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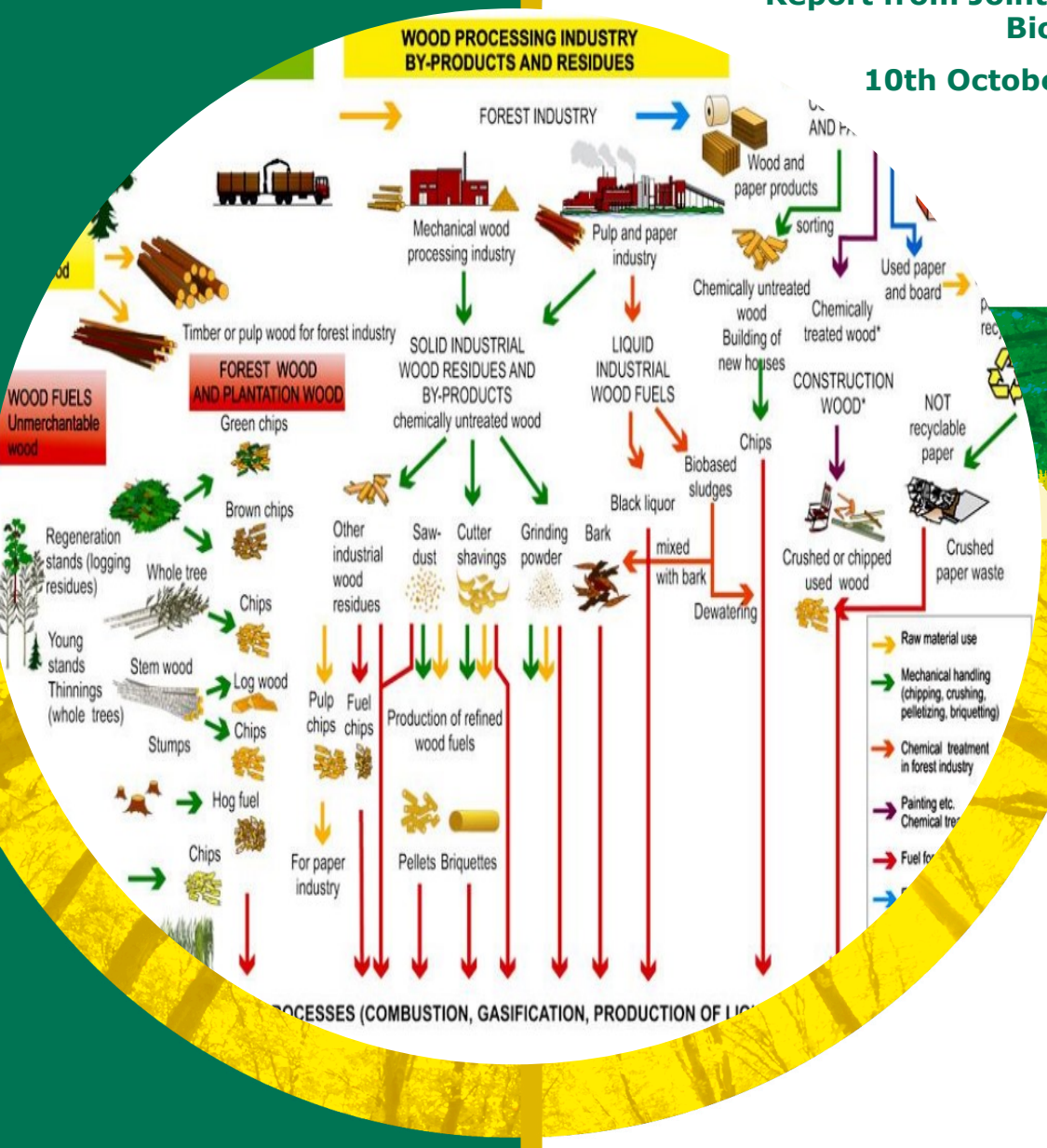
Bio-hubs as keys to successful biomass supply integration for bioenergy within the bioeconomy

Report from Joint IEA Bioenergy Task 43 & BioEast Initiative Workshop

10th October 2019, Sopron, Hungary



Front cover: Classification of the wood-based fuels according to CEN/TS 14961 (Heinimoe, J.; Alakangas, E., 2006)

IEA Bioenergy

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Bio-hubs as keys to successful biomass supply integration for bioenergy within the bioeconomy

Joint IEA Bioenergy Task 43 & BioEast Initiative Workshop, 10th October 2019, Sopron, Hungary

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Summary

IEA Bioenergy Task 43: Sustainable Biomass Supply Integration for Bioenergy Within the Broader Bioeconomy has launched an initiative to identify successful examples of biomass logistic and distribution points for bioenergy and the bioeconomy: bio-hubs. The goal of this initiative is to explore integrated bioeconomy supply chains to develop solutions for the reliable production and supply of higher-quality biomass for energy. These examples are also meant to serve as sources of inspiration that other biomass producers can use to enhance the sustainability of their own activities, as well as for policy makers to familiarize themselves with the bio-hub concept.

The Sopron workshop took bioenergy a step forward towards new biomass supply chains within a concept of bioeconomy. The innovative examples selected for this workshop show how biomass can be produced together with wood products and food in sustainably managed landscapes.

The aim of the workshop was to develop a framework for the successful establishment of bio-hubs in support of the bioeconomy. The workshop had a proactive format, consisting of showcase presentations and participatory SWOT analysis. Examples of four existing and emerging bio-hubs were presented, and workshop participants had the opportunity to consider how different biomass supply chains (forestry, agriculture, SRC) could evolve to bio-hub concepts.

In the second part of the workshop, biomass as a commodity was presented. Participants jointly outlined strengths, weaknesses, opportunities and threats (SWOT analysis) of having bio-hub as an alternative to the existing biomass supply. The SWOT analysis was performed in real-time, capturing, scoring and ranking inputs from 30 workshop attendees using the Sli.do application.

The joint IEA Bioenergy Task 43 and BioEast Initiative workshop was well attended with 55 participants from 17 countries. Most participants (64%) were from the BioEast macro-region and 90% of participants from the EU, but reaching as far as to Australia, Canada and New Zealand (10%).

BioEast Initiative and IEA Bioenergy foresee that the gathered knowledge and shared experience at the workshop will contribute to the improvement of sustainable biomass mobilisation for energy purposes, notably in the BioEast macro-region and in other member countries of the IEA Bioenergy Technology Collaboration Programme.

The results of the workshop will feed into the development of the framework for bio-hubs, which will then be further applied and tested as part of following activities.

To access the workshop presentations, please visit the IEA Bioenergy Task 43 website[1].

[1] http://task43.ieabioenergy.com/publications/bio-hubs-as-keys-to-successful-biomass-supply-integration-for-bioenergy-within-the-bioeconomy-joint-iea-bioenergy-task-43-and-bioeast-initiative-workshop-10-october-sopron-hungary/

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1 Introduction

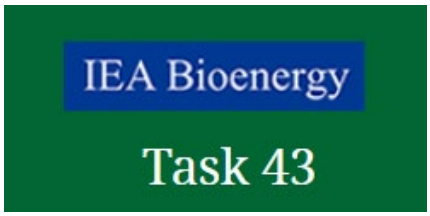
In 2018, IEA Bioenergy Task 43 launched an initiative to identify successful examples of biomass logistics and distribution points for bioenergy and the bioeconomy: bio-hubs. The goal of this initiative is to explore integrated bioeconomy supply chains to develop solutions for the reliable production and supply of higher-quality biomass for energy. These examples are also meant to serve as sources of inspiration that other biomass producers can use to enhance the sustainability of their own activities, as well as for policy makers to familiarize themselves with the bio-hub concept.

The joint IEA Bioenergy Task 43 and BioEast Initiative workshop "Bio-hubs as keys to successful biomass supply integration for bioenergy within the bioeconomy" took bioenergy a step toward new biomass supply chains within a concept of bioeconomy. The innovative examples selected for this workshop show how biomass can be produced together with wood products and food, in sustainably managed landscapes.

The aim of the workshop was to develop a framework for the successful establishment of bio-hubs in support of the bioeconomy. The workshop had a proactive format, consisting of showcase presentations and participatory SWOT analysis. Examples of four existing and emerging bio-hubs were presented where workshop participants had the opportunity to familiarize themselves with how different biomass supply chains (forestry, agriculture, SRC) could evolve to bio-hub concepts.

The workshop was co-hosted by IEA Bioenergy Task 43 and BioEast Initiative.

IEA Bioenergy Task 43 Sustainable Biomass Supply Integration for Bioenergy Within the Broader Bioeconomy addresses issues critical to mobilizing sustainable bioenergy supply chains, including all aspects of feedstock production, its markets and environmental, social and economic impacts. The objective is to promote sound bioenergy development that is driven by well-informed decisions by landowners, businesses, governments and others. The Task has a global scope and includes commercial, near-commercial and promising feedstock production systems in agriculture and forestry. The primary focus is on exploring technical and economic strategies to increase the quantity and quality of biomass for bioenergy within a profitable bioeconomy.



Scope of the Task 43:

explore technical and economic strategies to increase the quantity & quality of biomass for bioenergy within a profitable bioeconomy.

The Task explores technical and economic strategies to increase the quantity of biomass available, improve the quality of the biomass delivered for different energy purposes, and explore strategies to increase the value and foster confidence in biomass supply, for both direct and cascade use of biomass for bioenergy.

Objectives:

- Develop sustainable integrated land management strategies for biomass mobilisation
- Explore integrated bioeconomy supply chains to develop solutions for the reliable production and supply of higher-quality biomass for energy

The Task works exclusively with terrestrial biomass sources including residues, by-product or co-product production from forest and agriculture production systems; residues, by-products or co-products from bio-based manufacturing industries; cellulosic biomass from post-consumer waste;

as well as dedicated biomass crop systems as part of broader land management strategies. The Task focus is on the production and supply of biomass feedstock for energy leading to value creation within the broader context of bioeconomy.

The Work Programme of Task 43 is organized in two work packages:

WP1 - **Biomass production systems for sustainable bioenergy within the bioeconomy**	WP2 - **Integrated supply chain and logistics for sustainable bioenergy in the bioeconomy**
• Strategies to integrate innovated biomass crops to leverage and expand existing residue and co-product supply chains.	• Key biomass quality drivers as they relate to bioenergy technology needs.
• Scale of biomass crops required to economically supply bioenergy production as sole source and as an integrated contribution to residue supply chains.	• Identifying and managing technology bottlenecks in biomass supply chains.
• Quantifying the socioeconomic values of biomass crops as a part of a local, regional and national renewable energy strategies.	• Opportunities to economically extend the range of biomass supply chains through new and emerging biomass technology.
• Influencing biomass sustainability through strategies to increase volume, value and quality of biomass supply.	• Improving biomass quality and value with pre-processing or pre-treatment within the supply chain.

The IEA Bioenergy Task 43 WP2 goals' echo within the efforts of TWG Forestry and the emerging TWG Bioenergy and New Value-Added Materials within the BioEast Initiative.

BioEast Initiative: Central-Eastern European Initiative for Knowledge-based Agriculture, Aquaculture and Forestry in the Bioeconomy offers a platform to 11 Central and Eastern European (CEE) countries for a shared strategic research and innovation framework, working towards the development of a sustainable bioeconomy. Members of the BioEast Initiative are mostly Ministries of Agriculture, supported by a topic related science/research institution.

In 2018, the Slovakian Government established **TWG Forestry** with the aim to build an intensive analysis of demands in the CEE region on the forest-based sectors, the institutional and governance frameworks, and stakeholder perceptions on potentials and obstacles for implementing a forest-based bioeconomy.

In 2019, the Croatian Government initiated the establishment of **TWG Bioenergy and New Value-Added Materials** where bioenergy is perceived as an embedded activity in farming practice, as both a GHG emission savings and competitiveness tool. New value-added materials seek for research and innovation to produce bioeconomy goods from by-products of bioenergy (digestate, ash, CO_2…). The workshop interlinks the two TWGs and reinforces the aim to produce more value added per unit of biomass.

BioEast Initiative aspires that the workshop would unlock a significant improvement of mobilizing biomass for bioenergy, but also for bioeconomy, in the BioEast macro-region:

- mobilization of usable biomass resources of lower quality to production and non-production functions of ecosystems and cascading use of wood,
- improving the supply chain of fuel biomass in terms of security of supply, biomass energy properties and cost of production,
- increasing the efficiency of energy conversion processes from biomass, technical-economic and environmental parameters of heat, electricity, cooling production from liquid biofuels,
- optimizing the energy use of biomass in terms of mitigating the impacts of climate change and increasing the energy self-sufficiency of regions,
- achieving higher implementation of proposed and proven solutions in partner countries (considering economic, legislative, social and political aspects).

This workshop combines the efforts of IEA Bioenergy Task 43 and BioEast Initiative in promoting sustainable and reliable biomass supply in a form of bio-hubs for bioenergy within the broader scope of bioeconomy. The objective is to disseminate attractive examples among bioenergy market stakeholders fostering wider implementation.

Aims of the workshop:

- Sharing experiences and knowledge that strengthen the BioEast and IEA Bioenergy Task 43 vision in terms of mobilizing sustainable biomass supply and increased value added along the value chain.
- Exchanging worldwide concepts, programmes and projects with high replicability potential.
- Inspiring novel solutions that will accelerate promotion of both IEA Bioenergy Task 43 and BioEast Initiative's efforts.

2 Bio-hub case studies

The Sopron workshop took bioenergy a step towards new biomass supply chains within the broader concept of bioeconomy. The aim of the workshop was to develop a framework for the successful establishment of bio-hubs in support of the bioeconomy. For those reasons, different bio-hub concepts were selected to introduce and inspire the participants on a variety of concepts that a bio-hub can take. The presented examples shared the message that biomass can be produced together with wood products and food in sustainably managed landscapes.

The *existing agrarian bio-hub at Tschiggerl Agrar GmbH (Austria)* is a solid example of how a bundle of bio-based products can be produced from agricultural by-products (straw, corn cobs, hay…), without disturbing the usual crop production activities. It started as an idea of fuel switching to biomass for grain drying but evolved to a bio-hub where farmers deliver their by-products to increase income. Bio-hub has the know-how and technology to produce value added products for dynamic market. *Nordic examples of bio-hubs based on wood biomass* are a showcase of the emerging need to handle large quantities of biomass with specified quality for bioeconomy. *The Swedish experience of a bio-hub that manages cultivated biomass* (short rotation coppice – SRC) indicated challenges that SRC biomass is facing but also advantages of managing such biomass via bio-hub. The last example is a *virtual bio-hub East Europe Hub for sustainable wood mobilisation from Croatia* that connects stakeholders with information not only on biomass supply/demand but also on know-how supply/demand to generate higher value-added wood-based products in short chains.

Those existing and emerging bio-hubs were used to familiarize participants with how different biomass supply chains (forestry, agriculture, SRC) could evolve to bio-hub concepts.

2.1 AGRICULTURAL BIO-HUB: TSCHIGGERL AGRAR GMBH; AUSTRIA

by Alfred Kindler, Landwirtschaftskammer Steiermark, Austria

For several years, a group of farmers from south-east Styria and the Agricultural Chamber of Styria have been working on the recycling of previously unused agricultural residues. After a period of long and intensive work, Austria‘s first biomass logistics centre for agricultural residues was opened at the end of 2015 at Tschiggerl Agrar GmbH. Since February 2016, the logistics centre has been in full operation.

Farmers can take their residues there, to have them processed in the logistics centre (dried, crushed, pelleted) and then provided as recyclable materials to the region. Hay from natural meadows, straw, husks and fruit pomace are used as feed or bedding. In addition to the material use, the corn cobs are used for energy due to their very good combustion properties and similarity to wooden pellets. Depending on the variety and yield level, between 1,300 and 1,500 kilograms of cobs (equivalent to 600 – 750 liters of fuel oil equivalents) can be harvested per hectare without any operating costs.

At first, corn cobs were used to replace heavy oil in a 2 MW boiler for grain drying. With time, and marketing and communication strategy, more farmers were inclined to deliver their residues to form an agrarian bio-hub that supplies feed, bedding and fuel. The bio-hub provides the service of upgrading the produce (mixing different types of residues to achieve better quality feed, adding proteins or biochar) and looks for options of higher market values.

The organisational structure of this agrarian bio-hub emerged from a grain-based agro-cooperative with grain drying and storage service.

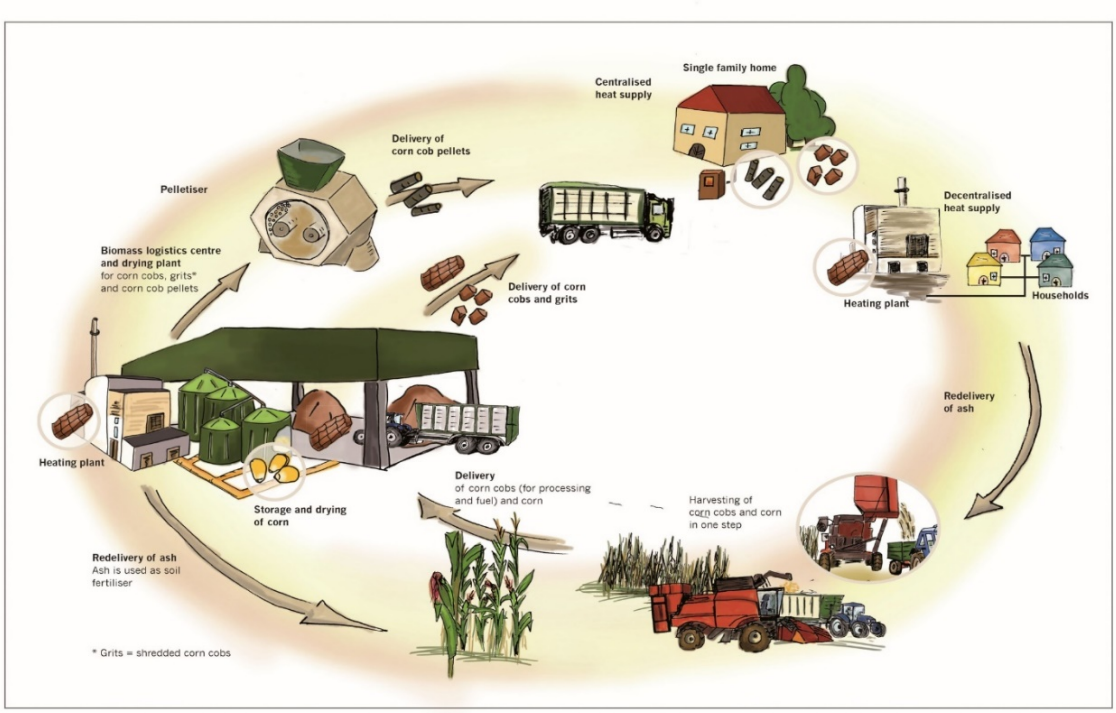


Figure 1 Operating scheme of the agrarian bio-hub

The logistic centre operates in two ways:

1. a farmer delivers residues to the logistic centre, pays an agreed sum to process the residues (pelletizing, mixing, grating) and takes back the upgraded biomass to the farm.

2. a farmer delivers residues to the logistic centre for processing and recieves an agreed share of the retail price.

Agrarian bio-hub can operate during the idle season for crop farming and generate additional income to crop farmers without much disturbance to the usual farm activities.

For more, please visit: https://www.sucellog.eu/en/concept-en.html

2.2 BIO-HUB WITH SHORT ROTATION COPPICE (WILLOW)

by Håkan Rosenqvist and Ioannis Dimitriou, SLU, Sweden;

The concept is to establish a short rotation coppice (SRC) willow plantation with about 15,000 cuttings per hectare. The first harvest is after about 4th year, following rotations each 3 or 4 years. Chips from willow are used in boilers for burning forestry residues and other wood material. Water content in fresh willow chips is about 50%.

Table 1 Operations related to SRC growing

SRC management	Limited work for growers after the planting year. Most management activities are outsourced. The farmer prepares the soil during the plantation year. Entrepreneurs take care of planting and harvesting. A planter or a harvester will plant or harvest a large area of SRC.
Planting	Capacity planting is about 1–3ha/h depending on the available equipment. The cultivations life is about 20-25 years.
Harvesting	The harvester capacity is about 0.5 h/ha. Harvesting occurs every 3rd or 4th year. A harvester covers about 1,000 ha of SRC.

The harvesting phase is the most challenging part where SRC cultivation is linked with its purpose and use. There are different ways of organizing the harvest:

- farmers have a contractor to harvest,
- farmers sell the chips themselves,
- entrepreneurs harvest and sell the chips,
- power plants or brokers buy willow unharvested at the field,
- collaboration between farmers in growers' association that sells chips and organizes harvesting.

SRC can be harvested as wood chips, whole shoots, billets or round balls.

Table 2 Advantages and disadvantages of different harvesting options of SRC

Direct chipping	
Advantages	**Disadvantages**
at the same time as harvesting is; the cheapest, ready to use in large boilers and lowest transportation cost	problems with storage and high moisture content is sometimes a problem
Shoot harvesting	
Advantages	**Disadvantages**
SRC can be stored, drying during storage and higher dry matter content which gives higher energy content	higher cost caused by field transport and chipping

Biomass from SRC achieves competitiveness against other conventional crops only in specific cases. Things that improve profitability of SRC plantations are: engagement in the management/cultivation and selling of chips, well-managed crops that result in high yields, geographical localisation, taking care of municipal sludge and/or wastewater in vegetation filters with SRC, collaboration between all parts of the chain. Examples of business concepts with SRC as a base is selling heat, dry and sell chips, take care of sludge or wastewater, such as in wastewater treatment plants.

SRC at the bio-hub (biomass terminal) can improve the stability of biomass supply and increase optimal biomass properties for a specialised buyer (plant). The moisture content of the fuel can be

controlled by mixing SRC with wood, straw etc. Increased security of delivery with storage at terminal when different fuels can replace each other, allows security of supply.

Delivery of SRC to the bio-hub must follow the agreement between the supplier and bio-hub manager. Stocks with SRC harvested as whole shoots that are chipped at delivery will increase possibilities to deliver at agreed times. It can be coordinated with forest fuel and deliver forest fuel in case of lack of SRC. Different reasons e.g. weather, machinery and planning, could prevent on-time delivery. The buyer often does not want to have agreements with many growers which calls for coordination of growers to deliver SRC biomass with properties and delivery as required by the buyer.

An important lesson on SRC from Sweden:

Biology and technology are not enough for SRC success. The importance of organization of SRC cultivation, especially harvesting, selling and using the fuel, should not be underestimated.

2.3 NORDIC BIO-HUBS

by Dan Bergstorm, SLU, Sweden

The Nordic forestry system is often considered a role model for developing forestry in many parts of the world. Our progression from manual to mechanized systems has improved cost-efficiency throughout the supply chains. However, fuel wood systems are still relatively undeveloped, in comparison to round wood systems, mainly due to the instability of market conditions during the last four decades, which has raised risks for developers. Nevertheless, there is an ongoing transition from a fossil-based to a bio-based economy globally, in which forest resources are likely to play an important role. This transition will increase market stability.

Currently, major efforts are being made to develop biorefineries in the Nordic countries, which requires improvement of current supply systems and development of new systems. Sweden and Finland are at the frontline in developing techniques and management systems for biomass supply, and associated technology is being transferred from Scandinavia to other markets, for instance Southern Europe, Russia, North America, Brazil and China. As the bioeconomy grows there will be increasing needs for efficient technologies for handling other tree-based assortments, including: whole tree parts, slash, stumps and small trees from traditional forests; and biomass from coppices, marginal land (roadsides, power-line passages etc.) and agriculture. These resources are currently utilized to a minor extent and mainly implemented for heat- and power-production, but could be upgraded for use as raw materials to produce pulp/paper, biofuels, chemicals, composites etc. in biorefineries. Thus, there is a great need for tailoring supply systems, considering region- and country-specific factors, such as biomass and land characteristics, management goals, industrial demands and infrastructure. To ensure the sustainability and efficiency of such technologies and systems it will be highly important to design supply systems that match industrial demands.

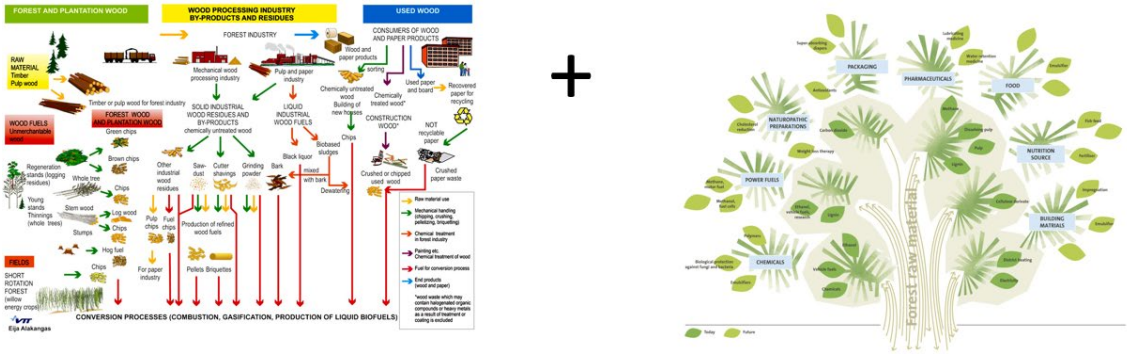


Figure 1 Could bio-hubs facilitate biomass supply to the existing and newly emerging markets in bioeconomy?

To secure the raw-material supply in a developed bioeconomy, bio-hubs/terminals will play a key role as: transit nodes for different transportation systems; upgrading and storage points; and sites where imbalances between supply and demand can be addressed. In future bio-based economies bio-hubs are likely to be more sophisticated than current terminals. For example, low grade biomass is not currently sufficiently valuable for long-distance transportation, and their bulkiness further reduces their value. However, if the biomass can be upgraded sufficiently, e.g. through fractionation, torrefaction, pyrolysis or pelletizing, for instance, its value would rise significantly. Mobile/semi-mobile refinery systems are currently being developed that would enable the first refining steps to be performed closer to the raw material sources and provide high flexibility. For countries like Sweden and Finland, especially in the northern parts, where there are long distances between the forest and industrial sites, such systems could play an important developmental role. For all these systems, development of biomass separation systems, enabling the separation of trees' components into (for example) extractive- and cellulose-rich fractions before further refining will be important for optimizing biomass utilization.

All-inclusive bio-hubs

To increase the competitiveness of biomaterials from different sources (e.g. forestry, marginal lands and agriculture), integrated supply systems could assure an effective supply to the energy- and bio-based industries. The benefits would be particularly evident in regions with limited forestry or agriculture activities, where separate systems simply cannot reach enough volume to be effective.

2.4 BIO-HUB FOR KNOWLEDGE BASE

by Ivan Ambroš, Competence centre Ltd, Croatia

From a local initiative of a sawmill industry emerged the establishment of a Wood Cluster Slavonian Oak in 2010. With the help of EU funding, the initiative was further strengthened by establishing the Competence Centre in the area of bioeconomy (2016) according to the strategy for Smart Specialisation of the Republic of Croatia 2016-2020. The Competence Centre acts as an East Europe Hub for sustainable wood mobilisation (ROSEWOOD Network HORIZON2020 project). The idea is gathering all experts within the forestry and wood industry value chain, from the tree in the forest all the way to the final eco-friendly products with high added value.

The necessity for bio-hubs emerged from the fact that, despite the high-quality forest on local area (Spačva basin forest with famous Slavonian oak, lat. *quercus robur*) and favourable forestry-based industry, the value-added activities are outside the community. Although local wood processing capacities for raw wood material existed, only a small amount of local raw wood material was being

processed by the local wood industry. In addition, despite existing local renewable biomass and bioenergy products (wood pellets and chips), the only biomass used for energy was fuel logs for heating in individual stoves.

Becoming aware that the Vukovar-Srijem County has the ingredients for a modern wood-based bioeconomy potential but lacked the know how to develop it, the County supported the establishment of a virtual bio-hub. The purpose of the bio-hub is to connect all wood-based stakeholders: from forest owners, wood processing industry, sawmills, pellet producers, environment protection experts, academia, innovators, associations etc. to promote the cascading use of wood, smart and sustainable use of valuable natural resource and create short value chains from forest to the final product.

Currently, the East Europe Hub is gathering 52 experts (and growing) from the entire value chain of forestry and wood industry from 10 countries of eastern Europe. In addition, it is linked with 3 other European Hubs and related experts. They share information not only on biomass quantities but also on best practice and innovations, examples suitable for developing new value chains and strengthening existing ones. The output of this stage of the project will be a "Roadmap for sustainable wood mobilisation with best practice examples and innovations" identified by expert members of the ROSEWOOD Network. The ROSEWOOD project started in February 2018 and will end in January 2020. The virtual bio-hub will continue its development in two dimensions:

1. Real-life: Innovation infrastructure with new product development with 3D advanced technologies, CNC and other machinery for making prototypes, with capacities for drying, boiler room etc. will be used by SME's to bring additional value to their products. Innovation infrastructure is now in the phase of construction works, expected to be fully built and equipped in 2021.

2. Virtual: Digitalisation of the virtual bio-hub with the follow up project ROSEWOOD 4.0 (HORIZON2020) starting from January 2020.

The main benefits from a virtual bio-hub:

The idea is to foster bioeconomy by strengthening local (short) value chain: to support the use of local wood for local wood-based, new, high added value, innovative product development across all stages of the value chain. A quality label for local wood can help to develop a better management of local forests and wooden products ensuring a reduced carbon footprint by limiting transport for transition to sustainable, resource-efficient, climate-resilient circular bioeconomy.

For more information, please visit: https://rosewood-network.eu

3 Bio-hub as a new market player for biomass supply: SWOT analysis

In the second part, the workshop switched to a participatory approach. Participants were invited to jointly assess the internal Strengths and Weaknesses as well as external Opportunities and Threats (SWOT analysis) of having bio-hubs as an alternative to the existing biomass supply, considering the four different concepts of bio-hubs and the introductory presentation on biomass as a commodity (W. Elbersen, WUR). The presentation's message: once defined and developed a limited number of lignocellulosic intermediate commodities (to link the biomass sources worldwide to markets), would lower the cost of biomass, increase the security of supply and foster efficient use of the available biomass. The SWOT analysis was performed in real-time, capturing and ranking inputs from 30 workshop attendees using the Sli.do application.

Figure 2 Mark Brown and Kelly Murphy facilitating SWOT analysis in real-time

Figure 3 Participants providing their inputs via smartphones to real-time SWOT analysis

Participants anonymously posted their views on **Strengths** by logging in to the platform via smartphones. The list of Strengths was populated in real-time on-screen. Participants were able to vote positively (Upvote) or negatively (Downvote) for each suggestion listed. If the suggestion was downvoted to the negative side, it was labelled as "non-valid". The process was repeated for **Weaknesses**, **Threats** and **Opportunities**.

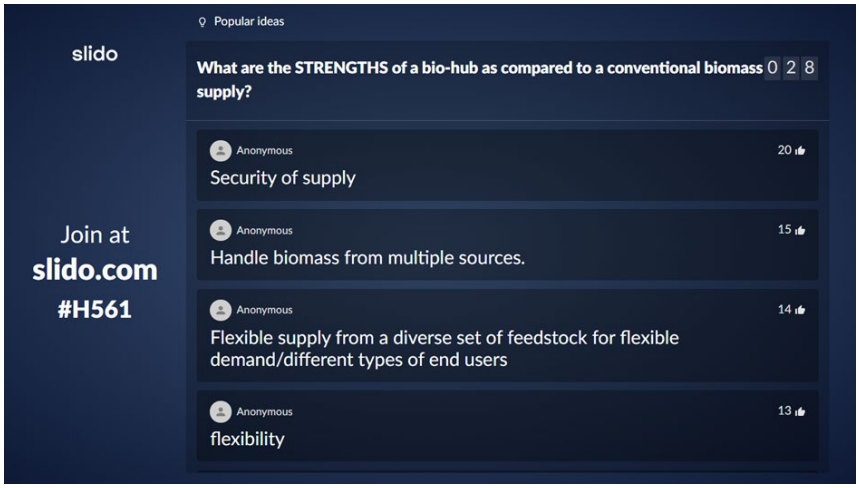


Figure 4 A snapshot of on-screen results on Strengths

After the break, participants were invited to rate on a seven-point scale the top 3 **Weaknesses** to evaluate the importance of each for bio-hub operations. The group then, anonymously, provided ideas on how to mitigate those **Weaknesses** and the suggestions were voted positively (upvoting)

or negatively (downvoting) by the group. The process was repeated for the top 3 **Threats**.

Finally, the participants anonymously assessed the importance of the top 3 **Opportunities** on a seven-point scale, provided ideas of action to realise the **Opportunities** and the suggestions were voted positively or negatively by the group.

The SWOT analysis excluded items that were downvoted to reach zero or a negative final score.

3.1 Summary of Bio-hub SWOT analysis

In summary, when assessing biomass supply via bio-hubs as an alternative to the conventional biomass supply existing in the area, participants identified more positive items than negative, both in the internal and external environment. The intensity of Opportunities was higher ranked than those of Weaknesses and Threats.

More Strengths (27) than Weaknesses (19) were recognized of having biomass supply organised via bio-hubs in comparison to the alternative. The highest ranked Weakness: "Too large investment" received a score of 13, which was the equivalent of the scores for 4th -6th place in the Strengths. The highest scored Strength: "Security of supply" received a score of 20, being the highest ranked item in the overall analysis. In the assessment of the external environment for bio-hub biomass supply, Opportunities (23) and Threats (16) were detected, after Upvoting and Downvoting. The ranking of the top 6 Opportunities was equal or above a score of 10, whereas Threats had only two inputs with such a score.

The results of the SWOT analysis implemented at the Sopron workshop, led to conclusions that bio-hubs have a potential to positively affect security of biomass supply, highlighted as the strongest valued Strength and feature of a bio-hub, in general. Consequently, the existence of bio-hubs would mobilise more of the economically non-feasible biomass potential and take the biomass market to the next level. The Weaknesses were related to the size of the operation, which could be minimized by learning from other large-scale business activities, logistics and storage. In that sense, there is a fair set of existing examples available to minimize the weaknesses detected. A good option would be to either start small (i.e. such as in the case of Tschiggerl Agrar GmbH) or to build upon the existing business case or facilities (i.e. such as in the case of the Nordic bio-hubs example) to grow to a large-scale operation with multiple suppliers and a diversified portfolio of products.

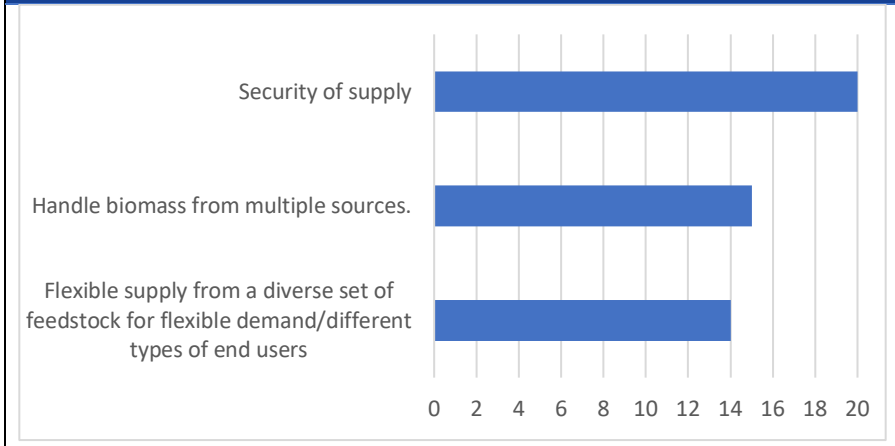
The external environment including biomass supply organised via bio-hubs was assessed with more intensity on the positive side. It was agreed that it would bring a positive influence to certification schemes and value optimisation that should lead to levelized prices of biomass, relative to the quality as well as the volume. Establishment of bio-hubs was perceived as having a positive socio-economic agent in a community that would allow the inclusion of more farmers and forest owners to participate in bioeconomy. Policies that would frame bio-hub establishment should maximise those opportunities to build a sustainable, reliable and inclusive biomass supply. The external challenges were also related to the bio-hubs size which could negatively affect the community in all three dimensions of sustainability (environmental, social and economic). Policies at place should mitigate those Threats, in terms of improved traceability of biomass and overseeing the influence of bio-hubs on biomass markets. Yet, in some cases when economies of scale are in place, especially with high fixed costs or high infrastructure development, a natural monopoly is a better option for the beneficiaries than the competitive market. Examples of natural monopolies are well known in the energy sector: gas network, district heating, electricity grid, oil pipelines... and are heavily regulated by government to control the power of this unique market position. On the other hand, regulations could support natural monopolies' infrastructure sharing to reduce the costs, i.e. railway services. It is important to notice that not all bio-hubs will reach such a large scale. The large-scale bio-hub is very likely for those bio-hubs needed either to move large quantities of biomass closer to the demand (the example of Nordic bio-hub) or justify the collection costs (SRC based bio-hub). On the other hand, with short supply chain bio-hubs (agri bio-hub or where wood supply is close to demand

or where short supply chains are promoted), the society will not gain from the natural monopoly agent and the market will settle with locally distributed bio-hubs.

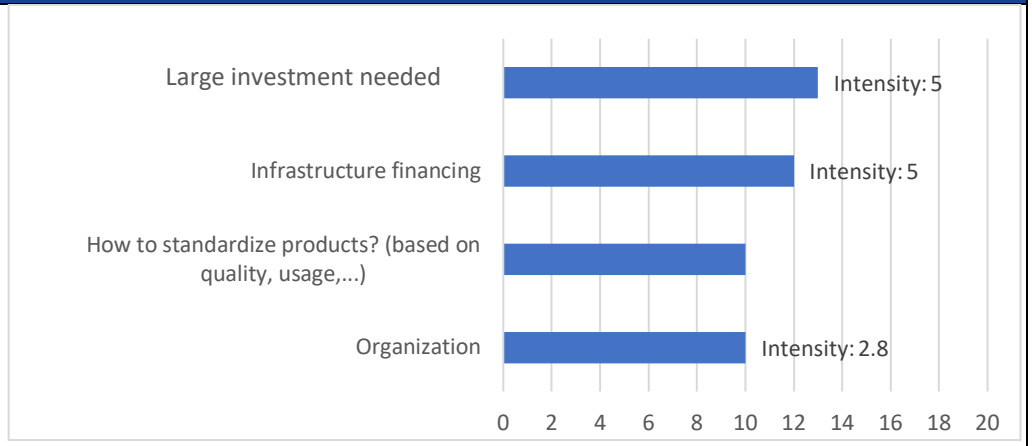
The following table provides an overview of the top ranked SWOT items on bio-hubs, compared to biomass supply with the alternative option, with related intensities of each. In the next sections, each of the SWOT item is investigated in more details.

Table 3 Top items of bio-hub SWOT analysis with related intensities

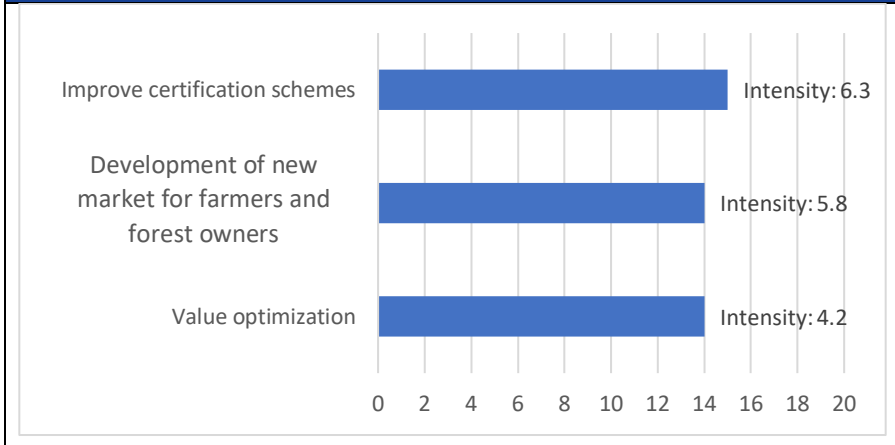
STRENGTHS



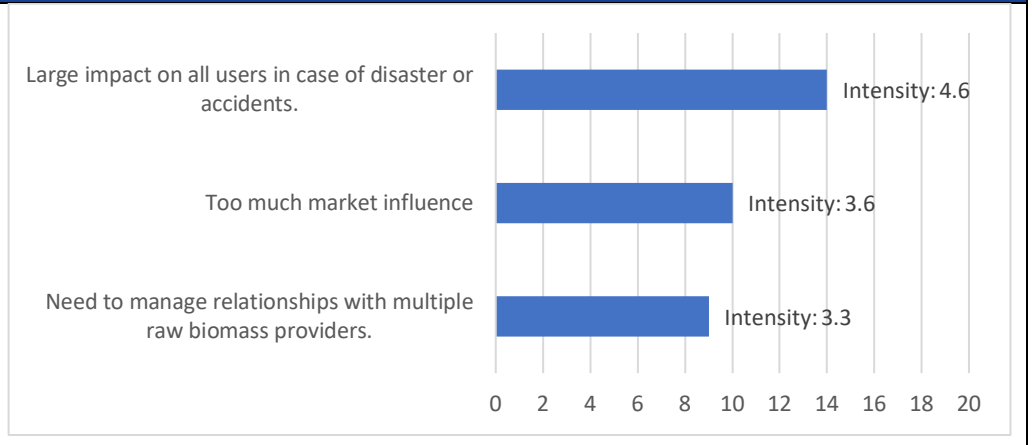
WEAKNESSES



OPPORTUNITIES



THREATS



3.2 STRENGTHS

Strengths would be the inner assets that bring the advantage to biomass supply via bio-hubs to the alternative. Those could be either qualities in which a bio-hub outperforms the alternative or a way that distinguishes biomass supply from the alternative, in say, providing new/unique services and values to biomass utilisation.

The participants identified 28 strengths (Annex) of having biomass supply organised via bio-hubs, in comparison to the existing biomass supply options. One item was excluded due to the total negative score. Voting identified the top 3 Strengths that scored close to or more then the majority (Table 3). The Strengths clustered around three themes from which the main message can be drawn:

- **Bio-hubs improve biomass supply** (10 Strengths) due to its ability to mobilize biomass from untapped resources and secure desired quality of biomass;

- **Bio-hubs improve biomass valorisation** (8 Strengths) as it would seek for higher value added or optimal options for properties of biomass available;

- **Bio-hubs improve the economics of biomass supply** (6 Strengths) due to its ability to sell biomass on behalf of small biomass suppliers and distribute biomass storage, processing, transport costs over larger quantities.

3.3 WEAKNESSES

Weaknesses are internal disadvantages that need to be addressed either to match or outperform the alternative. Those could be desirable assets which are currently absent, or points for improvement.

The participants identified 21 Weaknesses (Annex) of having biomass supply organised via bio-hubs, in comparison to the existing biomass supply options. 2 items were excluded from the analysis due to the downvoting and were related to sustainability issues: "returning the nutrients to the soil" (-5) and "quality control" (-1). The item "Need to manage relationships with multiple raw biomass providers" was moved from Threats to Weaknesses as it is an organisational (internal) issue, not an external challenge. Voting has surfaced the top 3 Weaknesses that haven't reached the majority within the Scores (Table 3). "Large investment needed" reached 15 Upvotes but was Downvoted by 2.

The participants were challenged to find solutions for the 3 top Weaknesses: "requires a large investment" (10 valid suggestions); "infrastructure financing" (13 valid suggestions) and "increased organisation/management requirements" (10 valid suggestions). The full list of suggestions is placed in the Annex.

The Weaknesses clustered around four themes from which the main message can be drawn:

- **Bio-hubs face the challenge of organisation and running the biomass supply** (10+1 Weaknesses) due to its complexity. There were 10 suggestions on how to mitigate this type of Weaknesses. The most voted suggestions were:

    - "Learn from others it is not rocket science" (15 votes) plus 2 similar suggestions.

    - "Networking between hub managers, joint trainings, experience sharing" (13

votes) plus 2 similar suggestions.

- "Train managers" (11), "Develop management system" (10) and 2 other similar suggestions.

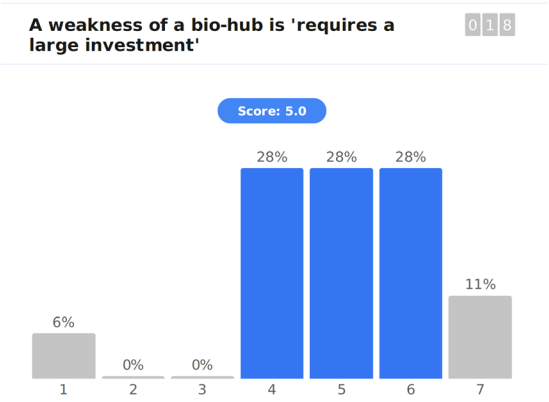
- **Bio-hubs has a challenge in start-up costs** (6 Weaknesses) as it might be perceived as too novel of a concept and a risky investment or high investment in infrastructure (setting around the bio-hub: roads, terminals, power supply…) and bio-hub itself. This challenge was divided into two sub-topics when asked for suggestions on how to mitigate them:

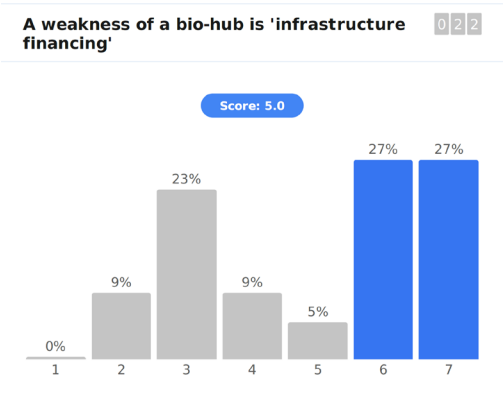
  - **Large investment in bio-hub** requirement had 10 valid suggestions out of which 8 suggesting options for investment risk sharing; joint investments with different stakeholders (18 score); co-investments with final user (11 score); build consortia (10 score) and similar.

  - **The challenge of infrastructure financing** is both an internal and external issue, depending on the investment side and assets ready at the location. Here it is considered as an internal Threat, if the bio-hub investor would have to carry out the load of infrastructure financing, either in terms of lobbying or actual investment in necessary infrastructure. In total, there were 13 suggestions of mitigation measures clustered around 3 suggestions: 1) involvement of the local stakeholders in bio-hub project (7 suggestions); 2) revival, revitalisation, re-organisation, use of the existing infrastructure (4 suggestions); 3) apply scientific solutions for transportation and logistics as in conventional goods (2 suggestions).

- **Bio-hubs could provoke undesirable socio-economic issues** (4 Weaknesses) as its size might overwhelm the local, smaller users or create parallel system to the existing supply chains. The size of a bio-hub might lead to the monopoly in biomass supply.

The intensity of the top 3 Weaknesses were assessed on a seven-point evaluation list with "large investment" and "infrastructure financing" scored equal in importance with 5/7, but with different distribution of importance. "Increased organisation/management requirements" scored 2.8.





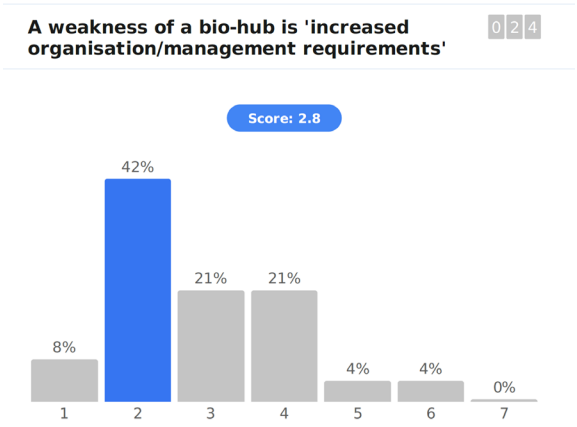


Figure 5 Slido bar charts on voting results for intensity of top 3 Weaknesses

3.4 OPPORTUNITIES

Opportunities arise from situations outside of the bio-hub itself, represent favourable occasions or chances for something positive to happen. Those could be governmental policies that steer biomass utilisation, such as strong political and financial support to develop the economy on renewable carbon. New technology or innovation developments would also belong to the opportunities that a bio-hub could capture. The challenge for all organisations is how to turn the external Opportunities to internal Strengths.

26 Opportunities were identified (Annex) of having biomass supply organised via a bio-hub, in comparison to the existing biomass supply options. 3 items were excluded from the analysis due to the downvoting. Voting has surfaced the top 3 Opportunities that were close to the half of the total votes (scores 14-15) (Table 3). "Improved certification schemes", "Development of new market for farmers and forest owners" and "Value optimization" reached 15 and 14 votes, respectively.

The participants were invited to suggest how to turn the top 3 Opportunities (external) to Strengths (internal): "improved certification schemes" (5 valid suggestions); "value optimisation" (11 valid suggestions) and "develop new markets for farmers and forest owners" (16 valid suggestions). A full list of suggestions is included in the Annex.

The Opportunities clustered around three themes from which the main message can be drawn, when including suggestions on how to internalize them to Strengths:

- **Bio-hubs provide the opportunity to take the biomass supply to the next level** (15 Opportunities) by facilitating that biomass supply and demand meet in security, quality, quantity, price and optimal biomass application. Stable and reliable biomass supply would allow the widespread application of bio-based products for industrial clients, ensure sustainability by improvement of certification schemes and traceability of biomass, among others.

    - Suggestions on how to internalize **Improved certification schemes** trading via bio-hubs would allow implementation of well-designed certification schemes (17 score) either through bio-hubs certification (7 score) or promotion of high-quality differentiation (4 score). Bio-hubs will reduce costs and implementation of certification schemes (2 scores each).

- "**Value optimisation**" had suggestions to internalization with differencing commodities to high value-added products (13 score) and creating new value products that markets need (12 score). There were 3 similar suggestions which were scored lower. To internalize Opportunities related to new value-added products, a bio-hub would need to have access to dynamic knowledge on innovations, research and technology. Ideally, it should serve as a "knowledge hub" to optimize the quality and quantity of available biomass supply new value-added chains – how far the bio-hub wants to be engaged along the value chain would be determined by a business case.

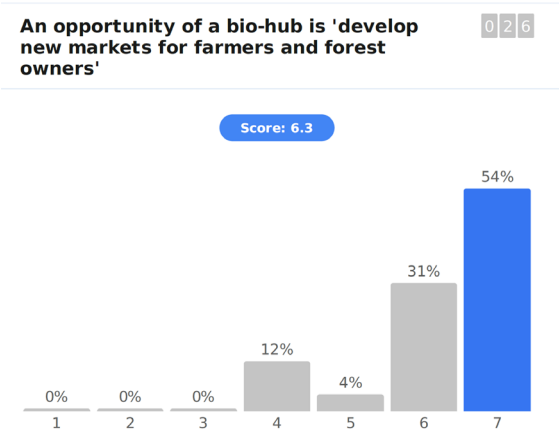
  Oher suggestions were related to optimal storage conditions and proper logistic management systems (9 scores each).

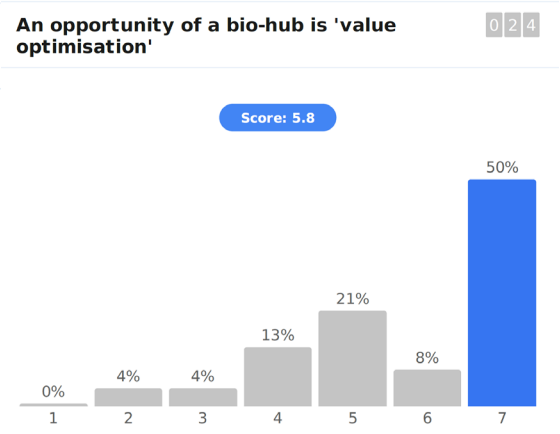
- **Bio-hubs provide the opportunity to trigger socio-economic benefits** (5 Opportunities) with creating new business opportunities and new markets for farmers and foresters, along improved traceability of biomass.

  - Opportunity to "**develop new markets for farmers and forest owners"** had the highest scores among all suggestions (18 score) and the most suggestions on how to turn that Opportunity into a Strength. 3 suggestions: "inform producers on new market possibilities" (18 score), "connect market demand with biomass production" (16 score) and "long term purchase guarantee contract" (9 score) were echoed in the other 13 suggestions.

- **Bio-hubs establishment has a positive political framework** (2 Opportunities).

The intensity of the top 3 Opportunities were assessed on a seven-point evaluation list with "develop new markets for farmers and forest owners" valued as the most intense with 6.3 score, with most frequent answer of top value (7). "Value optimisation" scored 5.8 with the most frequent answer of the top value (7). "Improved certification schemes" scored 4.2.





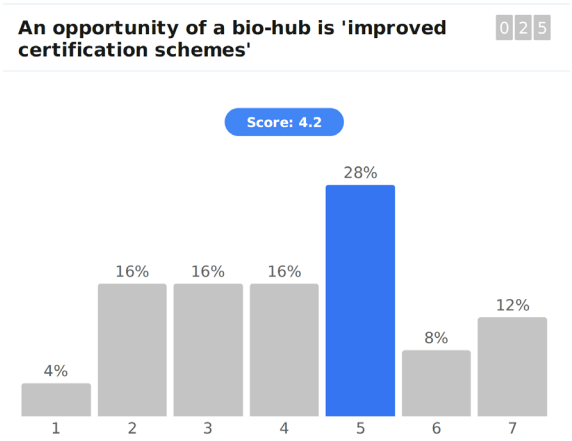


Figure 6 Sli.do bar charts on voting results for intensity of top 3 Opportunities

3.5 THREATS

Like Opportunities, Threats arise from situations outside of the bio-hub itself but, to the difference of Opportunities, they negatively affect the business activity. The sources of Threats are the same as for the Opportunities: governmental policy, market changes, technology advances, new products or market solutions that make the current business obsolete...

The participants identified 23 Threats (Annex) from the external environment that could negatively affect organising biomass supply via bio-hubs, in comparison to the existing biomass supply options. 5 items were excluded from the analysis due to the downvoting and were related to issues such as instability due to climate change, origin of biomass and lack of governmental support. 1 item was moved to Weaknesses, "Need to manage relationships with multiple raw biomass providers" as it was considered an organisational (internal) issue, not an external Threat.

Voting identified the top 3 Threats that haven't reached the majority within the scores (Table 3). "Large impact on all users in case of disaster or accidents" reached 17 Upvotes but was Downvoted by 3. "Too much market influence" had 15 Upvotes and 5 Downvotes to settle on the 2nd position with a score of 10.

The participants were challenged to find solutions for the 3 top Threats: "too much market influence" (11 valid suggestions); "'managing relationships with multiple suppliers'" (8 valid suggestions) and "long term investment vs versatility to market" (8 valid suggestions). A full list of suggestions is included in the Annex.

The Threats clustered around two topics evenly from which the main messages can be drawn, when blended with suggestions on how to mitigate them:

- **Bio-hub threats are mostly related to size** (8 Threats): from "having too much of market influence" to "higher risks to disastrous events due to the higher volumes" and "lower public support for large projects".
    - **Risk plan** (13 score), **risk distribution** (score 11) and 6 similar suggestions would be the ideas how to mitigate "**large impact for all users in case of disruption**". Other suggestions were: "embedding the project in the local community", "choosing proper locations" and "start small".

- The Threat "**too much market influence**" can be assessed both as an external and internal feature. This was reflected in the suggestions of the participants where suggestions were either in the direction of "create competition" (14 score) or product/portfolio differentiation. "Value chain approach must be implemented in all business models" was scored 6 and stood out from the suggestions above.

- The Threat "**managing relationships with multiple suppliers**" was questioned as to whether it was more suitable as a Weaknesses. In any case, the suggestions to mitigate it were "long term cooperation agreements" (score 14) and "learn from others, there are more complex supply systems" (score 12).

- The Threat "**managing relationships with multiple suppliers**" was suggested to be mitigated with "different end products" (14 score) and "long term contracts" (10 score). A suggestion to "always build for versatile and multiple use" pointed out the much-needed flexibility of such a complex system.

- **Bio-hubs could pose a threat in all 3 dimensions of sustainability** (8 Threats) from the general perspective (as it might be linked with the volume of biomass managed), to be specific:

  - **Environmental** (1 Threat): "Potential negative impact on biodiversity and other ecosystem services due to overuse of biomass" (Upvoted 7, Downvoted 5).

  - **Social** (2 Threats): "Poor connection to the local community" (Upvoted 5, Downvoted 5) and "Lack of cooperative initiatives to create value optimization" (Upvoted 3, Downvoted 2)

  - **Economic** (4 Threats): "Long term investment VS versatile market" (Upvoted 10, Downvoted 3); "Outflow of the biomass from the country" (Upvoted 11, Downvoted 6); and "lack of market" (Upvoted 6, Downvoted 4) and "technology" (Upvoted 8, Downvoted 5) readiness to switch to bio-based alternatives.

The intensity of the top 3 Threats were assessed on a seven-point evaluation list with "large impact for all users in case of a disruption" detected as the most intense with 4.6 score and the most frequent answers in 5 and 7. The Threat "'too much market influence" scored second with 3.6, which is about neutral. The least intense Threat was "managing relationships with multiple suppliers" with a score of 3.3 but most answers at the lower values.

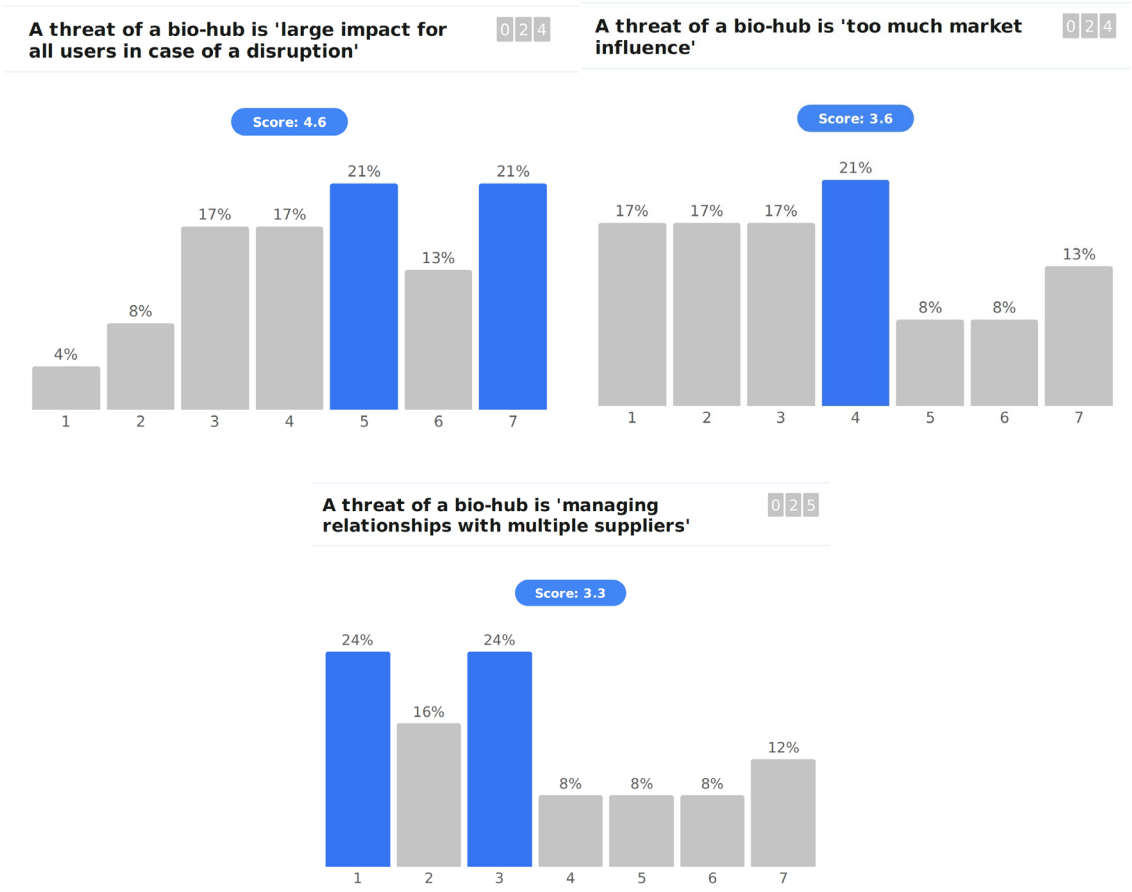


Figure 7 Sli.do bar charts on voting results for intensity of top 3 Threats

4 Conclusions and next steps

The joint IEA Bioenergy Task 43 and BioEast Initiative workshop "Bio-hubs as keys to successful biomass supply integration for bioenergy within the bioeconomy" was well attended with 55 participants from 17 countries, with 64% of participants from the BioEast macro-region and 90% of participants from the EU but reaching as far as to Australia, Canada and New Zealand (10%).

The results of the workshop will feed into the development of the framework for bio-hubs, which will then be further applied and tested as part of future activities. The Sopron workshop was the start of a larger project where IEA Bioenergy Task 43 will explore options to repeat the process with other expert groups and different geographical coverage. The idea is to conduct a validation survey across T43 network with SWOT results and use the final SWOT report to guide a Strategic project on bio-hubs.

Based on the objectives of IEA Bioenergy Task 43 outlined in the Report, it is proposed to implement a series of research and development activities focussed on documenting a best practice strategy for biomass supply centred around opportunities to manage quality, support new production and develop critical logistical mass through biomass amalgamation and pre-processing hubs. With the Sopron workshop, we started exploring the strengths, weaknesses, opportunities and threats for the establishment, development and growth of biomass hubs in support of a growing sustainable bioenergy supply for a country or region. With a focus on developing a better understanding and best practices that leverage the strengths, address the weaknesses, and develop the opportunities identified for bio-hubs, our intention is to identify and document existing and emerging examples of bio-hubs to apply the outcomes of this SWOT analysis. The aim would be verifying if the listed items have a generic profile applicable world-wide or are region specific. This would be possible with engaging several existing or emerging bio-hubs as field work case study sites to explore the SWOT items identified in the workshop, including specific exploration of residue to commodity principles in improving bio-hub function (ideally secure examples in North America, Western Europe, Eastern Europe and the Southern Hemisphere). The outcome is already linked with an emerging Special project group of IEA Bioenergy dedicated to defining features of a sustainable bio-hub for bioenergy within the broader bioeconomy. A workshop with a similar concept will be implemented in Canada in March 2020. The outcome of the Special project group on bio-hubs would be documentation and delivery of bio-hub best practice supported with techno-economic analyses: final workshop where best practices documents and web tool to direct deployment of bio-hub best practice.

BioEast Initiative and the IEA Bioenergy foresee that the gathered knowledge and shared experience at the workshop will contribute to the improvement of sustainable biomass mobilisation for energy purposes, notably in the BioEast macro-region and in other member countries of the IEA Bioenergy.

To access presentations, please visit the IEA Bioenergy Task 43 website[2].

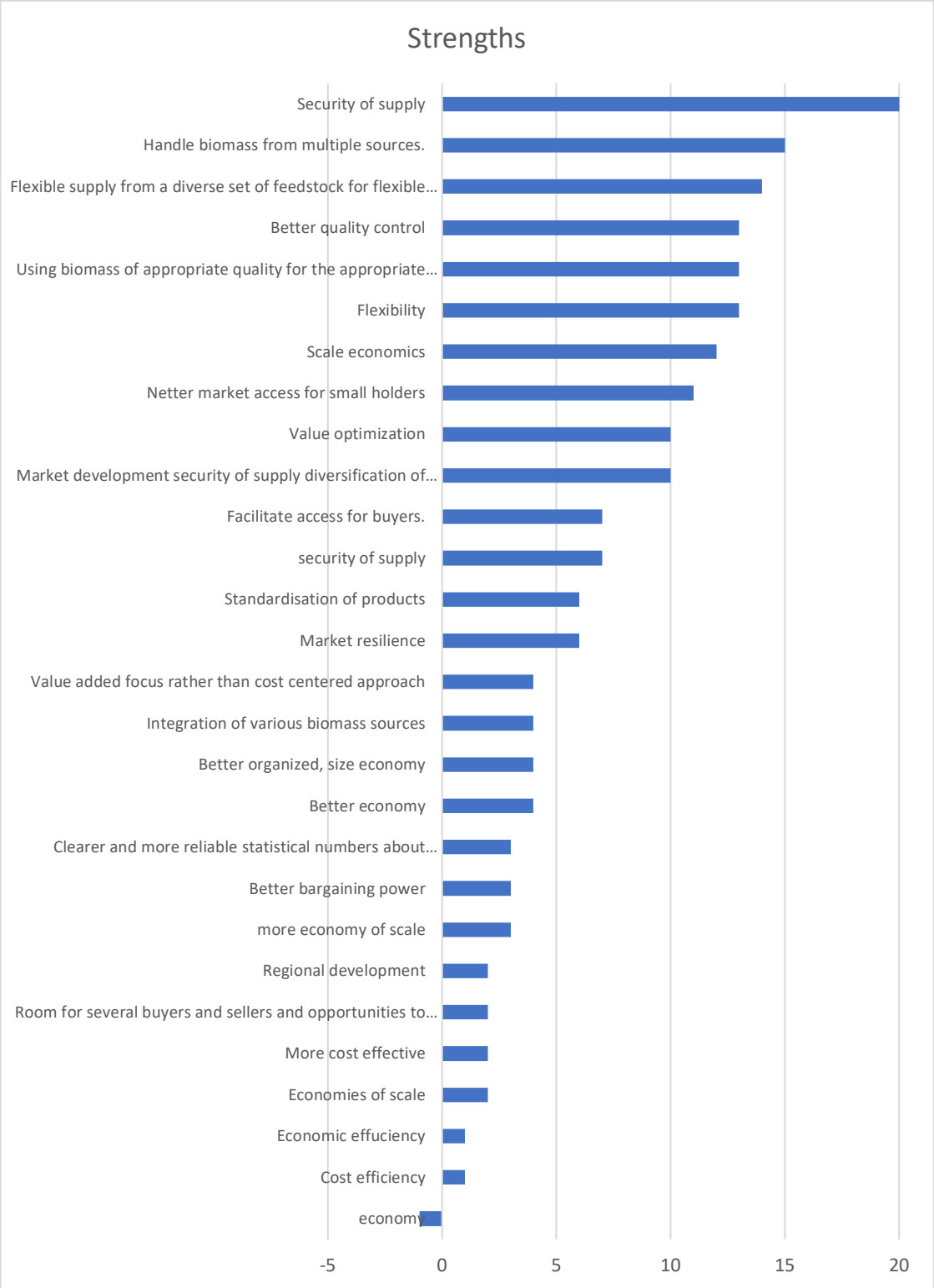
[2] http://task43.ieabioenergy.com/publications/bio-hubs-as-keys-to-successful-biomass-supply-integration-for-bioenergy-within-the-bioeconomy-joint-iea-bioenergy-task-43-and-bioeast-initiative-workshop-10-october-sopron-hungary/

Annex

Agenda

	Registration and introduction
09:30 – 10:00	• Host: welcome • BioEast Initiative (Barna Kovacs): Welcome • IEA Bioenergy Task 43 (Mark Brown): Welcome • WP2 Integrated supply chain and logistics for sustainable bioenergy in the bioeconomy
10:00 – 10:40	• Tomas Bucha & Milan Oravec: TWG Forestry within BioEast Initiative • Ivan Matić & Biljana Kulišić: TWG Bioenergy and BioMaterials within BioEast Initiative
10:40 – 12:20	Bio-hubs concepts (20' each)
	• Dan Bergstrom: Nordic examples with wood focus • Hakan Rosenqvist: SRC bio-hub • Alfred Kindler: Tschiggerl Agrar bio-hub • Ivan Ambroš: European Network of Regions on Sustainable Wood Mobilisation (HORIZON2020) – East Europe Hub - Centar kompetencija d.o.o., Croatia Survey on biomass supply (WP1) (<10')
12:10 – 12:40	Lunch break
12:40 – 16:00	Work in groups with coffee
	• Wolter Elbersen: "To be or not to be a biobased commodity. On the need for developing real lignocellulosic biomass commodities" • 4 questions: SWOT, H forms Wrap up discussion with IEA Bioenergy Task 43 & BioEast Initiative

SWOTs and scores[3]



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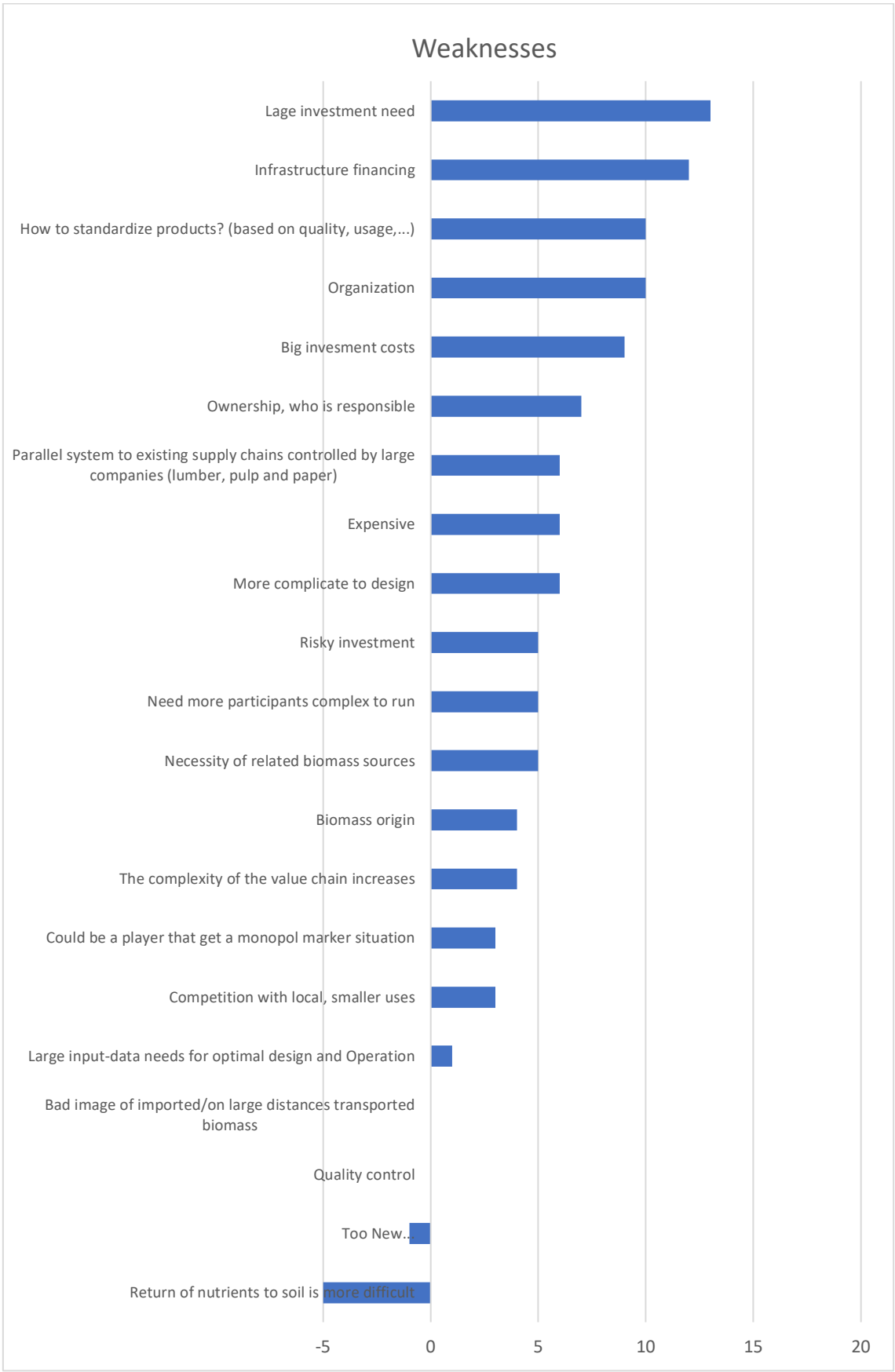
Weaknesses
Lage investment need
Infrastructure financing
How to standardize products? (based on quality, usage,...)
Organization
Big invesment costs
Ownership, who is responsible
Parallel system to existing supply chains controlled by large companies (lumber, pulp and paper)
Expensive
More complicate to design
Risky investment
Need more participants complex to run
Necessity of related biomass sources
Biomass origin
The complexity of the value chain increases
Could be a player that get a monopol marker situation
Competition with local, smaller uses
Large input-data needs for optimal design and Operation
Bad image of imported/on large distances transported biomass
Quality control
Too New...
Return of nutrients to soil is more difficult
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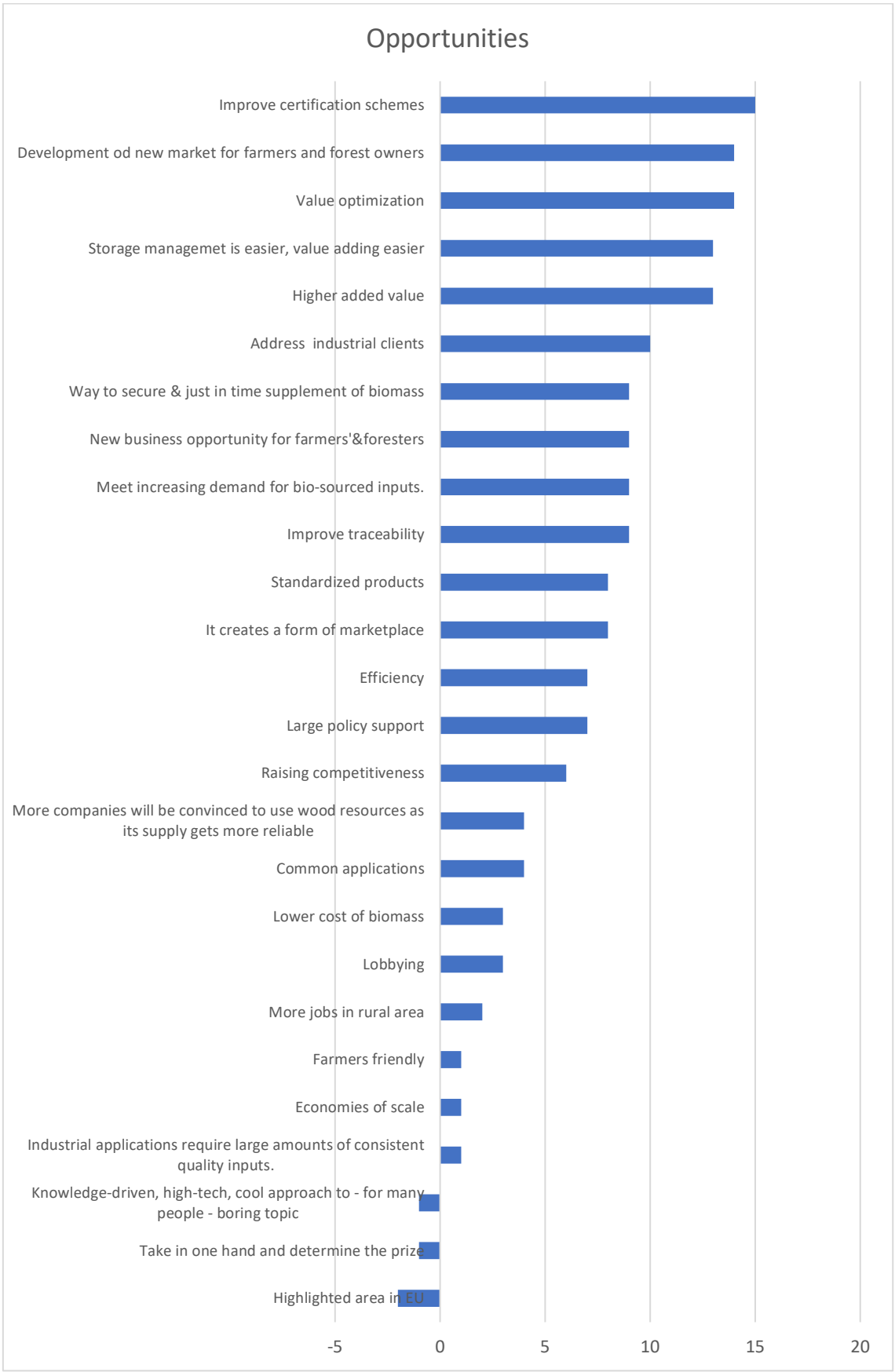
Opportunities
Improve certification schemes
Development od new market for farmers and forest owners
Value optimization
Storage managemet is easier, value adding easier
Higher added value
Address industrial clients
Way to secure & just in time supplement of biomass
New business opportunity for farmers'&foresters
Meet increasing demand for bio-sourced inputs.
Improve traceability
Standardized products
It creates a form of marketplace
Efficiency
Large policy support
Raising competitiveness
More companies will be convinced to use wood resources as its supply gets more reliable
Common applications
Lower cost of biomass
Lobbying
More jobs in rural area
Farmers friendly
Economies of scale
Industrial applications require large amounts of consistent quality inputs.
Knowledge-driven, high-tech, cool approach to - for many people - boring topic
Take in one hand and determine the prize
Highlighted area in EU
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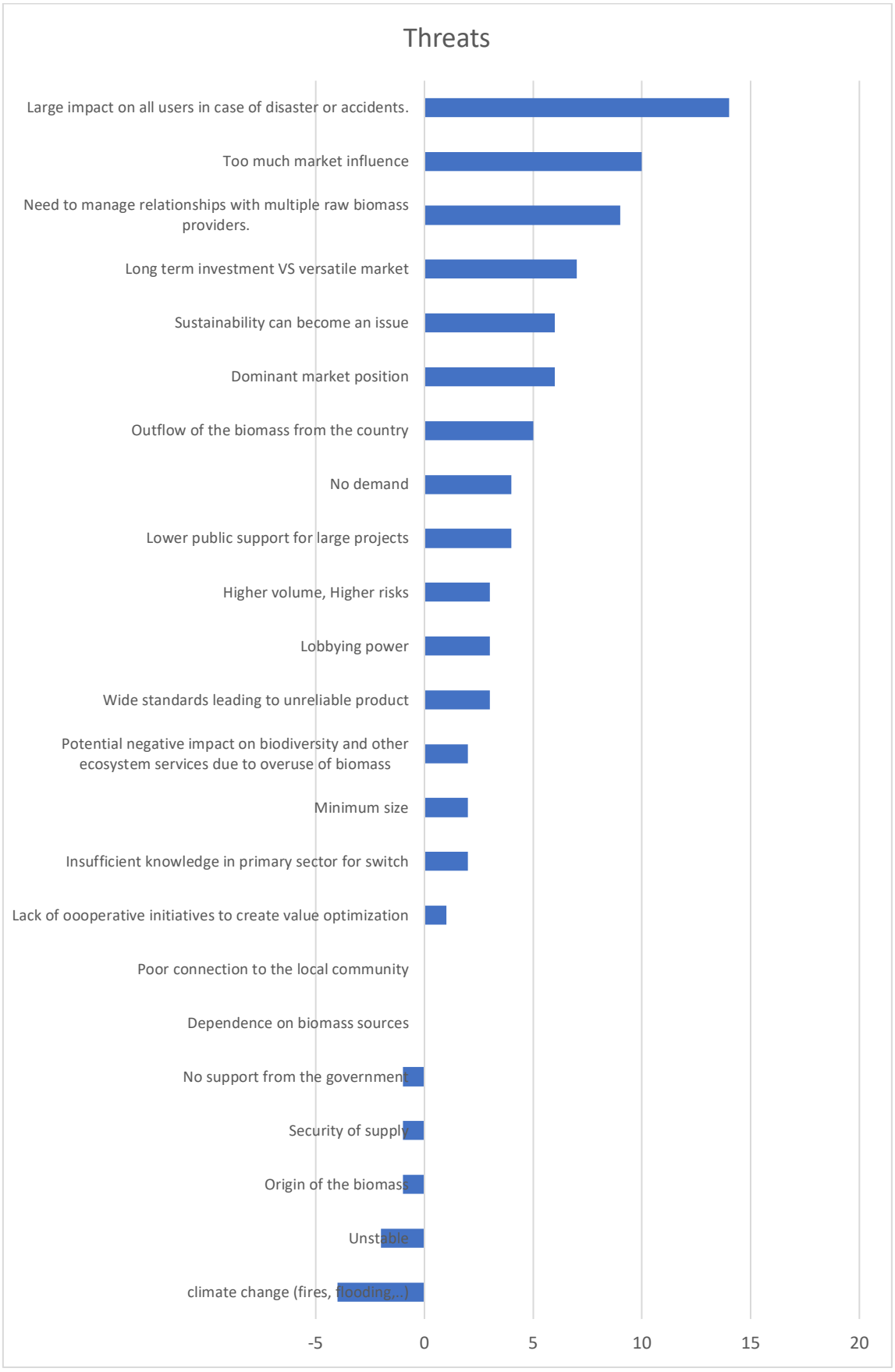
Threats
Large impact on all users in case of disaster or accidents.
Too much market influence
Need to manage relationships with multiple raw biomass providers.
Long term investment VS versatile market
Sustainability can become an issue
Dominant market position
Outflow of the biomass from the country
No demand
Lower public support for large projects
Higher volume, Higher risks
Lobbying power
Wide standards leading to unreliable product
Potential negative impact on biodiversity and other ecosystem services due to overuse of biomass
Minimum size
Insufficient knowledge in primary sector for switch
Lack of oooperative initiatives to create value optimization
Poor connection to the local community
Dependence on biomass sources
No support from the government
Security of supply
Origin of the biomass
Unstable
climate change (fires, flooding,..)
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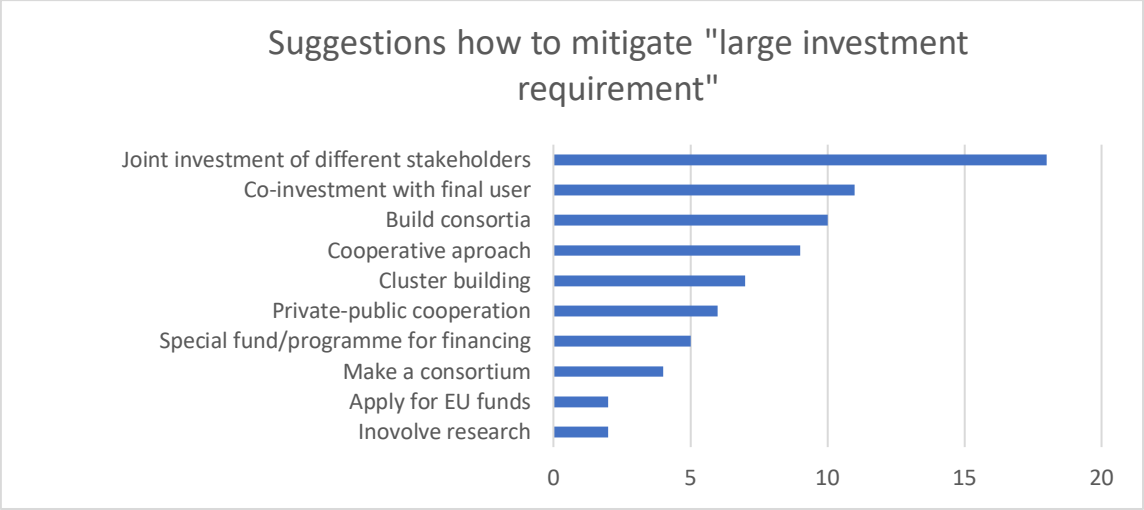
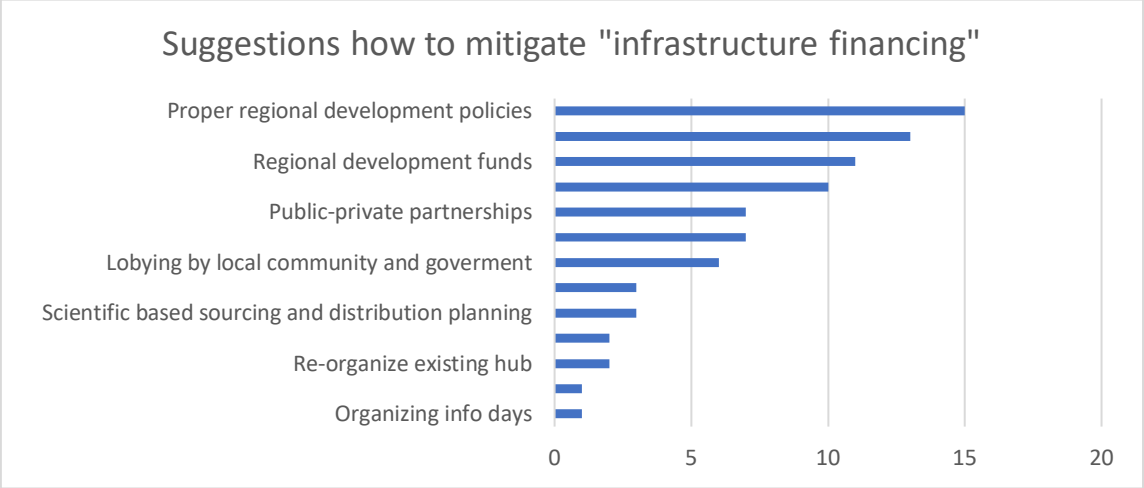
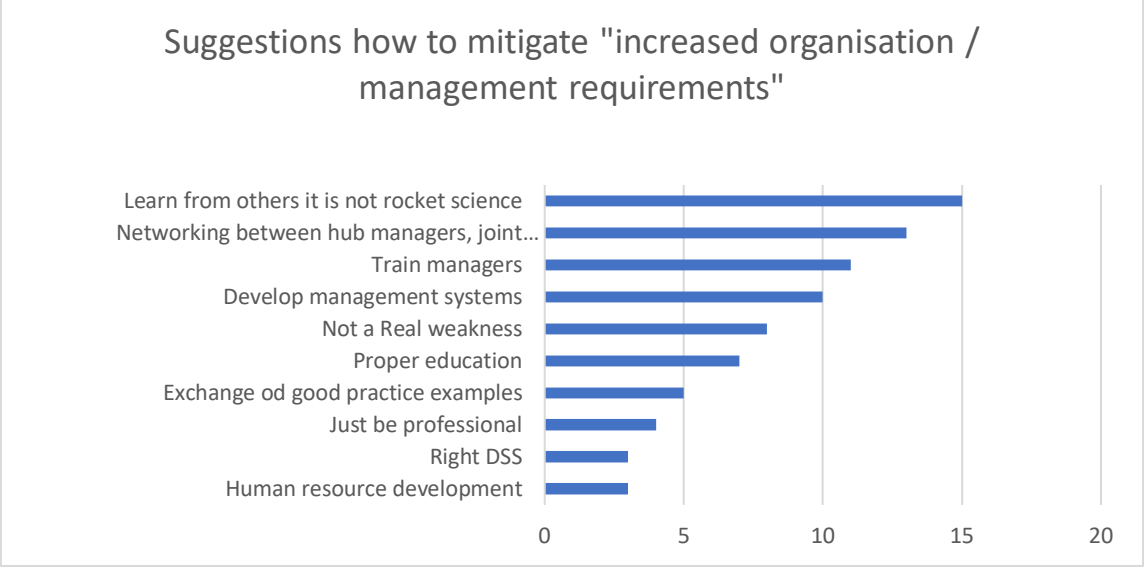
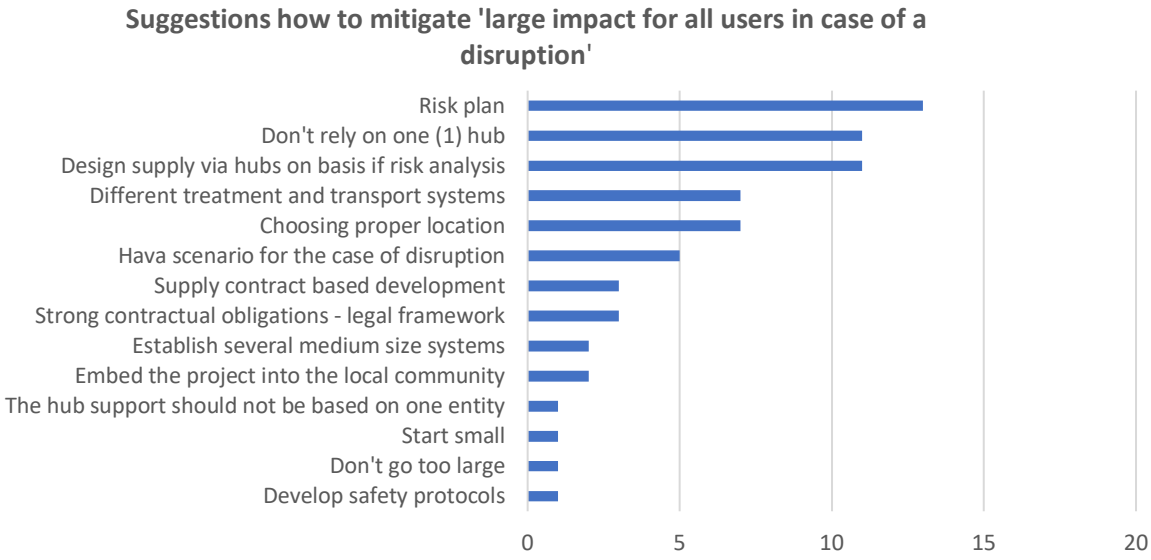
Full lists of suggestions for mitigating Weaknesses with votes

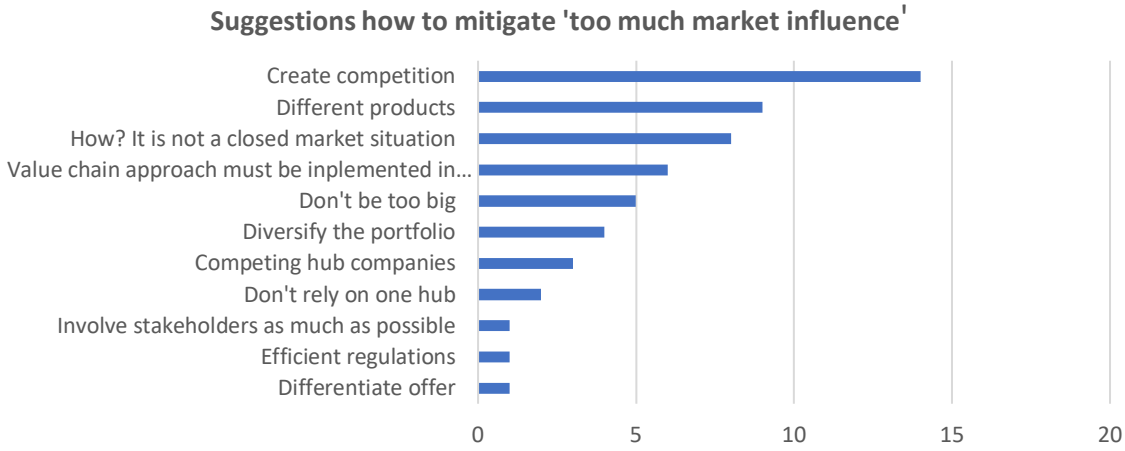


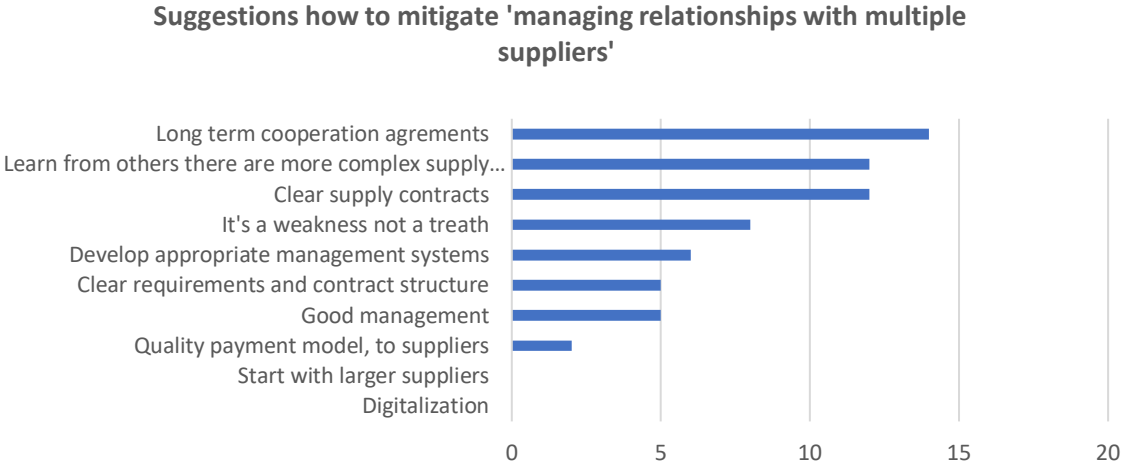


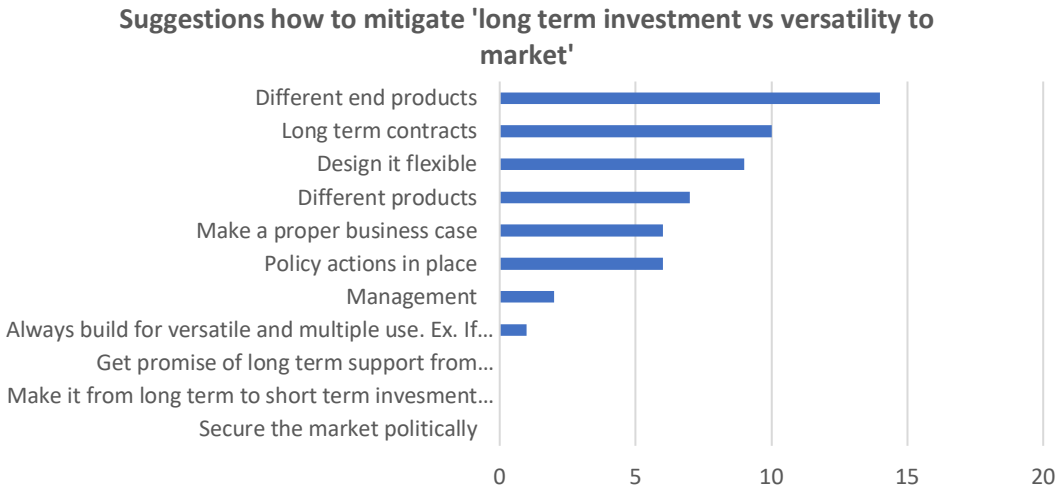


Full lists of suggestions for mitigating Threats with votes








Suggestions how to mitigate 'long term investment vs versatility to market'
Different end products
Long term contracts
Design it flexible
Different products
Make a proper business case
Policy actions in place
Management
Always build for versatile and multiple use. Ex. If...
Get promise of long term support from...
Make it from long term to short term invesment...
Secure the market politically
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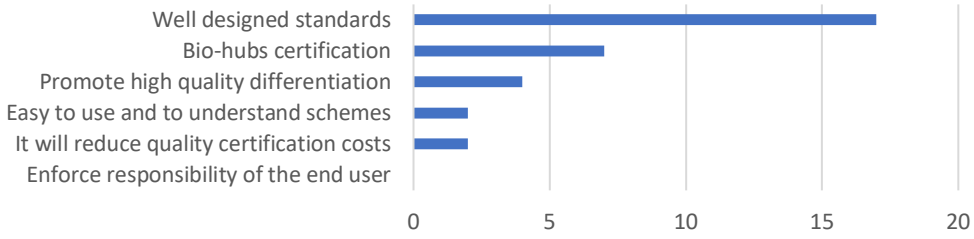
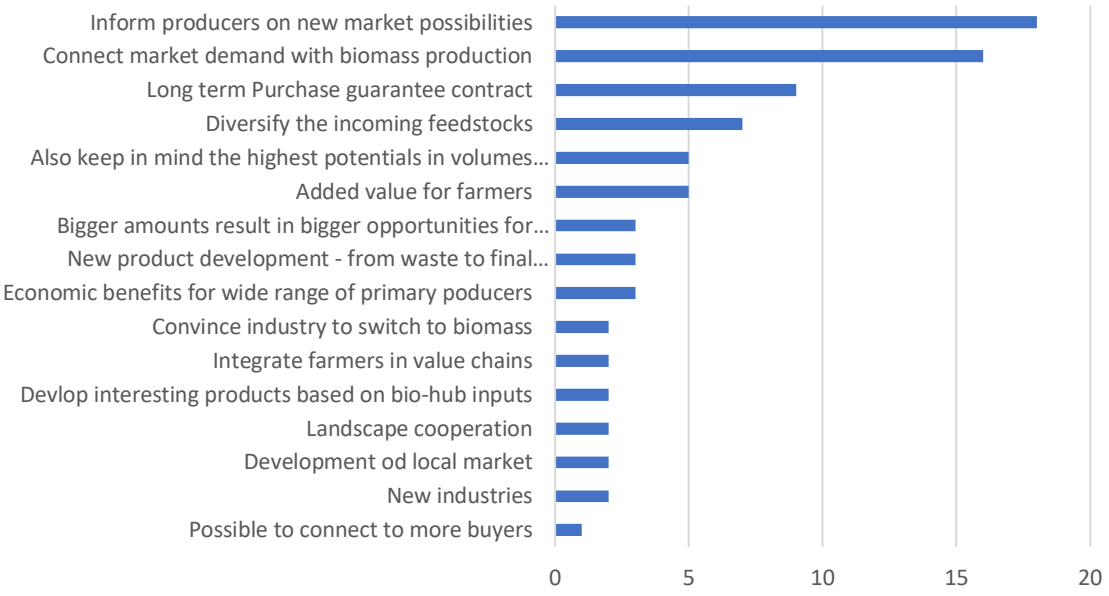
Full lists of suggestions of turning Opportunities to Strengths with votes

Suggestions how to turn Opportunities into Strengths with 'improved certification schemes'



Suggestions how to turn Opportunities into Strengths with 'value optimisation'

Suggestions how to turn Opportunities into Strengths with 'develop new markets for farmers and forest owners'



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