Circular utilisation options for three side streams in Alholmen Industrial Park

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Contents

1. Background and objectives of the study

Project aimed to identify concrete circular economy solutions and partners for specific side streams in the Alholmen Industrial Park

Background

- The Pietarsaari region development company **Concordia** (lead partner) and **Alholmen Industrial Park rf** are currently working on a project funded by the European Union from the Just Transition Fund (JTF).
- **The Alholmen Circular Economy Platform (ACEP)** project is aiming to boost Alholmen Industrial Park into a leading industrial circular economy ecosystem.
- In the project, AIP Industrial Park ecosystem's companies aim to **improve utilisation of their selected side streams**.
- Concordia needed support in conducting a study and analysis of **3 chosen side streams** from the Alholmen Industrial Park, and in identifying the most significant opportunities for further exploitation of the chosen side streams.

Objectives of the study

Point out the most significant bottlenecks and reuse or recycling opportunities for three chosen side streams.

Identify potential partners for various utilisation concepts in Pietarsaari area and beyond as well as present the value chains of the most potential utilisation pathways in a visual format.

Provide brief techno-economic-environmental expert analysis of the most promising utilisation pathways and recommendations of next steps in leveraging the side streams' circular potential

Project focused on three side streams

UPM BILLERUD

UPM is a Finnish forest industry company that operates in Europe, Oceania, Asia, Americas as well as Africa. In Pietarsaari UPM operates a pulp factory, Alholm sawmill as well as UPM Metsä service office.

Swedish **Billerud** operates in Europe, Asia, North America, Middle-East and manufactures paper and packaging materials. In Pietarsaari, Billerud has a paper plant.

The material streams selected for this project are branch reject from UPM´s processes as well as fiber sludge from Billerud´s processes.

walki

Head quartered in Finland, **Walki Group**, produces consumer and industry packaging and engineered materials.
In Pietarsaari, Walki has one of it´s production facilities where it produces wrapping materials for the paper industry, barrier lining, covering material for biomass and selected technical products.

The material stream selected for this project is Walki´s edge trim shreds that are a side stream from several processes.

NAUTOR'S SWAN

Since 1966 **Nautor Swan** has manufactured high quality sailing boats in its Pietarsaari plant. It´s yacts are divided into four lines: ClubSwan Yacts, Swan Yacts, Swan Maxi Yacts and Swan Shadow yacts.

The material stream selected for this project is Nautor´s left over veneer that is generated in the manufacturing process.

1.2. Description of the process and main methods used

Project's working method was based on active discussions with experts, side stream owners, AIP environmental team members[1] and potential company partners

1. Analyzing potential of side-streams[2]

- Desktop analysis: Analyzing advantages and disadvantages per side stream
- Internal sparring sessions with Sweco's expert panel members
- On-site visits at AIP
- Workshop to identify local synergies and major opportunities

2. Engaging stakeholders

- Identification and contacting of prospects
- Two workshops with project team and material utilisation partners. AIP environmental team members participated the process.

3. Finalizing value chain analysis

- A high-level value chain analysis
- Designing side stream material cards
- Sparring with Sweco's expert panel

4. Summarizing and presenting results

- Preparation and presentation of final report

[1]Alholmen Industrial Park (AIP) environmental team members and project managers are listed in appendix 3.
[2]The project's main scope was targeted at material circulation options rather than carbon capture. A potential value chain for carbon capture and utilization (CCU) is presented on page 19, but a more detailed examination of CCU would require a separate study.

2. Descriptions of the side streams and their circular utilisation potential

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Fifteen different utilisation concepts were identified, leading to partnership discussions with 9 different opportunities (and a total of 12 prospect companies)

UPM BILLERUD

Branch reject and fiber sludge

- Composting soil amendment (Soil Food, Humuspehtoori Oy)
- Recycled growing medium for plants or fungi (Biolan)
- Peat substitute as bedding for barns

Branch reject

- Composting soil amendment (Kiertokasvu)
- Soil amendment by composting with the sludge from a biogas plant (Jeppo Biogas Ab)
- Pyrolysis to biochar / pyrolysis oil
- Utilisation as a raw material for wood-plastic composite

Fiber sludge

- Use as bedding (Soil Food)
- Hydrothermal carbonization, HTC

walki

Edge trim shreds containing PE plastic

- Separation and utilisation of plastic and/or fiber from the edge trim shreds (Karjalan Paperi, Syklo)
- Utilisation in recycled composite products (fluo)

NAUTOR'S SWAN

Pieces of hardwood veneer

- Utilisation in utility items, gifts and jewellery (Nimmar, Valona, lovi)
- Utilisation in spatial elements (Nimmar, Risain)
- Utilisation as a raw material for wood-plastic composite
- Pyrolysis to biochar / pyrolysis oil

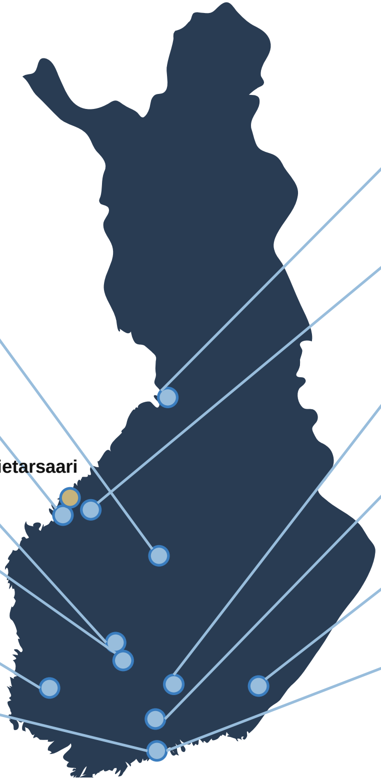
Gray boxes represent utilisation concepts that were ruled out in the process. Each box include the logos of potential partners related to the utilisation concepts that were identified during the process.

Yellow **boxes represent utilisation concepts that were discussed in partnership negotiations but were not considered the most promising**.

Green boxes represent utilisation concepts that were identified as the most promising, and from which deeper analysis was carried out for slides 10-18.

2.1 Different material utilisation concepts identified during the work

Prospect partners were sought from the Pietarsaari region as well as more broadly across Finland



Kiertokasvu, Saarijärvi
Kiertokasvu, part of the Ruthon Group, offers services for enhancing nutrient cycling and produces raw materials and recycled fertilizers from various types of waste.

Jepuan Biokaasulaitos, Jepua
The company focuses on nutrient recycling and renewable energy, producing energy from by-products of agriculture and the food industry.

Soilfood, Tampere
The company produces recycling fertilizers and soil improvement products from by-products.

Humuspehtoori, Pälkäne
Hummuspehtoori produces soil improvement products and fertilizers, as well as solutions for industry to recycle by-products.

Biolan, Eura
Biolan produces products for gardening, houseplants, and ecological living, such as renewable growing medium.

Valona, Helsinki
Valona is a Finnish design company that produces gift items, such as wooden jewelry, birch mobile decorations, and ornaments.

Lovi, Oulu
Lovi manufactures decorations and small items from Finnish birch plywood.

FL Pipe, Kaustinen (via Fluo Group)
FL Pipe is an international company that collects and processes plastic materials, offering plastic cores, pipes as well as compounding and product development.

Risain, Lahti
Risain is a circular economy operator that promotes the reuse of furniture and materials through its services.

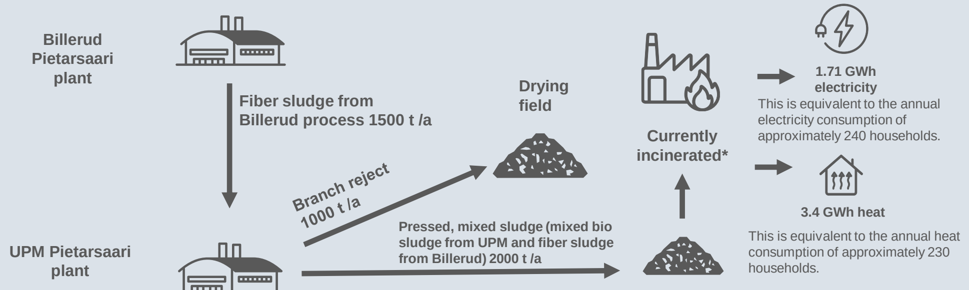
Syklo, Hyvinkää
Syklo offers innovative recycling solutions for its customers, receiving and processing different industry waste streams.

Karjalan paperi, Lappeenranta
Karjalan paperi buys and sells paper and carton materials for different needs. It processes materials from paper and pulp industry.

Niimaar, Helsinki
Niimaar is a Finnish company that produces design items from recycled wood.

Potential utilisation pathways for fiber sludge and branch reject

Current process



*Assumptions: The calorific value of sludge with 20 % dry matter content 10,25 GJ/tonne [1]. The overall efficiency of the power plant is 90% (30% for electricity and 60% for heat). The household's electricity consumption is 7,000 kWh per year. The household's heat consumption is 15,000 kWh per year.

Main qualities

- Fiber sludge is a by-product of production processes both from Billerud and UPM with approximately 70% from Billerud´s process and 30% from UPM process.
- Billerud generates approximately 1500t/a of fiber sludge that goes into UPM´s purification process.
- This material is mixed together with bio sludge and fiber sludge from UPM. The mixed sludge amounts to approximately 2000 t / a (solid mass). The mixed sludge is pressed and incinerated.
- UPM´s process also generates branch reject which is taken out from the process and dried in an intermediate storaging field. After that the mass is incinerated.

Key challenges in implementing circularity

- Currently, mixed sludge is incinerated due to lack of alternative utilisation pathway.
- Potential: Material is potentially suitable for using as soil amendment and animal bedding but further sampling, analysis and testing need to be carried out.
- Partners have experience in working with similar material streams.
- Drying, processing and shipping the material can add costs.

Potential utilisation pathways

1. Composting soil amendment

Bark sand + Fiber sludge /Processed branch reject → Composting → Soil amendment

2. Composting soil amendment

Branch reject → Composting → Soil amendment

3. Replacing tar as a bedding for animals

Dried fiber sludge → Processing → Cellulose based bedding for animals

4. Recyced growing medium for plants or fungi

Processing branch reject and separating inpurities or large parts → Drying the mass → Mixing the material with a suitable mass → Composting the mix

1. In Harto, 2019, p 13., Effective calorific value for fiber sludge at 35-40% dry matter content is 4 – 6 MJ/kg and for dried fiber sludge 12-19 MJ/kg. Available at: Diplomityo_Raty_Harto.pdf;jsessionid=B1309B3CDBFF0A42CFEB90043FF136D5

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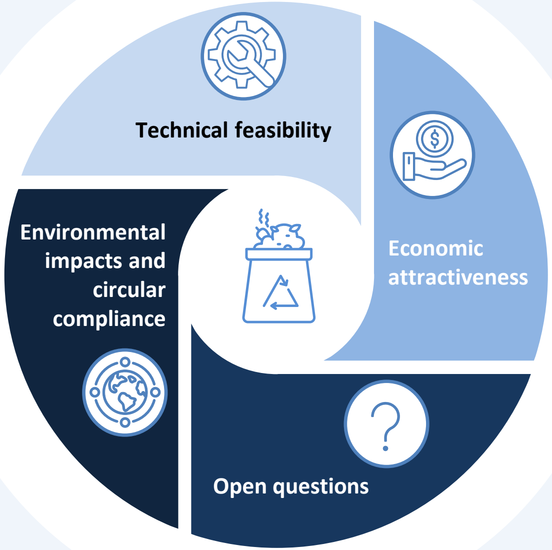
UPM/Billerud: Composting soil amendment

Description of the partnership and utilisation chain:
In this option, the fiber sludge and branch reject could be used as a basis for producing soil amendments by mixing it with bark and compost. Soil amendment can be utilized, for example, in agriculture and green construction, where it can improve soil structure, pH balance, and enable better growth conditions (e.g., water retention capacity). This initiative requires identifying a partner that produces soil amendment from side streams. Potential Finnish partners for this material utilisation pathway could be Soilfood or Humuspehtoori when it comes to fiber sludge and branch reject, and Kiertokasvu, when it comes to the branch reject.



- **Processing needs and technologies.** All potential partners have already existing processes for utilizing side streams to produce soil amendments.
- **Interests.** Soilfood is interested in both material streams, Kiertokasvu is particularly interested in the branch reject and Humuspehtoori is particularly interested in the mixed sludge. Partner conversation with Soilfood, Humuspehtoori and Kiertokasvu concluded that to proceed, first samples need to be taken from the material streams for an overview of the material properties.
- **Bark sand** has already been recognized as a potential material in the mix to produced soil amendment.

- **Potential for a viable business model.** The commercial application requires income back to UPM/Billerud or at leas that partners covers the logistics costs. Gate fee is not an option. The next step is that potential partners test the feasibility of the material for their processes.
- **Processing and shipping costs.** Associated costs depend i.e. on need for processing or drying the materials, shipping costs and location of processing location.

- **Upcycling potential.** From a circular economy perspective, this utilisation pathway would be beneficial, as it would create value from the material streams for the use of agriculture and green construction.
- **Substitution impact.** The potential benefits would be generated by substituting virgin or fossil-based raw materials of the fertilizer industry.
- **Other environmental impacts.** Improved soil structure and water retention.

- How suitable are the material streams for partner's processes?
- How to clarify the cost and revenue structures of utilisation pathways?

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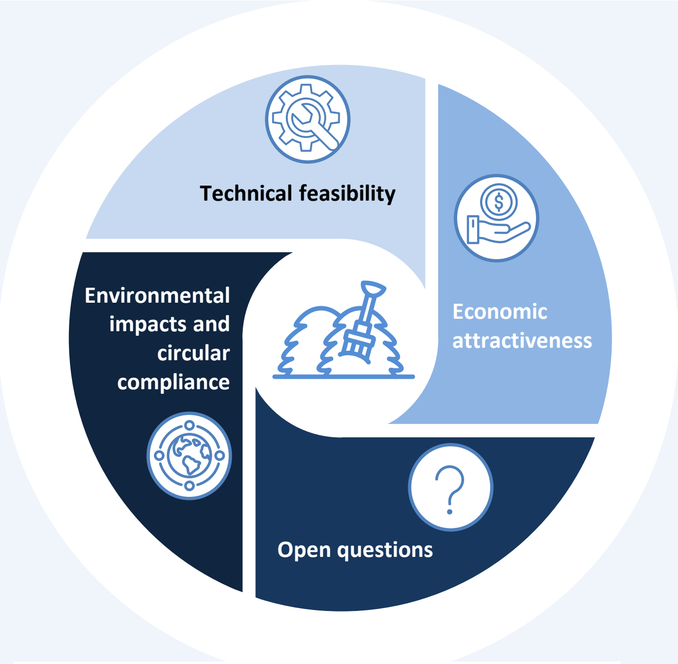
UPM/Billerud: Use as bedding

Description of the partnership and utilisation chain:
Peat is commonly used as bedding for animals. In this option, the fiber sludge from Billerud/UPM could be potentially used to produce cellulose-based bedding, utilized in animal farms.
A potential Finnish partner for this utilisation pathway could be Soilfood, that produces Wälly –bedding.

- **Proof of concept.** Soilfood has experience in processing bedding from side streams from the forest industry. They have recently started the production of dust-free Wälly bedding from wood fibers, that is suitable for animal farms.
- **Analysing material properties.** Partner discussion concluded that samples need to be taken and analysed to understand the material properties before proceeding.



- **Potential for sales volume.** There is potential demand for alternative bedding materials. Animal bedding is widely used in farming and requires frequent replacement. Wälly bedding is knows to be used in farms for different animals. Consequently, this utilisation pathway could offer a relatively high-volume demand for fiber sludge.

- **Upcycling potential.** There is relatively low upcycling potential in this utilisation pathway from circular economy perspective. However, processing the material stream into animal bedding provides a new use for the waste material that is now being incinerated.
- **Substitution potential and environmental impact.** Positive environmental impact from this utilisation pathway is created by substituting peat as bedding, which is known to cause negative environmental impacts. [1,2]

- How suitabile is this material stream for bedding production?
- What are the costs and potential revenues, and how should they be calculated?
- What are the required volumes?
- What are the alternative uses for the bio sludge, considering it is currently mixed with the fiber sludge before pressing and incineration?

1) Turvetuotanto
2) turpeen-rooli-ja-sen-kaytosta-luopumisen-vaikutukset-suomessa-tekninen-raportti.pdf

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Potential utilisation pathways for edge trim shreds with high PE content

Current process

Pietarsaari factory

Edge trim shreds 650 t/a

Currently incinerated*

1,35 GWh electricity
This is equivalent to the annual electricity consumption of approximately 190 households.

3,88 GWh heat
This is equivalent to the annual heat consumption of approximately 260 households.

*Assumptions: The calorific value of paper is 16.7 GJ/tonne[1]. The calorific value of plastic is 33 GJ/tonne. The overall efficiency of the power plant is 90% (30% for electricity and 60% for heat). The household's electricity consumption is 7,000 kWh per year. The household's heat consumption is 15,000 kWh per year.

Main qualities

- Edge trim shreds are a by-product of various production processes in Walki factory, amounting to approximately 650 t / a.
- The material contains a significantly high plastic content, approximately 50%.
- The edge trim shreds are primarily composed of PE and paper, but may also contain lacquer, aluminium, wet strength paper or whatever else is processed at the factory.

Key challenges in implementing circularity

- Due to its high plastic content, the material is currently incinerated, as it is difficult to utilise in the paper industry. Current incineration practices do not align with Walki Group's "Zero Waste by 2030" target.
- The material has been found technically suitable for recycling composite products. However, a business case or end user for these type of products has not yet been identified.
- Walki’s investment to new equipment like a baler would be potentially necessary for preparation for recycling.

1. Liljeström & Monni, 2020. JäPa-hankkeen loppuraportti. Available at: https://kivo.fi/wp-content/uploads/JaPa_hanke_loppuraportti_21102020_BenvirocOy.pdf

Potential utilisation pathways

1. Utilisation of plastic and fiber through pulping

Syklo

- Pulping to separate fiber and plastic
  - → Utilisation of fiber in biocomposites
  - → PE plastic to Syklo recycling facility → Granulation into recycled plastic

2. Utilisation of fiber through pulping

KP Karjalan Paperi

- Partner with capacity to pulping the material
  - → Utilisation of fiber in paper industry
  - → Incinerating plastic

3. Utilisation in recycled composite products

fluo

- Particle size reduction → Utilisation in pipe middle layer or other applications
- Other possible blend materials → Utilisation in pipe middle layer or other applications

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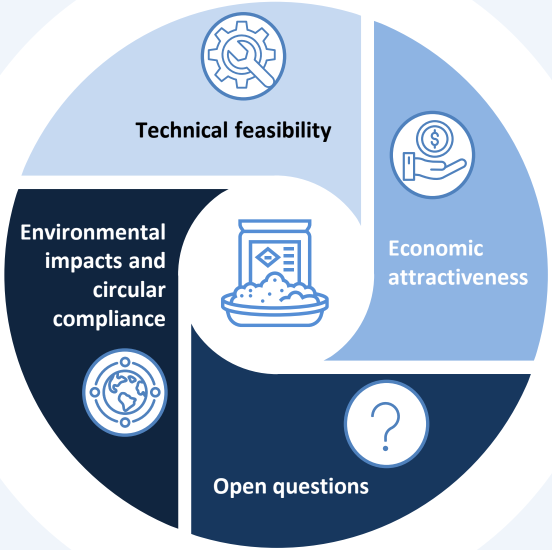
Walki: Separation and utilisation of plastic and/or fiber from the edge trim shreds

Description of the partnership and utilisation chain:
This utilisation pathway requires the separation of paper and plastic from each other. Pulping is a process where paper material is treated with mechanical force and liquid, enabling the fibers to be separated from other materials.

Among potential partners, Syklo could pulp the material itself and utilise the fiber in its biocomposite production in Hyvinkää. Additionally, the plastic could be recycled through a plastic recycling facility planned for the same site. Karjalan Paperi, on the other hand, would seek a processing partner from the paper industry. In this option, it is likely that only the fiber would be recycled, while the plastic would end up being incinerated.

- **Pulper type and material quality.** The separation of fibers and plastic during pulping requires specialized technology. High PE content can hinder fiber liberation and slow down the separation process, with no guaranteed success. High PE content can result in shorter or damaged fibers, which reduce the quality of the recovered pulp.
- **Energy requirements.** High PE content paper typically requires more energy-intensive pulping due to the toughness of the material. Optimizing energy consumption is crucial.
- **Contamination.** The presence of additional contaminants may complicate the process. High PE content can result in shorter or damaged fibers, which reduces the quality of the recovered pulp.



- **Case Syklo.** Biocomposites are valuable products, so if the fiber is technically suitable for the Syklo process, there is significant potential for creating a viable business case.
- **Case Karjalan paperi.** The business potential is not as high, and the agreement would likely resemble a waste management contract, where no money flows towards Walki, but Walki either disposes of the material at no cost or pays for waste management. In this case, proximity to the partner would be beneficial for minimizing logistics costs.
- If similar utilisation pathways are applied to different Walki plants, the economic scale could be quite significant.

- **Substitution impact.** Whether separated plastic can be recycled is critical for achieving the intended environmental benefits. The use of recycled plastic as a substitute for virgin materials has traditionally provided significant environmental benefits. Also fiber recycling fiber can replace the use of virgin materials.
- **Upcycling potential.** From a circular economy perspective, the utilisation of biocomposites would clearly offer upcycling potential. Recycling them as raw material for the paper industry would be traditional recycling, With lower energy consumption compared to the production of virgin paper.
- **Product longevity.** Biocomposites are used in industries such as automotive, construction, and consumer products. Their lifecycle and potential for reuse at the end of their lifespan depend on the specific application.

- Is it possible to pulp edge trim shreds with a high PE content? Do additives such as lacquers and aluminium interfere with the recycling process?
- What would be the quality and end-use of the recycled plastic in the Syklo case?
- Could the plastic be recycled back into Walki's own processes, or would the end-user be elsewhere?

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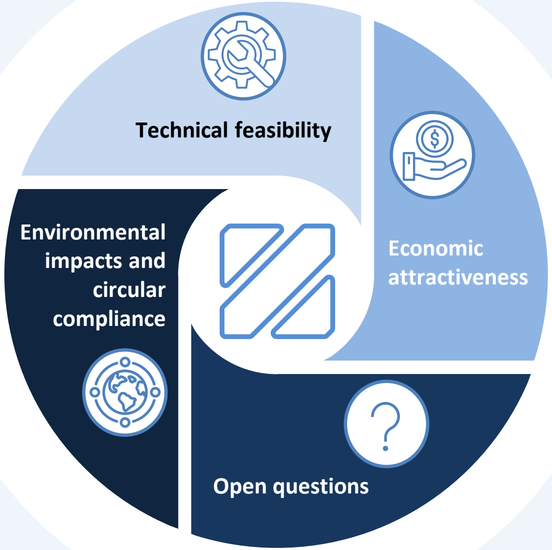
Walki: Utilisation of edge trim shreds in recycled composite products

Description of the partnership and utilisation chain:
PE-containing paper waste could offer opportunities as a raw material for various construction industry applications as recycled composite products. In this utilisation pathway, edge trim shreds would be processed as such into recycled composite products containing both plastic and fiber. Walki has prior experience in testing the material’s technical properties with a partner. The tests yielded promising results and showed that the material’s properties can be tailored by combining PE-containing paper with other materials. However the case did not progress due to the absence of a suitable utilisation partner. In this project, Fluo has expressed interest in utilising the material and has supplied it for testing with its partner, FL Pipe, for application in the intermediate layers of pipes.

- **Previous promising results.** Previous tests have shown promising results regarding the technical properties of the material. In composite products, plastic can act as a “glue” that binds different components together.

  A fluffier and softer product can be created by mixing the shredded material with bicomponent fiber prior to the process, where the oven's heat causes the fibers to bond. Alternatively, the material can be pressed using different settings to produce a denser board.



- **Finding viable business case.** Finding a business case is the most critical factor. Previous testing did not progress because an end user could not be found. For the product's end user, utilizing the material may require launching an entirely new product, which could pose a potential bottleneck.
- **Boosting regional economy.** The potential end user, FL Pipe, would be a local operator in Kaustinen, which would create positive regional economic impacts.
- **Future-proofing the concept.** Walki is developing a range of dispersion-coated solutions, which provide the necessary barrier properties while allowing the packaging to remain recyclable as fiber*. These solutions could significantly impact Walki's side streams. Large investments in the utilization of current edge trim shreds utilisation could make it difficult to make changes in the future. Waste management agreements should be written in a way that allows Walki to separate side streams if desired.

- **Substitution impact.** Replacing the middle layer of the pipe's virgin plastic material with recycled material.
- **Upcycling potential**. This utilisation pathway would be a relatively low-value recycling solution.
- **Product longevity.** The pipes are assumed to have a relatively long lifespan, but they are likely to be incinerated at the end of their life cycle.

- Could a viable business case emerge around this utilisation pathway to cover logistics and other costs?
- How quickly will dispersed plastics change the market?

*Read more: https://www.walki.com/casestories/dispersiontechnologyforeasyrecycling.html

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Potential utilisation pathways for Nautor´s left over veneer pieces

Current process

Pietarsaari building yard

Veneer pieces 13 t/a

Currently incinerated

7.5 MWh electricity
This is equivalent to the annual electricity consumption of approximately 1 household.

15.2 MWh heat
This is equivalent to the annual heat consumption of approximately 1 household.

*Assumptions: The calorific value of wood is 7 GJ/tonne[1]. The overall efficiency of the power plant is 90% (30% for electricity and 60% for heat). The household's electricity consumption is 7,000 kWh per year. The household's heat consumption is 15,000 kWh per year.

Main qualities

- High-end veneer pieces are a side product of boat manufacturing processes by Nautor. The size of the material stream amounts to approximately 13 t / a
- Used wood types of the veneer are oak, teak, walnut and poplar.
- The high-end veneer pieces are generated when edges of the material are trimmed out and branches cut off. The wood veneer is of high quality, yet short in size.
- There are two sizes of the pieces:
  - 5-50mm x 2500 mm
  - 100-200 mm x 100-500 mm
  - The thickness can range from 3mm to 2 cm.

Key challenges in implementing cicularity

- Currently, all material is incinerated, although it´s reuse could support Nautor´s sustainability actions.
- Material has promising properties, of high quality and can be further processed. Yet it is relatively narrow in width.
- Further analysis is needed to identify financially viable and scalable end-use applications.

1. Liljeström & Monni, 2020. JäPa-hankkeen loppuraportti. Available at: https://kivo.fi/wp-content/uploads/JaPa_hanke_loppuraportti_21102020_BenvirocOy.pdf

Potential utilisation pathways

1. utilisation in utility items, gifts and jewellery

VALONA NIMAAR lovi

Left over veneer pieces → Craftwork-/design actors → New utility/design items (to Nautor Boats)

Left over veneer pieces → Designing and crafting gift item(s) → Gift items to Nautor's / external clients

2. utilisation in spatial elements

NIMAAR RISAIN

Left over veneer pieces → Co-creating recycled product concept → Spatial elements produced with Nautor´s veneer used in targeted properties

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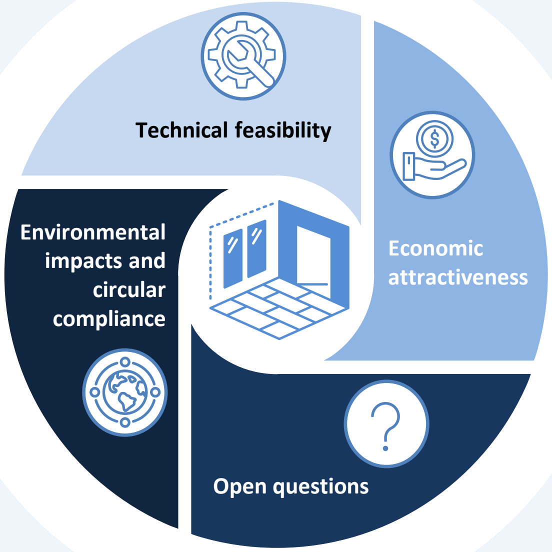
Nautor: Utilisation of veneer as spatial elements

Description of the partnership and utilisation chain:
In this option, veneer could potentially be used to manufacture various spatial elements, such as acoustic panels, cladding, shingle elements, and ceiling suspensions. To materialise, it is necessary to identify potential designers and craftsmen to design reference products. Kirkkonummi library is a reference site where wood has been utilized in various interesting ways.

A potential Finnish partner for this utlisation pathway could be Risain, a consultancy serving as a link to designers, manufacturers and property owners. Niimaar has been identified as a potential design partner.



- **Processing technologies and material suitability**. The partnership conversations concluded that processing could be possible with both lazer cutter and water jet cutter, whereas veneer glueing requires a glue press or a vacuum. Niimaar has a manufacturing facility in Lahti where veneer could be potentially processed. Fineline glueing would require more craftmanship and resources (to process veneer for example into finger panel). Wider veneers would be most suitable for fineline glueing.

- **Potentially high value products.** This utilisation pathway holds financial potential as the material would be used to high-value design products.
- **Cost of mechanical processing.** Significant proportion of manual work and the small scale of production is a risk for a viable business case.
- **Scale of production.** If a stable customer base for the products cannot be established, the risks for Nautor increase, as there is a chance the waste material will not be processed at a sufficient scale. Then, the internal sorting efforts could consume too many resources.
- **Creating the partnership network.** Risain has connections with carpenters and potentially, property owners who would be end users for the spatial elements.

- **Upcycling potential.** From a circular economy perspective, this utilisation pathway would clearly be beneficial, as it would create significant value from waste. This aligns well with the principles of the circular economy.
- **Substitution impact.** The potential benefits would stem from replacing virgin wood materials. Some of the material, cut in very small pieces, would, however end up being incinerated in the future as well.
- **Product longevity.** The spatial elements could potentially be long-lasting products, and their reuse in other spaces could also be a viable option.

- What are the requirements for Nautor's sorting process?
- How would the partnership network be structured? Would there be multiple users of the materials, or could an intermediary handle the delivery of processed materials to various designers?
- Is there a viable business case that benefits all parties involved?
- Is there technology available (glue press, vacuum) for veneer glueing?
- Organising logistics: Could deliveries be sent forward regularly?
- What are the potential applications? In what types of spatial elements could the material be used, and is it possible to create things like acoustic panels?

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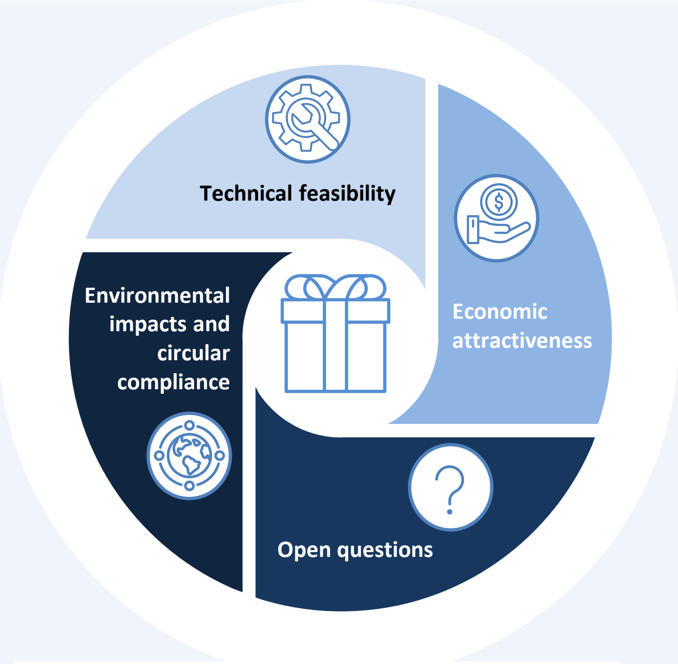
Nautor: utilisation of veneer utility items, gifts and jewellery

Description of the partnership and utilisation chain:
In this option, veneer could potentially be used to manufacture various new handicraft or design products. Preliminary ideas for such products include i.a. gift products (such as products, that can be used in Nautor´s boats), jewelry, utility items or details for furniture.

Potential Finnish partners could be Lovi and Valona. The material could be also interesting for designers, vocational schools, educational institutions and carpenters.



- **New requirements for Nautor.** The use of the veneer in utility items, gifts and jewellery requires material sorting.
- **Processing specs.** The material can be cut by water jet cutter (Lovi and Valona) or by laser (Valona).The thin material can potentially require glueing separate layers together or reinforcing the material with a suitable product, such as lacquer.

- **Potentially high value products.** This utilisation pathway holds financial potential in that the material could potentially be used as high-value gift and design items.
- Potential **brand value** of closed-loop solutions if manufactured items are e.g. utilized in Nautor´s boat.
- **Cost of mechanical processing.** Significant proportion of manual work and the small scale of production increase the production cost and put pressure on high pricing of the product.
- **Scale of production.** If a large enough customer base cannot be established, the risks for Nautor increase that the waste material won't be processed at a sufficient scale, and the sorting effort could consume too many resources.

- **Upcycling potential.** From a circular economy perspective, this utilisation pathway would clearly be beneficial, as it would create significant value from waste. This aligns well with the principles of the circular economy. However, it is unclear at this point, how much of veneer material could be used in such applications (e.g. annually).
- **Substitution impact.** The potential benefits would stem from replacing virgin wood materials.
- **Product longevity.** The products, in particular if long-life design and/ or utility products are chosen, could potentially be long-lasting. Yet, it is recommended to plan for product end-of-life utilisation for these items as well.

- What are the costs of sorting the veneer into different sizes?
- What are the costs related to the manual work required by glueing veneer together?
- What are the costs and processing the veneer enriched with different strengthening materials?
- Can lazer cutter process veneer alone?

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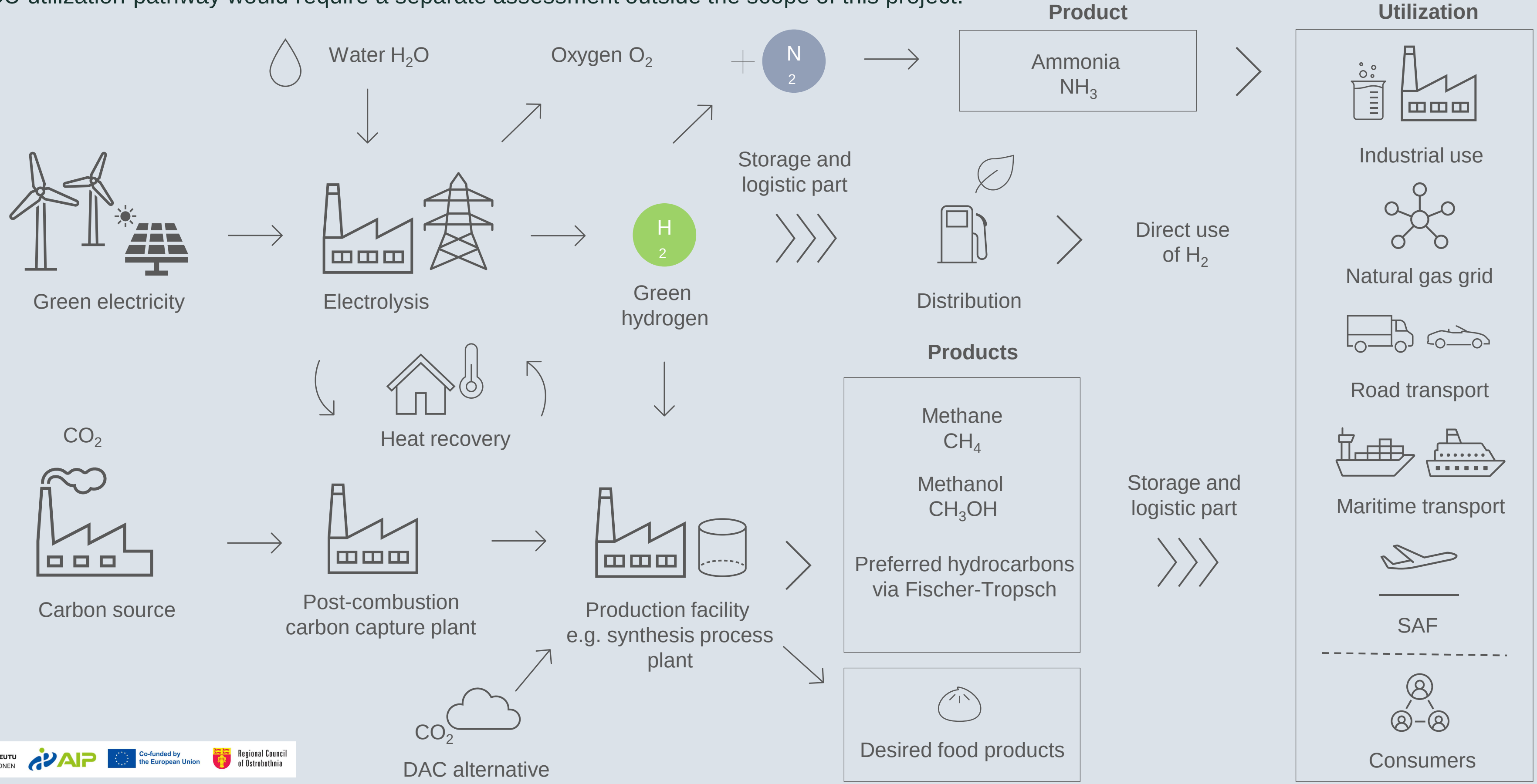
An alternative utilisation pathway for material recycling could be built around carbon capture and utilisation (CCU)

CCU utilization pathway would require a separate assessment outside the scope of this project.



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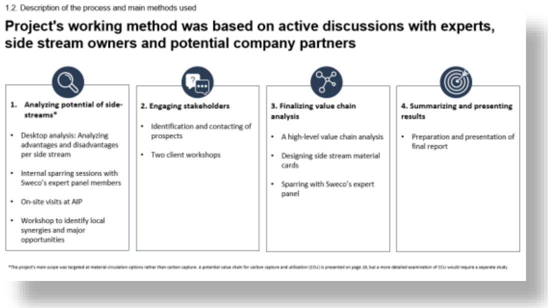
3. Conclusions and recommendations

The project provided valuable insights into circular economy matchmaking and identifying potential utilisation pathways for side streams



Key learnings

- **Success with utilisation concepts.** The project demonstrated that with the right expertise, potential utilisation ideas and partner organisations new opportunities can be identified relatively quickly. Sweco's internal expert panel and partner networks helped to progress relatively straightforwardly with exploring potential material utilisation opportunities. Material owners' active collaboration smoothened the process.

- **Matchmaking with potential partners**. The material streams prompted wide interest with partners and presumably, some of the utilisation pathways can be further advanced in the future. Developing profitable circular economy solutions requires a different approach compared to product development inside a company. Typically, the utilisation pathways call for collaboration between multiple actors. In some cases, a separate intermediary may be needed between the side stream owner and end user organisations.

- **Prioritising opportunities.** At this stage of the process, the technical and economic potential were briefly assessed. To further evaluate the circular value of the identified utilisation concepts, the following dimensions should be considered: substitution impact, upcycling potential, and product longevity & recyclability.

- **Regional vs. wider collaboration**. Although there are many benefits for identifying partnerships from the same region, it is recommended to scan the potential for partnerships with a broader scope. Identifying local partner to advance the utilization pathway can in some cases be key for profitability, especially for those pathways associated with lower value side streams. Local partnerships help keep logistics costs moderate.

Recommendations for next steps

Replicating the concept

- Promising results of this project provide hope that the same type of process could be replicated for other side streams in the region. Potential synergies with this project are possible if the same utilisation partners could be brought into discussions with other owners of similar side streams.

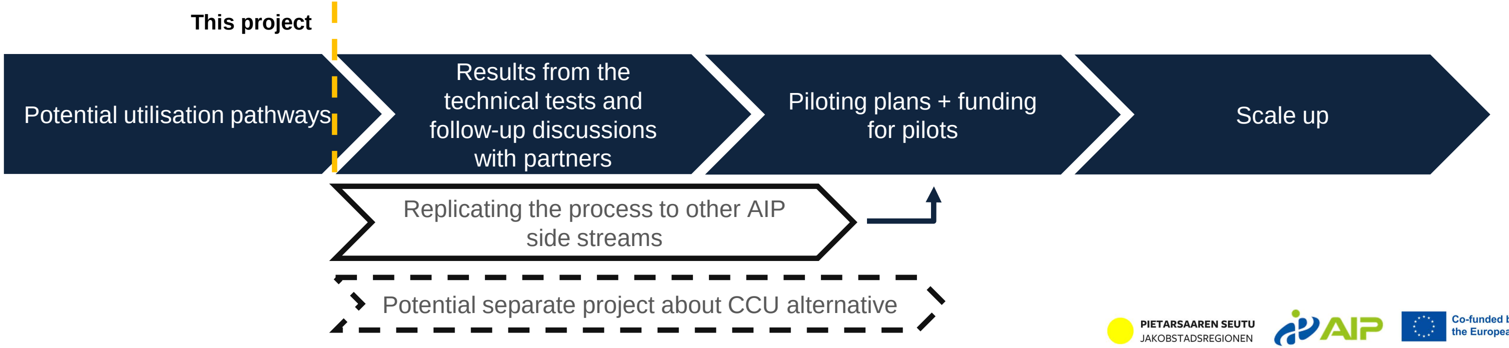
Advancing further collaboration

- This project met its objectives as an early-stage study. However, materializing the benefits of the different utilization pathways requires further collaboration. The consultant's analysis identified open questions for each material stream that need to be solved at the next stages.

Ensuring future funding

- The identified utilization pathways offer potential for applying follow-up funding. In the next phase, the focus could be on piloting the most promising utilisation pathways. Also, replicating the process with, e.g., 4-6 additional side stream owners should be carried out. In addition, it is important to assess whether a separate study should be conducted for the CCU utilisation pathway.

Life cycle assessment: The calculation and comparison of environmental impacts for the identified utilisation pathways and energy recovery were beyond the scope of this project. Gaining a comprehensive understanding of the potential environmental benefits of the utilisation pathways would require conducting a life cycle assessment.



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Appendix

Appendix 1. List of experts interviewed in the study

- Olli-Pekka Hyvärinen, Sweco: Technologies for utilizing biomasses
- Ilkka Nuutinen, Sweco: pyrolysis and CCU
- Janne Hautala, Sweco: Pulp and paper technology and sidestreams
- Pentti Linnamaa, ELY: utilisation of wood-based biomasses
- Saija Malila, Design Forum Finland: Design products for high-end wood waste
- Milja Seppälä, Tarkett: Parquet / veneer recycling

Appendix 2. List of companies contacted in the study

Company	Person	Material utilisation concept
UPM/Billerud		
Soilfood	Sampo Järnfelt, CCO, Chief Commercial Officer	Composting soil amendment
Humuspehtoori	Suvi Mantsinen, CEO	Composting soil amendment
Kiertokasvu	Ari-Pekka Hongisto, CEO	Composting soil amendment
Biolan, (TAI Wifotek)	Janne Pitkänen, Peat Production Director	Animal bedding/ Recyced growing medium for plants or fungi
Jepuan mädätyslaitos	Henri Malmi, CEO	Soil amendment by composting with the sludge from a biogas plant
Walki		
FluoGroup	Petri Aaltonen, CEO	Separation and utilisation of plastic and/or fiber from the edge trim shreds
Hikinoro	Antti Elevuori, CEO	Utilisation in recycled composite products
Syklo	Eero Martikainen, Head of Partnerships	Utilisation in recycled composite products
Walki Valkeakoski factory	Antti Peltola	Co-creation of utilisation concept
Karjalan paperi	Lotta Pirttimäki	Separation and utilisation of plastic and/or fiber from the edge trim shreds
Walki	Timo Lehmuskallio, Group Operational Excellence Director	Utilisation in recycled composite products

Appendix 2. List of companies contacted in the study

Company	Person	Material utilisation concept
Nautor		
Lovi	Mikko Paso, CEO	Utilisation in utility items, gifts and jewellery
Lovia	Outi Korpilaakso, CEO	Utilisation in utility items, gifts and jewellery
Valona	Elina Mäntylä, CEO	Utilisation in utility items, gifts and jewellery
Niimaar	Enni Karikoski, CEO	Utilisation in utility items, gifts and jewellery
Kalevalakoru	Kirsi Paakkari, CEO and lea aarinen koski (commercial director)	Utilisation in utility items, gifts and jewellery
Risain	Sirpa Rivinoja, Founder, Chair of the Board	Utilisation in spatial elements
Puucomp	Jari Pitkäranta, CEO	Utilisation in spatial elements
Centria University of Applied Science or MMI		Utilisation as a raw material for wood-plastic composite

Appendix 3. List of AIP environmental team members and project managers

Pamela Honga, Baltic Yachts, chairman

Tomi Heikkinen, UPM

Kaj Kujala, Nautor Swan

Björn Åkerlund, Alholmens Kraft

Pia Holkkola-Löf, Concordia

Ella Viitiö, Billerud

Arto Ylinalma, UPM Alholma Sawmill

Tony Hanner, Euroports

Jyrki Sironen, OSTP

Markus Niemi, Nordpipe Composite Engineering, NCE

Johanna Heinoja, Pietarsaari Port. Project director AIP

Åsa Björkman, Concordia. Project director

Appendix 4. Short descriptions of rejected material utilisation concepts

UPM/ Billerud:

1. Peat substitute as bedding for barns
2. Soil amendment by composting with the sludge from a biogas plant
3. Pyrolysis to biochar / pyrolysis oil
4. Utilisation of the branch reject as a raw material for wood-plastic composite
5. Hydrothermal carbonization (HTC) of the fiber sludge

Nautor:

1. Utilization of wood veneer as a raw material for wood-plastic composite
2. Pyrolysis of the veneer into biochar / pyrolysis oil

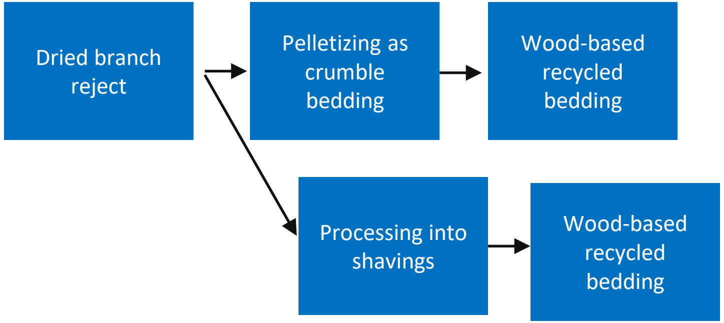
UPM / Billerud: Peat substitute as bedding for barns

Background

Peat is a commonly used material for bedding. Clean branch reject could potentially be used to produce wood-based bedding that is utilized in barns.

In the separation process, large branch parts are removed. The branch residue is processed either into shavings or pelletized as crumble bedding. Compared to shavings, crumble bedding improves the properties of the bedding, such as absorbency and dustiness. The recycled bedding material is packaged.

For this utilization concept, a saw or a partner who can process the fraction into pelletized crumble bedding is needed.



UPM: Soil amendment by composting with the sludge from a biogas plant

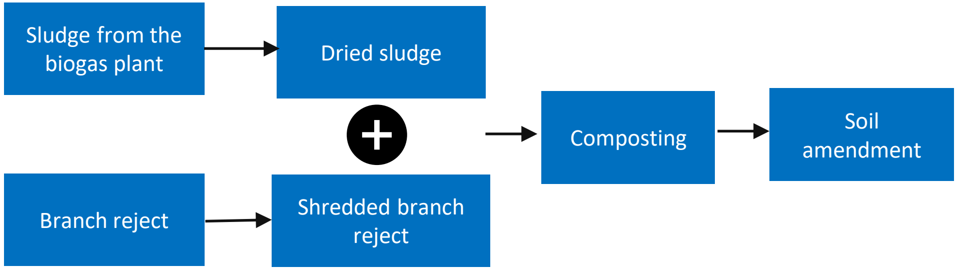
Background

UPM´s branch reject and the sludge produced as a by-product at a biogas plant are both nutrient-rich biomass.

Clean branch reject is mixed with dried sludge from the biogas plant. This improves the structure and nutrient content of the material. The mixture is composted.

Soil amendment can be utilized, for example, in agriculture as nutrients and in green construction, where it can improve soil structure, pH balance, and improve growth conditions.

his initiative requires identifying a biogas plant and a partner that produces compost/soil amendment. Potential partners for this utilization concept could be i.a. Humuspehtoori or Soilfood.



UPM: Pyrolysis to biochar / pyrolysis oil

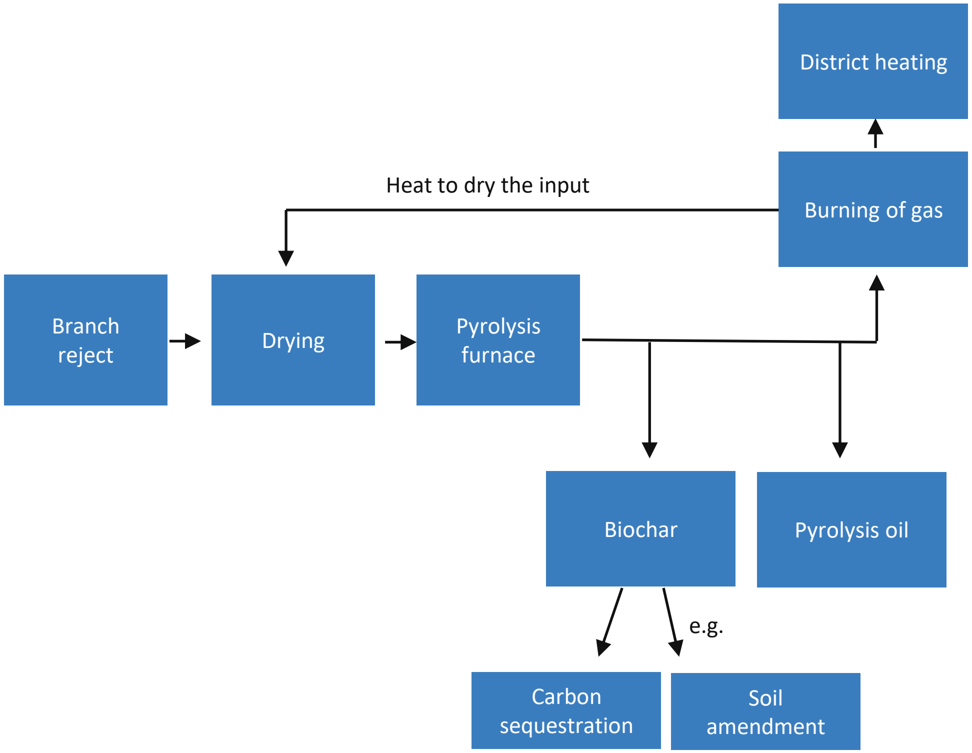
Background

In the interviews, the question arose about the possibility of processing branch reject through drying in the pyrolysis process to produce biochar / pyrolysis oil. At this stage, it remains an open question whether the mass would be suitable for pyrolysis and of even in quality.

In pyrolysis, branch residue is heated to high temperatures (300–700 °C) in a low-oxygen environment, causing organic material to break down without complete combustion. At this stage, gases and volatile compounds are released, leaving mainly solid carbon-rich material, biochar, and pyrolysis oil. Depending on the process, the pyrolysis plant can be optimized for the production of pyrolysis oil or biochar. The higher the temperature at which biomass is heated during pyrolysis, the more compounds break down and evaporate as gas. Consequently, the yield of pyrolysis gas increases while the yield of biochar decreases.

Biochar can be utilized, for example, in green construction, where it enables better growing conditions (e.g., water retention capacity). This activity generates carbon credits, which can be used in a secondary market.

This utilization concept requires a pyrolysis plant in a commercially viable distance from UPM´s plant. A rough estimate from commercially viable transport distance for uncondenced woodbiomass is in maximum100 km. The technical suitability of the material for pyrolysis is an open question at this stage.



UPM: Utilisation of the branch reject as a raw material for wood-plastic composite

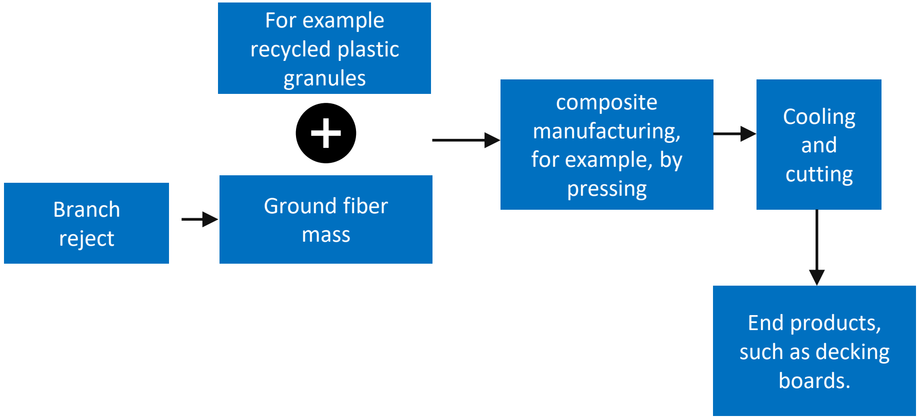
Background

The wood-plastic composite could potentially be suitable as a material for composite manufacturing. In the production of composites, biomass is crushed/shredded and mixed with a recycled plastic material that acts as a binder. Dyes can be added to the mass.

Composites are produced using various methods, such as casting, injection molding, or compression methods. In composites made by compression, the bond of the mass is improved through heating and pressing. After this, the composite is cooled and cut.

Wood-plastic composites can be made from recycled raw materials and can be recycled into new wood-plastic composite products. Wood-plastic composites have various applications, such as decking boards or furniture.

The utilization concept requires identifying a partner that manufactures composites. In Finland, companies like UPM and Raflatac produce wood-plastic composites. Generally, the production of composites requires a fairly homogenous flow of wood fiber.



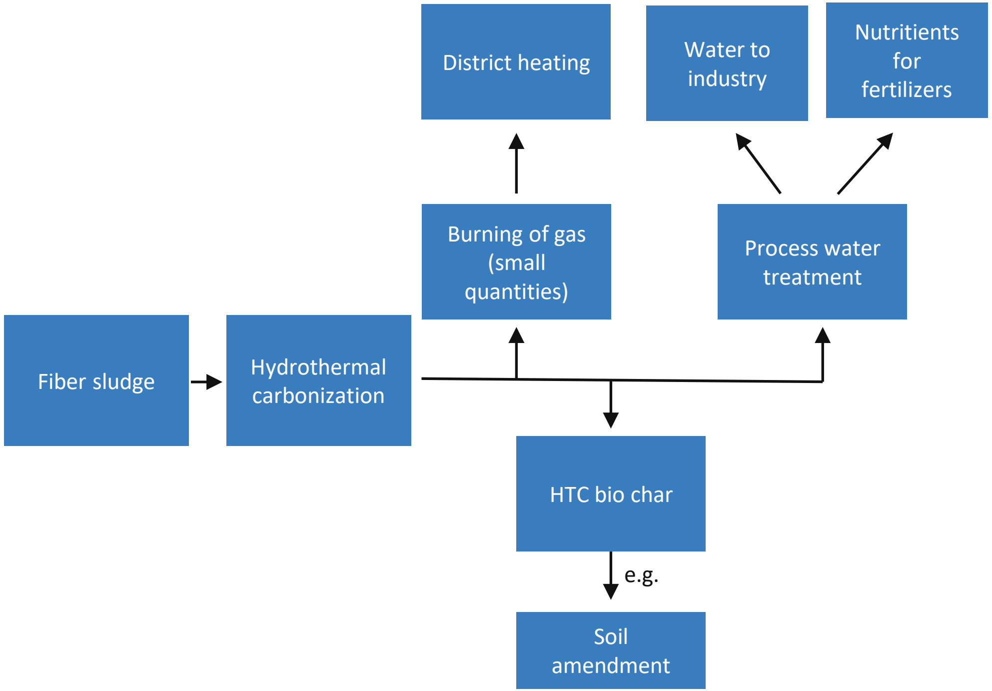
Billerud: Hydrothermal carbonization (HTC) of the fiber sludge

Background

Hydrothermal carbonization process (HTC) offers a solution for the treatment of wet biomass. The feedstock used in the process typically has a dry matter content of about 15%, but its concentration can be adjusted as necessary. The reaction typically occurs at a temperature of 180–250 °C and lasts for several hours. The resulting HTC bio char is separated by filtration, resulting in a dry matter content of about 60%. The charcoal can be further dried to a lower moisture content.

HTC charcoal is suitable for many of the same applications as biochar, but they are not identical products. For example, HTC bio char made from sewage sludge or digestate is rich in nutrients such as phosphorus and nitrogen, which may make it suitable for use as fertilizer. However, HTC bio char does not remain in the soil, so it is not suitable for carbon sequestration[1].

The water fraction from the filtration of the wet carbonization process contains many organic substances that require further treatment. The commercial viability of the wet carbonization process remains an open question. The technology appears to be at an earlier stage compared to traditional pyrolysis.



[1] https://www.bioenergia.fi/tietopankki/hiilensidonta/

Nautor: Utilization of wood veneer as a raw material for wood-plastic composite

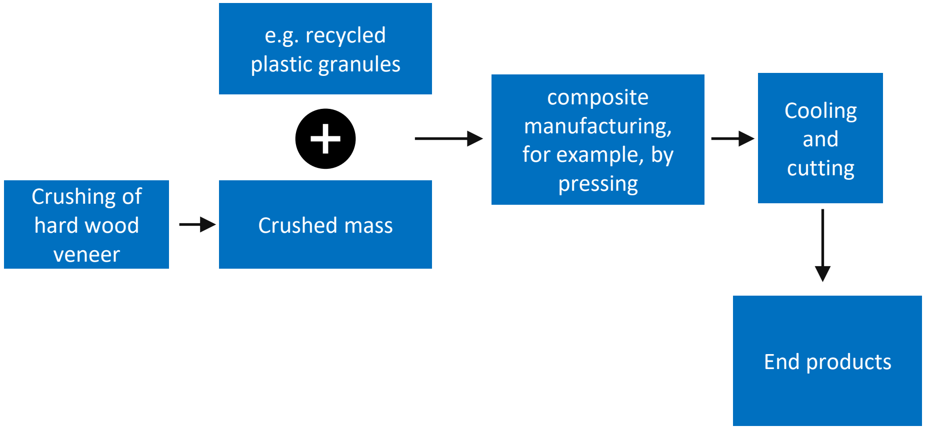
Background

Veneer waste could be suitable as a material stream for the production of wood-plastic composites. Hardwood veneer is crushed/shredded and mixed with a recycling plastic material that acts as a binder. Colorants can be added to the mass.

Composites are produced using various methods, such as casting, injection molding, or pressing methods. In composites made by pressing, the bonding of the mass is improved through heating and pressing. After this, the composite is cooled and cut.

Wood-plastic composites can be made from recycled raw materials, and they can be recycled into new wood-plastic composite products. There are various applications for wood-plastic composites, such as terrace boards or furniture.

Utilization concept requires identifying a partner that manufactures composites. In Finland, companies like UPM and Raflatac produce wood-plastic composites. Generally, the production of composites requires a fairly homogenous flow of wood fiber.



Nautor: Pyrolysis of the veneer into biochar / pyrolysis oil

Background

The wood veneer is crushed or shredded into small pieces. The shavings are fed into a pyrolysis furnace. In pyrolysis, biomass is heated to high temperatures (400–700 °C) in a low-oxygen environment, causing the organic material to decompose without complete combustion. At this stage, gases and volatile compounds are released, and what remains is mainly solid carbon-rich material—biochar and pyrolysis oil. Depending on the process, the pyrolysis plant can be optimized for the production of pyrolysis oil or biochar. The higher the temperature at which biomass is heated during pyrolysis, the more it decomposes and the more compounds volatilize into gas. Thus, the yield of pyrolysis gas increases while the yield of biochar decreases.

Biochar can be used, for example, in green construction, where it enables better growth conditions (e.g., water retention capacity). The activity generates carbon credits, which have a secondary market.

This utilization concept requires a pyrolysis plant in a commercially viable distance from Nautor. A rough estimate from commercially viable transport distance for uncondenced wood biomass is in maximum100 km. The technical suitability of the material for pyrolysis (e.g. due to glue) is an open question at this stage.

Hard wood veneer is a valuable timber, and its use as biochar can be seen essentially as a low-value utilization concept.