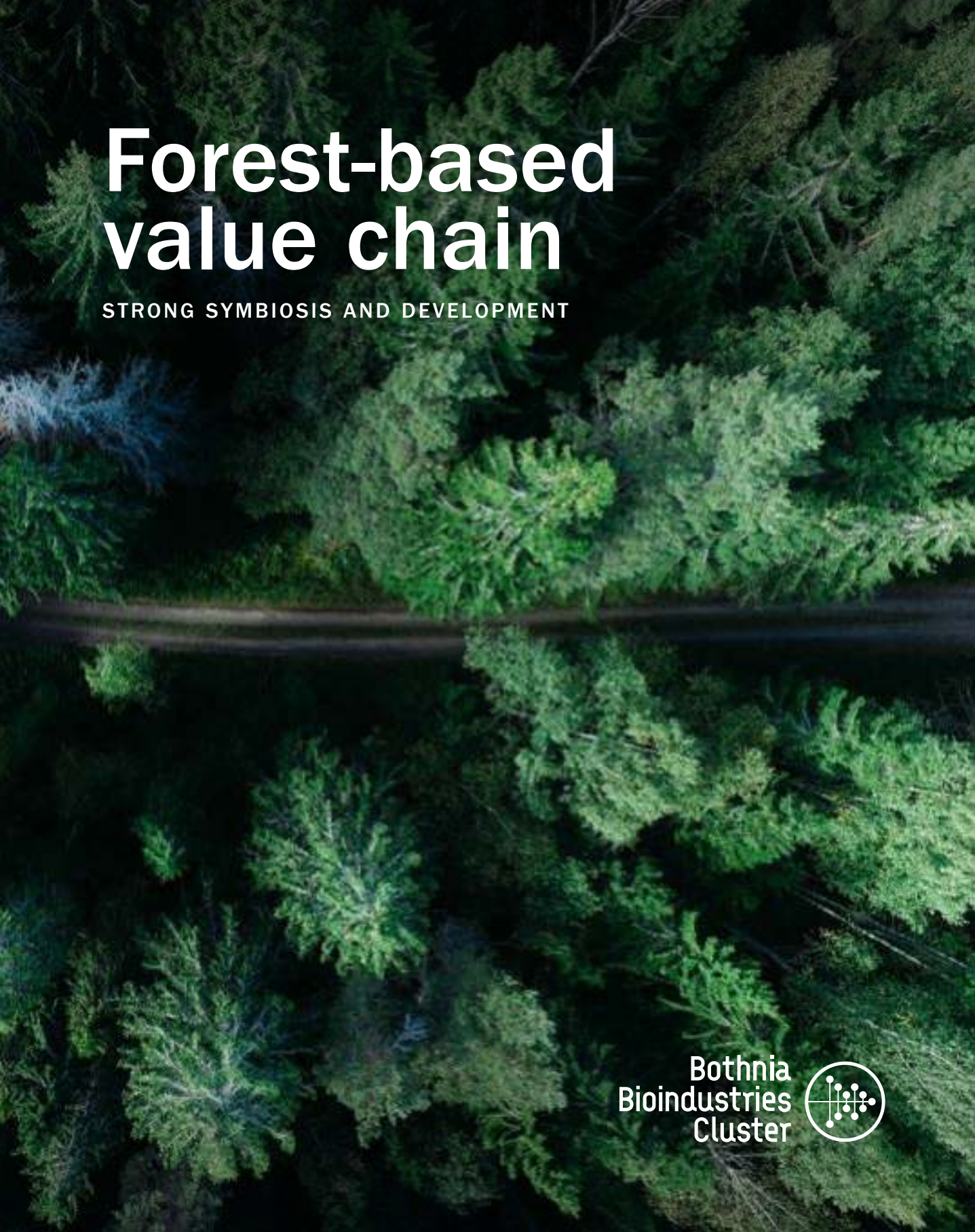
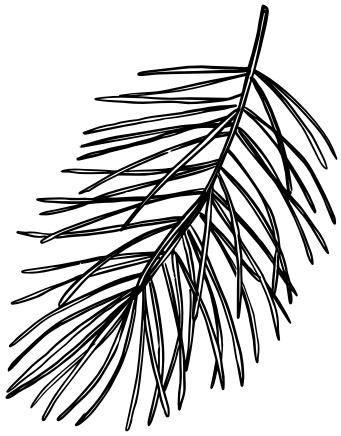


Forest-based value chain

STRONG SYMBIOSIS AND DEVELOPMENT

Bothnia Bioindustries Cluster

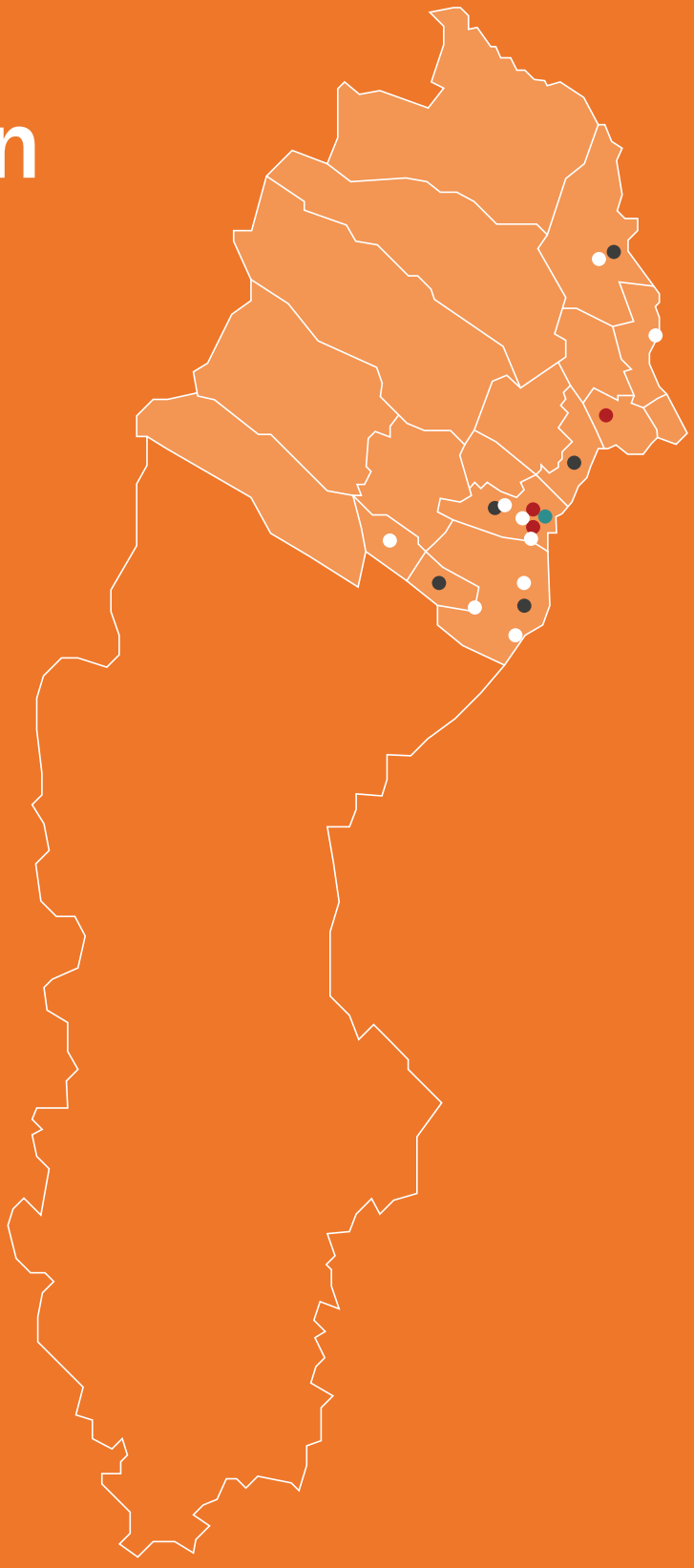


WELCOME TO THE SUB-ARCTIC FOREST.
Where renewable energy never runs out,
as the trees continue to grow tall.
Where everything can be both soft and hard,
light and tough – at the same time.

Where complex questions find their given answer,
as if it were predestined all along.
Where the force of durability and growth
is completely soundless and still.
Where the history is forever present and where
the solutions for tomorrow is hidden.

Welcome to our heritage.
Welcome to our future.

Our region



- Sawmill/Planing mill
- Pulp & paper industry
- Biorefinery
- Biofuel industry

2 000
EMPLOYEES IN FORESTRY
AND LOGISTICS

3 000
EMPLOYEES IN THE INDUSTRY

Over half of Sweden's landmass is covered by forest. Forestry is vitally important for the national economy, and most Swedes closely relate to forests and forestry activities. Sweden holds just under one percent of the world's commercial forest areas but provides ten percent of the sawn timber as well as the pulp and paper that is traded on the global market. Forests are an important source of renewable raw materials; they also store carbon dioxide and are valuable for wildlife, outdoor activities and recreation.

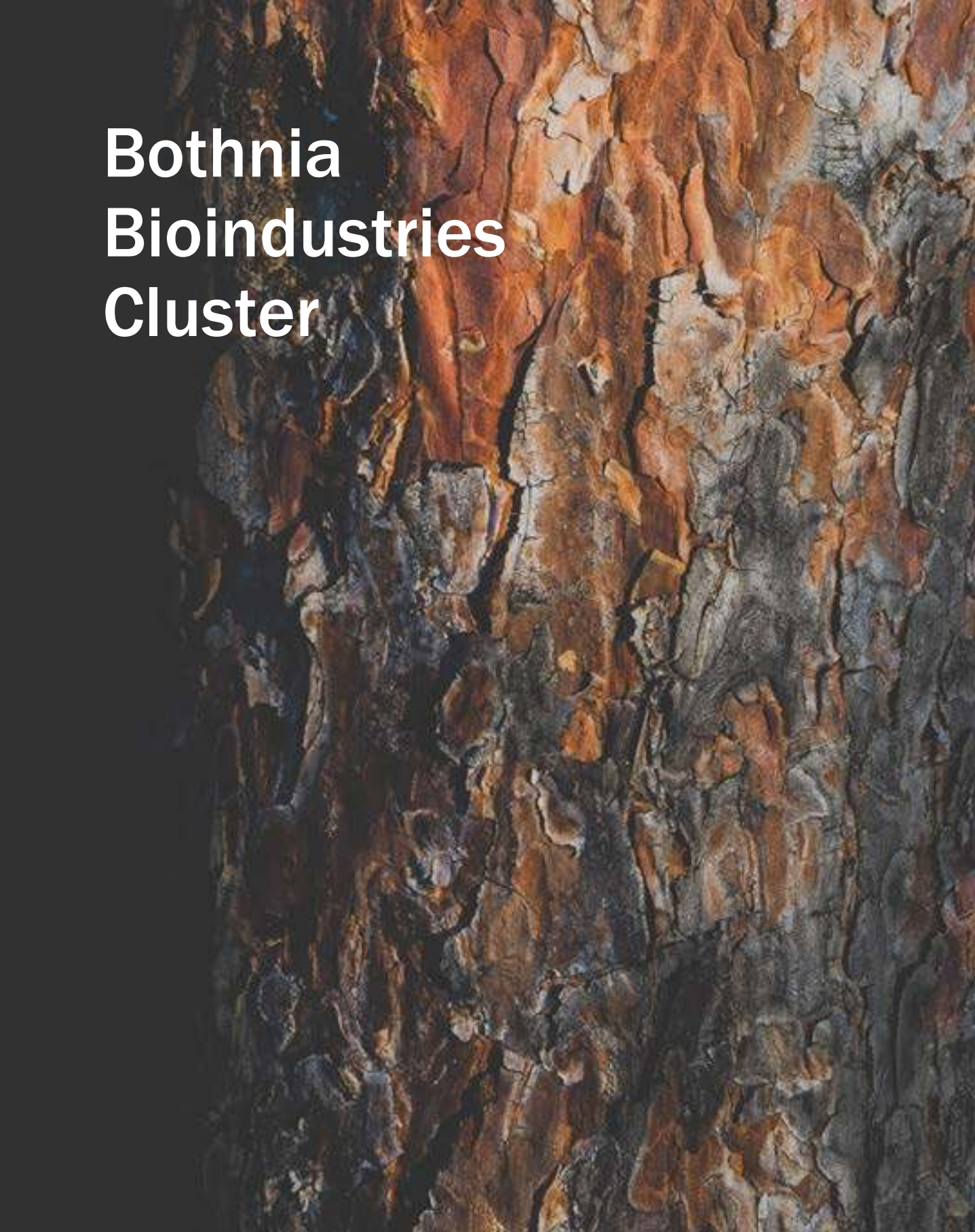
SWEDEN HAS A long-standing tradition of using natural resources from our forests, whilst simultaneously taking other values of the forest into account. Despite the increased use of biomass, the total stock of wood in the Swedish forest and stored carbon dioxide, has increased year by year.

OUR REGIONAL FOREST BASED value chain is situated in the far north of Sweden. Where the forest has played a major part in the growth of the region for centuries and where the industries still stand strong.

THE REGIONAL VALUE chain is comprising a productive forest area of 70.000 square kilometers, equivalent to the size of Ireland. The annual growth is approximately 21.450.000 cubic meter, whereof the forest owners harvest about 85%, meaning that the amount of forest in the region increases each year. The forestry is more or less totally certified according to the FSC or PEFC regulations, with some exceptions of private forest owners.

THE VALUE CHAIN covers 14 municipalities in Norrbotten county and 4 municipalities in Västerbotten county, a total of 117 691 square kilometers – equivalent of about a quarter of Sweden's total land area. The region's population of 277 000 people equals 2,8% of Sweden's total. The majority lives along the coastline, so there are several sparsely populated areas.

Bothnia Bioindustries Cluster



THE REGION'S DRIVING FORCE FOR FURTHER DEVELOPMENT OF THE BIO-BASED INDUSTRY AND TO PUSH SOCIETY TOWARDS A BIO-BASED ECONOMY.

Our point of departure is the region's specific conditions and the forestry value chain, since it creates the environment for today's bio-based industries as well as the new ones in the future.

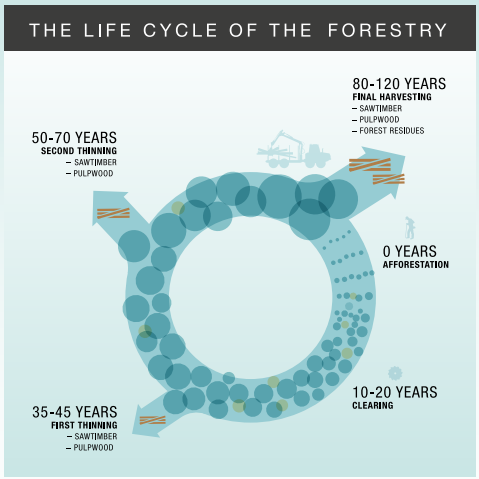
OUR COMMON GROUND is sustainability and that we are forest based. Our sustainability efforts start in the forest and goes all the way through the industry to the end users.

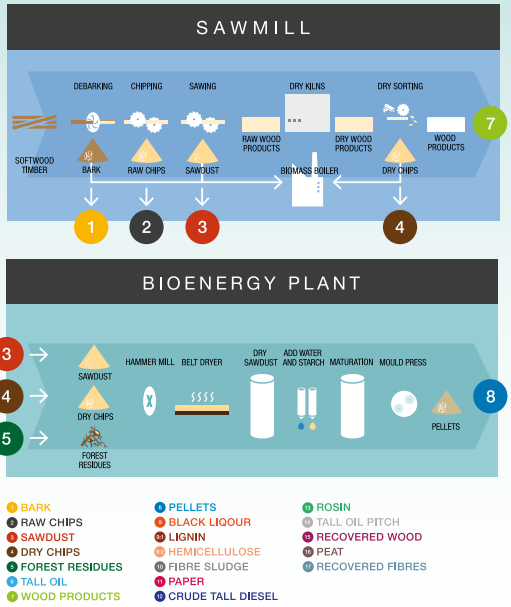
THE WHY FOR our collaborations is that we're all part of this value chain and due to the extreme strong symbiosis between all parts we all benefit from a prosperous whole as well as for each part. By enabling more and better usage of our total amount of biomass we bring more contribution margin to the whole value chain, but at the same time also add more materials and products to our bio-based economy.

THERE IS MASSIVE R&D on different technology reediness level to developing new bio-based materials and products, partly in our region but all over the world. To go from R&D till commercialization has many challenges, but one common for all efforts is to find a value chain where the new biorefinery find the right conditions, i.e. right type of biomass in enough volume and possibilities to system integration with the existing industry.

WE WILL EVALUATE business ideas and use entrepreneurs, technology providers and funding, both regionally and globally, to see what kind of biorefinery that can be added to our value chain. We have recently introduced one and if we can find enough biomass we might add two or three more.

THE CLUSTER IS hosted by Piteå Science Park and is funded via European Regional Development Funds as well as Region Norrbotten, Längmanska företagarfonden, Sparbanken Nord and the municipality of Piteå. It is membered by fourteen industry and research players across the region.





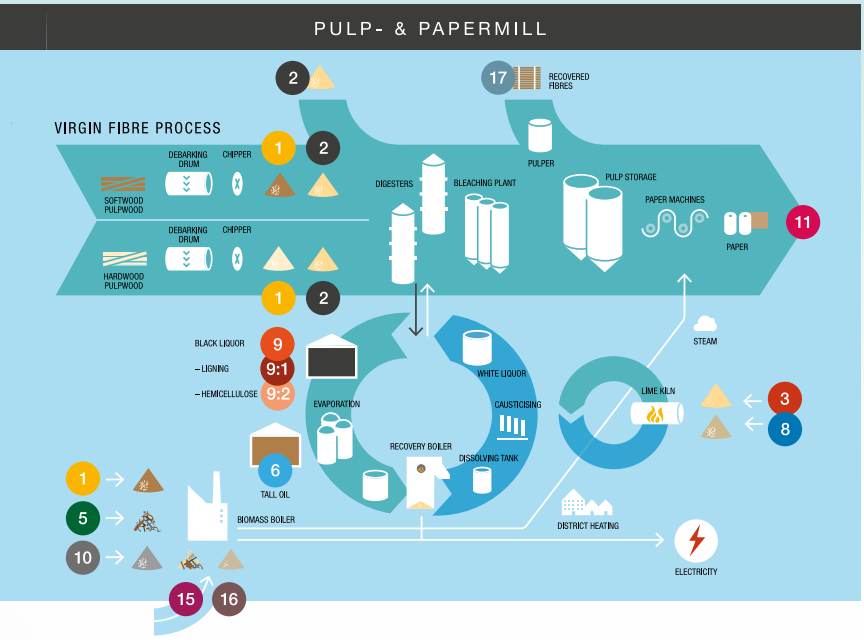
All materials and biomasses used in the value chain, main production and side streams, summarized on page 23.

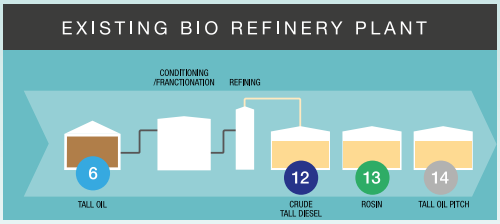
Forest based value chain

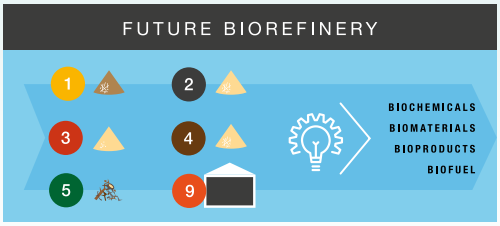
As a result of the joint history among the stakeholders and their strong symbiosis, the regional value chain is extremely interconnected, which has led the industry to where it is today. As in any chain formation, every part is equally important for the chain to function in the best way possible. Every part of the chain is both independent and joint at the same time, strong on its own but even more capable united with other valuable parts. It is the value chain perspective, close collaborations and valuable exchanges that will generate the innovations of tomorrow and a more profitable way of using forest-based biomass and the industrial side streams.

THE REGIONAL VALUE chain, i.e. Bothnia Bioindustries Cluster, has a rich history containing

FOREST BASED VALUE CHAIN





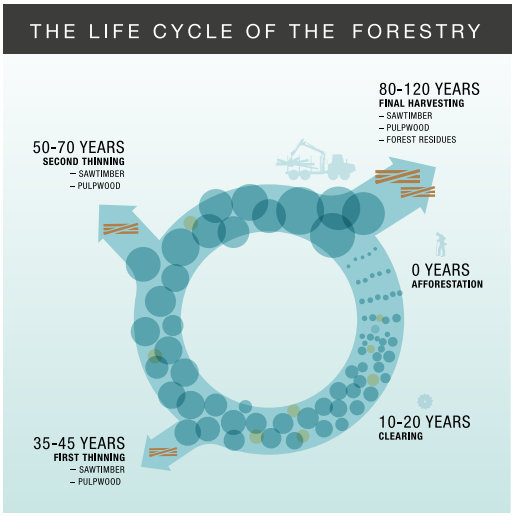


valuable experience, irreplaceable knowledge and excellent craftsmanship. Collaborations and mutual development have characterized the value chain for the last 200 years, bringing it to a world leading position. As demands, needs and requirements constantly are evolving, the bioindustry has to stay ahead and push the boundaries of what can be made out of timber, pulp wood, forest residues and all industrial side streams. Climate awareness is spread globally and encouraging all of us to act more thoughtfully in our everyday choices. The demand for renewable and recycled materials and products is at an all-time high and both B2B and B2C companies experience a “high demand, low supply” situation, longing for the next green innovation.

EVERY PART OF the value chain is presented over the next few pages, including their position in the value chain, main production and current side streams. Opportunities for the value chain’s next new bio-based materials and products lay in the existing structure, as presented ahead.

Forestry

Sweden is made up of 70 percent forest which naturally makes sustainable and efficient forestry a main priority. The latest Swedish forestry legislation, adopted in 1993, is based on two parallel goals: a production objective and an environmental objective. The production objective is that the forests and forestland shall be utilized efficiently and responsibly to provide a sustainably positive yield, which is thus a long-term goal for productive use of the forest. The environmental objective is to secure biodiversity and generic variation while providing the necessary conditions for plant and animal species that naturally belong in the forests to survive under natural conditions and in viable populations. It is a delicate balancing act, but if you believe that a bio-based economy is better than fossil-based, then we must find a balance where we continue to use the forest.



DURING THE 18TH and 19th centuries, many forests were over-exploited. After decades of political debate about the declining state of Swedish forests, the first Forestry Act was passed in 1903, requiring owners to replant after harvesting. Since then, Sweden's forest owners have been planting at least two new saplings for every tree harvested.

SINCE THE 1950s, even-aged forestry has been the dominant sivicultural system in Sweden in order to obtain a long-term sustainable flow of timber. An even age-class forest on a regional level, as well as on national level, is the long-term target. No carbon debt is created in a managed forest system like Sweden's. Quite the contrary: a carbon surplus is generated each year and increasing carbon assets are created. These carbon assets, the total standing stock, have doubled at the same time as the harvest has almost doubled in volume.

THE FOREST IS constantly growing, which means its renewable energy will never run out, provided it is managed and nurtured correctly. Economic, social and biological sustainability are declared as the cornerstones of sustainable forestry and Sweden's forestry has long led the way.

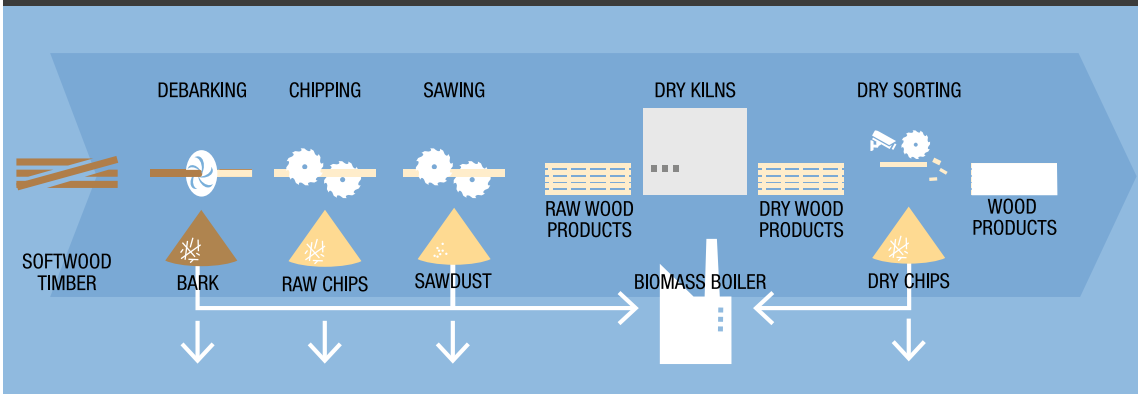
ECONOMIC SUSTAINABILITY: ensuring long-term wood production that generates sufficient profits to keep the forestry and forest management work going.

SOCIAL SUSTAINABILITY: aboriginal populations, workers' rights, recreational issues and opportunities for society, at both local and national level, to survive on its forestry in the long term.

BIOLOGICAL SUSTAINABILITY: the land's long-term production capacity, preserving the natural ecological processes, the preservation of biodiversity.

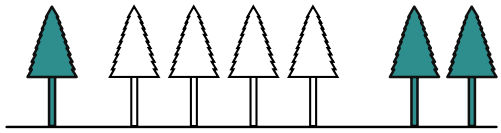
Sawmill

SAWMILL



The sawmills in the region use approximately 3,5 million cubic meters of timber a year. From each log half is processed into sawn timber and the other half becomes different types of side streams. The largest side stream is raw wood chips, approximately 30%, and is sent to pulp mills as raw material. The remaining side streams consists of bark, sawdust and dry wood from the bracking mill and are traditionally used as biofuel for internal use. Any excess volumes of biofuel are sent to a bioenergy plant or external heat and power production.

THE SAWMILLS ARE first in line to handle and process the wood. There is great value as well as potential in the sawmill side streams since the excess material easily are made into profit, rather than using the material as landfills and therefore being a substantial cost for the industry. Economic perspectives aside, to fully utilize and make use of natural material is the proper way to care for nature and bring us closer to a circular bio-based living.



Sustainable forestry is Sweden's oil reserve. Despite having harvested four times the number of trees that we had 100 years ago, we now have twice as much forest. This is the result of planting two or three trees for every tree felled.

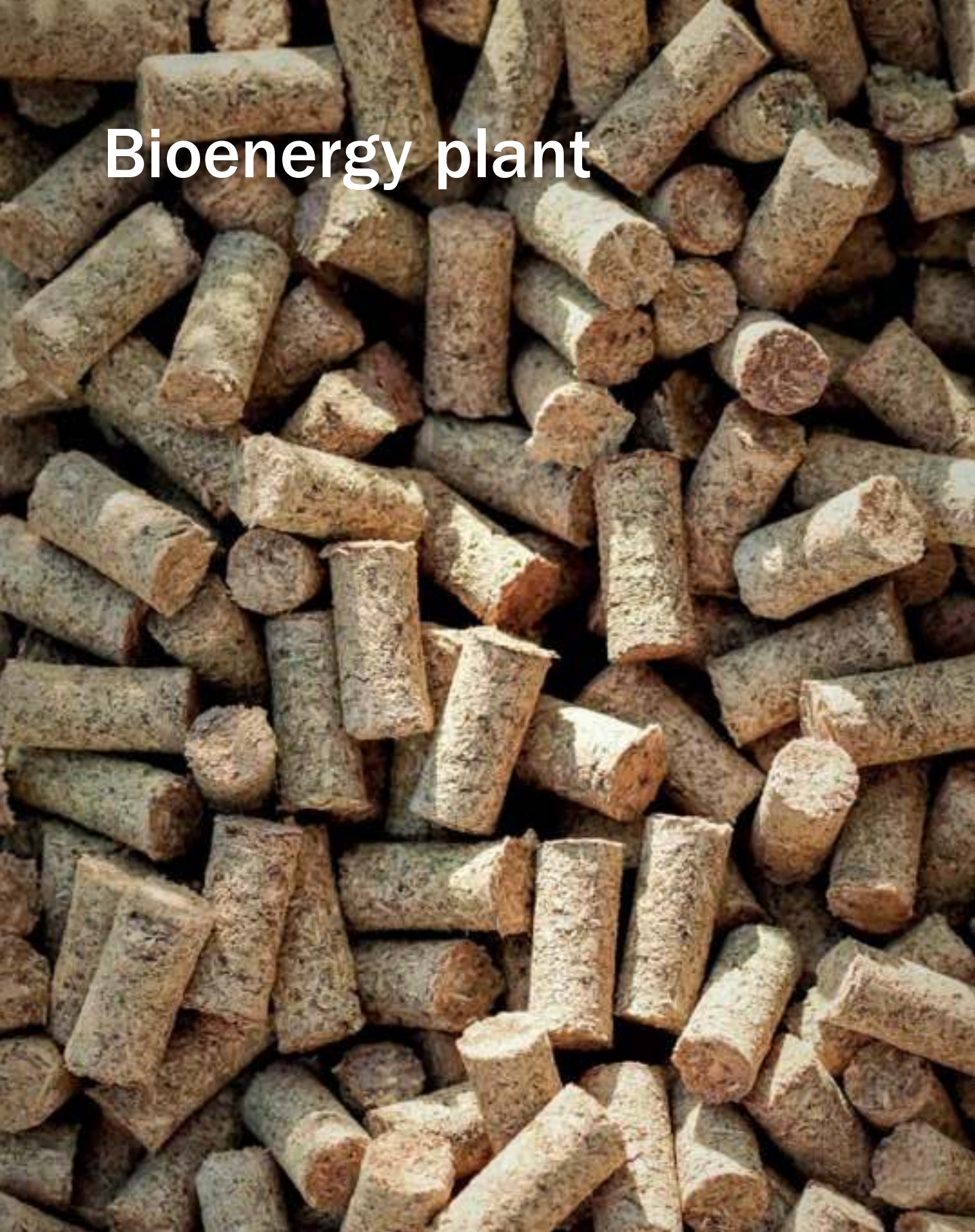
1 750 000 m^3
WOOD PRODUCTS

285 000 tonnes
SAWDUST

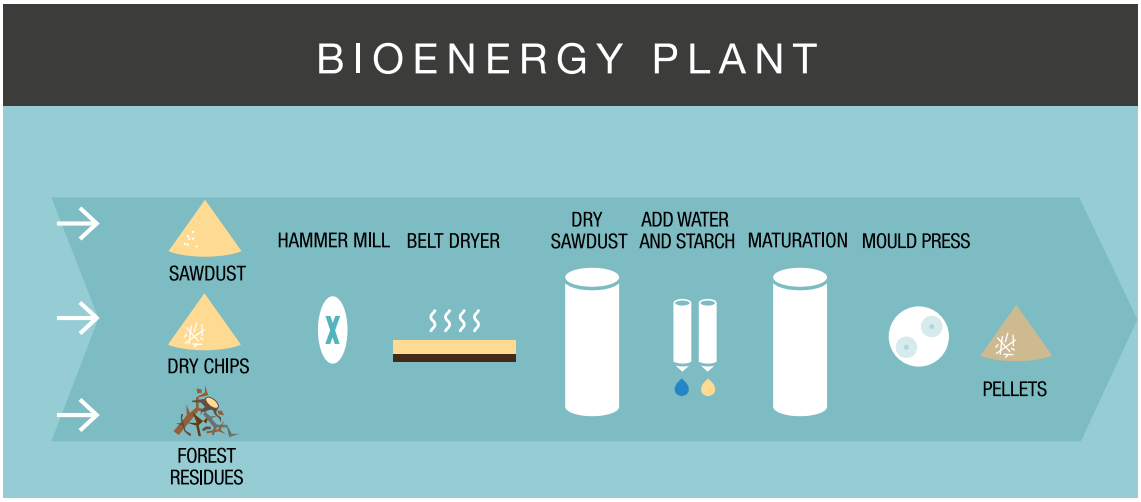
124 000 tonnes
BARK

44 000 tonnes
DRY WOOD

– OUR REGION CURRENTLY HOSTS 14 SAWMILLS.



Bioenergy plant



Bioenergy plants of the region mainly use sawmill side streams to produce wood pellets to be used for energy and heating, for both industries and private homes. The plants produce 150.000 tonnes of pellets annually and the pellets are mostly used within the region, since the business is logistically cost sensitive. Nearby pulp and paper mills use the pellets to heat lime kilns. Other examples of the many great synergies in the region are that the bioenergy plants use excess heat from nearby steel plants, sawmills or other nearby industries to dry the raw material for the pellets.

BIOENERGY IS ONE of the leading energy sources in Sweden today since the Swedish energy system has gone through a major transformation. Today, oil is almost entirely a transport resource, whereas bioenergy plays a major role in industry process steam, electricity production and district heating. Biomass is the main energy source in our region's energy intensive forest-based industries, an excellent way to lead by example and show the way for other energy intensive industries.

SWEDEN'S LONG-STANDING TRADITION of using the natural resources in the forests, whilst simultaneously taking the other values of the forest into account, is to be considered a strong reason to why bioenergy has become such a success. Another reason, enabling growth and success, is the broad political support and use of strong incentives like carbon dioxide tax deduction for biofuel.

– OUR REGION CURRENTLY HOSTS 5 BIOENERGY PLANTS.

THE LARGEST SOURCE of bioenergy in Sweden is the forest. Bioenergy is primarily used for heating – both in private homes and in district heating – as well as for electricity production and for industrial processes. Biofuels represent 56% of the final energy use in the industry sector.

EU LEADER: With 54% (2016) of the energy used in Sweden coming from renewable sources, the country tops the European Union.

SOURCE: Swedish Energy Agency

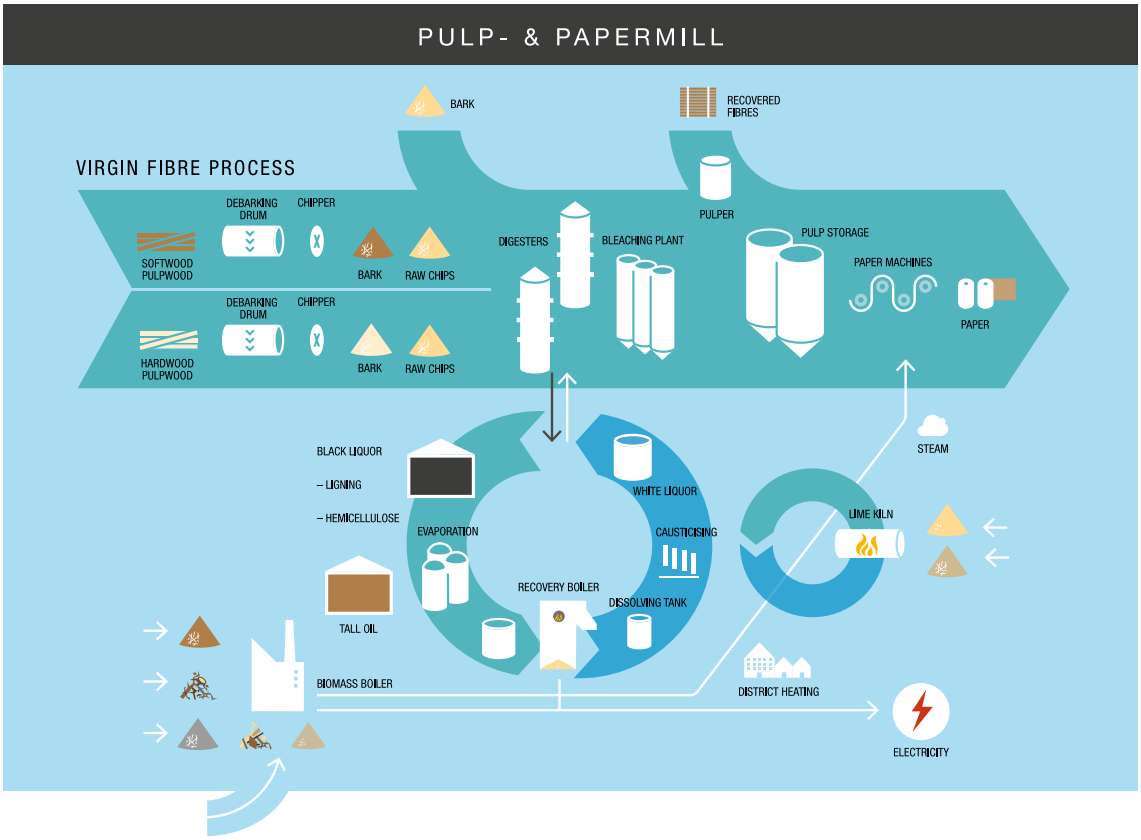
Pulp & papermills

1 415 000 tonnes
PULP & PAPER

399 000 tonnes
HEMICELLULOSE

381 000 tonnes
LIGNIN

220 000 tonnes
BARK



40 700 tonnes
TALL OIL

8 500 tonnes
METHANOL

4 300 tonnes
TURPENTINE

4 100 tonnes
FIBER SLUDGE

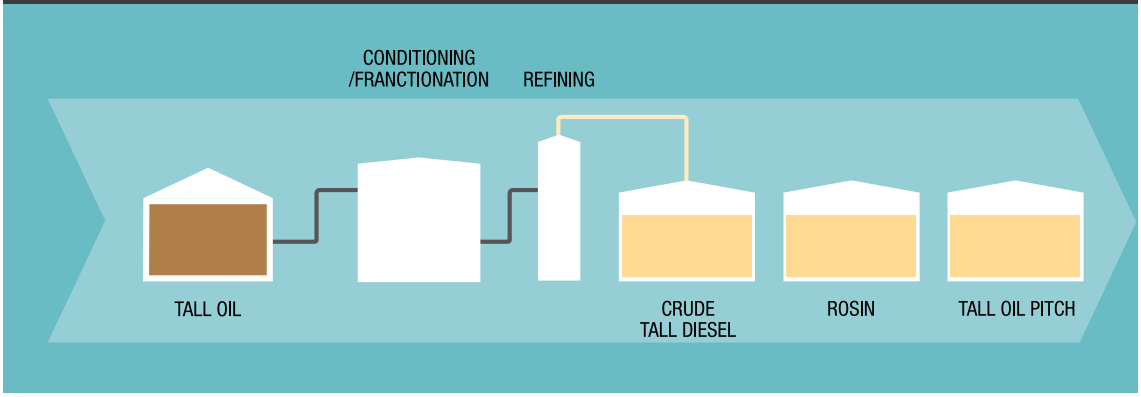
The pulp and paper mills use pulp wood from the forest, raw chips from the sawmills and recovered paper fibers from all of Europe as raw material in the production of pulp. Approximately half the wood used in the pulp process ends up as pulp and paper and the other half ends up being different side streams. The biggest side stream is black liquor and it is used as fuel in the recovery boiler, which is the heart of the mill. Other side streams, like bark, is used as fuel in the combined heat and power plant. The tall oil side stream is sold externally to biorefineries.

AS A RESULT of smart use of all industrial side streams the pulp and paper mills in the region are fossil free when it comes to energy needs. To top it all off, the mills are connected to a district heating system that provides excess heat to 3.700 houses and 22.000 citizens.

– OUR REGION CURRENTLY HOSTS 3 PULP AND PAPER MILLS.

Existing biorefinery plant

EXISTING BIO REFINERY PLANT



The existing biorefinery plant in our value chain produces raw tall diesel, rosin, tall oil pitch and turpentine. The raw tall diesel is further processed into HVO diesel at a refinery in Gothenburg. A significant amount of the tall oil produced as a side stream in the regions pulp- and papermills is used in the biorefinery plant, an excellent way to increase income and make great use of the resources. Today additional tall oil is sourced from other parts of Sweden and around the world to fill the capacity. Side streams of the existing biorefinery plant consists of rosin, turpentine and tall oil pitch. Rosin is later used in printer ink, sealing boats, paint, development of plastics etc. Crude sulphate turpentine is used in the making of perfume. Tall oil pitch primarily consists of high-boiling esters of fatty acids and rosin. It may also contain neutral materials, free fatty acids and rosin acids.

EVERY BIOREFINERY IS unique when it comes to resources, processes, technology and result, but what they all have in common is that it is all about making it commercially viable and at the same time minimizing the carbon footprint. The current biorefinery plant in the cluster uses industrial waste from pulp- and paper mills to produce renewable diesel, reducing emissions up to 90%, using the worlds greenest technology.

100 000 tonnes
CRUDE TALL DIESEL

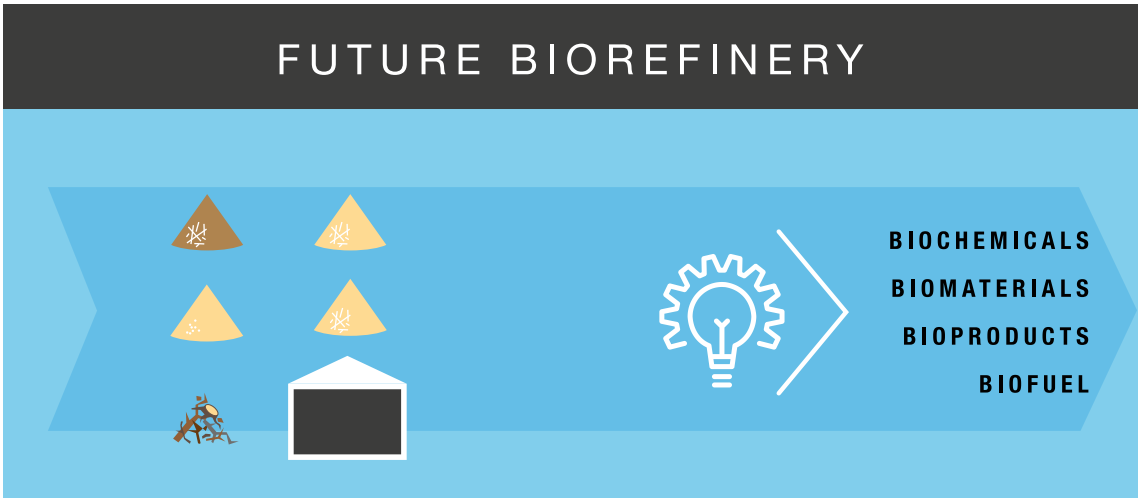
50 000 tonnes
METHANOL

25 000 tonnes
ROSIN

2 500 tonnes
TURPENTINE

– OUR REGION CURRENTLY HOSTS ONE BIOREFINERY PLANT.

Future biorefinery



The conditions to establish new biorefineries within the region is perfect. The many possibilities and opportunities to optimize the existing value chain to create added value to side streams and forest residue are right before us. Some technologies are even ready to scale up for commercialization, although, it all depends on a few conditions.

THE FIRST ONE is the amount of suitable biomass that can be liberated from the regional value chain for other use. That is, how much of the gross volumes of biomass, from industrial side streams and/or forest residue, that can be converted to net volumes for other use.

IT IS A matter of energy balance in the value chain and the forestry and forest industry within it can enable greater net volumes, which will lead to new opportunities and commercialization. As a part of a working and profitable value chain and in strong symbiosis with each other, it can be quite difficult to recognize where to start and what type of biomass to liberate, or what energy efficiency that can be improved to liberate more biomass for other purposes.

NETWORKING AND OPEN R&D will help answering questions like these and that is our main goal with Bothnia Bioindustries Cluster.

SECONDLY, THE CONDITION of our forests is an important factor when it comes to any bioindustrial development. Being able to ensure the growth of the forest is central in every matter. It decides whether it is possible to increase forest residue outlet, if peat or other types of biomass can be used as fuel and if the harvesting can be increased. The circular flow must be improved. By increasing the amount of “recycled wood chips” as fuel, the virgin biomass can be liberated to biorefineries, is the ideal way to do so.

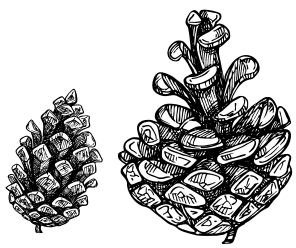
ACTIVE FOREST MANAGEMENT, greater collection of forest residues, focused use of fertilizer, and increased use of wood in buildings can be worth-while strategies for boosting carbon uptake and energy output from any boreal forest. The potential is substantial as boreal forests represent a very large carbon sink and energy source, and their role could be significantly enhanced.

Future

The regional value chain is extremely interconnected with a strong symbiosis between the stakeholders. All parts of the available industrial biomass side streams are already today utilized for different purposes. However, there is still potential for further optimization when it comes to utilizing the net biomass volumes, in particular when new technologies become available.

IN MOST CASES, industrial side streams and forest residues need to be utilized within the regional market, due to logistics costs. From a regional circular economic perspective, it is to be considered as positive, since it drives the usage of recycled biomass in our regional value chain for new materials and products.

IN ADDITION, THE regions rich industrial history, experience and expertise will provide any new bio-based investment or establishment with a valuable foundation and network. A proper system integration of a new biorefinery plant into the existing structure, will lower both the capital expenses and operating expenses, enabling a solid foundation and great possibilities.



DEVELOPING THE EXISTING industry structure and value chain, by collectively aiming for a better tomorrow and making sure that every side stream and biomass in our region is made in to profitable materials and products, we strengthen our position as innovative leaders of the bioindustry. Strong synergies and fulfilling collaborations will prepare every part of Bothnia Bioindustries Cluster for the future and make sure we meet the expectations and demands from tomorrows consumers, society and corporations.

BOTTLES made from wood may be an alternative to glass and plastic in the future. Researchers are working to develop and test this idea, soon making it reality.

CLOTHES made from forest based cellulose has been around for some time now. New manufacturing methods mean that you'll find clothes produced from the forest in a growing number of shops. Recyclable and soft as moss.

NATURAL CHEMICALS are made by breaking down wood into small molecules and it is possible to create new materials from it. The pharmaceutical industry as well as the green fuel industry use chemicals from the forest.

NATURAL COSMETICS is experiencing a massive upswing. Many creams and cosmetics contain moisturizing substances that come from the forest.

TOUGH TREES? Yes, wood in the form of nanofibers is as strong as Kevlar – five times stronger than steel and can be used in car bodies, bicycle helmets, yacht sails and even bulletproof vests.

GREEN AND RENEWABLE BATTERIES is the future. Swedish researchers are currently looking at how the forest can meet the challenge and they especially study how Lignin store electricity.

Lignin makes up about a quarter of a tree – so, we've got plenty!

SOURCE: Swedish Energy Agency

Annual production of the value chain

Produced material and resources during a year. Some of these figures are pure side streams, others are main productions.

1 750 000 m3
WOOD PRODUCTS

1 415 000 tonnes
PULP & PAPER

399 000 tonnes
HEMICELLULOSE

381 000 tonnes
LIGNIN

344 000 tonnes
BARK

285 000 tonnes
SAWDUST

150 000 tonnes
PELLETS

100 000 tonnes
TALL DIESEL

50 000 tonnes
TALL OIL PITCH

44 000 tonnes
DRY WOOD

40 700 tonnes
TALL OIL

25 000 tonnes
ROSIN

8 500 tonnes
METHANOL

6 800 tonnes
TURPENTINE

4 100 tonnes
FIBER SLUDGE

FOR SUSTAINABLE DEVELOPMENT

In 2015, world leaders agreed to 17 goals for a better world by 2030. These goals have the power to end poverty, fight inequality and stop climate change. Guided by the goals, it is now up to all of us, governments, businesses, civil society and the general public to work together to build a better future for everyone.

Ensure access to affordable, reliable, sustainable and modern energy for zall.

Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.

Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

Make cities and human settlements inclusive, safe, resilient and sustainable.

Ensure sustainable consumption and production patterns.

Take urgent action to combat climate change and its impacts.

Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

THE MEMBERS IN BOBIC ARE:

SVEASKOG

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SunCarbon

sunpine

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LULEÅ TEKNISKA UNIVERSITET

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