FlexSNG

Deliverable D2.3

Report of an integrated co-handling approach for forest and agro feedstocks

Dissemination level: Public

Date: 28/12/2022

Grant Agreement (GA) No. 101022432

Research and Innovation Actions (RIA) project

Granted by: Climate, Infrastructure and Environment Executive Agency (CINEA)

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No. 101022432 and the Government of Canada's New Frontiers in Research Fund (NFRF) and the Fonds de recherche du Québec (FRQ).

Document Control Sheet

Project	FlexSNG - Flexible Production of Synthetic Natural Gas and Biochar via Gasification of Biomass and Waste Feedstocks		
Call/Topic	International cooperation with Canada on advanced biofuels and bioenergy		
Type of action	Research and Innovation Action (RIA)		
Grant Agreement No	101022432		
Start date	01/06/2021	**Duration**	36 Months
Project Coordinator	VTT Technical Research Centre of Finland Ltd		

Work Package No	WP2	**Task No**	Task 2.3
Due date (in months)	M15		
Actual submission date	28/12/2022		

Lead Beneficiary	SF	
Contributor(s)	VTT, SFW, EIFER, CERTH	
Dissemination level	Public	X
	Confidential, only for members of the consortium (including the Commission services)	

Revision history

Version	Date	Modification	Author
1.0	22/09/2022	1st draft	Anders Eriksson, Lovisa Engberg Sundström, Maria Iwarsson Wide (Skogforsk)
1.1	07/12/2022	Final data review	CERTH, EIFER, VTT, SFW
1.2	28/12/2022	Final quality check	Sanna Tuomi (VTT)

Table of Content

1 Executive summary

This report is part of Task 2.3 of the FlexSNG project with the aim to on a conceptual level identify, how supply integration can bring potential benefits that help meeting the FlexSNG requirements and at the same time reduces feedstock and supply chain cost. The specific objective is to exemplify and explore ways of adding synergies when considering an integrated forest/agro/waste-supply approach which utilises the differences in the target feedstocks. The identified synergies will be transferred to Task 2.4 where these concepts can be incorporated in the optimisation methodology and used when the overall objective target of a 20% feedstock cost reduction later should be demonstrated. Northern Europe, and especially Sweden was used as an example region when exploring potential synergies. By analysing variations in seasonal and geographical availability and quality, a number of potential supply cost reduction concept were identified. These were:

- Co-handling and transport
- Central storage nodes and terminals
- Sharing of resources, machines and equipment
- Complementary effects with other systems
- Mixing different feedstocks to address quality challenges
- Using different feedstock recipes throughout the year
- Information and coordination

The conclusion is that there are aspects related to variations in time and geography that can be used to create a better combined feedstock supply with respect to the FlexSNG requirements. The concluding remark is that these aspects add a degree of freedom that the optimization models later can use when assessing optimised logistics.

2 Introduction

The overall objective of the FlexSNG project is to develop a flexible and cost-effective gasification-based process for the production of pipeline-quality biomethane, high-value biochar, and renewable heat from low-quality biomass residues and biogenic waste feedstocks. The flexibility of the gasification process lies in the ability to switch between two operation modes to produce a mix of end-products (biomethane, biochar and heat) that meets current price signals and market demand. At the same time, cost-effectiveness compared to state-of-the-art biomass-to-SNG technologies is expected by the combining of gasification process development and feedstock supply chain optimisation.

This report is part of Task 2.3 of the FlexSNG project and will exemplify and explore ways of adding synergies when considering an integrated forest/agro/waste-supply approach which utilises the differences in the target feedstocks. Pros and cons will be discussed, and variations in availability and quality demonstrated using different mapping examples. The aim is to identify, on a conceptual level, how supply integration can bring potential benefits that help meeting the FlexSNG requirements and at the same time reduces feedstock cost.

The identified synergies will be transferred to Task 2.4 where these concepts can be incorporated in the optimisation methodology and used when the overall objective target of a 20% feedstock cost reduction later should be demonstrated. Northern Europe (represented by Sweden and Finland), and especially Sweden will be used as an example area when exploring potential synergies.

The hypothesis is that there is a potential to optimize logistics when shifting the system boundaries and try to utilize all available feedstock streams, with their unique variations, to tailor a combined feedstock mix that better meets the FlexSNG requirements considering quality and cost (Figure 1). Besides individual feedstock adaptions to the specific FlexSNG demand (deliverable D2.2), there is also a dimension of a smart utilization of the differences between feedstock streams that has a potential to add synergies. At a strategic level, this description also helps in planning for relevant locations and feedstock combinations.

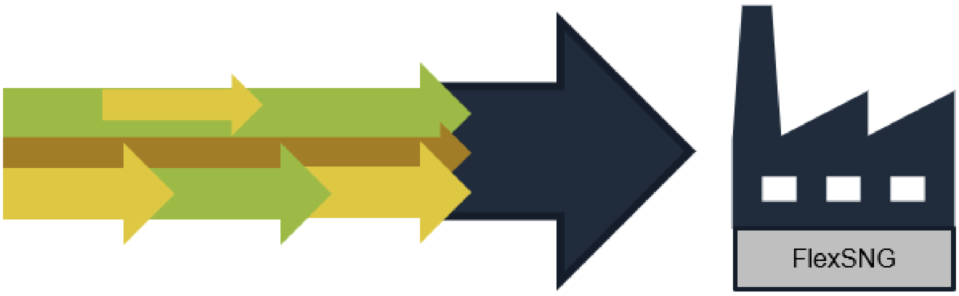

Figure 1. The concept of an integrated supply approach utilizing forest, agro and waste-based feedstocks to help meet the FlexSNG requirements of a steady flow of low-cost material with an acceptable quality.

3 General considerations for mixing of feedstock in the FlexSNG process

The FlexSNG feedstock requirements must be discussed together with supply cost. There is an ideal feedstock case and a feasible range outside the ideal that still is interesting. The tradeoff between those two must be balanced with feedstock supply cost.

A dry and homogenous feedstock with little variations in particle size and shape and an easy ash composition is preferable. However, when targeting low-cost feedstocks, all of those are often not possible to fulfill.

In addition, there are some technical boundaries that reduce the degree of freedom with respect to feedstock recipe for any given time. A specific plant is designed for a certain set of feedstocks. Separate feeding systems must be at place if both fluffy material, such as straw, and more bulky material are to be used at the same plant.

In the considered designs for the FlexSNG applications, forest derived feedstocks can be handled in any combination ranging from 0 up to 100%. Waste wood streams and solid recovered fuels can also be handled in any combination ranging from 0 up to 100%, at least if pre-treated sufficiently. The agricultural feedstocks are in general more challenging, e.g. due to ash melting and sintering problems. From the gasification point of view, it is best to handle more challenging agro-feedstocks separately and adapt the process, e.g. lower the gasification temperature.

The FlexSNG process seems agile to changes in feedstock composition and mixes and the necessarily adaptions can be achieved fast, e.g. changes in bed material. However, it is not feasible to change the operation settings and adapt the process too often, a minimum time of one week can be seen as feasible.

4 Variations in seasonal or geographic availability and quality

This section will, mainly in a Northern European perspective (and often using Sweden as an example country), describe variations in seasonal and geographical availability and quality. Section 5 will, based on this description, identify and formulate potential synergies that can reduce feedstock supply cost. Similar analyses has also been carried out in the Southern European areas.

The logging residue resources are rather evenly geographically distributed in both Finland and Sweden. Figure 1 shows the net potential of available logging residues in regeneration stands after leaving some residues for environmental and technical considerations (Figure 2). However, when adding the existing logging residue use by the heating sector, a clear difference appears between the northern and the southern part. The northern part of Sweden leaves almost all logging residues in the forest due to low demand, whereas the southern part is better to mobilize logging residues in a large scale. Nevertheless, also the southern part of Sweden can mobilize more residues. All cities in Sweden have district heating and all are major bioenergy users, so there is a strong correlation between population density and logging residue outtake.

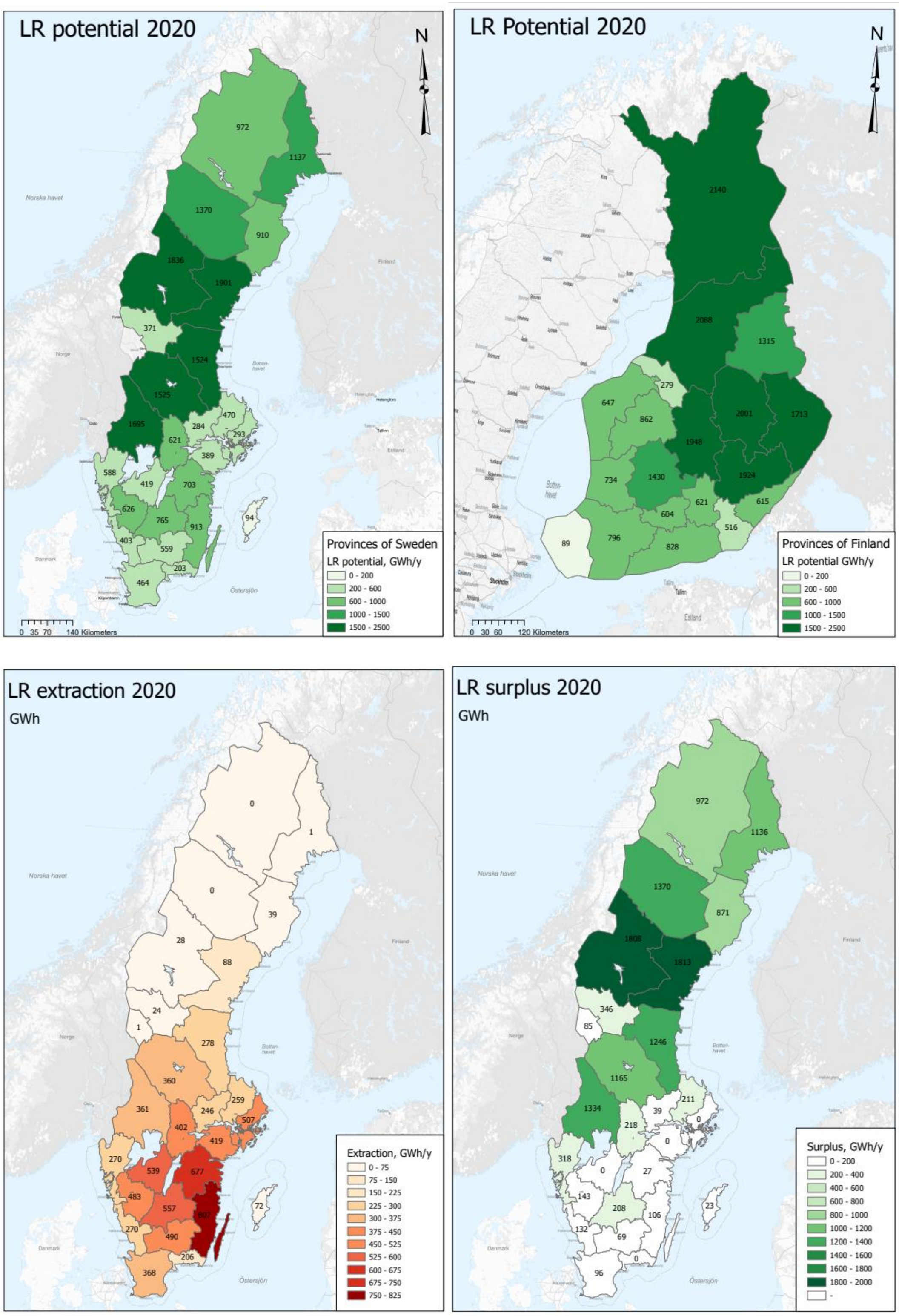

Figure 2. Net logging residue (LR) potential in Sweden [1] and Finland [2] in GWh per year in the top two figures. For Sweden, present yearly logging residue extraction per year and the resulting surplus in the bottom two.

Bark, which is a forest industry by-product, is generated in large volumes by sawmills and pulp mills at specific industry points and has therefore a different geographical characteristic compared to logging residues (Figure 3). However, despite this are resources evenly distributed on a regional level. Today, a large fraction of the bark is used internally at the industry and the surplus often sold to the heating market.

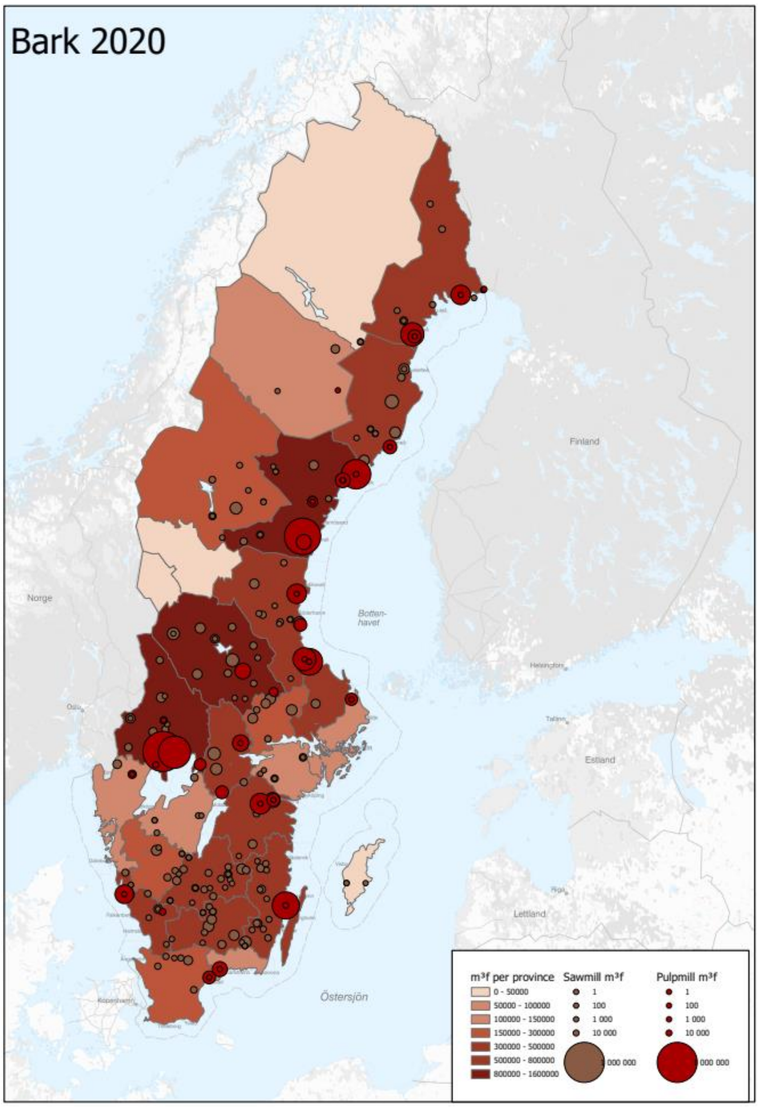

Figure 3. Geographical availability of bark in Sweden in GWh per year. Both point source and provincial availability is highlighted.

Available straw for energy applications is related to a combination of factors such as completion from other sectors, the distribution of agricultural land, the regional agricultural structure and the soil quality. Areas with a larger share of crop-production based farms have a larger surplus of straw compared to areas with more animal production where less straw is produced, and the use of straw for bedding is larger.

The southern part of Sweden has the highest straw surplus, a negative value in Figure 4 indicates a regional import need for straw.

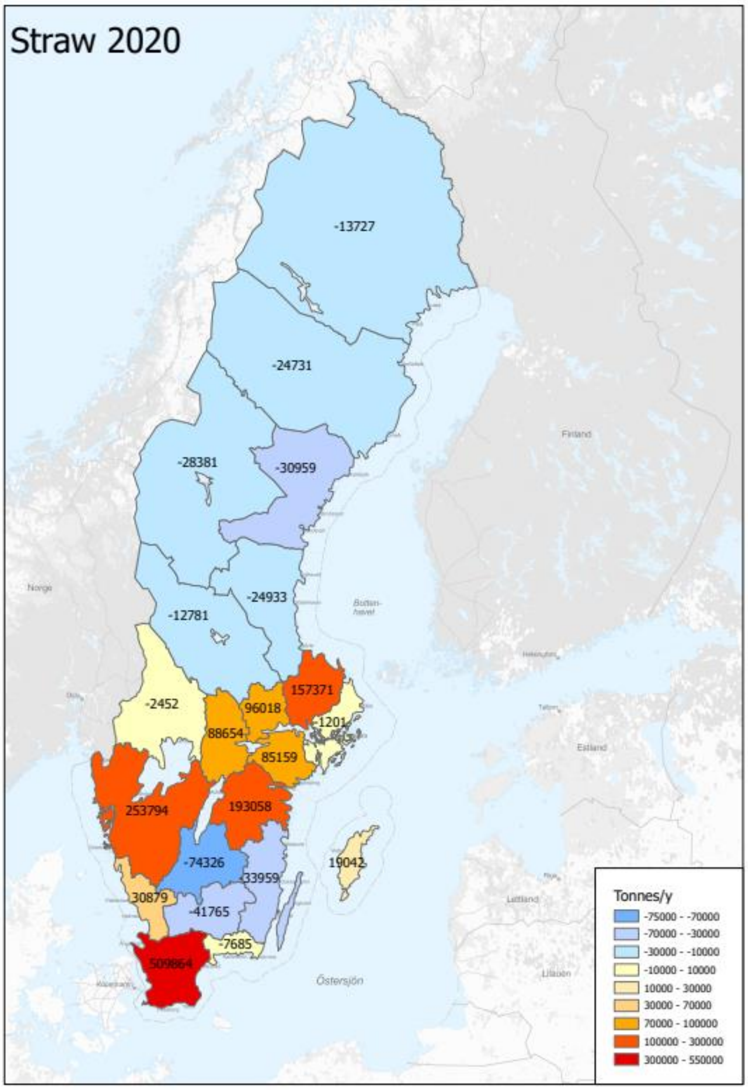

Figure 4. Net straw potential in Sweden in tonnes per year. Map developed based on data from the AGROinLOG project [3].

The population density also has a strong correlation to the waste sector. Both municipal solid waste and recycled waste wood are generated where people live. Both waste streams have existing systems for collection, sorting and fractioning and are often concentrated at a central point, e.g. a waste terminal. It is a continuous stream and waste can be found in all populated areas.

The production window for the targeted assortments in Sweden and Finland is listed in Table 1. Only straw have a seasonal pattern with regards to production.

Table 1. Production window for the targeted feedstocks in the Northern Europe case.

Production window	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Logging residue												
Bark												
Straw												
Municipal solid waste												
Recycled waste wood												

However, storage can help bridge the gap in supply and demand, and for straw, storage can be carried out with maintained quality, at least with respect to moisture content, which can be in the range of 12-24% irrespective of season if stored correctly [4].

For logging residues, there are large differences in expected moisture content depending on season and geography in Sweden. The material that is being delivered during the summertime is on average dryer compared to material delivered during the winter. There is also a clear east-west gradient with dryer material on the east coast compared to the west coast (Figure 5). However, the variation between individual deliveries is large ranging from 15-20% up to almost 60-70% independent of season. Household waste also have some seasonal variations with higher moister content during the winter.

Even though the moisture content is affected by many factors, such as handling and storage conditions, some general patterns can be observed by analysing the practice today. Some assortments have less variations over the seasons (e.g. straw and bark) and some vary more with season (e.g. logging residues) (Table 2).

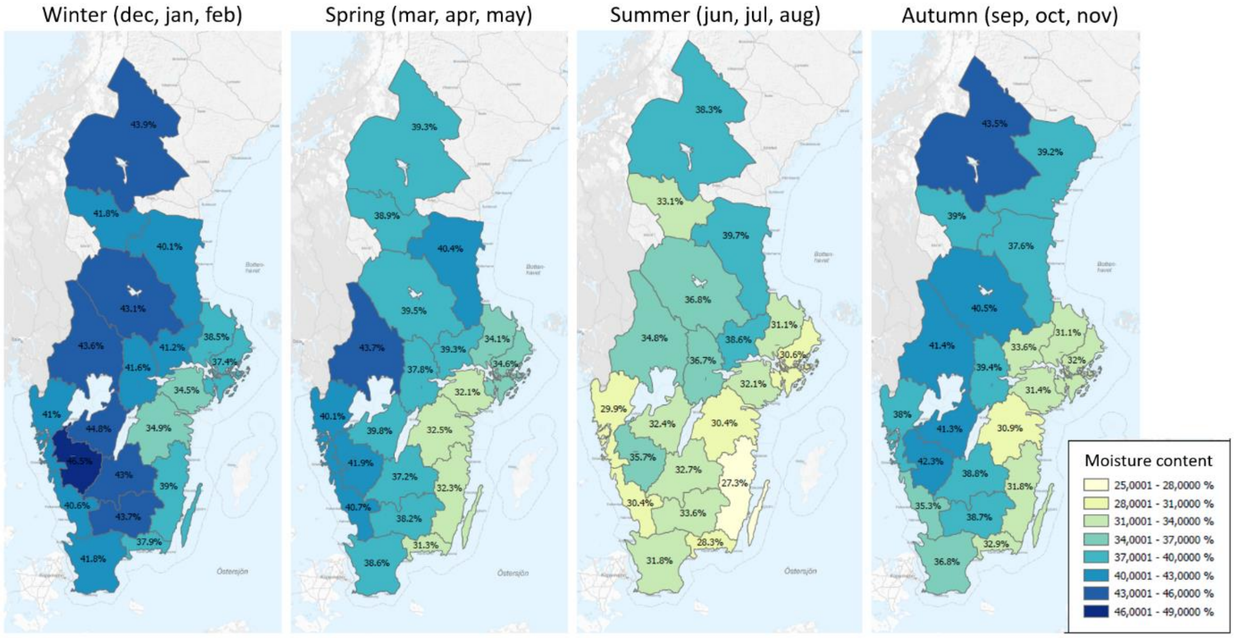

Figure 5. Measured average values for moisture content for logging residues in Sweden in different geographies and different time periods.

Table 2. Conceptual moisture content variations between feedstock assortments and time periods.

Moisture content	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Logging residue	Wet		Medium			Dry			Medium			Wet
Bark	Wet											
Straw	Dry											
Municipal solid waste	Wet			Medium						Wet		
Recycled waste wood	Dry											

One last aspect related to variability is that many of the feedstocks targeted for Northern Europe has an alternative use in the heating sector. It therefore has a clear seasonal demand and supply pattern which can be seen by analyzing logging residue supply in different time periods (Figure 6). This implies a need for up-scaling of production capacity and storage of residues over seasons to cope with this seasonal variations.

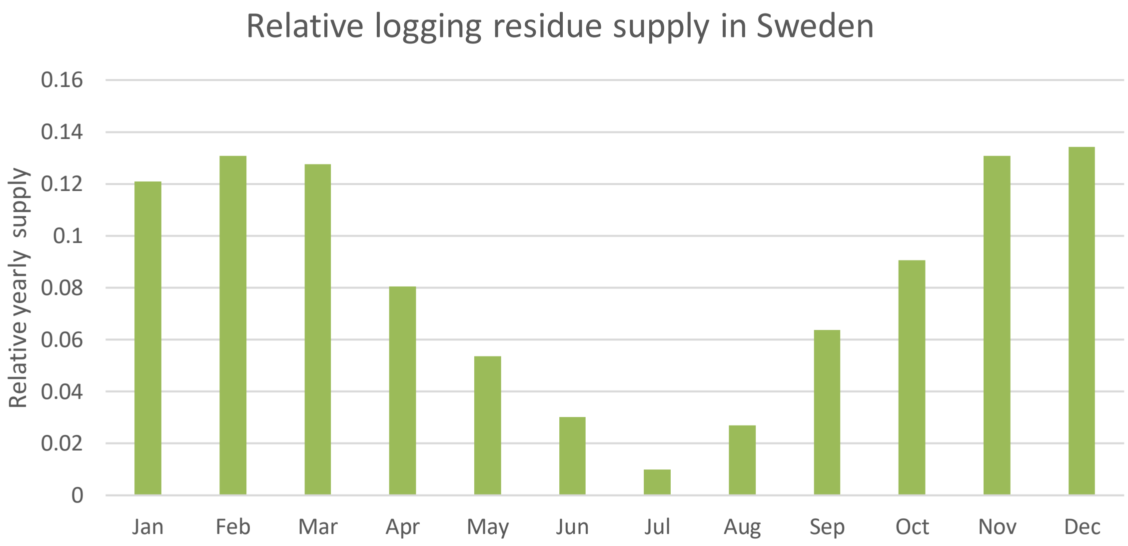

Figure 6. Relative yearly logging residue supply in Sweden in 2021.

5 Identified possible synergies

Based on the descriptions of how the targeted feedstocks varies with time and geography on a conceptual level, a number of possible synergies in terms of cost, quality and quantity has been identified. These synergies can be used to better cope with the FlexSNG requirements and be a part of the solution of a 20% supply cost reduction which later will be demonstrated.

5.1 Co-handling and transport

The feedstocks are dispersed in the geography and often available in low concentrations as showed by the potential and availability mapping. To cope with these aspects, a coordinated transport solution can be a feasible alternative. An integrated supply approach, with coordinated volumes from the forest, agricultural and waste sector, can reduce supply cost. This can be achieved by combining feedstocks with small volumes at multiple locations in coordinated routes and thus create a better use of transport capacity and a possibility to an increased back hauling.

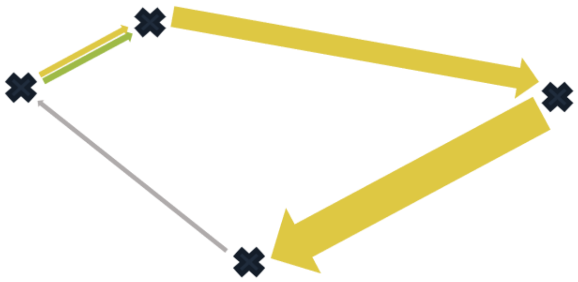

Figure 7. Conceptual sketch of a coordinated sequences of limited volumes from different feedstock bases at multiple pickup locations merged to a joint delivery to the FlexSNG plant.

5.2 Central storage nodes and terminals

To enable cost-effective supply from remote surplus areas a shift in transport mode (e.g train or ship) is often needed. A central terminal can open for this solution and also merge assortment with limited amount into a joint stream in sufficient quantities. This point can also be a good location for quality management such as e.g. screening and sieving or mixing different qualities. In addition, increased security of supply can be achieved if large volumes are stored. However, terminal handling also adds cost which needs to be weighed against gains in transport efficiency, reaching more distant markets or improved quality. Increased storage also increases storage related problems such as microbial degradation, which can lead to value losses and risk of fire.

Figure 8. Conceptual sketch of a concentration of different feedstocks at a central node (e.g. a terminal) where a change of transport mode is possible prior to final delivery to the FlexSNG plant.

5.3 Sharing of resources, machines and equipment

As illustrated above, some of the feedstocks, especially the ones in the agricultural sector, have a short production window. This is often challenging and stressful for the actors involved, but it also opens up for sharing of equipment. However, many of the targeted feedstocks have dedicated and specialized machines in their productions system, as described in Task 2.2. Possibilities for sharing can still be open, e.g. using the farm tractor for other purposes or sharing of personnel.

Figure 9. Conceptual sketch of sharing of resources when supplying forest, agro and waste-based feedstocks.

5.4 Complementary effects with other systems

The descriptions in section 4 highlight a possibility to take advantage of the seasonal supply pattern in the district heating sector. Present situation with a large up-scaling of production capacity during a few winter month is challenging, stressful and costly for all involved. For those assortments, a FlexSNG application can offer a demand outside the heating season and then complement the supply plan with other feedstocks during the conventional heating season.

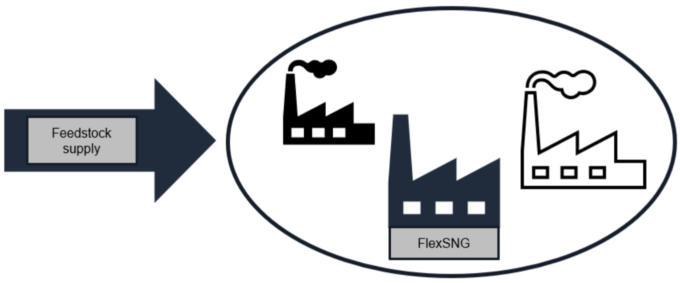

Figure 10. Conceptual sketch of the possibility to source material smarter when considering the FlexSNG plant in relation to other users of bio-based feedstocks (e.g. a heating district plant).

5.5 Changing feedstock mixes to address a challenging quality

All individual feedstocks have their own characteristics, as described in Task 2.1 report. Some feedstocks have challenges, e.g. related to form and shape, ash behavior or presence of heavy metals. Sorting, screening and sieving can improve quality and reduce the challenges. However, there are two other ways to cope with these challenges;

- Try to combine the challenging feedstock with a feedstock that helps bring the joint stream to an acceptable level. Either to co-feed it in low proportions or combine it with a feedstock that help limit the challenging aspects.
- Isolate and handle the challenging feedstock separately in specific campaigns (exemplified in Figure 11 for agro-based feedstocks during Aug and Oct). It is possible to modify and adapt the gasifier's conditions to better cope with the challenging feedstock.

5.6 Use different feedstock recipes throughout the year

One way of maximizing the use of quality differences is to source material when it is of highest quality. One example is to use logging residues in the summertime when it is at its driest point and other more stable feedstocks in other periods (Figure 11). There is also a possibility to use feedstocks with a short production window, especially if they are difficult to store, during short campaigns.

Given that many bio-based feedstocks have known storage problems, e.g. biodegradation, a strategy might be to utilize materials that are difficult to store faster and use more storable materials during other time periods.

In both cases, the combination can provide a better feedstock solution compared to the individual streams.

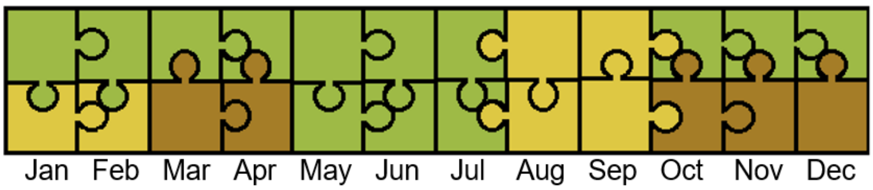

Figure 11. Conceptual sketch of using different feedstock recipes during different time periods.

5.7 Information and coordination

Another perspective, not visualized directly by section 4 but indirectly, is the need for information sharing to enable smart coordination and collaboration. It can be achieved in multiple ways but is most likely a corner stone to enable a smart integrated supply in practice.

6 Concluding remarks

The conclusion is that there are aspects related to variations in time and geography that can be used to create a better combined feedstock supply with respect to the FlexSNG requirements. The concluding remark is that these aspects add a degree of freedom that can be used to create smarter supply. In the demonstration of a 20% supply cost reduction, these aspects must be considered. Therefore, an optimization model that can handle different combination of feedstock streams over time will be developed to fully explore this potential.

7 References

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