole wooden town.

1870

By the 1870s, Oulu has the largest commercial fleet in Finland and was the biggest porter of tar in the world.

1886

Industrialization begins with railway construction from Helsinki to Oulu in 1886.

1958

University of Oulu was founded in 1958.

2000s

City develops into hi-tech city and centre of expertise.

1973

Birth of Nokia Headquarters in 1973.

1.2 THE CITY TODAY

Today, Oulu is coined the "12-minute City of Innovation". Oulu has the advantage of being a high-growth city with a young population. **In fact, the average age of Oulu is 36.6 years old, making it one of the youngest cities in Europe** (Oulu Convention Bureau, 2013). You can also get almost anywhere in the city within 12 minutes: because of this Oulu attracts educated, well-rounded people who can maintain their job within a reasonable commute, and also have time for leisure activities.

"In an economic sense it is a good starting point, a big share of population has a university level degree, so it is a well educated population. But then, it is not the case for all, there is a group of young people at age of 20 that we are seeing quite a lot of unemployment within that age group. So one of the main challenges is how to keep them included in the society. It also related to urban planning - we need to do solutions that are inclusive to this group. You will notice that in the city centre, young people are the biggest user group to use the city centre services" (S. Hirvonen-Kantola, personal communication, February 7, 2019).

One of the main strategies of the *Northern City with Attractive Opportunities* ecosystem of the OIA aims to achieve is ensuring the attractiveness of the region as the region grows and goes through structural changes. In particular, the city centre development has been an interesting question in Oulu for many years. With the growth of e-commerce, there remains less need for traditional commercial uses, and thus, **the City is seeking to envision what kind of identity the centre will have in order to attract this younger population.** At the same time, Oulu is a car-oriented city, as is the case with many cities in northern latitudes. Approximately 10 years ago, there were big parking issues, as the city was growing, there was a constant demand for more parking spaces. After several years and negotiations with many stakeholders and property owners later, an underground parking facility was approved and development of the city centre took off. The underground parking complex spans approximately the entire central downtown area, a massive space, resembling what can only be described as a cave: clearly indicating the preferred mode of transport to this day being the private automobile. **This has been heightened even further with the agglomeration of the smaller, more rural-oriented municipalities in the City of Oulu in 2013**.

Oulu and the municipalities of Haukipudas, Kiiminki, Olunsalo, and Yli-Ii were merged in 2013, thus the City of Oulu consists of not only the central urban area but stretches as far as 8km north-east to its rural parts. *"There used to be 65,000 cars before the agglomeration, and 95,000 cars afterwards. This indicates that many of the cars came from the neighbouring more rural-oriented towns which became part of Oulu later on. That gives you an idea that there are a lot of cars in these rural areas. [The people who live in these parts] need a car, it is part of the lifestyle and we have to take that into consideration in our planning" says Topias Yli-Vakkuri, planner at the City.*

In fact, the only real mode of public transport for the city is its bus lines which primarily connect the centre to its inner suburbs. Still, in the more rural areas, the private automobile remains the primary choice of travel within the region. **It also means that there are a lot of rural areas taking part in decision-making in the urban development of the city.** *"There are dynamic political discussions on where investments should happen, where to built infrastructure, where to put strategic projects and if they should be chosen with sustainability-first, efficiency of the economy, or how affordable it is - which elicits a lot of political discussions" (S. Hirvonen-Kantola, personal communication, February 7, 2019).*

The Oulu region is characterized by quite flat, low-lying landscapes with no large-scale topographical changes. In fact, the largest topographical change is an artificial ski-slope, created by a landfill, just north-east of the Linnanmaa campus area. At the same time, Oulu is gaining more land and more land every year: approximately 10-20 centimetres. As a similar case, the City of Vaasa in southwest Finland was once a city on the sea, but today it sits approximately 2 kilometres from coast. Oulu is also getting new land, however, this land is not suitable for built structures, but has provided important habitats for bird reserves. **With this relatively flat landscape, it has given the opportunity to spread the urban structure. The city is seeking to deal with sprawling development by densifying the existing urban tissue, providing better public transport, and creating strategic zones (or growth centres) which are emphasized first for growth targets.**

There are three main growth centres (C1) outlined in the Oulu Master Plan: Ritaharju, Hiukkavarra and Kaakkuri. The City Centre is also a strategic zone for growth. Secondary growth zones include Haukipudas and Kiiminki old town centres (C2). Tertiary and fourth level growth zones are reserved for more stable or slow-growing zones. *"We typically only provide necessary permits to projects as long as it is part of the existing infrastructure. Building new homes in areas with no roads or services usually does not get the required permits as the City has obligation to provide these services and it's not sustainable. So ultimately we want to make the urban structure much more dense so you are close to those existing services and infrastructure" (T. Yli-Vakkuri, personal communication, February 11, 2019).*

City Planning Trends

URBAN / RURAL
DIVIDE

ATTRACTIVENESS OF CENTRE /
ATTRACTIVENESS OF REGION

DENSIFICATION /
PUBLIC TRANSPORT EXPANSION

1.3 FUTURE OPPORTUNITIES

Blue Bioeconomy comes to Oulu

Laitakarin Kala Oy, a fish farm company, has recently applied for mainland Finland's largest fish farming location, 25 kilometres north of Oulu's city centre in Haukipudas, a rural area of the city which was agglomerated into the City of Oulu in 2013. The company is seeking to produce over 1 million kilograms of rainbow trout per year to be sold on both domestic and international markets.

In collaboration, the OIA's Industry 2026, the University of Oulu, the Natural Resources Institute of Finland (Luke) and the Finnish Environmental Institute (Syke) have been examining the potential streams and economic vitality of a **Blue Bioeconomy Ecosystem** to build a wider business and research ecosystem around Laitakarin Kala. **The aim: to create a more sustainable and profitable food production concept based on the symbioses between actors, renewable energies, and the utilization of side streams and clean solutions** (Oulu New Tech, 2017). This project is just one of several examples of blue bioeconomy projects making wave in Finland. With nationwide issues surrounding the domestic production of fish and other products which are highly imported, such as vegetables, the blue bioeconomy concept comes at a relevant time. In fact, approximately 80% of fish is imported into Finland every year, primarily salmon from Norway (30 million kg), and rainbow trout from Sweden (9 million kg) (Natural Resources Institute of Finland, 2016). **There is a huge demand for domestic food production in Finland, which is only amplified by newer food trends surrounding clean and unprocessed foods.**

The main concept of the blue bioeconomy ecosystem is to, with the fish farm at the heart of the ecosystem, examine what other business opportunities can work alongside the fish farm, which will be built regardless and is currently attaining the proper permits. In interviews with some key stakeholders in the concept, it was found that one of the main goals was to examine the potential scenarios of different value chains and determined their actual costs and profitability.

"Timo [The CEO of Laitakarin Kala Oy] has his business anyway, he will probably successful in the future because more and more people would like to eat domestic fish. But what else? Could there be one or two or five different kinds of ecosystems, and new kinds of businesses. And that was the angle we were trying to go from to get the funding and we will try still in the future. You need to have this research and figure out the different kinds of streams and if its economical. Or is it so that there is no business opportunities at all?" says Industry 2026's Pekka Tervonen.

The concept examined, in specific, the viability of a greenhouse which would grow tomatoes and cucumbers year round in conjunction with a recirculating aquaculture system (RAS). The concept also sought to unlock the full potential of waste produced, both from the fish and the greenhouse, in creating biomass for a biogas plant which could provide as an energy source for the system. Side streams from the further processing stages of the fish were considered, specifically the extraction of oil for biodiesel or for higher value chains such as cosmetic and pharmaceutical industries. In light of creating a circular economy, renewable energy sources were also considered in the ecosystem, including biomass, but also forest bioenergy from other industries, geothermal, solar, and potentially industrial waste heat.

However, the initial proposal was not seen as economically viable. **After years of studies, it was not self evident that the facility and system was competitive from an economic sense, due to many factors, but most significantly being its energy requirements.** Such an ecosystem has large energy demands, and specifically, the greenhouse exhibited the most significant energy requirements, especially around electricity for lighting, as Oulu has around 5 dark months every year.

Renewable energy sources also posed as a challenge to the profitability of the ecosystem, as each option had their limitations. A common factor is that there is an overall lack in technology available for some of these newer energy approaches, as well as a lack of companies willing to invest: *"But that's one of key issues again - how do you establish this new ecosystem and new businesses?...There is a lack of companies who can use this different way [of thinking] and you have to build this new company if they are not existing." (P. Tervonen, personal communication, February 13, 2019).*

Although facing these challenges, the blue bioeconomy ecosystem has massive potential. When considering the larger picture at stake: with global warming, food security and other environmental challenges occurring not just in the north but at a global scale, t**he blue bioeconomy concept has incredible opportunity to address questions surrounding the relationships between the very systems which we use daily: our food, waste and energy systems, and aims to close the link between production and consumption, which seems to be growing further and further apart in an ever-globalizing society.** At the same time and as seen in its very own history, Oulu has a strong foundation built over centuries that **supports innovation and new modes of thinking, with platforms such as the OIA and University of Oulu who continue to support research and development, entrepreneurs and start-ups to come to life.** Therefore, there are excellent opportunities to support experimental thought leadership in the realm of generating local circular economies within the Oulu region.

The current plans for the blue bioeconomy project has focused on creating profitable value chains for businesses in the fish farm's immediate business circle. **But looking at the project from a larger perspective, what other potentials exists for the ecosystem?** What other uses can benefit from the synergies offered by the ecosystem? **As a country, Finland offers many of the ingredients necessary for new technology and business models, with an extensive test-area network and flexible regulation.** At the same time, when we look at the potentials of such a concept from a wider level, the Baltic region has a strong foundation of research, development and investment within the realm of sustainable food production and local circular economy development, and **so investment opportunities exist not just at a national scale, but from a northern Baltic-wide perspective**. **Further, the new ecosystem will provide numerous jobs and economic growth to the Oulu region.** By integrating added layers of tourism opportunities in the form of eco-tourism can also aid in the prosperity of the ecosystem, generating a new funding stream. **In reality, the ecosystem serves not just a few pools for fish, but will provide plentiful of services and infrastructure to the city, bringing it back into the urban fabric and highlighting its historic significance as a vital industrial and employment area for the region.**

Thus, the thesis project aims to build **an economically viable and innovative business model which examines the relations between energy, fish, and food production.** The project looks at the opportunities of creating a self-sustaining bio-village: a tech-integrated and regenerative development concept where off-grid, capable neighbourhoods comprised of power positive homes and other uses, renewable energy, water management, and waste-to-resource systems become part of a shared local ecosystem.

Image Source: Etsy. *Vintage Photo Pile of Rainbow Trout and Fishing Pole Catch of the Day 1960's, Original Found Photo, Vernacular Photography.* Retrieved from https://www.etsy.com/listing/687643031/vintage-photo-pile-of-rainbow-trout-and

PART 02

PROJECT BACKGROUND

2.1 THE WAY WE MAKE THINGS

Cradle-to-Grave Industrial Models

As humans in modern society, we are used to doing things a certain way. Whether it's the design of a product, the construction of a building, or the planning of a neighbourhood: for years the way we make things is with an overarching linear model of material and waste. **Over the years, a massive disconnection has taken place: modern homes, buildings, and factories, even whole cities, are so closed off from natural energy flows that they act as virtual steamships.**

For thousands of years, human society has struggled to maintain the boundaries between human and natural forces; to do so was often necessary for their survival. Western civilization in particular has been shaped by the belief that it is the right and duty of human beings to shape nature into something better; as Francis Bacon put it, *“Nature being known, it may be master’d, managed, and used in the services of human life” (Braungart & McDonough, 2009: 84).*

This “cradle-to-grave" manufacturing model was spurred most significantly out of the Industrial Revolution. **The design goals of early industrialists were limited to the practical, profitable, efficient, and linear: many industrialists, designers, and engineers did not see their designs as part of a larger system outside of the most vital economic one. At the same time, early industrialists relied on what they thought as a seemingly endless supply of natural capital:** *“Nature itself was perceived as a ‘mother earth’ who, perpetually regenerative, would absorb all things and continue to grow.... Ralph Waldo Emerson, a prescient philosopher and poet with a careful eye for nature, reflected common beliefs when in the early 1930s, he described nature as ‘essences unchanged by man: space, the air, the river, the leaf’....many people believed there would always be an expanse that remained unspoiled and innocent’” (Braungart & McDonough, 2009: 24).*

The advantages of standardized, centralized production were manifold: it could bring greater, quicker affluence to industrialists. Manufacturing was also viewed as what Winston Churchill referred to as *“the arsenal of democracy”* where the productive capacity, because it was so massive, could produce an undeniably potent response to war conditions (Braungart and McDonough, 2009). Mass production also had another democratizing aspect, as seen in the Model T's success in the mid 20th century. **When prices of a previously unattainable item or service plummeted, more people had access to it.** On the same note, new work opportunities in factories improved standards of living as well as wage increases.

The cradle-to-grave manufacturing models touches many aspects of our built world. The growth of conventional agriculture is just one example, where ecosystems have been simplified, replacing relatively complex natural biological communities with simple man-made ones based on a few strands of crops. As we know, it is this cradle-to-grave model manufacturing model which also creates immense amounts of waste and pollution.

"Nature itself was perceived as a ‘mother earth’ who, perpetually regenerative, would absorb all things and continue to grow”

The Cradle-to-Grave Industrial Model

Cradle-to-Cradle Industrial Models

But since this is the way things have always been done, it must be done this way, right? Perhaps not. In *Cradle to Cradle: Remaking the Way We Make Things (2009)*, Braungart and McDonough, industrialist and architect, emphasize a shift to from cradle-to-grave to a more cyclical cradle-to cradle industrial process which can be compared much to the act of good gardening: **instead of seeing it as virtually "saving" the planet from our industrial advancements, it can be seen as learning to thrive on it** (Braungart & McDonough, 2009).

What if, instead of regarding humans as the all-encompassing detriment to planet earth, we could integrate our consumption patterns and leftovers into our natural environment? Waste, pollution, crude products and other negative effects of industrial processes are not a result of corporations doing something morally wrong, but rather, the consequence of outdated, unintelligent design (Braungart & McDonough, 2009). **The way we make things: products, buildings, cities, requires a major rethink, a new approach which directly combats the problem rather than slowly perpetuating it**. As Braungart and McDonough puts it, *"To be 'less bad' is to accept things as they are, to believe that poorly designed, dishonourable, destructive systems are the best humans can do...this is the ultimate failure of the 'be less bad' approach: failure of the imagination...this is a depressing vision of our species' role in the world" (67).*

The cradle-to-cradle model looks to the natural world as a source of inspiration to find a production system which mimics nature's model to our commercial and environmental advantage: **to design our industry systems not necessarily as smaller systems, but bigger and better in a way that replenishes, restores, and nourishes the rest of the world, with more niches, health, nourishment, diversity, intelligence and abundance, for this generation of inhabitants and for generations to come** (Braungart & McDonough, 2009).

Braunghart and McDonough finds links between the cradle-to-cradle model with a cherry tree:

"as it grows, it seeks its own regenerative abundance. But the process is not single purpose...in fact, the tree's growth sets in motion a number of positive effects. It provides food for animals, insects, and microorganisms. It enriches the ecosystem, sequestering carbon, producing oxygen, cleaning air and waste, and creating stabilizing soil, among its roots and branches on its leaves, it harbours a diverse array of flora and fauna, all of which depend on it and on another for the functions and flows that support life. And when the tree dies, it returns to the soil, releasing, as it decomposes, minerals that will fuel healthy new growth in the same place" (78-79).

The tree is not an isolated entity itself, cut off from the system around it, but rather it is productively engaged with them. This is the key difference between the growth of industrial systems as they now stand and the growth of nature. **We know that just about every process has side effects, positive or negative. But these sidestreams can be deliberate and sustaining rather then unintended and damaging.** This is the expanding role of the designer: to design not only 2-dimensional facades or 3-dimensional objects, but to become designers of ecosystems themselves. We can be inspired by nature to design some positive side effects into our own industrial models instead of focusing exclusively on a single end. It is this biological system which has nourished a planet of thriving, diverse abundance for millions of years. Only until very recently in the Earth's history, it was the only system that existed, and every living thing on the planet belonged to it.

This cyclical, cradle-to cradle system of nutrient and waste flow depends on a concept where waste does not exist: *"To eliminate the concept of waste means to design things-products, packaging, systems-from the very beginning on the understanding that waste does not exist...it means that the valuable nutrients contained in the materials shape the design: form follows evolution, not just function" (Braungart & McDonough, 2009: 103-104).*

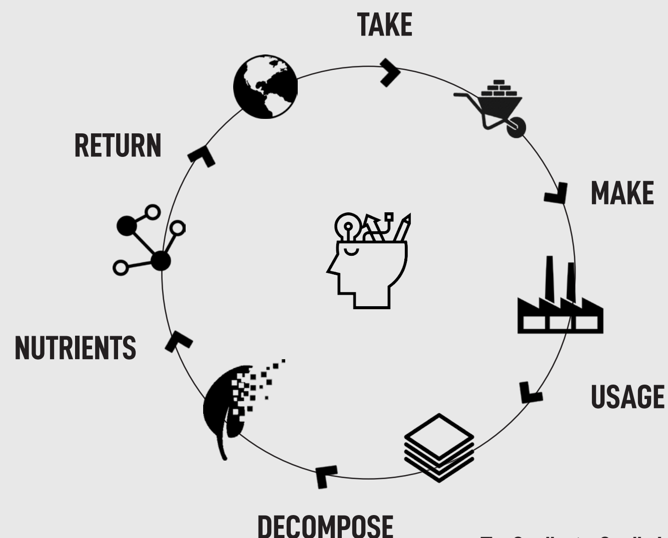
A model with no waste means that products are composed of either materials that biodegrade and become food for what Braungart and McDonough deems as *biological cycles*, or of technical materials that can stay in closed-loop *technical cycles* , in which they continually circulate as valuable nutrients for industry (Braungart & McDonough, 2009). In many ways, products can be designed in the same way that Native Americans used buffalo carcasses, optimizing every element, from the tongue to the tail. **Factories can be built in ways that optimizes the added value of by-products, that nourishes the ecosystem with biodegradable material and recirculates technical materials instead of dumping, burning or burying them.** Systems, including economic and ecological ones, can regulate themselves. Instead of using nature as a tool for human gain, industrial processes can become tools of nature itself. At the same time, if nature is the model, it is important to work with a rich connection with place. **Industries that respect diversity should engage with local material and energy flows and with local social, cultural, and economic forces, instead of viewing themselves as autonomous entities, unconnected to the culture or landscape around them** (Braungart & McDonough, 2009).

Respecting diversity in design also means considering not only how a product is made but how it is intended to be used, and by whom. In a cradle-to-cradle model, it may have many users over time and space. For instance as McDonough suggests, *"an office building or store, for* *example, might be designed so it can be adapted to uses over many generations of use, instead of built for one specific-purpose and later torn down or awkwardly refitted" (139).* The SoHo neighbourhood in New York is one such example, where buildings have gone through many cycles of use and lifetimes: as warehouses, showrooms and workshops, as storage and distribution centres, and more recently as artist lofts, offices, galleries and apartments.

In today's society, often champions of "sustainable development" tend to use the commonly known "triple-bottom" line approach based on the trio of ecology, equity and economy. This approach in many ways has had positive impacts on the efforts of enterprises and industries in incorporating sustainability goals into corporate accountability. But when examining what actually happens in practice, what often happens is that economic considerations are weighted the most, with the social and ecological benefits considered as an afterthought rather than given equal weight at the outset. In many ways, businesses assess their health as they always have-economically-and then "tack on bonus points" for eco-efficiency, reduced accidents, jobs created and philanthropy (Braungart & McDonough, 2009).

What is really needed is for these questions to be considered at the outset rather then after the fact. They can be used as a design tool which allows the designer to create value in all three sectors. What becomes challenging is shifting a model which has been prevalent for more than half a century. As Braungart and McDonough states, *"The shift to new models and more diverse input can be unsettling. In the face of immediate deadlines and demands, such changes can be seen as messy, burdensome, and threatening, even overwhelming...as Albert Einstein observed, if we are to solve the problems that plague us, our thinking must evolve beyond the level we were using when we created those problems in the first place" (165).* If we think about it as a culinary dish, we are not longer substituting ingredients, but rather, throwing out the recipe all together and starting from scratch: *"To commit to a new paradigm, rather than an incremental improvement of the old...immediate change is difficult in a market dominated by the status quo....the intention is not to be slightly more efficient, to improve on the old model, but to change the framework itself" (182).*

"To eliminate the concept of waste means to design things: products, packaging, systems, from the very beginning on the understanding that waste does not exist...it means that the valuable nutrients contained in the materials shape the design: form follows evolution, not just function"



The Cradle-to-Cradle Industrial Model

2.2 THRIVING IN THE NORTH

History of Arctic Sustainability

When we think about the implementation of cradle-to-cradle models of economy and resources, Finland has been leading globally in its transitioning into a bio-based and circular economy. Finland has been gradually shifting to an economy that relies on renewable natural resources, also known as *bioeconomy*, and the effective use of by-products and waste. When produced in a sustainable way, these bio-resources and materials can have an array of beneficial side effects, including carbon capture, curtailing erosion, protecting the soil, providing habitats and many other ecosystem services (Nordic Council of Ministers, 2017).

But what makes Finland and its northern regions like this so ingenuitive by nature? It is said that Finns are born with an *"Arctic attitude"*. Finland is a world leader in many categories because of its Arctic climate, not in spite of it. Finnish people don't just deal with it – they enjoy it, too. Ideas must withstand the challenges of the changing seasons. This goes for everything from technology to food to recreation. **For centuries, living and thriving in northern regions has required active adaptation to the environment. The Arctic identity of Finland has been shaped by climate, nature, geography, history and experience.** Finland as a whole is a truly Arctic country: with one third of all the people living north of the 60th parallel are Finns (Prime Minister's Office Publications, 2013).

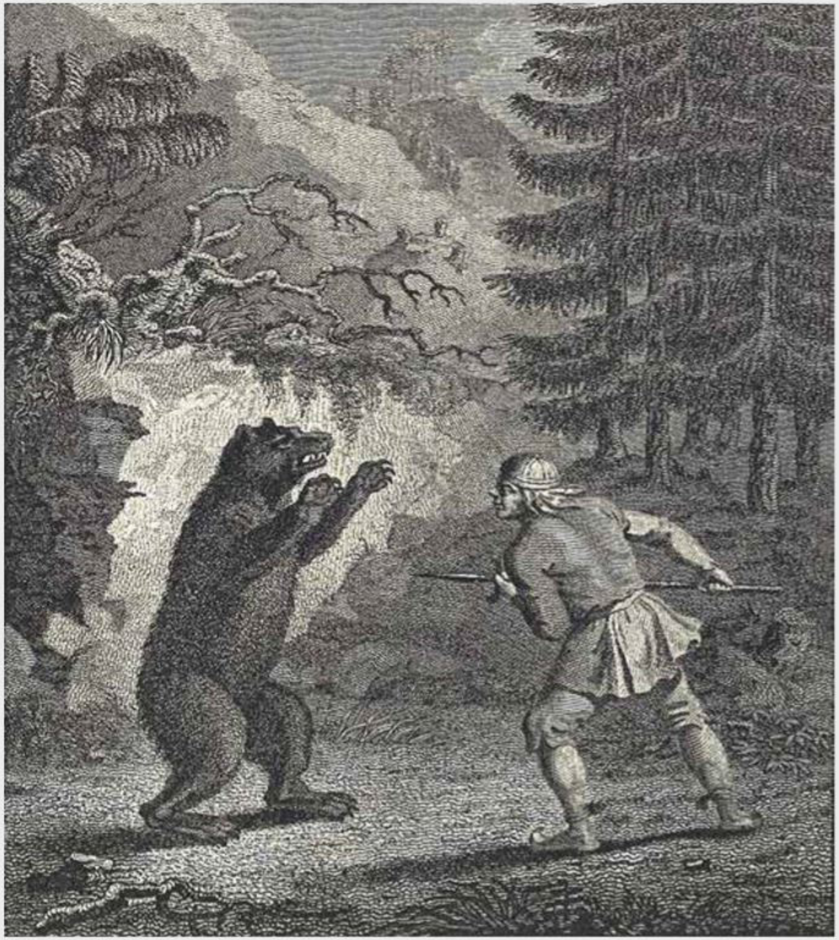
The skills and knowledge that human communities have amassed over the course of history has enabled the creation of a strong foundation for sustainable development of Arctic and subarctic areas and for the sustainable use of resources. The first small groups of Finnic people, dressed in skins and furs and carrying their bows and arrows and their spears came to the coastal districts of what we now know as Finland some 11,000 years ago (Lähteenmäki, 2017). These groups consisted of men who had come to the north to sound out the new area, who would stay only a short time to hunt in the forests and catch fish in the rivers and lakes or sea. They would have lived in flimsily built huts or tents before leaving to spend the darkest and coldest part of the winter back in the places they had come from. Gradually, they settled to live in these new areas, bringing their families with them. The first permanent settlements arose on the sea shores and at the mouths of the rivers, although for a long time they would have continued to move from place to place in families or hunting groups in search of game, building new huts or dwellings as necessary.

Some of these pioneer inhabitants would have come over the Baltic ice from Estonia, some from the south-east via the Karelian Isthmus and some from the Lake Onega region further east (Lähteenmäki, 2017). Scholars in later times came to refer to these ethnic groups as the Finno-Ugric people (the Baltic-Finns and Saami/Lapps). Harsh natural conditions prevented rapid population growth, so for a long time large uninhabited tracts remained and attracted new settlers.

To these populations, the north offered promises of a prosperous, albeit challenging, life. The sea, the rivers and the thousands of lakes, filled with an array of fish and seals, and the hinterland was a wilderness inhabited by big game such as bears, elk and wild deer and smaller mammals that were valuable sources of furs, such as beavers and foxes. **Archaeologists have characterized these first humans who ventured to the north as courageous, skillful and inventive. There is no doubt that living in the north had called for special skills to manage adequately in barren lands with long and harsh winters** (Lähteenmäki, 2017).

"The sea, the rivers and the innumerable lakes were teeming with fish and seals, and the hinterland was a wilderness inhabited by big game such as bears, elk and wild deer and smaller mammals that were valuable sources of furs... Archaeologists have characterized these first humans who ventured to the north as courageous, skillful and inventive. It certainly calls for special skills to manage adequately in these barren lands where the winters are so long"

Image Source: Vincenzi, G. *Nordic Sami (Saami) people in Sapmi (Lapland) in front of two Lavvo Tents.* Retrieved from https://www.pilotguides.com/articles/the-sami-people-of-lapland/



The ancient inhabitants of the present area of Finland lived off nature, which provided them with food and the other necessities of life, but was also in many ways a source of danger. Photo: L. Morel-Patio, *Paysages du Nord*. Paris 1856.

Image Source: Page from *Footprints in the Snow* (2017)

At the same time, the remoteness of the Finno-Ugric settlements from the centers of agrarian civilization and the natural conditions didn't conduce to borrowing useful crops and technologies, and to developing agriculture in general. Fishing and hunting dominated in the local economy, and such way of economic development required quite large territories (Stetsyuk, 1978). **Additionally, it was natural for the Finns to make use of parts of the prey animals they had caught and other products of nature in their weapons and tools and for culinary purposes** (Lähteenmäki, 2017).

As the centuries went by, however, these Finnic groups began to inhabit the coastal areas, lake shores and river banks, and were slow to move upstream to the heads of the rivers or into the forests in the interior of the country. In this time, the family units grew into larger clans or tribes, and eventually into mixed societies that were differentiable in terms of occupation, living habits and culture and were administered in the framework of ever larger geographical units. Thus the small Stone Age communities developed over the centuries into small towns that served as population centres.

These populations have laid the foundation for the sustainable development of the north. Currently, the Arctic region is undergoing a number of rapid, conflicting developments. **Arctic areas are witnessing the effects of global warming more dramatically than any other part of the world; new transport routes are opening up; energy resources and minerals are being exploited; and tourism is on the increase**. Combating climate change and mitigating its impact are vital for the stability and security of the Arctic region and it serves as the central point of departure for the activities being carried out there (Prime Minister's Office Publications, 2013).

Like many other countries in the Arctic region, Finland has published an Arctic strategy, in 2010 and with revisions in 2013 and 2016. Perhaps the most significant component about this strategy is that it **defines the country as an Arctic one in its entirety from the edge of the Helsinki conurbation (the "wolf limit") to the land of Santa Claus (Rovaniemi and above).** In addition, the recognition and acceptance of Finland's northern status has never been stated as boldly and unambiguously before. All official political statements strongly indicate that the country wishes to be looked on in future as a committed Arctic player, a country that is capable of reconciling the boundary conditions imposed by the environment of the north with the business opportunities that the region can offer, and of doing so in a manner that takes advantage of international cooperation (Lähteenmäki, 2017).

The sensitive Arctic environment and challenging natural conditions emphasise the importance of know-how and knowledge of the conditions, and the requirements related to the functionality and reliability of products and services are particularly emphasised (The action plan for the update of the Arctic Strategy 2017). It takes a tremendous amount of know-how to make production profitable and sustainable in northern conditions. New solutions and innovations are therefore required and continue to be needed to remain competitive. **Finland's extensive and in-depth Arctic expertise is a result of its highly advanced education system, where its position as an Arctic country is taken into account at all levels.** Arctic and cold climate research is carried out and training provided at several higher education institutions and research institutes in many academic disciplines (Prime Minister's Office Publications, 2013).

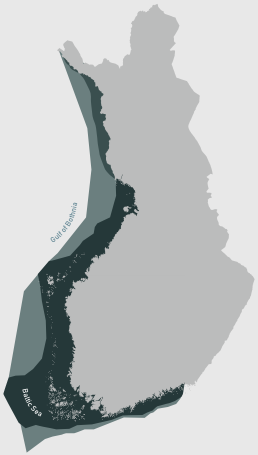
2.3 NATURAL RESOURCE ABUNDANCE

The Land of a Thousand Lakes

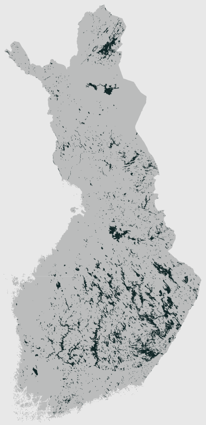
As we have seen, **Finland and its northern regions has great potential in replacing unrenewable and artificial resources with bio-based and natural resources, not least to the large areas in which biomass can be found, such as in its seas and forests.** With the Gulf of Bothnia and the Baltic Sea offering opportunities in blue bioeconomy growth, as well as Finland extensive network of rivers, Finland is also deemed the "Land of a Thousand Lakes". With a population of about 5.5 million people, it has over 187,000 lakes. A comparison of the number of lakes with its population reveals that there is one lake for every 26 Finns. Water makes up 10% of the land area in Finland (World Atlas, 2019).

In addition, **approximately two thirds of Finland's land area is under forest, making it the most densely forested country in Europe** (Natural Resources Institute of Finland 2018). The dominant types of trees in the forest include pine, birch, and spruce. The Baltic region has strong traditions and roots of using bio-based production for more than just food or feed: it can be found in wooden houses, wooden furniture, the production of sustainable textiles from wood residues, new food and feed products from agricultural sidestreams and seaweed, to name a few (Nordic Council of Ministers, 2017)

The natural environment is also embedded in Finnish culture and lifestyle. As soon as the snow melts in the spring, almost one fourth of all the Finns set out for their summer cottages on the edges of the forests and the shores of the lakes. **There are some 500,400 summer cottages in Finland altogether, of which more than 30,000 are in the northernmost province, Lapland, and quite a large number of these nowadays are modern "second homes" which can frequently be used in winter as well as for about three months in the summer** (Lähteenmäki, 2017).



Sea



Lakes

Rivers

Forest Coverage
76% of FInland's land area*

*Source: Natural Resources Institute of Finland

"Finland and its northern regions has great potential in replacing unrenewable and artificial resources with bio-based and natural resources, not least to the large areas in which biomass can be found, such as in its seas and forests."

Image Source: Flickr: goSaimaa - Lappeenranta & Imatra region. *Lake Saimaa.* Retrieved from https://www.flickr.com/photos/gosaimaa/10324399853/sizes/h/

2.4 BIOECONOMY GROWTH IN FINLAND

It is said that by the year 2030, the world will need 50% more food, 45% more energy and 30% more water (Ministry of the Environment, 2014). This growth in demand will increase pressure on our natural resources. The availability of raw materials and the efficiency of their use will thus become a new competitive advantage for Finland. This global development trend lays the foundation for a change towards bioeconomy. Bioeconomy is not a new concept: it is a combination of primary production and refining sectors and end product markets.

Finland has led an international example for a low-carbon and resource-efficient society and a sustainable economy, **With its plentiful of renewable natural resources, high level of expertise and industrial strengths, Finland is positioned as a pioneer of bioeconomy in the world.** Finland has set out a national *Bioeconomy Strategy*, where the primary goal is to boost the national economy and employment while enhancing the well-being of Finnish people.

The strategic goals of the Bioeconomy Strategy are:

1. *A competitive operating environment for the bioeconomy;*
2. *New business from the bioeconomy;*
3. *A strong bioeconomy competence base;*
4. *Accessibility and sustainability of biomasses.*

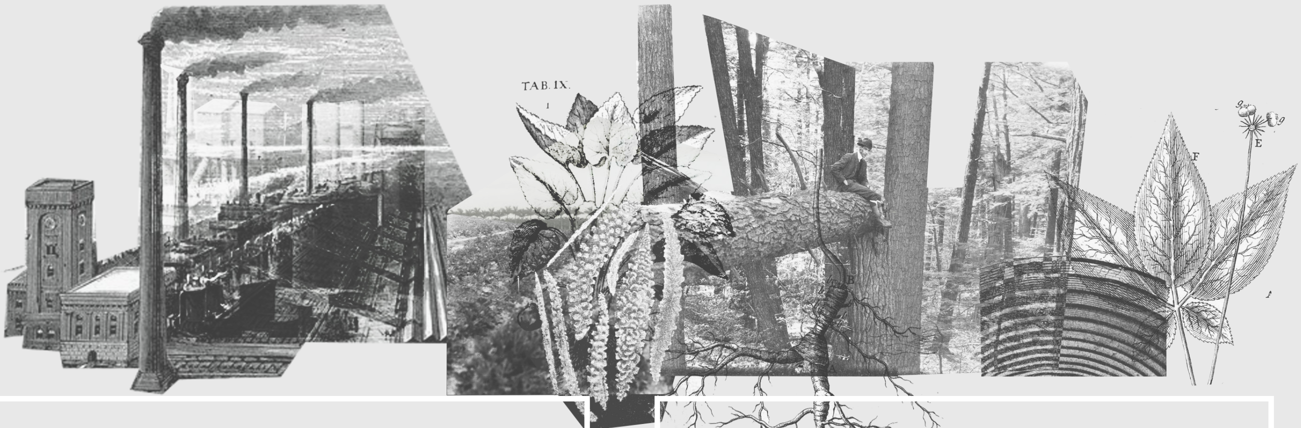
The **Finnish Bioeconomy Strategy** defines bioeconomy as *"an economy that relies on renewable natural resources to produce food, energy, products, and services" (Ministry of the Environment, 2014).*

The aim of the strategy is to reduce the dependence on fossil fuels, prevent the depletion of ecosystems and promote economic development by creating jobs in line with the principles of sustainable development. As such, bioeconomies have the potential to fundamentally alter the ways in which the global economy functions by replacing often fossil-based materials with bio-based materials from forest, farmland, marine plants etc.

Ambitious growth targets have been set for the bioeconomy in the strategy: **by 2025, the bioeconomy output will increase to 100 billion EUR and the number people employed will grow by 100,000 people** (Ministry of the Environment, 2014). Most recently, bioeconomy accounts for a 12% share of Finland's GDP in 2014, with a value added of national economy of 193.3 billion EUR, and the share of exports is approximately 22% (Natural Resources Institute of Finland, 2017). As most production is based in rural and coastal areas, it boosts development in more rural areas of the Nordic Region. **The Nordic bioeconomies have focused on increasing the value of currently underutilized living natural resources, as well as unlocking the full potential of residues and waste** through education, research, development and innovation, biotechnology, digitalization, biorefineries, infrastructure and financing (Nordic Council of Ministers, 2017).

The Kemi-Tornio region in northern Finland is just one example of a shift to more sustainable production models in recent history. The Kemi-Tornio region has established an Arctic industry and circular economy cluster to enhance industrial symbiosis and strengthen the development of bioeconomy in the region. The region is a particularly important area for industrial refinement and exports, as it is responsible for 80% of Lapland's industrial production. With a compact area radius of 25 kilometres, this also provides excellent industrial symbiosis benefits as it generate 1.7 million tonnes of industrial by-products and residues every year from a large ecosystem of mines, metal producers, pulp and paper mills, cardboard factories, fertilizer and fine chemical producers (Nordic Council of Ministers, 2017).

By analyzing the by-products and residue streams from companies in the region, value-added products can be produced by combining and re-thinking several by-product and residue streams. **For example, bioenergy from forest residues with the possibility for future large-scale biofuel production** (Nordic Council of Ministers, 2017). The bioeconomy strategy focuses on using a cross-sectoral approach: the Kemi-Tornio region plans to evolve from factory level optimization through symbiotic products towards a full-scale industrial symbiosis and circular economy (Nordic Council of Ministers, 2017).



Value Added of Bioeconomy

12% the share of bioeconomy

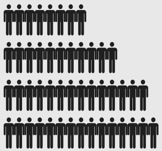
Value added of national economy
EUR 193.3 billion*

Projected Bioeconomy Growth (2025)

output of bioeconomy will increase by:

100 billion

number of people employed will grow by:



100,000 people

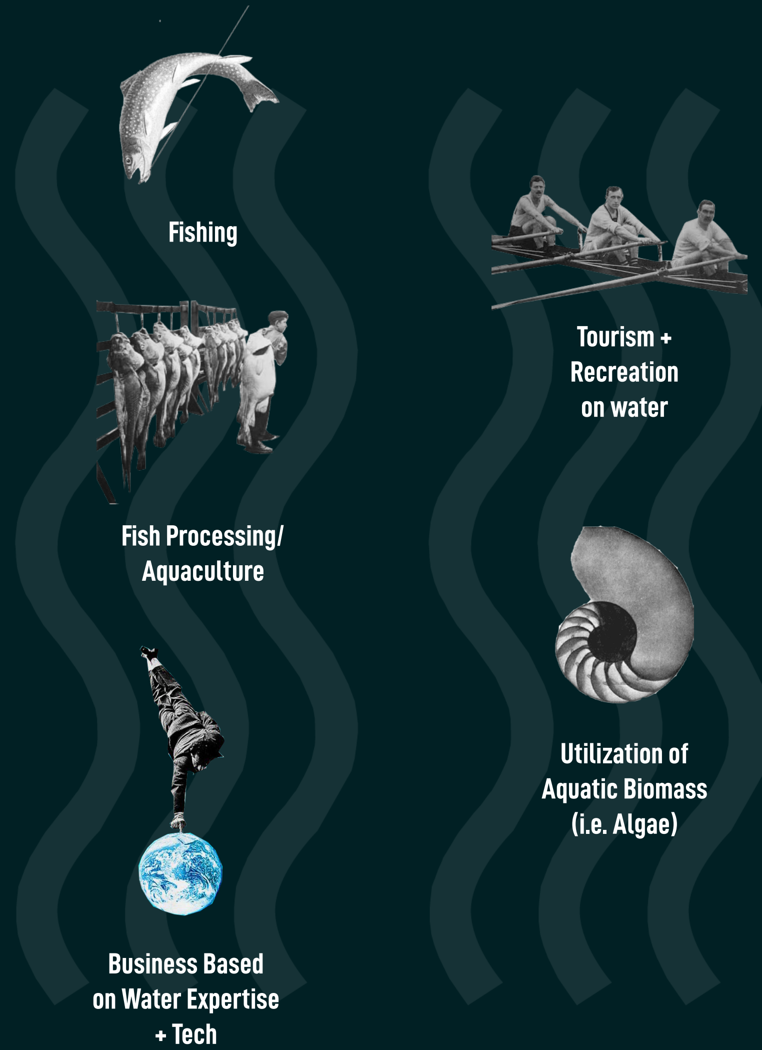
Preliminary Data. Sources: Statistics FInland & Natural Resources Institute of Finland, 2014

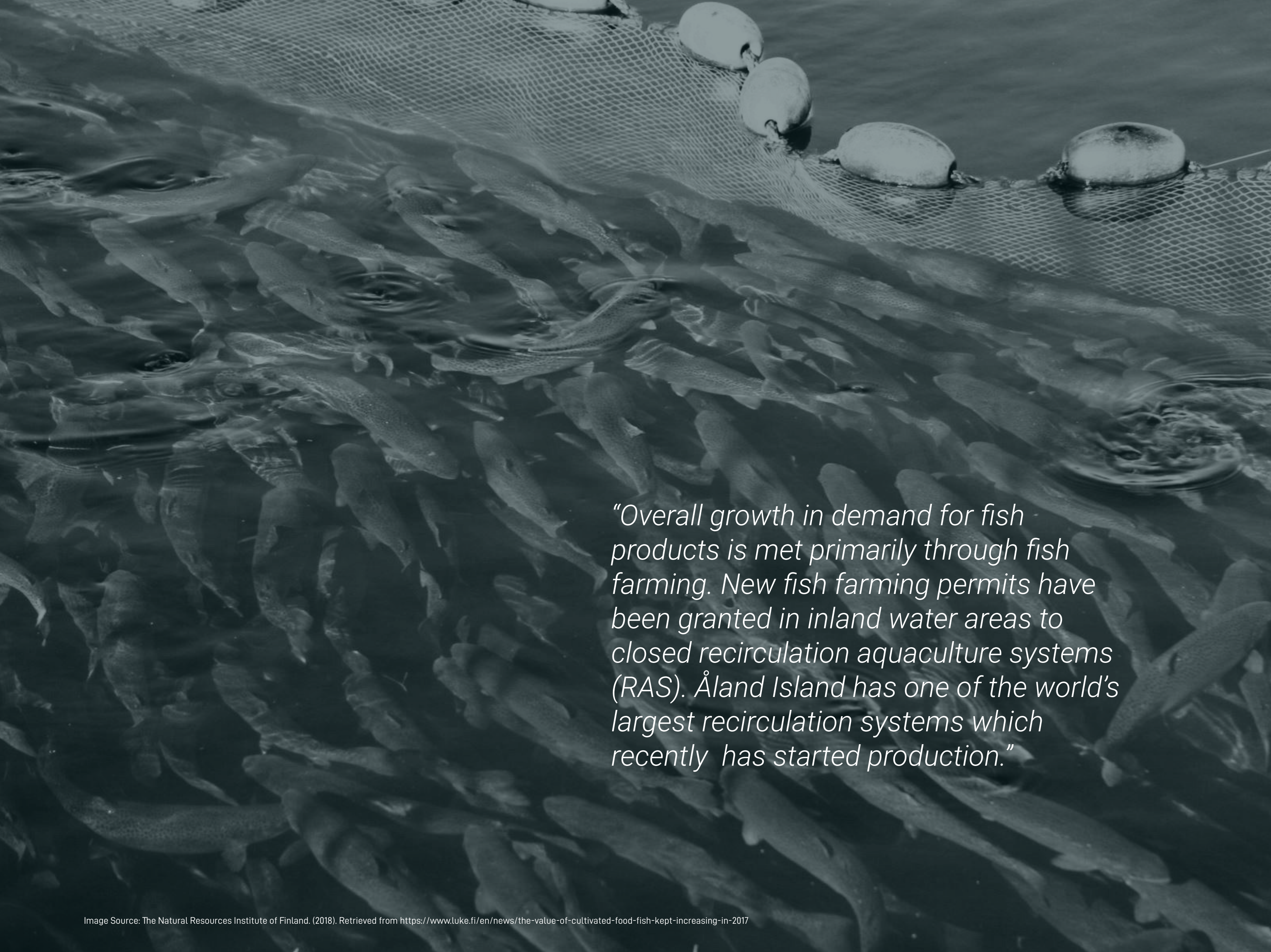
2.5 BLOOMING BLUE BIOECONOMIES

Finland as a Pioneer

Another sector of bioeconomy that has been developing in Finland is blue bioeconomy. In the wider perspective, the Nordic countries including **Finland are positioned strategically to be pioneers in blue bioeconomy: with large amount of lakes, rivers, and sea resources and the diverse expertise of a high standard in the field.** Finland in particular has adopted a national development plan for blue bioeconomy.

Blue bioeconomy refers to *"business activities based on the sustainable and intelligent use of renewable aquatic natural resources" (Nordic Council of Ministers (2016).* It comprises of activities such as fishing, fish processing and aquaculture, businesses based on water expertise and technology, tourism and recreation on water and the aquatic environment, as well as the utilization of aquatic biomass, such as algae. At the core of blue bioeconomy is the fisheries. **Offshore fish farming and fish feed recirculating Baltic Sea nutrients have recently been investigated as new solutions to expand sustainable marine aquaculture in the Baltic Sea** (Natural Resources Institute of Finland, 2016). **The overall growth in demand for fish products is met primarily through fish farming; as the supply from fishing operations is not increasing on a global level.** New fish farming permits have been granted in inland water areas to closed recirculation aquaculture systems (RAS). **For example, in Åland Islands, one of the world's largest recirculation systems has started production** (Natural Resources Institute of Finland, 2016). The cost of RAS is high and the technology is demanding, which is why it is still only gaining some popularity now. The following sections investigates the key services that blue bioeconomy provides.





“Overall growth in demand for fish products is met primarily through fish farming. New fish farming permits have been granted in inland water areas to closed recirculation aquaculture systems (RAS). Åland Island has one of the world’s largest recirculation systems which recently has started production.”

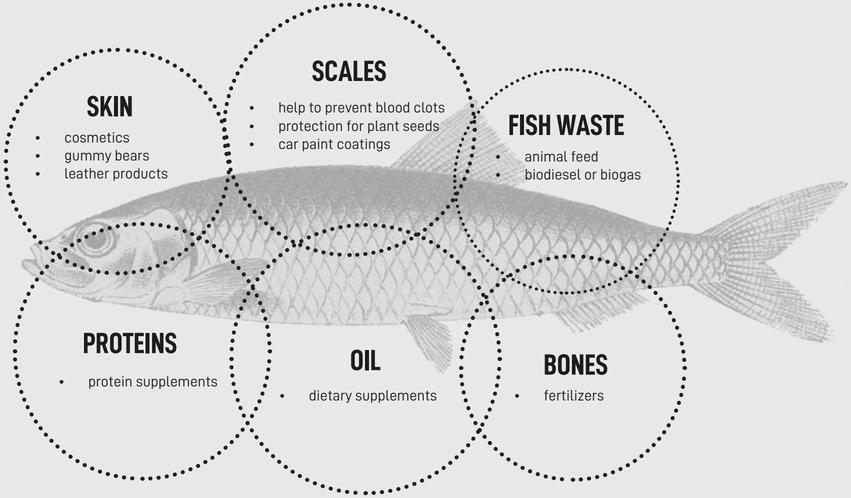
Image Source: The Natural Resources Institute of Finland. (2018). Retrieved from https://www.luke.fi/en/news/the-value-of-cultivated-food-fish-kept-increasing-in-2017

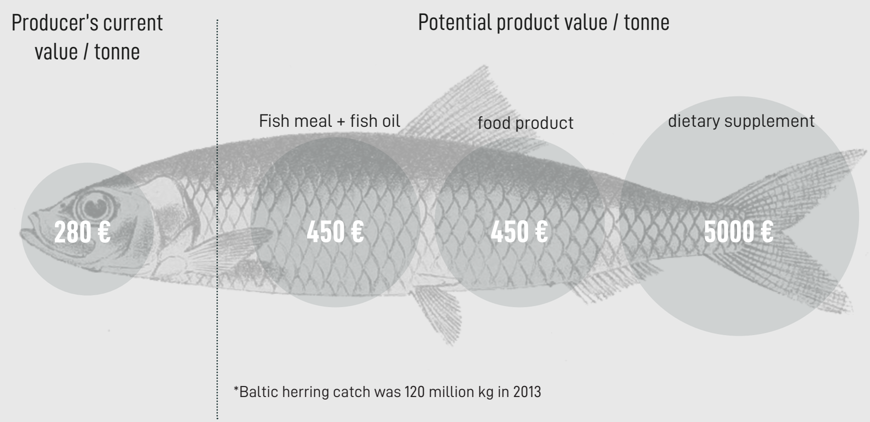
Nutrient Recycling + Industrial Symbiosis

One element of blue bioeconomy is nutrient recycling and industrial symbioses. Industrial side streams can be processed using a variety of procedures that make them suitable for reuse. In fish farming, nutrients can be extracted from waste water created by production and can be bound into recyclable substances, such as fertilizers for agriculture industries (Natural Resources Institute of Finland, 2016). This is particularly important for fish farming where nutrient load is one of the largest obstacles to increased production.

Added value to fish products

Further, the growth of business activities based on water and living aquatic resources is a central goal for blue bioeconomy. The efficient use of resources and new concepts and innovations need to be developed to diversify resource use and to produce added value. Added value in blue bioeconomy is generated through fish processing activities. Added value can be generated at every stage of processing, starting from the gutting of the fish (Natural Resources Institute of Finland, 2016). **New value is obtained when sidestreams of the production or low value catches are utilized.** For instance, fish oil extracted can be used for pharmaceutical or cosmetic industries. This is a promising new area of blue bioeconomy.





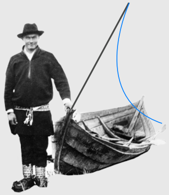
**Source: Natural Resources Institute of Finland*

Tourism Services

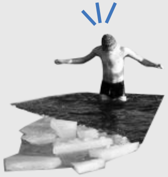
Another component of blue bioeconomy is the tourism services they provide. In Finland, 40% of the adult population owns or otherwise has access to a holiday home, with the majority being located next to lakes, sea shores or rivers (Natural Resources Institute of Finland, 2016). Additionally, two thirds of Finns spend each year in holiday homes, 70% go swimming in natural water bodies, 49% of Finns go boating and 1 in 10 engage in ice hole swimming (Natural Resources Institute of Finland, 2016). **This indicates the significance of water-based activities in the Finnish culture and the opportunities blue bioeconomy can provide in promoting tourism around water**. For the Baltic region, aquatic resources serves as critical resource both historically to this day, and it is why blue bioeconomy is gaining traction in several locations across the Baltic.

40% of adult population owns or has access to a holiday home

70% go swimming in natural water bodies



49% go boating



1 in 10 engage in ice hole swimming

salmo salar [atlantic salmon]

Image Source: Urho, L. *Atlantic Salmon*. Retrived from http://www.luontoportti.com/suomi/en/kalat/atlantic-salmon

2.6 REGIONAL SIGNIFICANCE OF SALMON IN THE BALTIC

Impacts on regional development of the Baltic region

In the past, salmon played a central role in the economy and culture of the Baltic region and was one of the major protein sources for its populations. **Over the years, salmon populations have collapsed due to logging, dams for hydropower production, pollution and overfishing** (Haapasaari et al., 2013). Today, salmon is a symbol of great cultural importance, with large public spending for habitat restoration and the willingness-to-pay by angler. The Finnish state has budgeted approximately 1.4 million EUR for annual stocking between the years of 2000-2004 and over 9 million EUR to spent for habitat restoration from 1997-2005 (Haapasaari et al., 2013). However, **estimates suggest that the cultural services of salmon are greater than the economic value of commercial salmon landings** with a new present value ranging from 6 million EUR to 25 million EUR in Denmark, Finland, Poland and Sweden from 2009-2015 (Haapasaari et al., 2013).

Baltic salmon, or *salmo salar l*, is the keystone migratory species in the Baltic Sea. An anadromous species, the fish are born in fresh water, spend most of their life in the sea and return to fresh water to spawn. Baltic Salmon reproduce naturally in nearly 30 rivers. In the past, this number was closer to 100 rivers, but as a result of damming, habitat destruction, pollution, and intense fishing, it has resulted in a massive decline. In the Baltic region, wild caught salmon is a source of living for a relatively small number of fishermen catching salmon for commercial or household subsistence use. **Commercial salmon landings have been declining from 5600 tonnes in 1990 to 900 tonnes in 2010, the lowest since 1970** (Haapasaari et al., 2013). Declining stocks, fish regulations in coastal areas and recent landing restrictions due to dioxin contents of salmon have resulting in a decline in commercial fishing efforts overall. This has been supported by an influx of farmed Atlantic Salmon in the European fishing markets (Haapasaari et al., 2013). Therefore, the social value of salmon in the region is higher than the value of commercial catch.

For centuries, Baltic salmon has been an important factor behind the well-being of Northern parts of Baltic Sea areas, including the Northern Ostrobothnia region. It has served as a source of healthy diet, an important export which brought significant wealth to communities, and is still evident in the Nordic landscapes. Several grand houses built with the money earned from salmon in the 19th and 20th centuries are still an integral part of the cultural heritage of the region (Haapasaari et al., 2013).

At the same time, annual rhythms of whole villages were adapted to the migration patterns of salmon: specific professions and skills were developed and buildings were built to serve the salmon fishing industry, shaping not only people's way of life and thinking, but shaping the urban fabric itself. Several of today's fishermen are descendants of the bygone salmon fishers that have contributed in the regional development of coastal areas still inhabited by the fee remaining salmon fishers. The future of salmon is more pronounced to sport fishing and recreational fishing in the rivers. Still, salmon remains a connecting element for a variety of people.

Those that expect to produce wealth to today's sparsely populated salmon river areas struggle to promote the improvement of salmon stocks and for developing infrastructure around fishing tourism (Haapasaari et al., 2013). **In northern parts of Nordic counties, salmon fishing and the overall fishing tourism in general is considered to have significant potential for the local and regional tourism business** (Haapasaari & Karjalainen, 2010).

The Baltic Drainage Area

Baltic drainage area. Rivers and reaches of rivers supporting salmon runs in the *past (thin line)* and **present (thick line)**.

Source: Karlsson & Karlström, 1994

Decline in Economic Value of Commercial Salmon Landings in FInland

Image Source: Northern Ostrobothnia museum, Uuno Laukka's collection, 2005

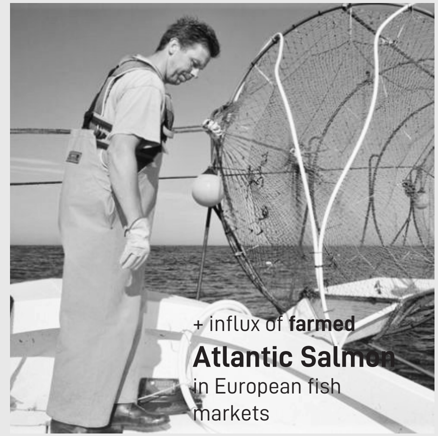
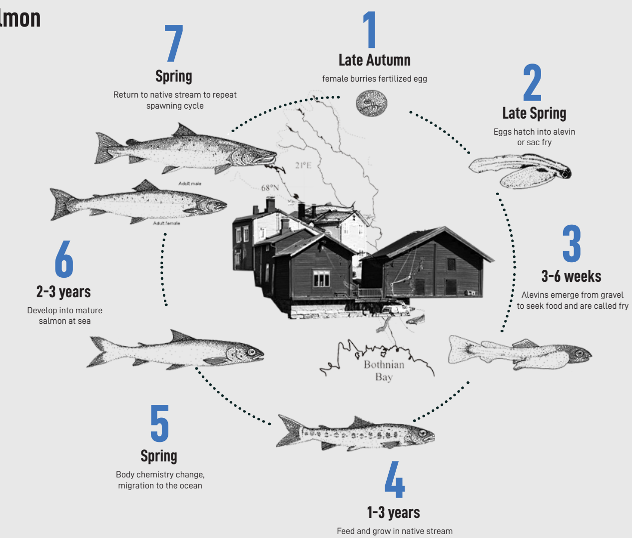


Image Source: Markku Saiha / Suomen Ammattikalastajaliitto ry [Finnish Professional Fishermen's Association]

Life Cycles of Salmon



To compensate for the current loss of natural spawning areas, hatchery-reared salmon has been stocked in several rivers across Finland. This may result in mixing of wild salmon in some rivers which causes a genetic risk for small wild salmon populations (Haapasaari et al., 2013). The goal is to have releases gradually come to a stop, however it is under considerable political discussion in Finland as hatchery-reared salmon is still considered to be important for professional fishermen fishing these waters. Stocking can be replaced with increasing natural reproduction potential by improving wild salmon passage in regulated rivers. In Finland's 159,000 km of rivers, 90% are regulated (Natural Resources Institute of Finland, 2016). **Currently, Finland's remaining indigenous wild salmon stocks are limited to 2 rivers that drain into the Arctic Ocean and 2 rivers that drain into the Baltic Sea** (Natural Resources Institute of Finland, 2016)**.** The Tornionjoki River, bordering Finland and Sweden in the northernmost part of the Gulf of Bothnia, is one of the most closely examined Baltic salmon stock. It is the largest 'pristine' river in Western Europe with no migration obstacles. **As a result, 1 in 3 of 1.5 million salmon that feed in the Baltic Sea are born in the Tornionjoki River and 50,000 to 100,000 salmon spawn in the river each year** (Natural Resources Institute of Finland, 2016). This was largely as a result of the recovery programs led in the 1980s when salmon stocks were near the brink of extinction.

In Finland, stream restoration has focused on main channels and tributaries that were channelized to facilitate timber floating, mainly between the late 19th and mid-20th centuries (Marttila et al., 2016). Since the 1970s, timber floating was gradually abandoned, and efforts to restore streams closer to their natural state was initiated (Yrjänä, 1998). The primary goal of restoration efforts has been to enhance fishing opportunities by recreating stream habitat, particularly for salmon. This includes returning large boulders and spawning gravel to the stream channel and reopening side channels (Marttila et al., 2016).

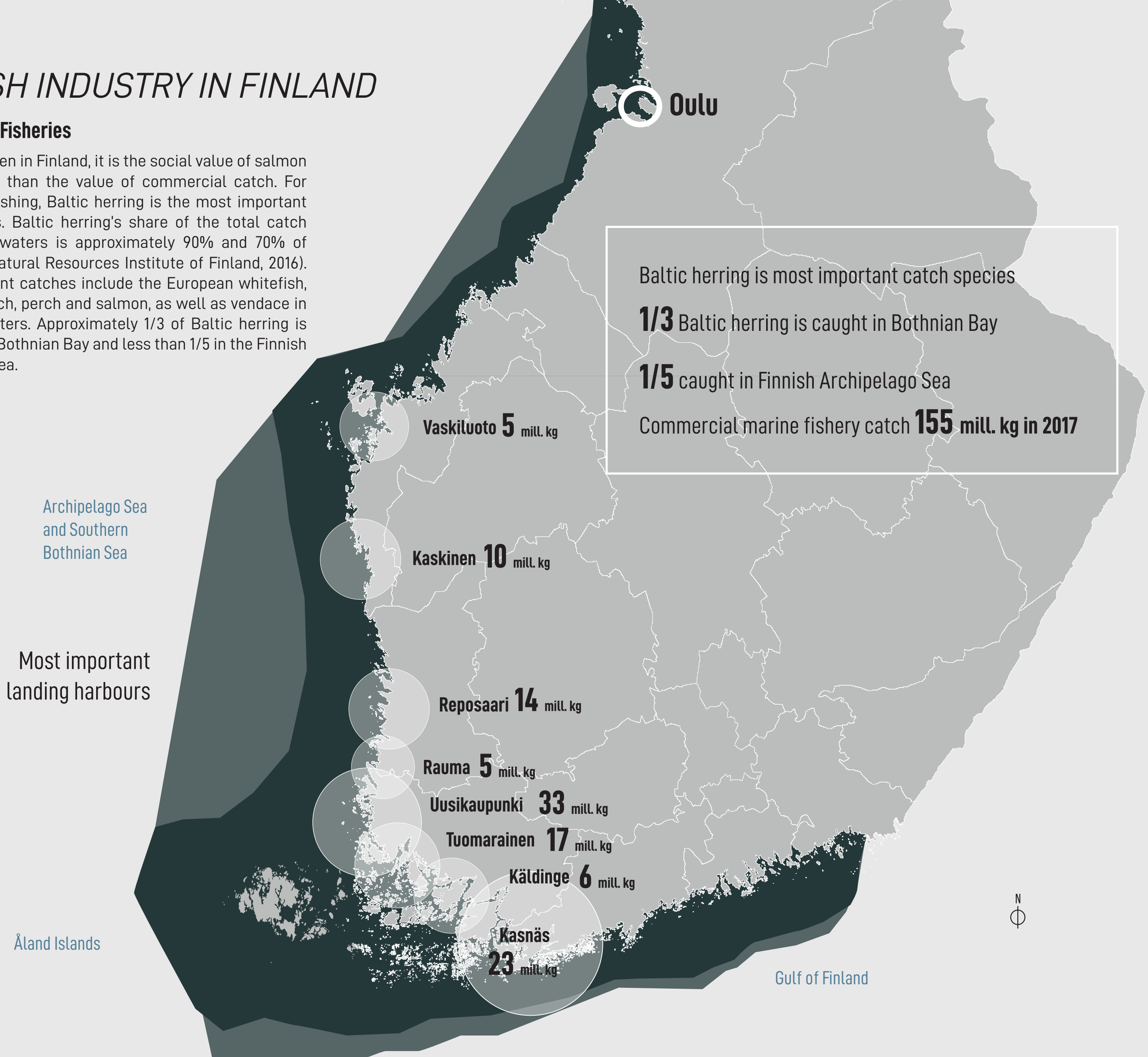
Tornionjoki River Drainage Area

Image Sources: Hayden et al., 2015

2.7 FISH INDUSTRY IN FINLAND

Commercial Fisheries

As we have seen in Finland, it is the social value of salmon that is higher than the value of commercial catch. For commercial fishing, Baltic herring is the most important catch species. Baltic herring's share of the total catch from marine waters is approximately 90% and 70% of total value (Natural Resources Institute of Finland, 2016). Other important catches include the European whitefish, sprat, pikeperch, perch and salmon, as well as vendace in the inland waters. Approximately 1/3 of Baltic herring is caught in the Bothnian Bay and less than 1/5 in the Finnish Archipelago Sea.



Recreational Fishing

Recreational fishing is one of the most popular sports in Finland, with approximately 1 in 3 Finns taking up fishing. There are approximately 1.6 million recreational fishers: with 40% being male fishermen and 20% being female.

1 in 3 Finns take up fishing

1.6 million recreational fishers

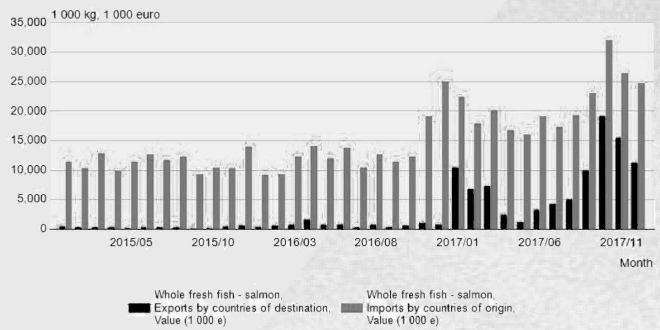
40% are male fishermen and

20% are female

Market + Consumption Trends

The increase in fish market in Finland has been largely based on imported fish. In the 1980s, approximately half of fish consumed was domestic. **Today, imported fish accounts for more than 80% of all fish sold. 50% of exported fish is from Norway, with salmonids dominating more than half of the fish market** (Natural Resources Institute of Finland, 2016)**.** Salmonids have replaced Baltic herring, which was the most important commercial fish in the early 1980s. Today, Norwegian salmon has taken its place. In fish farming, the most important species remains rainbow trout. Imported salmon and domestically produced rainbow trout are two of the major raw materials for the processing industry: its secure supply and stable quality are essential for fish processing.

Finns have a taste for fish and the demand for fish has doubled since the early 1980s (Natural Resources Institute of Finland, 2016). **Over the years, farmed and exported fish has replaced wild-caught domestic fish.** Of domestic fish species, consumers favour farmed rainbow trout the most, while the consumption of imported farmed salmon has been the highest. **Farmed fish accounts for over 40% of total fish consumption**. In Finland, a substantial share of consumed fish is caught by recreational fishermen (Natural Resources Institute of Finland, 2016). **There are approximately 1700 full-time enterprises engaged in various fishery sectors ranging in fishing, aquaculture, fish processing, and fish retail/wholesale.** Fish processing remains the largest sector in terms of profitability and employment provided (Pokki et al., 2015).



The value of imports and exports of fresh whole salmon per month in 2015–2017.

Source: Natural Resource of Institute of FInland, 2018

80% of all fish sold in Finland is **imported**

400 **mill EUR** worth of fish imported to be refined in Finland

50% of exported fish is from **Norway** (salmonids)

40% of total consumption is farmed fish: **rainbow trout** is most important species for farmed fish in Finland.

1700 **full-time enterprises** in fish sector ranging in fishing, aquaculture, fish processing, retail

Image Source: Bergsmo, T. I. Retrieved from https://www.hurtigruten.com/destinations/norway/inspiration/wildlife/skrei/

Growth in Aquaculture in Finland

Approximately 95 percent of fish farmed for food in Finland is rainbow trout (Natural Resources Institute of Finland, 2016). Domestic, farmed fish is a healthy and safe choice for consumers and it is recommended that people should consume a variety, combining both farmed and naturally caught fish to their diets. The Natural Resources Institute of Finland maintains breeding programmes for rainbow trout and European whitefish. Approximately 80% of domestic rainbow trout retailed in Finland originated from Luke's breeding programs (Natural Resources Institute of Finland, 2016). **Key areas of research of Luke include farming fish for food in recirculating aquaculture systems (RAS) and offshore cages.** Also research in new types of fish feed and farming species in order to diversify food fish production.

As we have seen, Finland's imports of fish are considerably higher then it produces or catches. Approximately 2/3 of all salmonids are farmed outside of the country, principally in Norway or Sweden. **Globally, the volume of fish farming has increased by 2 billion kilos annually and in 2015, the global food production of fish farming exceeded that of beef for the first time** (Natural Resources Institute of Finland, 2016). Through collaborations between fish farming operations and Luke, domestic production can be geared towards responding better to requirements set by fish processing and consumers. **Currently in Finland, about half of all domestic fish for food production is produced in Åland Islands** (Natural Resources Institute of Finland, 2016). **Efforts are being made to diversify food fish production.** Traditionally, fish farming has come with its concerns on its environmental impacts, mainly due to nutrient discharge which may cause local eutrophication. **Overall load has however fallen approximately 70% compared to the early 1980s, largely due to improved feeding techniques and development of feeds.** There also has been considerable growth in RAS technologies and have become popular in the world over. Not only is it a more environmentally friendly but is allows for opportunities to fish farm under optimal conditions around the year. RAS is a fish farming method in which water is circulated by pumping it from fish tanks into cleaning units and back (Natural Resources Institute, 2016). The methods aids in water savings, since the new water accounts for only in between 1-2% of the volume of circulating water. The technology can also significantly reduce nutrient load: it is found that phosphorous discharge can be up to 20% of that of traditional fish farming methods (Natural Resources Institute, 2016). However, RAS requires substantial investments in technology as maintenance costs are high due to energy consumption. **Experimental research and learning environments are therefore a key opportunity area for developing RAS systems in Finland.**

The National Spatial Planning for Aquaculture directs the farming of fish food towards suitable water areas that take into account the environment and other possible users such as cottage and water-based activities. **Several offshore areas in the Gulf of Bothnia have been selected as new opportunity areas for the growth of aquaculture. Today, offshore areas remain underutilized for food production.** The Food and Agriculture Organization of the UN (FAO) reports that offshore fish production represents one of the only options for feeing the world's growing and increasingly affluent population (Natural Resources Institute of Finland, 2016). In Finland, marine fish farming units have been so far sited in partially sheltered locations in archipelago or close to the open sea. This brings unique challenged with the winter and ice. Using common fish farming systems, production equipment must be returned from the offshore archipelago in the autumn in order to protect is from moving ice in the winter. More research is needed to develop innovative fish farming solutions that are durable, rapidly movable and/or submersible (Natural Resources Institute of Finland, 2016). Today, rainbow trout farming conditions are best in the water areas south of Finland were water flow rates and depth balance out the effect of higher summer temperatures. **In the future, optimal farming locations will move to open water areas and fish farming will become more prominent in the northern latitudes**.

"Key areas of research include farming fish for food in recirculating aquaculture systems (RAS) and offshore cages... experimental research and learning environments are a key opportunity area for developing RAS systems in Finland"

170 full-time aquaculture companies producing fish food markets and fish juveniles

95% of fish farmed for food in Finland is rainbow trout

6-8% whitefish and small amounts of trout, char and pike

10 companies produce most of fish and **80%** of fish is produced in sea cages

Overall load of nutrient discharge has fallen **70%** since the early 1980s

Image Source: The Linde Group (2019). Liquid oxygen from AGA is lifeblood for Finnish fish farm. Retrieved from https://www.aga.fi/en/news_ren/customer_testimonials/carelian_caviar/index.html

PART 03

DESIGN INTRODUCTION

3.1 AN INTRODUCTION TO THE SITE

Haukipudas Character

Just 25 kilometres north of the city centre, sits Haukipudas, a town of 19,000 people. Haukipudas was incorporated into the City of Oulu in 2013 along with Kiiminki, Olunsalo, and Yli-li. It is a popular cottage destination area with its shore running along the Gulf of Bothnia and with the Kiiminkijoki River entering through the town before running through the province. Historically, the town was a popular paper mill and fishing area. **Early in the Middle Ages, the lush Kiiminkijoki river attracted village settlements formed by several tens of houses formed near the coast, with most residents being from Southwestern and Western Finland** (Museovirasto, 2009). Agriculture, salmon, whitefish and herring were among the main industries of the population. By the mid 19th century, Maunu sawmill (1863-1908) was founded on the Kiiminkijoki River. At the end of the 19th century, the Halosenniemi sawmill was also established, which operated until 1950.

The most significant of the sawmill industries was the Martinniemi sawmill, which operated between 1905 and 1988 and was the largest employer in the Haukipudas municipality. Martinniemi sawmill products went to the world by sea and land along the Martinniemi junction. In addition to sawing timber, the sawmill produced wooden houses after the war, and paper pulp was made in the Martinniemi wood mill in Laitakar. Construction of sawmills moved from parish to industrial agriculture in rural communes, which in the 1950s, was Finland's second most industrialized country municipality after Harjavalta (Museovirasto, 2009). Today, Martinniemi Timber Oy operates in the old sawmill area. **Thanks to the sawmills, Haukipudas had become an important industrial and employment area in the Northern Ostrobothnian region.** However, today, no actual sawmills are working in Haukipudas. Today, Haukipudas is characterized as a rural area, with small farms, residential buildings and some industry. Many people who live in Haukipudas also work in Oulu and thus it is part of the urban structure of the city. Growth is relatively stable according to City Planning. The main focus of development has been strategically focused on the Haukipudas town centre. The economic strategy is to place new development where most of the services and commercial services are existing. *"In Haukipudas, development is not blooming" says the city planner. "For us, it is not a good idea to put services just anywhere, we want to densify the existing urban structure and not separate it" (T. Yli-Vakkuri, personal communication, February 11, 2019).*

But the word densify is perhaps an overstatement when describing urban development projects occurring in the area, which is primarily comprised of low-scale single family homes and rowhouses, a typical "densification" project for a town its size. The largest on-going plan in Haukipudas is a residential area that is proposing approximately 200 smaller houses just west of the town centre. *"The plan outlines both single family homes and well as rowhousing. It is intended that this development would cover the growth needs of the area. Small improvements and infill projects are also occurring within the area where there are appropriate spots for it" (T. Yli-Vakkuri, personal communication, February 11, 2019).*

"However, services and jobs would undoubtedly enliven the area" says Sari. **Haukipudas' long standing history as a key industrial community in the region provides a backbone for new industry opportunities.** Its proximity to nature also brings opportunities for recreation and tourism.

"In terms of tourism...in northern Finland, growth is about 17 percent per year, so it is constantly growing. We anticipate the growth for tourism will come to Oulu as well and we are preparing for that." (S. Hirvonen-Kantola, personal communication, February 7, 2019).


Laitakari
Martinniemi Centre
THE SITE
Kiiminkijoki Delta
Bridge across Kiiminkijoki River
Inkonnokka
Haukipudas Centre
N
0
1km

3.2 HISTORY OF THE SITE

Industrial Memories of Laitakarin Harbour

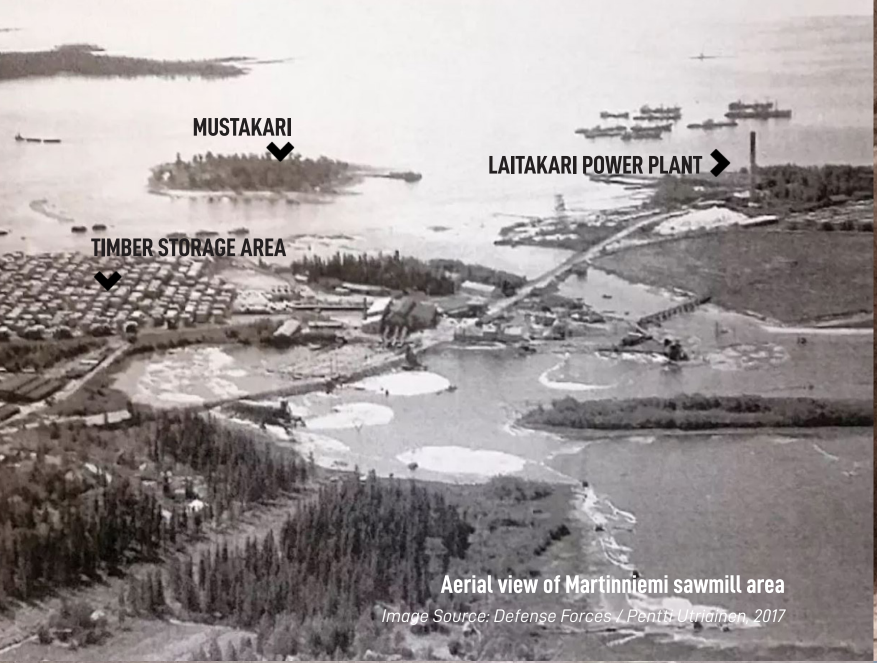
Laitakarin Kala Oy is seeking its fish farm location in the Laitakar harbour area of Martinniemi, in Haukipudas, approximately 25 kilometres north of Oulu's city centre. **According to the National Spatial Plan, the area is well suited for fish farming.** The water surface type of the region is *"outer coastal waters of the Bothnian Bay"* and its ecological status is good (Pöyry Finland Oy, 2016). The fish farm has been under the process of attaining proper environmental permits, but the wider business and research area under discussion has not reached city planning level. Regardless, Laitakarin Kala will be adding to the legacy of Martinniemi' s legacy as an important industrial and employment hub in the Oulu region.

The history of Martinniemi in the 20th century is strongly linked to the sawmill industry. Until the 1990s, Martinniemi was a dense sawmill community (MPP). **The Martinniemi Village Route in Oulu was once an international marketplace where hundred of ships searched for timber from the northern coast** (Hintsala, 2017). One may least expect today that the village once had an incredibly busy past, **being one of the largest sawmill areas in Finland during the 1950s.** Founded in 1905, the Martinniemi sawmill area has been mentioned as national significance for cultural and historical value and was one of the best preserved examples of the steam saw industry (Museovirasto, 2009). Demand for timber was intense, and Martinniemi timber was shipped to Egypt and around the world. The weekly loading times of the ships ensured an international heap for the village skates in the evenings: *"the sailors sailed here in the village, so there were lots of shops, restaurants and even two cinemas" says Pentti Pussinen, life-long resident of the Martinniemi village (Hintsala, 2017).* **The village was once the most prosperous in the Oulu region and was one of the most industrialized locations in Finland. There were 200 ships in the harbour in the summer, with about 600 people working at the sawmill and a couple more 100 working in the harbour** (Hintsala, 2017). Taking the forest side into account, Martinniemi mills employed a total of about 1,300 people. At its peak, the village had 15 shops, several restaurants, medical clinics, a pharmacy, and two cinemas.

In addition to sawing timber, wooden houses were produced at the mills. However, from the outset, the sawmill experienced many financial difficulties. After several bankruptcies the sawmill stopped running in 1988. Recently, the power plant and its barrel, which had become a significant landmark, disappeared from the landscape. Villagers were opposed to the demolition but the real estate manager who had done several other similar demolitions saw the old barrel as a security threat (Hintsala, 2017).

The Martinniemi Village Association and the Haukipudas Society applied for protect of the power plant, but in August 2017, the City of Oulu Building Board issued a demolition license to the power plant and its barrel on the grounds that the plant was a threat to security, with trespassing, mold and asbestos posing a threat to public health and safety. The barrel was also deemed dangerous due to the moisture which had reached the structure and was starting to decay. Still, **the power plant was an important monument to the people's work - the Bothnian sawmill industry tradition remains in the mind of the people, as there were 5 sawmills in Haukipudas at one time** (Hintsala, 2017). Martinniemi residents have always been an enterprising and tenacious group. Now there are almost 3,000 inhabitants, and the spirit of community is good - village association is active with hundred of people participating in common events.

"Founded in 1905, the Martinniemi sawmill area has been mentioned as national significance for cultural and historical value and was one of the best-preserved examples of the steam saw industry"



Aerial view of Martinniemi sawmill area
Image Source: Defense Forces / Pentti Utriainen, 2017

Timber from Martinniemi sawmill waiting to be loaded, top left is Laitakari power plant chimney
Image Source: Defense Forces / Pentti Utriainen, 2017

Boats waiting for timber in front of Martinniemi Sawmill
Image Source: Archive of Pentti Utriainen, 2017

Martinniemi Power Station and barrel, April 2009
Image Source: Mikko J. Putkonen

3.3 CURRENT PLANS

Martinniemi Partial Plan (2025)

In general, the *Martinniemi Partial Plan (2025)* is seeking to **secure Martinniemi as a residential/work area respecting historical tradition and landscape conditions.** Other goals include taking advantage of the scenic and environmental values of the shoreline and estuary as part of Martinniemi's image and attraction. **Approximately 3000 people live in the Martinniemi area, and the population growth is moderate increase by a few hundred residents by 2020** (Haukiputaan Kunta, 2008). Martinniemi has holiday homes concentrated to Laitakar and the Kiiminkijoki river. Most of the housing stock is characterized by private, small houses. There are few apartment blocks (ranging from 3-4 stories) in the centre. Rowhousing and business/ office space is concentrated to the centre of Martinniemi. The area's large industrial areas have been created by the sawmill industry needs of the past. There is a school, kindergarten and library located in the central area. Commercial services are to a minimum.

In the Regional Plan, Martinniemi has been widely designated as an urban area marked with the preservation of the cultural environment and landscape, by *"promoting functionality and economy of habitats by utilizing existing community structure and defragmentation of agglomerations" (Haukiputaan Kunta, 2008).* In the City of Oulu' s general master plan, **Martinniemi has been dedicated to industry, housing, holiday/tourism, recreation, agriculture/forestry and nature reserves. There are also opportunities for new growth trends as Oulu is a fast-growing region.** The basic principle however is, with this potential growth, to preserve the village-like nature of Martinniemi. In Martinniemi there is room for densifying residential construction in immediate areas but also there is need to prepare for expansion of urban construction, which requires investment in municipal infrastructure and supporting services. There are signs of new growth in the region's job development: although no significant increase in jobs is expected in Martinniemi. At the same time, **the maritime location of the old industrial areas in Martinniemi is unique which may give birth to new waterways leisure or business activities.** The plan indicates that there is not much need for new industrial sites, but room for new businesses in city plans. There is need for more study of underutilized industrial areas and potentially changing activity and function. It was found there are some contaminated areas in the sawmill areas and research and purification measures have been taken. The ground is currently refurbished for industrial use, the suitability for soil for housing would require further investigation at detailed planning stages.

With population growth, there is need for additional services, such as daycare services. In addition, Martinniemi's compaction is important for commercial services survival and development. **Furthermore, creating fast work connections and better public transportation options in the direction of Oulu would increase the attractiveness of the area. Densification of the village area should also be counterbalanced with the need for recreation, green connections and public areas.** The plan discusses the improvement of existing trails and connections.

The sea, beaches and green areas are Martinniemi' s strengths. **There are 3 Natura 2000 sites in Martinniemi including the Hayrysenniemi and Laitakari areas, protected by rocky shores, seaside meadows, swamps, beaches, natural forests, and unspoiled natural stages of ascension coastal forests and wooden marshes.** The southernmost parts located in Natura 2000 is the estuary of the Kiiminkijoki Delta. Birds in the beach areas are typical for the Bothnian Bay and there has been no major changes in the past 10 years. In Halonen Bay (Halosenlahden) and around Laitakari there are several meetings of dozens of water birds or waders as part of their migratory cycle, which presents recreational opportunities for bird watching.

Martinniemi is also located in the archipelago of ancient times which is still visible in the landscape structure of the area. The goal is to keep the archipelago character of the area in future planning. **Low valleys and key sea view should not be blocked with new construction**.

The partial plan outlines two visions for the Martinniemi area: one indicating more stable growth to 3000 inhabitants and the major goals surrounding preserving the existing character and safeguarding existing services. The second option examined a potential population growth to 5000 inhabitants as a result of Oulu's attractiveness and regional growth, and harnessing this growth by creating distinctive residential areas in marine areas which would increase attractiveness of the area. Ultimately, the municipality decided that the partial plan shall be made of the first option, with moderate growth for the year 2025. **Concentration of goals indicates that moderate development is planned with emphasis on improving services and placing growth in the central network of Martinniemi** (Haukiputaan Kunta, 2008)**.**

The current zone for the fish farm location is zoned for industrial use. According to city planning, the fish farm, as a pure industrial use, is permitted as long as the necessary environmental permits are attained. Bu the wider business and research area concept has not reached city planning level yet, and would likely require alterations to the plan. But looking at a wider perspective, what are the possibilities for the site? For the Martinniemi community, for Oulu and for its region? It is well-known that Oulu is a high-growth region with a young population, and one which innovative spirit is embedded in its very own history and identity. **How can economic vitality be secured at both a local and regional perspective while balancing the traditions, the village-like character and access to the landscape assets?** The vitality of a blue bioeconomy ecosystem brings many promises. to the site and area.

3.4 BLUE BIOECONOMY ECOSYSTEM CONCEPT

Initial Concept Findings

As we have seen, there are pressures for food security and domestic production, especially in areas where production conditions are more challenging, such as the north. **In addition to the disproportion amount of fish eaten in Finland being imported, vegetables, fruits and mushrooms are imported in significant quantities, amounting to almost 200 million EUR every year** (Anttila et al., 2017). With the Finnish Bioeconomy Strategy seeking to create 100,000 new bioeconomy jobs by 2030, and 40,000 clean tech jobs by 2020, there is great potential for improving the trade balance of food while also creating new bioeconomy and cleantech jobs (Ministry of the Environment, 2014). **There is a huge demand for domestically produced food, which is strengthened by new food trends such as clean and unprocessed foods, new breeding innovations, new protein sources, and the rising popularity of vegetarian food** (Anttila et al., 2017). Traditionally, Finnish primary production suffers from profitability issues and is fairly narrow. **Domestic competitiveness of food production can be improved by unlocking the full potential of circular economy solutions and clean technologies as well as making things work together more effectively.**

The initial plan for the blue bioeconomy project was looking for solutions for both fish farming and greenhouse cultivation. Named the "SIBE" or *Sinisen Biotalouden Ekosysteemi* report, which translates to blue bioeconomy ecosystem, developed a concept around an ecosystem where many actors work in symbiosis and evaluated its feasibility. At the heart of the ecosystem would be symbiotic fish and vegetable production according to the principles of a closed cycle. In addition, different actors resulting in side streams could be utilized and refined. **The blue bioeconomy project could serve as a starting point for the development of blue bioeconomy in northern Ostrobothnia.** The project is based on Laitakarin Kala's plans, which instead of building a conventional fish farm we see in many of the Baltic areas, the project looked at what other businesses could be involved alongside fish farming to support each other. The SIBE report outlines this concept of the blue bioeconomy business ecosystem, its value chains and actors, and estimates of material and energy flows. **The idea put forward by Laitakarin Kala and its supporters requires a radical change of policy and coordination, for which is why the study is preliminary and aimed at conceptualizing and evaluating the planned ecosystem and act as a first step towards the ecosystem realization**. The ultimate goal is to build a blue bioeconomy business and research cluster that an ecosystem is competitive and profitable, creates new business opportunities, and promote energy efficiency. The project was financed by the European Regional Development Fund and the Northern Ostrobothnia Federation, with a total budget of 100,000 EUR (Anttila et al., 2017).

In material efficiency, the goal is to use as little material, raw materials, and energy as possible. Businesses can improve their material efficiency, by for example improving the efficiency in the use of raw materials and energy production processes (Anttila et al., 2017). Ecosystems consist of individual companies who business models must be sustainable. **In order for the ecosystem to work, every actor involved must have genuine business interest**. In addition, each part of the value chain should produce added value for the customer. By managing the value chain functions and removing the unprofitable value, the ecosystem acquired improved competitiveness. *"The purpose of blue bioeconomy was to create scenarios for these value chains. The problems in these scenarios is how they work in practice and what is the actual cost" says Hari Haapasalo at the University of Oulu's Industrial Engineering department, who contributed to the SIBE research.*

The activities examined in the project was in addition to the start-up of fish farming, the area would operate a greenhouse that could work in symbiosis with it. In addition, various energy generation options and opportunities were discussed for partial energy self-sufficiency (Anttila et al., 2017). **In the scenario, the SIBE project looked at the option of Laitakarin Kala's fish juveniles would be produced on land, in a closed cycle on the plant's own recirculating aquaculture system (RAS)**. Each year, the plant would produce about 360,000 kg of rainbow trout to be exported to the open sea. The operation of the plant could be made year-round by growing alongside rainbow trout, for example whitefish. Nutrients and carbon dioxide are produced as by-products of wastewater. The plant would require energy for cooling, and if necessary, heating. Energy needs to the fish farm and the greenhouse were considered and alternative sources of energy were examined.

The Preliminary Ecosystem Concept outlines five value chains taken into consideration:

1. *Fish farming*
2. *Fish oil*
3. *Circulating plant*
4. *Greenhouse*
5. *Biogas Plant*

Furthermore, there are about 170 full-time aquaculture companies operating in Finland producing fish food markets and fish juveniles for further production (Anttila et al., 2017). Food production has been 14-15 million kg in recent years, of which about 90% is rainbow trout, 6-8% whitefish and small amounts of trout, char, and pike. Most of the fish produced is by less than 10 companies and 80 percent of the fish is produced in sea cages. As we have seen, domestic food production accounts for about a third of Finland's demand, and nearly 70 percent of food fish comes from Norway (salmon) and Sweden (rainbow trout). As stated, most of production is located in the Åland Islands, the Archipelago Sea and Satakunta in the southern parts.

RAS is a relatively new business and its profitability in Finland has been very weak. Development of technology and increasing know-how could make circulatory aquaculture more economically profitable. **In Åland, there is one large-scale RAS and another large plant for market-size rainbow trout built in Varkaus. The other 7 circulating plants grow rainbow trout and more valuable fish species such as whitefish and pike.** In recent years, 2 RAS plants have gone bankrupt. Therefore it is still a fairly new and developing technology.

In the examined value-chain scenario, within the year about half of the water used is removed from the recirculating plant. The leftover water is separated at the plant, where sludge contains the bulk of solids and unused phosphorous. Condensed sludge can be led to sewage treatment or biogas plant or composted. Carbon dioxide can also be recovered and utilized, for example , in a greenhouse. **Under this scenario, a total of 1560 tonnes of organic matter, consisting of sewage sludge, dead fish and trash were estimated** (Anttila et al., 2017).

In addition to producing sludge for biogas production, the project also examined combining the RAS with greenhouse cultivation. **At present, there are about 1200 horticulture products cultivated in greenhouses in Finland, with about 580 of these companies engaged in vegetable production, 530 ornamental plants, and 85 plants** (Anttila et al., 2017). A typical Finnish greenhouse is about 3000 square metres in size and managed by entrepreneur families (Yrjänäinen et al., 2013). **Even in the biggest companies, there are more self-employed entrepreneur families behind them. Tomatoes and cucumbers are the most produced produce, second are ornamental plants and third are potted vegetables** (Anttila et al., 2017). There is a high demand for cucumber and tomatoes retaining their leading position. Additionally, special tomato varieties have come alongside the traditional tomato. Potting salads have been favourable salads of Finns, though packaged salad mixed have also increased popularity in part of the expense of pots, and based on ease of use and better shelf life (Anttila et al., 2017). Despite the import, the market share of domestic production is quite good.

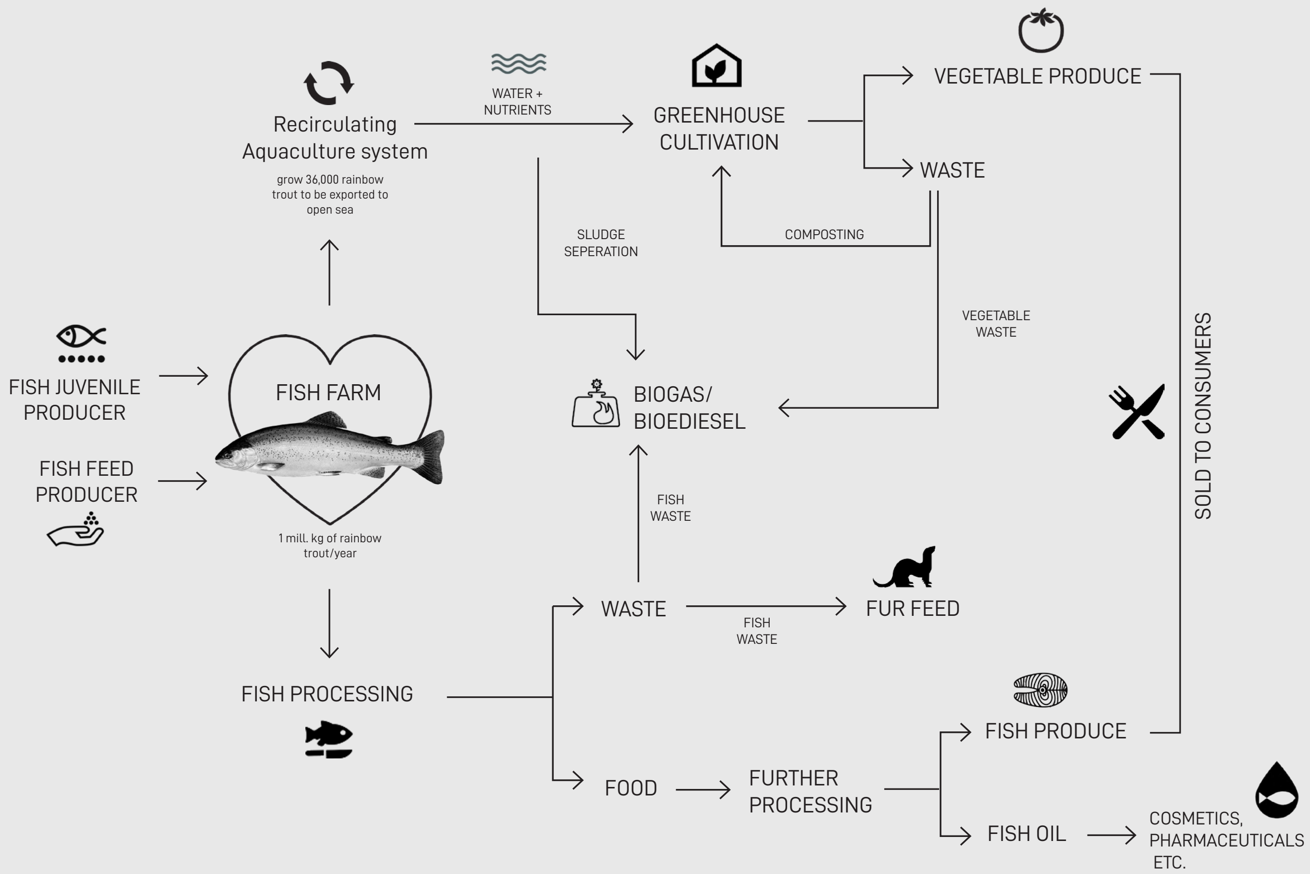
The total domestic consumption is as follows: 58% on tomatoes, 81% on cucumbers and almost 100% on potted vegetables (Anttila et al., 2017). **Consumer interest in vegetable origin is growing with the transparency of the production mode being a growing trend - environmental friendliness is a selling point and may enable products at a higher price.** For example, organic production, energy efficient or carbon neutrality could allow up to 10-40% a higher price for the product (Anttila et al., 2017).

The ecosystem examined potentials for aquaponic cultivation which combines fish breeding and crop cultivation. In this scenario, water from circulating water and/or the particle filtration slurry is fed to plant production. The detailed technical implementation can be varied because of nutrient requirements of the crops. The provided sludge from circulating water used for plant production must first be hydrolyzed in a more usable form for plants. In addition to water and nutrients, thermal energy and carbon dioxide as well as infrastructure and labour can be harnessed. Martin (2017) provides an overview of the advantages and challenges of aquaponic systems looking at a 1 hectare year-round growth of the greenhouse alongside the fish farming. The greenhouse would produce approximately 1,200 tonnes of cucumber. In addition, it was estimated that approximately 210 tonnes of vegetable waste is produced as a by-product of cucumber production, which could be composted, used as a soil improvement agent in fields or earthworks, or used for biogas production (Martin, 2017).

The most versatile by-product is the waste of fish - there are many types of recovery alternatives, such as fish oil processing, sales of biodiesel, or fish oil as raw material, sale of animal feed for fur animals or biogas production together with other organic waste. Fish processing, both in the aftermath and in the further processing, creates as a side stream. Traditionally, gut and intestines are removed and remains of fish are taken for further processing as fish fillets and other seafood sold in pre-packaged packaging for dealers to resell. In the future, one of the biggest competitions in the industry in terms of profitability is the use of these side streams. **Intestines could be sold directly to the processor, but the Oulu region has technical skills and readiness to easily separate the gut fish oil. Separated fish oil can be further processed into biodiesel, for example.** It was calculated that 60 tonnes of oil could be produced from the waste, equivalent to more than 5 single family homes the need for heating (Anttila et al., 2017). Fileting waste is another interesting stream, which can be generated into further processing. For filleting waste, the downstream processor Hätälä already has processes to help. Filleting waste consists of fish heads, skeletons and lard.

Nowadays, filleting waste is largely fed to fur animals. Remaining parts are currently sold to Kalajoki for further processing into fur feed. **However, there is massive potentials to unlock the higher value potential of the waste. In fileting waste it is also possible to separate fish oil. Fish oil from fileting waste is different from fish oil from cane waste in that it is possible to hygiene it for suitability for processing into higher value products such as cosmetics, pharmaceuticals or the food industry.**

Initial Ecosystem Concept



Energy Requirements

In addition to the value chains, the project examined the energy requirements of the concept and outlined some key energy production options. Firstly, the energy consumption of fish farming is depended on the production method. **The project examined the energy requirements of the scenario which combines traditional fish farming and production of fish in a circulating plant and winter storage of fish in basins.**

Traditional fish farming takes up little energy: its energy consumption is formed primarily from boat fuel, when fish farm structures are transported to breeding basins for service and maintenance. In winter storage, energy is required for continuous pumping of water and occasionally to prevent water cooling and potential piping to freeze. The goal is to raise water temperatures +0.5 °C every time it was based on measurements below zero, which occurs mainly at Christmas, in January and occasionally in February and very rarely in November and March (Anttila et al., 2017). **In RAS, heating requires water pumping, oxidation, cleaning, and cooling the plant, which consumes electricity.** In the examined option, the plant's fish juvenile production capacity is estimated at 360,000 kg/v, resulting in total electricity demand for circulating energy an average energy requirement of 1.44 GWh per year (Anttila et al., 2017). Treated farmed fish in processing plants also consume energy, for example, space heating and cooling, the use of various machines, equipment, and ice production.

The largest consumer of energy within the ecosystem, however is the greenhouse production. Greenhouse production based on year round and partly exposure-based production, is per areas, considered more energy-intensive than traditional light production because of energy required for heating, in addition to exposure. Especially in the energy consumption and energy efficiency of year-round greenhouse production, the climate impact of production is affected by the energy production method used, the geographical location of the crop, the structural solutions of the greenhouse, the production light and temperature requirements for plant species, production and cultivation techniques and yields (Yrjäväinen et al. 2013, Kaukoranta et al. 2014, Särkkä et al. 2017). For example, there are big differences in light requirements for vegetable plants. An aim could be to adjust the intensity of exposure and the daily duration so that cultivation is as energy as possible but also economically viable.

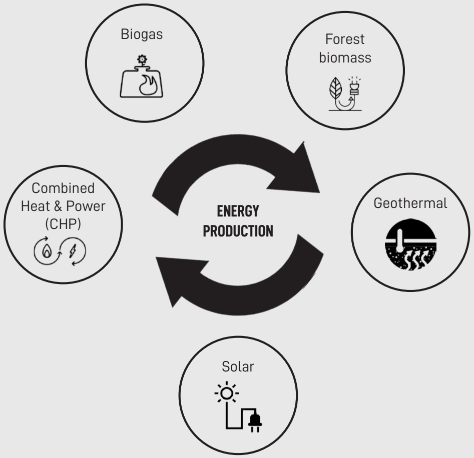
Energy efficiency can also be controlled not only by exposure but also by regulating the annual production time and rhythm, changing room temperature and even taking energy capture technology. It was estimated that the proposed 1 hectare greenhouse's energy consumption could be up to 19,000 MWh per year, with 80% of its energy spent on exposure, the equivalent of one thousand electrically heated houses (Martin, 2017). The price of LEDs is still to high so far for them to be economically viable so it was decided to look at this project with traditional exposure solutions. However, efficient use of intelligent exposure systems could most likely reduce the current use of electricity.

Success of the greenhouse company is that the exploitation of the new technology is based on business profitability and not energy savings alone. It was assumed that from spring to spring the plant is used evenly for rainbow trout. In May, the plant would be emptied of rainbow trout with potential for breeding of whitefish in May-July, for example. The maximum energy needs are in January and December. The coldest and darkest months of the year, the maximum electrical power needed is about 2.6 MW and the heating capacity is 0.6 MW (Anttila et al., 2017).

The energy requirement of the concept of a circulating plant and greenhouse production consists of for the most part, the exposure required for the annual greenhouse production electricity consumption. **Since the project's goal was to develop a circular economy business concept, fossil energy resources have not been considered. Firstly, for heat production, renewable and low-emission heat production methods are solid biofuels, biogas, heat pumps and solar collectors.**

"The largest consumer of energy within the ecosystem... is the greenhouse production. Greenhouse production based on year round and partly exposure-based production, is per areas, considered more energy-intensive than traditional light production because of energy required for heating, in addition to exposure"

Renewable Energy Options



ENERGY TYPE	CHALLENGE	OPPORTUNITY
Forest biomass	fish farm + greenhouse not typical producers of this type of energy	purchase of thermal energy from heating contractor is a potential opportunity (i.e. on site)
Biogas	not enough biomass from fish and greenhouse to be profitable	purchase or selling of biomass from other users (i.e. farms, industries, housing etc.)
Geothermal	survey indicated moderate levels of energy potentials at site location	install a collector pipe in a water body which is likely to be cheaper than thermal wells
Solar	lack of light in winter months, darkest months being January + February	take advantage of south facing facades, increase number of solar collectors on other uses and functions

1. Forest Biomass/ Bioenergy

The use of forest biomass in the energy production of Finnish greenhouse cultivation has increased in the 21st century. The amount of energy produced by wood fuels has more than doubled its share as grown from 10% to over 20% from 2006 to 2014 (Anttila et al., 2017). Both chips and pellet heating systems are good alternatives to greenhouses because they are enable the full use of biomass-based fuel use and heating automation. For fish farming or greenhouse entrepreneurs, it does not necessarily makes sense for them to act as a producer of thermal energy. A sensible alternative would be the purchase of thermal energy from a heating contractor who is responsible for the operation of the heating plant and acquires the necessary fuel.

2. Biogas Production

Both fish farming and greenhouse production generate biomass suitable for biogas production. Biogas is the result of the decay or organic matter. In principle, all organic matter can rot, but the techniques is best suited for easily degradable materials (Anttila et al., 2017). Biogas can be used as heat or produce electricity. Suitable raw materials for biogas are a variety of biomasses that can be agriculture, municipal or industrial waste. There are currently no greenhouse companies listed in the official garden statistic of Finland who use biogas as an energy source (Jordbriksverket, 2015). However, at least one biogas plant in Finland, *Juva Turakkalan Puutarha Oy,* buys electricity at around 1400 MWh and thermal energy at around 2000 MWh of biogas plant located next to Juva Bioson Oy. The project looked at how much fish farming and greenhouse biodegradable waste could be created and how much it would create available biogas and energy. The estimated bio-waste volumes were about 1770 tonnes per year in the concept. However, the research found that the biogas plant would not be profitable with the feed rates (Anttila et al., 2017). However, it could be improved if the nutrient-rich digestion could be sold, for example, to nearby farms. In any case, with the amount of bio-waste generated in the concept, the plant size would remain and the energy it produces could only cover a very small part of the size of energy the concept needs. A biogas plant would require much more feeds, such as farm manure or field biomass to be a reasonable investment, but with very few active waste producers, the opportunities for the sale of digestion residues is uncertain.

3. Geothermal Energy

Geothermal pumps collect heat from the sun stored in soil, rock or water. For very large sites, ground thermal solutions have already been implemented: in apartment buildings, hospitals, business and logistic centres, as well as industrial buildings. For greenhouses, land-based heating has been rarely used. According to the agricultural statistics on the agriculture sector, 23 land-based greenhouse companies with in total about 5400 MWh of thermal energy was produced by ground heat (Anttila et al., 2017). The Geographical Survey of Finland (2013) has made an assessment of the City of Oulu. Energy potential of land and bedrock would be moderate in the outskirts. The power of a ground source heat pump should not be dimensioned to cover the peak heating demand of the target but about 60-80% of the design capacity of the buildings. As an example, the peak power requirement may be produced by additional sources such as oil or gas boilers, which is often the case in greenhouses today (Anttila et al., 2017). The cost of producing ground heat is advantageous because it consists only of a pump, therefore the initial investment is often higher than that of electricity or other forms of heat production. In greenhouse production, purchase of ground heat may be limited to access to business investment funding. The location of Laitakarin Kala also poses opportunities to install a collector pipe in a water body which is likely to be cheaper than thermal wells, which could be a more rational alternative to land and bedrock energy. However, further investigation is required to examine the barriers of ice and flow conditions in the waterways and maintenance of fairways and harbor structures.

4. Combined Heat + Power (CHP)

Because the year-round greenhouse consumes a lot of electricity, it could combine heat and power (CHP) as a potential energy alternative. It was found that the heat and electricity needs of the SIBE project could be covered in a small-size CHP plant. Small CHP plants use biofuelds as energy sources which can be divided into production technology based on four basic principles; internal combustion engines and gas turbines, steam turbines, and others steam power equipment, neurotransmitter technologies and fuel cells. Internal combustion engines and techniques based on steam engines and turbines are already widely used in the market by several manufacturers - but some of the techniques mentioned above are still in development. One of the greatest challenges of CHP plants is that there must be enough demand for heat in particular. Surplus electricity can always be supplied to the electricity grid but the heat produced by the plant should have its own use or have a customer that can buy the thermal energy. The concept of fish farming and greenhouse production, especially in summer the need for heat is very low and if there is no external buyer. Therefore for the CHP plant - the efficiency of electricity generation alone is too low to make production profitable. Thus the CHP plant is unlikely to be economically competitive with the current scheme. If the planned site would create other activities that would utilize more heat energy, the situation may be different.

Key Findings/Challenges

One of the major challenges of symbiotic fish and vegetable production is the dependence of different activities: if one function fails, the entire system is in trouble. **In the centre of the value chain, is the fish farm, and in almost every function Laitakarin fish is linked in function in the role of either the customer or the seller.** By nature, fish breeding is a recurring activity with the same functions occurring annually and in part even daily. The fish farm constantly buys new juveniles and fish breeding, thus the feed buying in particular is such a large-scale activity and one of the biggest expenses that **the relationship between the feed supplier and fish farm is integral to the health of the ecosystem.** Feed for the circulating aquaculture to the juveniles is clearly the largest expense item: being almost half of the cost of the entire value chain. Thus, the breeding of rainbow trout and harvesting are the core activities.

There are several synergy benefits and challenges in the fish farming value chain. **Synergy benefits for greenhouse and fish production could produce centralized energy production, logistics, marketing, and labour.** Logistics is one critical aspect at almost every stage of the value chain. Transport is not limited to fish farming but also on other sidestreams, such as greenhouse production for further production. Commonly, each individual actor is responsible for its own logistics. Common logistics could makes sense for the ecosystem but there are practical implementation challenges. Integration of logistics is that each actor try to minimize their own logistics costs, which result in companies having signed agreements with transport companies. Furthermore, the main advantage of Laitakarin fish farm is its location - Hätälä is also located in Oulu has already made a purchase agreement with Laitakarin Kala. Kalajoki has an operator who is ready to buy both fish and debris and filleting waste as well. **Physical proximity and good personal relationships are the greatest benefits of the value chain. Physical proximity ensures that synergies are gained in logistics.** For example, fish from the fish farm are generally packaged in 10-20 kg packages that are transported for a fish processor, but in the case of Laitakarin Kala, the processor is so close that the package sizes can be up to 300 kg (Anttila et al., 2017). Larger packaging saves the amount of package needed. **In an ecosystem, the decision of one actor affects all surrounding businesses. Mutual trust is therefore critical. Price equalization is one benefit of symbiosis, where the fish farm and processor can help each other with pricing**. Rainbow trout in particular shows some seasonal fluctuations and the processor could pay a slightly lower price when the prices are high and the price higher when prices are low. This allows for more predictability in price for both parties.

In greenhouse production, the biggest cost item is the energy required by the one hectare greenhouse: with the greatest need for energy is with electricity, the share of thermal energy is considerably lower. The greenhouse consumes over 90%, so the price of energy is an essential factor to ensure the profitability of the plant production (Anttila et al., 2017). Existing solutions such as LED lamps and moving lights are not yet significant enough to reduce the cost structure of greenhouse production due to high investment costs. The SIBE project considered whether the greenhouse could be given up for vegetables to grow more energy efficient in well-isolated halls, where plants are grown without natural light but with LED lighting. Artificial light can be up to 4x higher in greenhouse production compared to sunlight. **Less energy-consuming farms would be worth exploring which indicates there is a necessary demand for radical innovations in energy efficiency of greenhouse systems.** When considering synergy benefits, the circulating greenhouse might also be better to use a so called de-coupled method, instead of closed rotation, where the symbiosis would only be utilized as appropriate.

As for the energy requirements, a profitable solution is still needed to be found. Solar energy could be explored further as well as industrial waste heat recovery, although on side industrial waste heat is not currently available, though could also be found in shopping centres, for example. Forest biomass is already used in greenhouse production, possibilities of acquiring thermal energy from a heating contractor should be further explored. Use of terrestrial heating has also become more popular in recent years, and it is worthwhile exploring the possibilities of utilizing the large amount of water resources on the site. Biogas was not found to be a sensible solution, as the amount of biowaste generated would not be enough for a profitable outcome. **There is potential to seek external sources of biomass that could be delivered in significant quantities to a biogas plant.**

The SIBE project started with a solution for a more sustainable fish and vegetable production system. **Thoughtful, innovative solutions turned out to be unprofitable and partially recoverable when compared to traditional solutions.** The benefits were found to be marginal that implementation is not foreseen at this time. The value chain of fish farming is very much thought about by committed players, as the whole project is based on this value chain. As we have seen, fish farming is the leading value chain for the whole project, without which the ecosystem won't work. Laitakarin Kala is already committed to the ecosystem in the fish farming value chain as with Hätälä Oy. It is up to the company to buy fish feed and fish juveniles for the ecosystem and businesses have been sought for both activities. There are also operators who buy raw materials for their own business, such actors can be found in Northern Ostrobothnia so it could be good for business to sell the fish waste.

Plant waste from the greenhouse can be composted and reused in its own operation, or supply to biogas plants in the area. **The separation of fish oil proves to be the most promising new business for the ecosystem, with a large technical know-how in fish oil separation in the Oulu region.** The circulation plant is also a big investment. Hardware vendors were mapped and Finland has several expertise in delivering these types of systems. The greenhouse was seen as the most uncertain part of the value chain. The biggest challenge for the greenhouse cultivation is finding an interested entrepreneur. *"It is very challenging.... because we don't have real investors coming to us saying 'I will build a 300,000 sq. m size greenhouse here and utilize biogas'. We can only provide options or scenarios for the value chains" (H. Haapasalo, personal communication, February 12, 2019).* By-products alone are not enough to attract greenhouse companies to the area. The greenhouse could be seen as an independent entity in which a greenhouse entrepreneur decides on possible cooperation with a circulating plant.

In conclusion, the SIBE project was special because this type of application of a business ecosystem concept in blue bioeconomy has not been studied before. Bioeconomy has its own specific features that can affect the formation of value chains and must be taken into account in future bioeconomy ecosystem creation. However, these special features lead to a value chain in primary production surrounded by very strong relationships. The business of these primary production industries is continuous but the volume of the production is uncertain due to the cyclical nature of the bioeconomy and the larger environment (Anttila et al., 2017). Production is also perishable so the goods have to move fast through the value chain. Fish and vegetables lose their value very quickly and long-term storage is not possible. T**here is need for innovation in the ecosystem for fish farming and greenhouse cultivation symbioses. In order to accelerate rapid mobility, actors in the primary value chain are also frequently physically close to each other which results in cost savings and stronger relationships.** Having a limited number of players also helps to maintain. Often, integration confused existing processes, making it easier to do compromises and thereby less efficient production (Anttila et al., 2017). If the margin is already low, this can lead to loss. In terms of the market, bioeconomy products usually end up with production going to existing markets where demand is certain and buyers are known. Therefore strong relationships that are natural in the bioeconomy are driven by production in traditional, secure, market demand. Although the closed loop concept was found to be unprofitable, **it is this blue bioeconomy ecosystem idea that is encouraging and presents many opportunities. The close location of actors themselves brings together several benefits such as common workplaces and energy saving solutions, shared human resources, and centralized packaging and logistics.** The preliminary study serves as a basis for future blue bioeconomy projects in Northern Ostrobothnia. With a project like this, **it is possible to scale ecosystem thinking across Finland to other similar one and know-how centres.** The topic may also spur international interests, such as in Norway, Russia and Belgium, to name a few.

"It is this blue bioeconomy ecosystem idea that is encouraging and presents many opportunities. The close location of actors themselves brings together several benefits such as common workplaces and energy saving solutions, shared human resources, and centralized packaging and logistics"

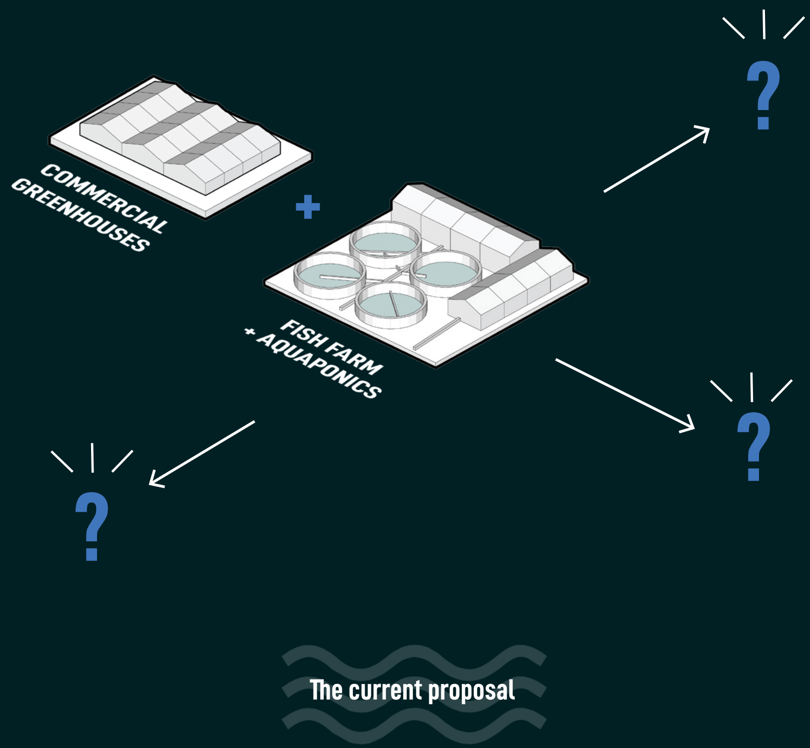
3.5 THE FUTURE OF LAITAKARI HARBOUR

Research Question

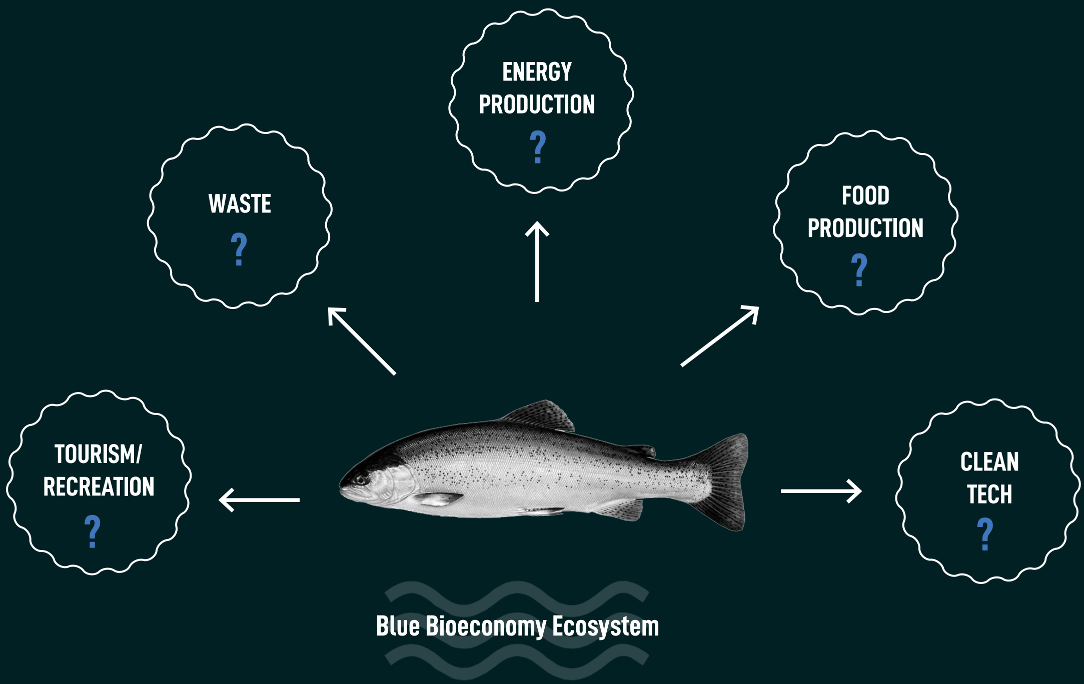
The initial blue bioeconomy ecosystem business model presents both challenges and opportunities. **Although the plan was seen as initially economically unprofitable, it presents an excellent starting point and builds a foundation for the potential of the ecosystem creation.** With large-scale issues of food security and consumption of produce and products domestically in an ever-globalizing society, the blue bioeconomy ecosystem concept has opportunity to showcase a new model of life that more closely connects people with nature, and consumption with production. **Examining the opportunities at a larger eco-scale, what opportunities can be harnessed and what other functions, uses, programs, can benefit from and provide added values to such an ecosystem?**

One of the major challenges the ecosystem faces is meeting the energy demands, particularly renewable energy sources. **By expanding the ecosystem, new opportunities to integrate other uses can be explored.** For instance, by considering the integration of living and working opportunities on the site, this provides new sources for both solar energy as well as new potential streams of waste which can be used towards biogas production.

At the same time, as a developing concept, the ecosystem environment has opportunities to attract a new sector of tourism to the site. Interested members of society can be involved through learning and experimentation in the aquaculture and expertise around water, from RAS systems, which remains a fairly new technological model, or aquaponics. By integrating an added layer of tourism opportunities to the site, new funding streams can be generated which can aid in creating a profitable business model. Further, at the larger eco-scale, the site has opportunity to become one of several "know-how" centres, connecting universities, RDI activities and expertise across the northern Baltic region.



What other opportunities can be explored to develop a fully-functioning ecosystem based on local circular economy opportunities?



PART 04

DESIGN CONTEXT

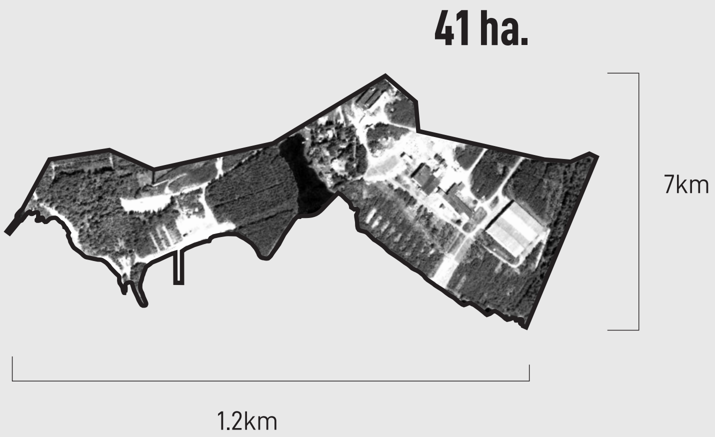
4.1 THE SITE

Current Use + Dimensions

The location of Laitakarin Kala Oy's operations will be in the Laitakari Harbour area of Haukipudas. Located in the village of Martinniemi, the site is isolated and used today primarily for Biomega Oy's bioenergy production. **The fish farm will be located near the existing Laitakari Industrial area, which is currently an open area and contains the recently demolished Martinniemi sawmill area**. The land in which the fish farm will be built is owned by UPM-Kymmene Corporation (564-410-1-223), which is zoned as an industrial site, located in a closed landfill. The current use of the area is currently very limited and underutilized.

To the north of the site boundary, is Laitakari, which is a forested area with some seasonal homes and recreational trails. Most of the use in this area is limited to the private residents in this area, or for recreational use and some snowmobiling. Snowmobiling is a popular activity in the area, and was exhibited in the grounds of Biomega Oy as well. In the summer months, the harbour is a popular recreational boating and fishing destination. **The water depth in this area is more than 20 metres deep. According to the National Spatial Plan for aquaculture, the area is well suited for fish farming**. In the winter months, the water freezes, and is a popular area for snowmobiling and ice fishing.

The site selected includes both the area designated for the fish farm location, including the demolished sawmill area, and areas south of the forest line, as well as the eastern side of the harbour, encompassing the active Biomega Oy Bioenergy grounds. **The site is approximate 1-1.5 kilometre distance from the centre of Martinniemi village.** The site is approximately 41 hectares, measuring 1.2 kilometres horizontally (east-west) and approximately 7 kilometres in the north-south direction.




Siikaletto
Laitakari
Biomega Oy
Martinniemi
Mustakari
Proposed Fish Farm Location
Kurtinhauta
N
0
1km

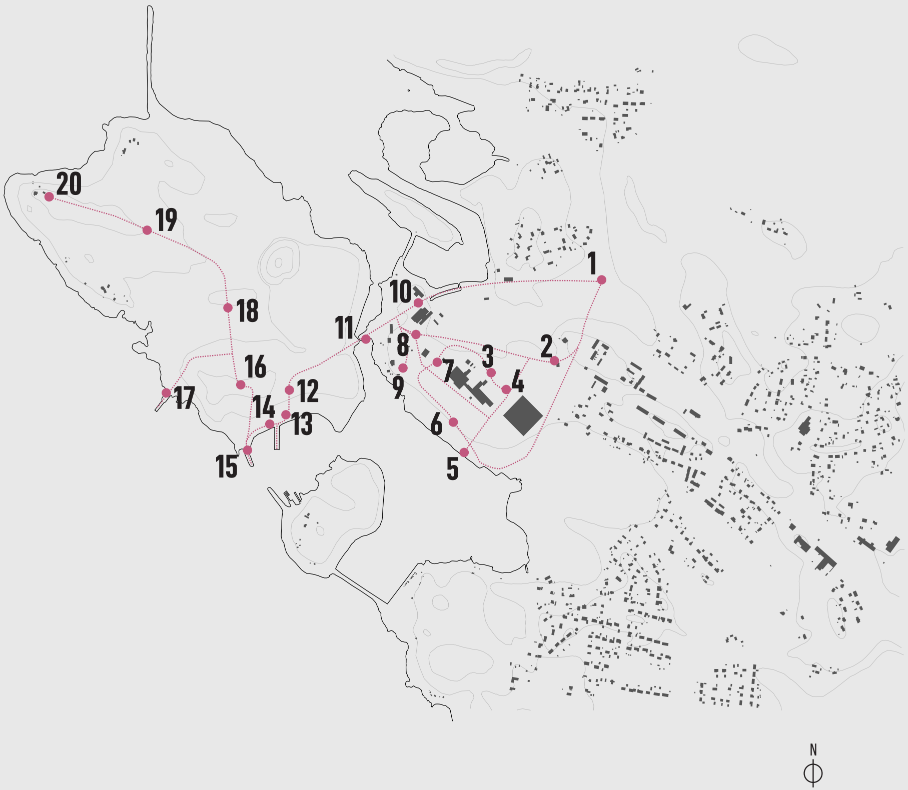
Sketch study of the industrial qualities on site

4.2 SITE IDENTITY

No Man's Land

The site historically can gone through many changes. In its peak, the area was once an extensive sawmill area. **Today, the site is currently underutilized and exhibits low-scale intensity of use. Aside from the currently active Biomega Oy Bioenergy production area, the majority of the site is not currently used**. Although underutilized, the site exhibits some interesting characters, reflective of its previous use as an extensive sawmill area. When entering the site from the Biomega Oy main entrance, the area has restricted entry and you are welcomed with a fence. **The actual production area is closed off from public use, though the area is also used for recreational purposes such as snowmobiling and dog-walkers**. However, the grounds are private and not intended for public access. The actual production area is a large forested zone with a few key buildings: including a large seasonal storage building which provides winter storage for mobile homes, caravans, cars, motorcycles, and boats, as well as providing repairs for boats. **Biomega Oy is one of the largest producers of bioenergy in the Oulu region. They buy wood directly from forest owners, forest machine contractors, as well as sawmill and forest management associations.**

In addition the site contains some historical brick buildings and barrels towards the north-west entrance of the Biomega energy grounds. **Beside this industrial area is an old established housing area, with unique historical homes, likely emblems of the sawmill days of Laitakari harbour.** Before crossing the bridge, the Säävälät Oy Civil Engineering grounds provides an open area with parking for trucks and other machinery. Across the bridge to Laitakari is a large open area which includes the demolished site of Martinniemi sawmill. The footprint of the building is still visible, with traces of brick still on the ground where the building once stood. A spit juts out into the harbour, which will be used for the fish farm operations. **North of this open area, is Laitakari, the forest with recreational trails and snowmobile routes, which contains seasonal homes towards the end north of the forest area.**

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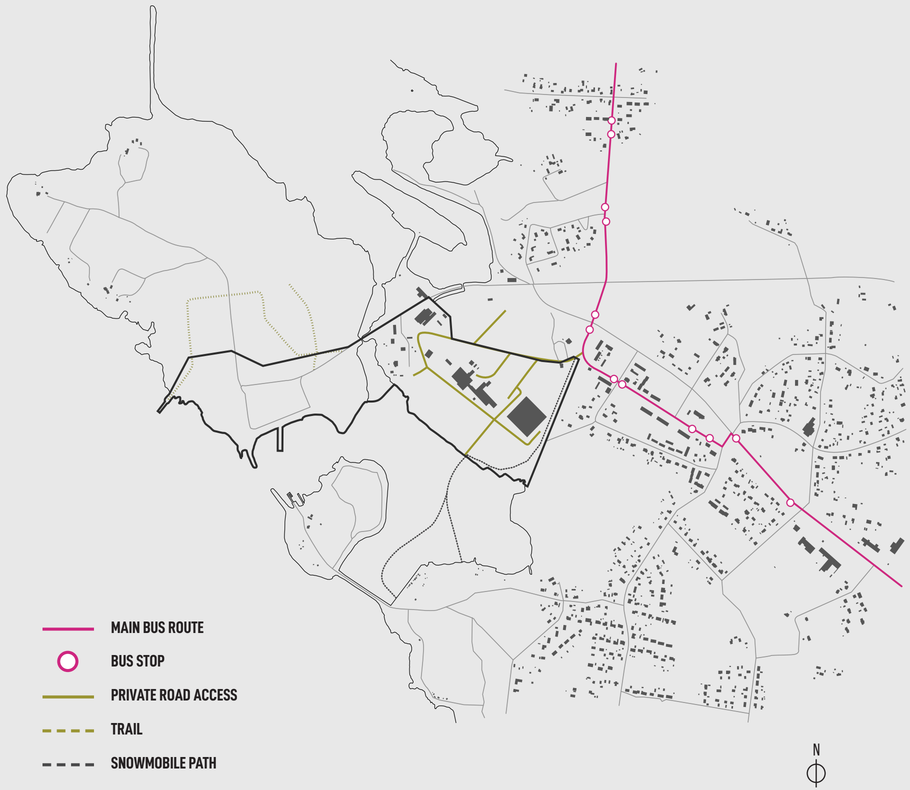
4.3 THE SITE AT PRESENT

Transport + Transit

Martinniemi is characterized as a rural area, with village-like character. Speaking to the city planner of Haukipudas, it became apparent that **the majority of residents have access to a private automobile and it remains the preferred choice in smaller residential areas of the City of Oulu.** Bus service in Oulu is quite extensive in the centre and the University campus area, but when it comes to smaller rural areas of the municipality, bus service becomes even more limited. **There is one bus line running in close proximity to the site, which travels along the main street of Martinniemen, namely called Martinniementie.** The bus runs approximately every 30 minutes to an hour, and from Oulu centre, you must transfer two busses in order to reach this area, which in total takes approximately 1 hour to reach (compare this to only a 20 minute drive by car - you can see the appeal).

As such, the area is dominated by private automobile use. The site itself is also dominated by private road access, increasing barriers to accessibility on site. As stated, the **Biomega Oy grounds are private, and so the area is characterized by dead end roads with limited access to employees and larger-scale vehicles such as trucks**. To reach the fish farm, there is only one road in, Laitakarintie, which leads to the industrial area of Laitakari harbour in a closed loop. The road extends further up into Laitakari forest area. Though, very little car traffic was seen in the area, approximately only 1-2 cars per hour. In general, the site lacks pedestrian permeability, and access is confined to the primary industrial activities on the site.



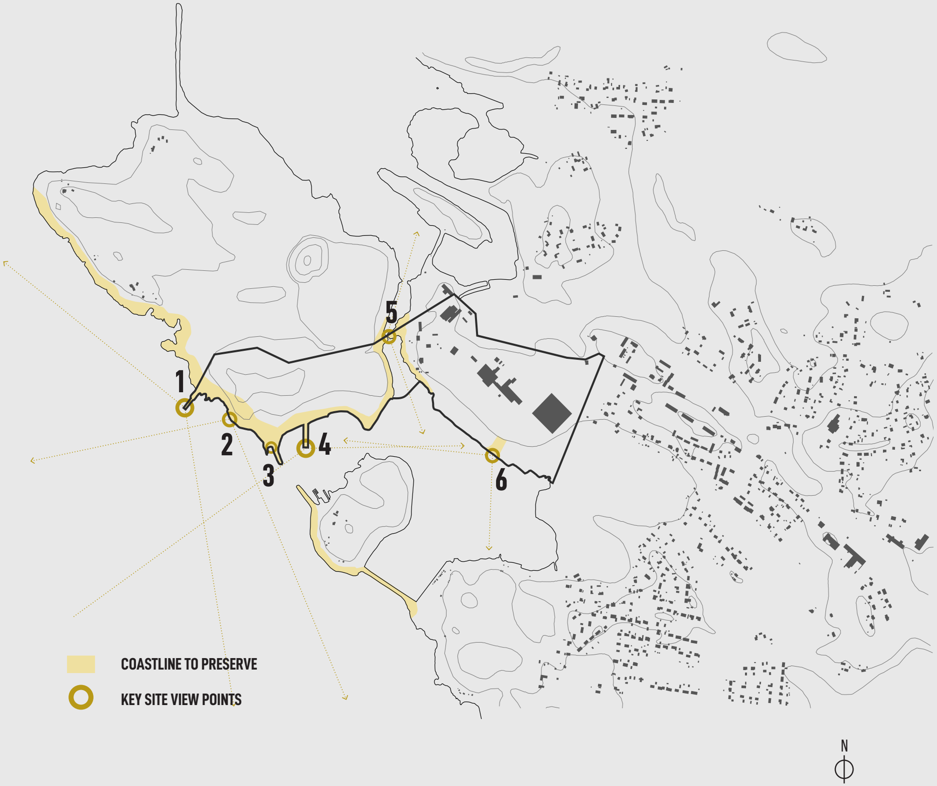
Natural Assets

One of the key characteristics of this area is the nature which is present on and around the site. It is no surprise forestry is a major component of Finland's economy, as the landscape is dominated by forests. The area exhibits both coniferous and deciduous types, namely pine, birch and poplar. In many places, former cultivated areas have become dominated by deciduous wilderness. **In addition, there are several productive forest areas surrounding and within the Biomega Oy grounds.**

The sea, beaches and green areas are Martiniemmi's strengths. There are theree (3) Natura 2000 areas in Martinniemi, including one north of the site, and the northern part of Laitakari which exhibits protected rocky shores, seaside meadows, swamps, natural forests and unspoiled natural stages of ascension coastal forests and wooden marshes. The Kiiminkijoki Delta, another Natura 2000 area, is also approximately 2km south-east from the site, which is a significant feature in the Oulu region. Birds in these areas are typical for the Bothnian Bay and there has been no major changes in the past 10 years. **Around Laitakari there are several meeting of dozens of water birds and waders as part of their migratory cycle, which present recreational opportunities for bird watching**. Martinniemi is also located in the archipelago character of ancient times which is still visible in the landscape structure of the area. **The city wishes to preserve this character in future planning, where low valleys and key sea views are preserved and not to be blocked by new construction.**

Key Views/Sightlines

Some of the key qualities of this area are the endless views of the Bothnian Bay. **The site sits on the outermost part of the coast, and so views namely from the east coast of the site provides extensive views of the Bothnian Bay and the sea ice in the winter months.** One of the main values to local citizens in these areas are these views, and it is one of the main reasons many move to this area. Another key component is that the forest line of the coast should be preserved in new planning. **The aim is to ensure a continuous forested edge**. Therefore new development should respect these views and consider the shoreline in its future planning.

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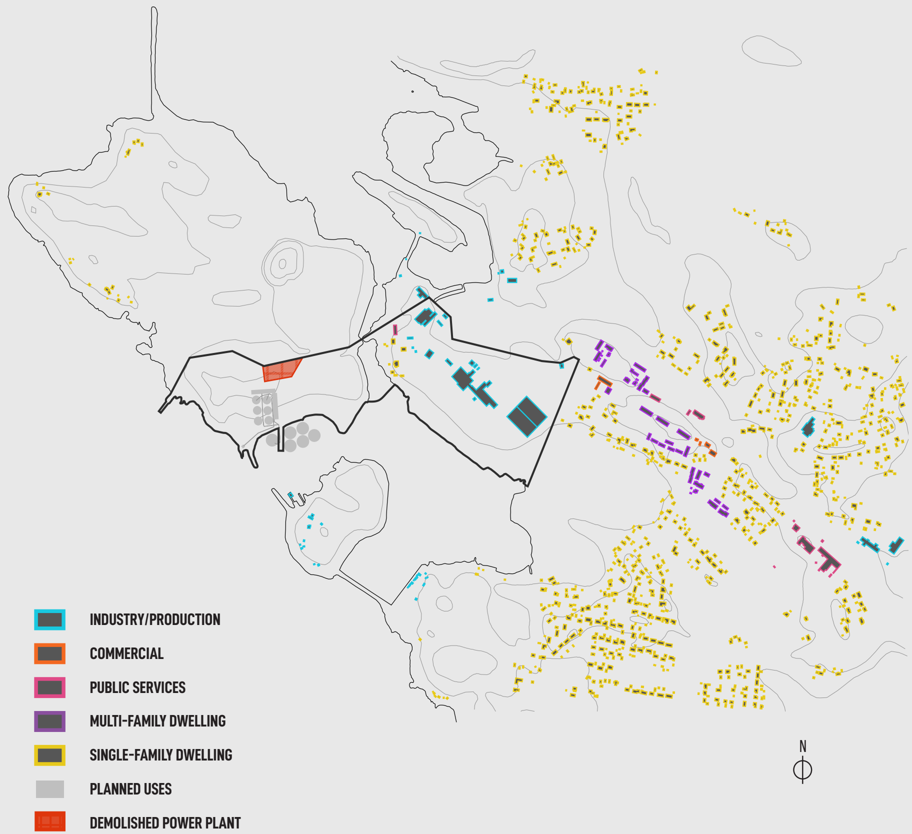
“If you were born in Oulu, the sea is really important. The scenery in front of you when you stand on the shore and you can see the endless horizon, that is really important for local people. Northern lights in these areas are also constantly changing and it can be something to consider using in design. Sometimes the horizon is white, light blue, sometimes pink, or dark blue.”

Functions

Martinniemi is dominated as a residential area with primarily low-scale single-family dwellings and rowhousing. There are some multi-family dwellings along the main street Martinniementie, with a maximum stories of 4 stories. **The centre of Martinniemi contains services including some retail services such as a K-Market for grocery services and Putaan Pulla, a popular wholesale bakery. In addition, there is a library (Martinniemen Kirjasto) and an Elementary School (Martinniemen Koulu), as well as a few private nurseries including one on site (Naperovakka Päiväkodit).** The city is anticipating moderate growth, and with this an new kindergarten is planned for the year 2025. The site itself is primarily dominated by industrial productive uses, with some private dwellings.



PART 05

DESIGN PROJECT

5.1 SITE VISION

Harnessing Local Circular Economy Opportunities

The vision for the site builds upon the blue bioeconomy ecosystem concept developed and seeks to expand the ecosystem into a fully functioning, self-sustaining district. **In the same ways that sidestreams of fish parts and waste can be harnessed to unlock their full potential and provide added value, added value can be generated to the ecosystem by integrating new functions and ingredients to the ecosystem.**

With a holistic approach to the design, the project seeks to generate a fully-functional blue bioeconomy ecosystem that harnesses the full potential of local circular economy opportunities and combines opportunities for living, working, and recreation with production activities. The proposal seeks to integrate production activities of a city: from food, to energy, to services, to industrial products, to enhance relations between citizens and to merge the tensions we often associate with production and local life.

Productivity can be achieved in many different ways and scales: through large-scale operations such as the fish farm, aquaponics and commercial-scale greenhouses, to small-scale production in private gardens, or in spaces for medium businesses to sell ideas, services and products. T**he project seeks to integrate production cycles, considering the distribution of waste and consumption at a local district-scale thinking and encourages diverse cycles of food, waste, water, and energy into the local context and in the larger eco-scale.**

This concept is not new; in fact, in 2015, James Ehrlich, researcher and entrepreneur at Stanford University, founded the term *Regen Villages*: a tech-Integrated and Regenerative Residential Real Estate Development model which seeks to create desirable off-grid capable neighbourhoods comprised of power-positive homes, renewable energy, water management, and waste-to-resource systems that are based upon on-going resiliency research – for thriving families and reduced burdens on local and national governments.

This concept can very well be adapted and applied in the case of Laitakarin Kala, which has already established the foundation for the creation of a functioning blue bioeconomy ecosystem. **The site will seek to create a shared local ecosystem which examines waste and water recycling, organic food production on site, mixed renewable energy and storage opportunities, as well as empowering the local community and integrating this once industrial hub back into the urban fabric.**

5.2 ECOSYSTEM CONCEPT

Building the Ecosystem

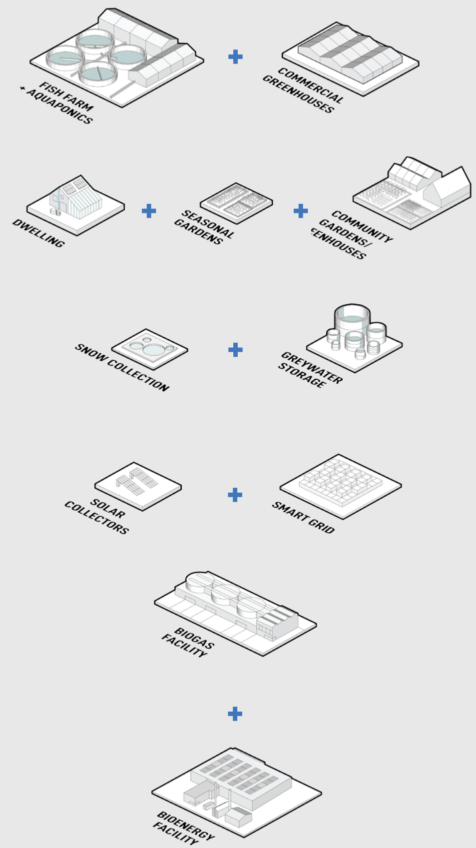
The ecosystem is based off a variety of interconnected components. The ecosystem emphasizes local-scale thinking into a variety of systems: from waste to water to energy to snow collection. At the heart of the ecosystem remains the fish farm and aquaponics system combined with commercial-scaled greenhouses. This initial ecosystem concept was examined in the SIBE report to produce both fish and vegetable products on the site. **However, by expanding the ecosystem with additional uses and functions, new value can be generated and benefit the ecosystem as a whole.** By adding additional uses such as private dwellings and commercial/office/workspaces, an array of benefits and new value can aid in the longevity and success of the system. Specifically, by incorporating living and working opportunities on site, additional ingredients such as seasonal gardens and community greenhouses can provide added value to the ecosystem, such as in organic waste collection for biogas production, or greywater for use in the RAS facility and aquaponics systems. Additionally, by integrating the existing bioenergy facility into the ecosystem, another renewable energy source can be added to the site.

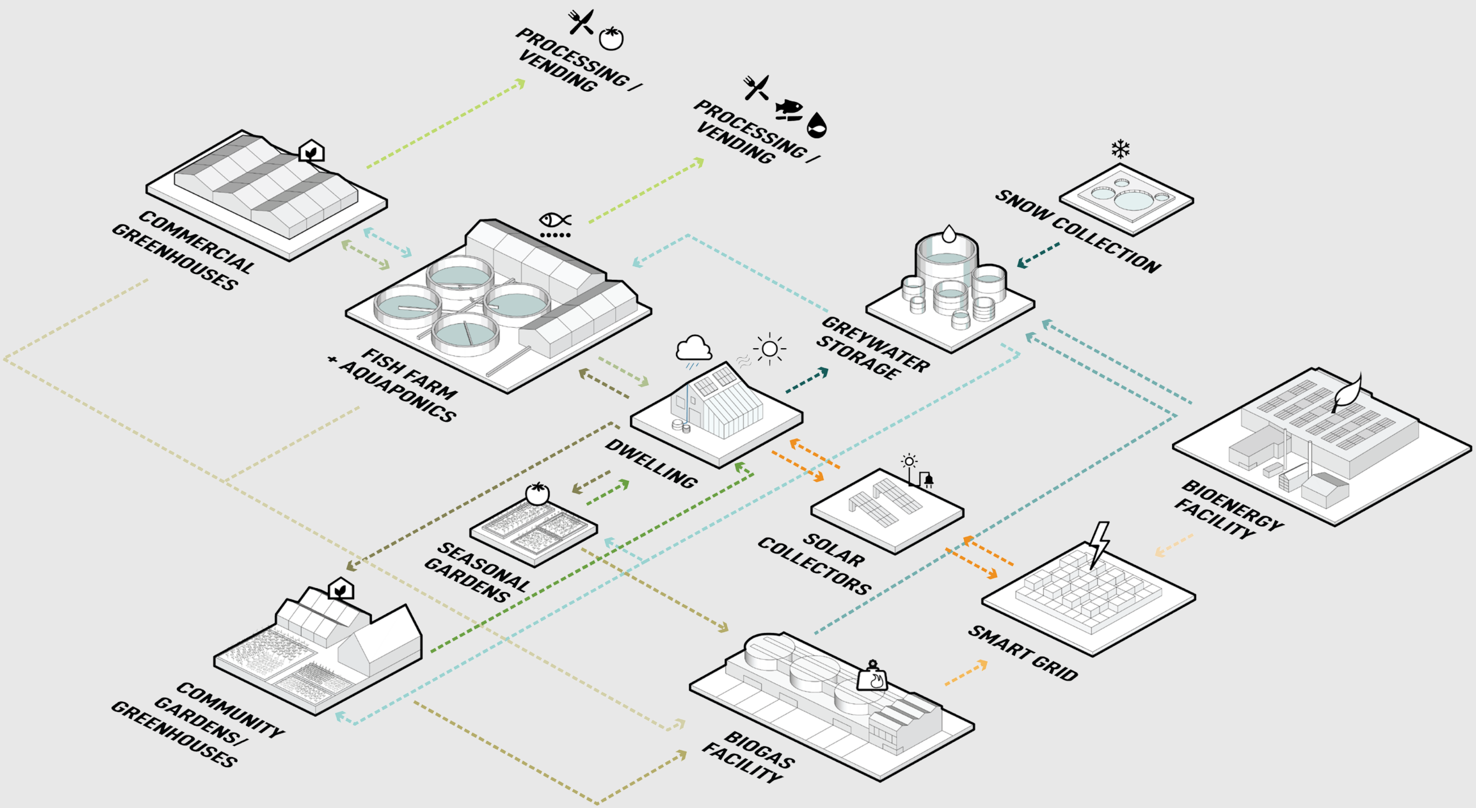
Another component of expanding the ecosystem involves diversifying the types of renewable energy types available within the local context. The benefits of diversification allow for different energy needs to met during the year and therefore works to provide a richer connection with place. For instance, solar collectors installed on south-facing roofs and façades can provide the energy demands for the dwellings, and surplus energy can be stored in a smart grid. In addition, biogas and bioenergy facilities provide energy which can be added to the smart grid. This surplus energy can then be used for the commercial-scale greenhouses and the RAS system. The system can work with seasons, optimizing solar power when it is available, storing it, and utilizing it when needed. In the winter months, when solar energy is not as available, the biogas facility can offset more of the energy needs which is stored in the smart grid. In addition, **producing power at a small-scale can be dramatically more effective then more centralized production. The shorter the distances reduce the power lost in high voltage transmission to insignificant levels** (Braungart & McDonough, 2008).

The ecosystem combines four key types of flows: the flow of food, water, waste and energy into a closed-loop system. Food produce from the seasonal gardens, community greenhouses and the fish farm/aquaponics system is provided for both home consumption on site as well as sold to commercial markets (primarily domestic) for further processing and vending. Greywater is collected from the private dwelling and from snow collection areas on the site. **Snow is managed at the local scale block and collected at key snow collection areas. Citizens can also harvest snow which can be sold for use for the fish farm/aquaponics.** The biogas and bioenergy facilities also produce excess water which is stored. Greywater can be used for irrigation purposes in the greenhouses and gardens and also treated to be distributed to the fish farm (winter storage) as well as for use in the RAS and aquaponics system.

Further, household organics can be distributed for use in the private seasonal gardens and the community gardens and greenhouses. Food waste also has the opportunity to be used for fish feed purposes and can be distributed to the fish farm. Local vegetable waste from the private seasonal gardens and community greenhouses can be distributed to the biogas facility. At the larger scale, waste from the fish farm, RAS, and aquaponics system: including fish waste, vegetable waste, and sludge produced from the RAS can be distributed for use in the biogas facility. Finally, energy is met through combined solar, biogas (with CHP plant), and bioenergy facilities which store energy into a smart grid.

Ecosystem Components





Ecosystem Flows

01 FOOD FLOWS

SEASONAL + COMMUNITY GARDENS
PRODUCE FOR HOME CONSUMPTION

FISH FARM + AQUAPONICS: HOME USE
FRUIT + VEGETABLES FOR HOME CONSUMPTION

FISH FARM + AQUAPONICS: COMMERCIAL USE
FRUIT, VEGETABLE + FISH PRODUCE SOLD TO DOMESTIC & INTERNATIONAL MARKETS

02 WATER FLOWS

GREY WATER COLLECTION
FROM HOUSING/OTHER USES + SNOW COLLECTION

INDUSTRY
BIOGAS + BIOENERGY PRODUCE EXCESS WATER

WATER RECYCLING
GREY WATER USED FOR IRRIGATION PURPOSES, TREATED WATER CYCLED TO FISH FARM + AQUAPONICS SYSTEM

03 WASTE FLOWS

HOUSE HOLD ORGANICS
ORGANIC WASTE FROM HOME USED FOR GARDENS AND COLLECTED TO BE USED FOR FISH FEED

LOCAL VEGETABLE PRODUCTION
VEGETABLE WASTE FROM SEASONAL GARDENS + COMMUNITY GARDENS USED IN BIOGAS FACILITY

FISH FARM + AQUAPONICS
FISH WASTE, SLUDGE FROM RAS SYSTEM AND VEGETABLE WASTE FROM COMMERCIAL GREENHOUSES USED IN BIOGAS FACILITY

04 ENERGY FLOWS

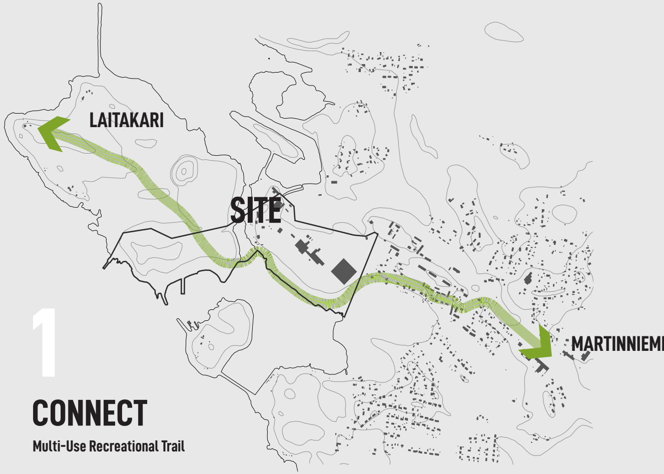
SOLAR ENERGY + SMART GRID
PROVIDES ENERGY FOR THE DWELLINGS + SURPLUS ENERGY DISTRIBUTED TO THE SMART GRID

BIOGAS FACILITY
ENERGY PRODUCED FROM BIOGAS FACILITY ADDED TO THE SMART GRID. SURPLUS ENERGY IS USED FOR GREENHOUSE + RAS SYSTEM

BIOENERGY FACILITY
ENERGY PRODUCED FROM BIOENERGY FACILITY ADDED TO THE SMART GRID. SURPLUS ENERGY IS USED FOR GREENHOUSE + RAS SYSTEM

5.3 DESIGN STRATEGIES

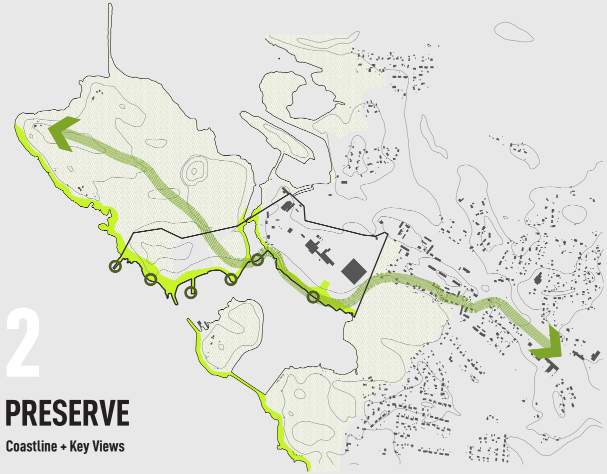
At the level of the site, the design is centred around four (4) key strategies. The first strategy seeks to provide a continuous pedestrian connection from the Laitakari forest and recreational area to Martinniemi village centre. **Naturally, the site falls in the middle of these two areas and so acts as the missing middle between this connection.** The pedestrian connection will create a multi-use pedestrian trail which can be used for pedestrians, cyclists and cross-country skiers. The second strategy is to preserve the existing natural areas surrounding the site and on-site where possible. **This also includes the preservation of key view points along the coastline and providing access to them.** The third strategy is to introduce nature into the proposed development area, by creating green spaces which preserve the forest-character of the area. The final strategy is to harness local renewable energy sources on site, including solar, biogas and the existing bioenergy production on site.



1

CONNECT

Multi-Use Recreational Trail



2

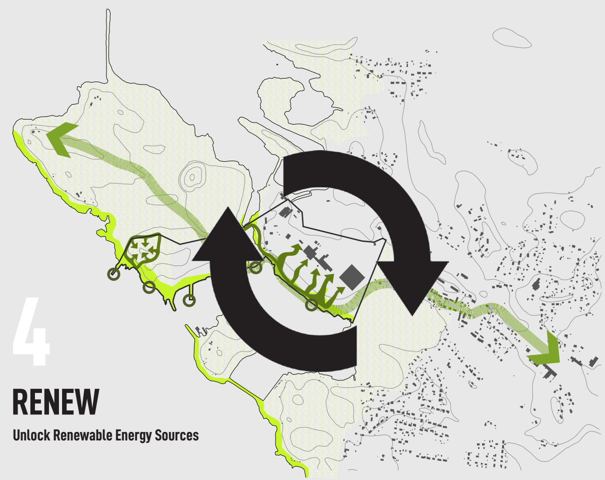
PRESERVE

Coastline + Key Views

3

INTRODUCE

Nature into the Development



4

RENEW

Unlock Renewable Energy Sources

Perspective View at
the Research + Learning Centre

5.4 MASTER PLAN

The master plan proposes a mixed productive and living area that is linked to the local context. The plan incorporates the planned fish farm with inland pools for winter storage, sea pools and the RAS system. This main production area includes other facilities related to the fish operations include water treatment facilities, a pumping station, and fish gutting and feed storage areas. Fish processing facilities as well as cold storage units are also within this area. Surrounding the fish facilities are commercial-scale greenhouses to grow a variety of vegetable produce including tomatoes, cucumbers, herbs and salads to be sold on commercial markets and for home consumption on site. The production area also contains the biogas facility with a CHP plant. **This industrial area is indented for production activities and public access is limited to tours of the facilities.**

Directly north of the main fish and greenhouse facilities exists the main research/learning centre in the place of the former sawmill, honouring the site's history and incorporating a new barrel which pays homage to the previous facility and serves as a landmark. Surrounding this main production facility are **two "biovillages" which consists of private dwellings with greenhouses, gardens and community greenhouses, which are linked to the fish farming and aquaponics activities happening on site.** The recreational trail passes through the eastern biovillage, across a new boardwalk and eventually leading to the **Bioenergy Business Park, a combined bioenergy production and research area with new co-working activities as well as RDI facilities related to the Oulu University of Applied Sciences (UAS).**

MASTER PLAN
SCALE 1/2000


Laitakari
Siikaletto
LOOKOUT
SÄÄVÄLÄT OY CIVIL ENGINEERING + STORAGE AREA
ENTRANCE BUILDING
PRODUCTIVE FOREST
TRAIL TO LAITAKARI
HISTORIC RESIDENTIAL AREA
BIOENERGY DEMONSTRATION FACILITY
CANTEEN
BIOENERGY FACILITY
PRODUCTIVE FOREST
Martinniemi
BIOVILLAGE
RESEARCH/LEARNING CENTRE
LABS/WORKSHOPS
RESTAURANT
RAS FACILITY
WATER TREATMENT
FISH GUTTING
FISH PROCESSING
GREENHOUSES
LIVE FISH STORAGE
FEED STORAGE
CHP PLANT
BIOGAS FACILITY
GREENHOUSES
BIOVILLAGE
BOARDWALK
DETAILED PLAN 1:500
SEA CAGES
BOATING DOCK
WATER PUMPING STATION
THE SPIT
BIOENERGY BUSINESS PARK
UNIVERSITY ADMINISTRATION
LABS/WORKSHOPS
MULTI-PURPOSE PARK
PRODUCTIVE FOREST
SEASONAL STORAGE
TRAIL TO MARTINNIEMI
MAIN DOCK
PRODUCTIVE FOREST
Mustakari

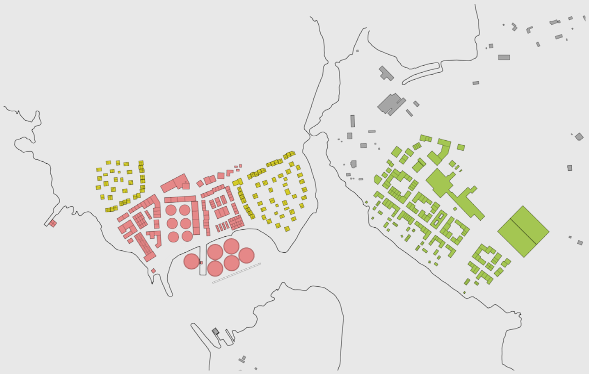
Existing/Proposed Structure

The project keeps the few buildings on site, including Biomega Oy's production facilities and winter storage. The plan also preserves the established residential cluster of historical homes to the east side of the site.

Districts

The design is divided into 3 key districts: including the core fish farm and production area, two biovillages, and the bioenergy business park. Although distinct areas, the districts are linked in their local cycles of food, waste, water, and energy flows.

PROPOSED STRUCTURE
EXISTING STRUCTURE



CORE FISH FARM + GREENHOUSE PRODUCTION AREA
BIOVILLAGES
BIOENERGY BUSINESS PARK

Functions

A variety of functions are established on site. The core fish farm and greenhouse production area consists of primarily productive/industrial uses with some mixed use commercial and office space towards the street to provide adequate buffer to the biovillages. The bioenergy business park combines mixed use commercial and office with productive uses surrounding the bioenergy facility.

Heights

Respecting the local context, the average height of the proposal is approximately 2-3 stories. The biovillages consists of primarily 1-2 story dwellings. The bioenergy business park combines a variety of scales from small-scale 1-2 story buildings to larger scale blocks consisting of 3, 4 and 5 story mixed use office and commercial spaces. The height respects the surroundings: in Martinniemi, the tallest building is around 4 stories high.

Pedestrian Paths

A continuous pedestrian connection is provided connecting Laitakari forest and recreation area to the new research/learning centre and across the site to Martinniemi village centre. In addition, small trails are incorporated within the biovillages and bioenergy business park to increase pedestrian activity in these area. Pedestrian linkages also provide more direct and shorter connections, which provides more attractive alternatives to the private car.

Transport

One of the significant aspects of the design was to distinguish pedestrian activity with logistics needs. Along the main arteries a new bus line is provided connecting the research centre, bioenergy business park to Haukipudas and to Oulu. Infrastructure intended for transport and loading related to industrial activities are separated from pedestrian linkages. The proposal does not seek to create an environment for cars but provides adequate access space, specifically for snow collection vehicles and for fire life safety.

Growing Zones

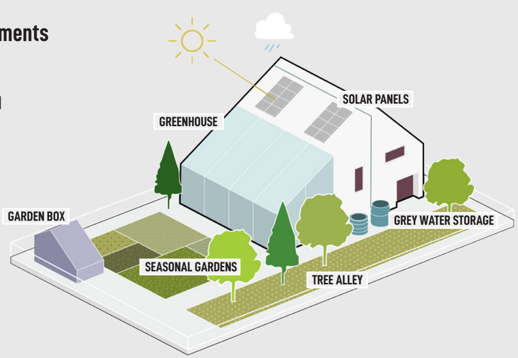
A variety of productive zones are incorporated on the site, including at the smallest scale: private seasonal gardens and moving to the larger scale, community greenhouses, gardens, and commercial-scale greenhouses in the main production areas. The bioenergy business park also includes greenhouses and growing pods as well as productive forest areas within the business park.

5.5 THE BIOVILLAGE

The biovillages serve as self-sufficient resilient neighbourhoods comprised of energy-positive dwellings, renewable energy use, greywater collection and storage, and waste-to-resource systems. The dwellings range from a variety of typologies ranging in different footprints, from rowhouses to semi-detached dwellings to single family dwellings. **Each dwelling contains its own indoor greenhouse and seasonal garden to produce a variety of year-round yield for consumption.** Solar collectors are incorporated on south facing façades to produce energy. The dwellings filter rainwater and snow is harvested per dwelling. In the central area of the village are communal gardens and community greenhouses and kitchens/ houses. Community greenhouses incorporate vertical gardens to grow food on a smaller footprint. Surrounding the network of private dwellings are multi-functional public spaces. **In the winter, these spaces become snow collection areas, which are collected, and melted into greywater.** Greywater from the dwelling and snow collection can either be used for irrigation of the local landscape or be locally treated for use in the fish farm and RAS/aquaculture system. Within the biovillage is a recreational forest and trail which can used by locals for physical activities such as walking, cycling and skiing.

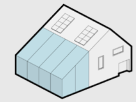
Housing Variety Elements

GARDEN BOX
GREY WATER COLLECTION
SEASONAL GARDEN
GREENHOUSE
SOLAR PANELS
TREE ALLEY

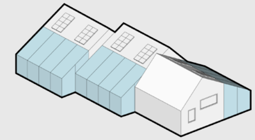


Housing Typologies

130 M2 FOOTPRINT

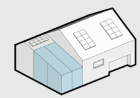


TYPOLOGY 1A SINGLE
HOUSE: 80 M2
GREENHOUSE: 50 M2

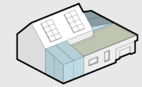


TYPOLOGY 1B ROWHOUSE
HOUSE: 80 M2
GREENHOUSE: 50 M2

140 M2 FOOTPRINT

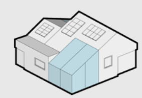


TYPOLOGY 2A SINGLE
HOUSE: 116 M2
GREENHOUSE: 24M2

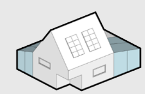


TYPOLOGY 2B SINGLE + TERRACE
HOUSE: 100 M2
GREENHOUSE: 40 M2
GREEN TERRACE: 50 M2

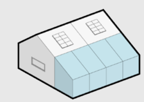
150 M2 FOOTPRINT



TYPOLOGY 3A SINGLE
HOUSE: 110 M2
GREENHOUSE: 40M2

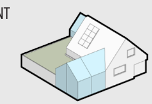


TYPOLOGY 3B SINGLE
HOUSE: 112 M2
GREENHOUSE: 38 M2

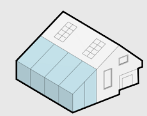


TYPOLOGY 3C SINGLE
HOUSE: 100 M2
GREENHOUSE: 50M2

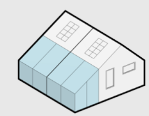
160 M2 FOOTPRINT



TYPOLOGY 4A SINGLE + TERRACE
HOUSE: 120 M2
GREENHOUSE: 40 M2
GREEN TERRACE: 52 M2

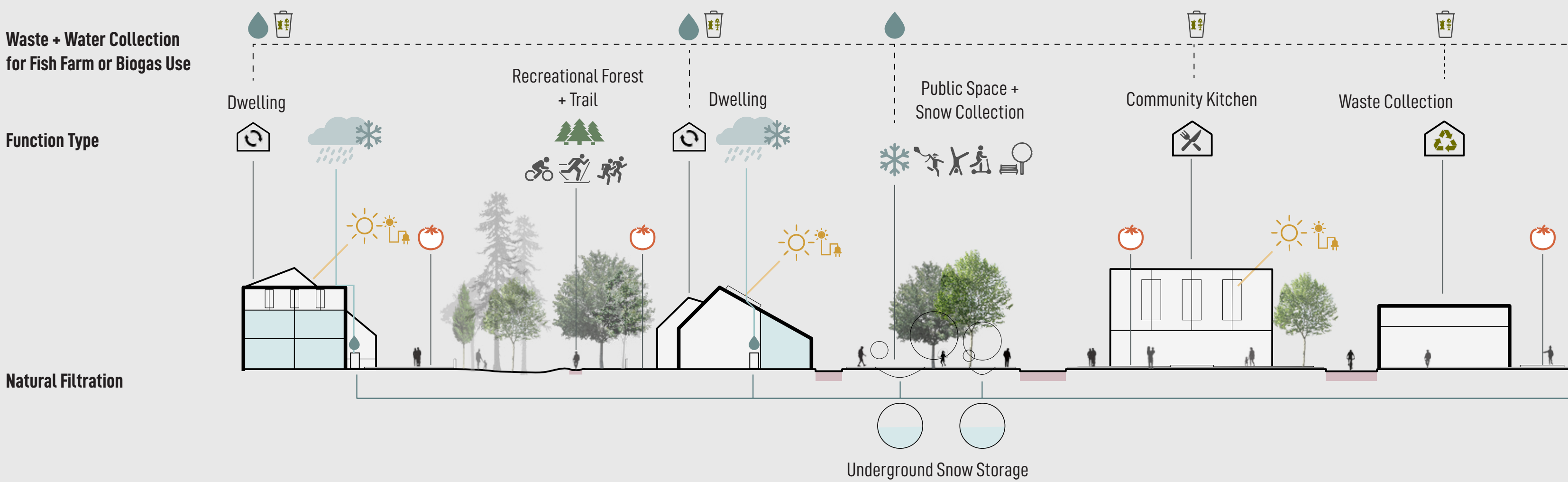


TYPOLOGY 4B SINGLE
HOUSE: 105 M2
GREENHOUSE: 55M2

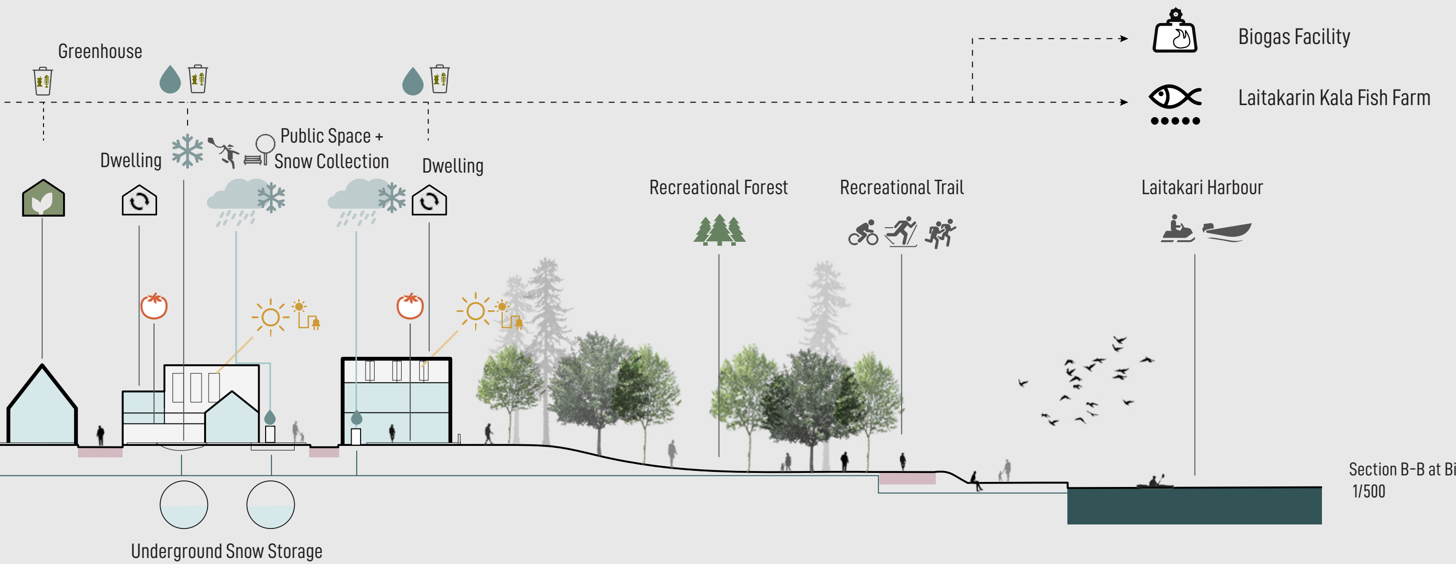


TYPOLOGY 4C SEMI
HOUSE: 105 M2
GREENHOUSE: 55M2

DETAIL PLAN OF THE BIOVILLAGE
SCALE 1/500



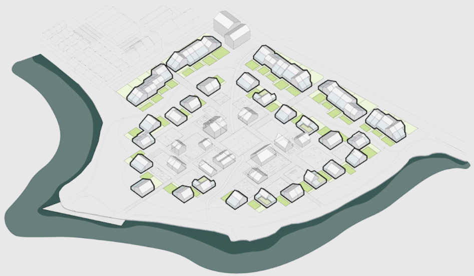
Waste + Water Collection for Fish Farm or Biogas Use
Function Type
Natural Filtration
Dwelling
Recreational Forest + Trail
Dwelling
Public Space + Snow Collection
Community Kitchen
Waste Collection
Underground Snow Storage



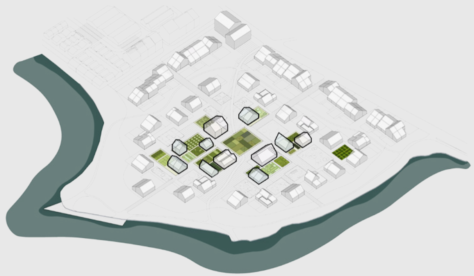
Section B-B at Biovillage
1/500

The Biovillage

Rowhousing, Villas + Seasonal Gardens



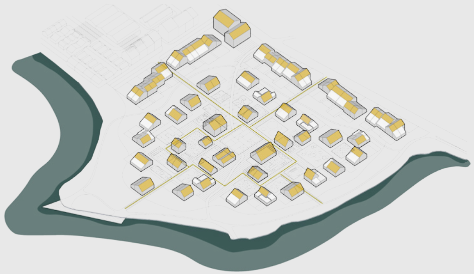
Community Greenhouses, Kitchens + Gardens



Main Access + Semi-Private Frontages

Multi-Purpose Public Spaces + Snow Collection

Solar Collection



Forest + Recreational Trails

Perspective View at
the Biovillage

5.6 BIOENERGY BUSINESS PARK

The Bioenergy Business Park **combines productive bioenergy activities which exist on site with new co-working spaces, labs, office spaces and university facilities tied to the Research & Development (RDI) activities occurring at the Oulu University of Applied Sciences (UAS)**, which include research and innovation in relation to energy-efficient construction in the northern climate, multi-disciplinary business and entrepreurship, and services and technology promoting health and well-being. T**he energy park combines biofuel trees, namely poplars and hybrid aspens, which is used for the bioenergy production and combines it with a living laboratory environment where employees can relax and interact.**

From the existing bioenergy production facilities on the site, Biomega Oy, which remains active, the block scales from a large block (Block "L"), which combines office spaces and UAS university and administration facilities, as well as some cafés/restaurants. Through the district runs the main street, or the *Research Row*, which incorporates a new bus line. The scale of the block transitions into a medium scale, which includes co-working spaces, medium-size businesses, RDI activities, and labs. Eventually, leading into the productive forest, the block "dissolves" into small scale work spaces and greenhouses within a forest setting. **The energy park includes upgraded paths leading to small-scale meeting points or public spaces in the forest, where collaboration and experimentation is promoted.** The main recreational trail passes through the bioenergy park, connecting from the biovillage and main fish farm/aquaponics production area through the bioenergy park and eventually to Martinniemi village centre. The park expands both horizontally but also towards the existing industry. **Forest-like atmospheres are provided within the "L-scale" blocks couryrads to provide pleasant outdoor amenity space for the employees in the area, and to bring nature into the industry area.** Waste from the greenhouses and greywater from snow collection reserves is also collected for use in the bioenergy as well as biogas facility.

Existing Industry

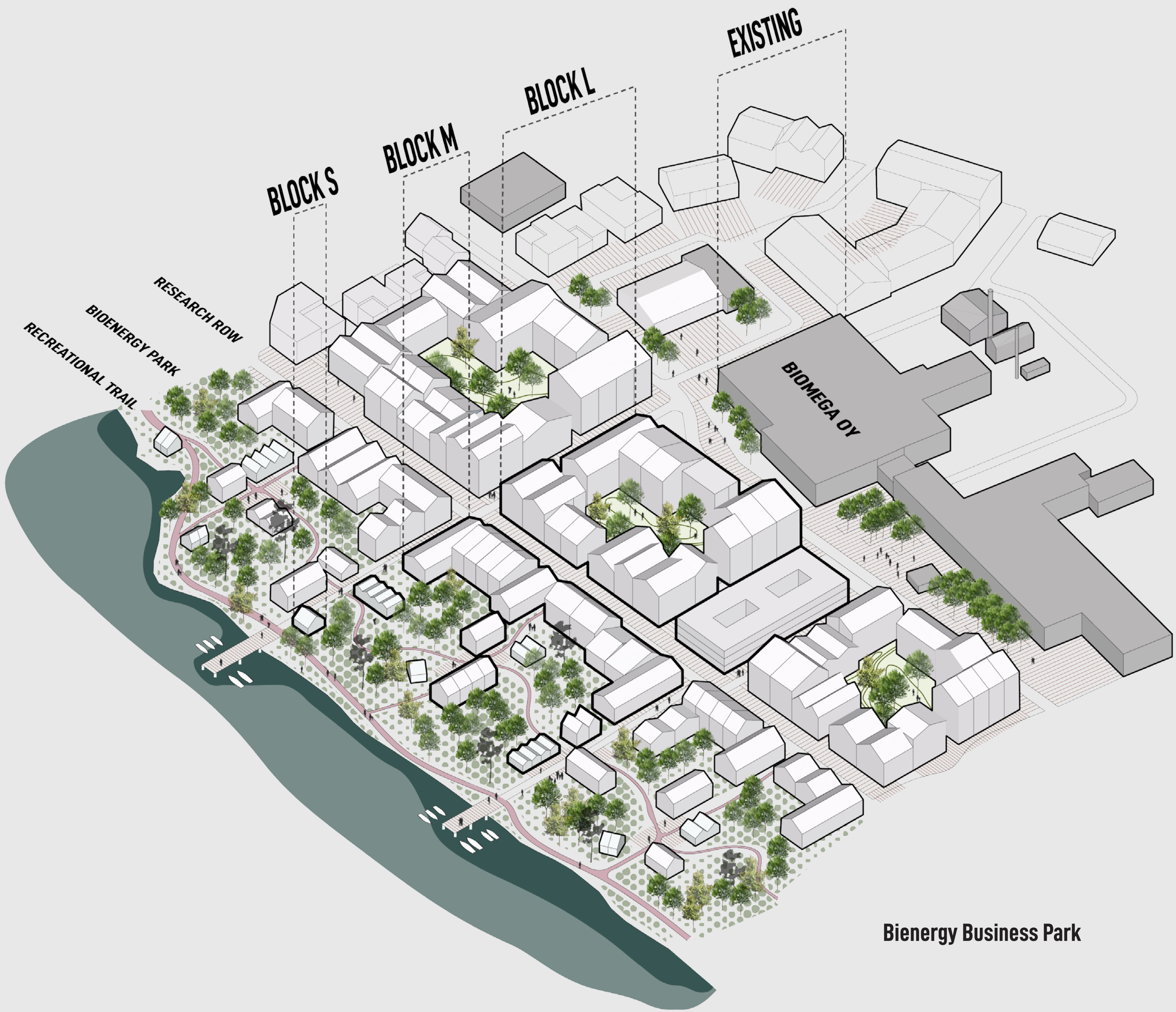
Block: Scale L

Block: Scale M

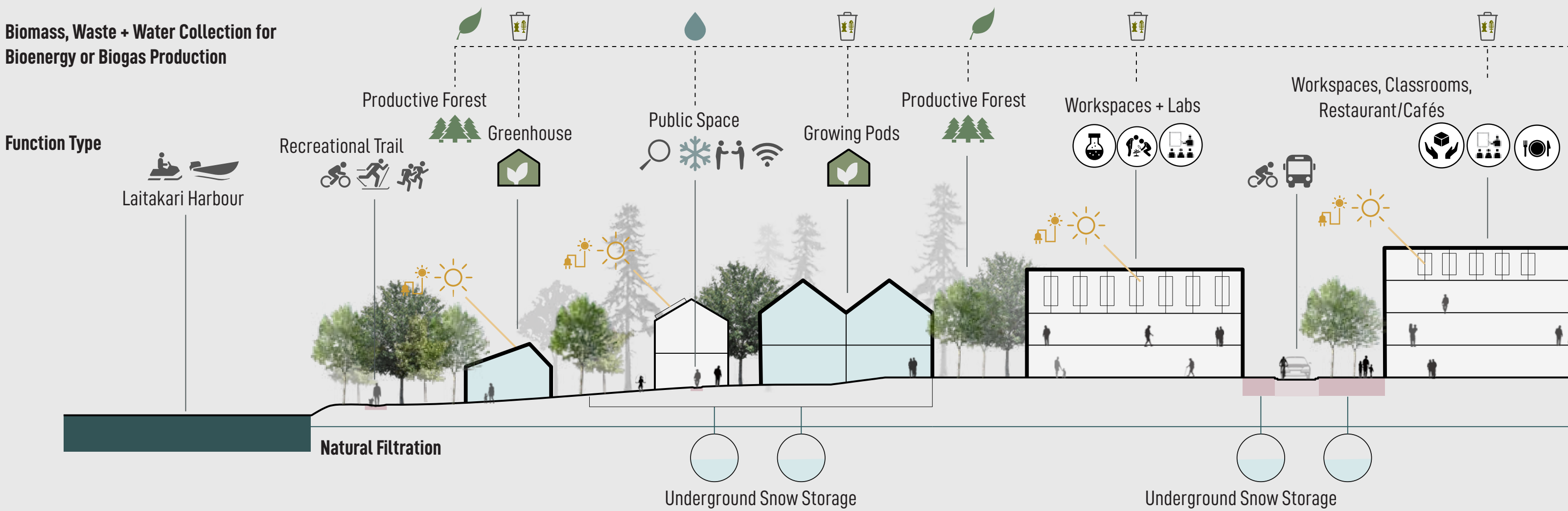
Block: Scale S

Research Row + Main Connections

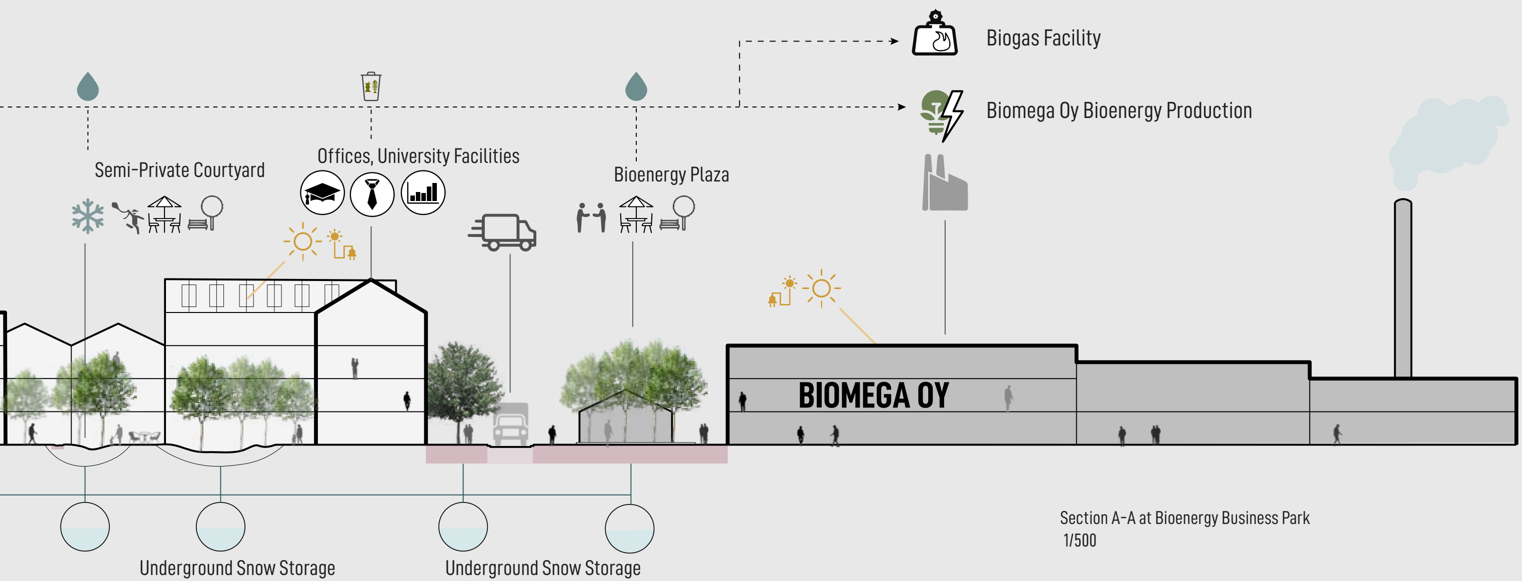
Productive Forest + Recreational Trail



Bienergy Business Park



Biomass, Waste + Water Collection for Bioenergy or Biogas Production
Function Type
Laitakari Harbour
Recreational Trail
Productive Forest
Greenhouse
Public Space
Growing Pods
Productive Forest
Workspaces + Labs
Workspaces, Classrooms, Restaurant/Cafés
Natural Filtration
Underground Snow Storage
Underground Snow Storage



Section A-A at Bioenergy Business Park
1/500

Perspective View at
the Bioenergy Business Park

5.7 AT THE LARGER ECO-SCALE

Blue bioeconomy ecosystem thinking has great potentials to be scaled at the larger eco-scale. The site has opportunities to integrate tourism as an added pillar of function to the ecosystem. As blue bioeconomy is a developing area of research and innovation, and RDI activities related to the usage of sidestreams of fish products, for cosmetic and pharmaceuticals for example, is just one example of research which can attract tourist and learning environment opportunities. **RAS technology is also fairly new in Finland, and experimentation and learning environments within this field can aid in its expansion across Finland.** Similarly, the use of aquaponics systems in Finland can also be a key area of research and learning. **The research/learning centre on the site will provide workshops, labs, and classrooms as well as guided tours of the RAS and aquaponic facilities to promote tourism on site.** A restaurant is also provided as a function in the research/learning centre to sell fish and food products developed on site.

At the larger eco-scale, the site has opportunity to integrate into a network of know-how centres. Finland has the opportunity to be a leader in the development of blue bioeconomy. Combining expertise with other academic institutions in the northern regions of Finland such as the Kemi-Tornio region which continues to develop circular economy outputs, but also transnationally with Sweden, in institutions such as the Luleå University of Technology and Umeå University, **the blue bioeconomy research and expertise belt can be combined with other experts into a northern Bothnian Bay cluster of research, innovation and development in blue bioeconomy-related activities**. This further provides funding streams which can aid in the research and practices in relation to symbiotic fish and vegetable production, and the utilization of waste and other sidestreams occurring on site.


Connecting Know-How Centres
Luleå University of Technology
Kemi-Tornio University of Applied Science
Laitakarin Kala
University of Oulu
SWEDEN
Gulf of Bothnia
Umeå University
FINLAND
University of Vaasa
N
0
50km

Perspective View at
the Village Sauna

PART 06

DESIGN FINDINGS + REFLECTIONS

6.1 SOME FINDINGS

Benefits of the Ecosystem

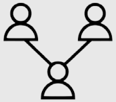
There are several benefits to creating an ecosystem, which is largely based on the symbiosis between actors and businesses as a result of physical proximity. **Physical proximity not only allows for savings, in energy, in centralized production, logistics, marketing and labour, but allows for for mutual trust and strong personal relations to exist between people and businesses.** In addition, it allows for the empowerment of the local community who become part of a shared local ecosystem, with distinct roles and responsibilities within their community.

At the same time, when industrial processes and production activities of the city respect diversity of place, **they engage with local materials and energy flows, and with the local social, cultural and economic forces, instead of viewing themselves as autonomous entities, unconnected to the culture and landscape around them.** As Braungart and McDonough state, a diversity of added value can be attained when *“we connect them to local material and energy flows, and to local customs, needs, tastes, from the level of the molecule to the level of the region itself” (123).*

Why Create an Ecosystem?

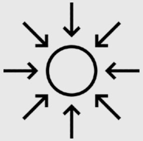
Dependence =
Postive benefits from working closely with other actors and businesses

Centralized production, logistics, marketing and labour results in savings



Committed players + mutual trust. **Empowerement** of local community

Physical proximity and **good personal relationships**



Tied to **local place and context**. Respecting local material and energy flows, cultural and economic forces

Who lives in the Biovillage?

The proposal provides dwellings for approximately 150-200 residents, with approximately 9500 square metres of residential floor space, and an average of 2 people per household. The dwellings exist in the two biovillages proposed on site. As the biovillage offers a specific ecological way of life, the residents attracted to this real estate development model can be those who also work within the industry in the area: the fish farm and aquaponics employees, RAS specialists, horticulturalists, biogas or bioenergy employees, to name a few. However, the goal of the area is to integrate local life with production activities, and so the biovillage is open for all and can provide a mixed society of workers and residents.

In addition, the proposal provides approximately 30,000 m2 of commercial/office ground floor area. Assuming a minimum of 10 square metres per employee, the **proposal can introduce approximately 1700-2000 new employees to the area.** These employees work in the fish facilities, including the fish farm operations, RAS facility, and processing facilities, as well as in the greenhouses and biogas plant. The bioenergy business park employs a significant portion of this amount with employees in the bioenergy facility itself as well as in new university facilities and RDI activities. **This is in line with the blue bioeconomy goals of creating 100,000 new bioeconomy jobs and 40,000 new clean-tech jobs in the next 10 years.**

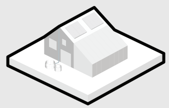
The diversity of productive areas is provides in different scales from seasonal gardens to commercial-sized greenhouses. **The proposal provides approximately 18,830 square metres of productive growing areas**, ranging in seasonal gardens (3867 m2), community gardens (2460 m2), small-scale greenhouses (both private and community: 5225m2), and commercial-sized greenhouses (7278 m2).

PROGRAM

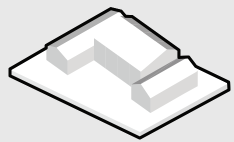
150-200 INHABITANTS ON SITE + **~ 1700 - 2000 NEW EMPLOYEES**

average 2 people/household

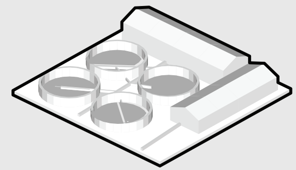
average 10 M2/employee



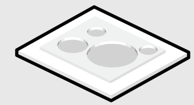
DWELLINGS
AREA
9472 M2



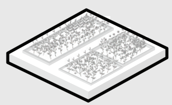
COMMERCIAL/OFFICE
AREA
29,718 M2



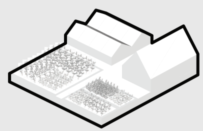
FISH FARM/RAS SYSTEM
AREA
16,182 M2



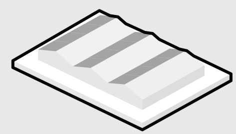
SNOW COLLECTION AREAS
AREA
4320 M2



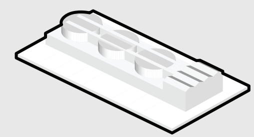
SEASONAL GARDENS
AREA
3867 M2



COMMUNITY GARDENS + GREENHOUSES
AREA
7685 M2



COMMERCIAL GREENHOUSES
AREA
7278 M2



ENERGY FACILITIES
AREA 10,339 M2

6.3 THE IMPORTANCE OF PROCESS

Balancing stakeholder requirements

As we have seen, building an ecosystem requires a group of committed stakeholders. A project stakeholder is defined as an *"individual or group who have an interest or some aspect of right or ownership in the project, can contribute in the form of knowledge or support, or can impact, or be impacted by, the project" (Bourne, 2005)*. An ecosystem like this requires committed businesses and actors ranging in fish farming (in which Laitakarin Kala is they key player), in greenhouse cultivation and production, in RAS systems, in energy production (such as a biogas company), in fish food processing companies, and in fish processing, to name a few. **What is required is coordination amongst all these stakeholders, each with their own distinct requirements and divergent interests and objectives.**

One of the greatest challenges of building an ecosystem with a diverse group of businesses and actors is understanding the specific needs and requirements from the outset. **Each player has different requirements including: different infrastructure, buildings, energy needs and facilities, for the environment of the fish farm.Because requirements from each player can be so diverse, and at times, contradictory, it is imperative to not only distinguish what the requirements are from the beginning, but to balance the requirements as best as possible:** *"The contractor, the maintenance, the investors…they typically have some contradictory requirements or interest - so they need to be analyzed at the very beginning [of the process] and then balanced, in order to be able to provide the best value at the end of the day" (H. Haapasalo, personal communication, February 12, 2019).*

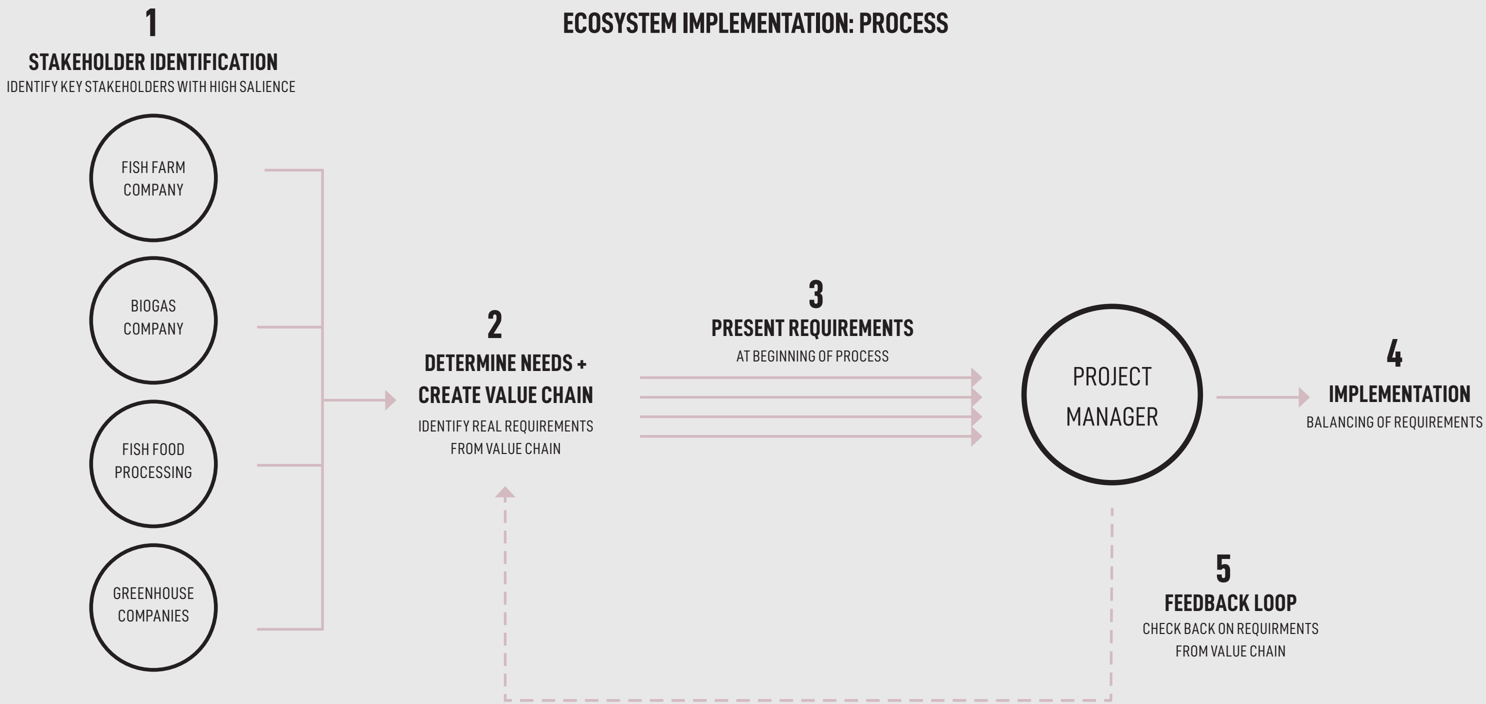
At the same time, an ecosystem of this size can result in a large amount of stakeholders. This poses a challenge when balancing the different needs of stakeholders. Aapoja and Haapasalo (2014) examines this further in stakeholder identification and classification in construction projects. In complex projects with a multitude of stakeholders, it poses challenges on not only the identification and management of stakeholders but also satisfying their requirements. Stakeholder analysis and identification aims to facilitate the understanding of how to manage stakeholders in invariably changing and unpredictable environments (Aapoja & Haapasalo, 2014). **One of the key aspects in stakeholder management is determining the salience and positioning of the stakeholder within the process.** In essence, stakeholder salience is *"the degree to which managers give priority to competing stakeholder claims" (Aapoja & Haapasalo, 2014).*

In other words, by measuring the "decision-making power" of stakeholders, we can determine which stakeholders carry higher salience, or higher value and which ones do not, and therefore which needs and requirements are most important to balance. **The higher the salience, the more important the stakeholder; and the more probable the ability for the stakeholder to contribute.** Stakeholders can be divided into generally 4 categories: the *"key players"*, or those with responsibilities for the project, the *"keep informed"* stakeholders consisting of different interest groups, such as residents, or local organizations with low-impact; the *"keep satisfied"* stakeholders such as national governments or similar organizations that have requirements or power to halt a project, but generally do not have personal interest; and finally the *"minimal effort"* group, who are not regarded as salient or focal to the project.

Traditionally in an urban development, up to hundreds of possible stakeholders can be listed, but what becomes important is deciphering which stakeholders carry the highest salience and therefore the highest weight in decision-making while also placing lower value on the minimal effort groups who carry low salience. This is often done most extensively in software companies: for instance in evaluating the salience of Nokia's internal stakeholder and product development, the most important component of the product design could be determined. *"If environment says it has to be green, or blue or poison-free, or packaging says it has to be light in weight…someone has to evaluate systematically at the very beginning…and we need some kind of systematic process to look at how to put the requirements and needs and guidelines and cornerstones into the very beginning" (H. Haapasalo, personal communication, February 12, 2019).*

Therefore when creating a blue bioeconomy ecosystem, it becomes crucial to examine who the key actors are at the beginning of the process, determine what their needs and requirements are, who the minimal effort groups are, and aim to balance the requirements from the beginning. It also becomes imperative that, throughout the process, the requirements are consistently checked back on in a constant "feedback" loop. This ensures that the requirements of the most crucial stakeholders are being balanced consistently. It is perhaps one of the most challenging components of creating an ecosystem and why it is stressed that creating a value chain, analyzing what is needed by each stakeholder in the early stages can help to realize the success of such a project. Importantly, the viability of the ecosystem is dependent on its economically feasibility and should be determined in the early stages.

ECOSYSTEM IMPLEMENTATION: PROCESS



6.4 CONCLUDING REMARKS

The proposal seeks to address the questions surrounding our relationships with the very systems we use daily, which seems to be growing futher apart in an ever-globalizing society. **By addressing these production and consumption systems: our food, water, waste and energy cycles, they can be more closely integrated and regenerative rather than damaging and degrading.** In reality, the proposal is more than just a few pools for fish: but provides plentiful of services to the community and to the region.

One of the greatest challenges in the implementation of such an ecosystem is that it requires new modes of thinking in an often status quo society. **Although blue bioeconomy is making an impact in Finland, its actual realization in practice is still under development.** Through research and discussion with people and parties who are seeking to realize blue bioeconomy concepts and who examine the actual economic practicalities, some of the greatest challenges comes with finding companies and technologies which just don't seem to exist yet, and so these activities must be created from scratch. In addition, to make an ecosystem like this profitable often requires radical change of policy and coordination.

Regardless, **the proposal provides a vision for the possibilities the blue bioeconomy ecosystem can contribute and what kind of life can be generated by harnessing the local circular economy opportunities on site**. The ecosystem not only provides solutions to the systems we use daily, integrating production and consumption cycles considering distribution, waste and consumption, **but provides a high quality of life for its residents and employees, merging the tensions we often associate with production and local life, and enhancing relations between citizens and the environment.**

"To commit to a new paradigm, rather than an incremental improvement of the old... immediate change is difficult in a market dominated by the status quo....the intention is not to be slightly more efficient, to improve on the old model, but to change the framework itself"

- Michael Braungart & William McDonough
in Cradle to Cradle, 2009

PART 07

END NOTES

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Final Presentation Jury: Björn Ekelund, Harrison Fraker

LUND UNIVERSITY

OULU BIOVILLAGE

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